STAFF REPORT

SAN FRANCISCO BAY ECOLOGY AND RELATED HABITATS

JULY 1, 2002

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

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PREFACE

The initial draft of the *San Francisco Bay Ecology and Related Habitats* background report was sent to the Commission on September 28, 2001 as the information foundation to the Bay Plan amendment process for the update to the fish and wildlife, marshes and mudflats, and dredging findings and policies; the addition of a subtidal areas policy section; and the update to the priority use area designations and Plan Map notes. This final draft incorporates comments from the National Marine Fisheries Service, the Cargill Salt Company and Deputy Attorney General, Tara L. Mueller, and also includes a new section of Commission approved Bay Plan policy and map changes.

Commission staff would like to thank all the science reviewers whose patience, comments and advice have helped immeasurably in the development of this staff report These science reviewers included: Sarah Allen, National Park Service, Point Reyes National Seashore; Andree Breaux, San Francisco Bay Regional Water Quality Control Board; Andrew Cohen, San Francisco Estuary Institute; Bruce Herbold, United States Environmental Protection Agency; Philip Williams, Philip Williams and Associates; Hal Markowitz, San Francisco State University; Michael Monroe, United States Environmental Protection Agency; Peter Baye, United States Fish and Wildlife Service; Josh Collins, San Francisco Estuary Institute; Wim Kimmerer, San Francisco State University; Michael McGowan, San Francisco State University; Steve Moore, San Francisco Bay Regional Water Quality Control Board; Fred Nichols, United States Geological Survey; Debra Smith, California Coastal Conservancy; John Takekawa, United States Geological Survey; Bruce Thompson, San Francisco Estuary Institute; Lynne Trulio, San Jose State University; Michael Vasey, San Francisco State University; Brian Mulvey, National Marine Fisheries Service; Paul Siri, University of California, Davis; Bill Sydeman, Point Reyes Bird Observatory; Bob Tasto, California Department of Fish and Game; Janet Thompson, United States Geological Survey; and Carl Wilcox, California Department of Fish and Game.

Commission staff would also like to thank Robert H. Twiss, Professor in the Graduate School and Professor Emeritus of Environmental Planning at the University of California, Berkeley, for facilitating the Subtidal Science Panel, held at BCDC in September 2000, as well as the entirety of scientists who lent their expertise to the endeavor as participants and made completion of chapter 9, "Restoring and Protecting Subtidal Habitats" possible. Members of the subtidal panel included Sarah Allen, Bruce Herbold, Wim Kimmerer, Hal Markowitz, Michael McGowan, Michael Monroe, Brian Mulvey, Fred Nichols, Paul Siri, Bill Sydeman, John Takekawa, Bob Tasto, Janet Thompson, Bruce Thompson and Philip Williams.

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Furthermore, development of this document depended in large part on the pioneering work of the numerous scientists and resource managers who spent five years collaborating on the *Baylands Ecosystem Habitat Goals* report and the *Baylands Ecosystem Species and Community Profiles* that established a vision for the restoration of San Francisco Bay and its aquatic life and wildlife.

The update to the San Francisco Bay Plan was funded in part by the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resources Management.

COMMISSION APPROVED BAY PLAN CHANGES

The following amended findings and policies and Plan Maps were adopted by the Commission on April 18, 2002 as part of Resolution No. 02-02 and are the culmination of the Bay Plan amendment process for the update to the fish and wildlife, marshes and mudflats and dredging findings and policies; the addition of a subtidal areas policy section; and the update to the priority use area designations and Plan Map notes. The staff background report *San Francisco Bay Ecology and Related Habitats*, initially sent to the Commission and the public on September 28, 2001, provided the information foundation from which the following updated findings, policies and Plan Maps emerged. The background report was considered by the Commission at three public hearings on November 15, 2001, December 6, 2001 and January 17, 2002, while the findings, policies and Plan Maps were considered by the Commission on February 21, 2002 and March 7, 2002.

Fish, Other Aquatic Organisms and Wildlife
Findings

a. Over the past 200 years, human actions have had a major effect on the form and natural functions of San Francisco Bay, resulting in a significant decrease in the size of the open waters of the Bay—from about 516,000 acres to 327,000 acres, an approximately 40 percent reduction—and notable changes in populations of fish, other aquatic organisms (e.g, crabs, shrimp, zooplankton and oysters) and wildlife habitat types, locations, quality and quantity. Loss or degradation of subtidal areas, tidal flats, tidal marshes and interconnected upland habitats, such as diked baylands, have been key factors in the population decline of many species of fish, other aquatic organisms and wildlife that depend on the Bay ecosystem for their existence.

b. At present, San Francisco Bay sustains nearly 500 species of fish, invertebrates, birds, mammals, insects and amphibians. It is an essential resting place, feeding area, and wintering ground for millions of birds on the Pacific Flyway. Nearly half of the state's waterfowl and shorebirds and two-thirds of the state's salmon pass through the Bay during their migrations.

c. Fish, other aquatic organisms and wildlife of the Bay benefit humans. They provide food, economic gain, and recreation. They are a resource for scientific research and education. No comprehensive estimate of the value of fish and wildlife for these purposes is available, but they enhance the intrinsic value and aesthetic appeal of the Bay.

d. Conserving fish, other aquatic organisms and wildlife depends, among other things, upon availability of: (1) sufficient oxygen in the Bay waters; (2) adequate amounts of the proper foods; (3) sufficient areas for resting, foraging and breeding; and (4) proper fresh water inflows, temperature, salt content, water quality, and velocity of the water. Requirements vary according to the species of fish, other aquatic organisms and wildlife. Conservation and restoration of these habitat components is essential to insure for future generations the benefit of fish, other aquatic organisms and wildlife in the Bay.

e. All parts of San Francisco Bay are important for the perpetuation of fish, other aquatic organisms, and wildlife because any reduction of habitat reduces their numbers in some measure.

f. The wildlife refuges, shown on the Bay Plan Maps, include national wildlife refuges, state wildlife areas and ecological reserves, as well as other shoreline sites around the Bay whose primary purpose is: (1) the protection of threatened or endangered native plants, wildlife, and aquatic organisms; (2) the preservation and enhancement of unique habitat types or highly significant wildlife habitat; or (3) the propagation and feeding of aquatic life and wildlife.

g. Under the California Endangered Species Act, the Commission must assure that the projects it permits conserve fish, other aquatic organisms, wildlife and plants listed pursuant to the Act and the Commission may not authorize the "taking," as defined in the Act, of certain fish, wildlife or plant species without the authorization of the California Department of Fish and Game. Further, under the federal Endangered Species Act and Marine Mammal Protection Act the Commission may not authorize a project that would result in the "taking" of fish, other aquatic organisms, and wildlife, including marine mammals, identified pursuant to the Acts, without the authorization of the United States Fish and Wildlife Service or the National Marine Fisheries Service.

h. Under the federal Magnuson-Stevens Act and the Endangered Species Act, San Francisco Bay is considered critical habitat for certain fish species, such as Chinook salmon and Delta smelt, by the United States Fish and Wildlife Service and the National Marine Fisheries Service because the Bay plays an essential role in their life cycles. The Magnuson-Stevens Act requires that the National Marine Fisheries Service provide conservation recommendations to state agencies, such as the Commission, when a proposed project would have adverse impacts on essential fish habitat.

i. The San Francisco Bay Area Wetlands Ecosystem Goals report provides a regional vision of the types, amounts, and distribution of wetlands and related habitats that are needed to restore and sustain a healthy Bay ecosystem, including the improvement of the well-being of many plant and animal species currently at risk of extinction.

Fish, Other Aquatic Organisms and Wildlife Policies

1. To assure the benefits of fish, other aquatic organisms and wildlife for future generations, to the greatest extent feasible, the Bay's tidal marshes, tidal flats, and subtidal habitat, should be conserved, restored and increased.

2. Specific habitats that are needed to conserve, increase or prevent the extinction of any native species, species threatened or endangered, species that the California Department of Fish and Game has determined are candidates for listing as endangered or threatened under the California Endangered Species Act, or any species that provides substantial public benefits, should be protected, whether in the Bay or behind dikes.

3. In reviewing or approving habitat restoration programs the Commission should be guided by the recommendations in the Baylands Ecosystem Habitat Goals report and should, where appropriate, provide for a diversity of habitats to enhance opportunities for a variety of associated native aquatic and terrestrial plant and animal species.

4. The Commission should:

(a) Consult with the California Department of Fish and Game and the U.S. Fish and Wildlife Service or the National Marine Fisheries Service whenever a proposed project may adversely affect an endangered or threatened plant, fish, other aquatic organism or wildlife species;

(b) Not authorize projects that would result in the "taking" of any plant, fish, other aquatic organism or wildlife species listed as endangered or threatened pursuant to the state or federal endangered species acts, or the federal Marine Mammal Protection Act, or species that are candidates for listing under the California Endangered Species Act, unless the project applicant has obtained the appropriate "take" authorization from the U.S. Fish and Wildlife Service, National Marine Fisheries Service or the Department of Fish and Game; and

(c) Give appropriate consideration to the recommendations of the California Department of Fish and Game, the National Marine Fisheries Service or the United States Fish and Wildlife Service in order to avoid possible adverse effects of a proposed project on fish, other aquatic organisms and wildlife habitat.

5. The Commission may permit a minor amount of fill or dredging in wildlife refuges, shown on the Plan Maps, necessary to enhance fish, other aquatic organisms and wildlife habitat or to provide public facilities for wildlife observation, interpretation and education.

Tidal Marshes and Tidal Flats
Findings

a. San Francisco Bay is comprised of a diversity of habitats. These habitats were formed and are sustained by the global forces of climate and sea level change, as well as the more local effects of topography; the ebb and flow of the daily tides; the volume, timing and location of fresh water inflow; and the availability and types of sediments on the bottom of the Bay and suspended in the water column. Bay habitats include subtidal areas, tidal flats, and tidal marsh; Bay-related habitats include diked baylands, such as salt ponds, managed marsh and agricultural baylands. Plants and animals require a variety of habitats to survive. For example, topsmelt (a fish species) utilize the shallow, protected sloughs of tidal marshes of the Bay, as well as open water during different times in their life cycle and daily feeding routine. The topsmelt is also food for many species of birds that inhabit the tidal marshes and upland areas surrounding the Bay.

b. San Francisco Bay is a substantial part of the largest estuary along the Pacific shore of North and South America and is a natural resource of incalculable value. An estuary is a partially enclosed body of water formed where fresh water from rivers and streams meet and mix with salt water carried in from the ocean by the daily tides. Estuaries are places of transition that provide rich and diverse habitats for aquatic and upland plants and animals. The sheltered waters of estuaries support unique communities of plants and animals specially adapted for life in the region where rivers meet the coast. Estuaries provide ideal spots for migratory birds to rest and feed during their journeys and many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn.

c. Wetlands are transitional areas between upland and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Examples of wetland habitats associated with the Bay include tidal flats, tidal marshes, lagoons, managed wetlands, agricultural baylands, salt ponds, wastewater treatment ponds, and riparian forests.

d. Wetlands can alter and moderate flood flows, recharge groundwater, maintain stream flows, reduce and prevent shoreline erosion by minimizing wave energy, and improve water quality by filtering surface runoff from surrounding lands. In addition, they trap sediments, thereby reducing the amount deposited in channels. Wetland plants help absorb available nitrogen, atmospheric sulfur, carbon dioxide and methane. Wetlands also are important habitat for the Bay's aquatic and upland plant and animal populations, serve as a primary link in the ecosystem's food chain, ensure the continued diversity of plant and animal communities, are an essential feeding and resting place for migratory birds on the Pacific Flyway, and provide needed and important open space and recreational opportunities in the Bay Area.

e. A transition zone, or "ecotone" is an environment that blends the habitat of plants and animals from each of the bordering habitats—such as tidal marsh and oak woodlands. Transition zones are important elements of wetland habitats. Around the Bay these zones contain a rich mixture of vegetation types, including many of the Bay's rare plants, and they provide food, shelter and high-tide refugia for wildlife, including the salt marsh harvest mouse and California black rail.

f. Over 137,000 acres of the Bay, its tidal marshes and tidal flats, have been diked from tidal action and include managed wetlands, agricultural baylands, salt ponds and wastewater treatment ponds. These habitats possess a particular importance in replacing habitat values lost with the elimination of the majority of the Bay's historic tidal marsh habitat, which may include: (1) providing high tide refuge and foraging habitat for species such as shorebirds and the salt marsh harvest mouse; (2) acting as a buffer between remaining tidal marshes, tidal flats and upland uses; (3) creating corridors for wildlife movement between upland habitats and the Bay; (4) retaining stormwater runoff and flood water; (5) filtering sediments and pollutants from stormwater flowing to the Bay; and (6) providing opportunities for recreation, research and education. Diked agricultural baylands, salt ponds and managed wetlands also offer the greatest opportunity to restore large parts of the Bay to tidal action.

g. The San Francisco Bay Area Wetlands Ecosystem Goals report provides a regional vision of the types, amounts, and distribution of wetlands and related habitats that are needed to restore and sustain a healthy Bay ecosystem, including restoration of 65,000 acres of tidal marsh.

h. Tidal marshes, which include brackish and salt marshes, are vegetated wetlands subject to tidal action that occur throughout much of the Bay extending from approximately Mean Sea Level to the maximum height of the tides. Established tidal marshes provide an essential and complex habitat for many species of fish, other aquatic organisms and wildlife. In the early 1800s, before diking and filling had begun, tidal marshes covered some 190,000 acres on the fringes of the Bay. Tidal marsh bordering the Bay now totals approximately 40,000 acres—a loss of approximately 80 percent of the Bay's historic tidal marshes.

i. Tidal marshes are an interconnected and essential part of the Bay's food web. Decomposed plant and animal material and seeds from tidal marshes wash onto surrounding tidal flats and into subtidal areas, providing food for numerous animals, such as the Northern pintail. In addition, tidal marshes provide habitat for insects, crabs and small fish, which in turn, are food for larger animals, such as the salt marsh song sparrow, harbor seal and great blue heron.

j. Tidal flats occur from the elevation of the lowest tides to approximately Mean Sea Level and include mudflats, sandflats and shellflats. Mudflats comprise the largest area of tidal flat areas and support an extensive community of invertebrate aquatic organisms, e.g., diatoms, worms and shellfish, fish that feed during higher tides, and plants such as algae and occasionally eelgrass. Shorebirds feed on tidal flats. Few mammals, however, inhabit tidal flats, the harbor seal being the most notable exception. Historically, around 50,000 acres of tidal flats occurred around the margins of the Bay, approximately 29,000 acres remain—a reduction of over 40 percent.

k. Sedimentation is an essential factor in the creation, maintenance and growth of tidal marsh and tidal flat habitat. However, scientists studying the Bay estimate that sedimentation will not be able to keep pace with accelerating sea level rise, due largely to declines in sediment entering the Bay from the Sacramento and San Joaquin Delta, thus potentially exacerbating shoreline erosion and adversely affecting the sustainability of future wetland restoration projects.

l. Plant and animal species not present in San Francisco Bay prior to European contact in the late 18th century, known as non-native species, which thrive and reproduce outside of their natural range have made vast ecological alterations to the Bay and have contributed to the serious reduction of native populations of certain plants and animals through: (1) predation; (2) competition for food, habitat, and other necessities; (3) disturbance of habitat; (4) displacement; or (5) hybridization. Many non-native species enter the Bay from commercial ship ballast water that is discharged into the Bay. Approximately 170 species have invaded the Bay since 1850, and possibly an additional 115 species have been deliberately introduced. By 2001, over 1,200 acres of recently restored tidal marshes have been invaded by introduced cordgrass species, such as salt meadow cordgrass, dense-flowered cordgrass, English cordgrass and smooth cordgrass. At present an average of one new non-native species establishes itself in the Bay every 14 weeks. Control or eradication is a critical step in reducing the harm associated with non-native species.

m. Fill material, such as rock and sediments dredged from the Bay, can enhance or beneficially contribute to the restoration of tidal marsh and tidal flat habitat by: (1) raising areas diked from the Bay to an elevation that will help accelerate establishment of tidal marsh; and (2) establishing or recreating rare Bay habitat types.

Tidal Marshes and Tidal Flats Policies

1. Tidal marshes and tidal flats should be conserved to the fullest possible extent. Filling, diking, and dredging projects that would substantially harm tidal marshes or tidal flats should be allowed only for purposes that provide substantial public benefits and only if there is no feasible alternative.

2. Any proposed fill, diking, or dredging project should be thoroughly evaluated to determine the effect of the project on tidal marshes and tidal flats, and designed to minimize, and if feasible, avoid any harmful effects.

3. Projects should be sited and designed to avoid, or if avoidance is infeasible, minimize adverse impacts on any transition zone present between tidal and upland habitats. Where a transition zone does not exist and it is feasible and ecologically appropriate, shoreline projects should be designed to provide a transition zone between tidal and upland habitats.

4. Where and whenever possible, former tidal marshes and tidal flats that have been diked from the Bay should be restored to tidal action in order to replace lost historic wetlands or should be managed to provide important Bay habitat functions, such as resting, foraging and breeding habitat for fish, other aquatic organisms and wildlife. As recommended in the Baylands Ecosystem Habitat Goals report, around 65,000 acres of areas diked from the Bay should be restored to tidal action. Further, local government land use and tax policies should not lead to the conversion of these restorable lands to uses that would preclude or deter potential restoration. The public should make every effort to acquire these lands from willing sellers for the purpose of restoration.

5. Any tidal restoration project should include clear and specific long-term and short-term biological and physical goals, and success criteria and a monitoring program to assess the sustainability of the project. Design and evaluation of the project should include an analysis of: (a) the effects of relative sea level rise; (b) the impact of the project on the Bay's sediment budget; (c) localized sediment erosion and accretion; (d) the role of tidal flows; (e) potential invasive species introduction, spread, and their control; (f) rates of colonization by vegetation; (g) the expected use of the site by fish, other aquatic organisms, and wildlife; and (h) site characterization. If success criteria are not met, appropriate corrective measures should be taken.

6. Non-native species should not be used in habitat restoration projects. Any habitat restoration project approved by the Commission should include a program for the periodic monitoring of the site for non-native species and a program for control and, if appropriate and feasible, eradication should an introduction occur. The use of non-native plant species in public access landscape improvements should be avoided where a potential exists for non-native plants to spread into the Bay, other waterways, or transition zones between tidal and upland habitats.

7. The Commission should continue to support and encourage the expansion of scientific information on the arrival and spread of invasive plants and animals, and when feasible, support the establishment of a regional effort for Bay-wide eradication of specific invasive species, such as non-native cordgrasses.

8. Based on scientific ecological analysis and consultation with the relevant federal and state resource agencies, a minor amount of fill may be authorized to enhance or restore fish, other aquatic organisms or wildlife habitat if the Commission finds that no other method of enhancement or restoration except filling is feasible.

Dredging
Findings
Only updated findings shown

n. Baywide studies would help determine the need for, appropriate locations for, and potential effects of in-Bay disposal for eelgrass or other shallow water habitat enhancement or restoration. The Commission has approved a pilot project, the Oakland Middle Harbor enhancement project, that could help to determine the feasibility of eelgrass or other shallow water habitat enhancement or restoration in the Bay.

Dredging
Policies
Only updated policies shown

1. Dredging and dredged material disposal should be conducted in an environmentally and economically sound manner. Dredgers should reduce disposal in the Bay and certain waterways over time to achieve the LTMS goal of limiting in-Bay disposal volumes to a maximum of one million cubic yards per year. The LTMS agencies should implement a system of disposal allotments to individual dredgers to achieve this goal only if voluntary efforts are not effective in reaching the LTMS goal. In making its decision regarding disposal allocations, the Commission should confer with the LTMS agencies and consider the need for the dredging and the dredging projects, environmental impacts, regional economic impacts, efforts by the dredging community to implement and fund alternatives to in-Bay disposal, and other relevant factors. Small dredgers should be exempted from allotments, but all dredgers should comply with policies 2 through 12.

3. Dredged materials should, if feasible, be reused or disposed outside the Bay and certain waterways. Except when reused in an approved fill project, dredged material should not be disposed in the Bay and certain waterways unless disposal outside these areas is infeasible and the Commission finds: (a) the volume to be disposed is consistent with applicable dredger disposal allocations and disposal site limits adopted by the Commission by regulation; (b) disposal would be at a site designated by the Commission; (c) the quality of the material disposed of is consistent with the advice of the San Francisco Bay Regional Water Quality Control Board and the inter-agency Dredged Material Management Office (DMMO); and (d) the period of disposal is consistent with the advice of the California Department of Fish and Game, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

11 a. A project that uses dredged material to create, restore, or enhance Bay or certain waterway natural resources should be approved only if:

(1) The Commission, based on detailed site-specific studies, appropriate to the size and potential impacts of the project, that include, but are not limited to, site morphology and physical conditions, biological considerations, the potential for fostering invasive species, dredged material stability, and engineering aspects of the project determines all of the following:

(a) the project would provide, in relationship to the project size, substantial net improvement in habitat for Bay species;

(b) no feasible alternatives to the fill exist to achieve the project purpose with fewer adverse impacts to Bay resources;

(c) the amount of dredged material to be used would be the minimum amount necessary to achieve the purpose of the project;

(d) beneficial uses and water quality of the Bay would be protected; and

(e) there is a high probability that the project would be successful and not result in unmitigated environmental harm;

(2) The project includes an adequate monitoring and management plan and has been carefully planned, and the Commission has established measurable performance objectives and controls that would help ensure the success and permanence of the project, and an agency or organization with fish and wildlife management expertise has expressed to the Commission its intention to manage and operate the site for habitat enhancement or restoration purposes for the life of the project;

(3) The project would use only clean material suitable for aquatic disposal and the Commission has solicited the advice of the San Francisco Bay Regional Water Quality Control Board, the Dredged Material Management Office and other appropriate agencies on the suitability of the dredged material;

(4) The project would not result in a net loss of Bay or certain waterway surface area or volume. Any offsetting fill removal would be at or near as feasible to the habitat fill site;

(5) Dredged material would not be placed in areas with particularly high or rare existing natural resource values, such as eelgrass beds and tidal marsh and mudflats, unless the material would be needed to protect or enhance the habitat. The habitat project would not, by itself or cumulatively with other projects, significantly decrease the overall amount of any particular habitat within the Suisun, North, South, or Central Bays, excluding areas that have been recently dredged;

(6) The Commission has consulted with the California Department of Fish and Game, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service to ensure that at least one of these agencies supports the proposed project; and

(7) After a reasonable period of monitoring, if either:

(a) the project has not met its goals and measurable objectives, and attempts at remediation have proven unsuccessful, or

(b) the dredged material is found to have substantial adverse impacts on the natural resources of the Bay, then the dredged material would be removed, unless it is demonstrated by competent environmental studies that removing the material would have a greater adverse effect on the Bay than allowing it to remain, and the site would be returned to the conditions existing immediately preceding placement of the dredged material.

b. To ensure protection of Bay habitats, the Commission should not authorize dredged material disposal projects in the Bay and certain waterways for habitat creation, enhancement or restoration, except for projects using a minor amount of dredged material, until:

(1) Objective and scientific studies have been carried out to evaluate the advisability of disposal of dredged material in the Bay and certain waterways for habitat creation, enhancement and restoration. Those additional studies should address the following:

(a) The Baywide need for in-Bay habitat creation, enhancement and restoration, in the context of maintaining appropriate amounts of all habitat types within the Bay, especially for support and recovery of endangered species; and

(b) The need to use dredged materials to improve Bay habitat, the appropriate characteristics of locations in the Bay for such projects, and the potential short-term and cumulative impacts of such projects; and

(2) The Commission has adopted additional Baywide policies governing disposal of dredged material in the Bay and certain waterways for the creation, enhancement and restoration of Bay habitat, which narratively establish the necessary biological, hydrological, physical and locational characteristics of candidate sites; and

(3) The Oakland Middle Harbor enhancement project, if undertaken, is completed successfully.

Subtidal Areas
Findings

a. The subtidal areas of the Bay encompass the land and water below mean low tide and are intricately tied to tidal flats and tidal marshes and are also linked to diked former parts of the Bay such as salt ponds, managed wetlands, agricultural baylands, and adjacent upland habitats. These areas include both shallow and deep segments of the Bay and are important for fish, other aquatic organisms and wildlife, such as bottom-dwelling benthic organisms, seabirds, waterfowl and some mammals, such as harbor seals, that move back and forth between deep and shallow water. The Bay's subtidal areas also serve as a corridor for fish and wildlife species moving between the Ocean and the Delta and other local rivers and streams entering the Bay.

b. Physical dynamics of the water column, such as fronts (the boundary between two dissimilar masses of water), eddies (a current of water running contrary to the main current), and retention zones (areas where tidal flows slow or stop due to either fresh water incursions or prominent bathymetric features), affect where fish concentrate and consequently where other species, such as seabirds and harbor seals, feed.

c. Tidal and fresh water flows influence all parts of the Bay and move salt, sediment, and other substances, such as plankton, throughout it. For example, flows over shallow subtidal areas resuspend and deposit sediment, which continually shapes the Bay, tidal flats and tidal marshes, while flows through deep subtidal areas are critical to salt transport throughout the Bay ecosystem. In addition, many fish, other aquatic organisms and wildlife use different parts of the Bay during their life cycles, and are strongly influenced by variations in physical processes.

d. Populations of many native fresh water and estuarine fish, marine mammals, and birds in the Bay, as well as certain native zooplankton and phytoplankton in Suisun Marsh, have declined due to increased pollutants, decreased freshwater flows, loss of habitat and an increased prominence of invasive species.

e. The mixing zone, also referred to as the entrapment or null zone, is centered in Suisun Bay where less-dense, fresh water flowing seaward out of the Delta and more-dense, salt water flowing landward on the tides into the Bay from the Pacific Ocean meet and mix producing an abundance of suspended nutrients and creating one of the Bay's most productive areas for fish and other aquatic organisms. Mixing zones also occur at a smaller scale where rivers and streams flowing into the Bay meet tidal waters.

f. Some parts of the Bay are particularly important to certain species of fish, other aquatic organisms and wildlife due to their high native biodiversity, productivity or scarcity (e.g., deep water over sand shoals, the mixing zone, oyster reefs, shallow and calm areas, eelgrass beds, areas where seaweed is found, and where tidal eddies, retention zones and fronts concentrate prey).

g. The Bay is a dynamic ecosystem influenced by natural processes on tidal and seasonal scales, as well as by events that occur annually or on longer-term scales. The depth and shape of the Bay (its bathymetry) is at any moment the result of the interacting forces of erosion and deposition of sediment. This natural balance has changed during the past 150 years due to such human actions as hydraulic mining (increased sediment input), dam construction (reduced sediment input), water diversion, filling, diking, and dredging, all of which have significantly altered the Bay's historic sedimentary processes.

h. Unlike land-based habitats, the Bay's subtidal areas are not easily divided into habitat classification categories. However, location can be very important. For example, fronts, stratification, turbulence, wastewater input, and fish aggregation can be quite local in nature. Furthermore, the value of a particular subtidal area to a species is influenced by the Bay's physical characteristics (including sediment type, depth, salinity, temperature and currents), by process (such as sediment movement, sand replenishment, wind and wave action, erosion and deposition), and biological features (including concentration of food or linkages between habitats). Thus, although general guidelines can be developed on a regional scale, the evaluation of specific projects requires knowledge of local conditions. In particular, local bathymetric features, which may have the greatest influence on physical, chemical, or biological properties, should receive great attention, since small changes in bathymetry may have unexpectedly large influences.

i. Major gaps in scientific knowledge exist about the subtidal areas of the Bay due to the dynamic nature of the system and the complexity of linkages between subtidal areas and the fish, other aquatic organisms and wildlife which depend upon them to rest, forage and breed.

j. Fill material, such as rock, oyster shells and sediments dredged from the Bay, can enhance or beneficially contribute to the restoration of subtidal habitat by: (1) creating varied subtidal areas beneficial to aquatic species, such as Pacific herring; (2) restoring native oyster reefs; (3) enhancing subtidal plant communities, such as eelgrass beds; and (4) recreating the bathymetry of disturbed areas, such as dredged channels.

Subtidal Areas
Policies

1. Any proposed filling or dredging project in a subtidal area should be thoroughly evaluated to determine the local and Bay-wide effects of the project on: (a) the possible introduction or spread of invasive species; (b) tidal hydrology and sediment movement; (c) fish, other aquatic organisms, and wildlife; (d) aquatic plants; and (e) the Bay's bathymetry. Projects in subtidal areas should be designed to minimize and, if feasible, avoid any harmful effects.

2. Subtidal areas that are scarce in the Bay or have an abundance and diversity of fish, other aquatic organisms and wildlife (e.g. eelgrass beds, sandy deep water or underwater pinnacles) should be conserved. Filling, changes in use, and dredging projects in these areas should therefore be allowed only if: (a) there is no feasible alternative; and (b) the project provides substantial public benefits.

3. Subtidal restoration projects should be designed to: (a) promote an abundance and diversity of fish, other aquatic organisms and wildlife; (b) restore rare subtidal areas; (c) establish linkages between deep and shallow water and tidal and subtidal habitats in an effort to maximize habitat values for fish, other aquatic organisms, and wildlife; or (d) expand open water areas in an effort to make the Bay larger.

4. Any subtidal restoration project should include clear and specific long-term and short-term biological and physical goals, and success criteria and a monitoring program to assess the sustainability of the project. Design and evaluation of the project should include an analysis of: (a) the scientific need for the project; (b) the effects of relative sea level rise; (c) the impact of the project on the Bay's sediment budget; (d) localized sediment erosion and accretion; (e) the role of tidal flows; (f) potential invasive species introduction, spread and their control; (g) rates of colonization by vegetation, where applicable; (h) the expected use of the site by fish, other aquatic organisms, and wildlife; and (i) characterization of and changes to local bathymetric features. If success criteria are not met, corrective measures should be taken.

5. The Commission should continue to support and encourage expansion of scientific information on the Bay's subtidal areas, including: (a) inventory and description of the Bay's subtidal areas; (b) the relationship between the Bay's physical regime and biological populations; (c) sediment dynamics, including sand transport, and wind and wave effects on sediment movement; (d) areas of the Bay used for spawning, birthing, nesting, resting, feeding, migration, among others, by fish, other aquatic organisms and wildlife; and (e) where and how restoration should occur.

6. Based on scientific ecological analysis and consultation with the relevant federal and state resource agencies, a minor amount of fill may be authorized to enhance or restore fish, other aquatic organisms or wildlife habitat if the Commission finds that no other method of enhancement or restoration except filling is feasible.

Plan Map 1

San Pablo Bay

PLAN MAP NOTES

Park Proposal for Area South of Hamilton Field - *Large, undeveloped area between Hamilton Field and Gallinas Creek is possible site for major county park. Due to extensive offshore mudflats, would not be suitable for water-oriented recreation.*

Skaggs Island - *The U.S. Fish and Wildlife Service proposes to acquire closed U.S. Navy military facility to be included in the San Pablo Bay National Wildlife Refuge. The proposed addition to the wildlife refuge would be in accord with Bay Plan policies.*

Salt Ponds and Other Managed Wetlands - *Large area, high-value wildlife habitat.*

San Pablo Bay National Wildlife Refuge - *The addition and restoration of land with high aquatic life and wildlife habitat value or good habitat restoration potential to the San Pablo Bay National Wildlife Refuge would be in accord with Bay Plan Policies.*

Point Pinole Regional Shoreline to Wildcat Creek - *Public access to the Bay for recreation is needed in this area, although existing shoreline conditions make this difficult. All development in this area should include provision for substantial public access.*

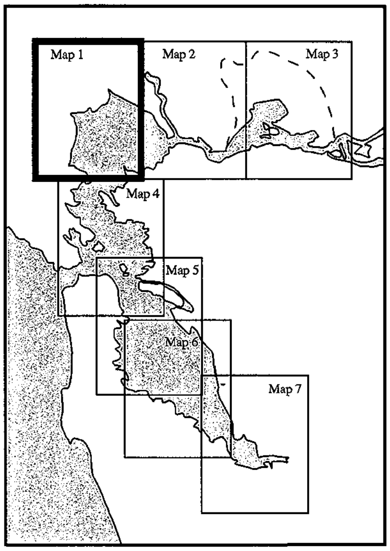
San Pablo Bay Wildlife Refuges - *The California Department of Fish and Game and the U.S. Fish and Wildlife Service are carrying out a cooperative program to acquire, restore and manage areas of high aquatic life and wildlife habitat value in San Pablo Bay.*

Proposed Marin Baylands National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh, seasonal marsh and uplands in a national wildlife refuge located on the west side of San Pablo Bay from the Petaluma River to an area south of Gallinas Creek in Marin County. The proposed wildlife refuge would be in accord with Bay Plan policies.*

Proposed San Francisco Bay National Estuarine Research Reserve (China Camp State Park) - *One of two sites in the Bay, the other being Rush Ranch Open Space Preserve, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*

Areas diked from the Bay have high-value wildlife habitat and restoration potential.

Petaluma Marsh - *The largest remaining intact tidal marsh within the Bay. Features characteristic of historic tidal marshes found here include a system of extensive channels, pans (ponds) and natural transitions to adjacent upland habitats.*



Amended May 2002

Plan Map 1

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. **Rat Rock** - Preserve island; no development.
2. **China Camp State Park** - Create continuous shoreline recreational area, including beaches, marinas, picnic areas, fishing piers, and riding and hiking trails.
3. Protect and provide public access to shellfish beds offshore.
4. **Hamilton Field** - Develop comprehensive wetlands habitat plan and long-term management program for restoring and enhancing wetlands habitat in diked former tidal wetlands. Dredged materials should be used whenever feasible and environmentally acceptable to facilitate wetlands restoration.
5. Restore former antenna field to tidal marsh and subtidal habitat.
6. Neils Island not within BCDC permit jurisdiction.
7. **Petaluma Marsh** - Marsh has high wildlife value; may be included in permanent wildlife area.
8. Provide public access to the Bay along levees if in a manner protective of sensitive wildlife.
9. **San Pablo Bay** - Tidal marshes and extensive tidal flats are valuable wildlife habitat. Protect wildlife values.
10. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
11. **Route 37** - Public access allowed in a manner protective of sensitive wildlife. Provide opportunities for wildlife compatible activities, such as wildlife observation and fishing.
12. **Skaggs Island** - If and when not needed by Navy, restore wildlife habitat.
13. **Regional Restoration Goal for San Pablo Bay** - Restore large areas of tidal marsh and enhance seasonal wetlands. Some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, and others should be restored to tidal marsh. Shallow subtidal areas (including eelgrass beds) should be conserved or restored. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible major park.

(B) Possible use of Bel Marin Keys Unit V site as a wetland restoration site using dredged material.

(C) Possible lagoon and park.

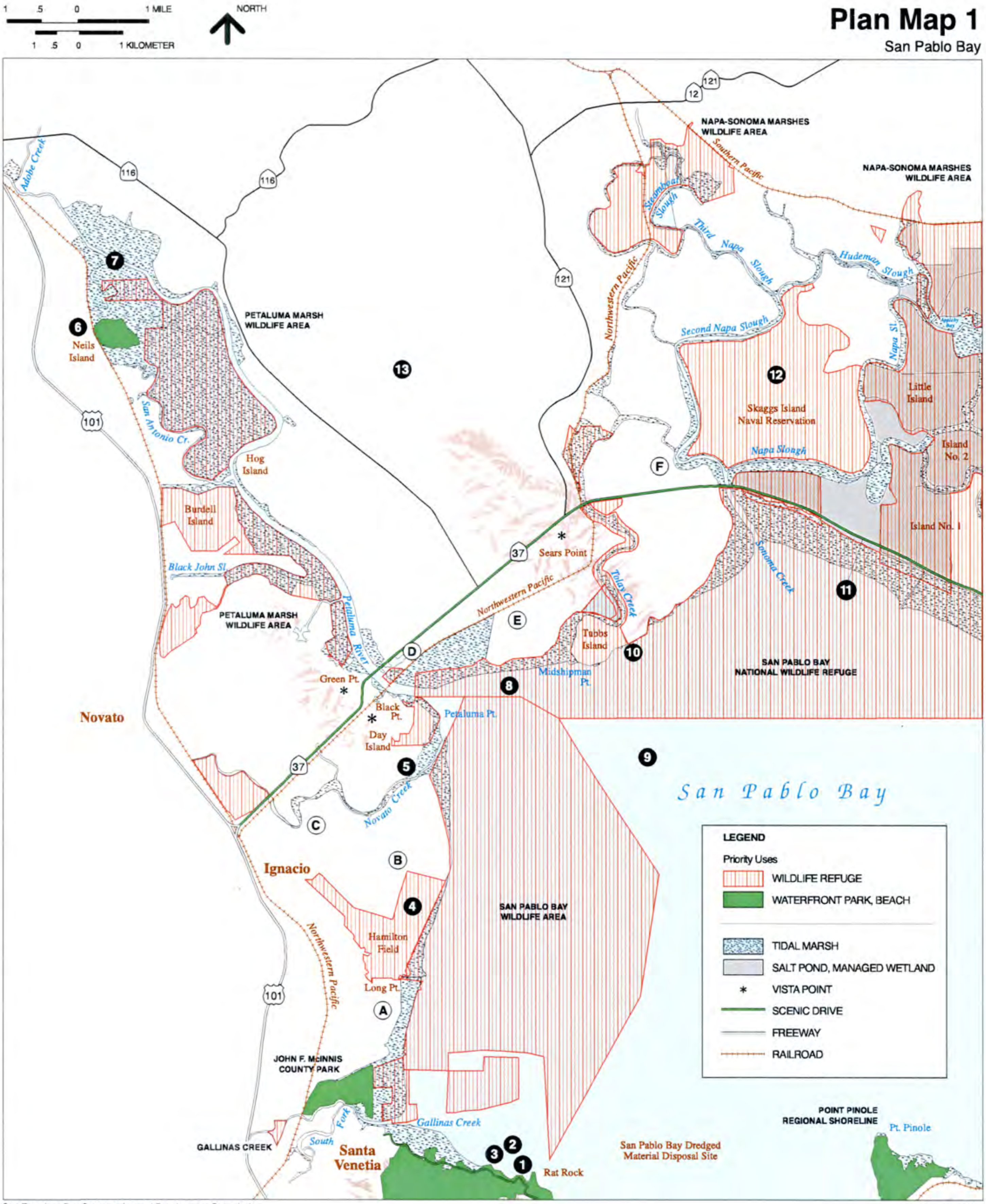
(D) Possible use of Port Sonoma Marina ponds as a regional dredged material rehandling facility.

(E) Possible use of North Point Property site as a wetland restoration site using dredged material.

(F) Possible park.

Plan Map 1

San Pablo Bay



San Francisco Bay Conservation and Development Commission

Amended May 2002

Plan Map 2

Carquinez Strait

PLAN MAP NOTES

Salt Ponds and Other Managed Wetlands - *Large area, high-value wildlife habitat.*

San Pablo Bay National Wildlife Refuge - *The addition and restoration of land with high aquatic life and wildlife habitat value or good habitat restoration potential to the San Pablo Bay National Wildlife Refuge would be in accord with Bay Plan policies.*

San Pablo Bay Wildlife Refuges - *The California Department of Fish and Game and the U.S. Fish and Wildlife Service are carrying out a cooperative program to acquire, restore and manage areas of high aquatic life and wildlife habitat value in San Pablo Bay.*

Benicia State Recreation Area - *Proposed park expansion should encompass principal overlooks and ridges on north side of strait, to preserve rugged and scenic character of hills, presently undeveloped.*

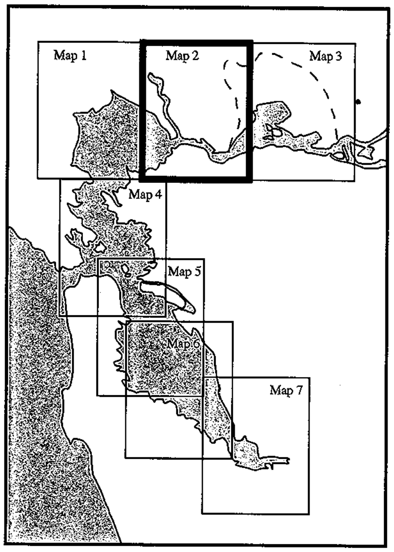
West Benicia Waterfront - *Detailed planning is needed to determine most desirable waterfront design west of West Second Street, emphasizing "urban" recreation uses with a minimum of Bay filling (and housing on existing private land).*

Benicia Waterfront Special Area Plan - *Special Area Plan was adopted by the Commission (April, 1977) and the City of Benicia to provide detailed planning and regulatory guidelines for the Benicia shoreline between West Second Street and the Benicia-Martinez Bridge. Refer to maps, policies, and recommendations of the Special Area Plan for specific information for this area.*

Martinez Waterfront - *Largely undeveloped at present, City has prepared specific plan for waterfront design and recreation uses.*

Scenic Area South Side of Carquinez Strait - *The scenic area includes principal overlook ridges and scenic road between Crockett and Martinez. To preserve presently undeveloped rugged and scenic hills, zoning should provide for extremely sparse development with control over tree removal and location of all structures; scenic easements should be acquired by East Bay Regional Park District, county, or other public body as necessary to guarantee permanent protection. Some park development may be appropriate in valleys leading to Bay.*

Areas diked from the Bay have high-value wildlife habitat and restoration potential.



Amended May 2002

Plan Map 2

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. **San Pablo Bay** - Tidal marshes and extensive tidal flats are valuable wildlife habitat. Protect wildlife values.
2. **Route 37** - Public access allowed in a manner protective of sensitive wildlife. Provide opportunities for wildlife compatible activities, such as wildlife observation and fishing.
3. **Regional Restoration Goal for San Pablo Bay** - Restore large areas of tidal marsh and enhance seasonal wetlands. Some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, and others should be restored to tidal marsh. Shallow subtidal areas (including eelgrass beds) should be conserved or restored. See the Baylands Ecosystem Habitat Goals report for more information.
4. **Mare Island Naval Shipyard** - The Mare Island dredged material disposal ponds, which are located in historic baylands, should be retained in water-related industry priority use for dredged material disposal and used as a regional disposal and rehandling area for dredged material except the three northernmost ponds. The three northernmost ponds could be used to provide wetland habitat for the salt marsh harvest mouse in order to mitigate any potential adverse impacts resulting from the future use of the other seven ponds for dredged material disposal and rehandling. Restoration of the three northernmost ponds, if necessary for mitigation, should be managed by the U.S. Fish and Wildlife Service as part of the San Pablo Bay National Wildlife Refuge and the Service's program for environmental education.
5. **Vallejo Water-Related Industrial Area** - Some fill may be needed.
6. **Carquinez Strait Shoreline** - Continuous public access should be provided along the bluff top and shoreline of Carquinez Strait and views of the water from shoreline vista points should be preserved.
7. **Benicia State Recreation Area** - No commercial uses except for convenience needs of park visitors. Develop riding and hiking trail along shoreline between Vallejo and Benicia.
8. **Benicia Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between West Second Street and the Benicia-Martinez Bridge.
9. **Benicia Industrial Park** - Reserve area east of old Route 21 for waterfront industry. Preserve and provide access to vista points and historic buildings.
10. **Regional Restoration Goal for Suisun Bay** - Restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay; enhance managed marshes to increase their ability to support waterfowl. See the Baylands Ecosystem Habitat Goals report for more information.
11. Pipelines and piers may be built over marshes.
12. **Port of Benicia** - See Seaport Plan.
13. **Selby** - See Seaport Plan. Some fill may be needed for port use.
14. **Rodeo** - Develop beach northwest of railroad. Provide safe, easy pedestrian access. Some fill may be needed.
15. **Pinole-Hercules Shoreline Park** (proposed) - Raise level of dry land, but preserve adjacent marshes. Provide safe pedestrian access across railroad tracks. Landscape existing sewage treatment plant.
16. **Wilson Point** - Proposed beach and park. Preserve rugged character of point. Provide safe, easy pedestrian access. Some fill may be needed. Protect and provide public access to shellfish beds offshore.

COMMISSION SUGGESTIONS

(A) Possible shallow-draft port.

(B) Possible use of Cargill crystallizer ponds as a regional dredged material rehandling facility.

(C) Napa Bay - Encourage recreational development of areas adjacent to shoreline. Provide continuous public access to shoreline.

(D) Provide continuous public access to shoreline from Napa Bay to existing park. Protect views of strait from hills.

(E) Potential park on hills overlooking the Bay.

(F) Benicia - Prepare precise plan and development program for waterfront west of West Second Street. Structures near waterfront should be kept low and well-spaced to protect views from hills inland. Provide maximum possible public access, including paths, beaches and small parks.

(G) Possible use of Praxis Pacheco as a dredged material confined disposal site.

Amended May 2002

Plan Map 2

Bay Plan Policies and Commission Suggestions

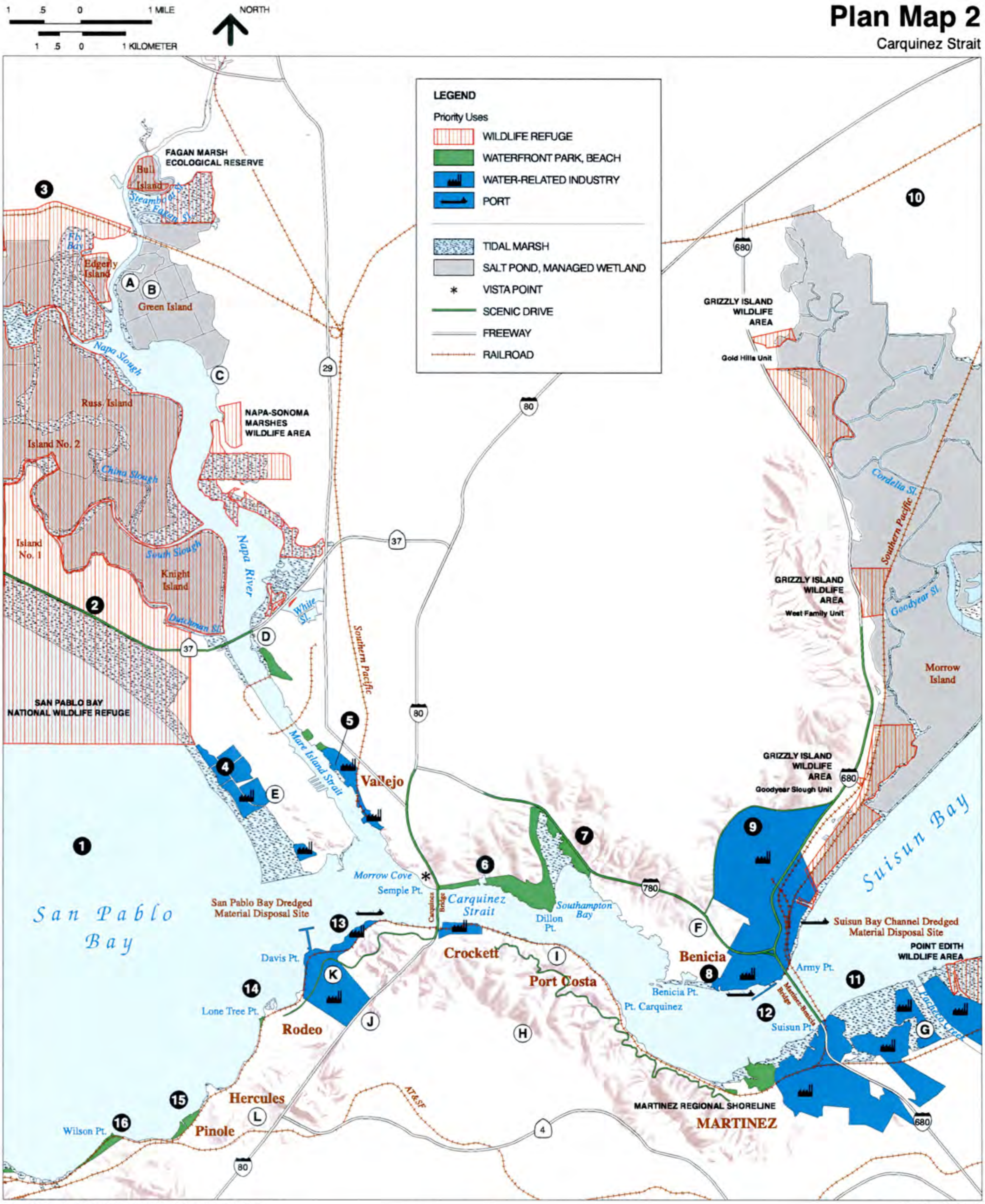
COMMISSION SUGGESTIONS (cont.)

- (H) Limit urban development; encourage cluster development to maximize Bay views and conserve natural landscape features.
- (I) Carquinez Strait, Bridge and Shoreline - Enhance scenic qualities, preserve views and increase public access.
- (J) Possible linked industry.
- (K) Possible use of Wickland Selby site as a regional dredged material rehandling facility.
- (L) Hercules - Design future development west of ridge to maximize and protect Bay views.

Amended May 2002

Plan Map 2

Carquinez Strait



Plan Map 3

Suisun Bay and Marsh

PLAN MAP NOTES

Suisun Marsh - *Thousands of acres of managed wetlands are maintained primarily by private duck-hunting clubs as migratory waterfowl habitat which also provides habitat for other wildlife species such as shorebirds. Areas are diked, but dikes are opened for periodic flooding. Suisun Resource Conservation District assists duck clubs in the protection and enhancement of managed wetlands.*

Suisun Marsh Protection Plan - *The Protection Plan is a more specific application of the policies of the Bay Plan because of the unique characteristics of the Suisun Marsh. The policies of both the Bay Plan and the Protection Plan apply within the Marsh in the absence of a certified Suisun Marsh Local Protection Program component. In event of policy conflict between the Bay Plan and Protection Plan, the policies of the Protection Plan control. Refer to maps and policies of the Protection Plan and the Suisun Marsh Preservation Act of 1977 for more specific information.*

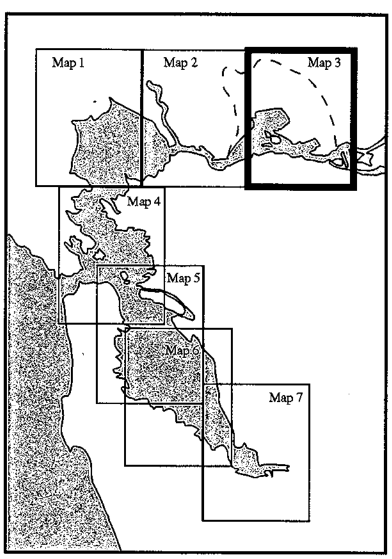
Suisun Marsh Local Protection Program - *Pursuant to the Suisun Marsh Preservation Act of 1977, the Commission has certified the Local Protection Program components of Solano County, Solano County Local Agency Formation Commission, the cities of Fairfield and Suisun City, Suisun Resource Conservation District, and Solano County Mosquito Abatement District. Marsh development permits for development in the Suisun Marsh must be consistent with the Local Protection Program component of the local agency with jurisdiction over the project. See the Preservation Act and the components of the Local Protection Program for more information.*

Collinsville Area - *The Collinsville-Montezuma Slough area is adjacent to the deep water shipping channel, has rail service, and consists of flat land. It is one of the largest available sites anywhere in the Bay Area for water-related industry. The shoreline fronting on the main shipping channel is limited, however, and this relatively small frontage should be carefully planned and shared for maximum industrial development.*

Recreational Potential - *Extensive, valuable recreational potential in river and island areas (e.g. Sherman Island "Sherman Lake" area popular for boating, fishing). Recreational use should be encouraged.*

Concord Naval Weapons Station - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

Proposed San Francisco Bay National Estuarine Research Reserve (Rush Ranch Open Space Preserve) - *One of two sites in the Bay, the other being China Camp State Park, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*



Amended May 2002

Plan Map 3

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

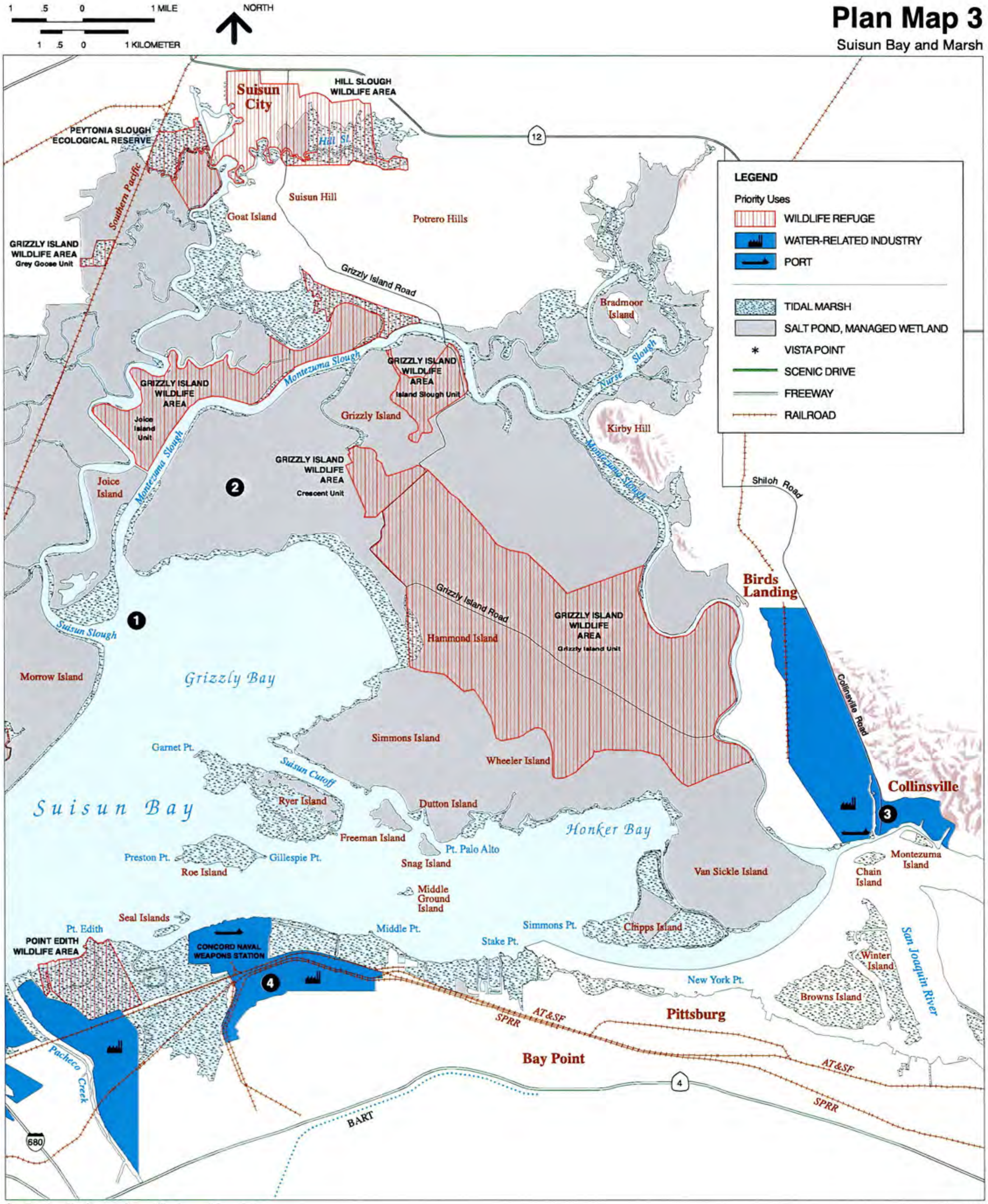
1. **Montezuma and Suisun Sloughs** - May be dredged for small boat uses.
2. **Regional Restoration Goal for Suisun Bay** - Restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay; enhance managed marshes to increase their ability to support waterfowl. See the Baylands Ecosystem Habitat Goals report for more information.
3. **Collinsville** - Industries should share limited deep water frontage. Wetland restoration or enhancement of diked wetland areas may occur provided that the restoration or enhancement project: (1) is carried out in a manner that will not preclude use of the deep water frontage and upland portion of the site for water-related industry and port use; (2) will not result in any adverse environmental impacts on the Suisun Marsh; (3) provides for the protection of adjacent property from flooding that could be caused by the project; and (4) includes a long-range management program that assures the proper stewardship of the wetland. Wetland restoration and enhancement projects may be carried out using dredged material from the Bay region. Wetland restoration and enhancement projects should be designed so as not to restrict development and operation of marine terminals on the deep water shoreline nor impede the movement of waterborne cargo, materials and products from the shoreline terminal to the upland portion of the site. A portion of the site may be used as a regional dredged material rehandling facility for Bay Area projects.
4. **Concord Naval Weapons Station** - If and when not needed by Navy, give first consideration to port or water-related industrial use. Port and industrial use should be restricted so that they do not adversely affect marshes. See Seaport Plan.

COMMISSION SUGGESTIONS

Amended May 2002

Plan Map 3

Suisun Bay and Marsh



Plan Map 4

Central Bay North

PLAN MAP NOTES

Point Pinole Regional Shoreline to Wildcat Creek *- Public access to the Bay for recreation is needed in this area, although existing shoreline conditions make this difficult. All development in this area should include provision for substantial public access.*

Naval Supply Center, Point Molate *- Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

George Miller Jr. Regional Park *- Use and landscaping of the private lands adjacent to the park should be coordinated by owners and city for compatibility with park.*

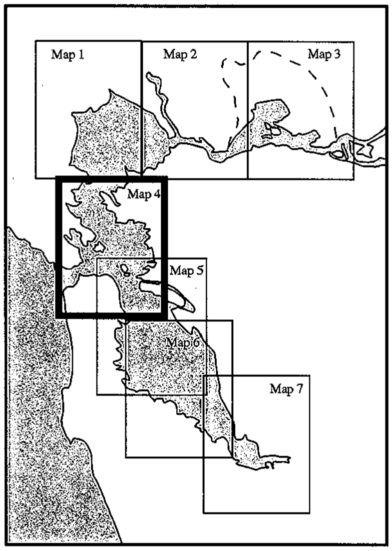
South Richmond Shoreline Special Area Plan *- The South Richmond Shoreline Special Area Plan was adopted by the Commission (May 1977) and the City of Richmond to provide detailed planning and regulatory guidelines for the Richmond shoreline from the west side of Shipyard Three to the southeastern border of the City, including Brooks and Bird Islands and all areas that are subject to tidal action. Refer to the maps, policies, and recommendations of the Special Area Plan for specific information for this area.*

Oakland North Harbor Area *- The Oakland North Harbor has not been included on the Seaport Plan maps as a port priority use area because need for it has not been substantiated and it has been found to be less desirable for port development than other sites based on environmental, land use, and access considerations. In addition, other uses having public benefits, such as conservation and recreation, have been proposed for this site. Additional studies will be necessary to determine the future use of this area.*

Oakland Army Base *- Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

San Francisco Waterfront Special Area Plan *- The San Francisco Waterfront Special Area Plan was adopted by the Commission (April 3, 1975) to provide detailed planning and regulatory guidelines for the waterfront of San Francisco from east side of Hyde Street Pier to south side of India Basin. Refer to the maps and policies of the Special Area Plan for specific information for this area.*

San Francisco Waterfront *- Suggested scenic transit system (special bus, elephant train, cog railway, etc.) could be major waterfront attraction, could eventually operate entire distance from Golden Gate Bridge (or even Ocean Beach) to Ferry Building (or south to China Basin).*



San Francisco-Marin Crossing *- The Central Bay is the most widely enjoyed part of the entire Bay and this attractive setting should be protected. Transportation agencies have reached general agreement that traffic congestion problems can best be solved by establishing a fast, modern, complete bus system. Therefore, Plan makes no provision for second deck on Golden Gate Bridge, or for any additional vehicular crossing. Increased auto capacity on Golden Gate Bridge, or a new vehicular crossing, could require new or enlarged toll plazas, service areas, access ramps, and freeways on both the San Francisco and Marin sides, with possible disruption of scenic areas on both sides of the Bay.*

Jurisdiction Note *- Along the shoreline in San Francisco and Marin Counties, Commission's jurisdiction extends 100 feet inland and does not include any area within the jurisdiction of the California Coastal Commission west of the line between Point Bonita and Point Lobos.*

Forts Baker, Barry, and Cronkhite *- Surplus Army land now being transferred to the Golden Gate National Recreation Area.*

Appearance and Design *- Housing density in hills of Sausalito, Tiburon, and Belvedere should respect the topography; cluster development appropriate in some areas.*

Amended May 2002

Plan Map 4

Central Bay North

PLAN MAP NOTES (CONT.)

Sausalito Recreational Ferry - *Ferry terminal could be connected to central area by "elephant train" along waterfront or Bridgeway. Or terminal could be placed in central area if parking can be provided.*

Sausalito - Commuter Ferry Terminal - *To minimize traffic and parking problem, should be served by mass transit or else designed to serve Sausalito and Mill Valley only with other terminals serving rest of Marin.*

Tiburon - Possible Commuter Ferry Terminal - *To minimize traffic and parking problem, should be served by mass transit, or else designed to serve southern Marin only with another terminal built to serve northern Marin.*

Tiburon Boulevard Widening - *Minimize fill by using existing roadbed as part of new right-of-way. Preserve hilltop vista point.*

Shoreline Parks - *Shoreline parks could be built in several areas between existing or proposed shoreline roads and the shore from Tiburon Peninsula to Point San Pedro. Further study needed.*

Point San Quentin - Possible Commuter Ferry Terminal - *No fill for parking beyond existing dikes.*

Proposed Marin Baylands National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh, seasonal marsh and uplands in a national wildlife refuge located on San Francisco Bay from the City of San Rafael to an area south of the city of Mill Valley in Marin County. The proposed wildlife refuge would be in accord with Bay Plan policies.*

Proposed San Francisco Bay National Estuarine Research Reserve (China Camp State Park) - *One of two sites in the Bay, the other being Rush Ranch Open Space Preserve, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*

Proposed Alameda National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh and a portion of the former Naval Air Station Alameda in a national wildlife refuge located at the western end of Alameda. The proposed national wildlife refuge would be in accord with Bay Plan policies.*

Amended May 2002

Plan Map 4

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. **Wilson Point Beach and Park** (proposed) - Preserve rugged character of point. Provide safe, easy pedestrian access. Some fill may be needed. Protect and provide public access to shellfish areas.
2. **Richmond Sanitary Landfill** - Proposed Park. Give priority consideration to beach development. Some fill may be needed for beach outside existing dikes.
3. **Point San Pablo** - As not needed for marine terminals, redevelop for recreational uses.
4. **The Brothers** - Preserve islands and lighthouse. Access by boat only.
5. **Point Molate to Point Richmond** - Develop riding and hiking trails. Some fill may be needed.
6. **Naval Supply Center** - If and when not needed by Navy, acquire and develop for park. Existing underground fuel storage tanks may be used by industry.
7. **Point Molate Beach** - Extended beach from Point Molate to Castro Point. Some fill may be needed.
8. **Castro Rocks** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young.
9. **Red Rock** - Protect wildlife values.
10. **George Miller Jr. Regional Shoreline** - Protect and provide public access to shellfish beds offshore.
11. **Port of Richmond** - See Seaport Plan. Some fill may be needed.
12. **South Richmond Shoreline Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between Shipyard Three and the southeastern border of the City of Richmond.
13. **Brooks Island Regional Preserve** - Preserve island character. Access by boat only. Protect wildlife values.
14. Protect and provide public access to shellfish areas offshore.
15. **Albany-Berkeley-Emeryville** - Develop public and commercial recreation areas. Some fill may be needed to create usable shoreline areas, protected water areas and park space.
16. **Eastshore State Park** - Park being planned from Bay Bridge to Marina Bay in Richmond for multiple uses including recreation, wildlife and aquatic life protection. Protect wildlife and aquatic life values at sites such as Emeryville Crescent, Hoffman Marsh and Albany Mudflats.
17. No freeway in Bay west of present shoreline unless all reasonable alternatives are found infeasible and need for Bay route is clearly shown.
18. **Oakland Port Area** - See Seaport Plan. Redevelop Outer, Middle, and Inner Harbors for modern marine terminals. Some fill may be needed. No fill that would impair ship navigation should be allowed in any area needed for such navigation.
19. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
20. **Treasure Island** - If and when not needed by Navy, redevelop for public use. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Provide continuous public access to Bay in a manner protective of sensitive wildlife.
21. **Yerba Buena Island** - If and when not needed by Navy or Coast Guard, redevelop released areas for recreational use. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
22. **San Francisco Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between the east side of the Hyde Street Pier and the south side of India Basin.
23. **Alcatraz Island** - Use under study. Retain in public ownership. Access by boat only. Protect wildlife values. Special design opportunity.
24. **Fisherman's Wharf** - Improve and expand commercial fishing support facilities. Enhance public access to and economic value of Fisherman's Wharf area by encouraging development of a public fish market.
25. **Fort Mason** - As not needed by Army, develop waterfront and northeast section as park.
26. **Presidio** - If and when not needed by Army, retain at least shoreline and undeveloped areas as regional park.
27. **Golden Gate Bridge** - Encourage improved public transportation. No second deck or new crossing for automobiles.
28. **Golden Gate National Recreation Area** - As not needed by Army, acquire and extend park. Preserve and protect rugged character, especially on Golden Gate and Pacific Coast sides. Limit access to water (at coves) to foot trails, possible funiculars. No commercial uses except for convenience needs of park visitors.

Plan Map 4

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES (cont.)

29. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
30. **Richardson Bay Special Area Plan** - See Special Area Plan for detailed planning policies for the water area and shoreline north of a line drawn betweeen Cavallo Point and Point Tiburon.
31. **Angel Island State Park** - Use only for camping, picnicking, water-oriented recreation. Access by boat only. No commercial uses except for convenience needs of park visitors. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
32. **Tiburon Oceanographic Center** - (former Navy Net Depot) If and when not needed by Federal Government, aquire and develop for park.
33. Protect and provide public access to shellfish areas offshore.
34. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
35. **Corte Madera Shoreline Park** (proposed) - Develop 60 - 100 acre shoreline park as part of future development.
36. **Point San Quentin to Point San Pedro** - In connection with shoreline parks and scenic drives, develop system of riding and hiking trails.
37. **Marin Islands National Wildlife Refuge and State Ecological Reserve** - Protect wildlife values. Onshore development should be compatible with wildlife dependent uses. Avoid significant adverse impacts on wildlife, including the regionally significant black-crowned night heron rookery where herons nest and raise their young.
38. **The Sisters** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
39. **Rat Rock** - Preserve island; no development. Protect wildlife values.
40. **China Camp State Park** - Create continuous shoreline recreational area, including beaches, marinas, picnic areas, fishing piers, and riding and hiking trails.
41. Protect and provide public access to shellfish beds offshore.
42. **Regional Restoration Goal for Central Bay** - Protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Natural salt ponds should be restored on the East Bay shoreline. Shallow subtidal areas (including eelgrass beds) should be conserved and enhanced. Wherever possible tidal marsh habitats should be restored, particularly at the mouths of streams where they enter the Bay and at the upper reach of dead-end sloughs. Encourage tidal marsh restoration in urban areas. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible scenic transit system along waterfront from Ocean Beach to China Basin.

(B) Possible commuter ferry terminal.

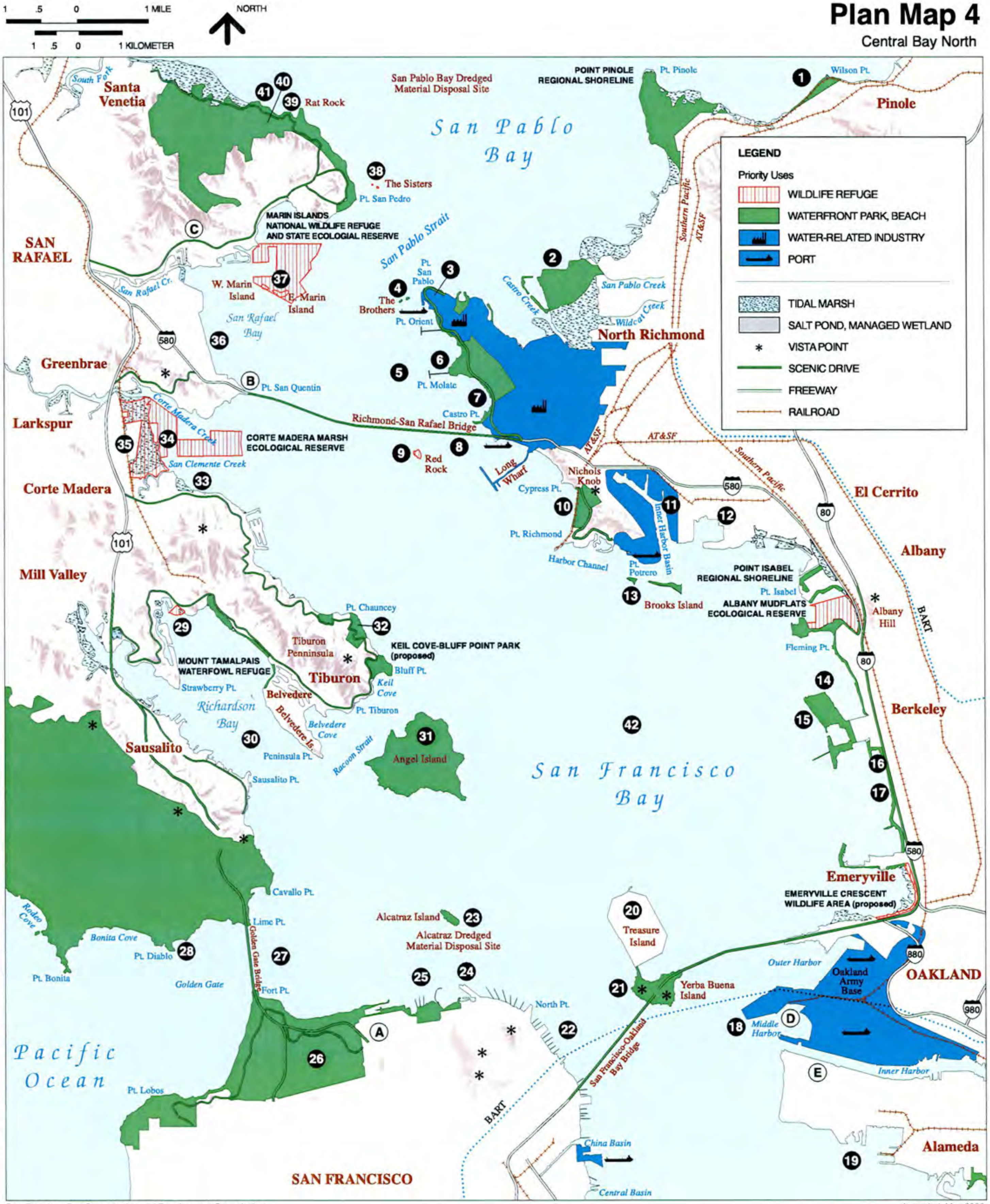
(C) San Pedro Mountain - Develop vista points along ridge.

(D) Possible habitat enhancement site at Port of Oakland Middle Harbor using dredged material.

(E) Possible reuse of dredged material at former NAS Alameda.

Plan Map 4

Central Bay North



Plan Map 5

Central Bay

PLAN MAP NOTES

Oakland North Harbor Area *- The Oakland North Harbor has not been included on the Seaport Plan maps as a port priority use area because need for it has not been substantiated and it has been found to be less desirable for port development than other sites based on environmental, land use, and access considerations. In addition, other uses having public benefits, such as conservation and recreation, have been proposed for this site. Additional studies will be necessary to determine the future use of this area.*

Oakland Army Base *- Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

San Leandro Bay Regional Shoreline *- Regional Shoreline to be developed by East Bay Regional Park District emphasizing ecology and increased recreation use of the shoreline.*

Bay Farm Island *- The site is adjacent to Oakland Airport, and may be suitable for airport-oriented industry. Bay Farm Island development should not interfere with aircraft operations at Oakland Airport.*

San Mateo (City) Waterfront *- Presently undeveloped. Detailed planning needed to determine most desirable waterfront design emphasizing recreation with minimum of Bay filling.*

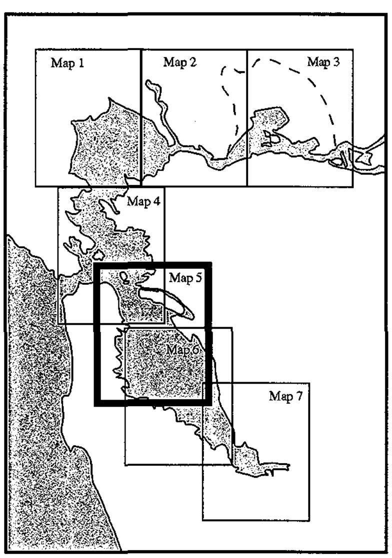
Burlingame Waterfront *- Developing waterfront requires detailed planning to determine the most desirable waterfront design emphasizing recreation and public access with a minimum of Bay filling.*

Hunters Point Freeway at Candlestick Point *- Connection to U.S. 101 south of Candlestick Point requires further study. If connection is close to Candlestick Cove, large overpass structure will be required, marring present spectacular views of Bay for motorists heading south on Bayshore Freeway to Bayview Hill. If connection is farther south, in Brisbane, long structure in Bay will be required. Other considerations include effects upon future development on shoreline of Candlestick Cove, and future U.S. 101 connections to proposed Geneva Avenue and Guadalupe Parkway extensions.*

San Francisco Waterfront *- Suggested scenic transit system (special bus, elephant train, cog railway, etc.) could be major waterfront attraction, could eventually operate entire distance from Golden Gate Bridge (or even Ocean Beach) to Ferry Building (or south to China Basin).*

San Francisco Waterfront Special Area Plan *- The San Francisco Waterfront Special Area Plan was adopted by the Commission (April 3, 1975) to provide detailed planning and regulatory guidelines for the waterfront of San Francisco from east side of Hyde Street Pier to south side of India Basin. Refer to the maps and policies of the Special Area Plan for specific information for this area.*

Proposed Alameda National Wildlife Refuge *- The U.S. Fish and Wildlife Service proposes to include tidal marsh and a portion of the former Naval Air Station Alameda in a national wildlife refuge located at the western end of Alameda. The proposed national wildlife refuge would be in accord with Bay Plan policies.*



Amended May 2002

Plan Map 5

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. **Oakland Port Area** - See Seaport Plan. Redevelop Outer, Middle, and Inner Harbors for modern marine terminals. Some fill may be needed. No fill that would impair ship navigation should be allowed in any area needed for such navigation.
2. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
3. **Government Island** - If and when not needed by Coast Guard, develop for public and commercial recreation uses.
4. **Alameda Beaches** - Some fill may be needed for beach and marina protection.
5. Protect and provide public access to shellfish areas offshore.
6. **San Leandro Bay** - Valuable wildlife habitat; great recreation potential. Develop boating facilities and parks, but preserve wildlife habitat. Provide continuous public access to northeastern and southern shoreline. Some fill may be needed.
7. **Oakland Airport** - Further expansion into the Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas clear of tall structures and incompatible uses.
8. **San Leandro Shoreline Park System** - Protect and provide public access to shellfish beds offshore.
9. **San Francisco Airport** - Further expansion into Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas free from tall structures and incompatible uses.
10. Protect and provide public access to shellfish areas offshore.
11. **Oyster Point** - Expand marina and develop shoreline park. Some fill may be needed.
12. Provide easy pedestrian access across freeway.
13. No freeway in Bay east of U.S. 101 unless all reasonable alternatives are found infeasible and need for Bay route is clearly shown.
14. **U.S. 101 Causeway** - Develop scenic frontage road and turnouts for fishing and viewing. Protect shellfish beds offshore.
15. **Bay View Park** - Provide trail link to waterfront.
16. **Candlestick Point Shoreline Park** (proposed) - Some fill may be needed.
17. **South Basin** - Some fill may be needed in inlet west of proposed freeway.
18. **Hunters Point** - See Seaport Plan.
19. **Port of San Francisco** - See Seaport Plan. Some fill may be needed.
20. **San Francisco Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between the east side of the Hyde Street Pier and the south side of India Basin.
21. **Yerba Buena Island** - If and when not needed by Navy or Coast Guard, redevelop released areas for recreational use. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
22. **Treasure Island** - If and when not needed by Navy, redevelop for public use. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Provide continuous public access to Bay in a manner protective of sensitive wildlife.
23. **Alcatraz Island** - Use under study. Retain in public ownership. Access by boat only. Protect wildlife values. Special design opportunity.
24. **Fisherman's Wharf** - Improve and expand commercial fishing support facilities. Enhance public access to and economic value of Fisherman's Wharf area by encouraging development of a public fish market.
25. **Fort Mason** - As not needed by Army, develop waterfront and northeast section as park.
26. **Regional Restoration Goal for Central Bay** - Protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Natural salt ponds should be restored on the East Bay shoreline. Shallow subtidal areas (including eelgrass beds) should be conserved and enhanced. Wherever possible tidal marsh habitats should be restored, particularly at the mouths of streams where they enter the Bay and at the upper reach of dead-end sloughs. Encourage tidal marsh restoration in urban areas. See the Baylands Ecosystem Habitat Goals report for more information.

Amended May 2002

Plan Map 5

Bay Plan Policies and Commission Suggestions

COMMISSION SUGGESTIONS

- (A) Possible habitat enhancement site at Port of Oakland Middle Harbor using dredged material.
- (B) Possible reuse of dredged material at former NAS Alameda.
- (C) Jack London Square - Expand commercial recreation facilities as needed. Provide continuous public access along Estuary to Lake Merritt Channel.
- (D) Brooklyn Basin - Expand commercial fishing and recreational facilities.
- (E) Possible scenic path, Coliseum to Bay.
- (F) Bay Farm Island - Undeveloped areas may be suitable for airport-related industry.
- (G) Possible extension of scenic drive.
- (H) Develop scenic drive and riding and hiking trail along waterfront from airport to Foster City.
- (I) Possible airport industry.
- (J) Possible park and marina.

Plan Map 5

Central Bay

Plan Map 6

Central Bay South

PLAN MAP NOTES

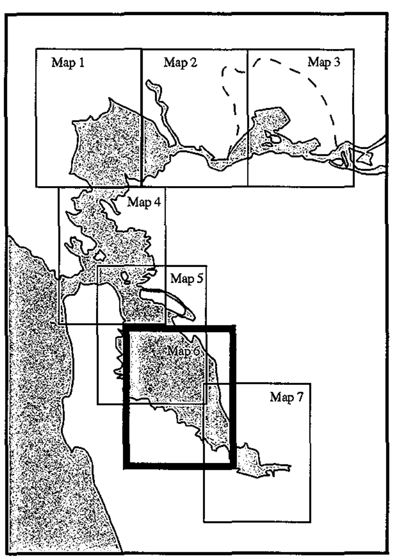
Hayward Area Waterfront - *The Hayward Area Shoreline Plan, a detailed plan for the Hayward area shoreline between the San Leandro city limits on the north and Fremont and Union City city limits on the south, was prepared by the Hayward Area Shoreline Planning Agency. The Plan, adopted by the City of Hayward, Alameda County, East Bay Regional Park District, and the Hayward Area Recreation District, provides for marsh restoration and shoreline recreation use.*

Greco Island - *Largest remaining marsh in South Bay. Tidal marsh and adjacent tidal flats are part of Don Edwards San Francisco Bay National Wildlife Refuge and are important feeding areas for birds. Area used by California Clapper Rail, a rare species of bird, endangered by loss of habitat.*

San Mateo (City) Waterfront - *Presently undeveloped. Detailed planning needed to determine most desirable waterfront design emphasizing recreation with minimum of Bay filling.*

Burlingame Waterfront - *Developing waterfront requires detailed planning to determine the most desirable waterfront design emphasizing recreation and public access with a minimum of Bay filling.*

Don Edwards San Francisco Bay National Wildlife Refuge - *The addition and restoration of land or water with high aquatic life and wildlife habitat value or good habitat restoration potential to Don Edwards San Francisco Bay National Wildlife Refuge would be in accord with Bay Plan policies.*



Amended May 2002

Plan Map 6

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1 **Oakland Airport** - Further expansion into the Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas clear of tall structures and incompatible uses.

2 **San Leandro Shoreline Park System** - Protect and provide public access to shellfish beds offshore.

3 If not needed for salt production, ponds west of Coyote Hills should be managed as permanent wildlife area.

4 **Dumbarton Bridge** - Design proposed high-level bridge to have slim profile and minimum supporting structure and to enable motorists to see Bay and shoreline. Approaches should provide for fishing and wildlife observation.

5 **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.

6 **Greco Island** - Expand wildlife refuge to include entire island. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young.

7 **Port** - See Seaport Plan. Expand marine terminals and water-related industries. Some fill may be needed.

8 Provide public access to the Bay along levees in a manner that is protective of sensitive wildlife. Provide trail linkage between San Carlos Airport and Whipple Avenue.

9 **Bair Island Ecological Reserve** - A joint management effort by the California Department of Fish and Game and the U.S. Fish and Wildlife Service. Restore and enhance habitat for the benefit of wildlife and aquatic life. Protect harbor seal haul-out and pupping sites where harbor seals rest, give birth and nurse their young.

10 **Redwood Shores** - Provide continuous public access to Bay and to Belmont, Steinberger, Smith, and Corkscrew Sloughs if in a manner protective of sensitive wildlife; where appropriate include paths, beaches, small parks, and wildlife observation areas. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.

11 **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.

12 **Foster City** - Provide continuous public access to Bay and Belmont Slough, including paths, beaches, and small parks.

13 Protect and provide public access to shellfish beds offshore.

14 **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.

15 **Coyote Point Park** - Expand beach and marina. Some fill may be needed. Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.

16 **Bayside Park** - Retain lagoon as open water.

17 **San Francisco Airport** - Further expansion into Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas free from tall structures and incompatible uses.

18 **Regional Restoration Goal for South Bay** - Restore large areas of tidal marsh connected by wide corridors of similar habitat along the perimeter of the Bay. Several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the region, and natural unmanaged salt ponds should be restored on the San Leandro shoreline. Natural transitions from tidal flat to tidal marsh and into adjacent transition zones and upland habitats should be restored wherever possible. See the Baylands Ecosystem Habitat Goals report for more information.

Amended May 2002

Plan Map 6

Bay Plan Policies and Commission Suggestions

COMMISSION SUGGESTIONS

(A) If no longer needed for salt pond production, enhance area for wildlife and aquatic life.

(B) San Mateo - Prepare precise plan and development program for waterfront emphasizing water-oriented recreation. Some fill may be needed.

(C) Burlingame - Prepare precise plan and development program for waterfront; include continuous public access to Bay shoreline for viewing and fishing. Some fill may be needed.

(D) Develop scenic drive and riding and hiking trail along waterfront from airport to Foster City.

Plan Map 6

Central Bay South

1 .5 0 1 MILE

1 .5 0 1 KILOMETER

NORTH

Plan Map 7

South Bay

PLAN MAP NOTES

Hayward Area Waterfront - *The Hayward Area Shoreline Plan, a detailed plan for the Hayward area shoreline between the San Leandro city limits on the north and Fremont and Union City city limits on the south, was prepared by the Hayward Area Shoreline Planning Agency. The Plan, adopted by the City of Hayward, Alameda County, East Bay Regional Park District, and the Hayward Area Recreation District, provides for marsh restoration and shoreline recreation use.*

Water Quality - *Water at extreme south end of Bay is often polluted so as to discourage recreational use of sloughs and Bay. Greater recreational use will require improved water quality. Some improvements in the quality of water in the South Bay are now being made pursuant to requirements of the San Francisco Bay Regional Water Quality Control Board, and studies underway by wastewater dischargers will lead to further improvements. The recommendations for long-range improvements to water quality contained in the Water Quality Control Plan for the San Francisco Bay Basin, prepared by the San Francisco Bay Regional Water Quality Control Board and approved by the State Water Resources Control Board, should be followed.*

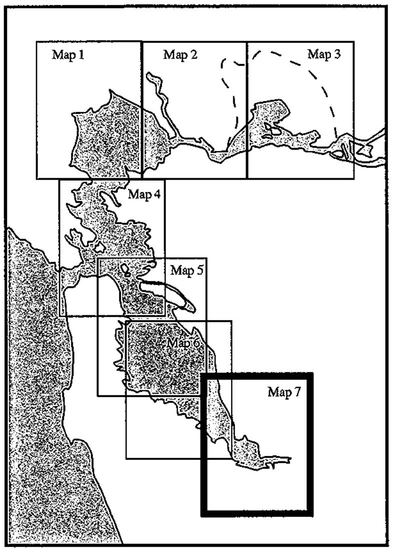
Subsidence - *Area subject to possible subsidence. Construction in or near Bay should be carefully planned, taking into account effects of future subsidence and sea level rise.*

Santa Clara County Shoreline - *The Santa Clara County Planning Policy Committee adopted a Policy Plan for the Baylands of Santa Clara County (July 1972) which establishes conservation and development goals and policies for the Santa Clara County shoreline.*

Alviso-San Jose Waterfront - *Detailed planning is needed to determine most desirable waterfront design and to overcome subsidence problems. Proposals should emphasize the great recreation potential of this area.*

Moffett Naval Air Station - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

Don Edwards San Francisco Bay National Wildlife Refuge - *The addition and restoration of land or water with high aquatic life and wildlife habitat value or good habitat restoration potential to Don Edwards San Francisco Bay National Wildlife Refuge would be in accord with Bay Plan policies.*



Amended May 2002

Plan Map 7

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. If not needed for salt production, ponds west of Coyote Hills should be managed as permanent wildlife area.
2. **Dumbarton Bridge** - Design proposed high-level bridge to have slim profile and minimum supporting structure and to enable motorists to see Bay and shoreline. Approaches should provide for fishing and wildlife observation.
3. **Newark Slough to Coyote Creek** - Protect harbor seal haul-out and pupping sites where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
4. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
5. **Newby Island** - Provide levee access for wildlife observation.
6. If not needed for sewage treatment purposes, oxidation ponds should be acquired as permanent wildlife area.
7. **Alviso** - Provide public access and occasional picnic areas.
8. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
9. If not needed for salt production, ponds north of Moffet Field should be reserved for possible airport expansion.
10. **Moffett Naval Air Station** - If and when not needed by Navy, site should be evaluated for commercial airport by regional airport system study. (Moffett NAS not within BCDC permit jurisdiction.)
11. If not needed for salt production, ponds between Stevens Creek and Charleston Slough should be wildlife area.
12. **South Bay** - Enhance and restore valuable wildlife habitat. Bay tidal marshes and salt ponds may be acquired as part of Don Edwards San Francisco Bay National Wildlife Refuge and managed to maximize wildlife and aquatic life values. Salt ponds can be managed for the benefit of aquatic life and wildlife. Provide continuous public access to the Bay and salt ponds along levees if in a manner protective of sensitive wildlife.
13. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site where harbor seals rest, give birth and nurse their young. Projects allowed only if protective of harbor seals and other sensitive wildlife.
14. **Regional Restoration Goal for South Bay** - Restore large areas of tidal marsh connected by wide corridors of similar habitat along the perimeter of the Bay. Several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the region, and natural unmanaged salt ponds should be restored on the San Leandro shoreline. Natural transitions from tidal flat to tidal marsh and into adjacent transition zones and upland habitats should be restored wherever possible. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

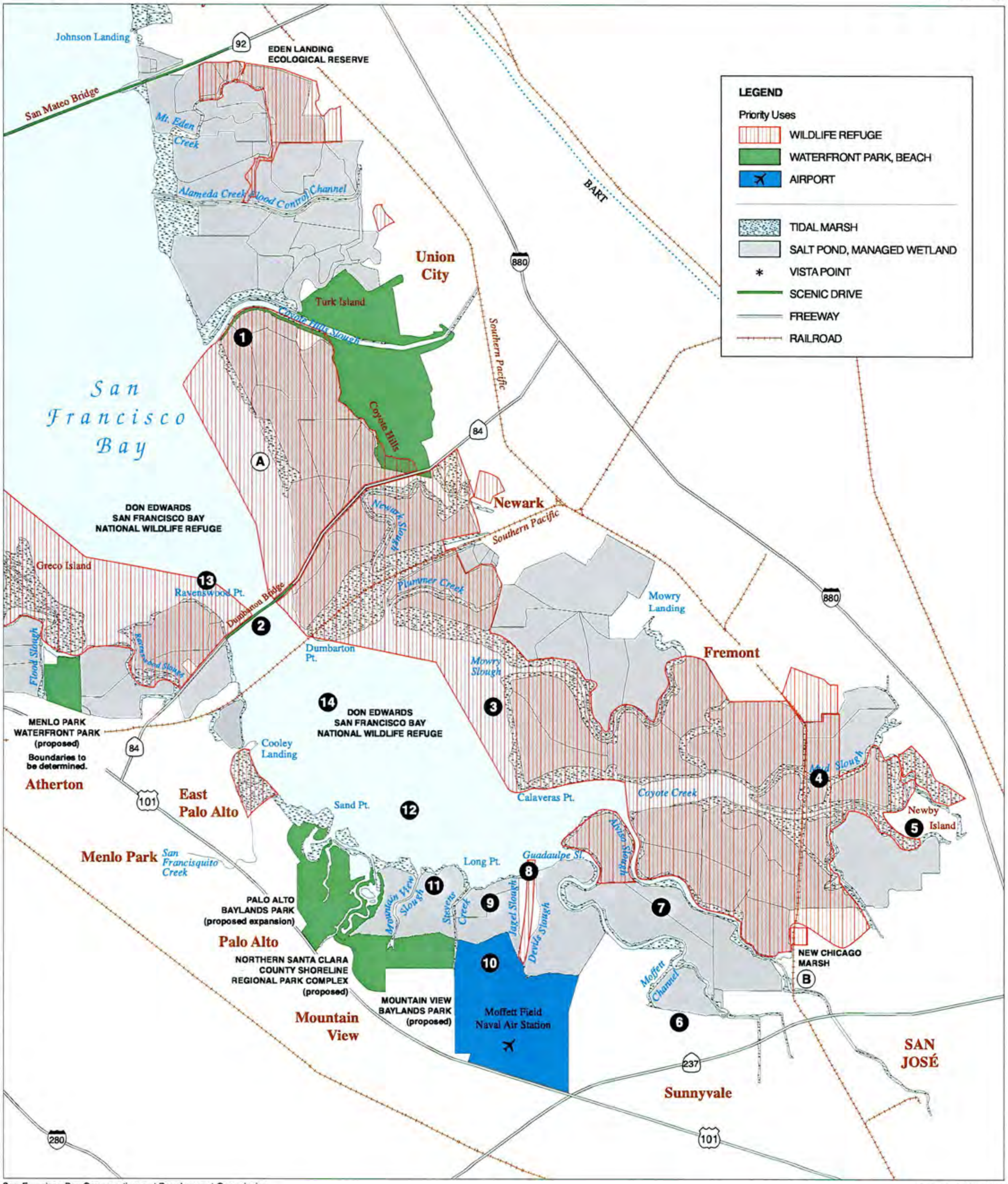
(A) If no longer needed for salt pond production, enhance area for wildlife and aquatic life.

(B) Alviso-San Jose - Provide continuous public access to slough frontage only at Alviso.

1 .5 0 1 MILE
1 .5 0 1 KILOMETER
NORTH

Plan Map 7

South Bay



Amended May 2002

SUMMARY

San Francisco Bay, as part of the San Francisco Bay-Delta estuary, is the largest estuary along the Pacific shore of North and South America and is a natural resource of incalculable value. An estuary is a partially enclosed body of water formed where fresh water from rivers and streams meet and mix with salt water from the ocean. Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water. In addition, estuarine environments are among the most productive on earth, creating more organic matter each year than comparably-sized areas of forest, grassland or agricultural land. The productivity and variety of estuarine habitats foster a wonderful abundance and diversity of wildlife and they are critical for the survival of many species. San Francisco Bay, in particular, presently sustains nearly 500 species of fish, invertebrates, birds, mammals, insects and amphibians. Furthermore, two thirds of the state's salmon pass through the Bay and Delta, as do nearly half of the waterfowl and shorebirds migrating along the Pacific Flyway.

San Francisco Bay Ecology. An ecosystem is a natural community of living organisms that interact with each other and with their physical environment in a way that perpetuates the community of organisms. Although large in geographic scope, San Francisco Bay is an ecosystem within which species inhabiting the water, wetlands, and uplands are interconnected through life histories and food web strategies. Thus, San Francisco Bay is a vital part of a natural community of organisms spanning from upland areas to deep water.

A food web is an assemblage of organisms in an ecosystem, including plants, herbivores (plant eaters) and carnivores (meat eaters), showing the relationship of who eats whom. An example of a food web includes the nearly forty species[1] of migratory shorebirds and waterfowl which feed on the brine shrimp, fish and brine flies living in the salt ponds in San Pablo and South San Francisco Bay.

A species' (plant or animal) habitat is generally described as the place where it lives or the place one would go to find it during some part or all of its life. San Francisco Bay is an ecosystem comprised of a diversity of habitats. These habitats owe their creation and continuation to the global factors of climate, tides, and sea level rise, as well as the more local physical forces of topography; the ebb and flow of the tides; the volume, timing, and location of freshwater inflow; and the availability and types of sediments suspended in the water column and which form the bottom of the Bay. As Bay habitats have been formed over time by physical processes, life has also defined the character of these habitats. The Bay's plants and animals have evolved alongside one another upon the varied backdrop of the Bay's physical landscape.

San Francisco Bay Habitats. In order to describe and understand the similarities, dissimilarities and interrelations among Bay habitats, it is helpful to organize them into a conceptual framework. This framework serves to break the San Francisco Bay ecosystem into comprehensible pieces with defined boundaries based on vegetation and geographic location. The categories of wetlands and related habitat types presented in this report were developed as part of the Baylands[2] Ecosystem Habitat Goals Project (Goals Project), which brought together representatives of the region's scientific and academic community to describe historical change in the San Francisco Bay ecosystem, the existing conditions of the ecosystem, and to assist in the development of regional habitat goals for the restoration of the Bay ecosystem.[3]

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[1] Species is defined as related organisms capable of interbreeding. Examples of species found in the Bay include the California clapper rail or pickleweed.

[2] Defined as the "lands that are touched by the tides, plus the lands that would be tidal in the absence of any levees, sea walls, or other man-made structures that block the tides." (Goals Project, 1999.)

[3] Goals Project. 1999. "Baylands Ecosystem Habitat Goals." A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./ S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

To facilitate this work, the Goals Project developed an atlas of wetland types and related habitats around San Francisco Bay. This atlas, called the Bay Area EcoAtlas, incorporates a habitat typology that reflects regional land use qualities and the accompanying patterns of wetland related habitat, or regional ecology, and is designed for resource assessment and local/regional planning use. The EcoAtlas represents over three years of intensive work, and reflects the efforts of over 100 scientists, academics, and volunteers in verifying the accuracy and guiding the design of the atlas for local and regional wetland habitat planning purposes.

Bay habitat types defined and mapped as part of the Goals Project include subtidal habitats (deep and shallow bay and channel), wetlands (e.g. tidal marsh, tidal flats and diked baylands) the transition zone (the habitat between wetlands and upland habitats) and upland habitats(e.g. moist grassland and riparian forest). The term "wetland," as used by Goals Project participants, the U.S. Fish and Wildlife Service (Fish and Wildlife Service), as well as the California Department of Fish and Game (Fish and Game), is the definition first presented in a 1979 report entitled *Classification of Wetlands and Deepwater Habitats of the United States* by Cowardin, Carter, Golet and LaRoe.[4] In this document wetlands[5] are defined as,

> ..lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes;[6] (2) the substrate is predominantly undrained hydric soil;[7] and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

The value of the Cowardin definition is in its inclusivity of different wetland habitat types and its primary function is in guiding scientific inquiry, conducting inventories of natural resources, and aiding in the acquisition and restoration of wetlands.

BCDC's wetland jurisdiction is defined geographically and includes, generally, submerged lands (subtidal areas), tidal flats, tidal marshes, managed wetlands, and salt ponds. Furthermore, under BCDC's law, the McAteer-Petris Act, BCDC is given a great deal of authority over Bay habitats. Specifically, BCDC may issue or deny permits for any proposed project that involves placing fill, extracting materials or making any substantial change in use of any water, land or structure within the Commission's jurisdiction.[8] BCDC's jurisdiction extends over the Bay, most tidally influenced baylands, and small portions of diked baylands. This jurisdiction includes submerged lands, the water of the Bay to the mean high tide line, marshlands lying between mean high tide and five feet above mean sea level, salt ponds, certain managed wetlands, and specific waterways. These specific waterways include portions of Plummer Creek, Coyote Creek, Redwood Creek, Tolay Creek, Petaluma River, Napa River, Sonoma Creek, and Corte Madera Creek. Each of these areas of jurisdiction belong to BCDC's bay jurisdiction, salt pond jurisdiction or certain waterways jurisdiction. In addition, BCDC has authority over a shoreline band which extends inland for 100 feet.

Historical Distribution of Baylands. The Bay and surrounding baylands which exist today are dramatically different in composition and character than what existed prior to the arrival of Europeans. Two-hundred years ago the deep parts of the Bay contained the submerged topog-

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[4] Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* FWS/OBS-79/31. U.S. Fish and Wildlife Service, Office of Biological Services. Washington, D.C.

[5] tidal flats are included in this definition of wetlands as they are covered by hydrophytes in the form of mats of microscopic, single-celled diatoms (plants), as well as occasional macroalgal (seaweed) species.

[6] Plants which are able to grow in water.

[7] Soil associated with the presence of water.

[8] Section 66604.

raphy of ancient valleys with old river courses draining the Santa Clara Valley and the Central Valley. Shallow water dominated the broad tidal basins of Suisun, North Bay and South Bay. The character of Central Bay, as both deep and subject to wave action from the outer coast, is much as it was prior to the arrival of Europeans. Together, the deep and shallow bays totaled about one-quarter of a million acres, roughly the same as the adjoining baylands.

Each day as the tide went out almost 50,000 acres of tidal flats emerged along the margins of the bays and larger tidal channels. Sandy beaches were common in Central Bay and the eastern shore of North Bay, totaling about 23 miles of narrow beaches fringed with tidal marshes and tidal flats. Landward of the tidal flats and beaches around the Bay were almost 200,000 acres of tidal marshes. Much of this habitat consisted of vast, contiguous tidal marshes that extended across 50,000 or more acres in Suisun Bay, North Bay, and South Bay. In Central Bay tidal marshes were much smaller, ranging from tens of acres to several thousand acres, due to the steep topography. Adjacent to the baylands, in the flatter portions of the region, tidal marshes graded through transition zones (where a mix of the two habitat types occurred) and into low-lying moist grasslands.

Large tidal channels connected the marshes to the Bay and spread into networks of thousands of smaller channels distributed throughout the marshes. At their mouths, the major channels were several hundred feet across; the great volume of water that flowed in and out of the channel networks during each tidal cycle maintained deep and shallow channels through the marshes, tidal flats, and into the Bay. Tributaries around the Bay, such as the Napa and Petaluma Rivers, had tidal flats and tidal marshes arrayed along a salinity gradient (from fresh to salt water) created by local runoff. Each of these areas supported great physical and biological diversity.

Throughout the Bay there were at least two common mosaics of habitat types. One mosaic was confined to the small coves of the steep terrain along what is now Lake Merritt, the San Francisco Peninsula, the Marin shoreline, and the eastern shore of North Bay. This mosaic consisted of small patches of mudflat, tidal marsh, riparian (creekside)forest, and sometimes beaches and willow groves. The other common mosaic consisted of much larger patches of tidal marsh and upland habitats and was associated with the rivers and larger creeks flowing into South Bay, the eastern shore of Central Bay, and the northern shores of North Bay and Suisun Bay.

Beginning in the mid-1800s, following the Gold Rush in the Sierra Nevada, large areas of the Bay's tidal marshes and tidal flats were filled, diked or drained. In addition, the increased supply of sediment from hydraulic gold mining in the Sierra Nevada mountains helped fill the remnant tidal channels that remained between the diked baylands, and caused shallow bays to evolve into mudflats, while deep parts of the Bay became more shallow. Extensive portions of the baylands were filled to provide land for ports, rail lines, and roads as the Bay Area became a major transportation center. In addition, early industrial developers in San Francisco, Oakland and other shoreline cities built many facilities on Bay fill or on land immediately adjacent to the Bay. Farmers began diking and draining the tidal marshes for crop production in the 1850s. Much of the initial impetus for this activity stemmed from the federal Arkansas Act of 1850 which gave states all of the unsold federal land within their borders that was "swamp and overflowed". Subsequent state legislation, particularly the Green Act of 1868, also spurred the conversion of wetlands into agricultural uses. While in the North Bay and Suisun Bay agriculture was the main impetus for the diking of bayland habitats, primarily tidal marsh, in the South Bay baylands were diked primarily for salt production. Diking for commercial salt production began around 1860 and by the 1930s almost half of South Bay's historical marshes had been converted into salt ponds. At their peak, salt ponds covered about 36,000 acres in and adjacent to the baylands.

Contemporary Distribution of Baylands. Due to diking and filling of the Bay there has been a significant decrease in the size of the Estuary and the composition of the Bay's habitats has changed accordingly. Deep and shallow subtidal habitats have decreased from about 270,000 acres to about 250,000 acres due to sediment deposition from Gold Rush hydraulic mining and bayshore fill. Tidal flat habitat has decreased from about 50,000 acres to 30,000 acres as a result of reclamation, bayfill, natural conversion of tidal flat to tidal marsh and erosion. Tidal marsh habitat has declined from about 190,000 acres to about 40,000 acres due to bayfill and diking to create managed marsh, agricultural baylands and salt ponds.

San Francisco Bay Area Ecosystem Goals Project. As described earlier, due to the enormity of change in the Bay's ecosystem over the past 150 years and the great opportunity for restoration of bayland habitats through the removal of dikes, San Francisco Bay Area Ecosystem Goals Project participants[9] in 1999 released a report entitled the *Baylands Ecosystem Habitat Goals* (Habitat Goals Report).[10] Representing a regional consensus of agencies and organizations involved with habitat restoration, including BCDC, the main objective of the Goals Project was to provide a picture of the types, amounts, and distribution of wetlands and related habitats needed to restore a healthy baylands ecosystem. Habitat restoration refers to those activities that involve restoring a habitat's biological and physical conditions, such as restoring tidal marsh habitat by breaching a levee into an area where diked baylands previously existed. Habitat enhancement is similar, but refers to those activities or projects that will improve certain habitat values, but will not change the habitat type.

The Habitat Goals Report provides a template for habitat restoration around the Bay. Meeting the habitat goals outlined by the Habitat Goals Report involves taking both a regional, sub-regional approach and segment-based approach to habitat restoration. While the segment-based recommendation relate to specific portions of the Bay and are too extensive to discuss here, the regional and sub-regional goals can be discussed here in greater detail. First and foremost, the Habitat Goals Report recommends that no additional loss of wetlands should occur within the Bay and that as filled or developed areas within the Baylands become available, their potential for restoration to fish and wildlife habitat should be fully considered. Region-wide, the Habitat Goals Report outlines seven major habitat changes necessary to restore a healthy Bay-ecosytem: (1) many large patches of tidal marsh connected by corridors to enable the movement of small mammals and marsh-dependent birds; (2) several large complexes of salt ponds managed for shorebirds and waterfowl; (3) extensive areas of managed seasonal ponds; (4) large expanses of managed marsh; (5) continuous corridors of riparian vegetation along the Bay's tributary streams; (6) restored beaches, natural salt ponds, and other unique habitats; and (7) intact patches of adjacent habitats, including grasslands, seasonal wetlands, and forests.

This regional perspective embodies six ecological design principles which outline that bayland restoration plans should: (1) center tidal marsh restoration, where possible, around existing populations of threatened and endangered species; (2) include restoration of tidal marsh along the salinity gradients of the Bay and its tributaries; (3) emphasize restoring tidal marsh along the Bay edge and where streams enter the baylands; (4) provide natural features, such as large tidal channels, within tidal marshes; (5) reestablish natural transitions from tidal flat through tidal marsh to upland and between diked wetlands and adjacent uplands; and (6) provide buffers on undeveloped adjacent lands to protect habitats from disturbance.

[9] Goals Project participants consisted of over 100 scientists and resource managers with expertise on a multitude of Bay-related topics.

[10] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

On a subregional scale, the Habitat Goals Report outlines specific goals for the four subregions of the Bay. These subregions include Suisun Bay, North Bay, Central Bay and South Bay. The goal for Suisun Bay is to restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay, and to restore and enhance managed marsh, riparian forest, grassland, and other habitats throughout the subregion. The goal for North Bay is to restore large areas of tidal marsh and enhance seasonal wetlands. Also, some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, while others should be restored to tidal marsh. Tributary streams and riparian vegetation should be protected and enhanced, and shallow subtidal habitats (including eelgrass beds in the southern extent of this subregion) should be preserved or restored.

The goal for Central Bay is to protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Shallow subtidal habitats (including eelgrass beds), as well as tributary streams and riparian habitats, should also be protected and enhanced. Furthermore, tidal marsh habitats should be restored wherever possible, but particularly at the mouths of streams and at the upper reach of dead-end sloughs. In addition, tidal marsh restoration in urban areas is encouraged. The primary goal in the South Bay subregion is to restore large areas of tidal marsh, connected by wide corridors of similar habitat, along the perimeter of the Bay. Furthermore, several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the subregion, and naturalistic, unmanaged salt ponds (facsimiles of historical, hypersaline backshore pans) is recommended to be restored on the San Leandro shoreline. In addition, the report authors recommend natural transitions from mudflat through tidal marsh habitat to adjacent uplands.

On a segment by segment basis the Habitat Goals Report maps and describes twenty distinct areas of the Bay both in map and narrative form and highlights: (1) major or unique features; (2) unique restoration opportunities; (3) restoration recommendations; (4) unique restoration benefits; and (5) possible constraints.

Overall, in upholding the intent of the Habitat Goals Report, BCDC should seek consistency between proposed restoration projects and the restoration goals outlined by the Habitat Goals Report. In achieving consistency between Commission permitting actions and the Habitat Goals Report, chapter 5 entitled "Habitat Goals" is critical as it outlines the goals, both in narrative and map-form, from a regional, subregional (Suisun, North, Central and South Bay) and segment-based (for example, South Marin, Coyote Hills, and San Francisco Area) perspective.

Values and Functions of Wetlands. A greater understanding of the value of restoring wetlands requires delving into the multitude of functions which they provide. Wetlands alter and control flood flows, recharge groundwater, maintain stream flows, reduce and prevent shoreline erosion, and filter surface runoff from surrounding lands, thus improving water quality. They also are critical habitat for the Bay ecosystem's fish and wildlife populations, serve as a primary link in the ecosystem's food chain, ensure the continued diversity of plant and animal communities, and are an essential feeding and resting place for migratory birds on the Pacific Flyway. In addition they help to maintain shipping channels by moderating the input of sediment into waterways, and contribute to the stability of global levels of available nitrogen, atmospheric sulfur, carbon dioxide and methane. Finally, wetlands provide the opportunity for a variety of recreational and educational activities and serve as a relief to the urbanized San Francisco Bay Area. On an economic scale, a recent study estimated the value of economic benefits provided by wetlands throughout the state of California to be in the range of $6.3 billion to $22.9 billion.[11]

[11] Goals Project, 1999.

Subtidal Habitats. Subtidal (aquatic) habitats include deep bay/channel habitats and shallow bay/channel habitats, according to the EcoAtlas classification system. However, aquatic habitat types are not the same as a habitat type on the land. For instance, when one thinks of a tidal marsh habitat, one thinks of a certain assemblage of topography, plants, and animals—in other words, a distinct, geographically bounded community. Such is not the case in the subtidal environment; in this far more fluid environment, plants and animals are not bounded as neatly by geography or place (with the possible exception of rooted eelgrass communities). Many estuarine fish species, for example, often swim to other parts of an estuary or out of an estuary as part of their normal life cycle or to avoid changes in salinity or turbidity.[12] In these environments, many aquatic creatures are not fixed, and their habitats cannot be fenced in or fenced out.[13] This lack of physical reference points makes it more difficult to map and manage aquatic habitats. Aquatic habitats are thus difficult to define, adding a layer of complexity to aquatic habitat mapping and management efforts.

Due to the dearth of data, and to difficulties in classifying subtidal habitats, it is not clear which subtidal habitat features have been lost and in what locations. However, general trends have occurred with subtidal habitats over the past 150 years. For example, the increased supply of sediment from hydraulic gold mining in the Sierra Nevada mountains caused some shallow parts of the Bay to become mudflats, while deeper areas of the Bay were made shallow. However, this trend has largely been reversed with parts of the Bay becoming deeper, as earlier deposited debris is eroded, at the same time that river-borne sediment, which once may have reached the Bay, is now being trapped behind dams. The Bay has also suffered a loss of habitat quality. For example, invasive species, pollution, and freshwater diversion, altered flow regime, and habitat destruction and modification have all decreased the quality and quantity of the Bay's subtidal habitats, and have contributed to the significant decline in many of the Bay's important species.

BCDC and other agencies with regulatory authority over the Bay are increasingly being asked to make decisions on activities that affect subtidal habitats. These activities fall into two broad categories: (1) proposed habitat improvement (including using dredged material for creating shallow water for development of eelgrass beds, or the creation of habitat islands for migratory birds), and (2) other projects (which may include extensive sand dredging, or lowering of rock formations in the Central Bay for navigational purposes). In particular, the Commission has regulatory authority over subtidal habitats for projects involving fill, extraction of materials, or changes in use. As it does with tidal wetlands, the Commission may incorporate permit conditions to help protect subtidal environments. The Commission may also initiate planning processes that examine subtidal issues. Additional protection and restoration techniques may also be available in partnership with other agencies (such as the creation of marine refuges, mitigation for subtidal impacts, or the placement of habitat-enhancing structures in the Bay).

In light of BCDC's authority over subtidal habitats and the dearth of scientific information regarding this important habitat type, BCDC convened a panel of scientists in September 2000 who described the difficulty of classifying and understanding the functions and values associated with subtidal habitat. The subtidal panel did, however, have general insight regarding subtidal habitat which has helped shape the new Bay Plan subtidal findings and policies found in this report. Some of the recommendations which arose from the subtidal panel include: (1) the San Francisco Bay subtidal environment provides valuable habitat for a number of species of concern; (2) subtidal habitats are both of ecological and economic importance (e.g., to tourism and commercial fishermen and recreational anglers); (3) areas of the Bay subject to tidal action

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[12] Fishweb Home Page. 1999. Queensland Government, Department of Primary Industries. (http://www.dpi/qld.gov.au/fishweb/habitats/content.html).

[13] Agardy, Tundi. 1999. "Global Trends in Marine Protected Areas." Trends and Future Challenges for U.S. National Ocean and Coastal Policy, August, ed. Billiana Cicin-Sain et al, 1999 Workshop Proceedings, National Ocean Service, NOAA.

should be expanded and subtidal habitats should be more complex ; (4) opportunities to enhance and restore subtidal habitat to achieve specific ecological objectives, such as native oyster reef restoration, should be explored; (5) there is a difference between subtidal habitats and the terrestrial bayland habitats in that subtidal habitats, for the most part, are still intact, making protection and restoration a different kind of challenge; (6) understanding the different functions of shallow subtidal habitat and deep subtidal habitat is important in terms of protection and restoration of the Bay's subtidal environment; and (7) subtidal habitat critical to the well-being of listed species should be protected to the greatest extent possible.

Transition Zone (Ecotone). A transition zone is a habitat type where a gradual change from wetland to upland habitat occurs. Transition zones are sometimes called "ecotones." In their natural condition wetlands frequently lie adjacent to upland habitats, with a transition zone in between. This transition zone is usually an area of lowland grassland that can support both vegetation and wildlife found in both wetlands and upland habitats.14 As a consequence, transition zones contain a rich mixture of vegetation types and are an especially important habitat for aquatic and terrestrial wildlife, such as the salt marsh harvest mouse. Furthermore, these transition zones are inextricably linked to wetlands ecosystems. They demonstrate an "edge effect" that blends the habitat of plants and animals from each of the bordering habitats – such as tidal marsh and grassland. Generally, only portions of the transition zone around the Bay is within BCDC's jurisdiction. However, the transition zone surrounding Suisun Marsh is largely protected due to policies found in the Suisun Marsh Protection Plan.15

Upland Habitats. Habitats upland from those located in and adjacent to the Bay are categorized as upland habitats. Examples of upland habitats include grasslands, willow groves and oak woodlands. While these habitats are outside of BCDC's jurisdiction, they are ecologically important due to their connection to and interrelationship with San Francisco Bay, including the functions and values they provide for Bay-related aquatic life and wildlife. Furthermore, impacts on upland habitats can effect downstream habitats located in BCDC's jurisdiction, making an understanding of the linkages between upland habitats associated with the Bay critical to protecting the Bay's plant and animal communities.

Biodiversity. The complexity of physical gradients and habitats associated with San Francisco Bay has enabled the evolution of a diversity of aquatic life and wildlife perfectly adapted for life in the Bay. Many kinds of values are associated with this biodiversity, including intrinsic value, recreational value, commercial value, ecological value, scientific value, educational value and aesthetic value. BCDC law, the McAteer-Petris Act[16] recognizes the value of aquatic life and wildlife by requiring that the "...nature, location and extent of any fill should be such that it will minimize harmful effects to the bay area, such as,...fertility of marshes or fish or wildlife resources...."[17]

Invasive Species. A phenomenon threatening the Bay's plant life, aquatic life and wildlife is the introduction of invasive species. An invasive species is an organism that is not native to the Bay, yet thrives and reproduces in it. Invasive species can be plants, animals, fish, insects, or any other type of organism. Some of these species invade land (terrestrial) habitats, while others invade water (aquatic) habitats. For example, the Bay's wetlands have been invaded by plants such as smooth cordgrass from the Atlantic Coast (*Spartina alterniflora*) and pepper weed (*Lepidium latifolium*), and organisms such as the red fox and the Atlantic green crab.

[14] San Francisco Bay Conservation and Development Commission. 1976. *Suisun Marsh Protection Plan Supplement.* San Francisco Bay Conservation and Development Commission, San Francisco, California.
[15] BCDC, 1976.
[16] California Govt. Code §66600-66682.
[17] California Govt. Code §66605(d).

The Bay's subtidal habitat has been invaded by almost every category of creature, including fish, jellyfish, worms, clams, crabs, mosses, barnacles, sea slugs, and a host of other life forms. In general, aquatic pests are generally transported to the Bay in four ways: (a) through vessels (either in solid ballast, ballast water, or hull fouling organisms), (b) through fisheries, marsh restoration, or biocontrol activities (where species are released to prey on other pest species); (c) by other commercial and private activities, such as when individuals release creatures to establish food sources (for example, carp or clams), or releases and escapes from residential ponds and aquariums; and (d) through scientific research. Because most introductions to the Bay occur through ballast water, the San Francisco Regional Water Quality Control Board (Regional Board) considers it the highest priority pathway for corrective measures.

Furthermore, invasive species can threaten native plants and animals by preying on them or competing with them for food, habitat, and other necessities. These invasive species, freed from the predators and environmental constraints of their native environment, can sometimes outcompete and displace native species. Thus, invasive species threaten native plants and animals in three ways: (1) by preying on them; (2) by competing with them for food, habitat, and other necessities; or (3) by disturbing their habitat, sometimes in a dramatic manner. Habitat disturbance includes changes to the physical structure of the habitat as well as changes to energy or food cycles. Scientists also suspect that invasive species threaten the native ones in three additional ways: (1) by facilitating the transfer of toxic materials up the food chain; (2) by changing the genetic make-up of certain plant species through hybridization; and (3) by introducing parasites and diseases.

Worth noting is that it is very difficult, if not impossible, to eradicate previously introduced invasive species from the Bay. In this instance, the best approach BCDC can take to minimize the effect of invasives on the Bay ecosystem is to design restoration and landscape design projects in such a way that exploitation of new areas is less likely. In terms of preventing new invasive species introductions into the Bay, altogether, an effort is underway at both the state and federal level to regulate the release of ballast water from ships into the Bay, which is the most common method of new invasive species introduction into the Bay.

Endangered Species Acts. Due to the impacts of invasive species on native species, as well as other causes, 51 species of plants and animals of San Francisco Bay are listed as threatened or endangered under the state and federal endangered species acts. These include twenty-one plants, ten invertebrates, six fishes, one amphibian, two reptiles, nine birds and two mammals. The federal Endangered Species Act (ESA) was passed in 1973 to combat these declines. Specifically, Congress found that species at-risk of extinction "are of aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." While the ESA is a federal law, state agencies, such as BCDC, do have certain responsibilities under the Act. For example, BCDC must avoid permitting any activity which would result in the "taking" of a listed species, which is defined as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a federally designated threatened or endangered animal species listed under the ESA. Furthermore, BCDC must require that project applicants get the proper permits from the United States Fish and Wildlife Service (Fish and Wildlife) and the National Marine Fisheries Service (NMFS) if any of the aforementioned activities may occur due to the permitting of a project by BCDC.

Modeled after the federal Endangered Species Act, California adopted its own Endangered Species Act (CESA) in 1984 with the purpose of furthering the state's role in the conservation of at-risk species. Declaring that it is the "policy of the state to conserve, protect, restore, and enhance" any endangered or threatened species and its habitat, the Act finds that not only is "the conservation, protection, and enhancement of these species and their habitat of statewide concern," but also that it is the policy of the state that "all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance" of the Act. BCDC's primary responsibility under the CESA is to avoid authorizing a project which would result in "taking" a state endangered or threatened species, except if the applicant has attained the proper permits from the California Department of Fish and Game.

Marine Mammal Protection Act. The Marine Mammal Protection Act (MMPA) was enacted in 1972 with the goal of protecting and conserving marine mammals. Instituted in response to the problem of marine mammal mortality associated with commercial fishing operations, the authority for implementing the Act belongs to Fish and Wildlife and the NMFS. Species in the Bay protected by the Act include sea otters, river otters, harbor seals and sea lions. The definition of persons subject to the provisions of the Act is expansive and includes state agencies such as BCDC. Thus, BCDC is responsible for ensuring that marine mammals are not harmed by a project approved by the Commission without the proper approval from Fish and Wildlife or the NMFS.

Essential Fish Habitat Provisions. Another aquatic life and wildlife protection policy relevant to BCDC and the Bay, the Essential Fish Habitat provisions of the Magnuson-Stevens Act requires cooperation among the NMFS, the eight regional fishery management councils, fishing participants, and others in achieving fish habitat protection, conservation and enhancement. The Essential Fish Habitat provisions of the Act offer resource managers a new tool to accomplish the goal of habitat protection by specifying areas critical to the survival of aquatic species under the purview of the regional fishery management councils. Currently, San Francisco Bay is defined as Essential Fish Habitat for a number of species, such as northern anchovy, leopard shark, starry flounder, brown rockfish, English sole, and Pacific sardine .

In regards to the implementation of the Essential Fish Habitat provisions, each federal agency proposing an action, the approval of a project, or the funding of a project that will adversely affect Essential Fish Habitat must consult with the NMFS to discuss how to minimize these impacts. More specifically, once NMFS learns of a federal or state project that may have an adverse effect on Essential Fish Habitat, NMFS is required to develop Essential Fish Habitat Conservation Recommendations for the project. These recommendations may include measures to avoid, minimize, mitigate, or otherwise offset adverse effects on Essential Fish Habitat. State agencies, however, unlike federal agencies, are not required to respond to any of the recommendations. In the strictest sense of the law, then, the Magnuson-Stevens Essential Fish Habitat provisions do not impose any additional requirements on BCDC, although, the recommendations to minimize impacts on sensitive fish species could be considered by BCDC on a voluntary basis.[18]

Another tool the Commission may use to protect Bay habitats and associated plant and animal life is through the designation of Bay Plan wildlife priority use areas. These wildlife priority use areas seek to protect areas designated as wildlife refuges or areas important to the protection of specific habitat types or plant and animal life. The definition of a wildlife refuge depends on the agency in question and its particular regulations or codes. In general, however, wildlife refuges are areas of land and water established and maintained for the restoration, preservation, and management of fish and wildlife including threatened and endangered species, and their habitat. BCDC's "priority use areas" reserve certain areas along the shoreline for critical water-oriented uses. Wildlife areas are one category of priority use areas. Thus, the wildlife priority use areas serve at least three different purposes: (1)to symbolically recognize areas that are already protected for wildlife purposes; (2) to proactively reserve areas that the Commission believes will be needed for wildlife refuges in the future; and (3) as per the Bay Plan Fish and Wildlife Policies, to show the specific habitats needed to protect and prevent the extinction of any species, or to maintain or increase any species that would provide substantial benefits.

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[18] Bigford, Thomas E., (ed). Vol. 21 (2) 1999. *The Essential Fish Habitat Provisions of the Magnuson-Stevens Act* in The Coastal Society Newsletter. The Coastal Society, Alexandria, Virginia.

CHAPTER 1

INTRODUCTION

The purpose of this staff report on San Francisco Bay habitats is to provide information on the ecology of San Francisco Bay, including the diversity of habitats associated with the Bay, the assemblages of plant and animal life dependent upon those habitats, and the principal threats affecting the well-being of the Bay's ecosystem in order to enable the San Francisco Bay Conservation and Development Commission (BCDC) to update its San Francisco Bay Plan (Bay Plan) findings and policies. Also addressed in this discussion is the role of invasive species in shifting the composition of the Bay's plant and animal communities from native species to largely non-native species, and therefore, forever altering the native biodiversity of the Bay. Scientific insight not only shines a light on large scale changes occurring in the Bay due to invasive species invasions, but science also helps us understand the complexities of the Bay's subtidal (aquatic) habitat, a part of the Bay which has been largely unexamined by the Commission, and the advances in scientific knowledge about the Bay since the Bay Plan was adopted by BCDC in 1968 has increased considerably.

This report on the habitats of the San Francisco Bay outlines BCDC's jurisdiction and regulatory authority over the Bay's habitats, and related aquatic life and wildlife, including the agency's responsibilities under the California and federal Endangered Species Acts. Also, information gathered and compiled in this report will provide the foundation necessary to create and recommend findings and policies for the future protection of the Bay's habitats, and the aquatic life and wildlife dependent upon the well-being of the San Francisco Bay.

Introduction to the Ecology of San Francisco Bay. The science of ecology provides scientists and non-scientists alike a valuable lens with which to view the natural world. Focusing on the relationship between an organism and its environment, ecology studies the interconnections which exist between a community of organisms and the physical environment where they live.[1] San Francisco Bay is home to a complex array of organisms. The terms and tools provided by the science of ecology will be used throughout this discussion to better understand the aquatic life and wildlife of San Francisco Bay and the habitats upon which they depend.

An ecosystem is a natural community of living organisms that interact with each other and with their physical environment in a way that perpetuates the community of organisms.[2] Although large in geographic scope, San Francisco Bay is an ecosystem. Species living in the waters of the Bay may interact with organisms living along the shore, in turn these organisms may interact with other organisms living in upland areas. Figure 1[3] illustrates the ecosystem concept well by showing how various species overlap in their distribution and utilization of the Bay ecosystem.

In addition, all of these organisms depend upon various portions of the San Francisco Bay's physical environment. Topsmelt (a fish species), for example, utilize the shallow sloughs of tidal marshes of South San Francisco Bay, as well as open water during different times in their life cycle and daily feeding routine.[4] In addition, the topsmelt are food for many species of bird and fish living in different parts of the bay.

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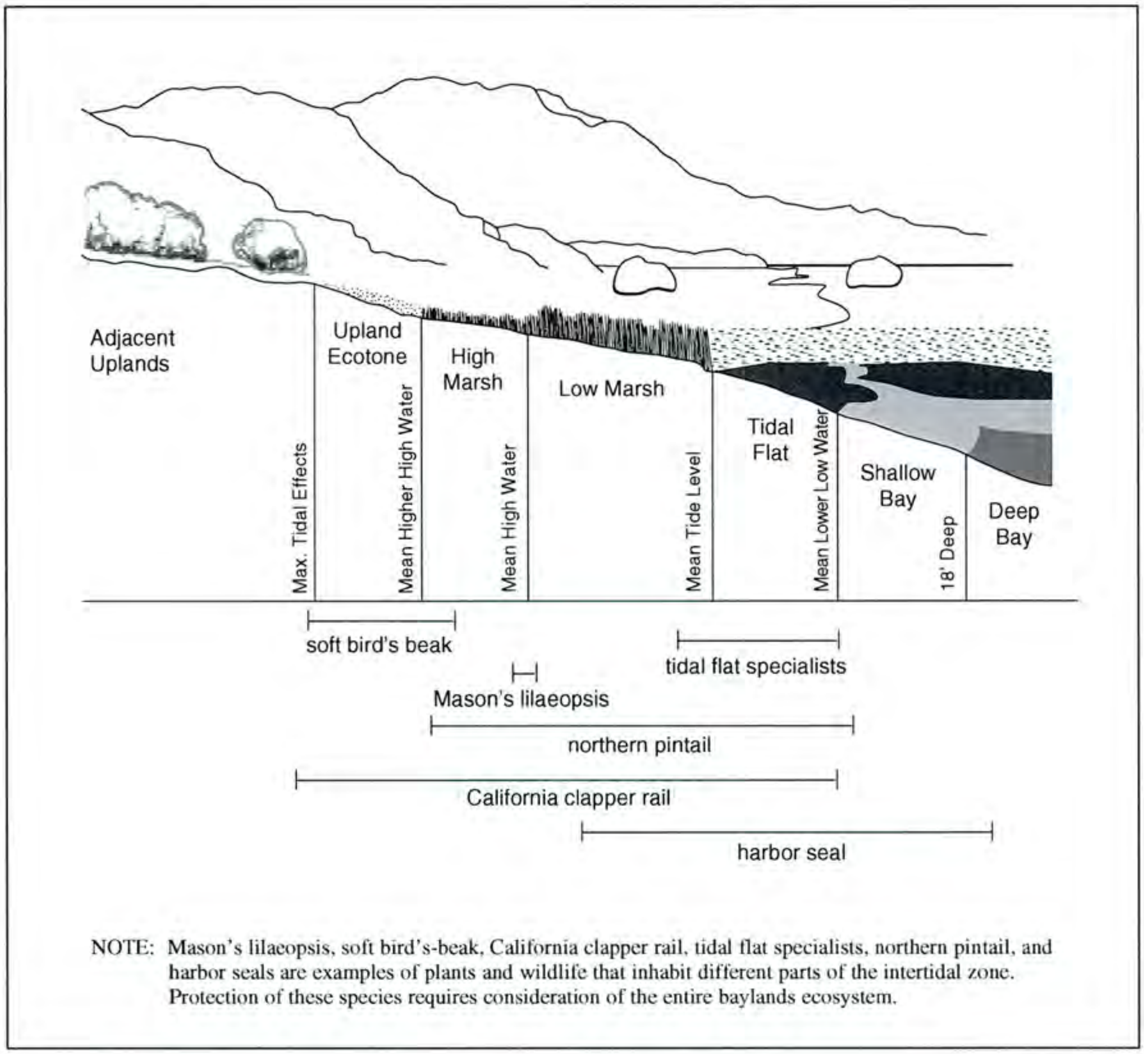
[1] Smith, Robert Leo. 1992. *Elements of Ecology*. Harper Collins, New York, New York.

[2] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

[3] Adapted from the Goals Project, 1999.

[4] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Species Narratives for Fish and Macroinvertebrates*



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals (1999).*

Figure 1
Intertidal Distribution of Selected Plants and Wildlife

The ecosystem concept captures these interconnections and presents the San Francisco Bay holistically as a natural community of organisms spanning from upland areas to deep water. Chapter 5, entitled the, "Distribution and Abundance of Species Associated with San Francisco Bay" will delve into the individual life histories of the organisms associated with San Francisco Bay, explaining what the organism eats and where it is found while breeding or resting. Understanding the needs of individual species is the first step in grasping not only the complexity of life around the bay, but also what is necessary to protect the continued well-being of each species.

The concepts of food webs and habitats are two more terms central to describing the lives of the aquatic life and wildlife associated with San Francisco Bay. A food web is an assemblage of organisms in an ecosystem, including plants, herbivores (plant eaters) and carnivores (meat eaters), showing the relationship of who eats whom.[5] An example of a food web includes the nearly forty species of migratory shorebirds and waterfowl which feed on the brine shrimp, fish and brine flies living in the salt ponds in San Pablo and South San Francisco Bay. The linkage between species in a food web illustrates the potential harm that can come to all of the species in the web if any of them are removed due to outright extinction or extirpation from one area. Chapter 3, "Threats to the Health of the Bay's Habitats," will explore potential impacts in detail, emphasizing the complexity and interconnected nature of threats as diverse as habitat loss, pollution and the modification of freshwater flows. Furthermore, chapter 4, entitled "Invasive Species," delves deeper into one of the greatest impacts threatening to alter the character of the Bay's ecosystem. This impact is the result of both deliberate and inadvertent introductions of non-native plant and animals species into the Bay ecosystem.

An organism's habitat is generally described as the place where it lives or the place one would go to find it. Some of the habitats found in and around San Francisco Bay include terrestrial habitats, such as salt ponds, tidal flats and tidal marshes, as well as subtidal habitats, such as shallow bays and channels. The distinctions between habitats are conceptual and help scientists understand the similarities and dissimilarities of physical processes found between and among parts of the Bay, as well as the specifics of communities of plants and animals associated with those areas. Chapter 2, "The Habitats of San Francisco Bay," describes the habitats associated with the Bay and the community of species which reside there.

Central to understanding the breadth of habitats around the Bay is the recognition of historical change. Diking and filling of parts of the Bay has come with a price to the expanse and diversity of habitats associated with the Bay. Chapter 2 discusses these historical losses and chapter 7, "Regional and Sub-Regional Approaches to Increasing the Health of the Bay's Habitats," utilizes the recommendations of the *Baylands Ecosystem Habitat Goals*[6] report, a document representing the work of many scientists, in order to describe how and where habitat around the Bay can be restored and better-managed to encourage the recovery of species of special concern.

San Francisco Bay as an Estuary. Covering an area of about 1,500 square miles, the San Francisco estuary includes the embayments of San Francisco Bay, San Pablo Bay, Suisun Bay and the Sacramento-San Joaquin Delta. Ninety percent of the freshwater flowing into the estuary comes from the Sacramento River, eastern streams with their source in the Sierra Nevada, and the San Joaquin River. The other 10 percent comes from the watershed surrounding San Francisco Bay.7 Unnatural sources of fresh water include storm drains and discharge pipes from sewage treatment plants. Salt water, on the other hand, arrives twice daily on ocean tides coming into the Central Bay through the Golden Gate and dispersing throughout the rest of the Bay.

While San Francisco Bay (including San Pablo Bay and Suisun Bay) falls within BCDC's jurisdiction, the Sacramento-San Joaquin Delta does not. However, a complete understanding of San Francisco Bay's ecology requires considering its biological and physical processes in context with the Pacific Ocean to the West and the Sacramento-San Joaquin-Delta to the East. Furthermore, within the San Francisco Bay Area BCDC does not have jurisdiction over all of the habitat-types, yet understanding those habitats in close proximity to the Bay enables better comprehension of those habitats within BCDC's jurisdiction. For example, many species associated with tidal marsh habitat also rely upon nearby upland habitat, such as agricultural baylands.

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[5] San Francisco Estuary Project. 1990. *An Introduction to the Ecology of San Francisco Estuary.* Produced by Save San Francisco Bay Association for the San Francisco Estuary Project. Oakland, California.

[6] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

[7] San Francisco Estuary Project, Aquatic Habitat Institute. 1991. *Conference Proceedings: State of the Estuary.* San Francisco Estuary Project, Oakland, California.

However, while BCDC has authority over tidal marsh habitat surrounding the Bay, agricultural baylands are not within BCDC's jurisdiction. The baylands (lands surrounding San Francisco Bay) include lands that are touched by the tides (tidal habitats), as well as historic areas of the Bay which were isolated from tidal action by levees, sea walls or other man made structures (diked habitats). BCDC has authority over the Bay, most tidally influenced baylands, and small portions of diked baylands. Landward of the baylands are the watersheds of San Francisco Bay. These watersheds are land areas from which creeks and rivers flow into the Bay. Although the Commission has jurisdiction over bayward portions of certain creeks and rivers which flow into the Bay, the majority of San Francisco Bay's watersheds are outside of BCDC's jurisdiction.

The San Francisco Bay-Delta is the largest estuary along the Pacific shore of North and South America and is a natural resource of incalculable value. An estuary is a partially enclosed body of water formed where freshwater from rivers and streams flow into the ocean, meeting and mixing with salty seawater. Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water. The sheltered waters of estuaries support unique communities of plants and animals, specially adapted for life at the margin of the sea. Estuarine environments are among the most productive on earth, creating more organic matter each year than comparably-sized areas of forest, grassland or agricultural land.

The productivity and variety of estuarine habitats foster a wonderful abundance and diversity of wildlife and they are critical for the survival of many species. Estuaries provide ideal spots for migratory birds to rest and refuel during their journeys and many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn. Most commercially valuable fish species depend on estuaries at some point during their development. In addition, estuaries provide habitat for more than 75 percent of America's commercial fish catch and for 80 to 90 percent of the recreational fish catch.[8] Freshwater affects salinity conditions and many physical and biological processes throughout much of the Bay. These affects occur at various geographic scales. For example, the flows of the Sacramento and San Joaquin river system influence the large salinity gradient from the Delta to Central and South Bay, with the Central and South Bay being more saline than San Pablo and Suisun Bay. The flows of smaller creeks and streams affect salinity gradients on a more local level.

Tides arising from the ocean are the major source of water for tidally influenced lands around the Bay. They are also an important water source for many diked habitats, particularly managed marshes during droughts. In San Francisco Bay there is a mixed-diurnal type of tide. Thus, there are two high tides and two low tides almost every day. The average local heights of the tides are called tidal datums. Figure 2 illustrates the connection between these tidal datums and Bay habitats. For example, tidal flat habitat occurs between Mean Lower Low Water (MLLW) and Mean Sea Level (MSL), while deep bay habitat occurs 18 feet below Mean Lower Low Water (MLLW). Overall, the tides influence the land around the bay in three basic ways. First, they carry nutrients sediments, salts, and other materials to and from the baylands; second, they create gradients of decreasing moisture and amount of tidal action from lower to higher tidal elevations, which in turn defines where certain species of plants and animals are found; and three, the tides provide the physical means for fish and other aquatic organisms to move across tidal flats and marshes at high tide.[9] Thus, in many ways the tides define the character of the Bay's habitats and the Bay ecosystem as a whole.

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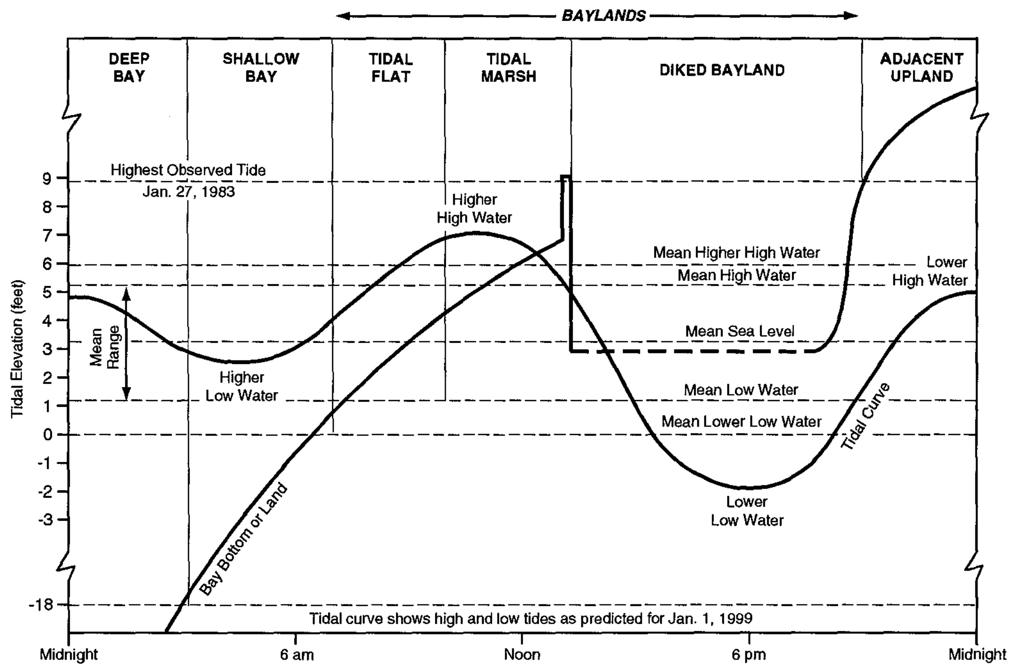
[8] U.S. Environmental Protection Agency Website. 1999. *About Estuaries*. (http://www.epa.gov/owow/estuaries/about1.htm)

[9] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.



NOTE: This schematic diagram shows tidal datums for a mixed tide for the major baylands and adjacent habitats. The tidal curve and datums represent the Golden Gate. Bay bottom and land elevations are much more variable than shown. The mean range of the tide also varies around the Estuary.

SOURCE: Adapted from USEPA & SFBRWQCB
Baylands Ecosystem Habitat Goals (1999).

Figure 2
Tidal Datums

The Historic Creation of San Francisco Bay. Historic sea level rise and consequent sedimentation helped make San Francisco Bay the valuable place that it is today for aquatic life and wildlife. Twenty thousand years ago, San Francisco Bay did not exist. At that time the world was in the grip of the last ice age and much of the planet's water was frozen into glaciers that covered a large part of the northern continents. With less water to fill the oceans, sea level was 400 feet lower and the Pacific shore lay out beyond the Farallon Islands. As the last glacial period ended around 15,000 years ago, the ocean began to rise and spread inland through a gap in the Coast Range, known today as the Golden Gate. For thousands of years the waters rose close to an inch annually, which was enough to advance the shoreline nearly one-hundred feet inland each year. Gradually, the rate of rise slowed until beginning 2,000 to 3,000 years ago, sediments began to accumulate in the shallows faster than the sea could cover them. These sediments supported the expansion of tidal flats and marshes around the edges of western Suisun Bay, Central Bay, North Bay and South Bay.

An adequate supply of sediment is still required to ensure continued tidal flat and tidal marsh formation, as well as to offset the effects of erosion on existing tidal marshes and tidal flats. There are two main sources of sediments necessary for the replenishment and formation of bayland aquatic life and wildlife habitat. These sources include inorganic silts and clays that are generated by freshwater flow, tidal currents, and wind-driven waves, as well as organic sediments that are created by the growth of plants within the baylands. Organic sediments are transported onto tidal flats from tidal marshes as tidal waters recede, becoming food for millions of invertebrates. These invertebrates include filter-feeding clams, oysters and mussels, as well as deposit-feeding mud snails, Baltic clams, and crabs.

Inorganic sediment enters the estuary from the Sacramento and San Joaquin river system, totaling more than six million cubic yards annually. Some of this sediment is transported to tidal marshes while the rest has helped to create San Francisco Bay's extensive subtidal areas and muddy bottom. Species dependent upon the Bay's muddy bottom include California bay shrimp, Dungeness crab, rock crab, white sturgeon, longfin smelt, the harbor seal and a variety of bird species. Recent research indicates that the volume of sediment provided to the estuary by the Sacramento River has been cut in half since 1960, due to the trapping of sediment by upstream dams.

San Francisco Bay as Home to Aquatic Life and Wildlife. The San Francisco Bay ecosystem presently sustains nearly 500 species of fish, invertebrates, birds, mammals, insects and amphibians. Two thirds of the state's salmon pass through the Bay and Delta, as do nearly half of the waterfowl and shorebirds migrating along the Pacific Flyway.[10] Historical anecdotes of aquatic life and wildlife of the San Francisco Estuary paint a picture of a time in which aquatic life and wildlife abounded beyond today's imagination. Two-hundred years ago, observers reported that migrating birds blackened the sky over the estuary, while salmon runs were described as being so dense that Delta rivers looked like silver pavement. Similarly, the multitude of white geese in one area was reported as giving the ground the appearance of snow.[11]

Today, extensive habitat loss and fragmentation have drastically reduced the number of species residing in the bay, as well as the population numbers existing within each species. Due to these significant losses, management and regulatory programs have been implemented by a host of agencies and organizations which seek to improve the survival rate of species whose numbers are declining. Appendix C, entitled "Management and Regulatory Programs that Protect Plant, Aquatic Life and Wildlife of the Bay," utilizes California's Natural Diversity Database to describe the range of programs currently in place to ensure the continued survival of species at risk of extinction. A major component of this chapter is an acknowledgement that human intervention is valuable in preventing a species' decline.

Contemporary Changes in the Bay Ecosystem. Humans exert a major influence on the form and function of San Francisco Bay. Not only has there been a significant decrease in the size of the Bay over the past 200 years, but significant changes in habitat location, quality and quantity have also occurred. For example, deep and shallow bay habitats have decreased from about 270,000 acres to about 250,000 acres. This is a result of sediment deposition from Gold Rush hydraulic mining and of bayshore fill. Tidal flat habitat has decreased from about 50,000 acres to about 30,000 acres. This loss is primarily a result of reclamation, bayfill, and the natural conversion of tidal flat to low tidal marsh and erosion. A 79 percent loss in tidal marsh habitat has occurred over the past 200 years, resulting in a decline of acreage from 190,000 to about 40,000 acres. This is a result of bayfill and diking to create managed marsh, agricultural baylands and salt ponds.12 Other Bay habitats have suffered similar losses.

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[10] San Francisco Estuary Project. 1999. *Wetlands.* (http://www.abag.ca.gov/bayarea/sfep/reports/fact/wetlands.html

[11] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[12] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif/ S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

Habitat loss and degradation have played key roles in the population decline of many species. Out of the 500 species of wildlife and aquatic life associated with the Estuary, 30 are listed as threatened or endangered under the state and federal Endangered Species Acts. These listings include ten invertebrates, six fishes, one amphibian, two reptiles, nine birds and two mammals. For species native to the San Francisco Estuary, such as the California clapper rail (a bird species living only in the tidal baylands), habitat losses have undoubtedly contributed to population declines. Species which depend on the Estuary for part of their life cycles, such as the Chinook salmon and California least tern, have also been impacted by habitat losses.

The Value of Aquatic Life and Wildlife. The complexity of physical gradients and habitats has enabled the evolution of a diversity of aquatic life and wildlife perfectly adapted for life in the Bay. Many kinds of values are associated with this diversity, including intrinsic value, recreational value, commercial value, ecological value, scientific value, educational value and aesthetic value. BCDC law, the McAteer-Petris Act[13] requires that the "...nature, location and extent of any fill should be such that it will minimize harmful effects to the bay area, such as,...fertility of marshes or fish or wildlife resources..."[14] According to the *San Francisco Bay Plan*, aquatic life and wildlife benefit humans by providing "food, economic gain, recreation, scientific research, education, and an environment for living."[15] BCDC's approach to the protection of aquatic life and wildlife based on these values has evolved over the years. Chapter 6, entitled "BCDC's Jurisdiction, Authority and Responsibility for Aquatic Life, Wildlife and San Francisco Bay Habitats," explores the agency's role pursuant to the McAteer-Petris Act, the *San Francisco Bay Plan*, the California Environmental Quality Act and the federal and state Endangered Species Acts. Furthermore, chapter 8, entitled "Wildlife Refuges," discusses efforts which state and federal resource agencies have made to protect the Bay's habitats through the establishment of wildlife refuges. The conclusion of chapter 6 and 8, as well as the entirety of this report, is that the opportunity for improving is constant and measures should be taken to not only protect these heritage resources, but to restore them to the maximum extent practicable.

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[13] California Govt. Code §66600-66682.

[14] California Govt. Code §66605(d).

[15] San Francisco Bay Conservation and Development Commission. 1998. *San Francisco Bay Plan*. San Francisco Bay Conservation and Development Commission, San Francisco, California. p.9.

CHAPTER 2

THE HABITATS OF SAN FRANCISCO BAY

San Francisco Bay is an ecosystem comprised of a diversity of habitats. These habitats owe their creation and continuation to the global factors of climate and sea level rise, as well as the more local physical forces of topography; the ebb and flow of the tides; the volume, timing, and location of freshwater inflow; and the availability and types of sediments. In turn, as Bay habitats have been formed over time by physical processes, life has also defined the character of these habitats. Plants, aquatic life and wildlife have evolved alongside one another upon the varied backdrop of the Bay's physical landscape. All of them are interconnected and dependent upon the others' well-being. A habitat is best defined as the geographic location where an organism lives or where one would go to find it.[1] Thus, habitats are distinct areas that both support a number of species and are defined by specific plant communities and key animal species. For example, the presence of the California clapper rail in an area is an indicator of tidal salt marsh habitat, as is the presence of tidal salt marsh plant community members such as pickleweed, Pacific cordgrass, and saltgrass. This chapter focuses on the Bay's habitats and includes a description of the historical changes which have occurred in the composition and location of these habitats due to human intervention.

A large part of understanding the similarities and dissimilarities of Bay habitats begins by organizing them into a conceptual framework. This framework serves to break the San Francisco Bay ecosystem into comprehensible pieces with defined boundaries based on vegetation and geographic location. Using this approach, tidal salt marsh habitat will be defined and described as unique from tidal flat habitat. Worth remembering, however, is that these distinctions in habitat type are made for the purpose of understanding. In nature habitats exist on a continuum. Deep bay habitats blend into shallow bay habitats, which then may blend into tidal flats or tidal marshes. The place where two habitats meet and merge is known as a transition zone or ecotone. These locations are distinct in the large diversity of plants and animals which they support. Their characteristics and value, along with those of the other habitats associated with the Bay, will be emphasized in the upcoming discussion.

The Baylands Ecosystem Habitat Goals Classification System. The categories of wetlands and related habitat types presented in this chapter were developed as part of the Baylands Ecosystem Goals Project.[2] The Goals Project has brought together representatives of the region's scientific and academic community to describe historical change in the San Francisco Bay ecosystem, the existing conditions of the ecosystem, and to assist in the development of regional habitat goals for the restoration of the Bay ecosystem.

To facilitate this work, the Goals Project developed an atlas of wetland types and related habitats around San Francisco Bay. This atlas, called the Bay Area EcoAtlas, incorporates a habitat typology that reflects regional land use qualities and the accompanying patterns of wetland related habitat, or regional ecology, and is designed for resource assessment and local/regional planning use. The EcoAtlas represents over three years of intensive work, and reflects the efforts of over 100 scientists, academics, and volunteers in verifying the accuracy and guiding the design of the atlas for local and regional wetland habitat planning purposes. Figure 3[3] presents the Bay Area EcoAtlas, which illustrates the contemporary distribution of habitats around San Francisco Bay. The EcoAtlas serves as the base map of the San Francisco Bay Plan.

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[1] Goals Project, 1999.

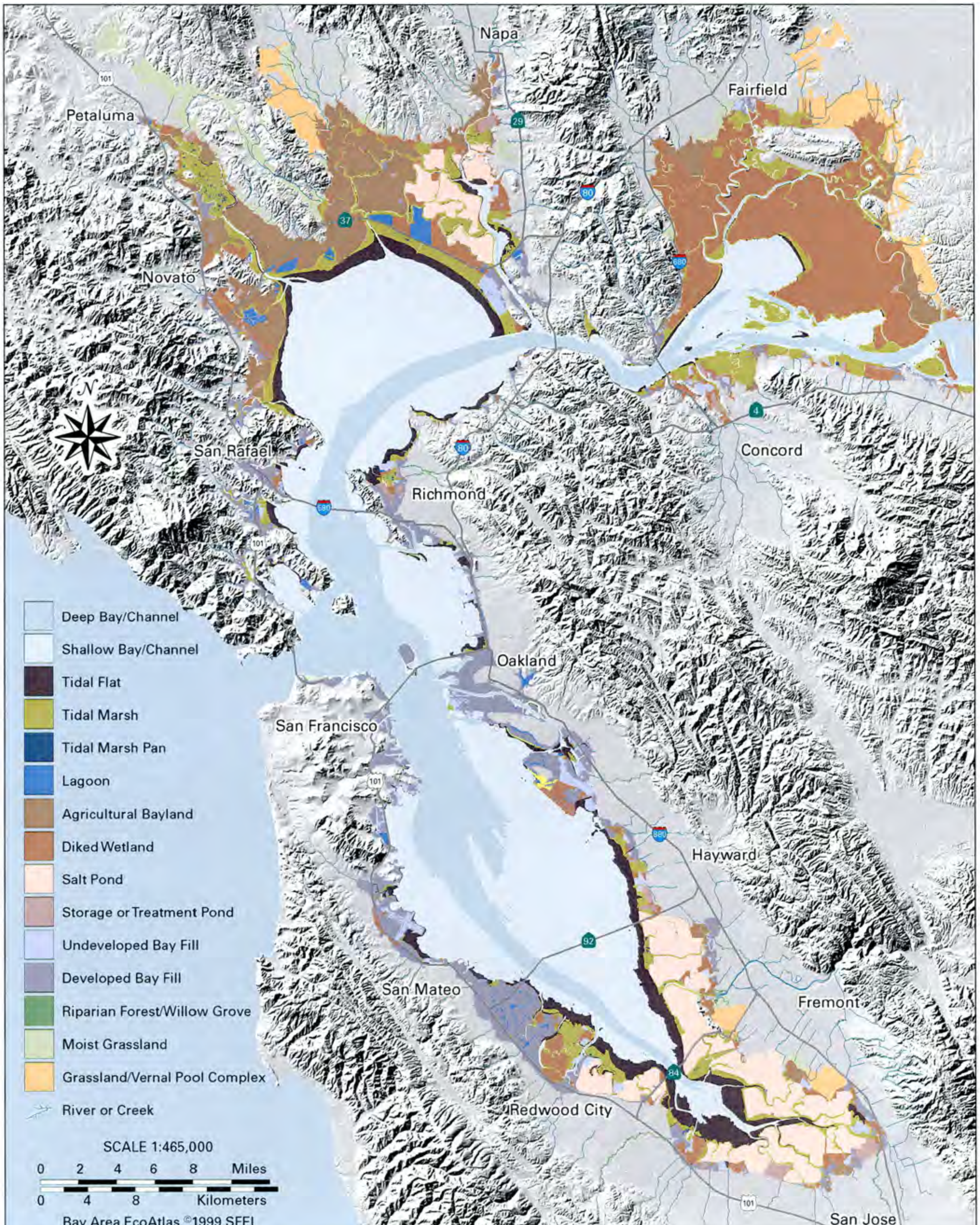
[2] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./ S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

[3] Adapted from the Goals Project, 1999.

Figure 3

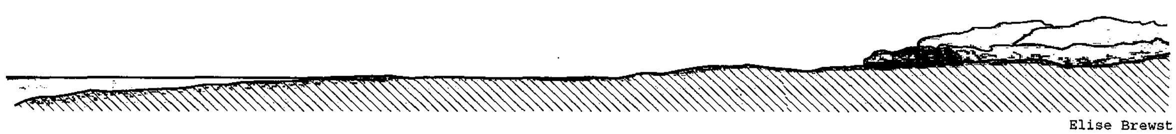
SOURCE: Adapted from USEPA & SFBRWQCB
Baylands Ecosystem Habitat Goals (1999)

Present Distribution of Baylands and Adjacent Habitats (ca. 1998)



BAYLANDS ECOSYSTEM

Bay	Baylands		Adjacent Habitats
	TIDAL	DIKED	
• Deep Bay • Deep Channel • Shallow Bay • Shallow Channel	• Tidal Flat • Tidal Marsh *Salt Marsh* *Brackish Marsh* • Lagoon	• Diked Wetland *Managed Marsh* *Diked Marsh* • Agricultural Bayland • Salt Pond • Storage/Treatment Pond	• Riparian Forest • Willow Grove • Grassland *Non-native Annual Grassland* *Moist Grassland* *Grassland/Vernal Pool Complex* *Coastal Prairie* • Oak Woodland *Coastal Live Oak Woodland* *Valley Oak Woodland* *Foothill Oak Woodland* *Mixed Evergreen Forest*



SOURCE:Adapted from USEPA & SFBRWQCB
Baylands Ecosystem Habitat Goals (1999).

Figure 4
Abbreviated Habitat Typology

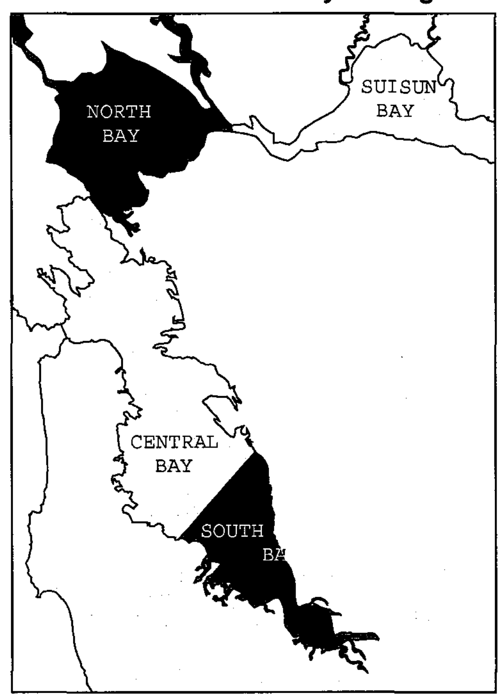
To devise the typology for the Bay, the Goals Project brought together scientists with recognized expertise in aquatic life, wildlife and plant biology to develop a habitat typology that reflects the needs of representative species found in the Bay. These scientists, in coordination with senior agency ecologists and biologists, have devised a typology that reflects a hierarchical habitat system similar to the system currently used by the U.S. Fish and Wildlife Service (the "Cowardin" system), but most importantly, this system incorporates the existing topology, or terrain, of the Bay ecosystem. This approach has captured important details of wetland ecology that are particular to the San Francisco Bay region, details that are not currently reflected in national or state surveys. Figure 4[4] outlines the habitat typology used by the Goals Project to define the habitats of San Francisco Bay.

The mapping foundation for this endeavor was carried out by the San Francisco Estuary Institute (SFEI). Using the 1987 National Wetlands Inventory (NWI) of the Bay Area as the initial base map, SFEI staff conducted site evaluations and solicited public and professional feedback regarding the features contained in the NWI maps, and began refining the feature data using the typology created by the Goals Project as a guide to identify features not reflected in the original NWI maps. Updates included reclassifying habitat types; incorporating recent aerial infrared photography of the Bay; and creating, deleting or modifying feature boundaries traced onto 1:24000 scale maps.

[4] Adapted from the Goals Project, 1999.

Subtidal Habitats. Subtidal (aquatic) habitats include deep bay/channel habitats and shallow bay/channel habitats, according to the EcoAtlas classification system. However, aquatic habitat types are not the same as a habitat type on the land. For instance, when one thinks of a tidal marsh habitat, one thinks of a certain assemblage of topography, plants, and animals—in other words, a distinct, geographically bounded community. Such is not the case in the subtidal environment; in this far more fluid environment, plants and animals are not bounded as neatly by geography or place (with the possible exception of rooted eelgrass communities). Many estuarine fish species, for example, often swim to other parts of an estuary or out of an estuary completely to avoid changes in salinity or turbidity.[5] In these environments, many aquatic creatures are not fixed, and their habitats cannot be fenced in or fenced out.[6] This lack of physical reference points makes it more difficult to map and manage aquatic habitats. Therefore, there are numerous ways one could think of an aquatic habitat. For example, the EcoAtlas classification system uses depths to divide the Bay into shallow and deep water habitats. Alternatively, a second approach examines portions of the food web (or trophic levels), including phytoplankton, zooplankton, and benthic (bottom-dwelling) organisms, etc. A third approach categorizes habitats based on type of substrate or bottom (for example, the Cowardin classification system, used by the U.S. Fish and Wildlife Service, distinguishes among rock bottom, unconsolidated bottom, aquatic bed, or reef). Yet another common approach considers each fish habitat separately (for example, examining the range and characteristics of salmon or herring habitat, including salinity, substrate, and other requirements).

Figure 5
Bay Subregions



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals*

Aquatic habitats are thus difficult to define, adding a layer of complexity to aquatic habitat mapping and management efforts. This report uses the deep bay and shallow bay habitat categories used in the EcoAtlas classification system, combined with a classification system found in the *CEQA-Equivalent Document on the Proposed Amendment to the San Francisco Bay Plan for Using Dredged Materials for Bay Habitat Projects* prepared by SAIC for BCDC and the Port of Oakland.[7] For further detailed information on subtidal habitats please see chapter 9, entitled "Restoring and Protecting Subtidal Habitats," which explores the dimensions of the San Francisco Bay's subtidal habitats. Included in this chapter is insight derived from the subtidal habitat panel held at BCDC, which brought together scientists with expertise on the Bay to discuss issues of concern to the understanding and protection of subtidal habitats by BCDC. Figure 5 illustrates the four distinct subregions of the Bay referenced in the following discussion.

[5] Fishweb Home Page. 1999. Queensland Government, Department of Primary Industries. (http://www.dpi/qld.gov.au/fishweb/habitats/content.html).

[6] Agardy, Tundi. 1999. "Global Trends in Marine Protected Areas." Trends and Future Challenges for U.S. National Ocean and Coastal Policy, August, ed. Billiana Cicin-Sain et al, 1999 Workshop Proceedings, National Ocean Service, NOAA.

[7] Science Applications International Corporation. 2000. *Administrative Draft, CEQA Equivalent Document on the Proposed Amendment to the San Francisco Bay Plan for Using Dredged Material for Bay Habitat Projects.* Prepared for BCDC, Under Contract to Port of Oakland, Environmental Department.

1. **Deep Bay and Channel.** Deep bay and channel habitats are those parts of the Bay that are deepest, specifically 18 feet below Mean Lower Low Water (MLLW). A prominent example of this habitat type is the Golden Gate and Central Bay, although North Bay, Suisun Bay and South Bay also have some deep bay and channel areas. Overall, deep bay and channel habitats account for about one-third of the total Bay waters. These deep water areas have a marine character, due to more dense saltwater from the tides sinking below freshwater flowing out of the Delta. Consequently, these habitats are home to organisms with a greater tolerance to ocean conditions than organisms residing elsewhere in the Bay.

   The sediments of deep bay and channel habitats vary from coarse sand to very fine silts and clays, depending upon the strength of currents. Where currents are strong, as in San Pablo Bay and Central Bay, the bottom is mostly coarse sand. Mud, consisting of a mixture of 80 percent silt and clay, covers the bottom of Suisun Bay and South Bay. These sediments provide shelter to a host of invertebrates, such as the California bay shrimp, Baltic clam, bay mussel and the Dungeness crab. The dominant plants of deep bay and channel habitats are phytoplankton.[8] Phytoplankton are food for zooplankton,[9] filter feeding fish and plant-eating invertebrates.[10] In turn, larger fish, mammals and water birds feed upon invertebrates, zooplankton, and smaller fish in this habitat.

   Fish species found in deep bay and channel habitats include northern anchovy, white sturgeon, brown rockfish and Pacific pompano.[11] In addition, young English sole are abundant in Central Bay. Anadromous fish, which spend most of their adult life in the ocean and return to freshwater streams to spawn, use deep bay and channel habitats as migratory corridors. Two of these species include Chinook salmon and steelhead. Marine mammals utilizing this habitat are harbor seals and California sea lions. Bird species which depend on deep bay and channel habitats include brown pelicans, double-crested cormorant, greater and lesser scaup, surf scoter, Caspian tern and the western grebe. Large aquatic invertebrates, such as California bay shrimp and rock crab, utilize deep bay and channel habitats for spawning, foraging and protection. Overall, the value of deep bay and channel habitat to organisms is as a transitional zone from deep to shallow waters, as a migration corridor between the Pacific Ocean and the Delta, as well as being a distinct home to organisms which depend on the habitat's sandy or muddy bottom and open water to feed, rest or breed.

   Deepwater habitats can further be divided by their substrate type into the following habitats:(a) Deep Water, Rocky Bottom; (b) Deep Water, Coarse-grained Sediment; (c) Deep Water, Fine-grained Sediment; and (d) Dredged Areas. Although these habitat types provide useful distinctions, they cannot fully capture the complexity of aquatic organisms and their habitat needs. For example, while benthic organisms may vary strongly by substrate type, plankton vary more by physical and chemical parameters such as light, temperature, salinity, available nutrients, upwelling, hydraulic conditions, among other factors. In other words, a discussion of habitats by substrate types can only paint a partial picture of aquatic habitats.

   a. **Deep Water, Rocky Bottom.** This habitat type, comprising approximately two percent of the Bay, occurs primarily in the Central Bay and in the mouth of the Bay, in areas that are naturally deep and have strong water currents that scour the bottom, in effect preventing the settlement of sediment. Rocky areas are inhabited by hard-

[8] Small floating plant life in aquatic ecosystems.
[9] Small floating or weakly swimming animals in aquatic ecosystems.
[10] Organisms without a backbone such as clams, shrimp and crabs.
[11] San Francisco Estuary Project. 1992. *Status and Trends Report on Aquatic Resources in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

substrate organisms, such as mussels, sponges, and tunicates. Benthic communities consist largely of attached invertebrates; fish and mobile invertebrates are also relatively common. Kelp and other attached vegetation that can grow in deep waters also can be found in these habitats.

b. **Deep Water, Coarse-grained Sediment (sand).** This habitat comprises approximately eight percent of the Bay, and also occurs largely in the Central Bay. This habitat can also be found in the navigation channels in San Pablo Bay and the entrance to Oakland Harbor. These habitats occur where the bottom currents are fairly strong, preventing the accumulation of fine sediments. These habitats support bottom (demersal) fish, animals living on the sediment surface (invertebrate epifauna), and animals living within the sediment (invertebrate infauna). Several species of flatfish appear to prefer sandy-silt sediments (either deep or shallow water). These fish include English sole, starry flounder, California halibut, and diamond turbot. Because the sediments in these habitats tend to be more physically dynamic and have lower organic content than areas of fine sediment, they often exhibit a lower abundance and diversity of organisms than fine sediment habitats.

c. **Deep Water, Fine-grained Sediment (mud).** This habitat type, comprising approximately seventeen percent of the Bay, is common in the deep areas of Central, North, and particularly South Bays. This habitat occurs where the bottom currents are somewhat weak, allowing fine sediment to accumulate. This habitat, like coarse-grained habitats, supports demersal fish and invertebrate epifaunal and infaunal communities.. Since this habitat is typically more stable than coarse-grained habitats, they often are more diverse. Communities in maintained deep areas are disturbed periodically by dredging.

d. **Dredged Areas**. This habitat type consists of dredged areas such as navigation channels, turning basins and port berths. These channels are located mostly in the North and Central Bay, and also in the South Bay, including berths in Oakland, Richmond, and Redwood City harbors. Substrate in these areas can be either fine-grained or coarse. Biologically these areas support benthic communities, fish species, waterbirds and marine mammals, however, species abundance and community diversity may be less in these deep water areas than in others due to the short and long-term impacts of dredging.[12] In light of the biological impacts and the need for dredging in the Bay economy, a number of state and federal government agencies, including BCDC, have been working for a period of ten years to address both the need for dredging and the minimization of impacts on species dependent on deep water habitats. One solution has been to establish environmental windows, defined as times in which dredging cannot occur in specific areas, due to the potential impact on sensitive species, such as Pacific herring.[13]

2. **Shallow Bay and Channel.** Shallow bay and channel habitat is defined by its location 18 feet below Mean Lower Low Water and Mean Lower Low Water. Figure 1 and Figure 2 in chapter 1 illustrate the location of this habitat type. These habitats are significantly shallower than deep bay and channel habitat, allowing a greater diversity of organisms

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[12] U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, State Water Resources Control Board. 1998. *Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region: Final Policy Environmental Impact*

[13] Table J-3 outlines in greater detail the environmental windows in effect for San Francisco Bay dredging. Table J-3 is found in the: United States Environmental Protection Agency, Region 9 and United States Army Corps of Engineers, South Pacific Division. July 1999. *Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region, Record of Decision.*

access to the habitat in order to breed and find shelter and food. San Pablo Bay is a good example of this kind of habitat, although shallow bays and channels are found in all four regions of the Bay. Two-thirds of Bay waters fall under this habitat type. They are rich environments, capable of supporting a vast array of benthic organisms,[14] birds, fish and mammals. While the sediment of this habitat is mud in most parts of the Bay, shell fragments from once abundant oyster populations contribute to the sediment of the eastern side of the South Bay.

Similar to deep bay and channel habitat, a variety of plants and animals depend on the muddy bottom and are interwoven into a community of phytoplankton, zooplankton, benthic invertebrates (clams, crabs, shrimp, etc.), fish, birds and mammals. Filter-feeding clams, oysters and mussels, as well as deposit-feeding mud snails, Baltic clams, crabs and polychaete worms graze the surface of the submerged muddy bottom for bits of food.[15] Together the filter-feeders and deposit-feeders are efficient harvesters of the phytoplankton and zooplankton sifting down from the surface of the water. In turn, the multitude of bottom-dwelling organisms are fed upon by larger species such as leopard sharks, starry flounders and bat rays. Sharks are particularly abundant in the shallow waters of South Bay and include the brown smoothhound, leopard shark, spiny dogfish, soupfin shark and sevengill shark.[16] The shallow waters of Richardson Bay are known to host fish species such as jacksmelt, topsmelt, and speckled sanddab. The diamond turbot is known to use shallow bay habitats as a nursery area. Significantly, several species of anadramous fish depend upon shallow bay and channel habitat as nursery and rearing habitat. These species include striped bass, American shad, Chinook salmon, steelhead trout, white and green sturgeon, as well as Pacific lamprey. Mammals, including North American river otters, harbor seals and California sea lions, rest and forage in shallow bays and channels.

Critical to the functioning of the Bay ecosystem as a whole is the connection which shallow water provides between subtidal habitats and terrestrial habitats. For example, shorebirds may utilize the edge between shallow water and tidal flat habitat. Similarly, certain fish species migrate from deep water to shallow water on their way to tidal marsh channels where they feed on high tide. This pattern repeats itself in reverse as low tide occurs and the movement of fish switches back towards deep water. Thus, shallow water habitat is used by some aquatic species as a migration corridor between deep water and wetlands. Beyond biology, shallow water habitat is critical to the form and function of the Bay as a whole, as it is through shallow water that sediment transport occurs.[17] Sediment transport is the movement of sediment throughout the Bay which both builds and erodes habitats of all kinds, including tidal flats and tidal marshes.

Out of the 171,818 acres which comprise shallow bay and channel habitat, 316 acres are eelgrass habitat. The largest portion of eelgrass (124 acres) is located in San Pablo Bay, with the next largest eelgrass bed located in Alameda (55 acres).[18] Eelgrass is the only seagrass found in San Francisco Bay, although other subtidal vegetation, such as gracillaria growing in Richardson Bay, is important to the Bay's ecology. Adapted to living submerged in the shallow waters of protected bays and estuaries, eelgrass is not a true

[14] Organisms associated with the bottom of the Bay

[15] San Francisco Estuary Project. 1990. *An Introduction to the Ecology of the San Francisco Estuary.* Produced by the Save San Francisco Bay Association for the San Francisco Estuary Project. Oakland, California.

[16] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[17] This paragraph is adapted from conversations which took place at BCDC's subtidal panel on September 28, 2000.

[18] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*

grass, but instead a flowering plant which extends into the sediment and functions to stabilize the soft muddy bottom. In addition, eelgrass leaves slow currents and dampen wave action, causing sediment and organic material to accumulate.

In concert with trapping sediment and stabilizing underwater slopes, eelgrass beds provide food, shelter and spawning grounds for many Bay fish and invertebrates. For example, the preferred spawning habitat for Pacific herring are eelgrass beds and gracillaria found in Richardson Bay. Associated with Richardson Bay and the large shallow area between Richmond and Oakland, the Pacific herring fishery has recently become the most valuable fishery in California. Juvenile Chinook salmon and juvenile Dungeness crabs are also known to find protection in eelgrass beds. Black brant, a bird species which migrates along the Pacific Flyway, depends on eelgrass as a dominant food source. The decline of the black brant is believed to be partially attributed to dwindling eelgrass resources. Table 1[19] illustrates some of the species which utilize eelgrass. Overall, the high biological productivity of shallow water habitat, the function it serves as a connection between the terrestrial and subtidal environment, and its role in sediment transport make this habitat type a critical component to the well-being of the subtidal environment, as a whole.

Table 1
Species Which Utilize Eelgrass Habitat

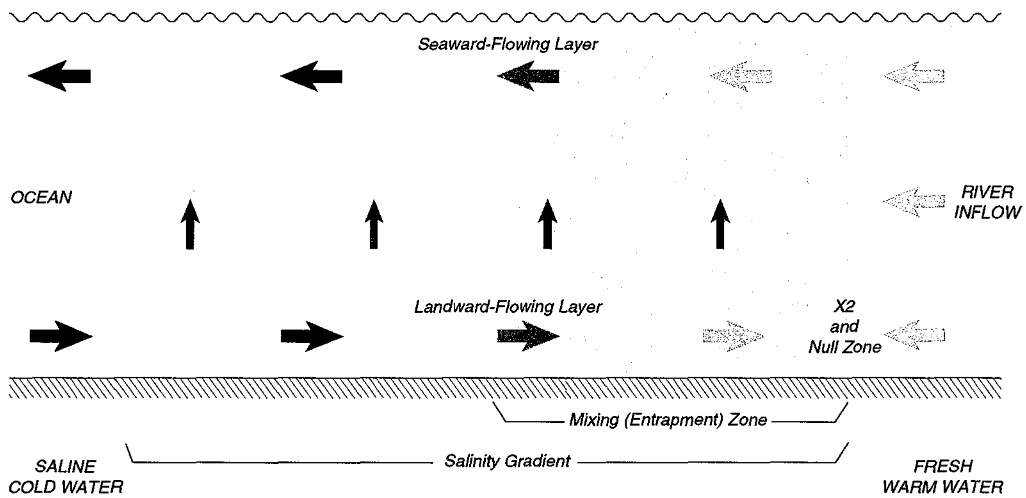
Species	Suisun Bay	San Pablo Bay	Central S.F. Bay	South S.F. Bay
white sturgeon		forage	forage	forage
Pacific herring		forage	spawning & forage	spawning & forage
Chinook salmon		forage	forage	forage
topsmelt				spawning & forage
jacksmelt		spawning & forage	spawning & forage	spawning & forage
Pacific staghorn sculpin		forage & protection	forage & protection	forage & protection
shiner perch		spawning & forage	spawning & forage	spawning & forage
amphipods		spawning, forage, & protection	spawning, forage, & protection	spawning, forage, & protection
California bay shrimp		forage & protection	forage & protection	forage & protection
mud crab		spawning & forage	spawning & forage	spawning & forage

SOURCE: Baylands Ecosystem Habitat Goals Project

Mixing Zone[20]. The mixing zone, also referred to as the entrapment zone, is the interface and mixing zone of less-dense freshwater flowing seaward out of the Delta and more-dense saltwater flowing landward on the tides into the Bay from the Pacific Ocean. The place where these two kinds of water meet is a brackish blending zone which varies in length depending on the range of the tide and the amount of freshwater inflow from the Delta. Within the mixing zone, the landward limit of circulation between the two layers of water is referred to as the null zone and the landward limit of saltwater penetration into the Delta is known as the X2. Many times the null zone and X2 are located together on the landward edge of the mixing zone (see Figure 6).

[19] Adapted from Goals Project, 1999.

[20] Adapted from Goals Project, 1999.



NOTE: Greatly simplified diagram showing hydraulic patterns producing the mixing zone, also known as the entrapment zone.

SOURCE: USEPA Status and Trends Report on Aquatic Resources in the San Francisco Estuary (1992)

Figure 6
Mixing Zone

An important function of the mixing zone is that it is a place where suspended sediment and nutrient particles accumulate, creating one of the Bay's most productive areas for aquatic life. Here is where the production of tiny plants called phytoplankton is greatest. In turn, the large amount of phytoplankton available in the mixing zone provides a great deal of food for small zooplankton, which in turn are food for larger aquatic life such as Pacific herring, Delta smelt, young striped bass and salmon. The mixing zone, therefore, is of critical importance to the aquatic food web of the Bay.

Depending on annual freshwater inflow from the Delta, the mixing zone usually occurs in the vicinity of Suisun Bay. Here the mixing zone may be several miles long and is most prominent when inflow is high. Similar, but smaller mixing zones occur along every river and creek that flows into the Bay. Restoring tidal marshes and tidal flats around Suisun Bay and along the local rivers and creeks associated with the Bay would increase the amount of nursery, resting, and escape habitat for many aquatic species that rely on these highly productive portions of San Francisco Bay.

Wetlands-An Overview. In order to grasp the nature of the wetland habitats of the Bay, the term "wetland" must be defined. The definition used by the Goals Report's authors, the U.S. Fish and Wildlife Service (Fish and Wildlife), as well as the California Department of Fish and Game (Fish and Game) is the definition first presented in a 1979 report entitled Classification of Wetlands and Deepwater Habitats of the United States by Cowardin, Carter, Golet and LaRoe.[21] In this document wetlands are defined as,

[21] Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* FWS/OBS-79/31. U.S. Fish and Wildlife Service, Office of Biological Services. Washington, D.C.

..lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes,[22] (2) the substrate is predominantly undrained hydric soil,[23] and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

The value of the Cowardin definition is in its inclusivity and its primary function is in guiding scientific inquiry, conducting inventories of natural resources, and aiding in the acquisition and restoration of wetlands. Only one of the three parameters–appropriate soils, hydrology or vegetation–must be met for an area to be categorized as a wetland. Due to its broadness, flexibility and comprehensive nature, the Cowardin definition is the most widely accepted definition utilized by wetland scientists in the United States.[24] Examples of wetland habitats associated with the Bay include tidal flats, tidal marshes, lagoons, diked wetlands, agricultural baylands, salt ponds, storage/treatment ponds, riparian forests and some kinds of grassland habitats.

In contrast to Fish and Wildlife and Fish and Game, the United States Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Army Corps) require that all three features be present for an area to be considered a wetland. This more strict jurisdictional definition of wetlands serves a different purpose. Unlike the broad, resource assessment based definition utilized by Fish and Wildlife and Fish and Game to capture ecological functions of wetlands, EPA and the Army Corps depend on the more strict wetlands definition to set forth the physical boundaries of their regulatory authority as it pertains to administering and enforcing land use and water quality laws. Along these lines, the State Water Resources Control Board and the Regional Water Quality Control Boards rely upon the Corps' regulatory definition for projects falling under the Clean Water Act, while BCDC's wetland jurisdiction is defined geographically and includes generally tidal areas, managed wetlands, and salt ponds.

Once defined, a greater understanding of wetlands requires delving into the multitude of functions which they provide. Wetlands alter and control flood flows, recharge groundwater, maintain stream flows, reduce and prevent shoreline erosion, and filter surface runoff from surrounding lands, thus improving water quality. They also are critical habitat for the Bay ecosystem's fish and wildlife populations, serve as a primary link in the ecosystem's food chain, ensure the continued diversity of plant and animal communities, and are an essential feeding and resting place for migratory birds on the Pacific Flyway. In addition they help to maintain shipping channels and contribute to the stability of global levels of available nitrogen, atmospheric sulfur, carbon dioxide and methane. Finally, wetlands provide the opportunity for a variety of recreational and educational activities and serve as a relief to the urbanized San Francisco Bay Area. On an economic scale, a recent study estimated the value of economic benefits provided by wetlands throughout the state of California to be in the range of $6.3 billion to $22.9 billion.[25]

Wetlands provide a critical support function to aquatic life and wildlife, in particular. Offering food and habitat for many fish, invertebrate, and wildlife populations, some species spend their entire lives in wetlands, while others use wetlands primarily for reproduction and as nurseries. Over 300 species of fish and aquatic life breed, feed and rest in the Bay's wetlands. Populations of clams, worms, and other invertebrates thrive in mudflats, and fish and crabs use shallow waters as nursery grounds. Wetlands are also important spawning and nursery grounds for many fish. The tidal and diked seasonal wetlands found in the San Francisco bay-

[22] Plants which are able to grow in water.

[23] Soil associated with the presence of water.

[24] Mitsch, W.J. and J.G. Gosselink. 1986. *Wetlands.* Van Nostrand Reinhold, New York, New York.

[25] Goals Project, 1999

lands are vital habitats that sustain migrating waterfowl and shorebirds along the Pacific Flyway, species that winter over in the area, and resident species that remain in the area throughout the year. Without the wetlands of San Francisco Bay, many species that migrate between countries would not survive. Instantaneous counts done as a snapshot in time reveal that nearly one million waterfowl and one million shorebirds depend upon the Bay's open water and wetland habitats at certain times of the year. In addition, many of the Bay's rare and endangered species are dependent upon or live only in wetlands.[26] Wetlands in and around San Francisco Bay include (1) tidal flat habitat, (2) tidal marsh habitat, (3) lagoons, and (4) diked baylands, such as diked wetlands, agricultural baylands, salt ponds and storage treatment ponds.

1. **Tidal Flat.** Habitats naturally blend from one into another. This blending is very apparent in the shift from shallow bay and channel habitat to tidal flat. Much of the distinction between the two is based on elevation and duration of cover by tidal water. Tidal flats are distinct from shallow bay and channel habitat because twice daily the land is exposed as the tides recede. Higher elevation allows this to occur. Between the elevation of the lowest tides (Mean Lower Low Water) and Mean Tide Level, tidal flat habitat occurs in the Bay and includes mudflats, sandflats, and shellflats.[27] Found in all four regions of the Bay, about one-third of tidal flat habitat is located in the North Bay and more than one-half is in the South Bay. Prominent examples of tidal flat habitat exist at Grizzly Bay, the Marin Shoreline, Emeryville Crescent and throughout the South Bay (see Figure 3). Much of the tidal flat habitat surrounding San Francisco Bay is within BCDC's jurisdiction.

   Some tidal flats occur along the edges of tidal marshes, while most do not due to extensive historic losses of tidal marsh habitat. Similar to tidal marshes, tidal flats are wetlands. Those tidal flats which do border tidal marshes benefit by receiving additional nutrients which are washed-out of the tidal marshes and onto the tidal flats as the tide recedes. These nutrient-laden organic materials, once on the tidal flat, provide food for millions of benthic invertebrates. Thus, a more nutrient rich habitat exists when tidal flats are located downslope from tidal marshes. Mudflats comprise the majority of tidal flat habitat. Supporting less than 10 percent cover of vascular vegetation, the dominant form of vegetation associated with tidal flat habitat is algae.[28] Species of algae living on mudflats include green algae, blue-green algae, diatoms[29] and red algae. Along with phytoplankton brought in by the twice daily tides which wash over mudflats, algae represents the largest portion of the diet of benthic organisms and plant-eating fish.[30] Plant-eating species associated with mudflats include the bay shrimp, Baltic clam, mud snail and the topsmelt. Examples of species higher up the food chain which are carnivorous (meat-eating) include the longjaw mudsucker leopard shark, white sturgeon, yellowfin goby and the Dungeness crab. These species feed on benthic invertebrates and smaller fish. The only mammal to consistently utilize mudflats are harbor seals. During low tide, harbor seals both rest and breed on tidal flats.[31] The most prominent wildlife group associated with mudflats are shorebirds. Equipped with different length beaks and long legs, shorebirds spend low tide probing the mud for food. Specifically, the mudflats of San Francisco Bay provide feeding habitat for wintering shorebirds of the Pacific Flyway

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[26] San Francisco Estuary Project. 1994. *San Francisco Estuary Project, Comprehensive Conservation and Management Plan.* San Francisco Estuary Project, Oakland, California.
[27] Goals Project, 1999.
[28] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.
[29] Minute colonial algae with silicified skeletons that form diatomite (Collegiate Dictionary)
[30] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.
[31] Goals Project, 1999.

and represent a key migratory staging and refueling area. Shorebird censuses have estimated the population of shorebirds in the Bay to be between 600,000 and 1.2 million, with the greatest numbers in the South Bay below the San Mateo Bridge. The most abundant species of shorebirds found on tidal flats around the Bay include western sandpipers, dunlins, dowitchers, marbled godwits and least sandpipers.[32] In addition, the western grebe, great blue heron, great egret, snowy egret, American wigeon and American avocet forage on mudflats.

Shorebirds eat a wide variety of invertebrates found on or near the surface of the mud. Common food items for shorebirds include benthic clams, worms and snails. Critical to a greater understanding of the daily life-rhythms of shorebirds is the link between the tides and the need for upland refugia. Shorebirds feast on a multitude of organisms when the tide retreats. The tide is critical to the provision of nutrients to the tidal flat and shorebirds exploit these resources while the tide is low. During high tide, tidal flat habitats are inundated with water. While the high tide brings nutrients to benthic organisms and enables fish species such as staghorn sculpin, starry flounder and longfin smelt to have access to the rich tidal flat habitat, shorebirds are displaced and must find refuge and food elsewhere. These needs are provided by upland wetland habitats, such as tidal marshes, agricultural wetlands, and diked marshes. Therefore, the protection of connections between higher and lower-elevation habitats is critical to the continuation of the daily life patterns of shorebirds.

2. **Tidal Marsh.** Tidal marsh habitat is defined as vegetated wetland that is subject to tidal action. Occurring throughout San Francisco Bay, the largest patches are on the northern edge of San Pablo Bay and along the Petaluma River (see Figure 3). Suisun Bay also supports a substantial acreage of tidal marsh, while Central Bay supports very little. Of all of the habitats associated with San Francisco Bay, only moist grasslands have suffered a greater historical loss than tidal marshes. Since 1800, tidal marsh acreage has declined by 79 percent due to bayfill and diking to create urban development, managed marsh, agricultural lands and salt ponds.[33] Currently, about 40,191 acres of tidal marsh exist around the Bay. This is down from a historical high of approximately 189,931.

   The character of tidal marsh plant communities found around the Bay is determined by salinity patterns, substrate, wave energy, marsh age, sedimentation and erosion. From these features, two distinct kinds of tidal marshes emerge. In the more saline parts of North, Central, and South Bays, tidal marsh is referred to as tidal salt marsh. In the more brackish areas with significant freshwater influence, tidal marshes are known as tidal brackish marsh. Suisun Bay, the middle reaches of the Petaluma and Napa Rivers, and the mouths of several streams in the South Bay are areas where tidal brackish marshes are found. Much of the tidal marsh habitat in San Francisco Bay is within BCDC's jurisdiction.

   The plant communities of both tidal salt marsh and tidal brackish marsh are defined in relation to their elevation and distance from shore. The low marsh zone occurs from approximately mean sea level to mean high water (the highest water level in BCDC's jurisdiction). The middle marsh zone occurs from approximately mean high water to mean higher high water, and the high marsh zone occurs near and above mean higher high water up to several meters above the extreme high water line.[34] Another name for the high marsh zone is the upland transition zone or marsh/upland ecotone. Here the high

[32] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary*. San Francisco Estuary Project, Oakland, California.

[33] Goals Project, 1999.

[34] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities*.

marsh vegetation in a tidal salt marsh or tidal brackish marsh typically blends with upland plant species. As mentioned previously in the section on transition zones and their functions, the ecotone between tidal marshes and upland habitat is a particularly important habitat for Bay-related wildlife because the zone features a diverse assemblage of plant life and consequently supports a diverse array of wildlife. This area is also important as refugia during high tide where birds and mammals can retreat until the tide lowers.

The distribution of tidal salt marsh plants and tidal brackish marsh plants is linked to tidal elevation and salinity. Table 2[35] illustrates the variations in plant life associated with both salinity and tidal elevation for tidal salt and brackish marsh.

	SALT MARSH	BRACKISH MARSH Saltier	BRACKISH MARSH Fresher
Mean Higher High Water	Saltgrass *(Distichlis spicata)* Fat Hen *(Atriplex patula ssp. hastata)* Alkali Heath *(Frankenia grandifolia)*	Pickleweed *(Salicornia virginica)* Saltgrass *(Distichlis spicata)* Fat Hen *(Atriplex patula ssp. hastata)* Gum Plant *(Grindelia humilis)*	Baltic Rush *(Juncus balticus)* Brass Buttons *(Cotula coronopifolia)*
Mean High Water	Pickleweed *(Salicornia virginica)* Dodder *(Cuscuta salina)*	Alkali Bulrush *(Scirpus robustus)*	Olney's Bulrush *(Scirpus olneyi)* Common Cattail *(Typha latifolia)* Narrow-leaved Cattail *(Typha angustifolia)*
Mean Tide Level	Cordgrass *(Spartina foliosa)*	California Tule *(Scirpus californicus)*	
Mean Low Water			California Tule *(Scirpus californicus)*
Mean Lower Low Water			

SOURCE: Adapted from *San Francisco Estuary Project* (1990)

Table 2
Characteristic Distribution of Tidal Marsh Vegetation

Pacific cordgrass, which can tolerate high salinity conditions, is the dominant plant of the low tidal salt marsh zone. As the primary colonizer on broad tidal mudflats that fringe tidal marsh plains, it occurs in virtually pure stands. Recently a non-native species from the Atlantic coast has also been found in certain low marsh zones around the Bay. Known as smooth cordgrass, this non-native invasive plant grows lower in elevation than Pacific cordgrass. Therefore, Atlantic cordgrass has the potential to colonize mudflats, thus displacing shorebirds who depend on mudflats to feed.

Pickleweed, a perennial succulent, dominates middle tidal salt marsh zones around the Bay. The high tidal salt marsh zone also supports pickleweed, but here it may grow alongside saltgrass, fathen and alkali heath. The high salt marsh zone also historically included many other native species which are now uncommon, rare or extirpated in San Francisco Bay due to disturbance by development and an influx of non-native plants. Common non-native plants of the high salt marsh zone include broadleaf peppercress, perennial peppergass, saltwort, iceplant, Australian saltbush, sicklegrasses and rabbit's-foot grass. Prominent examples of tidal salt marsh around the Bay include China Camp in the North Bay, Arrowhead Marsh in the Central Bay and Greco Island in the South Bay.

Tidal brackish marshes are present in areas where freshwater reduces the salinity of the tides. However, a distinct line does not exist between where a tidal salt marsh ends and a tidal brackish marsh begins in the Bay ecosystem. Instead, tidal marsh plant commu-

[35] Adapted from: San Francisco Estuary Project. 1990. *An Introduction to the Ecology of the San Francisco Estuary*. San Francisco Estuary Project, Oakland, California.

nities are dynamic, fluctuating with variable influence of rainfall and freshwater inflow to the Bay which alter marsh salinity and vegetation gradients geographically and over time. For example, a few wet years can shift a marsh's vegetation from that typical of a tidal salt marsh to that typical of a tidal brackish marsh. Petaluma Marsh is one of the most extensive examples of a tidal brackish marsh, although other prominent examples occur along the Napa River and in the Hill Slough/Rush Ranch area in Suisun Marsh.

Plant species richness and diversity increase significantly in tidal brackish marshes of the Bay when compared to tidal salt marshes. Cattails, California bulrush and alkali bulrush dominate the low marsh zone. The middle marsh zone hosts a diverse assemblage of plant species, including bulrushes, spike rush, Baltic rush, silverweed and the dominant salt grass.

Development in the San Francisco Bay Area has severely affected tidal marshes, especially high marsh zones and high marsh/upland ecotones. Filling marshes and isolating the remnants from sediment and freshwater flows has greatly reduced tidal marsh plant diversity. Past floral accounts of the Bay note a much greater diversity of marsh plants than exists today. More than 50 plant species found in the Bay marshes at the turn of the century are now extinct or exist only in isolated populations. Most of these plants resided in the high marsh or in the marsh/upland ecotone. Locally extinct species include Point Reyes bird's-beak, sea pink, salt marsh owl's clover, and smooth goldfields, all of which were extirpated from the South Bay. California sea-blite and California saltbush are both extirpated from the baylands . Rare tidal marsh species include the Suisun thistle, Delta tule pea, soft bird's beak, Mason's lilaeopsis, western dock and the slim aster.

Other important features of tidal marshes which add to their value as habitat for aquatic life and wildlife are tidal channels and pannes. Tidal channels and their smaller tributaries form drainage networks that distribute tidal waters throughout the marsh. Salt marshes generally have denser networks of tidal channels than do brackish marshes. In Suisun Bay, splittail, Delta smelt, Chinook salmon and longfin smelt utilize tidal channels. Marsh pans are natural ponds that form in the marsh plain. Less than one foot deep, these ponds fill with tidal water only during very high tides. They may also occur at the tidal marsh/upland ecotone where they receive infrequent tidal flow. Most pans are unvegetated and are influenced primarily by topography, microclimate, groundwater and freshwater runoff. Marsh pans are typical features of extensive, well-developed tidal marshes. The native hornsnail is presently dependent entirely on salt marsh pans in the South Bay due to competitive displacement and predation by the introduced non-native mud snail. The range of the native hornsnail once extended throughout tidal pickleweed marshes, intertidal creeks and mudflats of the Bay.[36] Examples of marsh pans are found at the edge of the Emeryville Crescent in Central Bay and near Mowry Slough in South Bay.

Muted tidal marshes are tidal marshes that receive less than full tidal flow because of a physical impediment, such as a man-made tide gate or a natural sand spit or berm. Lacking the plant diversity of a marsh which receives the complete range of tides, muted marshes are still important to different wildlife groups. Shorebirds, for example, utilize muted tidal marshes during their fall migration. Muted tidal marsh examples include Marta's Marsh in the North Bay, Point Pinole in Central Bay and Charleston Slough in the South Bay.

Tidal marsh systems are very highly productive, enabling a great deal of food energy to pass from plants, to plant-eating aquatic life and wildlife, and eventually to carnivorous organisms. Within the tidal marsh system, four different kinds of food chains exist. The

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[36] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

first food chain includes the organisms which feed on marsh plants such as cordgrass and pickleweed. Species in this group feed directly on the leaves, shoots, and seeds of marsh plants. A second food chain includes the aquatic organisms which eat benthic algae. The third food chain is represented by zooplankton which eat phytoplankton during periods of tidal submergence. The last major food chain in tidal salt marshes is the detrital[37] food chain. Decaying plant material is broken down by bacteria and provides food for a variety of aquatic and terrestrial invertebrates. Examples of species which feed on tidal marsh plants include the topsmelt, leafhoppers, the salt marsh harvest mouse, the salt marsh song sparrow and the hornsnail. Carnivorous species which are farther up these food chains include birds, such as the clapper rail and pintail; fish, such as the longjaw mudsucker and yellowfin goby; reptiles, such as the western toad and slender salamander; and mammals, such as the coyote and Suisun shrew.[38]

Tidal marshes provide a complex habitat for many species of aquatic life and wildlife, including invertebrates. Crabs associated with tidal marshes include the Dungeness crab and rock crab. The California bay shrimp, blacktail shrimp and oppossum shrimp are also found in tidal marshes.

The native Baltic clam is most abundant in the upper zone of the mudflat, but may also inhabit the root zone of adjacent marsh vegetation. Saltmarsh snails are abundant in higher portions of tidal salt marshes. Some non-native invertebrates residing in tidal marshes include the ribbed mussel, the burrowing and boring isopod,[39] the Asian clam and the mudsnail.

Tidal marshes also play a critical role in the life cycle of many species of fish, especially during the juvenile stage. By providing protection, food, nursery areas, and a balance between saline and fresh water, tidal marshes are an optimal habitat for fish to mature. Some of the fish species which utilize tidal marshes while juveniles include Chinook salmon, topsmelt, striped bass and tule perch.[40] The most abundant fish species in the shallow tidal marshes of the South Bay are topsmelt, arrow goby, yellowfin goby and the staghorn sculpin. Splittail are one of the most abundant resident freshwater species in many of the brackish sloughs in Suisun Marsh. Other species associated with Suisun Bay include Delta smelt, Chinook salmon and longfin smelt. Gobies, sculpins and three-spined stickleback are found in the tidal marshes of the North Bay. White Sturgeon are also know to depend on tidal marshes for resting and while foraging for food.[41]

Bird species also make extensive use of tidal salt marshes. The California clapper rail, a species at risk of extinction due to its dependence on tidal marsh habitat, utilizes many parts of the marsh during its life cycle. For example, the cover of cordgrass and pickleweed are used for nesting, while tidal channels are foraged for food. Other birds which use tidal marshes include the salt marsh yellowthroat and three different kinds of salt marsh song sparrows which reside in different parts of the Bay, specifically Alameda, San Pablo and Suisun. Each of the salt marsh song sparrows are dependent during their entire life cycle on tidal marshes. The salt marsh yellowthroat depends on tidal marshes during winter, utilizing other wetland habitats throughout the rest of the year. Some bird species which utilize tidal marshes for feeding include the great blue heron, great egret, snowy egret, and the black-

[37] Detrital refers to detritus, which is decaying plant or animal material in an ecosystem.

[38] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[39] A small crab-like invertebrate

[40] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[41] Goals Project, 1999.

crowned night heron. Birds known to nest in tidal marshes include the black-shouldered kite, the northern harrier, the marsh wren, the red-winged blackbird, and the Savannah sparrow. Tidal marshes of the Bay are also very important to migratory birds of the Pacific Flyway, with the vast majority of feeding and roosting activity occurring in tidal channels and marsh pans. Some of the migratory species observed in tidal channels and pans include black-necked stilts, least sandpipers, mallards and northern pintails.

Small and large mammals also call tidal marshes of San Francisco Bay home. The most prominent small mammals found in tidal marshes are the salt marsh harvest mouse, the salt marsh vagrant shrew and the Suisun ornate shrew. All three are at risk of extinction. The largest mammal found in association with tidal marshes is the harbor seal. They utilize tidal marshes as high tide haul-outs for resting, as well as giving birth to pups. Mowry Slough is a prominent example of a harbor seal haul-out. Other mammals associated with tidal marshes include the river otter, muskrat, mink, beaver and the California vole.

3. **Lagoon.** A lagoon is an impoundment of water that is subject to at least occasional or sporadic connection to full or muted tidal action. The impoundment may or may not receive a stream or other form of uplands runoff, and it can be natural (e.g. formed behind a barrier beach along an indented shoreline) or artificial. Historically, natural lagoons occurred in Central Bay on the Marin shoreline and along the San Francisco Peninsula. Today, no natural lagoons remain in the Bay, but artificial ones occur in the North Bay, Central Bay and South Bay. Examples include the lagoons at Sonoma Baylands, Foster City and Belvedere. Most of the lagoons in the baylands are not within BCDC's jurisdiction.

   A diversity of organisms utilize lagoons. Amphibians such as the California toad, Pacific treefrog and the California red-legged frog rest, forage and breed in lagoons. Reptiles such as the western pond turtle, California alligator lizard, coast garter snake and the San Francisco garter snake rest and forage for food in lagoons. Harbor seals forage in lagoons and the salt marsh harvest mouse rests, forages and breeds in them. A diversity of bird species also utilize lagoons including tule white-fronted geese, western sandpiper, longbilled dowitcher, mallard, ruddy duck, black-crowned night heron, American white pelican, brown pelican, double-crested cormorant, peregrine falcon and the salt marsh common yellowthroat.[42]

4. **Diked Baylands.** Diked habitats are those parts of the Bay which were once subject to tidal action and no longer are due to the presence of dikes and levees. Dikes are earthen levees made of locally excavated Bay mud placed along the margins of the marsh plain. Most of the Bay's tidal marshes were reclaimed in the late 1800's when the use of mechanical dredges became commercially available to landowners. Consequently tidal marshes were transformed into pastures, hayfields, salt ponds or cropland. Diked habitats, today, include diked wetlands, agricultural baylands, salt ponds, and storage/treatment ponds. Each of these habitats are valuable to a range of mammals, amphibians, reptiles, birds and invertebrates. Worth noting is that the vast majority of fish and aquatic invertebrates are not able to utilize diked habitats due to their isolation from the tides.

   a. **Diked Wetlands.** Areas of historical tidal marshes that have been isolated from tidal influence by dikes or levees, but which maintain wetland features, are categorized as diked wetlands by the Goals Project. The Commission historically has referred to portions of diked wetlands, not including managed wetlands, as

[42] Goals Project, 1999.

diked historic baylands. Specifically, the Commission has defined diked historic baylands as all areas that (1) were historically part of San Francisco Bay, including the Bay's marshlands as of 1850; (2) are hydrologically no longer part of San Francisco Bay or its marshlands, as a result of diking; (3) are not "salt ponds" or "managed wetlands;" (4) have not been filled; and (5) are not urbanized.[43] For the purposes of this discussion, managed wetlands will be discussed as a type of diked wetland. Worth noting, however, is that managed wetlands, located primarily around Suisun Bay, fall within BCDC's jurisdiction, while most other diked wetlands do not. Managed wetlands are defined by the Commission's McAteer-Petris Act as "consisting of all areas which have been diked off from the bay and have been maintained...as a duck hunting preserve, game refuge or for agriculture."[44] The plant communities of diked wetlands vary greatly from site to site and can resemble those of local tidal salt marsh, tidal brackish marsh, nontidal perennial freshwater marsh or seasonally wet grasslands. Plant community composition in diked wetlands is strongly influenced by the degree of soil salinity, how well soil drainage techniques work, and past land uses. Overall, diked wetlands tend to have lower native plant species richness than natural tidal plant communities, and often host a larger community of exotic plant species. Common native plant species of diked wetlands include pickleweed, saltgrass, alkali bulrush, bulrush and cattail.[45]

Diked wetlands possess a particular importance in their ability to replace lost habitat values associated with the decline in high tidal marsh habitat. Reclamation of Bay tidal marshes to create farmed wetlands and salt ponds almost eliminated historic high marsh habitat. In addition, with rising sea level, high tidal marsh and adjacent lower uplands provided area for marshes to retreat and colonize. Originally, high marsh habitat had acted as an important transition zone to adjacent upland habitat. Today, diked wetlands maintain some of these lost habitat values. For example, the endangered salt marsh harvest mouse, a species dependent on high marsh habitat, may occur in significant numbers in some diked wetlands.[46] One of the most valuable functions of diked wetlands is the high tide refuge and foraging habitat they provide, which helps sustain shorebird populations. Specifically, shorebirds forage on intertidal mudflats, but generally must leave these habitats twice a day when the tide covers them because their legs are short and they cannot forage in the deeper water. Consequently, they require habitats that allow them to forage safely during high tides. The shallow, unvegetated, or sparsely vegetated areas associated with diked wetlands provide this function.

Furthermore, the lack of vegetation is an important feature of these diked wetlands because it improves visibility, and allows shorebirds to move in small or large flocks, making use of the open vista and the line of sight necessary to spot the approach of avian predators. Diked wetlands also seem to be preferred by some species of dabbling ducks, such as teal and mallard. Even some diving

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[43] San Francisco Bay Conservation and Development Commission. 1982. *Diked Historic Baylands of San Francisco Bay: Findings, Policies and Maps.* San Francisco Bay Conservation and Development Commission. San Francisco, California.
[44] Section 66610 of the McAteer-Petris Act.
[45] Goals Project, 1999.
[46] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

ducks, which are mostly found on open waters of the Bay, seem to prefer the quiet waters of diked wetlands when they are more deeply ponded and during times of storms and rough waters on the Bay.[47] Finally, raptors, such as hawks, depend on diked wetlands for prey, as do many mammals.[48]

Although most diked wetlands have no more than a tenuous hydraulic connection with the Bay, they all contribute to the Bay ecosystem. These lands have diverse functions and values, such as maintaining wildlife habitat and contributing nutrients to the Bay regional ecosystem. The wide variety of water regimes and vegetation in close proximity contributes to the extent and unique diversity of habitat around the Bay. Diked baylands also act as a buffer between remaining natural tidelands and uplands, creating protected corridors for wildlife movement in and out of the wetland areas, as well as nesting, denning and breeding areas for some species. Diked wetlands also perform other important functions, such as retaining storm runoff and flood waters, contributing to water quality by assimilating wastes (i.e., trapping and/or removing pollutants from runoff), and buffering land areas from storms and erosion. In addition, their social value is high, due to their pleasing appearance and the opportunities they provide for recreation, research and education.

According to the Goals Project, two different kinds of diked wetlands exist based on whether or not they are managed for specific wildlife values. These include managed marsh, or managed wetlands, (within BCDC's jurisdiction) and diked marsh (primarily outside of BCDC's jurisdiction). Managed marsh is diked wetland habitat that is managed for wildlife, primarily waterfowl. Located in private duck clubs and on publicly owned wildlife management areas and refuges, managed marsh accounts for 80 percent of diked wetlands. Suisun Marsh is the largest managed marsh in San Francisco Bay, and is operated in such a way as to provide winter feeding habitat for migratory waterfowl and shorebirds. Accounting for 12 percent of California's remaining wetlands, Suisun Marsh also functions to provide habitat to migratory waterfowl and shorebirds in the early fall when Central Valley wetlands are not yet flooded, or when it is a drought year.[49] Other examples of managed marsh in the Bay include the Huichica Unit of the Napa-Sonoma Marsh and the Santa Clara Valley Water District pond adjacent to Coyote Creek.

Water is provided to managed marshes through tide gates and along artificial channels. Management objectives determine the timing, duration, depth and extent of water ponding in a managed marsh. Generally, managed marsh habitat is managed to favor a mixture of specific habitat characteristics, such as shallow submerged mud, perennial and seasonal open ponds, and floating and rooted emergent vegetation. Plant species favored by waterfowl and consequently grown in managed marsh include alkali, bulrush, barley, brass buttons, fat hen and sago pondweed. In brackish managed areas Baltic rush, saltgrass, and pickleweed occur. Other species commonly found in managed marshes include goosefoot, dock, celery, sea purslane and pepper grass. Some of the species of waterfowl found in managed marshes around the Bay include mallards, north-

[47] *Ecological Values of Diked Historic Baylands* by Madrone Associates et al., 1983.
[48] Barbara Salzman, Marin Audubon Society.
[49] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.*

ern shovelers, northern pintails and blue-winged teals. Numerous shorebirds, hawks and owls also rely on managed marsh habitat. Some of the mammals associated with Suisun marsh, in particular, include tule elk, the salt marsh harvest mouse, beaver, river otter and the coyote.

Diked marsh usually occurs in low areas adjacent to levees or dikes that have poor drainage or no drainage at all. Although not actively managed for wildlife, many diked marshes may have been subject to some kind of management in the past. Diked marshes are seasonal wetlands because rainfall and runoff from adjacent land are their primary water sources. Annual rainfall patterns determine the timing, duration, depth, and extent of ponding and soil saturation. In some years they are ponded for weeks or months, while in other years they may be alternately dry or continually dry.

The vegetation in diked marshes is generally cyclical, corresponding to annual climate and precipitation patterns. Plant species may consist of a mosaic of either fresh, brackish or saltwater species, depending on location. Plant diversity in many diked marshes is relatively low. However, it is the relative simplicity of these habitats which contributes to their high productivity and use by opportunistic foragers such as waterfowl and shorebirds. In other words, the "boom" and "bust" biomass[50] of diked marshes, based on rainfall and climate, is precisely what contributes to their wildlife values.[51] Also, where diked marshes are located near or adjacent to tidal marshes, they can be especially valuable as high tide refugia for small mammals and as roosting habitat for shorebirds and waterfowl. Sites which pond water in winter months are good foraging and roosting habitat for shorebirds.

Examples of diked marsh are at the Western Marsh and Central Lowlands at Bahia near the Petaluma River, also Gallinas Creek, the abandoned Fremont Airport, and Area H on the Redwood Shores Peninsula.[52]

b. **Agricultural Baylands.** Agricultural baylands consist of diked, former tidal marshes that are intensively cultivated for agricultural production, such as oat hay. These baylands may also be grazed by cattle, sheep or horses. During the wet season, large areas of agricultural baylands may become waterlogged or inundated, depending on the historic tidal marsh topography, the extent and effectiveness of artificial drainage, soil permeability, and the amount and seasonal distribution of rainfall. Until the middle part of this century, farmers controlled water levels on agricultural baylands with gravity-driven systems of drainage ditches. Subsurface and surface water flowed from fields to adjacent marshes through these ditches via one-way flapgates. These systems had limited efficiency, and low places in the fields (relict tidal channels and pans) often remained poorly drained well into the crop-growing season. Today, diked agricultural baylands have subsided to the point at which gravity-driven drainage systems are ineffective and farmers must pump water from their fields.

Most agricultural baylands support plant communities associated with wetlands and upland areas. Agricultural fields that are disked annually typically support a mixture of native annual wetland plants, such as popcornflower and toadrush. Some non-native plants associated with agricultural baylands include loosestrife, brass buttons and barley. Those areas which are uncultivated and ungrazed sup-

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[50] Weight of living material, usually expressed as dry weight per unit area (Elements of Ecology)

[51] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[52] Goals Project, 1999.

port more upland grasses and other vegetation than do cultivated fields. Some of the plants associated with these areas include wild mustard, fennel, and poison hemlock.

Agricultural baylands provide habitat for a diversity of species, in a variety of ways. They are important as roosting and feeding habitat for wintering shorebirds, including greater yellowlegs, long-billed curlew, least sandpiper, dunlin and long-billed dowitcher. They may be especially important for smaller shorebirds whose size prevents them from foraging on nearby tidal mudflats for the same duration as larger, longer-legged shorebirds. In addition, waterfowl, such as mallard and northern pintail, use agricultural baylands when they pond. Other bird species commonly found on agricultural baylands include snowy egret, black-crowned night heron, northern harrier, horned lark, savannah sparrow, red-winged blackbird, and western meadowlark. Some of the mammal species that use this habitat are California vole, California ground squirrel, striped skunk, coyote and black-tailed deer.

Overall, areas of shallow seasonal ponds are the most important habitats for shorebirds and waterfowl. These ponds, typically less than six inches deep, have feathered edges and a minimum of emergent vegetation. The area extent and duration of ponding vary markedly from year to year and are highly influenced by pumping and rainfall patterns. Areas with the highest habitat values are those that pond every year and which are frequently or continuously inundated during the wet season.

Agricultural baylands used for grazing rather than farming, especially those that are not frequently cultivated or mowed, provide abundant cover and food for wildlife. They also allow year-round use by more wildlife species than do intensively farmed areas. As most pastures are allowed to pond more extensively and for longer periods, they often provide better wintering habitat for waterfowl and shorebirds. Also, because grazing reduces dense plant cover, it improves access for birds. Ruderal areas -areas that are un-cultivated and ungrazed - support more upland grasses and other vegetation than do cultivated fields. Furthermore, some ruderal areas, especially the lower and wetter portions of most sites, provide support for amphibians and reptiles. Examples of species found in these areas include the California red-legged frog, the California tiger salamander, the California toad, the Pacific treefrog, the coast garter snake, the Western pond turtle and the San Francisco garter snake.[53]

c. **Salt Ponds.** Salt ponds, which include concentrators or evaporation ponds, are large ponded areas used to produce salt from Bay water. The brines in these ponds range from about 2.5 percent sodium chloride (Bay water salinity) to 25 percent sodium chloride (fully saturated brine.)[54] Artificially managed and engineered to produce salt, today's salt ponds were primarily created from converted tidal salt marsh, although the first artificial salt ponds began as extensions and improvements of natural salt ponds which occurred near Hayward.[55] Today, no natural salt-crystallizing ponds remain around San Francisco Bay. In terms of salt pond acreage in the Bay from past to present, there has been an increase of 2,062 percent. In the quest for salt, 1,594 acres have become transformed into 34,455 acres over the past 150 years. The majority of this increase in salt pond acreage

[53] Goals Project, 1999.

[54] Personal Conversation with Lori Johnson of the Cargill Salt Company, March 2002.

[55] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*

reflects a transfer of tidal marsh habitat into salt pond habitat. Contemporary salt ponds occur primarily in the North and South Bay. Salt ponds that are actively producing salt for commercial purposes are only found in the South Bay, south of the San Mateo Bridge. In the North Bay, none of the salt ponds west of the Napa River are managed to produce salt anymore. The California Department of Fish and Game manages these "inactive" ponds for wildlife purposes.

The process of making salt in salt ponds involves moving Bay water through a series of ponds, known as concentrators or evaporators, over a period of five years. During this time, solar evaporation increases the water's salinity from about 35 parts per thousand (ppt) to more than 180 ppt. The precipitation of sodium chloride salt from the highly saline water, or brine, takes place in ponds known as crystallizers. The salinity of the ponds represent a continuum of salinity levels from bay water or low-salinity ponds, farthest away from the salt production plants at Newark and Redwood City, to mid-salinity ponds and finally high-salinity ponds nearest the salt production plants. Although salinity levels fluctuate seasonally and in response to differences in precipitation, temperature and wind velocity, in general, the ponds farthest from the salt production plants are almost always low-salinity ponds, as they are the location where Bay water is taken into the series of ponds which are part of the salt production system, with the mid-salinity ponds in the middle of the salt production process and the high-salinity ponds closest to the salt production plants and at the end of the five year process.

As a side note, the salinity of the ponds is but a snapshot in time, as mentioned before, the salinity of the ponds is not static and may change in response to endangered species management concerns, such as the protection of the snowy plover, which may require that certain ponds are left to dry out and hence increase in salinity. Weather also may play a part in changes in salinity. Overall, the salt ponds and their diverse salinities provide not only places of commercial salt production, but they also provide a variety of habitat opportunities for species, such as the snowy plover, whose habitat has dwindled significantly elsewhere. A description of some of the species associated with the Bay's salt ponds are found below.

Plants associated with salt ponds include the sporadically occurring wigeon grass, single-celled green algae, blue-green algae, and photosynthetic bacteria. Ponds with salinity levels close to marine environments support macroalgae such as sea lettuce and marine plankton. Invertebrates found in salt ponds and which feed on many of these plant varieties include the Franciscan brine shrimp, the tiger beetle, the brine fly, the flower fly and the Millbrae brine fly. While some species of fish may be found in salt ponds, such as the topsmelt, longjawed mudsucker, threespine stickleback, Pacific staghorn sculpin and yellowfin goby, this habitat provides inconsistent and at best minimal habitat value to these species.

Salt ponds, especially those with low to mid-salinities, provide important habitat for bird species. They are of primary importance to migratory shorebirds and waterfowl. In addition, salt pond habitat provides year-round foraging habitat for a number of resident species, such as American avocet, black-necked stilt and western snowy plover.[56] In 1988, wintering waterfowl peaks in South Bay salt ponds were recorded at 75,000 birds, while wintering shorebirds exceeded

[56] Goals Project, 1999.

200,000 individuals.[57] Prominent residents of salt ponds include double-crested cormorants, great blue herons, great egrets, ruddy ducks, western snowy plovers, killdeer, California gull and Forster's tern. Seasonal visitors include the white pelican, northern pintail, scaup, dunlin, dowitcher, herring gull, least sandpiper, American coot and the bufflehead. As historic tidal marshes were transformed into salt ponds over the last century, an increase in numbers of specific bird species soon followed. These species include eared grebe, white pelican, bufflehead, western snowy plover, black-necked stilt, American avocet, Wilson's phalarope, red-necked phalarope, California gull, Caspian tern and Forster's tern. While population numbers of salt pond dependent bird species has increased, the loss of tidal marsh acreage has lead to downturns in population of tidal marsh dependent bird species. Two examples of tidal marsh dependent species at risk of extinction due to habitat loss and fragmentation include the California clapper rail and the California black rail.[58]

Based on salinity and salt pond location, the kinds of food available to bird species differs. Ruddy ducks, while wintering in salt ponds, eat brine shrimp, water boatmen (insect), wigeon grass and green algae. White pelicans, double-crested cormorant, Forster's tern and great egrets depend on fish populations living in low salinity ponds. Least sandpipers and American avocets are known to eat water boatmen and brine flies, while eared grebes eat brine shrimp. California least terns consume topsmelt when feeding in salt ponds near Hayward.

Examples of low-salinity salt ponds are Ponds A1/A2W in Mountain View, and Ponds 10 and 11 at Baumberg. Examples of mid-salinity salt ponds are Ponds A10-A14 at Alviso and Ponds 1A-4A in Union City. High-salinity salt pond examples include Ponds 4-6 at Mowry and the crystallizers at Newark and Redwood City.[59] The majority of salt ponds surrounding San Francisco Bay are within BCDC's jurisdiction.

d. **Storage/Treatment Pond.** Storage/treatment ponds are the last type of diked habitat associated with the Bay. Located in Napa, Hayward, and Sunnyvale, storage/treatment ponds are diked, perennial shallow or deepwater pond habitat that have been constructed to store or treat runoff, sewage, or industrial discharges. Most storage/treatment ponds are part of municipal wastewater treatment works, and store treated effluent before it is recycled or discharged to the Bay. This type of habitat is primarily outside of BCDC's jurisdiction.

In terms of vegetation, storage/treatment ponds support very little. They do, however, support a diversity of animal life similar to that found in lagoons. Examples of amphibians found in storage/treatment ponds include the California toad and the Pacific treefrog. Reptile species which depend on storage/treatment pond habitat include western pond turtles, coast garter snakes, central coast garter snakes and the California alligator lizard. In regards to mammals, the California vole rests, forages and breeds in storage/treatment ponds and the North American river otter rests and forages in them. The primary insects utilizing storage/treatment ponds are the winter marsh mosquito and western encephalitis mosquito, which may be food for waterfowl.[60]

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[57] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[58] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Other Birds Community Narratives.*

[59] Goals Project, 1999.

[60] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1998. *Draft Species Narratives for Invertebrates.*

Waterfowl associated with storage/treatment ponds include the tule white-fronted goose, the mallard, northern shoveler, American coot, scaup, bufflehead, northern pintail, canvasback and ruddy duck. Shorebirds dependent upon storage/treatment ponds include the western snowy plover, the red knot, the western sandpiper, the long-billed dowitcher and the Wilson's phalarope. Other birds who rest forage or breed in storage/treatment ponds include the eared grebe, pied-billed grebe, American white pelican, snowy egret, black-crowned night heron, peregrine falcon, Caspian tern, belted kingfisher, California least tern and the red-winged blackbird.[61]

Transition Zone. A transition zone is a habitat type where a gradual change from wetland to upland occurs. Transition zones are sometimes called "ecotones." In their natural condition wetlands frequently lie adjacent to upland habitats, with a transition zone in between. This transition zone is usually an area of lowland grassland that can support both vegetation and wildlife found in both wetlands and upland habitats.[62] As a consequence, transition zones contain a rich mixture of vegetation types and are an especially important habitat for aquatic and terrestrial wildlife. Generally, only portions of the transition zone around the Bay is within BCDC's jurisdiction. These transition zones are inextricably linked to wetlands ecosystems. They demonstrate an "edge effect" that blends the habitat of plants and animals from each of the bordering habitats – such as tidal marsh and grassland. In turn they support an especially diverse group of plants and animals which are able to thrive in a mixed habitat. Many wetland species seek temporary refuge in the higher elevations of the transition zone as well as adjacent uplands during flooding and high tides and forage in both areas for food. Other wetland-dependent species depend upon the adjacent upland habitat for their survival. For example, the endangered salt marsh harvest mouse uses the transition zone both for cover during high tide, as well as for feeding.[63]

The size of a transition zone can vary, or in some cases be entirely absent, depending on natural topography, or the type and amount of disturbance to natural conditions. For example, in urban areas, a wetland may be abutted by a roadway and the transition zone is absent; in rural areas, such as Suisun Marsh, transition zones are extensive, and are generally found between the five-foot and 10 foot contour lines. Many diked baylands act as substitutes for natural transition zones that have been replaced by development.

The transition zone is inextricably linked to the wetlands and is an essential area for wetland-related plant and animal life. Therefore, the transition zone should be considered and treated as part of the Bay's wetlands ecological system.

Upland Habitats. Habitats upland from those located in and around the Bay are categorized as upland habitats. While most of these habitats are outside of BCDC's jurisdiction, they are important due to their connection to and interrelationship with San Francisco Bay because of the habitats, functions and values they provide for Bay-related aquatic life and wildlife. Furthermore, impacts on upland habitats may pose a threat to downstream habitats located in BCDC's jurisdiction, making an understanding of the linkages between upland habitats associated with the Bay critical to protecting the Bay and its plant and animal communities.

Many upland habitats provide high tide refuge and food to animals associated with habitats next to the Bay, but they also host a distinct array of plants and animals of their own. In addition, they are a critical part of the Bay ecosystem, representing the continuum of use by aquatic life and wildlife from Bay waters to wetlands to upland areas. Plant communities outside of the

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[61] Goals Project, 1999.

[62] San Francisco Bay Conservation and Development Commission. 1976. *Suisun Marsh Protection Plan Supplement.* San Francisco Bay Conservation and Development Commission, San Francisco, California.

[63] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

historic range of the tides differ remarkably in composition to those historically and currently influenced by the tides. For example, upland plant communities tend towards greater structural diversity and species richness than those plant communities adjacent to the Bay. The reason for this difference is that climate, geology and hydrology, instead of tidal waters, have determined the composition of upland plant communities.[64] In addition, many upland habitats are characterized by high wildlife diversity.[65] This diversity of plant and animal communities is in addition to the distinct transitional zone (ecotone) between upland habitats and wetlands which was discussed earlier. Examples of adjacent habitat includes riparian forest, willow grove, grassland, oak woodland and mixed evergreen forest.

1. **Riparian Forest.** Riparian forest habitats occur where stream and river banks are lined with distinctive plant communities. In the South Bay, the list of common riparian trees includes western sycamore and cottonwood. Ash, California bay, laurel and box elder are locally abundant in the North Bay. Red willow, arroyo willow, coast live oak and valley oak are also common native riparian tree species. Common riparian understory species are elderberry, wild rose and blackberry. Non-native trees, such as acacia and eucalyptus, occur in the riparian forests of urban and suburban landscapes.

   The complexity of microhabitats created by the layering of trees, shrubs, herbaceous and aquatic vegetation promotes very high wildlife species diversity in riparian forest habitat. In fact, riparian forests are often considered to be the most valuable of habitats available to wildlife. They are also one of the rarest habitats in the San Francisco baylands.[66] Water, food and cover, all critical habitat requirements, are provided by this kind of habitat. Riparian vegetation that hangs over water shades the aquatic environment, thereby moderating water temperatures for fish. Leaf and insect droppings from overhanging vegetation contribute to the stream or creek's productivity, while roots and tree limbs improve the diversity of aquatic habitats available to fish and aquatic insects. A great number of bird species, such as those who nest in the holes of trees or feed on insects found on the bark of trees, depend entirely on this habitat for existence.[67] Fish species dependent upon riparian forest habitat vary by geographic location and the overall ecological health of the stream or creek. Suisun Creek and Sonoma Creek, for instance, provides habitat for steelhead and rainbow trout. Coyote Creek hosts a steelhead run, Chinook salmon, as well as rainbow trout. Insect species associated with riparian forests include the riparian shore fly and washino's mosquito. Migrating neotropical birds, such as the yellow warbler, use riparian forests for resting and refueling during migration.[68]

   Riparian forest habitat is most valuable to aquatic life and wildlife when it exists in an unbroken corridor throughout the length of a watershed.[69] In addition, the long and narrow shape of riparian forest habitat maximizes the extent of the transition zone between habitats, thereby increasing species diversity. When adjacent to grasslands or agricultural land, riparian forests provide nest sites for raptors and cover for upland species that use the habitat for foraging. These habitats also act as corridors between cover types

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[64] San Francisco Bay Area Wetlands Ecosystem Goals Project. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*

[65] Goals Project, 1999.

[66] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[67] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[68] San Francisco Estuary Project. 1992-1997. *State of the Estuary.* San Francisco Estuary Project, Oakland, California.

[69] Goals Project, 1999.

for use by species during migration. Other species who exploit the transition zone are the Pacific-slope and ash-throated flycatcher. Both bird species are dependent on the riparian forest/stream edge where they feed on aquatic insects rising into the air.

Food chains are multi-faceted in a riparian forest due to the variety of foods available to organisms. Mammals, such as the black-tailed deer and Audubon cottontail consume vegetation, as do some insect species. Deer mice, the western gray squirrels and rufous-sided towhees eat fruit and seeds. The black phoebe, Anna's hummingbird, ornate shrew, pallid bat and Pacific treefrog consume insects. Other carnivores include the coyote, opposum and great horned owl. The scrub jay is a common scavenging bird and the raccoon eats all kinds of food, such as seeds, fruits, insects, bird eggs and carrion. Other representative species associated with riparian forests are the California newt, ring-necked snake, ornate shrew, broad-footed mole, wood duck, downy woodpecker, tree swallow, northern oriole, song sparrow and the salt marsh common yellowthroat.

Examples of riparian forest exist along Suisun Creek, San Antonio Creek adjacent to Petaluma Marsh, Sonoma Creek and Coyote Creek.

2. **Willow Grove.** Willow grove habitat is a patch of willow trees that are associated with groundwater discharge, perennial ponds, or seasonal ponds. In the South Bay, some willow groves occur where intermittent streams terminate before reaching the Bay. In the Bay Area, willow groves were historically associated with springs and areas of groundwater discharge along the margins of the Bay, especially in the South Bay subregion. One of the few remaining examples of willow grove habitat is at Coyote Hills Regional Park.

   Willow groves support many species of amphibians, birds, and small mammals that also frequent riparian forests, as well as other Bay habitats. Representative species include Pacific treefrog, snowy egret, black-crowned night heron, northern harrier, raccoon, striped skunk, California toad, California red-legged frog, western pond turtle, California alligator lizard, the coast garter snake and the riparian shore fly. The dominant plant species found in this habitat is the arroyo willow, although associated species such as the California blackberry and silverweed may also be found here.[70]

3. **Grassland.** Prior to European settlement, grasses and sedges were widespread around the Bay. Native perennial grassland predominated near the Bay on valley floors and on the slopes of hills facing southwest. These grasslands were composed primarily of perennial bunch grasses and rhizomatous grasses with two of the dominant plant species being purple needlegrass and creeping wild rye. Both Rush Ranch in Suisun Bay and Coyote Hills near Newark possess representative examples of historic plant community composition.

   Grassland habitat is still widespread in the baylands, although the botanical makeup of this habitat differs markedly from earlier conditions. Four varied groups of grassland plant associations existing today include non-native annual grassland, moist grassland, grassland/vernal pool complex and coastal prairie.

   a. **Non-native Annual Grassland.** Non-native annual grassland emerged with the introduction of European grazing and agriculture in the 1800's. Subsequently, the region's grassland communities shifted from native perennials to Eurasian non-native annuals. Dominant species of these communities are wild oats, soft chess, ripgut brome, and Italian ryegrass. Non-native annual grassland occurs in the interior val-

[70] Goals Project, 1999.

leys surrounding the baylands, on the unforested hills facing southwest, and on the alluvial plains. Examples of non-native annual grassland exist at Potrero Hills, Hamilton Field and Coyote Hills.

Many species of wildlife frequent non-native annual grassland. In summer, amphibians such as the tiger salamander aestivate[71] in grassland soil to avoid heat stress. Reptiles associated with grasslands include racer, coachwhip, and gopher snake. In winter, grasslands provide important foraging habitat for sandhill crane, Canada geese and many species of migratory shorebirds. Some of the other bird species commonly associated with grasslands include turkey vulture, black-shouldered kite, red-tailed hawk, northern harrier, American kestrel, burrowing owl, western meadowlark and savannah sparrow. Mammals that reside in grasslands include ornate shrew, broad-footed mole, coyote, California ground squirrel, botta pocket gopher, western harvest mouse and California vole. Many of these species occur in this habitat year-round, while others move into this habitat at certain times of the year, primarily to forage.[72]

b. **Moist Grassland.** Moist grassland occurs in areas that are primarily flat and composed of water-deposited sediments. Due to the prior presence of water, soils in this habitat are primarily clay and silt and may include Dublin adobe soils, Clearlake adobe clay, Zamora adobe clay, Lindsey clay loam, and Yolo silty clay loam. These clay and silt soils slow the downward movement of surface water, leaving the habitat saturated for long periods of time, thus frequently supporting not only moist grassland, but also seasonal wetlands. Dominant moist grassland species include Italian ryegrass, Baltic rush, iris-leaved rush, Santa Barbara Sedge, and creeping wildrye.

   Moist grasslands, especially areas that have seasonal wetlands, attract more species than drier grasslands. In addition, many of the species that occur in non-native annual grassland habitat also utilize moist grasslands. Species representative of moist grassland habitat include western toad, western skink, meadowlark, horned lark, savannah sparrow and western harvest mouse.

   An example of a food web common to grassland habitats involves a variety of species. The black-tailed hare, Botta's pocket gopher, California vole and field cricket eat vegetation. Seeds are consumed by the California ground squirrel, western harvest mouse, horned lark and Savannah sparrow. The broad-footed mole, western skink, western toad and western meadowlark feed on insects, while the badger, red-tailed hawk and gopher snake are known carnivores.[73] In addition, the turkey vulture is a common scavenging bird. Historically, moist grasslands existed in large expanses near Suisun Marsh, in the upper reaches of Sonoma Creek and the Petaluma River, and adjacent to many of the habitats surrounding the South Bay. Today, examples of large areas of this habitat exist near Fairfield and in the Petaluma River area. Smaller areas of moist grasslands with seasonal wetlands are in Marin at St. Vicent's/Silveira Ranch. In South Bay, development has destroyed most of the historical moist grasslands. Current exceptions exist east of Coyote Hills in the Ardenwood area and near the upper reach of Mowry Slough in Newark.[74]

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[71] Dormancy in animals, through a drought or dry season (Elements of Ecology)

[72] Goals Project, 1999.

[73] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[74] Goals Project, 1999.

c. **Grassland/Vernal Pool.** Grassland/vernal pool habitats are surface depressions usually less than six inches deep that are underlain by an impervious substrate of natural materials. They occur almost entirely in California and rarely outside of North America. These impervious substrates, such as clay or bedrock, are ponded by direct rainfall or nearby runoff during the wet season. In turn, vernal pools are desiccated by evaporation early in the dry season. Vernal pools are typically freshwater environments since their primary water source is precipitation. Salt diffusion from underlying soils, however, causes some to be slightly brackish.

Significantly, vernal pools are associated with grassland vegetation, although the vegetation found within the vernal pool is unique to that growing around the vernal pool. Those plants associated with vernal pools are special because they are able to begin their lives submerged by water and complete their lives as terrestrial plants growing in dry environments. Upland vegetation found around vernal pools is typically non-native annual grassland.[75] Native vernal pool plant species include goldfields, popcornflower, Navarretia and Downingia.

Some wildlife species associated with vernal pools include fairy shrimp, tadpole shrimp, California tiger salamander, western spadefoot toad, common garter snake, black-necked stilt, and American avocet. Other bird species which utilize vernal pools are great egret, snowy egret, killdeer, greater yellowlegs, lesser yellowlegs and common snipe. Some waterfowl, especially mallard and cinnamon teal, nest in this habitat when water is present. In addition, migratory waterfowl and shorebirds both feed and roost in vernal pool habitat during winter.

Vernal pools are at risk because virtually all human activities, except rangeland grazing, destroy the unique hydrologic and geologic characteristics that initially created the vernal pool environment. They are extremely rare near southern San Francisco Bay and only slightly more frequent north of San Pablo and Suisun bays. Vernal pools north of Suisun Bay are particularly significant because they are often dominated by a federally-listed endangered plant species, Contra Costa Goldfields, which is extinct throughout much of its range. Large areas of grassland/vernal pool habitat once existed in San Francisco Bay. Currently, this habitat is found adjacent to Suisun Marsh, along Sonoma Creek, and in the Warm Springs area in the South Bay.[76]

d. **Coastal Prairie.** Coastal prairie is a type of grassland that occurs in limited distribution near the Bay in areas that are frequently exposed to moist marine air and which have clay soil. Dominant plant species include Douglas iris, reedgrass, oatgrass and hairgrass. Examples occur at Brooks Island, Ring Mountain Preserve, and the Golden Gate National Recreation Area.

4. **Oak Woodland.** Vegetation with an overstory dominated by oak trees is common throughout California's Mediterranean climate zone, including San Francisco Bay. Generally oak woodland habitats are found in valleys, foothills and lower mountain ranges around the Bay. Based on plant species dominance there are three types of oak woodland. These three types are coast live oak woodland, valley oak woodland, and foothill oak woodland.

   Oak woodlands are an integral part of the Bay's ecosystem as they provide needed foraging, roosting and breeding habitat for many species of amphibians reptiles, birds and small mammals that frequent the Bay Area. Some representative species associated with oak woodlands include ensatina (an amphibian), arboreal salamander, southern alligator

[75] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*
[76] Goals Project, 1999.

lizard, gopher snake, western rattlesnake, red-tailed hawk, California quail, acorn woodpecker, American kestrel, western scrub jay, western kingbird, California ground squirrel, Hoary bat, Audubon's cottontail and black-tailed deer. Some examples of food consumption in the oak woodland habitat includes the plant eating black-tailed deer, Botta's pocket gopher, Audubon's cottontail, and the California oak moth.[77] Seeds provide food for the western gray squirrel, the acorn woodpecker, the scrub jay and the black-tailed deer, while the western kingbird, white-breasted nuthatch, western toad and ornate shrew eat insects. Carnivores include the red-tailed hawk, gopher snake, coyote and striped skunk. The turkey vulture is a common scavenger in the more open areas of oak woodland habitats.

a. **Coast Live Oak Woodland.** Coast live oak woodland is distinctive among oak woodland habitat because it consists almost exclusively of closed canopy forests with few annual grass species growing in its understory. In contrast to other oak woodland habitats, poison oak is most commonly found growing beneath coast live oaks. While the dominant plant species of coast live oak woodland habitat is the coast live oak, other plant species found here include madrone, California blackberry, creeping snowberry, and cream bush. Associated with moderate to large amounts of rainfall, coast live oaks occur on the slopes of hills that are influenced by marine air flow and which have thin soils.[78] Examples of this habitat exist on the north-facing slopes along the Carquinez Strait, on the ridge between Black Point and Rush Creek near Novato, at China Camp, and on Angel Island.[79]

b. **Valley Oak Woodland.** Valley oak woodland occurs in a few places on the alluvial plains, valleys, and piedmonts adjacent surrounding the Bay. Valley oak is the dominant plant species in this habitat. At times valley oak woodland overlaps coast live oak woodland and foothill oak woodland. The understory of valley oak woodland consists of non-native annual and occasionally native perennial grassland. Associated plant species found in this habitat include creeping wild rye and Santa Barbara sedge. Not widely spread in the Bay Area, this habitat exists along Green Valley Creek near Cordelia, along the lower Napa River and along Sonoma Creek near Schellville.[80]

c. **Foothill Oak Woodland.** Foothill oak woodland occurs on the slopes of hills with deep soils and small to moderate amounts of rainfall. The dominant plant species in this habitat is the blue oak, although associated species include digger pine, manzanita, deerbrush, coffeeberry, and pink-flowered currant. Due to the foothill oak woodland's open canopy its understory is almost universally dominated by non-native annual grassland. Competition is particularly intense between annual grasses and blue oak seedlings before they develop roots long enough to reach subsoil water. Seedling mortality at this stage is so intense that much foothill oak woodland consists almost entirely of mature blue oaks that germinated in the 1860's, a decade when severe overgrazing reduced much presumably native perennial grassland from California's

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[77] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[78] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*

[79] Goals Project, 1999.

[80] Goals Project, 1999.

rangelands. Subsequent increase of non-native annual grassland has severely restricted reproduction of foothill woodland developing at that time.[81] This community is not widespread on lands near the Bay. An example exists at Black Diamond Mine Regional Park near Antioch.[82]

5. **Mixed Evergreen Forest.** Forests dominated by a mix of broadleaf and conifer evergreen trees are frequent in California where precipitation is relatively high and winter temperatures are mild. In the Bay Area, mixed evergreen forest is mostly restricted to north-facing slopes of hills in the North Bay and Central Bay. Examples of mixed evergreen forest occur in the headward reaches of north-facing draws of San Pedro Ridge near China Camp and on the northern side of the ridge between Black Point and Rush Creek. The dominant plant species in this habitat includes the California bay laurel, bigleaf maple, and madrone. Associated species are coyote brush, California huckleberry and poison oak. Some representative animal species found in mixed evergreen forests include the common garter snake, western fence lizard, Cooper's hawk, Nuttall's woodpecker, wrentit, dark-eyed junco, hermit thrush, purple finch, dusky-footed woodrat, brush rabbit, gray fox and the black-crowned night heron.[83]

The Role of Habitats in the Bay Ecosystem. Now that the San Francisco Bay has been broken down conceptually into its habitat components, putting the pieces back together again will be helpful to understanding the Bay as a dynamic, functioning and interconnected ecosystem. For instance, aquatic life and wildlife of the Bay move about, within and outside of specific habitats during their daily quest for food and refuge. To these organisms, boundaries between habitats are more fluid than fixed. For example, schools of Pacific herring mobilize in deep channels of the Bay and then move towards the shoreline to lay their eggs in shallow water. Smaller mammals, such as the endangered salt marsh harvest mouse, take refuge on levees and in the adjacent uplands to avoid the highest tides. Black-crowned night herons forage for food on tidal flats, but may breed in willow groves or oak woodlands.

Some songbirds, such as the salt marsh common yellowthroat move up and down local streams, from the brackish zones of tidal reaches to riparian forests. The Bay's wetlands also serve as a way station for Delta species such as splittail, Chinook salmon and the Delta smelt. Similarly, the transition zones represent those places of flux for plants between habitat types. These ecotones, as mentioned before, are places of great biodiversity where plant communities from adjacent habitats blend together. In short, while it is useful to understand the value of each habitat type individually, it is equally important to remember that these habitats are interconnected and function as a system.

Historical Habitat Changes in the Bay.[84] Dramatic shifts in habitat abundance have occurred in San Francisco Bay over the past 200 years. New habitats types have been added where once they did not exist, while other Bay habitats are but a reflection of their past enormity. These shifts in habitat type and abundance have lead to consequent changes in plant, aquatic life and wildlife composition around the Bay. In order to get a feel for some of these changes this discussion will start with a snapshot of how the Bay's ecosystem used to function prior to major alterations by humans.

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[81] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*
[82] Goals Project, 1999.
[83] Goals Project, 1999.
[84] This section is derived from the *Baylands Ecosystem Goals Report* of 1999.
Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

Figure 7[85] presents an overview of the former distribution of the Bay's habitats. Significantly, this map is a partner to Figure 3, the EcoAtlas map presented in chapter 2 which illustrates the contemporary distribution of habitat types in the Bay Area.

Once deep and shallow bay habitat totaled about one-quarter of a million acres. Shallow water dominated the broad tidal basins of Suisun, North Bay and South Bay, while the deep parts of the Bay contained the submerged topography of ancient valleys. Each major tributary had tidal flats and tidal marshes arrayed along a salinity gradient created by local runoff. Some gradients were steeper because they extended over short distances from fresh to saline conditions. Other gradients extended for longer distances from fresh to brackish conditions. For example, brackish marshes extended several miles along the larger creeks in North Bay, Central Bay and South Bay. These subregional and local gradients of salinity created a complex system of tributary estuaries along the major salinity gradient between the Golden Gate and the Delta, all of which supported great physical and biological diversity.

Each day as the tide went out, almost 500,000 acres of tidal flats emerged along the margins of the bays and larger tidal channels. In addition, vast contiguous marshes extended across Suisun, North Bay and South Bay. Tidal marsh acreage is estimated to have been upwards of 200,000 acres. Large tidal channels connected the marshes to the bays and spread into networks of thousands of smaller channels distributed throughout the tidal marshes. At their mouths, the major channels were several hundred feet across; the great volume of water that flowed in and out of the channels networks during each tidal cycle maintained deep and shallow channels through the tidal marshes, tidal flats, and into the bays.

In the flatter portions of the region, especially at the entrances to broad valleys, the tidal marshes graded gently into low-lying moist grasslands. These grasslands evolved on patches of poorly drained soils of fine clays. On larger creeks throughout San Francisco Bay riparian forests traced their way to the tides. Where creeks did not meet the Bay, willow groves emerged. Willow grove habitat was common at low elevations near the backshore of tidal marshes in Central Bay and South Bay. Some of the willow groves in South Bay extended over more than 200 acres.

Historic tidal marshes, willow groves, riparian forests, and moist grasslands comprised complex mosaics of habitats throughout the region. Two common mosaics in existence around the Bay depended in large part on topography. One mosaic was confined to the small coves and bays with steep terrain, along what is now Lake Merritt, the San Francisco Peninsula, the Marin shoreline, and the eastern shore of North Bay. These areas consisted of small patches of mudflat, tidal marsh, riparian forest, and sometimes beaches and willow groves. The other common mosaic consisted of much larger patches of tidal marsh and adjacent habitats. This second mosaic was associated with the rivers and larger creeks flowing into South Bay, the eastern shore of Central Bay and the northern shores of North Bay and Suisun.

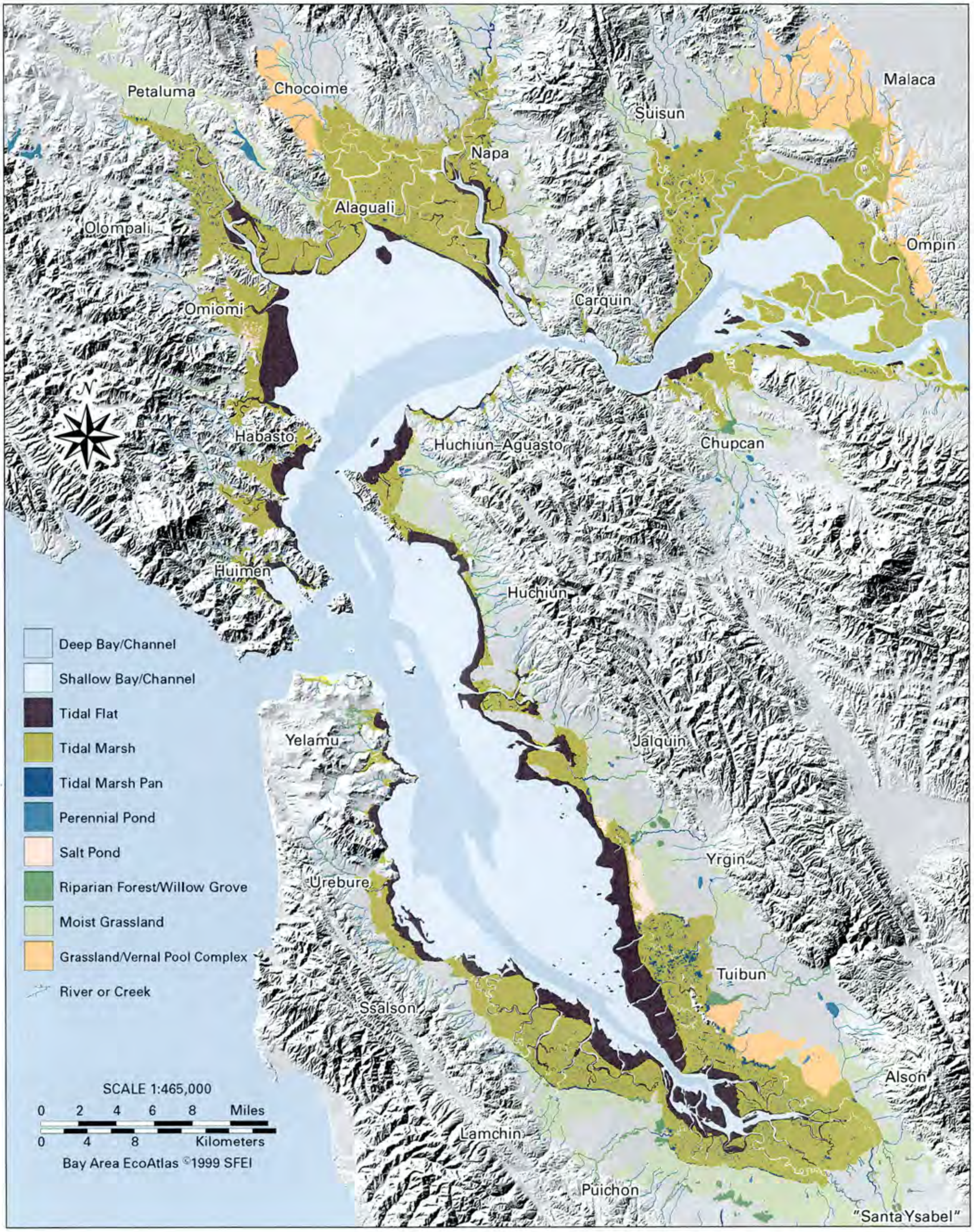
Beginning in the mid-1800's, following the Gold Rush in the Sierra Nevada, large areas of the Bay's tidal marshes and mudflats were filled, diked or drained. Extensive portions of these habitats were filled to provide land for ports, rail lines, and roads as the Bay Area became a major transportation center. In addition, early industrial developers in San Francisco and Oakland built many facilities on Bay fill or on land immediately adjacent to the Bay. Farmers began diking and draining the tidal marshes in the 1850's. Much of the initial impetus for this activity

[85] Adapted from the Goals Project, 1999.

Figure 7

SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals* (1999).

Past Distribution of Baylands and Adjacent Habitats (ca. 1800)



stemmed from the federal Arkansas Act of 1850, which gave to the states all of the unsold federal land within their borders that was saturated with water. Subsequent state legislation, particularly the Green Act of 1868, also spurred the conversion of wetlands into agricultural uses.

In Suisun Bay and the North Bay, most habitat shifts occurred in the change of tidal marshes into farmlands. The trend was different in the South Bay where lands around the Bay were never extensively diked for agriculture. Instead, large areas were reclaimed for salt production. This diking for commercial salt production began around 1860. By the 1930's, almost half of South Bay's historic tidal marshes had been converted into salt ponds. In 1952, the Leslie Salt Company (later purchased by the Cargill Salt Division), expanded salt production into North Bay with the purchase and conversion of nearly 11,000 acres of diked agricultural land into salt ponds. By the middle of this century, salt ponds had replaced nearly one-fifth of historic tidal marsh habitat in the North Bay. At their peak, salt ponds covered about 36,000 acres around the Bay. By the 1950's, there were only about 50,000 acres of tidal marshes in San Francisco Bay, about one quarter the previous amount of acreage. Table 3[86] outlines the dramatic changes in habitat acreage which have occurred in San Francisco Bay over the past two centuries.

Due to past and ongoing land use changes the composition of habitats in existence in the Bay has changed dramatically. Where once the habitats of the Bay consisted almost entirely of tidal marsh, tidal flat and upland habitats, today there also exists seasonal wetlands, agricultural lands, salt ponds and storage/treatment ponds. These changes have caused a significant diminishment in physical processes associated with Bay habitats, as well as a decline in the diversity of plant and animal communities dependent on upland habitats, tidal marshes and tidal flats. For example, diking for agriculture resulted in a variety of major landscape changes. Initially, the most obvious change was the reduction or elimination of tidal marsh vegetation as the land was farmed. In addition, after diking, decomposition and the lack of water in the peaty marsh soils caused the land surface to settle and subside. In some cases, as in Suisun Marsh, the topography became inverted.

Areas that once were high marsh became low, isolated depressions, lower than the relict channels and natural levees. In addition, diking has had a substantial impact on the quality of the Bay's water. The large loss of tidal marsh habitat around the Bay is believed to have contributed to decreased water quality and an increase in the turbidity of the Bay.

Habitat loss and degradation over the past two centuries have played key roles in population declines of many species dependent on the Bay. Currently, 51 species of plants and animals of San Francisco Bay are listed as threatened or endangered under the state and federal endangered species acts. These include twenty-one plants, ten invertebrates, six fishes, one amphibian, two reptiles, nine birds and two mammals. Urban and suburban development around the Bay has had an especially severe impact on many of the ecosystem's plant communities. About 30 percent of the upland area in the nine Bay Area counties is now urban and suburban. This has resulted in the loss of most of the historic moist grassland habitat, natural seasonal and perennial wetlands, willow groves and riparian forests.

Historic habitat loss and degradation in the Bay have also impacted the well-being of aquatic life and wildlife. For example, the loss of vernal pools, riparian woodlands and grasslands has lead to the depletion of several species of amphibians and reptiles in San Francisco Bay. Some, such as the California tiger salamander, red-legged frog, giant garter snake, and western pond turtle are facing possible extinction.[87] Similarly, winter-run Chinook salmon, as well as other anadromous fishes, have suffered population declines in the Bay due in part to the fragmentation and loss of tidal marsh habitat which is used by juvenile fish for protection and

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[86] Adapted from the Goals Project, 1999.

[87] San Francisco Estuary Project. 1999. *Comprehensive Conservation and Management Plan.* (http://www.abag.ca.gov/bayarea/sfep/reports/ccmp/ccmpch2.html)

Table 3
Past and Present Habitat Acreage for San Francisco Bay

Habitat Type	Historical (ca. 1800) acres	Modern (ca. 1988) acres	% Change +/-
Bays			
Deep Bay/Channel	99,529	82,410	-17%
Shallow Bay/Channel	174,442	171,818	-2%
Total	273,971	254,228	-7%
Baylands			
Tidal Flat	50,469	29,212	-42%
Tidal Marsh	189,931	40,191	-79%
Lagoon	84	3,620	4209%
Salt Pond	1,594	34,455	2062%
Diked Wetland	-	64,518	
Agricultural Bayland	-	34,620	
Storage or Treatment Pond	-	3,671	
Undeveloped Bay Fill	12	7,598	63217%
Developed Bay Fill	-	42,563	
Other Baylands	254	1,951	668%
Total	242,344	262,397	8%
Adjacent Habitats			
Moist Grassland	60,487	7,474	-88%
Grassland/Vernal Pool Complex	24,070	15,038	-38%
Riparian Forest/Willow Grove	4,800	774	-84%
Total	89,357	23,286	-74%

SOURCE: Baylands Ecosystem Habitat Goals Project

food. Habitat availability for the salt marsh harvest mouse has also declined precipitously in the past twenty years. While about 6,000 acres of habitat remains available to the northern subspecies in Suisun Bay, the southern subspecies is dependent on 760 acres of South Bay tidal marshes, where diking of tidal marshes, land sinkage, and shoreline erosion have continued to reduce tidal marsh acreage, especially at high tide.

Changes in land use over the last 200 years, while decreasing some habitat types have lead to vast increases in other habitat types. Salt pond acreage, for example, has increased in the Bay by 2,062 percent, while moist grassland habitat has decreased by 88 percent. Consequently, species associated with moist grassland habitat, such as the northern harrier and burrowing owl, have suffered declines in population at the same time species associated with salt ponds have benefited. As was mentioned earlier, eared grebe, white pelican, bufflehead, western snowy plover, black-necked stilt, American avocet, Wilson's phalarope, red-necked phalarope, California gull, Caspian tern, and Forster's tern have all increased their numbers in the bay due to the growth in salt pond habitat.[88]

In moving from understanding the contemporary distribution of habitat types around San Francisco Bay to improving their expanse through restoration, the history of their past distribution should not be limiting. Habitats such as diked wetlands and salt ponds, although new, do add value to the Bay ecosystem. In today's vast urbanizing Bay Area they fill the gaps by providing some of the support functions to aquatic life and wildlife that historic habitats once provided. Therefore, in establishing the range of habitats to be restored and protected, a balance between habitat types should be sought, without trying to exactly replicate the past. Furthermore, the habitat values provided by the current distribution of habitat types should be assessed before changes are proposed. For example, some biologists warn that by converting salt pond habitat to tidal marsh, a reduction in densities of some avian species, such as diving duck populations, may occur. This outcome results from the observation that while species diversity of waterbirds is generally higher in tidal marsh habitats, when compared with salt ponds, bird densities are higher in salt ponds in the winter and spring, primarily because of large populations of benthivores.[89]

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[88] Goals Project, 1999.

[89] Takekawa, J.Y., G.M. Martinelli, A.K. Miles, S. Fregien, D.H. Schoelhamer, W.G. Duffy, and M.K. Saiki. 2000. Salt Ponds and Avian Communities: Will Benefits of Tidal Wetland Restoration Exceed Costs to Waterbirds. Paper Presented at Symposium, Calfed Bay-Delta Program: Science Conference.

CHAPTER 3

THREATS TO THE HEALTH OF THE BAY'S HABITATS

The last 200 years of land use changes in San Francisco Bay have had dramatic effects on the Bay's habitats. Diking, draining and filling caused enormous changes in the composition of habitat types found around the Bay, with consequential declines in the acreage of historic habitat types such as tidal marshes and moist grasslands. In addition, tremendous increases in once rare or non-existent habitat types, such as salt ponds and diked wetlands occurred. These changes in land use have not only lead to precipitous declines in the habitats once expansive around the Bay, but significant downturns have also followed in the distribution and abundance of aquatic life and wildlife dependent on those habitats.

While filling of the Bay has substantially decreased due to increased regulatory authority (including the McAteer-Petris Act and the *San Francisco Bay Plan),* and indeed the Bay has increased in size since the Commission was created in 1965, habitats of the Bay face ongoing threats, many of them much more complex and interconnected than those which initially changed the Bay's ecosystem. For example, urbanization in upland habitats may not only fragment oak woodland or grassland habitats, but development also replaces soil with pavement, thus generating more stormwater runoff into lower lying wetlands. This stormwater runoff can not only cause erosion of stream channels on its way to the Bay, but it can carry pollutants, such as motor oil, from city streets to tidal marshes and the Bay. These multi-faceted threats facing the Bay's habitats will be the focus of this chapter. Once these threats are understood in greater detail it will be possible to address how best to avoid or minimize their effects on the well-being of the Bay's habitats.

Habitat Loss. Habitat loss is the conversion of a habitat into another form or land use which eliminates all of the original functions and values associated with the habitat. Urbanization and shoreline erosion are two of the main forces causing habitat loss both today and potentially in the future.

1. **Urbanization.** Population growth, the growth of the economy, and the consequent urbanization of the Bay Area have had significant impacts on upland habitats of the Bay. Plant communities have been especially affected with 30 percent of the upland areas in the nine Bay Area counties either suburbanized or urbanized. This has resulted in the loss of most of the historical moist grasslands, natural seasonal and perennial wetlands, willow groves and riparian forests.[1] Development also affects wetlands and stream corridors in virtually every watershed around the Bay, by placing homes, businesses and roads too close to streams. For example, riparian forest habitat is especially impacted when riparian vegetation is removed and stream banks are lined with rock or concrete in an effort to protect homes near streams from floods. In addition, population projections estimate that 10,000 acres of current wildlife habitat per year will be needed to accommodate future human growth.[2] The California tiger salamander, red-legged frog, San Francisco garter snake and western pond turtle are examples of wildlife especially hard hit by urbanization.

   The Bay Area's growing population also has the potential to spur shoreline development, causing further losses of wetland habitat. Continued urban development along the Bay shoreline, for example, can harm wetlands either directly, by destroying them dur-

[1] Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

[2] San Francisco Estuary Project. 1999. *Aquatic Organisms and Wildlife.* (http://www.abag.ca.gov/bayarea/sfep/reports/fact/aquaorg.html).

ing construction, or indirectly, by producing polluted runoff and wastewater discharges that may damage wetland plants and wildlife.[3] In fact, urbanization has been one of the major causes of wetlands losses in the past and is directly linked to an expanding population requiring more housing, more transportation and more employment opportunities.[4] Transportation needs, such as ports, airports and highway expansion, pose a major threat to the Bay's remaining wetlands and subtidal habitats.[5]. The loss of shallow subtidal habitats translates directly into potential impacts upon subtidal plant communities, such as eelgrass, and aquatic species, such as halibut, which forage for food in shallow subtidal habitats.[6]

Finally, habitat loss caused by economic pressures have the additional detrimental side-effect of permanently excluding marginal habitats, such as diked wetlands, from restoration to tidal marshes. For example, development of diked wetlands for housing, golf courses, business parks, and other large scale land use conversions threaten to encroach into restorable former tidal marsh sites.

2. **Shoreline Erosion.** Sediment supply both maintains and creates wetlands around the Bay by counteracting the natural force of shoreline erosion by Bay waters. Historically, the Sierra Nevada tributaries flowing through the Central Valley and into the Bay have been the main source of sediment, with the Sacramento River accounting for 90 percent of the sediment deposited in the Bay. Since the 1960's, however, with the building of dams and the trapping of sediment behind these dams, sediment supply to the Bay has dropped markedly. One indicator of this decline is the lowering of the bottom of San Pablo Bay as tidal currents move more sediments out of the Bay than are redeposited.[7]

   Complicating the decline in sediments is global warming induced sea level rise. According to the Union of Concerned Scientists and the Ecological Society of America in their recent report on climate change's ecological impacts on California, global models project that sea level will rise 8 to 12 inches by 2100.[8] This change represents a doubling or tripling of the rise which occurred over the last 150 years. With the decline in sediment due to dams and the increase in sea level rise, scientists studying the Bay estimate that sea level rise will outpace sedimentation in the future, thus reducing the chance that natural sedimentation will provide enough sediment to maintain existing tidal marshes.[9] Exacerbating the impact of greater sea level rise is the response expected by shoreline residents working to protect coastal homes, roads and other developments.

   Bulkheads, riprap, revetements and other engineering works placed to fend off the water will cause further losses of wetland habitats, such as tidal marshes and tidal flats, by preventing them from retreating further inland as sea level rises.

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[3] San Francisco Estuary Project. 1999. *Wetlands*. (http://www.abag.ca.gov/bayarea/sfep/reports/fact/wetlands.html).

[4] San Francisco Estuary Project. 1991. *Status and Trends Report on Wetlands and Related Habitats*. San Francisco Estuary Project, Oakland, California.

[5] San Francisco Estuary Project. 1992-1997. *State of the Estuary*. San Francisco Estuary Project, Oakland, California.

[6] San Francisco Airport Advisory Panel,National Oceanic and Atmospheric Administration, San Francisco Bay Conservation and Development Commission. 1999. *Report of the San Francisco Airport Science Panel.*

[7] San Francisco Estuary Project. 1992-1997. *State of the Estuary*. San Francisco Estuary Project, Oakland, California.

[8] Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State*. Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

[9] San Francisco Airport Advisory Panel, National Oceanic and Atmospheric Administration, San Francisco Bay Conservation and Development Commission. 1999. *Report of the San Francisco Airport Science Panel.*

On a similarly grand scale, global warming is expected to affect aquatic life by significantly reducing or eliminating shallow water and channel habitat, in addition to tidal flats around the Bay. For example, shallow water and tidal flat habitats of the South Bay that lie between present mean low water and the lower limit of urban development are almost certain to be lost with any appreciable sea level rise, as they are apt to be converted to flood control structures.[10]

Habitat Degradation. Habitat degradation occurs when some, but not all, of a habitat's functions or values are lost. For example, urban wastewater discharges of freshwater into tidal salt marshes can transform plant communities from saline to brackish. Tidal marshes in Alviso and Milpitas in the South Bay once hosted historic rare plant populations. These rare salt marsh plant communities were replaced by perennial pepperweed, bulrushes and tules with the influx of freshwater from the San Jose Wastewater Treatment Plant.[11] In addition, habitat degradation occurs when public access trails into a marsh are utilized not only by people, but also by non-native predators such as red foxes, which are partly responsible for the decimation of clapper rail populations around the Bay. Finally, pollution pervades and degrades the Bay's habitats in such a way that scoters (a type of duck) visiting during the winter have more pollution in their tissue when they leave than when they arrived.[12] Common forces of habitat degradation include: (1) pollution, (2) uncontrolled public access, (3) modification of freshwater flows, (4) the excavation and filling of wetlands, and(5) agricultural practices.[13]

1. **Pollution.** In its natural state, the Bay exhibited few, if any, adverse effects from pollutants. The sediment and naturally occurring chemicals that entered from upstream were assimilated into the estuarine ecosystem. Due to the advent of urban, industrial and agricultural activities, however, pollution has increased throughout the Bay. Early pollution consisted of mostly sewage, causing algae blooms in the Bay and low levels of dissolved oxygen. Technology introduced in the 1960's and 1970's greatly improved the treatment of municipal wastes and halted many of these problems. Today's pollution problems are much more confounding, consisting of pollution deriving from a variety of sources that are not so easily managed, and are longer lasting in the environment. The Office of Environmental Health Hazard Assessment, for example, recently found that the levels of polychlorinated biphenyls (PCBs), dioxins, chlordane, DDT and dieldrin was high enough in certain fish in the Bay to issue consumption warnings to anglers.[14] The sources of these pollutants are many, including, by-products of industrial processes, termite control, past mining activities and agricultural pest control. Other sources of pollution in the Bay include polluted runoff, low salinity treated wastewater discharge, oil spills, disposal of dredged material, and problems associated with prior solid waste disposal.

    a. **Polluted Runoff.** Polluted runoff is defined as the pollution carried by stormwater runoff to wetlands, creeks and other water bodies.[15] Some of the pollutants carried in polluted runoff include sediment, heavy metals, petroleum hydrocarbons, synthetic

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[10] San Francisco Estuary Project. 1992. *Status and Trends Report on Aquatic Resources in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[11] San Francisco Bay Area Wetlands Ecosystem Goals Project. 1997. *Draft Baylands Ecosystem Species and Communities: Plant Communities.*

[12] San Francisco Estuary Project. 1992-1997, *State of the Estuary.* San Francisco Estuary Project, Oakland, California.

[13] Goals Project, 1999. & San Francisco Estuary Project. Online Reports and Publications. http://www.abag.ca.gov/bayarea/sfep/reports/fact/wetlands.html.

[14] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. 1999. *Summary of the Chemicals of Concern Found in Fish: San Francisco Bay Pilot Study, 1994.* (http://www.oehha.ca.gov/scientific/FISH/sfpilot.htm).

[15] (Unpublished Final Staff Report) – San Francisco Bay Conservation and Development Commission. 1999. *Polluted Runoff in the North Bay Planning Area.* San Francisco Bay Conservation and Development Commission. San Francisco, California.

organic chemicals, and bacteria or viruses. In fact, the vast majority of metal pollution in San Francisco Bay comes from polluted runoff, accounting for anywhere between 30 to 70 percent of all toxic loads in the Bay.

Together the pollutants found in polluted runoff cause broad environmental damage to wetlands, riparian habitats, the Bay and the plant and animal species that live, rest and feed in these habitats. For example, sediment smothers aquatic spawning and feeding areas, clogs the gills of fish, and physically silts up wetlands. In the long run, excess sediment reduces wetland fish, shellfish and plant populations, thus making the wetlands less productive. Heavy metals disrupt fish and shellfish reproduction and accumulate in fish tissues, which can cause brain damage, birth defects or miscarriages when consumed by people. Petroleum hydrocarbons, which come from oil and gasoline, accumulate in sediments, kill fish at low concentrations, and change reproductive and feeding behavior. Eventually these hydrocarbons can be passed on to humans through the food chain and cause cancer.

In addition, synthetic organic chemicals, such as those found in paints, pesticides and household cleaners, inhibit bone development and induce abortion in fish. Bacteria and viruses contaminate shellfish and cause diseases. Finally, the physical changes resulting from pollutants in the ecosystem, such as an increase in temperature or salts, can damage aquatic species by causing loss of habitat, poor survival of juveniles, poor reproduction, slowed growth, and death among other effects.[16]

b. **Low Salinity Treated Wastewater Discharge.** Treated wastewater enters the Bay from 40 different municipal wastewater treatment plants, which discharge 600 million gallons of treated wastewater each day.[17] Most Bay Area municipal wastewater treatment plants discharge effluent to deepwater areas of the Bay with strong tidal currents. The effects of treated wastewater discharged into deepwater habitats is not discussed by the Goals report, however, the impacts upon wetland habitats are better quantified. For example, about eight percent of the marsh near the San Jose/Santa Clara Water Pollution Control Plant's outfall was converted from saltwater marsh to brackish marsh in 1997-1998.[18] Guadalupe Slough and Artesian Slough in the South Bay have also suffered similar plant community conversions, due in part to the influence of freshwater discharges. Specifically, treated wastewater flowing into wetlands makes the habitat fresher, thus, not only impacting salt marsh plant communities, but also harming salt marsh dependent species by modifying and degrading their habitat.

c. **Oil Spills.** Oil spills threaten the well-being of wetland habitats, aquatic habitats and the species associated with these habitats. Waterbirds are especially impacted, as the oil destroys the insulating quality of their feathers, allowing hypothermia to set-in. Oil spills have occurred in the Bay since the 1800's, but regulations since the 1950's have reduced chronic spillages and bilge discharges into the Bay. Spills do still occur, however. For example, in April 1988, a spill at the Shell Oil Refinery near Martinez resulted in 8,700 barrels of crude oil being released into the Bay. A total of 455 individual waterbirds were recorded as killed or oiled during the incident. The spill also affected 64 mammals, including muskrats and river otters. Nearly 760 acres of adja-

[16] U.S. Environmental Protection Agency. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* U.S. Environmental Protection Agency, Office of Water, Washington D.C.
[17] Goals Project, 1999.
[18] San Francisco Estuary Project, Friends of the San Francisco Estuary. October1999. Vol.8, No.5. *Estuary.* San Francisco Estuary Project, Friends of the San Francisco Estuary, Oakland, California.

cent tidal marsh habitat was polluted with oil, contaminating habitat used by rare species such as clapper rails, black rails, Suisun song sparrows, Suisun shrews and salt marsh harvest mice.[19]

Oil refineries operating around the Bay, along with the fleet of large capacity ocean-going tankers, increase the risk of oil spills in the Bay. For example, a large spill from a refinery or tanker during the height of the migratory waterfowl season could significantly impact local wintering populations for a long time. Moreover, because San Francisco Bay is a major shipping center, the threat of spills from other commercial and military vessels also exists. Recent studies by scientists have shown that even small oil slicks have profound impacts on bird populations, due initially to bird mortality and then to the cumulative effects over time of less birds reproducing and migrating. Therefore, a small spill that is restricted to a localized area can have a major impact over a wide region.[20] In addition, birds are slow to reproduce, making population recovery even more difficult to achieve after a spill. Bird species most vulnerable to the effects of an oil spill include: loons, western grebes, horned grebes, scaup, ruddy ducks, scoters, canvasbacks, common murres, cormorants, and brown pelicans.

While oil tends to stay on the surface of the water, dispersants used to combat oil spills have the potential to break up oil into fine globules, which then are able to enter the water column. Once in the water column, oil globules pose a risk to fish and other aquatic organisms. For this reason, dispersant use has been resisted by many as a means to moderate the impacts of oil spills.

d. **Disposal of Dredged Material.** Dredged material disposal and reuse present both opportunities and threats to the Bay's habitats. According to the Long-Term Management Strategy, Final Environmental Impact Statement and Environmental Impact Report,[21] disposal of material dredged from Bay shipping channels and ports and disposed of in-Bay may have six primary impacts on the Bay ecosystem. These potential impacts include: (1) redistribution of pollutants and/or the release of contaminants during dredging and disposal, (2) the burial of bottom-dwelling organisms,(3) the resuspension of sediment particles and resulting turbidity, (4) changes in the native sediment characteristics near disposal sites, (5) impacts on migrating special status species such as the winter-run Chinook salmon, and (6) degradation of subtidal habitat that may lead to reduced fishing success.

However, the reuse of dredged material does have potential benefits. Dredged materials can be used to complement natural sediment deposition during tidal marsh restoration.[22] For instance, restoring tidal marsh or creating shallow ponds for wildlife in subsided areas may require elevating the bottom substrate. Using dredged material is a way to accelerate this process, especially where the suspended sediment supply is limited. Where dredged material is used to raise elevations of subsided lands for tidal marsh restoration, care must be taken to avoid potentially negative effects such as

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[19] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[20] San Francisco Chronicle. January 4, 2000. *Minor Oil Slicks Can Be Lethal to Marine Birds, Scientists Say.* San Francisco Chronicle, San Francisco, California.

[21] U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, State Water Resources Control Board. 1998. *Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region: Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report.* Science Applications International Corporation Environmental Programs Division. San Francisco, California.

[22] Goals Project, 1999.

overfilling, burying historic slough traces, and inhibiting proper slough channel formation. Also, the risk of adverse effects of contaminants on water quality, plants and animals must be addressed on a project-by-project basis.

e. **Problems Associated with Prior Solid Waste Disposal**. Solid waste disposal sites have historically been located in wetlands around the Bay, especially prior to the establishment of BCDC. Problems associated with solid waste disposal include wetland degradation from leakage of material disposed of in the sites, including hazardous wastes. Overall, solid waste disposal sites damage wetland ecology and the ability of the habitat to support plant and animal life.[23]

2. **Uncontrolled Public Access.**[24] In recent years the public has become increasingly interested in gaining access to the Bay's shoreline for recreational enjoyment. BCDC, in particular, requires maximum feasible public access to be an integral part of shoreline development projects. However, there is evidence that public access may have adverse effects on wildlife, both direct (such as harassment or harvest) and indirect (such as habitat modification). In addition, effects can be both immediate and long term. Immediate effects may include nest abandonment (which may increase risk of predation of eggs or young), flushing, and increased stress, which can lead to reduced feeding or site abandonment. Long-term effects may include decreased reproductive success, decreased populations within a species or decreased total number of species. Furthermore, if improperly sited, public access may fragment habitats and serve as predator access rotes to wildlife areas.

   In light of potential effects of public access on wildlife, BCDC undertook in 1999 an in-depth two year research and policy development process, the Public Access and Wildlife Compatibility Policy Development Project, which would lead to revisions of policies in the *San Francisco Bay Plan*. The Project included the year-long participation of a broadly representative Policy Advisory Committee, and a nationwide opinion survey of natural resource area and park and recreation managers concerning the effects of public access on wildlife and the use of siting, design and management strategies to avoid or minimize potential adverse effects on wildlife.

   Conclusions from the Project included: (1) access to the Bay allows the public to discover, experience and appreciate the Bay's natural resources and can foster public support for Bay resource protection; (2) there is a need for more scientific studies of effects of human activities on wildlife, both on a local Bay scale and nationwide; (3) studies indicate that public access may have immediate effects on wildlife (including flushing, increased stress, interrupted foraging, or nest abandonment) and may result in adverse long-term population and species effects; (4) different kinds of disturbances have different effects on different species – effects are context dependent; (5) potential adverse effects from public access may be avoided or minimized through the employment of siting, design and management strategies, such as education and outreach programs, activity type and user behavior restrictions, buffers, and periodic public access closures; and (6)providing diverse and satisfying public access opportunities can reduce the creation of informal access routes to decrease interaction between humans and wildlife, habitat fragmentation, and vegetation trampling and erosion, and formal public access provides for more predictable human actions, which may increase the ability of wildlife to adjust to human use.

   The culmination of BCDC's *Public Access And Wildlife Compatibility Project* resulted in the Commission adopted revisions to its *San Francisco Bay Plan* public access findings and

[23] Goals Project, 1999.

[24] This section is adapted from: San Francisco Bay Conservation and Development Commission. 2000. Staff Report: *Public Access and Wildlife Compatibility*.

policies in March 2001. The revised findings and policies (expected to be in effect by August 2001) better reflect current knowledge on the interactions of public access and wildlife and provide more detailed policy guidance on how to provide for maximum feasible public access while protecting wildlife from significant adverse effects. As a component of the revised findings and policies, BCDC staff is currently undertaking an update of its advisory *Public Access Design Guidelines* to include information on specific siting, design and management strategies to avoid or minimize adverse effects of public access on wildlife.

3. **Modification of Freshwater Flows.** Freshwater flows to the Bay are critical to the healthy functioning of the Bay's ecosystem. These flows influence salinity gradients, affect shallow bay habitats, contribute sediments to maintain the marsh plain, and provide energy to the aquatic ecosystem. Changes in the volume and timing of freshwater flows have dramatically affected the Bay's habitats in measurable ways since about the 1920's, when diversions from the Sacramento and San Joaquin rivers began to increase markedly.

   Under natural conditions the seasonal timing of freshwater flows would differ between the Sacramento and San Joaquin river system and the local watersheds of the Bay Area. For the Sacramento and San Joaquin rivers, flows would generally increase in late fall, with the onset of the wet season, and continue to increase throughout the winter, peaking in spring during snowmelt, then declining to annual low levels during summer. For the local watersheds that do not get snow, the freshwater flows would peak in winter, rather than in spring. Many of the native species of fish and wildlife are adapted to these different flow regimes.

   While the effects of freshwater diversions are Bay-wide, the most obvious changes in the Bay occur upstream of Carquinez Strait. The overall effect of altered seasonal flows from the Central Valley has been to increase salinity in Suisun Bay during spring and summer and to decrease it during the fall and winter. In dry years, relatively high salinities now occur yearlong. On a smaller scale, hydrological changes in local streams have altered the salinity gradients and salinity regimes where they flow into the Bay, and this has affected the plant communities and habitat functions of tidal marshes.[25]

   The impact of water diversion on aquatic life are multi-faceted and severe. These impacts include entrainment of fish, the transport of aquatic life into new areas, changes in the distribution of temperature and salinity, alteration and confusion of migration patterns of spawning adults or outmigrating juvenile fish, and the entrainment of other sources of food important to the Bay's food web.[26] These problems are either exacerbated or improved based on whether California's weather cycle is in a drought year or a wet year. For example, a higher proportion of water is diverted during years of drought, therefore, greater numbers of fish are entrained. Also, smaller river volumes during periods of drought increase the density of young fish found in river channels, thus permitting easier foraging by predators. On the other hand, when flows are greater during wet years, the diversity of habitats available increases, especially shallow habitats where young fish enjoy greatly reduced predation pressures. Also, it is worth noting that some anadramous and marine fish species that spawn in the Bay require a sufficient plume of freshwater to allow them to find their way into the Golden Gate.

   Moderately high spring/summer flows also increase zooplankton abundance in the Bay, resulting in more available food for larval striped bass and smelt. This increase in zooplankton abundance during high outflow years is dependent upon sufficient phytoplankton abundance, zooplankton's primary food source. Sufficient phytoplankton

[25] Goals Project, 1999.

[26] San Francisco Estuary Project. 1992. *Status and Trends Report on Aquatic Resources in the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

abundance, in turn, is directly linked to the null zone and freshwater outflow. Scientists have found that the best location for the null zone is in Suisun Bay, where light levels stimulate the greatest amount of phytoplankton production in the shallow shoals. When freshwater outflow is decreased, the null zone retreats into the San Joaquin River, thus causing lower production rates of phytoplankton and also entrainment caused by export pumps.[27] The loss of phytoplankton during periods of low freshwater outflow from the Delta can have detrimental ripple effects throughout the aquatic food web.

To the greatest extent possible, the volume and timing of freshwater flows to the Bay should reflect historical or natural conditions under which the habitats, as well as the aquatic life and wildlife of the Bay evolved. Appropriately timed increased freshwater flows in tributaries as large as the Sacramento River, and as small as the intermittent streams of South Bay, would improve the diversity and functions of the Bay's habitats.[28]

4. **Excavation and Filling of Wetlands.** Section 66605 of the state McAteer-Petris Act and the *San Francisco Bay Plan* regulates the placement of fill in the Bay's tidal wetlands through a permitting process. This permitting process exists due to the detrimental impacts upon the Bay's resources caused by Bay fill. These impacts include the destruction of aquatic life and wildlife habitat, water pollution, and the overall diminishment of the scenic beauty of the Bay. Furthermore, Section 66632 of the McAteer-Petris Act expresses that within the Commission's jurisdiction, any person or governmental agency wishing to extract materials or make any substantial change in use must also receive permission from the Commission.

   Section 404 of the federal Clean Water Act regulates the placement of fill in wetlands, but does not have the authority to regulate soil removal, including the activities of land clearing, ditching, channelization, and even creating a pond.[29] The U.S. Army Corps of Engineers and the Environmental Protection Agency attempted to rectify this loophole in the Clean Water Act by presenting the problem to Congress in 1993. Denied an expansion of authority by Congress, the Corps and EPA redefined "discharge" in the Clean Water Act to include land clearing and excavation. Known as the Tulloch Rule, the modified interpretation was brought to court by landowners and overturned, meaning that landowners currently do not need a permit to excavate within a wetland.

5. **Agricultural Practices.** Some agricultural practices can harm wetlands, including disturbances of habitat due to planting, cultivation and mowing. Riparian habitats are harmed by grazing and contamination of water by manure. Deep-ripping and other practices affect hydrology, and levee maintenance and construction can also impact habitats. Polluted runoff carrying pesticides and herbicides have especially detrimental impacts on habitats. For example, diazinon and methidathion have been traced from orchards, rice fields and other crops to the Sacramento and San Joaquin Rivers. Eventually they end up in Suisun Bay where they become part of the food web.[30] Generally, the more intensive the agricultural practice, the less compatible the activity is with wetlands and wildlife. In

[27] Hollibaugh, James T. 1996. *San Francisco Bay, The Ecosystem: Further Investigations into the Natural History of San Francisco Bay and Delta with Reference to the Influence of Man.* Pacific Division of the American Association for the Advancement of Science c/o California Academy of Sciences, San Francisco, California.

[28] Goals Project, 1999.

[29] Environmental News Network. January, 19, 1999. *Landowners Win Wetlands Case.* (http://www.enn.com/news/enn-stories/1999/01/011499/tulloch.asp).

[30] San Francisco Estuary Project. 1992-1997. *State of the Estuary.* San Francisco Estuary Project, Oakland, California.

the Central Valley, for example, advances in farming promoting greater efficiency have adversely affected wildlife by leaving less grain waste, fewer weed seeds, and less cover for wildlife.[31]

Agricultural lands in many instances, however, provide important habitats and high tide refuge to wetland and wetland-related species. Furthering the linkage between agricultural practices and habitat health, Resource Conservation Districts (RCD) around the Bay Area offer technical assistance to farmers on how to minimize impacts to wetlands by applying best management practices, such as low-impact grazing strategies and runoff control.[32] Napa County's RCD, for example, has taken a leadership role in working with farmers to develop watershed plans for the North Bay.

[31] San Francisco Estuary Project. 1992. *Status and Trends Report on Wildlife of the San Francisco Estuary.* San Francisco Estuary Project, Oakland, California.

[32] Personal Conversation with Leora Elazar, staff member of San Francisco Bay Conservation and Development Commission.

CHAPTER 4

INVASIVE SPECIES

Invasive species are currently considered the primary threat to the Bay's biological diversity (biodiversity). Over 170 non-native species now inhabit the Bay. These species can crowd out native species, prey upon them, and disturb their habitats. Invasive species can also cause significant economic harm (for example, by damaging maritime structures or impairing water delivery systems).

The Bay's aquatic, wetlands, and upland environments have all been affected by invasive species. For example, the Bay's wetlands have been greatly impacted by these invasive species. Invasive species are now strongly contributing to the further demise of endangered wetland birds and mammals. Some native marsh species have been displaced by non-natives (for example, the native mudsnail *Cerithidea* has been displaced in some areas by introduced mudsnails). Other native wetland species, such as the endangered clapper rail, are preyed upon by the invaders (such as Norway rats or red fox). In some cases, the invading species have changed the very structure of the wetland habitat, to the detriment of some native inhabitants (for example, by colonizing the mudflats, Atlantic cordgrass (*Spartina alterniflora)* can reduce shorebird feeding habitat).

This chapter defines invasive species, describes the extent of the problem, and provides examples of the economic and ecological impacts of invasive species. The background data for this section, unless otherwise noted, is derived from Cohen and Carlton's seminal 1995 report on invasive species in San Francisco Bay, entitled *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of Biological Invasions of the San Francisco Bay and Delta.*[1]

What is an "Invasive Species?"[2] An invasive species is an organism that is not native to the Bay, yet thrives and reproduces in it. Invasive species are also called non-indigenous or non-native species, introduced species, exotic species, pest or weed species, and in the context of water, nuisance aquatic species. Although each term may be a bit different, the concepts refer to an organism living and reproducing outside of its natural range. The process of the species entering the Bay and establishing itself is called a biological invasion, or "bioinvasion."

An invasive species can be a plant, animal, fish, insect, or any other type of organism. Some of these species invade land (terrestrial) habitats, while others invade water (aquatic) habitats. For example, the Bay's wetlands have been invaded by plants such as smooth cordgrass from the Atlantic Coast (*Spartina alterniflora*) and pepper weed (*Lepidium latifolium*), and creatures such as the red fox, the Atlantic green crab, and others. The Bay itself has been invaded by almost every category of creature, including fish, jellyfish, clams, crabs, mosses, barnacles, sea slugs, and a host of other life forms. Upland invaders include yellow star thistle (a grasslands invader) and *arundo donax,* a bamboo-like plant that chokes river and creek habitats and has little or no habitat value for native species.

San Francisco Bay: A Highly Invaded Ecosystem. A brief survey of the Bay reveals how dominant invasive species have become. At the Bay's mouth, under the shadow of the Golden Gate Bridge, orange-red clumps of the Indo-Pacific moss animal *Watersipora,* 30 centimeters across and 20 centimeters deep, covers the dock sides. To the north, in San Pablo and Suisun bays, the Chinese clam *Potamocorbula* forms thick beds in the mud while Japanese gobies and

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[1] Cohen, A.C. and J.T. Carlton. 1995. Nonindigenous Aquatic Species in a United States Estuary: A Case Study of Biological Invasions of the San Francisco Bay and Delta. U.S. Fish and Wildlife Service and National Sea Grant Report No. PB96-166525. This report is available on line at http://nas.er.usgs.gov/publications/sfinvade.htm

[2] This section was not derived from the Cohen and Carlton report.

Korean shrimp swim overhead. In a brackish river a few kilometers away, large, coral-like masses formed from the calcareous tubes of an Australian worm harbor an abundant population of the Atlantic shore crab *Rhithropanopeus*.

Along the eastern and southern Bay shores, great masses of Atlantic and Asian seasquirts comprise the dominant fouling biota along with dense populations of bay mussels, represented in San Francisco Bay by both the native *Mytilus trossulus* and the Mediterranean *Mytilus galloprovincialis*. On the fringes of the Bay, dense beds of the New England ribbed mussel bind the upper intertidal sediments and lower marsh fringes, colonies of the Atlantic cordgrass *Spartina alterniflora* encroach upon the mudflats, and a New Zealand burrowing creature inexorably bores into the clay and mud banks of the Bay's shore. Moving in seasonal migrations over the mudflats, vast herds of the Atlantic mudsnail *Ilyanassa* rework the uppermost layers of sediment above the subsurface beds of the Atlantic softshell clam and the Japanese littleneck clam.

The exact composition of these invasive communities can change significantly, depending on the season, the amount of freshwater runoff or saltwater intrusion, the level of pollution, and other factors. However, the overall effect remains the same: the dominant members of many of the Bay wetland and aquatic communities are organisms that were not present 150 years ago.

The introduction of non-native species has earned the San Francisco Bay-Delta estuary the dubious distinction of being "the most invaded aquatic ecosystem in North America." The Bay has approximately 170 introduced species, and 115 that are not clearly introduced or native ("cryptogenic").[3] Moreover, the rate of invasions has been increasing. Between 1850 and 1970, an average of one new species established itself in the estuary every 46 weeks; now a new species establishes itself every 14 weeks.[4]

Exotic species reach the Bay in many ways. Some arrive in ship ballast water which is extracted from foreign waters and discharged into the Bay when the vessels take on or off-load cargo in the Bay Area. Some species, such as striped bass and various oysters or clams, were introduced purposefully for growing and harvest in the Bay.

In general, aquatic pests are generally transported to the Bay in four ways: (a) through vessels (either in solid ballast, ballast water, or hull fouling organisms); (b) through fisheries, marsh restoration, or biocontrol activities (where species are released to prey on other pest species); (c) by other commercial and private activities, such as when individuals release creatures to establish food sources (for example, carp or clams), or releases and escapes from residential ponds and aquariums; and (d) through scientific research. These introductions are often unintentional and occur through routine activities or materials such as seaweed packing for live baitworms and lobsters, agricultural seed, or dredging equipment. One mode of introduction which has been especially damaging to the Bay's tidal marsh and tidal flat habitats is the planting of non-native cordgrass species at specific sites around the Bay for landscaping and restoration purposes.

Because most introductions to the Bay occur through ballast water, the San Francisco Regional Water Quality Control Board (Regional Board) considers it the highest priority pathway for attention. Bait and fish stocking or aquaculture are considered low priorities (particularly since the Bay has no registered aquaculture facilities). Other pathways (such as vessel exterior surfaces) are considered as medium or medium-low priorities for attention.[5]

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[3] Figures from the Cohen and Carlton report have been adjusted to reflect the Bay rather than the Bay-Delta Estuary. These adjustments are based on a personal communication with Dr. Andrew Cohen of SFEI, 10/99.

[4] Dr. Andrew Cohen, San Francisco Estuary Institute. Personal communication.

[5] California Regional Water Quality Control Board, San Francisco Bay Region. April 2000. *Prevention of Exotic Species Introductions to the San Francisco Bay Estuary: A Total Maximum Daily Load Report to the U.S. EPA*. Regional Board, Oakland, CA.

Nonindigenous aquatic animals and plants have had a profound impact on the ecology of the Bay. No shallow water habitat now remains uninvaded by exotic species and, in some regions, it is difficult to find any native species in abundance. In some regions of the Bay, 100% of the common species are introduced, creating "introduced communities." In locations ranging from Suisun and San Pablo Bays and the shallower parts of the Central Bay to the South Bay, introduced species account for the majority of the species diversity.

Some species are introduced to the Bay's ecosystem, but do not become highly invasive—in other words, they do not vigorously reproduce and colonize new areas. However, some introduced species that appear to be "well-mannered" become highly invasive after a period of time due to natural time lags, changes in genetic makeup, changes in environmental conditions, or other factors. For example, English cordgrass (*Spartina anglica*) was introduced to the Bay's marshes in Corte Madera, and did not appear to be spreading aggressively. However, after a twenty year lag time, the population of English cordgrass has begun to spread. Although scientists are not certain of the causes, the English cordgrass appeared to undergo a long period of incubation before spreading.[1] In addition, another non-native cordgrass species, *Spartina densiflora,* has recently undergone a population explosion at Corte Madera Creek.

How do Invasive Species Impact the Bay? Invasive species are considered the most serious threat to the Bay's native biodiversity. Invasive species can threaten native plants and animals by preying on them or competing with them for food, habitat, and other necessities. These invasive species, freed from the predators and environmental constraints of their native lands, can sometimes outcompete and displace the native species.

Moreover, native species are often adapted to a certain set of environmental conditions, such as a specific type of food, or a certain physical habitat structure. After an invasive species establishes itself, it can sometimes make sweeping changes to the habitat, such as changing the energy or food cycles, changing the amount of pollutants, or changing the physical structure of the habitat. These changes are akin to altering the "rules of the game" for native species, in many cases making it more difficult for them to thrive.

Thus, invasive species threaten native plants and animals primarily in three ways: (1) by preying on them; (2) by competing with them for food, habitat, and other necessities; (3) by disturbing their habitat, sometimes in a dramatic manner; or (4) by changing their genetic make-up, in the case of certain plant species, through hybridization. For example, native Pacific cordgrass (*Spartina foliosa*) may be eliminated from certain tidal marshes around the Bay due to hybridization with non-native cordgrass species. Habitat disturbance includes changes to the physical structure of the habitat as well as changes to energy or food cycles. Scientists also suspect that invasive species threaten the native ones in two additional ways: (1) by making the food supply more toxic, and (2) by introducing parasites and diseases. Examples of these mechanisms will be explored in greater detail in this chapter.

When invasive species help push native plants or animals onto the endangered or threatened species list, this can result in increased restrictions on development, water diversions, wastewater discharges, channel dredging, levee maintenance, and other important economic activities. Invasive species can also cause economic harm by damaging marine facilities, choking tidal channels, increasing erosion or sedimentation, fouling water intakes, and undermining river and ditch banks. These creatures can also harbor human diseases.

Thus, invasive species can harm both the ecology and the economy of a region. This section provides more detailed examples of the types of ecological and economic changes caused by invasive species in the Bay area.

[1] Dr. Andrew Cohen, San Francisco Estuary Institute. Personal communication

1. **Threatening Native Plants and Animals.** Interactions with invasive species can reduce or eliminate populations of native species. For example, scientists have observed that (a) the introduced Atlantic mudsnail *Ilyanassa* has displaced from mudflats to salt marsh pannes and reduced the population of the native mudsnail *Cerithidea*; (b) introduced green sunfish, bluegill, largemouth bass and the introduced American bullfrog may have contributed to the decline of native red-legged and yellow-legged frogs in the Bay region, largely through predation; (c) introduced red fox, through predation, reduce or limit the recovery of populations of the endangered salt-marsh harvest mouse; (d) introduced crayfish have displaced some native crayfish species and threaten others; (e) introduced peppergrass (*Lepidium latifolium*) may displace rare native marsh plants, such as *Lillaeopsis masoni.*

   Thus, invasive species are now strongly contributing to the further demise of endangered wetlands birds and mammals. The case of the clapper rail, an endangered bird that inhabits the Bay's tidal marshes, illustrates the mechanics of this process in greater detail.

   Norway rats, established in many areas of California by the mid-1880s, have long been recognized as significant predators on clapper rail, starting with early observations such as the following (de Groot, 1927): "the clapper rail has no more deadly enemy than this sinister fellow. No rail dares nest on a marsh area which has been diked, for as surely as she does this vicious enemy will track her down and destroy the eggs. Many nests have I found bearing mute evidence of the fact that some luckless rail had gambled her skill at nest-hiding against the cunning of the Norway rat, only to have her home destroyed." Predation on both rail eggs and rail chicks is considered to be high, with rats taking as many as a third of rail eggs.[2]

   Although present inland in California since the 1870s, the red fox has appeared on the margins of San Francisco Bay, adding another critical clapper rail predator to the ecosystem a century after the appearance of the Norway rat. In California the red fox has preyed on the eggs and sometimes the young or adults, and disrupted nests or colonies, of the clapper rail (as well as other birds, including least tern, snowy plover, Caspian tern, black-necked stilt and avocet).[3] [4]

   The cordgrass zones of salt marshes support the highest clapper rail densities by providing cover and/or isolation from rats, raptors and feral predators,[5] and thus the expansion of these zones by the introduced Atlantic cordgrass *Spartina alterniflora* could benefit rails. Alternatively, competitive replacement of native cordgrass by *S. alterniflora* could reduce preferred cover for the rails.

   Reduction in clapper rail populations by exotic species through processes other than direct predation may also have occurred. In 1927, De Groot[6] reported, under the heading of "the invisible foe," the following concerning the relationship of adult rails to the Atlantic ribbed marsh mussel *Arcuatula demissa*: "This apparently harmless little mussel has been another of the rail's most relentless enemies, and the number of rail deaths attributable to its activities is incredible...Countless millions of these small mussels cover the edges and sometimes the entire bottoms of the gutters and creeks of the west Bay

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[2] Josselyn, M. 1983. *The Ecology of San Francisco Bay tidal marshes: a community profile.* FWS/OBS-83/23. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D.C.

[3] Takekawa, J. 1993. The California clapper rail: Turning the tide? Tideline (East Bay Regional Park District) 13(2): 1-3, 11.

[4] BDOC. 1994. Draft Briefing Paper on Introduced Fish, Wildlife, and Plants in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Bay-Delta Oversight Council, Calif. Resources Agency, Sacramento, 33 pp.

[5] Josselyn, 1983.

[6] de Groot, D. S. 1927. "The California Clapper Rail: its nesting habits, enemies and habitat." Condor 29:259-270.

marshes. Up under the banks, where the rail so commonly feed and hide when the tide is out, these death traps are found in great numbers...Along comes a rail gingerly pecking into the soft mud [and it] rams [its] beak into the open mussel and in an instant the trap is sprung and the rail is helplessly and hopelessly trapped... shaking and scraping and pulling are all in vain...[and] the poor rail eventually [dies] by starvation."

De Groot further believed that "at least seventy-five percent" of the adult rails of the Redwood marsh area in the South Bay had lost toes by entrapment in mussel shells. He argued that this led to the loss of juvenile birds as well: "But while the adult rail generally escapes with merely the loss of a toe or two, young birds must meet death frequently...[there is] some basis for stating that probably one or two chicks in every brood, if not more, meet an untimely end in this manner..." More recent observers note that clapper rails in the Bay are frequently missing one or more toes[7] [8] [9] and Josselyn[10] includes a photograph of an adult clapper rail missing one toe and with an *Arcuatula* clamped to another.

However, the rail/mussel interaction may not be all one sided, as suggested by Moffitt's study of rail feeding,[11] wherein he found in a sample of 18 birds that 66 percent of the animal food of the rail (and 57 percent of the total food) consisted of *Arcuatula*.

Although in some cases invasive species provide food or shelter for native species, on the whole, invasive species pose a tremendous threat to native wetland birds and mammals through predation (for example, the Norway rat preying on the clapper rail) and through direct competition (for example, the Atlantic mudsnail displacing the native mudsnail). Wetland species are also affected by habitat-altering species, such as *Spartina alterniflora* (discussed in greater detail below).

2. **Disturbing Native Habitats through Profound Structural Changes.** Invasive species can profoundly alter the structure of a wetland habitat, often to the detriment of the native inhabitants. For example, the Atlantic salt-marsh cordgrass *Spartina alterniflora* is colonizing the mudflats, resulting in the loss of shorebird feeding habitat. This cordgrass, which has converted hundreds of acres of mudflats in Willapa Bay, Washington into grass islands, has become locally abundant in San Francisco Bay, and is competing and/or breeding with the native cordgrass. *Spartina alterniflora* has broad potential for ecosystem alteration. Its larger and more rigid stems, greater stem density, and higher root densities may also decrease habitat for native wetland animals and fauna. Dense stands of *S. alterniflora* can accumulate sediment, inviting eventual encroachment from invaders such as pampas grass and iceplant while decreasing mudflat habitat. *S. alterniflora*'s dense canopy also decreases production of algae because of lower light levels, thus decreasing the food supply for organisms that directly consume algae.

   Another example is the Australian-New Zealand boring isopod *Sphaeroma quoyanum* which accelerates shoreline erosion in the Bay. This creature, a small crustacean, riddles many Bay shores with half-centimeter diameter holes. This boring activity can weaken rocks and prime them for removal by wave action. In this manner, the creature plays a major, and possibly the chief, role in erosion of intertidal soft rock terraces along the shore of San Pablo Bay. *Sphaeroma* has been burrowing into Bay shores for over a century, and it thus may be that in certain regions the land/water margin has retreated by a distance of at least several meters due to this isopod's boring activities. Thus, in effect, this activity can play a role in converting a tidal habitat to a subtidal habitat.

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[7] Josselyn, 1983.
[8] Takekawa, 1993.
[9] Moffitt, J. 1941. "Notes on the food of the California clapper rail." Condor 43: 270-273.
[10] Josselyn, 1983. P. 69.
[11] Moffitt, J. 1941.

As another example, in some intertidal and subtidal soft-bottom communities in the Bay, dense beds (> 2,000 individuals per square meter) of a type of Asian clam (*Potamocorbula amurensis*) have formed. These dense beds, in addition to other mechanisms, help the clam prevent the successful establishment of other organisms, native or introduced.

Thus, invasive species are physically eliminating or disturbing wetland habitat for native species—the Atlantic cordgrass, by converting mudflats into marshes, the Australian isopod, by chipping away at the land margin of the Bay, and the Asian clam, by creating dense beds in some parts of the Bay. Invasive species are also causing significant structural changes in both aquatic and upland habitats.

3. **Dominating the Food Web.** A vast amount of energy now passes through and is utilized by nonnative life forms in the Bay. In the 1990s, introduced species dominate many of the Bay's food webs. In some cases, these changes can leave less food for native species, or alter the types of food available for native species. Scientists do not yet fully understand the implications of some of these broad, systemic changes. However, the fact that introduced species now dominate many of the Bay's food and energy cycles provide an indication of how much the ecosystem has been altered.

   The major bloom-creating, dominant phytoplankton species are cryptogenic (not clearly native or invasive). Phytoplankton are small organisms that make up the primary food source for the aquatic food chain. Because of the poor state of taxonomic and biogeographic knowledge, it remains possible that many of the Bay's major primary producers—the primary building blocks of the food chain—are in fact introduced.

   Introduced species are abundant and dominant throughout the benthic (bottom-dwelling) and fouling communities of San Francisco Bay. These include 10 species of introduced bivalves, most of which are abundant to extremely abundant. Introduced filter-feeding polychaete worms and crustaceans may occur by the thousands per square meter. On sublittoral hard substrates, the Mediterranean mussel *Mytilus galloprovincialis* is abundant, while float fouling communities support large populations of introduced filter feeders, including mosses, sponges and sea-squirts. The role of the entire nonindigenous filter-feeding guild—including clams, mussels, mosses, barnacles, seasquirts, worms, sponges, hydroids, and sea anemones—in altering and controlling the Bay's food chain remains unknown.

   The potential role of just one filter feeding species, the Atlantic ribbed horsemussel *Arcuatula demissa*, provides insight into the potentially profound impact of introduced filter feeders on the estuary's ecosystems. Studying the energy flow in these mussels in a Georgia marsh, Kuenzler reported that, "The mussels... have a definite effect upon the water over the marsh, daily removing one-third of the particulate phosphorus from suspension. They regenerate a small part of this into phosphate, and reject the remainder in pseudofeces and feces which drop to the mud surface. It appears, therefore, that the mussel population may be very important in the phosphate cycle as a depositional agent, furnishing raw materials to deposit-feeders which regenerate the phosphorus.[12]" The potential tantalizing role of Arcuatula in the economy of Bay marshes as a biogeochemical agent remains to be investigated.

   Introduced clams are capable of filtering the entire volume of the South Bay and Suisun Bay once a day: indeed, it now appears that the primary mechanism controlling phytoplankton biomass during summer and fall in South San Francisco Bay is "grazing" (filter feeding) by the introduced Japanese clams *Venerupis* and *Musculista* and the Atlantic clam *Gemma*. This remarkable process has a significant impact on the standing phytoplankton stock in the South Bay, and since this plankton is now utilized almost entirely

[12] Kuenzler, E. J. 1961. "Phosphorus budget of a mussel population." Limnol. Oceanogr. 6: 400-415.

by introduced filter feeders, passing the energy through the guts of non-native life forms has likely reduced and/or fundamentally altered the energy available for native biota. Furthermore, the sheer dominance of the introduced filter feeders implies a reduction (or displacement) of the native filter feeders. Because of the lack of scientific knowledge about the Bay before 1850, scientists cannot provide precise lists of which native filter feeders have replaced. However, they are certain that this displacement has occurred.

Drought year control of phytoplankton by introduced clams—resulting in the failure of the summer diatom bloom to appear in the northern reach of the Bay—is a remarkable phenomenon. The introduced Atlantic soft-shell clams (*Mya*) alone were estimated to be capable at times of filtering all of the phytoplankton from the water column on the order of once per day. Phytoplankton blooms occurred only during higher flow years, when the populations of Mya and other introduced benthic filter feeders retreated downstream to saltier parts of the Bay. Because the phytoplankton bloom served as a food source, this change implies a decreased food supply for native organisms. For example, when the clam is less populous, the average annual primary production in Suisun Bay is 106 grams of carbon per square meter; when the clams are more prevalent, the mean annual production is only 39 grams of carbon per square meter.

Phytoplankton populations in Suisun and San Pablo Bays may now be continuously and permanently controlled by introduced clams. Arriving by ballast water and first collected in the Bay in 1986, by 1988 the Asian clam *Potamocorbula* reached and has since sustained average densities exceeding 2,000/m^2. Since the appearance of *Potamocorbula*, the summer diatom bloom has disappeared, presumably because of increased filter feeding by this new invader. The *Potamocorbula* population in the northern reaches of the Bay can filter the entire water column over the channels more than once per day and over the shallows almost 13 times per day, a rate of filtration which exceeds the phytoplankton's specific growth rate and approaches or exceeds the bacterioplankton's specific growth rate. Thus, scientists suggest that *Portamocorbula* has added a striking and persistent 'top down' level of control to biological productivity in the Bay. In layman's terms, this Asian clam appears to be hogging the food supply for native species.

Further, the Asian clam *Potamocorbula* feeds at multiple levels in the food chain, consuming bacterioplankton, phytoplankton, and zooplankton (copepods), and thus substantially reduces copepod populations both by depletion of the copepods' phytoplankton food source and by direct predation. In turn, under such conditions, the copepod-eating native opossum shrimp *Neomysis* appears to suffer a near-complete collapse in the northern reach. It was during one such pattern that mysid-eating juvenile striped bass suffered their lowest recorded abundance.

This linkage provides a direct and remarkable example of the potential impact of an introduced species on the Bay's food webs. In essence, the introduced Asian clam reduced the standing stock of phytoplankton, which lead to a decline in zooplankton, which in turn lead to a decline in fish (in this case, striped bass).

As with the guild of filter feeders, the overall picture of the impact of introduced surface-dwelling and shallow-burrowing grazers and deposit feeders in the Bay is not fully known. The Atlantic mudsnail *Ilyanassa* is likely playing a significant—if not the most important—role in altering the diversity, abundance, size distribution, and recruitment of many species on the intertidal mudflats of San Francisco Bay. Millions of migrating mudsnails sweep large areas of mudflat clear of diatoms sitting on the mud surface,[13] and *Ilyanassa* has further been shown to be an opportunistic omnivore, consuming tube-building worms and periwinkle snail egg cases.[14]

The arrival and establishment in 1989-90 of the Atlantic green crab *Carcinus maenas* in San Francisco Bay signals a new level of food web change and alteration. The green crab is a food and habitat generalist, capable of eating an extraordinarily wide variety of animals and plants, and capable of inhabiting marshes, rocky substrates, and fouling communities. European, South African, and recent Californian studies indicate a broad and striking potential for this crab to significantly alter the distribution, density, and abundance of prey species, and thus to profoundly alter community structure in the Bay to the detriment of many native plants and animals. In other words, by becoming an important carnivore in the marshes, rocky substrates and fouling communities, the crab has potential to dramatically alter the food web.

In short, these invasive species have altered the food web in many ways, for example, by controlling plankton and phytoplankton, or by introducing significant new carnivores. In some cases, these changes can leave less food for native species, or alter the types of food available for native species. Moreover, the fact that invasive species now dominate many of the Bay's food webs indicate that the Bay's native ecosystem has been extensively altered.

4. **Increasing Toxicity and Introducing Disease.** Invasive species can also introduce diseases or parasites (such as cholera or swimmer's itch). For example, cholera is transported by ballast water, including ships that report "no ballast on board" (NOBOB), which have unpumpable ballast water and sediments that may contain invasive organisms. One cholera case was treated in the San Francisco Bay in 1996. In this case, cholera was contracted by a merchant marine on an aircraft carrier at Alameda Naval Air Station. The merchant marine dropped his hammer into bilge water and subsequently retrieved it. Since cholera has a six-day incubation period, and the victim had not been out of the country for over a month, the exposure to this disease likely resulted from bilge water.[15]

   Ballast water in other regions has been found to contain red tide organisms (unfortunately the pathogen and toxic dinoflagellates composition of ballast water discharges in San Francisco Bay have not yet been characterized).[16] In 1997, a red tide was reported in the Berkeley marina. This red tide was found to be caused by a dinoflagellate species from tropical and subtropical coastal waters around the world. Noxious odors developed and organisms on pilings and the sides of floats sloughed off. The incident raised concerns about potential impacts to humans, fish, and other organisms. Reddish water was soon after reported in the Oakland Outer Harbor and in Berkeley's Aquatic Park, where workers removed 50 – 75 dead fish. It is not known definitively whether the toxic bloom in San Francisco Bay resulted from the warm waters associated with El Nino, or if this dinoflagellate was discharged in ballast water.[17]

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[13] JTC, pers. obs., Barnstable Harbor, MA.

[14] Brenchley, G. A. and J. T. Carlton. 1983. "Competitive displacement of native mud snails by introduced periwinkles in the New England intertidal zone." Biol. Bull. 165: 543-558.

[15] Benjamin, Bob, and Linda Frank. Alameda County Dept. of Public Health. Personal Communication as cited in California Regional Water Quality Control Board, 2000.

[16] Cohen, Dr. Andrew. 1988. *Ships' Ballast Water and Introduction of Exotic Organisms into the San Francisco Estuary: Current Status of the Problem and Options for Management.* San Francisco Estuary Institute, Richmond, CA.

[17] Cole, B., and A.N. Cohen. 1998. "Red Tide in Berkeley Marina Raises Concern for Toxic Blooms in Central Bay." IEP Newsletter 11(1) 11-13.

Beyond cholera and red tide organisms, local public health experts note that other pathogens that could be transported by ballast water, including *V. vulnificus* (which causes sepsis/shock), *Vibrio bronchosepticum* (which causes pulmonary dysfunction), and *V. aeromonas* (a self-limiting diarrheal illness).[18]

Invasive disease-bearing organisms may also impact native species. For example, the loss of some native shellfish may actually be a result of an introduced parasite rather than result of direct competition by invasive species. However, it is difficult to confirm the disease-related loss of due to the lack of epidemiological studies of small organisms in the Bay. Globally, marine disease epidemics may be affecting less visible species, many of which may be disappearing without notice.[19]

Scientists also believe that invasive species may threaten the native ones by making the food supply more toxic in some cases. For example, invasive clams can make selenium more available in the food web, thus resulting in the accumulation of harmful levels of selenium in the tissues of diving ducks. *Illynassa obsoleta* provides another example. This invasive mud snail is a major prey species for the endangered California clapper rail. However, this particular mud snail bioaccumulates mercury, selenium, and silver at higher rates than other prey species of the clapper rail.[20] Thus, invasive species can concentrate contaminants in the food web, thereby canceling out or reducing the effectiveness of various pollution prevention or treatment efforts.

5. **Impeding Scientific Studies.** Invasive species can also impede our scientific efforts to understand the Bay. For example, these creatures may cast doubt on 15 years' worth of water quality monitoring data, since the new invasive species appear to filter contaminants at different rates than the native species.

6. **Economic Impacts.** The economic impacts of invasive species are complex and poorly quantified. However, as in the case of the introduction of non-native cordgass species into Bay tidal marshes, it is estimated that as of 2001 well over 1200 acres of recently restored marsh has been invaded. The cost of these marsh restoration projects, in total, were in the millions. Positive impacts have included the value of food resources and recreational (sportfishing) resources provided by some introductions of fish and shellfish; the biological control of nuisance insect populations (e. g. by mosquito fish); and fish and wildlife enhancements such as the provision of food, habitat or other resources for valued species. (Table 4). Major negative impacts have included the fouling and blocking of waterways and water delivery systems; damage to or impairment of maritime structures and vessels (e. g. damage to wharves, docks, ferry slips and ships' hulls by marine wood-boring organisms; increased fuel and maintenance requirements resulting from hull fouling); disruption or impairment of vital services; damage to populations of economically important fish and wildlife species; the costs (both direct and indirect) of control efforts; and the inability, in the face of continuous new introductions, to adequately manage the Bay-Delta estuary's ecosystem, resulting in restrictions on activities in and near the Bay (see Table 5).

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[18] Baxter, Roger, M.D. Ente Hospital, as cited in California Regional Water Quality Control Board, 2000.

[19] Harvell, C.D., K.Kim, J.M. Burkholder, R.R. Colwell, P.R. Epstein, D.J. Grimes, E.E. Hoffman, E.K. Lipp, A.D.M.E. Osterhaus, R.M. Overstreet, J.W. Porter, G.W. Smith, and G.R. Vasta. 1999. "Emerging Marine Diseases—Climate Links and Anthropogenic Factors." Science 285:1505-1510.

[20] Schwarzbach, S.E., J.D. Henderson, C. Thomas, and J.D. Albertson. 2000. *Organochlorine Concentrations in Clapper Rail (Rallus longirostris obsoletus) Eggs and Mercury, Selenium, and Silver Concentration sin Rail Eggs, Prey, and Sediment from Intertidal Marshes in South San Francisco Bay*. Draft U.S. Fish and Wildlife Report, March 8, 2000.

Table 4
Positive Economic Impacts of Invasive Species in the San Francisco Bay-Delta Estuary (adapted from Cohen and Carlton, 1995)

ORGANISMS CAUGHT FOR FOOD, FUR, OR SPORT

- Striped bass, American shad, and other fishes
- Asian clams and snails
- Watercress
- Muskrat

BAIT

- Various fish and invertebrates sometimes used for bait

BIOCONTROL

- Mosquito fish contributes to the control of mosquitoes. However, other species that were introduced for biocontrol (such as blue catfish or South American weevils) have sometimes been unsuccessful or have even harmed desirable species.

EROSION CONTROL

- Atlantic cordgrass may be reducing erosion at San Bruno slough

Government introductions of organisms for sport fishing, as forage fish, and for biocontrol have frequently not produced the intended benefits, and have sometimes had harmful side effects, such as reducing the populations of economically important species. Few nonindigenous organisms that were introduced to the estuary by other than government intent have produced economic benefits. The clams *Mya* and *Venerupis*, both accidentally introduced with oysters, have supported commercial harvesting in the Bay or elsewhere on the Pacific coast, and a small amount of recreational harvesting in the Bay (though these clams may have, to some extent, replaced edible native clams); the Asian clam *Corbicula* is commercially harvested for food and bait in California on a small scale; the Asian yellowfin goby is commercially harvested for bait; muskrat are trapped for furs; and the South African marsh plant brass buttons provides food for waterfowl. There do not appear to be any other significant economic benefits that derive from non-governmental or accidental introductions to the estuary.

Although poorly quantified, harmful economic effects appear to be quite large. For example, a single introduced organism, the shipworm *Teredo navalis*, caused $615 million (in 1992 dollars) of structural damage to maritime facilities in three years in the early part of the twentieth century. The economic impacts of hull fouling and other ship fouling alone are clearly very large. Most of the fouling incurred in the Bay is due to nonindigenous species. Indirect impacts due to the use of toxic anti-fouling coatings may also be substantial. Waterway fouling by introduced water hyacinth has become a problem in Suisun Bay and the Delta over the last fifteen years, with other introduced plants beginning to add to the problem in recent years. Hyacinth fouling has had significant economic impacts, including interference with navigation. Although economic impact estimates are not available for the Bay for each species, the nationwide costs of the Asian clam are estimated at one billion dollars annually, and the costs of the green crab at $44 million annually.[21]

[21] Sheehan, Linda, Center for Marine Conservation. 5/11/00. Presentation at the Vessels and Varmints Workshop.

Table 5
Negative Economic Impacts of Invasive Species in the San Francisco Bay-Delta Estuary (adapted from Cohen and Carlton, 1995)

WATERWAY FOULING • Water hyacinth • European milfoil • Elodea	• Navigational and recreational impacts (such as fouling propellers and water intakes of boat engines, or causing marinas to close) • Interference with salmon migration • Costs of herbicide applications (including environmental and occupational health costs) • Costs of biocontrol efforts, mechanical removal & disposal.
FOULING OF VESSELS AND MARITIME STRUCTURES • Many kinds of plants and animals, such as seaweeds, sponges, mussels, barnacles, etc.	• Increased friction for ships and boats, resulting in slower speed, increase fuel costs, reduced maneuverability, and reduced effectiveness of military vessels. • Cost of anti-fouling coatings and associated pollution. • Occupational health costs of anti-fouling compounds • Increased maintenance costs, e.g., time spend in drydock
WOOD BORING • Shipworms • Isopods	• Damage to wooden maritime structures and vessels • Service disruption • Increase maintenance and construction costs • Impacts from toxic anti-fouling compounds
BURROWING • Muskrat • Crayfish • Isopod *Sphaeroma* • Chinese mitten crab	• Damage to levees, ditch walls, stream banks, shorelines • Damage to styrofoam flotation of marina docks
FOULING OF WATER SYSTEMS • *Corbicula* and others • Water hyacinth	• Increased sedimentation in canals, reducing flow rates • Increased maintenance costs. • Fouled irrigation pumps and fish screens.
PREYING ON AND COMPETING WITH ECONOMICALLY IMPORTANT SPECIES • Many species of fish • Crayfish • Bullfrog • Atlantic oyster drill	• Reduction of populations of commercial and sport fish. • Elimination of the Sacramento perch from native waters • Reductions in populations of certain native fish, crayfish and frogs, contributing to their listing or potential listing as threatened or endangered species, resulting in: 1) interference with water diversions, and 2) construction and development projects. • Costs of control efforts • Kills of nontarget sport fish from biocide applications • Occupational and environmental health costs of biocides • Predators or parasites on oysters, clams, and mussels
PROMOTING UNDESIRABLE SPECIES • Parrot's feather	• Said to provide excellent mosquito habitat
CROP DAMAGE • Crayfish	• Eats rice shoots

Table 5 (continued)
Negative Economic Impacts of Invasive Species in the San Francisco Bay-Delta Estuary (adapted from Cohen and Carlton, 1995)

INTERFERENCE WITH WATER QUALITY MONITORING • Mussels	• Invasive mussels may metabolize contaminants at a different rate, thus rendering water quality data questionable (since past studies were based on a native mussel indistinguishable from the invasive one).
ECOSYSTEM INSTABILITY/MANAGEMENT UNCERTAINTY • Continuous high rate of introductions	• New species may result in unmanageable fluctuations in important species. The need to protect these species may in turn result in added restrictions on many activities from wastewater discharges to dredging to construction.
POTENTIAL FOR DISEASE • Red tide dinoflagellates & others • Oriental lung fluke • Cholera pathogen	• These and other organisms could potentially cause red tides consisting of paralytic shellfish poisons (PSP), cholera epidemics, and debilitating diseases associated with the oriental lung fluke (carried by the Chinese mitten crab).

As another example, the invasive clam *Potamocorbula amurensis* concentrates toxic selenium in the food chain at a much higher rate than before, negatively affecting organisms higher up on the food chain such as diving ducks.[1] Since 1992, oil refineries in the Bay have spent approximately $45 million to remove selenium and to reduce its impacts. This amount does not include money spent on research and development, or subsequent maintenance and operations (such as hazardous waste disposal costs).[2] By elevating the concentration of selenium in the Bay, *Portamocorbula* has effectively undone a significant amount of the oil refineries' investment in pollution control.

Perhaps the greatest economic impacts may derive from the destabilizing of the Bay's biota due to the introduction and establishment of an average of one new species every 14 weeks. This phenomenal rate of species additions has contributed to the failure of water users and regulatory agencies to manage the Bay-Delta estuary so as to sustain healthy populations of anadromous and native fish, resulting in increasing limitations and threats of limitations on water diversions, wastewater discharges, channel dredging, levee maintenance, construction and other economic activities in and near the estuary, with implications for the whole of California's economy.

Bioinvasions and Ballast Water.[3] Ballast water appears to be the most important vector for introducing invasive marine species to the Bay and throughout the world (in part due to global commerce and increased shipping traffic). A recent survey discovered that 58 – 88% of the aquatic invasive species introduced into San Francisco Bay in the last decade originated from ballast water discharges.[4] Moreover, the rate of new invasions from ballast water has increased in recent years.[5] The San Francisco Estuarine Institute estimates that ships arriving from foreign ports discharge over a billion gallons of ballast water in the Bay-Delta estuary each year. A sin-

[1] Luoma, S.N. and R. Linville. 1997. Selenium Trends in North San Francisco Bay. IEP, as cited in California Regional Water Quality Control Board, 2000.

[2] Tang, Lila. California Regional Water Quality Control Board, San Francisco Bay Region. Personal Communication as cited in California Regional Water Quality Control Board, 2000.

[3] The remainder of this report is not derived from the Cohen and Carlton report.

[4] Cohen, Dr. Andrew. May 1999. "Invasions Status and Policy on the U.S. West Coast." San Francisco Estuary Institute, Richmond, CA.

[5] National Research Council. 1996. *Stemming the Tide: Controlling Introductions of Nonindigenous Species by Ships' Ballast Water*.

gle deballasting ship may discharge millions of foreign phytoplankton and invertebrate zooplankton per hour, and even greater numbers of protists, bacteria, and viruses.[6]

Ships take water into their ballasts to provide stability and to optimize steering and propulsion abilities. However, this ballast water is often teeming with living creatures. Bioinvasions can occur when a ship collects water from a foreign port or coastal area and then discharges that ballast water into the Bay. If the foreign organisms are compatible with the ecological and physical conditions of the Bay, they may survive, reproduce, and disperse.

Ballast water exchange is currently the only viable management tool to reduce the risk of ballast-mediated invasion, although there are other treatment options that are under investigation or being used in a test capacity, such as on-board treatments that may be feasible for a variety of vessels, as well as on-shore treatment, which is an option but may not be as preferable as on-board treatments. Ballast water exchange involves replacing coastal water with open-ocean water during a voyage. This process reduces the density of coastal organisms in ballast tanks that may be able to invade a recipient port, replacing them with oceanic organisms with a lower probability of survival in the Bay..

However, there are two significant short-comings of this procedure. First, the ability to safely conduct ballast water exchange depends upon weather and sea surface conditions, and it is not always possible to perform an exchange safely. Second, some coastal organisms remain in ballast tanks even after the exchange (for example, some organisms may take refuge in the ballast tank sediments), so this process is only partly effective. Indeed, although ballast water discharge is mandatory in the Great Lakes, and compliance exceeds 97%, introductions still occur.[7] For these reasons, most experts view ballast water exchange as an inadequate long-term solution. Alternative methods under investigation include on-board treatment of ballast water, on-shore treatment of ballast water, or management of where, when and how ballast water is loaded or discharged (for example, prohibiting ballast loading in ports where certain pathogens or highly invasive species are present).

The U.S. Coast Guard estimates that approximately 43% of ships calling at ports inside the Golden Gate Bridge that discharged ballast water did not exchange ballast water in the open water.[8] AB 703, introduced by Assembly Member Ted Lempert, now requires vessels carrying foreign ballast to exchange the ballast in open seas. The legislation also requires specified state agencies to analyze the status of invasions, the effectiveness of the ballast exchange program, and alternatives for ballast water treatment. It also sets penalties for noncompliance and levies fees on regulated vessels to pay for the program. However, travel along the coast (for example, from Los Angeles to San Francisco) is exempt from the bill. The bill also forbids state agencies, including BCDC, from adopting more stringent ballast water regulations until 2004, unless mandated to do so by the federal government.

Bioinvaders Beyond the Bow.[9] Invasive species can also use San Francisco Bay as a port or entryway to other ecosystems. For example, in addition to harboring invaders in their ballast water, ships can also harbor invasive species in their cargo[10] (and particularly in solid wood packing materials). These invasive species can then find their way into other ecosystems. For

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[6] California Regional Water Quality Control Board, 2000.

[7] Gerrity, P. 1999. Enforcement of Aquatic Nuisance Species Ballast Exchange Regulations on the Great Lakes. Paper Presented at the 9th International Zebra Mussel and Aquatic Nuisance Species Conference, Duluth, MN. April 1999.

[8] National marine Invasions Center, Smithsonian Environmental Research Center (SERC) www.serc.si.edu/invasions (Accessed 3/00).

[9]

[10] Although the USDA's Animal and Plant Health Inspection Service (APHIS) and the California Department of Agriculture's Plant Health and Pest Prevention Services (CDFA) inspect select cargo shipments for pests that may threaten California agriculture, there are concerns that these programs are not adequately preventing introductions. In addition, these programs focus on protecting agriculture and are not charged with protecting native biodiversity.

example, invaders harbored by from foreign lumber or in solid wood packing materials are believed to pose a significant threat to California's forest ecosystems.[11] A discussion of invasive species outside of the Bay is beyond the scope of this report. However, it is important to keep in mind that the Bay may be an entry point for invaders of other ecosystems.

Invasive Species and Biodiversity. At a meeting of natural resource managers, a speaker described the threat that invasive species pose to the Bay's native species. He explained that invasive species could displace or prey upon the native species, or disturb their habitat. One listener remarked, "So the bottom line is that we lose a few native species. So what?" One possible answer to this question involves biodiversity.

Biological diversity, or biodiversity, is the variety of the world's organisms, including their genetic diversity and the ecosystems they form. It is the blanket term for the planet's natural biological wealth. By protecting the variety of Earth's species, we protect potential sources of food, medicine, and commerce. Some people also believe in protecting biodiversity for aesthetic or moral reasons.

As the invasive species displace or eliminate native species, global biodiversity decreases[12] and ecosystems throughout the world become more homogenous, with the same assemblages of species occupying similar habitats worldwide (i.e., a wetland in Florida may have the same common species as a wetland in Australia, given similar environmental parameters such as salinity, temperature, etc.). At the extreme, invasive species could turn the Baylands into a biologically impoverished junk ecosystem of little natural biological value, consisting of species that could be found in similar habitats anywhere in the world. Another scenario might consist of a balance between native and invasive species, where harmful invasive species are controlled and "well-mannered" introduced species are appreciated for their contributions for food, medicine, landscaping, or other purposes.[13]

In short, by protecting the rich biotic heritage of San Francisco Bay, we also help protect global biodiversity (which in turn may preserve potential sources of food, medicine, or commerce).

Future Invasions. Scientists state that new invasions are certain to occur. They suggest that these invasions will come by ballast water from outside the Northeastern Pacific, through ship traffic along the Pacific coast, through fisheries products, fisheries activities, aquaria releases, and through recreational vessels entering the Bay or Delta from northern or eastern states. Readers are referred to Cohen and Carlton for more information about the invasions likely to occur.

However, if measures are taken, many future invasions may be averted. For example, zebra mussels, quagga mussels, and other fouling organisms have not yet invaded the West Coast states. Introduction of these potentially devastating species may be preventable through ballast water control and other measures.

What Can Be Done About Invasive Species? Invasive species can sometimes be prevented or controlled, or their impacts can be minimized. Prevention is the ideal alternative, because it avoids the direct and indirect costs of impacts and control methods. Prevention can take many forms, such as regulation (regulating ballast water to prevent discharge of new species into the Bay), education (educating travelers not to transport pest species, or educating pet owners not to release pets or fish into the wild), or guidelines (for example, urging federal agencies to plant

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[11] David Wood, U.C. Berkeley. 04/11/00. Lecture at U.C. Berkeley.

[12] Although, ironically, invasive species may technically increase the "biodiversity" of the San Francisco Bay, by adding life forms that were not previously here.

[13] Adapted from the U.S. Congress Office of Technology Assessment report, *Harmful Non-Indigenous Species in the United States*, on line at http://www.wws.princeton.edu/~ota/ns20/cataH_n.html

non-invasive species in marsh restoration activities). Currently little or no public education is conducted regarding invasive species in the Bay (although the Center for Marine Conservation distributes a pamphlet concerning zebra mussels, which are a potential threat for the Delta). Zebra mussels, which plague the Great Lakes, are an example of an invasive species that may be prevented.

Once a species has become established, it is nearly impossible to eradicate it.[14] If a species has not yet become widely established, sometimes it can be removed. If not, the species may be controlled. Removal and control tools include physical control methods (including mechanical (e.g., mowing), manual (e.g., hand pulling), or cultural techniques (such as burning)); chemical controls such as Roundup™ or Rodeo™ applied to the vegetation, and biological controls (such as the introduction of the pest's natural predators, introduction of sterile pests, or gene products). An example of a species that may be controlled at this time is the Atlantic cordgrass. Although it has been identified in several marshes in the Bay, it has not yet invaded all of them, so managed efforts may keep them from spreading and dominating the many wetlands restoration sites in the Bay.[15]

In some cases, the species has become ubiquitous, and the only choice left is to minimize its impacts. Examples in this category are the Chinese mitten crab and the green crab. Control programs for the Chinese mitten crabs focus on minimizing impacts on water diversion and fish salvage facilities. Programs for the green crabs focus on minimizing effects on commercial shellfish beds.[16]

However, invasive species control efforts can also harm the environment; thus the question becomes whether the control effort will do more harm than good. Each of these control methods mentioned above could potentially disturb the environment. For example, trapping could result in accidental catches of non-target native species. Future chemical controls could conceivably affect water quality, although the herbicides currently used in invasive species control (such as Rodeo™) only affect the plants to which they are directly applied (in other words, they do not appear to pollute groundwater or impact other plants through soil dispersion). Future biological controls, such as introduced predators, could conceivably become pests themselves. Thus it is important that the ecological side effects of invasive species control efforts be carefully considered.

BCDC and Invasive Species: What is the Commission's Role? If a project involving dredging, filling or a substantial change in use of land water or structure in BCDC's jurisdiction could reasonably be expected to contribute to the introduction or spread of invasive species that would adversely effect the Bay, the Commission could deny a permit for the project if it had the policy basis to do so in the Bay Plan, or it could require reasonable permit conditions to avoid the impact. Examples of projects that could result in invasive species impacts include expansion of port facilities (which could unintentionally increase bioinvasions through increased port traffic), expansion of boat yards, military terminals, drydocks, or other facilities that remove organisms from vessels (which could unintentionally increase bioinvasions through the disposal of hull cleaning wastes in the Bay), wetlands restoration or shoreline stabilization projects (which could involve the planting of non-native species or the disturbance of habitat) or dredging-related projects (which could create disturbed habitats vulnerable to invasions).

The Commission's authority to address invasive species stems from the McAteer-Petris Act, the Coastal Zone Management Act, and most specifically, the *San Francisco Bay Plan.* For example, the Bay Plan's policies state that important habitats needed to maintain or increase species are to be protected, maintained, or restored. Because invasive species have harmful impacts on fish and wildlife and can substantially alter marshes, mudflats, and other habitats, their intro-

[14] Sheehan, Linda, Center for Marine Conservation. 5/11/00. Presentation at the Vessels and Varmints Workshop.

[15] California Regional Water Quality Control Board, 2000.

[16] California Regional Water Quality Control Boardm 2000.

duction would violate the Bay Plan's policies. Through this and other resource protection policies, the Commission has the authority to require the prevention and control of invasive species for new projects in its jurisdiction, and it frequently does so.

However, the vast majority of invasive species vectors do not come before the Commission for a permit. For example, introductions through ballast water,[17] through bait packing materials, and through fisheries enhancement would not come before the Commission for approval, unless these activities somehow involved fill, dredging, or substantial changes of use within the Commission's jurisdiction.

Moreover, the vast majority of invasive species control efforts do not come before the Commission for a permit. For example, an effort to control invasive Atlantic cordgrass with chemical sprays, or an effort to trap red foxes would generally not come before the Commission, since these activities do not generally involve filling, dredging, or substantial changes in land use.

The Bay Plan currently contains no policies directly addressing invasive species. However, the Commission should modify its guidelines and policies to address invasive species directly and to ensure that the projects it approves do not contribute to the invasive species problem, and where possible, alleviate it, remembering that the Commission is precluded from taking certain restrictive actions regulating ballast water until January 1, 2004, by the aforementioned state Assembly Bill 703. In the interim, the Commission should maintain communication with the State Lands Commission, the California Department of Fish and Game, and the State Water Resources Control Board regarding the outcome of analysis undertaken as part of the requirements of AB 703. In addition, the Commission should consider measures to address the impacts associated with ballast water which could be implemented once the deadline of January 1, 2004 expires. For example, one approach could require ports which apply for facility expansion to adopt exotic species response plans which include both strategies and funding for controlling future invasions..[18]

The Commission's efforts in and of themselves will not be effective in halting the introduction of new species, or in controlling or combating existing invasions. Indeed, the sheer extent of the problem, the lack of clear federal, state, and local regulatory authority and funding, and the multiple pathways of species introductions make invasive species control a complex and confounding issue.

It may therefore be advisable for a regional Bay-related agency or non-profit organization to undertake a study regarding invasive species. This study could examine potential control efforts and consider possibilities for regional coordination between agencies with jurisdiction over bioinvasions. Such a study would allow examination of issues beyond the Commission's purview (such as seaweed packing for baitworms). There are many organizations, such as SFEI

[17] The issue of whether the Commission has authority over ballast water in the Bay has not yet been formally addressed. Ballast water discharge in the waters of the Bay is most likely not under the Commission's purview, unless the discharge is found to contain significant amounts of sediment or mass from dead organisms, or it is connected with the expansion of a land-based facility such as a Port. However, accumulated sediment is another matter. Sediment from ballasted cargo holds, which may amount to 500 gallons per ship, is typically shoveled or hosed out and dumped into port or coastal waters (Cohen, 1998). It is probable that the Commission has jurisdiction over these sediment discharges, should it wish to assert that jurisdiction.

[18] Andrew N. Cohen and Brent Foster, "The Regulation of Biological Pollution: Preventing Exotic Species Invasions from Ballast Water Discharged into California Coastal Waters," *The American Coast: Law on the Edge* 30, no. 4 (Spring 2000) 787-883.

and the Regional Water Quality Control Board, that are currently exploring solutions to the ballast water problem.[19] However, little if any attention is paid to the remaining pathways of introduction. A regional study or plan could give the Bay area a head start in addressing pathways of introduction beyond ballast water.

[19] For example, the Regional Board recently recommended that the U.S. EPA adopt a TMDL (total maximum daily load) of zero for invasive species, thus prohibiting any new discharge of invasive species.

CHAPTER 5

THE DISTRIBUTION AND ABUNDANCE OF SPECIES ASSOCIATED WITH SAN FRANCISCO BAY[1]

Aquatic life and wildlife are interdependent parts of the Bay ecosystem. While chapter 2, focused upon the habitats of the Bay, this chapter delves into the unique characteristics of the species who depend upon and help to define these habitats. Included in this discussion are the distribution and abundance of the organism, as well as its relevance to other species living in the same habitat. This chapter will also emphasize the conservation and management needs of each species, in light of the threats impacting its continued well-being. Appendix C follows-up on some of these same themes by exploring the management and regulatory programs established at the state and federal level to protect species at risk of extinction.

In order to simplify the breadth of information to be covered in this chapter, a table put together by the Goals Project is included. Table 6[2] illustrates the multiplicity of wildlife species which utilize the Bay's habitats for resting, foraging and breeding. The species listed in this table are only those discussed by the Goals Project as Key Species, which are intended to represent the overall complexity of species associated with the baylands ecosystem. As a result, the list is representative, but not comprehensive. In other words, many more species than are listed in this table utilize San Francisco Bay's habitats. However, the table does provide a balanced overview of the diversity of species dependent upon the Bay's habitats.

Fish and Macroinvertebrates

1. **Arrow Goby.** The arrow goby is probably the most abundant native goby in San Francisco Bay. Ranging from the Gulf of California to Vancouver Island, British Columbia, the arrow goby is common in tidal mudflats and shallow subtidal areas of bays, estuaries and coastal lagoons. The arrow goby grows to a maximum size of 45 to 50 mm. An interesting trait of the arrow goby is that it utilizes invertebrate burrows as a refuge from predators and as a temporary shelter during low tides. The arrow goby primarily inhabits burrows of the ghost shrimp, the fat innkeeper worm, the mud shrimp and various clams and mussels. In San Francisco Bay, larval arrow gobies are most abundant in South Bay and San Pablo Bay. Juveniles and adults are common in shallow subtidal and intertidal areas of South, Central and San Pablo Bays and have occasionally been collected in Suisun Bay. The arrow goby is also common in some tidal marsh habitats from South Bay to lower San Pablo Bay.

   This small fish is an important component of the intertidal food web, as it is a common prey item for a variety of birds and fish. For example, probing shorebirds such as willets, godwits and curlews capture arrow gobies while exploring burrows at low tides. In addition, California halibut, diamond turbot and Pacific staghorn sculpin feed on arrow gobies. The primary food source of arrow gobies are small benthic invertebrates.

   Arrow goby abundance and distribution may be linked to the abundance and locationof species whose burrows it utilizes for protection, such as the ghost shrimp. Therefore, a decline in ghost shrimp could potentially lead to a decline in arrow goby.

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[1] Most of this chapter is adapted from:
Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson. Editor. San Francisco Bay Regional Water Quality Control Board, Oakland, Calif.
[2] Adapted from the Goals Project, 1999.

Table 6

Abbreviated Habitat Support Function Matrix

	Shallow Bay or Channel	Tidal Flat	Lagoon	Beach	Rocky Shore	Low Tidal Marsh	Mid Tidal Marsh	High Tidal Marsh	Muted Tidal Marsh	Diked Wetland	Agricultural Baylands	Salt Pond	Storage or Treatment Pond	Riparian Forest	Willow Grove	Grassland	Oak Woodland	Mixed Evergreen Forest
Fish and Related Invertebrates																		
Chinook salmon	F	F				RF	R.F	RF										
Steelhead	F																	
White sturgeon	F	F				RF												
Striped bass	F	F				F	F	F										
Sacramento splittail	RF	RF				RFB	RFB	RFB										
Pacific herring	FB	FB																
Northern anchovy	FB																	
Arrow goby	RFB	RFB				RF												
Bay goby	RF																	
Delta smelt	F					RFB												
Jacksmelt	FB	FB																
Topsmelt	FB	FB				F	F	F										
Longfin smelt	F																	
Pacific staghorn sculpin	RF	FB				F	F	F										
Prickly sculpin						F	F	RFB										
Rainwater killifish						RFB		RFB										
Plainfin midshipman	RFB	RFB																
Shiner perch	FB	F																
Tule perch						RFB	RFB	RFB										
Threespine stickleback						RFB	RFB	RFB										
White croaker	FB	F					F											
Leopard shark	FB	F																
Bat ray	RF	RF				RF												
Brown rockfish	RF																	
California halibut	RF	RF																
Starry flounder	RF	RF				F												
Longjaw mudsucker		RFB				RFB	FB	FB										
Dungeness crab	RF	RF				RF												
Rock crab	RFB				RF	RF												
Mud crab	FB	FB				FB	RF	RF										
California bay shrimp	RF	RFB				RF												
Blacktail shrimp	RF	RFB				RF												
Opossum shrimp	F					F	F											
Softshell clam		RFB			RFB													
Japanese littleneck clam		RFB			RFB													
Ribbed horsemussel							RFB	RFB										
California horn snail		RFB				RFB	RFB	RFB										
Amphipods	RFB	RFB			RFB	RFB	RFB	RFB										

Key: R = Resting, F = Foraging, B = Breeding, ! = Uses vernal pools in this habitat, * = Uses artificial structures in this habitat

SOURCE: Baylands Ecosystem Habitat Goals Project

Table 6 (continued)
Abbreviated Habitat Support Function Matrix

	Shallow Bay or Channel	Tidal Flat	Lagoon	Beach	Rocky Shore	Low Tidal Marsh	Mid Tidal Marsh	High Tidal Marsh	Muted Tidal Marsh	Diked Wetland	Agricultural Baylands	Salt Pond	Storage or Treatment Pond	Riparian Forest	Willow Grove	Grassland	Oak Woodland	Mixed Evergreen Forest
Other Invertebrates																		
Franciscan brine shrimp												RFB						
Conservancy fairy shrimp																RFB!		
Fairy shrimp																RFB!		
California vernal pool tadpole shrimp																RFB!		
Reticulate water boatman			RFB					RFB	RFB	RFB	RFB							
Delphacid planthopper						RFB												
Cixiid planthopper								RFB	RFB	RFB	RFB							
Tiger beetle (C. oregona)						RFB	RFB	RFB	RFB									
Tiger beetle (C. senilis)								RFB	RFB			RFB						
Tiger beetle (C. haemorrhagica)								RFB	RFB	RFB								
Diffuse water scavenger beetle								RFB	RFB	RFB	RFB							
Minute moss beetle								RFB	RFB	RFB	RFB							
Western tanarthrus beetle								RFB				RFB						
Leaf beetle						RFB	RFB	RFB	RFB	RFB	RFB							
Inchworm moth							RF	RFB	RFB	RFB	RFB							
Pygmy blue butterfly								RFB	RFB	RFB	RFB							
Summer salt marsh mosquito			RFB				RFB	RFB	RFB	RFB	RFB			RF		RFB		
Winter salt marsh mosquito			RFB				RF	RFB	RFB	RFB	RFB					RFB		
Washino's mosquito														RFB	RFB			
Western encephalitis mosquito			RFB					RFB	RFB	RFB	RFB		RFB	RFB		RFB		
Winter marsh mosquito									RFB	RFB	RFB		RFB	RFB		RFB		
Grodhaus's midge			RFB				RFB	RFB		RFB	RFB					RFB		
Flower fly			RFB				RFB	RFB	RFB	RFB	RFB	RFB						
Cinereus brine fly						RFB	RFB	RFB		RFB		RFB						
Millbrae brine fly						RFB	RFB	RFB		RFB		RFB						
Riparian shore fly														RFB	R			
Brine fly (L. slossonae)							RFB	RFB		RFB		RFB						
Jamieson's compsocryptus wasp							RF	RF	RFB	RFB		RF						
Amphibians																		
California tiger salamander										RFB	RFB			RFB		RFB	RF	RF
California toad			RFB			F	RFB	RFB	RFB	RFB	RFB		RF	RFB	RFB	RFB	RF	RF
Pacific treefrog			RFB			F	RFB	RFB	RFB	RFB	RFB		RF	RFB	RFB	RFB	RF	RF
California red-legged frog			RFB				RFB	RFB	RFB	RFB	RFB			RFB	RFB	RFB		F
Reptiles																		
Western pond turtle			RF			RF	RF	RF	RF	RFB	RFB		RFB	RFB	RB	RFB	RB	RB
California alligator lizard			RF			RF	RFB	RFB	RFB	RFB	RFB		RFB	RFB	RFB	RFB	RFB	RFB
Central coast garter snake			RF			F	RFB	RFB	RFB	RFB	RFB		RFB	RFB	RFB	RFB		
Coast garter snake			RF			F	RFB	RFB	RFB	RFB	RFB		RFB	RFB	RFB	RFB	RFB	RFB
San Francisco garter snake			RF			F	RFB	RFB	RFB	RFB	RFB			RFB		RFB		

Key: R = Resting, F = Foraging, B = Breeding, ! = Uses vernal pools in this habitat, * = Uses artificial structures in this habitat

SOURCE: Baylands Ecosystem Habitat Goals Project

Table 6 (continued)
Abbreviated Habitat Support Function Matrix

	Shallow Bay or Channel	Tidal Flat	Lagoon	Beach	Rocky Shore	Low Tidal Marsh	Mid Tidal Marsh	High Tidal Marsh	Muted Tidal Marsh	Diked Wetland	Agricultural Baylands	Salt Pond	Storage or Treatment Pond	Riparian Forest	Willow Grove	Grassland	Oak Woodland	Mixed Evergreen Forest
Mammals																		
Salt marsh harvest mouse			RFB			RF	RFB	RFB	RFB	RFB	RF							
California vole			RFB				RFB	RFB	RFB	RFB	RF		RFB			RFB	RFB	
Salt marsh wandering shrew						F	RFB	RFB	RFB	RFB	RFB							
Suisun shrew						F	RFB	RFB		RF	RF							
Ornate shrew									RFB	RFB	RFB		RFB			RFB	RFB	
North American river otter	F		RFB	R	R	RFB	RFB	RFB	RFB				RF	RFB				
Southern sea otter	RFB	F		RF														
Harbor seal	F	RB	F	R	RB	RF												
California sea lion	RF			R	R													
Waterfowl																		
Tule white-fronted goose	RF		RF	R		RF	RF	RF		RF	RF		RF			RF		
Mallard	RF	F	RF	R		F		RFB	RF	RFB	RFB	RF	RFB	RFB		RFB		
Northern pintail	R		RF			F		RFB	RF	RFB	RFB	RF	RFB			RFB		
Canvasback	RF	F	RF						RF	RF		RF	RF					
Surf scoter	RF																	
Ruddy duck	RF	F	RF			RFB	RFB	RFB	RF	RFB	RFB	RF	RFB					
Shorebirds																		
Western snowy plover		F		RF								RFB						
Marbled godwit		RF	RF	RF	R	RF	RF	RF	RF	RF	RF	R	R			F		
Black turnstone		RF	R	R	RF	R	R	R	R									
Red knot		RF	R	R	R	RF	RF	RF	RF			RF	R					
Western sandpiper		RF	RF	RF	R	RF	RF	RF	RF	RF	RF	RF	RF					
Long-billed dowitcher		RF	RF	R	R	RF	RF	RF	RF	RF	RF	RF	RF			F		
Wilson's phalarope		F	RF	R						RF	RF	RF	RF					

Key: R = Resting, F = Foraging, B = Breeding, ! = Uses vernal pools in this habitat, * = Uses artificial structures in this habitat

SOURCE: Baylands Ecosystem Habitat Goals Project

Table 6 (continued)
Abbreviated Habitat Support Function Matrix

	Shallow Bay or Channel	Tidal Flat	Lagoon	Beach	Rocky Shore	Low Tidal Marsh	Mid Tidal Marsh	High Tidal Marsh	Muted Tidal Marsh	Diked Wetland	Agricultural Baylands	Salt Pond	Storage or Treatment Pond	Riparian Forest	Willow Grove	Grassland	Oak Woodland	Mixed Evergreen Forest
Other Bayland Birds																		
Eared grebe	RF	F	RF			RF		RF		RFB		RF	RF					
Western/Clark's grebe	RF	F	RF							RFB		RF						
American white pelican		R	RF	R					F	RF		RF	RF					
Brown pelican	R*F	R	RF	R		RF			R	RF		RF		RF				
Double-crested cormorant	RFB*	R	F	R	R	RF			F	F		RFB	RF					
Snowy egret		F	F	RF	RB	RF	RF	RFB	RFB	RFB	F	RF	RFB	RFB	B		B	
Black-crowned night heron	RF	F	RF	RF	RF	RF	RF	RF	RF	RFB	F	RF	F	RFB	B		RB	RB
Northern harrier		F	F			F	F	RFB	RF	RFB	R.F.B	F	F		RF	RFB		
Peregrine falcon	RFB*	RF	F	F	F	R*F	F	R*FB	F	R*FB	F	R*FB	F		RF	F	RF	
California clapper rail		F				RFB	RFB	RFB	RF	R								
California black rail							F	RFB										
Common moorhen								RFB	RFB	RFB								
California gull	RF	RF	RF	RB	R	F			RF	RF	RF	RFB	RF			RF		
Western gull	R*FB	RF	RFB	RF	RF	RFB		RFB	RFB	RF	RF	RFB	RF			F		
California least tern	RF	RF	RFB	RB		F	F	F	RF	F		RFB	F					
Forster's tern	RFB	RF	RF	R		F	F	F	RFB	RFB		RFB	F					
Caspian tern	F	RF	RFB	R	R	F			RFB	RB		RFB	F					
Burrowing owl								F	RFB	RFB	R.F.B	RFB				RFB		
Belted kingfisher	RF	F	RF			RF			RF	RF		RF	RF	RFB				
Horned lark										RF	RF					RFB		
Yellow warbler							F	F						RFB		RF		
Salt marsh common yellowthroat			RFB			F	RFB	RFB	RF	RFB	RFB			RFB				
Savannah sparrow						F	F	RFB	RFB	RFB	RFB	RF				RFB		
Song sparrow						F	RF	RFB	RFB	RF	RF	RF						
Red-winged blackbird							RF	RFB	RF	RFB	RFB		RFB	RF	RFB	RFB		
Western meadowlark								RFB		RFB	RFB	RF				RFB		
Barn swallow	RF	F	RFB			RF	RF	RFB	RFB	RFB	RFB	RFB	RF	RFB	RF	F		

Key: R = Resting, F = Foraging, B = Breeding, ! = Uses vernal pools in this habitat, * = Uses artificial structures in this habitat

SOURCE: Baylands Ecosystem Habitat Goals Project

However, as there is no long-term monitoring program in the Bay that coherently goby, its current population numbers are difficult to assess. In addition, due to its breeding patterns, the abundance of the arrow goby is known to fluctuate dramatically from year to year.

Critical to the survival of the arrow goby in the Bay is sufficient shallow subtidal and intertidal mudflats inhabited by those invertebrates whose burrows the arrow goby inhabits.

2. **Bat Ray.** Found in sandy and muddy bays and sloughs, as well as in rocky areas and kelp beds, bat rays are common from the Gulf of California to Oregon. In shallow bays, such as San Francisco Bay, they can be found feeding on tidal flats during high tide. Current population numbers of the bat ray in San Francisco Bay are unknown and its range is limited by salinity, preferring higher salinity such as that found in Central Bay.

Like sharks, bat rays have skeletons made of cartilage and are flat-shaped with enlarged pectoral fins which are winglike in appearance. Bat rays are bottom feeders, feeding primarily on benthic invertebrates. They in turn are preyed upon by recreational fishermen who catch them using cut fish as bait. Bat rays play an important role in the health of benthic communities, as the pits they dig into the sand or mud while feeding become new areas for organisms to make their homes, as well as exposing buried benthic invertebrates to the water column, thus allowing them to be eaten by other fish.

Critical to the survival of the bat ray in the Bay is sufficient sandy to muddy shallow bottoms with abundant benthic food sources.

3. **Bay Goby.** The bay goby ranges from Baja California to Vancouver Island, British Columbia. Common to bays and estuaries, the bay goby often lives in intertidal mudflats in the holes of burrowing invertebrates. The bay goby probably utilizes burrows as a refuge from predators and to avoid desiccation at low tides. Predators of the bay goby include California halibut and the Pacific staghorn sculpin. The presence of burrowing invertebrates, and the bat rays and leopard sharks which eat them, may have an effect on the abundance of bay gobies, as the abundance of bay gobies is dependent upon the availability of burrows.

   The bay goby grows to approximately 100 mm total length and has no commercial or sport value. In San Francisco Bay, the bay goby is common from South Bay to San Pablo Bay and is occasionally found in Carquinez Strait and lower Suisun Bay. From 1980 to 1992, the bay goby was the most common goby and the second most common fish collected by the California Department of Fish and Game during an otter trawl survey of San Francisco Bay.

   Critical to the survival of the bay goby in the Bay is shallow subtidal areas with mud or a mud/sand mixture and possibly intertidal mudflats. The presence of burrowing invertebrates is also beneficial. There is no evidence that this species utilizes tidal marshes in San Francisco Bay or elsewhere in its range.

4. **Brown Rockfish.** Ranging from Hipolito Bay in Baja California, to southeast Alaska, the brown rockfish is the most common rockfish in San Francisco Bay. Distributed throughout the Central Bay, the lower portion of San Pablo, and the northern portion of South Bay, the distribution of rockfish in the Bay is dependent upon salinity. Due to its marine character, the brown rockfish is uncommon in less-saline parts of the Bay. The brown rockfish has a modest population in San Francisco Bay and supports a small, but active recreational fishery, especially at Candlestick and Tiburon. The most common locations where brown rockfish are caught is from piers and from shoreline adjacent to rocky areas, including riprap.

   San Francisco Bay is a nursery area for brown rockfish and most juveniles found in the Bay immigrate to the Bay from the nearshore coastal area soon after settlement. Once in the Bay, juveniles are known to rear in the Bay for several years and thus the population is comprised of several year classes. While recruitment[3] from the oceanic population has been the primary means of population maintenance for San Francisco Bay, scientists are not sure whether residential adult populations in the Bay are spawning successfully and thus recruiting juvenile populations to the Bay.

[3] Defined as the process of adding new individuals to a population through growth, reproduction, immigration or stocking.

In regards to the brown rockfish's place in the food web, the species feeds primarily on invertebrates (crabs and shrimp), and small fish, such as anchovies. In turn, larger fish, such as striped bass, feed on brown rockfish. Critical habitat to brown rockfish in the Bay includes areas of structure such as piers, rocky reefs, jetties, breakwaters, riprap and rocky shores in higher salinity areas such as Central Bay.

5. **California Halibut.** The California halibut is a large marine flatfish that is popular in the market place because of its large size and excellent taste. Commercial fishing for California halibut was historically centered in the Baja California-Los Angeles area, but has recently shifted northward to the Santa Barbara region. California commercial fishermen landed an average of 534 tons per year from 1983 to 1987, and received $0.64-$1.59/kg in 1987. California halibut is also highly prized by recreational anglers and is caught primarily from piers and boats using hook, line, and live bait. Over 916,000 California halibut were caught by recreational anglers in 1985.

The geographic distribution of California halibut extends from the Quillayute River in Washington state, southward to Magdalena Bay in Baja California, Mexico. However, it is common only in bays and estuaries south of Tomales Bay, California, and reaches peak abundance in estuaries south of Point Conception, California. California halibut can be found in San Francisco Bay throughout the year at various life stages.

Catch records indicate that the abundance of California halibut within its historic range was high in the late 1960's, declined in the 1970's, and increased in the 1980's. The intense El Nino in 1982-83 coincided with higher abundance and landings of halibut. Yet, California halibut populations seem to be undergoing a long-term decline. This decline may be related to large-scale changes in the marine environment, over fishing, alterations and destruction of estuarine habitat, or a shift in location of population centers. Pollution has also been shown to have significant impacts on California halibut. Early records indicate that California halibut were uncommon in San Francisco Bay. Recently, consistent high salinities and possibly warmer ocean water have contributed to increased abundance of California halibut in the Bay. For example, California halibut showed increases in the Bay from 1989-1992. Possible reasons for this increase in abundance include increased local spawning, higher survival of larvae, and the migration of juveniles from southern coastal waters. Most halibut collected in the Bay are two years and older. Nevertheless, California halibut abundance is still very low relative to other common species of flatfish in the Bay.

In an attempt to increase California halibut numbers, natural breeding has been augmented by hatchery production. Although this effort could increase future population numbers (recruitment), negative effects of the hatchery program include a possible reduction in genetic variability within natural populations and a high cost, as well.

Halibut are carnivorous. Juveniles feed on zooplankton, crabs, gobies, bay shrimp, ghost shrimp, topsmelt and California killifish. Adult California halibut feed on northern anchovy, white croakers, octopus and squid. In turn, California halibut are an important food source for California sea lions, Pacific angel shark, Pacific electric ray and bottlenose dolphin. An interesting characteristic of California halibut is that they are an ambush predator. While foraging they lie partially buried on the sandy bottom and wait until their prey is close enough to seize.

Good spawning habitat for California halibut is limited to inshore waters or bays and estuaries with moderately shallow water. Favorable characteristics for bays and estuaries that serve as nursery areas include productive habitats with abundant food supplies, and shallow areas that allow juveniles to avoid predators. Overall, juveniles and adults prefer sandy bottoms.

6. **Chinook Salmon.** Chinook salmon are distinguished by their large size, small black spots on their fins, black pigment along the base of their teeth, and varying shades of flesh color from white, through shades of pink and red. The chinook salmon life history is characterized by adult migration from the ocean to natal freshwater streams[4] to spawn, and juvenile migration seaward during their first year of life. The chinook salmon is anadromous, meaning that it spends most of its adult life in the ocean and returns to freshwater to spawn. Four distinct kinds[5] of chinook salmon exist, based on the timing of adult spawning migration. These include winter, spring, fall and late-fall. In addition, two types of chinook salmon exist, based on their life histories. These include stream-type and ocean-type. Ocean-type spend less time in freshwater as juveniles than do stream-type. Chinook salmon of the Sacramento-San Joaquin River system are predominantly ocean-type. Importantly, studies have shown that fall-run, ocean-type chinook salmon use wetlands extensively while juveniles, thus creating a strong connection between the health of wetland habitats and the well-being of chinook salmon.

   Chinook salmon support commercial, recreational and tribal subsistence fisheries. However, these fisheries are in steep decline, thus prompting state and federal listings of the species under the Endangered Species Act, as well as emergency relief funding for displaced commercial fishermen in 1995 and 1996. The chinook salmon normally spawns in large rivers and tributaries. Once chinook salmon reach the juvenile stage and begin their migration to the ocean, certain habitats become critical to their survival. In riverine areas, both submerged cover, such as boulders, woody debris, and aquatic vegetation, as well as overhead cover, such as continuous riparian vegetation canopies, undercut banks, and turbulent water, provide shade, food and protection against predation to juvenile chinook salmon.

   Estuaries, such as the Bay, appear to play a vital role in Chinook salmon life history, as well. Tidal marsh habitat is especially important to juvenile salmonids. For instance, juvenile chinook salmon forage in the intertidal and shallow subtidal areas of tidal marsh, tidal flat, channel habitats, and open bay habitats of eelgrass and shallow sand shoal areas. These productive habitats provide both a rich food supply and protective cover within shallow turbid waters. The distribution of juvenile chinook salmon changes tidally, with fry moving from tidal channels during flood tides to feed in nearshore marshes.

   California's largest populations of chinook salmon originate in the Sacramento-San Joaquin River system. Spring-run chinook salmon are extinct in the San Joaquin River and only remnant runs remain in a few Sacramento River tributaries. Historically, spring-run chinook salmon spawned in small tributaries that have essentially all been blocked to migration by large dams. Fall and late-fall runs continue as they spawn in the main stems of the Sacramento and San Joaquin Rivers. Winter-run chinook salmon are unique to the Sacramento River and spawned in cold water tributaries above Shasta Dam prior to its construction. While distribution of out-migrating juvenile chinook salmon is not well known in the San Francisco Bay, they have been found throughout, including the South Bay on high outflow years.

   Chinook salmon populations have declined substantially, with winter-run at the point of near extinction and spring-run at severely depressed population levels. Whereas spring-run historically outnumbered all other runs, fall-run comprises the bulk of the present chinook salmon population. The remnant endangered population of winter-run now depends on cold water releases from Shasta Reservoir and the protection of the federal Endangered Species Act.

[4] Chinook salmon return to those freshwater streams where they were born (natal).

[5] Referred to by scientists as "races" of salmon defined by the timing of adult spawning migration.

Multiple and complex factors have impacted the well-being of chinook salmon during every stage of their lives. During the early freshwater stages of life, mortality is caused by the destruction of spawning grounds, fluctuations in water temperature, low dissolved oxygen, loss of cover, food availability and competition. Besides the above factors, human impacts such as river flow reductions, the construction of dams and the consequent creation of reservoirs, water diversions, logging practices, and pollution have affected population abundance. In the ocean, adult salmon are impacted by oceanographic conditions, food availability, predation and overfishing. In freshwater, adults are subject to natural factors such as drought and flood, and human impacts, such as fishing, dams, road construction, flood protection, dredging, gravel mining, timber harvest, grazing and pollution.

Species associated with and dependent upon chinook salmon are numerous. Sacramento squawfish, riffle sculpin, channel catfish, steelhead trout, striped bass, rockfish, egrets and herons all eat juvenile salmon. Harbor seals, California sea lion, North American river otter, and the Pacific lamprey all eat adult chinook salmon. Juvenile chinook salmon prey on a variety of invertebrates including bay shrimp and terrestrial and aquatic insects. Adults prey on squid, Pacific herring, northern anchovy and rockfish, among others. Critical to the survival of chinook salmon is good water quality, adequate flows, productive spawning and rearing habitat, state-of the-art positive barrier screens on water diversions, protection from excessive harvest, and free access to upstream migration, or well designed ladders for adult passage. Restoration efforts in the Bay also will continue to study and focus on the benefit of tidal marshes to the health and well-being of the salmon fishery.

7. **Delta Smelt.** The delta smelt is a small, short-lived native fish which is found only in the Bay-Delta estuary. The species was listed as threatened in 1993 under the federal Endangered Species Act. Habitat loss is thought to be one of the most important elements in causing its decline. New water quality standards adopted by the state in 1995 are aimed, in part, at improving habitat conditions.

   The delta smelt female does not produce many young (low fecundity) and is primarily an annual species, although a few individuals may survive a second year. The location and season of spawning vary from year to year. Spawning, which occurs in shallow freshwater sloughs, has been known to occur at various sites within the Delta, including the lower Sacramento and San Joaquin rivers, as well as in the sloughs of the Suisun Marsh. Delta smelt larvae have also been found in the Napa River, Montezuma Slough, and in the San Joaquin River up to Stockton. Overall, delta smelt's upstream range is greatest during periods of spawning. Downstream distribution is generally limited to western Suisun Bay. During periods of high Delta outflow, delta smelt populations do occur in San Pablo Bay, although they do not appear to establish permanent populations there. Recent surveys, however, show that delta smelt may persist for longer periods in Napa River, a tributary to San Pablo Bay. In terms of their place in the food web, delta smelt feed primarily on zooplankton, while striped bass are the most likely predator of delta smelt juveniles and adults.

   Delta smelt have experienced reduced population levels during the 1980's, and this is consistent throughout the Delta and Suisun Bay. However, declines may have occurred as early as the mid-1970's in the eastern and southern portions of the Delta. No single factor appears to be the sole cause of delta smelt decline, however, declines have been attributed primarily to restricted habitat and increased losses through entrainment by Delta freshwater diversions. Significantly, reduced water flow may intensify entrainment at pumping facilities, as well as reduce the quantity and quality of nursery habitat. Outflow also controls the location of the null zone, an important part of the habitat of the delta smelt. Reduced suitable habitat and increased entrainment occurs when the entrapment zone moves out of the shallows of Suisun Bay and into the channels of the lower Sacramento and San Joaquin rivers, as a result of low Delta outflow. The movement of the entrapment zone to the river channels not only decreases the amount of area that can be occupied by delta smelt, but also decreases food supply.

Although the effects of recent high diversions of freshwater, coupled with intermittent drought conditions, are the most likely cause of the decline of the delta smelt population, other contributing factors include: the presence of toxic compounds in the water, competition and predation, food supply, disease, very high outflows, and low spawning stock.

8. **Dungeness Crab.** Dungeness crab has been the object of an immensely popular commercial and recreational fishery in the San Francisco region since 1848. The San Francisco fishery, which today occurs exclusively outside the Golden Gate, was long a mainstay of statewide commercial landings. However, beginning in the early 1960's, it underwent a severe and long term decline which persisted until the mid-1980's.Today's annual catches of 2 to 3 million pounds are an immense decline from the 1950's when 9 million pounds were caught in the ocean off of San Francisco Bay in a one year period.[6] The principal causes of the decline have been related to changes in ocean climate, increased predation, and possibly pollution. Landings in the past decade have rebounded to some extent and are generally able to accommodate local market demand, but the northern California fishery (Eureka and Crescent City) continues to be the major provider of Dungeness crabs throughout the rest of California. The value of the Dungeness crab resource extends beyond the traditional economic return to the fishermen, seafood processors, and retail markets, as it is an important element in the tourism industry of San Francisco.

   In the San Francisco Bay region, Dungeness crabs spawn offshore, but large quantities of fertilized eggs are swept into the Bay by tidal action. The young crabs which mature in the Bay grow at about twice the rate of those raised in the open ocean. This substantially higher growth rate is due, in part, to the increased availability of food, abundant shelter, and warmer temperatures. Anywhere between 15 percent and 83 percent of the Dungeness crabs caught in the Gulf of the Farallones are reared in San Francisco Bay, as determined by a comprehensive Department of Fish and Game study carried out between the years1975-1978.[7]

   Estuaries are critical to the health of the Dungeness crab fishery, and the species as a whole. For example, scientists believe that the loss of tidal marsh in the Napa and Suisun area have affected the number of young crabs successfully maturing in the Bay. Other factors impacting Dungeness crabs include ocean temperature (cold water is preferred by mature crabs), ocean currents, predation, commercial fishing, and the pollution of nursery habitat.

   Within San Francisco Bay, juvenile abundance varies considerably from year-to-year, but is often highest in San Pablo Bay and lowest in South Bay. Once Dungeness crabs molt a few times they migrate to the Pacific Ocean where they will mature.

   Species associated with Dungeness crabs are many. Chinook salmon, starry flounder, English sole, Pacific tomcod, Pacific staghorn sculpin, white croaker, brown smoothhound shark, and skates prey on Dungeness crab. In turn, Dungeness crabs prey on other crabs, clams, phytoplankton and small fish.

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[6] San Francisco Chronicle. January 24, 2000. *Dungeness in Danger: Overfishing May Contribute to the Decline of the Bay Area's Beloved Crabs.* San Francisco Chronicle, San Francisco, California.

[7] Paul W. Wilde & Robert Tasto. 1983. Fish Bulletin 172. *Life History, Environment and Mariculture Studies of the Dungeness Crab, Cancer Magister with an emphasis on the Central California Fishery Resource.*

Juvenile crabs appear to prefer sandy or sandy-mud substrate, but are also found on other bottom types, such as shell debris. Structurally complex habitats, such as eelgrass, have the additional benefit of providing protection for juvenile crabs. In addition, chemical and physical characteristics of the water column, as well as sediment, are important habitat features for the Dungeness crab. For example, juvenile crabs are intolerant of low salinities. In addition, as juvenile crabs reach sexual maturity they emigrate out of estuaries into colder coastal waters. Similarly, Dungeness crabs of various life stages have shown sensitivity to sediment containing pesticides, chlorinated wastewater, or oil.

9. **Jacksmelt.** Jacksmelt are not an important commercial fish, yet they are commonly caught by recreational anglers fishing from piers. In an ecological sense, jacksmelt occupy an important niche in the food web of nearshore coastal, bay and estuarine ecosytems. For example, yellowtail, sharks, brown pelicans and gulls eat jacksmelt. In turn, jacksmelt eat small crabs, detritus and algae. Jacksmelt occur from Santa Maria Bay, Baja California, northward to Yaquina Bay, Oregon.. Locally, jacksmelt spawn in San Francisco Bay where eggs are laid on substrate, such as eelgrass. Presently jacksmelt are particularly abundant in Central Bay, South Bay and San Pablo Bay. The amount of freshwater inflow affects the distribution of jacksmelt by enabling them to live as far upstream as Carquinez Strait and San Pablo Bay, during years of low freshwater inflow, while during high flow years, they are restricted to the more saline Central and South Bay.

   Bays and estuaries provide important spawning habitat for jacksmelt. In general, the preferred spawning areas are situated in shallow nearshore habitats containing submerged vegetation. Juveniles and adults prefer sandy bottoms in water 1.5-15 meters below the surface. Furthermore, jacksmelt utilize open waters in San Francisco Bay and sloughs in and near Suisun Marsh and Napa Marsh. In addition, jacksmelt are more sensitive than topsmelt to fluctuation in salinity and temperature. Jacksmelt are also vulnerable to pollution and habitat modifications, because they depend on estuaries and embayments for spawning.

10. **Longjaw Mudsucker.** The longjaw mudsucker is the largest goby native to San Francisco Bay, reaching a size of 200 mm. Ranging from Baja California to Tomales Bay, it was successfully introduced to the Salton Sea in 1930. The longjaw mudsucker is a common resident of mudflats and sloughs in estuaries and coastal streams. It is also common in salt ponds, as it can tolerate a wide range of salinities. As the tide ebbs, the longjaw mudsucker retreats to burrows or buries itself in the mud, rather than migrate to deeper water. Due to their ability to live out of water and in freshwater for several days, mudsuckers or "mud puppies" are a sought after bait-fish. However, within recent years, the San Francisco Bay Area bait fishery has targeted the yellowfin goby, a large introduced species that is very common in many shallow water habitats.

    In San Francisco Bay the longjaw mudsucker has been collected in South, Central, San Pablo and Suisun Bays, although it is not common upstream of Carquinez Strait. This distribution is linked, in part, to their lack of tolerance for fresh or slightly brackish water. The longjaw mudsucker is the least common goby collected in open water habitats and channels, but the most abundant goby and third most abundant species found in smaller marsh channels around the Bay. The longjaw mudsucker is also common in the salt ponds of the Bay, being the most common goby and the second most common fish collected in South Bay salt ponds.

    The longjaw mudsucker preys upon waterboatmen (an insect species) and brine shrimp while living in salt ponds. In tidal marshes the species preys upon zooplankton of all sorts. In turn, longjaw mudsuckers are food for larger shorebirds, such as great blue herons and egrets.

There is no survey which routinely samples the longjaw mudsucker or its preferred habitat in San Francisco Bay, so the current status of the population cannot be assessed. It is unknown whether the introduction of the yellowfin goby, which shares the same habitat as the longjaw mudsucker, has had an adverse impact on the longjaw mudsucker. Habitat critical to the well-being of the longjaw mudsucker is the intertidal area of tidal marsh channels with complex channels, undercut banks, and pools of water at low tide. These more complex channels are typical of mature marshes and provide the benefit of protecting the longjaw mudsucker from predation.

11. **Opossum Shrimp.** The opossum shrimp is a native shrimp that is an important food source for many estuarine fish, especially young striped bass. The common name of the opossum shrimp derives from the fact that females carry their eggs and young in a pouch at the base of their last two pair of legs.

    The primary food source of opossum shrimp is phytoplankton and zooplankton. In turn, opossum shrimp are food for longfin smelt, striped bass and splittail. Opossum shrimp are found in greatest abundance in Suisun Bay and the western Delta, although it occurs as far upstream as Sacramento, the lower reaches of the Mokelumne River, and in the San Joaquin River to above Stockton.

    In regards to population, the opossum shrimp's abundance has varied considerably, but at a lower level of abundance than existed in the early 1970's. Specifically, population of opossum shrimp have declined substantially in Suisun Bay, yet they have occasionally rebounded to high levels. Possible causes of the variations in population and the overall declines are many, and have occurred alongside similar declines in zooplankton and fish species associated with the same habitat as opossum shrimp. They include, a decrease in the null zone's phytoplankton supply (part of the opossum shrimp's food supply), competition with invasive species for food and low Delta outflow which moves the null zone eastward into deeper channels and less productive areas. In addition, freshwater diversion has the potential to export opossum shrimp into Central Valley Project and State Water Project pumps. Pollutants may also play a role in the overall decline of zooplankton, such as the oppossum shrimp, in the upper estuary.

    Habitat critical to the well-being of the opossum shrimp is similar to that of the delta smelt, and includes a well-dispersed area of open water for most of the year, and clean, non-toxic over-wintering habitat in freshwater through the winter and early spring. Dead-end sloughs both in Suisun Marsh and upstream apparently serve as important refuges from predation during the annual period of low abundance and slow growth. With the advent of newly introduced competitors in the open waters of the Bay it is possible that such refugia will become important for the year-round maintenance of opossum shrimp.

12. **Pacific Herring.** The Pacific herring resource in San Francisco Bay is widely recognized for its commercial, recreational, and ecological values. The commercial fishery concentrates on ripe females for their roe (eggs), which are then exported to Japan. San Francisco Bay herring are reported to have some of the brightest and most metallic gold color roe of herring caught anywhere, making Bay Area herring highly prized by Japanese buyers. [8]In addition, some Pacific herring are caught for the fresh fish market, and also for use as live bait by recreational salmon trollers. About 500 fishing boats hold permits to catch Pacific Herring in the Bay. The quota for the year 2000 is 5,925 tons. Fishermen traditionally catch herring in nearshore areas of the Bay with gillnets. There also is a relatively new roe-on-kelp fishery operated from rafts. The economic value of the fishery in 1995-1996 was approximately 16.5 million dollars.

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[8] San Francisco Chronicle. January 21, 2000. *The Hunt is on for Herring in San Francisco Bay: Lucrative Fishing Business Gets Going After Late Start.* San Francisco Chronicle, San Francisco, California.

Adult herring congregate outside of San Francisco Bay before entering the Bay and generally spend about two weeks in the Bay before spawning. Spawning takes place from early November through March, with peak activity in January. The timing of spawning is believed to coincide with increased levels of zooplankton and phytoplankton production, which is used as a food source by larvae. Pacific herring spawn primarily on vegetation (eelgrass), rock rip-rap, pier pilings, and other hard substrates in intertidal and shallow subtidal waters. Female Pacific herring lay approximately 4,000 to 134,000 eggs each. These eggs adhere to the substrate in amounts ranging from a few eggs, to as much as eight layers thick. Pacific herring larvae, juveniles and adults are open water feeders who prey upon zooplankton and phytoplankton. In turn, gulls, surfperches, topsmelt, jacksmelt, rock crabs and white sturgeon eat Pacific herring eggs. California halibut, young salmon, California sea lion, harbor seal and striped bass eat juvenile and adult Pacific herring.

San Francisco Bay population levels fluctuate widely, with predation as the single most important factor affecting the population levels of Pacific herring. In addition to commercial and recreational fishing, humans influence herring survival by altering Pacific herring habitat and water quality.

Major populations of Pacific herring exist in the Pacific between San Francisco Bay and central Alaska. Within San Francisco Bay, the principal spawning areas are found along the Marin County coastline (i.e. Sausalito, Tiburon, and Angel Island), at the San Francisco waterfront and Treasure Island, on the east side of the Bay from the Port of Richmond to the Naval Air Station at Alameda, and on beds of vegetation in Richardson and South Bay. Juveniles are found in the deeper areas of the Bay between April and August, and have left the Bay by late June. Eventually, they move to offshore or nearshore marine habitats and do not return to the Bay until they are mature and ready for spawning.

Critical habitat to the health of Pacific herring is first and foremost, appropriate spawning habitat. This habitat includes seagrass or algae, as well as substrate that is rigid, smooth in texture, and lacking sediment. In addition, young Pacific herring need quiescent and productive shallow subtidal areas as rearing habitats. Water quality is an important factor as eggs are vulnerable to high levels of suspended particulate matter, particularly if the sediments are laden with contaminants (e.g. dredged material from former industrial sites). Additionally, larvae have been shown to be sensitive to hydrocarbons from spilled oil or other sources.

13. **Pacific Staghorn Sculpin.** The Pacific staghorn sculpin is found from Kodiak Island, Alaska to San Quentin Bay, Baja California. Significantly, the species is considered an indicator of stress in the estuarine environment as it not only has the ability to move freely between fresh and saltwater environments, but it also may spend its entire life in Pacific Coast estuaries.

    The principal food items for staghorn sculpin within San Francisco Bay are bay shrimp, bay goby, mud crab, shrimp and a variety of other non-burrowing benthic invertebrates. In turn, diving ducks, great blue heron, western grebe, Caspian tern, loons, cormorants and various marine mammals feed on the Pacific staghorn sculpin.

    The Pacific staghorn sculpin is the most abundant of all the sculpins found in the Bay. Small juveniles are often found intertidally and they gradually move from shallow inshore areas to deeper Bay waters. Juveniles and adults are most frequently captured in Central Bay and San Pablo Bay. Adults experience their widest distribution during high Delta outflow, and it appears that a portion of the adult population moves out of the Bay by late spring of their second year.

Success of local staghorn sculpin populations depends upon the quality and quantity of suitable habitat. Newly settled juveniles use intertidal and shallow subtidal mudflats for protection and feeding, although older juveniles and adults are said to prefer more sandy substrates and somewhat deeper waters. Pacific staghorn sculpin are known to bury themselves in soft substrates, and have been found buried in mudflats after the tide has retreated. Staghorn sculpin have also been found associated with eelgrass. Water quality factors are equally important for successful populations.

14. **Prickly Sculpin.** Few fishes occupy the wide range of habitats occupied by prickly sculpin populations. They live in waters ranging from fresh to brackish, in streams ranging from small, cold, and clear to large, warm, and turbid, and in lakes and reservoirs ranging from small to large. Most typically, they are found in pools and quiet water of moderate-sized, clear, low-elevation streams, with bottoms of sand, silt, and scattered rocks. They are also the most abundant sculpin in many coastal streams.

    As their body shape and cryptic coloration indicate, they spend most of their time quietly lying on the bottom. During the day they hide underneath or in submerged objects, such as rocks or logs. Prickly sculpins are found in coastal streams from southern Alaska to southern California. They are widespread throughout streams of the Central Valley, mostly at low elevations. In the Sacramento-San Joaquin Delta prickly sculpins are often the most commonly found native fish.

    Prickly sculpin feed primarily on large benthic insects, as well as small fish and the opossum shrimp. In contrast to staghorn sculpins, prickly sculpins larger than 20 mm are mostly found in association with emergent aquatic vegetation. Cover often takes the form of rocky or woody debris at upstream sites, or the roots and other underwater structures of rooted emergent plants in the Bay. Spawning requires the presence of such cover. In Suisun Marsh, adult prickly sculpins were found in much greater abundance in smaller sloughs, perhaps because of the greater availability of appropriate cover.

15. **Rock Crabs.** The brown rock crab is found along the west coast of North America from Washington State to Baja California. The red rock crab has a slightly more northerly distribution. A small recreational fishery exists for brown and red rock crabs in Central San Francisco Bay, and parts of South Bay and San Pablo Bay. A modest commercial fishery also occurs throughout California waters, with the vast majority of the catch taking place from Morro Bay southward. Unlike their close relative, the Dungeness crab, rock crabs are primarily sought after for their claws. In recent years, however, live whole crabs have become a larger part of the retail market.

    Rock crabs are both nocturnal predators and scavengers and have been shown to feed upon hard-shelled organisms such as clams, snails and barnacles. Juvenile rock crabs are preyed upon by other large invertebrates and fish, whereas adults are prey for marine mammals. In addition, sport fishermen account for the loss of a large number of rock crabs in San Francisco Bay.

    There are no known estimates of the overall population size of rock crabs in San Francisco Bay, although most studies have shown that population densities of rock crabs are well below one per square meter. Both rock crab species inhabit the low intertidal zone to depths of 300 feet or more, and although their utilization of individual habitats is similar, brown and red rock crabs differ in how they utilize estuaries. Specifically, the brown rock crab is principally a marine species and does not inhabit brackish areas, whereas the red rock crab can successfully survive in brackish waters.

    Areas of peak abundance appear to be in Central Bay, the northern portion of South Bay and the southern portion of San Pablo Bay, with the red rock crab having somewhat greater distribution than the brown rock crab. Both species have been shown to prefer rocky shore, or coarse gravel and sand substrate. Opportunity for concealment appears to be an important habitat feature. Sand and rock are also suitable substrates for juvenile crabs. Salinity and cold enough temperatures also play a big part in determining suitable habitat for red and brown rock crabs.

16. **Sacramento Splittail.** The Sacramento splittail is one of California's largest native minnows. In 1994 it was proposed for listing as a threatened species by the United States Fish and Wildlife Service, based on concerns of reduced abundance and distribution. In addition, the species supports a small sport fishery in winter and spring, when it is caught for human consumption and live bait for striped bass angling. Feeding studies describe splittail as opportunistic benthic foragers. Common prey items include opossum shrimp, detritus, insects and small fish. In Suisun Marsh, splittail opossum shrimp is their main prey item. Striped bass, in turn, commonly prey upon Sacramento splittail.

    The historic range of splittail included all low gradient portions of all major tributaries to the Sacramento and San Joaquin Rivers, as well as some other tributaries to San Francisco Bay. Sacramento splittail are most common in the brackish waters of Suisun Bay and the freshwater of the Sacramento-San Joaquin Delta. Within San Francisco Bay, Sacramento splittail were once found as far south as Coyote Creek in Santa Clara County.

    Today, Sacramento splittail may be found during wet years in the Napa and Petaluma Rivers. Much of the historic loss of Sacramento splittail habitat is attributable to migration barriers, and the loss of floodplain and wetlands to diking and draining activities over the last century. Additional factors that may affect population levels include habitat loss, recreational fishing, entrainment and toxic compounds in the water.

    Sacramento splittail abundance is largely dependent upon floodplain inundation associated with high freshwater outflow from the Delta. Higher flows increase inundation of floodplain areas such as Yolo bypass, which provides spawning, rearing and foraging habitat. Suisun Marsh and Chipps Island both illustrated low abundance in the 1980's during periods of low outflow. Attributes that help splittail respond rapidly to improved environmental conditions include a relatively long life span, reproductive capacity and broad environmental tolerances.

    Sacramento splittail are unique in that they are a freshwater species that is able to tolerate brackish water. In addition, they are able to withstand a wide range of temperatures. Both of these characteristics extend their distribution out of the Delta and into portions of the Bay. Critical habitat for Sacramento splittail are small dead-end channels, freshwater streams, and larger channels such as those found in Montezuma and Suisun Marsh. Specifically, juveniles and adults utilize shallow edgewater areas lined by emergent aquatic vegetation. Submerged vegetation provides abundant food sources and cover to escape from predators. Shallow seasonally flooded vegetation is also apparently the preferred spawning habitat of adult Sacramento splittail.

17. **Starry Flounder.** The starry flounder is a flatfish that is distinguished from other flatfish by alternating dark gray and orange-yellow bands on the fins. Found in high numbers for all life stages in San Francisco Bay, the starry flounder is a major sport fishing species in the San Francisco Bay. Starry flounder range from Santa Barbara northward to Alaska, then southwesterly to the Sea of Japan. Adult starry flounder inhabit shallow coastal marine water, whereas juveniles seek-out fresh to brackish water areas of bays and estuaries to utilize as nurseries. In the San Francisco Bay, starry flounder are found in three general areas, near Alcatraz in the Central Bay, in San Pablo Bay and in Suisun Bay. In recent years there has been a decline in the population in San Pablo Bay, which is associated with a decline in young in Suisun Bay.

    Major food items of starry flounder include small invertebrates, crabs, shrimp and sometimes fish. The factors influencing the resident starry flounder population and distribution may be similar to those affecting striped bass, delta smelt and the longfin smelt, in particular, hydrologic factors and other environmental conditions in San Pablo Bay and Suisun Bay. Recruitment from coastal populations has been the primary means of population maintenance for the Central Bay population. However, ocean temperatures have been above average over the recent past and it is possible that populations are moving northward into cooler waters. Temperature can also influence spawning and early development, decreasing hatching success and the survival of juveniles.

Habitat critical to the survival of starry flounder includes shallow to deep subtidal mud and sand flats. Juveniles depend upon the shallow areas of San Pablo and Suisun Bay, while open deeper waters with higher salinity are generally more acceptable for adults.

18. **Striped Bass.** Striped bass were introduced into San Francisco Bay in 1879, leading to a successful commercial fishery within ten years. The commercial fishery for striped bass was banned in 1935 following a substantial decline in abundance, which appears to have begun at the turn of the century. Striped bass are presently the principal sport fish caught in San Francisco Bay, and is estimated to bring approximately $45 million/year into local economies in the Bay. Striped bass can grow to 50 cm or larger and have the potential to live in excess of 30 years, although most are three to seven years old.

    Striped bass are present in the San Francisco Bay throughout the year, although they generally congregate in San Pablo and Suisun Bays in autumn and move into the Delta and Sacramento River system on their spawning migration during winter and early spring. Striped bass are anadramous, meaning that they move into freshwater to spawn. The timing and location of spawning depends on temperature, flow, and salinity, but typically peaks in May and early June.

    In contrast to the coastal Atlantic populations of striped bass, most of the local populations spend their lives in the San Francisco Bay. However, recent tagging studies suggest that striped bass are spending more time in Suisun Bay, the Delta and surrounding freshwater areas. The current distribution includes the San Francisco Bay, Suisun Bay, the Delta, tributaries of the Sacramento River and the Pacific Ocean.

    Adult abundance has declined over the past 30 years, from over 1.5 million to about 1.5 million in recent years. The decline was most dramatic during the 1970's, prompting the initiation of a hatchery stocking program to supplement natural production. Possible factors in the decline of the striped bass population include low Delta outflow and the location of the null zone, entrainment, the reduction in several invertebrate prey species due to displacement by the invasive Asian clam, and potentially toxic substances and illegal fishing.

    Food items which the striped bass depends upon are Sacramento splittail, Chinook salmon, threadfin shad, American shad and opossum shrimp. Critical habitats for the striped bass include the null zone, where juvenile striped bass are most abundant, as well as large river or tidal channels where eggs and larvae are constantly suspended in the water column. Overall, striped bass are able to tolerate a wide range of environmental conditions, including fresh and salt water, as well as highly turbid water.

19. **Topsmelt.** On the West Coast, topsmelt are represented by five recognized subspecies of which only one, the San Francisco topsmelt, inhabits San Francisco Bay. Topsmelt are a small but tasty food fish taken from piers by recreational anglers. Commercial fishing for topsmelt is limited.

Ecologically, topsmelt are an important prey item for many birds and fish. Topsmelt feed on zooplankton, phytoplankton, and detritus. They forage for food in deep water or on the bottom in shallow water.

Shallow sloughs and mudflats are utilized in late spring and summer to spawn. Common substrates upon which spawning occurs in the Bay is eelgrass. In San Francisco Bay, spawning has been observed in the South Bay, near the Aquatic Park in Berkeley and at the Dumbarton Bridge. Small schools of larvae often occur near the surface of both shallow and open water, and are particularly abundant in tidal basins and the sluggish waters of the South Bay. Juvenile topsmelt generally move into open waters of the Bay or into coastal kelp beds. Some juveniles may occur in Suisun Bay during summer and early fall as the null zone moves to the upper reaches of the Bay. In general, topsmelt seem to be much less common outside of the South Bay.

Field studies indicate that topsmelt are among the most abundant fish species occurring in shallow-water sloughs of the South Bay. Several factors may influence topsmelt abundance. Salinity, water temperatures, freshwater inflows, entrainment on intake screens at power plants, water diversion and the availability of shallow-water eelgrass beds for spawning. Destruction or removal of these types of vegetation may adversely affect topsmelt abundance.

Habitat critical to topsmelt in the Bay include mudflats, which are used for breeding, spawning and as nursery areas for young fish. Subtidal areas with sandy bottoms are also relied on heavily as nursery and foraging areas. In addition, intertidal streambeds are major foraging areas. Recent studies indicate that young topsmelt are sensitive to the effects of pollution. Thus habitats used by topsmelt for spawning and rearing must not be exposed to appreciable amounts of pollution.

20. **White Croaker.** The white croaker is found in small schools and ranges from Baja California to British Columbia. The species supports both sport and commercial fisheries. Central San Francisco Bay is a spawning location for the white croaker, and from there tidal currents transport them to South and San Pablo Bays. Once mature, white croaker emigrate back out of the Bay to the ocean. Thus, the Bay is utilized as a nursery area by white croaker, although spawning also occurs outside of the Bay. Food items of the white croaker include northern anchovies and shrimp.

    Habitats of the Bay utilized by white croaker are soft substrates where the water is the most marine-like in salinity and temperature. Due to the seasonal migration into and out of the Bay, the white croaker population within the Bay is an extension of the nearshore coastal population. In addition, the factors that influence the Bay population to the greatest extent are salinity, temperature, and the distribution of the nearshore population.

21. **Leopard Shark.** The leopard shark is one of the most abundant sharks in San Francisco Bay and is commonly found around piers and jetties. Both an important species to recreational fisherman, as well as being targeted by a limited commercial long-line fishery, the leopard shark is found in California bays and estuaries. Primary foods of the leopard shark are clam siphons, ghost shrimp, rock crabs, octopus, shiner perch, arrow goby, Pacific herring, northern anchovy, and topsmelt. The leopard shark probably has no predators except larger sharks and humans. However, heavy fishing mortality poses a threat to leopard sharks, as it does to all sharks, due to their slow growth, long time to maturity, and low fecundity.

    Overall, leopard sharks are primarily a marine species which occupies bays and estuaries unless freshwater flows lower salinity excessively. Sandy and muddy bottom areas are preferred, although they may be found near rocky areas and kelp beds along the coast. Estuaries, in particular, are used as pupping and resting areas for young sharks, although San Francisco Bay provides habitat to leopard sharks year-round. Furthermore, shallow mud and sand flats are used for foraging during high tide.

22. **Northern Anchovy.** The northern anchovy has the largest biomass and is the most abundant fish in San Francisco Bay. It is an important forage species for larger predators and consumes substantial amounts of phytoplankton and zooplankton. A bait fishery for northern anchovy occurs at the mouth of the Bay, although most of the stock occurs outside the Bay in the California Current. While northern anchovy can be found inside the Bay throughout the year, their seasonal peak is generally April to October. Furthermore, while the biomass of northern anchovy in the Bay is small relative to that in the California Current, the Bay is favorable habitat for reproduction because of ample food for adults to produce eggs, abundant zooplankton prey for larvae, and protection of eggs and larvae from offshore transport to less productive areas by coastal upwelling.

    Northern anchovy larvae eat dinoflagellates and zooplankton, while adults filter-feed in dense patches of large phytoplankton or small zooplankton. Species which depend on northern anchovy for food include California halibut, Chinook and coho salmon, rockfishes, yellowtail, tunas, sharks, harbor seal, northern fur seal, sea lions, common murre, brown pelican, sooty shearwater and cormorant.

23. **Steelhead.** Steelhead are the anadramous form of resident rainbow trout. In California steelhead may be classified into two races, summer and winter steelhead, based upon the timing of upstream migration into freshwater. The San Francisco Bay and its tributary streams support winter steelhead. Steelhead are a polymorphic species and as such populations within a stream may be anadramous, resident or mixtures of the two forms that interbreed. Steelhead do not support a commercial fishery within San Francisco Bay and its tributaries, due to a precipitous decline in their numbers. Currently, the National Marine Fisheries Service is considering listing them under the Endangered Species Act.

    Polymorphic salmonids exhibit a high degree of life history variation. Steelhead within San Francisco Bay may be classified as "ocean-maturing" or "winter" steelhead that typically begin their spawning migration in the fall and winter, and spawn within a few weeks to a few months from when they enter freshwater. Releases of cold water from several large Central Valley reservoirs on the Sacramento River system may induce steelhead to move into upstream tributaries as early as August and September. This means that upstream migrating steelhead may be observed within San Francisco Bay and Suisun Marsh/Bay between December and April, with most spawning occurring between January through Marsh.

    Steelhead may be found foraging in and migrating throughout the open water of estuarine subtidal and riverine tidal habitats within all areas of San Francisco Bay. Furthermore, small steelhead runs of unknown size are known to exist in all parts of the Bay. General factors influencing steelhead population numbers during upstream migration, spawning, and incubation include barriers to passage, diversions, flow fluctuations, water temperature, and other water quality parameters, such as sedimentation of spawning habitats. In addition, dredging and dredged material disposal within the Bay may contribute to degradation of steelhead habitat and interfere with migration foraging and food resources.

24. **Longfin Smelt.** The longfin smelt is a three to seven- inch long silvery fish that was once the most abundant smelt species in the Bay-Delta estuary. However, due to serious declines in abundance, the species may be considered for future listing under the California Endangered Species Act. The decline in abundance in San Francisco Bay is associated with freshwater diversion from the Delta. Longfin smelt may be particularly sensi-

tive to adverse habitat alterations because their two year life cycle increases their likelihood of extinction after consecutive periods of reproductive failure due to drought or other factors.

Longfin smelt are euryhaline meaning they are adapted to a wide salinity range. They are also anadramous. Spawning adults are found seasonally as far upstream in the Delta as Hood, Medford Island, and the Central Valley Project and State Water Project. Except when spawning, longfin smelt are most abundant in Suisun and San Pablo Bays. Prespawning adults and yearling juveniles are generally most abundant in San Pablo Bay and downstrêam areas as far as the South Bay and in the open ocean.

Longfin smelt feed upon zooplankton, oppossum shrimp and crustaceans. Species dependent upon longfin smelt include brown pelicans, river otters and striped bass. In general, longfin smelt are pelagic (utilize open water) and use the larger sloughs and rivers of the Delta and Bay. Optimum habitat for spawning includes submergent vegetation that can be used as a substrate for adhesive eggs. High quality habitat is also defined as having low levels of exposure to entrainment into water export facilities and agricultural or managed wetland diversions. Juvenile longfin use the open water, shallow shoal areas of San Pablo and Suisun Bays after being transported downstream from spawning areas in the Delta. An average X2 location in upper Suisun Bay defines good habitat conditions for longfin smelt. Adjacent tidal wetlands are also important to supporting the nutrient cycling and carbon input functions which in turn support the prey species upon which longfin feed.

25. **Threespine Stickleback.** The threespine stickleback is a polymorphic fish species and as such, populations within San Francisco Bay and its tributary streams support resident /freshwater and anadramous/saltwater forms, as well as mixtures of the two forms that presumably interbreed. This species is a visual feeder and primarily eats small benthic organisms, such as insect larvae. The threespine stickleback has no commercial value, but has important scientific value, especially to evolutionary biologists.

    Within San Francisco Bay, threespine stickleback are widely distributed and often locally abundant in fresh, brackish and saltwater intertidal upper marsh and riverine tidal marsh habitats. They are also abundant in large areas of formerly tidal salt and brackish marsh that have been converted to salt ponds in the South Bay and San Pablo Bay. Important factors negatively influencing population numbers include excess siltation and turbidity, increased water temperatures by the removal of riparian vegetation through stream channelization, pollution, the construction of barriers such as dams, and the introduction of piscivorous (fish eating) fish.

26. **Shiner Perch.** The shiner perch is a small but abundant species common to the intertidal and subtidal zones of bays, estuaries, and the nearshore region of California. In San Francisco Bay they are widespread, but are most abundant downstream of the Carquinez Strait. Shiner perch are commonly caught by anglers around rocks and pilings, from shore and docks, and just about any fishing area. They are also used as live bait in the San Francisco fisheries for striped bass and California halibut. Shiner perch feed on small invertebrates and are food for sturgeon, salmon, striped bass, California halibut, cormorant, great blue heron and bald eagles. The shiner perch appears to favor aquatic vegetation if present, but is also fond of shallow sand and mud bottoms. In San Francisco Bay, eelgrass beds may be an important feeding area.

27. **Tule Perch.** Tule perch are deep-bodied, spiny-rayed fish which are the only freshwater member of the surfperch family. They may be found in a variety of habitats from the slow-moving, turbid channels of the Delta, marshes between the mouths of Sonoma Creek and the Napa River, to relatively clear, fast-flowing rivers and streams. In tidal

riverine marshes, tule perch prefer slow-moving backwater and slough habitats with structurally-complex beds of aquatic plants and/or submerged woody debris.. These areas serve as important feeding and breeding habitats, as well as protective rearing areas.

Within San Francisco Bay tule perch have been recorded from Suisun Marsh, including Montezuma Slough, Suisun Bay, Carquinez Strait, the Napa River and its marshes, and Sonoma, Alameda and Coyote Creeks. Important factors negatively influencing population numbers include excess siltation and turbidity, reduced freshwater flows, pollution, removal of riparian vegetation through stream channelization and other flood control measures, and the introduction of some non-native species. Species which feed upon the tule perch include fish, herons, egrets and other wading birds, while the tule perch feeds upon zooplankton and insects, among others.

Mammals, Amphibians and Reptiles

1. **California Tiger Salamander.** The California tiger salamander is a terrestrial salamander with several white or yellow spots or bars on a jet-black field. Once distributed throughout much of California, the range of the California tiger salamander in the Bay Area has dwindled substantially. In San Francisco Bay, California tiger salamanders have disappeared from almost all of the lower elevation areas, save one small site on the San Francisco Wildlife Refuge near Fremont in Alameda County. There are also scattered populations currently inhabiting vernal pool and stockpond habitats in hills surrounding South Bay. A group of relict populations is also present in the North Bay region in vernal pool habitats near Petaluma.

   California tiger salamanders can live up to twenty years. As young they feed primarily on zooplankton and aquatic insects. As adults they subsist on insects and snails. In turn, California tiger salamander are food for San Francisco garter snakes, shrews, opossum, herons, egrets, and ducks. The California tiger salamander also depends on California ground squirrels and Botta's pocket gophers, whose burrows they utilize to stay cool and wet.

   California tiger salamanders appear to have disappeared from approximately 58% of their historic range in the state. This salamander is most affected by land use patterns and other human events which fragment habitat and create barriers between breeding and refuge sites. Some of the more important factors negatively influencing salamander populations include: conversion and isolation of vernal pool habitats (and surrounding oak woodland and grasslands) to agriculture and urbanization; lowering of the groundwater table by overdraft; mortality of juvenile and adult salamanders by vehicles on roads; the introduction of non-native predators such as mosquito fish, bullfrogs and crayfish into breeding habitats; the widespread poisoning of California ground squirrels and other burrowing rodents; and interbreeding with introduced salamanders originally brought in as fish bait. The best habitats for California tiger salamanders are vernal pool complexes with colonies of California ground squirrels or Botta's pocket gophers nearby. Such habitats are normally associated with grasslands or oak woodlands. Additionally, there needs to be abundant invertebrate resources and other native amphibian larvae in the vernal pools used by breeding salamanders.

2. **California Red-Legged Frog.** The California red-legged frog is a large brown to reddish brown frog with moderate-sized dark brown to black spots that sometimes have light centers. The species is the largest native frog in the state. Reproduction generally occurs at night in permanent ponds or the slack water pools of streams during the winter and early spring. The main food items of the California red-legged frog are aquatic insects, terrestrial insects, Pacific treefrogs, California tiger salamander, and the California mouse. Species which depend on the California red-legged frog for food are the Coast garter snake, the bullfrog, herons, egrets, and raccoons.

Historically, California red-legged frogs were found throughout the Pacific slope drainages. Just before the turn of the century, and up until the 1950's, it was still considered to be present in much of the San Francisco Bay region. However, earlier exploitation, subsequent habitat loss from agriculture and urbanization, and the introduction of exotic aquatic predators have presently reduced red-legged frog populations to scattered locations in the foothills and mountains of the San Francisco Bay region. Overall, California red-legged frogs have disappeared from approximately 70% of their original range.

Some of the more important factors negatively influencing frog populations include: conversion and isolation of perennial pool habitats (and surrounding riparian zones) to agriculture; reservoir construction projects, urbanization; lowering of the groundwater table by overdraft, overgrazing by domestic livestock, extended drought, mortality of juvenile and adult frogs by vehicles on roads; and the introduction of non-native predators such as mosquito fish, bullfrogs, and crayfish into breeding habitats.

Although California red-legged frogs can occur in ephemeral or artificially-created ponds devoid of vegetation, the habitats that have been observed to have the largest frog populations are perennial, deep water pools bordered by dense, shrubby riparian vegetation. This dense riparian vegetation is characterized by arroyo willows intermixed with an understory of cattails, tules, or bulrushes.

3. **California Toad.** The California toad is a moderate sized toad that is dusky gray or greenish with warts set in black patches. California toads are algae grazers when they are very young, and while juveniles and adults they feed on aquatic and terrestrial insects. In turn, California toads are food for the San Francisco garter snake, herons, egrets, raccoons and opossum. California toads are found all over California and are widespread in the Bay Area. However, the California toad is in decline in many urban areas where they once were common, such as the Los Angeles Basin. The possible reasons for the localized declines are insecticides used in eradicating introduced Mediterranean fruit flies, changing land use patterns by agriculture and urban communities, leaving less sites containing permanent water, and habitat fragmentation caused by roads and dense regions of urbanization. In the Bay Area, California toads are still relatively abundant in natural and moderately-altered habitats.

   The factors most associated with toad survival include breeding ponds that last for at least two months and sufficient cover (vegetative and small mammal burrows) that provide places for toads to feed and grow, as well as escape predators and desiccating conditions. California toad habitat includes grasslands, woodlands, meadows, gardens, golf courses, and parks. The largest populations of toads seem to be found around stockponds or reservoirs that have an abundance of invertebrate prey, many small mammal burrows that can be used for cover, and a lack of introduced predators, such as bullfrogs, in aquatic habitats.

4. **Pacific Treefrog.** The Pacific treefrog is a small frog with toe pads and a black eye stripe. The dorsal coloration is highly variable, and can be green, tan, reddish, gray, brown, or black. This frog has the most notable voice of the frog world as its call has been used as a natural background sound in innumerable movies produced by Hollywood. From late November to July males congregate at night around any suitable shallow pond of water and chorus to attract receptive females. Groups of two or three males tend to call in sequence during these choruses and the sequence is consistently started by one frog known as the leader. The choruses may continue into daylight hours and can be deafening if hundreds of thousands of calling males are involved.

   Common food items include aquatic insects and terrestrial insects, while the Pacific treefrog is food for the California red-legged frog, the California tiger salamander, herons, egrets, and the coast garter snake.

Pacific treefrogs are found in most parts of California. In the Bay Area they are very abundant. Here they are known to utilize habitats created by humans, especially in urban areas. Although populations are negatively influenced by the premature drying of breeding ponds and the continued loss of individuals through predation, treefrogs are able to successfully reproduce in sufficient numbers to overcome these setbacks. The largest populations seem to be present in complexes of shallow ponds (lacking fishes and other aquatic predators) surrounded by growths of tules and other aquatic vegetation, although Pacific treefrogs also seem to do well in golf courses, city parks, and other places that have permanent aquatic habitats and places with riparian vegetation.

5. **San Francisco Garter Snake.** The San Francisco garter snake is medium sized with a wide dorsal stripe of greenish yellow-edged with black, bordered on each side by a broad red stripe followed by a black one. The snake's belly is a bright greenish blue. This snake was one of the first reptiles to be listed as endangered by the U.S. Fish and Wildlife Service. Food items eaten by the San Francisco garter snake include Pacific treefrogs, California red-legged frogs, California toads, introduced bullfrogs, introduced mosquitofish, threespine sticklebacks, newts and earthworms. Predators of the San Francisco garter snake include hawks, herons, egrets, striped skunk, Pacific treefrog and California red-legged frog.

   San Francisco garter snakes are a Bay Area endemic that are essentially restricted to San Mateo County, California. They have disappeared from significant portions of their native habitat range due to habitat loss from agriculture and urbanization, especially from housing developments and freeway construction. Historically, the largest known populations of snakes were at a series of sag ponds (locally referred to as the "Skyline Ponds") along Highway 35 in the vicinity of Pacifica, Daly City, San Bruno and South San Francisco. Today, this complex of ponds has been completely covered by urbanization. About 70% of the current remaining San Francisco garter snake habitat is composed of artificially constructed aquatic sites such as farm ponds, channeled sloughs, and reservoir impoundments. Such habitats are often managed in ways that are detrimental to the snake and its preferred prey of California red-legged frogs.

   Current estimates put the number of San Francisco garter snakes at about 65 reproductive populations, or around 1500 total snakes. About half the known populations are protected to some extent by refuges such as water preserves or state parks. Habitat critical to the San Francisco garter snake includes natural sag ponds or artificial waterways that have been allowed to develop a dense cover of vegetation. Important to the survival of this species are large amphibian populations, many basking sites for juveniles and adult snakes that are secure from predators, as well as the presence of adjacent upland areas with abundant numbers of small mammal burrows that can be used as hibernation sites for snakes during the winter.

6. **Western Pond Turtle.** The western pond turtle is a moderate-sized drab brown or khaki-colored turtle often lacking prominent markings on its shell. In California, sexual maturity in western pond turtles occurs at between seven and eleven years of age, while sexual maturity is delayed in turtles that experience drought conditions. Western pond turtles are known to live over 42 years in the wild. The nesting season is from late April to early August, and is a time when females migrate from aquatic habitats to an unshaded, upland location that may be a considerable distance away.

   The western pond turtle historically occurred from Washington State down to Baja, California. They are present throughout the Bay Area, although at much lower numbers and fewer localities than before, especially in urban areas. The western pond turtle is declining in population size and numbers throughout its range, particularly in southern California and the San Joaquin Valley. Many turtles in these areas of decline are now composed almost entirely of old adults. The reason for these declines are largely due to urbanization, exploitation for the food and pet trade, extended drought, and the introduction of exotic predatory species such as largemouth bass and bullfrogs, which compete for the availability of prey items, especially with young turtles.

Food items which the western pond turtle depends upon are aquatic insects, aquatic vegetation and California tiger salamander. In turn, the western pond turtle is food for raccoons, striped skunk, opossum, bullfrog, black bear, herons, humans, and introduced predatory fish. Good habitat for the western pond turtle is warm water that is slow running and which has abundant basking sites and underwater refugia. The presence of dense stands of submergent or emergent vegetation, and abundant aquatic invertebrate resources, as well as suitable nesting sites and the lack of native and exotic predators, are also important.

7. **California Alligator Lizard.** The California alligator lizard has a broad head and a reddish blotched rear marked with nine or more dusky crossbands between the head and hind limbs. The top of the head is often mottled . Both juveniles and adults are active in the daytime, at dusk, and at night, and have a relatively low preferred temperature range. Because of this, they do not bask. Instead they prefer very dense cover and often position themselves under warmed objects such as rocks or pieces of wood during certain times of the day. Alligator lizards frequent riparian zones where their prehensile tails are used in climbing trees and other vegetation in pursuit of prey.

   Primary items eaten by the California alligator lizard are insects and spiders. In turn, they are food for the domestic cat, striped skunk, opossum, raccoon, herons, egrets, hawks, coyote, red fox, coast garter snake, and the bullfrog. The California alligator lizard is found in the Bay Area and throughout the state. Specifically, they are abundant in the foothills surrounding San Francisco Bay and are still present in good numbers over almost all of their historic range.

   Habitat important to the California alligator lizard is diverse. They occupy habitats from pickleweed flats to open grasslands, to oak woodlands, to mixed coniferous forest, to urban environments. However, the largest observed populations are in the riparian zones of oak woodlands and in coastal sage scrub near beaches.

8. **Central Coast Garter Snake.** The central coast garter snake is a medium-sized garter snake that is dark olive to black with a single yellow to orange dorsal stripe, and sometimes lateral stripes of pale yellow. The throat is also bright yellow. Juvenile and adult snakes feed almost entirely on fish such as threespine stickleback and sculpins, as well as Pacific treefrog, California red-legged frog, and coast range newt. Organisms which prey upon the central coast garter snake are hawks, bullfrogs, herons, egrets and raccoons.

   Central coast garter snakes inhabit small streams, ponds, and other aquatic habitats in the San Francisco Peninsula and the East Bay Hills, Contra Costa County (south of the Sacramento River), southward through the South Coast Range to Point Conception, Santa Barbara County, and east to the western edge of the San Joaquin Valley. The species are relatively common in the Bay Area, although, central coast garter snakes are negatively affected by habitat alteration, especially by agriculture and urbanization, which often results in intermittent aquatic habitats unsuitable for this species. These snakes are also negatively affected by the introduction of exotic predators such as bullfrogs and largemouth bass which are known to eat garter snakes. However, these central coast garter snakes are still relatively abundant in aquatic habitats located in the foothills surrounding the Bay Area, where urban development is less intrusive. Habitat important to the well-being of central coast garter snakes are riparian habitat with shallow ponds containing abundant numbers of native fish and amphibians, as well as thickets of vegetation nearby.

9. **Coast Garter Snake.** The coast garter snake is a medium-sized garter snake with a reddish to solid black color and a single pale to bright yellow dorsal stripe. In addition, the species has two lateral stripes of yellow to salmon color. The throat and the belly are usually tinged with orange flecks. This species of snake subsists largely on slugs, California slender salamanders, arboreal salamanders, Pacific treefrogs, western fence lizards, California voles, deer mice, young brush rabbits and nestling white-crowned sparrows. In turn the coast garter snake is food for raccoon, hawks, herons, egrets and the California kingsnake.

   Coast garter snakes are widely distributed in the Bay Area. In addition, their range extends from north of the Oregon border, south to Point Conception. Coast garter snakes are negatively affected by habitat alteration, especially by agriculture and urbanization, which often results in disturbed or open habitats unsuitable for this species. Because the snakes do not require permanent aquatic habitats for long term survival, like other garter snake species in the Bay Area, they are less affected overall by human activities. Coast garter snakes are still relatively abundant in terrestrial habitats located in the foothills surrounding the Bay Area.

   Coast garter snakes inhabit meadows (such as grasslands) and clearings with second growth in the fog belt, as well as chaparral. They are often abundant in canyons with coast live oaks, California bay and numerous shrubs, as well as riparian zones or other areas of dense vegetation, such as blackberries and thimbleberries next to more open areas.

10. **Salt Marsh Harvest Mouse.** This small, native rodent is endemic to the salt marshes and adjacent diked wetlands of San Francisco Bay, and is listed as an endangered species by the U.S. Fish and Wildlife Service and the State of California. The salt marsh harvest mouse is composed of two subspecies. The northern subspecies is found on the upper portions of the Marin Peninsula in the Petaluma, Napa and Suisun Marshes, as well as on the northern Contra Costa County coast. The southern subspecies is found in the more highly developed portions of the Bay from the Richmond area to down around the South Bay.

    Salt marsh harvest mice are dependent on the thick, perennial cover of salt marshes and move in the adjacent grasslands only in the spring and summer when the grasslands provide maximum cover. Their preferred habitats are the middle and upper portions of tidal marshes where pickleweed grows. They are vegetarians and can drink water ranging from moderately saline to salt water. They do not burrow but will build ball-like nests of dry grasses and other vegetation on the ground or up in the pickleweed.

    The major threats to the habitat of the salt marsh harvest mouse includes filling, diking, subsidence and changes in water salinity. Serious losses of tidal marsh habitat have occurred in San Francisco Bay over the last 150 years. Most of the remaining marshes have been back-filled or diked-off and hence most of these tidal marshes are narrow strips along the Bay side of the levees. Those strip marshes and most of the few larger marshes have lost their upper marsh and middle marsh zones, such that there is little escape cover available for the salt marsh harvest mouse during high tide. In the southern end of South Bay, the combination of subsidence caused by water drawdown and the freshening of that part of the Bay by wastewater discharge, has changed the composition of habitat critical to the salt marsh harvest mouse. Because of these influences the species has disappeared from many marshes in the South Bay and is present in very low numbers in others.

    The highest consistent populations are found along the eastern edge of San Pablo Bay and in old dredge spoil disposal ponds on the former Mare Island Shipyard property. Other areas supporting large populations include some parts of the Contra Costa

County coastline, some parts of the Petaluma Marshes, and the Calaveras Point Marsh in the South Bay, although the latter is deteriorating because of the declining salinity and correlated changes in vegetation.

Diked wetlands adjacent to the Bay have grown in importance to the salt marsh harvest mouse, as the tidal marshes bayward of their outboard dikes have decreased in size and quality. Most of these diked marshes in the South Bay are being threatened by urban and industrial development along their borders. In addition, most of these diked marshes are not managed to provide adequate vegetative cover for the species or to maintain their salinity over time.

11. **California Vole.** California voles are vegetarians, feeding extensively on marsh vegetation. They make runways through the vegetation, burrow extensively in non-flooded areas, and often utilize driftwood for cover. They are a critically important prey species for a wide variety of mammalian and avian predators. Habitat use extends from adjacent grasslands into both salt and freshwater marshes, at least into those where flooding does not occur regularly. Voles are good swimmers, however, and can survive occasional inundation. Voles are common inhabitants of San Francisco Bay wetlands.

    Four subspecies of California vole live in the baylands. One subspecies lives in upland areas, while the other three live near the Bay. The three Bay subspecies reside first, from Grizzly Island eastward into the Delta, second, on the Marin County side of the Bay and third, from Contra Costa County around the southern tip of the Bay and as far north as Redwood City. Of particular concern is the Bay subspecies associated with Contra Costa County. This subspecies is viewed as a species of special concern by the state of California, as it is darker and more yellow than the other three subspecies. Conservation of wetlands around the Bay should take into account these endemic subspecies of vole and attempt to achieve representations of the four recognized subspecies.

12. **Salt Marsh Wandering Shrew.** This subspecies of vagrant shrew is confined to the salt marshes of the South Bay. Their historical range extended from the northern end of the San Francisco Peninsula, down through the marshes of the South Bay, and up through the marshes of western Contra Costa County. Known or suspected populations today include the marshes south of Foster City and Hayward, as well as in the San Pablo Marshes of San Pablo Bay.

    This species' habitat is the wet middle marsh zone where dense cover, abundant food (invertebrates), suitable nesting sites, and continuous ground moisture exists. Their center of activity is in the middle marsh zone about 6 to 8 feet above sea level, and in lower marsh areas not regularly inundated. The higher marsh, 8 to 9 feet in elevation, is too dry and offers only minimal cover, so few to no shrews occupy this zone. Also, the lower tidal marsh zone is subjected to daily tidal floods and has cover too sparse for shrews.

    During the 1950's the salt marsh wandering shrew represented about 10% of the small mammals of the marshes. Today they are far less numerous. Little is known as to the cause of the declines or the effect of pollution, salinity changes, vegetation changes and subsidence on the shrew. Adding to the strain on the population of the salt marsh wandering shrew and the lack of knowledge surrounding the species, is the strict habitat and food requirements of this mammal. It exists in a narrow band of tidal salt marsh and does not seem to be present in diked marshes.

13. **Suisun Shrew.** The Suisun shrew is a small, dark, insect-eating mammal with a long, pointed nose and a well-developed scaly tail. One of the nine subspecies of ornate shrew that occur in California, the Suisun shrew is a relatively rare inhabitant of the salt marsh ecosystem of San Pablo and Suisun Bays. Suisun shrews typically inhabit saline and brackish tidal marshes characterized by Pacific cordgrass, gumplant, California bulrush,

and common cat-tail. Suisun shrews prefer dense low-lying vegetation which provides protective cover and suitable nesting sites, as well as abundant invertebrate prey species. Driftwood, planks, and other debris found above the high-tide line also affords the shrew with valuable foraging and nesting sites. In addition, adjacent upland habitats provide essential refuge areas for Suisun shrews and other terrestrial animals during periods of prolonged flooding.

Suisun shrews are carnivores and predators, feeding primarily upon invertebrate species. The shrews may also occasionally serve as prey for several large predators such as the short-eared owl, northern harrier, and black-shouldered kite. Cup-like nests composed of scraps of dead material from plants are used as nests for the young. In turn, these nests once abandoned may be used by other small mammals such as the salt marsh harvest mouse. The Suisun shrew is currently limited in its distribution to the scattered, isolated remnants of natural tidal salt and brackish marshes surrounding the northern borders of Suisun and San Pablo Bays. Four distinct population exist within this range. They include: the Grizzly Island population, found throughout the marshlands east of Suisun Slough; a peripheral population, found west of Suisun Slough and on Morrow Island; the Southampton population, restricted to the Benicia State Recreation Area; and the Sears Point population located in the Napa marshes.

14. **Harbor Seal.** Harbor seals are the only marine mammals that are permanent residents in San Francisco Bay. They have been observed as far upstream as Grizzly Island, but little regular use is evident north of the Corte Madera marshes. Harbor seals feed in the deeper waters of the Bay and two principal feeding areas are utilized. The first includes the area from the Golden Gate east to Treasure Island, northwest to the Tiburon Peninsula, and with a spur southward from Yerba Buena Island. This Central Bay feeding area is surrounded by nine haul-out and/or breeding sites. The second major feeding area includes open Bay waters from the San Mateo Bridge southward. This South Bay feeding area is surrounded by fourteen haul-out and/or breeding sites. Figure 8 illustrates known haul-out locations in the Bay and suitable habitat areas where harbor seals may be found.

    Haul-outs must have gently sloping terrain, deep water immediately nearby, and must also be free of disturbance by boats or from land. An average of two haul-out sites are occupied by an individual seal each day, more so in the fall and winter and more so in the South Bay. Haul-out sites used for pupping tend to be ones that are the most protected from disturbance. The use of such sites is persistent and seals are slow to discover and utilize new pupping sites. Scientists estimate that approximately 627 individuals are found in the Bay and that their population has not changed significantly over the last ten years.

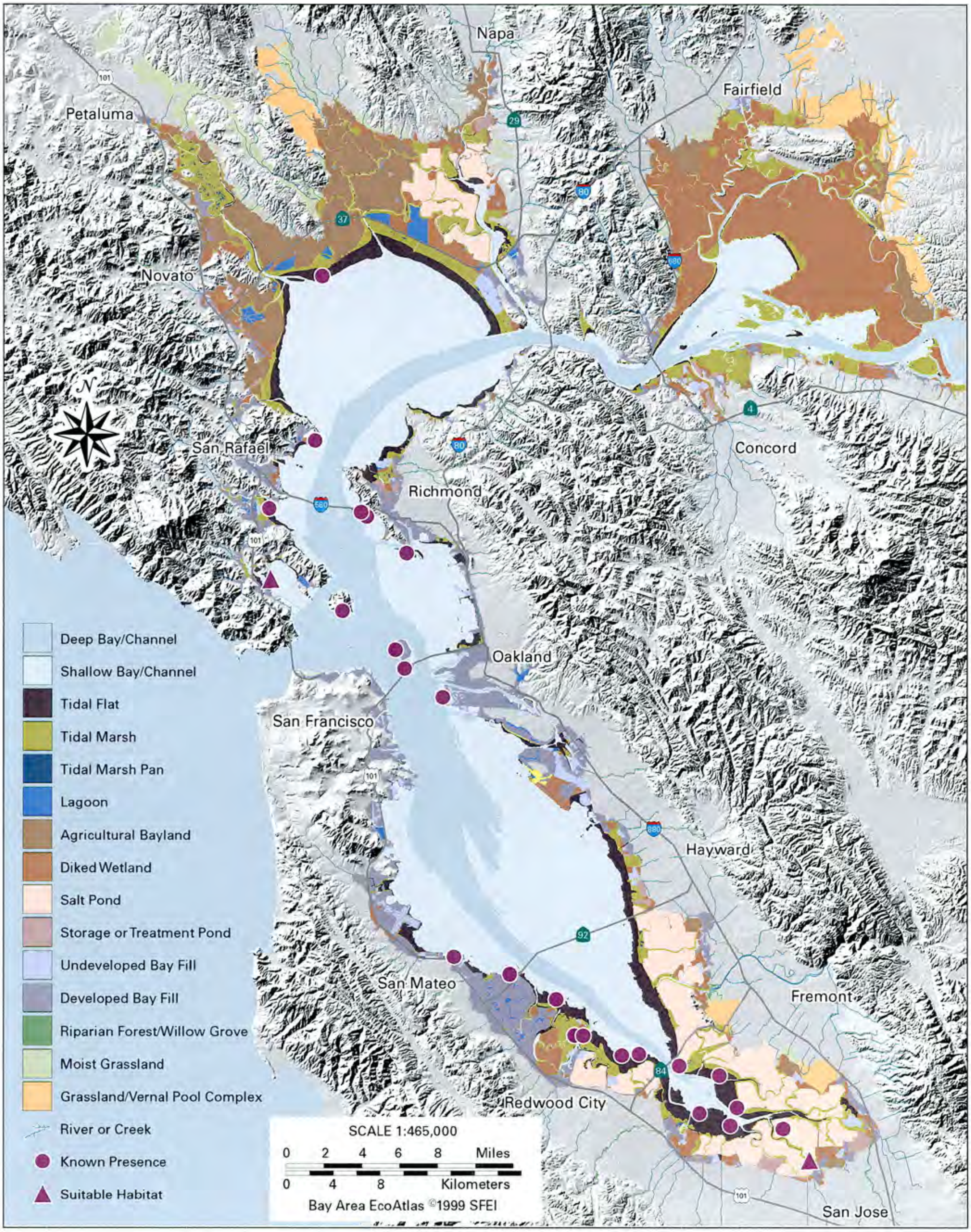
    Food which the harbor seal depends upon is primarily fish, but sometimes octopus are eaten. Common fish species eaten in the Bay include goby, staghorn sculpin, plainfin midshipman, white croaker, Pacific herring and jacksmelt. The long association of harbor seals with humans in the Bay, including being actively hunted until about 1890, has made them extremely wary. They will flush from haul-out sites at 300 meters away when they see humans. This makes them susceptible to harassment by persons on shore and boaters and kayakers on the Bay. For example, during the 1970's and 1980's, encroachment by humans caused the gradual abandonment of Strawberry Spit as a haul-out site used by harbor seals.

    Not only is protection from disturbance and adequate haul-out sites important to the well-being of harbor seals, but also the presence of food. For example, harbor seals are known to locate their haul-out sites in close proximity to prey, such as herring when they come into the Bay to spawn.

Figure 8

SOURCE: MARI Focus Team, Harvey and Torok 1994, Kopec and Harvey 1995

Current Harbor Seal Haul-Out Locations and Suitable Habitat



15. **River Otter.** In California, the distribution of river otters early in the 20th century included the Sacramento, San Joaquin and North Coast river drainages, eastward from the coast to the Sierra crest and to the Warner Mountains of Modoc County, and from the San Joaquin River east to the Sierra crest. The center of species abundance in California was in the Sacramento-San Joaquin Delta. While trapping is responsible for early declines, bringing about a ban on trapping in 1969, current declines are caused by habitat destruction, alteration and declines in water quality. Due to the fact that river otters spend almost all of their time in the water, they are put at risk of toxic contamination both by coming into contact with it in the water, as well as eating it after the pollutants have accumulated in the tissues of organisms lower down the food chain.

    Today, otters are found throughout fresh water habitats in northern California, as well as in brackish and salt marshes. Currently, the highest densities are found in the Klamath-Trinity drainage and the Sacramento River drainage, including Suisun Marsh. River otters are the top carnivore in riverine systems and eat a wide variety of prey. Otters most commonly eat fish and feed secondarily on crabs, mammals, reptiles, amphibians and insects. In Suisun Marsh crayfish are most commonly eaten, followed by birds and fish. Fish species consumed by river otters in the Delta include carp, Sacramento squawfish, tule perch and striped bass.

16. **Ornate Shrew.** Ornate shrews are small insect-eating organisms weighing five grams, on average. This subspecies of shrew may coexist with the Suisun shrew in the marshes of San Pablo and Suisun Bays. The coloring of the ornate shrew is grayish brown to a pale gray, which differentiates it from the Suisun shrew's darker color. The species' range is from the Sacramento Valley southwest to the Central Coast, including the San Francisco Bay. The ornate shrew prefers semi-arid grassland and riparian habitats, but it is also found in brackish and saltwater marshes in San Pablo Bay.

    Overall, the ornate shrew is an uncommon inhabitant of the upland, transition zones and marshes in the San Francisco Bay. Although it is not currently endangered, its local population status may be a general indicator of the health of an ecosystem, particularly as shrews are good indicators of contaminants in the baylands. Because they eat a variety of invertebrates they often accumulate toxins in their body faster than other species of similar size. In the future, this species may be utilized by scientists as on overall indicator of wetland health.

    The extremely high metabolism of the ornate shrew requires that it eats high energy foods throughout the day. Specifically, the ornate shrew eats invertebrates primarily and may find food and cover in low, dense, moist vegetation.

17. **California Sea Lion.** The California sea lion is the seal most often seen in zoos and circuses. In nature, the species occurs along the West Coast of North America, from Vancouver to the Gulf of California. This species uses those deep, principally marine waters that occur in the outer Bay, off Marin and San Francisco counties. On occasion, isolated individuals and carcasses have been found in Milpitas, Alameda, Napa, and as far up stream in the Delta as Sacramento. When salmon were netted en masse in the Delta 100 years ago, California sea lions were attracted in number as far as Sacramento to take advantage of the netting operation, much as they do today in the case of herring in the Bay.

    In San Francisco Bay, California sea lions occur year round. The greatest numbers are present during the winter herring run. Following the winter peak, numbers decline to just a few animals by June and July. Known haul-out spots in San Francisco are rare and include only Pier 39, occasionally at Angel Island, and at Seal Island outside of the Golden Gate. The largest numbers haul-out at Pier 39, as part of a recent phenomenon which now averages between 200 and 300 animals during the winter season. The use of wharves as haul-outs at Pier 39 is likely the result of increased total population across the sea lion's range, the construction of the wharves in the 1980's, the increasing temperature of the California current, and the chance finding of this site by several individuals seeking food during the low food El Nino year of 1989-1990.

The presence of this species in the Bay is contingent upon the availability of safe haul-out sites and easily available food. Thus its presence is largely tied to the presence of Pacific herring. In addition, the population in the Bay is sensitive to disturbance, capture in gill nets, and to certain diseases such as leptospirosis that are spread by cattle grazing in coastal areas.

18. **Southern Sea Otter.** The historic range of the sea otter is from central Baja California, Mexico, north through the Aleutian Islands. Intensive hunting, however, in the 18^{th} and 19^{th} centuries has restricted their range currently to California and portions of Alaska south to Vancouver, Canada. In San Francisco Bay, sea otters once occurred abundantly as far inland as the mouth of the Sonoma Creek. The population in the Bay was likely in the low thousands, but because of their pelts, all were hunted to extinction in the early 1800's. Today, sea otters are regularly found near Point Reyes and Pacifica. However, no documented sightings of sea otters in the Bay have been made in recent years, although sightings exist for the outer portion of the Golden Gate.

    Sea otters occur in shallow, usually protected, nearshore waters to about 15 meters deep. Normally, sea otters do not come to land, but use kelp for resting, support, and protection from sharks. The kelp, in turn, is maintained by the otters as they eat kelp grazers, such as sea urchins. Thus, the invasion of rocky habitat by sea otters is followed by a recovery of the kelp forest.

    The return of otters to the Bay is contingent upon the continued growth and expansion of the coastal population outside the Bay, the lack of oil pollution, and the availability of food. Other than the passage of time as the population continues to expand, oil pollution, even low-level chronic pollution, is problematic for recolonization of the Bay by this species.

Invasive Mammals. Although there are other, and perhaps equally pernicious, invasive species in and around the Bay, the species narratives associated with the Goals Report focused on invasive mammals that require control, including the red fox and the Norway and Roof rats.

1. **Red Fox.** The red fox is one of the most widely distributed mammals in the world, occupying a diversity of habitats and elevations. There are actually two red fox subspecies in California, the introduced red fox and the native, threatened red fox. The native red fox is found only in the Sierra Nevada and will not be the subject of this discussion.

    The red fox is originally from the Great Plains and was probably brought to the Central Valley for commercial fur farming in the late 1800's. The current distribution of the red fox is in portions of 36 counties, with the greatest concentrations in urban areas of the Los Angeles Basin and San Francisco Bay. The red fox was first seen in South San Francisco Bay in 1986, with subsequent sightings reported from all seven Bay Area counties. Populations of red fox have established themselves in or adjacent to tidal marshes, diked baylands, salt ponds, landfills, agricultural lands, golf courses, grasslands, and urban areas. In particular, the fragmented wetlands of the Bay have become a likely source for expanding populations, as many avian and mammalian prey can be found within these habitats.

    Red fox have extremely broad diets, including birds, small mammals, reptiles, amphibians, insects, vegetation and refuse. They are also known to be surplus killers, where food that is taken may be buried in the ground and never eaten. Because they are such capable predators, they are highly detrimental to native fauna, which is not adapted to avoid or escape them. For example, red foxes are known to decimate ground nesting bird populations through the predation of eggs, young and adults.

In San Francisco Bay, red fox have been implicated in the population declines of the California clapper rail, western snowy plover, California least tern, Caspian tern, and nesting species such as blue herons and great egrets. In response to growing evidence of the impacts of red fox on the California clapper rail, the U.S. Fish and Wildlife Service began a predator management program in 1991. The subsequent removal of red fox and other targeted predators has resulted in a significant increase in local populations of California clapper rail.

It is imperative that all future restoration and management activities within the wetland ecosystems of the Bay consider the present and future impacts of red fox on native wildlife. The long-term viability of many bird species and small mammal species will be impacted by expanding red fox populations in the Bay Area, so much so that no site will remain unaffected by this species.

2. **Norway Rat and Roof Rat.** Norway rats and roof rats are similar in appearance, though the roof rat has a longer tail and can vary in color between brown and black. Both the Norway and roof rat tend to dwell in different habitats, with the larger and more powerful Norway rat occupying more urban areas, and the smaller roof rat living in more natural areas. Where rats are found in San Francisco Bay marshes, then they are more likely to be roof than Norway rats. In addition, where urbanization abuts natural marshes, as it does in many areas of the South Bay, both are likely to find the marsh habitats quite hospitable. In the Central Bay, rats have been sighted at the Elsie Roemer Bird Sanctuary in Alameda, at Crown Beach, the Martin Luther King Regional Shoreline, Arrowhead Marsh, and at Brooks Island off the Richmond Harbor.

   South Bay marshes have revealed evidence of predation of not only clapper rail eggs, but also chicks by rats. A 1992 U.S. Fish and Wildlife study of hatching success and predation for 54 active clapper rail nests in the South Bay found rodents to be responsible for 90% of the eggs destroyed and 79% of the predation at monitored nests. The toll taken on native mammalian populations by the presence of rats in the marshes is not only one of direct predation, but also one of competition for habitat, as well as impacts from diseases. Overall, the most effective control measure at this time is to protect marshes from the rats with extensive buffer areas, as well as keeping buildings and garbage away from wetlands.

Shorebirds and Waterfowl. Waterfowl and shorebirds are characterized by their mobility and strong dependence on aquatic and wetland habitats. In particular, San Francisco Bay is renown as a major North American refuge for many species of waterfowl and shorebirds during their migration and wintering (August through April) periods, and the Bay provides breeding habitat during the summer for a few species (e.g., mallard, black-necked stilt and snowy plover). Furthermore, the Estuary is recognized as a Western Hemisphere Shorebird Reserve Network site of international importance for more than a million shorebirds in migration and as the winter home for more than 50% of the diving ducks in the Pacific Flyway with one of the largest wintering populations of canvasbacks.[9]

1. **Black Turnstone.** In San Francisco Bay, black turnstone is the most numerous of a group of uncommon shorebirds that typically use rocky unvegetated shores. Other species in this group include ruddy turnstone, surfbird, spotted sandpiper, American black oyster

[9] Goals Project, 2000.

catcher, and wandering tattler. These species occur in the Bay as migrants and winter residents which do not breed here, except for a few pairs of oystercatchers and an occasional pair of spotted sandpipers.

The black turnstone is a short-legged, short-billed shorebird, with a blackish back, chest and legs, and a white belly. Black turnstones are found exclusively along the Pacific coast of North America. In the Bay they occur widely throughout Central Bay, and in parts of the North and South Bay. Total counts of black turnstone for the Bay range from 40-137 birds in the fall, 69-144 in the winter, and 212 birds in the spring. These counts may underestimate true numbers, as the counts focus on tidal flats, rather than rocky unvegetated shores.

In the Bay black turnstones feed primarily in rocky unvegetated shores, including rock breakwaters and riprap, as well as natural rocky shorelines. They feed by picking food from the surface or turning over seaweed, rocks, or shells to search for prey. Feeding mostly on barnacles and limpets, black turnstones usually forage and roost in small flocks of a few birds to a dozen.

The black turnstone population in the Bay is probably limited by the availability of rocky intertidal habitat with an adequate food supply. Natural rocky shorelines are very limited in extent, and riprapped shorelines may have less abundant invertebrate prey than natural shorelines. In addition, maintaining or increasing population levels of the black turnstone in the Bay will require the preservation of natural and semi-natural rocky shorelines, as well as important feeding and roosting areas. Preservation of roosting areas must include protection from disturbance by people and dogs.

2. **Canvasback.** The canvasback is a diving duck that forages on aquatic plants or benthic invertebrates in the mouths of rivers or channels, large wetlands and brackish marshes. The continental population of canvasbacks hasn't increased greatly in the last 20 years, but based on mid-winter surveys its population in the Bay has continued to decline. Importantly, San Francisco Bay is one of the three largest wintering areas in North America. Threats to the well-being of canvasback in the Bay include contaminant risks and disturbance by boats, aircraft, people and pets. Consequently, it is a species of special concern for the U.S. Fish and Wildlife Service, and protection of this species was one of the reasons for the establishment of the San Pablo Bay National Wildlife Refuge. Associated species that use similar habitats in the Bay include the common goldeneye, greater and lesser scaup, redhead and ring-necked ducks.

   Canvasback have a steeply sloping bill with a body size similar to the mallard. Males are distinguished by their white back, underparts, and wings, black tail and breast, and red head with blood red eyes. Canvasbacks are the fastest flying large duck in North America, migrating along the Pacific coast to and from their northern breeding areas. They are found in most of the major estuaries along the lower west coast during winter, including Puget Sound, Willapa Bay, and Humboldt Bay, with the largest populations found in the San Francisco Bay. Overall, canvasback comprise 7 percent of the waterfowl in the Bay and 54 percent of the midwinter population in the Pacific Flyway. The largest numbers of canvasback in the Bay are found in North Bay salt evaporation ponds, with smaller numbers found in Suisun Bay and South Bay. Population numbers have decreased in the Bay from 60,000 canvasbacks in the 1960's to 25,000 birds in the early 1990's.

   Canvasbacks in San Francisco Bay feed predominately on clams, while in other areas, aquatic plants make up a larger portion of their diet. Unlike most ducks they are dependent on aquatic habitat through their life cycle, including the breeding period. They are bottom feeders that feed in shallow water over and near tidal flats. Trends in their decline may be reversed in the Bay by supporting more shallow, open water habitats, with dense clam populations and undisturbed roosting areas, particularly in the North and Suisun Bays where they have historically been most abundant.

3. **Long-billed Dowitcher.** San Francisco Bay supports large wintering populations of the long-billed dowitcher, numbering in the low tens of thousands. More than most other abundant shorebirds, this species concentrates in fresh and brackish water wetlands. The key habitat for this bird is managed wetlands. This species associates with dunlin, greater and lesser yellowlegs, black-necked stilt, and American avocet. The long-billed dowitcher is a medium-sized shorebird with short legs and a long bill. In breeding plumage, long-billed dowitchers have cinnamon underparts with bars of black on the sides of the breast and flanks; a white wedge on the rump, and black, buff, and white feathers above, with dull olive-colored legs.

   On the Pacific coast, long-billed dowitchers are found in both coastal and interior regions, including the Central Valley and in California Lakes. Few birds are known to migrate along the western Pacific, but San Francisco Bay is used during both migration and the winter. Long-billed dowitchers, however, do not breed in San Francisco Bay. The South Bay is the most important area for this species, with the North Bay and Suisun Bay also utilized. These birds prefer fresher water habitats over brackish and intertidal habitats. Therefore, seasonal wetlands and fresh water ponds are the most important to this species. In addition, the long-billed dowitcher is commonly found on soft, dredged-material habitats or disturbed sites. Long-billed dowitchers generally follow a pattern of feeding on tidal flats during low tide and roosting in adjacent wetlands or uplands during high tides. Their diet includes insects, benthic invertebrates and worms. Threats to their continued well-being spans from contaminant risks to disturbance by raptors, loud noises and humans.

4. **Mallard.** The mallard is a good representative of other dabbling ducks found in San Francisco Bay, such as the Cinnamon Teal and Gadwall. All three of these species represent resident breeding populations in the Bay, as well as migrational wintering populations from the northern breeding grounds. The largest populations of mallards occur in the Suisun Marsh. In addition, the managed marshes of the Suisun Bay are the most important habitat for mallards in the Bay. Managed wetlands are critical habitat for both resident breeding birds as well as migrants, providing food resources and wintering habitat. Mallards were also recorded as the number one dabbling duck of the San Pablo Bay and South Bay sub-regions, most often using seasonal wetlands habitats and low salinity salt ponds. The lowest numbers of mallards were recorded in the Central Bay region, with few mallards being recorded in the open bay habitats of all four sub-regions.

   Mallards are the most widely distributed species of waterfowl in North America, and are found virtually everywhere in high numbers except for the Atlantic flyway. During the 1996-1997 waterfowl season, mallard numbers in the Suisun Marsh fluctuated from a high of 29,580 in October 1996 to a low of 6,105 in January 1997. Some of the main factors influencing mallard distribution in the Bay is the availability of areas with low salinity water and the necessary food resources.

   Mallards are very opportunistic in their foraging behavior. They will feed on both natural food plants as well as agricultural waste grains while on their wintering grounds. The primary natural foods eaten by waterfowl in the Suisun Marsh are alkali bulrush, fat-hen, buttons, watergrass and smart weed. Aquatic invertebrates play an important role in mallard diets prior to and during the breeding season, due to the high energy demands of the hen for egg laying. Threats to the continued well-being of mallards in the Bay are disease and contamination. In addition, disturbance by humans may have negative affects on mallards. Finally, the maintenance of good wintering and breeding habitat in the Suisun Marsh and Napa Marsh is important to the continued use by mallards of San Francisco Bay. This can be accomplished by the protection of seasonal wetlands and the intensive management of diked managed wetland areas.

5. **Marbled Godwit.** San Francisco Bay holds the second largest known wintering concentration of marbled godwits, numbering between 15,000 and 20,000. Although marbled godwits are more restricted to estuarine habitats than other shorebirds such as the American avocet, willet, long-billed curlew, whimbrel and black-bellied plover, their habitat requirements are a good representation of the needs of these other species. These habitat requirements include expansive tidal flats used as foraging habitat during ebbing tides, as well as roosting and foraging habitat during high tides.

   The marbled godwit is a large, mottled, cinnamon-buff and black shorebird with long dark gray legs and a slightly upturned bill. The long-billed curlew is of similar coloration and size, but has a long distinctive bill. The willet is also similar in size, but is grayer and has a much shorter straighter bill.

   Marbled godwits occur in all regions of San Francisco Bay. The winter population size is in the range of 13,000-20,000 individuals, the second largest known concentration of wintering marbled godwits in the world. During fall, up to 28,800, and in spring up to 32,000 marbled godwits have been recorded in the Bay. The largest numbers of marbled godwits in the Bay occur in South Bay, totaling between 50-60 percent. San Pablo Bay comprises 25-40 percent of the population, while Central Bay typically holds only 10-20 percent. Small numbers are found on the tidal flats of Suisun Bay.

   This species characteristically probes deep into sandy to muddy substrates for invertebrate prey. Tidal flats and sandy beaches are the principal feeding habitat with wet to shallowly-flooded pastures and lawns sometimes used during high tides. Some foraging also occurs in salt marshes and occasionally on rocky reefs. In San Francisco Bay, marbled godwits forage primarily on tidal flats and to a much lesser degree in salt marshes, seasonal wetlands and possibly salt ponds. In addition, salt ponds are used by numerous large shorebirds as high tide roosting areas.

6. **Northern Pintail.** The northern pintail has historically been the most common puddle duck wintering in the San Francisco Bay region. Continental population declines have been severe and the declines have been even greater within the San Francisco Bay region. In particular, Suisun Marsh has seen peak numbers decline as much as 90 percent over the past several decades. Specifically, in the 1950's there were close to 200,000 pintails wintering in the Bay, while the 1990's have averaged under 20,000 pintails. Northern pintails are a long slender duck with a long neck and tail, and narrow, angular wings which appear centered on their body. Males in breeding plumage have a chocolate brown head with a white breast and foreneck extending upward into a stripe on each side of the head. Northern pintails use a wide variety of habitat types throughout the region, including managed marsh, seasonal wetlands, open bay and salt ponds. In addition, they utilize many of the habitats used by other waterfowl species. Species which are commonly found in similar habitats as Northern pintail are green-wing teal, the northern shoveler and the American wigeon.

   Northern pintails are known to use a variety of habitats within the Bay, including diked wetlands, salt ponds, open bays and mudflats. Very few pintails are found in the Central Bay, while the majority are found in Suisun Bay. In the North Bay and South Bay, significant numbers of Northern pintails utilize salt ponds and open water. The winter-time diet of northern pintails consists primarily of seeds and vegetative material, with important seeds including rice, swamp timothy, barnyard grass, flatsedges, southern naiad, and smartweeds. Other food sources include midge larvae. While in the Suisun Marsh, northern pintail commonly feed upon brass buttons, alkali bulrush and fat hen.

Overall, managed marsh, especially in Suisun Marsh, is the most critical habitat type for northern pintails in the Bay. Similarly, tidal flats are important feeding habitat when covered by small amounts of water. Unvegetated levees and small islands are important roosting habitats. Threats to the well-being of the northern pintail require further study as they encompass continent-wide impacts.

7. **Red Knot.** The red knot is a high-arctic breeding shorebird and a long distance migrant. Knots are most abundant on the Pacific coast of North America during spring migration and less abundant during fall. In winter, significant numbers of knots appear to be localized in distribution into three areas on the Pacific coast of North America. These include San Francisco Bay Area wetlands, San Diego Bay and Baja California, Mexico. In the Bay Area, habitat critical to the red knot includes intertidal flats used while foraging and undisturbed high tide roost sites. Because red knots frequently associate with dowitchers, dunlins and black-bellied plovers, management plans to preserve, enhance or restore habitat for red knots may also benefit these other species.

   Red knots look heavy and rounded in shape. The bill is blackish and faintly downcurved, the iris is dark brown, and the legs are rather short. Breeding-plumaged adults have dark gray legs, chestnut-red face and underparts, gray and black speckled backs, and a white undertail. Central Bay tidal flats along the Hayward shoreline are one of the most important sites for red knots in the entire Bay. Red knots also utilize tidal flat and salt pond habitats in the North and South Bay. In general, tidal flats are used as foraging sites, while at high tide red knots roost in flocks in areas such as salt evaporator ponds in Hayward.

   Red knots feed primarily on invertebrates found on the surface of tidal flats. Due to their rarity in the Bay, the protection of the red knot and its habitat merits special consideration. Similar to other shorebirds in the Bay, red knots are susceptible to human disturbance as well as risks of water contamination and oil spills.

8. **Ruddy Duck.** The ruddy duck is a widespread diving duck and has one of the largest wintering concentrations in San Francisco Bay. This species uses a variety of wetlands, including managed marsh areas, but prefers salt ponds found around the perimeter of the Bay. Bufflehead ducks use similar habitat. The ruddy duck's stiff, erect tail is its most pronounced attribute. During breeding season adult males display a reddish-brown coloration, white throat patch, and exceptionally bright blue bills. Both sexes have white cheek patches.

   The greatest number of ruddy ducks that migrate to California over winter at San Francisco Bay. Since 1986, based on mid-winter surveys, numbers have ranged from about 1,900 to 28,000. Salt ponds located on the east and south shores of South Bay have supported the greatest numbers of ruddy ducks in the Bay region, while salt ponds in the North Bay have supported the second highest numbers of ruddy ducks in the Bay. Habitats important to the ruddy duck are the use of salt ponds for feeding on invertebrates and the utilization of nearby open Bay water for roosting.

   Any efforts to restore wetlands in the Bay should consider the importance of human-created water impoundments, such as salt ponds, to wintering waterfowl populations, as ruddy duck populations have become dependent on these altered habitats for winter-season survival.

9. **Western Snowy Plover.** The population of western snowy plovers, a shorebird, that breeds along the Pacific coast of the United States and Mexico has declined due to habitat loss and degradation, but also from poor nesting success due to predation. Along the Pacific coast, San Francisco Bay is the northernmost area supporting over 100 breeding snowy plovers. Salt ponds, their levees, and pond edges provide almost all known snowy plover habitat in the Bay today. The majority of snowy plovers in the Bay nest in the South Bay, south of the San Mateo Bridge. Within the Bay, the population of snowy plovers has declined from 351 adults in a 1978 survey to 226 in a 1989 survey. Of the 226 snowy plovers found in 1989, 216 were found in the South Bay.

   Snowy plovers are known to move between salt pond breeding, foraging, and roosting sites, as well as mudflat foraging sites during all seasons. In San Francisco Bay salt evaporation ponds, the following prey are known food items of snowy plovers: flies, beetles, moths and caterpillars.

   Prior to the construction of salt ponds in the Bay there are no records of snowy plover breeding in the Bay. However, due to its reliance on San Francisco Bay today and dwindling habitat elsewhere, this species cannot afford any loss of Bay habitat. Plans for tidal marsh restoration should attempt to encourage natural formation of salt panne habitat at the Bay's edge for potential plover use. Also, several salt pond sites should be provided, rather than one large contiguous salt pond area.

10. **Surf Scoter.** This species is representative of sea ducks that primarily use deeper, open water habitat. Associated species are white-winged scoters, black scoters and red-breasted mergansers. The surf scoter is the most common of the three North American scoters that winter at San Francisco Bay. In addition, the Bay appears to be the most important inshore wintering habitat in the eastern Pacific, south of the Straits of Georgia and Puget Sound.

    Surf scoters are the most common of the three kinds of North American scoters which winter in the Bay. Scoters are most abundant in the Central Bay, with the next largest abundance found in South Bay. Scoters are also common in the North Bay, but less common in Suisun Bay. Overall population numbers in the Bay of all three species of scoters range from a high of 72,000 to a low of1,200 birds.

    Surf scoters are strong divers, feeding in the open waters of the Bay and also along the cliffs at the entrance to San Francisco Bay. They have also been observed feeding on rock-bound intertidal or shallow subtidal mussels or scallops at high tide. Their preferred diet consists of clams inhabiting silty or sandy substrate, or mussels attached to hard substrates such as pilings or rocks. Important habitats used by scoters are the open waters throughout San Francisco Bay, as well as the underlying sediments used for foraging. Scoters, in addition, will forage in tidal wetlands during high tide.

    In terms of threats, scoters are susceptible to contaminants and human disturbance. They are particularly intolerant of disturbance by motorboats. In addition, they require areas secluded from human disturbance at night and while foraging in intertidal areas during high tide.

11. **Tule Greater White-Fronted Goose.** Tule geese are primarily associated with managed wetlands and agricultural lands. Their habitat needs are similar to the Pacific greater white-fronted goose, the Canada goose, the Aleutian Canada goose and the tundra swan. In the Bay, the tule goose is only found in the Suisun Bay and North Bay subregions. For this species, Suisun Marsh is the third most important wintering area in California. In the North Bay region, mainly Napa Marsh, a small population uses the marshes, sloughs and adjacent agricultural lands. The peak number of tule greater white-fronted geese in the Bay was 8,615 in 1989.

In the Suisun Marsh, tule geese feed in ponds with alkali bulrush or in the barley/grass uplands of the sanctuary on Grizzly Island. Roosting areas have shallowly flooded uplands with a grass-pickleweed mixture. Tule geese observed feeding in the Napa Marsh were found in tidal areas fringed by emergent cattails, tules, alkali bulrush, and cordgass. The managed wetlands of the Suisun Marsh are the most important habitat for tule geese in the Bay. These wetlands managed for alkali bulrush and other wetland wildlife food plants are critical as feeding and roosting areas. In order to maintain current populations of the tule goose, Suisun Marsh's managed wetlands and associated upland habitats must remain intact. While tule geese do not nest in San Francisco Bay, an associated species, the Canada goose, does nest in the Napa Marsh.

The tule greater white-fronted goose is hunted in both the Suisun Marsh and the Napa Marsh, although estimated hunting mortality represents less than 5 percent of the known total population.

12. **Western Sandpiper.** The western sandpiper is the most abundant shorebird of California during fall and spring migration, and the second most abundant during the winter. The largest winter concentrations are found from San Francisco Bay south to Panama. Western sandpipers are found in all parts of San Francisco Bay. A comprehensive April count of shorebirds counted over 555,000 western sandpipers. Between 430,000 and 707,000 were found during five additional spring counts. The largest numbers were found in areas of the South Bay with large expanses of mudflats at low tide, backed by salt pond complexes.

    Western sandpipers feed mainly on invertebrates, but occasionally feed on small fish and plant matter. They are tactile feeders that typically probe in the mud for prey. Intertidal mudflat habitat is the most important feeding area for these birds. In salt ponds, western sandpiper also feed upon brine flies, insects, and seeds. While roosting, western sandpipers utilize salt pond levees, dry to very shallow salt ponds and diked baylands. Farmed and grazed habitats are crucial for upland refuge in extreme events such as severe winter storms.

13. **Wilson's Phalarope.** Wilson's phalarope is representative of the group of shorebird species associated with salt pond habitat, including red-necked phalarope, American avocet and black-necked stilt. The Wilson's phalarope has mostly white plumage with short legs and a mid-length straight bill. Following breeding farther north, this species congregates in June on large lakes such as San Francisco Bay's salt pond system, Mono Lake and the Salton Sea to prepare for southbound migration. By mid-September, the birds head south to feeding grounds in South America.

    Wilson's phalarope are found almost exclusively on the South Bay's salt ponds and their islands. Population numbers range around 213. Foraging occurs most commonly on open water habitats, Wilson's phalarope are also known to probe for food on mudflats. Common prey items include brine shrimp, seed of round stem bulrush, and the larvae of brine flies. This species roosts at night on open water. Due to the loss of breeding habitat in the grasslands of North America and changes in Mono Lake and the Salton Sea, the survival of this species depends on the presence of medium to high salinity salt ponds in the South Bay.

Other Bird Species of the Bay. Gulls, terns, grebes, pelicans, egrets, raptors, rails and many species of songbirds are representative of other bird species (bird species other than waterfowl and shorebirds) found in the San Francisco baylands. The abundance and distribution of other birds using the Bay is a reflection of the habitat changes which have occurred over the last 150 years. These changes have resulted in dramatic declines in some species (clapper rails) and in creases in other species (eared grebe or meadowlarks). Changes are most pronounced in species which are dependent on tidal marsh and those which have been able to exploit new habitats resulting from diking and filling of the Bay.[10]

1. **Eared Grebe.** Eared grebes occur rather widely as migrants and more narrowly through the winter in the Bay Area. Their preferred habitat is the medium or medium-high saline salt evaporator ponds where their numbers range up to several thousand per pond and where high concentrations of brine shrimp and water boatmen are found. These invertebrates are prime prey for the eared grebe.

   South Bay salt ponds, in particular, are highly utilized by the eared grebe and constitute important migration and wintering habitat. Due to its reliance on salt pond habitats in the Bay, this species would be highly impacted if salt pond habitats were eliminated or sharply reduced in extent.

2. **Western and Clark's Grebe.** The western and Clark's grebe are very closely related and the biology of the two species is virtually identical. The western and Clark's grebe are the largest grebes in North America and one of the largest in the world. They are the size of a medium-sized duck and are fish-eating, as emphasized by their stiletto-shaped beak, which is used for spearing fish.

   In the San Francisco Bay region, the western grebe outnumbers the Clark's grebe by 9 to 1. These species do not breed in San Francisco Bay and their peak numbers occur from October through April. No area-wide counts are available either historically or in recent years.

   Within the Bay, these grebes can be found in the waters of sheltered coves and sometimes in sloughs. Rarely are they found in the open Bay, except along tidal rips in the vicinity of Raccoon Straits and Angel Island. Both grebes are entirely aquatic, and never come to land unless ill. When foraging, these grebes dive by jumping up and forward. They use their feet for propulsion. Many of the fish consumed are near-bottom dwellers. Herring are likely an important part of the grebe diet in San Francisco Bay.

   The presence of these species in the Bay is contingent upon the availability of forage fish, such as herring. The decline in grebe numbers in southern Marin may be due to changes in the herring population size or distribution. In addition, these grebes seek sheltered waters for feeding and resting. In these same areas they are constantly displaced by boaters who seek similar locations for fishing. The prohibition of boats in the inner part of Richardson Bay provides needed sanctuary from disturbance.

3. **American White Pelican.** The American White Pelican is one of the larger birds of North America and certainly the largest fish-eating bird. This species is very gregarious, being both a colonial breeder and a group-forager. Occurrence in the San Francisco Bay Area is very localized and is confined to the non-breeding season, generally from June through December. The White Pelican frequents very shallow water and is rarely seen in the open parts of the Bay. One wintering population can be found at White's Slough, Contra Costa County, another in the Hayward area, and another population frequents salt evaporation ponds of the South Bay.

   Likely population numbers in the Bay range around a few thousand during their non-breeding season. Fish which they feed upon include rough fish such as stickleback, which they capture by corraling them in a group and scooping them up with their large beaks. Continued needs of the white pelican include the well-being of inland breeding sites and the presence of quiet waters, such as salt evaporation ponds.

[10] Goals Project, 1999.

4. **Brown Pelican.** The brown pelican is one of the largest fish-eating birds of coastal and estuarine waters. This species breeds colonially, constructing its nests on the ground or more commonly, in trees and shrubs. In San Francisco Bay, brown pelicans frequent all the deeper waters, including some salt evaporation ponds and the mouths of the larger creeks. They are not found much farther inland than San Pablo Bay and roost on small islands, such as Red Rocks, and on breakwaters, such as the Alameda Naval Air Station. Currently, several hundred occur within the Bay each summer and fall. As the species has recovered from the effects of DDT on its breeding productivity, population numbers in the Bay Area have slowly increased.

   In deeper waters, brown pelicans feed on schooling fish. Their diet in the Bay includes fish species, such as anchovies and smelt. They capture their meals by plunging beak-first from the air into the water, grasping fish up to a meter deep. As long as forage fish are available, the population of brown pelicans will do well. When forage fish are not available, brown pelicans are known to scavenge discarded fish from people. Except while nesting, brown pelicans are not intimidated by the presence of humans.

5. **Double-Crested Cormorant.** Cormorants are found the world over from the Arctic to the Antarctic. They are foot propelled divers and feed mostly on fish, although they take swimming invertebrates, such as shrimp, as well. Herring is important during winter and midshipmen are eaten during spring and summer. In the early part of the 20th century, almost all double-crested cormorants that foraged in the Bay likely nested on the offshore Farallon Islands. Since the late 1970's, they began to nest in small numbers around the Bay, especially on transmission towers, bridges and sometimes trees. This species now is widespread in San Francisco Bay and the Delta. The double-crested cormorant forages in shallow waters overlying bottoms of flat relief. This includes rivers and sloughs feeding into the Bay, as well as salt evaporation ponds, and areas such as San Pablo Bay. Large numbers are found in the tidal rips associated with Angel Island and Raccoon Straits

   Since the species is a colonial breeder, breeding birds are concentrated in only a few locations. These sites include the North Bay (salt evaporators near Napa), the Central Bay (Richmond and Oakland Bay Bridges) and another in the South Bay (Dumbarton Bridge). The birds then radiate outward from these colonies to forage at distances of 20 miles or more away. As of 1991, about 2,800 birds nested around the Bay in twelve colonies. This species is most prevalent in the Bay and Delta during winter, from November through March. Although no Bay-wide census has been conducted during winter, their numbers likely reach 10,000 or more. Protection from persecution and the increased availability of man-made structures on which to nest has contributed greatly to the increase in numbers during recent decades.

6. **Snowy Egret.** The snowy egret is a common, year round resident in the San Francisco Bay. This species uses fresh, brackish and salt water habitats throughout its range. Within the Bay it uses all of these habitats for foraging, although for breeding, it is rarely far from brackish or salt water. The densest concentrations of snowy egrets are found either where drying ponds concentrate suitable fish species or where fish blooms occur, mainly in seasonal wetlands and impoundments. Nonetheless, this species feeds widely along the tidewater margin, in nearby freshwater streams, lakes and reservoirs. Overall, healthy fish habitats are a central component to the well-being of the snowy egret. In addition, snowy egrets are generalists in their feeding habits, meaning that they forage for small fish, frogs, lizards, snakes, crabs, worms, snails, and insects.

   Areas of the Bay where snowy egrets are commonly found include Benicia, Oakland, Hayward, Fremont, San Jose, and Palo Alto. Numbers of birds from year to year are estimated to be greater than 1,112.

Snowy egrets are known to use a variety of habitats around the Bay. These include foraging on the mudflat tidal edge, along streams flowing into the bay and in salt ponds. At times unusual fish concentrations occur in seasonal wetlands and at these times unusually high concentrations of herons result. The two breeding population centers of this species in the North and South Bay illustrate the ability of the snowy egret to utilize a variety of habitats. South Bay observations clearly indicate the importance of salt pond habitats, as well as the edge of tidal flats and riparian areas, whereas in the North Bay use of salt ponds and other impoundments is less important than foraging in tidal areas.

The basic needs of this species are secure areas for nesting, adequate wetlands for foraging, and continued protection from direct persecution by humans. The greatest hazard at the present time for this species is the continuing population increase of the non-native red fox in the South Bay. For example, the Alviso heronry nests are largely in tules, slightly above the tidal line, and although the water offers some protection from predators, the red fox is able to overcome water barriers. As the population of red foxes increases it appears to be only a matter of time before this colony is extirpated.

7. **Black-crowned Night Heron**. The black-crowned night heron is a permanent resident of San Francisco Bay, meaning that it is found here year-round. This species is largely dependent on wetlands for foraging, and nests in trees and shrubs. Normally feeding at night, dawn or dusk, this species' chief prey items are fish, crabs, insects and amphibians, which it obtains by stalking or waiting for prey from a stationary position. When trees are available it will frequently uses them for roosting, otherwise it uses tules and cattails. The black-crowned night heron tends to use less open habitats than other egrets and herons, but is not so secretive as bitterns.

   This species is found regularly in Benicia, Oakland, Hayward, Fremont, San Jose, Palo Alton and Marin. Population numbers are upwards of 838 birds. Up to 300 pairs have nested on West Marin Island, and this is the densest concentration in the Bay Area. The Artesian Slough colony in the South Bay has had upwards of 150 pairs. The greatest threat to the well-being of this species in San Francisco Bay is the non-native red fox in the South Bay. Adequate wetlands for foraging, in addition to nesting sites secure from predation, are also critical to the continued well-being of the black-crowned night heron.

8. **California Clapper Rail.** The California clapper rail is indigenous to the estuarine tidal wetlands of San Francisco Bay, although it may occur as a transient in outer coast marshes such as Morro Bay and Elkhorn Slough. This species has a rusty colored breast, orange bill, and white and black feathers on the flank, all of which add up to perfect camouflage for the marsh vegetation where the California clapper rail resides.

   The primary diet of clapper rails consists of various invertebrate species, including mussels, clams, crabs, snails, spiders and fish. A majority of foraging occurs during low tide when mudflats and tidal sloughs are exposed and food is more readily available.

   The most recent estimates indicate a total population of 1040-1264 rails in the Bay. This represents a rebound from 300-500 individuals in 1990-1991. Studies indicate that 55% occur in the South Bay, 38% occur in Napa marshes and the remaining 8% occur in other North Bay and outer coast marshes.

   The California clapper rail occurs primarily in salt and brackish tidal wetlands of San Francisco Bay. Preferred habitat is subject to direct tidal circulation and is characterized by predominant coverage by pickleweed and extensive stands of Pacific cordgrass. In the North Bay, additional benefits are provided by abundant high marsh cover and an intricate network of tidal channels, which offer abundant invertebrate food sources. California clapper rails also occur in brackish wetlands consisting of bulrush. This type of habitat occurs along the larger creeks in the South Bay and in extensive areas of Napa Marsh, upper Petaluma River, Sonoma Creek, and in Suisun Bay. Other physical attributes of marshes that influence California clapper rail use, and which may create a self sustaining population of rails, include the size of the marsh, location relative to other marshes, buffer areas between marsh and upland, marsh elevation and hydrology.

During the early to mid 1900's, commercial and urban development destroyed over 85% of the primary salt marshes of the Bay, causing severe declines in the California clapper rail population. Presently, the species is restricted to fragmented salt marshes in the Bay. Predation by the non-native red fox has also had severe impacts on the California clapper rail. Other threats impacting this species include a progressive rise in sea level, contamination and continued diversion of freshwater inflow from the North Bay.

In the long-term only restoration of high quality tidal marsh habitat will ensure the future survival and recovery of the California clapper rail. The current amount and configuration of suitable habitat is insufficient to substantially increase rail densities and population sizes. Concomitant with tidal marsh restoration will have to be continued predator management of the red fox.

9. **California Black Rail.** A statewide survey conducted in the 1970's indicated that the marshes of the San Francisco Bay support the bulk of the California black rail population in California.[11] In the Bay this rail is primarily a bird of tidally influenced marshes and is most often seen during very high tides when it is forced out of the lower elevation pickleweed marsh. Prime California black rail habitat is the thin ribbon of salt marsh vegetation that occurs between the high tideline and the upland shore (the transition zone), an area with a gently sloping plain with very little elevational rise. Consequently, this area which the black rail is most dependent upon is also the most utilized by humans. In the Central and South Bay, bayfill has been added to the shoreline to build the cities of San Francisco, Oakland, Redwood City and Fremont. In the North Bay, conversion to agriculture has been the main cause of the loss of this habitat.

   The California black rail is highly secretive, with a dark slate color and faint white bars on its sides. Recent evidence confirms breeding in the North Bay at China Camp, Black John Slough and Day Island, as well as at Sonoma Creek. Breeding also occurs in parts of San Pablo Bay. There are many records of adults and juvenile black rails in Central and South Bay during the non-breeding season, but no breeding is known to occur in these areas. The lack of high tide refugia for birds and low marsh elevation in the Central and South Bay may explain why breeding populations are not found there. In addition, those few sites where the transition zone approximates natural conditions (large tracts of marsh with adjacent wildlands like the Petaluma Marsh, the Suisun Marsh, and Don Edwards San Francisco Bay National Wildlife Refuge) have become all the more valuable to the remaining population of California black rails.

   A survey conducted from 1986-1988 counted 608 black rails. Overall, the California black rail population is at risk of decline due to fragmentation and habitat loss associated with historic and ongoing pressures of agricultural practices, salt production and urbanization. Increases in black rail populations will require the protection of existing habitat and the restoration of good quality breeding habitats. This habitat should be undiked, fully tidal salt marsh with dense stands of pickleweed. Upland refugia which provides cover during highest tides is also critical. Formerly diked marshes that are restored to tidal influence may provide additional habitat for black rails if they encompass elevations at or above mean high higher water and are adjacent to extensive tidal marshes with full tidal influence.

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[11] U.S. Fish and Wildlife Service. Winter 1999/2000. *Tideline*. U.S. Fish and Wildlife Service, Newark, California.

10. **Common Moorhen.** The common moorhen is a kind of rail which predominantly utilizes open freshwater habitat with plant cover. Eating both plants and animals, the common moorhen feeds while swimming, walking on land, or while floating on plants. This species appears to be tied closely to freshwater impoundments within the Bay, and sometimes with freshwater streams.

    This species breeds in small numbers in Marin County, Suisun Marsh and in Santa Clara County, but is found more often in Santa Clara County. Specifically, the common moorhen nests every year in freshwater areas alongside the Bay, such as the Mountain View Forebay and the Moffett channel at the Sunnyvale Water Pollution Control Plant. This species also utilizes a number of the freshwater percolation ponds on the upper reaches of the Guadalupe River. In wetter years it extends its range to suitable percolation ponds with sufficient growth of cattails and tules, such as the small ponds at Coyote.

    At the present time, within the bounds of San Francisco Bay, almost every location used by this species has been constructed to serve the needs of local communities in one way or another. As a consequence, these habitats are not designed to benefit the common moorhen, leaving their protection and management unaccounted for. Overall, there are numerous opportunities both through education and legal mandates to improve the management of freshwater habitats in the Bay to benefit this species.

11. **California Gull.** California gulls are a recent addition to San Francisco Bay, drawn here by the availability of remote nesting grounds and rich food sources provided by the salt ponds and local refuse dumps. Associated species which use similar habitats include the Forster's tern, Caspian tern, black-necked stilt, American avocet, killdeer and Wilson's Phalarope. The adult California gull has a white head, chest and underparts. The top of the body is gray and the wing tips are black, while their bill is yellow with black and red spots.

    Approximately 10,000 California gulls nest at six sites in the South Bay. Nesting sites include the Knapp Property on Pond A6 near Alviso and the Alameda Naval Air Station. There are no known active colonies in the North Bay. Also, California gulls roost in large numbers during the winter on the levees and in the salt ponds of the South Bay. California gulls in the South Bay require remote insular abandoned levees and abandoned islands for nesting. The continued presence of such levees and islands will provide them with adequate nesting grounds. In addition, California gulls require high salinity salt ponds for their primary natural food source, mainly brine fly larvae, brine flies and brine shrimp. California gulls are also vulnerable while nesting to predation by feral cats and the red fox.

12. **Forster's Tern.** Forster's terns are mid-sized terns found in open water, salt ponds, and tidal wetlands. They nest and roost on dredge spoil islands and degraded, insular levees. They forage in salt ponds, open bay, slough channels and tidal marshes. Associated species which use similar habitats are the California gull, Bonaparte's gull, Caspian tern, American avocet, black-necked stilt and killdeer. Forster's terns have an all white body, a dark cap, black eyes, gray upper wings, an orange bill with a black tip, and orange legs.

    In the North Bay, nesting occurs in the Napa River Marsh salt ponds. In the South Bay they breed on dredge spoil islands, degraded levees in current and former salt ponds, slough channels, and diked marshes. Small numbers are found locally throughout the winter, Numbers increase during the spring as migrants begin to arrive in April. Migrants and local breeders who do not stay the winter are found here until late October-November. Forster's tern populations have been decreasing over the past 26 years. Between 1984 and 1988 upwards of 3600 birds were found in the Bay, while this number dropped to 2365 between 1992 and 1997.

Forster's tern forage on the open Bay, slough channels, freshwater and saltwater marshes, and on salt ponds. Forster's terns roost prior to, during and after breeding on the dredge-spoil islands and levees on which they breed. They also have been observed on docks, duck blinds and floating debris. During the breeding season Forster's terns move singly and in groups between their nesting sites within the salt ponds and foraging areas throughout the day.

The continued presence of isolated, insular islands is crucial to the continued presence of Forster's tern in the Bay. In all cases colonies are found within or in close proximity to former and current salt ponds. This habitat provides suitable nesting substrate isolated from human disturbance, and makes access more difficult for predators such as the red fox.

13. **Caspian Tern.** The Caspian tern is a cosmopolitan species that occurs at lakes, bays, estuaries, marshes and rivers on all continents except Antarctica. In the Bay Area, they nest locally in a variety of habitats, including current and former salt pond levees, and sandy beaches. The Caspian tern forages by hovering over the water, then diving below the surface to catch its prey. Their primary prey are fish and amphibians. Caspian terns forage on the open bay, salt ponds, marshes, freshwater ponds, rivers, reservoirs and at sea. In turn, they roost on salt pond levees, sandy beaches, mudflats, islands in salt ponds, slough channels, marshes and the bay. During the breeding season, most are observed roosting near nesting colonies, although some are seen at local reservoirs.

    The Caspian tern is the largest of the North American terns. Their body is white, their underwings are white, their upperwings are a light silvery-gray, and their crown is black, extending below the eye. In San Francisco Bay, the first breeding accounts are from the South Bay. Prior to 1990, the majority of Caspian terns nested here. Since 1990, the majority of birds nest at colonies in the Central and North Bay. Nesting colonies have been growing at Brooks Island and Alameda Naval Air Station in the Central Bay, after the colony abandonments in the South Bay. A Bay Area wide estimation of population is at 2,818 individuals.

    Caspian terns have declined in recent years in the South Bay, due in part to routine levee maintenance, levee erosion and predation. Their tendency to nest on attached levees also increases their exposure to predation. Contaminants may also pose a threat to local populations. Human disturbance during the breeding season also poses a risk to the well-being of the Caspian tern.

14. **Western Burrowing Owl.** The western burrowing owl is the only owl which routinely lives and nests underground. This owl is a small, brown and white mottled owl, approximately 9 to 11 inches tall. These owls can be found adjacent to the Bay on levees, next to salt ponds, on open unmanicured grasslands, or on manicured fields near the Bay's edge where ground squirrel numbers and foraging areas are adequate. These birds are primarily predators and in these locations feed on mice and insects. However, they are opportunistic and will eat species associated with wetlands, including amphibians and crabs. In the San Francisco Bay area, nearly all of the owls, approximately 170 pairs, are found in the South Bay and East Bay between Palo Alto and the Fremont-Newark area. Specific examples of sites where the western burrowing owl is found include the Oakland Airport and Moffett Field in Santa Clara County.

    The basic threat to burrowing owls in California is the annual, methodical loss of breeding and foraging to development by humans, including the destruction of ground squirrels and urban development. Other factors include soil disturbances, such as disking and grading, vehicular strikes and predation by non-native species. In agricultural areas, where the majority of owls live, chemical spraying also contributes to population declines.

Increasing burrowing owl numbers will require adding more nesting and foraging habitat. Importantly, burrowing owls are an indicator of the marsh-upland edge of the San Francisco Bay. Western burrowing owl habitat may be increased by adding upland transition zones between the high marsh and lands already converted to human use. These zones should include short grass habitat capable of supporting a healthy population of ground squirrels. Increasing habitat for burrowing owls will also provide upland refugia for marsh species that must escape high tides, such as the California clapper rail and the salt marsh harvest mouse. Since burrowing owls are predators, and since this habitat will also benefit marsh hawks, adequate cover for mice and rails must be provided.

15. **Savannah Sparrow.** The savannah sparrow is representative of bird species dependent upon both bay-related marshes and the adjacent upland grasslands and fields. Information is lacking on the full distribution of this species around the Bay, but known breeding sites do exist. Some of these include the San Pablo Creek tidal marsh and the South Bay, south of the San Mateo Bridge. The preferred nesting habitat in these areas consists of levee tops with annual grasses on top, and areas of high pickleweed growing on levee banks. The nesting population south of the San Mateo bridge was estimated to be between 800 and 1,000 pairs in 1977. Other sites where savannah sparrows are found, both during and out of the breeding season, include the Hickory Tract and Coyote Tract in Newark, the Coyote Tract in Fremont, Coyote Hills Regional Park, Newark Slough tidal marsh and the Don Edwards San Francisco Bay National Wildlife Refuge in Fremont. Savannah sparrows may also be found in parts of Suisun Bay, although abundance of the savannah sparrow across the Bay is still unknown.

    Major foods eaten by savannah sparrows are insects and spiders during the breeding season, while in the non-breeding season small seeds and fruits gleaned from the ground or low vegetation predominate their diet. Overall, the maintenance or restoration of the transition zone from marsh to upland habitat should be a goal as scientists suspect that it is the transition zone that supports the greatest densities of the savannah sparrow.

16. **Song Sparrow.** Three distinct subspecies of song sparrows reside in San Francisco Bay. The first subspecies resides in San Pablo Bay, the second is found around the Bay and the third resides primarily in Suisun Bay. Each of these birds are brownish above and whitish below, with darker brown to blackish streaks. On the mid-breast the dark streaks tend to be grouped, forming an irregular blotch. Differences in color and size mark the distinctions between the subspecies.

    Song sparrows forage for food in tidal marshes, preferring the muddy edges of small channels. They are also known to look for food on tidal mudflats. Examples of food which they consume includes marine invertebrates pecked from the mud, small fruits and seeds, and also insects. Overall song sparrows are an important part of the tidal marsh food web, due to their abundance in those tidal marshes where they are found. Those who feed on song sparrows include garter snakes and the non-native red fox.

    Prime habitat for this species is fully tidal brackish marsh with well-developed channels and sloughs. In addition, mud banks that are not too steep for low-tide foraging, and not too far from overhanging vegetation for protection from predators, are important.

    The abundance of these three subspecies differs due to habitat availability. The subspecies found around San Francisco Bay is estimated at 7,412 pairs, which is a little over 10 percent of the population that existed prior to diking and filling of tidal marshes. The subspecies found in San Pablo Bay is estimated at 15,607 pairs, while the Suisun Marsh subspecies stands at about 5,666 pairs, a reduction of about 90.4 percent from the 1850's.

The preservation of the existing blocks of habitat utilized by the song sparrow is the top priority for the protection of these three subspecies. Restoration and enhancement of tidal marsh habitat are also critical to the continued well-being of these three subspecies of song sparrows. In addition, tidal brackish marshes in the Suisun Bay should be maintained with adequate freshwater flows, ensuring that they maintain their brackish quality.

17. **California Least Tern.** The California least tern is one of three subspecies of least terns found in the United States. The other two subspecies reside on the east coast and in the interior of the country. California least terns typically arrive at California breeding areas in middle or late April. Courtship is observed from the time birds arrive and nesting is reported from early May through early June and from mid June through early July. The California least tern is migratory and when they are not breeding in California they range as far south as Costa Rica for the winter. In San Francisco Bay, the only known nesting sites producing fledglings are in Alameda, at the Oakland Airport and at the Pittsburg PG&E plant. In the past they were documented on Bair Island and various salt pond levees. The Bay Area's birds today are considered a critical population and vital to the recovery of the state's population. In 1995, the Alameda Colony was the state's fourth largest producer of fledglings. Exact numbers of birds in the Bay are unknown, although statewide in 1995, 2,536 pairs of least terns are estimated to have nested at about 35 California nesting locations.

    Food items which the California least tern depends upon are a wide variety of fish, such as northern anchovy, and small invertebrates, such as the water borne larvae of drone flies. For breeding and nesting in the Bay, California least terns require tracts of open sand or fine gravel substrate with sparse vegetation. Due to habitat loss, least terns have been opportunistic, using landfills and airports for nesting. In addition, nesting areas must be located near open water, usually along coastal beaches and estuaries which host adequate numbers of fish to sustain adults and growing young.

    Finally, in order for colonies to have guaranteed breeding success, adequate barriers or supervision to restrict public access is required, as well as persistent predator control and vegetation management.

18. **Salt Marsh Common Yellowthroat.** Three of twelve subspecies of common yellowthroat breed in California. The salt marsh common yellowthroat is one of these three. The name salt marsh common yellowthroat is somewhat of a misnomer, since this small bird occurs in salt marshes in the Bay only in the winter. Otherwise, this subspecies breeds in fresh and brackish marsh associated with and close to Bay wetlands. Yellowthroats are primarily insect-eating and glean insects on or near the ground from low vegetation, bushes, and small trees or from the surface of the mud. Examples of insects which this species eats includes wild bees, wasps, beetles, caterpillars, moths, flies grasshoppers and spiders. Areas in the Bay where the salt marsh common yellowthroat is known to breed includes San Pablo Bay, Napa Marsh, Palo Alto Marsh, Alameda Creek and Coyote Hills Regional Park.

    Increasing urbanization and a consequent loss of habitat over the past 100 years has lead to a precipitous decline of this subspecies of between 80-95%. Furthermore, a continued loss of habitat, poor habitat management, and drought or flood could seriously affect the future of the salt marsh common yellowthroat. Scientists differ on their estimates of abundance, yet studies have illustrated that population numbers are critically low in the South Bay and Peninsula, representing a great reduction in historical abundance.

    In the San Francisco Bay region as a whole, about 60% of salt marsh common yellowthroat breed in brackish marsh, 20% in riparian woodland/swamp, 10% in freshwater marsh, 5% in salt marsh and 5% in upland vegetation. Significantly, the salt marsh common yellowthroat also utilizes the borders between the aforementioned plant communities, with their territories often straddling the ecotones between freshwater or tidal marsh and the upland vegetation of weedy fields or grasslands, as well as riparian corridors.

Methods of protection and improvement of the well-being of this species includes further studies of quality and extent of wintering grounds, seasonal movement patterns, and minimum size of marsh habitat that will support breeding birds. In addition, habitat protection should be maintained in parks and refuges. Also, any area which includes yellowthroat breeding habitat should be protected from diking, draining or removal of vegetation. This protection should be extended to include a buffer zone around the actual occupied area.

Invertebrates

1. **Pygmy Blue Butterfly.** The Pygmy blue is a small butterfly with a wingspan, measuring between 13-20mm. This butterfly is found from southwestern Louisiana and Arkansas, westward to California and south to Venezuela. In addition, it is widely distributed throughout the San Francisco Bay. The greatest abundance of this species is in salt marshes, although it also utilizes lowland areas such as alkali flats, vacant lots and roadsides. Importantly, this butterfly is a prey item for birds found in the marshes of the Bay.

2. **Brine Flies.** There are numerous species of brine flies that can be found within the confines of the San Francisco Bay region. Three are exceptionally numerous within the confines of the San Francisco Bay region. These include: *Ephydra cinerea, Ephydra millbrae,* and *Lipochaeta slossonae. Ephydra millbrae* is found throughout the Bay in mid to upper marsh tidal pools that are infrequently affected by the tides. *Ephydra cinerea* is closely associated with hypersaline environments, especially slat ponds of the North and South Bay. *Lipochaeta slossonae* is commonly found in or near crystallizer ponds of the South Bay.

   These brine flies are a prey item of shore birds and game ducks. For example, snowy plovers, western gulls, black-necked stilts and American avocets are known to charge through large assemblages of brine flies catching disturbed adults as they attempt to fly away.

3. **Brine Shrimp.** Brine shrimp are small invertebrates found in highly saline ponds, lakes or sloughs. They have 11 pairs of swimming legs and the second antenna is greatly enlarged and used as a clasping mechanism in males. Brine shrimp feed on phytoplankton and blue-green algae that occur in Bay Area salt ponds.

   Historically in the Bay Area brine shrimp were found in salt pannes and sloughs where hypersaline conditions occurred. Currently they occur in salt ponds in the North and South Bay that are used for the commercial production of salt. Brine shrimp populations are lowest in the winter and peak in the summer months. Current populations of the brine shrimp probably far exceed historic populations because the salt ponds in which they occur are manmade.

   Many bird species feed on brine shrimp. Some of these species include mallards, California gulls, whimbrels, Wilson's phalarope, eared grebes, American avocets and potentially western and least sand pipers, willets, greater yellow legs and Bonaparte's gulls.

4. **Inchworm Moth.** This is a small moth with a wingspan of approximately 22-29mm. Commonly known as a measuring worm or inch worm moth, it has alternating patterns of vertical light and dark bands on the fore wings and plain tan hind wings. This insect is found throughout San Francisco Bay tidal and diked salt marshes and utilizes middle to high marsh habitat that has berms or levees with adequate populations of Alkali Heath.

Adults are on the wing from Marsh through November, with peak adult populations occurring during late spring and early summer. Snowy plovers have been observed consuming adults at the Baumberg Tract in Hayward. This insect may also be a part of the diet of other shorebirds.

5. **Tadpole Shrimp.** The California vernal pool tadpole shrimp is a small invertebrate found in ephemeral freshwater pools. They can reach a length of 5mm and have approximately 35 pairs of legs. Tadpole shrimp are primarily benthic organisms that feed on detritus and living organisms, such as fairy shrimp. The distribution of this species is not well known in the Bay Area, however, it has been collected at the Warm Springs Seasonal Wetland in the Don Edwards San Francisco Bay National Wildlife Refuge. Other populations have been found north of the eastern half of Potrero Hills in the North Bay. Seasonal wetlands occur sporadically in both the North and South Bay and may provide additional habitat for this species.

   The current status of the population of the tadpole shrimp in the Bay Area is not known. The loss of seasonal wetland habitat in the Bay may be significantly affecting the population of this species, especially since distribution information for the Bay is so limited. Species which feed on the vernal pool tadpole shrimp are waterfowl, the western spadefoot toad and tadpoles.

6. **Western Tanarthrus Beetle.** This invertebrate is a small beetle, approximately 3-5mm in length, that is reddish-orange in color. This species has been found in no other locality except for abandoned crystallizer ponds and salt pans of southern San Francisco Bay. In all instances these sites remain dry for most of the year, except during late winter when temporary pools of rainwater form. Examples of locations where this beetle is found include the San Francisco Bay National Wildlife Refuge, adjacent to the Dumbarton Bridge in Alameda County, and in the salt pans of the Baumberg tract in Hayward. In 1996, a previous population at Bayfarm Island was extirpated due to the modification of their habitat in preparation for development. These beetles feed on the carcasses of brine flies, and in turn are food for snowy plovers.

7. **Tiger Beetles.** Historically, San Francisco Bay had four species of tiger beetles. Only two are present today. One of the species (*Cicindela senilis senilis*) is found throughout the South Bay and Central Bay, with one population on Grizzly Island. The other species (*Cicindela haemorrhagica*) has become increasingly scarce, as its habitat continues to be altered for human needs. This beetle is currently found at the Trojan Marsh in San Leandro, Hayward Landing in Hayward, salt ponds west of Newark, and the Richmond Field Station in Richmond. Both tiger beetles are a likely prey item for shorebirds.

   These tiger beetles are easily identified by their large, bulging eyes and long, sickle-shaped mandibles that bear small teeth. In addition, their coloring is shining metallic blue to green with yellowish-white irregular markings. San Francisco Bay tiger beetles are commonly found along open, muddy margins of creeks and streams, and also along the muddy margins of salt pannes that are occasionally inundated by high tides.

   Tiger beetles are considered to be good indicators of coastal wetland disturbance, with the least disturbed habitats having the greatest species diversity. For example, those sites in the Bay that have had minimal disturbance tend to have the highest populations of tiger beetles.

8. **California Vernal Pool Tadpole Shrimp.** The California vernal pool tadpole shrimp is a small crustacean found in ephemeral freshwater pools. Their primary food is organic detritus, fairy shrimp and other invertebrates. Tadpole shrimp are primarily benthic organisms that swim with their legs down. They can also climb or scramble over objects and plow through bottom sediments. This species has been found in vernal pools rang-

ing in size from 5 square meters to 36 hectares. The water in the pools can be clear to turbid. Characteristic of vernal pools, they dry up in the late spring and are dry in the summer and fall and then fill with rain water in the winter and early spring.

Current status of the population of tadpole shrimp in the Bay Area is unknown. Loss of seasonal wetland habitat in the Bay Area may be significantly affecting the population of this species especially since distribution information for the Bay Area is so limited.

CHAPTER 6

BCDC'S JURISDICTION, AUTHORITY AND RESPONSIBILITY FOR AQUATIC LIFE, WILDLIFE AND SAN FRANCISCO BAY HABITATS

The most important question this chapter seeks to answer is the level to which BCDC is able to protect the well-being of the Bay's habitats. As this discussion will illustrate, gaps in protection exist between BCDC's jurisdiction and the expanse of ecologically valuable habitats associated with the Bay. For example, many diked wetlands, grasslands, and the transition zones between tidal marshes and upland habitats are largely outside of the purview of BCDC, due to limitations in jurisdiction and authority. These limitations, however, coincide with BCDC's responsibility under federal and state law to protect habitats, aquatic life, wildlife and plants. More specifically, as a state agency, BCDC is required to comply with certain federal and state laws, such as the Endangered Species Act and the California Environmental Quality Act, each of which mandates certain protections for Bay habitats. The overlap of these two areas, BCDC's jurisdiction and authority, and the agency's responsibility under relevant state and federal statutes, will be the focus of this chapter. Furthermore, the desired outcome of this discussion is a clear understanding of areas where BCDC could improve resource protection and strengthen its compliance with state and federal environmental laws.

McAteer-Petris Act. Under the McAteer-Petris Act[1], BCDC is given a great deal of authority over Bay habitats. Specifically, this jurisdiction includes tide and submerged lands[2], the water of the Bay to the mean high tide line, marshlands lying between mean high tide and five feet above mean sea level, salt ponds, certain managed wetlands, and specific waterways. These specific waterways include portions of Plummer Creek, Coyote Creek, Redwood Creek, Tolay Creek, Petaluma River, Napa River, Sonoma Creek, and Corte Madera Creek. Each of these areas of jurisdiction belong to BCDC's bay jurisdiction, salt pond jurisdiction or certain waterways jurisdiction. In addition, BCDC has authority over a shoreline band which extends inland for 100 feet. This area is considered BCDC's shoreline band jurisdiction. The Act also establishes specific priority use areas, both within and outside the 100 foot shoreline band jurisdiction, which are set aside for ports, water-related industry, airports, wildlife areas and water-oriented recreation. Worth noting is that BCDC's wildlife area priority use area designation does not distinguish between state managed wildlife areas and federally managed wildlife refuges. Instead, they are both considered wildlife areas under BCDC's jurisdiction. This distinction will be discussed in greater detail in chapter 8 entitled "Wildlife Refuges."

Analyzing each of the above discussed areas of jurisdiction points out some of the strengths in BCDC's authority over habitats of the Bay, as well as some of the gaps in protection. Beginning with marshlands (classified as tidal marsh habitat by the Goals Project Eco Atlas), BCDC has jurisdictional authority over marshlands extending to five feet above mean sea level. Within this jurisdiction, the stringent requirements outlined in the Act for fill, extraction of material, and substantial change in use apply when a project applicant applies for a permit. However, the farthest upland boundary of a tidal marsh may not end at this point. Therefore, the remaining portion of the marsh may lie outside of BCDC's bay jurisdiction and, instead fall within BCDC's shoreline band jurisdiction. In addition, portions of the marsh may extend outside of BCDC's jurisdiction entirely, depending on the expanse of the marsh. Furthermore, to the detriment of the tidal marsh, habitat values cannot be a determining factor in a permitting decision within BCDC's shoreline band jurisdiction. In other words, the commission may only deny an application for a permit for a proposed project within the shoreline band if the project fails to provide maximum feasible public access, leaving the high marsh area vulnerable to changes in use, such as development.

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[1] California Government Code 66600-66682.

[2] Tidelands are defined in Section 66610(a) of the McAteer-Petris Act as "land lying between mean high tide and mean low tide," while submerged lands are defined in the same section as "land lying below mean low tide."

Another habitat which falls primarily under the shoreline band jurisdiction, and which may be unprotected by BCDC's jurisdiction altogether, is the transition zone between high marsh habitat and upland habitats. This ecologically significant ecotone, while critical to a diversity of species, many times lies outside of BCDC's purview, leaving this habitat type vulnerable to changes in use. Other Bay habitats which lie outside of BCDC's purview are willow groves, grasslands, vernal pools, oak woodlands, and mixed evergreen forests. Furthermore, priority use wildlife areas, which are set aside to protect wildlife around the Bay, do not extend into the Bay, leaving terrestrial values accounted for and aquatic habitat values unaccounted for entirely. Chapter 8 and 9 will further explore this concern.

Finally, jurisdiction over certain waterways extends BCDC's certain waterways jurisdiction into portions of Plummer Creek, Coyote Creek, Redwood Creek, Tolay Creek, Petaluma River, Napa River, Sonoma Creek and Corte Madera Creek. This extension of BCDC's jurisdiction into certain waterways serves to extend habitat protection into all areas subject to tidal action, including submerged lands (shallow bay habitat), tidelands (tidal flat habitat), and marshlands (tidal marsh habitat) up to five feet above mean sea level.

Returning to the protection of wetlands outside of BCDC's jurisdiction, regulations do exist, yet the level of protection may still leave certain wetland habitats vulnerable to development pressures. More specifically, the United States Army Corps of Engineers (Corps) and the United States Environmental Protection Agency (EPA) both regulate wetlands outside of BCDC's jurisdiction under Section 404 of the Clean Water Act,[3] yet many diked seasonal wetlands and agricultural wetlands are not wet enough year round, or on a seasonal basis, to qualify as wetlands under the Corps' and EPA's wetland definition.[4] Importantly, the definition used by the Corps and EPA does not capture the transitional nature of wetland boundaries or identify wetland-related habitat values. The end result of the regulatory approach to wetlands, utilized by the Corps and EPA under Section 404 of the Clean Water Act, is a gap in protection for many seasonal diked wetlands and agricultural wetlands around the Bay. Furthermore, although local governments have a range of planning tools[5] at their disposal to fill in the gaps of protection where BCDC, the Corps, and the EPA fall short, the local response to wetland protection varies widely, with some local governments taking proactive steps to protect wetlands within their jurisdiction, while others leave all wetland protection up to federal regulators.

Coastal Zone Management Act.[6] A significant policy tool which increases BCDC's oversight of habitat protection in the Bay is the agency's ability to review federal projects and non-federal projects, which require either a federal permit or license, or which are supported by federal funds, under the Coastal Zone Management Act. Specifically, federal agencies make consistency determinations on their proposed activities and applicants for federal permits, licenses, other authorization, or federal financial assistance make consistency certifications where a project is either in or likely to affect the coastal zone (San Francisco Bay is part of the coastal zone).

In addition, federal consistency regulations were recently revised to require federal agencies to render consistency certifications for any federal activity, federal permit or license, or provision of federal assistance that may have reasonably foreseeable direct or indirect effects on any

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[3] United States Code, Title 33, Chapter 26, Sections 1251 et seq.

[4] As stated in federal regulation (CFR 328.3 (b); CFR 230.3(t) wetlands are:

> those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

[5] Local governments have a wide range of tools to choose from, and can define or address wetlands and related habitat values through general plans, specific plans, zoning ordinances, subdivision ordinance controls, environmental review processes, permit controls, agricultural preserves, and special purpose agencies and activities.

[6] 16 U.S.C.A. Sections 1451-1464

coastal use or resource.[7] This includes: (1) all federal activities, federal permits and licenses and federal assistance within the coastal zone; and (2) any federal activities, permits and licenses and assistance outside of the coastal zone that may have a reasonably foreseeable direct or indirect effect on any use or resource within the coastal zone.[8]

BCDC then has the opportunity to review the consistency determinations and certifications and to either concur with them or object to them. Also, BCDC has the authority to object to a federal consistency determination or certification if the federal activity, permit or license is inconsistent with the specific enforceable policies of the McAteer-Petris Act and the San Francisco Bay Plan. An objection may also occur if the federal agency or permit or license applicant has failed to provide sufficient information with which to evaluate the federal consistency determination or certification.[9]

The federal Coastal Zone Management Act of 1972, as amended, is a voluntary law enacted to encourage coastal states and territories to develop and implement programs to manage the nation's coastal resources. BCDC was one of the first agencies to participate in the federal project. In February 1977, the U.S. Department of Commerce approved the Commission's coastal management program for the San Francisco Bay segment of the California coastal zone.

Four different and distinct consistency requirements exist, each applying to a different kind of situation. These include: (1) federal activities that directly affect land or water uses within the coastal zone; (2) federal development projects located within the coastal zone; (3) projects which affect land or water uses within the coastal zone and which require a federal permit, license or other authorization; and (4) a state or local project that affects land or water uses within the coastal zone and that is supported by federal financial assistance.

Importantly, BCDC's ability to review federal consistency certifications and determinations enables the agency to ensure that the habitat protections outlined in the McAteer-Petris Act, the Suisun Marsh Preservation Act of 1977, the *San Francisco Bay Plan*, the *Suisun Marsh Protection Plan* and the agency's administrative regulations are upheld by the federal government in both federal projects and projects which the federal government permits or licenses, or for which the federal government provides federal financial assistance.

Section 404 of the Clean Water Act.[10] The primary statute regulating activities affecting wetlands is the federal Water Pollution Control Act, more commonly known as the Clean Water Act. Under the Clean Water Act, the US Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency regulates the disposal of dredge and fill materials, via Section 404, by prohibiting the discharge of dredged material into the waters of the United States (including adjacent wetlands), without prior approval from the Corps and the U.S. Environmental Protection Agency.[11] However, a recent U.S. Supreme Court decision most likely has eliminated fed-

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[7] 15 C.F.R. Sections 930.33 (a)(1), 930.53(a) and 930.95.

[8] 15 C.F.R. 930.33(b)-(d), 930.53(a) and 930.98.

[9] 15C.F.R. Sections 930.43 and 930.63.

[10] United States Code, Title 33, Chapter 26, Sections 1251 et. Seq.

[11] The geographic scope of the Corps' regulatory jurisdiction under Section 404 has broadened over time. The Corps' original jurisdiction was limited to narrowly defined navigable waters, which excluded most wetlands. However, a series of court decisions expanded the Corps' scope to include virtually all waters of the United States and most wetlands. Corps regulations issued in July 1975 redefined "navigable waters" to include:

> Coastal water, wetlands, mudflats, swamps and similar areas; freshwater lakes, rivers, and streams that are used, were used in the past, or are susceptible to use to transport interstate commerce, including all tributaries to these waters; interstate waters; certain specified interstate waters, the pollution of which would affect interstate commerce; and freshwater wetlands, including marshes, shallows, swamps and similar areas that are contiguous or adjacent to the above described lakes, rivers and streams, and that are periodically inundated and normally characterized by the prevalence of vegetation that requires saturated soil conditions for growth and reproduction.

eral jurisdiction over those waters (including wetlands) which are isolated and non-navigable and which are not adjacent to or hydrologically connected with any navigable water body.[12] The wetlands of San Francisco Bay are largely determined to be adjacent to or connected with a navigable water body.[13]

While the U.S. Fish and Wildlife Service and the National Marine Fisheries Service do not directly administer the program, they do have the authority and the duty to review section 404 permits that may affect fish and wildlife resources pursuant to their authority under the federal agency provisions of the federal Endangered Species Act[14] and the Fish and Wildlife Coordination Act.[15] Further, pursuant to section 401 of the Clean Water Act, the San Francisco Bay Regional Water Quality Control Board must certify that all section 404 permits are consistent with applicable federal and state water quality requirements.[16]

Overall, the Section 404 program regulates such activities as fills for development, water resource projects (including dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming or forestry activities. The basic requirement of the Section 404 program is that no discharge of dredged material[17] or fill material[18] can be permitted if there is a practicable alternative that is less damaging to the aquatic environment, or if the discharge would result in a significant degradation of the waters of the United States. Any private party or government entity (except the Corps itself) proposing to fill or dredge wetlands must apply for a Section 404 permit from the Corps authorizing the activity. The Corps then evaluates the project to determine whether a proposed discharge is consistent with guidelines established by the EPA (referred to as the Section 404 (b)(1) Guidelines[19]) and whether it is in the public interest to issue such a permit. A project will be denied if the project fails either of these two tests.

It is important to note that Section 404 does not regulate all activities affecting wetlands. For example, activities such as excavation, clearing, leveling, draining, and vegetation removal are not covered. However, Corps regulations were recently revised to provide that the use of mechanized earth-moving equipment to conduct landclearing, ditching, channelization, in-stream mining or other earth moving activities in waters of the United States is presumed to re-

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[12] See Solid Waste Authority of Northern Cook County vs. U.S. Army Corps of Engineers (2001) 121 S. Ct. 675)

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> Coastal water, wetlands, mudflats, swamps and similar areas; freshwater lakes, rivers, and streams that are used, were used in the past, or are susceptible to use to transport interstate commerce, including all tributaries to these waters; interstate waters; certain specified interstate waters, the pollution of which would affect interstate commerce; and freshwater wetlands, including marshes, shallows, swamps and similar areas that are contiguous or adjacent to the above described lakes, rivers and streams, and that are periodically inundated and normally characterized by the prevalence of vegetation that requires saturated soil conditions for growth and reproduction.

[14] Section 7, 16 U.S.C Sections 1536 (a)(2)

[15] 16 U.S.C. Section 661 et seq.

[16] 33 U.S.C. Section 1341.

[17] The discharge of dredged material generally refers to the placement of materials that were removed (or dredged) from waters of the United States back into the waters of the United States.

[18] The discharge of "fill material" generally means adding material such as concrete, dirt, rocks, or pilings to waters of the United States, in order to replace an aquatic area with dry land or to raise the elevation of an aquatic area.

[19] EPA has developed these guidelines pursuant to its authority under Section 404 (b)(1) of the Clean Water Act. These guidelines prohibit all discharges of dredged or fill material into regulated waters of the United States (including wetlands) unless the discharge is the least environmentally damaging practicable alternative to achieve the basic project purpose.

sult in a discharge of dredged materials into such waters "unless project-specific evidence shows that the activity results in only incidental fallback."[20] Section 404 (f)(1) specifically exempts discharges by the following activities from the permitting requirements under Section 404: normal farming, ranching and forestry activities (such as plowing, minor draining and harvesting); constructing and maintaining stock ponds or irrigation ditches, or maintaining drainage ditches; constructing or maintaining farm, forest or mining roads; maintaining or reconstructing structures that are currently serviceable; constructing temporary sedimentation basins on uplands; and activities for which a state administers an approved program for dredged or fill materials. However, this exemption does not apply where the purpose of discharge is to convert an area to a new use, or if the discharge impairs the flow, circulation or reach of the waters. In these cases, a Section 404 permit will be required.

Both BCDC and the Corps of Engineers have jurisdiction over the filling and dredging of wetlands, yet this jurisdiction is not coterminous. For example, BCDC does not have jurisdiction in areas that were once part of the Bay and have been diked off from the Bay, such as places where seasonal wetlands are found. However, BCDC does have jurisdiction over two important types of diked baylands found in San Francisco Bay–salt ponds and managed wetlands. In addition, BCDC's definition of fill is more broadly defined than the Corps' definition of fill. Whereas, the Corps' fill definition applies mainly to replacing aquatic areas with dry land or changing the bottom elevation of a waterbody,[21] BCDC's fill definition includes placing solid fill, pile-supported fill, floating fill and cantilevered structures. Outside of BCDC's jurisdiction applicants desiring to dredge or fill need not apply to BCDC for a permit, although applicants must apply to the Corps for a Section 404 permit.

National Environmental Policy Act (NEPA).[22] The National Environmental Policy Act (NEPA) of 1969 is a federal law with the purpose of declaring,

> that it is the continuing policy of the Federal Government, in cooperation with State and local government, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of America.[23]

In order to implement this purpose, federal agencies proposing any major federal action that may have a significant effect on the quality of the human environemnt must draft a detailed statement known as an Environmental Impact Statement (EIS). Major federal actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies, as well as new or revised agency rules, regulations, plans, policies or procedures and legislative proposals.[24] The EIS is required to include a statement of the purpose of and need for the proposed action, a description of the affected environment, a comparative analysis of alternatives to the proposed action, and a discussion of the environmental consequences of the proposed action, including direct, indirect and cumulative impacts.[25]

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[20] 66 Fed. Reg. 4550, 4552-January 17,2001.
[21] 33 CFR 323.2 (e)
[22] 42 U.S.C. Sections 43210-4347.
[23] Title 1, Section 101 (a).
[24] 40 C.F.R. Section 1508.18(a)
[25] 40 C.F.R. Sections 1502.10-1502.16

Further, federal agencies must prepare a Record of Decision (ROD) after preparing and adopting an Environmental Impact Statement.[26] The Record of Decision must include an explanation of the decision on the proposed action, factors considered in making the decision, and alternatives considered, including which alternative is environmentally preferable. The Record of Decision must also include a discussion of whether all mitigation measures necessary to avoid or minimize environmental harm were adopted and if not, why they were not. The federal agency also must adopt a monitoring and enforcement program.

As a state agency BCDC's regulatory authority overlaps with the requirements of NEPA in a number of ways. First, NEPA allows state agencies to comment on proposed projects for which Environmental Impact Statements have been drafted. These comments are then available to the President, the Council on Environmental Quality and the public. In addition, state agencies can combine efforts with federal agencies in meeting both CEQA and NEPA requirements for proposed projects by publishing joint EIR/EIS's. For example, the *Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region, Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report* combined the efforts of the Corps, EPA, BCDC, the State Water Resources Control Board, and the San Francisco Bay Regional Water Quality Control Board into a joint EIR/EIS.[27]

Finally, BCDC is able to use a previously prepared federal Environmental Impact Statement as a substitute for BCDC's required Environmental Assessment (EA) when proposing a permit or plan amendment. However, in order to utilize a previously prepared EIS the Commission must: (1) address all of the issues required to be addressed under the California Environmental Quality Act (CEQA); (2) analyze the same project or program for which BCDC is a lead or responsible agency under the California Environmental Quality Act; and (3) the document may not be out of date. Also, when using a NEPA document in lieu of a CEQA document, the record must show that BCDC has independently reviewed the document and determined that it meets CEQA requirements.

Similar to NEPA's EIR and modeled after the California Environmental Quality Act's Environmental Impact Statement (discussed in the following section), BCDC's Environmental Assessment must outline the proposed project or plan amendment's effects on the environment, feasible mitigation measures that would lessen significant adverse environmental impacts, as well as public benefits and feasible alternatives to the proposed project. In the case of substituting an EIS for an EA, BCDC may have to add supplemental information such as a discussion of mitigation, growth-inducing impacts, and energy conservation.

California Environmental Quality Act (CEQA).[28] Passed in 1970 and patterned after the federal National Environmental Policy Act (NEPA), CEQA requires state and local agencies to ascertain the environmental impacts of any project they propose to carry out or approve. Consequently, an Environmental Impact Report (EIR) must be prepared for any project which may have a significant effect on the environment, including land, air, water, minerals, flora, fauna, noise, and objects of historic or aesthetic significance.[29] Specifically in regards to BCDC's role in environmental protection, the Act states that,

[26] 40 C.F.R. Section 1505.2

[27] U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, San Francisco Bay Regional Water Quality Control Board, State Water Resources Control Board. 1998. *Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region: Final Policy Environmental Impact Statement/Programmatic Environmental Impact Report.* Science Applications International Corporation Environmental Programs Division. San Francisco, California.

[28] California Public Resources Code Sections 21000-21178.1

[29] Public Resources Code 21060.5.

it is the intent of the Legislature that all agencies of the state government which regulate activities of private individuals, corporations and public agencies which are found to affect the quality of the environment, shall regulate such activities so that major consideration is given to preventing environmental damage, while providing a decent home and satisfyingliving environment for every Californian.[30]

Furthermore, the purpose of an EIR is,

to identify the significant effects of a project on the environment, to identify alternatives to the project, and to indicate the manner in which those significant effects can be mitigated or avoided.[31]

In response to CEQA's requirement that state agencies prepare Environmental Impact Reports for projects that may impact the environment, such as BCDC's permit decisions and plan amendments, BCDC pursued an additional step and attained state certification by California's Secretary of Resources of its regulatory program as the functional equivalent of the EIR process. As a result, BCDC's Environmental Assessments are functionally equivalent to the Environmental Impact Report required by CEQA. Therefore, permit applications and planning amendments, if and when they require Environmental Assessments, are certified by the state of California as meeting the provisions of CEQA. Section 21080.5 of the Public Resources Code of California outlines the terms necessary for BCDC to meet the state's exemption.

In addition, while environmental documents prepared by state agencies pursuant to a certified regulatory program need not satisfy the specific requirements of CEQA, such documents still must meet all other applicable CEQA requirements, both substantive and procedural. This includes "mandatory findings of significance" which require a lead agency to find that a project may have a significant effect on the environment in cases where the project has: (1) the potential to substantially degrade the quality of the environment, substantially reduce the habitat of fish and wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, or reduce the number or restrict the range of an endangered, rare or threatened species; (2) the potential to achieve short-term environmental goals to the disadvantage of long-term environmental goals; or (3) possible environmental effects which are individually limited, but cumulatively considerable.[32]

Overall, the greatest purpose and value of BCDC undertaking Environmental Assessments is that the process enables a full, open and fair review of proposed projects by Commissioners, BCDC staff and the public at-large, while also ensuring that environmental impacts associated with BCDC permit proposals and plan amendments are minimized to the greatest extent possible.

The Federal Endangered Species Act.[33] The federal Endangered Species Act (ESA) of 1973 was passed in recognition of the need to protect fish, wildlife and plant species from extinction. Specifically, Congress found that species at-risk of extinction "are of aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people." The federal ESA is jointly administered by the Secretaries of the Interior, through the United States Fish and Wildlife Service (Fish and Wildlife), and the Secretary of Commerce, through the National Marine Fisheries Service (NMFS). Importantly, Fish and Wildlife oversees implementation of the ESA for terrestrial and freshwater species, while the NMFS oversees implementation of the ESA for most marine species, as well as anadramous fish species.

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[30] Section 2100.

[31] Section 21002.1.

[32] 14 Cal. Code of Regs.. Section 15065.

[33] 16 U.S.C. Sections 1531 et seq.

A critical function of the ESA is the listing of plant and animal species as threatened or endangered. The Fish and Wildlife and NMFS are responsible for determining whether a species should be listed as endangered or threatened based upon the best available commercial and scientific information. When considering whether to list a species, Fish and Wildlife and NMFS must publish a proposed listing rule in the Federal Register for public comment and then publish a final listing rule within one year of that date. Concurrently with publication of the final listing rule, Fish and Wildlife and NMFS must designate "critical habitat" for the species, unless one of several exceptions apply. Critical habitat includes both areas currently occupied by the species and areas outside the species' current geographic range that are essential to the conservation of the species. Once a species is listed, all protective measures authorized by the Act apply to the species and its habitat.

An endangered species is defined as "any species which is in danger of extinction throughout all or a significant portion of its range," while a threatened species is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Species relevant to the Bay that are listed and regulated by the NMFS include anadromous fish species, such as the winter-run Chinook salmon, spring-run Chinook salmon and steelhead trout. Examples of species associated with the Bay that are listed and regulated by the Fish and Wildlife include the salt marsh harvest mouse and the California clapper rail. Appendix C explains in greater detail many of the species of the Bay listed under both the federal and California endangered species acts. In addition, some marine mammals are protected under the ESA, and all marine mammals are protected under a separate federal law known as the Marine Mammal Protection Act of 1972, which is administered by the NMFS and Fish and Wildlife.

While the ESA is a federal law, state agencies, such as BCDC, do have certain responsibilities under the Act. Specifically, Section 9 of the ESA prohibits the "taking" of an endangered or threatened animal. "Taking" is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect" by any private individual, corporation, federal government, state government or local government. Harass in the "take" definition includes actions "that create the likelihood of injury to [fish or] wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns" such as breeding, feeding, sheltering, spawning, rearing and migration activities, as applicable to the species in question.[34] "Harm" not only includes actions that actually kill or injure fish or wildlife, but also includes significant habitat modification or degradation if this results in death or injury to individual members of a species, by significantly disrupting their essential behavioral patterns, such as breeding, feeding, sheltering, spawning, rearing and migration activities, as applicable to the species in question. BCDC, therefore, must avoid authorizing projects which would harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a federally threatened or endangered animal species listed under the ESA. Furthermore, BCDC must ensure that project applicants obtain the proper permits from Fish and Wildlife and NMFS if a "taking" may occur, as well as requiring that the project applicant provides mitigation where necessary.

Unlike the full protection the ESA offers animals, the ESA does not prohibit the "take" of listed plants on private lands, unless the plant species is listed under both California's ESA and the federal ESA, and a state of California "take" exception does not apply. The state of California's more stringent protections for listed plants under the California Endangered Species Act will be discussed in greater detail in the upcoming section. The most specific provision per-

[34] Mueller, Tara L., Esq. 1994. *Guide to the Federal and California Endangered Species Laws.* Planning and Conservation League Foundation, Sacramento, California.

taining to the ESA's protection of plants is the requirement that any person, including state agencies, are prohibited from removing or maliciously damaging or destroying any listed plant species "from areas under federal jurisdiction."[35]

Finally, in regards to the protection of plants under the federal ESA, the California Environmental Quality Act requires that significant environmental impacts on federal or state endangered or threatened plant species be discussed in regards to a project's impacts. BCDC, in this instance, is required by CEQA to discuss the impacts of permit decisions or plan amendments upon state and federally listed plants, as well as animals, within the agency's Environmental Assessments.[36] Overall, BCDC's responsibility to avoid the "taking" of endangered or threatened plants under the federal ESA is less clear than the stringent requirement of state agencies to avoid the "taking" of endangered animals under the Act.

The California Endangered Species Act.[37] Modeled after the federal Endangered Species Act, California adopted its own Endangered Species Act in 1984 with the purpose of furthering the state's role in the conservation of at-risk species. Declaring that is the "policy of the state to conserve, protect, restore, and enhance" any endangered or threatened species and its habitat, the Act finds that not only is "the conservation, protection, and enhancement of these species and their habitat" of statewide concern," but also that it is the policy of the state that "all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance" of the Act. Conserve" is defined as the use of all methods and procedures necessary to bring any endangered or threatened species to the point at which the measures provided pursuant to CESA are no longer necessary.[38]

The State of California, under the CESA, has the power to list state threatened and endangered species, as well as candidate species under consideration for listing. Species listed as endangered, threatened, or candidate species under CESA may also be listed as endangered or threatened under federal law, or may be listed solely under state law. Unlike the federal ESA, CESA also prohibits the "take" of candidate, as well as threatened and endangered fish and wildlife species. [39] The CESA and ESA work together, with the CESA extending protection to species which have not yet been listed under the federal ESA. The California Department of Fish and Game (Fish and Game) is in charge of the implementation of the CESA, and does so primarily by listing candidate, threatened and endangered species, as well as by regulating their "take." "Take" is defined by the Act as hunting, pursuing, catching, capturing or the killing of a species, listed as threatened or endangered under the Act, as well as attempting to do the former.[40] Unlike the federal ESA, CESA is unclear as to whether "take" includes the destruction or modification of a species' habitat.

BCDC's primary responsibility under CESA is to avoid authorizing a project which would result in the taking of a state candidate, endangered or threatened species, except if the applicant has attained the proper "take" permits from Fish and Game.[41] Furthermore, Fish and Game staff emphasize that state agencies, such as BCDC, should ensure that project applicants attain the proper permits when state listed plants are at risk during a project, in addition to state listed

[35] The restrictions regarding plants are less stringent than those protecting fish and wildlife, although under these provisions any person is prohibited from removing or maliciously damaging or destroying any listed species from under federal jurisdiction. A good argument can be made that the language includes not only federal lands, but state or privately owned lands subject to federal permitting or other regulatory authority (such as the U.S. Army Corps of Engineers' wetland "dredge and fill" permitting authority under Section 404 of the Clean Water Act).
[36] Mueller, 1994.
[37] California Department of Fish and Game Code Sections 2050-2068.
[38] Fish and Game Code Section 2061
[39] Fish and Game Code Sections 2080, 2085.
[40] Section 86.
[41] For more information see Fish and Game Code Sections 2080.1, 2081, 2081.5, 2084 et Seq.

animals.[42] Importantly, those species which are both state and federally listed do require a federal permit in order to "take" the species, thus instituting the more strict federal "harm" provision which requires the protection of critical habitat.

Finally, BCDC cannot "take" or authorize the "take" of any "fully protected species" as defined in Fish and Game Code Sections 3511, 4700, 5050 and 5515. Fully protected species that may be subject to BCDC's jurisdiction include, but are not necessarily limited to, the California brown pelican, California least tern, California clapper rail, light-footed clapper rail, salt marsh harvest mouse, and San Francisco garter snake.

Marine Mammal Protection Act.[43] The federal Marine Mammal Protection Act (MMPA) was enacted in 1972 with the goal of protecting and conserving marine mammals. Instituted in response to the problem of marine mammal mortality associated with commercial fishing operations, the authority for implementing the Act belongs to Fish and Wildlife and the NMFS. Species in the Bay protected by the Act include sea otters, river otters, harbor seals and sea lions. Specifically, Fish and Wildlife has authority over river otters and sea otters, while the NMFS manages harbor seals and sea lions. Specifically, the MMPA authorizes Fish and Wildlife and the NMFS to issue permits to "take" marine mammals for certain purposes including, public display, scientific research, educational or commercial photography, and enhancement of marine mammal populations. Both agencies also have authority to issue more general permits for the "taking" of marine mammals, each of which are subject to public comment and hearing requirements. Importantly, the federal ESA and the MMPA work together, with the MMPA providing additional protections to both listed and unlisted marine mammal species.

The major protection embodied in the Marine Mammal Protection Act, which is relevant to BCDC's authority, is the moratorium the Act places on the "taking" of all marine mammals without a permit from NMFS or Fish and Wildlife. Specifically, it is unlawful for any person subject to the jurisdiction of the United States to "take" any marine mammal (including non-endangered and non-depleted species) on the high seas or in waters or on lands under the jurisdiction of the United States. "Take" is defined by the Act as harassment, hunting, capturing, or killing of a marine mammal, or the attempt to do the former. Unlike the ESA, the MMPA is less restrictive in its definition of "take," as it does not include the term "harm," which in the ESA is interpreted to mean habitat modification or degradation. The term "person" is defined as any private person or entity, or any officer, employee, agent, department or instrumentality of the Federal Government, State, or political subdivision, thereof.[44]

The definition of persons subject to the provisions of the Act is expansive and includes state agencies as having a responsibility to avoid the "take" of marine mammals. However, the Act does not expressly outline that state agencies, such as BCDC, which have permitting authority over projects, and which may harm marine mammals, are mandated to ensure that these activities are consistent with the Act. Yet, BCDC's best approach to addressing its authority under the MMPA lies in ensuring that project applicants do not engage in any activity which is inconsistent with the MMPA. In such an instance where a "take" may occur, BCDC's best expression of authority is to ensure that the project applicant has received the proper permit from either Fish and Wildlife or the NMFS.

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[42] Personal Conversation with Stephanie Tom, California Department of Fish and Game.
Furthermore, differences of opinion currently exist on the permitting requirement for listed plants on private property. Under the Native Plant Protection Act (NPPA) of 1977, a private landowner must only give the Department of Fish and Game ten days to salvage "rare" (an earlier classification of at-risk plants found only in the NPPA) and "endangered" plants once they have been notified by the DFG of the rare or endangered plant's presence on the landowner's property. Mueller argues, however, that the ten day notice and salvage rule applies only to plants classified as "rare" under the NPPA.

[43] 16 U.S.C Sections 1361-1421

[44] Section 1362, Definitions.

Fish and Wildlife Coordination Act.[45] While Fish and Wildlife has no direct regulatory authority over wetlands, the agency does carry out basic responsibilities for migratory birds, fish, waterfowl, marine mammals and endangered species. Through its authorities under the Fish and Wildlife Coordination Act (FWCA) and the federal Endangered Species Act, Fish and Wildlife has considerable influence over the regulatory process. Under the FWCA, Fish and Wildlife reviews all federally funded, permitted or constructed projects in or near wetlands, with the goal of restoring fish and wildlife values associated with wetlands. Through this mechanism, Fish and Wildlife plays an important role in influencing the United States Army Corps of Engineers' permit decisions and conditions placed on projects affecting wetlands authorized by the Corps. The National Marine Fisheries Service (NMFS) is granted similar authority under the FWCA, especially as it concerns reviewing federal projects which may impact fishery resources.

Although BCDC, as a state agency, is not mandated by the FWCA to coordinate with federal resource agencies, BCDC does informally and formally coordinate with these and other agencies, with the intent of protecting fish and wildlife resources. For example, BCDC's regulations require that Fish and Game and Fish and Wildlife are sent a copy of major permit applications.[46] In addition, Fish and Game, NMFS and Fish and Wildlife are informally sent a listing of administrative permit applications and federal consistency determinations being considered by BCDC. Each agency, in turn, are given time to provide comments and questions before the Commission acts on a permit application. Addressing the comments and concerns of these agencies is a collaborative effort, with the primary goal being to avoid impacts to the resources whenever possible. BCDC staff may also informally contact other agencies if a question or concern regarding a permit application arises. Other avenues of coordination include interagency meetings hosted by the Corps, Fish and Game assistance with CEQA documents, and the Resources Agency Commissioner acting as a liaison between BCDC and Fish and Game.[47]

The Essential Fish Habitat Provisions of the Magnuson-Stevens Act.[48] Commercial and recreational fisheries contribute billions of dollars to coastal economies each year and until recently, were considered to be based on inexhaustible resource stocks. However, increasing pressures on marine ecosystems from overfishing, non-selective fishing gear, and habitat degradation now jeopardize many of the nation's fisheries and the coastal communities that depend on the industries for socio-economic and cultural vitality. Congress responded to widespread public concern about these problems in the 1996 reauthorization of the Magnuson-Stevens Act by imposing a two-year requirement on the eight regional fishery management councils, in collaboration with the National Marine Fisheries Service, to give heightened consideration to fish habitat in resource management decisions. Known as Essential Fish Habitat provisions, the Magnuson-Stevens Act requires cooperation among NMFS, the Councils, fishing participants, and others in achieving habitat protection, conservation and enhancement.

The Essential Fish Habitat provisions of the Act offer resource managers a new tool to accomplish the goal of habitat protection, by specifying areas critical to the survival of aquatic species under the purview of the regional fishery management councils. Specifically, Essential Fish Habitat (EFH) is defined by the Act as those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. To clarify this definition, the following interpretations are made: "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. "Substrate" includes sediment and structures underlying the waters, as well as the associated biological communities. "Necessary" refers to

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[45] 16 U.S.C. Sections 661-667 (e).

[46] California Code of Regulations, Title 14, Division 5, Section 10360 of BCDC's Regulations

[47] Personal Conversation with Steve McAdam, Deputy Director of BCDC.

[48] 16 U.S.C. 1801 et seq.

the habitat required to support a sustainable fishery, as well as the managed species' contribution to a healthy ecosystem, while, "spawning, breeding, feeding, or growth to maturity" covers all habitat types utilized by a species throughout its life cycle.

The entities responsible for defining EFH are national fishery management councils. For the Pacific Region, under the authority of the Pacific Fishery Management Council, Essential Fish Habitat is identified for fish species covered by three fishery management plans (FMPs).[49] These three fishery management plans include the Coastal Pelagic[50] Fishery Management Plan, the Pacific Salmon Fishery Management Plan[51] and the Pacific Groundfish Fishery Management Plan. Species which currently have EFH in the Bay include chinook salmon, leopard shark, English sole, Pacific sardine, lingcod, starry flounder, northern anchovy, sand sole, brown rockfish and jack mackerel.[52]

In regards to the implementation of the Essential Fish Habitat provisions, each federal agency proposing an action that will adversely affect Essential Fish Habitat must consult with the NMFS to discuss how to minimize these impacts. Once NMFS learns of a federal or state project that may have an adverse effect on Essential Fish Habitat, NMFS is required to develop Essential Fish Habitat conservation recommendations for the project. These recommendations include measures to avoid, minimize, mitigate, or otherwise offset adverse impact on Essential Fish Habitat. Consequently, Essential Fish Habitat consultations are in the process of being incorporated into federal interagency procedures established under the National Environmental Policy Act, the ESA, the Clean Water Act, and the Fish and Wildlife Coordination Act.

State agency responsibility to the EFH provisions of the Act are less stringent. While NMFS can comment on the impacts of state projects on EFH, the state agency is not required to respond to these comments, nor act upon them. In the strictest sense of the law, then, the Magnuson-Stevens Essential Fish Habitat provisions do not impose any additional requirements on BCDC.[53] However, BCDC does require that permit applicants ensure that all of their permit requirements from other agencies are met both during and before BCDC issues a permit. In this context, an applicant applying for a permit to fill the Bay must also obtain a permit from the Corps of Engineers. The Corps, as a federal agency, will be subject to the EFH provisions of the Magnuson-Stevens Act. As a result, BCDC may hear from the NMFS on such a project. In addition, BCDC is called upon to consider the environmental documentation provided by permit applicants, which may contain comments on EFH concerns from the NMFS. Overall, in its permitting decisions, BCDC must weigh the value of this information and illustrate that the public benefit of a project outweighs the possible detriment to the Bay's resources. In these instances, BCDC should follow its current procedure of interagency coordination and consider NMFS's comments on Essential Fish Habitat for each fish species associated with the Bay.

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[49] National Marine Fisheries Service, Habitat Conservation Division. 1999. *A Primer for Federal Agencies: Essential Fish Habitat, New Marine Fish Habitat Conservation Mandate for Federal Agencies.* (http://ucsd.edu/hcd/efhprim.htm).

[50] Pelagic refers to fish associated with open ocean waters,

[51] Amendment 14 to the Pacific Salmon Fishery Management Plan adopted EFH for chinook salmon.

[52] *Fisheries Management Plan (FMP) Species Distributions in San Francisco, San Pablo and Suisun Bays.* 1999. (http://swr.ucsd.edu/hcd/loclist.htm#SouthSFBay).

[53] Bigford, Thomas E., (ed). Vol. 21 (2) 1999. *The Essential Fish Habitat Provisions of the Magnuson-Stevens Act* in The Coastal Society Newsletter. The Coastal Society, Alexandria, Virginia.

CHAPTER 7

REGIONAL AND SUBREGIONAL APPROACHES TO INCREASING THE HEALTH OF THE BAY'S HABITATS[1]

Historical alterations of the Bay's habitats have had profound effects on its wildlife, plant communities, and on the overall health of the Bay. Increases in plant and animal species at-risk of extinction, habitat fragmentation, habitat loss and the invasion of non-native species are but a few of the impacts associated with land use changes in San Francisco Bay. In an effort to address these impacts, habitat restoration has become an effective tool utilized by both public and private entities. The focus of this chapter is on the value of habitat restoration to the future health of the Bay, as well as the specifics of its application to locations around the Bay.

Restoration refers to those activities that involve restoring a habitat's natural biological and physical conditions, such as restoring tidal influence to a diked wetland by breaching a levee, after the habitat has been altered or degraded. In the Bay Area, habitat restoration, particularly of wetlands, has been underway since the late 1960's. Habitat enhancement refers to those activities or projects that will improve certain habitat values, but will not change the habitat type. Between 1993 and 1997, at least 8,000 acres of wetlands in the Bay-Delta Estuary were restored or enhanced. As of 1999, 19,109 acres of restoration and enhancement projects in riparian and wetland habitats were either planned or in-progress throughout the San Francisco Bay-Delta Estuary.[2] Many of these projects consist of returning agricultural wetlands or salt ponds to tidal action.[3] Examples of restored tidal marshes in San Francisco Bay include the Faber Tract in Palo Alto, Pond 3 and Cogswell Marsh on the Hayward Shoreline, Muzzi Marsh in Corte Madera, and the Sonoma Baylands Project and Tolay Creek in Sonoma County.

While scientists have become more proficient at restoring wetlands, as well as other habitats over the years, many lessons needed to be learned. One of the major factors compromising early wetland restoration was lack of identified restoration goals and poor project design. Early projects that were developed to meet mitigation requirements tended to focus on specific habitat attributes and often incorporated unrealistic design, siting, and size constraints; far too often this guaranteed failure, particularly for riparian restoration. Another factor was the requirement to undertake mitigation on the same site as the development impact, and to create the same type of wetland habitat. This often resulted in mitigation projects being sited in disturbed or marginally suitable locations. Also, a lack of clear or realistic objectives frequently made it difficult to determine whether a wetland project was a success or failure.[4,5]

Over the years, restoration science has progressed substantially as scientists have learned from their early mistakes and have developed a better understanding of how natural wetlands function. Many articles and publications have been produced, particularly for tidal marsh restoration, and these provide a good basis for planning and implementing projects that have a high

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[1] The underlying logic and content of this chapter stems from the Baylands Ecosystem Goals Report: Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif/ S.F. Bay Regional Water Quality Control Board, Oakland, Calif.

[2] Association of Bay Area Governments. 1999. *Report Card: Comprehensive Conservation and Management Plan Implementation Progress, 1996-1999.*(Appendix A) (http://www.abag.org)

[3] San Francisco Estuary Project. 1992-1997. *State of the Estuary.* San Francisco Estuary Project, Oakland, California.

[4] BCDC. 1988. Mitigation: an analysis of tideland restoration projects in San Francisco Bay. San Francisco Bay Conservation and Development Commission, San Francisco, CA.

[5] Gahagan and Bryant. 1994. A review of the physical and biological performance of tidal marshes constructed with dredged materials in San Francisco Bay, CA. Prepared for U.S. Army Corps of Engineers, San Francisco District.

likelihood of success.[6 7 8] There has also been substantial headway in restoring wetlands other than tidal marsh — particularly seasonal wetlands, vernal pools, riparian forest — and in developing planning protocols that can provide a high certainty of success. In all cases, most successes stem from selecting suitable sites and relying on natural processes for wetland evolution and long-term management.

Projects that restore habitats often occur as a result of mitigation required by local, state and federal governments in order to offset habitat destruction or degradation caused by development projects. State and federal resource agencies, such as the U.S. Fish and Wildlife Service and the California Department of Fish and Game, have been most active in restoration and enhancement projects. Yet, while government entities drive the majority of restoration projects, private and non-profit entities also play a significant role in habitat restoration. For example, The Nature Conservancy, Trust for Public Land, Ducks Unlimited, Sonoma Land Trust, Save San Francisco Bay Association, the San Francisco Bay Joint Venture, and the Marin Audubon Society have all provided momentum, support and sponsorship for restoration and enhancement projects around San Francisco Bay.

The work of the San Francisco Bay Area Wetlands Ecosystem Goals Project sought to link public interest, agency support, and scientific expertise by presenting a regional template for habitat restoration. Worth noting is that the implementation of the habitat restoration goals, as outlined by the Goals Report, is voluntary. Groups interested in implementation of the Goals Report include the CalFed program, the California Coastal Conservancy, the U.S. Fish and Wildlife Service, the San Francisco Bay Joint Venture, and non-governmental entities such as Save the Bay, the Audubon Society and the Bay Area Open Space Council.

Implementing the recommendations made by the Goals Report will require close coordination among landowners, agencies and all other interested parties. In addition, the Goals Report suggests that restoration and enhancement projects will need to be coordinated and tracked so all those participating in restoration will know who is doing what. Furthermore, as research and projects are undertaken, the results will need to be made readily available. Unfortunately, poor coordination of restoration could result in many different kinds of problems. For example, scientists might unknowingly and unnecessarily duplicate research or monitoring work. Also, individual restoration projects might not take into account the need for concurrent enhancement of nearby seasonal wetland habitat. As another example, several tidal marsh projects that are sediment-dependent might be undertaken simultaneously in a segment of the Bay where there is not enough suspended sediment, thus jeopardizing the success of the projects. To avoid these types of problems, coordination might be achieved through a regional wetlands plan or a strategic wetlands planning effort.

Overall, achieving the restoration goals outlined in the Goals Project would have regionwide environmental benefits. A primary anticipated benefit would be the recovery of many of the species at-risk of extinction throughout San Francisco Bay. For example, if the tidal marsh restoration goals were attained, populations of the salt marsh harvest mouse and the California clapper rail would be expected to rebound, removing the need to protect them as endangered species. Likewise, restoring tidal marsh would improve habitat conditions for the Chinook salmon and Delta smelt. If the diked marsh enhancement goals were realized, entailing the restoration of tidal influence to a portion of diked marsh habitat, the well-being of migratory birds would be enhanced, due to improved habitat quality and availability. Restoring vernal

[6]Josselyn, M.N. and J.W. Buchholtz. 1984. Marsh restoration in San Francisco Bay: a guide to design and planning. Technical Report #3, Tiburon Center for Environmental Studies, San Francisco State University.

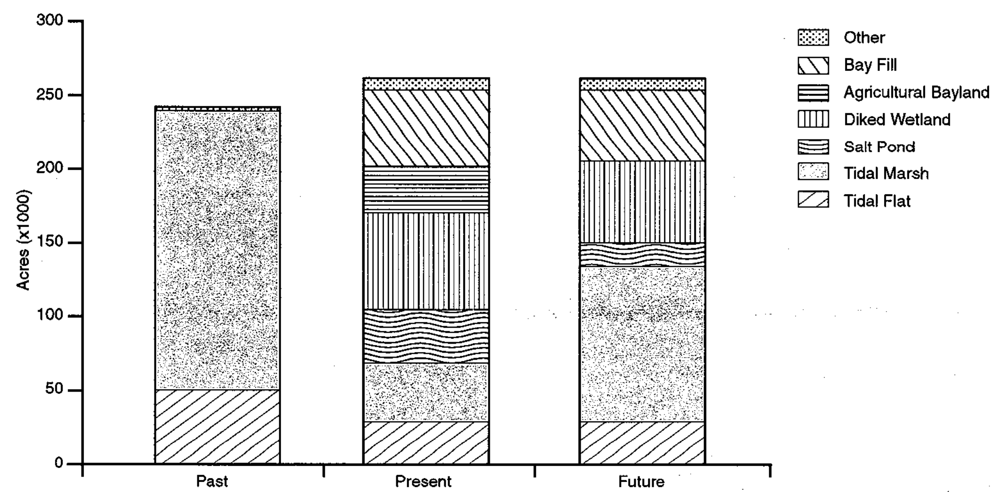
[7] PERL. 1990. A Manual for Assessing Restored and Natural Coastal Wetlands. Pacific Estuarine Research laboratory, California Sea Grant Report No. T-CSGCP-021. California Sea Grant, La Jolla, CA.

[8] Zedler, J.B. 1996. Tidal wetland restoration: a scientific perspective and Southern California focus. Published by the California Sea Grant Collete System, University of California, la Jolla, CA. Report # T-038.

pools and other seasonal wetlands would reverse declines of unique plant and animal communities, while restoring riparian corridors would benefit many species of amphibians, mammals and birds. Finally, the value of restoration outlined by the Goals Project extends beyond direct benefits to wildlife. For example, restoring large amounts of tidal marsh would also improve the Bay's natural filtering system, enhance water quality, increase primary productivity of the aquatic ecosystem, and reduce the need for flood control and channel dredging.

In light of the benefits attributed to achieving the restoration goals outlined by the Goals Project, the Commission endorsed the Draft Goals Report in 1998 as an important resource that the Commission should use in its update of the Bay Plan marshes and mudflats and fish and wildlife policies. This draft background report and the associated findings and policies are an extension of the Commission's vote affirming the scientific value of the restoration goals outlined by the Goals Report.

Regional Approaches. The habitat goals outlined by the Goals Project take a regional, subregional, and segment-based approach to restoration and habitat protection, with one premise as the foundation to all others. First and foremost, the Goals Report states that no additional loss of wetlands within the baylands ecosystem should occur and as filled or developed areas within the Bay become available, their potential for restoration to wildlife habitat should be fully considered. Figure 9[9] outlines the regional habitat acreage goals advocated by the Goals Project. Significantly, the Goals Project calls for increasing the total area of tidal marsh from the existing 40,000 acres to about 95,000 to 105,000 acres.



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals (1999).*

Figure 9
Past, Present, and Recommended Future Bayland Habitat Acreage for the Region

In addition to no-net loss of wetlands in the Bay Area, the Goals Project also outlines that a mosaic of habitats should exist around the Bay. This mosaic of habitats should include: (1) many large patches of tidal marsh connected by wildlife corridors to enable the movement of small

[9] Adapted from the Goals Project, 1999.

mammals and marsh-dependent birds from tidal marsh to tidal marsh; (2) several large complexes of salt ponds managed for shorebirds and waterfowl; (3) extensive areas of managed seasonal ponds and managed marsh; (4) continuous corridors of riparian vegetation along the Bay's tributary streams; (5) beaches, natural salt ponds and other unique habitats; and (6) intact patches of adjacent habitats, such as grasslands, seasonal wetlands and forests.

Ecological design considerations are another important component of the Goals Report's restoration recommendations. These design considerations apply knowledge from the science of ecology to restoration in order to account for the needs of the Bay's ecosystem as a whole. Key among these are that: (1) tidal marsh restoration should strive for large connected patches of habitat that are centered around existing populations of species at-risk of extinction; (2) tidal marsh should be restored along the salinity gradients of the Bay and its tributaries to enable species to follow shifts in habitat location due to variations in freshwater flows; (3) tidal marsh restoration should be emphasized along the Bay edge and where streams enter the Bay, in order to maximize the benefits for fish and other aquatic life; and (4) restored tidal marsh should also include natural features such as pans and large tidal channels, as these significantly increase the habitat's ability to support large numbers of species of fish, shorebirds and waterfowl.

The Goals Report also underscores the value of natural transitions between habitats. Specifically, natural transitions from tidal flat habitat through tidal marsh habitat and up into upland habitat should be reestablished throughout San Francisco Bay. Also natural transitions should occur between diked wetlands and adjacent uplands. Restoring these natural transitions is critical to restoring rare plant communities around the Bay.

In addition to a focus on the restoration of natural transitions between habitats, buffer zones (undeveloped land adjacent to a specified habitat) are described as advantageous by the Goals Report because they help protect sensitive habitats from disturbance. For example, buffers: (1) moderate the effects of storm water runoff; (2) reduce noise and glare; (3) intercept and trap sedimentation and harmful nutrients; (4) reduce direct human disturbance that can result from dumped debris or cut vegetation; and (5) provide visual separation between developed and non-developed areas. The minimum size of an effective buffer varies depending on its intended use and on site-specific conditions. Studies indicate that in order to prevent direct human encroachment buffers of 50 to 150 feet are necessary, while in order to provide effective water quality function the buffers should be 100 feet or greater. Studies in the state of Washington indicate that adequate wildlife buffers need 100 to 300 feet or more, depending on the area and the kind of wildlife under management.[10]

Another issue considered important to achieving the regional habitat restoration goals outlined in the Goals Report is phasing, which refers to the timing of restoration and enhancement projects. At the heart of this issue is the recognition that tidal marshes and diked wetlands cannot occupy the same places at the same time; increasing the acreage of one kind of habitat means decreasing the acreage of the other. One of the more critical aspects of phasing involves making decisions about habitats for threatened and endangered species, mainly that increasing habitat area for some species may reduce it for others. As a possible solution to these trade-offs, the Goals Report outlines that the phasing of restoration projects should occur both within each subregion and on a regional scale. For example, extensive restoration of tidal marsh habitat should be undertaken only when there is significant progress in enhancing diked wetlands or salt ponds in the same subregion. Also, tidal marsh restoration projects should include efforts to enhance diked wetlands, as well as other habitat types, thus ensuring that the preferred mosaic of Bay habitats are enhanced and restored.

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[10] Washington State Department of Ecology. 1992. *Wetlands Buffers: Use and Effectiveness.* Washington State Department of Ecology, Olympia, Washington.

Subregional Approaches. In addition to regional approaches to restoration and habitat enhancement, the Goals Project also provides recommendations for the appropriate blend of habitat types which should be present in each of the four subregions of the Bay. These four subregions are North Bay, Suisun, Central Bay and South Bay (see chapter 2 for an illustration of these subregions). While the following discussion of each of the four subregions is broad, the Goals Report goes one step further in detail and breaks each of the subregions up into smaller segments, such as Suisun Marsh East and Suisun Marsh West. Within these segments, even more descriptions are given as to where restoration should occur. For this reason, the Goals Report itself should be referenced when specific restoration projects or regional habitat planning efforts are being considered.

1. **Suisun Subregion.** The overall goal for Suisun subregion is to restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay, and to restore and enhance managed marsh, riparian forest, grassland, and other habitats throughout the subregion.

   In Suisun Marsh, there should be a continuous band of restored tidal marsh from the confluence of Montezuma Slough and the Sacramento/ San Joaquin rivers to the marsh's western edge. This band of tidal marsh should extend in an arc around the northern edge of the marsh and should blend naturally with the adjacent grasslands to provide maximum diversity of the upland ecotone, especially for the benefit of plant communities. A broad band of tidal marsh also should be restored along the southern edge of Suisun Marsh and around Honker Bay, in large part to improve fish habitat.

   On the majority of lands within Suisun Marsh, the long-standing practice of managing diked wetlands primarily for waterfowl should continue. These brackish marshes should be enhanced, through protective management practices, to increase their waterfowl carrying capacity. On the periphery of the marsh, moist grasslands with vernal pools should be enhanced, as should riparian vegetation along the tributary streams.

   On the Contra Costa shoreline, full tidal action should be restored to many of the marshes that currently are diked or that receive muted tidal flow. Restoration should incorporate broad natural transitions to foster a higher diversity of plant communities and associated animals, as well as buffers to protect these populations from adjacent disturbance. Also, riparian vegetation should be restored along as many stream corridors as possible.

   In the northern part of this subregion, achieving these goals will depend largely on the willingness of private duck club owners to convert managed marsh to tidal marsh. On the Contra Costa shoreline, achieving them will depend on the voluntary effort of corporate, military, and private landowners to restore many marshes to full tidal action. Acreage goals for this subregion call for increasing the area of tidal marsh from about 13,000 acres to about 30,000 to 35,000 acres, while maintaining approximately 32,000 to 37,000 acres of diked wetlands. With this change, about 65% of the existing managed marsh acreage would be retained. Figure 10[11] illustrates the future habitat acreages recommended by the Goals Project for the Suisun subregion.

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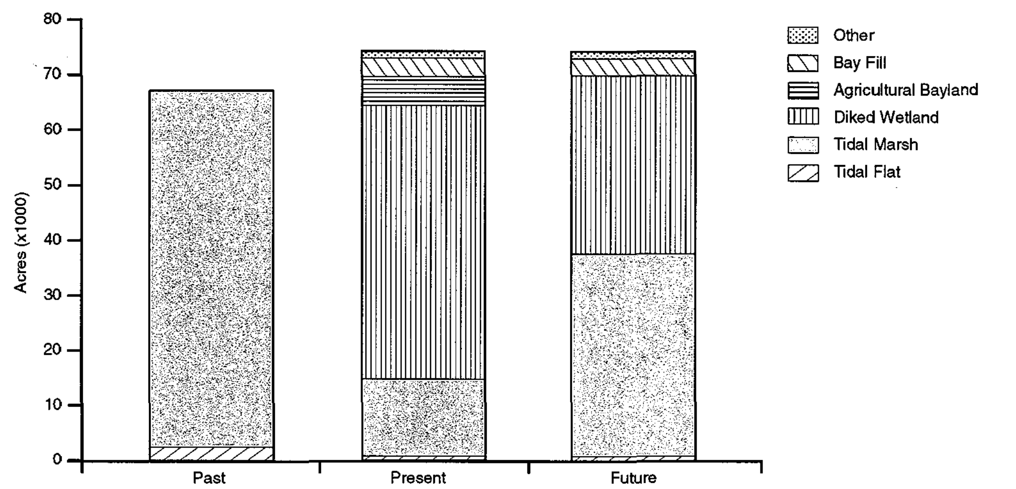
[11] Adapted from Goals Project, 1999.



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals (1999).*

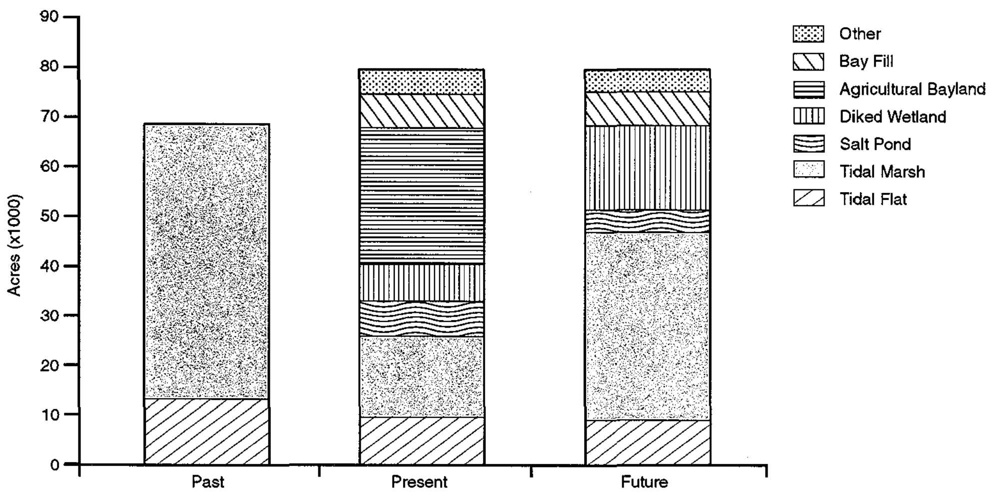
Figure 10
Past, Present, and Recommended Future Bayland Habitat Acreage for Suisun Subregion

2. **North Bay Subregion.** The overall goal for North Bay is to restore large areas of tidal marsh and enhance seasonal wetlands. Also, some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, while others should be restored to tidal marsh. Tributary streams and riparian vegetation should be protected and enhanced, and shallow subtidal habitats (including eelgrass beds in the southern extent of this subregion) should be preserved or restored. In addition, tidal marsh restoration should occur in a band along the Bay's shore, extending into the watersheds of the subregion's three major tributaries – Napa River, Sonoma Creek, and Petaluma River. Seasonal wetlands should be improved in the areas that currently are managed for agriculture. Significantly, achieving these goals will depend on the voluntary effort of farmers to convert agricultural wetlands to tidal marsh and to allow the remaining areas to be managed as seasonal pond habitat. In total, the goal for the North Bay subregion is to increase the area of tidal marsh from the existing 16,000 acres to approximately 38,000 acres, while also enhancing about 17,000 acres of diked wetlands to optimize their seasonal wetland functions. Figure 11[12] illustrates the future habitat acreages recommended by the Goals Project for the North Bay subregion.

3. **Central Bay Subregion.** The overall goal for Central Bay is to protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Shallow subtidal habitats (including eelgrass beds), as well as tributary streams and riparian habitats, should also be protected and enhanced. Furthermore, tidal marsh habitats should be restored wherever possible, but particularly at the mouths of streams and at the upper reach of dead-end sloughs. In addition, tidal marsh restoration in urban areas is encouraged.

   Although topography and urban and industrial development limit the potential for large-scale habitat restoration in this subregion, there are many opportunities to restore relatively small tidal marshes and other habitats, each of which should be pursued. Even

[12] Adapted from Goals Project, 1999.



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals (1999).*

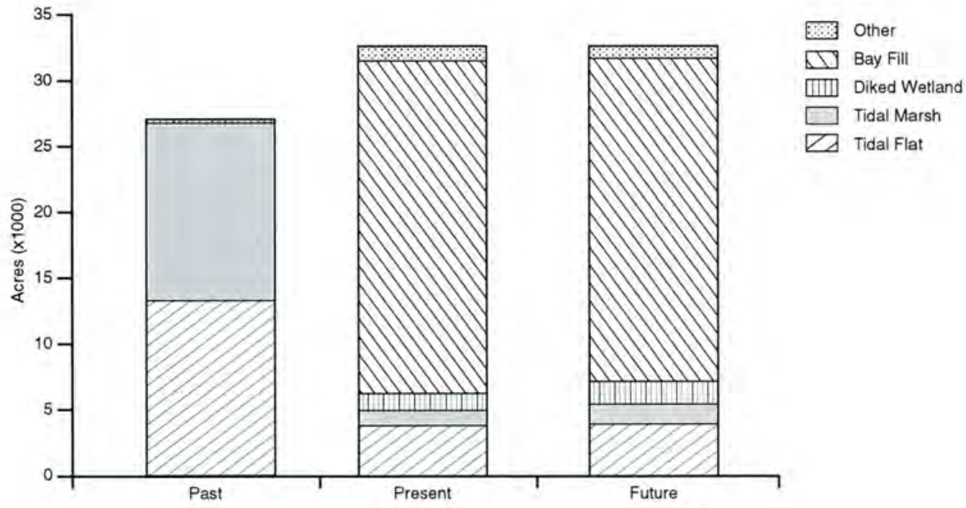
Figure 11
Past, Present, and Recommended Future Bayland Habitat Acreage for North Bay Subregion

small disconnected patches of tidal marsh would provide habitat islands for migrating native wildlife species and improve overall habitat conditions. Furthermore, even the smallest restoration efforts should try to incorporate transitions from intertidal habitats to adjacent uplands, as well as upland buffers. Lastly, shorebird roosting sites should be protected and enhanced.

Of particular importance in this subregion, especially in the southern half, is the need to control the spread of the invasive smooth cordgrass. Achieving the goals in this subregion will depend largely on the willingness of many private and public landowners to undertake habitat restoration and enhancement in the most urbanized portion of San Francisco Bay. Given the limitations of this subregion, the Goals Project recommends only a few hundred acres of tidal marsh restoration. Figure 12[13] illustrates the future habitat acreages recommended by the Goals Project for the Central Bay subregion.

4. **South Bay Subregion.** The primary goal in the South Bay subregion is to restore large areas of tidal marsh, connected by wide corridors of similar habitat, along the perimeter of the Bay. Specifically, several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the subregion, and naturalistic, unmanaged salt ponds (facsimiles of historical, hypersaline backshore pans) should be restored on the San Leandro shoreline. In addition, there should be natural transitions from mudflat through tidal marsh habitat to adjacent uplands. Nearby moist grasslands, particularly those with vernal pools, should be also protected and improved for wildlife. Furthermore, riparian vegetation and willow groves should be protected and restored wherever possible.

[13] Adapted from Goals Project, 1999.



SOURCE: Adapted from USEPA & SFBRWQCB *Baylands Ecosystem Habitat Goals (1999).*

Figure 12
Past, Present, and Recommended Future Bayland Habitat Acreage for Central Bay Subregion

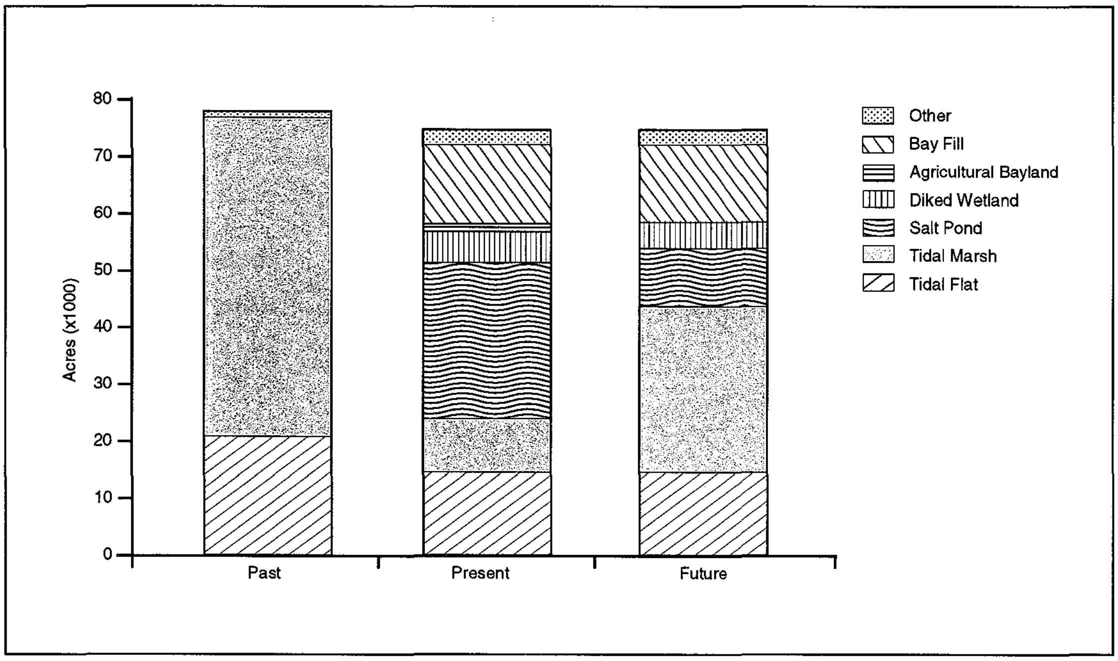
The acreage goals for this subregion call for increasing the area of tidal marsh from about 9,000 acres to about 25,000 to 30,000 acres. Also recommended is the management of salt pond habitat for the benefit of wildlife in the amount of 10,000 to 15,000 acres. Achieving these goals will depend largely on the willingness of the Cargill Salt Division to undertake major changes in its operations or if it ceases commercial salt production.

Also important is the willingness of many other private and public landowners to participate in habitat restoration. Figure 13[14] illustrates the future habitat acreages recommended by the Goals Project for the South Bay subregion.

Segment-Based Approach. As mentioned earlier, in an effort to further clarify the subregional habitat goals the Goals Report breaks down each subregion into 20 smaller geographic components called segments. For example, the North Bay subregion is separated into the Napa River area, the Sonoma Creek area, the Petaluma River area, North Marin and Contra Costa west. For each of these 20 segments of the Bay the Goals Report discusses five relevant restoration concerns, including: (1) major or unique features of the segment; (2) unique restoration opportunities; (3) restoration recommendations; (4) unique restoration benefits; and (5) possible constraints.

BCDC's Role in Promoting the Expansion of the Bay through Habitat Restoration. By providing a regional, subregional, and segment-based analysis of San Francisco Bay, the Goals Report provides an in-depth and scientifically sound template for regional restoration which BCDC should utilize to ensure consistency between the habitat goals and proposed restoration projects subject to approval by BCDC.

[14] Adapted from Goals Project, 1999.



SOURCE:Adapted from USEPA & SFBRWQCB
Baylands Ecosystem Habitat Goals (1999).

Figure 13
Past, Present, and Recommended Future Bayland Habitat Acreage for South Bay Subregion

Overall, a restoration of approximately 65,000 acres is recommended by the Goals Project. In addition, approximately 15,000 acres of salt ponds are recommended to be managed for wildlife and 17,000 acres of diked wetland habitat is recommended to be managed in such a way that optimizes seasonal wetland functions. BCDC's goals for the expansion of the Bay should coincide with those of the Goals Project. Therefore, BCDC's target acreage for expanding the Bay should reside around 65,000 acres. However, while the Goals Project advocates that the expansion of the Bay should occur primarily in the form of tidal marsh restoration, BCDC's subtidal panel, which brought together a number of scientists at BCDC to discuss subtidal habitat protection and restoration, recommended that restoration programs include subtidal habitats, as well, when seeking to expand the Bay. Further information regarding this conclusion is found in chapter 9 entitled "Restoring and Protecting Subtidal Habitats."

Currently, the Commission participates in a number of endeavors which further the goal of expanding the Bay. First and foremost, policies engendered in this report and proposed for the update of the Bay Plan suggest undertaking restoration and enhancement of the Bay whenever possible. Other actions which the Commission takes to foster the expansion of the Bay includes the internal review by staff of proposed restoration projects during the permitting process. Many times these projects benefit substantially with staff review and suggested improvements to design. In addition, the Commission's dredging policies pertaining to upland disposal and re-use of dredged material has enabled tidal marsh restoration to occur in previously diked wetlands where subsidence requires major inputs of new sediment to occur in order for the project to succeed. Examples of projects which have used or plan to use dredged materials include the Hamilton and Sonoma Baylands tidal marsh restoration projects.

Furthermore, BCDC also participates in a number of consortiums which have the restoration of the Bay as their goal. For example, the Commission may participate in a new group known as the San Francisco Bay Area Wetlands Restoration Program.[15] In concert with other state and federal resource agencies with responsibility for San Francisco Bay streams and wetlands, members[16] of this group seek to: (1) provide policy oversight to ensure sound implementation of the Habitat Goals; (2) provide a forum for identifying and resolving conflicting agency practices that impede the timely development and authorization of ecologically appropriate habitat projects; (3) facilitate the establishment and long-term implementation of a regional wetlands monitoring program with sufficient information sharing capability to inform an adaptive approach to habitat restoration for existing wetlands and new habitat projects; and (4) assist public and private entities to plan, design and coordinate appropriate high-quality habitat projects in keeping with the general concepts and recommendations of the Goals Report..[17]

In order to carry out the objectives of the San Francisco Bay Area Wetlands Restoration Program, four project groups are proposed to convene beginning in the fall of 2001. These project groups include the Executive Council, the Design Review Group, the Management Group and the Monitoring Group. Each project group will inform the process of a proposed restoration project in the following manner: (1) the Executive Council will provide support and leadership for a proposed project; (2) the Design Review Group will assist in the planning and design of the proposed project; (3) the Management Group will work to resolve obstacles to the timely development and authorization of the proposed project; and (4) the Monitoring Group will perform regional evaluation of restoration and mitigation projects so as to better inform future restoration efforts. Currently, the Commission is a member of the Bay Area Wetlands Planning Group, which will function as the Management Group when the program is initiated, and the Regional Wetlands Monitoring Program, which will function as the Monitoring Group under the program. The Commission has also been invited to sit on the Executive Council and participate in the Design Review Group.

Once it is established, the Commission would benefit in many ways by becoming an active participant in the San Francisco Bay Area Wetlands Restoration Program. First, the San Francisco Bay Area Wetlands Restoration Program would act as a filter for the Commission by highlighting those projects which meet the objectives of the Goals Project and pointing out those which do not. Also, interagency coordination early-on in the proposal of restoration projects would provide a forum for collaboration and ultimately streamline the completion of beneficial projects. In addition, the success of proposed projects would increase substantially with the early input of the Design Review Group and the later assessment of the project by the Monitoring Group. Thus, Commission participation in the program is key to ensuring both the sound implementation of the recommendations of the Goals Report and the most informed review of proposed restoration projects by the Commission and its staff.

The Commission is also a member of the Management Board of the San Francisco Bay Joint Venture (Joint Venture). Brought together by the North American Waterfowl Management Plan in 1995, the San Francisco Bay Joint Venture seeks to form partnerships between a spectrum of agencies , as well as non-profit and private organizations, in order to share skills, funding and information pertaining to the restoration and stewardship of San Francisco Bay wetlands and watersheds for waterfowl and associated wildlife. Specifically, the objectives of the Joint Venture include: (1) to secure, restore, and improve wetlands, riparian habitat and associated up-

[15] Bob Batha, personal conversation, December 2000.

[16] Members include the California Coastal Conservancy, BCDC, the California Department of Fish and Game, San Francisco Bay Regional Water Quality Control Board, State Water Resources Control Board, US EPA, US Army Corps of Engineers, and the US Fish and Wildlife Service.

[17] Bay Area Wetlands Planning Group. Project Summary for the Proposed San Francisco Bay Area Wetlands Recovery Project. Prepared for the June 20, 2000, public workshop.

lands by applying incentives and using non-regulatory techniques; (2) strengthening and supporting new sources of funding for such efforts; (3) improving habitat management on public and private lands through cooperative agreements and incentives; and (4) providing support for monitoring and evaluation of restoration projects and research to improve future restoration projects.

In light of these objectives, the Joint Venture has established habitat acquisition, restoration and enhancement goals for San Francisco Bay based primarily upon the Goals Report.[18] However, unlike the Goals Project, the timeline for completion of the Joint Venture habitat goals is 20 years rather than 100 years. In this time, the Joint Venture seeks to support the acquisition of 63,000 acres, restoration of 37,000 acres, and enhancement of 35,000 acres of Bay habitats, which include tidal marshes, tidal flats, lagoons, beaches and salt ponds. Furthermore, the Joint Venture seeks to support the acquisition of 16,000 acres, restoration of 6,000 acres and enhancement of 12,000 acres of diked wetlands around the Bay. Furthermore, the Joint Venture is also pursuing habitat goals in areas outside of the Commission's jurisdiction. These habitats include creeks, lakes, grasslands and associated wetlands. Current examples of projects supported by the Joint Venture include the Crissy Field restoration project in San Francisco, restoration of Bair Island in the South Bay and the 9,000 acre Napa/Sonoma marsh restoration project in the North Bay.

In terms of further recommendations to promote the expansion of the Bay, there may be a substantial role for BCDC to play in fostering a subtidal Goals Project modeled after the original Goals Project. Such an endeavor has the potential to provide much information on the Bay's subtidal environment and subsequently proffer suggestions on areas where subtidal restoration could occur. For example, there may be a great deal of benefit in opening acquired salt pond habitat up to tidal influence and restoring a certain amount of acreage to shallow subtidal habitat. Such an approach differs from just looking at the value of tidal marsh restoration to the Bay ecosystem. The need for and approach to this proposed endeavor is discussed in greater detail in chapter 9 and Appendix B.

Inventory and Restoration of Diked Baylands.[19] According to the Goals Report, the Bay currently has approximately 64, 518 acres of diked wetland habitat and 34, 620 acres of agricultural bayland habitat (see Table 3). Of the 99,138 acres of diked baylands currently found around the Bay, the Goals Report recommends enhancing and maintaining approximately 49,138 acres, while restoring the rest to other habitat types, mainly tidal marsh. Figure 3 illustrates the present distribution of habitat types around San Francisco Bay, including the location of agricultural baylands and diked wetlands.

Described in greater detail in chapter 2, diked wetlands encompass managed marsh and diked marsh habitats. Managed marsh is distinguished by the fact that it is managed for the benefit of wildlife, primarily waterfowl, and diked marsh occurs in areas adjacent to levees or dikes with poor drainage and are not managed for wildlife. However, diked marshes provide important habitat for waterfowl, shorebirds and small mammals. Agricultural baylands are diked, former tidal marshes that are intensively cultivated for agricultural production or are grazed by cattle, sheep or horses. This habitat type is especially important for many species of wildlife, including shorebirds and waterfowl.[20]

On a regional scale the Goals Report advocates that a diverse mosaic of habitat types are restored, protected and enhanced around the Bay, including diked baylands. Specifically the re-

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[18] Steere, J.T. and N. Schaefer 1999. *Restoring the Estuary. Implementation Strategy of the San Francisco Bay Joint Venture Restoring the Estuary: A Strategic Plan for the Restoration of Wetlands and Wildlife in the San Francisco Bay Area.* San Francisco Bay Joint Venture, Oakland, California. 98 pp.

[19] Acreages reflect what existed in 1998. Salt pond acreages and habitat goals are not included in this analysis.

[20] Goals Report. 1999.

port outlines that the mosaic of habitats should include extensive areas of managed seasonal ponds and large expanses of managed marsh, thus underscoring the important role that diked baylands play in the Bay ecosystem as a whole. However, worth noting is that in order to meet the goal of increasing the acreage of tidal marsh habitat in the Bay, the Goals Project participants recognized that certain shifts in habitat types would have to occur. In particular, a reduction in the acreage of all kinds of diked bayland habitats would be required to increase tidal marsh habitat around the Bay.

For each subregion of the Bay the habitat recommendations for diked baylands are as follows: (1) in Suisun Bay 32,000 to 37,000 acres of managed marsh, which represents about 65% of current managed marsh acreage, should be retained in their current state; (2) in the North Bay all agricultural baylands are recommended to be restored to tidal marsh habitat (approximately 22,000 acres) or enhanced to create diked seasonal wetlands (approximately 17,000 acres); (3) in the Central Bay a few hundred acres of diked wetlands are recommended to be restored to tidal marsh, thus representing a loss of diked bayland habitat in this region; and (4) in the South Bay agricultural baylands and a portion of diked wetlands are recommended for restoration to tidal marsh, and approximately 5,000 acres of diked wetlands in this region should be protected and enhanced for the benefit of shorebirds and waterfowl.

CHAPTER 8

WILDLIFE REFUGES

As explained in chapter 3, aquatic life and wildlife habitat in the Bay has been displaced or modified to the extent that a number of species are listed by federal and state agencies as threatened or endangered. Wildlife refuges are established primarily to conserve habitat important to the continuation of aquatic life and wildlife species and to protect threatened and endangered species. This chapter explores the characteristics and locations of state and federally owned wildlife refuges located in San Francisco Bay, as well as the proposed San Francisco Bay National Estuarine Research Reserve. Also addressed in this chapter are the proposed wildlife priority use area updates to the Bay Plan Maps. These updates are proposed in order to reflect the contemporary distribution of state and federal wildlife refuges in San Francisco Bay.

National Estuarine Research Reserve System (NERRS). NOAA's National Estuarine Research Reserve System (NERRS), established under the Coastal Zone Management Act, provides a research coordination system and education funding assistance for the scientific understanding of estuarine lands which are in a pristine state. The NERR program overlaps existing land management programs and, thus, is considered a program rather than a place.

The nationwide NERRS mission is to create a "protected areas network of federal, state, and community partnerships which serve to promote informed management of the nation's estuarine and coastal habitats through linked programs of stewardship, public education, and scientific understanding."[1] Goals include protecting representative areas; promoting partnerships; encouraging informed management and stewardship, developing scientific understanding through research, and providing education.

The current NERR proposal for San Francisco Bay combines three currently protected sites into a National Estuarine Research Reserve (including the Rush Ranch Open Space Preserve owned by the Solano County Farmlands and Open Space Foundation, China Camp State Park in Marin County, and Brown Island Open Space Preserve owned by the East Bay Regional Park District). These sites were chosen in part due to the NERR program's focus on protecting tidal wetlands. The NERR system is being proposed by San Francisco State University's Romberg Tiburon Center for Environmental Studies and the National Oceanic and Atmospheric Administration (NOAA). BCDC has also been a partner in this effort and will serve on the Management Advisory Board once the program is established.

The San Francisco Bay NERR will be a long-term program designed to bring active stewardship, monitoring, research, and education to a representative array of habitats in the Bay. These sites contain some of the last, largest, and most biologically valuable tidal wetland remnants in the Estuary. Although the current system of ownership protects the lands, it does not provide a regional perspective and ecological reference system for research and management, an effort which the NERR program intends to foster.

Each land managing agency retains jurisdiction over and responsibility for their sites, although NERRS provides a coordinating system. No new regulations are proposed. A management plan would be created to provide support, coordination, and guidance for the region's wetlands. Thus, the Reserve, if approved, would provide a regional approach rather than a site-

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[1] San Francisco State University, State of California Bay Conservation and Development Commission, and the U.S. Department of Commerce National Oceanic & Atmospheric Administration (Ocean & Coastal Resource Management). San Francisco Bay National Estuarine Research Reserve: Draft Environmental Impact Statement and Draft Management Plan. Silver Spring, MD, 1997

specific approach. Project managers estimate that the approval of the San Francisco Bay NERR will occur in early 2002.[2] As the proposed NERR is a program rather than a place with estuarine research rather than wildlife management as a goal, these lands will not be shown as wildlife priority use areas on the Bay Plan maps.

Overview of Federal and State Wildlife Refuges. The term "wildlife refuge" generally refers to a place where wildlife is protected or sheltered from danger or harm. Wildlife refuges are often state or federally owned and administered facilities such as the federal San Francisco Bay National Wildlife Refuge Complex or the state-owned Grizzly Island Wildlife Area in Suisun Marsh. However, wildlife refuges can also be owned and managed by non-profit organizations dedicated to such purposes, such as the National Audubon Society's Richardson Bay Sanctuary.

To understand the various functions and purposes of wildlife refuges, this section explores the classifications used by the California Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service (USFWS).

1. **Federal Wildlife Refuges.** The United States Fish and Wildlife Service owns and manages three wildlife refuges in the San Francisco Bay. They are the Marin Islands National Wildlife Refuge and State Ecological Reserve (131.29 acres), the Don Edwards San Francisco Bay National Wildlife Refuge (25,901.94 acres), and the San Pablo Bay National Wildlife Refuge (13,189.12 acres)–technically all three are part of the larger San Francisco Bay National Wildlife Refuge Complex. These refuges include over 39,000 acres of protected land on or near the Bay. The U.S. Fish and Wildlife Service also proposes to establish a 978 acre national wildlife refuge on Alameda Island on portions of the former Alameda Naval Air Station, and is studying the potential of another wildlife refuge of up to 17,600 acres along the Marin County Shoreline.

   The management of individual refuge system units is dictated in large part by the legislation, executive order, or administrative action that creates the unit. The refuge purpose(s) reflected in enabling legislation, executive orders and administrative actions may range from very narrow to very broad management goals. For example, the Antioch Dunes National Wildlife Refuge in the Delta was created primarily to protect critical habitat for endangered plant and animal species (including Lange's Metalmark Butterfly, the Dunes Evening primrose, and the Contra Costa Wallflower), thus public access is prohibited. In contrast, the Don Edwards San Francisco Bay National Wildlife Refuge serves the broader purpose of protecting wildlife, providing wildlife-oriented recreation, and facilitating nature study.

   The overall mission of the national wildlife refuge system is to administer a national network of lands and waters "for the conservation, management, and where appropriate, restoration of the fish, wildlife and their habitats within the United States for the benefit of present and future generations of Americans."[3] Compatible wildlife-dependent recreation, such as hunting, wildlife observation and fishing, is considered a "priority general public use" and receives priority consideration in refuge planning and management (National Wildlife Refuge Administration Act, Sec. 668dd).

   To gain a better sense of the functions of a wildlife refuge, we can take a closer look at a specific refuge in the Bay, in this case, the Don Edwards National Wildlife Refuge in the South Bay, established by House Resolution 12143 in 1972. The legislation establishes the refuge for the "preservation and enhancement of highly significant wildlife habitat…for the protection of migratory waterfowl and other wildlife, including species known to be threatened with extinction, and to provide an opportunity for wildlife-oriented recreation and nature study within the open space so preserved…" Over 200 species of birds

[2] Mike Vasey, personal communication, 04/00.

[3] USFWS web site, http://refuges.fws.gov/NWRSFiles/Legislation/HR1420/TOC.html

breed at the refuge or use it as a resting or feeding stop during migrations. In addition, the tidal marsh habitat provides refuge or feeding grounds for four endangered species, including the California clapper rail, the salt marsh harvest mouse, the California brown pelican and the California least tern. To protect these species and other habitat values, many activities (such as harvesting of plants) are prohibited, while others are allowed with restrictions (such as boating and hunting).

2. **Department of Fish and Game Lands.** The California Department of Fish and Game (Fish and Game) owns many lands oriented towards wildlife, including: (1) reserves, (2) ecological reserves, (3) marine resources protection act ecological reserves; (4) refuges; and (5) state wildlife areas (wildlife management areas). The two major classifications found in the Bay include ecological reserves and state wildlife areas. These ecological reserves and state wildlife areas include over 43,000 acres of tidal marsh, tidal flat, former salt pond, upland, and subtidal habitat in or around the Bay. Although each category has different management objectives, the management distinction between the ecological reserves and the state wildlife areas has blurred in recent years, due to greater emphasis on habitat protection in both categories.[4] Both ecological reserves and state wildlife areas are discussed in greater detail below.

    a. **Ecological Reserves.** Ecological reserves are designed to "provide protection for rare, threatened or endangered native plants, wildlife, aquatic organism and specialized terrestrial or aquatic habitat types."[5] Fish and Game is responsible for acquiring and managing ecological reserves, although the Fish and Game Commission can approve or disapprove of prospective ecological reserve designations. To protect the ecological reserves, Fish and Game regulations prohibit the disturbance or take of any form of plant and animal life, prohibit any type of collection, and contain other limited prohibitions on fishing, swimming, and other activities. The regulations also state that public entry and use must be compatible with the primary purpose of the reserve.[6]

       Ecological reserves at or near the Bay include Fagan Marsh Ecological Reserve, Redwood Shores Ecological Reserve, Corte Madera Marsh Ecological Reserve, Peytonia Slough Ecological Reserve, Albany Mudflats Ecological Reserve, Eden Landing Ecological Reserve, Bair Island Ecological Reserve, and Marin Islands Ecological Reserve.

    b. **State Wildlife Areas (Wildlife Management Areas).** State wildlife areas are established "for the purposes of propagating, feeding and protecting birds, mammals, and fish, and establishing wildlife management areas or public shooting grounds."[7] With approval from the Fish and Game Commission, Fish and Game may acquire or lease suitable areas for these purposes. Hunting and trapping are allowed on state wildlife areas during regular open seasons, and as specified by the regional manager of the area. Regulations for state wildlife areas allow the managers to restrict entry, camping, motor vehicle access, use of dogs, and other factors.[8] State wildlife areas on or near the Bay include the Petaluma Marsh Wildlife Area, Hill Slough Wildlife Area, the Napa-Sonoma Marshes Wildlife Area, Grizzly Island Wildlife Area Point Edith Wildlife Area, and the San Pablo Bay Wildlife Area.

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[4] State Interagency Marine Managed Areas Workgroup. "Improving California's System of Marine Managed Areas: Final Report of the State Interagency Marine Managed Areas Workgroup." State of California, 2000. p. B-23.

[5] 14 CA Code of Regs, 630

[6] 14 CA Code of Regs, 630

[7] State Interagency Marine Managed Areas Workgroup, 2000. P. B-23

[8] 14 Cal Code of Regulations, 550

In addition, three other Fish and Game properties are found around the Bay and they do not fall into any distinct management category. These areas are Gallinas Creek, Oro Loma Marsh and New Chicago Marsh.

Bay Plan Designated "Wildlife Priority Use Areas"[9] The Bay Plan designates certain areas along the shoreline for regionally important water-oriented uses, including wildlife areas. Under the McAteer-Petris Act, wildlife refuges are considered water-oriented land uses and, therefore, are shown as priority use areas on the Bay Plan maps. Section 66602 of the McAteer-Petris Act enables BCDC to establish these priority use areas, explaining that,

> The Legislature...finds and declares that certain water-oriented land uses along the Bay shoreline are essential to the public welfare of the Bay Area, and that these uses include ports, water-related industries, airports, wildlife refuges, water-oriented recreation and public assembly, desalinization plants, upland dredged material disposal sites, and power plants requiring large amounts of water for cooling purposes; that the San Francisco Bay Plan should make provision for adequate and suitable locations for all these uses, thereby minimizing the necessity for future Bay fill to create new sites for these uses...

Thus, establishing wildlife priority use areas allows BCDC to reserve adequate land for wildlife refuges, in order to ensure that future Bay fill to accommodate them in other areas around the Bay will be minimized. Furthermore, where land is designated as a "wildlife area," the Commission can not permit non-wildlife oriented uses, such as residential, commercial or industrial uses.

Worth noting is that two terms are used in the McAteer-Petris Act and the Bay Plan to discuss wildlife priority use areas. Specifically, "wildlife refuge" is used in Section 66602 and Section 66605 in the McAteer-Petris Act to define wildlife refuges as water-oriented uses requiring "adequate and suitable locations" around the Bay, while the term "wildlife area" is used throughout the Bay Plan Maps and Bay Plan policies. Therefore a slight difference in nomenclature exists between the McAteer-Petris Act and the Bay Plan. To date, there is no record as to why this difference between "wildlife refuge" and "wildlife area" terminology exists.

Wildlife priority use areas currently mapped on the Bay Plan Maps include Audubon Wildlife Sanctuary, Marin Islands, the Sisters, Rat Rock, Hamilton Field, Lower Tubbs Island, Joice Island, Grizzly Island, Red Rock, Emeryville-Oakland Shoreline, and Bair Island. These priority use areas were adopted in 1971, with the exception of Hamilton Field which was added in 1995.

Some of these areas may have been chosen because they were already dedicated to wildlife management at the time of the designation (such as the Audubon Wildlife Sanctuary on Richardson Bay or Grizzy Island Wildlife Area in the Suisun Marsh). Other areas were publicly owned but not dedicated to wildlife at the time (such as Rat Rock), and the Commission wanted to protect these areas from development.[10] Still other areas were neither publicly owned, nor dedicated to wildlife preservation as far as the records at the time of the designation reveal (such as Marin Islands or Red Rock). All of the original wildlife priority use designations share a striking geological property: with only one exception, all of the areas designated in 1971 were islands. The Commission and its staff may have assumed that these islands would be a less desirable place for development due to their isolation or ownership patterns. Table 7 outlines the past and present ownership patterns of the currently designated wildlife priority use areas found on the Bay Plan maps.

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[9] Note that the term "wildlife areas" differs in BCDC's laws from the term "wildlife refuges." A project considered a "wildlife refuge" by the McAteer-Petris Act may allow fill, while the Bay Plan prohibits inconsistent uses (such as an industrial or residential use) in an area designated as a "wildlife area."

[10] Proposed Bay Plan Map Amendments 1-71 through 29-71, considered at the October 1971 Commission meeting

Table 7

Ownership of Wildlife Priority Use Areas[11]

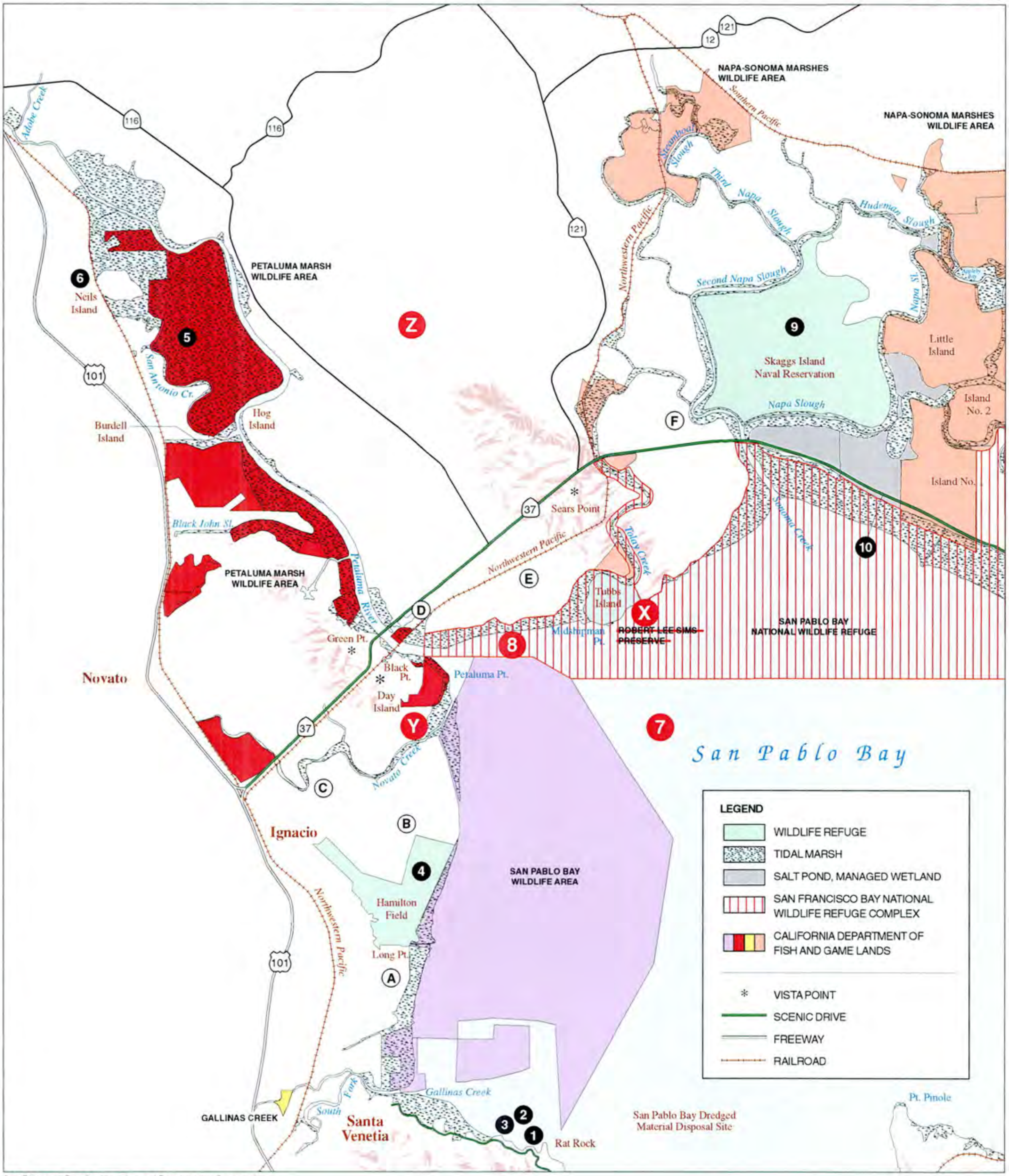
Area	Year of Designation	Ownership at Time	Dedicated to Wildlife at Time?	Current Ownership	Dedicated to Wildlife Now?
Audubon Wildlife Sanctuary	1971	Audubon	yes	Audubon	yes
Marin Islands	1971	private ownership	no	State and Federal	yes
The Sisters	1971	State	not specified	State	not specified
Rat Rock	1971	Marin County	no	Marin County	currently unused; zoned for Ag.
Hamilton Field	1995	U.S.A.	yes	U.S.A	yes
Lower Tubbs Island	1971	Nature Conservancy	yes	U.S. Fish & Wildlife Service	yes
Joice Island	1971	Dept. of Fish & Game	yes	Dept. of Fish & Game	yes
Grizzly Island	1971	Dept. of Fish & Game	yes	Dept. of Fish & Game	yes
Red Rock	1971	private ownership	no	private ownership	no
Emeryville Crescent	1971	not specified	no (but proposed as a park)	East Bay Regional Parks District	to be determined
Bair Island	1971	not specified	no	Dept. of Fish & Game and U.S. Fish and Wildlife Service	yes

Worth noting is that in some cases the Commission opted to use a Bay Plan Map Note, Commission Suggestion or Bay Plan Policy to indicate an area of important wildlife value, rather than to formally designate these places as wildlife priority use areas on the Plan Maps. The Bay Plan Map notes, policies and Commission Suggestions are proposed for update as part of this Bay Plan amendment, due to the fact that they are out of date. For example, many of the current Bay Plan Map Notes support the establishment of wildlife refuges, such as San Pablo Bay National Wildlife Refuge and Don Edwards San Francisco Bay National Wildlife Refuge, even though they now exist and have for many years.

[11] Note that the Marin County Assessor's Office records show that the State owns The Sisters. However, the State Lands Commission's records indicate that they do not (John Lamm, pers. communication). Nor does the federal government own the Sisters, according to the Bureau of Land Management records (Terry Elliott, pers. communication). Note also that "ownership at time" was determined by the notes in Resolution 16. Current ownership was determined from the Bay Area Open Space Council's Public Lands Database.

Figure 14a
Proposed Amendments to Bay Plan Map Wildlife Priority Use Areas - Plan Map 1

Plan Map 1
San Pablo Bay



San Francisco Bay Conservation and Development Commission

Figure 14b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 1

PLAN MAP NOTES

Park Proposal for Area South of Hamilton Field - *Large, undeveloped area between Hamilton Field and Gallinas Creek is possible site for major county park. Due to extensive offshore mudflats, would not be suitable for water-oriented recreation.*

~~***Possible Shoreline Channel*** - *Dredging shallow draft channel parallel to shore would greatly increase recreational opportunities for small boats and recreational ferries. This could be done so as to separate valuable marshes and mudflats from shoreline without damage to ecology. Dredged mud could be carefully placed to create new marsh, but dredging might be costly.*~~

Skaggs Island ~~***Security Group Activity (U.S. Navy)*** - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*~~ - *The U.S. Fish and Wildlife Service proposes to acquire closed U.S. Navy military facility to be included in the San Pablo Bay National Wildlife Refuge. In concept the proposed addition to the wildlife refuge would be consistent with Bay Plan policies.*

Salt Ponds and Other Managed Wetlands - *Large area, high-value wildlife habitat.*

San Pablo Bay National Wildlife Refuge - ~~*The marshes and mudflats of San Pablo Bay east of the mouth of the Petaluma River, including Lower Tubbs Island, are being acquired by the U.S. Department of the Interior for the federal San Pablo Bay National Wildlife Refuge. This program would be consistent with Bay Plan policies.*~~ *In concept the addition and restoration of land with high aquatic life and wildlife habitat value or good habitat restoration potential to the San Pablo Bay National Wildlife Refuge would be consistent with Bay Plan Policies.*

Point Pinole Regional Shoreline to Wildcat Creek - *Public access to the Bay for recreation is needed in this area, although existing shoreline conditions make this difficult. All development in this area should include provision for substantial public access.*

San Pablo Bay Wildlife Areas - *The California Department of Fish and Game and the U.S. Fish and Wildlife Service are carrying out a cooperative program to acquire, restore and manage areas of high aquatic life and wildlife habitat value in San Pablo Bay.*

Proposed Marin Baylands National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh, seasonal marsh and uplands in a national wildlife refuge located on the west side of San Pablo Bay from the Petaluma River to an area south of Gallinas Creek in Marin County. In concept the proposed wildlife refuge would be consistent with Bay Plan policies.*

Proposed San Francisco Bay National Estuarine Research Reserve (China Camp State Park) - *One of two sites in the Bay, the other being Rush Ranch Open Space Preserve, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*

Areas diked from the Bay have high-value wildlife habitat and restoration potential.

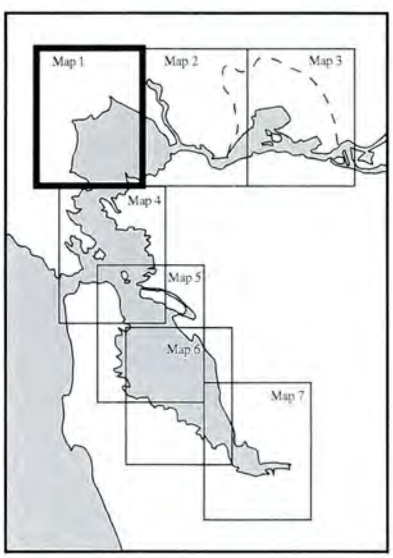


Figure 14c
Proposed Amendments to Bay Plan Map
Policies and Suggestions - Plan Map 1

BAY PLAN POLICIES

1. **Rat Rock** - Preserve island; no development.
2. **China Camp State Park** - Create continuous shoreline recreational area, including beaches, marinas, picnic areas, fishing piers, and riding and hiking trails.
3. Protect and provide public access to shellfish beds offshore.
4. **Hamilton Field** - Develop comprehensive wetlands habitat plan and long-term management program for restoring and enhancing wetlands habitat in diked former tidal wetlands. Dredged materials should be used whenever feasible and environmentally acceptable to facilitate wetlands restoration.
5. **Petaluma Marsh** - Marsh has high wildlife value; may be included in permanent wildlife area.
6. Neils Island not within BCDC permit jurisdiction.
7. ~~**San Pablo Bay** - Marshes and mudflats are valuable wildlife habitat; may be encroached upon only for fishing piers, small boat and barge channels, wildlife observation facilities, and piers necessary for industry. Design onshore development and public access to avoid adverse impacts on wildlife.~~
8. ~~Develop riding and hiking trails along levees.~~
9. **Skaggs Island** - If and when not needed by Navy, ~~redevelop as~~ restore wildlife ~~area~~ habitat. ~~using dredged material whenever feasible and environmentally acceptable, and water oriented recreational complex.~~
10. **Route 37** - ~~Access to Bay side for viewing and fishing only.~~ Limit access from highway to wildlife compatible uses such as wildlife observation and fishing.

X. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Y. Restore former antenna field to tidal marsh and subtidal habitat.

Z. **Regional Restoration Goal for San Pablo Bay** - Restore large areas of tidal marsh and enhance seasonal wetlands. Some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, and others should be restored to tidal marsh. Shallow subtidal areas (including eelgrass beds) should be conserved or restored. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible major park.

(B) Possible use of Bel Marin Keys Unit V site as a wetland restoration site using dredged material.

(C) Possible lagoon and park.

(D) Possible use of Port Sonoma Marina ponds as a regional dredged material rehandling facility.

(E) Possible use of North Point Property site as a wetland restoration site using dredged material.

(F) Possible park.

Figure 15a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 2

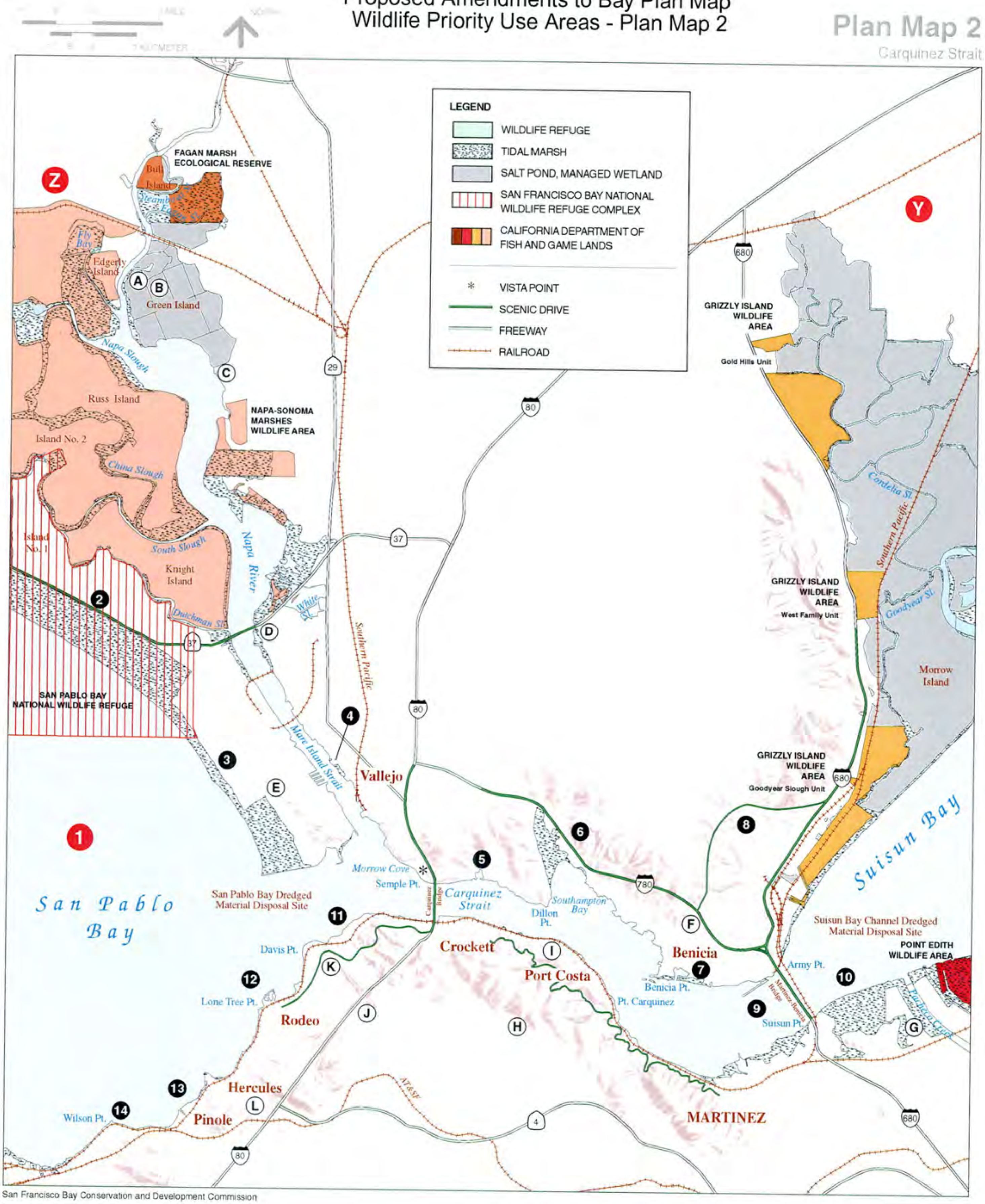


Figure 15b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 2

Plan Map 2

Carquinez Strait

PLAN MAP NOTES

Salt Ponds and Other Managed Wetlands - *Large area, high-value wildlife habitat.*

San Pablo Bay National Wildlife Refuge - *~~The marshes and mudflats of San Pablo Bay west of Vallejo and south of State Highway Route 37 are being acquired by the U.S. Department of the Interior for the federal San Pablo Bay National Wildlife Refuge. This program would be consistent with Bay Plan policies.~~ In concept the addition and restoration of land with high aquatic life and wildlife habitat value or good habitat restoration potential to the San Pablo Bay National Wildlife Refuge would be consistent with Bay Plan policies.*

San Pablo Bay Wildlife Areas - *The California Department of Fish and Game and the U.S. Fish and Wildlife Service are carrying out a cooperative program to acquire, restore and manage areas of high aquatic life and wildlife habitat value in San Pablo Bay.*

Benicia State Recreation Area - *Proposed park expansion should encompass principal overlooks and ridges on north side of strait, to preserve rugged and scenic character of hills, presently undeveloped.*

West Benicia Waterfront - *Detailed planning is needed to determine most desirable waterfront design west of West Second Street, emphasizing "urban" recreation uses with a minimum of Bay filling (and housing on existing private land).*

Benicia Waterfront Special Area Plan - *Special Area Plan was adopted by the Commission (April, 1977) and the City of Benicia to provide detailed planning and regulatory guidelines for the Benicia shoreline between West Second Street and the Benicia-Martinez Bridge. Refer to maps, policies, and recommendations of the Special Area Plan for specific information for this area.*

Martinez Waterfront - *Largely undeveloped at present, City has prepared specific plan for waterfront design and recreation uses.*

Scenic Area South Side of Carquinez Strait - *The scenic area includes principal overlook ridges and scenic road between Crockett and Martinez. To preserve presently undeveloped rugged and scenic hills, zoning should provide for extremely sparse development with control over tree removal and location of all structures; scenic easements should be acquired by East Bay Regional Park District, county, or other public body as necessary to guarantee permanent protection. Some park development may be appropriate in valleys leading to Bay.*

Areas diked from the Bay have high-value wildlife habitat and restoration potential.

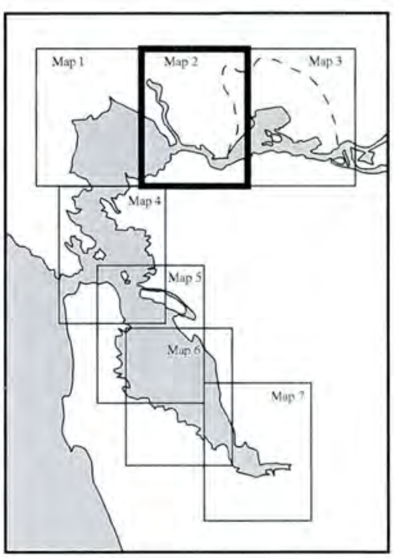


Figure 15c
Proposed Amendments to Bay Plan Map
Policies and Suggestions - Plan Map 2

Plan Map 2

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1 ~~**San Pablo Bay** - Marshes and mudflats are valuable wildlife habitat; may be encroached upon only for fishing piers, small boat and barge channels, wildlife, observation facilities, and piers necessary for industry. Design onshore development and public access to avoid adverse impacts on wildlife.~~

2 **Route 37** - ~~Access to Bay side for viewing and fishing only.~~ Limit access from highway to wildlife compatible uses such as wildlife observation and fishing.

3 **Mare Island Naval Shipyard** - The Mare Island dredged material disposal ponds, which are located in historic baylands, should be retained in water-related industry priority use for dredged material disposal and used as a regional disposal and rehandling area for dredged material except the three northernmost ponds. The three northernmost ponds could be used to provide wetland habitat for the salt marsh harvest mouse in order to mitigate any potential adverse impacts resulting from the future use of the other seven ponds for dredged material disposal and rehandling. Restoration of the three northernmost ponds, if necessary for mitigation, should be managed by the U.S. Fish and Wildlife Service as part of the San Pablo Bay National Wildlife Refuge and the Service's program for environmental education.

4 **Vallejo Water-Related Industrial Area** - Some fill may be needed.

5 **Carquinez Strait Shoreline** - Continuous public access should be provided along the bluff top and shoreline of Carquinez Strait and views of the water from shoreline vista points should be preserved.

6 **Benicia State Recreation Area** - No commercial uses except for convenience needs of park visitors. Develop riding and hiking trail along shoreline between Vallejo and Benicia.

7 **Benicia Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between West Second Street and the Benicia-Martinez Bridge.

8 **Benicia Industrial Park** - Reserve area east of old Route 21 for waterfront industry. Preserve and provide access to vista points and historic buildings.

9 **Port of Benicia** - See Seaport Plan.

10 Pipelines and piers may be built over marshes.

11 **Selby** - See Seaport Plan. Some fill may be needed for port use.

12 **Rodeo** - Develop beach northwest of railroad. Provide safe, easy pedestrian access. Some fill may be needed.

13 **Pinole-Hercules Shoreline Park** (proposed) - Raise level of dry land, but preserve adjacent marshes. Provide safe pedestrian access across railroad tracks. Landscape existing sewage treatment plant.

14 **Wilson Point** - Proposed beach and park. Preserve rugged character of point. Provide safe, easy pedestrian access. Some fill may be needed. Protect and provide public access to shellfish beds offshore.

Y **Regional Restoration Goal for Suisun Bay** - Restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay; enhance managed marsh to increase their ability to support waterfowl. See the Baylands Ecosystem Habitat Goals report for more information.

Z **Regional Restoration Goal for San Pablo Bay** - Restore large areas of tidal marsh and enhance seasonal wetlands. Some of the inactive salt ponds should be managed to maximize their habitat functions for shorebirds and waterfowl, and others should be restored to tidal marsh. Shallow subtidal areas (including eelgrass beds) should be conserved or restored. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible shallow-draft port.

(B) Possible use of Cargill crystallizer ponds as a regional dredged material rehandling facility.

(C) Napa Bay - Encourage recreational development of areas adjacent to shoreline. Provide continuous public access to shoreline.

(D) Provide continuous public access to shoreline from Napa Bay to existing park. Protect views of strait from hills.

(E) Potential park on hills overlooking the Bay.

(F) Benicia - Prepare precise plan and development program for waterfront west of West Second Street. Structures near waterfront should be kept low and well-spaced to protect views from hills inland. Provide maximum possible public access, including paths, beaches and small parks.

Figure 15d
Proposed Amendments to Bay Plan Map
Suggestions - Plan Map 2

COMMISSION SUGGESTIONS (cont.)

- (G) Possible use of Praxis Pacheco as a dredged material confined disposal site.
- (H) Limit urban development; encourage cluster development to maximize Bay views and conserve natural landscape features.
- (I) Carquinez Strait, Bridge and Shoreline - Enhance scenic qualities, preserve views and increase public access.
- (J) Possible linked industry.
- (K) Possible use of Wickland Selby site as a regional dredged material rehandling facility.
- (L) Hercules - Design future development west of ridge to maximize and protect Bay views.

Figure 16a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 3

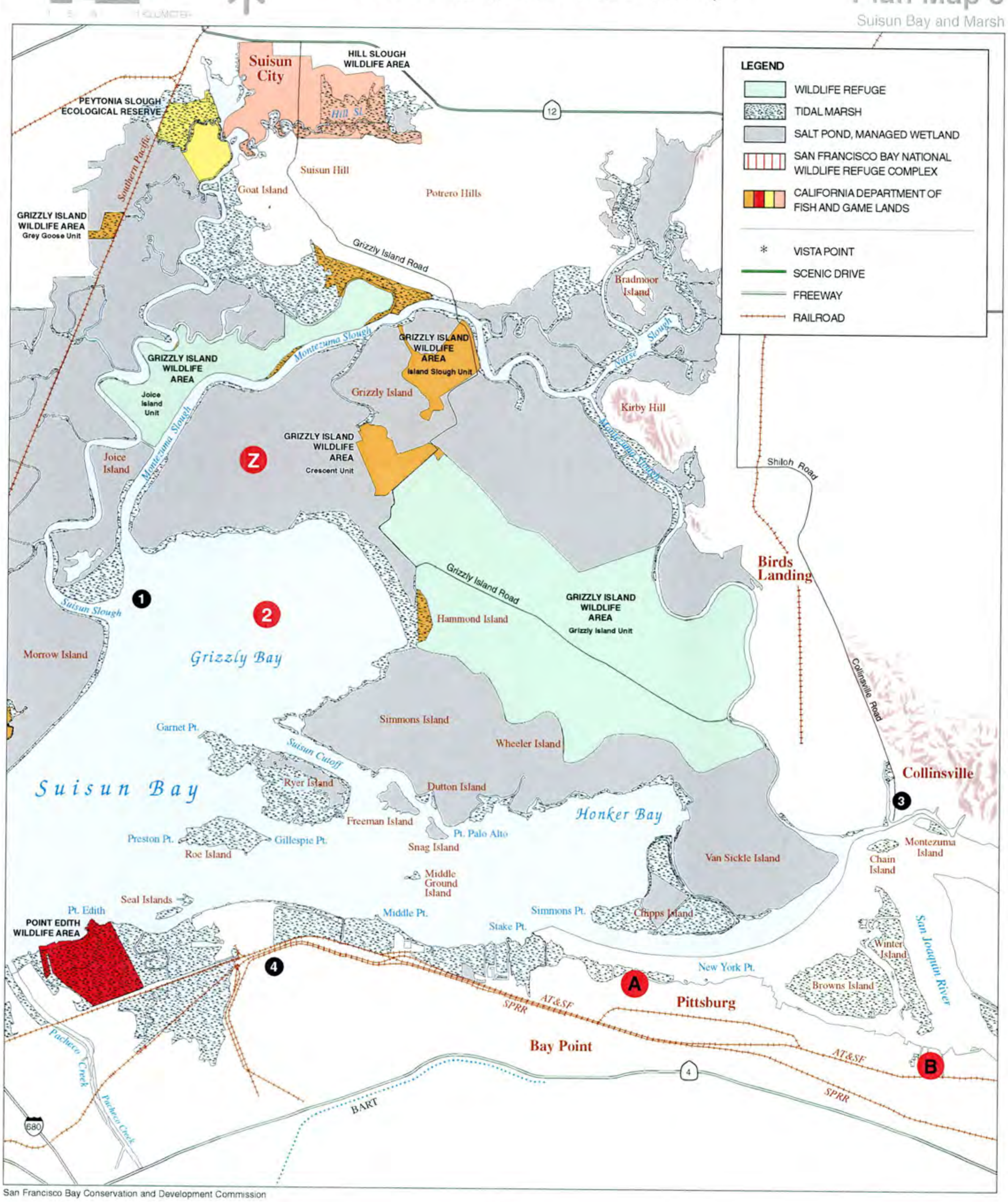


Figure 16b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 3

PLAN MAP NOTES

Suisun Marsh - *Thousands of acres of ~~controlled marshes~~ managed wetlands are maintained primarily by private duck-hunting clubs as migratory waterfowl ~~wildfowl~~ habitat which also provides habitat for other wildlife species such as shorebirds. Areas are diked, but dikes are opened for periodic flooding. Suisun Resource Conservation District ~~protects and enhances marshland areas.~~ assists duck clubs in the protection and enhancement of managed wetlands.*

Suisun Marsh Protection Plan - *The Protection Plan is a more specific application of the policies of the Bay Plan because of the unique characteristics of the Suisun Marsh. The policies of both the Bay Plan and the Protection Plan apply within the Marsh in the absence of a certified Suisun Marsh Local Protection Program component. In event of policy conflict between the Bay Plan and Protection Plan, the policies of the Protection Plan control. Refer to maps and policies of the Protection Plan and the Suisun Marsh Preservation Act of 1977 for more specific information.*

Suisun Marsh Local Protection Program - *Pursuant to the Suisun Marsh Preservation Act of 1977, the Commission has certified the Local Protection Program components of Solano County, Solano County Local Agency Formation Commission, the cities of Fairfield and Suisun City, Suisun Resource Conservation District, and Solano County Mosquito Abatement District. Marsh development permits for development in the Suisun Marsh must be consistent with the Local Protection Program component of the local agency with jurisdiction over the project. See the Preservation Act and the components of the Local Protection Program for more information.*

Collinsville Area - *The Collinsville-Montezuma Slough area is adjacent to the deep water shipping channel, has rail service, and consists of flat land. It is one of the largest available sites anywhere in the Bay Area for water-related industry. The shoreline fronting on the main shipping channel is limited, however, and this relatively small frontage should be carefully planned and shared for maximum industrial development.*

Recreational Potential - *Extensive, valuable recreational potential in river and island areas (e.g. Sherman Island "Sherman Lake" area popular for boating, fishing). Recreational use should be encouraged.*

Concord Naval Weapons Station - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

Proposed San Francisco Bay National Estuarine Research Reserve (Rush Ranch Open Space Preserve) - *One of two sites in the Bay, the other being China Camp State Park, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*

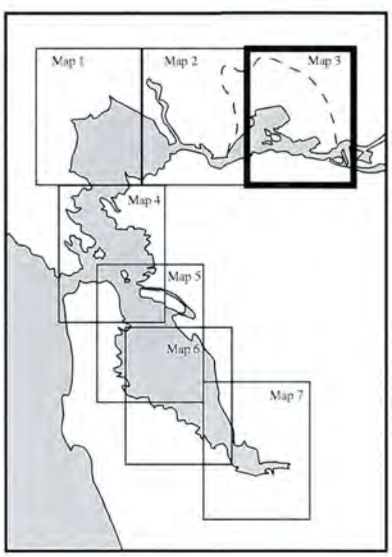


Figure 16c
Proposed Amendments to Bay Plan Map
Policies and Suggestions - Plan Map 3

BAY PLAN POLICIES

1 **Montezuma and Suisun Sloughs** - May be dredged for small boat ~~and shallow-draft industrial~~ uses.

2 ~~**Suisun, Grizzly and Honker Bays** - High value wildlife habitat, great recreational potential. Preserve marshes and mudflats; some fill and dredging may be needed to improve boating, viewing, hunting and fishing. Parts of bays and islands may be added to permanent wildlife areas.~~

3 **Collinsville** - Industries should share limited deep water frontage. Wetland restoration or enhancement of diked wetland areas may occur provided that the restoration or enhancement project: (1) is carried out in a manner that will not preclude use of the deep water frontage and upland portion of the site for water-related industry and port use; (2) will not result in any adverse environmental impacts on the Suisun Marsh; (3) provides for the protection of adjacent property from flooding that could be caused by the project; and (4) includes a long-range management program that assures the proper stewardship of the wetland. Wetland restoration and enhancement projects may be carried out using dredged material from the Bay region. Wetland restoration and enhancement projects should be designed so as not to restrict development and operation of marine terminals on the deep water shoreline nor impede the movement of waterborne cargo, materials and products from the shoreline terminal to the upland portion of the site. A portion of the site may be used as a regional dredged material rehandling facility for Bay Area projects.

4 **Concord Naval Weapons Station** - If and when not needed by Navy, give first consideration to port or water-related industrial use. Port and industrial use should be restricted so that they do not adversely affect marshes. See Seaport Plan.

Z **Regional Restoration Goal for Suisun Bay** - Restore tidal marsh on the northern and southern sides of Suisun Bay, Grizzly Bay and Honker Bay; enhance managed marsh to increase their ability to support waterfowl. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

~~A Water-Related Industry~~

~~B Water-Related Industry~~

Figure 17a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 4

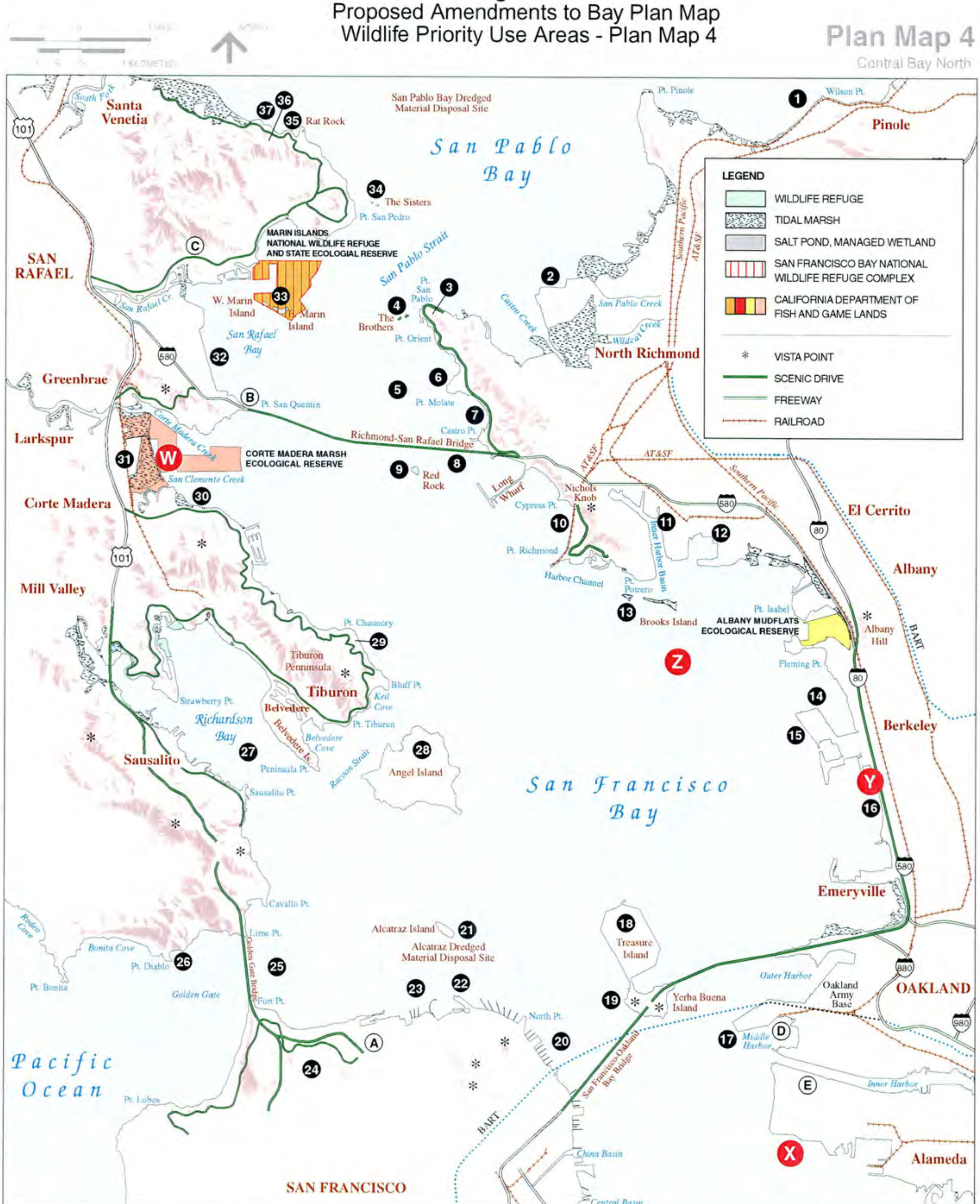


Figure 17b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 4

Plan Map 4

Central Bay North

PLAN MAP NOTES

Point Pinole Regional Shoreline to Wildcat Creek - *Public access to the Bay for recreation is needed in this area, although existing shoreline conditions make this difficult. All development in this area should include provision for substantial public access.*

Naval Supply Center, Point Molate - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

George Miller Jr. Regional Park - *Use and landscaping of the private lands adjacent to the park should be coordinated by owners and city for compatibility with park.*

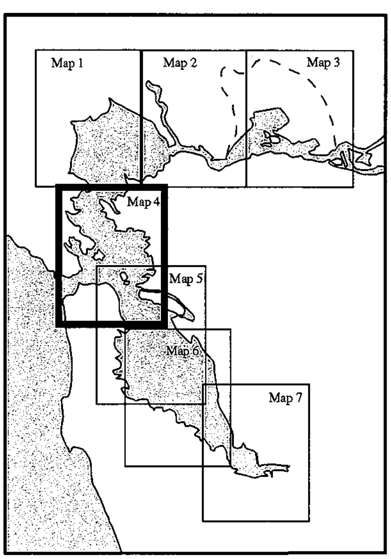
South Richmond Shoreline Special Area Plan - *The South Richmond Shoreline Special Area Plan was adopted by the Commission (May 1977) and the City of Richmond to provide detailed planning and regulatory guidelines for the Richmond shoreline from the west side of Shipyard Three to the southeastern border of the City, including Brooks and Bird Islands and all areas that are subject to tidal action. Refer to the maps, policies, and recommendations of the Special Area Plan for specific information for this area.*

Oakland North Harbor Area - *The Oakland North Harbor has not been included on the Seaport Plan maps as a port priority use area because need for it has not been substantiated and it has been found to be less desirable for port development than other sites based on environmental, land use, and access considerations. In addition, other uses having public benefits, such as conservation and recreation, have been proposed for this site. Additional studies will be necessary to determine the future use of this area.*

Oakland Army Base - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

San Francisco Waterfront Special Area Plan - *The San Francisco Waterfront Special Area Plan was adopted by the Commission (April 3, 1975) to provide detailed planning and regulatory guidelines for the waterfront of San Francisco from east side of Hyde Street Pier to south side of India Basin. Refer to the maps and policies of the Special Area Plan for specific information for this area.*

San Francisco Waterfront - *Suggested scenic transit system (special bus, elephant train, cog railway, etc.) could be major waterfront attraction, could eventually operate entire distance from Golden Gate Bridge (or even Ocean Beach) to Ferry Building (or south to China Basin).*



San Francisco-Marin Crossing - *The Central Bay is the most widely enjoyed part of the entire Bay and this attractive setting should be protected. Transportation agencies have reached general agreement that traffic congestion problems can best be solved by establishing a fast, modern, complete bus system. Therefore, Plan makes no provision for second deck on Golden Gate Bridge, or for any additional vehicular crossing. Increased auto capacity on Golden Gate Bridge, or a new vehicular crossing, could require new or enlarged toll plazas, service areas, access ramps, and freeways on both the San Francisco and Marin sides, with possible disruption of scenic areas on both sides of the Bay.*

Jurisdiction Note - *Along the shoreline in San Francisco and Marin Counties, Commission's jurisdiction extends 100 feet inland and does not include any area within the jurisdiction of the California Coastal Commission west of the line between Point Bonita and Point Lobos.*

Forts Baker, Barry, and Cronkhite - *Surplus Army land now being transferred to the Golden Gate National Recreation Area.*

Appearance and Design - *Housing density in hills of Sausalito, Tiburon, and Belvedere should respect the topography; cluster development appropriate in some areas.*

Figure 17c
Proposed Amendments to Bay Plan Map
Notes - Plan Map 4

PLAN MAP NOTES (CONT.)

Sausalito Recreational Ferry - *Ferry terminal could be connected to central area by "elephant train" along waterfront or Bridgeway. Or terminal could be placed in central area if parking can be provided.*

Sausalito - Commuter Ferry Terminal - *To minimize traffic and parking problem, should be served by mass transit or else designed to serve Sausalito and Mill Valley only with other terminals serving rest of Marin.*

Tiburon - Possible Commuter Ferry Terminal - *To minimize traffic and parking problem, should be served by mass transit, or else designed to serve southern Marin only with another terminal built to serve northern Marin.*

Tiburon Boulevard Widening - *Minimize fill by using existing roadbed as part of new right-of-way. Preserve hilltop vista point.*

Shoreline Parks - *Shoreline parks could be built in several areas between existing or proposed shoreline roads and the shore from Tiburon Peninsula to Point San Pedro. Further study needed.*

Point San Quentin - Possible Commuter Ferry Terminal - *No fill for parking beyond existing dikes.*

Proposed Marin Baylands National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh, seasonal marsh and uplands in a national wildlife refuge located on San Francisco Bay from Corte Madera Creek to an area south of the city of Mill Valley in Marin County. In concept the proposed wildlife refuge would be consistent with Bay Plan policies.*

Proposed San Francisco Bay National Estuarine Research Reserve (China Camp State Park) - *One of two sites in the Bay, the other being Rush Ranch Open Space Preserve, with one additional site in the Delta, named Browns Island Regional Shoreline. These sites are designated for inclusion in a federal-state cooperative scientific research and education program that is part of a national system of estuarine research reserves. The Commission supports the program as a member of the Management Advisory Board.*

Proposed Alameda National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh and a portion of the former Naval Air Station Alameda in a national wildlife refuge located at the western end of Alameda. In concept the proposed national wildlife refuge would be consistent with Bay Plan policies.*

Figure 17d
Proposed Amendments to Bay Plan Map Policies - Plan Map 4

BAY PLAN POLICIES

1. **Wilson Point Beach and Park** (proposed) - Preserve rugged character of point. Provide safe, easy pedestrian access. Some fill may be needed. Protect and provide public access to shellfish areas.
2. **Richmond Sanitary Landfill -** Proposed Park. Give priority consideration to beach development. Some fill may be needed for beach outside existing dikes.
3. **Point San Pablo** - As not needed for marine terminals, redevelop for recreational uses.
4. **The Brothers** - Preserve islands and lighthouse. Access by boat only.
5. **Point Molate to Point Richmond** - Develop riding and hiking trails. Some fill may be needed.
6. **Naval Supply Center** - If and when not needed by Navy, acquire and develop for park. Existing underground fuel storage tanks may be used by industry.
7. **Point Molate Beach** - Extended beach from Point Molate to Castro Point. Some fill may be needed.
8. **Castro Rocks** - Protect harbor seal hauli~~ng ground. No public access.~~ -out and pupping site.
9. **Red Rock** - ~~Preserve island. No development.~~ Protect wildlife values.
10. **George Miller Jr. Regional Shoreline** - Protect and provide public access to shellfish beds offshore.
11. **Port of Richmond** - See Seaport Plan. Some fill may be needed.
12. **South Richmond Shoreline Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between Shipyard Three and the southeastern border of the City of Richmond.
13. **Brooks Island Regional Preserve** - Preserve island character. Access by boat only. Protect wildlife values.
14. Protect and provide public access to shellfish areas offshore.
15. **Albany-Berkeley-Emeryville** - Develop public and commercial recreation areas. Some fill may be needed to create usable shoreline areas, protected water areas and park space.
16. No freeway in Bay west of present shoreline unless all reasonable alternatives are found infeasible and need for Bay route is clearly shown.
17. **Oakland Port Area** - See Seaport Plan. Redevelop Outer, Middle, and Inner Harbors for modern marine terminals. Some fill may be needed. No fill that would impair ship navigation should be allowed in any area needed for such navigation.
18. **Treasure Island** - If and when not needed by Navy, redevelop for public use. Protect harbor seal haul-out and pupping site. ~~Provide continuous public access to Bay~~ Projects allowed only if protective of harbor seals and other sensitive wildlife.
19. **Yerba Buena Island** - If and when not needed by Navy or Coast Guard, redevelop released areas for recreational use. Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
20. **San Francisco Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between the east side of the Hyde Street Pier and the south side of India Basin.
21. **Alcatraz Island** - Use under study. Retain in public ownership. Access by boat only. Special design opportunity.
22. **Fisherman's Wharf** - Improve and expand commercial fishing support facilities. Enhance public access to and economic value of Fisherman's Wharf area by encouraging development of a public fish market.
23. **Fort Mason** - As not needed by Army, develop waterfront and northeast section as park.
24. **Presidio** - If and when not needed by Army, retain at least shoreline and undeveloped areas as regional park.
25. **Golden Gate Bridge** - Encourage improved public transportation. No second deck or new crossing for automobiles.
26. **Golden Gate National Recreation Area** - As not needed by Army, acquire and extend park. Preserve and protect rugged character, especially on Golden Gate and Pacific Coast sides. Limit access to water (at coves) to foot trails, possible funiculars. No commercial uses except for convenience needs of park visitors.
27. **Richardson Bay Special Area Plan** - See Special Area Plan for detailed planning policies for the water area and shoreline north of a line drawn betweeen Cavallo Point and Point Tiburon.
28. **Angel Island State Park -** Use only for camping, picnicking, water-oriented recreation. Access by boat only. No commercial uses except for convenience needs of park visitors. Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Figure 17e
Proposed Amendments to Bay Plan Map Policies and Suggestions - Plan Map 4

BAY PLAN POLICIES (cont.)

29 **Tiburon Oceanographic Center** - (former Navy Net Depot) If and when not needed by Federal Government, aquire and develop for park.

30 Protect and provide public access to shellfish areas offshore.

31 **Corte Madera Shoreline Park** (proposed) - Develop 60 - 100 acre shoreline park as part of future development.

32 **Point San Quentin to Point San Pedro** - In connection with shoreline parks ~~and scenic drives, de~~velop system of riding and hiking trails.

33 **Marin Islands National Wildlife Refuge and State Ecological Reserve** - Protect wildlife value. Onshore development should be compatible with wildlife dependent uses. Avoid significant adverse impacts on wildlife.

34 **The Sisters** ~~- Preserve islands; no developmen~~t. Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

35 **Rat Rock** - Preserve island; no development. Protect wildlife values.

36 **China Camp State Park** - Create continuous shoreline recreational area, including beaches, marinas, picnic areas, fishing piers, and riding and hiking trails.

37 Protect and provide public access to shellfish beds offshore.

W **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

X **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Y **Eastshore State Park** - Park being planned from Bay Bridge to Marina Bay in Richmond for multiple uses including recreation, wildlife and aquatic life protection. Protect wildlife and aquatic life values at Emeryville Crescent, Hoffman Marsh and Albany Mudflats.

Z **Regional Restoration Goal for Central Bay** - Protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Natural salt ponds should be restored on the East Bay shoreline. Shallow subtidal areas (including eelgrass beds) should be conserved and enhanced. Wherever possible tidal marsh habitats should be restored, particularly at the mouths of streams where they enter the Bay and at the upper reach of dead-end sloughs. Encourage tidal marsh restoration in urban areas. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible scenic transit system along waterfront from Ocean Beach to China Basin.

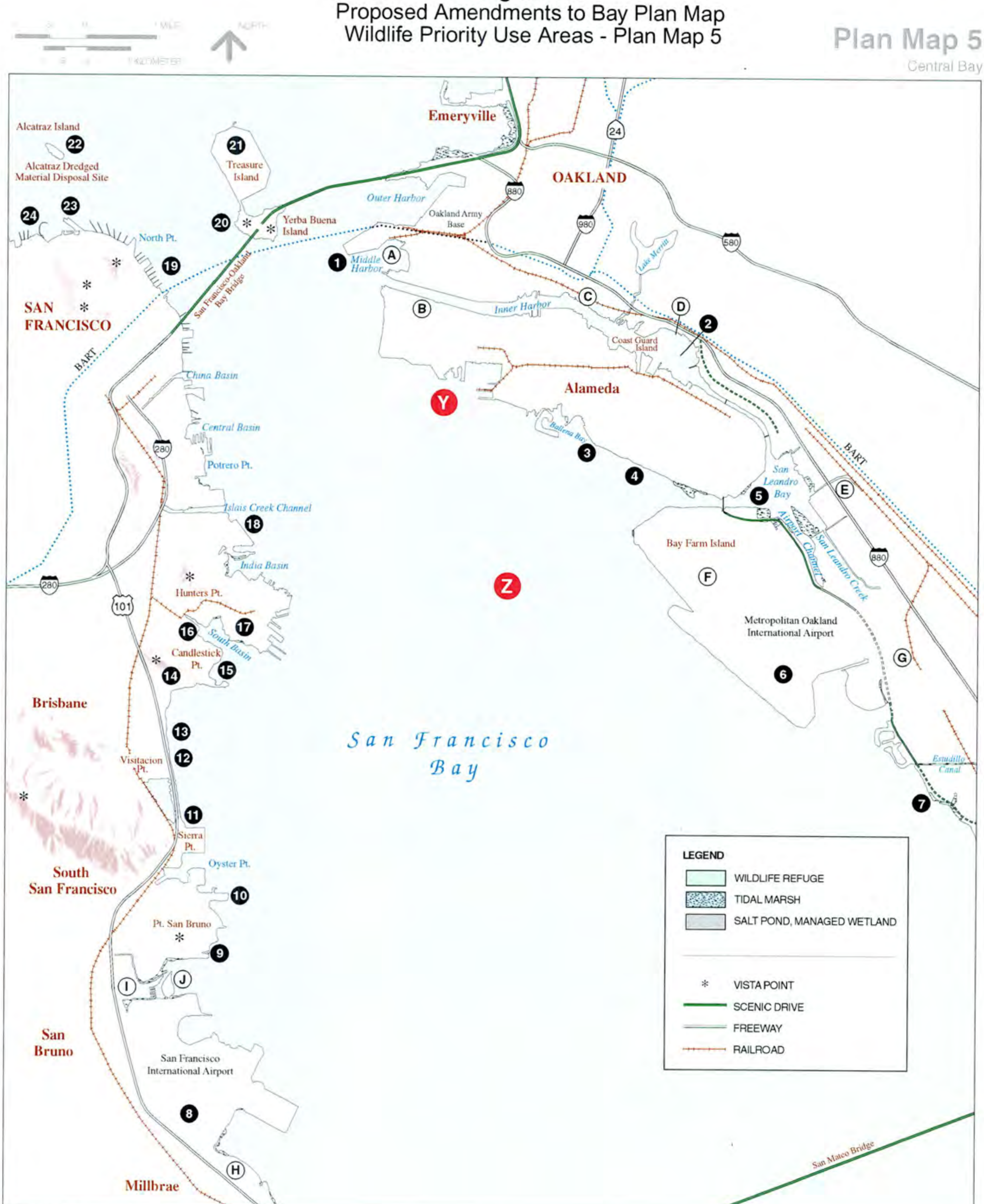
(B) Possible commuter ferry terminal.

(C) San Pedro Mountain - Develop vista points along ridge.

(D) Possible habitat enhancement site at Port of Oakland Middle Harbor using dredged material.

(E) Possible reuse of dredged material at former NAS Alameda.

Figure 18a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 5



San Francisco Bay Conservation and Development Commission

Figure 18b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 5

PLAN MAP NOTES

Oakland North Harbor Area - *The Oakland North Harbor has not been included on the Seaport Plan maps as a port priority use area because need for it has not been substantiated and it has been found to be less desirable for port development than other sites based on environmental, land use, and access considerations. In addition, other uses having public benefits, such as conservation and recreation, have been proposed for this site. Additional studies will be necessary to determine the future use of this area.*

Oakland Army Base - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

San Leandro Bay Regional Shoreline - *Regional Shoreline to be developed by East Bay Regional Park District emphasizing ecology and increased recreation use of the shoreline.*

Bay Farm Island - *The site is adjacent to Oakland Airport, and may be suitable for airport-oriented industry. Bay Farm Island development should not interfere with aircraft operations at Oakland Airport.*

~~***Possible Shoreline Channel*** - *Dredging shallow draft channel parallel to shore would greatly increase recreational opportunities for small boats and recreational ferries. This could be done so as to separate valuable marshes and mudflats from the shoreline, without damage to ecology. Dredged mud could be carefully placed to create new marsh, but dredging might be costly.*~~

San Mateo (City) Waterfront - *Presently undeveloped. Detailed planning needed to determine most desirable waterfront design emphasizing recreation with minimum of Bay filling.*

Burlingame Waterfront - *Developing waterfront requires detailed planning to determine the most desirable waterfront design emphasizing recreation and public access with a minimum of Bay filling.*

Hunters Point Freeway at Candlestick Point - *Connection to U.S. 101 south of Candlestick Point requires further study. If connection is close to Candlestick Cove, large overpass structure will be required, marring present spectacular views of Bay for motorists heading south on Bayshore Freeway to Bayview Hill. If connection is farther south, in Brisbane, long structure in Bay will be required. Other considerations include effects upon future development on shoreline of Candlestick Cove, and future U.S. 101 connections to proposed Geneva Avenue and Guadalupe Parkway extensions.*

San Francisco Waterfront - *Suggested scenic transit system (special bus, elephant train, cog railway, etc.) could be major waterfront attraction, could eventually operate entire distance from Golden Gate Bridge (or even Ocean Beach) to Ferry Building (or south to China Basin).*

San Francisco Waterfront Special Area Plan - *The San Francisco Waterfront Special Area Plan was adopted by the Commission (April 3, 1975) to provide detailed planning and regulatory guidelines for the waterfront of San Francisco from east side of Hyde Street Pier to south side of India Basin. Refer to the maps and policies of the Special Area Plan for specific information for this area.*

Proposed Alameda National Wildlife Refuge - *The U.S. Fish and Wildlife Service proposes to include tidal marsh and a portion of the former Naval Air Station Alameda in a national wildlife refuge located at the western end of Alameda. In concept the proposed national wildlife refuge would be consistent with Bay Plan policies.*

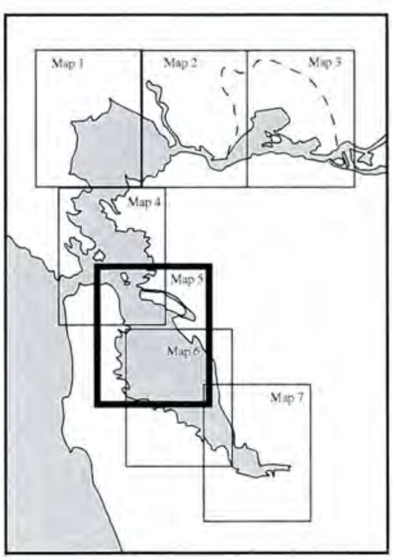


Figure 18c
Proposed Amendments to Bay Plan Map
Policies and Suggestions - Plan Map 5

Plan Map 5

Bay Plan Policies and Commission Suggestions

BAY PLAN POLICIES

1. **Oakland Port Area** - See Seaport Plan. Redevelop Outer, Middle, and Inner Harbors for modern marine terminals. Some fill may be needed. No fill that would impair ship navigation should be allowed in any area needed for such navigation.
2. **Government Island** - If and when not needed by Coast Guard, develop for public and commercial recreation uses.
3. **Alameda Beaches** - Some fill may be needed for beach and marina protection.
4. Protect and provide public access to shellfish areas offshore.
5. **San Leandro Bay** - Valuable wildlife habitat; great recreation potential. Develop boating facilities and parks, but preserve wildlife habitat. Provide continuous public access to northeastern and southern shoreline. Some fill may be needed.
6. **Oakland Airport** - Further expansion into the Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas clear of tall structures and incompatible uses.
7. **San Leandro Shoreline Park System** - Protect and provide public access to shellfish beds offshore.
8. **San Francisco Airport** - Further expansion into Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas free from tall structures and incompatible uses.
9. Protect and provide public access to shellfish areas offshore.
10. **Oyster Point** - Expand marina and develop shoreline park. Some fill may be needed.
11. Provide easy pedestrian access across freeway.
12. No freeway in Bay east of U.S. 101 unless all reasonable alternatives are found infeasible and need for Bay route is clearly shown.
13. **U.S. 101 Causeway** - Develop scenic frontage road and turnouts for fishing and viewing. Protect shellfish beds offshore.
14. **Bay View Park** - Provide trail link to waterfront.
15. **Candlestick Point Shoreline Park** (proposed) - Some fill may be needed.
16. **South Basin** - Some fill may be needed in inlet west of proposed freeway.
17. **Hunters Point** - See Seaport Plan.
18. **Port of San Francisco** - See Seaport Plan. Some fill may be needed.
19. **San Francisco Waterfront Special Area Plan** - See special area plan for detailed planning guidelines for the shoreline between the east side of the Hyde Street Pier and the south side of India Basin.
20. **Yerba Buena Island** - If and when not needed by Navy or Coast Guard, redevelop released areas for recreational use. Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
21. **Treasure Island** - If and when not needed by Navy, redevelop for public use. Protect harbor seal haul-out and pupping site. ~~Provide continuous public access to Bay~~ Projects allowed only if protective of harbor seals and other sensitive wildlife.
22. **Alcatraz Island** - Use under study. Retain in public ownership. Access by boat only. Special design opportunity.
23. **Fisherman's Wharf** - Improve and expand commercial fishing support facilities. Enhance public access to and economic value of Fisherman's Wharf area by encouraging development of a public fish market.
24. **Fort Mason** - As not needed by Army, develop waterfront and northeast section as park.

Y. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Z. **Regional Restoration Goal for Central Bay** - Protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. Natural salt ponds should be restored on the East Bay shoreline. Shallow subtidal areas (including eelgrass beds) should be conserved and enhanced. Wherever possible tidal marsh habitats should be restored, particularly at the mouths of streams where they enter the Bay and at the upper reach of dead-end sloughs. Encourage tidal marsh restoration in urban areas. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) Possible habitat enhancement site at Port of Oakland Middle Harbor using dredged material.

(B) Possible reuse of dredged material at former NAS Alameda.

Figure 18d
Proposed Amendments to Bay Plan Map Suggestions - Plan Map 5

COMMISSION SUGGESTIONS (cont.)

- (C) Jack London Square - Expand commercial recreation facilities as needed. Provide continuous public access along Estuary to Lake Merritt Channel.
- (D) Brooklyn Basin - Expand commercial fishing and recreational facilities.
- (E) Possible scenic path, Coliseum to Bay.
- (F) Bay Farm Island - Undeveloped areas may be suitable for airport-related industry.
- (G) Possible extension of scenic drive.
- (H) Develop scenic drive and riding and hiking trail along waterfront from airport to Foster City.
- (I) Possible airport industry.
- (J) Possible park and marina.

Figure 19a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 6

Plan Map 6
Central Bay South

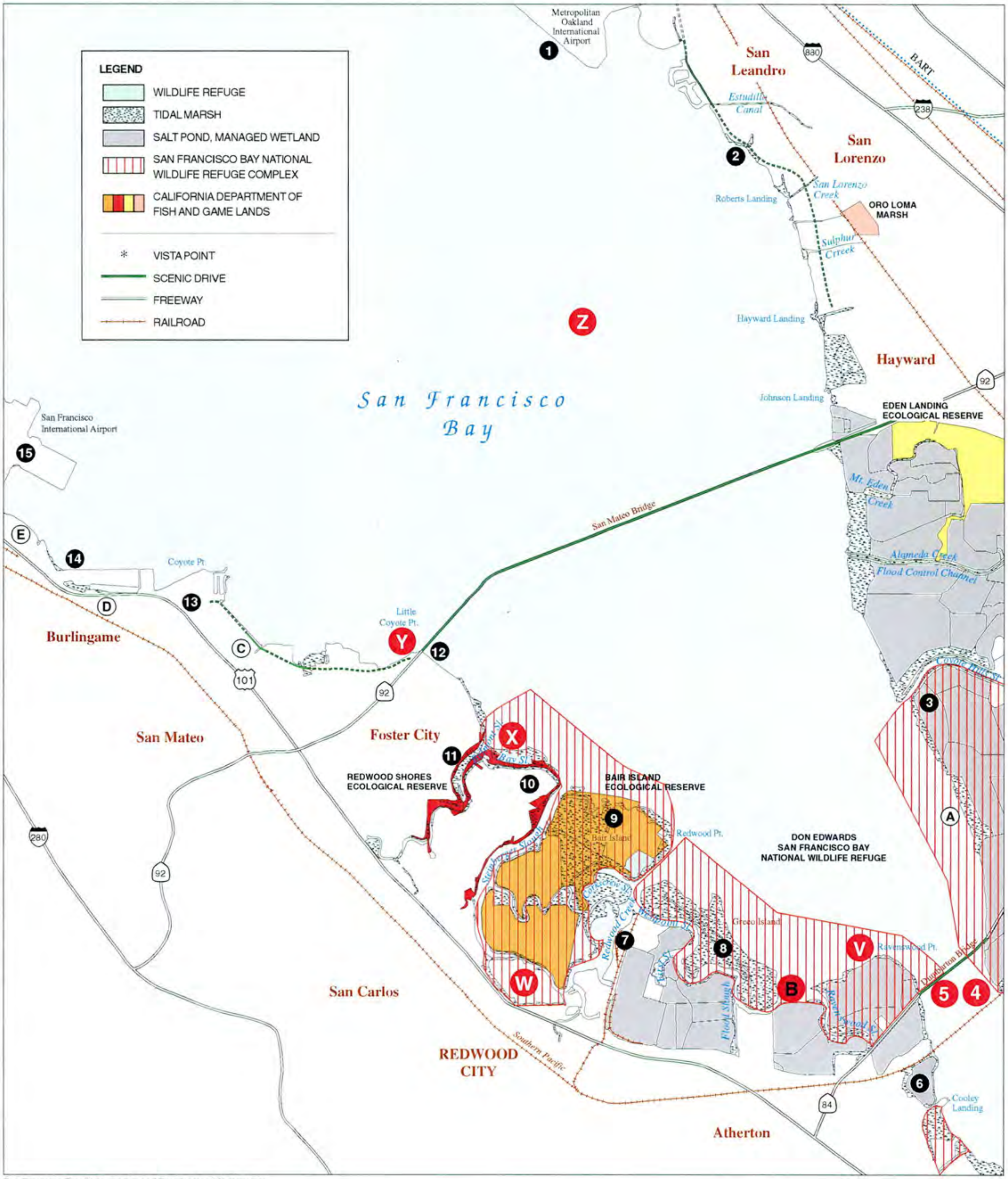


Figure 19b
Proposed Amendments to Bay Plan Map Notes - Plan Map 6

PLAN MAP NOTES

Hayward Area Waterfront - *The Hayward Area Shoreline Plan, a detailed plan for the Hayward area shoreline between the San Leandro city limits on the north and Fremont and Union City city limits on the south, was prepared by the Hayward Area Shoreline Planning Agency. The Plan, adopted by the City of Hayward, Alameda County, East Bay Regional Park District, and the Hayward Area Recreation District, provides for marsh restoration and shoreline recreation use.*

Greco Island - *Largest remaining marsh in South Bay. Tidal marsh ~~Marsh~~ and adjacent tidal flats ~~mudflats~~ are part of Don Edwards San Francisco Bay National Wildlife Refuge and are important feeding areas for birds. Area used by California Clapper Rail, a rare species of bird, endangered by loss of habitat.*

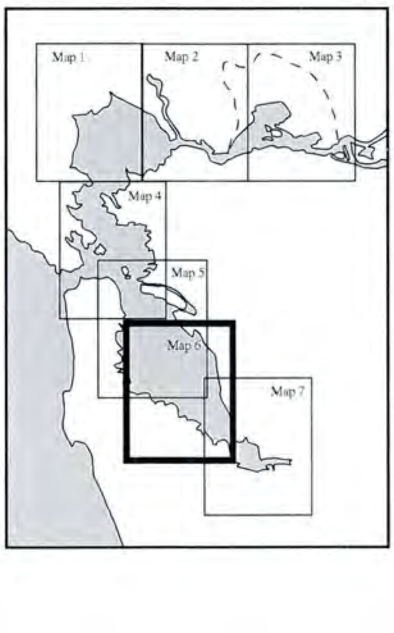
~~***San Francisco Bay National Wildlife Refuge*** - *Greco Island and a portion of Bair Island are to be acquired by the U.S. Department of the Interior as part of the San Francisco Bay National Wildlife Refuge. This proposal is consistent with Bay Plan policies provided that acquisition and operation of the refuge does not interfere with commercial shipping and recreational boating in Redwood Creek.*~~

~~***Deepwater Slough*** - *The Port of Redwood City's Deepwater Slough property (Bair Island site) has not been included on the Seaport Plan maps as a priority use area because need for it has not been substantiated and it has been found to be less desirable for port development than other sites based on environmental, land use, and access considerations. In addition, other uses having public benefits, such as conservation and recreation, have been proposed for this site. Additional studies will be necessary to determine the future use of this area.*~~

~~***Possible Shoreline Channel*** - *Dredging shallow draft channel parallel to shore would greatly increase recreational opportunities for small boats and recreational ferries. This could be done so as to separate valuable marshes and mudflats from the shoreline, without damage to ecology. Dredged mud could be carefully placed to create new marsh, but dredging might be costly.*~~

San Mateo (City) Waterfront - *Presently undeveloped. Detailed planning needed to determine most desirable waterfront design emphasizing recreation with minimum of Bay filling.*

Burlingame Waterfront - *Developing waterfront requires detailed planning to determine the most desirable waterfront design emphasizing recreation and public access with a minimum of Bay filling.*



Don Edwards San Francisco Bay National Wildlife Refuge - *In concept the addition and restoration of land or water with high aquatic life and wildlife habitat value or good habitat restoration potential to Don Edwards San Francisco Bay National Wildlife Refuge would be consistent with Bay Plan policies.*

Figure 19c
Proposed Amendments to Bay Plan Map
Policies and Suggestions - Plan Map 6

BAY PLAN POLICIES

1. **Oakland Airport** - Further expansion into the Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas clear of tall structures and incompatible uses.
2. **San Leandro Shoreline Park System** - Protect and provide public access to shellfish beds offshore.
3. If not needed for salt production, ponds west of Coyote Hills should be ~~acquired~~ managed as permanent wildlife area.
4. ~~**Dumbarton Point Waterfront Park** (proposed) - Boundaries to be determined. Water-oriented uses only. Some fill may be needed.~~
5. **Dumbarton Bridge** - Design proposed high-level bridge to have slim profile and minimum supporting structure and to enable motorists to see Bay and shoreline. Approaches should provide for fishing and wildlife observation. ~~Toll plaza site under study.~~
6. ~~If not needed for salt production, pond between Cooley Landing and railroad bridge should be developed for recreational use. Expand Cooley Landing marina northward.~~
7. **Port** - See Seaport Plan. Expand marine terminals and water-related industries. Some fill may be needed.
8. **Greco Island** - Expand wildlife ~~area~~ refuge to include entire island. ~~Access by boat only.~~ Protect harbor seal haul-out and pupping site.
9. **Bair Island Ecological Reserve** ~~**Wildlife Area** (proposed) - Boundaries to be determined. Preserve heron rookery. If possible, include small park overlooking Redwood Creek. If rookery is abandoned, convert site to park.~~ A joint management effort by the California Department of Fish and Game and the U.S. Fish and Wildlife Service. Restore and enhance habitat for the benefit of wildlife and aquatic life. Protect harbor seal haul-out and pupping sites.
10. **Redwood Shores** - ~~Provide continuous public access to Bay and to Belmont, Steinberger, Smith, and Corkscrew Sloughs; include paths, beaches, small parks, and wildlife observation areas.~~ Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
11. **Foster City** - Provide continuous public access to Bay and Belmont Slough, including paths, beaches, and small parks.
12. Protect and provide public access to shellfish beds offshore.
13. **Coyote Point Park** - Expand beach and marina. Some fill may be needed. Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
14. **Bayside Park** - Retain lagoon as open water.
15. **San Francisco Airport** - Further expansion into Bay only if clear need is shown by regional airport system study. Keep runway approach and takeoff areas free from tall structures and incompatible uses.

- V. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
- W. Provide public access to the Bay along levees in a manner that is protective of sensitive wildlife.
- X. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
- Y. **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.
- Z. **Regional Restoration Goal for South Bay** - Restore large areas of tidal marsh connected by wide corridors of similar habitat along the perimeter of the Bay. Several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the region, and natural unmanaged salt ponds should be restored on the San Leandro shoreline. Natural transitions from tidal flat to tidal marsh and into adjacent transition zones and upland habitats should be restored wherever possible. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

- (A) ~~Breach dikes and return area to Bay.~~ If no longer needed for salt pond production, enhance area for wildlife and aquatic life.
- (B) ~~Westpoint, Ravenswood, and Flood Sloughs - If flood control project is needed, develop controlled-level recreation lake at mouth of sloughs.~~
- (C) San Mateo - Prepare precise plan and development program for waterfront emphasizing water-oriented recreation. Some fill may be needed.
- (D) Burlingame - Prepare precise plan and development program for waterfront; include continuous public access to Bay shoreline for viewing and fishing. Some fill may be needed.
- (E) Develop scenic drive and riding and hiking trail along waterfront from airport to Foster City.

Plan Map 7
South Bay

Figure 20a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 7

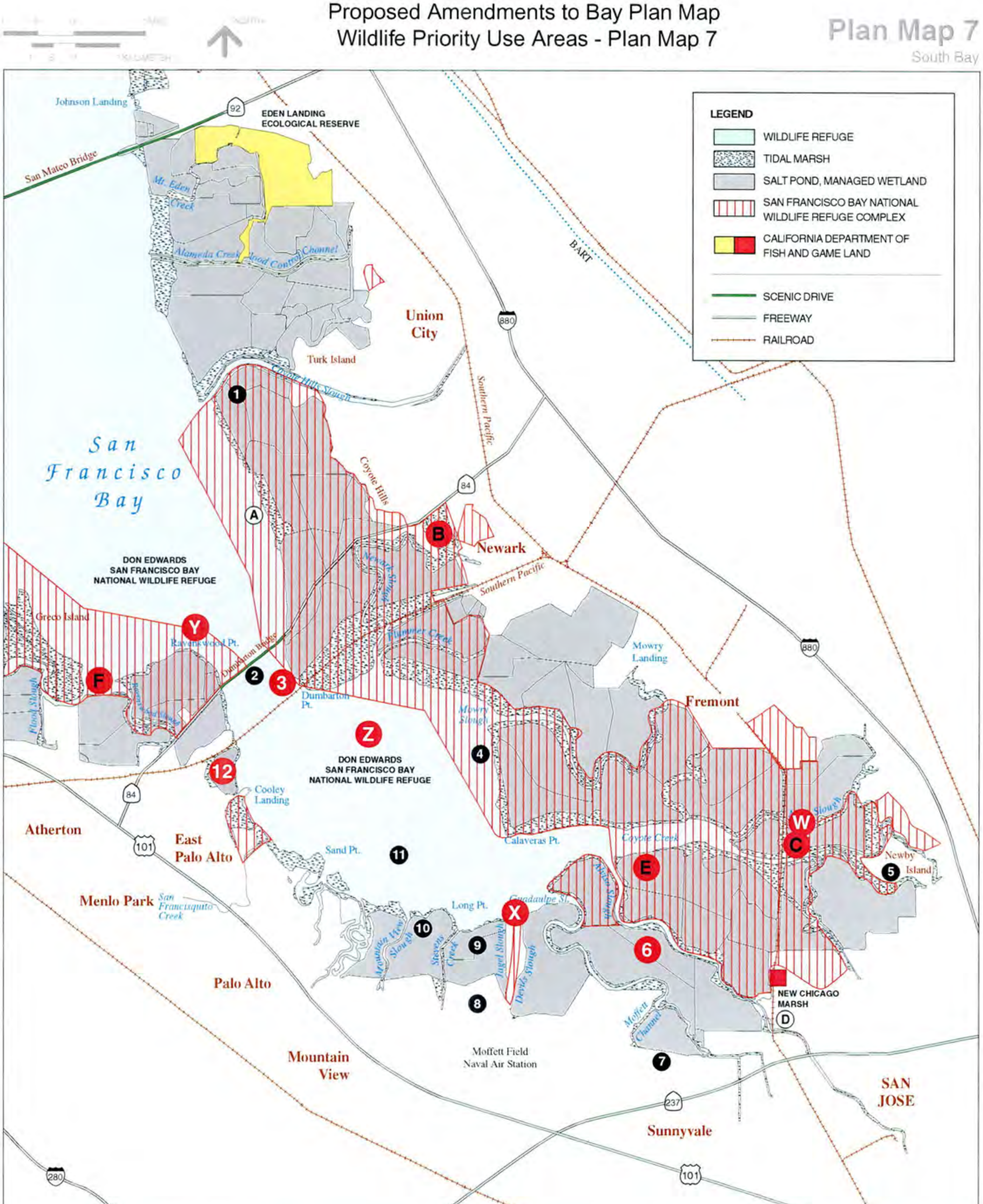


Figure 20b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 7

Plan Map 7
South Bay

PLAN MAP NOTES

Hayward Area Waterfront - *The Hayward Area Shoreline Plan, a detailed plan for the Hayward area shoreline between the San Leandro city limits on the north and Fremont and Union City city limits on the south, was prepared by the Hayward Area Shoreline Planning Agency. The Plan, adopted by the City of Hayward, Alameda County, East Bay Regional Park District, and the Hayward Area Recreation District, provides for marsh restoration and shoreline recreation use.*

~~***Toll Plaza*** - *Best site for toll plaza for new Dumbarton Bridge is on east shore on dry land and located so as to avoid cutting into the Coyote Hills.*~~

Water Quality - *Water at extreme south end of Bay is often polluted so as to discourage recreational use of sloughs and Bay. Greater recreational use will require improved water quality. Some improvements in the quality of water in the South Bay are now being made pursuant to requirements of the San Francisco Bay Regional Water Quality Control Board, and studies underway by wastewater dischargers will lead to further improvements. The recommendations for long-range improvements to water quality contained in the Water Quality Control Plan for the San Francisco Bay Basin, prepared by the San Francisco Bay Regional Water Quality Control Board and approved by the State Water Resources Control Board, should be followed.*

Subsidence - *Area subject to possible subsidence. Construction in or near Bay should be carefully planned, taking into account effects of future subsidence and relative sea level rise.*

~~***San Francisco Bay National Wildlife Refuge*** - *The U.S. Department of the Interior is to acquire approximately 23,000 acres of Bay, marshes, and salt ponds to be included in a national wildlife refuge. The inclusion of the salt ponds and marshes south of Coyote Hills Slough, and those between Coyote Creek and Guadalupe Slough in Santa Clara County, would be consistent with Bay Plan policies. The terms of acquisition should permit the salt ponds to continue in operation as long as desired by the owner of the ponds. Acquisition of the national wildlife refuge is strongly recommended.*~~

Santa Clara County Shoreline - *The Santa Clara County Planning Policy Committee adopted a Policy Plan for the Baylands of Santa Clara County (July 1972) which establishes conservation and development goals and policies for the Santa Clara County shoreline.*

Alviso-San Jose Waterfront - *Detailed planning is needed to determine most desirable waterfront design and to overcome subsidence problems. Proposals should emphasize the great recreation potential of this area.*

Moffett Naval Air Station - *Plan maps indicate recommended use for bayfront military installations if one or more of these bases is ever declared surplus by the military. The Bay Plan does not advocate the closing of any military installation.*

Don Edwards San Francisco Bay National Wildlife Refuge - *In concept the addition and restoration of land or water with high aquatic life and wildlife habitat value or good habitat restoration potential to Don Edwards San Francisco Bay National Wildlife Refuge would be consistent with Bay Plan policies.*

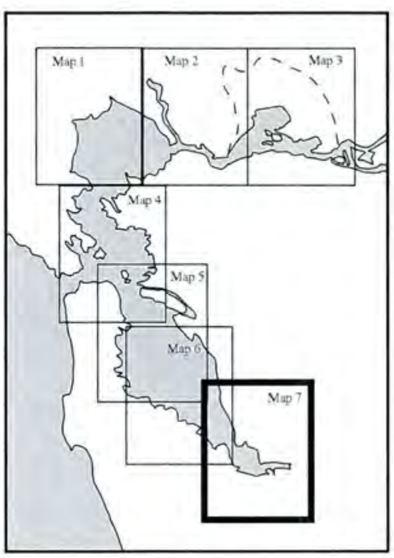


Figure 20c
Proposed Amendments to Bay Plan Map Policies and Suggestions - Plan Map 7

BAY PLAN POLICIES

1 If not needed for salt production, ponds west of Coyote Hills should be ~~acquired~~ managed as permanent wildlife area.

2 **Dumbarton Bridge** - Design proposed high-level bridge to have slim profile and minimum supporting structure and to enable motorists to see Bay and shoreline. Approaches should provide for fishing and wildlife observation. ~~Toll plaza site under study.~~

~~3 **Dumbarton Point Waterfront Park** (proposed) - Boundaries to be determined. Water-oriented uses only. Some fill may be needed.~~

4 **Newark Slough to Coyote Creek** - Protect harbor seal haul-out and pupping sites ~~nursery and hauling grounds~~. ~~No direct public access.~~ Projects allowed only if protective of harbor seals and other sensitive wildlife.

5 **Newby Island** - Provide levee access for wildlife observation.

~~6 **Alviso Slough** - Widen and strengthen levees for public access and occasional picnic areas. Some fill may be needed.~~

7 If not needed for sewage treatment purposes, oxidation ponds should be acquired as permanent wildlife area.

8 **Moffett Naval Air Station** - If and when not needed by Navy, site should be evaluated for commercial airport by regional airport system study. (Moffett NAS not within BCDC permit jurisdiction.)

9 If not needed for salt production, ponds north of Moffet Field should be reserved for possible airport expansion.

10 If not needed for salt production, ponds between Stevens Creek and Charleston Slough should be ~~added to North County Shoreline Park Complex as recreation lakes or~~ wildlife area.

11 **South Bay** - ~~Preserve~~ Enhance and restore valuable wildlife habitat. ~~and develop recreational boating~~. ~~Some fill and dredging may be needed. Parts of~~ Bay tidal marshes and salt ponds may be acquired as part of Don Edwards San Francisco Bay National Wildlife Refuge and managed to maximize wildlife and aquatic life values. Salt ponds can be managed for the benefit of aquatic life and wildlife ~~permanent wildlife areas~~.

~~12 If not needed for salt production, pond between Cooley Landing and railroad bridge should be developed for recreational use. Expand Cooley Landing marina northward.~~

W **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

X **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Y **Harbor Seal Haul-Out** - Protect harbor seal haul-out and pupping site. Projects allowed only if protective of harbor seals and other sensitive wildlife.

Z **Regional Restoration Goal for South Bay** - Restore large areas of tidal marsh connected by wide corridors of similar habitat along the perimeter of the Bay. Several large complexes of salt ponds, managed to optimize shorebird and waterfowl habitat functions, should be interspersed throughout the region, and natural unmanaged salt ponds should be restored on the San Leandro shoreline. Natural transitions from tidal flat to tidal marsh and into adjacent transition zones and upland habitats should be restored wherever possible. See the Baylands Ecosystem Habitat Goals report for more information.

COMMISSION SUGGESTIONS

(A) ~~Breach dikes and return area to Bay~~. If no longer needed for salt pond production, enhance area for wildlife and aquatic life.

~~B Possible aquatic park.~~

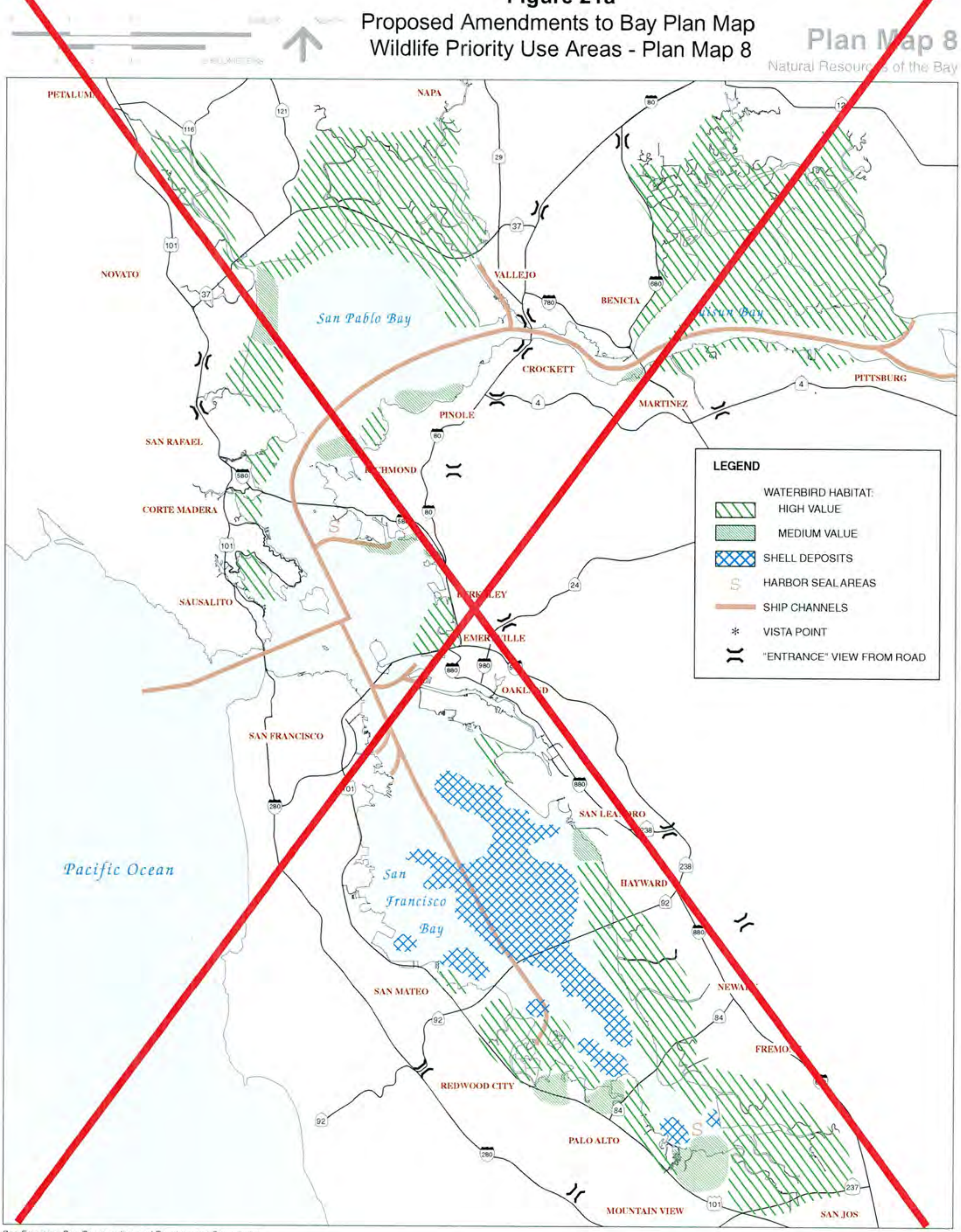
~~C Drawbridge - Possible park.~~

(D) Alviso-San Jose - Prepare precise plan and development program for waterfront area. Expand boating and commercial recreation facilities, and provide continuous public access to slough frontage only at Alviso.

~~E If not needed for salt production, deep ponds near Alviso Slough may be developed as controlled-level recreation lake. Shallow ponds near Coyote Creek have high wildlife value, should be excluded from intensive use area.~~

~~F Westpoint, Ravenswood, and Flood Sloughs - If flood control project is needed, develop controlled-level recreation lake at mouth of sloughs.~~

Figure 21a
Proposed Amendments to Bay Plan Map
Wildlife Priority Use Areas - Plan Map 8



San Francisco Bay Conservation and Development Commission

Figure 21b
Proposed Amendments to Bay Plan Map
Notes - Plan Map 8

Plan Map 8
Natural Resources of the Bay

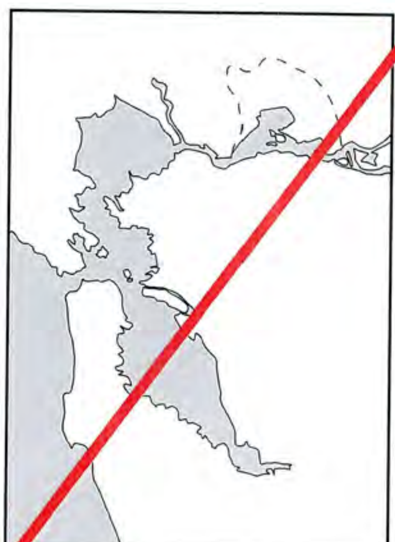
PLAN MAP NOTES

Habitat Values - *Plan map shows fish and wildlife areas rated as "high value" and "medium value" by State Department of Fish and Game. Other areas have value as habitat, but lesser value than the portions marked.*

Shell Deposits - *Oyster shells dredged primarily for use in manufacturing cement.*

Also shown on this map are important vista points and "entrance views" (first views of the Bay from roads through passes in hills) that are intended for protection in the same manner as other view points shown on Plan Maps No. 1 - 7.

Along the shoreline in San Francisco and Marin Counties, Commission's jurisdiction extends 100 feet inland and does not include any area within the jurisdiction of the California Coastal Commission west of the line between Pt. Bonita and Pt. Lobos.



CHAPTER 9

RESTORING AND PROTECTING SUBTIDAL HABITATS

This chapter examines the need and opportunities for protecting and restoring the Bay's subtidal[1] habitats (both shallow and deepwater). This chapter first explores the past and current distribution of subtidal habitats in the Bay. It then describes the Goals Project vision and template for future subtidal restoration in the Bay, and explores potential protection and restoration methods. This chapter also describes the results of a special panel convened by BCDC staff to discuss scientific matters pertaining to the characterization, protection and restoration of these habitats. Finally, it highlights the gaps in knowledge that need to be addressed to improve our knowledge of subtidal areas and their future management and restoration.

The "Whaling Capital of the World:" A Portrait of Past Habitats.[2] Although San Francisco was once hailed as "The Whaling Capital of the World," there is little evidence of that bustling fisheries heyday now. While whales were not hunted in the Bay itself, a multitude of other species were. Early observers could not heap enough superlatives onto San Francisco, calling it "one of the leading fishing centers of the United States," or the "metropolis of the Pacific fisheries.... For fishing products generally, on the Pacific Coast, the market of San Francisco is the only one of importance."[3] Even as late as the 1950's, study authors remarked that "no other area in California can match the rich fisheries potential of this region,"[4] due to supportive estuarine habitat that provided a biologically rich transition between the rivers and the ocean.

Indeed, the Bay was historically a region of remarkably rich fisheries resources, supporting bountiful populations of a variety of fish, and creating significant employment for fishers. The first organized commercial fishery developed between 1848 and 1850 when a colony of Italian immigrants began netting the salmon of the Delta's rivers and seining sardines, herring, and flatfishes in San Pablo and San Francisco Bays. Crabs and shrimp were soon added to the growing fisheries.

The fisheries of the Bay itself reached maximum production between 1870 and 1915. Nearly every species fished commercially was taken in record quantities, in some cases glutting the market. Table 8 shows the fisheries products of the Bay Area from 1888-1889. A few colorful anecdotes may also help to illustrate the richness of the Bay's fisheries during its boom period.

The early Bay shrimp fishery had no counterpart in the United States. For example, Chinese fishing camps near Hunter's point produced so many fish, that "it was custom in several San Francisco restaurants to place a heaping plate of cooked shrimps before the patron so that he could nibble while looking over the menu."[5]

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[1] In this chapter, the terms subtidal, submerged, and aquatic habitats will be used interchangeably as a means to describe both the land under the water (the benthos) and the open water in an effort to look at the Bay wholistically as a habitat in which species utilize the water column and the bottom of the Bay in an interconnected way.

[2] Information from this section was derived from Skinner, John. A Historical Review of the Fish and Wildlife Resources of the San Francisco Bay Area. California Department of Fish and Game, Water Projects Branch, June, 1962.

[3] Jordan, David Starr. The Fisheries and Fishery Industries of the United States. Goode, 1887. As quoted in Skinner, 1962.

[4] Skinner, p. 11.

[5] Scofield, W.L. California Fishing Ports. CA Dept. of Fish and Game, Fish Bulletin #96. 1954. As quoted in Skinner, 1962. p. 18.

Table 8
Fisheries Products of the Bay Area in 1892 (adapted from Skinner, 1962)

Species	Pounds	Species	Pounds
Sardines	703,130	Shad	491,394
Sturgeon	718,017	Salmon	348,4049
Smelt	1,506,103	Flounders	3,557,113
Herring	4,376,887	Crabs	2,750,000
Clams & Mussels	2,654,800	Shrimp & Prawns	5,315,075
Rockfish	644,372		

In 1890 there were so many sardines in the Bay "that they literally obstruct[ed] the passage of boats through the water."[6] The peak year for sardines was 1939, when over 491 million pounds were taken from local waters.

> Native oysters, clams and mussels were also plentiful in the Bay. In 1893, one observer wrote that …there are extensive deposits of this species (native oyster) in the shallow water all along the western part of the Bay, and their dead shells washed ashore by the high seas that accompany the strong winds of the winter season, have formed a white glistening beach that extends from San Mateo for a dozen or more miles southward. So abundant are they that this constantly increasing deposit of shells covers everything along shore and forms bars extending into the Bay... The supply is unfailing.[7]

Crabs were so numerous that, as undesirable bycatch, they began to destroy nets used for other fishing endeavors. As one observer wrote, "In some cases nothing but crabs are taken which destroy the nets and irritate the men so that they are inclined to leave them lie on the beach to die." Another source wrote that they are "taken in immense numbers (in the Bay) in seines, together with many shoal water species of fish, yet the supply seems to be undiminished."[8] But this condition was not to last long; shortly thereafter the crab fleet was forced to move outside the Golden Gate, and crab fishing limits were imposed in 1895.

Figure 22 shows the location of some of these historic fisheries (interested readers are referred to Skinner, 1962 which contains historic fishing maps and data relevant to the Bay). Smelt were found in the greatest abundance in the South Bay; salmon and shad were taken chiefly in the Sacramento River and its sloughs, and in Suisun Bay, although good catches were sometimes made in San Pablo Bay. The Northern part of San Pablo Bay was excellent flounder habitat. Sturgeon were principally caught in Suisun Bay, although those were also found in San Francisco and San Pablo Bays.

[6] Collins, J.W. Report on the Fisheries of the Pacific Coast of the United States in: Report of the U.S. Comm. of Fish and Fisheries for 1888, part III; The Fisheries of California, pp. 21-175. As quoted in Skinner, 1962.

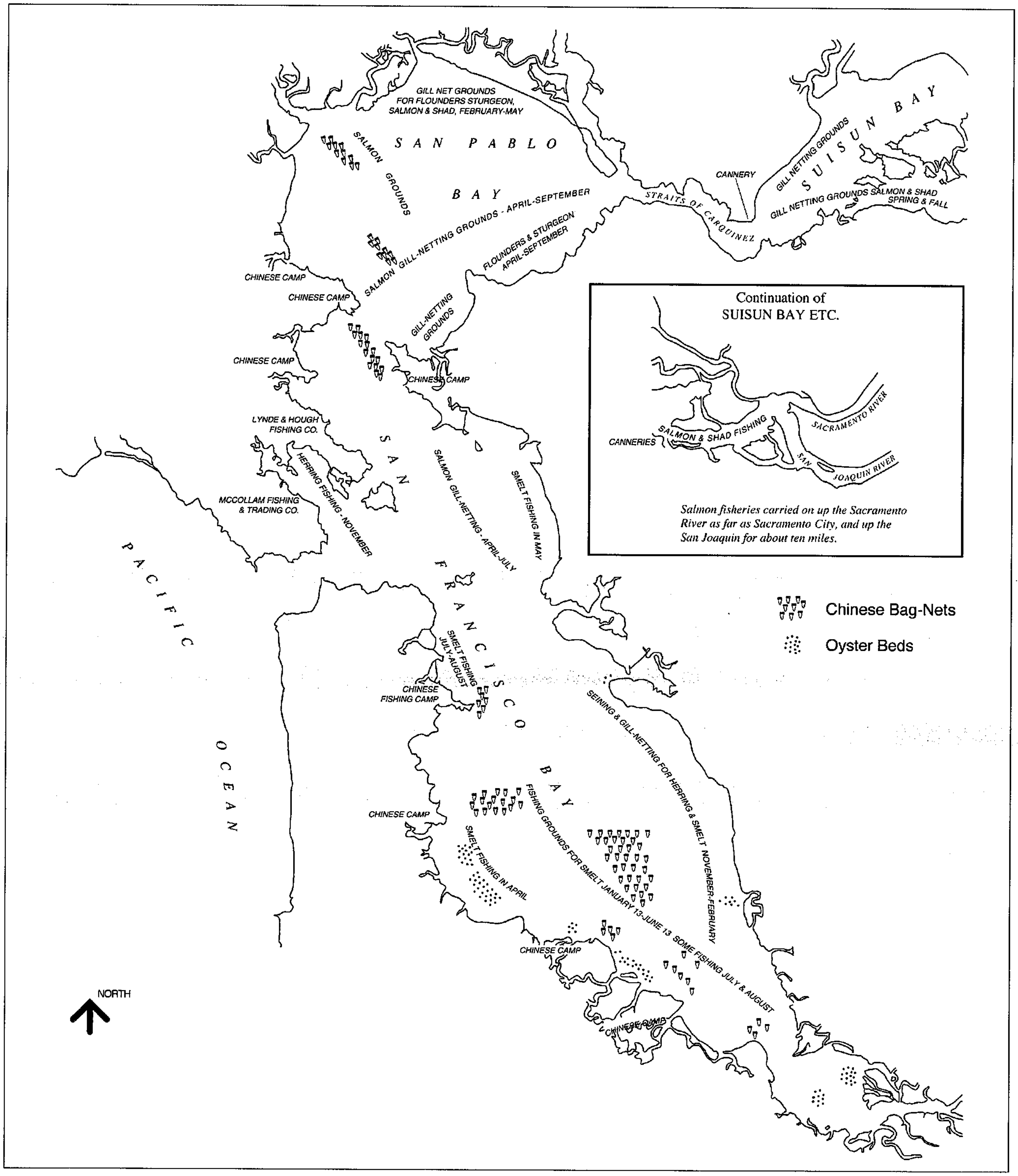
[7] Townsend, Charles H. Report of Observations Respecting the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States. U.S. Commission of Fish and Fisheries Report 1889-91. As quoted in Skinner, 1962.

[8] Weymouth, Frank W. Contributions of the Life History of the Pacific Coast Edible Crab. California Fish and Game, v. 2, #1, pp. 22-27. As quoted in Skinner, 1962.

Figure 22

SOURCE: Chart of San Francisco and San Pablo Bays, 1888-1889.

Historic Fisheries in San Francisco Bay, 1888-1889



Hints of problems soon emerged in the Bay. Fishing restrictions and anti-pollution acts were enacted in 1870, and wildlife sanctuaries were designated. Fisheries came under especially heavy exploitation between 1870 and 1915. The existing fish were "prosecuted severely," and new species of fish and shellfish, including striped bass, shad, eastern oyster and softshell clams were imported to increase production. The oyster and clam industry boomed, with oyster landings alone exceeding 15 million pounds in 1892 due to the successful introductions.

Nonetheless, the foundation of the Whaling Capital of the World soon began to crack. As one observer wrote:

> San Francisco's glory as a fishing port began to fade. Whales became scarce and sea otter were long gone. Salmon runs had declined and the canneries had closed. Stringent laws had prohibited the taking of sturgeon. Bay shrimp could not compete with ocean prawns. Eureka crabs broke the monopoly of the San Francisco Crab Fishermen's Unions.[1]

Between habitat quality changes and market forces, the boom turned to bust. As Skinner puts it,

> The skyrocketing population, coupled with industrial and agricultural growth in the Bay Area, resulted in a tremendous loss of wildlife. The resources were overhunted or overfished. In addition, habitat was, and continues to be, modified, vitiated or destroyed at an alarming rate. Dams for power, flood control, irrigation and water supply diminished anadromous fish populations by cutting off spawning areas and modifying water flows below dams. Excessive water diversion has caused entire streams to dry up; unscreened diversions have taken an enormous toll of fish. Reclamation of wetlands has resulted in vast reductions of waterfowl habitat and hence lowered abundance of these birds. Hunters and trappers have eliminated several game and fur species, and reduced others almost to the point of extinction.[2]

Before 1890, the quantity of fisheries products from the Bay itself began to decline. This was likely due to overfishing, but there is little question that pollution, siltation and ship wastes prevented recovery and hastened the decline. As one researcher wrote, in 1878-1879,

> Already the fishery carried on in the Bay of San Francisco is much less productive than it was in the early days of the American occupation; species that were abundant fail to attain their full dimensions. Nor is over-fishing the sole cause of this. The constant hurrying to and fro of the numerous ferry-boats and other streamers, indispensable to our comfort, tends to drive away the timid finny tribes, whilst the ashes and cinders let fall injure the character of the bottom. But the injury from this source is small compared with that inflicted by the constant fouling of the waters and consequent destruction of life by the foetid impourings of our sewers...into the waters to pollute them for the destruction of creatures of which human beings are largely depend for the means of life. As the supply in San Francisco Bay has become limited the scene of wholesale destruction is now shifted to Tomales Bay whence a very large proportion of our fish is now brought.[3]

Oysters, too, began their decline. Around 1900, some unknown factor or factors caused a radical change in the South Bay that harmed the oyster beds. The eastern oysters planted there took much longer to grow and they were thin, watery, and unfit for the market. San Francisco Bay was abandoned for Humboldt Bay.

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[1] Scofield, as quoted in Skinner, p. 18.

[2] Skinner, p. 11.

[3] Lockington, W.N. Biennial Report of the State Board of Fish Commissioners for 1878-79. As quoted in Skinner, p. 28.

As usual, San Francisco was a trend-setter in the world, although in this case it is a rather dubious distinction. Fisheries problems which now plague many of the world's oceans can be seen in the microcosm of early San Francisco: overfishing, bycatch waste issues (i.e., the incidental catch of non-targeted species), water pollution, habitat destruction, and more. Overall, the Bay's coping techniques have historically consisted of reactive crisis management rather than proactive planning (e.g., responding to the collapse of fisheries by eliminating most commercial fisheries; addressing declines of salmon and striped bass by rearing fish in hatcheries; handling entrainment of fish in pumps and water projects by trapping and trucking, etc.)[4]

No definitive baseline data are available to help us paint a comprehensive and thorough portrait of the subtidal habitats (what species used them, where, what the hydrological processes were in place, etc.). However, it is clear that the Bay's subtidal habitats were once rich with native life. Overfishing and pollution contributed to a decline of the Bay's bountiful fish populations. These changes eventually drove the vast majority of commercial fisheries out of the Bay, decimating the shrimp, oyster, clam, and mussel fisheries, among others.

Current Habitat Distribution. Chapter 2 of this report provides an overview of the Bay's subtidal habitats which include deep bay and channel and shallow bay and channel habitat. However, as mentioned in the earlier chapter, there are many other defining features of aquatic habitats beyond depth and substrate type. These include physical characteristics such as salinity gradients, bathymetry, vegetation, physical dynamics such as fronts and eddies, and more. Other defining features might include process characteristics such as sediment and sand dynamics, sand replenishment and transport dynamics, or wind and wave action. Biological characteristics might include food web dynamics, species requirements, or migratory patterns.

Thus, many characteristics beyond depth describe the subtidal environment and its value to a set of species. In fact, one could view aquatic habitats as an intersection of processes (e.g., freshwater outflow, winds, tidal flows, sedimentation and erosion, oceanic processes, etc) rather than a series of places. These elements of aquatic habitats are generally not easily captured by a map.

Another way of defining aquatic habitats is to think of them as home to various creatures, providing migration routes, spawning and feeding areas, etc. For example, a recent survey of organisms associated with the bottom of the Bay (benthic assemblages) determined that the benthos can be mapped in terms of the organisms found there due to their relationship to sediment type and salinity. This recent study by the San Francisco Estuary Institute and the City and County of San Francisco[5] was able to identify three major benthic assemblages[6] of organisms associated with the San Francisco Bay and the Delta. These benthic assemblages include the fresh-brackish assemblage (found in the Delta), the estuarine assemblage (found in Suisun Bay, San Pablo Bay and South Bay), and the marine assemblage (found primarily in the Central Bay).

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[4] Aquatic trends report, p. ES-10

[5] Bruce Thompson, Sarah Lowe, and Michael Kellog, *Results of the Benthic Pilot Study 1994-1997: Part 1 Macrobenthic Assemblages of the San Francisco Bay Delta, and their Reponses to Abiotic Factors.* (August 2000): Technical Report 39.

[6] Defined as "the coexisting organisms that inhabit a location (or locations) at a specific time (or period of time). The species composition and abundance of an assemblage may vary slightly from location-to-location, or time-to-time because assemblages are the manifestation of the responses of many individual organisms to slight differences in physical factors such as salinity or sediment-type, in biological factors such as competition or predation, and in organism life-cycles."

These assemblages are noteworthy because they illustrate the variations in salinity and sediment-type in different parts of the Bay and the response of organisms to those changes. Specifically, certain benthic organisms are found in distinct parts of the Bay due to their adaptations to different sediment types, pollution and salinity levels, as well as other effects. Furthermore, each of these assemblages can be broken down into more defined sub-assemblages of benthic organisms, which are described and mapped in Appendix A.

Due to interwoven physical and biological processes and the need for additional scientific analysis there currently is no definitive manner in which to define the Bay's subtidal habitats. However, the Goals Project's description of the Bay by depth (shallow and deep) and subregion (North Bay, South Bay, Suisun Bay and Central Bay)[7] provides a good foundation for BCDC's analysis. Further discussion of the Bay's subtidal habitats and the scientific work needed to more completely assess them will be discussed later in this chapter in the section pertaining to the results of the subtidal science panel held at BCDC in September 2000.

In an effort to add to scientific knowledge about the Bay and its habitats the California Academy of Science is currently undertaking a "SF Bay 2K" survey which when completed in 2004 will provide more information about the inhabitants of the subtidal regions and by inference the current distribution of subtidal habitats in the Bay. Specifically, this study aims to provide an ecosystem evaluation that will map the nearly 1,000 underwater species that inhabit the deep and shallow waters of the Bay. The survey will be spatially referenced (in other words, available for use on a geographic information system, or GIS) and will include spatial information on sediment types.[8] Furthermore, the study seeks to create a portrait of the Bay's biological history, including the impact which non-native species have had in altering the habitats of native species.

In terms of depth and subregion, many human-induced changes have occurred in the Bay since 1800, each of which are described in the following discussion. For example, the Goals Project reports that Suisun Bay lost 31% of its deep bay and channel habitat, as compared to 7% of its shallow bay and channel habitat. In the North Bay, the region lost 49% of its deep bay and channel habitat, compared to 2% of its shallow bay and channel habitat. In the Central Bay, the region lost 4% of its deep bay and channel habitat, compared to 6% of its shallow bay and channel habitat. In the South Bay, the region lost 3% of its deep bay and channel habitat, compared to a gain of 10% for its shallow bay and channel habitat.

Table 9 implies that proportionally, the Bay has lost more of its deep water habitat than its shallow water habitat in most areas. However, due to the trapping of river-born sediment behind dams and the erosion of sediments from subtidal areas in recent years, scientists estimate that certain areas of the Bay, such as Suisun and San Pablo Bays, are actually getting deeper.[9]

Although there is no classification system for subtidal habitats comparable to the Goals Project classification for wetlands habitats, there may be areas of particular importance in the Bay. For example, habitats used by endangered species are important, as are rare habitats such as native oyster reefs, habitats with vegetation such as eelgrass or gracilaria, or habitats that are known to be particularly productive (such as sand flats in Central Bay, or the large underwater rocks in the Central Bay). Physical struc- tures or processes may also be important in some places (such as stanchions of bridges that provide good foraging habitat for harbor seals due to the eddies of water which form behind them and accumulate prey). In addition, all hard struc-

[7] Moreover, due to the ecological connectedness of the Bay, such a typology may not be appropriate. The panelist section of this chapter describes this problem in greater detail.

[8] Terry Gosliner, California Academy of Sciences, personal communication.

[9] For more information see Dr. Bruce Jaffe of USGS's website at http://sfbay.wr.usgs.gov/access/sanpablobay/bathy/home.html

Table 9
Subtidal Habitat Change from 1800 to 1988

Region	Deep Bay/Channel Habitat Change	Shallow Bay/Channel Habitat Change
Suisun Bay	-31%	-7%
North Bay	-49%	-2%
Central Bay	-4%	-6%
South Bay	-3%	+10%

tures in the Bay (rocky intertidal and subtidal areas including rock outcrops, piers and bridgepilings, as well as other man-made structures) provide important habitat functions to aquatic life and wildlife dependent on the Bay.

Current Status and Threats to Subtidal Habitats. The top four threats to aquatic habitats, according to the 1993 *Status and Trends Report on Aquatic Resources in the San Francisco Estuary,*[10] include: (1) invasive species; (2) pollution; (3) freshwater diversion and altered flow regime; and (4) habitat destruction/modification of waterways and wetlands. These threats are described in detail in chapter 3 "Threats to the Health of the Bay's Habitats" and chapter 4 "Invasive Species."

Aquatic species are generally affected by a combination of these problems. For example, consider winter-run chinook salmon whose numbers dropped from 57,306 fish returning to spawn in the Bay-Delta in 1967 to 191 fish returning to spawn in 1991.[11] Dam construction played a large role in this decline by blocking upstream spawning habitat and decreasing flows. Other factors included other reduced or eliminated spawning habitats critical to the life cycle of salmon, such as tidal wetlands, inadequate stream flows needed for spawning, intermittent poor water quality, spawning gravel of unsuitable size, high stream temperatures (e.g., due to riparian habitat destruction) and losses of young fish to water diversions.[12]

Another example is the Delta Smelt, one of the few remaining native species found in the upper reaches of the Bay. Although it was once common, its numbers dropped sharply since the early 1980's. Factors for this decline include invasive species (which have reduced their food supply), loss to water diversions, and habitat modification.[13]

The threats discussed in chapter 3 have resulted in declines in aquatic resources in the Bay. The *Status and Trends Report* examined the health of the trophic (food chain) levels of aquatic resources and found the following trends, caused by the cumulative effects of the threats discussed above:

1. **Phytoplankton**. There is a long-term decline in phytoplankton in Suisun Bay, the staple at the bottom of the food chain which includes primary producers such as bacteria and algae. This decline is exacerbated by the large populations of the introduced Asian clam filtering the phytoplankton in the upper reaches of the estuary.

[10] San Francisco Estuary Project, 1992.

[11] Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, Editor. San Francisco Bay Regional Water Quality Control Board, Oakland, Calif.

[12] San Francisco Estuary Project. Comprehensive Conservation and Management Plan. Oakland, CA 1993, p. 53

[13] San Francisco Estuary Project. Comprehensive Conservation and Management Plan. Oakland, CA 1993, p. 53

2. **Zooplankton**. Zooplankton includes water fleas, opposum shrimp, rotifers and other microscopic animals found in the water column. They are important sources of food for small or larval fish. Certain species of rotifers, water fleas and copepods have experienced population declines in Suisun Bay over the last 20 years.

3. **Benthic Organisms**. These creatures inhabit at the bottom of the Bay, and include mussels, clams, crabs, worms, shrimps, etc. Many burrow in the mud and filter water and sediments for food. Depending on the species, these organisms have exhibited booms (such as the invasive Asian clam population) or declines (including grass shrimp, which is declining due to inadequate freshwater inflow and other factors, and Dungeness crab, which is declining primarily because of ocean temperature rise).

4. **Planktivorous Fish.** These are filter feeders that eat zooplankton or phytoplankton. They are among the most plentiful fish in the Bay, and include species such as Northern anchovy. Planktivorous fishes that spend significant parts of their life cycle in the Suisun Bay or Delta have declined. Marine dependent species such as Pacific herring and Northern anchovy remain stable. The Delta smelt is in serious decline, possibly due to drought and increased water diversions. Threadfin shad and Longfin smelt are also in long-term decline.

5. **Predatory Fish.** These fish eat other fish. Some are flatfish that wait on the bottom for prey to swim within their reach; others, like white croakers, chase their prey, which might include crabs, shrimp, small fish, etc. The two most common flatfish, English sole and starry flounder, are marine species that use the Bay mostly as a nursery. Starry flounder have declined as a result of changing environmental conditions and toxic contamination. White croaker, in contrast, has increased since 1980 as marine conditions in the Bay become more predominant, due to decreased freshwater flows. There has been little change in the population numbers of other marine-dependent species. However, freshwater dependent species are in decline. Invading species, such as the chameleon goby, are on the increase.

6. **Anadromous Fish.** Anadromous fish live some or all of their adult lives in salt water but migrate to freshwater to spawn. These fish can be planktivorous or predatory. There are four runs of Chinook salmon, and other fish such as striped bass, American shad, white sturgeon and steelhead trout. Naturally spawning Chinook salmon have experienced serious declines due largely to upriver dams and diversions. Some of these runs are now on the endangered species list described in Appendix C. Striped bass are suffering record low populations, largely due to water diversions, but also because of pollution, poaching, and inadequate food supply. White sturgeon has been declining worldwide and show effects of contamination (e.g., increased selenium levels).

   As a whole, it appears that native aquatic creatures and the quality of aquatic habitats are engaged in a significant downward decline, with the possible exception of some benthic organisms. This decline goes hand-in-hand with a decline of the larger ecosystem, as the processes affecting aquatic ecosystems affect the Bay, the Baylands, and the uplands as well. Moreover, fish and other aquatic organisms are an integral part of the food chain, thus their decline can lead to a subsequent decline in organisms that may depend on them.

BCDC's Jurisdiction Over Subtidal Habitats. Although BCDC has regulatory authority over the Bay, it is important to note that BCDC has little control over the complex, multi-jurisdictional threats discussed above (invasive species, pollution, freshwater diversion and altered flow regime, and habitat destruction/modification of waterways and wetlands). For example, of these threats, the Commission has little or no jurisdiction over freshwater diversion and pollution sources beyond its jurisdiction. But it does have limited jurisdiction over other threats, such as invasive species and most notably, habitat modification.

However, BCDC and other agencies with regulatory authority over the Bay are increasingly being asked to make decisions on activities that affect subtidal habitats. These activities fall into two broad categories: (1) proposed habitat improvement (including using dredged material for creating shallow water for development of eelgrass beds, or the creation of habitat islands for migratory birds), and (2) other projects (which may include extensive sand dredging, or lowering of rock formations in the Central Bay for navigational purposes, etc).

These activities may impact the quality of the Bay's aquatic environment and/or the distribution of subtidal habitat types. Habitat restoration provides an example. Habitat restoration or creation proposals would convert one habitat type into another (for example, deepwater habitats might be filled to an elevation suitable for eelgrass, or even to an elevation suitable for a habitat island for migratory songbirds).

Other projects, such as lowering the rocks in the Central Bay, or extensive sand dredging for commercial purposes, may not alter the distribution of habitat types directly. However, these types of projects will affect the quality of the subtidal habitats involved, at least on the short term and possibly the long term.

Goals Project Restoration Vision. The Goals Project, described in chapter 2, provides a template for future regional restoration of the baylands ecosystem. This section examines the portion of that vision that involves deep and shallow water habitats; however, it should be noted that subtidal habitats were not the primary focus of the Goals Project.

The Goals Project selected a number of key estuarine fish and associated invertebrates as indicators or as otherwise emblematic or important to the Bay habitats. These species were selected for a variety of reasons, for example, their presence as a native species, their ability to indicate health for a particular habitat type, or their importance in the food web, among other factors. In addition to choosing the key species shown in Table 10, the Goals Project also selected eelgrass as a key plant community and representative plant species for intertidal and subtidal habitat.

The overall habitat goal for Central Bay is to protect and restore tidal marsh, seasonal wetlands, beaches, dunes and islands. The Goals Project noted that shallow subtidal habitats (including eelgrass beds), as well as tributary streams and riparian habitats, should also be protected and enhanced. In the North Bay, the project participants suggested that shallow subtidal habitats (including eelgrass beds in the southern extent of this subregion) should be preserved or restored. No recommendations regarding subtidal habitats were made for Suisun or South Bay.

Eelgrass beds were the only subtidal habitat component for which the Goals Project made design and management recommendations. These recommendations included recognizing the importance of local wave energy, minimizing human-made turbidity, enhancing beds by revegetating areas within the bed margins, restoring beds only where key water quality features indicate a high likelihood of success, and scheduling planting when water is warmer.

The Estuarine Fishes and Associated Invertebrates Focus Team, a subteam of the Goals Project, also included recommendations on subtidal habitats (although these recommendations were not adopted by the Goals Project at large). These recommendations include: (1) avoiding any net loss of subtidal habitat through solid bay fill; (2) restoring shallow subtidal habitats in Suisun Bay in order to benefit Delta eelgrass which include: (1) identifying and vigorously preserving all existing eelgrass beds within each re gion; and (2) focusing restoration efforts in

Table 10
Estuarine Fish and Associated Invertebrates

Common Name	Scientific Name	Standardized Selection Criteria
Estuarine Fish and Associated Invertebrates		
Chinook salmon	*Oncorhynchus tshawytscha*	2,4,5,6,8
Steelhead	*Oncorhynchus mykiss*	2,5,6,8
White sturgeon*	*Acipenser transmontanus*	1,2,4,6,8
Striped bass	*Morone saxatilis*	2,5,6,8
Sacramento splittail	*Pogonichthys macrolepidotus*	2,4,5,6,8
Pacific herring	*Clupea pallasi*	2,4,6,8
Northern anchovy	*Engraulis mordax*	2,4,6,8
Arrow goby	*Clevelandia ios*	1,2,6,8
Bay goby	*Lepidogobius lepidus*	2,4,6,8
Delta smelt	*Hypomesus transpacificus*	2,4,6,8
Jacksmelt	*Atherinopsis californiensis*	5,6,8
Topsmelt	*Atherinops affinis*	2,5,6,8
Longfin smelt	*Spirinchus thaleichthys*	6,8
Pacific staghorn sculpin	*Leptocottus armatus armatus*	5,6,8
Prickly sculpin	*Cottus asper*	6,8
Rainwater killifish*	*Lucania parva*	2,8
Plainfin midshipman*	*Porichthus notatus*	2,5,6,8
Shiner perch	*Cymatogaster aggregata*	2,5,6,8
Tule perch	*Hysterocarpus traski*	2,6,8
Three-spined stickleback	*Gasterosteus aculeatus*	6,8
White croaker	*Genyonemus lineatus*	2,5,6,8
Leopard shark	*Triakis semifasciata*	1,4,6,8
Bat ray	*Myliobatus californica*	2,6,8
Brown rockfish	*Sebastes auriculatus*	2,5,6,8
California halibut	*Paralichthys californicus*	2,5,6,8
Starry flounder	*Platichthys stellatus*	2,5,6,8
Longjaw mudsucker	*Gillichthys mirabilis*	2,5,6,8
Dungeness crab	*Cancer magister*	2,4,6,8
Rock crab	*Cancer antennarius*	2,4,6,8
Rock crab	*Cancer productus*	2,4,6,8
Mud crab*	*Hemegrapsus oregonensis*	1,4,6,8
California bay shrimp*	*Crangon franciscorum*	2,4,6,8
Blacktail shrimp*	*Crangon nigricauda*	6,8
Opossum shrimp	*Neomysis mercedis (relicta)*	2,6
Estuarine Fish and Associated Invertebrates (continued)		
Softshell clam*	*Mya arenaria*	2,6,8
Japanese littleneck clam*	*Tapes japonica*	2,4,6,8
Ribbed horsemussel*	*Arcuatula demnisum*	2,4,6,8
California horn snail*	*Cerithidea californica*	2,6,8
Amphipods*	*Amphipoda* spp.	1,2,6,8

* Species profile not prepared.
1. Community Indicator
2. Habitat Indicator
3. Sensitive Species
4. Protected Species
5. Economic Indicator
6. Dominant Species
7. Pest Species
8. Practical Species

SOURCE: Baylands Ecosystem Habitat Goals Project

areas where freshwater can assist in its distribution, such as smelt, splittail and steelhead, as well as other fish species[1]; and (3) maintaining or creating linkages to tidal marsh to maximize values for fishes. In addition, the focus team also outlined recommendations for South Bay, San Pablo Bay and Central Bay. Table 11 illustrates the acreage and location of eelgrass beds in San Francisco Bay as of 1989.

Table 11

Acreage of Individual Eelgrass Beds in San Francisco Bay in 1989[2]

Location	Acres
San Pablo Bay	124
Point Orient	3
Naval Supply Depot	12
Point Molate Beach	26
Toll Plaza, East	0.5
Toll Plaza, West	0.5
Point Richmond, North	7
Point Richmond, South	4
Richmond Breakwater, North	18
Richmond Breakwater, South	7
Emeryville	13
Alameda	55
Bay Farm, North	2
Bay Farm, South	4
Coyote Point	1
Richardson Bay	13
Angel Island	3
Belvedere Cove	5
Point Tiburon	1
Keil Cove	10
Paradise Cove, North	4
Paradise Cove, South	3
TOTAL ACRES	316

The Goals Project also provided a list of potential restoration sites and projects. For deep and shallow Bay habitats, these included the following:

1. Oakland Middle Harbor: Restore shallow bay, intertidal mudflat, and eelgrass beds (Recommendation #78)

2. S.F. Bay near Bay Farm Island: Protect and enhance existing eelgrass beds (Recommendation #74).

[1] There is a gradually developing consensus among scientists that simply increasing shallow water habitats per se is not particularly defensible in the absence of specific, well-defined objectives in particular locations. Among the concerns are that these habitats will be quickly exploited by invasive species, while the value to native species is either not known or modest at best (comments of Dr. Fred Nichols, retired research oceanographer at USGS, 9/12/2001). CALFED is currently undertaking studies which may help address this concern.

[2] Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson. Editor. San Francisco Bay Regional Water Quality Control Board, Oakland, Calif.

These were the only proposed projects that involved subtidal habitats. However, other projects were suggested that would involve restoring intertidal or tidal marsh habitats in areas that are currently subtidal.

Although the Goals Project describes the need for eelgrass, it did not delve in depth into other submerged habitats, such as areas with sandy or rocky substrate. In fact, beyond eelgrass elements described above, it did not make any recommendations for shallow or deepwater habitat restoration. Which submerged habitats need protection and/or restoration? What are the opportunities and techniques to restore or protect those areas? How should we make tradeoffs among the various habitat types? What balance of subtidal habitats do we need to maintain a healthy Bay? Because of its primary focus on wetlands, the Goals Projects did not address the subtidal habitats in depth. Thus, these questions remain to be answered.

The Panel Results: Asking the Experts. Due to the dearth of information about San Francisco Bay's subtidal habitats, BCDC staff convened a group of esteemed scientists for a day-long discussion at BCDC's offices in September 2000. The purpose of the subtidal science panel was to gather data not readily available in the literature (such as the characterization and location of subtidal habitats) and to facilitate information sharing among scientists in the region. The panel, moderated by Professor Robert Twiss of the University of California, Berkeley, included Bruce Thompson from the San Francisco Estuary Institute; Bill Sydeman from the Point Reyes Bird Observatory; Bruce Herbold and Mike Monroe from the U.S. Environmental Protection Agency; Fred Nichols and John Takekawa from the U.S. Geological Service; Brian Mulvey from the National Marine Fisheries Service; Sarah Allen from the National Park Service, Point Reyes National Seashore; Michael McGowan, Hal Markowitz and Wim Kimmerer from the San Francisco State University Romberg Tiburon Center for Environmental Studies; Paul Siri from the University of California, Davis Bodega Marine Laboratory; Bob Tasto from the California Department of Fish and Game; and Phil Williams from Phillip Williams and Associates Ltd.[3]

In preparation for the panel discussion Professor Twiss and staff prepared a set of topical questions for the panelists to address and expand upon. A summary of the panel proceedings follows

How Do You Classify Subtidal Habitats? The panel concluded that there is no adequate existing classification of subtidal habitats, in part due to the complexity of the system and its tendency to vary from site to site. However, such a classification might be possible in the future. Such a classification should incorporate a host of physical, chemical, biological and process oriented features reflecting the reality that subtidal habitats are not necessarily bounded places, but rather are part of an interconnected dynamic and constantly evolving system. For example, the Bay is partly defined by freshwater flows from the Delta and marine waters forcing their way into the Bay from the Pacific Ocean. In turn, these factors, along with many others, help to define the array of unique areas throughout the Bay which are utilized by numerous plant and animal species. Hence, many interconnections exist between the physical and biological processes of the Bay. Some of the features which define the Bay and would help to form the foundation for a classification system include the following:

1. **Physical Characteristics**

   a. Depth (deep vs. shallow)
   b. Salinity gradients (stratification and mixing)
   c. Bathymetry (physical shape of the Bay)

d. Substrate type (including soft mud, hard mud, sand, rock, rip-rap, shells, eelgrass, other vegetation such as gracilaria, and pilings)
e. Physical dynamics in the water column (fronts, eddies, and retention zones)

2. **Process Characteristics**

a. Sediment and sand dynamics
b. Sand replenishment and transport dynamics
c. Salinity gradients (both horizontal and vertical stratification and dynamics)
d. Chronic human impacts (for example, chronic small oil spills)
e. Wind and wave action
f. Evolution of the system over time
g. Long-term residual currents and directions
h. Sources of material and rates of movement
i. Short term events such as erosion and deposition
j. Movement of toxic materials (e.g. with sediment)
k. Hydrodynamic circulation processes (e.g. tidal excursion and dispersion)
l. Differential erosion rates of soft versus hard (pre-centennial) mud
m. Salt transfer and transport as affected by bathymetry (feedback loop)

3. **Biological Characteristics**

a. Exchange of Energy/Food web dynamics (e.g., congregation and aggregation of plankton)
b. Mosaic of species: what species use which habitats, where, and when?
c. Linkages between habitats (e.g. daytime movement of fish between deep and shallow water)
d. Species requirements
e. Natural versus artificial habitats
f. Relative amount of productivity and interannual variations in productivity
g. Predator/prey relationships
h. Migration

However, members of the panel noted that classifying Bay subtidal habitats may be a difficult endeavor, due to the lack of data, and the extremely dynamic nature of the open water habitats (including seasonal variability, interannual physical variation, interdecadal climate changes, etc). In addition, many panelists warned that a classification system might be somewhat misleading and artificial, given that most species will use various habitats during different seasons, different life stages, and for different uses (e.g., refugia in deep water vs. feeding in shallow water). Hence, a connective value exists between habitats, a concept which is critically important to understanding the functioning of the Bay ecosystem.

Furthermore, habitats with similar structural characteristics in different parts of the Bay may not be of equal value to species of concern. For example, sandy habitats in Suisun Bay are much less important to fish species than are sandy habitats found in Central Bay. In addition, for some species, such as birds which move from open water to tidal flats, the connection between intertidal habitats and subtidal habitats is equally important to the connections which exist for species, such as fish, between various subtidal habitats. Thus, there is a strong argument for viewing the Bay as an interconnected and dynamic system rather than a disparate collection of habitats.

What Subtidal Habitats Are of Particular Concern or Value? As many of the panelists noted, the answer to this question presupposes a classification system (in other words, that we already know what the subtidal habitats actually are). Thus, this question cannot yet be adequately answered. In general, however, the shallow and deep areas of the Bay are critical to two different ongoing processes central to the functioning of the Bay. First, the shallow areas of the Bay are points where the sedimentary process takes place (the wave/shallow water interaction which resuspends sediments) and the deep channel areas of the Bay wherein most tidal flow and salt transport occurs.

In addition, the panelists suggested a few substrates, located in mostly shallow habitats, that might be of special concern. One of the substrate types considered to be of special value were eelgrass beds, but there was great dissention as to whether eelgrass played a particularly important role in San Francisco Bay (although it certainly is important to other ecosystems in areas such as Tomales Bay and Puget Sound). For example, some panelists argued that fish in San Francisco Bay do not presently seem to need eelgrass, while others argued that historically eelgrass is the preferred spawning substrate of Pacific herring, which as juveniles are preyed upon by migratory species such as salmon and sturgeon. Some scientists mentioned the importance of other kinds of vegetation, such as gracilaria (a seaweed) found in Richardson Bay, which is also spawning substrate for Pacific herring. Native oyster reefs also contribute to the health of estuarine ecosytems by providing both spawning substrate for other organisms, as well as broadcast spawn of their own, which in turn provides energy to the food web. Once found in greater numbers in the Bay, restoration of native oyster reefs at appropriate sites in the Bay is being considered.

Other habitat features mentioned during the course of the panel included sand shoals in the Central Bay, which are outstanding habitat for certain fish, such as halibut. and the large underwater rocks found in Central Bay. These rocks may serve as transition areas for fish entering the estuarine environment from the ocean, thus providing an area from which they can feed, find shelter and then spread into Central Bay. In addition, these rocks create fronts and eddies where prey for feeding seabirds and larger fish concentrate. Importantly, recreational fishermen target these underwater rocks due to the abundance of fish associated with these areas. Overall, many unique and important habitat features are found in Central Bay. Harbor seals also prefer to forage for food around areas where fronts and eddies are found. For example, the stanchions of bridges provide good foraging areas for harbor seals due to the eddies of water which form behind them and accumulate prey.

Others suggested that it would be useful for future efforts to approach this question by asking what habitats types did we have in the past and how have they changed in recent history. For example, deep sandy substrate may have been replaced by deep muddy substrate in certain areas due to river-born sediment from hydraulic gold mining washing into the Bay during the Gold Rush. From a biological perspective, some noted, the Bay also supported species that are no longer present (such as the waterfowl species, Black Brant). Still others suggested that we must think about what we will lose in the future. For example, due to possible Bay sediment deficit, tidal scouring and the resulting erosion which makes subtidal habitats deeper, we may lose several shallow subtidal habitats by 2050, and should plan for that possibility. Although the scientists suspect that the current sediment deficit is causing the erosion of shallow subtidal areas with no indication that it will stop anytime soon, they are not certain what is happening to the deep areas as a result of this process. Thus, there are potential dramatic changes occurring right now in habitat composition due to shifts in the sediment supply and relative sea level rise.

Is a Larger Vision Needed for Subtidal Habitats (Similar to the Baylands Ecosystem Habitat Goals?) The panel agreed that such an effort is warranted, although it should be on a much smaller scale than the Goals Project, due to the limited information existing. Panel members recommended that the process should involve the hydrogeomorphologists and physicists, working in tandem with the biologists, early on in the process to develop an understanding of past, present, and future landscape changes. They also expressed preferences to keep the process timely and speedy, to specify desired goals and levels of specificity, to use a small group approach, to avoid a GIS-based effort, and to create a library of subtidal restoration efforts so that restoration lessons may be gleaned (although there have not yet been subtidal restoration efforts in the Bay, there have been many wetlands restoration efforts, some of which have become more subtidal in nature). Others suggested that the vision consider other techniques (such as marine reserves) above and beyond restoration, since restoration may be less warranted in the Bay than in the wetlands.

BCDC staff agreed to define what it would ideally want from such a project (e.g., maps? restoration and protection suggestions?, etc). BCDC may also coordinate with other regulatory agencies, such as the National Marine Fisheries Service, to see what outcomes they would desire from such an effort. (Note: a short discussion of what BCDC would desire from such a project can be found in Appendix B).

Are Marine Reserves Warranted in the Bay? If So, Where? Unfortunately the panel did not have time to adequately address this crucial question, although they all agreed it warrants additional attention. Some panelists did suggest that this question could be the starting point for a Goals-type effort (for example, what is really valuable in the Bay?). Others suggested that subtidal habitats, particularly in Central Bay, should be added to the proposed San Francisco Bay National Estuarine Research Reserve (SF Bay NERR) for research and monitoring (the proposed SF Bay NERR does not acquire land or provide additional regulatory protection, but it does provide a coordinating device for research efforts, as well as funding support). Other panelists mentioned that if a system of reserves is defined, the system should consider spatial linkages and larval dispersal mechanisms. Finally, some panelists mentioned that future projects (such as an expanded ferry system) should minimize disturbance on these reserves.

Panel Suggested Conclusions. Though further research is needed, the panelists suggested a number of preliminary conclusions below. Where there was significant disagreement on a conclusion, this disagreement is noted. A few panelists agreed to craft further suggested findings (these have been included in a separate section, also below). Many of the panel's scientific conclusions have been incorporated into the staff's recommended findings and policies for subtidal habitat, which are proposed to be included in the update to the marshes and mudflats and fish and wildlife Bay Plan findings and policies.

1. **Description of Subtidal Habitats, Processes and Interconnections**

   a. Bathymetry is important for the Bay's ecology. For example, schools of herring and anchovies need connected deep water channels. In addition, the shape, configuration, texture and material of the bottom controls the movement of particles, such as sediment, larvae or eggs, which in turn shapes biological processes.

   b. Physical dynamics of the water column, such as fronts, eddies and retention zones determined by freshwater incursions and underwater rocks, affect where fish concentrate and consequently where other species, such as seabirds and harbor seals, feed.

2. **Value of Subtidal Habitats**

   a. The San Francisco Bay subtidal environment provides valuable habitat for a number of aquatic species of concern, such as Pacific herring, Delta smelt, Chinook salmon, steelhead, brown pelicans and harbor seals

   b. Subtidal habitats are both of ecological and economic importance (e.g., to tourism and commercial fishermen and recreational anglers).

   c. Subtidal vegetation, such as eelgrass, gracilaria and other macroalgal species are valuable in San Francisco Bay because they provide shelter, spawning ground and serve as a nursery for certain species, such as Pacific herring, as well as providing good foraging areas for bird species, such as the least tern. (Note that several scientists disagreed with this finding, suggesting that eelgrass beds, in particular, may not play a critical role in the Bay's subtidal environment, because as far as scientists know they are very limited in distribution within the Bay.)

3. **Subtidal Management**

a. Projects should minimize disturbance to subtidal habitats.

b. The following approaches should be incorporated into permit conditions for subtidal habitats: (1) adaptive management which would require the modification of a subtidal project throughout its duration as lessons are learned; (2) pilot projects to ensure that a subtidal project works in one location before it is authorized elsewhere; (3) monitoring of projects once they are approved to ensure desired results occur; and (4) performance criteria which allow scientists and resource managers to gauge the success of a proposed project.

c. Restoration projects in the subtidal environment must consider the sustainability of projects as they are affected by localized sediment erosion and accretion, large scale sediment deficit concerns, and impending relative sea level rise.

d. The Bay is a dynamic, evolving ecosystem, and resource management decisions should be assessed in relationship to the changes the Bay is undergoing.

e. Although impacts to a subtidal site may be site-specific, they may also affect the Bay as a whole, as its parts are interrelated.

f. Open water habitats are not well understood. Projects should be based on a preponderance of evidence that the benefits of approving the project exceed the environmental impacts to the Bay and its associated aquatic life and wildlife.

g. Site specifics matter. The same habitat type in two different areas may have very different functions and values to aquatic life and wildlife.

h. Eelgrass is important subtidal vegetation. Impacts to known eelgrass beds should be mitigated based on a standard accepted by both BCDC and other relevant agencies such as the Department of Fish and Game and the Army Corps of Engineers. (Note that several scientists disagreed with this finding, suggesting that eelgrass beds may not play a critical role in San Francisco Bay, because as far as scientists know they are very limited in distribution within the Bay.)

i. Native oyster reefs may warrant special protection and possible restoration.

4. **Further Knowledge Needed**

a. There is a need to document the benefit of subtidal habitats.

b. There is a need to inventory the Bay's subtidal environment and the aquatic life and wildlife which depend upon this resource. In particular, the relationship between the physical regime and the biological populations are largely unknown and deserve attention.

c. While scientific knowledge about the hydrodynamic processes defining the Bay is well advanced, there is a need to increase knowledge of other relevant physical processes, such as sediment dynamics, including sand transport, wind/wave effects on sediment movement and cohesive sediment interactions.

d. Major gaps in knowledge exist about the Bay's subtidal environment due to the dynamic nature of the system and the complexity of linkages between subtidal habitats and the species which occupy them.

5. **Protection and Restoration**

   a. Areas of the Bay subject to tidal action should be expanded; subtidal habitat should be increased. (Note: some scientists also suggested that subtidal habitats should be more complex. Willingness to trade one habitat for the other needs further discussion).

   b. Deep water habitat is valuable in the Central Bay; artificially created shallow water habitat in that subregion is not needed.

   c. Shallow water and deep water are important to aquatic life and wildlife.

   d. Opportunities to enhance and restore subtidal habitat should be explored.

   e. There is a difference between subtidal habitats and the terrestrial bayland habitats in that subtidal habitats, for the most part, are still intact, making protection and restoration a different kind of challenge.

   f. Maintaining a balance between shallow subtidal habitat and deep subtidal habitat is important in terms of protection and restoration of the Bay's subtidal environment. For example, many fish species depend on interconnected deep and shallow water habitat for their daily search for food and refuge. Furthermore, shallow water habitat is important for the movement of sediment, while deep water habitat is critical to salt transport throughout the Bay.

   g. Subtidal habitat critical to the well-being of threatened or endangered species should be protected to the greatest extent possible.

6. **Additional Conclusions from Panel Members**. As discussed above, a few panelists agreed to craft further suggested conclusions; these are listed below:

   a. The bathymetry of the bottom of the Bay has changed over time as a result of natural processes (for example, tides, sea level rise and changing climate and river flow) as well as human activities (for example, hydraulic mining, dam building, river diversion and dredging) with the result that the bathymetry at any location and moment in time reflects the balance of these competing physical forces.

   b. San Francisco Bay is a single ecosystem with interconnected subtidal habitats. Tidal and freshwater flows indirectly influence all parts of the Bay; salt, sediment, and other substances move throughout the Bay. Many of the biological resources use different parts of the Bay during various parts of their life cycles; these biological components often are strongly influenced by variations in physical processes.

   c. The ways that physical and chemical processes manifest themselves, and the ways that species use the system depend on the specific season, year and location. At every location bathymetry influences tidal dynamics, vertical stratification of the water column, transport of salt and other substances, as well as sediment movement. In sum, either directly or indirectly bathymetry affects the movement, residence and abundance of aquatic organisms.

   d. Bathymetric features, such as underwater rocks, deep channels and sand shoals have great influence on water movement in the local vicinity of these features and, in turn, influence the way these areas are utilized by aquatic life and wildlife.

   e. Linear boundaries on a map do not reflect the spatial continuity of many of the physical, chemical or biological characteristics of the Bay, nor do they illustrate the localized affects of fronts, stratification, turbulence, pollutant input, and fish aggregation.

APPENDIX A

BENTHIC SUB-ASSEMBLAGES[1]

Fresh-Brackish Sub-Assemblages

1. **Fresh-Brackish Muddy.** Located in the Delta, this sub-assemblage of benthic organisms is found in areas composed primarily of silty clay and fresh to brackish water. The primary benthic organisms associated with this area include a non-native filter feeding worm, *Manayunkia speciosa,* from the eastern United States, and a non-native clam from Asia, known as *Corbucula fluminea.*

2. **Fresh-Brackish Sandy.** Consisting primarily of sandy sediment and fresh to brackish water, this sub-assemblage is less diverse in benthic species than the fresh-brackish muddy assemblage. Also located in the Delta, the primary benthic species composing this sub-assemblage include the most common *C. fluminea,* as well as *Chaetogaster limnaei,* and *Paratendipes.*

3. **Estuarine Transition Sub-Assemblage.** This sub-assemblage is located at the confluence of the Sacramento River, Suisun and San Pablo Bay and is a transitional area between the freshwater of the Delta and the more saline water of the Bay. A defining feature of this sub-assemblage is that benthic organisms found here exist in an area which fluctuates greatly in salinity and suspended sediment concentrations, due to changes in Delta outflow, and therefore they must be able to tolerate a wide range of physical conditions. A primary organism associated with this sub-assemblage is the non-native Asian clam, *Potamocorbula amurensis.* Significantly, the presence of this invasive clam has changed the ecology of Suisun Bay by filtering out large quantities of plankton, and thus reducing its availability for other organisms.

Estuarine Sub-Assemblages

1. **Main Estuarine Sub-Assemblage.** Comprised of portions of both the North and South Bay, which have similar mixed fresh and saltwater salinity regimes, this sub-assemblage is composed primarily of two introduced benthic organisms, the introduced Asian clam, *Potamocorbula amurensis,* and the tube-dwelling amphipod, *Ampeliscaabdita.*

2. **Estuarine Disturbed Sub-Assemblage.** This sub-assemblage consists primarily of opportunistic benthic organisms which are tolerant of pollutants. Dominant species include tubificid oligochaetes and spionid polychaetes. Locations where these sub-assemblages occur include areas near an abandoned oil refinery discharge in Castro Cove and China Camp.

Marine Assemblages

1. **Central Bay Marine Muddy Sub-Assemblage**. Both marine and estuarine associated benthic organisms are found in this sub-assemblage, with *A. abditat* being the most commonly found species. Good indicators of this sub-assemblage include the presence of *Leptochelia dubia* and *Corophium insidiosum* because they were not found in other sub-assemblages.

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[1] Bruce Thompson, Sarah Lowe, and Michael Kellog, *Results of the Benthic Pilot Study 1994-1997: Part 1 Macrobenthic Assemblages of the San Francisco Bay Delta, and their Reponses to Abiotic Factors.* (August 2000): Technical Report 39.

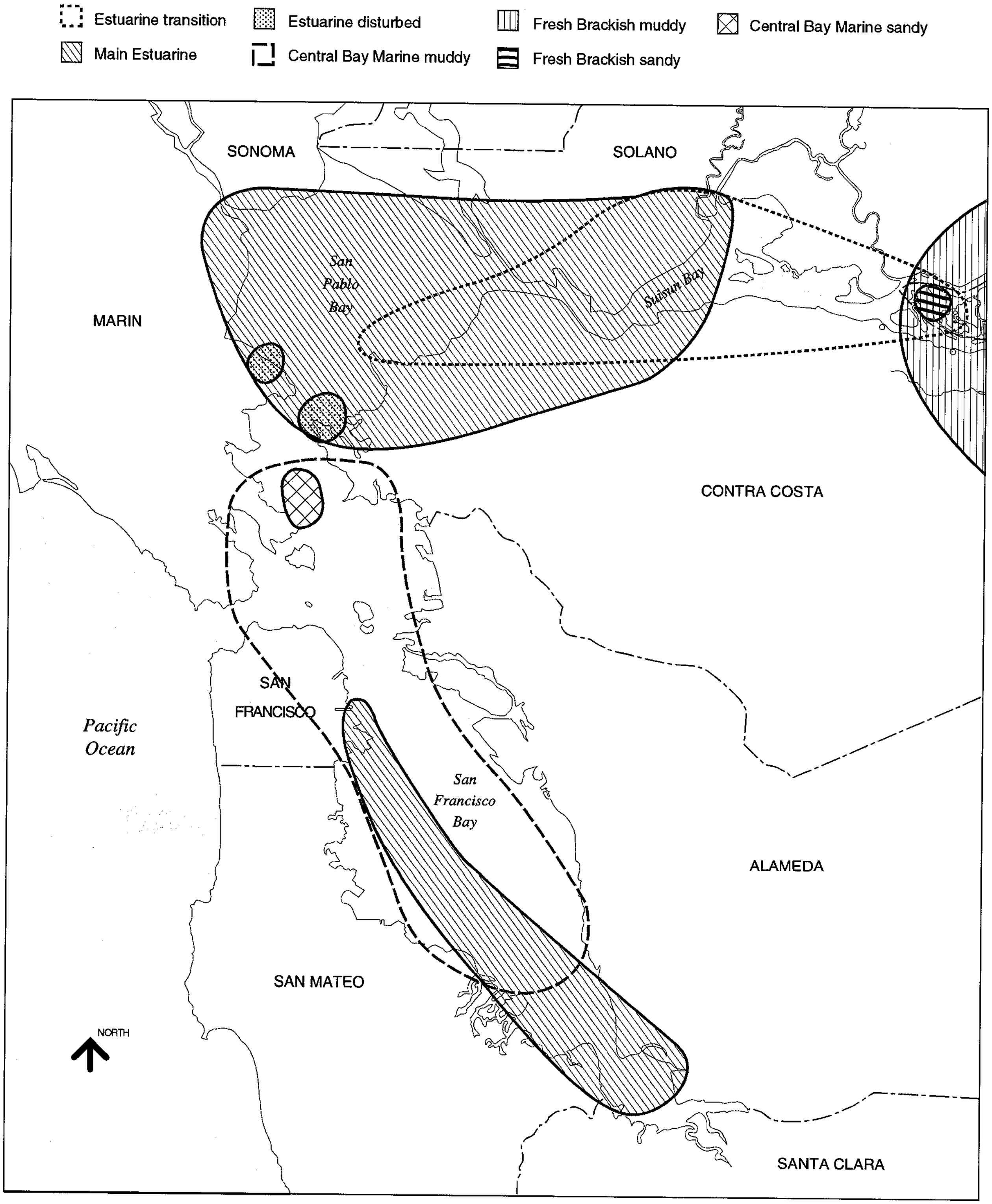
2. **Central Bay Marine Sandy Sub-Assemblage**. Composed of mostly sand, this sub-assemblage is characterized by low numbers of species and abundances within these species. The most abundant organisms associated with this sub-assemblage includes *Heteropodarke heteromorpha, Hesionura coineaui difficulis* and *Glycera tenuis.*

   Overall, the number of species-types and abundance of organisms within each of those species was highest in the marine-muddy sub-assemblage, while the lowest was in the fresh-brackish sandy sub-assemblage. The estuarine transition sub-assemblage also had low species and abundance. These benthic assemblages are mapped in greater detail below. It is important to keep in mind is that dynamic shifts in these assemblages sometimes occur due to factors as diverse as changes in Delta outflow and the introduction of invasive species.

Figure A-1

SOURCE: Adapted from SFEI *Results of the Benthic Pilot Study 1994-1997: Part I - Macrobenthic Assemblages of the San Francisco Bay-Delta, and their Responses to Abiotic Factors* (2000).

San Francisco Bay Benthic Sub-Assemblages



APPENDIX B

DESIRED OBJECTIVES FOR A SUBTIDAL ECOSYSTEM GOALS PROJECT FROM THE BCDC STAFF PERSPECTIVE

The subtidal science panel assembled by BCDC in September 2000, suggested that BCDC examine the Baylands Ecosystem Habitat Goals process and structure to ascertain what the Commission and other resource agencies might want from a similar effort for subtidal habitats.

Issues to Address. The issues addressed in the Baylands Ecosystem Goals Project would be of great interest to BCDC staff (including the discussion and mapping of past and present habitats, the approach to developing goals, key habitats of the subtidal system, the habitat goals themselves, factors to consider in restoring and enhancing subtidal habitats, scientific research needs, and next steps).

The following additional subjects would also be of interest to BCDC staff:

1. Are marine refuges warranted in the Bay? If so, where?
2. Are there sub-habitats or components of habitats in the Bay that are especially worthy of protection from disturbance? (in other words, habitats or features of special value?)
3. Should certain habitats be traded for others? If so, under what circumstances?
4. What habitats have we lost or gained in the four subregions of the Bay?
5. Guidelines for permitting projects in subtidal habitats.
6. Further exploration of a subtidal habitat classification system (if warranted).
7. A list of critical future research needed to more fully understand subtidal habitats.
8. Restoration, protection, and mitigation approaches and suggestions.
9. A discussion of the linkages between terrestrial habitats and subtidal habitats, where they are known to be critical to the well-being of particular species of concern, and how these linkages are best restored and/or protected.
10. A list of species of special concern associated with subtidal habitats.

Process Differences. Staff concurs fully with the process differences that the Subtidal Panel suggested (including a shorter timeline, smaller working group, etc.)

Other Differences. A key difference between a Subtidal Ecosystem Goals Project and a Baylands Ecosystem Goals Project is the matter of land ownership. The Baylands Goals Project provides a vision for all of the Baylands, many of which are privately owned. Thus, some portions of the vision must be implemented voluntarily by supportive landowners. However, subtidal habitats are owned and governed, in large part, by the public trust. The public trust is a publicly-owned property right which may be used by government to promote public trust purposes or to protect public trust values, such as navigation or habitat protection.* This authority over the subtidal environment may present opportunities which were not feasible in the Baylands Goals Project. For example, a Subtidal Goals Project could encompass not only a template for restoration and protection of subtidal habitats, but it could also suggest implementation measures and policy objectives to achieve those goals. In addition, this document could suggest activities which should be encouraged in the subtidal environment and activities which should be restricted in certain locations.

A Subtidal Goals Project may also need to focus more effort on both identifying and coordinating critical research needs, due to the relative dearth of information regarding subtidal habitats. Some of the potential products and research needed to complete a Subtidal Ecosystem Goals Project may include:

* Staff Report. 1984. *Fill Controls*. San Francisco Bay Conservation and Development Commission.

1. Historic maps and descriptions of the Bay region prior to the Gold Rush period.
2. Historic bathymetric maps of the Bay.
3. A map illustrating the primary anthropogenic influences on the Bay (e.g. municipal discharges, toxic hot spots, areas of sand dredging and invasive species distributions).
4. Detailed sonar images of the Bay bottom.
5. A sediment texture map of the Bay.
6. A series of maps presenting the prevailing hydrodynamic conditions in each area of the Bay, including processes at tidal to interannual time scales.
7. A study of sediment dynamics illustrating the processes that are influencing the movement and deposition/erosion of sediments in each area of the Bay.
8. Documentation of water chemistry, including the basic parameters of salinity, temperature, oxygen, suspended materials, phytoplankton (as chlorophyll) and how these are influenced by natural and human-induced factors.
9. Generalized patterns of distribution of non-motile organisms on the Bay bottom.
10. Habitats (for spawning, pupping, rearing, feeding, etc.) and migration routes of all plankton, nekton, fish and marine mammal species of interest and concern.
11. Habitats (for nesting, resting, feeding) for bird species that use the Bay at any time in their lives.
12. Habitats that are limiting to particular species.
13. Habitats by region and type that could be enhanced to improve the condition of important native species.

Agency Inclusion. Other agencies which could benefit from such an effort include the National Marine Fisheries Service, the Coastal Conservancy, the San Francisco Regional Water Quality Control Board, the U.S. Fish and Wildlife Service, the California Department of Fish and Game, and a multitude of non-profit organizations. These agencies should be consulted about how they might utilize the subtidal goals before such an effort begins.

Next Step. A funding source needs to be identified, as well as an organization interested in facilitating the process. Suitable agencies might include the U.S. EPA, the San Francisco Estuary Institute, the San Francisco Estuary Project, the National Marine Fisheries Service, or BCDC, among others.

APPENDIX C

MANAGEMENT AND REGULATORY PROGRAMS THAT PROTECT PLANTS, AQUATIC LIFE AND WILDLIFE OF THE BAY

Numerous laws and programs at the state and federal level have been established that are designed to ensure that species of aquatic life, wildlife and plant life do not become extinct. The focus of this chapter is on the primary measures undertaken by state, federal and non-governmental organizations to ensure the future well-being of species which are at-risk and associated with San Francisco Bay, as well as the species protected by these programs. Importantly, the aquatic life and wildlife addressed in this chapter are part of the group of species chosen by the Goals Project as representative members of the Bay's ecosystem. Representative species are those which are dominant members of a particular habitat, or which are habitat or community indicators, meaning that the presence of a certain species indicates to biologists the existence of a certain habitat or assemblage of associated species. Furthermore, the plant species addressed in this chapter were chosen by the Goals Project as belonging to important plant communities found throughout San Francisco Bay. Therefore, this list of at-risk wildlife, aquatic life and plant life is not all inclusive of Bay species threatened with extinction. However, this discussion focuses on the bigger picture of Bay habitats faced with the loss of many species, and the variety of programs being implemented in an effort to halt these potential extinctions.

This discussion regarding the categorization of species at-risk is reliant upon information outlined in the California Department of Fish and Game's, Wildlife and Habitat Data Analysis Branch, California Natural Diversity Database (CNDDB). The CNDDB is a continually refined and updated, computerized inventory of location information on the increasing number of rare animals, plants, and natural communities, as well as their status in regards to their rarity. The blueprint used to set up the CNDDB was developed by The Nature Conservancy (TNC) in the early 1970's. Similar programs have been established by TNC in all 50 states and a number of foreign countries. Collectively these programs are known as the Natural Heritage Network.

Programs Established to Protect Species in Decline[1]

1. **California Endangered Species Act of 1984.** Under the California Endangered Species Act a plant or animal species can be listed as endangered or threatened, or a candidate for listing as endangered or threatened. Similar to the federal ESA, species can be candidates for listing or de-listing as endangered or threatened, and can be "uplisted" from threatened to endangered or "downlisted" from endangered to threatened. Candidate species under CESA are the equivalent of species proposed for listing (or delisting) under the federal ESA. A state endangered species is defined as,

   > a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease.[2]

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[1] This chapter is adapted from the State of California, The Resources Agency, Department of Fish and Game, Wildlife and Habitat Data Analysis Branch, California Natural Diversity Database, Special Animals and Special Plants List from January 2000 at: http://www.dfg.ca.gov/endangered/specialanimals_jan2000all.pdf and http://www.dfg.ca.gov/whdab/plant4-00.pdf

[2] California Department of Fish and Game Code, Section 2062.

Under the California Endangered Species Act, a threatened species is,

> a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by the Act.[1]

A candidate species is,

> a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that the commission has formally noticed as being under review by the department for addition to either the list of endangered species or the list of threatened species, or a species for which the commission has published a notice of proposed regulation to add the species to either list.[2]

2. **Endangered Species Act of 1973.** Under the federal Endangered Species Act, species can be listed as endangered, threatened, proposed for listing as endangered, proposed for listing as threatened, a candidate species, delisted and proposed for delisted. Relevant to this conversation is the definition of endangered, threatened, candidate species and delisted. Specifically, an endangered species is, "any species which is in danger of extinction throughout all or a significant portion of its range."[3] A threatened species is defined as, "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."[4]

   A federal candidate species is a species proposed for listing as endangered or threatened, but for which no statutory protection other than Section 7 consultation requirements exist. Under the Section 7 consultation requirement, federal agencies must informally confer with the NMFS or Fish and Wildlife on actions likely to jeopardize the continued existence of a species that has been proposed for listing, or that may destroy or modify proposed critical habitat. Unlike listed species, where federal agencies must formally consult with NMFS or Fish and Wildlife, and are bound by the provisions of the consultation, agencies have discretion as to whether or not they accept conservation recommendations for a candidate species resulting from a conference.

   Finally, a delisted species is one whose future survival is deemed assured and for which no further protection under the Endangered Species Act is required.[5]

3. **Native Plant Protection Act of 1977, Rare Species.**[6] Written as a precursor to the California Endangered Species Act, the Native Plant Protection Act establishes two categories for species at risk of extinction–rare and endangered. While the endangered distinction is similar to that of the California Endangered Species Act (CESA), the rare definition is considered less stringent than the threatened and endangered definition under the CESA.[7] Plants considered rare under the Native Plant Protection Act are "not presently threatened with extinction," but present "in such small numbers that it may become endangered if its present environment worsens."

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[1] California Department of Fish and Game Code, Section 2067.

[2] California Department of Fish and Game Code, Section 2068.

[3] Federal Endangered Species Act, Section 3.

[4] Endangered Species Act, Section 3.

[5] Endangered Species Act, Section 4.

[6] California Department of Fish and Game Code, Sections 1900 et seq.

[7] Emily B. Roberson, Ph.D. and Tara L. Mueller, esq., "California Listed Threatened and Endangered Plants Are Protected Under the California Endangered Species Act" *California Land Use Law and Policy Reporter* (September 1999): 7-10.

4. **California Department of Forestry and Fire Protection, Sensitive Species.** The Board of Forestry classifies as sensitive those species that warrant special protection during timber operations. Specifically, species are listed as sensitive by the California Department of Forestry and Fire Protection if they meet three criteria. First, the California population of the species must require timberland as habitat for foraging, breeding or shelter. Second, the California population must be in decline or threatened by timber operations. Third, continued timber operations under the current rules of the Board of Forestry will result in the loss of the California population's viability.[8] Once all three criteria establishing the at-risk nature of the species are met, the species is determined to be sensitive and regulations ensuring the species' protection during timber operations are mandated and implemented.

5. **Department of Fish and Game, California Special Concern Species.**[9] The goal and responsibility of the California Department of Fish and Game is to maintain viable populations of all native species. To this end, the Department has designated certain vertebrate species as special concern species because declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction. The goal of designating certain animals as special concern is to halt or reverse their decline by calling attention to their plight and addressing the issue of concern early enough to secure their long term viability. Not all species of special concern have declined equally. Some species may just be starting to decline, while others may have already reached the point where they meet the criteria for listing as a threatened or endangered species under the state and federal endangered species acts.

6. **Department of Fish and Game, Fully Protected and Protected Species.**[10] Animal species listed by the Department of Fish and Game as protected species may not be taken or possessed without a permit from the Fish and Game Commission and/or the Department of Fish and Game. Fully protected species may not be taken under any circumstances.[11]This category of protection was written into the Fish and Game Code prior to the creation of the California Endangered Species Act in 1984. As a result, an overlap of species may exist where one organism is both fully protected or protected, as well as listed under the CESA and ESA.[12] Similarly, a species listed under the CESA is not necessarily listed as protected or fully protected by the Department of Fish and Game.

7. **United States Forest Service, Sensitive Species.**[13] The United States Forest Service participates in recovery programs with the California Department of Fish and Game and Fish and Wildlife to restore declining populations of animals and to protect their habitats. Furthermore, these recovery programs for at-risk species ensure that Forest Service activities do not further harm sensitive species by both identifying and managing them in a scientifically sound manner.

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[8] California Department of Forestry and Fire Protection, Forest Practice Rules, Sections 919.2, 939.12, 959.12. (http://www.fire.ca.gov/1999RULEi184.pdf)

[9] Four reports on Species of Special Concern were published by the Department of Fish and Game, *Amphibians and Reptiles of Special Concern, Fish Species of Special Concern, Bird Species of Special Concern* and *Mammalian Species of Special Concern.* Information on these reports is available in Appendix 3 of the Special Animals Report (http://www.dfg.ca.gov/endangered/specialanimals_jan2000all.pdf)

[10] Information on Fully Protected and Protected Species can be found in the Fish and Game Code, (birds at Section 3511, mammals at Section 4700, reptiles and amphibians at Section 5050, and fish at Section 5515). The Fish and Game Code is available on the internet at: http://leginfo.ca.gov/calaw.html.

[11] Fish and Game Code Sections 3511, 4700, 5050, 5515.

[12] Personal Conversation, Darleen McGraph, Department of Fish and Game.

[13] More information is available on the Unites States Forest Service's website at: (http://www.r5.pswfs.gov/robriefings/factsheets/tespecies.html).

8. **United States Bureau of Land Management, Sensitive Species.**[14] The Bureau of Land Management defines "sensitive species" as those which are (1) under status review by Fish and Wildlife or the NMFS; or (2) whose numbers are declining so rapidly that federal listing may become necessary; or (3) those with typically small and widely dispersed populations; or (4) those inhabiting ecological refugia or other specialized or unique habitats. In addition, existing California-Bureau of Land Management policy requires that for a species to be considered sensitive, it must meet two additional criteria. First, a significant population of the species must occur on Bureau of Land Management-administered lands, and secondly, the potential must exist for the improvement of the species' condition through Bureau of Land Management management practices.

9. **Fish and Wildlife Service, Migratory Nongame Birds of Management Concern.**[15] Species considered migratory nongame birds of management concern by the United States Fish and Wildlife Service are listed as such because they have documented or apparent population declines, small restricted populations, and/or a dependence on restricted or vulnerable habitats.

10. **Partners in Flight, Watch List.**[16] The Watch List identifies North American bird species that need help. Watch List species are those faced with population decline, limited geographic range, and/or threats such as habitat loss in their breeding or hunting grounds. The Watch List is an early warning system that focuses attention on at-risk bird species before they become endangered. The Watch List is compiled by Partners in Flight, a coalition of state, federal, and private sector conservationists working together to protect the birds of the western hemisphere. Partners in Flight updates the Watch List yearly to reflect the most current research and data. Overall, the Watch List is an attempt to shift conservation from reactive, last minute rescue attempts to preventive action. In addition, the national Watch List is the foundation for the state lists compiled by the Audubon Society.

11. **The Audubon Society, State Watch List for California.**[17] The Audubon Society's Watch Lists for each state is compiled in response to requests from the organization's membership. State Watch Lists are an effort to provide focus for the organizations' state education, citizen science and habitat protection initiatives. Audubon's state Watch Lists are not meant to supplant state lists of threatened, endangered and special concern species, but instead is an additional tool designed to help citizens conserve their local bird populations.

AT-RISK SPECIES OF PLANTS AND ANIMALS

Plants[18]

1. **Suisun Thistle:** Listed as federally endangered on November 20, 1997.
2. **Soft-Haired Bird's Beak:** Listed as rare under the Native Plant Protection Act in July 1979 and federally endangered on November 20, 1997.
3. **Mason's Lilaeopsis:** Listed as rare under the Native Plant Protection Act in November 1979.

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[14] Bureau of Land Management Manual, Section 6840.

[15] For more information visit the USFWS's website at: http://www.fws.gov/r9mbmo/reports/speccon/tblconts.html

[16] For more information visit (http://www.fws.gov/r9mbmo/conserv/pif.html).

[17] For more information visit Audubon's website at: http://www.audubon.org/bird/watch/state2/ca.html#who

[18] This section on plants is adapted from the State of California, The Resources Agency, Department of Fish and Game, Habitat Conservation Division, Wildlife and Habitat Data Analysis Branch, California Natural Diversity Database, State and Federally Listed Endangered, Threatened, and Rare Plants of California, January 2000 at: http://www.dfg.ca.gov/whdab/cnddb.htm or http://www.dfg.ca.gov/whdab/plant4-00.pdf.

4. **California Seablite**: Listed as federally endangered on December 15, 1994.

Animals[19]

1. **Conservancy fairy shrimp:** Listed as federally endangered.
2. **Vernal Pool Tadpole Shrimp:** Listed as federally endangered.
3. **Steelhead-Central California Coast Evolutionarily Significant Unit:**[20] Listed as federally threatened.[21]
4. **Chinook salmon-Central Valley Spring-run:** Listed as federally threatened and as a sensitive species by the United States Forest Service.
5. **Chinook salmon-Central Valley fall/late fall-run:**[22] Considered a federal candidate species, a Department of Fish and Game California special concern species, and as a sensitive species by the United States Forest Service.
6. **Chinook salmon-Winter-run**: Listed as both state endangered and federally endangered.
7. **Delta smelt:** Listed as both state threatened and federally threatened.
8. **Longfin smelt:** Listed by the Department of Fish and Game as a California special concern species.
9. **Sacramento splittail:** Listed as federally threatened and as a California special concern species by the Department of Fish and Game.
10. **California tiger salamander:** Considered a federal candidate species under the Endangered Species Act, a Department of Fish and Game California special concern species, and a Department of Fish and Game protected species.
11. **California red-legged frog:** Listed as federally threatened, as a Department of Fish and Game California special concern species, and as a protected species by the Department of Fish and Game.
12. **Western pond turtle:** Listed as a Department of Fish and Game California special concern species, and as a Department of Fish and Game protected species.
13. **San Francisco garter snake:** Listed as state endangered, federally endangered, as well as a Department of Fish and Game protected and fully protected species.
14. **American white pelican:** Considered a Department of Fish and Game California special concern species, as well as being on the Audubon Society's state Watch List for California.
15. **California brown pelican:** Listed as state endangered, federally endangered, and as a Fish and Wildlife Service migratory nongame bird of management concern. In addition, this species is listed as fully protected by the Department of Fish and Game.
16. **Double-crested cormorant:** Considered a Department of Fish and Game California special concern species.

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[19] This section on animals is adapted from State of California, The Resources Agency, Department of Fish and Game, Wildlife and Habitat Data Analysis Branch, California Natural Diversity Database, Special Animals, January 2000 at: http://www.dfg.ca.gov/endangered/specialanimals_jan2000all.pdf.

[20] An Evolutionarily Significant Unit is a distinctive individual salmon or steelhead population segment which can be listed as endangered or threatened by the National Marine Fisheries Service under the Endangered Species Act.

[21] Federal listing includes all runs in coastal basins from the Russian River, south to Soquel Creek, inclusive. Includes the San Francisco and San Pablo Bay basins, but excludes the Sacramento-San Joaquin River basins.

[22] Central Valley fall/late fall-run ESU refers to populations spawning in the Sacramento and San Joaquin Rivers and their tributaries.

17. **Northern harrier:** Considered a Department of Fish and Game California special concern species.

18. **American peregrine falcon:** Listed as state endangered, federally delisted, Department of Fish and Game fully protected, Fish and Wildlife Service migratory nongame bird of management concern, and as a California Department of Forestry and Fire Protection sensitive species.

19. **California black rail:** Listed as state threatened, Department of Fish and Game fully protected, and as a Fish and Wildlife Service migratory nongame bird of management concern. In addition, this species is listed on the Partners in Flight Watch List and the Audubon Society's state Watch List for California.

20. **California clapper rail:** Listed as state endangered, federally endangered, and as a Department of Fish and Game fully protected species.

21. **Western snowy plover (coastal population):** Listed as federally threatened and as a Department of Fish and Game California special concern species. In addition, this species is listed on the Partners in Flight Watch List and is considered a Fish and Wildlife Service migratory nongame bird of management concern.

22. **California gull:** Considered a Department of Fish and Game California special concern species.

23. **California least tern:** Listed as state endangered and federally endangered. In addition, this species is fully protected by the Department of Fish and Game and is considered a Fish and Wildlife Service migratory nongame bird of management concern.

24. **Forster's tern:** (nesting colony): This species is listed on the Audubon Society's state Watch List for California.

25. **Burrowing owl:** Considered a Department of Fish and Game California special concern species, a Fish and Wildlife Service migratory nongame bird of management concern, and a Bureau of Land Management sensitive species.

26. **California horned lark:** Considered a Department of Fish and Game California special concern species.

27. **Yellow warbler:** Considered a Department of Fish and Game California special concern species.

28. **Saltmarsh common yellowthroat:** Considered a Department of Fish and Game California special concern species.

29. **Suisun song sparrow:** Considered a Department of Fish and Game California special concern species.

30. **Alameda song sparrow:** Considered a Department of Fish and Game California special concern species.

31. **San Pablo song sparrow:** Considered a Department of Fish and Game California special concern species.

32. **Suisun shrew:** Considered a Department of Fish and Game California special concern species.

33. **Salt-marsh wandering shrew:** Considered a Department of Fish and Game California special concern species.

34. **Salt-marsh harvest mouse:** Listed as state endangered, federally endangered and also as a Department of Fish and Game fully protected species.

35. **Southern sea otter:** Listed as federally threatened and as a Department of Fish and Game fully protected species.

36. **Steelhead-Central Valley Evolutionarily Significant Unit:** Listed as federally threatened.

37. **Coho Salmon-Central California Coast Evolutionarily Significant Unit:** Listed as federally threatened.

38. **Green Sturgeon:** Currently under review for potential federal listing.