UC SANTA BARBARA

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A Prickly Situation

Purple sea urchins are munching their way through California's kelp forests at a speed and scale that have stunned scientists, fishermen and divers alike. But the kelp forests have long been home to red and purple urchins, so it's clear the three species can get along. Researchers at UC Santa Barbara sought to determine what factors disrupt this harmony.

"Why is it that in some places urchins cause the demise of a kelp forest, and in other places urchins and kelp can coexist?" asked Associate Professor Adrian Stier. "Our analysis shows what's going on under the hood. It offers a lot more resolution in explaining when and where you might expect urchins to devour kelp."

That analysis, led by doctoral students Mae Rennick and Bart DiFiore, appears in the journal Ecology. The authors combined laboratory experiments with 20 years of field data to uncover what prompts urchins to begin eating their way out of a home. The results suggest that the supply of kelp scraps, or detritus, may be the deciding factor.

Co-author Dan Reed, a research biologist at UCSB's Marine Science Institute, formulated the hypothesis behind this study several decades ago. "Back in the 1980s, we noticed one of our sites at San Nicolas Island transitioned back and forth between kelp forests and sea urchin barrens without any change in urchin density," he recalled. "This led us to believe that the availability of kelp detritus altered the foraging behavior of urchins from passive feeding, when detritus was abundant, to active grazing on living kelp, when detritus was scarce."

Rennick and DiFiore set out to test this hypothesis. They collected purple and red urchins from the field and brought them back to their lab. After acclimating the urchins to the tanks, the researchers withheld food from them for about a week. Then they added kelp into the different tanks, weighing it before feeding and 48 hours after feeding for purple urchins, and 96 hours for red urchins, to determine how kelp consumption changes with urchin density.

The scientists expected to observe one of three types of density-related feeding behaviors. Consumption might decrease with density if urchins compete with each other. Alternatively, urchins could ramp up their consumption rates, forming a feeding front like locusts. Finally, density could have no affect at all on consumption rates.

Indeed, the experiment revealed that urchins seem to feed independently. “Our analysis showed that there are linear relationships between urchin biomass and consumption rate,” DiFiore said.

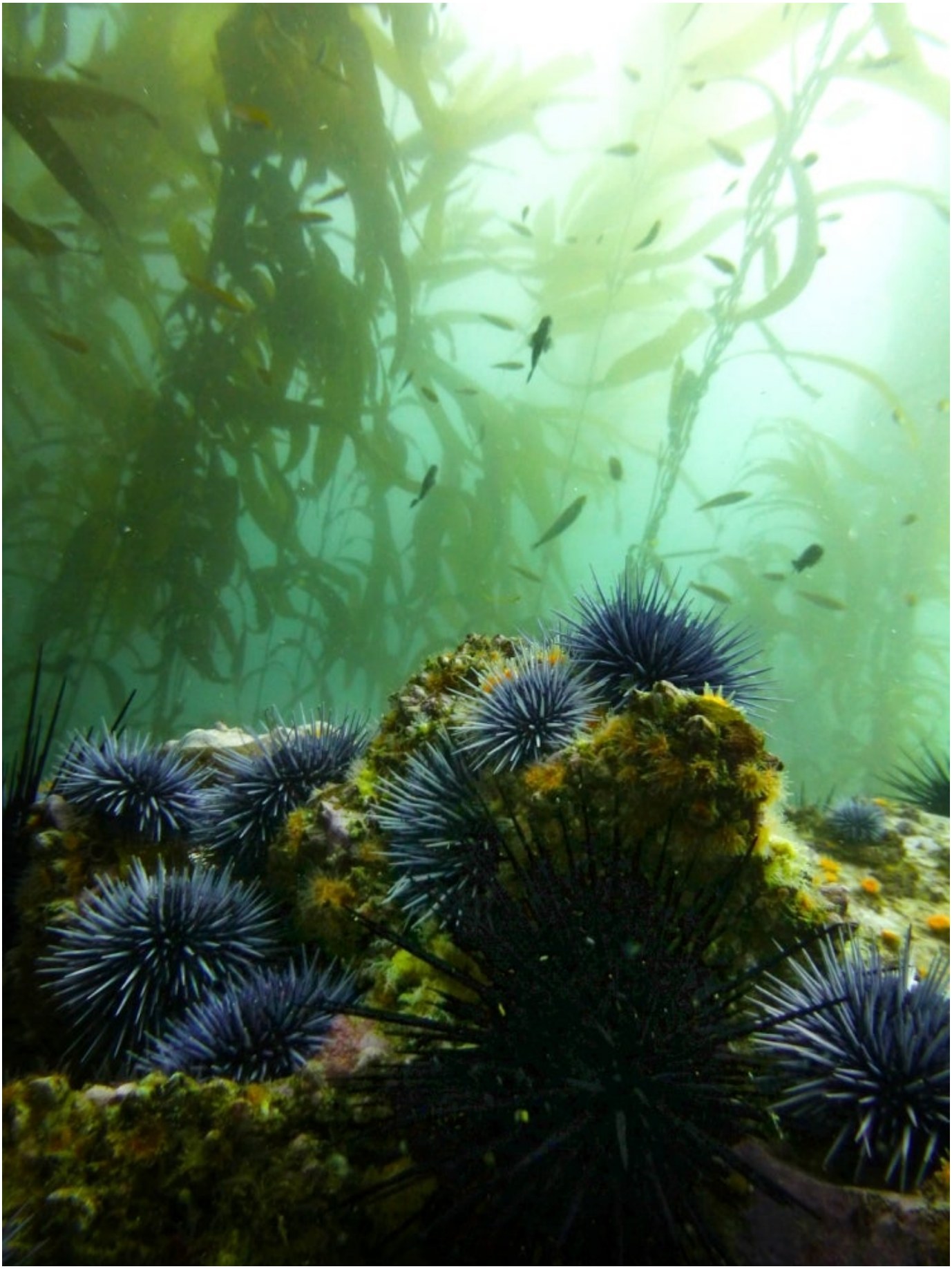
Next the team dove into timeseries data from the Santa Barbara Coastal Long Term Ecological Research site (SBC LTER). For 20 years, scientists have routinely tracked all sorts of characteristics at several field sites in the Santa Barbara Channel. The program, part of the National Science Foundation’s LTER network, is designed to support precisely this sort of in-depth research.

From their experiment the researchers learned how much the urchins need to eat, and from the LTER data they learned how much detritus the urchins might be getting, ascertained urchin density and determined the amount of living kelp at a given site and time. Combining the data and lab results enabled them to hindcast how much kelp both purple and red sea urchins may have consumed at each location in the SBC LTER in a given year.

They compared what happened to the standing stock of kelp when urchin demand was greater than detrital supply. The results were stunning. “We found this 50-fold decrease in the standing stock of kelp biomass when urchins required more detritus than they were getting,” DiFiore said. And this doesn’t necessarily spell the end of the urchins. Sea urchins are remarkably hardy and opportunistic. “They can kind of survive on anything,” he added.

A healthy kelp forest is incredibly productive, and there’s a lot of biomass turnover as the giant algae sheds fronds and blades. “It’s dropping its blades constantly as

those individual leaves die," DiFiore explained. "And so, you have this huge biomass available for urchins to eat."



Red and purple sea urchins often hide in crevices where they can snatch kelp scraps floating by from relative safety.

Photo Credit: KATIE DAVIS

In an ideal world, an urchin would squirrel itself away and catch kelp scraps drifting by with its tube feet. Then it would dine on its meal from the safety of its little hole. But if there's no longer enough detritus to support this secure lifestyle, the urchin is more likely to venture out and forage on living kelp. And the less kelp you have, the less detritus it supplies, and the more urchins come out. This creates a feedback loop that can push the ecosystem over a tipping point, causing a sudden shift in the community makeup. Finally, researchers have a grasp of one of the mechanisms driving urchins to mow down kelp forests.

Scientists have observed similar dynamics in other ecosystems. For example, *Littorina* snails in salt marshes switch between scavenging detritus from marsh grass and consuming the living plant when the supply of detritus drops below what the population can consume. And, like in the kelp forests, this change can wreak havoc on marsh ecosystems.

There's serious concern about kelp forests on the West Coast. The region has seen major, unanticipated declines in kelp north of Point Conception. "The thing is, urchins and kelp can coexist," Rennick said. "Figuring out what's upsetting that balance is going to be really important before we just accept this 'down with the urchins' sentiment."

The authors believe their findings can inform how to approach kelp forest management and indicate where efforts are likely to be effective. "The study suggests that the places most likely to benefit from restoration are those with a hardy supply of detrital kelp coming from elsewhere," Stier said.

"The best place to restore kelp isn't in the middle of an urchin barren, where there's no kelp around," he continued. "It's actually in places that are closer to other kelp forests. So maybe we ought to try extending the leading edge of a given kelp forest nearby."

Rennick is currently exploring "urchinomics." Right now, there's no market for purple urchins, which are the more voracious foragers between Southern California's two species. However, entrepreneurs have proposed harvesting them from the wild,

then growing them to market size in captivity.

Rennick is working to quantify how much this might help the kelp forest ecosystem. “‘When and where can removing urchins be beneficial to kelp forest restoration?’ is an outstanding question,” Stier said.

Meanwhile, DiFiore is trying to understand whether the urchin’s non-human predators can limit populations so that they don’t exceed the supply of detritus. Sheephead fish and lobsters are their main predators in SoCal. Of course, lobsters themselves underpin an important commercial fishery.

“These really big lobsters play a disproportionate role in eating urchins,” Stier explained, “and those are the very same individuals that are targeted by fishing.” DiFiore is investigating whether marine protected areas can act as a reservoir for predators like these large lobsters, thereby helping stabilize the kelp forests.

Although none of the authors believe that kelp forests will disappear altogether, the ecosystem faces an uncertain future. “The million dollar question is whether there’s anything we can do about it,” Stier said.

About UC Santa Barbara

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