



# Top-down and bottom-up indicators of bull kelp forest ecosystem health



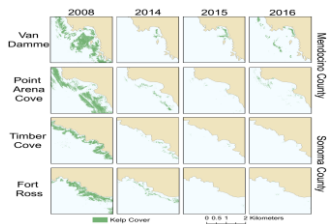
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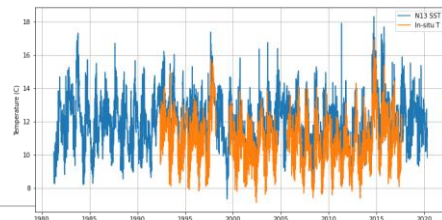
## Introduction

### Kelp Forest Indicators

The sudden collapse of the kelp forest reveals the need to develop indicators of ecosystem health



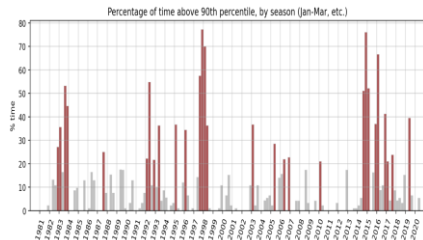
Bull kelp forests support lush species rich nearshore marine ecosystems that provide a suite of ecosystem services. These ecosystems have enhanced species diversity, support important recreational and commercial fisheries, sequester carbon and diminish waves. The sudden, unpredicted ecosystem shift from previously stable kelp forest to depauperate sea urchin barrens in 2014 (Rogers-Bennett and Catton 2019) reveals the need for indicators (García-Reyes et al. 2014) of ecosystem health.



Kelp Canopy Fly Over CDFW

## Temperature Results

We set the threshold at 30% such that when 30% of the season exceeded the 90% percentile of the time series, the season fails the criterion. This threshold successfully identifies previously important warm periods, 1982-1983 El Niño, 1997-1998 El Niño and the marine heat wave of 2014, 2015, 2016, 2017 and 2019.



## Methods and Results



Photo credit R. Travetti

### Kelp Forest Indicators

- A 40 year time series of benthic **seawater temperature** (blue) in conjunction with SST buoy temperature (orange) data
- A 20 year monitoring program using scuba of **sea urchins** in the northern California's bull kelp forest
- Threshold set at 90<sup>th</sup> percentile of urchin all transects (N=443) 2003-2013 prior to urchin outbreak in Sonoma and Mendocino Co. is set at >200 urchin per transect

## Conclusions

- We use long term kelp forest monitoring data to establish thresholds for healthy kelp forests
- Subtidal temperature and purple sea urchins are critical indicators of kelp ecosystem health
- Tracking indicators and establishing thresholds are essential for proactive kelp ecosystem restoration and management



Bull Kelp Photo credit E. Jones

### References

- García-Reyes, Largier & Sydeman 2014 Progress in Oceanography Synoptic-scale upwelling indices and predictions of phyto- and zooplankton populations. Prog. Oceanogr. 120: 177-188.
- Rogers-Bennett and Catton 2019 Marine heat wave and multiple stressors tip bull kelp forest to sea urchin barrens. Scientific Reports 9: doi.org/10.1038/s41598-019-51114-y