Delta Stewardship Council

Improving Habitats along Delta Levees:

A Review of Past Projects and Recommended Next Steps

Jessica Davenport, Darcy Austin, Jahnava Duryea, Daniel Huang, Daniel Livsey

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EXECUTIVE SUMMARY

This review of habitat improvements along Delta levees was conducted to support the development of the Delta Stewardship Council's (Council) Delta Levee Investment Strategy (DLIS), which focuses on flood risk reduction as the primary purpose of State levee investments. The report is intended to provide guidance to the Council to ensure that those investments also contribute to long-term improvement of river corridors, with net benefits for fish and wildlife.

The Council must ensure that the DLIS helps to implement the Delta Reform Act and the Delta Plan. The Delta Reform Act of 2009 established the Council and defined its mission: to achieve the coequal goals of water supply reliability for California and ecosystem restoration in the Delta, in a manner that protects and enhances the values of the Delta as an evolving place (Water Code section 85054). The Delta Plan includes 14 regulatory policies, including one that calls for levee projects to incorporate habitat benefits, where feasible, and another requiring the use of the best available science and adaptive management. This report is intended to support the application of best available science and adaptive management to habitat improvements along Delta levees.

It should be noted that levee-related habitat improvements alone are not expected to provide all the ecosystem benefits needed by native species. These projects take place within the larger context of ecosystem restoration in the Delta and Suisun Marsh, which will require more natural functional flows, restoration and conservation of a wide range of habitat types[1], improved water quality, and the management of nonnative invasive species. Nevertheless, given its significant role in Delta levee investments, the State must ensure that these habitat projects are part of a program that provides a net benefit for aquatic species in the Delta.

Restoration Mandates and Constraints

In addition to the Delta Reform Act, other previous legislative mandates require Delta levee projects to provide habitat improvements. Water Code section 12314(c) instructs the California

[1] The tradeoff associated with protecting productive farmland behind levees that also provides important terrestrial or seasonal wetland habitat versus breaching levees in order to restore aquatic habitat is an important issue. It will be addressed in the Delta Levee Investment Strategy, but it is beyond the scope of this paper.

Department of Fish and Wildlife (CDFW) to consider the value of riparian and fisheries habitat along riverine corridors. Water Code sections 12314(d) and 12987(d) require that state-funded Delta Levees Special Flood Control Projects, designed to improve Delta levees, must be consistent with a net long-term habitat improvement program and have a net benefit for aquatic species in the Delta.

In addition, levee construction and maintenance frequently results in impacts to habitat that must be mitigated according to the requirements of multiple regulatory agencies. Generally, regulatory agencies prefer that mitigation occurs on-site with in-kind functions. Due to various constraints, off-site mitigation was often used for projects in the Delta Levee Program, such as creation of marsh and riparian forest in the interior portions of islands, when habitat impacts were large during levee repair. When habitat impacts were relatively small, the RDs have satisfied their mitigation obligation through the purchase of bank credits (e.g., DWR's Bulk Credit Program).

Improvement of habitat along levees, whether for mitigation or enhancement, is challenging due to a range of regulatory and liability constraints. For example, the current nationwide policy of the U.S. Army Corps of Engineers (USACE) requires removal of trees and most shrubs from a "vegetation-free zone" on and around levees under their jurisdiction, and also prevents planting of most vegetation other than grasses within this zone. Federal legislation (Public Law 113-121, the Water Resources Reform and Development Act of 2014) required reevaluation of this policy by November 2015, but the reevaluation process had not yet been funded as of December 2015. In the meantime, the USACE allows local sponsors to apply for a variance, but the procedures for obtaining one are burdensome. Moreover, local sponsors responsible for USACE levees face a liability risk if they do not meet USACE engineering standards, i.e., they may not be eligible for rehabilitation assistance if their levees fail. Despite these constraints, it still possible to improve habitats along levees, especially in the waterside area beyond the vegetation-free zone (Figure 2).

Purpose and Approach

The purpose of this paper is to explore the question of how to ensure that future State levee investments, which are primarily aimed at flood risk reduction, also contribute to fulfilling the two State-level environmental mandates described above: 1) achieving the coequal goals, particularly with respect to ecosystem restoration; and 2) providing a net benefit for aquatic species in the Delta. The paper

provides a review of past projects, summarizes lessons learned from monitoring reports and through interviews with experts about which habitat designs may provide greater benefits to target native species, and provides guidance to ensure that project effectiveness can be better evaluated in the future. The paper also provides information about the costs of multi-benefit projects that combine levee construction and habitat improvements, as well as the costs of projects that improve habitats along levees but do not involve levee construction, e.g., projects that use riparian plantings to stabilize levee slopes and provide erosion control.

To collect the information required for our review of the effectiveness of habitat improvements along Delta levees, we conducted interviews with experts and, through coordination with other agencies and stakeholders, obtained project descriptions and associated monitoring reports and cost information. Project effectiveness was evaluated in terms of the project's stated objectives, performance measures, monitoring, and results, and whether or not a project could be shown to benefit target species.

Summary of Analysis

Our review of habitat projects found that the majority of reports used vegetation monitoring as a means of measuring success. Vegetation coverage is an indicator of habitat and is widely used as one of the ways to track progress in ecosystem restoration. However, the Delta is a highly altered ecosystem, and the relationships between vegetation coverage and benefits to target species are more complex than in systems that are closer to their historical ecological structure and function. Therefore, research and monitoring related to fish and wildlife response, as well as vegetation monitoring, is needed to determine whether projects are providing benefits to target species. Because fish and wildlife monitoring data were not available for most projects and existing data are inconsistent across projects, we were unable to compare the effectiveness of different types of habitat improvement projects. Instead, this report summarizes lessons learned from monitoring reports and through interviews with experts about which habitat designs may provide greater benefits to target native species.

Similarly, we experienced problems trying to accurately assess the costs of different habitat options associated with levee/habitat enhancement projects. Cost information for the habitat component of levee projects is rarely broken out from the risk reduction component (i.e., levee

construction or habitat improvements), making it impossible to cleanly parse out and compare costs of different types of habitat improvements. As a result, our analysis presents the total costs of projects (i.e., the cost of not only the habitat component, but also the construction of the flood risk reduction component) broken down broadly into different habitat enhancement project types, such as setback levee projects versus projects involving riparian planting within levee riprap.

Summary of Project Design Considerations

Despite our inability to draw firm conclusions regarding the effectiveness of different habitat improvement designs, our review of project monitoring reports did result in some observations regarding effectiveness that can inform the design of future projects. We examined four main levee structural modifications and related habitats: setback levees, adjacent levees, extra-wide levees, and planting benches (Figure 1, Figure 2, and Table 1).

Measuring Project Effectiveness and Lessons Learned

Monitoring the response of fish and wildlife to habitat improvement projects is an essential part of determining whether the projects are providing benefits to target species. Our review of monitoring reports from past habitat improvement projects confirmed the value of monitoring programs that measured project effectiveness in terms of both the amount of established structure (e.g., vegetation or woody material) and the wildlife response (e.g., use of habitat enhancement features by target species).

One of the primary lessons learned from this review is that habitat improvement techniques that have been shown to be highly effective in other systems may have beneficial, neutral, or even deleterious impacts on wildlife in the Delta. For example, although instream woody material (IWM) has been shown to benefit salmonids in other ecosystems, along the lower Sacramento River, high-density IWM increased occupation of invasive predatory fish by 20-fold while decreasing occupation of Chinook salmon fry by about 75% compared to control sites that lacked high-density IWM (FISHBIO 2015). However, IWM in low to medium densities correlated with enhanced occupation of salmonids and decreased invasive predatory fish (FISHBIO 2015).

Another important lesson is that planting riparian vegetation can be beneficial to native fish, even along levees protected by rock revetments. Along the lower American River, multiyear *post hoc* snorkel surveys indicated that out-migrating juvenile salmonids utilized riprapped reaches with riparian habitat and channel margin enhancements (e.g., shallow benches and IWM) at nearly the same frequency as control sites (i.e., “natural” non-riprapped levee slopes) (Fishery Foundation 2006).

These types of observations, learned directly from wildlife response monitoring, can provide the basis for developing Delta-specific best practices that maximize the potential for effective habitat restoration efforts.

Setback levees, constructed several hundred feet behind an existing levee, restore wide contiguous swaths of seasonal floodplain habitat by allowing reestablishment of natural riverine processes. In many parts of the Delta, however, particularly where islands are deeply subsided, setback levees are often infeasible because placing the huge amount of fill needed to bring the land up to floodplain elevation would be prohibitively expensive. Adjacent levees, constructed immediately behind an existing levee, often involve leaving the existing levee in place to protect the new levee from erosion. Adjacent levees, however, do not follow the conceptual model of providing ecosystem benefits through reestablishment of floodplain processes, and have not been monitored adequately to determine whether there are positive benefits to native species in the Delta. Given the high cost of setback levees

where Delta islands are at subtidal elevations and the uncertain ecological benefits of adjacent levees, expanding or modifying existing levees into "extra-wide" levees may be a more cost-effective option and may be more likely to be supported by landowners because they require less land conversion. Extra-wide levees (sometimes referred to as habitat levees) allow the levee to be graded to create a gradual waterside slope on which riparian, shaded riverine aquatic, and tidal marsh habitat can be established (Figure 2). In lieu of or in combination with an extra-wide levee or an adjacent levee, a planting bench on the waterside levee slope may be installed to provide the appropriate depths and elevations for establishing channel margin habitat. These benches may be stabilized with riprap (broken rock) covered with a mixture of soil and rocks that can support tidal marsh and/or riparian vegetation.

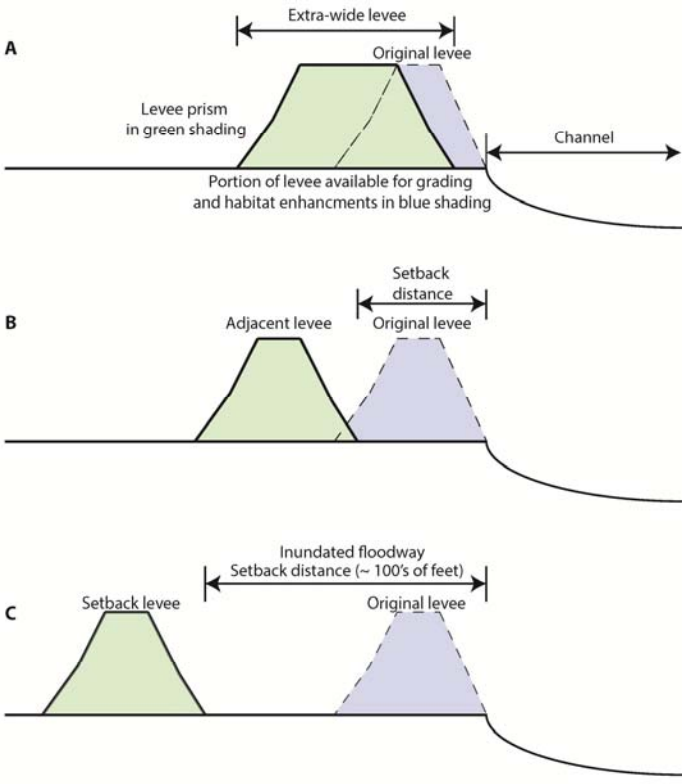

Figure 1. Illustrations of extra-wide, adjacent, and setback levees.

Figure 2. Diagram of an extra-wide levee with a planting bench on waterside toe of levee.
[1] Vegetation management zone (VMZ) in the diagrams is the same as the "vegetation-free zone" defined in the USACE's national policy, described above. Note that the riprap placed in planting bench along waterside levee slope for erosion control is also designed to prevent levee damage from burrowing mammals. Adapted from DWR 2014.

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Table 1. Principal considerations for Delta levee structures and related habitats.

	Setback levee	Adjacent levee	Extra-wide levee	Planting bench[a]
Definition	A levee constructed several hundred feet behind an existing levee which allows for removal of a portion of the existing levee and creation of additional floodplain connected to the channel.	A levee constructed immediately behind an existing levee. It may not necessarily result in removal of the existing levee.	A levee that has been widened to shift the regulated levee prism landward, creating more space for habitat improvement next to the channel and enhanced flood protection.	A terrace that creates a stable structure for establishing vegetation.
Habitat Benefits	Restores wide contiguous swaths of seasonal floodplain habitat by allowing reestablishment of natural riverine processes.	May not achieve same ecosystem benefits as a setback levee, since it does not allow natural riverine processes to fully reestablish.	May not achieve same ecosystem benefits as a setback levee, but may provide more benefits than an adjacent levee since it allows for a gradual waterside slope on which riparian, shaded riverine aquatic, and tidal marsh habitat can be established.	May be installed on waterside levee slope to provide appropriate depths and elevations for establishing shaded riverine aquatic habitat.
Constraints / Opportunities[b]	Foundation of a setback levee and the land between original levee and new setback levee should be no lower than intertidal elevation in order to achieve floodplain habitat; cost of fill is prohibitive for setback levees on deeply subsided islands.	Useful when maintaining an existing levee in a highly erosive environment is more expensive in the long-term than shifting the prism of the levee landward (e.g., Twitchell Island levees).	By shifting the regulated levee prism landward, construction of an extra-wide levee creates more options for habitat improvement on waterside slope.	Planting benches may be infeasible in locations with especially high water velocity and steep bathymetric gradients on waterside slope because of erosion issues.
Land Conversion Considerations[c]	Required setback distance for habitat benefits is generally several hundred feet and would require substantial conversion of dry land to seasonal floodplain.	Requires less conversion of land than setback levees, but more than an extra-wide levee.	Requires less conversion of land than setback levees and adjacent levees.	Planting benches inherently replace shallow and intertidal habitats.

[a] Planting benches can be installed as a standalone feature along the waterside slope of a traditional Delta levee, or in association with construction of an adjacent levee or extra-wide levee.
[b] All levees face a common constraint related to soil type: Peat soils make for poor, unstable foundations for a new levee. Options to stabilize peat soils (e.g., soil compaction) are expensive. In addition, all habitat improvements that increase vegetation cover also increase the risk of attracting burrowing animals (e.g., beavers) that can undermine levee integrity.
[c] Land converted from levee-protected dry land to seasonal floodplain can often still be used for some types of farming and recreation.

Cost Analysis

The main objective of the cost analysis was to determine the incremental cost of incorporating habitat improvement components into levee construction projects, either through the creation of habitat features on-site (e.g., creation of a habitat bench) or through acquisition of habitat credits from a mitigation bank. We assessed cost ranges of multi-objective levee projects that included both risk reduction aspects and habitat improvements using data provided to us by California Department of Water Resources (DWR) staff. In the past, Delta levee construction projects that incorporated habitat elements on-site generally involved planting of trees within riprap. The costs for these multi-objective projects ranged from approximately $1,400 to $5,200 per linear foot ($7 million to $26 million per linear mile). Based on the cost data available for these projects, we were unable to differentiate the costs of restoring the riparian habitat from the costs associated with the engineering design and construction of the levee improvement work. The levee improvement work is usually the fundamental driver of the costs of these projects, and the scale of construction work will be different depending on engineering design considerations. As such, the total cost of a multi-objective project is not a good indicator of the cost of the habitat restoration component.

DWR staff also provided data on two pilot-scale on-site riparian habitat enhancements along levees whose costs ranged from $80 to $200 per linear foot; in comparison, off-site mitigation credits from a mitigation bank at the edge of the Delta cost $61 per linear foot. Credits purchased from this same bank cost $62,295 to $120,000 per acre[2] for riparian forest and freshwater marsh habitat, while the cost of off-channel habitat created in the interior Delta islands ranged from $45,000 to $563,800 per acre.

Recommended Next Steps

Based on the findings of the review, we recommend taking several steps to improve habitat project siting and ensure that project siting and effectiveness can be better evaluated in the future:

1. **Develop appropriate performance measures as part an adaptive management plan.** As required by Delta Plan Policy G P1, habitat improvement projects along levees should have

[2] Also includes required buffer acreage that comprises the mitigation bank.

adaptive management plans that include appropriate performance measures, including fish and wildlife response, to assess effectiveness in providing benefits to target species.

2. **Track the incremental cost of habitat improvements.** DWR has recognized the importance of breaking down the costs of multi-benefit projects into habitat and flood risk reduction components. The Council supports DWR's proposal to make such a cost breakdown a requirement for receiving grant funding.
3. **Carefully consider the tradeoffs associated with on-site and off-site mitigation.** Destruction of shaded riverine aquatic habitat and emergent vegetation by placement of bank erosion control riprap along key migratory corridors for salmon should be mitigated on-site or at least elsewhere along the same corridor. If habitat is created in areas of the Delta that are not along these corridors, then the mitigation would not be expected to provide the same ecological benefits to salmon. However, if constraints or other considerations prevent the establishment of habitat mitigation on-site, then off-site mitigation may be the best option to mitigate for habitat impacts during levee repairs and rehabilitation, especially if it facilitates the creation of larger and more interconnected habitat patches.
4. **Use landscape-scale planning to guide project location and design.** As landscape-scale restoration planning is conducted in the Delta, as recommended in the Delta Plan, it will provide a framework for siting and designing projects to increase habitat connectivity and function. For example, efforts should be made to link together fragmented patches of habitat to build towards large contiguous habitat corridors.
5. **Measure fish and wildlife response through a standardized regional monitoring program.** By establishing a regional monitoring framework (similar to the CDFW-led Interagency Ecological Program Tidal Wetlands Monitoring Project Work Team framework), instead of developing monitoring protocols on a project-by-project basis, it will become easier to compare results across projects and improve understanding of the effectiveness of different habitat improvement options. Regional monitoring also supports program-level adaptive management and a landscape-scale approach, as described above. Additional and long-term funding is needed for this programmatic monitoring.
6. **Use the Delta Levees and Habitat Advisory Committee (DLHAC) to discuss incorporation of effective habitat improvement components into levee projects.** The DLHAC is a regular

standing meeting between DWR, CDFW, Delta RDs, and other Delta stakeholders. We envision that the Delta Science Program could become involved with the DLHAC, or a subcommittee thereof, to consult on habitat project siting and design.

None of the recommendations we have made in this report are novel; in one form or another, they have been previously suggested by other agencies or Delta stakeholders. Implementing them, however, will take leadership, persistence, and adequate long-term funding. Council staff looks forward to working together with our colleagues to address the issues raised in this paper.