Elements of Adaptive Management and Monitoring Plans with Examples

Summary

Adaptive management is a science-based, structured approach to iterative environmental decision making under uncertain conditions. It emphasizes acquisition and use of new knowledge, increasing likelihood of success in obtaining goals. Figure 1 illustrates the adaptive management cycle as described in the Delta Plan.

This document, developed by the Delta Interagency Adaptive Management Integration Team, presents a high-level example of an adaptive management and monitoring plan, and provides illustrative text from actual adaptive management plans in the appendix. This document is not intended to be a template and the organization as well as elements of the document can be adjusted to suit specific project needs. Following this example does not guarantee consistency with any specific regulatory requirements.

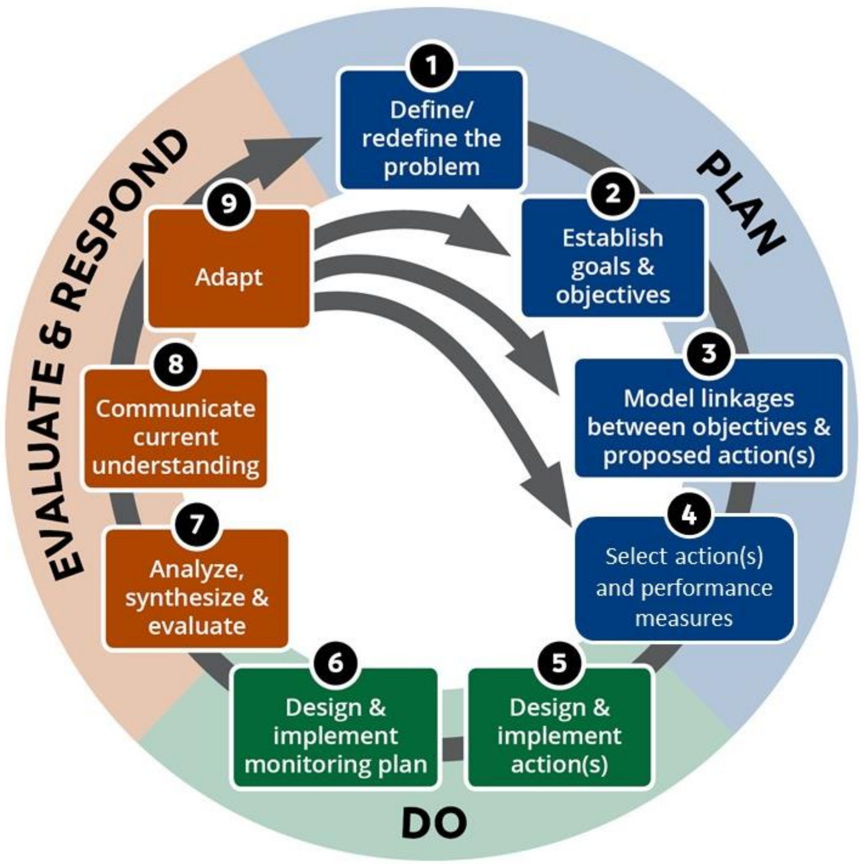

Figure 1. The adaptive management cycle as described in the Delta Stewardship Council's Delta Plan.[1] The shading represents the three broad phases of adaptive management (Plan, Do, and Evaluate and Respond), and the boxes represent the nine steps within the adaptive management framework. The circular arrow represents the general sequence of steps. The additional arrows indicate possible next steps for adaptation (e.g., revising the selected action based on what has been learned). These steps are explained in detail in Delta Plan Appendix C.

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[1] Delta Stewardship Council. "The Delta Plan." Sacramento, CA, 2013.

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Adaptive Management and Monitoring Plan: Description of Content

1. Project Description

If a biological assessment or other environmental document has already been completed the information below can be summarized from the existing document as appropriate.

1.1. Site Description

A description of the project site in its current state. The description can include the current state of vegetation, elevation, channels, levees, etc. It may contain figures and/or photos depicting the project site in its current state.

1.2. Project Description

A detailed description of the project itself. A project is generally considered to be the collection of the actions intended to meet certain goals and objectives.

1.3. Regional Setting

A description of the region surrounding the project site, potentially including land use, types of habitat, species present, and other planned restorations.

1.4. Expected Outputs and Outcomes

The expected outputs and outcomes of the project as it relates to the actions. May contain a figure or map depicting the site in its future state.

Outputs are on-the-ground implementation and management actions resulting from the project. This could include, ecosystems created, acres restored, and construction of levee breaches and new channels.

Outcomes are longer-term effects of the project outputs, for example ecosystem responses to restored acres, and increased tidal exchange after levee breaches leading to increased export of primary productivity from a site.

Both outputs and outcomes should be achievable, measurable, and as tangible as possible.

2. Project Plan

An overview of the project that can be related to Steps 1 to 4 of the adaptive management process (***Figure 1***).

2.1. Problem Statement

A clear explanation of the problem that the project is designed to address. Establishes the background for the goals and objectives of the project.

For examples, see Appendix B

2.2. Goals and Objectives[2]

How does the project address the problem? This section can include primary and secondary goals and objectives.

For examples, see Table 1, columns 1 and 2, and Appendix C

2.3. Model Linkages between Objectives and Proposed Action(s)

A description of the conceptual models relevant to the project.

Conceptual models articulate linkages between the problem statement and the goals and objectives. They explain how the proposed actions will address the objectives. Conceptual models provide a road map for testing hypotheses through statements that describe the expected outcome of an action. Both qualitative (conceptual) and quantitative models can effectively link objectives and proposed actions by illuminating if and how different actions meet specific objectives. Examples of completed conceptual models can be found on the Interagency Adaptive Management Integration Team website.

Software to create conceptual models can include Powerpoint, Google Slides, Keynote, freeware (e.g. io), more sophisticated quantitative programs (e.g. Netica), or diagramming programs (e.g. yEd).

For examples, see Figure 2 and Appendix D

[2] Alternative, commonly used terms for ‘goals and objectives’ are ‘fundamental and means objectives’, or ‘primary and secondary objectives’.

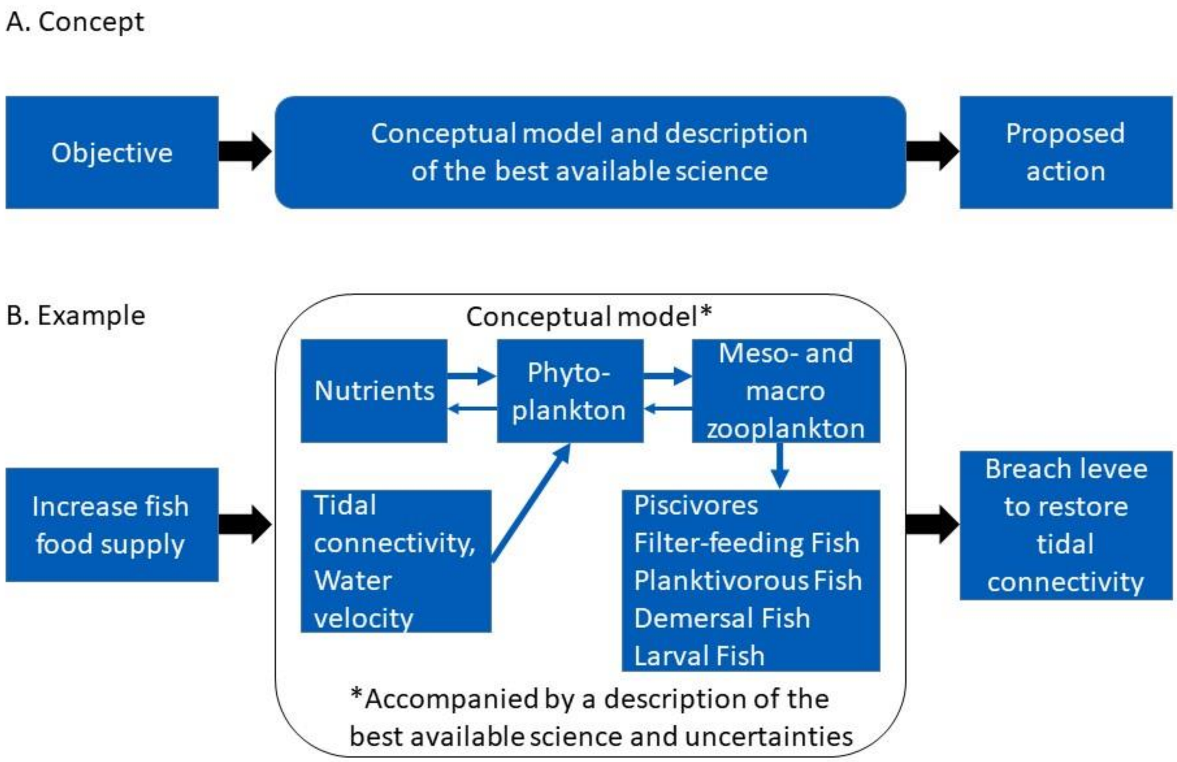

Figure 2. Conceptual models paired with a description of the best available science link project objectives to proposed actions (Panel A). A simple conceptual model shows that nutrients, tidal connectivity, and water velocity affect phytoplankton, which affect meso-and macrozooplankton. An increase in the latter positively affects piscivores, filter-feeding fish, planktivorous fish, demersal fish and larval fish. To meet the objective of increasing fish food supply, the model shows that breaching a levee to restore tidal connectivity is a reasonable proposed action to meet the objective (Panel B). Conceptual models also articulate specific uncertainties in the conceptual relationships, either visually or in text.

2.4. Selected Action(s)

Building on the description of relevant conceptual models (section 2.3), an articulation of why the project actions were selected to meet the objectives (Figure 2). Can include considerations of alternative actions and approaches, and justification for the selection of the proposed actions, including information such as:

- the level of the action(s) to be taken (research, pilot-scale project, or full-scale project)
- the geographical and temporal scale of the action(s)

- the degree of confidence in the benefits
- uncertainties in project design, and
- consequences of being wrong.

For examples, see Appendix E

3. Monitoring, Evaluation and Adaptation

An overview of the project that can be related to Steps 5 to 9 of the adaptive management process (***Figure 1***).

Among the Adaptive Management and Monitoring Plans completed in recent years for projects implemented in the Delta, some have placed the information on monitoring, metrics, and triggers in separate subsections while others have combined them into a single section.

3.1. Implementation of Monitoring / Adaptive Management

Information about the implementation process not currently documented in the project description. For example: responsible parties for specific aspects of implementation, funding sources, and other implementation-related details.

For examples, see Appendix F

3.2. Monitoring

Information about assets or categories that will be monitored, which usually includes monitoring protocols, assessment of baseline conditions, performance metrics, thresholds that will trigger a management response, planned management responses, and parties responsible for funding and implementing monitoring efforts (see Table 1 for examples).

Databases exist for many long-term monitoring studies conducted in the Delta and may be used for comparisons and to describe baseline conditions. More information on and links to environmental data sources can be found on the Interagency Adaptive Management Integration Team website.

Performance metrics provide a framework for assessing the progress toward achieving the goals and objectives.

There are three monitoring types: (1) Compliance monitoring is required by permits. The goal is to determine whether restoration actions have been completed as planned. (2) Effectiveness monitoring measures achievement of targets. (3)

Research tests a conceptual model by evaluating hypotheses with targeted research.

The Monitoring Compendium for Habitat Restoration Projects is a compilation of widely used protocols for monitoring physical and biological assets.

For examples see Table 1, columns 4 to 7 and Appendix G

3.3. Data Management

Data Collection, Storage, and Sharing

Information on the collection, storage, and sharing of data and metadata.

One example of a data management plan is the Data Handbook for Delta Science Projects.

Data Analysis and Project Evaluation

The process of analysis, synthesis, and evaluation of the monitoring results. It answers the question of how the expected and unexpected changes in conditions as a result of project implementation will be evaluated.

For examples, see Appendix H

3.4. Adaptation

Explanation of how the project may be adapted to reflect the refined understanding gained from analysis and synthesis of monitoring results and/or changes in conditions (such as environmental or socio-economic). It answers the question of whether and how, with new results and understanding, the project adaptive management framework could be revised. Description of possible next steps could include consulting with stakeholders, redefining the problem statement, amending goals and objectives, altering the conceptual model, or modifying project actions.

This section could refer to the potential management responses related to the triggers identified in Section 3.2. Due to funding and other limitations, alternative approaches may not be feasible at the project-scale but could be communicated in order to inform similar future projects (see Section 3.5 for more on communication venues).

For examples, see Appendix I

3.5. Reporting and Communication

The plan for communicating lessons learned from project implementation, data analysis, and project evaluation. Communication is a key step for informing and equipping policy makers, managers, stakeholders, and the public to appropriately respond and adapt.

Reporting and communication may entail: (1) stakeholder meetings and public outreach, (2) routine meetings with and annual reports for regulatory agencies to share monitoring and adaptive management results, (3) workshops and conference presentation to disseminate novel information, and (4) reports, peer reviewed papers, or outreach materials detailing project outcomes.

For examples, see Appendix J

Table 1. Example of an Adaptive Management Response Table (modified after Table 5 in Adaptive Management and Monitoring Plan, Yolo Flyway Farms Restoration Project, ICF 2017)

Goals	Objectives	Expected Outputs and Outcomes	Monitoring Category	Metrics	Trigger level	Potential Management Response
1. Enhance regional food web productivity and export to Delta in support of delta smelt and longfin smelt recovery.	No tidal muting occurs within the site.	Output: Construction of breaches and new channels. Outcome: Increased tidal exchange and excursion, leading to increased export of primary and secondary productivity from the site	Physical and Hydrology	• Elevation and topography including channel morphology and pond depths • Changes in tidal regime • Residence time in ponds and other habitats	Channel cross-section declines in area for 2 or more years in a row resulting in tidal muting within the site. An obstruction (tree, derelict vessel) lodged in the breach, resulting in tidal muting within the site.	The landowner will coordinate with the FAST on appropriate action(s) to take including, but not limited to, dredging to appropriate dimensions to maintain tidal exchange. Remove obstruction from channel.
Same as above	Food web contributions from the Project site are higher than from boundary conditions (Toe Drain). Food web contributions from the various habitat components within the site are maximized to the extent possible	Same as above	Food Web	• Chlorophyll a concentration • Phytoplankton abundance and community composition • Zooplankton abundance and community composition	Food web exports are lower in concentration than those found in the Toe Drain channel.	Modify elevations within the site to adjust residence time.

Table 1. Continued.

Goals	Objectives	Expected Outputs and Outcomes	Monitoring Category	Metrics	Trigger level	Potential Management Response
2. Provide rearing habitats for native fishes and wetland-dependent species and enhance ecosystem function	Find Chinook salmon juveniles within the site	Output: The Project site will create suitable terrestrial and aquatic habitat for target native species such as delta smelt, juvenile Chinook salmon, and giant garter snake. Outcome: The site will be occupied by target native species.	Fish	• Chinook salmon presence	No threshold for intervention	Release captive-reared juvenile salmonids with coded wire tag or radio tags to determine habitat use and growth within the site.
Same as above	Create a complex of foraging, refugia, and aestivation habitat within the site	Same as above	Terrestrial vertebrates	• Giant garter snake presence	No threshold for intervention	None
Same as above	Rate of colonization by native plant species is higher than that of non-native invasive plant species	Same as above	Wetlands and Vegetation	• Aquatic vegetation composition and cover • Vegetation composition and cover • Invasive plants cover	Growth rate of percent cover of nonnative invasive species is higher than that of native species for two years in a row	Chemical or physical control of non-native invasive species Replanting with native species

Table 1. Continued.

Goals	Objectives	Expected Outputs and Outcomes	Monitoring Category	Metrics	Trigger level	Potential Management Response
3. Maintain suitable water quality	Maintain suitable water quality conditions for native fish	<u>Output</u>: Suitable water quality conditions for native fish	Water Quality	• Water quality (temperature, EC, turbidity, pH, DO)	DO levels in excavated channels are below threshold for aquatic life; evidence of fish die-offs	Modify elevations within the site to adjust residence time.
4. Habitat succession: Provide topographic variability to allow for habitat succession and resilience against future climate change and sea level rise.	Maintain wildlife values and to protect adjacent properties and maintain access to allow for monitoring activities, control of non-native invasive plants, and for adaptive management activities	<u>Output</u>: Topographic variability including transition corridor from intertidal to upland elevations will be maintained	Physical Processes and Hydrology	• Topography and planform of transition areas. • Changes in tidal regime	Accretion or erosion that creates undesirable habitat conditions on the site	Removal or placement of material

4. Appendix

4.1. Appendix A. List of Adaptive Management Plans Cited

Lower Yolo Ranch Restoration Project Adaptive Management and Monitoring Plan

Tule Red Tidal Restoration Adaptive Management and Monitoring Plan

Wildlife Corridors for Flood Escape on the Yolo Bypass Wildlife Area Monitoring and Adaptive Management Plan

Winter Island Tidal Habitat Restoration Adaptive Management and Monitoring Plan

Yolo Flyway Farms Restoration Project Adaptive Management and Monitoring Plan

4.2. Appendix B. Problem or Purpose Statement

Excerpt from the Wildlife Corridors for Flood Escape on the Yolo Bypass Wildlife Area Monitoring and Adaptive Management Plan

Problem Statement

The Yolo Bypass Wildlife Area (YBWA) is owned and managed by the California Department of Fish and Wildlife (CDFW) to restore and manage a variety of wildlife habitats in the Yolo Basin, a natural basin in the north Sacramento-San Joaquin River Delta (see Location Map). The 16,770-acre YBWA is part of the Yolo Bypass flood control channel that protects Sacramento and other cities from flooding, and is also a haven for fish, waterfowl, shorebirds and wading birds, Neotropical migrants, raptors, invertebrates, reptiles, amphibians and bats. However, wildlife in the YBWA can often become stranded during flood events. As flood waters rise from east to west, wildlife, including deer, furbearers and ground nesting birds, lack adequate cover to move out of lower areas or to escape aerial predation. YBWA staff have observed wildlife mortality during flooding for a number of years. They report deer climbing trees in an attempt to survive (Jeffrey Stoddard, personal communication). Local farmers and ranchers in the area report a variety of wildlife including coyote, fox, rabbit and others seeking rooftops of nearby barns and structures to wait out flood waters (Greg Schmid, personal communication). Yolo Bypass Wildlife Area staff have observed wildlife mortality during flooding for a number of years and see this project as an opportunity to address that problem and restore habitat and ecosystem function on the Wildlife Area. Plans to restore habitat within the Sacramento San-Joaquin Bay Delta include large acreages within the Yolo Bypass. Significant portions of the Bypass acreage are under agricultural operation (grazing or cultivation). The restoration project sites we have selected are a mixture of grazed and unmanaged grasslands consisting primarily of annual grass and noxious invasive weeds offering generally poor-quality year-round habitat for mammals, birds and invertebrates such as native bees and butterflies. The project plan is to enhance wildlife habitat adjacent to and compatible with the agriculture operations in the Bypass by establishing 5 miles (22 acres) of new, floodway-compatible wildlife and pollinator corridor habitat to provide an exit and transit corridor for wildlife species to escape advancing floodwater and move to higher ground and enhancing year-round habitat for mammals, birds and invertebrates.

Excerpt from the Winter Island Tidal Habitat Restoration Adaptive Management and Monitoring Plan

Project Purpose

The Winter Island Tidal Habitat Restoration Project (Project) will restore 544 acres of tidal wetlands in Contra Costa County, California. This project is intended to contribute toward the restoration acreage requirements of the U.S. Fish and Wildlife Service's (USFWS) December 15, 2008 Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2008, File No. 81420-2008-F-1481-5), National Marine Fisheries Service's (NMFS) June 4, 2009 Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009, File No. 2008/09022), and the California Department of Fish and Wildlife's (CDFW) February 23, 2009 California State Water Project Delta Facilities and Operations Incidental Take Permit (ITP) (CDFW 2009, Permit No. 2081-2009-001-03).

Upon construction, the project would partially fulfill the Department of Water Resources (DWR) requirement to restore 8,000 acres of intertidal and associated subtidal habitat for Delta Smelt and salmonids and 800 acres of intertidal and associated subtidal wetland habitat in a mesohaline part of the estuary for Longfin Smelt. In September 2001, a Memorandum of Agreement Regarding the Early Implementation of Habitat Projects for the Central Valley Project (CVP) and State Water Projects (SWP) Coordinated Operations and Bay Delta Conservation Plan was signed by the USFWS, NMFS, CDFW, DWR, Bureau of Reclamation (Reclamation), and State and Federal Contractors Water Agency (SFCWA) that sets forth a process of identifying and evaluating habitat projects. The Fishery Agency Strategy Team (FAST), comprised of a technical representative from each fishery agency (USFWS, NMFS, Reclamation, and CDFW), was created to review and assist in the planning of the habitat projects and provides guidance to DWR, Reclamation, and SFCWA on the expected benefits of the habitat projects in meeting restoration objectives.

The Project will restore unrestricted, full tidal connectivity across approximately 544 acres to the interior of Winter Island to create tidal wetlands, associated high marsh, and riparian habitats on-site to benefit native fish species. By increasing tidal exchange to Winter Island, the currently muted tidal habitats will be restored to fully tidal, and the emergent and open water habitats of Winter Island would be more readily available to fish, including rearing juvenile salmon. Additionally, the greater tidal flows will result in increased availability of wetland-derived primary and secondary production to the surrounding waters, where it may bolster food resources for Delta Smelt and other pelagic fishes.

4.3. Appendix C: Goals and Objectives

Excerpt from the Tule Red Tidal Restoration Adaptive Management and Monitoring Plan

Project Goals and Objectives

The restoration goal of the Project is to benefit native fish species by establishing tidal connectivity to the Project site as described below. The restoration objectives to achieve this goal include:

1. Enhance regional food web productivity and export to Grizzly Bay in support of delta smelt and longfin smelt recovery.
2. Provide rearing habitats for out-migrating juvenile salmonids.
3. Provide rearing, breeding, and refugia habitats for a broad range of other aquatic and wetland-dependent species that utilize or depend upon the combination of brackish aquatic-tidal marsh habitat, including Sacramento splittail.
4. Provide ecosystem functions associated with the combination of Delta brackish water aquatic, tidal marsh, and upland interfaces that these species require.
5. Provide topographic variability to allow for habitat succession and resilience against future climate change and sea level rise.

Excerpt from the Winter Island Tidal Habitat Restoration Adaptive Management and Monitoring Plan

Project Goals and Objectives

The primary goal of the Project is to restore tidal connectivity to the interior of Winter Island to create tidal wetland habitat to benefit native fish species.

Project Objectives

- Enhance habitat appropriate for rearing salmonids, Delta Smelt, Longfin Smelt, and other native fish species.
- Enhance available pelagic and marsh-based productivity for native fish within and adjacent to the restoration site;
- Provide connectivity to the marsh plain for migrating salmonids.

4.4. Appendix D. Model Linkages between Objectives and Proposed Action(s)

Excerpt from the Lower Yolo Ranch Restoration Project Adaptive Management and Monitoring Plan:

Conceptual Models

The Project's restoration design and crediting has been based on an understanding of target fish species, Delta habitats, food webs, and tidal marsh evolution. This includes life history and habitat requirements of delta smelt, Chinook salmon, and longfin smelt, as well as ecological functions of tidal emergent wetlands and managed wetlands. Information from the Sacramento-San Joaquin Delta Regional Restoration Implementation Plan, Ecosystem Conceptual Model (Durand 2010) was used to capture current understanding of how the ecosystem works and how species may respond to restoration (Kneib et al, 2008; Opperman 2008). This understanding informed the design of sustainable habitat features that would increase rearing habitat for salmonids and food web productivity for delta smelt and longfin smelt, while minimizing potential negative effects on other species.

Delta Food Web

Since the introduction of the overbite clam (Potamocorbula amurensis) in 1987, food web and fishery production in the low salinity has declined to record low levels (Orsi and Mecum 1996; Kimmerer 2002; Baxter et al. 2008; MAST 2015). In the Delta, other factors have likely contributed to food web alterations, including loss of tidal wetland habitat and invasion of large primary producers (i.e., SAV) that support epiphytic-based carbon pathways (Grimaldo et al. 2009). It has been hypothesized that tidal wetland restoration will boost zooplankton production through detrital-based energy pathways (Howe and Simenstad 2007). Primary production of diatoms, green algae and chrysophyte phytoplankton in wetlands provides food resources for calanoid copepods that are, in turn, important food for juvenile fish, especially delta smelt (especially Eurytemora affinis, a major delta smelt prey species) (IEP MAST, 2015). Delta smelt also consume cladocerans, mysids, amphipods, and larval fish (IEP MAST, 2015).

In a drastically changing Delta landscape, restored flooded islands can also function as important sources of phytoplankton and zooplankton production (Mueller et al. 2002; Grimaldo et al. 2004, Lopez et al. 2006; Lehman et al. 2015). For example, among several habitats examined, Grimaldo et al. 2004 found that a restored flooded island (Mildred) with little SAV supported high densities of zooplankton and larval fish. Work by Mueller et al. 2002 found that Daphnia growth rates were almost twice at Mildred Island compared to other Delta habitats. Flooded islands, not likely a common feature of the historic Delta, can have high residence time which promotes primary production (Lucas et al. 2006) if clam grazing is minimal (Lucas and Thompson 2013). These findings are interesting because, overall, primary production within the channels of the Delta are inherently low because of high turbidity and low light levels (Jassby et al., 2002; Lopez et al., 2006). Work by Sobczak et al. (2002) suggests that the Delta food web is dominantly fueled by phytoplankton because much of the upstream detrital carbon is not bioavailable to consumers.

High productivity originating from tidal wetlands can be exported to surrounding areas, but the magnitude, extent and direction of net transport is variable (Howe and Simenstad, 2007; Lehman et al., 2010; Lehman, 2013; Lehman et al., 2015). For example, small vegetated ponds at the north end of Liberty Island (Upper and Lower Beaver Ponds) had greater concentrations of organic and inorganic material, and were important sources to the adjacent open water pond, the barren open waters of south Liberty Island (Lehman et al. 2015). Exchange between ponds was important to wetland flux. Lehman and others identified small vegetated ponds as an important source of inorganic and organic material to the wetland, and noted the importance of small scale physical processes within ponds to material flux of the wetland.

The Project will implement restoration actions designed to affect key physical process of the restoration site, such as maximizing residency time, diversity, and associated food web production by capturing and slowly draining water on the existing landscape. This water will come from daily tidal exchange or from seasonal inundation during flood events in the Yolo Bypass. Water will be partially impounded behind existing berms that are part of the irrigated pasture landscape that now exists on the Project site. Notches would be excavated in certain spots to allow for water and biota to flow out into surrounding tidal marsh plain and channels, and will help reduce the potential for fish stranding. In order to facilitate outflow from the site, swales will be cut to drain the deepest portions of the site.

Depth of the swales will vary in order to vary the hydrology within the associated network and test different residency time hypotheses.

The tidal wetland restoration area will connect to the Toe Drain via two engineered breaches excavated along the eastern property boundary. The dimensions of these engineered breaches were sized according to the methods used to determine the tidal channel geometries, as described above. The breaches will be sited to minimize, if possible, any areas supporting existing vegetation. Opportunities to relocate/transplant existing vegetation elsewhere would be afforded to the appropriate resource agencies prior to construction.

4.5. Appendix E. Selected Action(s)

Excerpt from the Winter Island Tidal Habitat Restoration Adaptive Management and Monitoring Plan

Salinity was modeled on two theoretical design alternatives prior to initial planning efforts. These alternatives were similar to alternatives that were included in subsequent planning and modeling efforts. Modeling showed that a restoration of Winter Island would have a minimal effect on salinity and would not cause compliance issues with existing Water Rights Decision D-1641 (RMA 2015).

Five design alternatives were subsequently developed to narrow the target for data collection and additional modeling. These alternatives included:

- Alternative 1: A minimum construction footprint alternative that includes breaches at the north and south water control structures.
- Alternative 2: A breach at the north and south water control structures and an excavated eastern tidal channel.
- Alternative 3: A south breach, a small breach in the north to remove the water control structure, and an excavated eastern tidal channel.
- Alternative 4: A breach at the north and south water control structures, a breach on the western levee, and an excavated eastern tidal channel.
- Alternative 5: A maximum buildout alternative that included breaches at the north and south water control structures, an excavated eastern tidal channel, and an excavated, sinuous internal channel with ditch blocks to re-route water throughout the site.

An excavated eastern tidal channel was incorporated to increase access for outmigrating fish and the western breach was included to increase flow to the western side of the island and provide a connection to the historic Brown's Island tidal marsh. The maximum buildout alternative was an attempt at recreating historic sinuous channels that would typically be found in tidal marshes.

Due to the similarities of Alternatives 1, 2, and 3, only Alternative 3, 4, and 5 were included in hydrodynamic modeling. Bathymetric, topographic, and rare plant surveys were performed to gather preliminary data for modeling and to address the feasibility of the design alternatives.

Hydrodynamic modeling was performed to evaluate peak water velocities and particle exposure time (a proxy for primary production) for each alternative. Peak water velocities were similar amongst all alternatives (3 to 5 ft/sec). This range of water velocities should maintain fine sediment scout, resulting in naturally resilient channel structures and discourage establishment of floating and submerged aquatic vegetation (Fischenich 2001). However, similar water velocities amongst alternatives disincentivized Alternative 5's large construction footprint.

Particle exposure times were similar as well, with Alternative 3's 2.2-day average exposure time marginally more favorable for primary production (Reynolds 1997). While a breach near Brown's Island would have been beneficial, Alternative 4 was eliminated due to dense populations of Delta Tule Pea (*Lathyrus jepsonii*) and Suisun Marsh Aster (*Symphyotrichum lentum*), and a shallow bathymetry profile in Middle Slough that would make construction infeasible. Alternative 3 was chosen as the preferred alternative based on benefits to target species and feasibility of construction.

Restoration Design and Uncertainties

Winter Island is currently a muted tidal wetland with relatively dense cover of non-native emergent vegetation over its lower elevations. Modeling shows that breaching the north and south levee would connect the interior channel that runs through the island to the exterior, tidal waters, and would be sufficient to restore the wetland from muted to fully tidal. The restoration design strategy for this site is a "less is more" approach, with a focus on returning unfettered tidal action to the site and letting nature take its course. The benefits to this approach include reducing disturbance to animals and plants already inhabiting the site, and minimizing further compaction of soils. However, this approach limits the opportunities for incorporating experimental elements into the design of the restoration project.

Although the IEP Tidal Wetland Monitoring Conceptual Models and simulation modeling of post-restoration hydrology suggest that natural processes will maintain tidally connected to the site, some uncertainty exists about the physical evolution of the breach and levee degrade. The level of invasion by nuisance emergent and submerged aquatic vegetation is another area of uncertainty as many of these species dominate the landscape. The Conceptual Models (Sherman et al. 2017) and experience in the region indicate that various species of predominantly non-native vegetation are likely to take advantage of construction-related disturbance and improved connectivity to invade the new restoration site. Conversely, increased flow through the island may help to flush out non-native invasive vegetation such as *Ludwigia* that is already prevalent within the project area. Data gathered during post-construction monitoring will be used to improve future modeling of such uncertainties, and in some cases, may indicate remedial actions.

4.6. Appendix F. Implementation of Monitoring/Adaptive Management

Excerpt from the Tule Red Tidal Restoration Adaptive Management and Monitoring Plan

Implementation Mechanisms

During the interim management period, SFCWA will provide physical management actions under contract with appropriate, competent entities. The monitoring activities may be conducted by public, private, or non-profit entities.

Responsible Parties

1. LAND OWNER AND RESPONSIBILITIES

The Project site is owned by WES, under contract with SFCWA, and CDFW. After construction is complete, SFCWA intends to transfer fee title of the Tule Red portion of the site to CDFW who will become responsible for all of the management and maintenance activities for the entire site.

SFCWA is the party responsible for ensuring execution of the restoration, management, and certain monitoring of the site during the interim management period, and is therefore sometimes referred to as the Land Owner. CDFW will take over Land Owner responsibilities after the interim management period. The Land Owner may cooperate with public, private, or non-profit entities to perform all or some of the tasks identified in this Plan.

The Land Owner's responsibilities shall include but not be limited to the following:

- Implementing or causing to be implemented all habitat creation and management activities.
- Executing the management, monitoring, maintenance, and reporting responsibilities as described in this Plan.

- Performing general inspections to ensure restored habitat values are protected and maintained.
- Performing or causing to be performed some of the monitoring actions and surveys as described in the monitoring component of this Plan.
- Analyzing portions of the monitoring data resulting from the monitoring activities and implementing any remedial or adaptive management actions as agreed to by the FAST.
- Filing annual reports with the FAST describing the status and evolution of the restored habitats, general plant and tidal area health, presence and abundance of invasive flora and fauna, hydrologic conditions, wildlife utilization, trespass and trash problems, and other management, maintenance, monitoring and reporting activities.
- Maintaining a file on the Project detailing management, maintenance, monitoring, and reporting activities, correspondence, and determinations. The file will be available to the FAST for inspection.
- Coordinating and approving any research activities proposed on the site.
- Other similar duties not specifically described above.

2. QUALIFIED PERSONNEL/MONITORING BIOLOGISTS

The Land Owner shall retain professional biologists, botanists, restoration ecologists, and other specialists ("Qualified Personnel"), including "Monitoring Biologists" to conduct specialized tasks and monitoring as described in this Plan. The Monitoring Biologists shall be familiar with wetland biology and have knowledge relative to monitoring protocols, management techniques, endangered species needs, and fisheries ecology.

Monitoring Biologists must have current USFWS, NMFS and/or CDFW authorizations and permits to conduct monitoring surveys for listed species.

Duties of the Qualified Personnel may include, but are not limited to:

- Monitoring and maintaining habitat function.
- Monitoring and maintaining erosion control.
- Identifying and evaluating the presence of invasive species and developing management recommendations.
- Conducting surveys that are required by this Plan.
- Evaluating site conditions and recommending remedial actions and/or adaptive management actions to the Land Owner.

- Assisting in the review or planning of any additional restoration actions following initial construction.
- Preparing annual reports.

3. CHANGES IN PERSONNEL

Significant personnel changes will be reported in annual reports to the FAST. If needed or desired by the FAST, any related transfer of management responsibilities will be coordinated with a site visit with the FAST.

4.7. Appendix G. Monitoring

Excerpt from the Tule Red Tidal Restoration Adaptive Management and Monitoring Plan

Water Quality

Purpose: Water quality within a tidal wetland can affect the vegetation response to the restored hydrology as well as potentially affecting fish and wildlife survival and reproduction within the restored site. Water quality can have a strong influence on whether or not the Project is meeting the following objectives:

1. Food web contribution
2. Salmon rearing habitat
3. Habitat for other species

A variety of water quality characteristics can influence the productivity, habitat suitability, or toxicity to fish or vegetation within a restored site. A basic set of water quality parameters will be recorded over several intervals after the breach to characterize water quality during habitat development to determine suitability of the habitats in supporting the objectives above.

Metrics: Measurements will be taken for temperature, dissolved oxygen, pH, turbidity, and conductivity (EC). Methyl mercury (MeHg) will also be sampled in spring, summer and fall.

Monitoring Methods: 4 to 5 water quality measurement data sondes will be deployed at the breach and within the various restored tidal marsh habitat components in years 1, 3, and 5. Water quality will be monitored in the CDFW drain water outfall, the marsh ponds, the tidal pannes, the higher order channels and at the breach. One grab sample for MeHg will be collected seasonally during an outgoing tide to assist in characterization of MeHg production in years 1, 3, and 5. Methyl mercury will be sampled following SWAMP and CALFED methods.

Foodweb

Purpose: Restoration of tidal wetlands such as the Project site is hypothesized to support native fish species by increasing the production of nutritionally valuable phytoplankton, zooplankton and other invertebrates. In addition, recent studies have shown that shallow autotrophic habitats can export algal biomass and fuel secondary production in adjacent deep heterotrophic habitats, but only if these habitats are properly connected (Lopez et al., 2006; Lehman et al., 2010). Standing stock of primary productivity will be monitored along with the different phytoplankton species produced in the restoration site. Secondary productivity (zooplankton, benthic invertebrates) produced and exported from the restoration site will also be monitored.

Evaluating the quantity and quality of the food supply available at the Project site for larval and juvenile fish in Grizzly Bay will address the following objectives:

1. Food Web Contribution
2. Salmon Rearing Habitat

Metrics: Food web contributions will be measured by primary production (chlorophyll a and phytoplankton), zooplankton, and benthic and epibenthic invertebrates.

Methods: Where possible, food web sampling for the Project will be coordinated with the existing IEP monitoring program, UCD Suisun Marsh study, and/or the IEP Tidal Wetlands

Monitoring program for restoration sites. This sampling program is initially proposed to be conducted seasonally for at least three years and up to five years post-breach (Table 4). The scale and intensity of monitoring efforts, as summarized in Tables 5 and 6, will be re-evaluated following Year 3.

Water quality parameters, such as water temperature, dissolved oxygen, conductivity, turbidity, and nutrients, will be measured at time of survey (grab sample or instantaneous measures with a water quality probe). Collected plankton and benthic samples will be preserved in a solution of 95% ethanol. Samples will be analyzed in a laboratory for abundance and species composition, with all organisms identified to the lowest possible taxonomic level possible. Subsampling may be used to allow cost-effective and efficient enumeration.

Potential methods are described below, from pilot sampling plans by the IEP Tidal Wetlands Monitoring (Contreras et al., 2015). The sampling protocols for this seasonal food web monitoring will be refined as needed based on review of the final construction, data needs, and information from pre-construction monitoring.

a) PRIMARY PRODUCTION

Chlorophyll a concentrations will be measured as an indicator of primary productivity. At permanent water quality monitoring stations (2-4 stations) set up on-site, sondes will collect continuous chlorophyll a fluorescence. In addition, at each zooplankton trawling station, field crews will measure chlorophyll a in vivo fluorescence using a YSI sonde with chlorophyll a probe. Crews may take horizontal profiles of the site. At a subset of sampling stations, they may also take a sample to calibrate fluorescence readings in the lab. Field crews will fill a 2.8 L bottle approximately half full with water pumped from a depth of one meter, withdraw two 100 mL sub-samples and aspirate them through 47 mm diameter glass fiber filters of 0.3 μm pore size. The filters will then be frozen on dry ice for return to lab (IEP protocol: Brown, 2009). The details of water quality monitoring stations and instrumentation will be developed further in consultation with IEP and DWR.

Phytoplankton density and composition will be monitored near the discharge of the Project site and on the site. Phytoplankton sampling will be conducted in conjunction with high tide events that inundate the site and allow connectivity and export. At a subset of zooplankton trawling stations, field crews will collect phytoplankton samples with a submersible pump from a water depth of one meter (approximately three feet) below the water surface. Crews will store these samples in 50-milliliter glass bottles with two ml of Lugol's solution as a stain and preservative. Laboratory personnel will sort the samples in the lab to calculate percent composition of major taxonomic groups (diatoms, flagellates, blue-green algae, etc.) using a microscope or by photographing samples and using automated image recognition software.

Other methods may be considered, depending on available funding and partners. These could include using (1) a FluoroProbe to estimate community composition based on differences in photosynthetic pigment spectra among major classes of producers (green algae, cyanobacteria, diatoms, dinoflagellates and cryptophytes), or (2) a portable flow cytometer (FlowCam) to take images of cells passing through water. DWR's ongoing water quality monitoring has successfully used the FlowCAM to quantify live and preserved phytoplankton >15μm and preserved zooplankton.

[…]

Excerpt from the Wildlife Corridors for Flood Escape on the Yolo Bypass Wildlife Area Monitoring and Adaptive Management Plan

Monitoring

1. A timeline and checklist will be used to track progress toward adequate site preparation, seed/plant installation and irrigation line installation.

2. Baseline plant count will be conducted after the initial restoration planting has been completed.
3. During the two subsequent growing seasons, plant counts will be conducted to determine mortality.
4. Wildlife use will be monitored before and after implementation of planting activities.
    a. During the grant cycle, the RCD will document wildlife use, working with the Point Blue Conservation Science NRCS Partner Biologist to collect baseline and post-installation data on summer/winter bird counts from area bird searches, bee and butterfly use from spring and summer surveys, and annual wildlife species indexes through the use of trail camera visual capture.
    b. Given that the funding timeframe is shorter than the timeframe needed for woody plants to mature and provide intended habitat, and that there are limitations to monitoring wildlife use during flood events, monitoring will emphasize protocols that wildlife enthusiasts and hobbyists with minimal training can execute, and thus, they would lend themselves to citizen scientist or university students continuing the work after the funding cycle.
    c. Bird use of the project sites will be monitored using the Area Search Bird Count Protocol. This method is designed for people who have good bird identification skills, but not necessarily training in bird count methods. Bird clubs like the Audubon Society or seasoned birders could complete these counts.
    d. The pollinator monitoring will combine elements of the UC Davis and partners' Streamlined Bee Monitoring Protocol and simple butterfly counts, both of which can be performed by enthusiasts or with minimal training and good observational skills.
    e. Lastly, we hope that citizen scientists recruited by Yolo Basin Foundation can continue developing data on baseline and to review the photo or videos from the remote camera traps on the corridor, from the start of the project to beyond the grant cycle.

Over the course of the four year project, we expect to monitor as follows:

2017 - Baseline wildlife monitoring completed

2018 - Restoration activities completed and plant baseline survey completed. Measure miles and acres of project areas restored.

2019 - Year 1 plant survival and wildlife monitoring completed.

Replace all dead plants.

2020 - Year 2 plant survival and wildlife monitoring completed.

If 75% or greater plant survival, no replanting need. If less than 75% plant survival, replant to at least 75% of plan.

[...]

4.8. Appendix H. Data Analysis and Project Evaluation

Excerpt from the Wings Landing Tidal Restoration Project Adaptive Management and Monitoring Plan

Data Analysis and Project Evaluation

Monitoring metrics will be related to each hypothesis using a variety of established statistical techniques as recommended in the Tidal Wetland Restoration Monitoring Framework. Data will be integrated and compared with IEP long-term monitoring data and any special studies, where applicable. In the annual reports for the Proposed Project, the data will be graphed, summarized, and any preliminary statistics presented. Many hypotheses and analysis methods will be more appropriate for the Programmatic Monitoring Report, which will synthesize data from all FRP projects.

Hypothesis: The area of substrate and structure suitable for rearing, refuge, and/or adult residence of at-risk fish species on the Project Site will increase after restoration. (P1)

Analysis: Maps of pre-and post-restoration topography and bathymetry will be presented, with a table comparing area of different habitat types before and after restoration. The tidal stage inside and outside the restoration site will be graphed over a representative tidal cycle, with calculation of residuals and lag time between the two stages, if applicable.

Hypothesis: At risk fish species including Delta Smelt, Longfin Smelt, Chinook Salmon, Green Sturgeon, and steelhead will be present in and adjacent to the restored and enhanced tidal marsh habitat for some portion of their life history, with a frequency similar to, or higher than the existing tidal marsh and adjacent sloughs, and reflecting current population trends. (P4)

Analysis: Without targeted fish sampling, this hypothesis can only be tested through special studies. If there has been fish sampling on the site, fish CPUE will be summarized before and after restoration, and in comparison with reference wetlands and IEP long-term monitoring trends. A more rigorous testing of this hypothesis will be included in the Programmatic Report.

Hypothesis: Establishment and growth of aquatic vegetation will influence fish community structure and abundance on the Project Site. (P14)

Analysis: The aquatic vegetation communities onsite will be mapped, and percent invasive vegetation will be graphed in comparison to the reference site. The influence of the vegetation on fish communities will only be testable with special studies.

[...]

4.9. Appendix I. Adaptation

Excerpt from the Tule Red Tidal Restoration Adaptive Management and Monitoring Plan

Intervention Thresholds and Responses

While it is not anticipated that major modification to the site will be needed, an objective of this Plan is to guide monitoring and to identify any thresholds that may compromise the Project objectives, and to propose potential management responses or further focused monitoring efforts. This section summarizes the five Project objectives, the expected outcomes related to those objectives, the metrics by which progress towards meeting the objectives is measured, as well as thresholds for undertaking a management response if goals are not being met or problems occur which require intervention.

[...]

Food Web Contribution

Objective: Enhance regional food web productivity and export to Grizzly Bay in support of delta smelt and longfin smelt recovery

Expected Outcome: The levee breach and new channels will increase tidal exchange and excursion on the site. This tidal exchange will increase the export of primary and secondary productivity from the site.

Monitoring Category: Physical Process and Hydrology

Metric: Elevation and topography, including channel cross sections. Hydrology measured with level-loggers in various locations throughout the Project site.

Goal: Breach channel erodes until reaching equilibrium and little or no tidal muting occurs within the site.

Intervention Threshold (trigger level): Breach channel declines in cross-section area for 2 or more years in a row from excessive sedimentation, resulting in tidal muting within the site. An obstruction such as a large tree or derelict boat or barge lodged in the breach could occur, resulting in tidal muting within the site.

Potential Management Response: The Land Owner will coordinate with the FAST on appropriate action(s) to take including, but not limited to, dredging or removal of obstruction. Any dredging will be limited to the period between September1 and November 30. Any dredging will be reported in the Annual Report. Equipment may include long-reach excavator, barge-mounted dragline, suction dredge, or backhoe.

Monitoring Category: Food Web

Metric: Chlorophyll a, Phytoplankton, zooplankton, benthic macroinvertebrates, particulate and dissolved organic matter.

Goal: Food web contributions from the Project site are higher than from boundary conditions (Grizzly Bay). Food web contributions from the various habitat components within the site are maximized to the extent possible.

Intervention Threshold (trigger level): Food web components in marsh ponds and tidal pannes are lower in concentration than those found in the primary channel.

Potential Management Response: Increase intensity of water quality monitoring to determine conditions that may be leading to lower productivity. Modify the height of the berm around the marsh ponds or tidal pannes (raise or lower). Methods may include excavation by amphibious long-reach excavator, or other small mechanized aquatic equipment (e.g. “marsh master”). Prior to any modification to the features, the following information will be provided to FAST and the Corps:

- A description of the proposed work
- The elevation of the existing landforms
- The daily and monthly tidal range of the features to be modified
- Water quality measurements for the features

The results of an on-site field inspection for protected plants located within the proposed area of disturbance including but not limited to:

a. Soft bird's beak (Cordylanthus mollis ssp. mollis)
b. Salt marsh bird's beak (Cordylanthus maritimus ssp. maritimus),
c. Hispid bird's beak (Cordylanthus mollis ssp. hispidus),
d. Delta tule pea (Lathyrus jepsonii var. jepsonii)

[...]

4.10. Appendix J. Reporting and Communication

Excerpt from the Wings Landing Tidal Restoration Project Adaptive Management and Monitoring Plan

STAKEHOLDER COMMUNICATION AND REPORTING

Stakeholder involvement, public outreach, and communication of novel information are important components of restoration and adaptive management. The FRP holds planning meetings throughout the planning and design phases of each project with landowners, stakeholders, local agencies, and other restoration teams to exchange information, discuss concerns, and provide input. Monitoring and adaptive management results will be communicated to regulatory agencies through routine meetings and annual reports. Novel information will be disseminated through conferences like the Bay-Delta Science Conference and State of the Estuary Conference as well as through scientific teams such as the Interagency Ecological Program Tidal Wetland Monitoring Project Work Team.

DWR will submit annual project-specific monitoring reports to the resources agencies for the duration of the monitoring program. The monitoring reports shall include:

a. General project information including: project name; applicant name, address, and phone number, consultant name (if applicable), address, and phone number; acres of impact and types of habitat affected; date project construction commenced; indication of monitoring year;
b. Goals and objectives of the project;
c. Monitoring and maintenance dates with information about activities completed and personnel;
d. Summary of all quantitative and qualitative monitoring data;
e. Color copies of a subset of monitoring photographs;

f. Maps identifying monitoring areas, transects, planting zones, etc. as appropriate;

g. A list of success criteria and progress towards meeting them; and

h. Planned remedial action for the coming monitoring period, which must address failures to meet performance.

A final report to cover the entire Wings Landing Tidal Habitat Restoration Project will be prepared at the end of the 10-year monitoring term. More thorough analyses of the effectiveness of the overall restoration program in meeting the objectives of the 2019 NMFS and USFWS Biological Opinions and the 2020 LTO ITP will be provided in the FRP annual reports.