The health of foundation species promotes the stability of the ecosystems that depend on them

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Sea palms and giant kelp lean into the current off the coast of Santa Cruz Island as señorita fish dart between the fronds. Credit: SARAH SAMPSO/ BRANDON DOHENY

Anyone who's read "The Lorax" will recognize that certain species serve as the foundation of their ecosystems. When the truffula trees disappear, so to do the swomee-swans and bar-ba-loots. However, the same is not necessarily true the other way around.

Scientists have taken a growing interest in ecological stability—the factors that make an ecosystem robust against pressures and perturbations—especially in light of human impacts like climate change and pollution. Though many presume that the stability of an ecosystem's foundation species will promote stability overall, few have quantified this effect as of yet.

Researchers at UC Santa Barbara's Marine Science Institute (MSI) have leveraged long-term ecological data to probe this question in Southern California's kelp forests. They found a correlation between the stability of giant kelp and the stability in understory seaweed and seafloor invertebrates, such as sponges, as well as higher biodiversity over all. Their results appear in the journal *Ecology*.

A foundation species shapes its entire environment and defines an ecosystem. "The ecosystem in which they live is often named after them, like oyster beds, coral reefs, or redwood forests," said Robert Miller, a research biologist at MSI and one of the paper's coauthors. They generally provide the ecosystem's physical structure or main source of food, and as such, have a strong effect on the species that live there.

"The fact that a foundation species, such as giant kelp, could promote the stability of the species for which it provides food and habitat might seem trivial," said lead author Thomas Lamy, a postdoctoral researcher at MSI. "This was part of the original definition of a foundation species—which dates back to around 1972—but had never been tested before."

The researchers pored over 18 years of ecological data from nine shallow reefs in the Santa Barbara Channel. The information included species size and abundance, biodiversity, and biomass, among many other useful data. Statistics and mathematical modeling enabled the scientists to uncover trends and patterns in the data.

The team considered different groups of organisms separately to better understand the ecosystem's dynamics. "It's hard to compare the diversity of, for example, bacteria with the diversity of whales," Miller remarked. For this study, that meant looking at understory algae and invertebrates separately, which revealed nuances that were hidden when the groups were lumped together.

"We found a positive link between the stability of the giant kelp and the stability of understory macroalgae and seafloor invertebrates," said Lamy.

So, giant kelp has a giant effect on the kelp forest. "It can sound rather intuitive," he acknowledged, "but sometimes these are the most difficult ideas to test. As pointed out before, this requires a lot of ecological data."

Fortunately, the researchers had the benefit of nearly two decades of data and observations courtesy of the Santa Barbara Coastal Long-Term Ecological Research Project (SBC LTER). The Marine Science Institute manages the SBC LTER, which is part of a network of sites run by the National Science Foundation.

"That's the advantage of the LTER program: It enables us to look at long-term questions that are critical to ecology," Miller said.

The group found that most of giant kelp's influence on the forest's stability came indirectly. Robust kelp increased species diversity and this

in turn increased the ecosystem's stability. In a previous study, the group found that biodiversity alone can bolter stability. If the abundance of different species fluctuates out of sync with each other, their variability tends to even out as a whole, leading to a more stable ecosystem overall. And greater biodiversity means more species contribute to this effect.

"This is what we would expect if giant kelp truly is a foundation species that the whole ecosystem is depending on," Miller said.

Stable kelp forests may harbor more species by promoting steady recruitment, balancing the availability of limiting resources, or providing refuge from different stresses, Lamy suggested. The team plans to investigate these mechanisms in future work.

The relationship between kelp and kelp forests is of particular interest and concern to scientists, who think that the stability of kelp is likely to change in the future. Climate change promises to bring more warming events, larger waves, and stronger storms, all conditions that place pressure on giant kelp. Understanding the relationship between foundation species' stability and ecosystem stability will help us anticipate how the ecosystem will react and then respond accordingly.

More information: Thomas Lamy et al, Foundation species promote community stability by increasing diversity in a giant kelp forest, *Ecology* (2020). DOI: 10.1002/ecy.2987

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