Introduction to Kelp Forests

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Oceanic currents and nutrient upwelling are primarily responsible for the geographically asymmetrical, world-wide distribution of kelp forests. Kelp forests occur only in relatively cool marine habitats, in temperate zones and polar waters cooler than approximately 21° Centigrade, about 70° Fahrenheit. Cool surface waters do not occur at the same latitudes on opposite sides of the oceans. The rotation of the earth drives warm oceanic waters toward the poles along the eastern shores of the continents, whereas Coriolis effects bring cold, polar water toward the equator along the western sides of the continents (Castro and Huber, **Marine Biology**, Chapter 3). Thus, there are kelp forests along the coasts of California and Chile, but on the opposite side of the Pacific, along the coasts of Asia and Australia, there are no kelp forests to be found at these latitudes. Kelp forests occur far south along the west coast of North America, to Baja California at about 28° north latitude, but on the east coast of North America kelp forests occur primarily north of 40°.

Kelp plants grow rapidly and these often enormous brown algae require a steady supply of nutrients. Nutrients are supplied by upwelling, promoted by the offshore movements of eastern boundary currents such as the California Current and the Peru Current, due to the Coriolis effect, and the replacement of these surface waters from below by water rich in nutrients. These nutrients, primarily nitrogen and phosphorous, are fertilizers that stimulate rapid growth of the kelp, at rates of up to 50 cm/day, almost 2 feet per day! The fronds of the giant kelp *Macrocystis* can reach lengths of 65-100 feet, but unless the plants grow toward the surface they will not have sufficient sunlight for photosynthesis. Since plant tissues are denser than seawater, without buoyancy of some kind kelps can not grow upward. Buoyancy is provided by structures called pneumatocysts, gas filled bladders at the base of each frond, that lift the plants toward the surface where the fronds produce a dense canopy. Lift from the pneumatocysts is counteracted by the holdfasts which grip the rocks. Holdfasts are the structures that attach the kelp to the rocks, but holdfasts are not completely analogous to the roots of terrestrial flowering plants. Although both holdfasts and roots grip the substrate, holdfasts do not supply water or nutrients to the rest of the plant. Instead, nutrients, water and carbon dioxide are directly absorbed from the surrounding seawater.

Kelp forests produce unique habitats in the sea. Whereas most of the algae in the ocean are tiny, single-celled, and planktonic, kelp are huge, multi-celled plants anchored to the bottom, producing dense 3-dimensional forests. Like the tree canopy in mature terrestrial forests, the dense, floating kelp canopies absorb so much sunlight that other marine algae do not grow well in the dim light below. As a result not many other species of algae can exploit the understory beneath the canopy. On the other hand, the species diversity of animals within the kelp forest is very high because the kelp plants provide an enormous amount of protective cover and food. Indeed, kelp forests are among the most diverse habitats in the world for temperate zone marine animals. Communities of animals live among the surface canopy, communities of animals live attached to the fronds of the kelp, communities of animals live in midwater, swimming amid the fronds and stipes, and communities of tiny animals live deep within the interstices of the

holdfasts. It is important to emphasize the absolute dependence of these animal communities upon the kelp itself. The kelp plants provide the very fabric within and about which all of these animals live. When the kelp forest is destroyed by storms, by the warm waters of an El Niño event, or by overgrazing by sea urchins, then the animals that depend upon the structure or nutrition of the dominant species of giant kelp are all eliminated as well.

Kelp forests are surprisingly unstable ecosystems. This has been demonstrated along the west coast of the North America when the animals communities within the kelp forests have been altered by human activity. For example, several hundred years ago Russian sealers discovered the large populations of sea otters that lived amid the kelp forests of the northwest coast. Sea otters have the densest, most beautiful, warmest, and ultimately most expensive of all animal pelts. Not surprisingly, sea otters were soon harvested to the point of near extinction, and then slowly the kelp beds began to disappear. One of the favorite foods of sea otters is the sea urchin, and in the absence of otters the urchin populations expanded rapidly. The urchins soon exhausted all of the smaller algae upon which they normally fed and they turned to eating the less nutritious holdfasts of the giant kelp. When the holdfasts were destroyed, the buoyant fronds floated away, and entire kelp forests simply vanished. During the past 50 years marine biologists have documented the return of many of these kelp beds because populations of sea otters, now a protected species, are extending slowly south along the coast, eating sea urchins, and restoring the natural balance of nature.

Kelp forests were also disrupted some 50 years ago when huge amounts of untreated raw sewage were dumped off the coast of Palos Verdes. Sea urchins are not only grazers of benthic algae but they are also excellent scavengers of particulate material in the water, which they capture on their spines and with their tube feet. The sewage was food to the urchins, and their populations exploded until the entire bottom was carpeted almost solidly with sea urchins. But occasionally the ocean currents would shift, sewage would become temporarily unavailable, and the urchins would feed instead on kelp holdfasts. The result was that the Palos Verdes kelp beds disappeared. Today treatment plants in the Los Angeles basin have nearly eliminated the release of raw sewage into coastal waters, reducing the threat to kelp forests from overgrazing by urchin

Article Questions

1. What is responsible for kelp forest distribution?
2. Where in the U.S. can you find kelp forests?
3. What are the primary nutrients needed for kelp growth?
4. Define pneumatocyst.
5. Give two ways in which kelp forests are harmed.
6. How is the sea otter population related to the kelp forest health?
7. How have California cities helped prevent damage to kelp forests?