Giant Kelp Forests: Stepping Stones to Biodiversity

NSF LTER Symposium: Understanding Our Ocean Connections
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UC Santa Barbara
Santa Barbara, CA
kelp canopy

Photo Credit: Ron McPeak

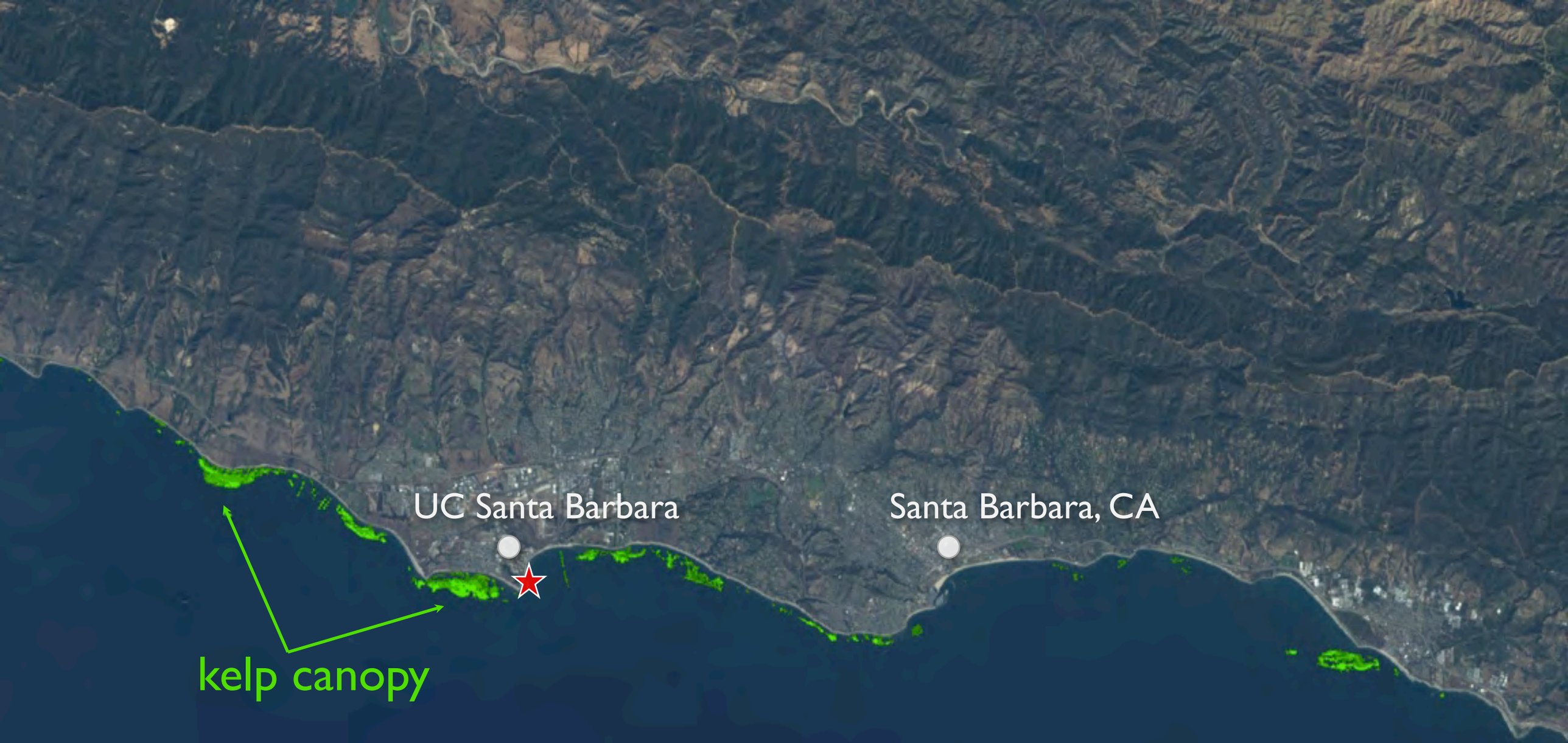
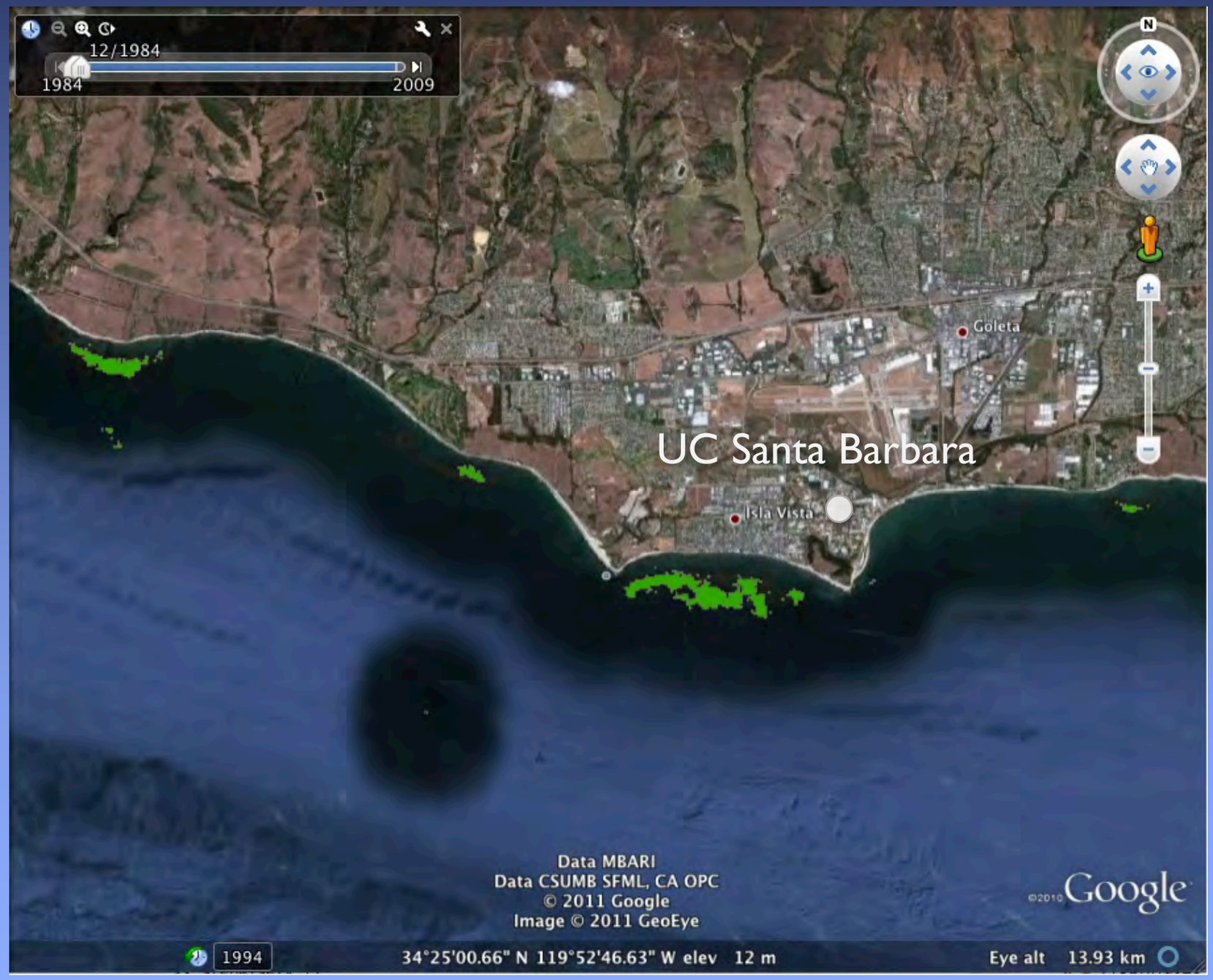

UC Santa Barbara
Santa Barbara, CA
kelp canopy

Photo Credit: SBC LTER

Giant kelp is highly dynamic



Giant kelp is a foundation species

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The number of living creatures of all Orders whose existence intimately depends on the kelp is wonderful.
Darwin 1839

Photos: SBC LTER

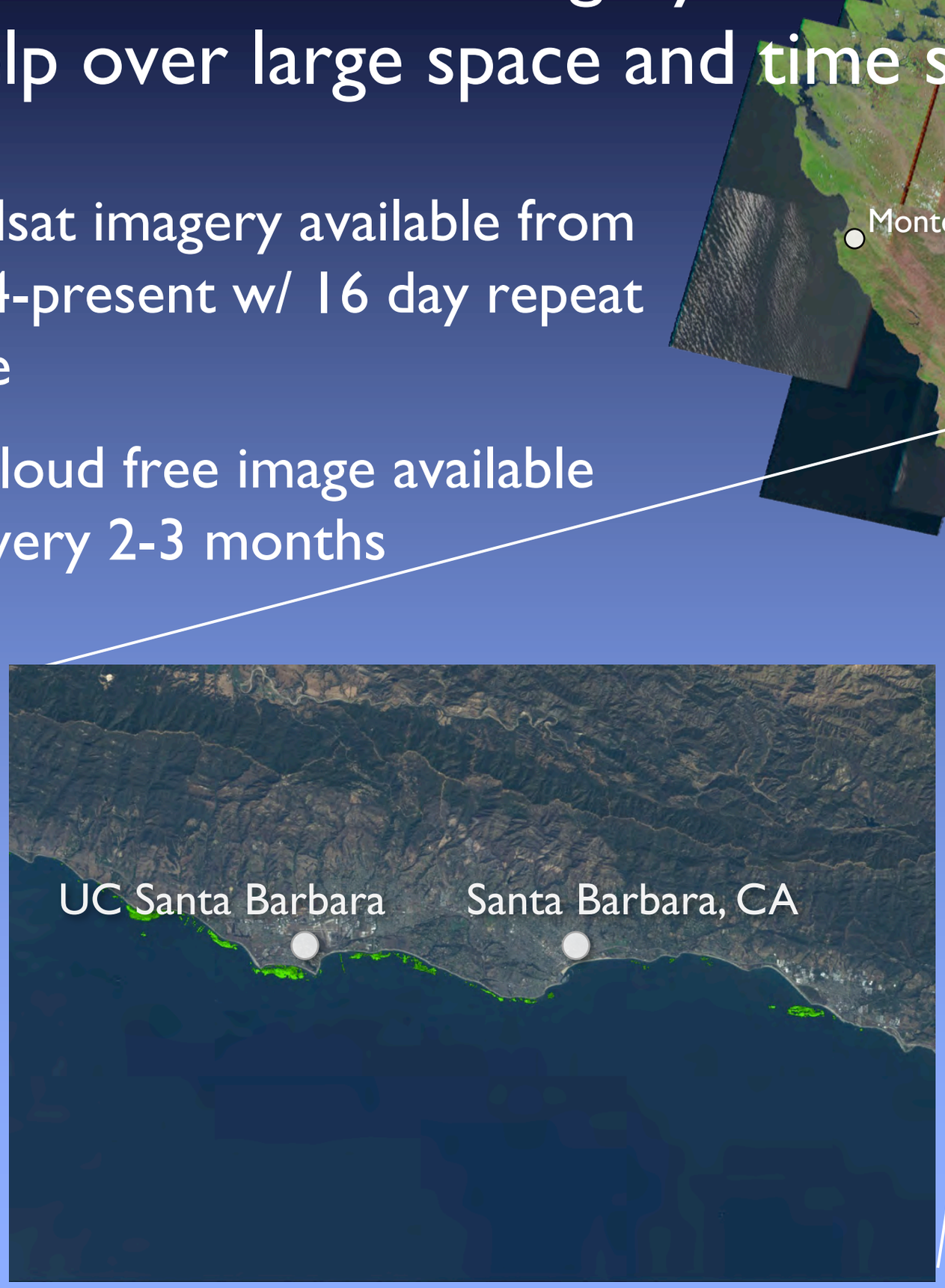
Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here from the destruction of the kelp.
Darwin 1839

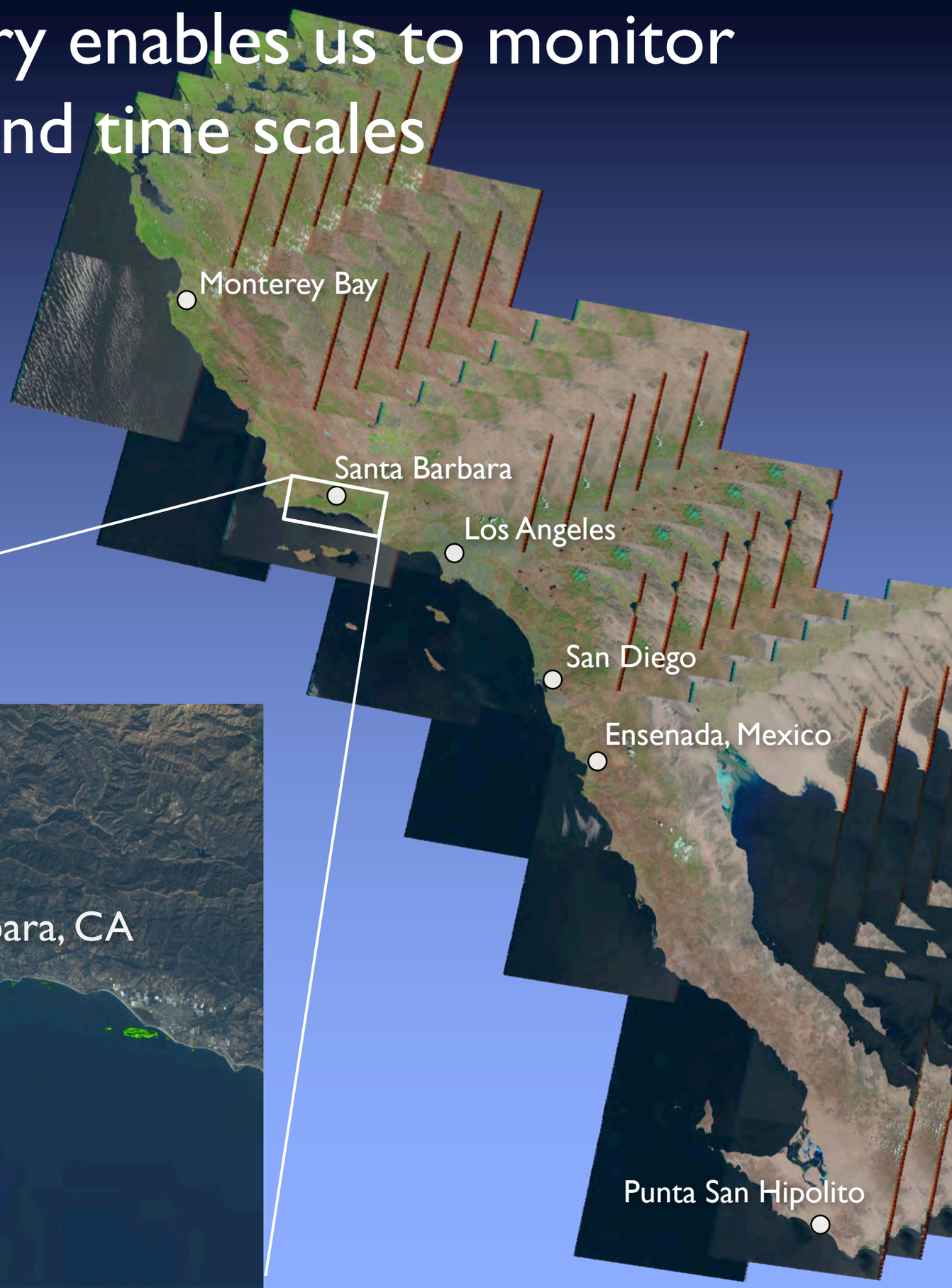
1. How is giant kelp resilient to repeated disturbance?

2. How does repeated disturbance impact giant kelp community structure?

Landsat satellite imagery enables us to monitor kelp over large space and time scales

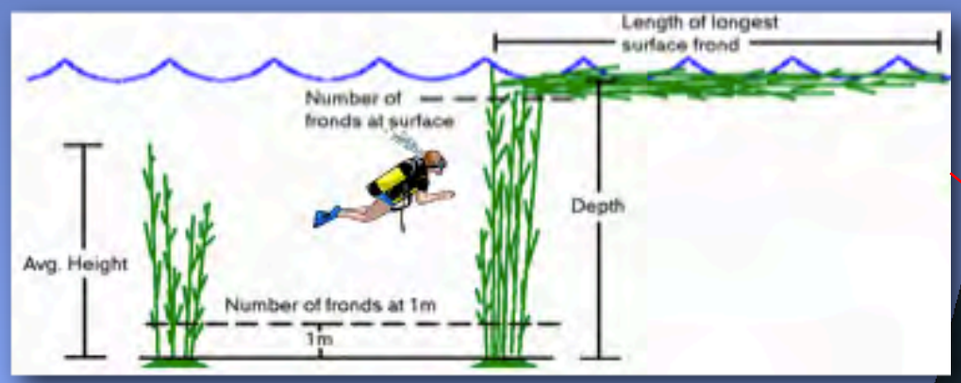
- Landsat imagery available from 1984-present w/ 16 day repeat cycle
  - Cloud free image available every 2-3 months





In situ data enables us to transform imagery into biologically meaningful data

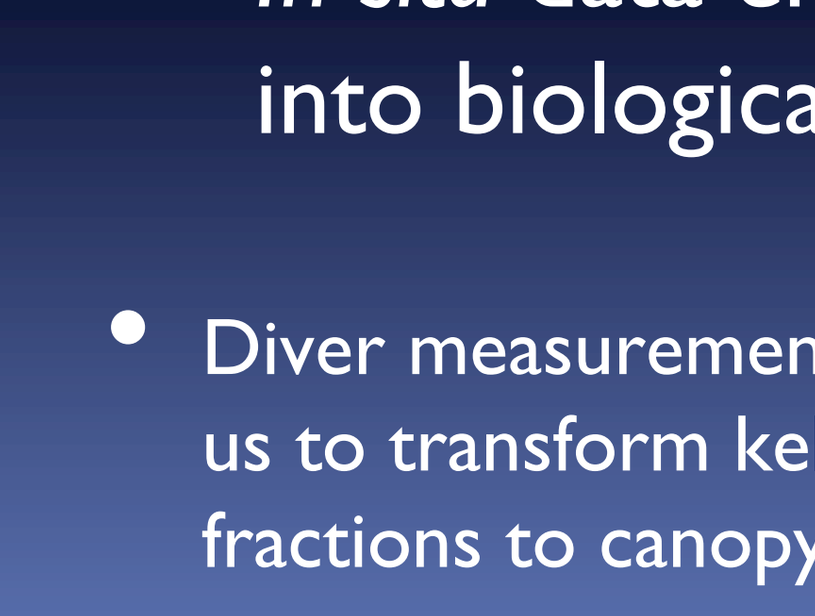
- Collected kelp canopy biomass data from SCUBA diver surveys

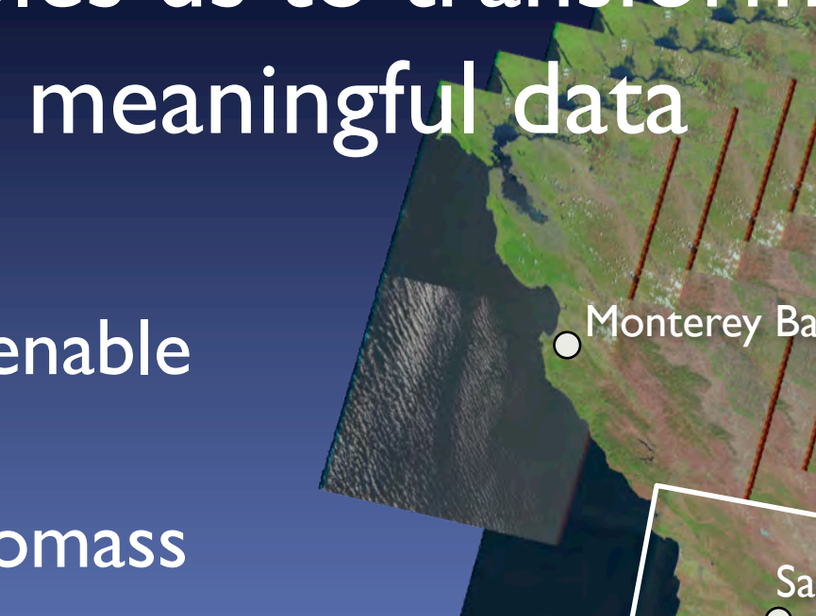


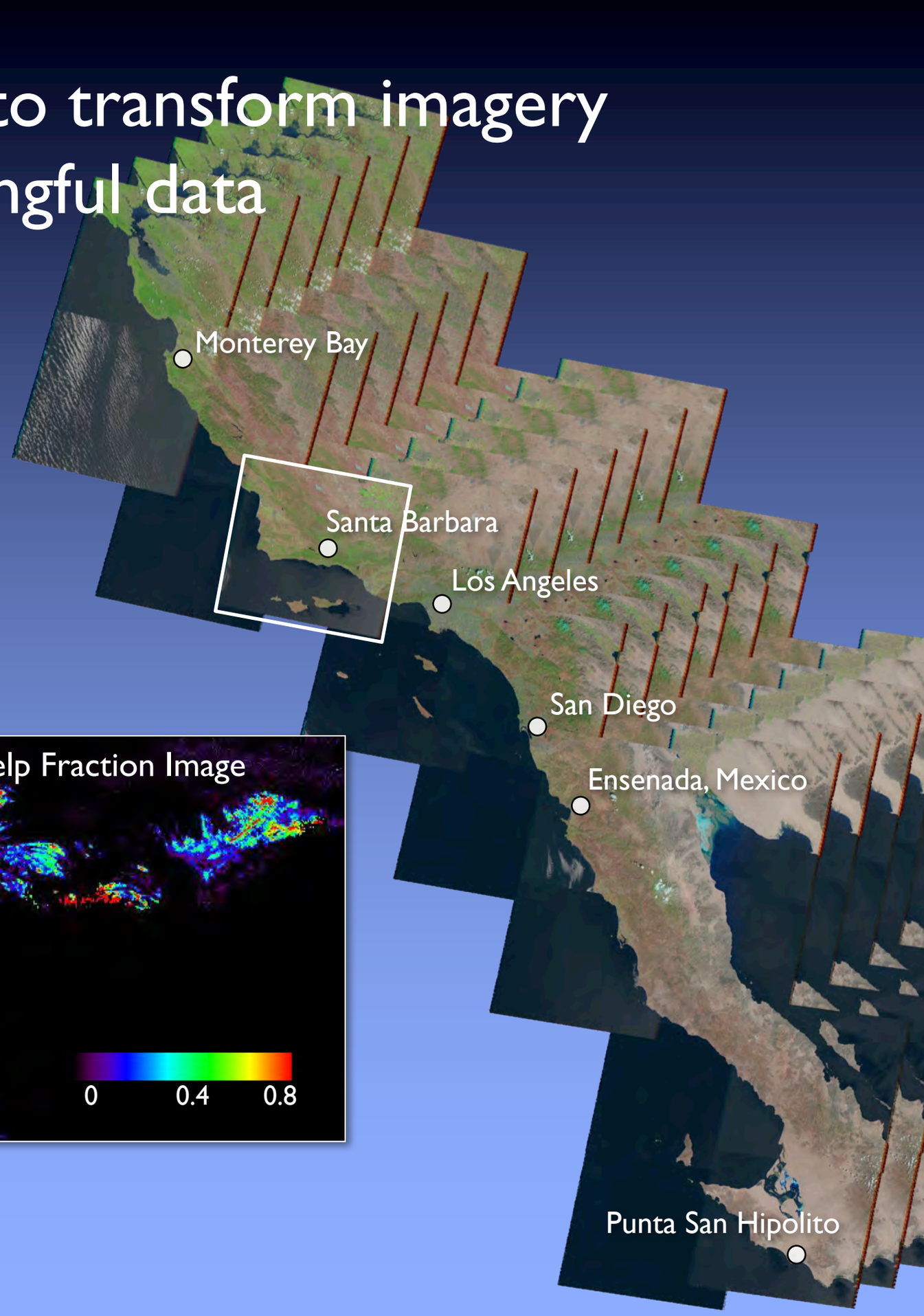
Monterey Bay
Santa Barbara
Los Angeles
San Diego
Ensenada, Mexico
Punta San Hipolito
Santa Barbara
LTER kelp forest monitoring sites

In situ data enables us to transform imagery into biologically meaningful data

- Diver measurements enable us to transform kelp fractions to canopy biomass







Cavanaugh et al. (2010, 2011)
Bell et al. (in review)

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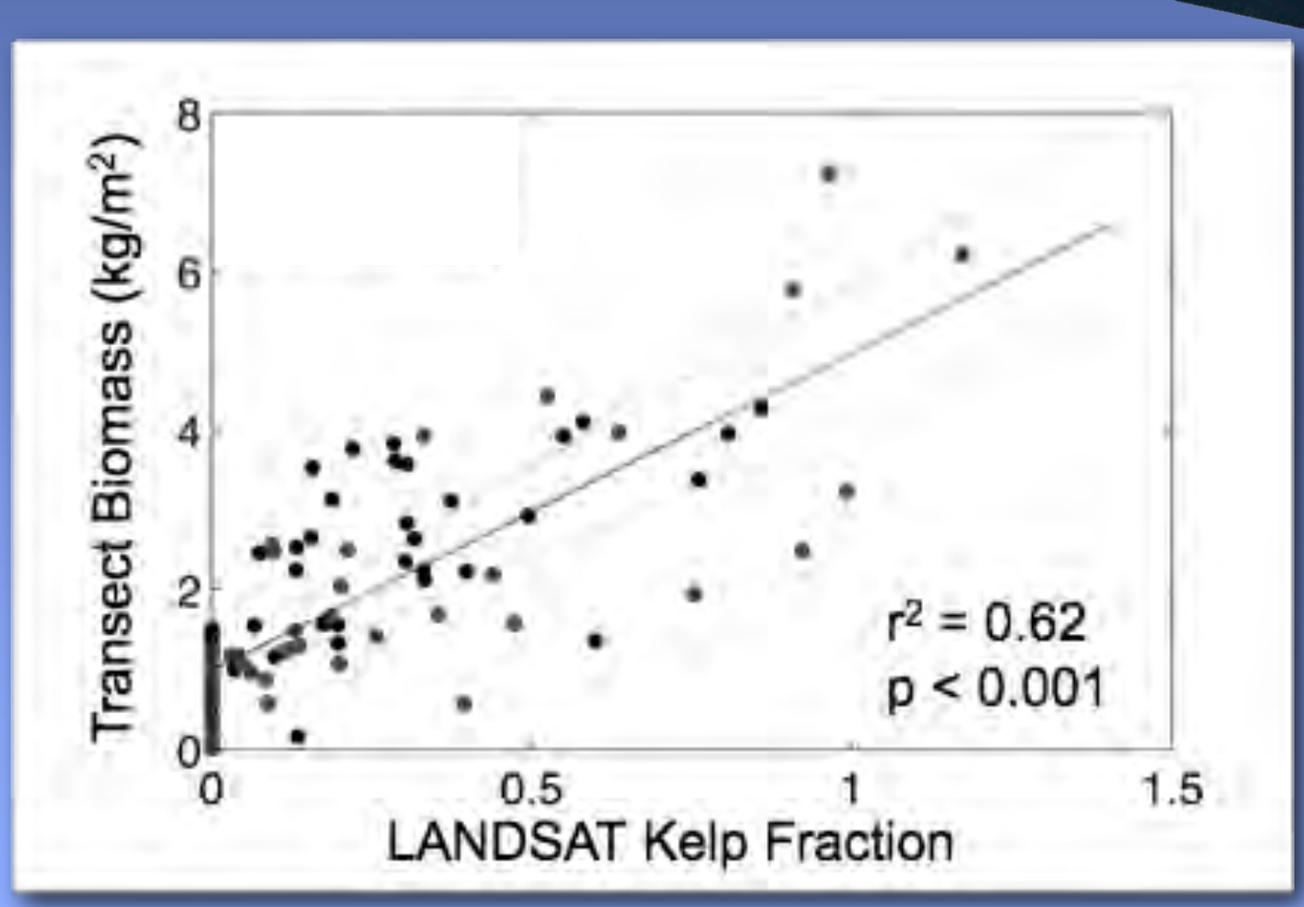

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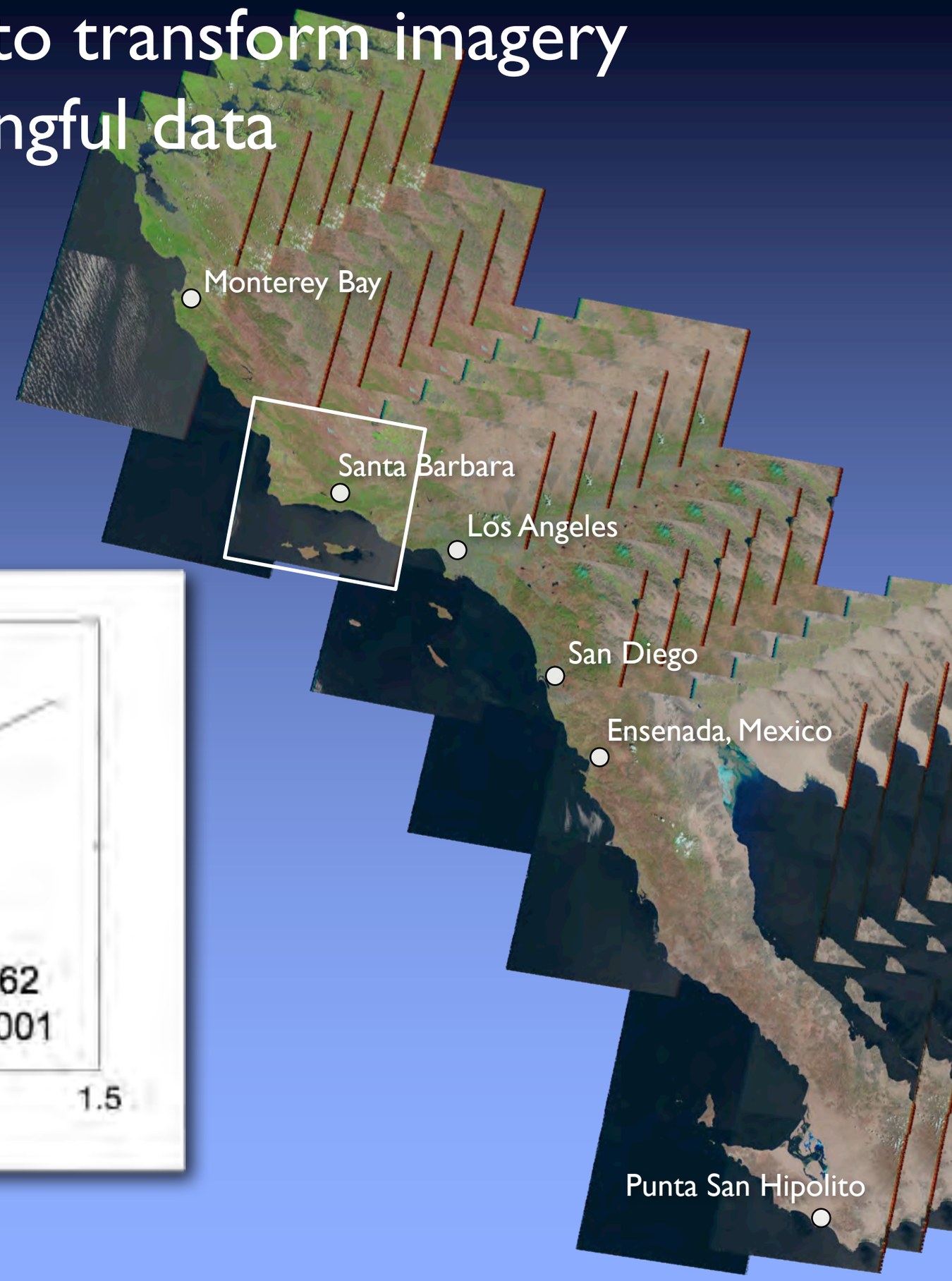
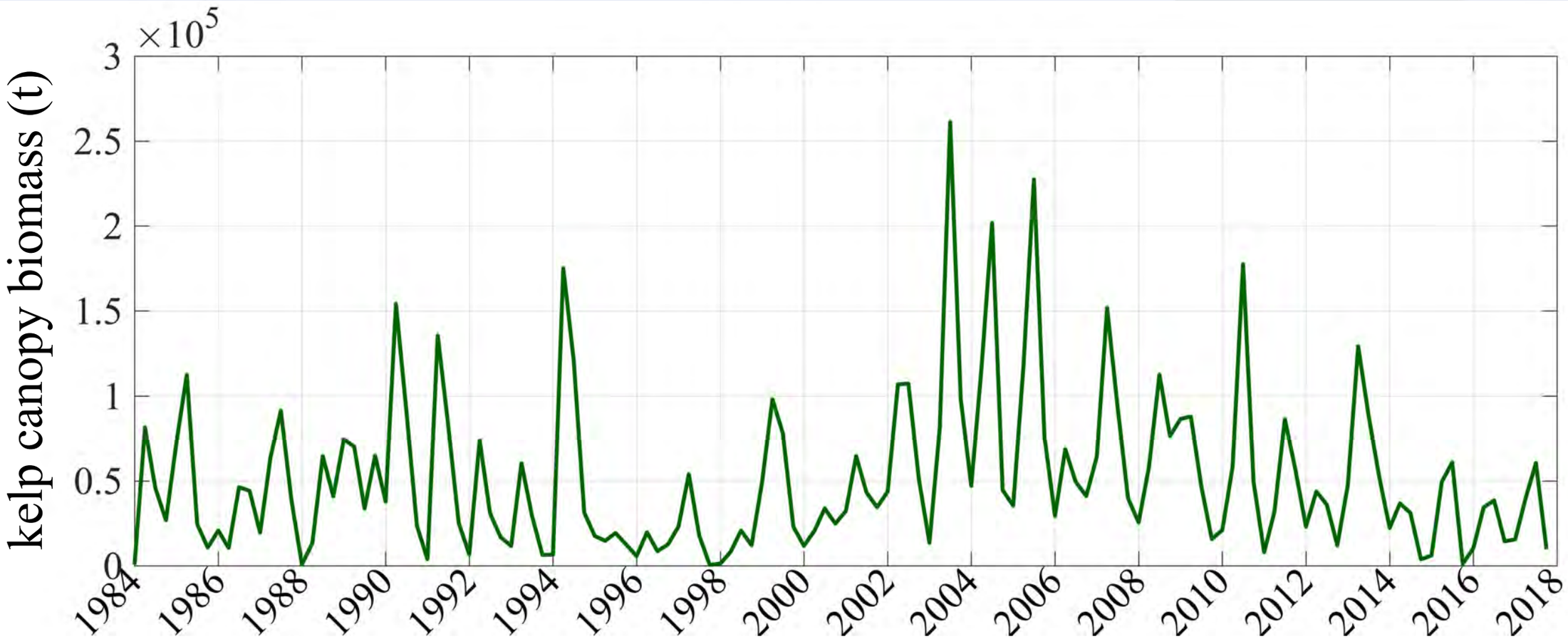


First repeated, regional scale estimates of kelp canopy biomass

Temporal dynamics of giant kelp in southern California (1984-2017)

- Highly variable from year to year
- No clear long-term trend
- Declines during strong El Niños



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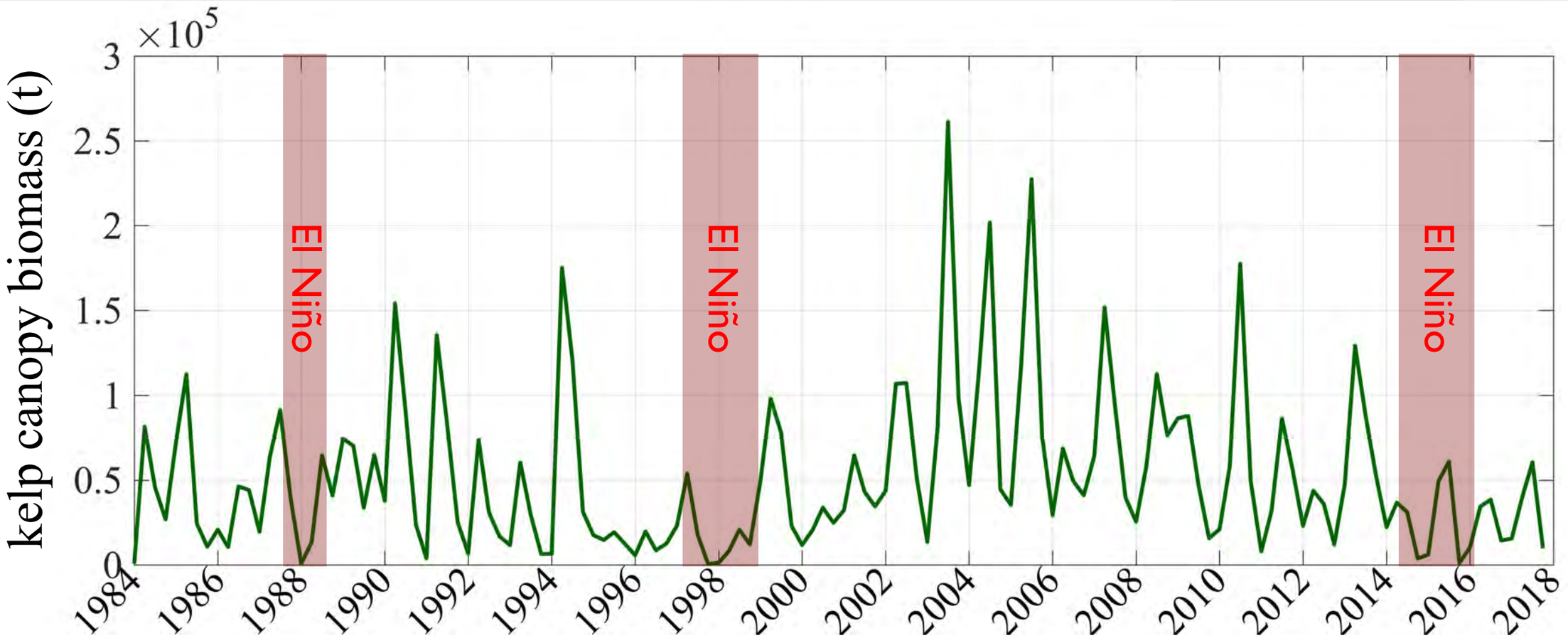
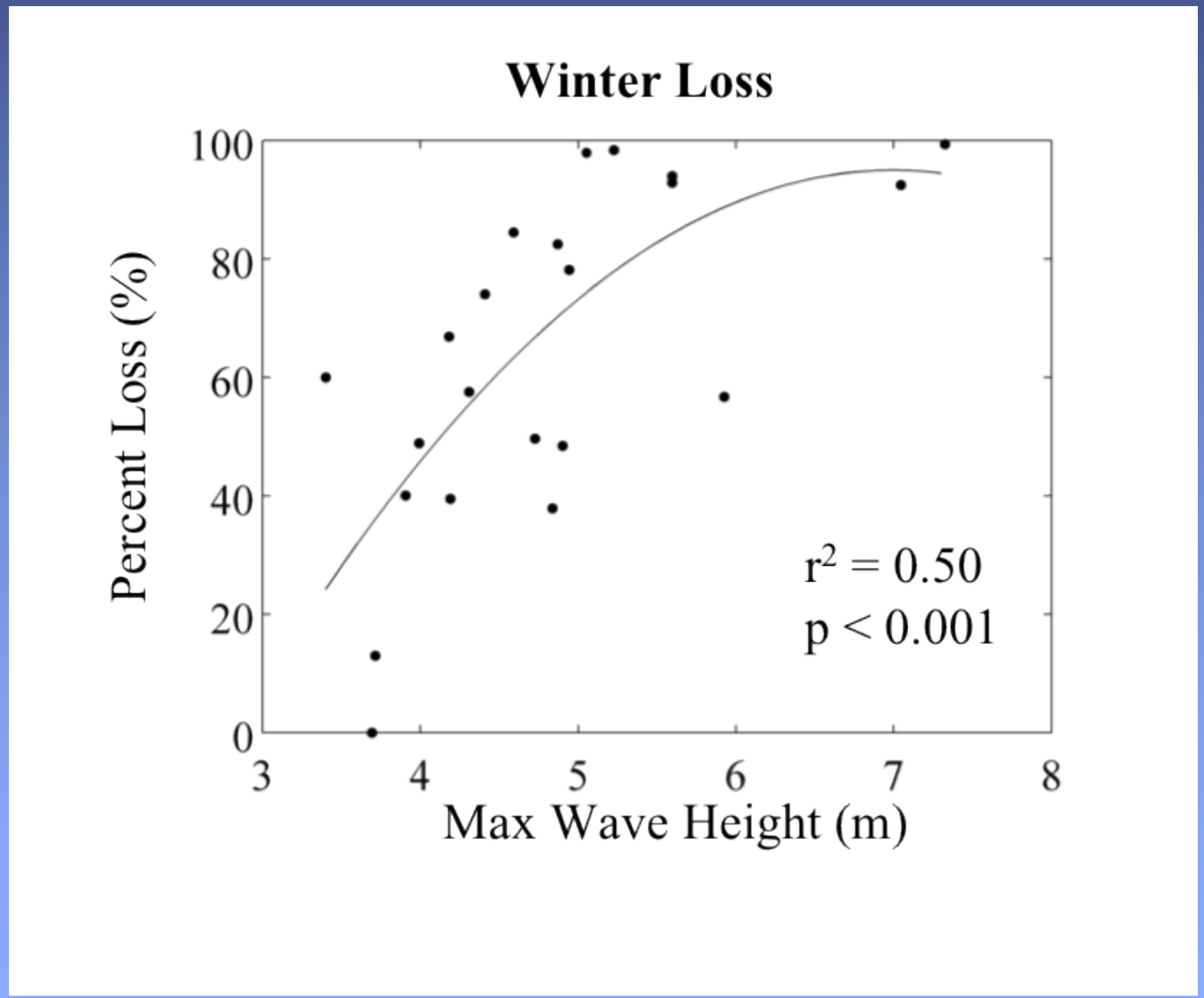


Wave disturbance is an important control of kelp abundance and net primary production (NPP)



Cavanaugh et al. (2011)

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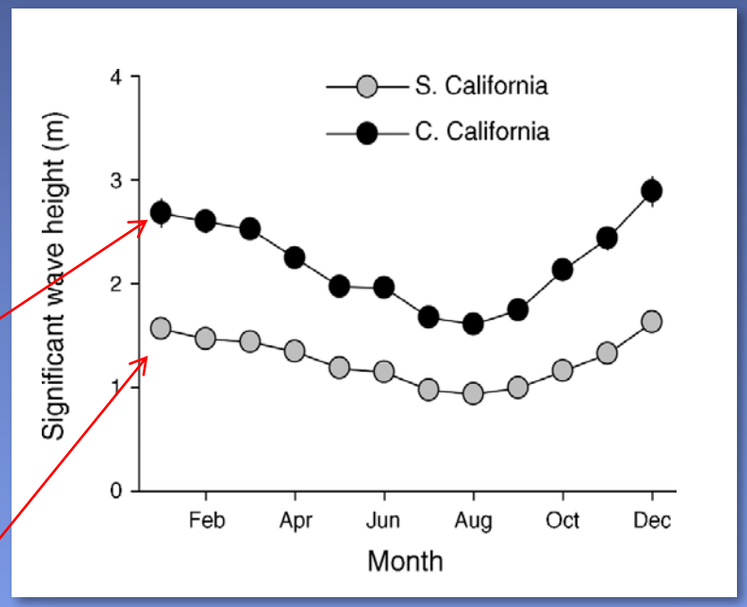

Lower, more variable wave disturbance in southern California

Reed et al. (2011)

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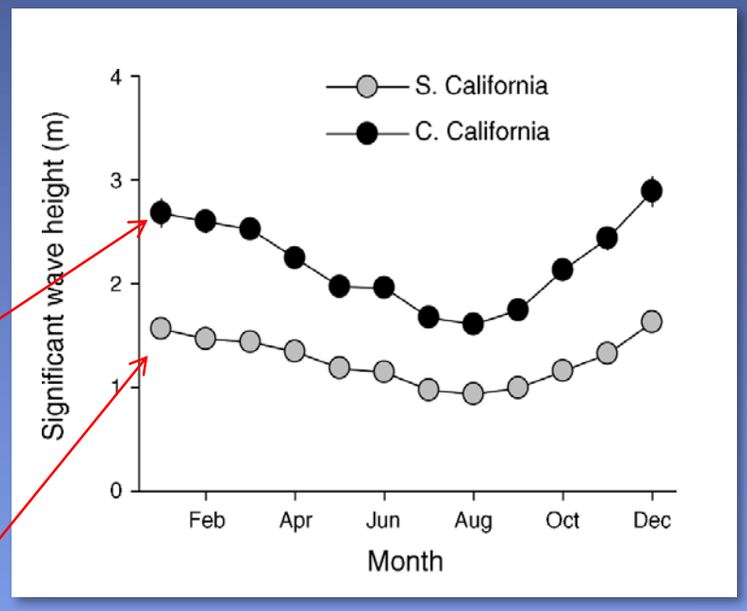
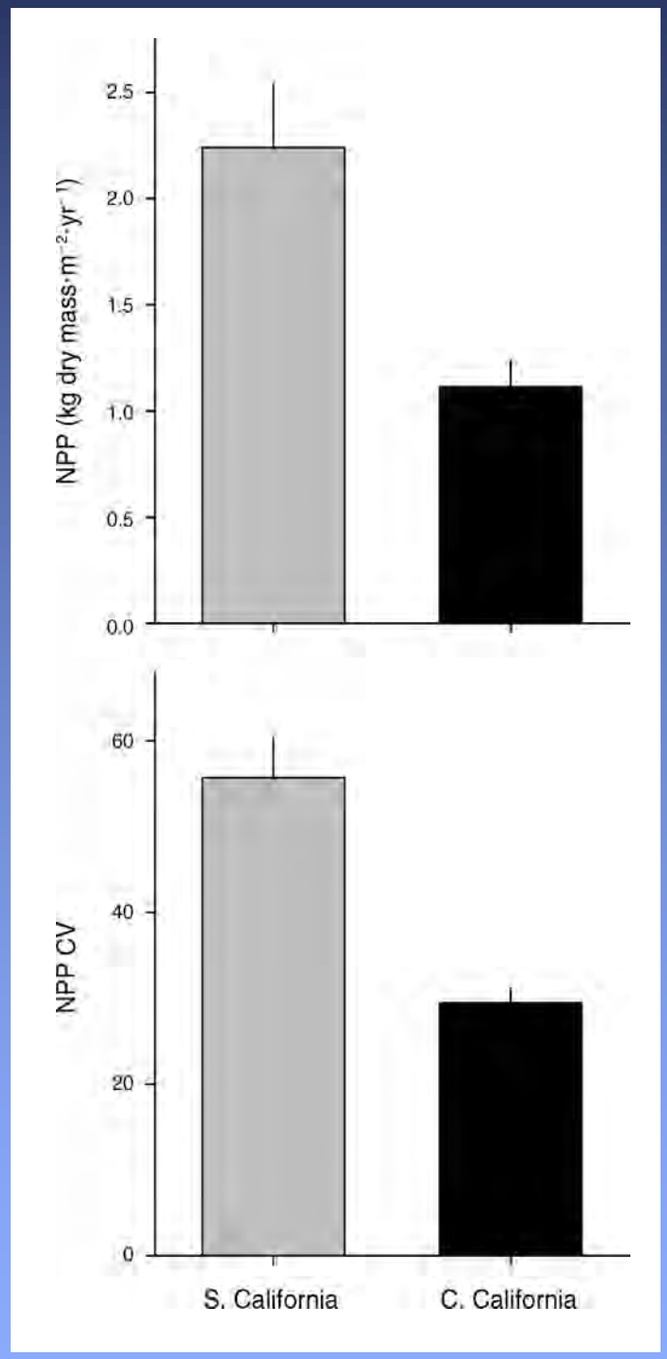
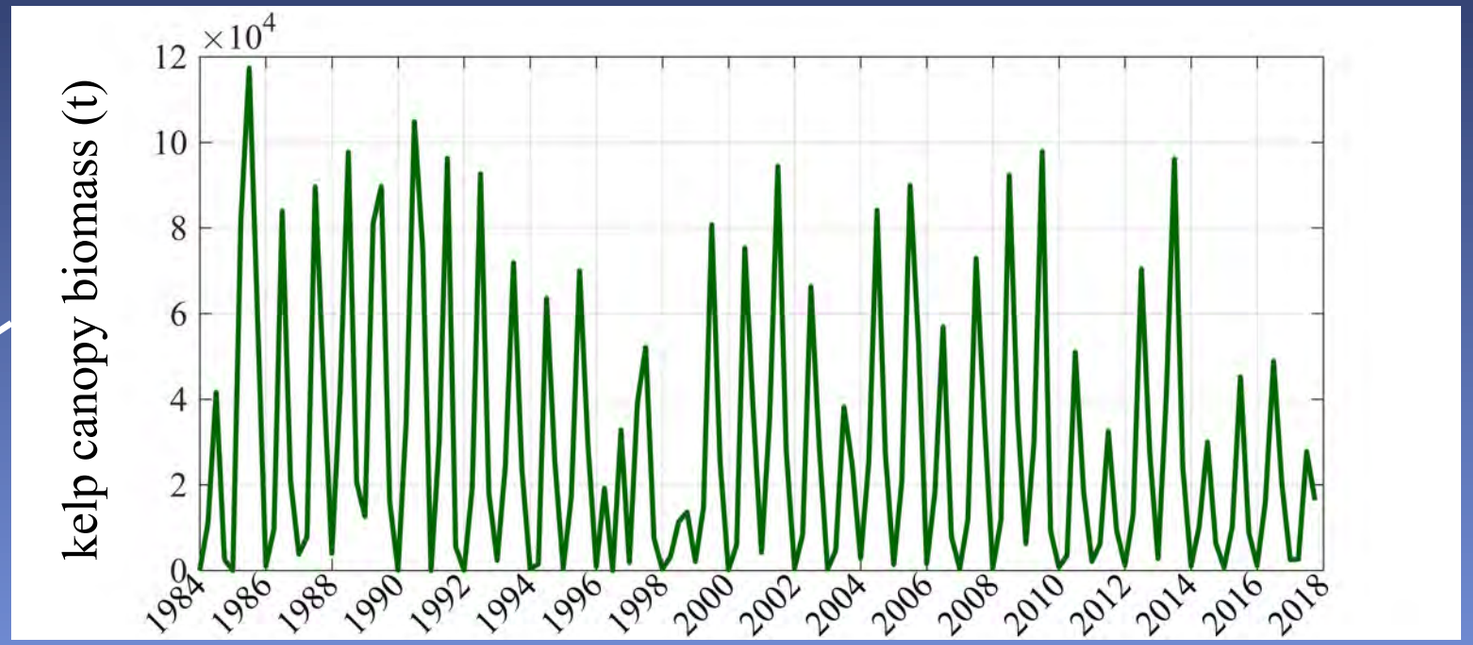


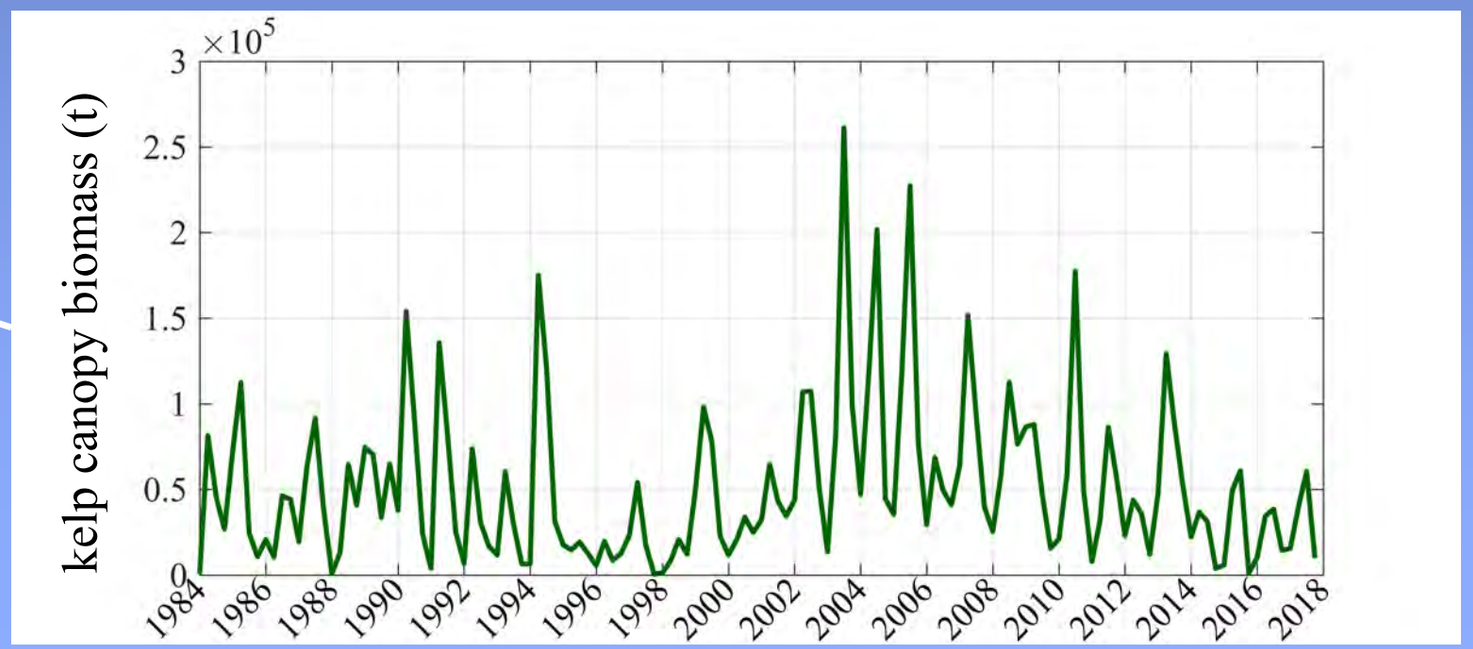
Lower, more variable wave disturbance in southern California



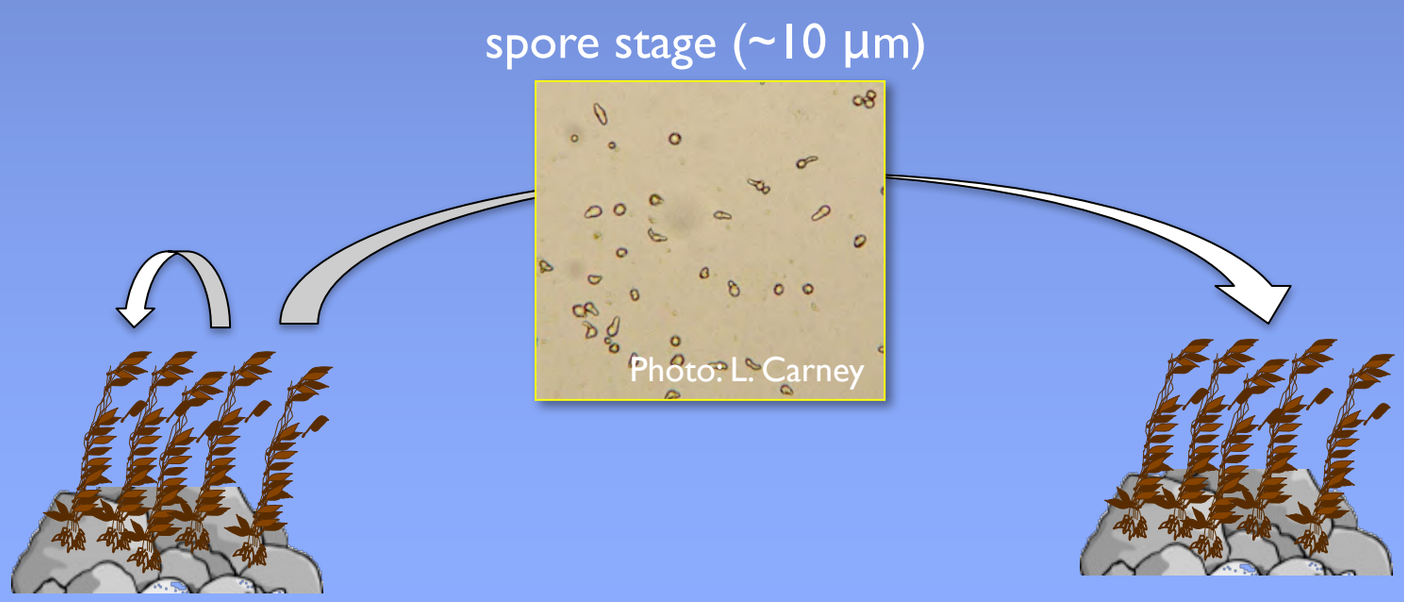
Higher, more variable NPP in southern California

How is giant kelp resilient to repeated disturbance?





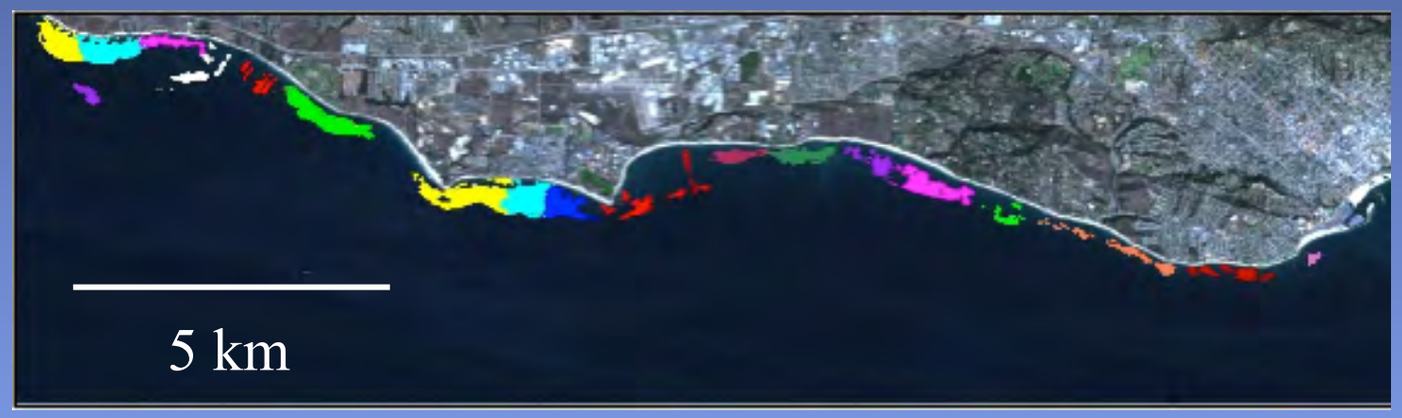
Connectivity of giant kelp is key to resilience



- Giant kelp reproduces by releasing a reproductive stage that sinks slowly
- Dispersal distances are on the order of meters to kms

We used Landsat satellite imagery and ROMS ocean current simulations to…

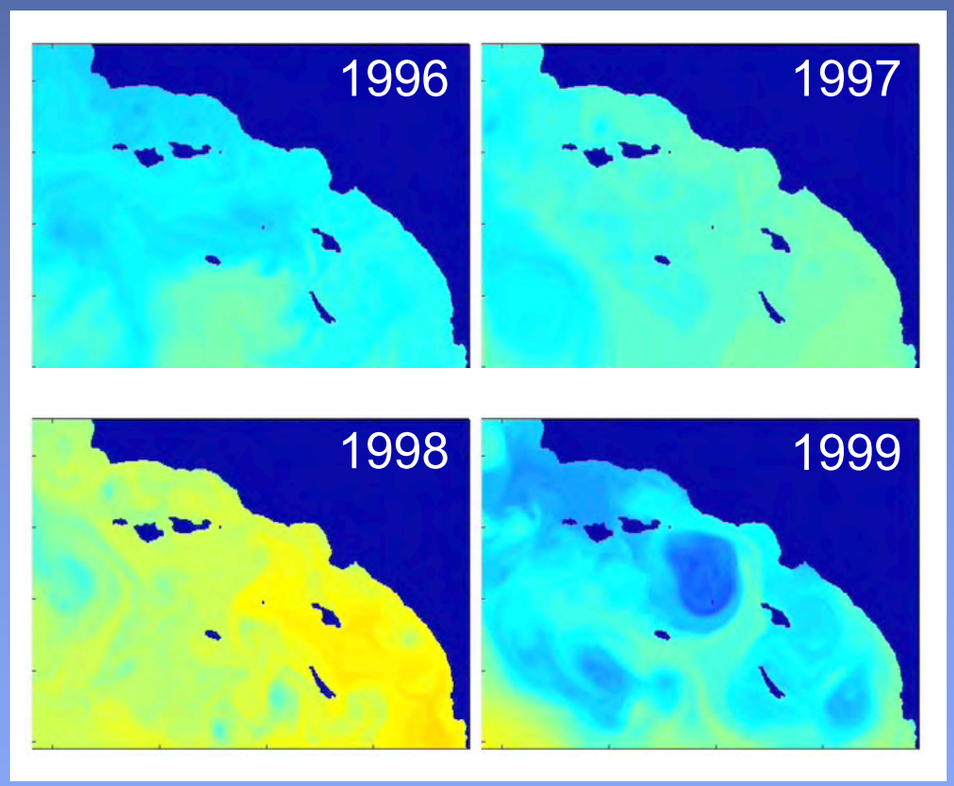
1. Delineate "patches" of kelp



Landsat satellite imagery

Cavanaugh et al. (2014)

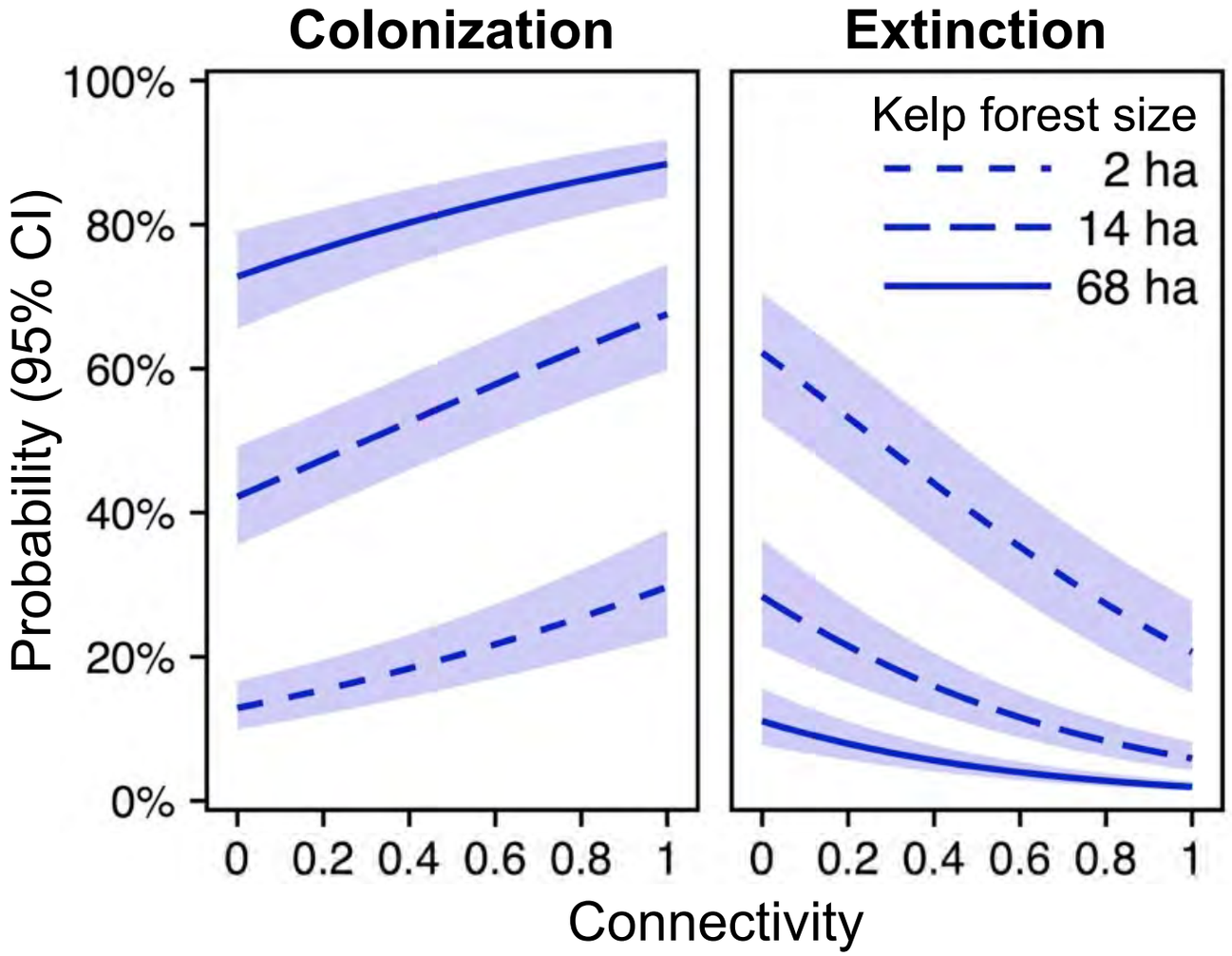
2. Estimate connectivity between patches



Regional Oceanic Modeling System (ROMS)

Mitarai et al. (2009)

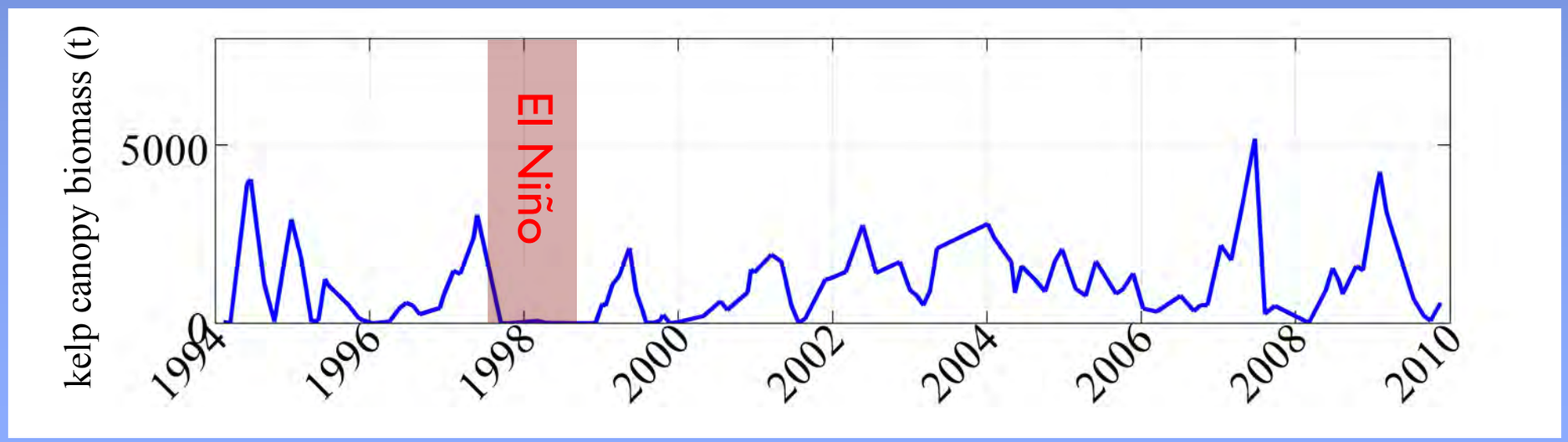
Connectivity improves recovery and persistence



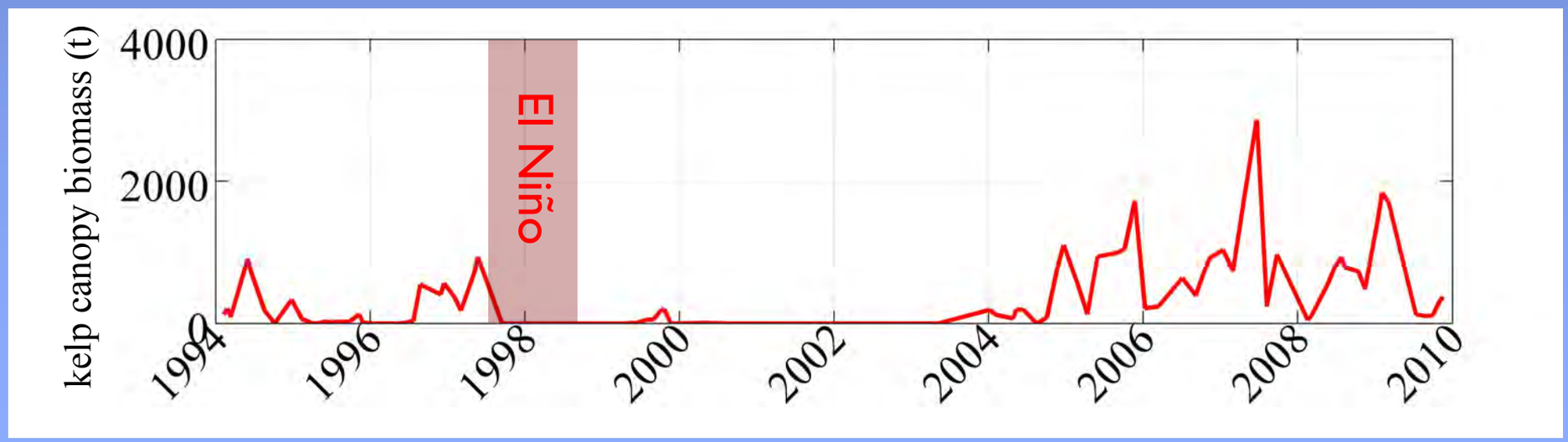
Castorani et al. (2015, 2017)

Connectivity improves recovery and persistence: A tale of two patches

Well connected patches are less likely to go extinct and more likely to recover from extinctions



Isolated patches are more likely to go extinct and less likely to recover



How does loss and recovery of kelp affect the community?

The number of living creatures of all Orders whose existence intimately depends on the kelp is wonderful.
Darwin 1839

Photos: SBC LTER

Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here from the destruction of the kelp.
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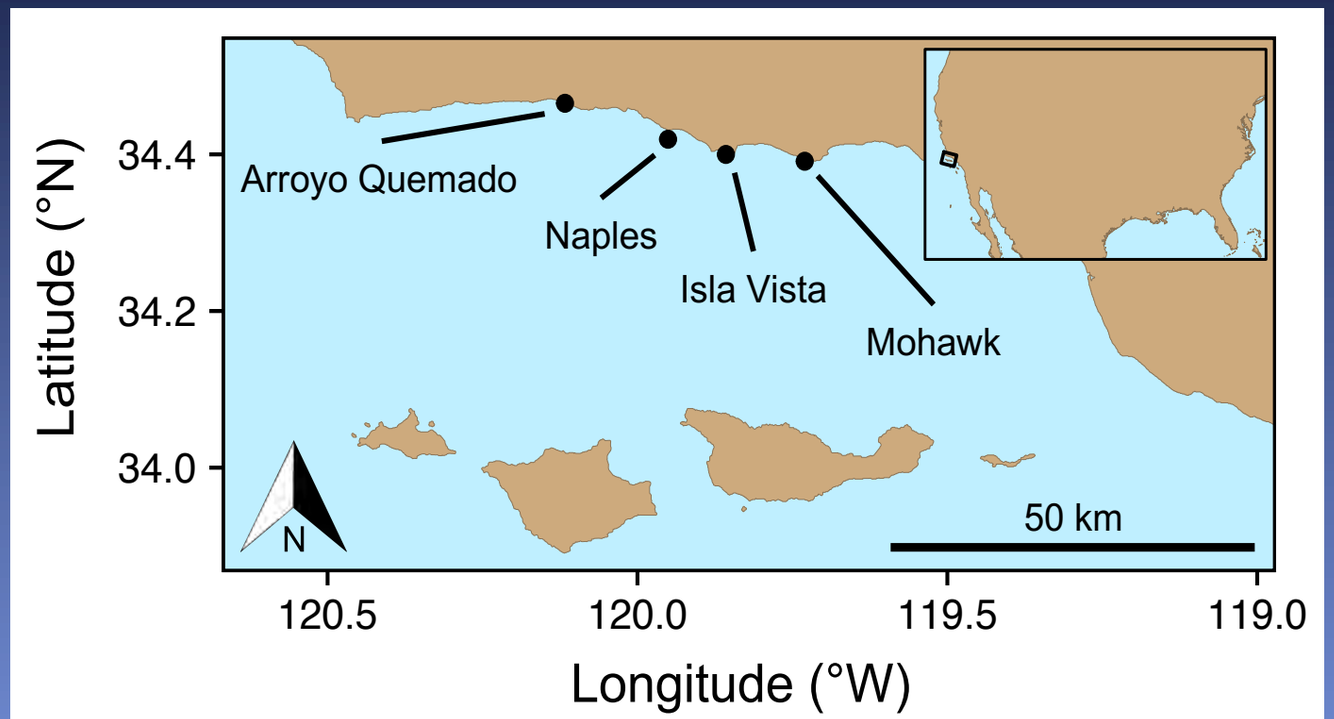
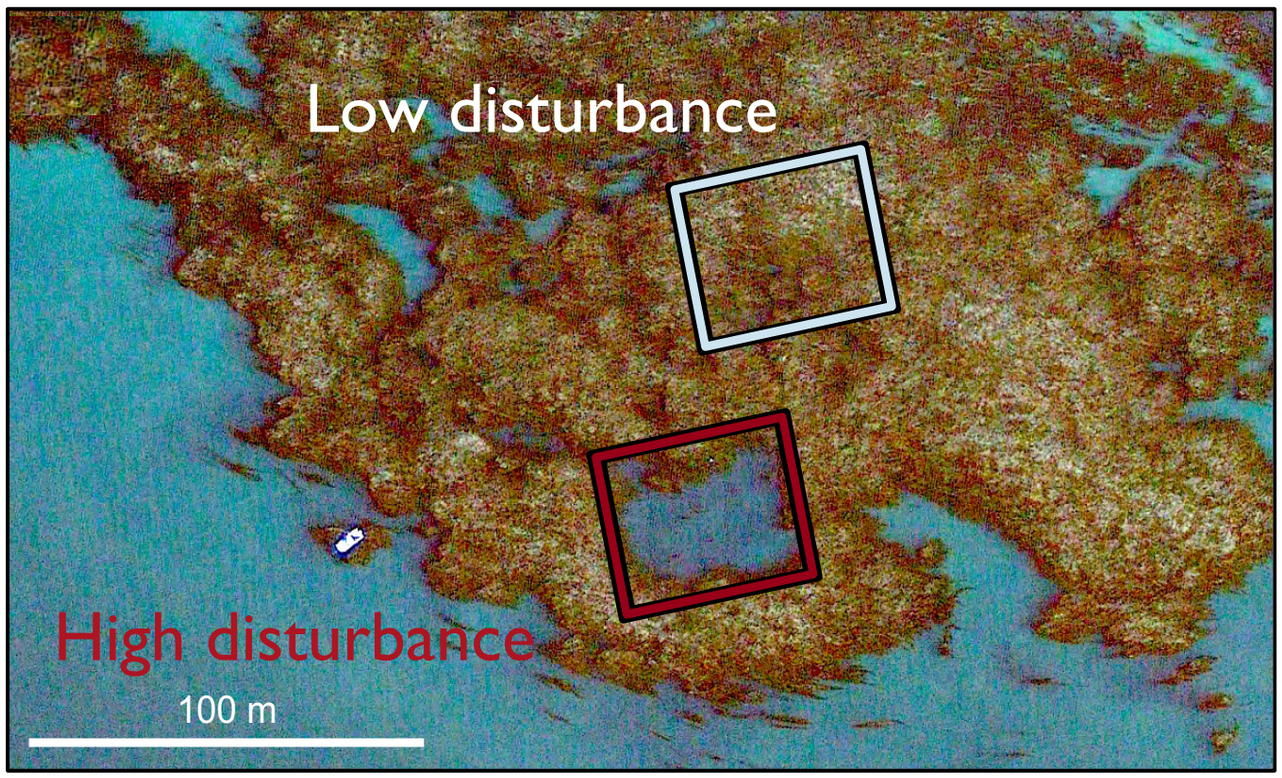
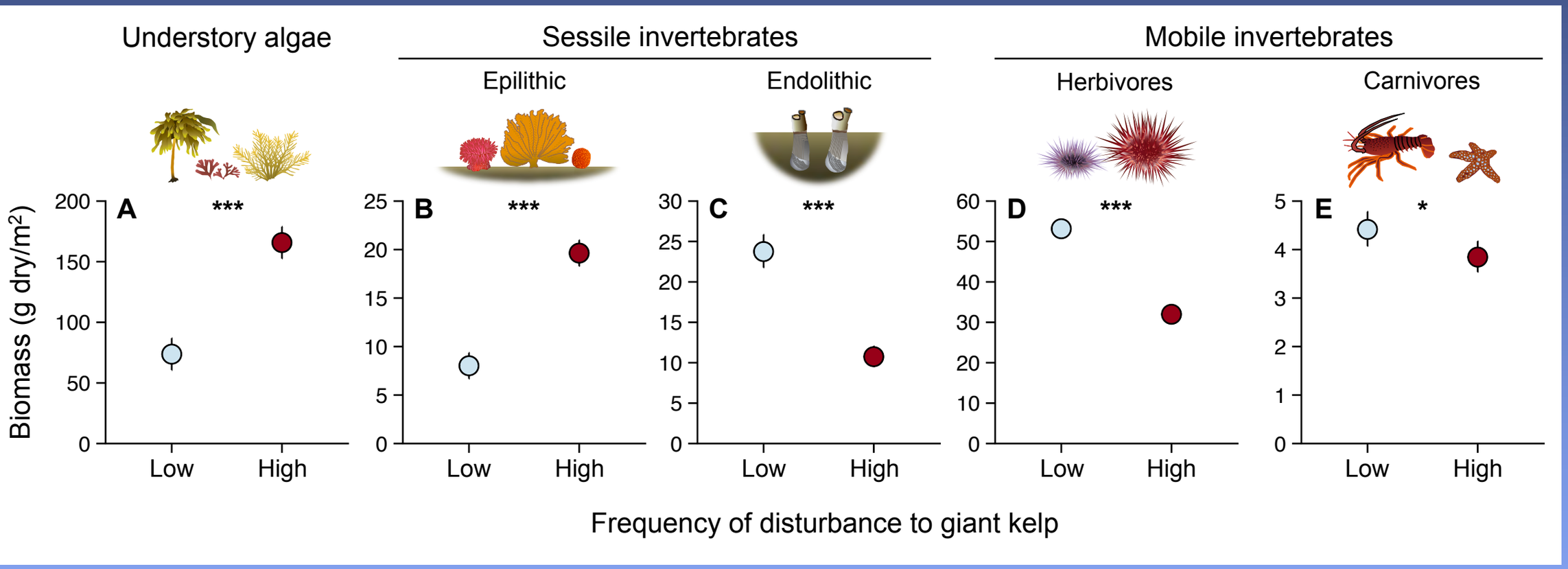
Large scale giant kelp disturbance experiment





- 4 sites
- 2,000 m^2 plots
- 9 years
- Removed all giant kelp in treatment plots each winter
- Measured abundance and diversity of all trophic levels

Frequent loss of giant kelp:

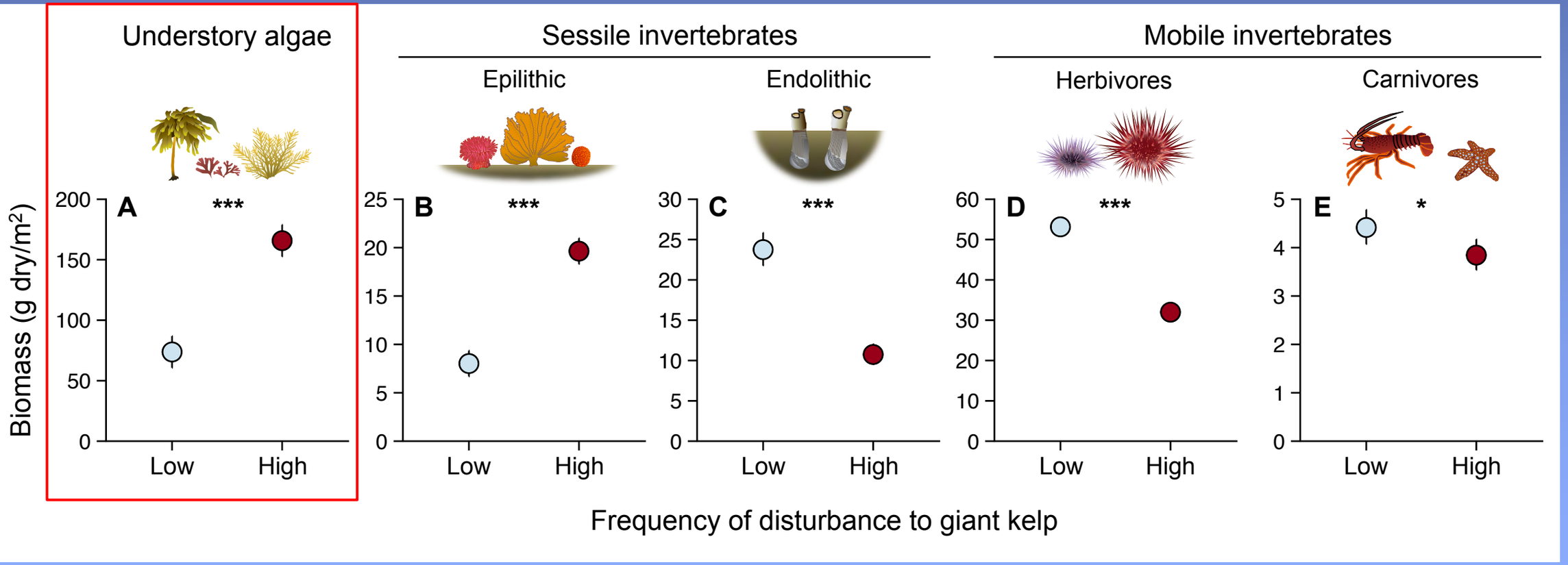


Castorani et al. (in revision)

Frequent loss of giant kelp:

Increases amount of light that reaches seafloor…

…Improving the growth of smaller understory algae

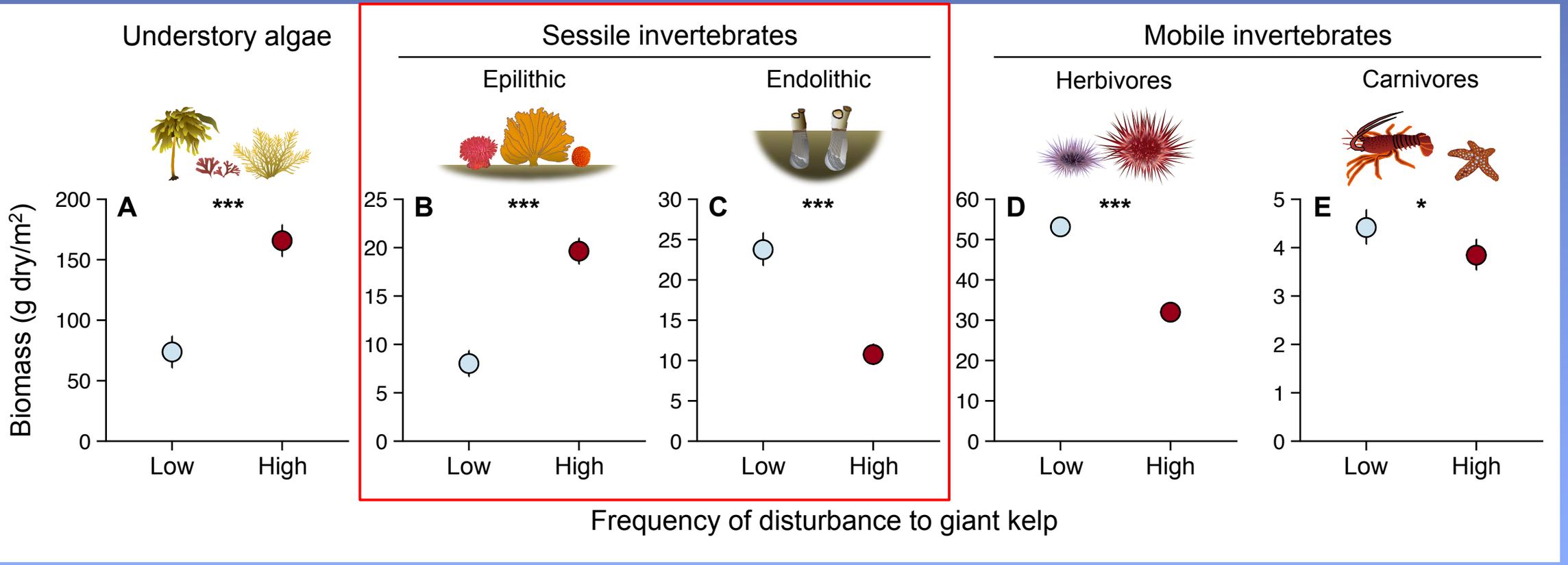


Castorani et al. (in revision)

Frequent loss of giant kelp:

Creates space on the rocky seafloor substrate…

…Facilitating invertebrates that grow attached to rock

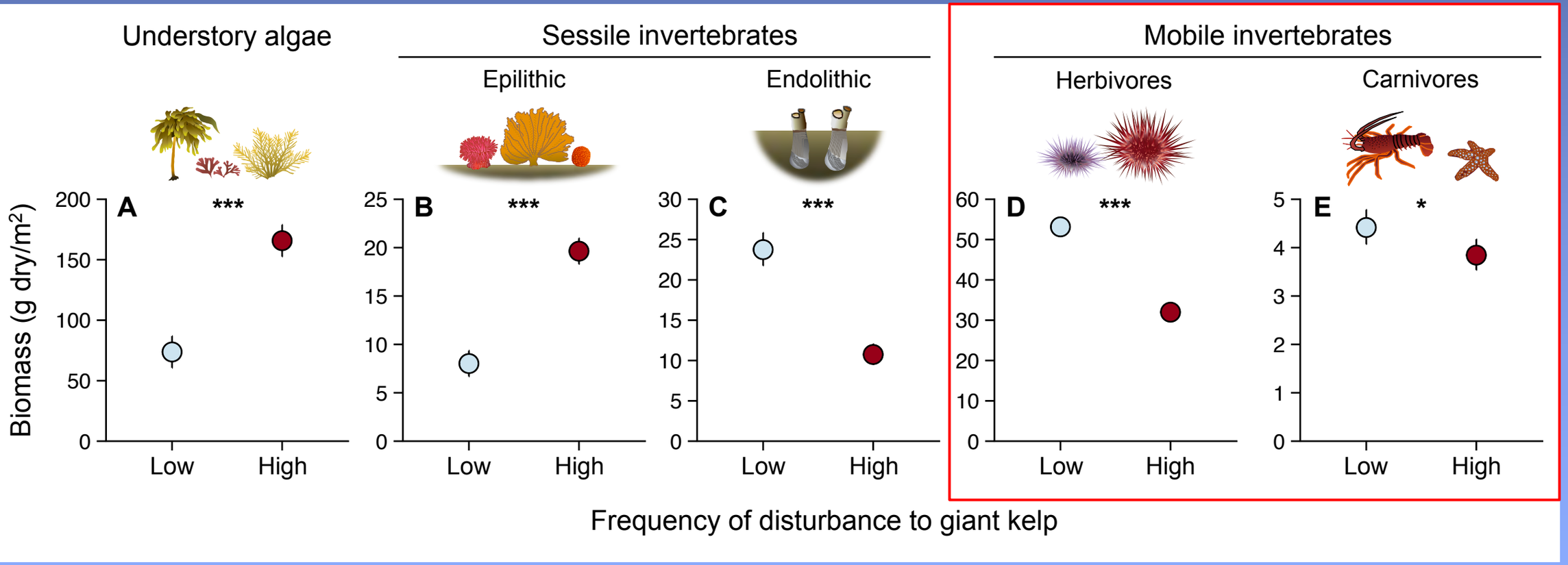


Castorani et al. (in revision)

Frequent loss of giant kelp:

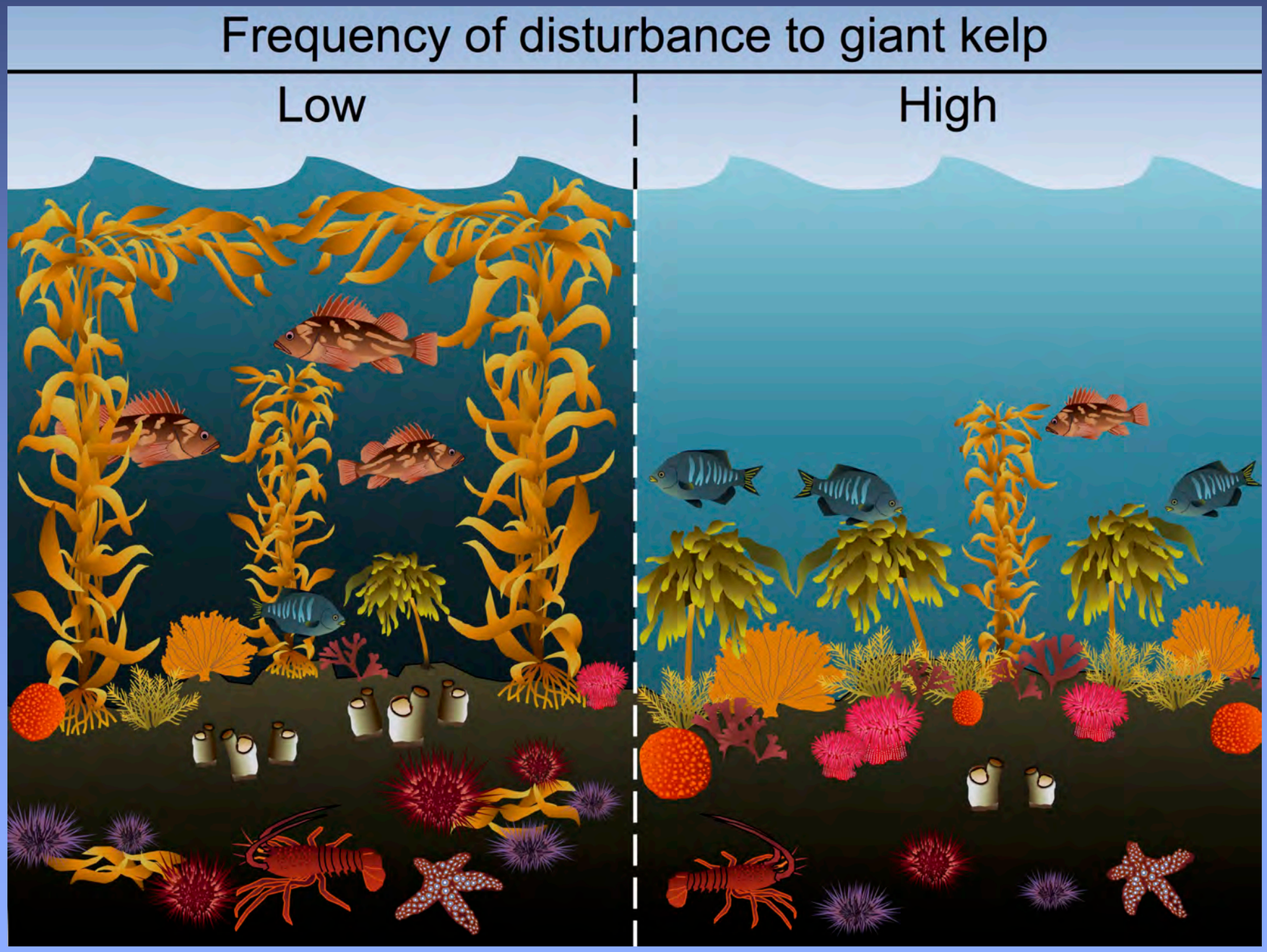
Reduces the amount of food from living and detrital giant kelp…

…Reducing the abundance of giant kelp herbivores



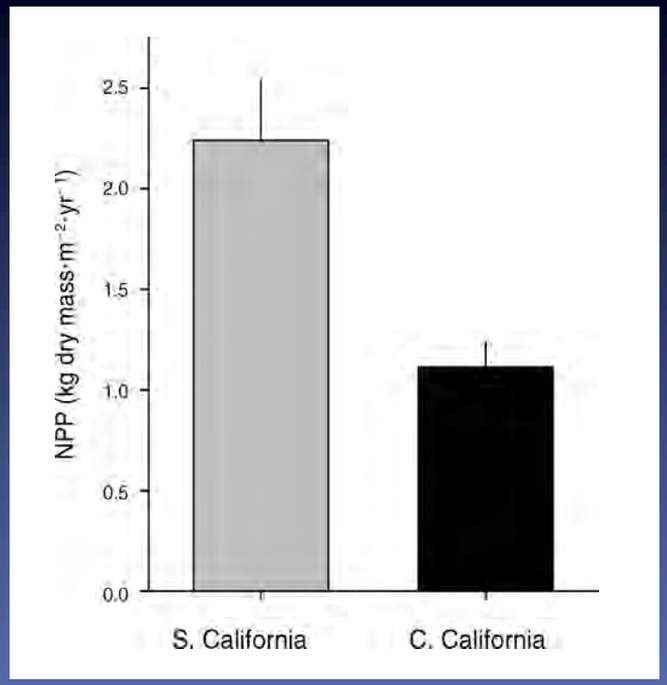
Castorani et al. (in revision)

Disturbance to foundation species has ecosystem wide consequences due to impacts of physical habitat and food availability



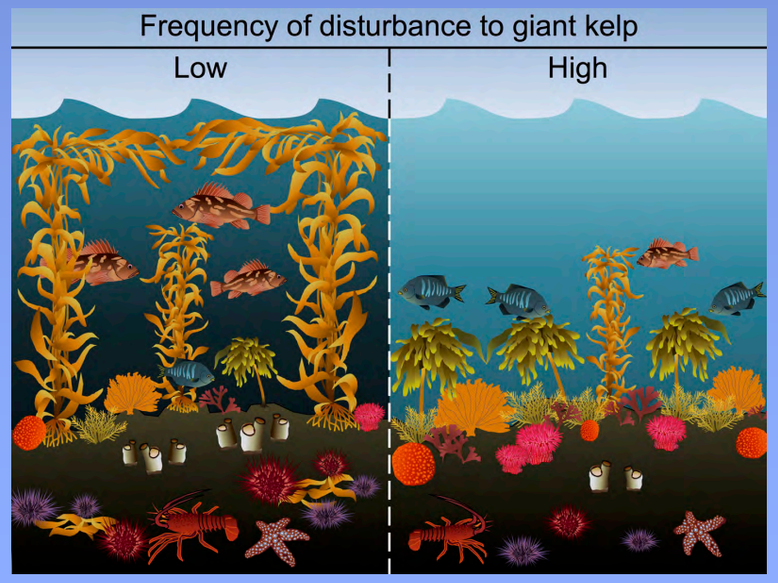
Summary

1. Disturbance controls primary production of giant kelp forests in California

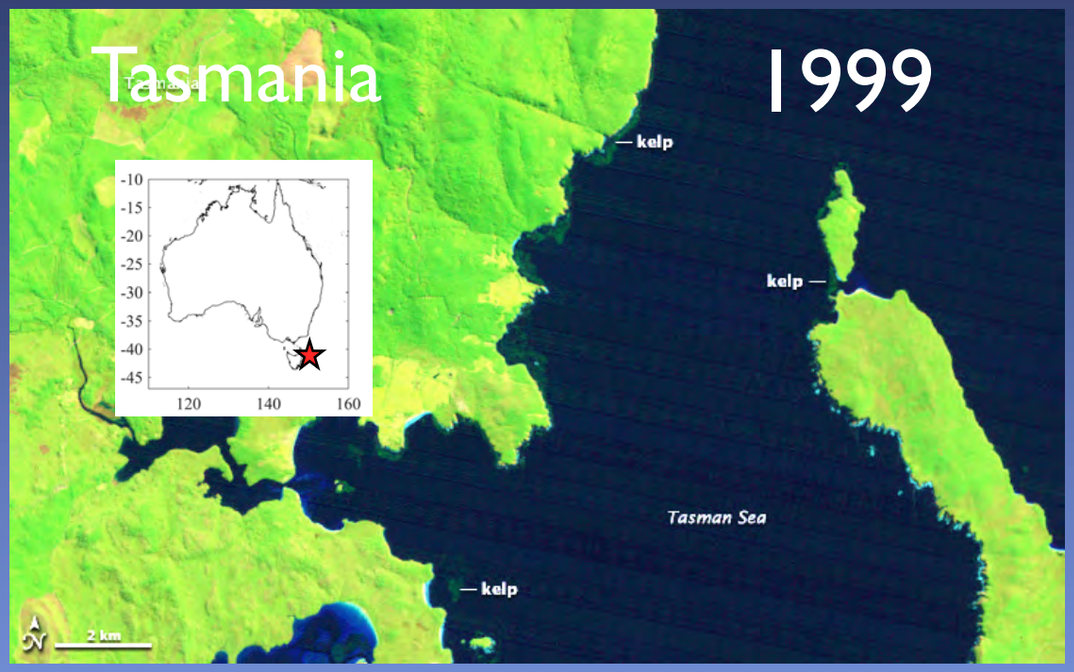


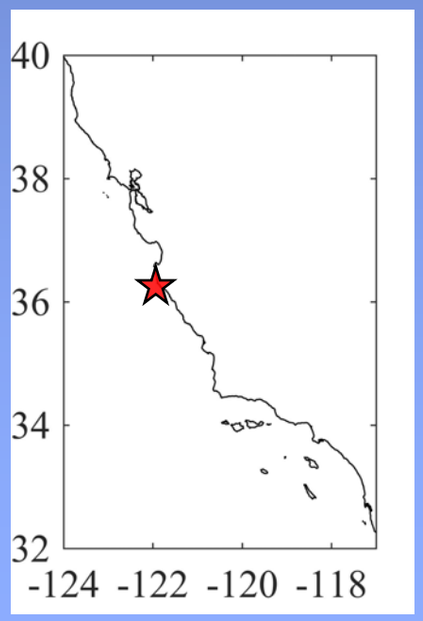
2. Connectivity of giant kelp populations makes them resilient to disturbance

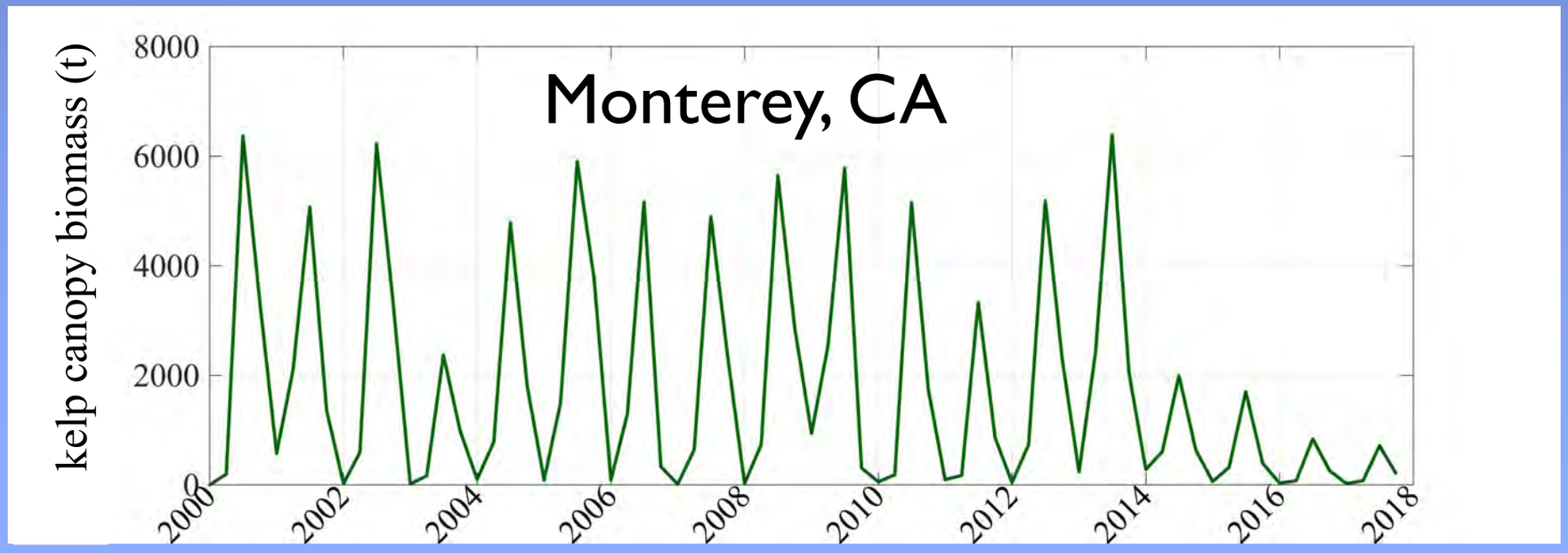
3. Repeated disturbance to giant kelp impacts community by altering physical habitat and availability of food



Long-term environmental change or multiple interacting stressors can overwhelm the resilience of giant kelp







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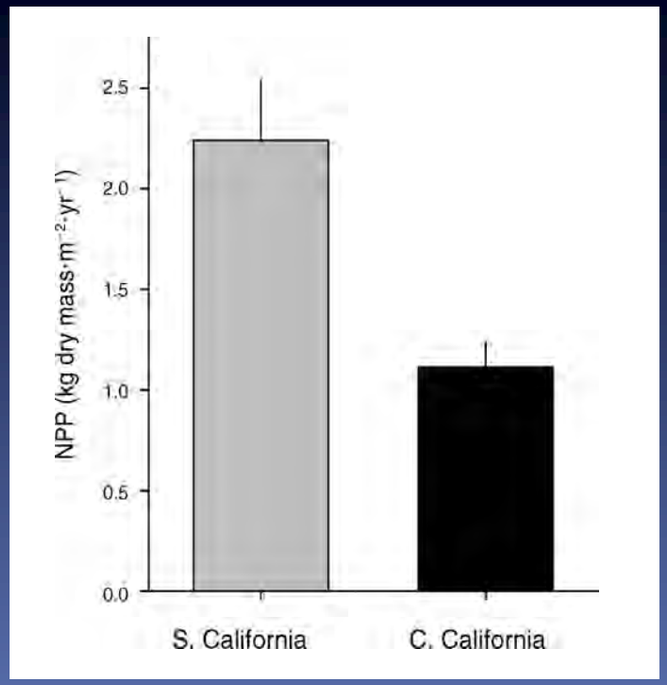

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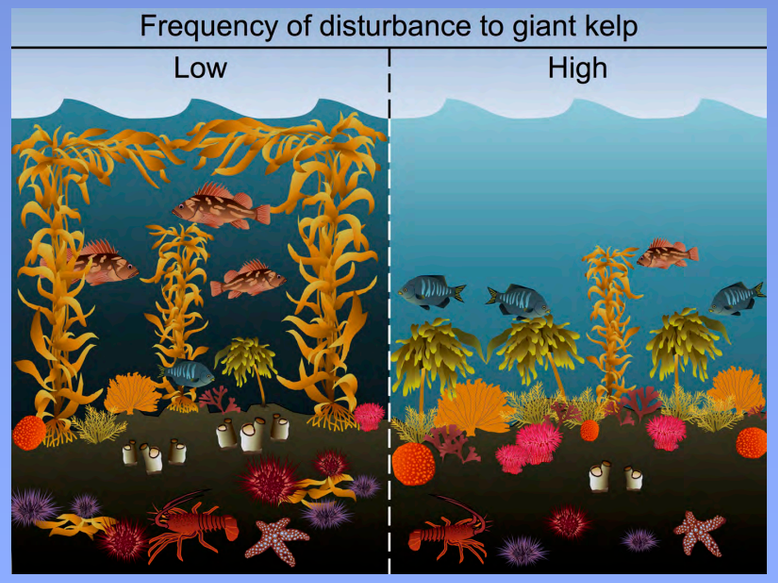

Acknowledgements

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