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CEERP SM3 Research, Monitoring, and Evaluation Workshop: Summary Report

October 2024

Kristin Jones
Nichole Sather
Heida Diefenderfer

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99354

Preface

Pacific Northwest National Laboratory (PNNL) conducted this project for the U.S. Army Corps of Engineers (USACE), Portland District. The Corps project manager and contracting representative were Mark Bierman and Jacob Macdonald, respectively. The PNNL project manager and technical oversight representative was Heida Diefenderfer and the PNNL Project No. is 82335.

Summary

The Columbia Estuary Ecosystem Restoration Program (CEERP) workshop, “CEERP Synthesis Memorandum (SM3): Research, Monitoring, and Evaluation,” was held in Portland, Oregon on June 24–25 2024. A diverse group of 26 domain experts with demonstrated knowledge and experience working in the Columbia River Estuary (CRE) participated. The primary purpose of the workshop was to inform and support development of the forthcoming third Synthesis Memorandum for CEERP to meet requirements under the Columbia River Fish Mitigation program. The workshop furthered the collaborative understanding of the state of the science regarding the CRE, helped to identify remaining knowledge gaps and uncertainties, and assisted in the prioritization of future restoration research and monitoring.

The structure of the workshop was designed to facilitate interactive discussion among all participants and generate a record of existing knowledge as well as new ideas and insights. To facilitate participation, attendees were grouped into four areas of domain expertise: Wetland Ecosystem Monitoring, Fish and Food Webs, Physical Processes, and Programmatic Planning. Activities were conducted individually or in self-selected groups.

The first agenda item was a panel discussion with four CEERP decision makers designed to evoke a conversation between panelists and participants. Following the panel, the bulk of the workshop was spent participating in eight breakout activities, one of which was prefaced by a presentation of the uncertainties previously identified by the CEERP Expert Regional Technical Group (ERTG, Appendix C, ERTG Uncertainties Presentation). The four domain subgroups met to collaborate on four activities and then reported out to all participants each time the workshop reconvened. This allowed for substantive contributions to be made by all individuals and for a variety of perspectives to be shared amongst the group as a whole. The final activities involved synthesis of all prior activities and knowledge generated, followed by anonymous voting on future research questions and a successful group effort to find consensus about priorities.

During the synthesis activity, domain groups reflected on the knowledge gaps and uncertainties still remaining related to restoration of the CRE, despite the large amount of data that has been collected. Each group discussed common themes in its responses, shown in Table 3 of the report, and summarized here:
Common themes discussed in the synthesis activities included data and knowledge gaps, for example: non-salmonids, the role of beneficial use of dredged material (BUDM) in habitat restoration, wetland health metrics, and mechanisms and process driving sediment accretion. Many participants also wrote about the need for increased collaboration between researchers and management and the possibility of incorporating social science into restoration projects, to involve the community more effectively. Communication both among researchers and management was an important topic, but also increasing communication with the community, landowners, and local governments, particularly determining how to tell both local and programmatic success stories. This would allow for communities to understand the value of the restoration work that is happening in the estuary, leading to increased public support and landowner buy in.

Workshop activities and participant discussions lead to the generation of recommendations for advancing CEERP goals and restoration of the CRE. Most of these are beyond the ability of the SM3 effort, yet they provide considerations relevant to future program planning, design, and execution:

- More frequent research presentations to ERTG and decision makers to promote information sharing, interactive discussion, and relationship building.
- Turn AEMR data into actionable information through analysis and synthesis, in a way that is transparent, and publicly accessible.
- Explore and shift to new data collection techniques that are most relevant to the research questions, rather than relying solely on what has always been done.
- Involve communities early and often in restoration projects. Share program success with affected communities. Find what resonates with each community and use that as a starting point for communication.
- Use lessons learned from other systems, not just from estuary research or this region.
- Long-term monitoring is critical to understand how systems are changing.
- Gain the trust of local governments and present importance of estuary research.
- Include potential adverse effects from invasives and climate change in estuary research projects.
- Turn data into a story that can be relatable to more than just the scientific community.
- Improve collaboration within the research community to utilize unique strengths.
- Make research results accessible through presentations and outreach.
- Hold more events like this workshop to get experts talking, collaborating, and generating ideas relevant to advancing CEERP.

Acknowledgments

The workshop was developed, organized, and coordinated by Nichole Sather and Heida Diefenderfer of PNNL, with funding by the U.S. Army Corps of Engineers, Portland District. We wish to thank Mark Bierman of the USACE and Jason Karnezis of BPA for their collaboration on development of the workshop, from clarifying the objectives at the start through final review of the activities. We would like to thank members of the ERTG, Janine Castro and Amy Borde, for their presentations and participation. We thank Allan Whiting, BPA, for securing the BPA Rates Hearing Room reservation. We also wish to acknowledge Kristin Jones of PNNL for staffing the workshop in the room and documenting and collating outputs from all activities in this report. We utilized our own notes as well as notes contributed by Laurie Weitkamp, Kailan Mackereth, and Kate Buenau in the preparation of this report.

Acronyms and Abbreviations

- **AEMR** - Action Effectiveness and Monitoring Research
- **BPA** - Bonneville Power Administration
- **BUDM** - Beneficial Use of Dredged Material
- **BiOp** - Biological Opinion
- **CLT** - Columbia Land Trust
- **CEERP** - Columbia Estuary Ecosystem Restoration Program
- **CRE** – Columbia River Estuary
- **CREST** - Columbia River Estuary Study Taskforce
- **ERTG** - Expert Regional Technical Group
- **LCEP** - Lower Columbia Estuary Partnership
- **NOAA** - National Oceanic and Atmospheric Administration
- **OHSU** - Oregon Health & Science University
- **PNNL** - Pacific Northwest National Laboratory
- **RME** – Research monitoring and evaluation
- **SM3** - Synthesis Memorandum No. 3
- **USACE** - United States Army Corps of Engineers
- **USFWS** - United States Fish and Wildlife Service
- **WDFW** - Washington Department of Fish and Wildlife

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1.0 Context and Purpose of Workshop

The Columbia Estuary Ecosystem Restoration Program (CEERP) workshop, "CEERP Synthesis Memorandum (SM3): Research, Monitoring, and Evaluation," was held in Portland, Oregon on June 24–25 2024 at the BPA Rates Hearing Room and the U.S. Army Corps of Engineers (USACE) building. This workshop was intended to support the concurrent development of the third Synthesis Memorandum for CEERP. The goals of the workshop were to collaboratively understand the state of the science around the Columbia River and Estuary (CRE), identify remaining knowledge gaps and uncertainties, and assist in the prioritization of future restoration research and monitoring. To accomplish this, a diverse group of domain experts with demonstrated knowledge and experience working in the CRE was invited to participate.

1.1 Workshop Participants

The workshop was attended by 26 restoration experts who perform a range of restoration and management-related roles at a variety of organizations: federal and state agencies, including action agencies and regulators; research institutions, and non-profit organizations (Table 1).

Table 1. Participants list, including corresponding organization and role.

Attendee	Organization	Role
Alex Uber	Washington Department of Fish and Wildlife	Engineer
Allan Whiting	Bonneville Power Administration	Habitat Lead
Amy Borde	Expert Regional Technical Group	Monitoring Program Lead
Ashley Smithers	Washington Department of Fish and Wildlife	Habitat Restoration Biologist
Catherine Corbett	Lower Columbia Estuary Partnership	Scientist
Chanda Littles	United States Army Corps of Engineers – Portland District	Coastal Ecologist
Chris Magel	NOAA Fisheries	Natural Resource Management
Curtis Roegner	NOAA Fisheries	Research Fishery Biologist
Denise Lofman	Columbia River Estuary Study Taskforce	Director
Heida Diefenderfer	Pacific Northwest National Laboratory	Restoration Ecologist and Research Scientist
Ian Sinks	Columbia Land Trust	Stewardship Director
Janine Castro	ERTG, US Fish and Wildlife	Project Leader and Geomorphologist
Jason Smith	Columbia River Estuary Study Taskforce	Habitat Restoration Program Manager
Joe Needoba	Oregon Health & Science University	Associate Professor and Researcher

Attendee	Organization	Role
Kailan Mackereth	Pacific Northwest National Laboratory	Aquatic Ecologist
Kate Buenau	Pacific Northwest National Laboratory	Quantitative Ecologist
Keith Marcoe	Lower Columbia Estuary Partnership	Scientist
Laura Brown	Washington Department of Fish and Wildlife	Restoration Coordinator
Laurie Weitkamp	NOAA Fisheries	Research Fish Biologist
Maggie McKeon	Pacific Northwest National Laboratory	Coastal Engineer and Research Scientist
Mark Bierman	United States Army Corps of Engineers – Portland District	Estuary Program Manager
Narayan Elasmar	Columbia River Estuary Study Taskforce	Fisheries Ecologist
Nikki Sather	Pacific Northwest National Laboratory	Aquatic Ecologist
Paul Kolp	Lower Columbia Estuary Partnership	Ecologist
Tawnya Peterson	Oregon Health & Science University	Assistant Professor and Researcher
Will Templeton	Coastal Oceans	Coastal Engineer and Modeler

1.2 Workshop Structure

The intention of the workshop was to facilitate interactive discussion among all participants. To the extent possible, presentations by the facilitators—Nichole Sather and Heida Diefenderfer—were limited and instead, discussion and collaboration were promoted through small breakout groups and individual activities (Figure 1; Appendix A, Agenda Handout). Presentations, when given, were intended to provide context to the activities and promote further thinking and discussion surrounding the topics (Appendix B, Workshop Slides). To facilitate participation, attendees were grouped into four areas of domain expertise based on a pre-workshop survey and knowledge of their work: Fish and Food Webs, Physical Processes, Programmatic Planning, and Wetland Ecosystem Monitoring.

The first agenda item was a panel discussion with four CEERP decision makers, designed to encourage a conversation between panelists and participants. Following the panel, the bulk of the workshop was spent participating in eight breakout activities, one of which was prefaced by a presentation of the uncertainties previously identified by the ERTG (Appendix C, ERTG Uncertainties Presentation). The fish and food webs, physical processes, programmatic planning, and wetland ecosystem monitoring subgroups met individually for collaboration on four activities and reported out to all participants when the workshop reconvened. This allowed for substantive contributions to be made by all individuals and for a variety of perspectives to be shared amongst the group as a whole. The final activities involved synthesis of all prior activities followed by anonymous voting on future research questions and a successful group effort to find consensus about priorities.

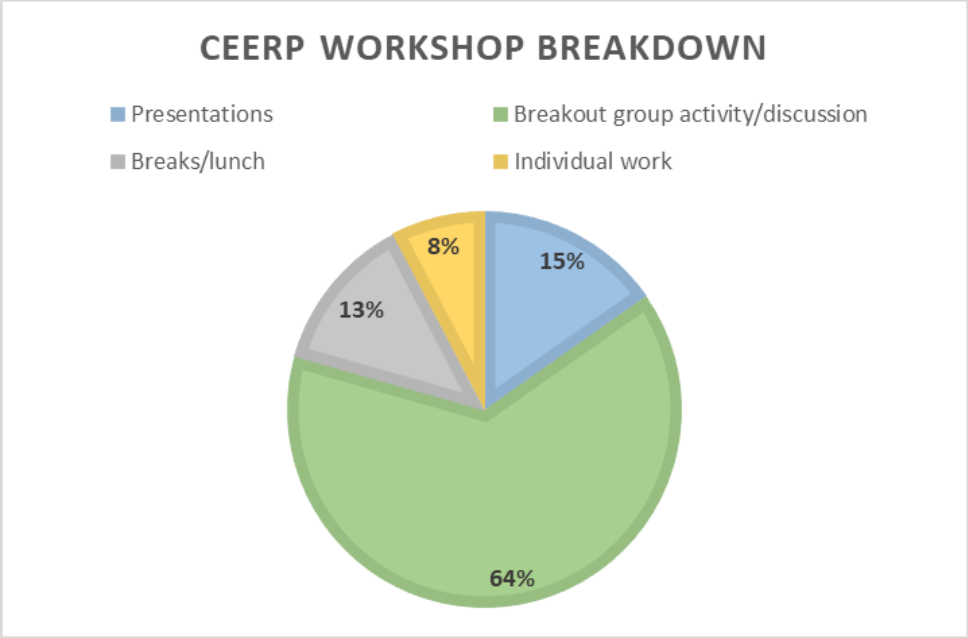


Figure 1. Time breakdown of the CEERP workshop as shown on the agenda (actual timing may have been slightly different).

2.0 Perspectives from CEERP Decision Makers: A Conversation

Purpose: Learn how data informs decision-making across a spectrum of CEERP program participants.

Description: CEERP relies on diverse stakeholders and participants. While CEERP is aimed at a common goal centering on ecosystem restoration, participants' respective roles in the program can translate into distinct needs relative to using data for decision making. The panel featured speakers representing different organizations and institutions to understand how they access and use data to support decision-making.

Format: Panel discussion.

Panelists included:

- Allan Whiting (BPA): Habitat lead
- Mark Bierman (USACE): Estuary program manager
- Chris Magel (NOAA): Natural resource management
- Janine Castro (representing the ERTG): Project Leader for the USFWS Columbia River Fish and Wildlife Conservation Office

Questions were posed to the panelists in advance and the panel began with each individual answering the following questions:

1. *Please tell us how your organization and the programs you steward intersect with CEERP – what are the drivers and the reasons you're engaged?*
2. *What are some of the most important things that research and monitoring have taught us since CEERP began?*
3. *How do you use data to inform and make program (or ERTG) decisions?*
4. *What are some new or emerging topics at your organizations as they relate to CEERP?*
5. *What things would you like to know more about to support decision making?*

2.1 Summary of panelist comments

Allan Whiting: The BPA has been funding a lot of research in the estuary and will continue to do so. Big projects are needed, particularly those around managing climate change and uncertainty.

Mark Bierman: USACE has different authority; it can't acquire land and has less flexible spending, but it can fund research projects and partner with others. One of the goals of the Corps is to understand how salmon interact with the estuary. They are putting emphasis on mitigation both for fish, and for Tribes near the river through the fish mitigation program and the Tribal housing program. The Corps also wants to explore BUDM and understand how to maximize its benefits.

Chris Magel: NOAA is looking to understand how to best prepare salmonids for life in the ocean, which will require robust life cycle models. Other areas of interest are predation mitigation associated with habitat restoration and tributary spawning grounds, resiliency to future threats such as climate change, and the longevity of placement of dredge material.

Janine Castro: ERTG has learned the landscape perspective; that fish don't need to access the habitat to benefit from it, as long as there is connectivity and that location matters, both within estuary and the interaction between habitat patches. ERTG would like to learn more about synergies between habitat patches, the future of flow management, and more information for the landscape scoring factor.

2.2 Concerns/issues that still need to be addressed

Following the individual panelist presentations, panelists had the opportunity to ask questions of each other and then questions were taken from all attendees. While the panel conversation shed light on organizational research and funding priorities, some unanswered questions were identified. Workshop participants felt that salmon life cycle models created so far are lacking and need improvement, particularly when it comes to representation of the estuary, which is often left out or lumped together with the ocean. There were also concerns about data accessibility, and discussion around the best ways to present data transparently. There was agreement on the importance of finding ways to make public outreach meaningful and accessible while telling the story of the estuary in a manner that engages people emotionally and intellectually.

Following the conversation, panelists were asked to name CEERP-relevant milestones that they expect to see in the next few years, the period in which recommendations from SM3 will be implemented.

2.3 Future milestones

USACE: Beneficial Use of Dredged Material (BUDM) modeling, and a new CEERP website.

NOAA: Improvement of the life cycle model with more variables and more data, focusing on predation mitigation from birds, pikeminnow and pinnipeds. Also, the date of the next Biological Opinion (BiOp) may be sooner than currently assumed.

BPA: Will be starting bigger and more complicated projects and are rethinking funding to add flexibility and build relationship with federal and other large funders. Would like to figure out socioeconomic constraints on paying people who do restoration, monitoring, and evaluation what they're worth to reduce turnover.

ERTG: Dredged material maintenance plan, Columbia River treaty, BiOp on the Willamette, and other litigation.

3.0 Activities

The sequence of activities was designed with a logical flow intended to elicit existing knowledge and to generate new ideas and insights. To that end, activities on Day 1 began by determining what knowledge relevant to CEERP is known versus unknown, followed by envisioning future programmatic outcomes for CEERP. This transitioned into an exploration of future Action Effectiveness and Monitoring Research (AEMR) needs and how existing data can contribute to knowledge advancement. After participants had time for reflection overnight, Day 2 began with a synthesis of learning from the first day, followed by the generation of and consensus on research priorities.

3.1 The CEERP State of the Science (aka What We Know)

Purpose: Through audience participation, build on the status of knowledge on ecosystem science and restoration in the CRE and benefits to juvenile salmonids and steelhead.

Description: The previous Synthesis Memoranda provided the CEERP community with updates on new scientific discoveries in the CRE. However, the ongoing nature of research and publication means that certain data and information may be missing from these Synthesis Memoranda documents. This activity included a combination of presentations on key findings and interactive discussion among domain expertise groups. The groups identified key lessons learned from the CEERP program and helped build on the status of knowledge on ecosystem science and restoration in the CRE.

Format: Brief presentation of key findings in previous Synthesis Memoranda, and the Restoration and Monitoring Plans' Master Matrix of Learning, by facilitators (Appendix B, Workshop slides) followed by breakout groups.

3.1.1 Summary from each expertise group

Fish and Food Webs:

- There are a lot of different stocks of salmon and other species, such as lamprey, shad, and chum, that don't use the same habitat at the same time. Many of these species are using a diversity of habitats in the estuary.
- Salmon diets suggest fish are feeding near the surface; however, prey resources are tightly coupled with benthic habitats.
- Remote sensing using drones is an efficient method for imaging and monitoring habitat and vegetation changes in the estuary.
- Understanding spawning grounds of the lower tributaries and monitoring adult returns is a good way to inform management of stocks and promote successful restoration.

Physical Processes:

- Almost all tributaries are significantly cooler than the mainstem, many have better sediment and temperature regimes, and are very dynamic.
- Accretion rates in the reference wetlands are generally positive, but information on where the sediment is coming from for areas that are accreting is lacking.
- The location of dredged material placement is changing and the number of public notices for dredging is increasing.

Programmatic Planning:

- The ERTG scoring is outdated and too narrowly focused on juvenile salmon only.
- ERTG scoring doesn't include adult salmon, climate change, adaptation, or anything above the tidal influence.
- Turnover of staff is high and data sharing is limited; however, regular check-ins between sponsors and restoration practitioners would be beneficial.

Wetland Ecosystem Monitoring:

- There are more data available in recent years on water quality in conjunction with wetland vegetation due to having more water quality and in situ sensors.
- There have been observations made that the size of snowpack and flow doesn't match.
- It's clear that abundance of Wapato is increasing at some sites, and this could be due to more warm days and less intense freshet.
- Restoration scientists have learned how to control reed canary-grass through spraying of herbicide and conversion of mid and high marsh back to native species.

3.2 Uncertainties and Knowledge Gaps (aka What We Don't Know)

Purpose: Workshop participants identify knowledge gaps critical for advancing CEERP program objectives

Description: There are numerous sources for knowledge gaps and uncertainties relative to CEERP goals and objectives (e.g., Synthesis Memoranda, ERTG critical uncertainties report, project-level future research recommendations). The drivers for research needs can be dynamic (e.g., changes to institutional priorities) or may shift because new knowledge has been gained. This activity sought to identify future research, monitoring, and evaluation (RME) focus areas, hypotheses, and research questions. Workshop participants, working in their domain expertise groups, identified knowledge gaps critical for advancing the CEERP program objectives.

Format: Brief presentation of ERTG Uncertainties by ERTG member, Amy Borde, of Columbia Land Trust (Appendix C, ERTG Uncertainties Presentation), followed by breakout groups.

3.2.1 Summary from each breakout group

Fish and Food Webs:

- Is predation random or selected based on certain factors, such as size, condition, etc.?
- How do we prepare for climate change and make the habitats successful in the future?
- What are the mechanisms driving prey productivity and what are the tipping points?
- Is there a connection between prey quality and quantity and habitat quality?
- Do shad compete with salmon in the lower estuary?
- How much sediment do we have to add to make habitats successful in the future?

- Fit chips (i.e. fish biomarkers) to downregulate stress response in fish; can these be studied to understand their relevance to CEERP and ability to assess fish health and benefits of restoration actions?

Physical Processes:

- How much sediment travels from the mainstem to the wetlands?
- Is dredged material more persistent in shallow or deep water?
- Do the primary drivers of sediment accretion differ between fluvial and tidal systems?
- How fast can plant communities respond to changes in inundation?
- Will increased shipping traffic increase the need for dredging?
- Can flushing flows be used to augment sediment in the estuary?
- What are the changes in inundation due to flow changes and sea level rise?

Programmatic Planning:

- Will NOAA give the action agencies credit for projects that benefit tidally influenced adult returns?
- Understanding short-versus long-term BUDM costs and benefits
- How do we implement changes to ERTG scoring to be more robust to a range of restoration actions (i.e., beyond floodplain reconnections) and to provide some level of acknowledgement for projects that may help address key CEERP uncertainties?
- How can we better support long-term landowner engagement toward positive outcomes?
- How can we make it easier to better support complex restoration projects, and how do we build more support for pilot projects?

Wetland Ecosystem Monitoring:

- How will climate change impact the wetlands? Need for predictive modeling and climate projections
- Need for understanding changes in wetland productivity and distribution of vegetation and marsh types
- How does species composition change for different prey resources?
- Need vegetation, organic matter, prey, design features (shading, large wood, deeper channels), and temperature data to inform predictive models
- What is the sediment accretion needed for wetlands to keep up with climate or management changes?

3.3 Visions for Future CEERP Outcomes (aka, What We Imagine)

Purpose: Participants will each create a vision statement describing a future state of the CRE.

Description: This activity supported time for individual thinking on what their thoughts were for the future vision of the CEERP program. In 5 years, what will we have achieved to advance our knowledge of the system to benefit habitat and juvenile salmon and steelhead? Participants each created a vision statement describing a future state of the CRE, including a research question, how the success was achieved, leadership and collaboration efforts, and why this achievement was important (Appendix D, Visions).

Format: Individual activity: Newspaper article highlighting a future state of the Columbia River and estuary. Individuals shared their vision/headlines with other participants.

3.3.1 Themes seen throughout visioning exercise

Themes and topic areas represented throughout the participants' visioning exercises are listed in Table 2 (Appendix D, Visions).

Table 2. Themes from Visions for Future CEERP Outcomes exercise.

Engagement and Collaboration	**Climate Change**	**Methods**	**Outcomes**
Community and landowner collaboration	Climate resilience	Habitat restoration	Watershed restoration
Tribal support	Natural climate solutions	BUDM pilot projects	Ecosystem functions restoration
Scientist and working group collaboration	Climate change and sea level rise resiliency	Dam removal	Floodplain reconnection
Public support	Carbon sequestration		Multispecies benefit
Federal agency partnership			Salmon stock recovery
Community improvement	**Metrics, Indicators, and Testing**	**Research Topics**	Ecosystem services benefits
Cross sector partnership	Drone measurement	Snowpack impact on salmon	Reconnections of tidal rearing habitat
Federal and university collaboration	Vegetation indicators	Sediment accretion	Spawning grounds restoration
Stakeholder engagement	Fish health biomarkers	Prey resources	Large adult return
	Water quality	Prey export to mainstem	Habitat diversity
Modeling	Pre and post construction monitoring	BUDM habitat outcomes	Diverse invertebrate composition
Hydrodynamic modeling	Mesocosm testing		Habitat suitability
Predictive modeling			Land acquisition of critical salmon habitat
Numerical and statistical modeling			Restoration of floodplains

3.3.2 Highlights of relevant headline activities

Headlines generated during the activity were chosen to be highlighted here if they presented a clear research question, addressed the methods and actions taken to achieve the desired outcome, and explained why the outcome of the project was impactful.

1. Addressing community concerns saves salmon
    a. Research question: How to solve the habitat-community conundrum and address critical issues using cross-sector collaboration, partnerships, and building trust.
    b. How was this achieved: Collaboration between federal, state, and private funders across sectors, with a focus on sea level rise, flooding, and critical infrastructure improvements identified by communities but using an ecosystem function lens.
    c. Why was this important: These improvements led to significant investment in rural communities in Oregon and Washington, creating thousands of acres of habitat improvements critical for salmon recovery.
2. Fish health biomarkers changes perspectives on effectiveness of ecosystem restoration
    a. Research question: How to develop novel biomarkers to evaluate fish health.
    b. How was this achieved: Collaboration between federal agencies and universities to conduct lab studies over 5 years. Lab testing found and validated biomarkers, followed by mesocosm and field testing.
    c. Why was this important: The biomarkers have changed the way ecosystem restoration and the benefits have been understood, providing indicators of fish health with a quick turnaround time on the order of hours to days.

3. Estuary no longer a bottleneck to salmon recovery
    a. Research question: How to increase salmon survival in the estuary
    b. How was this achieved: 30 years of collaboration with many partners all working towards a common goal. Creating steppingstones of productive salmon habitat and exporting prey to mainstem nourishes larger salmon during the trip downstream.
    c. Why was this important: Increased salmon habitat provides abundant productive areas for fish as they move towards the ocean and improves chance of survival.

3.4 Future AEMR

Purpose: Explore Action Effectiveness and Monitoring Research (AEMR) approaches and evaluate the level of knowledge and impact associated with the monitored indicators. Evaluate the frequency, duration, and spatial scale of AEMR data collection.

Description: The tiered levels of AEMR monitoring indicators have been deployed at numerous sites over many years. This workshop activity collectively evaluated the knowledge and impact these monitored indicators provide to decision-making and restoration planning. Participants were not constrained by the current AEMR three-tiered structure but focused on indicators that are applicable to research questions.

Format: Breakout groups. Participants placed individual indicators on Figure 2, with respect to the knowledge and impact the indicator provides for decision makers.

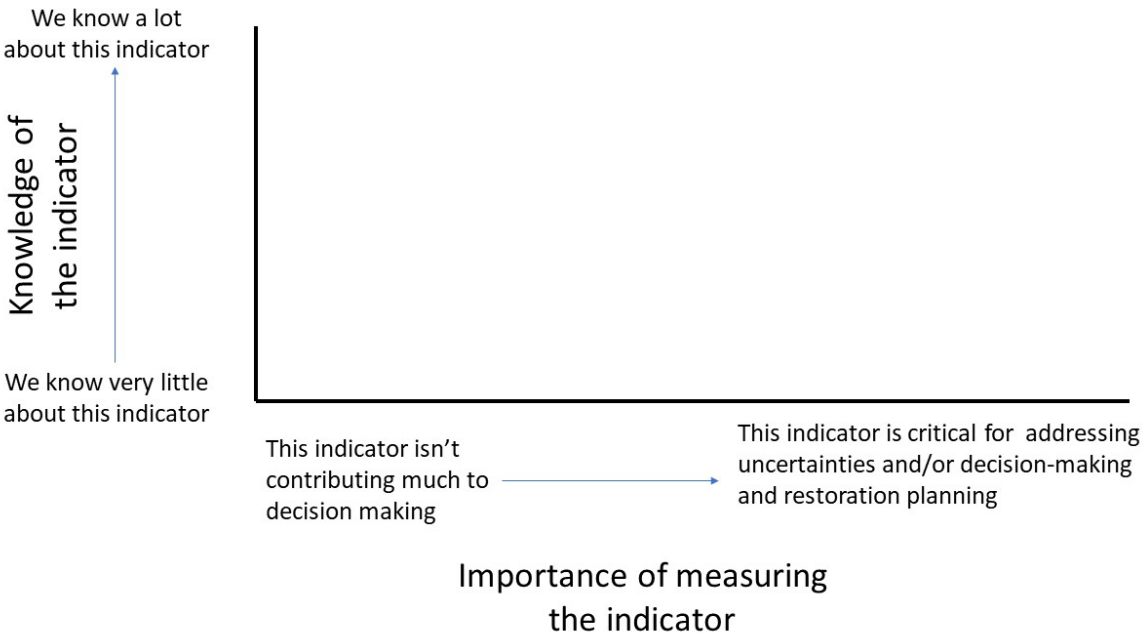


Figure 2. Measure of indicator knowledge and importance plot used in Future of AEMR activity.

3.4.1 Summary, comments, and suggestions for improvement

Throughout this activity, participants found that the indicators that we know the least about seemed to be the ones of high importance. Participants found it challenging to assign importance between site scale versus program scale and some concluded that specific research questions could help determine the importance of indicators/metrics. Many of the groups placed the fish indicators (growth, condition, stock, survival) high on importance but low on knowledge. Indicators that generally were placed as being both important and high on knowledge were latitude/longitude, temperature, salinity, and WSE.

Participants felt that this exercise was worthwhile and needed more time and deeper conversation to more fully engage in discussion about each indicator. Another aspect when discussing the value of metrics and indicators that participants deemed important is the cost associated with the metric/indicator, and they thought including this factor in the exercise would have added more insights, particularly given the advances in monitoring technology. Participants also found that it was difficult to agree on where to place metrics/indicators on the plot and given the variety of perspectives in the room, there were differing opinions on what the plots should look like. While this caused some difficulty, it also allowed for interesting and engaging discussion.

3.5 Advancing Knowledge with Existing Data

Purpose: Brainstorm ideas to leverage existing datasets to address knowledge gaps and uncertainties.
Description: The decades of CEERP research and monitoring studies have significantly advanced the understanding of salmon ecology and restoration science in the CRE. Yet, the number of uncertainties is incongruent with federal research budget constraints. This activity is intended to explore opportunities to do more with the data we have in-hand. Participants brainstormed ideas to leverage existing datasets to address knowledge gaps and uncertainties in this walk and talk activity.

Format: Participants formed into groups of four, according to similar domain expertise, or inter-disciplinary backgrounds and reported back to the full group of participants

The following questions were suggested as prompts:

- What data do you have or know about that could be used to advance findings relative to CEERP uncertainties?
- What research questions would you ask?
- What resources would you need?
- What collaborations would you build to extend the impact of this existing data?

3.5.1 Summary from discussions

A common theme among discussions was focused on how data gets turned into information in an accessible way. Creating long reports that people don't read, isn't useful. Finding a way to share and display data accessibly is worth further conversation. Conversations also revolved around modeling and how data can be collected in a way that makes it easier to link the data and relate states and processes when building models. Another data consideration was determining what to collect, balancing the interplay between the ease of collection and processing with the actual utility of that data. As technology changes, we should consider which techniques are most conducive to addressing critical uncertainties, instead of focusing solely on techniques and metrics that have been measured in the past. Much data has already been collected from AEMR, so we are "data rich", but turning that data into information is where the challenge lies, especially when funding might not give equal weight to data analysis relative to data collection. How can CEERP do this in a way that turns information into a story that is more accessible and engaging?

3.6 Synthesis

Purpose: This activity was intended to gather participant conclusions, based on professional experience and workshop participation, on key findings and relevance to CEERP.

Description: Having spent a day participating in various workshop activities, this activity was designed to draw on participant expertise to integrate and synthesize knowledge from across program elements and topics.

Prompts:

- How would you tell the story of ecosystem restoration for juvenile salmon in the lower Columbia River and estuary?
- What conclusions do you draw about what we know and don't know?
- Consider a special focus on 2018-2024 to coincide with the dates to be represented in SM3.
- Consider the activities from day one: CEERP state of the science; Knowledge gaps; Vision for future RME; AEMR; Advancing knowledge with existing data

Format: Individual writing activity followed by discussion.

3.6.1 Common themes by domain group

All domain groups reflected on the knowledge gaps and uncertainties still remaining related to restoration of the CRE, despite the large amount of data that has been collected. While there were other similarities between domain groups in their synthesis activities, each group discussed common themes in their responses (Table 3).

Fish and Food Webs: This group discussed the lack of data around fish species in the estuary outside of salmonid species, the need for incorporating estuary and ocean data into life cycle models and the need for long term data to show and predict patterns and trends in climate change effects. In addition, improving understanding of functional attributes (e.g. prey productivity, salmon growth and health) and mechanisms driving these attributes at different wetland and aquatic habitats has strong implications for management, decision making, and evaluation associated with habitat restoration and BUDM sites. Many participants in this group also mentioned the need for increased community engagement, collaboration among researchers and management, and incorporation of social science into restoration projects in order to more effectively share information and bring together all key players.

Physical Processes: Many of the responses in the domain group were focused on knowledge gaps, indicating that many uncertainties that exist today are the same uncertainties that existed 20 years ago. Some of those knowledge gaps included: fundamental metric of wetland health and resilience, mechanisms and processes driving sediment accretion, and data related to flow, sediment transport, turbidity, and water level. Despite the data gaps, it was cautioned that data should only be collected if it informs uncertainties or future threats, not collected just to be collected. Participants discussed the importance of involving the community in a participatory manner in restoration and the need for better communication to the community to relay scientific and restoration successes.

Programmatic Planning: This group identified knowledge gaps around the role of BUDM in sea level rise resilience and habitat restoration, plant community response to sea level rise and climate change, the impact of restoration projects on communities, and expanding projects beyond juvenile life stages. Participants spoke about the need for investment in data management, adaptive management, and the importance of collaboration. A common occurrence in many responses was the question of how local and programmatic success stories are best told to communities. This would allow for communities to understand the value of the restoration work being done in the estuary.

Wetland Ecosystem Monitoring: Many of these responses were focused on data, monitoring, and adaptive management. Participants felt that data needed to be expanded to include other

species in the estuary, but not just be collected just to collect data, but make sure that it has a purpose. Upfront investment in data management and the inclusion of social and economic metrics in projects was suggested. There were also knowledge gaps identified related to sediment accretion, and detrital production, breakdown, and export. Garnering public support, increasing landowner buy in, and understanding the motivations goals of the community were indicated as important steps for future restoration projects.

Table 3. Common themes found in synthesis activities by domain group.

Common Themes			
Fish/Food Web	**Physical Processes**	**Programmatic Planning**	**Wetland Monitoring**
Data gaps (e.g., other key species)	Wetland knowledge gaps and uncertainties (health, resilience)	Climate change and sea level rise resilience	Data collection and management
Model development (e.g., life cycle model)	Community engagement and participation	Success story telling	Social science and community engagement
Social science and collaboration between scientists and management	Data gaps (accretion, sediment transport, elevation)	Adaptive management	Hydrology, sediment accretion, and detritus
Community engagement and useful data presentation			Monitoring methods and adaptive management

3.7 Research Priorities

Purpose: Identify and prioritize key research questions to advance CEERP decision-making.

Description: Breakout groups brainstormed research questions and down selected from their list to share three key questions to the larger group of participants. Individual attendees ranked the resulting 12 research questions in Mentimeter, an online polling platform. The ranking resulted in a prioritized list (Figure 3, see next page) which was followed by a group activity to categorize the 12 questions by topic areas.

Format: Breakout groups.

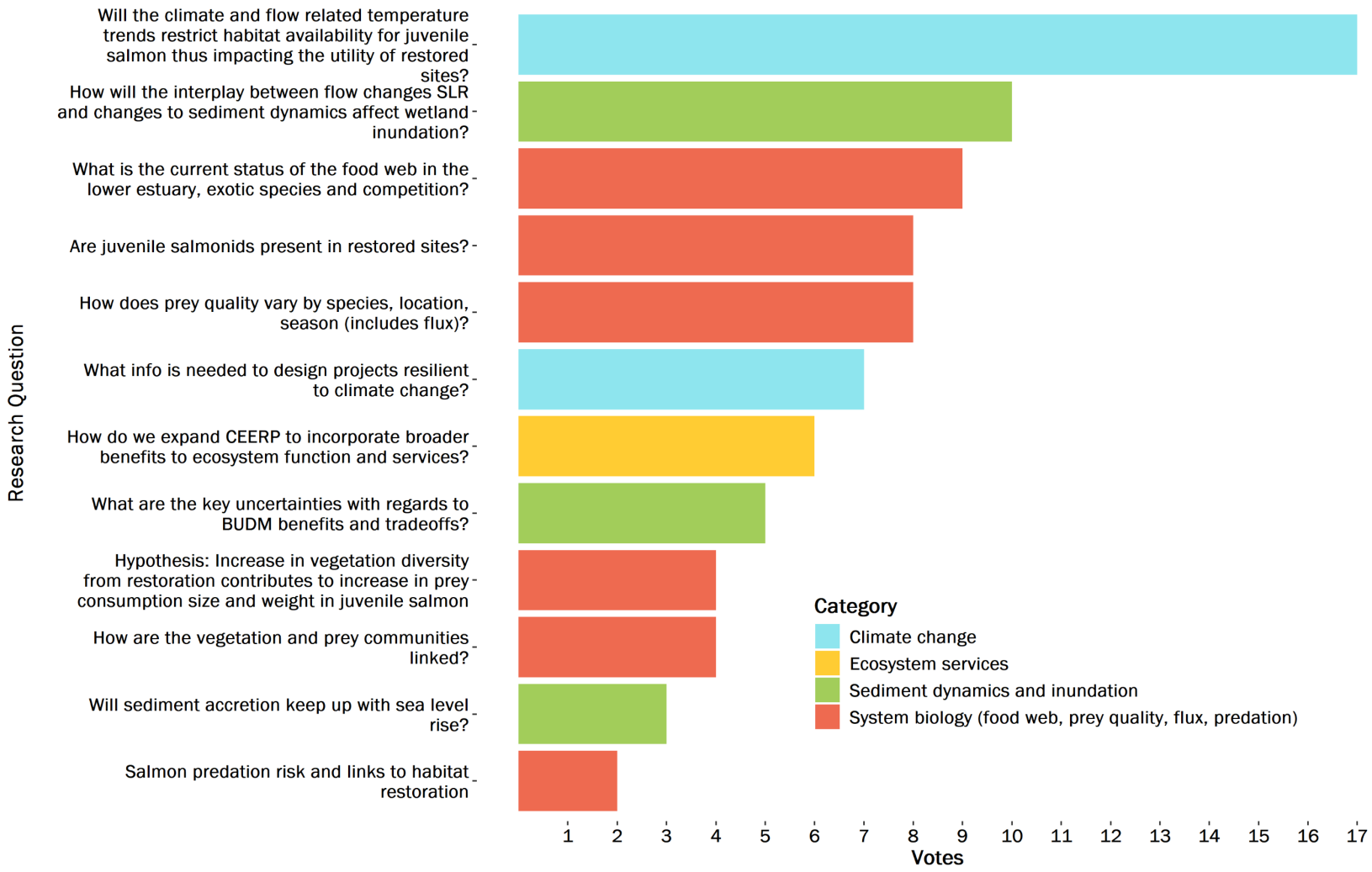


Figure 3. Research questions, ranked in order of most to least votes. The four breakout groups submitted their top three research questions which were compiled into a list of 12 questions categorized into four research focus areas. Workshop participants individually ranked the 12 questions from most to least important.

3.7.1.1 Common themes among other research questions not included in the top 12

The exercise generating research priorities resulted in many more potential research questions than the top twelve listed above. While too many to list here, there were some common themes, some of which overlap with research questions in the top 12. The fish and food web group asked questions about metrics and indicators, life cycle modeling, prey quality, quantity, productivity, life cycles, and seasonality, and climate change effects. The physical processes group asked questions about effects of increased water temperatures, wetland resilience, habitat patches and sediment accretion, sea level rise and flow changes, and wetland inundation. The wetland ecosystem monitoring group asked questions about detritus import/export, supply and variability, prey production, vegetation communities' composition and biomass, and sediment accretion rates. The programmatic planning group asked questions about climate change impacts, BUDM, fish growth, condition, and carrying capacity, and public engagement and data sharing.

4.0 Reflections from the Workshop and Emerging Recommendations

The CEERP workshop brought together a diverse group of experts from a variety of perspectives, yet in the final discussion of research priority and synthesis activities, many participants affirmed that there was consensus among breakout groups regarding the top final research questions (Figure 3) and noted that similar ideas had been generated by different breakout groups. This was likely driven by participants' extensive prior experience in the CRE and with CEERP, and shared understanding of the fundamental questions that are critical to move estuary restoration forward. Such shared understanding was indicated by the relative speed and ease with which four small subject-matter focused groups generated research questions for ranking, which all participants grouped into the four agreed-upon categories described in the preceding section.

Some of these critical questions involved communication and collaboration with the community at the start and throughout a restoration project and the display, distribution, and accessibility of data. Participants reflected on the vast amount of data already generated, but also the wide variety of data gaps still needing to be filled and the need to do the work to convert data into information. One of the common themes heard throughout the second day by many participants was the need to incorporate social sciences into the CRE restoration process to unite all key players. There was support for increased community engagement and meaningful communication with landowners and local government.

This workshop was a space for restoration experts to share their expertise and guide future research and provided an outlet for multiple perspectives to be shared and heard. The word "collaboration" came up extensively throughout discussions: collaboration with community, with decision makers, with other researchers, and among peers. That was the goal of this workshop and seemed to be one of the strongest recommendations from participants: increase collaboration before, during, and after restoration projects to leverage expertise and build relationships. Overall, participants felt the workshop was a good way to critically think about the work being done in the CRE and that the restoration community would benefit from more frequent in-person meetings.

Throughout the workshop activities and discussions, participants generated and articulated various recommendations for advancing CEERP goals and restoration of the CRE. Most of these are beyond the capacity of the SM3 effort, yet they provide considerations relevant to future program planning, design, and execution:

- More frequent research presentations to ERTG and decision makers to promote information sharing, interactive discussion, and relationship building.
- Turn AEMR data into actionable information through analysis and synthesis, in a way that is transparent, and publicly accessible.
- Explore and shift to new data collection techniques that are most relevant to the research questions, rather than relying solely on what has always been done.
- Involve communities early and often in restoration projects. Share program success with affected communities. Find what resonates with each community and use that as a starting point for communication.
- Use lessons learned from other systems, not just from estuary research or this region.

- Long-term monitoring is critical to understand how systems are changing.
- Gain the trust of local governments and present importance of estuary research.
- Include potential adverse effects from invasives and climate change in estuary research projects.
- Turn data into a story that can be relatable to more than just the scientific community.
- Improve collaboration within the research community to utilize unique strengths.
- Make research results accessible through presentations and outreach.
- Hold more events like this workshop to get experts talking, collaborating, and generating ideas relevant to advancing CEERP.

Given the successful completion of the workshop, facilitators and CEERP action agencies will next consider insights from participants, potentially taking the following next steps: Focusing on key research questions for organizing progress made in the last 5+ years and recommendations for future work in the forthcoming SM3; presentation of workshop results (conference, forum, website etc.); creation of additional subcommittees (monitoring, social sciences) for additional input and expertise on specific topics of interest; holding additional meetings or workshops; and continuing the conversation on monitoring metrics and indicators.

Appendix A – Workshop Agenda

CEERP SM3 Research, Monitoring, and Evaluation workshop agenda

Monday, June 24
BPA Rates Hearing Room

8:30 – 9:00	**Welcome!** Participants check-in, settle into the meeting room
9:00 – 9:55	**Introduction to the workshop** - Purpose, objectives, outcomes - Participant expectations and outcomes - Breakout groups - Group Norms - Introductions
9:55 – 10:55	**Perspectives From CEERP Decision Makers; a Conversation** - Learn how data informs decision-making across a spectrum of CEERP program participants - Panelists: Mark Bierman (USACE), Jason Karnezis (BPA), Janine Castro (ERTG), Chris Magel (NOAA)
10:55 – 11:10	**Break**
11:12 – 12:10	**Summary of the CEERP State of the Science** - Presentations and breakout groups - Participants will build on the status of knowledge on ecosystem science and restoration in the LCRE and benefits to juvenile salmon and steelhead.
12:10 – 1:00	**Lunch** - Boxed lunches provided to participants
1:00 – 2:00	**Uncertainties and Knowledge Gaps** - Presentation on ERTG Uncertainties - Participants will identify knowledge gaps critical for advancing CEERP program objectives -
2:00 – 2:45	**Vision for the future CEERP Outcomes** - Participants will advance thinking on a future state of the LCRE
2:45 – 2:55	**Break**
2:55 – 3:45	**Action Effectiveness, Monitoring, and Research** - Presentation and review of the CEERP AEMR Plan - ERTG feedback of AEMR and associated data collection efforts

	- Participants will evaluate the level of knowledge and impact associated with various monitored indicators
3:45 – 4:45	**Advancing knowledge with existing data** - Participants will brainstorm ideas to leverage existing datasets to address knowledge gaps and uncertainties
4:45 – 5:00	**Close out**

Tuesday June 25

USACE

8:30 – 9:00	**Welcome!** Participants check-in, settle into the meeting room
9:00 – 9:15	**Reflections from day one activities**
9:15 – 10:15	**Synthesis** - Participants to develop approaches and conclusions on how to integrate key findings from workshop and ongoing research activities, relative to CEERP program goals.
10:15 – 11:15	**Research Priorities** - Participants to participate in brainstorming of research and a prioritization exercise to determine the most pressing needs
11:15 – 12:00	**Close out**

Appendix B – Workshop Slides

Pacific Northwest NATIONAL LABORATORY

Bonneville

US Army Corps of Engineers

Columbia Estuary Ecosystem Restoration Program (CEERP)

CEERP SM3 Research, Monitoring, and Evaluation Workshop

BPA Rates Hearing Room
June 24, 2024

Pacific Northwest NATIONAL LABORATORY

Workshop participant expectations

Common themes:

- Identifying data and knowledge gaps
- Discussing next steps in research, monitoring, and data collection
- Gain understanding of a variety of researcher perspectives
- Synthesis of knowledge gained about Columbia River Estuary
- Understanding how researchers' work can align with broader restoration efforts

Key word: Collaboration

Things you would like to learn

- Determining best next steps.
- Identification of metrics/indicators that can be measured to reduce uncertainties and fill data gaps.
- Incorporation of climate change and cumulative effects into estuary research and restoration.
- Future of the AEMR program.
- Understanding impacts of restoration activities, cumulative effects, climate change, and other human activities on juvenile salmon.
- Approaches to monitoring.

3

Breakout Groups

Physical Processes	Wetland Ecosystems
Alex Uber	Amy Borde
Allan Whiting	April Silva
Heida Diefenderfer	Ashley Smithers
Janine Castro	Ian Sinks
Keith Marcoe	Jason Smith
Maggie McKeon	Joe Needoba
Paul Kolp	Kate Buenau
Will Templeton	Narayan Elasmar
Programmatic Planning	**Fish/Food Web**
Alex McManus	Chris Magel
Catherine Corbett	Curtis Roegner
Chanda Littles	Kailan Mackereth
Denise Lofman	Laurie Weitkamp
Laura Brown	Nikki Sather
Mark Bierman	Tawnya Peterson

4

Group norms

- Share the air
- Be present, or be elsewhere
- Be the crew, not the passenger
- Aim for quantity
- Defer judgement, filter
- Think blue sky
- Parking lot

Introductions

Name

Title/Role

Organization

*what is something fun you have planned for this summer?

Perspectives from CEERP Decision makers; a conversation

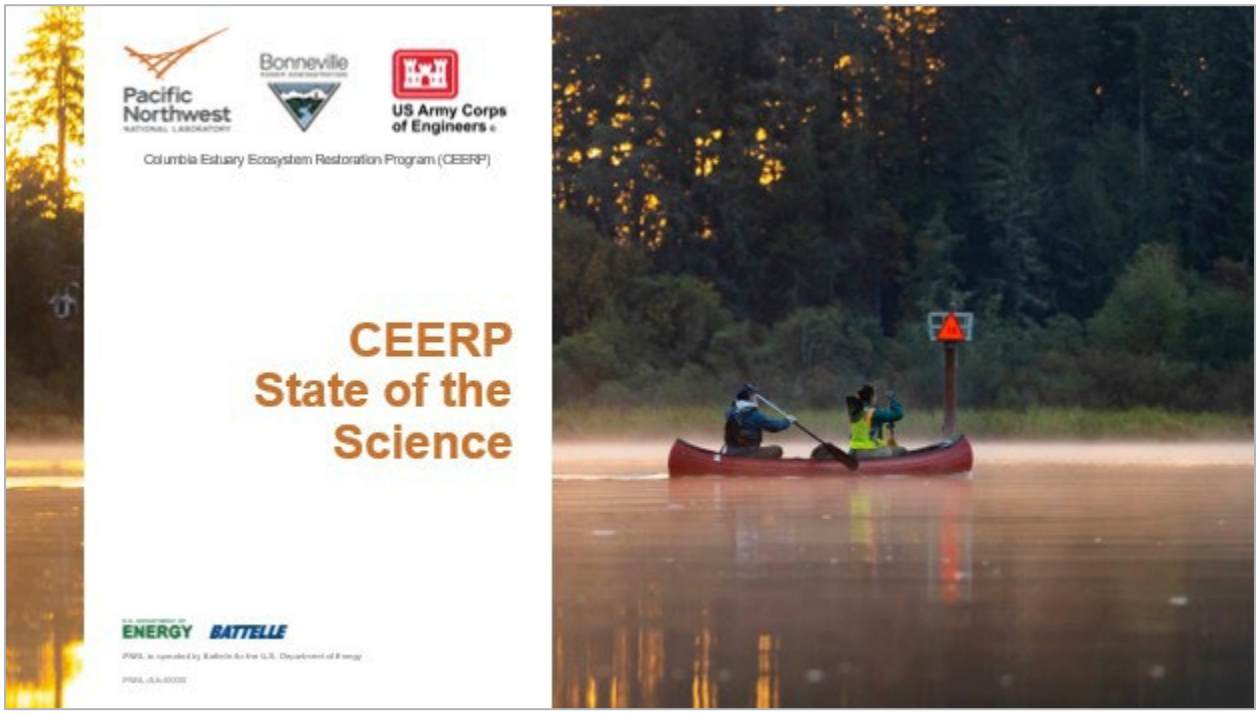
Purpose: Learn how data informs decision-making across a spectrum of CEERP program participants

Panelists:

Mark Bierman USACE	Jason Karnezis BPA
Janine Castro ERTG	Chris Magel NOAA

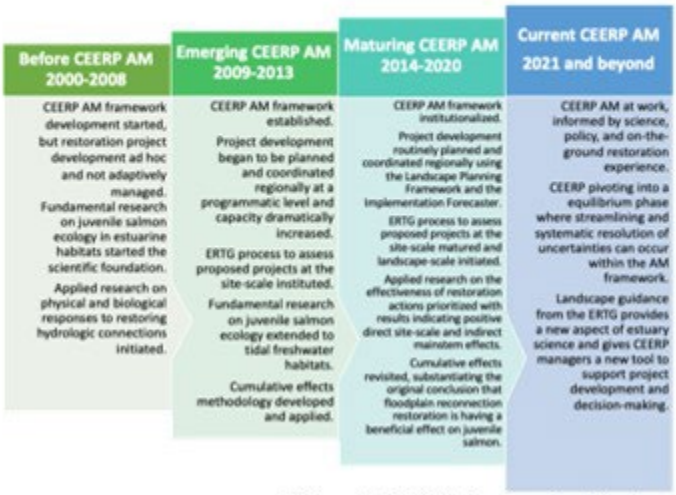
USGS

7



Historical and Contemporary Research

- Historical research and data
  - CREDP studies: 1978-1984
  - Dawley et al. studies: 1966-1983
  - archival data
- Contemporary research
  - Critical uncertainties, status and trends, and AEMR
  - 2012 Synthesis Memorandum
  - 2018 Synthesis Memorandum
  - Master Matrix of Learning



Littles et al. 2022, Restoration Ecology

2012 Synthesis Memorandum

What are the contemporary patterns of juvenile salmon habitat use in the estuary, and what factors or threats potentially limit salmon performance?

Hatcheries are a driver of contemporary life history diversity

Estuary rearing today may not reflect habitat/restoration needs of less represented and at-risk stocks

Unsure if hatchery practices - massive releases of similarly sized fish - enhances predator populations in the LCRE

Advocate for restoration that results in full reconnection of hydraulic connections, not partial connections

Historic loss of marshes in LCRE may be reducing overall current capacity of the system

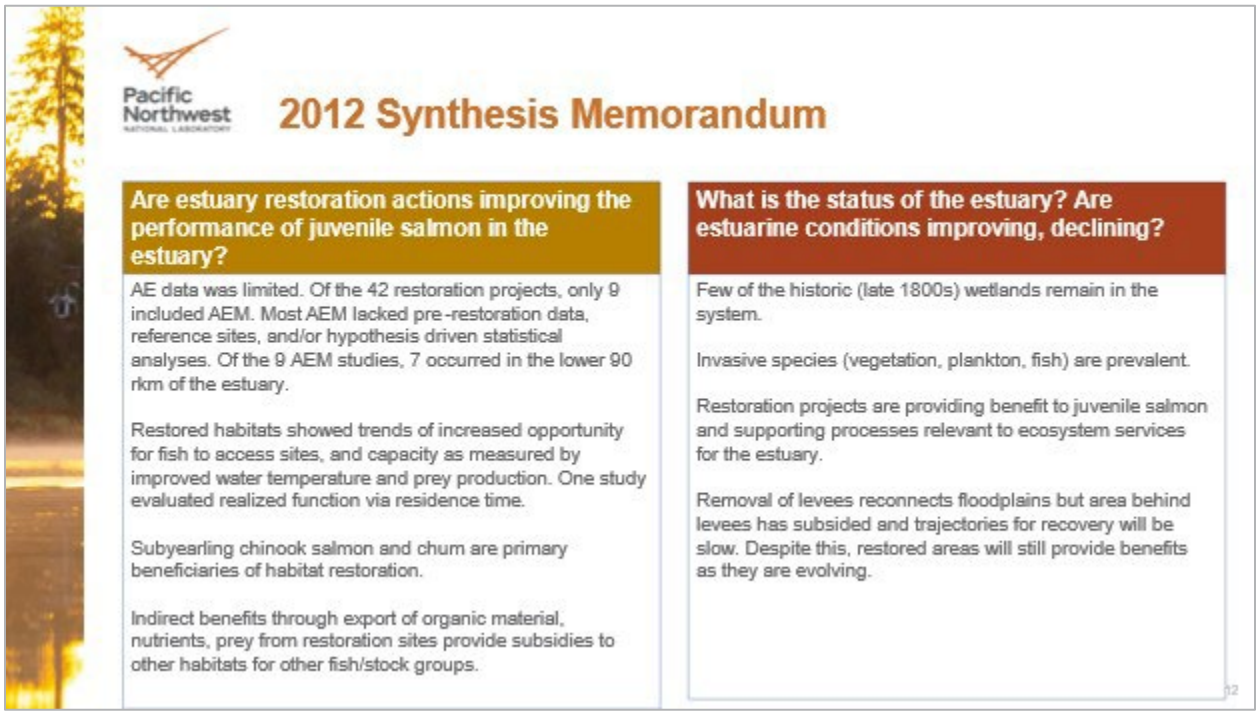
Not enough info on competition and predation within wetlands between salmon, non-native fish, and fish predators

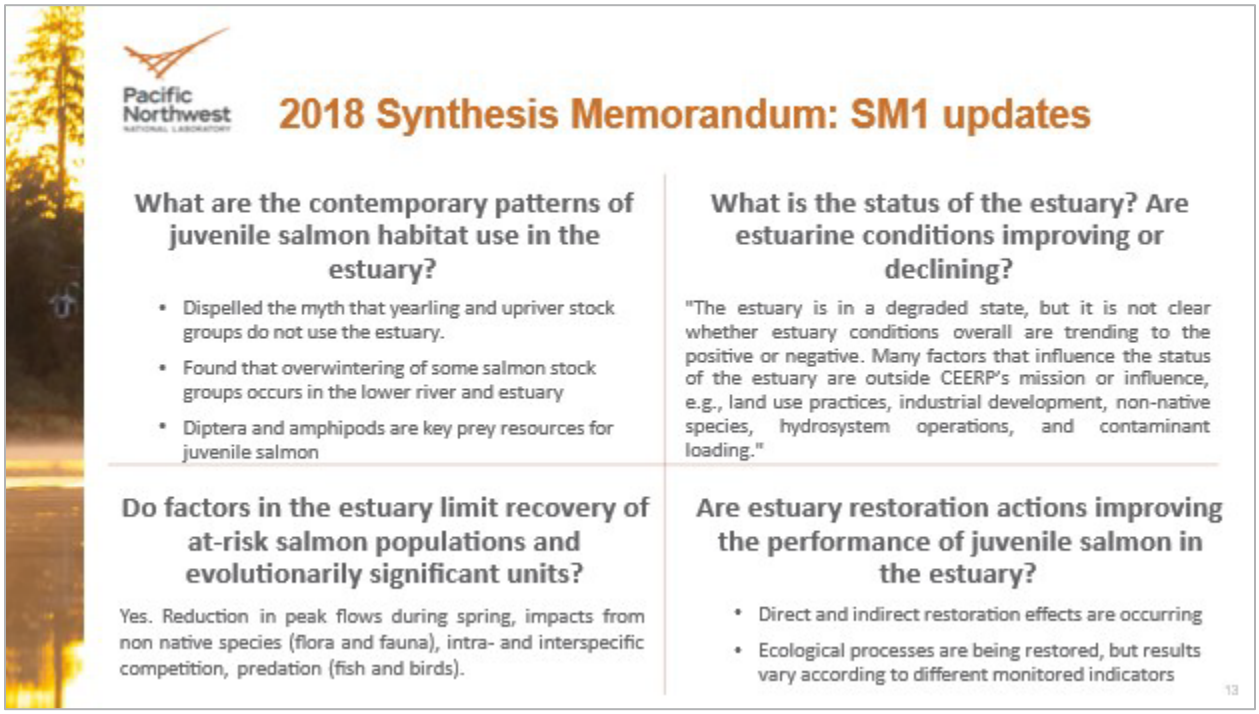
Do factors in the estuary limit recovery of at-risk salmon populations and ESUs?

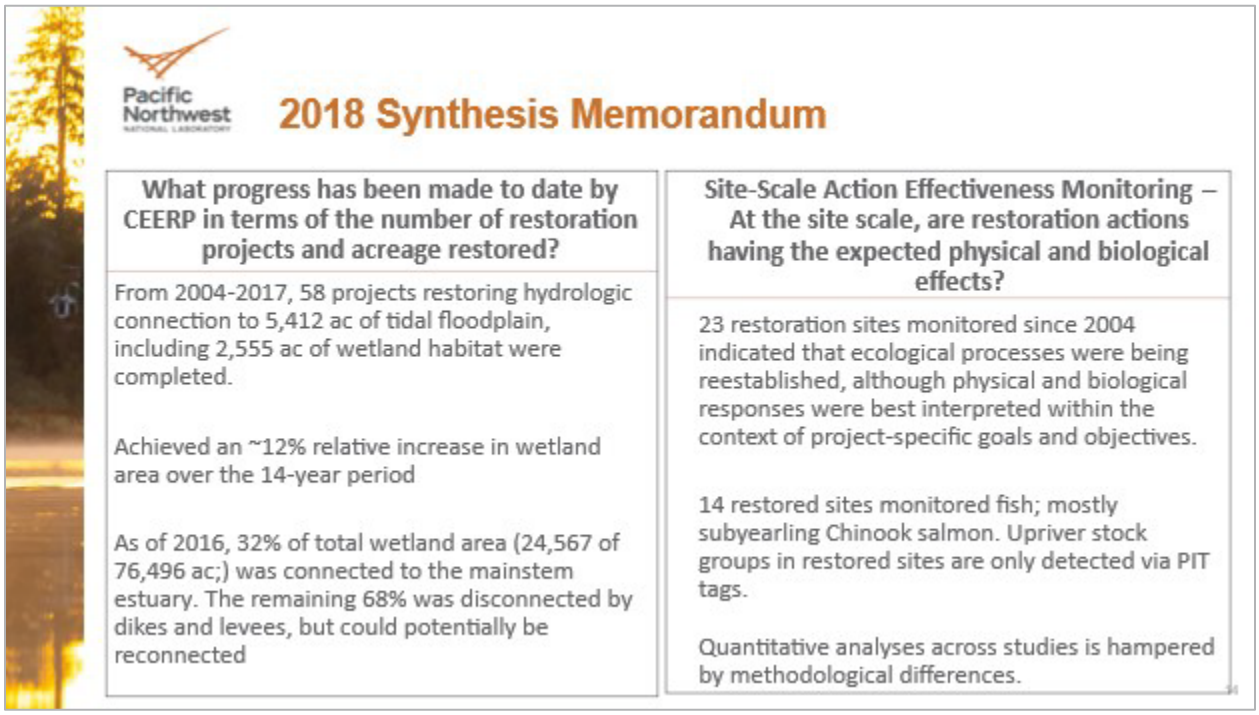
New information on genetic stock distribution and otolith chemistry has helped to understand the life history variations present in the estuary.

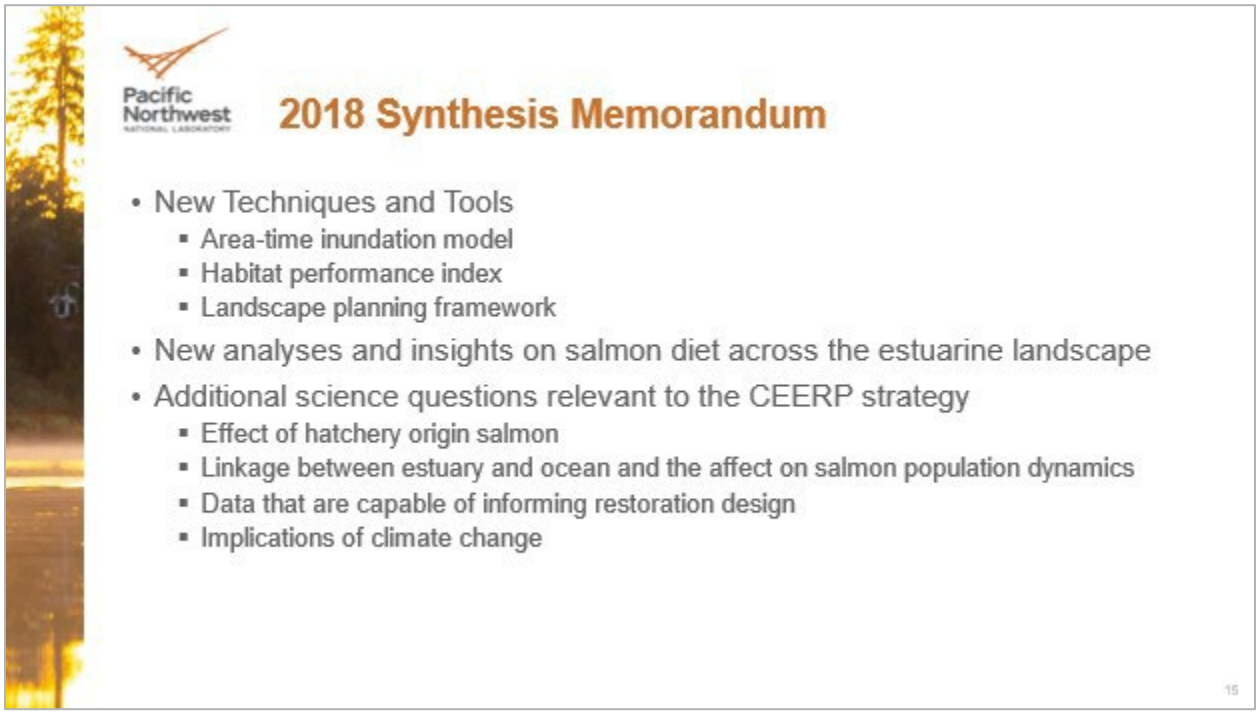
However, studies are not linking estuarine rearing with adult survival; need new approaches for this

Need more surveys in mid and upper reaches of genetic stock groups


Pacific Northwest
2012 Synthesis Memorandum
Are estuary restoration actions improving the performance of juvenile salmon in the estuary?
AE data was limited. Of the 42 restoration projects, only 9 included AEM. Most AEM lacked pre-restoration data, reference sites, and/or hypothesis driven statistical analyses. Of the 9 AEM studies, 7 occurred in the lower 90 rkm of the estuary.
Restored habitats showed trends of increased opportunity for fish to access sites, and capacity as measured by improved water temperature and prey production. One study evaluated realized function via residence time.
Subyearling chinook salmon and chum are primary beneficiaries of habitat restoration.
Indirect benefits through export of organic material, nutrients, prey from restoration sites provide subsidies to other habitats for other fish/stock groups.
What is the status of the estuary? Are estuarine conditions improving, declining?
Few of the historic (late 1800s) wetlands remain in the system.
Invasive species (vegetation, plankton, fish) are prevalent.
Restoration projects are providing benefit to juvenile salmon and supporting processes relevant to ecosystem services for the estuary.
Removal of levees reconnects floodplains but area behind levees has subsided and trajectories for recovery will be slow. Despite this, restored areas will still provide benefits as they are evolving.
12


Pacific Northwest
2018 Synthesis Memorandum: SM1 updates
What are the contemporary patterns of juvenile salmon habitat use in the estuary?
• Dispelled the myth that yearling and upriver stock groups do not use the estuary.
• Found that overwintering of some salmon stock groups occurs in the lower river and estuary
• Diptera and amphipods are key prey resources for juvenile salmon
What is the status of the estuary? Are estuarine conditions improving or declining?
"The estuary is in a degraded state, but it is not clear whether estuary conditions overall are trending to the positive or negative. Many factors that influence the status of the estuary are outside CEERP's mission or influence, e.g., land use practices, industrial development, non-native species, hydrosystem operations, and contaminant loading."
Do factors in the estuary limit recovery of at-risk salmon populations and evolutionarily significant units?
Yes. Reduction in peak flows during spring, impacts from non native species (flora and fauna), intra- and interspecific competition, predation (fish and birds).
Are estuary restoration actions improving the performance of juvenile salmon in the estuary?
• Direct and indirect restoration effects are occurring
• Ecological processes are being restored, but results vary according to different monitored indicators
13


Pacific Northwest
2018 Synthesis Memorandum
What progress has been made to date by CEERP in terms of the number of restoration projects and acreage restored?
From 2004-2017, 58 projects restoring hydrologic connection to 5,412 ac of tidal floodplain, including 2,555 ac of wetland habitat were completed.
Achieved an ~12% relative increase in wetland area over the 14-year period
As of 2016, 32% of total wetland area (24,567 of 76,496 ac;) was connected to the mainstem estuary. The remaining 68% was disconnected by dikes and levees, but could potentially be reconnected
Site-Scale Action Effectiveness Monitoring – At the site scale, are restoration actions having the expected physical and biological effects?
23 restoration sites monitored since 2004 indicated that ecological processes were being reestablished, although physical and biological responses were best interpreted within the context of project-specific goals and objectives.
14 restored sites monitored fish; mostly subyearling Chinook salmon. Upriver stock groups in restored sites are only detected via PIT tags.
Quantitative analyses across studies is hampered by methodological differences.


Pacific Northwest
2018 Synthesis Memorandum
• New Techniques and Tools
▪ Area-time inundation model
▪ Habitat performance index
▪ Landscape planning framework
• New analyses and insights on salmon diet across the estuarine landscape
• Additional science questions relevant to the CEERP strategy
▪ Effect of hatchery origin salmon
▪ Linkage between estuary and ocean and the affect on salmon population dynamics
▪ Data that are capable of informing restoration design
▪ Implications of climate change

Annual CEERP Restoration and Monitoring Plan (R&M Plan) 2014-2024 (2018-2024 for SM3)


Columbia Estuary Ecosystem Restoration Program

2017 RESTORATION AND MONITORING PLAN

FINAL


Appendix A. CEERP Adaptive Management: Master Matrix of New Learning and Adjustments to Restoration Implementation and RME Strategies, 2017

Master Matrix of New Learning and Adjustments: Monitoring, Journal Articles, Technical Reports, Conferences & Workshops, Feedback from Practitioners lead to adjustments to restoration and/or RME.
https://www.cbfish.org/EstuaryAction.mvc/Documents

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Master Matrix of Learning (MML) in the CEERP Restoration and Monitoring Plan (R&M Plan)

Monitoring and research activities reviewed/documented in **annual CEERP Restoration and Monitoring Plan**

Includes **"Master Matrix of New Learning and Adjustments to Strategies"** a tool to categorize new information and effects on strategy

CEERP managers continually attend seminars, workshops, conferences; review technical reports and journal articles; gather information

CEERP managers annually vet potential **adjustments to** or **reinforcement of** program based on learning within CEERP and other science and restoration

- Published research
- Gray Literature/Reports
- Presentations
- Sponsor Lessons Learned

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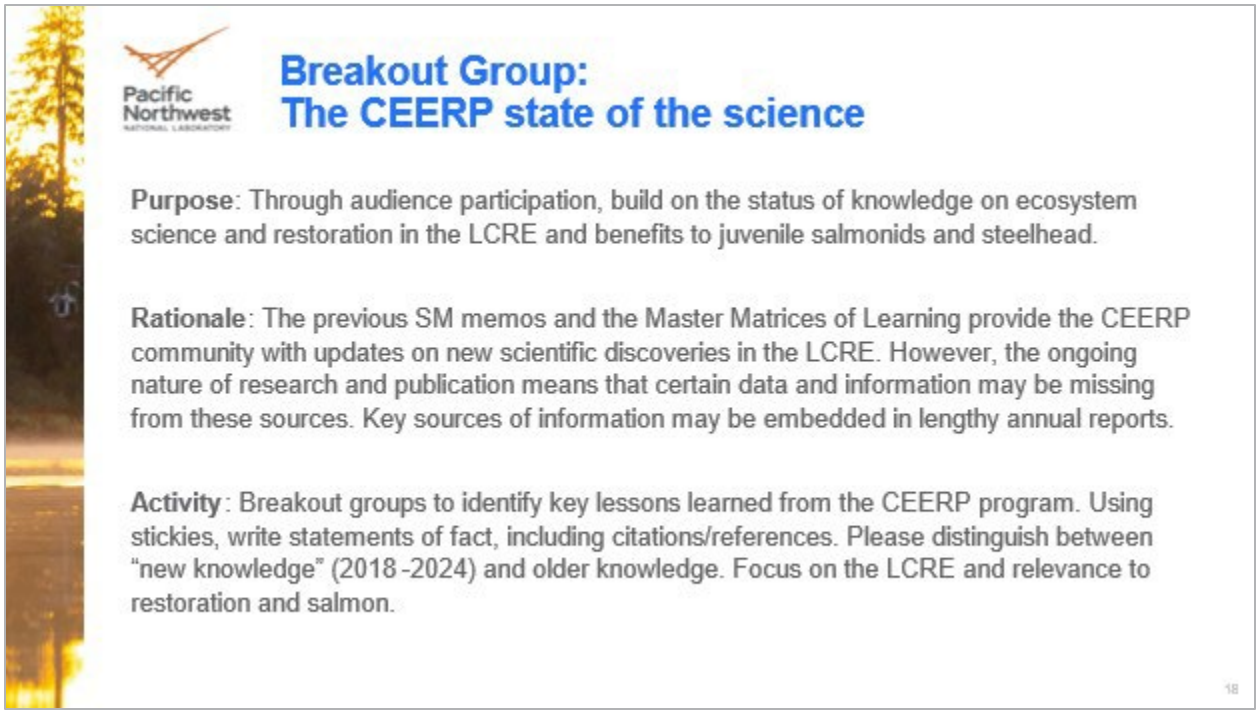
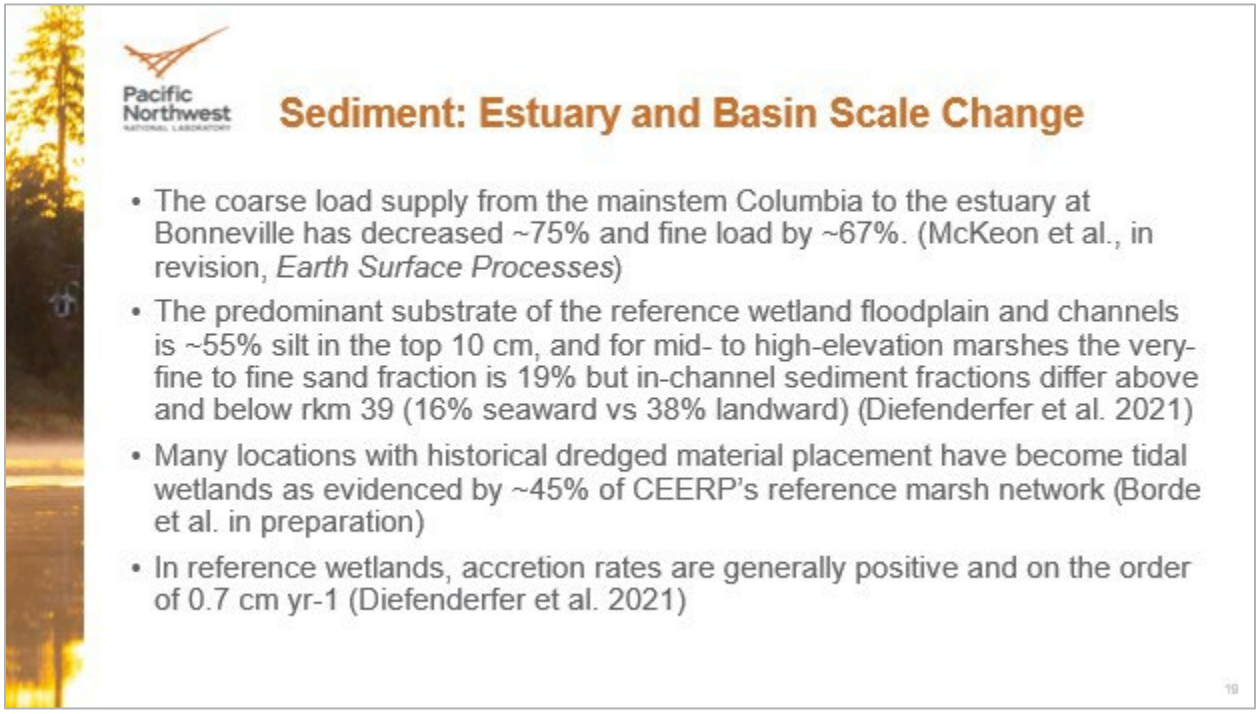
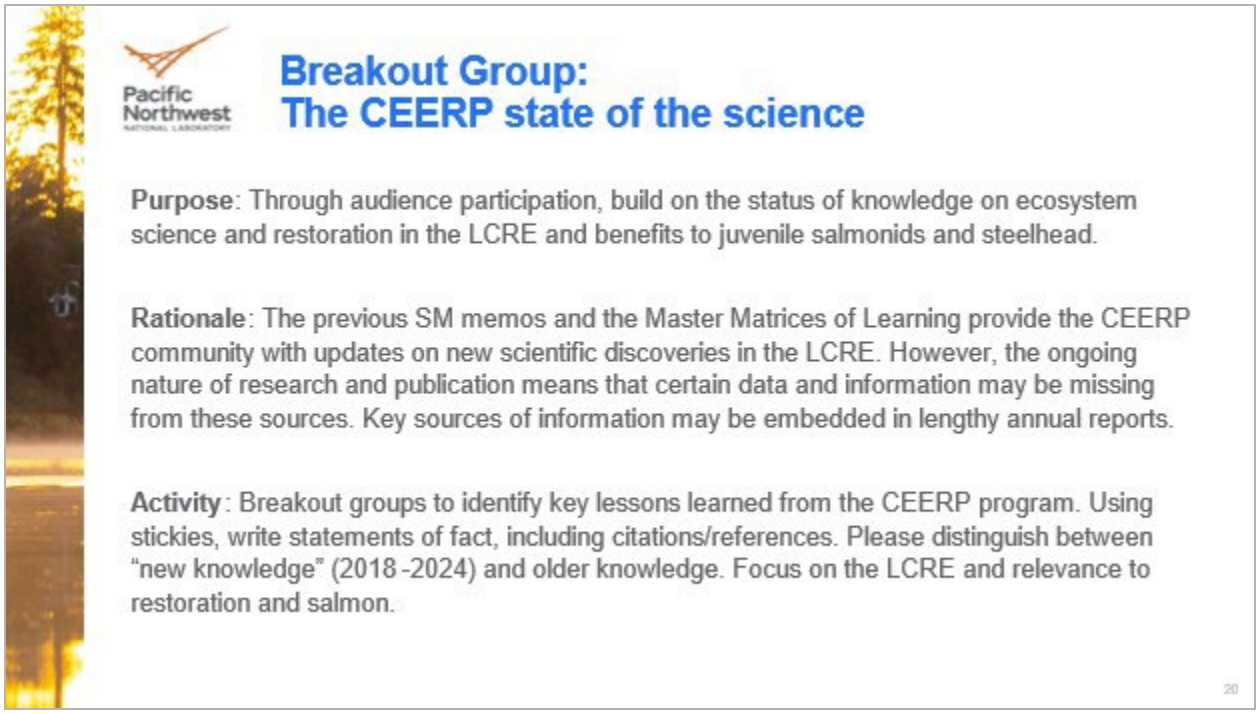

Pacific Northwest
Breakout Group:
The CEERP state of the science
Purpose: Through audience participation, build on the status of knowledge on ecosystem science and restoration in the LCRE and benefits to juvenile salmonids and steelhead.
Rationale: The previous SM memos and the Master Matrices of Learning provide the CEERP community with updates on new scientific discoveries in the LCRE. However, the ongoing nature of research and publication means that certain data and information may be missing from these sources. Key sources of information may be embedded in lengthy annual reports.
Activity: Breakout groups to identify key lessons learned from the CEERP program. Using stickies, write statements of fact, including citations/references. Please distinguish between "new knowledge" (2018-2024) and older knowledge. Focus on the LCRE and relevance to restoration and salmon.
18


Pacific Northwest
Sediment: Estuary and Basin Scale Change
• The coarse load supply from the mainstem Columbia to the estuary at Bonneville has decreased ~75% and fine load by ~67%. (McKeon et al., in revision, *Earth Surface Processes*)
• The predominant substrate of the reference wetland floodplain and channels is ~55% silt in the top 10 cm, and for mid- to high-elevation marshes the very-fine to fine sand fraction is 19% but in-channel sediment fractions differ above and below rkm 39 (16% seaward vs 38% landward) (Diefenderfer et al. 2021)
• Many locations with historical dredged material placement have become tidal wetlands as evidenced by ~45% of CEERP's reference marsh network (Borde et al. in preparation)
• In reference wetlands, accretion rates are generally positive and on the order of 0.7 cm yr-1 (Diefenderfer et al. 2021)
19


Pacific Northwest
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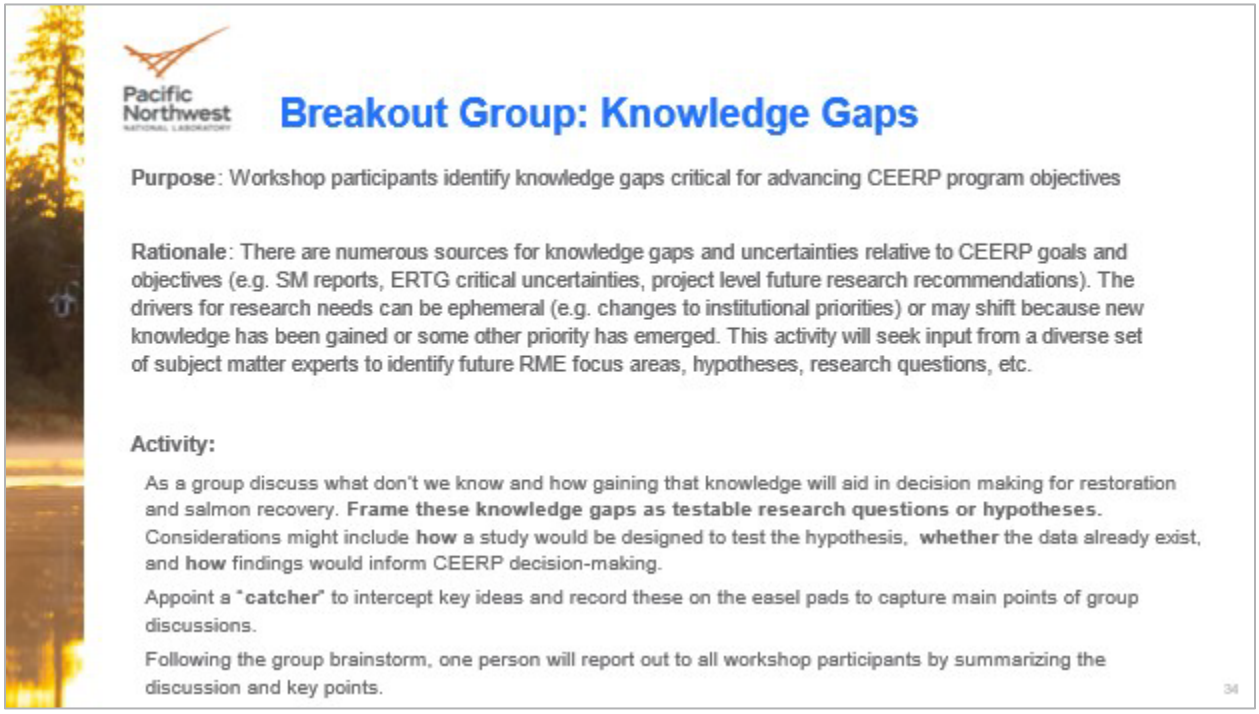
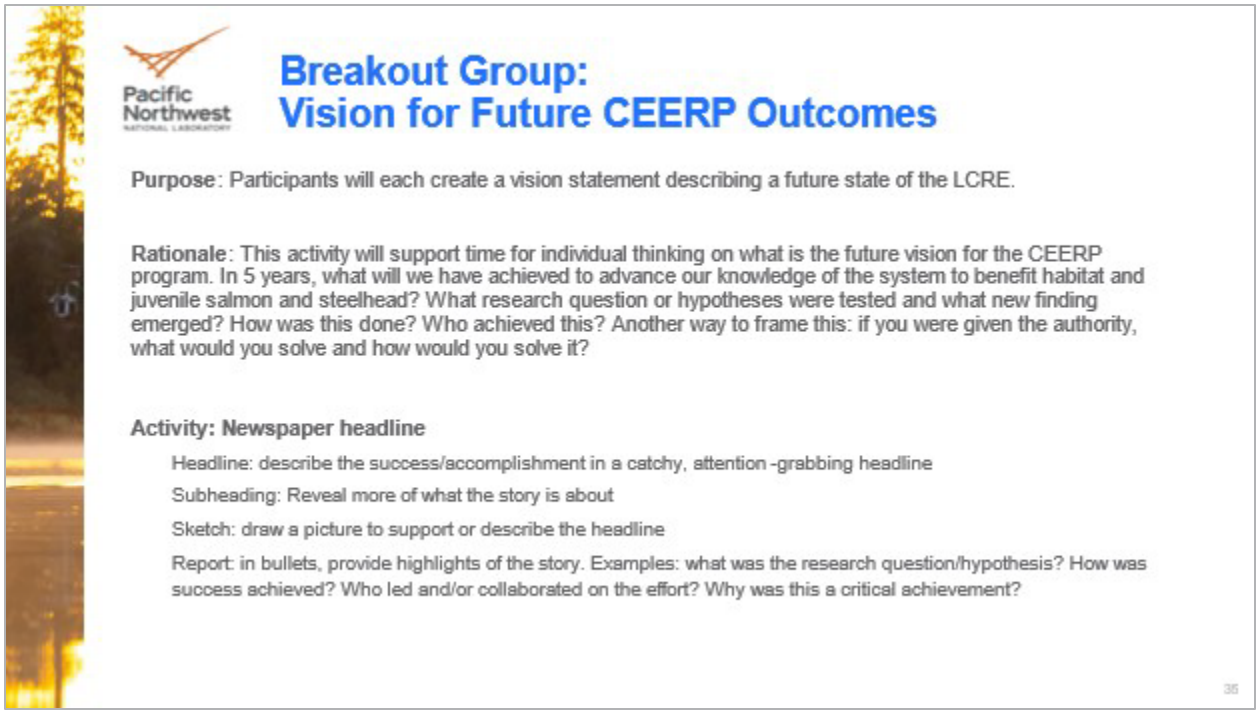
20


Pacific Northwest
Breakout Group: Knowledge Gaps
Purpose: Workshop participants identify knowledge gaps critical for advancing CEERP program objectives
Rationale: There are numerous sources for knowledge gaps and uncertainties relative to CEERP goals and objectives (e.g. SM reports, ERTG critical uncertainties, project level future research recommendations). The drivers for research needs can be ephemeral (e.g. changes to institutional priorities) or may shift because new knowledge has been gained or some other priority has emerged. This activity will seek input from a diverse set of subject matter experts to identify future RME focus areas, hypotheses, research questions, etc.
Activity:
As a group discuss what don't we know and how gaining that knowledge will aid in decision making for restoration and salmon recovery. Frame these knowledge gaps as testable research questions or hypotheses. Considerations might include how a study would be designed to test the hypothesis, whether the data already exist, and how findings would inform CEERP decision-making.
Appoint a "catcher" to intercept key ideas and record these on the easel pads to capture main points of group discussions.
Following the group brainstorm, one person will report out to all workshop participants by summarizing the discussion and key points.
34


Pacific Northwest
Breakout Group:
Vision for Future CEERP Outcomes
Purpose: Participants will each create a vision statement describing a future state of the LCRE.
Rationale: This activity will support time for individual thinking on what is the future vision for the CEERP program. In 5 years, what will we have achieved to advance our knowledge of the system to benefit habitat and juvenile salmon and steelhead? What research question or hypotheses were tested and what new finding emerged? How was this done? Who achieved this? Another way to frame this: if you were given the authority, what would you solve and how would you solve it?
Activity: Newspaper headline
Headline: describe the success/accomplishment in a catchy, attention -grabbing headline
Subheading: Reveal more of what the story is about
Sketch: draw a picture to support or describe the headline
Report: in bullets, provide highlights of the story. Examples: what was the research question/hypothesis? How was success achieved? Who led and/or collaborated on the effort? Why was this a critical achievement?


Pacific Northwest
Action Effectiveness Monitoring, and Research

Pacific Northwest

CEERP AEMR Plan

Purpose of AEMR: determine the ecological success of restoration actions at a site, landscape, and estuary -wide scales

Rationale for the AEMR Plan : SM1 findings highlighted missed opportunities to understand how salmon were benefitting from restored habitats.

Foundations:

- Hypothesis driven monitoring and research
- Two primary focus areas:
  - Fish-based indicators
  - Habitat-based indicators
- Framework requires coupling of monitored indicators with a study design and robust analysis, synthesis, and evaluation.

Columbia Estuary Ecosystem Restoration Program

PROGRAMMATIC PLAN FOR ACTION EFFECTIVENESS MONITORING AND RESEARCH

Prepared by the Bonneville Power Administration and U.S. Army Corps of Engineers, Portland District

US Army Corps of Engineers.

June 2017

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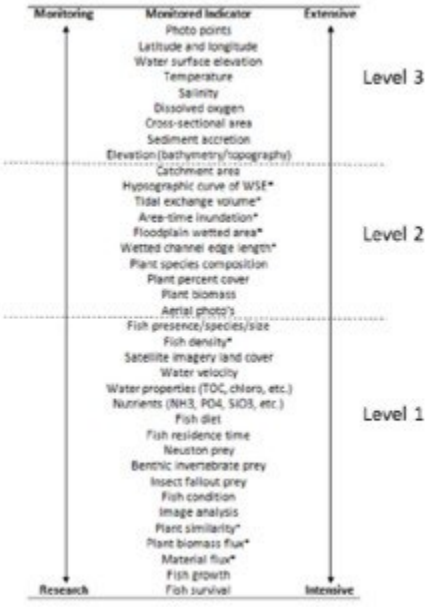
Pacific Northwest

CEERP AEMR Framework

CEERP Restoration Objectives:

- increase capacity
- Increase opportunity; access and export
- Improve ecosystem realized functions for juvenile salmon



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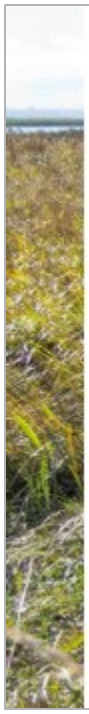


Pacific Northwest NATIONAL LABORATORY

AEMR Levels

Designation	Name	Monitored Indicators	Sampling Intensity	Statistical Design	Sampling Episodes*
Level 1	Intensive	Ecosystem processes and functions, e.g., fish density and residence time, material flux (export)	Selected restoration projects	Essential	1-3, 5, and 10 y
Level 2	Core	Ecosystem structures, e.g., plant community structure, percent cover, and biomass	Selected restoration projects	Depends on project and CEERP objectives	1, 3, 5, and 10 y
Level 3	Standard	Ecosystem controlling factors and other features, e.g., water surface elevation, water temperature, sediment accretion, channel cross-section, and photo points	All sites	Not applicable	1-5 y

*Additional years of sampling may be necessary.

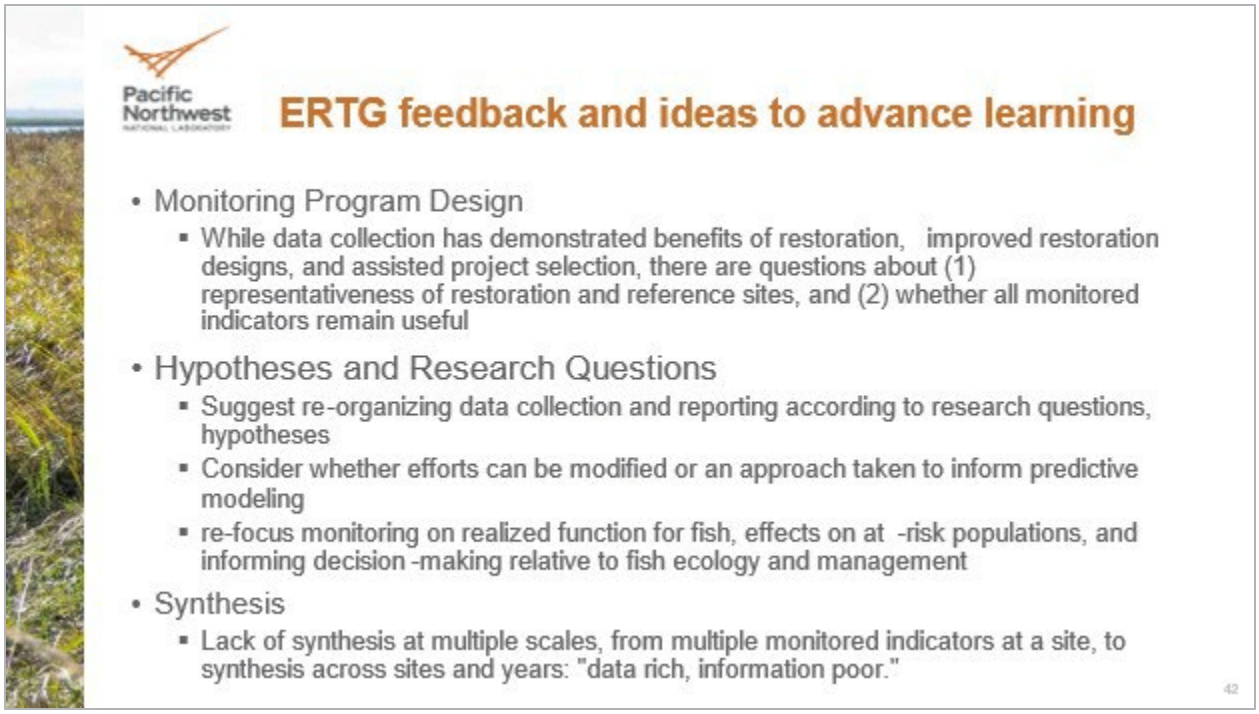
40

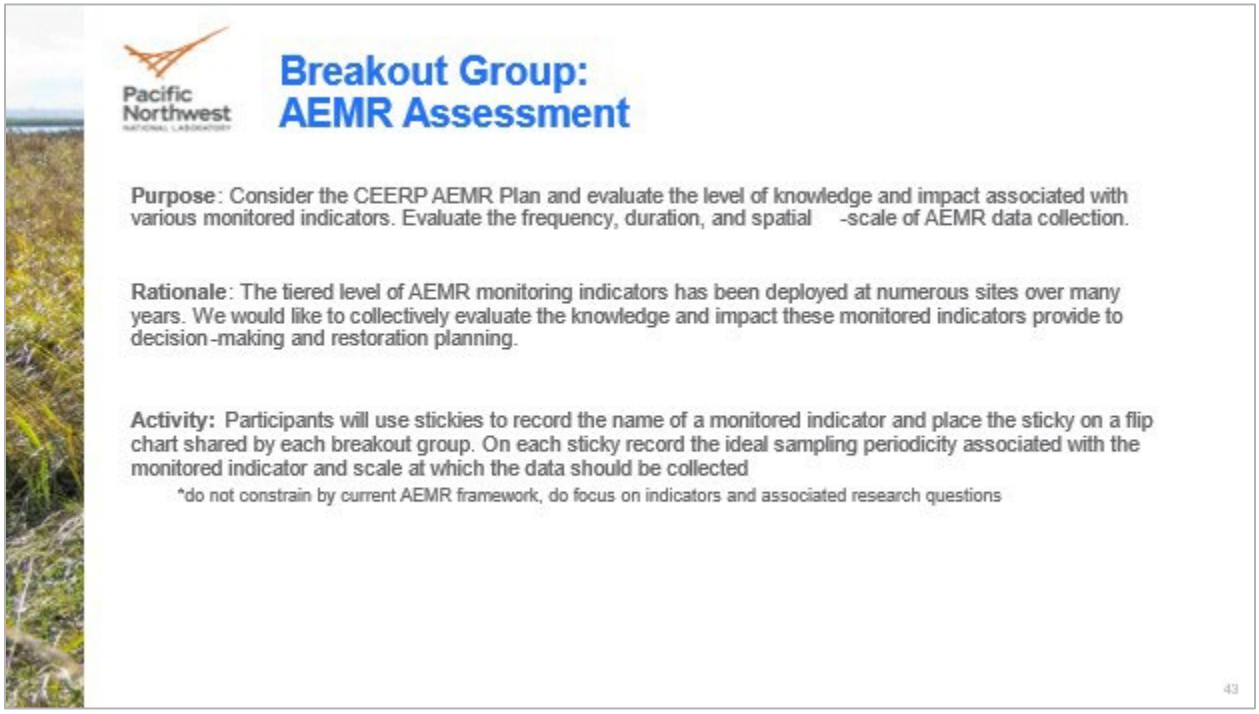
44 AEMR sites

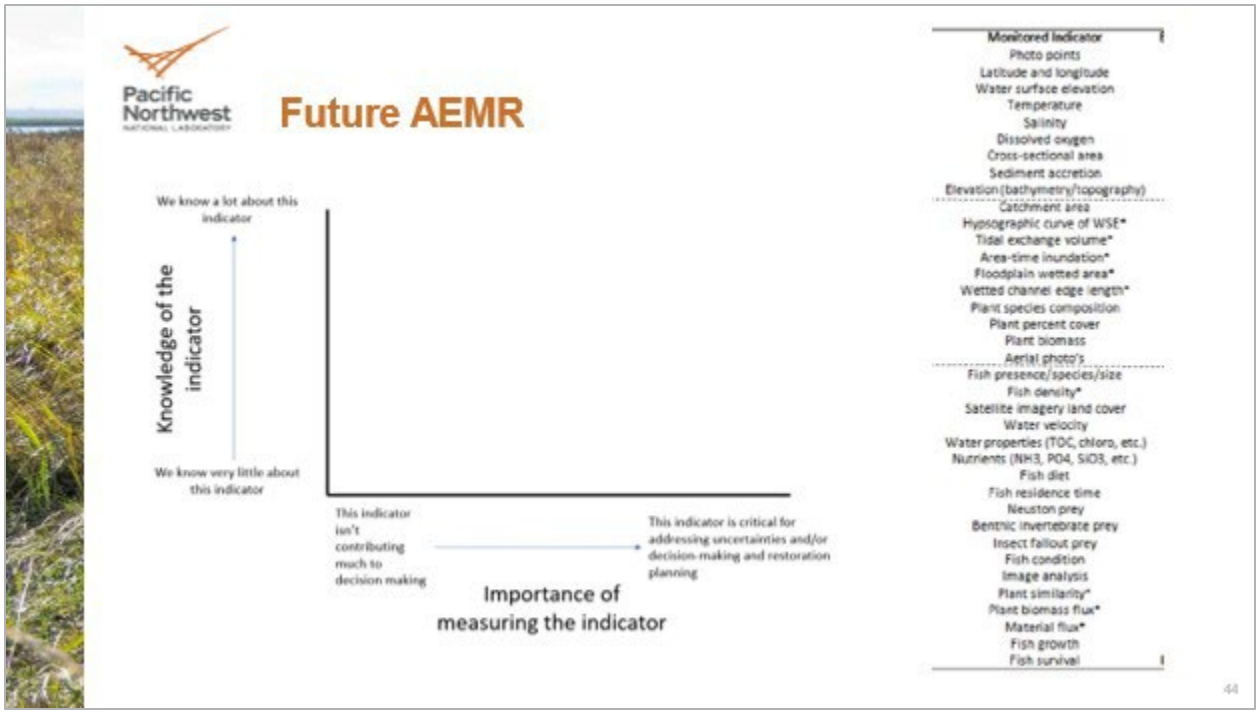
AEMR: 2018-2023

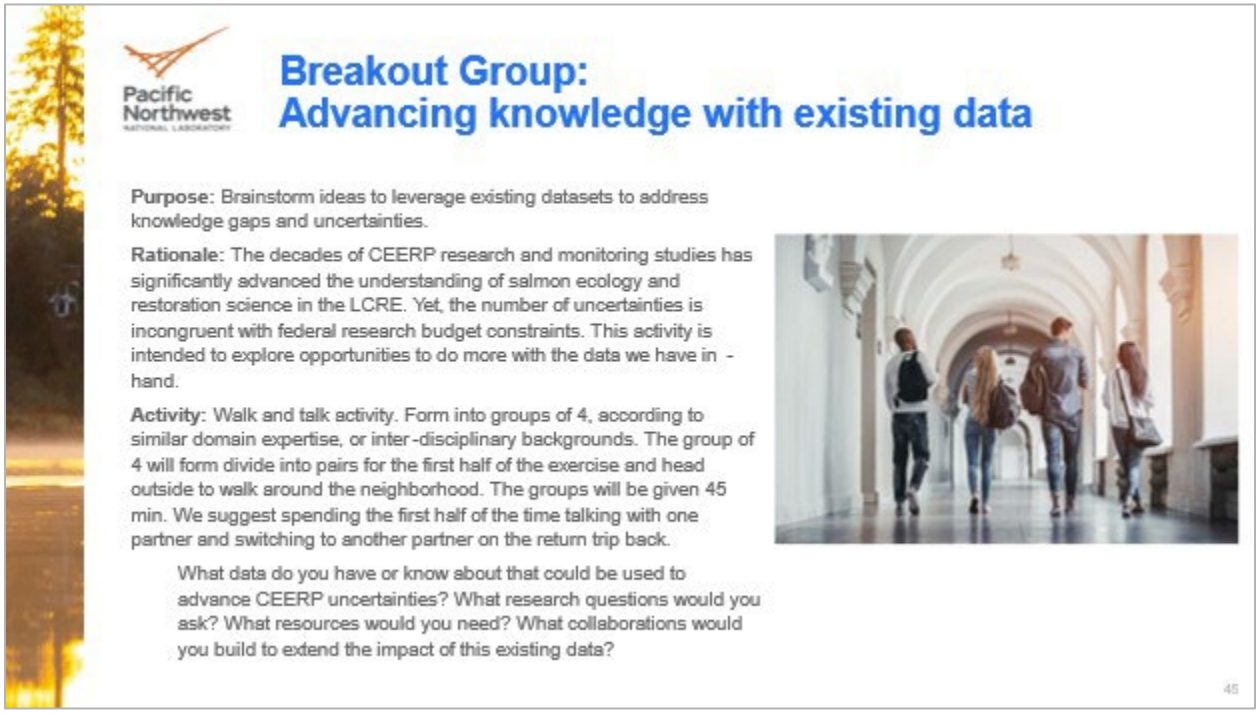
	Metric								
Reach	Fishing	PIT Tag	Macro-Inverts	Plants	Cross Sections	Sediment Accretion /Erosion	Water Surface Elevation/ Depth	Water Temp	Photo Points
A	1	0	5	6	6	21	25	25	25
B	1	0	3	3	3	28	36	36	41
C	0	0	0	0	0	10	13	13	13
D	1	0	1	1	1	3	2	2	3
E	0	0	0	0	0	2	2	2	2
F	6	6	8	12	12	26	45	45	44
G	1	1	3	3	3	10	11	11	11
H	0	3	0	0	0	0	1	3	3
Total	10	10	20	25	142	100	135	137	142

41


Pacific Northwest
ERTG feedback and ideas to advance learning
• Monitoring Program Design
▪ While data collection has demonstrated benefits of restoration, improved restoration designs, and assisted project selection, there are questions about (1) representativeness of restoration and reference sites, and (2) whether all monitored indicators remain useful
• Hypotheses and Research Questions
▪ Suggest re-organizing data collection and reporting according to research questions, hypotheses
▪ Consider whether efforts can be modified or an approach taken to inform predictive modeling
▪ re-focus monitoring on realized function for fish, effects on at -risk populations, and informing decision -making relative to fish ecology and management
• Synthesis
▪ Lack of synthesis at multiple scales, from multiple monitored indicators at a site, to synthesis across sites and years: "data rich, information poor."
42


Pacific Northwest
Breakout Group:
AEMR Assessment
Purpose: Consider the CEERP AEMR Plan and evaluate the level of knowledge and impact associated with various monitored indicators. Evaluate the frequency, duration, and spatial -scale of AEMR data collection.
Rationale: The tiered level of AEMR monitoring indicators has been deployed at numerous sites over many years. We would like to collectively evaluate the knowledge and impact these monitored indicators provide to decision -making and restoration planning.
Activity: Participants will use stickies to record the name of a monitored indicator and place the sticky on a flip chart shared by each breakout group. On each sticky record the ideal sampling periodicity associated with the monitored indicator and scale at which the data should be collected
*do not constrain by current AEMR framework, do focus on indicators and associated research questions
43


Pacific Northwest
Future AEMR
We know a lot about this indicator
Knowledge of the indicator
We know very little about this indicator
This indicator isn't contributing much to decision making
This indicator is critical for addressing uncertainties and/or decision-making and restoration planning
Importance of measuring the indicator
Monitored Indicator
Photo points
Latitude and longitude
Water surface elevation
Temperature
Salinity
Dissolved oxygen
Cross-sectional area
Sediment accretion
Elevation (bathymetry/topography)
Catchment area
Hypsographic curve of WSE*
Tidal exchange volume*
Area-time inundation*
Floodplain wetted area*
Wetted channel edge length*
Plant species composition
Plant percent cover
Plant biomass
Aerial photo's
Fish presence/species/size
Fish density*
Satellite imagery land cover
Water velocity
Water properties (TOC, chloro, etc.)
Nutrients (NH3, PO4, SiO3, etc.)
Fish diet
Fish residence time
Neuston prey
Benthic invertebrate prey
Insect fallout prey
Fish condition
Image analysis
Plant similarity*
Plant biomass flux*
Material flux*
Fish growth
Fish survival
44


Pacific Northwest
Breakout Group:
Advancing knowledge with existing data
Purpose: Brainstorm ideas to leverage existing datasets to address knowledge gaps and uncertainties.
Rationale: The decades of CEERP research and monitoring studies has significantly advanced the understanding of salmon ecology and restoration science in the LCRE. Yet, the number of uncertainties is incongruent with federal research budget constraints. This activity is intended to explore opportunities to do more with the data we have in - hand.
Activity: Walk and talk activity. Form into groups of 4, according to similar domain expertise, or inter-disciplinary backgrounds. The group of 4 will form divide into pairs for the first half of the exercise and head outside to walk around the neighborhood. The groups will be given 45 min. We suggest spending the first half of the time talking with one partner and switching to another partner on the return trip back.
What data do you have or know about that could be used to advance CEERP uncertainties? What research questions would you ask? What resources would you need? What collaborations would you build to extend the impact of this existing data?
45

Pacific Northwest
NATIONAL LABORATORY

CEERP SM3 Research, Monitoring, and Evaluation Workshop

USACE
June 25, 2004

Pacific Northwest
NATIONAL LABORATORY

Reflections from Day 1

What stuck with you?

What are you puzzling over?

Were you surprised by anything?

Did you learn something you didn't expect?

Do you have new enthusiasm or motivation to advance your work?

48

Breakout Group: Advancing knowledge with existing data

Report out

Breakout: Synthesis

Purpose: Gather participant conclusions, based on professional experience and workshop participation, on key findings and relevance to CEERP. Integrate knowledge from across program elements and topics addressed during the workshop.

Rationale: By the end of 2024 a Synthesis Memorandum will be produced and we want to provide an opportunity to incorporate your perspectives.

Activity: How would you tell the story of ecosystem restoration for juvenile salmon in the lower Columbia River and estuary? What conclusions do you draw about what we know and don't know. Special focus on 2018 -2024. Consider the activities we undertook on day one:

- CEERP state of the science
- Knowledge gaps
- Vision for future RME
- AEMR
- Advancing knowledge with existing data

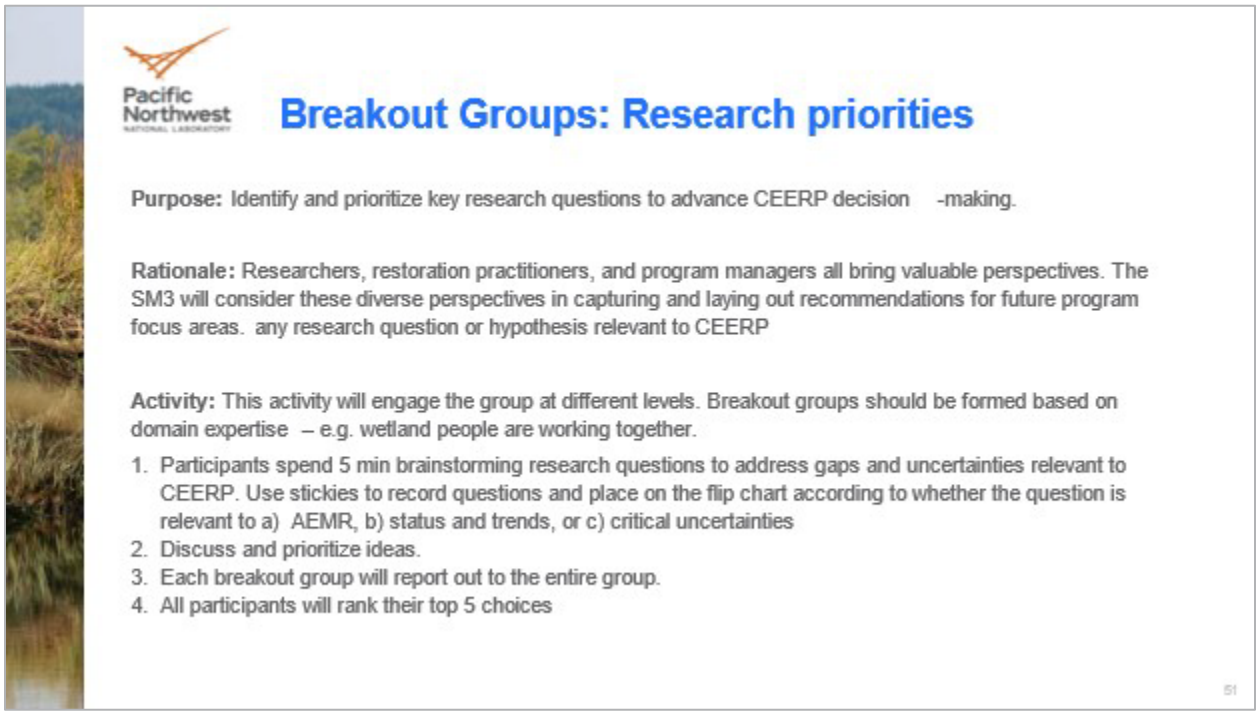
syn·the·sis
/ sinTHəsəs/

noun

noun: **synthesis**; plural noun: **syntheses**

1. the combination of ideas to form a theory or system.
   "the synthesis of intellect and emotion in his work"

Similar: combination union amalgam blend


Pacific Northwest
Breakout Groups: Research priorities
Purpose: Identify and prioritize key research questions to advance CEERP decision -making.
Rationale: Researchers, restoration practitioners, and program managers all bring valuable perspectives. The SM3 will consider these diverse perspectives in capturing and laying out recommendations for future program focus areas. any research question or hypothesis relevant to CEERP
Activity: This activity will engage the group at different levels. Breakout groups should be formed based on domain expertise – e.g. wetland people are working together.
1. Participants spend 5 min brainstorming research questions to address gaps and uncertainties relevant to CEERP. Use stickies to record questions and place on the flip chart according to whether the question is relevant to a) AEMR, b) status and trends, or c) critical uncertainties
2. Discuss and prioritize ideas.
3. Each breakout group will report out to the entire group.
4. All participants will rank their top 5 choices
51


Pacific Northwest
Ranking research priorities
52

Appendix C – ERTG Uncertainties Presentation

Prime Directive

What are the main uncertainties affecting the ERTG's evaluation and scoring of proposed and completed restoration projects?

Uncertainties:

ERTG (Expert Regional Technical Group). 2022. *Uncertainties*. ERTG #2022-02, prepared for the Bonneville Power Administration, National Marine Fisheries Service, and the U.S. Army Corps of Engineers. Portland, Oregon.

Predictive Modeling:

ERTG (Expert Regional Technical Group). 2022. Predictive Modeling. ERTG #2022-01, prepared for the Bonneville Power Administration, National Marine Fisheries Service, and the U.S. Army Corps of Engineers. Portland, Oregon.

Monitoring:

ERTG Memo: Thoughts on Research, Monitoring, and Evaluation (RME) for the Columbia Estuary Ecosystem Restoration Program (CEERP) – FINAL—February 21, 2022.

Background for Uncertainties Work Product

We propose the following elements as keys to increasing predictability of coastal restoration projects:

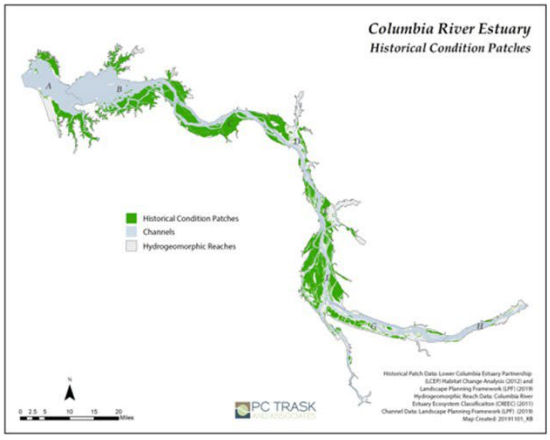
1. **Admit that uncertainties exist**, and address as many as possible in early pre-implementation phases.
2. ... where restoration is done as compensatory mitigation, **consider overcompensation** ... to account for uncertainties.
3. **Evaluate uncertainties** through hypothesis driven pre- and post-implementation experiments.
4. **Develop predictive models**, when appropriate, based on the data.
5. **... use performance monitoring** information to adjust performance measures to align better with the intent of goals; re-examine the effectiveness and direct applicability of performance measures.
6. **Disseminate information** for use in future projects; incorporate published papers and oral presentations at regional and/or national meetings as essential products of the project.

Excerpt from "Adaptively Addressing Uncertainty in Estuarine and Near Coastal Restoration Projects" by Thom et al. 2005

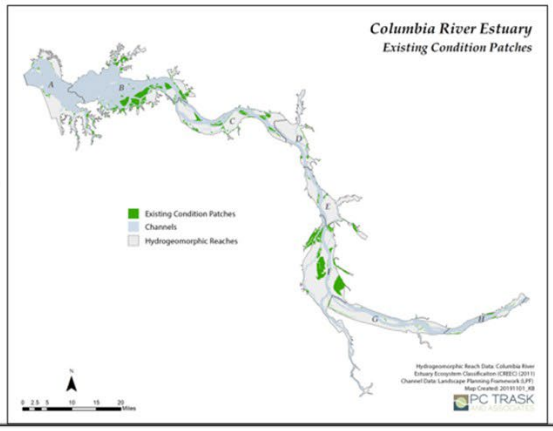
Scales of Uncertainties

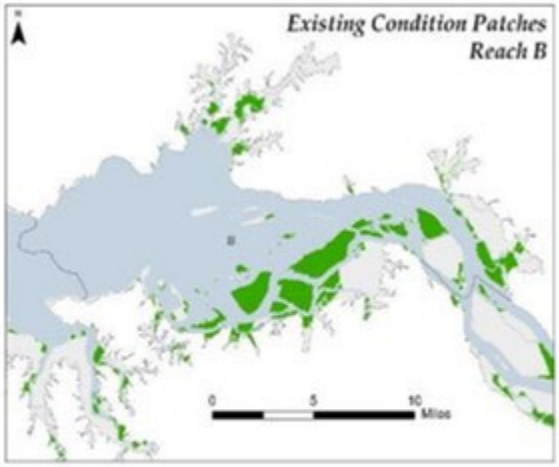
System Scale
How will **climate change** affect the LCRE ecosystem and restoration strategy?
How does **water management** in the Columbia River basin influence habitat-forming processes, habitat conditions, and connectivity between the mainstem and floodplain wetlands in the LCRE?
How does intensive **hatchery production** limit the effectiveness of estuary restoration for naturally produced salmon populations?

- Drainage Area: 660,480 km2
- <45% of historical salmon habitat
- ~10% historical abundance



Estuary Scale
How does reconnecting fragmented estuarine landscapes improve **life history variation and adult survival** in naturally produced populations?
How do **transitional habitats** in the designated priority areas compare in importance to other salmonid rearing habitats in the estuary?

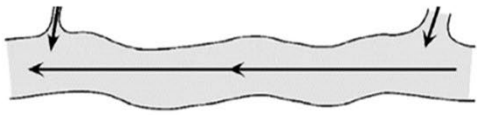




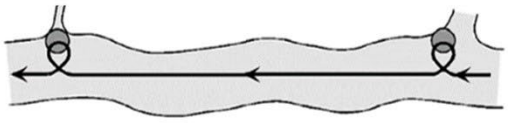
Landscape (reach) Scale
How does **patch size** influence habitat use and function for salmon migrants?
How does **travel distance** between habitats influence salmon access and performance?

Landscape Scale, Stepping-Stone Model

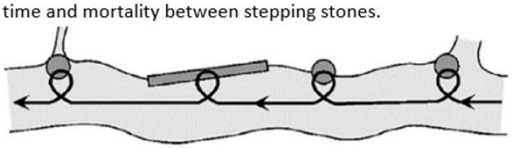
1. Initial Condition – no habitat: short residence; low feeding opportunity; high predation, physiological stress, mortality.



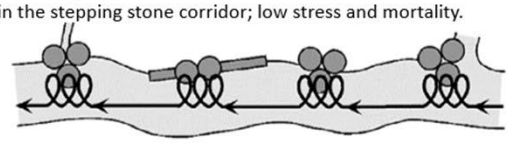
2. Initial Priority – restoration at tributary junctions: some habitat; some residence, feeding, refuge; high fish density and use by multiple stocks.



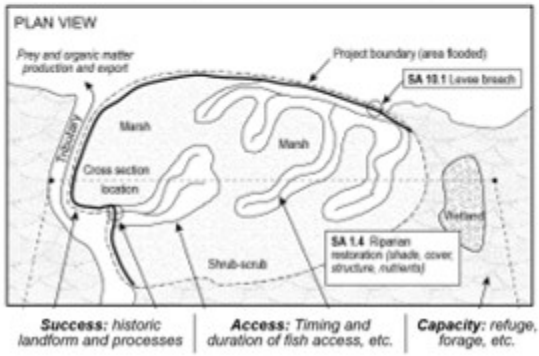
3. Stepping Stone Corridor: some residence, feeding, refuge in each stepping stone; long residence, reduced travel time and mortality between stepping stones.



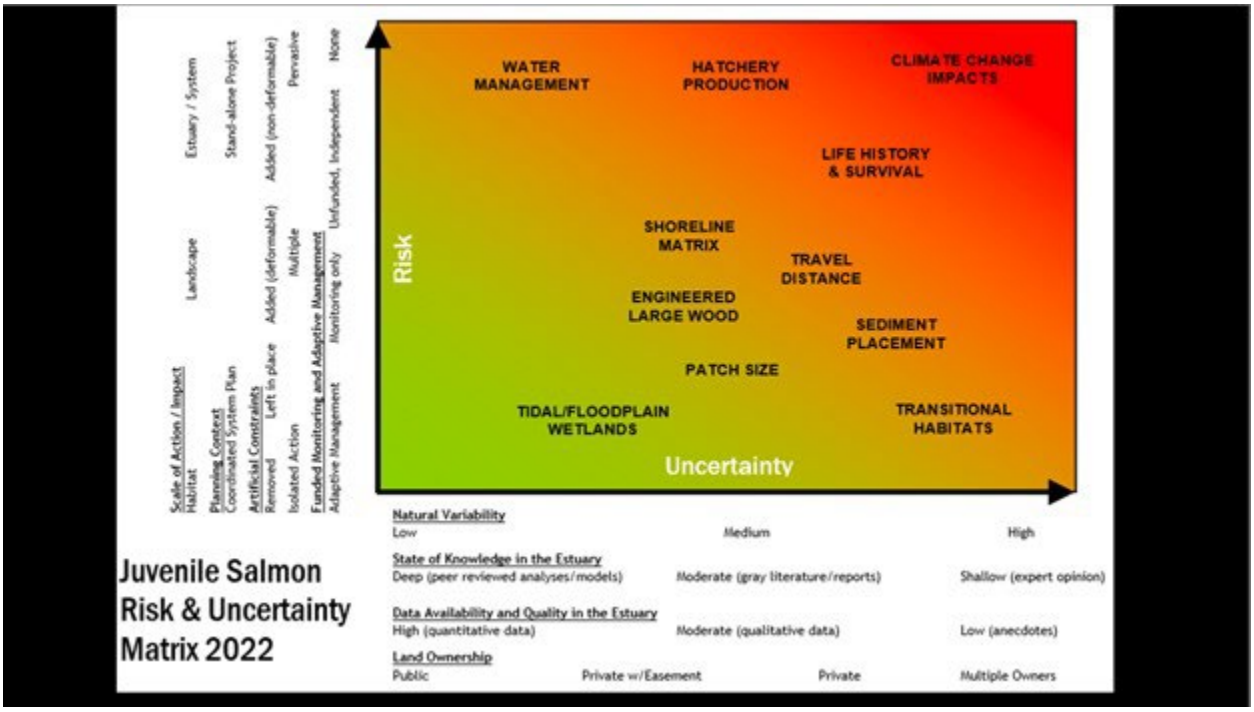
4. Mature System Restoration – large, well-connected habitat patches: long residence in large habitat patches and in the stepping stone corridor; low stress and mortality.



From: Hood et a. 2021.



Habitat Scale
How do **tidal wetlands** respond to different types of restoration actions?
What are the roles of **floodplain wetlands** for juvenile salmon?
Are **sediment placement** actions detrimental or indeed beneficial to juvenile salmonids and their food sources and habitats?
What is the amount, distribution, and ecological role of **large wood** in tidal emergent marshes and river floodplains?
What are the functions of **shoreline matrix** habitats for juvenile salmon along channel margins of the mainstem river and tributaries?
What ecological measurements best estimate **SBU's and PBU's** for various restoration actions?



Climate Change
Overview of climate change **projections** and how they relate to changes in the estuary
Identify **indicators** most important to monitor change
Provide overview of recommendations to implement wetland **vulnerability assessments**
Methods to improve **project planning and design**
Considerations for **project scoring**

Climate Resiliency in the Columbia Estuary Ecosystem Restoration Program

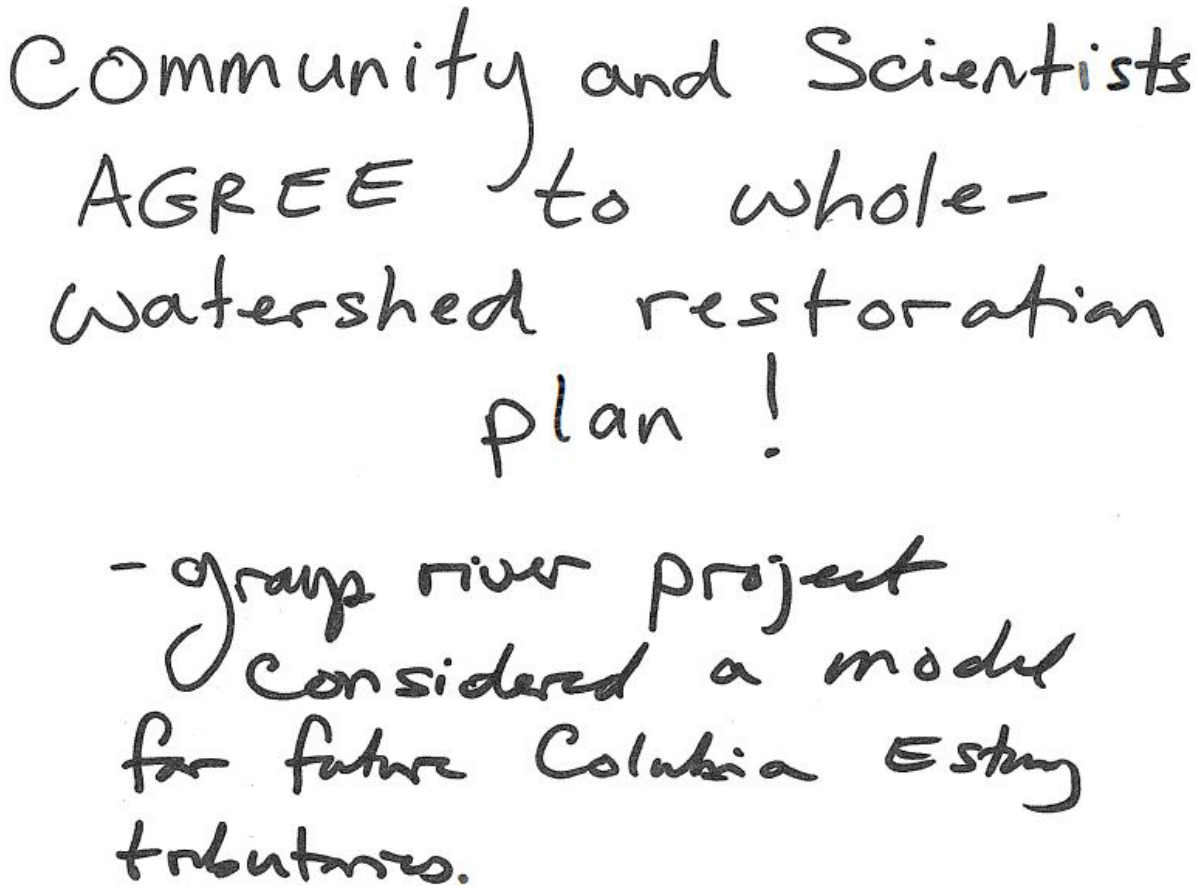
DRAFT

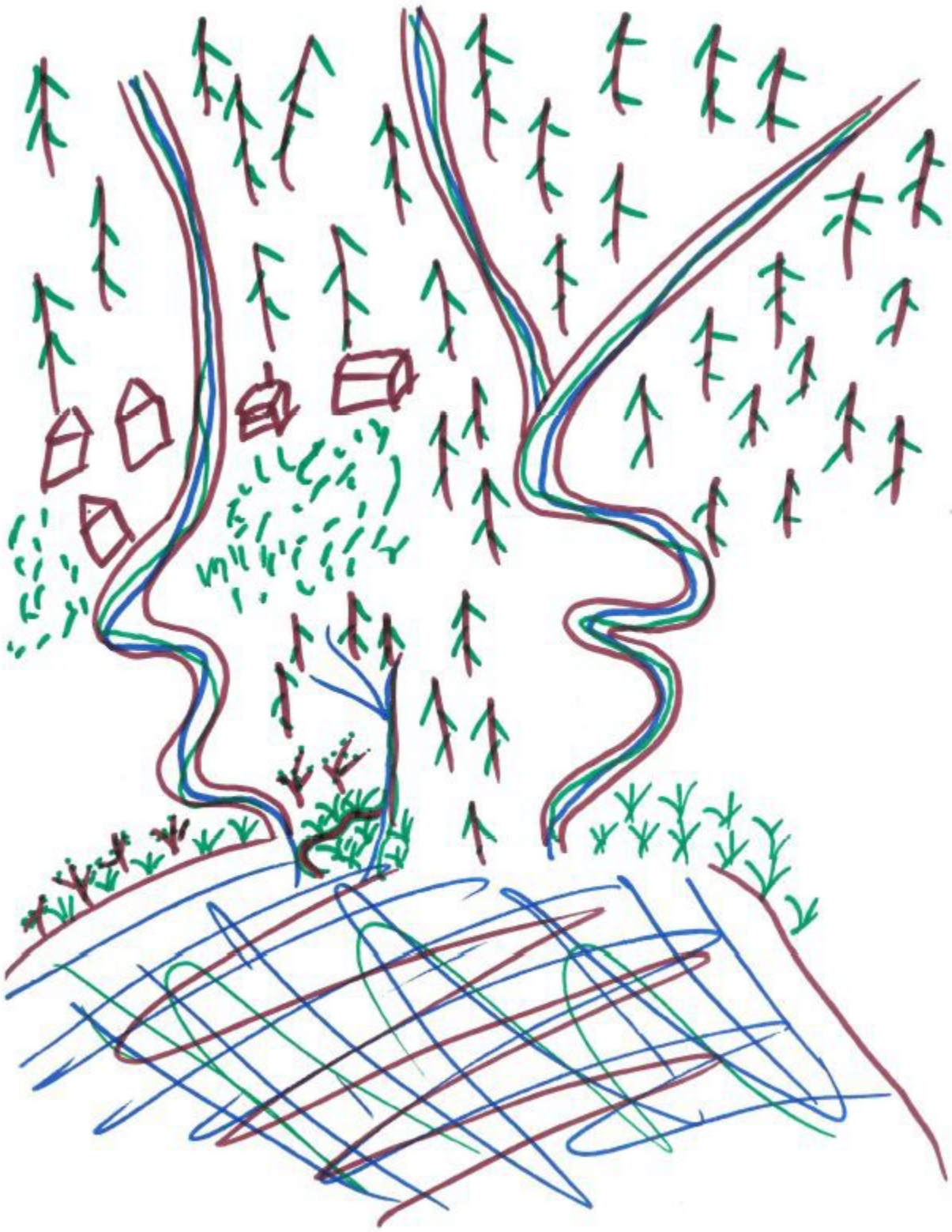
Prepared by the Expert Regional Technical Group
of the Columbia Estuary Ecosystem Restoration Program

Prepared for the Bonneville Power Administration, National Marine Fisheries Service, and U.S. Army Corps of Engineers

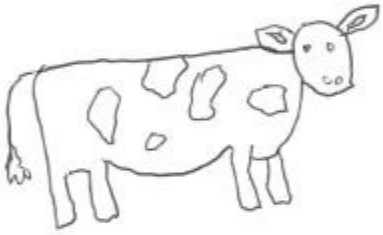
June 2024

Appendix D – Vision Exercise Results





Ridgefield National Wildlife Refuge Bans Cows

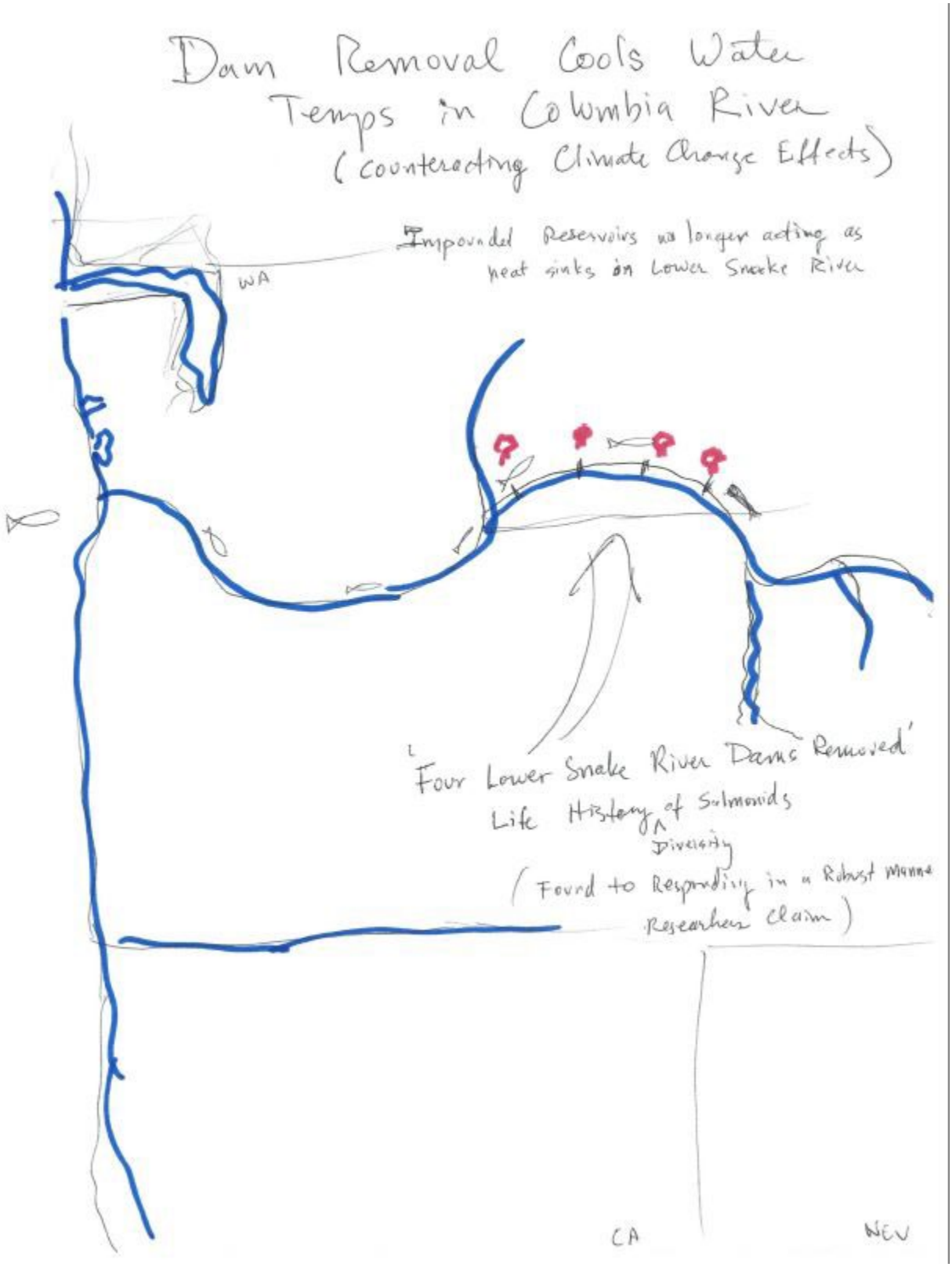


Researchers + Ranchers work together to humanely relocate herd of cows to Battle Ground

Campbell Slough is an important wetland for migrating salmon.

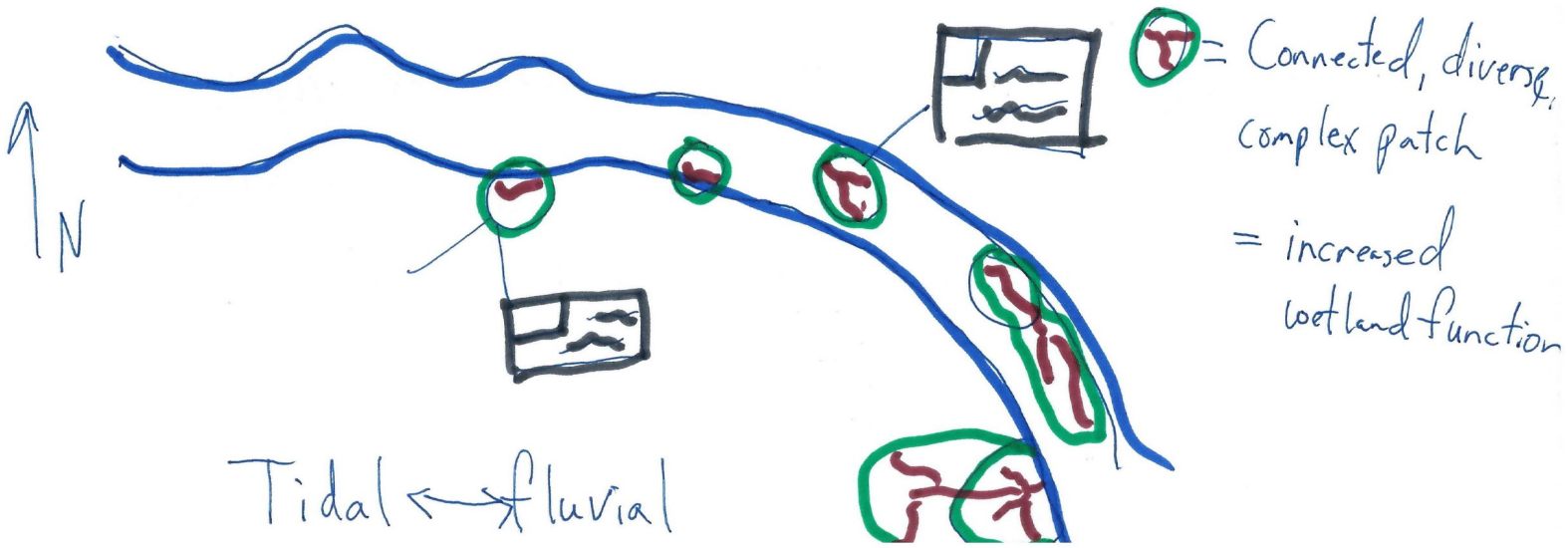
Manure and disturbance impacts water quality, including E. coli, cyanobacteria, and low dissolved oxygen.

Experts agree that this management action is a collaboration that will lead to better outcomes for salmon and cows.


Dam Removal Cools Water Temps in Columbia River
(counteracting Climate Change Effects)
Impounded Reservoirs no longer acting as heat sinks on Lower Snake River
WA
Four Lower Snake River Dams Removed
Life History of Salmonids
Diversity
(Found to Respond in a Robust Manner Researchers claim)
CA
NEV

CEERP achieves new success through design & implementation of 5 large-scale, climate resilient habitat restoration projects

- Multiple tribes support estuary initiative benefitting salmon stocks across Columbia Basin.

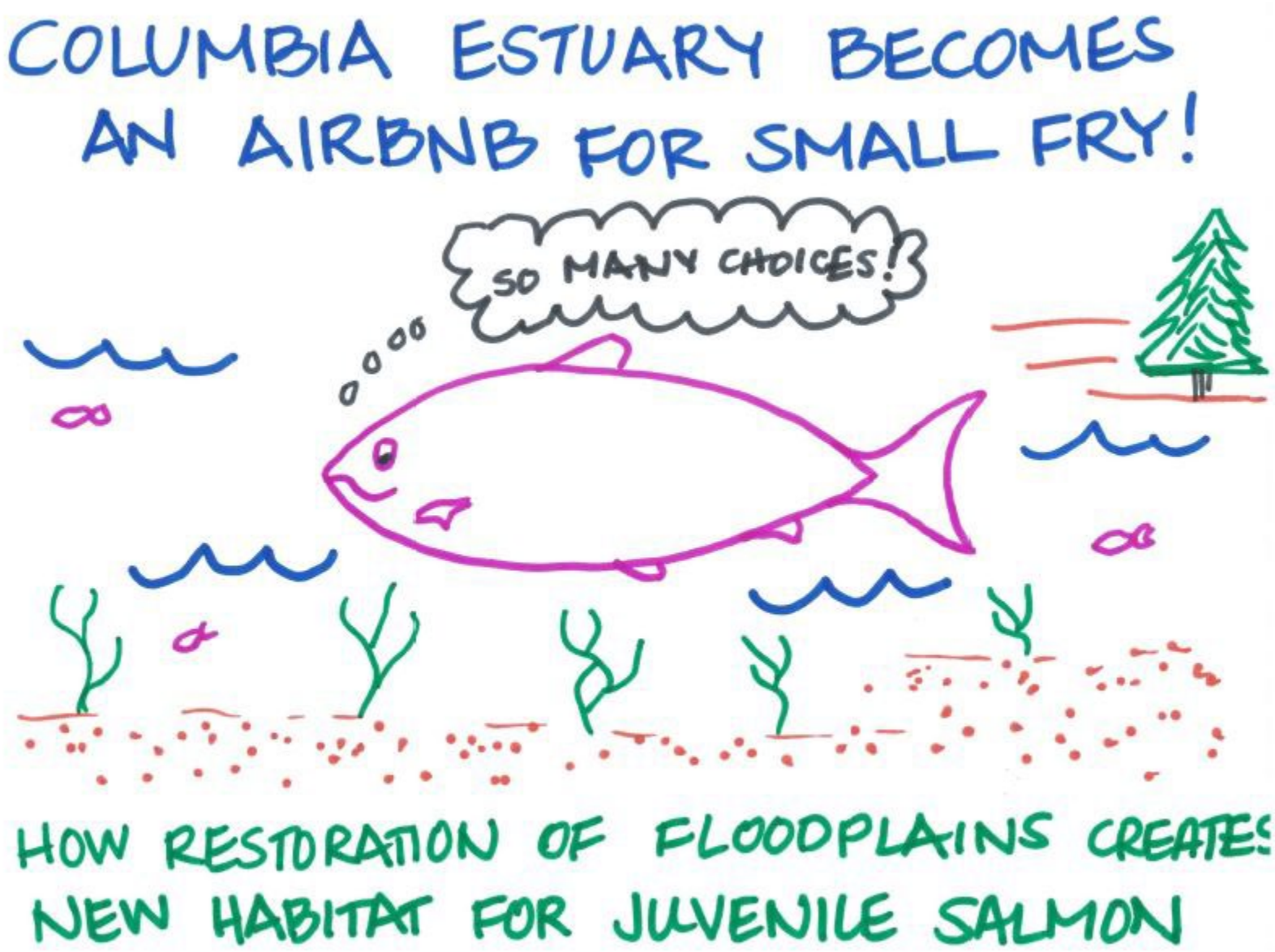


- Patch Size = Scale accomodating SLR & Δ in Hydrology

- Partners = Chinook, Grande Ronde, Cowlitz, Warms Springs, Umatilla

Funders = State of WA, OR, BPA, ACoE, NOAA, USFWS.

H1: • Mutiple juvenile life histories derive benefit from Estuary projects and fitness to surive uncertainty in Ocean conditions associated with GCC.

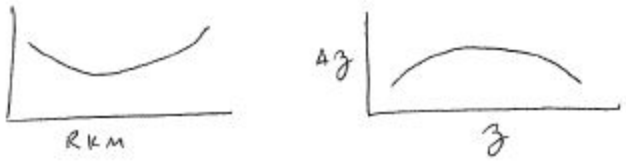

COLUMBIA ESTUARY BECOMES AN AIRBNB FOR SMALL FRY!
SO MANY CHOICES!
HOW RESTORATION OF FLOODPLAINS CREATES NEW HABITAT FOR JUVENILE SALMON

WE = SCIENTISTS

6/24/2029

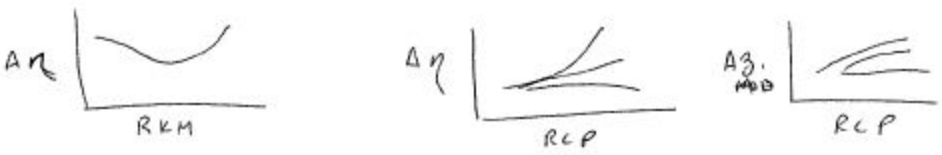
① WE ARE REASONABLY SURE ~~WHAT~~ HOW WETLAND ACCRETION VARIES W/ ELEVATION & REACH AND ~~WHETHER~~ THE SEDIMENT SOURCE + TRANSPORT MECHANISMS DRIVING THAT ACCRETION

Δz = accretion
z = elevation
RKM = River Kilometer

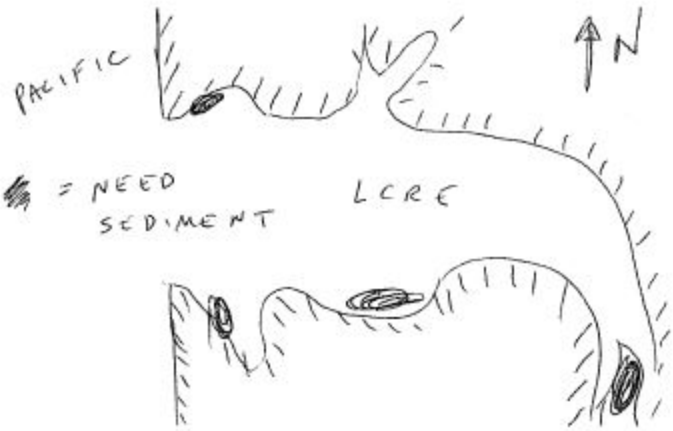


② WE HAVE COMPLETED A SUITE OF HYDRODYNAMIC MODELS THAT PROVIDE SLR + ACCRETION ENVELOPES FOR CLIMATE PATHWAYS FOR THE LCRE.

$\Delta\eta$ = CHANGE IN WSE



③ WE HAVE ESTIMATES OF HOW MUCH SEDIMENT IS NEEDED AND WHERE TO MAINTAIN CRITICAL WETLANDS & AND THEIR FUNCTIONAL PROCESSES



HI!
ITS MAGGIE!

Restoration of Columbia River Estuary saves world from Climate Change

- LCEP and its partners restored over 50% of the habitat lost since late 1800's
- With that restoration and protection of habitat, partners were able to sequester all the carbon needed to meet the Paris agreement and limit global warming to < 1.5°C from pre-industrial times.
- LCEP and it partners including the Blue Carbon Working Group identified how much carbon is sequestered by each project (vs methane released) and then re-prioritized types of projects / techniques in order to meet their goals
- The whole world gave a huge sigh of relief that carbon capture and other artificial mechanisms of maintaining global temperatures under 1.5°C were not needed + that natural Climate solutions could make this much a benefit

Public Lands Commit to Process-Based Management to Restore Ecosystem Functions in the Lower CRE

- Floodplains are Reconnected & Ecosystem Services Realized!

1) Public support & understanding of the numerous multispecies benefits of (urban segregation) floodplain reconnection

2) Changes in habitat behind levees versus on

Working with features to support floors - landowners understand the value of their existing habitat

3) Recognition that there are few spaces to do large scale ecosystem process based restoration & that public lands provide that opportunity!

HEART OF ESTUARY RESTORED!

July 4, 2034

– Long-Term efforts to return Tenassilahe Island to the river finally pay off!

- USFWS & BPA partner to relocate "all" (CWTD)
- USACE funds feasibility study, design, and construction of the project.
- USACE places small volume of dredged material in strategic locations as high ground for few remaining deer.
- Project seen as a model for how federal agencies can partner on restoration projects.

Addressing Community Concerns Saves Salmon

Focusing on
- SLR, flooding, critical infrastructure improvements identified by communities using an ecosystem function lens has led to significant investment in rural communities in OR & WA which in turn has created thousands of acres of habitat improvements.

Partners & funders have included fed, state & private funders. Partners are working across sectors.

? What would I solve & how I solve it?

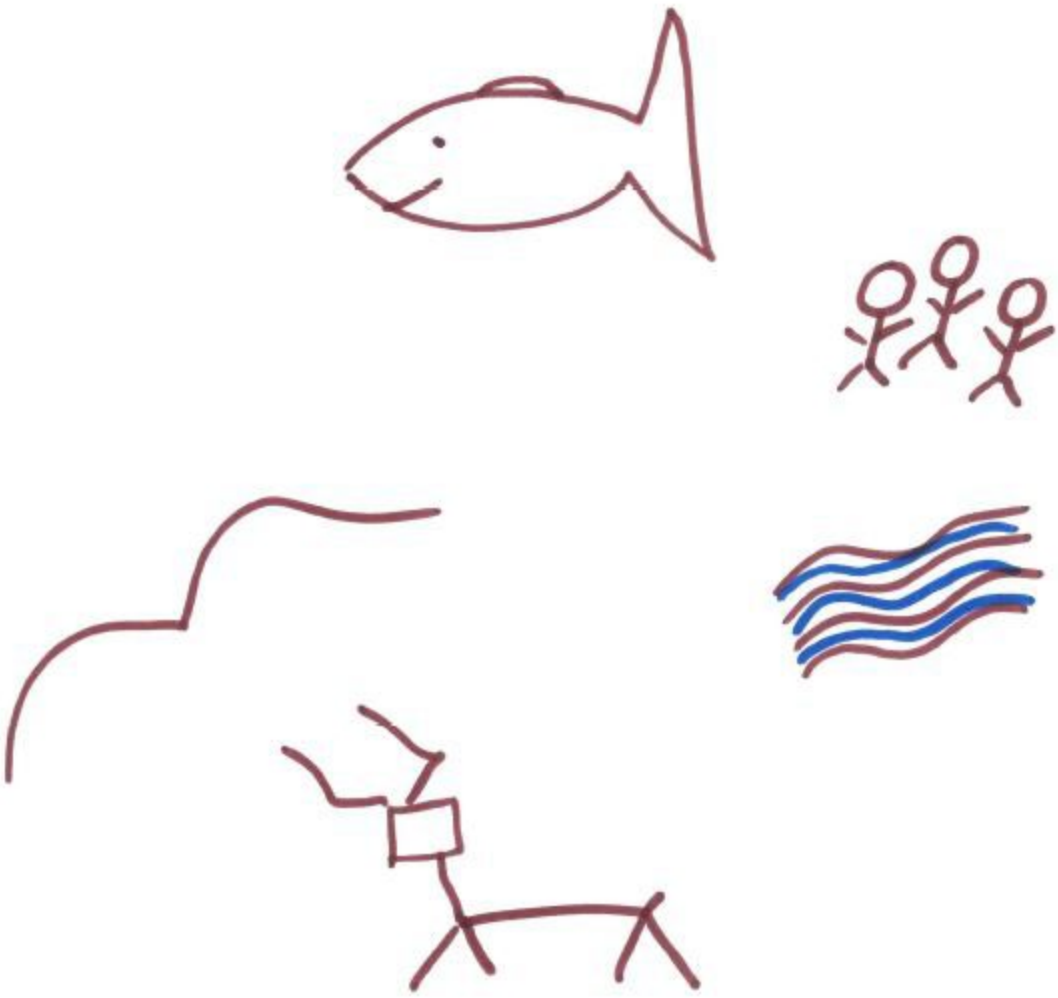
	Solving The habitat - community conundrum
Habitat	Partnerships, Trust, $
Community	Cross-sector collaboration
Monitoring	Address critical issues

CEERP has been instrumental in recovering multiple salmonid stocks

- CEERP restoration actions have been linked to key estuary functions that ~~have~~ are linked to multiple salmon life-history stages
- recovery of ecosystem functions has had multiple benefits to several other species + ecosystem services

10-year vision

CEERP Benefits

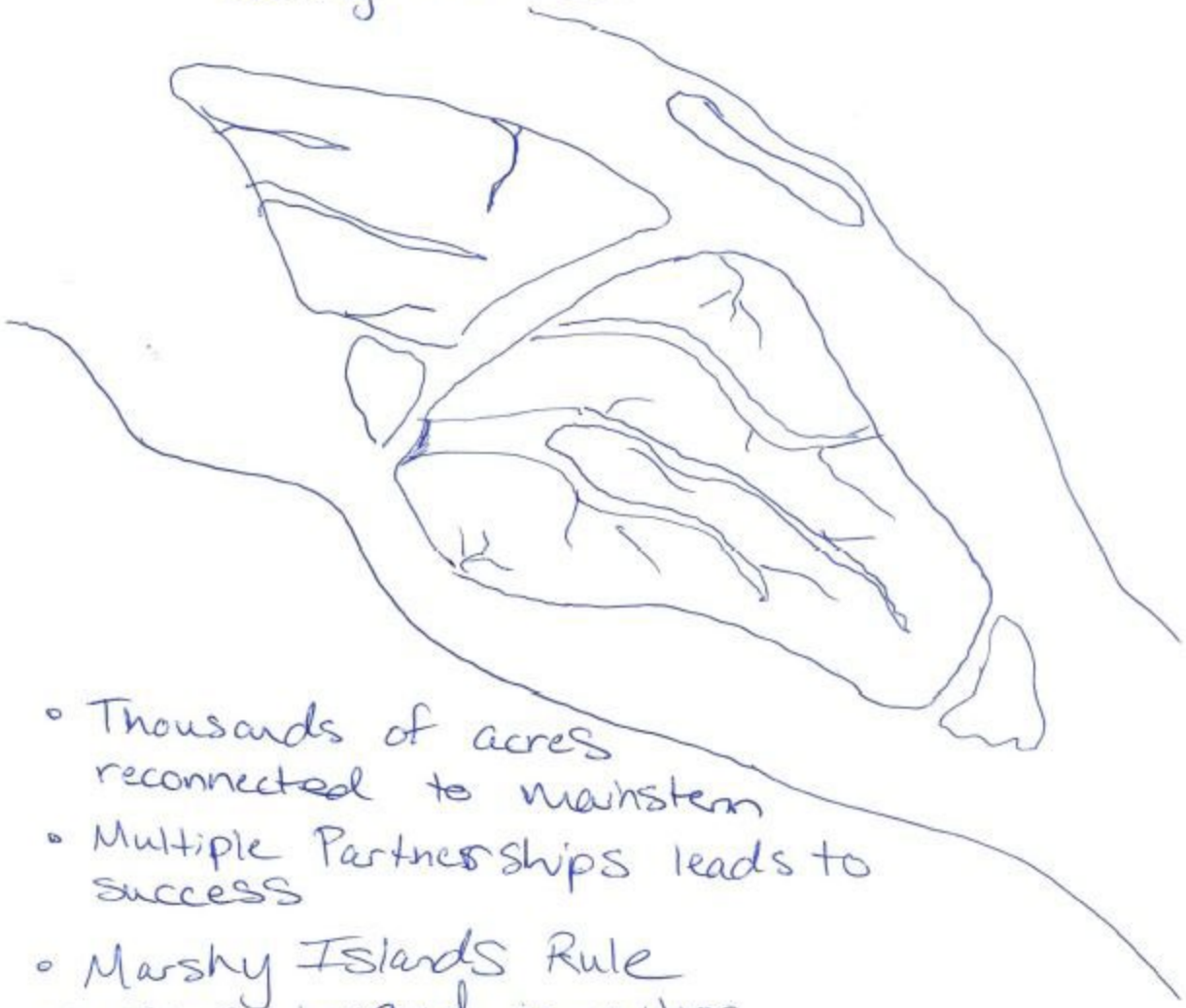


BUDM sites have helped recover critical ecosystem functions below Bonneville Dam

- staggered BUDM implementation at 10 sites in the lower estuary have demonstrated net ecosystem benefits XX years after placement
- ongoing monitoring of XX metrics have shown marked recovery of habitat
- BUDM pilot sites have been most successful (i.e., in terms of salmonid benefits) in these contexts, reaches, sizes, elevation profiles, etc.

A PATH TO RECOVERY: A SALMON SUCCESS STORY.

Columbia white-tailed Deer de-listing leads to massive reconnection of tidal rearing habitat.



- Thousands of acres reconnected to mainstem
- Multiple Partnerships leads to success
- Marshy Islands Rule
- Lessons Learned in-action

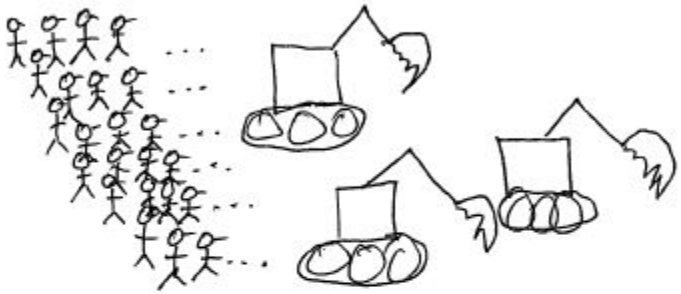
Drones reveal hidden gems of restoration

Indicators of restoration success can be measured by drones and inform future restoration actions.

To answer whether restored wetlands provide benefits to salmon, several structural metrics are measured @ 30 reference and 30 restoration sites every 5 years
With many partners

- channel extent + evolution over time (access)
- vegetation communities
- vegetation biomass (capacity)
- Unveg : Veg ratio (vulnerability)
- Elevation
- Temperature
- Planting survival

* Anonymous donor gift 1,000,000,000,000,000,000,000 gold bars to the LCRE for the sole use of restoration. Amy Borde was selected to lead the charge. She was compensated with a chip off the smallest bar.

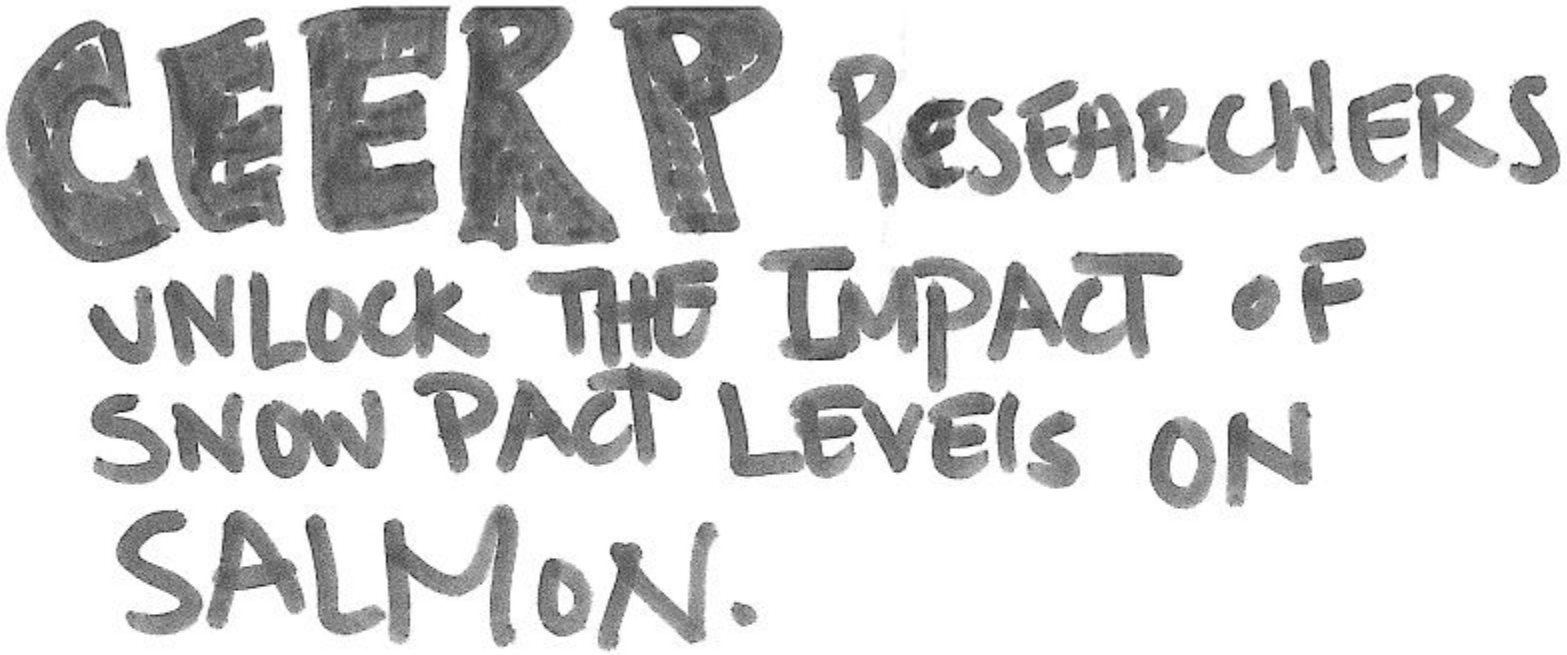


heavily plant, spray PHAR, mound + plant & Veg using drones. Monitor using sedimen

Remember sturgeon? Remember how we shut fishing down? We are doing the same for salmon... sorry... Not sorry. Stay tuned - There will be mini seasons.

LOW SNOW PACK IN COLUMBIN BASIN MEANS TROUBLE FOR SAIMON. OR DOES It?!

* Multi aggencies in the lower Columbia River study the impacts that changing hydrology (water levels) have on the habitat of wetlands & Rivers.


CEERP RESEARCHERS
UNLOCK THE IMPACT OF
SNOW PACT LEVELS ON
SALMON.

- Do changes in Hydrology [redacted] climate impact the sediment accretion. and vegetatural changes in wetlands?
- How does this change in Hydrology, Sea level Rise impact Habitat of wetlands.
- What do PREDICTIVE models, predict about Sediment.

Return of the Redds

- Chum restored to Youngs Bay watershed!

- Diverse collaboration of Fed, State, local partners!

- Spawning grounds successfully restored

- natal stock raised in hatcheries + released over last 5 years.

- Finally, huge adult return!

- Champagne all around, while monitoring continues.

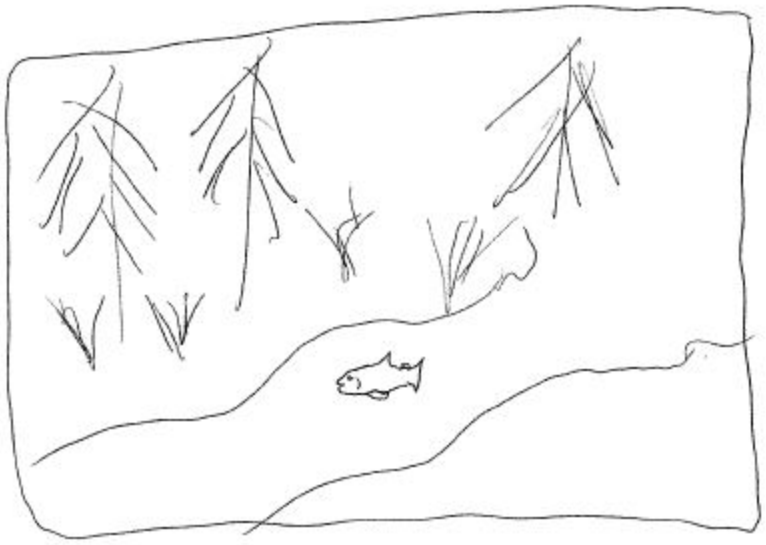
Salmon Scores perfect 10.0 at Migration Olympics

- w/ great preparation and training overcoming obstacles
- Can now "retire" fulfilled to some years of "retirement"
  - Hopeful to produce future olympians

- State of the art predictions for
  - best food to eat
  - where to rest / recover
  - avoiding competitors
  - best pool to train in

Headline: ~~Scientists~~
Fish Health Biomarkers changes perspectives on effectiveness of ecosystem restoration

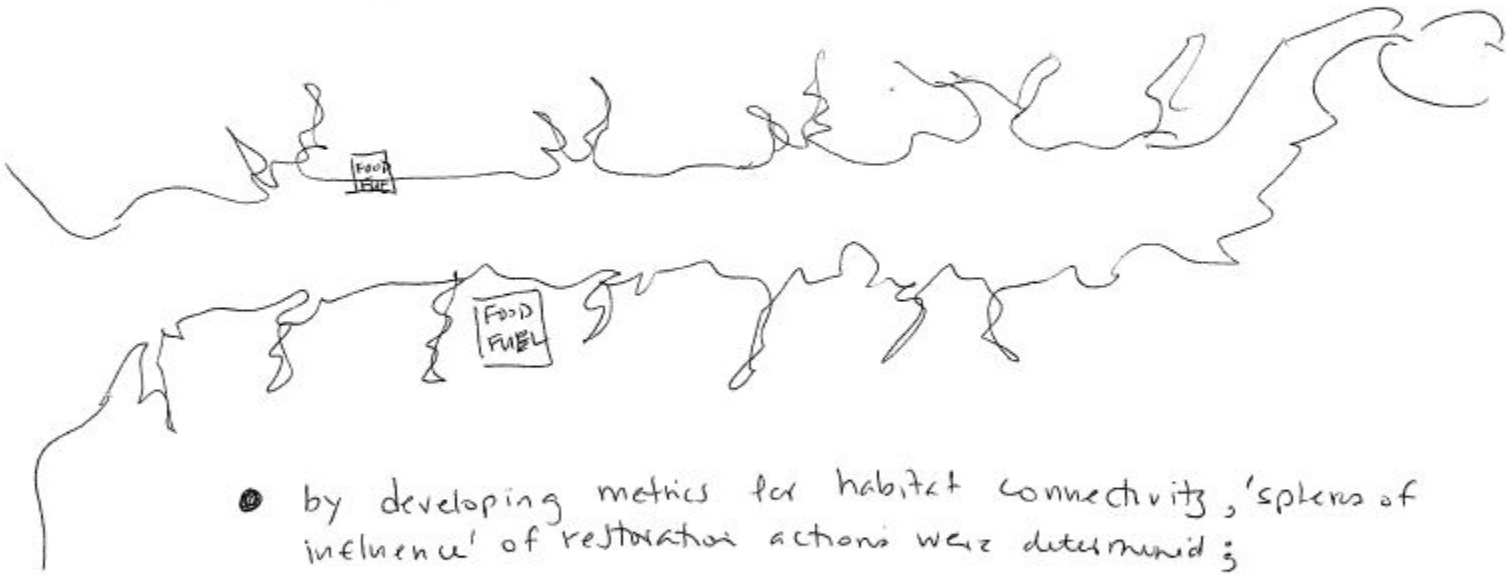
Subheadline



- Scientists from federal agencies & universities collaborate to develop novel biomarkers to evaluate fish health
- The markers have changed the way ecosystem restoration & the benefits have been understood. They provide indicators of health on the order of hours or days
- The studies have been conducted over the last 5 years. Lab testing to find & validate. Mesocosm testing to validate markers in semi-rig env. then field testing

Rest stops keep juvenile salmon truckin' to the ocean:

- Creating a network of habitats that support prey resources, water quality, + ~~safety~~ protection from predation

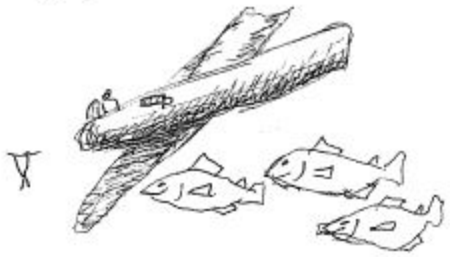


- by developing metrics for habitat connectivity, 'spheres of influence' of restoration actions were determined;
- densities of salmon ~~prey~~ along stretches of river were determined in space + time & overlain on spatial extent + frequency of restored habitats
- habitat suitability for ~~fish~~ prey, ~~and~~ competitors, salmonids, and predators were mapped under different ~~through~~ future-ready habitat restoration

Headline: Estuary no longer a bottleneck to Salmon recovery!

"30 years of collaboration by many partners has increased Columbia estuary salmon habitat to the point ~~where~~ so it no longer limits salmon survival, head of NOAA says."

- "Stepping stones" of productive habitat ~~for~~ provide abundant ~~habitat~~ prey/ to fish during movement to ocean
- Prey exported to mainstem nurishes larger salmon during rapid trip downstream
- Work wouldn't be possible with cooperation by many groups working towards common goal.
- Improvements expected to continue into future.



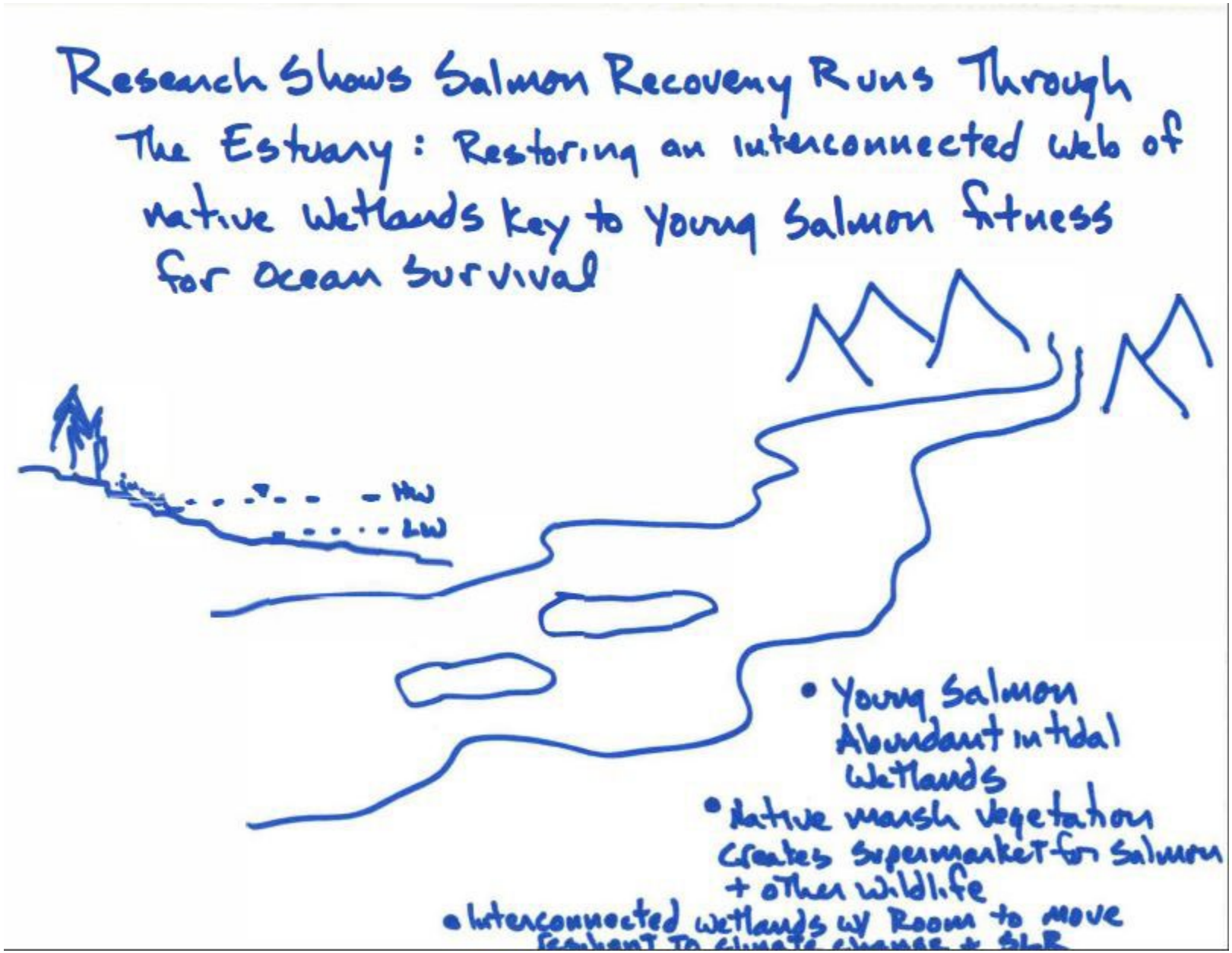
Happy Salmon in restoration site

Estuarine Wetland Buffets fuel Young Salmon

Habitat diversity [redacted] in estuarine wetlands has created a smorgasborg of [redacted] high quality food for young salmonids moving through or hanging out in the estuary... Yummo!

- Benefits extend beyond local habitats.

- restoration projects focused on diff. components of habitat enhancement
- [redacted] diff. habitats, both small & large scale, [redacted] differ in invert. composition
- Assessment of diff. invert associated w/ diff. habitat characteristics and incorporation of energetic content can show habitat [redacted] relationship


Research Shows Salmon Recovery Runs Through The Estuary: Restoring an interconnected web of native wetlands key to young salmon fitness for ocean survival
HW
LW
• Young salmon Abundant in tidal wetlands
• Native marsh vegetation creates supermarket for salmon + other wildlife
• Interconnected wetlands w/ Room to move

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