Study reveals how kelp forests persisted through the large 2014–2016 Pacific marine heat wave

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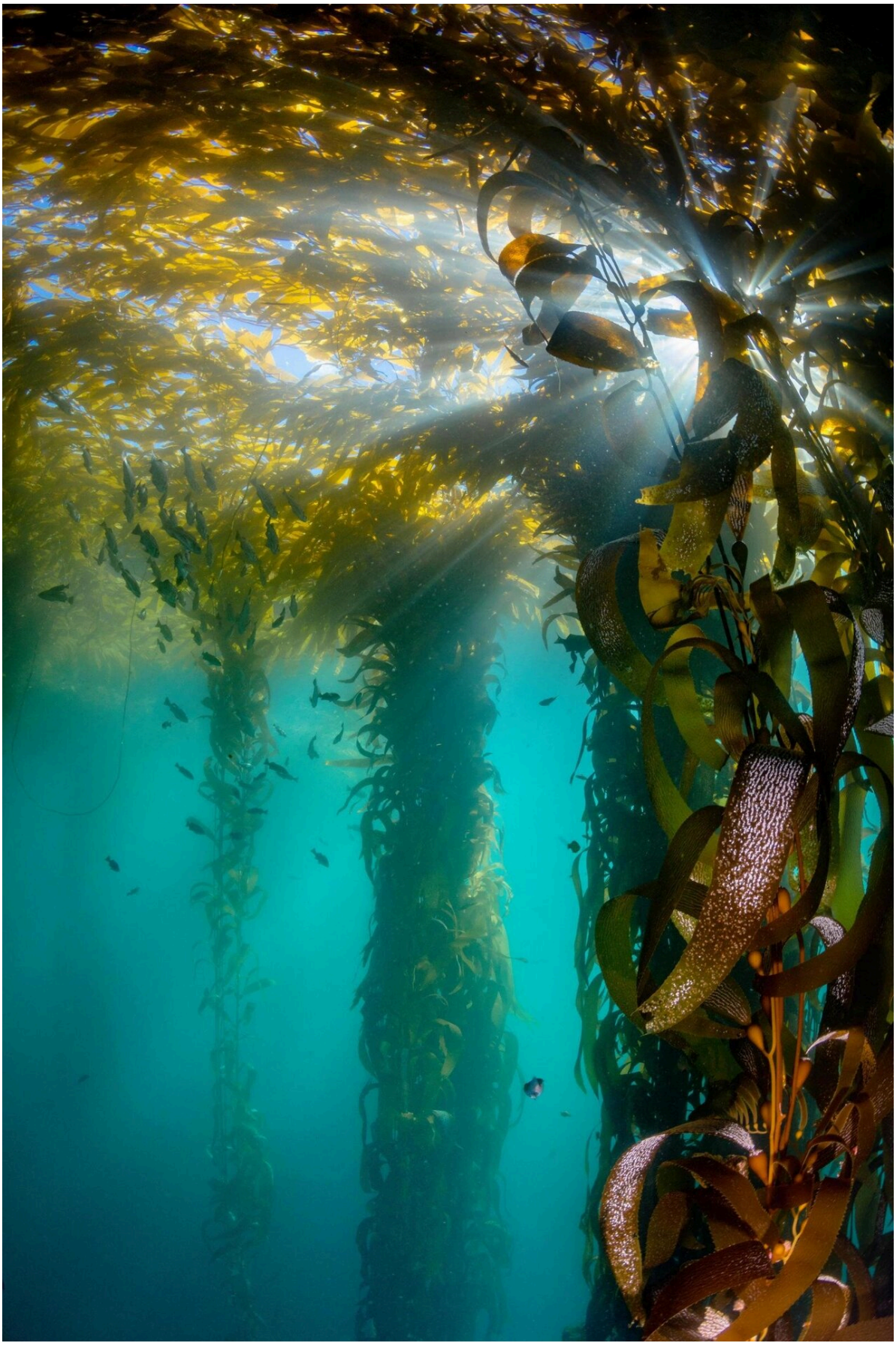

Wild kelp forests seen during a dive at Monastery beach in Carmel, CA. Credit: Monterey Bay Aquarium / Patrick Webster

New research led by Monterey Bay Aquarium and the University of California, Santa Cruz, reveals that denser, and more sheltered, kelp forests can withstand serious stressors amid warming ocean temperatures. Published in *Proceedings of the Royal Society B*, the study also offers the first comprehensive assessment of how declines in kelp abundance affected marine algae, invertebrates, and fishes living in Monterey Bay.

The study comes after a multi-year marine heat wave—the product of a 2014 'blob' of warm water prolonged by a 2015–2016 El Niño event—bathed the North American west coast with sweltering sea temperatures.

It all started a decade ago when a triple-whammy of stressors—the large marine heat wave, a sea star die-off, and a sea urchin outbreak—led to pronounced declines in kelp abundance on California's central coast.

Using a 14-year dataset, researchers discovered those events caused a 51% decline on average in kelp forest density in the years following the heat wave (2017–2020 vs. 2007–2013). As of 2020, the decline had increased to 72%. Some kelp forests, though, made it through these extreme events.

"We found that larger stands of giant kelp prevented shifts in sea urchin foraging behavior, and these persistent forests were better at withstanding multiple stressors," said Dr. Joshua Smith, the study's lead

author and Ocean Conservation Research Scientist at Monterey Bay Aquarium.

"Something that surprised us was that persistent kelp forests were located in areas that are typically less productive. These persistent forests had a gradual reef slope and protection from wave exposure, which enabled them to become densely packed with kelp prior to the marine heat wave."

While this study identified the importance of habitat features in driving forest persistence, predators can also help the kelp. Another recent Monterey Bay Aquarium study reinforced the role that sea otters play in preventing kelp declines by eating up sea urchins.

Where kelp patches were more exposed and less dense, the sudden rise of sea urchins in 2014 led many kelp forests to become 'barrens'—areas scoured by hungry sea urchins along the rocky reef. Smith and co-authors examined changes in species composition across the mosaic of barrens and persistent forests to untangle how kelp loss impacts the broader ecosystem.

"While some kelp forests have endured, the structure of the ecological communities in the barren areas have yet to return to their pre-2013 state," Smith added.

"Across the region, the number of species did not decline, but changes in their relative abundances led to an overall decline in species diversity, most notably for marine algae and kelp-associated invertebrates." With less kelp and other macroalgae around, the study noted a disproportionate increase in animals that eat plankton, such as barnacles, scallops, tube snails, and planktivorous fishes.

The study sought to understand the effects and resulting consequences of

the marine heat wave and is part of Monterey Bay Aquarium's larger effort to understand kelp recovery and restoration mechanisms. Globally, kelp has been declining for a half-century, and at an average rate of 1.8% a year.

With over half of the ocean surface experiencing extreme marine heat every year since 2014, warming ocean temperatures present a serious threat to cold-water species like kelp. As kelp forests and other marine ecosystems around the world face increasing threats associated with climate change, conservation of ecosystems, like kelp forests, and predators, like sea otters, can mitigate the impacts of extreme events.

"This study offers important insights to help inform strategies for protecting areas where kelp can persist on its own, and siting for kelp restoration efforts, here in California and around the world," said Dr. Pete Raimondi, a marine ecologist at UC Santa Cruz who was not a co-author on the study.

More information: Joshua G. Smith et al, Consequences of kelp forest ecosystem shifts and predictors of persistence through multiple stressors, *Proceedings of the Royal Society B: Biological Sciences* (2024). DOI: 10.1098/rspb.2023.2749

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