Conference on Research, Monitoring, and Restoration in the Lower Columbia River, Estuary and Nearshore Ocean

Proceedings

April 19-20, 2006 • Astoria, Oregon

US Army Corps of Engineers ®
Portland District

Lower Columbia River Estuary Partnership

CREST
Columbia River Estuary Study Taskforce

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Edited by:

Gary E. Johnson, Pacific Northwest National Laboratory

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Preface

The 2006 Conference on Research, Monitoring, and Restoration in the Lower Columbia River, Estuary and Nearshore Ocean was held at the Liberty Theater in Astoria, Oregon on April 19-20. The conference was convened because a substantial amount of habitat restoration, monitoring, and research have occurred in the area since the last related event in 2003. The purpose of the conference was to exchange data and information among researchers, policy-makers, and the public, i.e., inter-relate science with management. Conference organizers invited presentations synthesizing material on the estuary turbidity maximum (Session1), lower river and estuary ecology (Session 2), habitat restoration and monitoring (Session 3), ocean ecology (Session 4), and management perspectives (Session 5). Facilitated panel/audience discussion periods were held at the end of each session. Contributed posters conveyed additional data and information.

These proceedings include abstracts and notes documenting clarifying questions/answers for each presentation, as well as the panel/audience discussions. The conference program is outlined in the contents section. A list of conference attendees is contained in Appendix A. A compact disk is attached on the back cover. It contains material in hypertext-markup-language from the conference website and the individual presentations.

Please contact Gary Johnson (503-417-7567) with comments and questions about the conference.

Acknowledgments

The conference was sponsored by the Bonneville Power Administration, the Columbia River Estuary Study Taskforce, the Lower Columbia River Estuary Partnership, the Oregon State Department of Land Conservation and Development, and the U.S. Army Corps of Engineers. The conference steering committee was comprised of Ed Casillas and Cathy Tortorici (NOAA), Marci Cook and Kim Larson (USACE), Gary Johnson (Pacific Northwest national Laboratory), Scott McEwen (Estuary Partnership), Robert Warren (CREST) Steve Waste (Northwest Power and Conservation Council), and Tracy Yerxa (BPA). We appreciate the hospitality and assistance from the staff of the historic Liberty Theater: Rosemary Baker-Monaghan, Larry Bryant, and Paulette Mallory. The event was catered by Baked Alaska. Turner Odell (RESOLVE) moderated the conference. Bruce Sutherland (retired, ODEQ) was the conference note-taker. Mardy Tremblay (Estuary Partnership) helped with on-site registration and logistics. Kathi Ruiz (PNNL) coordinated conference logistics and designed the conference website. We thank Councilwoman Joan Dukes and Reverend Irene Martin who provided welcoming and closing remarks, respectively.

Contents

Speakers and Session Chairs

Robert Bailey is the Oregon Coastal-Ocean Program Manager in the Department of Land Conservation and Development in Salem, Oregon. Bob is a 1968 graduate of Portland State University in Earth Science. He began his planning career with Coos County, Oregon, in 1971, where he directed the first Coos Bay Estuary Plan and participated in designating the Nation's first estuarine reserve at South Slough in 1974. He has served on numerous regional and national panels including a Heinz Foundation panel establishing National Ecosystem Indicators and a National Academy of Sciences Ocean Studies Board panel reviewing the National Sea Grant Program.

Dan Bottom is a Research Fishery Biologist with NOAA Fisheries, Northwest Fisheries Science Center in Newport, Oregon. Dan received a B.A. in Botany from Duke University in 1972 and his M.S. in Marine Studies from the University of Delaware in 1975. He worked as a project leader for the Oregon Department of Fish and Wildlife for more than 20 years, conducting fisheries research in stream, estuarine, and ocean environments. He is currently studying salmon habitat associations and life histories in the Columbia River estuary and the effects of wetland restoration projects in Oregon's Salmon River estuary.

Jennifer Burke is a GIS Research Analyst and Fishery Biologist with the Wetland Ecosystem Team at the University of Washington. Jen received her Masters in Marine Resource Management from Oregon State University in 2004 for her thesis analyzing early life histories of salmon in the Columbia River estuary. Jen began her fisheries career 12 years ago with the Research Division of the Oregon Department of Fish and Wildlife. Since early 2000, Jen's interest in GIS has propelled her into the expanding field of spatial mapping and analyses.

Matt Burlin is the Habitat Restoration Coordinator for the Lower Columbia River Estuary Partnership in Portland, Oregon. He earned a Bachelor's degree in Environmental Resource Management from Virginia Tech and a Master's degree in Urban and Regional Planning from Portland State University in 2004. Matt worked previously as Grants Coordinator for the City of Portland's Community Watershed Stewardship Program. Presently, he works with numerous partners throughout the lower river and estuary supporting on-the-ground restoration projects that protect and restore habitats for salmon and other species.

Edmundo Casillas is the Estuarine and Ocean Ecology Program Manager for NOAA Fisheries, Northwest Fisheries Science Center in Seattle, Washington. Ed holds a B.A. in Environmental Biology from the University of California at Santa Barbara and a Ph.D. in Fisheries Biology from the University of Washington. Ed's research interests include the effects of toxic compounds on marine fishes, invertebrates, and salmon and the role of natural climate change on the growth and survival of juvenile salmon in estuarine and coastal marine environments of the Pacific Northwest.

Joan Dukes is Vice-Chair of the Northwest Power and Conservation Council in Portland, Oregon. She was appointed to the Council by Oregon Governor Ted Kulongoski in 2004. A graduate of Evergreen State College, Joan has served the public as a Clatsop County Commissioner and an Oregon State Senator. She has a broad base of experience in education, transportation, and fisheries issues. Joan is a resident of Svensen, a community near Astoria, Oregon.

Michael Hudson is a Fishery Biologist for the Native Trout Program at the Columbia River Fisheries Program Office of the U.S. Fish and Wildlife Service in Vancouver, Washington. Michael received his M.S. from the University of Illinois in 1997 with a thesis describing the population genetic structuring of walleye in Minnesota and Wisconsin. He currently conducts research, monitoring and evaluation projects on coastal cutthroat trout, bull trout, and redband trout.

David Jay is an Associate Professor in the Department of Civil and Environmental Engineering at Portland State University. He has a Ph.D. in Physical Oceanography from the University of Washington and an M.S. in Marine Environmental Studies from Stony Brook University. David has modeled tides, estuarine circulation, salinity intrusion, turbidity maximum processes and human alterations of the Columbia River estuary, and described Columbia River Plume circulation and mixing processes. David's present research concerns physical processes, human impacts, and climate change in river-estuary systems.

Gary Johnson is a Research Scientist with the Marine Sciences Laboratory (MSL) in Sequim, Washington. The MSL is part of the Pacific Northwest National Laboratory, operated by Battelle under contract to the U.S. Department of Energy. Gary received a B.A. in Mathematics/Marine Biology from the University of California at Berkeley in 1976 and a M.S. in Biological Oceanography from Oregon State University in 1981. His research interests include data and program integration in the Lower Columbia River and estuary.

Kim Larson is a Fishery Biologist and Team Leader for the Environmental Planning and Compliance Team with the U.S. Army Corps of Engineers, Portland District. He holds a Bachelor's degree from the University of Arizona (1970) and a M.S. in Fisheries from the University of Washington (1972). He and his team are responsible for determining and accomplishing compliance with environmental laws and regulations required for Portland District civil works. His work involves compliance with the National Environmental Policy Act, the Clean Water Act, and the Endangered Species Act, among other laws. Kim is currently involved with projects for habitat restoration and monitoring in the Columbia River estuary.

Irene Martin is an author, fisher and Episcopal priest who is active in fisheries and community issues. She was an advisor to the Columbia Estuary Data Development Program from 1977-1982, a founding member of the Friends of Skamokawa Foundation, a board member of Salmon for All (1998-2002), a board member of the Lower Columbia Fisheries Enhancement Group (2003-2006), and currently serves on Washington State Fish and Wildlife Department's Commercial Fisheries Advisory Group for the Columbia River, and as a Washington advisor to the Pacific States Marine Fisheries Commission. Her books include <u>Legacy and Testament, the Story of Columbia River Gillnetters</u> (Washington State Univ. Press, 1994), <u>The Beach of Heaven, a History of Wahkiakum County</u> (Washington State Univ. Press, 1997), <u>Lewis and Clark in the Land of the Wahkiakums</u> (Scrubjay Press, 2003) and <u>Sea Fire, Tales of Jesus and Fishing</u> (Crossroad, 2003). She received the James B. Castles Heritage Award from the Washington State Historical Society Center for Columbia River History in 1998, and the Governor's Heritage Award in 2000. Her most recent publication is "A Social Snapshot of the Columbia River Gillnet Fishery," published in 2005 for Salmon for All.

William Maslen is the Director of the Department of Fish and Wildlife at the Bonneville Power Administration. Bill holds a Bachelor's degree in Wildlife Sciences from Oregon State University. He has worked in the Columbia Basin since 1978 and directly with Bonneville Power

Administration since 1988. Bill's main focuses involve integrating fish concerns with hydro-generation and hydro-operations.

Dale McCullough is a Senior Fishery Scientist at the Columbia River Inter-Tribal Fish Commission (CRITFC) in Portland, Oregon. He has worked for CRITFC for over 20 years. Dale has a B.S. in Zoology from Ohio University, a M.S. in Biology from Idaho State University, and a Ph.D. in Fisheries from Oregon State University. He works on salmon habitat protection and land management effects on habitat and has a special interest in water temperature and sediment relationships to salmonid survival.

Scott McEwen is Director of Technical Programs for the Lower Columbia River Estuary Partnership in Portland, Oregon. He received a B.S. from the School of Natural Resources at the University of Michigan in 1987. Scott is responsible for developing and implementing the Estuary Partnership's Habitat Restoration and Conservation Program and its long-term monitoring strategy. He also manages other aspects of the Estuary Partnership's scientific basis, including identifying additional research and data needs, developing the GIS capacity, developing and managing environmental indicators, and reporting on the lower Columbia River and estuary.

Mary Moser is a Research Fishery Biologist for NOAA Fisheries, Northwest Fisheries Science Center (NWFSC) in Seattle, Washington. She holds a Ph.D. in Zoology from North Carolina State University and a B.A. in Biology from Kalamazoo College, Michigan. Before coming to NWFSC she was a member of the research faculty at the University of North Carolina-Wilmington where her research focused on the role estuaries play in the life history of diadromous fish. Mary currently investigates lamprey ecology in the Columbia River.

Turner Odell is a Senior Mediator in the Portland, Oregon office of RESOLVE, a non-profit organization providing neutral consensus-building services for environmental, energy, and health-related public policy issues. Turner received his B.S. from Cornell University in Resource Economics and his J.D. from the Rutgers School of Law. As an attorney and a mediator, he has nearly 15 years of experience in environmental law, policy, and conflict resolution. At RESOLVE, Turner's practice focuses on designing, convening, and facilitating workshops, policy dialogues, interagency and stakeholder workgroups, and other agreement-focused multi-party processes involving complex scientific, environmental, and public policy issues.

Philip Orton is doctoral candidate at the Lamont-Doherty Earth Observatory of Columbia University in New York. He has a Bachelor's degree in Physical Oceanography from the University of Michigan and a M.S. in Marine Science from the University of South Carolina. He has worked for much of the last eight years at the Oregon Graduate Institute, taking part in projects on Land-Margin Ecosystem Research Columbia River Estuarine Turbidity Maximum, Ocean Survival of Salmonids, and River Influences of Shelf Ecosystems, among others. His primary research goal is to understand and predict how water masses and constituents from river systems are assimilated into estuaries and, later, into the ocean.

Walter Pearson is Associate Director of the Marine Sciences Laboratory in Sequim, Washington, which is a part of the Pacific Northwest National Laboratory, operated for the U.S. Department of Energy by Battelle Memorial Institute. His bachelor's and master's degrees are in Biology from Bates College and the University of Alaska. His doctorate is in Oceanography from Oregon State University. Walt's primary area of expertise is the study of the effects of pollution and human activities on marine and estuarine environments, and especially on the fisheries these environments support. His current research addresses juvenile fish passage through culvert systems, oil spill impacts on marine fisheries, stranding of juvenile salmon by ship wakes, and the effects of dredging on Dungeness crab.

Fred Prahl is a Professor in the College of Oceanic and Atmospheric Sciences at Oregon State University, where he has worked for the past 22 years. Fred has a Bachelor of Science degree (1975) in Chemistry from the University of Kentucky as well as a Masters (1979) and Ph.D. (1982) degree in Oceanography from the University of Washington. He has specific expertise in using and teaching others how to use organic chemical tracers to solve fundamental problems in sedimentology and aquatic ecology. For nearly 10 years, he was a member of the team of investigators that the National Science Foundation sponsored to investigate the dynamics and biogeochemistry of the Columbia River estuarine turbidity maximum.

Thomas Rien is Program Leader for Columbia River Investigations for the Oregon Department of Fish and Wildlife in Clackamas, Oregon. Tom has a Bachelor's degree in Wildlife Science from Oregon State University. He is involved in evaluations of the northern pikeminnow control program, mainstem chum and Chinook salmon spawning, and fall Chinook exploitation and escapement in Oregon's coastal rivers. He has led white sturgeon studies upstream from Bonneville Dam. Tom currently studies green sturgeon population trends and juvenile white sturgeon recruitment trends below Bonneville Dam.

Curtis Roegner is a Research Fisheries Scientist with NOAA Fisheries, Northwest Fisheries Science Center, Point Adams Research Station in Hammond, Oregon. He has a M.S. in Marine Science from the College of William and Mary (1990) and a Ph.D. in Oceanography from Dalhousie University in Canada (1996). Curtis' longstanding interests include benthic-pelagic coupling by bivalve mollusks, estuarine-ocean exchange of phytoplankton and invertebrate larvae, and the influence of hydrodynamic processes on the growth and distribution of organisms. His current research focuses on juvenile salmon ecology, estuarine hydrology, larval recruitment and the ecology of benthic invertebrates, and the restoration of estuarine and tidal freshwater habitats in the Columbia River.

Charles ("Si") Simenstad is a Research Professor and Coordinator of the Wetland Ecosystem Team in the School of Aquatic and Fishery Sciences, University of Washington. He holds B.S. (1969) and M.S. (1971) degrees from the School of Fisheries at the University of Washington. As an estuarine and coastal marine ecologist, Si has studied ecosystems throughout the Pacific Northwest and Alaska for over thirty years. Much of this research has focused on the functional role of estuarine and coastal habitats to support juvenile Pacific salmon and other fish and wildlife, and the associated ecological interactions that are responsible for enhancing their production and life history diversity. He led the National Science Foundation-supported Columbia River Estuarine Turbidity Maxima/Land-Margin Ecosystem Research program. Si's recent research has integrated ecosystem interactions with applied issues such as restoration, creation, and enhancement of estuarine and coastal wetland ecosystems, and ecological approaches to evaluating the success of coastal wetland restoration at ecosystem and landscape scales in the Columbia River estuary and elsewhere.

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

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

Marc Trudel is a Research Scientist with the Department of Fisheries and Oceans (DFO) in Nanaimo, British Columbia. He obtained a Ph.D. in Biology from McGill University in Montreal, Canada in 2000, and M.S. and B.S. degrees in Biology from the University of Montreal in 1994 and 1991, respectively. Marc joined DFO in 2000 to conduct research on the ocean ecology of juvenile salmon. By conducting field surveys off the west coast of British Columbia and southeast Alaska, Marc investigates the effects of ocean conditions and climate on the distribution, migration, growth, and survival of juvenile salmon during their marine life.

Steve Waste is the Program Manager for Analysis and Evaluation at the Northwest Power and Conservation Council in Portland, Oregon. He holds a B.S. in Environmental Studies from Evergreen State College; a M.S. in Natural Resources from Humboldt State University; a M.P.A. in Planning, Public Policy, and Management from the University of Oregon; and a Ph.D. in Fisheries Management from the University of Washington. At the Council, Steve serves as the Councils' ex officio on the Independent Scientific Advisory Board. He is responsible for the Council's research program and monitoring and evaluation efforts, including those in the lower Columbia River and estuary.

David Welch is a Principle at Kintama Research Corporation in Nanaimo, British Columbia. He received a B.S. in Biology and Economics from the University of Toronto and a Ph.D. in Oceanography from Dalhousie University in 1985. David is the former head of the Canadian government's High Seas Salmon Program, where he was responsible for studying the ocean biology of pacific salmon. He is also chief architect of the Census of Marine Life's POST (Pacific Ocean Salmon Tracking) project. He started Kintama Research to develop the technology platform necessary for delivering data from an ocean array capable of directly measuring the survival of migrating fish in the ocean and supporting the need for an improved ocean observational capacity.

Allan Whiting is Wetlands Coordinator at the Columbia River Estuary Study Taskforce (CREST) in Astoria, Oregon. He has a B.A. in International Relations from Beloit College (1992) and a Master's degree in Community and Regional Planning from the University of Oregon (2000). At CREST, Allan assists local jurisdictions in conducting wetland assessments, delineations, and functional profiles. His current interests include habitat restoration, flood hazard mitigation, GIS mapping, and effectiveness monitoring in the Columbia River estuary.

Robert Willis is Chief of the Environmental Resources Branch at the U.S. Army Corps of Engineers, Portland District. He received Bachelor's and Master's degrees in Biology from Portland State University. During his career, Bob has been involved with a number of regulatory issues, fish and wildlife mitigation planning projects, applied biological research, and projects to enhance the environment. He has responsibility for fish and wildlife investigations, fish passage research and design, cultural resource investigations, and environmental planning studies, including those in the lower Columbia River and estuary.

Jeannette Zamon is a Research Fishery Biologist with NOAA Fisheries, Northwest Fisheries Science Center, Point Adams Research Station in Hammond, Oregon. She has a M.S. from Cornell University and a Ph.D. degrees from the University of California at Irvine. Her ongoing research includes salmon diet in the Columbia River estuary, seabird ecology in coastal Oregon and Washington, and oceanographic features that create good feeding conditions for fish, birds, and mammals.

Introduction

Welcome

Joan Dukes, Northwest Power and Conservation Council

As a resident of Svenson, Oregon since 1975 and a State Senator representing Clatsop County for 18 years, Joan has seen changing conditions in the Estuary. The river reflects who we are and our heritage. Remember, fishermen are good river keepers, but no one anticipated the impacts that development has brought over the years. The estuary has had many special projects but rarely did any effort go into understanding the estuary and the impacts these projects had on it. Therefore, we need science to "listen" to the river and convey to the public what is going on. We also need a plan to lead us toward an understanding of what is there, what we want and what can be restored. In conclusion, without quality estuary conditions, fewer salmon will return to spawn.

Opening Remarks

Gary Johnson, Pacific Northwest National Laboratory

The purpose of this conference is to exchange data and information on research, monitoring, and restoration efforts in the lower Columbia River, the estuary, and the nearshore ocean, i.e., interrelate science and management. The conference's scope does not include channel deepening, dredge material disposal, and related topics (for information on these matters, see www.nwp.usace.army.mil). This is the fourth in a series of conferences/workshops about the estuary: (1) The Biological Integrity Workshop was held in Sandy, Oregon in May 1999. This workshop included discussions about assessing the health of the estuary ecosystem. (2) The Habitat Conservation and Restoration Workshop was held in Astoria, Oregon in June 2001. This workshop developed science-based criteria to identify and prioritize restoration projects in the estuary. (3) The Research Needs Workshop took place in Portland, Oregon in April 2003. This workshop identified gaps in the knowledge-base for the estuary.

The 2006 conference format involves invited talks that synthesize information, facilitated panel/audience discussion periods at the end of each session, and posters for project-specific data. Conference proceedings (notes, abstracts, power point presentations) will be made available in July 2006. We gratefully acknowledge the support and efforts of the sponsors, steering committee members, the session chairs, and the speakers.

The conference will be moderated and facilitated by Turner Odell of RESOLVE.

Session 1: Estuary Turbidity Maxima

Introduction

Kim Larson, U.S. Army Corps of Engineers, Portland District

The Estuary Turbidity Maxima (ETM) session was organized by the Corps. This session is part of a continuing Corps effort to understand processes in the estuary as they pertain to Corps projects and authorities. The focus of some work is on the biochemical significance of the dynamic functions of the estuary and the ETM. The ETM is the area where salt water of the ocean encounters the fresh water of the river resulting in a dynamic zone of mixing and turbulence where bottom material is re-suspended to provide an energy source for the food web.

Biogeochemical Character of the Columbia River's Estuarine Turbidity Maxima

Fred Prahl, Oregon State University

Abstract (F.G. Prahl, L.F. Small, B.A. Sullivan, P.A. Covert)

Rivers deliver particles containing both natural and anthropogenic organic matter to their estuaries and adjacent coastal margins. The fate of this eroded particulate material depends upon its hydrodynamic characteristics and its susceptibility to biogeochemical alteration. Organic carbon budgets for world rivers show 50% of the organic matter delivered to the ocean, at most, can be accounted for by burial in marine sediment records. The vast majority is remineralized by some as yet unclearly defined macro/microbiological means within or shortly after passage through the freshwater – seawater interface. One possible site of such remineralization is within dynamic estuarine turbidity maxima (ETM) that develop at the land-sea contact zone of rivers such as the Columbia.

In this talk, we will review what is now known about the bulk chemical characteristics of particulate material delivered by the Columbia River to its estuary and causes for significant change in these characteristics on timescales ranging from seasonal and longer. We will then provide evidence that ETM developed tidally in the Columbia River's estuary act like a 'conveyor belt', selectively trapping chemical constituents of river-borne particulate material on neap tides and eroding 'trapped,' potentially quite biogeochemically 'processed' materials on spring tides. Finally, we will present a yet limited database showing that refined knowledge of particle aggregation / disaggregation processes is key to advancing our understanding of how river-borne particles and associated chemical constituents, both natural and anthropogenic, are specifically processed biogeochemically in passage through the Columbia River's complex estuarine interface and impact the 'health and well-being' of this environment.

Clarifying Questions

Q: What is the ratio of particulates versus dissolved carbon in the river vs. ETM?

A: There is a 50 / 50 blend in the river. In the ETM, the particulate concentration is enhanced.

Q: Where does the manganese component come from?

A: We are not sure of the source but do know that it can be mobilized and demobilized by microbes and that it is an important factor in particulate dynamics.

The Role of Mixing in Columbia Estuarine Trapping and Transport

Philip Orton, Lamont-Doherty Earth Observatory, Columbia University

Abstract (P. Orton and D. Jay)

Vertical turbulent mixing is a primary determinant of estuarine constituent transport and particle trapping, yet our understanding of stratified mixing is incomplete. A fundamental difficulty with numerical hydrodynamic modeling is the incomplete representation of the nonlinear physics of turbulent mixing. Numerical models require vertical mixing parameterizations because of computer processing constraints, but studies have shown that the many available schemes do not adequately reflect mixing variability over a wide range of freshwater input forcing. An important goal, if we are to understand estuary transport dynamics and improve numerical models, is to obtain a more diverse database of field observations of vertical mixing parameters.

We first review the role of turbulent mixing in hydrodynamic theories and classification schemes for estuaries, with special attention given to simplified tools (analytical models) for evaluating the effects of forcing variability (e.g., river flow). Estuarine circulation, often referred to as the sub-tidal or residual circulation, is the pattern of flow where fresher surface waters have a net seaward flow, while more saline deeper waters have a net up-estuary flow. This pattern intensifies as an estuary approaches a weakly mixed two-layer system of circulation with a strong density interface (pycnocline).

Prior studies have shown that the Columbia River estuary varies between stratified salt wedge conditions and partially mixed estuary conditions, with freshwater input and tidal forcing governing the state at any given time. During neap tides or strong riverflow, the estuary is highly stratified and exhibits strong estuarine circulation, due to stratification dominating over vertical mixing. During spring tides (except under conditions of extreme river flow), the estuary is well-mixed to partially mixed, with weak estuarine circulation, due to increased tidal currents and mixing.

Our mixing observations in the Columbia confirm that two types of mixing are common, with highly different signatures and results. Bottom boundary layer mixing -- driven by the frictional interaction of tidal currents with the riverbed -- is dependent upon the intensity of near bed currents. Internally driven turbulence initiated around the pycnocline (e.g., due to shear instability or internal wave breaking) is also common. This type of mixing is often strongly influenced by variations in channel cross-sectional area and is highly heterogeneous. Pertaining to the estuarine turbidity maximum formed at the head of the salt wedge, the level of mixing encountered by river-borne particles abruptly decreases as they are advected from vigorously mixed river waters into weakly mixed waters over the head of the salt wedge. This enhances

particle settling into the salt wedge head and helps concentrate suspended sediments there. We conclude by discussing likely historic changes in Columbia River estuary mixing and circulation.

Clarifying Questions

None.

Particle Retention in the Columbia River Estuary Turbidity Maximum

David Jay, Portland State University

Abstract

River estuaries like the Columbia trap and retain suspended particulate matter (SPM) in "estuarine turbidity maximum" or ETM. An ETM is a confined region where SPM is concentrated by physical circulation processes, aggregation, and cycles of deposition and erosion. ETM often play a major factor in estuarine secondary productivity, because they slow the otherwise rapid transit of organic matter (detritus) from the river through the estuary to the ocean. An ETM traps particles that are large enough to settle to the bed during periods of low current, but low-density enough to be easily re-suspended. The existence of suitable particles under a wide variety of river flow and tidal conditions suggests that estuarine ecosystems adapt to create (through aggregation) particles that retain organic matter in the estuary despite large changes in physical forcing.

The Columbia estuary has ETM in both channels near the head of salinity intrusion; there is a weaker, more transient ETM associated with the entrance fronts. Because river outflow is larger in the south channel, the north channel has higher SPM concentrations and longer particle residence times. Compared to other estuaries with ETM, peak SPM concentrations in the Columbia are moderate, 0.5 to 1.5 g l^{-1}, reflecting the very high energy level and strong currents. On the other hand, the Columbia ETM plays a very large role in secondary productivity.

Analysis of the SPM conservation equation suggests that five primary parameters govern ETM processes in the Columbia. The Rouse number P is a ratio of particle settling velocity to vertical turbulent mixing – only particles with an intermediate value of P appear in the ETM. Small particles are exported and sand remains on or near the bed. Advection number A quantifies the tendency for particles to be transported landward near the bed by the tides. Maximum trapping occurs where A ~0 in mid ETM; A is strongly positive seaward of this point. Supply number SR (P times the ratio of river flow to tidal current speed) represents the tendency of river flow to supply (and remove) SPM. As a river-dominated system, river flow in the Columbia rapidly supplies and exports material; particle turnover is rapid. Aggregation number G represents the tendency of the system to trap particles by aggregation. Aggregation is effective in the Columbia in creating particles to be trapped but does not play a large role in the SPM dynamic balance. All four of these parameters (and several others not important in the Columbia) affect the Trapping Efficiency E, which is the ratio of maximum ETM concentration of SPM to the concentration in the river that supplies the material trapped. The Columbia is near the low-E extreme of estuaries and retains particles for only a few days (very high flows) to a few months (low flows). There is little or no permanent deposition of fines on the bed of the ETM. Dredging and reductions in river

flow and sediment supply have together increased bottom depths and salinity intrusion over time in the Columbia, especially during spring and early summer. All of these factors have caused the system to be more effective in retaining SPM at this time than was historically the case.

Clarifying Questions

Q: What affects the salinity intrusion and how has it changed?

A: They have looked at this issue but it was not a part of this talk.

Q: Since the spring freshet historically had much higher flows, has this changed the ETM?

A: Yes, large topographic changes have occurred and this has affected the ETM. Bathymetry affects location of the ETM. Historically, high spring flows pushed out all the fine particulates once a day. The ETM did not start until after the spring freshet. Likewise during earlier times, much more sediment was transported by the system.

Ecological Substance of the ETM: Biotic and Food Web Connections on the 'Conveyor Belt'

Charles "Si" Simenstad, University of Washington

Abstract (C. Simenstad, G. Anderson, J. Cordell, B. Crump)

As now-dominant nuclei of biogeochemical processing, the Columbia River's estuarine turbidity maxima (ETM) both respond to and contribute to anthropogenic changes in the river's basin and estuary. The "conveyor belt" concept that emerged from the NSF-funded Land-Margin Ecosystem Research (LMER) studies suggests a common trapping and retention process that not only facilitates processing of selectively trapped biochemical constituents from upriver over neap-spring tidal cycles, but also promotes a unique assemblage of ETM microbes and zooplankton consumers that dominate estuarine food web processes. However, the ETM food web is distinctly different in organic matter sources and structure than that supporting visual-feeding planktivores. Although there may be mechanisms whereby some ETM enhanced food particles enter shallows-surface waters, food web pathways supporting planktivores tend to be dominated by wetlands organic matter as compared to the dominance by freshwater phytoplankton in the ETM food web. While the meager extent and frequency of scientific investigations in the Columbia River estuary limit comparisons, changes in estuarine food web structure have likely occurred with changes in the strength of the ETM conveyor belt and the sources, biomass, and timing of organic matter trapped in the ETM over the last two centuries. However, both the magnitude and implications of these changes are conjectural because there is no direct evidence that secondary production is limited by ETM or other food web processes. Compositions and relative abundances of consumer organisms have changed because of changes in ecosystem structure and dynamics and overexploitation in a few circumstances, but ramifications of these changes on the estuarine food web is similarly uncertain. It is quite evident that the modern food web has been augmented to some degree by the introduction of non-indigenous species, many of which have become prominent in ETM assemblages; the occurrence of some consumers, such as American shad (Alosa sapidissima) and Asian copepods, is now

pervasive but highly variable throughout the system. Albeit poorly understood, it is likely the interaction of organic matter sources, constituents, and ETM processes that regulates the structure and dynamics of the Columbia River estuarine food web.

Clarifying Questions

None.

Panel/Audience Discussion - Session 1

Q: With the apparent shift in the primary source of organic matter from detritus and phytoplankton, is the ETM region the best place to look for restoration to put organic matter back into the estuary, i.e., is the ETM the best place to look for a signal from the cumulative effects of estuary habitat restoration?

> **A1:** Food webs with respect to salmon are very localized – local production supports salmon. The ETM may be too tight to be an indicator for cumulative effects of restoration. We need an integrative measure, such as a food web indicator or a particular species.
>
> **A2:** The question gets at the issue of lateral transport between marshes/shallow water habitats and the ETM in the main channels. We need to learn more about this. We don't understand the exchanges between the periphery and the ETM. If you add more detritus, it will change but we don't know how.

Q: Youngs Bay is 2/3 filled in as a result of the Astoria/Warrenton bridge. How does this affect the ETM?

> **A1:** There is a major impact as a result of decreased intertidal volume and exchange. We think these changes could be negative, but are not sure about the impact and consequences.
>
> **A2:** This question illustrates an uncertainty – we know there's a minor ETM in Youngs Bay, but we don't know if organic matter coming down Youngs Bay gets incorporated in the ETM and how much gets out.
>
> **A3:** We know there is not as much salinity intrusion and that water is being held there much longer but we don't know the consequences.

Q: How do climate changes such as El Nino and La Nina and increases in mean sea level affect the position of the ETM?

> **A1:** El Nino can increase salinity intrusion due to dryer winter conditions and reduced river flows.
>
> **A2:** We are in a period of higher sea levels so this can impact the ETM.

Q: Does particulate generation in the ETM fuel *Corophium* populations?

> **A:** We don't know whether ETM material gets to organisms that dwell on the flats.

Q: Upstream in tidal freshwater in the absence of the salt wedge, is there any similar ETM mechanism in the river and its tributaries resulting from the effects of the tide?

A1: Yes, you can get that in some systems but it has not been observed in the Columbia River. In addition, the mechanism to trap detritus is not there. Tidal freshwater ETMs may be transient.

A2: Where the Willamette and Columbia come together, it would be possible if there was sufficient temperature differential to cause stratification. But this is not likely, so the process probably doesn't occur.

A3: In tidal freshwater, don't see trapping, but do see peaks in suspended load.

Q: In the Columbia Slough you can see colder Willamette River water going up the Slough. Is there an ETM here?

A: You could get some trapping of particles but no flocculation because there is no salt.

Q: Were other water quality parameters, such as D.O., pH, etc., studied in the ETM?

A: Other parameters were not studied due to resource limitations and abundant D.O.

Q: Has there been research in other Oregon estuaries on ETM and food web linkages?

A1: Not much.

A2: Coos Bay would be a good one to study but smaller systems may not support persistent ETMs.

Q: Is the food web energy kept in the lower river or is some of it driven upriver?

A: If fish are the mechanism to transport energy laterally or upstream, then upriver movement of ETM energy could occur. Also, sturgeon likely take advantage of ETM energy and would be a good vector, although this hasn't been studied.

Q: Most of the measurements used to study ETM are from instruments fixed in position, i.e., the measurements are Eularian. Are there some uncertainties about the ETM that would be best studied by following the ETM, i.e., Lagrangian measurements?

A: We tried following an ebb tide and measured turbidity, temperature, and salinity. We have not only looked at tracking particulates. There are considerable technical issues in tracking a particle. It's a good idea, but things move really fast in the Columbia River estuary. There will be an International Conference on the Physics of Estuarine and Coastal Seas in Astoria in September 2006 that may address this question.

Session 2: Lower River and Estuary Ecology

Introduction

Cathy Tortorici, NOAA Fisheries

This session focuses on fish and other species; it's not all about salmon. Talks range from a description of the estuarine environment to juvenile salmon ecology to crabs, lamprey, sturgeon, and cutthroat trout.

Physical and Biological Features of Estuarine Habitats

Curtis Roegner, Northwest Fisheries Science Center, NOAA Fisheries

Abstract

The Columbia River Estuary (CRE) is characterized by extremely strong spatial and temporal variation in physical parameters. These in turn affect the distribution of biota and rates of biological processes. In this presentation, I use examples from current research efforts to illustrate the important physical forcings, show the resultant hydrological gradients, and present some effects on various organisms. Hydrology and geomorphology interact to define three major sections of the lower Columbia River. These sections are based largely on the degree of mixing of salt and fresh water. The Marine Zone is characterized by a relatively high influence from coastal processes, the Estuarine Mixing Zone has highly variable salinities that depend on river flow and tidal energy, while the Tidal Freshwater Zone is beyond the reach of saltwater and is affected mainly from factors originating upstream. Within each of these spatial zones, river flow, tidal mixing, and wind stress have varying effects on hydrological features such as temperature, salinity, and water velocity. Temperature has the most widely recognized impacts on biological systems, and the temporal and spatial patterns of water temperature variations in the CRE will be outlined. In the salt-influenced regions, the very sharp gradients of salinity and water velocity will be illustrated. Biological examples ranging from phytoplankton dynamics, larval and juvenile crab distribution, and the composition of shallow water fish communities will be used to highlight bio-physical relationships.

Clarifying Questions

Q: Where did the 19 degrees come from?

> **A:** Salmon studies.

Q: Is the 19 degrees a new phenomena or historic?

> **A:** This issue is being studied currently.

Ecology of Juvenile Salmonids in the Lower River and Estuary with Emphasis on Subyearling Salmon

Dan Bottom, Northwest Fisheries Science Center, NOAA Fisheries

Abstract

Estuaries often are described as productive rearing habitats and important transitional environments for juvenile salmon during their seaward migration. Yet until recently, the estuarine ecology of Columbia River salmon rarely has been studied, and the estuary's contribution to salmon decline and recovery often has been overlooked. Recent analyses reveal substantial changes in estuarine hydrology and ecology that have reduced estuarine rearing opportunities for juvenile salmon. Diking, filling, and flow regulation have eliminated juvenile salmon access to historic wetland and floodplain habitats and may have altered estuarine food chains. Together estuarine habitat changes, releases of hatchery fish, and population losses upriver appear to have reduced variation in salmon distribution, abundance, and size frequencies relative to predevelopment periods. Simplification of salmon life histories in turn may reduce population resilience and the overall productive capacity of the Columbia River Basin. These results argue that salmon recovery plans must re-establish the habitat linkages needed to support the anadromous life cycles of salmon, including the linkages between upriver populations and their productive rearing and transitional habitats in the estuary.

Clarifying Questions

Q: Is the data on the partition of various stocks based on one sampling?

> **A:** No, it is an amalgam of several data sources.

Q: You identified two different scenarios for the role of the estuary: migration corridor and supporting habitat. Are there studies that determine which is true?

> **A:** If diversity is important, the benefit will also vary. Some years the fish who shoot through the estuary will do better, compared to those who linger but we see variability which suggests that this is a survival factor. If you only go for fish that pass quickly you will get a homogenous group of fish and this would likely have a negative impact on the population. The fact that multiple life history types are present means a particular strategy must have been important evolutionarily. The point is that there is not one optimum strategy.

The Role of the Columbia River Estuary in the Ecology and Life History of Dungeness Crabs

Walter Pearson, Marine Sciences Laboratory, Pacific Northwest National Laboratory

Abstract

Dungeness crabs, *Cancer magister*, use both nearshore oceanic areas and estuaries in their life cycle. In the spring, Young of the Year (YOY) crabs enter west coast estuaries. Growth of YOY crabs has proven significantly greater in estuaries than in the ocean. In the fall of the next year, age 1+ crabs leave the estuaries for the ocean. Within estuaries, age 0+ crabs are found in

intertidal and shallow subtidal areas on substrates with shell hash, eelgrass, or other shelter. After growth to 20-mm carapace width, the age 0+ crabs move to subtidal areas. Age 1+ crabs shelter in subtidal areas and forage over intertidal areas during high tide. Side-channel habitat near the estuary mouth has the highest age 1+ crab densities, with the lower estuarine main channel and upper estuary habitats having significantly lower densities. The characteristics of the preferred lower side channel habitat include shell substrate, macroalgae, shallow depths, high food abundance, temperatures less than 18 degrees Celsius, and salinities above 25 practical salinity units (psu). The estuaries provide relatively steady contributions to annual crab production that can sustain the overall population when the crab production in the ocean decreases to low levels. The amounts of side channel habitat appear to influence the relative contributions of different estuaries to the annual crab production.

The bottom salinity regime governs how far Dungeness crabs penetrate into the Columbia River estuary. Dungeness crabs are rare above River Mile 17. In studies for the U.S. Army Corps of Engineers, the dredge entrainment rates for ages 2+ and 3+ crab were found to significantly decrease as the bottom salinity decreased. The entrainment of younger crab appeared to be governed by factors in addition to or other than salinity. River flow dominates the Columbia River estuary while daily and lunar cycles of tidal flow govern the amount of salt entering the estuary. Seasonal changes in the interactions between tidal cycles and river flow determine bottom salinity regimes and crab distribution in the Columbia River estuary.

Knowing the life history events of the Dungeness crab has proved important to informed decisions concerning dredging and disposal operations in the Columbia River. In studies for the U.S. Army Corps of Engineers, the distribution of crabs in shallow areas along the northern side of the mouth of the Columbia River was observed. The density of age 1+ crabs increased abruptly in mid-September and the increased density continued through November. This observation is thought to represent the fall outmigration of age 1+ crabs from the Columbia River and has influenced decisions concerning disposal of dredged materials. Currently, other studies are being conducted by the Corps to understand the potential project impacts on Dungeness crab.

Clarifying Questions

Q: Do crabs show evidence of homing instinct?

> **A:** No, not like salmon. The megalopae do undertake vertical migration. They are dependent on the tides.

Q: What do the crabs eat on the flats?

> **A:** Clams and worms.

Q: Was the Columbia River a good habitat before flow regulation?

> **A:** We don’t know but it is a good question.

Anadromous Fishes without Adipose Fins: What Do We Know About Pacific Lamprey and Green Sturgeon in the Estuary?

Mary Moser, Northwest Fisheries Science Center, NOAA Fisheries

Abstract

While there has been very limited research on the estuarine distribution and habitat use of salmonids, the amount of information on other anadromous occupants of estuaries is even more meager. This is particularly true for lamprey. Two parasitic anadromous lampreys occur in the Columbia River estuary: Pacific lamprey (*Lampetra tridentata*) and river lamprey (*L. ayresi*). Both species have been proposed for listing under the Endangered Species Act. Macroopthalmia (metamorphosed juveniles) of Pacific lamprey emigrate from freshwater rearing areas over an extended period, with peaks in winter (November-January) and early summer (June-July). It is at this time that they enter the parasitic phase of their life history. There is no information on the residence time or distribution of these fishes in estuarine waters and very little is known about host selection and marine migration. Pre-spawning adult Pacific lampreys occur at Bonneville Dam (Columbia River KM 235) at the beginning of May, and therefore are probably in the estuary in early spring. However, nothing is known about potential staging in the estuary prior to their free-swimming migration.

Somewhat more information is available on green sturgeon (*Acipenser medirostris*). The southern Distinct Population Segment (DPS) of green sturgeon has recently been listed as Threatened under the Endangered Species Act, and both the Northern and Southern DPSs of this species occur in the Columbia River estuary. Green sturgeon are known to spawn only in the Sacramento, Klamath, and Rogue rivers; however, both juveniles and adults occupy the estuaries of other rivers. Here they are susceptible to capture, primarily as bycatch in salmon and white sturgeon fisheries. Recent acoustic telemetry studies have indicated that green sturgeon make extensive marine movements and can move rapidly between the Columbia River estuary and Willapa Bay (the next estuary to the north). In Willapa Bay, green sturgeon typically arrive in early April and depart in October-November. However, information on their estuarine distribution, the extent to which they feed in estuaries, abundance, and population structure is scant.

Clarifying Questions

Q: Why is there a bimodal outmigration?

> **A:** We don't have the genetic background on lamprey to enable us to answer this question. Not much is known about stock structure.

Q: What do the lamprey feed on during the amyocyte phase?

> **A:** Diatoms are the main food source. The lamprey filter feed through a mucous-lined pharynx.

Q: What other species of fish are they parasitic on?

> **A:** We don't know their specific preferences nor how long they stay on a host. Most of the host data is based on scarring; these data are not consistently recorded. They do have a broad range of prey.

Columbia River Sturgeon Population Trends and Habitat Use

Tom Rein, Oregon Department of Fish and Wildlife

Abstract

The Columbia River white sturgeon population below Bonneville Dam consists of at least one million fish larger than two feet in total length. White sturgeon are seasonally migratory within the Columbia River and use the marine environment to an unknown extent. Telemetry evaluations have shown individual sturgeon occupy seasonal home ranges up to several kilometers long. Fish move extensively within the home ranges at diurnal and much shorter time scales. Home ranges of individual fish may overlap extensively. On an annual time frame all fish left the telemetry study area, but many fish returned after several months to use similar home ranges. Generally speaking white sturgeon prefer areas with sandy bottom substrate, which encompasses most of the lower Columbia River.

Recent research has demonstrated an apparent preference for habitat areas with measurable slope and bottom roughness, but no clear pattern of depth preference. White sturgeon spawning habitat can be characterized by substrate, and water depth, velocity, and temperature. In the lower Columbia River, white sturgeon spawn at depths of 4 to 23 m, over cobble or boulder substrates, at mean water column velocities >1 m/s, when water temperatures are 10-18 C, during April-July. The channel morphology below Bonneville Dam creates water velocity conditions that make about 150 ha of spawning habitat seasonally available within 5 km of Bonneville Dam in nearly all water years.

Green sturgeon population trends and distribution are known chiefly through inference from harvest patterns. Non-reproductive adult green sturgeon are primarily a marine species. In the Columbia River they are most numerous in the estuary during July through October. Green Sturgeon are not known to spawn in the Columbia River, and based on empty stomachs in most harvested fish we believe they do not feed extensively in the river. The question of why they are seasonally present has only been addressed through speculation. Since green sturgeon were petitioned for listing under the Endangered Species Act in 2001, Oregon and Washington have dramatically reduced harvest numbers through regulation changes. While this has reduced green sturgeon harvest, it also has limited any new information on population trends.

Clarifying Questions

Q: Were there movements throughout the system historically?

> **A**: White sturgeon moved throughout the river system. Celilo Falls was not a barrier, except perhaps at high flows.

Q: What is the preferred spawning habitat for green sturgeon?

> **A**: In the river channel above salinity intrusion during high flow in April and May. Unlike white sturgeon which have a swim up phase with downriver drift, green sturgeon have a burrowing phase.

Q: Why don't green sturgeon and white sturgeon mix?

> **A:** We don't know.

Defining the Importance of the Lower Columbia River and Estuary for Coastal Cutthroat Trout

Mike Hudson, U.S. Fish and Wildlife Service

Abstract (M. Hudson, J. Johnson and J. Zydlewski)

The current status and distribution of the lower Columbia River coastal cutthroat trout populations is not well understood, but what is known indicates that at least the anadromous component of these populations may be declining in abundance. How populations interact with one another and utilize the lower Columbia River estuary to complete their life cycle is also poorly understood. We can say with certainty, however, that lower Columbia River coastal cutthroat trout depend upon the estuary to complete the life cycle of fluvial and anadromous life history components. Due to the complex relationship between sympatric migratory and resident components of coastal cutthroat trout populations, the estuary likely is important to the overall health of coastal cutthroat trout populations in the lower Columbia River basin. Recent investigations by this office into the movement and habitat use of juvenile and adult coastal cutthroat trout in the lower Columbia River and estuary indicate that multiple life stages of this species may be present in this portion of the Columbia River throughout the year. Therefore, the potential to be impacted by activities, detrimental or beneficial, may be more likely for this species than for any other Pacific salmonid because of its extensive use of the lower Columbia River and estuary. However, the relationship between estuary habitat parameters and coastal cutthroat trout population parameters requires further investigation. Understanding this relationship may be important to assessing the biological response of habitat restoration in the lower Columbia River basin being conducted to benefit Pacific salmonids.

Clarifying Questions

Q: What is a coastal cutthroat trout? Is it different from a sea run or resident cutthroat?

> **A:** It is a combination of the sea run form and the stream form. They are genetically identical.

Q: You noted that one fish will sit in the same spot for a long time. Do they come back to the same spot?

> **A:** We are not sure but we did track one trout that came back to the same spot.

Q: How old do these fish get? Is there information from scale analysis?

> **A:** We are not too sure about adult age but they migrate at age 2 to 3.

Q: Is the anadromous form important to the species?

> **A:** We assume it is important to the species similar to the steelhead form of trout. The anadromous form provides more variability to adapt to lost habitat, and thus enhances survivability of the species.

Q: Are there populations that could not be anadromous?

> **A:** We don't know but the question could be important to salmon if we could show that traits can be revived if habitat opportunity exists.

Panel/Audience Discussion - Session 2

Q: What do we know about the interactions and trends between native and introduced species? Predation? Competition?

A1: We know that Asiatic clams are being used by white sturgeon but we don't know how valuable a food source they are. We also don't know if clams are competing for the phytoplankton resource.

A2: Native freshwater clams and Asiatic clams are found in the Grays River, but we don’t have knowledge of how they interact.

Q: What are the potential impacts of global warming on the estuary?

A1: We do know that a changing snow pack will force species to adapt but we don't know what will happen. Changes in the snow pack will cause changes in the hydrograph.

A2: For crabs, temperature change will affect them but we don't know how to extrapolate global trends to the local environment.

Q: Two weeks ago, the *Oregonian* featured an article about toxics in the waters above Bonneville Dam and how they affect White sturgeon. What do we know about this?

A: Contaminants are probably not the most important factor in sturgeon survival. Changing conditions with respect to sediments, temperature, etc., are probably more significant but it is possible that contaminants are impacting spawning effectiveness.

Q: American shad were not discussed. What do we know about their impacts?

A: Shad are a diet item for sturgeon but the growing population is a potential issue for future studies. There is evidence that shad may have chemicals that inhibit the spawning of predators.

Q: What is the three-spined stickleback's role in the ecology of the estuary?

A: We know there are a lot of them and we know they tend to be an indicator of harsh conditions in the estuary. In some shallow spots, we have found 40,000 stickleback compared to 40 salmon. We have someone who will be studying this issue.

Q: What do we need to know about the impacts of dredging?

A1: White sturgeon is a species of concern for ODFW. We would like to know if the small ones are being smothered or do they just move out of the way? We do know that larger sturgeon are either unaffected by a disposal event or may move toward it to feed on things stirred up by the dredging.

A2: For eulacons, we don't know whether they spawn in the main channel. Sampling has shown them spawning on the Washington side of the river in the shallows. Disposal should be limited next to shore where smelt spawn.

A3: We have gained more knowledge about crabs as a result of questions regarding disposal and dredging. Much of what we know about the effects of dredging comes from specific, localized studies; you can’t answer the question of impacts of dredging using generalities.

A4: We need to look at historical changes. Are there major break points with respect to dredging? We have been working on models of this to sort of hindcast possible changes, especially with respect to changes in habitat opportunity as a result of dredging.

Q: In response to restoration efforts, what tools are available to measure resulting effects on salmon populations? Number of fish is only a part of the story. What's the ecological cost/benefit?

A: We have developed monitoring protocols that will hopefully standardize the approach and allow for estimation of the cumulative change in the system. There is a push for a diverse suite of indicators (bathymetry, vegetation, fish, etc.), although not all metrics would be sampled all the time. These monitoring protocols are currently being applied at a tide gate replacement (Vera Slough) and a dike breach (Kandoll Farm). Contact Blaine Ebberts (503-808-4763) of the Corps for more information on the standard monitoring protocols for habitat restoration projects in the CRE.

Q: Will the data developed be centralized enough that we as managers can use it and compare, i.e., what's the plan for data roll-up?

A: That's the vision.

Q: If we do a restoration project for a particular species, how do we know the project is helping that species?

A: Look at performance of the species. For example, in the Salmon River estuary, we have restored a natural system and expect to be able to monitor changes at the population level. The Grays River is also a good possibility for looking at population-level changes but comparing habitat to habitat will probably not be too useful. We need to find a tractable system to look at collective effects.

Q: The 1920 salmon work identified 20 life histories. Is that too many? Why don't we use scale analysis today?

A: We want to know if we can show those kind of results from scale analyses. Someone is currently working on this but the results are preliminary. Be cautioned that scale analysis is dependent on a growth difference to know when the fish entered the estuary.

Q: In the Salmon River study, you saw increased usage of marsh habitats, but was there any apparent change in population?

A1: We haven't done it long enough yet. We need to maintain the data set for several years. We hope to be able to see different variables in population. The ultimate effect is on adult returns.

A2: Regarding the future and what to worry about, remember that global change will likely affect us over larger areas than local study sites. It's prudent to worry about the larger scale phenomena.

Session 3: Habitat Restoration and Monitoring

Introduction

Scott McEwen, Lower Columbia River Estuary Partnership

In the past four years, the amount of habitat restoration and monitoring has increased. This session looks at a new habitat classification scheme for the CRE, the broad restoration effort, and monitoring of restoration projects.

Estuarine Landscape Classification and Inventory

Jen Burke, University of Washington

Abstract (C. Simenstad and J. Burke)

Research and monitoring along extensive tidal freshwater-euhaline gradients of the lower Columbia River estuary (LCRE) necessitated a classification scheme describing the dynamic scale-dependent and scale-independent ecosystems and processes. Evaluation of existing approaches to classifying large tidal floodplains and estuaries revealed that they either did not address tidal-freshwater ecosystems or were of insufficient resolution to identify essential elements and geomorphic features. Therefore, we developed a nested hierarchical framework that delineates ecosystems and component features of the LCRE. The LCRE Ecosystem Classification aggregates land and aquatic cover classes according to the ecosystem processes that structure landscape attributes, including biotic habitats, at different spatial scales. Of the six hierarchical levels (Ecosystem Province, Ecoregion, Hydrogeomorphic Reach, Ecosystem Complex, Catena, Primary Cover Class), the first three are based on the U.S. Environmental Protection Agency's ecoregions and the lowest level, Primary Cover Class level 6, is based on remote sensing land cover data. Ecosystem Complexes and Catena (Level 4 and 5), based on bathymetric and geomorphic analyses, are the most challenging but likely most useful strata for estuarine science and management. We demonstrate the applicability of this approach by mapping the variability and historical changes in landscape metrics within Ecosystem Complexes among Hydrogeomorphic Reaches across the LCRE. The coupling of an ecosystem landscape classification with metric analyses in a GIS expands restoration and monitoring of the estuary beyond the standard tally of acres towards understanding the functional response of the system to natural and anthropogenic processes.

Clarifying Questions

Q: Is the classification addressing tidal restoration? Will other data be included?

> **A:** Yes, we will be bringing in diked lands and other land forms, as well as layers for dikes and tidegates. We don't have a good floodplain delineation for the CRE, but we will be trying to bring this into the classification as well.

Q: Where do the people fit into this picture? They are not part of the model.

A: True, although indirectly people are part of the present change layer. Our next level will be to determine how to measure restoration.

Q: How do you define edge density? Are you using FRAGSTATS?

A: Yes, it is automatically calculated in the GIS software. See Jen Burke for the algorithm.

Q: In the past, substrate composition was a key habitat mapping element. How is it incorporated in this material? Where is the linkage between energy regime and substrate type?

A: We have the potential to bring this information in but the substrate data are not very good.

Q: How did you establish limits of tidal influence on the upslope edge?

A: We're not doing this yet. We hope the forthcoming LiDAR data will help this work.

Overview and Prioritization of Habitat Restoration Projects

Matt Burlin, Lower Columbia River Estuary Partnership

Abstract

Habitat restoration in the Columbia River Basin remains a top priority for species recovery in the lower Columbia River and estuary. Until recently, the development of habitat restoration projects within the system was not systematically approached. Habitat restoration in the lower river system has increased within the last ten years, but efforts have been primarily opportunity-driven in nature. Further, trends since 1999 indicate that the number and total acreage of projects have increased on an annual basis. Finally, as we have learned more about the needs of target species and habitat forming processes, our abilities to provide effective and efficient projects have also improved.

In response to these trends, a comprehensive, landscape-based strategy for restoration has been identified as necessary to maximize a project's benefits and significance to the system. As several efforts are underway to develop prioritization methods to aid in this process, one need has emerged: the need to develop a more accurate understanding of where to strategically apply finite restoration resources in order to ensure that we are achieving the environmental benefits we seek. This presentation will examine three prioritization frameworks within the lower Columbia River and estuary that attempt to achieve this goal.

Clarifying Questions

Q: You haven't addressed the people issue yet. There are potential public relations problems. How will you go about bringing people into the equation?

A: Efforts to coordinate with the public are ongoing. Improving the accuracy of the supporting data has been the first priority. Moving forward will be a back and forth process but we recognize that it must be integrated with all interested parties. We understand that impacts are societal, not just ecological.

Q: When will the GIS layers be available to the public?

A: Some of the information is available now. Eventually more will be but we need to do QA/QC so the release date is uncertain. We are open to data sharing agreements to ensure proper acknowledgment of the sources of the data.

Q: What's the definition of a management unit based on?

A: Hydrology; HUC 6.

Q: When will the public be brought in?

A: During the individual project proposal development process. The public must be part of the process from the beginning. Land owner participation is key.

Q: The prioritization template seems useful to organize opportunities for projects, but how does it address landscape issues?

A1: Landscape processes will be considered at the management area level as we determine how it all fits together. We built the process using a conceptual ecosystem model.

A2: Landscape is taken as a process relative to the site, i.e., landscape processes affect the ability of a restored site to be maintained. We will define the probability of restoration working in the larger context. Salmon are not addressed explicitly in the prioritization model, but ultimately response could be layered over the top. Focus is on the habitat forming processes.

A3: Research by UW and NOAA will be used to inform the prioritization.

Q: 10,000 acres of restoration is the number that was used. How will we know when it is enough?

A: The prioritization process allows us to ask better questions. It should ultimately help us research the concept of how much is enough. Before we even address this question, however, we need to better understand the benefits of our present efforts. It's quality, too, not just quantity.

Q: How is the prioritization framework used to answer questions, for example at a tidegate replacement?

A: At the site level, we look at stressors which impact controlling factors. In this case, the tidegate is the stressor. The factors are weighted and then we determine the ideal situation for the particular restoration scenario. The most ideal locations for the restoration action will come to the top.

Q: The problem of how to put the human factor into it could be partially addressed by adding a layer of land ownership, right?

A: Agree in concept. If we had a public interest layer it could be added. Our system has the flexibility to do this.

Effectiveness Monitoring of Restoration Projects in the Columbia River Estuary from a Practitioner's Perspective

Ian Sinks, Columbia Land Trus,t and Allan Whiting, Columbia River Estuary Study Task Force

Abstract

The interest in restoring lost estuarine wetland habitats in the Columbia River has increased markedly in recent years. This interest has been primarily due to an acknowledgement that estuary habitat restoration may play an important role in the recovery and persistence of "at risk" populations of fish and wildlife and provide broader ecological benefits to the estuary as a whole. There has also been a corresponding increase in funding availability and partner capacity to implement habitat restoration projects, including over 5,000 acres of restoration and enhancement projects initiated over the past five years.

However, given its novelty in the Columbia River, estuary restoration has not been adequately evaluated and early restoration projects are therefore experimental in nature. For this reason it is important that initial restoration projects be adequately monitored to determine if project goals and objectives are being achieved. Information derived from monitoring will also improve the general understanding of the ecology of the Columbia River estuary, help build adaptive management strategies for restoration and conservation areas, and inform the planning and design of future restoration projects.

To address these issues Columbia Land Trust and CREST have been working collaboratively to develop an effectiveness monitoring program that will measure effectiveness of dike breach projects in intertidal floodplain areas. In order to maintain consistency across efforts methods are being designed in consultation with other researchers (e.g., NOAA Fisheries and the University of Washington). In addition, it is hoped that data collected by these site-specific efforts will contribute to a regional effort to assess the cumulative effects of restoration across the estuary (USACE and PNNL).

This session will provide an overview of effectiveness monitoring efforts related to projects restoring fish access and hydrologic connections to floodplain habitats in the estuary. We will also provide a focused discussion of initial monitoring efforts by Columbia Land Trust and CREST to evaluate specific restoration projects in peripheral embayments of Oregon and Washington. Restoration project elements, the development of conservation goals and objectives as the criteria for success, and specific monitoring protocols will be reviewed along with some of our initial results and lessons learned from the first year of monitoring. A consistent theme within this talk will be the perspective of an on-the-ground practitioner limited by finite resources and staff capability to implement the work.

Clarifying Questions

Q: How do you incorporate adaptive management so that lessons learned can be passed on to the next project?

> **A:** We are very early in the process. We have good data coming in but no systematic approach yet to disseminate it. We need to develop a larger picture of how to get the information out and use it to improve design. However, within a given project or site, we are using the monitoring data for our decision processes.

Q: We need an annual meeting to exchange restoration project monitoring data and help synthesize data. What do you think?

> **A:** It's a good idea to share information and thinking. Many of these are "pioneer" monitoring efforts, so lessons learned will be useful to others.

Q: How will we know whether replacing a tide gate will affect salmon survival? We can monitor the use but do the changes really help?

> **A:** We don't estimate survival in our monitoring, but we are studying foraging. We need to learn what the fish do when they are behind the new tide gate, i.e., what is their diet? Are they food constrained?

Q: Be careful not to simply count fish. Diversity of life histories is a critical element. How do we measure this so we can better understand variability? Are you looking at environmental linkages?

> **A1:** We need the help of the scientific community to look at fish behavior and to help integrate our site-specific local data with the bigger picture.

> **A2:** We also have monitoring requirements for the funding entities. We start with the basics then work up. It often comes down to available resources for monitoring.

Q: How are you using reference sites? How often can you do a baseline and how good is your baseline?

> **A:** Not as often as we would like. Due to resource limitations we tend to focus on some of the critical sites, e.g., high-profile sites are more likely to have baseline monitoring than others.

Q: Is there an indication of changes in macroinvertebrate populations due to the restoration project?

> **A:** Some of our sites were pastures that are now periodically inundated with tidal water. It's early in the monitoring, but we are seeing a lot invertebrates in samples of juvenile salmon stomach contents and benthos.

Q: CREST and CLT are locally driven organizations. How can the larger players in the region help you?

> **A:** Leveraging resources, working with the cumulative effects project, developing monitoring protocols, synthesizing data, and keep the money coming. We have been able to glean support from larger efforts sponsored by the Corps and others.

Panel/Audience Discussion - Session 3

Q: It seems that restoration has an implicit goal to get back to some historical state. However, the estuary is a very dynamic environment. How do we get back to a historic state when we have a dynamic system that is constantly changing?

> **A:** Tributaries are very dynamic and we are still trying to get a handle on them. The system is so altered we can't get back to historic conditions. We learn from past conditions to design better restoration projects today. As an example, even if we remove a tide gate, the system is still altered.

Q: The talks in this session included spatial scales from landscape GIS maps to on-the-ground, site-specific restoration projects. Explain the linkages between the scales folks are working at. How can we ensure that it all comes together so everyone is working together?

A: Lots of communication is going on, but it is not always structured. We need a more structured approach to include more meetings like this. Folks are talking and making connections.

Q: How do we know what to do at a restoration site? We do understand a lot more now but a big problem is elevation. We can do elevation measurements at some sites and it is a good connector but other sites like the Grays River have become so disturbed that an elevation determination is very difficult.

A1: Topographic data can help limit errors but we still need to develop context to layer the system and we still need resources and help. We also need to understand changing flow patterns.

A2: A lot of excellent information sources and researchers are out there, we need time and resources to bring it together.

Q: Written quality assurance plans need to go with monitoring. Are they being developed?

A: We have developed them but still need improvement. Replication is still an issue for us. As an example, we have had a difficult time with the control of dissolved oxygen. The EPA restoration funding mandates extensive QA/QC plans.

Q: There are many gaps in available data. For example, tributary flows are missing. We need a systematic gauging of rivers and a tide gauge network. We also don't know much about substrate. Our data comes from the early 70's but we know nothing about the current situation. There’s a sediment budget that affects substrate that influences habitat structure.

A: We definitely need a tide gauge network.

Q: Most of the grants for restoration are for 2 or 3 years. How do you address the need for long-term monitoring?

A1: A five-year window is common so long-term follow up is a constant struggle. Need to keep the monitoring simple so it can be handed-off to volunteers. We also need to continue to raise funds.

A2: Many of us have grappled with this. We need different monitoring strategies depending on the situation. We need to know what frequency and duration to use for different parameters. We also need to identify needs and raise funds around specific monitoring needs. The standard monitoring protocols work by the Corps helps.

Q: Are there efforts to integrate data from the system to help determine the big picture? Are the site-specific monitoring data being rolled up into the estuary-wide efforts, e.g., the restoration project prioritization process?

A1: Monitoring projects are going on in different areas and some comparing and contrasting is going on. For example, data from the Estuary Partnership’s ecosystem monitoring project should feed back into the prioritization process.

A2: We must constantly remind ourselves to think about the management applications of our data.

A3: Monitoring often gets the short end of the stick. We need a system to monitor the ecosystem. The habitat monitoring from the Estuary Partnership will go a ways toward reaching ecosystem needs. Also, we need a suite of reference sites to compare with the project sites in order to roll-up data estuary-wide.

Q: We have a dilemma – funds spent on on-the-ground restoration are not available for monitoring and vice versa. How do we achieve a balance? Do we need to monitor every restoration project?

A1: We need to revisit the issue of monitoring each site. Need to determine how to prioritize monitoring needs. Perhaps every site should have at least a minimal amount of monitoring.

A2: The more we can learn from reference sites, the more efficient we can be at smaller sites. Also, a few intensively monitored sites coupled with others with minimal monitoring may be a useful strategy.

Q: The process of quality assurance plan development leads you to consider what questions you want to answer and how you decide if the effort is successful and at what scale. So, prior thinking can help improve efficiency down the road. If others appreciate the quality of the data, they might be able to apply the results later.

A: Yes, we need to look at what is known and coordinate it at a larger scale.

Q: There is a lot of monitoring that comes with publicly funded projects. Is monitoring data available and if not could it be?

A: There are major ongoing data management efforts in the basin, e.g., the Northwest Environmental Data Network (NED). It's likely there will be progress to providing data more widely than is the case today. This question is a very important issue.

Q: Are there missed opportunities out there that we may not be aware of? As an example, see the on-going passive restoration of a site at Fort Clatsop. The site is being used by critters. We could look at sites like this and use them as references.

A1: We need to calibrate a standard to see if we are on the right path and to do this we need different habitat sites. We could use sites like the one at Fort Clatsop. We need to determine how to extrapolate results to the larger picture. It is a large area and it is sometimes hard to find these missed opportunities. We may need to do a more systematic inventory of possible restoration sites than has been the case to date.

A2: In 1986, a survey of diked areas was completed. Some 76 sites were identified including 5 or 6 on the lower Columbia River that could be useful. The biggest problem is aging the sites; we need this to know the time sequence of development.

Q: Are we looking at this as an ecosystem? Do we need to address larger issues that affect whole system, i.e., fishing, predation, dams, etc. We need to really look at issues affecting salmon populations over the entire Columbia system, right?

A: Yes, we need to do that. This discussion should be part of the last session today, Management Perspectives.

Session 4 – Ocean Ecology

Introduction

Ed Casillas, NOAA Fisheries

Research efforts for many years were directed primarily at the mainstem dams. In 1996 with an amendment to the Northwest Power Act, the focus changed to include the lower river, estuary, and plume. It was recognized that we need to understand all of the habitats that salmon occupy throughout their life cycle. Population recovery cannot be focused in one area. We are striving to learn how the ocean environment benefits salmon and to use this information in decision-making. Management needs to make decisions on how to proceed; it's our job to make the information available.

Where the Columbia Meets the Sea: Salmon Ecology in the Columbia River Plume

Jeanette Zamon, Northwest Fisheries Science Center, NOAA Fisheries

Abstract

In the area where the Columbia River empties into the sea, a large pool of freshwater forms on the ocean surface. This freshwater input is known as the Columbia River Plume. The Plume is one of the largest physical habitat features in coastal Oregon and Washington. It is also one of the most dynamic features because its size, shape, and strength are affected by river flows, tides, and winds. The Plume serves many ecological roles, including being a transportation mechanism, a spawning or nursery habitat, and a feeding ground.

In addition to serving general ecological roles, the Plume is a transition habitat for inbound and outbound Columbia River salmon. This talk will provide a broad conceptual overview of how outbound juvenile salmon can be affected by Plume processes and ecology. Plume effects on physical habitat, distribution, food, growth, pathogens, predators, and the presence of alternative food for salmon predators will be highlighted.

Clarifying Questions

None.

Ecology of Juvenile Pacific Salmon in the Northeast Pacific Ocean

Marc Trudel, Fisheries and Oceans Canada

Abstract

Salmon stocks from the Columbia River and Snake River formed one of the most valuable fisheries on the West Coast of North America, with annual returns approaching 16 million fish during the late 1800s. However, salmon returns sharply declined during the 1980s and 1990s to close to one million fish. Although a number of factors may be responsible for the decline of Columbia River salmon, several lines of evidence suggest that these drastic declines were partly attributable persistently unfavorable ocean conditions.

The general objectives of our research are to assess the effects of ocean conditions and climate on the growth and survival of Pacific salmon, including Columbia River salmon. This is achieved by (1) characterizing the physical, chemical, and biological conditions encountered by juvenile salmon in the Northern California Current, transition domain, and the Alaska Coastal Current, (2) assessing and contrasting the biological and physiological status of juvenile salmon in these regions, (3) identifying the physical and biological changes in the ocean that lead to reduced ocean survival, and (4) identifying the regions of poor growth and the stocks occurring in these regions.

Our work shows that a significant proportion of Columbia River salmon is undertaking a rapid northward migration that quickly takes them well beyond the mouth of the Columbia River, and that the ocean environment is not uniformly suitable for salmon growth and survival along the West Coast of North America. More specifically, our work shows that, while plankton productivity and temperatures tend to be higher in southern British Columbia, salmon are generally smaller and leaner, and have lower growth and marine survival in this region. Hence, Columbia River salmon that undertake a northward migration to the Aleutian Islands must first encounter an area of poor growth before reaching a more suitable area for growth and survival. Our work suggests that the west coast of British Columbia may act as a bottleneck for Columbia River salmon survival.

Clarifying Questions

None

Pacific Ocean Salmon Tracking (POST)

David Welch, Kintama Research Corporation

Abstract

Ecology is variously defined as (1) “The study of the relationship of organisms with their environment,” (2) “the study of the distribution and abundance of organisms”, and (3) “The study of ecosystems.” However, in many ways, the quaint statement that “ecology is scientific natural

history" seems most appropriate for the purpose of this conference, with its focus on the role of the ocean & estuary in determining salmon dynamics.

Despite widespread support for bringing salmon abundances back to near historic levels of abundance, it is my view that we do not know enough to understand why we have failed to do so. It is not a lack of commitment. Bob Lackey has written persuasively about the fact that most people support the principle but are unwilling to accept the practice. I agree with his thesis, but feel that we are also missing something fundamental within current fisheries management—for otherwise, we would be more successful. Given recent "rags to riches" swings in salmon returns, the issue of the degree that changes in the ocean and estuary largely determine abundance and may obscure our ability to measure the influence of changes in the hydrosystem takes on great importance. We know strikingly little about the real ecology of Pacific salmon in either the estuary or the ocean—how long they linger in any one place (their distribution) or where they die (how the ocean effects survival—their abundance). Despite being based on the astonishing technological revolution brought about by modern electronics, the POST array was really designed to answer mid 17th century questions about the ocean distribution and survival response of Pacific salmon to the estuary and ocean environment—effectively returning us to Haeckel's era.

Beyond the intrinsic interest in measuring salmon survival and establishing an ocean ecology, the need for a complete life cycle view of salmon ecology is critical to many policy questions facing the Columbia. Global warming is expected to cause massive changes in the environment as a result of increasing greenhouse gas levels. The magnitude of the probable temperature increase and the rapidity with which it is expected to occur are well outside of society's previous experience. I believe that, given the record of the last half-century, the likely impacts on salmon will therefore be far outside our ability to manage. If climate change anywhere near projected levels occur they will, I believe, prevent credible assessment and management advice being developed in a sufficiently timely manner to prevent major fishery collapses. It is now critical to begin doing a serious job of explaining to policy makers and politicians why salmon populations fail to return from the ocean, and to identify the relative importance of different parts of their life cycle to contributing to current failures. This will require information on the distribution, migration, and feeding success of salmon in the ocean which we have never been able to obtain. The development of POST promises a radical change in how fisheries research can be conducted in either estuarine or continental shelf waters. It is intended to change marine salmon research from a discipline based on a very limited observational capacity in the marine environment to one based on direct experiment with strong statistical rigor in the observations.

Clarifying Questions

None.

Panel/Audience Discussion - Session 4

Q: The presence of anchovy and baitfish might lessen predation pressure on juvenile salmonids because they'd serve as an alternate prey source for hake and other predators. However, do any of the forage fish compete with salmon for food?

A: Bob Emmett of NOAA fisheries is working on this issue. Some work has been done on this but it is not easy to measure. You need to remove one to see the impact and this is difficult in the ocean. For competition over food to occur, food needs to be limiting.

Q: What is the relationship between restoration in the estuary and impacts to salmon in the ocean, i.e., are we doing things in the estuary that affect survival in the ocean?

A: Not too much effort has been directed at this question. We need to know where these fish are going and we need to know if treatment is actually causing any changes or are other factors more important. Not much effort has been directed at tracking fish once they leave the estuary.

Q: What is the connection between life history diversity and the ability to tolerate changing ocean conditions?

A1: In Canada, they do weak stock management; there are weak stocks we try to protect while allowing fishing on strong stocks. So, having a wide diversity of stocks may be good from one point of view but not others.

A2: It is difficult to do "longitudinal" studies. We're trying to coordinate studies in the estuary with ocean research studies. It is important to compare indicators under different environmental conditions. For example, one might compare parasite load in fish in the estuary with those in the ocean/plume. We need to know the agents of mortality. Survivorship in different life stages is affected by different factors. We are just starting to make some of these comparisons because it takes 3 to 4 years to get the adult returns.

Q: Thinking longer into the life cycle, what is the balance between top-down versus bottom-up ecological controls? Does one become more important over time?

A1: Lots of questions are still unanswered on the ocean ecology of salmon. We need to understand what causes variability in salmon populations.

A2: In the southern range, we see low numbers in terms of the total so top-down controls may be most important. In the north, where we see larger numbers of fish, the bottom-up control might be applicable because of the competition factor. It's also possible that is not so much predation as it is a distributional change or physiological response to poor ocean conditions.

Session 5 – Management Perspectives

Introduction

Steve Waste, Northwest Power and Conservation Council

The Northwest Power and Conservation Council is an interstate compact. The Council has a Fish and Wildlife Program, funded by BPA and operating on a three-year funding cycle. The Council has a long history of supporting research and monitoring but mostly upstream of Bonneville Dam. In 2000, there was major shift toward the estuary. Now the Council is formally involved in the estuary, hopefully for the long term.

For the current cycle, research and restoration priorities have been identified. And, the Council has just finished developing a conceptual framework for monitoring. The Council is also heavily involved with the Pacific Northwest Aquatic Monitoring Partnership as they try to bring coherency to the effort.

The Council has greater interest in the estuary now but the challenge is how do we take information and make it available to managers to affect decisions. We need to organize ourselves to do effective management. Data need to be understandable and available to managers for decision-making.

States

Robert Bailey, Oregon Dept of Land Conservation and Development

Abstract

Oregon's Coastal Management Program is part of the state's land use planning program. We are keenly interested in the protection of resources. We respond to real world demands from the private sector that affect public resources. "Scientists need questions – managers need answers." Part of the responsibility of scientists is to make information available and part of the responsibility of managers is to seek out information. The degree to which managers make the right decisions depends on the robustness of the data, and its applicability and availability. How managers get information is a collective issue. We should have them annually to ensure a transfer of relevant information. There is an opportunity for organizations like CREST to provide coordination and synthesis and get information out to decision makers. There are plenty of issues to work on, e.g., liquefied natural gas terminals, dredging, the role of NGOs. Conferences like this are invaluable.

Tribes

Dale McCullough, Columbia River Intertribal Fish Commission

Abstract

A Framework for Salmon Recovery? Management Roadblocks and Needed Direction

Regional management scenarios are placing increased emphasis on what is happening in the mainstem, estuary, and the ocean. It is typically believed that there is nothing we can do about ocean conditions, although undoubtedly we do much to pollute the ocean and manage ocean fisheries. The focus of this conference is on the estuary, but the significant control on survival of populations and ESUs expressed by mainstem operations as they influence the estuary is a physical linkage that is not discussed in practical terms of changing management and studying the habitat and biological response.

There is a direct linkage between management, policy, and the research plans stemming from it. The research discussed in these sessions is essentially constrained in its hypotheses and results by the extent of the river management scenarios permitted by the Corps and BPA and the cumulative degradative actions permitted. Is it likely that the effectiveness of river flow elevations will be revealed from estuary studies on opening new marsh habitats when flows are to be highly constrained and only tidal fluctuations are available for study?

NOAA published a very high quality technical memorandum (Bottom et al. 2005, Salmon at River's End) on the role of the estuary in the decline and recovery of Columbia River salmon. It explained in great detail how the dams and their operation have devastated the estuary with flow restriction and alteration of the sediment regime. Yet, in its recommendations section there were no hypotheses to test the improvement in estuary function by restoring flows and sediment regime. These limiting factors are essentially off the table. Now we have a new generation of estuary researchers launched on a decades-long course of gathering information that is professed to be needed to set new management priorities and priorities for funding even more studies. Forgotten is what the identified limiting factors were that were noted in both Bottom et al. (2005) and in the Return to the River (RTTR 1995). RTTR was premised on the management principle of restoring normative conditions. Normative does not imply a 100% return to Lewis and Clark days but it does imply significant attempts to use that condition as a template and replicate that system to the greatest extent feasible. The Power and Conservation Council appears to have jettisoned this principle. This seems to be supplanted by the principle that the current condition will be the baseline for the future and that the river will never return to its historical condition.

So we have discounted the obvious management shifts in the river that are likely to have far-reaching consequences. Many factors for decline have virtually been taken off the table and are essentially forbidden to even be discussed (the hydro system operations, western water rights, mining laws). Many current management priorities are now promoted as scapegoat targets, such as seal and sea lion predation, pikeminnows, Caspian terns, "the hatchery problem." These are problems to varying extents, but they are problems stemming from the hydro system and river management. To correct these problems would eliminate important sources of mortality, but what remains is the continuing significant mortality due to the hydro system itself (dam passage, delay in the warm reservoir system). Other problems are promoted as overriding all our humanly abilities, such as global climate change and the annual ocean condition, and relieving us of the need to address hydro issues, given that these big picture issues are the real drivers. The salmon have evolved with significant natural variations in climate and ocean conditions. What they can't necessarily adapt to is the further perturbation to this environmental regime imposed by hydro operations. For example, sockeye have shifted their upriver migration approximately 1 month

earlier over the past decades as Columbia River mainstem temperatures have increased. Yet even this ability to accommodate environmental change has not been sufficient and these adults are still subject to water temperatures that are now about 2°C warmer during their current migration period than they were historically. The concept that fish life history is so plastic that fish can find a way to deal with changes imposed on the system is mistaken.

In the face of long-term natural environmental change when fish come under cycles of increasing stress, the prudent thing to do would be to adopt a "precautionary principle" in management that espouses not taking exceptional risks—not attempting to ride on a knife edge of viability but to allow additional margin for error in judgment and apply additional margins of safety. In the tributaries this implies not permitting 50% of riparian timber to be harvested in headwater streams but further protecting water temperature from basinwide cumulative increase. In the mainstem it implies seasonal flow targets that are patterned on historic variation and fish moving through the system at rates that match their natural life histories and in natural ways so that they imprint properly.

It was suggested that we cannot return the system to historic conditions. In a significant way this is inaccurate. CRITFC hydrology and engineering staff have demonstrated that it is possible to restore normative flows to the Columbia replicating historic flow regimes to a far greater extent than is done currently while still staying within flood control and gas cap guidelines. This proposal has been available to the region for quite some time. In what way will new estuary research be factored into future river management when proposals to address estuary condition in a serious way are discarded? Is the new generation of researchers being simply caught in a game of displacement science while we entertain a constant barrage of new proposals to place the estuary at risk? In recent months we have seen proposals to deepen the channel, increase permits for irrigation withdrawal from the river, and bring in LNG terminals. Incremental development succeeds by accepting a series of cumulative impacts, each one more and more difficult to distinguish likely impacts statistically against a background of worsening river conditions. The COE is now in the mode of "ecosystem restoration" but restoration always comes with the precondition of antecedent degradation. First they are funded to conduct an action with a substantial impact to environmental condition. This is followed by partial funding to correct both unforeseen impacts of the action (e.g., Caspian tern, sea lion removal, pikeminnow bounties) and some direct impacts to the estuary, resulting in funding to local groups to reopen estuary dikes, etc. Degradation is generally a certain outcome from hydro actions. Restoration is generally an experimental venture with uncertain success. It is a significant concern that the balance between degradation and restoration is a net downward path.

Our key agency charged with protecting salmon (NOAA) has an enormous science staff studying everything from A to Z in the river. Its scientists are among the best in the country. But just as private research teams have been encouraged to submit their findings and data to NOAA and the region for use in better decision-making, NOAA research goes to NOAA management, is internally analyzed, interpreted, filtered, referred to politicians, and decisions are made for river management that are often counterintuitive or uninterpretable by the public as stemming from science. How can the public perceive clearly what science says vs. management vs. politics and social value when all these functions are confused in one organization. How is it that there never seems to be a new proposal for major development in the Columbia that is rejected as being too harmful.

In order to forge a clear way out of this mess to recovery we look for opportunities to close gaps. These are places where we can take actions that will, by themselves or as a suite of related actions, improve survival or extend the rearing or spawning potential of fish (improve habitat abundance). Many habitat actions in the tributaries and estuary, however, will require decades to achieve substantial effectiveness. The desired risk level associated with Technical Recovery Team recovery goals is 5% in 100 years or better, but this is the risk that should materialize by the time the restoration actions are effective. This means that in the interim populations will be at much higher risk unless some actions can be identified that will result in rapid benefits.

Aside from allowing the river to function in a normative manner, one of the key technical needs of managers is to have a comprehensive assessment of fish health. Comprehensive analysis of fish condition and ecosystem processes is needed. The need exists for an agency to take on comprehensive analysis of factors affecting the survival of populations in the river. Such analysis should be independent of whether or not a species is listed. The public should not have to petition for a species to be listed before such comprehensive analysis of population health is made.

Breakdowns in tracking water quality impacts are evident in the region. WDOE's list of category 5 point source water quality problems in the estuary is linked to point sources but these are very limited in apparent scope. They are also based on the use of assigned mixing zones where toxic levels are permitted. No problems are assumed outside these zones. Nonpoint source impacts, such as basinwide temperature increases, are typically analyzed in the well-mixed flow of the river so that localized impacts become obscured. Effects of increased temperature stemming from heated small streams entering the mainstem Columbia could possibly cause localized impacts in the river margin. Changes in river margin temperatures in reservoir sections have the potential to impose intensified impact to salmonids such as subyearling Chinook that rear in marginal, slower flows. Water quality laws and research need to be directed to effects in localized but highly used habitats.

Incrementalism in impacts to fish viability has become so pervasive that a normative background can be difficult to ascertain from any existing reference conditions. Incremental degradation is mirrored by incremental development of BiOps. Each BiOp is a separate analysis, whereas each should be subsumed in a comprehensive restoration plan. There has been a concern for a long time in the NPCC's Fish and Wildlife Program that habitat actions that are proposed seem to be simply those that are available and that these do not necessarily fit the needs of a long-term plan in content or sequence. A similar concern might be expressed in research. Are research plans also simply opportunistic activities that fit funding opportunities or are they well directed to addressing hypotheses on response to the best needed changes to the entire river management plan? The quality of the research being done in the estuary is exemplary and the local efforts (both private and public) to make changes are a significant advance for the river. I simply wish to promote research that studies response to significant and essential change in management.

U.S. Army Corps of Engineers

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

Abstract

The Corps of Engineers has had a direct management interest in the Lower Columbia River for some time. For many years, this was related to the traditional missions of navigation, flood control, and hydropower. For navigation, this reaches back to 1878 when the Columbia River navigation project was authorized to provide for a 20-ft minimum channel depth. The Columbia River jetties were authorized in 1884. This navigation interest continues today as the Columbia River navigation channel is being deepened to a 43-ft depth, and as the Columbia River jetties are currently being repaired. Additional flood control measures and other improvements for navigation purposes in the Lower Columbia River have also been developed over time. Further upriver, the Federal Columbia River Hydropower System (FCRPS) was developed to provide hydropower, navigation, and flood control. The FCRPS development raised several Lower Columbia River management issues due to changes in the hydrograph and, particularly, potential effects on listed salmonids. Consequently, the Columbia River Fish Mitigation Program has included several evaluations in the Lower Columbia addressing salmonid habitat utilization and survival.

More recently, the Corps has assumed a new mission: ecosystem restoration. In 1986, Congress passed the first in a series of bills authorizing the Corps of Engineers to undertake environmental restoration projects in partnership with local sponsors. This first step towards a true environmental authority led the way for the expansion of the Corps' missions in 1990 to include environmental restoration. As a priority mission, environmental restoration now competes equally with flood control and navigation for increasingly limited Federal dollars. Of particular interest, Section 536 of the Water Resources Development Act of 2000 authorized the Corps to carry out ecosystem restoration projects in the Lower Columbia River and Tillamook Bay. Currently, only projects within the Lower Columbia River and its estuary have been funded. To learn more about these authorities, see http://www.nwp.usace.army.mil/pm/planning/envrest.asp.

This presentation will provide a brief overview of current Corps activities in the Lower Columbia River related to understanding ecosystem processes and ecosystem restoration projects. It will relate what we have learned at this conference to Corps authorities, justification of potential actions, and future direction.

Bonneville Power Administration

Bill Maslen, Fish and Wildlife Division, Bonneville Power Administration

Abstract

The Bonneville Power Administration’s (BPA) fish and wildlife responsibilities come from two primary sources, the Northwest Power Act and the Endangered Species Act. The BPA, along with all Federal agencies, have trust responsibilities to the tribes and follow provisions of the Clean Water Act, and National Environmental Policy Act, among others.

Columbia River Basin fish and wildlife enhancement activities need to address the entire range of habitat from the headwaters to the estuary and ocean. The Columbia River estuary provides a transition between the freshwater and marine environments for both juveniles and adults. In recognition of the Columbia River estuary's importance to salmonid populations in the Basin, the region's conservation and enhancement plans have included work on estuarine habitat, research, and monitoring as important actions. BPA will continue to work with the region to support and further advance this important work.

As a key part of the regional mitigation efforts, BPA and others in the region have developed a comprehensive estuary program to inventory, protect, and restore key habitats. The program includes monitoring, research, and analysis to evaluate the condition of the estuary, identify limiting factors, assess the effectiveness of actions, and understand key uncertainties important to management decisions. There are always more information needs identified than there are available funds, and a balance with competing, on-the-ground mitigation-action needs is required.

A key element for BPA and one that is often not addressed in the region is a way to identify the relative importance of various monitoring activities and research that BPA is asked to fund. Without a way for BPA or the region to judge the benefits of monitoring and research relative to other priorities put forth, there remains a danger that valuable and limited resources are not used to the best advantage of the Basin's fish and wildlife. Managers need monitoring and research proposals that clearly identify the management questions they are intended to inform or answer. Researchers need better information on priority management questions that their research should be addressing. This conference is one form for this communication, but additional technical and policy level forums are needed to advance this communication and improve the identification and prioritization of information needs.

NOAA Fisheries

Cathy Tortorici, Northwest Regional Office, NOAA Fisheries

Abstract

The National Marine Fisheries Service's mission is to conserve, protect, and manage living marine resources in a way that ensures their continuation as functioning components of marine ecosystems, affords economic opportunities, and enhances the quality of life for the American public. Specifically in the Pacific Northwest, our agency conserves, protects, and manages Pacific salmon, groundfish, halibut, and marine mammals and their habitats under laws such as the Endangered Species Act (ESA), the Magnuson-Stevens Fishery Conservation and Management Act, and the Marine Mammal Protection Act. Our agency also works in the non-regulatory arena to provide technical assistance and facilitate conversations on how best to manage our trust resources. Important to the success of our core mission is collaboration with a variety of stakeholders including Federal, state, and local entities, interest groups, and the Tribes in numerous forums to accomplish our work.

One of the ecosystems central to our work in the Columbia River Basin is the Columbia River estuary. Our Northwest Fisheries Science Center plays a key role in generating research that we

rely upon, along with other best available science, to develop policy about how best to manage our trust resources and this important ecosystem.

The biggest policy-related issue facing management of the Columbia River ecosystem is working to place the value of this estuary from the ecological and socio-economic standpoints in the context of the rest of the Columbia River Basin. This can only be accomplished through targeted research on fish use and ecosystem processes that can be translated into on-the-ground restoration work, continued improvement in the "regulatory" documents NMFS produces (e.g., recovery plans, ESA Section 7 consultations), and information that can be made available to all interested parties throughout the basin.

Panel/Audience Discussion - Session 5

Q: Letting the river be a river is a powerful statement. We have greatly altered the natural environment but salmon have survived in spite of us. Is giving back part of the river incrementally with projects the best way to let a river be a river? Regulations and permits can be daunting but sometimes small local projects can be effective. We need simple tools to make the process more effective.

> **A1:** The Pacific NW Aquatic Monitoring Partnership is a self-organizing, volunteer group that is putting some tools together.
>
> **A2:** The notion of letting the Columbia River be a river is on everyone's minds. But, the interests that altered the river are over 150 years old. Given that, as managers now, we need good information so we can make informed decisions in an adaptive management process and hopefully not further degrade the river.
>
> **A3:** True, but there are opportunities for the river to be more like a river. For example, restore natural flow and sediment regimes. Focusing research on current conditions is restrictive; it would be beneficial to experiment with natural flows.

Q: With respect to research, we are poorly situated to have a truly scientific recovery plan. We are not looking at the big issues because we are short on funding from organizations like NSF and other big scientific funding groups that provide us the kind of resources needed to look at big issues. Instead our research tends to be more based on the concern of the day, e.g., channel improvement, salmon restoration, etc.

> **A:** The Northwest Power and Conservation Council has developed a roadmap for moving forward – it's the Research Plan. It's a start but long range solutions can't be developed very well out of adversarial forms. We need good planning and coordination. The NPCC is trying to develop mechanisms to make our process better. Polarization does not do us well.

Q: Using the subbasin plans to prioritize decision making is problematic without adequate information. Comments?

> **A:** Guidance for subbasin plans is not followed too well by all folks. Future plans need to be more specific at the local scale. RME is important but there needs to be funding to put things on the ground as well. There has tended to be more focus on BPA for funding and other organizations that should be funding on the ground work have fallen to the wayside.

Closing Remarks

Irene Martin, Local Author, Fisher, and Historian

Thirty years ago, Russell Bristow developed the vision for CREST and later CREDDP. He would have been delighted about the monitoring and research going on now.

The health of the estuary affects people. Changes in the last 10 years have been devastating to the fishing industry and the local economy. We need to take advantage of this local connection.

Work done by scientists is important to the local community because what happens in the estuary affects the local community. The long-term memory of local residents such as fishermen should be a critical tool in developing restoration strategies. They can help managers see how decisions fit into the larger picture and they can help researchers understand more about historical conditions. They can help show how each decision has an impact.

The social element of decision making must be considered because the decisions affect local people. Researchers and managers must make connections with the local community. Research should be made available through libraries, colleges, and local agencies. Time should be devoted to making presentations on research to local folks.

Public support is critical to success. The biggest advocates for the estuary are those whose livelihood depends on it. The best allies for the estuary are the people who live next to it.

The End

Appendix A: List of Attendees

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