San Francisco Bay Subtidal Habitat Goals Report

CONSERVATION PLANNING FOR THE SUBMERGED AREAS OF THE BAY

EXECUTIVE SUMMARY

SAN FRANCISCO BAY is one of the largest estuaries on the West Coast and one of the most important both for the habitat it provides for fish and wildlife and for the many benefits and opportunities it offers people. Its natural beauty gives the Bay Area the iconic identity for which it is known throughout the world, while its waters ensure an enviable climate and quality of life for over 7.5 million residents. Residents commute across the bay on ferries, or enjoy it while boating, fishing, swimming, windsurfing, and birding in and around its waters. Visitors from around the country and world are drawn to this heart of the Bay Area as well, adding millions of dollars each year to the local and state economies. The bay is a busy center of commerce: cargo ships and tankers from around the Pacific Rim depend on its ports and infrastructure, and approximately two million tons of sand are mined from beneath its surface each year for use in construction. Historical oyster shell deposits are mined for livestock and chicken feed, soil conditioner, and as a dietary supplement for human consumption.

In addition to offering these aesthetic, economic, and recreational values, the bay supports a critical food web. Herring and Dungeness crab, among many other species of fish and shellfish, rear in its waters while sturgeon, salmon, and steelhead feed and rest in the bay during their migrations to and from its

rivers and streams and the ocean. Its vast open water, sloughs, rivers, streams, and tidelands host millions of migratory birds every year as they move up and down the Pacific Flyway, as well as provide habitat for numerous resident water, shore, and song birds. The bay also provides important habitat for marine mammals, shellfish, and aquatic invertebrates—the smaller, often unseen but important inhabitants of the estuarine ecosystem.

Looking Beneath the Surface

Subtidal habitat is a critical piece of this ecosystem. Subtidal habitat, as defined in this report, includes all of the submerged area beneath the bay's water surface: mud, shell, sand, rocks, artificial structures, shellfish beds, eelgrass beds, macroalgal beds, and the water column above the bay bottom. Although this hidden underbelly of the bay is often thought of as a featureless mud bottom, its unique habitats provide diverse three-dimensional structures, including sand waves more than three meters high. Its eelgrass and shellfish beds act as ecosystem engineers and provide substrate for reproduction and food resources for species such as herring and salmon; rocky outcrops offer substrate for seaweeds and invertebrates; mixed sediments in shoals and channel banks are used by a variety of species. Many shellfish, macro- and micro-invertebrates, fish, marine mammals, diving ducks, and other wildlife feed, rest, hide, and reproduce in subtidal areas. Large populations of shorebirds feed on the estuary's subtidal and intertidal mudflats.

The bay also supports a variety of indirect ecosystem services, including nutrient cycling, climate regulation, flood protection, water quality maintenance, and sediment transport. The Subtidal Habitat Goals Report recommends preserving and restoring the bay's subtidal resources for their ecosystem functions and habitat values as well as for their ecosystem services to humans. The vision statement and goals presented in the report were developed using

the best available science in the interest of supporting, maintaining, and improving upon these ecosystem functions, values, and services.

Report Audience and Use

Along with the Baylands Ecosystem Habitat Goals Project and the Uplands Habitat Goals Project, the San Francisco Bay Subtidal Habitat Goals Project (Subtidal Goals Project) represents a milestone in regional habitat planning for San Francisco Bay and its watersheds. Bay Area planners and resource managers now have a comprehensive and innovative ecosystem-based management vision for a continuum of habitat types from the bottom of the bay to tidal wetlands and grassland transition zones to upland areas.

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The Subtidal Goals Project report is neither a policy nor a regulatory document. It is designed to give resource managers, regulatory agencies, environmental groups, researchers, industry, and anyone interested in this important bay habitat the basic information they need to plan conservation, restoration, research, and protection activities related to subtidal habitat in the San Francisco Estuary.

Implementation of the goals in the report will occur through a number of avenues: local governments may incorporate these recommendations into their planning processes and documents. Non-profits may use the report when seeking funding for restoration or management projects, and researchers may wish to refer to it for guidance in writing proposals. Regulatory agencies may use this report to evaluate, revise, or implement their policies. However, new policies or modifications to existing policies proposed on the basis of this report will require a separate process in which each agency will analyze recommended policies in the context of its existing authorities and public input process.

The Subtidal Goals Project is a collaboration among the San Francisco Bay Conservation and Development Commission (BCDC), California Ocean Protection Council (OPC)/California State Coastal Conservancy (SCC), the National Oceanic and Atmospheric Administration (NOAA), and the San Francisco Estuary Partnership (SFEP). Lead staff from those agencies worked with the broader scientific community, managers, restoration practitioners, and stakeholders over several years to develop the goals set forth in this document. More about the process used to develop the project can be found in Appendix 1-1.

NOAA, BCDC, SFEP, and SCC each have different authorities, mandates and policies regarding conservation and management of subtidal habitats. As such, each agency may choose to use this document in different ways.

- While this document does not supersede or change NOAA authorities or mandates, NOAA staff may reference information in this document when implementing consultations pursuant to the Endangered Species Act and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act.

- NOAA may reference this document when evaluating research priorities both for NOAA Science Centers and other scientific entities.
- The NOAA Restoration Center may use this document to help prioritize restoration projects for funding and support.
- San Francisco Bay Conservation and Development Commission staff may use this document as background when considering future revisions to the San Francisco Bay Plan and may reference it when evaluating proposed projects under BCDC's existing regulatory authority over development in and around San Francisco Bay.
- The San Francisco Estuary Partnership may reference this document when implementing the Comprehensive Conservation and Management Plan for San Francisco Bay, in seeking federal dollars for San Francisco Bay conservation, and in selecting restoration and/or research projects to fund.
- The State Coastal Conservancy may use this document to identify acquisition opportunities, prioritize conservation and strategic planning, and develop restoration projects to support and fund. The Ocean Protection Council may utilize the document in making decisions and prioritizing research areas, especially as they relate to issues of land-sea interactions, ecosystem research, and climate change planning.

Planning Framework and Approach

The vision statement of the project is to achieve a net improvement of the subtidal ecosystem in San Francisco Bay through science-based protection and habitat restoration.

The Subtidal Goals Project takes a bay-wide approach to setting science-based goals for maintaining a healthy, productive, and resilient ecosystem. The vision statement of the project is to achieve a net improvement of the subtidal ecosystem in San Francisco Bay through science-based protection and habitat restoration. Where possible, these subtidal goals are designed to connect with intertidal habitats and with goals developed by other projects, including goals for baylands and uplands habitats. Unlike in the Baylands Goals effort, historical information about subtidal habitat is lacking. Thus the goals set forth in this document do not attempt to restore the bay to historical conditions but are designed to improve the condition of the subtidal ecosystem. The baseline for the project is 2010, and the planning horizon is 50 years.

Collecting and mapping baseline geospatial data of all of the subtidal habitat types was a critical piece of this project. Maps of habitat distribution, ownership, and stressors for each habitat type—as well as proposed restoration sites for native oysters and eelgrass and pilot locations for intertidal sand beaches and living shorelines—are presented throughout the report.

Early in the process, the following key planning decisions were made:

- The geographic scope of the Subtidal Goals Project is San Francisco Bay from Sherman Island west to the southern extent of the bay and seaward to the Golden Gate (Point Bonita to Point Lobos). Although the Sacramento-San Joaquin Delta is not included in the project scope, conditions in the delta and their relationship to subtidal habitat in the bay are addressed in the sections on freshwater input and climate change (see Chapter 3).
- For the purposes of this project, "*subtidal habitat*" includes all submerged areas of the bay. The project also includes certain *intertidal habitats* that were not specifically addressed in the 1999 Baylands Ecosystem Goals Report: intertidal mudflats, eelgrass, sand beaches, rocky intertidal and subtidal areas, and artificial substrate.
- The report uses a precautionary approach, erring on the side of conserving and protecting resources.
- Available information about existing conditions serves as a baseline.
- The goals build upon opportunities and information developed by existing subtidal pilot projects, including in-the-water monitoring, restoration, mitigation, and research projects in San Francisco Bay.
- This document avoids setting priorities among habitats although restoration of some may result in conversion of others: for example, some soft substrate may be lost or enhanced through restoration of eelgrass or shellfish beds.

- Because there is a great deal of uncertainty about the functions and value of subtidal habitats and the utility and likely success of restoration, this report recommends using an adaptive management approach in implementing the goals.
- As part of adaptive management, progress on achieving the goals—as measured by improved scientific understanding and practical experience in subtidal habitat restoration and protection—should be reviewed and evaluated in a report by 2020. The goals can then be modified as needed. Interim updates on particular topics can be provided within 10 years, and discussed at regional forums and conferences.

Establishing the Goals

Goals for each of the subtidal habitats are based on the vision statement and the following **foundational science goals**:

- Understand the value of the habitats
- Understand the interactions among habitats
- Understand the long-term prospects for subtidal habitats
- Develop mechanisms for adapting to climate change

Cross-Habitat Goals were also developed in response to four issues—invasive species, oil spills, marine debris, and public access/awareness—that affect all subtidal habitats:

- Minimize the impacts of aquatic invasive species on native subtidal habitats in San Francisco Bay.
- Protect San Francisco Bay from both acute and chronic oil spills.
- Prevent and capture land or marine sources of trash before they enter the bay.

- Identify, prioritize, and remove large sources of marine debris from intertidal and subtidal areas of the bay.
- Increase public awareness and foster support for subtidal habitat protection.

Taking into account the extent of scientific understanding of each habitat each goal was then vetted through a decision tree. That process led to establishing specific habitat goals and actions in one of four broad directions:

- Enhancing, creating, or restoring particular habitats
- Protecting habitats
- Observing habitats, taking no action
- Eliminating habitats

Other key conclusions reached after vetting each habitat through the decision tree include:

- Subtidal to intertidal mudflats support valued services and are under various threats from human activities and climate change. Opportunities for restoration are based on uncertain techniques, so this report emphasizes protecting habitat and applying restoration methods experimentally.
- Muddy soft-bottom habitat is essential for some species and probably supports the most known ecosystem services of any habitat. Although it is plentiful, several threats exist. However, there are few opportunities for restoration, leading to an emphasis on protection.
- Sand bottom is used for sand mining, but little is known about its role in non-extractive ecosystem services. This lack of knowledge leads to a recommendation to protect existing sand resources while pursuing research into the impacts of sand mining and the value of this habitat type to species and ecosystem services.

- Rock outcrops support ecosystem services and are under threat, but restoration would be logistically difficult and therefore unlikely; the report thus recommends protection actions only.
- Artificial structures support valued ecosystem services but also can impair others. Since they are artificial, most of them cannot be considered to be in short supply, nor are they under threat. Conversely, there is interest in removing some of them, especially derelict structures no longer in use, leading to an expansion of other more favored habitats.
- Several habitats (e.g., eelgrass, oyster beds) have clear benefits in supporting valued ecosystem services, although the degree of support is uncertain. They are likely in short supply and under various threats, and restoration has been successful at small scales. Therefore restoration goals are the principal focus for these habitats, although protection goals are also necessary.
- Algal beds support ecosystem services (although at a small scale), but they can also be nuisances under some conditions. Because it is unknown whether and which species of algal beds are under threat or in short supply, the decision tree process led to identifying research goals only.
- The water column forms the background for all of the other habitats. It supports all ecosystem services. Its existence is not threatened, but water quality could become degraded. However, as discussed in Chapter 3, water quality is the province of various agencies and is not addressed in this project.

Habitat Snapshots

Science, protection, and restoration goals were developed for the following six subtidal habitats:

Soft Substrate

1. *Soft Substrate*. More than 90% of the estuary's bottom is composed of particles small enough to be moved by tidal currents. Soft-bottom habitat includes the soft substrate, organisms living on or within the substrate, and the overlying water column. This habitat is threatened by construction activities, deposition of material from dredging and sand mining, wakes from ships and ferries, and a variety of contaminants, including some toxic "hot spots." Soft-bottom habitat may also be threatened by an overall decrease in sediment supply from upstream, and by sea-level rise. The report therefore recommends that the quality of this habitat be improved and that it be managed properly.

Rock

2. *Rock*. Relatively little hard substrate occurs naturally in the estuary. Rock habitat encompasses boulders to bedrock; i.e., rock that is not normally moved by currents. Shellfish beds and some algal beds are a subset of rock habitat. This habitat is threatened by blasting for navigational safety, colonization by invasive species, possibly by sediment deposition, and in the case of intertidal rock, from oil spills and trampling. While rock habitats support valued ecosystem services and are in short supply in the estuary, restoration seems impractical. The Subtidal Goals Project recommends protecting and managing rock habitat from being removed for vessel traffic and damaged by public access, and enhancing it by removing invasive species and debris. It also recommends improving scientific understanding of the ecosystem services this habitat provides and the species that use it.

Artificial Structures

3. *Artificial Structures*. Artificial structures are found throughout the estuary and include a wide variety of human-built objects designed to protect shorelines and shoreline structures and for transportation, recreation, and more recently, restoration (oyster shell and artificial reefs). While artificial structures support some valued ecosystem services, they are not in short supply, and they can have some detrimental effects. The Subtidal Goals Project recommends further study of the advantages and disadvantages of removing abandoned pier pilings, and if removal is decided upon, that it be done using an adaptive management approach. It also recommends using a pilot project approach, and if creosote pilings are removed, providing eelgrass as a substitute substrate for attracting spawning herring. Goals for artificial structures focus on protecting the habitat values of existing actively-used structures, removing and preventing structures that harm the subtidal system, and improving understanding of the role of these structures in the subtidal system.

Shellfish Beds

4. *Shellfish Beds*. Hard-bottom shellfish beds are locations where a shellfish species occupies more than 50% of an area of more than a few square meters. Five species of shellfish occur in San Francisco Bay: native Olympia oysters, California mussels, hybridized Bay mussels, and non-native ribbed horsemussel and green bagmussels (the latter two are not considered in this report). Small populations of the non-native Pacific oyster are found in the South Bay, where eradication efforts are underway. The Olympia oyster is the most abundant and the only species that is a native confined to estuaries. Numerous individuals have been found on hard substrates in the Central Bay and to a lesser extent in San Pablo and the South Bays. Native oysters are threatened by high rates of sedimentation and extended periods of low salinity. Human-induced threats include water pollution, boating, shipping, and dredging, which can disrupt oyster beds or cause sediment to smother the beds. The Subtidal Goals Project recommends building upon the demonstration oyster restoration work that has been performed to date, and moving toward larger-scaled pilot projects while focusing on knowledge gained in the process (adaptive management). Goals for shellfish beds include protecting existing native oyster beds, creating and enhancing additional beds, and improving scientific understanding of ecosystem services, factors influencing the beds, and restoration methods.

Submerged Aquatic Vegetation

5. *Submerged Aquatic Vegetation*. The term "submerged aquatic vegetation" (SAV) refers to all underwater flowering plants. In the San Francisco Estuary, SAV includes sago pondweed (*Stuckenia pectinata*, formerly *Potamogeton pectinatus*), eelgrass (*Zostera marina*), and other species of seagrass, including the surfgrasses (*Phyllospadix torreyi* and *P. scouleri),* and widgeongrass (*Ruppia maritima*). Several freshwater plant species, mostly introduced, are found mainly in the delta (e.g., the Brazilian waterweed *Egeria densa*, an invasive nuisance species) and are outside of the geographic scope of this project. In San Francisco Bay, eelgrass is much more extensive than other SAV, and its role and restoration potential are understood better than for other SAV (Appendix 8-1). The largest eelgrass beds in the estuary are in shallow subtidal regions of San Pablo Bay and Richardson Bay, with smaller beds scattered in shallow areas mainly between Carquinez Strait and Hayward. The largest bed in the bay is located between Point San Pablo and Point Pinole, and contains about half of the total acreage. Threats to SAV in San Francisco Bay include activities associated with shipping and boating, which can disrupt seagrass beds directly through destruction of plants by boat propellers, anchors and anchor chains, dredging, and construction of facilities (e.g., docks, harbors, breakwaters, ports). Indirect effects arise through increased suspended sediments due to dredging and boat wakes, or shading from structures such as docks. Hardening of the shoreline can reflect waves, increasing wave action and limiting or destroying beds. Most of these threats apply to eelgrass in the San Francisco Estuary but

are focused in localized areas. Impacts from dredging seem to have a limited spatial and temporal effect; damage from boat anchors, shoreline development, and ship wakes is also likely to be localized. Oil spills can inundate and smother eelgrass beds, particularly those in the intertidal or shallow subtidal zones. Eelgrass beds may respond to rising sea level by establishing closer to the present-day shoreline and dying out at greater depths. The dwindling sediment supply to the estuary may decrease turbidity, allowing eelgrass to grow at greater depths but possibly also promoting competing blooms of phytoplankton.

The restricted extent of eelgrass beds may limit their support of valued ecosystem services. Restoration has been demonstrated to be feasible although questions remain about the anticipated trajectory of restoration and associated response of ecosystem functions and services. Restoration is warranted for eelgrass beds, but should be done within an experimental framework.

Macroalgal Beds

6. *Macroalgal Beds*. Four species of macroalgae—*Ulva* spp., *Gracilaria pacifica, Fucus gardneri,* and the introduced *Sargassum muticum*—are sufficient to create beds in the estuary; however, their distribution and extent is poorly known. Macroalgae provide a suitable food source for a variety of grazers, predominantly macroinvertebrates. Water birds use it to line their nests. The beach wrack produced by macroalgae is an important food source for invertebrates living in beaches, mudflats, and marshes: they in turn provide food for shorebirds and other species along the shore. There have been few reports of nuisance blooms of macroalgae in the bay, although this could change if turbidity decreases. Intertidal algal beds are vulnerable to trampling and recreational harvesting as well as oil spills and dispersants. Because it is unclear whether additional macroalgal beds would be beneficial in the bay or that they are in short supply, and because it is difficult to distinguish algal beds that support ecosystem services from those that interfere with them, the Subtidal Goals Project recommends that additional research be performed and existing macroalgal beds protected.

The Science Goals[1]

Three key principles governed the establishment of science goals for subtidal habitats:

- Acknowledge key gaps in the knowledge needed for decisions about the value of restoration, and for effective protection and restoration. Substantial gaps are addressed by the following research questions:

  Which ecosystem services do the target habitats support, and how?

  What is the relationship between quantity of the habitat and the amount or value of those ecosystem services?

  What interactions (conflicts or synergies) are likely among those services or the ecosystem processes that produce them?

  What are the threats to various habitats or the species using them?

  What actions would enhance or diminish the amount or value of ecosystem services?

- Take a broad, long-term perspective. The goals should account for both long-term change in the estuary and spatial patterns at all scales. Research that informs managers about future conditions and applies broadly across the estuary should take the highest priority.

- Acknowledge and allow for limitations on gathering knowledge. The science goals should be achievable in a reasonable time and realistic as to the likely outcomes. Conducting research on subtidal habitats is difficult, particularly so in turbid estuaries where these habitats are largely invisible. These limitations should be acknowledged in determining research priorities and sequencing, and in setting expectations for the information needed for restoration and protection.

1. This summary presents the broadest level goals. More detailed, specific objectives and actions can be found in the report.

SCIENCE GOALS

Soft Substrate
Understand the extent of ecosystem services provided by soft-bottom habitats.
Understand the threats to mudflats and other soft-bottom habitats.
Determine suitable methods for protecting mudflats and beaches.
Understand the magnitude of the ecological risks posed by contaminants bound to the sediments.

Rock Habitats
Understand the ecosystem services provided by rock habitat and the species dependent on them.
Understand the ecosystem services provided by restored rock habitat.

Artificial Structures
Understand how artificial structures generally affect the estuarine ecosystem.
Determine the roles of individual artificial structures proposed for removal.

Shellfish Beds
Understand the ecosystem services the shellfish beds support, and in what quantities, in their current state and after restoration.
Understand the factors controlling the development and persistence of oyster and other shellfish beds.
Develop the most effective ways of restoring and protecting oyster beds.

Submerged Aquatic Vegetation (SAV)
Understand the ecosystem services the eelgrass beds support, and in what quantities, in their current state and after restoration.
Understand the factors controlling the development and persistence of eelgrass beds.
Develop the most effective ways of restoring and protecting eelgrass beds.
Assess the status and distribution of other SAV.

Macroalgal Beds
Understand the roles of macroalgal beds of different species in providing ecosystem services or interfering with services provided by other habitats.
Understand changes in the extent or condition of macroalgae.

The Protection Goals

Protection goals for each of the habitat types focus on preserving existing habitat. When information about specific threats to each habitat was available, more detailed protection objectives and actions were included.

The resource management committee prioritized stressors that can degrade or otherwise influence subtidal habitats, and the administrative core group conducted an exercise to compare severity, scope, and irreversibility of these stressors against each subtidal habitat type (see Appendix 1-1). This exercise resulted in the following key conclusions:

- Bottom disturbance is a stressor of concern across several habitats.
- Placement of artificial structures is a potential stressor of concern for the shellfish and submerged aquatic vegetation "living" habitats.
- Eelgrass habitat has multiple stressors of concern.
- Contaminants are a stressor of concern for soft substrate, especially mud habitat.

This was the starting framework for developing protection goals. This information was then further developed by science advisor Dr. Wim Kimmerer and the science committee (see Appendix 1-1) and incorporated into conceptual models for each habitat. Those models more fully describe the functions of and threats to the habitats and form the basis for all of the goals for each habitat type in Chapters 4–9.

PROTECTION GOALS
Soft Substrate
Consider the potential ecological effects of contaminated sediments when developing, planning, designing, and constructing restoration projects or other projects that disturb sediments.
Promote no net increase in disturbance to San Francisco Bay soft bottom habitat.
Promote no net loss to San Francisco Bay subtidal and intertidal sand habitats.
Develop a coordinated, collaborative approach for regional sediment management for San Francisco Bay.
Rock Habitats
Promote no net loss of natural intertidal and subtidal rock habitats in San Francisco Bay.
Artificial Structures
Enhance and protect habitat functions and the historical value of artificial structures in San Francisco Bay.
Improve San Francisco Bay subtidal habitats by minimizing placement of artificial structures that are detrimental to subtidal habitat function.
Shellfish Beds
Protect San Francisco Bay native shellfish habitats (particularly native oyster *Ostrea lurida*) through no net loss to existing habitat.
Protect areas in San Francisco Bay with potential for future shellfish expansion, restoration, or creation.
Submerged Aquatic Vegetation (SAV)
Protect existing eelgrass habitat in San Francisco Bay through no net loss to existing beds.
Establish eelgrass reserves.
Identify and protect areas in San Francisco Bay for future eelgrass expansion, restoration, or creation.
Protect existing widgeon grass habitat in San Francisco Bay.
Protect existing sago pondweed habitat in San Francisco Bay.
Macroalgal Beds
Protect San Francisco Bay *Fucus* beds through no net loss to existing beds.
Protect San Francisco Bay *Gracilaria* beds through no net loss to existing beds.

The Restoration Goals

Restoration should be targeted to locations and situations where long-term success is most likely.

In this report, the term "restoration" includes creating, enhancing, remediating, and rehabilitating habitat. The restoration goals are not meant to return subtidal habitats in San Francisco Bay to conditions that may have existed in the past. Rather, they are meant to improve upon conditions that exist today, with restoration targets based on what is known about ecosystem services provided by habitats, limiting factors, and the potential for habitats to be created or enhanced within the bay. Restoration should also be designed for the long term, and planning must therefore account for expected long-term changes. Restoration should be targeted to locations and situations where long-term success is most likely. This report recommends developing a better understanding of the likely success of restoration in particular areas, the local processes and conditions as they may affect the habitat, and the present and future threats.

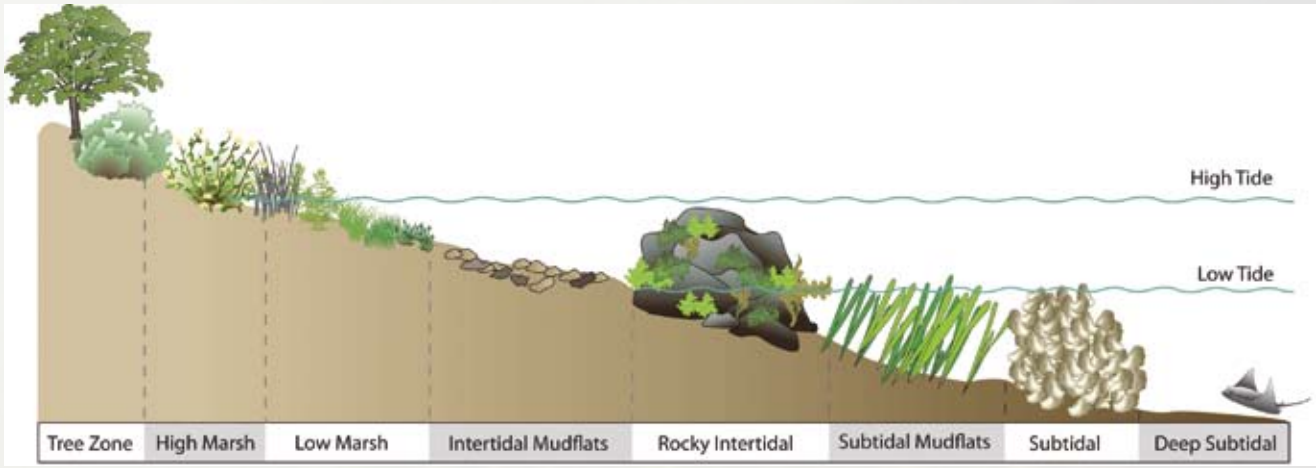
RESTORATION GOALS
Soft Substrate
Encourage the application of sustainable techniques in sand habitat replenishment or restoration projects.
Encourage removal of artificial structures that have negative impacts on soft bottom habitat function.
Rock Habitats
Restore and maintain natural intertidal and subtidal rock habitats in San Francisco Bay.
Artificial Structures
Where feasible, remove artificial structures from San Francisco Bay that have negative or minimal beneficial habitat functions.
Promote pilot projects to remove artificial structures and creosote pilings at targeted sites in combination with a living shoreline restoration design that will use natural bioengineering techniques (such as native oyster reefs, stone sills, and eelgrass plantings) to replace lost habitat structure.
Shellfish Beds
Increase native oyster populations in San Francisco Bay within 8,000 acres of potential suitable subtidal area over a 50-year time frame through a phased approach conducted within a framework of adaptive management.
Submerged Aquatic Vegetation (SAV)
Increase native eelgrass populations in San Francisco Bay within 8,000 acres of suitable subtidal/intertidal area over a 50-year time frame using a phased approach under a program of adaptive management.

Integrating Subtidal Habitat Restoration with Other Habitats

Integrating subtidal restoration with tidal wetland projects helps protect the enormous investment that has been made in restoring tidal wetlands around the bay.

Most of the habitat restoration projects implemented in and around San Francisco Bay in the last 40 years have focused on single habitat types such as marshes and riparian zones. Yet integrating restoration of subtidal and nearby marsh and upland habitats may provide greater ecological benefits and cost savings, help ameliorate habitat fragmentation, and help protect shorelines from climate change impacts, including sea level rise. Integrating subtidal restoration with tidal wetland restoration projects whenever possible thus helps protect the enormous investment that has been made over the past several decades in tidal wetlands around the bay.

One means to integrate them is through living shorelines. Living shorelines utilize a suite of bank stabilization and habitat restoration techniques to reinforce the shoreline, minimize coastal erosion, and maintain coastal processes while protecting, restoring, enhancing, and creating natural habitat for fish and aquatic plants and wildlife. This technique coined the term because it provides



"living space" for estuarine and coastal organisms, accomplished by the strategic placement of native vegetation, sand fill, organic materials, and reinforcing rock or shell for native plants and animals to settle on.

The decision tree used for vetting goals for the other habitat types (see Chapter 2) provides no guidance for integrating subtidal habitats with marshes and riparian habitats or for establishing living shorelines. The Subtidal Goals Project therefore suggests using an adaptive management approach to implementing pilot restoration projects that integrate subtidal habitat with other habitat types.

HABITAT INTEGRATION SCIENCE GOALS
Understand the ecosystem services supported by marsh-subtidal integration and living shorelines, and in what quantities.
Develop best practices for integrating subtidal restoration with adjacent wetlands.
Develop best practices for pilot projects to develop living shorelines.

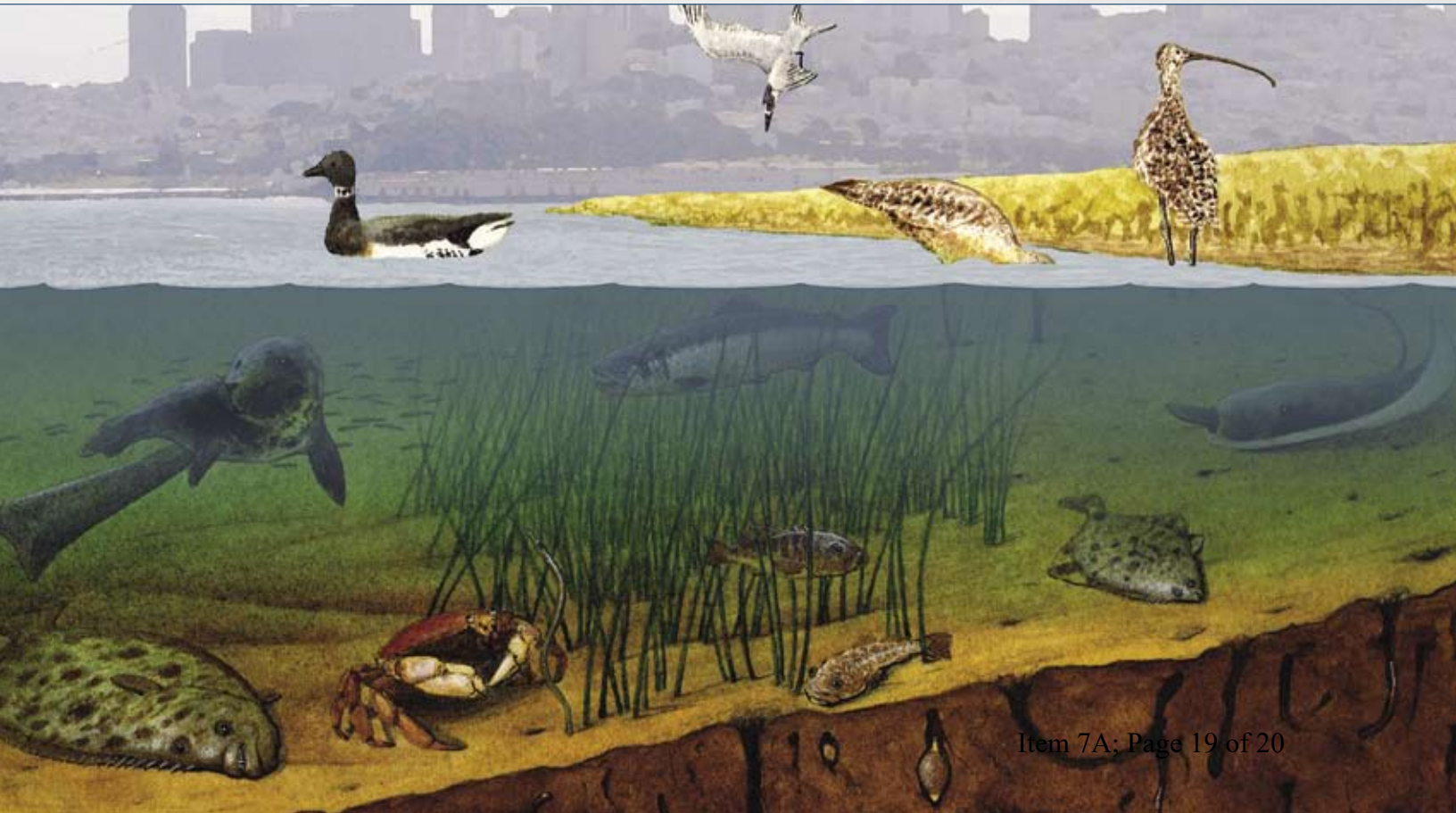
HABITAT INTEGRATION RESTORATION GOALS
Explore the integration of upland, intertidal, and subtidal habitats in San Francisco Bay.
Integrate habitat flexibility to increase resilience in the face of long-term change at habitat restoration sites around the bay.
Explore the use of living shoreline projects as a way to achieve multiple benefits in future shoreline restoration.

Potential Future Regulatory Actions for Subtidal Habitat

Several agencies regulate activities within the subtidal area of the bay. Some are focused on species protection, fisheries management, or water quality. Others have a broader habitat focus, while others must balance ecosystem and development needs. In reviewing these goals, some agencies may determine it prudent to take regulatory action through their existing authorities or to expand their current authorities through legislation or regulation changes. In either case, agencies must utilize existing public rule making processes. While regulatory measures would likely reduce impacts to the subtidal habitats, more research about these habitats is needed. As research is completed to better understand the functions and ecosystem services of subtidal habitats, information gained should directly inform management actions. In the interim, the Subtidal Goals Project recommends using a precautionary approach in managing subtidal habitats.

Implementing the Goals

To implement the goals, consistent and enduring support will be needed from a wide variety of stakeholders and yet may be difficult to secure, given political changes, staff turnover, budget fluctuations, and shifts in priorities. Successful implementation of the goals will require an entity or entities charged with raising funds and overseeing the realization of the goals in this document and the process of adaptive management necessary to realize the ecosystem benefits envisioned by this program. Implementation will require organizing stakeholders, identifying



owners of subtidal parcels, monitoring and tracking restoration projects, reviewing and reporting on knowledge gained and on progress in implementing the goals, revising the goals as needed, and educating the public about subtidal habitat in the estuary. This implementing entity might be an existing organization, a collaborative partnership among several agencies, or a new entity (such as a Joint Powers Authority or special district) created for this purpose.

The Subtidal Goals Project recommends that the lead entity (or entities) establish a Bay Area Subtidal Habitat Forum (Forum) to engage a broad network of agencies and partners who will participate in implementing subtidal habitat research, protection, and restoration goals. This Forum, made up of local, state, and federal agencies, academic institutions, non-profits, businesses, and industry, would increase regional coordination, collaborative planning, and support for and awareness of subtidal protection and restoration. The Forum should be charged with leading adaptive management and ensuring progress is being made towards the goals in this document.

Thoughtful planning must be put into the process by which the Forum is constituted, including determining how leadership is selected, which members should be included for participation and how they will be selected, what operating practices should be adopted, which agency staff resources will be provided, and what additional funding or resources are needed and where those resources will come from. Existing successful regional partnerships such as the San Francisco Bay Joint Venture and the Southern California Wetlands Recovery Project provide models for such a Forum.

The San Francisco Bay regulatory, agency, and environmental communities have an impressive record of taking bold and innovative actions to protect estuarine habitats and encourage public involvement. Making the goals set forth in this report a reality will take similar bold, sustained, and innovative efforts. The goals offer measurable objectives and actions that when implemented, will improve San Francisco Bay subtidal habitats. We hope you will join us in embracing the principles and recommendations included in this plan and look forward to working with a diverse group of stakeholders on implementing the goals.

A NOTE ON THE APPENDICES

Multiple reports informed the planning process for the Subtidal Goals Project. Because they are voluminous, the appendices are available on disk inside the report's back cover, and on-line at www.sfbaysubtidal.org.