Northwest **Power** and **Conservation** Council

September 4, 2024

MEMORANDUM

TO: **Council Members**

FROM: **Patty O'Toole**

SUBJECT: **Overview of the Columbia Estuary Ecosystem Restoration Program (CEERP)**

BACKGROUND:

Presenter: Jason Karnezis, Estuary Lead Bonneville Power Administration

Summary: Jason will provide an update and overview of the Columbia Estuary Ecosystem Restoration Program (CEERP) and its implementation.

Relevance: The CEERP is described as a measure in the Council's estuary strategy in the 2014 Columbia River Basin Fish and Wildlife Program (Program). The Program calls for implementation, monitoring and evaluation of habitat actions in the estuary.

Workplan: Fish and Wildlife Division work plan 2024; Program planning & coordination

Background: The Bonneville Power Administration (Bonneville) and the U.S. Army Corps of Engineers, Portland District (Corps) developed the Columbia Estuary Ecosystem Restoration Program (CEERP) to understand, conserve, and restore ecosystems in the lower Columbia River and estuary.

The agencies developed the CEERP in response to three main drivers: the Council's Fish and Wildlife Program, the Water Resources Development Acts (Sections 206, 536, and 1135), and the Biological Opinions for operation of the Federal Columbia River Power System (FCRPS). The program's objectives are to 1) increase the capacity (quality) of estuarine and tidal-fluvial ecosystems; 2) increase the opportunity for access by aquatic organisms to and for export of materials from shallow water habitats; and 3) improve ecosystem functions for juvenile salmonids.

Primary approaches to restoration are to restore hydrologic connections between the mainstem and floodplain, create and/or enhance shallow water habitat, and reestablish native vegetation. Typical estuary restoration projects include the conservation and restoration of riparian areas, off-channel habitats, and estuarine wetlands and floodplains through levee modification and breaching; tidal channel creation; tide gate and culvert removal or modification; and invasive species control.

The Independent Scientific Advisory Board reviewed elements of the CEERP in 2012.

More Info: CEERP Implementation Plan. See attached.
Paper: Estuary ecosystem restoration: implementing and institutionalizing adaptive management.

Columbia Estuary Ecosystem Restoration Program

2024 RESTORATION AND MONITORING PLAN

DRAFT

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

US Army Corps of Engineers®

February 2024

Preface

The Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers Portland District (Corps) developed this 2024 Restoration and Monitoring Plan for the Columbia Estuary Ecosystem Restoration Program (CEERP) to document restoration actions and associated monitoring during the previous calendar year (2023) and communicate program plans for the current year (2024). The plan combines the three elements of the CEERP adaptive management process: compiling and learning from new data and information, using this learning to update program strategies for restoration and monitoring, and laying out planned activities for the coming year. The intent is to provide a succinct, efficient description of new learning, adjustments to strategy based on new learning, and resulting program actions.

Anne Creason (BPA), Heida Diefenderfer (Pacific Northwest National Laboratory), Jason Karnezis (BPA), Chanda Littles (Corps), Mark Bierman (Corps), and Allan Whiting (BPA) developed this plan. Ian Edgar, Sneha Rao Manohar, and Sarah Kidd of the Lower Columbia Estuary Partnership (LCEP) provided the maps of locations for restoration projects and Action Effectiveness Monitoring and Research (AEMR) and the data for tables documenting AEMR activities. Review comments from regional partners were sought, discussed, and incorporated into the final draft as appropriate. For more information, please contact Chanda Littles (Corps, 503-808-4784) or Jason Karnezis (BPA, 503-230-3098).

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Summary

The Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers Portland District (Corps) produced this 2024 Restoration and Monitoring (R&M) Plan for the Columbia Estuary Ecosystem Restoration Program (CEERP) to document the ecosystem restoration and monitoring implemented and planned in the lower Columbia River and Estuary (LCRE or Estuary) during the previous (2023) and upcoming (2024) calendar years. As a reminder, beginning in 2023, NOAA and the Action Agencies agreed to deliver an abridged version of this report every other year, only focusing on actions completed from the prior year (2022) and planned actions for 2023, omitting the review of the state of the science and its applicability to the CEERP program. This 2024 R&M plan thus looks back two years to review the state of the science, lessons learned, and any adjustments necessary to the program via a Master Matrix of Learning, which captures publications, conferences, workshops, on-the-ground restoration and monitoring activities, and other resources to adaptively manage CEERP.

The overall goal of the CEERP is to understand, conserve, and restore ecosystems in the LCRE. The program's objectives are to (1) increase the capacity (quality) of estuarine and tidal-fluvial ecosystems; (2) increase the opportunity for access by aquatic organisms to, and for export of materials from, shallow-water habitats; and (3) improve ecosystem functions for juvenile salmonids steelhead, and bull trout. Primary approaches to meeting these objectives are to restore hydrologic connections between the mainstem and floodplain, enhance shallow-water habitat, and reestablish native vegetation. The CEERP's three main drivers are the Northwest Power and Conservation Council's (Council's) Fish and Wildlife Program, the Water Resources Development Acts (Section 536 and the Continuing Authorities Program), and the Action Agencies ([AAs]; BPA, Corps and Bureau of Reclamation) 2020 Biological Assessment (BA) of the Effects of the Operations and Maintenance (O&M) of the Federal Columbia River System (CRS), as well as associated National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) 2020 CRS Biological Opinions.

The *2024 Restoration and Monitoring Plan* builds from previous CEERP planning documents, including annual restoration and monitoring plans during 2013–2023, Strategy Reports and Action Plans from 2012 and 2013, results of AEMR (PNNL and NMFS 2020), and the 2012 and 2018 Synthesis Memoranda (Thom et al. 2023; Johnson et al. 2018). The plan presented here includes by reference the CEERP *Programmatic Plan for Action Effectiveness Monitoring and Research* (BPA/Corps 2017). These documents serve to guide and inform the Action Agencies, the NMFS, the USFWS, the Council, CEERP restoration project sponsors (CIT, CLT, CREST, LCEP, and WDFW), researchers, and various interested parties as the CEERP is implemented.

Lessons learned in 2022 and 2023 and over the last decade of the CEERP continue to affirm that hydrologic reconnection of lost floodplain habitats and the associated restoration of habitat-forming and functional processes improve ecosystem functions and juvenile salmon use at restored sites (PNNL and NMFS 2020). This growing evidence confirms that an ecosystem-based restoration approach is beneficial and AAs plan to continue implementing this main strategy. CEERP restoration projects and reference-site monitoring are providing growing support for the hypothesis that juvenile salmon benefit *directly* and *indirectly* from tidal wetland restoration (Roegner and Johnson 2023; Sather et al. 2020; Weitkamp et al. 2020). An evidence-based evaluation of the CEERP concluded that "all lines of evidence from the LCRE indicated positive habitat-based and salmon-based responses to the restoration performed under the

CEERP" (Diefenderfer et al. 2013). Accordingly, the AAs' strategy for restoration continues to emphasize large-size, full hydrologic reconnection projects at sites near the mainstem river across the 234 km LCRE. Further, with the Expert Regional Technical Group (ERTG) producing new guidance and tools to incorporate the consideration of landscape principles in project planning, design, and assessment, smaller projects are being pursued and are expected to play an increasing role in helping meet restoration objectives. To implement the CEERP, the AAs will continue to engage the ERTG in the review of Estuary habitat restoration projects (ERTG 2024; to be reviewed in the 2026 plan), identification of uncertainties, and input on the prioritization of restoration efforts. In addition, the AAs will continue to implement AEMR, including sampling for juvenile salmon, when feasible.

A Master Matrix of new learning from 2022-23, along with associated CEERP actions for restoration implementation and the research, monitoring, and evaluation (RME) strategy for 2024 are contained in Appendix A. This matrix of learning, created via AA collaboration, serves a fundamental purpose in the CEERP adaptive management process, i.e., the identification, assessment, and application of new learning, as appropriate. CEERP restoration practitioners, researchers, ERTG, NMFS, USFWS, and the AAs are given the opportunity to review and identify significant lessons learned, papers published, presentations given, and new emerging data that informs decisions made about the future direction of the CEERP.

In the 2020 BA, the AAs proposed to continue habitat improvements in the Estuary as part of their consultation with NMFS and USFWS under the Endangered Species Act with a goal of reconnecting an average of 300 acres of floodplain habitat to the mainstem Columbia River per year. The AAs plan to continue to implement CEERP restoration projects to work toward achieving this objective. The proposed action also includes provisions for the AAs to conduct associated AEMR to inform decision-making and adaptively manage the program as new data and information become available. This information is shared annually through this plan.

The AAs have several actions planned for CEERP restoration and monitoring during 2024. For restoration, three projects are anticipated to begin or complete construction during 2024—Wolf Bay (49 acres [ac]), Agency Creek (22 ac), and Warren Slough (24 ac). Project sponsors are continuing to work on developing and implementing projects in future years as well. The AEMR program will collect data at 31 pre- and post-restoration projects. In addition, RME for vegetation, juvenile salmon, and food web dynamics will be conducted together with routine status and trends monitoring under the LCEP's Ecosystem Monitoring Program (EMP) at six additional sites, bringing the total number of monitored sites to 37 during 2024.

In summary, the CEERP 2024 Restoration and Monitoring Plan describes the AAs' fundamental strategy for Estuary habitat actions and RME—apply an ecosystem-based approach to restore, enhance, or create structures, processes, and functions in the Estuary; and perform RME to assess the effectiveness of these actions, while building our understanding of ecosystem functions in the LCRE. The AAs intend for the CEERP to take advantage of lessons learned and knowledge gained from previous restoration and RME efforts in the LCRE and elsewhere to achieve a cost-effective and biologically effective ecosystem restoration program.

Acronyms and Abbreviations

AAs	Action Agencies
AEMR	action effectiveness monitoring and research
AFEP	Anadromous Fish Evaluation Program
AMP	adaptive management plan
APE	area of potential effect
BA	Biological Assessment
BDA	beaver dam analogue
B.C.	British Columbia
BPA	Bonneville Power Administration
BUDM	beneficial use of dredged material
CA	California
CEERP	Columbia Estuary Ecosystem Restoration Program
CERF	Coastal and Estuarine Research Federation
CIT	Cowlitz Indian Tribe
CLT	Columbia Land Trust
Corps	U.S. Army Corps of Engineers
Council	Northwest Power and Conservation Council
COVID	coronavirus disease
CREST	Columbia River Estuary Study Taskforce
CRB	Columbia River Basin
CRE	Columbia River Estuary
CREC	Columbia River Estuary Conference
CWTD	Columbian white-tailed deer
DJI	Da-Jiang Innovations
EMP	Ecosystem Monitoring Program
ERTG	Expert Regional Technical Group
FCRPS	Federal Columbia River Power System
FY	fiscal year
GHG	greenhouse gas
HO	hatchery origin
HIP	Habitat Improvement Program
IFRMP	Integrated Fisheries Restoration and Monitoring Plan
LCEP	Lower Columbia Estuary Partnership
LCR	lower Columbia River
LCRE	lower Columbia River and Estuary
LWD	large woody debris

MML	Master Matrix of Learning
MOA	Memorandum of Agreement
NCER	National Conference on Ecosystem Restoration
NMFS	National Marine Fisheries Service
NO	natural origin
NOAA	National Oceanic and Atmospheric Administration
NP	natural production
O&M	operations and maintenance
ONCOR	Oncorhynchus (database)
OR	Oregon
PA	Proposed Action
PAMF	Phragmites Adaptive Management Framework
PDT	Project Delivery Team
PIT	passive integrated transponder
PNNL	Pacific Northwest National Laboratory
PNW	Pacific Northwest
PNWR	Portland and Western Railroad
PRC	Project Review Committee
RCG	reed canarygrass
RDC	restoration design challenge
RGB	red, green, blue
RME	research, monitoring, and evaluation
RTK	real-time kinematic
SBU	survival benefit unit
SC	Steering Committee
SER	Society for Ecological Restoration
SET	surface elevation table
SRWG	Studies Review Work Group
SWG	Science Work Group
TEK	Traditional Ecological Knowledge
UAS	uncrewed aerial system
UAV	uncrewed aerial vehicle
WA	Washington
WDFW	Washington Department of Fish and Wildlife

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1.0 Introduction

As two of the three Action Agencies (AAs) for the 2008 Biological Opinion (BiOp) (NMFS 2008) on the operation and maintenance of the Federal Columbia River Power System (FCRPS), the Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers Portland District (Corps) established the Columbia Estuary Ecosystem Restoration Program (CEERP) to implement mitigation for impacts of the FCRPS on anadromous salmonids listed under the Endangered Species Act. CEERP is also responsive to the Corps' restoration authorities (e.g., Water Resources Development Act of 2000, Sec 536 and the Continuing Authorities Program) and the Northwest Power and Conservation Council's (Council's) Columbia River Basin Fish and Wildlife Program (NPCC 2014).

In the 2020 Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species (2020 BA), the AAs committed to continuing habitat improvements in the Estuary with a goal of reconnecting an average of 300 acres (ac) of floodplain habitat to the mainstem per year. The AAs will continue implementing CEERP restoration projects to achieve this goal. The proposed action described in the 2020 BA also included provisions for conducting Action Effectiveness Monitoring Research (AEMR) to inform decision-making and adaptively manage CEERP as new data and information become available. These activities are communicated annually through the restoration and monitoring plan.

The purpose of this *CEERP 2024 Restoration and Monitoring Plan* is to document learning, coordination, and monitoring updates from calendar years 2022-23 and communicate program plans for restoration, monitoring, and adaptive management activities to be performed during calendar year 2024. This plan helps document CEERP's adaptive management (Ebberts et al. 2017; Littles et al. 2022) and is a deliverable to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) in accordance with the 2020 BiOp for the Columbia River System (NMFS 2020). In this plan, we (the AAs) provide a succinct, efficient description of new learning, adjustments to restoration and monitoring strategies based on this new learning, and the resulting program actions in 2024 to restore and monitor ecosystems in the lower Columbia River and Estuary (LCRE).[1] Planned program actions in 2023 were described in last year's biennial abbreviated Restoration and Monitoring Plan (BPA/Corps 2023). The intent is for program managers and stakeholders to use the plan to communicate, plan, and coordinate CEERP activities.

1.1 Background

The CEERP is founded on a specific goal and associated principles, objectives, and management questions that are pursued within a designed adaptive management process. CEERP's overall goal is to understand, conserve, and restore ecosystems in the LCRE. The CEERP objectives reflect an ecosystem-based approach: (1) increase the capacity[2] (quality) of estuarine and tidal-fluvial ecosystems; (2) increase

[1] By definition, the LCRE includes tidally influenced areas of the mainstem and floodplain from Bonneville Dam to the mouth of the Columbia River.

[2] Capacity is a category of habitat assessment metrics including "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality," for example, invertebrate prey productivity, salinity, temperature, and structural characteristics (cf. Simenstad and Cordell 2000).

the opportunity for access[3] by aquatic organisms to shallow-water habitats and for export of materials from shallow-water habitats; and (3) improve ecosystem-realized functions[4] for juvenile salmonids. To meet these objectives, CEERP's strategy for ecosystem restoration emphasizes hydrologic reconnections to restore the access to and capacity of habitats that have been cut off from the mainstem Estuary, while also working to improve the quality of existing habitats used by juvenile salmonids and other species (Simenstad and Cordell 2000). This strategy is founded on basic principles of ecological science and landscape ecology (NRC 1992). The primary CEERP actions are to restore hydrologic connections between the mainstem and floodplain, enhance shallow-water habitat, and reestablish native vegetation.

The strategy for LCRE habitat restoration employs an ecosystem-based approach, applying the best available ecological science (Johnson et al. 2003). A formal adaptive management process (Ebberts et al. 2017 and Littles et al. 2022) is in place to implement CEERP's strategy through annual cycles of project development, prioritization, implementation, monitoring and research, and synthesis and evaluation, and by periodically revisiting the strategy (Thom et al. 2013; Johnson et al. 2018). Briefly, this process involves an annual cycle with three main elements (Figure 1.1): restoration actions are implemented, monitoring is conducted, and learning is captured and reapplied to subsequent restoration and monitoring strategies. Monitoring activities are based on Johnson et al. (2008) and BPA/Corps (2017). In addition, the Expert Regional Technical Group (ERTG) for Estuary habitat restoration reviews and scores proposed CEERP restoration projects (Krueger et al. 2017). The ERTG also develops work products in response to requests from its steering committee (composed of BPA, Corps, and NMFS representatives) that are particularly relevant to CEERP management and strategy, e.g., landscape principles (ERTG 2019). In sum, the strategy and adaptive management process for the CEERP are straightforward by design because what we term the "see-spot-run" approach facilitates an emphasis on learning by doing.

Figure 1.1. CEERP's adaptive management process. The term "monitoring" covers research, monitoring, and evaluation.

[3] Access is a category of habitat assessment metrics that "appraise the capability of juvenile salmon to access and benefit from the habitat's capacity," for example, tidal elevation and geomorphic features (cf. Simenstad and Cordell 2000).

[4] Ecosystem function is defined as the role that plant and animal species play in the ecosystem. It includes primary production, prey production, refuge, water storage, nutrient cycling, etc.

1.2 Approach

Annually, the AAs collaboratively assess lessons learned from a wide variety of sources with the aim of informing implementation of the program the following year. The centerpiece of this effort is the compilation of the Master Matrix of Learning (MML; Appendix A). Sponsor lessons learned are conveyed to program managers continuously through processes including ERTG site revisits (ERTG 2024), restoration project proposals and scoring, and presentations at regional and national conferences as well as the ERTG annual meeting. Additional 2022-23 evidence for the MML was gathered by compiling and reviewing materials including: relevant journal articles about the Columbia River Estuary or other, similar systems; program-related reports; presentations from conferences, workgroups, and workshops; and ERTG activities and work products. Many of these products were developed or coauthored by CEERP stakeholders and showcase the breadth and depth of knowledge generated by program participants. Learnings for which no adjustment was needed are listed in Appendix B. Lessons learned from the five CEERP sponsors are included to share notable experiences and observations for restoration and monitoring activities (Appendix C).

To inform adaptive management of the program in 2024, processing of the new information from 2022-23 was accomplished by taking four main steps:

1. Build –Team members compile and list materials in a spreadsheet by title and type.
2. Screen – Six individuals reviewed assigned materials and made a preliminary recommendation about whether the lessons learned had the potential to lead to an adjustment in strategy or practice or any action by CEERP managers, whether restoration or monitoring. For those deemed actionable, reviewers wrote a short version of the learning and drafted a proposed adjustment or action for discussion.
3. Discuss – Individual reviewers presented findings and learnings with proposed adjustments or action items (and findings with undecided significance) to other reviewers and staff for discussion and refinement. The findings with confirmed adjustments were retained in the MML (Appendix A), while citations for the remaining items were recorded for thoroughness (Appendix B) but excluded from the MML.
4. Finalize – Task leads used tables, maps, restoration descriptions, and specific MML actions to create the main body of the plan in combination with the full MML (Appendix A). Once these four steps were completed, the basis of the plan was ready for implementation in 2024. Team members will use the MML to separate 2024 CEERP action plans for the AAs and for the sponsors. These plans will be shared, reviewed, and discussed, and CEERP managers will select and prioritize actions to complete in 2024. These actions will be shared and reported on in upcoming CEERP Restoration and Monitoring Plan—the 2025 (abbreviated, with no Master Matrix of Learning) and 2026 (full-length, including action plan outcomes) —to reflect our adaptive management process and accomplishments.

1.3 Learning

We reviewed items from six main categories of learning: management, coordination, project review, conferences/workshops/workgroups/presentations, reports, and peer-reviewed journal articles. Within these categories, we reviewed 3 technical reports and 23 journal articles that were published during 2022-23 as well as additional reports and articles uncovered from prior years' publication. We also reviewed

selected highly relevant websites such as the Vital Sign Indicator for Puget Sound and include two herein. We highlight 8 conference presentations based on attending and reviewing conferences, workshops, workgroups, and presentations including, but not limited to, the Columbia River Estuary Conference, Coastal & Estuarine Research Federation National Conference, American Fisheries Society Oregon Chapter Annual meeting, River Restoration Northwest, and LCEP Science Workgroup meetings. In addition, the AAs requested and were provided lessons learned from CEERP's project sponsors about restoration and monitoring during the last two years. The AAs discussed and identified new learnings and associated actions for CEERP. CEERP actions in response to these learnings are described in Section 2 for restoration, and Section 3 for monitoring. The full table reflecting these learnings is in Appendix A – 2022 CEERP Adaptive Management: Master Matrix of Learning and CEERP Actions. Citations that are reviewed but do not warrant any CEERP action are captured in Appendix B. Although citations in Appendix B do not warrant any CEERP action, many of them reaffirm or support work and principles upon which CEERP is based.

1.4 Document Organization

This 2024 CEERP Restoration and Monitoring Plan contains three main sections following this Introduction (Section 1): Restoration (Section 2), Monitoring (Section 3), and Programmatic Activities (Section 4). References are listed in Section 5. Appendix A contains the MML, which includes associated CEERP actions for restoration and monitoring. Appendix B contains references to sources reviewed that reaffirmed but did not result in actions for CEERP. Appendix C contains lessons learned provided by restoration project sponsors.

2.0 Restoration

The AAs' strategy for restoration continues to emphasize large-size, full hydrologic reconnection projects at sites near the mainstem river across the 234 km LCRE. However, large projects (typically >100 ac [ERTG 2010]) take more time and are more challenging to implement than small projects due to more complex social issues (e.g., multiple landowners with different goals and timelines), technical hurdles (e.g., engineering complexity and environmental permitting), and coordination needs (e.g., integrated effort among BPA, the Corps, and project sponsors) (Littles et al. 2022). Although emphasis is on large projects, smaller projects are also pursued and implemented to support restoration objectives as such opportunities present themselves, especially when they have potential importance at the landscape-scale (Hood et al. 2022). The AAs engage the ERTG to technically review and provide feedback on proposed projects.

2.1 2023 Restoration Accomplishments

During 2023, sponsors had planned to complete four restoration projects: Aldrich Point, Wolf Bay, South Tongue Point, and Svensen Island. Due to permitting delays, restoration projects were completed at two sites—Aldrich Point and South Tongue Point. Future projects and their status are also discussed in Section 2.3.

2.2 2022-23 Restoration Learning

New learning from 2022-23 was identified and then actions were developed as appropriate for implementing CEERP restoration moving forward (Table 2.1; Appendix A contains the full MML).

Table 2.1. Actions for CEERP 2024 *restoration* strategy and implementation based on new learning from 2022-23.

Title	Short Reference	Learning	CEERP Action
Impacts of a Cascadia subduction zone earthquake on water levels and wetlands of the lower Columbia River and estuary.	Brand et al., 2023	A combined hydrodynamic and habitat model are used to predict the potential effects of a Cascadia subduction zone earthquake. The study modeled four scenarios including current conditions, subsidence solely from the M9 earthquake, M9 subsidence + infrastructure failure, and M9 subsidence + infrastructure failure + liquefaction. There were variable effects on the tidal range, up to an approximate 10% increase. The habitat model indicated a significant loss in forested and scrub shrub wetland habitats, as well as intertidal habitat, whereas there would be a marked increase in low marsh and subtidal habitat.	Results of this study could be incorporated into the larger CEERP discussions about incorporating resilience into restoration projects. While the focus to date has primarily centered around climate resilience, there is a good argument for addressing other projected sources of natural and man-made disturbances. Initial action item could be a "special topics" discussion with the ERTG and SC about how results of this study might inform restoration planning and priorities.
Estimating juvenile salmon estuarine carrying capacities to support restoration planning and evaluation.	Hall et al. 2023a	Study arrives at estimated carrying capacities for Chinook and coho salmon, which have decreased from historical capacities and are estimated to decline more with sea level rise and in areas projected to lose vegetated tidal wetland habitat, while projected to increase in vegetated wetland due to sea level rise. Most interesting, study demonstrates how carrying capacity estimates can be used to estimate changes in juvenile salmon capacity following restoration, which can be used to both design and evaluate restoration projects.	CEERP management to have ERTG examine and discuss how biological metrics (like CC) could be used in evaluating CEERP projects as current physical metrics of evaluation (i.e., hydrology, scour, velocity, or habitat area) do not necessarily directly link to habitat capacity. This is relevant to ongoing discussion about estuary habitat uncertainties.
Distribution of large wood in river delta tidal marshes: implications for habitat restoration.	Hood 2022	Very few LWD studies in estuarine environments. GIS analysis in Skagit deltas showed large wood densities were 28 to 50 times lower in Puget Sound tidal channels than in Western Washington streams. Do not assume same benefit for LWD as when placed in fluvial environments. We need more studies on LWD in the LCRE	BPA is sponsoring Research at the CREST restoration project, South Tongue Point, to study the effects of installed LWD in estuaries. LWD installed fall 2023. Study design and sampling plan designed by PNNL and CLT.

Using bioenergetics and landscape connectivity to plan effective tidal delta restoration projects for Chinook salmon.	Howe & LeMoine 2023	Hydraulic, landscape connectivity, and bioenergetic models were employed to evaluate the abundance and growth potential of juvenile Chinook salmon across varying restoration and climate scenarios. Authors used restoration design and monitoring data from projects encompassing roughly 900 acres of the Stillaguamish delta, Washington, and assessed which recovery actions provided cumulative, broad-scale, and resilient restoration benefits to juvenile Chinook salmon.	Study complements the landscape design principles currently being implemented by the ERTG and may provide a means for enhancing the direct linkage to salmonid benefits (e.g., by adding explicit bioenergetic considerations). An immediate next step for CEERP would be to invite the authors to present their approach and preliminary findings to the ERTG and SC.
Long-term changes in river tides in the Lower Columbia River Estuary.	Jay et al. 2023	Flood dynamics in the LCR have dramatically changed over the last 170 years, primarily due to channel improvements (e.g., deepening and channel training structures). Tides and storm surges persist further upstream for any given flow level. A wavelet tidal analysis program was used to estimate tide behavior. Key findings included observations that tidal waves are moving upstream faster, and storm surges penetrate further into the system.	No specific action for CEERP at this time, but findings may be relevant for to future discussions related to restoration project resilience and habitat projections long-term.
A Resist-Accept-Direct (RAD) future for Salmon in Maine and California: Salmon at the southern edge.	Kocik et al. 2022	This study of Maine and Californian rivers is historically focused, documenting socio-cultural factors in North American salmon reduction and illustrating the differential application of RAD to different socio-cultural subsystems in the watersheds (Figure 2). Includes a national review of hatchery program efforts to recover salmon across the RAD spectrum. According to the definition on p. 461, CEERP is a "resist" strategy because it reconnects floodplain. Bottom et al. 2005 is cited relative to increased focus on estuarine rearing habitats. Interesting conceptualization of hatchery programs as initially "resist" but transitioning to "accept." Authors suggest a Resist-Accept-Direct (RAD) framework for more effectively accounting for current and future climate projections may affect salmon recovery efforts in tandem with historic stressors (i.e., the 4-Hs, hatcheries, hydropower, harvest, and habitat). Figure 2 provides a schematic for how the RAD approach might be applied to a watershed in terms of specific actions to resist, accept, and direct.	Could be useful to have a work session with ERTG and ERTG-SC to conceptualize the application of the Resist-Accept-Direct approach to CEERP, though many related decisions were already made by CEERP. For example, to reconnect the floodplain (resist) but not to interfere with cities and highways (accept). (SC contractor could prepare a map-type visual of such decisions converted to the RAD framework.) There may be opportunities to utilize the RAD approach that could be brainstormed (1) to "direct," (2) lessons learned from hatchery programs nationwide that are reviewed and could dovetail with ERTG work on Conceptual Foundations, and (3) climate change considerations related to ERTG special assignment. CEERP managers will forward to ERTG members working on climate resilience work product to assess whether framework might be helpful in that context.

Patterns and predictors of soil carbon accumulation rates across multiple Pacific Northwest estuaries.	Poppe et al. 2023	Authors evaluated carbon accumulation rates across 25 PNW estuaries and various tidal wetlands using tracers and surface elevation tables. They tested multiple potential predictors of CAR including wetland type, land use, salinity, groundwater levels, wetland elevation, vegetation, temperature, relative sea level rise, riverine sediment discharge, and watershed area. CAR was generally higher at restored sites and correlated more with sediment accretion than carbon density.	No immediate action for CEERP, but findings could be incorporated into pending ERTG work product on climate resilience—especially since there was at least some evidence that restored wetland sites may accumulate more carbon.
Contesting neoliberal knowledge politics in restoration governance: the restorationist's dilemma.	Rozance et al. 2020	Numerous factual inaccuracies and suggestions about CEERP restoration and monitoring in Youngs Bay appear to be based on undated interviewed with 10 practitioners (likely around 2015). Misrepresents the history and timing of CEERP monitoring program development and its parts. Attempts a "take-down" of the scientific basis of CEERP. The key issues in restoration ecology critiqued were originally incorporated in CEERP monitoring design but the paper doesn't cite Ebberts, Thom, or Johnson foundational reports. Paper doesn't seem to be deeply cited, i.e., presents functional trajectories as recent understanding (but see Simenstad and Thom 1996) and presents the problems with "no net loss" in wetland mitigation as new (but see National Research Council 1992).	This work does not cite some of the foundational publications that have informed CEERP AM to date. In addition, the ERTG moved away from survival benefit units (SBUs) and introduced the land scape framework as a more comprehensive way of assessing restoration actions. Ebberts et al. 2017 and Littles et al. 2022 provide a more recent, holistic, and thorough assessment of CEERP.
Analysis of fish community characteristics relative to pile structures in the lower Columbia River and estuary.	Sather & Rose 2022	Study used ancillary data to evaluate how and whether pile dikes or dredged material placement sites affected salmonid and other fish use. Piles and BUDM sites did not appear to have a detectable adverse effect on fish abundance, the composition of Chinook genetic stocks, Chinook size, or density. The greatest effects were attributed to season and habitat type.	If more pilot restoration projects are pursued within CEERP that utilize BUDM or pile structures, a more targeted study of fish response may be warranted to more definitively parse out any short- or long-term effects due to new placement or pilings.

How the US is fighting back against deadly floods.	Sherriff, 2023	Article highlights recent 100-year flood events, particularly in Vermont, that have devastated disadvantaged, low-income communities in particular. One of the primary solutions presented for improving climate resiliency is restoring natural floodplain habitats.	CEERP could do a better job cataloguing low-income and disadvantaged communities within the vicinity of restoration projects to document the potential benefits with regard to mitigating flood risk.
Promoting resiliency of coastal habitats through holistic assessment and planning.	Stein & Walker 2023	Study focused on habitat type conversion through restoration and management actions that could allow restored habitats to better subsist under climate change. Evaluation framework included documentation of risk, uncertainty, functional prioritization, and possible resource trade-offs to assess the net environmental benefit of a proposed action.	This study offers an opportunity for CEERP to engage with broader regional partners to leverage approaches that are being implemented to evaluate possible climate resilience. For example, the incorporation of functional habitat characteristics to help set restoration priorities may be applicable to CEERP. An immediate next step could be the identification of specific habitat traits within the LCR that may facilitate greater resiliency—perhaps within the ERTG work product currently under development.

2.3 2024 Restoration Action Plan

CEERP-related restoration is conducted by the Corps under Section 536 of a Water Resources and Development Act and the Continuing Authorities Program. CEERP restoration is also funded under BPA's Fish and Wildlife Program through projects with the CLT (BPA project# 2010-073-00), the CREST (BPA project# 2010-004-00), the CIT (BPA project# 2012-015-00), the LCEP (BPA project# 2003-011-00), and the WDFW (BPA project# 2010-007-00).

During 2024, four CEERP restoration projects are anticipated for construction and ten restoration projects are anticipated to be in the active design phase (Figure 2.1). Brief descriptions follow for the hydrologic reconnection components of four restoration projects scheduled for construction during 2024 (this list is subject to change). This information is from the project templates prepared for the ERTG review process.

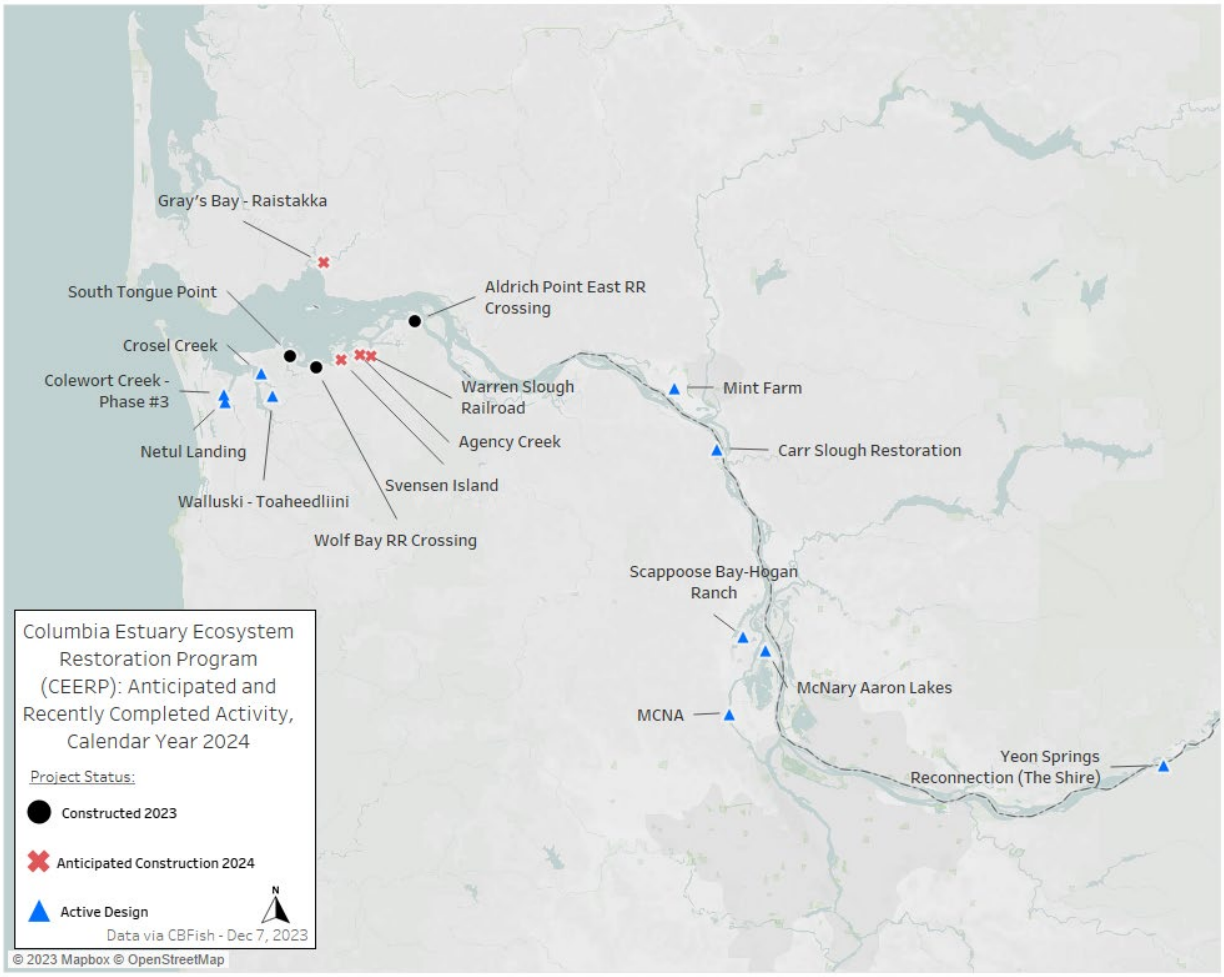

Figure 2.1. Map of CEERP projects constructed in 2022-23, under active design in 2024, and anticipated for construction in 2024. (Courtesy of K. Marcoe, I. Edgar, and S. Kidd, LCEP) (All projects are subject to change.)

- **Wolf Bay RR Crossing:** CREST's Wolf Bay project is one of a series of projects intended to improve hydrologic connectivity and juvenile salmonid access to adjacent habitat through the defunct PNWR railroad line in Reach B Oregon. This project functionally expands the existing railroad trestle opening by adding two adjacent 30 ft. side-by-side bridges that will eliminate a depth and velocity barrier to fish access at the 43-acre site. Additionally, a new railroad breach on the east end of the site will be constructed using a 40 ft. bridge to provide a second access point to Wolf Bay's relatively pristine floodplain habitats. These hydrologic improvements to the railroad levee will enhance an existing juvenile salmonid habitat patch that is relatively isolated, because the nearest downstream patch is nearly 5 km away, while the nearest upstream patch is about 1.4 km away.
- **Agency Creek:** CREST's Agency Creek restoration is one of a suite of projects in the eastern portion of Cathlamet Bay that will reconnect wetland habitat through the defunct PNWR railroad. Agency Creek is located near RM 25 about a mile downstream from the town of Knappa. This project will improve fish access to a combined 22 acres of wetland across two separate parcels by removing three undersized, perched culverts and replacing them with a 40-ft span bridge, as well as removing approximately 725 ft of derelict levee remaining from historical agricultural and logging activities. Restored hydrologic connectivity will increase tidal exchange, improve channel edge habitat complexity, and enhance food web flux throughout the project site. Landscape-scale benefits include enhancing an existing 35-acre mainstem-adjacent habitat patch in a priority reach (Reach B) of the estuary.
- **Warren Slough:** CREST's Warren Slough restoration is one of a suite of projects in the eastern portion of Cathlamet Bay aimed at reconnecting wetland habitat through the defunct PNWR railroad. Warren Slough is located near RM 26, running parallel to Ziak-Gnat Creek Road northeast of the town of Knappa. The project will improve juvenile salmonid access to a 22-acre wetland complex by removing two undersized, perched culverts and replacing them with a 40-ft span bridge. Restored hydrologic connectivity and native wetland plantings will enhance vegetation diversity, increase channel edge habitat complexity, and produce a range of prey resources and foraging interface. Landscape-scale benefits include expanding upon an existing 228-acre habitat patch in a priority reach (B) of the estuary.
- **Svensen Island:** Project restoration measures include removal of existing dike and tidegate structures to reestablish tidal hydrology on site. Channel enhancements will also be included to emulate natural tidal slough channel structure. Removal of exotic pasture grasses will allow natural colonization of estuarine plant communities from adjacent seed banks. Remnant dredge materials will also be removed on properties north end to reference estuarine plant colonization elevations.

3.0 Monitoring

Research, monitoring, and evaluation (RME, or "monitoring") is essential to CEERP's adaptive management process and restoration efforts. Traditionally, CEERP monitoring has been organized into four categories (Johnson et al. 2008): implementation and compliance monitoring, status and trends monitoring, AEMR, and critical uncertainties research. CEERP covers all four categories. First, BPA routinely monitors implementation and compliance of restoration actions, with project reports available at: https://www.cbfish.org/EstuaryAction.mvc/Actions. Second, status and trends monitoring provides a baseline for assessing changes in LCRE ecosystem conditions through time. Status and trends monitoring, conducted by LCEP and various subcontractors, examines plant community composition, primary and secondary production, juvenile salmon ecology in floodplain wetlands, sediment, hydrology, and water quality parameters in the mainstem LCRE. Third, AEMR studies are pursued and integral to CEERP adaptive management because they increase our understanding about which restoration actions work, which do not, and why. Monitored indicators typically include water surface elevation, water temperature, sediment accretion, vegetation community composition and biomass, fish community composition, and juvenile salmon distribution and density. AEMR studies carried out by various CEERP partners sometimes incorporate a paired restoration-reference site design. In this report, the *Columbia Estuary Ecosystem Restoration Program: Programmatic Plan for Action Effectiveness Monitoring and Research* (BPA/Corps 2017) is incorporated by reference, including the AEMR levels.[5] Fourth, critical uncertainties are monitored, which, in the context of CEERP, refer to uncertainties that if better understood or resolved would improve program strategy and management. The ERTG work product for CEERP uncertainties addressed relevant topics at system, estuary, landscape, and site scales (ERTG November 2022). The general strategy for CEERP monitoring during 2024 is to continue work in the four aforementioned RME categories.

This section describes activities accomplished during 2023 (Section 3.1), adjustments for 2024 (Section 3.2), and an action plan for 2024 monitoring (Section 3.3).

3.1 2023 Monitoring Accomplishments

Monitoring accomplishments are presented in order of those funded by the Corps followed by those funded by BPA.

The Corps AFEP Estuary studies in 2023 included AEMR and critical uncertainties research conducted for the continued study of the beneficial use of dredged material (BUDM) at the Woodland Islands restoration project (AFEP study code EST-P-19-01). At Woodland Islands, the USACE placed 237,000 CY of dredged material totaling 13.5 acres of off-channel margin sand. Research and adaptive management plan(s) for the Woodland Islands BUDM site included monitoring changes in elevation, sampling sediments, planting and monitoring vegetation, sampling fish, characterizing changes in the benthic community, and tracking other environmental indicators (Hansen et al. 2024; Sather et al. 2023).

[5] The three levels of AEMR: Level 1, "intensive AEMR," examines ecosystem processes and functions, e.g., juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors; Level 2, "core AEMR," assesses core indicators of ecosystem structures and controlling factors such as plant species composition, percent cover, and biomass; and, Level 3, "standard AEMR," monitors key controlling factors and other indicators, e.g., photo points, water surface elevation, and salinity.

The Action Effectiveness Monitoring and Research of Dredged Material Placement at Woodland Islands report by PNNL was finalized in December 2023 (Sather et al. 2023). This PNNL-led Before-After-Control-Impact (BACI) study of one impact site and two control sites was used to evaluate environmental and benthic invertebrate response associated with dredged material placement. Sampling for two years before and two years after dredged material placement showed that benthic invertebrates were produced in off-channel habitats at all locations, including many common juvenile salmon prey items, though spatial variation was a significant factor for both environmental and biological response. Estimated invertebrate abundance was significantly lower at impact than control after dredged material placement, as measured by three abundance metrics. However, benthic invertebrate composition was similar before and after, suggesting the potential for recolonization as the habitat evolves.

In 2023, the Corps completed the second of three years of fish sampling at Woodland Island to monitor its use by juvenile salmon and assess its potential use by predatory fish species compared to channel island habitat further upstream that would more closely mimic pre-placement conditions (Hansen et al. 2024). As currently planned, the next fish sampling at the project will be in 2025. Supplemental planting was also conducted in 2023, with the project sponsor adding approximately 2,300 willow stakes, 500 Douglas spirea, and 2,200 wetland herbaceous plants to the riparian zone below 12.5 feet NAVD88. Planting effort was focused on the two embayments where the greatest vegetation survivorship has been observed.

Progress continues under the AFEP study (EST-P-20-01) using passive integrated transponder (PIT) technology to detect fish use at the Dairy Creek restoration project, which connects Sturgeon Lake to the mainstem Columbia River (Josephson 2024). The PIT array was installed in November 2020, and the monitoring reports have been completed for 2021, 2022, and 2023. In 2022, the Dairy Creek PIT tag array detected 28 different salmonids and sturgeon using the waterway. The eight (8) sturgeon detected were all White Sturgeon previously tagged in the Lower Columbia River from River miles 0-146. For the salmonids (20 total detected), the majority were Hatchery Summer Steelhead (35%) and Hatchery Fall Chinook (25%). Wild Steelhead, Hatchery Spring Chinook, and Hatchery Summer Chinook each had a couple of detections, followed by single detections of Wild Summer Steelhead and Hatchery Coho. Most of the detected fish in Dairy Creek came from hatchery programs, except for three (3) wild Steelhead and eight (8) wild White Sturgeon. Similar to previous years' data, there has been a wide distribution of upriver stocks using the channel, including stocks from Northern Washington and Idaho. In 2023 the Dairy Creek PIT tag array detected 63 different salmonids and sturgeon using the waterway. The three (3) sturgeon detected were all White Sturgeon previously tagged in the Lower Columbia River from River miles 0-30. For the salmonids (60 total detected), the majority were Hatchery Spring Chinook (46%), Hatchery Fall Chinook (17%) and Hatchery Summer Steelhead (13%). Wild Steelhead and Wild Summer Steelhead each had a number of detections, followed by single detections of Wild Spring Chinook, Wild Chinook (unknown run), Hatchery Summer Chinook, and Hatchery Coho. For both 2022 and 2023, most of the detected fish were from hatchery programs. It is unclear at this point why detections in 2023 were so much greater in number than detections in 2022 (Josephson 2024). This monitoring effort represents AEMR Level 1 sampling at a reconnected floodplain lake that can be tracked over time and compared with other restoration sites along the mainstem.

Transitioning to BPA-funded research and monitoring, annually, LCEP manages another part of the AEMR program, focusing on Level 2 and Level 3 data collection, coordination, and support (Kidd et al. 2023a). Based on Schwartz et al. (2019), the goals of the program are to determine the effect "…of habitat restoration actions on salmon at the site and landscape scale, identify how restoration techniques

address limiting factors for juvenile salmonids, and improve restoration techniques to maximize the effect of restoration actions…AEMR shows restoration sites are achieving increases in hydrologic connectivity and salmonid opportunity; however, plant community recovery is more variable across sites. Given the inherent inter-annual climate variability, it is difficult to predict specific restoration outcomes on a year-to-year basis. Re-establishment of natural physical processes to sites can be accomplished in a short period of time, but to understand how the site will respond ecologically will need to take place over a more extended period. Ultimately, continued monitoring will elucidate long-term trends and improve our understanding of the connections between physical processes, habitat responses, and the resulting benefits to juvenile salmon."

Research on restoration design challenges (RDCs) by Columbia Land Trust and Pacific Northwest National Laboratory (PNNL) during 2023 included completion of the seven-year experiment to evaluate strategies for controlling reed canarygrass (*Phalaris arundinacea*) (Borde et al. 2023; Borde et al. in review). The experiment took place at two tidal wetland restoration sites in the LCRE: Kandoll Farm and Kerry Island. Mainly, the study evaluated five years of herbicide treatment, with additional seeding in years 3–5. Cover and species richness were monitored annually and two years after treatments. While seeding did not significantly affect cover or species richness, cover and richness were increased and *P. arundinacea* cover reduced by herbicide treatment. The effects of elevation and time-since-restoration were also further explored. Future restoration strategies in tidal freshwater could implement this method and intervene before tidal wetlands are reconnected to the mainstem river.

LCEP also manages BPA's EMP, an integrated status and trends program for the LCRE. Kidd et al. (2019) indicate that EMP "…researchers collect key information on ecological conditions for a range of habitats throughout the lower river characteristic of those used by migrating juvenile salmon and provide information to aid the recovery of threatened and endangered salmonids. The program inventories different types of habitats within the lower river, tracks trends in the overall condition of these habitats over time, provides a suite of reference sites for use as endpoints in regional habitat restoration actions, and places findings from management actions into context with the larger ecosystem…Data collected under the EMP provides context for AEMR results and EMP sites often act as reference sites to which habitat restoration sites are compared. Long-term observations are essential for capturing the range of and potential drivers of annual variability in environmental conditions, and the longer a monitoring program is implemented, the more descriptive the data set becomes." A collaborative paper was published from the EMP including University of Washington, LCEP, Pacific Northwest National Laboratory, and NOAA:

- Ecological effects of reed canarygrass in the lower Columbia River (Cordell et al. 2023).

Additional research on RDCs by PNNL and Columbia Land Trust in partnership with Columbia River Estuary Study Taskforce (CREST) focused on implementing the large wood study design (Diefenderfer 2023). The design was realized on the ground by CREST and subcontractors at the South Tongue Point, OR site in summer and fall of 2023. Consultation with PNNL scientists during implementation helped to ensure that when alternative options arose or were necessitated, decisions remained consistent with the study design to the extent possible. PNNL and BPA initiated permitting for invertebrate, fish, and other sampling that is planned to begin in March of 2024.

To help assess the utility of the existing and ongoing sediment accretion rate data collected by the CEERP EMP and AEMR, the Sediment Sentinel System, consisting of surface elevation tables (SETs) and sediment stakes, was expanded in 2022-2023 to include turbidity monitoring, under critical

uncertainties research by PNNL. Additionally, two new SETs with paired marker horizons were installed during 2023 at two new sites at Whites Island and Sauvie Island, respectively. The new pairs were sampled for the baseline month of August and a second time in October. Surface elevation measurements were also taken at seven of the eight previously established sites, four times during the year (October, March, July, and August). One site, Baker Bay, was sampled an additional time in August to quantify any adjustments due to a SET arm failure and subsequent repair. Cunningham Lake was measured once in October; this site is compromised by cow presence during low water, but infrequent measurements are ongoing to quantify the effects of cows on elevation in response to stakeholder feedback. An up-to-date basin-scale sediment budget developed under critical uncertainties research has received anonymous peer review and a request for revisions at the journal, *Earth Surface Processes and Landforms* (McKeon et al. in revision).

Additional outputs of PNNL's Estuary Uncertainties research project were four published manuscripts:

- "Impacts of a Cascadia Subduction Zone Earthquake on Water Levels and Wetlands of the Lower Columbia River and Estuary" (Brand et al. 2023).
- "Warming of the Lower Columbia River, 1853 to 2018" (Scott et al. 2023).
- "Warming of the Willamette River, 1850–Present: The Effects of Climate Change and River System Alterations" (Talke et al. 2023); and
- "Shallow-Water Habitat in the Lower Columbia River Estuary: A Highly Altered System" (Templeton et al. 2024).

3.2 2022-23 Monitoring Learning

The Proposed Action (PA) on Columbia River System operations in the 2020 BA provides further direction for CEERP monitoring. The PA states the AAs will "…continually evaluate the effectiveness of habitat restoration and inform any necessary adjustments to the current habitat restoration and monitoring strategies." The PA also states the AAs will "…consistently coordinate with NOAA, ERTG, and resource practitioners to discuss the appropriate level of monitoring for a given [restoration] site and for addressing critical or new uncertainties." In 2024, the AAs will continue to direct the ERTG to revise and prioritize critical uncertainties to inform CEERP-related restoration and monitoring.

We identified new learning from 2022-23 and developed actions, as appropriate, for implementing CEERP monitoring moving forward (Table 3.1; Appendix A contains the full MML).

Table 3.1. Actions for CEERP 2024 monitoring strategy and implementation based on new learning from 2022-23.

Title	Short Reference	Learning	CEERP Action
Impacts of a Cascadia Subduction Zone earthquake on water levels and wetlands of the Lower Columbia River and estuary	Brand et al. 2023	The distribution of habitat types and tidal range would likely be changed by Cascadia Subduction Zone rupture, with 93% of wetland habitat types converted to a potential vegetation type currently associated with a lower band, e.g., mud flat to open water.	ERTG-SC to direct a geospatial analysis of buffers at higher elevations around today's wetland elevations, to provide information for future scenario planning.
Ecological effects of reed canarygrass in the lower Columbia River	Cordell et al. 2023	Important study to verify assumptions related to restoration projects that promote plant diversity for improving habitat function for needs of juvenile salmon. Study focused on lower areas of estuary where tidal influence remains dominant hydrology. Study addresses key uncertainty around understanding the assumed problem with reed canary grass infestation common to most sites in the CRE. In general, the findings of the study affirm plant diversity is good for foraging needs of Juvenile salmon.	Studies like this should continue in other reaches of the Estuary for areas that are more susceptible to seasonal flooding from seasonal storms and annual spring freshet. It would benefit from bringing in other studies completed from evolving areas such as Kerry Island or observations made from other fish studies (i.e., JR Palensky).
Integrating knowledge through synthesis in large-scale ecosystem restoration	Diefenderfer et al. 2022	Need for a synthesis center concentrating resources from agencies and academia on the challenge of the cumulative effects of restoration.	Potential for CEERP managers to include a cumulative effects framework on the pending website overhaul. Potential to highlight or link to other estuary cumulative effects studies and ongoing efforts.

Synthesis and meta-analysis of literature to evaluate coastal restoration effectiveness for Chinook salmon, Puget Sound	Hall et al. 2023b	Authors conducted a cumulative effects evaluation using existing monitoring and restoration data for the Whidbey Basin, Puget Sound. They tested specific hypotheses related to how restoration efforts were benefitting juvenile Chinook salmon. They developed a scoring and weighting framework to evaluate support for various hypotheses through a causal criteria analysis (CCA). The CCA and effect-size meta-analysis facilitated the evaluation of the effectiveness of multiple restoration strategies.	The ERTG and SC may consider implementing a similar approach to complement the revisit work that is already underway. The integration of monitoring and restoration data in assessing potential benefits to salmon is interesting and it would be good to know what metrics they used in assessing salmon "benefits." An immediate next step for CEERP would be to invite the authors to present their approach and preliminary findings to the ERTG and SC.
Lower Columbia River Ecosystem Monitoring Program Annual Report for Year 17 (October 1, 2021 to September 30, 2022).	Kidd et al. 2023a	The 2023 Ecosystem Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.	The 2023 Ecosystem Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.
Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program Annual Report (October 2021 to September 2022).	Kidd et al. 2023b	The 2023 Action Effectiveness Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.	The 2023 Action Effectiveness Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.

Variation in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) diets across the channel and habitats of the lower Fraser River, British Columbia, Canada	Levings et al. 2023	Authors evaluated stomach contents of juvenile Chinook salmon from trawl data collected across transects parallel to the shore. Chironomids were dominant in fry and smolts, whereas cladocerans were only found in fry, and arboreal insects were only consumed by smolts. Mudflats, sandflats, marshes, and shallow water habitats were more extensive and produced the most prey for juvenile salmonids. However, insects associated with shrubs and trees were also key diet items for smolts.	Study adds to a growing body of evidence highlighting the importance of off-channel habitats for juvenile salmonids and the potential for prey to be exported from those habitats to channels where they are readily consumed by juvenile salmonids.
Puget Sound Vital Signs: Estuary area in functional condition	Puget Sound Info, 2023	The Estuary Area in Functional Condition is one of the many Indicators on the Puget Sound Info site, which include tracking: human, estuarine, water quality, etc. There is understandably no target set for this and other indicators.	Consider incorporating something like the Vital Signs information in the CEERP website. The percentage/acreage of estuary in functional condition is a possibility but may take a fair bit of new mapping/analysis to estimate/track. Perhaps the Implementation Forecaster data or LCEP have something like this already in hand. Puget Sound Info does not currently have a target for this vital sign. The also have "number of accessible pocket estuaries and embayments" as a vital sign (under development). What other metrics could be described/communicated on the CEERP website in addition to number of floodplain acres created/restored?
Export of macroinvertebrate prey from tidal freshwater wetlands provides a significant energy subsidy for outmigrating juvenile salmon	Roegner & Johnson, 2023	Affirms assumptions of indirect benefits from restoration projects and contribution to estuarine food web productivity. Study targets type of vegetation class with insect taxonomy and makes estimate of wetland energy subsidy, and relevance for foraging need of juvenile salmon. Study characterizes physical structure of study site along with observational data to better understand variables shaping macrodetrital flux patterns for areas in lower estuary sections of CRE.	Findings seem translatable at scientific and policy scales to support future investments in estuary for salmon recovery. May be beneficial to expand studies like these to compare findings to upper reaches of the CRE.
Analysis of fish community characteristics relative to pile structures in the lower Columbia River and estuary	Sather & Rose, 2022	"…both prey abundance and quality (energy content) are important factors determining subsidies to the larger environment." Also, "as a percentage of total transport, large and energy-rich prey taxa contributed more to the total energy transport than more numerous taxa."	Directed research into salmon at pile dikes.

Warming of the Columbia River, 1853 to 2018	Scott et al. 2023	Study evaluated changes in average water temperatures in the Columbia River since 1853 and attributed modern increases to three major causes: warming air temperatures, altered river flow, and water resource management.	No major action for CEERP at this time, but study could be cited in the pending ERTG work product addressing climate resilience as a reference noting the changes in CR water temperatures.
Tribal leadership of a mature observation and prediction system for the Columbia River estuary	Seaton & Gradoville 2023	The Columbia River Inter-Tribal Fish Commission (CRITFC) highlighted its recent adoption of the Coastal Margin Observation & Prediction (CMOP) program. CRITFC expressed goals to expand CMOP's observation and prediction infrastructure to support Tribal and regional priorities for salmon, steelhead, and lamprey. Plans are underway to monitor the salmon food web in the estuary through eDNA; integrate the effect of tributaries in the river-to-ocean models; refine the spatial resolution of wetlands; and simulate climate impacts integrating multiple contributors.	There is an opportunity for CEERP to be proactive in working with CRITFC to better understand existing and planned CMOP capabilities and how or whether the estuary monitoring data being collected at restoration sites may compliment those efforts. An immediate next step could be a meeting with the authors, ERTG/ERTG SC, monitoring, and research practitioners in CEERP, perhaps as a special session or invited talk with extended time for discussion.
PMEP's West Coast Nearshore State of the Knowledge habitat report and spatial data tools	Sherman et al. 2023	Authors summarize efforts to consolidate and synthesize nearshore habitat data across the U.S. West Coast. They highlight spatial datasets currently available through their web-based services.	CEERP can work to coordinate more with wider regional partners to leverage data, tools, and lessons learned. Immediate next steps could be to seek out forums or other opportunities to interface with these entities. Ideally, CEERP should seek to maintain these broader collaborations with meetings or other forums with one or more West Coast stakeholders (outside the immediate region) at least once a year.
Examining the cumulative effects of estuarine habitat restoration on juvenile salmon in the Puget Sound, WA	Sobocinski et al. 2023	Authors are implementing an evidence-based evaluation of cumulative effects at the landscape scale to evaluate the effectiveness of habitat restoration projects implemented over the past 25 years at Whidbey Islands. They developed a hierarchical, nested hypothesis framework and an integrated model to assess the evidence for varying hypotheses.	CEERP can take a closer look at the cumulative effects framework for potential synergies with ongoing work. For example, the ERTG conceptual foundation work product currently under development may help identify key hypotheses that will help organize subsequent studies and monitoring results to better assess the weight of evidence supporting those hypotheses to date.
Valuing the flood reduction benefits of marshes in the San Francisco Bay	Taylor-Burns et al. 2022	Many studies show that nature-based solutions, such as marsh restoration, provide significant benefits for flood risk reduction, but few quantify these benefits socially or economically. Even fewer studies assess the benefits of restoration scenarios, particularly under climate change.	Forward to Diefenderfer/McKeon for NOAA-funded work in Gray's River watershed. Highlights the need for continued strategic engagement with public to illuminate the greater purpose of habitat restoration (beyond single-species focus). Suggest presentation topic for SWG/ERTG meeting to determine if CEERP needs to formalize an engagement strategy.

Lower Columbia River Basin Flood Stage - Frequency Study	USACE, 2022	Describes how river dynamics have changed based on contemporary modeling, including hydraulics. Unclear whether it is all predicted or based on some observations as well; would be nice to see a curve comparing the two. Show flood mitigation benefits of dams in addition to implications for climate change.	Important piece speaking to changing nature of formative hydrologic process of the CRE. Sponsors would benefit from its implications for affirming this in the field with observational data and its implications for projects in the form of design criteria.

3.3 2024 Monitoring Action Plan

CEERP monitoring activities will be conducted via four main avenues: the Corps' AFEP, LCEP's EMP and AEMR work, and BPA's PNNL RDC research for CEERP. AEMR programmatic sampling is planned for 31 restoration project sites during 2024 (Figure 3.1 and Table 3.2). Data will be collected for various monitored indicators for AEMR Levels 1, 2, and 3 (Table 3.3).

The Corps will continue to monitor elevation changes and vegetation growth at the Woodland Islands BUDM in 2023. The next round of fish sampling will be in 2025.

In 2024, LCEP will continue conducting both EMP monitoring and Level 2 AEMR monitoring as well as coordinating and assisting with the Level 3 AEMR monitoring (Figure 3.1 and Table 3.2). AEMR sites are selected using a prioritization framework to address spatial gaps in previous AEMR work and address CEERP uncertainties, risks, and assumptions (BPA/Corps 2017). EMP work on continued status and trends monitoring will take place at six sites: Ilwaco Slough, Welch Island, Whites Island, Cunningham Lake, Campbell Slough, and Franz Lake Slough. PIT arrays at the Dairy Creek restoration project on Sauvie Island and the Steigerwald Reconnection Restoration Project will continue to detect PIT-tagged fish. Additionally, planned fish "spot check"[6] sampling is being conducted at the North Unit Phase 2 Project (Deep Widgeon and Millionaire Lakes), Steamboat Slough, and the Kandoll Farm Restoration Project (all at 10 years post-restoration). Critical uncertainties research conducted by EMP partners will address food web dynamics, primary and secondary productivity, and linkages at the base of LCRE food webs using data from reference sites. The action agencies, in coordination with NOAA Fisheries, are planning to update the Roegner et al. (2009) NOAA Technical Memo to reflect new and adjusted protocols for monitoring in the LCRE. The original authors will be the lead for incorporating new and improved methods learned from research practitioners in the LCRE.

LCEP and its research partners continued to draft seven of eight manuscripts to serve as a synthesis for that program, because the last EMP synthesis was published in 2013. Manuscripts will document status and trends research, which were fully described in the *2022 Restoration and Monitoring Plan* (BPA/Corps 2022) (lead organizations in parentheses):

- Combined Influence of a Marine Heat Wave and Drought on the Columbia River Estuary Ecosystem (OHSU).
- Water Column Primary Production and Net Ecosystem Metabolism in the Lower Columbia and Willamette Rivers (OHSU).
- Multispectral UAV Data for Wetland Plant Community Mapping: Predicting and Evaluating Restoration Impacts (LCEP).

[6] This is a 2-day fish check-in performed at years 5 and 10 post-restoration following standard AEMR protocols described by Kidd et al. (2020). Fish are collected using a bag seine (BS; 37 x 2.4 m, 10 mm mesh size). All sets will be deployed using a 9 ft. Zodiac inflatable raft. The objective of the sampling is to determine the fish community and whether salmon were present or absent. All non-salmonid fish will be identified to the species level, counted, and released. All salmonids will be measured (fork length, nearest mm), weighed (nearest g), and released. A genetic sample will be taken from the caudal fin on all captured Chinook salmon. All salmonids will be checked for adipose fin clips, or other external marks, coded wire tags, and PIT tags to distinguish between marked hatchery fish and unmarked (presumably wild) fish. A fish condition index (Fulton's) will be calculated.

- Recurring Chytrid Parasitism among Spring Diatom Populations in Shallow, Off-Channel Habitats of the Lower Columbia River (OHSU).
- Biogeochemical Connectivity Between Off-Channel and Mainstem Habitats in the Tidal Columbia River and its Influence on Ecosystem Metabolism (OHSU).
- High Abundances of Cyanobacteria in Off-Channel Habitats of the Columbia River (OHSU).
- Characteristics of Juvenile Chinook Salmon in Tidal Wetlands of the Lower Columbia River: Results of a Long-Term Monitoring Program (NMFS).

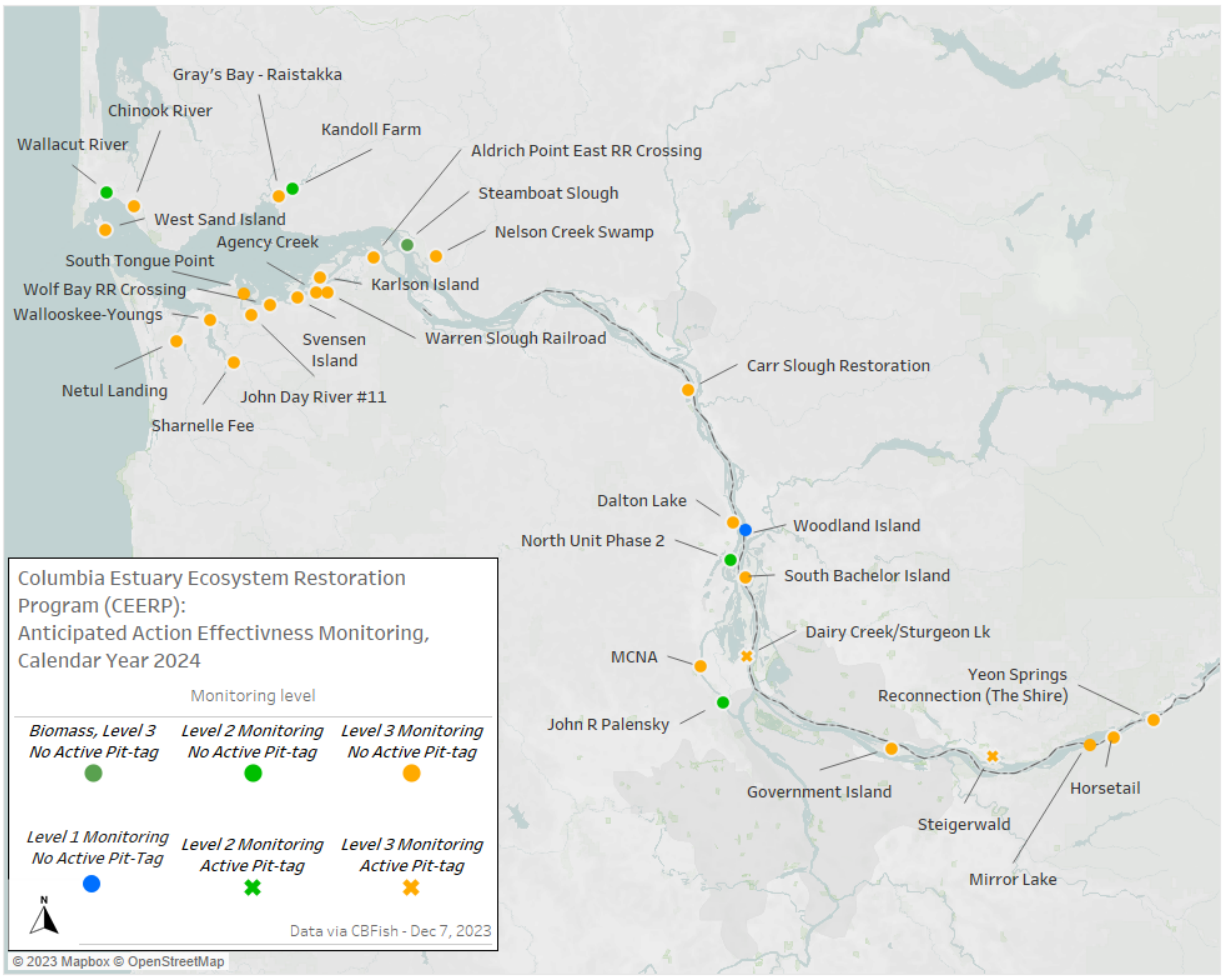

Figure 3.1. AEMR Levels 1, 2, and 3 monitoring planned for 2024. By convention, the AEMR levels are nested such that most sites follow a monitoring plan in which Level 1 also includes Levels 2 and 3, and Level 2 also includes Level 3. However, this is not always routinely carried out due to resource availability. See Tables 3.2 and 3.3 for additional details. (Map courtesy of K. Marcoe, I. Edgar, and S. Kidd, LCEP.)

Table 3.2. Basic inventory of monitoring done across AEMR sites for Level 2 and Level 3 Monitoring in 2023 and scheduled and planned data collection for 2024 and 2025. For a full data inventory for 2023 see Table 3.3. An interactive data inventory for all historic data collection and map interface can be found here: (link)

Project Name	Monitoring Agency	Projected Completion Year	Monitoring Year		
			2023	2024	2025
Agency Creek	CREST	2024	3	3	3
Aldrich Point East RR Crossing	CREST	2023	3	3	3
Batwater	LCEP	2015			3
Buckmire Ph 1	CREST	2015			3
Carr Slough Restoration	CREST	2025		3	3
Chinook River	WDFW	2014	3	3	
Dairy Creek/Sturgeon Lk	CREST	2018	3	3	3
Dalton Lake	CREST	2022	3	3	3
Elochoman Slough East	CLT	2015			3
Government Island	CREST	2019	3	3	
Gray's Bay - Raistakka	CLT	2024	3	3	3
Horsetail	LCEP	2013		3	
John Day River #11	CREST	2020	3	3	3
John R Palensky	CREST	2021	3	2, 3	3
Kandoll Farm	CLT	2013		2, 3	
Karlson Island	CREST	2014		3	
La Center Wetlands	LCEP	2015			2, 3
Louisiana Swamp	LCEP	2013	3		
MCNA	LCEP	2025		3	3
Mirror Lake	LCEP	2008		3	
Nelson Creek Swamp	CLT	2022	3	3	3
Netul Landing	CREST	2025		3	3
North Unit Ph 1 Ruby	CREST	2013	2, 3		
North Unit Ph 2 Millionaire	CREST	2014		2, 3	

North Unit Ph 3 Jack	CREST	2015			3
Sharnelle Fee	CREST	2014		3	
South Bachelor Island	WDFW	2019	3	3	
South Tongue Point	CREST	2025		3	3
Steamboat Slough	LCEP	2014	3	2, 3	
Steigerwald	LCEP	2022	2, 3	3	2, 3
Svensen Island	LCEP	2023	2, 3	3	2, 3
Wallacut River	CLT	2016		2, 3	
Wallooskee-Youngs	LCEP	2017	3	3	3
Walluski - Toaheedliini	CREST	2025			3
Warren Slough Railroad	CREST	2024	3	3	3
West Sand Island	CREST	2020	2, 3	3	2, 3
Wolf Bay RR Crossing	CREST	2023	3	3	3
Woodland Island	USACoE	2020	1	1	1
Yeon Springs Reconnection (The Shire)	Cowlitz Indian Tribe	2025		3	3

Table 3.3: Full inventory of AEMR sites sampled and data collected for Level 2 and Level 3 Monitoring in 2023 and scheduled and planned data collection for 2023 and 2024. While not detailed in this list, photo point monitoring is assumed to be taking place at any site receiving Level 3 monitoring. An interactive data inventory and map interface can be found here: (link)

Project Name	Monitoring Agency	Projected Completion Date	2023 Levels	Fishing	PIT Tag	Macros	Plant Community	X-Sec	Sediment Accretion/ Erosion	Water Surface Elevation/ Depth	Temp	Photos
Agency Creek	CREST	2024	3						X	X	X	X
Aldrich Point East RR Crossing	CREST	2022	3						X	X	X	X
Bear-Marys-Ferris	CREST	2018	3						X	X	X	X
Chinook River	WDFW	2014	3						X	X	X	X
Dairy Creek/Sturgeon Lk	CREST	2018	1, 3		X				X	X	X	X
Dalton Lake	CREST	2022	3						X	X	X	X
Government Island	CREST	2019	3						X	X	X	X
Gray's Bay - Raistakka	CLT	2024	3						X	X	X	X
John Day River #11	CREST	2020	3						X	X	X	X
John R Palensky	CREST	2021	3						X	X	X	X
Louisiana Swamp	LCEP	2013	3						X	X	X	X
Nelson Creek Swamp	CLT	2022	3						X	X	X	X
North Unit Ph 1 Ruby	CREST	2013	2, 3	X		X	X	X	X	X	X	X
South Bachelor Island	WDFW	2019	3						X	X	X	X
Steamboat Slough	LCEP	2014	3						X	X	X	X
Steigerwald	LCEP	2022	1, 2, 3	X	X	X	X	X	X	X	X	X
Svensen Island	LCEP	2022	2, 3			X	X	X	X	X	X	X
Wallooskee-Youngs	LCEP	2017	3						X	X	X	X
Warren Slough Railroad	CREST	2024	3						X	X	X	X
West Sand Island	CREST	2020	2, 3				X	X	X	X	X	X
Wolf Bay RR Crossing	CREST	2022	3						X	X	X	X
Woodland Islands	USACE	2020	1	X	X					X	X	

BPA also funds CEERP-support work contracted through PNNL concerning RDCs. The critical uncertainties research including RDC work in 2024 will include three primary elements:

- **Implementing the Large Woody Debris (LWD) Study Plan** – The ecological function of LWD in estuaries is poorly understood. A study plan produced in prior years of RDC research emphasizes linkages between large wood placement and effects on food webs supporting juvenile salmon. During fiscal year 2021 (FY 2021), the team tested field methods. During FY 2022, BPA, PNNL and CLT identified potential sites and sponsors and began to plan implementation. The CREST project, South Tongue Point, was implemented in 2023 including three control channels and three channels in each of which three log jams including root wads were placed (Diefenderfer et al. 2023). The time horizon to implement LWD monitoring is estimated to be 5 years. A partnership with Clatsop Community College was initiated through PNNL's U.S. Department of Energy funded Community College Internship program, with an intern starting in January of 2024 and being co-mentored by CREST.

Surface Elevation Tables (SETs), Marker Horizons, and Sediment Pins – SETs have been installed in the LCRE positioned to represent tidal river and estuarine system zones as well as energetic conditions including bay, mainstem river, and tributary to the extent possible, and a gradient from marsh to forested wetland. Data have been collected on a generally quarterly basis. To validate the sediment accretion stake method, and thus provide a level of confidence for the large existing data set for sediment accretion, some SETs were placed at EMP long-term study sites where stakes have already been in place for multiple years. Consistent with temperate coastal wetlands elsewhere, wetland accretion in the Pacific Northwest has been linked to inundation by sediment-laden (turbid) water. Inundation and turbidity can be easily measured by deploying a turbidity and pressure sensor on a wetland platform. When co-located with measurements of long-term accretion (i.e., SET data), inundation and turbidity data provide valuable information about sediment supply and delivery. FY24 will be the first year when SETs were deployed at all sampling locations for a full year. PNNL anticipates at least five years of data collection, i.e., through FY27, to obtain SET data over a range of river discharge conditions. The intent, in FY24, is to begin analyzing the mechanisms of sediment transport from the water column to wetland floodplain surfaces based on continuing data collection through PNNL's Sediment Sentinel System.

4.0 Programmatic Activities

This section contains information about CEERP coordination, peer review, data management and dissemination, reporting and communication, and schedule of activities.

4.1 Learning Dissemination

The *Columbia Estuary Ecosystem Restoration Program: 2022 Restoration and Monitoring Plan* (BPA/Corps 2022) contained actions for CEERP implementation to be pursued during 2022-23 by CEERP managers, restoration sponsors, and monitoring practitioners. Many of these actions were accomplished through interagency and sponsor coordination (see Section 4.2), while others will carry over to 2024 and beyond (Table 4.1).

Table 4.1. Implementation of the *2022 Restoration and Monitoring Plan*.

Primary Initiatives Identified in 2022 R&M Plan	2022/23 Action
Share with ERTG for consideration and crosswalk in the Conceptual Foundation paper for 2022.	ERTG Conceptual Foundation paper expected to be finalized in 2024.
In the forthcoming CEERP Conceptual Foundation paper, the ERTG is planning to consider constraints from hatchery management actions outside the Estuary on salmon performance within the Estuary.	ERTG Conceptual Foundation paper expected to be finalized in 2024.
AAs to engage sponsors on power and limitations of current sediment metrics collected at AEMR and EMP sites to inform future restoration. AAs and sponsors to investigate whether additional metrics need to be captured in the design phase of future restoration projects to address channel and floodplain design as suggested here in the presentation.	CEERP managers evaluating AEMR and EMP work in SM3.
AAs are to suggest discussion of BDA design, placement, and use at LCEP SWG and with ERTG.	BDAs discussed amongst CEERP practitioners and ERTG at ERTG 2022 site revisits. General consensus amongst practitioners is that if beavers are active at a site, there is no notable benefit to installing BDAs.
BPA is to discuss species-specific requirements in HIP IV with the BPA HIP lead in anticipation of the next consultation and iteration of HIP.	Not addressed.
CEERP managers are to evaluate the Social Benefits Wheel, Ecological Recovery Wheel, and broader Gann et al. (2019) Standards to see how/whether the current CEERP adaptive management framework compares and what elements might be improved for a more comprehensive look at the effects of our restoration	CEERP managers did not address; however, will revisit topic in the broader discussion about social capital and ecosystem services in SM3.

actions. Share findings with ERTG and CEERP sponsors. Potential for a brown bag session to facilitate greater engagement with a broader group of LCRE stakeholders.	
Follow up with researchers monitoring fish data to see if hatchery release timing can be added as a co-variate during analysis. Gauge interest in having workgroup or special session. Ask ERTG to consider LCRE carrying capacity at CEERP restoration sites and relationship to HO fish.	See MML action addressing Hall et al. 2023a publication. BPA funded carrying capacity paper at Shillapoo; WDFW reported results at 2023 Annual ERTG meeting.
Encourage sponsors to consider fire and other disturbance variables in built and future restoration projects as part of climate change discussions.	ERTG climate resilience work product is incorporating other potential forces of disturbance in consideration of climate resiliency and may consider fire disturbance.
Using a landscape principles perspective, continue to experiment with new restoration actions and investigate uncertainties identified with ERTG to evaluate the efficacy of new actions and need for additional RME.	The Landscape Principles document continues to be a foundational guiding framework for the ERTG and restoration project implementation.
AAs to evaluate the need and format for AMPs in ongoing conversations between the ERTG and AAs concerning restoration site revisits (i.e., triggers, thresholds, etc.). CEERP managers will work with the ERTG and sponsors to determine whether AMPs would be beneficial for restoration projects (site-specific).	ERTG currently completing 2023 site revisit work product which will help identify potential early intervention strategies where needed. AMP developed on Steigerwald project. Continued to pursue this topic on 2023 site revisits.
AAs signed letter of support for PNW Blue Carbon Working Group. Continue to consider and track co-benefits to CEERP, such as protecting lands in a more natural state, increasing native plant sources and diversity, and community resilience to flooding.	The PNW Blue Carbon Working Group received new funding from the NOAA Effects of Sea Level Rise (ESLR) program in the fall of 2023 for a two-year study of gray and green infrastructure options (e.g., levees and hydrologic restoration) for functions including flood control and blue carbon; the two sites are Coos Bay, and the Grays River on the lower Columbia.
Increase coordination activities between the ERTG, ERTG SC, CEERP sponsors, and researchers. Continue to formalize opportunities for sharing information and data such as sponsor workshops and seminars. Use the Littles et al. (2022) Table 2 and Figure 4 to continue to memorialize CEERP actions and ongoing restoration activities.	CEERP managers have opened up ERTG meetings to sponsors and researchers and have had combined site visits.
Follow up with relevant stakeholders and speakers to gage interest in establishing a workgroup or follow-up workshop on the topic of sediment monitoring,	This topic was regularly discussed in 2022 and 2023, but a formal workgroup has not yet been established. The Sediment Sentinel System, consisting of surface

management, and modeling for CEERP partners.	elevation tables (SETs) and sediment stakes, was expanded to include turbidity monitoring under critical uncertainties research by PNNL. An up-to-date basin-scale sediment budget developed under critical uncertainties research has received peer review and a request for revisions at *Earth Surface Processes and Landforms* (McKeon et al. in revision). Pending results of SM3, this may or may not raise to a level of immediate priority for CEERP managers.
Consider convening special session to learn and explore how TEK has informed restoration design, outcomes, or adaptive management in the LCRE or elsewhere.	CEERP managers have not addressed yet and will determine the best forum moving forward.
AAs are to discuss use of muted tidal regulators in restoration design w/ WDFW and request a presentation to the ERTG SC.	Not addressed. CEERP managers consider MTRs as no different than tidegates for ERTG scoring purposes.

In 2022-23, numerous opportunities facilitated engagement with the larger scientific community, disseminated results, and invited feedback from restoration practitioners. While this information did not always constitute new learning that led to a CEERP action, it still added value to the program by making connections and creating opportunities for potential future collaboration. Substantial dissemination by CEERP managers, sponsors, and stakeholders including ERTG addressed intended actions from the 2021 and 2022 plans via oral presentations at conferences, seminars, and workgroups. Many presentations are cited in the tables and reference lists herein. Many learnings overlap between papers, presentations, workgroups, etc., for example, reports or manuscripts that led to oral presentations, which broadened dissemination and feedback. The AAs and stakeholders scheduled meetings and workshops between decision-makers and RME researchers and practitioners to facilitate basin-wide adaptive management. These steps are part of the CEERP adaptive management process (Figure 1.1).

The biennial Columbia River Estuary Conference is convened to exchange information about CEERP restoration and monitoring among the AAs, project sponsors, researchers, and interested parties. In the spring of 2023, it was successfully reinstated after being on hold due to the COVID-19 pandemic and associated health restrictions (see https://www.estuarypartnership.org/columbia-river-estuary-conference-2023). Attendance and participation were excellent and the theme, "Reconnection," resonated for many attendees. From the conference website: "So much of our work centers around reconnecting species to their historical habitats, hydrology to more historical flow patterns, and mindsets to managing resources while weaving in traditional ecological knowledge. Reconnecting as a community is an important step in discussing our knowledge of ecological conditions in the lower Columbia and nearshore ocean, the implications of these conditions for native species, and our management approaches."

Many talks at national conferences showcased learning that addressed intended CEERP actions. The biennial Coastal and Estuarine Research Federation (CERF) conference, convened in Portland, provided another opportunity to exchange information about CEERP restoration and monitoring among the AAs, project sponsors, researchers, and interested parties including researchers from outside the area (Box 4.1).

Box. 4.1. Example of national dissemination of CEERP programmatic research, restoration, and monitoring 2022–2023 (see https://conference.cerf.science/).

Coastal and Estuarine Research Federation (CERF), Portland, OR 12-16 November 2023.

- Several sessions, field trips, and a workshop included presentations on CEERP.
    - Steigerwald Wildlife Rescue and Multnomah Falls field trip
    - PNW Blue Carbon Working Group dinner meeting
    - Tableau for Environmental Science workshop
    - Sessions:
        - Effects of human modifications of estuaries (Monday)
        - Nature-based solutions for coastal ecosystems (Monday)
        - Temperate tidal swamps (Monday)
        - Biogeochemistry in estuaries and coasts (Tuesday)
        - Advances in blue carbon research and applications to policy and planning (Wednesday-Thursday)
        - Assessing cumulative effects of restoration on coastal ecosystem resilience (Wednesday)
        - Understanding climate change impacts and implementing solutions in coastal watersheds (Thursday)
        - All things climate. All the time. (Thursday)
        - Shallow water mapping in coastal environments (Thursday)
- One session focused entirely on CEERP retrospective reporting: *"Highlights from the Columbia Estuary Ecosystem Restoration Program (CEERP) in Oregon and Washington states."* It was convened by H.L. Diefenderfer, A.B. Borde, J.P. Karnezis, and C. J. Littles and moderated by Diefenderfer. The purpose was to present advances in West Coast estuarine and tidal river floodplain wetland restoration focused on CEERP, headquartered in the CERF 2023 host city, Portland, Oregon. Project managers, engineers, monitoring experts and other practitioners were invited to present approaches to restoration planning, site design, and monitoring. Additionally, program managers and scientific and technical advisors described CEERP from its origin through the present and future, incorporating remaining uncertainties, challenges, and adaptive management for discussion.
- Session Agenda (Thursday, November 16, 2023):
    - Introduction: Highlights from the Columbia Estuary Ecosystem Restoration Program (CEERP) in Oregon and Washington States. Jason Karnezis, BPA.
    - Columbia estuary restoration program advances: Project evaluation cards, and site selection using landscape ecology principles. Dan Bottom, NMFS, retired
    - Looking beyond the restoration site: Lessons from the Columbia River Estuary. Nichole Sather, PNNL
    - How does CEERP contribute to the recovery of ESA-listed salmon and steelhead? Chris Magel, NMFS
    - Sauvie Island restoration: 10 years of habitat restoration success and lessons learned. Allan Whiting, BPA.
    - Dredging for new ideas for salmon recovery: Habitat reconnection and restoration in the LCRE. Laura Brown, Washington Department of Fish and Wildlife.
    - Export of macroinvertebrate prey from tidal freshwater wetlands provides an energy subsidy for juvenile salmon. Curtis Roegner, NOAA Fisheries.
    - Revisiting habitat assumptions at a beneficial use of dredged material site in the Columbia River. Chanda Littles, USACE.
    - Experimental control of *Phalaris arundinacea* in tidal marshes. Amy Borde, Columbia Land Trust.

4.2 Coordination and Peer Review

To the greatest extent possible, CEERP makes use of existing processes, programs, technical groups, and plans to avoid redundancy and increase efficiency. The main resources CEERP incorporates are as follows:

- **AAs Estuary RME Coordination Meetings** – Routine, ongoing RME coordination between BPA and the Corps is conducted during monthly meetings as needed.
- **AAs/LCEP Estuary RME Coordination Meetings** – Routine, ongoing RME coordination between BPA, the Corps, and LCEP is conducted during monthly meetings as needed.
- **AFEP Annual Conference** – The AFEP Annual Conference provides presentations of the Corps' Estuary RME studies to a broad scientific community, including CEERP practitioners.
- **AFEP Studies Review Work Group (SRWG)** – The SRWG provides peer review of preliminary and final proposals and draft technical reports from the Corps' Estuary RME studies.
- **BPA-sponsor monthly coordination meetings** – BPA and Estuary project sponsors meet monthly (at a minimum) to discuss the status of feasibility, design, and construction of restoration projects.
- **CEERP Sponsor Workshops** – These workshops, led by the AAs, involve CEERP sponsors/restoration practitioners in the annual CEERP Restoration & Monitoring Plan process and provide an opportunity for collaborative discussion of larger program topics. As of this writing, no 2024 workshops are yet planned.
- **Corps Product Delivery Teams (PDTs)** – Corps PDT members attend various CEERP events and share information about sediment management strategies and other topics of mutual interest in the Lower Columbia River.
- **Columbia River Estuary Conference (CREC)** – Since 2006, a usually biennial conference in Astoria, Oregon focusing on presentations directly related to CEERP.
- **ERTG** – The ERTG for Estuary habitat restoration reviews and provides feedback on proposed CEERP restoration projects. ERTG meets monthly and the annual ERTG regional meeting provides a forum at which to discuss restoration and the ERTG review process with CEERP sponsors.
- **ERTG SC** – The ERTG Steering Committee meets bi-weekly and collaborates to guide ERTG's project review activities and work products, as well as discuss larger program strategy and topics related to CEERP.
- **LCEP Science Work Group (SWG)** – SWG meetings are conducted periodically throughout the year. CEERP activities and Estuary-related topics are presented and discussed. SWG provides an avenue for CEERP project sponsors to meet and includes a broader scientific community to share emerging scientific information and innovative ways to implement restoration projects and monitoring.
- **LCEP Project Review Committee (PRC)** – The PRC provides technical review of proposed restoration projects, the results of which are communicated to the AAs. This group of restoration experts and practitioners meets three times a year to review, visit, and discuss restoration projects

for CEERP and other related programs. CEERP managers use input from the PRC and ERTG to inform project decision-making.

- **Northwest Power and Conservation Council's Fish and Wildlife Program** – CEERP continues to incorporate the 2020 Fish and Wildlife Program addendum (NPCC 2020[part II]). All BPA-funded Estuary projects were reviewed by the Independent Scientific Review Panel in 2021 as a part of the activities documented in the Anadromous Fish Categorical Report. A final report was produced in 2022 (Northwest Power and Conservation Council, Anadromous Fish Habitat and Hatchery Review Report, 2022).

4.3 Community Outreach

The success of CEERP depends on public engagement and stakeholder outreach. Examples of formal outreach include the biennial Columbia River Estuary Conference, LCEP's Science to Policy Forum, and the Council's Geographic Review Process. In addition, BPA and the Corps conduct public outreach as part of the National Environmental Policy Act process and have environmental compliance and public affairs staff that routinely coordinate with local officials and community members. Moreover, BPA funds sponsors to conduct outreach and coordination as part of their project development work. The CEERP sponsors (CLT, CREST, CIT, LCEP, and WDFW) all have explicit landowner coordination tasks in their contracts with BPA, as well as their specific missions. These partners, who often live and work in the same communities where restoration occurs, are positioned to effectively incorporate local knowledge and build support for the CEERP.

4.4 Data Management and Reporting

Data management and dissemination are critical to efficiently and effectively applying data in decision-making initiatives, including BPA's Fish and Wildlife Program and CEERP, across the Columbia River Basin. Data repository specifications for regional RME are being managed by the Pacific Northwest Aquatic Monitoring Partnership in the www.monitoringmethods.org tool and tracked in BPA's Pisces Web contracting tool and the reporting system at www.cbfish.org. Standardized methods for RME data have been developed to facilitate comparison of results over time for selected parameters, and they are documented at www.monitoringmethods.org. For CEERP, these methods include the data collection protocols by Roegner et al. (2009).

RME findings are currently reported through several avenues. Research project technical reports can be found on the BPA Pisces library website (http://www.cbfish.org/Report.mvc/SearchPublications/). Synthesis documents are produced as needed or requested by different partners and as funding allows. The schedule for planned coordination for CEERP 2024 is shown in Table 4.2.

Table 4.2. Schedule of key CEERP events in 2024.

CEERP Event	Date	Lead	J	F	M	A	M	J	J	A	S	O	N	D
AFEP annual meeting	December	Corps												X

CEERP Event	Date	Lead	J	F	M	A	M	J	J	A	S	O	N	D
CEERP Special Sessions Postponed	CEERP Science Seminar Subcommittee													
ERTG meetings	Monthly	ERTG	X	X	X	X	X	X	X		X	X	X	X
ERTG annual regional meeting	December	ERTG												X
LCEP PRC meetings	3X	LCEP		X		X							X	
Synthesis Memo Workshop	1X	PNNL					X							
SWG meetings	Periodic	LCEP			X	X	X			X	X	X		

4.5 Closing

CEERP continues to aggregate and analyze pertinent information for the AAs to evaluate whether they warrant actions under CEERP. Key actions derived from new learning that are planned for 2024, detailed in Table 2.1 and Table 3.1, include the following:

1. Convene a workgroup for relevant CEERP stakeholders and researchers to discuss use of unmanned aerial vehicles and protocols related to restoration and monitoring.
2. Follow up with relevant stakeholders and speakers to gauge interest in establishing a workgroup or follow-up workshop on the topic of sediment monitoring, management, and modeling for CEERP partners.
3. Incorporate learnings into ERTG Uncertainties work products.
4. Continue the conversation about the most effective means of Estuary data management.

For 2024, construction is scheduled for four restoration projects (Figure 3.1) and monitoring is planned for 37 project sites (Figure 4.1 and Table 4.2). This 2024 CEERP Restoration and Monitoring Plan conveys the AAs' fundamental strategy for Estuary habitat actions and monitoring—apply an ecosystem-based approach to restore, enhance, or create ecosystem structures, processes, and functions in the Estuary, and perform RME to assess the effectiveness of these actions, while building our understanding of ecosystems in the LCRE. The 2026 restoration and monitoring plan will refer to the actions identified in the tables listed above to discuss progress made in 2024-25.

5.0 References

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Appendix A – CEERP Adaptive Management: Master Matrix of Learning for Restoration and Monitoring, 2024

As part of the annual CEERP adaptive management cycle, the table below contains new learning and associated adjustments/implications/actions, if any, related to CEERP restoration and monitoring. The approach to compiling, screening, summarizing, and reporting the sources of new information is described in Section 1.2. Materials reviewed included 2022 and 2023, with the exception of prior materials overlooked in earlier Research and Monitoring Plans (e.g., BPA/Corps 2022). Only items with learnings that led to actions for CEERP are included in the table.

The sources of new learning to populate CEERP's MML for 2024 were as follows:

- CEERP management
- CEERP coordination
- Project reviews
- Conferences/workshops/workgroups/presentations
- Technical reports
- Journal articles.

Table A.1. CEERP Adaptive Management: Master Matrix of Learning for Restoration and Monitoring, 2024[7]

Title	Short Reference	Type: Topic	Learning	CEERP Action
		Action Required		
Impacts of a Cascadia Subduction Zone Earthquake on Water Levels and Wetlands of the Lower Columbia River and Estuary	Brand et al. 2023	Mon: Modeled effects of an M9 earthquake (same magnitude as the 1700 earthquake) on wetlands in the Columbia River estuary.	The distribution of habitat types, and tidal range, will be changed by Cascadia Subduction Zone rupture, with 93% of wetland habitat types converted to a potential vegetation type currently associated with a lower band, e.g., mud flat to open water.	ERTG-SC to direct a geospatial analysis of buffers at higher elevations around today's wetland elevations, to provide information for future scenario planning.
Impacts of a Cascadia Subduction Zone Earthquake on Water Levels and Wetlands of the Lower Columbia River and Estuary	Brand et al., 2023	Rest: Predictive modeling	A combined hydrodynamic and habitat model are used to predict the potential effects of a Cascadia subduction zone earthquake. The study modeled four scenarios including current conditions, subsidence solely from the M9 earthquake, M9 subsidence + infrastructure failure, and M9 subsidence + infrastructure failure + liquefaction. There were variable effects on the tidal range, up to an approximate 10% increase. The habitat model indicated a significant loss in forested and scrub shrub wetland habitats, as well as intertidal habitat. Whereas there would be a marked increase in low marsh and subtidal habitat.	Results of this study could be incorporated into the larger CEERP discussions about incorporating resilience into restoration projects. While the focus to date has primarily centered around climate resilience, there is a good argument for addressing other projected sources of natural and man-made disturbances. Initial action item could be a "special topics" discussion with the ERTG and SC about how results of this study might inform restoration planning and priorities.
Ecological effects of reed canarygrass in the lower Columbia River	Cordell et al. 2023	Mon: Prey production of different wetland types	Important study to verify assumptions related to restoration projects that promote plant diversity for improving habitat function for needs of juvenile salmon. Study focused on lower areas of estuary where tidal influence remains dominant hydrology. Study addresses key uncertainty around understanding assumed problem with reed canary grass infestation common to most site in the CRE. In general,	Studies like this should continue in other reaches of the Estuary for areas that are more susceptible to seasonal flooding from seasonal storms and annual spring freshet. It would benefit from bringing in other studies completed from evolving areas such as Kerry Island or observations made from other fish studies (i.e. JR Palensky)

[7] See section 5.0 for full citations under 'Action Required' and Appendix B for full citation under 'Affirms current CEERP course of action'. Those citations appearing in the main text in this plan, but which do not require a new action, appear in both lists.

			the findings of the study affirm plant diversity is good for foraging need of Juvenile salmon.	
Integrating Knowledge Through Synthesis in Large-scale Ecosystem Restoration	Diefenderfer et al. 2022	Mon: Cumulative effects of post-Deepwater Horizon restoration on the US Gulf of Mexico Coast.	Need for a synthesis center concentrating resources from agencies and academia on the challenge of the cumulative effects of restoration.	Potential for CEERP managers to include a cumulative effects framework on the pending website overhaul. Potential to highlight or link to other estuary cumulative effects studies and ongoing efforts.
Estimating Juvenile Salmon Estuarine Carrying Capacities to Support Restoration Planning and Evaluation	Hall et al. 2023a	Restoration: Examine more than 4500 unique estimates of published juvenile Chinook and coho salmon densities in North American range. Data were categorized by species and life stage, habitat type, seasonal period, and geographic region to develop frequency statistics, which were used in a habitat expansion approach to estimate carrying capacities based on habitat extent	Study arrives at estimate carrying capacities for Chinook and coho salmon, which have decreased from historical capacities and are estimated to decline more with sea level rise and in areas projected to lose vegetated tidal wetland habitat, while projected to increase in vegetated wetland due to sea level rise. Most interesting--demonstrate how carrying capacity estimates can be used to estimate changes in juvenile salmon capacity following restoration, which can be used to both design and evaluate restoration projects.	"CEERP management to have ERTG examine and discuss how biological metrics (like CC) could be used in evaluating CEERP projects as current physical metrics of evaluation (i.e., hydrology, scour, velocity, or habitat area) do not necessarily directly link to habitat capacity. This is relevant to ongoing discussion about estuary habitat uncertainties."
Synthesis and meta-analysis of literature to evaluate coastal restoration effectiveness for Chinook Salmon, Puget Sound	Hall et al. 2023b	Mon: Action effectiveness monitoring to inform adaptive management	Authors conducted a cumulative effects evaluation using existing monitoring and restoration data for the Whidbey Basin, Puget Sound. They tested specific hypothesis related to how restoration efforts were benefitting juvenile Chinook salmon. They developed a scoring and weighting framework to evaluate support for various hypotheses through a causal criteria analysis (CCA). The CCA and effect-size meta-analysis facilitated the evaluation of the effectiveness of multiple restoration strategies.	The ERTG and SC may consider implementing a similar approach to complement the revisit work that is already underway. The integration of monitoring and restoration data in assessing potential benefits to salmon is interesting and it would be good to know what metrics they used in assessing salmon "benefits." An immediate next step for CEERP would be to invite the author to present their approach and preliminary findings to the ERTG and SC.

Distribution of Large Wood in River Delta Tidal Marshes: Implications for Habitat Restoration	Hood 2023	Rest: LWD design in fluvial dominated estuaries	Very few LWD studies in estuarine environments. GIS analysis in Skagit deltas showed large wood densities were 28 to 50 times lower in Puget Sound tidal channels than in Western Washington streams. Do not assume same benefit for LWD as when placed in fluvial environments. We need more studies on LWD in the LCRE	BPA is sponsoring Research at the CREST restoration project, South Tongue Point, to study the effects of installed LWD in estuaries. LWD installed fall 2023. Study design and sampling plan designed by PNNL and CLT.
Using bioenergetics and landscape connectivity to plan effective tidal delta restoration projects for Chinook salmon	Howe & LeMoine 2023	Rest: Action effectiveness monitoring to inform adaptive management	Hydraulic, landscape connectivity, and bioenergetic models were employed to evaluate the abundance and growth potential of juvenile Chinook salmon across varying restoration and climate scenarios. Authors used restoration design and monitoring dana from projects encompassing roughly 900 acres of the Stillaguamish delta, Washington and assessed which recovery actions provided cumulative, broad-scale, and resilient restoration benefits to juvenile Chinook salmon.	Study complements the landscape design principles currently being implemented by the ERTG and may provide a means for enhancing the direct linkage to salmonid benefits (e.g., by adding explicit bioenergetic considerations). An immediate next step for CEERP would be to invite the author to present their approach and preliminary findings to the ERTG and SC.
Long-term changes in river tides in the Lower Columbia River Estuary	Jay et al. 2023	Rest: Hydrodynamics	Flood dynamics in the LCR have dramatically changed over the last 170 years, primarily due to channel improvements (e.g., deepening and channel training structures). Tides and storm surges persist further upstream for any given flow level. A wavelet tidal analysis program was used to estimate tide behavior. Key findings included observations that tidal waves are moving upstream faster, and storm surges penetrate further into the system.	No specific action for CEERP at this time, but findings may be relevant for to future discussions related to restoration project resilience and habitat projections long-term.
Lower Columbia River Ecosystem Monitoring Program Annual Report for Year 17 (October 1, 2021 to September 30, 2022).	Kidd et al. 2023a	Mon: Action effectiveness monitoring of CEERP projects	The 2023 Ecosystem Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.	This Restoration and Monitoring Plan includes efforts to evaluate the latest EMP and AEMR reports as part of 2024 SM3 evaluation. The Action Agencies will be evaluating the metrics, sampling frequency, duration, and location criteria to evaluate their usefulness in addressing several of the most recent ERTG work products, towards the goal of prioritizing RM&E efforts in CEERP.

Action Effectiveness Monitoring for the Lower Columbia River Estuary Habitat Restoration Program Annual Report (October 2021 to September 2022).	Kidd et al. 2023b	Mon: Status and trends monitoring in the LCRE	The 2023 Action Effectiveness Monitoring Program annual report will be reviewed as part of the third Synthesis Memorandum effort, in 2024.	This Restoration and Monitoring Plan includes efforts to evaluate the latest EMP and AEMR reports as part of 2024 SM3 evaluation. The Action Agencies will be evaluating the metrics, sampling frequency, duration, and location criteria to evaluate their usefulness in addressing several of the most recent ERTG work products, towards the goal of prioritizing RM&E efforts in CEERP.
A Resist-Accept-Direct (RAD) future for Salmon in Maine and California: Salmon at the southern edge	Kocik et al. 2022	Rest: Implemented the Resist-Accept-Direct (RAD) approach to fisheries proposed by Thompson et al. (2021). Assessing restoration effectiveness in a broader context	This study of Maine and Californian rivers is historically focused, documenting socio-cultural factors in North American salmon reduction and illustrating the differential application of RAD to different socio-cultural subsystems in the watersheds (Figure 2). Includes a national review of hatchery program efforts to recover salmon across the RAD spectrum. According to the definition on p. 461, CEERP is a "resist" strategy because it reconnects floodplain. Bottom et al. 2005 is cited relative to increased focus on estuarine rearing habitats. Interesting conceptualization of hatchery programs as initially "resist" but transitioning to "accept." Authors suggest a RAD framework for more effectively accounting for current and future climate projections may affect salmon recovery efforts in tandem with historic stressors (i.e., the 4-Hs, hatcheries, hydropower, harvest, and habitat). Figure 2 provides a schematic for how the RAD approach might be applied to a watershed in terms of specific actions to resist, accept, and direct.	Could be useful to have a work session with ERTG and ERTG-SC, to conceptualize the application of the Resist-Accept-Direct approach to CEERP, though many related decisions were already made by CEERP. For example, to reconnect the floodplain (resist) but not to interfere with cities and highways (accept). (SC contractor could prepare a map-type visual of such decisions converted to the RAD framework.) There may be opportunities to utilize RAD approach that could be brainstormed (1) to "direct", (2) lessons learned from hatchery programs nationwide that are reviewed and could dovetail with ERTG work on Conceptual Foundations, and (3) climate change considerations related to ERTG special assignment. CEERP managers will forward to ERTG members working on climate resilience work product to assess whether framework might be helpful in that context.

Variation in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) diets across the channel and habitats of the lower Fraser River, British Columbia, Canada	Levings et al. 2023	Mon: Juvenile salmon prey across habitat zones	Authors evaluated stomach contents of juvenile Chinook salmon from trawl data collected across transects parallel to the shore. Chironomids were dominant in fry and smolts; whereas cladocerans were only found in fry; and arboreal insects were only consumed by smolts. Mudflats, sandflats, marshes, and shallow water habitats were more extensive and produced the most prey for juvenile salmonids. However, insects associated with shrubs and trees were also key diet items for smolts.	Study adds to a growing body of evidence highlighting the importance of off-channel habitats for juvenile salmonids and the potential for prey to be exported from those habitats to channels where they are readily consumed by juvenile salmonids.
Patterns and predictors of soil carbon accumulation rates across multiple Pacific Northwest estuaries	Poppe et al. 2023	Rest: Climate resiliency	Authors evaluated carbon accumulation rates across 25 PNW estuaries and various tidal wetlands using tracers and surface elevation tables. They tested multiple potential predictors of CAR including wetland type, land use, salinity, groundwater levels, wetland elevation, vegetation, temperature, relative sea level rise, riverine sediment discharge, and watershed area. CAR was generally higher at restored sites and correlated more with sediment accretion than carbon density.	No immediate action for CEERP, but findings could be incorporated into pending ERTG work product on climate resilience - especially since there was at least some evidence that restored wetland sites may accumulate more carbon.
Puget Sound Vital Signs - Estuary area in functional condition	Puget Sound Info, 2023	Mon: Public information on the status of restoration and monitoring work in the Puget Sound.	The Estuary Area in Functional Condition is one of the MANY Indicators on the Puget Sound Info site. There are a large number of indicators being tracked - human, estuarine, water quality, etc. There is understandably no target set for this and other indicators.	Consider incorporating something like the Vital Signs information in the CEERP website. The percentage/acreage of estuary in functional condition is a possibility but may take a fair bit of new mapping/analysis to estimate/track. Perhaps the Implementation Forecaster data or LCEP have something like this already in hand. PSInfo does not currently have a target for this vital sign. The also have "number of accessible pocket estuaries and embayments" as a vital sign (under development). What other metrics could be described/communicated on the CEERP

				website in addition to number of floodplain acres created/restored?
Export of macroinvertebrate prey from tidal freshwater wetlands provides a significant energy subsidy for outmigrating juvenile salmon	Roegner & Johnson, 2023	Mon: Report on macrodetritus flux patterns and ecological benefits	Affirms assumptions of indirect benefits from restoration projects and contribution to estuarine food web productivity. Study targets type of vegetation class with insect taxonomy and makes estimate of wetland energy subsidy, and relevance for foraging need of juvenile salmon. Study characterizes physical structure of study site along with observational data to better understand variables shaping macrodetrital flux patterns for areas in lower estuary sections of CRE.	Findings seem translatable at scientific and policy scales to support future investments in estuary for salmon recovery. May be beneficial to expand studies like these to compare findings to upper reaches of the CRE.
Contesting neoliberal knowledge politics in restoration governance: the restorationist's dilemma	Rozance et al. 2020	Rest: "We underline Robertson's (2000) work on the commodification of wetlands in wetland banking by uncovering and describing the less direct but comparable process of public sector neoliberal environmental governance of wetlands; in particular, Bonneville Power's treatment of wetlands in terms of their benefit to salmon populations, measured in Survival Benefit Units (SBUs)."	Numerous factual inaccuracies and suggestions about CEERP restoration and monitoring in Youngs Bay appear to be based on undated interviewed with 10 practitioners (likely around 2015). Misrepresents the history and timing of CEERP monitoring program development and its parts. Attempts a "take-down" of the scientific basis of CEERP. The key issues in restoration ecology critiqued were originally incorporated in CEERP monitoring design but the paper doesn't cite foundational reports (e.g., Ebberts et al. 2017, Thom et al. 2018, or Johnson et al. 2008, 2018). Paper doesn't seem to be deeply cited, i.e. presents functional trajectories as recent understanding (but see Simenstad and Thom 1996) and presents the problems with "no net loss" in wetland mitigation as new (but see National Research Council 1992).	This work does not cite some of the foundational publications that have informed CEERP AM to date. In addition, the ERTG moved away from SBUs and introduced the landscape framework as a more comprehensive way of assessing restoration actions. Ebberts et al. (2017) and Littles et al. (2022) provide a more recent, holistic, and thorough assessment of CEERP.

Analysis of fish community characteristics relative to pile structures in the lower Columbia River and estuary	Sather & Rose, 2022	Mon: Reanalyzed existing data to examine potential relationships between fish assemblages and piles, and characteristics of juvenile Chinook salmon in the shallow nearshore. Fish response to pile structures	"Both prey abundance and quality (energy content) are important factors determining subsidies to the larger environment" "as a percentage of total transport, large and energy-rich prey taxa contributed more to the total energy transport than more numerous. Study used ancillary data to evaluate how and whether pile dikes or dredged material placement sites affected salmonid and other fish use. Piles and BUDM sites did not appear to have a detectable adverse effect on fish abundance, the composition of Chinook genetic stocks, Chinook size or density. The greatest effects were attributed to season and habitat type.	Directed research into salmon at pile dikes. If more pilot restoration projects are pursued within CEERP that utilize BUDM or pile structures, a more targeted study of fish response may be warranted, to more definitively parse short or long-term effects due to new placement or pilings.
Warming of the Columbia River, 1853 to 2018	Scott et al. 2023	Mon: Climate resiliency	Study evaluated changes in average water temperatures in the Columbia River since 1853 and attributed modern increases to three major causes: warming air temperatures, altered river flow, and water resource management.	No major action for CEERP at this time, but study could be cited in the pending ERTG work product addressing climate resilience as a reference noting the changes in CR water temperatures. Send to ERTG.
Tribal leadership of a mature observation and prediction system for the Columbia River estuary	Seaton & Gradoville 2023	Mon: Climate resiliency, data integration, and modeling	The Columbia River Inter-Tribal Fish Commission (CRITFC) highlighted its recent adoption of the Coastal Margin Observation & Prediction (CMOP) program. CRITFC expressed goals to expand CMOP's observation and prediction infrastructure to support Tribal and regional priorities for salmon, steelhead, and lamprey. Plans are underway to monitor the salmon food web in the estuary through eDNA; integrate the effect of tributaries in the river-to-ocean models; refine the spatial resolution of wetlands; and simulate climate impacts integrating multiple contributors.	There is an opportunity for CEERP to be proactive in working with CRITFC to better understand existing and planned CMOP capabilities and how/whether the estuary monitoring data being collected at restoration sites may compliment those efforts. An immediate next step could be a meeting with the authors, ERTG/ERTG SC, monitoring, and research practitioners in CEERP - perhaps as a special session or invited talk with extended time for discussion.

PMEP's West Coast Nearshore State of the Knowledge habitat report and spatial data tools	Sherman et al. 2023	Mon: Data integration and tools	Authors summarize efforts to consolidate and synthesize nearshore habitat data across the U.S. West Coast. They highlight spatial datasets currently available through their web-based services.	CEERP can work to coordinate more with wider regional partners to leverage data, tools, and lessons learned. Immediate next steps could be to seek out forums or other opportunities to interface with these entities. Ideally, CEERP should seek to maintain these broader collaborations with meetings or other forums with one or more West Coast stakeholders (outside the immediate region) at least once a year.
How the US is fighting back against deadly floods.	Sherriff, 2023	Rest: Climate resiliency, floodplain restoration, and EJ communities	Article highlights recent 100-year flood events, particularly in Vermont, that have devastated disadvantaged, low-income communities in particular. One of the primary solutions presented for improving climate resiliency is restoring natural floodplain habitats.	CEERP could do a better job cataloguing low-income and disadvantaged communities within the vicinity of restoration projects to document the potential benefits with regard to mitigating flood risk.
Examining the cumulative effects of estuarine habitat restoration on juvenile salmon in the Puget Sound, WA	Sobocinski et al. 2023	Mon: Restoration effectiveness monitoring and cumulative effects	Authors are implementing an evidence-based evaluation of cumulative effects at the landscape scale to evaluate the effectiveness of habitat restoration projects implemented over the past 25 years at Whidbey Islands. They developed a hierarchical, nested hypothesis framework and an integrated model to assess the evidence for varying hypotheses.	CEERP can take a closer look at the cumulative effects framework for potential synergies with ongoing work. For example, the ERTG conceptual foundation work product currently under development may help identify key hypotheses that will help organize subsequent studies and monitoring results to better assess the weight of evidence supporting those hypotheses to date.
Promoting resiliency of coastal habitats through holistic assessment and planning	Stein & Walker 2023	Rest: Adaptive management and climate resiliency	Study focused on habitat type conversion through restoration and management actions that could allow restored habitats to better subsist under climate change. Evaluation framework included documentation of risk, uncertainty, functional prioritization, and possible resource trade-offs to assess the net environmental benefit of a proposed action.	This study offers an opportunity for CEERP to engage with broader regional partners to leverage approaches that are being implemented to evaluate possible climate resilience. For example, the incorporation of functional habitat characteristics to help set restoration priorities may be applicable to CEERP. Immediate next step could be the identification of specific habitat traits within the LCR that may facilitate greater resiliency - perhaps within the

				ERTG work product currently under development.
Valuing the Flood Reduction Benefits of Marshes in the San Francisco Bay	Taylor-Burns et al. 2022	Mon: Linking economic impact of restoration to local communities' economic outlook.	Many studies show that nature-based solutions, such as marsh restoration, provide significant benefits for flood risk reduction, but few quantify these benefits socially or economically. Even fewer studies assess the benefits of restoration scenarios, particularly under climate change.	Forward to Diefenderfer/McKeon for work in Gray's. Highlights the need for continued strategic engagement with public to illuminate the greater purpose of habitat restoration (beyond single-species focus). Suggest presentation topic for SWG/ERTG meeting to determine if CEERP needs to formalize an engagement strategy.
Lower Columbia River Basin Peak Stage - Frequency Report	USACE, 2022	Mon: Changes in river hydrology current and projected	Very interesting read how river dynamics have changed based on contemporary modeling, including hydraulics. Can't tell if it is all predicted or based on some observations as well, would be nice to see a curve comparing the two. Also show flood mitigation benefits of dams + implication for Climate Change.	Important piece speaking to changing nature of formative hydrologic process of the CRE. Sponsors would benefit from its implications for affirming this in the field with observational data and its implications for projects in the form of design criteria.
Affirms current CEERP course of action				
Management Implications from Pacific Northwest Intensively Monitored Watersheds	Bilby et al. 2022	Mon: Wide ranging, emphasizing 10 actions that should be taken to incorporate IMW findings into restoration program planning. Hint: Use an AM framework and plan on needing a lot of time to see results.	The document is 99 pages long, but the text is only ~30 pages. The appendix highlights each of the 13 IMWs individually with links to additional resources. Focus is on fluvial systems that flow to the Columbia River.	Reinforces our general understanding of the processes and components of what makes a good AM Program.

Coos Bay	Brand et al. In review	Mon: The use of coastal wetland restoration as a type of "green infrastructure" for the purpose of lessening impacts of sea level rise on coastal communities.	This hydrodynamic modeling study of Coos Bay, OR showed that wetland restoration can mitigate impacts of sea level rise on Highway 101 and other features of interest to local community stakeholders for 2050 SLR scenarios but that the effect is greatly diminished by 2100.	Affirms CEERP's support for and coordination with NOAA- and NFWF-funded community outreach and hydrodynamic scenario modeling for Grays River, WA.
Tidal-Hydrological Dynamics of Water Temperature across Freshwater Forested Wetlands	Buenau et al. 2023	Mon: Comparison of swamp and marsh wetland channel water temperatures in the Grays River watershed with Grays and Columbia River temperatures.	"Notable cooling effect of tributary...Interiors of tidal forests most often have cooler water temperatures than their bounding waterbodies...Tidal forests had maximum temperatures cooler than emergent marshes by 3-4.5° C during warm, high-stress months for juvenile salmonids. Strong seasonality suggests role of tidal forests will vary by life history.	Affirms need to finalize landscape scale analysis of temperature by CEERP critical uncertainties research. Reinforces restoration but suggests reorientation on tributaries and swamps: "Temperature mediation is a compelling justification for widespread restoration of tidal forests and tributary wetlands." "Cooler sites on tributaries may justify additional distance from mainstem."
Successful Juvenile Life History Strategies in Returning Adult Chinook from Western Washington	Campbell et al. 2023	Rest: Examination of varying juvenile life histories of Chinook salmon in WA estuaries and contributions to adult returns	Life history expression varies by year and may be linked with habitat parameters such as temperature, flow, nonnative predators, nearshore environmental conditions, and estuary habitat availability, suggesting that increased habitat capacity for a given life stage will benefit population abundance.	No adjustment. Reinforces general understanding that juvenile life history residence time in the estuary should be supported through continued estuary habitat restoration efforts.
CEERP science support annual report, 2023.	Diefenderfer (ed.), 2024	Mon: Annual report of data collected through the PNNL Sediment Sentinel System and analysis.	The Sediment Sentinel System, consisting of SETs and sediment stakes, was expanded in 2022-2023 to include turbidity monitoring. Additionally, two new SETs with paired marker horizons were installed during 2023 at two new sites at Whites Island and Sauvie Island, respectively.	Affirms PNNL deployment of the Sediment Sentinel System to explore drivers of sediment accretion rate. Affirms continued monitoring of sediment at restoration and reference sites.
River restoration success: a question of perception.	Jahnig et al 2011	Mon: Review of restoration project evaluations at 26 rivers in Germany to understand how project funders and managers are evaluating success. What metrics are they using and is there anything left on the table that they are not	Standardized approaches to evaluate restoration measures success have not been developed. Usually centered on measurable parameters, but subjective aspects such as landscape aesthetics or recreational value are often left out. 26 rivers in Germany analyzed. Bottom line: lack of objective monitoring data means that managers are not able to reasonably evaluate success. Managers often base	None. Reinforcement of idea that clear goals and good monitoring data is key to truly understanding if a restoration project was a success. Subjective parameters can be a measure of success as well - landscape beauty, educational opportunity, etc. For CEERP - good to keep this idea in mind, but our necessary focus on listed fish makes broader

		using/evaluating/communicating?	perception on landscape aesthetic values or on perceived benefit to the public. Recommend: goals need to be thoughtfully formulated prior to restoration implementation and it is necessary to monitor the projects from different perspectives.	perceptions less relevant at this point for the program.
Migration in drought: Receding streams contract the seaward migration window of endangered salmon	Kastl et al. 2022	Mon: Study conducted in the lower Russian River Basin, CA, to investigate cumulative impacts of increased water temperature, plus water scarcity, on coho salmon migration.	The study area has comparable precipitation patterns to the Coast Range tributaries of the LCRE; however, it does not have a major freshet and interior basin snowpack buffering conditions like the CR. Study streams are tiny in comparison: i.e., most have no flow or flow < 1.5 liters/second July-August. Finding: drought reduced juvenile coho migration window from 11 to 7 weeks and a 2.6 degree C increase in temperature moved the window forward by 3 weeks.	Affirms the importance of LCRE-specific investigations of water temperature and water surface elevation being carried out by the monitoring and research programs.
Evolving Columbia River Basin sediment loads, late 1800s–2020.	McKeon et al. 2023	Mon: CRB sediment load changes since the 1800s.	Mainstem Columbia River sediment load estimates decreased by 46-78% corresponding to changes in river flow. Greatest changes occurred since 1980, primarily in the coarse fraction and coincident with greater flow regulation. Tributary load decreases were smaller than the mainstem.	Reinforces the exploration of Beneficial Use of Dredged Material available through Corps' operations.
How is success or failure in river restoration projects evaluated? Feedback from French restoration projects	Morandi et al. 2014	Mon: Stream focused restoration and full citation unavailable.	Based on 44 French pilot projects that included such The results show that: 1) the quality of an evaluation strategy often remains too poor to understand well the link between a restoration project and ecological changes; 2) in many cases, the conclusions drawn are contradictory, making it difficult to determine the success or failure of a restoration project; and 3) the projects with the poorest evaluation strategies generally have the most positive conclusions about the effects of restoration. Recommendations are that evaluation strategies should be designed early in the project	Affirms current conversations about focusing on how projects are performing post construction. Requires consideration on the front end of the proposal process (ERTG template, suggested placing it at 30%).

			planning process and be based on clearly defined objectives.	
Freshwater growth can provide a survival advantage to Interior Columbia River spring Chinook salmon after ocean entry	Norrie et al. 2022	Mon: To determine if size- or growth-selective mortality occurred in juvenile Interior Columbia River spring Chinook salmon as they migrated through the LCRE and during early marine residence, examined 2 cohorts in years with differing survival (2016 and 2017). Reconstructed the size and growth of individual Chinook salmon from otoliths and compared these attributes in fish caught at 4 sites in the LCRE to those caught in the ocean off OR and WA.	Observed evidence of growth-selective mortality in 2017 but not 2016. In 2017, when overall survival was lower, fish caught in the ocean grew significantly faster in freshwater than individuals caught in the estuary. Given that the fish had resided in the ocean for an average of 30 d, results indicate growth-selective mortality in 2017 occurred soon after ocean entry. The finding that growth in freshwater may impact marine survival adds to the growing body of evidence that processes occurring both prior to and after ocean entry impact the marine survival of this species.	No adjustment. Reinforces importance of estuary residence time and available LCRE habitat for outmigrating salmonids.
Remote sensing of wetland restoration projects to benefit juvenile salmon: integrating LiDAR with hyperspectral imagery	Roegner et al. 2023	Mon: Describes applications of uncrewed, remote-sensing techniques including restoration trajectories, vegetative biomass, and sediment volume change.	Summarizes readiness levels of new, rapidly evolving technology. Key findings are that machine learning was a useful assistant to analyze red-green-blue imagery, which produced good results when compared to hyperspectral imagery; a framework is proposed, including metrics and indicators.	No adjustment. Reinforces importance of continued experimentation by the sponsors with uncrewed techniques for monitoring.

Restoration Success: How is it being measured?	Ruiz-Jaen et al. 2005	Mon: A review of how restoration success has been evaluated in restoration projects and compare those results with guidelines established by the Society of Ecological Restoration.	According to the authors, most of the reviewed studies are using multiple measures to evaluate restoration success, but they suggest projects to include: (1) at least two variables within each of the three ecosystem attributes (diversity, vegetation structure, and ecological processes) that clearly related to ecosystem functioning and (2) at least two reference sites to capture the variation that exist in ecosystems.	None. Reinforcement of the idea of the importance of using multiple variables to evaluate the success of restoration projects.
Warming of the lower Columbia River, 1853 to 2018 (Also see Talke 2023, same method, on Willamette)	Scott et al. 2023	Mon: Recovering archival historical data and statistical modeling of temperature in the CRB with a focus on effects in the estuary.	"Annual averaged water temperature increased by 2.2 C ± 0.2 C since the 1850s, a rate of 1.3 C ± 0.1 C/century...the modern system is warmer but exhibits less temperature variability. The reservoir system reduces sensitivity to short-term atmospheric forcing. ... increased water temperature is driven by warming air temperatures, altered river flow, and water resources management...An approximately 1.2 C ± 0.2 C increase has occurred since 1950."	Affirms need to finalize landscape scale analysis of temperature by CEERP critical uncertainties research. Do we need to think more about temperature refugia in estuarine wetlands as a scoring priority or as part of a landscape scale principles approach.
Shallow-Water Habitat in the Lower Columbia River Estuary: A Highly Altered System	Templeton et al. 2024	Rest: Using a statistical approach as opposed to a numerical one, an investigation into the causes of decreases in Shallow Water Habitat Areas from 1928 to 2004. The investigation hindcasts based on daily higher high water and system hypsometry, and scenario modeling is used to attribute habitat losses to various factors.	The results of this study diverge considerably from previous studies cited, and the hydro system is estimated in this analysis to play a smaller role in the reduction in SWHA compared to those other studies. The study attributes the difference in results primarily to a change in the definition of SWHA. More detailed topography and differences in hypsometric assumptions likely also played a role.	None currently. Program needs to think consider sensitivity to seismic events and SLR in our project planning, and as more levees are removed and floodplains reconnected, coordination with FCRPS water managers will be increasingly important.

Appendix B – Additional References Reviewed: Finding of No CEERP Action

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Appendix C – Additional Information Reviewed: Lessons Learned Submitted by Restoration Project Sponsors

Table C.1. Lessons learned submitted by restoration project sponsors.

Sponsor	Lessons Learned	Adjustment
CLT	Herbicide treatment is a viable alternative for control of P. arundinacea (reed canarygrass; RCG) in tidal marshes. Experimental treatment over a 3-year period reduced RCG cover, while increasing native species cover. The effects persisted for the duration of the monitoring period - 3 years following cessation of treatment. The experimental site with established RCG cover responded better to Fall and Spring treatments, however, the newly restored site with emerging RCG cover had an equal or better reduction with just a Fall treatment. Mid-marsh elevations, near the limit for RCG, had a stronger treatment response than high elevations. Seeding did not have a discernable effect, however native species colonized treated areas regardless of seeding.	Application of herbicide is better than other approaches. *See* Borde et. al (2023; in review)
	Pre-restoration site preparation can reduce invasives and increase success of planting efforts. Nelson Creek Swamp (Lower Elochoman Phase 3) is an example where 2 years of reed canarygrass (RCG) control (herbicide and mowing) prior to restoration resulted in improved conditions for planting over 150,000 shrubs and trees. High diversity and numbers of woody plantings were planted in zones targeted to fill ecological niches and increase resiliency. As of summer 2023, plantings have been qualitatively observed to be successful, with few mortalities. Quantitative counts will be conducted using drone imagery.	**Sponsors**: make sure pre-treatment opportunities are considered and explicitly discussed in the ERTG project template.
	Grazing can be used to help control RCG, such as at Columbia Stock Ranch, but it has potentially detrimental effects on wildlife. White tailed deer seem to avoid cows based on collared deer GPS data from USFS, meaning that the use of grazing for vegetation management or community benefit can be a conflict with biological objectives.	**Facilitating Information Exchange:** Depending on landowner interest, grazing could be beneficial with mitigation for habitat and wildlife.
	Outreach regarding restoration is critical but needs to come from organizations other than project sponsors. For example, the Land Trust is being held responsible for BPA or other fish and wildlife policy and actions which can create points of tension.	**Action Agencies working** on increasing transparency, so information is more readily accessible and publicly available to sponsors and stakeholders.

	Uncrewed aerial systems (UAS) have great potential to increase the spatial extent and frequency of restoration monitoring. This study developed methods for vegetation classification, sediment volume change, and biomass estimation. The study also provided a framework for evaluating ecological change at intertidal sites. The proposed metrics and indicators require vetting from the monitoring community, and it is hoped this document can serve as an initial move towards standardization of methods, processing, and reporting.	**Action Agencies to investigate** how UAS technology can increase efficiencies with current AEMR strategy; ask sponsors to provide information on UAS capabilities (potential sponsor-led information sharing workshop).
	Use of drones/UAV technology appears very useful to monitor channel development and evolution. Channel evolution has been observed on the ground, and UAVs may be the best way to quantify this.	**Action Agencies** to investigate how UAS technology can increase efficiencies with current AEMR strategy; ask sponsors to provide information on UAS capabilities (potential sponsor-led information sharing workshop).
	Settlement of setback levee in the lower estuary can continue for years (decades?). Mill Road example: approximately 500 feet of setback levee (county road) has settled approx. 18 inches over the past 12 years. Project was completed after 2 years of settlement monitoring which showed stability, but over time it has continued to settle creating a maintenance issue. In this case, also complicated by public ownership and control of infrastructure.	**Sponsors**: Consider setback levee settlement in project designs; consideration of factors that may result in settlement (core characteristics of sediment). Also, query sponsors: how widespread is this issue?
	Nelson Creek/Lower Elochoman III Floodplain Restoration project included a low water pilot channel in the main creek channel design to ensure low flow post construction had a channel pathway (~1' deep x 3' wide). This channel did not persist past first higher flow event.	**Ask CLT:** Is site specific--did create a different channel or was this sheet flow?
	Cattail and wapato establishment have been high over the past 2-3 years in restoration sites (Kerry Island, Kandoll Farm, Walluski South and Devils Elbow). Understanding the ecological factors and trajectory of this establishment would be valuable, as well as the community benefits to salmonids.	**AAs:** Include in habitat uncertainties and prioritize in matrix amongst other uncertainties.
	Hiring a consultant for historic and cultural resource review as part of EC may be a better strategy for projects under tight timelines. Utilizing BPA staff is very appreciated, but staff capacity seems to be lacking and can result in project delays.	**BPA acknowledges**; however, BPA cultural resources review capacity can vary depending on timing. BPA CR group has just expanded so expect more BPA support moving forward.

	Where significant restoration investments are being made within a watershed or community (i.e., Grays River) it would be valuable to have resources to invest in community resources such as improved stream gaging that supports community safety as well as watershed planning, project design and long-term monitoring.	**CLT and PNNL** working to determine if additional resources are available. **AAs**: look into helping to connect other federal resources.
LCEP	The updated protocols for monitoring juvenile salmonid habitats in the lower Columbia River estuary are the culmination of extensive research and practice, providing detailed guidance for the ecological monitoring of tidal wetlands. Initiated in 2018, the development of these protocol updates was extended due to the pandemic, a period that underscored the value of collaboration, stakeholder engagement, and the integration of new field methodologies. The protocols are presented as a living document, intended to be updated with new insights as they arise, thus ensuring that monitoring efforts stay effective and relevant to the evolving goals of restoration programs. This approach facilitates the ongoing recovery of salmonid populations and the sustained health of estuarine ecosystems. Feedback and comments are requested by February 1, 2024, to precede a dedicated workshop in Spring 2024, which will further refine and enhance the protocol's application.	LCEP protocols are not an update to the CEERP protocols nor have they been adopted by CEERP. **AAs** are evaluating these protocols as part of the update of the CEERP protocols NOAA technical memorandum (Roegner et al. 2009)
	Over a decade of wetland monitoring data has been effectively visualized and analyzed using Tableau, which has provided significant insights into wetland status and trends that inform restoration and monitoring strategies. This innovative approach to data management facilitates more informed decision-making for future restoration projects.	Action Agencies evaluating utility and usability across all sponsors and for restoration planning.
	Utilizing UAV multispectral data enhances wetland monitoring and restoration planning by providing detailed assessments of plant community development and salmonid habitat opportunities. This integrated approach, combining UAV data with field surveys, offers a cost-effective, accurate method for creating vegetation maps that inform restoration impact assessments and guide adaptive management strategies. A manuscript detailing these findings is currently in preparation.	**Action Agencies** to investigate how UAS technology can increase efficiencies with current AEMR strategy; ask sponsors to provide information on UAS capabilities (potential sponsor-led information sharing workshop).
	The research on the use of multispectral UAV data for wetland plant community mapping has underscored its transformative impact on wetland monitoring and restoration planning. The integration of UAV data with traditional field surveys using advanced processing tools like Pix4D, R, and ArcGIS has proven effective in creating detailed vegetation maps that reflect both native and non-native species distribution and the topography of restoration sites. These maps facilitate a comprehensive assessment of habitat conditions and dynamics over time, enhancing the ability to predict and evaluate the ecological consequences of restoration efforts and climatic variations. The project highlights the value of UAV technology in improving the accuracy and cost-efficiency of ecological assessments, crucial for the adaptive management of wetland habitats and the support of salmonid populations. It illustrates that shifts in plant community composition, influenced by site hydrology, are key indicators of habitat quality and the successful function of restored wetland ecosystems.	**Action Agencies** to investigate how UAS technology can increase efficiencies with current AEMR strategy; ask sponsors to provide information on UAS capabilities (potential sponsor-led information sharing workshop).

	The Steigerwald Lake National Wildlife Refuge restoration monitoring exemplifies innovative strategies in large-scale floodplain management. By establishing clear, testable hypotheses during the design phase, utilizing predictive hydraulic and ecological models, and integrating long-term reference data, the project set a robust framework for evaluating post-restoration outcomes. The use of UAV data collection underscored the significance of combining traditional survey methods with cutting-edge technology. This approach not only increased the efficiency and affordability of monitoring a vast area but also enhanced the precision and reliability of data on plant communities, water quality, geomorphic changes, and fish use. The Steigerwald project serves as a testament to the importance of interdisciplinary planning and the use of adaptable, cost-effective technologies to ensure the success of ecological restoration and to provide a model for future projects aiming for ecological recovery and sustainability.	**Action Agencies** to investigate how UAS technology can increase efficiencies with current AEMR strategy; ask sponsors to provide information on UAS capabilities (potential sponsor-led information sharing workshop).
	Understanding the development of plant communities in tidal wetlands is deeply intertwined with soil dynamics. By monitoring the biogeochemistry of soil, we can gain crucial insights into the environmental conditions that promote invasive species, such as Reed canarygrass. This knowledge is pivotal for directing restoration efforts and managing native plant communities more effectively. Our research connects soil chemistry to the success of restoration, illustrating how tidal flooding and soil attributes shape the biogeochemical foundation that either supports or hinders the establishment of native wetland flora. A manuscript detailing these findings is currently in preparation.	To the extent biogeochemistry results inform restoration success, will be assessed by CEERP managers upon publication.
	Five years post-restoration, the Wallooskee restoration site has successfully transitioned from an agricultural field to a thriving tidal wetland. UAV imagery shows substantial changes in habitat conditions, with native wetland plant communities now flourishing. Soil conditions, sediment dynamics, and water parameters have also notably progressed toward natural reference site conditions, indicating a positive trajectory toward becoming a high-quality habitat for salmonids. To fully convey the extent and implications of these findings, adequate preparation time is paramount to ensure that all presentations meet the high standards of quality and scientific integrity expected by LCEP, the ERTG, and other stakeholders. For future ERTG Revisits, we recommend direct coordination between project sponsors, LCEP, and ERTG to foster AEMR data sharing and collaboration on project outcomes.	CEERP managers acknowledge that sponsors require adequate notice for data requests for future presentations.
	The Tableau for Environmental Science workshop demonstrates the transformation of complex ecological data into interactive, user-friendly visual formats. Tableau's capabilities for easy data analysis, mapping, and sharing provide a powerful tool for environmental scientists, enabling more efficient and effective communication of research findings and monitoring data.	**AAs** still determining utility of Tableau for widespread program integration.
	Designed to accompany the Tableau for Environmental Science Workshop, we unveiled a detailed 150-page workbook tutorial designed to equip individuals with no prior experience with the skills to navigate Tableau's robust platform. It showcases the process of converting extensive ecological data into engaging, interactive dashboards. The tutorial emphasizes Tableau's streamlined functionality for data analysis, mapping, and dissemination, serving as a critical instrument for environmental scientists to enhance the efficiency and clarity of their data communication.	AAs will inquire with CEERP sponsors regarding the utility of the workbook tutorial and/or their experiences of using Tableau.

	In this presentation, we delve into the sophisticated realm of Tableau's advanced applications, designed to push the boundaries of data visualization and analysis. Drawing a decade of wetland data insights, we explored techniques that transform complex ecological datasets into clear, interactive narratives with other National Estuary Partnerships. We demonstrate the capabilities of Tableau to not only map and share data but to also drive powerful storytelling in science, making data patterns understandable and actionable. This session was dedicated to unveiling the full potential of Tableau, empowering both other scientists and NEPs to unlock new levels of efficiency and effectiveness in their environmental research communications.	**AAs** still determining utility of Tableau for widespread program integration.
	The ecological comparison between invasive reed canarygrass and native Lyngbye's sedge in the lower Columbia River indicates that the native sedge supports a more abundant and higher quality detritus for juvenile salmon prey resources. Despite similar overall invertebrate biomass between the two plant types, the native sedge fosters greater abundance of specific prey groups vital to salmon diets. This suggests that the presence of reed canarygrass may reduce the ecological service of providing prey for juvenile salmon, with potential implications for salmon trophic function. Further research could clarify the impact on juvenile salmon and guide restoration and management priorities.	*See* Cordell et al. (2023)
	The Ecosystem Monitoring Program's integration of Tableau for data visualization represents a significant leap in data sharing and analysis. This approach not only tracks the health and trends of habitats in the lower Columbia River but also provides dynamic, interactive insights for stakeholders, enhancing their understanding of ecological conditions and aiding in the strategic planning for the recovery of salmonids. The program's data for 2022 reflects a comprehensive assessment across various sites, offering invaluable information for addressing uncertainties in habitat restoration and adapting to environmental changes.	**AAs** querying sponsors and managers to evaluate the programmatic data sharing capabilities and still determining utility of Tableau for widespread program integration.
	Nutrient concentrations and plankton biomass in the Columbia River provide critical insights into the food web supporting juvenile salmon. High spring diatom proportions indicate robust oxygen production and water quality, while summer algae blooms can impact water clarity and quality. Zooplankton diversity and stable isotope analyses reveal complex food web interactions, with significant contributions from phytoplankton and periphyton to the diets of salmonid prey. These findings emphasize the value of comprehensive monitoring to understand and support the nutritional foundations of salmonid habitats, ensuring their effective management and conservation.	**AAs:** Consider this and all other EMP research within the context of SM3.
	The Columbia River's discharge in 2022 exhibited varied patterns, with high winter flows, below-average early spring flows, and a significant spring freshet peaking in mid-June. This highlights the river's dynamic hydrology, essential for ecosystem management and understanding riverine habitats. Additionally, water temperatures generally followed long-term averages, but with higher than average temperatures post-freshet. Water quality at off-channel EMP sites remained good, though some sites experienced environmental conditions indicative of heightened biological activity. These findings underscore the importance of continuous monitoring to adaptively manage aquatic ecosystems amidst changing climatic and environmental conditions.	**AAs:** Consider this and all other EMP research within the context of SM3.

	The fish community monitoring in the Lower Columbia estuary reveals distinct assemblages across the five trend sites, with a consistent presence of thirteen major fish families. The diet of juvenile salmon varies by location, reflecting the diverse aquatic environments from marine-influenced waters at Ilwaco Slough to freshwater habitats upstream. Chinook salmon are the dominant salmonid species at all sites, with varying genetic stocks identified. These findings highlight the importance of habitat diversity for supporting salmon populations and underscore the need for site-specific management approaches to protect and enhance these critical ecosystems.	**AAs**: Consider this and all other EMP research within the context of SM3.
	Habitat structure monitoring in 2022 reveals stable plant cover across most trend sites. Variability in non-native species like reed canarygrass is closely linked to spring and summer river discharge levels, influencing its dominance. Meanwhile, the abundance of native species appears to respond to the timing and intensity of river freshets, with some showing a delayed reaction to changes in discharge levels. These observations underline the importance of managing hydrological regimes to support native vegetation and control invasive species, which is crucial for maintaining healthy wetland ecosystems.	No adjustment.
	The Action Effectiveness Monitoring program managed by LCEP has demonstrated notable success in assessing and improving habitat restoration actions for salmon recovery. The program utilizes a data-driven approach with standardized protocols and collaborative stakeholder engagement to quantify ecological changes post-restoration. Notably, the Wallooskee-Youngs Project has evolved rapidly into a productive wetland (5 yrs. post), and other sites like John R Palensky, Dibblee Point, and Flight's End also show positive trajectories. These projects illustrate the crucial role of hydrological connectivity and native plant communities in supporting salmonid habitats. However, challenges such as grazing pressure, sea level rise, and the need for adaptive management practices like mowing reduction have been identified. Overall, the AEM program underscores the importance of continuous monitoring and dynamic data presentation through platforms like Tableau to inform and enhance restoration strategies.	**AAs** to ask ERTG to evaluate AEM program in 2024 as part of development of the third programmatic Synthesis Memorandum.
	The restoration of the Wallooskee-Youngs site from a historical dairy farm to a vibrant tidal wetland within five years highlights the critical role of hydrologic connectivity in wetland recovery. The removal of levees and restoration of tidal flooding have led to a significant increase in native plant diversity, improved nutrient cycling, and enhanced off-channel habitats for aquatic species. UAV imagery has been instrumental in documenting the transition, revealing a substantial shift toward the conditions of natural reference sites. These changes signify a promising future for the site as a high-functioning habitat for salmonids, demonstrating the success of targeted restoration actions in reviving estuarine ecosystems.	

	The Flight's End Project, through its efforts to reestablish connectivity and restore native vegetation, has made strides in reviving native plant communities five years post-restoration. Despite the presence of extensive bare ground, likely a result of mowing, and the challenge of adapting to sea level rise, the project has successfully provided increased accessibility for salmonids. The predominance of Cladocera in the macroinvertebrate community and the confirmed use of the site by salmon indicate a positive response from the local ecosystem to the restoration efforts.	
	In its first year post-restoration, the John R Palensky Project is on track to become a fully functional floodplain wetland habitat. The restoration efforts have successfully reestablished hydrological connectivity to the Multnomah Channel, which is reflected in the hydrology patterns now similar to the reference site. The significant freshet event created more open water and bare ground. Similar restoration projects typically take 2-3 years before extensive vegetation establishes in the emergent marsh communities (Kidd et al. 2023). An increase in native vegetation cover indicates positive ecological responses to the restoration actions. Although sediment accretion is not keeping up with sea-level rise, the soil conditions align with the reference, suggesting steady progress toward the project's ecological goals. Continued monitoring is critical to understand the long-term success of these restoration efforts, with specific attention to the challenges posed by sea-level rise and the need for ongoing adaptive management strategies.	
	The ten-year post-restoration assessment of Dibblee Point reveals that strategic actions taken to restore tidal connectivity and wetland complexity have been largely successful. The monitoring indicates that the wetland is functioning with native vegetation and processes akin to natural conditions. However, the challenge of keeping pace with sea level rise, particularly in low marsh areas, has been identified. The significant increase in macroinvertebrate abundance and the ongoing use of the site by salmon validate the restoration efforts. This project serves as a lesson in the importance of long-term monitoring to track restoration impacts and the need to consider future climatic changes in restoration planning.	
	The EMP's comprehensive assessment in 2022 of the lower Columbia River's wetland habitats—crucial for the survival of juvenile salmon—reveals the significant impact of river discharge and climate conditions on ecological dynamics. The program's multi-faceted approach, including the analysis of plant communities, water quality, and food webs, allows for a nuanced understanding of habitat function and the needs of threatened salmonid species. The use of long-term undisturbed sites as a reference point helps differentiate between natural variability and human-induced changes. The adoption of Tableau for data visualization promotes interactive engagement with the findings, enhancing the translation of complex data into actionable insights for habitat restoration and climate adaptation strategies.	**AAs** to ask ERTG to evaluate EMP program in 2024 as part of development of the third programmatic Synthesis Memorandum.

	The exploration into using Tableau for the visualization and analysis of a decade's worth of wetland habitat monitoring data has provided valuable lessons in data management and visualization. The team's transition from Excel to Tableau was driven by the need for more robust software capable of handling the extensive georeferenced datasets collected since 2008, including water surface elevation and temperature, vegetation, soil statistics, and sediment accretion. The adoption of Tableau facilitated not only basic data management and quality assurance but also enabled the efficient exploration and analysis of complex datasets. The creation of interactive dashboards has enhanced communication with project partners, allowing for immediate examination of post-restoration site development. This approach exemplifies how advanced data visualization tools like Tableau can streamline data interpretation and support the decision-making processes in restoration and adaptive management efforts. Moving forward, the integration of drone imagery and vegetation models is expected to augment the robustness of this data analysis method, offering a replicable technique for other researchers and practitioners facing similar data challenges.	The **AAs** have not adopted Tableau for CEERP and are still determining utility of Tableau for widespread program integration.
	The development of a comprehensive Tableau dashboard presenting years of site monitoring data offers a valuable lesson in the power of visual data synthesis and dissemination. It highlights the necessity of interactive platforms for effective communication of sediment accretion trends, sea level rise comparisons, and hydrological data, with the added functionality of direct data downloads. This dashboard not only enhances understanding of habitat opportunities for critical species but also enables stakeholders to actively engage with and analyze water surface elevation data. The ease of access to such detailed ecological information fosters collaborative research and informed decision-making, crucial for adaptive management and the advancement of restoration objectives. This initiative demonstrates the significant benefits of leveraging advanced visualization tools to make ecological data more accessible and actionable in the pursuit of ecosystem preservation and restoration. Future work includes separating sediment accretion and hydrology data into separate dashboards.	**AAs** querying sponsors and managers to evaluate the programmatic data sharing capabilities and still determining utility of Tableau for widespread program integration. The **AAs** have not adopted Tableau for CEERP.
	Annually, LCEP presents the AEMR results and overall lessons learned to the ERTG. Notably in 2022, Wallooskee-Youngs, Flight's End, La Center Wetlands, Wallacut River, and North Unit Ruby Lake Projects have all provided vital lessons in post-restoration monitoring of tidal wetlands. Within three years, Wallooskee-Youngs transitioned from farmland to a tidal wetland with a diverse native plant community, matching water conditions with nearby natural waterways, and an influx of juvenile salmonids. Flight's End showed a promising ratio of native to non-native plants. La Center Wetlands has become a functional fluvial wetland, mirroring the hydrologic conditions of the East Fork Lewis River, and showing potential as a salmonid habitat, despite slightly higher summer temperatures. Wallacut River's restoration has achieved hydrological similarity to its reference site; adjustments are expected over time to foster native species and reduce invasive Reed Canarygrass. North Unit Ruby Lake has transformed from an inaccessible lake to a productive environment for salmonids, with hydrologic conditions aligning with its reference site and an increase in native plant cover, particularly Wapato. These projects collectively underscore the critical importance of long-term monitoring, adaptive land management, and the need to anticipate climate impacts for successful restoration and the creation of sustainable salmonid habitats.	

CREST	When designing new tidal channels in sandy soils it is best to provide a wide opening at the mouth of the channel with a moderate slope. This "flared design" with gentle side slopes (less than 4:1), reduces the risk of bank sloughing or debris blocking the channel.	**Sponsors:** Lesson Learned on Tidal Channel Design (under Restoration Practices). **AAs:** Consider Restoration Practices Workshop
	Material quantity estimates based on LiDAR are best estimates. Dense vegetation requires additional on-the-ground survey efforts to accurately capture true ground elevations and excavation/fill quantities.	**Sponsors**: Lesson Learned on Design (under Restoration Practices). **AAs**: Consider Restoration Practices Workshop
	Having an expansive Area of Project Effects (APE) is important to ensure flexibility for field fitting channel alignments, targeting invasive vegetation, or making minor adjustments to the grading areas.	**Sponsors**: Lesson Learned on Construction Prep (under Restoration Practices). **AAs**: Consider Restoration Practices Workshop
	Place outside water level and temperature data loggers just upstream of the reconnected channel to minimize influence of the "plume" coming out from the channel.	**Sponsor**: Lessons Learned on Monitoring Practices. **AAs:** Consider Monitoring Practices Workshop
	PVC piping is used throughout our sites for monitoring. Recently we've noticed some beaver chews on the piping. If this continues, we should examine more strategic placement of this piping or investigate alternative materials or methods.	**Sponsor**: Lessons Learned on Monitoring Practices. **AAs**: Consider Monitoring Practices Workshop
	Setting up pre-project site visits and/or virtual tours with the BPA EC staff can be quite helpful to kick off the HIP programmatic.	**Sponsor**: Lesson Learned on Environmental Compliance
	The Oregon DEQ is no longer recognizing the 401 Water Quality certification through the HIP 4 Programmatic. This will result in additional permit review costs and longer timelines for restoration projects occurring in Oregon.	**Sponsor**: Lesson Learned on Environmental Compliance
	Post project monitoring reports are typically due within 6 months of the initial replanting efforts, which generally shows poor plant survival (since it's less than 1 growing season). Most restoration sites see improved plant survival and coverage 2-4 years after restoration and planting efforts.	**Sponsor**: Lesson Learned on Environmental Compliance
	The US Army Corps regulatory branch is now requiring full wetland delineations on floodplain restoration projects – regardless of their size or anticipated impacts. Previously, the USACE and State regulators made a project-by-project decision, now they are applying this broad standard. This is a costly and time-intensive change for permitting of projects. It would be helpful if the Federal regulators (perhaps through the HIP programmatic risk level) could examine the benefits and risks for these restoration projects and then make a specific decision as to whether a full wetland delineation is needed for a given restoration project.	**Sponsor**: Lesson Learned on Environmental Compliance

WDFW	Opportunities for sponsors to get out in the field and talk about projects with other sponsors are invaluable. They promote organic information sharing, increased partnership, and opportunities to strategize. Revisits provided a great opportunity for this over the past year.	CEERP managers would like to hear more about the shared knowledge imparted during these coordination meetings. If Lessons Learned, please include specific information (i.e., technique, approach, etc.).
	Good projects never die, they just grow in importance. 3rd party analyses can help promote important conversations and move decision making.	No adjustment.
	Continuity in personnel is key in restoration. Trust building with landowners, partners, and coworkers takes time. Floodplain reconnection changes the landscape in a way that feels final, and there has to be significant trust established to take that step.	No adjustment. CEERP managers acknowledge complexities in engagement with different stakeholder groups and will continue to develop strategies to best engage local communities based on specific needs.
	Sometimes it's okay to build a berm for the sake of salmon recovery. WDFW sees this happen at numerous other restoration sites to protect private lands, even if the long-term goal is to have those lands inundated too. Salmon recovery needs to occur now; build the berm if that's what gets the project done.	No adjustment.
WWR	MTRs add cost in raw materials without documented success metrics in terms of benefits to fish. While some access is provided with structures of this kind, that access is limited and, as the name suggests, natural processes that develop and maintain juvenile salmon habitat are muted. More study is needed to understand the efficacy of these structures providing juvenile fish benefits that a) justify added costs and, b) make this action viable over other structures or complete structure removal.	CEERP managers consider MTRs as no different than tidegates for ERTG scoring purposes.

Columbia Estuary Ecosystem Restoration Program (CEERP) in Oregon and Washington states

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Where, Why, & What, is CEERP?

- Objectives
  - Increase the opportunity for access by aquatic organisms to, and for export of materials from, shallow-water habitats
  - Increase the capacity and quality of estuarine and tidal-fluvial ecosystems
  - Improve ecosystem realized functions
  - Habitat restoration is focused on benefiting all juvenile salmonid Columbia Basin populations
- Guiding restoration principle: Ecosystem Based Approach (Johnson et al. 2003)
- Original and Primary Strategy: ***Floodplain reconnections close to the mainstem***

Kandoll Farm – Columbia Land Trust

CEERP Partners:

crest
COLUMBIA RIVER ESTUARY STUDY TASKFORCE

Lower Columbia Estuary Partnership

Columbia Land Trust
CONSERVING THE NATURE YOU LOVE

COWLITZ INDIAN TRIBE

Pacific Northwest
NATIONAL LABORATORY

Washington Department of FISH and WILDLIFE

W2R WOLF WATER RESOURCES

Who, cont'd:

CEERP's Expert Regional Technical Group (ERTG)

- Senior scientists with estuary expertise (ODFW, WDFW, NOAA, USFWS, PNNL, CLT)
  - Evaluate and assign benefits to restoration projects
  - Articulate, document, publish and refine scoring criteria
  - Define and prioritize scientific uncertainties in the estuary
  - Produce focused work products (Landscape Principles, Site Revisits)
  - Regular interaction with restoration practitioners and program managers

ELSEVIER

Journal of Environmental Management

Volume 188, 1 March 2017, Pages 337-350

Research article

An expert panel process to evaluate habitat restoration actions in the Columbia River estuary

Kirk L. Krueger [a], Daniel L. Bottom [b], W. Gregory Hood [c], Gary E. Johnson [d], Kim K. Jones [e], Ronald M. Thom [f]

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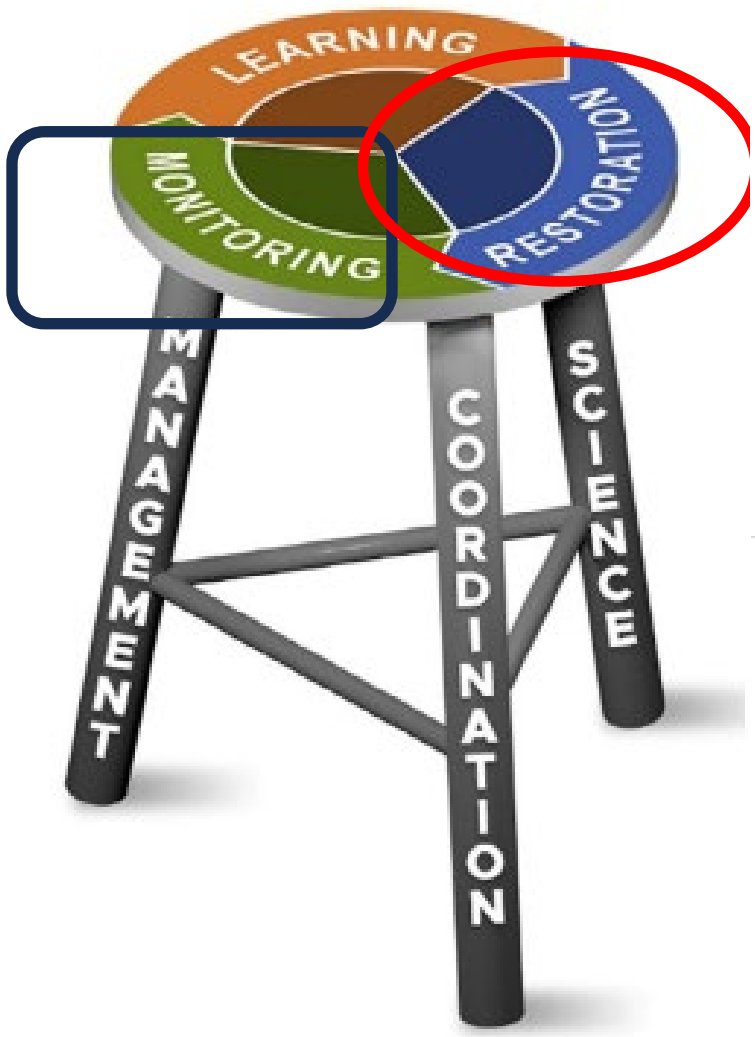
The adaptive management framework of CEERP



Littles et al. 2022

Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

RESEARCH ARTICLE

Published in 2017

Estuary ecosystem restoration: implementing and institutionalizing adaptive management

Blaine D. Ebberts[1,2], Ben D. Zelinsky[3], Jason P. Karnezis[3], Cynthia A. Studebaker[1], Siena Lopez-Johnston[3], Anne M. Creason[3], Lynne Krasnow[4], Gary E. Johnson[5,6], Ronald M. Thom[7]

RESTORATION ECOLOGY
The Journal of the Society for Ecological Restoration

Published in 2022

UN DECADE ON ECOSYSTEM RESTORATION

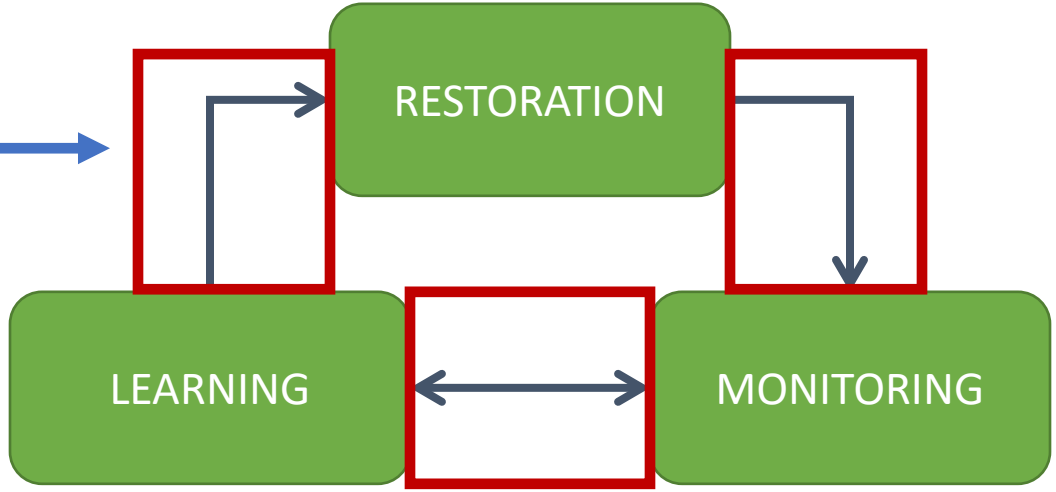
TECHNICAL ARTICLE

Adaptive management of large-scale ecosystem restoration: increasing certainty of habitat outcomes in the Columbia River Estuary, U.S.A.

Chanda Littles[1,2], Jason Karnezis[3], Katie Blauvelt[4], Anne Creason[3], Heida Diefenderfer[5], Gary Johnson[6], Lynne Krasnow[7], Phil Trask[4]

How do we CEERP?

Annual cycle



Key Principles for CEERP's continued evolution

1. Frequently engage partners on Restoration and Monitoring priorities
2. Seek lessons learned, especially failures
3. Foster collaborative, iterative approaches to complex challenges
4. Provide and attend multiple forums to exchange ideas
5. Document everything – prioritize primary literature publications, capture institutional knowledge, increase regional visibility
6. Make it better, every year

cbfish.org - Columbia Basin Fish & Wildlife Program - Estuary Program

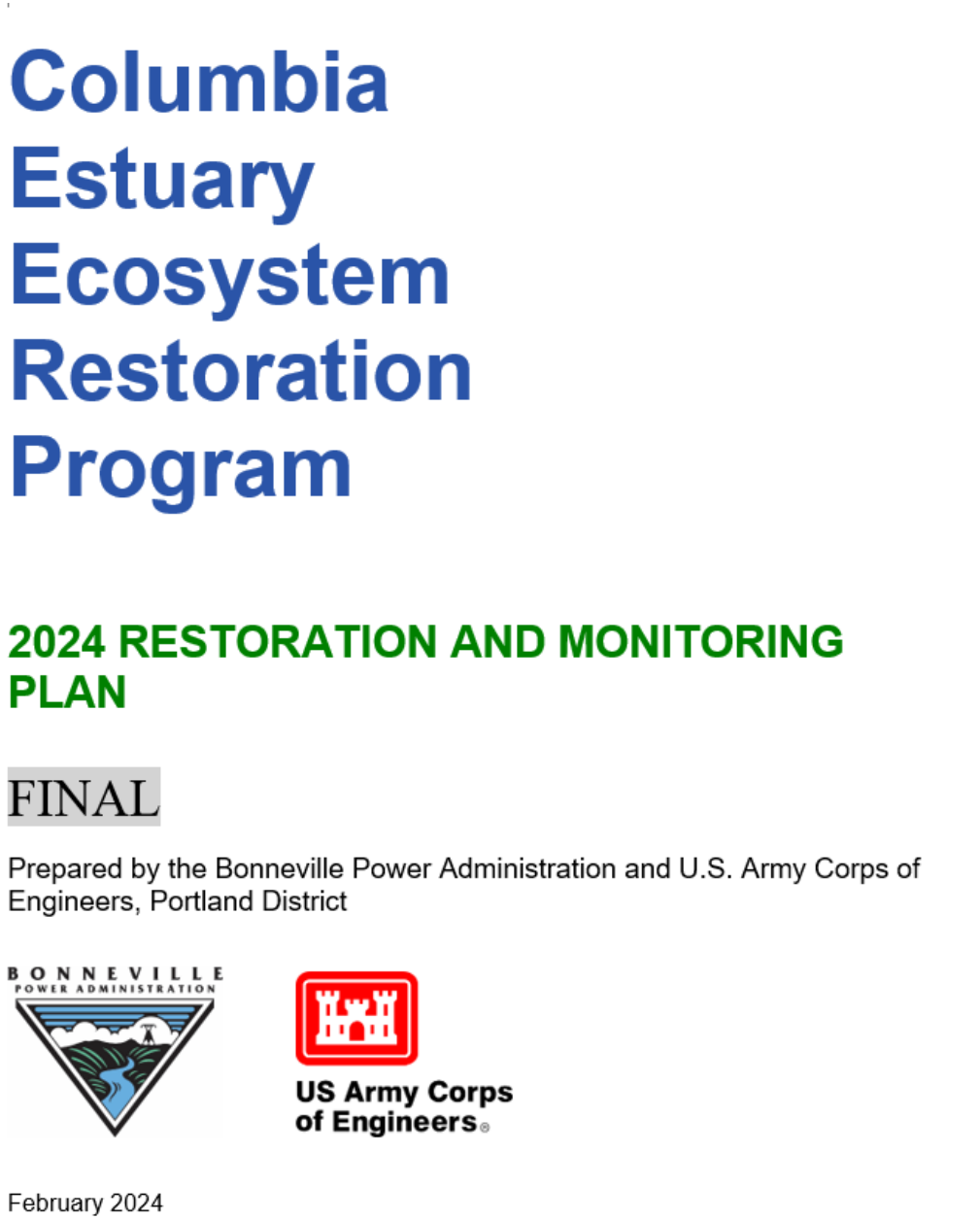
CEERP Adaptive Management

Ebberts et al. 2017, https://doi.org/10.1111/rec.12562
Littles et al. 2022, https://doi.org/10.1111/rec.13634

CEERP AM | Restoration | Uncertainties | Pilot Studies | Data Sharing

Annual reporting

- Captures lessons learned from restoration and research practitioners
- Memorializes workshops, conferences, presentations pertinent to estuary restoration
- Summarizes most recent habitat restoration and research accomplishments
- Forecasts expected work portfolio for the year.
- Organizes all pertinent literature and other learnings into a Master Matrix of learning



CEERP is now entering its third decade of restoration and monitoring efforts

- 80 +projects completed
- 11,100 + acres of reconnected tidally influenced floodplain habitats

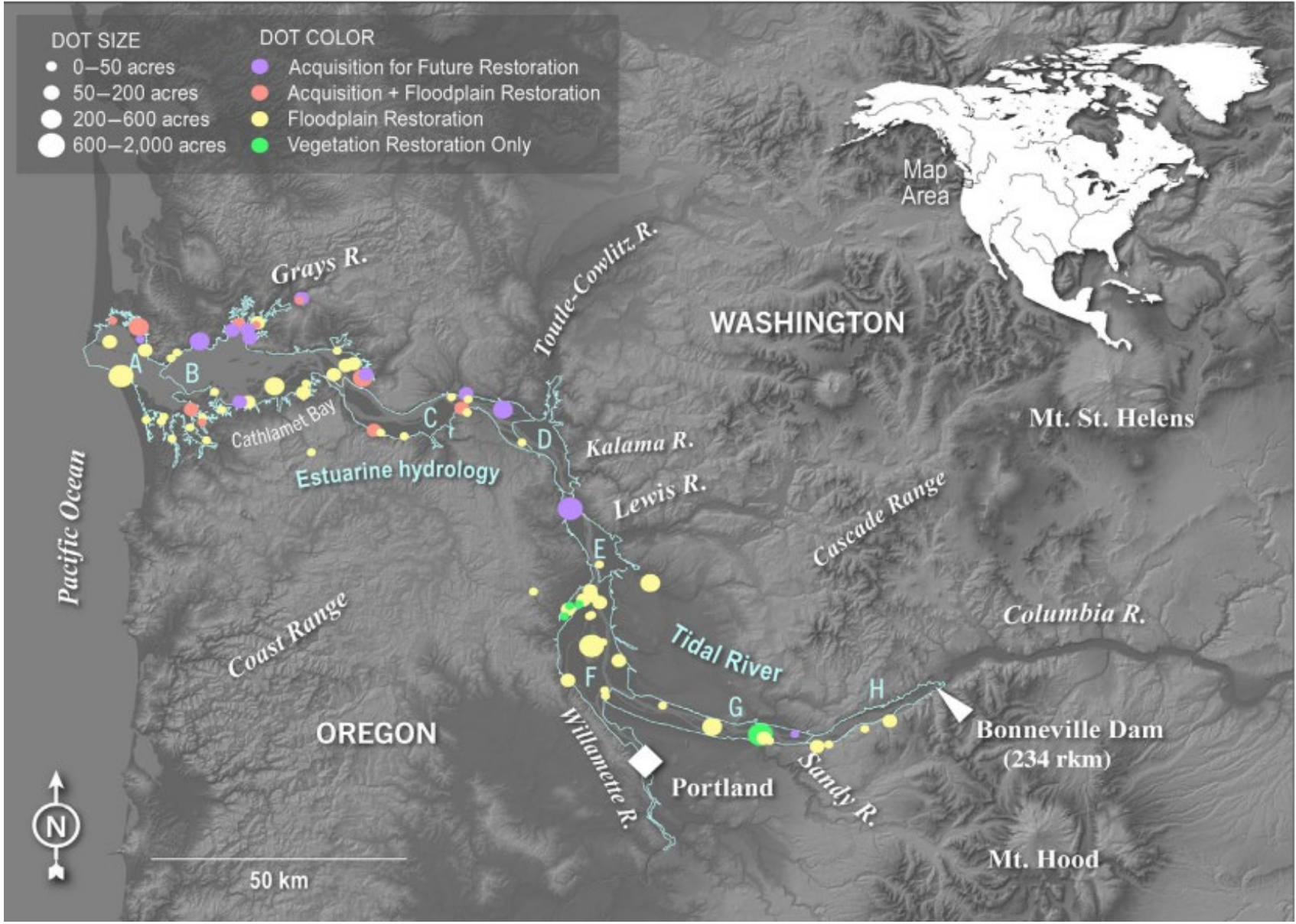
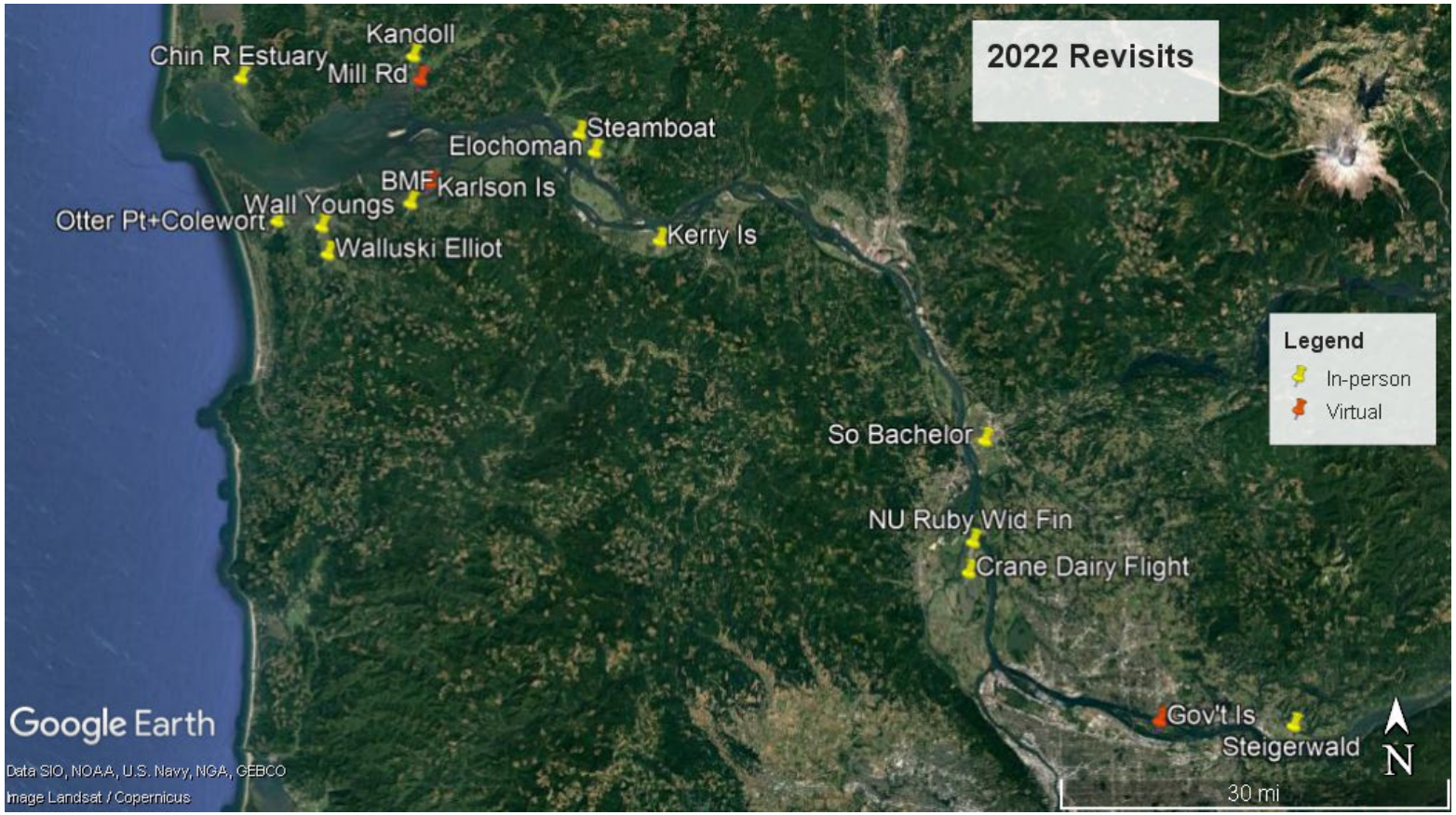


Figure 2. Map of the Columbia River Estuary showing the size and type of acquisition and restoration projects implemented by CEERP, 2000–2020. Hydrogeomorphic reaches (Simenstad et al. 2011) A through H are labeled. “Floodplain Restoration” refers to hydrological restoration (i.e. breach levees or upgrade culverts, etc.) and “Vegetation Restoration Only” refers to invasive vegetation removal, native plantings, and riparian enhancements. One project with acquisition and vegetation restoration only was lumped into the “Acquisition + Floodplain Restoration” category.

Restoration Project Revisits



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ERTG Work Products:
Synthesis of Site Evaluation Cards Based on Revisits during 2022

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

February 14, 2024

ERTG (Expert Regional Technical Group). 2024. *Synthesis of Site Evaluation Cards Based on Revisits during 2022*. ERTG #2024-01, FINAL, prepared for the Bonneville Power Administration, National Marine Fisheries Service, and the U.S. Army Corps of Engineers. Portland, Oregon. Available from https://www.cbfish.org/EstuaryAction.mvc/Documents.

"The quantitative analysis considered the scores of Certainty of Success, Access and Opportunity, and Capacity and Quality as measures of site scale function and ecological processes *pre- and post-construction* and coupled with the acreage of sub-actions at each site, a cumulative estimate of Survival Benefit Units (SBUs) at each site. **The overall picture is that the projects are functioning as intended and sometimes better."**

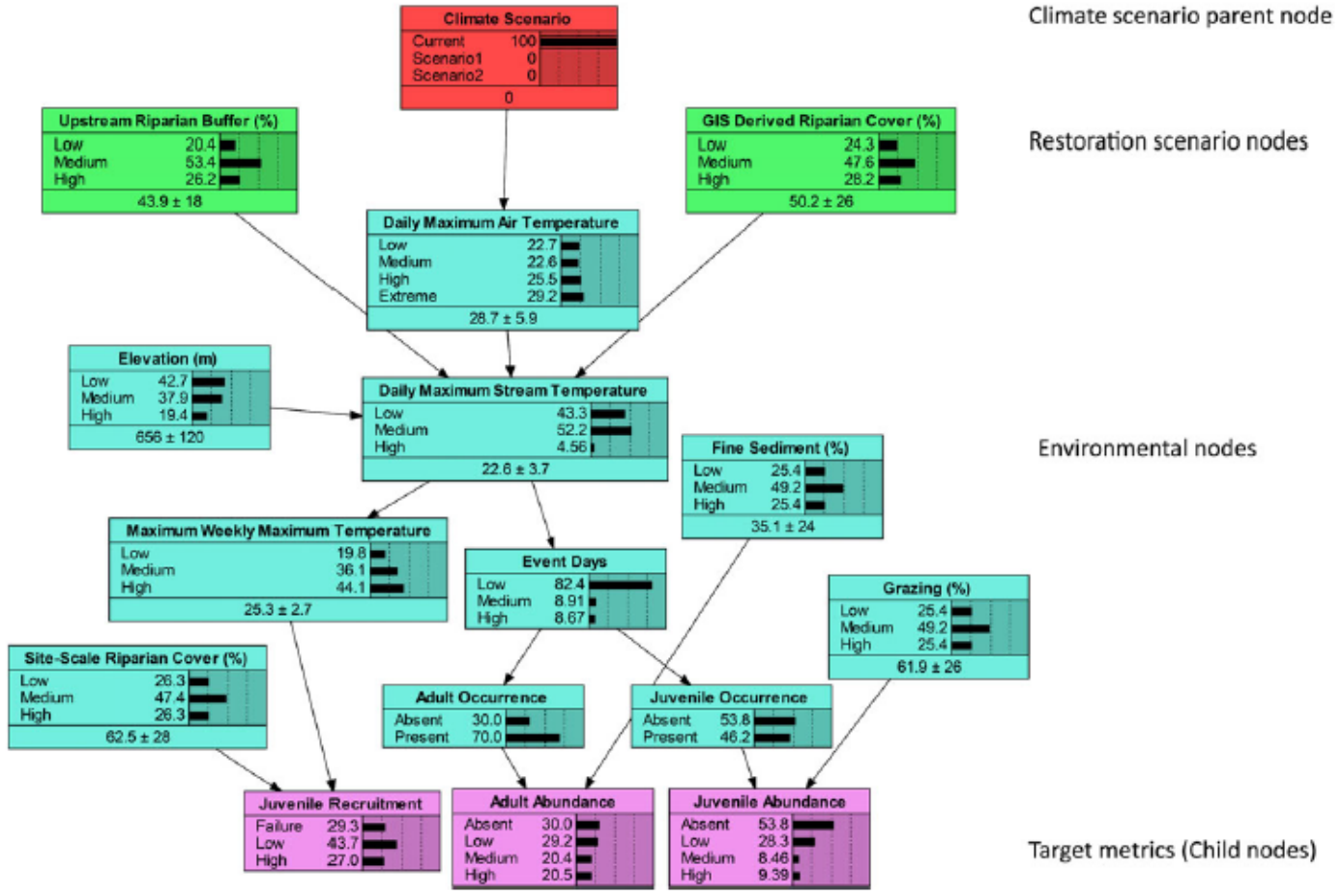
Priority CEERP Uncertainties

- How will climate change affect the LCRE ecosystem and restoration strategy and what actions could be taken to mitigate for adverse effects? *[System]*
- How does reconnecting fragmented estuarine landscapes improve life history variation and adult survival in naturally produced populations? *[Estuary]*
- How do transitional habitats in the designated priority areas (e.g., priority reaches, tributary junctions) compare in importance to other salmonid rearing habitats in the estuary? *[Estuary]*
- How does patch size and travel distance between habitats influence salmon use, access, and performance? *[Landscape]*
- What are the functions of shoreline matrix habitats for juvenile salmon along channel margins of the mainstem river and tributaries and what is the restoration potential? *[Habitat]*

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. Available from https://www.cbfish.org/EstuaryAction.mvc/Documents

Climate Change

- Apply predictive models to examine ecosystem responses to various climate change scenarios
- Monitor long-term trends in water level, temperature, and sedimentation
- Incorporate climate resiliency into project designs and CEERP restoration strategy



Turschwell et al. 2017, Bayesian belief network (BBN) model to predict how riparian restoration could help mitigate effects from climate warming, https://doi.org/10.1002/aqc.2864

Crozier et al. (2021) conducted a comprehensive study on climate change effects to Chinook salmon and concluded:

> "*The urgency is greater than ever to identify successful solutions at a large scale and implement known methods for improving survival. Management actions that open new habitats, improve productivity within existing habitat, or reduce mortality through direct or indirect effects in the ocean are desperately needed. We can find new ways to improve salmon habitats while maintaining other benefits for people, like reconnecting floodplains with rivers and natural marshes to recharge aquifers and mitigate flooding, storm surge, and channel erosion.*"

Draft recommendations:

- Develop tidal marsh resiliency assessment framework to prioritize restoration.
- Implement experimentation into restoration project design to reduce climate-related uncertainties, and enhance resilience, related to climate mitigation strategies and to inform design and evaluation of projects.
- Expand GIS tools to include climate change and resiliency elements in evaluation of projects.

Climate Resiliency in the Columbia Estuary Ecosystem Restoration Program

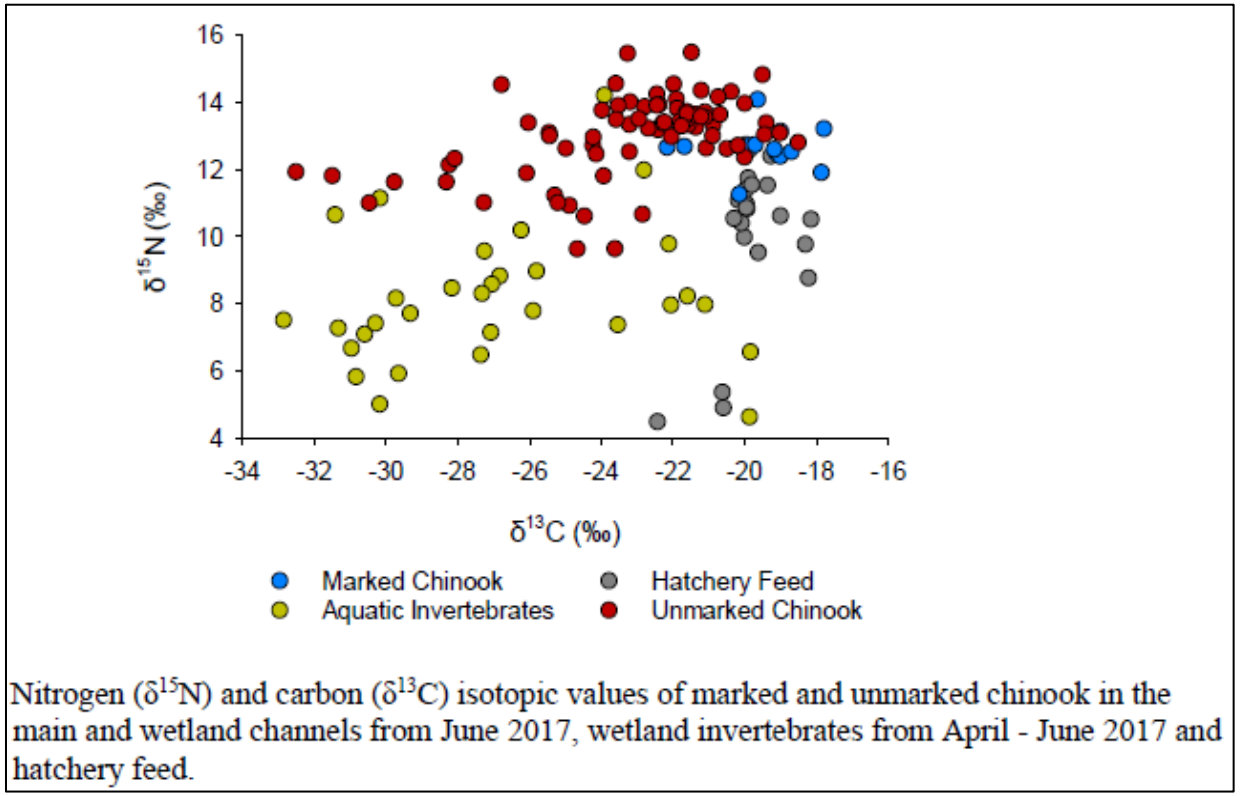
REVIEW DRAFT

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

July 2024

Linking Estuary Habitat to SALMON life history variation and adult survival



Nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) isotopic values of marked and unmarked chinook in the main and wetland channels from June 2017, wetland invertebrates from April - June 2017 and hatchery feed.

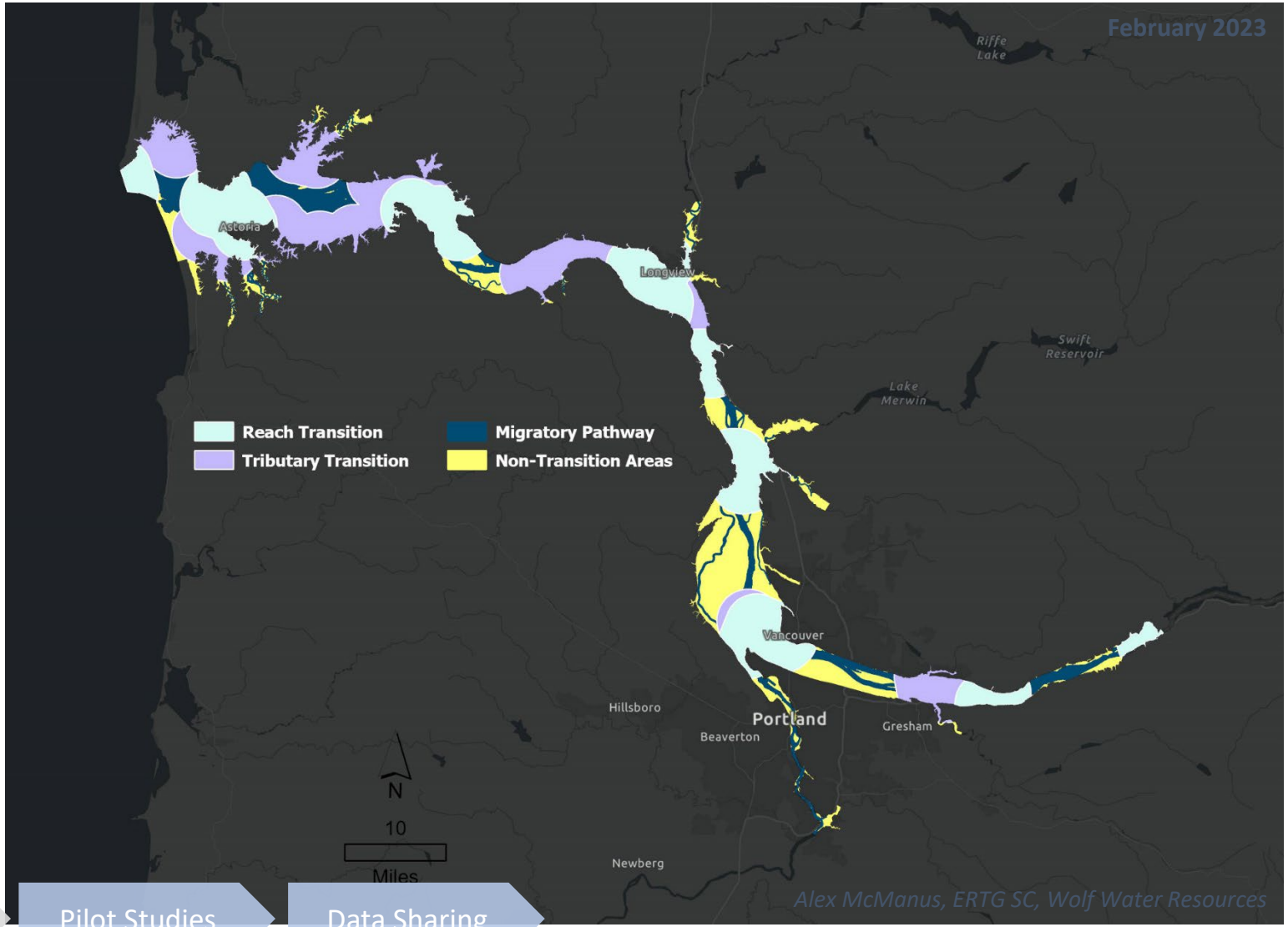
- Objective: use chemical signatures (isotopic markers) in adult otoliths to determine whether prey during juvenile rearing/migration originated in wetlands versus mainstem
- Begin with a workshop series to overview methods, limitations, and suitability for this purpose
- Identify potential chemical indicators and select target populations (e.g., by watershed or ESU) for a future pilot study
- Sampling program across multiple juvenile cohorts, ESUs, and years to identify markers and assess the significance of estuarine rearing habitat to adult returns

Sather er al. 2020. *Differential habitat use by subyearling chinook salmon in the lower Columbia River and estuary*. Chapter 7 in Restoration Action Effectiveness Monitoring and Research in the Lower Columbia River and Estuary, 2016-2017.

Barnett-Johnson et al. 2010, *Genetic and otolith isotopic markers identify salmon populations in the Columbia River at broad and fine geographic scales*, https://doi.org/10.1007/s10641-010-9662-5

Relative Importance of Transitional Habitats for Salmonid Rearing

- Test the hypothesis that salmon habitat use and performance increase near reach transition boundaries and tributary junctions compared to other locations.

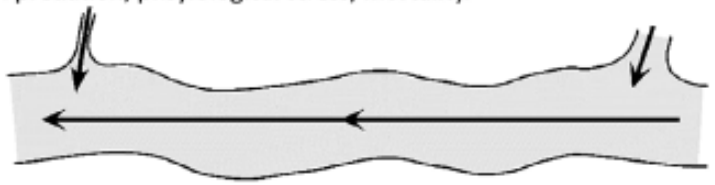


Hood et al. 2021. *Using landscape ecology principles to prioritize habitat restoration projects across the Columbia River Estuary*. Restoration Ecology 30(3): e13519. https://doi.org/10.1111/rec.13519

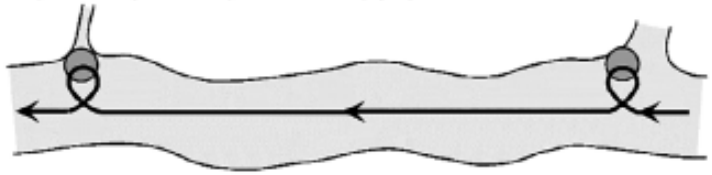
Patch size and travel distance Effects on salmon use, access, and performance

- Test the underlying assumption that more patches and shorter distances between available habitat will ultimately improve juvenile salmon use/survival as they migrate through the estuary.

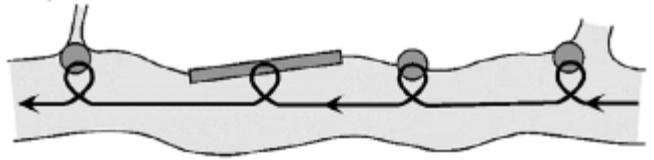
1. Initial condition--no habitat: short residence; low feeding opportunity; high predation, phsyiological stress, mortality.



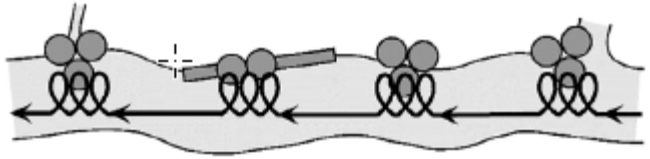
2. Initial priority--restoration at tributary junctions: some habitat; some residence, feeding, refuge; use by multiple stocks; high fish density due to proximity to tributary population sources.



3. Stepping stone corridor: some residence, feeding, refuge in each stepping stone; long residence in system of stepping stones; reduced travel time and mortality risk between stepping stone refuges. Riparian shoreline matrix habitat restoration with comparable overall residence time to a patch can substitute for wetland floodplain stepping-stone habitat patch restoration.



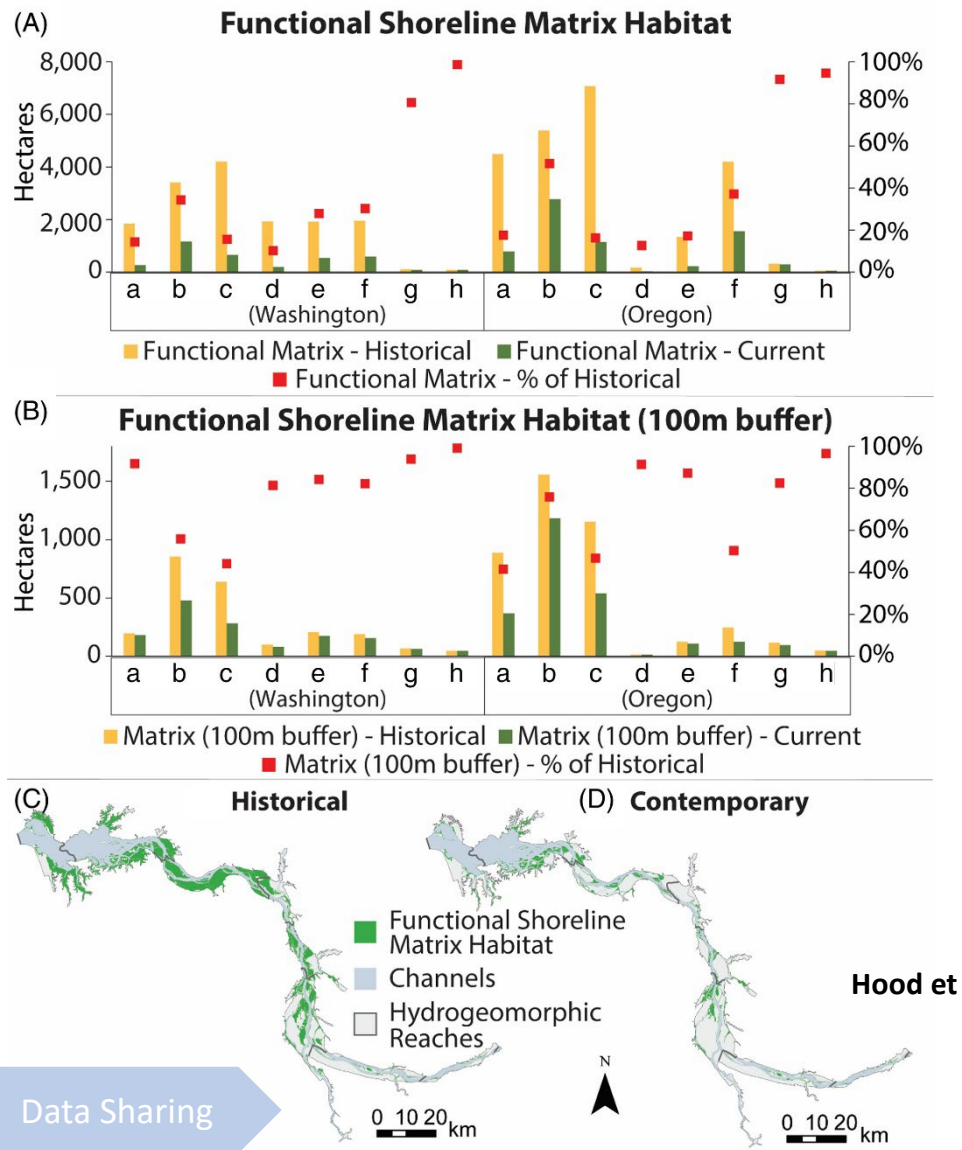
4. Mature system restoration--large, well-connected habitat patches: long residence in large habitat patches, long residence in stepping stone corridor; low stress and mortality within and between large, well-connected habitat patches.



Conceptual model of stepping-stone habitat adapted from Hood et al. 2021.

Functions and Restoration Potential of shoreline matrix habitats for juvenile salmon

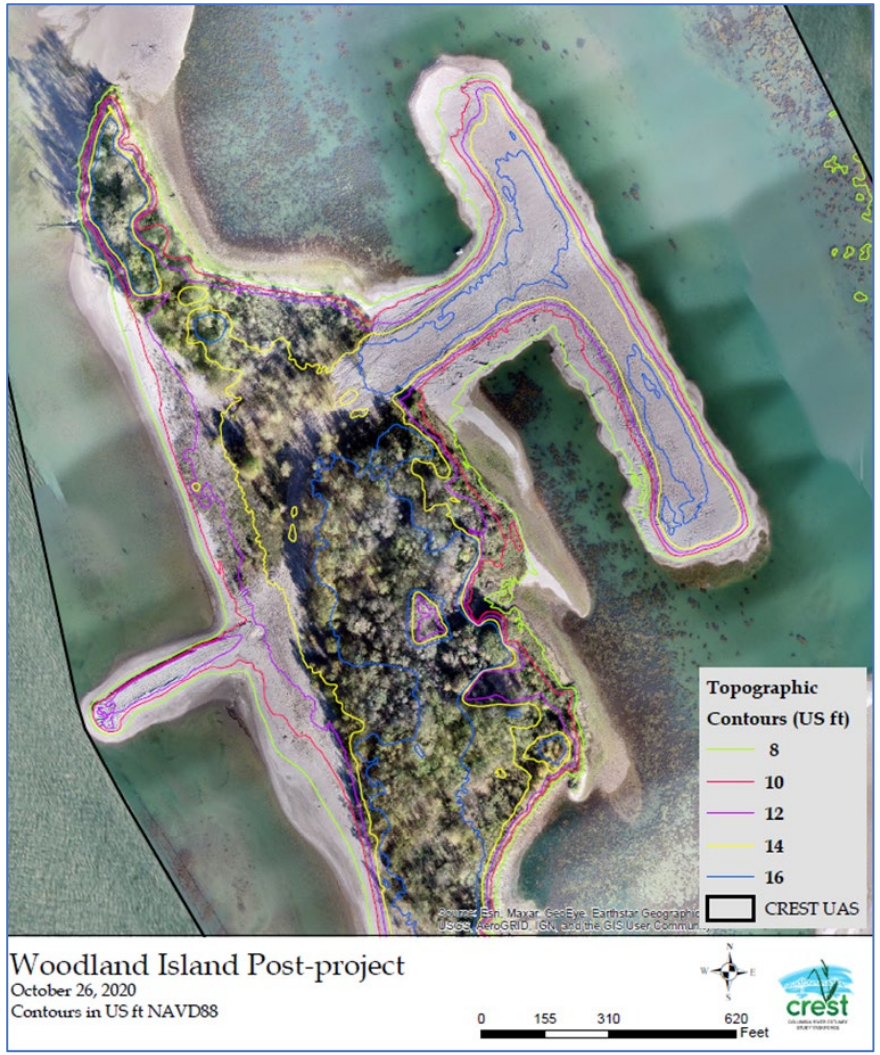
- Perform a global literature review of matrix (i.e., narrow fringing wetlands and riparian forests, armored or riprapped banks) restoration projects in estuaries
- Restore select matrix sites in the estuary, and design protocols to monitor use by juvenile salmon
- Investigate whether matrix habitat may have a role in providing thermal refugia for out-migrating salmon.



Hood et al. 2021

Pilot Restoration Projects: Woodland Islands BUDM Site

- Benthic monitoring (PNNL)
  - Sediments
  - Macroinvertebrates
  - Hydrographic data (CTD), surface/floor
- Avian monitoring
  - Aerial surveys conducted by Corps' Fish Field Unit
- Topography and bathymetry
  - Fall 2021-2026
- Vegetation
  - CREST planting, winter 2021-22 and winter 2022-23
  - Multispectral analysis 2024-2026
- Fish
  - USGS sampling in spring 2022, 2023, and 2025
  - Environmental parameters, juveniles, predators, prey, genetics



“Adapting the Program”

What are we restoring to? What does success look like?

Better leverage the expertise of CEERP practitioners and support strategic collaborations

Increase emphasis on climate-smart restoration projects

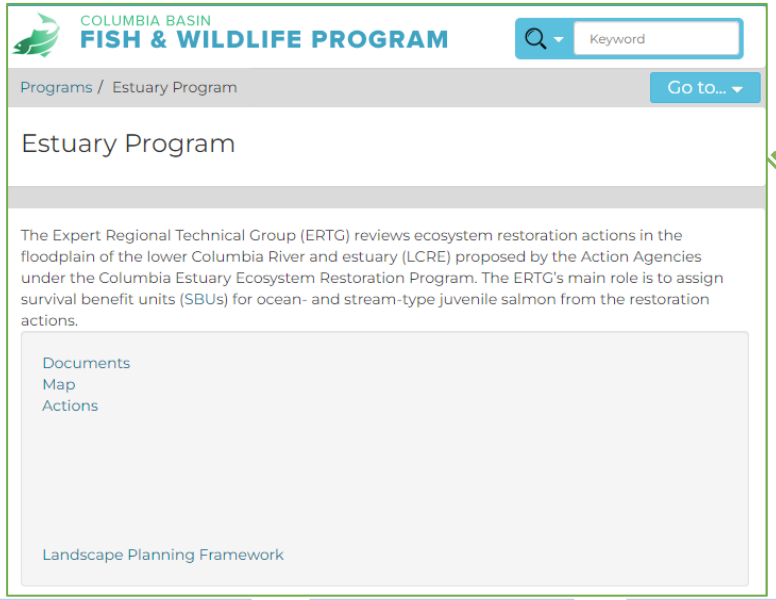
Improve the system for tracking the flow (and retention) of institutional knowledge

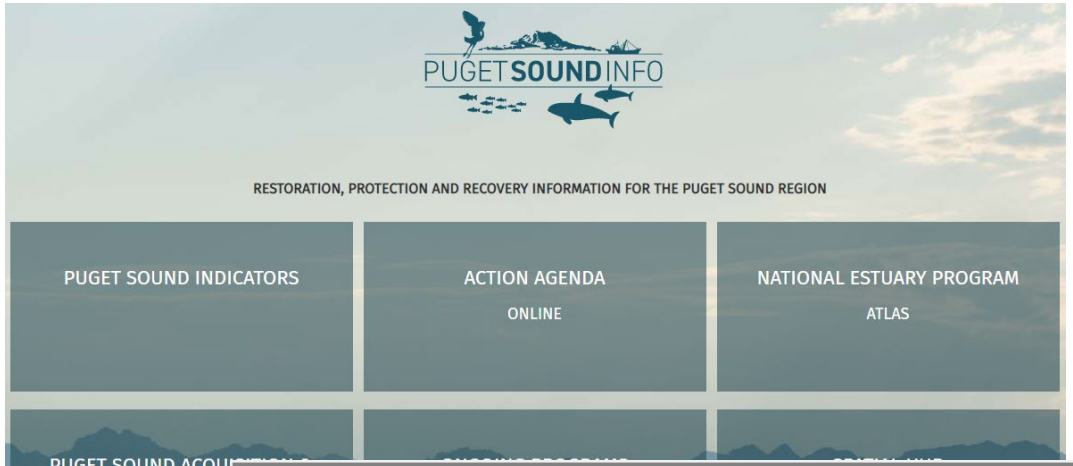
Enhance opportunities for pilot studies that may address emerging uncertainties

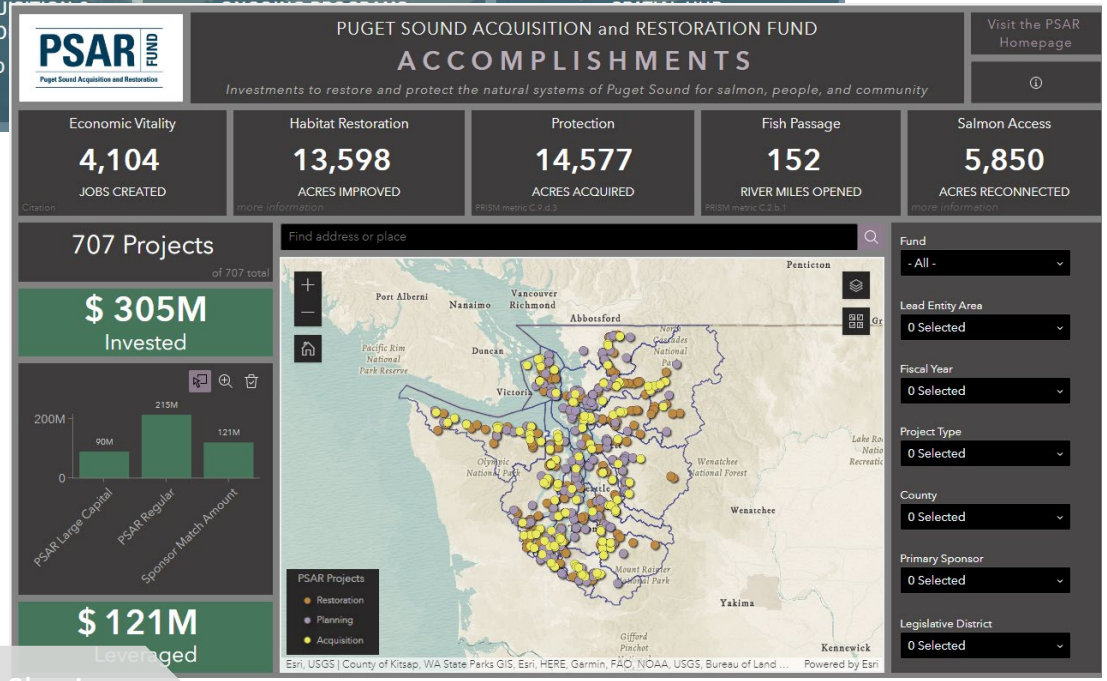
Steigerwald floodplain reconnection, Photo credit: CCFP

CEERP Data Sharing and Transparency

- Initiating the development of an informational website designed to outline CEERP's adaptive management framework, conceptual foundation, progress towards meeting restoration goals, new learning, monitoring results, and project details provided by Sponsors
- Improves upon the current cbfish website that serves more as a library for maintaining CEERP sponsored papers, and other work products.
- Looking to other estuary programs (Puget Sound) as an example for how to structure information to increase transparency and accessibility.







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