# Proceedings
## 2010 Columbia River Estuary Conference

**Adaptive Management of Ecological Restoration**

**May 25-26, 2010**
**Astoria, Oregon**

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# Preface

Numerous agencies, non-governmental entities, and interested parties are engaged in restoration activities, and associated research and monitoring, in the lower Columbia River and estuary (LCRE). Participation in these activities has increased dramatically in the past 7 years in recognition of the importance of the LCRE ecosystem to the viability of Columbia River populations of salmonids and other species. With this growth, there is a need to periodically share results, learn from others, and improve the collective knowledge of the participants. This exchange of information is vital to decision-making within an adaptive management framework to improve LCRE ecosystems. Therefore, the theme of the 2010 Columbia River Estuary Conference was:

> *Bringing together project leaders, program managers, and research scientists to share lessons from ecological restoration and endangered species recovery in the LCRE*.

The overall purpose of the conference was to provide a forum to develop recommendations for future application of lessons learned from research, monitoring, and restoration of ecosystems in the LCRE. (Note: channel deepening, dredge material disposal, and related topics were beyond the scope of this conference.) Previous related events include the Biological Integrity Workshop (1999), the Habitat Conservation and Restoration Workshop (2001), the Research Needs Workshop (2003), the Conference on Research, Monitoring, and Restoration in the Lower Columbia River, Estuary, and Nearshore Ocean (2006), and the Columbia River Estuary Conference: Ecosystem Restoration (2008).

The 2010 conference was organized into six sessions of oral presentations and a poster session. The first presentation session involved a panel of agency managers conveying their agencies' practices for adaptive management of LCRE ecosystem restoration. This was followed by sessions on strategy and prioritization, other adaptive management programs, uncertainties research, and lessons from ecosystem restoration projects. In the last session, the panelists from the first session returned to share their take-home lessons from the conference. There were 19 contributed papers and 13 posters, each addressing the implications of their work to implementation of ecosystem restoration.

The Conference was sponsored by the Bonneville Power Administration (BPA), Columbia River Estuary Study Taskforce (CREST), Lower Columbia River Estuary Partnership (LCREP), Oregon Department of Environmental Quality, National Oceanic and Atmospheric Administration (NOAA) Fisheries, and the U.S. Army Corps of Engineers Portland District (USACE). The steering committee comprised Jeff Breckel (Lower Columbia Fish Recovery Board), Catherine Corbett (LCREP), Heida Diefenderfer (Pacific Northwest National Laboratory [PNNL]), Blaine Ebberts (CENWP), Marcy Foster (BPA), Gary Johnson (PNNL), Scott McEwen (Columbia Land Trust), Patty O'Toole (Northwest Power and Conservation Council), Micah Russell (CREST), Cathy Tortorici (NOAA Fisheries), and Tracey Yerxa (BPA).

The conference proceedings herein include the abstracts and document the question/answer and discussion periods. The proceedings and presentations may be accessed at the conference website: http://cerc.labworks.org/. For more information about the conference, please contact Gary Johnson (503 417 7567, gary.johnson@pnl.gov).

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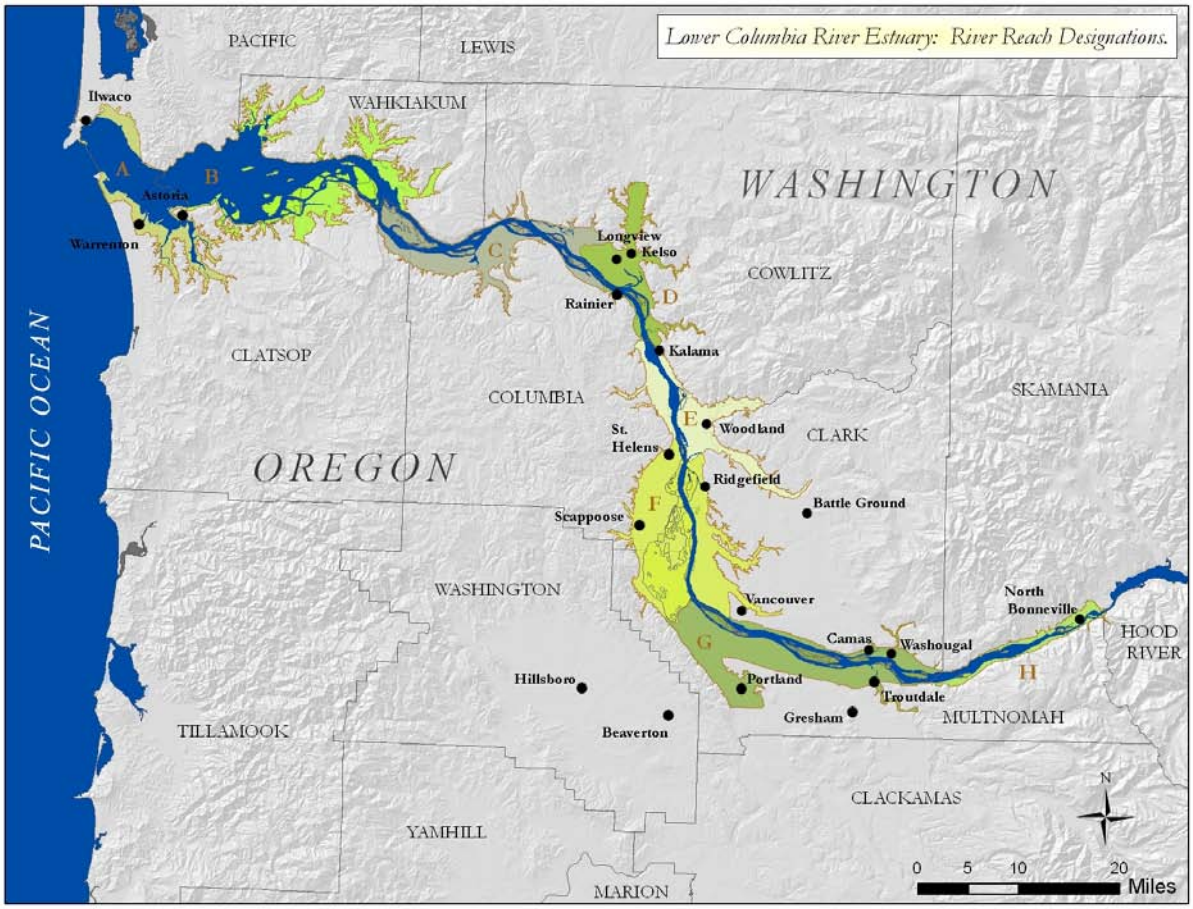
# Map of the Lower Columbia River and Estuary



# Session 0: Introduction

## Welcome

Joan Dukes

Northwest Power and Conservation Council

The Council was created under the authority of the Northwest Power Act of 1980, a federal law. The Council was given two mandates: to work on mitigating environmental impacts and to guide sustainable power. The Council adopted the sixth version of the Power Plan in February 2010, and the Fish and Wildlife program is part of the Power Plan.

What is the connection between the estuary and the Power Plan? The Northwest Power Act requires payment for mitigation and directs payment from the Bonneville Power Administration (BPA), approximately $200,000,000 in basin-wide funding, with $70 million of that figure directed into capital projects. Prior to 2002, the estuary was a bit of an afterthought. Then the series of Biological Opinions placed greater significance on the estuary and discussed the potential for an increase in survival of federally listed outmigrating juvenile salmonids. The Council formally adopted the estuary in the 2008 Plan, and in 2009 $8 million dollars was dedicated to the estuary. This funding amount equals 2.8% of the 2009 fiscal year budget, the same as the funding level in 2004. The question is, is this funding level adequate?

Adaptive management has been at the heart of the Council's program since the first Plan was adopted in 1982. No one is certain if any particular action will increase survivability of fish and wildlife. Even if a project fails, it will inform future actions. Obviously the upriver dams change the patterns of water flow and temperatures in the estuary and we know less about survival of the salmon and steelhead in the area of the estuary that all fish pass through on their way upstream. We are learning how to make the estuary more hospitable to salmon and steelhead through the collective efforts of the conference attendees and many others. Future success depends upon improving and maintaining productive habitat in the estuary and using science-based decision-making to guide future efforts.

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# The Importance of the LCRE Ecosystem Restoration

Bill Iyall and Taylor Aalvik

Cowlitz Tribe

Unlike some other Columbia basin tribes, the Cowlitz people are a landless tribe. The Treaty of 1855 wasn't ever fully recognized so the Cowlitz never got their ancestral lands, members were scattered to the winds, and some stayed in the area. Eventually, the Indian Claims Commission determined that 1.66 million acres were exclusively used and occupied by the Cowlitz people. The Cowlitz Tribe received 67 cents per acre, and the funds are held in federal trust. The Cowlitz Tribe became a federally acknowledged tribe in 2000; this acknowledgment was upheld in 2002. The ancestral lands of the Cowlitz people include a very dynamic environment as represented by Mt. St. Helens. The name "Cowlitz" means "seeker of medicine spirit," meaning the spirit of Mt. St. Helens.

The Tribe has been instrumental in engaging the U.S. Army Corps of Engineers (USACE) in looking at solutions for the USACE Sediment Retention Structure on the North Fork Toutle River. The structure was designed to have a 30-year life span and reached holding capacity in 28 years. A new or modified sediment-retention structure is needed, as well as a fish-passage structure. Historically, the Tribe dip-netted smelt from the Cowlitz River and used them for ceremonial and subsistence purposes. However, the smelt ceremony will only be in pictures this year due to extremely low returns. The Tribe supports that the National Oceanic and Atmospheric Administration (NOAA) listed the species, which will allow for more funds and effort to study and preserve the species. For this and many other reasons the lower Columbia River and estuary (LCRE) is culturally important to the Cowlitz Tribe. The Tribe wants to recover access to its cultural and natural resources. Its mission is to conserve, protect, and restore culturally significant natural resources within traditional homelands.

An overview of the Tribe's Natural Resources Department (NRD) was provided. The Cowlitz NRD has a geographic information system (GIS) department, and has been busy looking at historic information through Government Land Office maps of early surveys when the government began to classify lands in order to divide those lands for homesteaders; this has generated valuable information for the Tribe. For example, an 1860s image of the Longview area shows the confluence of the Cowlitz and Coweeman rivers with the Columbia River had many side channels and back-river channels, compared to highly fragmented lands today shown in the overlay. A holistic view of the environment is important to the Tribe when planning for restoration.

The Tribe recognizes that partnerships are key to adaptive management of the estuary. The LCRE is a diverse environment with multiple stakeholders who among them have multiple goals; some of these goals compete or overlap with each other. Successful management requires not only partnerships but also clear and open communication. The Tribe values not just the iconic salmon but also native traditional foods like Wapato and Columbian white-tailed deer. The Tribe is starting to do more restoration projects themselves, such as the recently completed Lower Lewis large woody debris restoration project at the mouth of Allan Creek. The Tribe's Natural Resources Division includes five full-time folks: Taylor Aalvik, Rudy Salakory, Nathan Reynolds, Erik White, Shannon Wills, and part-time staff David Russell and Ed Arthur.

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## Opening Remarks

Gary Johnson

Pacific Northwest National Laboratory

Restoration activities are accelerating; restoration strategies and project selection and prioritization processes are maturing; research on critical uncertainties and action effectiveness is advancing the knowledge base; and adaptive management frameworks are in place. To maximize cost-effectiveness and biological performance, it's time for routine and deliberate adaptive management of the ecological restoration effort in the lower Columbia River and estuary.

The 2010 Columbia River Estuary Conference is the sixth in a series as follows: 1999 – Biological Integrity Workshop; 2001– Habitat Conservation and Restoration Workshop; 2003 – Research Needs Workshop; 2006 – Conference on Research, Monitoring, and Restoration in the Lower Columbia River, Estuary, and Nearshore Ocean; 2008 – Conference on Ecosystem Restoration. Proceedings from most of the earlier events can be found at the conference website (http://cerc.labworks.org/).

An overview of the conference format and scope (see Preface) was provided. The opening remarks concluded with the statement, "Let's not just talk about adaptive management of ecological restoration, let's really do it!"

# Session 1: Agency Practices to Adaptively Manage Ecosystem Restoration in the Lower Columbia River and Estuary

## LCFRB and Adaptive Management of LCRE Ecosystem Restoration

Jeff Breckel

Lower Columbia Fish Recovery Board

The Lower Columbia Fish Recovery Board (LCFRB) developed a salmon and steelhead recovery plan for the Washington portion for the Lower Columbia through a collaborative effort involving federal and state agencies, tribes, local governments, and other interested parties. That plan, adopted by NOAA Fisheries in 2006, sets forth goals, strategies, measures, and actions for returning salmon and steelhead populations to healthy, harvestable levels. The LCFRB plan will soon be linked with the Oregon recovery plan for the Lower Columbia and the estuary module of the NOAA salmon recovery plan to create a comprehensive recovery plan for the entire Lower Columbia Evolutionarily Significant Unit.

The recovery plans draw upon the best available science and weigh legal, cultural, social, and economic factors to chart a course to recovery. However, uncertainty remains as to whether the course we have plotted will achieve our goal of healthy, harvestable salmon and steelhead populations. Our knowledge of the fish and their needs is imperfect. Our understanding of critical ecological processes is limited. We have assembled a comprehensive package of actions and priorities that we believe will put us on the trajectory to recovery, but we remain unsure of precisely how much needs to be done or how the fish will respond.

Key to the success of our recovery efforts is our ability to assess our progress, address our uncertainties, and adjust our course as needed. The LCFRB is working with its federal, state, and local partners to put in place a research, monitoring, and evaluation (RME) program to support these tasks. The RME effort is driven by the same collaborative approach used to develop and now implement the recovery plan. It focuses on the need to identify key management questions and uncertainties and it works to provide a framework for setting priorities and coordinating monitoring efforts by multiple entities to address key questions and uncertainties effectively and efficiently.

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## U.S. Army Corps of Engineers and Adaptive Management of Lower Columbia River and Estuary Ecosystem Restoration

Joyce Casey, Chief

Environmental Resources Branch, Portland District – USACE

The U.S. Army Corps of Engineers has many authorities for ecosystem restoration at both the national levels and levels specific to the lower Columbia River and estuary. The drivers for the USACE Portland District to conduct ecosystem restoration are many, including having a primary mission for USACE Civil Works, meeting Biological Opinion requirements, assisting in Endangered Species Act listing recoveries, and supporting regional efforts such as the Lower Columbia River Estuary Partnership's Comprehensive Conservation Management Plan. The Portland District has created an Adaptive Management (AM) Plan for Ecosystem Restoration in the LCRE. While this AM plan was, by necessity, originally Portland District-specific, we have been and will continue working with our regional partners to transform the plan into a regional Adaptive Management Plan. Decisions directing which project to restore come from many sources: our specific need for cost-share sponsors, internal USACE processes, specific Program needs, and regional coordination efforts. Our AM plan is relatively new and is considered a work in progress. As additional projects are restored both by the USACE and our regional partners, we expect the plan to evolve to become more thorough and functional. Action effectiveness studies will enhance our knowledge of ecosystem restoration processes and inform our future guidance and efforts.

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## BPA and Adaptive Management of LCRE Ecosystem Restoration

Greg Delwiche

Bonneville Power Administration

Under the 2008 FCRPS Biological Opinion (BiOp), the 2009 Adaptive Management Implementation Plan, and the 2010 supplemental BiOp, the Action Agencies (AAs; BPA and USACE) and NOAA Fisheries are managing the Reasonable and Prudent Alternative actions adaptively through 2018, to ensure that ongoing implementation incorporates the best available science and reflects the current status of listed fish. Using adaptive management, actions can be modified over time if the best available science indicates that a changed action would better meet BiOp commitments. In the estuary, the AAs are working with partners and implementers to identify and prioritize project types and locations that will yield the highest survival benefits. One example of working with our partners is the recent Washington Memorandum of Agreement among Bonneville Power Administration, U.S. Army Corps of Engineers, and the State of Washington for on-the-ground estuary projects toward achieving estuary survival benefit units committed under the BiOp.

Estuary survival commitments under the BiOp are approximately 49 survival benefit units for ocean-type fish and 30 units for stream-type fish to increase survival of fish in the Columbia River estuary by

2018. Survival benefit units to be attained through AA actions have been distributed to both BPA and the USACE as agreed upon by the agencies.

- The total BPA commitment for the 2008 BiOp is 30 ocean-type survival units and 18 stream-type survival units.
- The total USACE commitment for the 2008 BiOp is 14 ocean-type survival units and 8 stream-type survival units.

The methodology used to develop survival benefit units for estuary actions is based on estimates for survival improvements from 23 recovery actions in the NOAA Recovery Plan's Estuary Module. The AAs are currently focused on increasing the pace of estuary project completions and the number of survival benefits achieved within implementation time periods. The AAs have developed a Program Management Plan, which lays out individual and shared agency strategies and actions for achievement of survival unit targets within the 2010–2013 and 2014–2018 time periods for BiOp implementation. One key implementation strategy is to identify and prioritize project types and locations that yield the highest survival benefits. BPA is working with our estuary partners to adaptively manage our responsibilities and resources for fulfilling BiOp commitments.

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## Columbia Land Trust's Adaptive Approach to Restoration in the Lower Columbia River and Estuary

Glenn Lamb

Columbia Land Trust

As one of the principal implementers of restoration in the Columbia Estuary, Columbia Land Trust has conserved over 4,000 acres of Columbia Estuary floodplain over the last 9 years. Columbia Land Trust has accomplished this by permanently securing a land base from willing land owners through fair market processes.

These lands now serve as a platform from which on-the-ground restoration projects are able to be implemented. These restoration projects result in some of the highest survival benefits for threatened and endangered salmon in the estuary. Assembling the properties necessary for a viable restoration project can take a number of years. Columbia Land Trust is uniquely positioned for this role due to 1) its long view on restoration and conservation in perpetuity; 2) its long-standing relationships with private and public landowners in the estuary; and 3) its reputation as an engaged land owner in its own right in communities located in the estuary.

Columbia Land Trust has identified and is developing numerous additional estuary acquisition and restoration projects. Columbia Land Trust adapts our projects as we learn from ongoing research on the survival and productivity of juvenile salmonids in shallow water habitats in the Columbia estuary. Columbia Land Trust also uses effectiveness and reference site monitoring from its own projects and at those of others to improve our understanding of restoration approaches.

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## LCREP and Adaptive Management of LCRE Ecosystem Restoration

Chris Hathaway
Lower Columbia River Estuary Partnership

The Lower Columbia River Estuary Partnership (Estuary Partnership) uses a collaborative, stakeholder-driven process to implement the goals and objectives within our Comprehensive Conservation and Management Plan (CCMP or Management Plan), a requirement of all estuaries in the National Estuary Programs (NEP). The NEP is authorized by Congress and accountable to Congress, the states, and the U.S. Environmental Protection Agency (EPA). The Estuary Partnership Management Plan calls for the protection and restoration of 19,000 acres of habitat by 2014, implementation of a long-term monitoring strategy to assess the estuary ecosystem condition and changes over time, and increased public awareness and involvement in the stewardship of the lower river and estuary.

The Estuary Partnership's role is to foster partnerships and actively facilitate and coordinate the monitoring, restoration, and stewardship efforts of our private and public partners and fill in gaps as needed to best implement the objectives within our Management Plan. We apply a multi-tiered approach to successfully meet our objectives: 1) establishing clear program actions; 2) identifying, securing funding, and developing projects that align with program actions; 3) garnering partners' feedback and support for steps needed to implement actions and identify gaps; and 4) providing a decision framework that supports responsive and responsible program and project management decisions. The Estuary Partnership uses its Science Work Group, Board of Directors, and annual science-to-policy exchanges as integral steps in the decision framework to provide scientific and policy feedback on specific issues such as habitat restoration project selection, toxic contaminant source identification and reduction actions, coordinated ecosystem and action effectiveness monitoring, and improved habitat restoration project-development strategies. The Estuary Partnership regularly compiles and assimilates emerging scientific information and evolving agency priorities to place in context with the multiple layers of local needs from the project implementation scale to the program management scale. In turn, it seeks opportunities to support its partners in meeting Management Plan objectives by building partners' capacities, securing outside funding, providing science and data, and filling gaps. This presentation will discuss the Estuary Partnership's adaptive management approach in detail and describe how lessons learned are incorporated into day-to-day decisions.

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## CREST and Adaptive Management of LCRE Ecosystem Restoration

Micah Russell

Columbia River Estuary Study Taskforce

CREST, a bi-state Council of Governments, provides environmental planning, habitat restoration, and research services to the Columbia-Pacific Region. In the past decade, CREST has increasingly focused on implementing restoration of juvenile salmon rearing habitat in the tidal portions of the Columbia River estuary. This has included some of the first dike breaches and floodplain enhancements in the region, necessitating a robust effectiveness monitoring program. Lessons learned from project management and monitoring data inform the development of new projects and contribute to regional research studies. Although project funding decisions lie with partner agencies, CREST uses knowledge of various project review and selection criteria, on-the-ground feasibility, ecological value and connectivity, and knowledge of community relationships to determine whether a project is worth pursuing. From an implementer's perspective, the most powerful adaptive management comes in applying lessons learned to improved community outreach and engineering designs. Micah Russell, Director of CREST, will discuss ongoing efforts to coordinate CREST programs with regional partners for the purposes of adaptive management.

**SESSION 1 PANEL QUESTIONS AND ANSWERS**

**Q:** How will the Section 408 process affect the development of the dike breaching proposals?

**A**: Kevin Bryce, Deputy District Engineer for the USACE Portland District – In the Columbia River estuary there is a range of different types of levees. Some are for local purposes; others are authorized by Congress and were built under federal flood-protection laws. Now if we want to go and breach a levee, we have to go back through the USACE, and possibly back to Congress through what is known as the Section 408 process, to see if there is no longer a federal reason for the levee and determine if it can be decommissioned. Not every levee needs this congressional approval; it depends upon whether it's ever been federally authorized or not. The Corps wants to bring together the stakeholders to address the misconceptions that are out there about this process.

Micah Russell, CREST: CREST has a project that is going through the 408 process now. This project is one of the first through this new process with the Portland District. CREST is proposing to build a cross-dike to protect nearby landowners before they would breach a dike for restoration. CREST is now going through risk analysis modeling. They plan to take it through the Section 408 process over the next year. CREST encourages the Corps to work with action agencies to get a streamlined programmatic solution in the future, because most dikes have some Corps jurisdiction that will trigger Section 408 review and approval. This new review and approval process will slow down the restoration implementation process if it is not dealt with programmatically.

**Q:** Who is in charge? Who is the clearing house for information on estuary restoration and RME?

**A:** Greg Delwiche, BPA – The Lower Columbia River Estuary Partnership (LCREP) functions as the coordinator for the estuary.

Glenn Lamb, CLT – LCREP's Science Work Group has been working on this coordination.

**Q:** Question for Glenn: What has the Columbia Land Trust (CLT) learned from the Grays River projects as a poster child for what can go wrong?

**A:** Glenn – As said earlier, previous experiences become part of CLT's considerations when developing new projects. As an example, Klickitat County wanted CLT to continue to pay property taxes and protect habitat. CLT is also doing some fire control (thinning) and other "common ground" projects to build local support. In Grays River, the Grange identified some marginal farmland that frequently flooded that could be converted to habitat and protect other upland habitats that are less frequently flooded.

**Q:** What does funding for adaptive management look like to address projects in the future? Can we fund new projects, research, and monitoring? How do we fund learning from our mistakes, when funding is so competitive, especially when we have gone from culvert replacements to larger more complex projects. How do we go back and resolve projects that didn't function as expected?

**A:** Greg – They would have to be presented to compete with new projects, and possibly have a line item for "adaptive management."

Bruce McIntosh, ODFW – Agrees we have done many of the "low hanging fruit" projects, that new projects are more complex, and it's a challenge to turn it into a funding mechanism.

Jeff Breckel, LCFRB – We have to keep in mind the varying definitions of adaptive management, in scope and scale. How good are the goals and objectives? How do you know? How is failure defined? How is it achieving ecological objectives at a broader scale, like the watershed? We're never going to have enough money to do all the RME and AM that we'd all like to have. What are the critical answers we need to generate?

Chris Hathaway, LCREP – Some projects will fail, we should expect that. When we invest a lot of money, and then have a project not go forward for whatever reason we should be able to learn from that experience too.

Blaine Ebberts, USACE – PNNL and NOAA research supports a framework for AM. This framework includes working cooperatively amongst the partners (BPA, LCREP, CLT, CREST, etc.). If the region keeps moving in a cooperative, collaborative direction, funding for AM should be part of the effort.

Glenn Lamb, CLT – Noted there are two models for management – one is a military type "command and

control," or the other is chaos. If there are multiple funding mechanisms, they will require different types of information. We should be careful we don't tie ourselves so tight they can't allow new sources.

**Q:** How involved have panel members been with the Tribes; have they asked to collect anything on their lands, food sources, or other?

**A**: Glenn Lamb – CLT has had conversations with the Yakama and the Cowlitz Tribes.

Bill Iyall – The Cowlitz people realize there must be some retention of infrastructure, like dikes in Longview. They are also working with the Corps for example on the Toutle Sediment Retention Structure (SRS); the SRS has a 30-year design life, and at 28 years reached its capacity. The Tribe has a plan to work with the USACE and the Washington Department of Ecology in partnership to stabilize the Toutle River and the floodplain above the SRS that will address the safety issues as well as create better habitat for fish and elk than what is there now.

# Session 2: Strategy and Prioritization

## Adaptive Management: The Columbia River Experience

Peter J. Paquet

Northwest Power and Conservation Council

The concept of adaptive management was developed by C.S. Holling and Carl Walters in the 1970s. Adaptive management seeks to aggressively use management intervention as a tool to strategically probe the functioning of an ecosystem. Interventions should be designed to test key hypotheses about the functioning of the ecosystem. This approach is very different from a typical management approach of "informed trial-and-error," which uses the best available knowledge to generate a risk-averse, "best guess" management strategy, which is then changed as new information modifies the "best guess." Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management as a tool not only to change the system, but as a tool to learn about the system. Adaptive management was first introduced into the Columbia River basin in the 1984 revision to the Northwest Power and Conservation Council's Columbia River Basin Fish and Wildlife Program. Subsequently it has been incorporated into numerous natural resource planning processes at nearly all levels of government, including Biological Opinions on operation of the Federal Columbia River Power System under the Endangered Species Act.

The use of adaptive management in the Columbia River basin has had mixed results. Using the basic principles of adaptive management, this presentation will examine the degree to which the adaptive management concept has been successfully implemented in the basin. It will focus on both past efforts and the degree to which they have resolved significant scientific questions and will speculate on how more recent initiatives will affect future efforts to implement the adaptive management approach.

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## Toward an Integrated Ecosystem Restoration Adaptive Management Program in the Columbia River Estuary

Ronald Thom[1], Blaine Ebberts[2], Catherine Corbett[3]

[1]Pacific Northwest National Laboratory, [2]Portland District Corps of Engineers, [3]Lower Columbia River Estuary Partnership

Agencies and other entities are actively pursuing habitat restoration and conservation projects in the Columbia River estuary. In general, these entities communicate, at least informally, about their activities. Each differs in its mission, jurisdiction, funding sources, driving factors, and operational characteristics. However, all of them aim to maximize the probability of success of their projects in the face of a broad range of uncertainties. Since 2004, there has been an effort by the U.S. Army Corps of Engineers to develop an adaptive management (AM) program that can inform decisions about its conservation and restoration actions. This effort led to discussions among the various entities as to

potentially coordinating efforts under the umbrella of a system-wide AM program. Coordination should produce efficiencies that can reduce costs and result in more effective projects. Further, coordinating will allow a broader system-wide assessment of the response of the estuary to cumulative sets of projects. The challenge is to define the level of coordination and the common ground at which coordination can be done most efficiently. We summarize our interim effort, which includes a clear statement of program goals, an organizing model, a plan for assessing progress through a meta-analysis of projects, and a summary of recommendations for improving success. Next steps include engagement with members of the broader community who are actively engaged in restoration to understand their information needs and the level of effort required to implement AM estuary-wide. This will be developed in a regional annual adaptive management report for the estuary.

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## Development of an Ecosystem Restoration Strategy for the Lower Columbia River Using a Multiple-Lines of-Evidence Approach

Catherine A. Corbett[1], Chaeli Judd[2], Keith Marcoe[1], Gary Johnson[2], Ron Thom[2], and Evan Haas[1]
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[2] Coastal Assessment and Restoration Group,
Pacific Northwest National Laboratory, Sequim, WA, USA

As of June 2010 the Lower Columbia River Estuary Partnership and regional partners will have protected or restored 16,235 acres of habitat in the Columbia River estuary since 1999, surpassing the original Estuary Partnership Comprehensive Conservation and Management Plan goal of 16,000 acres by 2010. However, the next goal of 19,000 acres restored or acquired by 2014, listed in the Estuary Partnership's updated Management Plan and the EPA's 2009-2014 Strategic Plan, will be more challenging as will the actions listed within the Washington and Oregon Recovery Plans for listed salmon and steelhead and the 2008 Federal Columbia River Hydropower System Biological Opinion. To reach the targets in these plans, habitat restoration in the estuary will require a more focused, science-based, regional habitat restoration strategy and close coordination and cooperation amongst the multiple restoration partners working in the estuary. There has been no restoration strategy focusing on the estuary ecosystem that uses an ecosystem-based approach directed toward restoring ecosystem structure and function. Partners agree on this goal, but have not had an overarching, unifying regional strategy that focuses restoration on areas that will provide the greatest ecological benefit. This strategy will greatly increase the efficacy of restoration project selection and implementation, and will help regulatory agencies identify mitigation options to offset development impacts from future projects in which type-for-type compensatory estuarine habitats have not been identified.

To develop this restoration strategy, the Estuary Partnership is continuing to build upon an existing habitat restoration prioritization framework produced by Pacific Northwest National Laboratory (PNNL) for the Estuary Partnership in 2006. That framework uses a two-tiered approach to evaluate site and landscape level disturbances to prioritize areas for habitat restoration and to compare restoration projects against each other. Subsequently, the Estuary Partnership and others have developed additional tools essential to completing a regional habitat restoration strategy. During an ongoing effort, the Estuary Partnership with PNNL is incorporating these new tools to build another level of

assessment into the prioritization framework, including a habitat change analysis, a juvenile salmon habitat suitability index, and tributary priorities from the Washington and Oregon Salmon and Steelhead Recovery Plans. The strategy uses a multiple-lines-of-evidence approach to identify key areas for habitat protection and restoration within the estuary, and as new data sets come online, such as the Columbia River Estuary Ecosystem Classification and landcover maps, they can be included in the strategy as additional lines of evidence or the sole analysis, depending on the focus of the user.

The Estuary Partnership will soon vet this strategy with the Estuary Partnership Science Work Group and others and incorporate their input before final adaptation. The strategy will be a dynamic product constructed to expand or be easily updated with additional data sets and analyses in an iterative process.

| **CORBETT: QUESTION AND ANSWER** |
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| **Q:** What about the landowners? It was the last thing mentioned? |
| **A**: This is really based on ecological functions; the next step would be the willing-landowner overlay. |

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## Strategic Restoration/Preservation Planning of Juvenile Salmon Habitat Based on the Columbia River Estuary Ecosystem Classification

Charles A. Simenstad[1], Jennifer Burke[2], Mary Ramirez[1], Allan Whiting[3], Phil Trask[3], and Danelle Heatwole[1]
[1]School of Aquatic and Fishery Sciences, College of the Environment, University of Washington
[2]National Park Service; [3]PC Trask & Associates

To better understand the organization of ecosystem processes and structure and inform estuary management along the ~233-km gradient of the Columbia River estuary, the University of Washington, U.S. Geological Survey (USGS), and Lower Columbia River Estuary Partnership are developing the Columbia River Estuary Ecosystem Classification (CREEC). Based on the regulating processes that affect spatial variability and temporal change in these ecosystems, the extent of anthropogenic alteration to these processes, and available geospatial data, we have documented six hierarchical scales (levels) of ecosystem organization, ranging from ecosystem provinces to primary cover classes. These levels vary by the magnitude and extent of geologic, hydrologic, geomorphologic, and land cover/land use. Although still in revision with the acquisition of more current geospatial data, the CREEC is already providing some value to planning and management activities, research, and monitoring in the estuary. As an example, given the pressing mandates to restore juvenile salmon habitat in the estuary, the Bonneville Power Administration, NOAA Fisheries, and the U.S. Army Corps of Engineers are also supporting the application of the CREEC to more strategically identify salmon habitat restoration and protection needs. The CREEC offers a spatially explicit framework for understanding the variation in

estuarine habitats available to juvenile salmon from different Evolutionarily Significant Units entering, rearing, and migrating along different reaches of the estuary. Several levels of the CREEC (i.e., ecosystem complex, Level 4; and geomorphic catena, Level 5) are particularly applicable to identifying and ranking juvenile salmon habitat features in the estuary and tidal floodplain for restoration or protection. A potentially important provision of this analysis is identifying the spatial distribution of "fish catena," such as tributary confluence and off-channel wetlands, dendritic tidal channels, and tidal forested sloughs, that would constitute strategic restoration/preservation targets. We are vetting with external experts the application of the CREEC, as well as draft ecological principles that relate fish catena to landscape ecology and conservation biology principles most likely applicable to setting priorities on spatially explicit habitat requirements for juvenile salmon in different reaches of the estuary. Both the ecosystem process framework and the geospatial basis for the CREEC enable repeatable analyses for both historical and future spatial data sets, and guide the definition of quantifiable metrics and rules to identify optimal characterization and location of estuarine salmon habitat.

| **SIMENSTAD: QUESTION AND ANSWER** |
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| **Q:** I'm glad the talk discussed the temporal element, but how do you use the FRAGSTAT data to address a dynamic temporal element like tidal data?<br><br>**A**: Analytically it's possible to use the tidal prediction chart model data to address the issue. |

# Session 3: Other Adaptive Management Programs

## Adaptive Management of Ecosystem Restoration in the Mississippi River Delta

Tomma Barnes

U.S. Army Corps of Engineers, New Orleans District

Abstract not provided.

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## Using Rapid Prototyping to Kick-Start Adaptive Management on the Platte and Missouri Rivers

Andrew J. Tyre

School of Natural Resources, University of Nebraska-Lincoln

Making any kind of decision involves some effort on the part of decision-makers to forecast the future; the only alternative is to make decisions entirely at random. This step in rational decision-making approaches often leads scientists to call for further research to improve predictions and add additional complexity, providing decision-makers with endless opportunities to delay decisions until forecasting ability improves. Unfortunately, this goal is almost never reached to everyone's satisfaction, particularly when using ecological models. Rapid prototyping turns the prediction problem around—starting with the decision that must be made, it poses the question: What is the simplest model of the system that differentiates between the alternatives? Models built in this way can be used iteratively to develop a fuller understanding of the decision problem at hand, and in particular, the tradeoffs that must be made between competing objectives. I will draw on examples from current work advising adaptive management processes on the Platte and Missouri Rivers to illustrate the concepts behind rapid prototyping.

| TYRE: QUESTION AND ANSWER |
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| **Q:** So after going through all this process, where is the group going from here?<br><br>**A**: We have been delivering reports to various people, now that the adaptive management process has shifted from one group to another and we now have access to the actual decision-makers. It doesn't happen quickly. It is important to know who the decision-makers actually are; they should be in the room when the decision-making happens. |

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## Implementation and Adaptation of the Caspian Tern Management Plan for the Columbia River Estuary: Will it reduce mortality of Juvenile Salmonids in the Estuary?

Daniel D. Roby, Donald E. Lyons, Yasuko Suzuki, Peter J. Loschl,
Jessica Y. Adkins, Stefanie Collar, and Tim Marcella
USGS-Oregon Cooperative Fish & Wildlife Research Unit, Oregon State University
Ken Collis and Allen F. Evans, Real Time Research

The Caspian tern (*Hydroprogne caspia*) breeding colony on East Sand Island near the mouth of the Columbia River is the largest of its kind in the world (~10,000 nesting pairs) and includes about 65% of the entire Pacific Coast population of the species. Terns from this colony consumed about 6.4 million juvenile salmonids (*Oncorhynchus* spp.) during the 2009 out-migration. The Corps of Engineers initiated management of Caspian terns in 2008, as described in the Final EIS for *Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary*. This management plan, which was developed jointly by the Fish and Wildlife Service, the Corps, and NOAA Fisheries, seeks to redistribute most of the Caspian terns nesting on East Sand Island to alternative sites (islands) in interior Oregon, northeastern California, and San Francisco Bay by 2015. To date, the USACE has built eight islands in interior Oregon and northeastern California as alternative Caspian tern colony sites; three islands have been colonized by Caspian terns, many from the Columbia River estuary. The USACE also restored bare-sand nesting habitat for Caspian terns at East Sand Island in March 2010; without annual restoration of bare-sand habitat, the East Sand Island tern colony would be eliminated within a few years by encroaching vegetation. The area of Caspian tern nesting habitat on East Sand Island in 2010 is 38% less than the area of habitat prepared for terns in previous years. This reduction in area of nesting habitat was allowed by creation of new Caspian tern nesting habitat outside the Columbia River estuary. Adaptive adjustments to this plan, based on results to date, may permit a reduction by 65 to 75% in smolt mortality due to tern predation in the estuary, while restoring declining or extirpated Caspian tern breeding colonies within their native range.

| **ROBY: QUESTIONS AND ANSWERS** |
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| **Q:** Was there any work done on identifying the stock composition?<br><br>**A**: Yes, between the islands, both the species and the stock composition changed. Fewer Chinook smolts were taken, and they started replacing Chinook with anchovy, surf perch, herring, smelt, other schooling marine prey fish. |
| **Q:** It looks like the total nesting pairs are up from 7,000 to 11,000 now? Is this attributable to better nesting ground or are they attracted from other areas?<br><br>**A**: Yes, it looks like there has been a significant increase; however, the East Sand Island population has remained relatively stable, what you are seeing is an increase at East Sand over Rice Island. |

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## Columbia River Estuary Double-Crested Cormorants: Adaptive Research for Adaptive Management?

Donald E. Lyons, Daniel D. Roby, Jessica Y. Adkins, Yasuko Suzuki, Karen N. Courtot,
Peter J. Loschl, and Tim Marcella.
USGS-Oregon Cooperative Fish & Wildlife Research Unit, Oregon State University
Ken Collis and Allen F. Evans, Real Time Research

In recent years, there has been growing interest in predation on juvenile salmonids (*Oncorhynchus* spp.) by double-crested cormorants (*Phalacrocorax auritus*) in the Columbia River estuary. The cormorant colony on East Sand Island is the largest in western North America and has doubled since 1997. Research efforts have focused on 1) quantifying cormorant impacts on smolts; 2) evaluating possible management tools to reduce cormorant predation, modeled after the approach successfully used to reduce predation on smolts by Caspian terns (*Hydroprogne caspia*); and 3) assessing the status of the west coast double-crested cormorant population. Juvenile salmonids make up a small proportion of the cormorant diet (typically 10% of all biomass consumed); but, due to their sizable food requirements and large population, double-crested cormorants have in recent years consumed 9 – 11 million smolts annually, or 5 – 10% of smolts that arrive in the estuary. Various techniques have been demonstrated as possible tools for adaptive management of cormorants, including precluding nesting by removing or covering suitable nesting substrate, and attracting cormorants to new or restored breeding sites, if free of human or predator disturbance. The double-crested cormorant population in western North America has been growing at about 3% per year over the last 15 years; however, cormorant numbers in the west are an order of magnitude smaller than those in eastern and central North America. Most of the growth in the western cormorant population has occurred at East Sand Island in the Columbia River estuary; numbers have declined in both British Columbia and coastal Washington. Because the East Sand Island colony makes up ca. 41% of the western cormorant population, any management of cormorants there would have significant consequences for the regional population.

| **LYONS: QUESTIONS AND ANSWERS** |
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| **Q:** The fish population mortality estimate you noted was for East Sand Island only; is there additional mortality for the other cormorants up and down the Columbia?<br><br>**A**: The cormorants do forage way upstream like around Puget Island. Further upstream they are not breeding and the nonbreeding populations are quite a bit smaller. The mortality estimates don't include those nonbreeding birds. |
| **Q:** Why are Washington and British Columbia losing cormorants while Oregon is gaining birds?<br><br>**A**: There is speculation that disturbance by people and a larger bald eagle population has reduced the cormorant population. Bald eagles will kill adult cormorants on the colony and eat them. Eagles can destroy a small colony but there is protection in numbers for larger colonies. |

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## Upscaling to the Tidal Basin Landscape: Restoration of Riparian Areas, Salt Marshes, Eelgrass, and Native Olympia Oysters within the South Slough Estuary, Oregon

Steven S. Rumrill

South Slough National Estuarine Research Reserve

Coos Bay and the South Slough estuary have experienced a long legacy of habitat alteration and degradation over the last century due to timber harvests, diking, filling, dredging, and the large-scale conversion of tideflats for municipal development, shoreline agriculture, industrial facilities, and mariculture operations. Urbanization of the greater Coos Bay estuary has taken a substantial toll on multiple habitat components that are tightly linked to the estuarine tidal basin, including riparian areas and freshwater tidal wetlands, salt marshes, eelgrass beds (*Zostera marina*), and populations of native Olympia oysters (*Ostrea lurida*). About 25% of the historic wet surface area of the estuary has been lost to diking and filling of intertidal tideflats, and the bathymetry of the tidal basin has been deepened and simplified by dredging of the maritime navigational channel. The South Slough National Estuarine Research Reserve (NERR) has taken active steps over the past 20 years to restore and enhance several different types of habitats in a long-term effort to regain some of the lost ecological functions within the South Slough tidal basin. These habitat restoration and enhancement projects include 1) Winchester Tidelands Restoration Project (a series of linked riparian areas, freshwater wetlands, salt marshes; 2) Ferrie Head Eelgrass Enhancement Project (Ferrie head & Valino Island); and 3) the Olympia Oyster Recovery Project (Younker Point and Valino Island). Although we have made modest progress with these habitats, the South Slough continues to function as a heavily altered land-margin ecosystem. Eutrophication of the greater Coos Bay estuary and large-scale invasion of the tidal basin by non-indigenous aquatic species continue to pose important problems that must be addressed by solutions that extend well beyond the geomorphic boundaries of the watershed and nearshore marine ecosystem.

| **RUMRILL: QUESTION AND ANSWER** |
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| **Q:** There is a proposed liquefied natural gas project in Coos Bay; how do you think that will that affect the Coos Bay and South Slough project?<br><br>**A**: The liquefied natural gas terminal project requires 60 million cubic yards of deepening and widening of the channel, which will allow for more saltwater intrusion and associated habitat changes. Primary concerns are loss of eel grass from channel widening. |

# Session 4: Uncertainties Research

## Resource Partitioning, Habitat Connectivity, and Foraging Variation Among Salmonids in the Estuarine Habitat Mosaic

Bethany Craig

University of Washington

While many studies have examined resource use by particular species in the estuary, few have compared use patterns among species. Niche theory presents the concept that species must partition resources in order to successfully coexist in an ecosystem. The fact that multiple salmonids generally coexist in the same estuaries demands that they must partition resources in some way. This can be done temporally, spatially, and/or trophically. Prey subsidies across ecotones can affect partitioning by augmenting the available resources to individuals that otherwise partition spatially. This talk describes the extent of these processes in a freshwater tidal estuary, and how they influence foraging by juvenile salmonids in the system. Specifically, I assess resource partitioning among three species of juvenile salmonids in the estuarine habitat mosaic: chum (*Oncorhynchus keta*), coho (*O. kisutch*), and Chinook (*O. tshawytscha*). I also quantify the degree to which wetland prey export relates to salmonid foraging in the estuarine river mainstem. I sampled salmonid diets and prey availability in a forested wetland, restoring wetland, and the river mainstem within the Grays River estuary, Washington over a 2-year period.

Salmonids partitioned resources along all three axes: temporal, spatial, and trophic. Overall partitioning was greatest along the trophic axis, but the degree of resource overlap differed among species and size classes. Fish of different size classes tended to partition resources more temporally, while those of similar size exhibited more diet partitioning. I did not find any correlation between levels of partitioning and foraging rates, although partitioning may confer fitness benefits in other ways.

The second part of this talk tests whether wetland prey export subsidizes the prey base for salmon in the river mainstem. I found that significantly greater numbers of terrestrial-derived invertebrates were exported from wetlands than entered from the river. Certain insect taxa composed a greater proportion of export than of the overall wetland prey base, suggesting that not all insects are exported equally. Mainstem insect densities were greater upstream of the wetlands at high tide than downstream, and upstream taxa composition was more similar to that of exported prey. These observations suggest that export does in fact subsidize the prey base in parts of the river. Chum and Chinook used the river habitat to a much greater extent than coho, so I hypothesized that they would be the main beneficiaries of the subsidy. Chum diets were not significantly different across areas of prey subsidy. Chinook, however, did exhibit significant diet differences that were driven primarily by differences in consumption of exported prey taxa. Despite apparently taking advantage of the subsidy, Chinook did not exhibit greater rates of caloric intake in subsidized areas of the river. It is possible, however, that prey subsidies from the wetlands permit Chinook to effectively remain in the river without needing to compete with coho in tidal wetlands for abundant prey.

The results of this thesis show that salmonids use estuarine resources differently. Efforts towards conservation and restoration of tidal wetlands for salmon should account for species-specific requirements if they are to be successful.

| CRAIG: QUESTIONS AND ANSWERS |
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| **Q:** When you say "upriver" do you mean upriver in the Grays system or in the Columbia mainstem (as in stocks above Bonneville Dam).<br><br>**A**: Meaning the Grays River; however, there is more variation among coho that do rear in the Columbia estuary to move to different watersheds in the Lower Columbia. |
| **Q:** Wouldn't looking at the otoliths be a better way to look at the growth pattern?<br><br>**A**: Yes, however the Grays is a freshwater estuary (not saline) so it wouldn't be as effective, because their scale patterns don't show marked changes. |

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## Wetland Habitat Inundation Patterns in the Tidally Influenced Columbia River and Estuary

Amy B. Borde, Heida L. Diefenderfer, Shon A. Zimmerman, and Ronald M. Thom
Pacific Northwest National Laboratory
Marine Sciences Laboratory

Our research conducted over the last 5 years in the lower Columbia River and estuary quantifies the hydrologic conditions necessary for development of brackish and tidal freshwater wetland plant communities and quantifies potential fish access to tidal wetland channels. We have collected vegetation cover, elevation, and hydrology data from 37 reference condition wetland sites distributed throughout the floodplain of the 235-km tidally influenced Columbia River below Bonneville Dam. These previously limited data are required to understand the distribution of wetland community types in this regulated river system with complex tidal and flow-dominated hydrologic processes. Analyses include ordination of species richness relative to spatial variation of physical controlling factors, cluster analysis of community types, and the magnitude, timing, and duration of surface-water inundation within and between communities and sites. Initial results allow us to preliminarily quantify the relationships between 1) species richness and controlling factors, 2) community type and elevational gradients, 3) specific inundation patterns and community types, and 4) inundation of tidal channels and potential fish access. Further, we have quantified the elevation ranges and inundation tolerances of some invasive species; important information for management. This research fundamentally informs the prioritization

of land acquisition and restoration at the estuary program level, the design of restoration projects, and action effectiveness monitoring.

| BORDE: QUESTION AND ANSWER |
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| **Q:** How sensitive are the wetlands to sea level rise or changes in flows?<br><br>**A**: There is some sensitivity; over time they would change, however they do stay stable relative to fluctuating water levels. The question is how much and how fast? If we push the elevations up too far, we'll just end up with more reed canary grass than anything else. |

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## Results of Multi-Year Coordinated Fish, Fish Prey, Habitat and Water Quality Data Collection under the Ecosystem Monitoring Project

*Lyndal Johnson[1], Kate Macneale[1], Amy Borde[2], Jennifer Morace[3], Catherine A. Corbett[4], Sean Sol[1], and O. Paul Olson[1]
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[2]PNNL Coastal Assessment and Restoration Group
[3]USGS Oregon Water Science Center
[4]Lower Columbia River Estuary Partnership

Since 2007, NOAA Fisheries, Pacific Northwest National Laboratory (PNNL), and U.S. Geological Survey (USGS) have been collecting coordinated fish, fish prey, habitat, and water quality data at four to six sites annually for the Lower Columbia River Estuary Partnership under the Ecosystem Monitoring Project with funding from Bonneville Power Administration. One "fixed" station, Campbell Slough, near the Ridgefield National Wildlife Refuge has been monitored yearly to assess inter-annual variation in wetland habitat conditions and salmonid presence and abundance, while four other "status" sites are rotated around the basin, with collection efforts focusing on different river reaches each year. NOAA Fisheries monitors fish and juvenile salmon prey to provide information, such as stock, growth rates, stomach contents, and fish condition, on juvenile salmon use of the tidal freshwater portion of the Columbia River estuary. PNNL collects data on wetland vegetation species, elevation, and surface-water elevation, while USGS deploys probes to monitor the water column for parameters relevant to salmonids (e.g., temperature and dissolved oxygen).

We have collected multi-year monitoring data at two sites through summer 2009: Campbell Slough (2007–2009) and Franz Lake (2008–2009). In summer 2010 we will analyze and synthesize the results for these data to produce an interpretive report on the findings. This presentation will describe results for fish sampling; prey availability and preference; vegetation, elevation, and surface-water levels; and water-column conditions at these two sites. Some findings include the following:

- Juvenile salmon were using both sites from April, when sampling began, until June.
- Although wild salmonids were present at both sites, hatchery salmonids made up substantial proportions of the catch.
- The Franz Lake site had a greater diversity of salmonids, with significant numbers of coho, chum, and Chinook salmon, while Chinook salmon predominated at Campbell Slough.
- Fish community characteristics (number of species, species richness, and diversity) were similar between sites, but the percentage of non-native species tended to be higher at Campbell Slough.
- Fish length, weight, and condition factor were similar between sites, after differences in proportions of wild and hatchery fish and sampling dates are taken into account.
- Contaminant concentrations tended to be highest in juvenile Chinook salmon from Campbell Slough.
- A wide range of prey availability and richness were observed for both sites, which were fairly similar in terms of abundance of prey collected.
- Across sites and time, prey were more abundant in samples collected nearshore and associated with emergent vegetation relative to samples collected in deeper, open water.
- Juvenile Chinook salmon consumed primarily aquatic fly larva and pupa (Diptera) at both sites.
- Results from a mean selectively analysis, which compares available prey versus consumed prey, indicate a high selection of dipterans versus Cyclopoida and Cladocerans, even though these latter macroinvertebrates were more abundant.
- Overall, emergent vegetation cover at the sites was composed of approximately 60 % native and 40% non-native species, which did not change significantly between years.
- Variation in vegetation species richness and composition occurred between years, as did inundation patterns.
- Differences in water levels between years likely affected vegetation composition and potential for fish access and feeding.

| **JOHNSON: QUESTIONS AND ANSWERS** |
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| **Q:** There are some similarities and difference between the sites. How are you translating the data into decision-making for salmonids?<br><br>**A**: The purpose was to document conditions at reference sites. The data will inform designs at restoration sites and be used to evaluate the restoration sites to see how the restored sites compare to the reference sites. |
| **Q:** Which seasons are sampled?<br><br>**A**: Currently we are sampling from April through August. We are trying to get permits to sample a |

broader season.

**Q:** On the genetic stocks of fish, the data shows a predominance of fall Chinook from Spring Creek and West Cascades populations. What is the source watershed of these fish?

**A**: Spring Creek populations are based in the Columbia River Gorge, down to the mouth of the estuary; West Cascades populations are more in the intermediate range of the Lower Columbia from the Cowlitz and Lewis River systems – not sure specifically what watersheds they are from.

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## Life History Variation and Growth of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Columbia River Estuary

Lance Campbell[1], Daniel L. Bottom, Eric C. Volk, and Ian A. Fleming
[1]Washington Department of Fish and Wildlife

Despite evidence that juvenile Chinook salmon (*Oncorhynchus tshawytscha*) use North Pacific estuaries for growth and salinity acclimation, research in the Columbia River estuary has led to opposing hypotheses about the estuary's importance as a salmon-rearing environment. Many contemporary tagging studies indicate that salmon residency within the estuary is short (< 1 week) and that mortality of estuarine migrants is a significant impediment to recovery of depressed salmon stocks. On the other hand, life history interpretations from fish scales collected early in the twentieth century suggest that juvenile Chinook salmon reared extensively in the estuary, leading some to hypothesize that life history variation has been constrained by anthropogenic changes in the Columbia River basin. To test these hypotheses we measured strontium-86 and calcium-43 in salmon otoliths collected in the lower Columbia River estuary in 2003–2005 to quantify the period of salt-water residency of juvenile salmon and to back-calculate their sizes at salt-water entry. The estimated salt-water residency of juvenile Chinook ranged from 0 to 176 days with a mean residence time of 54, 67, and 30 days in 2003, 2004 and 2005, respectively. Chinook salmon that resided in salt water for more than 30 days comprised 55, 51, and 30% of the total estuary beach seine collections during each of these years. Forty to fifty percent of Chinook salmon had entered the saline portion of the estuary at a fork length < 60 mm. Furthermore, we found a negative relationship between the size and time of entry with residency, where smaller earlier migrants on average resided for longer periods than larger late migrants. Peak migration times occurred in May, and 90% of the outmigration was completed by August 30 in all years. This pattern is substantially truncated relative to the results of a 1914-1916 salmon life-history survey, which showed that the historical outmigration period lasted well into the fall and was characterized by late pulses of new recruits into the lower estuary. Nonetheless, recent otolith results indicate that subyearling Chinook salmon use the saline portion of the estuary in a high proportion and for extended periods of time in contrast to short residency times reported by contemporary tagging and marking studies.

| CAMPBELL: QUESTIONS AND ANSWERS |
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| **Q:** What are your ideas about the residence time for juvenile salmonids above the saline portion of the CRE? Could 25 mm size juvenile salmon be expected?<br><br>**A**: Small fish move in responses to temperatures in freshwater environments. If the habitat is suitable they would be expected to remain longer in tidal freshwater portions. |
| **Q:** How would you explain the difference in residence time compared to Dawley et al. work of a few days?<br><br>**A**: Size classes they observed were different. We saw the smaller sizes more often.<br>. |
| **Q:** Did you see any Willamette smolts in the fall?<br><br>A. Occasionally we caught Willamette fish, but with a super low frequency, like only 1 or 2 fish. |
| **Q:** Did they sample in December?<br><br>A: Yes, we did when the weather was good. We did sample through fall and winter weather permitting. We do have genetics work for the entire river; in our data there are Upper Columbia summer and fall Chinook , and some Willamette fish as I mentioned, that are entering at larger sizes and residing in the estuary. |

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## Juvenile Salmon Ecology and Restoration of Tidal Freshwater Habitats

Nichole Sather and Gary Johnson, Pacific Northwest National Laboratory
David Teel, NOAA Fisheries
John Skalski, University of Washington
Adam Storch, Tucker Jones, Christine Mallette, Oregon Department of Fish and Wildlife

Until recently, information pertaining to the ecology of juvenile salmon in tidal freshwater habitats in the Columbia River had been limited. Since 2007, we have conducted research centered 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? To characterize fish community and habitat characteristics, the study area includes sites within hydrogeomorphic reaches D and E (Cowlitz to Lewis rivers) and reach G (vicinity of the Sandy River delta). Our research indicates juvenile salmon are present in a

diversity of shallow tidal freshwater habitats throughout the year. However, we have not found fish community structure and salmon density to be significantly associated with a particular habitat type. High variability in biotic and abiotic environmental metrics makes it difficult to reveal statistically significant associations between salmon density and ecosystem structures. Despite the challenges of reducing uncertainties of the ecology of early life stages of salmon in tidal freshwater, our research has provided data concerning the distribution of distinct genetic stocks of juvenile salmon, food habits of Chinook and coho salmon, and residence times of Chinook salmon (> 95 mm) in shallow water habitats. These results indicate ecosystem restoration is best guided by data derived from a combination of structural and functional attributes within a variety of habitat types.

| **SATHER: QUESTION AND ANSWER** |
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| **Q:** Are you planning to repeat the study if they do major restoration in the Sandy River Delta?<br><br>**A**: Yes, we are implementing a before-after-control-impact design. |

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## The ISAB Food Web Review: Understanding the Biological Basis for Fish Production and Restoration in the Columbia River Basin

Robert J. Naiman

Independent Scientific Advisory Board and University of Washington

All life is linked by trophic processes that provide energy for living, growing, migrating, and reproducing. This understanding was instrumental in the decision by the Northwest Power and Conservation Council, NOAA Fisheries, and the Columbia River Indian Tribes to support an Independent Science Advisory Board review of food web processes that are fundamental to the productivity of the Columbia River system. This presentation provides an overview of our review on the structure and dynamics of Columbia River food webs. The objective is to evaluate and synthesize the current understanding of aquatic food webs and their influences on native fish restoration efforts in the Columbia River basin. The spatial scope includes tributaries, impoundments, and mainstem Columbia and Snake rivers, as well as the estuary and plume. Selected key topics include effects of non-native species and hatchery releases, pathways for marine-derived nutrients, bioaccumulation of chemical contaminants, and use of bioenergetic models. The presentation will address the importance of food webs—as a component of habitat—that need to be considered in restoration actions. The ISAB is paying special attention to food web-related issues that influence ecological restoration, reduce system-scale uncertainties, and provide knowledge for augmenting project effectiveness. The ultimate goal is to improve the Council, NOAA Fisheries, and the Tribes' Columbia River research and restoration programs by actively considering food web issues. It is expected that the review will be completed by autumn 2010.

| NAIMAN: QUESTIONS AND ANSWERS |
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| **Q:** Are you able to look at ocean acidification and implications for the plume and estuary?<br><br>**A**: The simple answer is no. The ocean side of the equation is so large and complex it would require a separate review, which could be started as early as next year. A review of that kind will come out as a recommendation of this study. |
| **Q:** How have you begun to tease out information about the invasive species issue—like Japanese knotweed and its impacts on invertebrates? What has been found in the literature?<br><br>**A**: There are some studies out there. We do have a chapter on riparian food webs; the issue is largely related to the detritus produced by knotweed—it's very poor quality compared to native plants. We are trying to emphasize the bioenergetic models and encourage others to look at the issue in more depth through our recommendations. |
| **Q:** The review seems to have put a lot of emphasis on the consumptive side; how much is known about primary and secondary productivity? Will there be an attempt to put the production side into context? What are the implications of climate change on productivity?<br><br>**A**: Productivity will be a big part of the report; there is nothing definitive to say at the moment. |
| **Q:** We live in an age of hybrid food webs. You said "we're never going back" to predevelopment conditions. What happens to organisms when their food webs are altered?<br><br>**A**: Most organisms have some ability to adapt. The quality or availability of non-native foods are inferior to native food webs. For example, fish arrive in the estuary at a given point in time and space, but their best prey base blooms 3 weeks earlier. They end up losing the abundance and have to choose inferior prey. This issue is affecting overall carrying capacity of the CRE. |
| **Q:** Is it better to change the question and manage to a different kind of food web?<br><br>**A:** I'm not sure how you would manage for food webs. For example what would you do at an appropriate scale to affect the salmon? You can look at smaller scales, but we are wrestling with larger scales. |
| **Q:** It's great to see this review; it's been a long time coming for someone to look at this scale, and at prioritization. Will the report take the step of saying we should reduce the input of contaminants or just lay the baseline? |

**A:** We're not sure yet if it will take an Intergovernmental Panel on Climate Change kind of approach. There are too many high priorities. If we are going to be effective with this report, it needs to focus on relatively few things. We need to say how much it will cost going forward and lay a course of action for the next decade.

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**SESSION 4: GENERAL QUESTIONS AND ANSWERS FROM BOTH DAYS**

**Q:** Question for Amy Borde – You were looking at vegetative communities, and have a place where cattle got in and confounded the results. Anecdotally what happened?

**A**: Obviously there was a result of reduced cover, but there was also an increase in diversity and richness, which is a common response to disturbance. The grazing by the cattle did reduce some invasive species, like reed canary grass and indigo. Maybe there is some way to use grazing as a selective restoration tool.

**Q:** As a person who puts restoration on the ground, I see a lot of variability in juvenile use. What is the importance of wetland habitats, and what are the trends? How important is the emergent wetland habitat?

**A**: We have a good handle on the structure. Data on elevation and substrate conditions are providing a framework for restoration design, but there are more questions about how the habitats function and we still need to pull together the data on prey. The next step is to incorporate multiple components, not just fish or plants, but also nutrients, water quality, etc.

**Q:** Comment more than a question – thinking about the South Slough system in Coos Bay, we are finding important feeding behavior in bare channels, adjacent to eel grass beds and learning that adjacency to habitat types is also important. We need to know what the habitat has to offer fish, but we also need to know what the rest of the habitats contribute to the ecosystem to restore the broader floodplain processes. We don't want to create a boutique for juvenile salmon but to restore the larger processes, go back to predevelopment conditions as far as we can go back.

**Q:** What happens when you restore habitat but you don't have any fish use? Is it a failure?

**A**: Not necessarily; we treat restored habitats as isolated units, but if they were connected would they be used in the late fall and winter? We need to look at connectivity of more diverse habitats. The focus has been on emergent wetland habitats, but we don't have comparable data on other habitat types; we don't have a complete set of information. We don't know enough about food types that are preferred compared to inferior food types.

# Session 5: Lessons from Ecological Restoration Projects

## Lessons Learned on LCRE Ecosystem Restoration from the Perspective of the Expert Regional Technical Group

Greg Hood*[1], Ed Casillas[2], Kim Jones[3], Kirk Krueger[4], and Ron Thom[5]
*Presenter
[1] Skagit River System Cooperative
[2] National Marine Fisheries Service
[3] Oregon Department of Fish and Wildlife
[4] Washington Department of Fish and Wildlife
[5]Pacific Northwest National Laboratory

The 2008 Biological Opinion (BiOp) on operation of the Federal Columbia River Power System called on the Action Agencies—the Bonneville Power Administration and the U.S. Army Corps of Engineers—to establish an expert group for habitat restoration in the lower Columbia River and estuary. The specific purpose of the Expert Regional Technical Group (ERTG) is to provide technical review and assessment of the survival benefits for salmon populations from estuary habitat actions mandated in the BiOp. Since the ERTG's formation in summer 2009, its members have become familiar with the method used in the 2008 BiOp to ascribe survival benefits from LCRE restoration projects and have started applying it to projects brought forth by the Action Agencies. The ERTG recognized the need to standardize the existing method to achieve reasonable consistency with previous applications, reduce subjectivity, and provide repeatability and transparency. The method uses scores for certainty of success, potential survival benefits, and proportion of the restoration goal to calculate assigned survival units. In addition, the ERTG has developed a standardized project proposal form to assist in project review. Field visits to the sites are conducted and projects are formally presented to the ERTG for scoring. The ERTG process strives to be as transparent as possible. Meetings are open, except for breakout sessions when the ERTG scores projects. Meeting notes are disseminated to all interested parties. In the future, the ERTG will work to improve the scientific, quantitative basis for the method to ascribe survival benefits of ecosystem restoration.

| HOOD: QUESTIONS AND ANSWERS |
| --- |
| **Q:** One of the things we are struggling with on projects on the Multnomah Channel is that projects that support multiple Evolutionarily Significant Units (ESUs) are ranked higher, compared to projects with benefits for a single ESU (such as on Multnomah Channel) that would support diversity in the system at large.<br><br>**A**: Projects that support multiple species are expected to provide more benefits over time. The idea is |

to get the biggest bang for the buck. Thus, the higher scoring for projects with multispecies benefits.

**Q:** That approach may be in conflict with Oregon salmon recovery plan and "unfair" to areas providing benefits to a single ESU.

**A**: The Action Agencies and National Oceanic and Atmospheric Administration (NOAA) Fisheries should be considering this issue as it pertains to habitat restoration under the BiOp.

**Q:** On land acquisition, what is the difference between acquiring 100 acres of properly functioning shallow water habitat at risk for development, versus restoring 100 acres of the same type of habitat that is degraded and would take longer to restore?

**A:** That is a policy decision that has been made by the Action Agencies and NOAA Fisheries.

**Q:** What is the biological difference between those two scenarios (protection of functioning habitat compared to restoration of degraded habitat, as asked above)?

**A:** As an ecologist, I understand the question. In the ERTG's role, we have to think of what is the certainty that development will occur, and what are the regulatory protections already in place. We know that impacts still occur because counties and other agencies sometimes don't enforce their regulations. We see it every day.

**Q:** Why wouldn't you want to score the preservation projects anyway, to know what you are losing in the event of development or changes in the future?

**A:** As an ERTG member, this is a policy decision. As an ecologist, I don't always know what the threat is. If you were to score them, they should score high, then you have another sort of avenue to compare to restored sites. As a reference site, it would help for scoring check.

**Q:** That would provide a landscape justification for preserving sites that provide and support other habitat processes.

**A:** Yes we probably should preserve lands, but what is the best mechanism? If the regulations were enforced overall we would require less conservation.

**Q:** When restoring habitats, what is the threshold for design that could avoid non-native species?

**A:** I have no simple answer, but the ERTG wants people to think about whether they are potentially designing an attractive nuisance.

**Q:** In terms of projects, are you looking at stimulating food web production as opposed to just habitat creation?

**A:** Take for example a project that proposes dike breaching; by doing that we are restoring tidal hydrology, increasing input/output of productivity, and delivery of benthic or terrestrial organisms that are immediate benefits as soon as hydrologic connectivity is restored, and on top of that fish can occupy the habitat. When doing riparian restoration, we can get rid of exotic species, but we need to know the impact of changing from invasive to native species on primary productivity.

**Q:** Thinking of simpler ways to stimulate food web production such as stimulating it with nutrient enhancement or increases in simple sugars in the ocean. Are there ways in which nutrient supplementation is appropriate?

**A:** In southwest Washington they have used excess salmon carcasses as nutrient enhancement.

**Q:** I live in the location of the photo currently on the screen. Regulations have required permits for dike maintenance when they've been doing the same thing for years and they don't want to breach the dikes and have tried to restore benefits.

**A:** It seems that landowners should be compensated if they want to sell their land.

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## Implementing Salmon Recovery: Lessons Learned

Amy Ammer, Columbia River Estuary Study Taskforce and Madeline Dalton, North Coast Restoration Association

Restoration projects have distinct phases: identification, development (including design), obtaining funding, and implementation. Anticipating potential problems at each stage is crucial to the completion of a successful project. Identifying potential problems requires an understanding of stakeholder interests, project goals and objectives, limiting site conditions, and funding constraints. When the sponsoring organization has the capacity, knowledge, and funding to address problems immediately, unforeseen challenges can be met and conquered. CREST project managers Amy Ammer and Madeline Dalton will describe some lessons learned for recent restoration projects by addressing phase-specific issues and what was done to resolve them.

**AMMER AND DALTON: QUESTION AND ANSWER**

**Q:** These are complex projects; what is the time commitment from concept to implementation?

**A**: It takes about 6 months with a landowner to get a concept framed up that can be agreed upon, then 1 to 2 years for securing funding, plus 2 to 3 years for construction and permitting. Overall, it averages 3 to 5 years total, or 1 to 2 years after funding is received.

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## Progress in Habitat Restoration and Protection in the Columbia River Estuary: An Analysis of Historic and Projected Rates and Types of Projects

Chris Collins, Catherine Corbett, Keith Marcoe, and Evan Haas

Lower Columbia River Estuary Partnership

The Comprehensive Conservation and Management Plan of the Lower Columbia River Estuary Partnership includes a goal of protecting and restoring 19,000 acres of habitat by 2014. To measure progress in meeting this goal, the Estuary Partnership tracks major partners' habitat restoration and protection projects within the lower Columbia River and estuary. This restoration inventory includes a description of each project as well as specific metrics, such as location; sponsoring entity; phase of project (acquisition/protection; planning and design; implementation), acres or stream miles affected; and type of project (tidal reconnection, culvert improvement, vegetation planting, invasive species removal, large wood debris placement, channel modification/streambank stabilization). The inventory allows us to produce maps of project locations and detailed breakdowns of project types and implementation rates.

As of June 2010 the Estuary Partnership and regional partners will have protected or restored 16,235 acres of the habitat in the Columbia River estuary. The 50 projects supported by the Estuary Partnership through Bonneville Power Administration, U.S. Environmental Protection Agency, and National Oceanic and Atmospheric Administration funding, have accomplished the following:

- 2,946 acres protected or restored with more than 100 regional partners;
- 570 acres of historic floodplain reconnected to tidal influence;
- 58.2 miles of stream habitat opened.

In a 2009 preliminary analysis evaluating types of projects, the most common type of restoration technique was vegetative plantings with at least one project every year and an annual average rate of four projects. The second most common project type was intertidal reconnections (e.g., tide gate replacements, dike breaches) with an annual average of two projects. Overall, on average since 2003, 1.6 acquisition projects, 1.7 planning and design projects, and 5.6 implementation projects have been completed annually.

This presentation will describe the inter-annual variability of projects including types of projects, rates of progress, and acres restored. The presentation will evaluate the past rate of restoration progress in intertidal reconnections; plantings; large wood placement; and bank stabilization projects as well as number of acres associated per type of project; average cost of project (for a select subset of projects); and annual rate for design, acquisition, and implementation projects. We will also provide an estimate of the future rate of progress and probability in meeting the 19,000 acre goal by 2014, based upon past performance. Finally, we will examine the most common types of projects and reasons behind their success and reasons behind slower rates in progress of other types of projects to provide important information on future needs in the regional restoration program for the LCRE.

| COLLINS: QUESTIONS AND ANSWERS |
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| **Comment:** – The Lower Columbia River Estuary Partnership (LCREP) can get Salmon Recovery Funding Board data for Washington State restoration projects to fill gaps on projects and have a comparative data set. The data are available on line. |
| **Q**: Projects have lots of hidden costs like monitoring, LCREP staff time, etc. Have they looked at that?<br><br>**A**: No. Other costs are less defined and squishy across projects, and they are harder to track. |
| **Q:** Have you tried to multiply the 19,000 acres (restoration goal) by the cost per acre by project type to get a rough cost estimate?<br><br>**A**: No, not yet. |
| **Comment:** Just a word of caution because humans like to count things. At the end of the day we have to ask the question, is this project the highest and best use of the resources? We always have to keep our eye on the ball. |
| **Q:** Do you have any budget to monitor throughout the area? We know you have an effectiveness monitoring plan, but has the cost-benefit analysis been part of that? What is LCREP doing to say what the effectiveness of the projects is? Are those data linked to their cost benefit analysis?<br><br>**A**. Not yet. |
| **Q**: I live at Brownsmead, where 1,000 acres were fixed at our own expense. We got $5,000 for fish-friendly tide gates from the Oregon Watershed Enhancement Board, and we like the cleaner water. You all need to thank the landowners for what they have done to get more support.<br><br>**A:** That is a good comment. |

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# Riparian Wetland Response to Livestock Exclusion in the Lower Columbia River Basin, USA

Sarah Holmen-Shewell, J. Alan Yeakley

Department of Environmental Science and Management

Portland State University

Riparian wetland restoration represents an important component of recent endangered salmon recovery efforts in the Columbia Basin, Pacific Northwest, USA. Livestock exclusion is an example of a passive restoration practice throughout the region. However, few studies have focused on the effects of livestock or livestock exclusion on riparian wetland ecosystems in these temperate regions. The purpose of this study was to examine the characteristics of riparian plant communities along a successional gradient of livestock exclusion in the lower Columbia River basin (LCRB). This study examined two passive restoration sites with different time frames post livestock exclusion (3 years and 13 years, respectively) and a control site with continued livestock grazing presence. Preliminary results indicate that native plant species richness was significantly lower in the excluded riparian wetlands than in the grazed wetland ($p<0.05$, Wilcoxon Test). The long-term excluded wetland had significantly lower Shannon Diversity Index than both the short-term excluded and the grazed wetlands. The invasive grass *Phalaris arundinacea L.* was found to be the dominant vegetation cover in all three wetlands with significantly greater dominance in the long-term excluded wetland. These results suggest that livestock exclusion alone may be ineffective at managing riparian plant communities in the LCRB where invasive species like *Phalaris arundinacea L*. are abundant. Other more practical management strategies could include continued grazing at low densities, while reducing livestock impacts and controlling *Phalaris arundinacea L*. dominance.

| **HOLMEN-SHEWELL: QUESTIONS AND ANSWERS** |
|---|
| **Q:** When looking at biodiversity, does the reed canary grass (RCG) crowd out the native species?<br><br>**A**: Both increased when the cattle were excluded. |
| **Q**: The study had one site each of long-term and short-term exclusion; are they representative of grazed sites or is it unique?<br><br>**A:** We did look at other sites, talked to folks with grazed sites or restored sites, and we found that RCG creeps in over time and dominates, though it may not be extreme like the 95% cover situation. If you have that much of an aggressive species like RCG present you need a long-term management plan for it. |
| **Q:** Do the cows like the Wapato?<br><br>**A**: They do but sometimes it's too muddy to access it. The cows like the RCG, but they really like all the |

grasses and other species. RCG comes up early and could use grazing to keep it down early. If the cattle stay on late in summer they do affect the wapato greatly; accidental cattle intrusion earlier can be helpful to control the RCG. Later in the summer when the wetlands dry out the cows do hit the wetlands really hard and do a lot more damage by compacting the soil and heavily grazing the wetter greener areas.

**Q**: Does the size of the wetland affect the effect of the cattle on the grazing?

**A**: Yes, in that the size of the site determines how many cattle you can put on it.

**Q:** Did you look at impacts from native ungulates?

**A:** To my knowledge there weren't any on their site. Readings suggest native ungulates like native plant species.

**Q:** What does AMU stand for?

**A**. Animal Management Unit. This is used to determine how much food is available to be used by the livestock. It's a measure of carrying capacity.

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# Session 6: Conclusions and Recommendations

## Concluding Remarks

**Micah Russell, CREST**

It was an informative two days, and a lot was learned from the adaptive management discussion. We need to get going quickly on implementation and CREST is excited about the opportunities before us. CREST will continue to learn from projects and studies throughout the estuary, and are committed to that level of effort on long-term monitoring. CREST would like to work on emerging issues in their designs such as food web bioenergetics, toxics reduction, and climate change. From the uncertainties research, we learned that residence time for juvenile salmon in the estuary is longer than first thought, and we need to take advantage of overwintering and rearing habitat opportunities.

**Glenn Lamb, CLT**

CLT is really excited to continue doing the work and building within the organization and the larger community the sense of what the vision is for the estuary. CLT is also excited about continuing the conversation around salmon and people, to continue to make the connection between people and nature. Part of the communication about adaptive management is being true to the loop aspect of adaptive management and continuing to learn and communicate with the people in the estuary. For the sake of the salmon, CLT is trying to create a complex habitat area, and to do that CLT doesn't focus on just the salmon, but the habitat and the full ecosystem being worked on. The simple idea of complexity can buffer uncertainties and provides the most benefit. There are private landowners not working with CLT or other groups and we need to recognize and acknowledge landowners who are already doing good work on their own.

**Steve Vigg, WDFW**

Yesterday at the end, there was a lot of good information on monitoring of individual restoration projects and of what species are using the sites. There is starting to be some good data about what shallow-water habitats are being used by fall Chinook salmon, but what about other stocks and species, what habitats are they using? The 1980s data showed that upriver stocks migrated more quickly through the habitats, but from what was presented during the last 2 days people need to be open to looking at benefits for shallow-water habitats versus channel migration. Bird predation was thought to be under control, but up to 15% may be consumed by just the Sand Island colonies. These numbers are similar to the survival rate units increase required under the Biological Opinion. WDFW will look for opportunities for adaptive management to do pit tagging on major tributaries in Washington and set up arrays on the restoration sites.

**Jeff Breckel, LCFRB**

It was good to learn about the research and restoration efforts. In some ways, though, it's so brief that it's hard to absorb it all. It's clear that folks are practicing adaptive management—from folks who are doing research and on-the-ground restoration in terms of the social, economic, and engineering aspects of projects. Hopefully we can see this learning process expand to become a more informative of future efforts in the lower Columbia, to know what questions are being answered. The questions vary on scope and scale; some agencies are looking Columbia basin-wide, some on the estuary level, some on the smaller watershed level, some on a site-specific project level. We need to look at it from all levels and focus on it collectively in the future. As scientists and researchers we have to ask the questions with the applied community. We need to share all the information that is being gathered, but unless we can make it useable to the programs and restoration project sponsors it really doesn't have any value. We need to get the information from the researcher to the end-user and decision-makers. As useful as these conferences are, he would like to see us put these concepts to work in a workshop format to create a framework for cooperation, a plan or a project, and roll up our sleeves and produce an adaptive management plan for the lower Columbia River and estuary.

**Joyce Casey, USACE**

The conference was remindful of how complex our natural systems actually are; we sometimes heard more about what we don't' know than what we do know. The layers of complexity are many when we manage constrained systems for restored systems. Adaptive management is the ultimate in science management. The science community can't work in a vacuum and neither can the decision maker or policy makers. We need to make sure the policy systems are optimal for doing this type of restoration work in this area; to make sure the budgeting systems support the restoration and adaptive management work that needs to be done. We must be aware of the question for the Session 1 panel: Who is in charge? The USACE will make sure management systems are aligned with the science to optimize those feedback loops. The conference has provided some ideas and concepts to take back and continue to strive to do restoration work better and more effectively.

**Greg Delwiche, BPA**

Decision-makers crave certainty so they postpone making decisions while working on the clear crystal ball. We have to get on with it and get the restoration going more. We need to meet our very clear targets to get going and use adaptive management as we go. We need to not get caught up too much in making too much mapping, analysis, or project selection process that would slow things down. The Bonneville Power Administration (BPA) has partners identified for 75% of the survivability units needed through restoration work and they still have 25% of the survivability units unaccounted for, so they need to identify new partners. The Lower Columbia River Estuary Partnership has been identified as being in the coordinator role. Much work will be done on private land, so understanding landowner interests is critical to seeing actions that are good for fish can be part of their lifestyle. Threats can be turned into opportunities. Small projects aren't as desirable but they can be done quickly and effectively, can get local buy-in and start the snowball going, and ramp up from there to bigger projects.

**Chris Hathaway, LCREP**

Much research is taking place and our knowledge is expanding but there is still a lot we don't know. This influences how we make restoration decisions. There is a real ecological sense about doing restoration around habitat-forming processes. The food web presentation was enlightening. LCREP has been pushing the idea of toxics monitoring, noting toxics could be undermining everything we do in restoration. LCREP was established to perform a coordinating role; it is a nonprofit with 20 staff people that all want to play a helpful role, and figure out how best to do that to benefit everyone in the region.

**Bruce McIntosh, ODFW**

It's nice to get out of windowless rooms and be reminded of the importance of diversity and food webs. Adaptive management has been a lot of hand waving in the past; now it's time to connect the dots between the corrective efforts of the planning and get on with it. While LCREP sits in that coordinator spot, there is more work that needs to be done on that front. To be successful in adaptive management we have to ask good questions, understand how we measure progress, and we have to monitor at meaningful scales and times so it's tied to the expected response. Some results are immediate and some take time. We have to evaluate what we do and the generation times and activities. We are all accountable at the end of the day and need to learn from what we do and be willing to change. As someone trained in the science, he is impressed by the human element of change, the theme of uncertainty, and reminds us "don't believe everything you think and be prepared to be surprised."

| **SESSION 6 PANEL: QUESTIONS AND ANSWERS** |
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| **Q:** Demonstration projects came up yesterday as something that has the potential to be implemented at a large scale, involve and educate the public, and evaluate the fundamental framework and model that we've been talking about in the last 2 days. There is nothing on the Columbia River floodplain at the scale of the Intensely Monitored Watersheds program that is built on an interagency framework.<br><br>**A**: Examples were given of Oregon Watershed Enhancement Board and U.S. Forest Service partnering on putting their money together into discrete watersheds, to try and find out how long and what will it take to get all the things done in certain watersheds and seeing what the response is. It takes a lot of small acts to be great, and don't be afraid to be bold, to take some risks, and try to do bigger projects that we can point at. |
| **Q:** Would it be an opportunity to reach out to landowners by asking in a Request for Proposal context about restoration ideas and about using resources to implement a demonstration project this way? Maybe landowners would be willing to take a more active role in adaptive management if they were engaged like this.<br><br>**A:** Yes, those conversations are happening on some very large projects. In the past getting permission |

to look at really big and complex projects was too daunting. Conversations are moving ,but we need to reward and provide substantial incentives to landowners with a multi-year commitment to funding.

**Q:** I am not a scientist but I have a background in public relations and marketing. We heard we need to gather public support and connect landowners with the science community. Have we thought to recognize the heroes and award landowners? How do we get beyond intellectual concepts of science and make it accessible through the heart (she just joined LCREP). Unlike the Chesapeake Bay, we don't really know in the general public just how amazing the estuary is. We need to integrate science and social awareness.

**A:** This sounds like an offer to help do that?

Two responses by Greg at BPA: In small towns local newspapers are still read and viable and this is a possibly good way of looking for project sponsors to be recognized in the local papers. Also, informal opinion leaders are key to spreading information. Those people need to be found in the communities.

Jeff at LCFRB: Celebrating success and recognizing people is key. Take for example the Clark County Sammy Awards; this program is very popular and is used to acknowledge volunteers, stewards, landowners etc. Jeff has learned in the last 10 years that many landowners want to do something good, but they also want to be listened to, they want their vision considered, and they don't want us to go at them too hard on the technical and scientific background. Salmon recovery is a human endeavor; while science helps us it's in the end still a human endeavor.

**Q:** We have heard the last 2 days about uncertainties and monitoring to give feedback, but contingency planning is absent in the conversation. The question of what will we do if the projects fail hasn't been answered. We should do this ahead of time, before we start, so we can be prepared for the changes, costs, and time increases. This is important so we know how to adjust later as we go around the adaptive management wheel.

**A:** Adaptive management certainly needs to be built into project design from the get go. The USACE Section 536 funds and the Washington Memorandum of Agreement on estuary restoration includes a detailed feasibility study built and works to foresee what issues might occur and deal with those contingencies as they are developed. Adaptive management is not just about scientific management but about human systems, agency management and agency processes. The Corps has the ability to incorporate adaptive management into its programs. Like scientific learning is a long time coming so too is institutional learning; we need to maximize flexibility.

**Q:** From the perspective of a watershed council, they appreciate seeing the data but the data haven't been translated into what they mean for them with putting projects on the ground. We need funding for that translation, so that the watershed council can try to be strategic and understand all of what the data mean, so they can have more understanding of cause and effect. We want to be allowed to put more demonstration projects on the ground. Being strategic may come at an interesting cost. While the watershed councils are good working at small scales doing quality work, if they switch to working on 5- to 7-year projects, this takes time away from the larger community, from being in contact with more and different stakeholders, etc. The watershed council would possibly have to give up its role as convener

and coordinator of stakeholders if it starts spending its time on big complex projects.

**A:** The lesson that we are learning is that to take big restoration bites are the exception, more modest or small increments are going to build community connections. We have a technically based strategy but we are still opportunistic in putting projects on the ground through building acceptance with key members of the community. We have to understand that the course will not be straight and keep the eye on the big picture.

There is a human/community element and an important cultural element to the contribution that Indian tribes can make. Look at the work done by the basin-wide tribes in the upper basin; they have become leaders in restoration. We need to look for opportunities to work with the Cowlitz Tribe; it is expressing an interest to be more involved, and we need to bring them in more.

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## Closing and Acknowledgements

Gary Johnson

The conference proceedings will be published later in 2010 and posted on the CREC website. They will include abstracts for the presentations and posters, documentation of the question/answer and discussion periods, and the PowerPoint presentations. Thanks go out to the Liberty Theater for sharing their beautiful space; the conference sponsors (BPA, USACE, LCREP, NOAA, Oregon Department of Land Conservation and Development); and the Steering Committee. The conference was catered by Baked Alaska. The following individuals were especially critical to the success of the conference:

- Kathi Ruiz (PNNL) organized, prepared, and executed conference logistics;
- Patty O'Toole (NPCC) was instrumental as a Steering Committee member;
- Amanda Bryson (PNNL), with assistance from Ron Kaufmann (PNNL), operated the presentation computer and projector;
- Windy Hovey (LCREP) helped at the registration desk;
- Kelley Jorgenson (Kelley Jorgenson Consulting) gathered and prepared the notes contained in the proceedings.
- Erin Donley and Susan Ennor (PNNL) helped edit the proceedings.

The next Columbia River Estuary Conference will be in 2012. See you then!

# Poster Abstracts

## A Spatially Based Area-Time Inundation Index Model Applied in Tidal Wetlands of the Lower Columbia River and Estuary

André M. Coleman, Pacific Northwest National Laboratory, Hydrology Group
Heida L. Diefenderfer, Pacific Northwest National Laboratory, Marine Sciences Laboratory
Duane L. Ward, Pacific Northwest National Laboratory, Hydrology Group
Amy B. Borde, Pacific Northwest National Laboratory, Marine Sciences Laboratory

The hydrodynamics of floodplain areas in the lower Columbia River and estuary directly affect habitat opportunity and quality for endangered salmonids. Inundation patterns throughout the estuary are primarily influenced by tidal cycles, hydro system operations, climate, and physical barriers such as dikes and tide gates. These patterns are controlling factors in the development of physical and biological structure, including fluxes through the terrestrial and aquatic systems. Ongoing wetland/riparian restoration efforts are intended to increase available habitat opportunity through hydrologic reconnection between main stem river channels and diked areas of the historical river floodplain. The habitat opportunity can be evaluated by quantifying wetted area, frequency, and duration of inundation. A geographic information system-based area-time inundation index model has been developed that integrates 1) advanced terrain processing of Light Detection and Ranging (LiDAR) data to reveal the microtopography of floodplain zones, 2) continuously collected and elevation-surveyed water-level sensor data, and 3) a wetted area algorithm to determine areal inundation extent. The area-time inundation index is calculated as the number of hectare-hours of inundation, including both in-channel and floodplain area, summed at 10-cm increments and divided by the total possible hectare-hours for each site. These methods provide a means to quickly evaluate habitat opportunities at proposed restoration sites, monitor change to existing restoration sites, understand inundation impacts under representative and altered flow regimes, determine trade-offs between water-surface elevation and habitat opportunity, and provide a standardized functional metric for inter-site comparisons. Results of this modeling effort are presented for seven areas in the lower Columbia River estuary, including tidal marsh, forested wetland, and restoration sites.

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## Comprehensive Systems Approach to Adaptive Management: A USACE Initiative

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The U.S. Army Corps of Engineers Campaign Plan highlights the need for comprehensive system approaches to water resource management. A national team has formed to develop an Adaptive Management (AM) framework that can be incorporated into Corps' Civil Works projects, providing flexible decision-making in the face of uncertainty. The Comprehensive Systems Approach to AM team, consisting of Corps' staff and contractors participating in large scale ecosystem restoration projects throughout the United States, is charged with developing a "Draft Guide to Adaptive Management Implementation." This guide will build on the National Research Council's review of AM for Water Resource Planning 2004 and complement a Department of Interior's Technical Guide published in 2007. The poster will illustrate ongoing AM efforts. It will also present a draft of the Corps' AM process, from developing the guide and opportunities to integrate AM into the Corps' and its partners' Planning, Engineering and Design, Construction, and Operations.

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## Enhancement of the Habitat Restoration Prioritization Framework for the Lower Columbia River

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Since the mid-1800s, the lower Columbia River has been altered by a variety of anthropogenic impacts. Collectively, these factors have significantly reduced the quantity and quality of habitat available for juvenile salmonids and other species. In the last decade the Lower Columbia River Estuary Partnership (Estuary Partnership) and its partners have restored approximately 16,235 acres of the habitat that has been lost. However, much remains to be accomplished and the next phase of habitat restoration in the estuary will likely require larger, more complicated projects that demand a more focused, scientifically based, regional strategy. Various tools and products have been developed to aid in the restoration process. While these have assisted organizational efforts aimed at restoring particular locations, at this time there is no overarching, unifying regional strategy that evaluates potential

restoration projects within a larger ecosystem-based context where the structure and function of the larger scale landscape are considered.

The Estuary Partnership, in collaboration with Pacific Northwest National Laboratory, has been working towards such a strategy, with the development of its Restoration Prioritization Framework. This is a multi-tiered approach for evaluating restoration potential over a broad range of spatial scales, within an ecosystem-based context. Tier 1 of this project provides a geospatial assessment of the level of current anthropogenic disturbance to the landscape and suggests best restoration practices based on level of disturbance. Tier 2 consists of a scoring system that can be used to rank a particular set of restoration proposals. Tier 3, the focus of this project, provides further enhancement to the existing framework. In this tier, a habitat-suitability index will be generated to evaluate habitat opportunities for salmonids. In addition, a historical landscape assessment will provide information about changes in the quality, complexity, and diversity of habitats and habitat-forming processes that have occurred over time. Combining information from these two data sets can then help to identify potential target areas for restoration within the overall ecosystem. When completed, the Prioritization Framework will serve as an effective tool to advance an ecosystem-based strategy for habitat restoration, with a specific goal of restoring endangered salmonids. In conjunction with additional restoration tools, it can be combined into a multiple-lines-of-evidence approach to identify key restoration locations and select projects that have the highest probability of meeting performance objectives.

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## Habitat Characterization and Fish Usage of Remnant *Picea sitchensis* Tidal Freshwater Wetlands on the Columbia River Estuary

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The loss of virtually all brackish and most freshwater Sitka spruce (*Picea sitchensis*) wetlands in the Columbia River estuary (CRE) since 1870 was documented by the Columbia River Estuary Data Development Program in the 1980s; however, only cursory descriptions of these swamp ecosystems and their habitat functions have been published. Our intensive physical and biological sampling data from 2005 through 2010, from four of the largest tidal freshwater remnants, indicate that spruce swamps occur at 1- to 4-m NAVD88 (North American Vertical Datum of 1988) in the CRE. Analysis of Light Detection and Ranging data quantifies the hummocky microtopography and shows that total channel length and watershed area are correlated with surveyed channel cross-sectional area at the mouth. In-channel fluxes are moderated by large woody debris (LWD) and beaver dams, with morphology classified as a forced step-pool channel type. Channel substrates are fines (total organic carbon [TOC] 3.1%) dense with nematodes and oligochaetes; floodplains also contain coarse sands/gravels (TOC 5.2%) and sediment stake data show that most swamp sites are vertically accreting (mean rate 0.53 cm/yr). Spruces attain large statures, rooting on LWD hummocks in association with salal (*Gaultheria shallon*) and red huckleberry (*Vaccinium parvifolium*). Subdominant trees are red alder (*Alnus rubra*) and

western redcedar (*Thuja plicata*), with a well-developed shrub layer. The observed plant species richness was 74. Mean quarterly litterfall was highest October through January (342 g/m$^2$) and lowest April–July (43 g/m$^2$). Preliminary analysis of electrofishing data indicate the presence of Pacific lamprey (*Lampetra tridentata*) as well as juvenile coho salmon (*Oncorhynchus kisutch*) and chum salmon (*Oncorhynchus keta*) in the swamps during the spring months; spawning-run eulachon (*Thaleichthys pacificus)* were observed in winter. Fallout traps deployed in the spring months contained 58 taxa (half present in juvenile salmon diets) and small neuston samples 46 taxa. The flood regime and water properties are also described.

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## Assessment of Habitat Use and Habitat-Specific Survival and Travel Time of Acoustic-Tagged Salmonid Smolts in the Lower Columbia River Estuary

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In 2009, over 10,000 juvenile salmonids (yearling and subyearling Chinook salmon and steelhead) were implanted with Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic transmitters and released into the forebay of John Day Dam. Nearly 100 acoustic telemetry receivers were deployed downstream of Bonneville Dam, with most (76) receivers deployed in the lower 50 km at Three Tree Point (rkm 50), Harrington Point (rkm 37), in Grays Bay (rkm 29–34), at the Astoria Bridge (rkm 22), and near the mouth of the river (rkm 8 and 3). Detections of acoustic-tagged fish at these receivers allowed us to determine the primary migration pathways used by juvenile salmonids to migrate through the estuary and how use of different pathways influenced survival and travel time. Although most (57% – 74%) yearling and subyearling Chinook salmon and steelhead were detected migrating downstream in the main navigation channel at Harrington Point, the majority (79%) of fish detected at the Astoria Bridge were detected in the north (Washington) channel, suggesting that many fish migrated through small tidal channels or across shallow tidal shoals and bars between Rice Island and the Astoria Bridge. Our results also indicated that a relatively large percentage (26%) of the subyearling Chinook salmon detected at Harrington Point migrated through Grays Bay compared to 9% of yearling Chinook salmon and 6% of steelhead. Yearling and subyearling Chinook salmon that migrated through Grays Bay took, on average, 7 to 22 h longer to travel from Harrington Point to the Astoria Bridge than fish that migrated, at least part of the way, in the navigation channel. The probability of survival from Harrington Point to the Astoria Bridge was 0.74 (SE = 0.06) for steelhead and 0.82 (0.04) for subyearling Chinook salmon that migrated through Grays Bay, which was lower than the survival of fish that migrated, at least part of the way, in the navigation channel (0.88 – 0.99). Survival of steelhead and subyearling Chinook salmon from Grays Bay to the Astoria Bridge was 0.90 (0.05) and 0.93 (0.02), respectively. The large difference in survival to the Astoria Bridge from Harrington Point versus Grays Bay indicates that survival was particularly low through the 4-km-long shallow-water area that separates Harrington Point from the deeper channels of Grays Bay. Although not the objective of the study described above, our results suggest that JSATS may be a useful tool for identifying habitats in need of restoration and for evaluating restoration efforts on both site-specific and population-level scales. Strategic placement of JSATS acoustic telemetry receivers can reveal the proportion of the tagged population using a particular

habitat and the residence times and survival estimates for implanted fish migrating through or rearing in the habitat, which can be compared to the tagged population as a whole.

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## Implications of Pre-Restoration Monitoring for the Proposed Rechannelization of the Sandy River Delta in Tidal Freshwater of the Columbia River

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Site-specific understanding of the Sandy River delta gained from pre-restoration monitoring is applicable to a discussion of the efficacy of the proposed reconnection of the old Sandy River to the Columbia River. The primary outlet of the Sandy River was plugged with an earthen dam in the 1930s. The low degree of connectivity between the Sandy River and the historic confluence likely constrains the functional integrity of this floodplain-deltaic ecosystem. Removal of the dam will be aimed at reestablishing the connectivity of the Sandy River channel to its historic confluence. In pre-restoration sampling of fish and habitat characteristics within a formal before-after-control-impact design, we noted the low degree of surface-water connectivity was correlated with low dissolved oxygen within the remnant channel, yet the absence of elevated water temperatures indicated the remnant channel maintains some degree of hyporheic connection with the Sandy River. Vegetation surveys near the remnant channel indicate a large proportion of obligate wetland species. Compared with other sites closer to the Columbia River, the remnant channel was also noted to have the greatest amount of submerged aquatic vegetation. We sampled juvenile Chinook and coho salmon in the remnant channel during our study. Removal of the earthen barrier likely would increase fish accessibility to this channel, as well as other habitats within the historic Sandy River delta. Changes in the flow regime, coupled with riparian plantings as part of other restoration efforts in the delta, will likely increase water quality, sediment export, and nutrient flux within the Sandy River delta. Confluences offer a source of heterogeneity in main stem rivers by influencing morphological features and aquatic habitats. Reconnecting the old Sandy River channel to the Columbia River will likely increase the opportunity and capacity of habitats for aquatic biota, including juvenile salmon.

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## Variation in the Floral and Faunal Structure of Freshwater Tidal Forest Ecosystems along the Columbia River Estuary Gradient: Applications to Ecological Restoration

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Freshwater tidal forested wetlands are dynamic, complex ecosystems that typically occur prominently in large, floodplain river estuaries throughout the world. In the Columbia River estuary, forested wetlands were once abundant along the tidal freshwater-estuarine gradient but have been reduced dramatically since Euro-American development of the region. We quantitatively characterized a portion of the remaining forests and found that they vary in both floristic and faunal structure, species composition, and species richness across the scale of the estuarine gradient. In the lower estuary, Sitka spruce-dominated tidal forested wetlands are characterized by high vegetation species richness and complex forest and scrub-shrub habitat components. In the upper estuary, deciduous tree species including black cottonwood and Oregon ash dominate the forest component of the wetlands. A greater diversity of wetland habitat types (scrub-shrub, emergent, and aquatic) are associated with the forested wetlands in the upper estuary, but each component has relatively low species richness. A transitional area in the mid-estuary contains forested wetlands that display some similarities to both the upper and lower estuarine forested wetlands. Geomorphology and hydrological regimes of the estuary appear to be the factors controlling the variation in forested wetlands characteristics along the estuarine gradient. Recent restoration efforts in the Columbia River estuary have focused on forested wetlands, but alterations to the hydrological disturbance regime in the system have made restoration of forested wetlands a difficult task. Our quantitative characterization of the structure and composition of these systems provides insight into restoration design and the successional trajectory of these important but highly affected habitats in the Columbia River estuary.

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## Potential Winter Growth of Chinook Salmon in a Tidally Influenced Area of the Columbia River

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Little is known about the contribution of winter feeding to the energy budgets of juvenile salmon in tidal freshwater area of the lower Columbia River. However, tidal freshwater habitats may play an important role in energy acquisition, growth, and ultimately survival during winter. To assess this hypothesis, we applied a bioenergetics model for Chinook salmon to data collected as part of the Tidal Freshwater Monitoring project. The purpose of this analysis was to simulate potential growth during winter conditions in habitats near the Sandy River Delta (rkm 219–235). In this contribution, we present results from our bioenergetics synthesis and discuss potential consequences of overwinter feeding for juvenile Chinook salmon in tidal freshwater habitats of the lower Columbia River.

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## Constructing Oregon's Diked Lands Vulnerability Inventory to Support Strategic Planning for the Impacts of Sea Level Rise

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Department of Land Conservation and Development

Now is not the first time that Oregon's coast line has undergone great change. The pioneering spirit of the late 1800s and early twentieth century led many farmers to alter estuaries to their own agricultural advantage. Many tidally influenced wetlands surrounding the estuaries were thus drained, diked, and filled so as to be used as flatlands, mainly for cattle grazing. Dikes and tide gates were built to prevent tidal inundation and ditches were dug to drain these diked areas. While this created ideal conditions for Oregon's dairy farming businesses, more than 68% of Oregon's estuarine habitat was lost. Lost with these habitats were vital estuarine functions and tidal volume.

Today, interest in dikes and diked lands does not just have to do with reclaiming these estuarine habitats, but also has to do with new changes in Oregon's coast due to climate change. The effects of climate change are likely to include a rise in tidal elevations as well as increased flooding and storms. Knowing where Oregon's dikes are located, what condition they are in, and who is responsible for them is therefore critical in decision-making about where dikes should be breeched in order to restore tidal wetlands and where they need to be maintained in order to protect private and public infrastructure.

The primary objectives of the project are to 1) create a GIS-based product that includes an inventory of hydromodification structures in Oregon's estuaries, along with their associated attributes such as property ownership and structure vulnerability; and 2) distribute this tool, along with other methods, to both increase awareness of sea-level-rise issues in tidal areas and to support improved planning on the use and maintenance of structures and lands susceptible to tidal influence amongst local planners and stakeholders.

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## Mitigation and Conservation Banking as a Tool in River Restoration

Sky Miller

Wildlands of Washington, Inc.

Mitigation and Conservation Banking can be a tool in landscape-scale river-restoration activities. Wildlands is currently conducting the acquisition, design, entitlement, and construction of five conservation and/or mitigation banks in Washington State. This presentation will describe briefly these ongoing projects that include a 313-acre floodplain restoration certified for wetland credits and a 364-acre estuary restoration project certified for 'salmon credits' under the Endangered Species Act. Before, during, and after construction photos will be shown. The certification process for wetlands and endangered species habitat credits will be discussed, and how those credits are created, released, and

sold. Particular attention will be focused on a Columbia River tidal floodplain restoration project under design and permitting that will reconnect and restore 1,100 acres (nearly 2 $mi^2$) by breaching dikes, removing cattle, plugging ditches, removing tide gates, planting native riparian trees, excavating side channels filled with dredge spoils and the installation of engineered log jams to replicate the riparian functions until mature forests can be re-established.

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## Green Sturgeon Use of the Columbia River Estuary

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USGS Columbia River Research Laboratory

The U.S. Geological Survey (USGS) is using passive acoustic telemetry to investigate the temporal and spatial use of green sturgeon (*Acipenser medirostris*) within the Columbia River estuary. The southern distinct population segment (DPS) of green sturgeon was recently listed as threatened by the National Marine Fisheries Service. Both southern and northern DPS of green sturgeon are known to occupy the Columbia River estuary in early summer through early fall, although little is known regarding their spatial distribution and habitat preferences during this time. Green sturgeon use of navigation channels is of particular interest due to the potential for encounters with channel maintenance operations and shipping that could result in unobserved mortalities. The USGS is coordinating with WDFW, ODFW, CRITFC, NMFS and USACE to deploy and maintain acoustic receivers within these areas and to tag green sturgeon with depth and temperature sensing acoustic tags.

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## Monitoring Restoration Effects via Remote Sensing and Ground Data Classification

Jerry Tagestad

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Ground-based monitoring of the biological and physical effects of restoration activities provides important quantitative data that can be used to update adaptive management strategies. Although monitoring data are located spatially using precise global positioning system coordinates, they typically do not provide a comprehensive spatial picture of the effects of restoration. In particular, it is not economically feasible to conduct ground-based before and after monitoring of vegetation throughout entire large restoration areas. In contrast, while remotely sensed imagery can provide a view of the change in spatial patterns over large areas, images provide a qualitative view of the phenomena of interest. By combining quantitative monitoring data with multispectral remote-sensing data, we were able to develop vegetation maps for two restoration sites on the Columbia River estuary, located in the vicinity of Youngs Bay and Grays Bay. These maps document the spatial patterns of changes in plant communities due to hydrologic reconnection restoration activities (dike breaching, culvert installation, and tide gate installation). These map products can inform adaptive management strategies by

providing evidence of large-scale environmental change that may not be evident in the quantitative ground data collected via currently accepted monitoring protocols.

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## Germany and Abernathy Creek Restoration Implementation Plan

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The Germany and Abernathy Creek Restoration Implementation Plan developed an approach and project list to recover threatened populations of chum, winter steelhead, coho, and Chinook salmon in two tributaries to the Columbia River near Kelso, Washington. A streamwalk survey was conducted to sample channel confinement, substrate, riparian areas, floodplains, large woody debris (LWD), and channel type attributes. Data from this survey were grouped with existing habitat assessment data from the Intensively Monitored Watersheds (IMW) program and limiting factors from the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Germany and Abernathy Creeks are part of an IMW cluster that evaluates relationships between physical conditions and salmonid production in freshwater. The IMW program has completed extensive habitat and fisheries baseline assessments in both watersheds.

Survey results suggest that previously identified limiting factors, including hydrology, sediment, and LWD, continue to exert dominant controls on channel morphology, floodplain conditions, and riparian communities. Increases in peak discharge, channel armoring, decreased availability of spawning gravels, decreased hydrologic/geomorphic connection between main and side channels, and a lack of LWD were primary symptoms of habitat degradation and indications of changes in hydrogeomorphic processes. Sixty projects were identified over 20 miles of Germany and Abernathy Creeks on the main channel, side channels, and in the floodplain corridor to address these factors and to improve salmonid refugia and juvenile rearing habitat. Engineering and non-engineering solutions were identified to improve short- and long-term habitat conditions for salmonids. LWD inputs, engineered log jam structures, side channel reactivation, conifer planting, and invasive species control were identified as important methods in achieving restoration endpoints. The projects were prioritized in terms of target species and their importance to their Evolutionarily Significant Unit, the value of that project to those species, and the anticipated improvement to the associated habitat.

A crucial assumption of the identified methods is that current hydrogeomorphic processes are not self-corrective and that reestablishment of salmonid populations is dependent on improvements to instream and riparian communities. Improvements to habitat will occur only through significant energy inputs focused both on encouraging physical changes on a reach scale and through understanding how watershed processes affect site conditions. As restoration projects are implemented over time, continued IMW monitoring will measure changes in habitat quality and fish productivity.