NOAA Fisheries
Climate Science Strategy

Northeast Regional Action Plan

ASMFC Briefing | May 2016

WHY	Growing demands and requirements for climate-related information.
GOAL	Increase the production, delivery, and use of climate-related information to support agency and stakeholder decisions.
ASK	Provide input on the draft Regional Action Plans.

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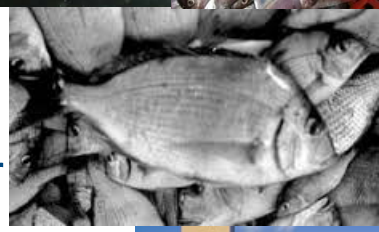
Changes in Marine Resources

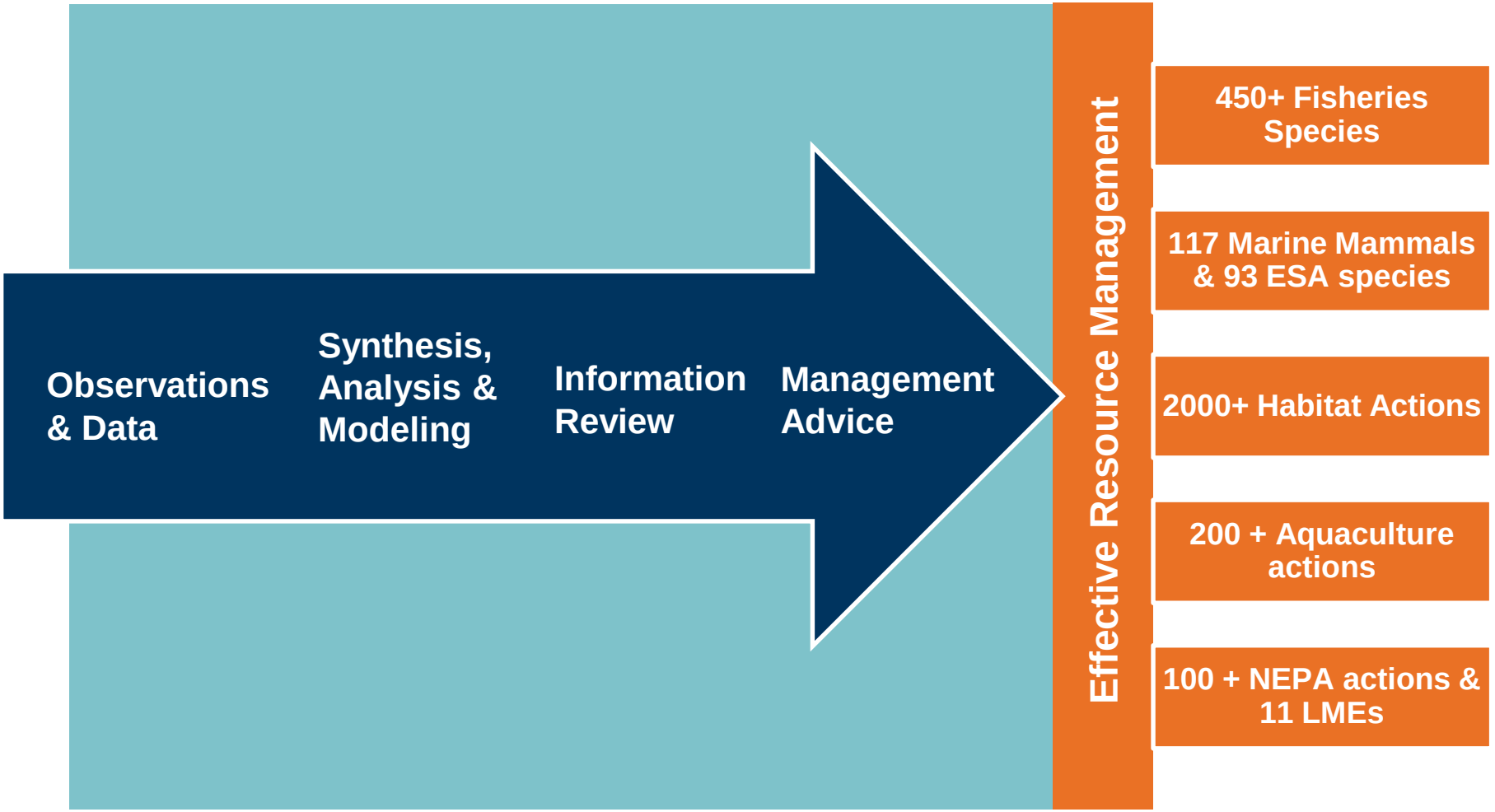
- Distribution of Atlantic surfclam affected by warming (increased mortality in Mid-Atlantic)
- Butterfish thermal habitat affects catchability
- River herring thermal habitat projected to decrease
- Atlantic Croaker productivity projected to increase; distribution projected to move northward
- Distribution of Scup and Black Sea Bass related to temperature
- Species from the south - blueline tilefish, snowy grouper
- Distribution change documented for 30+ spp.
- Many other examples …



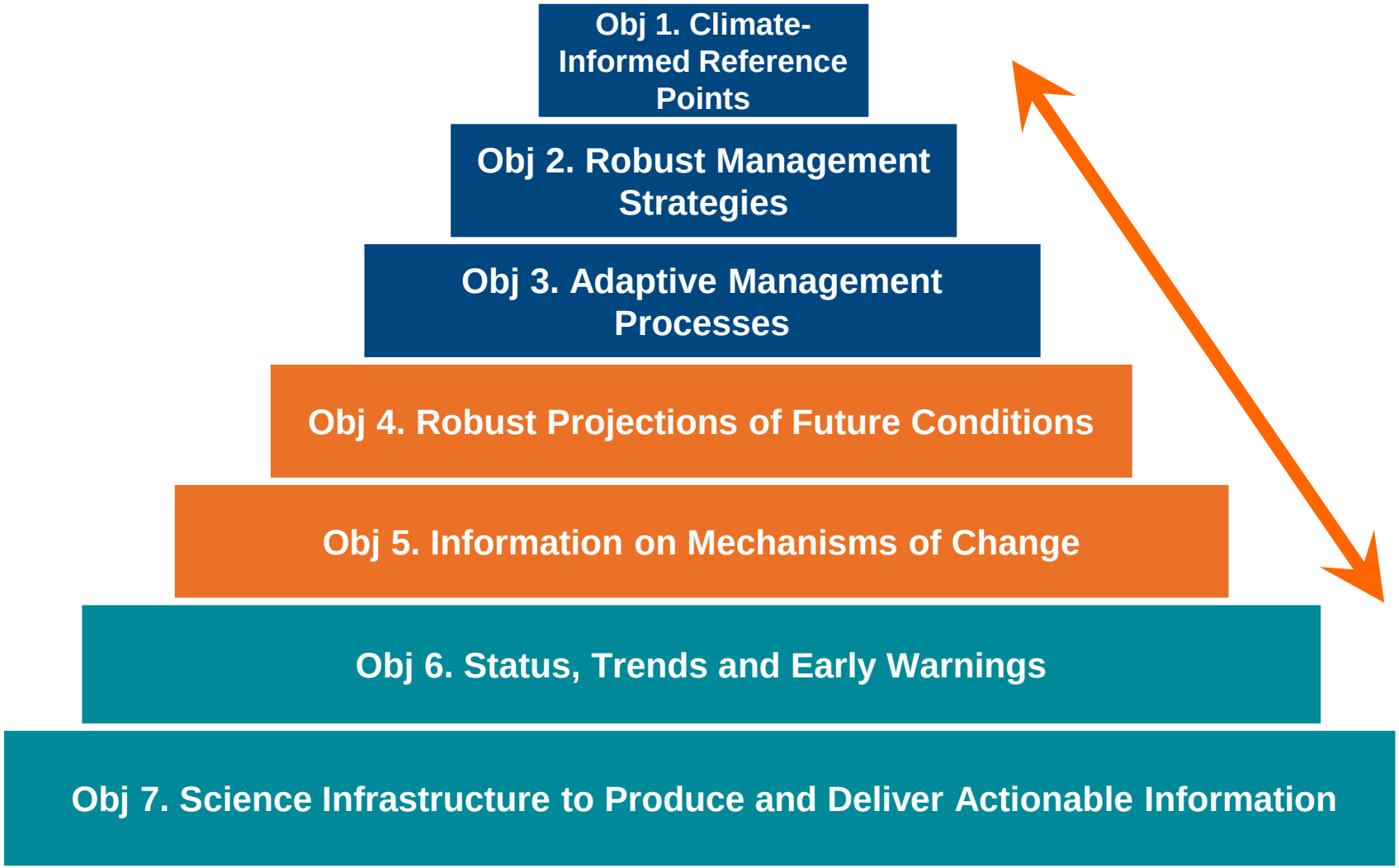




WHY	Growing demands and requirements for climate-related information.
GOAL	Increase the production, delivery, and use of climate-related information to support agency and stakeholder decisions.
ASK	Provide input on the draft Regional Action Plans.

Process to Improve Climate Information to Fulfill Our Mission



Climate Science Strategy - Objectives



Climate Science Strategy – Recommendations Immediate Actions

1	progress	**Conduct LMR climate vulnerability analyses in each region.**
2	progress	**Maintain and develop Ecosystem Status Reports to track change and provide early-warnings.** http://nefsc.noaa.gov/ecosys/ecosystem-status-report/sitemap.html
3	progress	**Increase capacity to conduct climate-informed Management Strategy Evaluations**

Climate Science Strategy – Recommendations
Short-term Actions (6-24 months)

1	★	**Complete region-level action plans.**
2		**Strengthen climate-related science capacity nation-wide.**
3		**Increase resources for process-oriented research.**
4		**Establish climate-ready terms of reference for ESA, MSFCMA, MMPA stock assessments and Biological Opinions, etc.**

Complete region-level action plans

NEFSC-GARFO Working Group – Draft RAP

- Regional Strengths
- Regional Weaknesses
- Priority Actions
  - *No New Resources*
  - *New Resources*
- Partnering

Received input from ASMFC, NEFMC, MAFMC and other NOAA Line Offices in December 2015

Draft will be released for public comment next week (week of 9 May). Open for public comment until end of July.

WHY	Growing demands and requirements for climate-related information.
GOAL	Increase the production, delivery, and use of climate-related information to support agency and stakeholder decisions.
ASK	Provide input on draft Regional Action Plan.

Questions?

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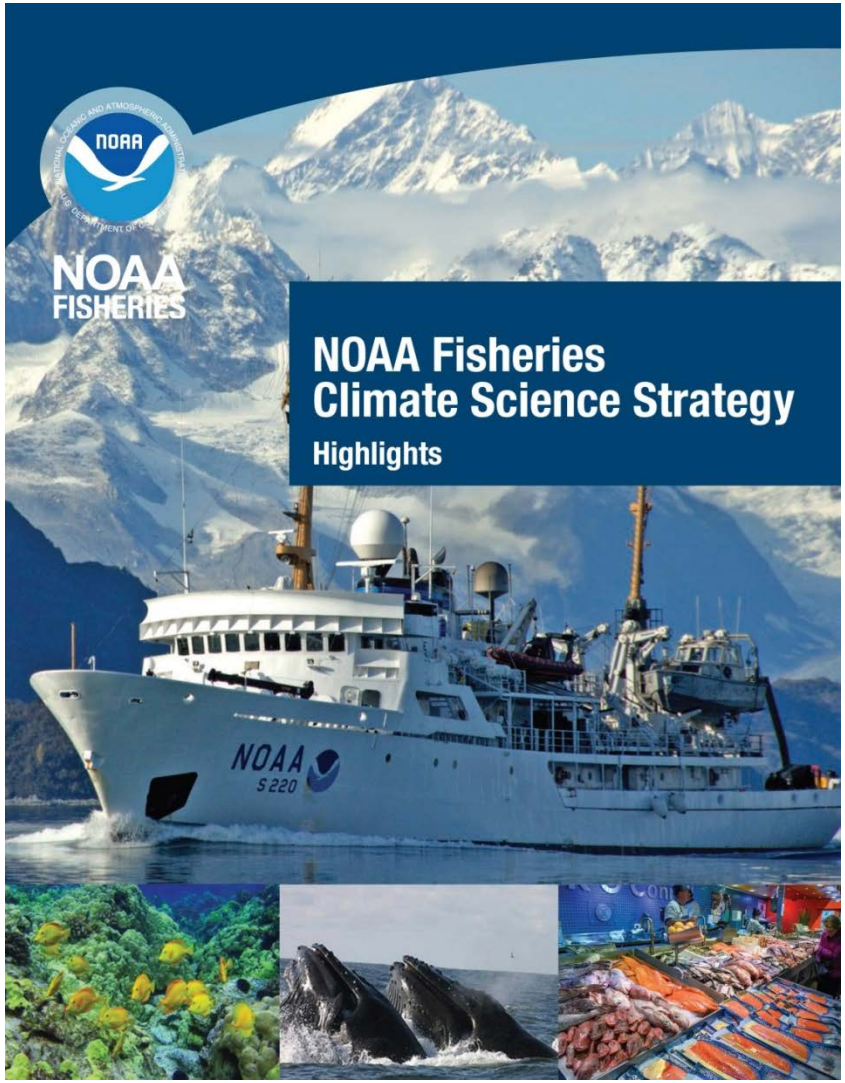
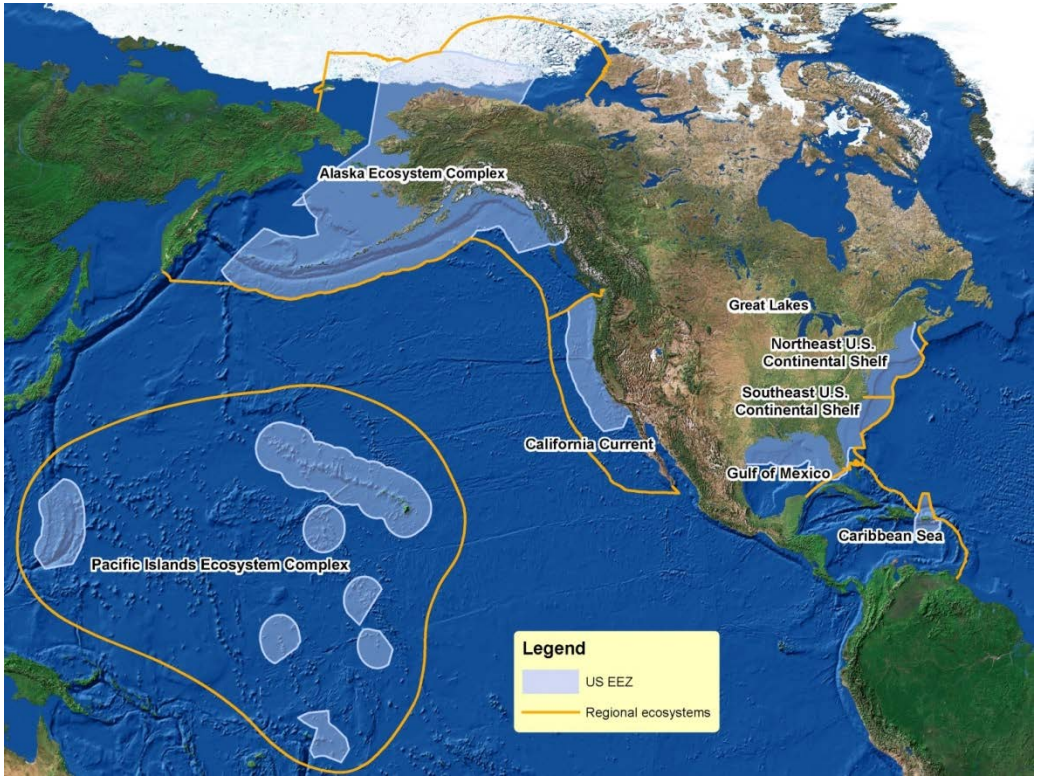
South Atlantic Climate Science Regional Action Plan (*DRAFT*)

Heidi Lovett
May 2016



Goal: Increase the production, delivery, and use of climate-related information in fulfilling NOAA Fisheries mandates

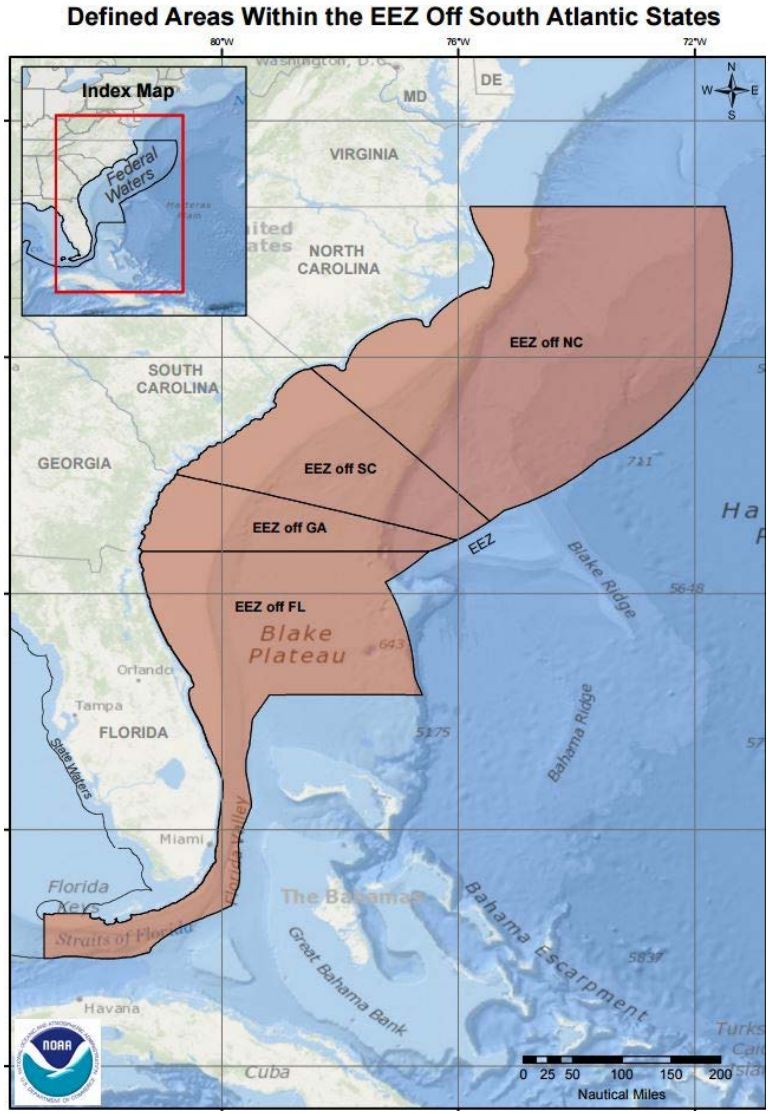
Regional Action Plans

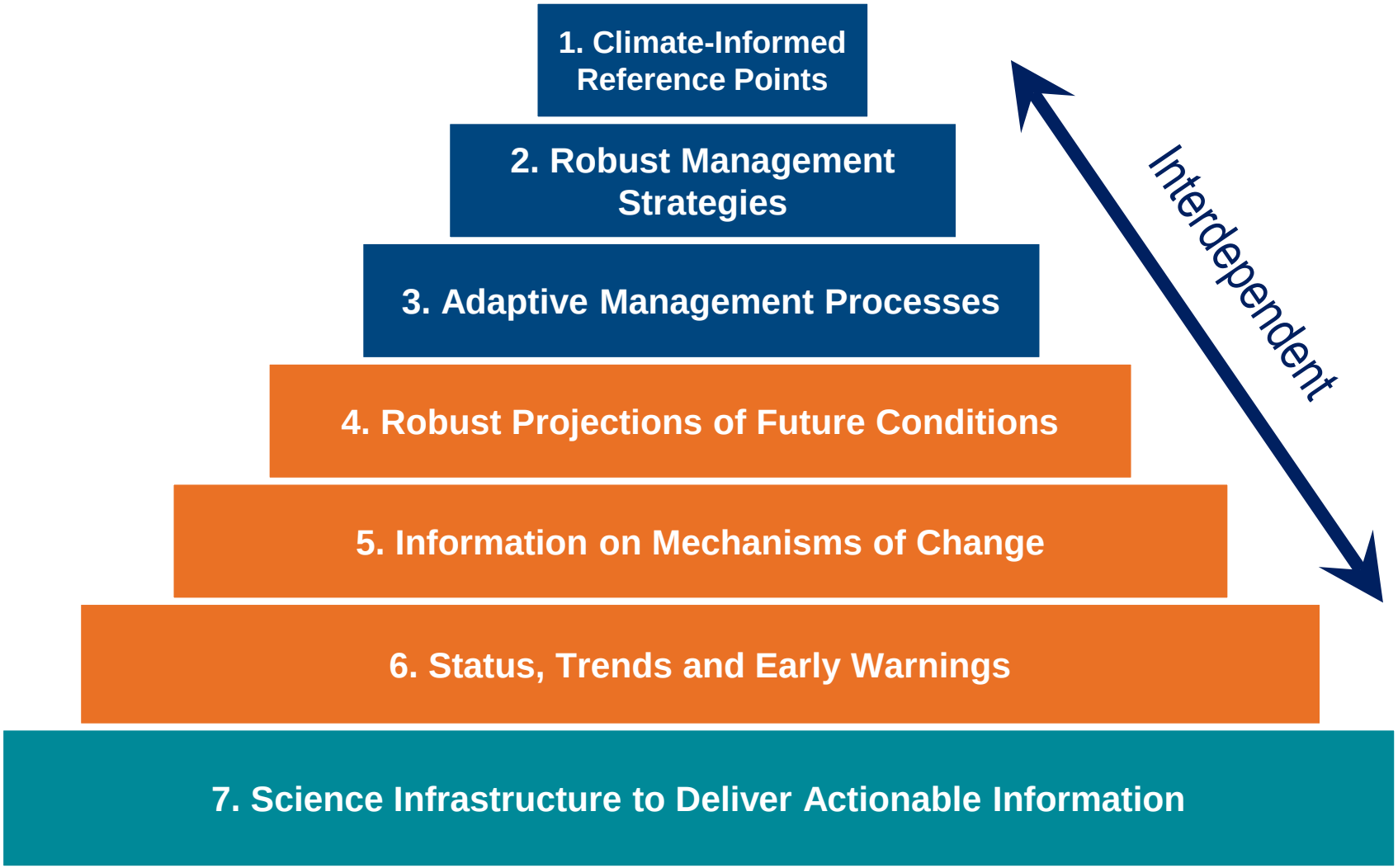


- Develop with key partners Councils, States, & other partners
- Customize for each region
- Inform future planning and budgeting
- Build and expand partnerships and leverage resources

Southeast Regional Action Plan

- *Draft* plan for South Atlantic - a great time for input!
- Scheduling, staging, prioritizing actions
- Thorough assessment of funding requirements
- Identify additional partners




1. Climate-Informed Reference Points
2. Robust Management Strategies
3. Adaptive Management Processes
4. Robust Projections of Future Conditions
5. Information on Mechanisms of Change
6. Status, Trends and Early Warnings
7. Science Infrastructure to Deliver Actionable Information
Interdependent

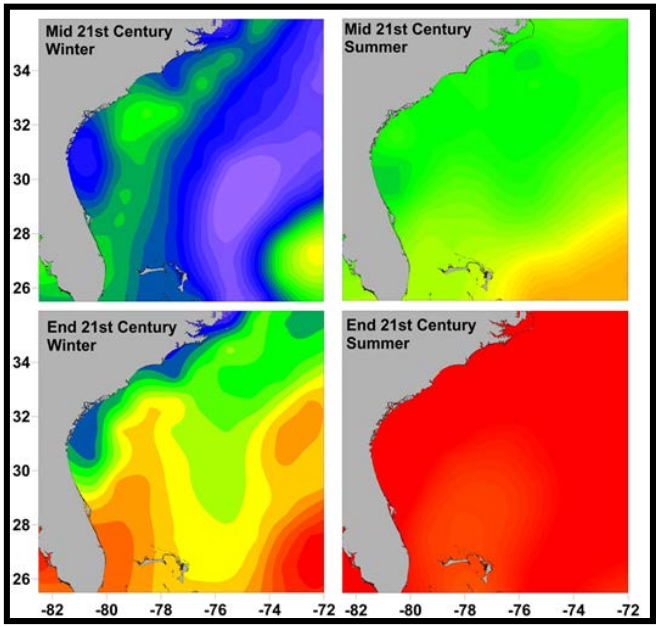
7. Science Infrastructure to Deliver Actionable Information

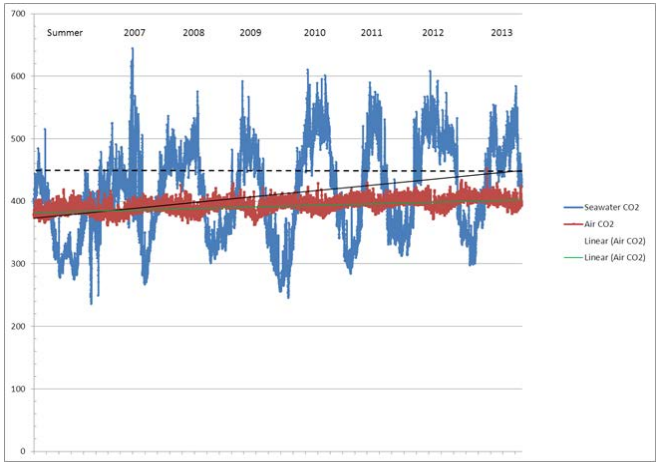
- Strategic planning for climate science
- Build and strengthen capacity
- Infrastructure
- Strengthen partnerships
- Citizen Science

NOAA Ship *Pisces*

6. Status, Trends and Early Warnings

- Critical baseline data
- Ecosystem Status Report
- Early warning toolbox

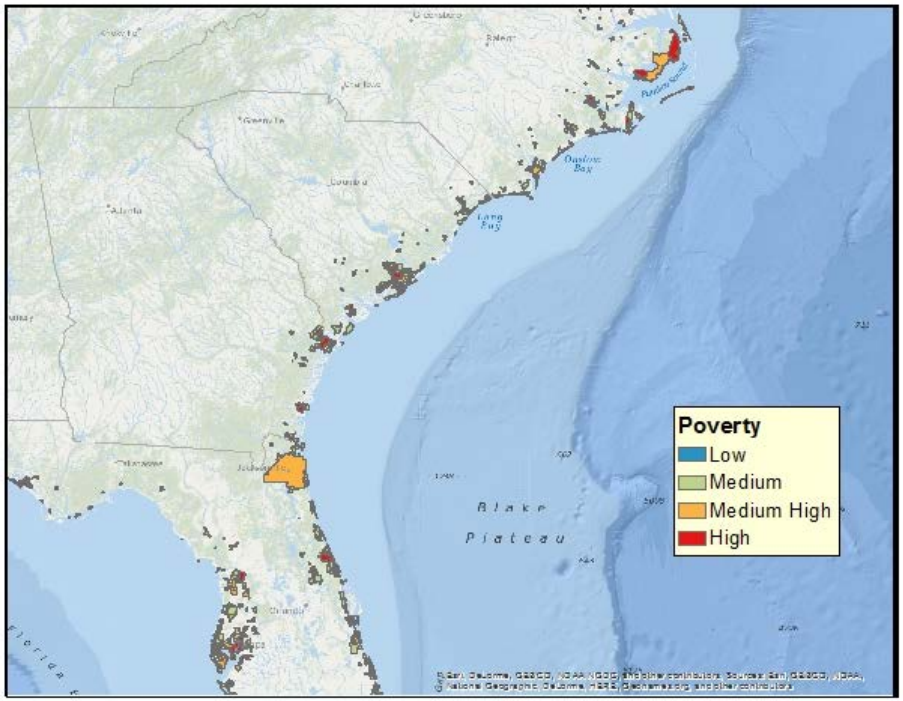




5. Information on Mechanisms of Change

- Vulnerability Assessments
  Priority Species
  Community Vulnerability

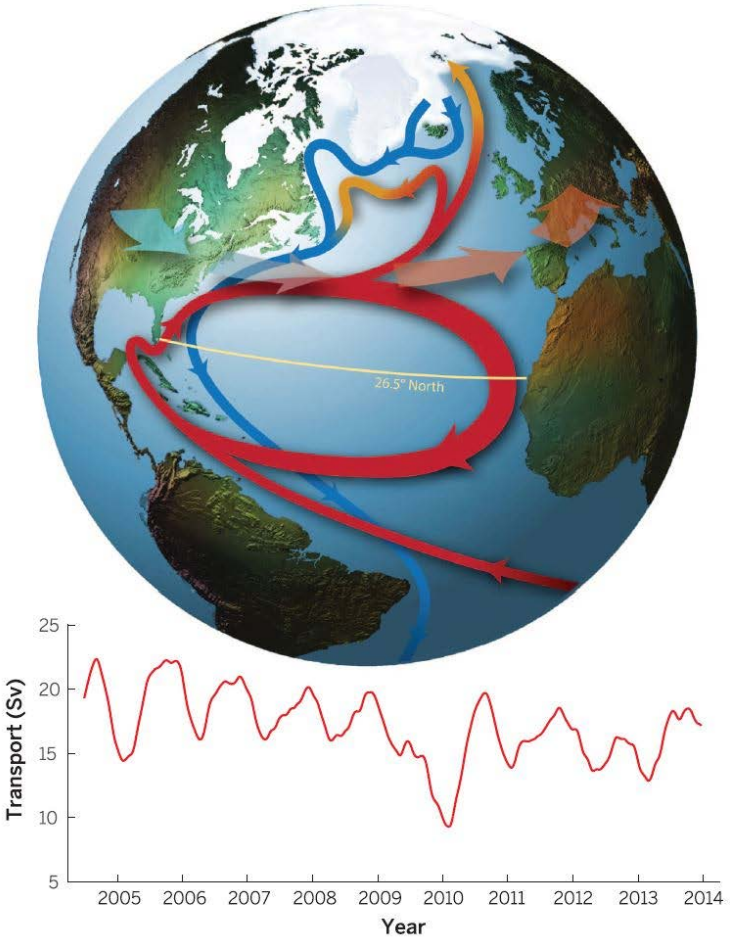
- Research & Monitoring
  Sea level rise
  Ocean acidification
  Coral Reefs



4. Robust Projections of Future Conditions

- Predictive Modeling
- Application of existing models
- Standard modeling toolbox

AMOC schematic and time series of AMOC strength



Srokosz & Bryden 2015

3. Adaptive Management Processes

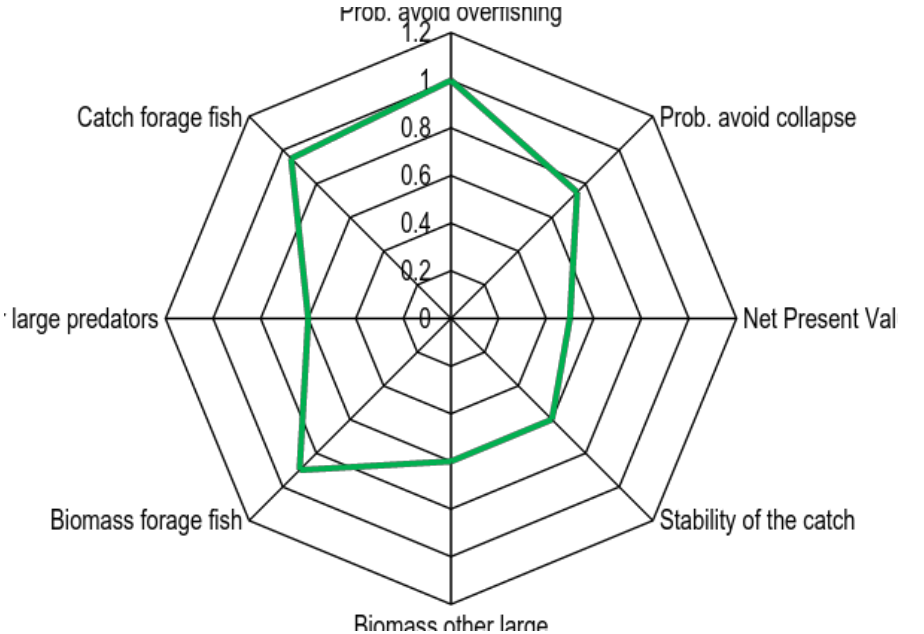
- Quantify management tradeoffs under climate change scenarios
- Respond to events in real time
- Strengthen dialogue, e.g., what trends are fishermen observing?

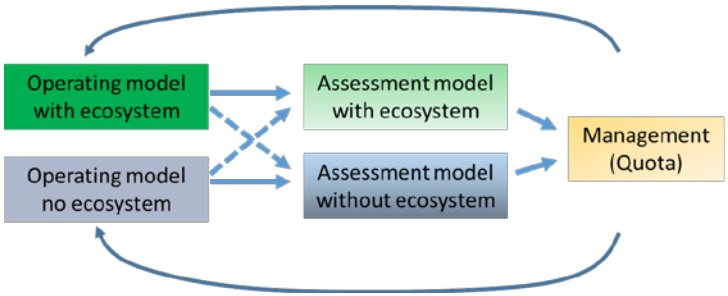
		Buffer between OFL and ACL	
		Large	Small
Predicted future stock productivity	High		
	Low		

Marine Resource Education Program (Tampa, FL)

2. Robust Management Strategies

- Management Strategy Evaluations
- Define management objectives collaboratively
- Ecosystem Considerations Summary





1. Climate-Informed Reference Points

- Consider climate as we develop reference points.
- Share ideas, models, approaches among regions

Next Steps

- Refine action items for the South Atlantic
- Input from Councils, States, and other partners
- Respond to internal comment on the Gulf of Mexico action items
- Incorporate Caribbean ecosystem
- Public comment (summer 2016)
- Finalize regional action plan by October 2016

Comments, Questions, or To Get Involved:
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Acknowledgements

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Northeast Fisheries Climate Vulnerability Assessment – ASMFC-Specific Results

Atlantic States Marine Fisheries Commission

May 2016

Need

Climate Change is a long-term change in part of the land-atmosphere-ocean system

Already observing impacts of climate change on variety fish stocks.

Expected Changes:

- Changes in stock ***productivity***
- Changes in ***distribution***
- Changes in species ***interactions***

Quantitative approach for all species not possible at this time: limited by resources and understanding

Goal and Objectives

Goal:

Produce a practical and efficient tool for assessing the vulnerability of a wide range of fish stocks to a changing climate

Objectives:

1. Develop relative vulnerability rankings across species
2. Determine attributes/factors driving vulnerability
3. Identify data quality and data gaps

What do we mean by vulnerability?

- Vulnerability = risk of ***changes in stock abundance or productivity*** *in a changing climate*
- Stocks with ability to shift distributions in a changing climate may receive a "low vulnerability" ranking
- Subset of the attributes may be useful in identifying stocks that possess the ***ability to shift distributions***

Methodology

Exposure

- Sea surface temperature
- Air temperature
- Salinity
- Ocean acidification (pH)
- Precipitation
- Currents
- Sea level rise

*** Exposure factors will vary depending on the region*

Sensitivity

- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

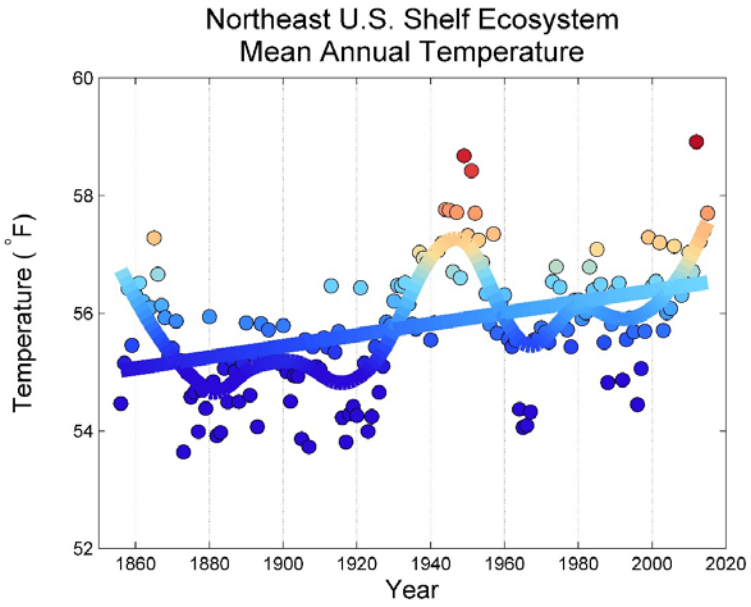
https://www.st.nmfs.noaa.gov/Assets/ecosystems/climate/documents/TM%20OSF3.pdf

Northeast U.S. Climate Change and Variability

Recent increase in ocean temperatures - a combination of climate change and decadal-scale variability

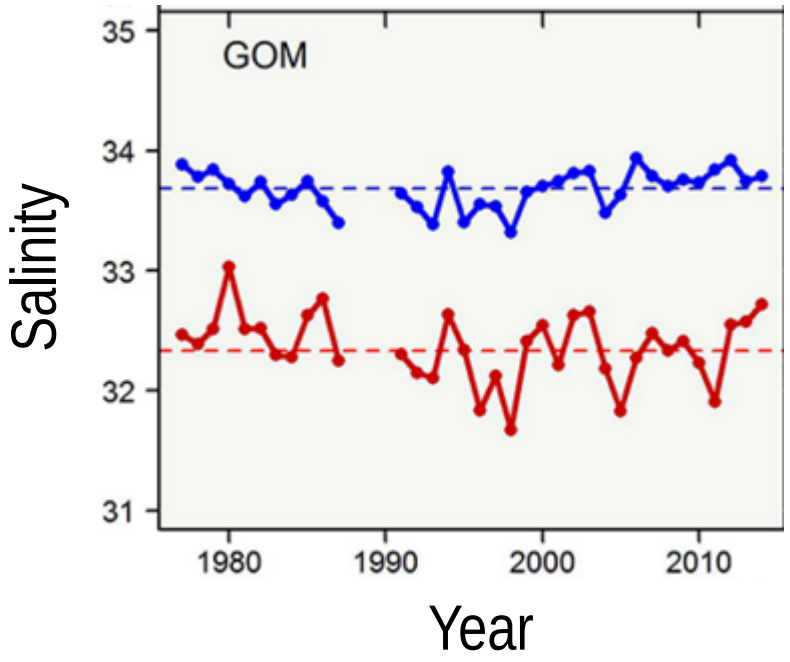
Climate change: Long-term difference in the earth, atmosphere, and ocean conditions

Climate variability: Natural variability within the climate system (for example year-to-year)



Northeast U.S. Climate Change and Variability

- Temperatures increasing
- Precipitation and streamflow changing
- Large-scale circulation changing
- pH decreasing (ocean acidification)
- Wind patterns changing
- Sea-level rising
- And more ….

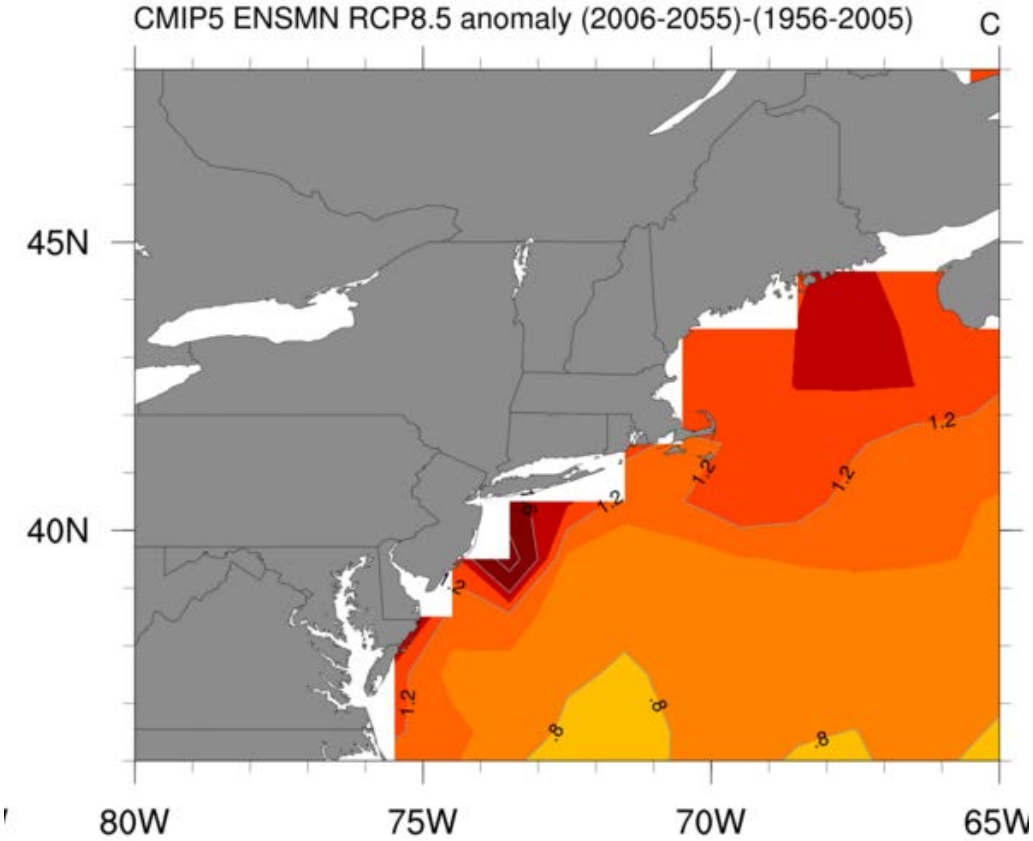


Change & Natural Variability

http://www.nefsc.noaa.gov/ecosys/ecosystem-status-report/physical-pressures.html

Northeast U.S. Climate Change and Variability

- IPCC AR5 Class Models/ RCP 8.5
- Relatively course ~1^{o} latitude/longitude
- Change 1956-2005 to 2006-2055
- New finer resolution model (Saba et al. 2016) also predicts large warming



http://www.esrl.noaa.gov/psd/ipcc/

Sensitivity

Definition: Biological attributes believed to be indicative of the stock's response to climate change. They include the stock's resilience and its adaptive capacity[1]

12 attributes relate to current life history characteristics:

- Habitat Specificity
- Prey Specificity
- Sensitivity to Ocean Acidification
- Sensitivity to Temperature
- Stock Size/Status
- Other Stressors
- Adult Mobility
- Spawning Cycle
- Complexity in Reproductive Strategy
- Early Life History Survival and Settlement Requirements
- Population Growth Rate
- Dispersal of Early Life Stages

[1] Williams et al. 2008

5 Point Tally Scoring System

- The scoring for each attribute is done by the experts assigning 5 tallies within the 4 scoring bins
- This gives experts the ability to express uncertainty in their score

Example:

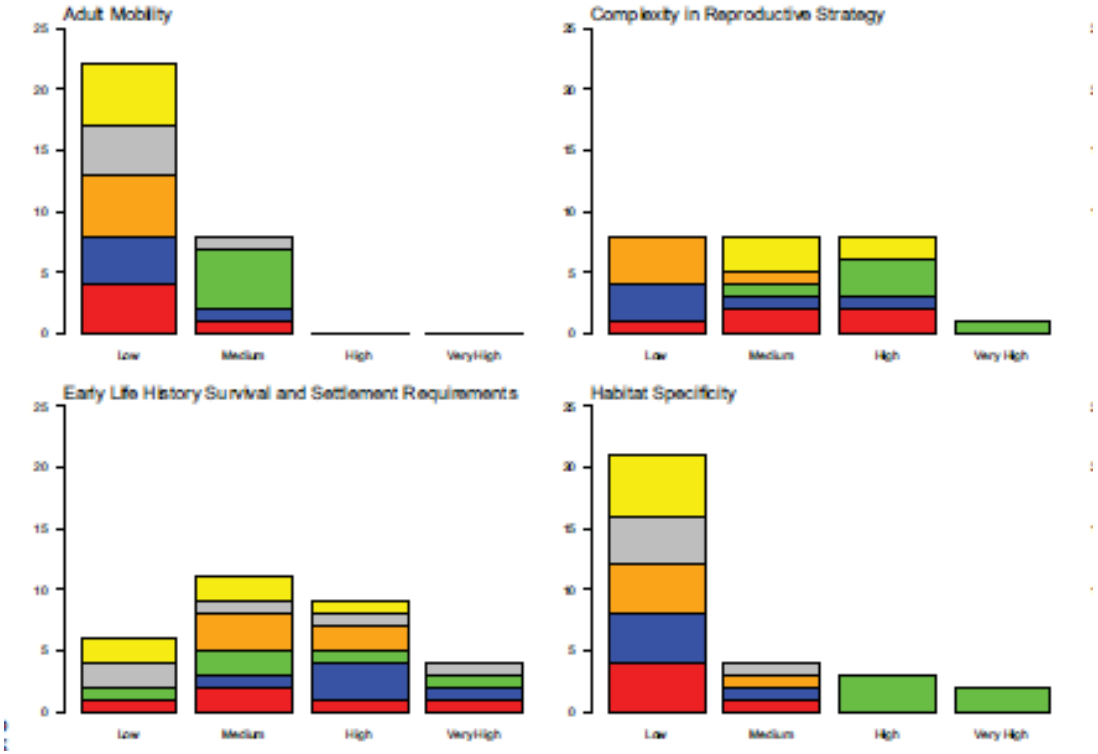
Expert Scores - Low uncertainty scenario			
Low	Moderate	High	Very High
	5		

Expert Scores - Moderate uncertainty			
Low	Moderate	High	Very High
		3	2

Expert Scores - Higher uncertainty scenario			
Low	Moderate	High	Very High
1	1	2	1

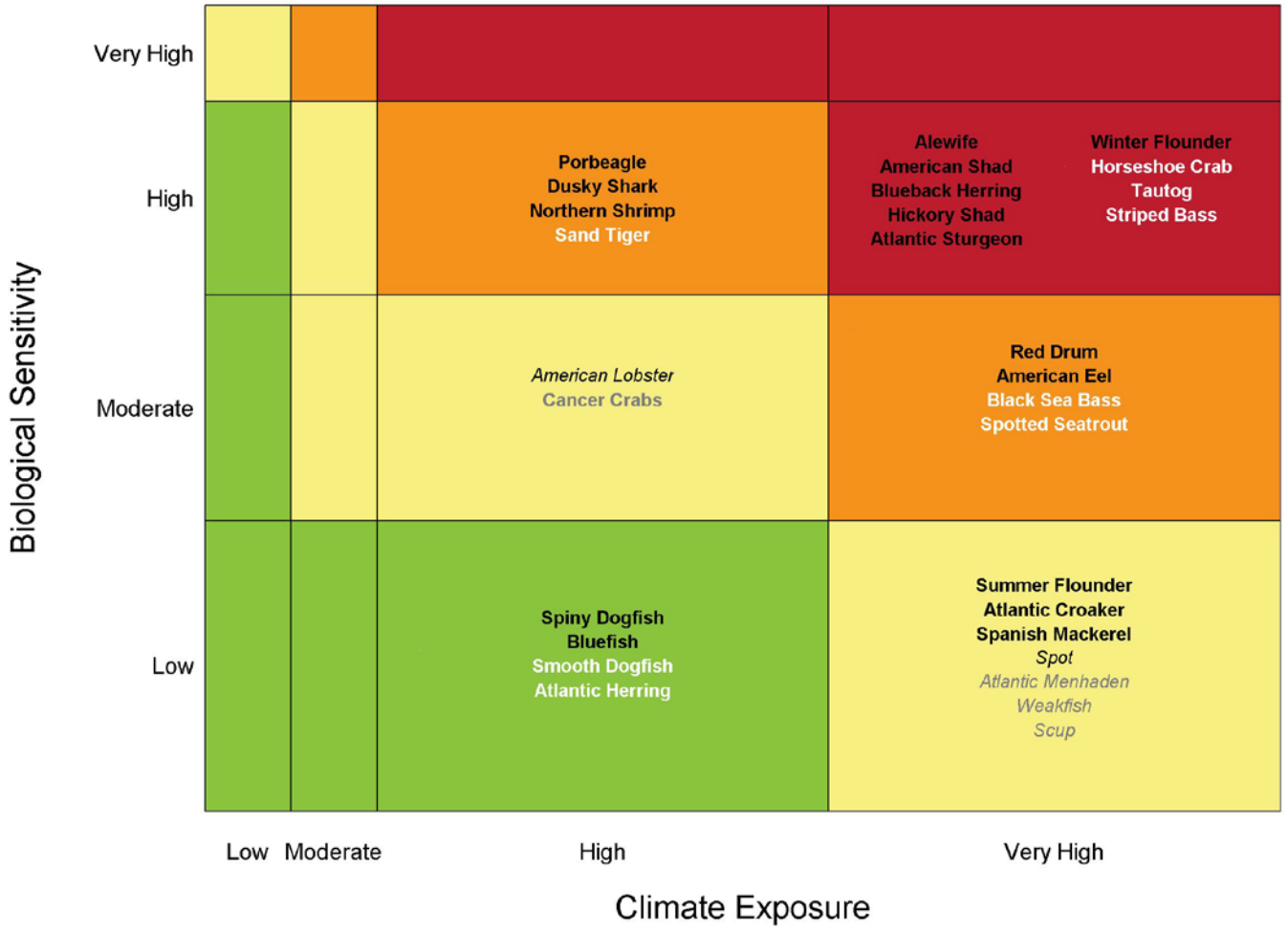
Expert Scoring Process

- Experts score individually prior to workshop
- Experts compare and discuss scores at workshop
- Experts can adjust their scores if needed



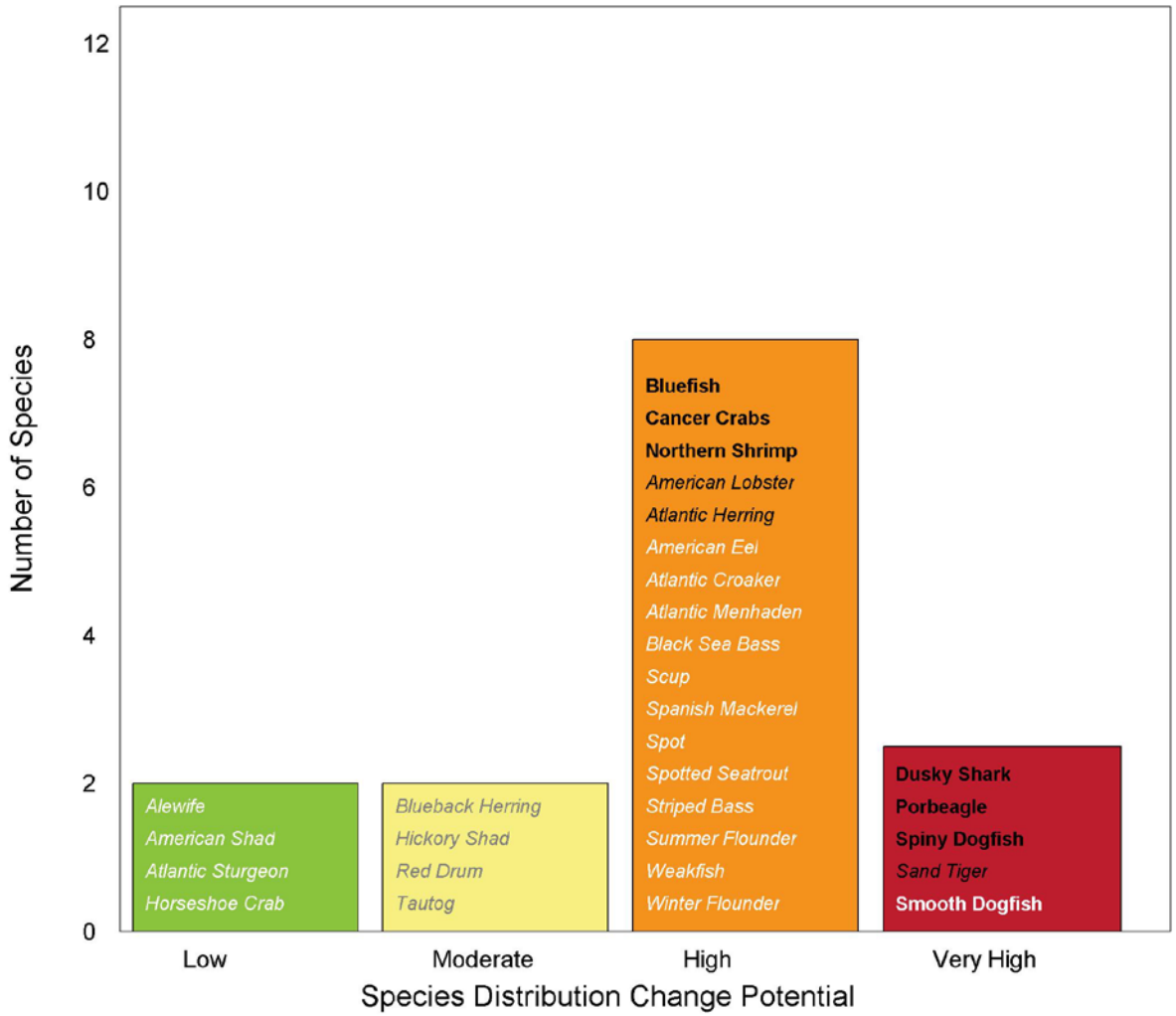
Each color represents the 5 tallies for one expert

Results – Vulnerability Matrix



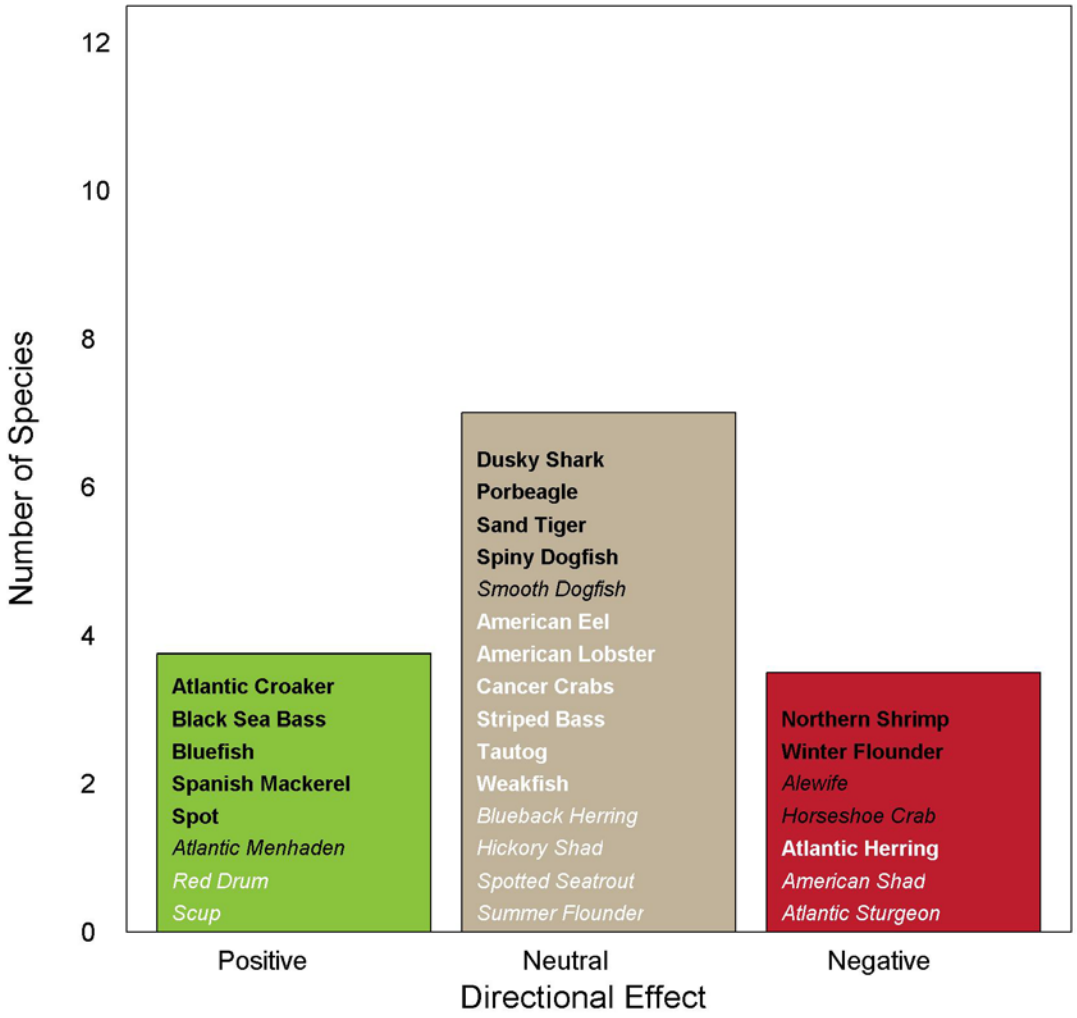
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

Results – Potential for Distribution Shift



http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

Results – Directional Effect of Climate Change



http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

Vulnerability Narratives

Alewife – *Alosa pseudoharengus*

Overall Vulnerability Rank = Very High

Biological Sensitivity = High
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

Alosa pseudoharengus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Stock Status	2.5	1.4	
Other Stressors	3.3	2.2	
Population Growth Rate	2.2	1.4	
Spawning Cycle	3.2	2.9	
Complexity in Reproduction	3.2	3.0	
Early Life History Requirements	3.3	2.4	
Sensitivity to Ocean Acidification	1.5	1.8	
Prey Specialization	1.5	3.0	
Habitat Specialization	2.6	3.0	
Sensitivity to Temperature	2.0	3.0	
Adult Mobility	1.6	2.8	
Dispersal & Early Life History	2.8	2.6	
Sensitivity Score	High		
Sea Surface Temperature	4.0	3.0	
Variability in Sea Surface Temperature	1.0	3.0	
Salinity	1.7	3.0	
Variability Salinity	1.2	3.0	
Air Temperature	4.0	3.0	
Variability Air Temperature	1.0	3.0	
Precipitation	1.3	3.0	
Variability in Precipitation	1.4	3.0	
Ocean Acidification	4.0	2.0	
Variability in Ocean Acidification	1.0	2.2	
Currents	2.0	1.0	
Sea Level Rise	2.8	1.5	
Exposure Score	Very High		
Overall Vulnerability Rank	Very High		

Low
Moderate
High
Very High

Climate Exposure: Very High. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Ocean Acidification (4.0) and Air Temperature (4.0). Alewife are anadromous, spawning in freshwater, developing in freshwater and estuarine habitats, feeding as adults in marine habitats.

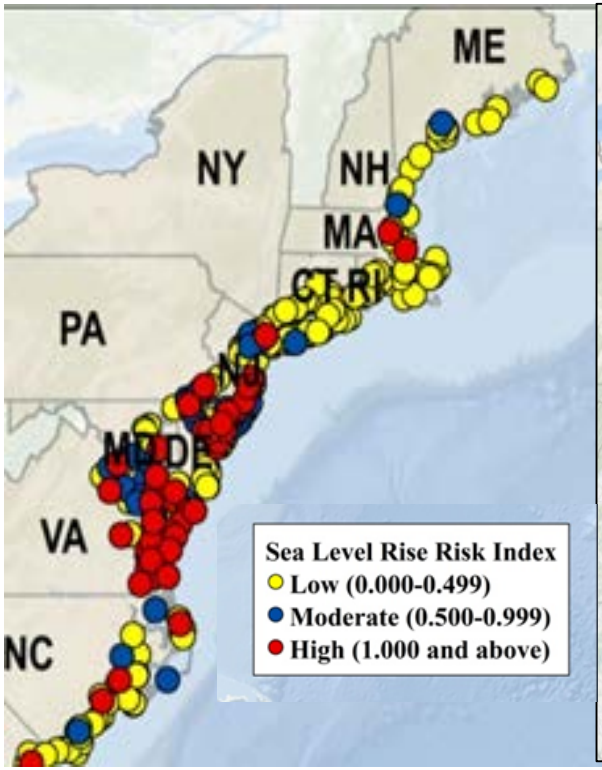
Biological Sensitivity: High. Four sensitivity attributes scored above 3.0: Other Stressors (3.3), Early Life History Requirements (3.3), Spawning Cycle (3.2), Complexity in Reproduction (3.2). Alewife are anadromous and exposed to a number of other stressors including habitat destruction, blockage to spawning habitats, and contaminants (Limburg and Waldman, 2009). Spawning time varies latitudinally and is linked to spring warming (Monroe 2002). Eggs and larvae inhabit freshwaters and then juveniles move to estuarine and ocean waters.

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756

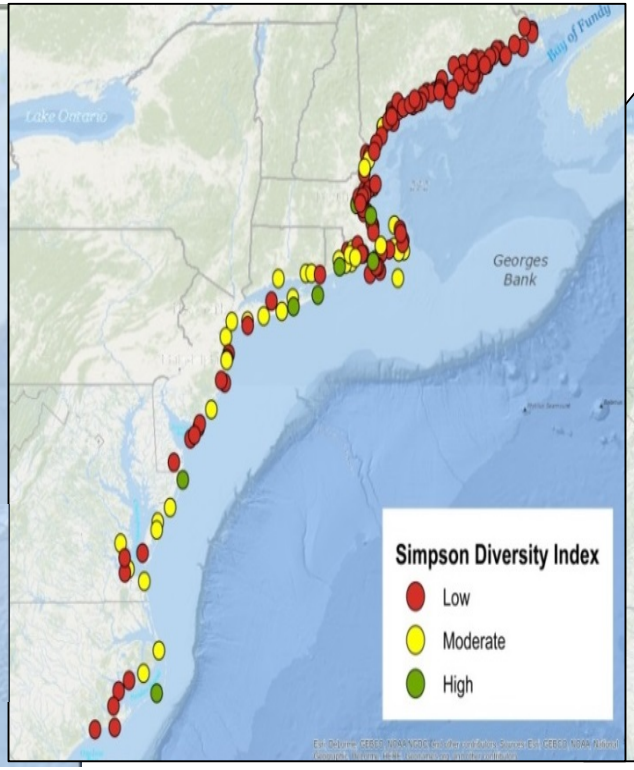
Community Vulnerability

NMFS Social Indicators Project:
https://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index

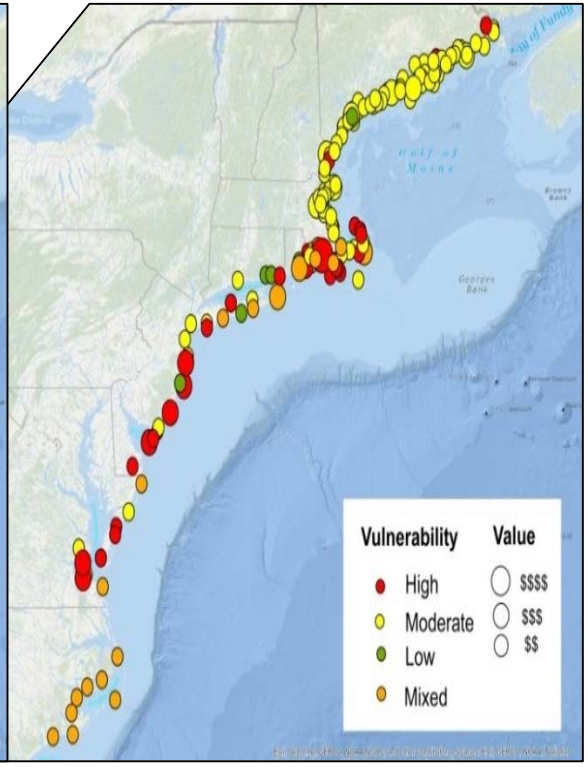
Sea-level rise risk



Landings diversity



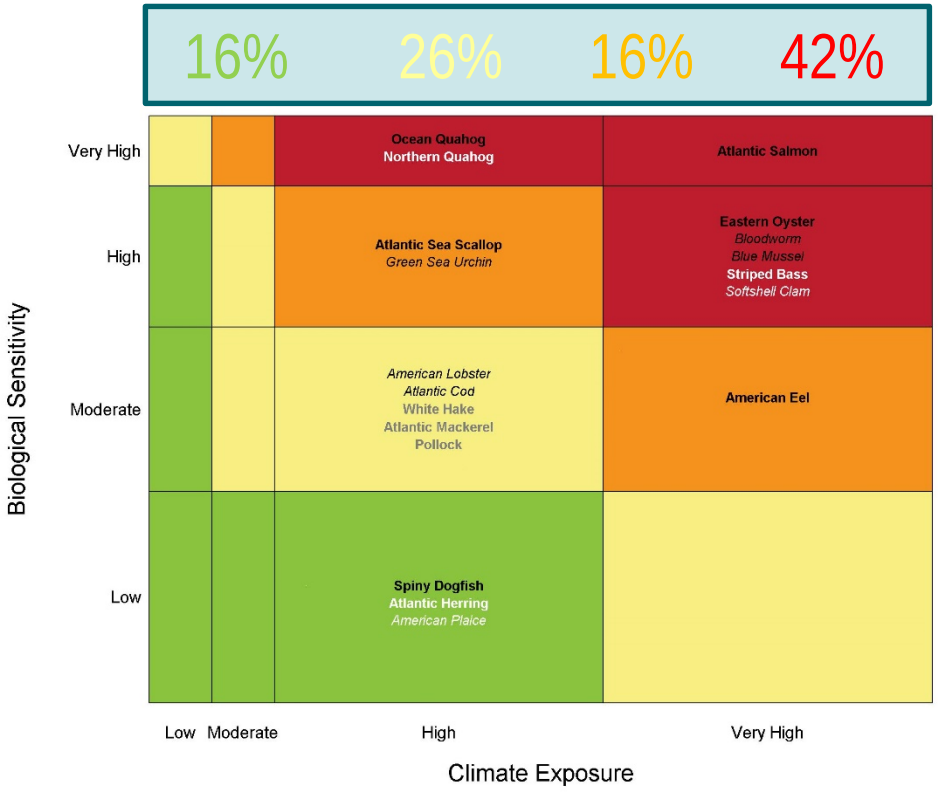
Landings climate vulnerability

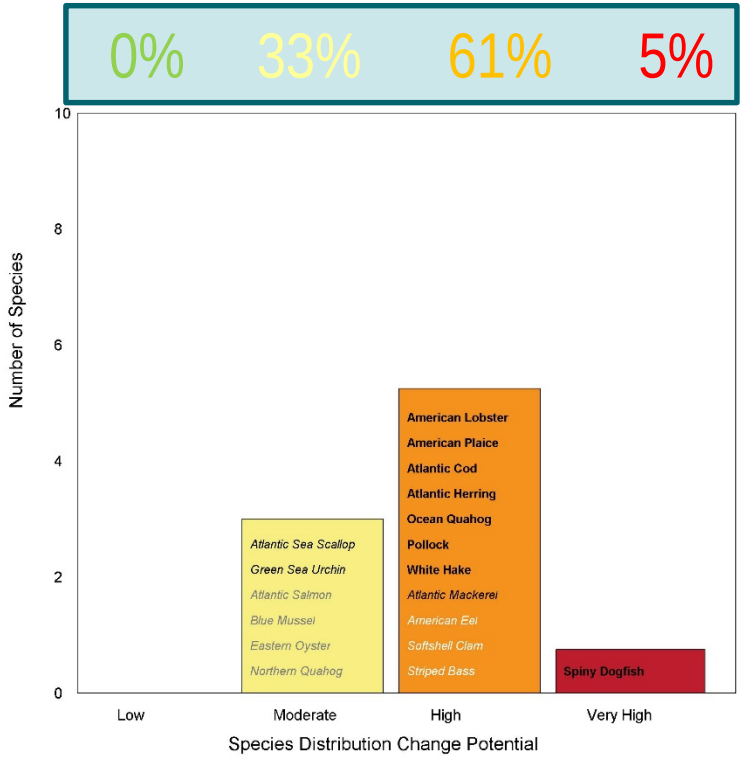


Colburn et al. (in press)

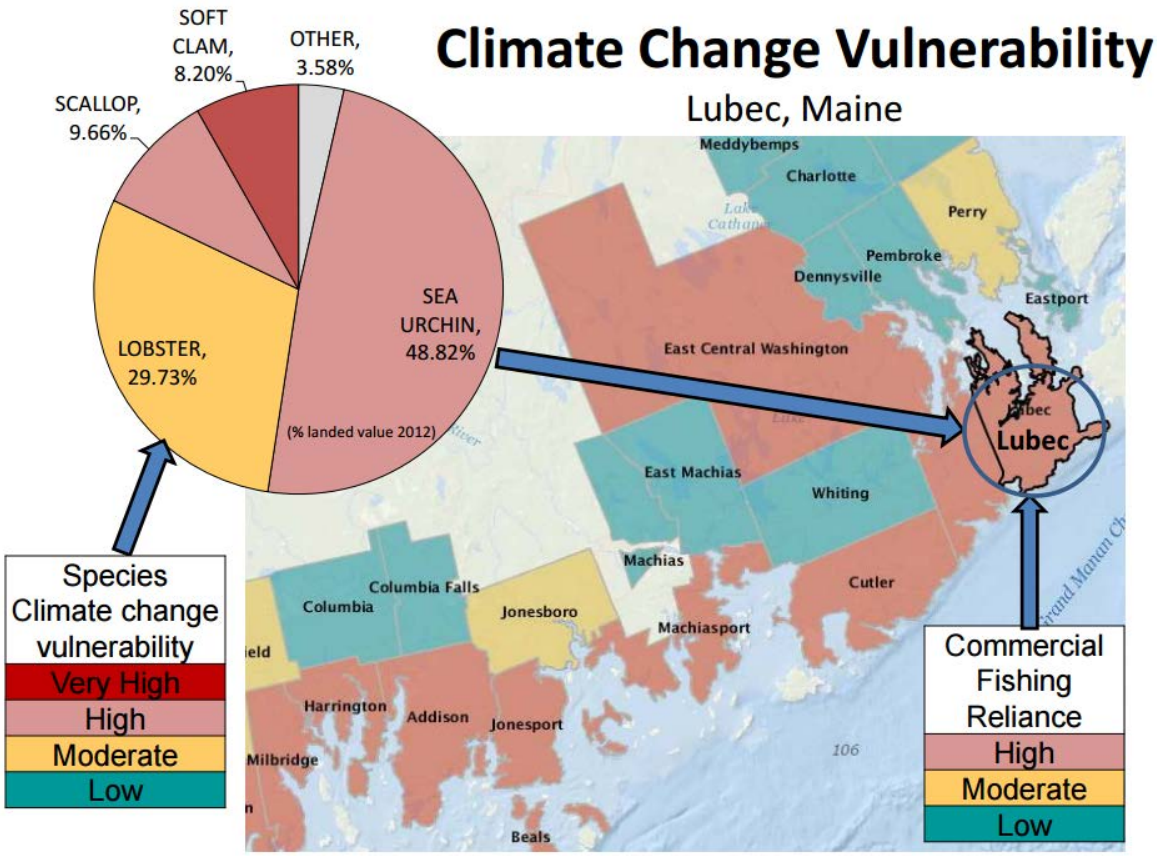
State Vulnerability

- Vulnerability to change in productivity and potential for distribution shift for 82 species
- Commercial, recreational, and aquaculture species in Maine





State / Port Vulnerability



Colburn et al. (in press)

Trigger Questions--

- Are state vulnerabilities useful in addition to ASMFC-level results?
- How do you envision using the results?
- As you look through the results, are there tweaks we can do to make the results more useful?



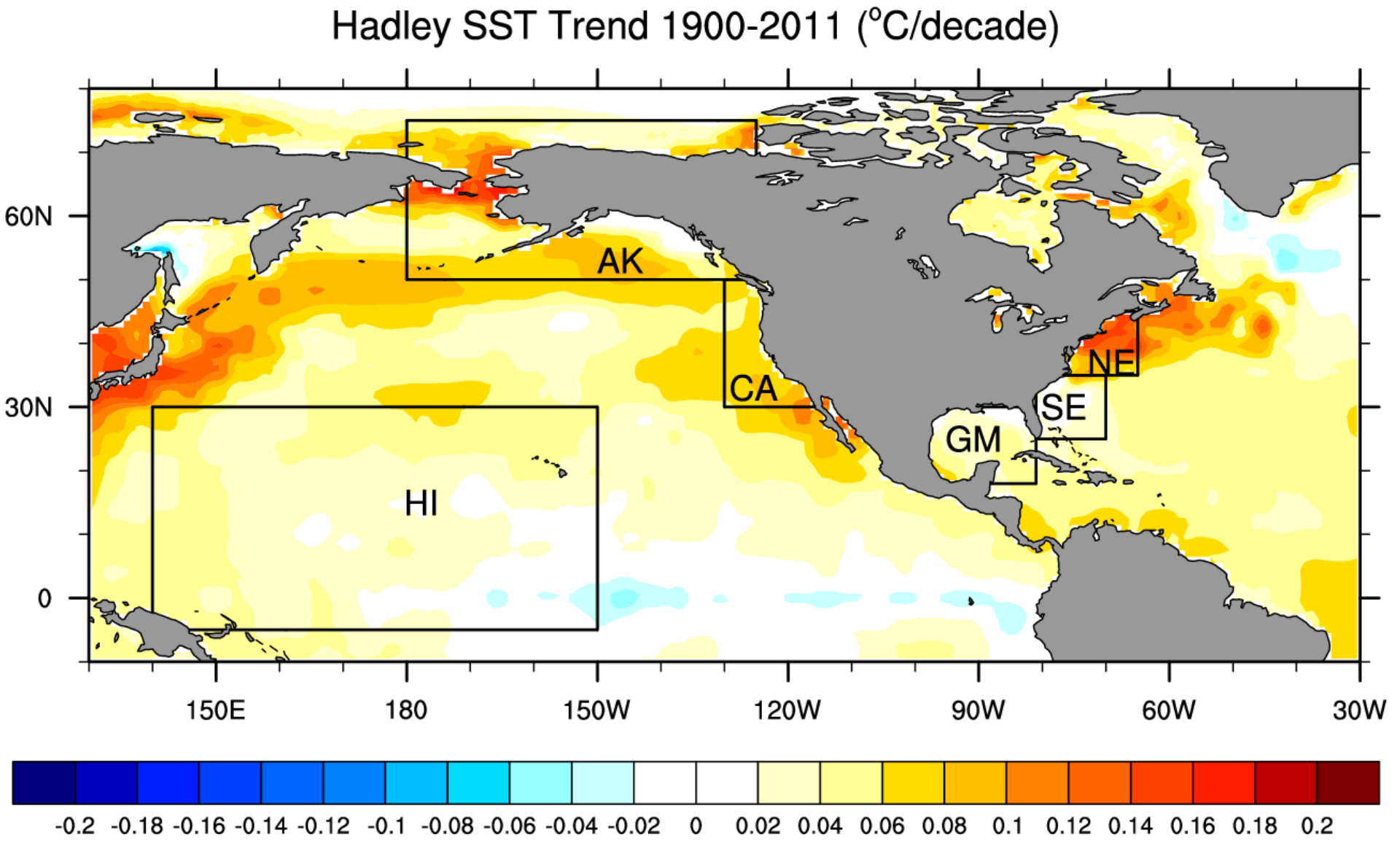

Climate Impacts on Atlantic Stocks and Harvest Allocation Challenges

Spring Meeting
Alexandria, Virginia
May 2016

Overview

1) Detecting climate-induced changes in stock distributions
2) Soliciting Commissioner feedback on harvest re-allocation options
3) Technical and management process to adjust harvest allocations
4) Future directions

Observed sea surface temperature trend



ASMFC-NMFS collaborative investigation

Focal Stocks:

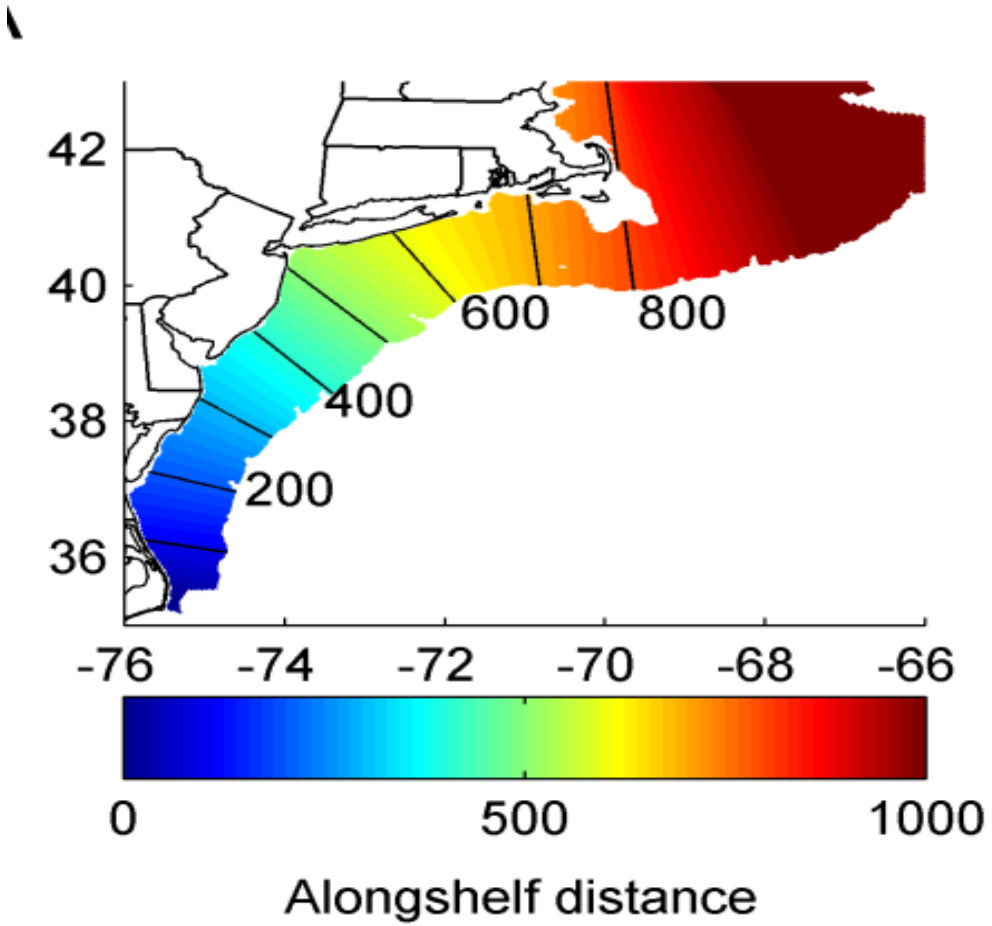
black sea bass, summer flounder, scup, winter flounder

Distribution shift patterns? Factors driving distribution shifts?

Hare, Richardson, Bell (NEFSC) & Griffis, Morrison (NOAA-HQ)

ASMFC Management and Science Committee

Quantifying stock distribution shifts



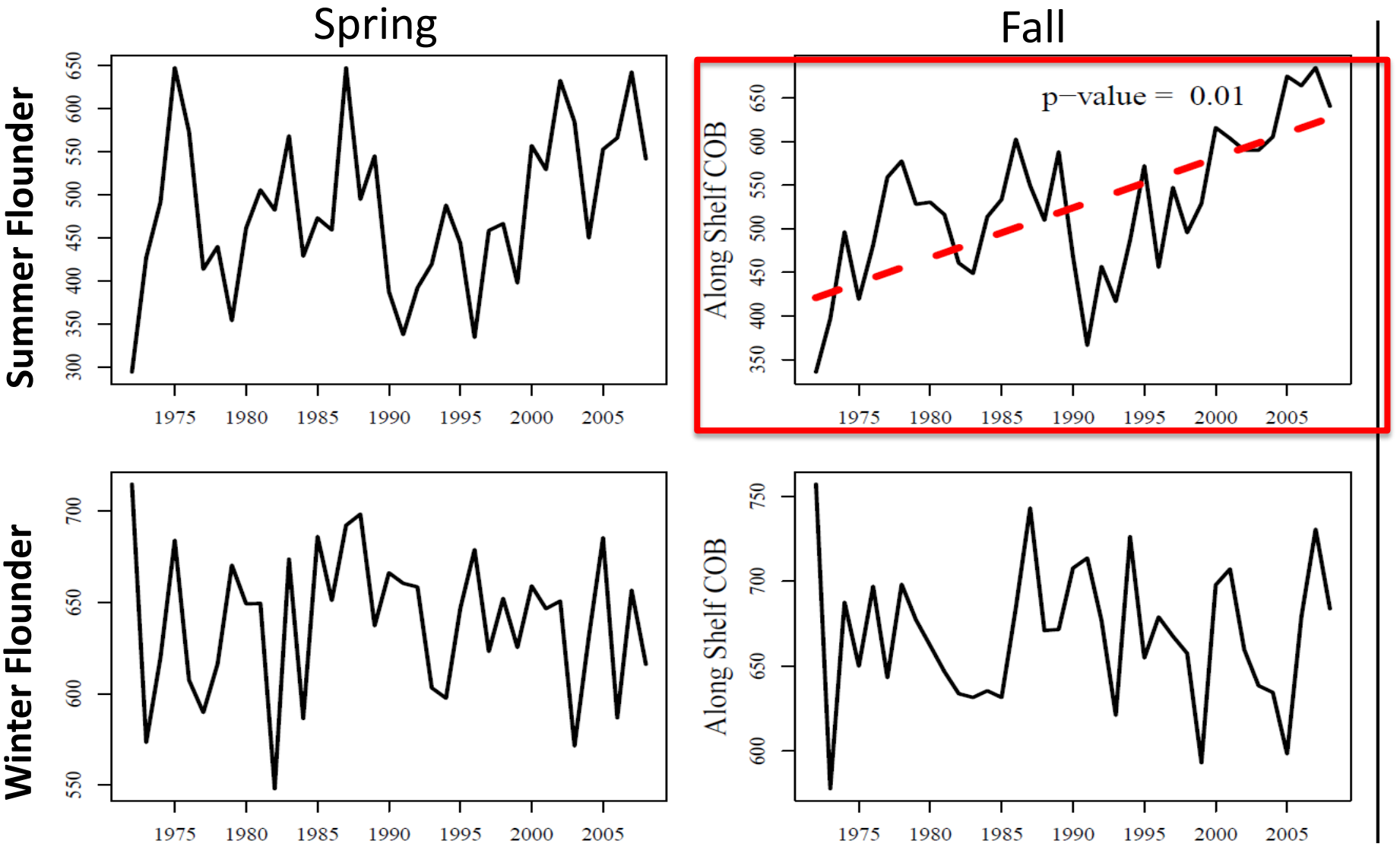
NEFSC trawl survey data analysis

Inshore and offshore strata

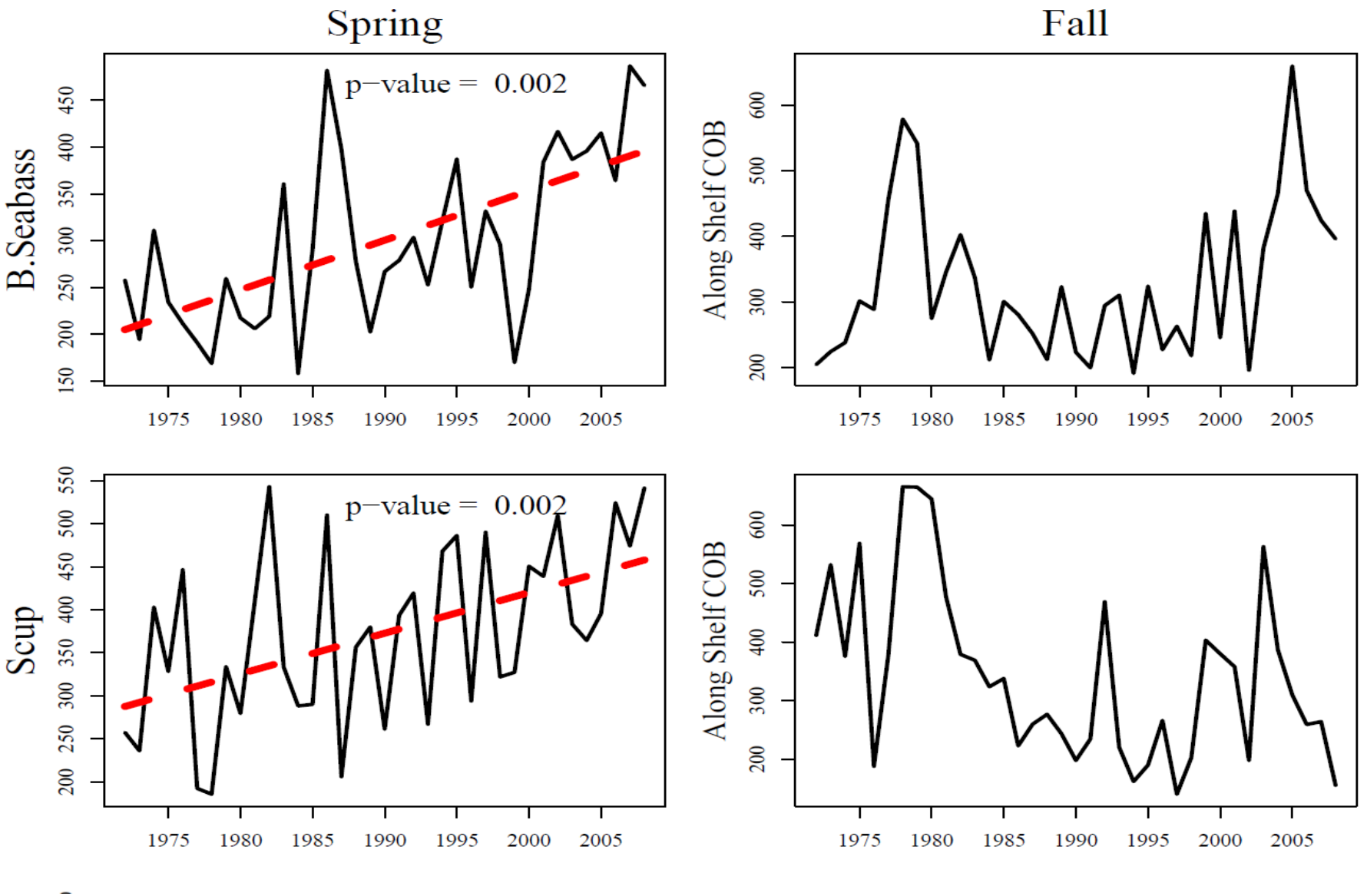
1972 – 2008

Center of Biomass: the distance along the Northeast shelf

Changes in center of biomass by species and season



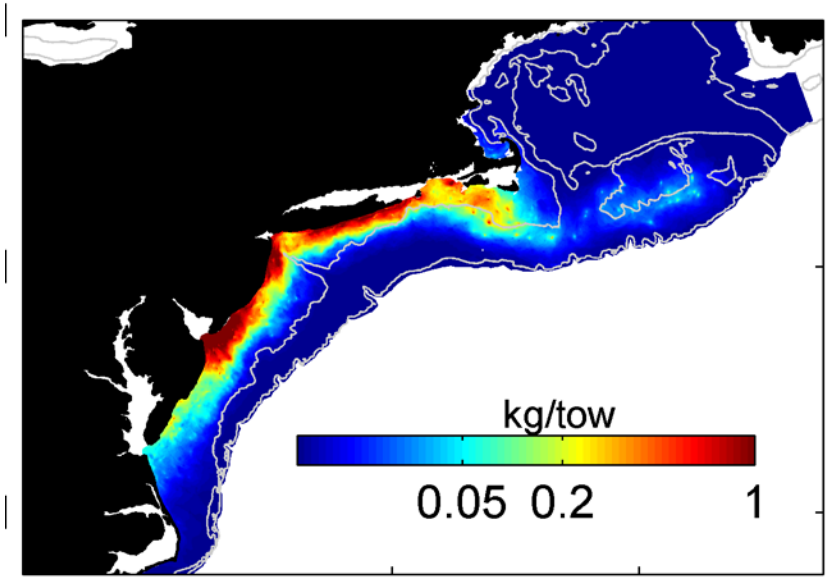
Changes in center of biomass by species and season



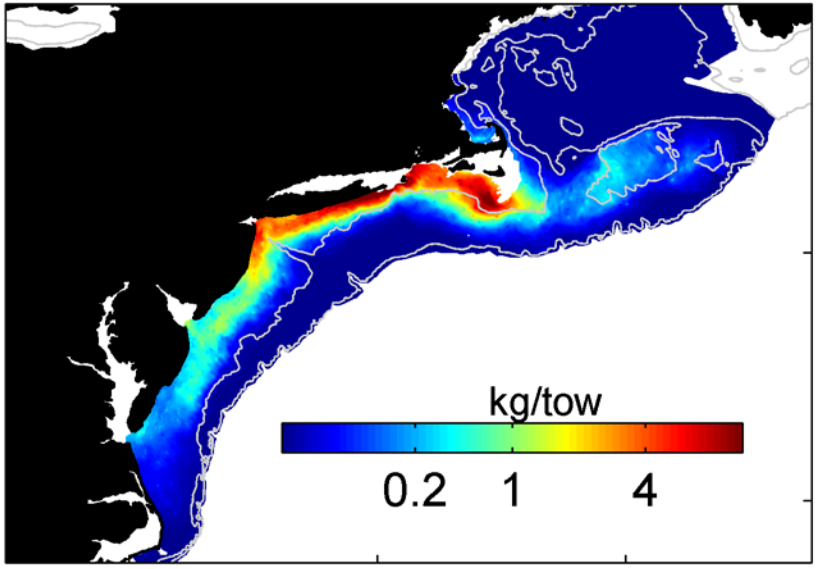
Summer Flounder

- poleward shift in distribution
- biomass increase over time

1980-1989

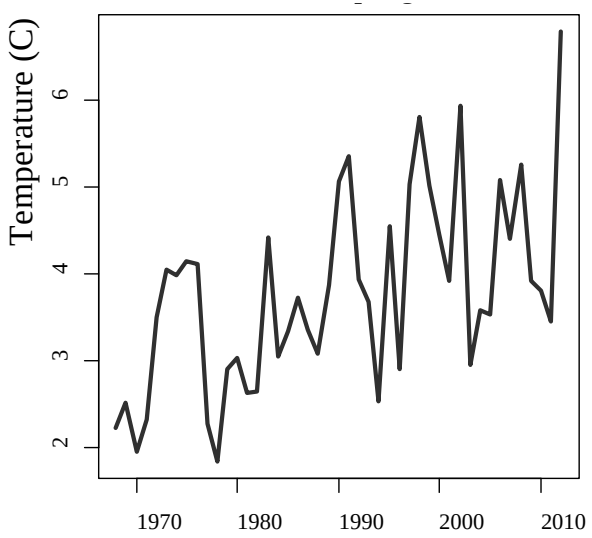


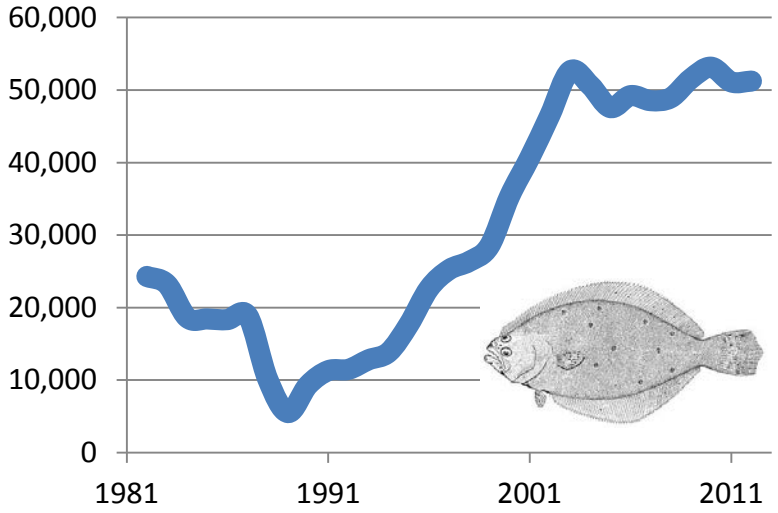
2000-2008



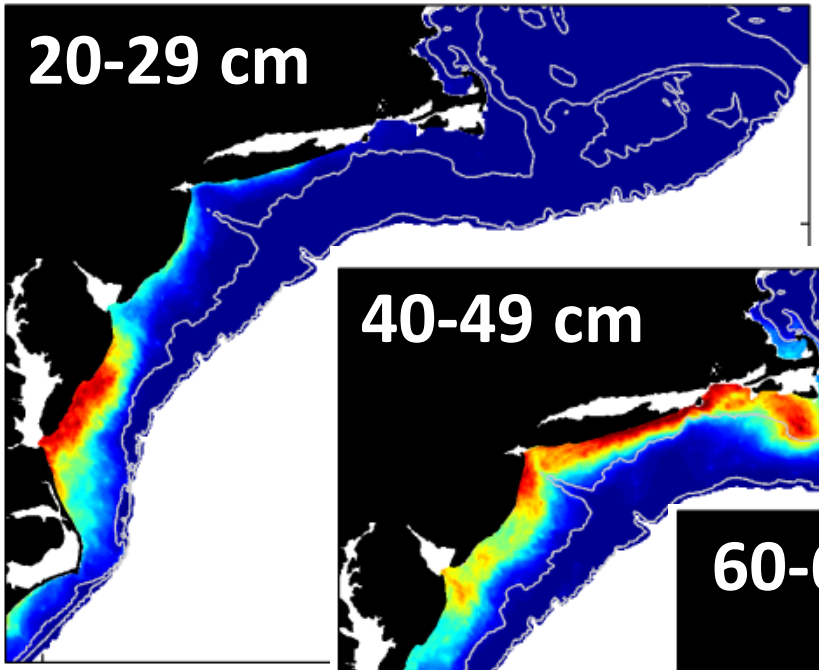
Factors driving distribution shifts

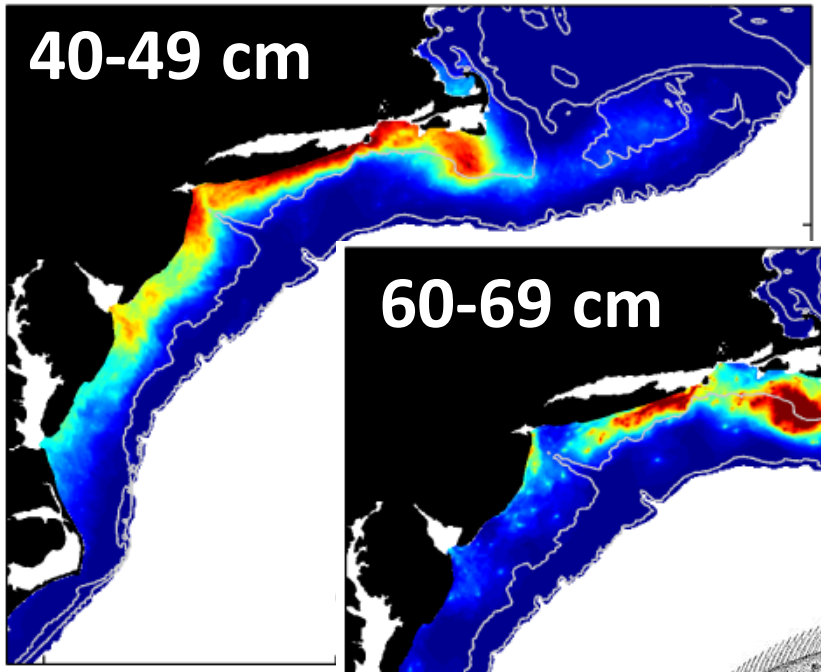
- Increasing temperature
  - -Species tend to move north as temperatures warm
- Changes in population abundance
  - -Populations occupy a larger, expansive area as numbers increase
- Changes in population size structure
  - -Reducing fishing pressure tends to result in larger fish
  - -Larger fish often occur further north than smaller fish

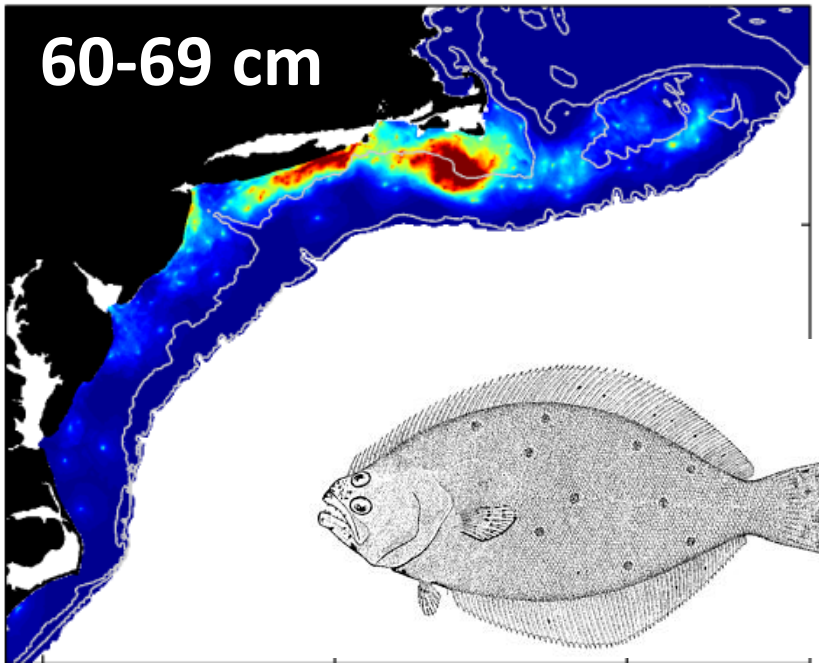




Summer flounder size structure

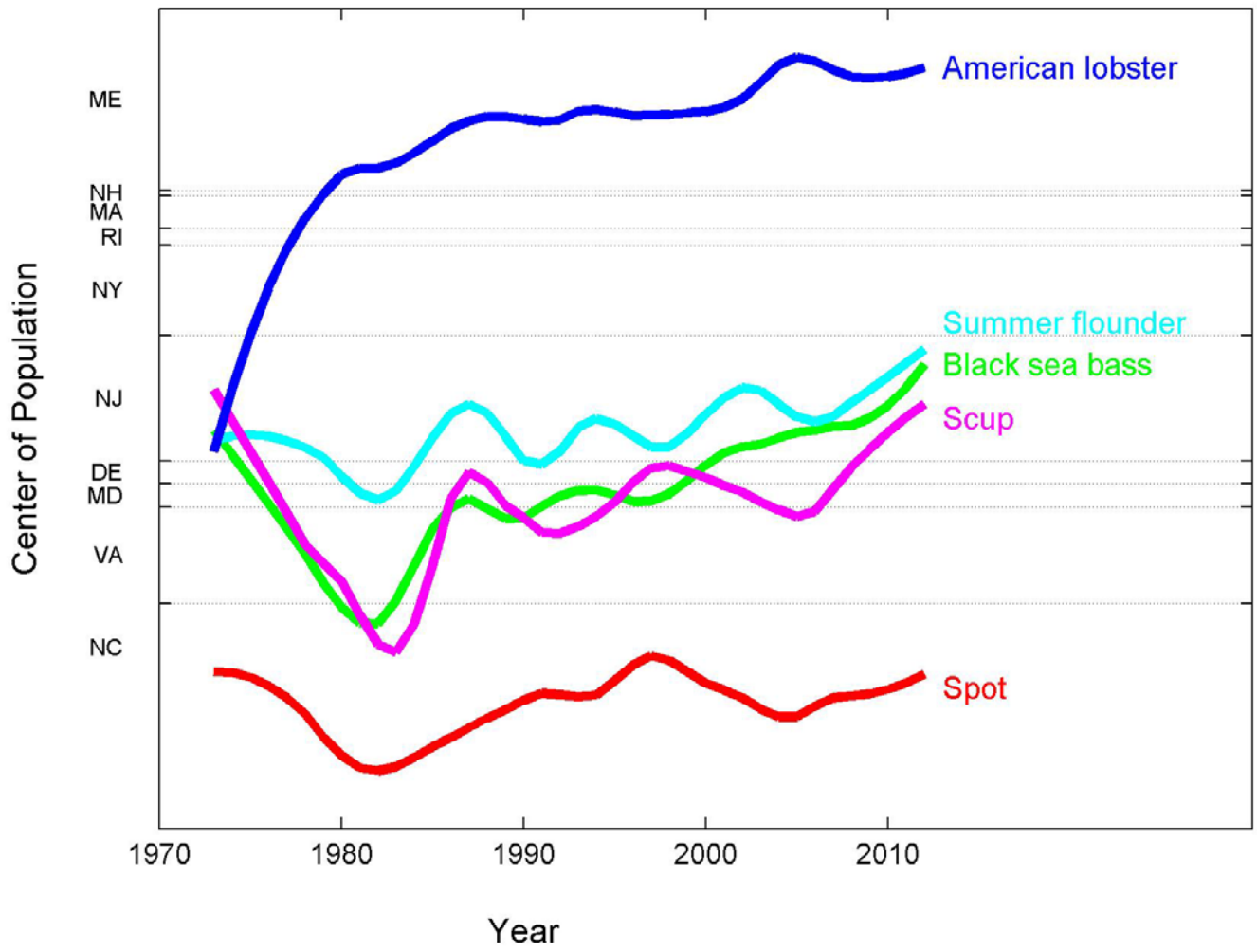






Smaller fish further south
Larger fish further north

Stock shifts by Atlantic state borders



Conclusions – Stock Distribution Shifts

- Climate change and stock distribution relationships are COMPLICATED
- Evidence of poleward shift in black sea bass, scup and summer flounder
  - Significant impact of temperature on shift in black sea bass and scup
  - Shift in summer flounder largely driven by population recovery and expansion of the length distribution
- Winter flounder stock not shifting
- Fishing pressure and climate both impact distribution and abundance

Exploring Harvest Reallocation Options

1) Survey of fisheries managers

2) Define methods for adjusting harvest allocations

3) Define frequency for re-evaluating stock distribution changes and allocations

Reallocation Survey Responses

- 73% did not support status quo (maintain percent allocations by state based on historical catches)

<u>New allocation options</u>

1) Biomass → Harvest - harvest %s proportional to changes in biomass %s (trawl survey data)
2) **50/50 - half of harvest based on new biomass, half based on historical allocation**
3) Fishery Performance – harvest allocations based on recent catch and retention rates

Reallocation Survey Responses

Flexible landing options

1) Fishermen land in the state closest to catch, count toward state quota where licensed

- catch off NJ, land in NJ → VA quota

2) Fishermen land in the state closest to catch, count toward state quota where landed

- catch off NJ, land in NJ → NJ quota

Reallocation Survey Responses

Recovered Stocks and Reallocation

77% would support allocating 'surplus biomass' to the states experiencing increases associated with a shifting stock

State vs. coast wide or regional allocations

60% would not support changing from state-by-state to coast wide or regional quotas

Frequency of allocation adjustments

83% supported 3-5 year intervals

Future Focus Areas

Poleward shifts of North Atlantic stocks
- lobster, cod, pandalid shrimp

Poleward shifts of South Atlantic stocks
- red drum, tilefish, tarpon, mahi, (cobia)

* New climate focus in stock assessments

Tracking shifts in habitat types & understanding subsequent stock productivity implications

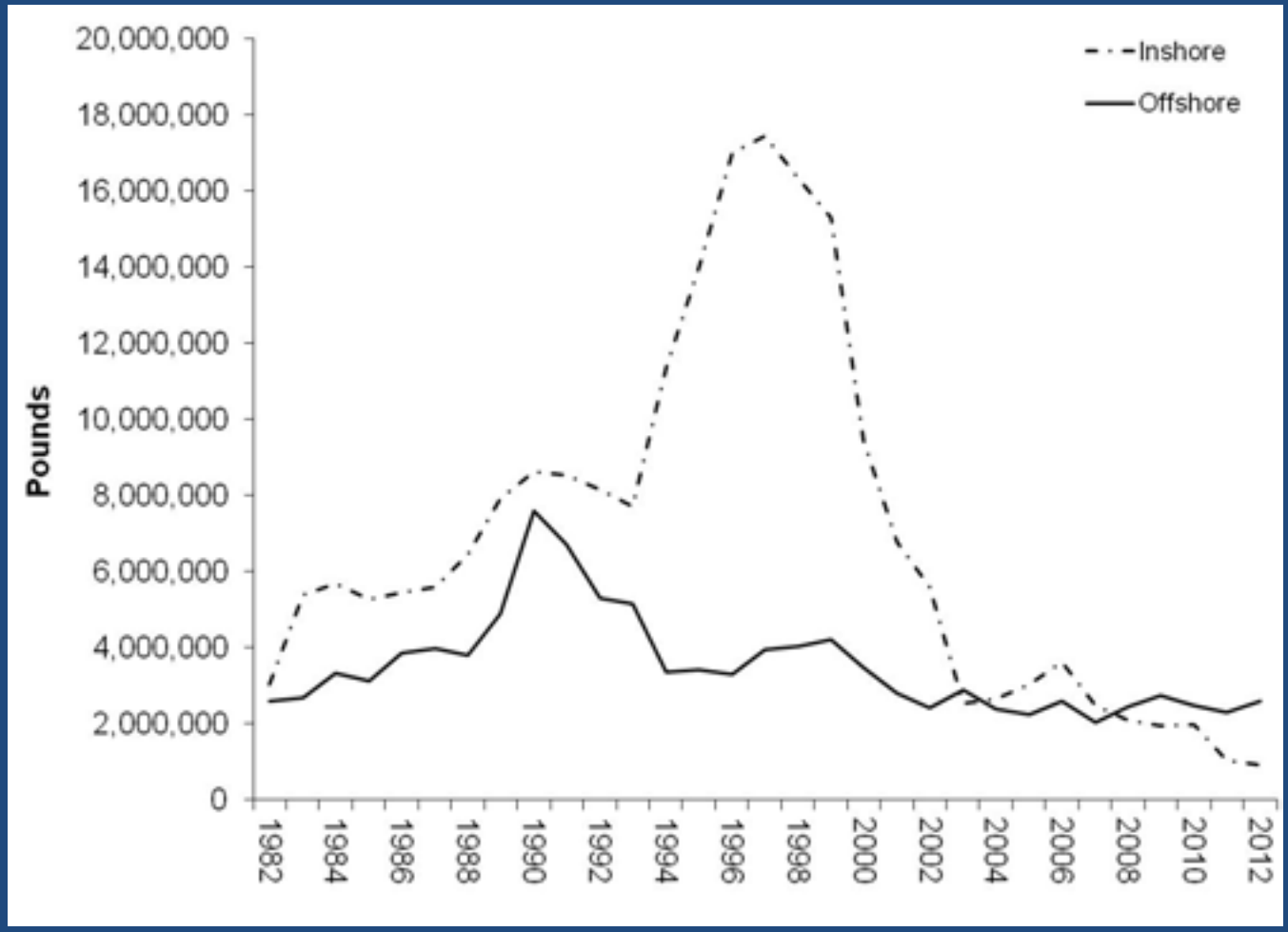
- shoreline hardening + rising sea levels = estuarine SAV declines
- mangroves in Georgia?
- Fish Habitat Partnership assessments

Harvest Allocation Winners and Losers

Socioeconomic analysis of re-allocation

Southern New England Lobster

SNE commercial lobster landings 1982 to 2012



2006 Lobster Stock Assessment

- “SNE stock is in poor condition”
- “stock is below the abundance threshold”
- “at or near the fishing mortality threshold”
- “declining trend in population abundance is well established and warrants a reduction in fishing mortality”

2009 SNE Lobster Stock Assessment

- "The stock is below the reference abundance threshold and below the effective exploitation threshold."
- *"the SNE lobster stock is depleted* ***but overfishing is not occurring.****"*
- Lobster TC recommends a 5 year moratorium.

2010 TC Report – Recruitment Failure in SNE Lobster Stock

- "stock is experiencing recruitment failure caused by a combination of environmental drivers and continued fishing mortality"
- "Overwhelming environmental and biological changes coupled with continued fishing greatly reduce the likelihood of SNE stock rebuilding."
- "Widespread increase in the area and duration of water temperatures above 20^0C throughout SNE inshore waters."

2010 TC Report (cont.) – Recruitment Failure in SNE Lobster Stock

- Prolonged exposure to water temperature above 20^0C causes:
  - respiratory and immune system stress
  - increased incidence of shell disease
  - suppression of immune defenses in lobster

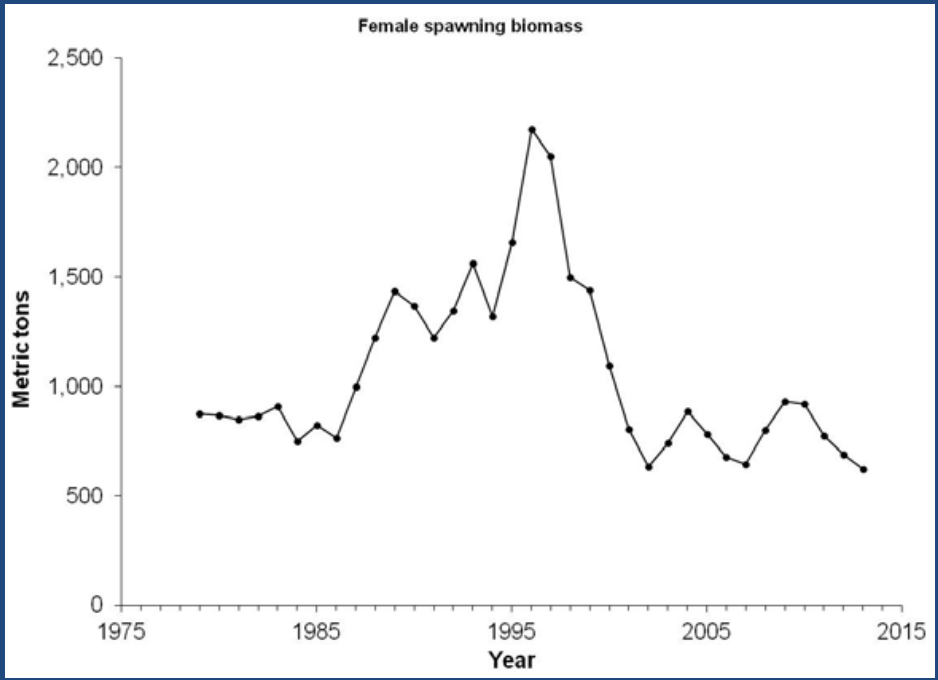
- "distribution of spawning females has shifted away from inshore SNE areas into deep water in recent years. This shift may impact larval supply to inshore nursery grounds."

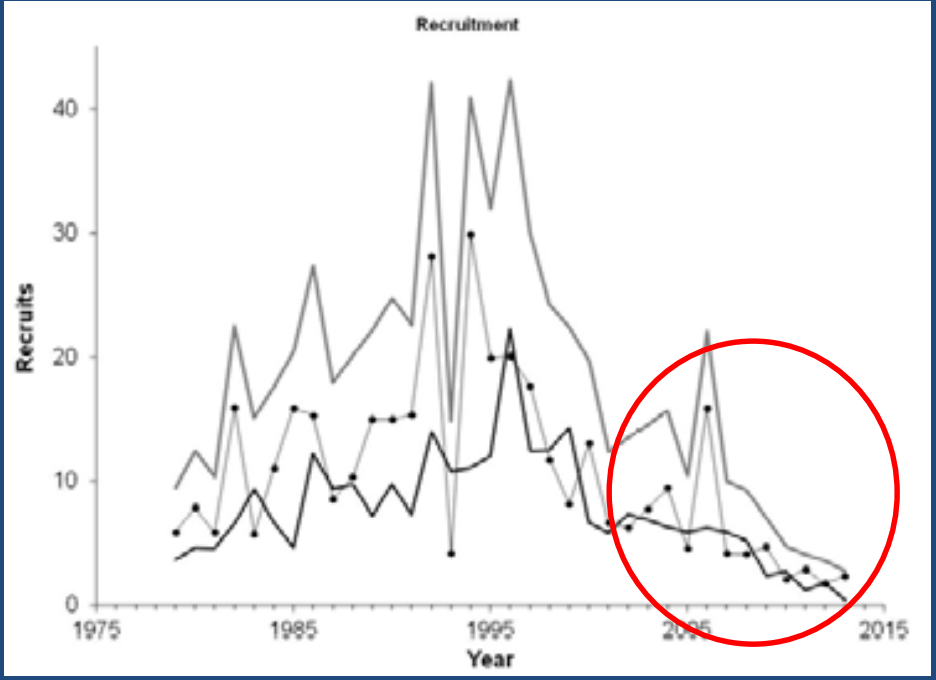
Management Responses to 2009 stock assessment

- Addendum XVII – 10 % reduction in exploitation
- Addendum XVIII –major trap reductions in 2 lobster management areas
- Finalized development of trap transferability program in 2 lobster management areas (*to scale the SNE fishery to the size of the resource*)

2015 Lobster Stock Assessment

Spawning biomass and recruitment estimates for SNE American lobster during 1979-2013 from the basecase model

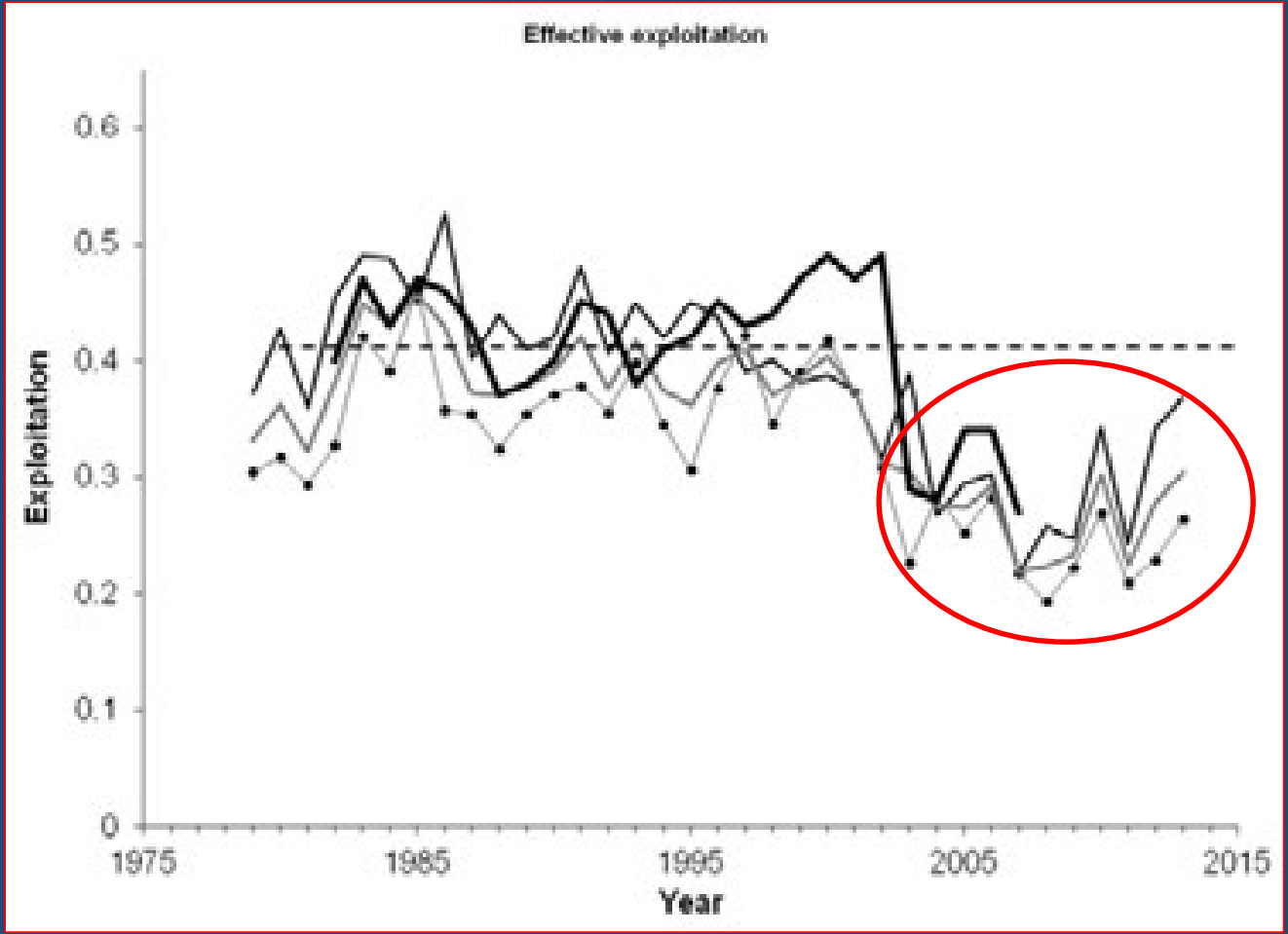




2015 Lobster Stock Assessment

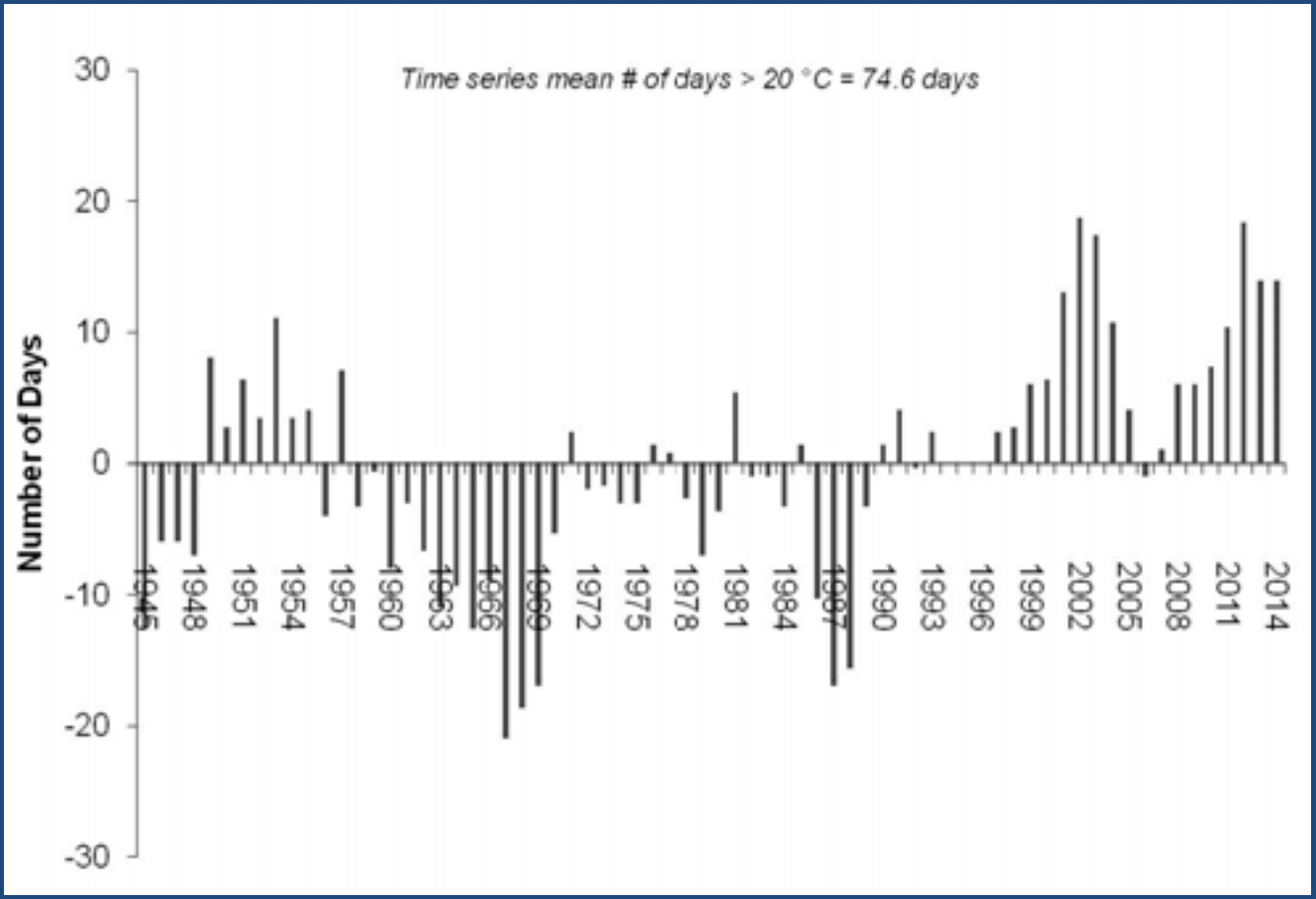
Annual effective exploitation for SNE American lobster during 1979-2013 from the basecase model.

Horizontal line shows threshold reference point



2015 Lobster Stock Assessment

Sea surface temperature anomalies from the mean # of days > 20° C at Woods Hole, MA, 1945 to 2014.

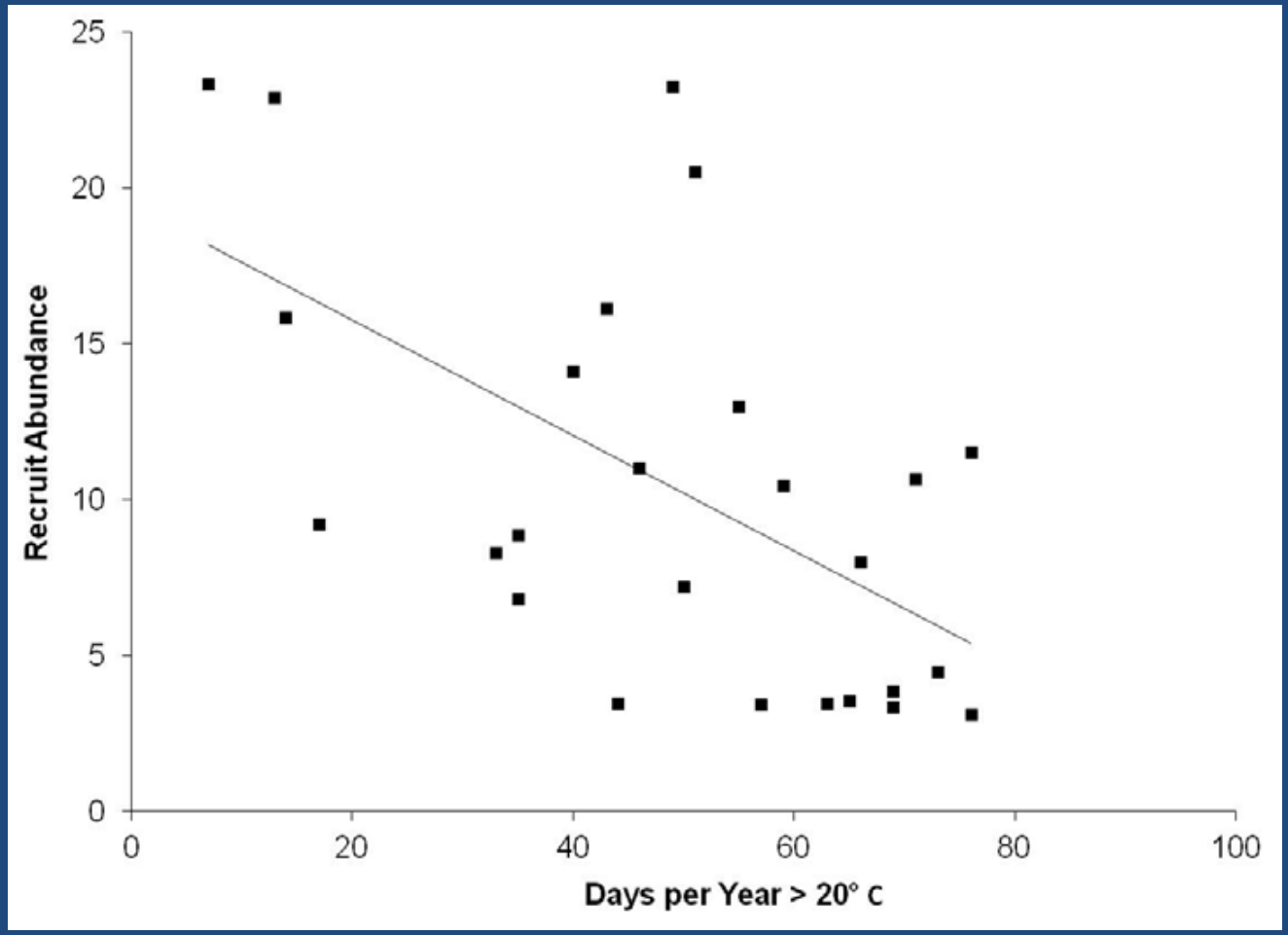


2015 SNE Lobster Stock Assessment

- "There is a ***significant negative correlation between*** the annual ***relative abundance of recruit-size*** (10 mm CL below min size) lobsters, as measured in four fall surveys (NMFS_SNE, MA, RI, CT) from 1984-2009 and the ***annual number of days with average temperature above 20° C***…"

2015 Lobster Stock Assessment

Annual relative abundance of recruit-size lobster versus the annual number of days with average temperature above 20° C.

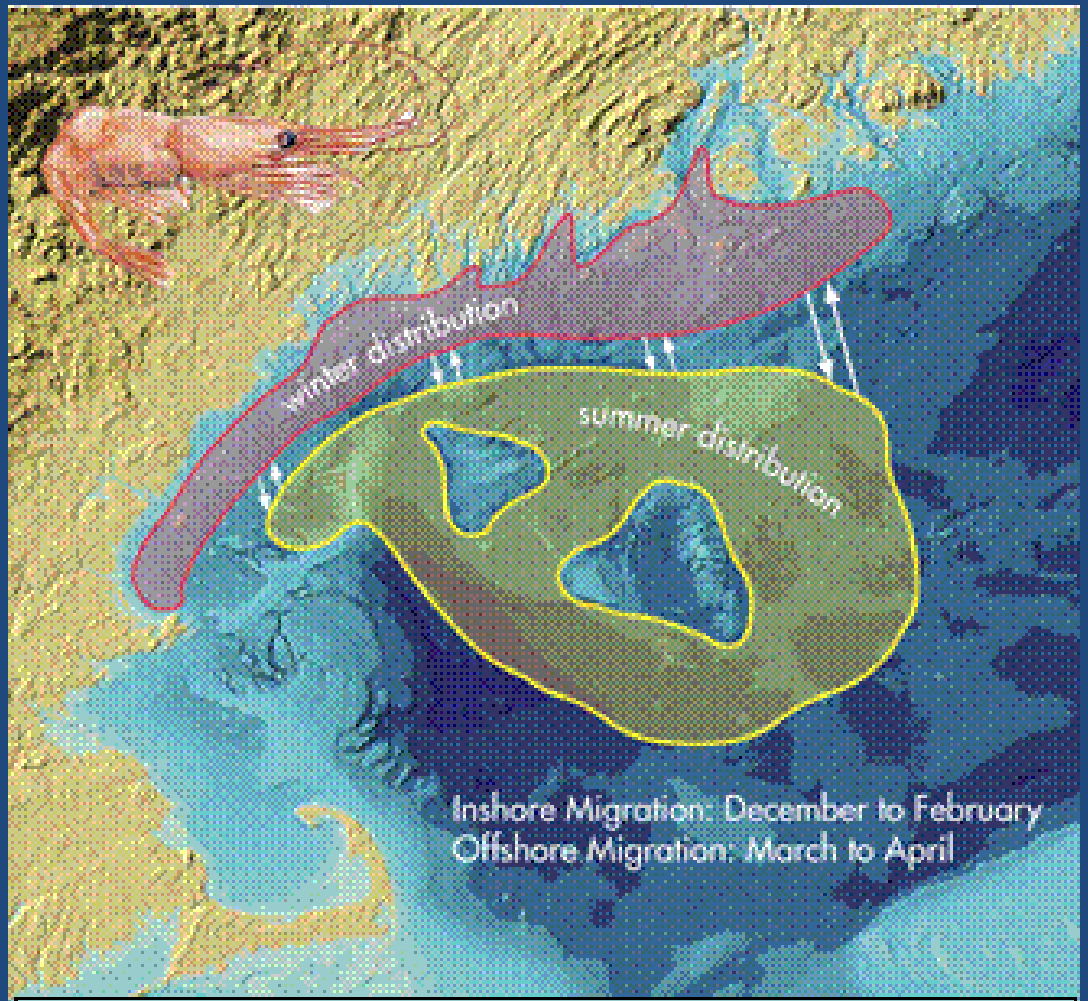


2015 SNE Lobster Stock Assessment
Peer Review Panel Report

- "inshore portion of the SNE stock has clearly collapsed"
- "*Fishing mortality does not appear to be extremely high ……supports the conclusion* that ***biological factors have contributed to bringing the stock to this point***."
- "the offshore [portion] is also in jeopardy and the Technical Committee and Review Panel believe the stock has little chance of recovering unless fishing effort is curtailed."

Gulf of Maine Northern Shrimp

Gulf of Maine Northern Shrimp

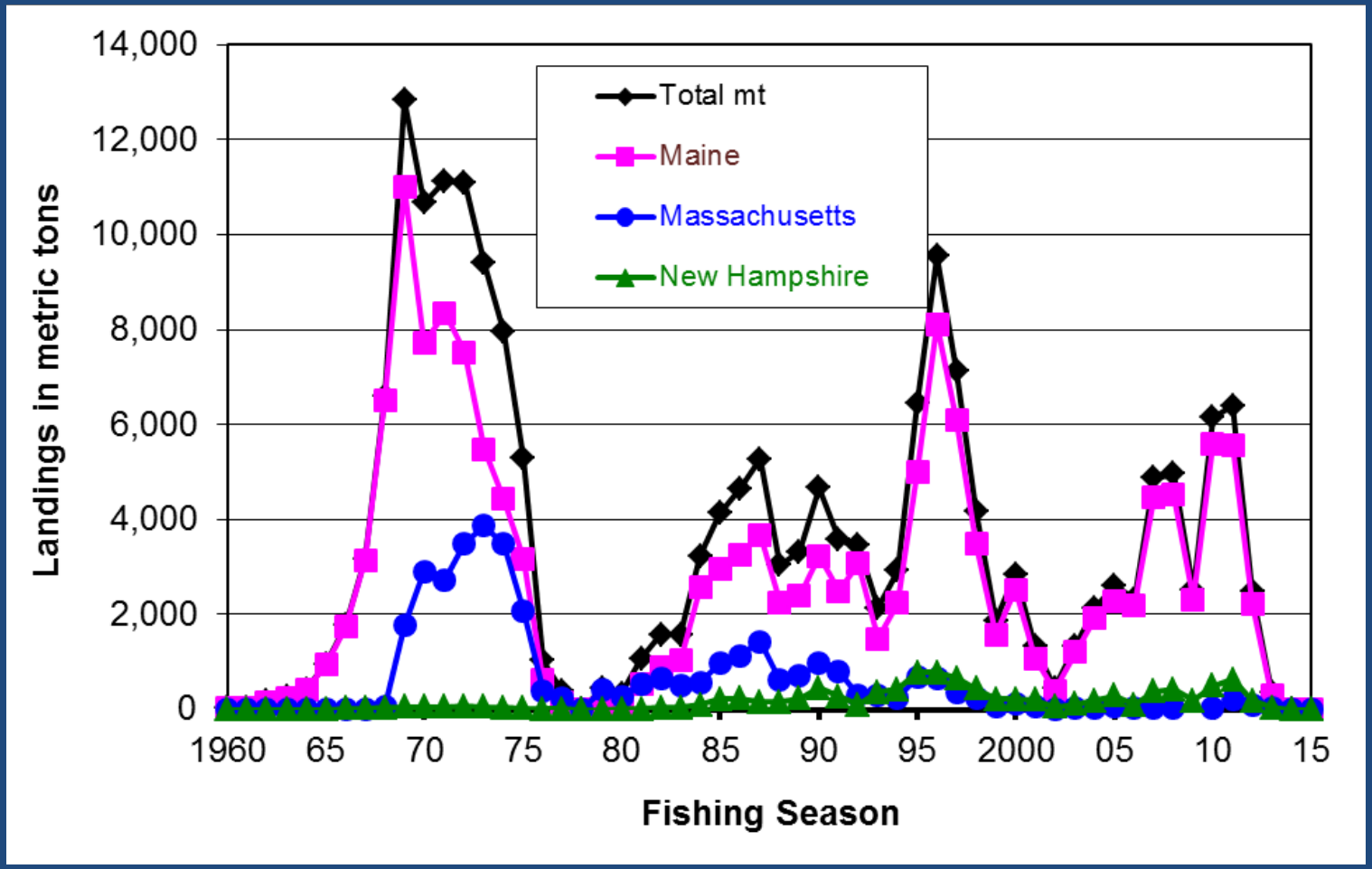


Distribution of adult female northern shrimp (NAMA, 2006)

Gulf of Maine Northern Shrimp

- 1972 Northeast State/Federal Management Program
- 1980 ASMFC management
- 1986 1st FMP
- "Pronounced fluctuations in abundance have been documented for this stock, with ***environmental factors apparently playing a major role.***"

Northern Shrimp Landings

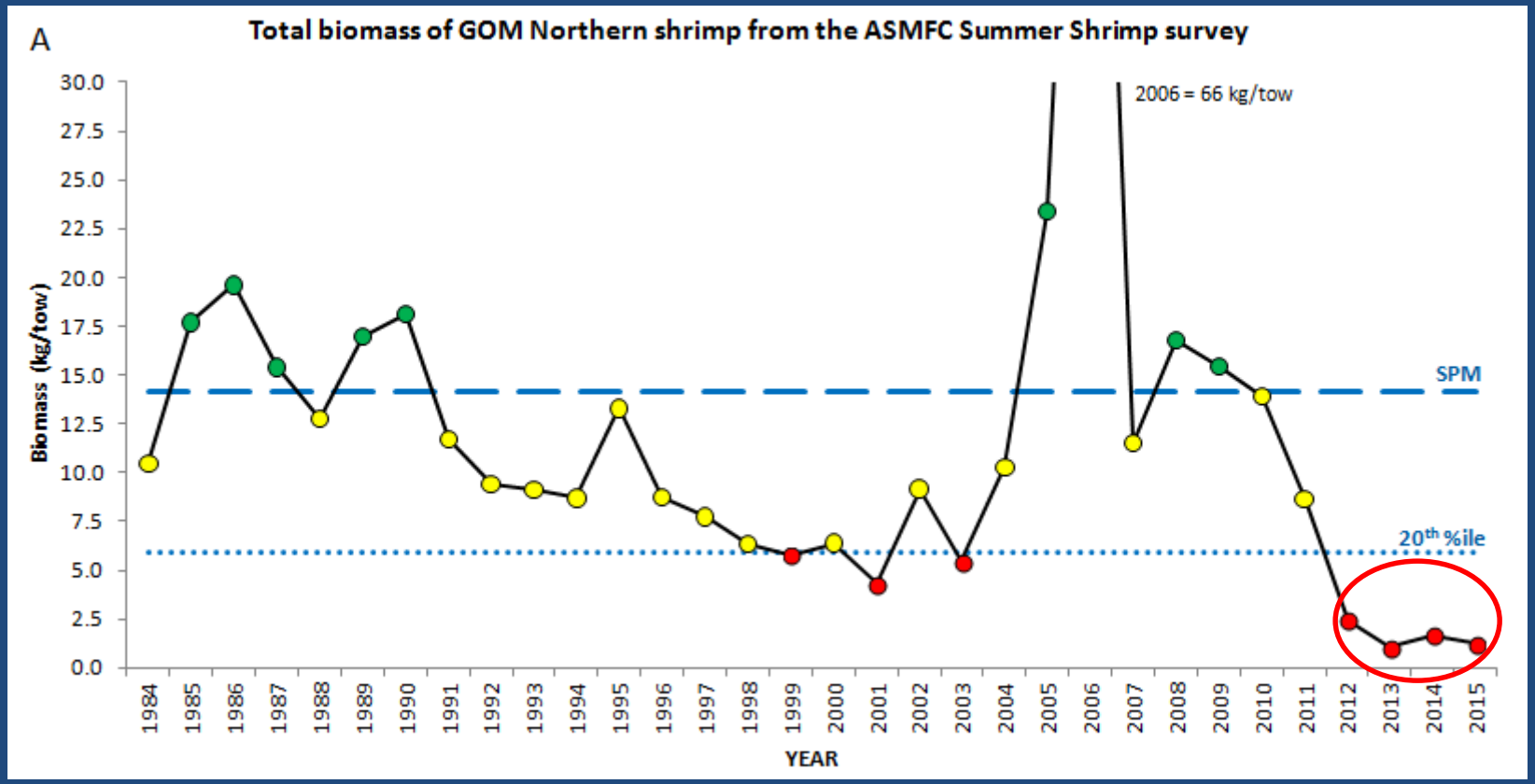


Northern Shrimp Fisheries Management

- Use combination of:
  - input controls (season, gear restrictions, landing days, etc.)
  - output controls (seasonal landings cap)
  - Input and output controls developed each year based on annual stock assessments

- **Harvest moratorium since 2014 (3 years)**.

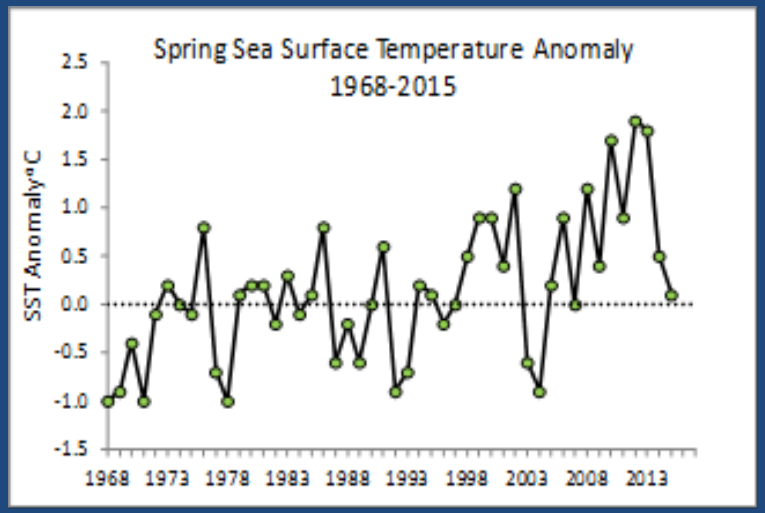
Northern Shrimp
2015 Stock Assessment

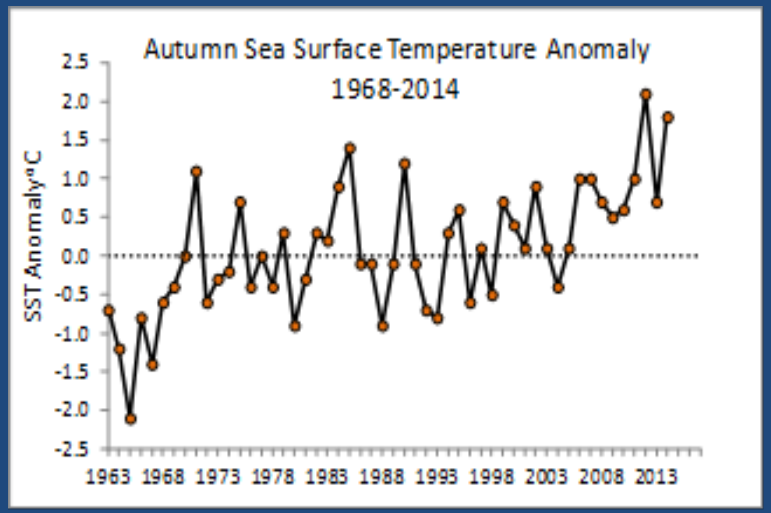


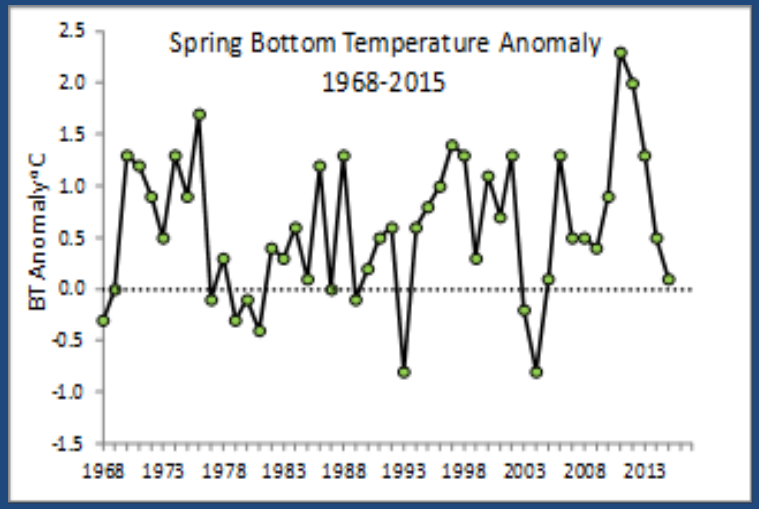
Northern Shrimp
2015 Stock Assessment

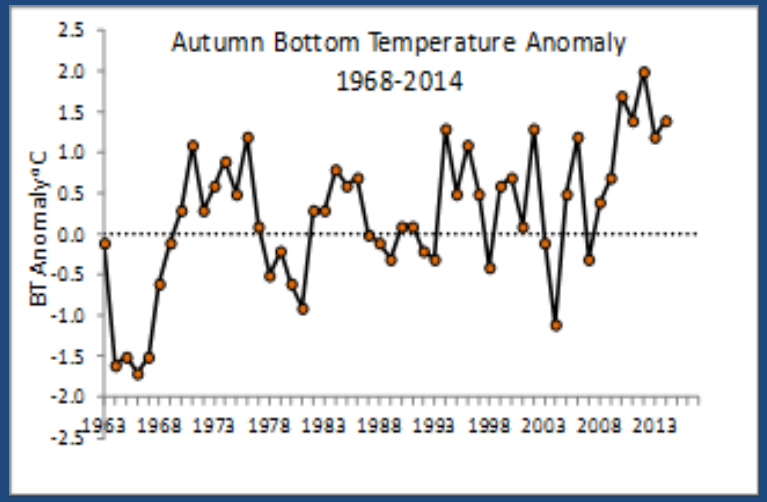
- "Ocean temperature has an important influence on Northern Shrimp in the Gulf of Maine and is correlated with survival during the first year of life. "
- "Relatively cool temperatures during the larval period (winter/early spring) and early benthic juvenile stage (late summer) are beneficial to survival and thus recruitment."
- "*Overall, temperature conditions for Northern Shrimp have been poor since around 2000*."

Northern Shrimp
2015 Stock Assessment .

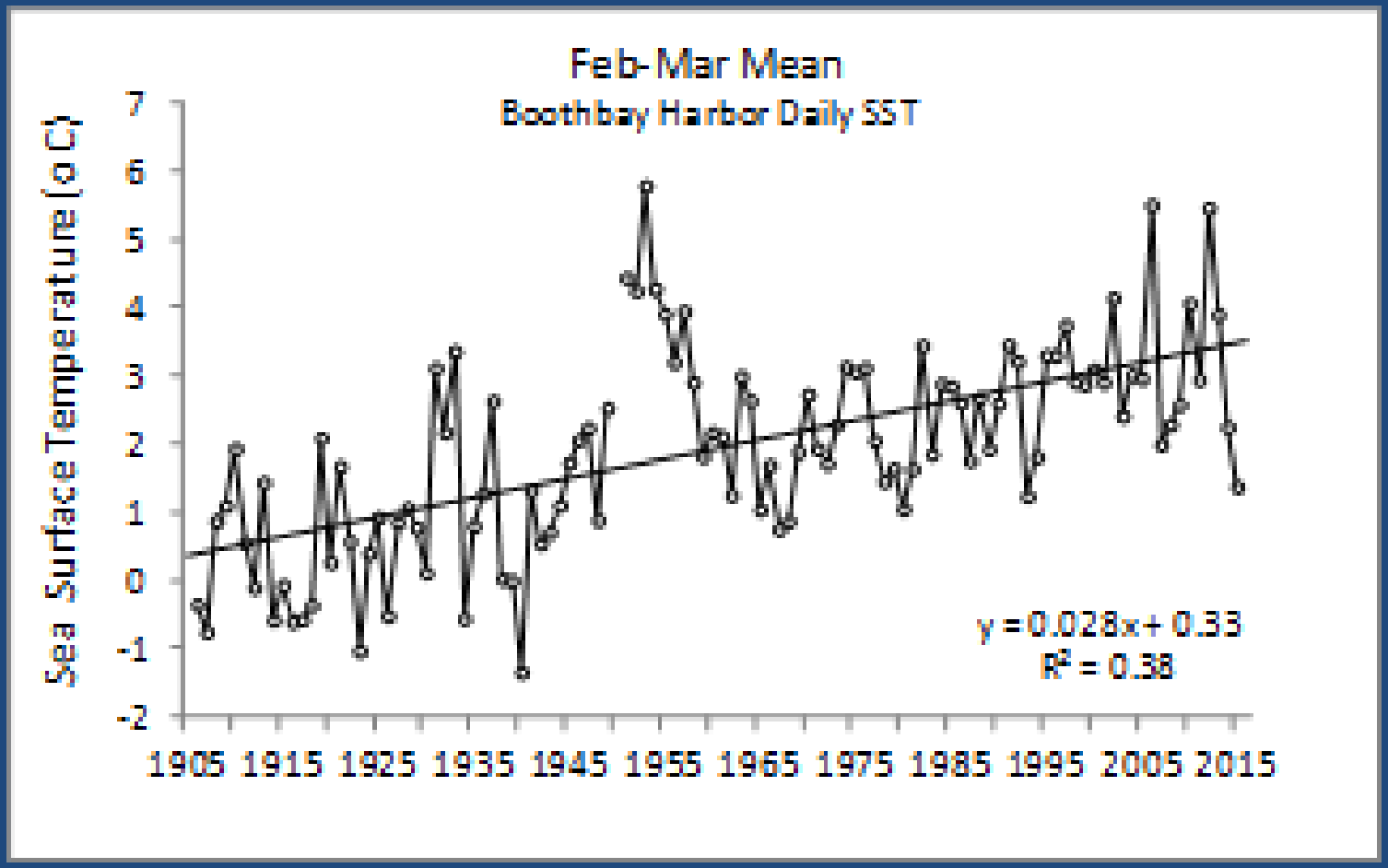








Northern Shrimp
2015 Stock Assessment



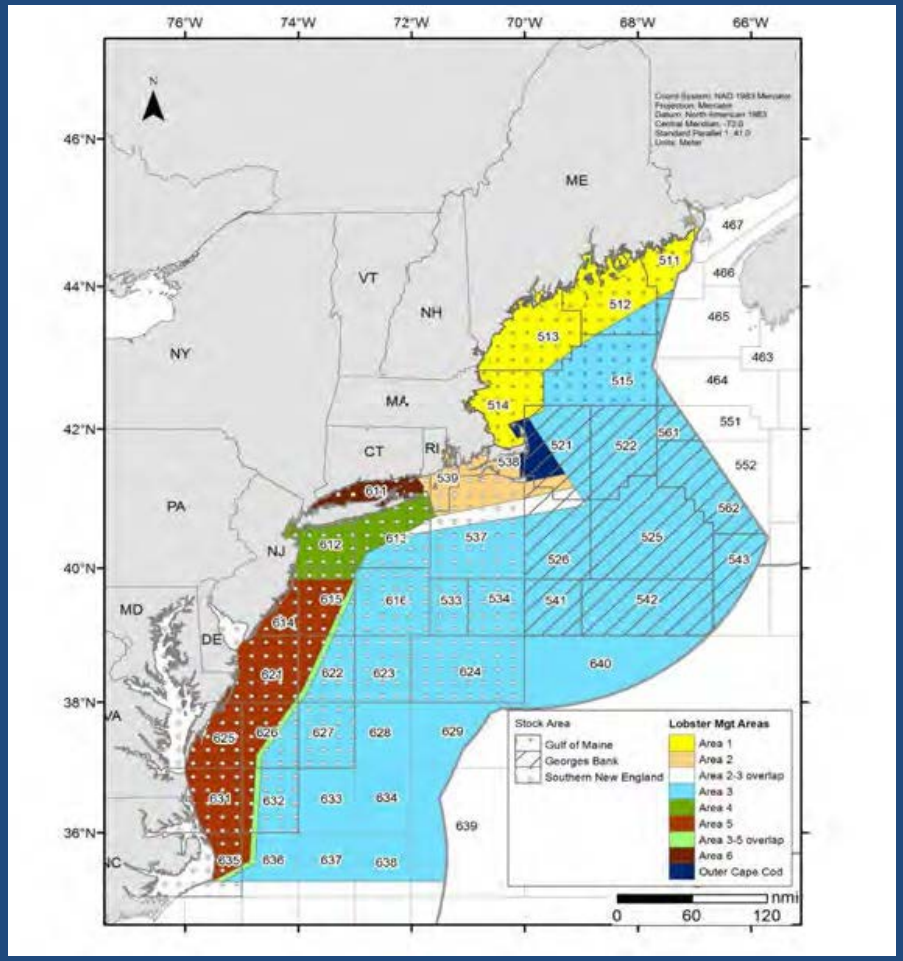
Northern Shrimp
2015 Stock Assessment

- "Low or failed recruitment of the five most recent year classes is unprecedented."
- "NSTC considers the Gulf of Maine northern shrimp stock to have collapsed with little prospect of recovery in the near future. "
- "***Long term trends in environmental conditions are not favorable for Northern Shrimp***"
- ***Survival index for the 2014 year class was low despite cooler ocean temps and a harvest moratorium.***

Given that climate change and rising ocean temps are predicted to occur into the foreseeable future,

How do we **adapt** fisheries management?

SNE Lobster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Stock Area
Gulf of Maine
Georges Bank
Southern New England
Lobster Mgt Areas
Area 1
Area 2
Area 2-3 overlap
Area 3
Area 4
Area 5
Area 3-5 overlap
Area 6
Outer Cape Cod
nmi
0
60
120

2015 SNE Lobster Stock Assessment

- "…SNE stock is not rebuilding and is experiencing recruitment failure. A longer and more geographically widespread harvest moratorium in SNE would be necessary to increase spawning stock abundance enough to boost recruitment and allow the stock to rebuild."