

# Exploring kelp response and recovery to climate-driven disturbances with Kelpwatch.org, a visualization and analysis webtool

ITRS

Tuesday 10th January 2023

Vienna Saccomanno, Ocean Scientist

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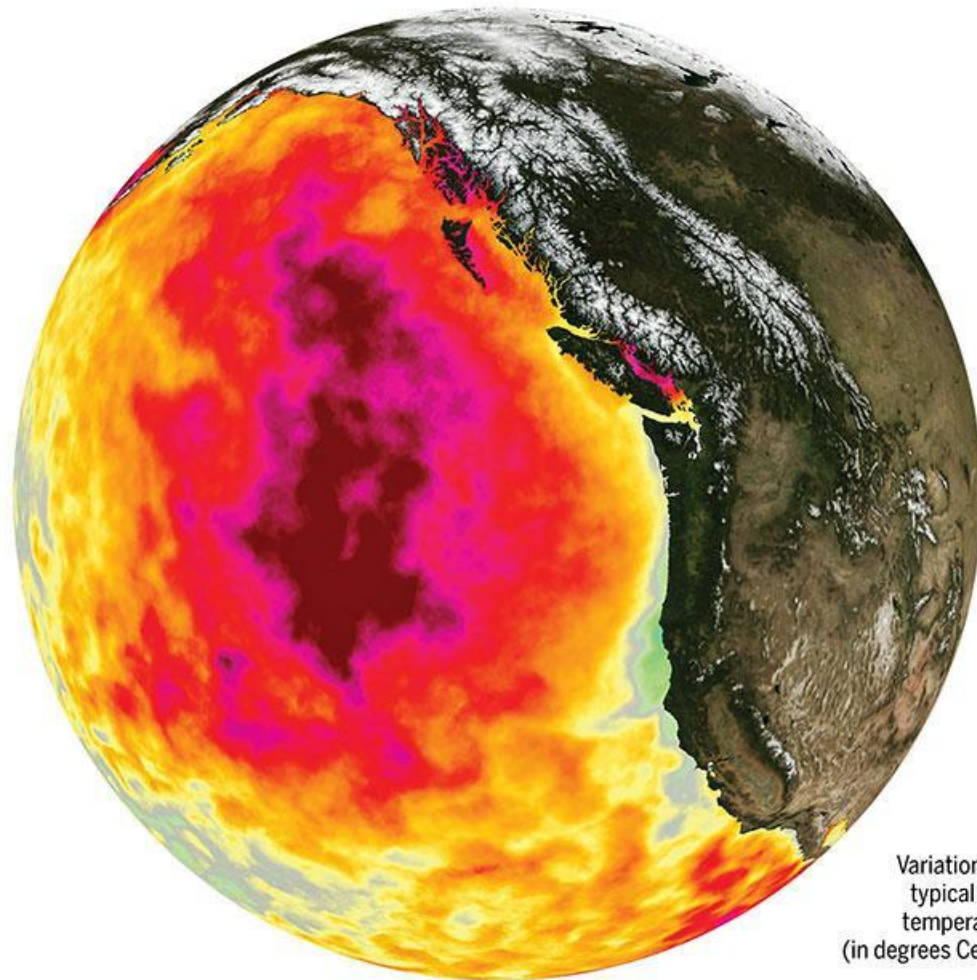
Tom W. Bell<sup>1</sup>, Kyle C. Cavanaugh<sup>2</sup>, **Vienna R. Saccomanno**<sup>3</sup>, Katherine C. Cavanaugh<sup>2</sup>, Henry F. Houskeeper<sup>2</sup>, Norah Eddy<sup>3</sup>, Falk Schuetzenmeister<sup>3</sup>, Nathaniel Rindlaub<sup>3</sup>, and Mary Gleason<sup>3</sup>

1 - Woods Hole Oceanographic Institution

2 - University of California Los Angeles

3- The Nature Conservancy





3  
0  
-3  
Variation from  
typical water  
temperatures  
(in degrees Celsius)

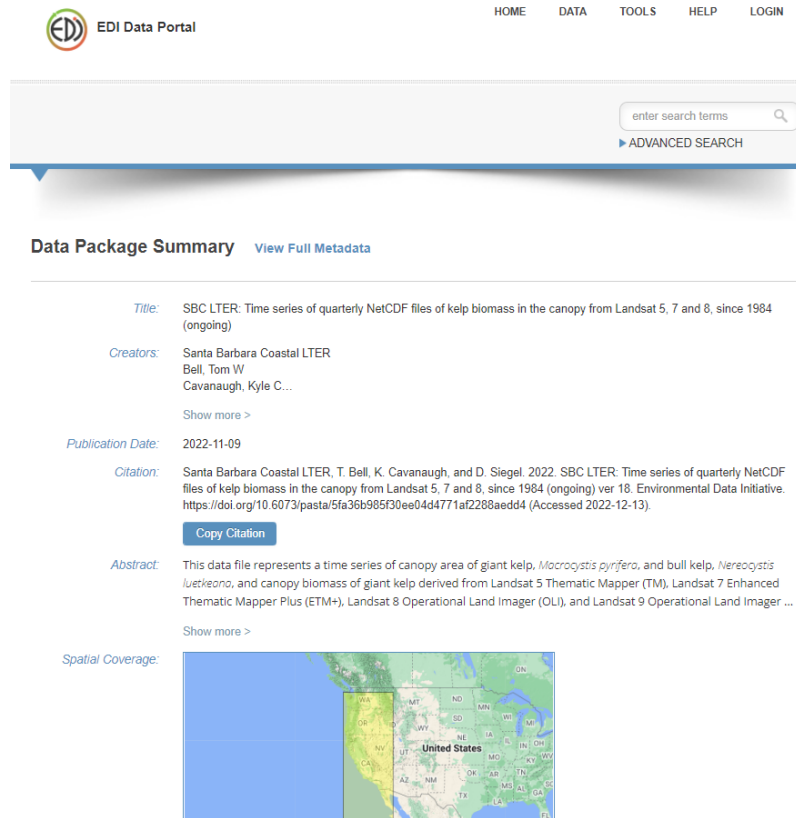
**May 2015**

Image: NASA Physical  
Oceanography  
Distributed Active  
Archive Center

# The Kelpwatch.org data


Santa Barbara Coastal LTER, T. Bell, K. Cavanaugh, and D. Siegel. 2022. SBC LTER: Time series of quarterly NetCDF files of kelp biomass in the canopy from Landsat 5, 7, 8 and 9, since 1984 (ongoing) ver 17. Environmental Data Initiative.

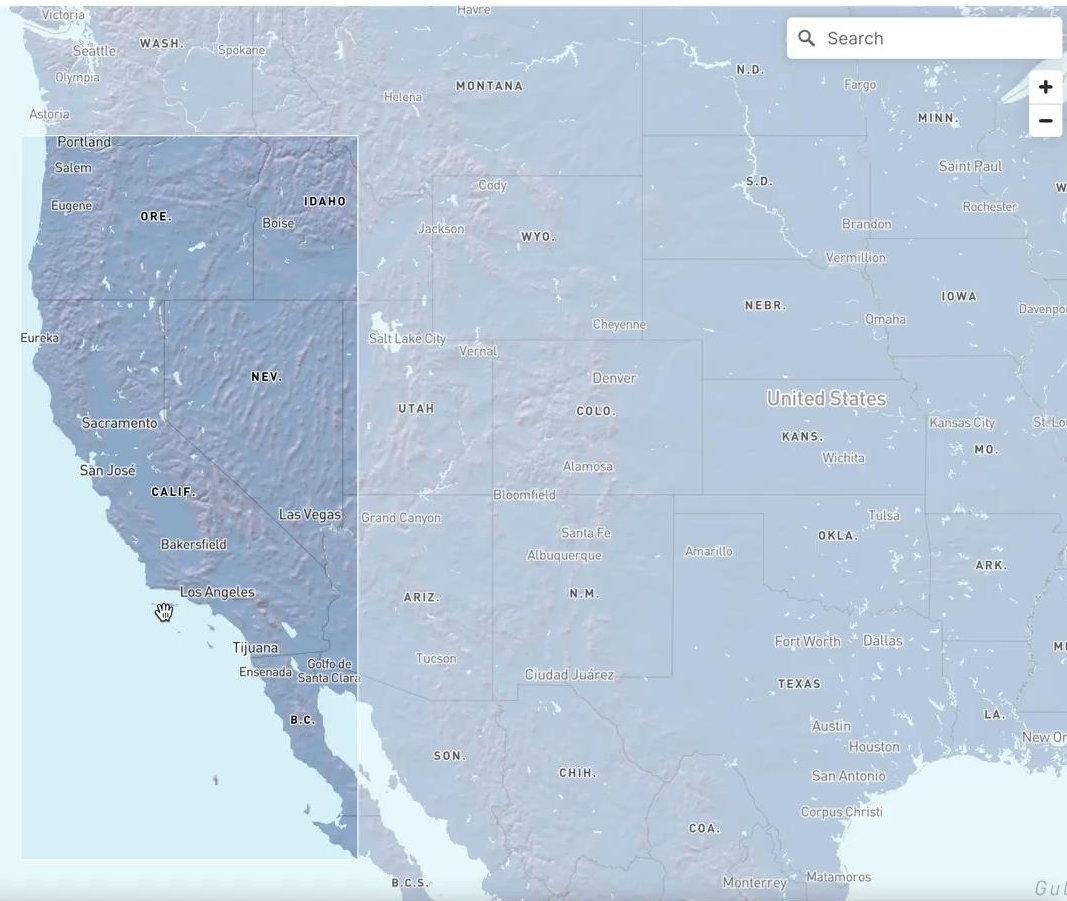
<https://doi.org/10.6073/pasta/c560928d61e21ae42b32877160099554>



The screenshot shows the EDI Data Portal interface. At the top, there is a navigation bar with the EDI logo and the text "EDI Data Portal". To the right of the logo are links for HOME, DATA, TOOLS, HELP, and LOGIN. Below the navigation bar is a search bar with the placeholder text "enter search terms" and a magnifying glass icon. To the right of the search bar is a link for "ADVANCED SEARCH".

The main content area is titled "Data Package Summary" with a link for "View Full Metadata". Below this title, the following information is displayed:

- Title:** SBC LTER: Time series of quarterly NetCDF files of kelp biomass in the canopy from Landsat 5, 7 and 8, since 1984 (ongoing)
- Creators:** Santa Barbara Coastal LTER, Bell, Tom W, Cavanaugh, Kyle C...  
[Show more >](#)
- Publication Date:** 2022-11-09
- Citation:** Santa Barbara Coastal LTER, T. Bell, K. Cavanaugh, and D. Siegel. 2022. SBC LTER: Time series of quarterly NetCDF files of kelp biomass in the canopy from Landsat 5, 7 and 8, since 1984 (ongoing) ver 18. Environmental Data Initiative. <https://doi.org/10.6073/pasta/5fa36b985f30ee04d4771af2288aed4> (Accessed 2022-12-13).  
[Copy Citation](#)
- Abstract:** This data file represents a time series of canopy area of giant kelp, *Macrocystis pyrifera*, and bull kelp, *Nereocystis luetkeana*, and canopy biomass of giant kelp derived from Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), and Landsat 9 Operational Land Imager ...  
[Show more >](#)
- Spatial Coverage:** 

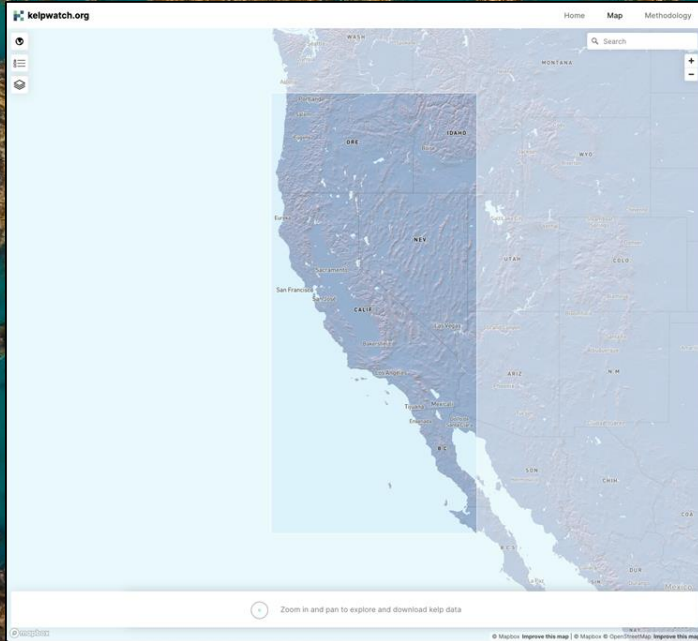


Search

Zoom in and pan to explore and download kelp data

## Research questions

1. What were the regional trends in kelp canopy area across the spatial extent of the data over the past 38 years?
2. What were the spatial patterns of kelp canopy area in response to and recovery from the 2014-2016 marine heatwave period?
3. How do local-scale patterns in recent kelp canopy area in a subregion compare to historical data?



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## Research questions

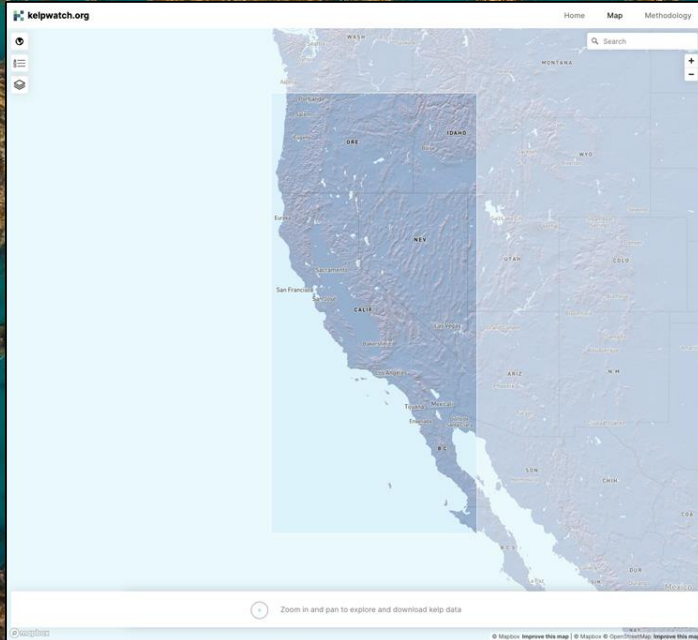
1. What were the regional trends in kelp canopy area from Oregon to Baja CA, MX over the past 38 years?
2. What were the spatial patterns of kelp canopy area in response to and recovery from the 2014-2016 marine heatwave events?
3. How do local-scale patterns in recent kelp canopy area in a subregion compare to historical data?

Tom W. Bell<sup>1\*</sup>, Cavanaugh, KyC<sup>2</sup>, **Saccomanno, VR<sup>3</sup>**, Cavanaugh, Ka<sup>2</sup>, Houskeeper, HF<sup>2</sup>, Eddy, N<sup>3</sup>, Schuetzenmeister, F<sup>3</sup>, Rindlaub, N<sup>3</sup>, and Gleason, M<sup>3</sup>. Kelpwatch: A new visualization and analysis tool to explore kelp canopy dynamics reveals variable response to and recovery from marine heatwaves. *In review.*

1 - Woods Hole Oceanographic Institution

2 - University of California Los Angeles

3 - The Nature Conservancy

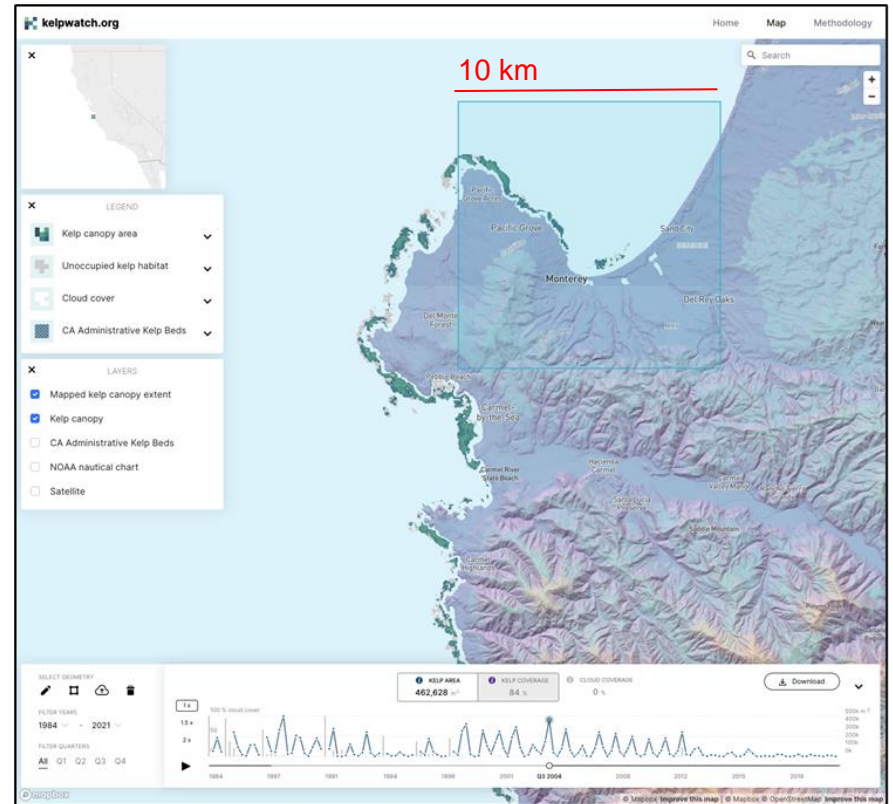


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# What were the spatial patterns of kelp canopy area in response to and recovery from the MHW period?

1. Uploaded 10x10 km cells to Kelpwatch.org along data extent - downloaded quarterly data
2. For each 10x10 km cell, took annual maximum and created a time series.
3. For each 10x10 km cell, examined kelp canopy dynamics during and after MHW relative to the historical mean across years preceding MHW (1984 to 2013)
4. Mapped it



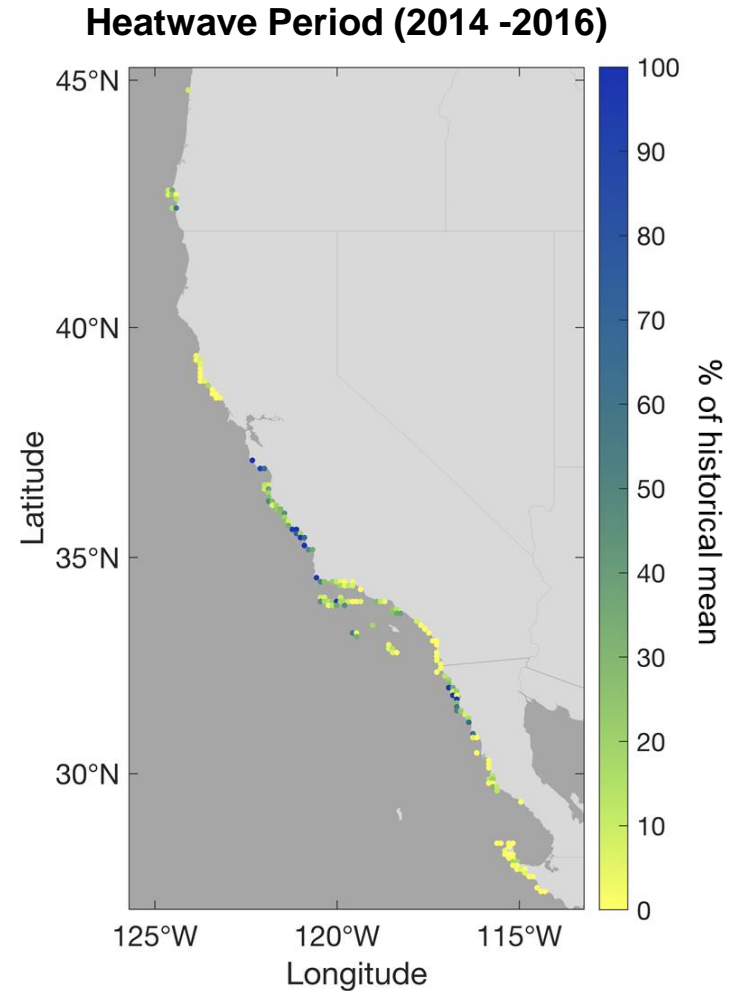
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4. Mapped it

year	quarter	kelp_area_m2	count_cells_kelp	count_cells_no_clouds	count_cells_historic_footprint
1984	1	0	0	0	1678
1984	2	71084	361	1661	1678
1984	3	297588	878	1646	1678
1984	4	80581	676	1671	1678
1985	1	0	0	0	1678
1985	2	257854	563	749	1678
1985	3	308862	788	974	1678
1985	4	216324	832	1508	1678
1986	1	7931	164	1666	1678
1986	2	12673	184	1674	1678
1986	3	170398	861	1672	1678
1986	4	151580	934	1674	1678
1987	1	21271	215	1662	1678

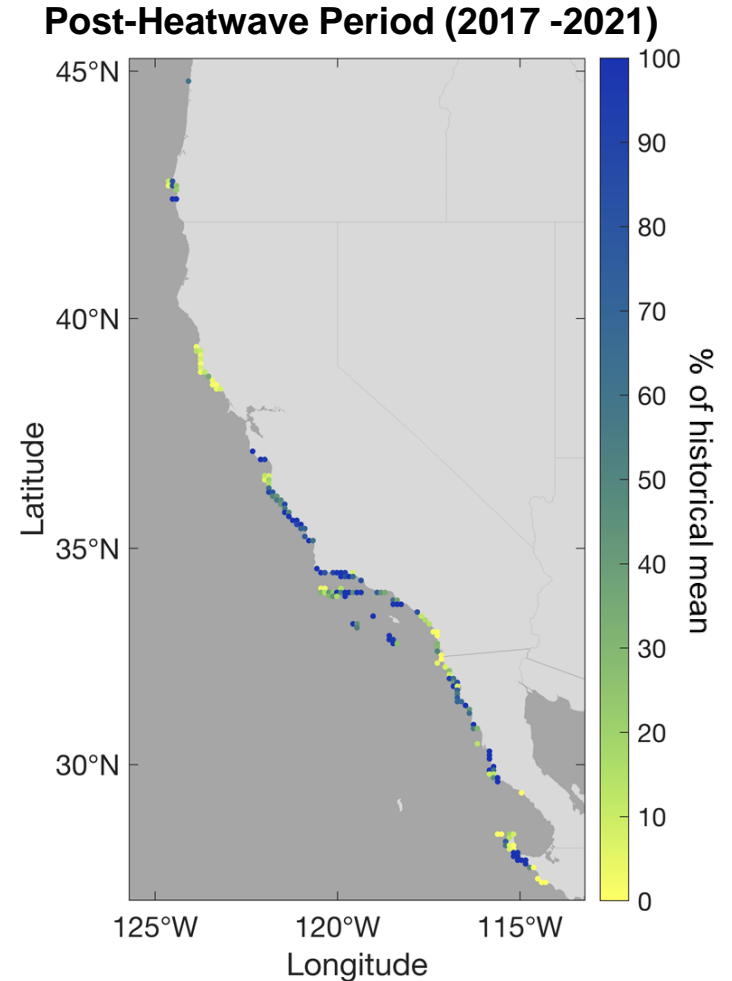
# Kelp canopy response to MHW

- Response = minimum annual kelp canopy area in each cell during MHW relative to historical mean (1984-2013).
- Kelp canopy area was reduced to a minimum annual area of 21.7% (SD 37.8%) across all 10x10km cells.



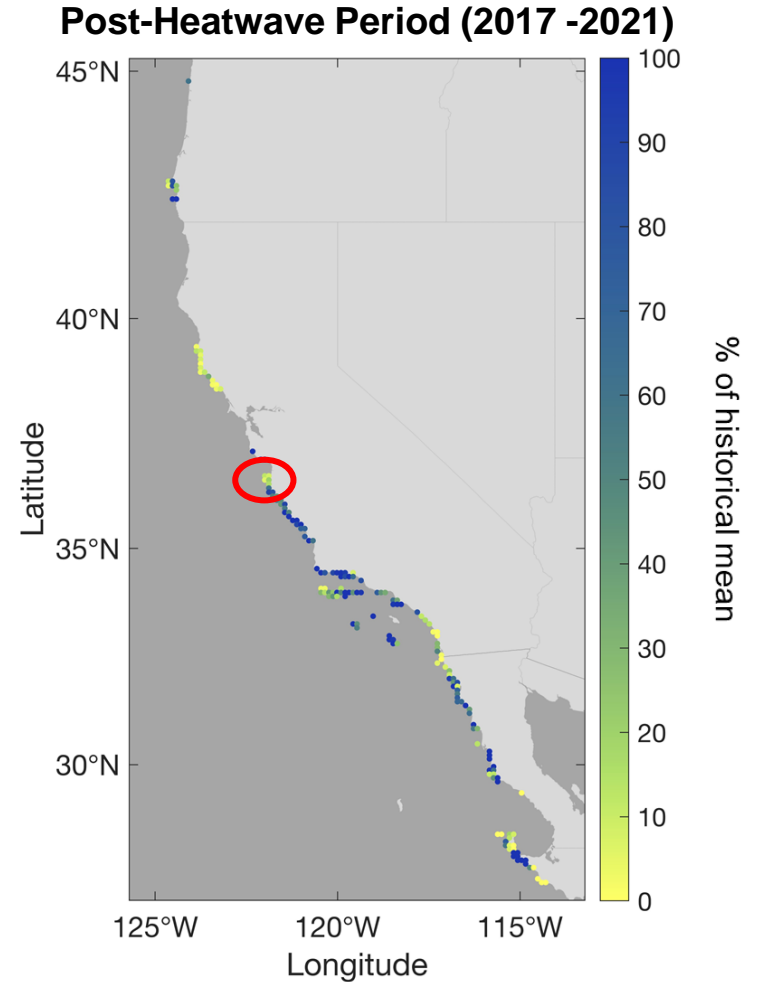
# Kelp canopy recovery from MHW

- Recovery = mean annual kelp area from 2017-2021 relative to historical mean (1984-2013)
- On average all of the cells recovered to about 73% (SD 85.8%) of the historical average.



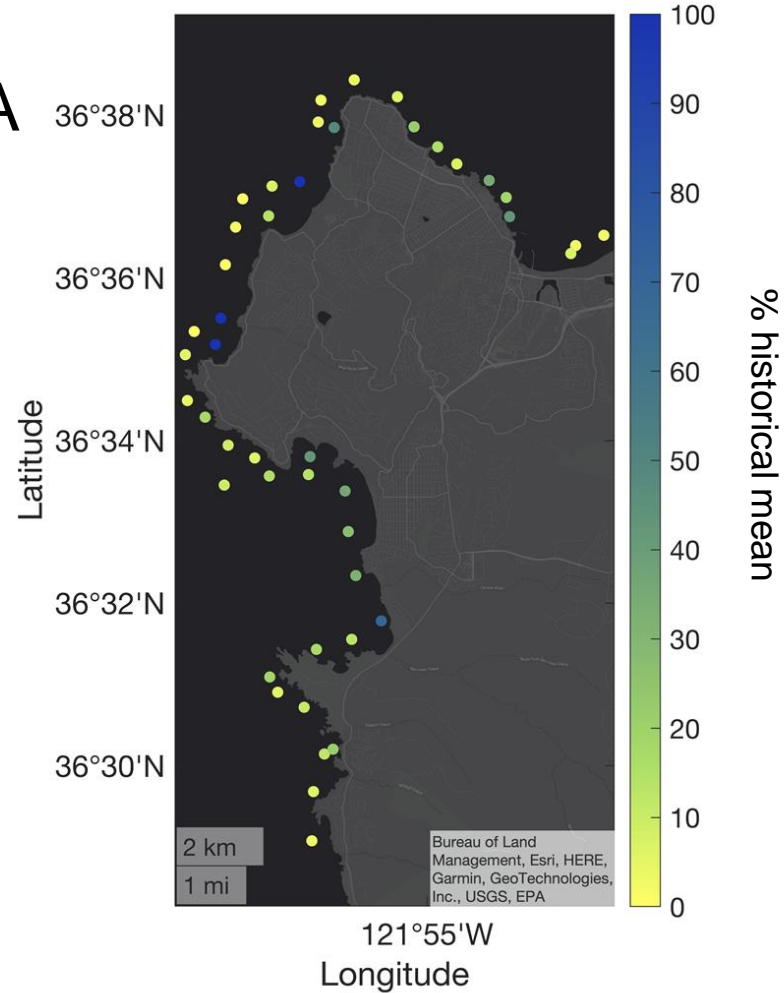
# Kelp canopy recovery from MHW

- Recovery was strong along Central California coast with a mean regional recovery of 96.8% (SD 107.9%)
- Except kelp canopies around Monterey Peninsula.



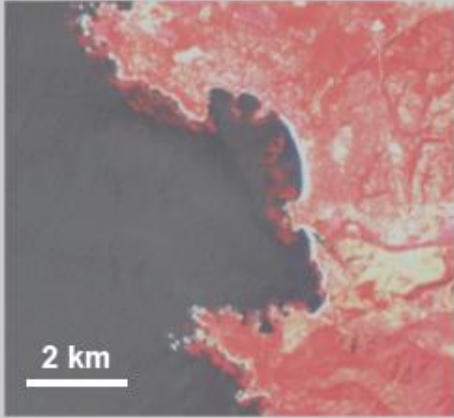
# How do recent, local-scale patterns in kelp canopy around Monterey CA compare to historical data?

- 1x1 km cells along 40 km of coastline
- Mean annual kelp area during period of decline (2014-2021) relative to historical mean = recent state of kelp canopy
  - ~90% of cells <50% of historical mean
  - ~46% of cells <10% of historical mean
  - 6.5% of cells at or above historical mean
- Longest period of low canopy cover on record for this area



# Landsat imagery (false color) around Monterey Bay, CA

September 18, 2011



September 15, 2016

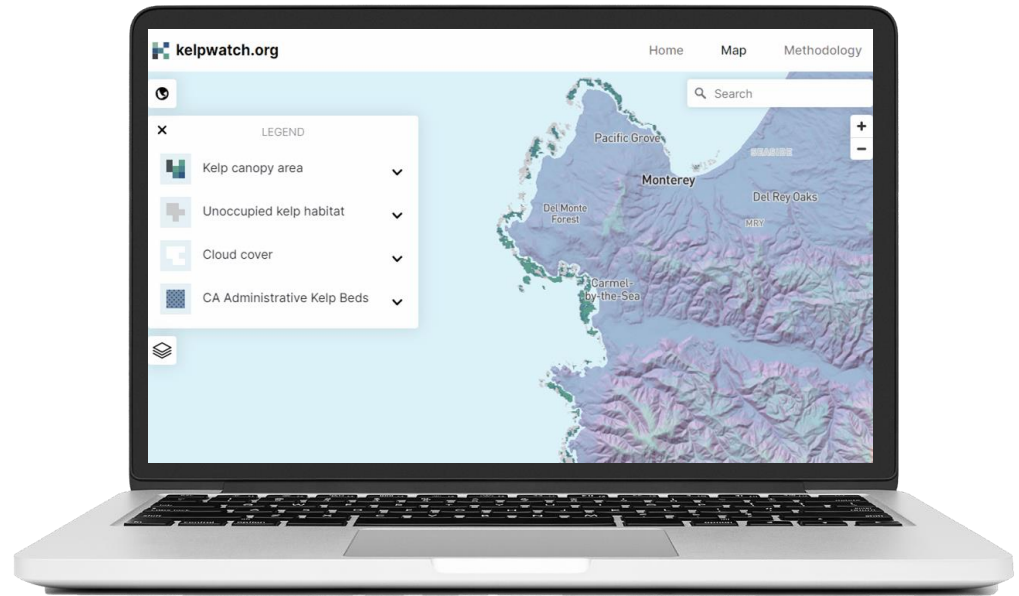


September 29, 2021



Thank you!

- Tom Bell, WHOI
- Kyle Cavanaugh, UCLA
- Henry Housekeeper, UCLA
- Kate Cavanaugh, UCLA
- Norah Eddy, TNC
- Falk Schuetzenmeister, TNC
- Natty Rindlaub, TNC
- Mary Gleason, TNC
- Steve Lonhart, NOAA (manuscript review)
- Kristen Elsmore, CDFW (manuscript review)
- GreenInfo Network (web development)
- Development Seed (web development)



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Questions?

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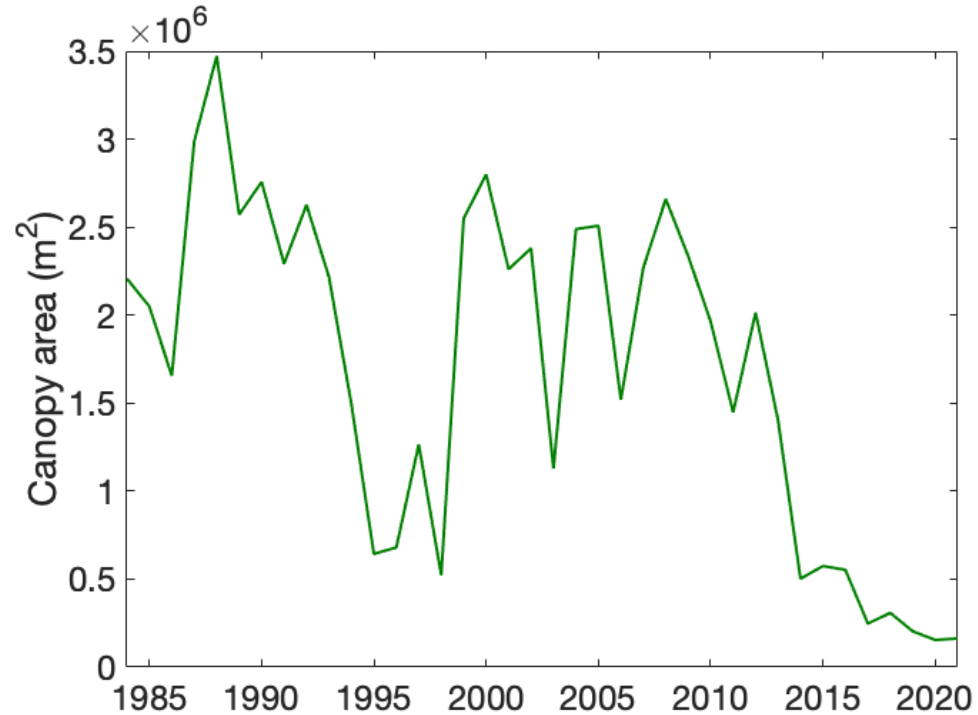
## Kelpwatch.org Expansion Plan

- Falkland Islands (ETA 2023)
- SE Alaska (ETA 2023)
- Chile (ETA 2023/2024)
- Tasmania (ETA 2024)
- New Zealand (ETA 2024)
- South Africa (ETA 2024)

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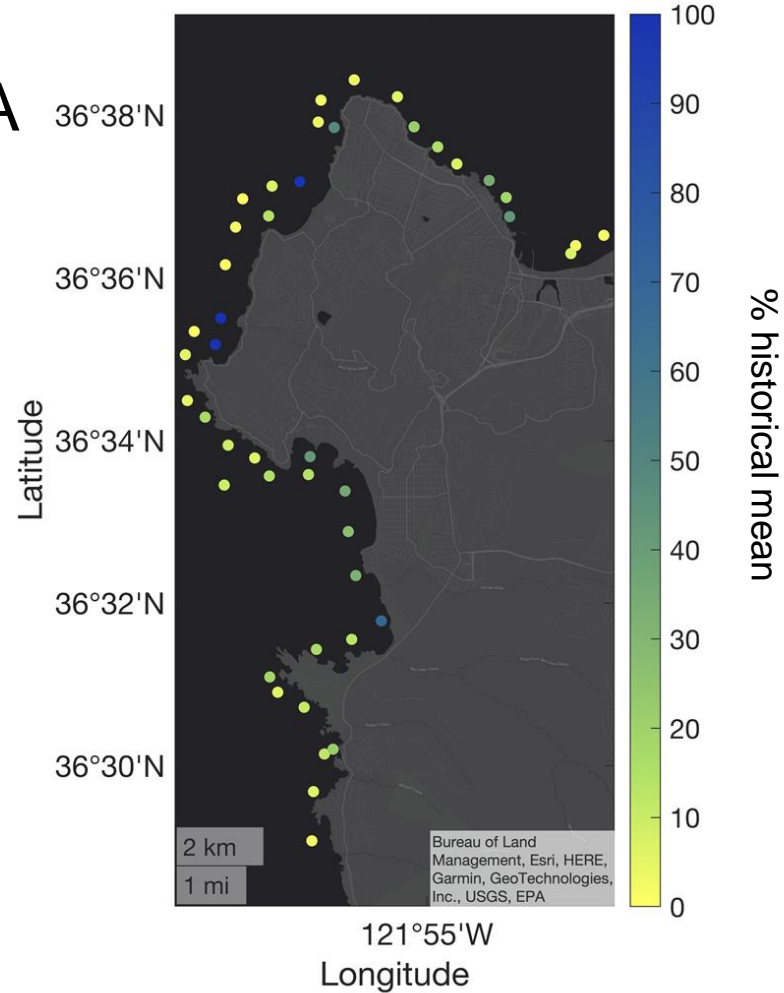


How do local-scale patterns in recent kelp canopy area around the Monterey Bay Peninsula subregion compare to historical data?



# How do recent, local-scale patterns in kelp canopy around Monterey CA compare to historical data?

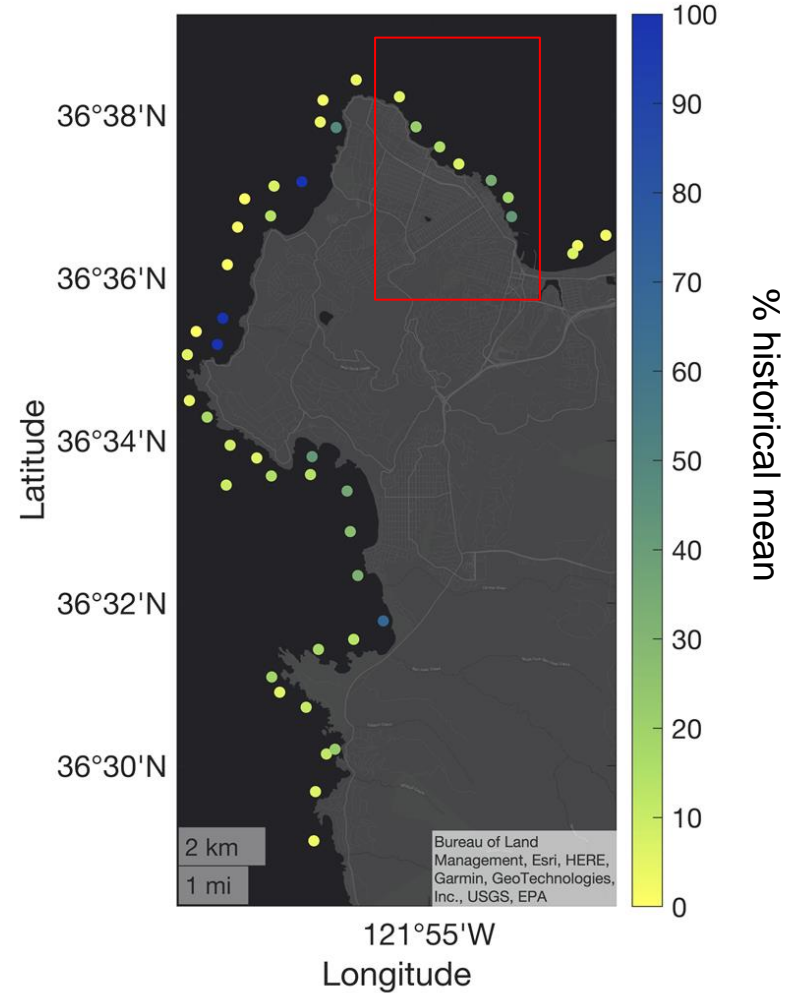
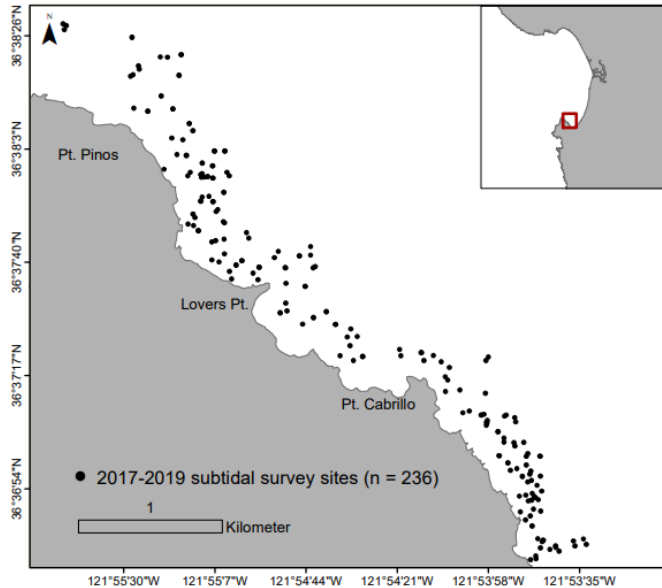
- Smith et al 2021 - field-based analysis of spatial patterns of sea otter foraging
- Why was this subregion less resilient than other areas in Central California?
- Longest period of low canopy cover for this area



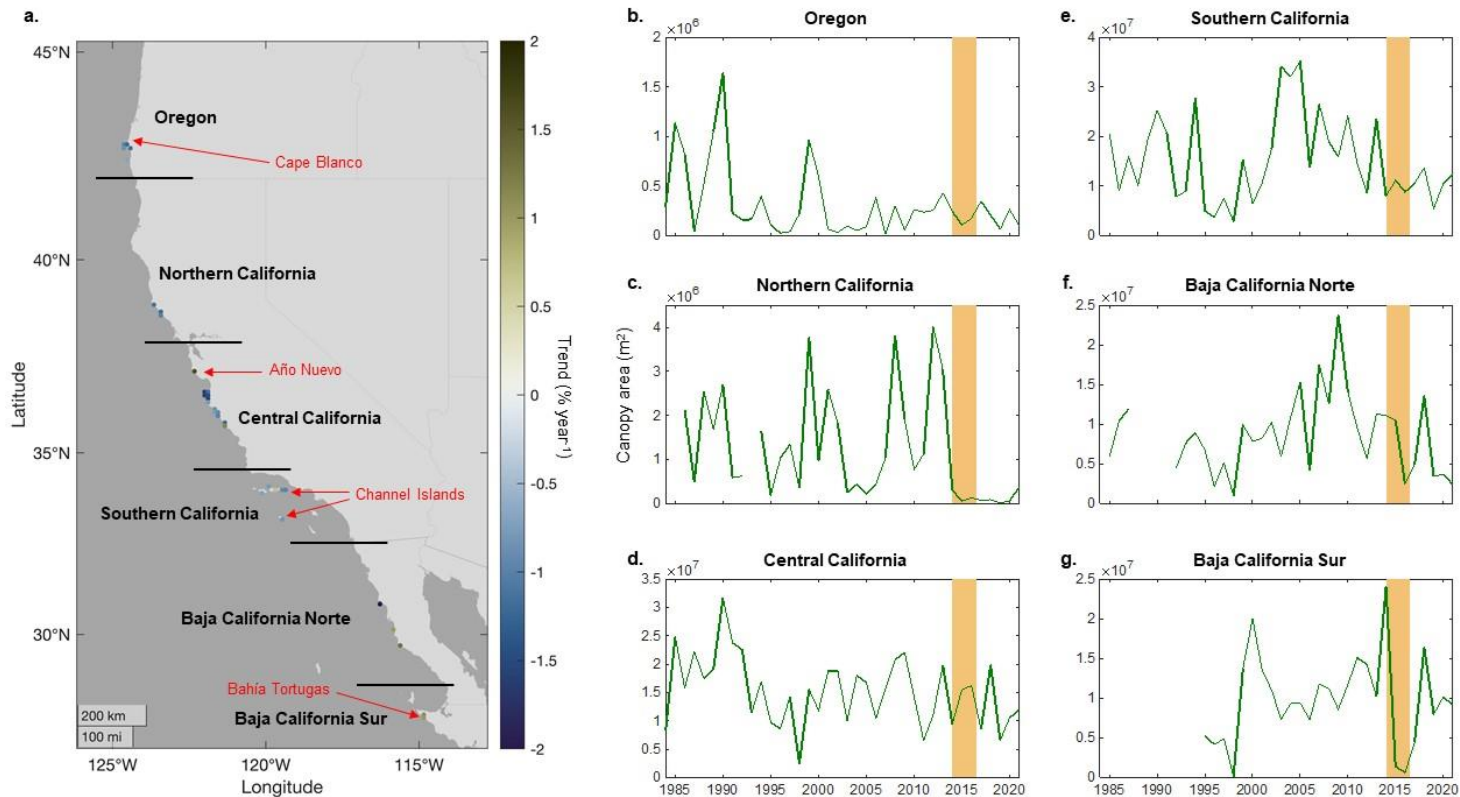
# Field-based analysis spatial context

Smith, J. G., et al. (2021). Behavioral responses across a mosaic of ecosystem states restructure a sea otter–urchin trophic cascade. *Proceedings of the National Academy of Sciences*, 118(11), e2012493118.

**Figure S1.** Subtidal rocky reef survey sites along the Monterey Peninsula, California, USA.



# What were the regional trends in kelp canopy over the past 38 years?



# Landsat kelp canopy classification paper

Bell TW, Allen JG, Cavanaugh KC, Siegel DA. Three decades of variability in California's giant kelp forests from the Landsat satellites. *Remote Sens Environ.* 2020;238: 110811. doi:10.1016/j.rse.2018.06.039