# Santa Barbara Coastal LTER

Photo credit: U.S. LTER

Santa Barbara Coastal (SBC) LTER focuses on giant kelp forests fringing the coast of the Santa Barbara Channel in semiarid southern California. Kelp forests are prominent on shallow reefs at the coastal margin in temperate regions of the world and are highly valued for their ecosystem goods and services. Research at SBC LTER is dedicated to understanding how oceanic and terrestrial processes alter material flows to influence the ecology of these iconic coastal systems. In its first 19 years, SBC LTER has demonstrated the surprising resilience of giant kelp forests in the face of natural and human disturbance and the key role of dispersal and connectivity in driving that resilience. Through the combination of sustained measurements, long term experiments, satellite imagery, and modeling, SBC LTER is developing a mechanistic understanding of ecosystem structure and function and is poised to predict the impacts of climate change and human activities on kelp forest ecosystems.


Between 2008-2018:

**68** investigators

**16** institutions represented

**101** graduate students

Coastal

Principal Investigator:

Robert Miller

Marine Science Institute, University of California, Santa Barbara

Est. 2000

Funding Cycle:

LTER IV

NSF Program:

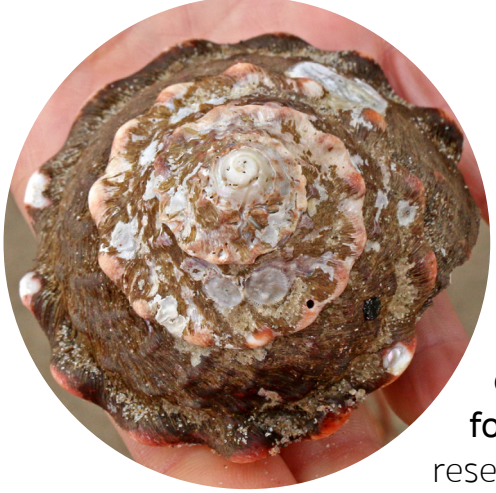
Geosciences / Division of Ocean Sciences

Biological Sciences / Division of Environmental Biology

# Key Findings

**Giant kelp shapes an entire ecosystem.** Results from long term measurements and experiments reveal that climate-driven disturbances that alter giant kelp abundance cascade through the kelp forest community, affecting biodiversity and ecosystem function. These effects are due to kelp's overwhelming influence on environmental conditions and habitat availability rather than its effects as a food source for fauna. [Products 1, 2]

**Fires mobilize nutrients to the ocean.** Fire and land use affect the amount and timing of nutrient organic matter and sediment delivery from watersheds to the ocean. Drought and fire followed by rain causes large fluxes of terrestrial nutrients to the coastal ocean. During storms, runoff plumes containing high concentrations of nutrients remain close to the coast, but are advected offshore and quickly diluted once the storms pass, thereby reducing the contribution of land-derived nutrients to the productivity of coastal ecosystems. [3, 4]



**Phytoplankton are the breadbasket of the kelp forest.** Decades of research based on carbon stable isotope analyses supported the idea that macroalgal detritus, especially that of kelp, is a major source of food to coastal marine ecosystems, particularly suspension feeders. Comparative and experimental research from SBC LTER has overturned this paradigm, showing that phytoplankton, not kelp, are the main food resource for coastal benthic suspension feeders. [5, 6]

**Kelp forests are surprisingly resilient to unprecedented warming.** A marine heat wave of extreme magnitude and duration in 2014-15 allowed SBC LTER researchers to test predictions about the effects of climate change on kelp forests. Although kelp was diminished by the prolonged high temperature and low nitrate conditions, it rebounded quickly, and most other flora and fauna were not greatly affected. Ocean sampling revealed that ammonium and urea persisted during warm periods and experiments showed that kelp can use these recycled nitrogen sources. [7-8]

Photo credits: SBC LTER (left); Erika Zambello (top and right)

Photo credit: Erika Zambello / U.S. LTER

# Synthesis

**Big waves trump grazing and nutrients.** Cycles of disturbance and recovery in kelp forests occur on time scales of years, making it an ideal system for studying processes that play out over much longer time scales in many ecosystems. Cross-site research between SBC LTER and researchers from central California demonstrated that regional differences in wave disturbance overwhelmed those in nutrient supply and grazing intensity to determine differences in giant kelp standing biomass and primary production. [9]

## Partnerships

Santa Barbara Channel Marine Biodiversity Observation Network (MBON) | NASA | Bureau of Ocean Energy Management | University of California, Santa Barbara

**Diverse ecosystems undergo drastic change.** Abrupt transitions or regime shifts are increasing for many ecosystems. Santa Barbara Coastal LTER contributed to a cross-site study of ecological responses to a changing environment in pelagic ocean, coastal benthic, polar marine, and semi-arid grassland ecosystems. In the majority of cases, abrupt transitions and underlying mechanisms were detected, providing information to help manage state changes. [10]

## Data Accessibility

The SBC LTER's information management system focuses on ease of data access, organization, integrity, and long term preservation. A flexible framework is designed to adapt to changes in NSF and community guidelines as information needs evolve. Since its inception, SBC has been a leader in the LTER Network Information System, working with other LTER sites and the wider community, including the National Center for Ecological Analysis and Synthesis, to improve data integration and availability within and beyond the LTER Network. In keeping with this history, SBC LTER is playing a key role in the new Ecological Data Initiative to curate LTER data network-wide.

Photo credit: Erika Zambello / U.S. LTER

# Broader Impacts

**Hands on science for girls.** Tech Trek is an on-campus residential science and math summer program at UC Santa Barbara to develop interest and self confidence in female students starting eighth grade, using hands-on field, laboratory and classroom activities designed around SBC LTER research.

**Teaching the teachers.** Four LTER sites, including SBC LTER, founded the groundbreaking Math Science Partnership project: *Pathways to Environmental Literacy* to connect research with teacher professional development. Site researchers and educators continue to deliver research based curricula on key concepts, including ocean circulation, weather, and biodiversity, to over 1,000 middle and high school students per year.

**Local impacts of global change.** Collaborating with scientists from Scripps Institution of Oceanography and the U.S. Geological Survey, SBC LTER investigators forecasted the vulnerability of Santa Barbara County's wetlands, watersheds and beaches to sea level rise. The results were presented in public meetings, and will be used by local land use planners and decision makers to inform coastal land use and sea level rise adaptation plans.

Photo credit: Erika Zambello / U.S. LTER

**The Golden Forest.** The new SBC LTER book in the LTER Schoolyard Series presents coastal ecology in a beautifully illustrated format. Owen visits his cousin Neko in California, where they have a snorkeling adventure and learn about kelp's role in the water and on coastal beaches.

## Top Products


1. Byrnes, JE et al. 2011. Climate-driven increases in storm frequency simplify kelp forest food webs. **Global Change Biology.** doi: 10.1111/j.1365-2486.2011.02409.x
2. Miller, RJ et al. 2018. Giant kelp, Macrocystis pyrifera, increases faunal diversity through physical engineering. **Proceedings of the Royal Society B: Biological Sciences.** doi: 10.1098/rspb.2017.2571
3. Romero, L et al. 2016. Characterizing storm water dispersion and dilution from small coastal streams. **Journal of Geophysical Research.** doi: 10.1002/2015JC011323
4. Aguilera, R and Melack, JM. 2018. Relationships among nutrient and sediment fluxes, hydrological variability, fire, and land cover in coastal California catchments. **Journal of Geophysical Research.** doi: 10.1029/2017JG004119
5. Page, HM et al. 2008. Assessing the importance of land and marine sources of organic matter to kelp forest food webs. **Marine Ecology Progress Series.** doi: 10.3354/meps07382
6. Miller, RJ et al. 2013. $\delta^{13}C$ and $\delta^{15}N$ of particulate organic matter in the Santa Barbara Channel: drivers and implications for trophic inference. **Marine Ecology Progress Series.** doi: 10.3354/meps10098
7. Reed, DC et al. 2016. Extreme warming challenges sentinel status of kelp forests as indicators of climate change. **Nature Communications.** doi: 10.1038/ncomms13757
8. Smith, JM et al. 2018. Urea as a source of nitrogen to giant kelp (Macrocystis pyrifera). **Limnology and Oceanography Letters.** doi: 10.1002/lol2.10088
9. Reed, DC et al. 2011. Wave disturbance overwhelms top-down and bottom-up control of primary production in California kelp forests. **Ecology.** doi: 10.1890/11-0377.1
10. Bestelmeyer, BT et al. 2011. Analysis of abrupt transitions in ecological systems. **Ecosphere.** doi: 10.1890/ES11-00216.1