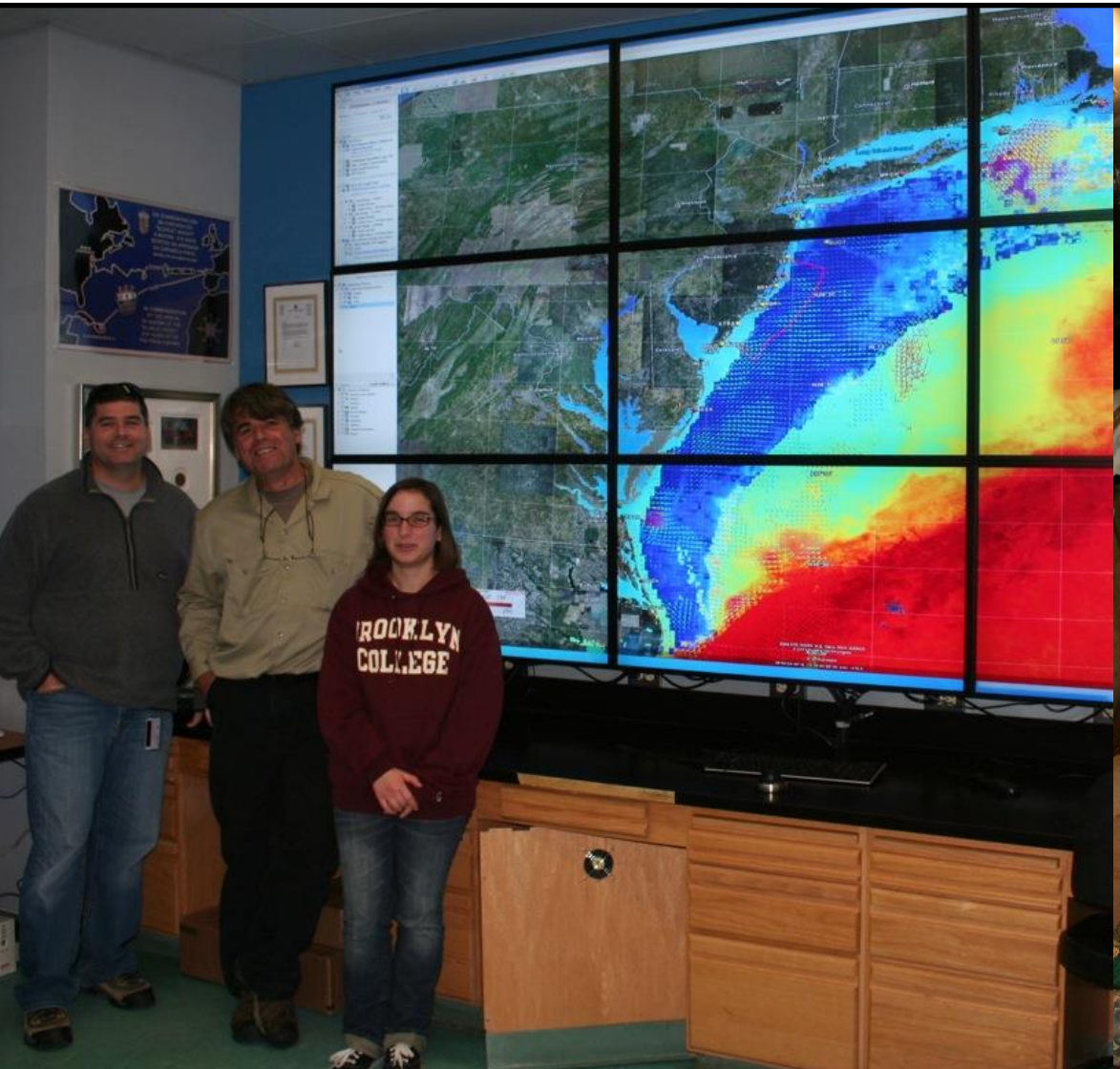
Processes underlying climate shifts in mid Atlantic Bight fish distributions inferred from sustained collaborative research within a winter fishery



Outline

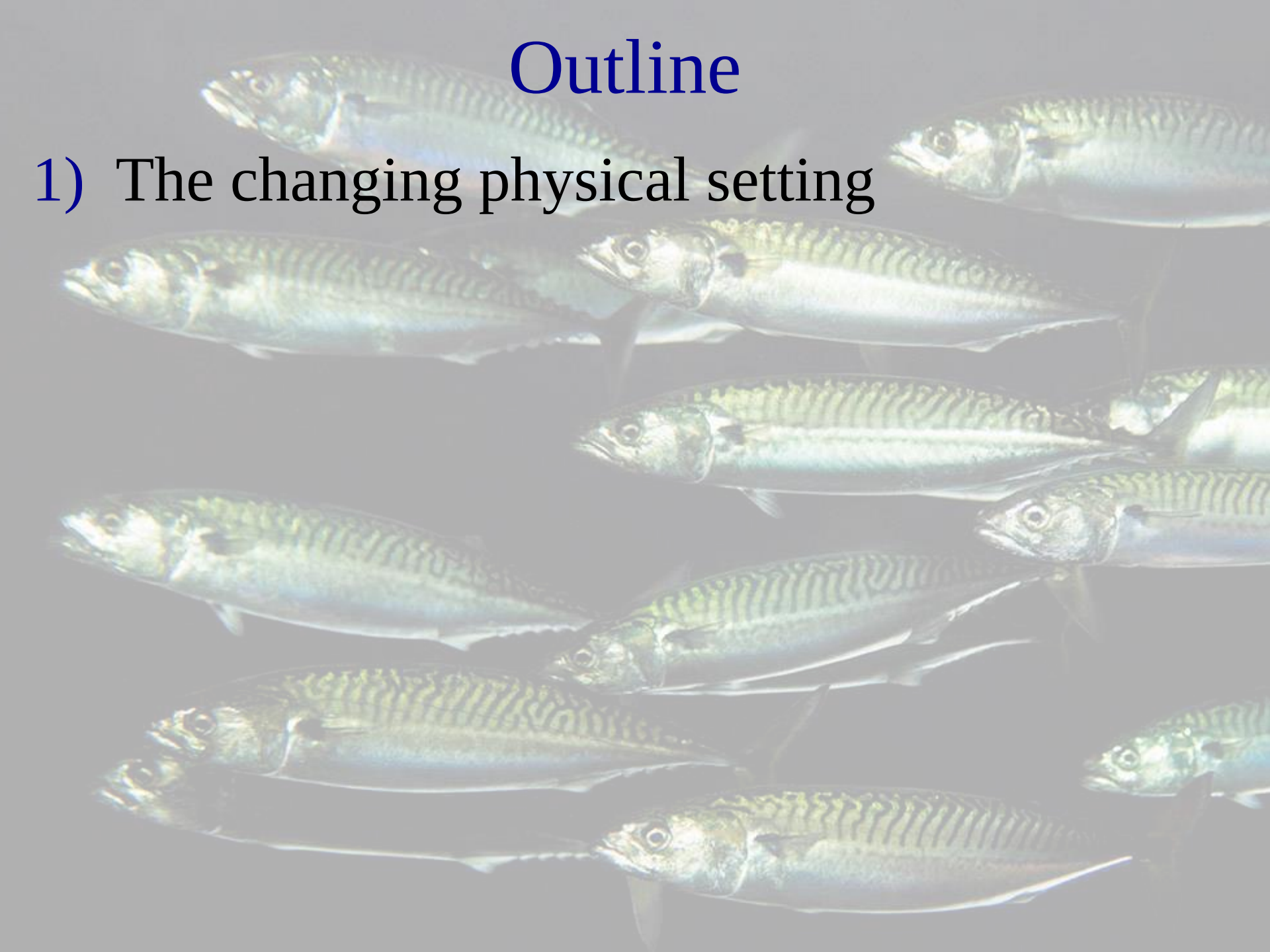
1) The changing physical setting

2) The problem of attribution.
   What are the underlying mechanisms of Climate-population/ecosystem impacts

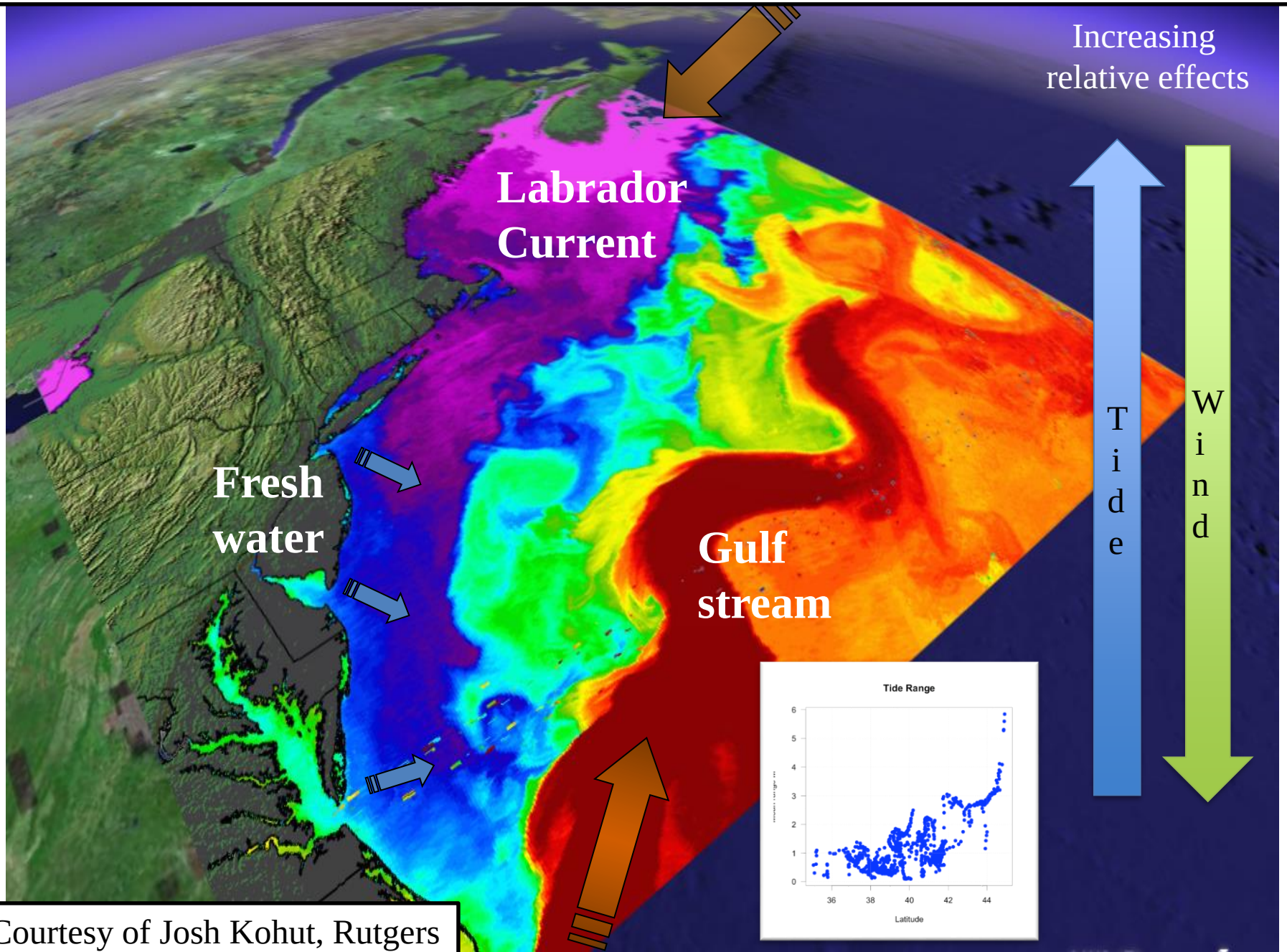
3) Collaborative exploration of possible causes of NW Atlantic Mackerel distribution shifts.

Outline

1) The changing physical setting



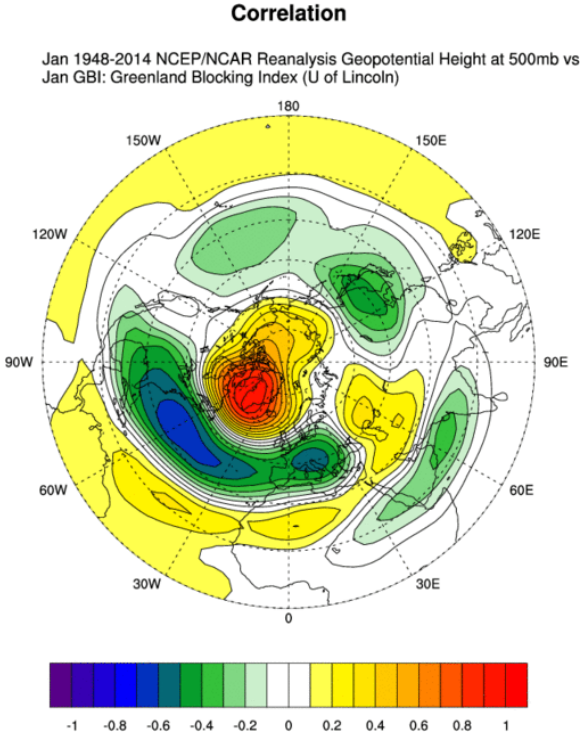
Oceanography of the NW Atlantic

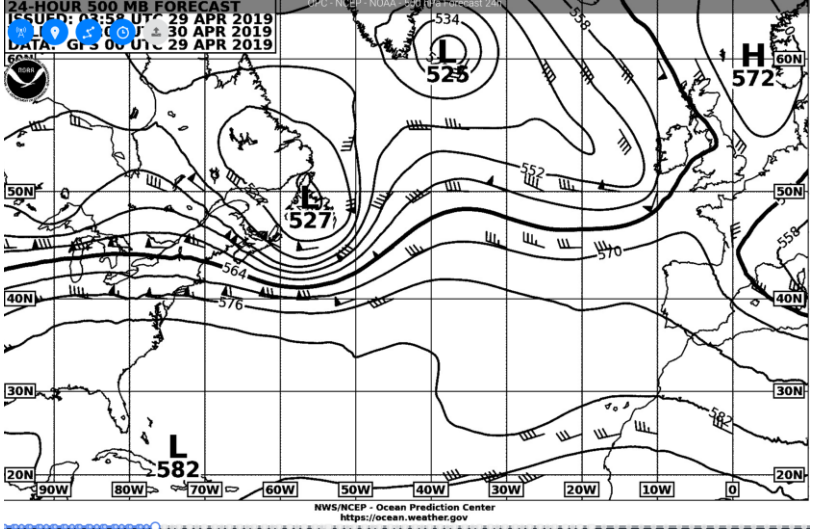


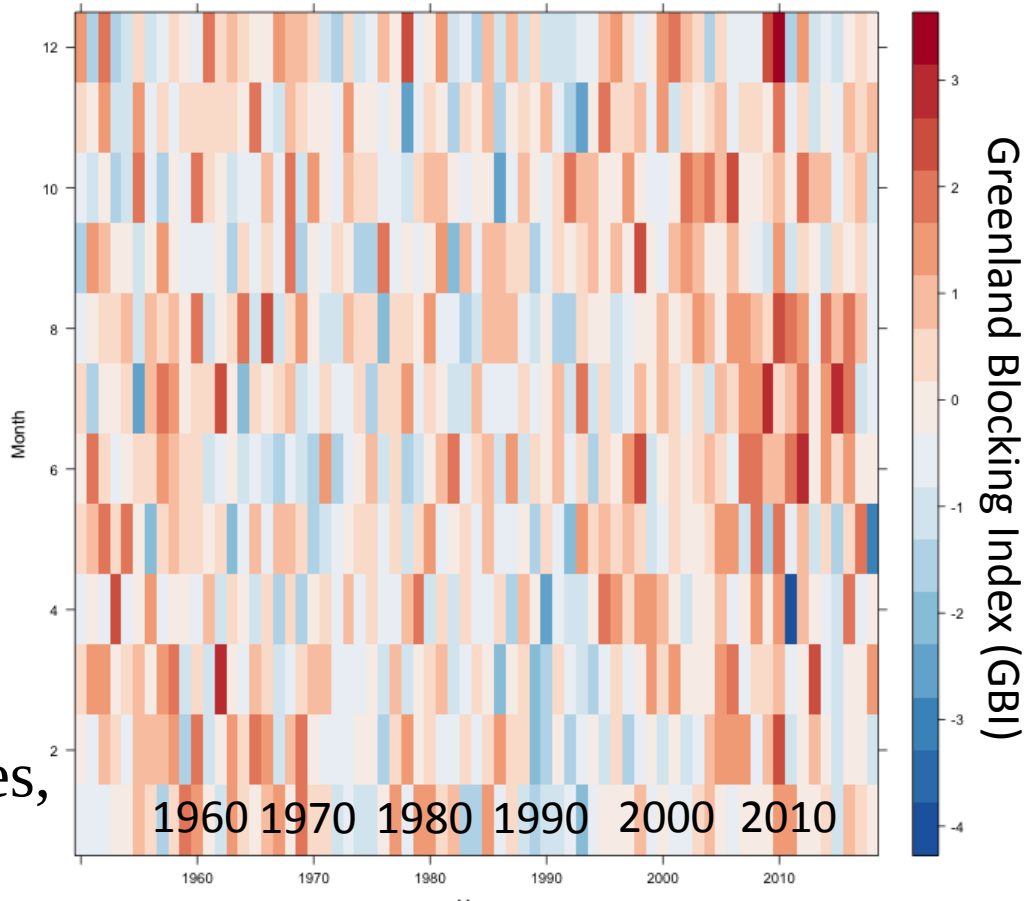
Courtesy of Josh Kohut, Rutgers

Changes in atmospheric circulation

Weather system steering winds at 500mb of 16-20K feet

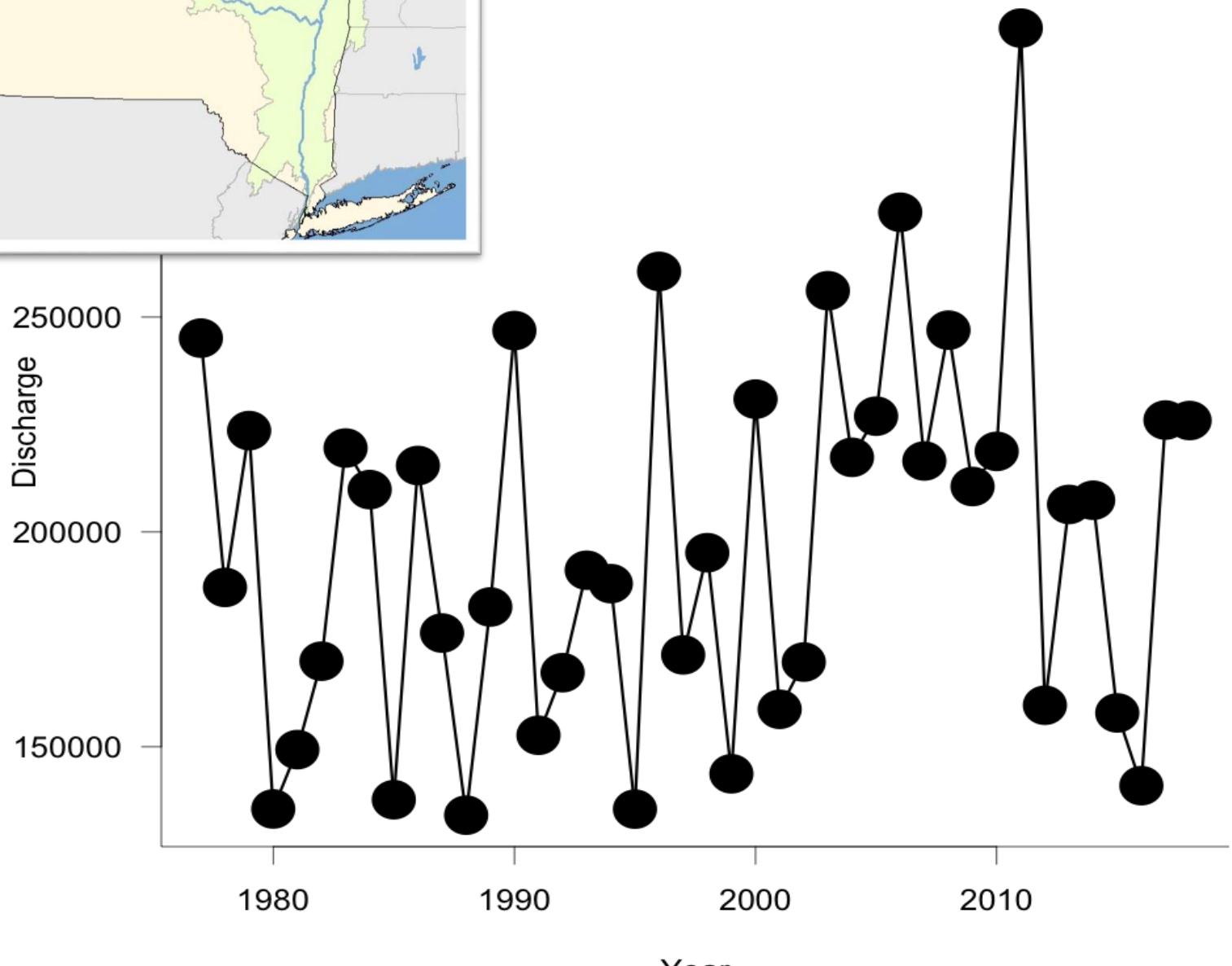




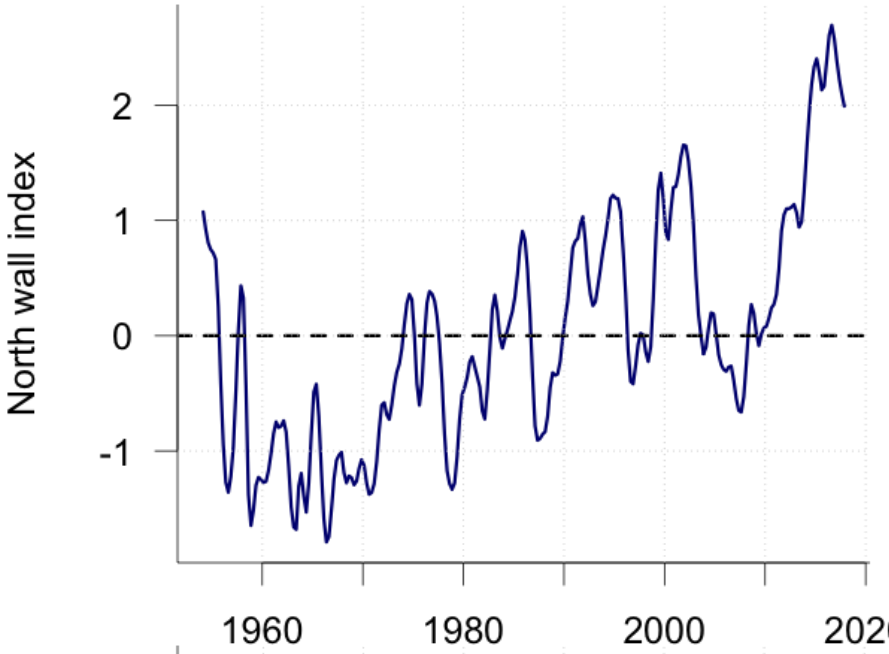


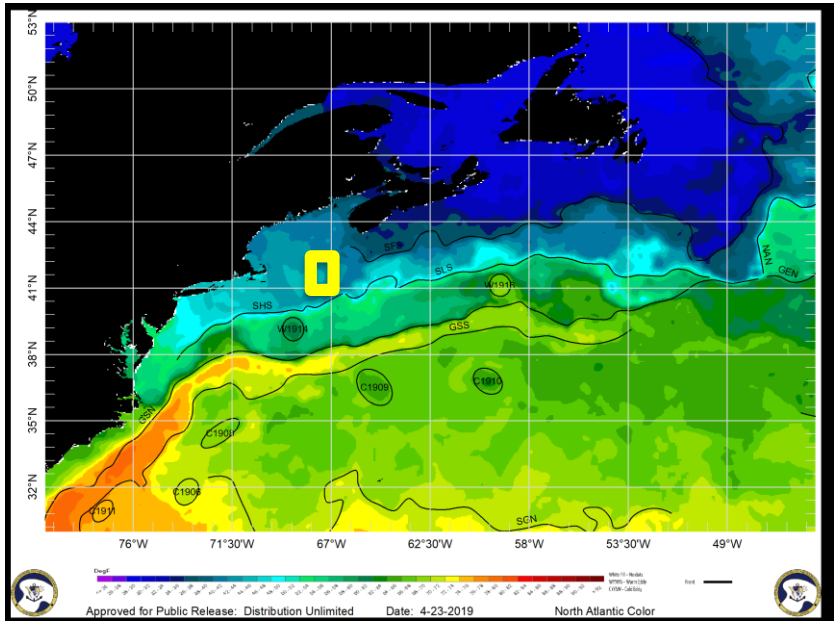
Effects: Jet stream dynamics, rates of frontal passage, persistence of winds, temperatures, rain etc.

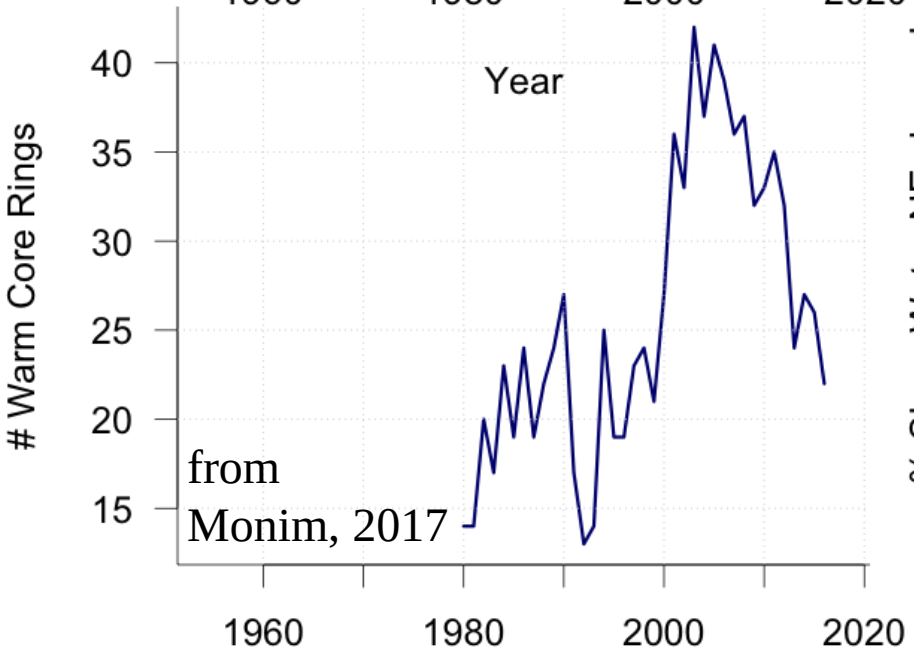
Cumulative Hudson River Discharge

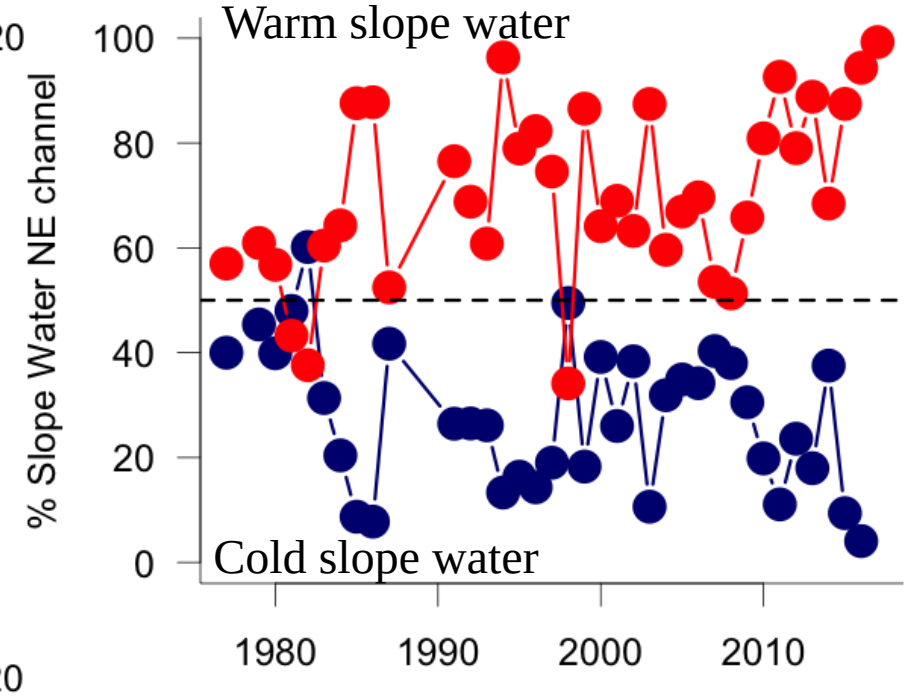


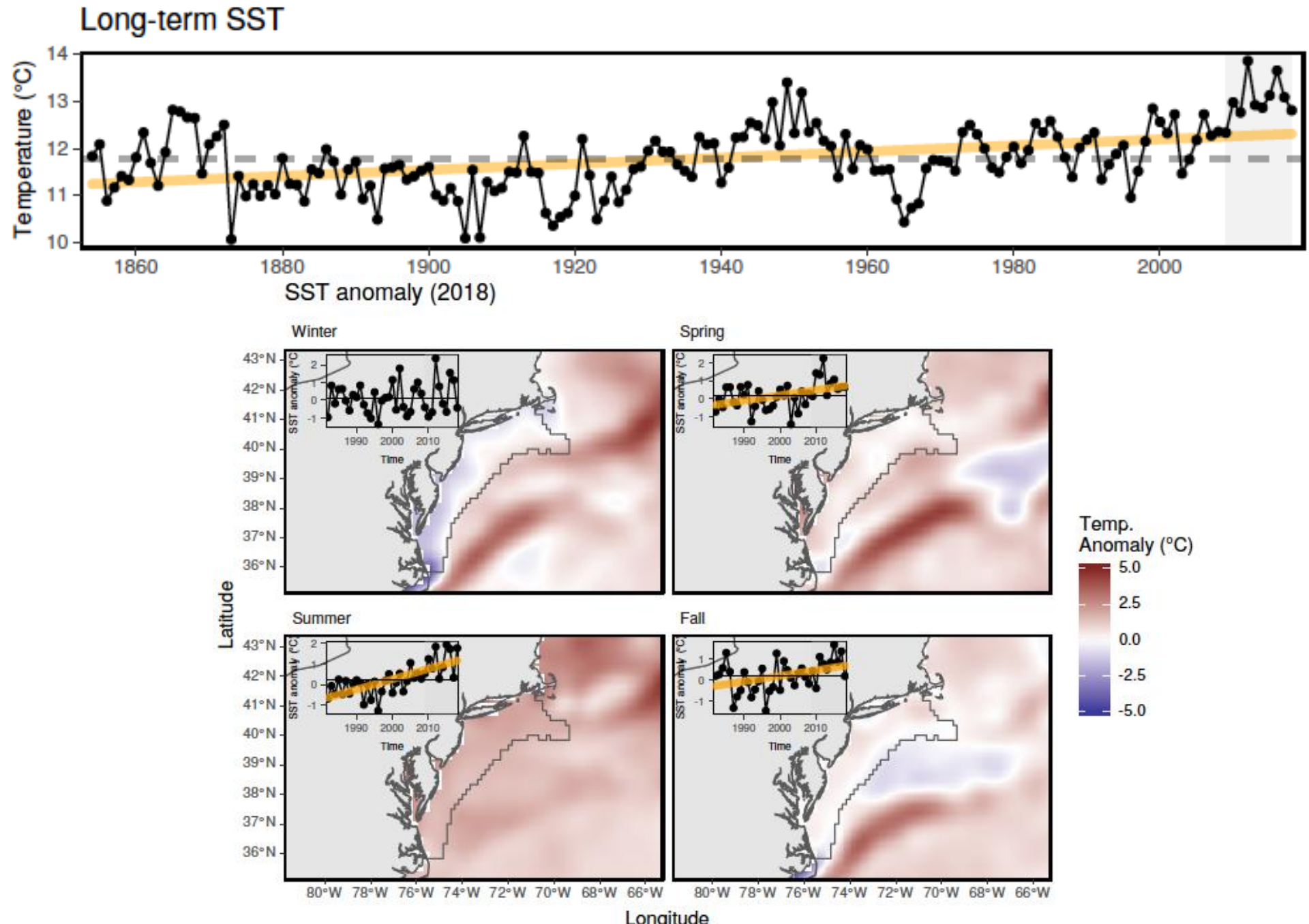
Changes in Circulation
The Gulf Stream



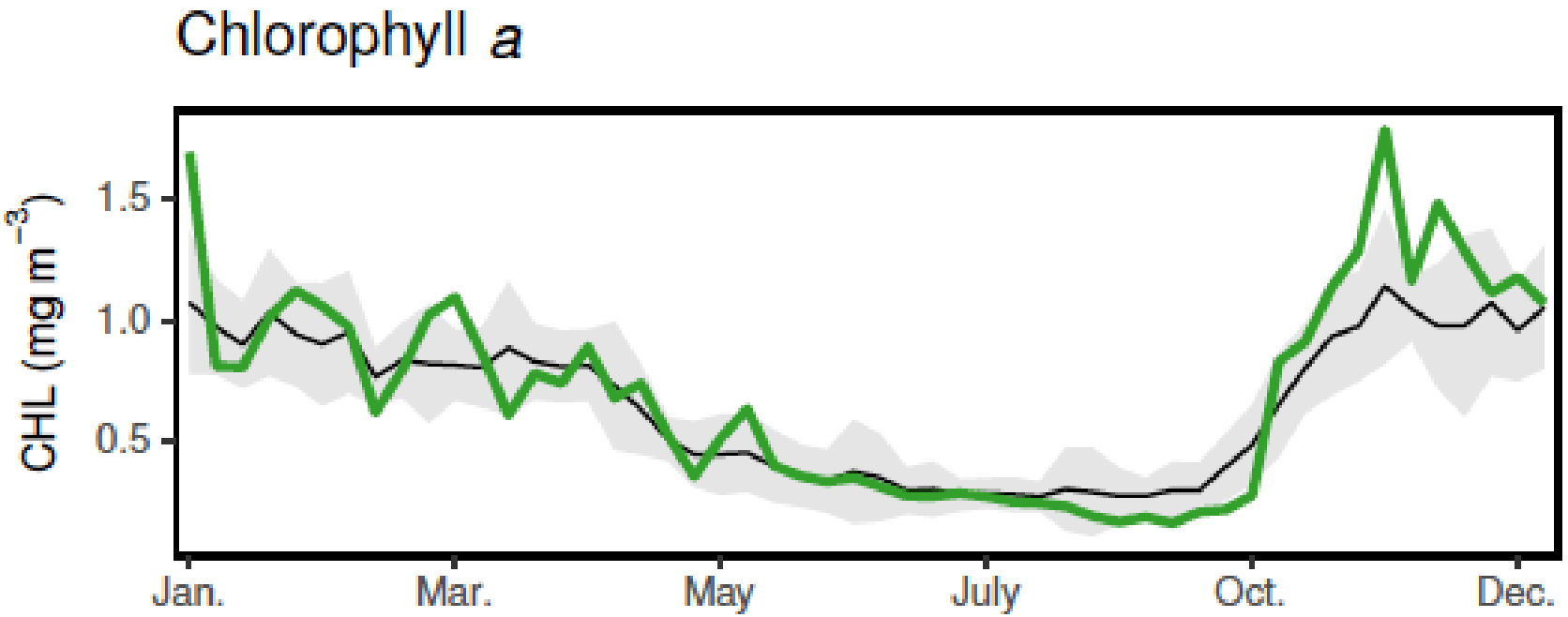


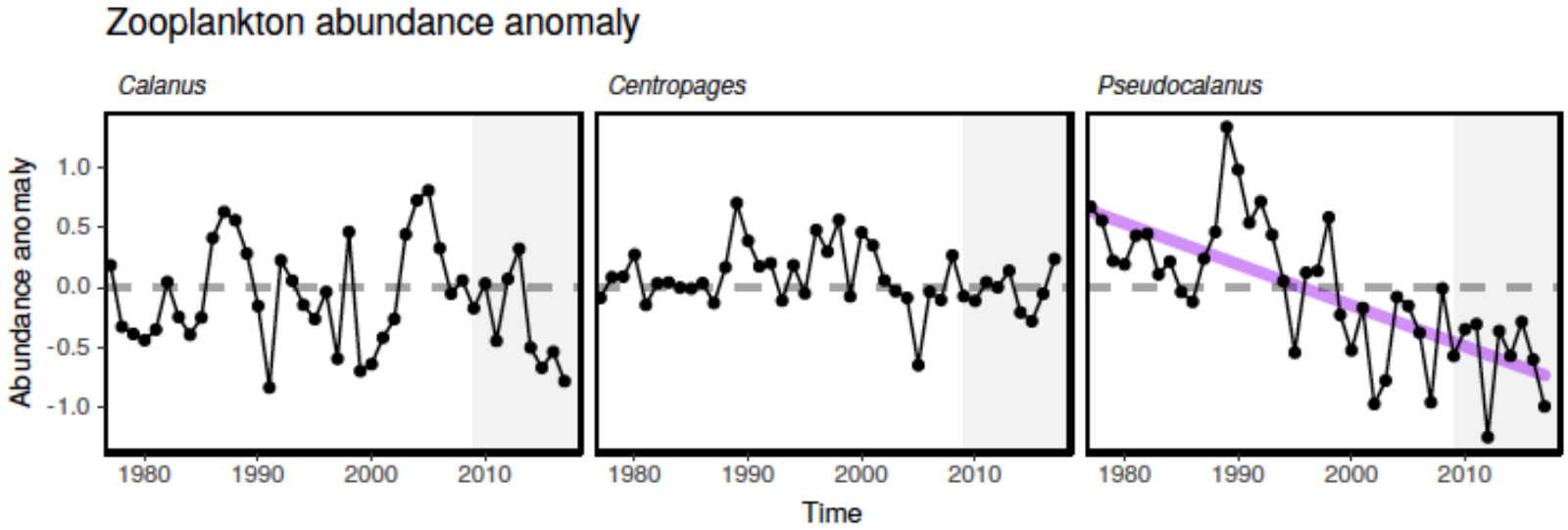




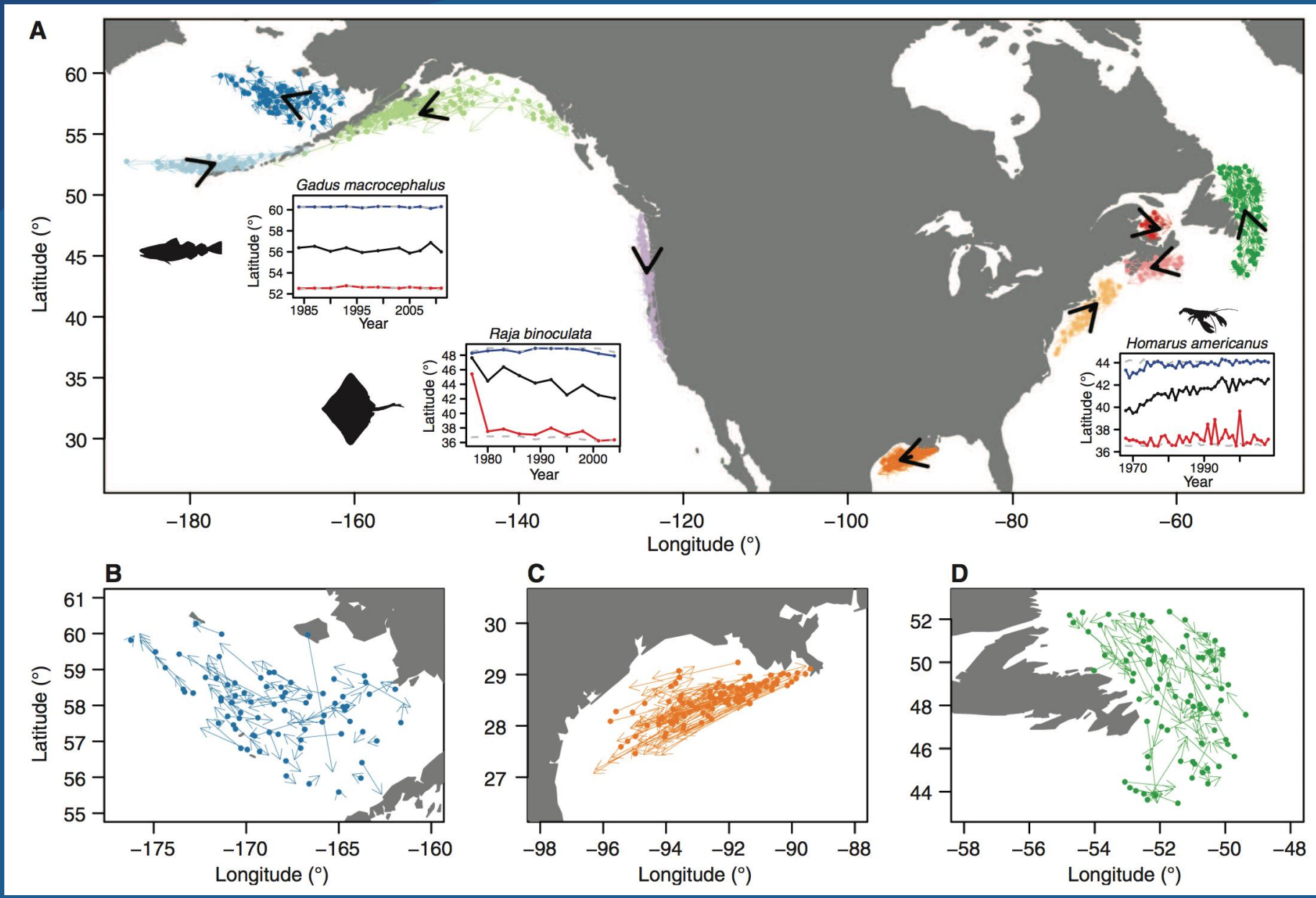

Long-term SST
Temperature (°C)
14
13
12
11
10
1860
1880
1900
1920
1940
1960
1980
2000
SST anomaly (2018)
Winter
Spring
Summer
Fall
Latitude
43°N
42°N
41°N
40°N
39°N
38°N
37°N
36°N
80°W
78°W
76°W
74°W
72°W
70°W
68°W
66°W
Longitude
SST anomaly (°C)
Time
1990
2000
2010
Temp. Anomaly (°C)
5.0
2.5
0.0
-2.5
-5.0

Bottom up effects on the ecosystem





Pinsky et al., 2013. Distribution shifts in many fish stocks



Stationarity assumptions violated in population assessments & there are huge conflicts fishery governance

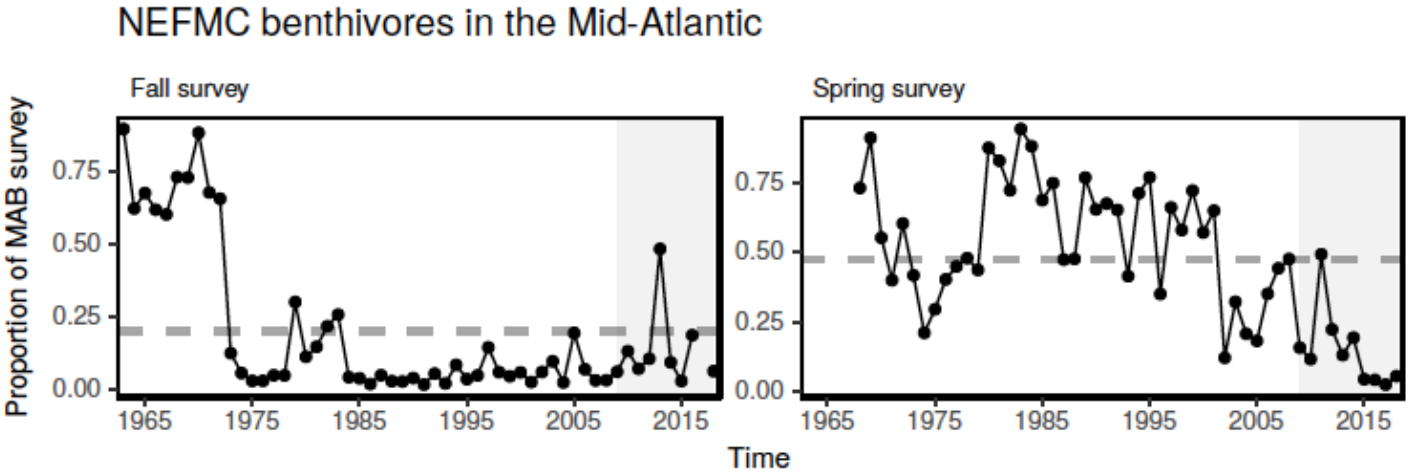
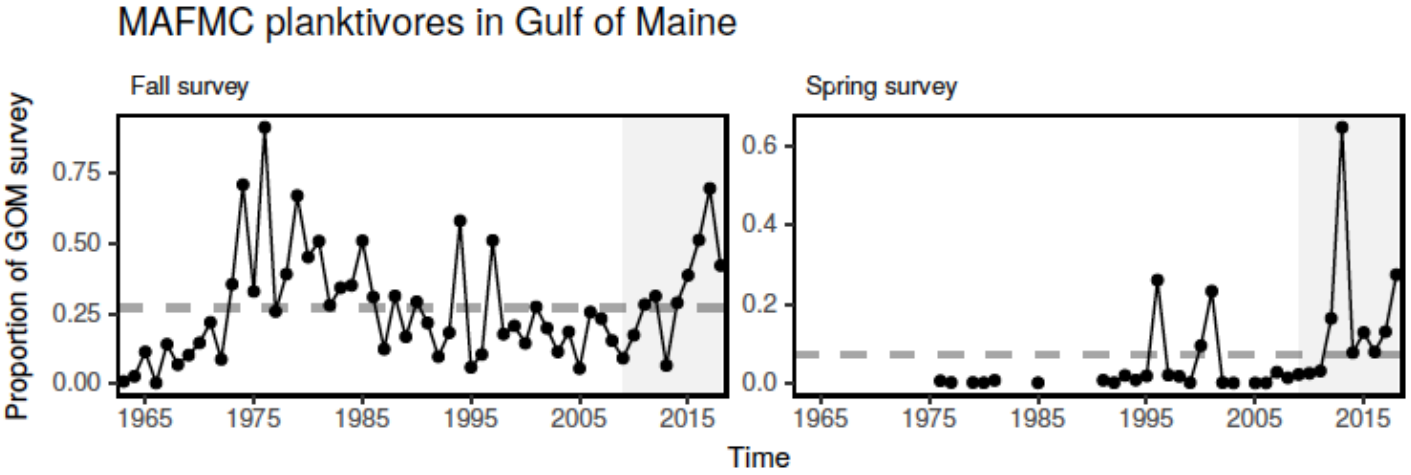


Figure 17: New England-managed survey proportion of MAB benthivores.

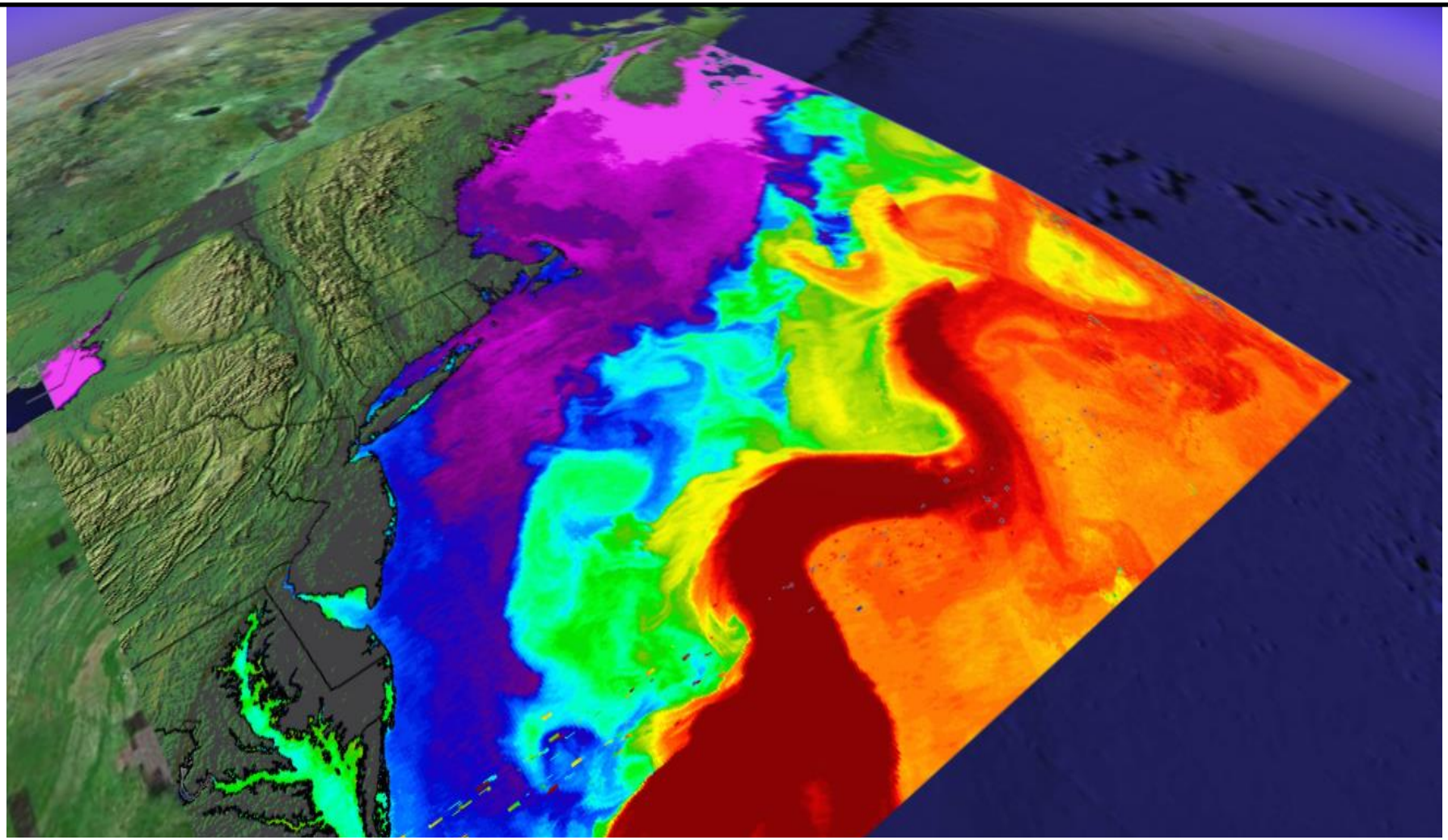


Outline

1) The changing physical setting

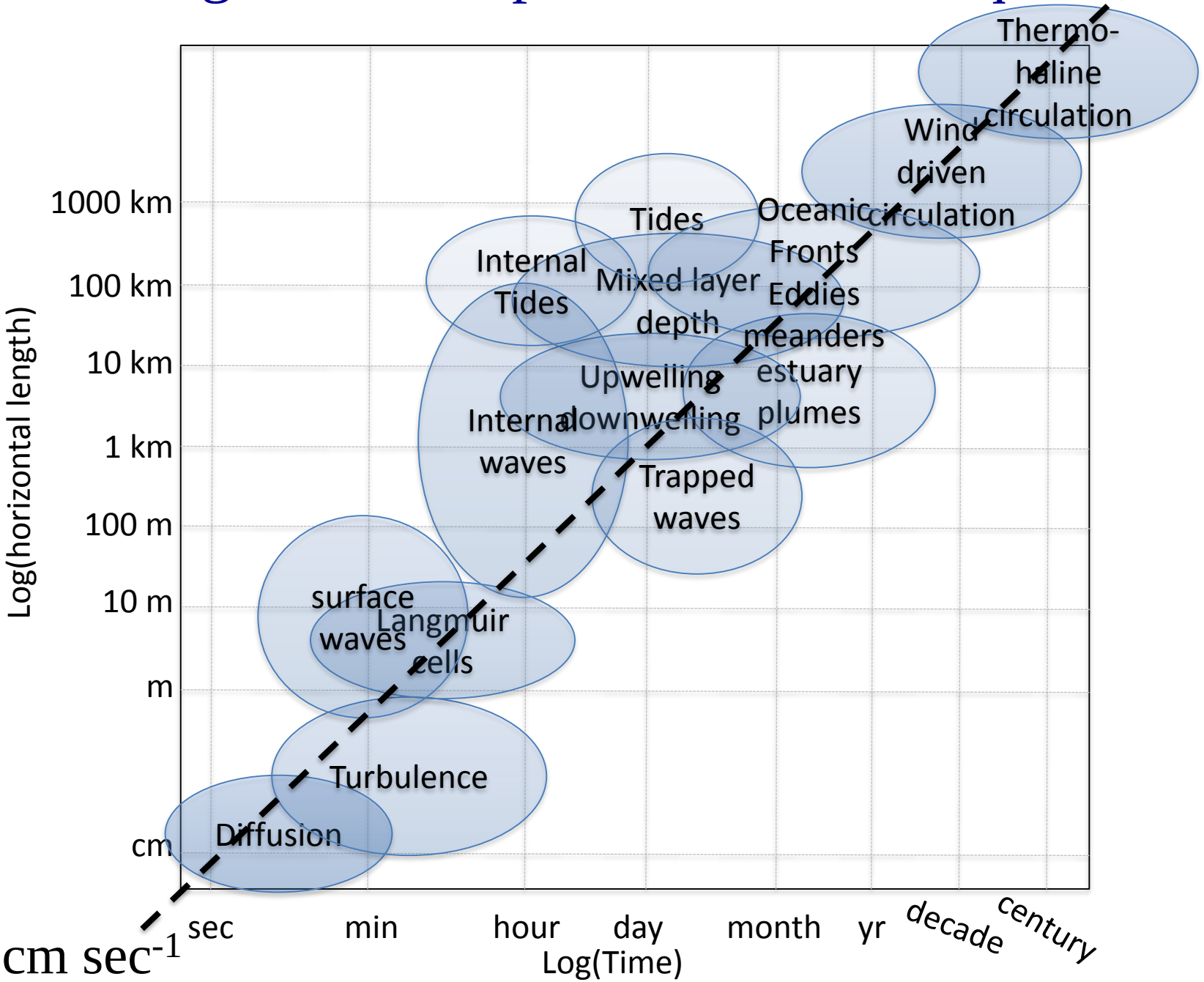
2) The problem of attribution.
   What are the underlying mechanisms of Climate-population/ecosystem impacts

There's usually only 1 big complex ecosystem



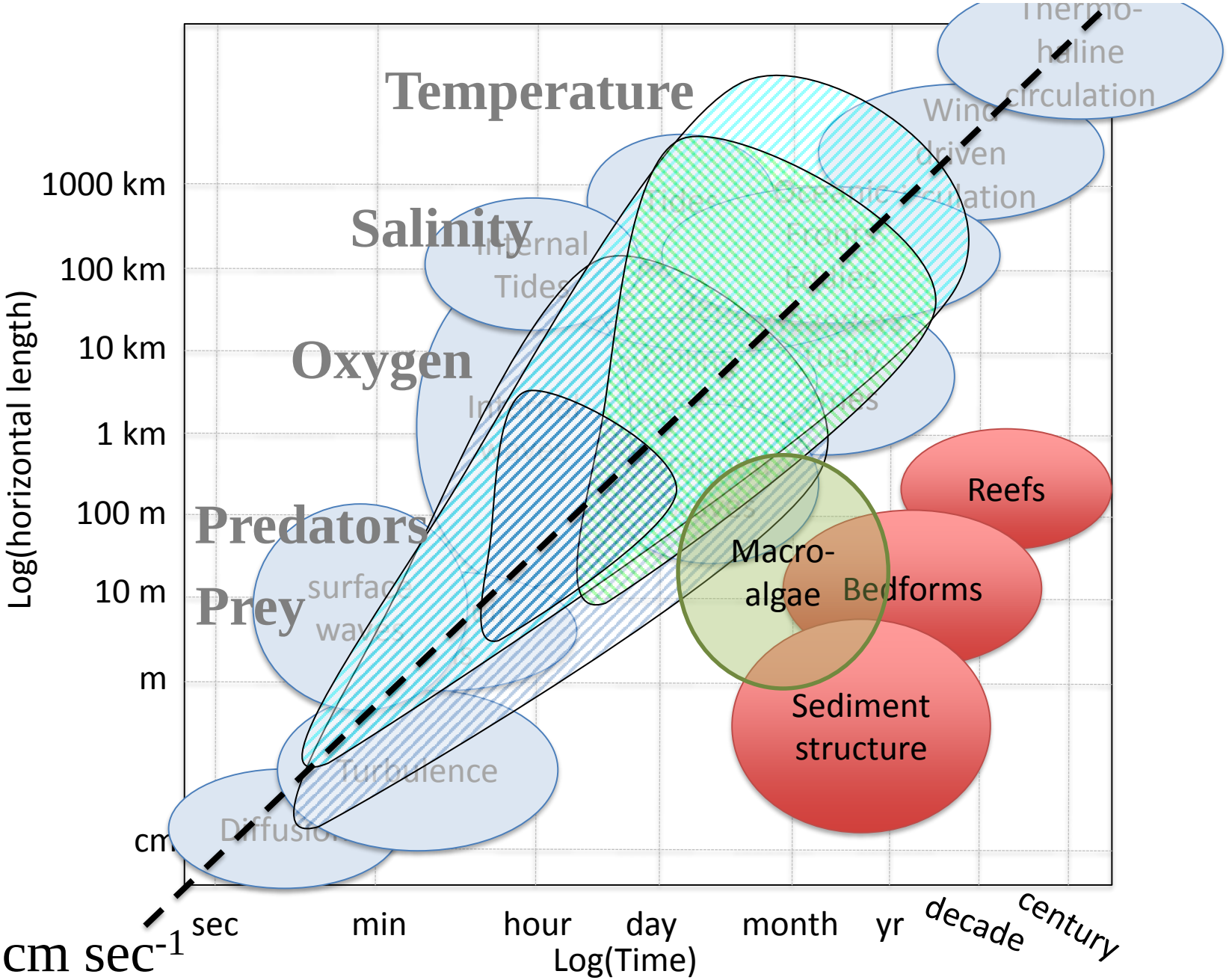
Manipulative experiments providing strong inferences about cause & effect are not possible. Only comparative mensurative studies are possible

Organisms coupled to turbulent liquid



$0.3\ \text{cm sec}^{-1}$

Environmental features driving fish dynamics



0.3 cm sec^{-1}

Population viability requires coupling habitats uniquely suitable for specific life stages in complex life cycles

Juvenile Nursery Habitats

Growth

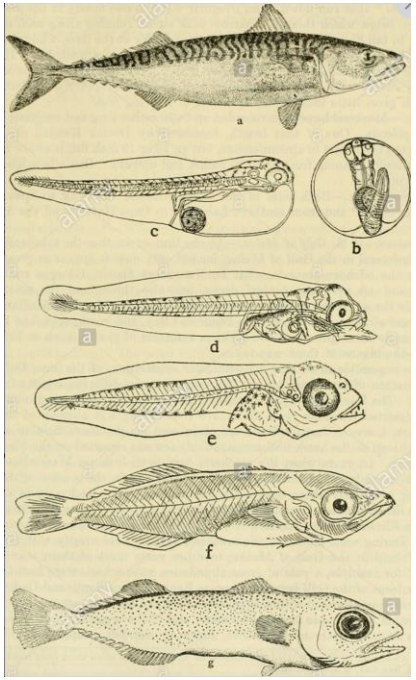
Summer-Fall Feeding Habitats

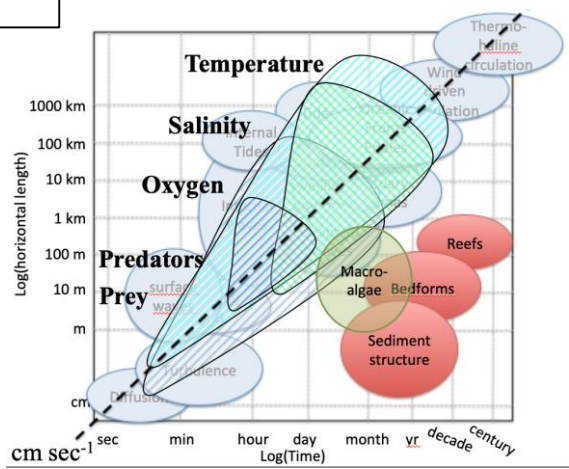
Movements

Spawning, Egg & Larval Habitats

Mortality

Overwintering Habitats



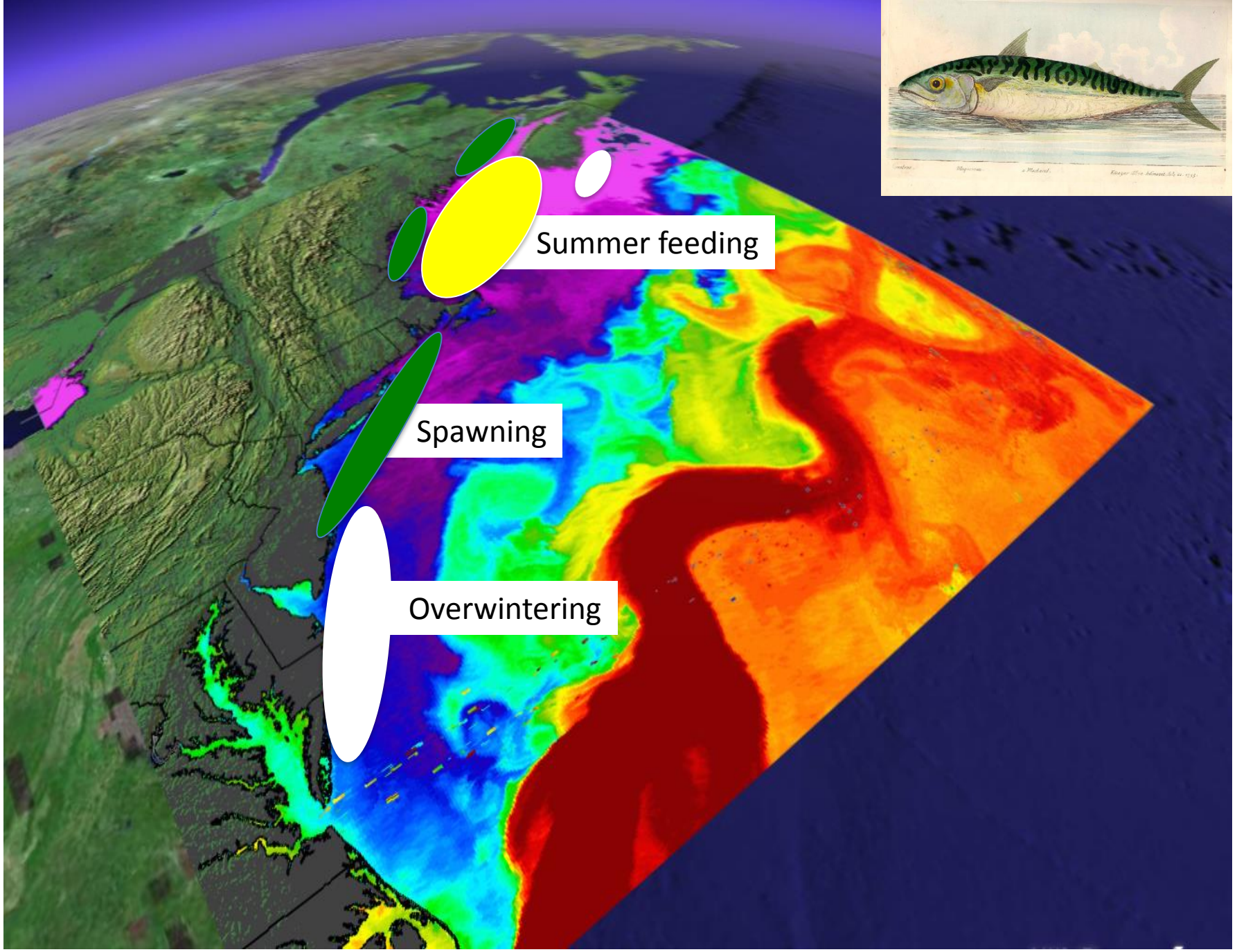


Outline

1) The changing physical setting

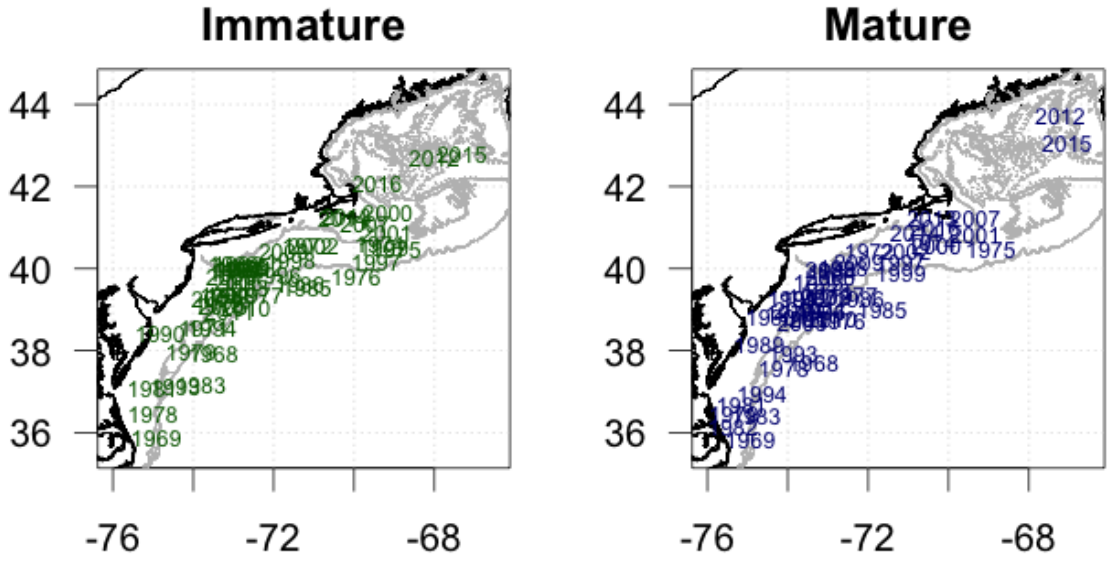
2) The problem of attribution.
   What are the underlying mechanisms of Climate-population/ecosystem impacts

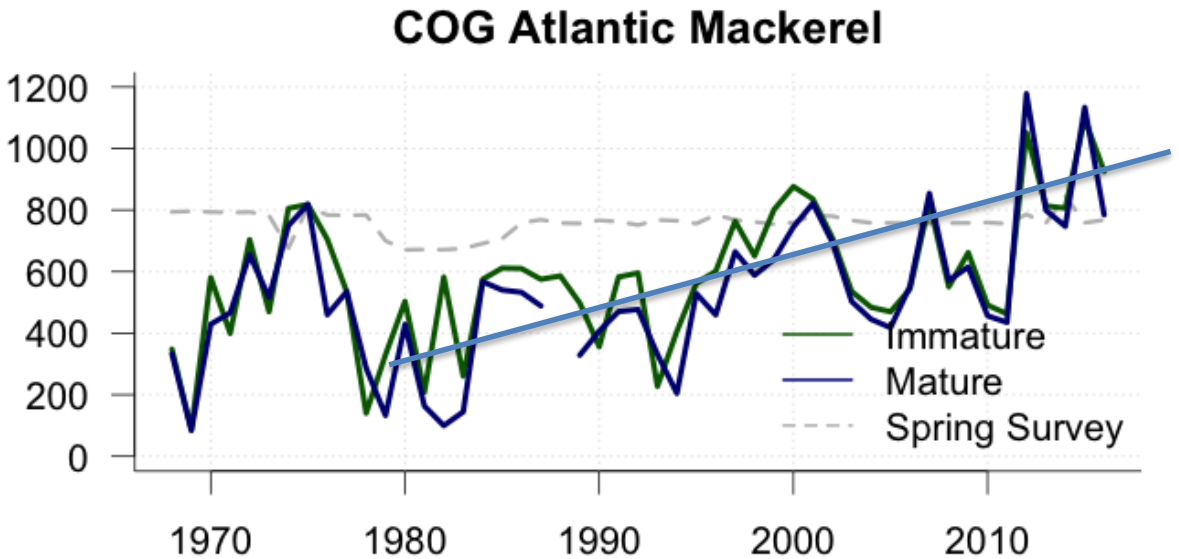
3) A collaborative exploration of possible causes of NW Atlantic Mackerel distribution shifts.


Summer feeding
Spawning
Overwintering

Atlantic Mackerel distribution shifts in spring NEFSC bottom trawl survey

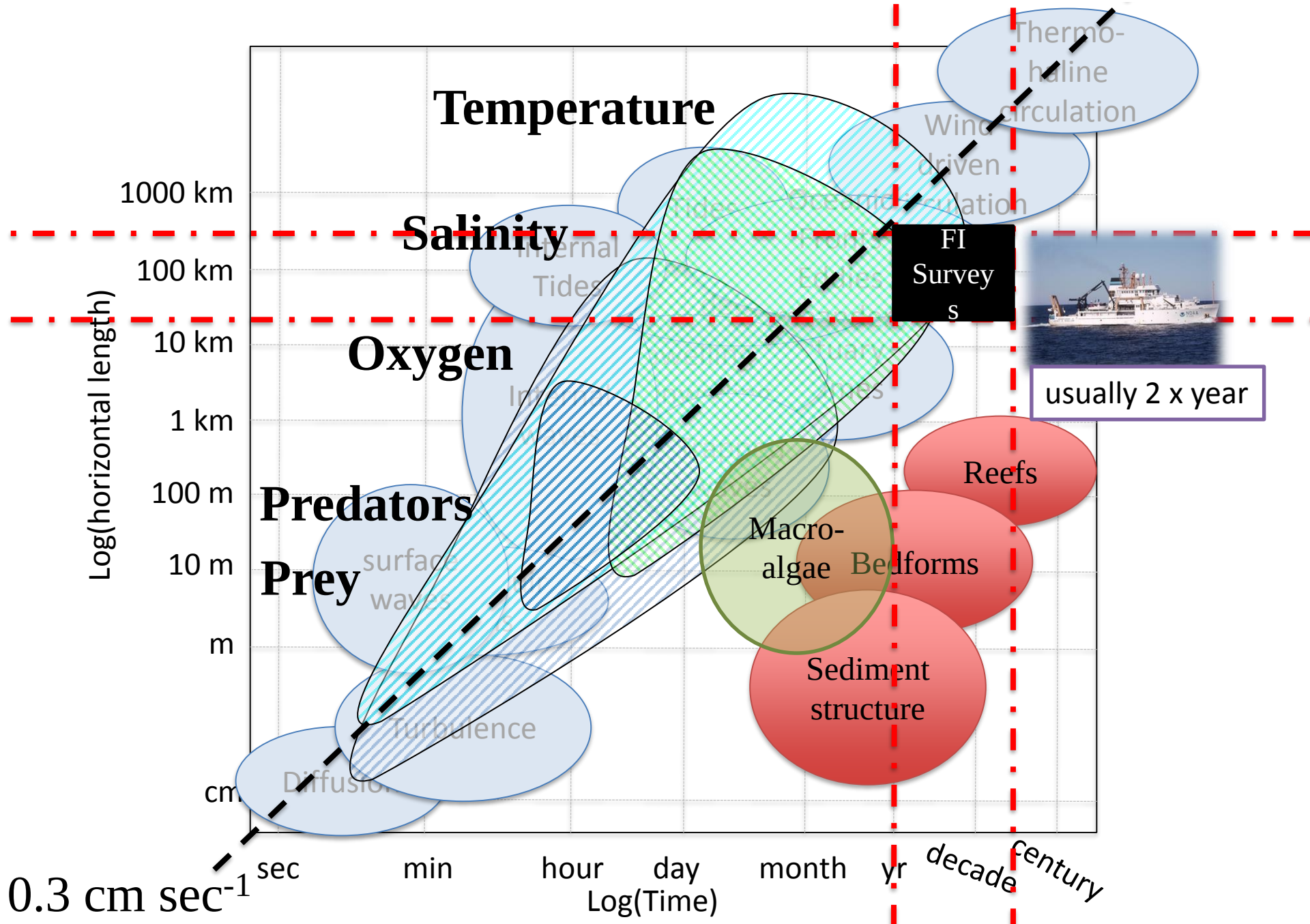
(mid March-mid May)





~15 km yr^{-1}
(8 NM)

What can we sample using tradition data sources?

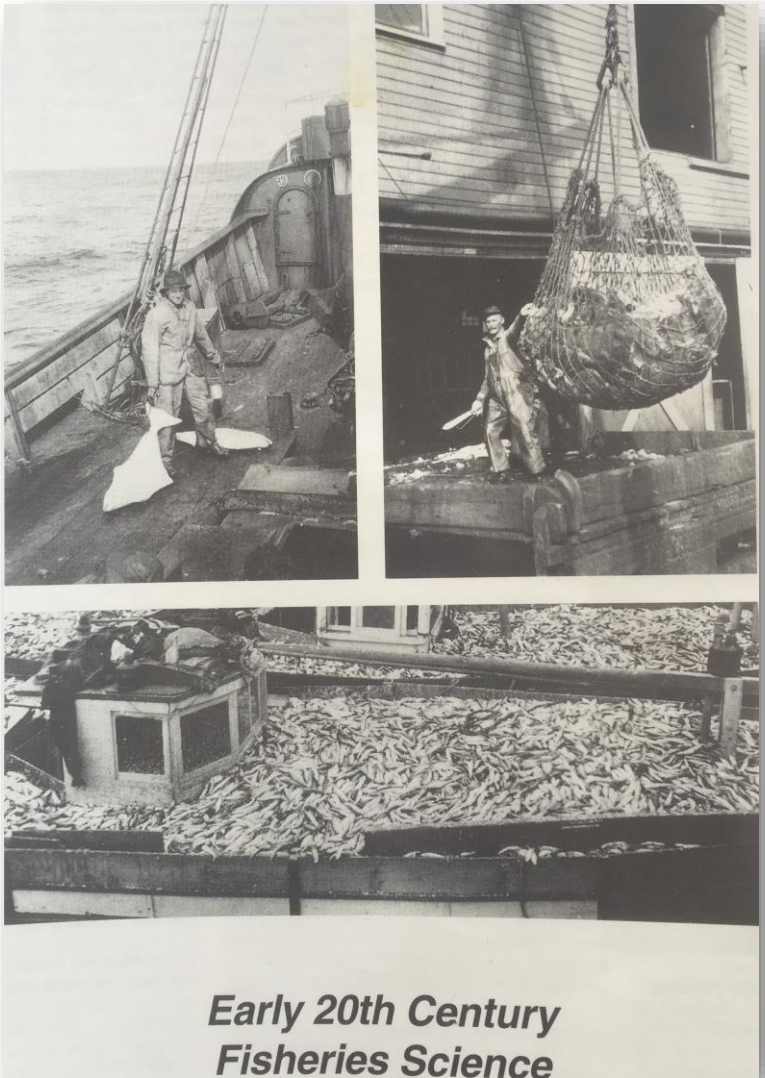


Method: Do mensurative study of fish & fishery by embedding continuous collaborative research within active fishery

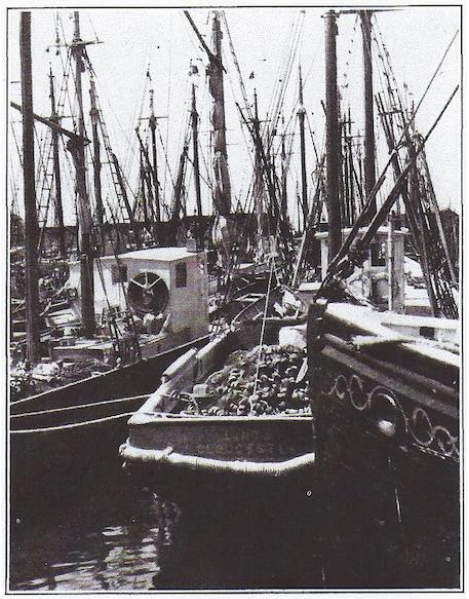
Fisheries science used to be done this way!

Johan Hjort

O Elton Sette



Atlantic Mackerel landings US waters

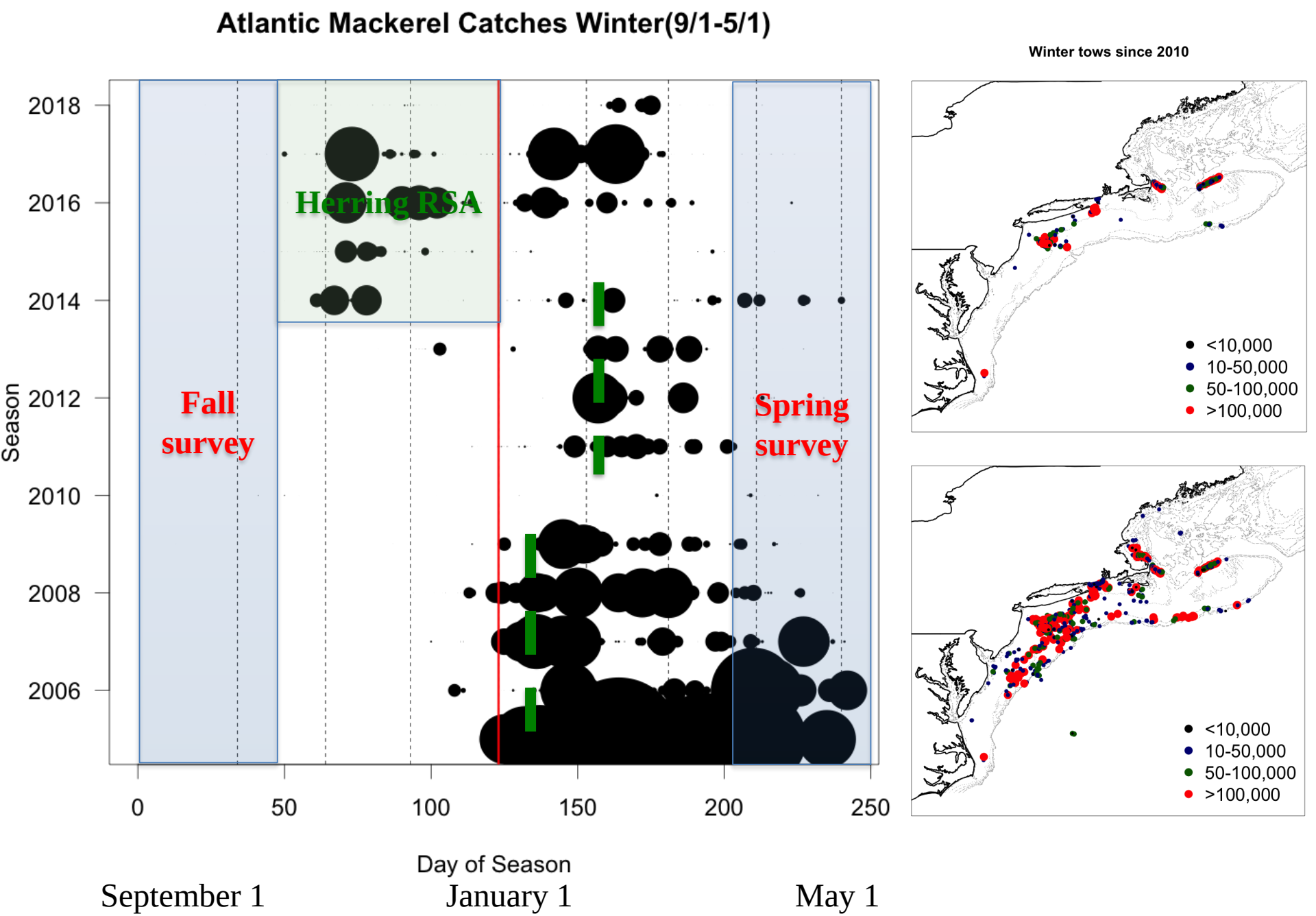


Gloucester Fishing Fleet at Cape May, New Jersey.

1816 Year without a summer

The Great Heat

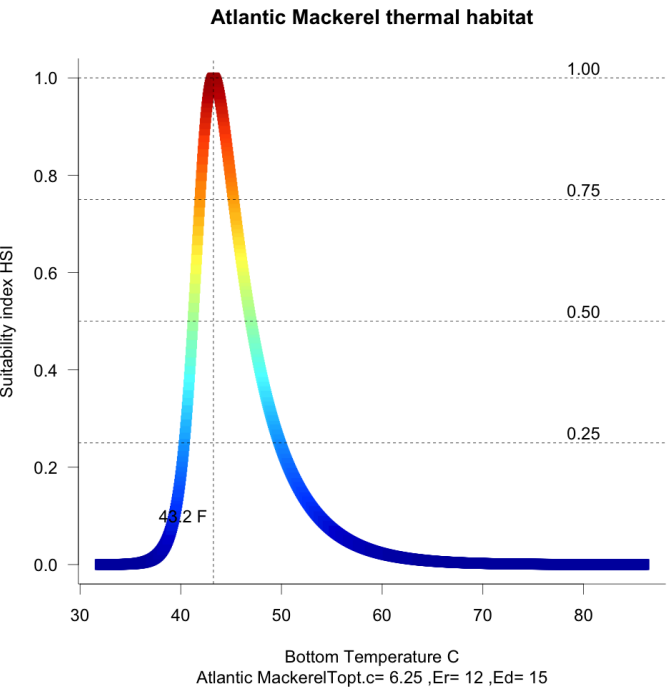
Soviet invasion Magnuson-Stevens

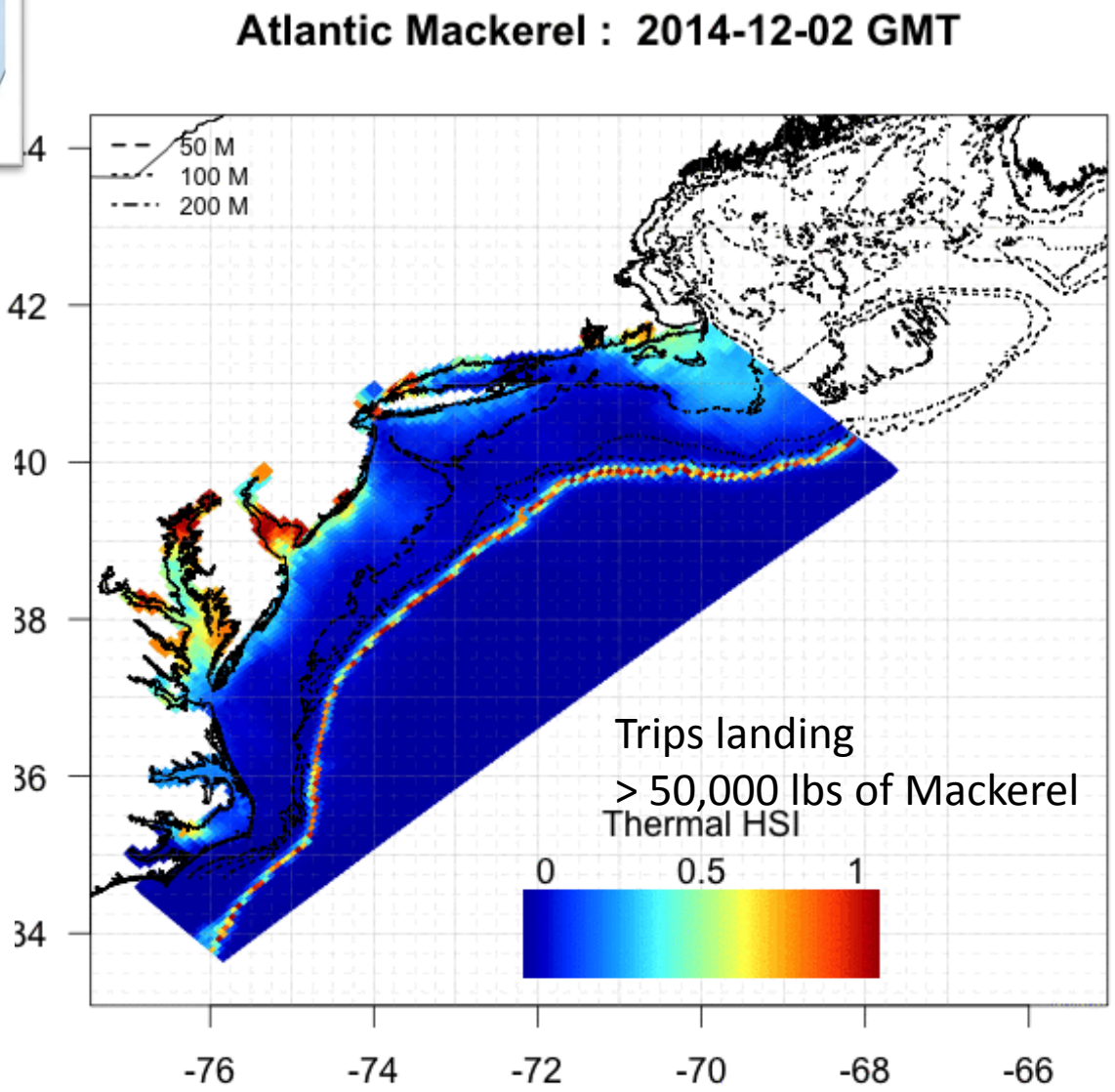


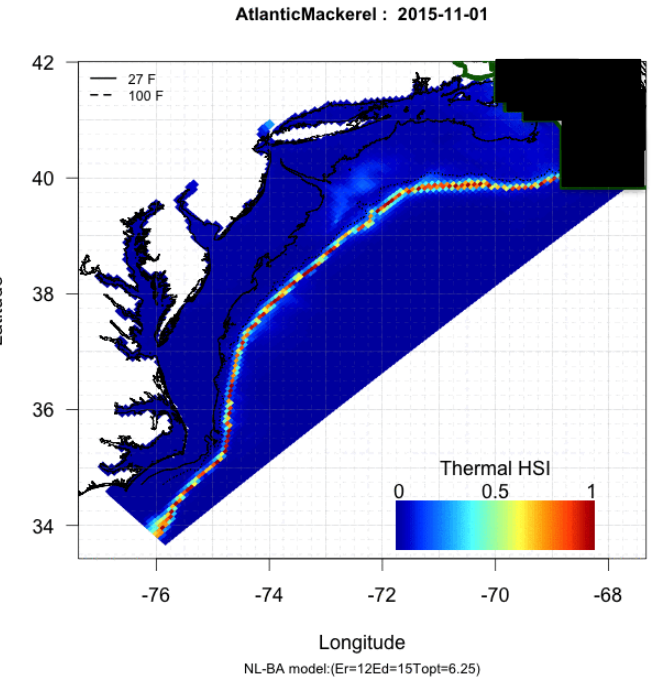
Hypothesis: Warm winters are delaying migration that is not extending as far Southwest

Develop winter habitat model with fishery project it to validate it

NORTHEAST FISHERIES SCIENCE CENTER
STUDY FLEET





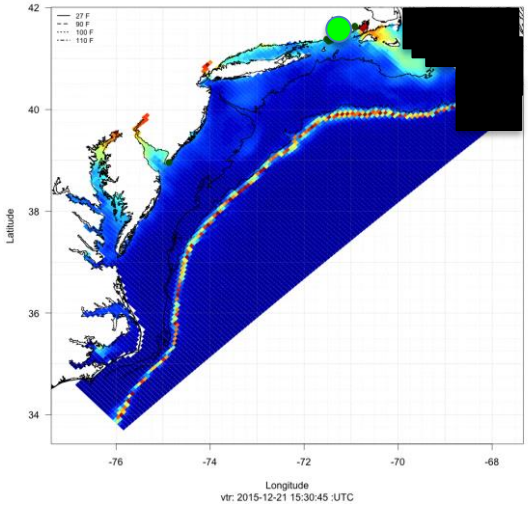


NORTHEAST FISHERIES SCIENCE CENTER

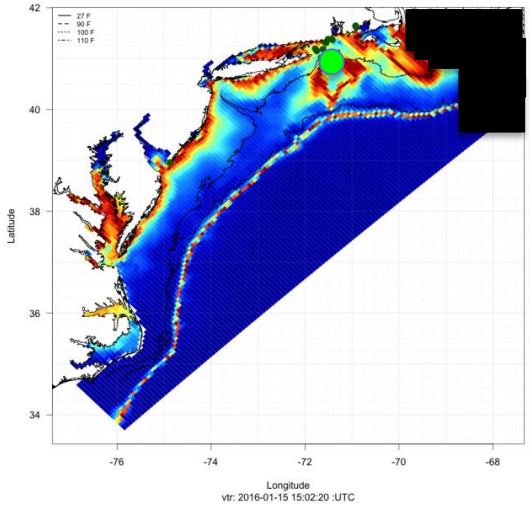
STUDY FLEET

Haddock closure in the herring fishery. (Large mackerel boats are herring boats & the fish form mixed schools)

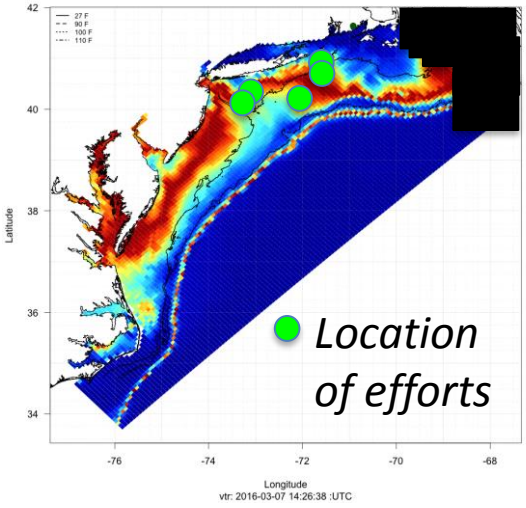
Dec 21, 2015



Jan 15, 2016

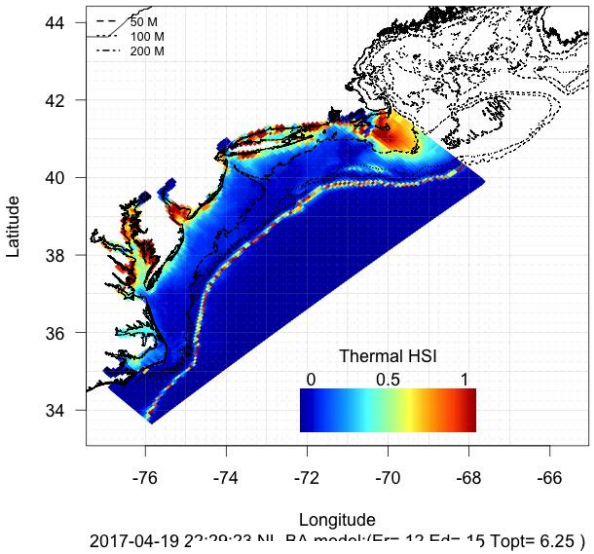


Feb 7, 2016

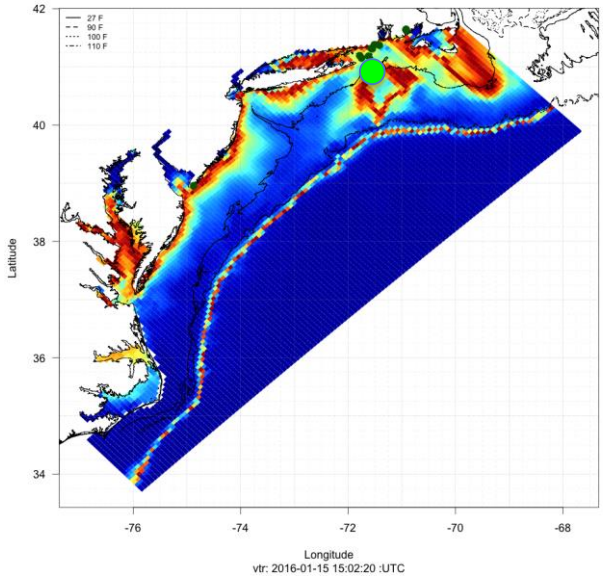


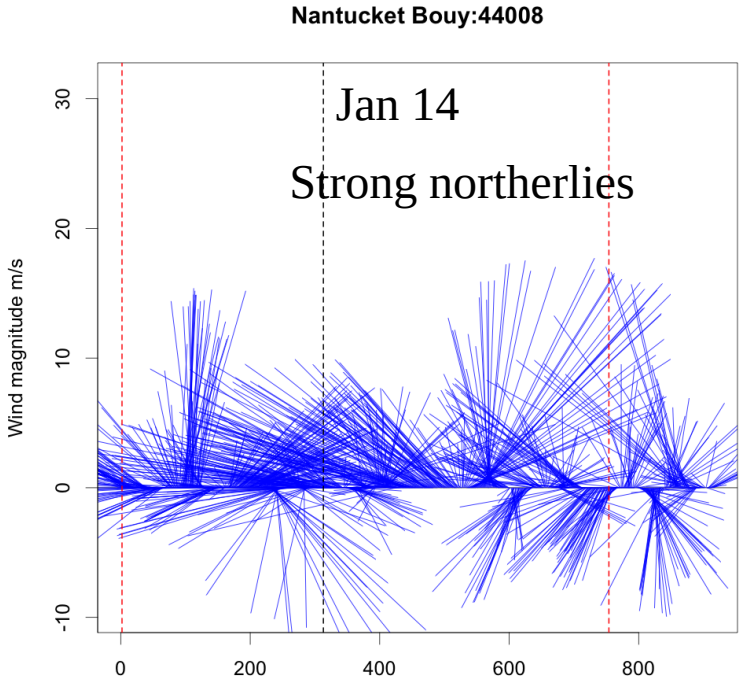
Example: Formation of thermal bridge
From GOM to Southern New England shelf

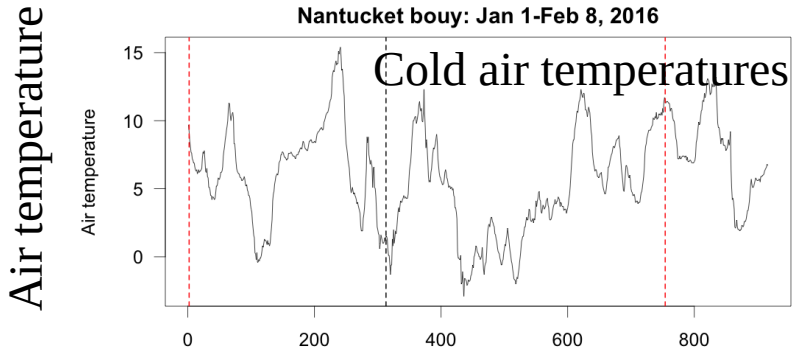
A Jan 8, 2016 T

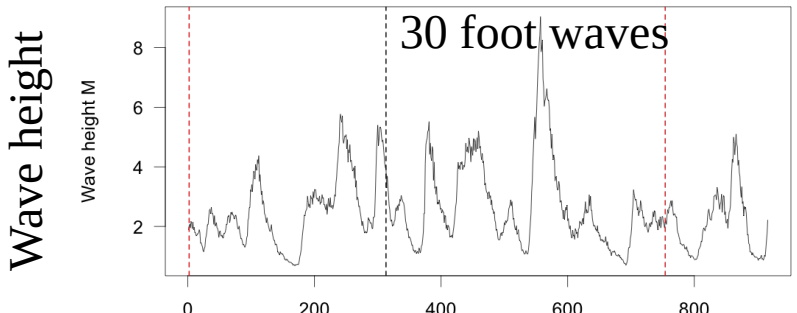


Jan 15, 2016

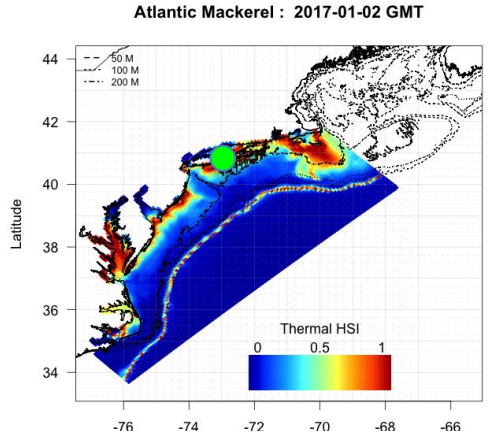




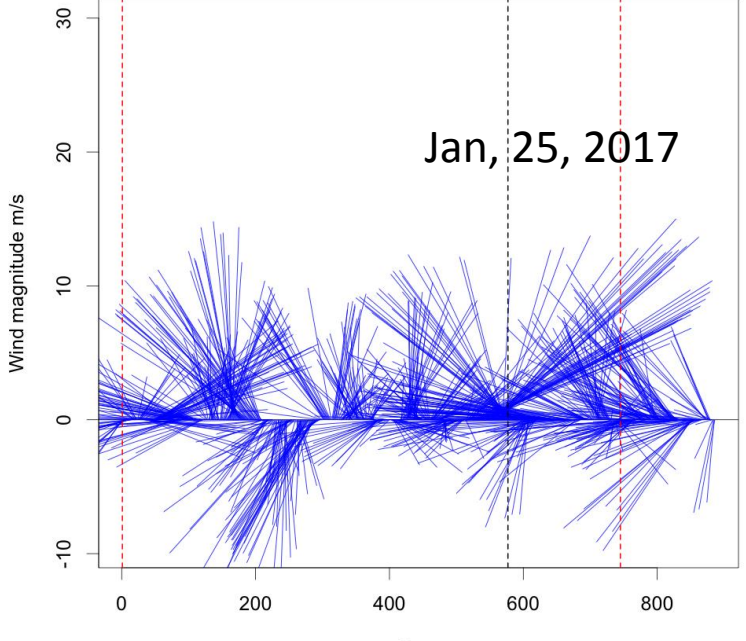


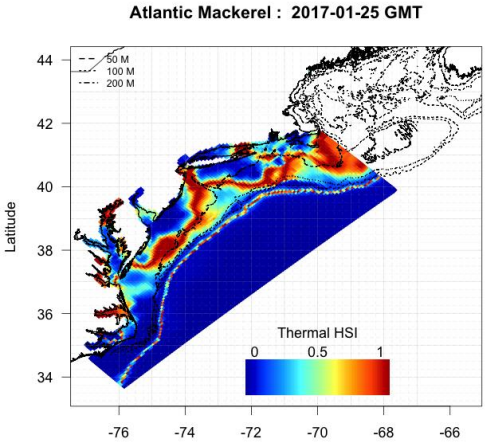


Example: Formation of thermal bridge across Hudson shelf valley

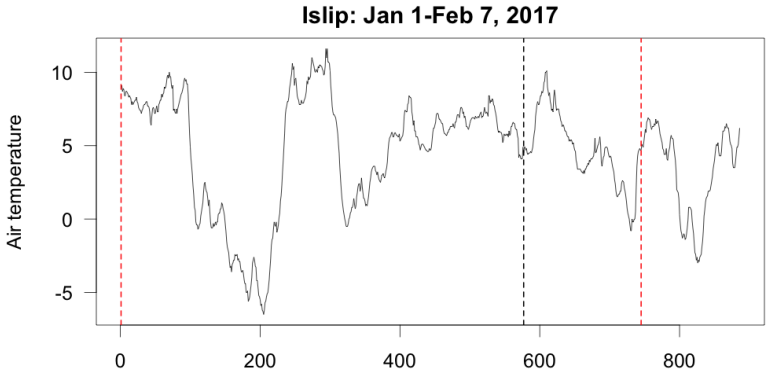


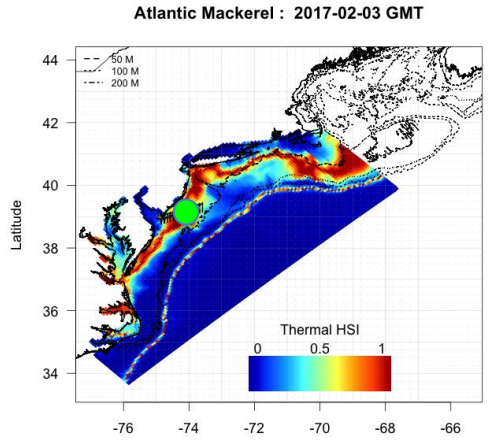
Early January



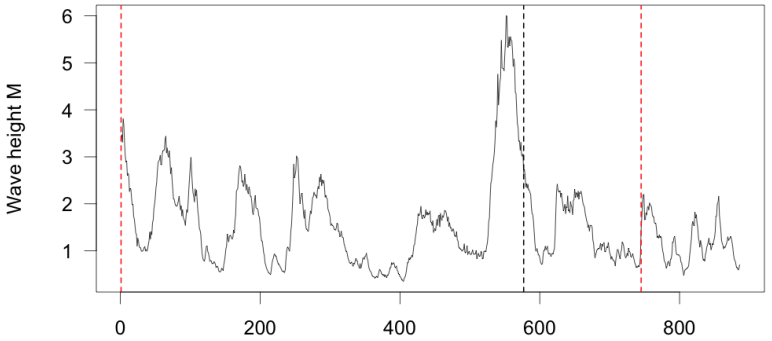


Ocean response from Storm Jan 24-25

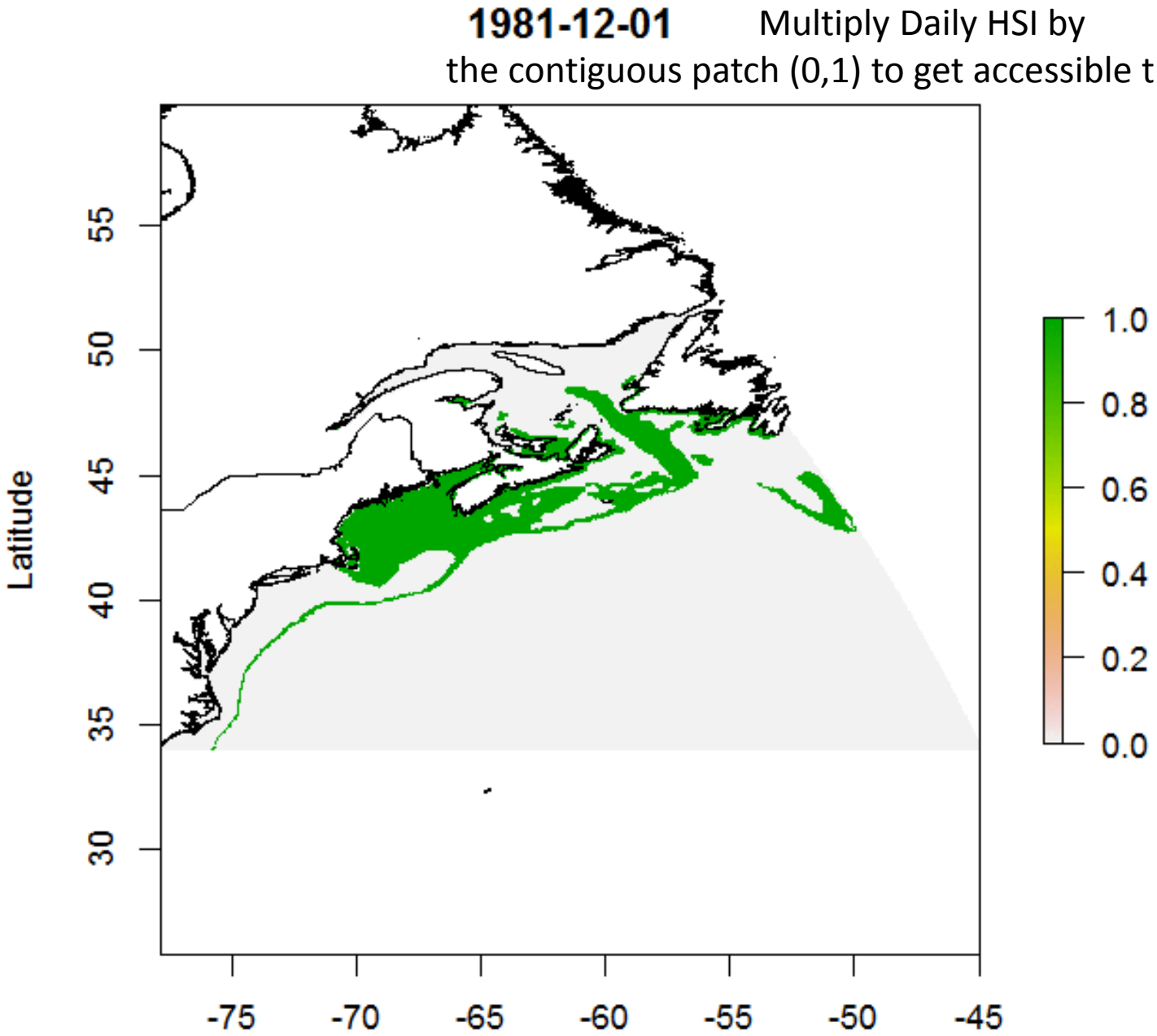




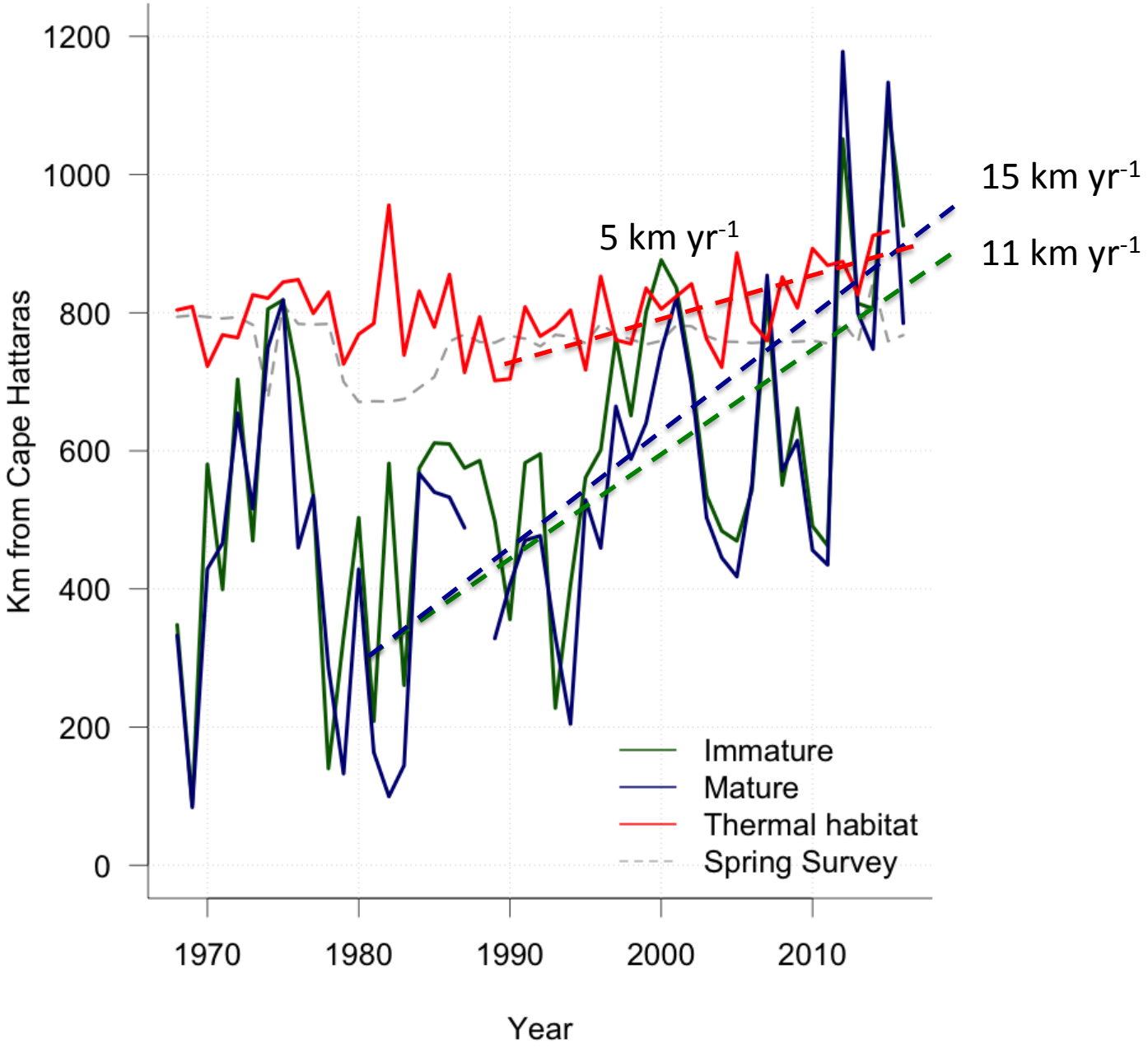
Catches south of Hudson early February



Explicitly incorporate connectivity into a habitat hindcast



Cool! But does it explain the distribution shift?



Fishery ecological knowledge of mackerel migration

Before 1990

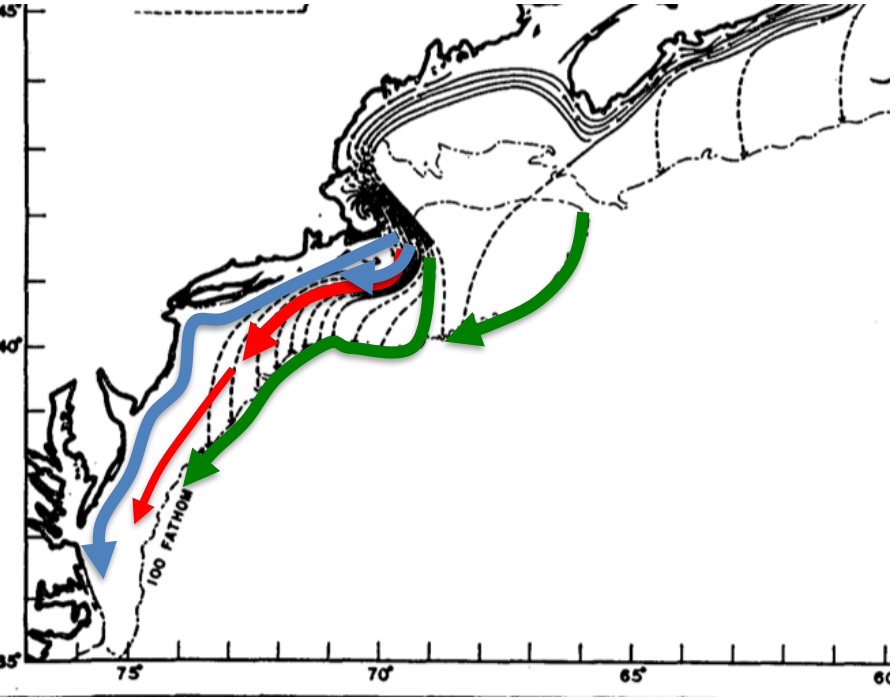
Fall

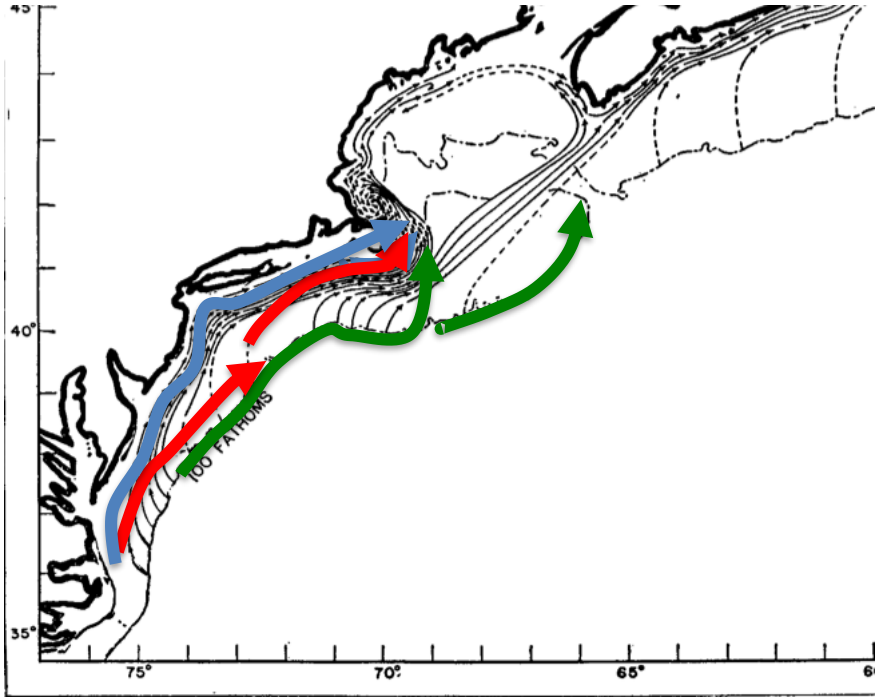
Spring

Inshore run of large fish (Nov-Dec)

Midshelf run of small & medium fish (Jan)

Shelf break run





Axelson et al. 2017 SAW/SARC working paper

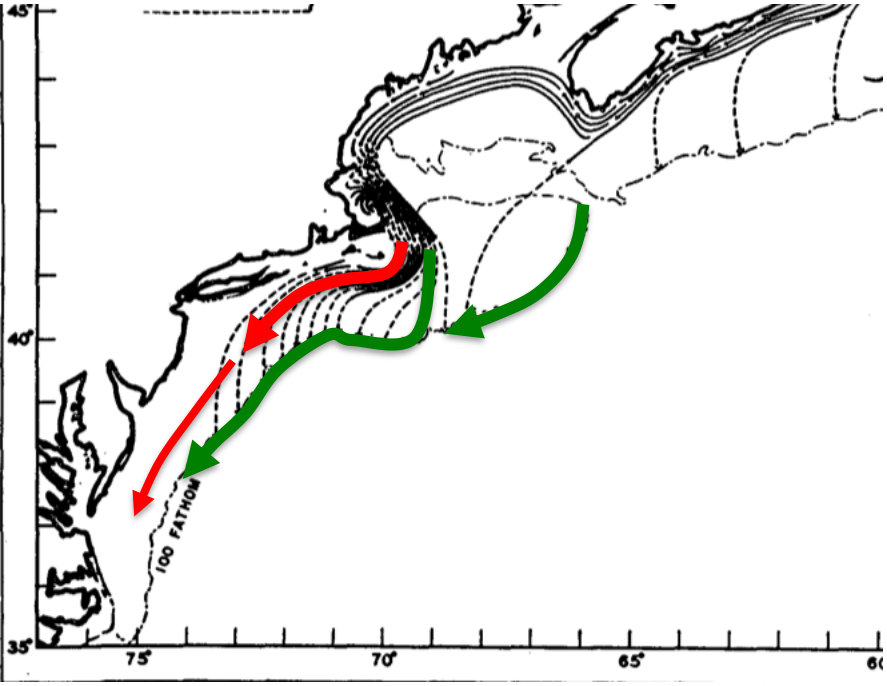
Fishery ecological knowledge of mackerel migration

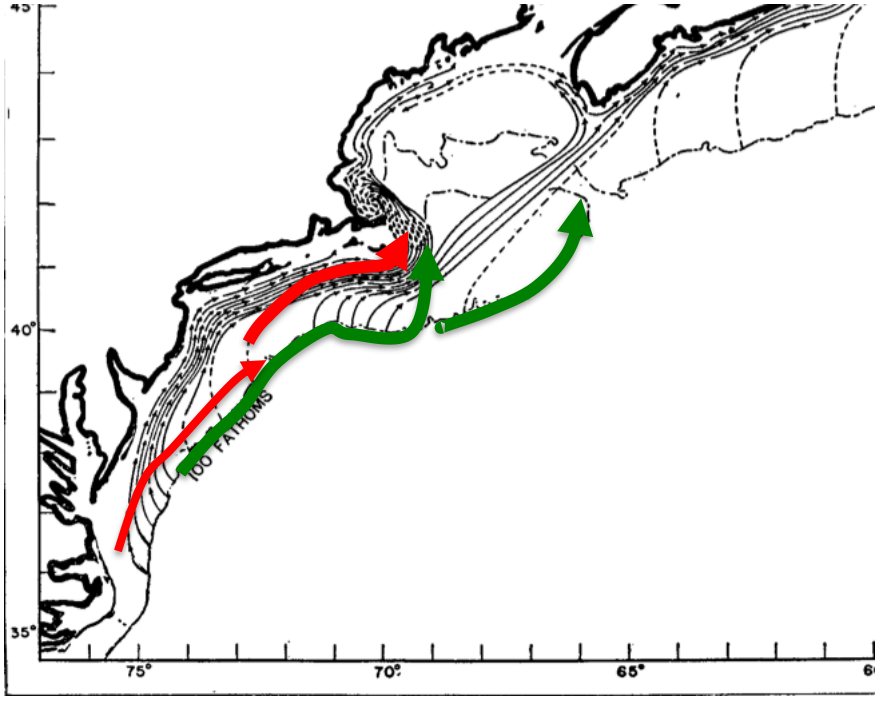
By 2000

Fall

Spring

Inshore run of large fish (Nov-Dec)
Midshelf run of small & medium fish (Jan)
Shelf break run





Axelson et al. 2017 SAW/SARC working paper

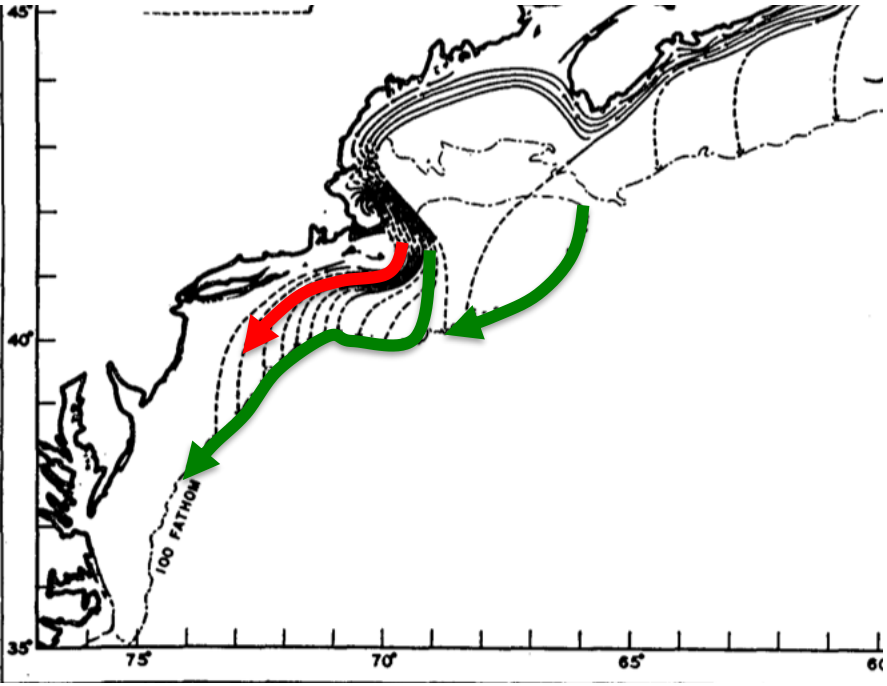
Fishery ecological knowledge of mackerel migration

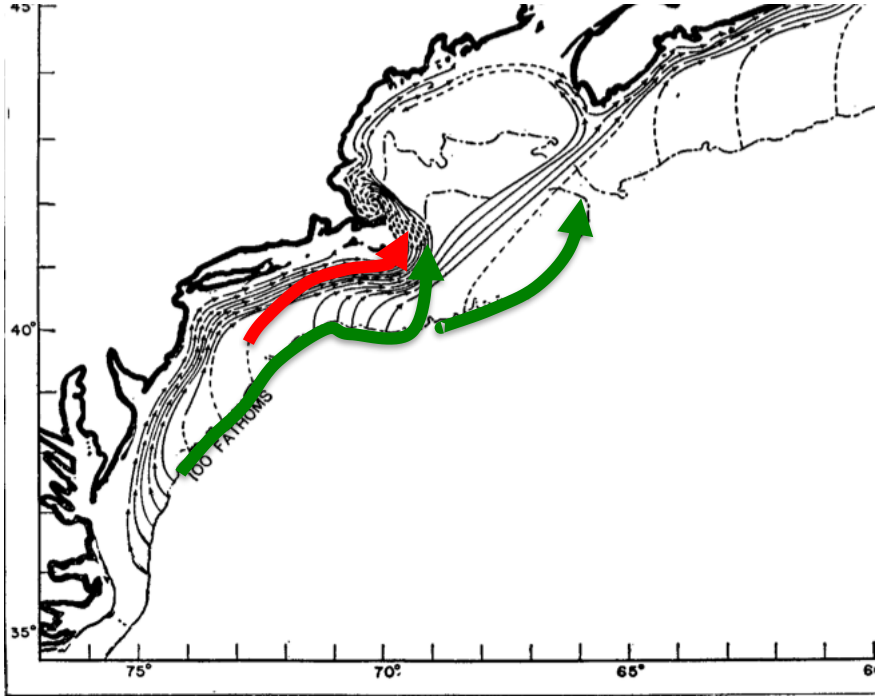
Fall

Since 2000

Spring

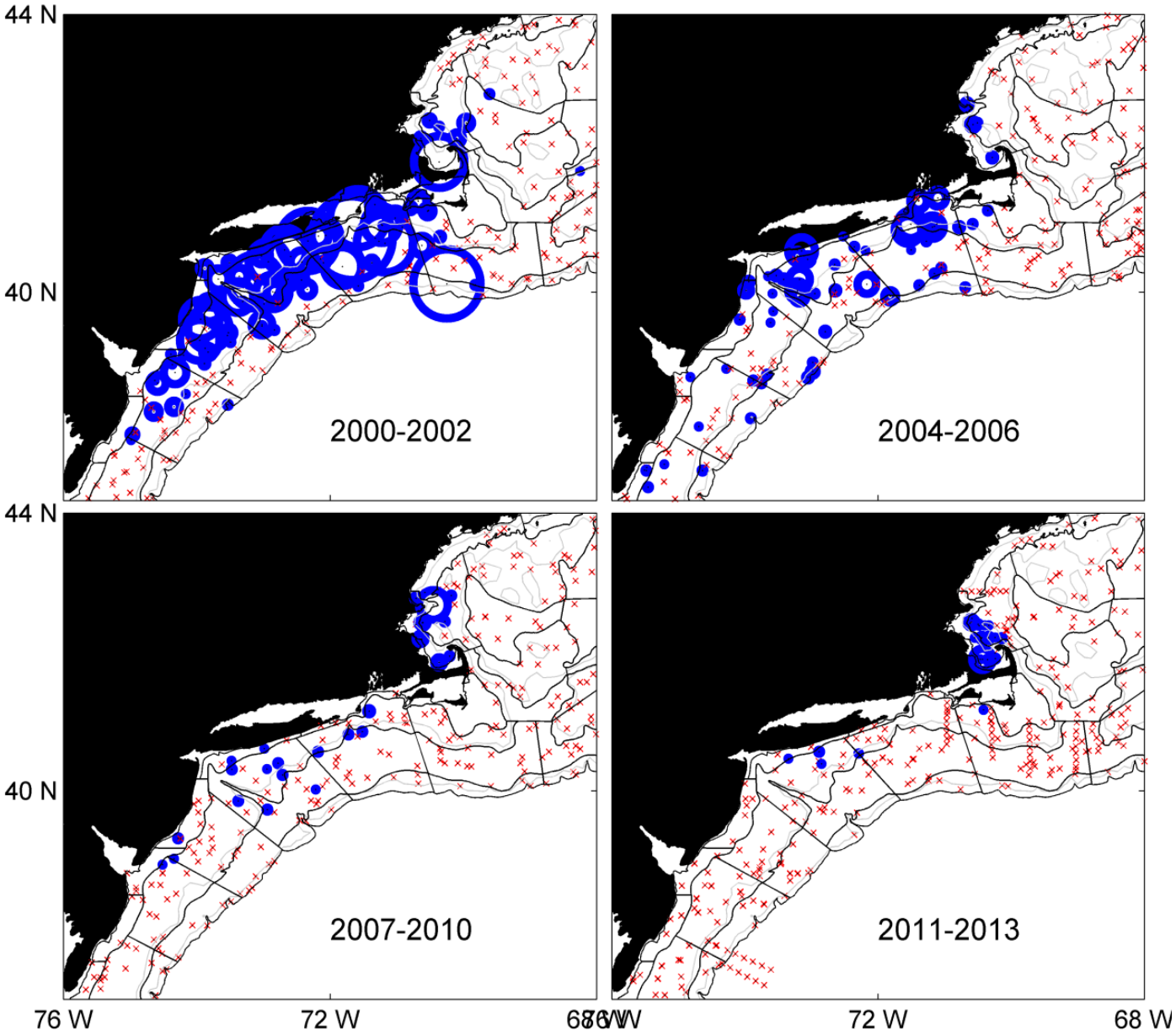
Inshore run of large fish (Nov-Dec)
Midshelf run of small & medium fish (Jan)
Shelf break run





Axelson et al. 2017 SAW/SARC working paper

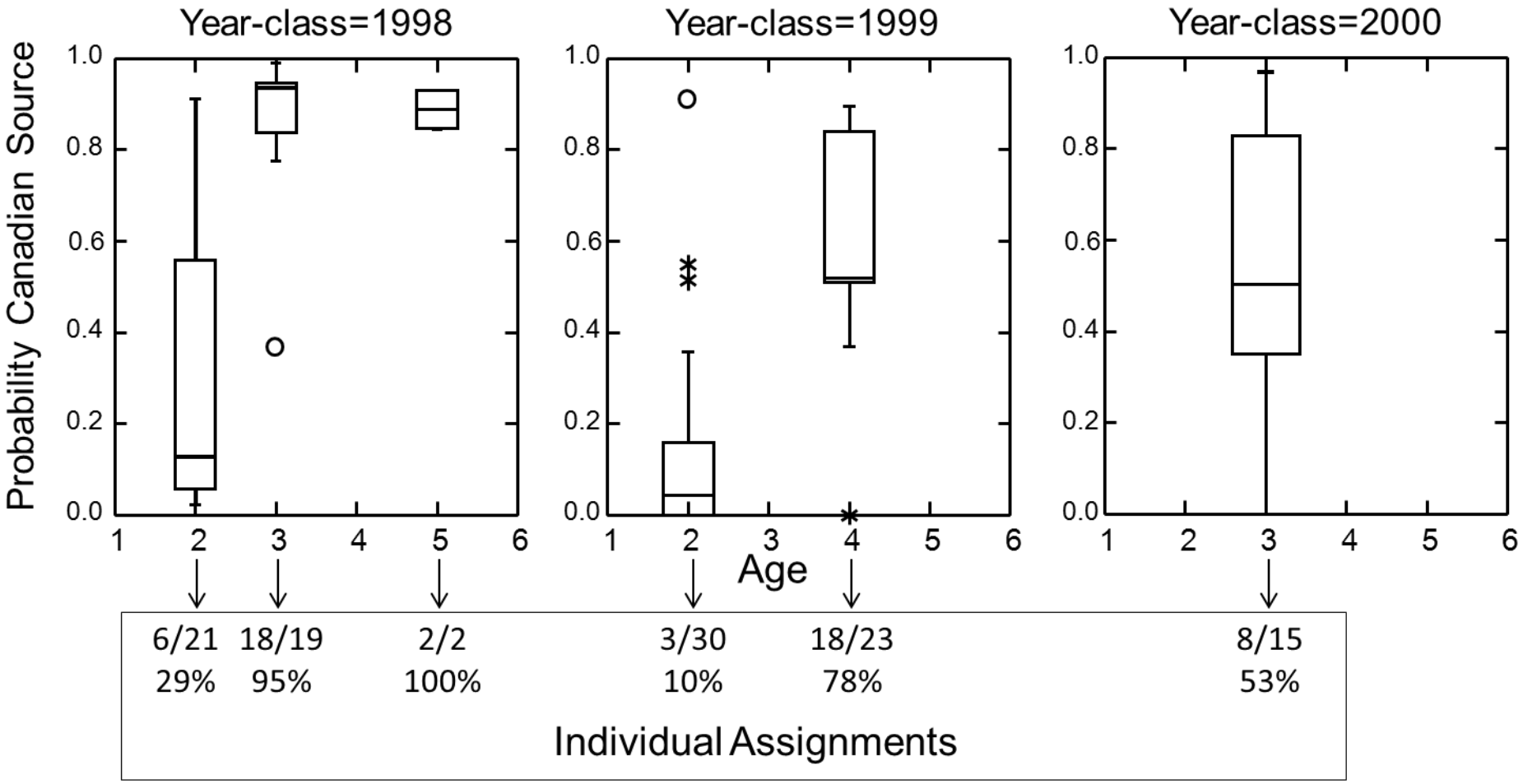
Larval densities & a spawning ground collapse?



Stock structure: otolith microchemistry, Secor et al.

Most older fish now come from Canadian spawning ground

The reverse was the case mid 20th century



Final slide

- There's never a magic bullet. There are multiple effects that are cumulative

- Marine population/ecosystem level studies very difficult. Systems are big complex and you have only 1 system. Mensurative experiments are tricky.

- "The past is not prologue". You need to understand mechanisms to understand the present and to forecast the future as novel conditions develop with changing climate.

- Non traditional sources of information become necessary when traditional information fails to describe the system at appropriate scales

Changes in fish distributions & productivity

Changes in fish distributions & productivity

Gear, space time frame of survey

$$O_{fi}|d_{fi} * (\text{true state}) * d_{fd}|O_{fd}$$

Markets, gear regulations

Restrictions to access