

# Climate velocity and implications for fisheries management

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Malin Pinsky & Jim Morley



Rich Seagraves

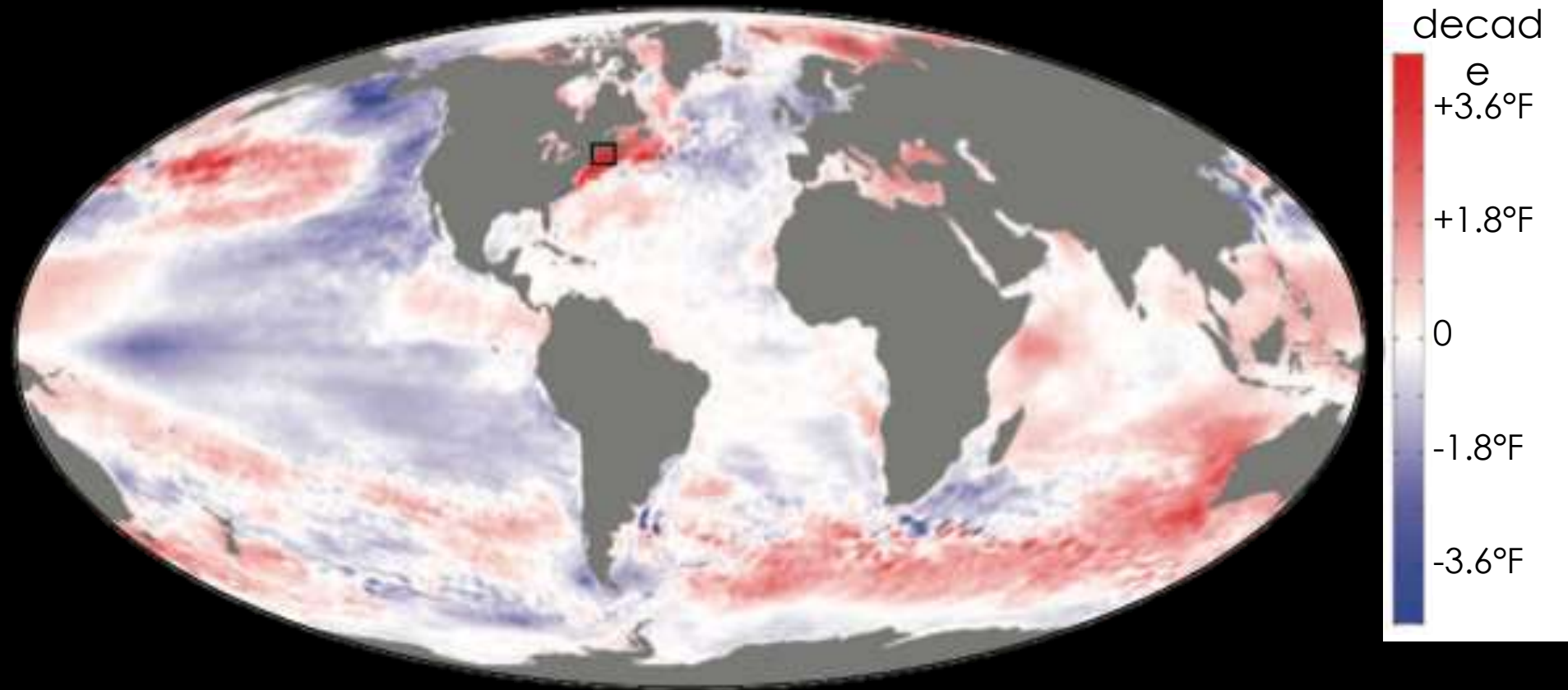


Lauren Rogers



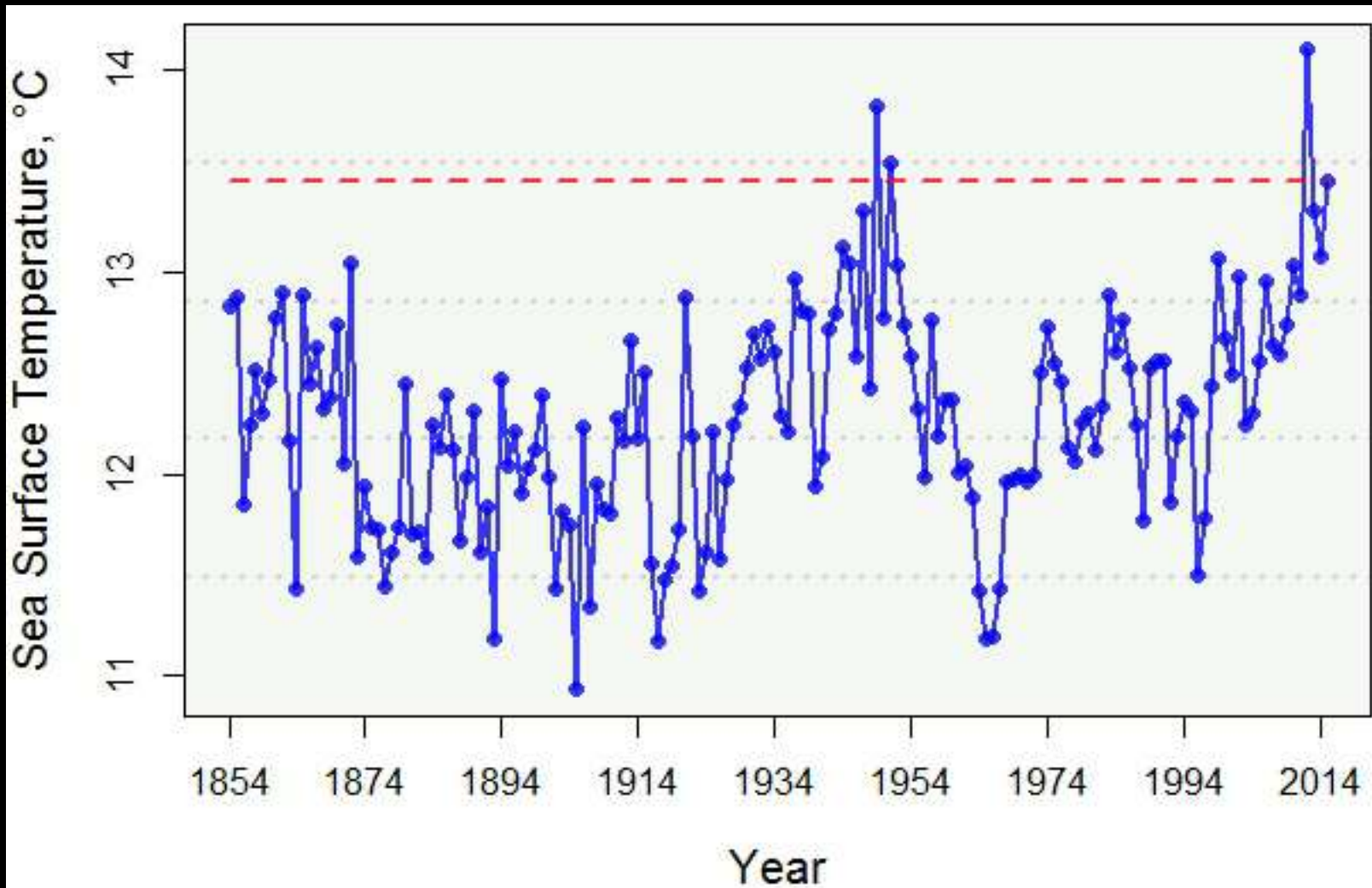
# Ocean hotspots 2004-2013

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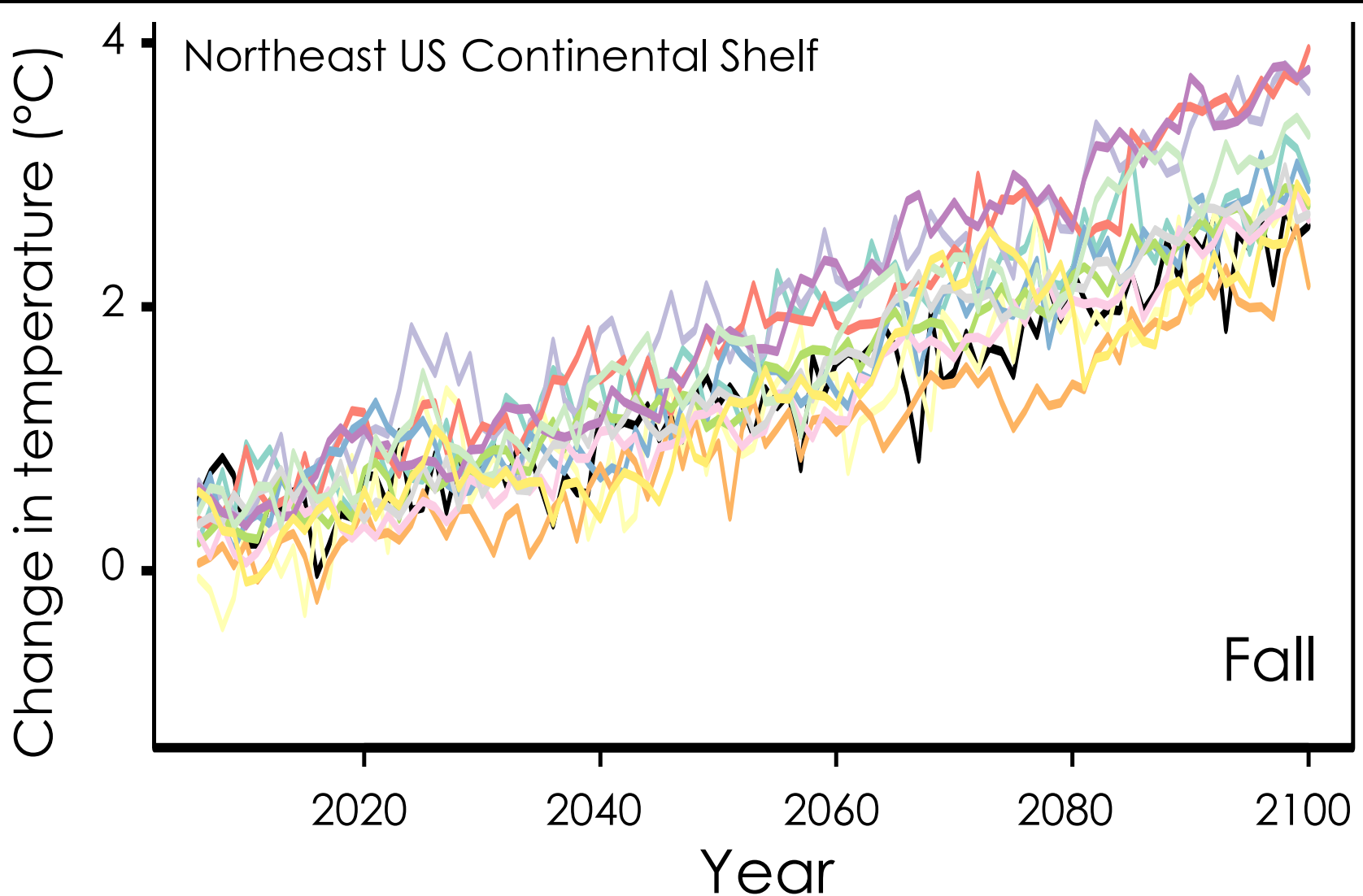


# Trends and variability

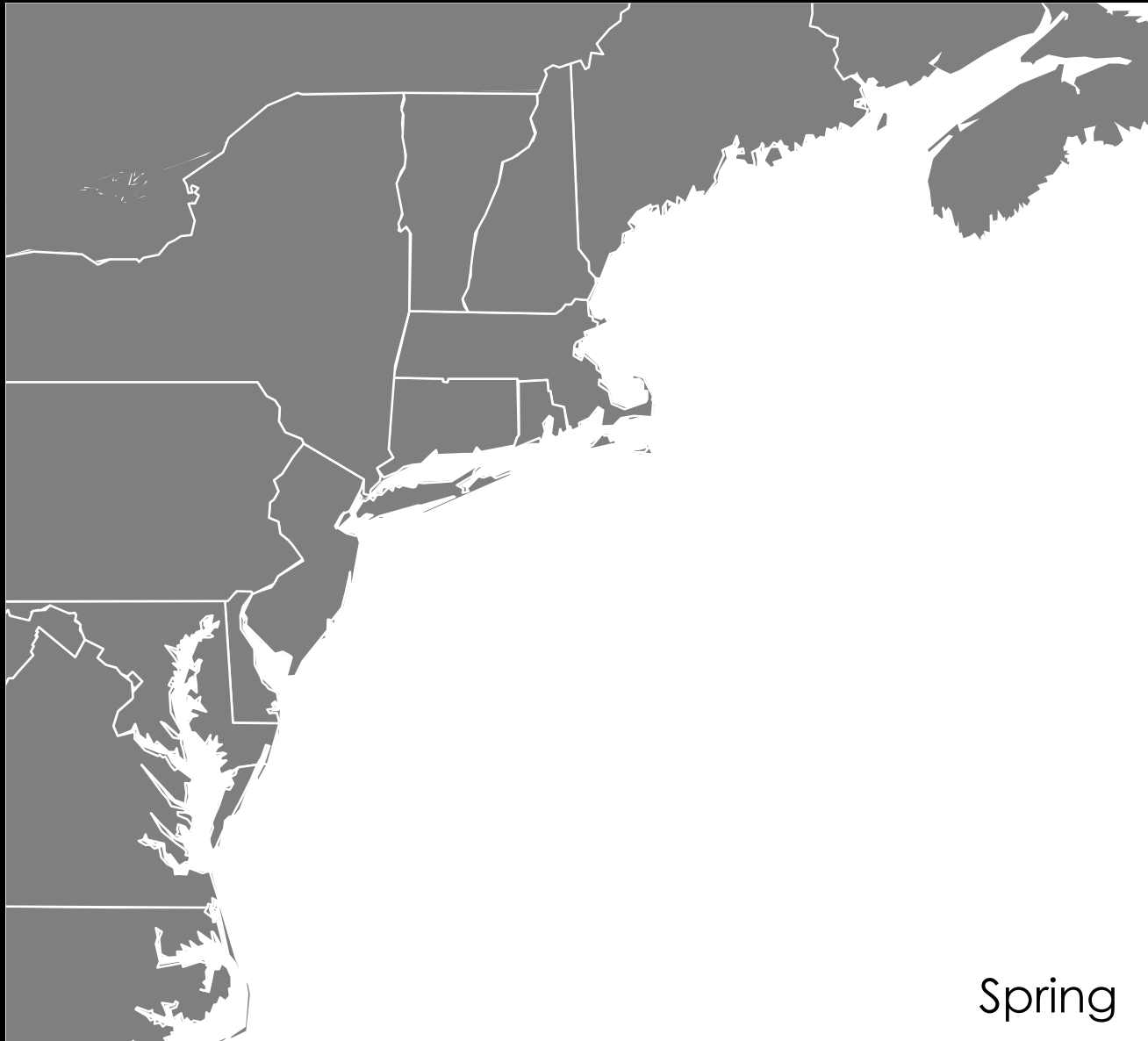
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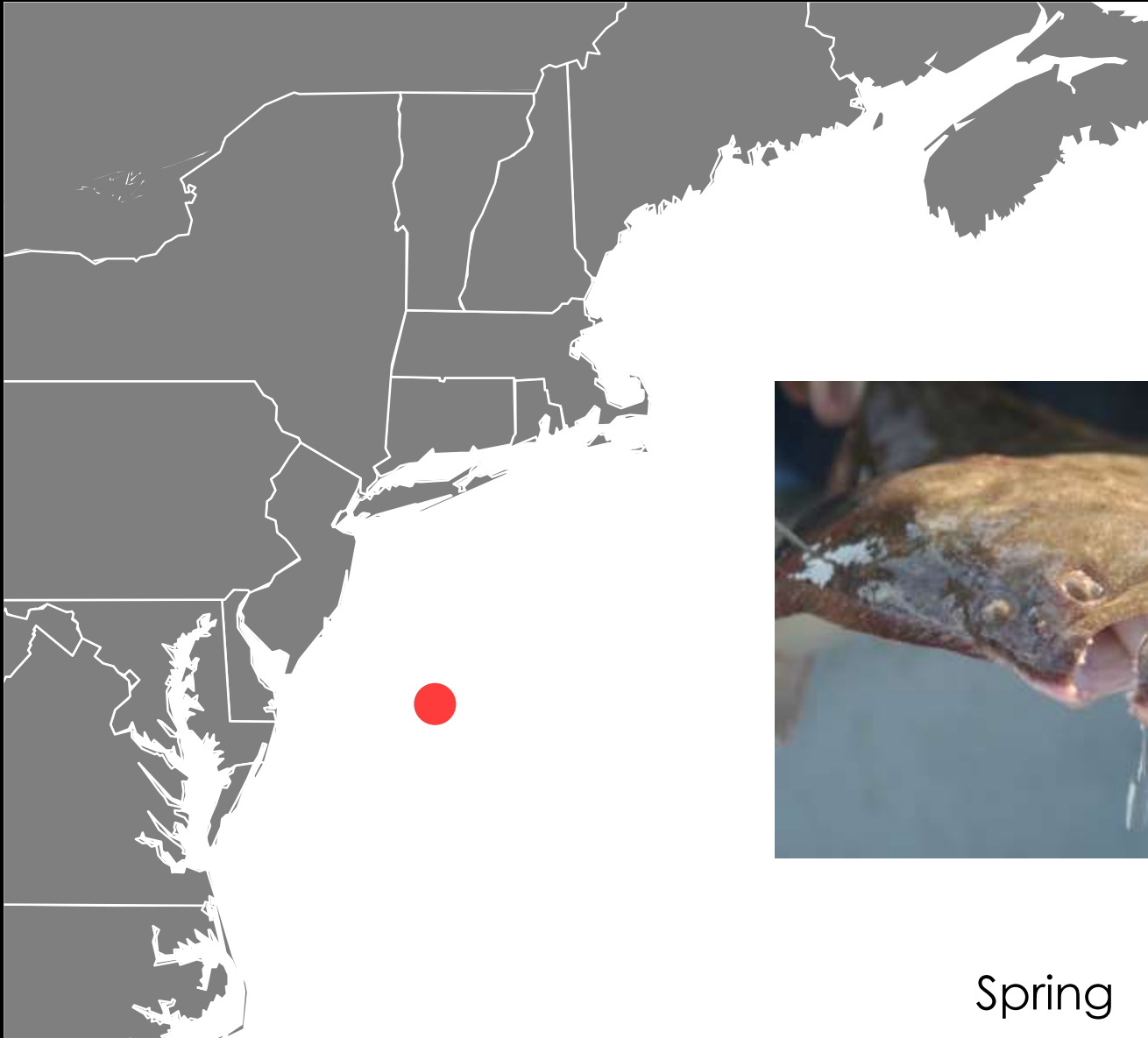
# Future warming (business as usual)



# Distribution shifts 1968-2008

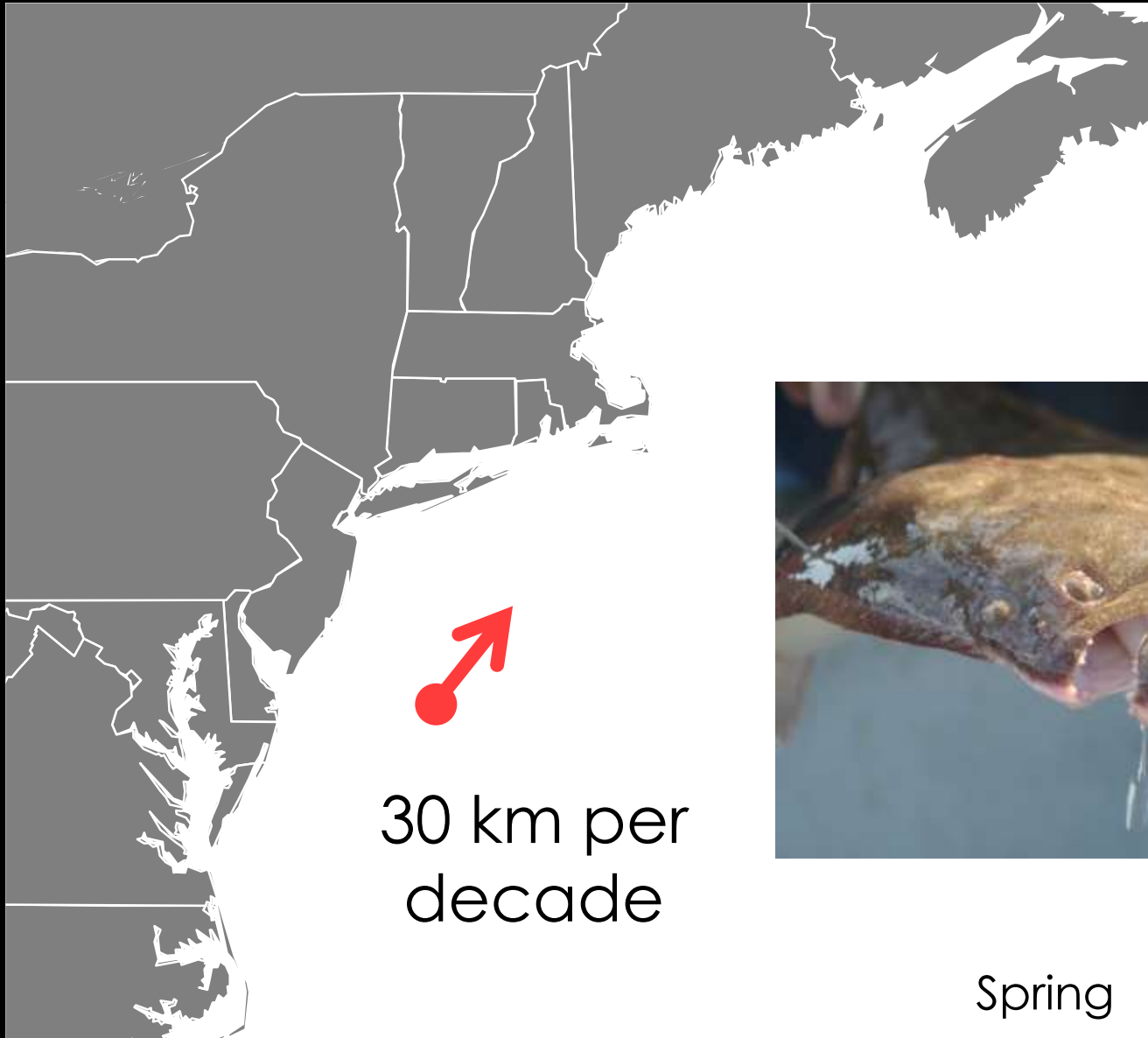


# Distribution shifts 1968-2008



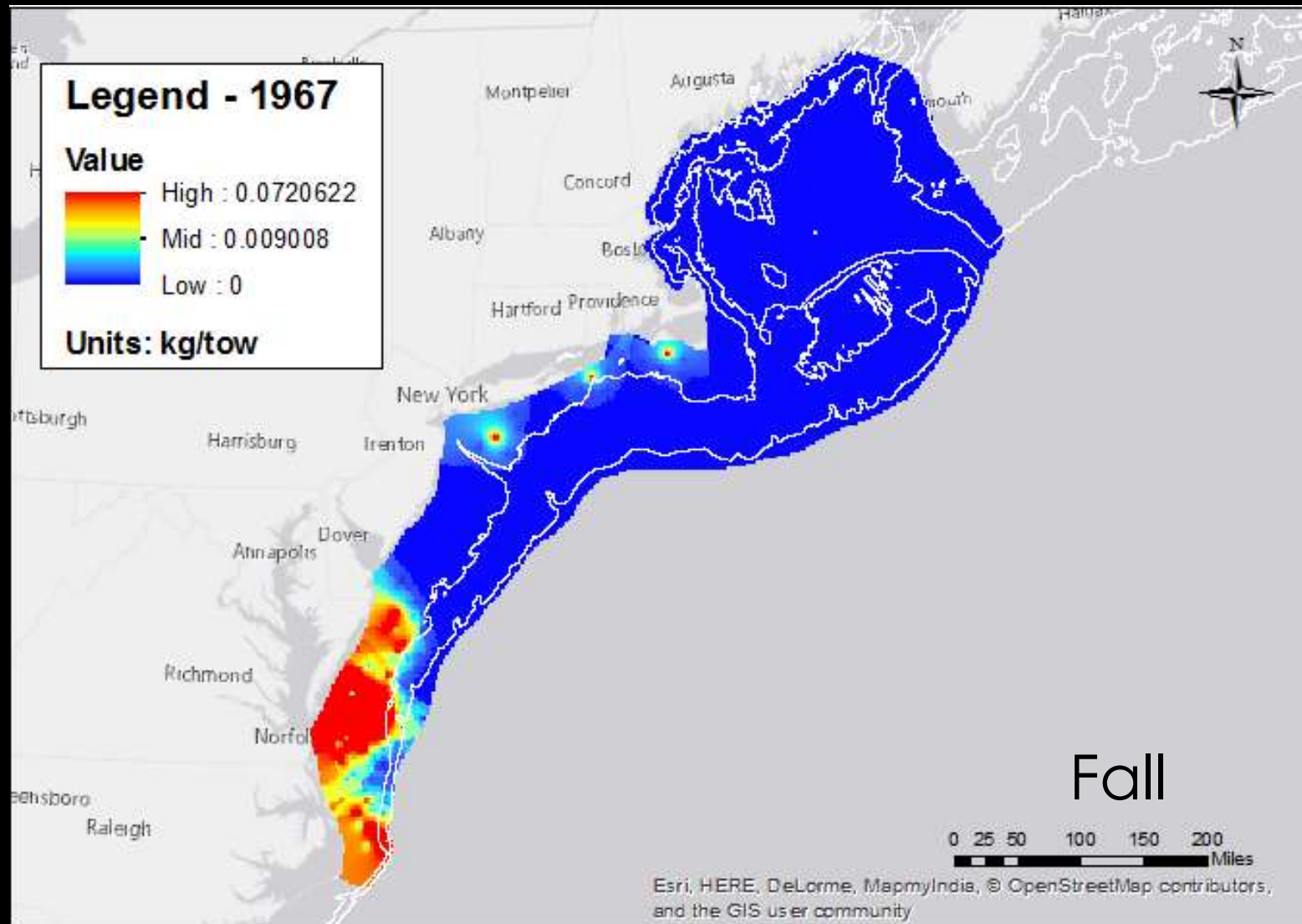
Spring

# Distribution shifts 1968-2008



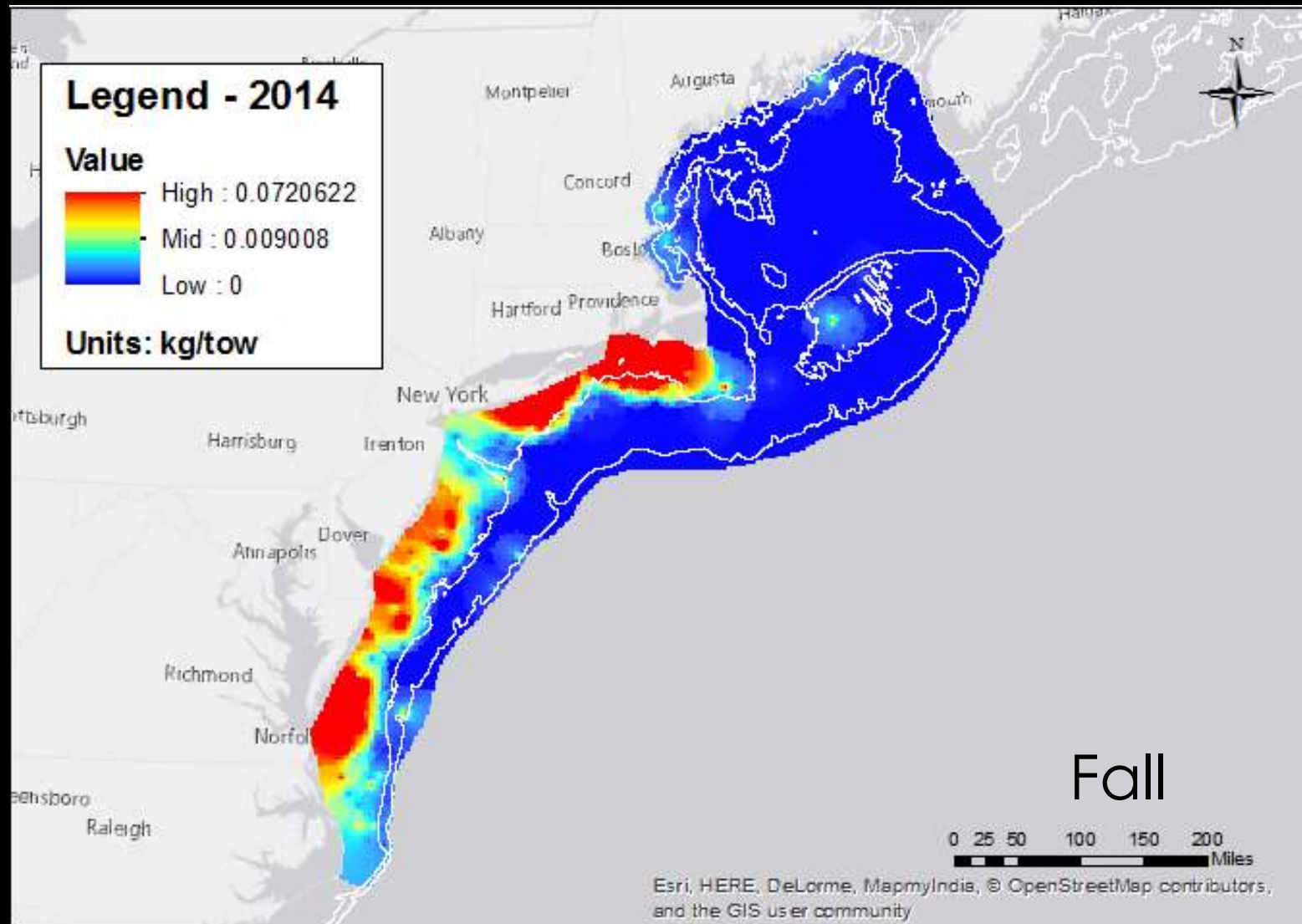


# Black sea bass: 1967

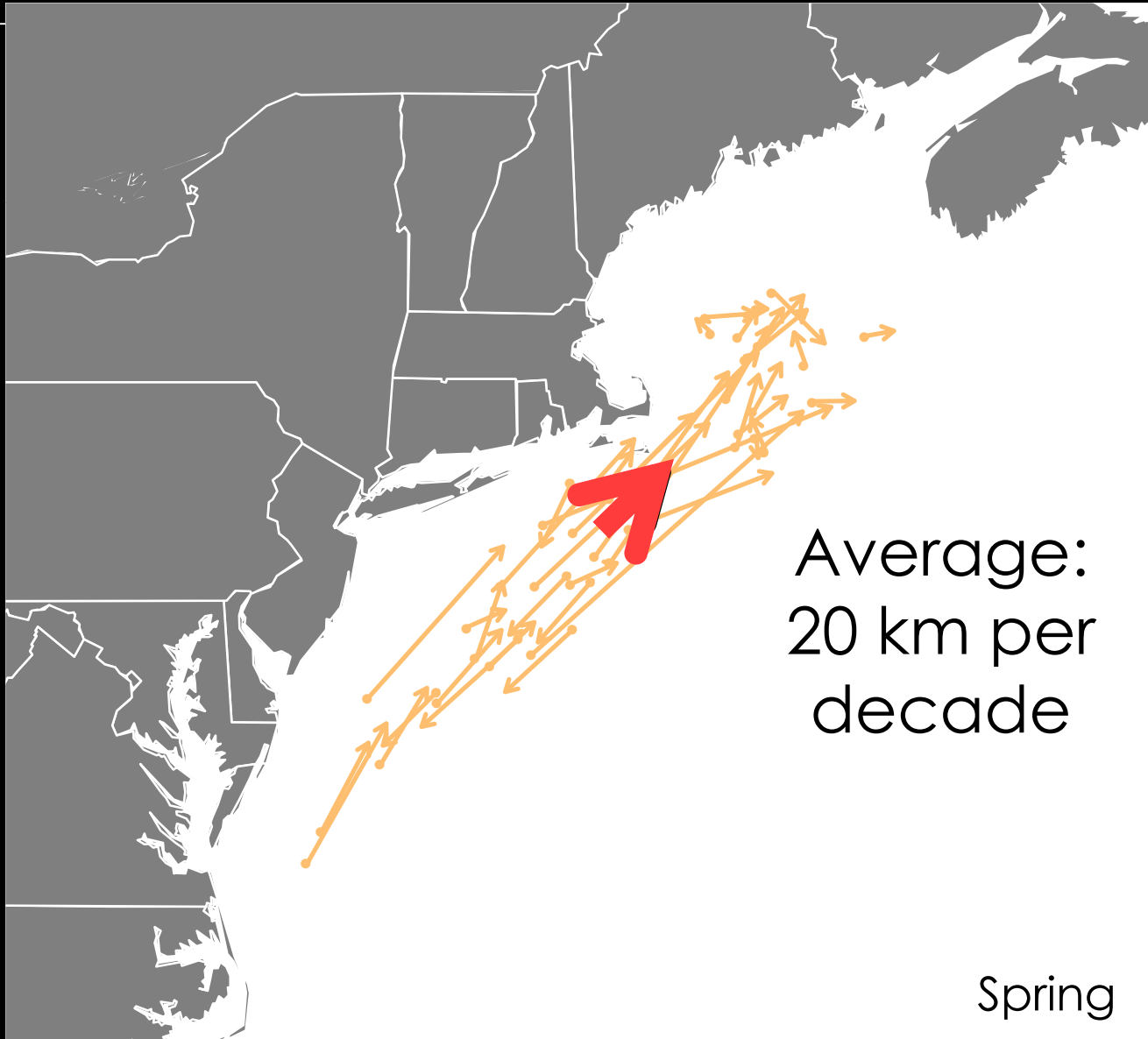




# Black sea bass: 2014



# Variation across species

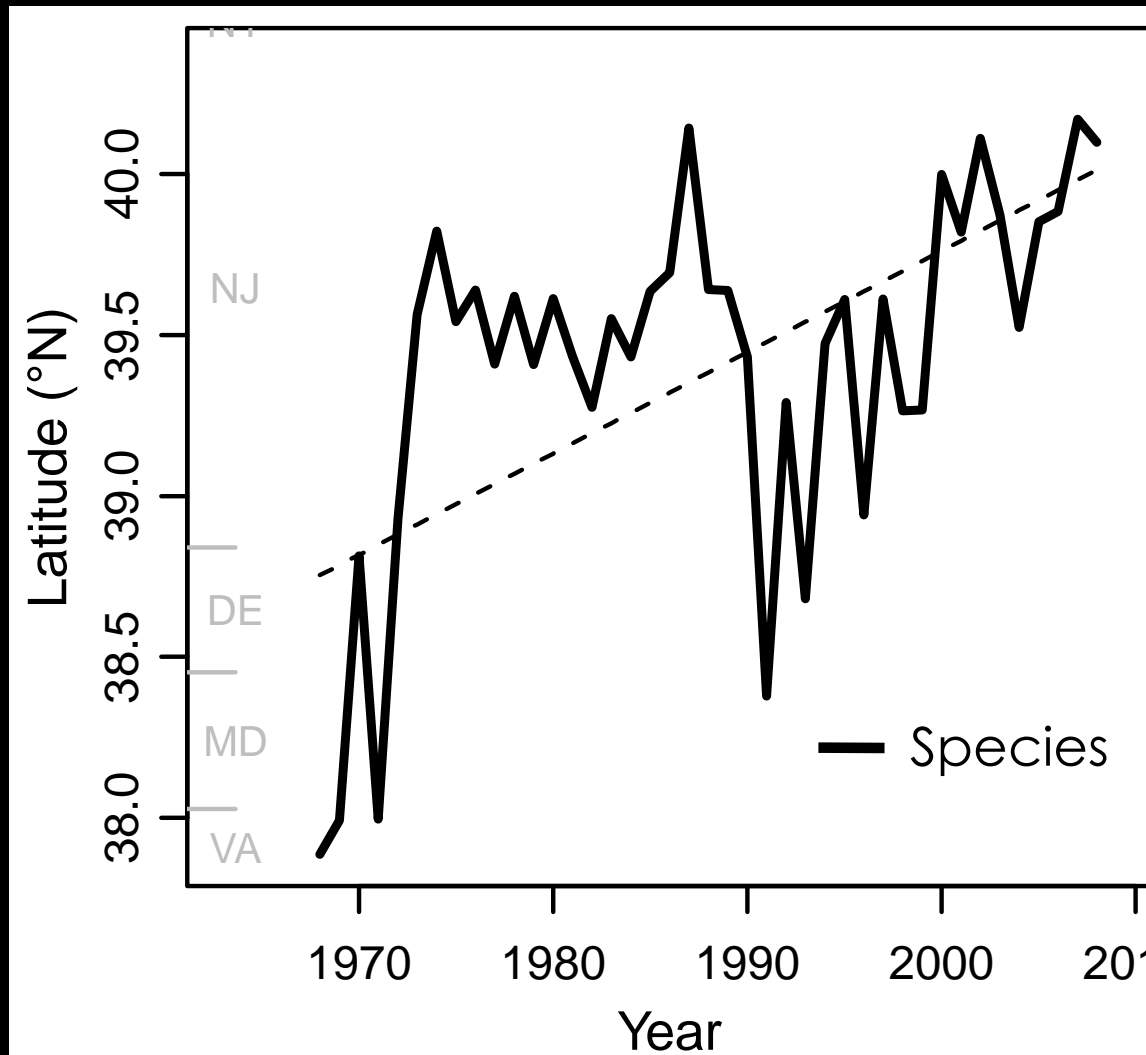


# Implications for fisheries

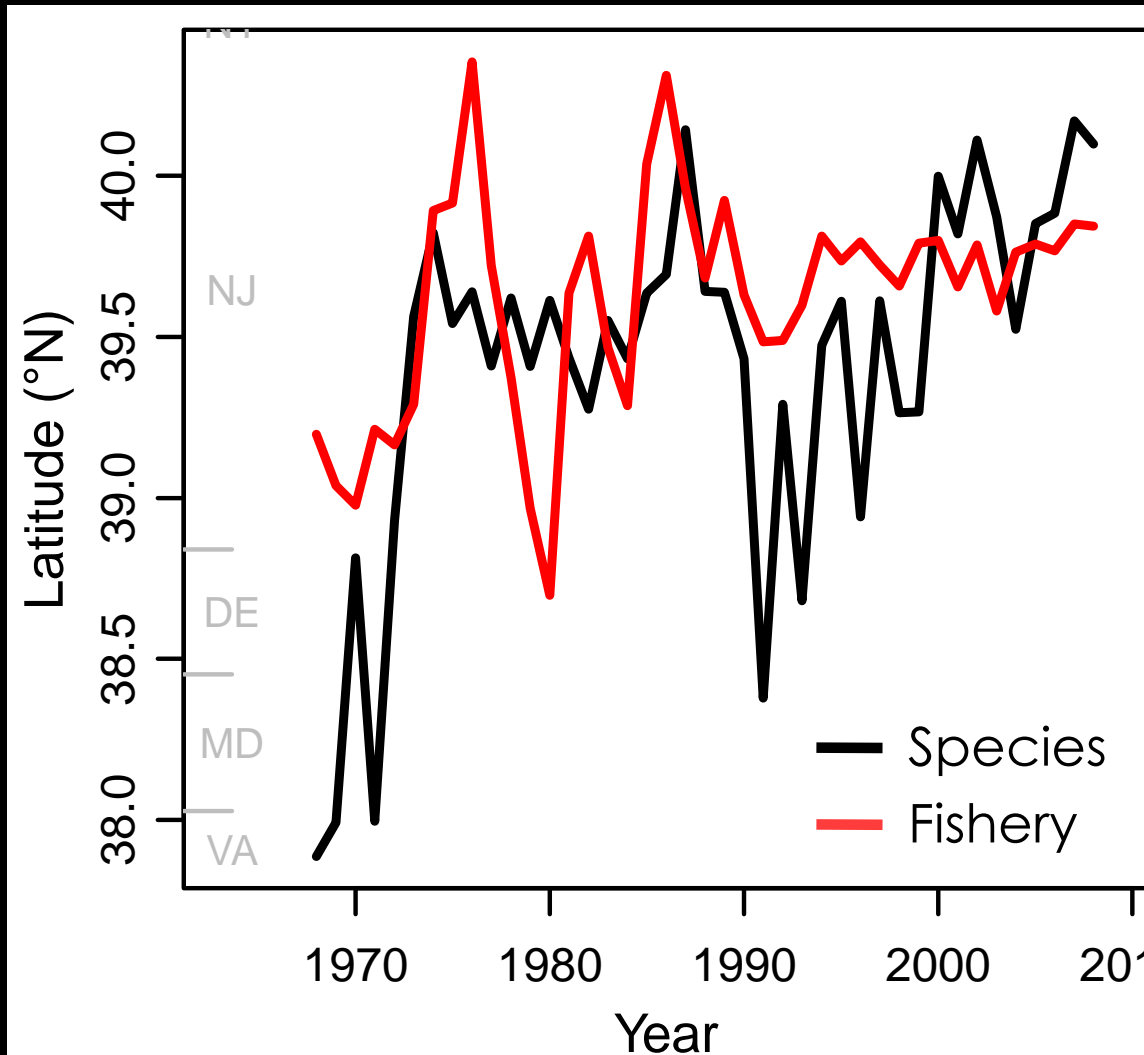
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- Fishing and landing locations

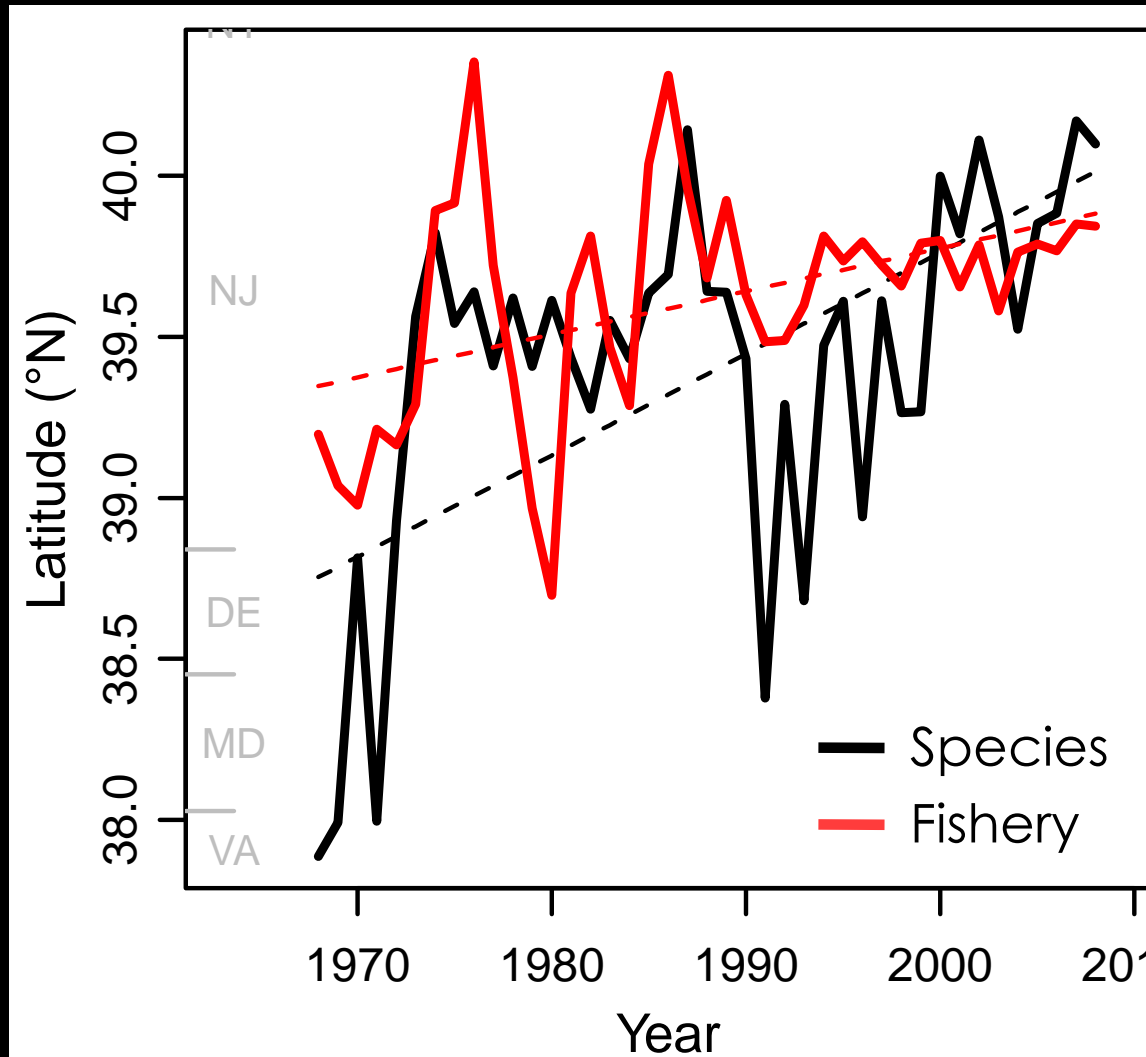
# Poleward shift of summer flounder



# Fishery landings shift as well



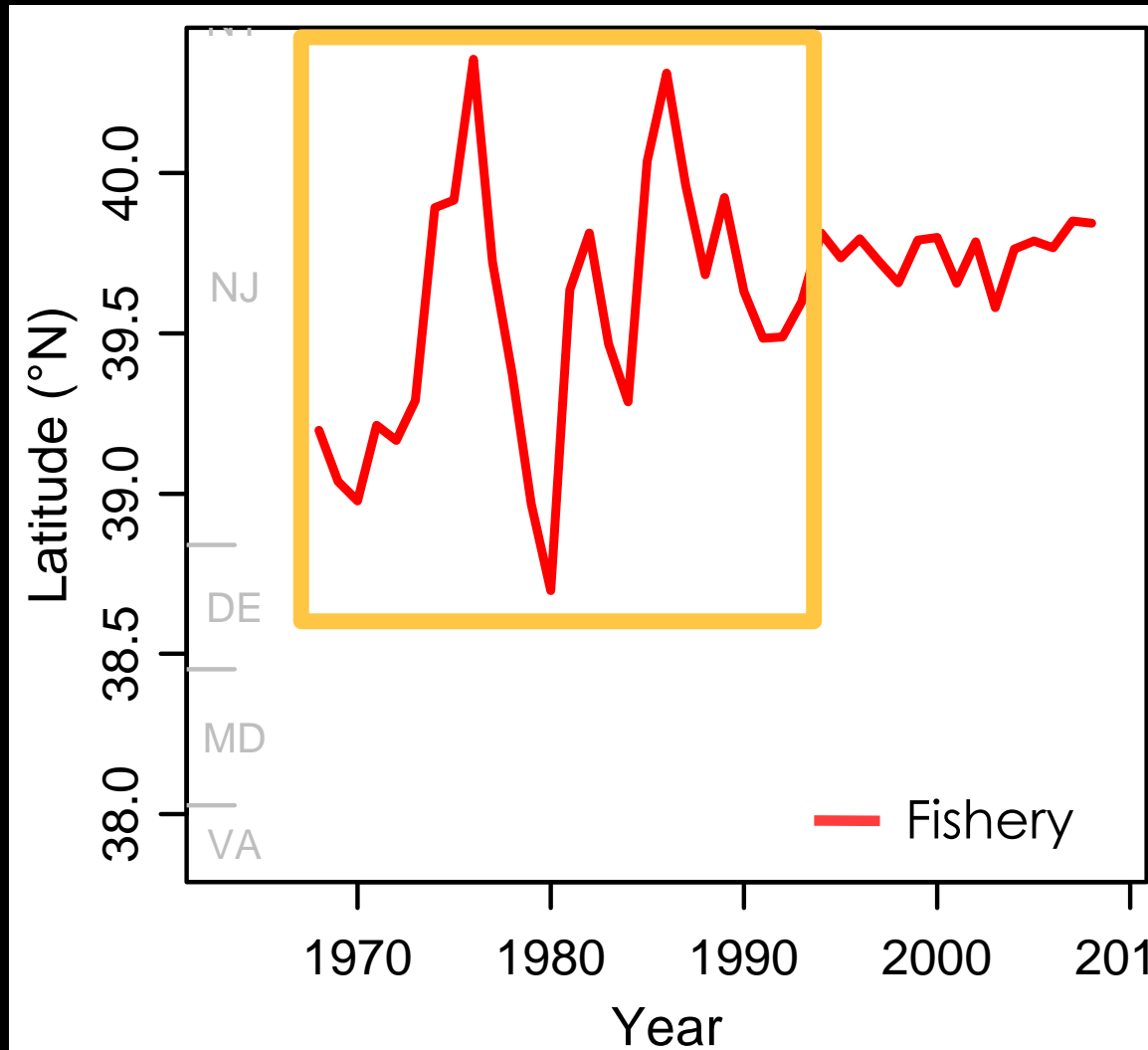
# Fishery landings shift more slowly



68%  
slower

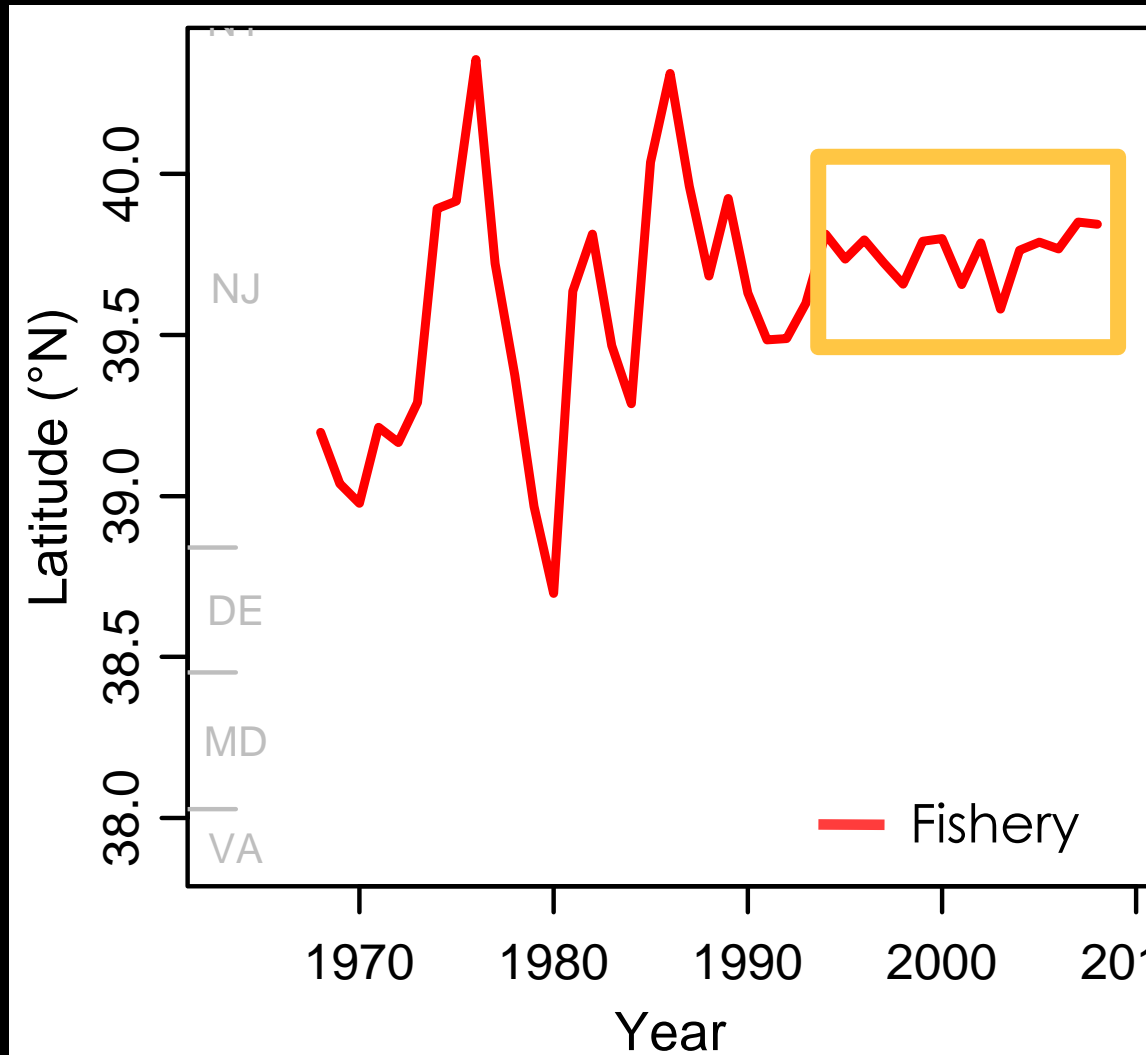


# Early: high variability in landings

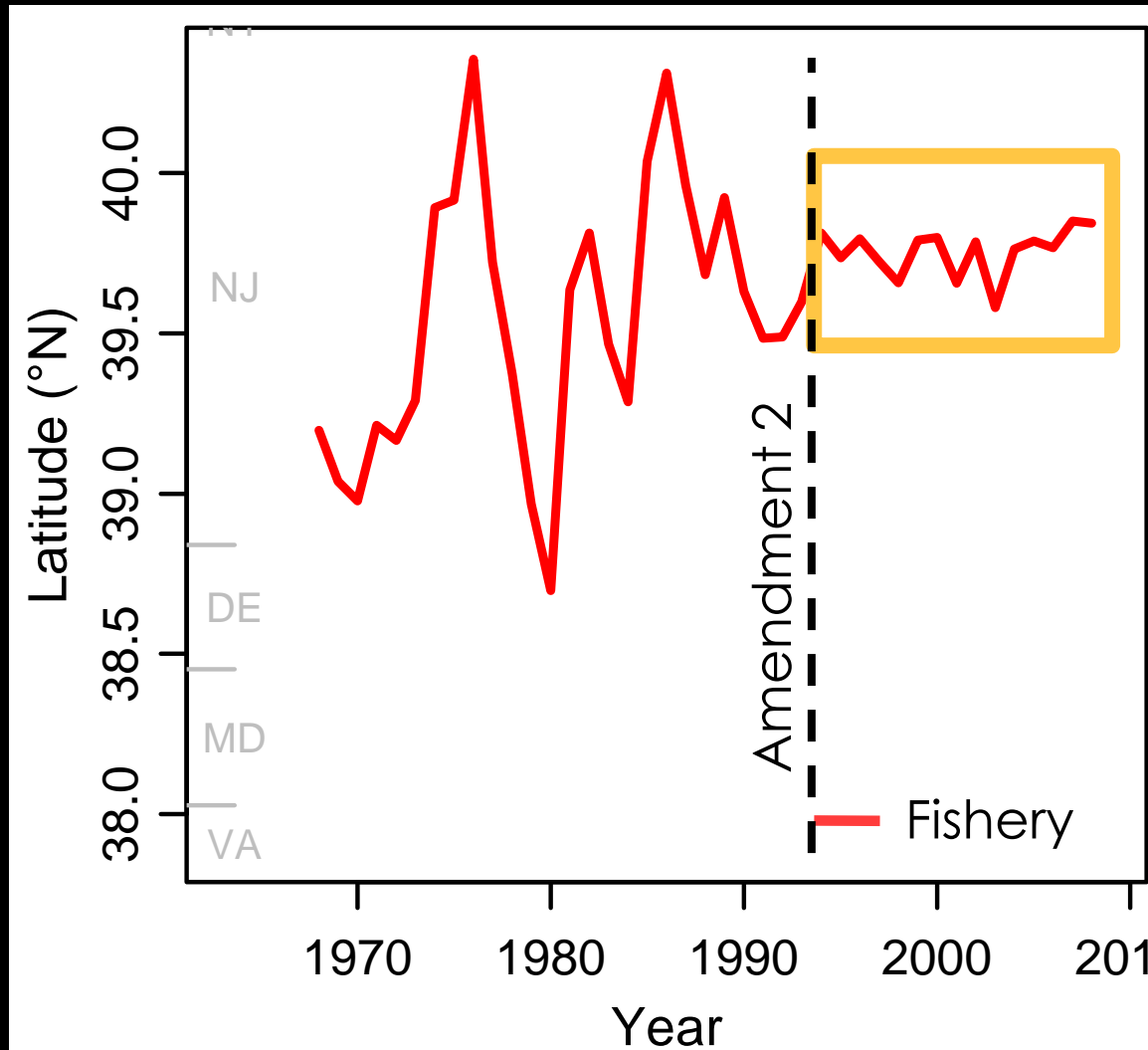




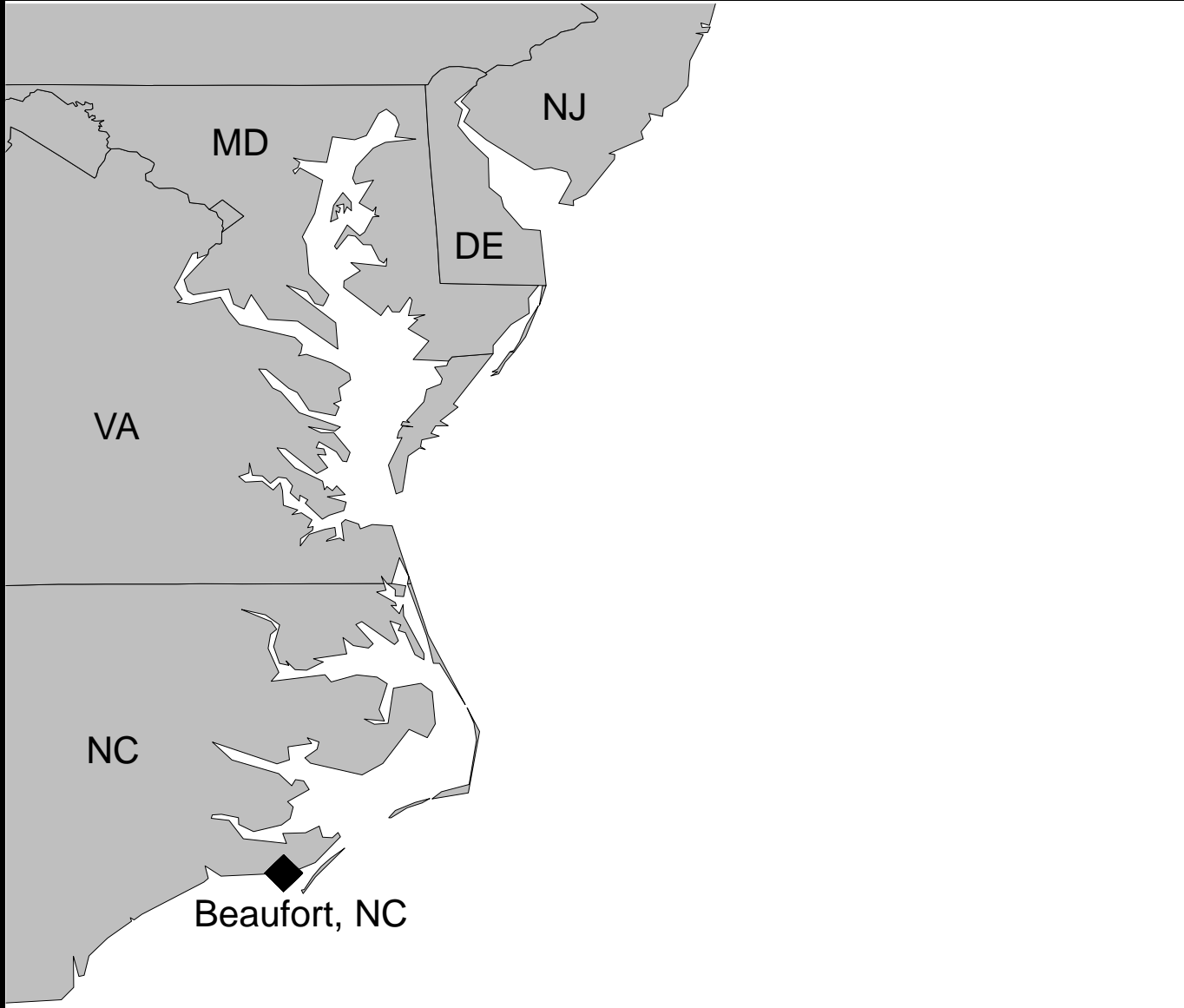
# Late: low variability in landings



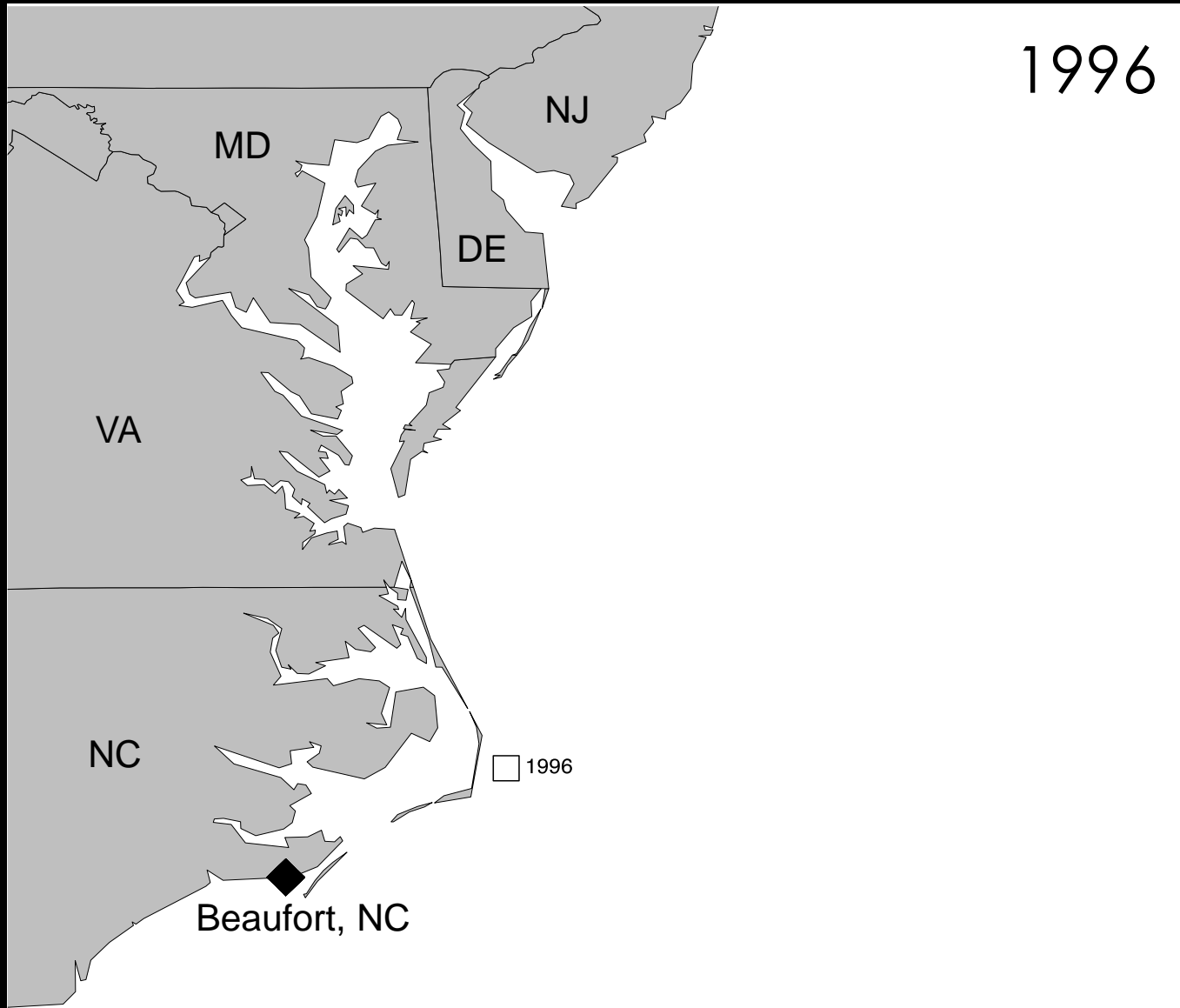
# State quotas implemented



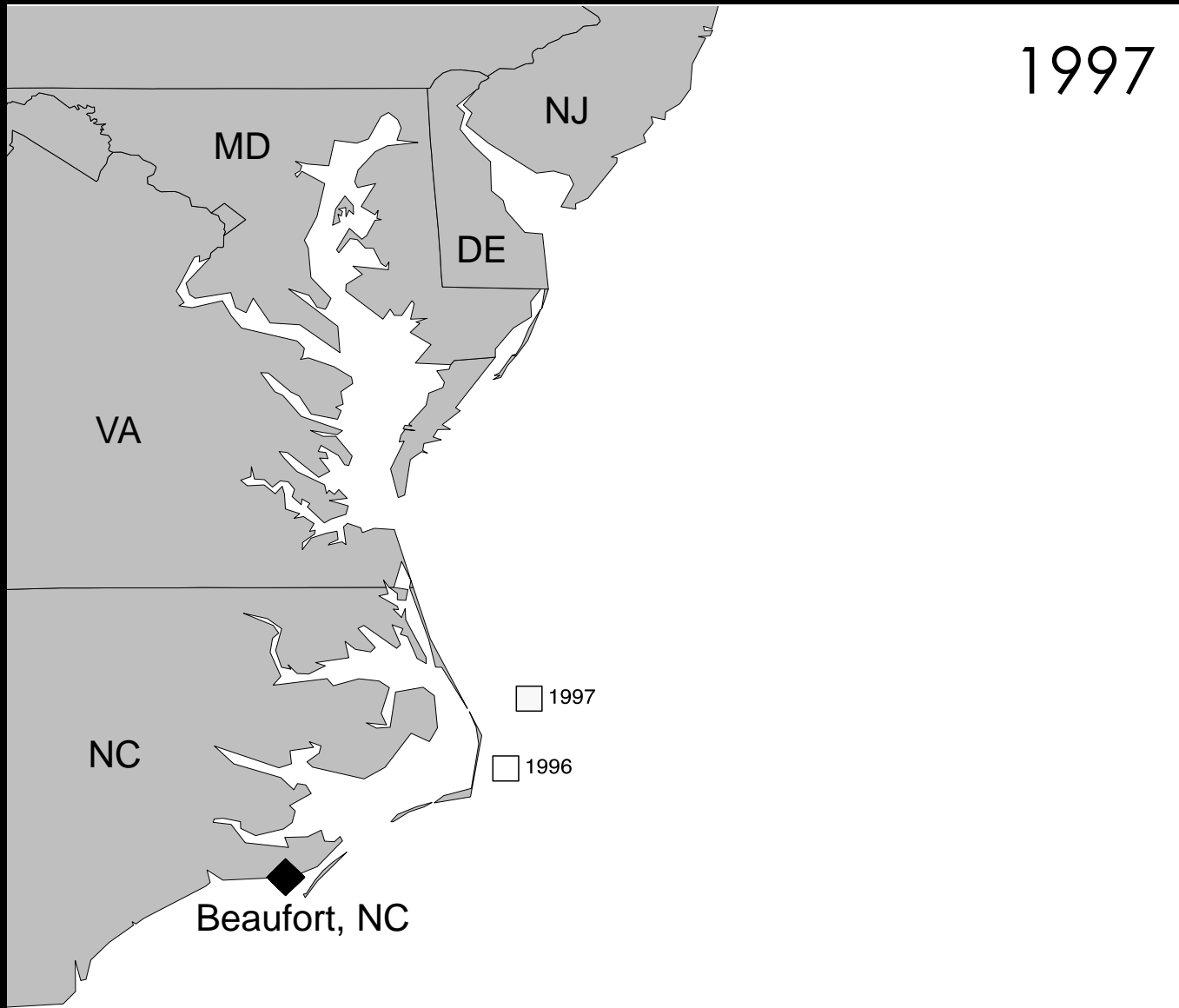
# Center of large trawler fishing trips



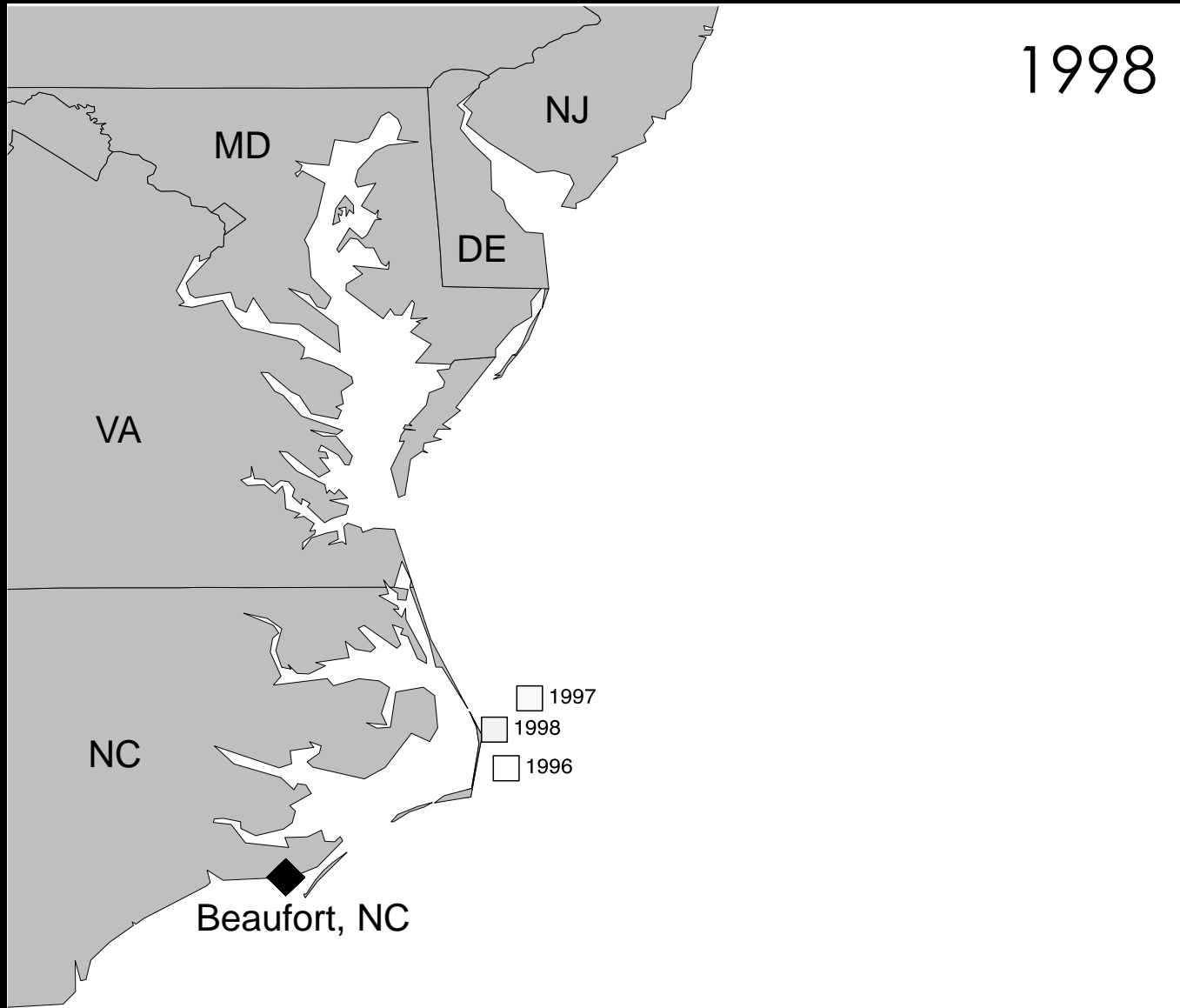
# Center of large trawler fishing trips



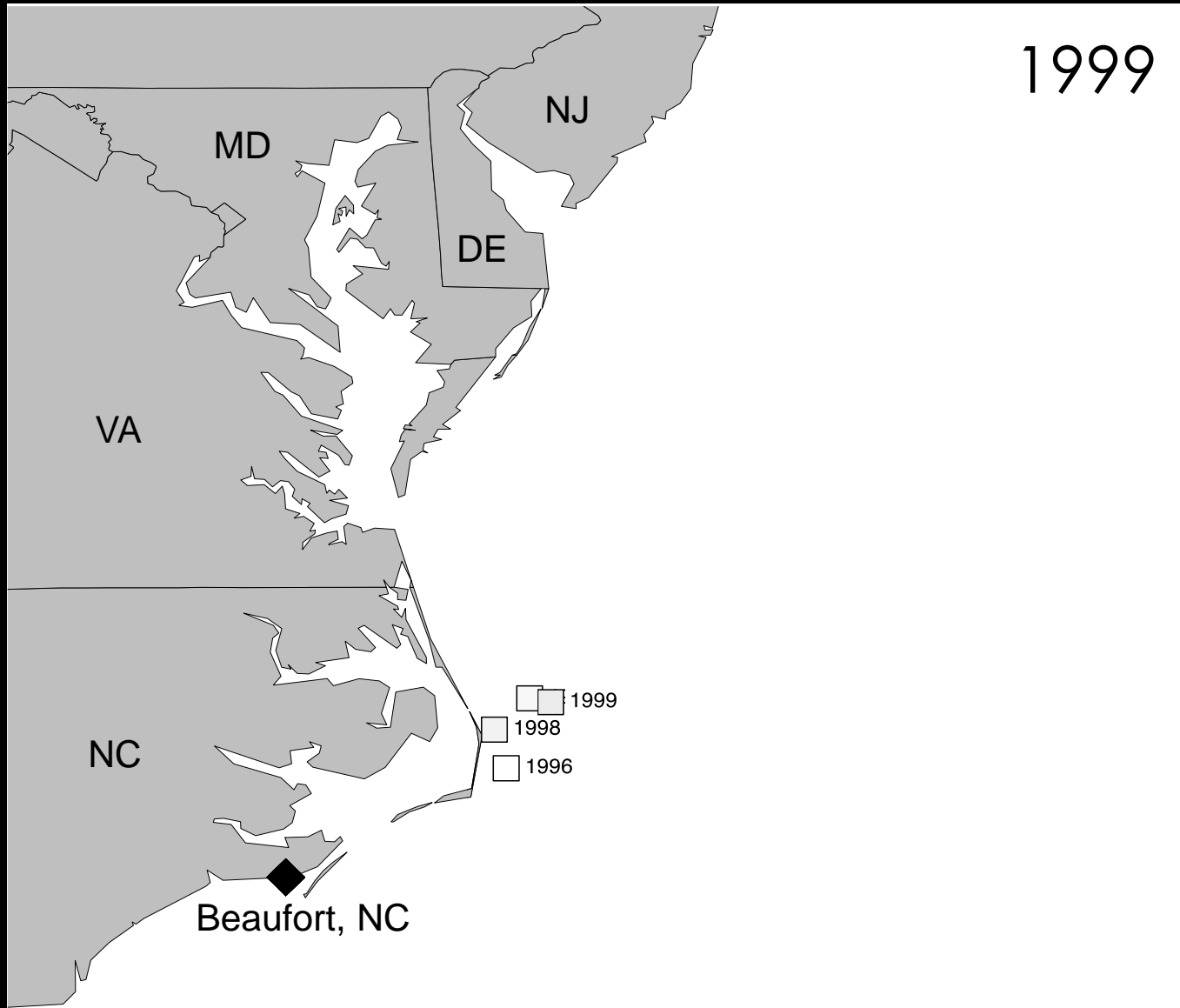
# Center of large trawler fishing trips



# Center of large trawler fishing trips

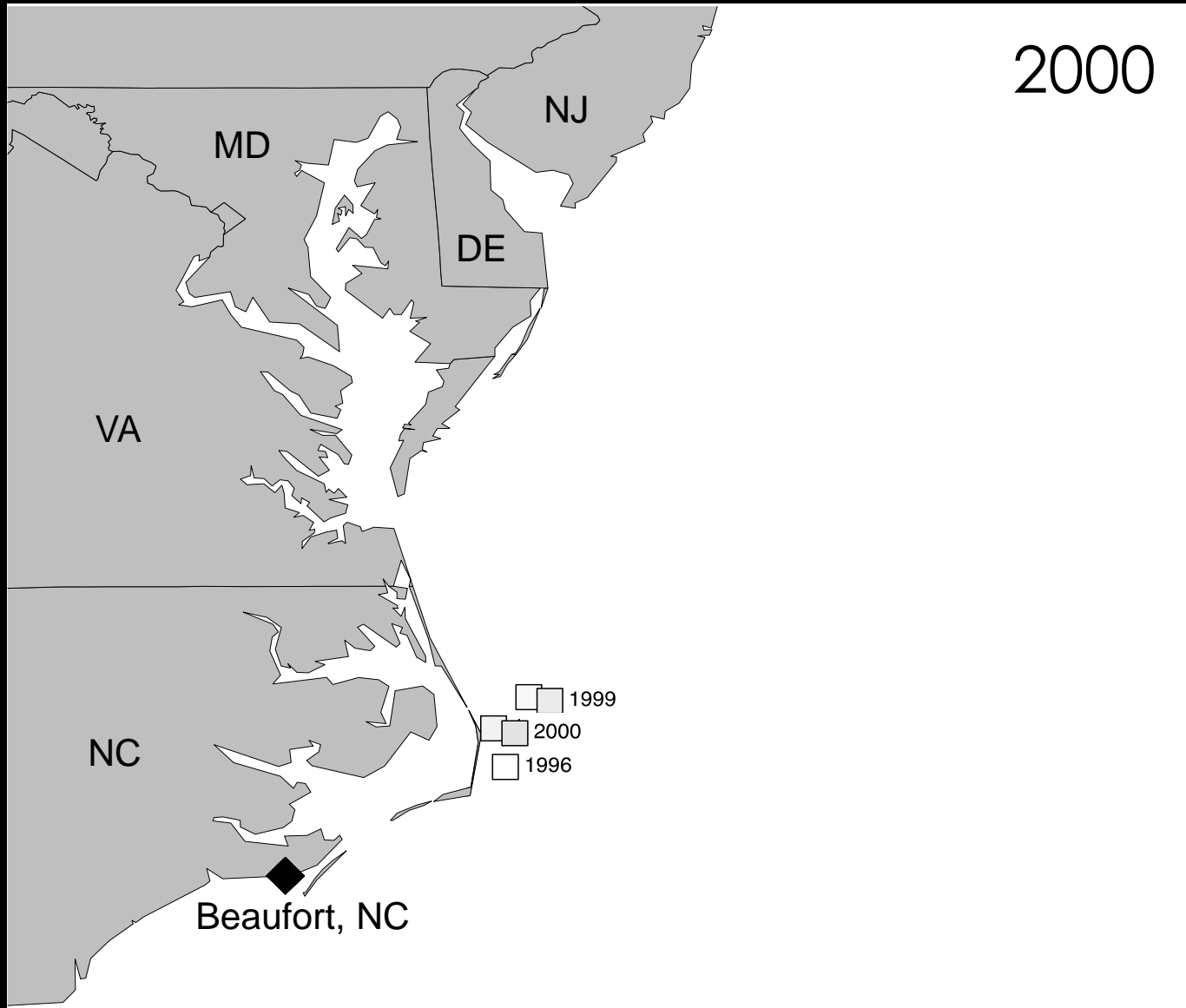


# Center of large trawler fishing trips

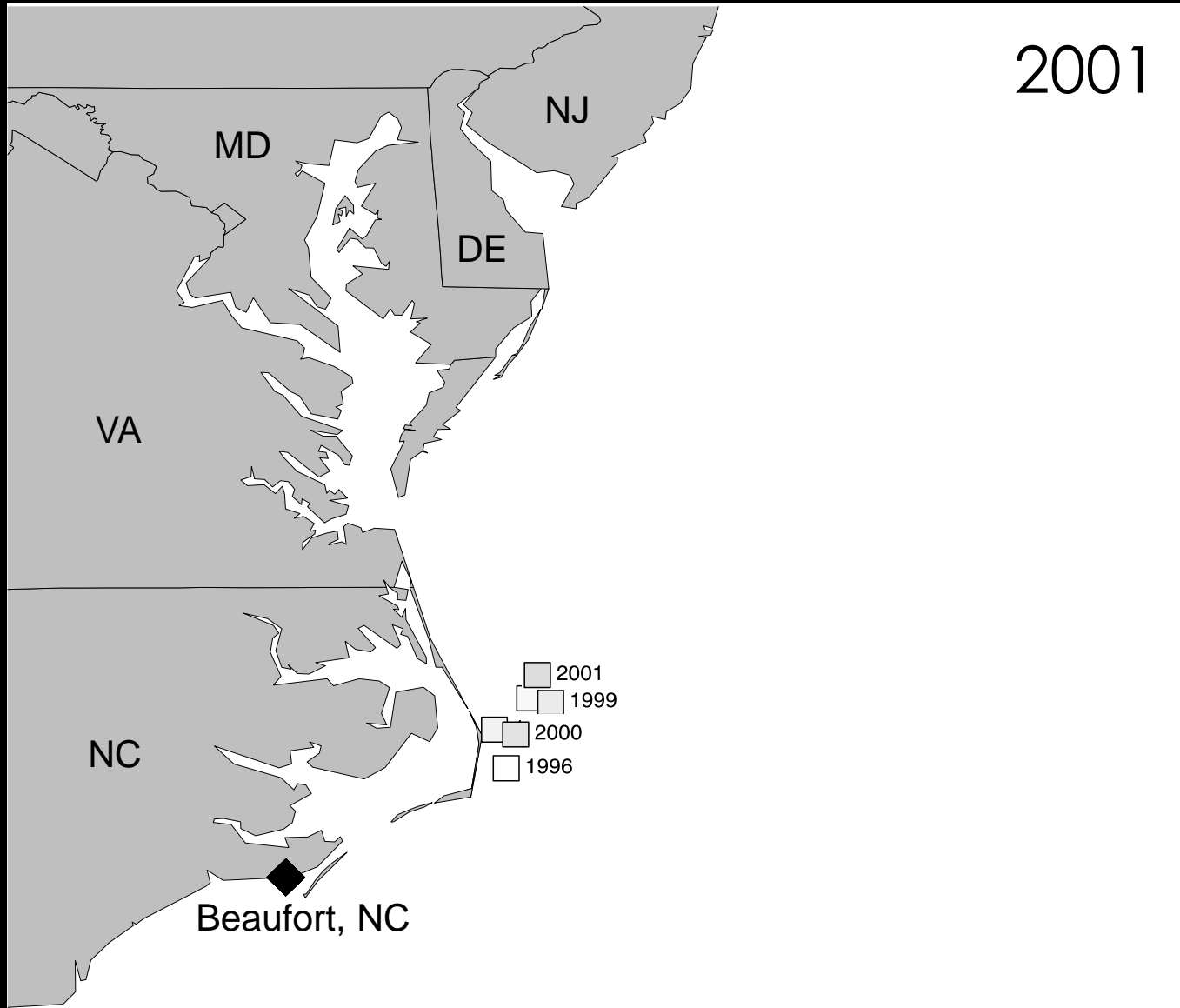




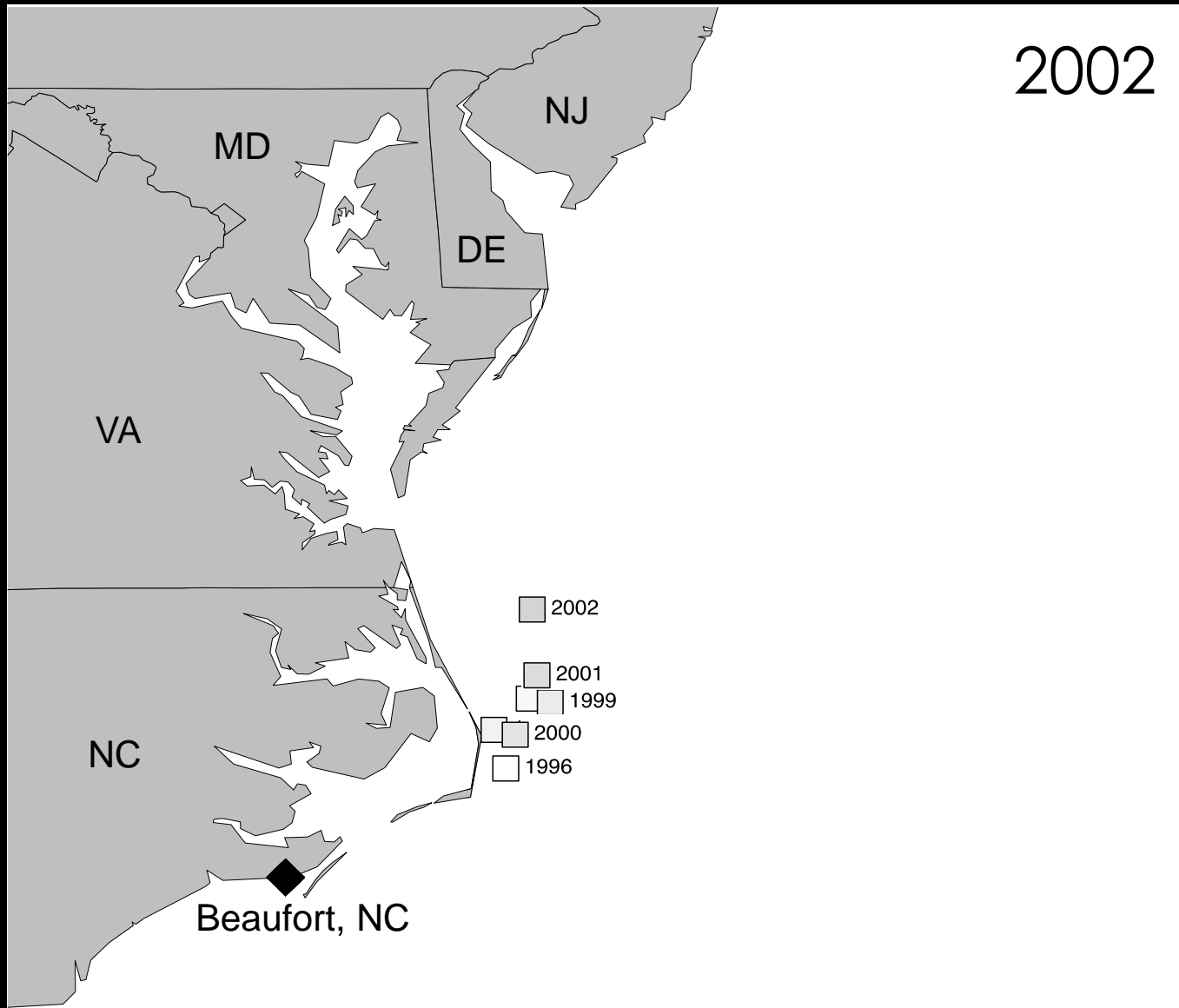
# Center of large trawler fishing trips



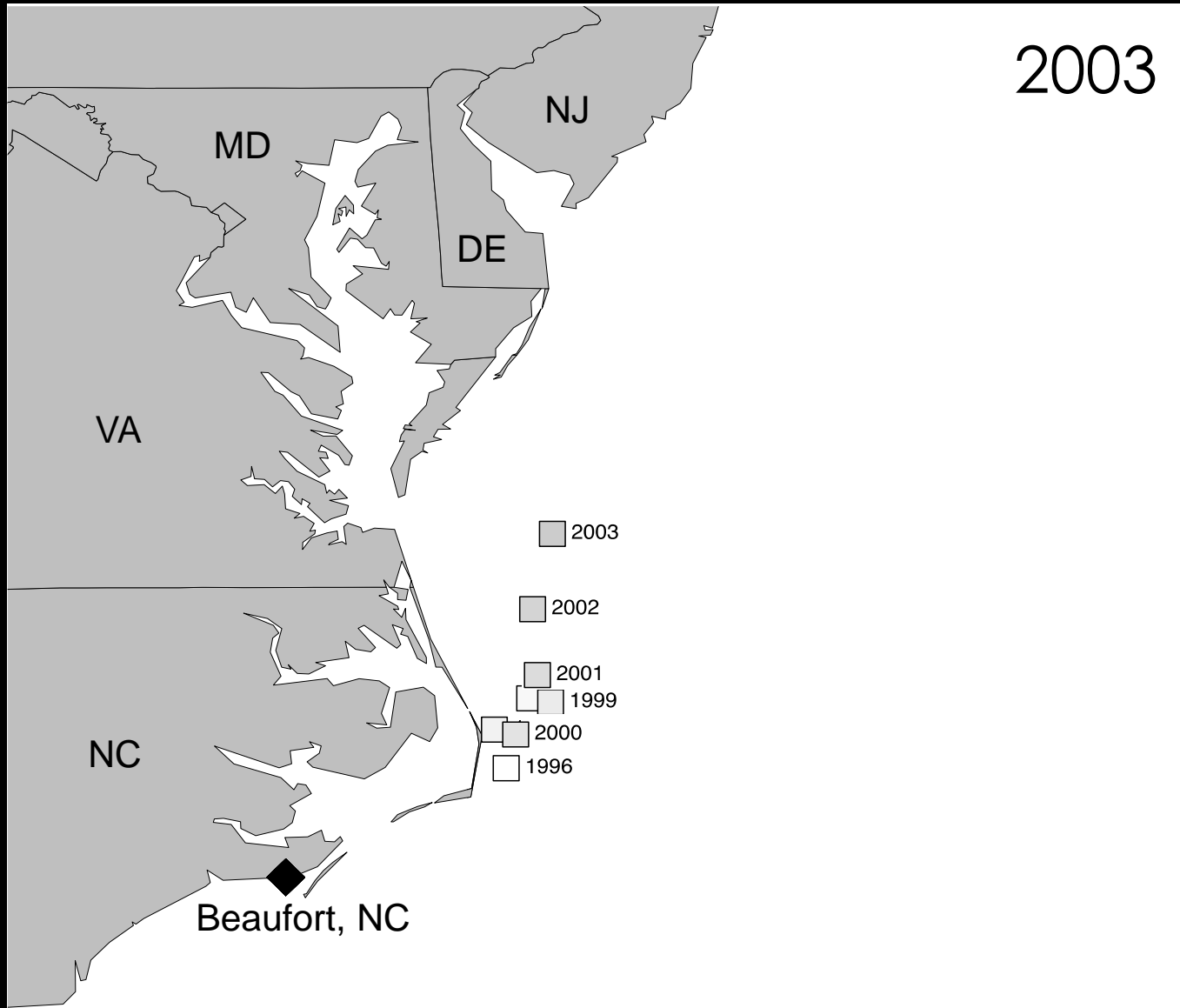
# Center of large trawler fishing trips



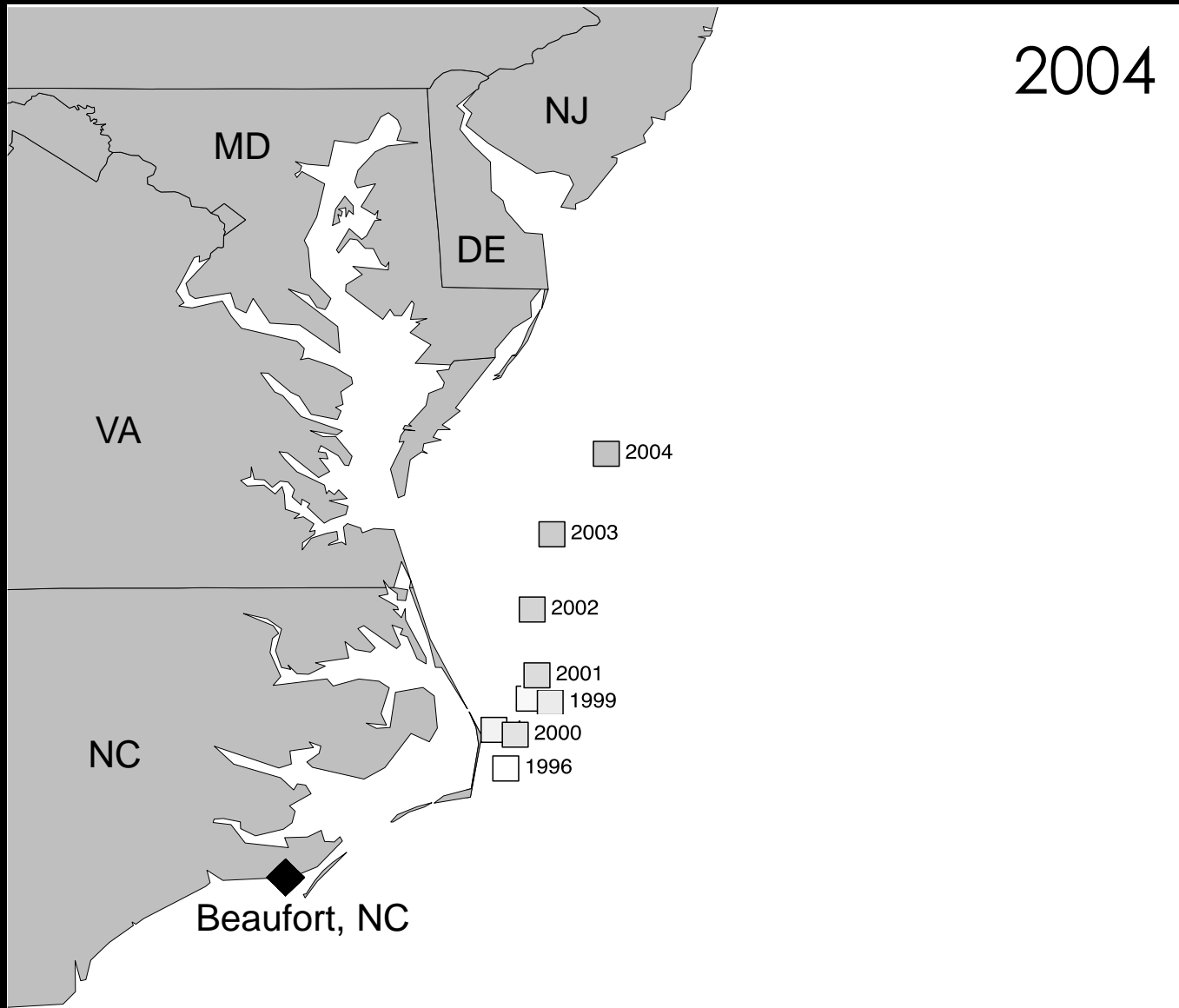
# Center of large trawler fishing trips



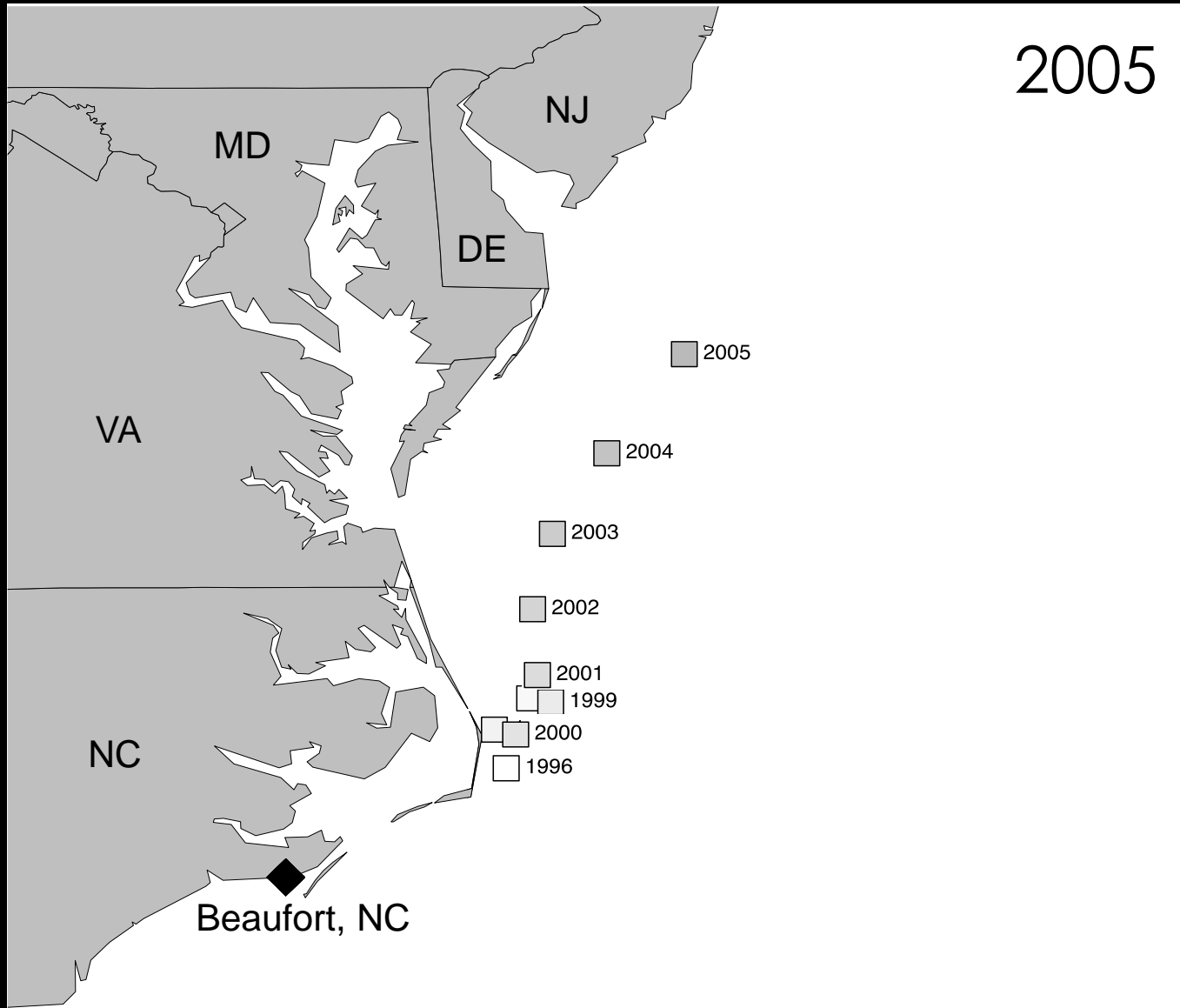
# Center of large trawler fishing trips



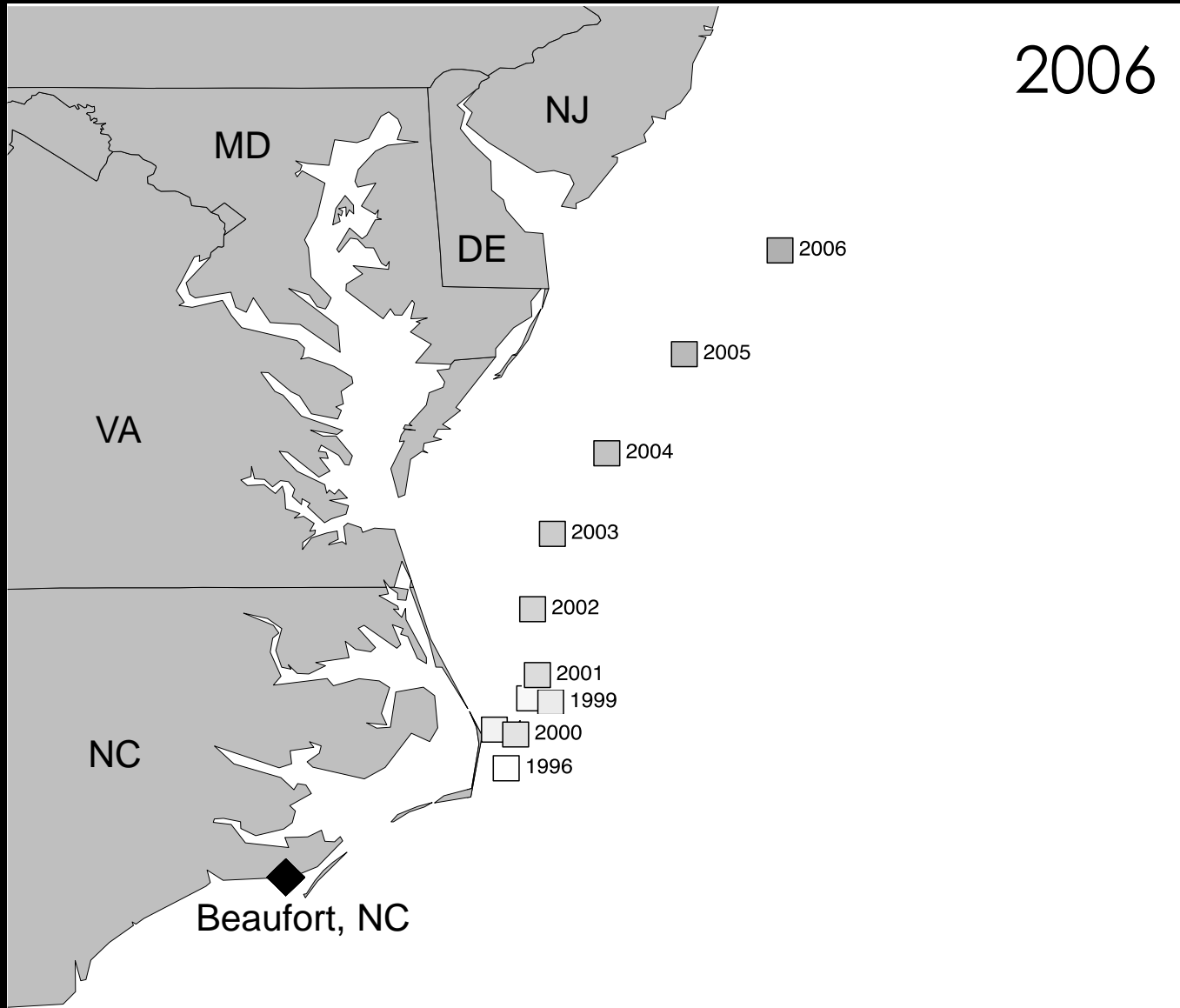
# Center of large trawler fishing trips



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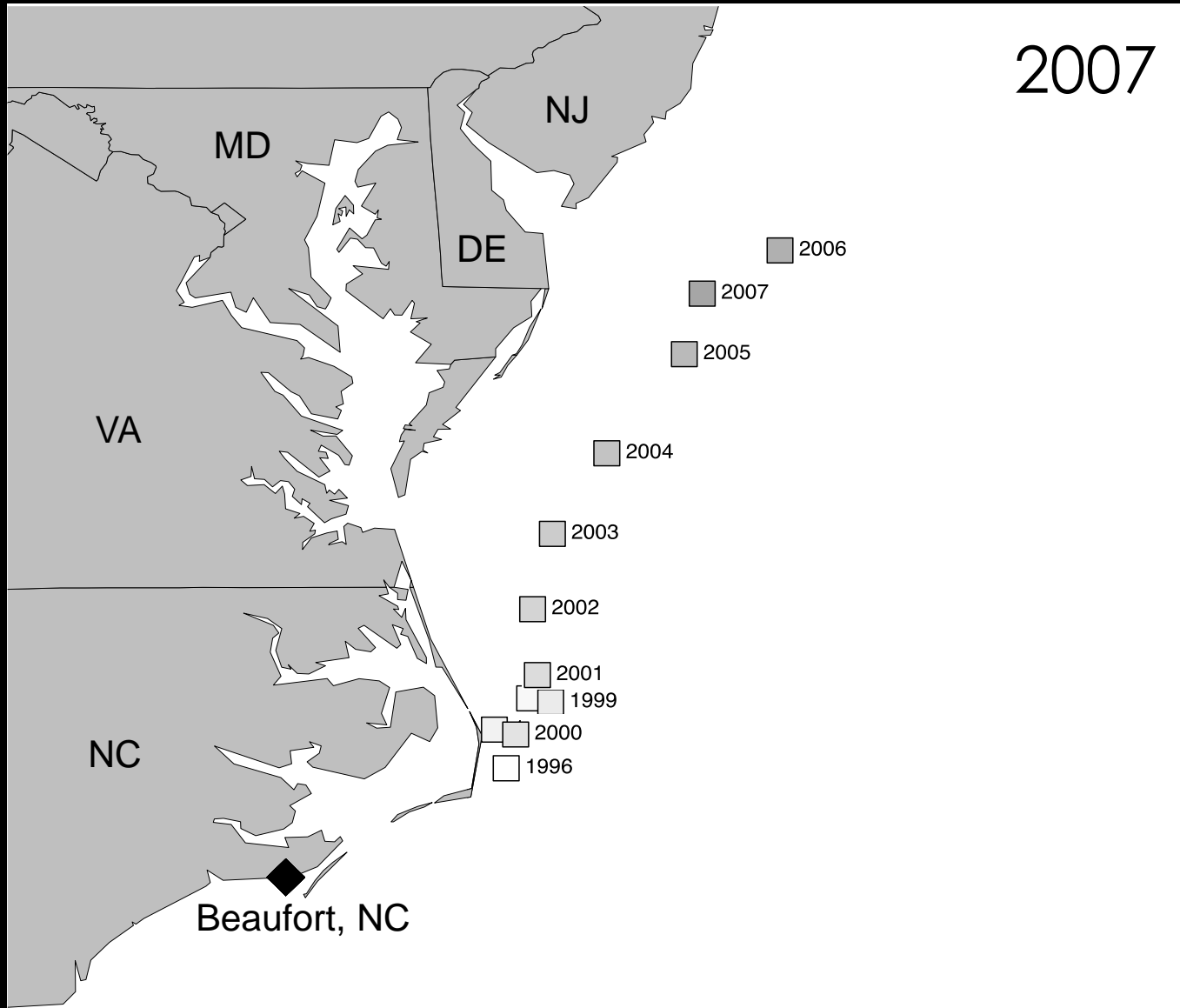


# Center of large trawler fishing trips

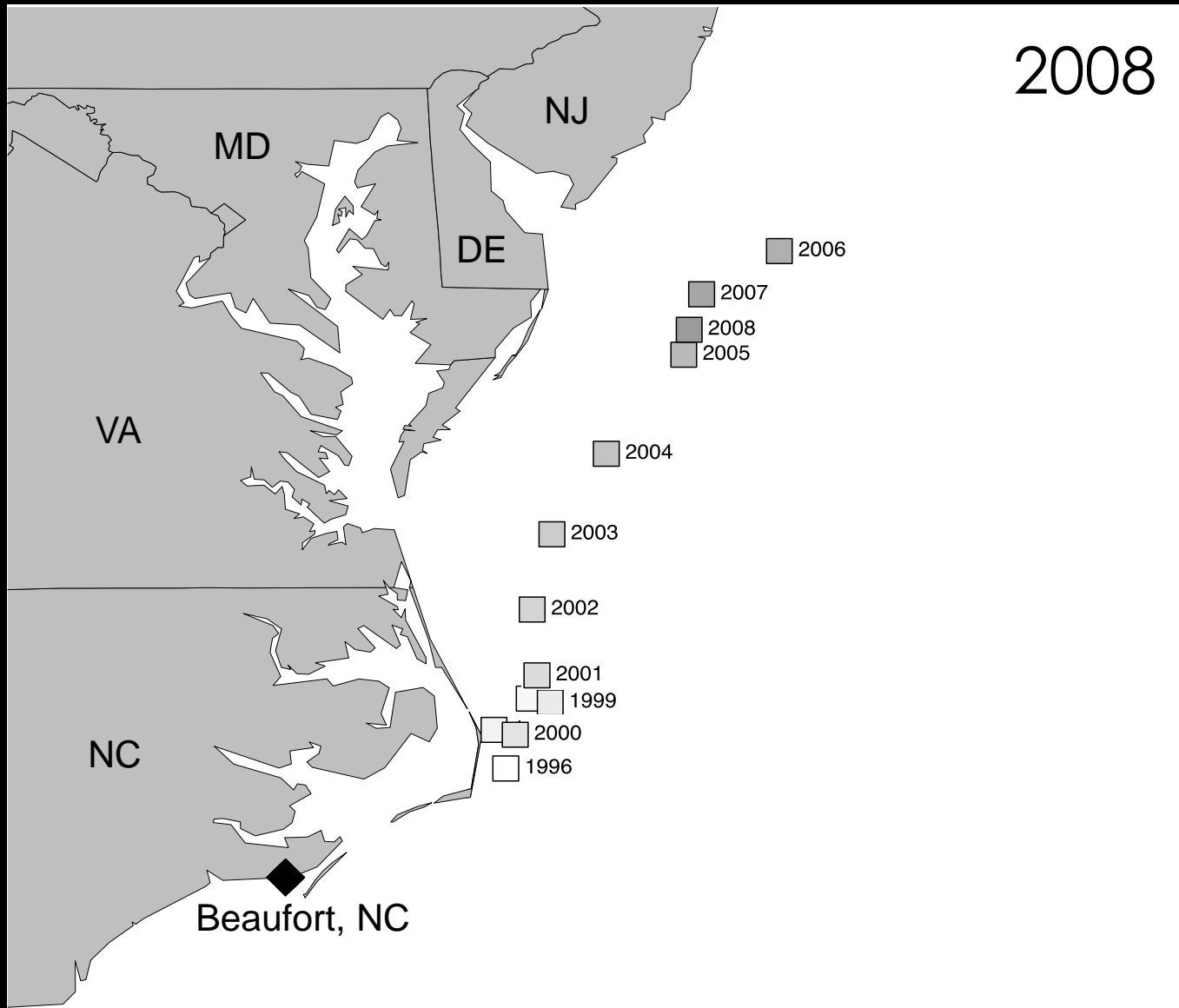




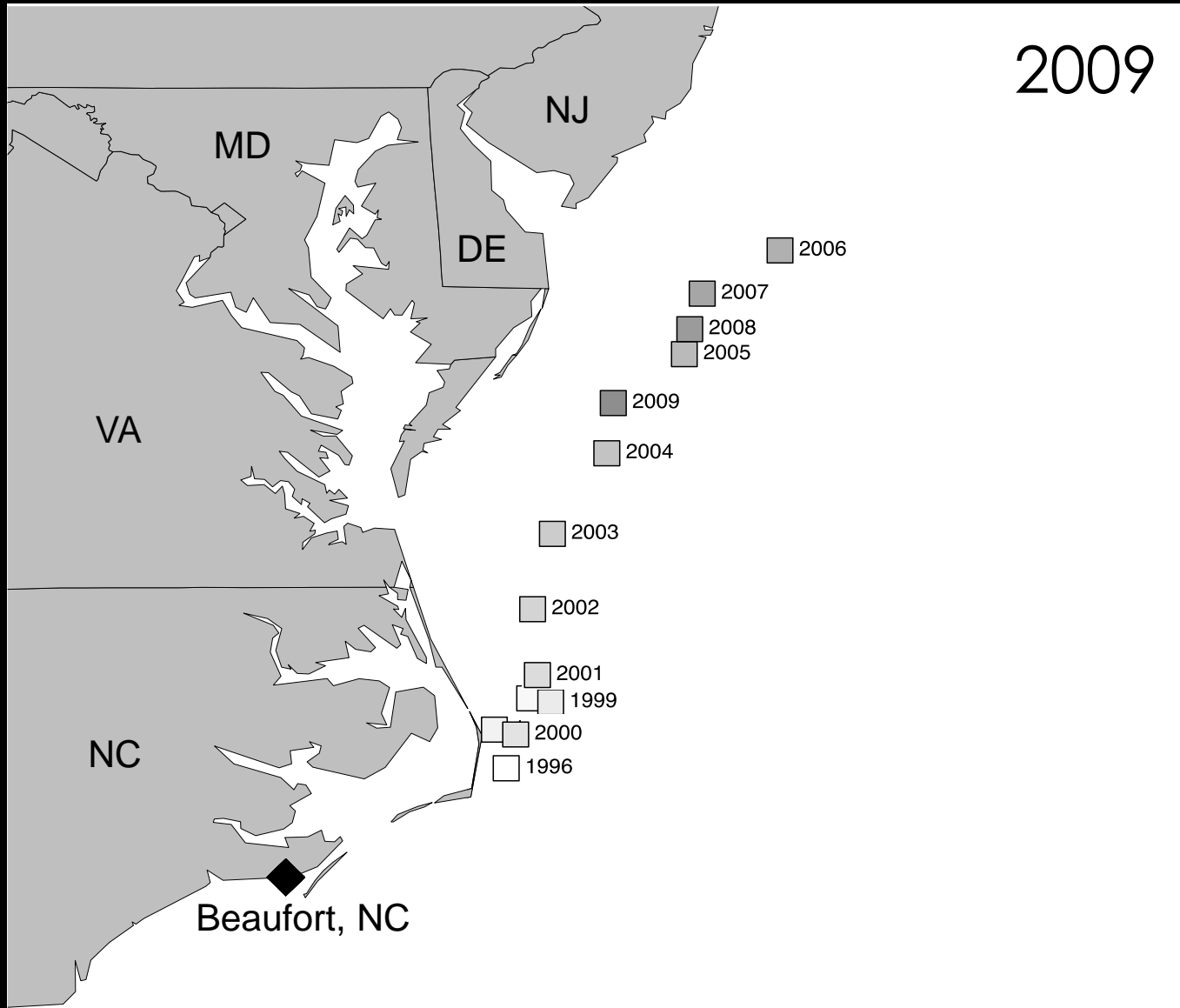
# Center of large trawler fishing trips



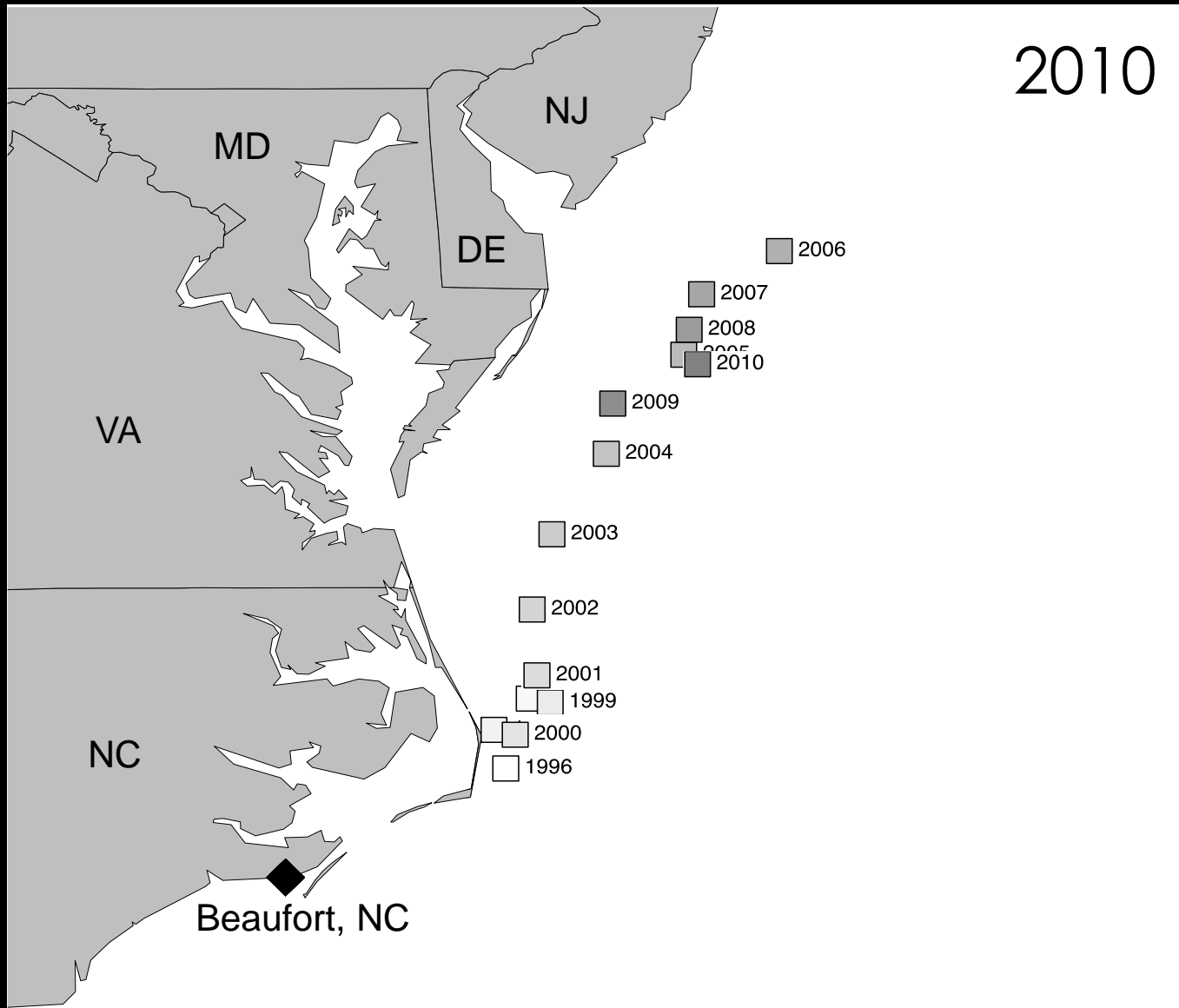
# Center of large trawler fishing trips



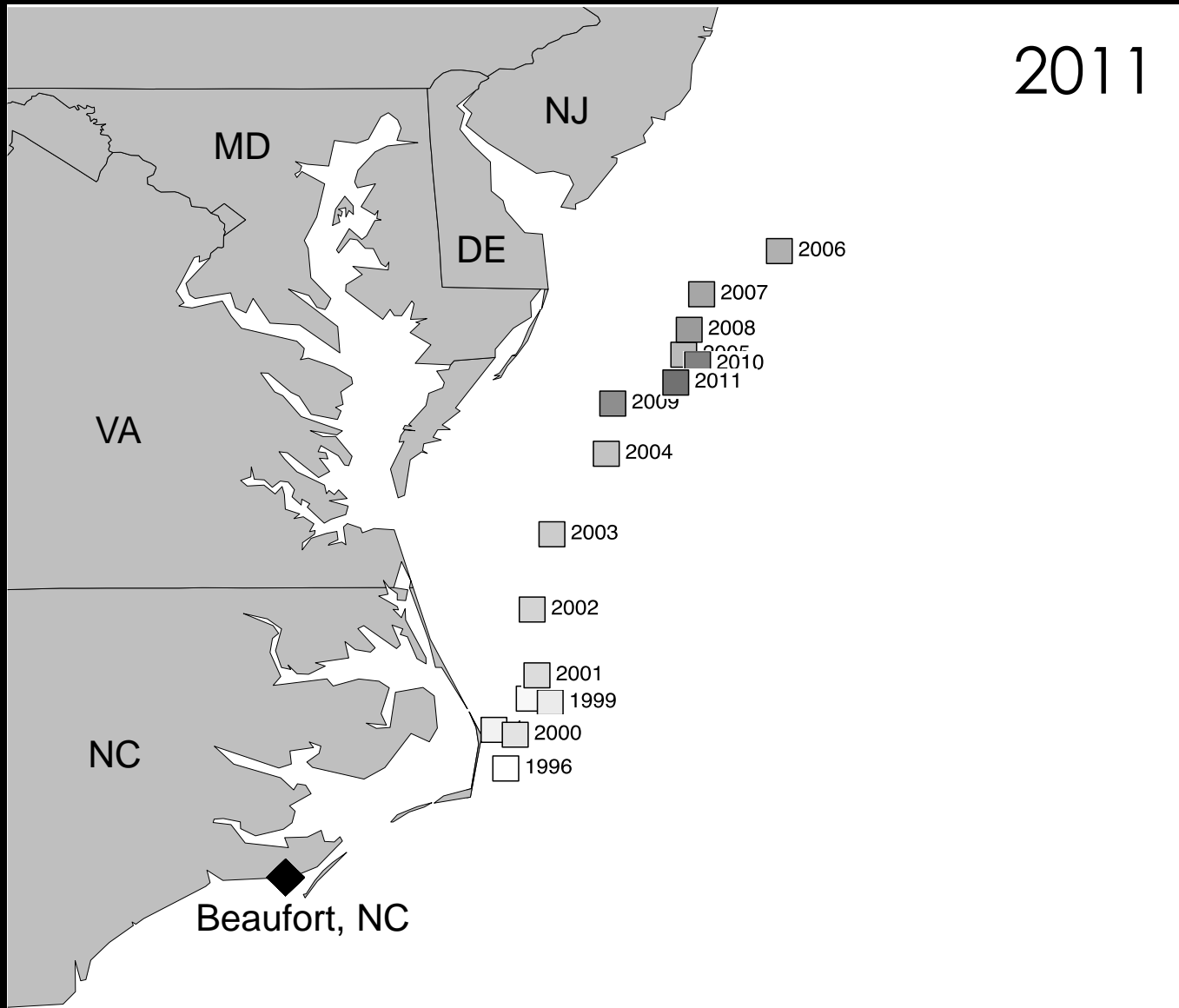
# Center of large trawler fishing trips



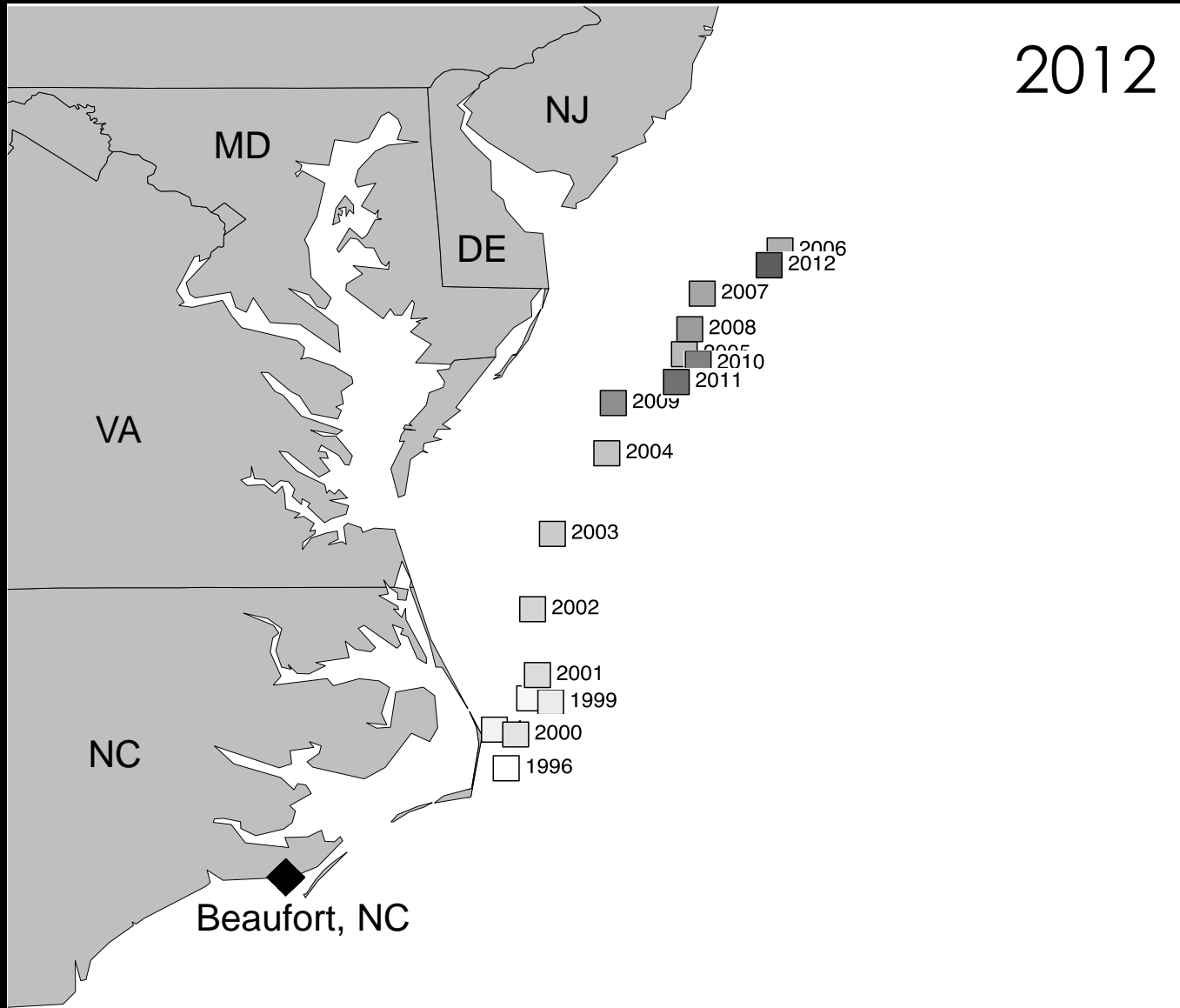
# Center of large trawler fishing trips



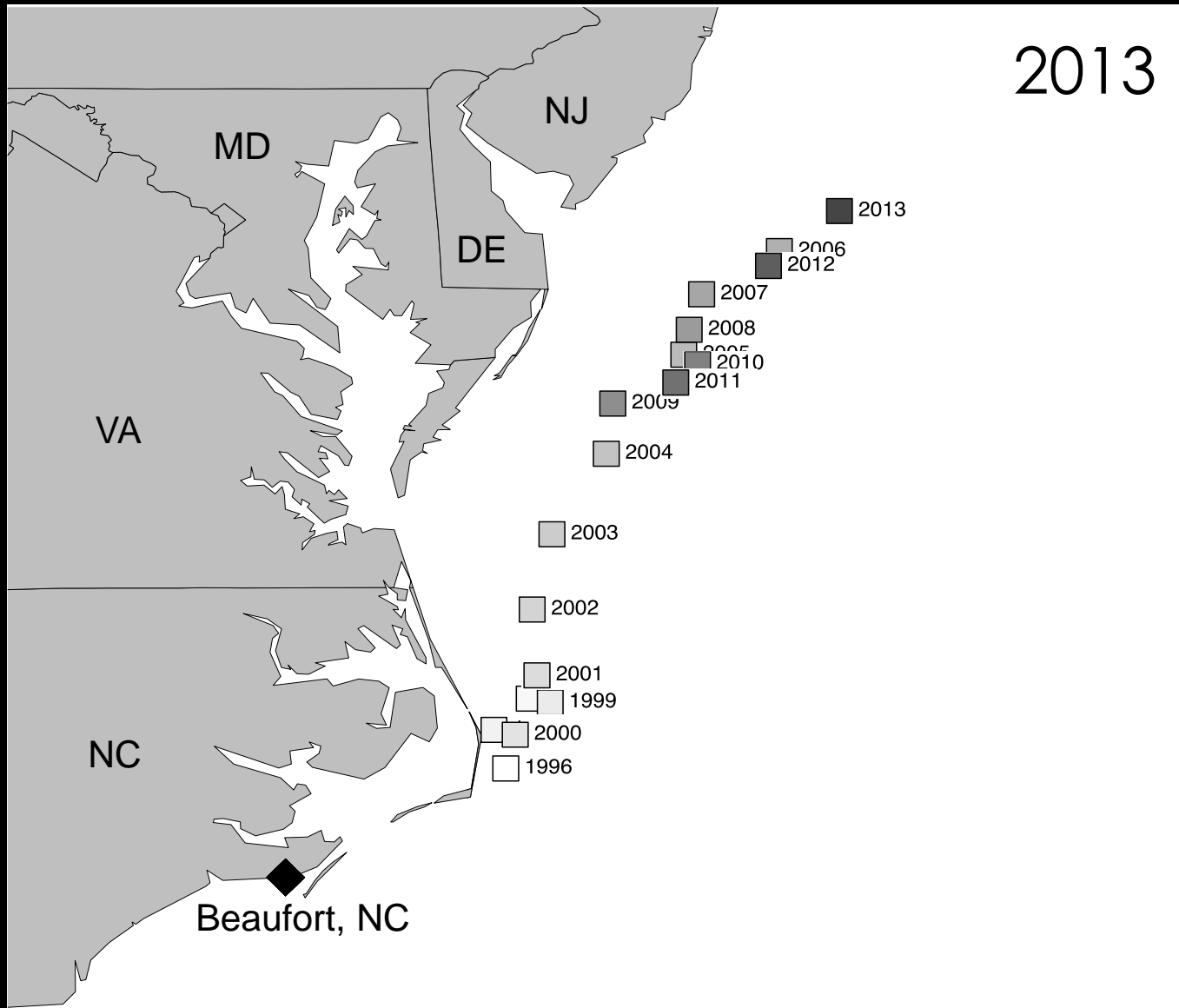
# Center of large trawler fishing trips



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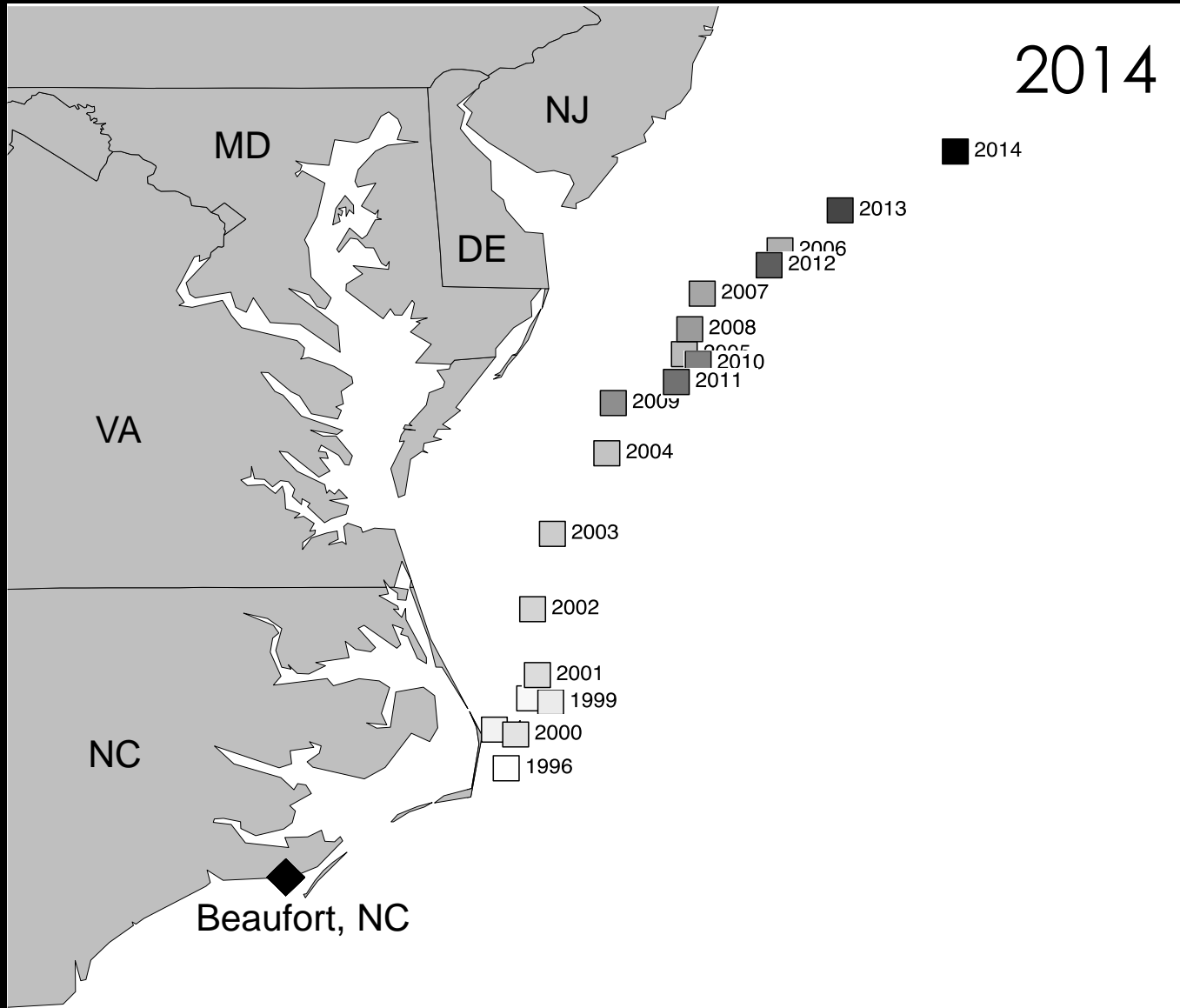


# Center of large trawler fishing trips





# Center of large trawler fishing trips



# Implications for fisheries

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- Fishing and landing locations
- Stock definitions

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- Reference points

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- Rebuilding goals

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- Fishing and landing locations
- Stock definitions
- Reference points
- Rebuilding goals
- Bycatch

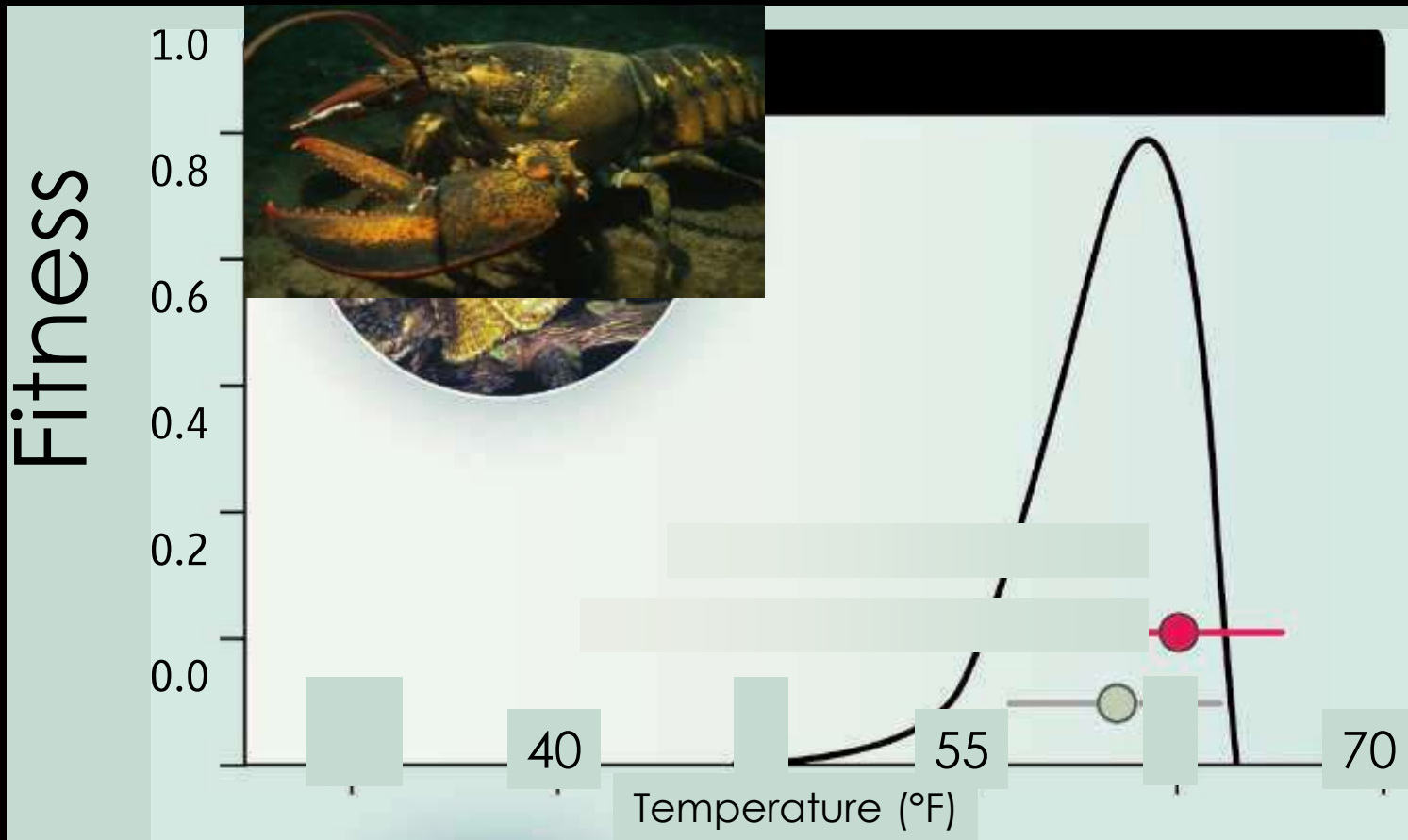
# Implications for fisheries

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- Fishing and landing locations
- Stock definitions
- Reference points
- Rebuilding goals
- Bycatch
- Closed areas

Why?

# Temperature and physiology





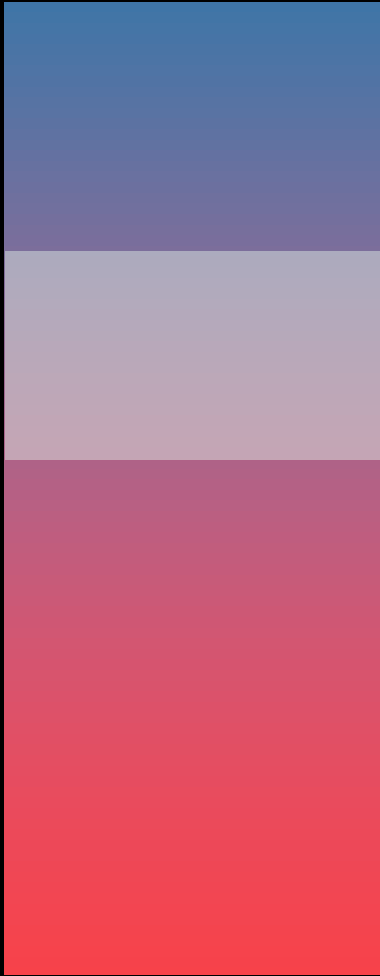
# Climate velocity

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# Climate velocity

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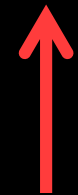


# Climate velocity



# Climate velocity

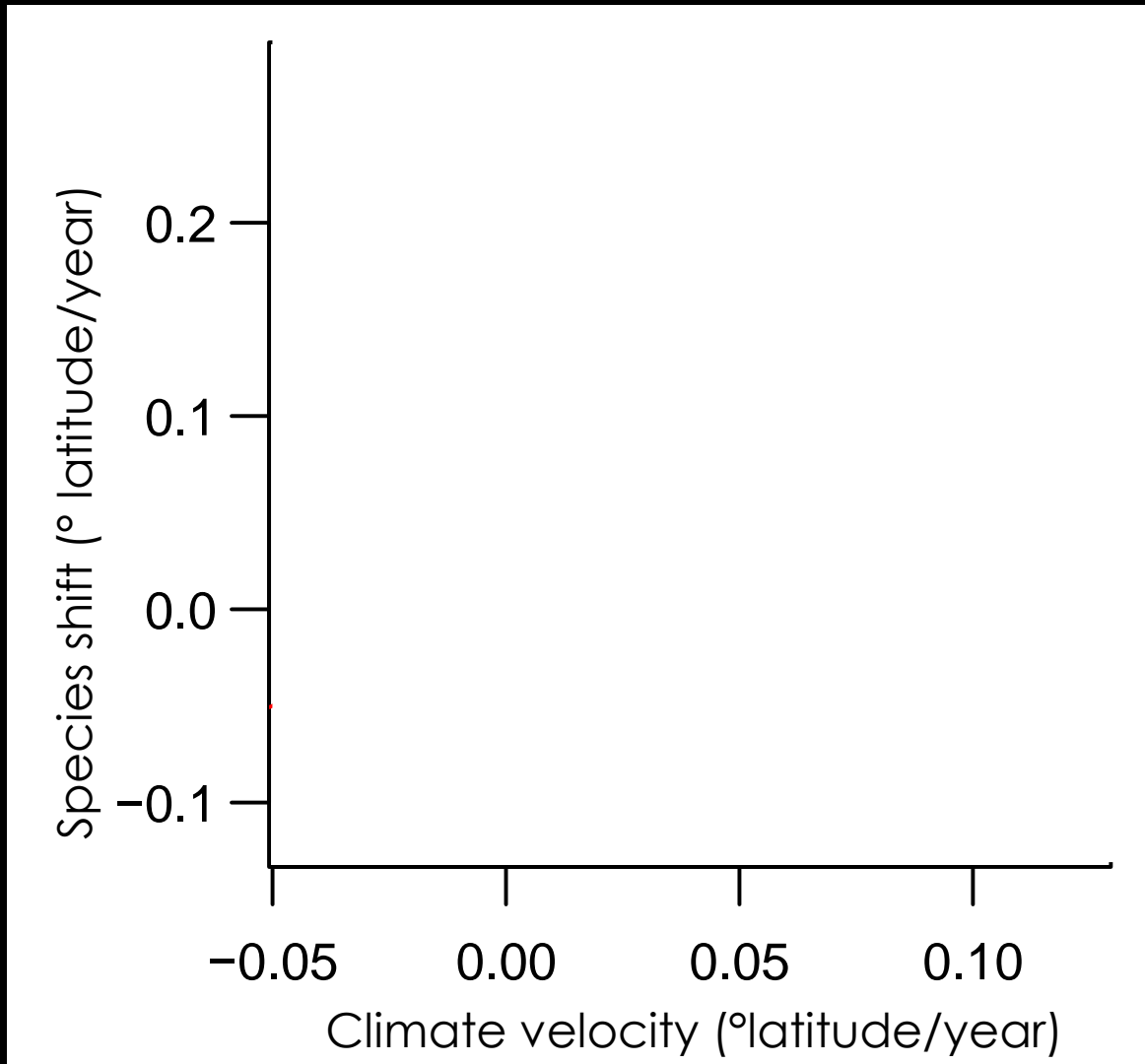
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°latitude  
per year

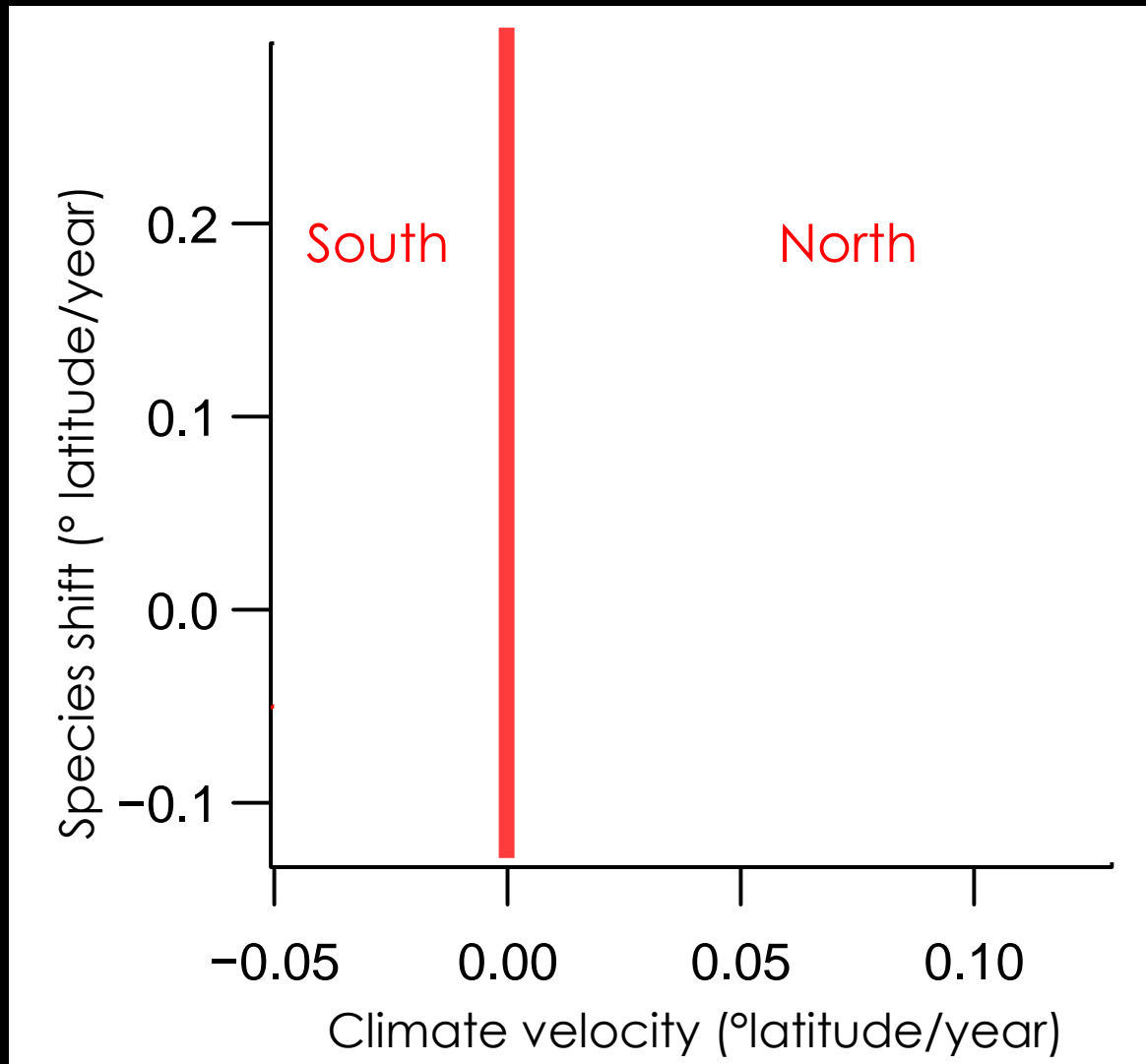
# Across 325 taxa...

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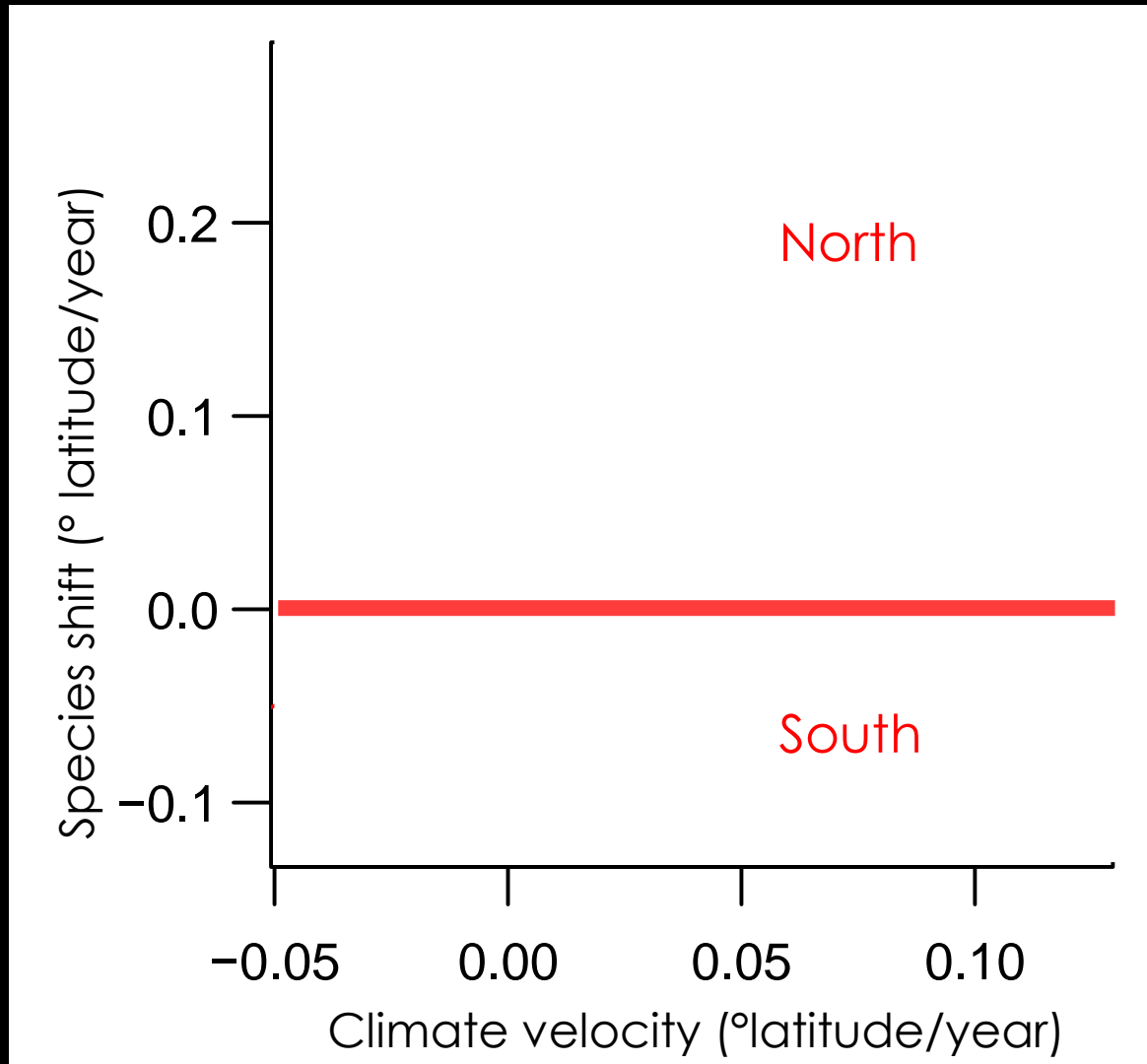
# Across 325 taxa...

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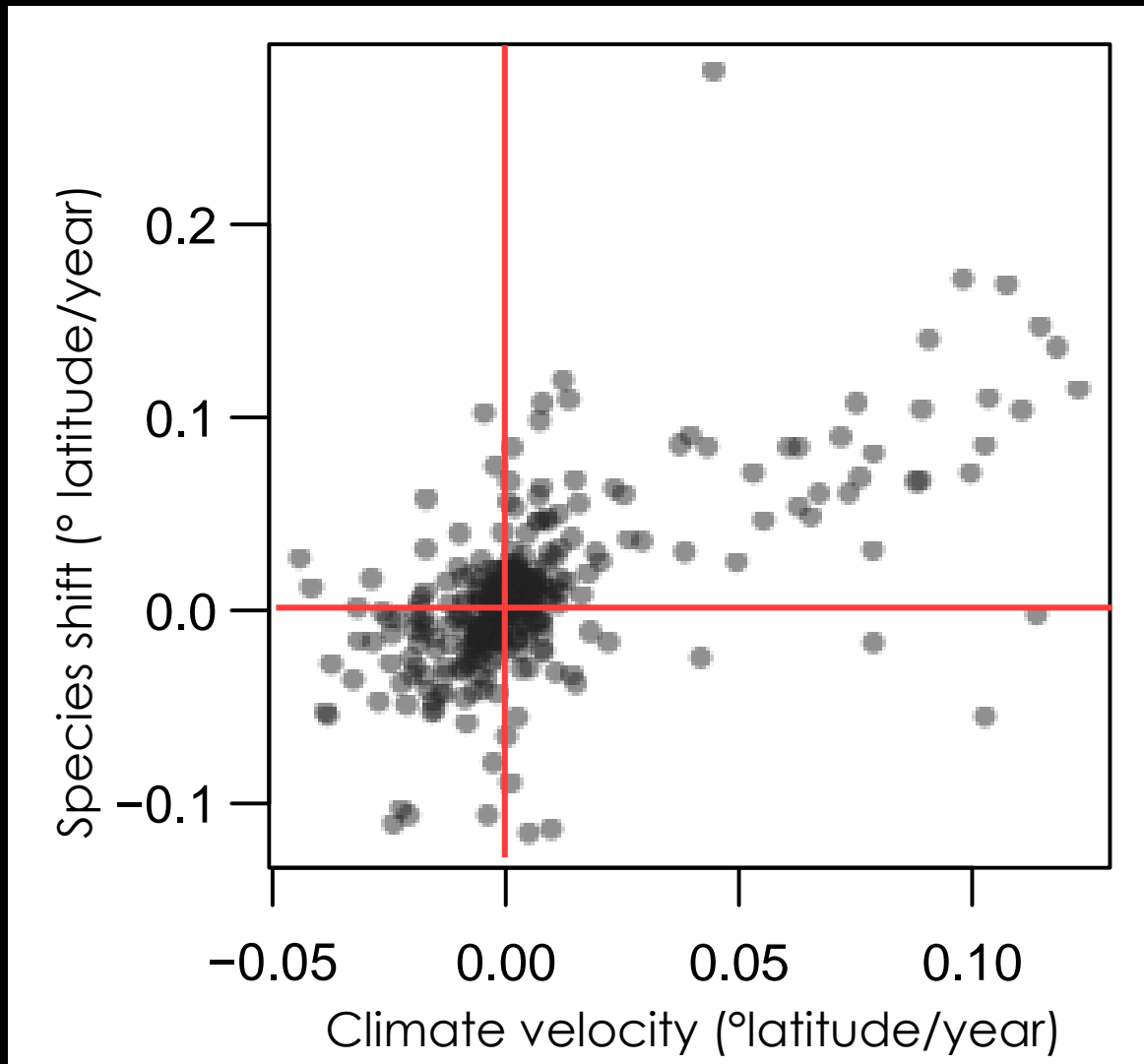
# Across 325 taxa...

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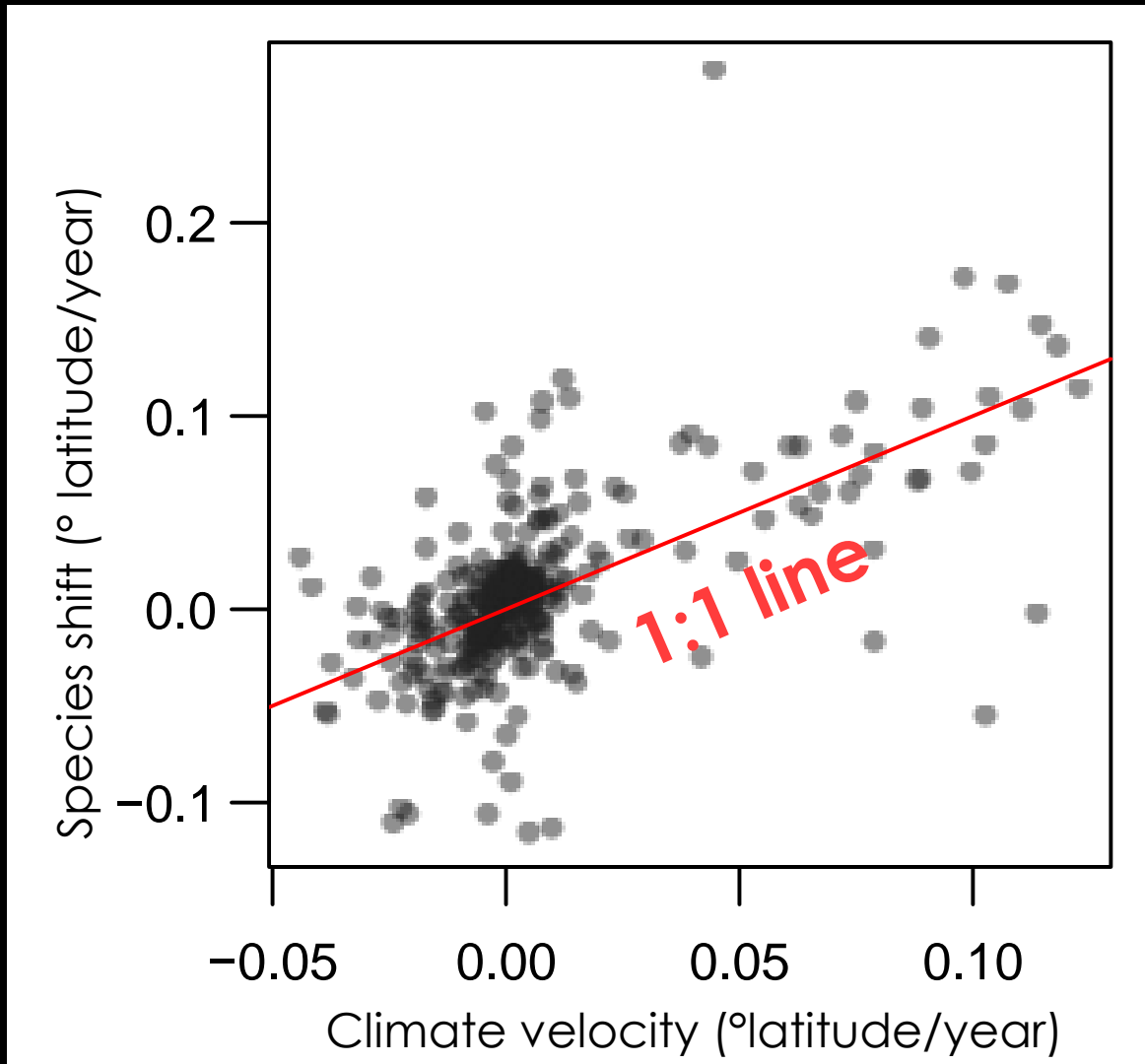
# Species follow climate velocity

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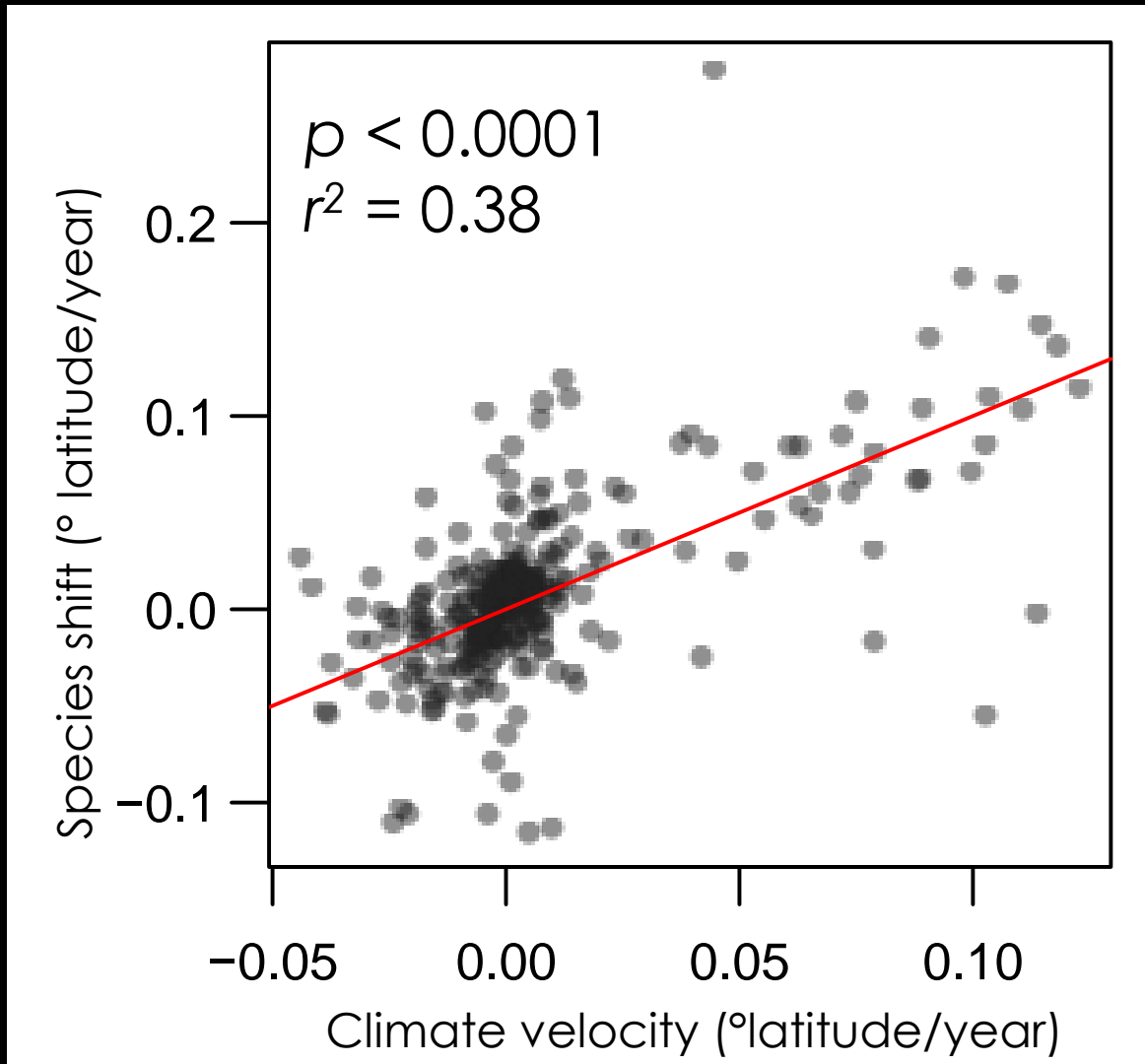


# Species follow climate velocity



# Species follow climate velocity

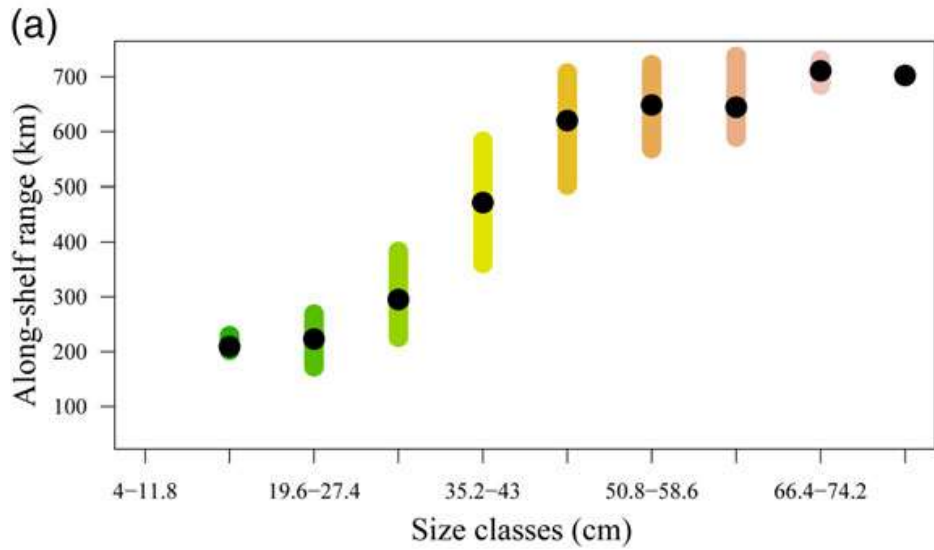
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# Interacting mechanisms

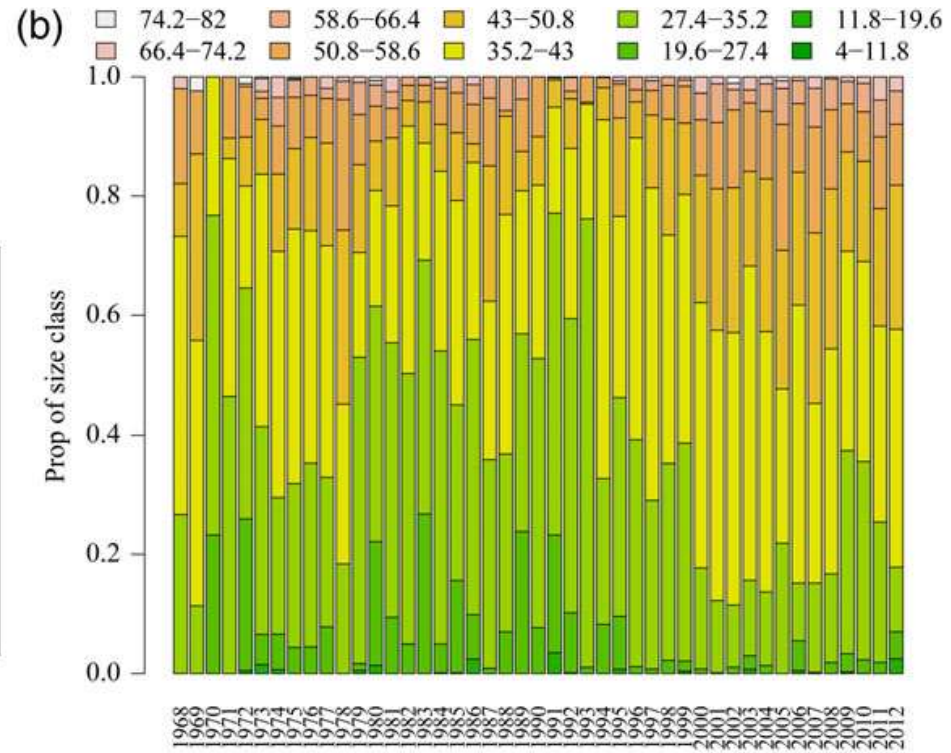
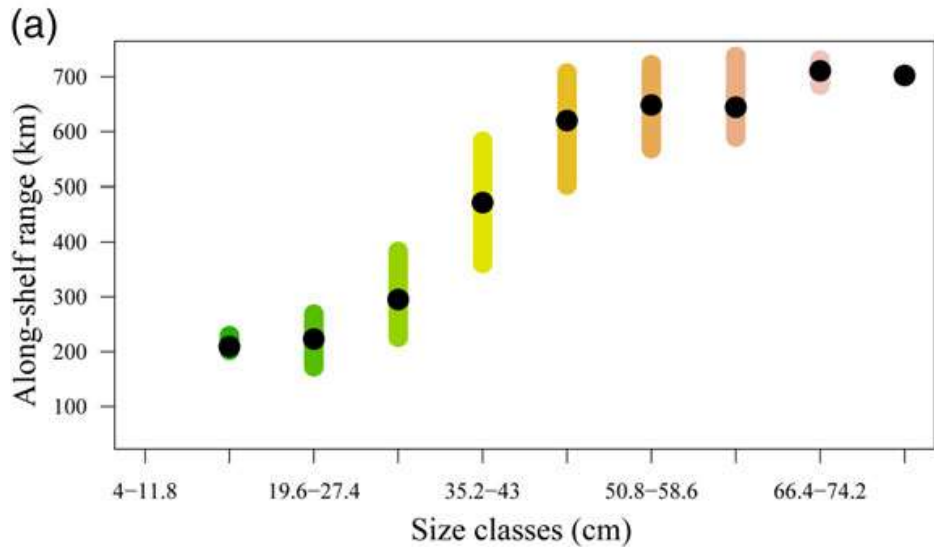
- Predators & prey
- Habitat availability
- Population size
- Fishing pressure

# Summer flounder & recovery



Big fish are further north

# Summer flounder & recovery



There are  
more big fish

# Project goals

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September 2016 to August 2017



Funded by



# Project goals

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1. Develop species distribution projections for 2020-2100



Funded by



# Project goals

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1. Develop species distribution projections for 2020-2100
2. Characterize dominant sources and magnitude of uncertainty



# Project goals

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1. Develop species distribution projections for 2020-2100
2. Characterize dominant sources and magnitude of uncertainty
3. Identify priority species for adaptive management

# Project goals

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1. Develop species distribution projections for 2020-2100
2. Characterize dominant sources and magnitude of uncertainty
3. Identify priority species for adaptive management
4. Incorporate results into a web-based tool

# Focal species

- Summer flounder
- Scup
- Black sea bass
- Monkfish
- Atlantic mackerel
- Illex squid
- Longfin squid
- Butterfish
- Spiny dogfish
- Golden tilefish
- Bluefish
- King mackerel
- Spanish mackerel
- Snowy grouper
- Spanish sardine
- Atlantic thread herring
- Sand lance
- Atlantic menhaden
- Atlantic herring
- Round herring
- Striped anchovy
- Bay anchovy

# Focal species: **managed**

- Summer flounder
- Scup
- Black sea bass
- Monkfish
- Atlantic mackerel
- Illex squid
- Longfin squid
- Butterfish
- Spiny dogfish
- Golden tilefish
- Bluefish
- King mackerel
- Spanish mackerel
- Snowy grouper
- Spanish sardine
- Atlantic thread herring
- Sand lance
- Atlantic menhaden
- Atlantic herring
- Round herring
- Striped anchovy
- Bay anchovy

# Focal species: **emerging species?**

- Summer flounder
  - Scup
  - Black sea bass
  - Monkfish
  - Atlantic mackerel
  - Illex squid
  - Longfin squid
  - Butterfish
  - Spiny dogfish
  - Golden tilefish
  - Bluefish
- King mackerel
  - Spanish mackerel
  - Snowy grouper
  - Spanish sardine
  - Atlantic thread herring
  - Sand lance
  - Atlantic menhaden
  - Atlantic herring
  - Round herring
  - Striped anchovy
  - Bay anchovy

# Focal species: forage

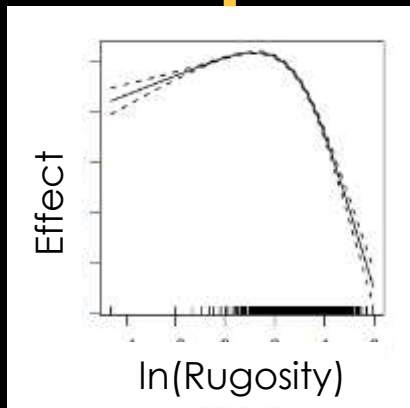
- Summer flounder
- Scup
- Black sea bass
- Monkfish
- Atlantic mackerel
- Illex squid
- Longfin squid
- Butterfish
- Spiny dogfish
- Golden tilefish
- Bluefish
- King mackerel
- Spanish mackerel
- Snowy grouper
- Spanish sardine
- Atlantic thread herring
- Sand lance
- Atlantic menhaden
- Atlantic herring
- Round herring
- Striped anchovy
- Bay anchovy

# Focal species: **in progress**

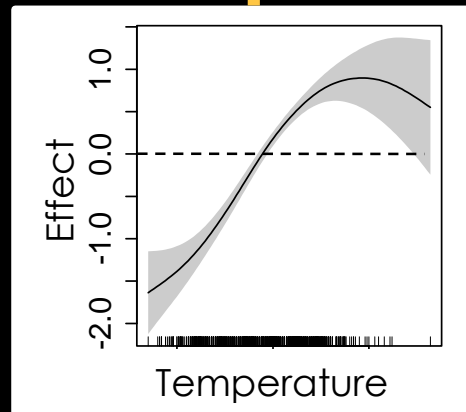
- Summer flounder
- Scup
- Black sea bass
- Monkfish
- Atlantic mackerel
- Illex squid
- Longfin squid
- Butterfish
- Spiny dogfish
- **Golden tilefish**
- Bluefish
- **King mackerel**
- Spanish mackerel
- **Snowy grouper**
- Spanish sardine
- Atlantic thread herring
- **Sand lance**
- **Atlantic menhaden**
- Atlantic herring
- Round herring
- Striped anchovy
- Bay anchovy

# Approach

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Habitat preferences



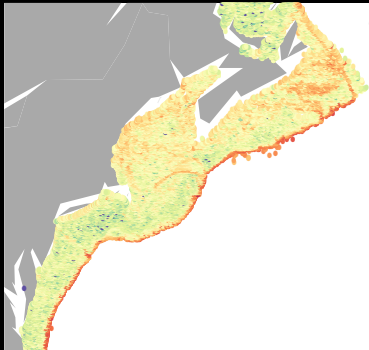
Temperature preferences



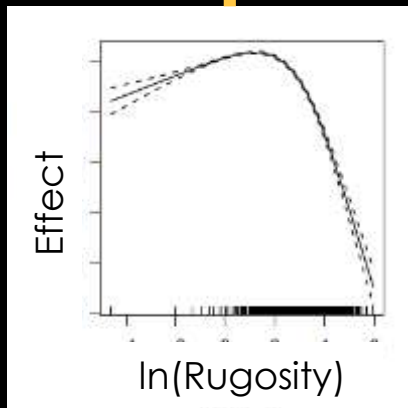
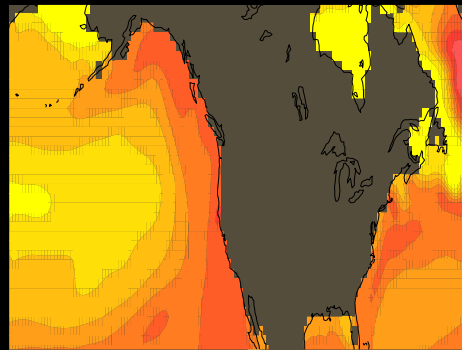
# Approach

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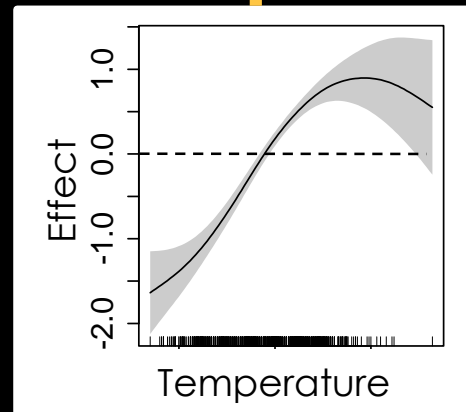
Bottom habitat



Climate projections



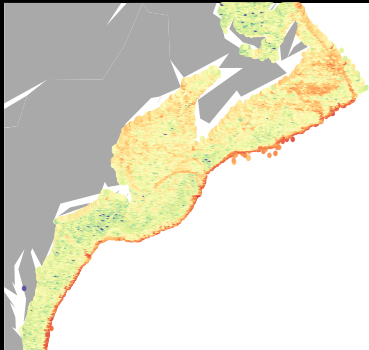
Habitat preferences



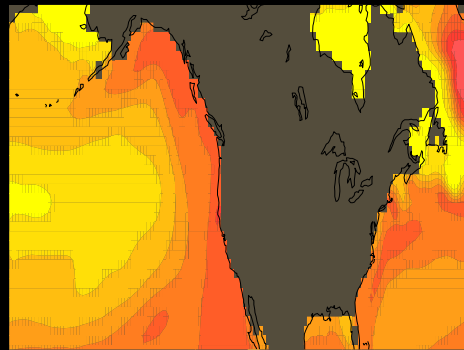
Temperature preferences

# Approach

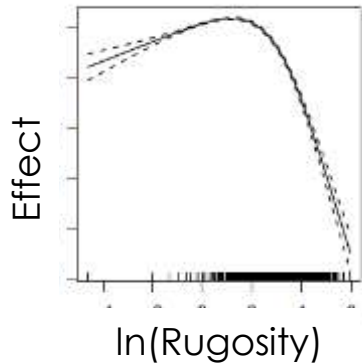
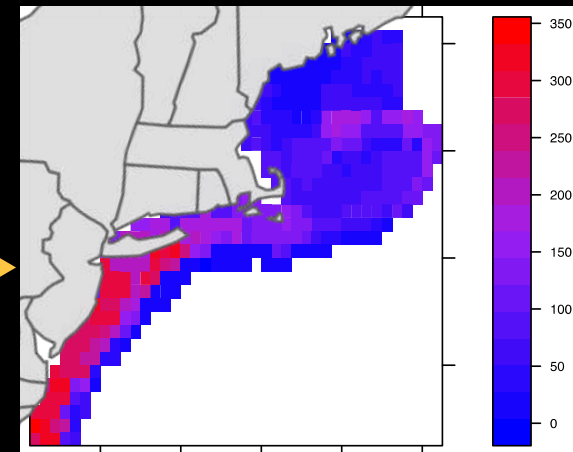
Bottom habitat



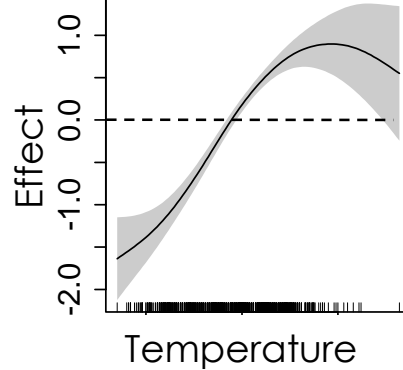
Climate projections



Species Distribution Projections

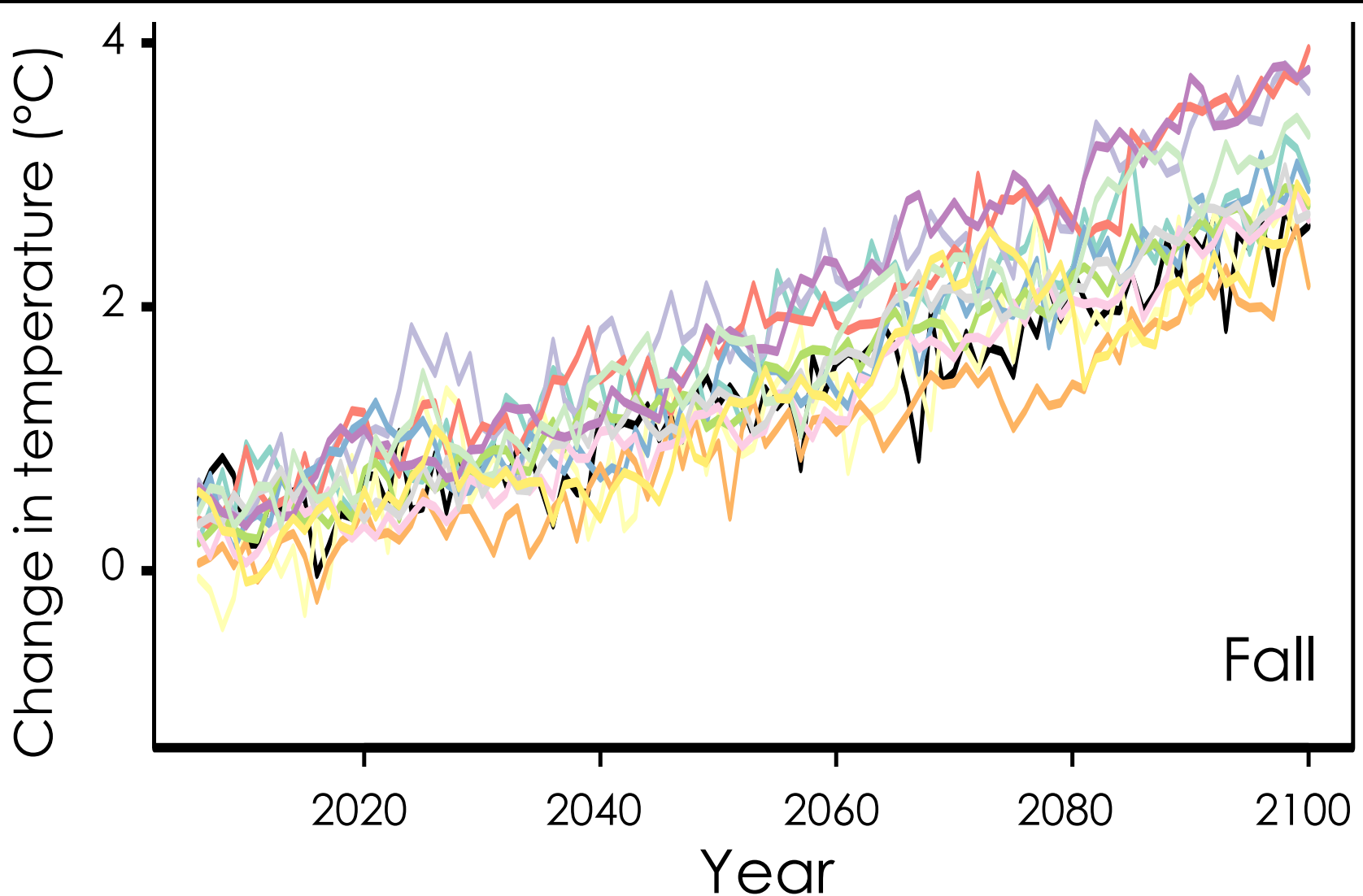


Habitat preferences



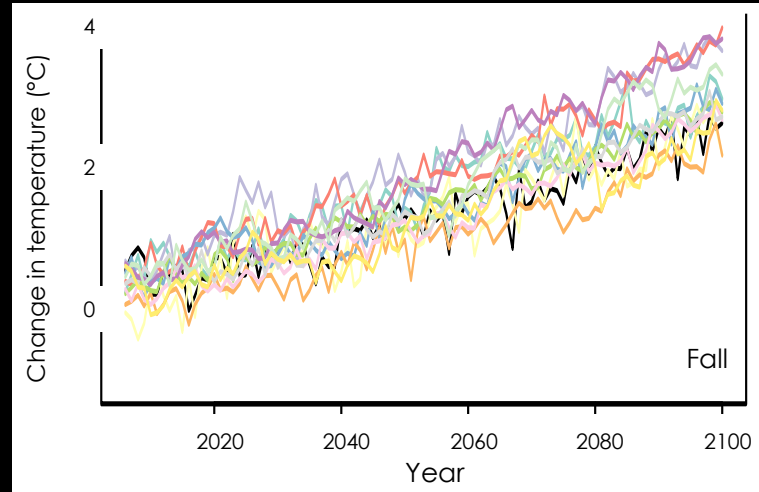
Temperature preferences

# Range of future scenarios



# Ensemble of projections

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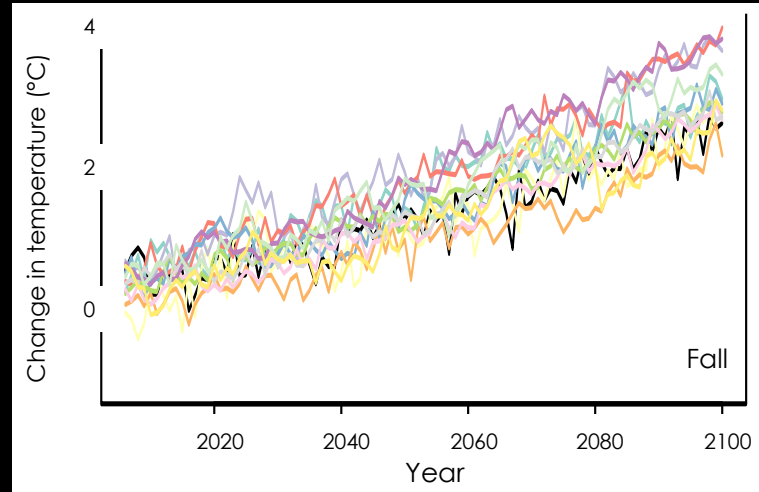


2

climate scenarios  
RCP 4.5 and 8.5

# Ensemble of projections

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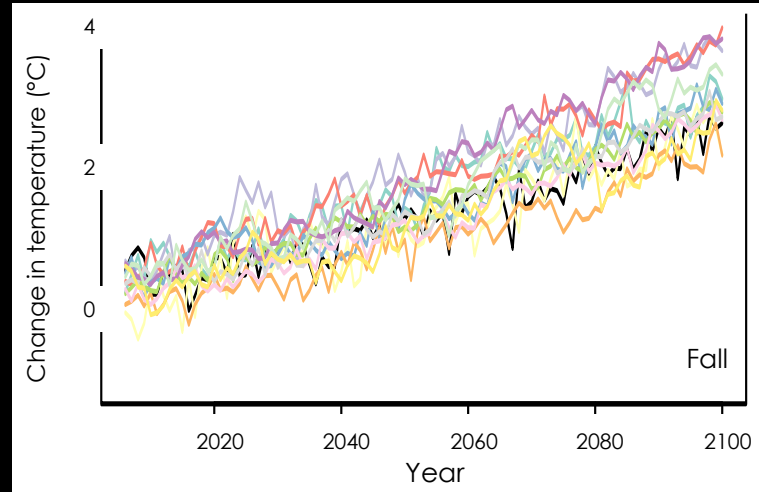
2 x 13

climate scenarios  
RCP 4.5 and 8.5

global climate  
models

# Ensemble of projections

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2 x 13 x 5

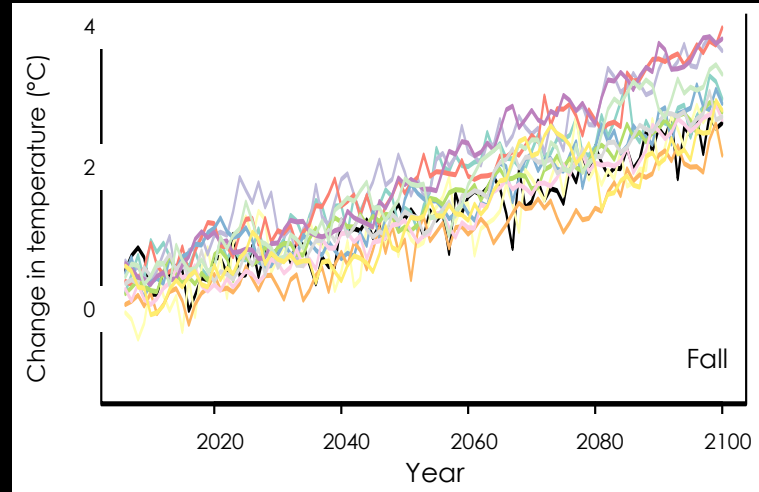
climate scenarios  
RCP 4.5 and 8.5

global climate  
models

time periods

# Ensemble of projections

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$$2 \times 13 \times 5$$

climate scenarios  
RCP 4.5 and 8.5

global climate  
models

time periods

= 130 projections/species

# Assumptions

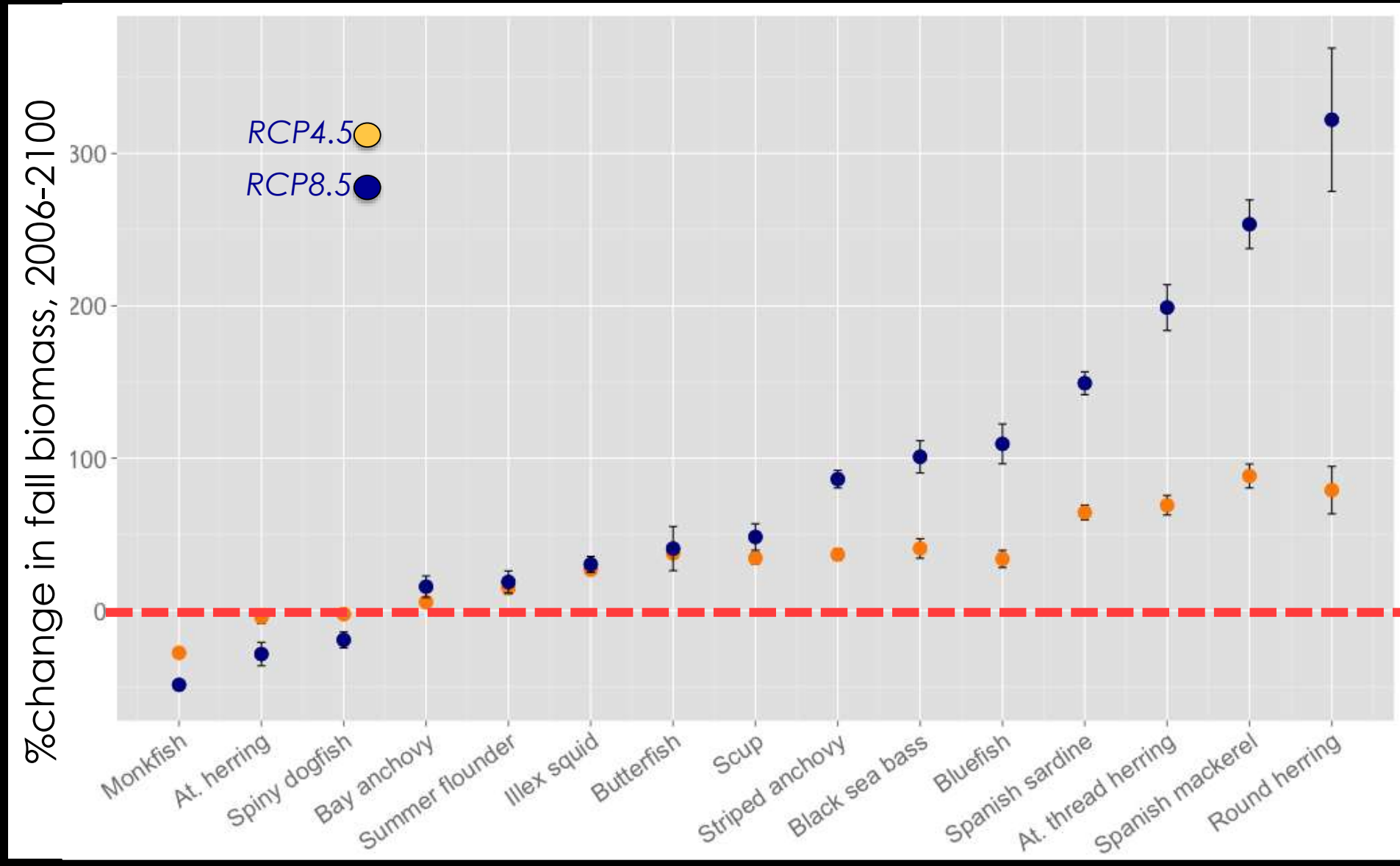
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- Fishing stays constant
- Species interactions stay constant
- Ocean productivity constant
- Species can move quickly

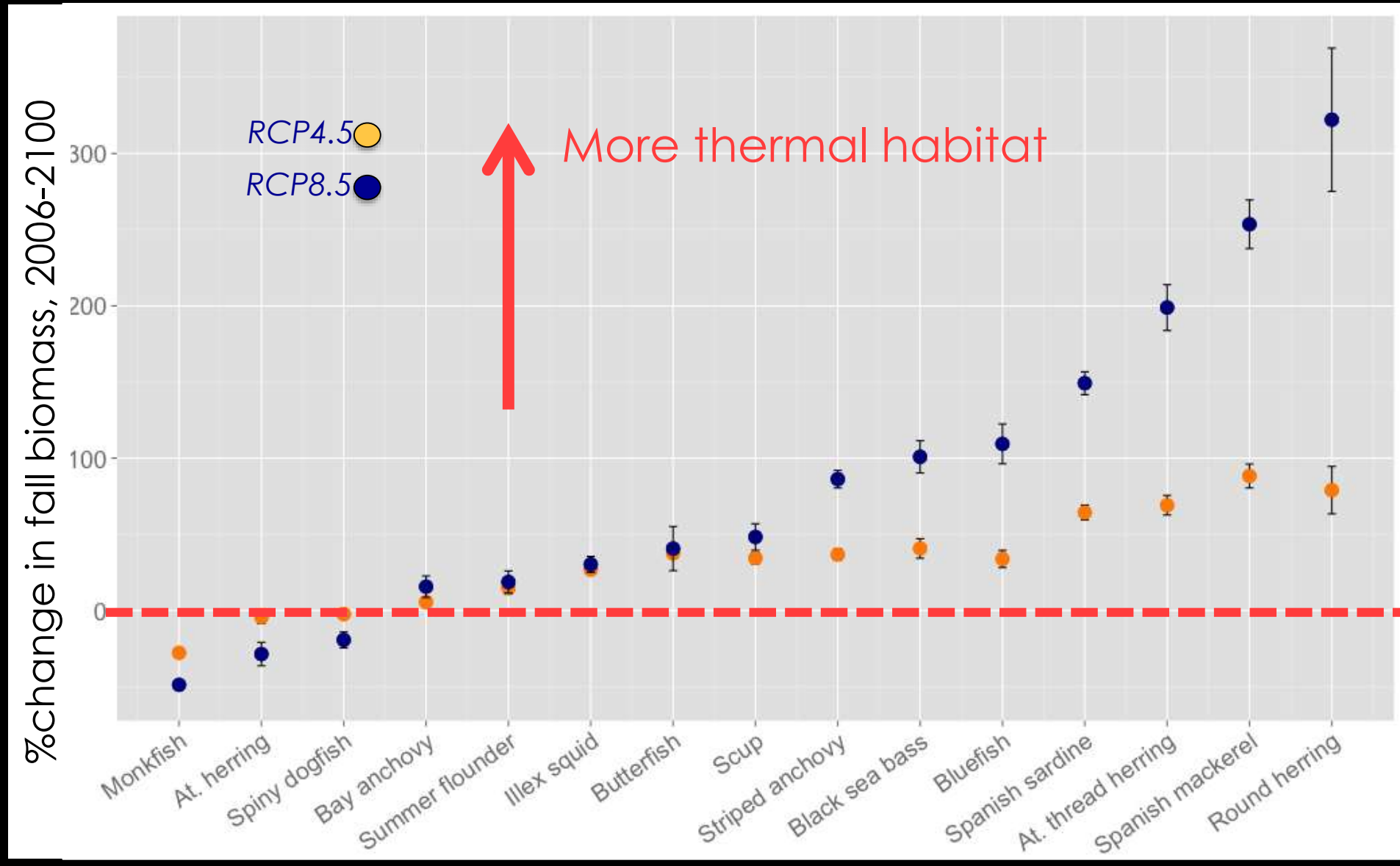


Preliminary results

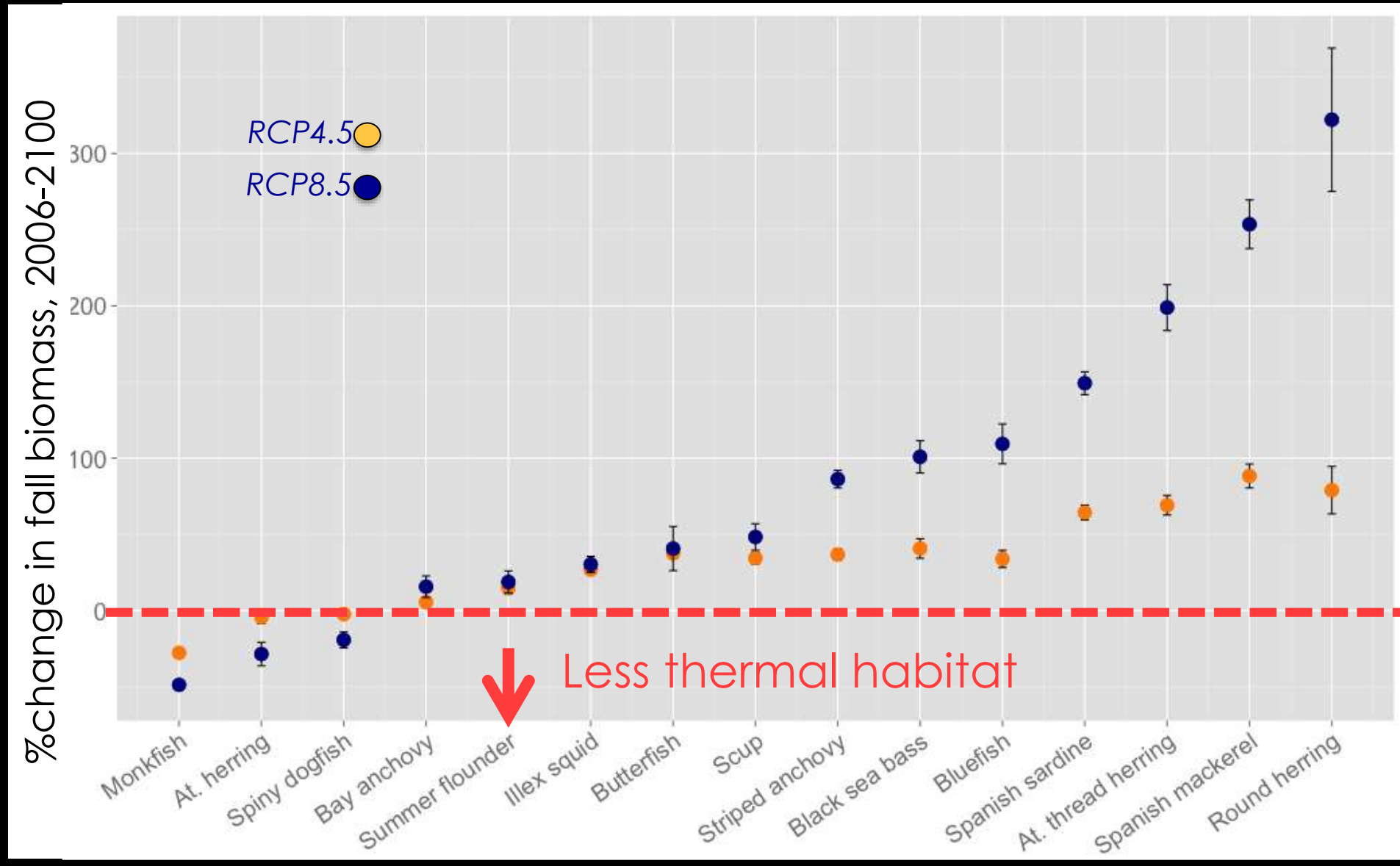
# Winners and losers across the NEUS



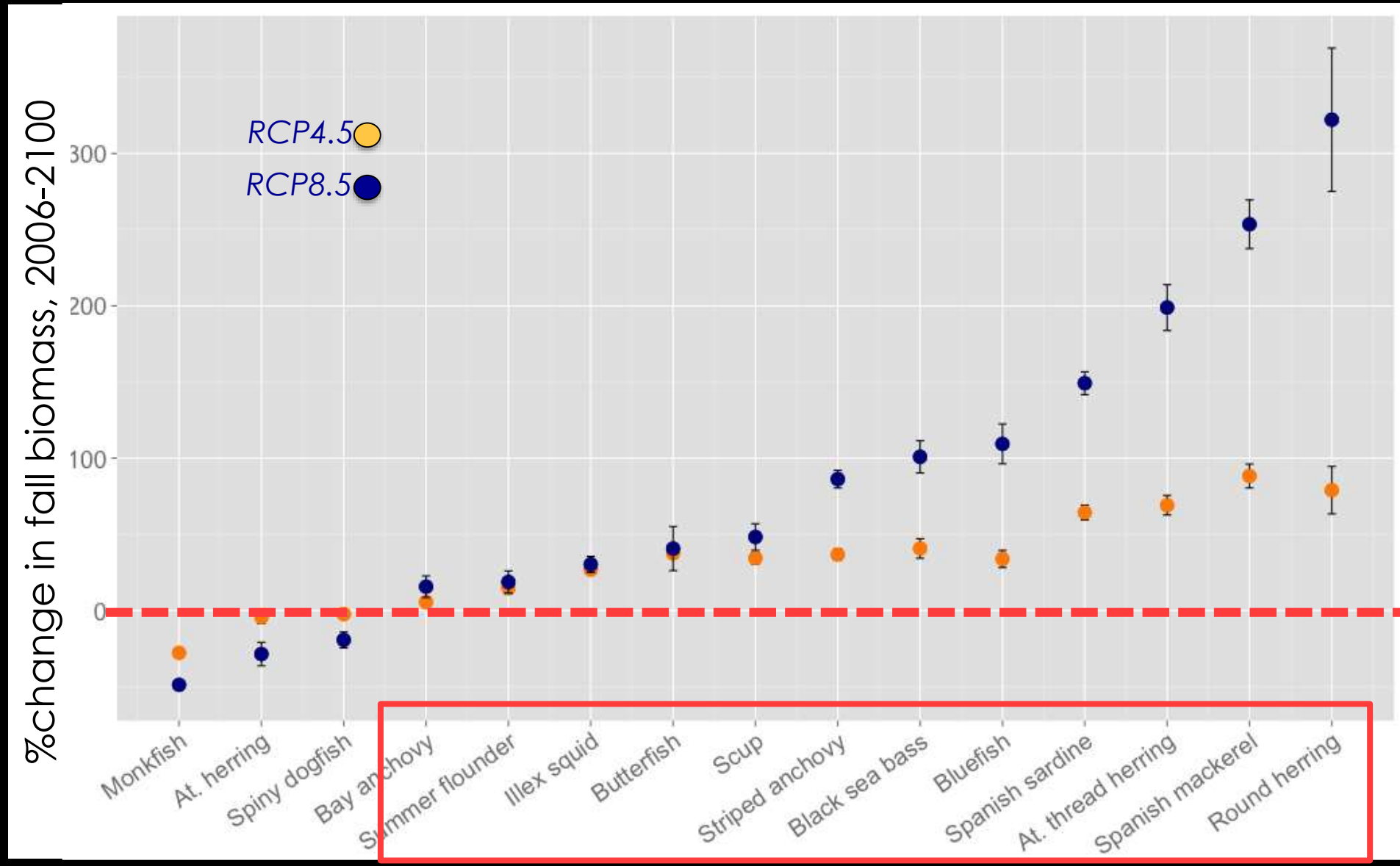
# Winners and losers across the NEUS



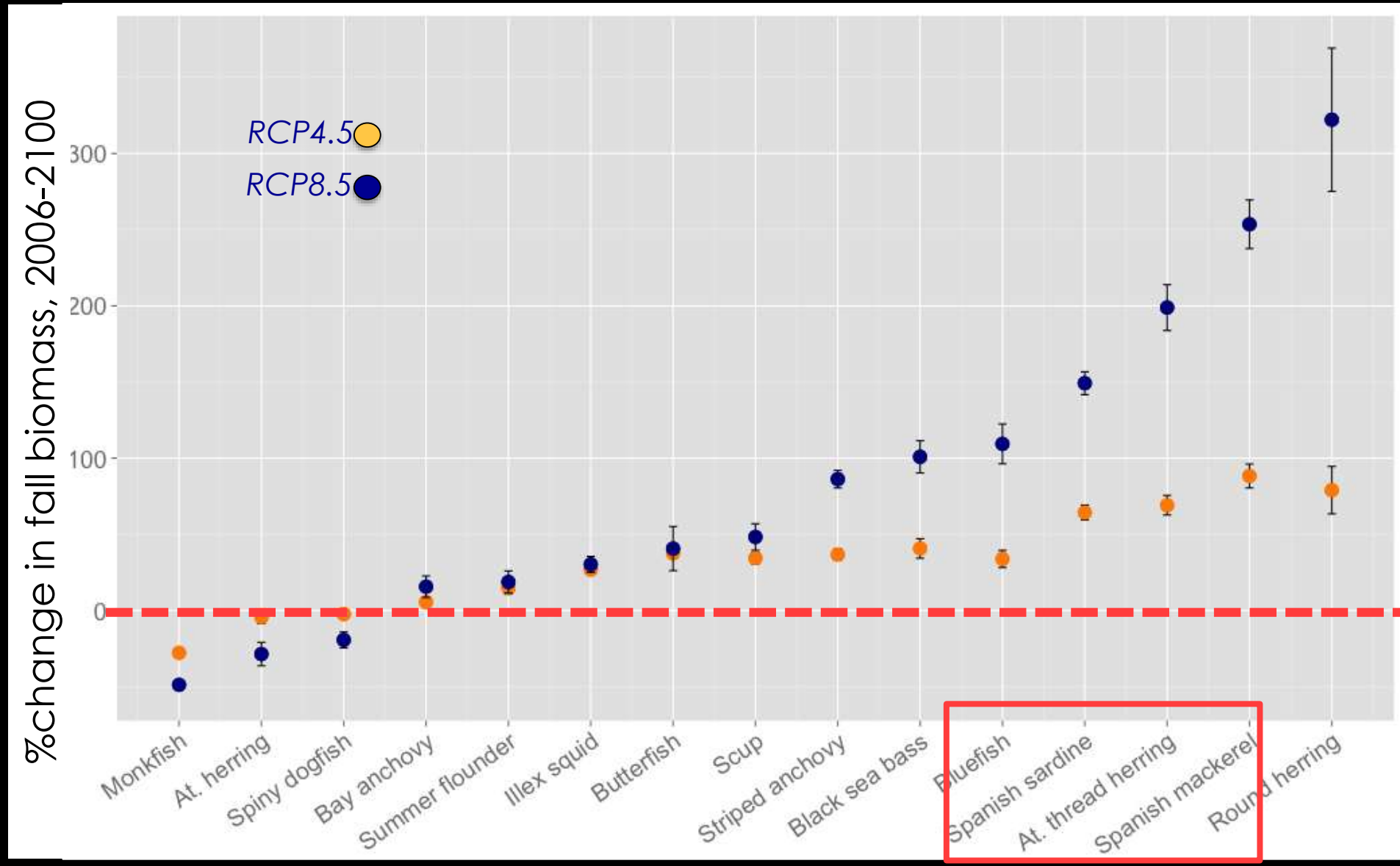
# Winners and losers across the NEUS



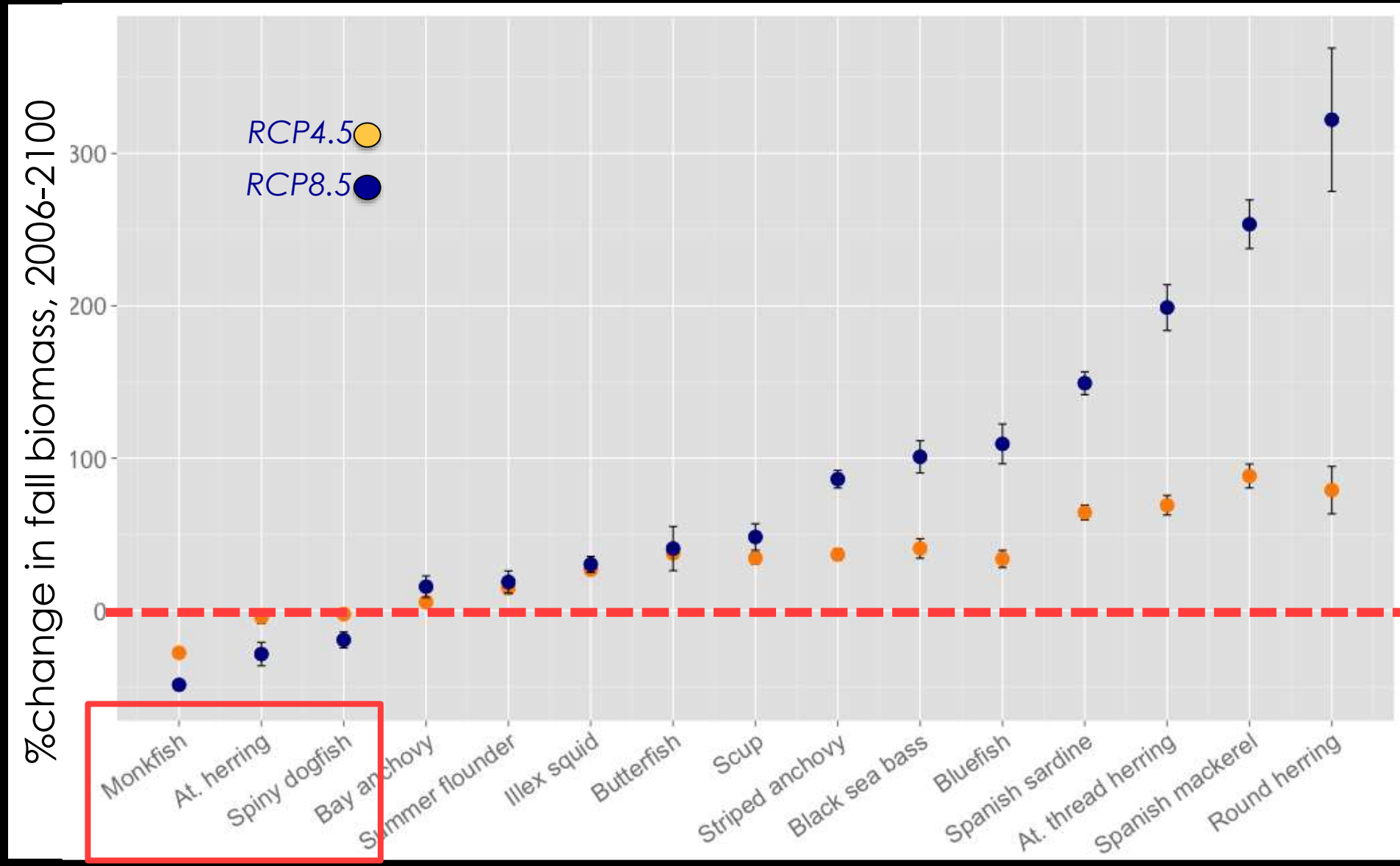
# Winners and losers across the NEUS



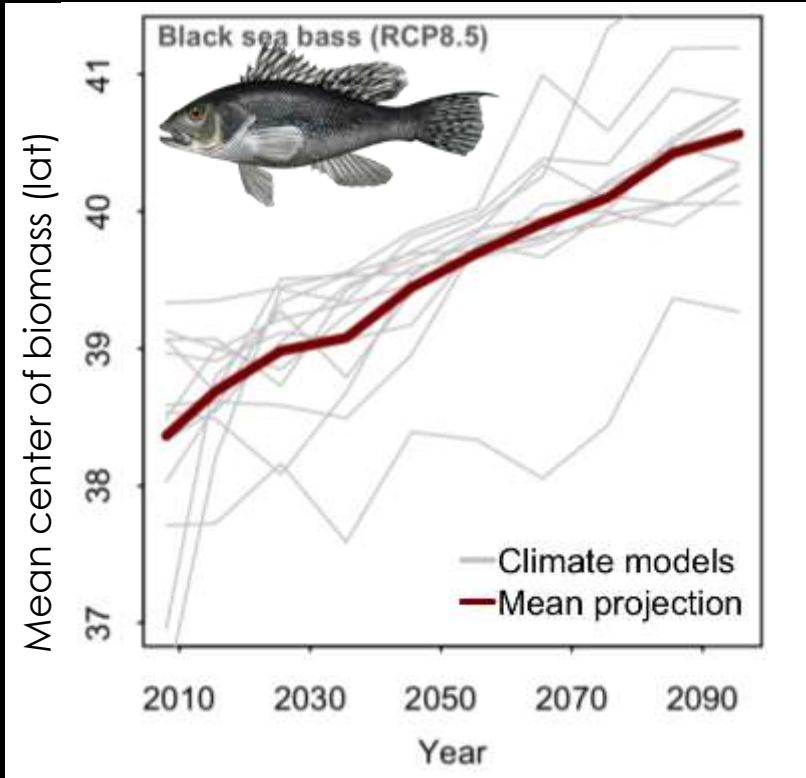
# Winners and losers across the NEUS



# Winners and losers across the NEUS



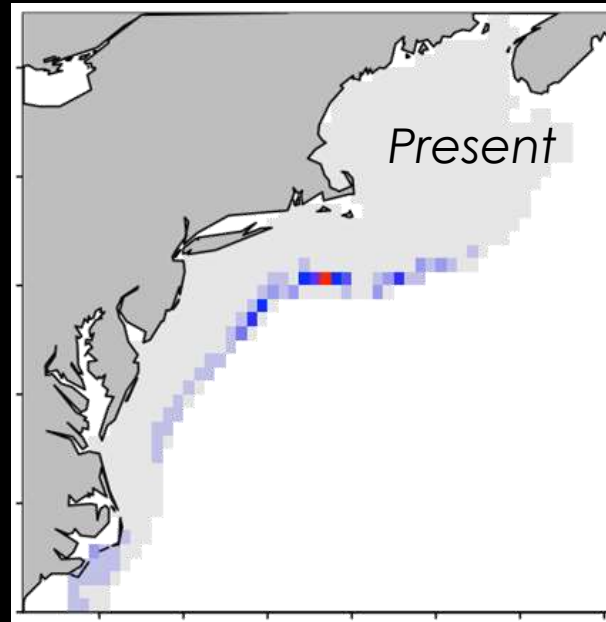
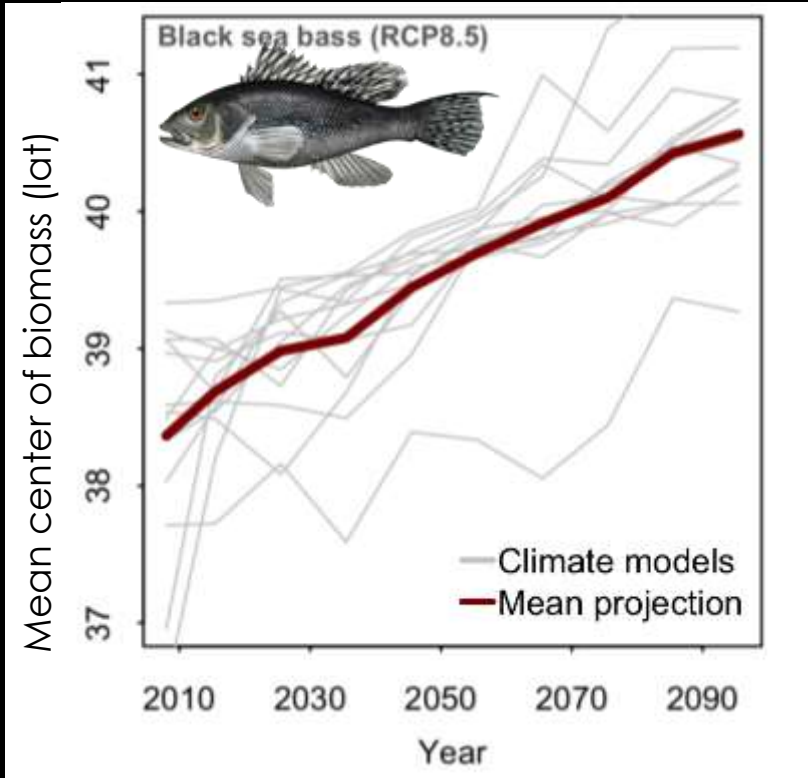
# Black sea bass (spring)



Business as usual (RCP 8.5)

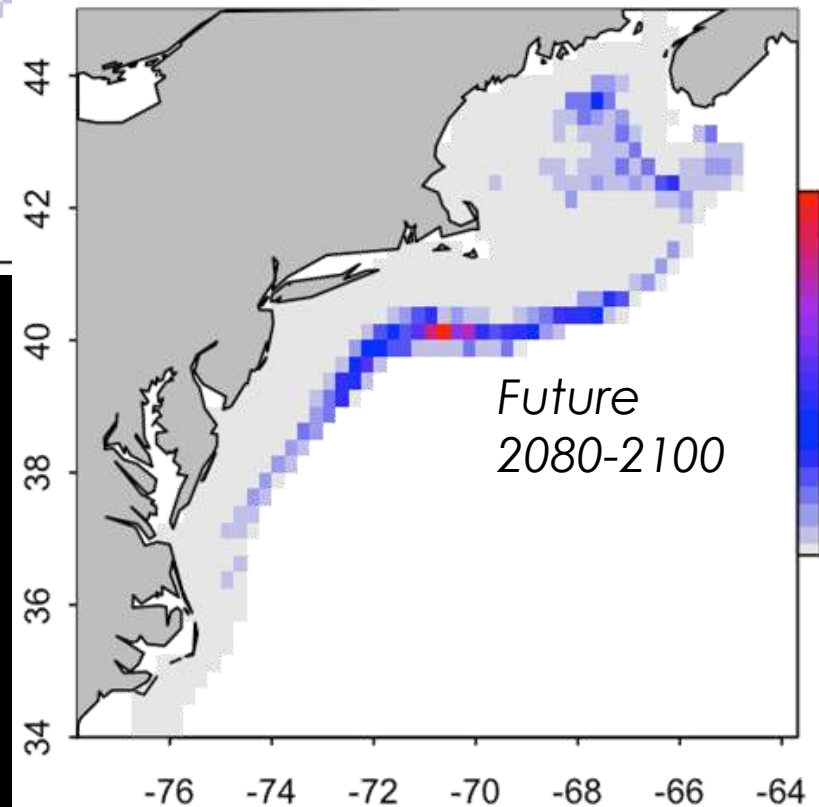
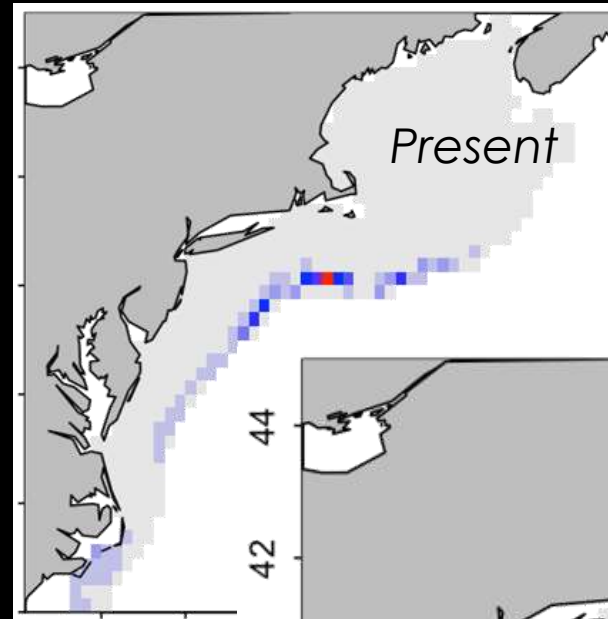
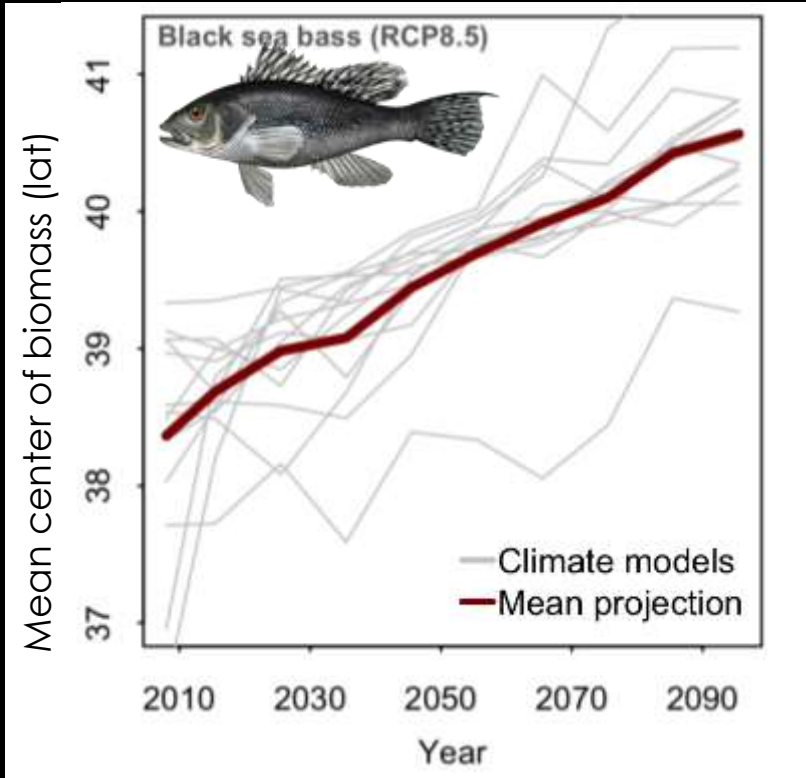


# Black sea bass (spring)



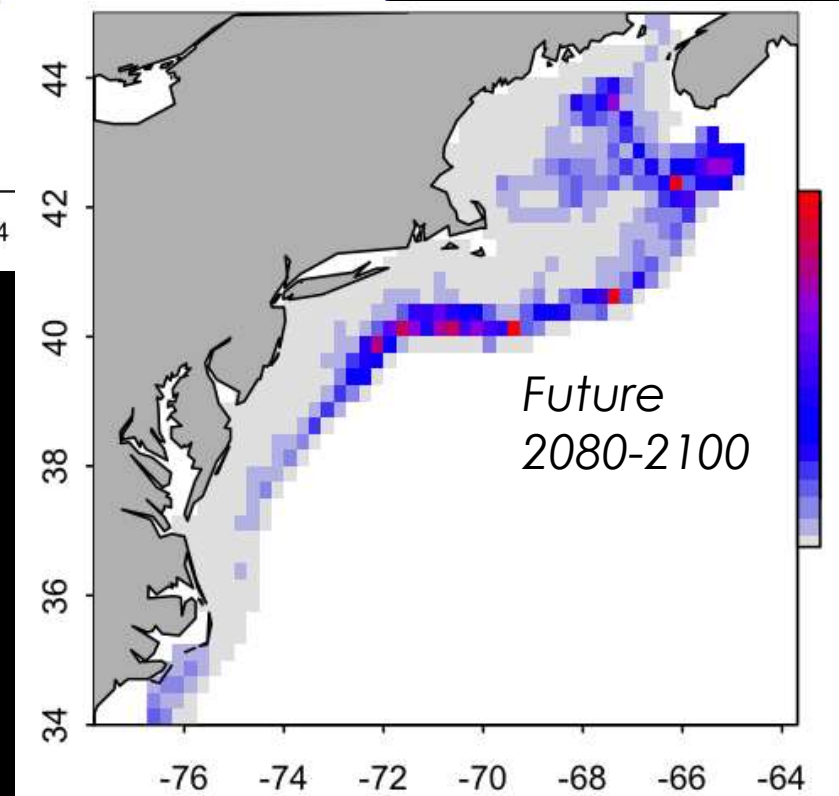
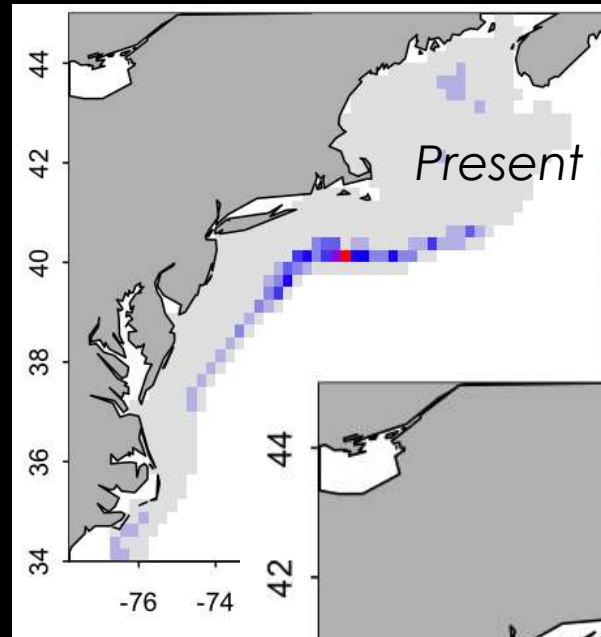
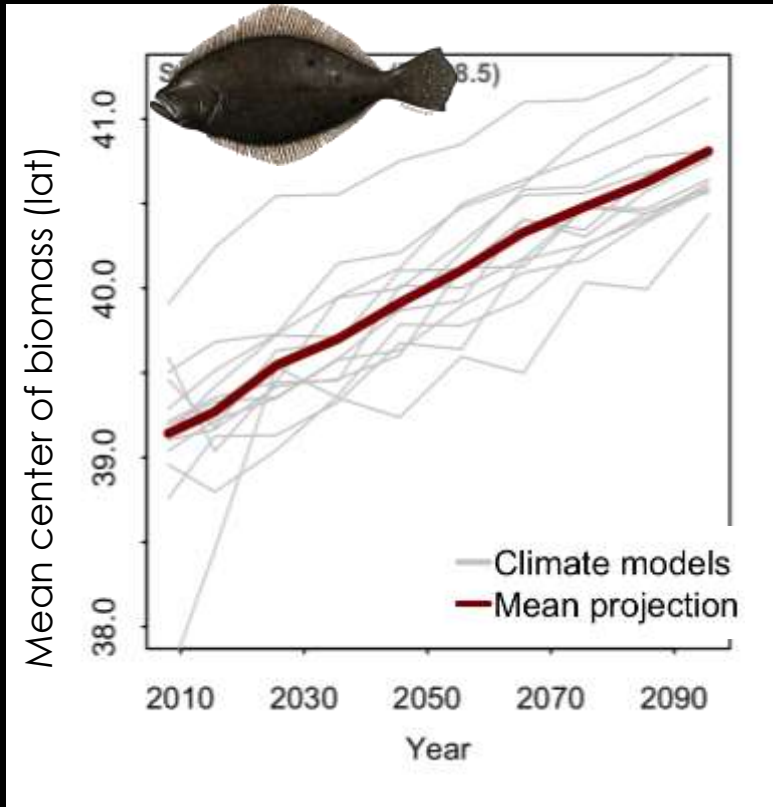
Business as usual (RCP 8.5)

# Black sea bass (spring)



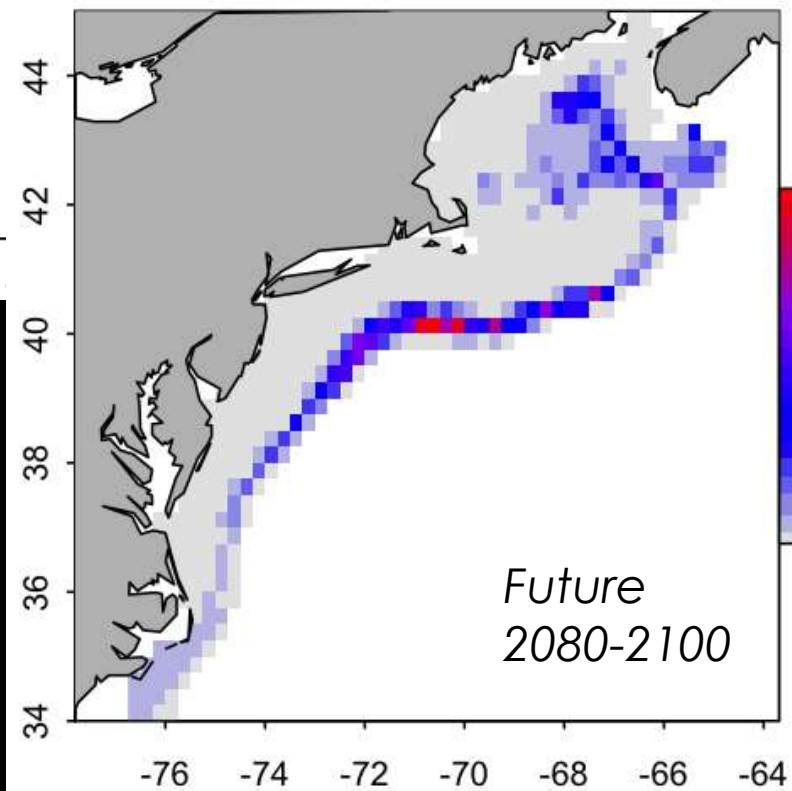
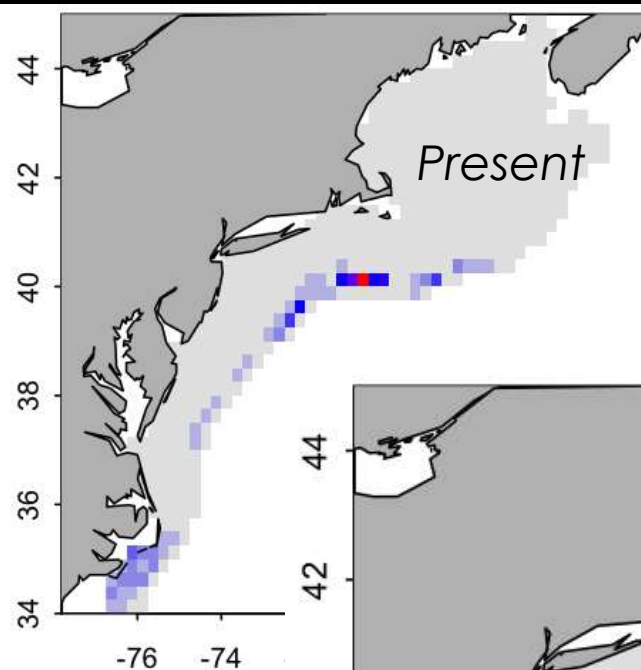
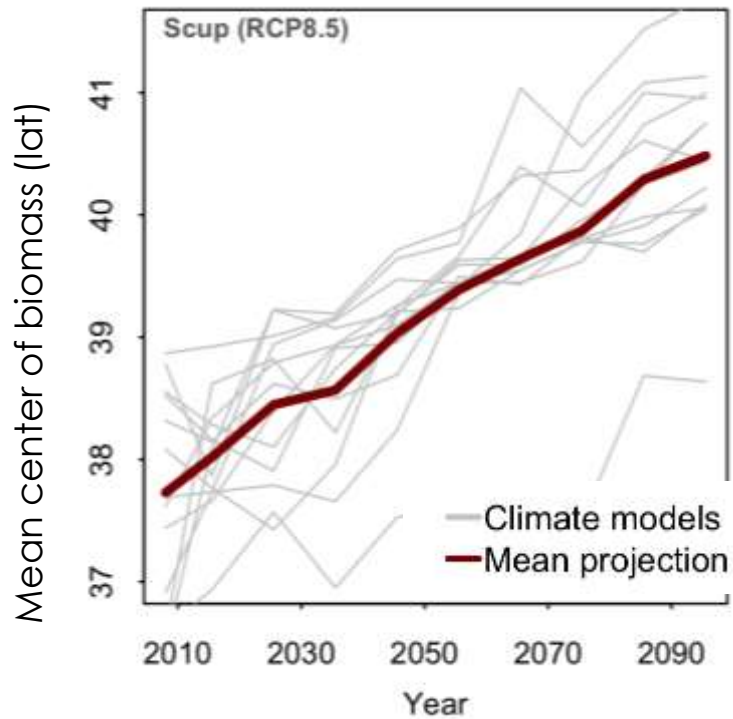
Business as usual (RCP 8.5)

# Summer flounder (spring)



Business as usual (RCP 8.5)

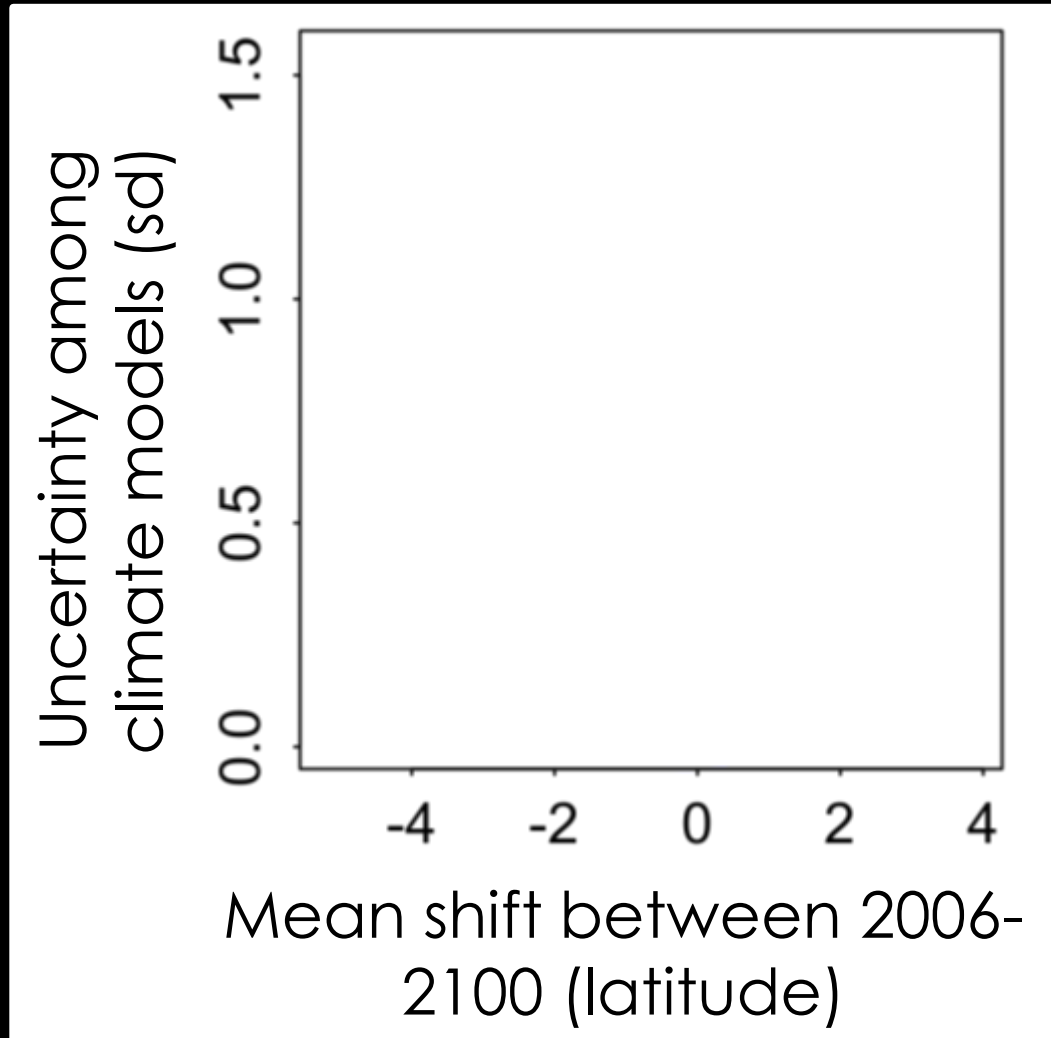
# Scup (spring)



Business as usual (RCP 8.5)

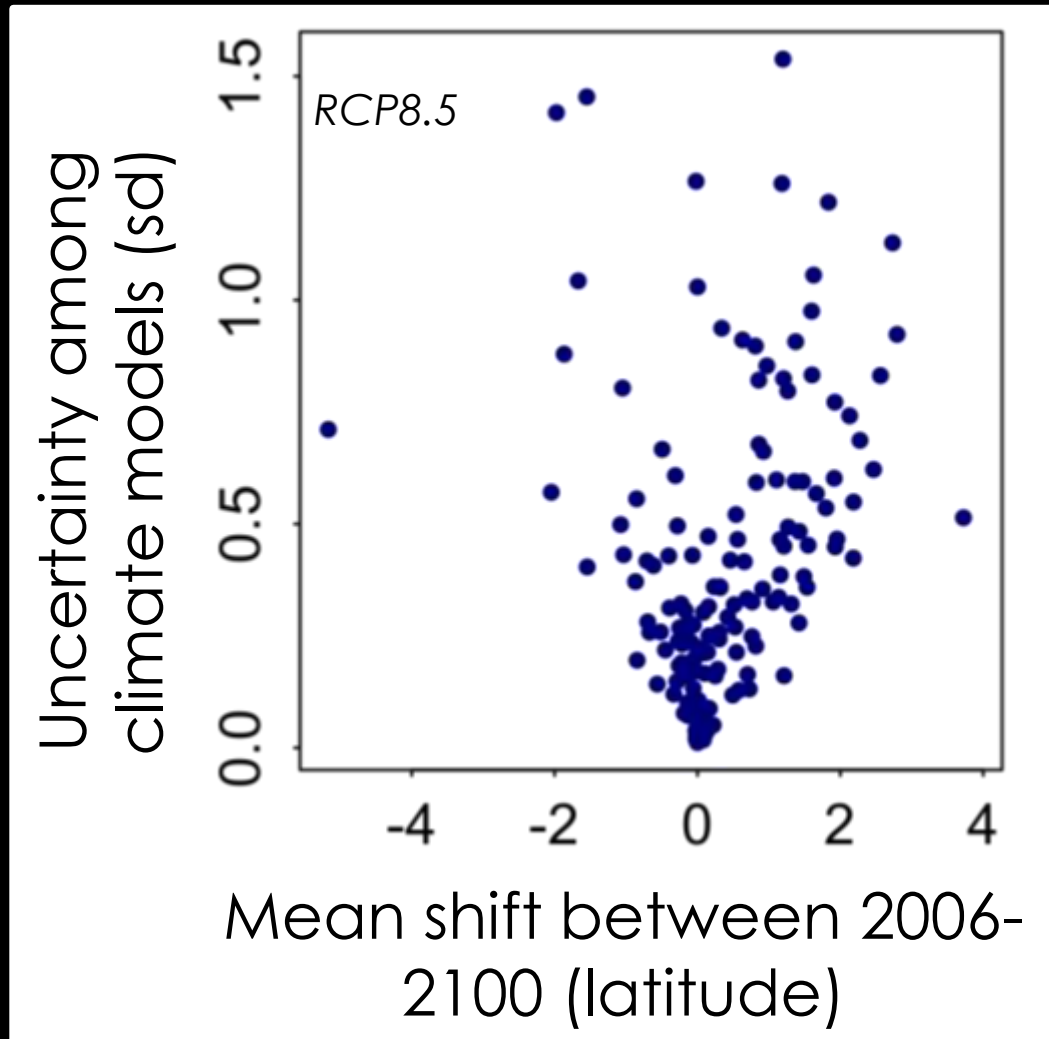
# Characterizing uncertainty

---

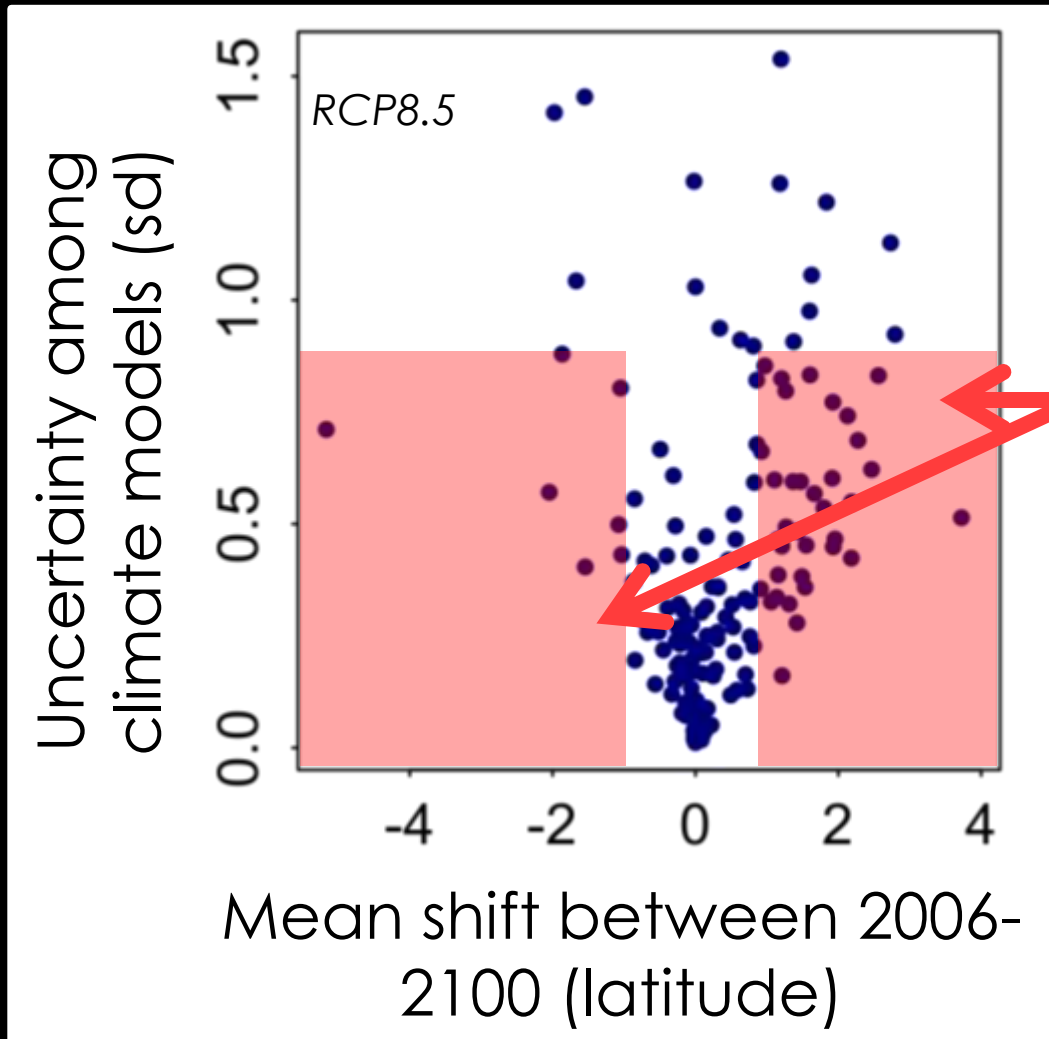


# Characterizing uncertainty

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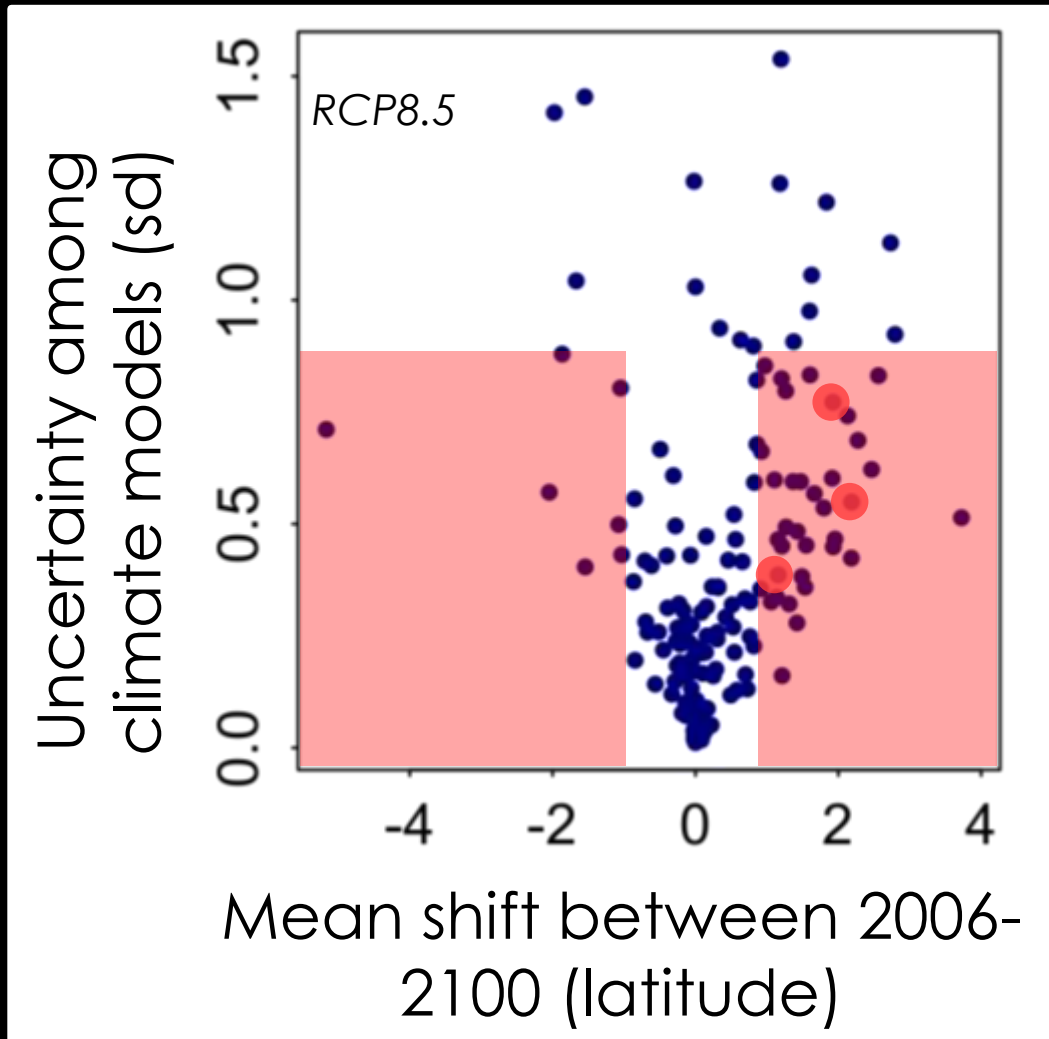
# Characterizing uncertainty



Large shift &  
Higher certainty

# Characterizing uncertainty

---



*bluefish*

*butterfish*

*summer flounder*



# Ongoing research

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- New data sources and missing species
  - NEAMAP, SEAMAP, MARMAP

# Ongoing research

- New data sources and missing species
  - NEAMAP, SEAMAP, MARMAP
- Uncertainty
  - Ecological model and parameter

# Ongoing research

---

- New data sources and missing species
  - NEAMAP, SEAMAP, MARMAP
- Uncertainty
  - Ecological model and parameter
- Projections posted on OceanAdapt

# <http://oceanadapt.rutgers.edu>

This page allows you to explore changes in the distribution of marine animals in the U.S. by region. Select "All" to graph the average change in species' distributions from the initial year. Choose a specific species to plot the latitude and depth for the center of its distribution, or to show animated maps of its distribution over time.

SELECT A REGION:

- NORTHEAST US FALL
- ALEUTIAN ISLANDS
- EASTERN BERING SEA
- GULF OF ALASKA
- GULF OF MEXICO
- NORTHEAST US FALL
- NORTHEAST US SPRING
- SOUTHEAST US FALL
- SOUTHEAST US SPRING**
- SOUTHEAST US SUMMER
- WEST COAST ANNUAL
- WEST COAST TRIENNIAL

SHOW:  COMMON

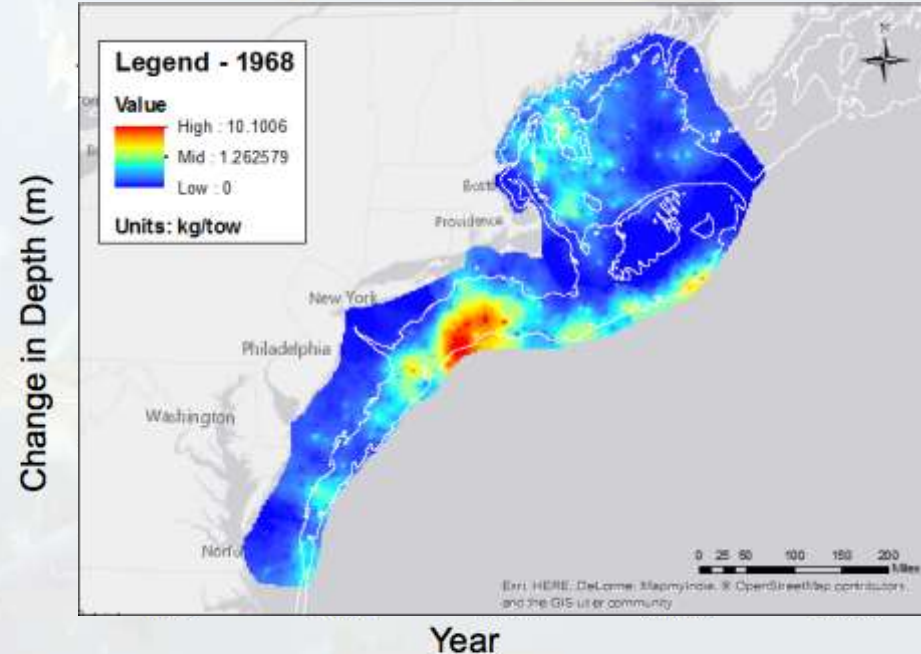
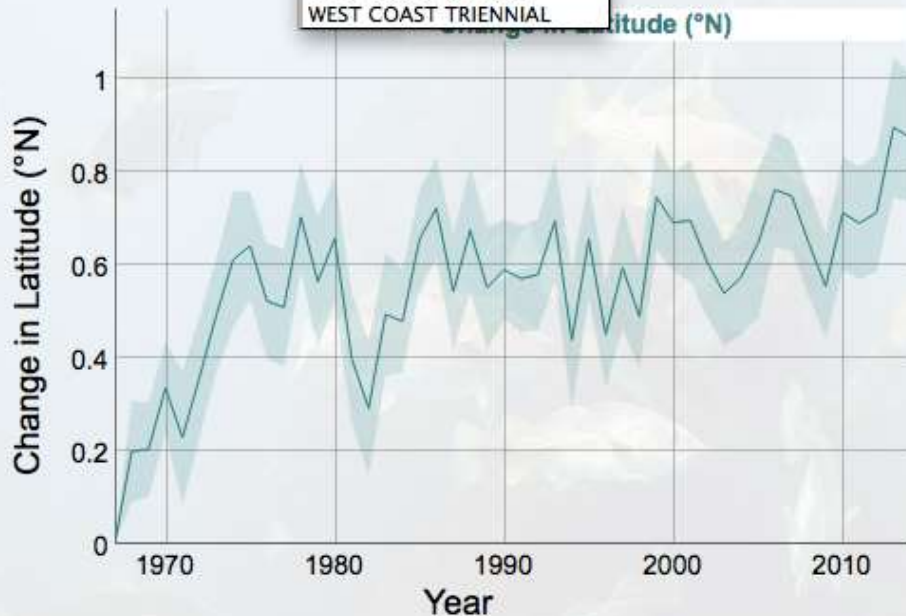
SCIENTIFIC SPECIES NAME

SELECT A SPECIES

SCIENTIFIC SPECIES NAME

VIEWS: **ALL** |

CHANGE IN DEPTH |



# 1. Address the basics

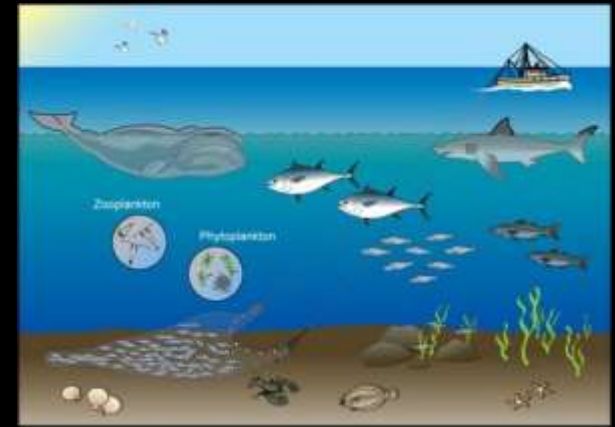
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Intact habitat



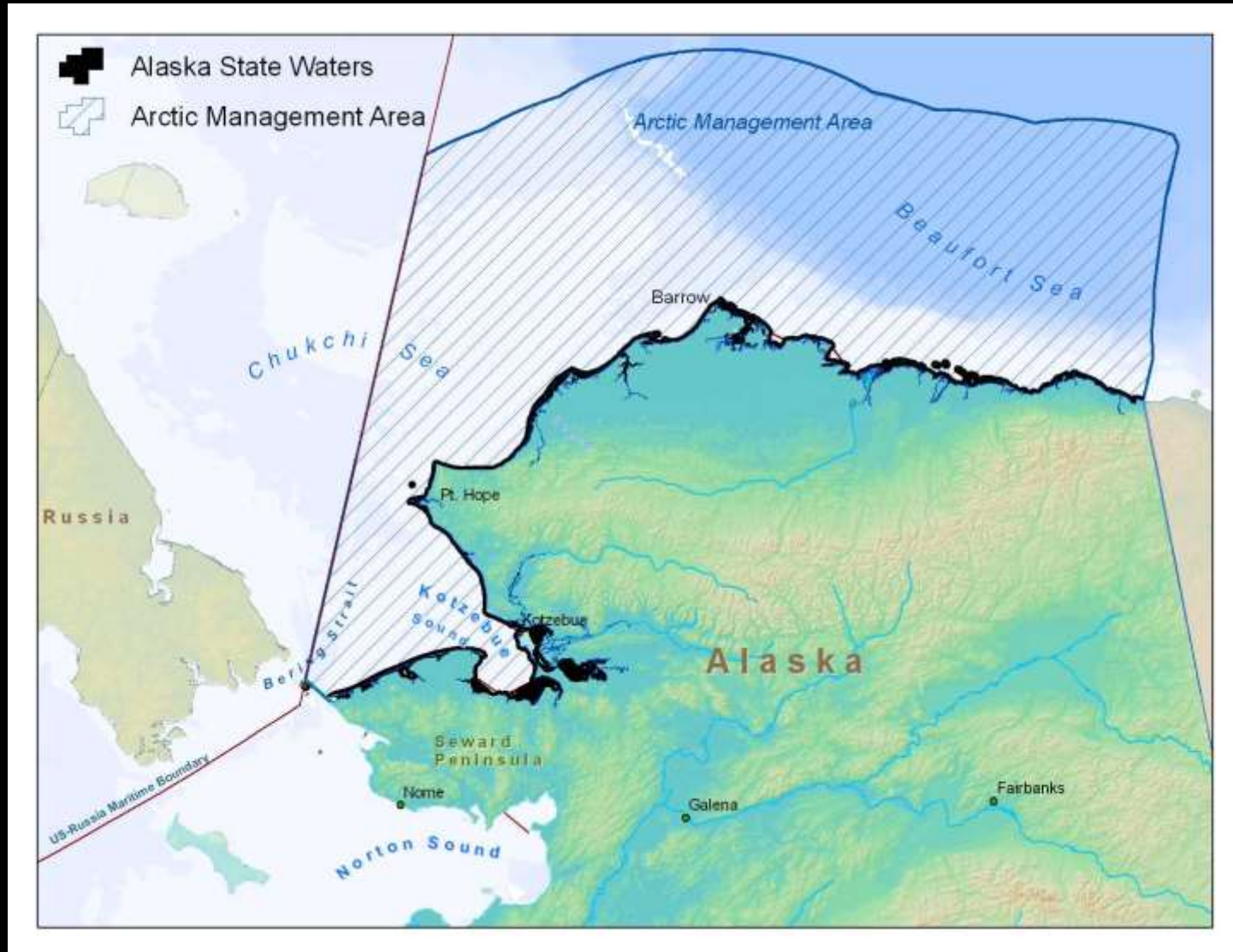
Sustainable fishing



Healthy ecosystems/  
abundant prey

## 2. Prepare for emerging fisheries

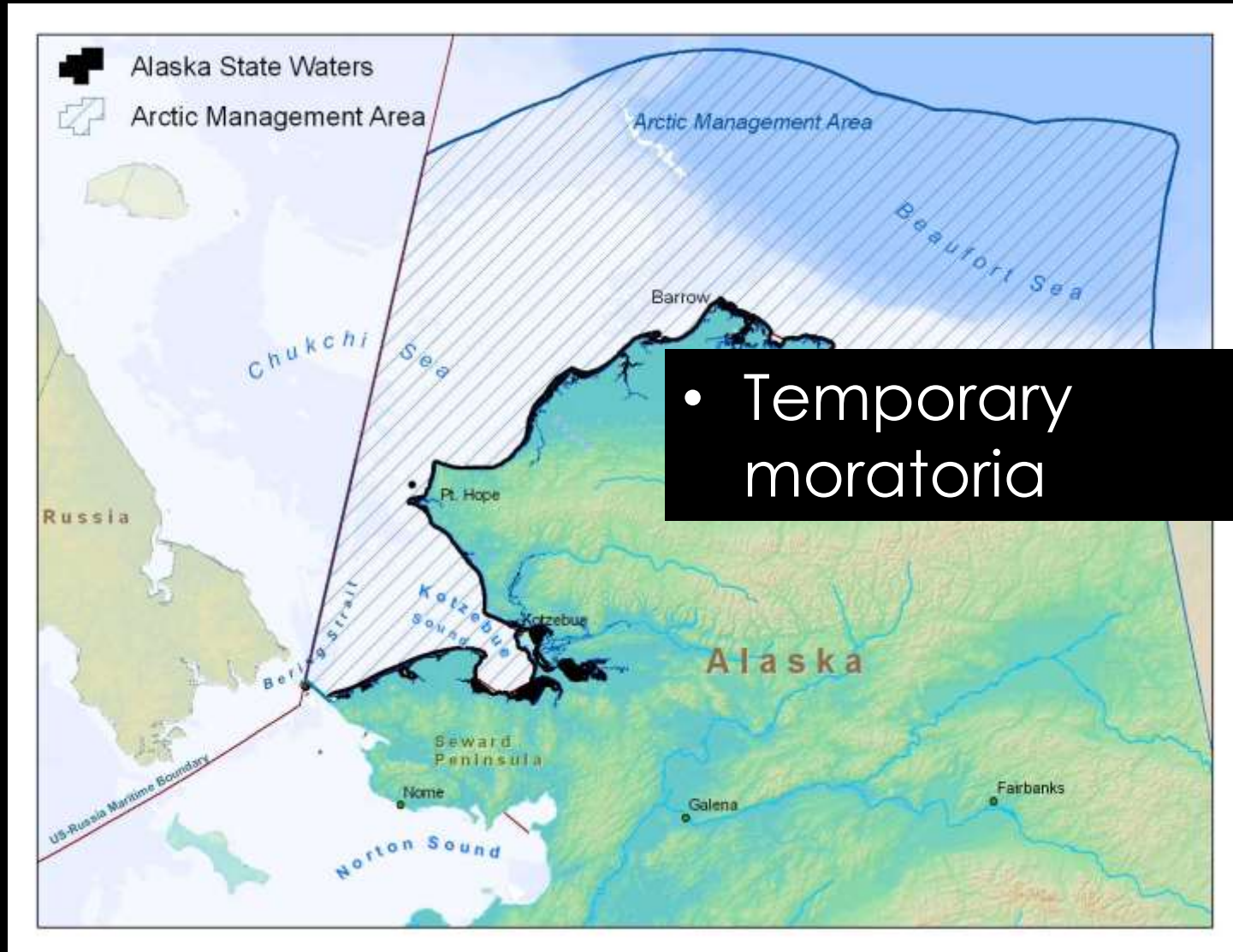
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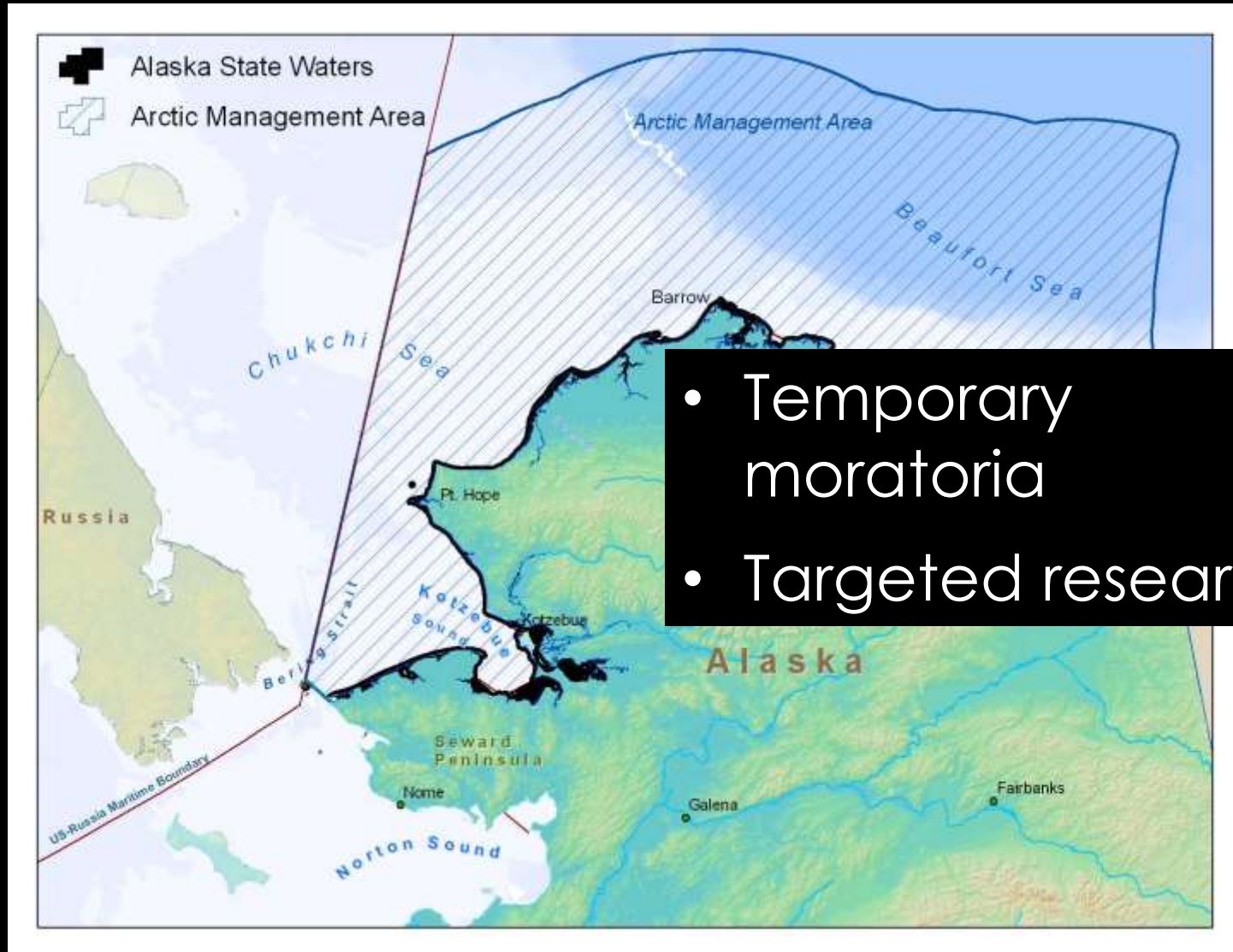
## 2. Prepare for emerging fisheries

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## 2. Prepare for emerging fisheries

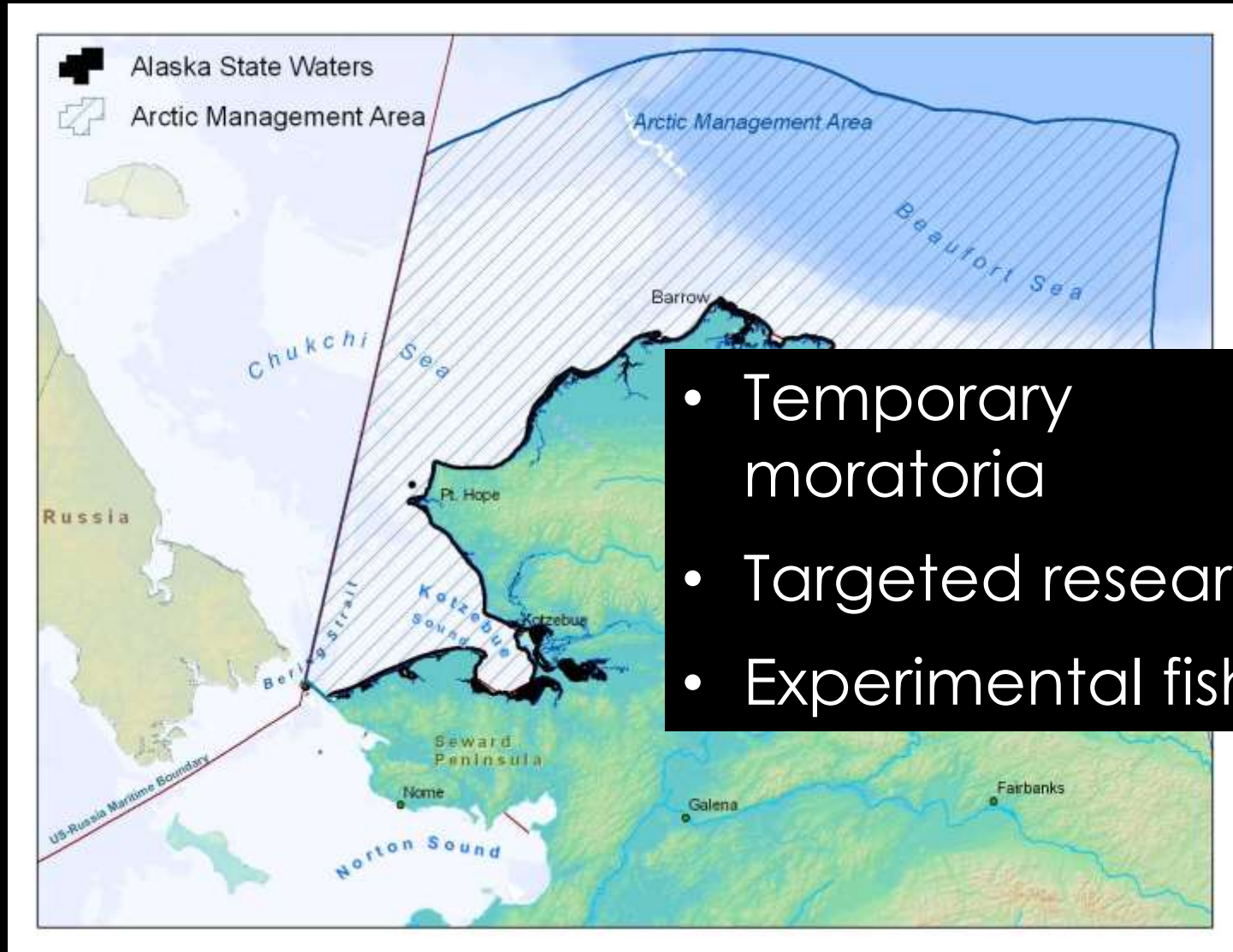
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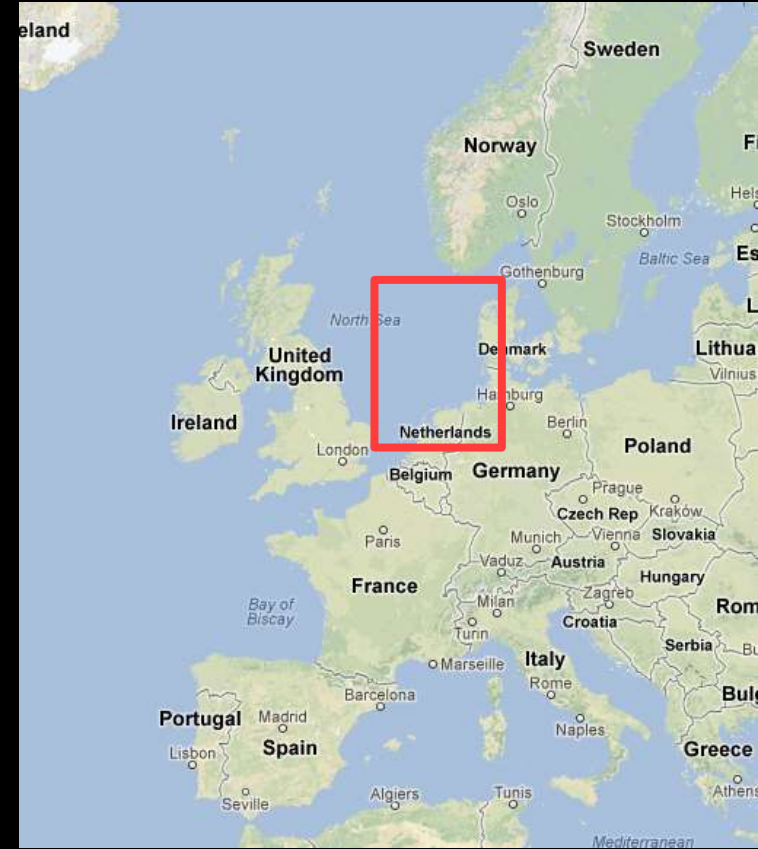
## 2. Prepare for emerging fisheries

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# 3. Evaluate spatial boundaries

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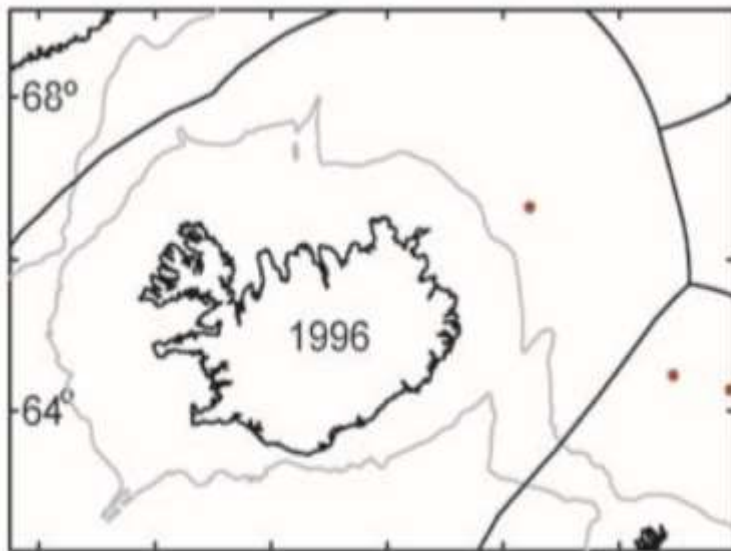


# 4. Coordinate among organizations

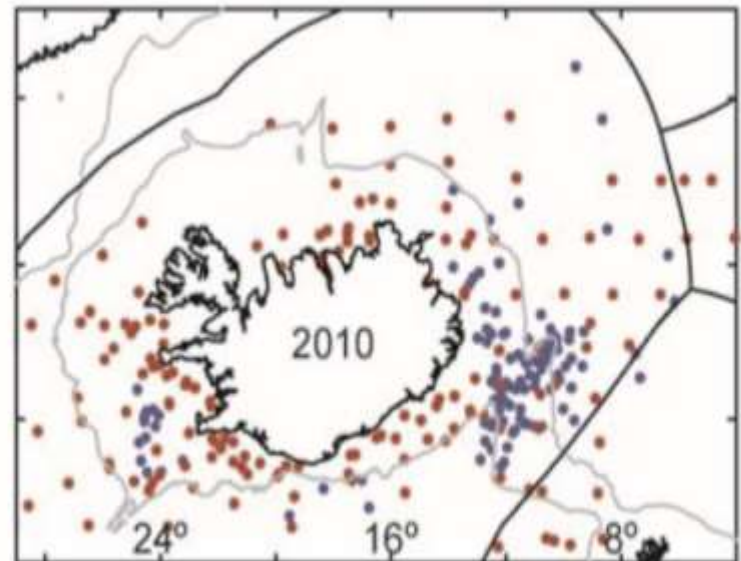
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mechanisms for cooperation and side-payments

c)



d)



# 5. Climate effects in assessments

---

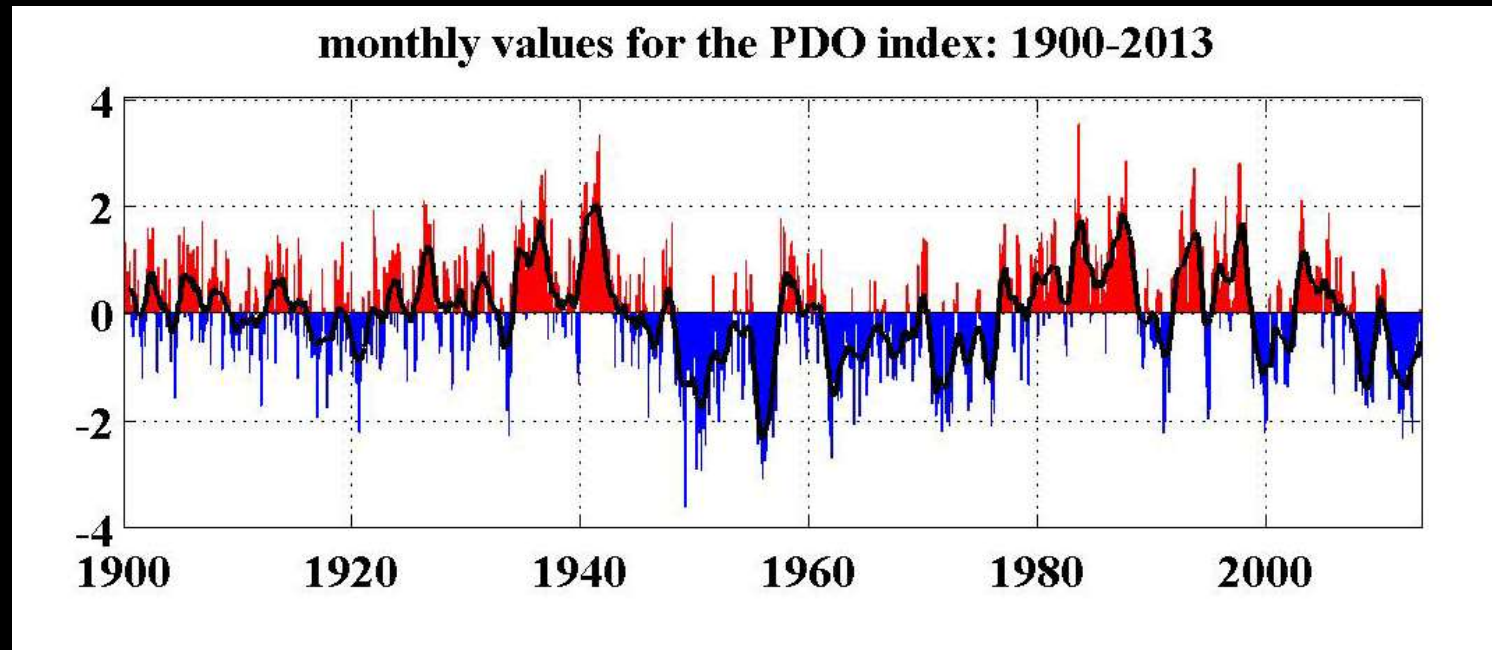
Multiple approaches:

# 5. Climate effects in assessments

---

Multiple approaches:

- Use data from current regime

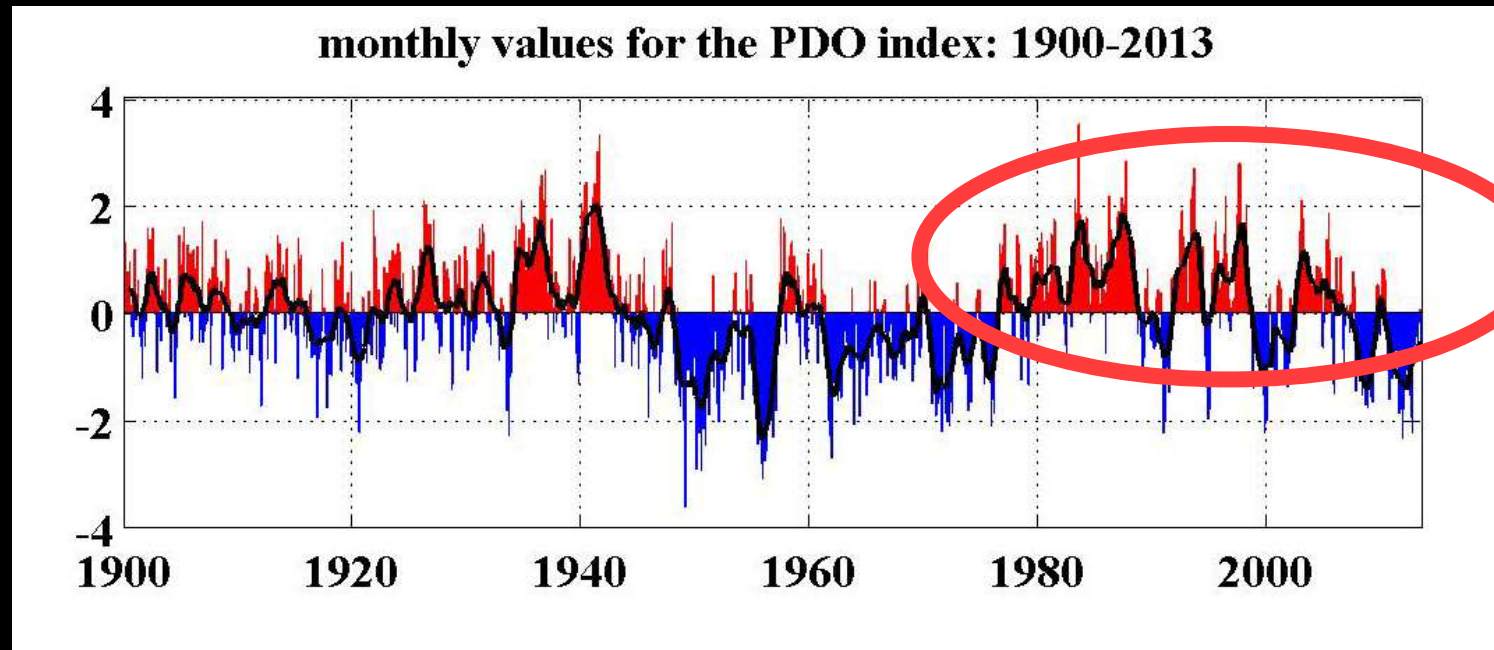


# 5. Climate effects in assessments

---

Multiple approaches:

- Use data from current regime



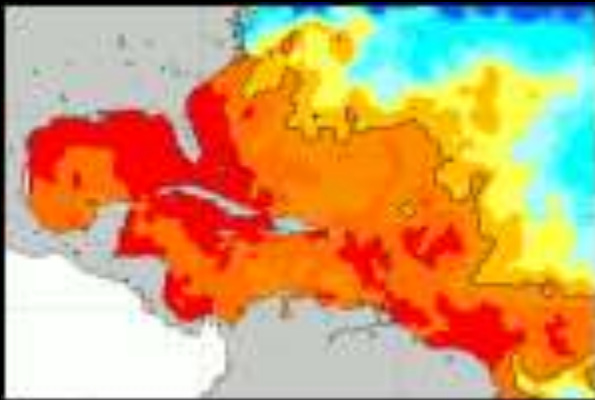


## 5. Climate effects in assessments

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Multiple approaches:

- Use data from current regime
- Use an environmental covariate

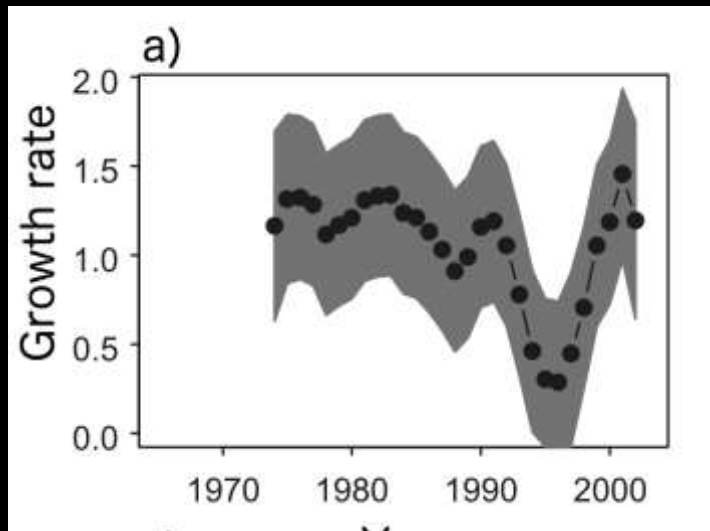


# 5. Climate effects in assessments

---

Multiple approaches:

- Use data from current regime
- Use an environmental covariate
- Empirical methods



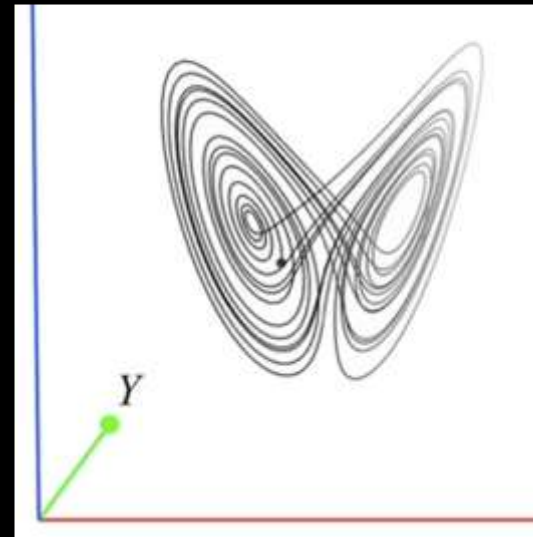
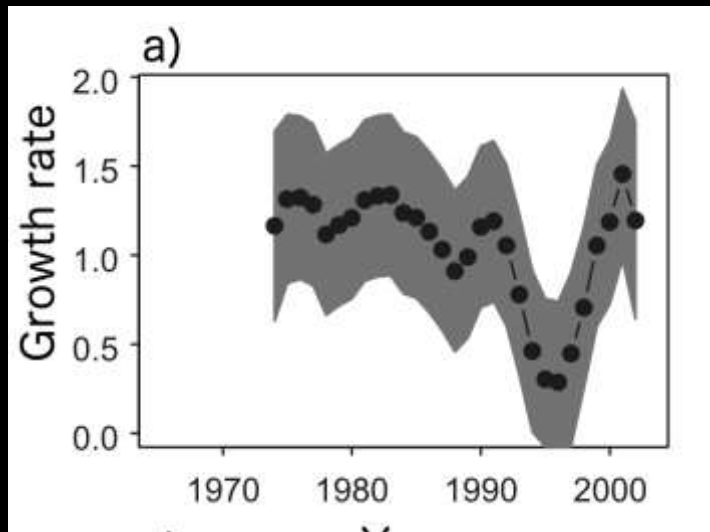


# 5. Climate effects in assessments

---

Multiple approaches:

- Use data from current regime
- Use an environmental covariate
- Empirical methods

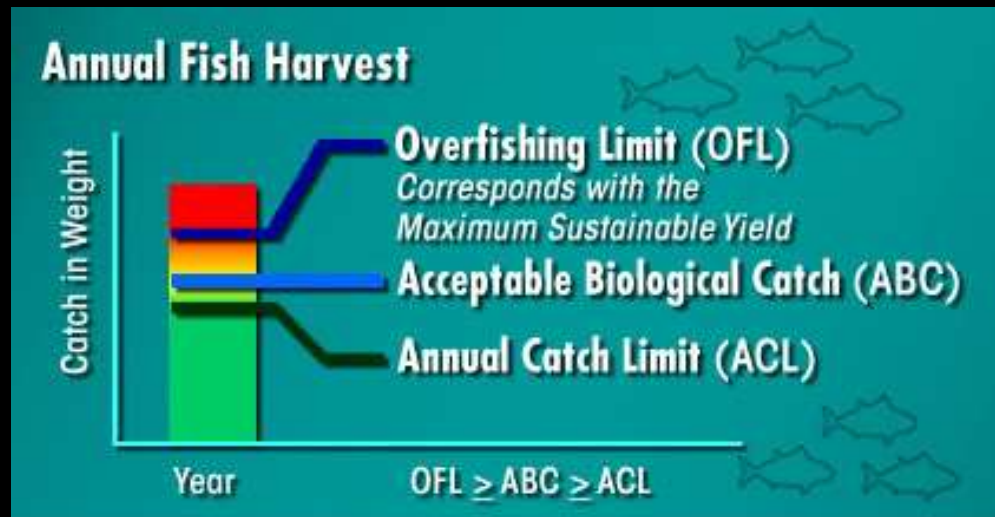


# 5. Climate effects in assessments

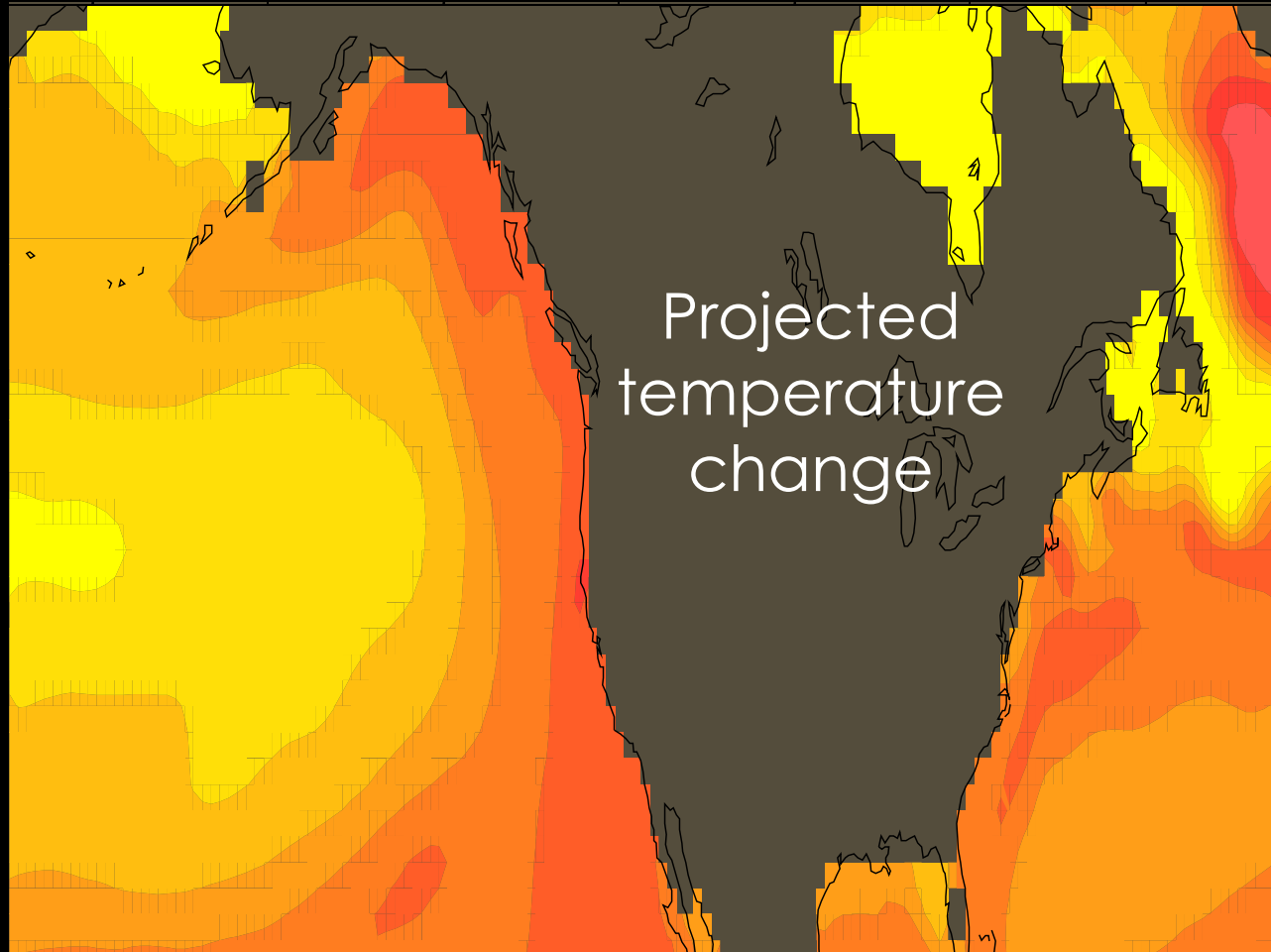
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Multiple approaches:

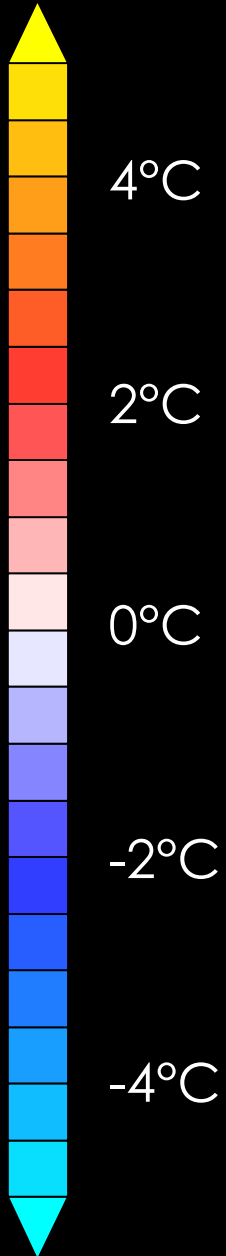
- Use data from current regime
- Use an environmental covariate
- Empirical methods
- Add a precautionary buffer



# 6. Scenario evaluation



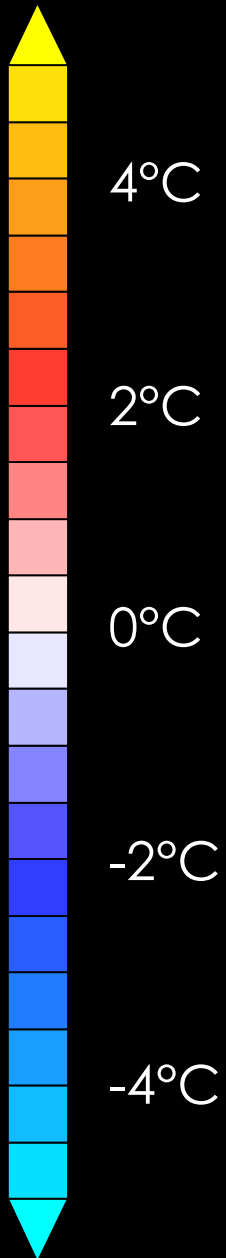
GFDL CM3 model RCP8.5



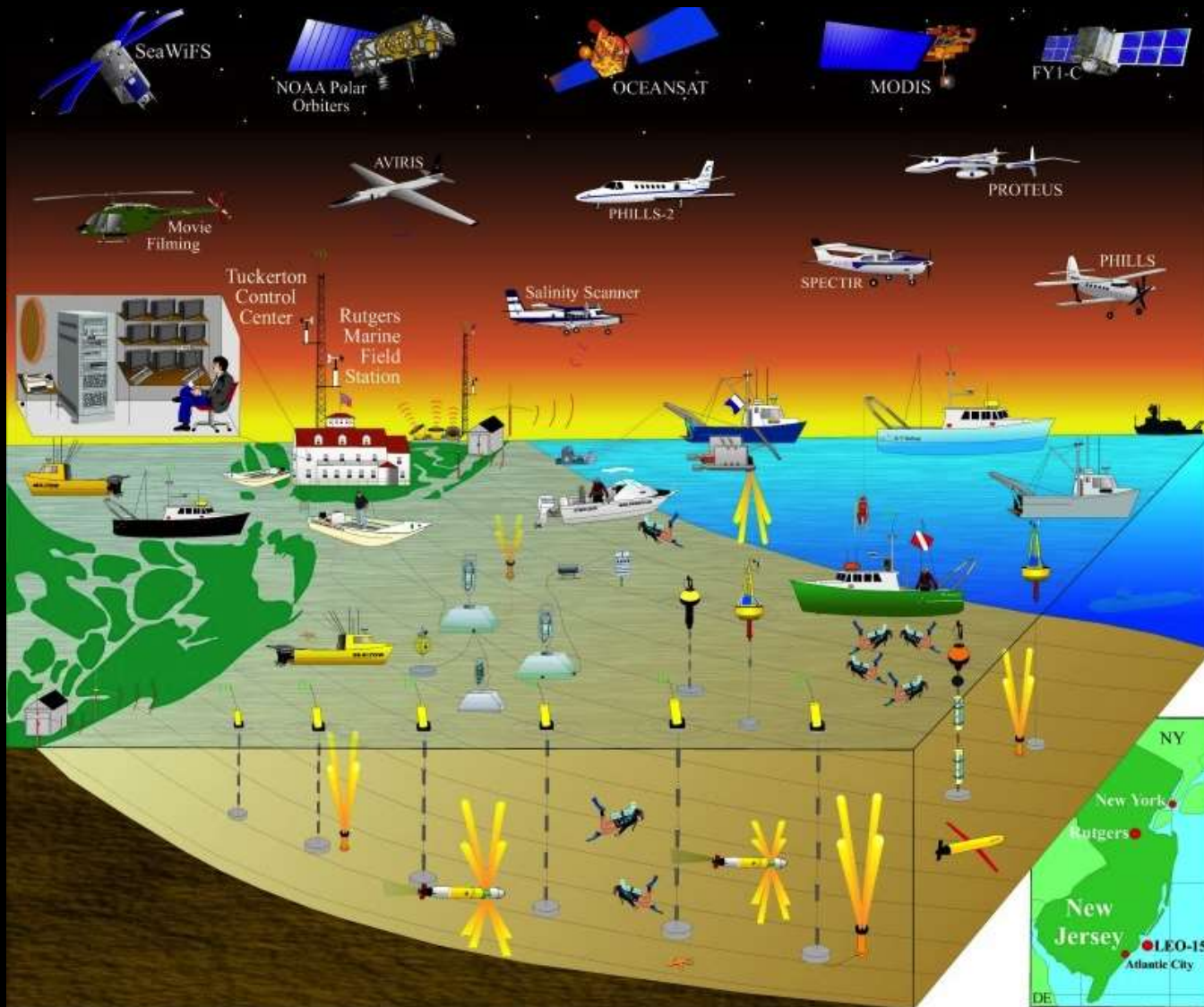
# 6. Scenario evaluation



GFDL CM3 model RCP8.5



# 7. Monitor for surprises & respond



# 8. Consider barriers to adaptation



Chronicle / Kat Wade

# Summary

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- Temperature will warm and fluctuate
- Species will shift over this century
- Interaction among factors (including climate) determines fish abundance and availability



# Acknowledgments

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Thomas Frölicher  
Jon Hare  
Mike Fogarty  
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Nate Mantua  
Bonnie McCay  
Kevin St. Martin  
Eli Fenichel

Emma Fuller  
Talia Young  
Kaycee Coleman  
Simon Levin

## Pinsky Lab





Questions:

What information do you need?



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