CHAPTER NINE

Macroalgal Beds

BEDS OF MACROALGAE CONSTITUTE the third biogenic habitat along with submerged aquatic vegetation and shellfish beds in San Francisco Bay and are by far the smallest in total extent. Four species of macroalgae were listed by NOAA (Schaeffer et al. 2007) as sufficiently abundant to form beds: *Ulva* spp., *Gracilaria pacifica*, *Fucus gardneri*, and the introduced *Sargassum muticum*. The extent and characteristics of algal beds in San Francisco Estuary are poorly known. Together, Silva (1979) and Josselyn and West (1985) reported 162 species of macroalgae in San Francisco Bay of which 33 were estuarine and the remainder characteristic of the California coast. Five species have been reported as introduced in the bay. No quantitative analysis of the extent of subtidal beds has been conducted, although a subtidal *Laminaria* (kelp) bed has been identified off Raccoon Strait. Efforts have been made to eradicate the North Atlantic brown alga *Ascophyllum nodosum* from the bay (Miller et al. 2004). A seasonal survey of macroalgal abundance and species composition within eelgrass beds is underway (see Appendix 8-1).

Brown "feather boa" kelp, *Egregia menziesii,* occurs in the more marine regions of the Central Bay.

Like eelgrass beds, macroalgal beds provide both physical habitat and food for numerous organisms (Figures 9-1, 9-2). Also like eelgrass beds, subtidal macroalgal beds can alter flow fields, providing small organisms with shelter from currents and predators, and can trap sediments, alter sediment chemistry, and provide a substrate for spawning. The red algae, *Gracilaria/Gracilariopsis* spp., are important substrate for herring roe in the bay (Ryan Watanabe, CDFG, pers. comm.). Intertidal macroalgae can retain water, providing a refuge for intertidal organisms like juvenile Dungeness crabs during low tides.

Although algal beds constitute biogenic habitats, it is not clear whether they are always a desirable habitat. Beds of some macroalgae, including *Ulva* spp. and *Gracilaria pacifica,* can form nuisance blooms in response to high nutrient concentrations, and may overgrow eelgrass and interfere with their photosynthesis. However, to date there is little evidence of the formation of nuisance blooms in the bay, although Nichols (1979) did report decaying mats of algae in the South Bay in the summer of 1975.

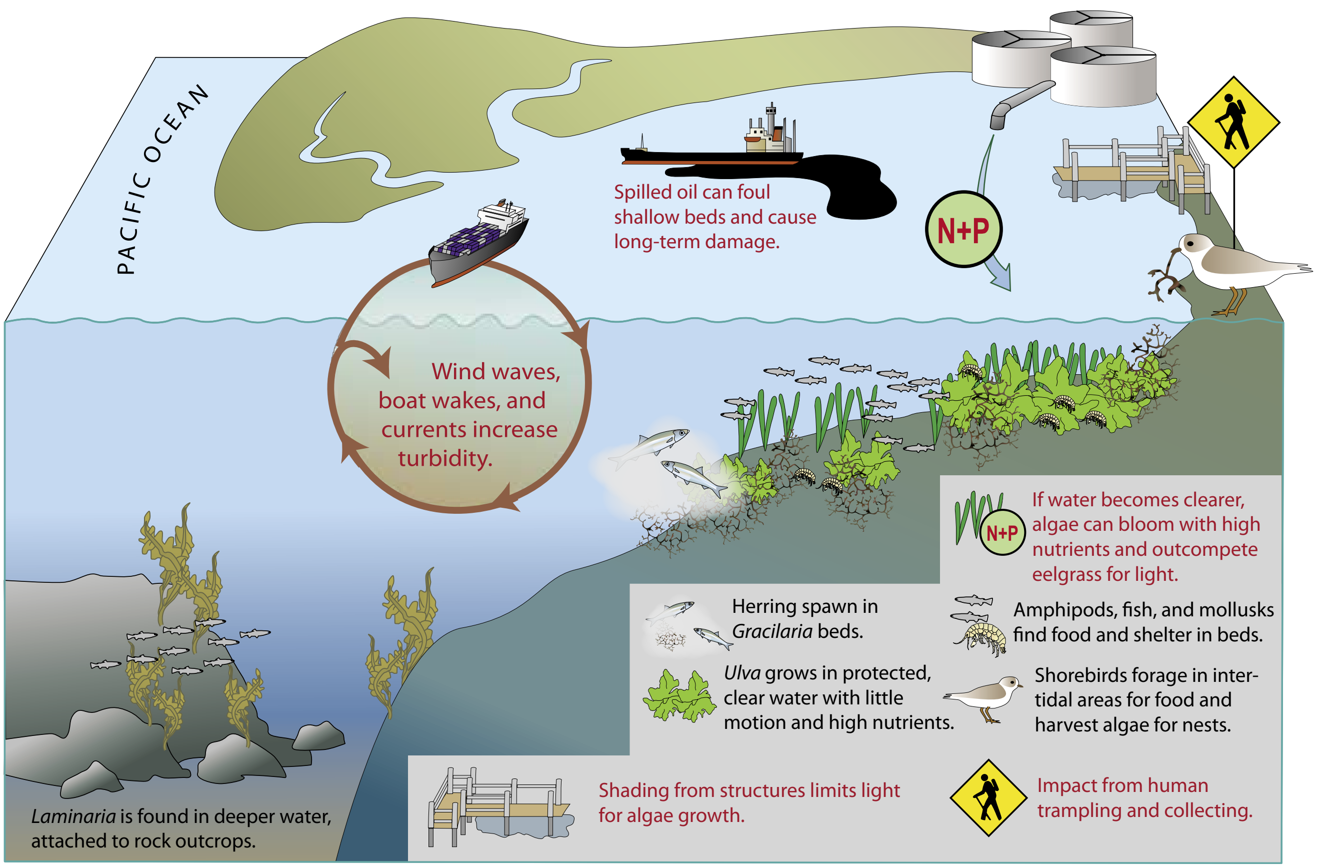

Figure 9-1: Conceptual diagram for algal beds in the San Francisco Estuary. This diagram displays processes that occur in and on algal beds, some of the ecosystem services these habitats provide, and threats to algal beds.

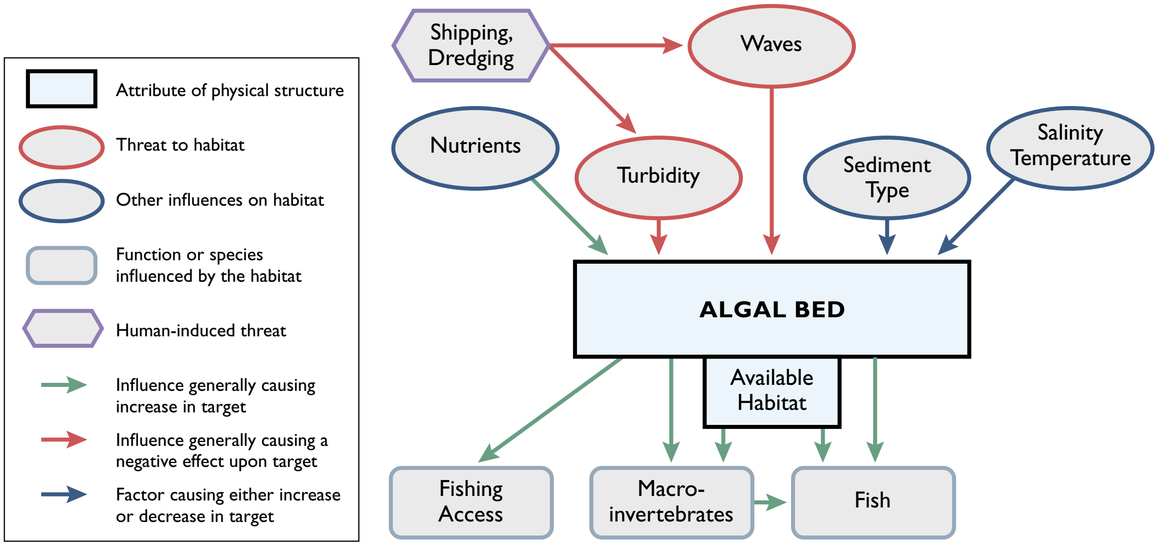

Figure 9-2: Influences on macroalgal beds and functions and services provided by algal beds. The elements in this diagram are site- and species-specific, and all do not apply at all sites.

Conceptual Model for Macroalgal Beds

In contrast to eelgrass, many macroalgae provide a suitable food source to a variety of grazers, predominantly macroinvertebrates. At least one amphipod species, *Amphithoe valida*, readily consumes *Gracilaria* sp. (K. Boyer, SFSU, 2009 and 2010, pers. comm.). Gulls and cormorants will pick macroalgae from the intertidal beach wrack to line their nests. The wrack produced by macroalgae is an important food source for invertebrates living interstitially on beaches, mudflats, and marshes. These invertebrates in turn provide a food source for shorebirds and many other species along the shore. In contrast to tropical regions where many herbivorous fish species feed on macroalgae, a relatively small number of fish species in temperate regions use macroalgae as a substantial part of the diet. The topsmelt, *Atherinops affinis*, common in San Francisco Bay, can feed on macroalgae (Logothetis et al. 2001). There is no published information on the importance of algal beds in support of populations of consumer organisms in the bay.

Many common seaweeds can be found in San Francisco Bay, including sea lettuce (*Ulva* spp.), rockweed (*Fucus gardneri*), and Turkish towel (*Gigartina papillata*).

Estuarine species of macroalgae differ greatly in morphology, biochemistry, and habitat requirements. Some species of macroalgae are abundant in rocky high-energy sites with strong currents and breaking waves. Others are more abundant in protected waters, where they can form beds on soft substrate (Josselyn and West 1985). Some macroalgae can have very high nutrient uptake rates that do not saturate (Kamer et al. 2004) and can therefore take advantage of the usually high nutrient concentrations in San Francisco Bay (Cloern 1999, but see Dugdale et al. 2007). The high turbidity of the bay may inhibit algal bloom formation as it does for phytoplankton and eelgrass, except in intertidal areas. In addition, low-salinity pulses likely reduce the viability of algal beds within the estuary, particularly outside of the Central Bay, but stress on macroalgae from high and low temperatures is unlikely except in sunny intertidal

Feather boa kelp on the shores of Angel Island.

locations. The distributions and local abundances of macroalgae likely vary as these influences vary.

The greatest concern over algal beds seems to be their propensity to respond to eutrophication by overgrowth and expansion, i.e., forming nuisance blooms (Valiela et al. 1997). Large blooms of macroalgae have a negative impact on eelgrass in Tomales Bay (Huntington and Boyer 2008). However, surveys of macroalgae on eelgrass beds in San Francisco Bay revealed only occasional instances where the macroalgae were likely to impede growth of the eelgrass (see Appendix 8-1). There have been few reports of nuisance blooms in the bay. This could change if turbidity of the water decreases further (Schoellhamer 2009). In addition to eutrophication, intertidal algal beds are vulnerable to other human disturbances such as trampling and recreational harvesting, as well as oil spills and the use of dispersants during cleanup (Foster et al. 1998).

Rationale for Establishing Goals for Macroalgal Beds

Applying the decision tree in Chapter 2 (Figure 2-1) to macroalgae, it is not clear that additional macroalgal beds would be beneficial, nor is it clear that macroalgal beds are in short supply. It is difficult to distinguish algal beds that support ecosystem services from those that interfere with these services. Since we do not know enough to make a definitive statement, the decision tree leads us to the need for more research as the most suitable outcome. Applying the precautionary approach adopted for this project, existing beds should be protected while research to improve our knowledge is conducted.

Goals for macroalgal bed habitat focus on conducting research, protecting existing non-nuisance beds, enhancing the beds by removing invasive species and debris, and improving our understanding of ecosystem services, bed dynamics, and nuisance versus non-nuisance beds.

Science Goals for Macroalgal Beds

MACROALGAL BEDS SCIENCE GOAL 1

Understand the roles of macroalgal beds of different species in providing ecosystem services or interfering with services provided by other habitats.

Question A. What is the current extent of macroalgal beds by species?

A survey to determine the extent of the macroalgal beds is needed to allow for an understanding of their roles, species composition, including introductions of new species, impacts on the estuarine ecosystem, and vulnerabilities, for example, to oil spills.

Question B. What ecosystem services do macroalgal beds support, and in what quantities?

If the extent of algal beds is very small, the magnitude of any services is also likely to be small. However, initial estimates of the area of beds (Question A) combined with rough estimates of the magnitude of functions, such as spawning habitat for herring, would provide a context for assessing the overall role of algal beds.

Question C. To what extent, and in what densities of which species, do algal beds or growths interfere with other habitats or form nuisance blooms?

Algae may overgrow eelgrass or oyster beds and potentially other habitats. This may result in reduced growth and possibly the survival of eelgrass and oysters.

MACROALGAL BEDS SCIENCE GOAL 2

Understand changes in the extent or condition of macroalgae.

Question A. How do the beds change with changing conditions?

It would be useful to understand any trends toward a larger or smaller extent of algal beds, and particularly the reasons for these trends.

Sea lettuce on the subtidal shores of East Marin Island.

Protection Goals for Macroalgal Beds

MACROALGAL BEDS PROTECTION GOAL 1

Protect San Francisco Bay *Fucus* beds through no net loss to existing beds.

(See Rock Habitats Protection Objectives 1-1 and 1-2.)

MACROALGAL BEDS PROTECTION GOAL 2

Protect San Francisco Bay *Gracilaria* beds through no net loss to existing beds.

(See Rock Habitats Protection Objectives 1-1 and 1-2.)

Restoration Goals for Macroalgal Beds

We do not have enough information about existing macroalgal bed distributions and threats to make specific restoration goals for this habitat type. (See experimental techniques described in Chapter 3: Cross-Habitat Invasive Species Control Objective 1-1; Cross-Habitat Oil Spills Prevention Action 1-3-5; and Chapter 10: Subtidal-Wetland Design Integration Restoration Action 3-1-2.)