



# Connecting our Changing Ocean to Marine Ecosystems

**Josh T. Kohut**

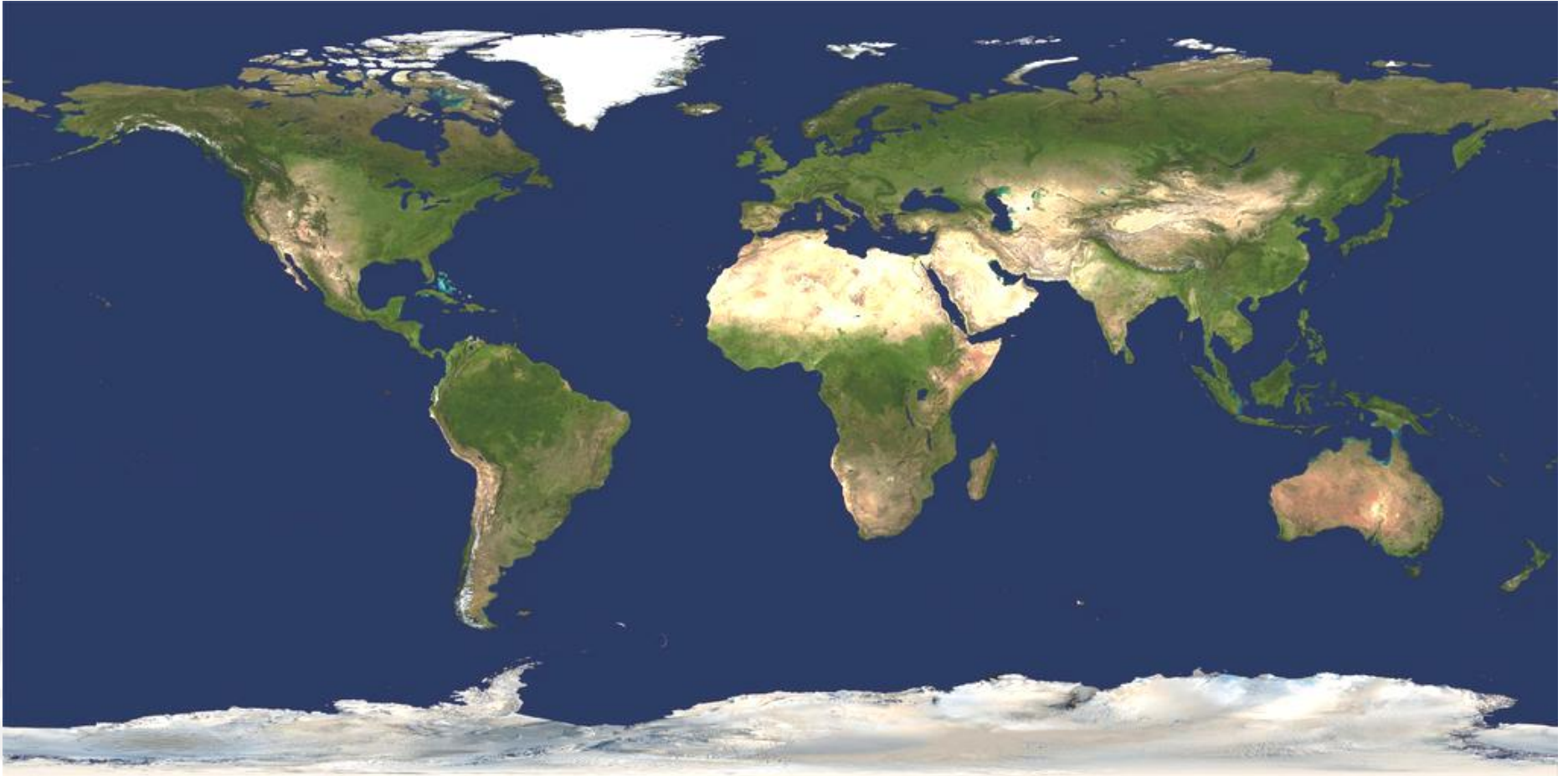
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**RUTGERS**

JERSEY ROOTS, GLOBAL REACH

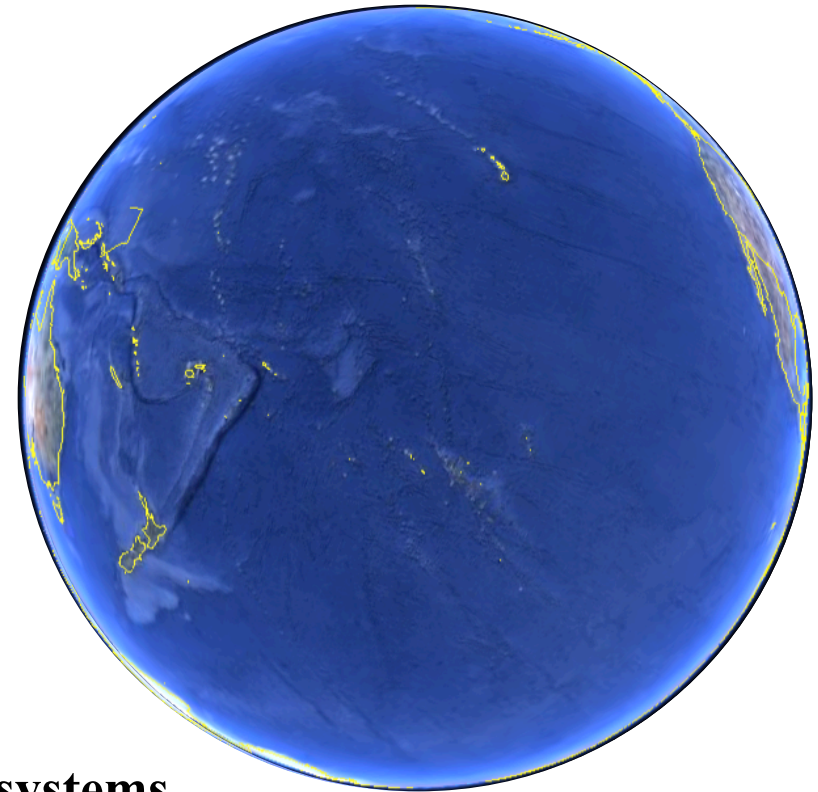
Coastal Ocean  
Observation Lab

# How Many Oceans Are there?

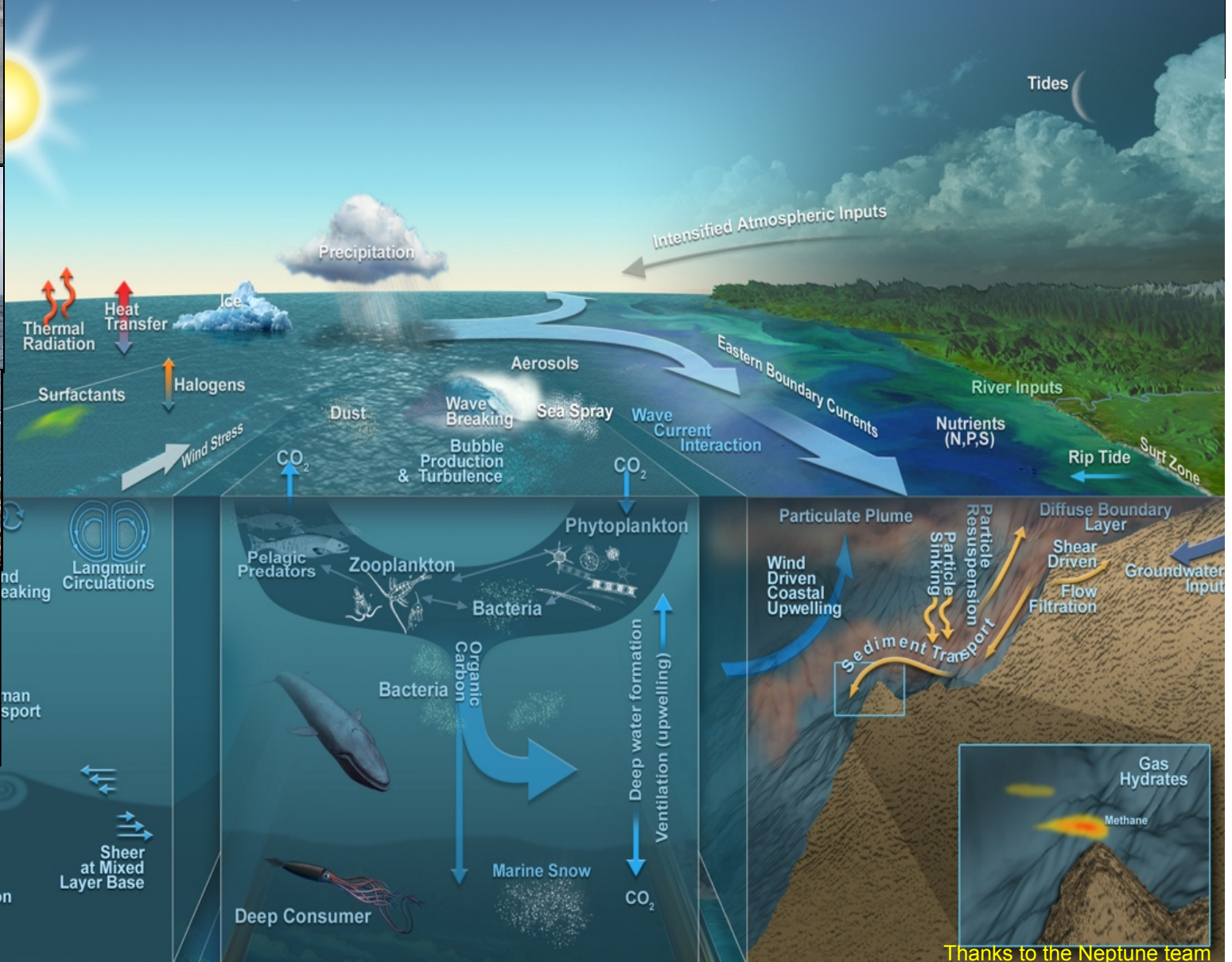


# Our Global Ocean...

- covers 71% of the Earth's surface.
- contains 97% of the Earth's water.
- has an average depth of 12,430 feet.
- supports a great diversity of life and ecosystems.
- is a major influence on weather and climate, making earth habitable.
- has had less than 10% explored by humans.



# Marine systems are complex

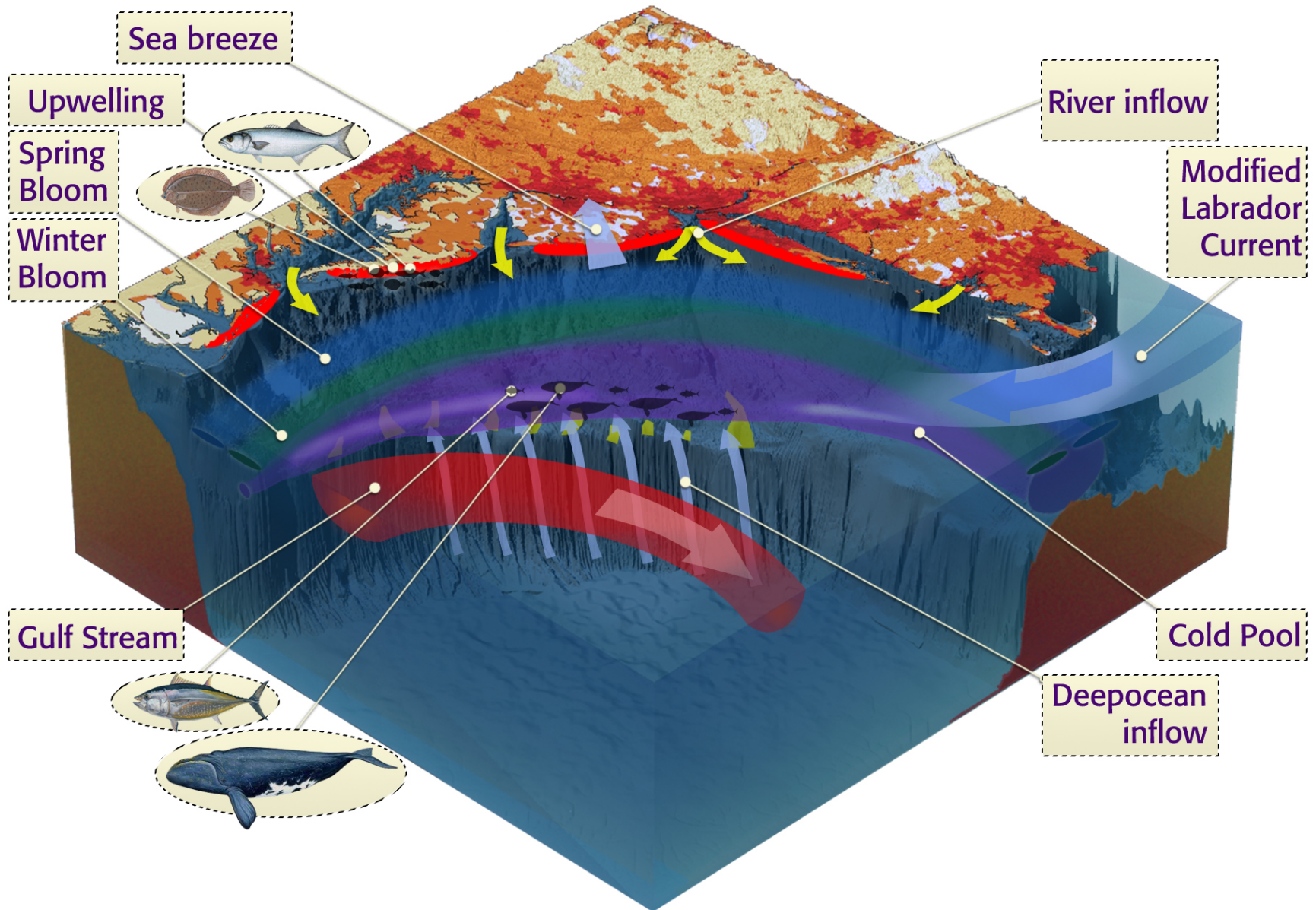


Thanks to the Neptune team

If we were going to develop a model to investigate these connections, what variables would we need to include?

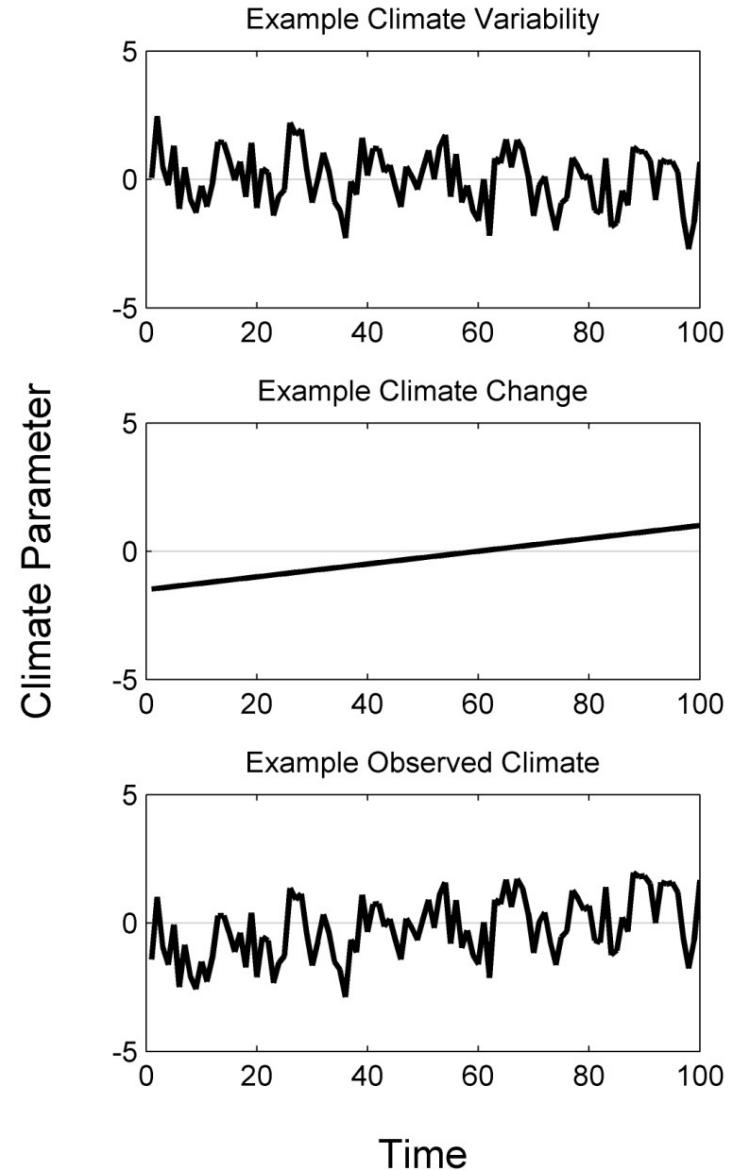
*SEP 2: Developing and Using Models* - In science, models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others.

# The Mid-Atlantic Bight



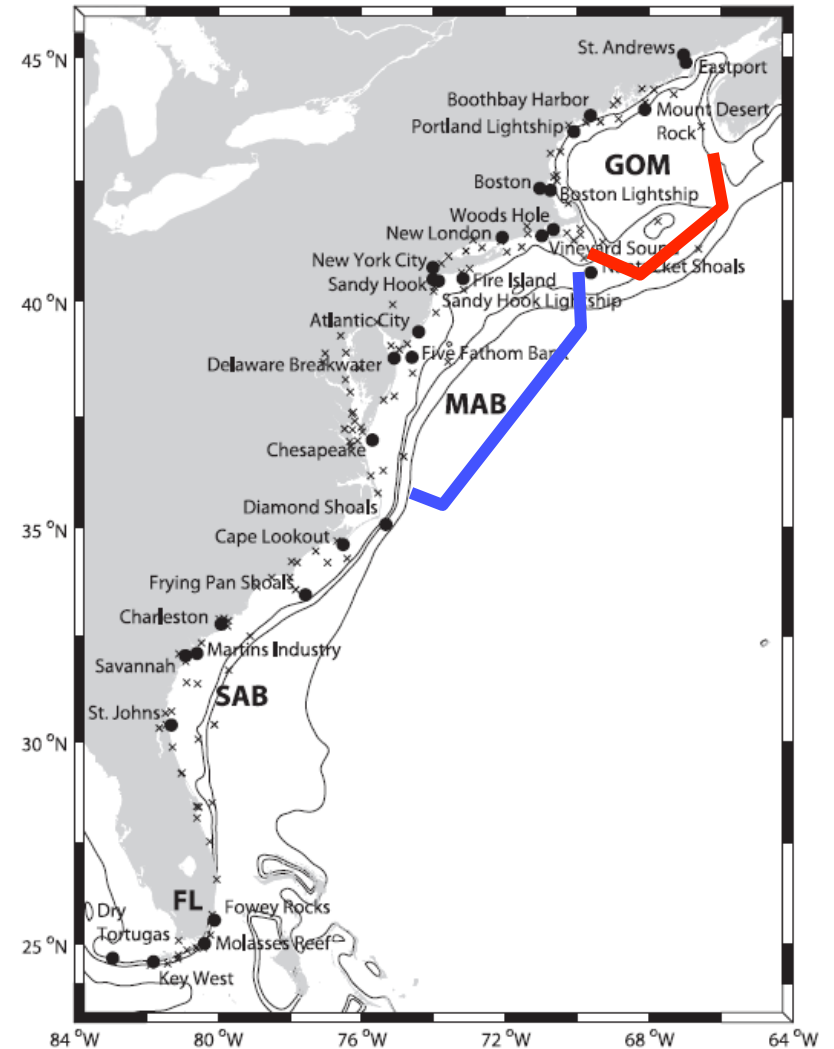
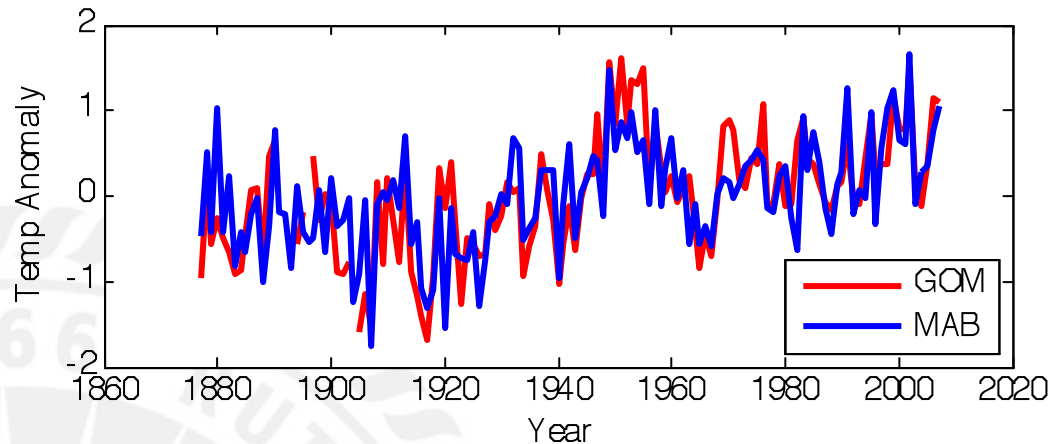
# Background

- Important difference “climate change” vs “climate variability”
- Climate variability – natural variability within the climate system
- Climate change – change in the climate system



# Northeast US Shelf Ocean Temperature

- Evidence for variability
- Evidence for change  
( $\sim 1\text{-}2\text{ }^{\circ}\text{C}$  increase since 1920)

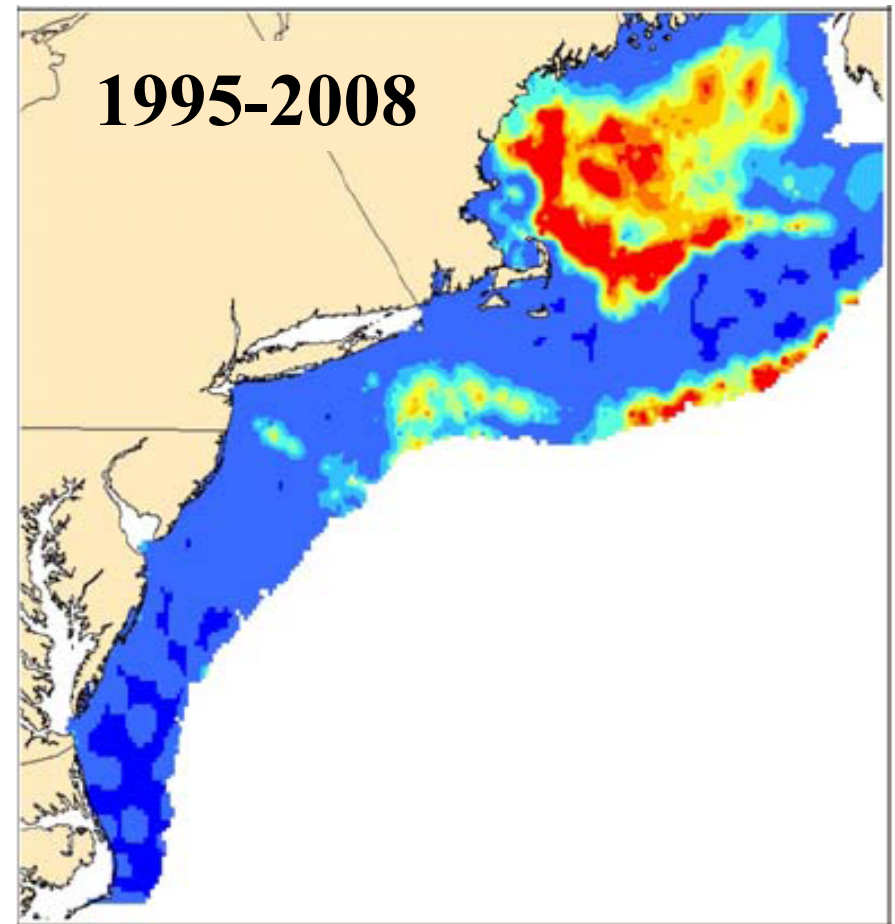
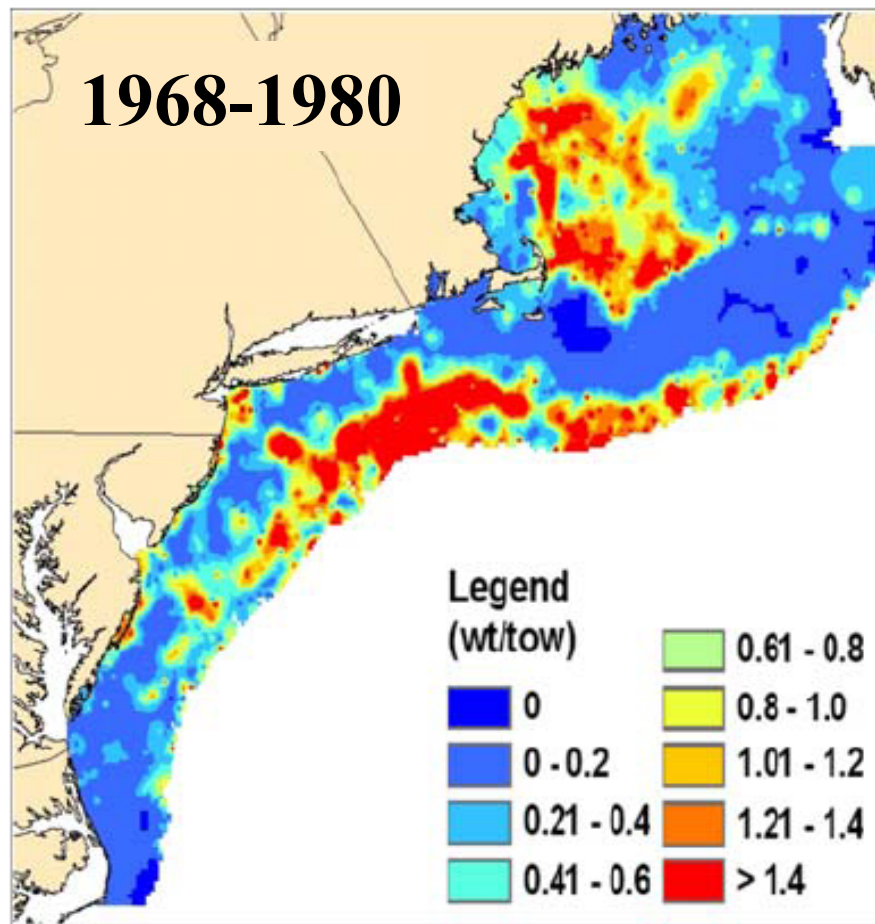




# Shifting distributions

## *Red Hake*

24 of 36 stocks have shifted poleward and/or deeper  
(1.6 km yr<sup>-1</sup> and 0.25 m yr<sup>-1</sup>)



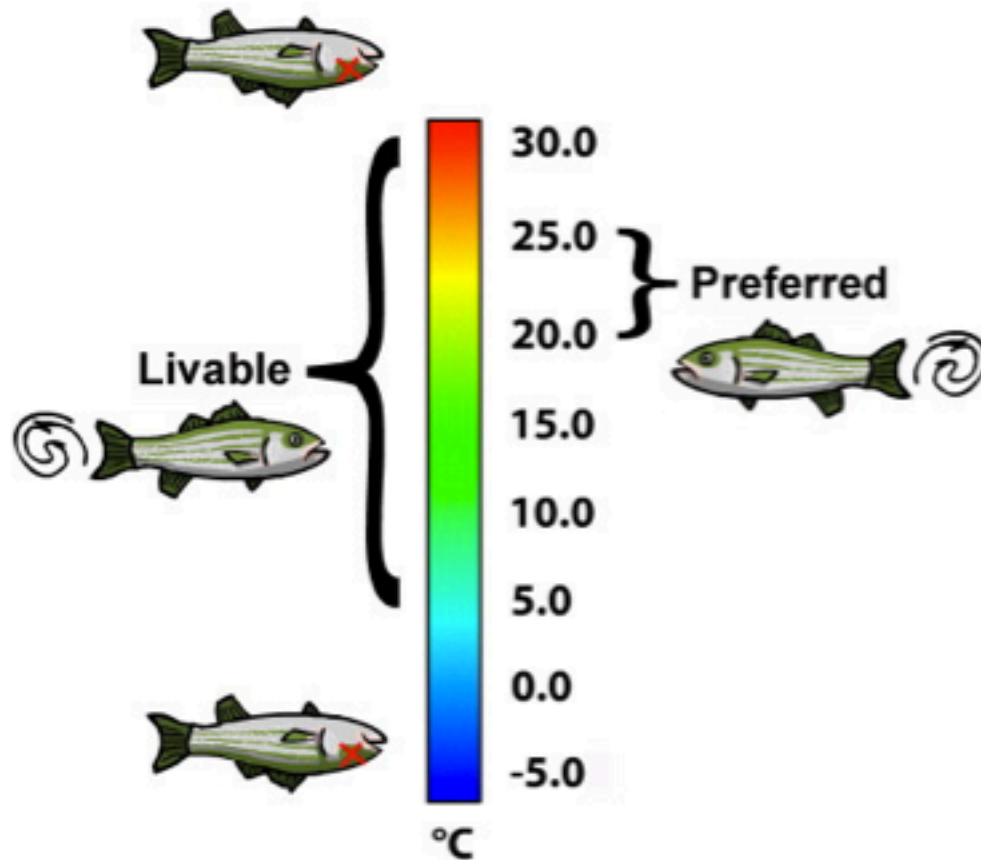
Nye J. et al. (2009) Marine Ecology Progress Series 393:111-139

Construct an explanation,  
including quantitative  
relationships between variables,  
that predicts and/or describes  
why fish migrate.

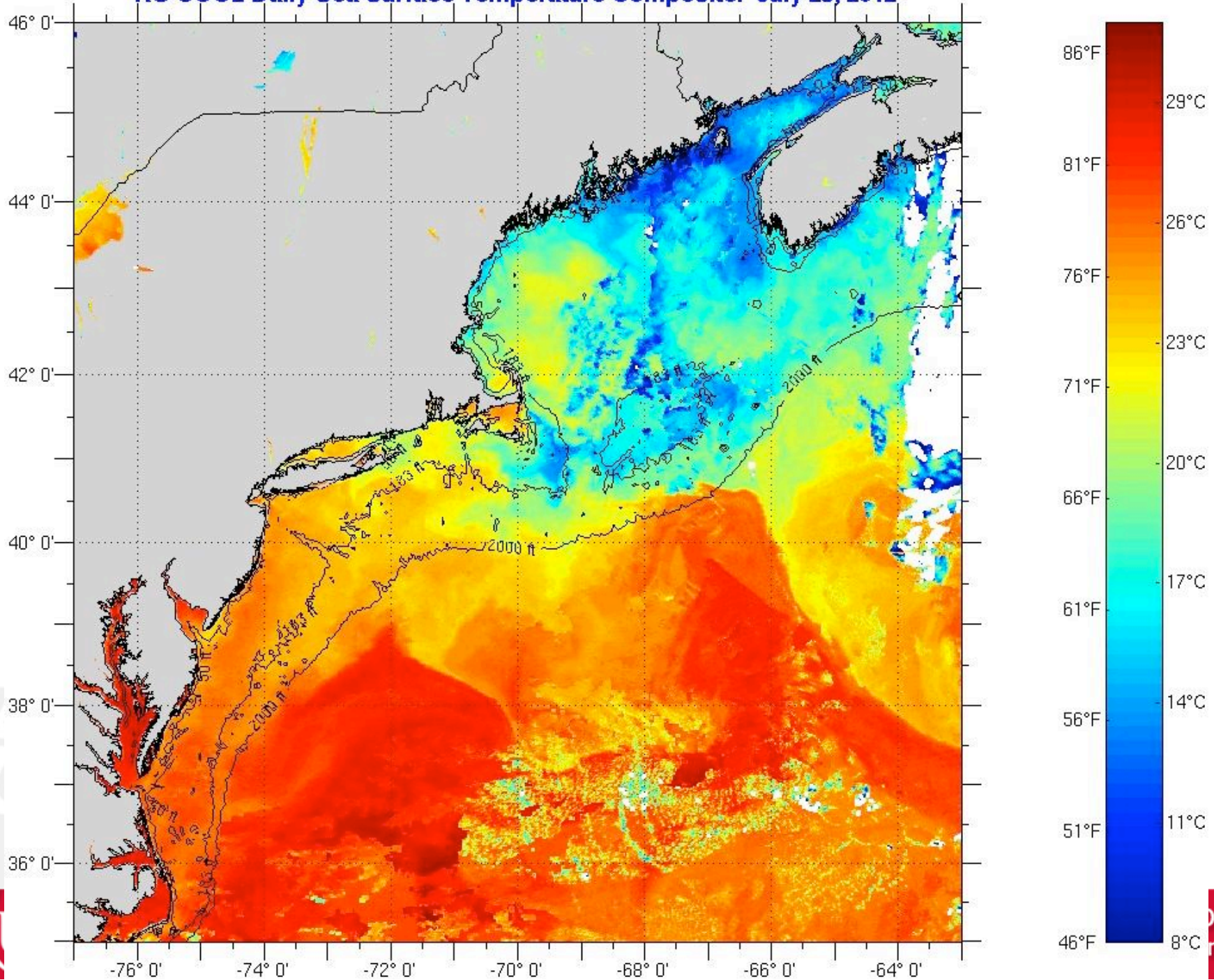
*SEP 6: Constructing Explanations and Designing Solutions* - The goal of science is to construct explanations for the causes of phenomena. An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data.

## Water Temperatures for Striped Bass

Based on the data collected, scientists found out that adult striped bass like to swim in water temperatures between 20 - 23° Celcius (which is equal to 68 - 73° Fahrenheit).



# RU COOL Daily Sea Surface Temperature Composite: July 25, 2012



Ocean Lab

## Problem

*Do fish in the ocean have favorite places?*

## Investigation

1. [Where are the Fish?](#)
2. [Tag a Striped Bass](#)
3. [How to Read a SST Map](#)
4. [Temperature & Time to Find Fish](#)
5. [Striped Bass Migration Path](#)

## Explanation

## My Journal

## COOL New Terms

## Adventure Outline


## Teacher Unit Plan


## Temperature & Time to Find Fish


In the activity below, you'll use water temperature data that has been averaged for each month to decide where you think the Striped Bass will be swimming over the year.


After you read the directions in the white box, click on the X in the upper right to start. When your Data Table has data for each location, click on "Table Complete!" in the top right corner of the data table.

YOUR NAME HERE

 Click on a triangle to pull up the temperature information for that location. X

 Click on this button to highlight the best water temperatures for striped bass (20-23°C).

 Click this button to highlight the months which have the best water temperatures.

 In the data table, make a check mark, by clicking in the box, for the months that have the best water temperatures in that location. Repeat for each location.

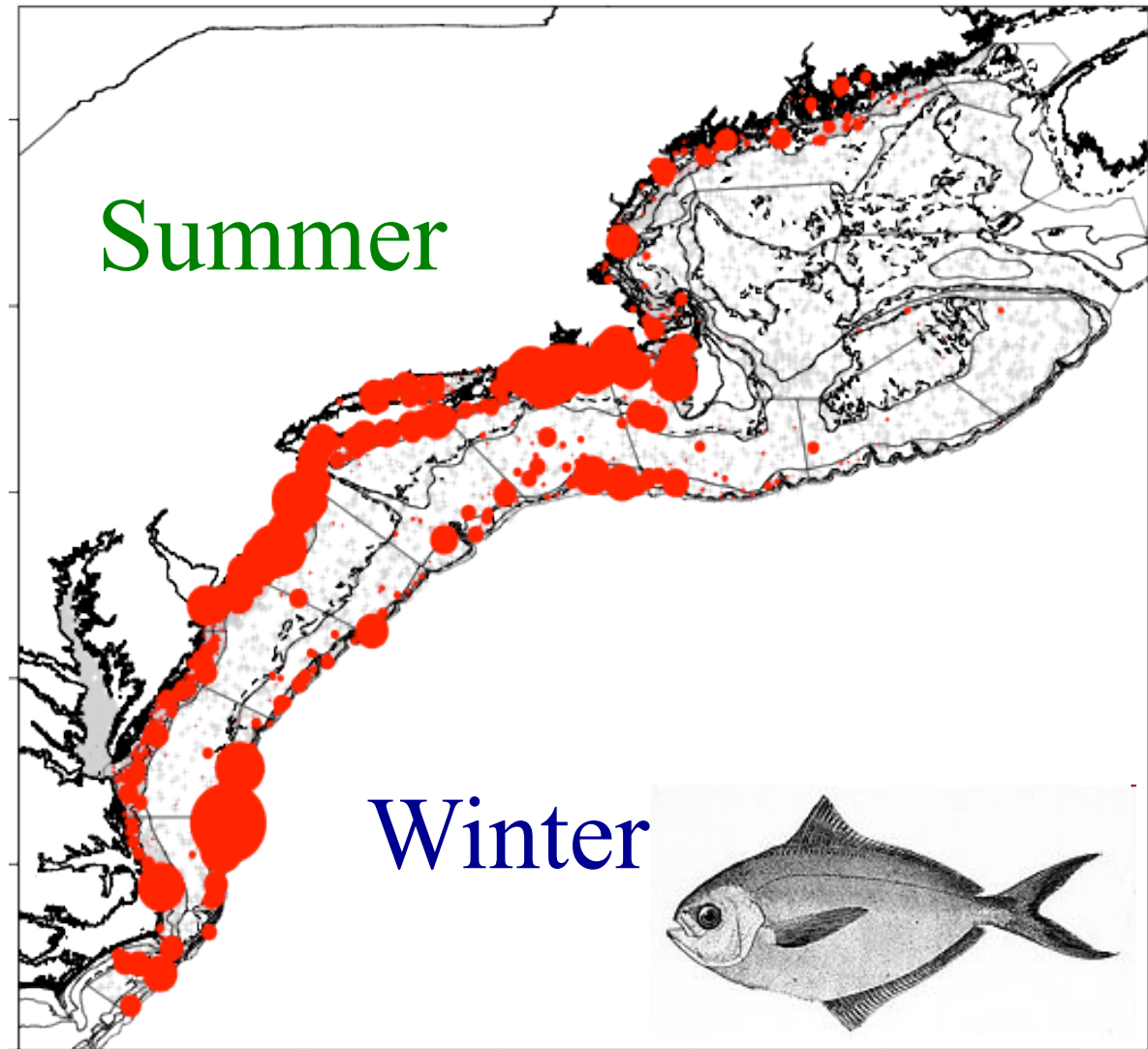
Month	Massachusetts	New Jersey	North Carolina

**Temperature Good for Living**    **TABLE COMPLETE!**

For each location, click on the box for the months that have best water temperatures. A check will appear.

# Ecosystem Connections: Butterfish

Temperature dependent seasonal migrations spring & fall between coastal zone & shelf break habitats

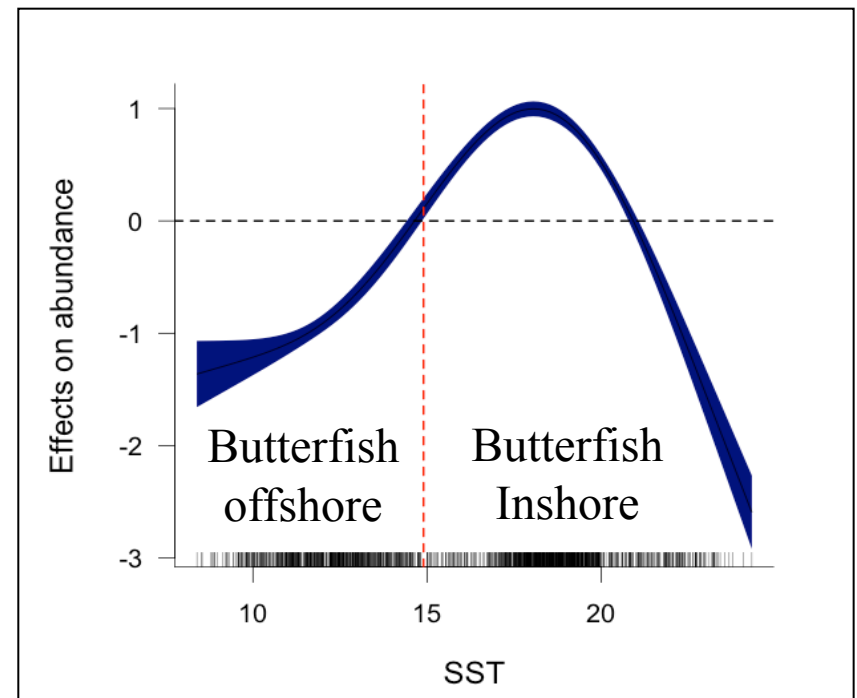
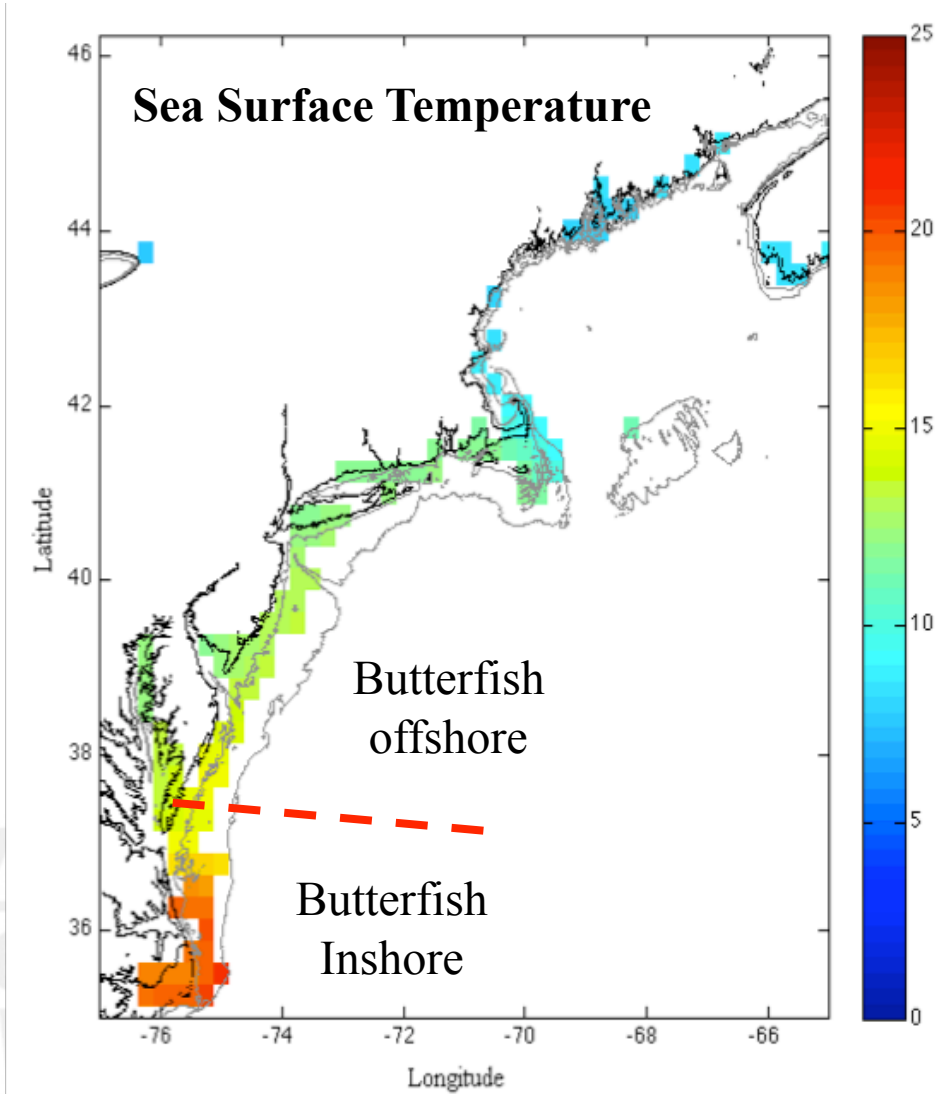


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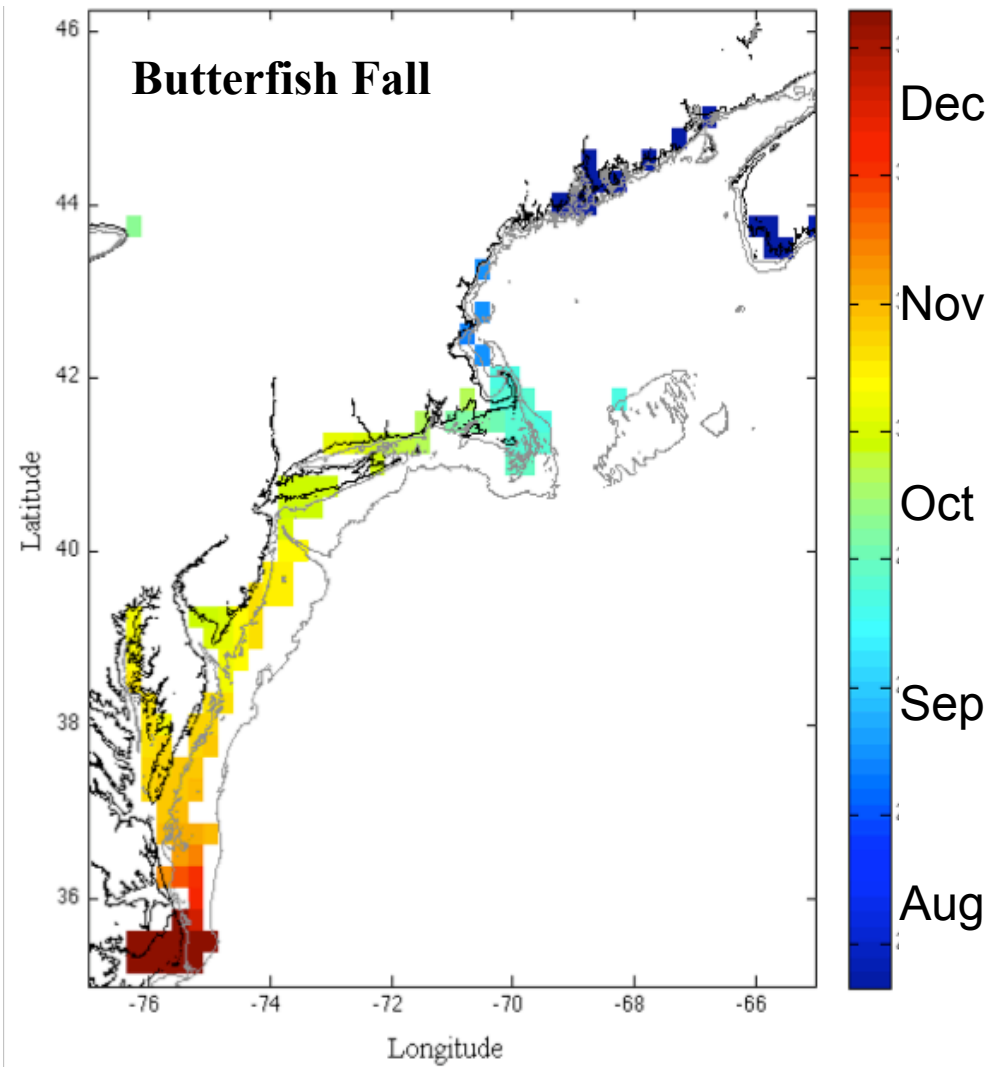
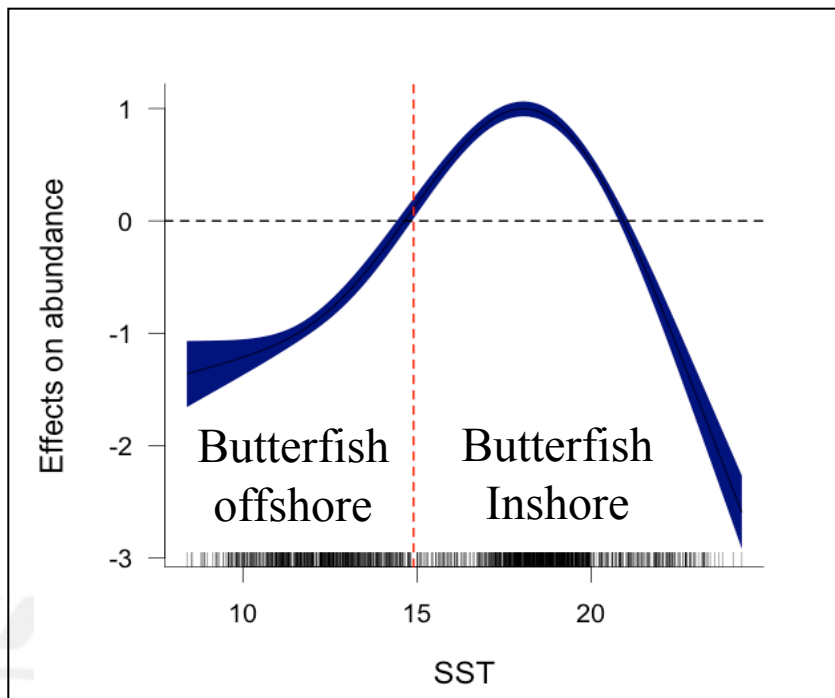
JERSEY ROOTS, GLOBAL REACH

Coastal Ocean  
Observation Lab

# Timing of Butterfish 'Fall'

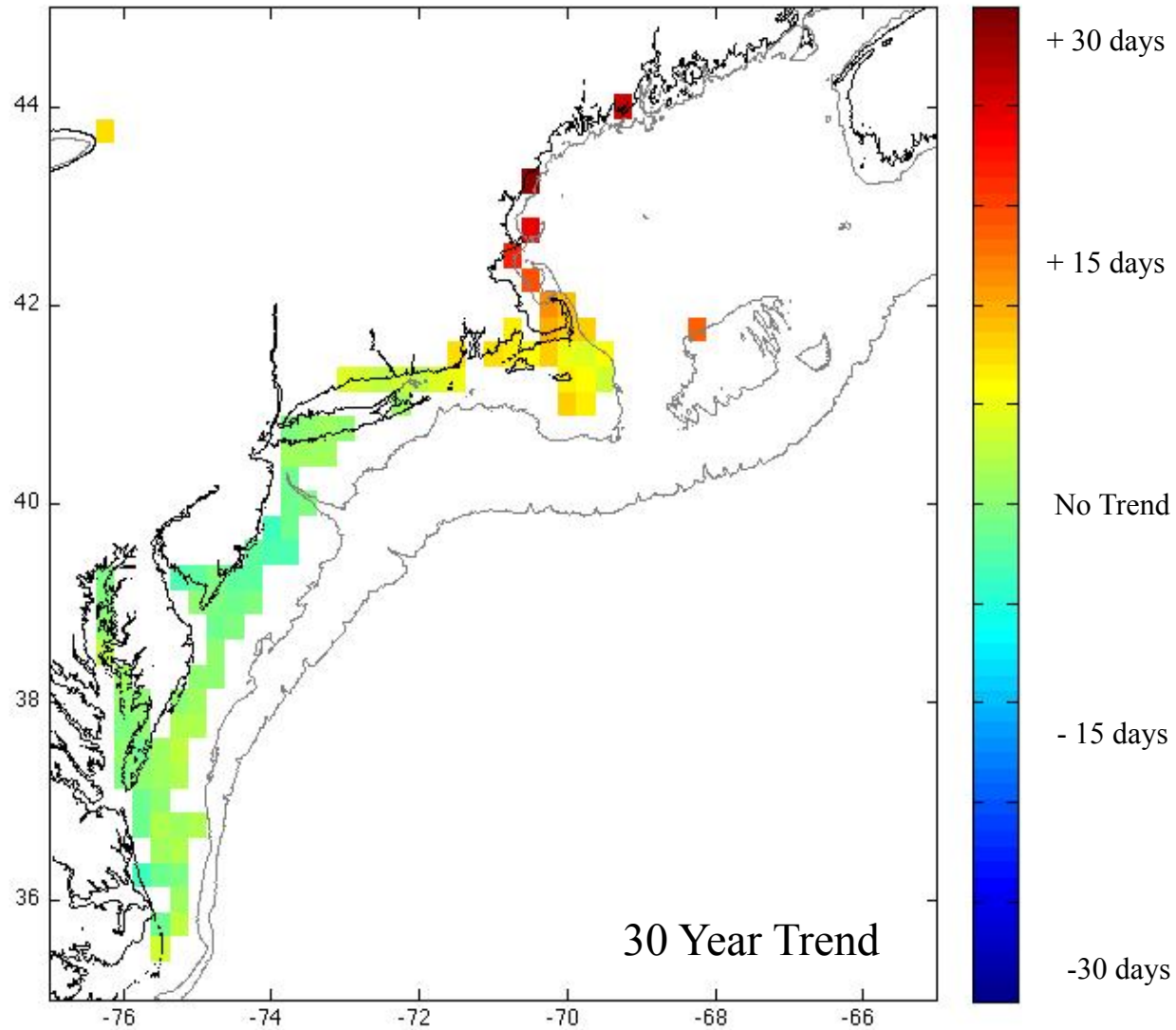


# Timing of Butterfish 'Fall'





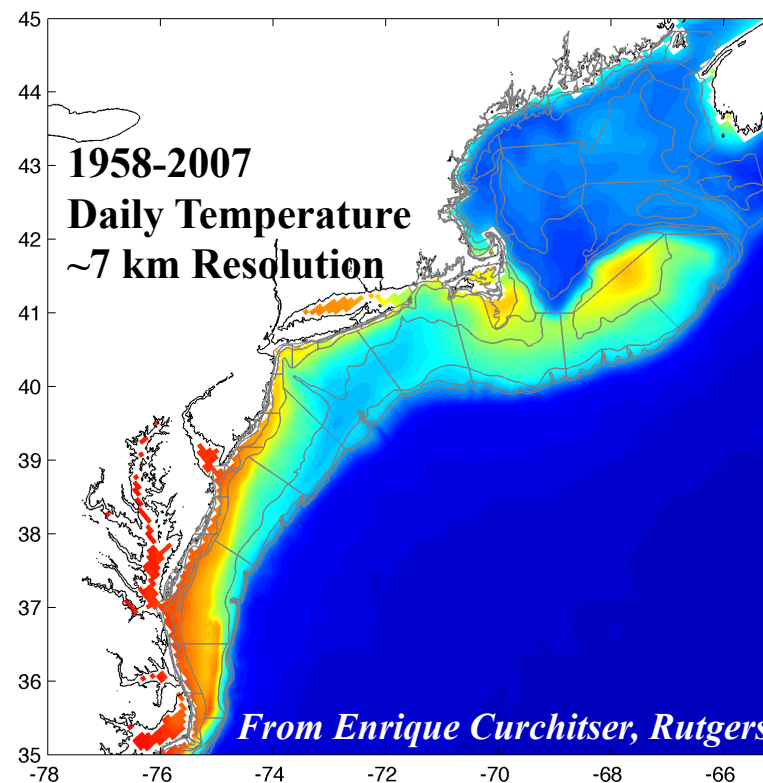
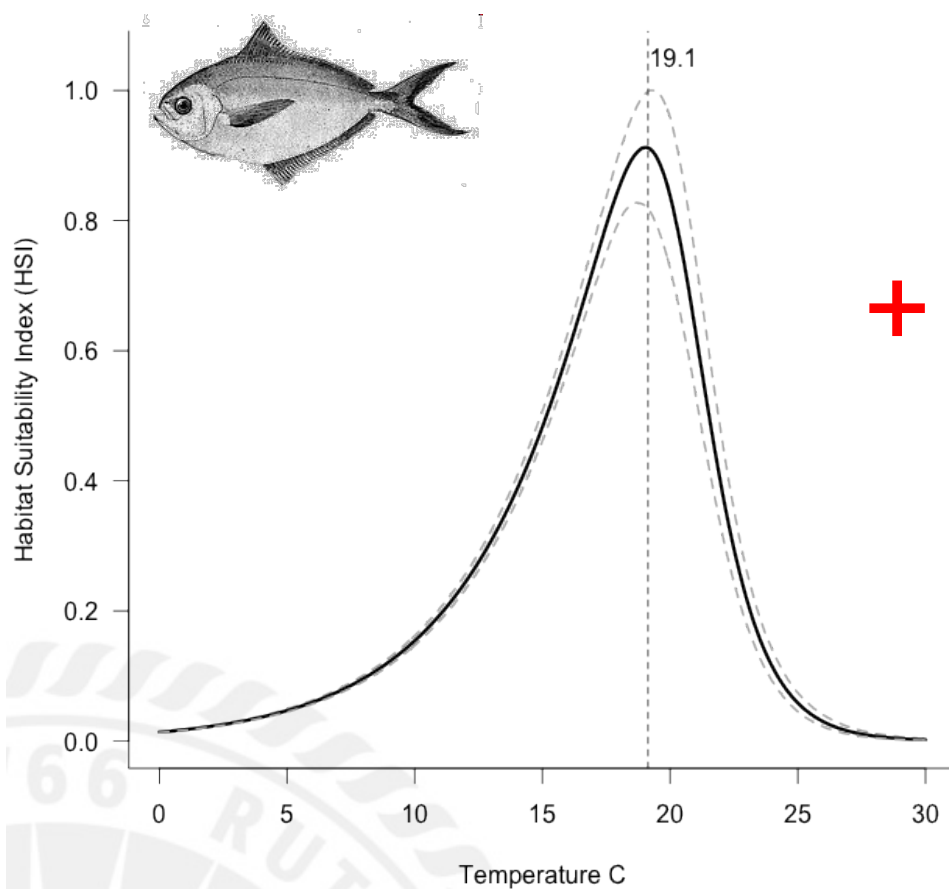
# Timing of Butterfish 'Fall'



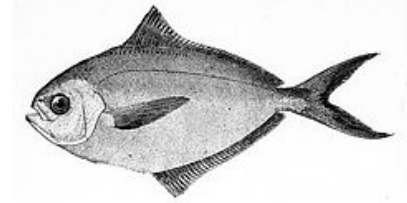
# Can We Model This?

Niche model: nonlinear extension of Boltzmann-Arrhenius equation (mechanistic basis in enzyme kinetics)

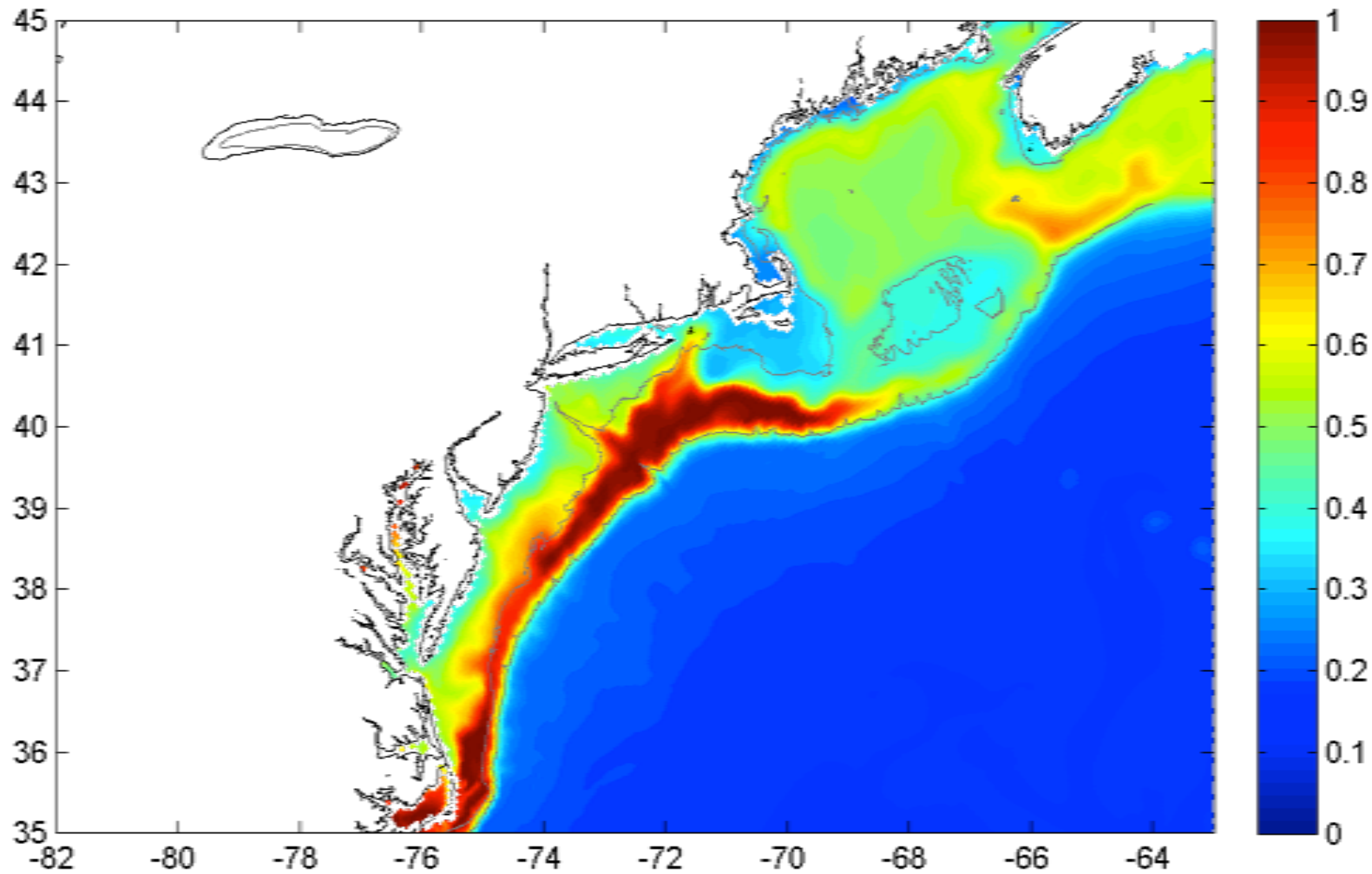
Water temperature hindcast from oceanographic model



# Butterfish Habitat Model *1989 - 1992*



20-Feb-1991

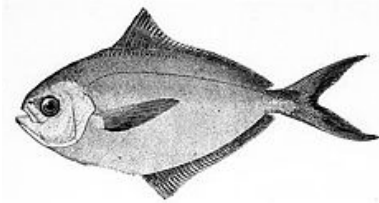


Index of  
thermal  
habitat  
quality

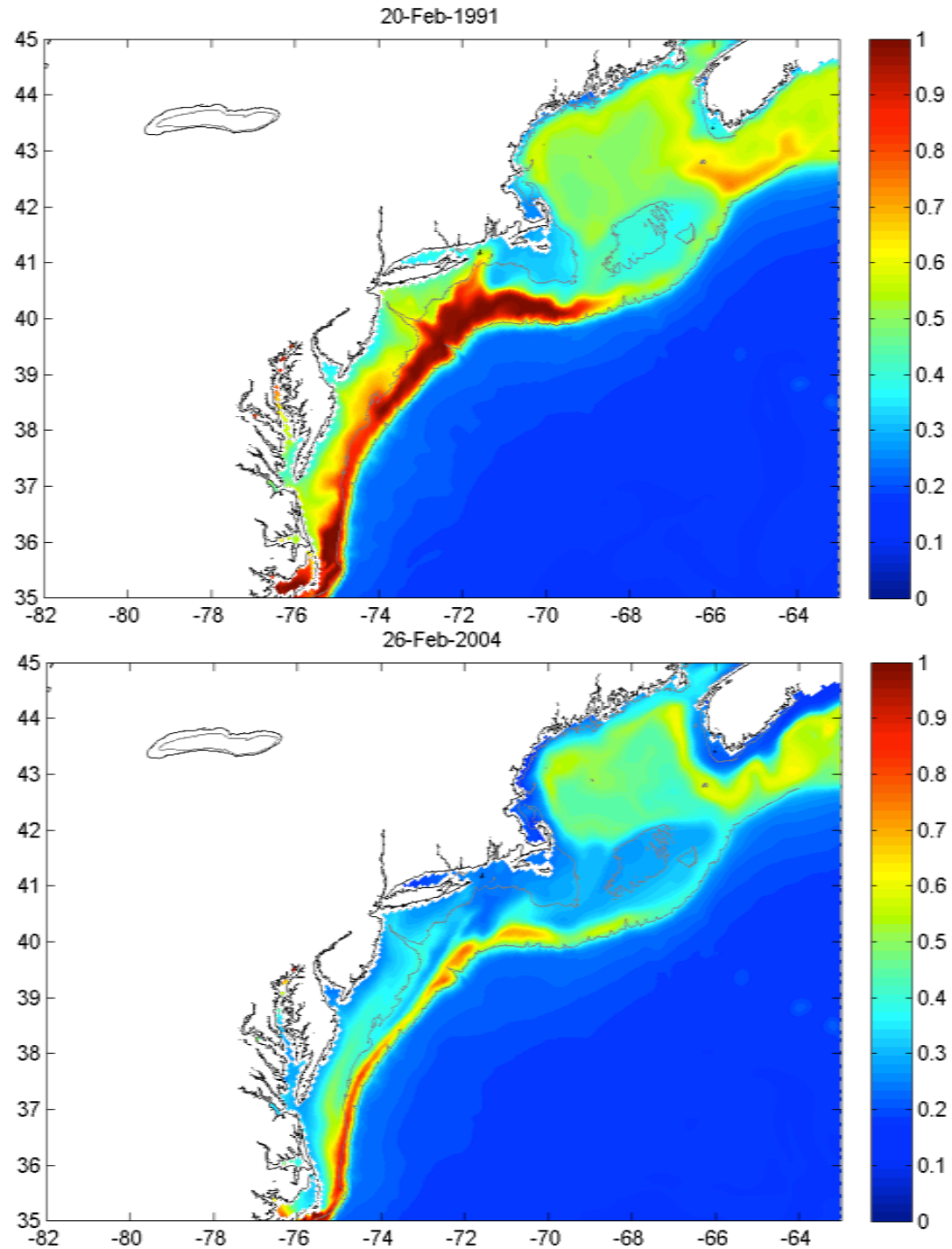
# Mechanistic Habitat Model

*Daily: 1958-2007*

1989-1992



2002-2004

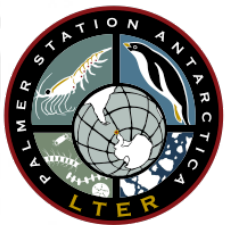
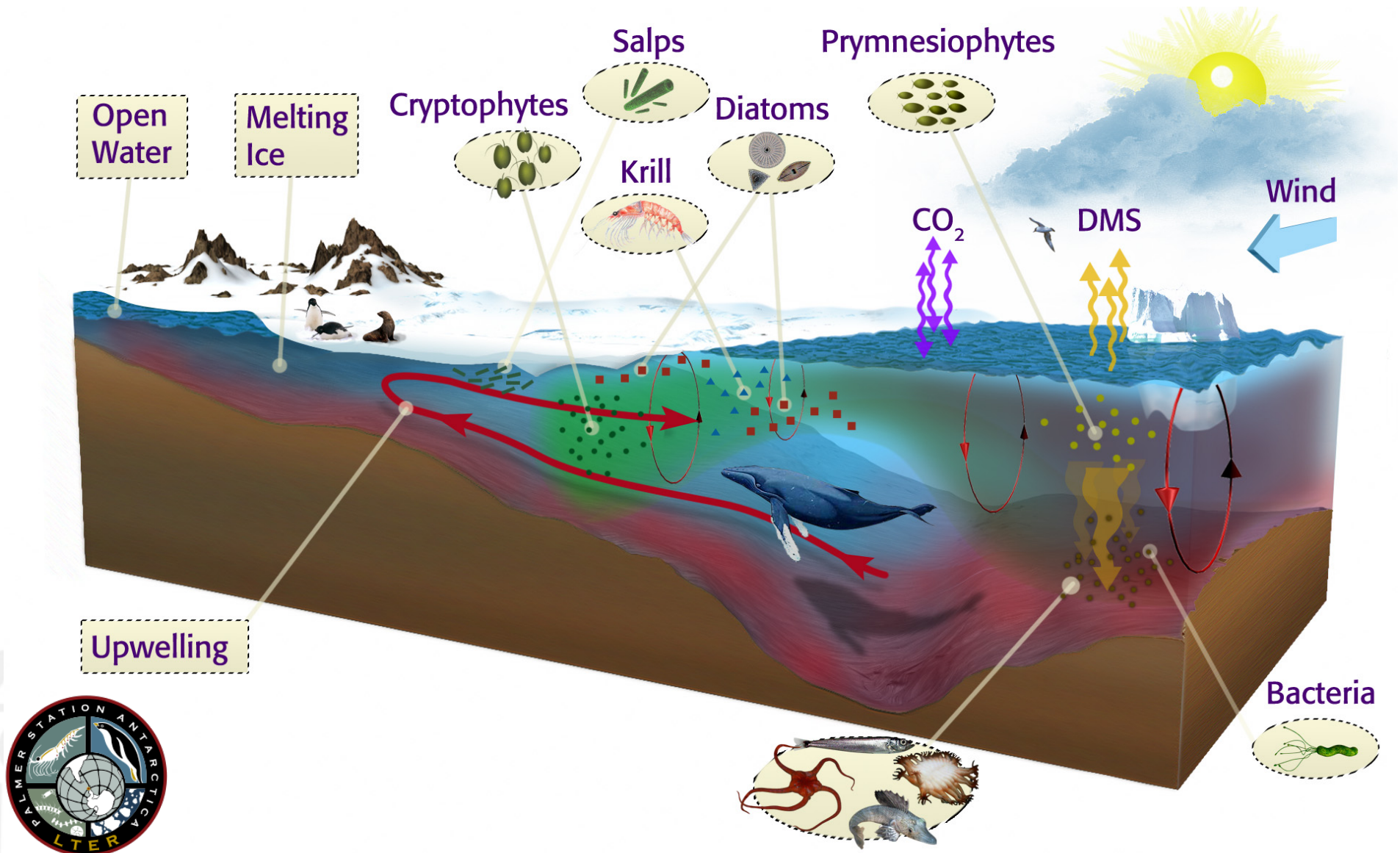


Using the data, is there a relationship between the variables? Develop a question to investigate the data further.

*SEP 1: Asking Questions and Defining Problems* - Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation.

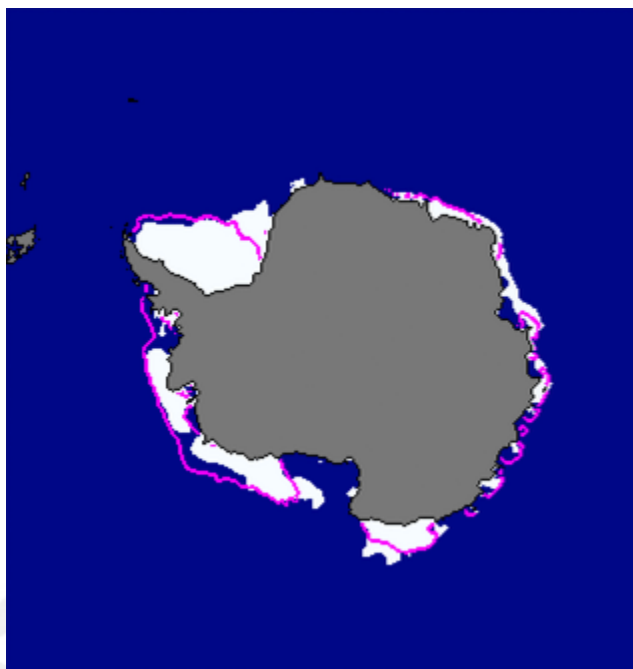
Asking questions also involves asking questions about data, claims that are made, and proposed designs.

# Polar Ecosystems



# Large Seasonal Signals

February 2007

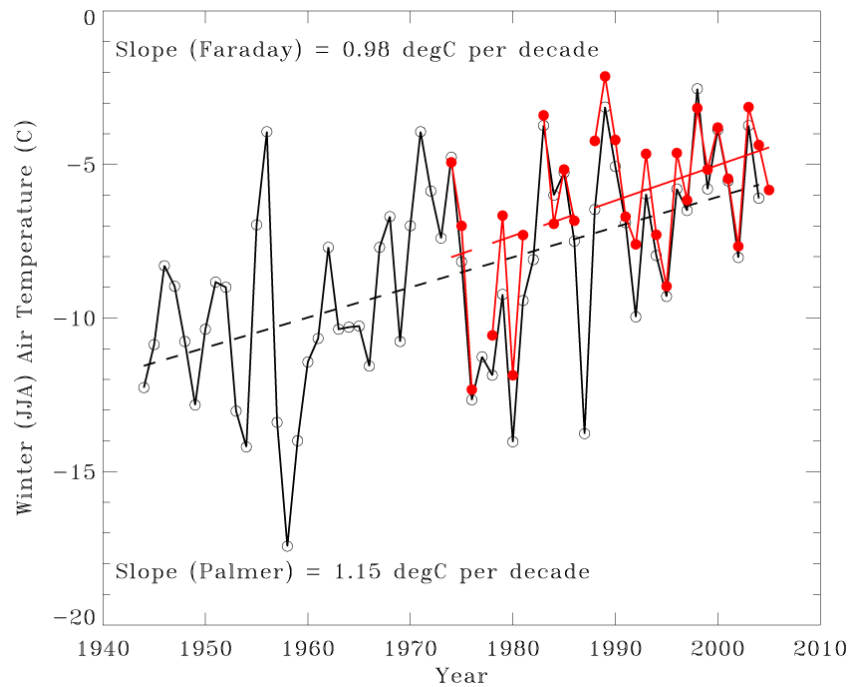


September 2007



# Antarctic Peninsula is warming

## Mean Winter Temperatures

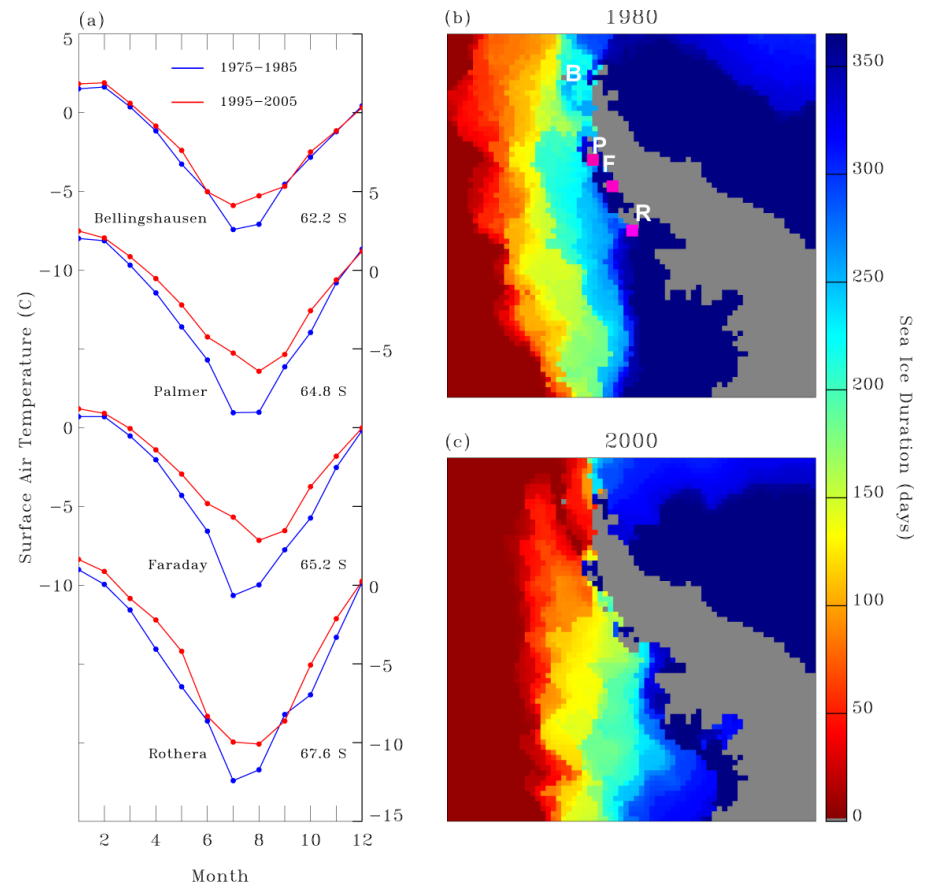


Black British Faraday and Ukraine Vernadsky Station.

Red is United States Palmer Station

<http://www.antartica.ad.uk/met/data.html>

## As Winters warm Sea Ice Duration Drops

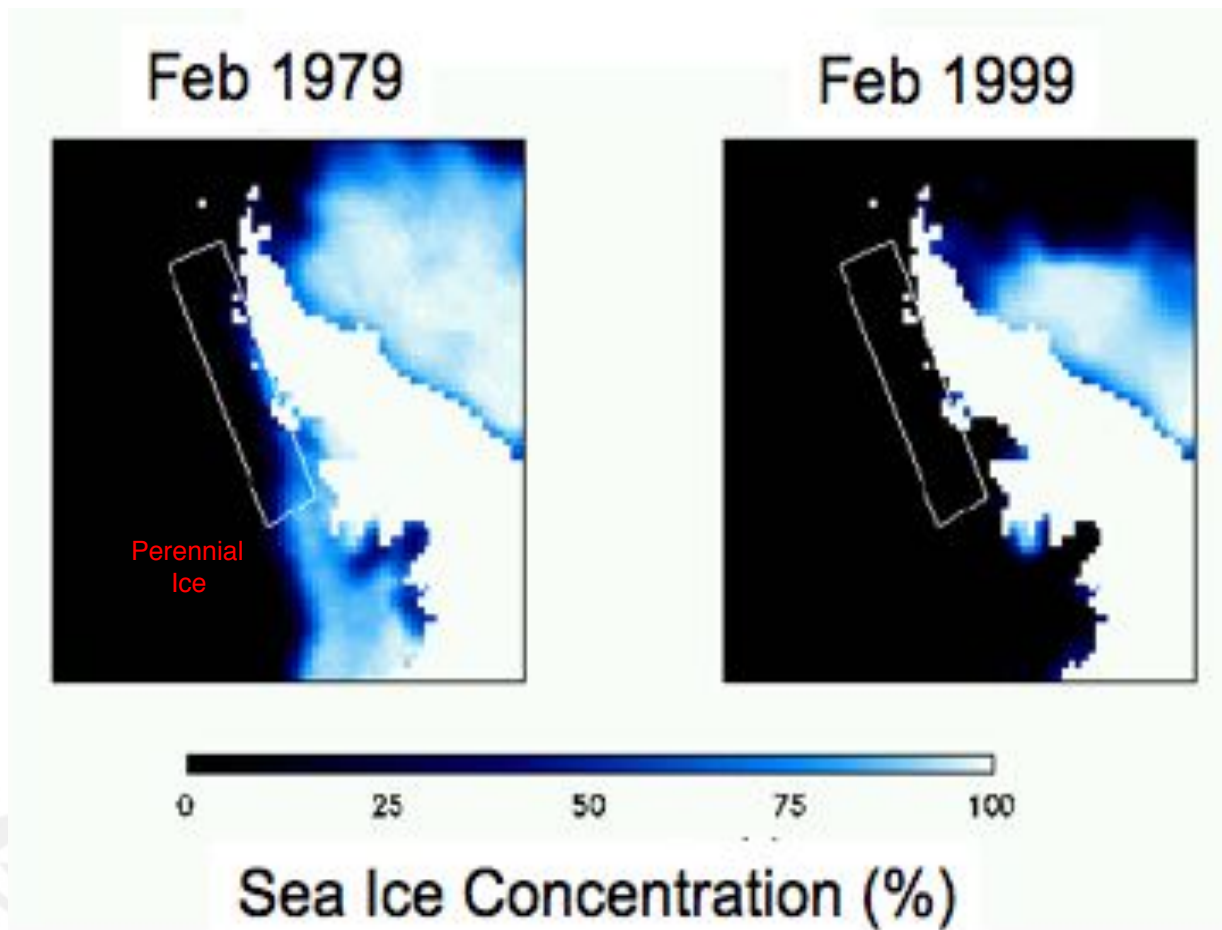


Surface Air temp.

Sea Ice Duration



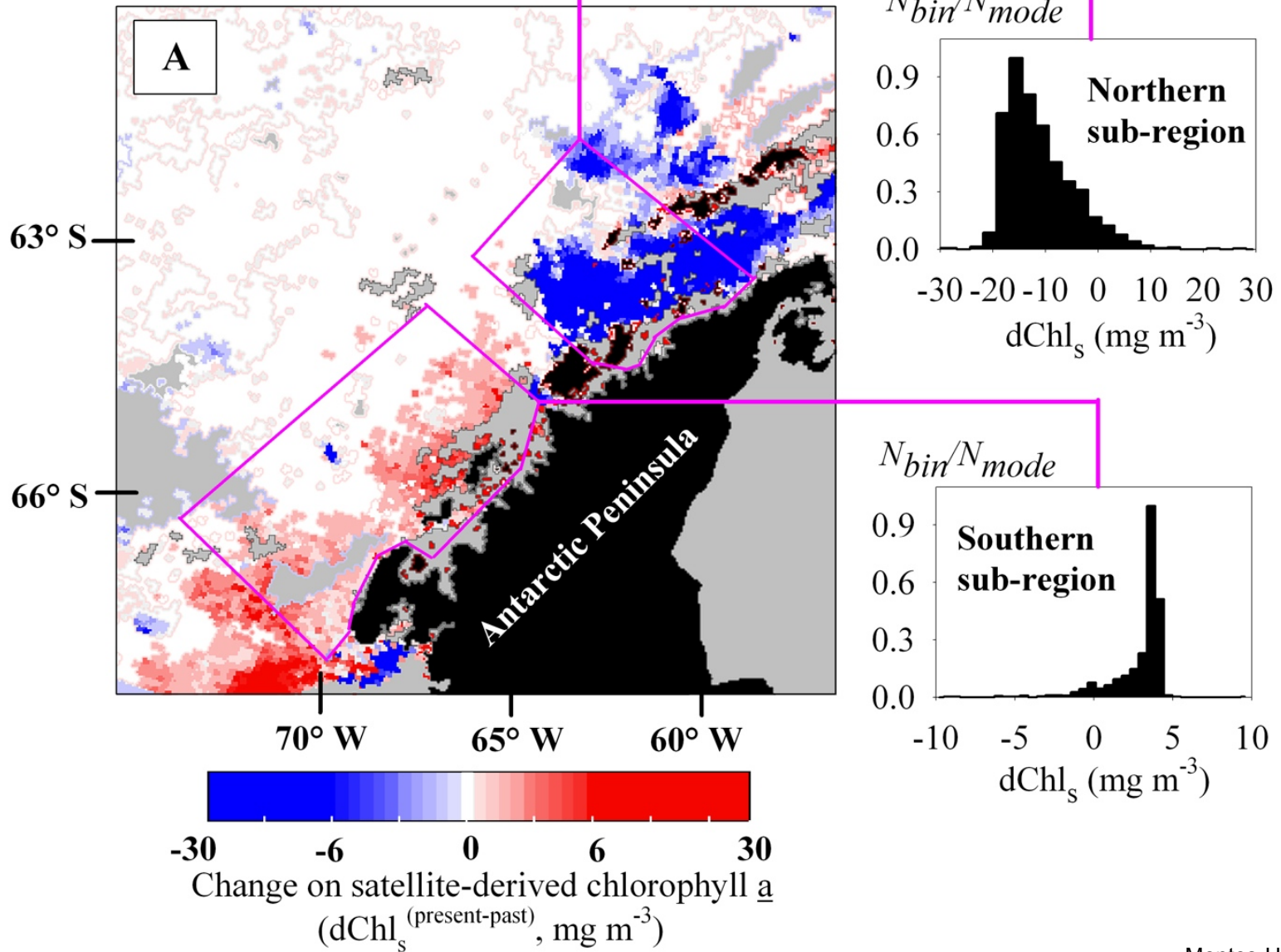
# Large changes present in this ocean



# Use the maps to identify temporal and spatial relationships in phytoplankton along the Western Antarctic Peninsula.

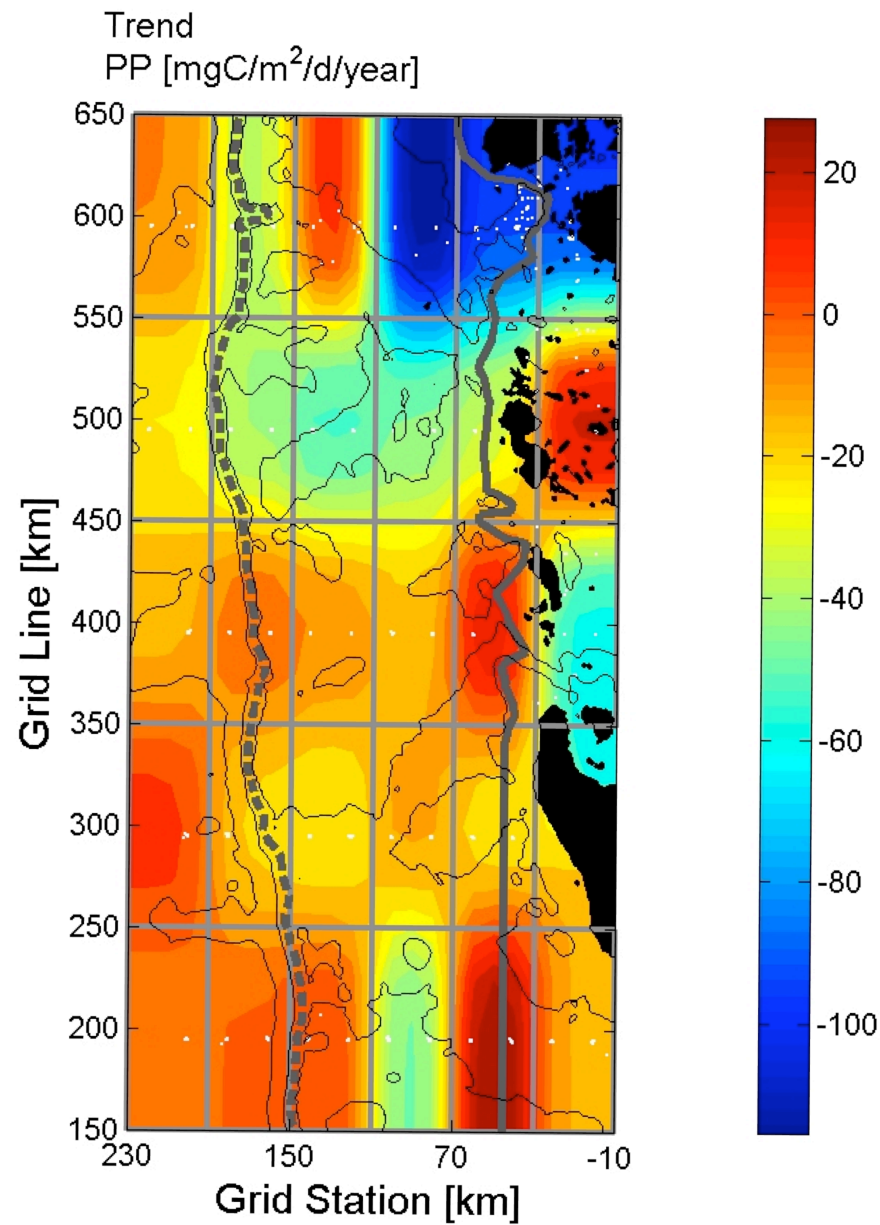
*SEP 4: Analyzing and Interpreting Data* - Students are expected to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error. It is important students present data as evidence to support their conclusions.

# Remote Sensing (Decadal changes)



Montes-Hugo et al. 2009

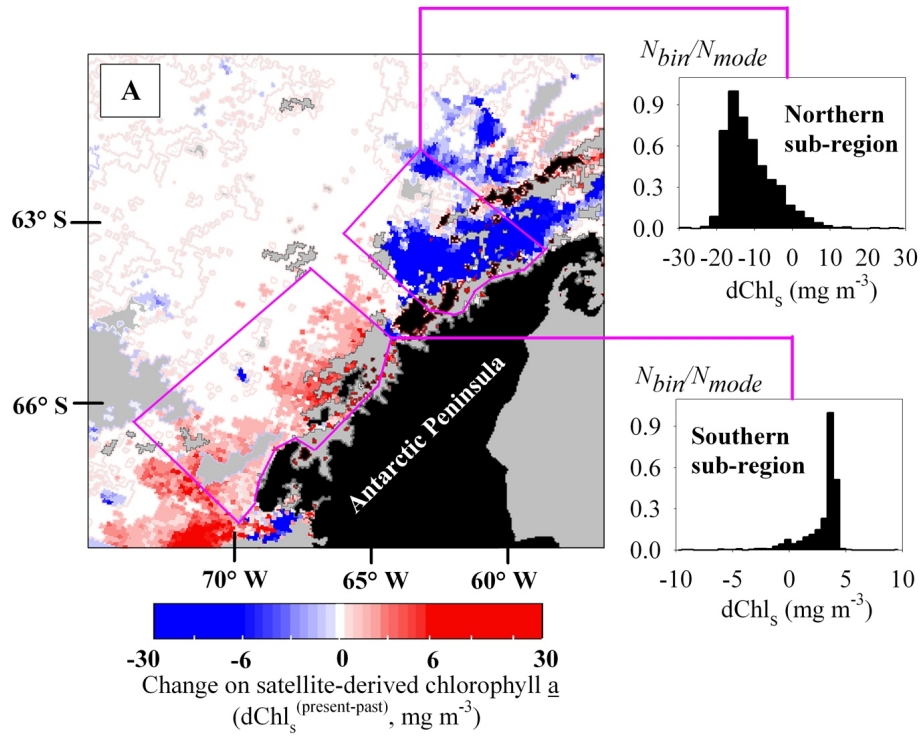
Ship Observed  
(Decadal changes)



Vernet et al. 2008

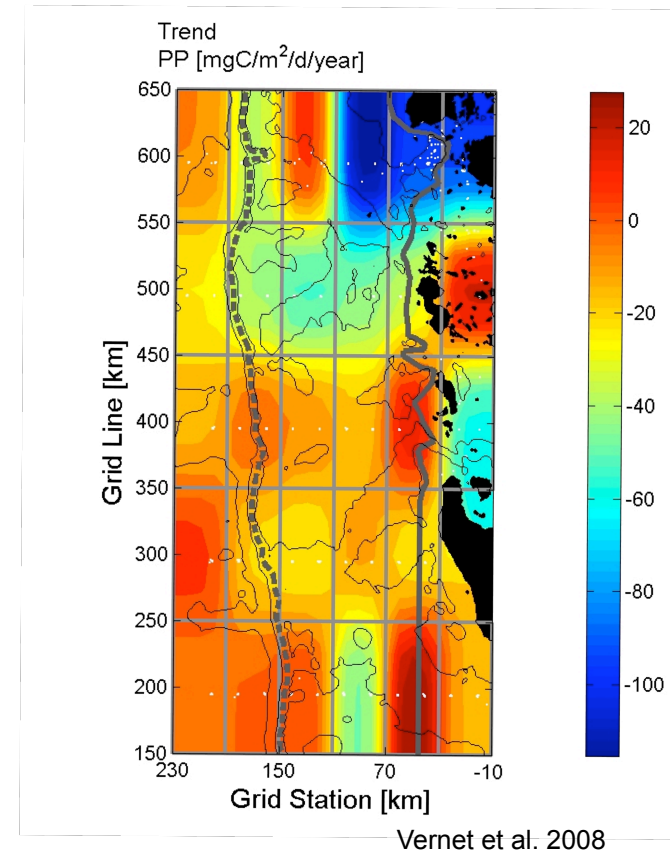
# There are indications in changes in the primary production

Remote Sensing (Decadal changes)



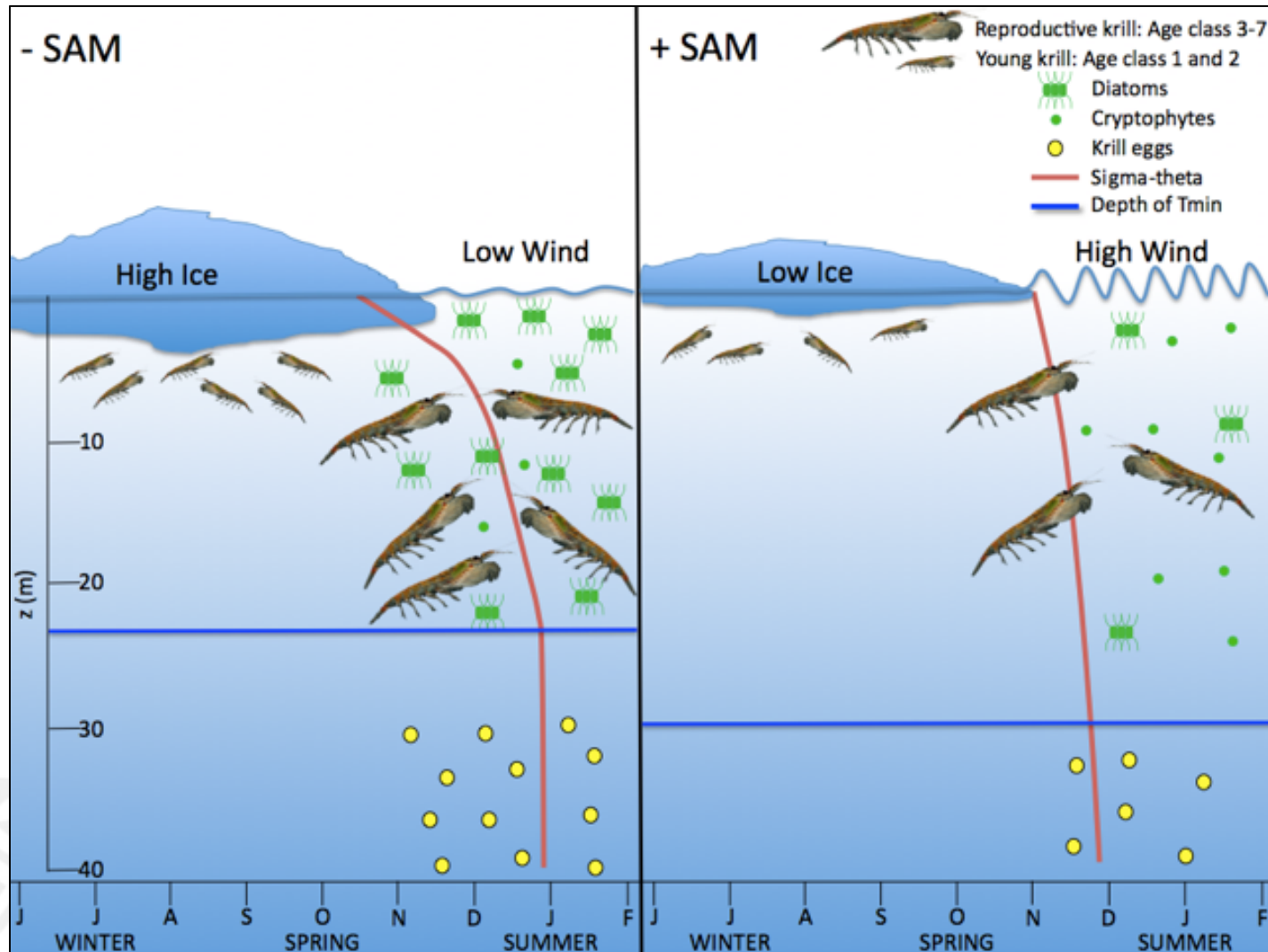
Montes-Hugo et al. 2009

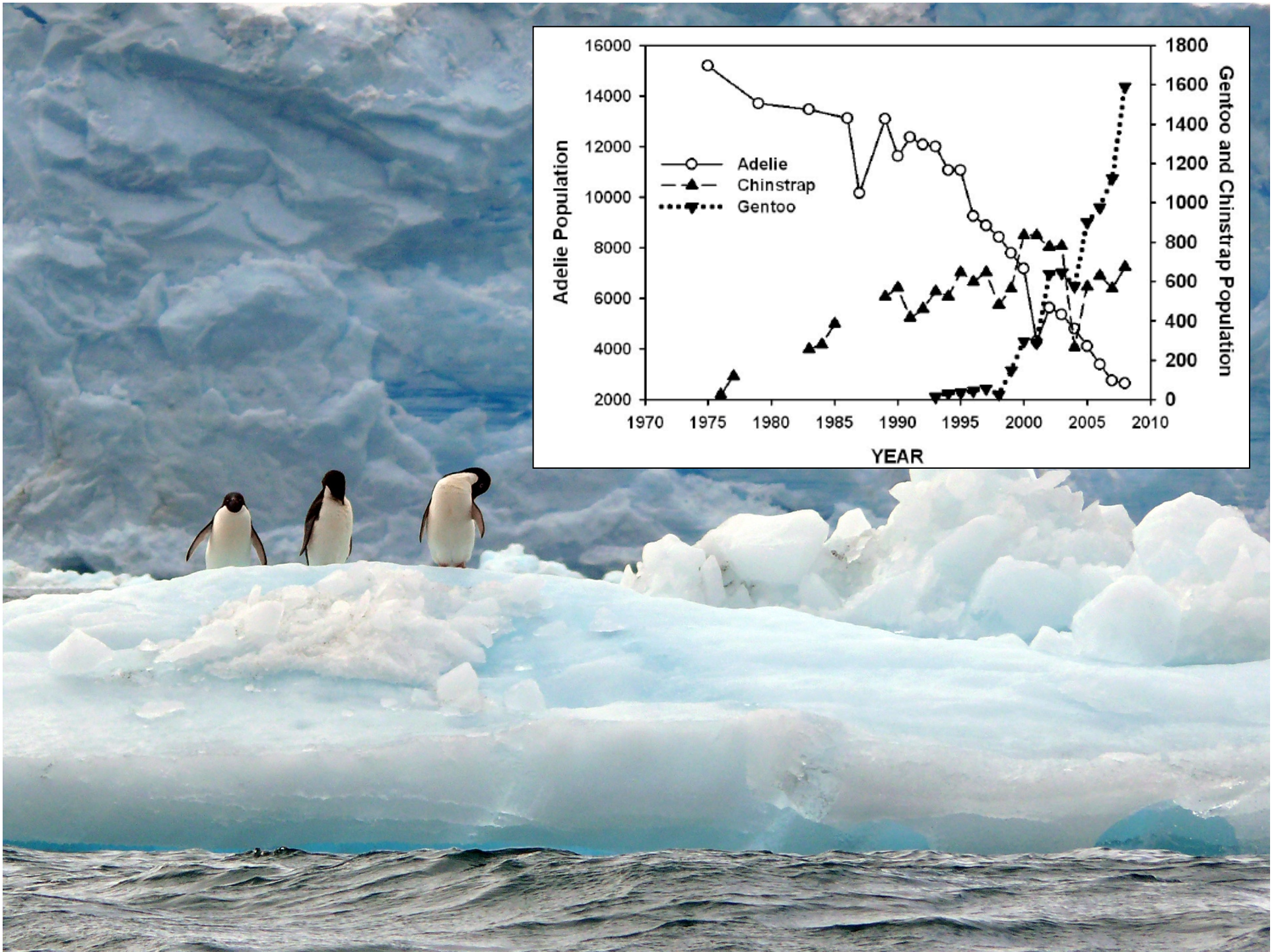
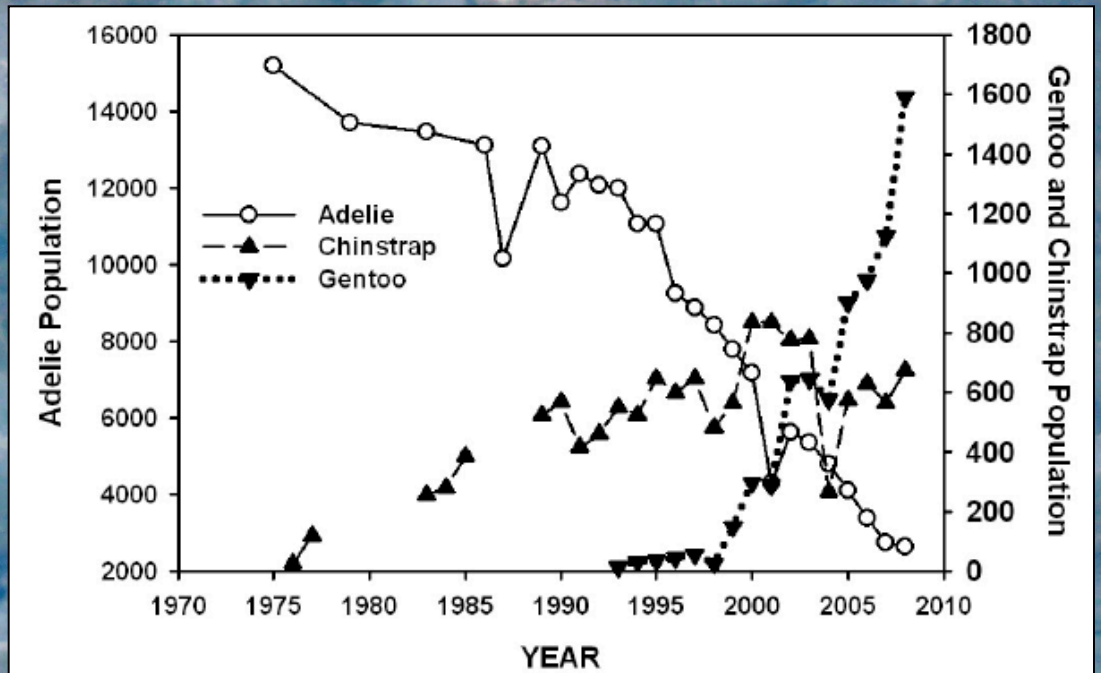
Ship Observed (Decadal changes)



# There are indications in impacts on the zooplankton Community

## *Antarctic Krill*







# ANTARCTICA

BEYOND THE ICE



03:12



HD vimeo

R

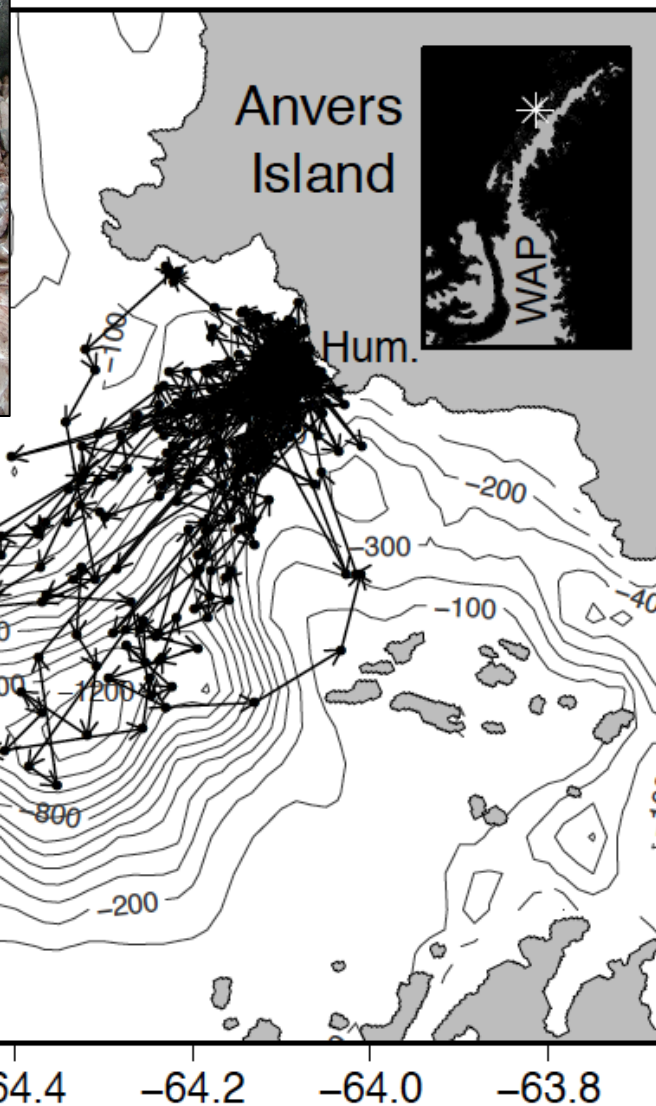
Antarctic: Beyond the Ice Trailer

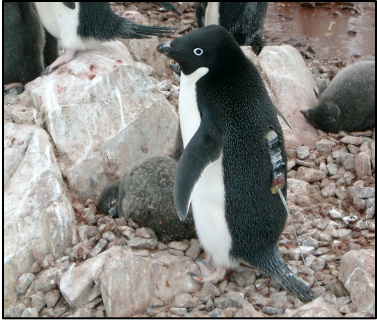


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Lab

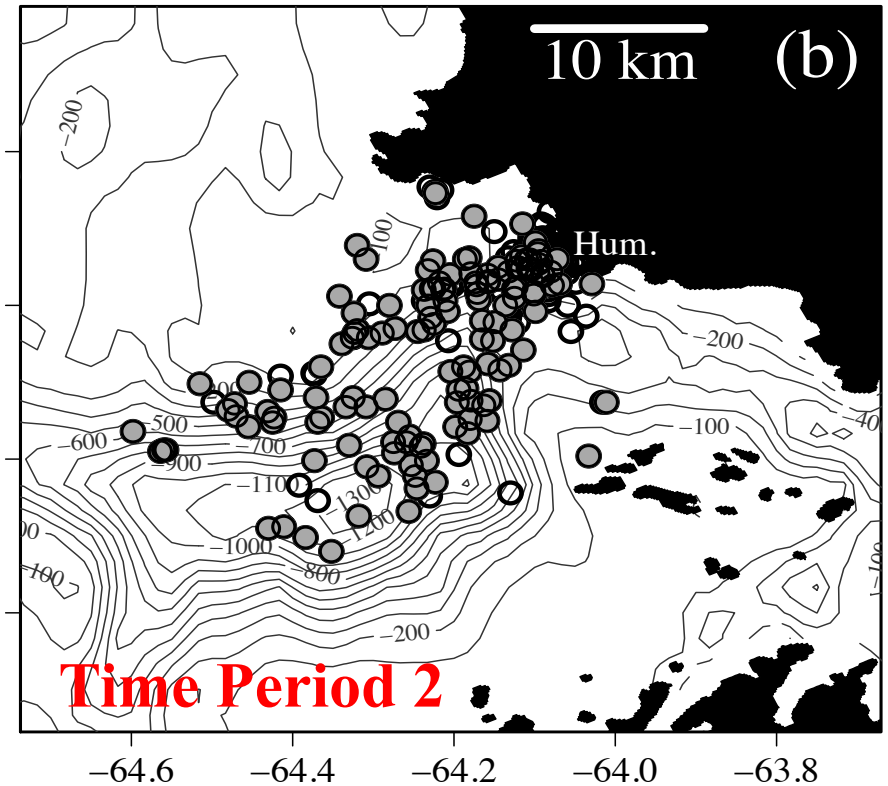
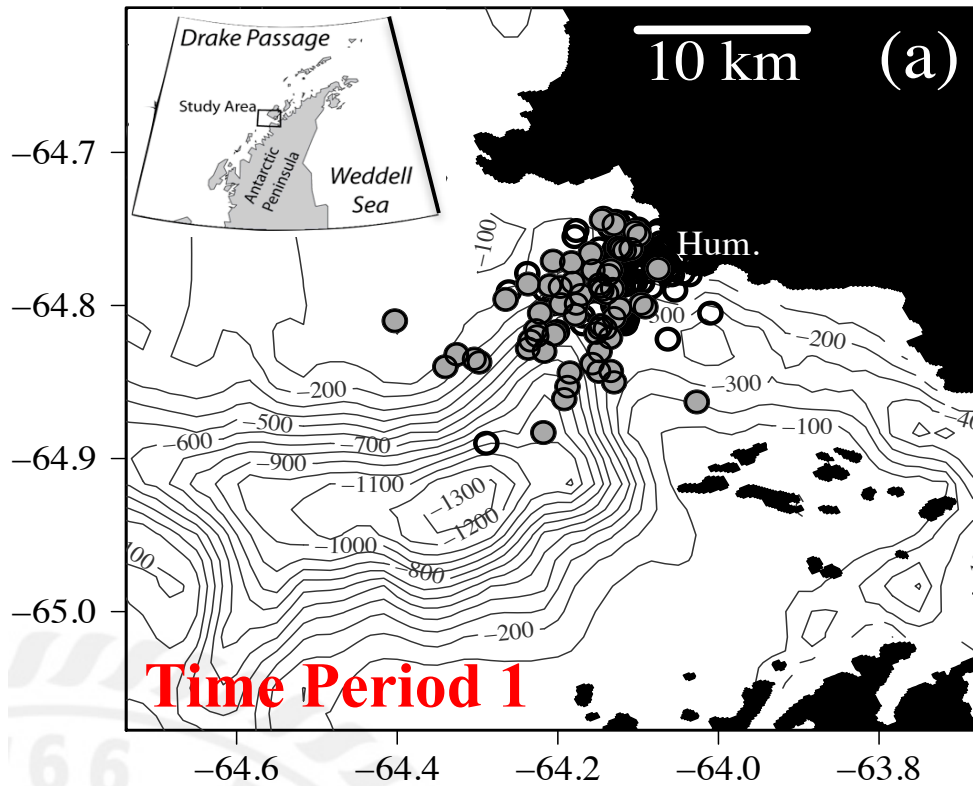


# Tracking Penguins

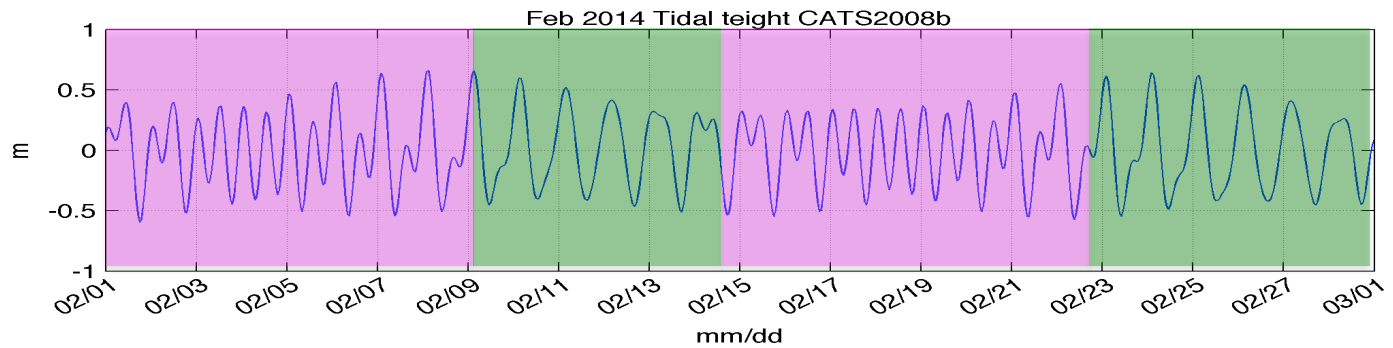
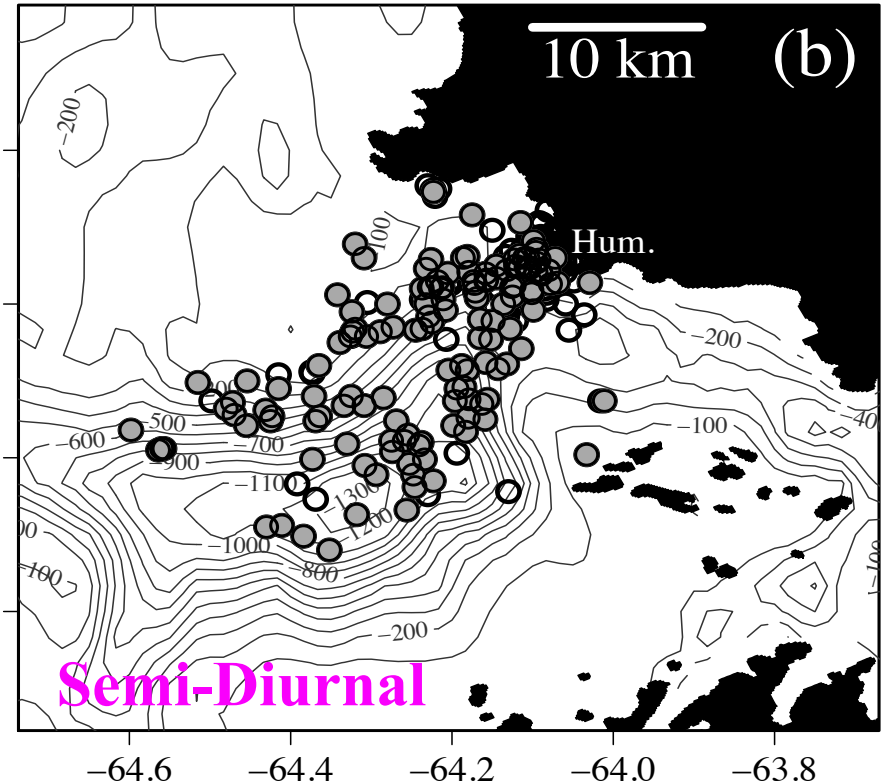
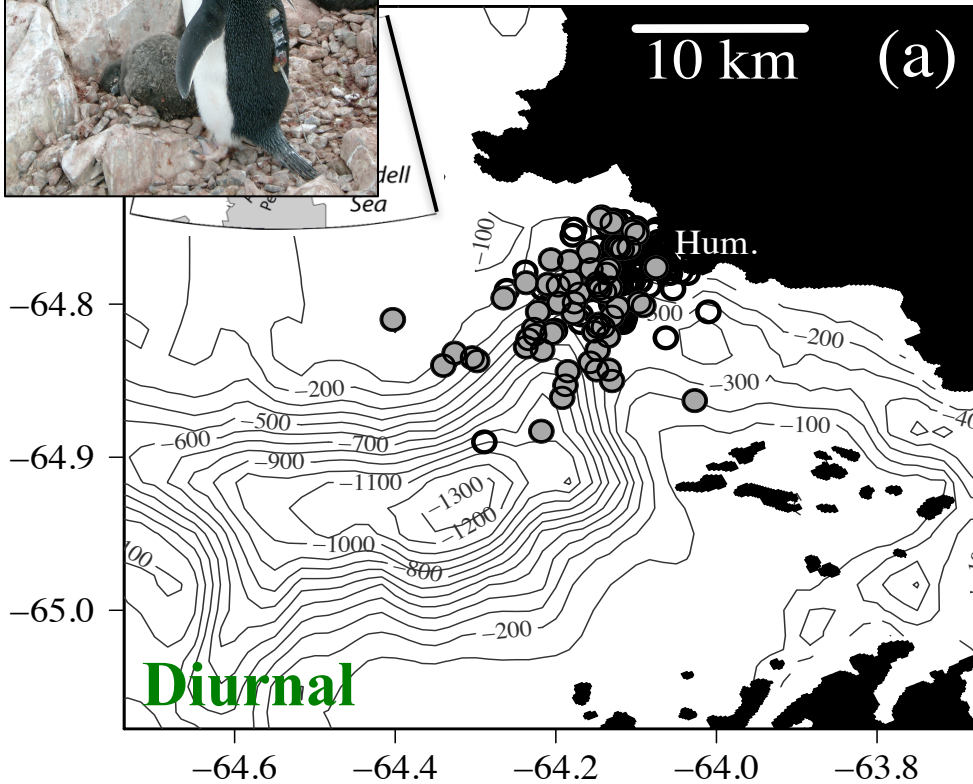




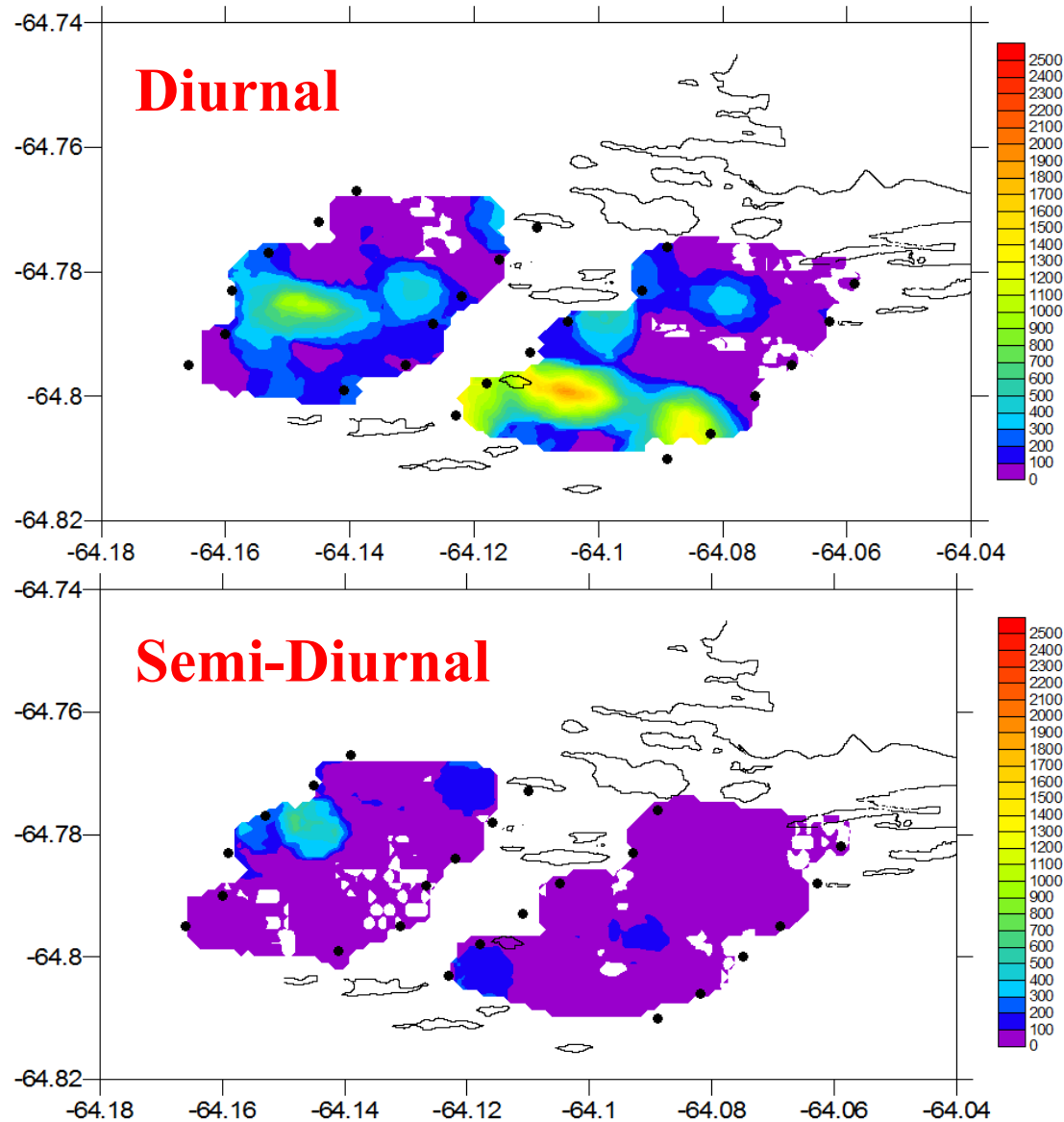
# Tidal Dependence on Penguin Foraging Behavior?



# Tidal Dependence on Penguin Foraging Behavior?



# Tidal Dependence on Zooplankton Distribution?



Collect data through the simulation to serve as the basis for evidence to answer the question: what effects where predators forage?

*SEP 3: Planning and Carrying Out Investigations* - Scientific investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works.

# Adélie Penguin Foraging Simulation

1. Find a partner – your baby chick is very HUNGRY
2. Start in the colony (starting line)
3. Pick order – one forages while the other cares for the chick
4. Each round is a day – 30 second total (15 second for each)
5. Plastic cup is your stomach to fill with krill (markers)
6. Collect krill with hand that is not holding bag
7. One krill at a time from one bucket
8. Krill need to come from different buckets - you ate what was there or scared it away so have to go to a different location
9. Instructions to know: “Forage”, “Switch”, “Time to Eat”

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**Red  
Markers**

**Game  
Markers**

Round 1

Round 2

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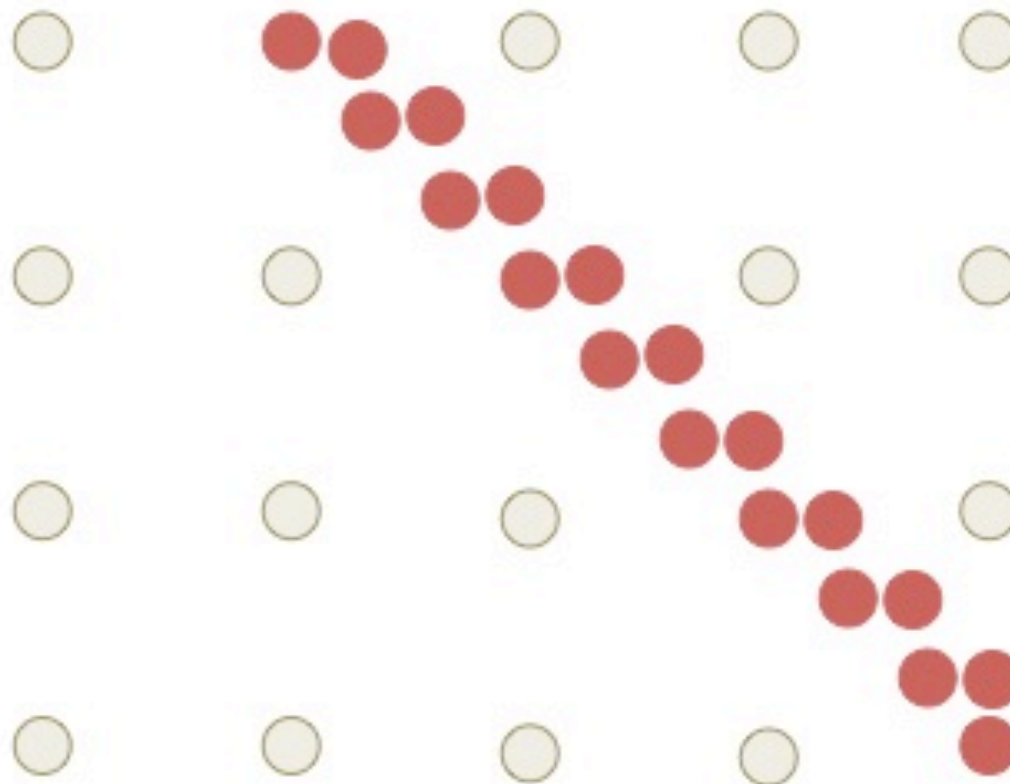
Average Number of Beans (Krill)

Round 1 Red/White

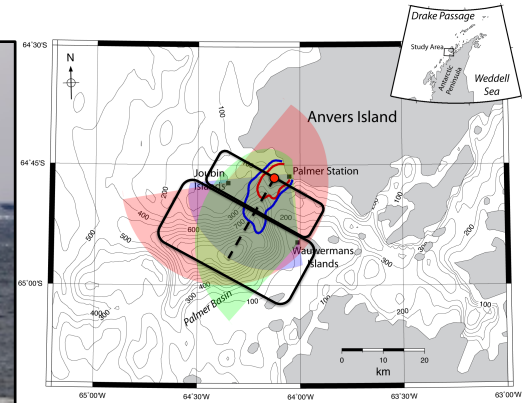
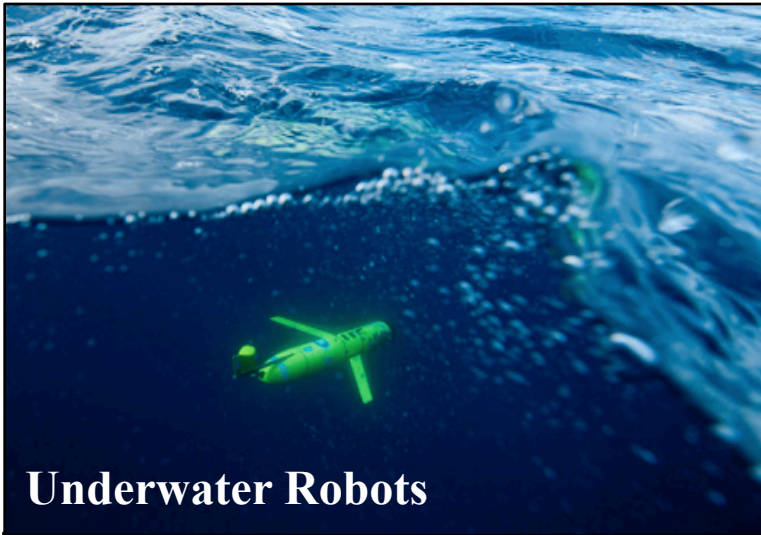
Round 2 Red/White







# Technology to be deployed: *Our adaptive Approach*



END

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