

# Do Tipping Points Loom? Extending 20+ years of Long-Term Monitoring to Assess Impacts of Climate Change on Rocky Shore Macrophyte Assemblages

Bruce Menge, Megan Davis, Sarah Sellke, Zechariah Meunier,  
John Dickens, Heather Fulton-Bennett, Kaitlyn  
Tonra and Sarah Gravem



Oregon State  
University



# **Context: Stability of Coastal Ecosystems in the face of Climate Change**

**Project 1. Abundance and colonization of intertidal kelp**

**Project 2. Phenology and reproductive output of intertidal kelp**

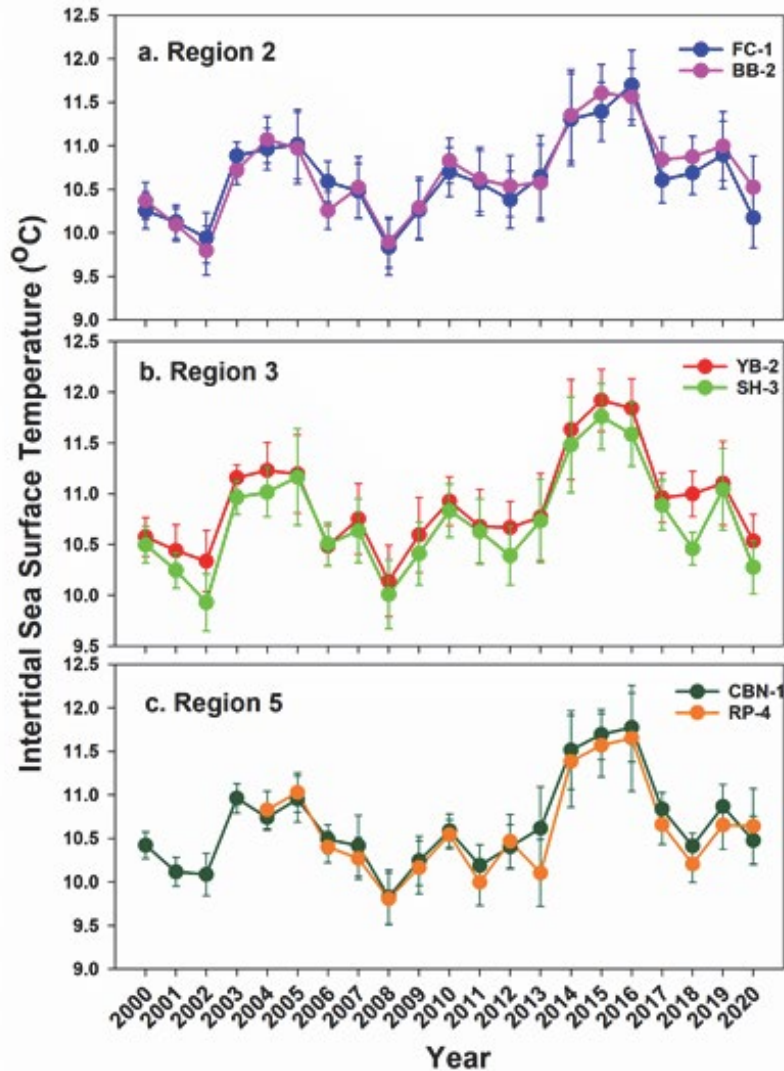
**Project 3. Persistence of low intertidal macrophytes (algae, surfgrass)**

**Project 4. Testing the resilience and recovery of macrophyte communities**

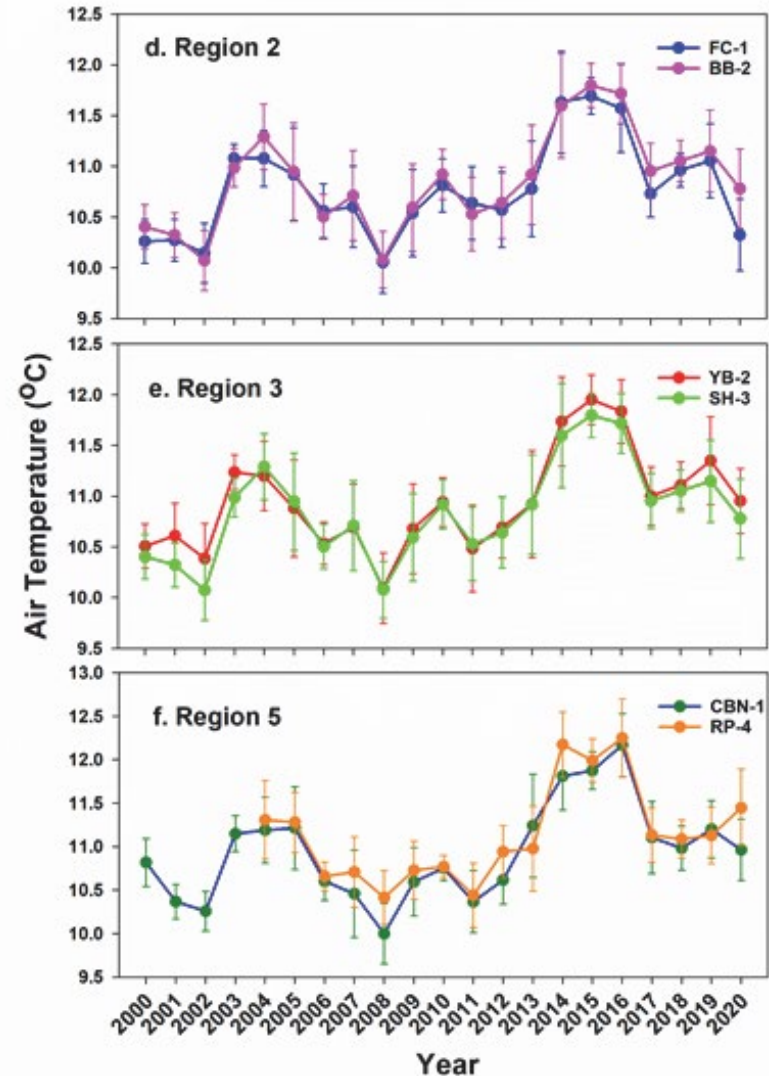
**Project 5: Novel pattern of mussel mortality-disease, toxin, or?**

# Climate warming: a CHRONIC stress

## Water Temperature

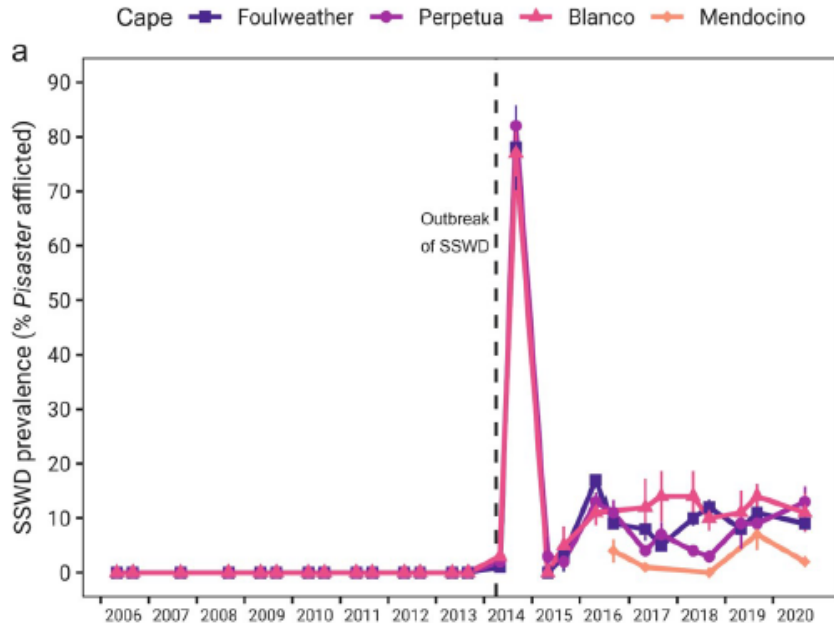


## Air Temperature

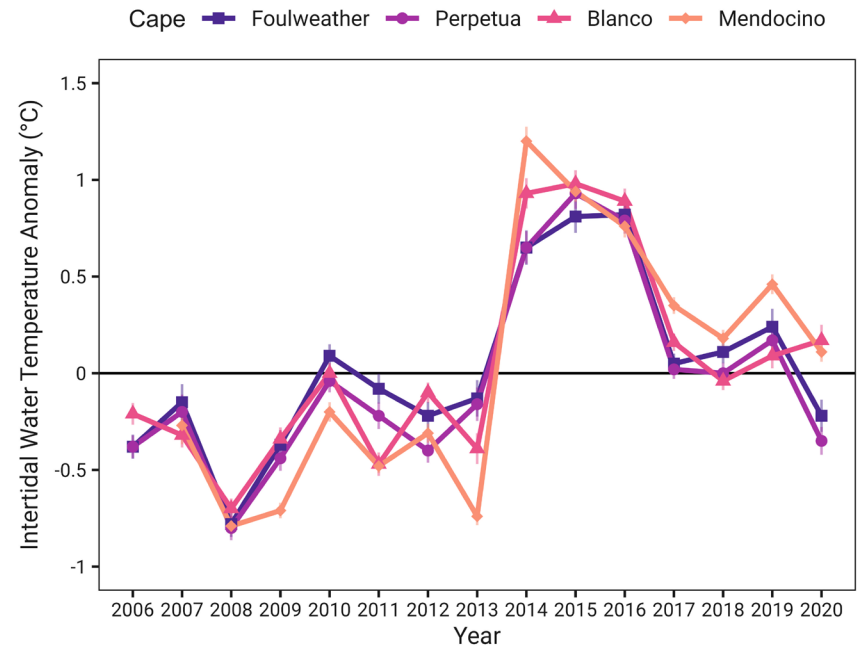


# Large ACUTE recent perturbations

## Sea Star Wasting Disease (SSWD)



## Marine Heat Wave/El Niño



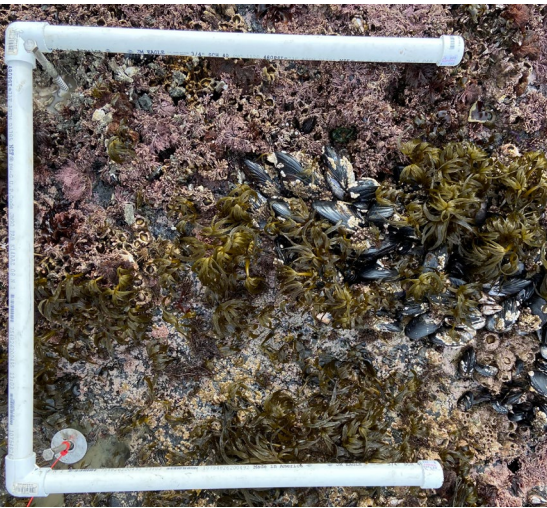


# Project 1: Kelp colonization, abundance, and grazer abundance (PhD Student Sarah Sellke)

## Experimental Design - Recruitment



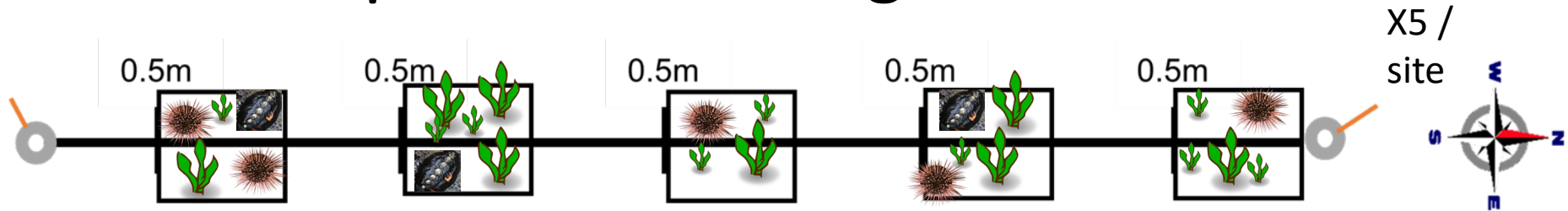
Above – 2 transects laid out in adult *E. menziesii* beds  
Below – permanent *P. palmaeformis* quadrat



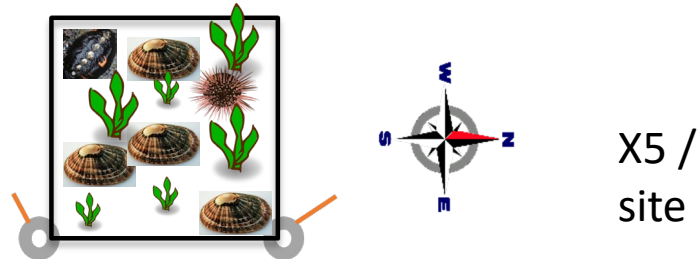
- 6 sites at 3 capes
- Data collected at least monthly (or as weather allows)
- *H. sessile*, *E. menziesii*, *L. littoralis*, *A. marginata*
  - 5 total 5m long permanent transects in existing kelp beds
  - 5 0.5x0.5 meter quadrats within each transect
    - Recorded the density of recruits, grazers, and kelp recruitment substrate
- *P. palmaeformis*, *L. sinclairii*
  - 5 total 0.5x0.5 meter permanent quadrats in existing kelp beds
    - Recorded the density of recruits, grazers, and kelp recruitment substrate

# Project 1: Kelp colonization, abundance, and grazer abundance (PhD Student Sarah Sellke)

## Experimental Design - Recruitment

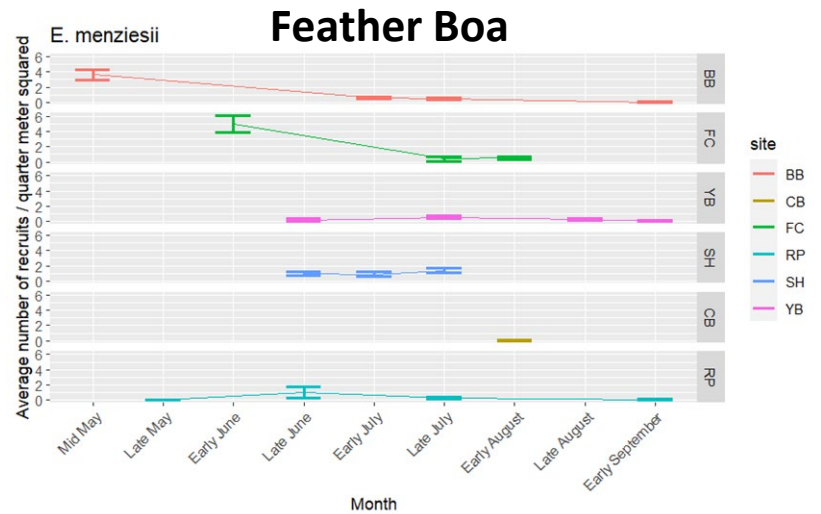
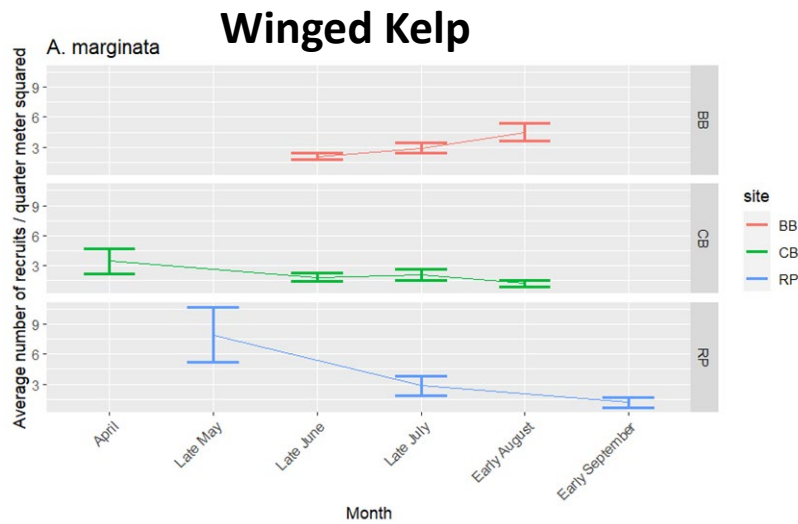
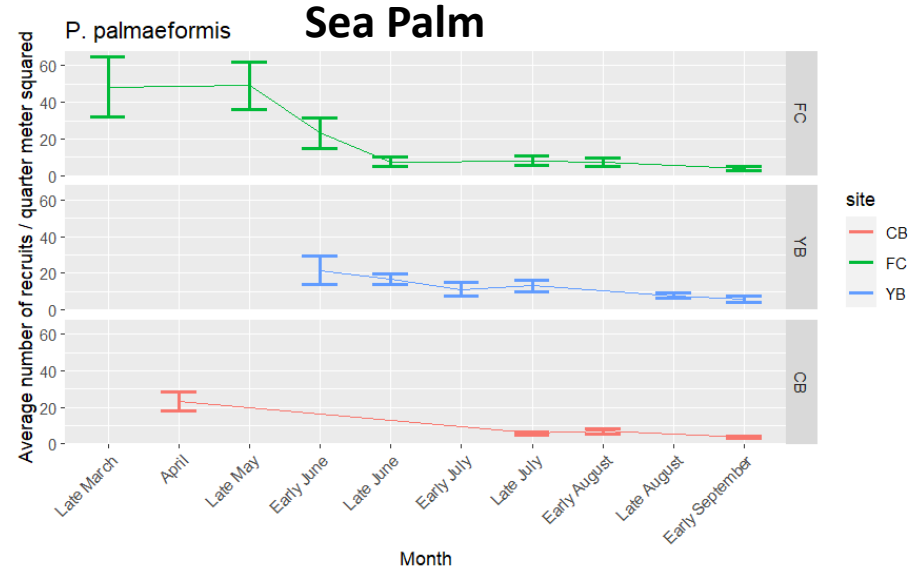
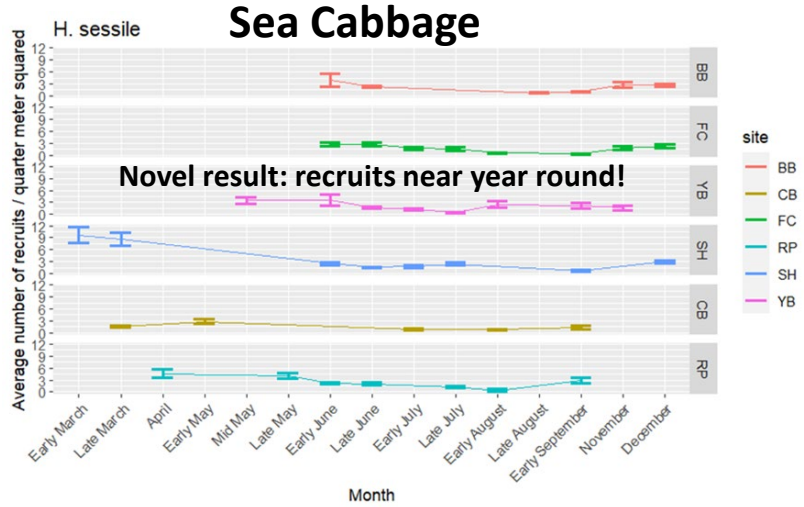


*Hedophyllum sessile*, *Egregia menziesii*, *Lessoniopsis littoralis*, *Alaria marginata*

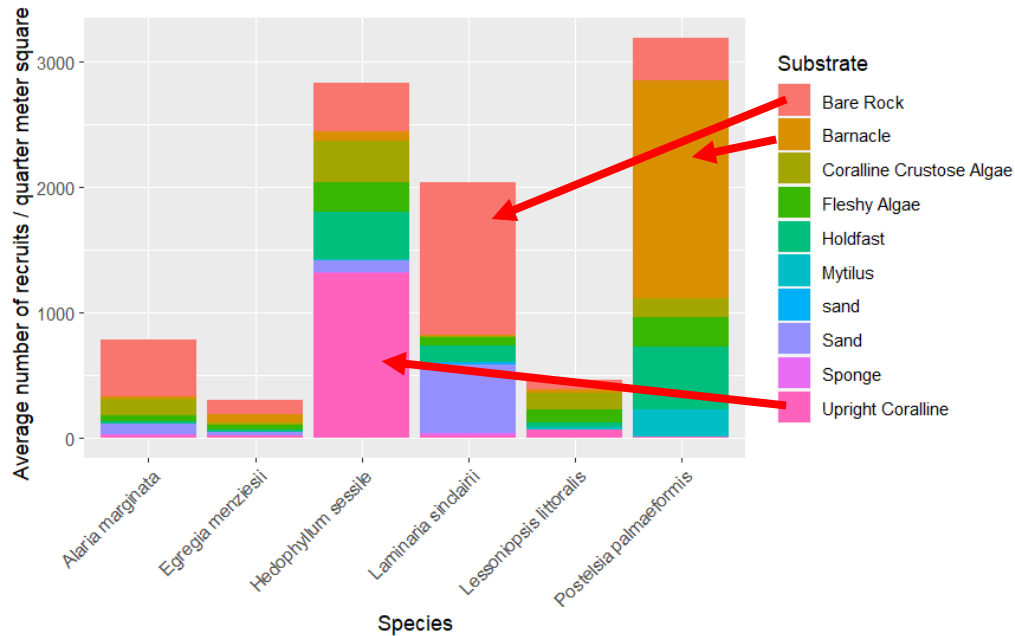
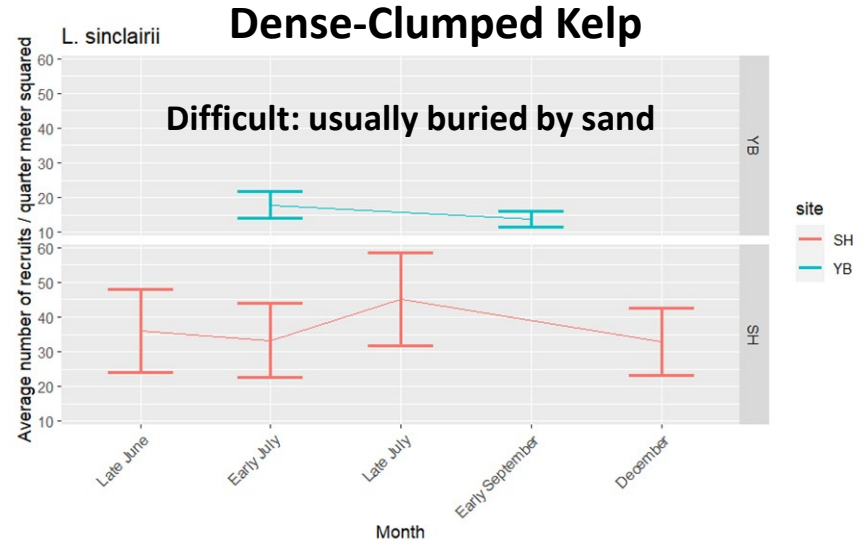
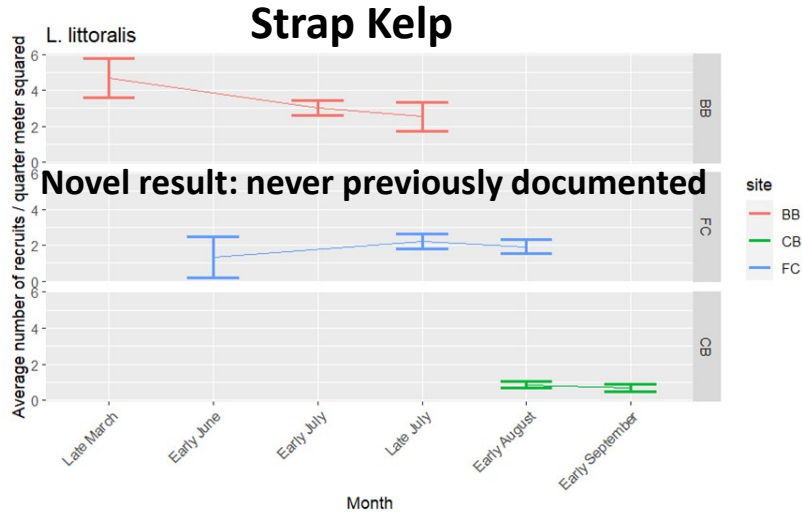


*Postelsia palmaeformis*, *Laminaria sinclairii*

# Results: Kelp recruitment



# Results: Kelp recruitment





# Project 2: Kelp reproductive ecology (PhD student Megan Davis)

## Study Design

- **Four species: *Alaria marginata*, *Hedophyllum sessile*, *Lessoniopsis littoralis*, *Postelsia palmaeformis*.**
- **Permanent transects at five sites along three capes, >10 samples per species per site.**
- **Quadrats laid along transect at an interval of one meter, photographed, and one individual haphazardly selected for sampling.  
Data collected twice per month, dependent on the tide and the swell.**

## Project 2: Kelp reproductive ecology (PhD student Megan Davis)

*Reproductive Frond for Sori  
Size/Ratio Analysis*

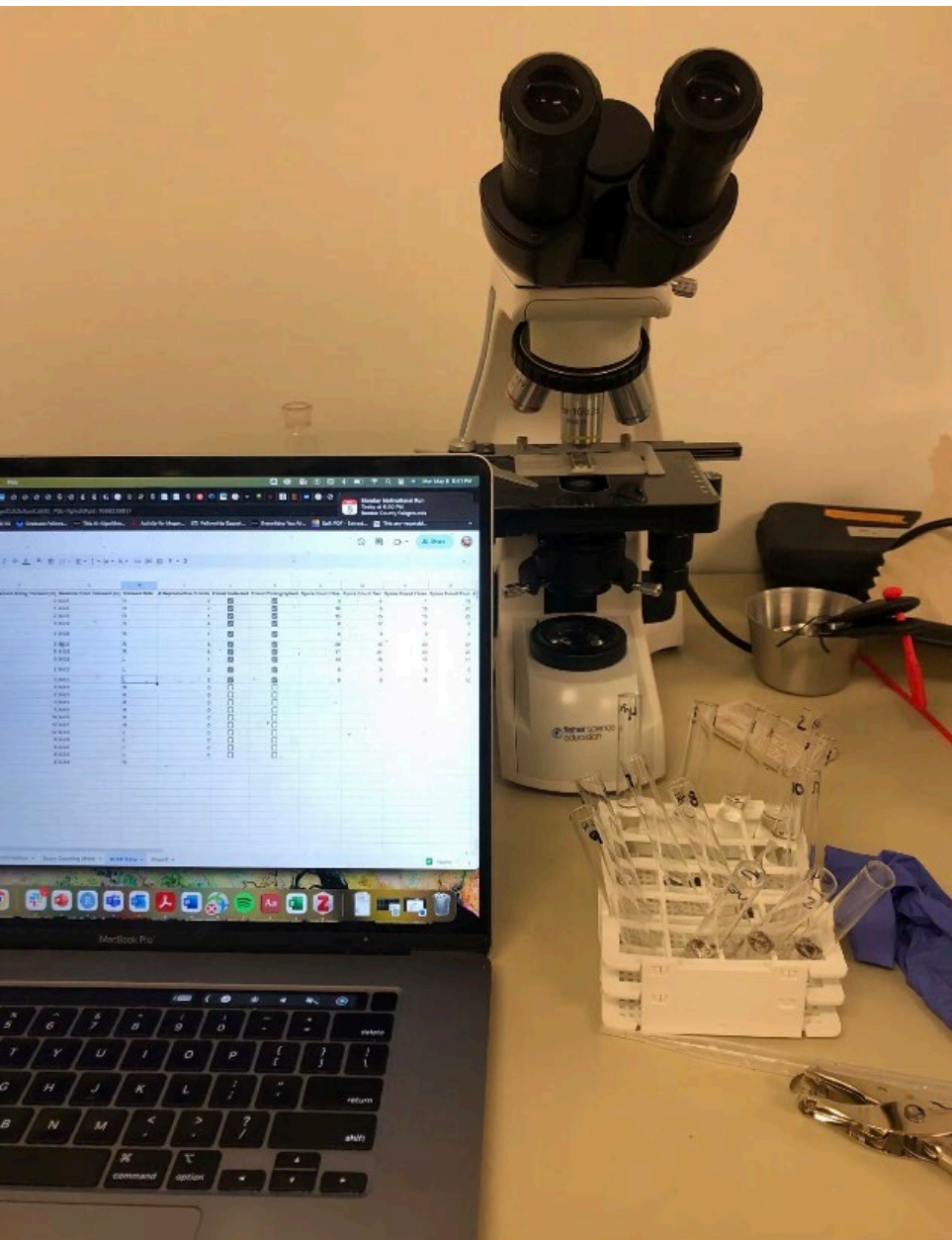


*Plot for Algal Percent Cover  
Analysis*





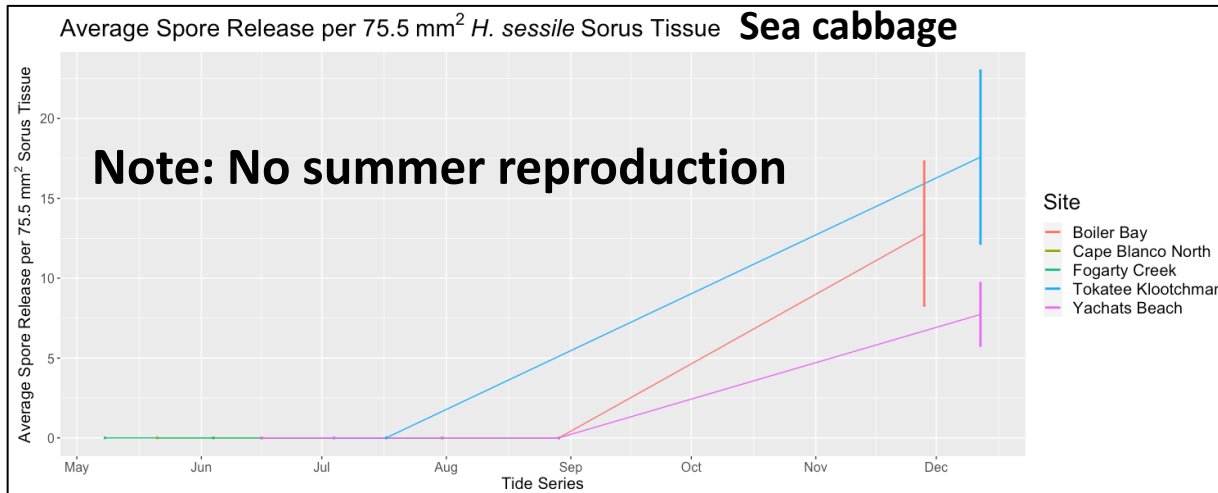
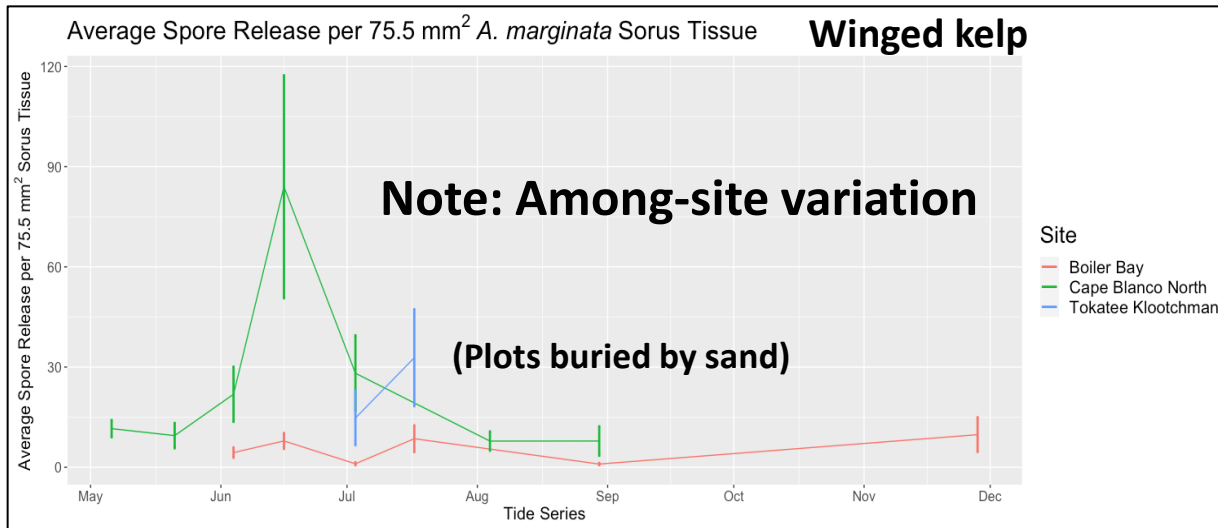
# Project 2: Kelp reproductive ecology (PhD student Megan Davis)



## Lab-Based Data Collection

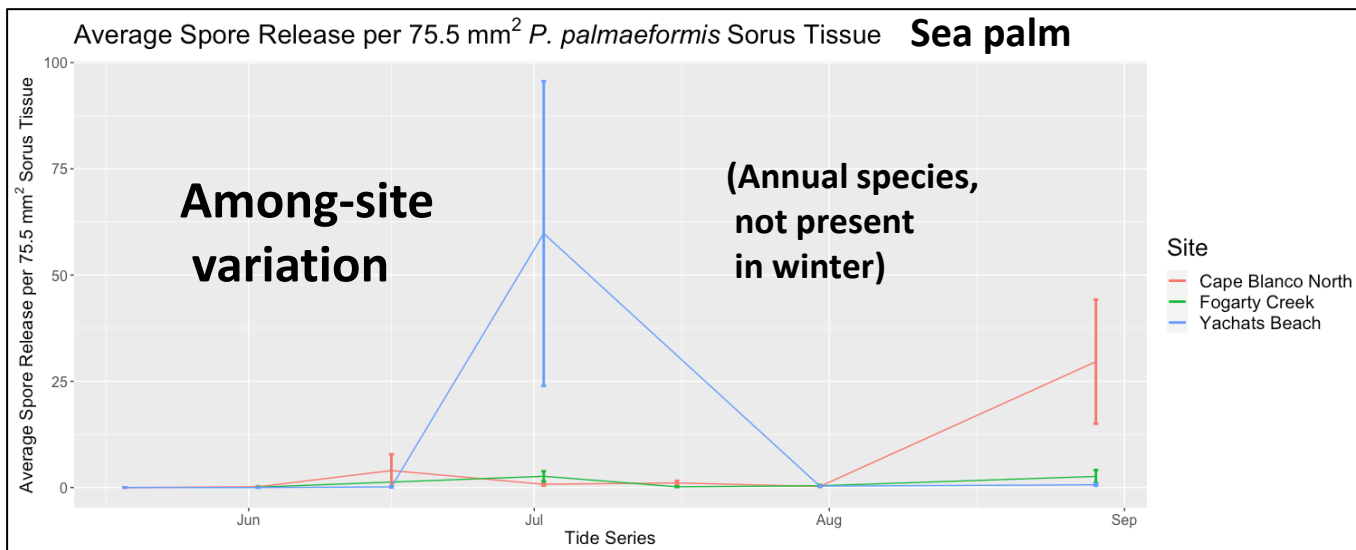
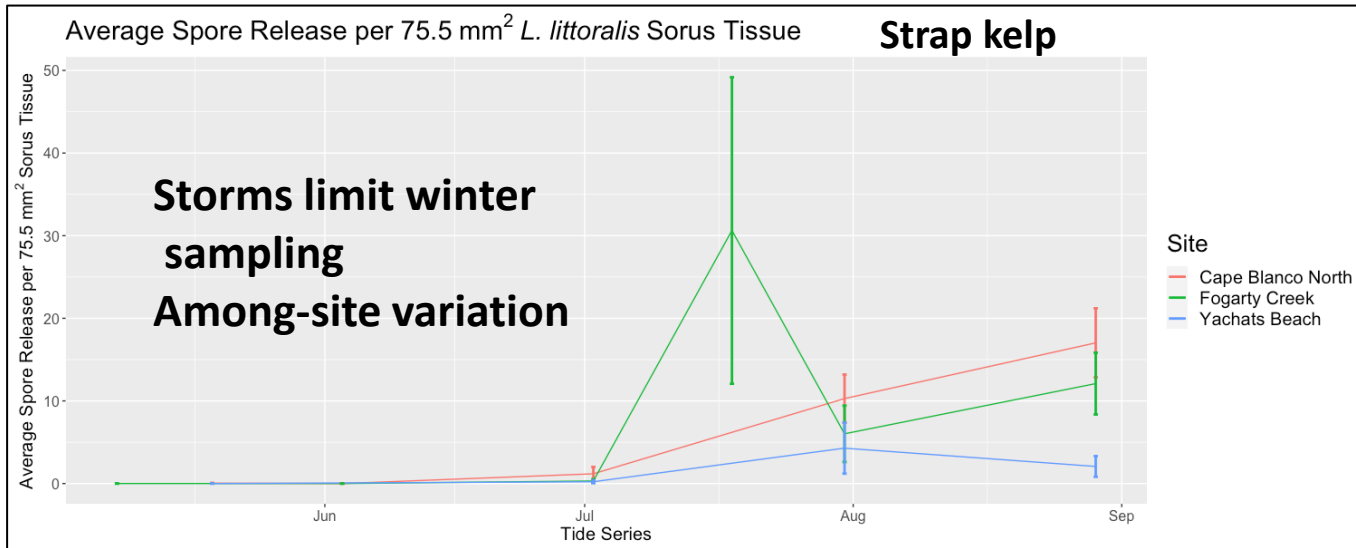
- **Standardized amount of sporophyll tissue removed and submerged in Instant Ocean solution to induce spore release.**
- **Amount of spore release measured using a hemocytometer.**

# Results: Kelp reproduction





# Results: Kelp reproduction



# Summary of Kelp Research

**Novel results: Quantification and spatio-temporal variation in -**

- **Recruitment**
- **Reproductive patterns (phenology)**
- **Reproductive (spore) output**

**Surprises:**

- **Persistent recruitment of sea cabbage (*Hedophyllum sessile*).**
- **Variable reproductive output in space (i.e., among sites).**

**2024 Field season:**

**Kelp growth rates, size (holdfast diameter, length)**

**Earlier start (winter sampling when possible, March rather than June)**

# Project 3: Community Dynamics: Experiment One

## Disturbance Experiment at Fogarty Creek

Undisturbed Plot Time 0 YR



Disturbed Plot Time 0 YR



Undisturbed Plot Time 1 YR



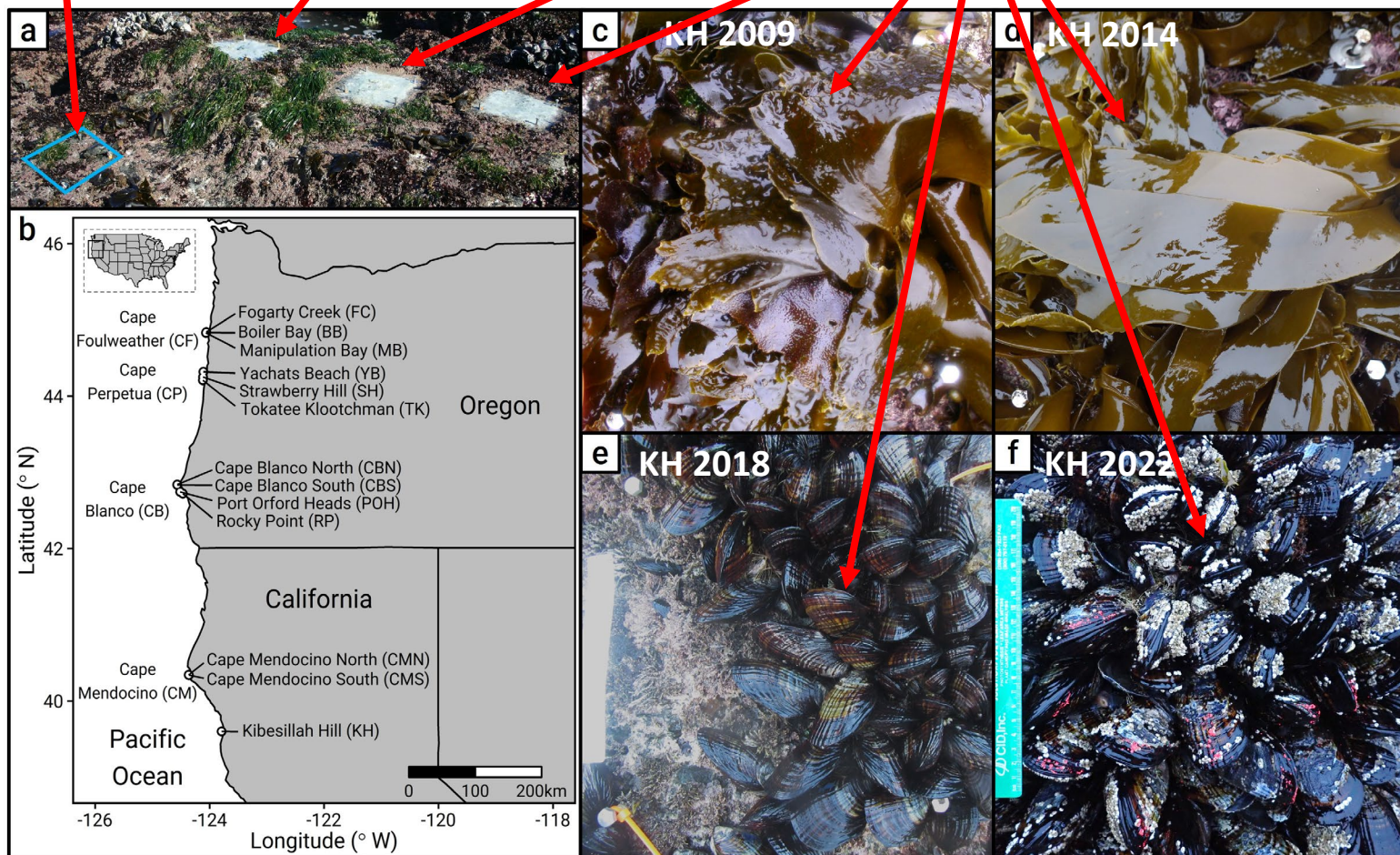
Disturbed Plot Time 1 YR





# Project 3: Community Dynamics: Experiment Two

Design: (a) Fixed plots, 15 x 15 cm, 5 reps of four treatments – unmanipulated control, cleared then macrophyte removal, cleared then sessile invertebrate removal, recovery (cleared, allowed to recover, c-f below)  
(all initial clearances in 2006)





# New Project 5: A “Subtle” Mass Mortality of Mussels

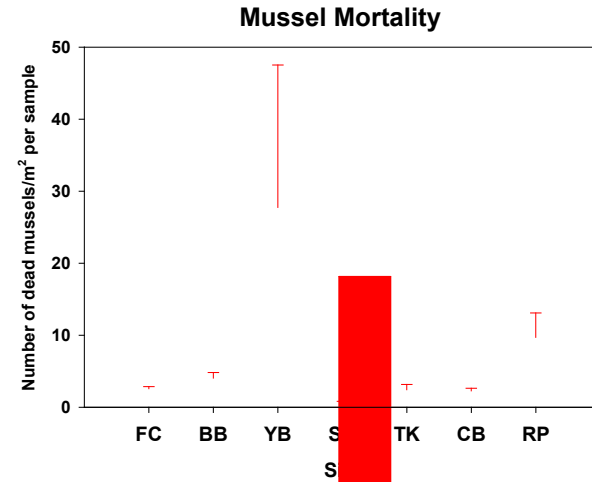


**In June 2023, suddenly started seeing (many-100s to 1000s) individual dead mussels surrounded by live, seemingly healthy mussels.**

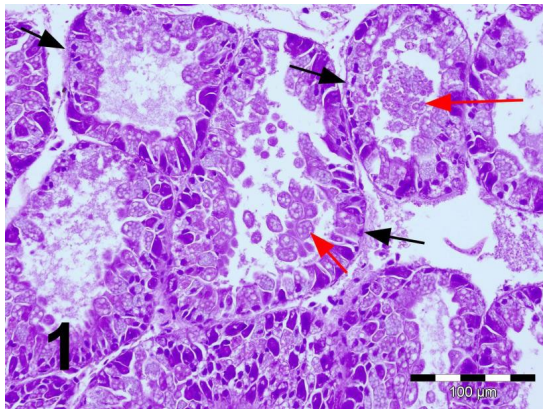
# All sizes affected



# Mortality varied spatially (and also persisted through fall)

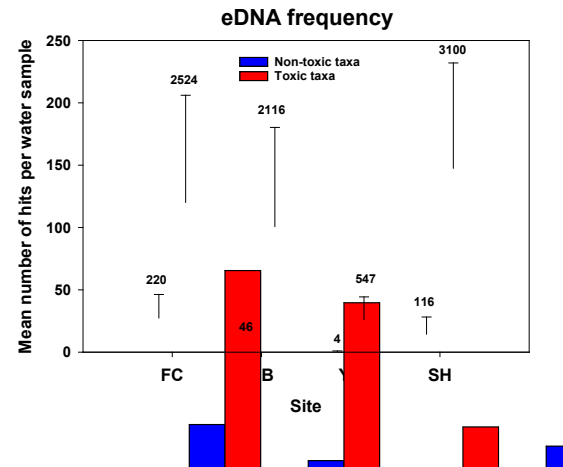


# Mortality Associated with Digestive Tract Anomalies



Cross section of mussel digestive tissue showing detached cell walls (black) and detached inner cell layer (red)

# Evidence consistent with water-borne toxin (dinoflagellates)



# **Conclusions**

**Big Picture: Major concern with climate change  
LOSS OF FOUNDATION SPECIES**

**KEY FOUNDATION SPECIES: KELPS (BOTH INTERTIDAL  
AND SUBTIDAL), MUSSELS**

**Critical for mitigation planning and resource management  
to understand how the dynamics of these  
taxa are influenced by warming and by acute stresses**

**OOST Funding greatly enhances our efforts in these  
directions, and also helps build scientific capacity**

# Extra Slides



# Project 1: Use of Drones to quantify macrophyte and mussel abundance





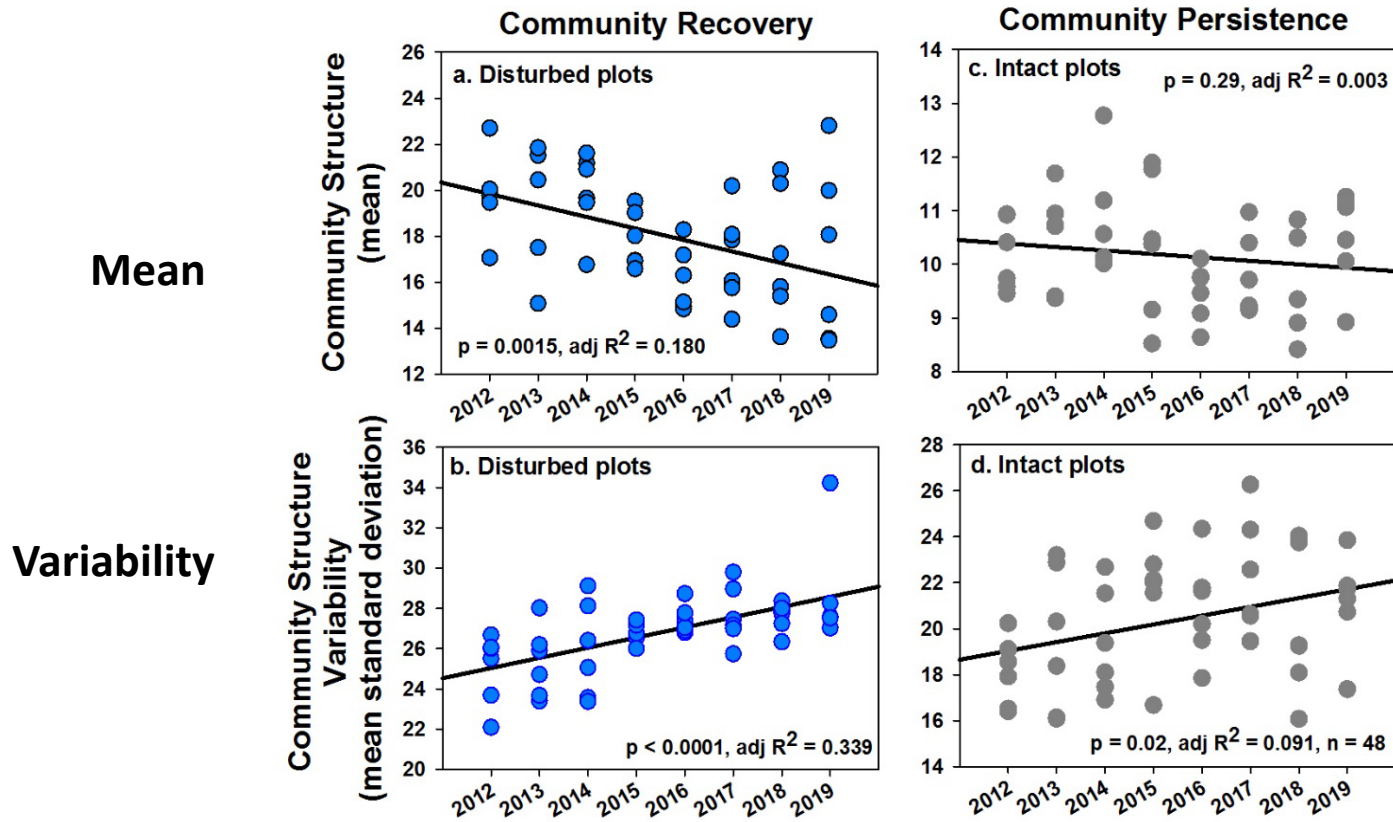
## Project 2: Resumption of Permanently Marked Macrophyte Plots





# Prior Results (OOST funding supported 2023-24 Experiment)

## Low Intertidal Zone Recovery Experiment Series



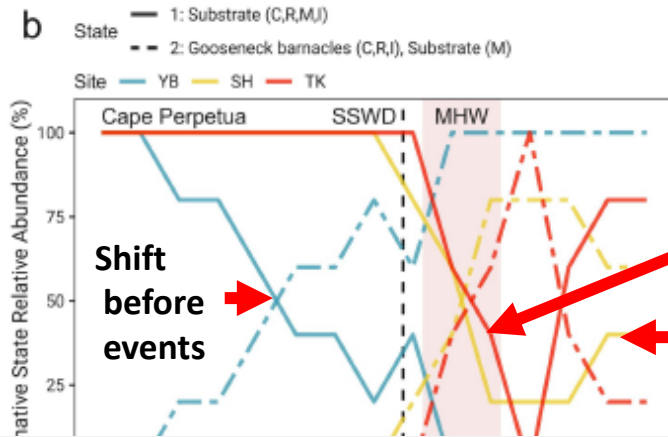
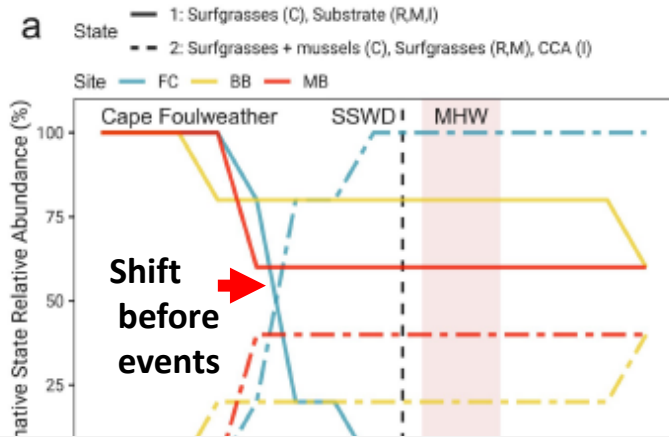
Each dot is the mean for a site each year

Community structure *recovery rate declined (a), variability increased (b) (less stable)*

Intact communities did not change (c), but surprisingly, *became more variable (d) (less stable)*

# Consequence? Site-specific Regime Shifts

## “Hidden Markov Modeling”



Shift w. reversal

Shift: bare to

Shifts before acute perturbations (e.g., goosenecks at YB): climate change?

