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Best Practices for Southern California Coastal Wetland Restoration and Management in the Face of Climate Change

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DISCLAIMER

While the authors appreciate the support and advice from the aforementioned individuals, the primary authors are solely responsible for the content. This document does not necessarily reflect the official position of the agencies and project partners. Any errors should be attributed to the primary authors.

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1. EXECUTIVE SUMMARY

1.1 Introduction

Southern California coastal wetlands have been heavily altered and degraded, and face growing threats from climate change. Over the last 40 years, significant efforts have been undertaken to preserve our few remaining coastal wetlands and restore the natural habitats, diversity, and ecological functioning. However, the manner in which these wetlands should be restored has proved to be one of the most contentious topics in restoration ecology. The complex nature of restoration has resulted in many social, legal, and scientific hurdles. Past restoration issues have not been fully resolved, and now, climate change adds a new layer of complexity to managing and restoring coastal wetlands into the future. Although there is no single recipe for a successful wetland restoration, this document aims to aid managers and decision-makers in protecting and sustainably managing wetlands in a changing world.

The most imminent threat from climate change for wetlands is sea level rise (SLR). Wetlands move inland under natural SLR conditions, but now, with human-induced climate change, SLR is expected to move too fast for many wetlands to keep pace. Additionally, southern California's wetlands are often limited by human infrastructure and dense populations of over 20 million people—which further complicates their future. As wetlands are being squeezed from both landward and seaward margins, we face the loss of the crucial ecosystem services wetlands provide, including acting as natural biological filters, a nursery habitat for commercially important species, and providing flood protection to coastal infrastructure. Today's decision-makers and planners are forced to consider tradeoffs between the survival of coastal wetlands (including the ecosystem services they provide) and protection of coastal development. Management of southern California wetlands will require frank evaluation of previous restorations to tackle climate change issues in the future.

Past southern California restoration strategies have varied drastically. Southern California projects to date have been managed in a piecemeal fashion, essentially treating each restoration project as a different experiment. The enormous loss of historical wetlands along with the mounting pressures of climate change create a definite need for better coordination of management

Climate change adds a new layer of complexity to managing and restoring coastal wetlands into the future.

efforts across the region that better incorporate lessons learned from past restorations. Therefore, this study was designed with two objectives in mind: 1) offer recommendations for the best management practices (BMPs) throughout the southern California coastal wetland restoration process, and 2) offer recommendations as to how wetlands managers can incorporate climate change into BMPs throughout the restoration process.

1.2 Study Findings

Fifteen wetland professionals (individuals involved with all phases of previous [often multiple] southern California restorations) identified over 300 potential BMPS in a series of initial interviews. The authors refined these through a series of prioritization efforts and literature review, and then those BMPs were discussed at a workshop of wetland restoration experts. The most commonly discussed restoration issues identified through the interview process fell within four primary categories: climate change (17%), process organization (16%), stakeholders (13%), and design (12%). The guidance document focuses heavily on these four categories. The major findings are highlighted here by restoration phase:

1. Planning
2. Construction/Restoration Implementation
3. Post-Restoration Management

1.2.1 Planning

All four of the key restoration issues are part of the planning process. This reflects the increasing “human dimension” entering the planning of wetland restorations (i.e., the need to balance past, present and future societal, political, and economic goals with ecological needs). Strategies for organization and stakeholder engagement are integral in creating a smooth planning process. Defined guidelines for stakeholder interaction introduced at the beginning of the process allow stakeholders to focus their efforts where their input can have the largest impact. The stakeholder structure developed for this study optimizes stakeholder input and support by specifically engaging stakeholders at seven crucial steps in the restoration process:

1. Setting Goals
2. Prioritization of Goals During Project Scoping
3. Design Input
4. Plan Evaluation

5. Public Comment on the Draft Environmental Impact Report (EIR)
6. Restoration Implementation
7. Management and Site Stewardship

Process organization (how agencies and decision-makers organize the process of restoration planning) has varied for every southern California coastal wetland restoration project. A preliminary strategy is essential in understanding the amount of flexibility needed within a project. Goals must be rigid enough to provide a framework for the project but also flexible enough to integrate limitations of the site and the inevitable unknowns the project will encounter. There are many uncertainties in restoration planning, but the organizational structure and process should not be one of them. Clear and consistent process organization can be facilitated by strong regionally focused agencies. Such agencies can act as a coordinating entity while also serving as a memory bank for the decision-making process, including tracking best practices.

This regional perspective is critical due to the tremendous habitat losses already incurred and is becoming increasingly necessary under climate change scenarios. As project-specific climate change implications are understood, this understanding must be incorporated into a regional perspective, thus allowing coastal wetlands to be managed as an interconnected system rather than as individual wetlands. This will allow managers a better perspective of how the region's wetland resources will likely change with climate change. The National Research Council's 2012 SLR projections for California is an important regional tool for assessing vulnerability and managing climate change in coastal wetlands. Agreed upon SLR estimates allow planning entities to enhance consistency across agencies in their development of approaches to SLR.

A regional perspective may be desirable with respect to species inclusion in restorations because not every wetland project should or can provide the necessary habitat components for all species of interest. The trajectory of climate change is moving wetlands away from the "natural" or "historical" wetlands of days gone by. Developing goals for restoration that focus on function will provide for the most resilient and sustainable habitats in the future. Determining which sites have the greatest ability to transgress with sea level rise and sustain necessary habitats is important, as these may provide the greatest protection of biodiversity across the region.

A regional perspective is critical due to the tremendous habitat losses already incurred and is becoming increasingly necessary under climate change scenarios.

1.2.2 Construction

The construction of wetland restoration projects often involves contouring landforms to optimize certain habitat functions. While these efforts can vary widely in scale, sediment itself can provide significant hurdles. Sediment contamination (chemical and biological), quality, and quantity are critical variables to consider prior to and during the construction process. These issues can greatly influence restoration strategies such as design and development of tidal networks. Sediment and excavation are heavily influenced by water flow and topography. A complete understanding of these processes is critical to adapt plans during the construction process.

The structure and organization of the construction process is given less attention than other project phases. On-site managers who understand the principles of restoration and construction logistics need to constantly communicate with construction crews in order to provide the strongest environmental protection. Full-time on-site project teams should consist of a site manager, resident biologist, and resident engineer independent of the contractor's team. The reality of construction is that contractors must meet deadlines that may conflict with fully meeting project objectives. In order to more closely align the goals of all of the parties involved, tools like liquidated damages or performance-based contracting directly tied to restoration goals and objectives are needed. These tools provide the project team with needed leverage if certain milestones are not met. Contract documents must be as clear as possible to avoid misinterpretation by contractors. This combination of detail and oversight will be the most effective way to provide the highest level of environmental protection during the construction process.

1.2.3 Management

Post-restoration management is often reactive and underfunded because management issues were not adequately considered during the initial planning process. Adaptive management is the iterative process in which management actions are continuously monitored and evaluated, and then changes in management are implemented if necessary. It acknowledges the insufficient base for decision-making and allows for an iterative process to adapt management strategies. Anticipating potential problems and creating triggers for action (consistent evaluation criteria) during the planning stages can alleviate lag times during management. Use of proactive adaptive management plans that clearly identify potential problems, triggers for action, and the agency responsible for action are needed. By establishing a formal adaptive management plan during the planning phase, wetland managers have the greatest opportunity to consider potential problems, apply previous learning experiences from other restoration projects, and allocate funds in advance.

Allowing for a post-construction optimization period can aid in providing additional funding to implement adaptive management and to evaluate the restoration progress. Adaptive management should include “no regret” strategies, actions that generate net social and ecological benefits under all future

scenarios of climate change. Management strategies must include a full range of SLR predictions when evaluating a project's vulnerability. Restoration progress should be based on specific criteria that focus on function and processes. Evaluation criteria that include physical, hydrological, flora/fauna and water quality attributes are suggested. Establishing landmarks in restoration progress such as major changes in function or key species population growth can provide funding agencies and the general public with the social fulfillment needed to justify supporting future restoration efforts. Proactive adaptive management, no regret strategies, and defined evaluation criteria will be necessary in coastal wetland management to meet the needs of today and provide flexibility for the future climate change.

1.3 Use of Document

This document is intended to be utilized by those directly involved in coastal wetland restoration. This document focuses specifically on BMPs developed for the southern California region, but many BMPs can be applied to restoration practices throughout California and across the country. Implications for use in other regions and countries depend on the political and social climate of where the restoration takes place, but the BMPs have potential application to coastal wetland restoration projects worldwide.

The table of contents is designed to allow users with their own restoration issue(s) to quickly reference similar problems and find the associated BMP. This document is divided into three phases—restoration: planning, construction/restoration implementation, and post-restoration management. Within each phase there are 3–5 categories of identified restoration issues (e.g., stakeholders, preliminary strategy, and process organization). Specific identified restoration issues are discussed within the category of restoration issue accompanied by the BMP for each specific issue.



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2. PLANNING

The “human dimension” increasingly enters the planning of restorations¹ and must somehow balance societal, political, and economic goals with ecological needs in addition to balancing historical, current and future issues. The planning process is generally the longest phase of restoration. Identifying preliminary strategies to aid in process organization and stakeholder engagement are integral in creating a smoother planning process.

2.1 Preliminary Strategy: Goal Development and Limitations

The first steps of coastal wetland restoration revolve around development of project goals. A majority of restoration goals focus around three central themes: restoration of species, restoration of a whole ecosystem, and restoration of valuable ecosystem services.² Each of these themes has a unique set of advantages and disadvantages associated with them (Table 1). Regardless of the specific focus of the restoration project, a combination of focused objectives and flexibility is needed in restoration goal development to ensure the feasibility of achieving those goals. Goals must be rigid in that they provide a strict framework for the project but flexible enough to integrate limitations of the site and the inevitable unknowns the project will encounter. Developing a preliminary strategy is integral in understanding the amount of flexibility needed within any project setting.

Table 1. Advantages and disadvantages of designing restorations with respect to different types of goals (Ehrenfeld 2001).

<i>Level</i>	<i>Advantages</i>	<i>Disadvantages & Causes of Failure</i>
Species	Rescue of endangered species Increase in biodiversity	Lack of recognition of ecosystem- and landscape-level interactions and processes Inadvertent damage to other species Attention to one target species may divert attention to other species
Ecosystem functions	Recognition of large-scale processes necessary for species' persistence Encouragement of integration of management goals of diverse agencies, interest groups Recognition of dynamic nature of ecological entities	Definition of “ecosystem” unclear; can lead to problems identifying unit to be restored Definition of “ecosystem function” unclear; functions are heterogeneous in scale and generality, and are poorly correlated with one another
Ecosystem services	Generation of public support, funding Specific actions readily identified	Same problems of definition, scale as with ecosystem function Value depends on constancy of “willingness to pay,” economic conditions Creation of one service may preclude others

1 Thayer, G.W. and Kentula, M.E. 2005. Coastal Restoration: Where have we been, where are we now, and where should we be going? *Journal of Coastal Research* 40: 1-5

2 Ehrenfeld, J. G. 2000. Defining the limits of restoration: the need for realistic goals. *Restoration Ecology* 8:2-9.

2.1.1 Restoration Issue: Baseline, historical, and climate change studies are expensive.

The lack of baseline and preliminary data can be the source of numerous restoration issues. Preliminary studies are costly and require a significant time commitment; therefore, projects without adequate funding are forced to limit the extent to which preliminary studies are employed or are forced to bypass such valuable studies. The insight provided by these studies can result in project cost savings and possibly reduce the need for future large-scale restoration efforts within a site.

BMP: Collaboration with nonprofits, local research institutions, and private agencies can reduce or cover the costs of preliminary studies.

Collaborating with such entities early in the preliminary stages of restoration provides many co-benefits in addition to funding preliminary studies. Connecting with local research institutions facilitates active integration of the best available science into the decision-making process. Similarly, incorporating non-profit organizations can provide for stronger stakeholder connections and the opportunity for citizen scientist projects to develop. Additionally, private foundation contributions made through charitable grants can provide opportunities to invest in preliminary studies that increase project/site-specific understanding to possibly avoid unnecessary costs and complications.



Photo credit: M. Abramson

Using volunteers to complete small projects led by either project scientists or team leaders can help feed into the success of the overall restoration.



2.1.2 Restoration Issue: How should the needs of different endangered species be balanced?

The Endangered Species Act (ESA) was largely developed in recognition of the need for conservation of biodiversity and the protection of the habitats those species depend upon. However, the implicit need to manage for numerous protected species can result in tradeoffs affecting other species in negative ways. Species tradeoffs and the balance of the large-scale ecological process involved in maintaining a population are extremely complex.³

BMP: If minimum viable populations or habitat acreage needed for species to be self-sustaining (determined from the literature and preliminary studies) are not at threshold levels, consider the scope of project and the ability to recover necessary ecological processes to support the species of interest.

See section 2.4.4 for greater discussion on species inclusion in restoration projects.

2.1.3 Restoration Issue: Project funding limits restoration extent, and larger water quality issues impair restoration.

The amount of frustration in funding of southern California wetland restoration projects is mirrored by the frustration of managing larger water quality issues. Watershed management in southern California is heavily burdened by the number of agencies that control and manage upstream flows. Some of these agencies are unique to the particular watershed and therefore must be addressed on a site-by-site basis. The ability to limit upstream water quality problems is generally outside the scope of a restoration project, but certainly has implications on the trajectory of the overall restoration progress.

BMP: Phasing of a project may be appropriate if watershed constraints limit restoration extent.

This particular issue was best exemplified in the Malibu Lagoon Restoration, where initial funding and water quality constraints restricted the initial restoration effort to modify an existing parking lot. Use of low impact development methods for the parking lot addressed some of the initial water quality constraints and planners were able to increase the wetland habitat by two acres. In addition to water quality improvements, phasing allowed the project to install infrastructure (pipes and chases for irrigation of plants) and stage areas for drying soils in preparation for the next phase.

³ Zedler, J.B. 1996. Coastal mitigation in Southern California: The need for a regional restoration strategy. *Ecological Applications* 6:84-93.

2.2 Stakeholders: Include and Incorporate

Stakeholder issues were the third (13% of comments) most often identified problem during the interview process for this project. When restoration efforts are based in highly urbanized areas such as southern California, the restoration is as much about restoring the ecosystem services they provide as it is the natural habitat itself. Coastal wetlands offer unique interactions with nature in highly urbanized settings—which can invoke strong stakeholder feelings about restoration projects, leading to both benefits and problems. Urban residents are often eager to become involved in restoration activities through “Friends” groups and can have the capability to accomplish tasks that if left to agency or city planning might otherwise be ignored or limited.⁴ However, stakeholder involvement has also resulted in major delays in projects from both protest and litigation. Therefore, restorations seeking increased public approval and acceptance should involve activities that reconnect stakeholders physically, cognitively, and behaviorally with natural ecosystems.⁵

2.2.1 Restoration Issue: The stakeholder process is unclear and too open-ended.

An open-ended stakeholder process allows stakeholders to interrupt the flow of decision-making. Stakeholder input is indeed vital and required (see section 2.2.4) in the process of restoration of southern California wetlands, but stakeholders often do not understand the steps and framework California has in place to ensure environmental protection. Currently, there is no defined stakeholder process for wetland restoration that clearly communicates the opportunity for stakeholder involvement.

BMP: Articulate to stakeholders how they will be involved in restoration planning and decision-making within each phase of the process in order to incorporate stakeholder input effectively while also allowing for effective decision-making.

4 Callaway, J.C., and Zedler, J.B. 2004. Restoration of urban salt marshes: Lessons from Southern California. *Urban Ecosystems* 7:107-124

5 Casagrande, D. G. 1997. The human component of urban wetland restoration. *The Yale School of Forestry and Environmental Studies Bulletin* 100:254-270

Increasing the efficiency of stakeholder input increases the decision makers' ability to incorporate that input, and thus creates a more effective process.



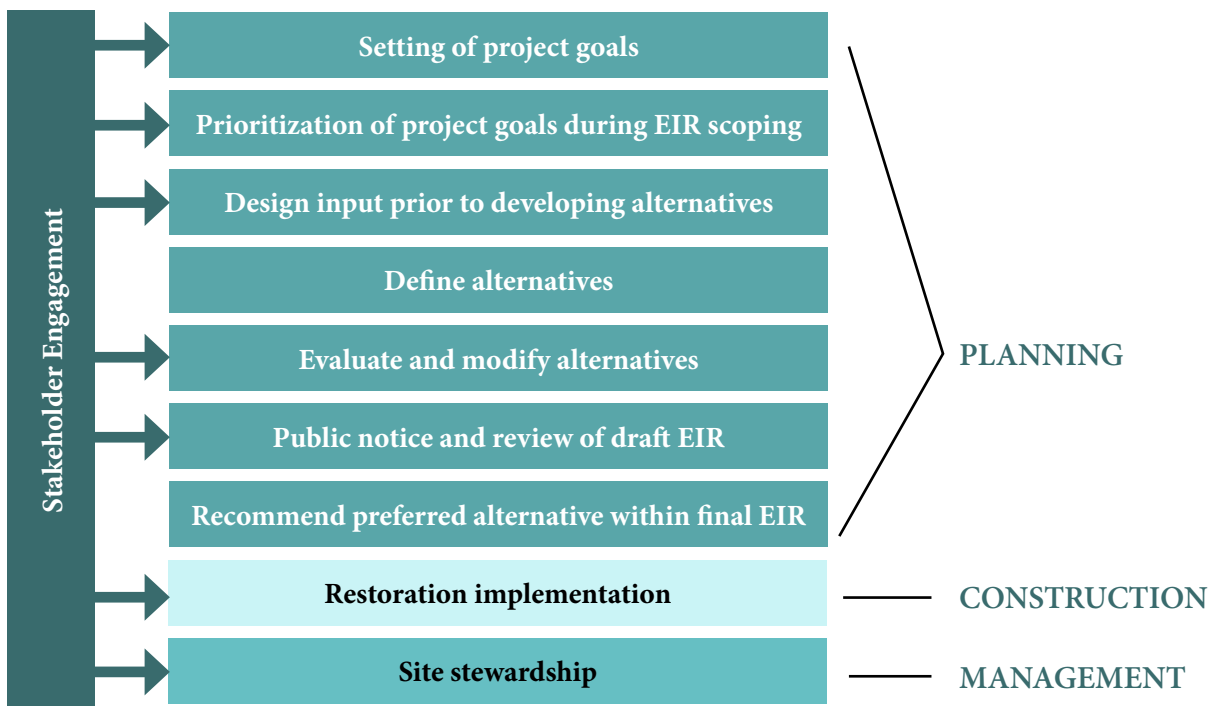
Defined stakeholder interaction guidelines should be introduced at the beginning of the process. Stakeholder guidelines allow stakeholders to focus their efforts during times that decision-makers can actually incorporate information and, therefore, stakeholder input would have a larger impact on the overall process. Increasing the efficiency of stakeholder input increases the decision-makers' ability to incorporate that input, and thus creates a more effective process. Comments raised after the appropriate time to influence decisions are frustrating to everyone involved, especially when the comments could have improved that project if they had been received at the appropriate time. The stakeholder structure developed here (Figure 1) aims to optimize stakeholder input and support throughout the process by specifically engaging stakeholders at seven crucial steps in the restoration process:

1. **Goal Setting:** After the lead agency has identified a basic framework for the project goals, stakeholders should incorporate their input into goals outlined by the lead agency.
2. **Prioritization of Goals During Project Scoping:** The project planning team should guide stakeholders through discussion and prioritization of goals that are cumulatively developed. A ranking of project goals can be analyzed using pairwise ranking and should be shared with stakeholders to acknowledge stakeholder values across groups. An increased role of stakeholders in development of goals and priorities will increase the legitimacy of the process.⁶
3. **Design Input:** Stakeholders should be solicited for specific design input, especially in regard to interpretive features and public access (see section 2.2.4). Design charrettes, public workshops, and other tools can be used to elicit stakeholder opinions about possible alternatives. Designs should be evaluated by the project team (and scientific advisory team, if applicable) to develop project alternatives.
4. **Plan Evaluation Process:** Once project alternatives are developed, stakeholders should be involved in the process of evaluating each alternative prior to development of the draft Environmental Impact Report (EIR). Focus groups, decision trees, and preference ranking are useful participatory tools that can increase discussion of alternatives. After stakeholders have been given an opportunity for their own evaluation of alternatives, the draft EIR should be produced.
5. **Public Comment on Draft EIR:** The California Environmental Quality Act (CEQA) requires a public comment period for the draft EIR. Stakeholders should focus their comments on the sufficiency of the document in identifying environmental impacts and methods to avoid and mitigate those impacts. The lead agency is required to address the comments in the Final EIR, providing sufficient rationale behind the agency's decisions.
6. **Restoration Implementation:** Public participation just prior to construction regarding input on materials and finishes can contribute useful insight into the end uses of the project. Using volunteers to complete small projects led by either project scientists or team leaders can help feed into the success of the overall restoration.

6 Pomeroy, R., and Douvère, F. 2008. The engagement of stakeholders in the marine spatial planning process. *Marine policy* 32:816-822.

7. **Management and Site Stewardship:** Stakeholders, especially those living nearby, have the ability to track the development of a restoration after it is completed often on a more regular basis than agencies. An avenue for communicating stakeholder observations and the ability to respond to legitimate problems should be included within an adaptive management strategy. Incorporating stakeholders into monitoring in a formal manner could better track the restoration as it develops and also provide stakeholders with the opportunity to evaluate the results with the stated objectives firsthand.

Figure 1. Stakeholder engagement opportunities during the wetland restoration process.





2.2.2 Restoration Issue: Connecting with groups who are focused on the restoration while also engaging the larger community is poorly executed.

The terms stakeholder and community have been defined in many different ways throughout public participation literature. Identifying who is a stakeholder is often problematic in addition to the complication of reaching out to a cross-section of the community. Additionally, the term community now includes social media that extends far beyond traditional land-planning boundaries. Failure to engage all elements of the community can result in conflicts from those who were unintentionally left out, especially those who feel they have been intentionally excluded. The legal mandate for public participation is often too passive for some classes of organizations who still clearly have a vested interest in restoration projects.

BMP: In addition to the use of legally mandated public meetings, open houses, tours of wetlands, and social media campaigns are useful tools to create connections throughout the community and allow for informal access to project information.

Stakeholders need to have access to structured involvement throughout the process, and social media can offer the larger community access and updates on the process as it progresses. Traditional routes of outreach should not be ignored/abandoned in lieu of a strong social media campaign but rather strengthened by social media. Social media offers opportunities to connect with stakeholders like never before, but direct input in the process should remain within the structure of public meetings and draft comments to avoid the few individuals who falsely act as many via social media. Use of nominated stakeholder representatives at public meetings, like the regional stakeholder group within the California Marine Life Protection Act (MLPA) process,⁷ can help focus stakeholders' voices to allow decision-makers to more easily consider and accommodate stakeholder needs. Social media should be utilized to inform the public about upcoming meetings, deadlines, and decisions made throughout the process. Social media is a good avenue to invite stakeholders to open houses and wetland tours, where they can meet with agency officials and other local stakeholders.

2.2.3 Restoration Issue: Social context of site can drive stakeholders and the planning process

The social context of a site includes consideration of the surrounding neighborhoods and public infrastructure associated with it. Sites closely associated with areas of affluence or even lower income neighborhoods with extreme limited access to green spaces can feel very strongly about projects that impact (even though the impacts are intended to be temporary) access to their environmental resources.

BMP: Strategically consider who the stakeholders are and what their interests are in the project. Get all interested parties on the same page in terms of their knowledge base. Use a shared information voice.

⁷ Gleason, M., McCreary, S., Miller-Henson, M., Ugoretz, J., Fox, E., Merrifield, M., McClintock, W., Serpa, P., and Hoffman, K. 2010. Science-based and stakeholder-driven marine protected area network planning: a successful case study from north central California. *Ocean & Coastal Management* 53:52-68

Considering the stakeholders' specific interests in the project can help managers create targeted educational materials and strategies to keep stakeholders informed throughout the process. Close collaboration with mediators/facilitators to create targeted materials that provide a shared knowledge base is needed. If decision-makers are able to reference a shared knowledge base, it is likely to facilitate a shared information voice among stakeholders and allow increased opportunities for compromise and expedite decision-making. A shared knowledge base can be accomplished through access to guidance materials and process materials via a project website, social media (see section 2.2.2), and/or production of general information reference documents.

2.2.4 Restoration Issue: Need for local knowledge and support from stakeholders

As the end users of restoration projects, the public plays a critical role in the restoration process both through legal requirements and local knowledge. Public review of restoration projects is required under the CEQA in order to encourage the public to respond to environmental issues posed by agency projects.⁸ Local knowledge, especially knowledge of specific site uses, such as educational, recreational, and public access needs, is extremely valuable and often best provided by the users themselves.

BMP: Consider the needs of surrounding communities/end users through open and sustained communication with stakeholders throughout the restoration process.

Interacting with stakeholders early can help to explain to them why some ideas from stakeholders might not necessarily be appropriate. Keeping stakeholders involved throughout the entire process requires continually updating and sharing interesting developments in the project (see section 2.2.2). Keeping stakeholders interested and active is critical and may be achieved through events or volunteer opportunities. If stakeholders take ownership of a project through their contributions and involvement, they become site stewards, ensuring an increased longevity for the restoration project. Restoration must take into consideration the needs of the surrounding communities and site uses. Stakeholder input can be critical for interpretive design features (e.g., sitting areas for large student groups or stable platforms for siting scopes) to facilitate education and public access (e.g., surfer expressways for easy beach access).

If stakeholders take ownership of a project through their contributions and involvement, they become site stewards, ensuring an increased longevity for the restoration project.

8 Bass, R. E., Herson, A.I., and Bogdan, K.M. 1999. CEQA Deskbook. Solano Press



2.2.5 Restoration Issue: Stakeholders are dynamic and often polarized groups who can disrupt project progress at many stages.

Stakeholders without proper forums to bring comments before decision-makers often feel excluded from the process. Even those utilizing the proper lines of communication through public hearings are often limited to only a few minutes to provide comments. Stakeholders who feel excluded from the process will find more disruptive ways to have their voices heard by interrupting public meetings, protests, and litigation.

BMP: Use of bridging organizations/moderators/facilitators (those who are outside of ownership) to manage public comments can help move the project forward.

For public meetings, use a mediation/facilitation person, someone who anticipates issues, comes up with answers, and understands constituents. Facilitators should constantly integrate the structure of public involvement for the process (see section 2.2.1). Utilize a designated public comment period at public meetings to reduce interruption during decision-maker negotiations. If necessary, special public meetings should be used to provide sufficient time for public comment. Bridging organizations/moderators/facilitators should include or work closely with a public relations person to create targeted stakeholder outreach materials (newsletters, social media, events) to keep the public informed and up to date on the process (see sections 2.2.2 and 2.2.3).

2.3 Process Organization: Organizing Ourselves in Planning

Process organization addresses the issue of how agencies and decision-makers choose to organize the process of restoration planning. Some of the organizational structure is dictated by legal requirements, while a majority of the process is haphazardly and inconsistently constructed. Each southern California coastal wetland restoration project has developed its own process structure. Even projects that occur in the same county may have drastically different processes that can result in confusion on both the part of agency persons and stakeholders (see section 2.2.1 for more on the importance of identifying a structure for the stakeholder process). The differences in the ways planning teams approach process organization reflect the fact that the players (decision-makers, agencies, stakeholders, etc.) involved are different for each project. Process organization is not only a problem for new or developing restoration projects but will be a problem for completed restoration projects that failed to consider climate change in their initial restoration and will require future restorations to continue to meet restoration objectives. There are many uncertainties in restoration planning, but the way in which a process is organized should not be one of them.

2.3.1 Restoration Issue: Consensus decision-making is very time consuming and requires the necessary people with the authority to make decisions to be present.

Utilizing a consensus decision-making process is more time-consuming, but may better balance values among the lead agency and other project agencies to create stronger user buy-in. When the decision-making process is unclear, it may appear that the lead agency is making unilateral decisions that can negatively affect relationships between the agencies involved in the process. Consensus building is a highly objective and fact-driven process requiring the group to share a common knowledge base that can lead to greater translucency in the decision-making process. The consensus process varies from majority rule in that consensus building requires the agencies involved to jointly develop solutions rather than utilize a set of predetermined options. Often, agencies delegate a representative to attend planning meetings, but those representatives may lack the authority to make final decisions on behalf of the agency. The time spent during the approval process in back and forth communication within an agency to get proper approval and then between agencies can greatly slow the process.

BMP: If a consensus process is used, the process of approval (within and among agencies) has to be quick to allow for decisions to be made efficiently.

Consensus building is recognized as an effective strategy for complex, controversial policy and decision-making,⁹ but it requires an efficient approval process within and among agencies. A well-defined structure of reaching a consensus is necessary from the start of the process to minimize conflict among agency persons. Consensus planning requires strong interpersonal skills and thus can also benefit from the aid of a facilitator/coordinator who can help define the official structure for consensus. An important element of the consensus structure is having the proper agency individuals (with the necessary authority to make decisions on behalf of their agency) present, or representatives must have a quick internal process to gain approval. Defining discrete deadlines for gaining internal agency approval outside of the meeting is vital. An agency's ability to reach an internal decision should be on the order of hours or days rather than weeks or waiting until the next meeting to avoid delays in project planning.

Consensus building is recognized as an effective strategy for complex, controversial policy and decision making, but it requires an efficient approval process within and among agencies. A well-defined structure of reaching a consensus is necessary from the start of the process to minimize conflict.

⁹ Innes, J. E., and Booher, D.E. 1999. Consensus Building and Complex Adaptive Systems. *Journal of the American Planning Association* 65:412-423



2.3.2 Restoration Issue: It is difficult to effectively pull together all the necessary people and agencies for a restoration project.

Restoration projects require numerous agencies, contractors, and technical advisors to complete a project. The time allocated to identifying all the necessary players needed for a restoration project is in of itself time intensive. Projects rarely have the same lead agencies, thus each project requires creating new connections and reconstructing relationships between all the necessary people and agencies. Lack of consistency in lead agencies and contractors used can result in the loss of lessons learned from prior projects.

BMP: Strengthen and utilize agencies with regional focus that have the ability to act as a friendly coordinating agency and provide a memory bank for decision-making processes.

The creation of a new agency may not be necessary. There are a few agencies, including the Coastal Conservancy or the Southern California Wetland Recovery Project (SCWRP), that could feasibly fulfill this role as project and regional coordinator. A regional organization should keep track of agencies, contractors, and technical advisors used on previous projects and provide new lead agencies with the contact information or introductions. By connecting required permitting agencies and other valuable players that were involved on nearby projects, the regional agency provides a quicker start to project relationships and also ensures a built-in project memory bank.

2.3.3 Restoration Issue: Regionally relevant scientific advice is needed for individual projects.

Not all projects utilize a Scientific Advisory Panel/Team (SAP/SAT) or a Technical Advisory Committee (TAC). SCWRP utilizes a regional SAP to meet regional goals.¹⁰ Of the SCWRP's six identified regional goals, No. 5 is to promote information exchange and dissemination. SCWRP has identified strategies to accomplish goal No. 5, however, those strategies do not include coordination of restoration BMPs.

BMP: Each project should include a project SAP/SAT or TAC. The single project SAP/SAT/TAC should act as a subcommittee of the larger regional SAP to provide for better communication up and down between planning levels and to capture BMPs.

¹⁰ Southern California Wetlands Recovery Project Regional Strategy (November 2001) can be found at: <http://scwrp.org/wp-content/uploads/2013/08/WRP-Regional-Strategy.pdf>

The complexities and interdisciplinary nature of restoration projects require the combined expertise of a panel to properly develop and evaluate restoration projects. Every single interview subject identified a need for an avenue to exchange technical and scientific information regarding BMPs. This guidance document is only the first step in achieving a regional approach that coordinates lessons learned through prior restorations. By expanding the mandate of the SCWRP SAP to coordinate with the project SAP/SAT/TAC to communicate BMPs, site-specific lessons are uploaded to the regional level that are still relevant at the project level.

2.3.4 Restoration Issue: Long project timelines result in project delays that may affect budget and stakeholder interest/trust in the project.

The CEQA EIR process alone is a 9–18 month process that can often extend even longer. In addition, there are numerous other permits from local, state, and federal agencies required to undertake a coastal wetland restoration project. The long timeline created by the permitting process can increase the likelihood of turnover in agency personnel, late hits or loss of interest from stakeholders, and increases the threat to the budget. Permitting agencies often request additional measures, which can be costly and seem unnecessarily protective, but are preferable.

BMP: The permit review can be streamlined by integrating the permitting/review process with the planning process.

A lead agency should integrate CEQA with other state and federal environmental reviews to the fullest extent possible (CEQA Guidelines §15124). Better integration of the planning process during the permitting process can create opportunities for continued agency and stakeholder engagement (see section 2.2.1) and strengthen the consensus process (see section 2.3.1). Utilizing a strong regional agency to facilitate connections with required permitting agencies and experts can aid in strengthening project relationships to speed the process along (see section 2.3.2). Utilization of data/research from both the regional and project advisory teams can potentially reduce the time required to gain permit approvals (see section 2.3.3). Finally, including permitting agencies on the SAP/SAT/TAC can help address issues with the proposed actions before submitting a permit.

Every single interview subject identified a need for an avenue to exchange technical and scientific information regarding best management practices.

A lead agency should integrate CEQA with other state and federal environmental reviews to the fullest extent possible.



2.4 Design: Incorporation of Biological and Historical Knowledge

The question, “What are we restoring to?” references not only the temporal and physical element of restoration design but also the definition of restoration itself. It is important to distinguish between the terms restoration, rehabilitation, and creation (see Figure 2) to convey to stakeholders and wetland managers the differences between the expectations, sustainability, and time/financial investments needed to complete a project.¹¹ Restoration, as defined by the National Research Council, is described as returning an ecosystem to a “close approximation of its condition prior to disturbance.”¹² Throughout this guidance document, restoration has been used as it has been generally applied to past southern California wetland restoration projects and was described by Middleton as a site with the objective of “self-regulation integrated within its landscape rather than to reestablish an aboriginal condition that can be impossible to define and/or restore within the context of current land use or global climate change.”¹³ Today’s southern California coastal wetlands are incapable of restoration as defined by the National Research Council (1992) because there is no way to completely remove anthropogenic impacts; often passive restoration alone is insufficient. Today, a majority of restorations are based more in the arena of reallocation that utilizes a combination of passive and active restoration. However, they are forced to comply with site constraints caused by the human footprint. Thus, reallocation projects follow the flow shown in Figure 2, resulting in a “new natural wetland” or a “new wetland” that provides a different, but also valuable, set of ecosystem processes to support similar ecosystem service of the aboriginal wetland.

2.4.1 Restoration Issue: Open or closed inlets? Landscapes have drastically changed. Watersheds have been completely altered, including infrastructure that did not historically exist.

Today’s watersheds and constraints are very different from 200 years ago and will undergo significant changes with climate change. Use of historical data in restoration design can provide some notions about the hydrology and how frequently the mouth was open during past tidal regimes to help predict frequency of opening in the future.

BMP: Try to reoccupy the historical channel network and reestablish hydrology if possible to incorporate historical perspective (typically more successful and less expensive).

11 Simenstad, C., Reed, D., and Ford, M. 2006. When is restoration not?: Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration. *Ecological Engineering* 26:27-39

12 National Research Council (US). Committee on Restoration of Aquatic Ecosystems-Science, Technology, and Policy. 1992. *Restoration of aquatic ecosystems: science, technology and public policy*. National Academy Press.

13 Middleton, B. 1999. *Wetland restoration, flood pulsing, and disturbance dynamics*. John Wiley & Sons. 388 pp.

Understanding the historical conditions with regard to tidal inlet can greatly influence the course of the rest of the restoration. Consider Jacobs et. al's 2011¹⁴ report on the classifications of California estuaries' natural closure patterns. If there are significant physical departures from the historical hydrology, it raises a whole new range of concerns and will require a more active approach to restoration design. Incorporation of more engineered water control structures (tidal gates, slot gates, etc.) provides for recovery of some natural ecosystem processes, albeit significantly altered from how they would occur in the natural/historical wetland.¹⁵ Consider the major deviations from historical information and what processes are influenced by those differences. Understanding the nature of geomorphic processes and their environmental/biological consequences on the landscape is necessary to determine what aspects can be maintained or potentially enhanced given the limitations of the modern landscape.

2.4.2 Restoration Issue: Incorporating historical data will become increasingly difficult with climate change as conditions move further away from historical conditions.

While there is uncertainty as to what extent and how exactly climate change will alter coastal wetlands, there is little ambiguity regarding the fact that these low-lying coastal habitats are indeed vulnerable to future change (see sections 2.5 and 4.2 regarding climate change planning and management). The trajectory of change due to climate change is moving wetlands further and further away from the “natural” or “historical” wetlands of recent histories past.

BMP: Utilize historical knowledge to understand historical processes, but move forward with current constraints. Develop goals for the restoration that focus more on function rather than recreating historical conditions if the project is to be resilient and sustainable in the future.

Sites should be designed gradually enough to create transition zones that provide species with the ability to adapt to sea level rise. Designing channels and habitats in such a way that allows for accretion of sediment over time will slow the loss of habitats.

14 Jacobs, D., Stein, E.D., and Longcore, T. 2010. Classification of California estuaries based on natural closure patterns: templates for restoration and management. Southern California Coastal Water Research Project, Costa Mesa, CA. Technical Report 619:50 can be found at: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/619.a_EstuarineClassificationRestorationDesignRevised.pdf

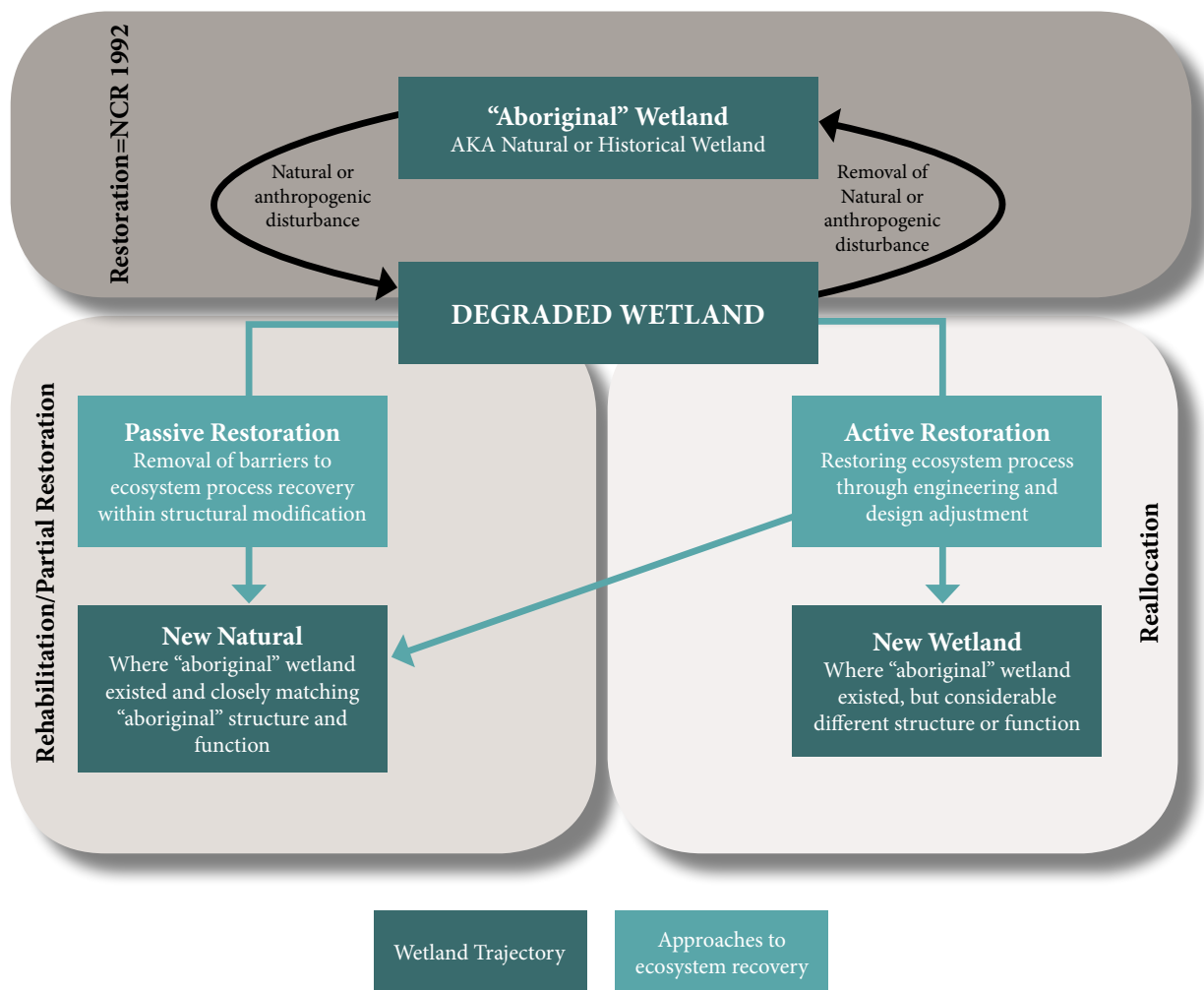
15 Simenstad, C., Reed, D., and Ford, M. 2006. When is restoration not?: Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration. *Ecological Engineering* 26:27-39

Consider the major deviations from historical information and what processes are influenced by those differences.



Historical references can impart knowledge of past historical processes, but not necessarily be directed toward exact reconstruction (especially given the limitations of modern footprints). The National Research Council¹⁶ noted that the restored systems most likely to become self-sustaining and resemble natural wetlands of the region are those that consider hydrological, topographic variability; hydrogeomorphic, subsurface and ecological landscape processes; and climate considerations.

Figure 2. Pathways of wetland trajectory to provide ecosystem recovery through three ecosystem phases; restoration, rehabilitation/partial restoration and reallocation through two different ecosystem approaches. Adapted from Simenstad et al. 2006.



16 Council, N. R. 2001. Compensating for wetland losses under the Clean Water Act. Committee on Mitigating Wetland Losses, Board on Environmental Studies and Toxicology, Water Science and Technology Board, National Research Council. 322 pp.

2.4.3 Restoration Issue: Biologists/scientists do not have enough interactions with the engineers during the planning process.

Engineers often function as the architects of the restoration structure, while biologists become the painters who add the finishing touches. The expectation is that biologists must work with the palette that engineers provide them. To biologists, engineers seem to often overdesign systems, but to engineers, biologists may not have exact outcomes in mind and/or the ability to communicate designs.

BMP: Active engagement between engineers and biologists (and additional technical/scientific advisors) is needed throughout the process to avoid creating non-biologically relevant designs and provide an opportunity to integrate the latest scientific information into restoration design.

Biologists and engineers may not have all the answers, and consulting additional regional and local technical/scientific advisors is needed (see section 2.3.3). Meetings between engineers and biologist in addition to other technical advisors such as sedimentologists and geomorphologists during the development of alternatives are needed. Integrating biologists more in the development of alternatives can enable engineers the opportunity to explain their rationale behind designs and give biologists the chance to point out potential biologically irrelevant designs. Once an alternative is selected, the biologists should reconvene with the engineers to discuss the more fine-scale elements of the plan in regard to sloping, channel design, and use of berms. Both disciplines should also utilize historical data to bolster design decisions (see section 2.4.2).

2.4.4 Restoration Issue: When protected species do not naturally occur at a site but are known to occur throughout the region

Species protection is paramount in conserving biodiversity within wetlands. Southern California is host to 150 animal species and 52 plant species that depend on rivers, streams, and wetlands, and are considered as threatened or endangered by either state or federal agencies.¹⁷ Table 1 discusses both the benefits and negative consequences on designing restoration to focus on target species.

¹⁷ Southern California Wetlands Recovery Project Regional Strategy (November 2001) can be found at: <http://scwrp.org/wp-content/uploads/2013/08/WRP-Regional-Strategy.pdf>

Restoration projects are sites with the objective of “self-regulation integrated within its landscape rather than to reestablish an aboriginal condition that can be impossible to define and/or restore within the context of current land use or global climate change.”

Reallocation projects utilize passive/active restoration that results in a “new natural wetland” or a “new wetland.” These “new” wetlands provide a different but also valuable set of ecosystem processes to support similar ecosystem service of the aboriginal wetland.

Today’s southern California coastal wetlands may be incapable of restoration as defined by the National Research Council (1992) because there is no way to completely remove natural and/or anthropogenic impacts.



BMP: Take a regional perspective for species inclusion in restoration. Determine the best sites throughout the region to restore necessary habitats that would best support the species of interest. Not every wetland project should or can provide the necessary habitat components for all species of interest.

Species may be best managed on a regional scale, especially under the context of climate change in which species ranges are likely to shift. Not all wetlands are large enough to include all the processes needed to sustain all threatened or protected species. Some wetlands that currently host sensitive species are threatened themselves by substantial acreage loss due to sea level rise. The translocation of sensitive species to wetlands that can transgress with sea level rise may offer more protection for species biodiversity throughout the region. Species of interest should be addressed on a species-by-species basis in order to take into consideration genetically distinctive units.

2.5 Climate Change: A Head Start on Preventing Future Loss

The opportunity to incorporate climate change planning into coastal wetland restoration is now. Previously completed restorations have been designed to be self-managing and include resilience, but resilience has a limit. Keeping pace with anthropogenically stimulated climate change is unlikely, and managers will have to make decisions that balance short- and long-term goals. Recent guidance on SLR in California (see Table 3 in section 4.2) is an important tool in managing climate change in coastal wetlands. Armed with an agreed-upon estimate of SLR for the Southern California Bight, managers can move forward in the process of determining wetland vulnerability to climate change.



Photo credit: The Bay Foundation

2.5.1 Restoration Issue: Excessive focus on subtidal “water restorations”

Southern California has artificially increased subtidal habitat and the coast of salt panne habitats through the practice of restoration. The cause behind this increase of subtidal habitat use in restoration planning was discussed by interview subjects as a result of compensatory mitigation, strong pressure from agencies, and the recognition of the importance of wetlands as nurseries for both commercially important and protected fish species. Ultimately, restorations considered depth, but not the evolution of the substrate in the absence of balance between sediment surface and hydrologic forcing.

BMP: Focus on marsh and upland restorations that allow for future transgression with SLR if project goals are to reflect all habitat types in the future.

Subtidal habitats are anticipated to increase with future SLR as a result of interior ponding and subsequent marsh drowning.¹⁸ Sites need sufficient vertical zonation for the maintenance of a diversity of habitats now and in the future. A more balanced approach for managing habitat types is needed to increase resilience to SLR. Tailoring the 3-D geometry to a particular site is challenging and needs careful design to take site-specific constraints into consideration thus engineers are as vital in the process. Providing for future transgression through practices that will increase marsh and upland habitats will provide for natural transgression with SLR. In turn, this will ensure that a representative range of habitats exists in the future.

2.5.2 Restoration Issue: Restoration planning is too narrow and too short-term to meet the needs of climate change.

Short-term performance standards limit the ability to implement long-term climate change planning. Mitigation practices or restorations requiring a site to meet performance standards in a relatively rapid (1–10 years) timespan make it harder to incorporate climate change goals because these goals are often in opposition.

BMP: Use larger planning areas and longer term frameworks (accommodating for sea level rise and other aspects of climate change).

¹⁸ Cahoon D.R., Hensel, P.F., Spencer, T., et al. 2006. Coastal Wetland Vulnerability to relative sea-level rise: Wetlands and natural resource management. Springer, pp 271-292

Providing for future transgression through practices that will increase marsh and upland habitats will ensure that a representative range of habitats exists in the future.



Using larger planning areas, sites where land acquisition is feasible or public infrastructure has the ability to be relocated can allow for natural transgression of wetlands (see section 4.2.2). Wetland edge habitats will play an increasing importance in wetland restoration success. Planning with a longer-term framework allows for the core restoration to be established today with the ability to meet short-term goals but also allows the continuation of efforts to increase and maintain upland habitats and support accelerated transgression of habitats.

2.5.3 Restoration Issue: There is no defined regional strategy for adapting restoration for climate change, and site-specific scale of climate change is largely ignored in restoration planning.

Few projects have site-specific climate change models. Adaptations needed to compensate for climate change, specifically SLR, will largely depend on site characteristics regarding accretion/subsidence and the ability to transgress. The National Research Council (2012) predicts southern California marshes will be provided with the necessary sediment inputs to survive through SLR projected for 2030 and 2050.¹⁹ With climate change, it is expected that less frequent but more intense storm events will affect sites differently depending on hydrologic conditions and watershed constraints of individual sites. Therefore, site-specific modeling under different climate change scenarios will help to plan for the best methods to implement restoration strategies in light of climate change.

BMP: Climate change will require site-specific planning as well as regional strategies. Encourage managers to do a scoping project like the Climate Change Implications for Ballona Wetlands Restoration²⁰ and then to incorporate site-specific information into a regional profile.

The Climate Change Implications for Ballona Wetlands Restoration report investigates the potential impact of precipitation change (25% increase and decrease) and sea level rise (1.0m and 1.4m added to present-day tidal levels) to two proposed alternatives. There are two models applied in the study: one to simulate hydrologic processes within the wetland and the other to simulate the primary hydrologic processes within the watershed connected to the wetland. This study did not model a no-project alternative, which would be very useful in understanding the impacts of climate change without restoration. As climate change implications are understood on a project-by-project basis, that understanding should be incorporated into a regional profile to allow managers to have a better perspective of how wetland resources will likely evolve with climate change.

¹⁹ NRC (National Research Council). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington. National Academy Press.

²⁰ Bergquist, S.P., Pal, J.S., Trott, W., Brown, A., Wang, G., and Luce, S.L. 2012. Climate Change Implications for Ballona Wetlands Restoration. Report prepared for the US EPA Climate Ready Estuary Program. 65 pp document http://www.santamonicaby.org/Documents/BallonaCREStudy_FINAL%20Report_12-12-12.pdf



3. RESTORATION CONSTRUCTION BEST MANAGEMENT PRACTICES

The restoration implementation/construction phase is the shortest yet most expensive phase in the restoration process. The methods used for restoration construction are also highly controversial. The use of bulldozers (active restoration) or shovels (a more passive restoration) is confronted again (see section 2.4 and Figure 2) because the reality of the planned methodology is brought to the forefront of public attention. Public protest at restoration sites can hinder the construction process, potentially causing delays and reducing the already very narrow weather and biological window for construction. Additionally, construction implementation is the least-documented phase as decisions are often rapidly made (rarely consulting the full body of project decision-makers to troubleshoot unexpected problems).



Photo credit: M. Abramson



3.1 Process Organization: Construction

The structure and organization of the construction process is usually ignored more than any other project phase (also see discussion on Planning/Process Organization in section 2.3). Carrying an organizational strategy throughout the entire process provides guidelines, timelines, and the ability to adapt plans as needed throughout the restoration process. Documentation of decisions made during construction could provide first-time wetland restoration contractors with information that would reduce problems and delays. A contractor's primary goal is generally meeting his or her time deadline; therefore a BMP document created by contractors for contractors would likely be an important tool. Maintaining a database and requiring the contractor to document these decisions, however, would need to be enforced and shared with future projects by a regional entity (see section 2.3.2).

3.1.1 Restoration Issue: Private construction firms without restoration experience are often unable to monitor their own attributes and provide sufficient buffers for environmental protection.

Restoration projects generally use a bidding process to determine the construction contractor used for a project. There is no requirement for a construction contractor to have previous restoration experience. There are many legal nuances specific to wetland restoration. Lead contractors may be aware of the legality of some of the environmental laws that apply to construction actions (e.g., the Clean Water Act (CWA) and the ESA), but it is unlikely their laborers are. A single individual bulldozer driver has the potential to heavily impact biota and water quality in a single scoop. Job site supervision is imperative.

BMP: On-site managers who understand the principles of restoration and construction logistics should be constantly communicating with construction crews to provide the greatest amount of environmental protection. Full-time project site teams should consist of a site manager, resident biologist (RB) and resident engineer (RE) outside of the contractor's team. This combination of oversight will be the fastest route that also ensures the highest level of environmental protection.

Prequalifications for contractor bids that require a certain level of experience could help weed out unqualified contractors or allow for the disqualification of bids if contractors do not meet prequalification requirements. Overseeing construction contractors with a full-time project site team (site manager, RE and RB) under separate contract to the proponent would provide the quickest and best informed construction decisions. Contractors have the ability to read engineering plans but lack the insight to augment plans to maintain biological or engineering intent when confronted with a problem. When deadlines approach, contractors commonly use requests for information (RFIs) as a stall tactic or to shift blame onto the project site team. The cost of a project site team seems prohibitive, but cost savings can be realized through decreases in work stoppage and penalties for violating environmental laws. Additionally, decision-making that involves the aforementioned on-site trio (site manager, RE, and RB) to direct the contractor can reduce the need to repeat construction tasks multiple times and create agreeable circumstances among the different disciplines.

3.1.2 Restoration Issue: Detecting and relocating protected species is costly and time consuming.

Under the ESA, the term “take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Use of biological monitors is critical in preventing “take” as defined by ESA. Biological monitors also create favorable public opinion by showing that the project is going to great efforts to reduce take and harm of protected species.

BMP: Create a sensitive species plan that clearly identifies appropriate adjacent habitats to transfer the animals into if protected species are found.

Having a prepared action plan for protected species can reduce project delays. Recognition of different habitat needs for small mammals, birds, and reptile/amphibian species should be taken into consideration. Use of biological monitors to set appropriate boundaries to avoid affecting sensitive species is critical, but there must be proper training of on-site laborers to ensure the perimeters are maintained in the absence of monitors.

3.1.3 Restoration Issue: Single-phase construction projects miss the opportunity to incorporate science that can provide cost-effective learning for later stages.

Adaptive restoration or “learning while doing” is accomplished by completing restoration in stages where lessons learned from early stages are applied to later stages.²¹

BMP: When a site is large enough, phasing of construction can provide the ability to utilize adaptive restoration. Biologists should be on site during the construction process conducting experiments at each phase at an appropriate scale.

Adaptive restoration allows for continuous evaluation of the project and the ability of construction to sufficiently meet project objectives. Adaptive restoration offers the ability to apply BMPs utilized at other sites under similar scenarios while implementing experimental strategies that may enhance previous knowledge.

²¹ Zedler J.B., Callaway, J.C. 2003. Adaptive restoration: a strategic approach for integrating research into restoration projects. *Managing for healthy ecosystems* 164-174.

Adaptive restoration or “learning while doing” is accomplished by completing restoration in stages where lessons learned from early stages are applied to later stages.



3.1.4 Restoration Issue: Unexpected delay/costs during construction can result in removal of previously planned portions of the project.

Utilizing preliminary studies can help reduce the number of unexpected problems, especially in regard to contamination issues (see section 2.1.1). However, there are many other unforeseen complications that can delay construction or increase construction costs. For example, archeological findings have been a major delay in multiple restorations, affecting planting timing or even resulting in loss of seedlings (see section 3.3.2 for discussion on seedling sensitivity). Multiple adjustments due to inadequate on-site supervision from biologists and engineers (see section 3.1.1) can cause increased delays and costs. Exclusion of previously planned elements can harm plan integrity and erode trust established with stakeholders during the planning process.

BMP: During the planning phase of restoration, a post-construction optimization period should be allocated for unexpected events encountered during construction. An optimization period can allow a project to proceed on time, on budget, and without exclusion of planned project elements.

An optimization period allows funding to be allocated for after the initial construction phase is complete so project elements that were possibly excluded can be revisited. If there are elements that need to be shifted to the optimization phase they must be elements that are not the foundation of project design (e.g., channel or creek design) but elements that serve more of an auxiliary function (i.e. public infrastructure) outside of delineated wetlands. External public infrastructure is still a very vital part of the restoration because it provides access and education. The full project team should carefully consider which elements can be left until the optimization phase.

3.2 Sediment and Excavation Issues

The construction of wetland restoration projects often involves contouring landforms to optimize certain habitat functions. While these efforts can vary widely in scale, sediment itself can provide significant hurdles during the construction process. Sediment contamination (chemical and biological), quality, and quantity are critical variables to consider prior to and during the construction process. Sediment issues have the potential to influence restoration strategies such as design and development of tidal networks. Sediment and excavation are heavily influenced by hydrological and geomorphological process, and therefore require a complex understanding of the processes in order to make changes to plans during the construction process.

3.2.1 Restoration Issue: Unexpected site unknowns (contamination, grain size, buried items, etc.) slow progress or become major site constraints. If sediment quality or grain size differs drastically, sediment cannot be placed on the beach.

Sediment contamination of a site can be a major constraint in site selection due to cost and possible ecological effects. If sediment quality is not calculated during a preliminary study, the estimates of cost of remediation, removal and disposal can be drastically underestimated. Even sediment that is not contaminated must match grain size in order to be placed on the beach. If sediment grain size differs, the transportation cost for removal and off-site disposal drastically increases. Since many wetlands were filled in the early part of the 20th century, there is great uncertainty in what one might find once the digging begins. For example: during excavation of Sweetwater Marsh, an old city dump was discovered.

BMP: Preliminary sediment studies can identify contaminants and help provide better economic models for project excavation costs. The planning process must include worst-case scenario cost estimates for export/treatment of sediment if no/limited sediment sampling is done before restoration.

If preliminary studies are not conducted, then worst-case scenario estimates should be planned for sediment removal. Preliminary studies can limit the tying up of funds under worst-case scenario estimates by providing some insight into sediment quality, since there is such great uncertainty with what one might find once digging commences. See section 2.1.1 for a discussion on the value of preliminary studies. Additionally, having cost-effective and environmentally beneficial re-use scenarios for sediment can be influential as a project motivator.

3.2.2 Restoration Issue: Soil amendments can transport invasive plant species during restoration construction. Similarly, water trucks can carry aquatic invasives.

Soil amendments commonly made to balance salinity or to increase organic content can transport seeds from previous jobs. Often, animal-derived fertilizers can contain seeds. Restorations are particularly sensitive to the introduction of seed stocks since there may be a significant lag in planting after soil amendments, allowing opportunistic seed stocks to thrive. Additionally, water trucks have the potential to transport New Zealand Mud Snails in addition to other aquatic invasives.

Sediment itself can provide significant hurdles during the restoration process, sediment contamination (chemical and biological), quality, and quantity are critical variables to consider prior to and during the construction process.



BMP: Site managers need to ensure that sediment trucks are sterilized from previous jobs if soil amendments are made.

This requires great effort on the part of site managers to convey the importance of sterilizing trucks and the potential negative effects contaminants could otherwise have on the project. This particular sediment scenario was very problematic for the restoration of Carpinteria Salt Marsh.

The Malibu Lagoon restoration went to great lengths to prevent aquatic invasions coming into and also potentially leaving the site. All trucks coming on-site had to be steam cleaned with water temperatures in excess of 212°F. Contractors were required to provide proof of sterilization, which was done through the use of logbooks for any trucks or equipment that had contact with the lagoon water. All equipment that had contact with the water had to be pressure washed and steam cleaned in a special area and then was required to remain on-site for 72 hours after it was cleaned.

3.2.3 Restoration Issue: When to dig or not to dig tidal creeks? Forcing fine grading is very expensive and does not always replicate creek dynamics.

The question of “When to dig or not to dig?” has been shown to be inconsistent throughout the region. In portions of Tijuana Estuary, instead of incising the whole tidal creek, a network was jump-started by beginning small erosion excavations. These starter creeks were dug right at the channel’s edge with the intention that tidal creeks would then form on their own. In Tijuana Estuary, the process resulted in great success and the development of a tidal creek network. However, at San Dieguito Lagoon, which employed a very similar strategy, tidal creeks failed to develop.

BMP: Dig more extensive tidal creeks if historical processes (hydrological, wind, tidal currents, etc.) are no longer in place. Hydrologists/geomorphologists are an important component of the design team and will be the best judge of remnant historical hydrological processes.

Understanding why the same technique for restoring tidal creeks worked at one site and not another (even within the same county) is dependent on many variables, including the grading and shape of channels. Wetland managers interviewed agree that the best insight into the need for a simple jump-start or digging a full tidal creek network is largely dependent on the remnant hydrological processes. In both scenarios, biologists voiced concerns over the digging of only linear creeks. A more sinuous natural design is preferred by biologists and could be modeled with hydrologists to determine the most likely path to success. Also see discussion on incorporating historical processes into restoration design and the importance of interactions between biologists and engineers (see sections 2.4.1–3).

3.3 Vegetation Community Complexities

Vegetation complexities are perhaps one of the most studied components of restoration because the questions lend themselves best to the general structure of academic science (matching the timescales of Master and Ph.D. dissertations). The depth of science can complicate matters for wetland managers who are looking for simple solutions to solve planting problems. The problems discussed in this section target large-scale issues that can have sweeping effects on planting outcomes. The intent of this section is not to diminish the importance of bottom-up processes and understanding of vegetative communities, but rather to guide contractors with effective strategies that will provide the greatest benefit or circumvent many problems in a single action. The importance of adaptive restoration (see section 3.1.3) can allow biologists to understand the intricacies of plant communities. This can be especially important when planning microhabitat dynamics that may help slow habitat transgression and loss (see section 2.4.2).

3.3.1 Restoration Issue: Restoration can inoculate and introduce genetic plant pollutions and disease.

Understanding plant stock origins is important to reduce unintended genetic and disease introductions. The rate of genetic introductions will likely increase if biologists/botanists are not available to identify plant species/stock before they are used. Off-site nurseries offer another opportunity for plant contamination to enter the system. When it is necessary to go off-site to obtain species that are no longer present at the site in order to increase species diversity or to provide a habitat for sensitive species (e.g., cord grass), closely examining the plant stock for scales, fungus, and other potential disease is important.²²

BMP: On-site nurseries can reduce plant introductions. Know where plants come from and if they have known hybrids to help prevent unwanted species introductions.

On-site nurseries are critical for large-scale restorations. In addition to reducing introductions, plant salvage and on-site rearing can reduce the costs of planting effort. Seed collection and plant salvage must occur prior to breaking ground.

²² Zedler J.B., (2000) Handbook for restoring tidal wetlands. CRC Press.

Reduction of unintended introductions of plants and animals requires a great effort on the part of the on site project team.



3.3.2 Restoration Issue: Seedlings are more sensitive than older plant stages.

Seedlings require more intensive care (increased watering and weeding in upland areas or carefully managing inundation timing in low-lying areas) to increase survival rates, but older stages are much more expensive and can require extensive nursery space and time to rear.

BMP: Plant salvage should occur far enough in advance to allow a variety of maturation stages for each species (i.e., variably aged plants, not just sprouted juveniles).

Salvaging multiple plant stages can provide cost savings over purchasing older phases and can reduce unwanted genetic and disease introductions. Plant salvage should ideally occur three full planting seasons prior to major earth-moving elements. Salvage should also occur at the time of clearing and grubbing of vegetation. Plant growers will need to be on-site during the clearing and grubbing operations to ensure collection and salvage of appropriate plant species. An added benefit of planting older stages includes the ability to meet habitat goals sooner than if seedlings alone were used. Plant sensitivity at any stage is greatest in areas that are submerged for long periods of time and additionally in areas that are not frequently inundated. Timing of planting is critical for areas inundated for long periods of time (see section 3.3.4). Hydroseeding, which typically consists of applying a stabilizing emulsion with hydro-mulch equipment, can temporarily protect exposed soils from erosion by water and wind in areas that are not frequently inundated.

3.3.3 Restoration Issue: There is a lack of understanding of which plant species must be planted and which will recruit naturally.

Species with the ability to propagate through trimmings and cuttings are likely to be present in the soil and water despite the earth moving. Pickleweed (*Salicornia sp.*) is an example of an important habitat-forming species that has the ability to recover without planting efforts.

BMP: If there is a natural source of pickleweed, there is no need to plant it unless faster results or additional salinity reduction is needed. Monitor recruitment and phase planting to increase plant diversity throughout the restoration.

Pickleweed is an important ecosystem engineer that reduces soil salinity by preventing rapid evaporation of salt water, thus reducing the formation of salt pannes. Of course, relying on sites to recover naturally requires extended times to meet habitat criteria, increased weeding efforts to reduce competitive dominants, and potentially increased patchiness of species.

3.3.4 Restoration Issue: Timing is important for planting. If one phase is delayed, the timing will be off for subsequent phases and can have drastic effects on planting.

The length of tidal inundation is a key element of transplant survival. There are many reasons that a project can be delayed (see section 3.1.4) that may interfere with planting schedules. The pressure to finish on time and utilize contractors and/or volunteers when they are scheduled can cause the planting effort to be forced during less than optimal tidal conditions. Some areas may require being isolated from inundation for an establishment period.

BMP: Consider surprises/delays (e.g., finding native artifacts) and think of the cost of loss of entire plant seed/juvenile stock in timing adjustment.

If the timing is not right for planting because of unanticipated delays consider delaying planting until the timing is right. The cost of losing a carefully reared plant stock may be much more costly (both financially and in regard to genetic diversity) than waiting. Some areas may require being isolated from inundation to ensure adequate timing for plants to establish. Some plants will need to creep down from above or be allowed to grow tall enough so that they can float above water surface level (see section 3.3.2).

3.3.5 Restoration Issue: Planting is generally done all at once. Phased planting is financially constraining and can affect soil salinities.

Planting completed in a single phase removes the opportunity for adaptive restoration. Phased planting can allow salt crusts to form in areas that were graded/cleared, but not replanted immediately. These salt crusts can prevent seed germination from existing seed banks. Allowing for natural recruitment means weeds also have the opportunity to establish.

BMP: If high salinity is not a factor, planting in phases allows you to wait (up to a year if hydrology has been significantly altered) to see what naturally recruits. Natural recruitment may have less diverse plant populations, but microtopography resulting from allowing hydrological processes to settle can help keep plant diversity higher.

The length of tidal inundation is a key element of transplant survival.



Phased planting can allow hydrological processes to settle, which is especially important when cutting only starter creeks that are anticipated to develop further creek networks (see section 3.2.3). Phased planting will help determine which plants are thriving in certain areas, allowing for subsequent plantings to be more carefully honed. Weeding efforts are important immediately after planting, particularly in upland habitats, and should coincide with phased planting efforts to prevent competitive exclusion of desired species.

3.3.6 Restoration Issue: Much of elevation and plant species range literature is based on Tijuana Estuary, which is constantly open, with a very different tidal regime than other southern California wetlands.

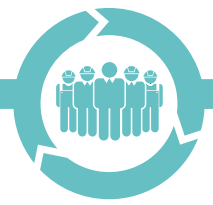
Relying on a single range for plant species throughout the region can result in loss of transplants or plants growing in unexpected places. Soils are often redistributed throughout the site, which may affect salinity and, therefore, plant tolerance and range within the site. Species ranges greatly influence the placement of species that did not occur at the site prior to restoration.

BMP: Use a comprehensive scientific basis for predicting plant distributions to better understand how tidal regimes vary throughout the region. Use of pre-restoration plant distribution data for the site will more realistically predict plant distributions (high vs. mid-marsh, etc.).

Understanding of site elevation and vegetation ranges pre-restoration is likely to be a better indicator of where those species may occur post-restoration. Consider how ranges might be affected by soil amendments of increasing elevation. If dredge sediment is reallocated in the site, consider the change in soil salinity and the consequence to plant species assemblage. In seasonally closed wetlands, consider planting slightly above expected elevations to account for long periods of being submerged. For new introductions of species that did not exist prior to restorations, consider where the plants came from and the species that surrounded them in their original habitat. Then, plant desired introductions adjacent to those species that surrounded them in their original habitat.



Photo credit: M. Abramson



4. POST-RESTORATION BEST MANAGEMENT PRACTICES

While post-restoration problems arise during management, most of this section's BMPs should be implemented during the planning phase. Implementing these BMPs during planning will allow for the development of creative solutions for the complicated problems associated with climate change. Even the best-laid plans and best management practices can still result in projects that fail to meet project goals or provide proper wetlands function. Monitoring and multi-priority adaptive management plans can be used to ensure that restoration goals have been met and provide maximum benefits through proper wetlands function. Adaptive management can be defined as the best action that is developed through monitoring and assessment of the dynamic relationships (both physical and social) rather than being developed a priori.²³ Restorations mature over time, and feedback between species compositions and ecosystem processes will develop over different timescales.²⁴ Adaptive management acknowledges the insufficient basis for decision-making. This allows an iterative process, utilizing recommendations and research post-restoration to increase the benefits of the restoration effort. "No regret" strategies, actions that generate net social and ecological benefits under all future scenarios of climate change, include both adaptation and mitigation as co-benefits.²⁵ These "no regret" strategies will be necessary in coastal wetland management to meet the needs of today and provide flexibility for future climate change planning.



Photo credit: C. Nordby

23 Thom, R.M. 2000. Adaptive management of coastal ecosystem restoration projects. *Ecological Engineering* 15:365-372

24 Palmer, M.A., Ambrose, R.F., Poff, N.L. 1997. Ecological theory and community restoration ecology. *Restor Ecol* 5:291-300. doi: 10.1046/j.1526-100X.1997.00543.x

25 Heltberg, R., Siegel P.B., Jorgensen S.L. 2008. Addressing human vulnerability to climate change: toward a "no regrets" approach. *Global Environment Change* 19 (1):89-99.



4.1 Monitoring and Adaptive Management

Monitoring is the yardstick by which wetland managers justify actions and adapt management strategies in order to best achieve restoration goals. Thom 2000²⁶ and many others loosely define adaptive management as “learning by doing,” but as previously discussed, this definition should be applied to “adaptive restoration” (see section 3.1.3). In order to be truly successful, adaptive management plans must be developed during the planning phase and implemented during the management phase to create the greatest likelihood of meeting project goals. When this strategy is employed, the definition of adaptive management turns from “learning by doing” to “learning from what has been done well in the past” while also incorporating the dynamic relationships (both physical and social) as a project develops. By initially anticipating potential problems and creating triggers for action during the planning stages, wetland managers can alleviate lag times and act quickly to modify problems. When considering adaptive management within the “learning from what was done well” framework, there is an even greater emphasis on the need to establish and track BMPs throughout the region.

4.1.1 Restoration Issue: Post-restoration management is generally reactive and underfunded because management issues were not considered during the planning process.

To the knowledge of all managers interviewed, Ballona Wetlands is the only restoration in southern California that incorporates an official adaptive management plan. However, all southern California projects identify project goals (with levels of clarity and conciseness varying), but few of these identify clear performance criteria by which to judge the restoration. Even fewer projects identify triggers for action. Without clear measurement criteria that identify triggers for action, the ability to adapt management strategies becomes much more difficult or may only occur after the system has become highly degraded.

BMP: Use a proactive adaptive management plan that clearly identifies potential problems, triggers for action, and the agency responsible for action. Proactive adaptive management plans can provide pathways for funding and action before problems arise.

By establishing a formal adaptive management plan during the planning phase, wetland managers have the greatest opportunity to consider potential problems and apply previous learning experiences from other restoration projects. Anticipation of post-restoration problems allows for the opportunity to allocate funds specifically for identified problems or at the minimum allow for a period of optimization post-restoration that would otherwise exclude maintenance and monitoring (see section 3.1.4). Not all problems anticipated during planning will arise, and other problems not considered are also likely to occur, but a formal adaptive management plan developed during planning is the best opportunity for the full project team to consider what has been learned from previous restoration efforts throughout the region.

²⁶ Thom, R.M. 1997. System-development matrix for adaptive management of coastal ecosystem restoration projects. *Ecological Engineering* 8:219-232

4.1.2 Restoration Issue: Nesting islands are often ineffective immediately after restoration and have high maintenance requirements.

Southern California restorations that have utilized nesting islands such as Batiqitos Lagoon and San Elijo have found that there are inherent problems with utilizing nesting islands for restoring target species. While an island can decrease access to predators, it also decreases access for management purposes by requiring a water crossing for maintenance purposes. Nesting habitats require heavy weed control and maintenance of vegetation to very specific levels of cover. If the islands are not constructed properly (e.g., substrate composition is wrong for the targeted species of interest), augmentation of the islands may be more drastic than simple maintenance. Additionally, even when islands are constructed and maintained properly, predator control may still be a problem.

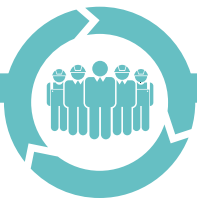
BMP: Utilize current knowledge regarding construction of nesting islands and plan for heavy maintenance (weed and vegetative control and monitoring, augmentation of sediment, and, in some places, fence construction) of islands/habitats in order to produce productive nesting habitats.

Very detailed habitat suitability characteristics for the endangered California Least Tern (*Sterna antillarum browni*) are provided in a study comparing San Dieguito Lagoon nesting sites to five other southern California nesting sites.²⁷ Characteristics measured included shell cover (13%), soil compaction (reading of 60), vegetation cover (7%), organic cover (3%), soil texture, and organic content (.63–.82%). This study creates an almost formulaic recipe for the construction of Tern nesting islands, but these islands are still very difficult to maintain. Predator control has been shown to be paramount in the recovery of target species in nesting habitats. Predator control includes building fences when necessary. Chain-link fencing combined with the use of layered chick fencing and Nixalite (an anti-perching measure) can prevent the drowning of chicks and predatory birds from perching and waiting to attack (based on the US Fish and Wildlife recommendation to improve San Dieguito nesting habitats).

In light of these difficulties to construct and maintain nesting islands, one should consider the tradeoffs made when restorations are managed for a single species (see section 2.1.2). Consider the possibility of target species and their associated habitats being managed on a regional scale rather than trying to make every wetland project all inclusive (see section 2.4.4).

To the knowledge of all managers interviewed, Ballona Wetlands is the only restoration in southern California that incorporates an official adaptive management plan.

²⁷ WRA. 2009. Nesting Site Suitability Study. A technical memorandum prepared for SCE–San Dieguito Wetlands Restoration Project



4.1.3 Restoration Issue: Uplands, high marsh, and public access areas take longer to restore due to management of invasive species.

Edge habitats such as uplands, high marsh and areas accessible to the public are subject to greater potential for invasive introductions due to both human influence and domestic/feral animals. Long time lags between monitoring periods can allow invasive, opportunistic and competitive dominants to take hold and negate initial restoration planting efforts and cause habitats to recover much more slowly.

BMP: Monthly maintenance of uplands, high marsh, and public access areas should be required for the first few years in order to reduce the abundance of invasive species. Monitoring should consist of visual observations of invasive weeds and an estimate of total cover within specified habitat areas.

Because maintenance is often underfunded, use of an optimization period (see section 3.1.4) can aid in providing funds for the extra maintenance needed in these vulnerable areas. If city or other management districts are responsible for maintaining weeds/invasive species on the periphery of wetlands, collaborate with agencies to develop a strategy to inform and partner with them to meet maintenance needs. Additionally, “friends” and other community groups can be trained to monitor and remove invasive species with proper guidance from agency persons/biologists. The photo on the right shows community members organized by Friends of Ballona Wetlands removing invasive grasses in upland areas adjacent to residential homes on the periphery of Ballona Wetlands. Training materials such as visual flashcards of invasives and native plant species can help volunteer-based groups to become a very effective and low-cost tool to remove and monitor invasives. The added benefit to utilizing community groups is the increased community ownership and knowledge of the restoration project.



Photo credit: S. Fejtek

4.1.4 Restoration Issue: How to determine if a restoration is successful

Project goals should define the necessary endpoints by which project success is gauged. The word “success” has been used in many ways, including: to judge/predict outcomes, to refer to specific attributes of a project (such as colonization success or compliance success), and as criteria by which to judge a project.²⁸ A majority of interview subjects supported the latter view of success, provided that there are clearly defined criteria established during the planning process.

BMP: Evaluate restoration “progress” based on specific criteria that focuses on function and processes. Use criteria that is reviewed by a subcommittee of scientists to agree upon which monitoring methods should be used for each criterion to best infer wetland function.

Use of criteria and indicators that correlate with the reestablishment of function and process can be good indicators of progress. Establishing landmarks in restoration progress, such as major changes in function or key species population growth, can provide funding agencies and the general public with the social fulfillment needed to justify supporting future restoration efforts. Evaluation of native and invasive vegetation is useful, but hydrological and biogeochemical conditions are necessary to fully infer return of wetland function. The Army Corp of Engineers suggest evaluation criteria that includes physical, hydrological, flora/fauna and water quality attributes such as those in Table 2.²⁹



Photo credit: C. Nordby

^{28, 27} Zedler, J.B. 2007. Success: an unclear, subjective descriptor of restoration outcomes. *Ecological Restoration* 25:162-168

²⁹ United States Army Corp of Engineers. 2012. 12505-SPD Regulatory Program Uniform Performance Standards for Compensatory Mitigation Requirements

Table 2. Evaluation criteria adapted from the U.S. Army Corp of Engineers' recommendations for coastal wetlands

Evaluation Criteria Type	Evaluation Criteria	Target for Measurement of Evaluation Criteria [Suggested Measure]
Faunal	Use of the Shannon-Wiener Diversity index of target riparian/aquatic species present within the boundary of project site, including approved buffer, equal to at least 80% of reference site by year 5	Diversity [Shannon-Wiener Diversity Index] within 80% of reference site or peer-reviewed study for similar habitat type by end of monitoring period
Flora	Dominance of natives: ensure target (PM pick one or more: percent absolute cover [for combined strata], density, or height) of native species are met for tree, shrub, and herb strata by year 5	≥75% of reference; if no reference site: relative cover*: ≥75% combined strata
Flora	Dominance of exotics: ensure target (PM pick one or more: percent absolute cover [for combined strata], density, and height) are met for exotic species (tree, shrub, and herb) strata by year 5	≤ 100% of reference; if no reference site: ≤10% absolute cover with zero tolerance for species considered highly invasive [Cal-IPC List or equivalent regional list]
Flora	Recruitment: ensure target levels of new, native individuals are naturally recruited by year 5	≥75% of reference; if no reference site: ≥5% of dominance
Flora	Species richness: ensure target native species richness values of tree, shrub, and herb strata are met by year 5	≥75% of reference
Flora	Spatial habitat heterogeneity: ensure (PM pick one or more: vertical and/or horizontal) target spatial habitat heterogeneity is met by year 5	≥100% of reference
Hydrologic	Hydric Soil Indicators: Area intended to be wetlands must exhibit USDA NRCS hydric soil characteristics appropriate for the region (e.g., as determined by Corps Regional Supplements to the Corps Delineation Manual) by year X.	Case-specific: PM set target [soil pits]
Hydrologic	STANDARD VARIES BASED ON INTENDED INLET CONDITION: <u>Always open inlet</u> : The project site is open to free exchange of tidal waters, with no obvious hydrologic alteration or restrictions present. Seasonally open inlet: The project site tidal inlet is open at a frequency and duration to provide design-level site inundation and salinities. Rarely open inlet: The project site is not open to free exchange of tidal waters, except during rare extreme hydrologic events (typically occurring once or twice per decade).	Specific target depends on tidal inlet type and should be informed by regional reference site information. [V _{HYDRO} Table 9 in Regional HGM Guidebook for Northwest Gulf of Mexico Tidal Fringe Wetlands provides a target for always open inlets; it also represents the opposite condition for the rarely open inlet type. See Jacobs et al.'s Classification of CA Estuaries Based on Natural Closure patterns for additional guidance in SCB.]
Hydrologic	The project site must maintain total aquatic edge (tidally wetted linear edge measured at Mean High Water [MHW]) within 10 percent of as-built conditions, as well as comparable distribution of aquatic edge-providing features across the project site sufficient to support the target habitats. (Note the target for measuring linear aquatic edge can be modified to High Tide Line or another datum if less frequently flooded areas [i.e., less frequently than daily] are also of interest.)	Case-specific: PM set target (10% as default for aquatic edge area); standard can also be modified (e.g., measured at High Tide Line (HTL)) to include less frequently flooded (less than daily) areas to evaluate distribution and sustainability of higher marsh habitat types; increases in aquatic edge, even if above the target percentage, may be acceptable (depends on restoration goals). (Conduct annual analysis of aerial photographs or field surveys of all aquatic features).
Hydrologic	Groundwater in the target tidal habitat type(s) in the project site occurs within X feet of the ground surface during the wet season and Y feet of the ground surface during the dry season.	Case-specific: PM set target (observation of water in soil pits at the recommended depth during the recommended season, or installation of piezometers and measure water level at recommended intervals/seasons)
Physical	The buffer adjacent to aquatic resource habitat at project site is dominated by native vegetation and has undisturbed soils. Specifically: a) By end of year N, at least % cover by native vegetation; b) Permittee shall document undisturbed soils throughout buffer.	Case-specific: PM set target [CRAM Field Book]
Physical	Project site soil surface elevations must vary less than 10 percent compared to as-built conditions, excluding areas affected by tidal channel or inlet migration and similar natural/non-anthropogenic	Case-specific: PM set target (10% as default) (e.g., +2 ft MSL as-built elevation would be expected to vary less than 0.2 ft)
Physical	Project site must provide different physical features or surfaces capable of dissipating wave energy, storing water, organic matter, and sediment, and providing habitat for organisms.	[Estuarine CRAM field book's structural patch richness] description provides a generic target that could be modified to suit the region
Water Quality	Ensure an appropriate index of aquatic invertebrate health is within 10% of reference	Within 10% of reference (Benthic IBI, EPT index)
Water Quality	Organic carbon	≥75% of reference (% soil organic carbon)
Water Quality	Net primary productivity	≥75% of reference (g NPP/sq meter)
Water Quality	Redox Potential	+/- 1 unit of reference (pE)
Water Quality	Pollutant reduction: measure concentration inflow/outflow	Case-specific: PM set target (concentration inflow–concentration outflow)
Water Quality	Pollutant reduction: measure change in mass balance	Case-specific: PM set target (change in storage)
Water Quality	Pollutant reduction: measure change in sediment chemistry	Case-specific: PM set target (change in concentration)
Water Quality	Pollutant reduction: measure sediment accumulation	Case-specific: PM set target (inches of accumulation)
Water Quality	Pollutant reduction potential	Case-specific: PM set target (NO3 lost/unit time)
Water Quality	Dissolved oxygen	Case-specific: PM set target (mg/L)

4.2 Climate Change: Managing Wetlands Resources in a Warming World

There is still great uncertainty regarding climate change-induced effects on precipitation and ocean acidification, but California has the recent benefit of statewide mandated SLR projections. In response to Governor Schwarzenegger’s 2008 executive order, the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT) was created. CO-CAT’s responsibilities are to ensure the state’s ability to adapt to climate change impacts on ocean and coastal resources while supporting implementation of global warming emission reduction programs. The State of California Sea Level Rise Guidance Document was designed to create consistency across agencies in their development of approaches to SLR.³⁰ Perhaps most important is the designation of a use of SLR ranges (Table 3. from the NRC 2012 report on SLR)³¹ for considerations of risk tolerance and adaptive capacity. Managing wetlands resources with climate change will differ throughout the region due to uncertainty of climate change predictions, structural complexity of a site (current and future human infrastructure both within and surrounding a site), and the age of the restoration project approval.

Agreed upon SLR estimates allow planning entities to enhance consistency across agencies in their development of approaches to sea level rise.

Table 3. NRC 2012 Sea Level Rise Projections Using 2000 as the Baseline

Time Period	South Cape Mendocino
2000–2030	4 to 30 cm (0.13 to 0.98 ft)
2000–2050	12 to 61 cm (0.39 to 2.0 ft)
2000–2100	42 to 167 cm (1.38 to 5.48 ft)

30 CO-CAT Coastal and Ocean Working Group of the California Climate Action Team. 2013. State of California Sea Level Rise Guidance Document. Can be found at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf

31 NRC (National Research Council). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington. National Academy Press



4.2.1 Restoration Issue: Managing projects in the face of climate change is complicated due to levels of uncertainty of SLR predictions and consistency of ranges among agencies.

Current SLR projections primarily vary due to uncertainties about future global greenhouse gas emissions and modeling of land ice melting rates.³² SLR will have different effects based on regional geographic scales that are much larger than the southern California region. The NRC projections (see Table 3) are divided at Cape Mendocino based on tectonic movement. Additional components that can affect SLR on a more local scale include sediment compaction/accretion/subsidence and pumping of groundwater and/or hydrocarbons. Models that focus on a more local scale can provide a better understanding of the potential influence SLR will have on past, current, and future projects.

BMP: Models must include a range of SLR projections if we hope to account for variation in sea level rise estimates. Coordinate with other state agencies to use the same projections of SLR when evaluating projects.

The State of California Sea Level Rise Guidance Document recommends using SLR ranges from the 2012 National Research Council findings to create a greater consistency across agencies in their development of approaches to SLR.³³ For projects developed by or under the regulatory authority of multiple agencies, using the same SLR values will increase efficiency of analyses. As changes occur within the watershed, such as dam removals or reduction of channelization, site models will need to be updated to maintain a more accurate estimate of climate change effects on the wetland.

4.2.2 Restoration Issue: Few areas in southern California provide opportunities for transgression.

Wetlands are likely to respond to SLR in two major ways: 1) transgression of habitats through inland expansion of wetland vegetation zones and submergence at lower elevations and 2) interior ponding and marsh drowning.³⁴ Urban areas like southern California are often surrounded by development and therefore unable to naturally transgress inland. Approximately 40% of the coastline covered by wetlands in southern California lack viable areas to transgress.³⁵ Many plants are less productive when inundated,

32 Stocker, T.F., Qin, D., Plattner, G.K., et al. 2013. IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press

33 CO-CAT Coastal and Ocean Working Group of the California Climate Action Team. 2013. State of California Sea Level Rise Guidance Document can be found at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf

34 Titus, J.G., Hudgens, D.E., Trescott, D.L., et al. 2009. State and local governments plan for development of most land vulnerable to rising sea level along the US Atlantic coast. *Environ Res Lett* 4:044008. doi: 10.1088/1748-9326/4/4/044008

35 Heberger, M., Cooley, H., Herrera, P., Gleik, P.H., and Moore, E. 2009. The impacts of sea level rise on the California coast, Rep. CEC-500-2009-024-F, 101 pp., Calif. Energy Comm., Sacramento

creating feedbacks that can quickly result in transformation and eventual loss of habitat.³⁶

BMP: Retreat when possible and invest heavily in projects that still have opportunity to transgress.

Common SLR policy strategies include protection, accommodation, and retreat. Planned retreat limits armoring, discourages development in threatened areas, and plans for the eventual relocation of structures inland in the path of rising sea levels.³⁷ Retreat is paramount in providing wetlands the area needed for natural habitat migration. Preventing further development along the landward edge of wetlands through land acquisition, regulation or zoning can provide protection for development. Projects that are surrounded by infrastructure should not be abandoned due to the possible potential for relocating public infrastructure. It may be in the interest of public safety to relocate such structures in the future anyway due to SLR. Investing heavily in projects with few obstacles to natural transgression is ideal. Restoration projects that include diversions, levee construction, and channelization efforts should be evaluated in terms of their impacts on supplying necessary sediment and capacity to facilitate habitat shifts with SLR. For example: the Ballona Wetlands Ecological Reserve Restoration Project utilizes concrete flood control levees that may allow for needed habitat shifts but also could prevent the necessary increase in flood plain capacity with SLR.³⁸ Therefore, there is a careful balancing of protection and preservation of ecological functions needed in the restoration management and planning process.

A suitable area for retreat is paramount in providing wetlands the area needed for natural habitat migration.

36 Cahoon, D.R., Hensel, P.F., Spencer, T., et al. 2006. Coastal Wetland Vulnerability to relative sea-level rise: wetland elevation trends and process controls. Wetlands and natural resource management. Springer, pp 271-292

37 Grannis, J. 2011. Adaption Took Kit: Sea-Level Rise and Coastal Land Use. Georgetown Climate Center. Can be found at: http://research.fit.edu/sealevelriselibrary/documents/doc_mgr/456/SLR_Adaptation_Tool_Kit_-_Grannis_2011.pdf

38 Climate Change in Urban Estuaries Symposium Proceedings. 2013. Santa Monica Bay Restoration Commission



4.2.3 Restoration Issue: Older phased restoration projects did not incorporate climate change in planning.

Interviewees agreed that older projects (even those completed as recently as 2013, i.e., Malibu Lagoon restoration) failed to include climate change considerations in the planning process. This leaves managers to now determine how best to adapt to climate change without large-scale projects. The project will likely meet short-term goals, but may struggle in the near future to continue to meet long-term project goals under climate change.

BMP: Use project phasing to incorporate climate change needs if portions of restoration have already been completed without including climate change considerations.

Projects that are built in phases provide the best opportunity to meet both short-term and long-term goals, avoiding future full-scale restoration projects. Phasing allows the employment of adaptive restoration (see section 3.1.3) to meet short-term goals while allowing time for science to develop, providing the best chance to meet longer-term goals. Phasing projects requires strong project team fidelity to maintain decision-making intent and coordination between project phases.

4.2.4 Restoration Issue: Strict habitat targets will be difficult to maintain into the future with climate change. Evaluation criteria must change with climate change.

Setting evaluation criteria is important for assessing project progress (see section 4.1.4 and Table 2). Strict habitat targets, as often defined in mitigation permits, may trigger actions to solve today's short-term problems instead of considering the lifetime of a project.

BMP: Evaluation of project progress (habitat area requirements) should be rethought. Establish broader targets with the understanding that wetlands are dynamic systems. Avoid measuring progress based on variation from the original vision. Not only do these systems evolve over time, but habitats will shift drastically depending on SLR and availability for transgression.

See section 4.1.4 and Table 2 for a larger discussion regarding evaluation criteria and determining the success of a restoration.

4.3 Design Elements That Encourage Effective Management

Design elements that can have important management and maintenance implications include access, structural components, and grading. Expectations of project progress can influence how the project is assessed and can affect how the project is ultimately viewed by funding agencies and grant providers. Design elements are perhaps the most site-specific of the planning and managing portions of restoration. Projects completed throughout the region have the advantage of hindsight and the recognition that had BMPs discussed within this section been applied during the planning process, these issues could have been lessened in severity or, in some cases, avoided altogether.

4.3.1 Restoration Issue: Feral animals and people entering the wetland

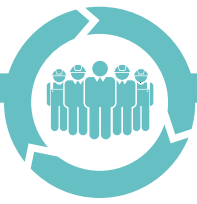
The influence of feral and domesticated free-ranging cats can cause substantial wildlife mortality and are speculated to be the single greatest source of anthropogenic mortality for US birds and mammals.³⁹ Methods by which project design can reduce unwanted intrusion of both animals and people should be considered.

BMP: Use water crossings near the periphery/sensitive habitats to reduce animal and human intrusion.

Water crossings incorporated into project design can thwart both animals and people from entering sensitive habitat areas and help safeguard protected species. The depth of the water is not necessarily as important as the frequency of inundation. Creeks that are only seasonally inundated dry out and may even act as corridors of transportation, but those creeks that are inundated regularly enough for the soil to remain saturated are often just as uninviting as deep water to both people and animals.

Creative solutions will be necessary to balance short-term and long-term goals with sea level rise.

³⁹ Loss, S.R., Will, T., Marra, P.P. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nat Commun* 4:1396. doi: 10.1038/ncomms2380



4.3.2 Restoration Issue: Natural processes may take decades or centuries to develop, but projects expect results in the first few years after restoration is complete.

Restoration design strongly influences the pace at which a project progresses. The decision to open or close inlets (see section 2.4.1) and the grading of habitats (see section 2.4.2) both influence the progress of a restoration. The timescales along which processes occur vary drastically. Timescales of ecological processes should be considered during goal setting in order to determine how best to evaluate project progress.

BMP: Set intermediate goals (1-yr, 5-yr, 10-yr post-restoration) that work toward large objectives to allow for natural development of wetland.

4.3.3 Restoration Issue: Infrequent inundation can cause incorrectly graded sites to fail to meet performance standards for vegetation, but grading lower will be more sensitive to sea level rise.

This is a prime example of how managers are conflicted with meeting both short-term and long-term goals (see section 2.5.2).

BMP: If performance goals are in place, but the project is still conscious of sea level rise, then grade elevations a little higher, but use irrigation for the immediate future to meet performance goals of today.

Creative solutions will be necessary to balance short-term and long-term goals. Irrigation systems leave more of a human footprint and may be more expensive than grading. However, this provides the benefit of meeting performance criteria today while avoiding the future cost and impact of using heavy equipment to increase elevation to withstand future SLR.

4.4 Budgeting for Future Management Needs

Often, once goals or permit requirements (in the case of mitigation) have been met, there is little incentive or requirement for an agency to continue their efforts.⁴⁰ Thus, monitoring and adaptive management (including operations and maintenance) are underfunded and often lack the structure to coordinate efforts between biologists, engineers, and modelers to make educated decisions to meet management needs.

⁴⁰ Sudol, M.F., Ambrose, R.F. 2002. The US Clean Water Act and habitat replacement: evaluation of mitigation sites in Orange County, California, USA. *Environmental Management* 30:0727-0734.

4.4.1 Restoration Issue: Considerable finances and effort are required to maintain permanently open systems

If the project includes the decision to maintain an open inlet (see section 2.4.1), then funding in perpetuity should be considered during planning. Funds allocated under current climate conditions may be inadequate to maintain an inlet opening with SLR. As SLR occurs, inlets that were once capable of being cleared through the use of standard heavy equipment may require the use of more costly (and likely more frequent) floating dredges.

BMP: Allocate appropriate funding to keep the inlet open in perpetuity. In case of mitigation, require the mitigator to pay if the inlet is required to remain permanently open.

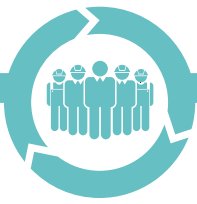
Water quality and system dynamics can rapidly degrade upon closing, slowing project progress and reducing system functions. The currently utilized approach of finding funding as you go can risk public perception of the project and the benefits the restoration aims to provide.

4.4.2 Restoration Issue: Maintenance is generally underfunded.

BMP: A good estimate of what project maintenance issues are, estimates of the quantity of maintenance, and a good economic analysis are needed to accurately estimate costs. A period of optimization post construction can provide access to funding that would otherwise exclude maintenance and monitoring.

Employing an adaptive management plan during planning can be the best way for the entire project team to consider maintenance issues (see section 4.1.1). Estimates of the quantity of required maintenance should include a range under different scenarios. A good economic analysis is needed not only to realistically budget funds but also to safely invest project funds in a long-term endowment. Few projects have employed economists during restoration planning. This could provide the best insight to economic climate and how best to plan for future maintenance needs. Allocating an optimization phase during the planning process can allow for funds that are typically not allowed to cover operations and maintenance to be used post-construction (see section 3.1.4).

Employing an adaptive management plan during planning can be the best way for the entire project team to consider maintenance issues in advance.



4.4.3 Restoration Issue: There are currently limited planning and funding allocated for episodic events.

Current episodic climate events, such as Pacific Decadal Oscillations (PDO) and the more frequent El Niño Southern Oscillations (ENSO), coupled with increased storminess (more frequent extreme events with greater extremes) that are forecast with climate change can heavily impact wetland systems. Planning for environmental extremes is complicated and costly. The current approach in planning for extreme events operates under the assumption that these types of events are rare and that the cost of cleanup would be less than the cost of prevention of impacts.

BMP: A new approach is needed for dealing with episodic problems. In order to best estimate the effects of extreme events, recommendations should be based on evidence-based data coupled with worst case scenarios planning.⁴¹

Use of long-term data sets that capture events like PDO and ENSO extremes can be modeled along with extreme “king” tide events to best model potential increased impacts anticipated with climate change and SLR. Extreme event recovery funding will likely become more difficult to secure as coastal structures and homes are increasingly threatened. Approaches that provide habitat resilience and natural recovery require adaptive restoration approaches (see section 3.1.3) that allow for the testing of changing vegetation communities to determine the communities most likely to preserve biodiversity.⁴²

41 Sutherland, W.J., Pullin, A.S., Dolman, P.M., Knight, T.M. 2004. The need for evidence-based conservation. *Trends in Ecology & Evolution* 19:305-308.

42 Zedler, J.B. 2009. How frequent storms affect wetland vegetation: a preview of climate-change impacts. *Frontiers in Ecology and the Environment* 8:540-547.

5. LIST OF ACRONYMS

BMP – Best Management Practices

CEQA – California Environmental Quality Act

CO-CAT – Coastal and Ocean Resources Working Group for the Climate Action Team

CRAM – California Rapid Assessment Method

CWA – Clean Water Act

EIR – Environmental Impact Report

EIS – Environmental Impact Statement

ENSO – El Niño Southern Oscillation

EPT – Ephemeroptera, Plecoptera, and Trichoptera Index

ESA – Endangered Species Act

IBI – Index of Biological Integrity

MHW – Mean High Water

MLPA – Marine Life Protection Act

NRC – National Research Council

NPP – Net Primary Production

PDO – Pacific Decadal Oscillation

PM – Project Manager

RB – Resident Biologist

RE – Resident Engineer

SAP – Scientific Advisory Panel

SAT – Scientific Advisory Team

SCB – Southern California Bight

SCWRP – Southern California Wetland Recovery Project

SLR – Sea Level Rise

TAC – Technical Advisory Team



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