National Oceanic & Atmospheric Administration

NATIONAL MARINE SANCTUARIES

ABOUT YOUR SANCTUARIES

Ecosystems: Kelp Forests

Kelp forests grow predominantly on the Pacific Coast, from Alaska and Canada to the waters of Baja California. Tiered like a terrestrial rainforest with a canopy and several layers below, the kelp forests of the eastern Pacific coast are dominated by two canopy-forming, brown macroalgae species, giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis leutkeana*).

Giant kelp, perhaps the most recognized species of brown macroalgae, forms the more southern kelp forests, from the southern Channel Islands, California to northwestern Baja.

Four national marine sanctuaries harbor kelp forests. Giant kelp inhabits the Channel Islands National Marine Sanctuary as well as the Monterey Bay National Marine Sanctuary, where giant kelp and bull kelp coexist. In the more northern Gulf of the Farallones and Olympic Coast National Marine Sanctuaries, kelp forests are comprised of predominantly bull kelp.

Conditions required for growth: Kelp forests grow along rocky coastlines in depths of about 2 m to more than 30 m (6 to 90+ ft). Kelp favors nutrient-rich, cool waters that range in

The Importance of the Keystone

In nature, all living things are in some way connected. Within each community each species depends on one or more of the others for survival. And at the core of individual ecosystems is a creature, or in some cases a plant, known as a keystone species.

temperature from 5o to 20o C (42o to 72o F). These brown algae communities live in clear water conditions through which light penetrates easily. Kelp recruits most successfully in regions of upwelling (regions where the ocean layers overturn, bringing cool, nutrient-rich bottom waters to the surface) and regions with continuously cold, high-nutrient waters. Because the amount of dissolved inorganic nitrogen decreases significantly in marine waters warmer than 20oC, kelp experiences reduced or negative growth rates in warm water. This phenomenon is particularly evident in southern California where giant kelp forests deteriorate in the summer months.

Along the central California coast where the distribution of giant kelp and bull kelp overlap, giant kelp out competes bull kelp for light.

Kelp survival is positively correlated with the strength of the substrate. The larger and stronger the rock on which it is anchored, the greater the chance of kelp survival. Winter storms and high-energy environments easily uproot the kelp and can wash entire plants ashore.

The kelp forests in Gulf of the Farallones National Marine Sanctuary are small and localized compared to those in the Channel Islands, Monterey Bay, and Olympic Coast sanctuaries. Conditions influencing kelp forest development in Gulf of the Farallones National Marine Sanctuary may include: increased wave motion, unsuitable substrate, urchin predation, and turbidity and salinity effects of

This species operates much like a true key stone, which is the stone at the top of an arch that supports the other stones and keeps the whole arch from falling down. When a keystone species is taken out of its environment, the whole system could collapse.

In California's Monterey Bay National Marine Sanctuary the sea otter is a keystone species in the kelp forest ecosystem. Kelp forests provide food and shelter for large numbers of fish and shellfish. Kelp also protect coastlines from damaging wave action. One of the sea otter's favorite delicacies is the sea urchin who in turn loves kelp.

When present in healthy numbers, sea otters keep sea urchin populations in check. But when sea otters decline, urchin numbers explode and grab onto kelp like flies on honey. The urchins chew off the anchors that keep the kelp in place, causing them to die and float away, setting off a chain reaction that depletes the food supply for other marine animals causing their numbers to decline.

By the early 20th century when sea otters were nearly hunted out of existence for their fur, kelp beds disappeared and so did the marine life that depended on kelp. Years later, conservationists moved some

the San Francisco Bay plume.

Unique Characteristics of Kelp Plants: Instead of tree-like roots that extend into the substrate, kelp has "anchors" called holdfasts that grip onto rocky substrates.

From the holdfasts, kelp plants grow toward the water's surface. Gas bladders called pneumatocysts, another unique feature of kelp, keep the upper portions of the algae afloat. A giant kelp plant has a pneumatocyst at the base of each blade. In contrast, a bull kelp plant has only one pneumatocyst that supports several blades near the water's surface.

Life histories: Giant kelp is a perennial (i.e. it lives for several years) while bull kelp is an annual (i.e. it completes its life cycle in one year). Both types of kelp have a two-stage life cycle. They exist in their earliest life stages as spores, released with millions of others from the parent kelp, the sporophyte. The spores grow into a tiny male or female plant called a gametophyte, which produces either sperm or eggs. After fertilization occurs, the embryos may grow into mature plants (sporophytes), completing the life cycle.

remaining otters from Big Sur to Central California. Gradually, their numbers grew, sea urchin numbers declined, and the kelp began to grow again. As the underwater forests grew, other species reappeared.

Protecting keystone species, like sea otters, is a priority for conservationists. Often, the extent of the keystone functions of a species aren't known until the species has been removed from its environment and the ecosystem changes. Rather than wait until it may be too late for the system's health and survival, scientists make every effort to keep an ecosystem working as nature had intended.

(Photo Kip Evans)

Holdfast of a giant kelp (Photo: John Heine)

Giant kelp can live up to seven years. Factors such as the severity of winter storms may affect its life span. Its average growth (in spring) is 27 cm/day (~10 inches/day), yet it may grow up to 61 cm/day (2 ft/day). The average growth of bull kelp is 10 cm/day (~4 inches/day).

The Kelp Forest Ecosystem: A host of invertebrates, fish, marine mammals, and birds exist in kelp forest environs. From the

holdfasts to the surface mats of kelp fronds, the array of habitats on the kelp itself may support thousands of invertebrate individuals, including polychaetes, amphipods, decapods, and ophiuroids.

California sea lions, harbor seals, sea otters, and whales may feed in the kelp or escape storms or predators in the shelter of kelp. On rare occasions gray whales have been spotted seeking refuge in kelp forests from predatory killer whales. All larger marine life, including birds and mammals, may retreat to kelp during storms or high-energy regimes because the kelp helps to weaken currents and waves.

Giant kelp (Photo: Shane Anderson)

Perhaps the most familiar image of kelp forests is a picture of a sea otter draped in strands of kelp, gripping a sea urchin on its belly. Both sea otters (*Enhydra lutris*) and sea urchins (*Strongylocentrotus spp.*) play critical roles in the stable equilibrium ecosystem. Sea urchins graze kelp and may reach population densities large enough to destroy kelp forests at the rate of 30 feet per month. Urchins move in "herds," and enough urchins may remain in the "barrens" of a former kelp forest to negate any attempt at regrowth. Sea otters, playing a critical role in containing the urchin populations, prey on urchins and thus control the numbers of kelp grazers.