Bays and estuaries: A vital link in

The bays and estuaries found along the coastline of California, teeming with fish, birds, and other wildlife, as well as a variety of plants, are truly a visual marvel and one of the state's most valuable resources.

By Eric Larson and John Mello

Bays and estuaries are described physically as partially enclosed bodies of ocean water that are protected from the full force of waves, winds, and storms by the land masses which form their outer perimeters. Bays are wide inlets or indentations of the ocean into the coastline, while estuaries are inlets which contain the terminus of a river or stream system. The defining feature of an estuary is the mixing of fresh water from upland and riverine sources with oceanic salt water. The estuary ecosystem forms a zone of transition from land to sea and from fresh to salt water. California's bays and estuaries vary widely in shape and size, and are often referred to as lagoons, harbors, inlets, esteros, and sounds. The sheltered waters of California's bays and estuaries support unique assemblages of plant and animal communities, varying by environmental conditions and location. Habitat types which form within California's bays and estuaries include shallow open waters, fresh and saltwater marshes, sandy beaches, tidal mud and sand flats, rocky shorelines, oyster-shell beds, river deltas, eelgrass meadows, and kelp beds.

California's bay and estuarine environments sustain remarkably high levels of productivity. Often referred to as the "ocean's nursery," these waters support early life stages of such important organisms as California halibut, Dungeness crab, Pacific herring, starry flounder, and numerous surfperch species. Representative organisms typifying California estuaries include birds such as rails and stilts, harbor seals, leopard sharks, and clams and oysters. These animals are linked to one another and to an assortment of specialized plants and microscopic organisms through a complex food web unique to these environments. Tens of thousands of birds, mammals, fish and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. California's bays and estuaries also provide areas for migratory birds in the Pacific Flyway to rest and forage.

Besides serving as critical habitat for wildlife, the bays and estuaries that dot California's coastline provide other important ecological and human benefits. Bay and estuarine plants and soils act as natural buffers between land and ocean, absorbing flood waters, dissipating storm surge, and filtering sediments, nutrients, and other pollutants. The state's bays and estuaries, from Humboldt Bay down through San Diego Bay, are also cultural centers of coastal communities, serving as the focal point for local commerce, recreation, and cultural activities. The protected waters of California's bays and estuaries support important public infrastructure uses, serving as harbors and ports vital for the state's shipping, maritime, and industrial related economy.

Biological Importance

From a biological perspective, no other ecological component is more important to bay and estuary ecosystems than their plant communities. Plant communities, including tidal wetlands, shallow subtidal vegetation and marine algae, provide vital functions in the overall health and productivity of bays and estuaries. When one thinks of a productive and vital marine environment, a kelp forest or a coral reef


DFG photos John Mello

Above, winter sunset on Humboldt Bay. Below left, brown sea hare.


Photo © Ken Howard

California's marine ecosystems

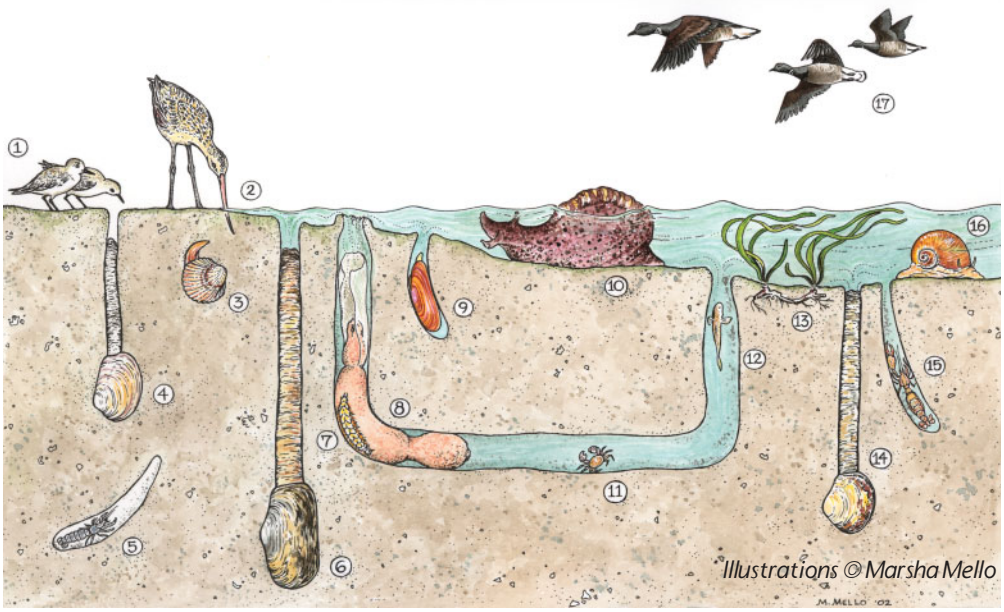
probably comes to mind. Few people are aware that the eelgrass meadows and mudflats found in California's bays and estuaries are one of the most productive marine systems found in the world and are essential to the life- cycles of several open ocean animals. Eelgrass (a flowering marine seed plant) is able to capture nutrients entering the system from the open ocean or from the freshwater rivers and streams that flow into the bays. Eelgrass is very efficient at absorbing these nutrients into its leaves and roots and is responsible for turning these nutrients into usable food available to other plants and the animals that are permanent residents or just visitors to this habitat. Eelgrass leaves create a canopy in which small plants and animals find protection from larger predators and strong tidal currents. Within this canopy, microscopic unicellular plants and animals, which are free-floating in the water column, flourish and provide food for other planktonic animals such as larval forms of clams, mussels, worms, barnacles, crabs and fish. Several marine species, important to sport and commercial fisheries, spend their larval and juvenile lives in these eelgrass meadows including lingcod, cabazon, English sole, speckled sanddab, several species of nearshore rockfish, and Dungeness crab. Pacific herring lay their eggs on eelgrass leaves when they come into Humboldt, Tomales, and San Francisco bays to spawn in late fall through early spring.

Above, a ghost shrimp. Below left, a moon snail crawls through eel grass. Below right, a large nudibranch flexes its body to swim between eelgrass shoots.

Many interesting animals are unique to the eelgrass meadows and are dependent on this habitat. One of the most abundant fishes found in eelgrass is the bay pipefish. This long and slender fish, a close relative to the sea horse, will mimic the movements of eelgrass to hide from predators. Male pipefish are equipped with a brood pouch in which females will lay their eggs. After a short incubation period, it is the male pipefish that appears to give birth. Many animals associated with eelgrass use protective coloration to escape predators and are beautiful shades of "eelgrass green." The isopod crustacean, *Idotea resecata*, and the Taylor's sea hare are both a brilliant green and live their lives almost entirely on the flat blades of eelgrass. The grass shrimp, also a brilliant green, hides on eelgrass during the day and swims in the eelgrass beds at night.

Take a visit to one or more of California's bays and estuaries to view the eelgrass meadows and neighboring mudflats. On a good low tide, one can see some of the ordinary creatures that live on the leaves of the marine plants or directly on the mudflats and in the thick rich mud. One might see the large gastropods *Aplysia* or *Navanax* as they cruise the surface for food or mates. Aplysia (sometimes called the California brown sea hare) can grow to over 15 inches in its short one-year lifespan and is often colored red, brown, or green with a network of dark lines radiating from scattered round spots along the length of its body. This husky sea hare exudes a dark-purple ink when irritated and shows a clear avoidance reaction to predatory sea stars. *Navanax*, a brilliantly colored predatory sea slug, can be found on mudflats from Monterey through Southern California. This voracious sea slug, which grows to about five inches, is known for following the mucus trails of smaller gastropods and swallowing them whole, including their shells. Its light yellow egg masses are often seen deposited on eelgrass leaves.

During a low tide one will also see thousands of holes covering the mudflats. These are created by the mud-dwelling invertebrates that represent an important link in the bay and estuary food web. Most of these creatures are filter-feeders that suck in mud and seawater through their systems, selecting the most nutritious materials



1. Sanderling - 2. Marbled godwit - 3. Basket cockle - 4. Washington clam - 5. Blue mud shrimp - 6. Geoduck - 7. Scale worm - 8. Innkeeper worm - 9. Sickle razor clam - 10. Calif. brown sea hare - 11. Pea crab - 12. Arrow goby - 13. Eelgrass - 14. Gaper clam - 15. Ghost shrimp - 16. Moon snail - 17. Brandt

and taking in oxygen. Some of these animals are considered edible delicacies. Gaper, geoduck, and Washington clams are actively dug for and enjoyed by hundreds of sport clammers each year. The most common crustaceans, and the ones responsible for many of the holes on the surface of the mudflats, are the blue mud shrimp and the bay ghost shrimp. These energetic digging shrimps are popular bait for sport fishermen.

The abundant food supply found in healthy bays and estuaries is essential to the survival of numerous animals that occupy higher levels of the food chain. The brant goose, known for its long migrations along the Pacific Flyway, feeds almost entirely on eelgrass. Several other species of marine waterfowl, such as the Canada goose, surf scooter, and bufflehead, depend on eelgrass directly or indirectly as a food source. The mudflats are essential feeding grounds for several shorebird species that migrate from their breeding grounds in Alaska or Canada to over-winter in California. The marbled godwit, willet, and long-billed curlew, along with many other shorebirds, have long legs and specially adapted bills for picking worms and small crustaceans out of the mud. A wide variety of other water birds are also dependent on bays and estuaries for food and shelter depending on the time of year, including brown and white pelicans, herons, egrets, cormorants, loons, grebes, terns, and gulls.

When the tide comes in and covers the eelgrass meadows and mudflats, predatory fishes are able to start hunting for food. One of the most conspicuous fishes is the bat ray, whose wing-like fins you can see breaking the water as it digs in the mud for clams, crabs, shrimp and other invertebrates. Brown smoothhound sharks also take advantage of the abundance of fish and crustaceans. The sleek leopard shark, which can grow to over six feet, eats a wide variety of food including brown smoothhounds, fish, clams, crabs, and shrimp. Other notable fish that are found in our bays and estuaries include California halibut, green and white sturgeon, striped bass, and, perhaps the most remarkable, the sevengill shark. The sevengill shark, found in both San Francisco and Humboldt bays, grows to over eight feet and is very close to the top of the marine food web. Prey items for this shark include leopard sharks, bat rays, bony fishes, and marine mammals. One sevengill shark captured in Humboldt Bay was taken to the Monterey Aquarium for exhibit. After a three-year stay at the aquarium it was tagged and released off the coast of Monterey and, much to the surprise of most, was recaptured a few months later back in Humboldt Bay (a 300-mile journey).

Marine mammals also utilize the abundant food supply and sheltered waters of our bays and estuaries. The Pacific harbor seal is the most common marine mammal seen in our bays; this pinniped usually fishes in bay channels and "hauls out" (comes to shore) on isolated mudflats to rest, give birth or nurse pups.

California sea lions are seen to a lesser extent except in areas where manmade structures such as docks and piers are present.

A close up of h

Collaborative studies in and around Humboldt Bay for the past two years are beginning to reveal details and patterns about this unique, coastal ecosystem. A seasonal study of eelgrass distribution and abundance has measured the standing crop of eelgrass during summer and winter. Early summer is usually when the greatest amount of eelgrass is found in Humboldt Bay. Increased day length and thus light, nutrients reaching the bay from coastal upwelling, and generally warmer bay temperatures all stimulate eelgrass growth. The amount of eelgrass in Humboldt Bay during summer is approximately twice as great as during winter months. There are more plants and they are larger. During spring and summer, flowering shoots develop and release seeds. As the flowering shoots die back, stronger winds and cooler seawater temperatures associated with fall and winter storms reduce eelgrass meadows to lower numbers of plants. Strong winds blowing across the Bay tear leaves and whole shoots from the sediments. Large windrows of eelgrass leaves are piled on Bay shores and along beaches just outside the Bay. All of the work to measure eelgrass plants is done during the lowest tides of the year. These tides allow us to glimpse some of the animals living in the eelgrass, but do not fully reveal the complexity and diversity of life found in Humboldt Bay eelgrass beds.

To better understand the fauna living in and among eelgrass, a two-year project studied juvenile fish utilization of Humboldt Bay eelgrass beds. Ten eelgrass beds were sampled monthly and over 40 species of fishes

By Susan McBride

Environmental Impacts

Because of the complexity of California's bays and estuaries, these ecosystems are imperiled by their proximity to intense human activity and development. Sewage, industrial waste, dredging, filling of marshes and

Humboldt Bay

were found. Some fishes use the eelgrass beds year round while others are found there as very young fish. Fishes that use eelgrass beds in their early life include juvenile rockfishes, kelp and rock greenling, cabezon, starry flounder, and lingcod. Fishes found year round in the eelgrass beds include bay pipefish, threespine sticklebacks, staghorn sculpins, speckled sanddabs, English sole, and tubesnouts. There are many reasons fish are found in eelgrass beds, including refuge from predators and increased food availability. In addition to diverse fish populations, many species of crustaceans and mollusks live on and among the eelgrass adding to the complex web of life found in these underwater meadows.

Overall, when eelgrass is at its peak abundance, the greatest numbers of fishes and invertebrates, especially young Dungeness crabs and flatfish, abound in Humboldt Bay. While Bay temperatures and salinity are high, the young fish and crabs remain in the shallow waters of the eelgrass beds, but as winter rains lower the salinity and Bay temperatures decline, the numbers of fishes and invertebrates also decreases. The exact timing of this pattern varies from year to year, and the abundance of particular fishes shows high variation. In the two-year study, the first year of sampling found less than a dozen young lingcod and greenlings, but in the second year more than 100 were found during spring months alone. We hope to better understand these patterns and their causes as our studies of Humboldt Bay continue.

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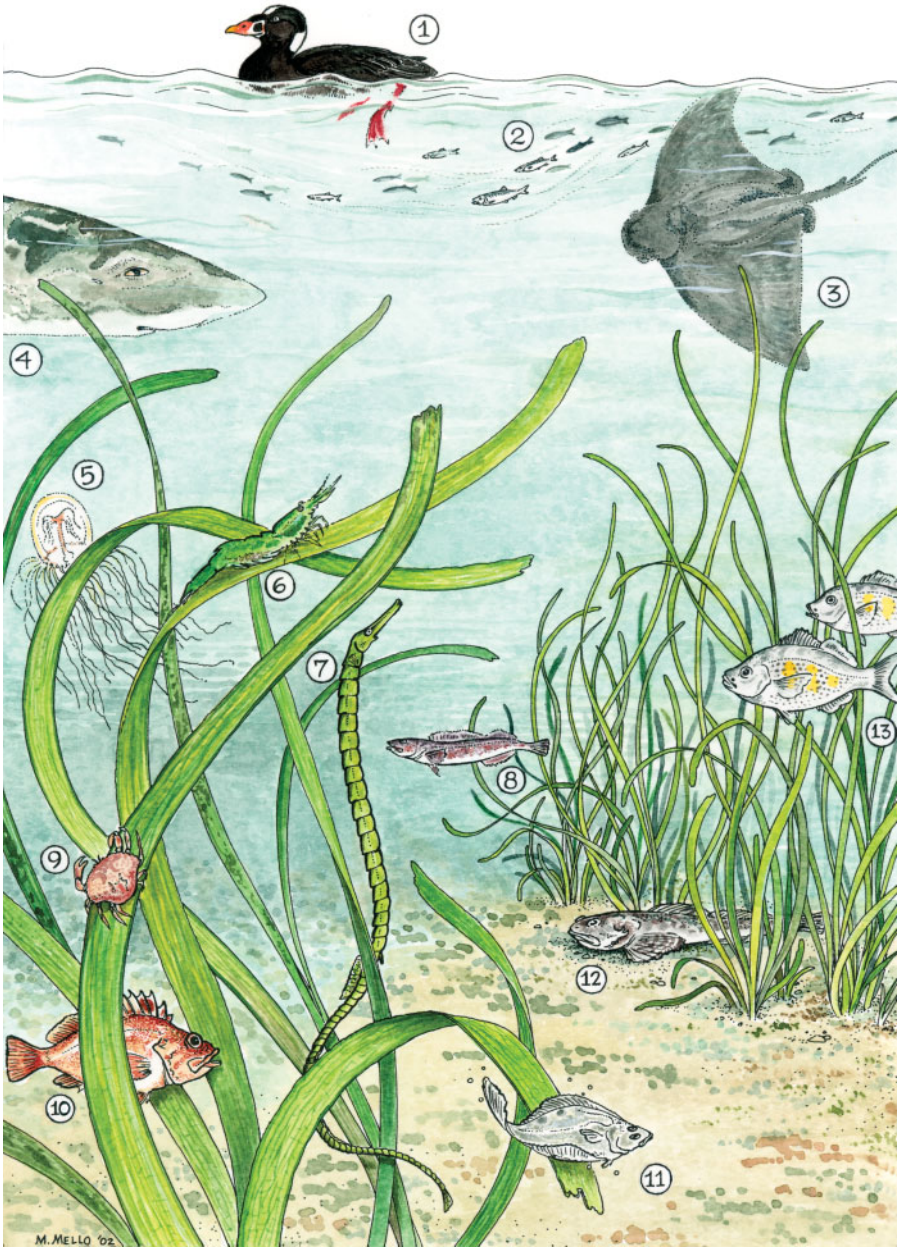

1. Surf Scoter - 2. Pacific herring - 3 .Bat ray - 4. Leopard shark - 5. Bell jelly - 6. Grass shrimp - 7. Bay pipefish - 8. Lingcod - 9. Dungeness crab - 10.Copper rockfish - 11. English sole - 12. Staghorn sculpin - 13. Shiner surfperch

tidal flats, and oil development and spills typify the long-term degradation of many of California estuaries. As a result, 40 animal and 10 plant species that occur in or depend on bay and estuarine ecosystems are listed by the federal government as threatened, endangered, or protected. In addition, environmental harm from nonindigenous, or invasive, species has increased exponentially in recent years. For example, San Francisco Bay is considered by experts to be the "the most invaded estuary in the world." Notable examples of deleterious nonindigenous species are the Chinese mitten crab, the Asian clam, and the European green crab. Such invaders are capable of wreaking extensive ecological and economic harm.

Habitat loss has also greatly affected California's bays and estuaries. The loss of tidal and subtidal wetland habitats on a statewide level is substantial. Where vast mosaics of eelgrass meadows and tidal wetlands once predominated, agriculture, housing, or other developments have been formed from lands diked from the bays or filled in shallow water areas. The total loss of California tidal wetlands is estimated at nearly 5 million acres, representing a loss of over 90 percent of the historic wetland acreage present before 1850. In the majority of cases, once portions of bay and estuary ecosystems are destroyed they are lost forever. Although some restoration has occurred, the fight remains one of preservation.

As California's population grows, the potential of adverse environmental impacts can be expected to increase. So too will the importance of protecting its bay and estuarine resources for all of their natural, economic, and aesthetic values.

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