Decreases in standing biomass and physiological state of giant kelp canopy during the 2014 – 2015 warming event in the Santa Barbara Channel

Tom W. Bell*[1], Daniel C. Reed[2], David A. Siegel[1]

[1]Earth Research Institute, University of California, Santa Barbara; [2]Marine Science Institute, University of California, Santa Barbara

***(thomas.bell@lifesci.ucsb.edu)**

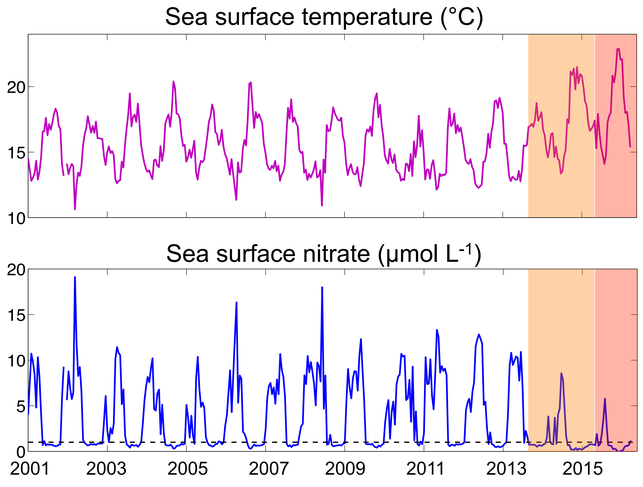
Motivation

- Giant kelp is a highly dynamic, globally distributed species that supports an ecologically and economically important ecosystem.
- The Santa Barbara Coastal Long-term Ecological Research Project (SBC LTER) maintains monitoring sites at several kelp forests in the Santa Barbara Channel.
- Satellite, airborne, and field data were combined to understand the impacts of the anomalously warm event on this foundation species.

Objectives

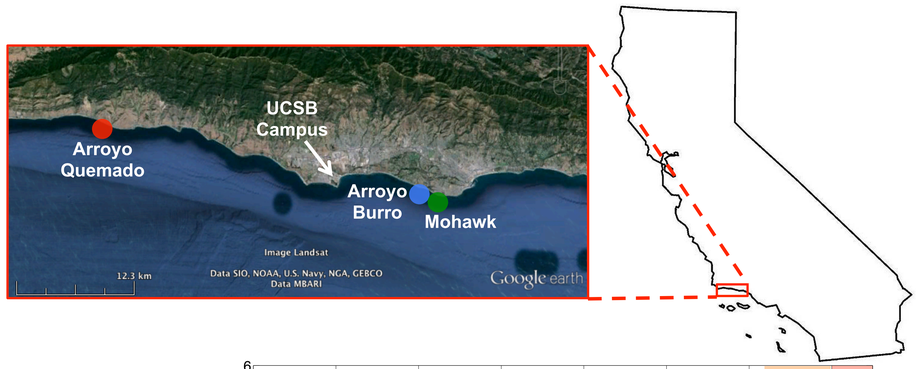
- Identify how the temperature and nutrient environment has changed in areas around long-term kelp monitoring sites.
- Assess changes in the biomass and physiological condition (i.e. chlorophyll:carbon) of the giant kelp canopy and determine how these changes are linked to changes in the environment.
- Use data and conclusions to support work mapping the physiological condition and net primary production of giant kelp canopy using hyperspectral imagery.

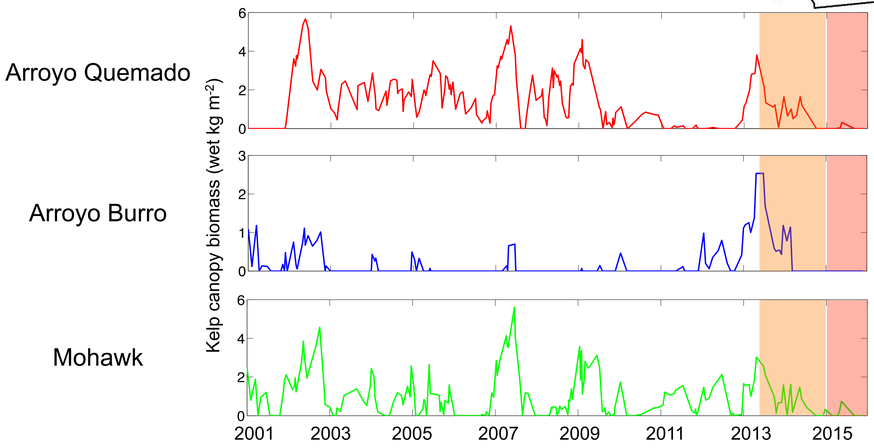
↑ surface temperature and ↓ nitrate concentrations near SBC LTER kelp forest sites



- Orange region represents anomalously warm event (~June 2013 – February 2015), red region represents El Niño. Sea surface temperature from MODIS. Surface nitrate estimated from SST (Zimmerman & Kremer 1984). Dashed line represents 1 µmol L^{-1}, below which is unfavorable for kelp growth.

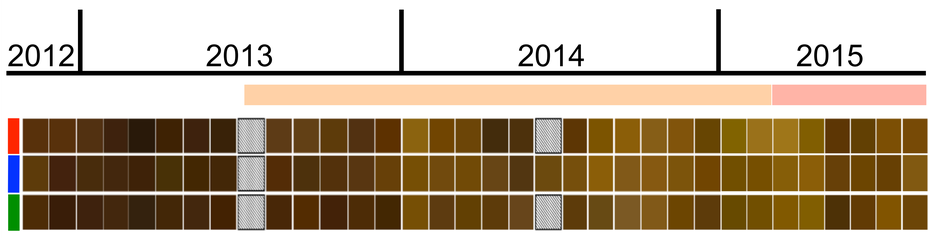
Decreased kelp canopy biomass during anomalously warm period leading to complete disappearance in late 2015





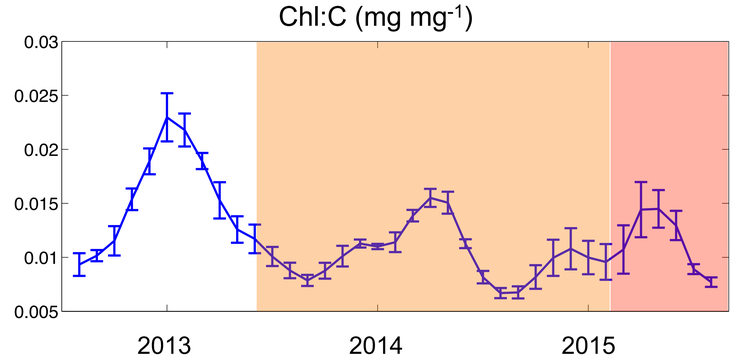
- Giant kelp canopy biomass estimated from Landsat satellites (Cavanaugh et al. 2011; Bell et al. *in prep*).

Color of canopy blades lightens during anomalously warm temperature period



- Reflectance measured across the visible and near-infrared range showed a lightening of kelp canopy blades from the 3 long-term monitoring sites shown above. Dashed boxes represent missing data. Colors represent average values from 15 kelp blades sampled at each site using photographs in laboratory.

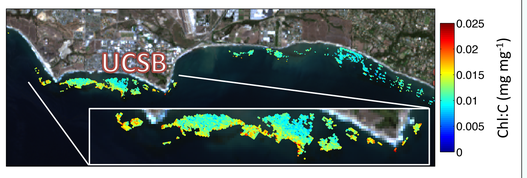
Concurrent decreases in Chl:C, a proxy for physiological condition

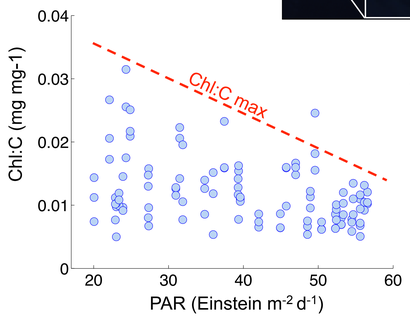


- Chl:C from each reef is related to available nitrate in the surface waters (r^2 = 0.6, $p < 0.001$). Error bars are SE. Pigment extracted following Seely et al. 1972.

Chl:C follows anticipated dependencies on light and nutrients, may lead to remote estimation of NPP

- Chl:C of giant kelp canopy estimated from AVIRIS hyperspectral imagery on 4/13/2013 (Bell et al. 2015).





- Laboratory estimated Chl:C decreases as a function of PAR. Residuals from max line scale with growth rate for other marine autotrophs (Behrenfeld et al. 2005).
- Declines in kelp biomass and physiological condition (Chl:C) are associated with anomalous warm event.
- Chl:C is strongly associated with surface nitrate concentrations and did not adjust to the low nitrate conditions present during the warm period or current El Niño episode. This possibly led to reduced growth rates in the surface canopy.

Acknowledgements

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