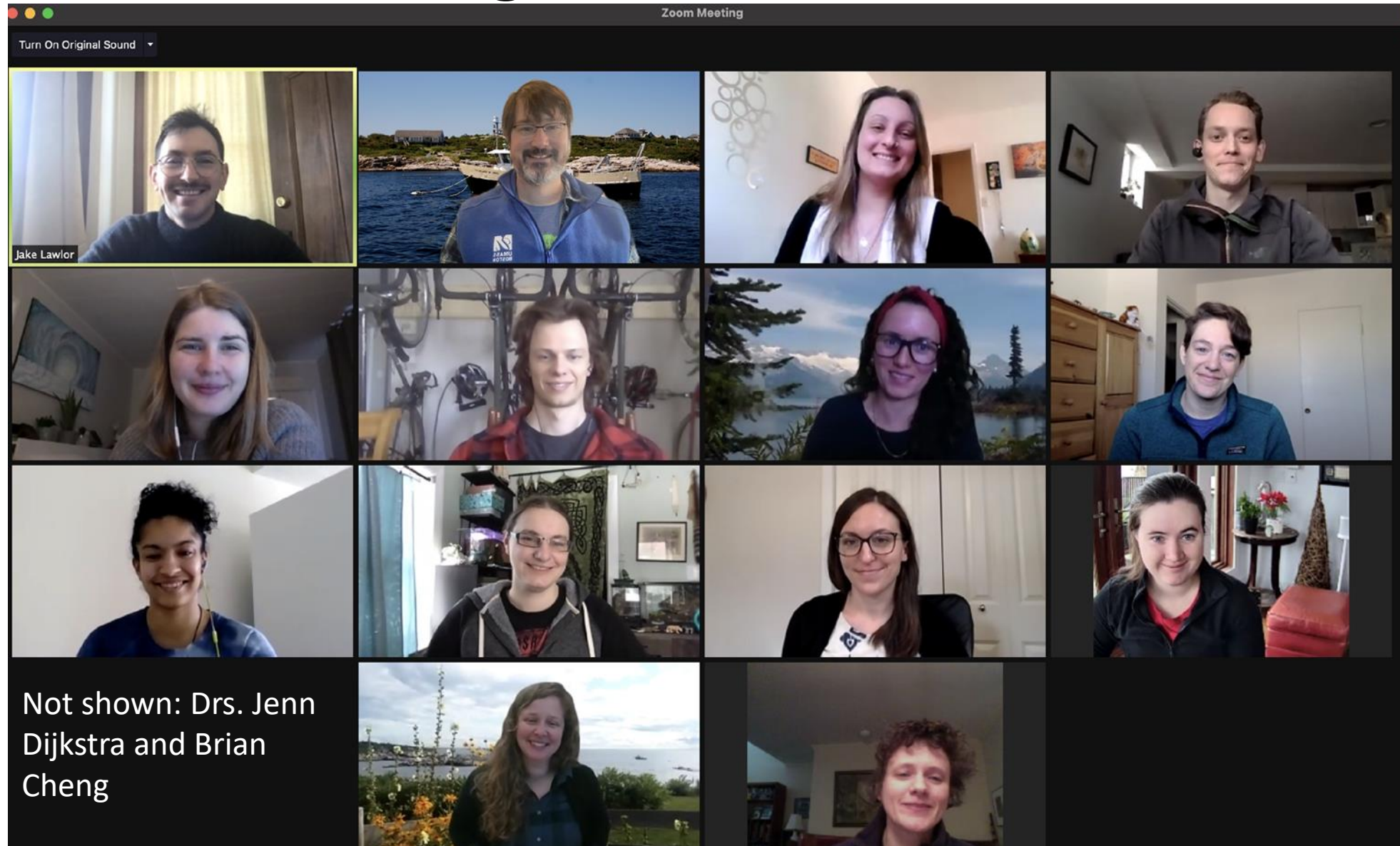


Downscaling Global Change with Forty Years of Data from Intertidal and Subtidal Reefs in Maine

Jarrett E.K. Byrnes^{1*}, Andrea Brown², Julien Beaulieu³, Amelia Hesketh⁴, Nicole S. Knight², Jake Lawlor², Jenny Muñoz⁴, Alexis Pereira⁵, Tianna Peller^{2,6}, Kate Sheridan², Laura Super⁴, Ellen K. Bledsoe^{7,8,9}, Joseph B. Burant^{4,9}, Jennifer A. Dijkstra¹⁰, Kylla Benes¹¹

1 - UMass Boston, 2 - McGill University, 3 - Université de Québec à Montréal, 4 - University of British Columbia, 5 - University of Guelph, 6 - University of Zurich, 7 - Living Data Project, 8 - University of Regina, 9 - University of Arizona, 10 - University of New Hampshire 11 - University of Montana

The Living Data Project Synthesis Group to Unlock Long Term SML Data





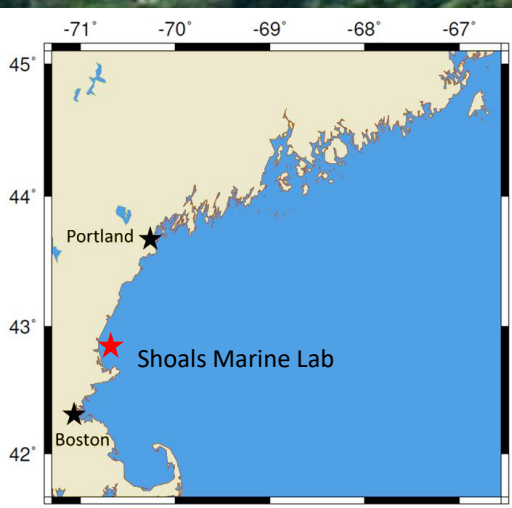
ITRS 2023

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google Earth

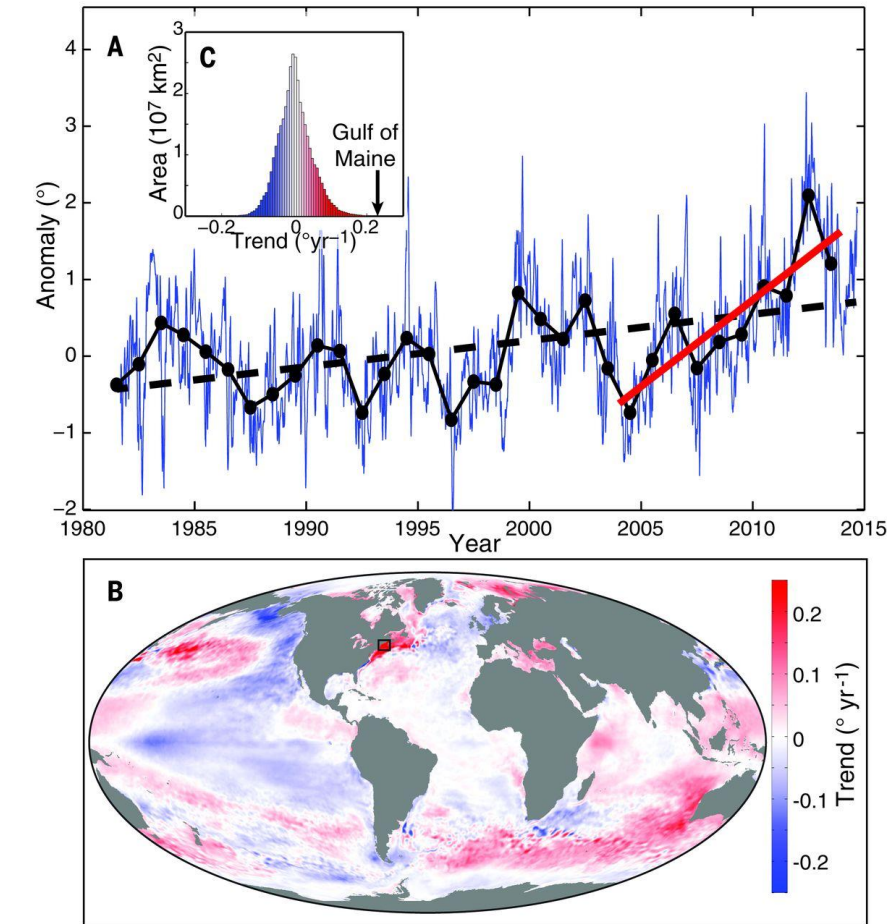
Shoals Marine Lab

- Established in 1973 by John M. Kingsbury & John Anderson
- Jointly operated by Cornell & UNH
- Provides place-based undergrad education and research in marine science
- A plethora of biological data sets going back to the 1970s



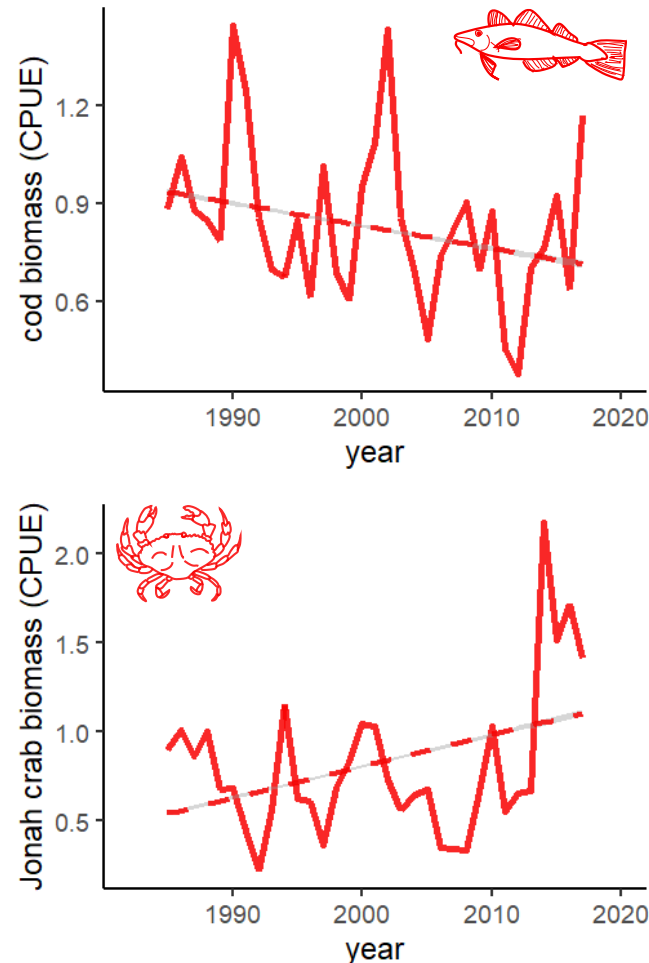
Massive Regional Change in the Gulf of Maine Over the Past Forty Years

One of the Fastest Warming Marine Systems



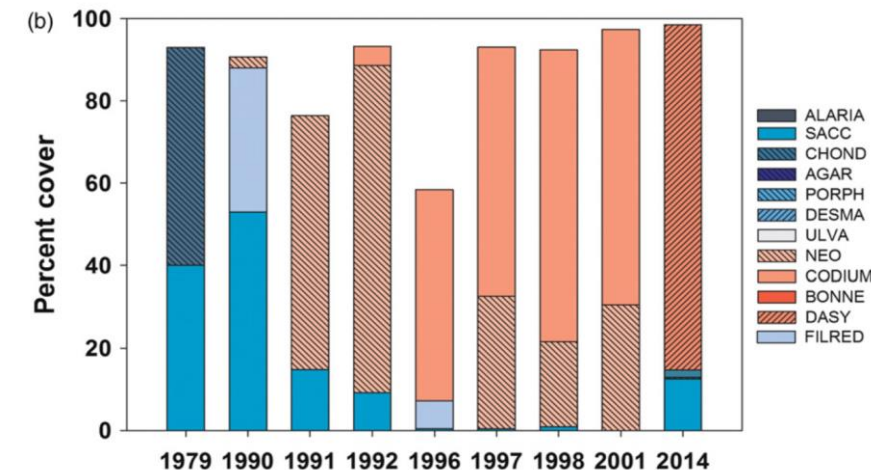
Pershing et al. 2015, *Science*

Fishing-Driven Reshuffling of Top Predators



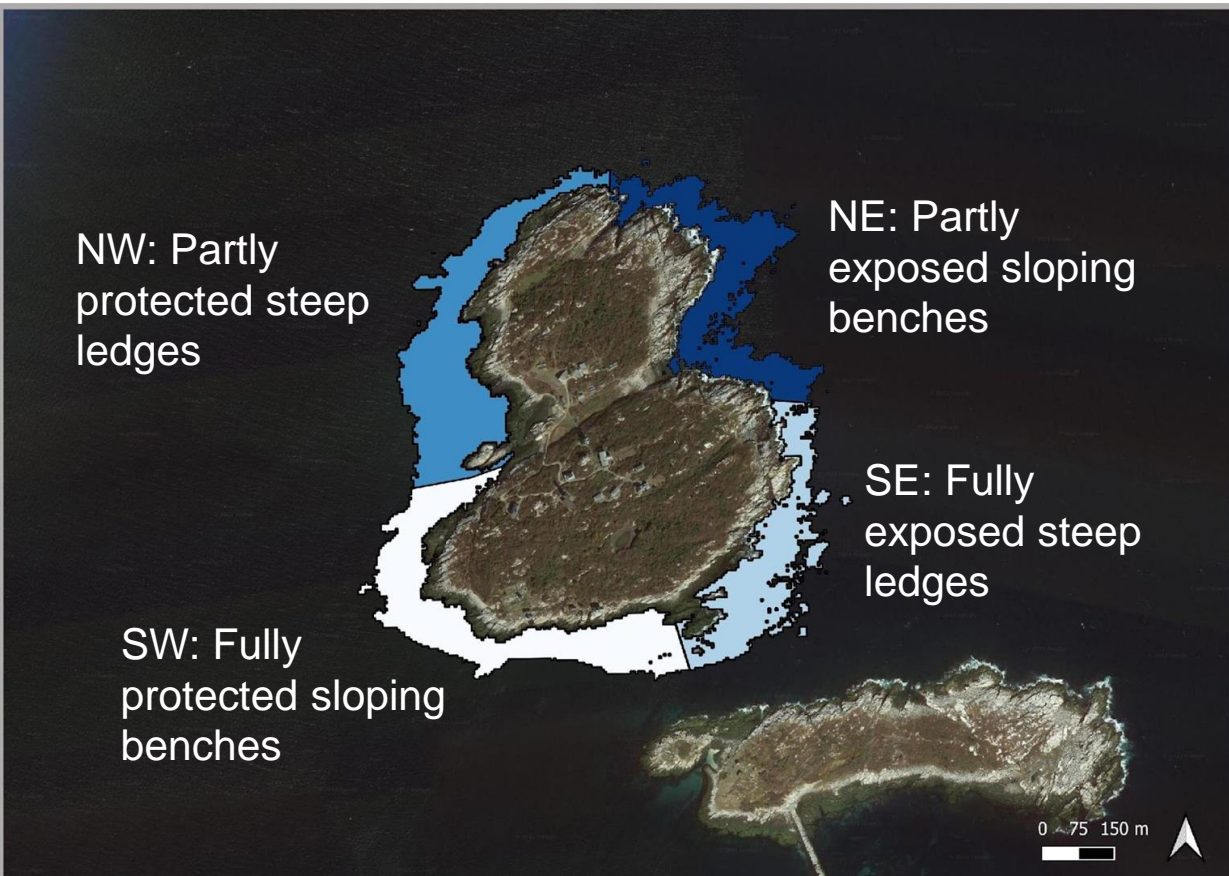
Steneck et al 2013

Kelp -> Barrens -> Invasive Reds



Dijkstra et al. 2017

How Does Regional Change Translate to Local Impacts?

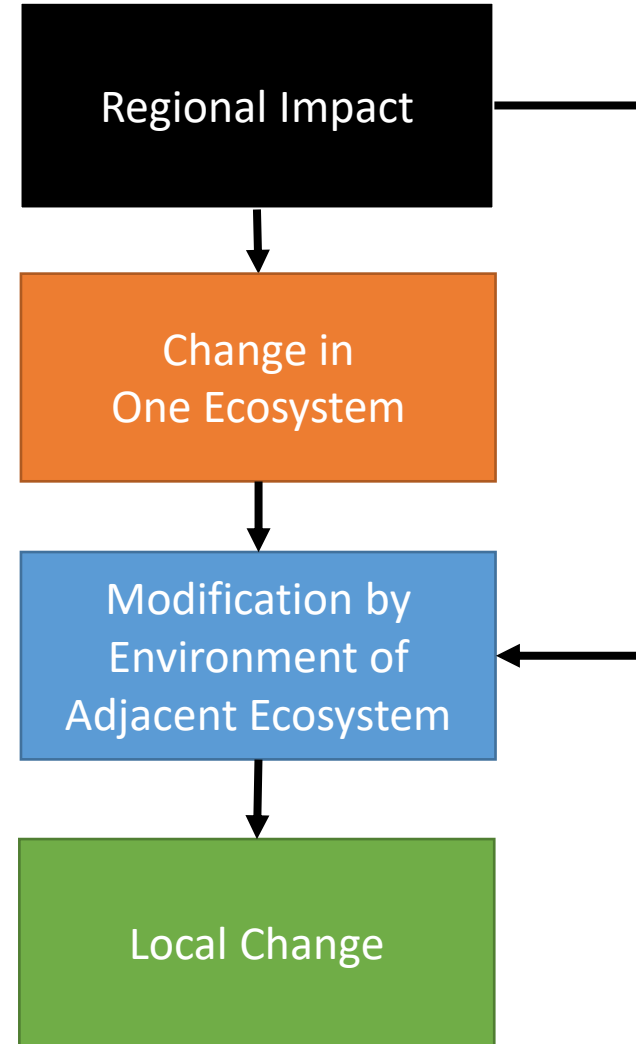
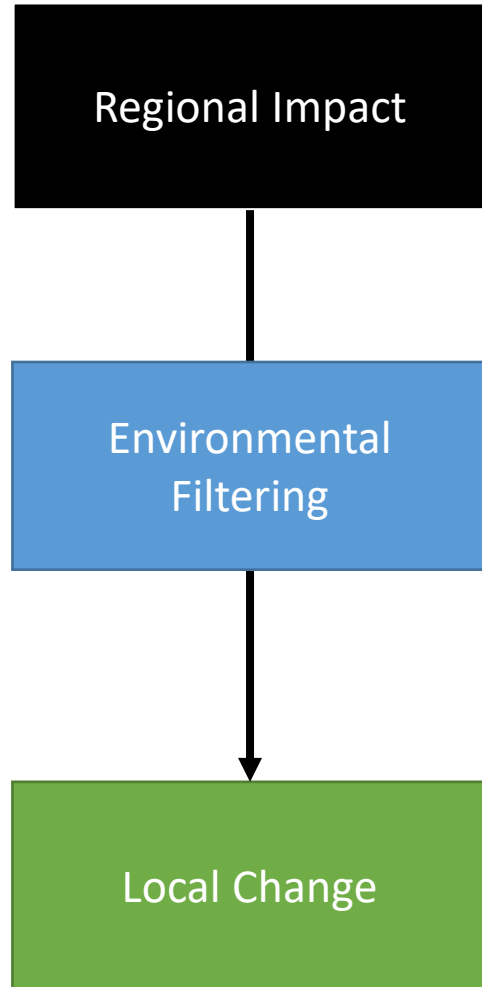


Variability in Local Environments Might Moderate Change



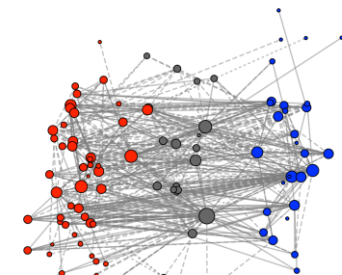
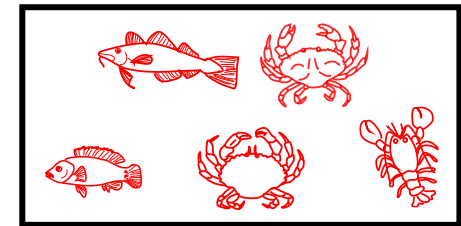
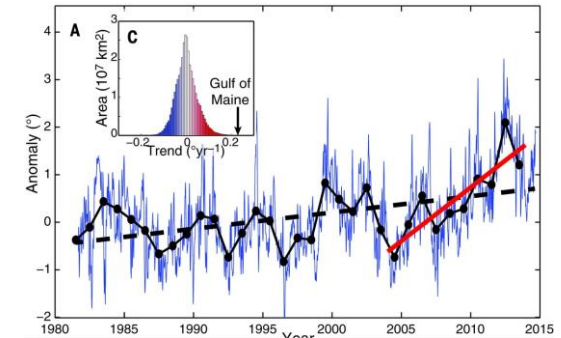
Cross-Ecosystem Connections Might Mediate/Moderate Change

How Does Regional Change Translate to Local Impacts?



How Does Regional Change Translate to Local Impacts in the Isles of Shoals?

1. To what extent is climate change in the driver's seat in the intertidal?
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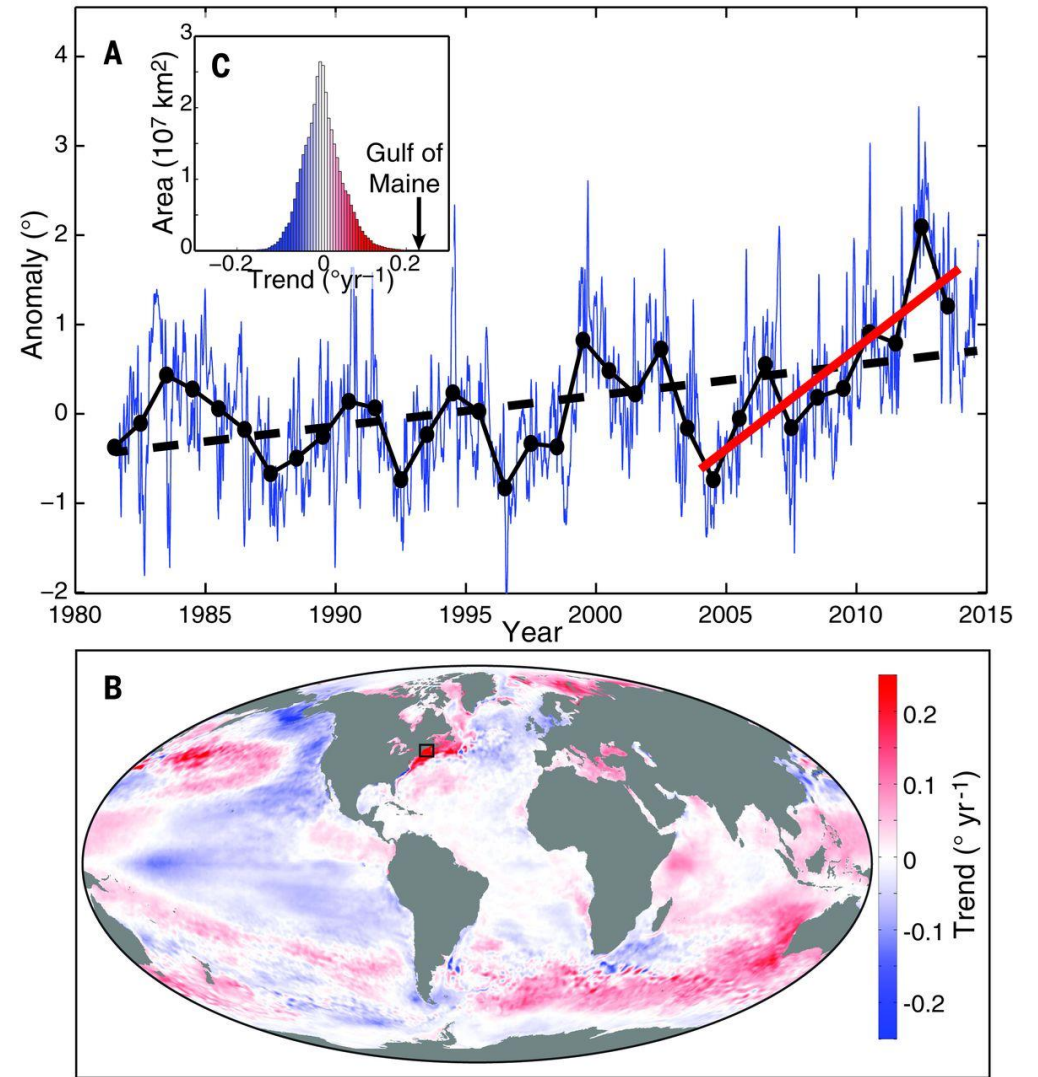
Is climate the primary driver of the SML Intertidal?



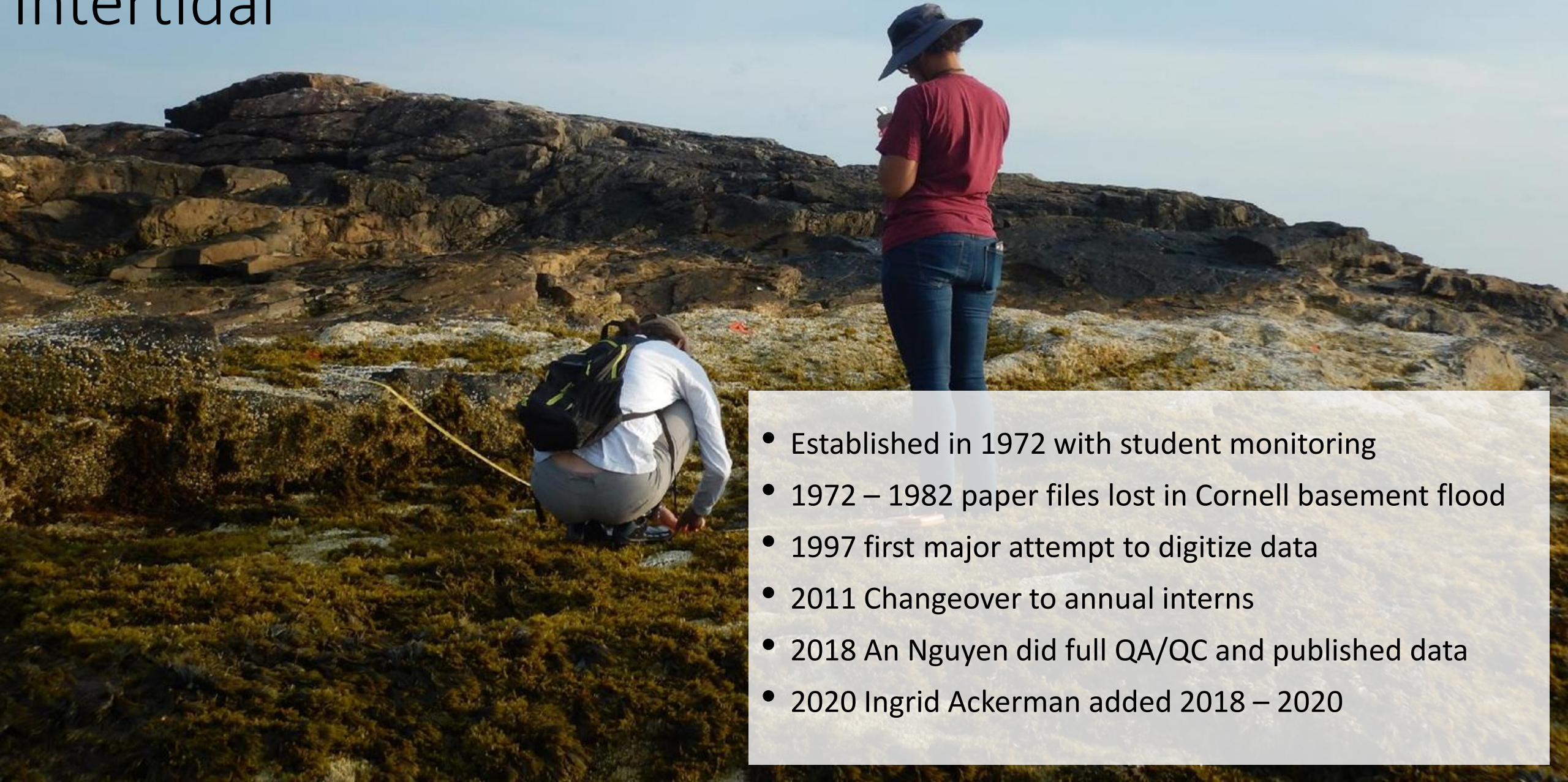
Jake Lawlor



Amelia Hesketh

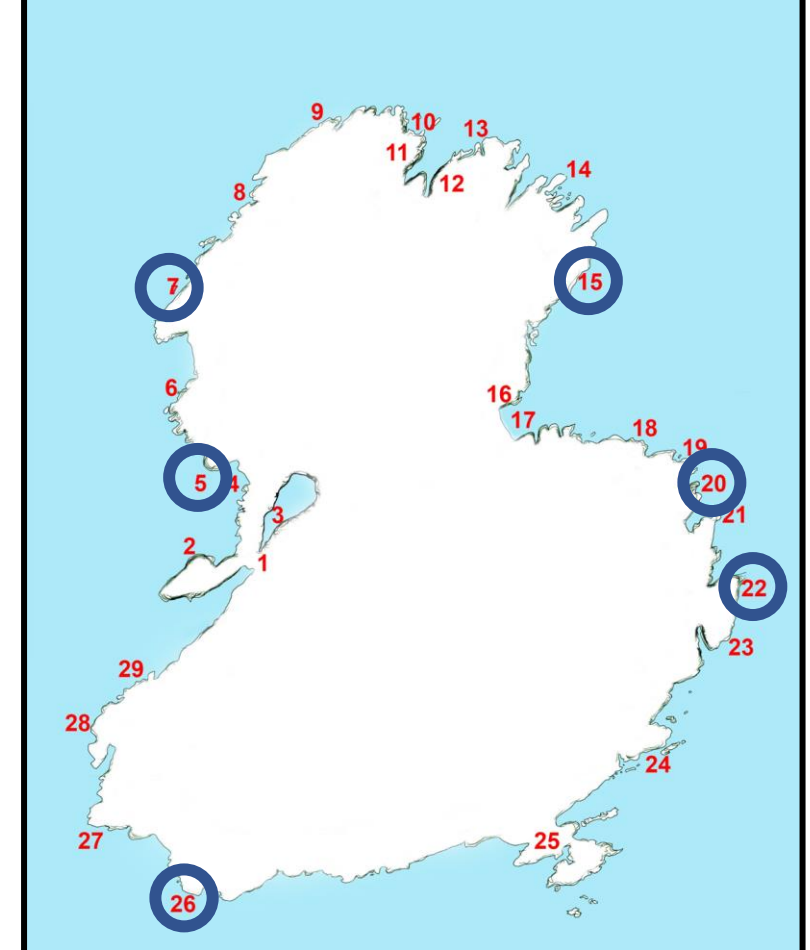
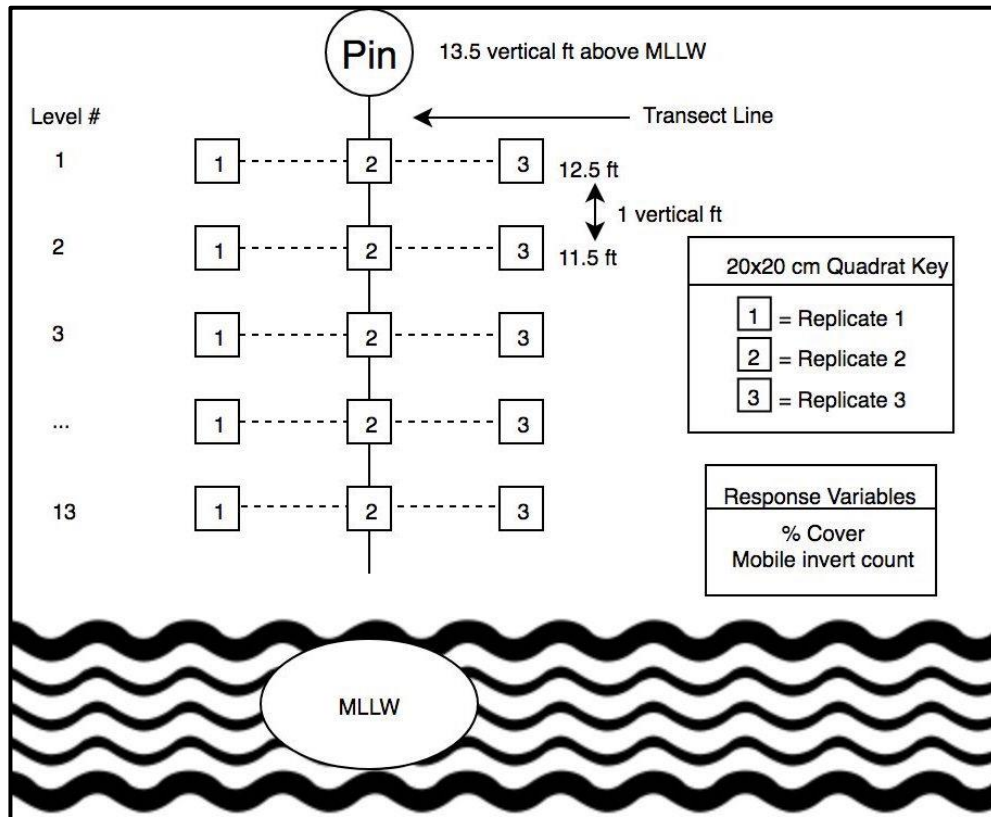


Forty Years of Intertidal Data from the SML Intertidal



- Established in 1972 with student monitoring
- 1972 – 1982 paper files lost in Cornell basement flood
- 1997 first major attempt to digitize data
- 2011 Changeover to annual interns
- 2018 An Nguyen did full QA/QC and published data
- 2020 Ingrid Ackerman added 2018 – 2020

Sampling Design



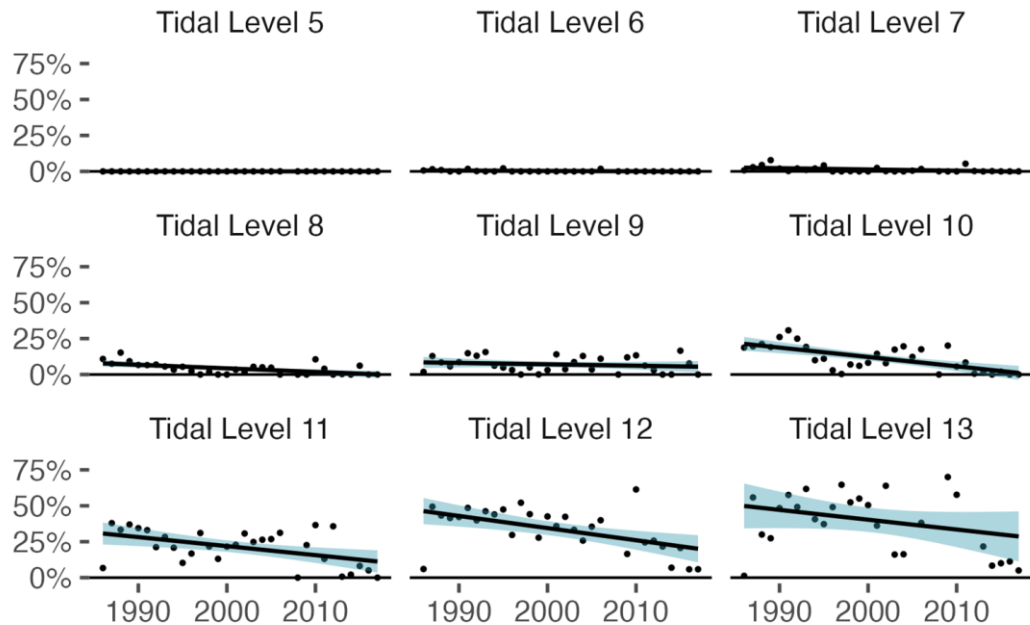
Canopy Cover

Primary Cover

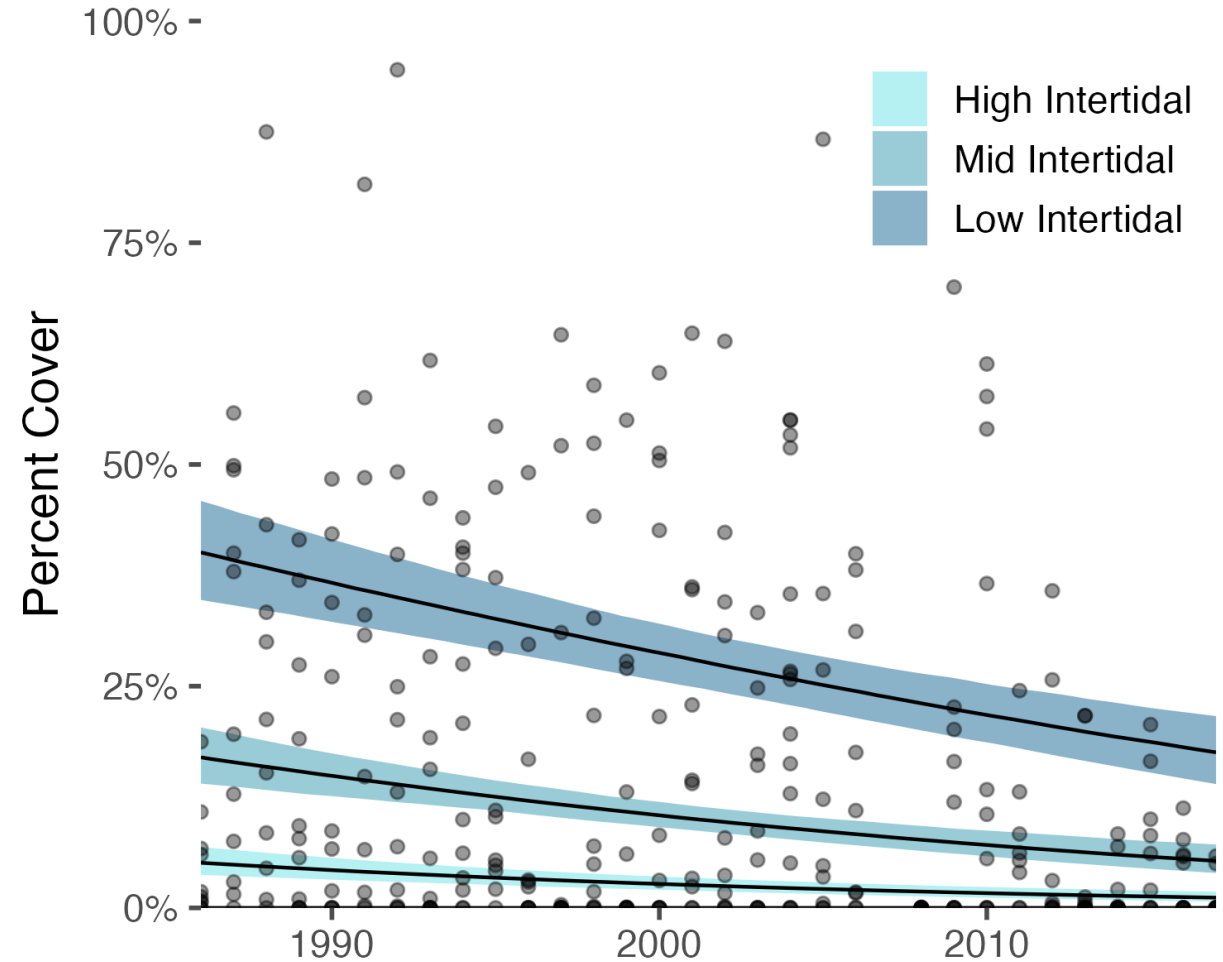


- 20 x 20 cm quadrats
- Percent cover of sessile organisms
- Counts of mobile organisms
- Sizes of select species

Determining Abundance Change



Example species: **Chondrus Crispus**



Occurrence-based thermal indices

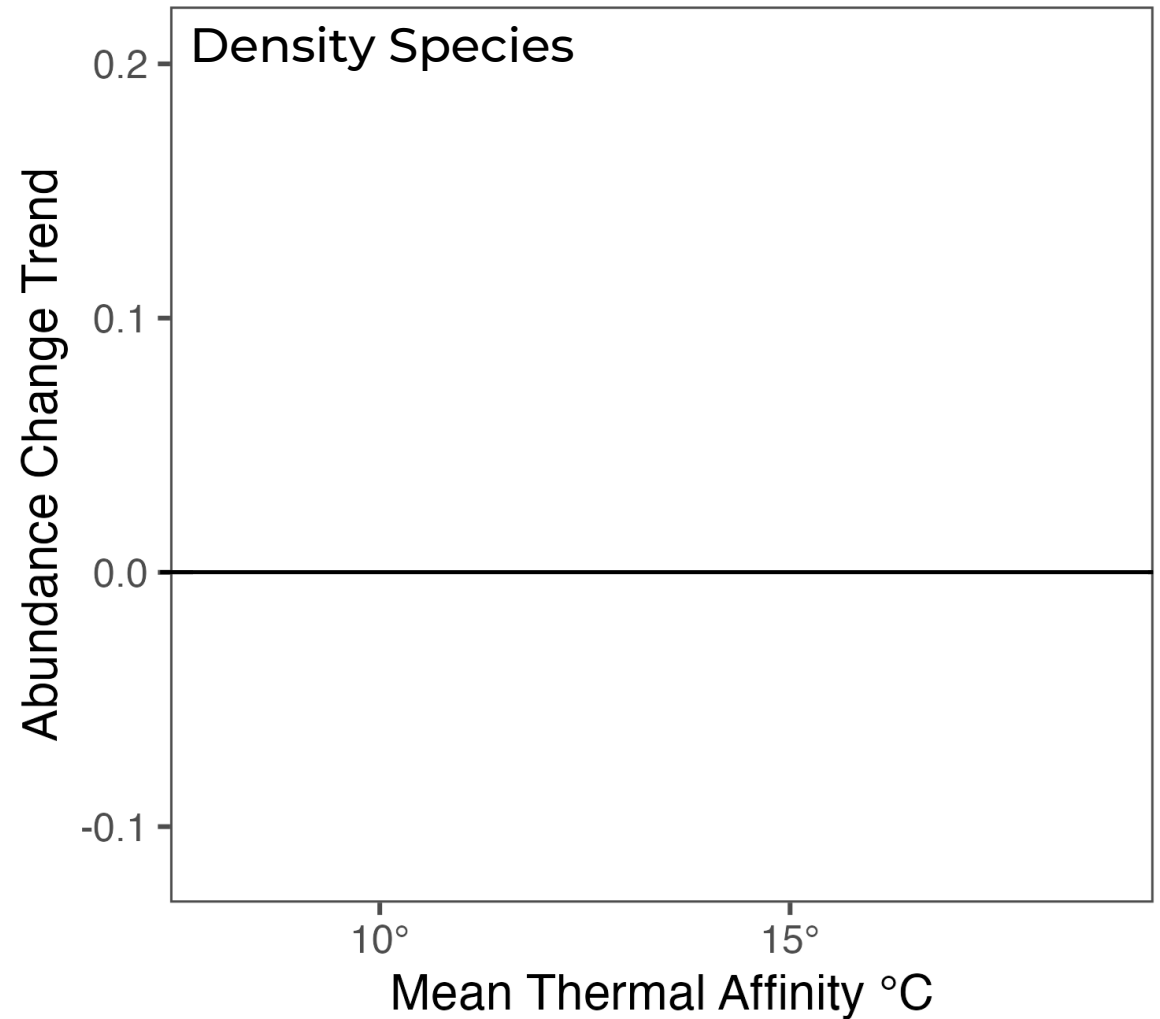
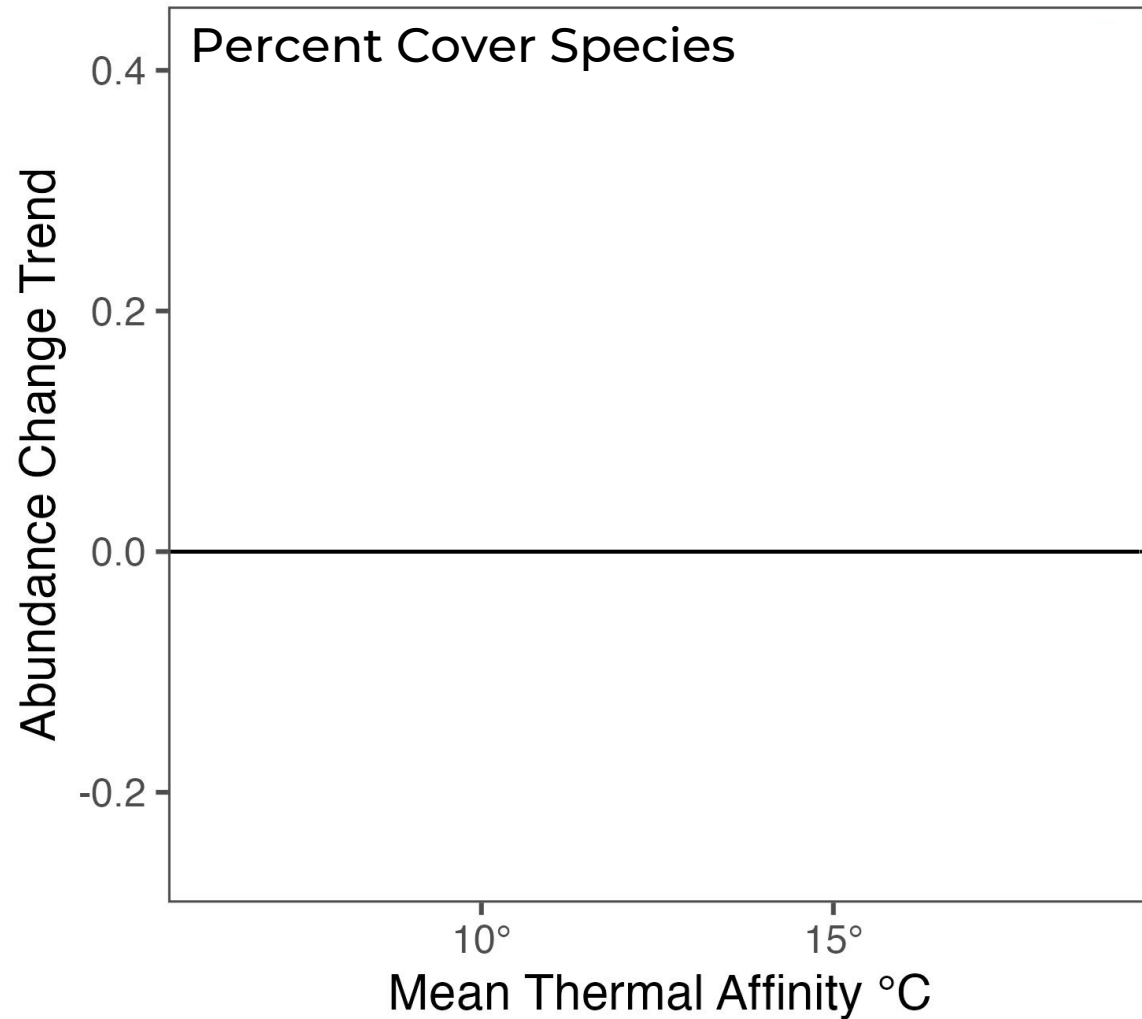


OBIS SPECIES OCCURRENCE
RECORDS

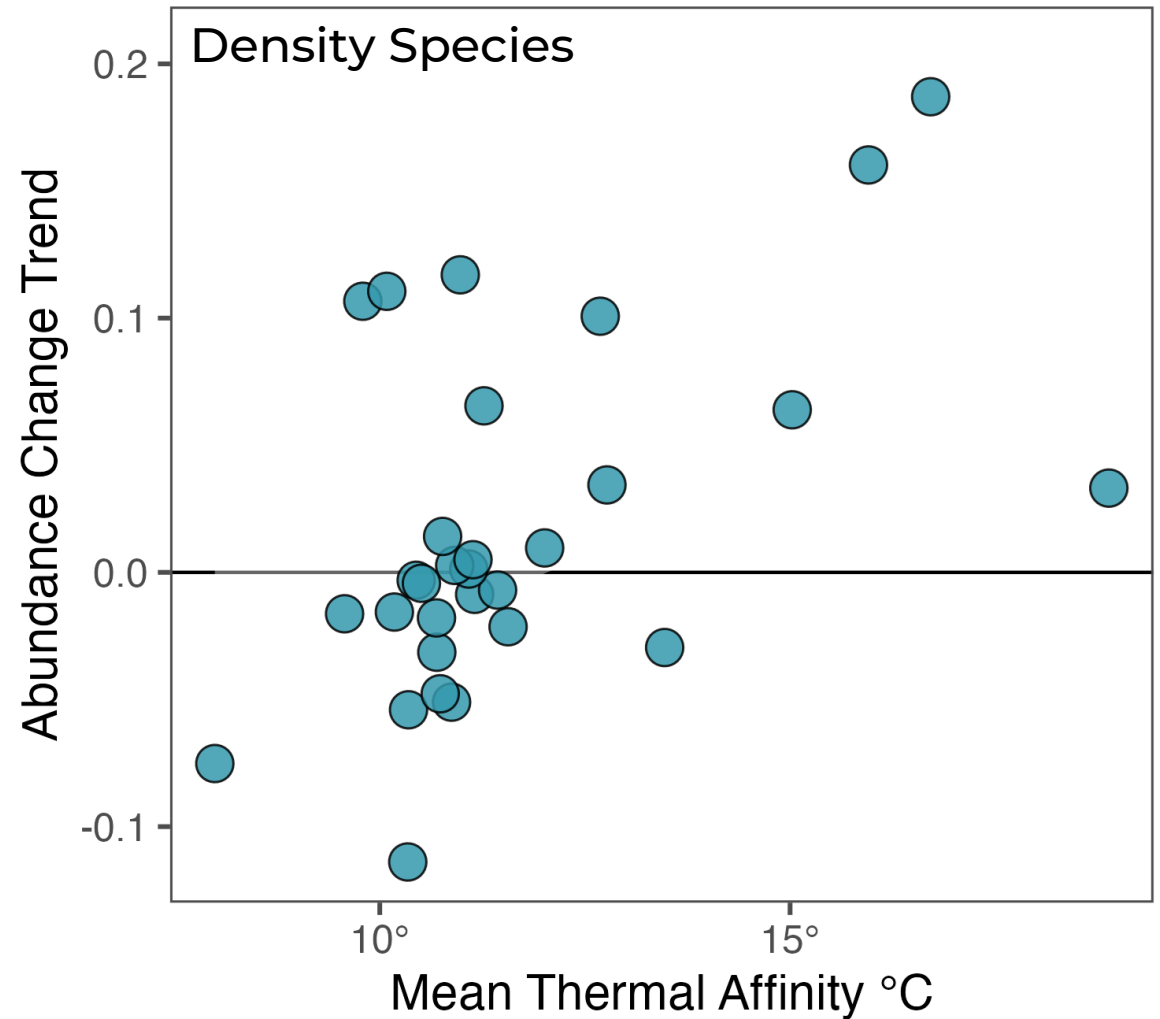
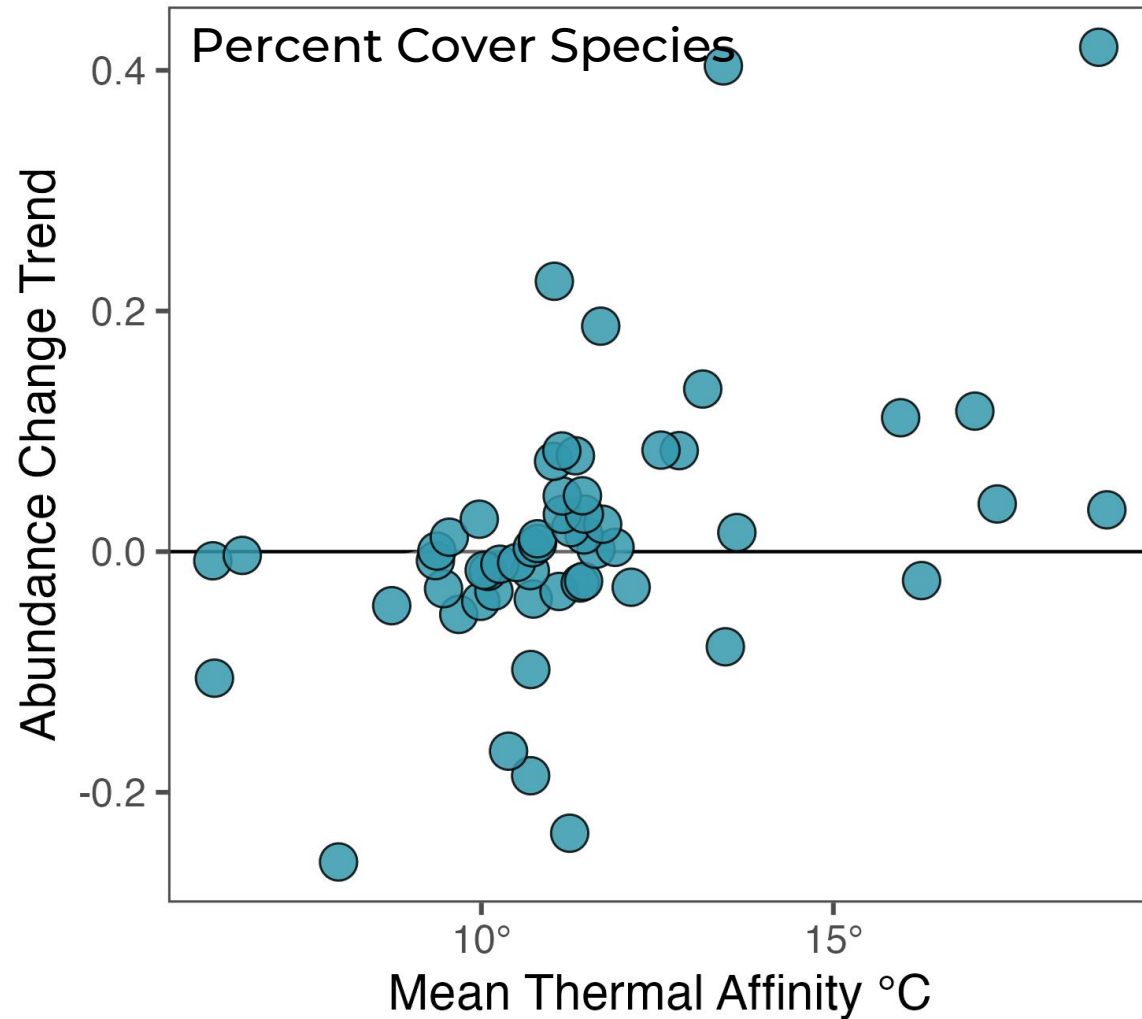


BIO-ORACLE MARINE
TEMPERATURE LAYERS

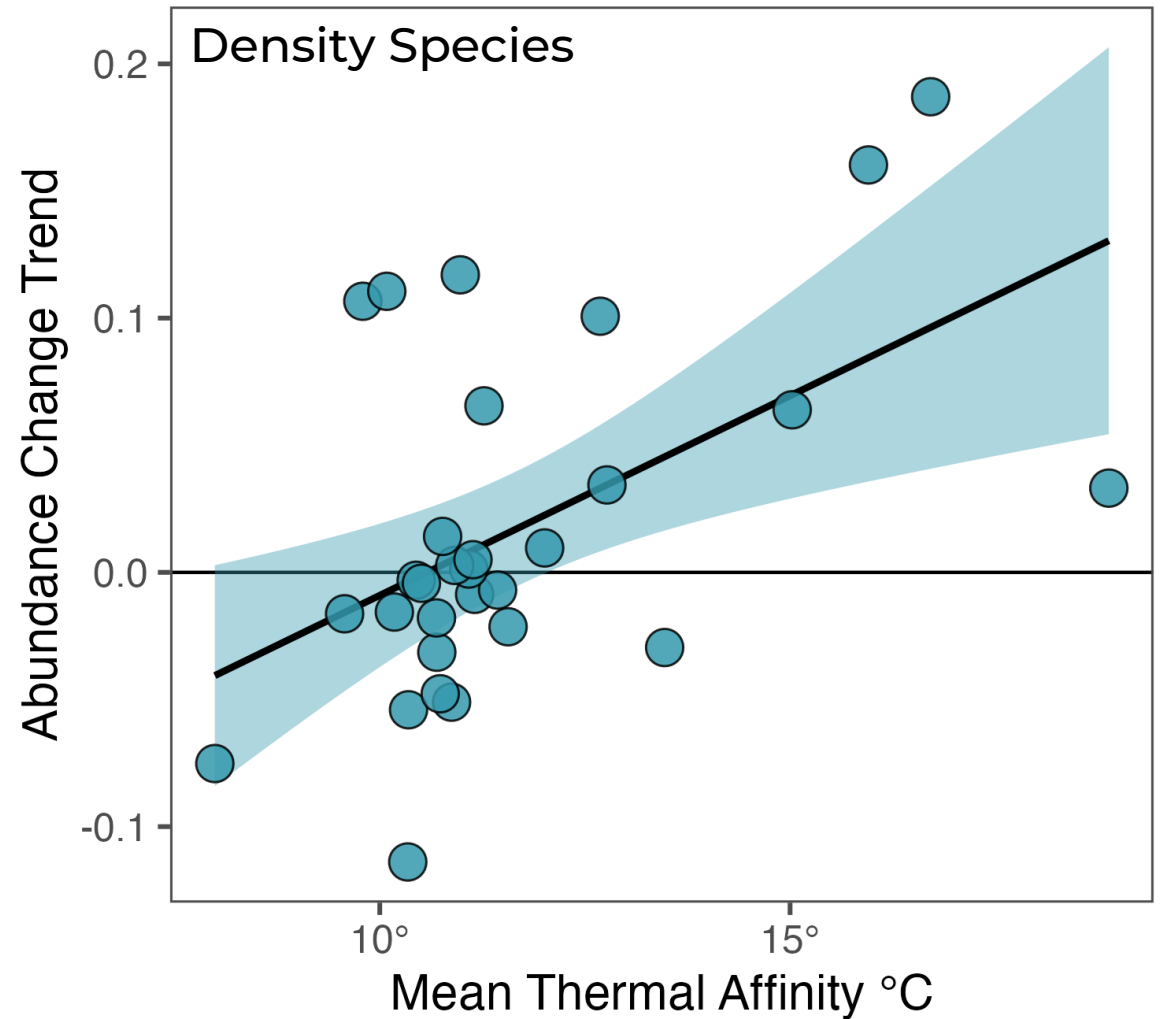
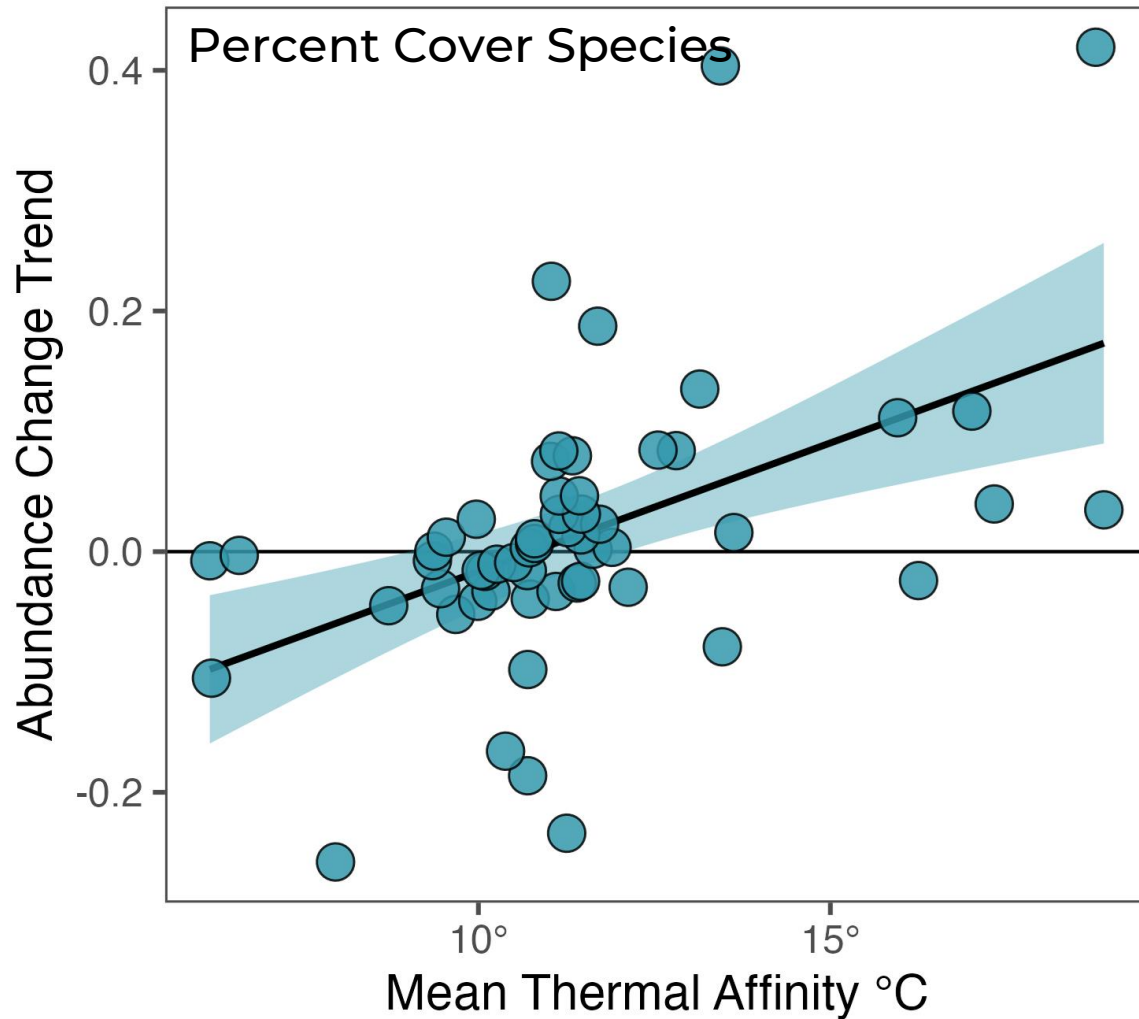
How does temperature tolerance predict abundance change?



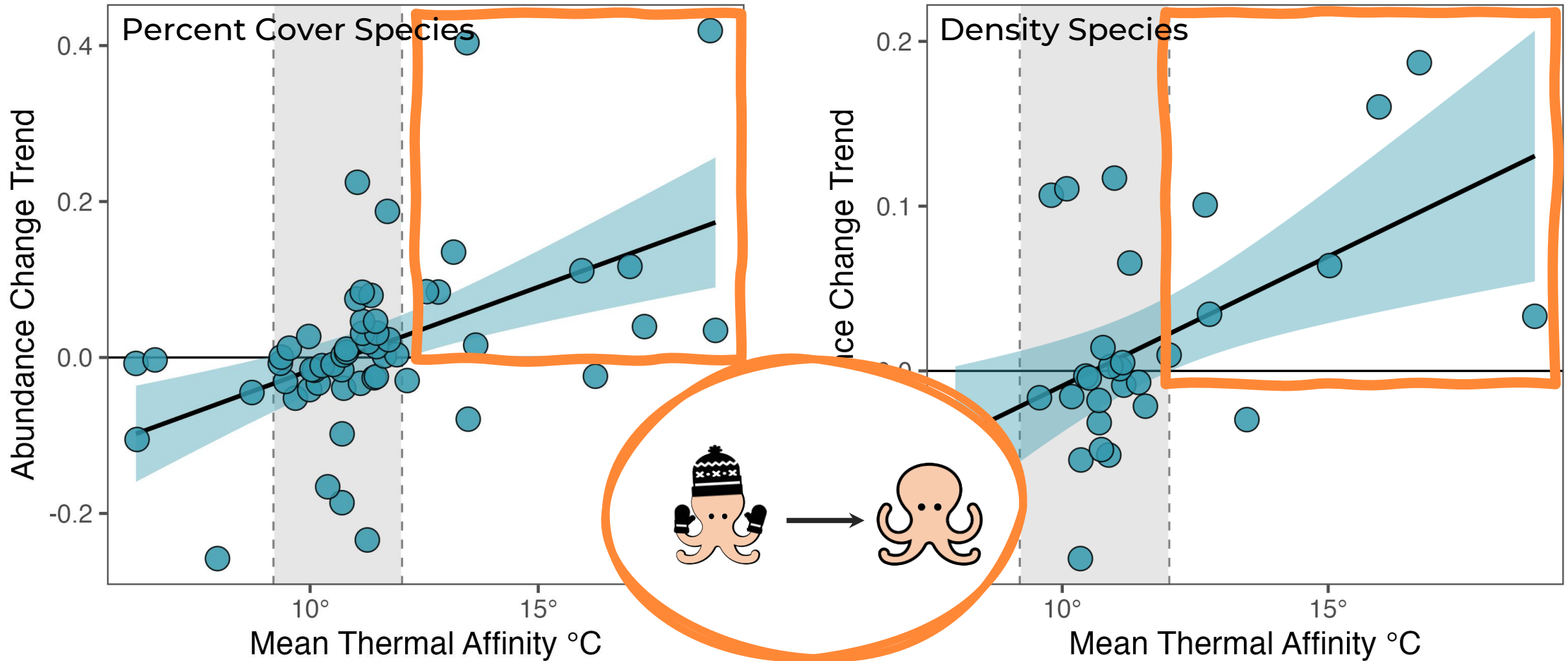
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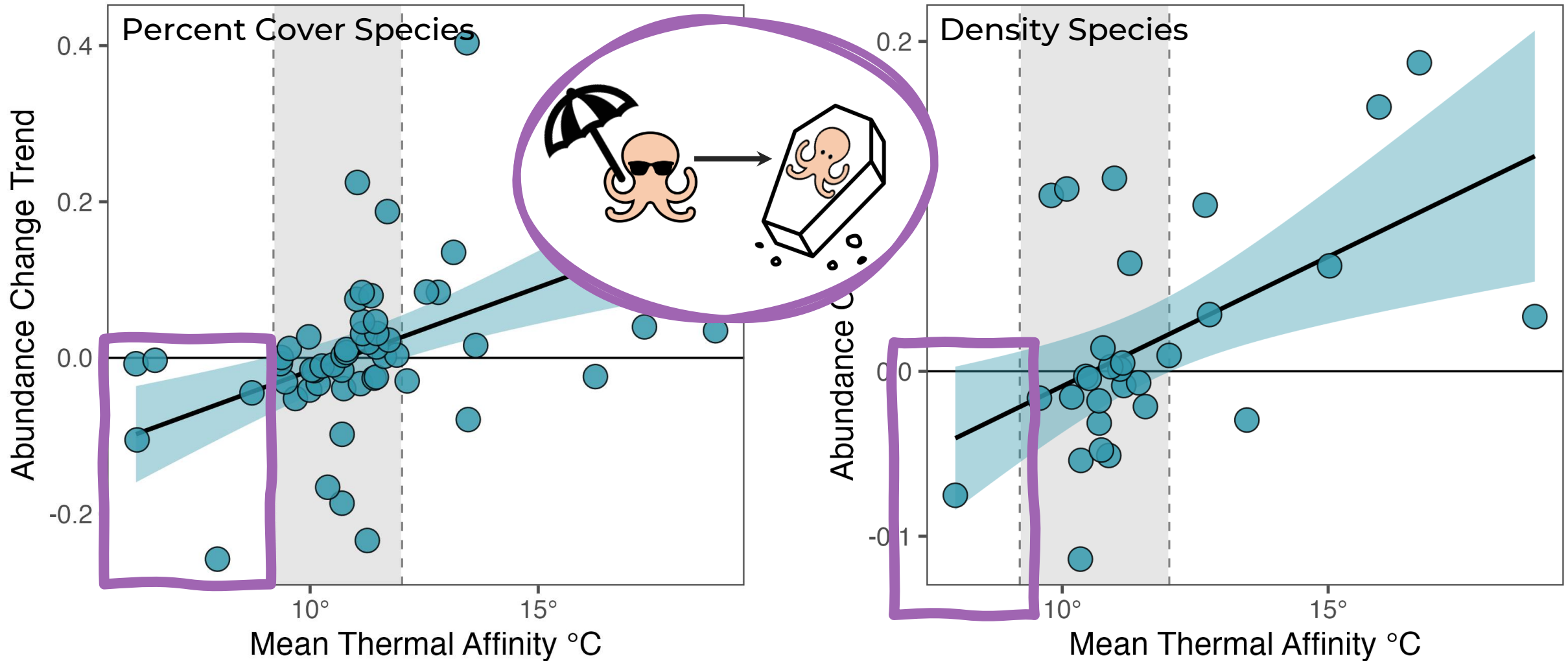
How does temperature tolerance predict abundance change?



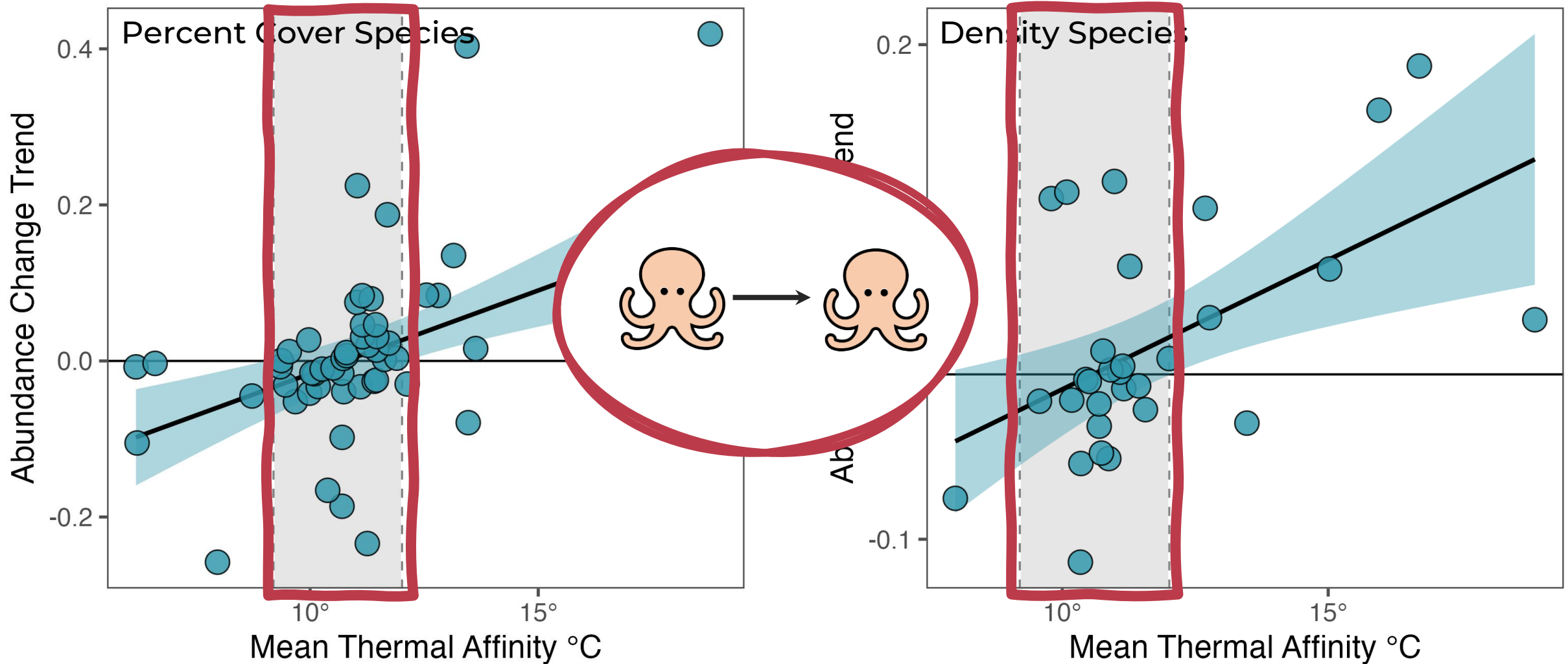
How does temperature tolerance predict abundance change?



How does temperature tolerance predict abundance change?

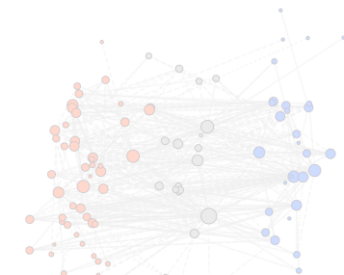
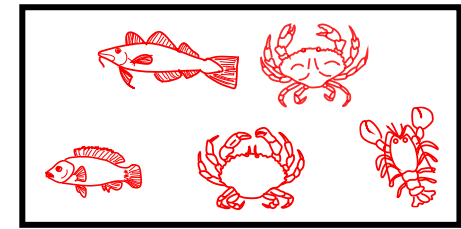
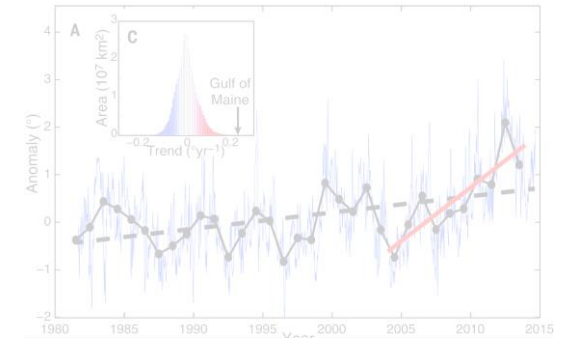


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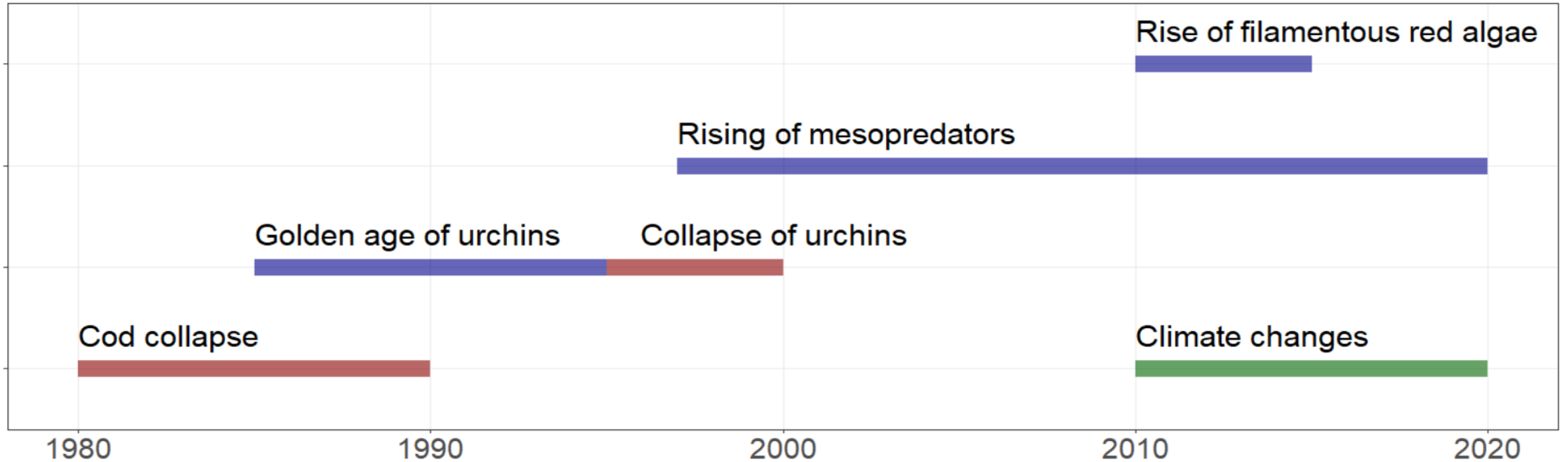


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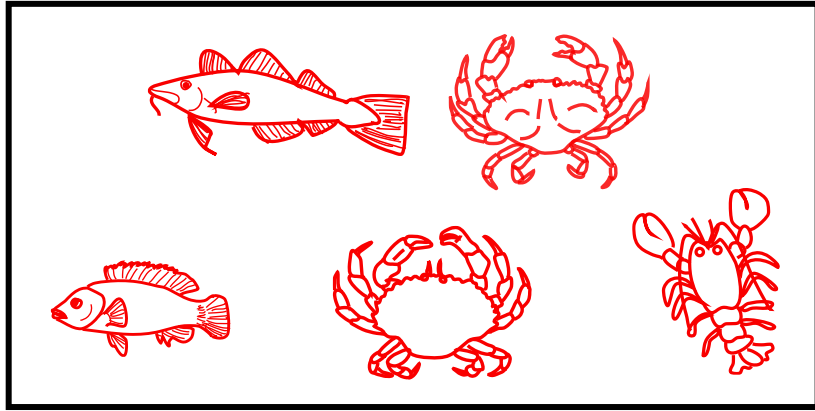


Regime Shifts – The Gulf of Maine

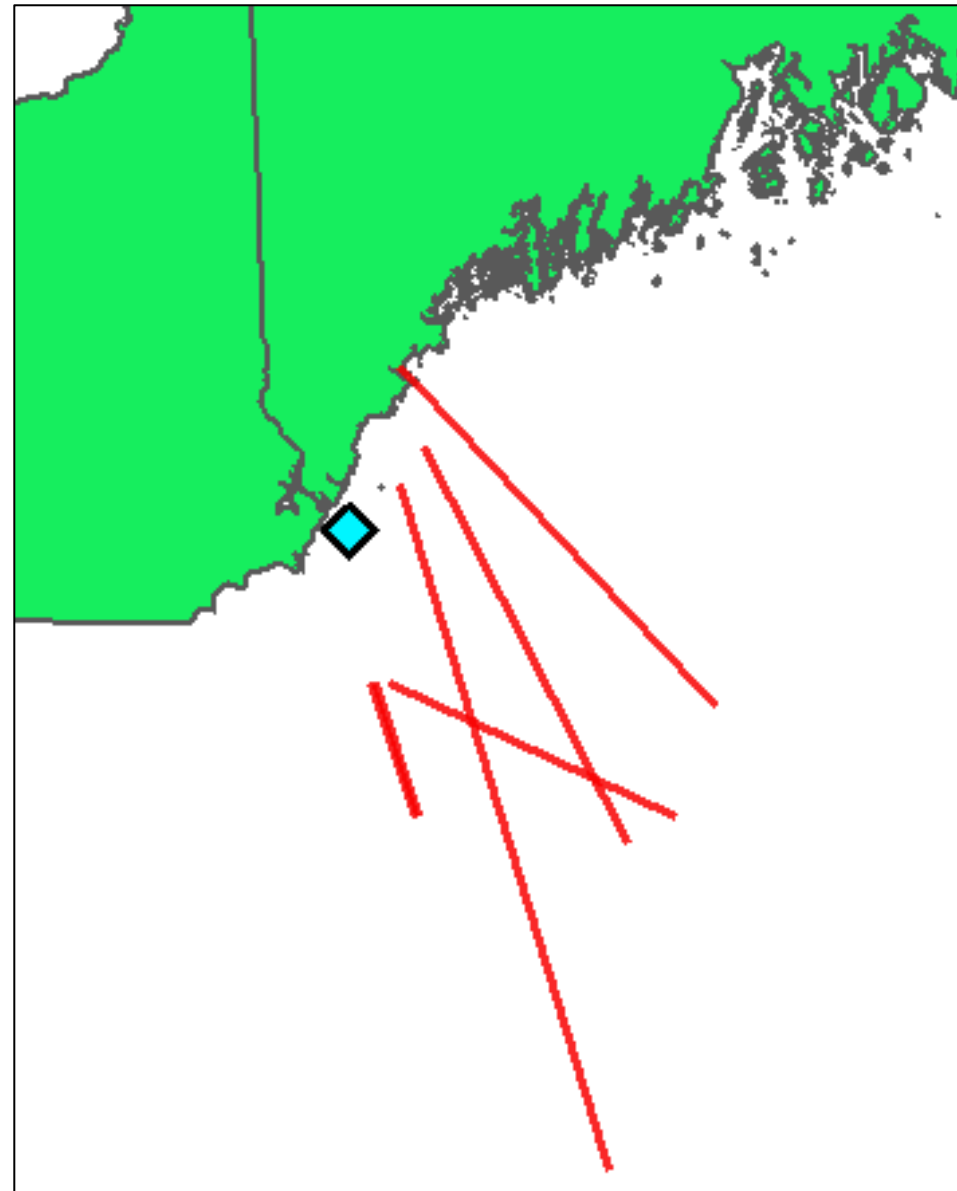


Ref: NOAA data, Steneck et al. 2013, Dijkstra et al. 2017, Pershing et al. 2015

NOAA Seasonal Trawl Data



- 6 trawl areas with consistent seasonal records within 100km of SML 1980 – Present
- Calculated average biomass per unit effort from spring and autumn data
- Used PCoA to get community structure and fit GAMs to look at regime shifts



Julien Beaulieu

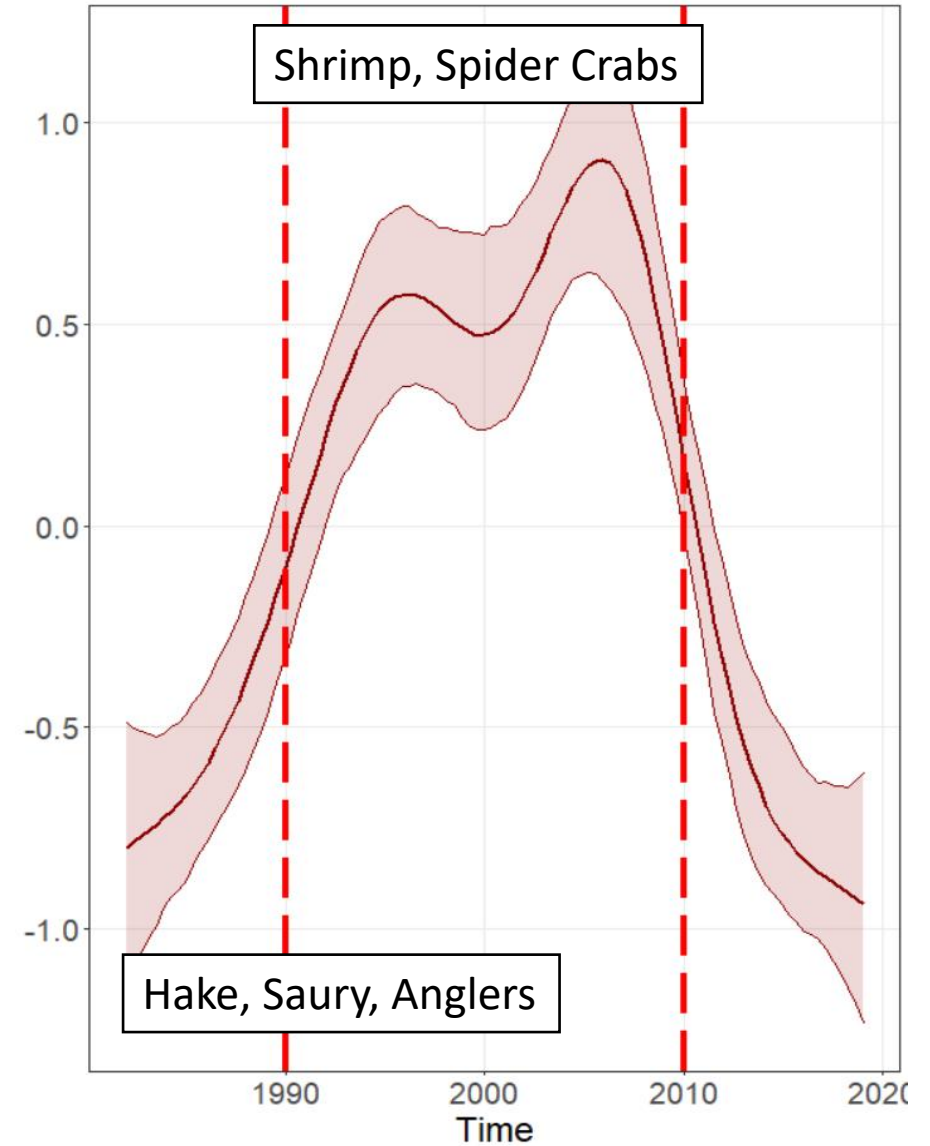
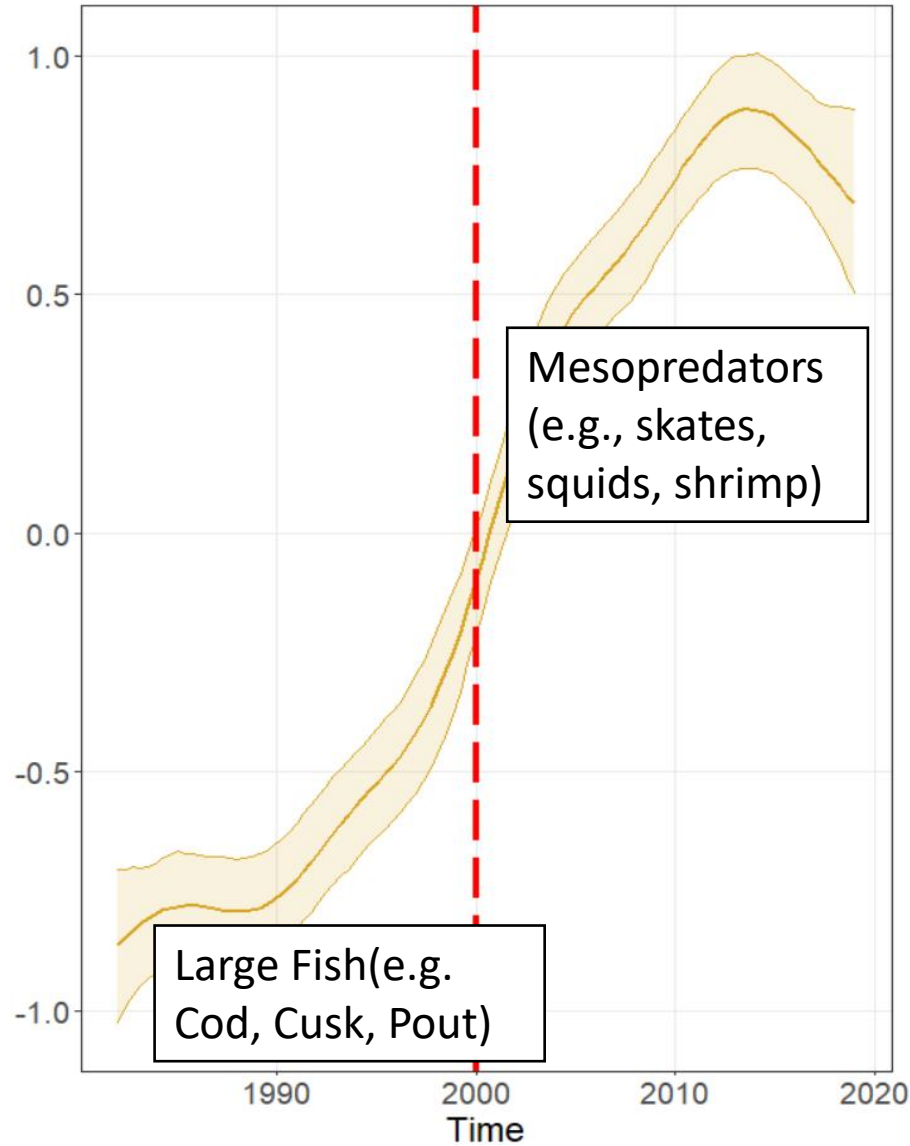
GAMS on PCoA Show Three Regime shifts in ~1990, 2000 and 2010

Lycenchelys, Shrimp
squids, Barndoor skate, Shrimp
Spider crabs

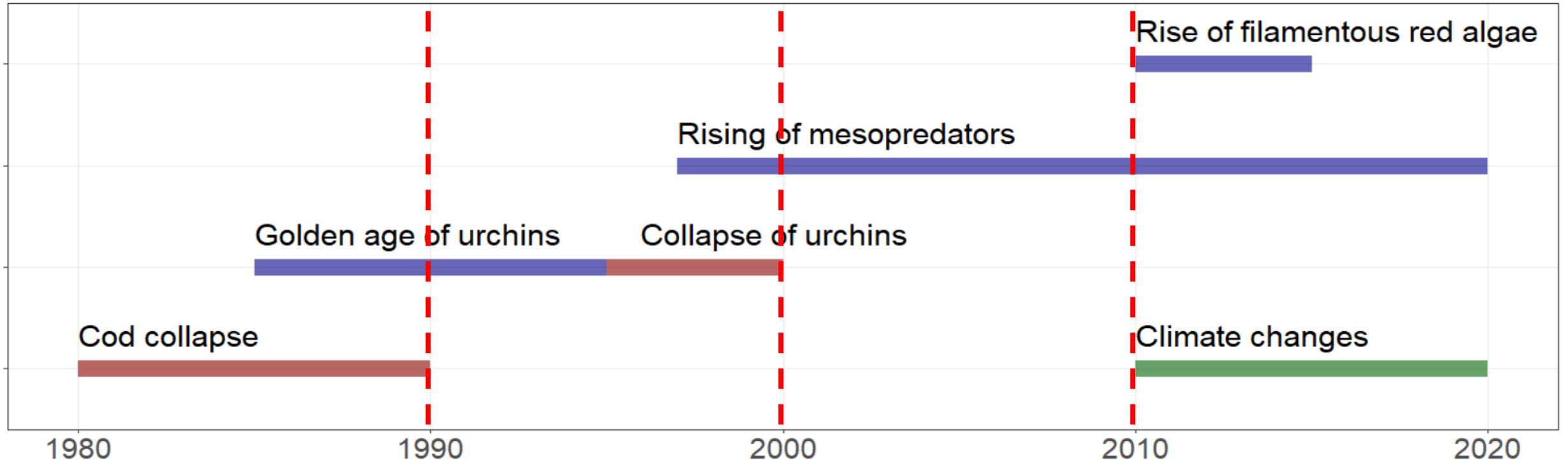
Subtidal PCoA1 (23% var)

Subtidal PCoA2 (11% var)

Cod, Cusk, Pout
Snakeblenny, King crab
Angler, hakes



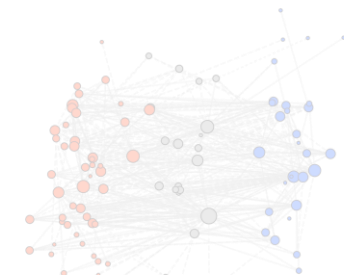
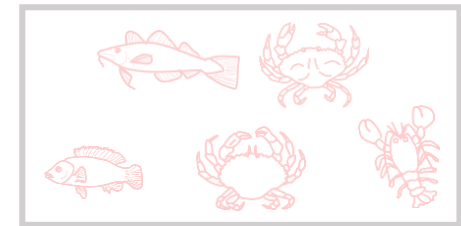
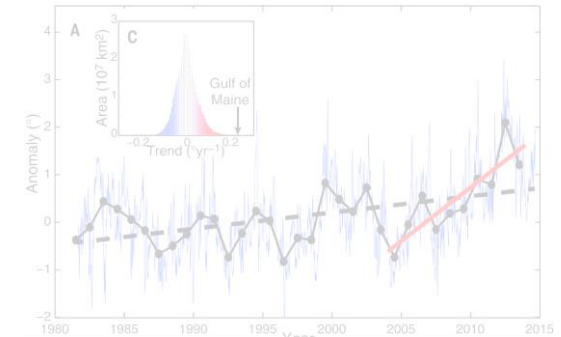
Regime Shifts – The Gulf of Maine



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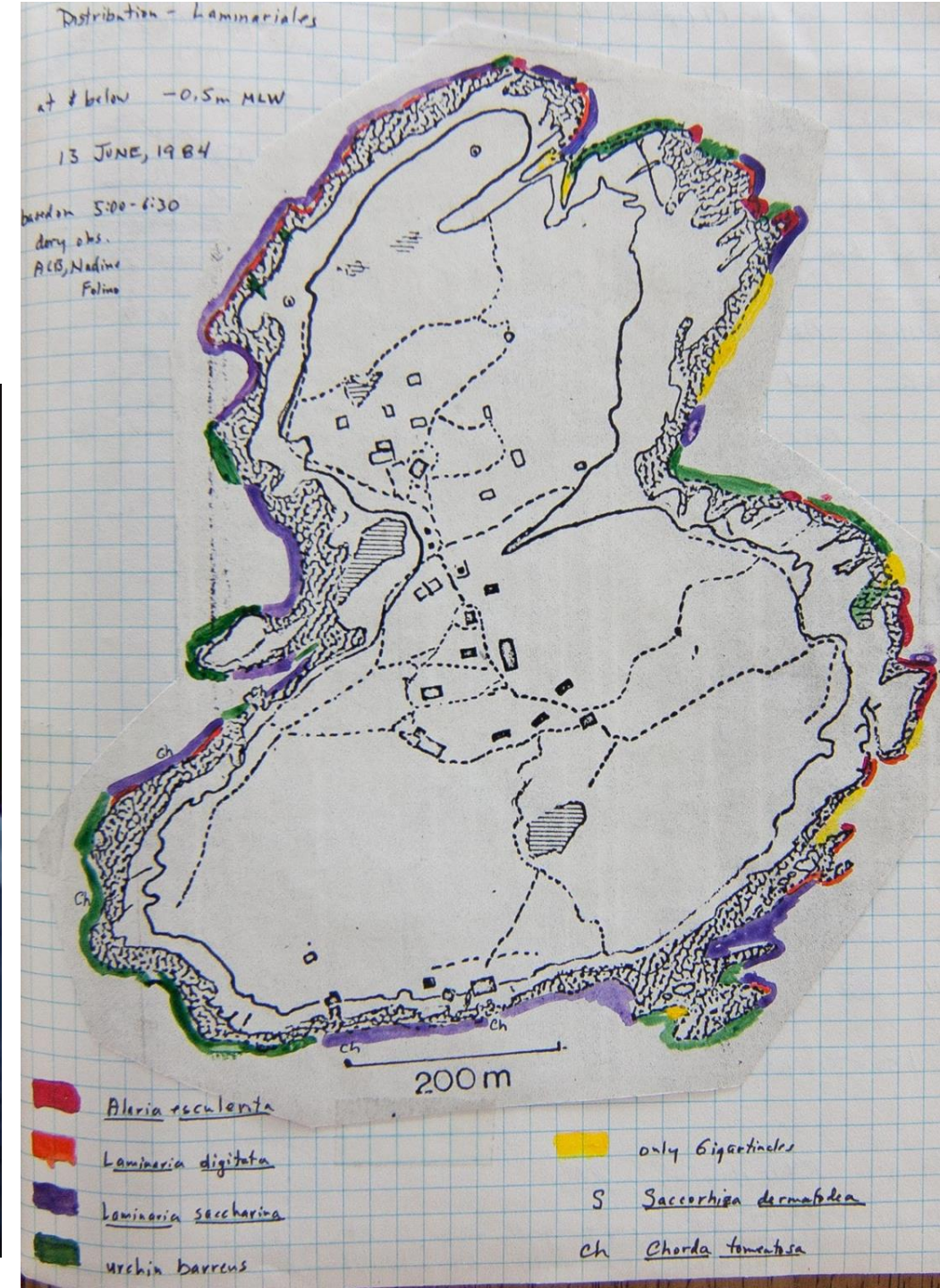
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Maps of Dominant Shallow Subtidal Habitat from 1980 - 1990



Dr. Art Borrer





Aleria esculenta



Laminaria digitata



Laminaria saccharina



urchin barren



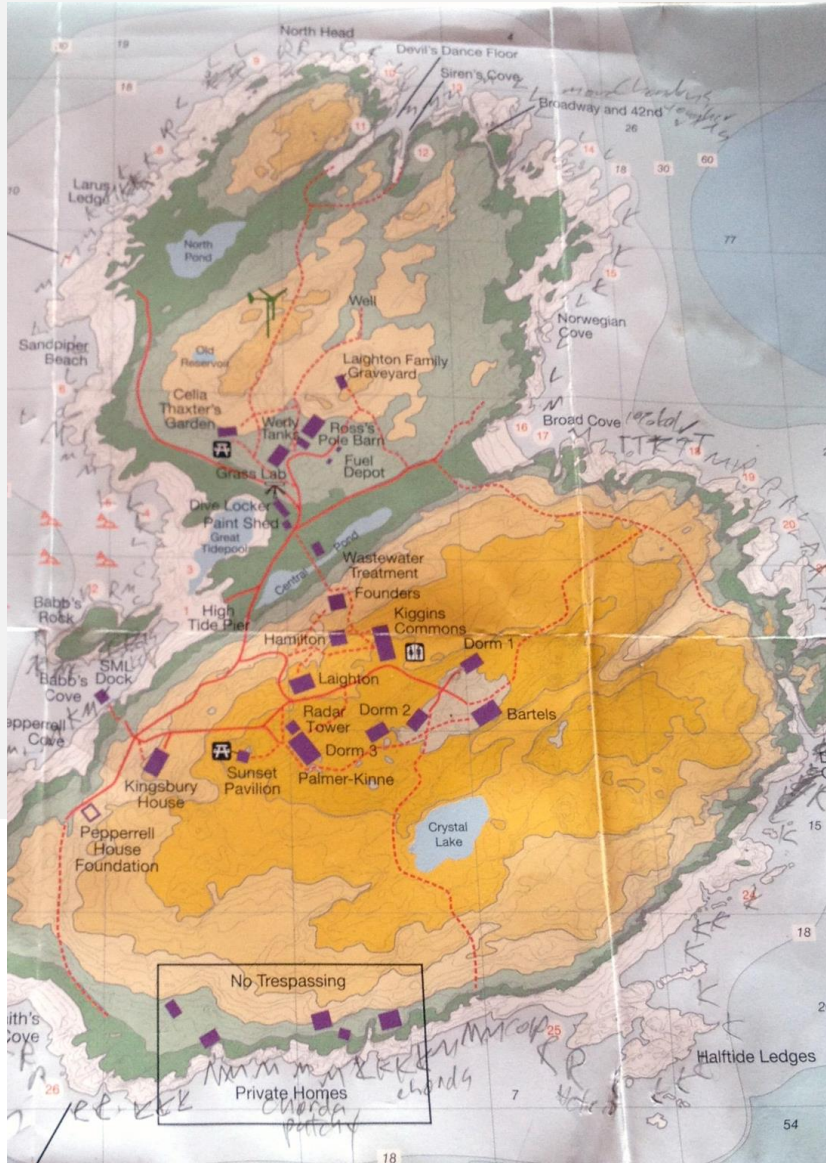
only Gigartinales

S

Saccorhiza dermatodea

Ch

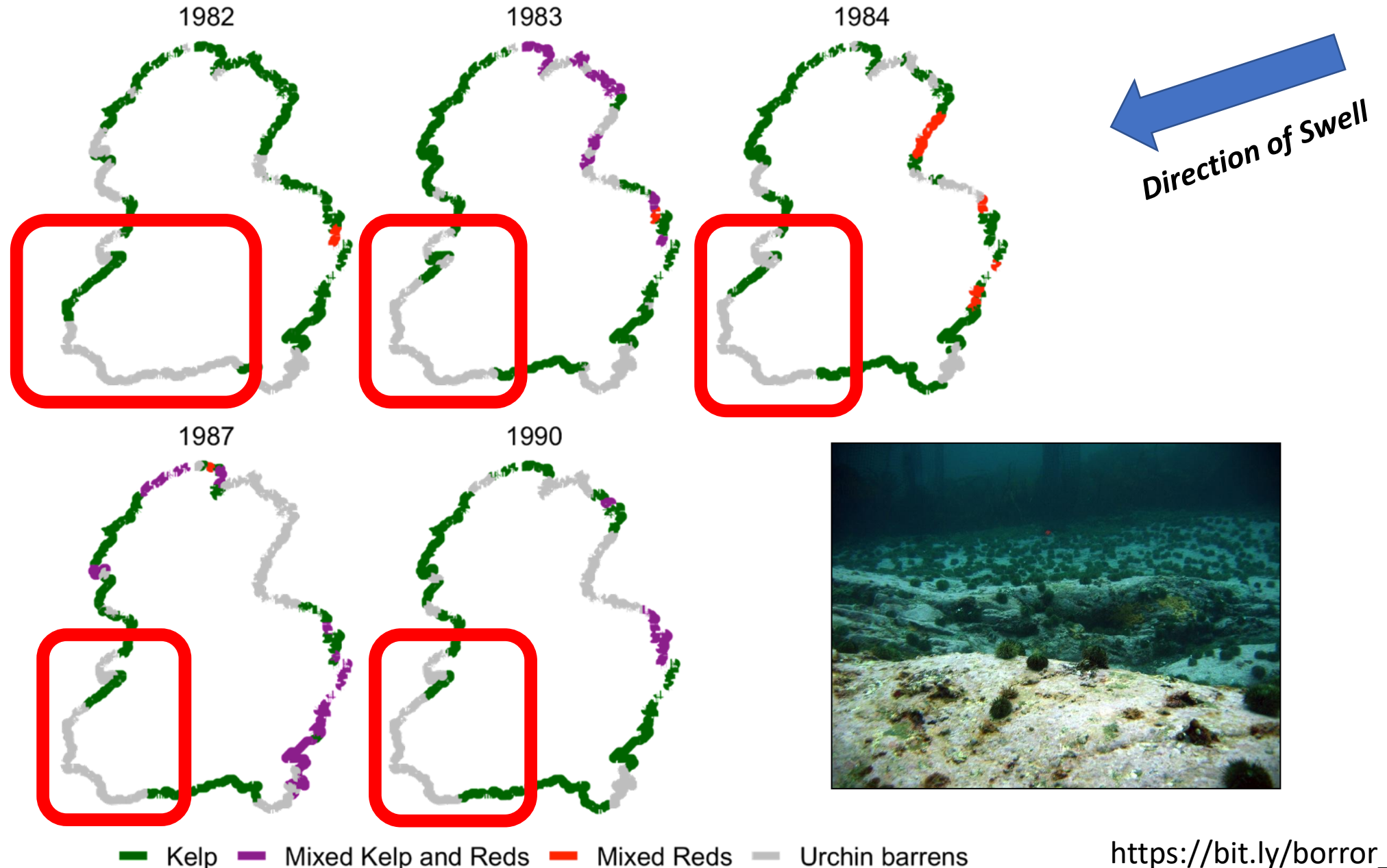
Chorda tomentosa



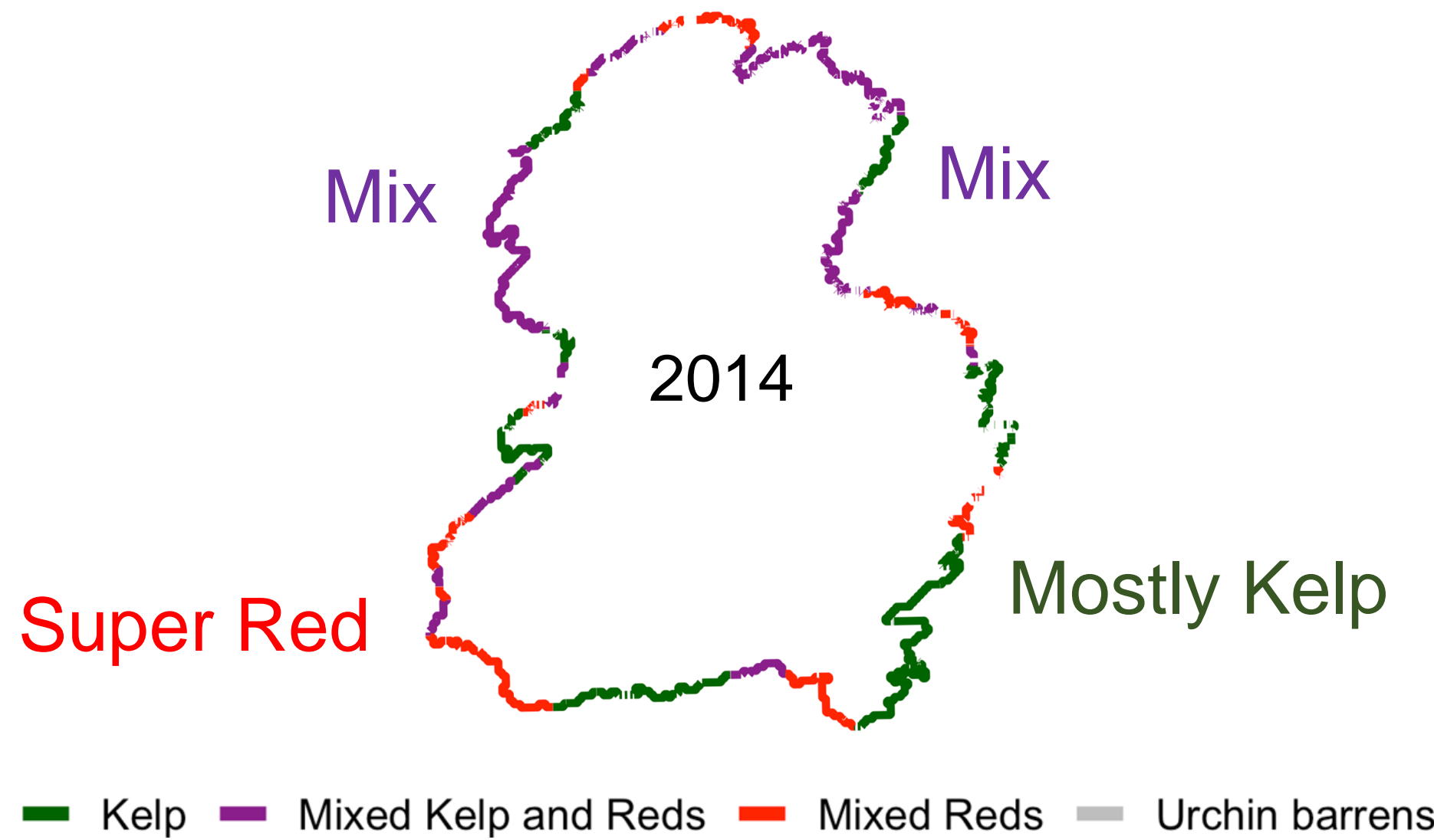
Dr. Jim Coyer

A Sunday Morning Boatride: Resurveying in 2014

Barrens Expansive on Protected Sloping Coast

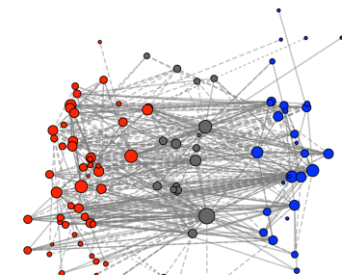
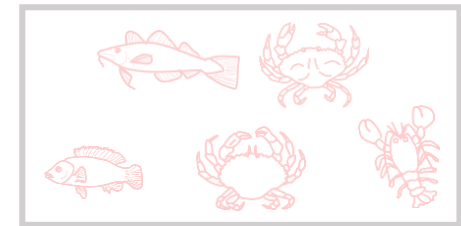
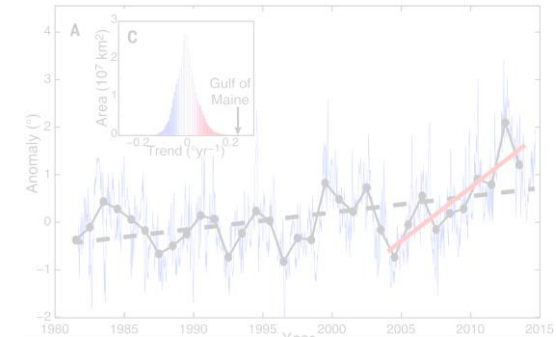


Urchins Gone, Reds Favor Protected Zones or Simpler Topography

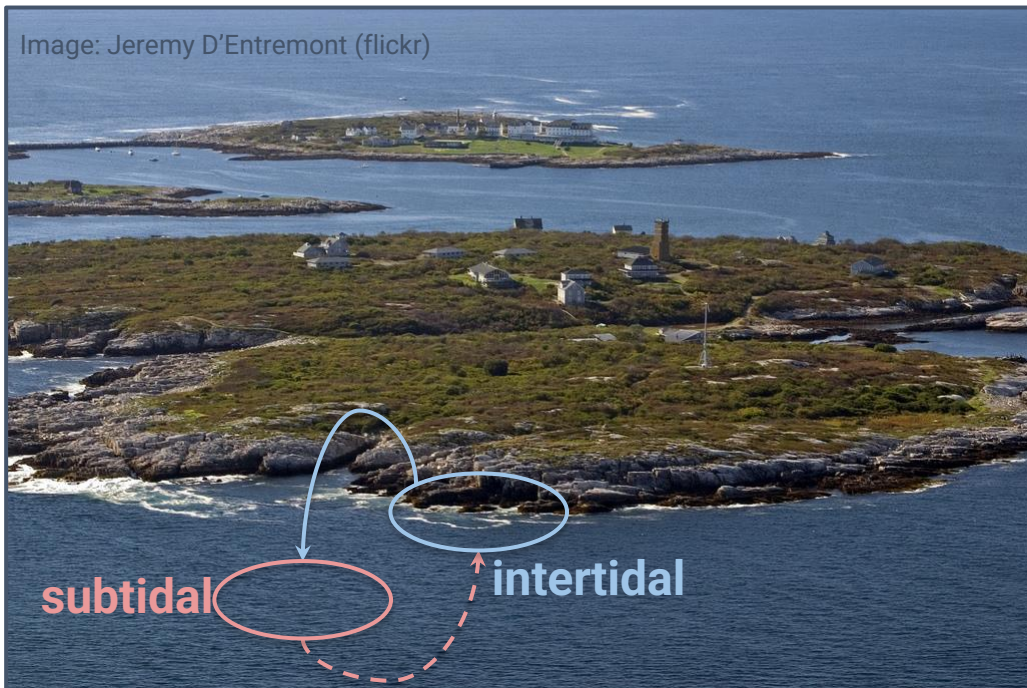
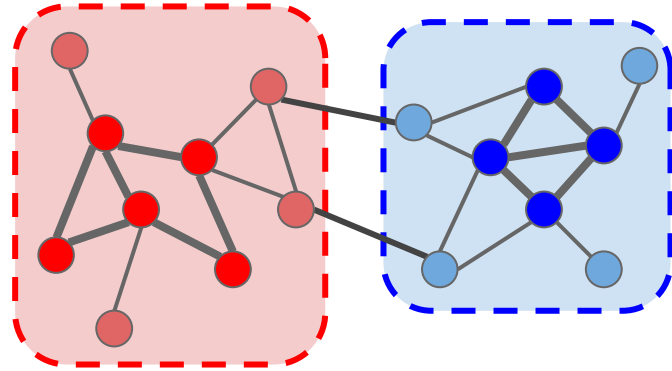


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How Linked are the Intertidal and Subtidal?



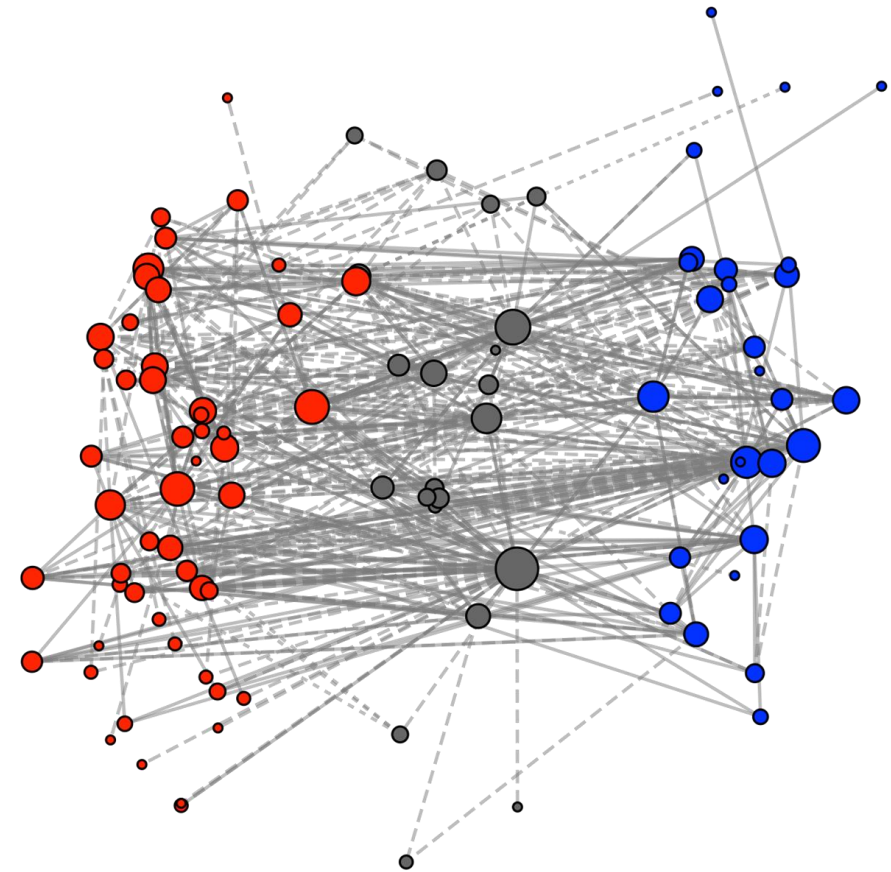
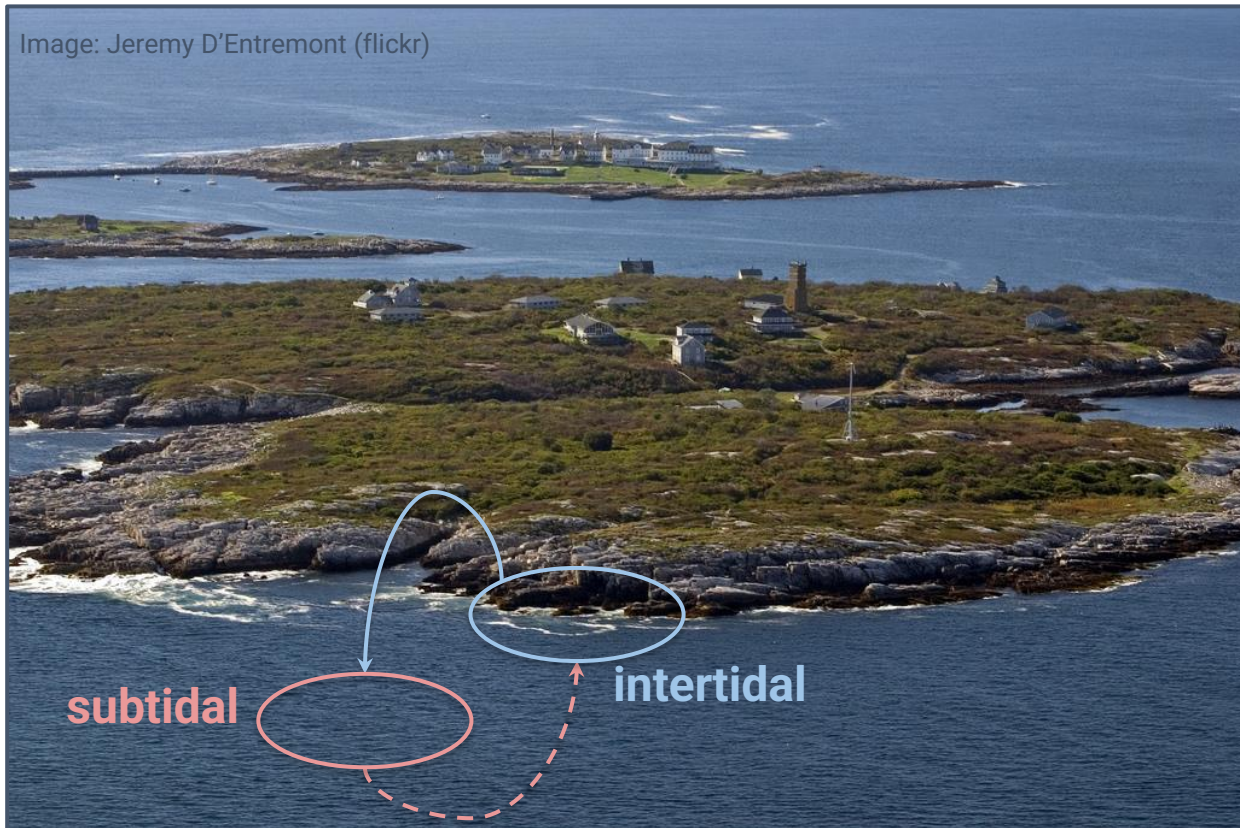
Dr. Joey Burant



Dr. Tianna Peller

- Literature based diet analysis of all species sampled in intertidal and subtidal surveys
- 2,933 papers searched and 9,822 trophic links identified
- Added 27,451 links from Global Biotic Interaction Database
- Database currently being cleaned for GLOBI
- Which trophic interactions and species span both habitats?

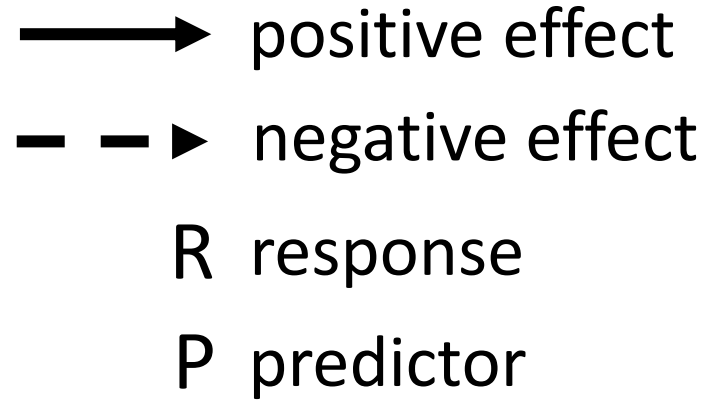
24% of Feeding Interactions Cross Between the Intertidal and Subtidal



Most Common Linking Species:

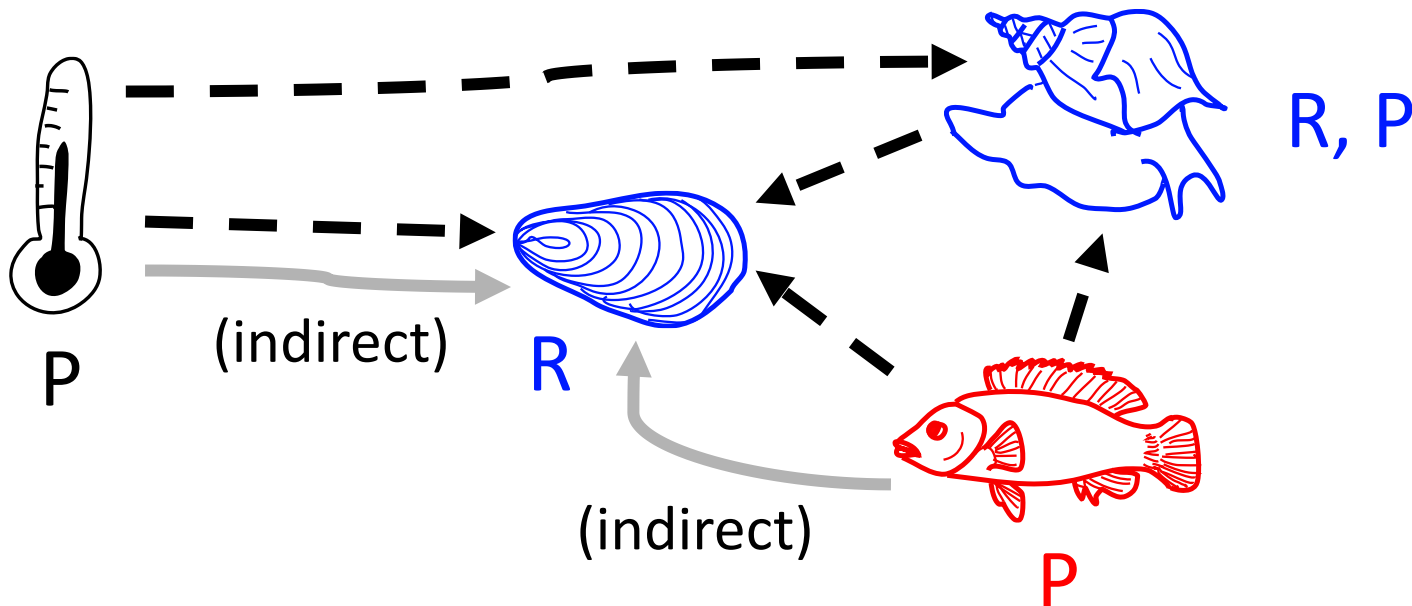
- 1 – European green crab
- 2 – Green sea urchin
- 3 – Blue mussel

Coupling the Intertidal, Subtidal, and Climate with SEMs



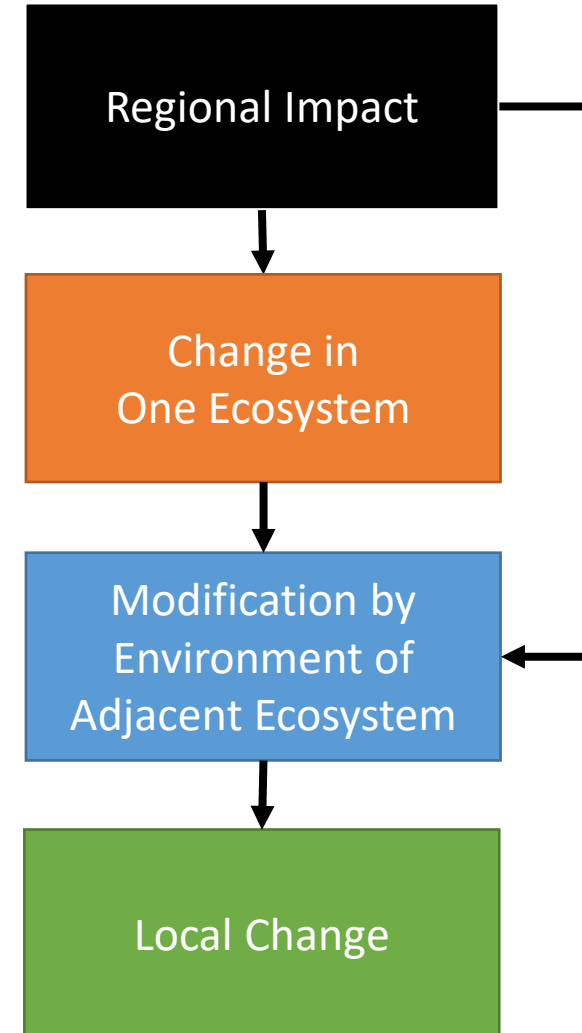
Nicole Knight

Structural Equation Model



- SEMs used Econometric correlated random effects models with group mean centering for causal analysis
- Considered interactions with wave exposure to examine context dependency
- N = 7,412

Understanding How to Downscale Regional Impacts Requires Holistic Systems Thinking





Thank you!



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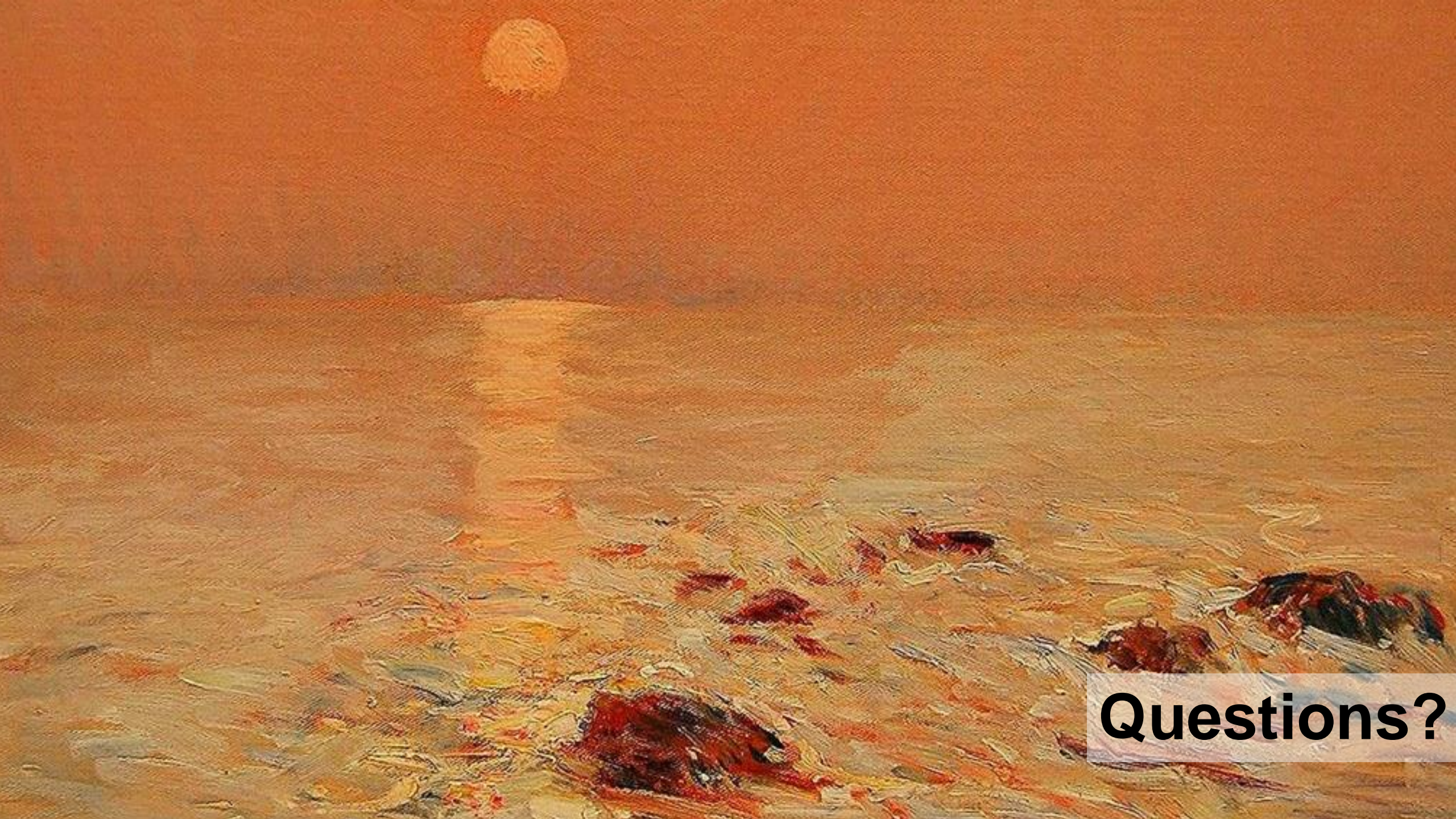


University of
New Hampshire



University
of Regina





Questions?