Kelp Ecosystems Monitoring: The Aquatic Forest

Focus *questions*

What is kelp?

Why are kelp forest ecosystems important?

What natural and human activities affect kelp forests?

How and why are researchers monitoring kelp forests?

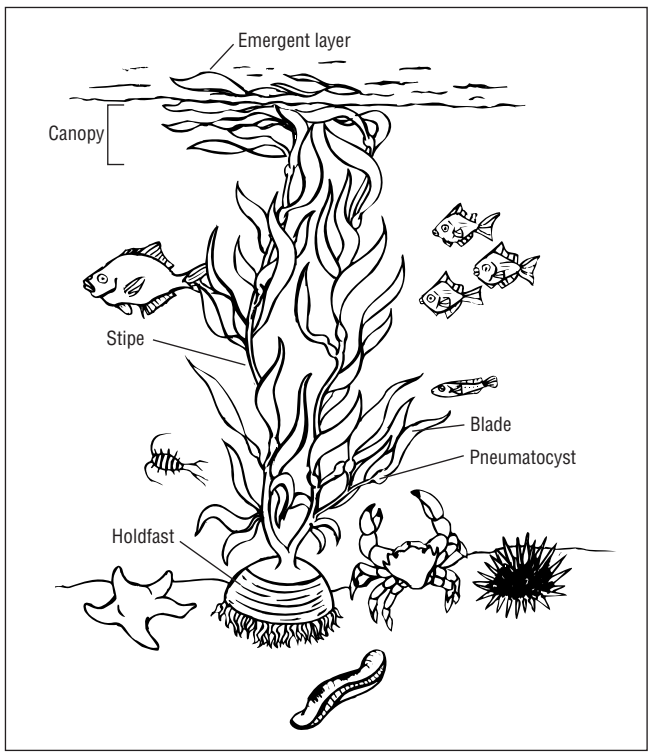
If you were to dive into the cool coastal waters of the Channel Islands, you might find yourself swimming through a magnificent underwater forest of enormous seaweed. Schools of shimmering fish and sleek bat rays glide past as you wind through giant seaweed "trees" that are anchored to rocks on the seafloor and extend to the ocean's surface. You are in the realm of an amazing alga called giant **kelp,** a type of seaweed that can grow almost two thirds of a meter per day (2 feet). Under perfect conditions, giant kelp can reach lengths of over 30 meters (100 feet) in its lifetime!

Over the past 20 years, JASON host researcher David Kushner and his colleagues have been monitoring the kelp forests around the Channel Islands. JASON host researcher Holly Lohuis and other marine educators and naturalists take boat trips to the Channel Islands, teaching students and travelers about the islands and the diverse **species** that they support. Over the years, these researchers have noticed that some kelp forests that were once thick and full of life have disappeared. Is the kelp disappearing because of water pollution? Are hungry sea urchins eating so much kelp that they are leaving the ocean floor bare? Or is it the effect of El Niño events, which bring warmer water, with fewer life-supporting nutrients, to the area?

Scientists don't know for sure why the kelp is diminishing. But they do know how important it is to keep a watchful eye on the kelp forest ecosystem. If the kelp forests vanish forever, hundreds of animal species will lose their homes. In fact, the entire ecosystem will collapse! David Kushner and Holly Lohuis are committed to monitoring and protecting this important underwater environment.

What is kelp?

When strong waves roll toward the shore, kelp stays grounded; it's anchored to rocks by a unique structure called a **holdfast.** Shooting from the top of the holdfast is the kelp **stipe,** a stem-like structure that supports numerous **blades.** These blades are pushed toward the sunlit surface of the water by hollow, gas-filled **pneumatocysts.** The blades absorb sunlight and nutrients that are used during photosynthesis to produce oxygen and sugars.



A kelp plant and other marine species.

Giant kelp (the largest known kelp species) grows blades for reproduction as well as nourishment. The reproductive blades release male and female spores that float with the tide, then settle on the ocean floor and develop into male and female **gametophytes.** Once fertilized, a female gametophyte's egg becomes a microscopic **sporophyte,** which then develops into a single blade that splits many times, allowing the kelp to grow rapidly. In the giant kelp life cycle, one generation of the kelp is the gametophyte and the

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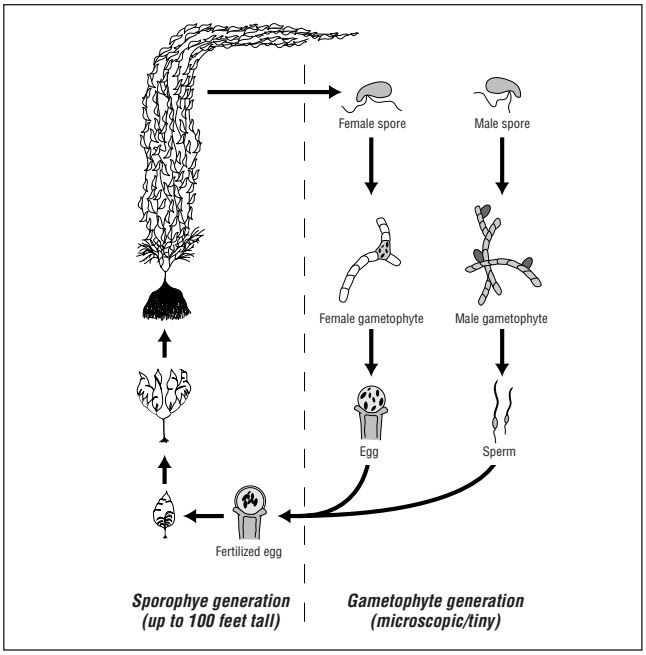
next generation is the sporophyte. (See the illustration below.) This life cycle, which is common among plants, is called **alternation of generations.**



The giant kelp life cycle.

Along the California Coast, in the spring, warm surface waters are blown offshore and cold, nutrient-rich water rises from the depths of the ocean. Giant kelp plants sprout new blades and the kelp forest experiences a surge of life during this season. The longer days and greater exposure to sunlight help giant kelp populations explode. In the summer, warmer water moves back into the kelp forests, and the coastal sea becomes flat and calm. Healthy kelp blades cover the surface, providing food and shelter for many animals (though blocking sunlight from plants living at the bottom of the ocean). Toward the end of the summer, the kelp forest is thriving; but growth slows again in the fall, as the days grow shorter and nutrient-poor water arrives. When winter moves in, frequent storms cause huge waves to rip kelp from the sea floor and damage kelp blades. The cycle continues, and when spring arrives, the kelp flourishes once again.

Why are kelp forest ecosystems important?

A holdfast's primary purpose is to give kelp a strong grip on the seafloor, but it also provides a home for hundreds of species, like sea urchins, brittle stars, and sea slugs. In fact, every part of the kelp plant is used for food and shelter by hundreds of animals of all shapes and sizes. In the understory (the area between the surface and the holdfast) swim schools of sparkling halfmoon perch and topsmelt, bright orange garibaldi, and other colorful fish. Giant kelpfish, señoritas, and surf perch dart among the kelp stipes and blades of the understory, and swim toward the canopy (where the kelp's blades reach the water's surface). Many invertebrates (animals without a backbone) can also be found in the forest, munching on kelp blades. Among these are kelp crabs and kelp isopods, shrimp-like creatures that are only about 4 centimeters (1½ inches) long.

Seabirds float on top of the water, resting on the canopy or looking for something to eat. Sea lions and seals feed on the fish and invertebrates that gather in the kelp forests. Even gray whales have been spotted swimming in the kelp beds around the Channel Islands, snacking on the tiny animals that cling to the kelp blades.

Though seabirds and pinnipeds may be trying to catch fish, many herbivores (plant-eating animals) that live in the kelp forest—like the opaleye, halfmoon, and sea urchin—depend on kelp itself as a source of food. Kelp-forest dwellers also eat blades that have broken away, known as drift algae. When these animals consume kelp, they gain nutrients produced by the plant through photosynthesis. At the same time, the herbivores are being hunted by carnivorous predators, like sea stars, crabs, and other species of fish.

A kelp forest.

What natural and human activities affect kelp forests?

Sea urchins normally feed on kelp, but if they become too numerous, they eat all the drift algae and begin feeding on living kelp plants. Eventually, they can destroy the entire kelp forest, leaving what is called a sea urchin barren. Under normal conditions, the sea urchin population is kept in check by predators, like California sheephead, spiny lobster, and sun stars. But during El Niño events, when unusually warm water flows from the south along the California coast, many things change in the kelp forest ecosystem.

The ideal water temperature for giant kelp is 14° Celsius (57° Fahrenheit). But water temperatures rose above 21° C (70° F) during El Niño events in the 1950s, 1960s, 1980s, and 1990s. Water that warm is bad for kelp: it causes reduced photosynthesis and loss of canopy blades. The kelp cannot last long under such conditions, and much of it is lost. Urchins eat whatever is left. Sometimes kelp forests can re-grow, once the cool, nutrient-rich waters return. But some kelp forests are slow to grow back, and the sea floor is temporarily left barren. Storms, disease outbreaks, pollution, sewage, human activities (such as overfishing species that prey on sea urchins), and invasion of human-introduced species may also contribute to kelp loss.

Humans harvest kelp for a substance called algin, which is used in many household products and medicines. This flexible substance helps control and thicken liquids; it is used to improve the texture of many common foods and other goods, such as store-bought ice cream, pudding, toothpaste, paint, and pet food. Giant kelp is harvested using large ships that cut about 1 to 2 meters (3 to 6 feet) from the canopy. Because kelp has such a tremendous growth rate, it recovers quickly and is ready for another harvest a month later. Each year, 97,000 tons of giant kelp are harvested along the southern California coast.

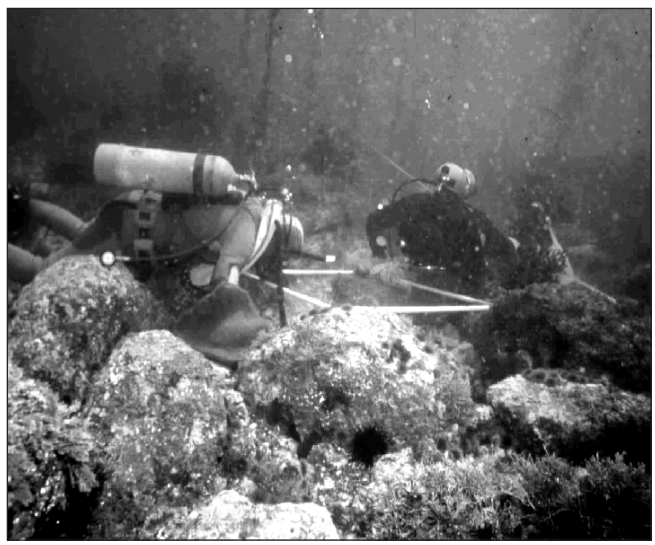
How and why are researchers monitoring kelp forests?

The kelp forests surrounding the Channel Islands are some of the best examples of the kelp forest ecosystem in southern California. By monitoring the health of these threatened kelp forests, host researcher David Kushner can understand the effects that El Niño events and humans have on the plants and animals living in this ecosystem. His work is part of a collaborative effort to understand the kelp forest, with help from the National Park Service, National Marine Sanctuaries, and the State of California.

Humans like to eat many kelp-forest animals—abalone, a marine mollusk, is a prime example. Over the years, abalone have been gathered from the ocean by both recreational and commercial fishers. In the

Studying Kelp from Air and Space

Aerial photography is one other tool scientists use to determine kelp coverage in the Channel Islands. Aerial photographs are useful because they show some contrast between the kelp forests and the surrounding water. Infrared photographs are even more useful because they show kelp in a sharper contrast: they show the heat given off by living things, so kelp glows yellow-orange in the photographs. Infrared images are generally taken on a monthly basis at an altitude of 2,500 meters (1.6 miles). Kelp density can also be monitored using remote sensing—images made by satellites in space. NASA's Landsat 7, a U.S. satellite, obtains images of Earth (including the Channel Islands), which provide useful information about inland and coastal locations. For more information, visit the Landsat 7 Web site at **landsat.gsfc.nasa.gov/index.htm.**



Divers monitor kelp species.

Research article

Research article

1990s, California began using data collected by the park's monitoring program to track declining abalone populations. The state used this data in its decision to close the pink, green, and white abalone fisheries in 1996, and the red abalone fishery in southern California in 1997. Without the data provided by the monitoring program, abalone populations could have been completely wiped out by overfishing.

David Kushner uses a 1-meter (3.2-foot) **quadrat** (a square measuring device) to measure plant and animal populations within the kelp forests in the Channel Islands. He uses quadrats together with 100-meter (328-foot) **transects** (lead-filled woven nylon line marked at 1-meter intervals) that are installed permanently at the monitoring sites. During each quadrat sampling effort, he lines up a quadrat along the transect line to determine the **density** of certain mobile and immobile species within the quadrat.He determines densities for 18 species, including fish, algae, and invertebrates. For 2 hours, Kushner tallies the number of juvenile and adult giant kelp, sea urchins, bat stars, giant spined sea stars, snails, and other species that he sees. Then he records his results on an underwater data sheet. Kushner also carries out another kind of sampling: monitoring species by descending to the floor of the ocean and slowly moving along the transect line, counting certain plants and animals as he goes. The monitoring team gathers information at the same spot once a year (usually between June and October) to monitor change in densities of species over time.

Journal Question

How can humans help protect the kelp forests in the Channel Islands?

Fact or *Fallacy?*

When large pieces of kelp break off during storms and become drift algae, all resident animals need to abandon the drifting kelp and quickly find a new home on other kelp plants or they will not survive.

Fallacy: *Animals continue to feed and find shelter on drifting kelp for weeks or even months after it is severed.*

Vocabulary

Alternation of generations *n.* The most common life cycle among marine plants, consisting of an alternation between a gametophyte generation and a sporophyte generation.

Blade *n.* The leaf-like part of kelp where most of the plant's photosynthesis takes place.

Density *n.* The number of individual plants or animals per unit of area.

Gametophyte *n.* A microscopic kelp plant that forms when spores are released by specialized reproductive kelp blades.

Holdfast *n.* The root-like structure of kelp that anchors the kelp to rocks on the ocean floor.

Kelp *n.* A photosynthetic type of alga consisting of a holdfast, stipe, and blade(s).

Pneumatocysts *n.* Also known as gas bladders or floats, these gas-filled structures, located at the base of each blade, help push the blades of the giant kelp toward the sunlight at the surface of the water.

Quadrat *n.* A square frame used by divers to mark off distinct areas in which to monitor the number of selected species.

Species *n.* A group consisting of animals (or plants) that share many physical characteristics and can interbreed.

Sporophyte *n.* A kelp plant (often quite large) that forms when a gametophyte's egg is fertilized.

Stipe *n.* The section of kelp that connects the holdfast and the blades. A stipe looks like a land plant's stem.

Transect *n.* A line, marked at regular intervals, along which scientists align their quadrats to monitor species.