4.0 Ecosystem Management Strategies

This chapter spells out management strategies for the Bay's natural resource values by each component viewed in a whole-ecosystem context. Values are collective benefits derived from the Bay, such as wildlife habitat, species abundance and diversity, water purification, industry and military support, tourism, recreation, and aesthetic and spiritual rewards, as well as the intrinsic value of the resource itself.

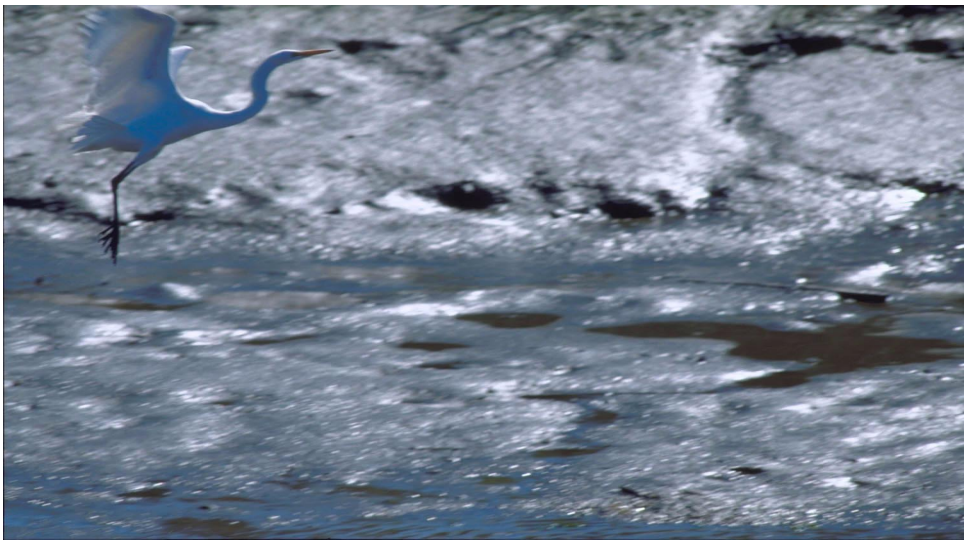


Photo 4-1. Egret at Low Tide.

In this Ecosystem Management Plan, we intend to foster strategies that identify the physical, chemical, and biological roots of these values and protect them.

4.1 San Diego Bay's Natural Resource Values and Ecosystem Management

- The Bay is ideal for human occupation, as well as attractive and valuable to marine species and birds.

As with other coastal bays, San Diego Bay's core natural resource values are its warm, nutrient-rich, shallow waters, shelter from waves, and somewhat reduced number of marine predators. These factors combine to make the Bay especially valuable as a nursery for many marine species, a productive feeding and resting ground for migrating birds and fish, a safe haven for nesting sea birds, and a protected harbor for shipping, commerce, and military staging activities. Adjacent land attracts nesting and roosting birds and human occupation and use. Some of the Bay's estuary-like functions are those presently concentrated in the southern end, where warmer water and higher salinities provide opportunities for organisms indigenous to estuaries to thrive. Throughout the Bay, eelgrass beds support productivity unmatched by most habitats, while unvegetated areas provide foraging opportunities for species that depend upon invertebrates of the soft-bottom substrate for food. The intertidal shorelines provide prey for foraging shorebirds and, especially at high tide, juvenile and adult fishes. Ideal for industry and military use, the harbor-like northern end of the Bay, which opens onto the ocean, provides shelter from waves and the necessary depth for commercial transit.

The maps presented in Chapter 2 and elsewhere summarize some of the ecological values we currently understand about the Bay. Effectively protecting and managing for these values in a complex ecosystem with an intense urban interface requires comprehensive and targeted strategies at multiple scales of resolution. The purpose of the first three chapters of this Plan is to describe the baseline condition of the Bay, as well as to identify information gaps in our ability to assess the Bay's condition. In Chapters 4 and 5, we define policy and management concerns in order to establish objectives and target strategies to address them in a specific way that can be prioritized. In some cases we have an insufficient base from which to work, and the strategy emphasizes information gaps that must be filled to support management decisions.

4.2 Habitat Protection and Management

4.2.1 Strategy by Habitat

4.2.1.1 Deep Subtidal

- See also Section 2.4.1 "Deep Subtidal."

Specific Concerns

- Deep subtidal habitat has increased at the expense of shallower types, which are the most productive Bay habitats both locally and regionally.
- Channels of adequate depth and width are needed to support the navigation and commerce functions of the Bay; existing depths may not be adequate for future needs.
- Deep water use by foraging and rafting birds may be disturbed temporarily by turbidity plumes from construction and dredging projects, and chronically by boat and ship traffic. Turbidity effects from vessel traffic on biological resources are unknown.
- Spatial and seasonal patterns of temperature, salinity, plankton, and invertebrates (water column and benthic) in deep water habitat have not been adequately described, yet they have significant implications for the Bay's ecosystem.

- Deep water links regions of the Bay together hydrologically, affecting the export of energy and organisms among habitats and out to sea. Deeper dredging and lengthening of deep channels affect Bay circulation, velocity, tidal flushing, subsurface erosion, and sediment movement throughout the Bay, but with unknown ecological implications or significance.
- Most of the deep benthic habitat has been disturbed by channel dredging and repeated maintenance dredging, with the presumed impact based on the untested assumption that recolonization by natives, not invasive exotics, occurs fairly rapidly.
- Inputs may still be affecting ongoing contamination status of the deep water column and sediment, with unknown consequences for biota.
- Opportunities are needed in the Bay to provide for more shallow habitat without impacting the navigation channel function of deep water habitat. Narrowing the width or constraining the realignment of navigation channels to provide more shallow subtidal habitat restoration opportunities may conflict with harbor safety.

Photo 4-2. Bay Traffic.

Current Management

Compared to historic (1859) conditions, deep water habitat in the Bay has increased by 1,800 acres (728 ha), or 100%, opening up the harbor for navigation. The deeper and more extensive the dredging, the more harbor- and ocean-like the Bay becomes, rather than providing the unique functions now concentrated in shallow areas along Bay margins. Seasonal stormwater inflow is probably the most important source of nutrients to deep water of the Bay, which historically would have come from the various natural drainages. The volume, seasonality, and composition of this water has changed due to urbanization of the upper watershed.

- Dredge or fill impacts within deep subtidal habitat are usually considered temporary as benthic organisms recolonize the habitat within a short time.

Dredge or fill within deep subtidal habitat generally requires a form of mitigation at a reduced level than shallower habitats. Even if an area is determined to have lesser habitat value, it generally still has function and thus requires mitigation for impacts. These impacts are usually considered temporary since benthic organisms will recolonize the habitat within what is believed to be a short time frame. However, this time frame and the nature of the recolonization (i.e. species composition and abundance) are untested in the Bay. Guidelines for avoiding, minimizing, and then mitigating these impacts are those of the overarching Section 404 of the CWA, with onsite and in-kind mitigation usually the preferred type. Actual requirements in San Diego Bay are decided on a case-by-case basis.

Evaluation of Current Management

- The efforts of residents and regulatory protection have made San Diego Bay cleaner than it was 30 years ago.

Good water quality is a key attribute requiring protection in this habitat. Toxic, point-source discharges have largely been abated with the exception of accidents, residual from past abuses, and possible contaminants from ship and boat hulls. Efforts by San Diego residents in the 1950s and 1960s to divert sewage to ocean outfalls, and subsequent regulatory protection, have resulted in a much cleaner Bay than that of 30 years ago. While there are still point sources other than sewage from industrial and military sources that need work, cleanup of nonpoint source pollution remains the primary and potentially more elusive target.

It is poorly known what effects the deepening and shrinkage of the Bay from its historic proportions and changes in the dynamics of freshwater inflow have had on how the Bay functions as a whole system. These may have changed tidal flushing, nutrient availability, and other processes that are tied to the interchange of energy and organisms among habitats, as well as the quality of habitat available.

While the deep water region is recognized as supporting the least abundance and diversity of organisms in the Bay, it remains important in providing decomposition functions that make nutrients available to higher organisms. The role the deep water region plays in transporting planktonic larvae of both resident and migrating organisms is also important. However, this role is so poorly quantified that prioritizing management activities remains difficult.

Proposed Management Strategy—Deep Subtidal

***Objective:** Retain sufficient deep subtidal habitat to support safe navigation, good water quality, and physical and biological functioning in balance with the need for other habitat types in the Bay.*

I. Support continued management of the deep subtidal for navigation.

- ***A.*** Maintain adequate width and depth of existing channels for safe navigation.
- ***B.*** Conduct dredge and fill operations in the deep subtidal as based on the use strategy detailed in Section 5.3.1 "Remediation of Contaminated Sediments."
- ***C.*** Allow for limited extension of existing channels.

II. Protect the water quality, and physical and biological functions of deep subtidal habitat in conjunction with other Bay habitats.

A. Determine the ecological significance of changes to the Bay's water quality, circulation patterns, sediment movement, and biota that could result from proposed projects (e.g. deepening or lengthening navigation channels) in the deep subtidal.

1. Use appropriate models, such as the TRIM hydrodynamic model developed at SPAWAR, to help answer management questions related to sediment transport in deep waters, such as the effects of deeper dredging on habitat functions of the more marginal Bay habitats.

2. Verify the soundness of these models.

3. Support the development of sediment and water quality standards specific to San Diego Bay that will provide a measure of the health of this habitat.

4. Promote better understanding of the biotic consequences of water and sediment contamination of the Bay's deep water habitat.

5. Identify the important biological functions of deep subtidal habitat through appropriate research, as described below.

B. Promote adequate mitigation and enhancement actions for effects due to expanding or deepening the deep subtidal.

1. Protect bird rafting and foraging in the open water, navigation channel areas.

a. Prevent the creation of turbidity plumes from dredging and construction projects as much as possible.

b. Identify and implement methods to reduce disturbance by ships, boats, and recreational craft.

c. Avoid dredging so close to salt marsh or mudflat habitat that they will erode away.

d. Keep new navigation channels to a minimum.

e. Consider keeping new navigation channels to the east side of the Bay, where they are currently aligned.

2. Specify and apply existing criteria to evaluate effectiveness of mitigating and enhancing deep subtidal habitat.

C. Explore alternative methods to recapture some of the abundant deep subtidal areas in order to develop more of the scarce shallow subtidal (<12 ft/3.7 m) habitat.

1. Identify possible sites where realignment of existing navigation channels could provide sufficient slope and width for shallow subtidal habitat.

III. Pursue cost-effective, targeted monitoring and applied research that address management-related questions about the deep subtidal habitat.

A. Evaluate the spatial and seasonal distribution and abundance of biota in the deep subtidal habitat zone, with priority on those biota for which inadequate information is available.

1. As a further focus, determine the rate, extent, and quality of recolonization of benthic deep subtidal habitat disturbed by maintenance or construction dredging projects, including the effect, if any, on the spread of invasive exotic invertebrates (e.g. Japanese mussel).
2. Determine the linkages of ecosystem function between deep subtidal and the other Bay habitats.

B. Directly measure and observe long-term trends in key biological and water quality parameters of the deep subtidal zone, using scientifically valid methods that are low in expense, in order to foster their long-term implementation, yet high in providing insight.

1. Obtain necessary sampling equipment and establish an adequate number of representative sampling stations in diverse locations throughout the Bay. Sample intensely around project sites and during a range of seasonal, diurnal, and tidal cycles.
2. Focus on evaluating indicators that are relatively easy and cheap to measure so that they may more likely be monitored on a long-term basis (e.g. chlorophyll a, zooplankton biomass, transparency, dissolved oxygen, temperature).
3. Obtain samples at the surface and at incremental depths to the bottom, including the benthic.
4. Seek cooperative assistance in implementing monitoring, such as from Navy or Port personnel, volunteers, or college students who can be trained and have boat access to the stations.
5. Compare results with those for equivalent parameters collected in the ocean and estuaries of the Southern California Bight.

C. Work in partnership with the RWQCB as portions of the Bay Panel's San Diego Bay Coordinated Monitoring Program are implemented.

1. Allow for differences in priorities recommended by this Plan.
2. Ensure the sharing of data and the avoidance of duplication.

4.2.1.2 Moderately Deep Subtidal

Specific Concerns

- Moderately deep subtidal habitat provides an opportunity for habitat enhancement with fewer navigational need conflicts, by shoring it up to shallower depths. However, the opportunity for beneficial use of dredge material for such enhancement comes rarely and may require innovative implementation of CWA and other applicable guidelines without compromising their intent, including protection of water quality, fish habitat, and other functions and values.
- Moderately deep areas are candidates for expansion of deep navigational channels.

■ See also Section 2.4.2 "Moderately Deep Subtidal."

Current Management

This habitat is managed similarly to deep water.

Evaluation of Current Management

While the same questions about current management remain for this habitat as for deep water, they are perhaps of more immediate importance in moderately deep habitat. This is because the habitat overall is more stable, having remained undisturbed by dredging for well over 50 years, and thus the benthic community and its functions may be better developed. These moderate depths can be made shallower and more productive by the use of dredged material. The shallower habitat would be expected to benefit from the establishment of algal communities on the benthos, unlike deeper habitat where insufficient light reaches the bottom to support these communities. As a result, they have a separate value from deep water areas by virtue of their long-term lack of disturbance from dredging, potentially more well-developed benthic community, and their enhancement potential.

Proposed Management Strategy—Moderately Deep Subtidal

Objective: Protect and enhance the attributes of moderately deep habitat that support diverse and abundant invertebrate forage for fishes and birds, as well as needed exchanges of energy, materials, and biota among habitats, in balance with the need for shallow and intertidal habitats.

Barred sand bass

I. Protect rafting shorebirds (see Section 4.2.1.1 "Deep Subtidal"), fishes, and production of abundant and functionally diverse invertebrate forage for rays, California halibut, sand bass, and other predators.

- ***A.*** Discourage new navigation channels in this habitat in order to protect opportunities for creation or enhancement of shallow and intertidal habitats.

II. Moderately deep subtidal habitat should be targeted for potential habitat enhancement by converting to shallower depths that are more productive.

- ***A.*** Conduct the preplanning necessary to take advantage of opportunities for filling moderately deep habitats to shallow or intertidal elevations.

III. Investigate and monitor attributes of moderately deep habitat as described for deep habitat, but with emphasis on the benthos which is expected to be better developed than in deeper habitat.

4.2.1.3 Unvegetated Shallow Subtidal

■ See also Section 2.4.3.1 "Unvegetated Shallow Soft-Bottom."

Specific Concerns

- Only about 58% of historic (1859) shallow subtidal habitat, both vegetated and unvegetated, remains today in the Bay. It is therefore considered a scarce habitat that requires protection and enhancement.
- While less productive for fishes overall than vegetated sites, unvegetated shallow habitat plays an important ecological role in food web support and is critical to the needs of certain rays and flatfishes, including use as a nursery by the California halibut, a commercial species. Red algal mats add three-dimensional structure to this habitat in much of the Bay especially in the summer, and its significance has not been evaluated. These values need quantification, and then protection if the value is found to be of importance. Shallow subtidal habitat may be lost to projects such as expanding navigation channels, pier construction, or the building of boat ramps.

- Project construction in shallow subtidal can create temporary turbidity that impacts foraging for the endangered California least tern and other birds.
- The values of unvegetated shallow subtidal are poorly described or quantified, and so are not fully appreciated during project impact review and mitigation discussions. This may be partly due to its lesser protection under Section 404 of the CWA (no designation as a Special Aquatic Site).

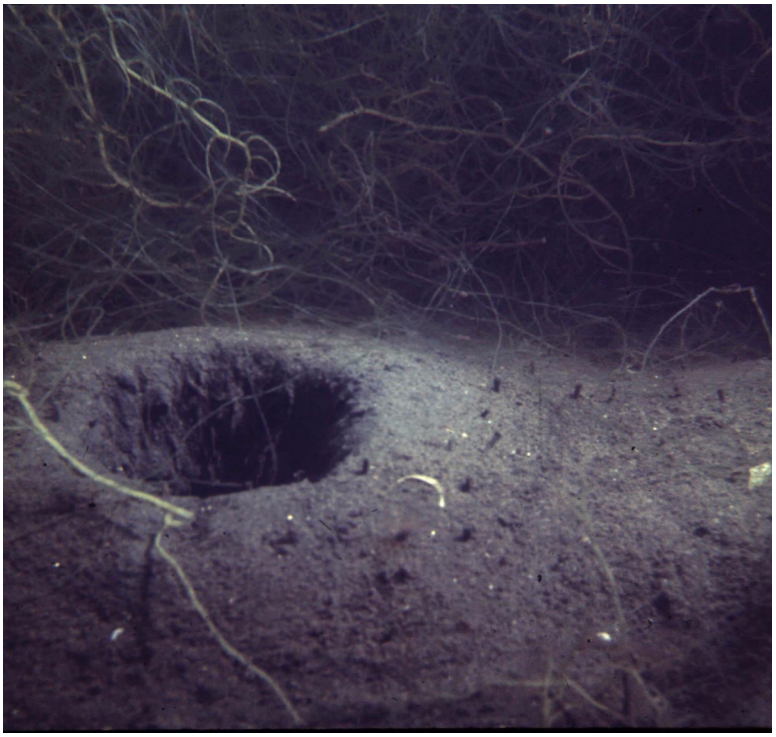


Photo 4-3. "Crater" Produced by a Tube Worm or Bivalve Mollusk.

- While recognizing that much of the Bay functions as a nursery for various fishes, specific nursery locations within unvegetated shallow subtidal areas of the Bay are not identified, so they cannot be managed to prevent conflict with users.

Current Management

- Mitigation decisions for unvegetated shallow subtidal habitat are made on a case-by-case basis within the guidelines of Section 404 of the CWA.

This habitat has been broadly protected as waters of the United States under Section 404 of the CWA since its implementation in 1972, and by Section 10 of the Rivers and Harbors Act. Within those guidelines mitigation decisions in the Bay are made on a case-by-case basis.

Under the ESA, in subtidal habitats turbidity plumes created during dredging operations in the upper water layers (to about 18 in/46 cm) (M. Kenney, pers. comm.) must be contained by silt curtains or otherwise mitigated due to interference with foraging by the least tern and brown pelican, which are listed species. In addition, noise created during construction or maintenance activities such as pile driving must also be mitigated during periods when these species are foraging due to the potentially significant effect of noise on fish forage. Least terns do not appear to be much affected by at least some noise patterns, since they nest at Lindbergh Field.

Evaluation of Current Management

- Unvegetated shallow subtidal in the Bay is important as a nursery for the California halibut, but this species continues a long-term decline in abundance attributed to overfishing (Frey *et al*. 1971; Karpov 1981; Barsky 1990).

While projects in this habitat are infrequent, state and federal programs appear to have allowed a range of interpretation and enforcement when they do occur, with emphasis on site- and project-specific decisions, dependence on perceived availability of sites and ability to identify alternatives, reliance on limited funding available for a specific project, and reliance on what is thought to be a reasonable permit requirement based on the size of the project. There is no local policy in place for protecting this habitat as there is for eelgrass. The lack of descriptive or quantitative information about the values at stake in unvegetated areas has probably hindered its protection, especially since it has been considered "less productive" compared to neighboring eelgrass beds. Unvegetated shallow subtidal in the Bay is important as a nursery for the California halibut. This species continues a long-term decline in abundance attributed to overfishing (Frey *et al*. 1971; Karpov 1981; Barsky 1990).

Proposed Management Strategy

Portions of the following outline form part of a proposed "Southern California Policy to Protect Unvegetated Shallows," a draft of which may be found in Appendix H. Appendix H also contains a background paper on the functions, values, and response to disturbance of unvegetated shallow subtidal habitat "Soft Bottom Shallow Subtidal Habitat Functions and Values: A Basis for Policy Development."

Proposed Management Strategy—Unvegetated Shallow Subtidal

- Portions of the following outline form part of a proposed "Southern California Policy to Protect Unvegetated Shallows," a draft of which may be found in Appendix H. Appendix H also contains a background paper on the functions, values, and response to disturbance of unvegetated shallow subtidal habitat.

***Objective:** Protect and enhance the attributes of unvegetated shallows that sustain a diverse and abundant invertebrate community, fish and wildlife foraging, nursery function for certain species such as the California halibut, as well as an ecological role in detritus-based food web support.*

I. Avoid loss and minimize unavoidable losses of unvegetated shallows. Allow no net loss of unvegetated shallows in either acreage or in existing net biological values. Net biological value could be evaluated using the guidelines below in outline *IIB1b*.

- ***A.*** Provide clear guidelines for avoiding impacts as a first priority.

II. Provide effective mitigation and enhancement for impacts to unvegetated shallow subtidal habitat quantity and quality.

- ***A.*** Continue to implement Best Management Practices (BMPs) during construction and dredging projects to keep temporary turbidity increases to a minimum, for the protection of foraging birds and fishes.
- ***B.*** Fully mitigate project impacts due to dredging or fill.
  - *1.* Since project impacts are relatively infrequent and small-scale in unvegetated shallows, implement mitigation requirements on a case-by-case basis using the following as a guide:
    - *a.* Provide clear guidelines for minimizing impacts.
      - *1.* Alternative, innovative designs should be encouraged and considered early in the project planning stages that minimize impacts. Adjustments in project siting should also be considered to avoid or minimize impacts.

b. Mitigate unavoidable impacts, recognizing and providing a means to define at least some differences in site value and restoration potential.

1. Differences in site value could be determined by:

A. Area affected.

B. Patch size/fragmentation.

C. Abundance/density of infauna.

D. Diversity of infaunal lifestyles (dwelling modes and feeding modes). High density of one species or lifestyle (e.g. subsurface-deposit feeders) can indicate a fairly degraded system. Suspension feeders, burrowers, tube builders, etc. all coexisting denote a fairly healthy system.

E. Presence of larger infauna (ghost shrimp, clams etc.).

F. Site maturity (time since last disturbance).

G. Use as a nursery by halibut or other fishes.

c. Consider recolonization rates for mitigation ratio discussions. Recolonization rates for invertebrates impacted in the unvegetated shallow subtidal have not been examined in San Diego Bay, but depend on several factors (degree of disturbance, proximity of propagules, individual species' life span) and may vary from six months to three years (see Section 5.1.1 "Dredge and Fill Projects").

d. Facilitate the local, beneficial use of dredge material for enhancement projects when the material has appropriate characteristics. When replacement shallow subtidal habitat sites are needed to mitigate for project-caused losses, convert from medium or deep subtidal habitats.

1. Mitigation requirements for effects on medium or deep subtidal should be minimized, in the context of an enhancement project, or waivered altogether, due to the net benefit to the Bay and the objectives of this Plan.

2. Armoring (adding rock or other hard substrate) of unvegetated shallows is a conversion from a habitat that is scarce compared to its historic area and proportions to one that is not indigenous to San Diego Bay. It should be treated as a partial fill.

C. Evaluate effectiveness of mitigation and enhancement efforts.

1. Use the same parameters described under *IIB1* to evaluate effectiveness compared to a control site. The monitoring of an adjacent or other acceptable control area (subject to the approval of the resource agencies) should also be conducted to account for any natural changes or fluctuations, and should be included as an element of the overall program.

2. Continue to make the following part of permitting requirements:

a. Specify and apply existing criteria in permit conditions to measure effectiveness of BMPs to turbidity control.

b. A monitoring schedule that indicates when each of the required monitoring elements will be completed should be provided to the resource agencies prior to or concurrent with the initiation of the mitigation.

c. Monitoring reports should be provided to the resource agencies within 30 days after the completion of each required monitoring period.

III. Pursue enhancement opportunities in unvegetated shallows, in support of target species identified to be markers of the health of this habitat, such as the California halibut (see Section 6.2.1 Long-term Monitoring for the Bay's Ecological Condition and Trend).

IV. Pursue cost-effective, targeted monitoring and applied research to address management-related questions about unvegetated shallow subtidal habitat.

A. Improve knowledge of the inhabitants of unvegetated shallow subtidal sites within the Bay.

1. Identify fish nursery locations by species in unvegetated shallow subtidal throughout the Bay at a scale typically useful for project planning (1 in = 600 ft), so that these locations may be protected from user conflicts.

2. Describe the role of very small invertebrate species (interstitial infauna) living within the unvegetated shallow subtidal soft bottom community, as little is known about species composition, structure, or productivity.

B. Improve understanding of the range of attributes in shallow soft-bottom areas that add productivity and diversity to this habitat, such as:

1. the role and significance of red algae beds,

2. the reason for the predominance of sponges in areas of south Bay,

3. the significance of changes in substrate to changes in the benthic community,

4. what it is about the habitat that makes it attractive as a nursery for certain species,

5. whether the length of time since last disturbance affects community composition or structure, and

6. the effects of natural versus human-induced fluctuations in turbidity, nutrients, temperature, deposition rates, and grain size profile.

C. Improve understanding of the dependencies of other habitats on shallow soft-bottom areas.

4.2.1.4 Vegetated Shallow Subtidal

■ See also Section 2.4.3.2. "Vegetated Shallow Subtidal."

Specific Concerns

- Only about 58% of historic (1859) shallow subtidal habitat (both vegetated and unvegetated) remains today in the Bay and it is therefore considered a scarce habitat that requires protection and enhancement.
- The functional value of eelgrass and sea lettuce beds may vary by their size, fragmentation, and proximity to intertidal, marsh, or stream outflow areas. These values are not described or documented well enough that they can be used in mitigation planning.

Photo 4-4. Eelgrass Bed.

- Shallow subtidal areas of the Bay that have potential to harbor eelgrass generally already have it at some level, so there is a diminishing opportunity to locate new eelgrass planting sites as mitigation for projects, unless deeper areas are filled or upland areas are excavated.
- It is unknown why some eelgrass beds are more resilient than others to environmental or anthropogenic disturbance.
- Eelgrass communities are vulnerable to in-water project impacts and activities.
- Eelgrass adjacent to mudflat or salt marsh may provide a refuge for specialized fishes, such as killifish, that migrate from intertidal areas during low tides. This function needs documentation, and then protection if appropriate.

Current Management

Under the Fish and Wildlife Coordination Act, the NMFS, USFWS, and CDFG have commenting authority on Section 404 permits that may impact fish resources. NMFS is considered the lead authority of expertise in matters affecting eelgrass or fish resources of the Bay.

- The Southern California Eelgrass Mitigation Policy provides more specific guidance for vegetated shallow subtidal than is defined by EPA Guidelines.

This habitat has been broadly protected as a Special Aquatic Site under Section 404 of the CWA since its implementation in 1972. A regional policy, the Southern California Eelgrass Mitigation Policy, was agreed upon by the regulatory agencies in July 1991 (most recently revised 2/2/99), and has been periodically updated since then. Prior to 1991 there was no standard policy for eelgrass mitigation. Transplanting of an equivalent area was generally required, but such transplants did not necessarily have to be successful (R. Hoffman, pers. comm.). The policy provides more specific guidance for the Bay's submerged aquatic vegetation than defined by the EPA Guidelines. It can be viewed in its entirety at the website http://swr.ucsd.edu/hcd/eelpol.htm.

- Harvesting donor plants for eelgrass transplanting must be approved by CDFG, and transplanting techniques must be current.

Under the policy, mitigation that occurs concurrently with the impact requires that 1.2 acres (.49 ha) be transplanted for each acre impacted. A ratio greater than 1:1 is required due to the time required for beds to acquire similar structure to that

being replaced. A 1:1 ratio applies if eelgrass transplanting occurs at least three years ahead of the impact, if the impact is temporary, or if the maximum width of impact through the existing eelgrass bed is less than 10 ft (3 m). Eelgrass transplanting may occur adjacent to or nearby the impacted site but in the same Bay region (north, north-central, south-central, or south) by altering deeper habitat, or by excavating uplands to a proper elevation. Donor material for transplanting is to be taken from the impact site and a minimum of two other distinct sites to ensure greater genetic diversity. Harvesting of donor plants must be approved by CDFG since they have authority over state waters. Transplanting techniques must be current with the best available technology at the time of the project. Approaches and techniques used to transplant eelgrass are found in Volume 3 of the South San Diego Bay Enhancement Plan (Macdonald *et al*. 1990) and the Proceedings of the California Eelgrass Symposium in 1988 (Merkel and Hoffman 1990).

Monitoring of the percent vegetation cover and density at the transplant site is required for a five-year period for most projects. A control eelgrass bed, generally adjacent to the transplant site, must be monitored to help account for any natural changes or fluctuations in the bed width or density that may occur. Success criteria are based on similar vegetative cover and density between the transplant site and the impact site, with specific coverages and densities required within certain time periods. If the transplant site fails to meet these criteria, then a Supplementary Transplant Area must be established. If the area of successful transplanting exceeds the mitigation requirements, the additional area can be used as credit in a kind of "mitigation bank" specific to that project proponent. Such credit is tracked under permit terms and conditions for an individual project sponsor rather than the traditional mitigation bank that is formalized at the national rather than local level. The Policy contains a punitive component, in which seven percent additional eelgrass area must be planted for every month of delay under the permit.

Guidelines on mitigation for turbidity impacts are the same as for unvegetated shallows, above.

Evaluation of Current Management

- The CWA and the Southern California Eelgrass Mitigation Policy have abate d the rate of habitat loss for vegetated shallows.

The rate of loss of shallow subtidal habitat has abated with vigilant implementation and enforcement of the CWA and Southern California Eelgrass Mitigation Policy. Eelgrass is believed to be currently established wherever it has potential to grow. It is assumed that since fish readily inhabit newly planted eelgrass beds, that they retain functional value compared to the impacted site. Use by fish in mitigation sites compared to a control has been evaluated in Mission Bay (Hoffman 1990), but a comparison of natural versus transplanted beds for other functions in San Diego Bay has not been attempted.

Proposed Management Strategy—Vegetated Shallow Subtidal

***Objective:** Protect and enhance the attributes of vegetated shallow subtidal sites that sustain a diverse and abundant invertebrate community, fish and wildlife foraging, nursery function for numerous fishes, as well as an ecological role in detritus-based food web support.*

I. Allow no net loss of shallow subtidal habitat in acreage or in existing net biological values. Seek long-term enhancement of eelgrass habitat.

- ***A.*** Continue enforcement of mitigation standards under the Southern California Eelgrass Mitigation Policy.

1. When replacement shallow subtidal habitat sites are needed to mitigate for project-caused losses, convert from medium or deep subtidal habitats in preference to other habitats.
2. Apply BMPs during construction and dredging projects to keep turbidity to a minimum to protect foraging birds and eelgrass beds from disturbance.

B. Evaluate effectiveness of mitigation and enhancement efforts.

1. Specify and apply existing criteria to measure effectiveness of turbidity control BMPs.

C. Disseminate learning on effective techniques in eelgrass mitigation in conference proceedings and elsewhere.

D. Manage all subtidal areas with eelgrass as sensitive nursery and foraging areas for fish.

1. Determine if conflicts occur between surface use of vessels above eelgrass and use of the beds by waterbirds, foraging sea birds, the green sea turtle, and others.

II. Pursue cost-effective, targeted monitoring and applied research to address management-related questions about vegetated shallow subtidal habitat.

A. Seek better understanding of the ecological functioning of eelgrass beds in the Bay.

1. Determine why some eelgrass beds are more resilient than others to environmental or anthropogenic disturbance.
2. Identify benefits of eelgrass beds in proximity to intertidal and marsh areas to improve mitigation planning and enhancement project design.

B. Improve understanding of the inhabitants of vegetated shallows within the Bay.

1. Identify fish nursery locations by species throughout the Bay at a scale useful for project planning (1 in = 600 ft).
2. Identify bird use of eelgrass beds.

C. Determine the success of eelgrass transplant projects in attaining full functional value for all resources (e.g. detrital exchanges with other habitats; amount of organic material produced per unit area, per unit time; invertebrate use; fish use, bird use; etc.).

4.2.1.5 Intertidal Flats

■ See also Section 2.4.4.1 "Intertidal Flats."

Specific Concerns

- Only 16% of the historic (1859) mudflat acreage of the Bay remains, and the functional value of that remaining has been diminished.
- The potential for existence and enhancement of mudflats is limited because they cannot be sustained in the presence of any significant wave action. They must also have a source of fine-grained sediment, and they must occupy broad, flat expanses to be conducive to establishment of necessary anaerobic conditions and permanent invertebrate burrows.

- The physical processes needed to maintain functional intertidal mudflats are being or have been negatively affected by development.
- Continued channel dredging and shoreline armoring, as well as loss of influx from rivers and streams have changed circulation patterns in the Bay, with possible loss of the potential to conduct intertidal enhancement in some locations.

Photo 4-5. Mudflat.

- The relative importance of various wildlife uses of intertidal flats needs to be better described and quantified if these uses are to be protected in mitigation policy. Examples are use as a nursery for development of fish larvae that drift in from open water, as refuge for young-of-year flatfish and decapod invertebrates, for foraging by shorebirds and wading birds, for least tern foraging for smaller fishes consumable by chicks (M. Kenney, pers. comm.), for western snowy plover foraging, and Belding's savannah sparrow.
- Young-of-year California halibut appear to make substantial use of intertidal flats (Allen 1998), and this species shows evidence of decline in abundance (Frey *et al.* 1971; Karpov 1981; Barsky 1990).
- Physical characteristics of subsets of intertidal habitat that provide important function for sensitive species are not described or quantified well enough to be identified in mitigation policy, so they are not necessarily protected. For example, birds use narrow versus broad intertidal differently, as well as coarse-grained versus fine-grained.
- Mudflats may depend on detrital food reaching them from other habitats, such as the salt marsh and eelgrass beds, and on microalgae living in the mud. Their proximity to these habitats may affect their value.
- Intertidal flats are vulnerable to oil spills, organic matter enrichment, and disturbance by personal watercraft.
- We do not know if the nutrient supply function of mudflats in the greatly reduced intertidal areas of the Bay is limiting overall Bay productivity.

- For shorebirds and some fishes, access to intertidal flats may limit their overall ability to use the Bay.
- Unvegetated mudflat habitat is at risk of being lost through invasion by native salt marsh species as well as by the possible introduction of a more aggressive exotic cordgrass, as has happened in San Francisco Bay.
- Inadequate funding has been applied to restore this habitat type.
- In intertidal areas, birds are more abundant and diverse on sandy flats than on rocky substrates, yet such preferable habitats are among the most impacted in the Bay and have not been sufficiently protected from development project impacts.
- Presence of eelgrass in shallow subtidal habitat may preclude the enhancement of an adjacent mudflat under routine application of CWA guidelines.

Current Management

- Mudflats are considered a special aquatic site and may be occupied by the threatened western snowy plover. Protection is from two federal sources: the CWA and the ESA.

Protection of Bay mudflats comes from two federal sources. They are considered a special aquatic site under Section 404 of the CWA, and they may be occupied by the threatened western snowy plover protected under the ESA. The EPA Guidelines under the CWA for mudflats, in addition to the broader guidelines, apply a burden of proof requirement to demonstrate that no practicable alternatives exist that will meet a project's purpose. NMFS and CDFG comment on activities in mudflats as they provide forage for fish, but USFWS remains the lead authority because of the importance of these areas to listed shorebirds. The CCC also regulates mudflats under their definition of a wetland, which includes a 100ft (30.5 m) buffer on the upland edge (14 California Code of Regulations 13577).

Evaluation of Current Management

Intertidal flats are severely reduced from their historic proportions in the Bay and elsewhere in southern California from impacts that pre-dated the CWA. Many dependent shorebirds are declining along the Pacific Flyway. While the Salt Works has replaced some of the original ecological role of intertidal habitat, impacts continue. Routine application of CWA guidelines has not resulted in any improvement.

State and federal programs appear to allow great flexibility and latitude of interpretation and enforcement, with emphasis on site- and project-specific decisions, dependence on availability of sites and ability to identify alternatives, reliance on limited funding available for a specific project, and reliance on what is thought to be a reasonable permit requirement based on the size of the project. The project-by-project nature of the permit process and flexibility allowed seem to have led to a continued, gradual loss of intertidal habitat despite the laws, regulations, and policies in place. Until recently, with a mudflat creation projected proposed under the Navy's CVN II project, few resources have been committed to creating or restoring this habitat.

Proposed Management Strategy

- This Plan proposes a Southern California Intertidal Habitat Protection Policy. A draft of this policy is presented in Appendix H.

This Plan proposes a Southern California Intertidal Habitat Protection Policy. A draft of this policy is presented in Appendix H. It draws from the following outline.

Proposed Management Strategy—Intertidal Flats

***Objective:** Achieve a long-term net gain in the area, function, value, and permanence of intertidal flats, and the physical conditions that support this habitat.*

I. Protect existing areas of intertidal flats within the Bay and their use by dependent birds, fishes, and invertebrates, giving priority to medium and low intertidal elevations**.**

A. Avoid future impacts by using alternative locations for Port and Navy projects.

B. Establish an efficient, orderly, and comprehensive Baywide or regional policy with respect to intertidal habitats and shoreline management, similar to the Southern California Eelgrass Mitigation Policy, which will provide the needed consistent and predictable standards for project planners to first avoid, then minimize environmental impacts. (See the draft policy proposed by this Plan in Appendix H, which draws from the following.)

1. Provide clear guidelines, both including and going beyond existing guidelines (USEPA Section 404[b][1] Guidelines for Specification of Disposal Sites for Dredged or Fill Material) for avoiding impacts, minimizing impacts, and mitigating unavoidable impacts to intertidal habitat, and recognizing and providing a means to identify differences in site value and restoration potential.

a. Encourage coordinated environmental impact review during the site selection and design stages, not after.

b. Minimize the creation of new shoreline stabilization structures and reconstruction of expendable, existing armoring (see also Section 4.2.1.7 “Artificial Hard Substrate”).

c. When new armoring or reconstruction of degraded armoring is unavoidable, incorporate maximum practical habitat value for native species, giving priority to “soft” solutions (see also Section 4.2.1.7 “Artificial Hard Substrate”).

d. Provide mitigation to offset the impacts of new shoreline armoring.

e. Provide incentive for habitat enhancement of existing shoreline stabilization structures (see also Section 4.2.1.7 “Artificial Hard Substrate”).

2. Facilitate priority work on broad, gently sloping intertidal areas rather than small, narrow ones, in order to maximize the benefit derived from enhancement effort.

3. Investigate and then consider the relative importance of the following as appropriate as a basis for habitat valuation when planning or evaluating mitigation projects:

- Area affected.
- Patch size.
- Abundance/density of infauna.
- Diversity of infaunal lifestyles (dwelling modes and feeding modes). High density of one species or lifestyle (e.g. subsurface-deposit feeders) can indicate a fairly degraded system. Suspen-

sion feeders, burrowers, tube builders, etc. all coexisting denote a fairly healthy system.

- Presence of larger infauna (ghost shrimp, clams, etc.).
- Sediment stability with wave action, flooding, or migrating sand.
- Drainage/flushing at low tide.
- Use by foraging fishes/rays when the tide is in.
- Use as a nursery by juvenile fishes and decapod invertebrates.
- Habitation by exotic species (e.g. *Musculista senhousia*).
- Use by foraging shorebirds.
- Time since last disturbance by dredging or other disturbance.
- Natural vs armored condition of shoreline.

4. Consider the following principles when determining mitigation techniques:

- Enhance water circulation as affected by surrounding structures to ensure stability/persistence of intertidal sediments.
- Grade to appropriate tide levels—unvegetated high intertidal supports relatively few organisms.
- Improve drainage conditions.
- Place structures subtidally to stabilize.

C. Avoid potential impacts from dredging which could cause the erosion of intertidal habitats. If such dredging is unavoidable, provide adequate measures to benignly stabilize the potential erosion.

D. Avoid loss of mudflat enhancement opportunities due to projects in adjoining habitat types.

E. Pursue exotic species control measures to prevent invasion of mudflats by *Spartina densiflora* or other exotic species (see Section 4.3.1 "Exotic Species").

F. Delineate the locations of all intertidal mudflats within the Bay based on a commonly agreed-upon definition and at a project-planning scale (1 in = 600 ft).

II. Increase the acreage quality and function of mudflat habitat.

A. Conduct Baywide and regional restoration planning for mudflats.

1. Thoroughly characterize existing mudflat remnants in the Bay by microhabitat use for foraging fishes and shorebirds, fish nursery functions, sensitive species support, connectivity or isolation with other habitats, and patch size and shape. Identify the physical or chemical factors that affect habitat use, in support of more effectively targeting mitigation policy and enhancement strategies.

2. Set targets for use by western snowy plover, foraging California least tern, juvenile California halibut, and other declining birds or fishes, where baseline data are available to support the setting of targets.

3. Identify locations and prohibit development in inappropriate locations such as those with significant intertidal resources or fragile biophysical characteristics.

B. Identify specific locations for intertidal enhancement in the Bay, such as abandoned navigational channels or areas of moderately deep subtidal.

1. Preserve existing native shoreline vegetation.
2. Consider expansion of the CVWR to create intertidal mudflats as described in Macdonald *et al*. (1990), by using prior CVWR construction techniques or by building an experimental breakwater to induce natural sedimentation.
3. Expand Emory Cove tidal flats, along with marsh enhancement and expansion, and creation of new eelgrass beds that connect with those off of the South Bay Wildlife Preserve and south Coronado Cays (Macdonald *et al*. 1990).

C. Facilitate the local, beneficial use of dredge material for enhancement projects when the material has appropriate characteristics and volume.

D. Enhance the interchange of nutrients, organisms, and organic matter between mudflats and other habitats in the project design.

E. Develop demonstration projects to convert medium subtidal into mudflat habitat.

1. Document the techniques that have worked elsewhere (e.g. mudflat terraces in Puget Sound) and apply as appropriate.
2. Assess the success of the projects in developing functional mudflat characteristics.

F. Apply successful techniques from demonstrations in additional enhancement projects at sites that are appropriate.

G. Foster innovation and experimentation with mudflat development and improving the habitat value of shoreline structures.

1. Conduct demonstration projects, such as small-scale enhancement of riprap-stabilized banks with mudflat "terraces" using riprap or other measures.
2. Experiment with breakwaters to reduce turbulence in areas where this limits mudflat development or quality.
3. Monitor and assess for appropriate techniques and for functional equivalency to natural mudflats.

4.2.1.6 Salt Marsh

■ See also Section 2.4.4.2 "Salt Marsh."

Specific Concerns

- Only about 12% of the historic salt marsh habitat remains in San Diego Bay, and there are little means to get it back that are not excessively expensive.
- Existing, protected marsh at SMNWR may not be large enough to be self-sustaining or to support dependent species. The salt marsh habitats of the Bay are fragmented by levees, roads, and other barriers, cutting off connection to both middle-intertidal and upland-transition habitats that are needed for species migration and recolonization.

- Light-footed clapper rail, Belding's savannah sparrow, and salt marsh bird's beak are at risk of extinction because of losses and degradation to salt marshes of California.
- Constructed wetlands such as the CVWR, Connector Marsh, and Marisma de Nacion do not function in an equivalent manner to natural marsh in terms of clapper rail support, but do better in some other ways such as support of invertebrates and fishes. These salt marsh restoration projects have experienced long delays in achieving functional equivalency.
- There are several marsh areas that do not have the needed features to attract use by marsh-dependent birds, probably due to lack of channels and proper elevations, intrusion of inappropriate soils, inappropriate nutrient levels, or lack of natural fluctuations in salinity levels.
- While salt marsh alone supports less avian diversity than salt ponds or mudflats—the best of both is when they occur together in sufficient acreage at the right elevations. The beneficial, mutually enhancing juxtaposition of habitats is not recognized in mitigation policy.
- Salt marsh has been favored over unvegetated intertidal in mitigation policy as implemented in the Bay, probably because salt marsh is considered a Special Aquatic Site (a wetland), for which no net loss provisions and higher mitigation ratios apply. While salt marsh is a productive habitat because of photosynthesis by marsh plants and algae, and because of access to nutrients from nitrogen fixation by bacteria or blue-green algae as well as flood tides, there is some evidence that nitrogen may be limiting to the system, at least in constructed marshes.

Photo © 1998 Tom Upton.

Photo 4-6. San Diego Bay Salt Marsh.

- The most important controlling factors for Bay salt marshes are not monitored. These are uninterrupted tidal circulation that provides water, nutrients and oxygen to the marsh, and the infrequent, highly modified freshwater flow regimes of the associated drainages. Surrogates of functioning (plant cover, density, and composition) are monitored because they are related to use by certain targeted plants and birds.

- The yellowfin goby and sailfin molly are exotic fishes inhabiting Sweetwater Marsh that may have already affected community structure. There are also exotic plant introductions, especially at the higher end of the salt marsh.

Current Management

- A standard of no net loss of value or function has been applied to San Diego Bay salt marsh, which is occupied by endangered and sensitive species.

Salt marsh is the only Bay habitat defined as a wetland under the CWA. Since 1994, the standard for no net loss of value or function has been applied to the salt marsh, which means a minimum of one-to-one functional replacement. With only 12% of the historic salt marsh remaining in the Bay, there is no latitude for additional loss.

Salt marsh of San Diego Bay is frequently occupied by endangered or other sensitive species. In the mitigation standards developed for disturbance to salt marsh occupied by the federally endangered light-footed clapper rail, California least tern, and salt marsh bird's beak, an effort was made to use structural surrogates for the functional needs of the clapper rail, such as cordgrass of sufficient height to support use of the plant for nesting. Standards by which the overall performance of two constructed marshes could be evaluated were described in the Biological Opinion associated with this project (US Fish and Wildlife Service 1988), which was designed to offset construction of the Sweetwater Channel, a freeway interchange, and the widening of Interstate 5. The standards are described in Table 4-1.

Table 4-1. Salt Marsh Mitigation Standards.

Location	Standard
The home ranges	The constructed salt marshes need to be large enough to contain seven clapper rail home ranges (i.e. seven nonoverlapping areas, each 2 to 4 acres/0.8 to 1.6 ha in size). Each home range should be composed of low, middle, and high salt marsh; the low marsh should be at least 15% of the area and the high marsh should be at least 15% of the area.
The high marsh	In each home range, the high marsh should contain at least 75% of the native vascular plant species found in reference sites in the natural marsh. In each home range, the high marsh should have few exotic species—they should occupy less than 10% of the cover. There should be five patches of salt marsh bird's beak; each patch should be at least 10.7 ft^2 (1 m^2) in size and contain at least 20 plants; the patches should be at least 394 ft (120 m) apart. The salt marsh bird's beak patches described should be self-sustaining (i.e. stable or increasing in number and area) for three years.
The middle marsh	In each home range, the middle marsh should contain at least 75% of the native vascular plant species found in reference sites in the natural marsh. The middle marsh shall provide at least 70% cover and contain 75% of the native species typically found in this zone, in a comparable area at the Refuge.
The low marsh[1]	In each home range the low marsh should have at least 50% cover of cordgrass. Each home range should have at least one large patch of tall, dense cordgrass, i.e. a patch 969–1076 ft^2 (90–100 m^2) in size where the cordgrass is 24–31 in (60–80 cm) tall and 90–100% in cover. The tall, dense cordgrass patch described needs to be resilient (i.e. maintain itself for three years and exhibit nitrogen fixation).

1. Alternative low marsh criteria were used in 1995 for assessing clapper rail habitat. Zedler's (1993) criteria considers the rail's need for a proportion of very tall stems to support its floating nests during high tides, and states that there should be at least one 1,076 ft^2 (100 m^2) patch that averages 100 stems/m^2 of which at least 90 stems are taller than 24 in (60 cm) and 30 stems are taller than 35 in (90 cm) when sampled with 10 circular quadrats 13.5 ft^2 (1.256 m^2) in size (Zedler 1993). At the 1995 annual meeting of the USFWS, California Department of Transportation, USACOE, and PERL, it was decided that the mean height criterion for cordgrass, 24–31 in (60–80 cm), was adequate.

Regular monitoring at Sweetwater conducted by the Pacific Estuarine Research Laboratory (PERL) at SDSU (Zedler 1996) includes water quality (dissolved oxygen, temperature, salinity profiles, nutrients in the water column); fish sam-

pling; exotic fish traps; benthic invertebrates using core samples in channels; marsh vegetation species and cover; cordgrass heights and density; and soil salinity and soil nutrients.

Evaluation of Current Management

- In comparing natural to constructed marsh functions, most standards were met within seven years. However, use of low marsh for nesting has yet to meet mitigation criteria.

Two marshes were constructed from previously deposited fill material: Connector Marsh, which was built as a hydrologic link between Sweetwater Marsh and Paradise Creek, and Marisma de Nacion, which was planted with cordgrass in 1991. To evaluate the success of the project, PERL compared nearby natural marsh functions to those of the constructed marsh. They found a range of success and failure in the constructed marsh (Zedler and Langis 1990; Boyer *et al.* 1996). The standard for abundance and diversity of fishes, as forage for the least tern, was satisfied within the first three years of the marsh (1989–1991). The standard for invertebrates was met in five years (1989–1993). The requirement for salt marsh bird's beak was met for the first time after six years, but the following year there were severe declines due to drought (an 85% reduction in area, and a drop in plant numbers from 14,000 to 1,200). The standard for use as high tide refuge by the light-footed clapper rail was met in the high and midmarsh after seven years, while use of the low marsh for nesting has yet to meet mitigation criteria.

While the no-net-loss standard helps protect the remnants of salt marsh remaining in the Bay, creating additional acreage may require unique approaches to mitigation.

Proposed Management Strategy—Salt Marsh

Objective: Ensure no net loss of existing structure and function of salt marsh habitat, and achieve a long-term net gain in its quantity, quality, and permanence.

I. Protect salt marsh functions, such as primary productivity, nitrogen supply, detritus- and grazer-based food web support, endangered species support, and general fish and wildlife support.

- ***A.*** Participate in regional salt marsh restoration planning.
  - *1.* Thoroughly characterize existing salt marsh remnants in the Bay by microhabitat use for foraging fishes and shorebirds, fish nursery functions, sensitive species support, connectivity or isolation with other habitats, and patch size and shape (See also *IIIA*).
  - *2.* Set targets for light-footed clapper rail support, Belding's savannah sparrow use, salt marsh bird's beak population stability, and young-of-year California halibut and other flatfish use, where baseline data are available to support the setting of targets.
  - *3.* If baseline data are not available, conduct appropriate studies.
- ***B.*** Protect access to and from the marsh for species that migrate in and out tidally or during different life history stages.
- ***C.*** Provide public access controls especially near breeding colonies by posting, fencing, and patrols, to address walkers, dogs, lighting, noise, and trampling.

D. Patrol marsh areas that are vulnerable to illegal activities. Organize general habitat cleanup of the marsh and other shoreline sites. Especially critical for cleanup is monofilament line, which can fatally entangle birds.

E. Continue to control predation, the primary reason for reproductive failure of the least tern and western snowy plover.

1. Enhance the "island" nature of the CVWR to help control predators.

F. Control evident shoreline erosion on Chula Vista east shore midbay-front marshes and the levees of south Bay, using soft solutions (i.e. without armoring the intertidal zone).

G. Investigate changes in marsh function and value due to presence of exotic fishes, invertebrates, and plants. Prioritize control efforts based on these results.

II. Expand and enhance existing habitat.

A. When planning restoration, consider the marsh as part of a larger system of habitats that depend on each other.

B. To maximize the potential for success, as a first priority, link smaller sites to larger parcels. Next priority is to expand smaller and then larger parcels. Last priority is to construct new marsh where none has been historically.

C. Reevaluate recommendations of the South Bay Enhancement Plan (Macdonald *et al.* 1990).

1. Excavate the north end of D-Street into a salt marsh/mudflat complex. Use the dredge spoil for beneficial reuse or habitat enhancement.
2. Consider expansion of salt marsh on north side of Gunpowder Point at SMNWR.
3. Expand at E-Street marsh on south side of Gunpowder Point by excavating uplands and extending existing tidal channels into new areas.
4. Enhance J-Street Marsh by excavating a perimeter channel to separate the marsh from the SDG&E power plant; excavating a system of small, secondary tidal channels throughout the marsh and possibly partly across the tidal flats; and creating refuge islands for escape from high spring tides or major flooding episodes. Conduct load-bearing capacity strength tests on soils due to reportedly unusually soft and non-cohesive soils that may not stay in place.
5. Restrict vehicle access and boats anchored at the South Bay Marine Biology Study Area. Eliminate parking and other illegal activities. Eliminate garbage. Convert peripheral uplands to marsh. Excavate tidal channels into degraded marsh. Excavate secondary tidal channels to provide circulation.
6. Conduct marsh enhancement at Emory Cove in conjunction with expansion of marsh and tidal flats, and creation of new eelgrass beds that connect up with those off of the South Bay Marine Biology Study Area and south Coronado Cays.

D. Advocate project budgets that emphasize consideration of biological variables before engineering takes place, such as:

1. Whether planting is needed or recolonization will happen naturally.
2. Means to control exotic introductions.
3. Site selection to maximize connections, interchanges, animal movement among habitats.
4. Means to minimize delays in achieving functional equivalency.

III. Fill priority information gaps.

A. Characterize the linkages between the salt marsh and other habitats, and their relative importance for a broad range of species, food chain support, and water quality functions.

B. Investigate the hydrologic requirements of salt marsh plants and animals, including minimum water depth, hydroperiod, dissolved nutrients, flushing, the role of large but infrequent events such as El Niño, and the effects of long-term sea level rise.

C. Study the relationship of substrate to salt marsh plants and animals, and to chemical and biological functioning.

D. Characterize the existing remnant natural marshes by microhabitat subsets, patch size and shape, connectivity and isolation, and sensitive species support.

E. Make salt marsh restoration more predictable in terms of what is possible to achieve and how long is required to achieve it.

1. Investigate nitrogen deficiency in the marsh and effective augmentation methods and timing.
2. Investigate bioremediation measures for contaminated soils.
3. Investigate means to control exotic introductions.
4. Investigate innovative ways to accelerate the restoration process, especially for listed species support, such as native plant propagation techniques, and use of soil amendments.

F. Continue to compare natural and constructed marshes: soil salinity; water quality (dissolved oxygen, temperature, water salinity profiles, nutrients in the water column); fish species composition and relative abundance; exotic fish presence and abundance; benthic invertebrate assemblage relative abundance and density; marsh vegetation species and cover; cordgrass heights and density; and soil nutrients. Investigate causal relationships.

4.2.1.7 Artificial Hard Substrate

Specific Concerns

This section uses the terms "soft" and "hard" shorelines. Soft shorelines are those comprised of natural or introduced materials similar to those indigenous to the Bay. Hard shorelines are made up of rock, concrete, wood, or other hard substrate introduced to the Bay.

■ See also Section 2.4.4.3 "Artificial Hard Substrate."

□ Only 26% of the Bay shoreline remains in a natural condition or is made of natural materials indigenous to the Bay, yet it has been estimated that only 7% of the shoreline is naturally vulnerable to erosion (Smith 1976). (Over-

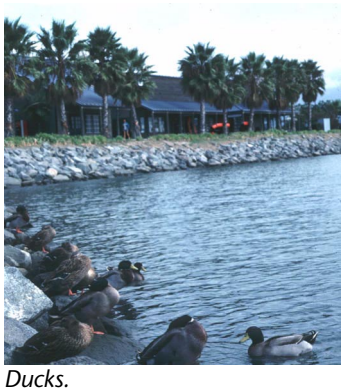


Photo © 1998 Tom Upton.

Ducks.

steepened banks associated with dredged channels account for additional need for stabilization structures.) The remainder has been armored by riprap, seawall, wharves, and piers.

- Armoring of the Bay's shoreline has either eliminated intertidal habitat or diminished the value of what remains. Conversion of high-value soft substrate to lower-value hard substrate has created rocky intertidal habitat that was not historically found in the Bay. Riprap and concrete dominate the intertidal zone today yet provide low habitat value, especially for birds. Potential redesign of protective structures could increase their habitat value.
- Technical expertise may be limiting the availability of designs to make riprap walls and other artificial structures more valuable as habitat and less damaging to intertidal habitats.
- There are currently no financial incentives to improve the habitat value of necessary armoring, to minimize its use, or to remove unnecessary armoring in favor of a natural shoreline.
- There is currently very limited consideration of soft rather than hard structural solutions, or any innovative thinking about means to enhance habitat value of shoreline structures.
- There is inadequate environmental guidance or consensus to control development or shoreline stabilization structures at inappropriate locations.
- Permit applicants are required to consider cumulative impacts, but not to mitigate for them. Littoral cell analysis and alternatives analysis are not required in permit applications that require shoreline modification.
- Noise during pile-driving can affect fish and least tern foraging.
- Intertidal habitat in the Bay is very valuable ecologically, is in short supply, and could be enhanced near shoreline structures. Structures can affect adjacent sandy beaches, which have very high value for birds, especially as high tide refugia.
- While rock or other hard substrate added to the Bay's soft bottom is a net benefit to productivity (no mitigation is required for pier demolition, for example), it is not known if some substrates are better than others, or if the addition results in any net gain to the ecosystem as a whole.
- There needs to be resolution of and a consistent regulatory approach to concerns about placement of riprap in intertidal areas as opposed to subtidal. Whereas in subtidal, hard substrate is viewed as a benefit because of improved productivity, in intertidal areas it could be viewed as a negative effect because of the loss of infaunal species consumed as forage for shorebirds.
- Better design of shoreline structures, perhaps ones that extend structures underwater to control the steepness of the slope, would prevent the need for repeated maintenance of these structures, and perhaps result in improved habitat value.

Current Management

Shoreline stabilization structures (pier pilings, bulkheads, riprap, floating docks, sea walls, mooring systems, and derelict ships/ship parts) form extensive artificial habitat in the northern and central portions of San Diego Bay and to a lesser extent in the southern Bay. Docks and marinas currently shade roughly 131 acres (53 ha) of Bay habitat, and bridges about 11 acres (4.5 ha). There are 45.4 mi (73.1 km) or 74% of the Bay's shoreline that are stabilized with rock or con-

crete. This includes about 20 mi (32 km) of shoreline armored with seawall, considered to have low habitat value because of its lack of surface complexity. The unquantified habitat value of the armored shoreline is expected to vary by material, construction, and elevation in relation to sandy or muddy substrate, and by maintenance activities.

- Alternative approaches to shoreline armoring in the Bay are preferred.

The federal Coastal Zone Management Act (CZMA) of 1972 discourages shoreline armoring. CZMA provided federal guidelines for developing coastal zone management programs, to be implemented by each state's coastal zone management programs, but leaving participation voluntary. The CCC grants a General Consistency Determination for periodic replacement and repair of piers and shoreline structures (California Coastal Commission 1993). The CCC must find that a proposed project "is consistent with the marine resource, habitat, access, recreational, and shoreline structure policies of the CCMP." The more recent amendment to the CZMA—the Coastal Zone Reauthorization Amendments of 1990—established the Section 309 Coastal Zone Enhancement Grants Program. One of the Program's improvement objectives is to develop and adopt procedures to assess, consider, and control cumulative and secondary impacts of coastal growth and development. The Section 309 program is administered by the Office of Coastal and Ocean Resource Management of NOAA (Canning 1992). Guidance for implementing Section 309 discourages shoreline armoring and establishes a preference for alternative approaches such as set back requirements.

- There are general directives described in state policy for shoreline modification projects. Implementation is at the discretion of state agency directors.

A 1978 state policy for directors of state agencies when reviewing environmental impact documents, certifying plans, issuing permits, or granting funds describes general objectives for shoreline modification projects: "When shoreline erosion control projects are necessary, they should restore natural processes, retain shoreline characteristics, and provide recreational benefits to the extent possible..." It appears that implementation is at the discretion of directors of state agencies.

Some states have separate shoreline protection legislation, such as Washington's Shoreline Management Act, with which county and local regulations provide the primary driver behind shoreline management, not the CWA. California has no equivalent law.

Evaluation of Current Management

Since the 1800s San Diego Bay has been developed to support a wide variety of human activities. The resulting man-made features, including concrete bulkheads, riprap, pier pilings, marina floats, and other dock structures, are now and will continue to be intertidal and subtidal habitats for marine algae, invertebrates, and fishes.

Shoreline stabilization continues with little consideration of environmental damage or alternative approaches. Little attention has been paid to this aspect of Bay development as an issue; partly as a consequence, no permit has been challenged on these grounds.

■ This Plan proposes a major change in routine management of the Bay's shoreline by the following approaches: (1) development of a formal Policy for Protection of Intertidal Habitats (see Appendix H); (2) fostering incentives to improve the habitat value of existing shoreline structures; and (3) provision of Baywide shoreline protection and restoration planning, to protect and enhance the remaining natural or "soft" shorelines.

While the CWA protects all areas of Bay below the +7.8 ft tide line, impacts to intertidal habitats by placement of artificial structures continue. States, like Washington and North Carolina, that have a coastal shoreline protection law in place appear to be more successful. Marine ecologists have performed little research on creating higher habitat value out of such structures. Exceptions are dock "ecosystems" (Russell *et al.* 1983; Hawkins *et al.* 1992) and littoral flat terraces that have been implanted in riprap stabilized shorelines at the Port of Seattle (Simenstad and Thom 1992).

Proposed Management Strategy

This Plan proposes a major change in routine management of the Bay's shoreline by the following approaches: (1) development of a formal Policy for Protection of Intertidal Habitats (see Appendix H); (2) fostering incentives to improve the habitat value of existing shoreline structures; and (3) provision of Baywide shoreline protection and restoration planning, to protect and enhance the remaining natural or "soft" shorelines.

Proposed Management Strategy—Artificial Hard Substrate

Objective: Minimize the use of shoreline stabilization structures that impact or replace natural intertidal habitats, and maximize the value and function that necessary artificial structures contribute to the Bay ecosystem.

I. Protect existing areas of natural or artificial soft shoreline around the Bay.

- ***A.*** Establish a formal Intertidal Policy for the Bay, and potentially for all of southern California, modeled after the Southern California Eelgrass Mitigation Policy that incorporates guidance on shoreline stabilization from this Plan (see also Section 4.2.1.5 "Intertidal Flats").
- ***B.*** Seek alternative locations for Port and Navy projects.
- ***C.*** Require examination of shoreline modification alternatives. A project proponent should provide in their review an inventory of existing shoreline stabilization devices and unarmored areas that may be impacted adjacent to and near the project site; predicted impact upon area shore and hydraulic processes, adjacent properties, shoreline and water uses, and upland stability; and alternative measures (including nonstructural) that will achieve the same purpose.
- ***D.*** Require technical peer review of hard solution applications. Hard shoreline modifications should be allowed only after it is demonstrated that nonstructural solutions are not able to reduce the damage.
- ***E.*** Riprapping and other bank stabilization measures should be located, designed, and constructed primarily to prevent damage to *existing* development.
- ***F.*** Shoreline stabilization with the use of artificial structures should be discouraged in eelgrass, salt marsh, and identified important fish nursery areas, except for fish and wildlife enhancement.
- ***G.*** Require mitigation through USACOE permits for loss of natural or soft shoreline that affects shorebird feeding opportunities.

1. Document shorebird use value along shorelines vulnerable to placement of structures in advance of projects.

H. Identify sites for shoreline enhancement projects that would benefit from disposal of dredge material.

I. Encourage the Navy, Port tenants, and municipalities, in cooperation with permitting agencies and SANDAG, to:

1. Place structural design limitations on hard solutions.
2. Restrict inappropriate development.
    a. Require setbacks.
    b. Post construction standards.
    c. Place limits of hard structures.
3. Create incentives to reduce inappropriate development.
    a. Tax credits.
    b. Transferable development rights.
    c. Land acquisition.
4. On developed lands, create incentives for relocation or removal of structures threatened by erosion. Encourage replacement of hard structures with soft solutions.

II. Provide enhancement to increase the habitat value of necessary hard structures, to make them more like natural rocky shores.

A. Develop a San Diego Bay Shoreline Stabilization and Restoration Plan that arrests erosion and accretion problems around the Bay, and that will allow regulators to view the Bay as a whole system, rather than piecemeal.

1. The Plan should provide techniques for adding habitat value to structures as they need to be replaced.
2. The Plan should identify means to provide economic incentive to improving the habitat value of existing structures.
3. The planning process should involve the Port, US Navy, regulators, and resource agencies.

B. Establish general guidelines for shoreline structures for environmental compatibility.

1. Bank stabilization should be located, designed, and constructed primarily to prevent damage to existing development.
2. New development should be located and designed to prevent or minimize the need for shoreline stabilization measures. New development requiring shoreline stabilization should be discouraged.
3. Consider confining bulkheading and filling to the upper one-third of the intertidal zone.
4. If important nursery or foraging areas are identified for fish of the intertidal zone, then restrict the extent to which bulkheads or riprap may encroach on these zones.

5. Encourage crenulation of the shoreline (making it more irregular or wavy) to create more shallow water niches and intertidal accretion in small inlets while maintaining the functionality of the stabilization structures.

C. Institutionalize a preference for soft solutions, using natural materials similar to those indigenous to the Bay.

1. Require the design and use of naturally regenerating systems for prevention and control of beach erosion over bulkheads or other structures where:

   -the length and configuration of the beach will accommodate such systems;

   -such solutions do not detrimentally interrupt littoral drift, or redirect waves, currents, or sediments to other shorelines;

   -beach enhancement may be permitted as a conditional use when the applicant has demonstrated that no significant change in littoral drift will result that will adversely affect properties or habitat;

   -such protection is a reasonable solution to the needs of the site;

   -it will reduce otherwise erosional conditions.

2. Require supplementary beach nourishment to impacted beaches in a drift cell where structural stabilization projects are necessary.

D. Reduce reliance on hard solutions.

1. Natural materials and processes should be used to the maximum extent possible.
2. Proposals should demonstrate the use of natural materials and processes and that nonstructural solutions to bank stabilization are unworkable in protecting existing development.
3. Bulkheads may be allowed only when evidence demonstrates that (a) serious wave erosion threatens an established use or existing building(s) on upland property and/or (b) bulkheads are necessary to the operation and location of water-dependent and water-related activities provided that all alternatives have proven infeasible.
4. Use of a bulkhead to protect a platted lot where no structure presently exists is discouraged.
5. Shoreline uses should be located in a manner so that bulkheading is not likely to become necessary in the future.
6. Affected property owners and public agencies should be encouraged to coordinate bulkhead development for an entire drift sector or homogenous reach in order to avoid exacerbating erosion on adjacent properties.
7. The cumulative effects of allowing bulkhead segments of shoreline should be evaluated prior to granting individual permits or exemptions.
8. Bulkheads should not be approved as a solution to geophysical problems caused by factors other than wave erosion.
9. Investigate ways to provide market or other incentive to convert existing structures to more environmentally compatible ones.

III. Pursue cost-effective, targeted monitoring and applied research to address questions about shoreline structures in support of the management objective.

A. Conduct an analysis of shoreline erosion to determine if any stabilization structures are unnecessary.

B. Determine the ecological functioning of the Bay's artificial habitats in relation to other habitats, to develop better protection and enhancement priorities.

1. Evaluate the "refuge" function of riprap for juveniles and predators.

2. Monitor the quantity and quality of existing and enhanced shoreline structures within the Bay.

C. Promote research into understanding and improving the habitat values of artificial hard substrate.

1. Encourage experimentation with armored shorelines to make them more like natural rocky shores, or find soft solutions.

2. Use the permitting process and cooperative agreements to foster this experimentation.

3. Consider adding light panels to piers to allow light transmission to organisms in the water below.

4. Develop demonstration projects for minimizing the need to armor the shoreline and maximizing the value of necessary hard substrate additions to the environment.

5. Boat ramps have been identified as sometimes providing improved shorebird habitat. Investigate the characteristics that provide this benefit and incorporate it into project designs.

6. Assess the success of projects in developing functional habitat characteristics.

D. Apply successful techniques from demonstrations to additional enhancement projects at appropriate sites.

4.2.1.8 Salt Works

■ See also Section 2.4.5 "Salt Works."

Specific Concerns

- Man-made dikes and levees of the Salt Works have become essential for nesting, roosting, and providing refuge for high numbers and diversity of shorebirds. Dikes require periodic maintenance and there is potential for enhancing their ability to foster successful bird use.
- Nearly half of the shorebirds that visit San Diego County may use the Salt Works (Warnock *et al.* 1989), yet the features that most support shorebird use are not described or quantified, and so are not necessarily protected.
- The recent acquisition of most of the Salt Works for a USFWS refuge opens many opportunities for restoration and enhancement of the salt ponds for nesting, foraging, and roosting birds. This needs to be balanced with human access for wildlife viewing and compatibility with wildlife use.
- Predators of sensitive nesting birds are affecting the birds' reproductive success.

Photo 4-7. Black skimmers on Salt Works Levee.

Current Management

- The Port has negotiated a Cooperative Agreement with USFWS to restore Salt Works lands for fish and wildlife refuge purposes.

An agreement for acquisition of 800 acres (324 ha) of the Western Salt Company together with the leasehold interest of 600 acres (243 ha), for use as a wildlife refuge was recently reached with SDUPD (escrow closed 4/1/99). The Port also has negotiated a Cooperative Agreement with the USFWS concerning mitigation benefits to the Port in the approximately 690 acres (279 ha) of Western's property and leasehold interest in the approximately 600 acres (243 ha) of state lands together with the Port's commitment of $900,000 for management and restoration planning, potentially including some substrate enhancement (up to three acres0 for the least tern and a small amount for fish foraging enhancement. This agreement was reached in anticipation of the Port's acquiring 25 acres (10 ha) of land on Camp Nimitz, NTC, which has a conservation easement as a least tern nesting site.

All of the issues related to management and ecosystem restoration of the Salt Works (now South San Diego Bay National Wildlife Refuge) will be addressed in planning documents (including a Comprehensive Conservation Plan and a Restoration Plan) written by USFWS as the lead agency.

Evaluation of Current Management

Despite its artificial nature, existing management of the Salt Works has successfully provided major and scarce ecological function for shorebirds, waterbirds, endangered and threatened species, and nesting sea birds by controlling public access, providing substrate for nesting and roosting, and important foraging habitat. Its imminent designation as a USFWS Refuge will allow protection and enhancement of these functions. Enhancement of fish values is constrained by high salt levels in the ponds, and possibly some compatibility issues between fish pens and nesting seabirds.

Proposed Management Strategy—Salt Works

Objective: Protect and enhance the important wildlife functions of the Salt Works, with emphasis on sensitive birds, shorebird foraging, and sea bird nesting.

I. Protect existing values for shorebird foraging, high tide refuge, and sea bird nesting.

- ***A.*** Ensure the values and functions of the salt ponds are made perpetually available for shorebird and waterbird foraging, roosting, and nesting for sensitive species.
- ***B.*** Limit human disturbance.
  1. Continue to exclude vehicles from nesting levees during nesting season.
     - *a.* Restrict cars and trucks to USFWS use as necessary.
     - *b.* Continue to close access when birds do not segregate themselves to nest away from trafficked areas.
     - *c.* Consider limiting vehicles to golf-cart types, preferably electric.
  2. Determine means to allow human access to enjoy the wildlife values of the salt ponds without impacting wildlife.
     - *a.* Investigate options of remote cameras or small-scale guided tours.
     - *b.* Consider the use of boardwalks and viewing towers at appropriate points around the perimeter of the Salt Works.
  3. Keep nesting area and nearby shorelines clear of monofilament line.
- **C.** Manage predators of the California least tern, western snowy plover, and other nesting species on the dikes.

II. Restoration planning for the new wildlife refuge should enhance intertidal foraging values and habitat for nesting birds at the Salt Works (both sea birds and salt marsh species), especially sensitive ones.

- ***A.*** Set targets for endangered, threatened, or other target species support, based on baseline data, to help focus the development of enhancement strategies.
- ***B.*** Analyze the salt ponds for an optimal arrangement and combination of salt marsh, tidal flat, salt pond, and dike habitats.
  1. Consider means to optimize the interconnection between the salt ponds and nearby mudflat and salt marsh habitat.
  2. Consider careful dredging and grading to allow for expansion of intertidal habitat.
  3. Consider managing the water level in ponds that remain inactive for months to support more shorebirds.
- **C.** Seek means to enhance nesting sites for sensitive avian species.
  1. Characterize the biophysical conditions of nesting sites selected preferentially by different bird species in order to identify enhancement opportunities.

2. Consider recontouring of some dikes to make them flatter so that eggs of ground nesting birds do not roll away.
3. Consider creating additional nesting islands with dredge spoil.
4. Evaluate the potential benefit of depositing new dredge spoil of sandier texture, possibly with high shell content, on dikes that now consist of silty material that is detrimental to the reproductive success of nesting sea birds.

D. Participate in Baywide and coarser-scale planning for shorebirds.

III. Address information gaps related to enhancement planning for the Salt Works.

A. Quantify the relative importance of physical and chemical factors that contribute to wildlife value at the salt ponds, including dike and pond substrate and stability; connectivity or isolation with other habitats or human disturbance; pond size; shape; salinity; water level; invertebrate support; and other physical, chemical, or biological factors that may affect its wildlife value.

B. Determine vegetation management techniques for Salt Works dikes related to soil salinity, compaction, salt crusting, and time since last maintenance in order to maximize target species support.

4.2.1.9 Upland Transitions

■ See also Section 2.4.6 "Upland Transitions."

Specific Concerns

- Terrestrial habitats along Bay margins, including beaches, foredunes, backdunes, and coastal scrub, support numerous rare species, as well as provide essential nesting, roosting, and refuge from high tides and adverse weather for a large number and diversity of avian species. Even nonnative eucalyptus groves along Bay margins support substantial use by nesting herons. Yet, these habitats are among the most threatened by development and management trends.
- Many water-dependent species also depend on available uplands. For example, the snowy plover prefers certain plants of southern foredune habitat, which may indicate a need for the protection of this habitat.
- Beaches (e.g. nesting and roosting sites) as high tide refugia are depleted for shorebirds, and are threatened by sea level rise.
- Although long stretches of beach remain on the ocean side of the Silver Strand Peninsula, few are located on the Bay shore, and most are subject to heavy recreational use or are used for military training, possibly limiting their use by wildlife.
- Upland transition habitat serves as crucial habitat for nesting, roosting, and foraging bird species, including the endangered least tern and threatened snowy plover. They comprise habitat for several sensitive plant and animal species of limited distribution found in few other habitats, including Nuttall's lotus, tiger beetles, coast horned lizard, wandering skipper, San Diego jackrabbit, coastal burrowing owl, and coastal horned lark.
- Surrounding development has compressed predator and prey species into the few remaining natural areas, resulting in unnaturally high rates of predation and disturbance, particularly in beach areas around San Diego Bay.

- Currently available upland habitat may be the most threatened habitat on the Bay. The D Street fill is the largest parcel of undeveloped acreage and as such has enhancement potential available nowhere else for species that depend on adjacent uplands. Areas of relic coastal dune habitat along the eastern edge of Highway 75 and at NRRF have potential for supporting many coastal dune species.
- Invasion of exotic plants such as iceplant degrades some upland transition areas that have potential for harboring sensitive species, such as Silver Strand State Beach and NRRF.

Current Management

■ Although various activities manage and protect least tern nesting sites around the Bay, upland transition areas are not protected under the CWA. However, the CCC regulates sandy beaches.

Upland transition areas are not protected under the CWA. However, the CCC regulates sandy beaches, plus a 300 ft (9 m) buffer measured landward from the inland extent of the beach. Also, near the Bay these areas are sometimes occupied by species protected under the ESA, such as the California least tern and western snowy plover. Least tern nesting sites around the Bay are intensively managed and protected, as described in Section 4.3.6.2 "California Least Tern." The level and consistency of activity varies from site to site, but activities range from fencing, grading, predator management, adjustment of sand grain size to discourage predatory ants, and monitoring nesting success.

Current protection mechanisms for adjacent uplands of the Bay are summarized under Section 4.2 "Habitat Protection and Management." Excluding sandy beaches and including all uplands of NRRF, close to 300 acres (121 ha) out of about 900 acres (364 ha) of undeveloped uplands have some sort of protection, such as association with a refuge, future refuge, or reserve. Navy land under lease to CDPR and to the County of San Diego is considered vulnerable to development in the long term, as is the NRRF.

Gunpowder Point uplands are currently managed to support Belding's savannah sparrow and the California least tern.

Some coastal dune and coastal sage scrub restoration has been under way in upland transition habitat of the Naval Magnetic Silencing Facility at Point Loma. Restoration included acacia, hottentot fig and arundo removal. Small plantings of *Abronia maritima, Ambrosia chamissonis, Lotus nuttalianus,* and *Coreothrogyne filaginifolia* were accomplished. Seeding (with different mixtures for backdune and foredune) was done for A*bronia maritima, Ambrosia cheiranthifolia, Camissonia cheiranthifolia, Eriogonum parvifolium, Cardionema ramosissima, Nemacaulis dunata*. Seeding for the coastal sage scrub species *Artemisia californica, Baccharis sarathroides,* and *Encelia californica* was also completed.

Evaluation of Current Management

■ Although likely the most impacted habitat, unless tied in to a threatened or endangered species, upland transition areas remain vulnerable.

Upland transition is likely the most impacted of all habitats with some exceptions. Intensive management of upland transition sites for the California least tern has resulted in an improvement in number of nesting pairs of the least tern in California to approximately 4,000. This is believed to be due to predator management and better site protection from disturbance (Caffrey 1997). Further discussion on the California least tern and other listed species is in Section 4.3.6 "Sensitive Species Special Protections."

Areas of upland transition outside of California least tern nesting sites, the refuge, CVWR, or D-Street Fill remain vulnerable to development or further disturbance, unless a direct tie-in to a threatened or endangered species can be

identified. Some, such as the parcels along Highway 75, could be enhanced for intertidal flat or salt marsh values if excavated, and so the upland transition values would be in competition for those.

Proposed Management Strategy—Upland Transitions

Objective: Ensure no net loss of availability, structure, and function of high value adjacent uplands, and achieve a long-term net gain in their quantity, quality, and permanence.

I. Protect all adjacent uplands known to have important functional values for the Bay, such as support of rare species, nesting, roosting, and refuge.

- ***A.*** Characterize each parcel with upland transition values with respect to threatened or endangered species support, other rare species support, high tide refuge, marsh buffer, urban buffer, site disturbance history and current pattern, and presence/cover of exotic species.
  1. Protect threatened, endangered, and rare species use as a first priority.
  2. Protect high tide refugia values as a second priority.
  3. Protect buffer areas.
- ***B.*** Describe and quantify the relative importance of linkages to Bay-dependent uses between upland and intertidal parcels. Then protect these linkage with adequate buffers.
- ***C.*** Protect wildlife use of upland transition areas from adverse human effects.
  1. Enforce leash laws and keeping of cats indoors by pet owners, especially near least tern or light-footed clapper rail nesting sites.
  2. Organize community cleanups of garbage.
  3. Patrol parcels for illegal activity.
  4. Control exotics such as hottentot fig.
- ***D.*** Seek acquisition into public ownership, purchase of conservation easement, or other long-term habitat protection status for upland parcels along Highway 75.

II. Enhance disturbed upland transition areas.

- ***A.*** Characterize the site potential and target assemblages of each parcel.
- ***B.*** Control exotics and restore native vegetation to uplands of the SMNWR at least in part by the establishment of adequate buffers between developed areas and marsh habitat.
- ***C.*** Control exotics on coastal dune remnants as a first priority, because of the rare species that depend upon them.
- ***D.*** Enhance upland transition habitat on NRRF in support of rare species, balancing the need for intertidal flats and salt marsh habitat.
- ***E.*** Protect high tide refugia function of D-Street Fill in balance with intertidal enhancement needs.
- ***F.*** Encourage appropriate native and water-conserving landscape designs or "Bayscaping."

III. Support use of education, signage, and art as a means of encouraging people to respect wildlife in upland transition areas, such as has been already accomplished at the Navy parcel leased to CDPR, along trails of the natural area at Grand Caribe, and at the South Bay Marine Biological Study Area.

A. Conduct adequate planning to anticipate and control vandalism.

4.2.1.10 River Mouths and Floodplains

■ See also Section 2.4.6.4 "River Mouths."

Specific Concerns

- River mouths as a source of sedimentation, organic matter and freshwater input have been controlled by dams or diverted, so they no longer have the same natural role. The nature of change from the natural system to the present one with a large component of urban runoff has not been quantified as to its effects on the Bay ecosystem (e.g. what portions of input are balanced out versus actually changed).
- Dabbling ducks are found primarily in shallow brackish water near the mouths of drainages (and similar water on the salt ponds and seasonal wetlands of the NRRF). Brackish water is scarce.
- Organic material and mud that used to be supplied by the seven streams entering the Bay no longer enter the Bay as they did naturally. The Bay floor has changed, at least temporarily, from a muddy to sandy bottom.
- The channelized nature of the river mouths affects the ability to restore salt marsh habitat that can occur along river mouths or corridors, by narrowing their potential occurrence into a narrow corridor along the dikes that contain the river.

Current Management

Like the upland transition habitat, freshwater wetlands adjacent to salt marshes have been severely impacted by development and reduced runoff from rivers and creeks.

Evaluation of Current Management

The damming and channelization of local rivers has eliminated much of their natural function. Water delivery is, as it was under natural conditions, generally limited to after winter storms; however, the primary runoff is now over urban hardscape. Since San Diego imports the majority of its water, much of the runoff is now from imported sources rather than winter storms.

Proposed Management Strategy—River Mouths and Floodplains

Objective: Allow river mouths and floodplains to, as nearly as possible, fulfill their natural ecological function as an intermittent and episodic source of sedimentation, organic matter, and freshwater input for the Bay.

I. Protect what remains. Investigate ways to protect or substitute natural functions.

A. Protect the structural complexity of the riparian portion of the lower Otay River.

II. Enhance river mouth and floodplain functions and values as a natural corridor, linkage, and buffer between salt water and freshwater habitats.

A. Identify opportunities to replace the episodic siltation function formerly played by uncontrolled rivers, such as disposal of dredge material at the river mouth under the direction of a competent hydrologist.

B. Restore the ecological functioning of the Otay River mouth.

1. Seek enhancement of the floodplain functions of the Otay River near its mouth, as suggested in plans for the 100-year floodplain area of the MKEG/Egger-Ghio parcel (City of San Diego Otay-Nestor Community Plan), recently purchased by the California Coastal Conservancy.

2. Reestablish the natural salt marsh function at the mouth of the Otay River (Macdonald *et al.* 1990).

3. Retain the parcel's function as an ecological transition between the salt marshes of the Otay channel and freshwater riparian habitat.

III. Study the importance of natural functions of river and stream mouths relative to substitutes of these functions.

A. Investigate the ecological implications of an estimated 75% reduction in sediment load entering the Bay (Smith 1976), especially with regard to salt marsh habitat.

B. Investigate the ecological implications of changes in the volume and nutrient content of water delivery to the Bay with the majority now being urban runoff from largely imported water sources.

C. Investigate nutrient loading into the Bay and its connection with algae and phytoplankton blooms.

4.2.2 Mitigation and Enhancement

Specific Concerns

- The inability to cross jurisdictional, ownership, and project boundaries does not allow mitigation planning to consider the functions most limiting to the San Diego Bay ecosystem as a whole. It is believed that more landscape-based, cross-jurisdictional planning could improve the sustainability of projects, and perhaps result in a better network of systems that are more productive and functional for all biological communities, rather than just the specific project site and habitat.
- There has been a loss of certain functions of salt marsh habitat due to mitigation projects that have not replaced all of the structure and function of the lost habitat for several years after implementation.
- Experimentation and innovation in design and monitoring for ecologically sound mitigation projects are currently accomplished only within the confines of permit processing and economics of project proponents. Broader research support is needed to encourage innovation and improved techniques.
- Alternative approaches to enhancement have not been fully explored as a management opportunity. This is especially true for enhancing habitats that have been depleted so severely that they rarely experience project impacts any longer, but their reduced and fragmented acreage remains a problem for

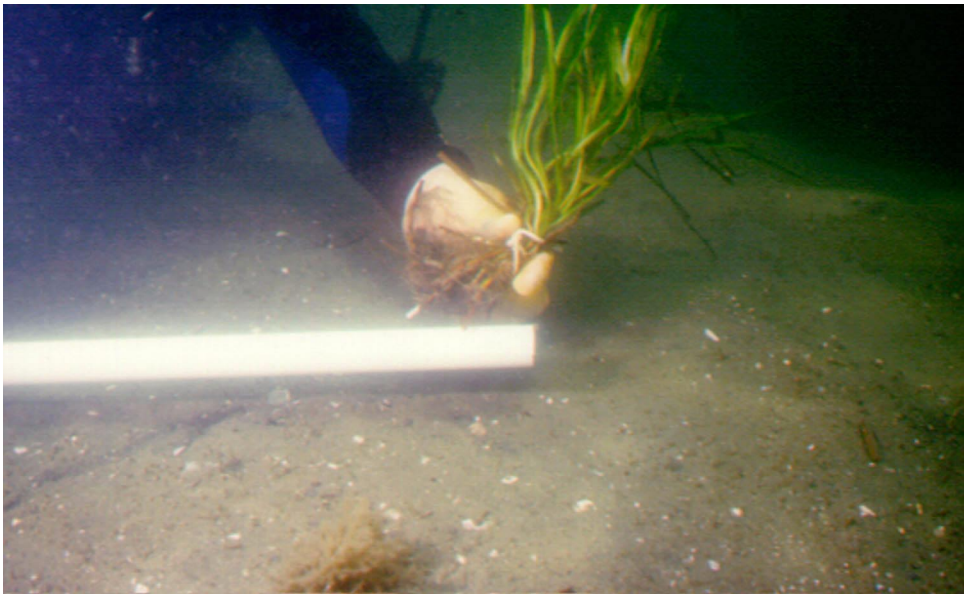


Photo © 1998 Robert Hoffman

Photo 4-8. Planting Eelgrass.

both sensitive species that depend on them and the ecosystem as a whole. An example is careful and restricted use of out-of-kind mitigation in habitats that are more scarce than the impacted one, or mitigation banking. Such approaches must not result in reduced fish or other pre-project values.

- Beneficial use of dredge material in San Diego Bay has been hampered by inadequate preplanning and identification of sites.
- Misunderstood, complicated, and sometimes unanticipated mitigation requirements have been a problem for project planners.
- There is a lack of continuity in personnel in agencies both on the regulatory and project proponent sides. High turnover may result in difficulty in applying a timely, effective, consistent and predictable mitigation standard.
- Without provisions in current mitigation projects to accommodate and provide buffers for expected sea level rises and possible warmer water temperatures, the long-term success of mitigation projects may be jeopardized. For example, cordgrass at the lower end of the salt marsh could be drowned out, or eelgrass could be killed by lack of light penetration when water deepens.

Current Management

- Projects that fall under the CWA or harbor species protected under the ESA result in creation, restoration, and enhancement of Bay habitat.

Much of the creation, restoration and enhancement of habitat that has occurred in San Diego Bay is the result of mitigation for impacts caused by development and other projects that either fall under the regulatory purview of the CWA or the ESA. Mitigation of direct, indirect, or cumulative impacts may also be conducted under NEPA, CEQA, CZMA or CCA. Section 3.6 "Overview of Government Regulation of Bay Activities" provides a broad description of various federal and state laws under which mitigation may be required for projects in San Diego Bay.

Mitigation is the avoidance, minimization, rectification, and reduction or elimination of negative impacts or compensation by replacement or substitution (Office of Technology Assessment 1984). When an unavoidable impact requires compensation through creation, restoration, or enhancement of habitat, the mitigation site may be adjacent or nearby to the impacted habitat (onsite mitigation),

or may be outside the habitat sustaining the impacts (offsite mitigation). The mitigation project may replace the resources that are lost with resources that are physically and biologically the same (in-kind mitigation) or different (out-of-kind mitigation) (Lewis 1989). Mitigation that requires replacing habitat may involve creation of new habitat, or restoration and enhancement of existing habitat. Habitat creation is the conversion of one type of habitat into another type by human intervention (Lewis 1989) (e.g. excavating a wetland out of upland habitat).

- Achieving compliance criteria is not the only value provided by mitigation projects.

A mitigation project is considered successful under the CWA or ESA when the project compliance criteria are achieved. However, a project that does not achieve its compliance criteria may provide other useful values, and a project that does achieve compliance criteria may not be considered "successful" in replacing the ecological function when compared to natural habitat.

Guidelines for mitigation under Section 404(b)(1) of the CWA are listed in EPA regulations (40 CFR 230–233) and the Memorandum of Agreement between the USACOE and EPA on these Guidelines. Of the special aquatic sites identified to receive greater scrutiny under these Guidelines—sanctuaries and refuges, wetlands, mudflats, vegetated shallows, riffle and pool complexes, and coral reefs—only wetlands (in the Bay's case, the salt marsh) are specifically identified as requiring "a minimum of one-for-one replacement (i.e. no net loss of value) with an adequate margin of safety to reflect the expected degree of success associated with the mitigation plan."

- A permit may be denied if "significant degradation" would result, or if an alternative exists that will meet the project purpose. The USACOE will grant a permit unless it is determined to be contrary to public interest.

For intertidal habitat other than salt marsh, unvegetated shallows, and deep subtidal habitats in the USACOE jurisdiction (below +7.8 ft/2.4 m), compliance with 404(b)(1) Guidelines is essentially evaluated qualitatively and involves exercise of the judgment of the USACOE in each permit application. The USACOE is required to deny the permit if the findings show that the proposed discharge, even with mitigation, would result in "significant degradation," to include consideration of effect of the fill on the water bottom, water flow and circulation, turbidity, the aquatic ecosystem and organisms, contamination of the water, and downstream resources (40 CFR 230.10[c]). The Guidelines apply an additional burden of proof requirement covering special aquatic sites such as salt marsh, mudflats, and eelgrass beds—to demonstrate that no practicable alternatives exist that will meet the project purpose (40 CFR 230.10[a]).

Within the restrictions of EPA Section 404(b)(1) Guidelines, the USACOE will grant a permit unless the permit is determined to be contrary to public interest. To determine effect on public interest, the USACOE is required to balance the benefits expected against the foreseeable detriments of the proposed project. The factors considered in this review are conservation, economics, aesthetics, environmental quality, historic values, fish and wildlife values, flood control, land use, navigation, recreation, water supply and quality, energy needs, safety, food production, and the general public and private need and welfare (33 CFR 320.4).

Under authority of the CCA and the federal CZMA, the CCC has jurisdiction over permits for development in the coastal zone within wetlands, tidelands, submerged lands (below mean low tide), beaches, estuaries, riparian habitat, streams and public trust lands. The definition of wetlands used by the CCC differs from that of the USACOE in that it includes nonvegetated areas such as mudflats and an additional 100 ft (30 m) wide terrestrial buffer measured from the upland edge of the wetland.

Mitigation is also required for impacts to threatened and endangered species protected under the federal and state ESAs. Excluding species that are associated with riparian habitat, there are five federally endangered species, one federally threatened species, and five state endangered species associated with San Diego Bay (see Table 2-28 for sensitive species and their habitats list). The federal ESA requires that USFWS protect and restore threatened and endangered species and their critical habitat, and that federal actions avoid impacts to these species. For San Diego Bay, the USFWS uses the relative percent loss of a habitat type compared to historic conditions as a guide in establishing mitigation requirements (M. Kenney, pers. comm). Under the parallel state ESA, the CDFG must be consulted on state projects that may impact endangered species.

The TOC believed that it is important to document the evolution of mitigation policy in southern California. To begin this process, a brief history of mitigation in southern California is presented below.

Brief History of Eelgrass Mitigation in Southern California

The practice of mitigation for projects permitted under the Clean Water Act, Endangered Species Act, and other environmental laws has evolved greatly over the more than 20 years since these laws were first enacted and enforced. During the late 1960s to early 1980s, a series of federal laws were passed that, together, form the core national policy for protecting natural resources. How this policy manifested itself in southern California and San Diego Bay is a story of, at first, resistance to change, then step-by-step acceptance and progressively honing the pragmatic details of making the policy work site by site, project by project.

An example is the evolution of mitigation practices for impacts to eelgrass habitat. At first, neither the regulator nor the project sponsor knew how to successfully establish eelgrass in a technical sense. There was no field experience on which to base methods. According to regulatory guidelines, the goal of compensatory mitigation was to prevent any net loss of function, area, or value. No one knew if compensation for impacts was even accomplishable, let alone enforceable. Methods were developed over time by both scientific experimentation and trial-and-error.

In addition, there was resistance to even attempting to compensate for eelgrass losses. Some project sponsors flatly refused to attempt eelgrass planting until they were threatened with legal action. The original criterion for "success" was simply getting the project sponsor to conduct eelgrass planting at all.

In the 1970s, the Navy was one of the first to mitigate for a Bay fill with eelgrass planting. It failed based on today's success criteria, but at the time there were no performance standards. With evolving technical expertise, it became clear that eelgrass could be established successfully in the field, and that a certain density of planting could be required within a specified time frame. Enforceable performance standards began to become a practicality.

Gradually, as requirements and enforcement became more consistent and predictable, mitigation became accepted simply as a cost of doing business. This cost began to increase as the technically easy site were taken, and project sponsors were forced into more challenging environments. Coincident with this cost increase, the number of permit applications decreased. Today, the requirement to compensate for eelgrass impacts requires more technical expertise, money and innovation than ever. The dramatic losses of eelgrass habitat that occurred prior to the Clean Water Act have abated.

The sum of this experience is found in the Southern California Eelgrass Mitigation Policy, first approved in 1991by NMFS, USFWS and CDFG, and last revised in 1999. The Policy is endorsed by the USACOE and the CCC. It has helped standardize the resource agencies' response to projects such as dredging, pile-driving, in-water military training and operations, and research and development work.

Some past mitigation projects in San Diego Bay are shown in Map 4-1, which includes a brief description of each.

Evaluation of Current Management

This evaluation focuses on mitigation under the CWA and ESA. While the NEPA review process can also play a role in reducing environmental effects, many projects are small enough that a significant impact cannot be documented. In addition, to be effective, a biologist must be involved at the site-selection and design phase, typically much earlier in the planning process than NEPA currently becomes engaged in some organizations.

Eelgrass

- Full functional value is achieved in eelgrass transplant sites within two to three years. Most eelgrass transplant projects have resulted in an increase of eelgrass coverage.

Mitigation policy and management for eelgrass has been very successful in increasing the amount of eelgrass habitat in San Diego Bay. During the last 10 years, most eelgrass transplant projects in San Diego Bay have met the permit success criteria of vegetative cover and density and have resulted in a net increase in eelgrass coverage. Although the success criteria are based on structural attributes only, a study conducted in Mission Bay suggests that full functional value is achieved in transplant sites within two to three years (R. Hoffman, pers. comm., Hoffman 1990). Fish use was compared between a transplanted site and adjacent natural eelgrass beds, and within two to three years fish use of the transplanted eelgrass was equivalent to the natural eelgrass. Although benthic invertebrates and other resources were not specifically studied, it was assumed that they were present to support the fishes. In a study by Takahashi (1992) in the Bay, the invertebrate fauna in transplanted eelgrass beds was found to become established within a short time. Additional studies could determine the success of eelgrass transplant projects in attaining full functional value for all resources including, for instance, development of detrital exchanges with other habitats. Detrital exchange is a primary way organic matter is made available to consumers--many animals feed on detritus.

Currently, at least some eelgrass is present in all locations of San Diego Bay that are suitable for its growth (R. Hoffman, pers. comm.). This means that there are currently few, if any, suitable sites for transplanting. Since there is currently no out-of-kind mitigation allowed for eelgrass impacts, projects must excavate uplands or fill deeper habitat to a suitable depth to support eelgrass transplants. For example, to mitigate recent Navy dredging that impacted eelgrass habitat, the dredge material was deposited in an area too deep to support eelgrass. Filling in this habitat solved the light penetration problem and the site became suitable for eelgrass growth.

Intertidal Flats

No mudflat mitigation projects have been attempted in the Bay. However, a mudflat island has been approved through all the permitting agencies for construction off the NAB shoreline as mitigation and enhancement related to the second new nuclear carrier project. Recent excavation of uplands at NASNI as mitigation for berthing the first new nuclear carrier has resulted in some accumulation of material for use by shorebirds. Generally, however, with nearly three-quarters of the shoreline length affected by stabilization structures and over-steepened or affected by too strong a current, and only 16% of the original tidal flat area remaining compared to historic acreages, little opportunity remains for enhancement of severely depleted intertidal flats through conventional mitigation policy implementation.

Salt Marsh

Management of salt marsh, as in all habitats, is based on an incomplete understanding of the functioning of the wetland system and has generally resulted in efforts that replace the structure and some, but not all, functions of these habitats. The most visible lack of function is the lack of use by marsh birds, especially for nesting by the light-footed clapper rail. This loss has occurred both at the CVWR and at the Paradise Creek and Marisma de Nacion constructed marshes.

Photo © 1999 Tom Upton.

Photo 4-9. Black-necked Stilt.

The Connector Marsh mitigation project is an example of a project where mitigation criteria were changed, after litigation, to include functional requirements, as described above (Table 4-1). The functions of the marsh system have not yet been achieved due to problems with nitrogen levels, abundances of invertebrates, the presence of exotic species and others (Zedler 1991). The low success of mitigation projects has resulted in an overall net loss of salt marsh in the time frame evaluated, since the impact site is damaged and the mitigation site does not fully replace the habitat or functioning of the historic wetland (Zedler and Powell 1993).

Work completed recently in Mission Bay (Levin *et al.* 2000) examined four years of faunal recovery in a newly constructed marsh compared to a reference site. Fishes and invertebrate epifaunal components of the constructed marsh developed the most rapidly. Within 6-9 months, densities of these groups had recovered to natural marsh levels. However, size structure and other properties remained different in the created and natural systems. Macrofauna developed more slowly. Density and species richness were similar between the constructed and natural marsh after two and one-half years, but species composition continued to differ after three and one-half years. Insect larvae colonized first, followed by oligochaetes. Natural spatial recovery in sediment particle size, soil organic matter, and elevation appeared to drive plant recovery and faunal recolonization patterns in the constructed marsh. Higher sea level associated with El Nino appeared to accelerate faunal development.

Levin made the following recommendations for salt marsh restoration based on this study:

1. Assess elevation carefully in design of restored marsh habitat. Lower elevations are wetter and promote more rapid development of macrofaunal assemblages.
2. Analyze pre-existing spatial variation in soil texture and organic matter content and where possible, use historical marsh sediments. Finer-grained sediments with below-ground detritus promote marsh grass growth and a more abundant and diverse infauna. Sites that historically supported marsh habitat are more likely to exhibit these sediment properties and will experience enhanced restoration success.
3. Amendment of constructed marsh soils with Milorganite or a similar sewage-based product may promote development of plant and animal communities most similar to those in natural marshes.
4. Recognize rafting as a major marsh recolonization mechanism for fauna and create linkages (e.g. connecting channels) that promote transfer of plant and algal rafts from natural habitat.
5. Incorporate intertidal pools and other shallow-water habitat in the design of constructed marshes to provide nursery habitat for resident fishes.
6. Slow recovery rates and inter annual variability suggest that long-term monitoring is required to accurately evaluate restoration success.

Proposed Management Strategy—Mitigation and Enhancement

***Objective:** Improve the success of mitigation and enhancement projects based on regulatory, functional, and ecosystem criteria.*

I. Achieve no net loss of structure and function of natural intertidal and shallow subtidal habitats, and a long-term net gain in acreage and function.

- ***A.*** Aggressive avoidance should remain the primary strategy to avoid loss of natural resource values in the Bay.

II. Improve the effectiveness of mitigation policy in achieving the ecosystem objectives of this Plan.

- ***A.*** Seek an "optimum" landscape mix based on the best available knowledge of the following habitat attributes:
  - Most impacted (e.g. intertidal flats, salt marsh including, river mouths, shallow subtidal).
  - Most vital in terms of function (unknown).
  - Most limiting to protection of rare species (e.g. upland transition and intertidal sand flats, mudflats).
  - Most at risk of loss (e.g. intertidal and upland transition).
- ***B.*** Establish a consensus among regulatory and resource agencies on target acreages in each of the above categories, as a guide for mitigation planning. Revisit targets on a regular basis to evaluate their practicality as a management tool.

C. At every reasonable opportunity, mitigation opportunities should be oriented towards improving the value of severely depleted habitats for which little opportunity exists for enhancement in the usual project mitigation setting. Intertidal flats, upland transition, and cordgrass are such habitats. Such efforts should not result in a loss of fish or other pre-project habitat values.

D. Allow more flexibility in crossing jurisdictional boundaries (both ownership and regulatory agency) in order to implement on a case-by-case basis the beneficial use of dredge material, out-of-kind mitigation, or other means, to enhance severely depleted habitats. Such efforts should not result in a loss of fish or other pre-project habitat values.

E. Conduct the necessary preplanning and develop agreements with regulators whereby mitigation for a series of projects may be combined for the purpose of accomplishing a larger or more ecologically effective project, without fines or penalties. This is a form of mitigation banking.

F. Maximize the habitat value and function of man-made structures in the Bay through the permitting process.

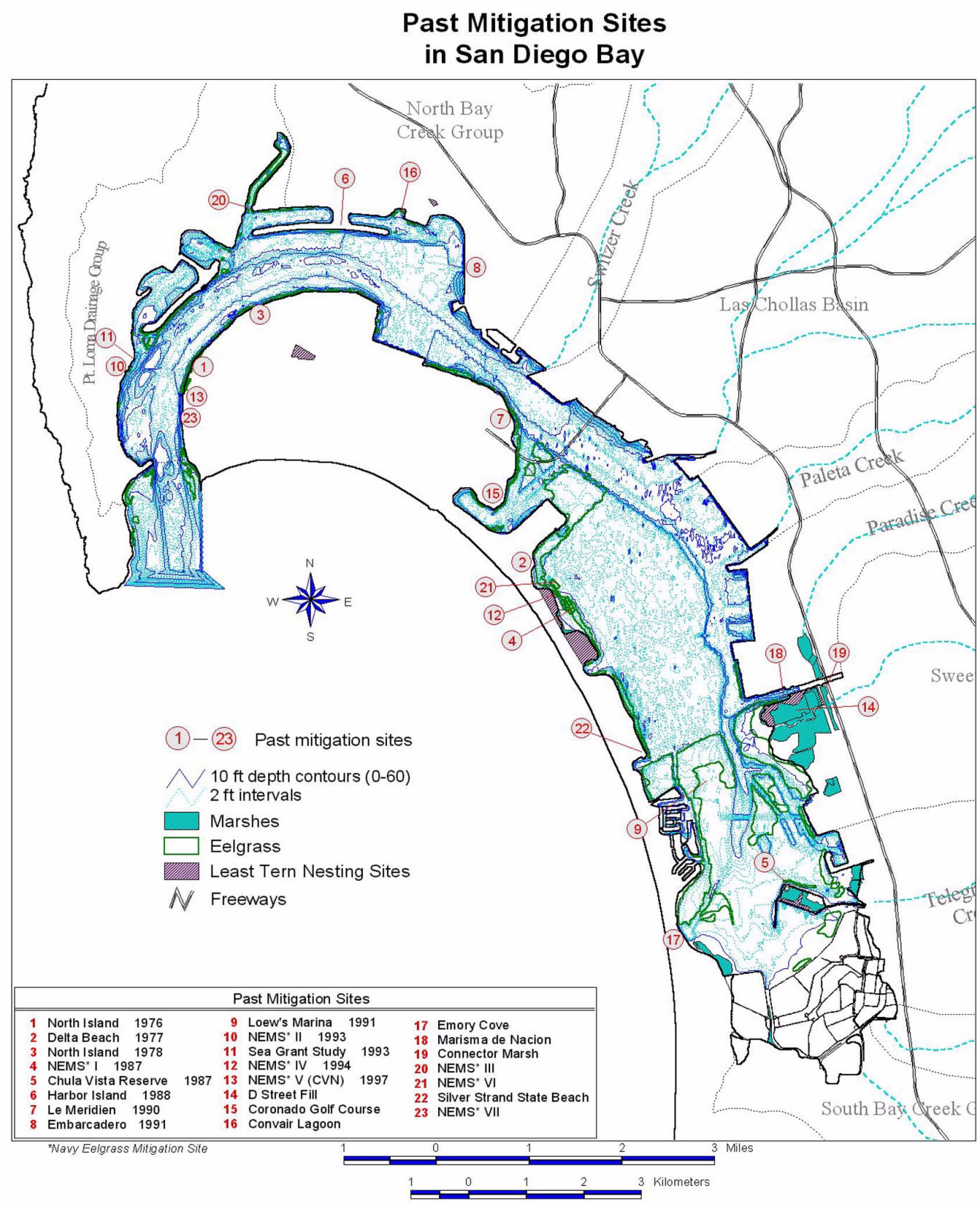
1. Assess the relative habitat values of existing man-made structure in the Bay.

2. Find means through the permit process, or otherwise, to encourage experimentation and installation of man-made structures that function more like mudflats and tidepools.

G. Mitigation performance standards should include both structural and functional criteria. Structural criteria describe the abundance, composition, and biomass of the ecosystem components (such as sediment, pore water, plant, invertebrate, and vertebrate properties). Functional criteria emphasize the processes that take place among the components, such as primary and secondary productivity, and use by species.

1. Conduct research to develop and validate practical, specific, quantitative measures for attributes of habitats that promote functions upon which plants, fish, and wildlife depend, such as:

- Provision of food (trophic functions).
- Provision of stopover or safe habitat for migratory species.
- Provision of nursery grounds for juvenile stages of fish, shellfish and birds.
- Support of endangered or threatened species.
- Shoreline stabilization (reduced erosion).
- Groundwater recharge.
- Trapping of particulates and pollutants from the watershed.
- Elemental recycling.
- Buffering of shoreline from destructive action of storm waves and currents.
- Export of energy and organisms to adjacent open water habitats.
- Bioturbation and irrigation of sediments (release or burial of pollutants).



Map 4-1. Past Mitigation Projects in San Diego Bay.

- Biodiversity maintenance.

2. Consider the contents of Table 4-2 as a preliminary example of attribute measures that should be researched to determine their level of importance, practicality, and cost-effectiveness for use as a performance standard.

Table 4-2. Attributes That Should be Researched to Determine Their Level of Importance, Practicality, and Cost-effectiveness for Use as a Performance Measure.

Attribute	Subtidal Unvegetated	Subtidal Vegetated	Intertidal Mudflat	Intertidal Sandflat	Upland Transition	Salt Marsh	Shoreline Structures
Sediment Properties ■ particle size, ■ organic matter content, ■ salinity, ■ incident light, ■ Eh/pH (redox), ■ permeability and porosity, ■ drainage patterns, ■ sediment accumulation and erosion, ■ pollutant concentrations.	X	X	X	X	X	X	
Landscape Properties ■ patch area and configuration (dimensions), ■ elevation, ■ boundary integrity, ■ connectivity to other habitats.	X	X	X	X	X	X	
Vegetation Cover ■ algae and vascular plant density and biomass, ■ primary production, ■ density of critical function, ■ density of endangered plants.		X			X	X	X
Invertebrates ■ abundance/density/diversity of infauna, ■ density of critical function taxa, ■ diversity of infaunal/epifaunal lifestyles (e.g. dwelling modes such tube builders, burrowers, or attached) and feeding modes (suspension feeders, surface deposit feeders, herbivores/grazers, carnivores, scavengers,; ■ presence of larger infauna (ghost shrimp, clams, etc.) ■ bioturbation.	X	X	X	X	X	X	X
Vertebrates ■ use by rays, California halibut, and other fishes (e.g. killifish), ■ use by birds (habitat, feeding, nesting), ■ diet analysis by stomach contents or isotopic analysis.	X	X	X	X	X	X	X
Exotics ■ proportion (by abundance, biomass or % cover), ■ habitat alteration by exotics, ■ exotic species role in food chains.	X	X	X	X	X	X	X
Endangered or Threatened Species Use ■ density and diversity, ■ spatial and temporal distribution, ■ threats.	X	X	X	X	X	X	X
Linkages With Adjacent Habitats ■ migratory birds, ■ fishes, ■ particulate and pollutant transport.	X	X	X	X	X	X	X

3. Develop a mechanism to ensure the incorporation of attribute measures that are determined to be important into permit conditions for monitoring.

H. Use the Southern California Eelgrass Mitigation Policy as a model for developing and improving policy in intertidal and shallow unvegetated areas, including the imposition of penalties for failure to meet mitigation standards (see Appendix H).

I. Explore the use of public-private partnerships to implement up-front mitigation, with sufficient time to demonstrate "success" prior to project approval.

J. Whenever possible, mitigation performance standards should use long-term, functionally based assessments, particularly for created habitats. Alternatively, mitigation performance evaluation should be integrated with regularly conducted "State of the Bay" assessments proposed by this Plan. Long-term observations are necessary because of the extremes that occur in southern California (e.g. high variability in rainfall and stream flow), and to identify cause and effect.

K. Mitigation banking may be advantageous as a policy instrument on a restricted basis, such as for implementing out-of-kind mitigation for specific ecological objectives of this Plan, or other watershed-based or regional plan, within a basic no-net-loss framework. Since mitigation banking presupposes continued development impacts on protected habitats, including those recognized to be highly limiting and already heavily impacted in the Bay, it should be accomplished as part of a public process that seeks to guide and balance the desirability of any future losses and includes this Plan's goal and objectives.

III. Conduct Baywide or coarser-scale mitigation planning.

A. Identify and map all potential restoration and enhancement sites in the Bay. Use Map C-6 and Table 4-3 as a starting point.

B. Identify target acreages for each of four Bay regions for functional habitat enhancement on a landscape level.

C. Indicate the most appropriate restoration procedures for each site. Use scientific principles as a guide:

1. Large patch sizes support and maintain high biodiversity.
2. Improve, expand, and link existing habitat remnants in preference to creating new habitat patches. Good linkages with adjacent habitats and few barriers to water flow and animal movement support greater biodiversity. Small habitat remnants are likely to have lower resilience and less resistance to natural and man-made perturbations.
3. Specific communities will develop best if located near or adjacent to an existing community of the same type (so it can invade and establish on its own).
4. In some cases, maximizing habitat "edges" will maximize a system's value, such as for marsh bird foraging. However, maximizing edges can have negative effects depending on disturbance regimes and the target management species.

D. Favor in-kind mitigation as a first choice unless the out-of-kind mitigation is for a more scarce habitat (Table 2-3) than the impacted site. Use the following priorities as a guideline for mitigation siting:

1. Link smaller, disconnected sites to larger ones.
2. Identify sites of high habitat value or that function as biodiversity reserves (e.g. intertidal salt marsh, mudflats, eelgrass beds) and expand these areas.
3. Expand area of smaller patches of high value or biodiversity, emphasizing the currently existing habitat.
4. Once expanded patches show promise for attracting and supporting sensitive species, create such habitat types at locations that formerly included them.
5. Leave as a last priority the creation of habitats at sites where they have never occurred historically.

Table 4-3. Candidate Enhancement Opportunity Areas.

Area	Description and Possible Enhancement Opportunities/Constraints
1—D Street Fill	Area of approximately 100 acres (40 ha) of dredge spoil from Sweetwater Channel. Portions currently graded for least tern nesting. *Enhancement potential:* excavation of a tidal channel across fill, and creation of additional intertidal salt marsh habitats (~25 to 30 acres/~10 to 12 ha). Expanded predator management. Potential credits available. *Possible Constraints:* Must balance marsh enhancement with needs of existing tern site. Spoil disposal method to be determined.
2—Gunpowder Point	A 36 acre (15 ha) "island" of coastal sage scrub and maritime succulent scrub surrounded by a small areas of intertidal salt marsh and flats. *Enhancement potential*: creation of expanded tideflat or salt marsh habitat, but most of enhancement potential is for upland transition habitat. *Possible Constraints:* Suitability of soils, proximity to D-Street Fill may result in problems associated with improved nesting for predators of the least tern and snowy plover.
3—National City Marina / Marine Terminal	Soften shoreline, crenulate (make more irregular) and less steep on western face, for example. Look for alternative that at least does not steepen the slope.
4—F, G, and J Street marshes, connector marsh, and associated mudflats	Intertidal mudflat and low-lying salt marsh and upland transition located immediately adjacent to SDG&E on J Street. Ephemeral tidal marsh at "F" Street and poorly flushed saltwater marsh on "G" Street, both serviced by a small, ineffective culvert. *Enhancement potential:* An additional channel, refuge islands, secondary tidal channels, and Bayward expansion of the marsh. Needs improved flushing, possibly by new enlarged culvert and channel between culvert and Bay. Needs clearing of sediment, trash. Should close to recreational all-terrain vehicle traffic. *Possible Constraints:* Questions regarding current habitat conditions and possible impacts associated with enhancement projects. Suitability of soils.
5—Chula Vista Wildlife Reserve	Reserve created by constructing an access levee/road and a ring levee system in a subtidal area of south San Diego Bay. Dikes were designed to erode down over time. *Enhancement potential:* Integrate with any mitigation plans for power plant. Create additional intertidal wetlands. Improve wetland-upland transition. CVWR could be expanded on the south, west, or north sides of the present Reserve. Reduce water-born debris. Establish tidal channel system. Tern nesting could be expanded or improved by addition of a sand cap. *Possible Constraints:* Effects on SDG&E intake/outflow channels (but the existing plant is scheduled to be torn down or re-engineered in the long run). Possible alteration to water temperature patterns in south Bay. Effects on green sea turtle, fisheries, and waterfowl values. Impact of construction activities on current habitat values.
6—South Bay Salt Ponds	Once the largest expanse of tidal salt marsh in south San Diego Bay, now commercial salt ponds. *Enhancement potential:* Improvement of levees by replacement soil material and vegetation removal. Exclusion of vehicles from the nesting levees during nesting season. Creating intertidal mudflat habitat and salt marsh. Predator management. *Possible Constraints:* Impacts of enhancement projects on current habitat values.
7—Lower Otay River Wetlands	An undeveloped upland site adjacent to tidal flow. *Enhancement potential:* Realign Otay River to a more natural configuration through Pond 20 and the Egger-Ghio property. Also broaden it. Excavate 8 acres (3 ha) fresh-brackish pond, establish 44 acres (18 ha) of tidal salt marsh and channels, and another 40 acres (16 ha) of willow-riparian woodland and mudflat riparian scrub. This could involve dredging or removing the train track berm. Control trash by upstream trash catchers?
8—Emory Reserve	Area of degraded wetlands and transitional uplands currently used as an illegal parking lot. *Enhancement potential:* Marsh enhancement. Elimination of vehicle access. Conversion of peripheral uplands to wetland habitats. Fencing and excavation of small area (0.1 to 0.2 acre/.04 to.08 ha) for salt marsh enhancement. Control trash. Close off access.
9—Emory Cove Boat Basin and Channel	Ten acre (4 ha) area of subtidal open water habitat surrounded by intertidal mudflats. *Enhancement potential:* Fill in channel.
10—Coastal Strand Dunes and Native Plant Restoration	*Enhancement potential:* Remove exotic species, revegetate with natives, and restore dunes.

Table 4-3. Candidate Enhancement Opportunity Areas. (Continued)

Area	Description and Possible Enhancement Opportunities/Constraints
11—Grand Caribe / Coronado Cays	Swimming and recreation beach. Low tidal flux and sandy shore. Walkway along beach to provide access for viewing wildlife, jogging, and fishing. An existing plan is to raise the elevation and build a hotel, which would prevent restoration. *Enhancement potential:* Excavate beach to create intertidal habitat.
12—Crown Cove and Navy land (leased)	Beach and open water habitat. *Enhancement potential:* Beach cleanup, construction of a boardwalk and launch dock to avoid disturbance of marsh habitat. Enhancement of remnant salt marsh and dunes.
13—US Navy Radio Receiving Facility	*Enhancement potential*: Restore dunes, vernal pools. Remove exotic plants (iceplant). Create additional California least tern, western snowy plover nesting areas, or other wildlife values. Protect salt marsh bird's beak, Nuttall's lotus, San Diego sunflower, coast barrel cactus, variegated dudleya, light-footed clapper rail, reddish egret, Belding's savannah sparrow, Pacific pocket mouse, long-billed curlew, black skimmer, burrowing owl, common loon, and white-faced ibis.
14—Paleta Creek Mouth	*Enhancement potential:* Remnant salt marsh, shoreline and creek may be restorable. Work with landowner to shallow the banks as they lead into the Bay.
15—Chollas Creek Mouth	*Enhancement potential:* Remnant salt marsh, shoreline and creek may be restorable.
16—Shoreline between SUBASE and fuel pier	Disturbed dune system. *Enhancement potential:* Protect foraging and loafing value for birds. Remove invasive exotic plants. Remove parking lot. Recontour the cliff to historic configuration. Fill in and build up beach. Protect the beach and restore the uplands.
17—Silver Strand State Beach	*Enhancement potential*: Restore dune and upland habitats.
18—NASNI shoreline	Currently varies from beach to random rubble to rock revetment. *Enhancement potential*. Enhance shoreline structures or remove boat ramp, old seaplane ramp.
19—NTC boat channel	*Enhancement potential*. Soften, crenulate the shoreline by excavation, or otherwise provide ecologically beneficial shoreline structures. Improve wetland-upland transition. Consider vegetated swales or water treatment channels for runoff.
20—Coronado Bayfront	Shoreline now too narrow for effective shorebird use. *Enhancement potential:* Soften and broaden the shoreline and existing mudflat for improved intertidal. Combine erosion control with ecologically beneficial shoreline treatment. Portions can be filled without retaining wall.
21—Coronado golf course shoreline	*Enhancement potential*. Enhance shoreline without affecting boat channels, and without riprap or walls.
22—North Delta/NAB/Least Tern Nesting Shoreline	*Enhancement potential*. Reconstruct mudflat.
23—SDG&E Power Plant site	Significant population of endangered sea turtles to be affected by loss of warm water output from shut-down power plant. *Enhancement potential*. Integrate with plans for Chula Vista Wildlife Reserve.
24—Sweetwater River Mouth and Flood Control Channel	*Enhancement potential*. Reconnect the stranded channel (now isolated by a riprap channel), and soften the shoreline. Restore natural connection and riparian habitat, including east of I-5. Remove pampas grass and shore up shoreline.
25—Port's Rohr site	Remnant salt marsh could be enhanced.
26—Borrow Area	Fill in to surrounding elevation or shallower for eelgrass.
27—Convair Lagoon	About 7 acres (.28 ha) capped for PCB contamination and an L-shaped berm put in place. It is possible to extend the fill to the east and west of the riprap berm around the cap to increase the shallow water area for eelgrass habitat, e.g. by disposal of fill. Protect shoreline for use by loafing marine birds.
28—Alpha Beach / Crown Cove	Gentle the slope to widen the beach, and enhance for intertidal mudflat, while filling in on interior side to replace lost eelgrass, designing for no interim loss.
29—Mudflat off of Sweetwater NWR	Protect and enhance mudflat values.
Concepts from South San Diego Bay Enhancement Plan 1990, INRMPs for Navy installations, members of TOC.	

E. Where no match is possible for in-kind mitigation, or where extensive modifications are likely to be unsuccessful, establish out-of-kind compensations that still contribute to the goal and objectives of this Plan.

F. Integrate watershed and regional planning into Bay ecosystem enhancement goals.

IV. Develop the inter-agency agreements and permit mechanisms necessary to achieve ecosystem-level strategies advocated by this Plan.

V. Conduct more effective preplanning to avoid costly delays in project mitigation.

- ***A.*** Major project proponents should hold quarterly meetings with regulators during which projects are presented at the 10% design phase.
- ***B.*** Develop a project preplanning form to help communicate key parameters of a project, regulators' expectations, and compatibility of projects with the objectives of this Plan. An example is shown in Table 4-4.

VI. Support more effective regional mitigation policy and innovation and experimentation in mitigation technology, allowing for an adaptive management approach.

- ***A.*** Determine how to identify and measure habitat values and functions (see also *IID*).
- ***B.*** Research rare, endangered, and exotic species, particularly population dynamics; how they interact within their communities; minimum viable population size; and the habitat size necessary to support them (Williams and Zedler 1992).
- ***C.*** Carry out ecological studies to determine what conditions limit ecosystem development so that appropriate performance standards can be met (Zedler 1996a).
- ***D.*** Link research with mitigation monitoring to help explain habitat requirements, causes, and effects.
  1. Gain further understanding on what are the "natural" or expected levels of population fluctuations of eelgrass beds.
  2. Determine if there are some potential threats to eelgrass beds that can be managed for, such as introduction of exotic species.
  3. Gain knowledge on biological organization and physical estuarine processes, such as primary productivity, nutrient dynamics and habitat specificity (e.g. the salinity tolerance of marsh plants or estuarine usage of fish and wildlife). Start by organizing and making available data that already exists.
  4. Facilitate small-scale experimentation with techniques to improve the success of mitigation, and disseminate this information to others.
  5. Verify physical modeling of Bay circulation and tidal flushing.

4.2.3 Protected Sites

Specific Concerns

San Diego Bay has already lost about one-third of its original habitat area, much of it the intertidal and shallow subtidal regions that provide the Bay's core wildlife values. The emphasis in this section is on permanent safeguarding from development of minimum habitat acreages through protected site designations as well as active management. Regulatory protections by agencies are addressed in Chapter 5.

Table 4-4. In-water Project Preplanning Checklist

In-water Project Preplanning Checklist (Draft)

The purpose of this checklist is to: 1) support early and effective communication between the resource agencies and project proponents; 2) track projects and habitat changes over time as part of a long-term monitoring program; and 3) possibly use as an opening page of Environmental Assessments.

1. Location of Project
   - Intertidal (+7.8 ft. to –2.2 ft. MLLW) (see Sections 2.4.4 and 4.2.1.5 for description of values and strategies for their protection)

     Fill? Yes/No If yes, then provide area covered:_____. 404(b)(1) analysis is required

     Dredging?

     Coverage by Structures?
   - Shallow Subtidal (–2.2 to –12 ft. MLLW) (see Sections 2.4.3, 4.2.1.3, and 4.2.1.4 for description of values and strategies for their protection)

     Fill? Yes/No If yes, then provide area covered:_____. 404(b)(1) analysis is required

     Dredging?

     Coverage by Structures?

     Eelgrass Impacts?
   - Medium Subtidal (–12 to –20 ft. MLLW) (see Sections 2.4.2 and 4.2.1.2 for description of values and strategies for their protection)

     Fill? Yes/No If yes, then provide area covered:_____. 404(b)(1) analysis is required

     Dredging?

     Coverage by Structures?

     Eelgrass Impacts?
   - Deep Subtidal (>20 ft. MLLW) (see Section 2.4.1 and 4.2.1.1 for description of values and strategies for their protection)

     Fill? Yes/No If yes, then provide area covered:_____. 404(b)(1) analysis is required

     Dredging?

     Coverage by Structures?
2. Timing of Project
   - Does project occur during California least tern nesting season, April 1 to Sept. 15?
   - Avoidance and minimization measures:
3. Location of Deposition of Dredged Material
   - Offshore Site L.A. 5?
   - Ocean beaches? If yes, then are the following affected: kelp beds, rocky habitat, grunion spawning, surf grass, or nesting by western snowy plover?
   - Landfill? Where is it and what contaminates and contaminate levels has it been approved for?
4. Have contaminant surveys for dredged material been conducted?
5. Are there opportunities for habitat enhancement with this project? (See Section 4.2.2 "Mitigation and Enhancement" for habitat enhancement strategies)
6. What Bay Ecosystem Plan objectives does this project support?

Photo 4-10. Heron Park Sign at NASNI.

Concerns specific to protected habitat sites in the Bay include the following:

- Regulatory protections are addressed in Chapter 5.

- Much of the existing wildlife habitat in San Diego Bay is not protected through permanent designations, particularly intertidal and shallow subtidal habitats.
- Some bird populations are impaired by reduced amounts of intertidal habitats (salt marsh, mudflat, and areas with a mix of shallow zones) both in San Diego Bay and elsewhere along the Pacific Flyway.
- Minimum size, configuration, and management of protected sites is needed to protect and sustain natural habitat values and functions.
- Management of protected sites is often impeded by inadequate funding and staffing. Some sites are prone to illegal activities because of inadequate surveillance.
- Regulatory protection under the CWA does not necessarily guarantee that replacement mitigation sites achieve the value and function of natural ones in the time frame allotted for project monitoring. This has been demonstrated in the salt marsh (Zedler 1996a).

Current Management

Marine and coastal habitat areas in San Diego Bay that are designated for some level of protection from development are listed in Table 4-5, shown in Map 4-2 and are discussed below. Acreage figures are given for habitat types located within the sites. These federal, state, and local areas have varying degrees of management protection.

- Table 4-5 describes types of federal, state, and local protections for various habitats within the Bay.

Created in 1988, the 316 acre (128 ha) **Sweetwater Marsh National Wildlife Refuge** is a federally owned and managed component of the National Wildlife Refuge (NWR) System. Its designation protects the largest remaining tidal salt marsh in San Diego Bay. The allowable uses of this lawsuit-created refuge were spelled out in the US Fish and Wildlife Service's Biological Opinion of 1988, rather than in a specific management plan. Emphasis by the US Fish and Wildlife Service is on protection of the site's endangered bird species (i.e. California least tern, western snowy plover, light-footed clapper rail, Belding's savan-

Table 4-5. Marine and Coastal Habitat Areas in San Diego Bay That are Designated for Some Level of Protection from Development [table to be completed to include changes].

Designated Areas[1]	INRMP San Diego Bay Habitat Classification	Acres	Hectares
Habitat Protection Areas (in order of relative protection)			
Sweetwater Marsh National Wildlife Refuge (316 acres/128 ha)/US Fish and Wildlife Service.			
Permanently part of National Wildlife Refuge System and restricted by 1988 USFWS Biological Opinion. Emphasis on endangered species protection, and environmental education and interpretation.	Intertidal Flats Marsh Upland Transition	7.3 223.4 97.9	3.0 90.4 39.6
South Bay Marine Biological Study Area (19.4 acres/7.9 ha)/County of San Diego, Parks and Recreation Department (US Navy license).			
Also known as "South Bay Wildlife Preserve" or as "Educational Ecological Preserve." Use limited to study of marine biology and open to students in County. Five Year Renewable License with the Navy since 1972.	Intertidal Flats Marsh Upland Transition	1.7 15.7 1.9	0.7 6.4 0.8
Emory Reserve (102.4 acres/41.4 ha)/San Diego Unified Port District			
	Intertidal Flats Marsh Upland Transition Shallow subtidal	74.5 8.5 4.0 15.4	30.2 3.4 1.6 6.2
Chula Vista Wildlife Reserve (61.73 acres/24.98 ha)/San Diego Unified Port District.			
Designated in Master Plan as "Habitat Replacement"; uses limited to nature study, academic research and instruction, and similar resource uses. Boundary and use can be amended.	Intertidal Flats Marsh Upland Transition	10.2 33.0 18.6	4.1 13.3 7.5
Silver Strand State Beach (40 acres/16 ha)/CDPR (US Navy lease).			
Managed under 1984 general plan, uses include day use picnicking and a trail system on the Bay portion. Navy lease expires in 2022. One parcel presently under negotiation with Navy for exchange purpose.	Intertidal Flats Upland Transition	0.6 39.4	.24 16.0
South San Diego Bay Unit of San Diego National Wildlife Refuge (4742 acres/1919.8 ha)/US Fish and Wildlife Service and SLC.			
Property and lease purchased in 1999 by the Port from Western Salt and donated to the USFWS for the refuge. Primary intent is for wetland habitat restoration, California least tern nesting site mitigation, and shorebird habitat protection. A small portion on the outskirts may be excluded in the transfer for development by the Port.	Intertidal Flats Marsh Saltpond Upland Transition Eelgrass Riparian Fallow agricultural fields Shallow subtidal	492.0 57.0 1088.0 589.0 691.0 8.0 146.0 1721.0	199.2 23.1 440.5 238.5 279.8 3.2 59.1 696.8
SUBTOTAL Habitat in Protected Sites (Refuge/Reserve/Study Area).		**5,281.5**	**2138.3**
San Diego Unified Port District Jurisdiction: Land and Water Use Designation with Some Level of Habitat Protection (in order of relative protection)			
"*Wetlands*" (292.05acres/118.2 ha) as defined by SDUPD.			
To be preserved, protected, and where feasible, restored. Included is a Wildlife Preserve subarea contiguous to the north of the Navy-owned and designated South Bay Wildlife Preserve (aka Marine Biological Study Area).	Shallow Subtidal Eelgrass Marsh Intertidal Flats 	12.1 71.2 30.9 176.8 1.1	4.9 28.8 12.5 71.6 .45
"*Habitat Replacement*" (80.53 acres/32.6 ha) (Besides Chula Vista Wildlife Reserve [see above], also a portion of D Street Fill).			
Uses limited to nature study, academic research and instruction, and similar resource dependent activities.	Upland Transition	18.8	7.6

Table 4-5. Marine and Coastal Habitat Areas in San Diego Bay That are Designated for Some Level of Protection from Development [table to be completed to include changes]. (Continued)

Designated Areas[1]	INRMP San Diego Bay Habitat Classification	Acres	Hectares
"*Open Bay*" (328.37 acres/132.9 ha)			
For the multiple uses of recreation and natural habitat.	Deep Subtidal	23.0	9.3
	Medium Subtidal	71.3	28.9
	Shallow Subtidal	88.5	35.8
	Eelgrass	102.8	41.6
	Intertidal Flats	36.1	14.6
	Marsh	6.75	2.7
"*Estuary*" (957.54 acres/387.5 ha)			
Uses limited to new or expanded boating facilities, intake and outfall lines, restoration work, nature study, aquaculture, and resource-dependent activities. Can be used for boating, fishing, and similar water sports as long as efforts are made to reduce potential environmental damage.	Deep Subtidal	26.8	10.9
	Medium Subtidal	94.6	38.3
	Shallow Subtidal	528.8	21.4
	Eelgrass	185.7	75.2
	Intertidal Flats	118.7	48.1
	Marsh	2.7	1.1
	Upland Transition	0.2	.08
SUBTOTAL Habitat in SDUPD Zones			
Only these Water Use Zones Estuary, Habitat Replacement (including Chula Vista Wildlife Reserve, Open Bay, and Wetlands).	Deep Subtidal	49.8	20.2
	Medium Subtidal	165.9	67.2
	Shallow Subtidal	629.3	254.8
	Eelgrass	359.7	145.6
	Intertidal Flats	341.7	138.3
	Marsh	73.3	29.7
	Upland Transition	37.6	15.2
SUBTOTAL		1,657.3	671.0
TOTAL for All Sites with Some Level of Habitat Protection			
All categories (without double-counting of Chula Vista Wildlife Reserve).	Deep Subtidal	49.8	20.2
	Medium Subtidal	165.9	67.2
	Shallow Subtidal	2365.8	957.8
	Eelgrass	1050.7	425.4
	Intertidal Flats	917.7	371.5
	Marsh	378.0	153.0
	Primary Saltpond	1088.0	440.5
	Upland Transition	820.9	332.3
	Riparian	8.0	3.2
TOTAL		**6,844.8**	**2,771.2**

1. The Sweetwater Marsh National Wildlife Refuge is administered by the USFWS. Correct acreage obtained from USFWS, 1997. The CVWR is administered by the SDUPD and property acreage is an estimation from the 1996 Revised SDUPD Master Plan. The South Bay Marine Biological Study Area is administered by the County of San Diego, leased from the US Navy. Correct acreage as reproduced from a map provided by Realty Division, Southwest Division, Naval Facilities Engineering Command.

The SDUPD Jurisdiction Water Use Designations were reproduced from the 1996 Revised SDUPD Master Plan and acreages are approximations. See San Diego Bay SDUPD Jurisdiction Master Plan Water Designations Map 3-4 and San Diego Bay Habitat Map C-1 for locations. All habitat acreages are approximations as the habitat map is still in draft format.

Note: 18.8 acres of "D" Street Fill currently not in INRMP footprint.

nah sparrow) and restoration of salt marsh habitat, focusing on the reintroduction of the endangered plant, salt marsh bird's beak (Zedler 1996). Nature interpretation and environmental education is actively pursued through the Chula Vista Nature Center, operated by the non-profit Bayfront Conservancy Trust and the City of Chula Vista. Public access is encouraged but restricted to approved trails during daylight hours. Volunteer groups help manage the property through cleanups, trail building, revegetation, installation of artificial nesting platforms, and more. No hunting is allowed.

- South Bay Marine Biological Study Area's use is limited to the study of marine biology and open to local students.

The **South Bay Marine Biological Study Area** (also called "South Bay Wildlife Preserve" or "Ecological Preserve" on some maps and signs) is a 27 acre (10.9 ha) site in the southwest corner of the Bay that is owned by the Navy and has been leased to the County of San Diego since May 1972. As of 1974, the Navy has issued five-year licenses to the County for the purpose of "the establishment of an Educational Ecological Preserve which is open to the public," with use limited to the study of marine biology and open to the students of the Unified School Districts of

San Diego County. As conditions of the lease, the Navy requires a parking limit of 50 cars, minimization of electrical interferences with the NRRF, and compliance with the CWA's Section 404 conditions for wetlands. The site contains 26.35 acres (10.7 ha) of "federally protected wetlands" and the County cannot do any manipulation projects, including restoration, without a "Modification of License" from the Navy to ensure Section 404 permit compliance. The current license extends from June 1997 to 2002 (E. Ewell, Navy Realty Specialist, pers. comm.).

The County Parks and Recreation Department manages the Study Area and has developed a parking lot, established foot and bike paths, and has sought to stop bait fishing (e.g. mudsuckers). An information kiosk is planned in the near future. Surveillance is provided by two County rangers, one to three times per week depending upon the season (M. Webb, California Department of Parks and Recreation, pers. comm.). A management plan for the site may be prepared within the upcoming year (A. Rast, California Department of Parks and Recreation, pers. comm.).

- The Chula Vista Wildlife Reserve is the most well-recognized site designated by the Port for protection.

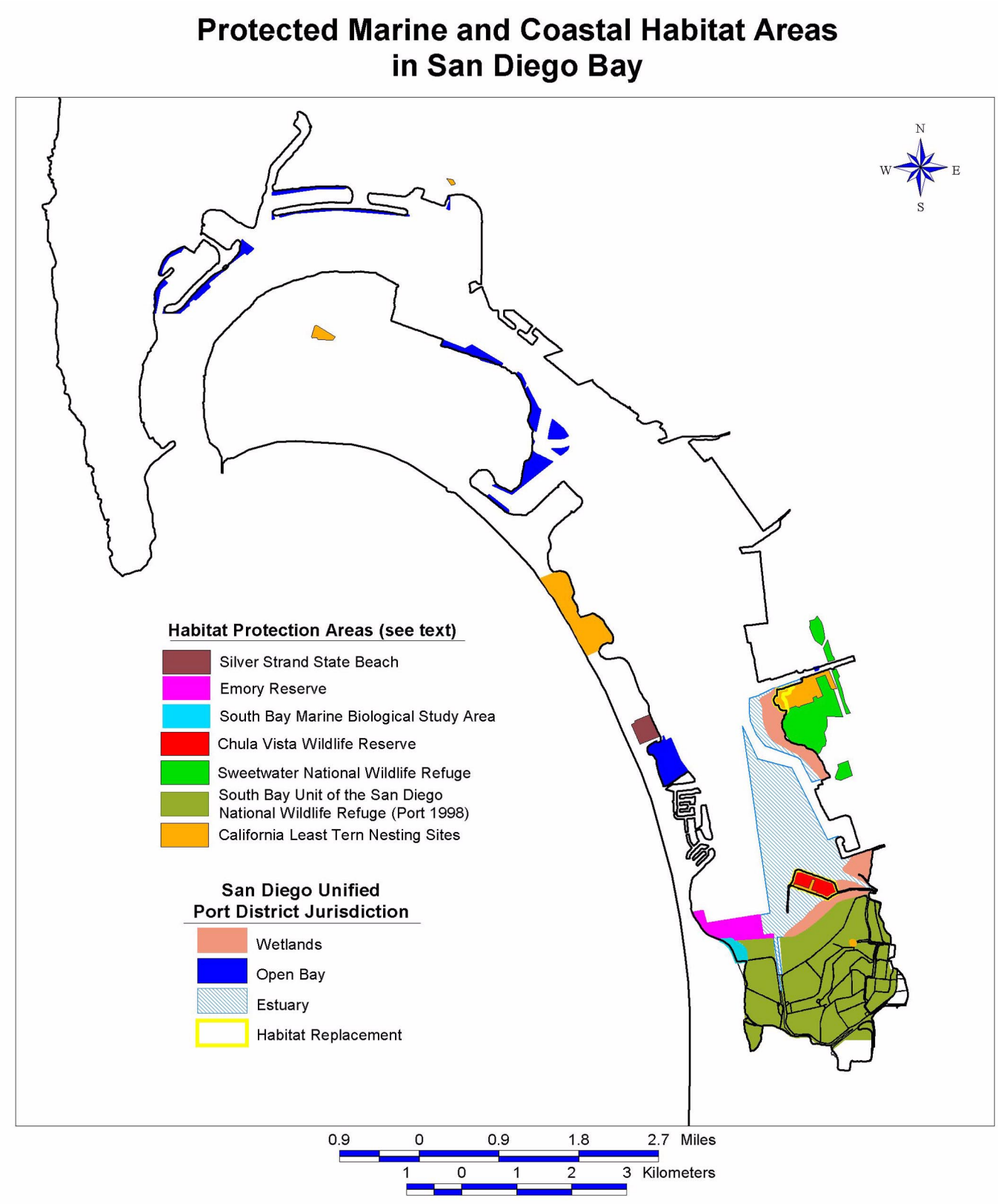
Protected sites by the **San Diego Unified Port District** are described in the Port's Master Plan and accompanying Planning Area Maps (1980, as amended). The **Chula Vista Wildlife Reserve** may be the most obvious protected site by its title, though designated "Habitat Replacement" in the Master Plan. It is a 55 acre (22 ha) artificial island created during 1977–1980 with dredged sediment from the Port's completion of the Chula Vista boat basin. In 1983, the constructed perimeter dikes were breached in two basins to allow tidal flow with the intent of creating a salt marsh. Use is limited to nature study, academic research, instruction, and similar resource-dependent activities. However, other water areas in the Port's jurisdiction are also designated for some level of protection from development, with "*Wetlands*" and "*Habitat Replacement*" the most restrictive categories and "*Open Bay*" and "*Estuary*" the most flexible. The **Emory Reserve** contains 8.5 acres (0.4 ha) of vacant uplands adjacent to Highway 75. Table 4-6 describes the intent of allowable uses within each planning designation.

- Salt ponds and other habitat in South Bay will be permanently protected as part of the San Diego National Wildlife Refuge due to the 1998 real property exchange between the Navy, Port and USFWS.

In 1999, the Port purchased 800 acres (234 ha) of salt ponds in the south Bay from Western Salt, an action called "a stunning move forward in protection of the Bay" by one local environmentalist (Klimko 1998). Most of this acreage has been deeded to the US Fish and Wildlife Service to be managed as part of the **South San Diego Bay NWR**, with the Port contributing $900,000 for creation of a management and restoration endowment for the new refuge. In addition, the Port bought out the unexpired lease on 600 acres (243 ha) owned by the SLC and presently leased by Western Salt. This acreage will likely be added to the refuge for a total of about 1,400 acres (567 ha). A Comprehensive Conservation Plan will be created for the site by USFWS which includes provision for an open public process.

The US Navy also provides habitat protection, particularly for shorebird habitat, through the following:

1. Security restrictions on public access;
2. Proactive management program for California least tern nesting colonies, as described in a MOU with USFWS (US Fish and Wildlife Service and US Department of the Navy1993);
3. Policies in each facility's INRMP.



Map 4-2. Protected Marine and Coastal Habitat in San Diego Bay—1998.

- Habitat protection is provided by the Navy through a combination of designations and management practices.

Silver Strand State Beach encompasses two parcels on the Bay side of this coastal strand habitat. During World War II, the US Navy dredged and filled most of this site, creating a larger parcel of above-water property out of the tidal flats. An area of relict coastal dune habitat can still be found along the eastern edge of Highway 75. A parcel of about 40 acres (16 ha) adjacent to the Naval Amphibious Base is leased from the Navy to the CDPR for the State Beach, with a lease expiration date of 2022. Together with a southern state-owned parcel, the State Beach property includes 4,600 ft (1,402 m.) of Bay frontage (California Department of Parks and Recreation 1984). The Navy-leased parcel is currently the focus of negotiation between the US Navy and CDPR for exchange purposes, so the parcel may become state owned within a few years (J. Boggs, US Department of the Navy, pers. comm.).

- CDPR manages state-owned and Navy-leased parcels on the Bay side of Silver Strand State Beach for certain habitat protections as well as for passive recreational use.

Management by CDPR is based on the 1984 general plan for this State Beach. The leased parcel is a passive recreation area with a formalized trail system to control foot and bike traffic. After discovering a population of the sensitive and endemic plant Nuttal's lotus, plans for a campground were dropped. Interest in developing boat berthing and access was expressed in the Plan, but the Navy has not clarified its approval of such use of the tidelands. The state-owned parcel is developed with day use and maintenance facilities. If other sensitive species are found, the park will restrict public access to the specific site (E. Navarro, California Department of Parks and Recreation, pers. comm.). A habitat restoration plan was recently implemented on the 40 acre (16 ha) parcel (M. Wells, California Department of Parks and Recreation, pers. comm.).

Evaluation of Current Management

- Designated protected habitat amounts to 1,560 acres within the Plan's footprint.

As shown in Table 4-5, the amount of designated protected habitat is 1,156.2 acres (468.1 ha) in addition to over 2,000 acres (809 ha) that are protected to some degree from development through Port use restrictions. Biologists are most concerned about the shortage of intertidal flats and marsh areas within the Bay, and a significant amount of these habitat types are not adequately protected at this time (Zedler 1996b; R. Ford, pers. comm.; B. Collins, pers. comm.).

- Biologists are most concerned about the shortage of intertidal flats and marsh areas within the Bay.

Although 215 bird species are known to use the SMNWR, biologists are concerned about sustaining this small and fragile habitat (B. Collins, pers. comm.). The Sweetwater salt marsh is fragmented by levees and roads, cutting off connections to adjacent ecosystems necessary for species migration and recolonization. Questions have been raised as to the adequacy of the marsh size to provide for sustainable populations of its dependent species, such as the salt marsh bird's beak and light-footed clapper rail (Zedler 1996b). The Refuge lacks a specific management plan. Missions and policies for the NWR System as a whole were established with the Refuge Organic Act, and more recently by Congress in the National Wildlife Refuge Improvement Act of 1997, which calls for a "Comprehensive Conservation Plan" for refuges lacking a plan. When adequate funding is available, the US Fish and Wildlife Service will prepare one for the SMNWR (B. Collins, pers. comm.). The SMNWR provides permanent federal protection. The new 1,400-acre (567-ha) addition of the South San Diego Bay Unit of the San Diego NWR will have a specific restoration plan prepared within two years, with the funding provided by the Port for this purpose (Klimko 1998).

- Not all designations offer permanent protection as owners can change their intent or the size of the boundaries. Protective management practices continue to benefit these sites.

Other designations, such as the South Bay Marine Biological Study Area and the CVWR, may be less permanent as tideland owners can change their intent for use of the sites or the size of the boundaries. The Port's Master Plan designations and allowable uses can be changed by amendments, or through the Master Plan revision, which is to occur by 2000. This planning process, however, is open to public scrutiny and final approval by the CCC. During the past 18 years, no changes in protective measures have occurred for these designations. In addition, the Port provides some beneficial habitat management: debris removal, wildlife monitoring, predator control, pollution controls, speed limit enforcement for boats in South Bay, Emory Cove derelict boat removal, environmental education, and other efforts (SDUPD 1995a).

Almost 15 years old, the Silver Strand State Beach general plan needs to be updated to reflect the change from the original anticipation of intensive recreation of the bayside parcels to the more passive use and resource protection management that is currently practiced. Also, in the near future, the Navy-leased parcel may be owned by the State of California. CDPR's staff anticipates that an amendment to the general plan will be made within a few years (E. Navarro, pers. comm.).

- Wetland ecologists advocate public acquisition of natural and restorable wetland sites.

Constructed marshes such as the CVWR in south Bay, Connector Marsh, and Marisma de Nacion (both at Sweetwater Channel) are quite young and have not yet become fully functional marshes (Zedler 1996b). While protected from development and adverse uses, these sites are not equivalent to adjacent natural marsh habitat. Wetland ecologists have advocated public acquisition of the remaining natural wetland areas and restorable wetland sites, with the greatest habitat needs being salt marsh and intertidal flats (Zedler 1991; Zedler 1996b).

Proposed Management Strategy—Protected Sites

Various options are available to provide additional permanently protected sites in San Diego Bay, if this is considered to be a priority: (1) expansion of National Wildlife Refuge; (2) creation of Marine Protected Areas (MPAs); or (3) additional protective management practices within existing designated sites.

- A new national wildlife refuge unit is being proposed for the south Bay by the US Fish and Wildlife Service as an addition to the San Diego National Wildlife Refuge.

A new South San Diego Bay Unit of the existing San Diego National Wildlife Refuge is presently proposed by the US Fish and Wildlife Service (US Fish and Wildlife Service 1997a). The Service wants to establish the unit "to protect and restore the small portion of the Bay where native habitats remain," with a focus on benefiting "federally listed and other trust species." Alternatives being considered range from No Action to 2,200 acres (890 ha) to 4,994 acres (2,021 ha) of habitat. The preferred alternative is for 4,772 acres (1,931 ha) of submerged land (subtidal), salt pond, eelgrass (shallow subtidal), intertidal, beach and dunes, salt marsh, and riparian habitats. This proposal was "jump-started" by the Port contributing about 1,400 acres (567 ha) of salt ponds to the USFWS for the proposed Refuge.

- Management practices for the new NWR will be addressed in a future Comprehensive Conservation Plan.

Following the release of a Conceptual Management Plan, and an Environmental Assessment completed in February 1999, the USFWS decided on the acquisition boundary. Priority uses, where compatible, established in the NWR Improvement Act of 1997 for refuges include fishing, hunting, wildlife observation, photography, environmental education, and interpretation. The manner in which these priorities mesh with habitat protection and ecosystem management needs for San Diego Bay would have to be addressed and resolved in a future Comprehensive Conservation Plan for the new refuge. Refuge managers have the ability to use their professional judgement in determining compatible uses.

■ Marine Protected Areas are intended to protect intertidal or subtidal habitats. Table 4-6 gives examples of some available state designations that are options for the Bay.

In coastal marine waters, MPAs are designated for a variety of purposes and are represented by various state and federal names, such as marine refuges, reserves, sanctuaries, or ecological preserves. Marine Protected Areas are commonly defined as "Any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment." (IUCN in McArdle 1997a). Table 4-6 lists the state MPA options that have not yet been used but could apply to sites within San Diego Bay. Quite a few of these options have been designated on the ocean side of Point Loma and La Jolla.

Table 4-6. State Marine Protection Area Options: Intent, Methods, Examples.

Program or Designation	Intent	Method of Designation	Responsible Agencies/Regional Examples
Ecological Reserves (Fish and Game Code Sect. 1580 14 Cal.Adm.Code 630)	To protect threatened or endangered native plants, wildlife, or aquatic organisms or specialized habitat types, both terrestrial and aquatic, or large heterogeneous natural marine gene pools for the future use of mankind. Designated to be preserved in a natural condition or to be provided some level of protection for the benefit of the general public to observe native flora and fauna and for scientific study or research. In general, all living resources in a reserve are protected, unless specifically exempted.	CDFG, with approval of the Fish and Game Commission, may obtain, accept on behalf of the state, acquire, or control, by purchase, lease, easement, gift, rental, MOU, or otherwise for the purpose of establishing Ecological Reserves. Commission adopts general regulations for the occupation, utilization, operation, protection, enhancement, maintenance, and administration of the reserves, including any limits on resource takings, activities, and other uses. Shore angling generally allowed, but not boating or swimming without a permit.	Calif. Fish and Game Commission, CDFG; local agency also. San Dieguito Lagoon Ecological Reserve San Diego-La Jolla Ecological Reserve
Refuges (Clam, Fish, Game, Marine Life) (Fish and Game Code Sect. 10500–10514 *et al.*)	To protect specified invertebrates and plants for the purpose of propagating, feeding, and protecting wildlife. Categories include waterfowl, marine life, fish, and clam refuges. Designation may be for one or more category and may include other specified limitations on activity.	Legislative action is needed to establish, except for clam refuges. Fish and Game Commission may accept donations, land, or wildlife, and may acquire by purchase, lease, rental or otherwise, and occupy, develop, maintain, use or administer land, or land and water, or land and water rights, suitable for refuges. SLC lease may be needed.	Calif. Fish and Game Commission, CDFG. San Diego Marine Life Refuge
Reserve (Fish and Game Code 200 *et al.*)	No legally mandated mission accompanies reserve designation. Each site has its own site-specific regulations.	Fish and Game Commission receives proposal and follows a multi-step designation process. Then regulations are proposed, with public hearings, and a Final Statement is submitted to the Office of Admin. Law for approval. SLC lease may be needed for submerged lands.	Calif. Fish and Game Commission; CDFG. Point Loma Reserve
State Reserve, or State Underwater Park (Public Resources Code 5019.71; 5019.65.)	Reserve—Areas with outstanding natural or scenic characteristics of statewide significance established to preserve in a condition of undisturbed integrity. Underwater parks exist within or adjacent to existing units, leased from SLC.	Designated by CDPR Commission. CDPR works in cooperation with CDFG for regulations. Underwater park is not an official designation type with the State Park System.	CDPR/CDFG/or City (Underwater park) San Diego-La Jolla City Underwater Park
University of California Natural Reserve System	To preserve and manage the state's natural diversity to meet the university's teaching and research needs in disciplines that require field work. Each reserve functions as an outdoor classroom or laboratory.	UC Natural Reserves are designated by the Regents of the University of California.	UC Office of Pres., NRS Office, and UC campus. Kendall-Frost Mission Bay Marsh UC Reserve

■ Interest is growing in Marine Protected Areas as they are viewed as a useful means to managing marine resources at an ecosystem level.

The success of MPAs in protecting marine resources is also varied. In a recent evaluation, identified benefits included an increase in marine populations when "no take" policies are enforced, maintenance of species and genetic diversity, and natural baselines to measure effects of resource use, such as fishing (McArdle 1997a and 1997b). Ineffectiveness was attributed to lack of clearly defined management objectives; inadequate enforcement; external factors; fragmented boundaries; and piecemeal, crisis-oriented designations. Interest in MPAs is growing rapidly as they are being viewed more often as a means of managing marine resources at an ecosystem level.

***Objective:** Ensure effective protection of a minimum quantity and quality of the remaining marine and coastal habitat in San Diego Bay, targeting a mix of habitat types that maximizes ecosystem function and carrying capacity.*

I. Provide protection from development of additional areas of sensitive and high value habitat.

A. Seek protective designation of habitat parcels with priority based on the most vital to ecosystem function. Since the Bay ecosystem is not understood well enough such that a minimum acreage and configuration of habitats is known, use the following as a guideline in the meantime:

- most impacted habitat;
- most at risk of loss;
- most limiting to protection of rare species.

B. Expand connections among marine, coastal, and upland natural habitat remnants, with careful consideration of the needs of and risks to endangered species remnant populations and habitats.

1. Pursue opportunities to provide linkages of smaller marsh, intertidal, and shallow unvegetated habitats, and improve value of connecting habitat.

2. Seek linkages of coastal habitats with adjacent ecosystems (uplands, riparian corridors, and nearshore waters).

a. Promote benefit to ecosystem values of San Diego Bay with ongoing natural community planning programs, watershed management approaches and plans , and riparian park planning (e.g. Otay River).

3. Guard against potential increase in predator-prey conflicts and exotic species introductions that may arise on coastal habitat from improved access to riparian and upland habitat (see Section 4.3.6.2 "California Least Tern" and Section 4.3.1 "Exotic Species").

C. Investigate the usefulness of a state-designated MPA for marine habitat not protected under other designations.

1. Determine pros and cons of the various MPA options for presently under-protected sites, particularly intertidal habitat.

2. If the evaluation is positive, then pursue designation.

D. Encourage the prompt development of a Comprehensive Conservation Plan for the new refuge unit that incorporates the recommendations of this Plan.

II. Support protective management of existing protected areas within San Diego Bay.

A. Promote the development of effective, up-to-date, adaptive management plans that are consistent with this Plan for:

1. Sweetwater Marsh NWR in combination with the South San Diego Bay NWR by USFWS.

2. South Bay Marine Biological Study Area by the County of San Diego Parks and Recreation Department.

3. Chula Vista Wildlife Reserve by the Port.

4. Sites designated for habitat protection values (i.e. wetlands, estuary, open bay, and habitat replacement) by the Port in its Master Plan.
5. Silver Strand State Beach by the CDPR.

B. Support an implementation plan for the proposed MOU for a Silver Strand Habitat Bank at NRRF between the US Navy and USFWS.

C. Encourage policies in the management plans that adequately protect the functions of the existing habitat.

1. Promote cooperative agreements with resource protection agencies.
2. Include appropriate policies from this Plan.
3. Allow only those uses that are compatible with their habitat protection purpose.
4. Support a watershed planning approach whenever appropriate (see Section 5.2 "Watershed Management Strategies").

D. Seek adequate funds for the planning and maintenance of the protected sites by the managing agencies.

1. Encourage local, state, and federal agencies to include adequate funding within their budgets for this purpose.
2. Provide adequate surveillance of sites to discourage illegal activities.
3. Support the establishment of Environmental Restoration Funds as a supplemental funding source for management of these protected sites.

4.3 Species Population Protection and Management

4.3.1 Exotic Species

Specific Concerns

As noted in Section 2.5.7 "Exotic Marine and Coastal Species," more than 80 nonnative species are found within this Plan's "footprint." Moving from acknowledgment to management of the situation must involve addressing these concerns:

■ See also Section 2.5.7 "Exotic Marine and Coastal Species."

- Nonnative species invasion poses one of the most serious threats to the integrity of San Diego Bay's ecosystem, and the rate of local introduction is increasing (Crooks 1998).
- Experience elsewhere shows that ignoring an alien species often leads to a crisis situation where the species can no longer be eradicated and actions to limit the population become very expensive, if not impossible (Cohen and Carlton 1998).

■ Invasions of nonnative marine and coastal species pose a very serious threat to the Bay ecosystem.

- Invasive exotic plants can threaten the composition of coastal salt marshes, reduce mudflat areas, impact mitigation sites, and displace native coastal plants (Zedler 1992a).
- Species invasion of San Diego Bay is less studied than in other coastal bays, with very little known about the vast majority of invading species and their effects on the ecosystem.
- Controlling existing problems and preventing new introductions will require a novel strategy and a political commitment that may be difficult to achieve.

- Landside space for ballast water treatment is unavailable. The sewer system does not tolerate salt water.

Current Management

- Management of ballast water from ships in port is the major focus of federal policy to control invasive nonnative aquatic species.

A major source of exotic marine species in bays is from the dumping of ballast water originating from a ship's most recent port-of-call (Cohen and Carlton 1995). In the San Francisco Estuary, ballast water discharges are reportedly responsible for a substantial portion of the more than 200 exotic species there (Cohen 1998). Foreign and domestic commercial vessels exchange ballast water within San Diego Bay as a standard operating procedure when off-loading cargo (D. Winship, Port Operations, pers. comm.). In addition, ship ballast tanks are emptied at shipyard dry docks during maintenance and repairs. Besides the discharge of ballast water, ballast sediment of up to 500 gallons per ship is also emptied at drydock. While empty ships are said to be "in ballast" when carrying ballast and no cargo, ships that are carrying cargo may also contain considerable amounts of ballast water (Cohen 1998).

Policies addressing the management of invading marine species, particularly from ballast water, are found at the state, federal, and international levels. In the forefront, federal policy is evolving quickly, as well as expanding geographically from the Great Lakes and East Coast to the West Coast. Due to the serious effects experienced by the invasion of the freshwater zebra mussel in the Great Lakes, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. This Act was extended and amended by the National Invasive Species Act (NISA) in 1996. Mandatory midocean ballast exchanges are presently required only for ships entering the Great Lakes region.

- Voluntary midocean exchange of ballast water in western ports will soon be encouraged by the US Coast Guard, with ballast activities to be reported on standard forms or stiff penalties can result for lack of reporting.

Regulations and voluntary guidelines to implement NISA were proposed in the Federal Register in April 1998, with numerous public comments received by August (US Department of Transportation 1998). Interim rules were finalized July 1, 1999 (Lt. M. Cunningham, US Coast Guard, pers. comm.). Once adopted, voluntary midocean exchange is to be encouraged for ships entering western ports. The USCG will require vessel operators to report their ballast activities upon arrival to port on a standardized reporting form promoted by the International Maritime Organization (IMO). The Port currently includes the USCG reporting form in their ballast water permit (Lt. M. Cunningham, pers. comm.). In this initial "fact-finding" phase of NISA implementation, stiff penalties can result from noncompliance with the reporting requirement. In the second phase of implementation, which should occur during the year 2000, USCG will begin boarding vessels to test ballast water for exotic species (Lt. M. Cunningham, pers. comm.). To evaluate the effectiveness of the voluntary controls, a periodic review of the program will be conducted every three years. If needed, the Secretary of Transportation has the authority to and will promulgate regulations that are mandatory and enforceable. Helping to implement the act are the National Aquatic Nuisance Species Task Force with representation from seven federal agencies, a Western Regional Panel composed of members with various interests and a Research Grant program. In addition, a National Ballast Water Information Clearinghouse and a national database were established through the Smithsonian Environmental Research Center to help implement NISA, including an evaluation of open-ocean ballast water exchange (Ruiz *et al.* 1998).

- The Navy ships using the Bay apparently perform open ocean ballast exchange as their standard operating procedure, even though policy does not require it yet.

Navy policy for ballast water is presently spelled out in its Environmental and Natural Resources Program Manual (Chap. 19–10, US Department of the Navy1994). The Navy adopted the intent of the existing US Coast Guard standards, which promote the IMO guidelines as voluntary public health measures "to decrease the possibility of further introduction of cholera and other pathogens into US waters." While no mention is made of environmental concerns, Navy policy requires that ballast water taken from potentially polluted areas be offloaded outside of 12 nm from shore, with clean sea water taken on and discharged two times prior to closer entry. Exotic species will soon be addressed also as NISA requires that the Navy "shall implement a ballast water management program for seagoing vessels." Open ocean ballast water exchange is apparently a standard operating procedure of the Navy ships that enter San Diego Bay (Lt. M. Cunningham, pers. comm.).

- The IMO leads the world effort to stop the spread of invasive exotics, trying to standardize procedures in each country's ports.

The IMO has led the world effort for standardized and appropriate rules on ballast water discharge to prevent the spread of nonindigenous organisms, mainly at the request of the 1992 United Nations Conference on Environment and Development. Recognizing that scientific and technological advances are necessary to develop the best solutions, the IMO views its guidelines as interim tools to help minimize the risks associated with ballast waste discharge. Countries are encouraged to "conform to the maximum extent possible with the guidelines" until better tools are available. Besides education, training, and reporting procedures, the IMO also promotes the guidelines in the design of new ships or the modification of existing ships to enable safer ballast exchange in open ocean.

- State policy calls for compliance of all ships using ballast water and entering state ports in completing ballast water report forms from the US Coast Guard.

The State of California adopted the Aquatic Nuisance Species Prevention and Control Act of 1992, which was extended until January 1, 2000 through recent legislation (SB 1003). Adopting the IMO guidelines as state policy, the act mandates the CDFG to assist the US Coast Guard in distributing ballast control report forms to ships entering state ports. As a condition of using the waters of the state, the operators of all vessels using ballast water must complete and return the form to the US Coast Guard. Noncompliance is an infraction punishable by a fine of not more than $500. However, the reporting requirement has not yet been implemented (Cohen 1998). Other state policies to control exotic plants or animals are few. The California Fish and Game Commission has adopted a policy (Fish and Game Code Section 6400) that requires Commission approval for the planned introduction of any plant or animal species, or for the importation of live organisms by a registered aquaculturist (Section 15600).

For all sources and types of invasive exotics, a new Executive Order "Invasive Species" came out in February 1999 with the purpose of assigning responsibilities to federal agencies to prevent the introduction and spread of and to provide control of invasive species, plant or animal, aquatic or terrestrial (US President 1999). A National Invasive Species Management Plan is required to be drafted by a new Invasive Species Council within 18 months, with performance-oriented goals and objectives and specific measures of success for federal agency efforts. In addition, the USDoD's Armed Forces Pest Management Board serves as a source of information on exotic species and noxious weeds for any requesting US Navy facility. In response to the new Executive Order, the Pentagon's acquisitions chief has directed the military services to incorporate invasive species prevention measures into existing operational and transportation policies, as well as into INRMPs and pest management plans.

■ Ballast discharges from commercial vessels in the Bay must be in compliance with the Port's tariff that addresses water quality concerns.

Acting under the marine discharge regulatory authority of the Clean Vessel Act (33 CFR part 157), the US Coast Guard urged the Port to provide some controls for ballast discharge. As a result, the Port adopted a tariff in 1994 that requires all commercial ships off-loading or on-loading cargo at Port terminals to minimize discharge to protect water quality (Tariff #1-G.0475). To discharge clean ballast, the ship master must have a Clean Ballast Water Discharge Permit signed by the Port's marine operator and posted on the gangway. Violations call for immediate removal of any pollutants (e.g. oil, sludge) and payment for cleanup. Additionally, the US Coast Guard performs annual boarding inspections of foreign vessels and can check ships' logs for records of any open ocean ballast exchange. These logs are signed by licensed shipmasters (Lt. M. Cunningham, pers. comm.).

In October, 1999 California passed Assembly Bill 703, creating the Ballast Water Management for Control of Nonindigenous Species Act, which became effective January 1, 2000. The Act involves various roles for the State Lands Commission (SLC), CDFG, SWRCB, and Board of Equalization. Vessel operators are now required to develop and maintain a Ballast Water Management Plan and to train their crews. Vessels bringing ballast or sediment into state waters must employ one of the following ballast management practices: 1) conduct a mid-ocean ballast water exchange before entering state waters; 2) retain ballast water on board; 3) use an alternate method approved by the SLC; 4) discharge all ballast water to an approved shoreside facility; or 5) conduct a ballast water exchange in an area approved by SLC. The SLC has adopted the Coast Guard's Ballast Water Report Form. CDFG and the Office of Oil Spill Prevention and Response will conduct research in support of the new law. SWRCB is responsible to implement studies to evaluate alternatives to treating or managing ballast water. The Board of Equalization will collect vessel fees into the "Exotic Species Control Fund," which will support the statewide programs.

Local actions have been taken in other bays concerned with exotic imports from ballast water. The Ports of Vancouver, Canada and Humboldt Bay, California have adopted ordinances requiring open ocean exchanges before ships can use their ports, while the Port of Oakland, California is also considering adopting such regulations (Cohen 1998).

Evaluation of Current Management

It is still too early to evaluate the effectiveness of voluntary ballast water controls for Pacific ports that resulted from NISA of 1996, as they have not yet been put into operation. A coordinated, national effort is being made to address aquatic exotics but most of the focus is on the known dangers of the zebra mussel, an effort that some have said has come too late following years of warnings about their threat (Nalepa and Schloesser 1993, in Crooks 1998). Funds are allocated to the National Sea Grant College Program to administer competitive research grants to study all aspects of aquatic nuisance species, a program under which several studies of San Diego Bay's exotic species have recently been funded (Lambert and Lambert 1998; L. Levin, pers. comm.; Reusch and Williams 1998). Although $500,000 was authorized for research grants on the Pacific Coast (in addition to San Francisco Bay), no research funds have been specifically appropriated for the western region through this Act.

■ The federal NISA offers the best opportunity at present for effective prevention of ballast water introductions.

Some observers of the serious exotic species situation in San Francisco Bay are disgruntled with the slow pace of the Act's regulatory approach (at least a year behind schedule) and the lack of actual research grant funds (Cohen 1998). Emphasis in the act on the zebra mussel problem can detract from the need for a strong focus on other invasive species problems. The federal law, however, has the most oppor-

tunity for enforcement of ballast water controls at this time. Its fines for noncompliance with the ballast report requirement far exceed those of the state's law, although the continued support of the state toward the ballast water reporting requirement is very helpful in promoting a unified, cooperative effort.

International efforts are to be commended for bringing this ecological problem to broader attention and for taking the lead in developing worldwide ballast control measures. The major obstacle to compliance appears to be over the safety issue due to the apparent instability of certain vessels, particularly tankers and some container ships, releasing ballast water in midocean. In the Great Lakes, researchers have found that a small amount of an environmentally benign chemical, glutaraldehyde, can effectively eliminate invading species when introduced into ballast water and eliminate the need for midocean exchange (Britt 1998). Another option, which eliminates ship safety issues and may be the most feasible, is to off-load ballast water and store it for later use by departing ships in need of ballast, or treat it to kill the organisms it contains (Cohen 1998).

- Concern over the safety of open ocean ballast exchange in certain ships is being addressed by research, technical assistance, and education.

A new UC Sea Grant Extension project (begun in March 1998) will provide technical assistance and education to the Pacific Coast maritime industry on safer alternatives (e.g. microfiltration, ozonation, heat treatment) to the open ocean exchange of ballast water. Methods will include forums, video-conferencing, newsletters, and a website. Cooperators also include National Estuary Programs, the shipping industry, resource agencies, and other regional groups. Funding came from the National Sea Grant College Program's Special Initiatives Program for outreach activities and from CalFed-BayDelta (J. Cassell, UCSG, pers. comm.).

Confusion over what is intended by the term "ballast water control" has not helped. Water quality concerns are related but different from exotic species control concerns. The Port's "ballast control" program does not prevent the discharge of ballast water with exotic species into San Diego Bay; it only seeks to prevent discharge of oils, grease, sludge, and other chemical pollutants. The Navy's ballast water control program is also for a different purpose as it is intended to prevent importation of human disease organisms, but it does lead to the right action by preventing in-bay discharge.

- No effort is being made to control pleasure boats from transporting exotic species on their hulls from port to port.

Management is absent for controlling another important source of invasive species—thousands of pleasure-craft travelling from port to port. A recent survey of southern California harbors and marinas found a pattern of introductions of nonindigenous ascidians (tunicates) coming from the hulls of traveling recreational boats (Lambert and Lambert 1998). The nonnative species have become fouling pests in marinas, covering docking facilities and other artificial structures in the water with a slimy coat. Without some major changes in the rules governing the movements of these boats, the researchers warn that exotic species will continue to appear at an ever-escalating rate. However, research is pursuing effective anti-fouling paints that are environmentally safe (e.g. no metals like TBT) that could help minimize the attachment of organisms to boat hulls (see also 5.1.2 "Ship and Boat Maintenance and Operations"). One experimental alternative is the use of a strong repellent made from hot chile peppers that could be applied to hull bottoms (Henry 1998). According to one report, California Fish and Game Code Section 2271 and Section 6400 make it illegal to release exotic organisms into California waters via ballast dumping or any other means, with penalties up to $5,000 and one year in jail for each violation (Cohen 1998).

■ See also: Section 5.1.2 "Ship and Boat Maintenance and Operations."

As an added measure, the CDFG is recommending that the State Water Resources Control Board adopt ballast controls in its California Ocean Plan, which sets standards to protect coastal waters for water quality, but not invasive species (M. Fluharty, pers. comm.). The Department's Office of Spill Prevention and Response stresses that strict monitoring and control measures are needed to control marine exotics from ballast water. However, CDFG has no policies relating to the prevention of accidental introductions or the control of established exotics.

The aquarium trade has legally imported sailfin mollies, but they were probably released into local streams by aquarium hobbyists unaware of the species' potential impact. The mollies are now commonly found in the Sweetwater Marsh, probably causing ecological harm to native species and communities (California Department of Fish and Game 1998).

■ Systematic surveys of exotic species in the Bay are not being done, unlike other major bays in the Pacific.

The lack of local information necessary to develop a targeted management strategy is a dilemma. Systematic ecological surveys of the introduction, distribution, abundance, and effects of nonindigenous species are not being conducted within San Diego Bay, unlike other major Pacific bays (e.g. San Francisco, Honolulu). Awareness of new exotic species, their locations, and impacts usually comes about as a secondary product of studies and inventories performed for other purposes (Fairey *et al.* 1996; Zedler 1996a; Allen 1997). California Sea Grant recently held a workshop to assess management and research needs for marine nonindigenous species, but with no apparent participation by any San Diego interests (Olin and Cassell 1998). One recent Sea Grant study, however, was directed at evaluating the extent of exotic ascidian (tunicate) species in southern California harbors and marinas, including San Diego Bay (Lambert and Lambert 1998). A Scripps researcher has looked at an overview of nonindigenous marine species reported in San Diego County and also examined the effects of two invertebrate species, *Musculista senhousia* and *Sphaeroma quoyanum*, capable of producing ecosystem-scale changes to the Bay's habitat (Crooks 1997, 1998). For exotic coastal plants, the CDFG commissioned an evaluation that has relevance to invasive plant species management at the Bay (Zedler 1992a).

■ Prevention is a better tool than control for invasive exotic coastal plants, with only limited success stories in wetland weed control. Local landscaping regulations could be improved as a tool for prevention.

Control efforts appear to have focused primarily on invasive exotic coastal plants, particularly in the transition zone from wetlands to uplands and when a highly valued resource is affected. Unfortunately, success stories with wetland weed control are few. Attempts are made by agencies and volunteer groups to remove iceplant from sand dunes, for example, but continual maintenance is required. Herbicide use is effective in some instances (B. McMillan, US Fish and Wildlife Service, pers. comm.). Prevention is found to be the best tool, followed by treatment of new sites at the earliest occurrence of exotic species (Zedler 1992; Zedler 1996). The City of San Diego's Biological Mitigation Ordinance prohibits the use of invasive exotic plant species near a designated "open space" area. However, the Bay is not so designated. While some local cities have ordinances requiring native plant species for new landscaping or mitigation, no similar policies could be found for the Navy or the Port.

■ Timing of control is very important, as delays can allow a population to explode beyond the capability of any known control measures.

Management of invasive species is focusing on those presently having obvious negative effects. Recent studies reveal that observed effects may range from "relatively large spatial (bay-wide) and temporal-scale (decades) to small-scale interactions that take place in a matter of weeks in small patches on a tidal flat" (Crooks 1998; Reusch and Williams 1998). To be effective, management actions need to understand invasions in the context of the existing and historical natural systems (L. Levin, pers. comm.). Some species have taken decades since intro-

duction to become a "pest," showing that it is "potentially dangerous" to predict future status of an invader from its current status (Crooks 1998). Timing is of the essence, since delays in implementing appropriate control or extirpation measures can cause the measures to be ineffective if the invading population grows too large (L. Levin, pers. comm.).

Proposed Management Strategy—Exotic Species

- Prevention of the introduction of new species is the first priority, but understanding the biology of exotics is necessary before controls of existing populations can be effective.

Prevention of new introductions is the most desirable, although most challenging, strategy. Since ballast water is the most important means of dissemination, effective controls should be placed on all ships entering the Bay, using the strategy of NISA of 1996. CEQA and NEPA assessments of Port and Navy projects involving marine ports or terminals should identify, discuss, and adopt mitigations for the ballast water impacts (Cohen 1998). The present ballast water exchange program of the Navy should be continued and evaluated for its effectiveness. At the minimum, the boating community needs to be aware of their role in the possible transfer of exotic species from port to port while effective preventive measures can be found. In addition, the aquarium trade businesses and customers must become aware of the impacts and prevention of releasing nonnative species (e.g. sailfin mollies, *Caulerpa alga*) into the local environs (Tangley 1998).

Maintaining quality habitat should also help prevent or minimize exotic species invasions. Disturbed sites, even when disturbed temporarily for restoration purposes, show an increased number of nonindigenous species (Crooks 1998). Increased freshwater inflows and altered hydrologic regimes from the Bay's watershed also have contributed to exotic plant germination and establishment, a problem particularly apparent at Sweetwater Marsh (Kuhn and Zedler 1997). Impaired water quality in San Diego and Mission Bays has modified habitat and made the areas more susceptible to invasions by alien species *(*e.g. *M. senhousia, T. rex*) (Crooks 1998; Ed. note).

- Basic descriptive research is required to enact effective control measures.

To identify consequences and to enact effective control measures for previously introduced species, the biology of exotic species and the existing ecosystem must be better understood. Basic descriptive research, such as natural history, ecological surveys, and taxonomy, is one key step (Crooks 1998). Likely invaders that pose a serious threat to the integrity of the Bay's ecosystems were identified in Section 2.5.7.5 "Potential Invasions of Exotics to San Diego Bay," though a comprehensive list would be much longer. The Bay Panel's Comprehensive Management Plan for San Diego Bay (1998) has recommended, as a high priority category, the monitoring of exotic coastal plants within upland transition areas and of benthic invertebrates (abundance, distribution, and species composition) in its ecological monitoring program. Specific assessment for other types of nonnative species (e.g. tunicates, fish, marine plants, and algae) were not addressed by the Bay Panel, but should be included in an overall survey in order to evaluate the current exotic species situation.

- Control measures include mechanical, chemical, biological, and harvest management.

Once exotic species are established, at least four types of management controls can be used: (a) mechanical (through physical removal), (b) chemical (through conventional pesticides), (c) biological (through introduction of known natural predator or parasite), and (d) harvest management (through promotion of a sport or commercial fishery) (Lafferty and Kuris 1996). Biological controls of marine pests are still in the experimental stage but hold promise. Each type has

associated advantages and disadvantages, and combinations of more than one can be applied. Through adaptive management, managers can learn from experience to help identify the best tools for exotic pest control.

- Those species with the greatest potential to disrupt the ecosystem need to be targeted as top priority for control.

Targeting control of the most noxious, potentially ecosystem-damaging species in a timely fashion should also be a high priority because not all alien species create serious problems. For example, the introduction of a destructive invasive like *Spartina densiflora* or *alterniflora* could destroy the Bay's few remaining mudflats or could cause hybridization with the native cordgrass (*S. foliosa*) and expand into the lower intertidal zone. This habitat destruction has occurred in San Francisco Bay, with negative effects on shorebird and other native populations dependent on unvegetated mudflats for food and habitat (Daehler and Strong 1997).

- Bayscapes is a successful program promoting environmentally sound landscaping for the Bay that could be applied to San Diego Bay.

Volunteer groups like the California Native Plant Society and the California Exotic Pest Plant Council are actively working to develop local and statewide strategies for the management of invasive exotic plants and can offer technical advice and volunteer labor, as the local CNPS chapter has already done through work parties removing ice plant from sand dunes near the Bay (C. Burrascano, CNPS, pers. comm.). A successful program used in Chesapeake Bay called Bayscapes, which promotes environmentally sound landscaping that protects the Bay, could also be applied to San Diego Bay to help minimize exotic plant problems associated with community landscaping (Reghetiloff 1998).

- Potential management conflicts should be anticipated and alternatives developed in advance.

In addition, the State Interagency Noxious Weeds Coordinating Committee can possibly help streamline state and federal permits and work out agency conflicts to control invasive exotic plants. One conflict that arose in *Spartina alterniflora* control in San Francisco Bay was the proposed use of a known effective herbicide that was also prohibited by USFWS for application near the endangered clapper rail (D. Hickson, California Department of Fish and Game, pers. comm.). Such potential management conflicts should be anticipated in San Diego Bay and alternatives developed in advance. For example, one alternative for *S. alterniflora* eradication is the potential use of a native scale insect which is tolerated by the native cordgrass, *S. foliosa*, but damages *S. alterniflora* (D. Strong, pers. comm. to Lisa Levin). In Puget Sound, Spartina Watch volunteers try to catch new *S. alterniflora* infestations while they're still small enough to be controlled with a shovel. Highly infested areas can cost as much as $1,000–$40,000 per acre for agency staff to control and/or restore (Matthews 1998). However, distinguishing the native from the exotic Spartina in the field is not easy and may require a specialized plant taxonomist or molecular biologist if any suspicious new plants appear in the Bay.

***Objective:* Control exotic species invasions in San Diego Bay to minimize disruption of the Bay's ecosystem and continue to improve through an adaptive management approach.**

- Prevention is first priority.

I. Prevent the introduction of exotic marine and coastal species into San Diego Bay, as a first priority for control.

A. Promote ballast water management for vessels entering San Diego Bay.

1. Support the efforts of the US Coast Guard and CDFG to obtain ballast control report forms from all ships entering San Diego Bay.

a. Ask the Legislature to amend and extend the State Aquatic Nuisance Species Prevention and Control Act of 1992 for two to four more years beyond January 1, 2000.

2. Co-sponsor a UC Sea Grant forum in San Diego to inform the maritime industry of the ballast water control issue and the safer alternatives being considered to open ocean exchange in order to obtain better practices.
3. Promote the voluntary sampling of ballast water of San Diego ships by the US Coast Guard to look for exotic species.
4. Support the continuation of the Navy's ballast water exchange policy for open ocean exchange and encourage the implementation of a ballast water management program that explicitly addresses the nonindigenous invasive species problem.
5. Inform the National Aquatic Nuisance Species Task Force and its Western Regional Panel of San Diego Bay's problems and concerns with existing and potential aquatic pests.
6. Review the results of the three-year NISA program review. If the voluntary ballast water control program is not working adequately, and alternatives are not available, request that the Secretary of Transportation promulgate mandatory and enforceable regulations for the Pacific coast.

B. Focus on methods to reduce or prevent the number of new invasive exotic species.

1. Periodically update and distribute the list of known exotic species found at San Diego Bay (see Tables 2-27 and 2-26).
2. Promote education about appropriate preventative methods.
    a. Develop and promote a "Bayscapes" program to benefit the Bay through compatible landscaping practices along the Bay and in the watershed, which includes the following components (see also Sections 4.2.1.9 Upland Transition and 5.1.3 Shoreline Construction):
        1. Provide local nurseries with a list of existing and potential exotic plant species known to cause problems in San Diego Bay and encourage them not to offer these plants to their customers.
        2. Provide local, state, and federal agencies with the exotic coastal plant list and encourage them to prohibit these species through their development review and permitting processes.
        3. Present a model by having the Port and Navy take the lead in practicing Bayscaping on its own properties.
        4. Notify homeowners, landscapers, and gardeners of the list and encourage them not to use these plants in their landscaping.
        5. Define a management corridor within which measures are taken during construction and other activities that minimize the disruption of coastal soils or native sods in order to prevent weed invasion.
        6. Encourage citizens, organizations, and local government to become Bayscapers through the practice of Bayscaping.
        7. Develop a list of native species useful for landscaping and encourage use of these plants.
        8. Update Navy documents, including Base Exterior Architecture Plans, to advocate use of native plants in landscaping plans.

b. Request local aquarium and bait shops to inform their customers about the existing, potential harmful effects on San Diego Bay from the intentional or accidental release of exotic fish and marine invertebrates into local streams, ponds, and the Bay.

3. Support state policies that control invasive nonindigenous coastal and marine plants and animals through the Fish and Game Code and other appropriate regulations.

■ Understand biology and status.

II. Evaluate the status and biology of invaded ecosystems and nonindigenous marine and coastal species in San Diego Bay, focusing on those with the most potential for ecological disruptions.

A. Study the basic biology of existing and probable new arrivals that have the potential to become pests or alter habitats (see Tables 2-27 and 2-26).

1. Determine habitat requirements, native predators and parasites, food requirements, and other life history requirements.

2. Identify use of exotics by native animals (e.g. insect use of plants).

3. Conduct research into the effects of exotic species on the abiotic environment.

4. Analyze native-exotic species interactions.

B. Evaluate the introduced species for their effect on the Bay's ecosystem.

1. Continue research on known problem species.

2. Determine negative and positive effects on native species, the Bay's food web, and habitat quality, as well as assess the magnitude of each species' impact.

3. Rank the relative impact of the known exotic species found in the Bay in order to determine control priorities.

C. Support the implementation of the exotic species portion of the Bay Panel's proposed ecological monitoring program with the addition of other marine plant and animal groups.

1. As species taxonomy can be quite difficult and is frequently changing, encourage careful taxonomic identifications to species level, particularly of marine invertebrates and marine algae.

2. Promote cooperative interagency efforts to collect and analyze comprehensive monitoring data, including shared funding and staffing.

3. Support easy access to the ecological monitoring program's results (e.g. agency website).

4. When feasible, minimize costs by using knowledgeable volunteers to assist with exotic species inventories at the Bay.

D. Enjoin financial resources from public and private sources.

1. Pursue research grants from the National Sea Grant Program targeting NISA implementation.

2. Seek appropriations for the National Aquatic Nuisance Species Task Force and its Western Regional Panel for the above studies and for an ecological survey of San Diego Bay, as provided in NISA 1996.

3. Approach private foundations as a sole or matching grant source.

- Control problems and restrict expansion.

III. Control existing exotic species problems and restrict their future expansion at San Diego Bay.

A. Provide for an early warning system for newly discovered species.

1. Target locations with higher probability for newly arrived species (e.g. marine terminal docks, marinas, near dry docks, poorly flushed (back bay) settings, and disturbed sites).

2. Evaluate the results of all species monitoring in the Bay for the presence of new exotics on an annual basis at least.

3. Notify the Bay Exotic Species Committee proposed by this Plan if any new exotic species are identified.

4. Determine the potential of the new species to become invasive, based on case histories in other areas and lag timing. Eradication is most effective during the lag phase of low numbers and isolated locales.

5. Develop a descriptive list of possible control measures, including mechanical, chemical, biological, and harvest management.

B. To control new invaders with the potential to become problems, provide a rapid response, and respond at the appropriate spatial scale.

1. Identify and prioritize the best available techniques to eradicate or reduce the species of concern.

2. Work on developing biological controls that could be used for existing and potential arrivals, while ensuring safety of nontarget species.

3. Encourage the formation of volunteer efforts, such as Spartina Watch or Adopt a Beach to be able to identify and respond to the removal of new infestations at their first appearance.

C. Provide exotic species control measures to substantially reduce existing problem areas and to prevent new problem sites.

1. With the assistance of volunteers, promote workshops and small-scale eradication demonstration projects at Bay sites.

2. Map the existing problem areas and determine priority sites and control measures.

3. Monitor progress, evaluate the effectiveness of measures, and revise as needed.

D. Explore and establish mechanisms to mimic or restore natural hydrologic regimes.

1. Investigate opportunities for reclaiming dry weather runoff to prevent it from reaching the Bay.

IV. Form a San Diego Bay Exotic Species Task Force of resource managers, researchers, and interested public to implement the above strategy.

A. Coordinate invasive species control actions.

1. Hold an annual workshop on the topic, including a brainstorming session on alternative measures.

2. Provide an information center on exotic species and control measures.

B. Oversee the Exotic Species Control Endowment Fund.

1. Monies to the endowment from grants or other sources can be contributed as in-lieu mitigation for certain proposed projects in the Bay.
2. Use interest payments on the principle for species control projects.

4.3.2 Plankton

Specific Concerns

- The lack of understanding about plankton dynamics in the Bay underlies a lack of understanding about the relative importance of various human activities and how they impact ecosystem health and ecosystem function.
- The lack of knowledge about what drives phytoplankton productivity in the Bay contributes to an inability to protect the plants and animals that depend upon it.
- The lack of understanding about zooplankton use of and dynamics in the Bay by both resident and open coast species hinders understanding of habitat values, and thus sound decision-making about habitat protection.

Current Management

There is no direct management of Bay plankton. However, laws that protect water quality and habitat indirectly protect plankton populations.

Evaluation of Current Management

There exists a lack of basic understanding of plankton assemblages in different areas of San Diego Bay and their changes relative to seasonal and other fluctuations in environmental conditions. Evaluating both primary (phytoplankton) and secondary (zooplankton) productivity is important to understanding the Bay. It would also allow an assessment of the strength of the dependency between plankton productivity and changing conditions in the water column. Information about the dynamics of the larval stages of benthic invertebrates and Bay fish species would lead to a more complete understanding of reproductive activity among resident species. Finally, the information obtained will make it easier to interpret human impacts in the open water environment of the Bay.

The current inadequacy of understanding affects management all the way up the food chain. Since there are certain efficiencies in identifying the strength of dependencies of physical and chemical factors on species at the bottom of the food chain, filling this information gap is considered a critical need.

Proposed Management Strategy—Plankton

Objective: Identify and protect the physical and chemical factors in the Bay that contribute to plankton productivity, and use of the Bay by zooplankton from coastal waters.

I. Conduct long-term investigations of the plankton in Bay waters in a way that can be integrated with plankton studies in coastal waters and those of other bays.

A. These investigations should address the following:

- Strength of the dependency of Bay physical and chemical factors on plankton dynamics.
- Phytoplankton productivity and its relationship to nutrient inflow and general water quality conditions.

- Fate of both resident and open coast zooplankton in the Bay, its use of various habitats, and its diurnal, tidal, and seasonal dynamics.
- Identification of the impacts of various human activities on plankton and the plants and animals that depend on it.
- Larval exchanges with other bays.
- Plankton as food for benthic invertebrates.
- Causes of fluctuations in zooplankton populations.
- Understanding biodiversity.
- Tracking exotic introductions.
- Understanding of pollutant transport.
- Effects of toxic chemicals on plankton species and assemblages.

B. Communicate and disseminate findings on an annual basis to a broad audience of scientists, natural resource policy makers, planners, project proponents, and the public.

II. Protect the physical and chemical factors that contribute to the health of plankton populations and needed use of the Bay by larvae drifting in from the open coast.

4.3.2.1 Benthic Algae

Specific Concerns

- The lack of understanding about algal dynamics and how they are affected by pollution and disturbance in the Bay is a lost opportunity to use algae as an indicator of ecosystem and individual habitat health.
- The lack of knowledge about what drives algal standing crop and seasonality in the Bay contributes to an inability to identify threats and protect the plants and animals that depend upon it.

Current Management

Algae is not managed directly, but regulatory protection from pollution, disturbance, and habitat loss is likely to protect the function algae plays in ecosystem health.

Evaluation of Current Management

There is a lack of understanding of benthic algae and its role, especially in the northern and central regions of the Bay. Standing crop and seasonality are important characters that can reveal much about ecosystem dynamics, especially in habitats such as intertidal flats and unvegetated shallow subtidal where algae can impart important physical structure to a site.

Proposed Management Strategy—Benthic Algae

Objective: Identify and then protect the abundance, biomass, and diversity of algal functional groups that reflect Bay ecosystem health.

I. Protect the structure and function of beneficial algal assemblages in the Bay.

A. Relate physical/chemical/biological factors to algal types and abundance, and actively manage the substrate or related factors.

B. Seek to reduce the abundance and standing crop of algal types that indicate pollution or disturbance by managing the pertinent disturbance.

C. Determine the ecological role and productivity contribution of *Gracilaria* algal mats that dominate some portions of the Bay's unvegetated shallows. How are they formed, what allows them to remain, and are they at risk from disturbance?

1. Determine if dredging new channels may change hydrodynamics enough to affect algal mats that may have an important role in unvegetated shallows.

2. Determine if boat traffic negatively affects algal mats.

II. Take advantage of opportunities to efficiently and effectively use attributes of algal communities to monitor ecosystem health.

A. Investigate the use of periphytic diatoms as indicators of pollution, which have specific responses to both thermal and chemical disturbances.

B. Investigate the usefulness and practicality of using opportunistic or successional algal species as indicators of habitat or ecosystem health.

III. Fill important information gaps that contribute to understanding algae's contribution to ecosystem health.

A. Combine any studies of invertebrate assemblages with quadrat sampling for algae.

B. Improve understanding of the ecological role of algal mats in unvegetated, shallow subtidal habitat.

C. Improve understanding of the ecological role of algae in intertidal flats.

D. Improve understanding of the relative importance of the role algae played by algae in salt marsh productivity.

4.3.2.2 Invertebrates

Specific Concerns

- Invertebrates that have not previously been managed for harvest are now being harvested by certain ethnic groups for human consumption (see also Section 4.3.3.1 "Harvest Management").
- A lack of understanding of the relative importance of attributes of sediment and water quality compared to predation and other factors in shaping the invertebrate community makes management difficult.
- Invasive, exotic invertebrates can significantly impact native invertebrate assemblage and the higher trophic species that depend upon them.

Current Management

Invertebrates are not managed directly, except for the few with harvest limits. However, regulatory protection from pollution, disturbance, and habitat loss also protects the functions invertebrates play in ecosystem health.

Evaluation of Current Management

The lack of information about invertebrate community structure in the Bay has led to difficulty in managing these species. This is a missed opportunity for better ecosystem management, since these species can be an early indicator of problems.

Proposed Management Strategy for Invertebrates

Objectives: Identify and then protect the abundance, biomass, and diversity of invertebrate functional groups that reflect health in each habitat and the ecosystem as a whole. Ensure that harvested invertebrate species are safe for human consumption.

I. Protect invertebrate populations as a source of food for shorebirds, fishes, and rays.

- ***A.*** Provide priority protection to invertebrates of intertidal and shallow subtidal flats.
- ***B.*** Relate the diversity and abundance of invertebrates to attributes of the substrate and water quality where they live, and manage substrate and water quality directly.
- ***C.*** Determine the relative ecological contribution of invertebrates of artificial structures compared to those of indigenous unconsolidated substrate.
- ***D.*** Determine the relative importance of predation by fishes, rays, and shorebirds in shaping the invertebrate community, compared to attributes of the sediment and water quality.

II. Ensure the safety for human consumption of harvested invertebrates.

- ***A.*** Support continuation of the Mussel Watch Program to detect trends in bioaccumulation of toxics.
- ***B.*** Determine the effects of toxic chemicals in Bay sediments on infaunal invertebrate assemblages.
  1. Encourage the continuation of studies such as those of Fairey *et al.* (1996) to assess health of the benthic community, the effects of toxics and their degree of severity, and associated substrate or water quality conditions.

III. Develop and implement methods that detect changes in the quality of the benthic invertebrate assemblage, especially with respect to food for shorebirds, water quality and toxics, and overall ecosystem health.

- ***A.*** Monitor for introduction of invasive exotic invertebrates, and populations of those already occurring in the Bay.
- ***B.*** Conduct a baseline inventory of the Bay's benthic invertebrates, with emphasis on functional groups and developing indices of health, or on identification of "keystone" species that may be used for long-term monitoring of habitat and ecosystem health.
  1. Relate results to attributes of substrate and water quality.
  2. Conduct studies on a seasonal basis.
- ***C.*** Standardize the protocols used when conducting impact assessments so that work may be more directly comparable.

D. Investigate the importance of the regeneration of nutrients by benthos for phytoplankton.

4.3.3 Fishes

- See also Section 2.5.4 "Fishes."

Specific Concerns

- Though the Bay is an important nursery and refuge area for marine fishes, success in the protection of fish habitats has been variable.
- Fish health may be affected by water quality conditions within the Bay, especially by contaminants.
- Important information gaps need to be filled through new monitoring and research.

- See specific subsections on Harvest Management and Artificial Propagation below.

Specific fish topics of Harvest Management and Artificial Propagation are addressed separately in detailed subsections following this section.

Current Management

Croaker

Management of fish habitats occurs in varying degrees. As a vegetated subtidal habitat, eelgrass beds are protected under the CWA's Sect. 404 protecting Special Aquatic Sites and the federal "no net loss" policy. (See Section 4.2.1.4 "Vegetated Shallow Subtidal" for description of management of this habitat.) Ocean and nearshore habitat conditions are now being addressed through the Essential Fish Habitat effort of NMFS. Required by the Magnuson-Stevens Fishery Management and Conservation Act, these habitats must be identified for all commercially and recreationally harvestable species that are listed in the Coastal Pelagic and Pacific Groundfish Management Plans. The program has no regulatory teeth, but it does allow NMFS to comment on all federal actions that may impact designated Essential Fish Habitat. CDFG's Bay and Estuary Ecosystem Program is identifying the roles that nearshore habitats have in the life history of certain species, such as corbina, spotfin croaker, yellowfin croaker, sand bass species, and kelp bass (www.dfg.ca.gov/Mrd).

- Fish health concerns have been observed but are not evaluated as to cause.

In contrast, fish health is another concern but one subject to little management. Most observations of diseased fish have either been an anecdotal or a secondary result of studies focused on other topics like water quality. For example, an ecological monitoring program of constructed wetlands in Sweetwater Marsh NWR by PERL noted "heavy loads of protozoan parasitic cysts and fluke metacercariae" on longjaw mudsuckers (Pacific Estuarine Research Laboratory 1996), which are suspected to be related to poor water quality. Fish health as it poses a risk to human health from fish caught and eaten from the Bay was the topic of a recent study (San Diego County Department of Health Services 1990). Based on potential human health risks, only the levels of mercury in the round stingray and PCBs in the Pacific mackerel showed significant results. Barred and spotted sandbass also were contaminated with lower levels of mercury.

As noted in Section 2.5.4 "Fishes," extensive surveys of fish fauna have been done of the Bay, with an ongoing Baywide study that included sampling sites seasonally for a five-year period.

Evaluation of Current Management

- Critically important eelgrass habitat is being successfully managed. However, unvegetated shallow subtidal and artificial habitat sites are not as well managed to benefit fish.

A habitat success story is the eelgrass mitigation policy developed cooperatively by a group of federal and state resource agencies and administered by NMFS. Since its implementation, there has apparently been no net loss in the acreage of eelgrass habitat within the Bay, with the exception of normal cycles associated

with El Niño events. This important fish habitat is well described in Section 2.4.3.2 "Vegetated Shallow Subtidal," with management evaluation and proposed strategy presented in Section 4.2.1.4 "Vegetated Shallow Subtidal." Other fish habitats may not be faring as well. Unvegetated shallow subtidal sites that are critical for bat rays, halibut, and other species do not receive the same level of protection as vegetated sites since they are not classified as "special aquatic sites" under Section 404 of the CWA (see Section 4.2.1.3 "Unvegetated Shallow Subtidal"). Marina areas in the Bay lack the abundance and diversity of fish that would be expected there by biologists (R. Hoffman, pers. comm.).

Primarily through their feeding, bottom-dwelling, resident fish may bioaccumulate toxins from sediment contaminated many years ago. What effects the contamination of fish with mercury and PCBs have on reproduction and viability of fish within the Bay is unknown. A review of the literature on lethal and sublethal effects of copper on fish and other animals was recently completed by the US Geological Survey, indicating a wide range of physiological effects at nominal copper concentrations of 4–10 μg/L (Eisler 1998). Larvae of topsmelt, a common species in the Bay, showed increasing sensitivity to copper with increasing age. However, little research has been done on marine species. Much of the copper found in the Bay is within the sediments, a long-term legacy of its use as a biocide in anti-fouling paints on boat and ship hulls. Elevated copper levels (>108 ppm) were found throughout sediments along the developed margins of San Diego Bay (Fairey *et al.* 1996).

While the five-year, Baywide fish sampling study by Allen provides a very useful database on abundance, biomass, and frequency of occurrence, this program does not provide information concerning some important factors for management. As noted above, artificial, man-made habitat areas were not sampled so implications for their management are absent. Age class data were apparently not gathered, so an analysis cannot be made of the relative contribution of the Bay for juvenile and adult phases of the fish surveyed. If bays are reportedly critical habitat as nurseries and refuge, the age structure and growth rates of fish inhabiting the Bay should also be evaluated.

Proposed Management Strategy—Fishes

The issues of habitat protection, water quality improvement, and monitoring and research are addressed in several other sections of this Plan as noted below. Additional recommended actions are as follows.

Objective: Protect and enhance fish population abundance and diversity, with priority to those using the Bay as a nursery or refuge, and to indigenous Bay species.

■ See 4.2.1 "Strategy by Habitat."

I. Maintain and improve habitat that provides reproductive and nursery functions.

- ***A.*** Continue the successful eelgrass strategy as described in Section 4.2.1.4 "Vegetated Shallow Subtidal."
- ***B.*** Improve management of other fish habitats as proposed in Section 4.2.1 "Strategy by Habitat," Section 4.2.1.6 "Salt Marsh," Section 4.2.1.5 "Intertidal Flats," Section 4.2.1.3 "Unvegetated Shallow Subtidal," Section 4.2.1.2 "Moderately Deep Subtidal," and Section 4.2.1.1 "Deep Subtidal."

II. Protect the health of the fish inhabiting the Bay.

- See compatible use strategies related to water quality improvement in Section 5.2 "Watershed Management Strategies."

A. Implement the Compatible Use Strategies to protect and improve water quality proposed in Chapter 5 (i.e. Ship and Boat Maintenance, Stormwater Management, Oil Spill Prevention and Cleanup, Remediation of Contaminated Sediments).

III. Support research and monitoring that will help improve fish management decisions.

A. Assess the abundance, diversity, and biomass of fish occupying artificial habitats of the Bay.

B. Evaluate the age structure and growth rates of fish inhabiting the Bay.

C. Promote research on the toxicity levels and effects of the contaminants on the marine fish species, at all life stages, found in the Bay.

D. Conduct a thorough, quantitative study to assess the recreational fishery and food gathering by ethnic groups:

1. to estimate species taken and fishery take by species.

2. to evaluate the effects of this take on Bay species.

IV. Promote education and outreach.

A. Increase environmental education programs and availability of informational literature and signs to raise awareness of threats, concerns, and management needs for fishes.

B. Assemble an interagency team to develop strategies for implementing internal and external educational programs and identify possible funding mechanisms for conservation and enhancement of fishes in the Bay.

4.3.3.1 Harvest Management

- Fish habitats and population status in the Bay are described in Section 2.5.4 "Fishes."

Specific Concerns

Harvesting of finfish and shellfish in the ocean and in the Bay has triggered these concerns:

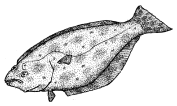
- Overfishing of some marine species in the ocean is depleting populations, while little information is known about the status of most harvestable species.
- Few Fish Management Plans exist for the commercial species inhabiting the Bay, although they are required by federal policy.
- Sport harvesting of fish and shellfish caught in San Diego Bay is not well monitored.
- Enforcement of sport fishing regulations is not adequate due to budget limitations.
- Overfished populations in the ocean may cause ripple effects in the Bay ecosystem.
- Ethnic groups fishing in the Bay are harvesting nontraditional species. This has unknown management implications and possible effects on the Bay ecosystem.

- Management activities that the Port or Navy can implement are not likely to influence species that are harvested outside the Bay.

Current Management

- See 3.3.6 "Fisheries" for use and value of the Bay fishery.

The abundance and diversity of fish populations within San Diego Bay can be affected by management of the commercial and sport fisheries in the ocean, at long distances from the Bay. On the other hand, harvest management within the Bay can affect the status of ocean populations. Evaluating the effects of harvesting can be complicated by other causes of change in fish abundance and diversity, such as weather conditions.



California Halibut

Management of marine fish stocks is a dual responsibility of the state and federal governments. Within the state's 3 mi (5 km) offshore jurisdiction, CDFG provides the lead, while the NMFS oversees ocean stocks between the 3 and 200 mi (5 and322 km) limits. Through the Fishery Conservation and Management (Magnuson) Act of 1976, Fish Management Plans are to be prepared. A Pacific Coast Groundfish Management Plan and a Coastal Pelagics Plan have been adopted by the Pacific Fisheries Management Council, a federally appointed regional body of managers and fishermen.

California's management of its marine fisheries was fundamentally changed in 1998 with the passage of AB 1241, under which fisheries management authority was transferred from the legislature to the California Fish and Game Commission (UCCE 1998). Fishery management plans are now mandated to be developed by the CDFG, with the Fish and Game Commission authorized to adopt regulations implementing those plans. The plans will be the primary basis for managing the state's marine recreational and commercial fisheries, and must include measures needed for a sustainable fishery. A status report must be submitted to the Commission by September 2001.

- CDFG is the responsible agency for managing fishing within the Bay.

The harvesting of fish and shellfish in San Diego Bay is managed directly by CDFG. Ocean fishing regulations are drafted by the Marine Resources Division, reviewed in public hearings, revised if needed, and adopted by the Fish and Game Commission. Emergency actions to close a fishery temporarily can be taken on short notice, following approval by the Commission and the Office of Administrative Law. Such action was taken recently to close the red abalone fishery in California (California Department of Fish and Game 1997b).

- Monitoring specifics for fish and invertebrate populations is in Chapter 6 "Monitoring and Research."

Harvest regulation seeks to manage sustainable populations through a combination of techniques: area and seasonal closures; gear limitations; and size, catch, and possession limitations. For example, the daily bag limits for species of interest for sport fishing in San Diego Bay are found in Table 4-7. If no specific limit is listed in the CDFG sport fishing regulations for a species, then the general daily limit is ten finfish of any one species (or 20 in combination) and 35 shellfish (California Department of Fish and Game 1997b). Some species are listed in the regulations as having no limit: grunion, topsmelt, jacksmelt, starry flounder, and most clams, among others. Zero take applies to a few protected species, such as garibaldi, black sea bass, and speckled (bay) scallops. Several species of marine plants are also prohibited from being cut or disturbed: eelgrass, surf grass, and sea palm. Seasonal restrictions apply to a few Bay species: white sea bass, grunion, and California spiny lobster, among others. Wardens from the Department's Wildlife Protection Division enforce the sport and commercial regulations. Sport fishing licenses are required for everyone except those fishing from certain public fishing docks.

Penalties for most violations are misdemeanors, with the amount of fines imposed by judges in local municipal courts. A portion of the fine monies may go to the County's Fish and Game Advisory Commission for use in local fish conservation projects.

Table 4-7. Sport Fishing Limits on Fish and Invertebrate Species of San Diego Bay (CDFG 1997).[1]

Species	Limit/day (Season)	Species	Limit/day (Season)
Fish			
leopard shark	3	Pacific bonito	10
blue shark	2	kelp bass	10
Pacific angel shark	10	barred sand bass	10
soupfin shark	1	spotted sand bass	10
bat ray	10	queenfish	no limit
striped bass	2	barracuda	no limit
jacksmelt	no limit	cabezon	10
topsmelt	no limit	white sea bass	3, or 1 (3/15–6/15)
grunion	no limit (6/1–3/31)	California corbina	10
northern anchovy	no limit	yellowfin croaker	10
Pacific herring	no limit	spotfin croaker	10
Pacific sardine	no limit	white croaker	no limit
California halibut	5	barred surfperch	10
sole (3 sp.)	10	pile surfperch	10
starry flounder	no limit	rubberlip surfperch	10
turbot (3 sp.)	10	walleye surfperch	10
opaleye	10	sculpin	10
jack mackerel	no limit	longjaw mudsucker	10
Calif. tonguefish	10		
Shellfish (crustaceans and other invertebrates)			
bay (grass) shrimp	5 lbs	chione, littleneck, soft-shelled clams (5 sp.)	50
ghost shrimp	50	Pismo clams	10
rock crabs (3 sp.)	35	gaper clams	10
Calif. spiny lobster	7 (10/1-3/31)	jackknife clams (3 sp.)	35
rock scallops	10	razor clams (2 sp.)	20
whelks	35	sand dollars	35
mussels (4 sp.)	10 lbs (in shell)	octopus	35
limpets	35		

1. See species list for scientific names in Appendix D.

- Landing data collected at local docks do not separate fish caught in the Bay from those caught in the ocean.

Commercial and some recreational catches are monitored through landing data at local docks, including how much, what kind, and the price paid for commercial fish at the boats. Statistics are processed annually on commercial fish landing receipts, commercial passenger fishing vessel records (sport fishery), and commercial fishing logs by the Marine Fisheries Statistics Unit (Read 1996). A logbook system is maintained for the spiny lobster trap fishery. However, published records do not include a separate listing for fish caught in San Diego Bay, only those landed at docks in the county, which would include pelagic and Mex-

ican-water fish. Commercial fishing no longer exists in the Bay. An experimental gillnet fishery for striped mullet was started in 1977, but ended in 1997 because of the mandated closure of gillnet fisheries in southern California (Duffy 1987; K. McKee-Lewis, California Department of Fish and Game, pers. comm.).

- Bay boat anglers tend to release their catch while shore anglers tend to keep and eat their catch.

The recreational fishery is the most important harvest activity on the Bay. Most of the boat fishing is by the catch-and-release method, while shore fishing is primarily catch-and-keep. When ocean conditions are unsafe, charter boats will switch to fishing in the Bay (R. Fletcher, California Sportfishing Association, pers. comm.). The Marine Recreational Fisheries Statistical Survey operated by NMFS provides statistical data while the Recreational Fisheries Information Network managed by the Pacific States Marine Fisheries Commission offers more "user friendly" data (see Table 4-8).

Table 4-8. Recreational Angler Catch Sampling List of Major Species for Inland Marine San Diego County, 1993–1998.[1]

Species	Sampler Examined Catch Numbers
Pacific (Chub) mackerel	1887
Spotted sandbass	653
Barred sandbass	472
Yellowfin croaker	188
White croaker	141
California halibut	106
Northern anchovy	40
Queenfish	39

1. Information from Pacific States Marine Fisheries Commission catch numbers sampled from marine recreational anglers for all modes of fishing in inland marine areas for San Diego County for 1993–1998 (www.psmfs.org/reefin).

Research on some marine sport fish is conducted by CDFG's Southern California Sport Fish Research Program to provide a biological basis for improvement in management practices, with current emphasis on white seabass, halibut, and barred sandbass. The Department's Bay and Estuary Ecosystem Program identifies the role that nearshore habitats have in the life history of certain species, such as corbina, spotfin croaker, yellowfin croaker, sand bass species, and kelp bass (www.dfg.ca.gov/Mrd).

Evaluation of Current Management

- Evaluation of the adequacy of harvest management suffers from inadequate information on most fish stocks.

How well these harvest management efforts are succeeding in sustaining the finfish and shellfish populations of the Bay is difficult to evaluate. Debate continues on classifying stocks as "overexploited" or "underutilized." Monitoring of most California stock is very limited or nonexistent, with the comment "population size and structure unknown" a common description of the status of individual species in the most recent state reference report (Leet *et al.* 1992). No monitoring occurs of the Bay's commercial or recreational bait fish harvest (e.g. ghost shrimp, topsmelt). Sampling data on some Bay stocks, however, appear to indicate relatively healthy populations, although historical population levels are not available for comparison of many species (Allen 1997; Chapter 2).

■ See Sections 2.5.4 "Fishes" and 4.3.3 "Fishes" for more information about the status of fish in the Bay.

Through the 1976 Magnuson Act, Congress changed the federal fisheries management focus from expansion of fisheries to their conservation and allocation (McEvoy 1986). However, economic and social factors were to be considered in producing the "optimum yield" of the fisheries and fishermen were decision-makers on the Pacific Fisheries Management Council setting regulations. Some scientists believe the "incessant sociopolitical pressure for greater harvests" in combination with "the intrinsic uncertainty in predicting the harvest" are the causes for federal management failing to achieve the principle goal of sustainability of much of the ocean fisheries (Botsford *et al.* 1997).

As a result of the 1996 Sustainable Fisheries Act (reauthorizing the 1976 Act), NMFS was directed to report to Congress on the status of fisheries and the identification of overfished stocks. Some Bay groundfish species were evaluated, including English sole, jack mackerel, starry flounder, leopard shark, soupfin shark, cabezon, and spiny lobster, among others. Only the English sole, jack mackerel, and spiny lobster had enough information to determine that the stocks were not overfished, while it is unknown whether the other four species are "approaching an overfished condition" (NMFS 1997).

Bycatch of nontargeted species had been a problem when commercial fisheries existed in the Bay. When gillnets were set across the Bay's channel for striped mullet, for example, green sea turtles became a bycatch even when the nets were attended (McDonald *et al.* 1994). The PSFMC allows a minimally acceptable biological catch of incidentally caught fish, in such categories as "Other Flatfish" (e.g. sanddabs) (Leet *et al.* 1992).

■ Harvest controls are one of the few direct management tools available. More attention is needed on the bait fishery harvest and its effect on the nearshore food chain.

Trends in harvest levels are often used as the only evidence of population size, and therefore, the sole indicator of problems with harvest management. Declines in harvest may reveal poor breeding replacement (recruitment) too late to halt reversals. In the example of the Pacific angel shark fishery, researchers and agency biologists began in 1979 to collect information on angel shark distributions, migrations, growth rates, and reproductive rates. A management plan followed in 1986, creating regulatory guidelines. Although a new minimum size limit was required to protect immature sharks, the drop in landings that followed was determined to be a reflection that management regulations were initiated too late to maintain a sustainable yield angel shark fishery with mid-1980s harvest levels (Leet *et al.* 1992). Factors other than harvest can cause increases or declines in the size and structure of harvestable species, but harvest controls are one of the few direct management tools available.

■ CDFG's enforcement of harvest regulations suffers from an inadequate budget in the face of increasing fishing pressures.

Intertidal invertebrates have been protected from wholesale collecting for over 25 years, yet "shore pickers" in the past decade have decimated sites of species previously thought to be of little interest (California Department of Fish and Game 1972; Knudson and Vogel 1996). A combination of reasons are suggested: new ethnic groups are seeking nontraditional seafood species; poachers are more effectively getting commercially valuable species; interest in the "live fishery" for the aquarium trade; and underfunded, understaffed enforcement efforts (Knudson and Vogel 1996). The principle problem is one of a lack of an adequate enforcement budget (S. Crooke, California Department of Fish and Game, pers. comm.; W. Tippetts, California Department of Fish and Game, pers. comm.; R. Hoffman, pers. comm.). CDFG's primary funding source continues to come from the sale of fishing licenses, which has declined in number and revenue despite an increase in population and management duties. As the stocks decline, the number of people fishing legally decreases, yet the management responsibilities rapidly rise in response to the crises.

Proposed Management Strategy—Harvest Management

Objective: Foster harvest management that can support viable, self-sustaining populations and promote native species richness within the San Diego Bay ecosystem.

I. Support adequate monitoring and research of harvestable species in the Bay.

- ***A.*** Promote more effective measurement of all types of recreational harvesting within the Bay.
  1. Expand periodic censusing (e.g. boat and dock checks) of all species.
  2. Increase censusing of California halibut and sandbass.
  3. Require that data collectors keep separate data for the San Diego Bay sport fishery so that their catches can be considered separately from those in the ocean.
  4. Evaluate the effect of recreational harvesting on those Bay species with "no limits" in the CDFG regulations.
  5. Encourage a bait fishery monitoring program, including ghost shrimp.
- ***B.*** Encourage CDFG's Southern California Sport Fish Research Program and its Bay and Estuary Ecosystem Program to investigate the life histories and habitat requirements of commercially and recreationally important fish species that use the Bay.

II. Advocate effective enforcement of existing state and federal fishery management regulations.

- ***A.*** Encourage better public education about the need for fishing regulations and their meaning.
  1. Seek publishing of sport fishing regulations and notices in the languages of the ethnic populations fishing the Bay.
  2. Encourage CDFG to develop unambiguous, clear language in stating their regulations, including a more user-friendly format.
  3. Locate access and facility sites to minimize or avoid conflicts with sport fishing access and high-value habitats.
- ***B.*** Support improved publicity and deterrents.
  1. Promote the use of appropriately stiff fines by local judges as a deterrent for future fishing violations.
  2. Encourage CDFG to publicize the arrest, conviction, and awarded court fines to discourage additional violations and poaching.
- ***C.*** Seek stable revenue sources to supplement license revenues for CDFG's enforcement efforts.
  1. Investigate establishing a San Diego Bay Harvest Management Endowment Fund that can receive funds as in-lieu mitigation, grants, donations, and fines.
  2. Encourage alternative state funding sources to supplement fishing license fee revenues for CDFG budget.
- ***D.*** Pursue improved regulation of sport fisheries if present state and federal harvest regulations and enforcement cannot meet the above objective.

E. Encourage NMFS to complete Fish Management Plans for all commercially and recreationally important fish that use the Bay, as required under the Magnuson-Stevenson Act of 1996.

4.3.3.2 Artificial Propagation

Specific Concerns

- Some fish species, such as California halibut, are declining and it may be necessary to enhance depleted populations by stocking.
- Other fish species are declining and may need special protection, such as surfperches.
- Water quality in some marinas in the Bay may limit their use as mariculture sites for less tolerant species like white seabass.
- Concentrated feeding and rearing of fish can increase nutrient levels and may cause eutrophication and changes in the benthic habitats near mariculture installations.
- Mariculture pens may concentrate diseases, and use of antibiotics to control such diseases can have unforeseen effects on native fish and wildlife.

Background

■ Interest is now increasing in the use of San Diego Bay for mariculture.

As ocean fishery stocks and yields continue to decline, there is increasing interest in mariculture, the techniques applied to growing marine organisms in captive, semicontrolled conditions. This approach to artificial propagation of marine life for commercial sale or to enhance existing fisheries is often conducted in bays because of the protection and quiet water conditions they provide. Surprisingly, there has been little mariculture activity in San Diego Bay until recent years, but interest is now increasing.

Longjaw mudsucker.

In the late 1960s and early 1970s, Dr. George Schuman operated a mariculture laboratory at the South Bay Power Plant through an agreement with SDG&E. His intent was to use thermal effluent from the generating station as a warm water source in which to culture American lobsters (*Homarus americanus*) and penaeid shrimp, thereby shortening the time required to produce them. There were also plans to carry out this penaeid shrimp culture on a large scale, using the adjacent ponds of the Western Salt Company. After initial exploratory work, these projects ended and the laboratory was closed. Similar cooperative mariculture research on American lobsters and other species was then continued by San Diego State University at the SDG&E Encina Power Plant on Agua Hedionda Lagoon in Carlsbad, California.

Current Management

Existing Mariculture Projects

■ Shelter Island Yacht Club is the location for a white seabass aquaculture effort.

In 1996, the fishing group of the Southwestern Yacht Club, working in cooperation with the United Anglers of California, established a floating raceway culturing system for young white seabass (*Atractoscion nobilis*). The white seabass is an important species in both sport and commercial fisheries with a very high market demand. Despite fishery management regulations in place since 1931, both commercial and recreational catches of white seabass have continued to decline markedly (Vojkovich and Reed 1983; Vojkovich, California Department of Fish and Game, pers. comm.).

■ The state is evaluating the feasibility of enhancing white seabass populations through artificial propagation in southern California.

The Ocean Resources Enhancement and Hatchery Program (OREHP) was established by the State Legislature in 1983, with CDFG as the lead agency, to evaluate the feasibility of culturing and releasing juvenile fish to enhance depleted populations of white seabass in southern California. This long-term stock enhancement evaluation program (Kent *et al.* 1995) is being conducted in part at the Leon Raymond Hubbard Jr. Marine Fish Hatchery in Carlsbad, California, which is operated for OREHP by the Hubbs-SeaWorld Research Institute. Here, young white seabass are cultured in large numbers from fertilized eggs produced by a broodstock of adult fish. When these juvenile fish reach a total length of approximately 3–3.5 in (51–64 mm), they are marked by insertion of a coded wire tag, used to identify the spawning group and release site of individual fish when they are subsequently recaptured following release into the ocean. The marked fish are transported to one of a series of 12 net pen culturing facilities, which include the San Diego Bay installation at the Southwestern Yacht Club. These facilities are located in bays or other protected nearshore ocean locations extending from San Diego Bay to Catalina Island, Santa Barbara, and Channel Islands Harbor (Kent *et al.* 1995). Most of them are operated under the auspices of United Anglers of California, whose members donate their time in feeding and maintaining the young white seabass.

After a time period averaging four months in the net pen systems, these fish are released into ocean or outer Bay locations known to be inhabited by young, white seabass. At the time of their release, the fish are approximately 8 in (203 mm) in total length. OREHP also supports directly associated field studies conducted by scientists from San Diego State University, Hubbs-Sea World Research Institute, and CSU Northridge. These studies include sampling for white seabass along the open coast of southern California and in selected bays and estuaries from Imperial Beach and San Diego Bay to Santa Barbara and Catalina Island. These studies are designed to recapture tagged white seabass, with the data used to evaluate the success of stock enhancement, and also to learn more about the distribution, abundance, and population characteristics of this species.

■ Rearing the white seabass to a relatively large size before they are released also helps to ensure that fewer of them will be taken by predators and thus more will survive to augment the population.

Floating culture systems, such as the one operated at the Southwestern Yacht Club in San Diego Bay, form an extremely important part of the program. Holding the fish in floating net or raceway enclosures makes it possible to rear them to a large size without having to employ large culturing tanks or ponds, and eliminates the associated high cost of pumping seawater to such land-based systems. Natural movement of Bay water through the net enclosures ensures a supply of oxygen-rich water and efficient removal of wastes. Rearing the white seabass to a relatively large size before they are released also helps to ensure that fewer of them will be taken by predators and thus more will survive to augment the population. Equally important, participation in the project by volunteer members of United Anglers of California helps to reduce production costs during this very labor-intensive phase of culture and also provides a hands-on opportunity for the volunteers to contribute directly to the stock enhancement process.

The floating raceway system now in use at the Southwestern Yacht Club measures 8 ft x 24 ft (2 m x 7 m) and is suspended in a water depth of approximately 5 ft (1.5 m). Similar floating raceways are being used at 5 of the 12 sites along the southern California coast, while floating net pens or pools are employed at the remaining sites. Initially, there had been a number of problems with the system at the Southwestern Yacht Club site, primarily associated with water quality and water circulation (M. Drawbridge, Hubbs-Sea World Research Institute, pers. comm.).

Regulatory Process

- Mariculture operations require approval from CDFG and usually the CCC.

Proposals for mariculture installations, such as those in San Diego Bay, are normally subject to review and approval by both the CDFG and the CCC. No additional approval is required by the San Diego Regional Water Quality Control Board unless waste discharge through an outfall is involved. Because the OREHP white seabass enhancement effort is administered by the CDFG, no overall CCC permit is required to culture or release these fish (Kent *et al.* 1995). As an established part of this program, net pen systems for producing white seabass, such as the Southwestern Yacht Club installation, require approval by CDFG as the lead agency through its OREHP Advisory Panel. Net pen installations also require an administrative approval from the CCC (D. Kent, Hubbs-Sea World Research Institute, pers. comm.).

Evaluation of Current Management

It appears that there is potential for at least some additional mariculture in San Diego Bay. Production of marine fish and invertebrates for commercial sale or for use in stock enhancement could be accommodated in suitable Bay locations, using net pen systems.

- Very few adequate sites remain in the Bay for mariculture except for floating net pens or raceway systems in areas like marinas.

However, there are several factors that limit this potential in San Diego Bay. First, commercial and military installations and areas set aside as natural habitats already occupy many sites in the Bay suitable for mariculture. There are simply very few adequate mariculture sites remaining. Mariculture using floating net pen or raceway systems lends itself best to this situation, because these can be operated within existing, developed areas, such as marinas, and in open water away from the shore.

In addition, all mariculture operations require consistently good water quality and associated water circulation. This probably will limit the use of some marinas and other developed areas in San Diego Bay, at least for culturing less tolerant species. The initial problems encountered in rearing young white seabass at the existing Southwestern Yacht Club site are a case in point.

- Water quality can be adversely affected by large operations due to their concentrated food and wastes.

It is also important to recognize that large mariculture operations can have adverse effects on the Bay ecosystem. Concentrated feeding by animals in culture can lead to uncontrolled growth of exotic species. In addition, concentrated production of wastes by cultured animals can cause blooms of noxious algal species and changes in bottom conditions. These problems must be considered in evaluating the design, operation, and placement of mariculture systems.

Successful mariculture also requires an installation that is reasonably secure from vandalism and other human intrusion. In a busy, urbanized commercial port such as San Diego Bay, such security may be difficult to maintain.

- Limitations won't prevent further development of mariculture in the Bay, but must be accounted for in site selection.

None of these limitations will prevent further development of mariculture installations in San Diego Bay. However, they must be given very serious consideration in the site selection process.

Planned Mariculture Projects

- An additional net pen system for white sea bass culture has been approved by the Port, but the location had not yet been selected.

In 1998, the San Diego Oceans Foundation proposed to the Port that the Foundation install and operate a larger net pen system in San Diego Bay, as part of the OREHP stock enhancement program for white seabass. This net pen system would be

approximately 33 ft x 33 ft (10 m x 10 m) in size (M. Drawbridge, pers. comm.). The concept has been approved and the Port has contributed $60,000, but the specific location for the system in the Bay and other details have not yet been determined.

Proposed Criteria

While there are no firmly established guidelines, several practical criteria are normally employed in evaluating the merits and possible shortcomings of a proposed mariculture project and its installations in the marine environment. The first, and most important of these, is the biological or commercial need for culturing a particular species of fish or invertebrate. Species such as the white seabass, for which the population size, fishery yield, and market supply have declined markedly, would have the highest priority for mariculture production. This would be true both for culture leading directly to commercial sale in fish markets or the production of juvenile fish released for stock enhancement. In contrast to the approach normally employed for species in terrestrial habitats, high ranking of candidate species for mariculture does not require that they be threatened or endangered species, only that the fishery stocks and yields are substantially depressed and, usually, that commercial or recreational demand for the species exceeds its natural supply. These effects on the population are caused by fishery and environmental problems normally involving overfishing, associated ineffective fishery management practices, changes in habitat conditions, or a combination of these factors.

A second important criterion is the degree to which existing mariculture technology for a species is well established and will likely lead to successful culture. In the case of the white seabass program, for example, production techniques such as use of net pen systems are already well established and very successful, which would lead to a high ranking.

A third set of criteria involves questions about water quality. Two primary, general questions are normally considered. First, are water quality conditions (e.g. good water circulation, low concentrations of toxic chemicals) at the proposed mariculture site adequate to help ensure successful production of the species? Water quality problems encountered thus far with the floating raceway system for white seabass at the Southwestern Yacht Club in San Diego Bay were solved after some problems the first year. Second, is the proposed mariculture installation likely to cause any degradation of water quality conditions (e.g. from animal wastes or uneaten food) at the site?

Proposed Management Strategy—Artificial Propagation

***Objective:** Explore the potential for enhancing the numbers of fish species that are in decline through artificial propagation in San Diego Bay while protecting the Bay ecosystem.*

I. Allow only the propagation of those fish species with populations declining due to fishing pressure and other effects.

- ***A.*** Support the continued evaluation by CDFG of the culturing of white sea bass, using the Bay as one of the test sites in southern California (i.e. OREHP).

II. Support the use of state-of-the-art mariculture technology.

III. Ensure good water quality in the vicinity of the propagation facility and the protection of the Bay's ecosystem.

A. Identify whether adequate water quality conditions (e.g. good water circulation, low concentrations of toxic chemicals) are available at a proposed location to ensure successful propagation of the species.

B. Require that any mariculture installation in the Bay does not degrade the water quality conditions of the site (e.g. from animal wastes or uneaten food).

C. Ask CDFG to ensure that the cultured fish are not diseased and that the potential for the spread of any introduced disease or antibiotics from the operation to wild fish stocks is not possible.

D. Encourage CDFG and NMFS to work together on a policy to ensure that genetic diversity of propagated species will be protected through the cultural practices.

4.3.4 Birds

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Photo © 1998 Tom Upton.

Photo 4-11. Heron.

Specific Concerns

■ See also Section 2.5.5 "Birds."

- Effects on Pacific Flyway bird populations from substantial losses of historic nesting, foraging, and loafing habitats locally are not well documented or understood for most Bay-dependent birds
- Remaining habitats—especially important ones like intertidal mudflats and upland transitional habitats—are further degraded and fragmented directly by a host of factors, including invasion of exotic plants and animals, reconfiguration of sub- and intertidal topography and substrate type, shoreline stabiliza-

tion structures, watercraft grounding or anchor impact, contamination from localized terrestrial runoff, and compaction by vehicle wheels.

- Human disturbance at or near feeding, nesting, and roosting areas places birds at risk when the birds are displaced, forced to expend excess energy in flight, exposed to higher risk of predation, or excluded altogether from these habitats due to disruptive effects of watercraft, aircraft and kites, lights and pyrotechnics, and vehicles at or near bird habitats.
- Intertidal mudflats and upland transitional habitats are not adequately protected in existing regulations, nor is there an institutional mechanism like the Southern California Eelgrass Mitigation Policy to advance innovation and develop management techniques for these important bird habitats.
- Predation is intensified as birds subsisting on fewer and smaller habitat patches are targeted by locally thriving urban populations of predators and scavengers, such as domestic cats and dogs, rats, gray foxes, opossums, kestrels, ravens, crows, gulls, raccoons, and the recovering peregrine falcon. This problem will probably always require intensive management for declining populations.
- Potential for disease outbreaks such as avian cholera and botulism are heightened as birds are crowded into diminished habitat patches, and water quality is impaired.
- Human-produced contaminants and toxins, including oil, threaten all Bay-dependent species from potential accidental spills, nonpoint and point source runoff, and bioaccumulation.
- Monofilament line, fish hooks, plastic six-pack rings, plastic balloons, and other items of human-generated refuse potentially threaten individual birds with injury or mortality, as do above-ground utility lines across flight paths.
- Changes to the invertebrate and vertebrate prey base of Bay-dependent birds due to direct, indirect, and cumulative causes raise concerns.
- Creative initiatives for conservation of Bay birds and their habitats have not been fully explored, including public information and education, garnering volunteer support of conservation projects, supporting ecotourism, and others.

Current Management

The majority of bird species around San Diego Bay are federally protected under the Migratory Bird Treaty Act. Introduced and pest species are not protected. Additional protection is afforded to endangered and threatened species under the federal and state ESAs. These species are monitored and managed to varying degrees depending on perceived threats, conflicts, habitat requirements, and project funding. Intensity and frequency of management efforts vary widely from year to year and can range from no regular monitoring to intensive daily monitoring and management, depending on the species, agency involved, and other variables. For example, the Navy and Port have funded long-term extensive monitoring and management of California least tern nesting areas on its properties. Other agencies fund less intensive measures on an irregular basis: snowy plovers receive less intensive monitoring than least terns by the Navy (plover monitoring is not funded directly), Belding's Savannah sparrows are only monitored for population estimates every five years by USFWS.

The destruction of habitat is somewhat limited by the permit and review process required under the NEPA, the CEQA, the CCA, and Section 1600d of the California Fish and Game Code, Section 401. Dredging and filling of wetlands is further

limited by the CWA Section 404 under the USACOE. Each process requires review by the USFWS, the CCC, and the CDFG. Specific review criteria only indirectly related to birds may be performed by NMFS, EPA, RWQCB, and San Diego County Health Department. Additional limitations are imposed by local jurisdictions (US Navy commands; County of San Diego; SDUPD; cities of San Diego, Coronado, National City, Chula Vista, and Imperial Beach) in the form of land-use planning tools including overlays, zoning, buffer restrictions, and permitting. Disturbance to waterfowl is somewhat reduced through watercraft speed limits by Port Ordinance, and some roosting and nesting areas of sensitive species are protected by limiting public access. Portions of the Bay also fall within the San Diego National Wildlife Refuge Complex planning zone and the MSCP, requiring additional oversight by USFWS, CDFG, and local agencies. The Port or the Navy did not participate in the MSCP, whereas the cities did participate.

Additional management and review input is provided by public and special interest groups, including nonprofit conservation organizations, such as Environmental Health Coalition, Baykeeper, the Audubon Society, and the Sierra Club.

Baseline data on waterbird species diversity, abundance, and distribution on the Bay was documented in three studies (US Fish and Wildlife Service 1995; Ogden 1994; Ogden 1995), but methodology was not standardized. The three sections of the Bay were monitored in different years and focus was on subtidal habitats. Only minimal data were collected on intertidal and shorebird usage. Funding was provided by the Navy and USFWS. The US Navy is currently funding shoreline bird monitoring along its properties on the Silver Strand. Previous monitoring included bird surveys along the NASNI shoreline (Copper 1997a, 1997b). The Point Reyes Bird Observatory previously coordinated a five-year monitoring program of Pacific Flyway shorebirds (Page *et al.* 1992), and annual Audubon Society Christmas Bird Counts provide nonstandardized but long-term data on abundance and diversity. Bird species diversity, abundance, and distribution data may be supplemented by a five-year Bird Atlas project that was started in 1997 by the San Diego Natural History Museum using volunteers (San Diego Natural History Museum 1997). Otherwise, no long-term Baywide bird monitoring project has been attempted. USFWS staff plan to conduct regular surveys in south San Diego Bay (B. Collins, pers. comm.), having conducted previous surveys of the most numerous species nesting at the south Bay Salt Works (US Fish and Wildlife Service 1993).

The US Navy funds snowy plover and least tern monitoring at the NAB, NRRF, and at the NASNI tern site (Copper 1997a, 1997b, 1997c; Copper and Patton 1997). Previous funding included snowy plover monitoring at NASNI, least tern monitoring at the NTC (Copper 1997a; Copper and Patton 1997), and least tern foraging studies (Copper 1985, Baird 1997). The Port currently funds monitoring of least terns at three nesting properties (Patton 1997) and US Geological Survey/National Biological Survey have monitored for snowy plovers (Powell *et al.* 1997).

Evaluation of Current Management

Legislation, enforcement, planning, and review processes have been successful in slowing the loss of species, habitat, and populations of waterbirds. In the case of some species and groups, such as the herons and egrets, remarkable rebounds in population numbers were noted following protective legislation earlier this century. However, while most waterbirds and shorebirds dependent on San Diego Bay and other southern California coastal habitats are migratory and the cause of decline may be far distant, the downward trend continues. This trend is evident through a combination of sources studying these populations through-

out the region, yet there remain no long-term monitoring programs for these species as a whole. Even among those species classified as endangered or threatened, the monitoring, management, and population estimates are nonstandardized and vary widely among not only species but nesting sites. Intensive management of California least terns has proven effective in increasing their population and securing terrestrial habitats around the Bay where other species also benefit, including snowy plovers, horned larks, and roosting shorebirds. However, neither the funding nor physical sites of these programs are secure indefinitely, and habitat degradation, predation, and population reductions are likely if such management were to cease.

While baseline data of bird use of the Bay exists, it is inadequate for addressing primary management concerns and needs. The previously mentioned studies of bird use on the Bay did not use consistent methods or species groupings, were relatively short-term in duration, and focused on only particular areas or sites within the Bay.

Rates of habitat loss and degradation have slowed, but habitat issues remain the primary concern for waterbirds. Habitat degradation and disturbance need to be addressed through education, as well as through controls in planning and review processes. Clear identification of bird population and habitat management priorities for the Bay are lacking and this risks cumulative loss of habitats. While progress has been slowly made in some areas, such as the control of nonnative predators, populations of native predators and scavengers continue to increase and magnify the impacts of predation bird populations dependent upon the Bay. The persistence of contaminants and toxins in the substrate and food chain of the Bay and continuing potential for new spills or leakage should be acknowledged in continued planning efforts. The complex nature and multiple sources of potential influence on factors such as water quality, nonnative species establishment and impact, and fisheries size and production indicate that these issues will remain threats to birds around the Bay without a multipronged approach to their solution.

Proposed Management Strategy—Birds

Objective: Maintain, enhance, and restore habitats on San Diego Bay aimed at providing for the health of resident and migratory populations of birds that rely on the Bay to complete their life cycle. Foster broader public knowledge and appreciation of the functional, aesthetic, recreational, and economic values of the bird resources of the Bay.

I. Protect, enhance, and restore habitats that migratory bird populations depend upon.

- ***A.*** Maintain and enhance primary roosting, foraging, and nesting sites.
  1. Complete a comprehensive habitat classification system for the Bay that clearly defines the tidal, upland, and transitional habitat subsets (e.g. how a mudflat is partitioned) used on a recurring basis by Bay birds.
  2. Map distribution of these habitats across the Bay and relative importance to birds based on existing information and additional survey data as needed.
  3. Identify opportunities for maintaining and enhancing these primary habitats.
- ***B.*** Establish long-term priorities for management and conservation of habitat for Bay birds.

1. Prioritize birds species groups and associated habitats most in need of future management and conservation based on local population and habitat declines, and Flyway and national priorities established by the North American Waterfowl Management Plan, Partners in Flight Bird Conservation Strategy, and the US Shorebird Conservation Plan.
2. Establish biologically appropriate planning units within the Bay ecosystem as needed and defined by the priority conservation needs.
3. Establish specific habitat acquisition, enhancement, restoration, protection and management objectives, and completion timelines based on priorities within the planning units. Tie in where possible expectations for anticipated population responses based on habitat management.

C. Maintain a policy of no net loss of subtidal, intertidal, or terrestrial transition habitats, and a long-term net gain in the carrying capacity of these habitats.

1. Continue enforcing no net loss of subaquatic vegetation throughout the Bay, since this habitat provides forage and harbors prey for many Bay-dependent birds. See also Appendix G for additional management strategies for intertidal mudflats.
2. Acquire or protect high priority remnant habitats.

D. Identify opportunities through mitigation and nonmitigation funding to protect existing, restore degraded, and recover priority bird habitats.

1. Establish a southern California intertidal mitigation policy that will provide incentive for protecting and increasing the acreage or function of intertidal habitat for sensitive birds. (See Appendix G.)
2. Seek means to maximize the impact of mitigation effort for small projects by combining funds from multiple projects at a single site.
3. Seek nonmitigation funds to expand and restore intertidal, upland transition and other habitats identified as important to declining species.
4. Develop an incentive-based means (such as mitigation banking) to allow entities other than USFWS Refuges to participate in safeguarding and enhancing the function of the Salt Works for foraging and nesting shorebirds.
5. Identify opportunities for restoration of severely degraded or lost priority habitats.

■ See Section 4.3.1 "Exotic Species."

E. Establish a Baywide policy of reducing invasive nonnative vegetation that impacts bird habitat.

F. Support cleanup efforts to reduce contaminants and toxic buildup in the ecosystem, including monitoring and reducing nonpoint sources.

1. Identify priority locations, schedules, and funding mechanisms to achieve cleanup efforts in high priority habitats, in concert with the Ecological Risk Assessment work being conducted at SPAWAR.
2. Support and build upon the San Diego Audubon Society's sponsorship of the National Audubon Society's ARK program for south Bay cleanup using volunteers.

G. Encourage Bay interests and jurisdictions to adopt uniform environmental protection, enforcement, management plans, and policies that affect priority bird habitats in the Bay.

H. Allow for management plans that address bird habitat management to adapt to new knowledge based on research and monitoring.

I. Coordinate with current local, regional, and national bird conservation initiatives to reduce duplication of effort and maximize local conservation of Bay birds.

II. Protect bird populations that use the Bay ecosystem.

A. Establish a long-term standardized population monitoring program throughout the Bay.

1. Identify or develop standardized, scientifically sound survey protocols to collect and analyze population abundance and distribution of birds across water, upland, and transitional habitat types and seasonally.
2. Ensure that survey protocols will establish current local population sizes and also permit credible estimates of population trends at five-year intervals.
3. Consolidate existing information and determine how current established monitoring programs might contribute to Bay databases and monitoring protocols, including the Breeding Bird Survey, Breeding Bird Atlas, Colonial Waterbird Surveys, International Shorebird Survey, Hawk Migration Surveys, Breeding Bird Census, Christmas Bird Counts, Winter Bird Population Studies, survey information collected locally by federal and state agencies, and the Service's Bird Banding Laboratory.

B. Increase the Bay's carrying capacity for shorebirds.

C. Establish specific population goals for priority resident bird populations and secure and conduct the necessary management of habitat to support those populations.

1. Identify focus species and sources of information that can be used to establish realistic population goals, such as known peak population sizes within the past 20 years.
2. Ensure full representation of species groups and habitats at the Bay level.
3. In association with establishing population goals, identify the quantity and feasibility of habitat needed to support those population goals.

D. Provide secure colonial nesting sites, allow for population recovery, manage predators, and protect adjacent foraging areas for the California least tern and other declining species.

1. Promote cooperative agreements on predator management that result in more effective protection of nesting birds.
2. Promote pet management year-round in housing areas near nesting sites.
3. Urge that predator management measures be integrated into the design, development, and management of habitat areas.

E. Take practical steps, such as watercraft speed reduction, noise and light reduction or shielding, pet control, avoidance of bird assemblages, and habitat disturbance.

1. Continue to enforce 5 mph speed limits and encourage watercraft avoidance of bird assemblages, in cooperation with the US Coast Guard and SDUPD harbor police.
2. Investigate whether speed limit zone and buffers can be made more focused based on bird behavior.
3. Identify areas of significant waterbird use that could be enhanced by rerouting boat traffic, in consultation with the US Coast Guard.
4. Advocate seasonal restrictions for watercraft in priority bird-use areas.

F. Establish a central repository database of existing and new information on bird populations and habitat use in the Bay.

G. Coordinate with current local, regional, and national bird surveys and conservation initiatives to reduce duplication of effort and maximize local conservation of Bay birds.

III. Conduct research in support of the management objective.

A. Develop cost-effective, standardized survey protocol across species groups and habitats.

B. Improve understanding of how each Bay habitat functions to support avian species.

1. Investigate shorebird partitioning in microhabitats of intertidal mudflats.
2. Identify and monitor juvenile and larval fish populations and other prey bases within the Bay.
3. Identify primary roosting and foraging sites, taking into consideration that these will change to some degree.

C. Conduct focused studies in feeding ecology of sensitive species to improve understanding of habitat functions in the Bay and in relation to coastal waters.

1. Supplement feeding ecology studies with post-mortem analysis of stomach food content.
2. Conduct post-mortem analyses (within 24 to 48 hours after death for usable results), including tissue analysis to discover if death was caused by such things as toxics in the food chain.
3. Conduct direct observation studies of foraging.
4. Study the habitat and feeding dependencies of sensitive species dependent on coastal waters.

D. Investigate the direct and indirect effects of shoreline stabilization structures on remaining priority bird habitats.

E. Investigate the technical feasibility and mechanics of restoring intertidal habitats.

F. Identify and monitor fish populations and other prey bases within the Bay.

G. Continue monitoring boater disturbance of birds, including disturbance patterns before and after implementing new management to evaluate efficacy.

H. Consider the possible influences of El Niño, global warming, and other broader effects on local habitat availability and suitability, especially those located on habitat edges that are most likely to be affected (e.g. cordgrass at low edge of salt marsh, or upper intertidal, which may be invaded by native salt marsh).

IV. Promote education and outreach.

A. Increase environmental education programs and availability of informational literature and signs to raise awareness of threats, concerns, and management needs.

1. Identify birdwatching locations for potential ecotourism development and encourage public use of public lands consistent with maintaining local resource values.

2. Promote the Salt Works as a prime birding area and opportunity to relate the value of habitat to Bay birds.

3. Find means to designate areas for nondisruptive viewing opportunities for wildlife-oriented recreation.

4. Develop appropriate access facilities, use schedules, regulations, and enforcement to support nondisruptive forms of active recreation.

B. Assemble an interagency team to develop strategies for implementing internal and external educational programs and identify possible funding mechanisms for bird conservation in the Bay.

4.3.5 Marine Mammals

■ See also Section 2.5.6 "Marine Mammals."

Sea lions.

Specific Concerns

- Bioaccumulation of environmental contaminants can affect the health of predator species, particularly bottlenose dolphins.
- Physical and noise harassment from boats and other activities in the Bay can disturb resting and feeding areas.
- Harbor seals and sea lions are particularly vulnerable to oil spills.
- As in other California bays, a potential exists for harbor seals and sea lions to become nuisances around piers, fishing boats, or other haul out sites in public places.
- Little is known about coastal bottlenose dolphin use of the Bay or the Bay's contribution to supporting this coastal stock's population of only 250 to 350 individuals.

Current Management

■ Optimum sustainable population levels is the goal of the Marine Mammal Protection Act.

All marine mammals are listed and protected by the MMPA of 1972 (as amended), which serves as the principal basis for the nation's marine mammal programs (Weber 1985). The act requires that marine mammals be restored to their optimum sustainable population levels within the 200 mi (322 km) offshore federal fishery management zone. Its focus is the establishment of a moratorium on the taking of all marine mammals. "Taking" includes hunting, capturing, killing, or harassing. Allowable "takes" are for tagging, branding, surveying, and collection of scat.

As part of the Department of Commerce's NOAA, the NMFS is charged with administering the federal species acts for most marine mammals (with USFWS charged with otters, polar bears, and walrus). Overseeing the implementation of MMPA is the independent Marine Mammal Commission. It reviews permits for the taking of marine mammals and supports research and studies addressing problems related to the conservation and protection of marine mammals and their habitat.

- Navy policy addresses marine mammal protections.

Navy policy reflects the MMPA: (a) no Navy vessel shall deliberately harass a marine mammal; and (b) the protection of marine mammals shall be taken into consideration during operations and planning (Ch. 19–11.3, US Department of the Navy 1994). In addition, the Navy is authorized to "take" not more than 25 marine mammals for the purposes of national defense, with the concurrence of the Secretary of Commerce (California Resources Agency 1997). Locally, Navy dolphins, primarily bottlenose, are kept and trained at the Point Loma Naval Complex.

- State management of marine mammals defers to federal authority for the most part.

At the state level, the MMPA preempted state management authority over marine mammals and state policy now only refers to the federal act (Fish and Game Code Sect. 4500). The 1999 MMPA amendments could provide the State of California with some control over seals and sea lions when they contribute to the demise of listed salmonid species (M. Fluharty, pers. comm.). In addition, the California Marine Resources Protection Act of 1990, which was adopted as an initiative constitutional amendment (Proposition 132), banned fishing after 1994 with gill nets and trammel nets within 3 nm offshore of southern California (Fish and Game Code Chapter 3, Article 1.4). These nets were known to contribute to by-catch problems of certain marine mammals.

Oil spill prevention and cleanup are another management action potentially affecting marine mammals. CDFG's Office of Oil Spill Prevention and Response takes the lead for the state, while several agencies are involved at the federal level (i.e. USCG, NMFS, Navy). In addition, medical care of oiled wildlife is required under state (Lempert-Keene-Seastrand Oil Spill Act, SB 2040) and federal (Oil Pollution Act 90) laws (Jessup 1998).

Evaluation of Current Management

- See Section 2.5.6 "Marine Mammals," for status details.

Overall, the MMPA appears to be successful. Population trends of all marine mammal species in the Southern California Bight seem to be stable or increasing, except for the natural cyclical loss of pinnipeds during El Niño events. In particular, the population of sea lions may now be higher than their historic levels, with 160,000 to 200,000 sea lions in the Channel Islands area (M. Fluharty, pers. comm.). The dolphin populations were probably never common in the nearshore or Bay environments around San Diego (J. Barlow, NMFS, pers. comm.). Gray whale populations are increasing about 2 to 3% each year and are almost near historic levels (Leet *et al.* 1992).

The MMPA allows the tuna purse-seine fishing industry to minimize its incidental capture of porpoises using the best available technology, which appears to have reduced conflicts (Weber 1985). Recently, additional take was proposed by Congress, with critics asserting that this change will not be sufficiently protective. By banning coastal gill nets, California reduced one of the hazards to coastal marine mammals (Bonnell and Dailey 1993). However, they are still susceptible to: (a) entanglement or by-catch in drift or gill net fisheries greater than 3 nm off shore, (b) ship strikes by cargo ships and others, and (c) gunshot

wounds from frustrated fishermen, as harbor seals and sea lions are viewed as competitors and nuisances of the fishery. NMFS recently funded a grant to develop and test a nonlethal device to deter sea lions near fishing boats.

In response to a Congressional request for an evaluation, the NMFS has reported that rapidly growing populations of California sea lions and Pacific harbor seals on the west coast are causing increasing incidents of sea lions that cannot be deterred from docks and marinas, and that sea lions and harbor seals may be a threat to public safety at such locations (NMFS 1999). NMFS's goal is to reduce human interactions with nonlethal techniques, but some situations may need "more effective tools" when a few animals are threatening people and property. Federal or state managers should be authorized, NMFS argues, to lethally remove identified problem marine mammals if individual animals fail to respond to repeated attempts to deter them. To implement the agency's recommendations would require Congress to amend the MMPA. San Diego Bay, however, is not listed on their map of seal and sea lion "trouble spots," although the Channel Islands are.

- Harbor seals and sea lions tolerate human contact and can become a nuisance at public places.

Tolerance of a certain level of development appears to characterize the marine mammal species presently inhabiting or visiting the Bay. Harbor seals and sea lions are often seen basking on large buoys and feeding near fishing boat docks, where they may partially benefit from the artificial environment and easy food source. Densities of seals and sea lions on docks and piers have not yet reached problem levels, unlike popular tourist piers in San Francisco Bay and Monterey, but they could become so in the future.

- As top predators, pinnipeds and dolphins can concentrate high levels of contaminants from the environment.

The effects of high volume boat and ship traffic, oil spills, contaminated sediments, and other disturbances on the numbers and health of marine mammal populations in San Diego Bay have not been studied. Contamination of the food chain through exposure to toxicity and bioconcentration within tissues could lead to problems of Bay resident species that are top predators in the food chain, such as the pinnipeds (Fairey *et al.* 1996). Within the Bight, the highest levels of DDT in any marine animal are found in bottlenose dolphins, with elevated PCB levels (J. Barlow, pers. comm.). The comprehensive water quality management strategy by the Bay Panel is intended to reduce contaminant levels within the Bay (San Diego Bay Interagency Water Quality Panel 1998). However, efforts to mitigate the environmental impacts of projects in the Bay do not always address marine mammals, perhaps because they do not have the priority of listed species and their habitats are not classified as sensitive or critical (US Department of the Navy 1995).

- The status of coastal bottlenose dolphin in the Bay is unknown, and the stock has low numbers.

Research on certain marine mammal species is conducted locally at Carl Hubbs/Sea World, Inc. in Mission Bay and at San Diego State University. Dr. R.H. Defran's lab has long-term data (since 1981) on the population numbers, dynamics, and movements of the bottlenose dolphin for an extensive area of the coast (Defran *et al.* 1986; Hansen and Defran 1990; Hanson and Defran 1993). However, the status of this species in San Diego Bay is not known despite the awareness that bottlenose dolphin schools are regularly encountered in the Bay and only 250 to 350 individuals of the coastal stock are believed to exist between Ensenada, Mexico and Monterey Bay, California.

Proposed Management Strategy—Marine Mammals

Since none of the marine mammal species are presently being monitored in the Bay, this information gap needs to be filled as a first priority for management. In particular, the coastal bottlenose dolphin requires focused evaluation. Habitat must be

identified and protected while impacts on marine mammals are addressed in environmental assessments of projects. Populations of sea lions, and harbor seals should be managed to prevent them from becoming nuisances at public sites.

Objective: Maintain a healthy balance of marine mammal species inhabiting or visiting San Diego Bay.

I. Support the collection and analysis of information needed to better manage marine mammals in the Bay.

- ***A.*** Assess the population, distribution, and time of use over a four- to five-year period for bottlenose dolphins, gray whale, Pacific harbor seal, and California sea lion.
  1. Reevaluate their status in the Bay every 3 to 5 years.
- ***B.*** Identify prey species and better understand their role in the community structure.
- ***C.*** Describe haul out sites, rest areas, feeding areas, and patterns of use for pinnipeds and feeding and rest area patterns for dolphins.
- ***D.*** Determine the contribution of the Bay to the abundance of the coastal bottlenose dolphin stock.

II. Support effective management of marine mammal habitat.

- ***A.*** Protect feeding areas, resting areas, and any haul out sites within the Bay as necessary.
  1. Address the potential effects of proposed projects on these identified marine mammal sites through NEPA and CEQA processes.
  2. Identify and implement effective mitigation practices where needed.
- ***B.*** Support the prompt cleanup of toxic hot spots and oil spills in San Diego Bay in areas frequented by marine mammals and their prey.

■ See Section 5.3.2 "Oil Spill or Hazardous Substance Prevention and CleanUp."

- ***C.*** Evaluate the effects that high volume boat and ship traffic, noise levels, oil spills, contaminated sediments, and other disturbances have on the numbers and health of marine mammals inhabiting the Bay.

III. Maintain a balanced marine mammal population in the Bay.

- ***A.*** Identify practices to safely discourage harbor seal and sea lion use of a public area, when densities approach the level of a nuisance.
  1. Discourage the public from feeding these wild animals.
  2. Employ nonlethal deterrent devices as the preferred method, where needed.
- ***B.*** Work with NMFS and CDFG to maintain a healthy balance of marine mammals in San Diego Bay.

4.3.6 Sensitive Species Special Protections

4.3.6.1 Green Sea Turtle

■ See also Section 2.6.1.1 "Green Sea Turtle."

The green sea turtle (*Chelonia mydas*) is the only species of marine reptile to inhabit San Diego Bay. Under the ESA, this species is listed as threatened wherever found, except for breeding colony populations in Florida and on the Pacific coast of Mexico, which are listed as endangered. It has experienced a decline throughout its entire geographical range. The San Diego Bay population is predominantly a part of the Mexican breeding population, and as such, is endangered (P. Dutton, NMFS, pers. comm.). A recent federal recovery plan for the species lists the following threats pertinent to San Diego Bay that jeopardize the survival or impede population recovery (NMFS and US Fish and Wildlife Service 1998).

Specific Concerns

- Propeller and collision injuries to turtles continue to be caused by high speed boating in the Bay, particularly where they are most vulnerable in the South Bay.
- Marine debris, such as plastic and other persistent waste, continues to cause mortalities through entanglement or blockage of the turtle's digestive tract.
- Dredging can destroy forage habitat, as well as cause harm or death in the drag head, due to the preferred location of the Bay's turtles on the floor of dredge channels.
- Inadequate information about the turtle's home range impedes protection of its entire critical habitat.

In addition, a new concern has recently arisen.

- The proposed closure of the south Bay power plant with the loss of its warm water discharge may have a large effect on the status and condition of the turtles in San Diego Bay.

Photo © 1998 Greg O'Corrie-Crowe.

Photo 4-12. Green Sea Turtle.

Current Management

- The breeding population continues to decline despite international cooperation.

The local turtles are part of the eastern Pacific population of the species. Until excessive exploitation began over 40 years ago, the turtles were abundant and widespread. Despite international conservation efforts at breeding beaches, the breeding population of this species is declining at its known nesting beaches in Mexico. Possible causes include difficult field enforcement from illegal harvest and trade in sea turtle products and continued incidental take of sea turtles by shrimp trawlers (NMFS and US Fish and Wildlife Service 1998).

- The warm water environment of South Bay, enhanced by the power plant's heated discharge, has created year-round habitat that accelerates the turtle's growth rate.

As noted in Chapter 2, the green sea turtle is present year-round in south San Diego Bay, though originally it may have been only a summer visitor. The Bay is the northernmost site for a resident population of the East Pacific green sea turtle (NMFS and US Fish and Wildlife Service 1998). Based on preliminary genetic studies and their morphology, the females of this population appear to nest on beaches in Mexico (P. Dutton, pers. comm.). The adults and juveniles migrate to feeding grounds in bays along the coast of Baja all the way up to San Diego Bay and occasionally Mission Bay, areas that are vital as forage and developmental habitats (Dutton *et al.* 1994; NMFS and USFWS 1998). These warm water turtles spend much of the cooler months in the heated effluent channel of the south Bay power plant, dispersing further into the Bay during the warmer months (McDonald *et al.* 1994). An estimated 30 to 60 mature and immature turtles currently reside in San Diego Bay. With the enhanced environment from the power plant, the San Diego Bay turtles' growth rate is significantly higher than those not using the Bay (McDonald *et al.* 1995).

Both the NMFS and the USFWS have combined efforts to protect and build sea turtle populations in the United States Pacific ocean through their March 1998 Recovery Plan for the east Pacific green sea turtle. However, NMFS is the lead agency on sea turtle recovery for the San Diego Bay region because the ESA delegates authority to NMFS for green sea turtles in their marine environment and to the USFWS for green sea turtles on their nesting beaches. Under the federal ESA, projects and actions must avoid impacts to this species and the project proponent must seek a formal consultation with NMFS.

- Current management focuses on monitoring the status and location of the turtle population within the Bay.

Local management efforts primarily focus on monitoring the population status and the location of the turtle within the Bay. This effort is presently coordinated by a NMFS sea turtle scientist. Funding within NMFS is limited, and in the past funds came from a variety of sources: San Diego County Fish and Wildlife Advisory Commission, Hubbs-Sea World Research Institute (Hubbs-Sea World Research Institute), and USFWS (McDonald and Dutton 1993).

Evaluation of Current Management

- Green sea turtles are not a high priority for NMFS at the moment, though a new regional position with responsibility for turtles was recently filled.

Presently, research on the green sea turtle population in San Diego Bay is not funded, critical habitat under ESA cannot yet be designated and only minimal annual data collection is possible. Although the NMFS' Southwest Fisheries Science Center (La Jolla lab) has recently hired a sea turtle scientist (P. Dutton) who continues to study the Bay's turtles, the agency has to rely heavily on the assistance of volunteers. The green sea turtle is a high priority for the Southwest Region of NMFS, but efforts to date have focused on the central Pacific population around Hawaii and not on the eastern Pacific population found in San Diego and Mexico.

- Boat collisions and propellers continue to cause the greatest problem for turtles within the Bay. Better enforcement of the 5 mph speed limit in south Bay is suggested.

Boat propellers and collisions have severely injured turtles in the Bay, causing 80% of turtle deaths reported in San Diego Bay and Mission Bay (McDonald and Dutton 1992). A posted boat speed limit of 5 mph in the south Bay by the San Diego Harbor Police (Port Code 4.04) primarily intended to protect birds from harassment, should also benefit sea turtles. The animals are more vulnerable during the cooler months when they congregate near the power plant. To "minimize boat collision mortalities, particularly within San Diego County" is one of the major priority actions identified to achieve species recovery (NMFS and US Fish and Wildlife Service 1998). Although the addition of personal watercraft by the Harbor Police has helped them to enforce the speed limit, speeding by recreational boats, particularly local water-skiers and jet skis, continues to be a problem and is considered "rarely enforced" in the Recovery Plan (P. Dutton, pers. comm.; NMFS and US Fish and Wildlife Service 1998).

- Marine debris, such as monofilament netting, also causes mortality of turtles in the Bay.

Entanglement in and ingestion of marine debris is also identified in the Recovery Plan as a major problem, noting that an adult turtle was recently found dead in the Bay from monofilament netting tightly packed in the esophagus. The Port regulates rubbish and waste disposal within its jurisdiction (Port Code 8.60), while the Navy has similar controls over wastes from its operations in the Bay. The US Coast Guard is authorized to enforce federal marine pollution laws.

The debilitating and sometimes fatal fibropapilloma tumor disease, while widespread in the Hawaiian green sea turtle population, is not prevalent in the east Pacific population. Although apparent early stages of the disease were observed on some Bay turtles in 1990, the disease does not seem to have spread to more individuals or become debilitating to the original animals (McDonald and Dutton 1990; P. Dutton, pers. comm.).

- The turtles are considered vulnerable to dredging in the Bay.

Other threats are listed in the Recovery Plan that are a known problem with "extent unknown" (and no priority given). Environmental contaminants in San Diego Bay, in particular heavy metals and PCBs, are suggested as the cause of small lesions in some turtles. Seagrass degradation and natural disasters are also mentioned. In addition, threats that are listed as "not a current problem" include marina/dock development, dredging, construction blasting, and power plant entrapment. However, the Bay's turtles are described in the Plan as being vulnerable to dredging since juvenile and adult turtles spend most of their time motionless on the floor of dredge channels (citing Stinson 1984; McDonald and Dutton 1992).

- The proposed closure of the SDG&E power plant may cause changes to the turtles' presence and condition in the Bay.

A new potential threat is the proposed closing and removal of the SDG&E power plant within 10 years of its impending acquisition by the Port (SDUPD 1998). Now that 30 to 60 turtles have become year-round residents in the Bay due to the warmed water from the plant's effluent, the discontinuance of this heating source will likely cause changes to the turtle population. Their presence in the winter months would be most affected. Another effect to be evaluated is the expected reduction in their growth rate, which has increased significantly due to the enhanced temperatures (McDonald *et al*. 1995). Such a growth advantage is a likely benefit to the recovery of this endangered species and San Diego Bay has become a de facto turtle sanctuary because of the enhanced conditions (P. Dutton, pers. comm.). Impacts to the turtle population would have to be thoroughly addressed under both NEPA and the ESA when removal of the power plant is at the formal proposal stage.

Proposed Management Strategy—Green Sea Turtle

- The 1998 Recovery Plan lists criteria and actions that must be taken to allow for delisting of this species.

The Recovery Plan lists the following relevant criteria that must be met in order to consider delisting of this species:

- All regional stocks that use US waters have been identified to source beaches based on reasonable geographic parameters.
- Existing foraging areas are maintained as healthy environments.
- Foraging populations are exhibiting statistically significant increases at several key foraging grounds within each stock region.
- All priority #1 tasks have been implemented (see #1 below).

Major actions that are needed to achieve recovery were also identified. Those actions pertinent to the Bay are (1) minimize boat collision mortalities, particularly within San Diego County, California; (2) determine population size and status in US waters through regular surveys; (3) identify stock home range(s) using DNA analysis; and (4) identify and protect primary foraging areas in US jurisdiction.

Objective: Protect the listed green sea turtle population inhabiting San Diego Bay and seek to contribute to its recovery.

I. Maintain foraging and resting areas in the Bay as a healthy and safe environment for the turtle in order to increase the local foraging population. (#1)

A. Minimize boat collision mortalities. (#1)

1. Improve posting of the 5 mph speed limit signs in the South Bay.

2. Ensure San Diego Harbor Police are aware of the need to protect the green sea turtles and the need to provide enforcement in the south Bay, including the winter months when turtles congregate and are especially vulnerable.

3. Educate the boating and water-skiing community about protecting the turtle population.

B. Minimize persistent marine debris within San Diego Bay, that could harm the turtle through entanglement or ingestion.

1. Educate the fishing, boating, and tourist communities about the impacts of plastics, monofilament line, and other nondegradable debris on turtles.

2. Support regular voluntary cleanup campaigns of in-water and onshore debris.

3. Effectively enforce regulations prohibiting rubbish and waste disposal in the Bay, and encourage all regulatory entities to provide effective enforcement.

C. Address and resolve potential impacts on turtles through the project review process.

1. Provide effective mitigation for any impacts to eelgrass beds, and discuss project implications to turtle foraging habitat, in any environmental analysis.

2. Include the potential effects of dredging projects on resting and foraging green sea turtles in environmental impact assessment documents, and propose effective mitigation practices.

3. Ensure thorough analysis and mitigation of the impacts of the proposed closure of the SDG&E power plant on the turtles' status and condition within the Bay.

II. Contribute to the understanding of the green sea turtle's life history needs.

A. Help determine population status in the Bay through regular surveys. (#1)

1. Contribute to annual population estimates of the Bay's resident turtles and to the estimation of their annual growth rates.

2. Evaluate the contribution of the Bay's population to the species status and recovery.

3. Determine the status of tumor disease in the resident turtle population.

B. Seek to identify the turtles' seasonal and migratory movements within and outside the Bay. (#1)

1. Contribute to outfitting an adequate number of turtles (i.e. 10–20) with transmitters that can track them to their source nesting beaches, as well as to their foraging and resting sites.

2. Also promote identification of the turtles' home range(s) through DNA analysis.

3. Identify the turtles' foraging and resting areas within the Bay to aid in preventing potential impacts from recreational boating and dredging.

4. Help identify what factors control the turtles' movement patterns to, from, and within the Bay.

■ See also Section 5.3.1 "Remediation of Contaminated Sediments."

C. Continue the cleanup of existing contaminants within the Bay and the prevention of additional contamination to the Bay (see Section 5.3.1 "Remediation of Contaminated Sediments").

D. Support adequate funding within NMFS to carry out their implementation actions needed to delist this species.

III. Promote better awareness of the green sea turtle's endangered status and the identified solutions to its recovery.

A. Educate users of the Bay.

1. Inform commercial and recreational fisheries operating out of the Bay about the need to protect turtles from incidental mortality and harassment. (#1)

B. Encourage sustained and effective international cooperative efforts to protect the green sea turtle. (#1)

4.3.6.2 California Least Tern Specific Concerns

Photo © Mark Pavelka @ US FWS.

Photo 4-13. California Least Tern.

- California least tern populations are not self-sustaining without intensive management, and probably never will be.
- There is a strong relationship between endangered species success and predator management. While there are differences among sites, predator management has at times been inconsistent from site to site, with the variation primarily related to different contracting agencies, their mandates and responsibilities, and individual biologist experience or opinion.
- Land managers practicing successful predator management have supported progressively more of the populations of sensitive species and are then held to more restrictive use due to the success of their programs. Good management should not be punitive.
- Natural predator avoidance tactics used by the California least terns are no longer successful in smaller colonies. The species' inherent strategy for predator avoidance is based on their habit of nesting in large, conspicuous colonies, grouped closely together. They occasionally rise into the air as a clamorous unit, to frighten and sometimes mob would-be predators. In many cases, the tern now nests in such low numbers that this self-protection tactic is no longer successful.
- The California least tern's need to nest on the ground in small colonies in what is now an urbanized setting, with no protective buffer between the colony and surrounding areas, leaves it vulnerable to intense predation at unnatural levels. A single feral cat or skunk can wipe out a colony in a night, forcing abandonment of that colony. Avian predators such as kestrels, ravens, crows, gulls, burrowing owls, shrikes, northern harriers,

and peregrine falcons can cause severe losses to breeding adults, young birds, and eggs in a single episode.

- Implementation of predator management field methods requires expertise and can be very species- and site-specific. Some of the most common predators are common species such as ravens or feral cats, while other severe losses have been caused by species, which themselves have a sensitive status: the peregrine falcon, gull-billed tern, northern harrier, shrike, and burrowing owl. Agency mandates and responsibilities also affect the approach taken.
- Predation of the least tern by other endangered species is cause for live capture and relocation. Project Wildlife has borne the burden of care for peregrine falcons. This service is expensive.
- Severe losses of least tern and snowy plover nests have occurred due to delayed response to predator activity. This delay may be a result of inexperience or a requirement to document whether a predator present in the vicinity of a nesting colony is actually taking young.
- Disagreement among those with responsibility to prevent take of least terns and snowy plovers by predators is pervasive with respect to both when action should be taken and methods used.
- The loss of good roosting platforms for terns in the mooring areas of Shelter Island and the City of San Diego may have impacted tern foraging. The proximity of roosting to foraging areas is important for saving the tern's energy between feeding bouts, thus allowing them to bring more energy to chicks. (Baird 1997)
- Human disturbance affects reproductive success.
- Abundant vegetation can cause unsuitable nesting sites.
- Dock and pier shading may influence the ability of terns to forage.

Current Management

In 1984 NAB Coronado, recognizing that a portion of their property known as Delta Beach had been utilized as a nesting area by California least terns and to mitigate for impacts on the California least terns due to construction of the LAMPS MK III project at NASNI, designated Delta Beach as a California Least Tern Preserve. Under specifications of the MOU, the Navy intensified management of tern colonies at NASNI, NTC, and NAB by conducting predator management and extensive biological monitoring. In an attempt to alleviate or at least minimize predator- and human-related problems, the preserve is fenced. A permanent position is funded for predator management through USDA Animal and Plant Health Inspection Service/Wildlife Services. The predator control program is required to identify mammalian and avian predators and develop methods to trap, eliminate, or relocate predators. The Navy's least tern management program on the preserve is aggressive and consistently funded, with the result that NAB shoulders a growing share of the responsibility for the least tern's reproductive success. Fencing of Delta Beach North and Delta Beach South is key to this success.

Predation and human disturbance can both cause shifts of terns among nearby colonies and thereby result in poor reproductive success. Off-road vehicle harassment at the Sweetwater site led to abandonment of that site in 1980, at which time terns began opportunistically using the newly created CVWR. Predation pressures at Chula Vista

are believed to be the cause of abandonment of that site in 1985. At this point, Sweetwater experienced a return population, only to later be abandoned due to heavy predation by peregrine falcons and northern harriers (US Fish and Wildlife Service 1995).

Evaluation of Current Management

The lack of consistency and predictability of labor needed for predator management from year to year has made it difficult to keep experienced workers on hand for maximum effectiveness at tackling a challenging task. The MOU between the Navy and USFWS has been a help in providing funding consistency up front, rather than depending on project-by-project funding. In exchange for enhanced and proactive predator management, the Navy received some flexibility in timing of in-water construction that could affect the success of least tern foraging. USDA-Wildlife Services is currently negotiating with USFWS-Refuges to provide a full-time, year-round position to manage predators on refuge property. This should allow Wildlife Services to keep more experienced personnel available, as well as provide for effective management by providing adequate lead and follow-up to tern season.

Some biologists have held back on capture or removal of species predating on nests of California least tern or western snowy plover due to concerns about biodiversity. Predators are confined to the same small areas as the prey and the prey have lost most of their natural defenses, such as large numbers and occupying large areas. The predators play a disproportionately effective role. Most aspects of the environment are already managed, and it is better to preserve a remnant system by intervening with respect to a balance between predator and prey that can no longer occur "naturally."

Proposed Management Strategy—California Least Tern

Objective: Manage predators of the California least tern to maximize colony success as measured by fledgling productivity and pair numbers.

I. Improve effectiveness and consistency in predator management by implementing a more comprehensive, Baywide approach.

- ***A.*** Support an agreement between the Port and USFWS-Ecological Services for predator management at least tern colonies under the jurisdiction of the Port, modeled after the Navy-Ecological Services MOU for least tern management and in-water construction activity.
- ***B.*** Advocate the expansion of this type of agreement to Mission Bay and other nesting sites.

II. Develop a set of recommended guidelines for an acceptable level of predator management effort for all colonies on the Bay.

- ***A.*** The start date for predator work should be a month before anticipated nesting, around February 1 for the snowy plover, and around March 1 for the least tern. Effort should continue until all nests are fledged.
- ***B.*** Incorporate appropriate protocols for predator management conducted by Refuges, USDA-Wildlife Services, or other agencies in a region-wide environmental impact assessment statement.
  1. Develop protocols for the most common species, the ones for which a tern or plover loss is unacceptable under any circumstance.

III. Conduct monitoring and research in support of the management objective.

A. Establish a Baywide, consistent approach to monitoring nesting attempts and hatching success to determine the success of predator management activities.

B. Expand the use of means to limit predator-prey interaction, such as by fencing.

4.3.6.3 Light-footed Clapper Rail

Specific Concerns

- Severe depletion and fragmentation of salt marsh habitat, especially cordgrass as nesting habitat, has affected the light-footed clapper rail's ability to survive.
- The lack of high tide refugia in the high marsh or uplands may limit the rail's use of some areas.
- The rail is threatened by predation, especially from adjacent urban areas.
- Cordgrass may be decimated by major floods and El Niño sea storms.
- Constructed marshes have had difficulty growing cordgrass to sufficient height in a timely manner so it is suitable for the rail's use. Nitrogen deficiency has been problematic.

Current Management

The light-footed clapper rail is a federal and state endangered species that is a permanent resident of the salt marsh. At constructed marshes at the Sweetwater Refuge, cordgrass planting was targeted towards support of the clapper rail, but nitrogen deficiency apparently stunted its growth and it took many years to meet mitigation criteria.

Evaluation of Current Management

Salt marsh habitat with potential to grow cordgrass is limited and fragmented in the Bay. It is vulnerable to El Niño and other storms that can cause it to die off.

Proposed Management Strategy—Light-footed Clapper Rail

Objective: Protect the listed light-footed clapper rail population inhabiting San Diego Bay and seek to contribute to its recovery.

I. Protect nesting, foraging, and high-tide refuge areas.

A. Protect cordgrass sites likely to be affected by erosion.

II. Enhance areas with potential for growing cordgrass.

III. Conduct research and monitoring in support of the management objective.

A. Investigate means to improve cordgrass restoration techniques.

4.3.6.4 Western Snowy Plover

Specific Concerns

- The western snowy plover's preference for nesting on sandy beaches has led to its decline as a nesting bird along the coast.
- Foraging areas have been restricted by development, but also by the presence of human recreational activities in foraging areas.
- Increases in salt marsh vegetation may make areas less attractive for plovers because it could act as a barrier preventing chicks from foraging successfully and escaping incoming tides (Copper 1997c).
- Predation of plover young by birds and mammals is the primary cause of reproductive failure.
- Nests and chicks are hard to detect and can be damaged (Copper 1997c).
- Nonnative iceplant does not support plover nesting (Copper 1997c) and may out-compete preferred plants of adjacent dunes such as *Camissonia* sp.
- Plovers can be impacted negatively by sympatric and colonial nesting colonies of the least tern (e.g. ocean beaches of NAB, Coronado).

Current Management

Because western snowy plover nesting nearly completely overlaps that of the California least tern, it has benefitted by default from intensive management in these locations. Its federal threatened status appears to not have resulted in much direct management intervention, since projects are uncommon in its primary foraging locations. However, critical habitat was ordered by the U.S. District Court on December 1, 1999, and this will affect management of the beaches in San Diego Bay.

Evaluation of Current Management

Issues of predator management for the western snowy plover overlap those of the California least tern. Control of the common raven is an example of the results of an inconsistent predator management approach to the plover. Ravens have adapted well to human development and occur in disproportionately large numbers on tern/plover sites. There are few if any sites that support tern or plover nesting without some form of predator management. In 1998, at NAB, there was an effort to prevent plover nest loss through aggressive control of ravens, and as a consequence there were no plover nests lost to ravens either at NAB or at adjacent Silver Strand State Beach. NAB supported 34 plover nests in 1998. D Street, on the other hand, which had supported up to ten plover nests in past years had only two nests in 1998, one of which was depredated by ravens. Predator management at that site was delayed until April, while plovers typically begin nesting in late March. At Tijuana there were approximately twelve nests and some were lost to ravens until control was initiated. Past efforts to use aversive techniques failed at NAB and may have enhanced raven predation on plover nests. Aggressive management of ravens at all plover sites should increase success rates and nest numbers comparable to those at NAB (E. Copper, pers. comm.).

The preference by western snowy plover for the high intertidal mudflat is not understood, so may not necessarily be protected with respect to project impacts. The same is true for its use of adjacent uplands for nesting, such as remnant dunes containing *Camissonia* sp.

Proposed Management Strategy—Western Snowy Plover

Objective: Protect the listed western snowy plover population inhabiting San Diego Bay and seek to contribute to its recovery.

I. Protect nesting and foraging areas.

- ***A.*** Support consistent and effective predator management at nest sites (see also Section 4.3.6.2 "California Least Tern").
- ***B.*** Protect unvegetated areas or remnant dune sites above the high tide line which are potential nesting sites.
- ***C.*** Human use should be reduced during nesting season, particularly in the upper dunes, dog leashing enforced, and signs posted.
- ***D.*** Prohibit beach raking which can affect invertebrate populations upon which the plover depends.
- ***E.*** Clean up trash which attracts predators.

II. Enhance remnant dune areas as potential nest sites in areas that can be protected from human disturbance and predators during nesting season.

- ***A.*** Remove exotic iceplant and other nonnatives from remnant dunes.
- ***B.*** Support broader beaches with gentler slopes to support plover nesting.

III. Conduct research and monitoring in support of the management objective.

- ***A.*** Study the plover's preference for higher mudflat, so that function may be protected or enhanced.

4.3.6.5 Salt Marsh Bird's Beak

■ See also Section 2.6.1.7 "Salt Marsh Bird's Beak."

Specific Concerns

- There is a severe loss of salt marsh habitat in San Diego Bay, and little means to get it back that are not excessively expensive.
- Remaining populations are isolated and subject to sudden decline due to drought.
- There is a lack of linkage between the salt marsh and upland habitat for pollinators.
- There is uncertain long-term persistence of salt marsh bird's beak populations that have been planted for mitigation projects (Zedler 1996c).

Current Management

Salt marsh bird's beak is a federal and state endangered species. It also is listed as category IB by the CNPS, which makes it mandatory for full consideration in environmental documents related to CEQA. Salt marsh bird's beak occurs within the salt marsh and is also regulated by legislation applying to wetlands (see Section 4.2.3

"Protected Sites"). The USFWS adopted a recovery plan for salt marsh bird's beak in 1984, calling for the establishment and persistence of 12 populations prior to downlisting the species to a threatened status (US Fish and Wildlife Service 1984).

In San Diego County, only the Naval Radio Receiving Facility and Tijuana Estuary support a natural population of salt marsh bird's beak. Management of this plant has involved vegetation monitoring since 1979. Salt marsh bird's beak had not been observed at Sweetwater Marsh since 1987 and was reestablished there in 1990 to fulfill a CalTRANS mitigation requirement. Monitoring of these plants has indicated that although seed set was almost as high as the natural population for some colonies, for others it was very poor. Concern over the ability of the Sweetwater marsh population to become self-sustaining encouraged CalTRANS to fund a study on factors affecting reproductive potential of salt marsh bird's beak. This research project has resulted in valuable information on the ecology of salt marsh bird's beak and implications for its management. The reestablishment of salt marsh bird's beak at Sweetwater Marsh has been successful according to the mitigation criteria, with an estimated 14,000 plants in 1994. Mitigation requirements were for a three-year period with at least 100 plants (Zedler 1996c). The success of the population in terms of long-term stability are still not certain. There seems to be a lot of variation in population size from year to year and on longer time scales, due to factors such as extreme events.

Evaluation of Current Management

■ See Sections 4.2.2 "Mitigation and Enhancement" and 4.2.1.6 "Salt Marsh" for more detailed discussion of this species in context of habitat management.

See Section 4.2.2 "Mitigation and Enhancement" and Section 4.2.1.6 "Salt Marsh" for more detailed discussion of this species in the context of habitat management. Mitigation requirements for salt marsh bird's beak usually require its presence for approximately three years. Although attainment of this criteria may indicate a healthy, self-sustaining population, we cannot be sure, due to the lack of data, what population size is needed for long-term persistence (Zedler 1996c).

The reestablishment of salt marsh bird's beak has occurred mostly on high marsh remnants (Zedler 1996c). The success of reestablishment on dredge material is uncertain, but will likely not be as successful (Zedler 1996c).

Proposed Management Strategy—Salt Marsh Bird's Beak

Objective: Seek the recovery of the salt marsh bird's beak population through habitat protection and enhancement.

I. Improve knowledge of the species requirements.

- ***A.*** Determine the population size needed for long-term persistence of salt marsh bird's beak (Zedler 1996c).

II. Promote adaptive practices to attain success in restoring population.

- ***A.*** Employ techniques to establish a self-sustaining, functional population.
  1. Due to its narrow regeneration niche, very specific habitat requirements for salt marsh bird's beak must be used for successful establishment (Zedler 1993).
  2. Ensure pollination by providing adjacent uplands that include alternate hosts for salt marsh bird's beak's bee pollinator (Zedler 1993).

3. If necessary, restore natural processes that supply nutrients to the high marsh (Zedler 1996c).
4. Sustain the natural salinity regime (Zedler 1996c).
5. Allow natural disturbances that create small-scale open patches in the high salt marsh canopy (Zedler 1996c).
6. Have well separated sites available for growing salt marsh bird's beak so disturbances that might wipe out one colony would not occur throughout the transplanting location (Zedler 1996c).
7. Mitigation performance standards should not only be based on the size of each colony, but should also include an estimate of seed production (Zedler 1996c).
8. Colonies at the Tijuana Estuary should be used as a reference to determine if success is attained. (e.g. success = when the numbers of plants produced are at least 90% of the mean colony size at Tijuana Estuary and the numbers of seed capsules produced are statistically indistinguishable from those at Tijuana Estuary) (Zedler 1996c).

B. Implement a regional restoration plan for the species (see Sections 4.2.2 "Mitigation and Enhancement" and 4.2.1.6 "Salt Marsh").

C. Monitor the quality and quantity of plant sites and reevaluate practices as needed.

4.4 Ecosystem Approach

Specific Concerns

- While routine management of the Bay is on a project scale, and this Plan attempts to view the Bay as its own ecosystem, some important resources or resource dependencies may fall through the cracks of management if not considered at different scales and time frames (see, for example, Regan *et al.* 1995).
- Cumulative effects assessment has not been accomplished effectively with the project-by-project approach to management.
- Concern for biodiversity argues that different biological communities be well dispersed throughout the Bay in something approaching their natural dispersion and proportions, rather than concentrated in one subregion or another (see, for example, The Keystone Center 1991).
- The complexity of the Bay as an ecosystem and the difficulty of dealing with this complexity argues for the use of management indicator species to provide a focus for decision-making.

Current Management

Current management of natural resources in San Diego Bay is project- or species-based. Research and monitoring effort is also generally driven by project impact CEQA assessment under the CWA, ESA, and NEPA. Assessment from a broader, landscape or ecosystem perspective, in which interdependencies among habitats and populations are examined, is generally not done.

Evaluation of Current Management

The premise of this Plan is that management on a project-by-project basis is inadequate to protect Bay resources, fundamentally because the scale and time frame associated with projects is unlikely to be adequate to consider all the resources and interdependencies that may be affected. At the same time, viewing issues on a Baywide, ecosystem level may allow some important management issues to fall through the cracks.

Resource managers, both terrestrial and marine, have come around to a hierarchical approach to ecosystem and biodiversity management as a framework for analyzing the spatial and temporal complexity of landscape pattern, dispersal biology, and the functional interrelationships among habitats, populations, and their physical environment (Norton and Ulanowicz 1992; Turner *et al.* 1993; Urban *et al.* 1987, cited in Regan *et al.* 1995; NRC 1994, 1995; NMFS 1995, cited in Ruckelshaus and Hays 1998). Guidance criteria for selection of spatial scales are biologically based. San Diego Bay naturally breaks out into certain regions, and these natural breaks should be considered as one level of analysis that should be undertaken.

Resource managers need a focus for management decisions that are ecologically based and can provide insight into environmental conditions and the impacts of management decisions. Indicator species are used for this purpose. Selection criteria for an indicator species vary depending on the objective, but typically species selected as management indicators are (1) high-profile species that people want to keep track of closely (e.g. federally listed species), (2) species representing important habitat types and that are believed to be functionally equivalent to many other species with similar habitat/ecological needs, or (3) flagship or umbrella species that range widely (i.e. wolf, grizzly bear, tiger) and managers assume that managing for their broad habitat and area needs will also provide for all other species in those habitats. Marine scientists and managers have also arrived at the indicator species concept (Ruckelshaus and Hays 1998).

There has been criticism in the scientific literature about the use of indicators, mostly because some scientists are skeptical that there are two species—let alone multiple ones—which are so ecologically similar that they can be monitored and managed as one. This is a central assumption in the use of indicator species. To respond to some of this uncertainty in the scientific community and also continue to recognize indicators as a necessary management tool (since it is impossible to track all plants and animals in a planning area), the US Forest Service has recently developed some draft criteria for selecting indicator species that could help focus further discussions on the topic with respect to San Diego Bay. They are as follows:

- Biological information in the scientific literature supports use of the species as an indicator;
- Species is sensitive to management activities in the local or regional vicinity;
- Species is considered a keystone species or habitat specialist;
- Species is a year-long resident of the vicinity (nonmigratory), or population trends of the species in the local or regional vicinity are closely tied to habitat conditions resulting from resource use locally;
- Species is indigenous or endemic;
- Species is found in similar habitats across most or all of the planning area;
- Species is appropriate for the primary ecological scale of interest (planning or geographic area);

- It is biologically and economically feasible to monitor populations and habitat at similar spatial scale;
- Populations are sufficient size or density to be reasonably detected and monitored;
- Population trend information is already available or being collected.

Some final considerations in planning whether and how to use indicators is to formally recognize the scientific debate during the planning process and in the planning documents, state clearly the logic and assumptions in selecting any indicator species, recognize the use of indicators as one of several planning tools at different scales, and recognize that using indicators will likely entail long-term commitment of resources/funding by someone to monitor them over time.

Proposed Management Strategy—Ecosystem Approach

Objective: Seek to protect Bay natural resources and their function by planning at biologically meaningful, hierarchical scales and time frames.

I. Establish management objectives based on four hydrodynamic-based subregions of the Bay as described by Largier (1996, 1997).

1. North Bay, the **Marine Region.** Circulation in the marine region is dominated by tidal exchange with the ocean. In San Diego Bay, this area of efficient flushing is within perhaps 3 to 4 mi (5 to 6 km) of the entrance, reaching almost to downtown. Residence time of Bay water is just a few days. The net result of these circulation patterns in the Bay is the presence of cold, clean ocean water at depth, explaining the mussel watch result that the mussels at the mouth of the Bay are the cleanest in the county (Largier 1996, 1997).
2. North-Central Bay, **Thermal Region.** In the thermal region, still in north Bay but extending to approximately Glorietta Bay, currents are driven primarily by surface heating. The vertical exchange of water results from entry of a cold, oceanic plug at depth with the flood tide, then the receding of warm, Bay surface water with the ebb tide.
3. South-Central Bay, **Seasonally Hypersaline Region.** Between about Glorietta Bay and Sweetwater Marsh is a seasonally hypersaline (saltier than sea water) region. Water is stratified by salinity gradients induced by evaporation.
4. South Bay, **Estuarine Region.** South of the Sweetwater Marsh is an estuarine region where occasional inputs of freshwater discharge from the mouth of the Otay and Sweetwater Rivers. Residence time of Bay water may exceed a month in this region.

A. Define the historical context of each region, as shown in Table 4-9.

B. Describe the existing fish and wildlife values of each region. Consider the following:

1. Marine Region. Abundance of schooling fish, a young-of-year topsmelt and surfperch nursery; use of intertidal primarily as high tide refugia rather than foraging.
2. Thermal Region. Large areas of former mudflat are missing. Young-of-year topsmelt and surfperch nursery.

Table 4-9. Historic and Current Habitat Acreages in Four Bay Regions.

Habitat[1]		North Bay	North-Central	South-Central	South Bay	Totals
Old Habitat 1859	Intertidal	1,996	1,009	1,074	2,068	6,147
	Shallow	1,255	845	2,690	1,609	6,399
	Moderate Deep	218	209	424	104	955
	Deep	884	760	498	69	2,211
	Totals	4,353	2,823	4,686	3,850	15,712
Current Habitat	Intertidal	138	51	55	733	977
	Shallow	510	184	1,267	1,772	3,733
	Moderate Deep	483	323	1,214	199	2,219
	Deep	2,027	1,187	1,134	93	4,441
	Totals	3,158	1,745	3,670	2,797	11,370
Percent Loss/Gain(–/+)	Intertidal	–93%	–95%	–95%	–65%	–84%
	Shallow	–59%	–78%	–53%	+10%	–42%
	Moderate Deep	+122%	+55%	+186%	+91%	+132%
	Deep	+129%	+56%	+128%	+35%	+101%
	Totals	–28%	–38%	–22%	–27%	–28%

1. Intertidal excluding Salt Marsh (+2 to –2.2 ft in Map C-1, high tide line to –3 ft on 1859 coverage); Shallow Subtidal (–2.2 to –12 ft); Moderately Deep Subtidal (–12 to –20 ft); Deep Subtidal (>–20 ft)

3. Hypersaline Region. Abundant slough anchovy, topsmelt, spotted sand bass.
4. Estuarine Region. Abundance of shorebirds and waterbirds, nesting sea birds. Abundant slough anchovy, Pacific mackerel (seasonally), striped mullet, gobies.

II. Select indicator species for focusing Bay management.

A. Consider the following as potential indicator species:

1. California halibut, a commercial species that uses the Bay as a nursery; uses unvegetated shallow, with many young-of-year found in intertidal flats.
2. Light-footed clapper rail for the lower marsh.
3. Young-of-year topsmelt, a resident species distributed throughout the Bay.
4. Black brant for its close association with eelgrass.
5. Giant kelpfish or pipefish for their close ties to eelgrass and resident status.
6. Western snowy plover, for its use of high mudflat and upland transition.
7. California killifish, California halfbeak, or other fish that at some life stage requires movement between shallow and intertidal habitats.

III. Require that cumulative effects analyses be conducted on both Baywide and subregional scales, with consideration of the agreed-upon objectives and indicator species for each subregion.

IV. Conduct research and monitoring in support of the management strategy.

V. Adjust the selection of scales, objectives, and indicator species based on adaptive management principles.