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Estuary ecosystem restoration: implementing and institutionalizing adaptive management

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We implemented and institutionalized an adaptive management (AM) process for the Columbia Estuary Ecosystem Restoration Program, which is a large-scale restoration program focused on improving ecosystem conditions in the 234-km lower Columbia River and estuary. For our purpose, "institutionalized" means the AM process and restoration programs are embedded in the work flow of the implementing agencies and affected parties. While plans outlining frameworks, processes, or approaches to AM of ecosystem restoration programs are commonplace, their establishment for the long-term is not. This article presents the basic AM process and explains how AM was implemented and institutionalized. Starting with a common goal, we pursued a well-understood governance and decision-making structure, routine coordination and communication activities, data and information sharing, commitment from partners and upper agency management to the AM process, and meaningful cooperation among program managers and partners. The overall approach and steps to implement and institutionalize AM for ecosystem restoration explained here are applicable to situations in which it has been incomplete or, as in our case, the restoration program is just getting started.

Key words: collaboration, habitat restoration, learning, monitoring

Implications for Practice

- A common goal, open dialog, and long-term commitment among stakeholders and restoration managers are key to institutionalizing an adaptive management (AM) process for ecosystem restoration that is effective and long-lasting.
- Institutionalizing AM can overcome struggles and limitations arising from differing missions and authorities of multiple collaborating agencies charged with ecosystem restoration.

Introduction

Effective and long-lasting adaptive management (AM) of large-scale ecosystem restoration programs addressing uncertainty and resulting in improved program outcomes requires more than a well-thought-out process—it requires institutionalization of the process. By this we mean that the AM process and restoration program are embedded in the work flow of the implementing agencies and affected parties. AM frameworks for ecosystem restoration programs are common, but their implementation has not always achieved the stated goals (Allen & Gunderson 2011; Westgate et al. 2013). Where AM has been most effective (see e.g. Zedler 2017), there are (1) well-understood program goals and objectives; (2) an established governance structure; (3) dedicated, formalized processes linking restoration, monitoring, and learning activities; (4) buy-in from agency management; (5) clear communication among affected parties, and other features (Schreiber et al. 2004; Thom et al. 2016). The purpose of this article is to describe *how* restoration program managers implemented and institutionalized AM for the Columbia Estuary Ecosystem Restoration Program (CEERP) (Fig. 1).

As CEERP's co-managers, the Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers (USACE) conceived, developed, and conducted the CEERP in response to multiple motivating factors. Various Water Resource and Development Acts, such as 1996 Section 206 (Aquatic Ecosystem Restoration) and 2000 Section 536 (Lower Columbia River Ecosystem Restoration), authorize USACE to perform ecosystem restoration in the estuary. To help meet requirements of the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (16 U.S.C. §839–839h) and the Endangered Species Act of 1973 (16 U.S.C. §§1,531–1,544), CEERP

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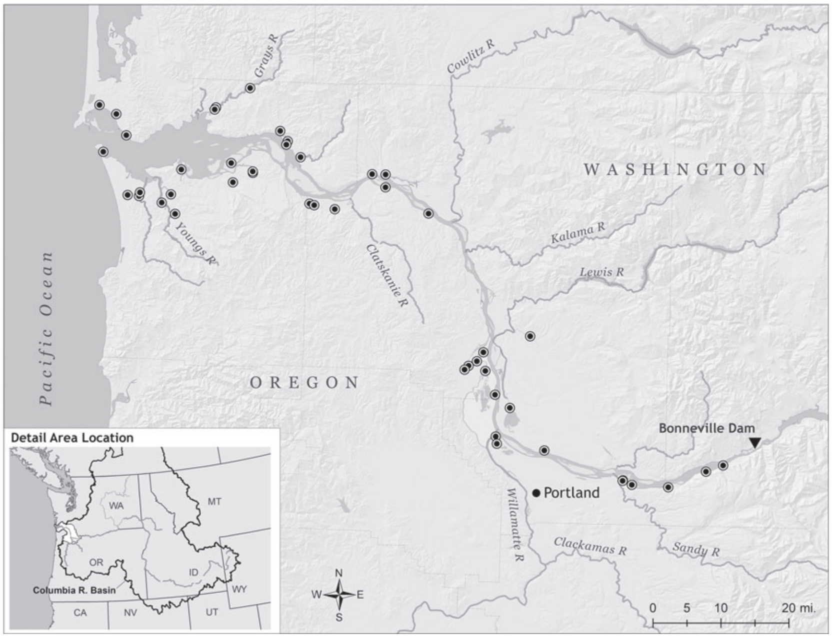

Figure 1. Map of the Columbia River estuary. The head-of-tide is at Bonneville Dam. The black dots designate locations of CEERP restoration projects.

provides mitigation for effects from operation of the Federal Columbia River Power System. In particular, the listings of 13 populations of salmon and steelhead under the Endangered Species Act have resulted in Biological Opinions (BiOps) calling for BPA and USACE to conduct ecosystem restoration in the estuary (e.g. National Marine Fisheries Service 2008).

The overall goal of CEERP is to understand, conserve, and restore ecosystems in the estuary, which includes tidally influenced areas of the main stem river and floodplain from Bonneville Dam to the Pacific Ocean (Fig. 1). To fulfill the ecological objectives supporting this goal (Table 1), CEERP employs an ecosystem-based approach to restoration (Johnson et al. 2003). The term restoration is used here in the broad sense to include creation, enhancement, protection, and conservation (National Research Council 1992; Shreffler & Thom 1993). During the period from 1870 to 2010, agricultural and industrial land development by building dikes and levees resulted in losses of 70% of tidal vegetated wetlands and 55% of forested uplands (Marcoe and Pilson 2017). As a result, the primary CEERP restoration strategy is to reconnect water flows to previously connected wetland habitats to the main stem estuary, such as by breaching dikes and levees (BPA & USACE 2012). For juvenile salmonids specifically, restoration is intended to increase access to wetlands for feeding and refuge (Roegner et al. 2010) and increase export of prey (primarily insects) from the restoring wetlands to the main stem river where the prey are consumed by out-migrating salmonids (Diefenderfer et al. 2016*a*).

The need for an AM process for CEERP was evident early in the program's development (Thom et al. 2008). In 2008, the National Marine Fisheries Service (2008) included performance goals for estuary restoration called "survival benefit units (SBU)." (A SBU is an index intended to represent the effect of CEERP restoration on juvenile salmonid survival; the units are assigned on a restoration project-specific basis [Krueger et al. 2017].) While the goal and objectives of CEERP are intentionally ecosystem based and not species specific, its performance goals are legally binding. Uncertainty in the goals themselves and how to achieve them necessitated the rigor and structure an AM process can provide to a restoration program. For example, how to quantify SBUs in a standard, repeatable fashion was an uncertainty until an expert panel was established and developed an appropriate method (see Krueger et al. 2017). In addition, programmatic policies based on AM can help managers spend restoration funds wisely in a study area that is large and dynamic (Fig. 1), and where multiple stakeholders (Table 2) have an interest and say in the outcome. Moreover, because staff turnover occurs at all levels and agencies, having an institutionalized AM process can help smooth transitions and keep the program on track. CEERP management agencies also have broad mandates to practice AM. For BPA, AM measures are included in the Northwest Power and Conservation Council's Fish and Wildlife Program (Northwest Power and Conservation Council 2014). For USACE, AM is recommended by the Environmental Advisory Board (EAB 2005, 2006*a*, 2006*b*) and Department of the Army (1995). In sum, managers recognized that a formal, institutionalized AM process was needed for CEERP to meet the ecosystem restoration goals and objectives, as well as the goals for SBUs.

Here, we present the basic AM process and explain how AM was implemented and institutionalized for the long-term to maximize the functional performance of CEERP and its restoration projects. The overall approach and actions are applicable to situations in which AM of ecosystem restoration programs has not been effective or long-lasting or, as in our situation, the restoration program is in its infancy.

Table 1. CEERP's objectives. Note, specific quantitative metrics or targets have not been developed for the objectives. The performance goals for survival benefit units relate qualitatively to the CEERP objectives.

Objectives
Understand what effect primary stressors[1] have on ecosystem controlling factors[2], e.g. flow regulation, passage barriers.
Conserve and restore factors that control ecosystem structures[3]/processes[4], e.g. hydrodynamics, water quality.
Increase quantity and quality of ecosystem structures, e.g. estuarine habitat for juvenile salmonids.
Maintain and enhance estuary food webs to benefit salmonid performance[5].
Improve salmonid performance in terms of life-history diversity, fish condition, growth, and survival.

Glossary

[1] Stressors are external or anthropogenic entities or processes that affect ecosystem controlling factors.
[2] Controlling factors are the basic physical and chemical conditions that construct and influence the structure of the ecosystem.
[3] Ecosystem structures are the types, distributions, abundances, and physical attributes of the plant and animal species composing the ecosystem.
[4] Ecosystem processes are interactions among physicochemical and biological elements of an ecosystem that involve changes in state.
[5] Performance is an indicator of the state of anadromous salmonid populations and their habitats. Performance can be defined by growth, foraging success, spatial structure, life-history diversity, and habitat conditions.

Table 2. CEERP's stakeholders and governance structure: CLT, Columbia Land Trust; CREST, Columbia River Estuary Study Taskforce; CRITFC, Columbia River Inter-Tribal Fish Commission; CT, Cowlitz Tribe; ERTG, Expert Regional Technical Group; LCEP, Lower Columbia Estuary Partnership; NMFS, National Marine Fisheries Service; NPCC, Northwest Power and Conservation Council; ODFW, Oregon Department of Fish and Wildlife; OHSU, Oregon Health Sciences University; OSU, Oregon State University; USFWS, U.S. Fish and Wildlife Service; USGS, U.S. Geological Survey; UW, University of Washington; WDFW, Washington Department of Fish and Wildlife.

Category	*Role*	*Responsible Parties*
Managers	Make final decisions about program implementation	BPA, USACE
Funders	Fund restoration and monitoring activities	BPA, USACE
Restoration sponsors	Work with landowners and identify, develop, design, and construct restoration projects	CLT, CREST, CT, LCEP, WDFW
Monitoring practitioners	Perform standard monitoring at restoration sites	CLT, CREST, CT, LCEP, WDFW
Research entities	Conduct scientific research	NMFS, OHSU, OSU, PNNL, USFWS, USGS, UW
Advisory groups	Provide programmatic reviews and guidance	ISAB, NMFS, ERTG Steering Committee
Associated groups	Stay abreast of CEERP activities	CRITFC, NPCC, ODFW

Methods

CEERP's AM process is based on four programmatic principles (Thom et al. 2008). First, AM is *implementable* in that the program is cost-effective, feasible, and reasonable to implement. Second, AM is *nonredundant* in that the program uses existing organizational processes. Third, AM is *collaborative* in that the program captures and complements learning from other projects and works cooperatively to accomplish restoration in the estuary by various agencies and entities. And, fourth, AM is *science based* in that the program adheres to scientific principles of data acquisition, analysis, and interpretation; appropriate questions drive research, monitoring, and evaluation (RME); and hypotheses are developed to help frame RME.

Scientific Basis and Uncertainty

Development of the scientific basis for CEERP started with a conceptual ecosystem model for the estuary study area (conceived by Thom et al. 2004, and adapted by Diefenderfer et al. 2016*a*). This model helped organize communications, prioritize ecological stressors, identify uncertainties and data gaps, and inform the restoration strategy. Specifically, the conceptual model showed the relationship between an important ecosystem stressor (dikes and levees as barriers to connectivity between wetlands and the main stem estuary) and ecosystem structures (e.g. emergent marsh), processes (e.g. production of prey [insects]), and functions (e.g. growth of juvenile salmon). In turn, we developed an ecosystem-based, strategic approach to restoration (Johnson et al. 2003).

Assessments of the state of the science for juvenile salmonid ecology in the estuary (Bottom et al. 2005; Fresh et al. 2005) revealed strengths and weaknesses in the knowledge base that guided subsequent program development and RME. Weaknesses, which represent uncertainties, at the time included lack of information about stock-specific use of wetland habitats and juvenile salmon ecology in tidal freshwater habitats. Moreover, the Expert Regional Technical Group (ERTG) identified uncertainties from the point of view of scoring proposed restoration projects (ERTG 2012) and Thom et al. (2013) identified gaps (uncertainties) in the knowledge base. Over the past decade, we have applied AM to reduce uncertainty and improve program outcomes.

Scientific investigations during the monitoring phase of the AM process are an ongoing cornerstone to address uncertainty. For CEERP, this research has focused on uncertainties related to juvenile salmonid migration patterns (Harnish et al. 2012; Roegner et al. 2012), residence times (Johnson et al. 2015; McNatt et al. 2016), ecology (Bottom et al. 2011; Sather et al. 2016), responses to restoration (Roegner et al. 2010), genetic stock composition (Teel et al. 2014), food webs (Maier & Simenstad 2009), geomorphology (Diefenderfer & Montgomery 2008; Diefenderfer et al. 2008), and hydrodynamics (Jay et al. 2014, 2016), among other subjects. Currently, uncertainties in the CEERP include the following questions: What is the ecological role of large woody debris in tidal wetlands in the estuary? What is the best way to control reed canarygrass (*Phalaris arundinacea*)? Reducing uncertainty, and thereby strengthening CEERP's scientific basis, is a critical part of the CEERP AM process.

Components

USACE initiated formal development of the CEERP AM process in 2007 (Fig. 2). Based on experience implementing AM, the process was refined in 2012 (Johnson et al. 2012; Thom et al. 2012) and again in 2014 (BPA & USACE 2014). While details of the AM process necessarily evolved, key components of the basic "see-spot-run" AM cycle were consistent: restoration, monitoring, and learning (Fig. 3).

The restoration component covers decision-making for restoration and monitoring. CEERP managers make decisions about which restoration projects to advance in the restoration design and construction phase, in context of the basic restoration strategy to reconnect tidal wetlands to the main stem estuary and in consultation with restoration sponsors and other stakeholders. These decisions are informed by results from a prioritization exercise (Thom et al. 2010) that is based on disturbance theory applied at site and landscape scales (Shreffler & Thom 1993) and project rating criteria involving predicted changes in ecosystem function, likelihood of achieving project goals, size of project, and cost (Evans et al. 2006). Management decisions are also informed by project reviews conducted by the ERTG for estuary ecosystem restoration (Krueger et al. 2017) and the Lower Columbia Estuary Partnership's Project Review Committee. Decisions about restoration projects are documented in the annual CEERP Restoration and Monitoring Plan, a key document in the AM process (e.g. BPA and USACE 2016) (Table 3).

For CEERP, the monitoring component includes routine monitoring (systematic collection and reduction of data) and focused research (investigations to test hypotheses and address uncertainties), as well as modeling and analysis. Management of monitoring is guided by programmatic plans for overall estuary RME (Johnson et al. 2008) and for monitoring the effectiveness of restoration actions (BPA and USACE 2017). An estuary-wide habitat classification system based on geomorphology (Simenstad et al. 2011) provided a landscape perspective for restoration and monitoring. Roegner et al. (2009) established protocols for key monitored indicators. Basic monitoring for water surface elevation, water temperature, sediment accretion, and photo points is conducted at almost all project sites for 1–5 years after construction. More intensive monitoring and research concerning vegetation, macroinvertebrates, and fish also are conducted. CEERP managers and interested regional parties developed a method to plan and prioritize action effectiveness monitoring (Johnson et al. 2015). CEERP addresses ecological uncertainties through focused research projects, such as investigations of salmon prey production in habitats dominated by the invasive reed canarygrass (Hanson et al. 2016). To improve restoration project effectiveness, managers allocate other resources to address uncertainties concerning restoration design (Diefenderfer et al. 2016*b*). Monitoring and research activities are reviewed and documented each year in the CEERP Restoration and Monitoring Plan (e.g. BPA & USACE 2016).

In our AM process, results from monitoring feed the learning component through synthesis and evaluation of monitoring data. In turn, results from synthesis and evaluation inform program strategy and decision-making concerning habitat improvement objectives, prioritization, and methods. As such, instituting learning through synthesis and evaluation brings the AM process full circle. The annual Restoration and Monitoring Plans have a "Master Matrix of New Learning and Adjustments to Strategies." Each year, CEERP managers review technical reports and journal articles; attend seminars, workshops, and conferences; and generally gather information relevant to CEERP restoration. New or reaffirmed learning is identified, and implications to restoration implementation and RME are formulated and adjustments are made as needed. For instance, large woody debris was commonly used in channel restoration projects, but the expert panel concluded there is uncertainty about the ecological function of large wood in estuarine environments (ERTG 2016). In response, CEERP managers and restoration practitioners adjusted restoration practice to describe the value of including large wood, which can be a costly component of a restoration project. The annual efforts to capture learning are periodically synthesized in an AM deliverable called the "Synthesis Memorandum" (Table 3). This document includes summaries and analyses covering multiple years of data. Thom et al. (2013) synthesized relevant CEERP monitoring data available through 2012; a new Synthesis Memorandum is scheduled for 2018 (Fig. 2). For restoration program evaluation, CEERP managers supported development (Diefenderfer et al. 2011) and application (Diefenderfer et al. 2016*a*) of an evidence-based approach to the cumulative effects of CEERP restoration actions. Learning also is acquired and adjustments are made in response to formal scientific peer review of the restoration program, and implicitly its AM process, by the Northwest Power and Conservation Council (Independent Scientific Advisory Board 2012, 2014). Contributions from the ERTG are also a source of learning (e.g. ERTG 2011). Adjustments identified through the monitoring and learning components in the AM process continually strengthen CEERP's scientific basis and strategy.

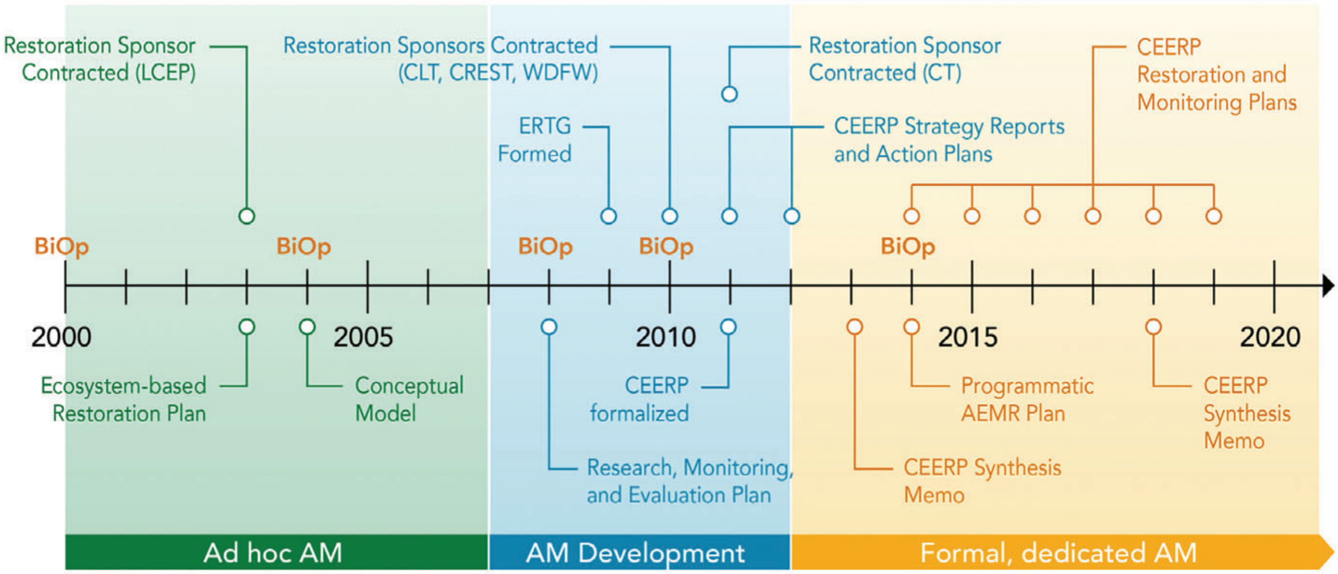

Figure 2. CEERP timeline.

Figure 3. CEERP's AM process.

Results

As a result of the AM process, CEERP managers identified adjustments to restoration strategy and activities based on new learning. Several examples follow. First, in response to input from the ERTG, CEERP managers now emphasize large-size, full hydrologic reconnection projects at sites near the main stem river across the 234-km estuary, as opposed to small-size projects away from the main stem (BPA and USACE 2012). These adjustments to restoration strategy are borne out in the trend over the 2007–2016 period of increasing size per project (Fig. 4) and decreasing distance from the main stem estuary (Fig. 5).

Second, as a result of ERTG developing an approach to assigning SBUs to floodplain lake restoration actions that was necessarily conservative because of uncertainty about juvenile salmonid accessibility and densities in floodplain lakes (ERTG 2013), CEERP managers originally deprioritized floodplain lakes as prospective restoration actions. However, after reassessment internally and with further input from the ERTG, USACE decided to move forward with a floodplain lake project with the intent to learn and inform possible future projects of this type.

Third, based on preliminary cost-benefit evaluations during 2014 that indicated habitat creation using dredge material may not be cost-effective for CEERP, USACE proceeded cautiously with this concept. Upon reexamination, however, USACE decided to develop a pilot project in 2017 to assess the technical and economic feasibility of this restoration approach.

Fourth, as an outcome of uncertainties research on the ecological role of reed canarygrass (Hanson et al. 2016), CEERP managers confirmed that it is necessary to support reed canarygrass removal and control as part of restoration projects.

Fifth, lessons learned over the last decade of the CEERP indicate that hydrologic reconnection of lost floodplain habitats and the associated restoration of habitat forming and functional processes improve ecosystem functions and associated juvenile salmonid fitness (e.g. Diefenderfer et al. 2016*a*). CEERP managers see this as an affirmation of hydrologic reconnection as the main strategy for restoring ecosystem function in the Columbia River estuary.

CEERP managers have also identified adjustments to the AM process itself. A simplified AM process diagram (Fig. 3) makes it easier to communicate to high-level managers and policymakers. A comprehensive synthesis and evaluation only needs to occur every 4 to 5 years, because, in our situation, this is the amount of time it takes to acquire enough new data and information to warrant the effort. The initial Strategy Report and Action Plan (2012 and 2013) have been combined since 2014 into a single deliverable, the annual Restoration and Monitoring Plan (Table 3).

Restoration implementation under CEERP over the last 10 years has ramped up (Fig. 6) as the AM process matured. Fifty projects restoring over 3,700 total acres (15.0 km^2) have been implemented since the beginning of 2007. In addition, CEERP has acquired over 2,500 acres of floodplain habitat (10.1 km^2). The CEERP AM process described herein has been fundamental to these achievements, because it provided a stable governance structure, a means of applying learning

Table 3. CEERP AM deliverables.

Deliverable	*Responsible Parties*	*Periodicity*	*Years Produced*	*Comment*
Strategy Report	BPA and USACE	Annual	2012, 2013	—
Provides strategic recommendations, course adjustments, and guidance on restoration project development and RME priorities based on results of synthesis and evaluation of RME data.				
Action Plan	BPA and USACE	Annual	2012, 2013	—
Provides the plan for specific restoration projects and RME activities for a given year; that is answers who, what, when, where, and why.				
Synthesis Memo	Research agencies	Every approximately 5 years	2013, planned for 2018	Covered data and information through 2012
Provides synthesis and evaluation of CEERP progress and key findings from RME studies, meta-analyses, retrospective analyses, and evidence-based evaluations.				
Restoration and Monitoring Plan	BPA and USACE	Annual	2014, 2015, 2016, planned for 2017, 2018, and so on	Merged the original CEERP Strategy Report and Action Plan deliverables
Provides a succinct description of new learning, adjustments to strategy based on new learning, and resulting program actions to restore ecosystems in the estuary which managers and stakeholders can use to communicate and coordinate CEERP activities. Replaces the annual Strategy Report and Action Plans.				
Site Evaluation Card	Monitoring practitioners	Various	Planned for 2017, 2018, and so on	—
Provides concise, standard reporting of RME results for individual restoration projects.				

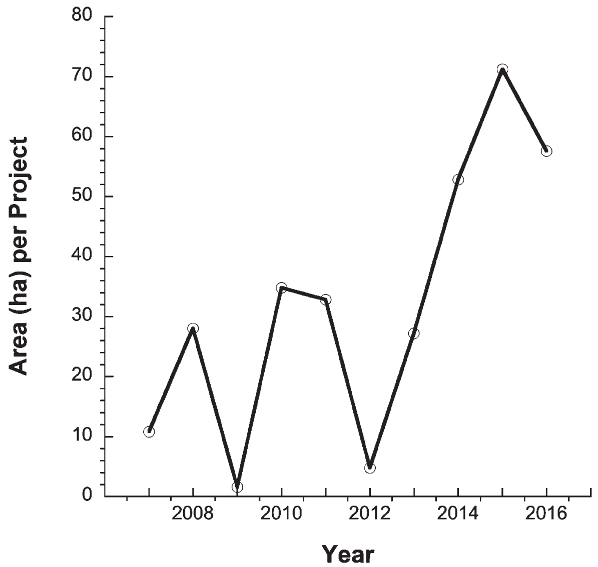

Figure 4. Annual mean project size (km^2) for 2007–2016.

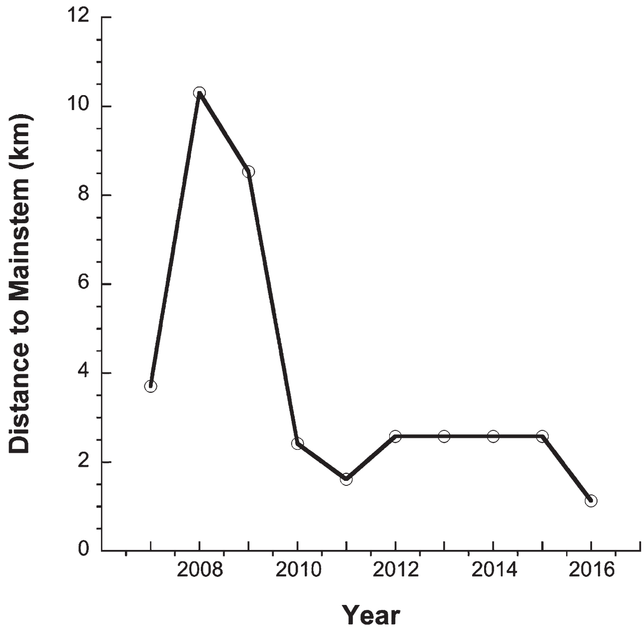

Figure 5. Annual mean distance (km) of projects to the main stem estuary for 2007–2016.

from monitoring and peer review to adjust restoration program strategy, and a coordinated approach to decision-making.

Discussion

For an AM process to be effective and long lasting, a restoration program must have strong scientific underpinnings, be relevant to cooperating agencies, and be feasible to implement (Murray & Marmorek 2003; Schreiber et al. 2004)). This article shows how CEERP AM meets these features through the institutionalization of a process that maximizes the functional performance of CEERP restoration projects. Above, we explained the basic AM process (restoration, monitoring, and learning) as implemented for CEERP. We now discuss how the program was institutionalized for the long term in the Columbia River estuary. As defined above, institutionalization

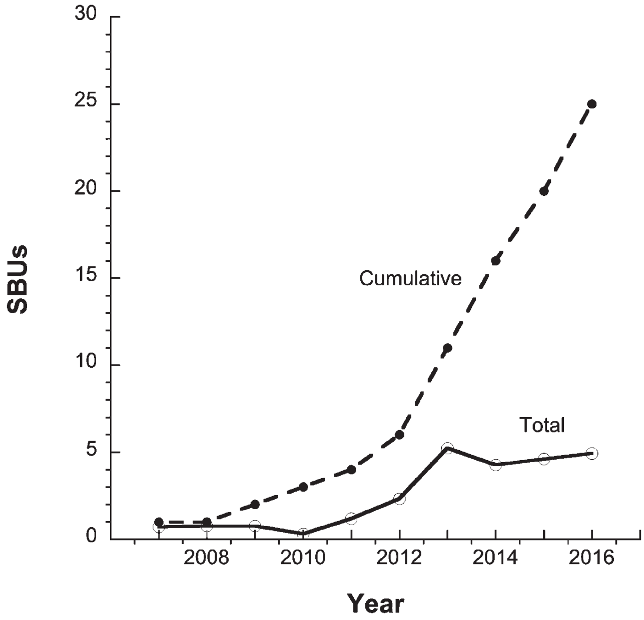

Figure 6. Total annual and cumulative survival benefit units (SBUs) for 2007–2016. SBUs for stream- and ocean-type life histories were summed.

means “ … the AM process and restoration program are embedded in the work flow of the implementing agencies and affected parties.”

Actions to foster institutionalization included establishing and consistently implementing a governance and decision-making structure; undertaking routine coordination and communication activities; sharing data and information; working to earn commitment to the AM process; and cooperating with each other and being persistent. This is consistent with the National Academies of Sciences, Engineering, and Medicine (2016), who noted, “Based on experience of other large restoration programs, AM requires a strong commitment to a dedicated organizational structure that supports AM planning, identifies and prioritizes key uncertainties, learns by analysis and synthesis of monitoring data, and makes adjustments to restoration projects based on new information in a timely fashion.” The points that follow were crucial for implementing and institutionalizing the AM process and the CEERP program.

We have a common goal. The CEERP goal is admirable and the objectives are scientifically sound, but these alone might not have fostered institutionalizing AM because they are not stringent. On the other hand, SBU performance goals for National Marine Fisheries Service (2008) are legally binding and indisputable. The SBUs provide a common, quantitative goal to work toward in the AM process.

We established and consistently implement a governance and decision-making structure. In this structure (Table 2), the funding agencies (BPA and USACE) govern the program and make decisions about which restoration projects and monitoring work to fund. They receive input from restoration sponsors, monitoring practitioners, and researchers who have well-defined roles and responsibilities (Table 2). For a given project, the specific funding agency has final say. Most USACE projects require cost-sharing, which can come from BPA; in these cases, decisions are reached by consensus between USACE and BPA. Regional stakeholders respect this governance and decision-making structure as part of the AM process.

We share data and information. The CEERP website contains documents, maps, and restoration project descriptions (https://www.cbfish.org/EstuaryAction.mvc/Index). Monitoring and research data are shared at *Oncor* (http://oncor.pnnl.gov/drp.html), a geospatial data management and information system that is under development. *Oncor* is intended to catalog monitoring, research, and other data and facilitate data sharing among researchers and monitoring and restoration practitioners. This will enable synthesis and evaluation of data generated by multiple entities that can be applied in CEERP AM. The *Oncor* database and the CEERP website will directly support monitoring studies and restoration project development. Data and information are also shared at the biennial Columbia River Estuary Conference, a forum for exchange of information, new scientific findings, and policy concerns (http://www.estuarypartnership.org/CREC2016). Information about accomplishments, new learning, and upcoming activities also are shared through the annual CEERP Restoration and Monitoring Plans (e.g. BPA & USACE 2016).

We undertake routine formal and informal coordination and communication activities. Coordination among stakeholders is critical to implementing CEERP AM across multiple entities (see Table 2). It takes a dedicated effort to explain the AM process, roles and responsibilities, and benefits to all parties. This work helps foster partnerships critical to implementing AM and CEERP as a whole. For instance, a meeting of the ERTG and regional stakeholders is convened annually at which CEERP accomplishments and plans are described and an open discussion period is provided for practitioners and sponsors to air concerns and ask questions of CEERP managers and the ERTG (ERTG 2016). Monitoring and research are coordinated through an annual meeting early in the calendar year to exchange preliminary results from the previous year and to discuss monitoring and research activities for the upcoming year. Informal, offline communications by phone or at gatherings after work are integral to the AM process.

We work to earn commitment and buy-in to the AM process and the restoration program. The coordination, communication, and sharing of the data and information described above all serve to promote transparency of the AM process. This has resulted in commitment and buy-in from upper management to support staff implementing the AM process and CEERP. Commitment is fostered by having people in the critical role of AM coordination within each agency who understand the science, the agency, the partner agencies, and the AM process. These people have earned credibility within their agencies by communicating and meeting their program goals and objectives. Furthermore, we strive for commitment from our regional partners (Table 2) to respect the importance of the AM process and cooperate in its implementation.

We embrace independent scientific peer review. At the behest of CEERP managers and the Northwest Power and Conservation Council, the Independent Scientific Advisory Board has reviewed the CEERP twice (Independent Scientific Advisory Board 2012, 2014). CEERP managers are responsive to these reviews. For example, a review recommendation to publish the ERTG scoring process, itself an independent scientific peer review at the project level, was fulfilled by Krueger et al. (2017).

We resolve conflicts and cooperate with each other. Cooperation between the two managing agencies is absolutely critical for effective CEERP AM. The BPA/USACE CEERP Coordination Team meets biweekly to discuss restoration project development and prioritization, implications of new monitoring and research findings, communications with upper management, and other topics. These meetings can occur offsite at a "second office." This communication, cooperation, and collaboration between the two funding agencies and among CEERP stakeholders is critical because it helps resolve conflicts between the co-managing agencies by minimizing angst, facilitating the AM process, and keeping the program focused on the CEERP and SBU goals.

We are dedicated to implementing the AM process. Plans are only as valuable as their implementation. We coordinate and communicate regularly, and we update and refresh CEERP AM deliverables as necessary (Table 3). While a certain structure and process are needed to keep the program on track, it is also important to be flexible; we adjust the level of effort for the deliverables at any given time depending on what is needed.

CEERP AM was institutionalized differently by the BPA and the USACE. The CEERP AM process was initially developed by the USACE as part of a research project in the Anadromous Fish Evaluation Program (Thom et al. 2008). BPA took the CEERP AM mantle in response to a request from the Northwest Power and Conservation Council for programmatic improvements (see Independent Scientific Advisory Board 2012). BPA had the relative flexibility to institutionalize CEERP AM because its management requirements for implementing ecosystem restoration and monitoring are less rigid than the USACE's. Only Congress could create the CEERP as a formal program within the USACE. The USACE, as mentioned above, funds restoration-related work under the Water Resources and Development Act of 2000, Section 536 (Ecosystem Restoration in the Lower Columbia River Estuary), among other authorities. Most importantly, the USACE Portland District designated a program manager and a technical lead for CEERP. As a federal action agency under the Biological Opinion on Federal Columbia River Power System operations, the USACE became a formal cooperator in CEERP. The USACE and BPA both support CEERP's AM principles and apply lessons learned from ongoing and long-standing research—work by the numerous partners and practitioners in the estuary. Despite basic differences in management structure and mission, BPA and the USACE are able to work well together on CEERP because the staff involved respect one another as they work toward common goals.

CEERP and its AM process are a part of a regional fabric for restoration in the Columbia River estuary. The program continues to function well in pursuing its goals of restoring wetland ecosystems, monitoring, and learning from the results. That the governance process is sound is evidenced by its persistence after the two founding agency managers moved on to new phases of their careers. Once the AM process was developed, it was essential to work to institutionalize it to make CEERP a biologically-effective, cost-efficient, transparent, and long-lasting ecosystem restoration program. How this was done for CEERP could serve as an example for other large-scale, long-term ecosystem management efforts.

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