

Chapter 1: Introduction to the Elkhorn Slough Estuary

Introduction

This chapter describes the location and watershed of the Elkhorn Slough estuary, relevant past management plans, and the goals of the Elkhorn Slough Tidal Wetland Project. The work conducted by the collaborative Tidal Wetland Project teams, made up of over a hundred coastal resource managers, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, scientific experts, and community members is summarized. This chapter also describes past restoration and conservation planning reports and efforts.

Site Description

Elkhorn Slough, a seasonal estuary extending inland for seven miles (11 kilometers) from the midpoint of Monterey Bay in Central California (Figure 1), provides extraordinary biological diversity and recreational opportunities. The estuary contains approximately 2,690 acres (1,090 hectares) of distinctive habitat types including subtidal channels, tidal creeks, mudflats, salt marshes, and tidal brackish marshes (ESNERR, unpublished data). These habitats provide a rich ecosystem essential for over 340 bird (135 aquatic species), 550 marine invertebrate, and 102 fish species (Caffrey et al. 2002). Elkhorn Slough is an important nursery for commercial and recreational fish and a premier migratory stopover for birds. Estuaries like Elkhorn Slough are among the most threatened ecosystems in California, and as a result, a disproportionate number of rare, threatened, and endangered species reside in these areas. In the Elkhorn Slough watershed, two dozen species are included in these categories. The estuary also provides many beneficial human uses such as recreational boating, hiking, and bird watching. Moreover, the coastal wetlands minimize shoreline erosion and filter polluted waters.

Chapter Summary Points

- Elkhorn Slough, located at the midpoint of Monterey Bay in Central California, provides essential habitats for over 780 aquatic bird, marine invertebrate, marine mammal, and fish species.
- The Tidal Wetland Project was initiated in 2004 to conserve and restore estuarine habitats in the Elkhorn Slough watershed.



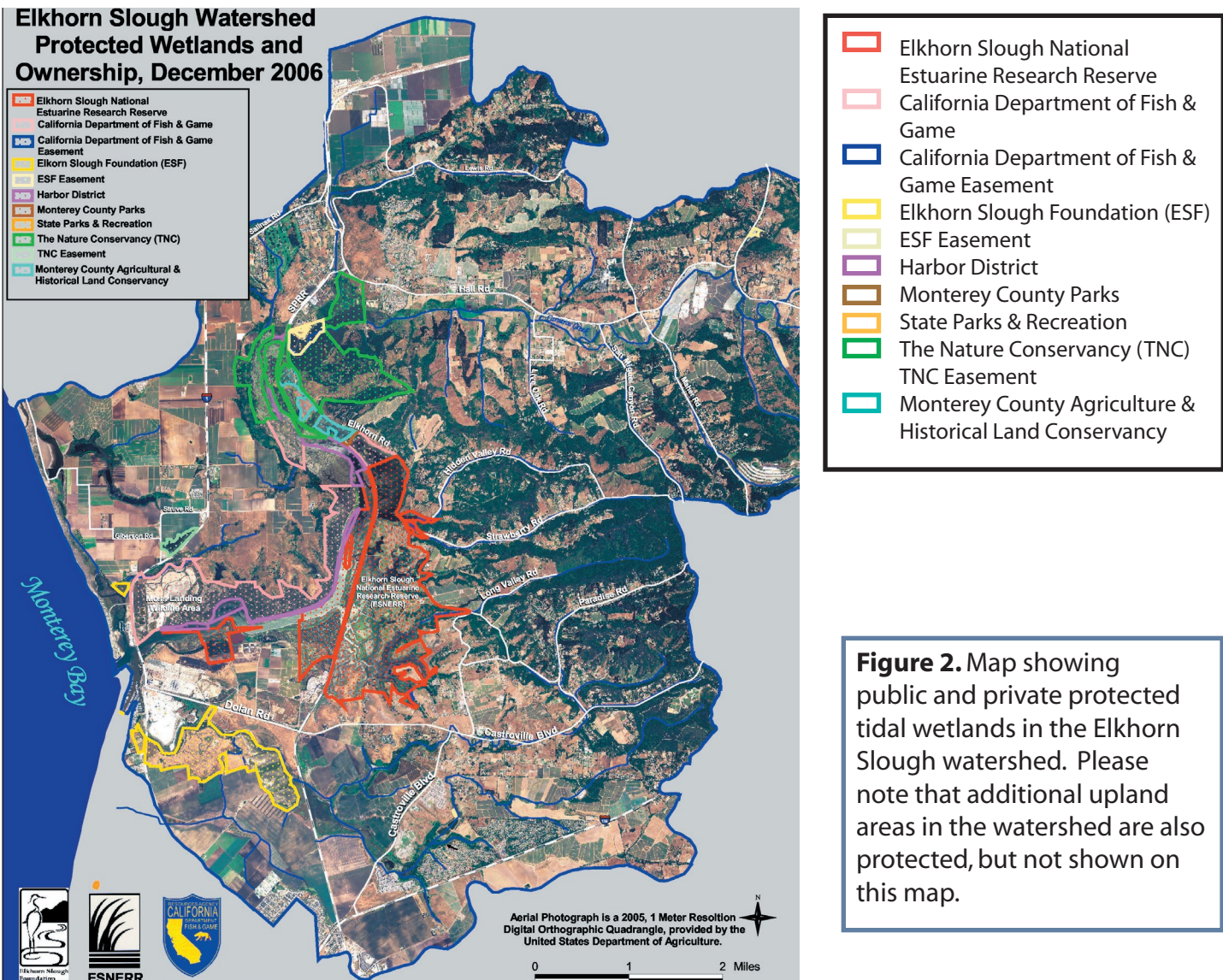
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Figure 1. Maps show the location and surroundings of Elkhorn Slough (2005 NAIP Orthos).

The National Audubon Society designated Elkhorn Slough as a Globally Important Bird Area, and the Manomet Bird Observatory named the estuary a Western Hemisphere Shorebird Reserve. Significant conservation efforts to protect Elkhorn Slough's precious resources began in the 1980s. As a result, the National Oceanic and Atmospheric Administration has designated some of the southeastern areas within the estuary as the Elkhorn Slough National Estuarine Research Reserve (ESNERR) and designated the main channel as part of the Monterey Bay National Marine Sanctuary. The California Department of Fish and Game (CDFG) owns and manages ESNERR (which includes 980 acres of wetland and 583 acres of upland) and has designated this land as a State Ecological Reserve (Figure 2). CDFG also owns and manages 755 acres (not part of ESNERR) in Elkhorn Slough and the 688-acre Moss Landing Wildlife Management Area, which extends into Elkhorn Slough from the Highway 1 Bridge (Figure 2). The Nature Conservancy (TNC) and the Elkhorn Slough Foundation (ESF) have invested in protecting over 3,500 acres of the watershed lands. TNC owns or has easements on 345 acres of wetland (427 acres of upland) and the Elkhorn Slough Foundation owns or has easements on 134 acres of wetland (2,610 acres of upland) (Figure 2). These multiple designations and strategic land acquisitions recognize the importance of Elkhorn Slough as a vital ecosystem, protecting approximately a quarter of the estuary's habitats.

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The conservation and restoration of Elkhorn Slough estuarine habitats are a California priority because coastal salt marsh ecosystems are among the most threatened in the state. Approximately 91 percent (4.5 million acres) of California’s wetlands have been lost since 1850, with an 80 percent loss of coastal marshes (Dennis and Marcus 1984, CDPR 1988, Dahl 1990). The restoration of Elkhorn Slough estuarine habitats also addresses the national conservation priority of “no net loss of wetlands” (EPA 1983).

Watershed

Estuaries such as Elkhorn Slough are defined as coastal embayments consisting of deepwater subtidal habitats with adjacent intertidal wetlands. These estuarine habitats are usually semi-enclosed by land with open access to ocean waters that enter with the tides and are diluted by freshwater (Cowardin et al. 1979, Ferren et al. 1996). Freshwater enters Elkhorn Slough from Carneros Creek and the Pajaro River (during flood events only) at the head of the estuary and the old Salinas River Channel draining the Tembladero watershed at the mouth of Elkhorn Slough (Figure 3). Intermittently during summer months, the water control structure between the Salinas River and Old Salinas River Channel is opened, and waters from the larger Salinas watershed may enter Elkhorn Slough (Figure 4). The Elkhorn Slough watershed is 30,292 acres

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(12,260 hectares) (Figure 4). However, Elkhorn Slough is part of a larger interconnected network of estuarine habitats. Waters from the Moro Cojo watershed (13,349 acres/5400 hectares) and Gabilan/Tembladero (Alisal) watershed (101,026 acres/40,880 hectares) also drain into Elkhorn Slough (Figure 4). These waters enter Elkhorn Slough through the Old Salinas River Channel at the Moss Landing South Harbor, where flooding tides push these waters at least three-quarters of the way up the estuary (Figure 3, Johnson et al. in press).

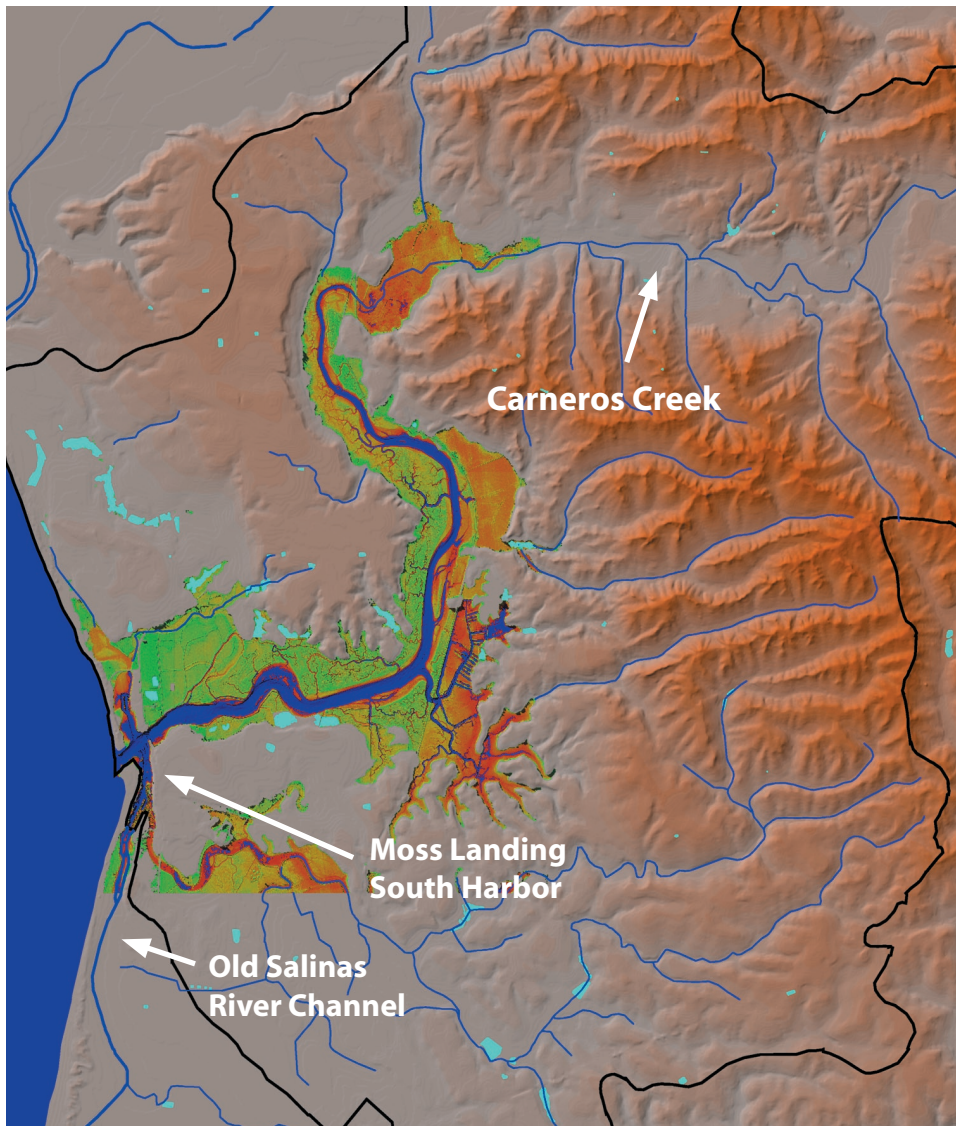


Figure 3. LIDAR map of Elkhorn Slough estuarine habitats superimposed on a DEM image showing the location of Carneros Creek, the Old Salinas River Channel, and the Moss Landing South Harbor.





Figure 4. Map of watersheds surrounding the Elkhorn Slough estuary (map adapted from CSUMB 2007). The white dot on the map indicates the area where Salinas River waters intermittently enter the Old Salinas River Channel and Elkhorn Slough.

Relevant Management Plans

The *Tidal Wetland Strategic Plan* not only synthesizes recent findings and decisions about Elkhorn Slough estuarine habitats, but also builds upon a number of past planning efforts and reports. ABA Consultants prepared the 1989 *Elkhorn Slough Wetland Management Plan* for the Monterey County Planning Department and the California State Coastal Conservancy. This document summarized information about habitat erosion, sedimentation, water quality, the natural history of Elkhorn Slough, and recommended wetland enhancement plans and implementation strategies. One focal point of the document was to identify long-term management problems. It stated: "The major environmental problem within the Elkhorn Slough is the erosion of marsh, mudflat, and upland habitat" (ABA Consultants 1989). The Tidal Wetland Project is now addressing this problem.

A number of water quality issues were also discussed in the 1989 Plan, including saltwater intrusion, high nutrient levels in groundwater, coliform bacteria contamination of waterways, impacts of persistent pesticides (chlorinated hydrocarbons and tributyltin), effects of less-persistent but more immediately toxic chemicals (such as chlorpyrifos and dacthal), and potential human health concerns from contaminated shellfish. Saltwater intrusion and contaminated groundwater are still problems. Use of persistent pesticides

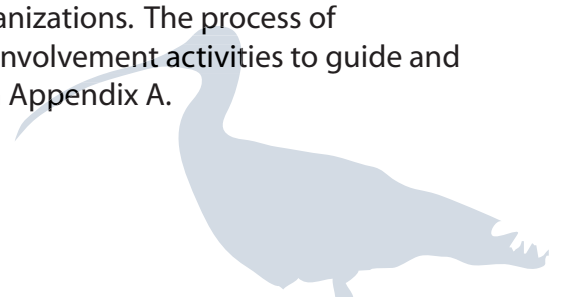
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has been phased out, but high chemical concentrations are still present in the sediment. Although some agricultural land near waterways has been taken out of production, agriculture is still very chemical-intensive, and little is known about the potential movement of short-lived but acutely toxic chemicals off of farmland. High concentrations of chemicals are still found in local shellfish, generally associated with heavy runoff events, but shellfish harvesting appears to have decreased, reducing human health concerns (pers. comm. Jim Oakden). Marine non-native invasive species were not perceived as a problem in 1989, but have now been recognized as a significant issue. A number of conceptual wetland enhancement plans for specific sites were presented in the 1989 Plan. Most of the parcels have been acquired for conservation, but the implementation of enhancement and restoration activities has been slow. Although this current *Tidal Wetland Strategic Plan* addresses the most critical issue endangering Elkhorn Slough, marsh loss and the erosion of estuarine habitats, a number of other issues remain to be tackled in the future.

A number of additional plans and reports also support current restoration planning efforts in Elkhorn Slough. The *Elkhorn Slough Tidal Hydraulics Erosion Study* was prepared for the U.S. Army Corps of Engineers by Philip Williams and Associates, Ltd. and Moffatt & Nichol Engineers (PWA 1992). The purpose of the study was to determine if the creation of the Moss Landing Harbor has caused, or is causing, the erosion of the vegetated marshlands in Elkhorn Slough. The study also examined other possible causes that may have led to erosion and evaluated and recommended solutions to the habitat erosion problems in Elkhorn Slough. In 1996, Monterey County adopted the *Moro Cojo Slough Management and Enhancement Plan* that outlines management actions for those habitats. The *Elkhorn Slough Watershed Conservation Plan* has served as a guide for conservation activities in Elkhorn Slough by identifying important natural resources, the most significant impacts (stresses and sources of stress) to those resources, and strategies to protect them over time (Scharffenberger 1999). It identified coastal marsh as a vital resource in the Elkhorn Slough watershed and described one of the major impacts as the “loss and conversion of marsh habitat as a result of past human alterations of tidal influence and hydrology”. The *Elkhorn Slough National Estuarine Research Reserve 2007 Management Plan* highlights key strategies to protect the five main habitat types in the watershed. The Reserve plan identifies major physical modifications to estuarine habitats resulting in habitat erosion, marsh loss, and reduced water quality as high priorities that need to be addressed through support of the Tidal Wetland Project. Most of these management plans can be found on the project web pages at <http://www.elkhornslough.org/tidalwetlandproject>.

Tidal Wetland Project Teams

The Tidal Wetland Project was initiated in April 2004 to develop and implement strategies to conserve and restore estuarine habitats in Elkhorn Slough. As with many restoration efforts, it was recognized early on that the scale and complexity of the estuarine habitat impacts required significant input from scientific experts, resource managers, and key stakeholders. Elkhorn Slough also contains multiple jurisdictional boundaries that are managed by different agencies and nonprofit organizations. The process of assembling a Strategic Planning Team, Science Panel, and community involvement activities to guide and support restoration planning and implementation efforts is detailed in Appendix A.



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Strategic Planning Team

The Tidal Wetland Project's Strategic Planning Team (SPT) consists of over twenty coastal resource managers, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, and scientists with experience in tidal wetland restoration planning. The primary role of the SPT is to make decisions about Elkhorn Slough Tidal Wetland Project restoration strategies. The SPT created restoration goals and objectives, developed joint restoration strategies with the Science Panel, and provided input on background materials (Appendix B). The SPT will continue to evaluate and prioritize the development and implementation of restoration strategies.

Science Panel

Over thirty regional scientists and resource managers with local or regional expertise in estuarine ecology, hydrology, water quality, restoration, and geology were selected to be on a team designated as the Science Panel. The primary role of the Science Panel is to provide technical advice to the SPT about restoration strategies based on the best available science. The Science Panel summarized and reviewed relevant research studies and developed preliminary restoration strategies jointly with the SPT. The Science Panel will continue to provide reviews of restoration strategies and identify adaptive management and monitoring activities for restoration projects.

Community Involvement

Objectives of community involvement activities include increasing community awareness, participation, and stewardship of Elkhorn Slough's estuarine wetlands. Another goal is to provide and enhance ongoing opportunities for the public to educate resource managers and scientists about community needs that should be taken into consideration for restoration activities. Community input for the Tidal Wetland Project is encouraged and regarded as highly valuable for the success of future restoration efforts. Tidal Wetland Project efforts to facilitate and encourage community involvement include community forums and field tours, monthly community email bulletins, a web form for comments, contacts database, fact sheets, and presentations to individuals and community groups (Appendices A and B).

Tidal Wetland Project Purpose and Vision

Tidal Wetland Project Purpose and Scope

The purpose of the Elkhorn Slough Tidal Wetland Project is to develop and implement strategies to conserve and restore estuarine habitats in the Elkhorn Slough watershed. The geographic scope includes both historic and current estuarine habitats in the Elkhorn Slough watershed. Although there are multiple impacts to estuarine habitats, the Strategic Planning Team decided to prioritize restoration planning efforts due to funding limitations. Physical modifications were chosen as the focus because they have caused the greatest past alterations to habitats and are currently causing rapid marsh loss and habitat erosion.



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Vision for Elkhorn Slough Estuarine Habitats

The vision statement developed by the Strategic Planning Team for the Tidal Wetland Project is:

We envision a mosaic of estuarine communities of historic precedence that are sustained by natural tidal, fluvial, sedimentary, and biological processes in the Elkhorn Slough Watershed as a legacy for future generations.

Tidal Wetland Project Goals, Objectives, and Planning Principles

Goals and Objectives

The goals and objectives for Elkhorn Slough's estuarine habitats emphasize three main points: (1) conserve high quality habitats, (2) restore degraded sites, and (3) re-establish the physical processes. The objectives for Goal 1 focus on saving the highest quality habitats in the estuary by reducing the dramatic rates of salt marsh loss and the erosion of channel, mudflat, and tidal creek habitats. The degraded estuarine habitats indicated in Goal 2 were prioritized based on the habitat types that had experienced the highest rates of loss over time in Elkhorn Slough. The objectives for Goal 3 summarize the current understanding of natural processes that need to be restored to make restoration efforts successful and sustainable over time.

Goals and Objectives for Elkhorn Slough Estuarine Habitats

Goal 1. Conserve the existing highest quality estuarine habitats and native biodiversity by aiming for a more natural rate of habitat change.

Objectives. Significantly reduce the rate of:

- A.** salt marsh conversion to other habitat types,
- B.** subtidal channel erosion,
- C.** loss of soft sediment from mudflat and subtidal channel habitats, and
- D.** tidal creek conversion to other habitat types.

Goal 2. Restore and enhance the estuarine habitats of Elkhorn Slough. Aim for the natural distribution, extent, and quality of Elkhorn Slough habitats with special emphasis on habitats with the highest loss rates.

Objectives. Strive to increase the extent of:

- A.** salt marsh habitats, including the natural distribution and abundance of tidal creeks, pannes, vegetated plains, and wetland/upland transitional areas,
- B.** tidal brackish marsh habitats, including the natural distribution and abundance of tidal creeks, pannes, vegetated plains, and wetland/upland transitional areas,
- C.** freshwater/saltwater natural transition gradients and connectivity, and
- D.** high quality soft sediment in mudflat and subtidal channel habitats



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Goal 3. Restore and enhance the natural processes (hydrologic and geomorphologic) of Elkhorn Slough and its watershed to sustain a more stable and resilient estuarine system. Emphasize the roles of natural sources, transport, circulation, filtration, and storage of water and sediment.

Objectives. Take actions to:

- A.** attain a more appropriate tidal influence by reducing the tidal prism in undiked areas,
- B.** restore appropriate levels of tidal exchange to former tidal areas that have no tidal connection or a very restricted tidal exchange if it will not exacerbate habitat erosion and salt marsh loss in other areas, and
- C.** re-establish or augment the supply of suitable sediment to increase the elevations and resiliency of subsided marsh areas.

The SPT, with agreement from the Science Panel, asserted that future restoration projects in Elkhorn Slough should fit within the guidelines of these goals and objectives. Although it is likely that projects may not meet all of the goals and objectives, priority will be given to those that meet multiple objectives and there will be a preference for restoring the specific habitat types that historically occurred in each location wherever possible.

Planning Principles

The SPT developed planning principles that are general considerations the team will incorporate during the planning and implementation of future restoration projects. These principles are intended to be used in coordination with the vision, goals, and objectives statements.

Planning Principles

- Consider the broadest range of possible approaches to achieve the goals and objectives.
- Accommodate boating, farming, transportation, recreation, and other human uses necessary to support people in the region.
- Incorporate the needs of special estuarine conservation targets such as estuarine-dependent species, state- and federally-listed species, migratory species, and formerly dominant species.
- Give priority to actions that focus on protecting estuarine habitats most rapidly being lost both locally and in the region.
- Mitigate or avoid the negative impacts and consider the positive impacts of management strategies to neighboring landowners.
- Support projects that improve water quality for estuarine habitats and humans.
- Take into account present natural and cultural constraints and future geomorphological and climatic conditions (i.e. sea-level rise) in selecting restoration strategies.
- Consider how restoration and management strategies might be tested and implemented through pilot projects and reversible steps.
- Take advantage of opportunities for short-term pilot and demonstration projects that answer research questions most relevant to adaptively managing the resource.

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- To the extent possible, find solutions that minimize the long-term cost of ongoing maintenance required to sustain ecological services of habitats or the natural processes that control them.
- Maintain flexibility so that the planning process and potential strategies can be adaptively managed in the future.
- Recognize that the geographic scope is variable depending on estuarine processes so different scales need to be considered.
- Keep a watershed perspective. Consider the conservation and management efforts of adjoining upland and stream habitats.
- Document the major assumptions of all restoration designs and determine if the project seems reasonable to accomplish the goals.
- Learn from the successes and failures of similar projects that have been implemented and favor management strategies with high rates of success.
- Collaborate and stay informed about other planning processes in the area without disrupting those efforts.
- Aim for more aesthetically-pleasing structures when large-scale projects are designed.

Describing Estuarine Habitats

The Science Panel developed documents that described the loss and degradation of Elkhorn Slough's estuarine habitats while also defining the pertinent causes. Final documents created during this process are listed below and available on the Tidal Wetland Project website (<http://www.elkhornslough.org/tidalwetlandproject>) along with a list of primary authors and major conclusions. Descriptions of estuarine habitats and historical changes are summarized in Chapter 2, and discussions about major human alterations and conceptual models of likely causes of habitat erosion and marsh loss are found in Chapter 3.

- *150 Years of Human Alterations and Tidal Habitat Change (1870-Present) in Elkhorn Slough*
- *Likely Major Mechanisms of Tidal Marsh Loss*
- *Key Physical Processes Causing Habitat Erosion in Elkhorn Slough*
- *Evolution of Elkhorn Slough and Associated Wetlands 20,000 years before present (ybp) to 1880 A.D.*
- *Elkhorn Slough: A Review of the Geology, Geomorphology, Hydrodynamics, and Inlet Stability*
- *Groundwater Information for Elkhorn Slough (DRAFT)*

Habitat Predictions

The Science Panel has created statements supported by scientific consensus that predict future estuarine habitat trends based on present trends and existing scientific knowledge. As explained below, these predictions clearly state that salt marsh, mudflat, tidal creek, and channel habitats will continue to deteriorate over time. Moreover, habitat erosion rates may accelerate in upper Elkhorn Slough areas.



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50-Year Predictions of Elkhorn Slough Estuarine Habitat Trends¹

The relationship between the cross-sectional area and tidal prism in the Elkhorn Slough system is not at equilibrium.

- The extent of salt marsh will continue to significantly decrease and convert to mudflat and tidal creeks.
- The extent and cross-sectional area of tidal creeks will continue to increase at the expense of smaller tidal creeks, salt marsh, and mudflat.
- Sediment in soft-bottom areas exposed to strong tidal currents will erode, leaving harder substrates with larger grain sizes and weight/volume ratios (bulk density).
- The cross-sectional area of the main channel will likely increase in the upper Elkhorn Slough.² The erosion rate in the upper Slough is currently less than the rate in the lower Slough, but will likely increase over time.
- Bank erosion will continue (and may accelerate in the upper Elkhorn Slough) causing significant marsh loss.
- The cross-sectional area will continue to increase significantly in the lower main channel of Elkhorn Slough.
- The extent of mudflat will continue to increase at the expense of salt marsh.

¹*Predictions are only relevant for undiked estuarine habitats.*

²*The geographic break between the upper and lower Elkhorn Slough is Parsons Slough.*

