Kelp forests are connected to local beach ecosystems, study shows

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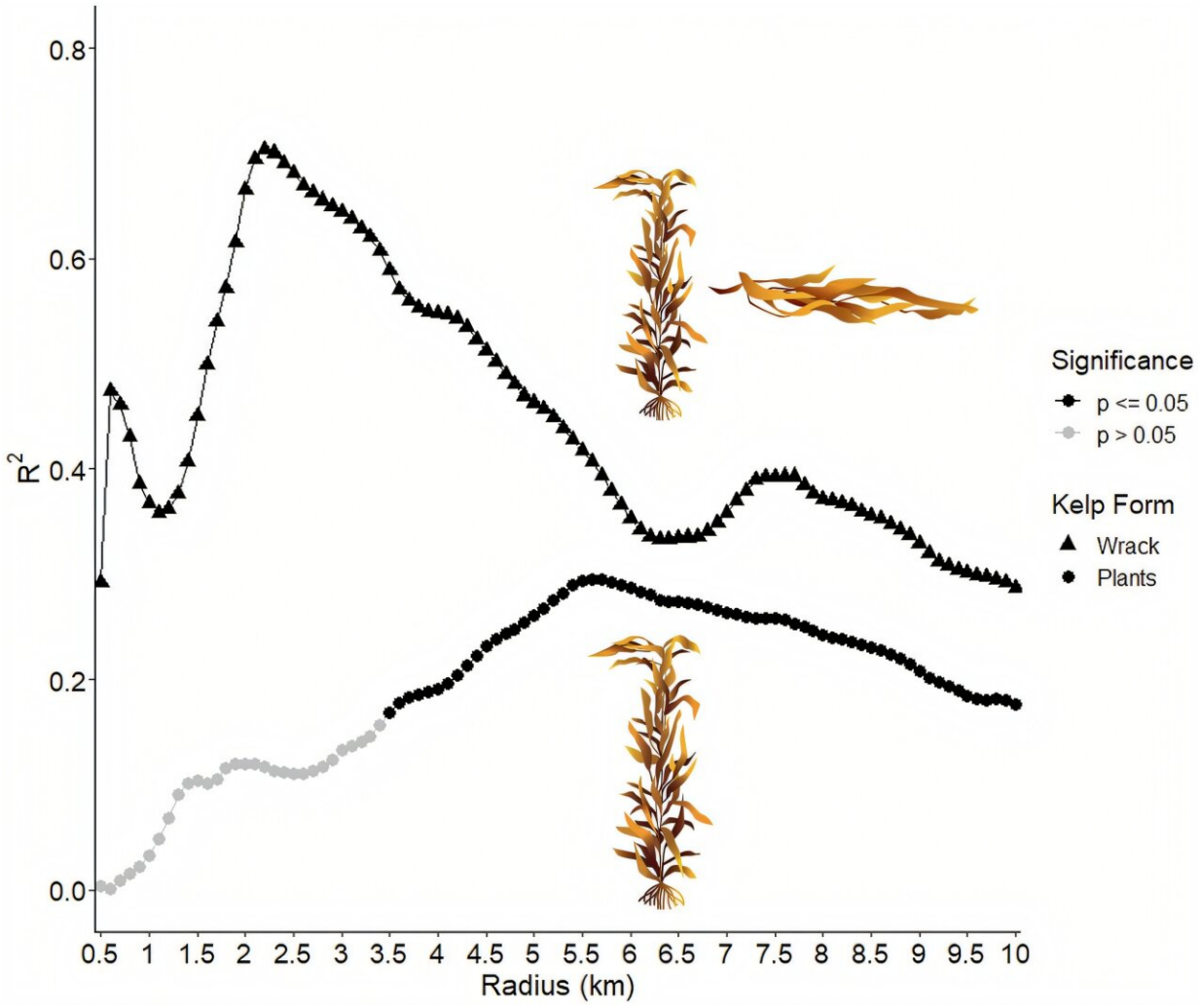

Relationships between kelp wrack cover and kelp plant counts to kelp canopy biomass at increasing radii from the beach sites. Credit: *Communications Biology* (2025). DOI: 10.1038/s42003-025-08354-8

The kelp forest is ephemeral, yet foundational. Fronds of this fast-growing giant seaweed come and go with the seasons, storms and waves, supporting communities of fish, invertebrates and even mammals wherever they emerge. As dynamic as they are in the ocean, kelp forests are also essential for its nearby shoreline communities, as fronds of this seaweed wash up on the beach, providing sustenance for invertebrates and serving as the foundation of beach food webs.

However, the extent of this cross-ecosystem connection is not fully understood.

"We know that there's a link between the kelp forest and the beach," said Kyle Emery, a researcher at UC Santa Barbara's Marine Science Institute. "But what we didn't know is over what spatial scale that connection is operating."

Now, Emery and colleagues are coming closer to such an understanding. In the journal *Communications Biology*, the team utilizes data taken in and around the kelp forests of the Santa Barbara Channel to elucidate the factors that drive the kelp connection between the nearshore and the beach. This, in turn, can inform habitat conservation and recovery efforts along the coasts, which are facing increased environmental pressures.

An elusive foundation species

Unlike forest ecosystems with more "permanent" foundation species such as trees, kelp forests come and go with changing ocean conditions, disappearing, propagating and reappearing in cycles throughout the year, subject to circumstances including temperature, pollution, grazing and wave action. This variability has made it challenging to quantify the underlying relationship of the beach ecosystem to the kelp forest, represented by kelp wrack—whole plants and/or fragments of kelp that

wash up on the beach.

"I wanted to determine the spatial relationship between the amount of kelp on the beach and the amount of kelp in the kelp forest," Emery said. By accounting for the biomass of kelp and where it goes, he explained, the researchers could begin to uncover a predictive relationship between the two variables.

Taking kelp dynamics data from the kelp forests within the National Science Foundation-supported Santa Barbara Coastal Long-Term Ecological Research (SBC LTER) study area—and building on years of satellite imaging work developed for kelp at UCSB—the research team analyzed the distribution of kelp on the beach at different spatial and temporal scales. These measurements involved local scales of 25 km of coastline survey at monthly intervals for more than five years, and a regional, 100 km scale study which utilized repeated snapshot surveys over fall and winter at 24 study sites.

"The analysis was a stepwise approach, looking at the relationship between the amount of kelp in the kelp forest and the amount of kelp on the beach at sequentially increasing radii from these beach sites," Emery explained.

Their results? "The connectivity between kelp forests and beaches is a very local process," Emery said, meaning that food webs and biodiversity of the beaches within less than 10 kilometers of kelp forests reap the most benefit from these subsidies. This highlights the importance of kelp forest extent and condition to the structure and function of nearby sandy beach food webs.

Furthermore, the researchers found that this connectivity was strongest in winter—a result of storm and wave action limiting the number of wide beaches that are able to receive the wrack.

"This has important implications for the conservation of beaches," Emery explained. "You can identify which beaches are likely to be biodiversity hotspots because of their proximity to kelp forests."

Efforts to conserve kelp would also benefit nearby beach food webs. Additionally, there are efforts to study kelp as part of a blue carbon strategy, in which kelp is grown as a way to sequester carbon. "But one of the bigger unknowns is the fate of kelp," Emery explained. "So when kelp is dislodged from the reef, improving our understanding of where it's likely to end up is important for that carbon accounting and budgeting."

The researchers' work illuminates the somewhat difficult to discern relationship between kelp forests and nearby beaches, both highly dynamic ecosystems. Related studies, which will build on these findings, are even more granular and involve tagging the seaweed to find out exactly where it ends up as it makes its landward journey from the kelp forest to the beach.

Research in this study was also conducted by Jenifer E, Dugan, Robert J, Miller, David M. Hubbard and Jessica R. Madden of UCSB; and Kyle Cavanaugh of UCLA.

More information: Kyle A. Emery et al, Deciphering spatial scales of connectivity in a subsidy-dependent coastal ecosystem, *Communications Biology* (2025). DOI: 10.1038/s42003-025-08354-8

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