FRAGILE

Background, A garibaldi swims among giant kelp plants near the Channel Islands off southern California. **Inset,** Severed fronds of giant kelp comprise "paddies" that drift offshore and provide shelter from predators for juvenile fishes.

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Background, Close-up view of a giant kelp plant reveals the pneumatocysts (gas bladders) that support the plant and the saw-edged blades that gather life-giving sunlight and nutrients. **Inset,** Marine ecologist Mia Tegner examines a giant kelp plant's holdfast in the Point Loma kelp forest.

FOREST

KELP COMMUNITY BECOMING UNDERWATER GHOST TOWN

In the mid-1950s, when Jim Stewart hankered for something more palatable than hot dogs for dinner, he and his diving comrades would simply grab a spear and head out to the Point Loma kelp bed off San Diego. There they would find a cornucopia of seafood waiting for the taking.

"When I first started diving there, the lobsters and abalones were everywhere I turned," said Stewart, now Scripps diving officer emeritus. He also remembers brushes with giant sea bass the size of Volkswagens and broomtail groupers weighing more than 100 pounds.

Scripps marine ecologist Mia Tegner regretfully admits that she has never seen Stewart's underwater world despite the thousands of dives she and her team of researchers have conducted to monitor the health of the Point Loma kelp forest. By the time

BY JANET HOWARD

Left, Mia Tegner examines giant kelp, *Macrocystis pyrifera,* in her Scripps lab. **Below,** Sea urchins swarm over a kelp plant's holdfast. The holdfasts anchor kelp to rocky substrates and are essential to the plants' survival in strong currents and wave surge. Kelp holdfasts are vulnerable to grazing by sea urchins, voracious algae eaters that can devour large areas of kelp forest.

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Background, Mia Tegner handles a kelp plant damaged as the result of El Niño-induced changes in local ocean conditions. **Insets, clockwise from top,** Local kelp forest inhabitants include rockfishes, cabezons, and moray eels.

Tegner arrived at Scripps as a student in the 1970s, the giant sea bass, huge schools of yellowtail, and stacks of abalones were already gone.

"We see a whole lot less fish than we used to," said Tegner. "If I see half a dozen white sea bass or yellowtail, I get excited."

Indeed, the kelp forest Tegner knows is a quiet shadow of its former self. Over the past several decades, the fragile ecosystem has been barraged by overfishing, raging El Niño storms, and steadily rising ocean temperatures.

Tegner points to overfishing, however, as the biggest enemy the kelp forest has had to face.

"Giant sea bass and broomtail groupers were probably wiped out in this area by divers in the 1950s," she said. "And then divers started working on the big kelp bass and the big sheephead. These are very rare around here now."

Perhaps the biggest blow to the kelp bed came in the early 1960s with the development of the gill-net fishery.

"The fishes you'd anticipate seeing—sheephead, kelp bass, white sea bass—were just no longer there," said Stewart. "The only things left were fish small enough to swim through the holes in the nets."

While the use of gill nets within three miles (4.8 km) of the southern California coast was banned in the early 1990s, Tegner said it will take the kelp community years to recover.

Meanwhile, animals of the kelp bed now face a new threat: the development of the live-fish industry, which provides fishes for restaurants where customers select their entree as it swims in an aquarium. The popularity of these restaurants is on the rise in some parts of the world.

"Some fishermen are targeting fishes that are about the size of an individual meal—they especially want colored fishes, like female sheephead," Tegner said. "But they are basically going after anything they can catch."

Part of the problem is that customers are willing to pay exorbitant prices for a single live fish, said Scripps marine ecologist Paul Dayton, who also studies the Point Loma kelp forest.

"Consumers will spend so much money that it is profitable for people to catch the last fish—and they won't be happy until they do," he said.

The overfishing of species such as sheephead can have a devastating impact on the health of the kelp forest because sheephead eat sea urchins, a main predator of the giant kelp, *Macrocystis pyrifera*. Left unchecked, sea urchins can eat their way through a kelp forest, virtually destroying it. They like to burrow into kelp holdfasts and, with time, they will excavate the center of the holdfast, leaving some plants weakly anchored and susceptible to storm damage and detachment, according to Tegner.

In addition to female sheephead being hunted for the live-fish industry before they reach sexual maturity, adult males also are being targeted by spear fishermen,

and juvenile sheephead are being collected for the aquarium trade.

"This is a classic example of what is wrong with the way we manage fisheries," said Tegner. "Here is a fish that has played an important role in controlling urchin populations, and has an effect on populations of abalones, lobsters, and all the fishes that depend on the kelp. Yet we aren't doing anything to help protect its community function."

Tegner worries that sheephead may eventually go the way of abalone.

"When I began my career, I saw black abalone layered three and four deep in the intertidal zone of the Channel Islands," she said. "Their populations were fished heavily and, for more than a decade, they also have suffered from a disease that has decimated populations all over southern California."

No species of abalone has been hit as hard as the white abalone, which now hovers on the brink of extinction. Popular for its tender meat, the high price it brought fishermen soon caused its stocks to be depleted.

Chances are slim that the white abalone will make a comeback without human intervention. Adult white abalone must be close together for successful fertilization. A recent census off the Channel Islands turned up only three white abalone in about seven acres of habitat that had once been home to thousands.

While some kelp-forest animals are not faring well, spiny lobsters appear to be holding their own, Tegner said. She suspects that steadily warming ocean temper-

Right, Paul Dayton in his lab at Scripps.

Below, Thousands of plants from the La Jolla kelp forest washed ashore as the result of strong storm waves during the El Niño of 1982-1983.

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Background, Mia Tegner dives in the kelp forest near San Clemente Island. **Insets, clockwise from top,** Sea slugs, marine snails, and fringehead gobies reside in the kelp forest.

atures are helping lobsters to prosper.

Two Scripps scientists, Dean Roemmich and John McGowan, reported in 1995 that sea-surface temperatures in the California Current increased an average of two to three degrees Fahrenheit between 1951 and 1993. Tegner and Dayton's research indicates this warming trend has been associated with a two-thirds decrease in the average size of giant kelp plants as measured by their number of stemlike structures called stipes, a huge reduction in biomass.

"Whether this is an interdecadal shift or the harbinger of global warming will take years to determine, but the ecosystem implications are very serious," the two scientists wrote in a recent research paper.

The role of El Niño events in disrupting the health of southern California kelp forests also cannot be overstated. At times during the last century, the surface canopy of the Point Loma forest has covered up to four square miles (10.4 km^2). After the El Niño storms of 1982-1983, it was reduced to virtually nothing. In addition to the damage caused by strong waves, the warm, nutrient-depleted waters associated with El Niños led to diminished plant growth, surface canopy deterioration, and even plant mortality. Preliminary results from this year's storms indicate that plant densities have decreased by 60 to 90 percent.

"The storms had a very strong effect, but there are still plants out there that survived," Tegner said. "If we get cold water in the kelp bed, those plants are likely to regrow and reproduce and get the bed going again."

While the effects of El Niño and overfishing are taking their toll on the kelp beds, Tegner said that pollution poses little hazard today.

The impact of sewage on the kelp beds became front-page news in the late 1980s when the Environmental Protection Agency (EPA) mandated that San Diego spend a minimum of $3 billion to upgrade its treatment of sewage before discharging it more than two miles (3.2 km) offshore of Point Loma.

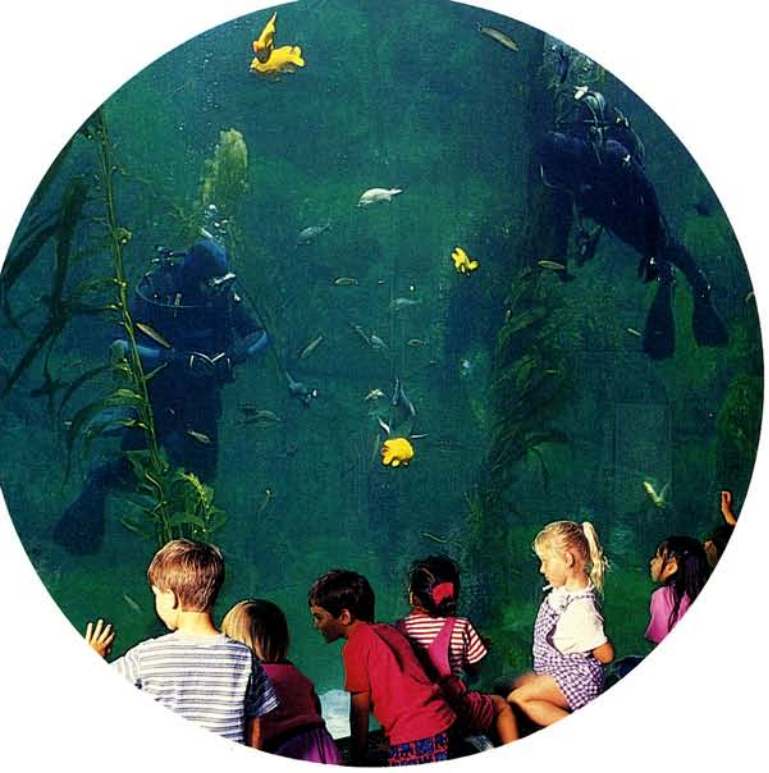
Tegner was one of a group of Scripps scientists, including late Director Emeritus Roger Revelle, who spoke out against the plan.

"We have real problems with our marine environment and they wanted to spend $3 billion—not million—but $3 billion on something that might not have had a detectable effect on the ocean," Tegner said.

The suit by the EPA was eventually decided in San Diego's favor, and in the process Tegner was transformed into a vocal advocate of the oceans.

It is a role she took on gladly and continues today.

"It is very important for me to see that my science has a useful role in the real world," she said. "I don't want to write papers that sit in the library and gather dust. The people



Left, Children watch as a diver feeds residents of the Birch Aquarium's giant kelp forest exhibit. The 70,000-gallon (266,000 l), two-story-high tank is home to a small forest of kelp plants, along with 30 species of fishes and invertebrates.

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Background, top Close-up of giant kelp.

Background, bottom, Mia Tegner.

Insets, Scripps research divers Kristin Riser and Peter Edwards accompany Tegner on a day of diving in the Point Loma kelp forest.

of California are paying for this work, and they should receive the benefits of it."

Recently, Tegner worked closely with California State Senator Mike Thompson, who authored a bill passed by the state legislature that closed commercial and sport harvesting of abalone south of San Francisco for the next decade.

Dayton gives Tegner a lion's share of the credit for helping to get the ban on abalone fishing passed.

"She went to Sacramento two or three times to testify," he said. "She really was the credible scientific voice that got the thing through."

Such effectiveness in helping shape public policy is too rare among university researchers, Dayton said.

"It's difficult for academics to get involved in the public arena," he said. "It takes a lot of time and there are few rewards. Your colleagues are often after you because you are too 'green,' or they accuse you of selling out. But Mia puts her heart and soul out there and she is very effective at making things happen."

After 25 years of studying kelp-forest ecology, Tegner said she is optimistic that a good portion of the damage done to the kelp forest and other coastal marine habitats can be reversed.

Perhaps the greatest hope for replenishing marine life is the establishment of marine reserves, she said.

Dayton, who is responsible for overseeing several marine reserves in the San Diego area, is anxious to expand the existing marine reserve at La Jolla Cove so that it would extend about a mile farther south to Casa Cove and off the coast beyond the La Jolla kelp beds.

"I think that with an expanded reserve we would be able to get much of our natural system back," he said. "At least we would see the return of broomtail grouper, sea bass, and some of the other major species."

Tegner also has been working with California State Assemblyman Fred Keeley on a bill to overhaul the way California fisheries are managed.

"The California Fish and Game laws were set up in the 1800s, when there were very few people here and natural resources were incredible," Tegner said. "Things today have changed drastically and we need a totally new approach to management."

One of the goals of the bill is to allow the Department of Fish and Game and the Fish and Game Commission to act more quickly in closing down or reducing pressure on threatened fisheries, she said.

In the end, however, Tegner believes that the public will have to demand change in how the California fisheries are managed.

"I have become a strong believer that unless the push comes from the public, the scientists are talking to deaf ears," she said.

Tegner is the first to admit that part of the reason the public hasn't been demanding change to date is that many of the animals at risk don't have the appeal of dolphins or whales.

"It's a huge part of the problem," she said. "There is nothing sexy about a sea urchin or a sea cucumber. But to biologists, they are all important."

Anyone tailing Tegner's Mazda RX-7 knows she means what she says. The cryptic message on her license plate: "SIURCHN."

Not Just Another Day at the Office

The sky is overcast and a damp chill settles over the water as Scripps marine ecologist Mia Tegner and her research dive team load their scuba gear into a 24-foot fishing boat on the shore of Mission Bay in San Diego.

Pushing off from the dock, the team members don full-length parkas and brace against the wind as they turn the small craft in the direction of the Point Loma kelp forest, about a 30-minute ride away.

It is a trip familiar to the trio, who have spent years carefully monitoring the health of the kelp bed, often diving in the area two to three times a week.

Upon arrival, Tegner scans the surface for an orange float that marks a site outside the kelp forest where they plan to make their first dive. After throwing an anchor overboard, Tegner and Peter Edwards shimmy into their scuba gear while Kristin Riser organizes equipment. The sun breaks through the clouds just as Tegner and Edwards gently roll out of the boat.

The two dive 106 feet (32.3 m) through murky water to the ocean floor, where they take temperature readings and a water sample for later nutrient analysis. The purpose of this short dive is to learn about the mechanism that brings cold, deep water up into the kelp forest. This source of nutrient-rich water is believed to be vital to maintaining the health of the kelp bed. The temperatures along the bottom this day are a chilly 57 degrees Fahrenheit (13.8°C), warmer than normal, but a bit cooler than earlier in the winter.

"This suggests that we may get some upwelling of cold water that will bring nutrients into the kelp forest," Tegner says. "That should help the giant kelp recuperate more quickly from the effects of El Niño."

After clambering back on board, the divers fire up the small outboard motor. During their next two dives they census and map giant kelp plants located along transect lines on the seafloor. They also check on the reproductive health of mature kelp plants to study how the kelp forest has been impacted by the recent El Niño storms.

"It's been thrashed this year—just thrashed," says Tegner, after climbing back aboard for lunch. "But at least it is not as bad as it was in 1982-1983. Then we had whole areas of kelp forest that were completely cleared of plants."

While many plants have survived, they have far fewer stipes than last fall and fewer sporophylls—reproductive blades that form a skirt at the bottom of each plant. Such data provide a good index of how well the plants are faring and their capacity for producing new recruits.

In addition to monitoring natural changes in the kelp forest, Tegner's team often conducts various experiments to learn more about the forces that dictate the ecosystem's overall health. While such experiments provide scientists with useful information, Tegner says it is the long-term monitoring of the kelp bed that has paid the greatest dividends.

"For many years, long time-series observations were considered 'mindless monitoring,'" Tegner says. "It was out of favor, and we had a great deal of trouble getting funding. Now, the pendulum has swung, and I think it is widely recognized by the granting agencies as well as most scientists that we need both experiments and long-term monitoring programs."

But gathering long-term data on the kelp forest also requires that Tegner's dive team be on the job week-in and week-out. By the day's end the three have completed five dives.

"It can be sort of brutal," says Riser matter-of-factly of the rigors of research diving. "But, I think your body just gets used to it."