NOAA FISHERIES

Northeast Fisheries Science Center

# Integrating ecosystem and climate effects

TOR # 6

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# TOR 6

Does the Center have in place an effective process for taking ecosystem and climate change factors into consideration in the stock assessment process?

# Presentation outline

- Ecosystem and climate processes: overview
- Do we have the data for integration?
- Do we have the analytical tools for integration?
- Do we have an effective process for integration?
- Successes, Challenges, Solutions

# Why include ecosystem and climate effects?

"Would you please elaborate on 'then something bad happened'?"

# Presentation outline

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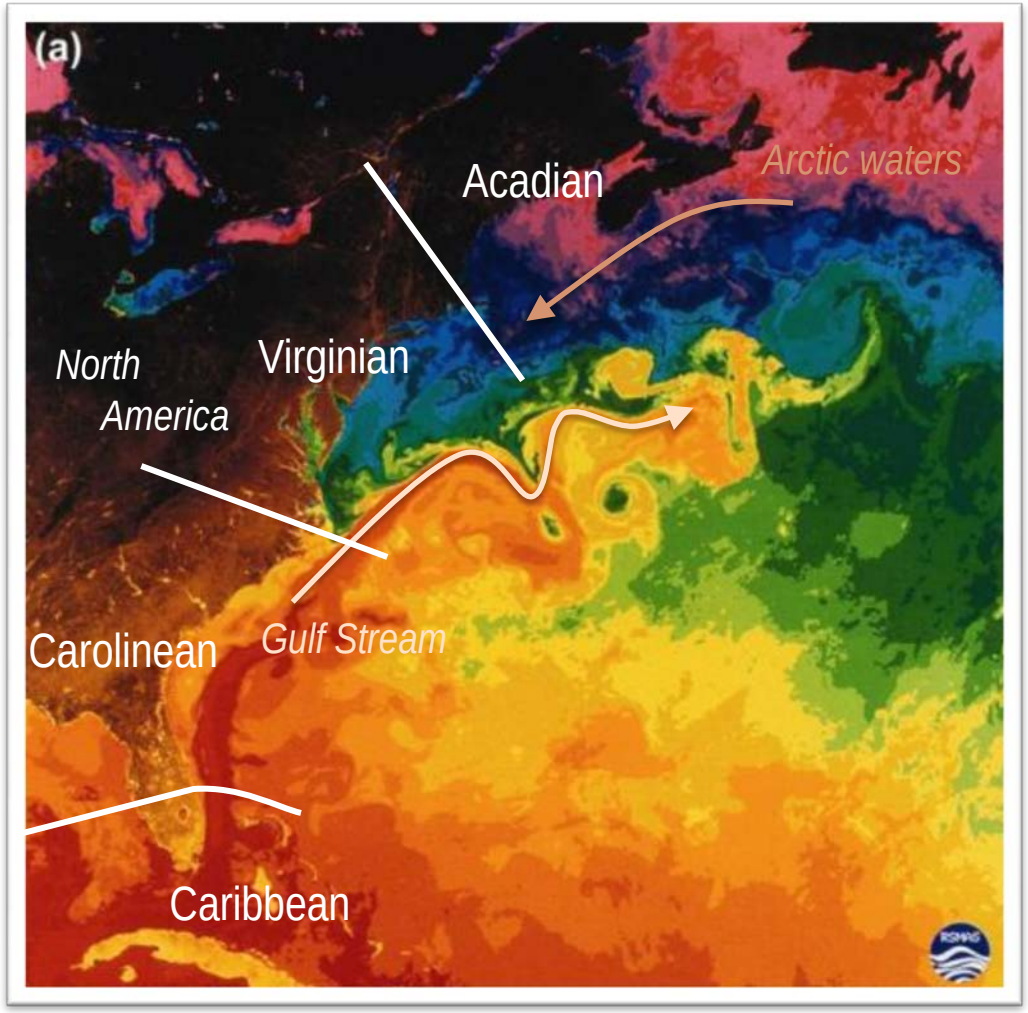
# US East Coast Marine Ecosystems

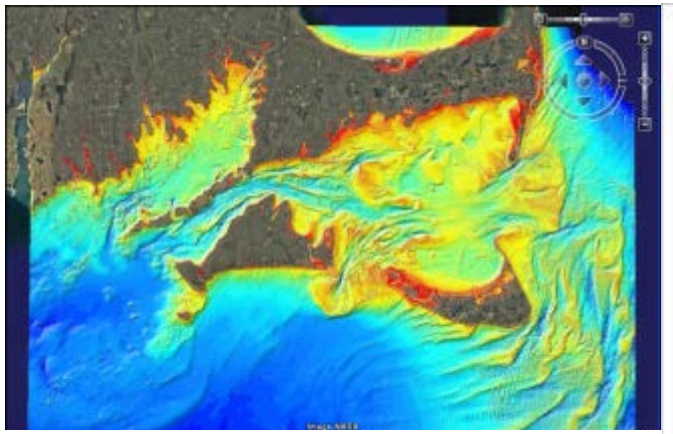
- Contrasting provincial conditions, species
- Strong seasonality
- Range of scales important

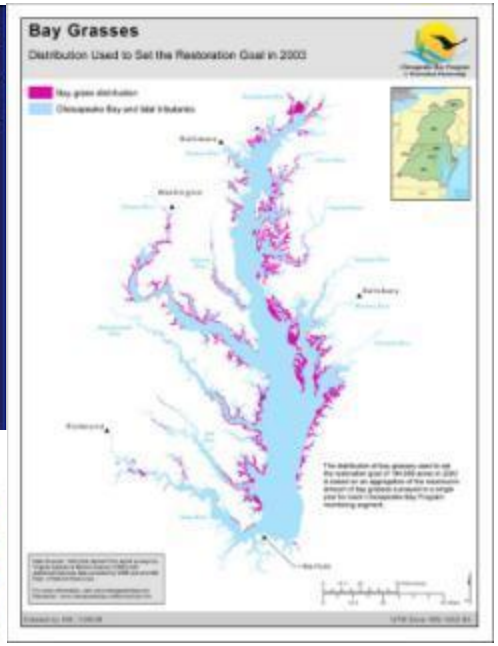


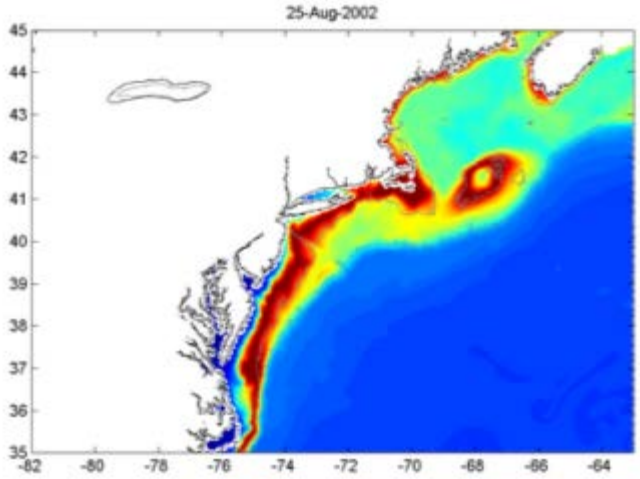

After Talley et al., 2011

# Wide range of linked habitats

- Aquatic-marine
- Benthic-pelagic
- Shallow-deep
- Permanent-intermittent



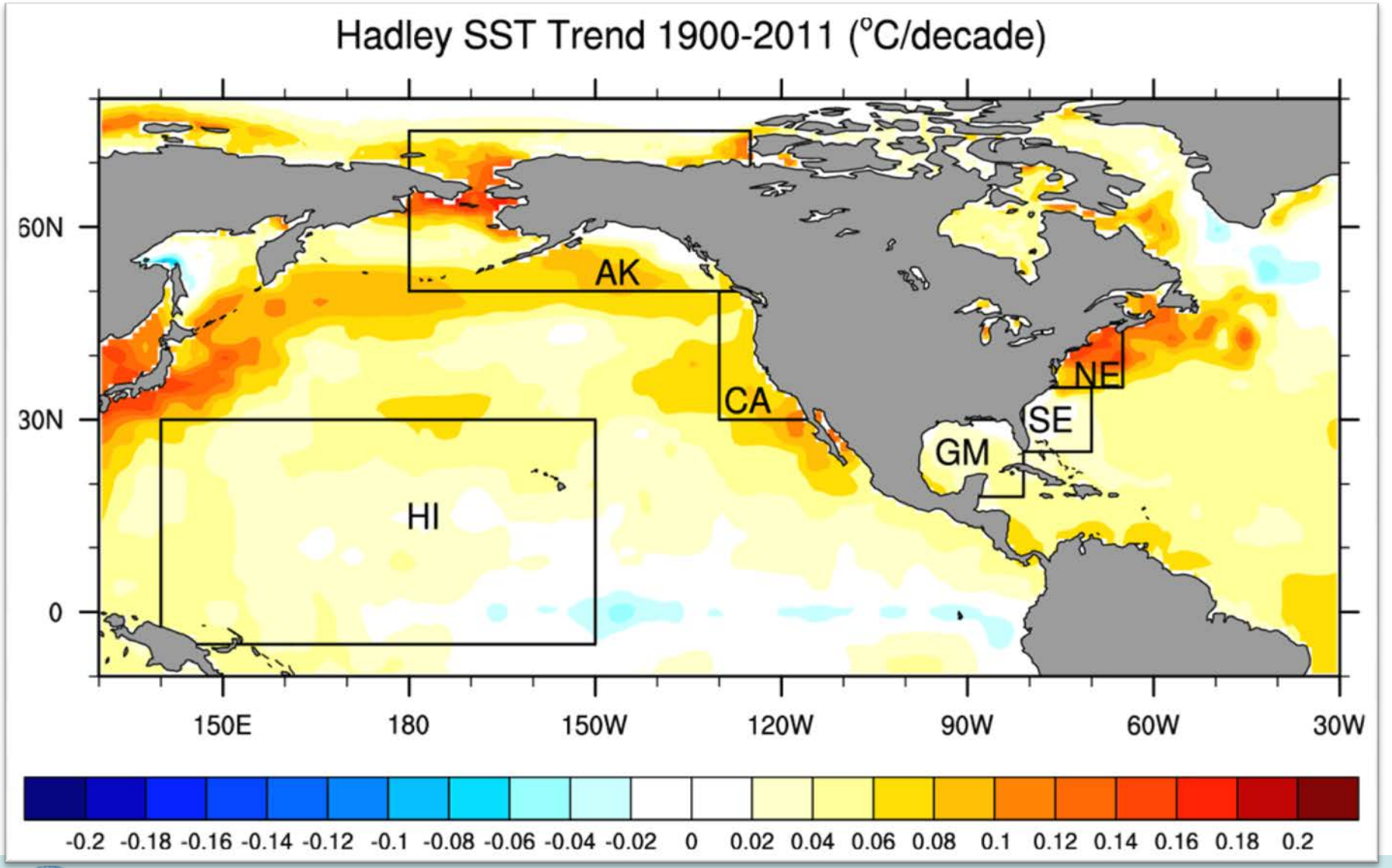


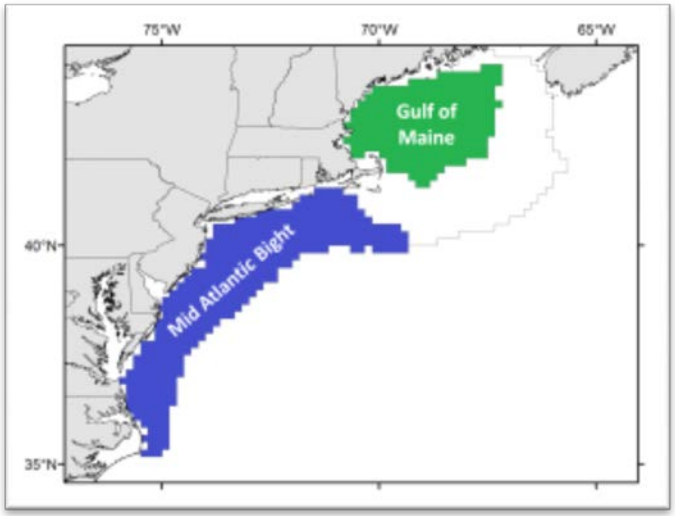

http://www.myroms.org/cstms/wiki/images/c/cb/Model_map.png
http://www.chesapeakebay.net/maps/map/bay_grasses_distribution_used_to_set_the_restoration_goal_in_2003
http://oceanexplorer.noaa.gov/explorations/13midatlantic/logs/may17/may17.html
https://www.st.nmfs.noaa.gov/ecosystems/habitat/funding/projects/fy2012-projects

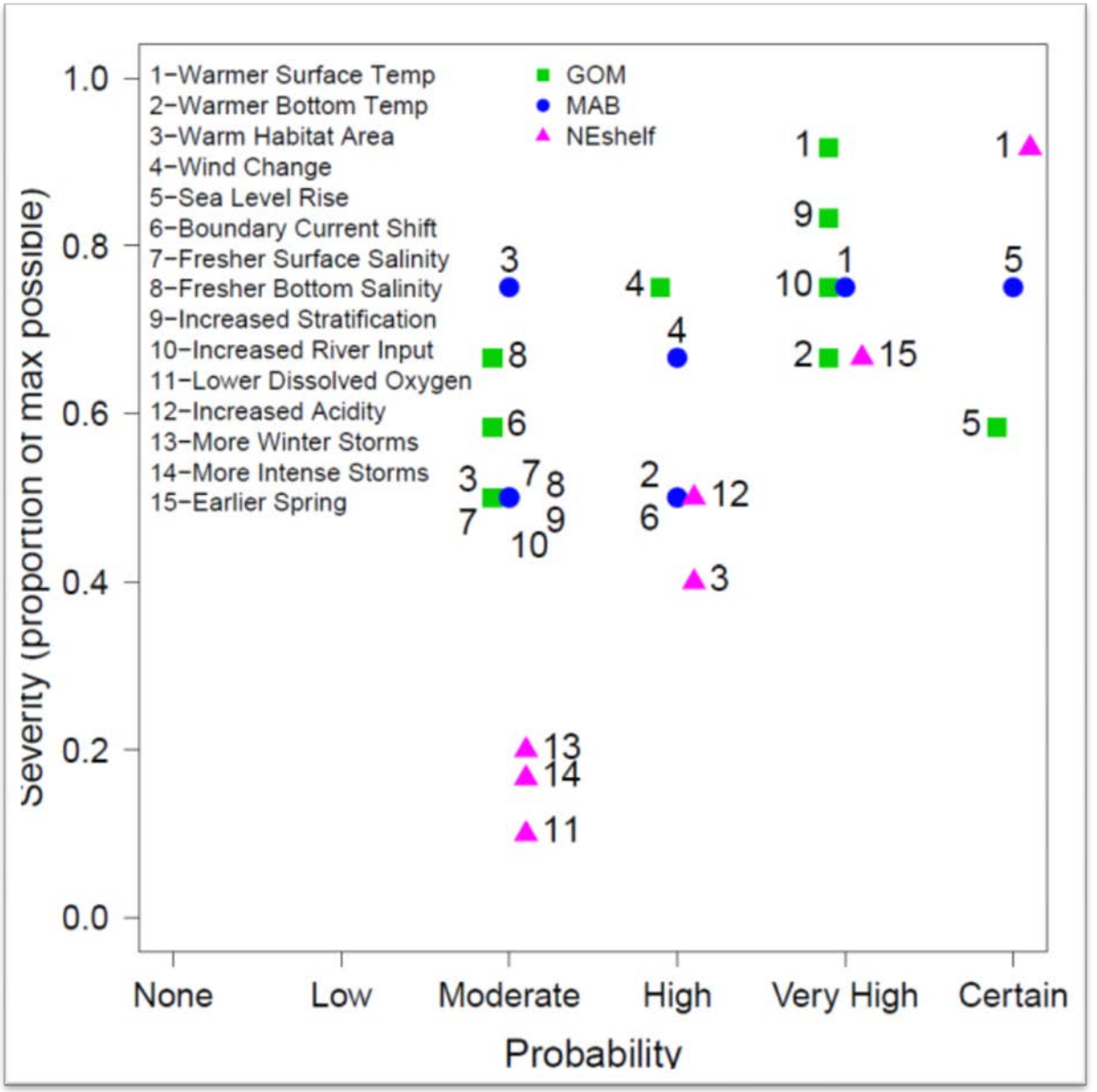
# Strong climate change signal

Courtesy Michael Alexander (NOAA/ESRL/PSD), Jamie Scott and Antonietta Capotondi (CIRES)



# Climate risks vary at the regional scale



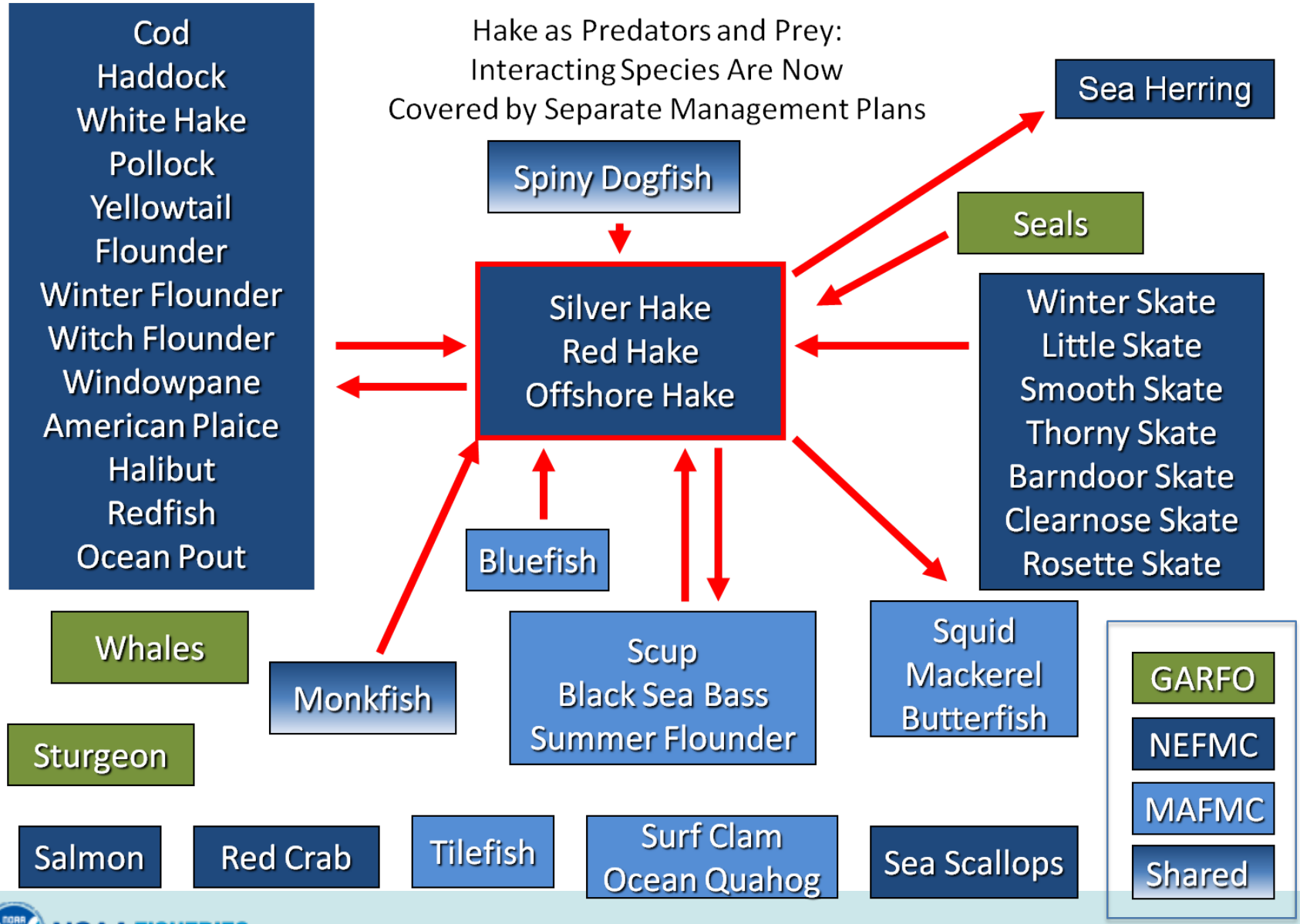

*Gaichas, Link, and Hare 2014 ICES JMS*

# Human dimensions: a comparison

vs.


| | **Alaska** | **Northeast US** |
|---|---|---|
| marine shelf area | 1,000,000 square km | 250,000 square km |
| human population | 0.71 million (0.6 m coastal) | 74 million (60 million coastal) |
| total economic production | $49 billion | $4 trillion (New England $802 billion) |
| 2012 landings | 2.4 million tons | 0.6 million tons |
| 2012 fisheries revenue | $1.7 billion | $1.2 billion |
| 2012 seafood jobs | 56 thousand | 305 thousand (MA 107 thousand) |

# Fishery management plans in conflict?



# Presentation outline

Ecosystem and climate processes: overview

**Do we have the data for integration?**

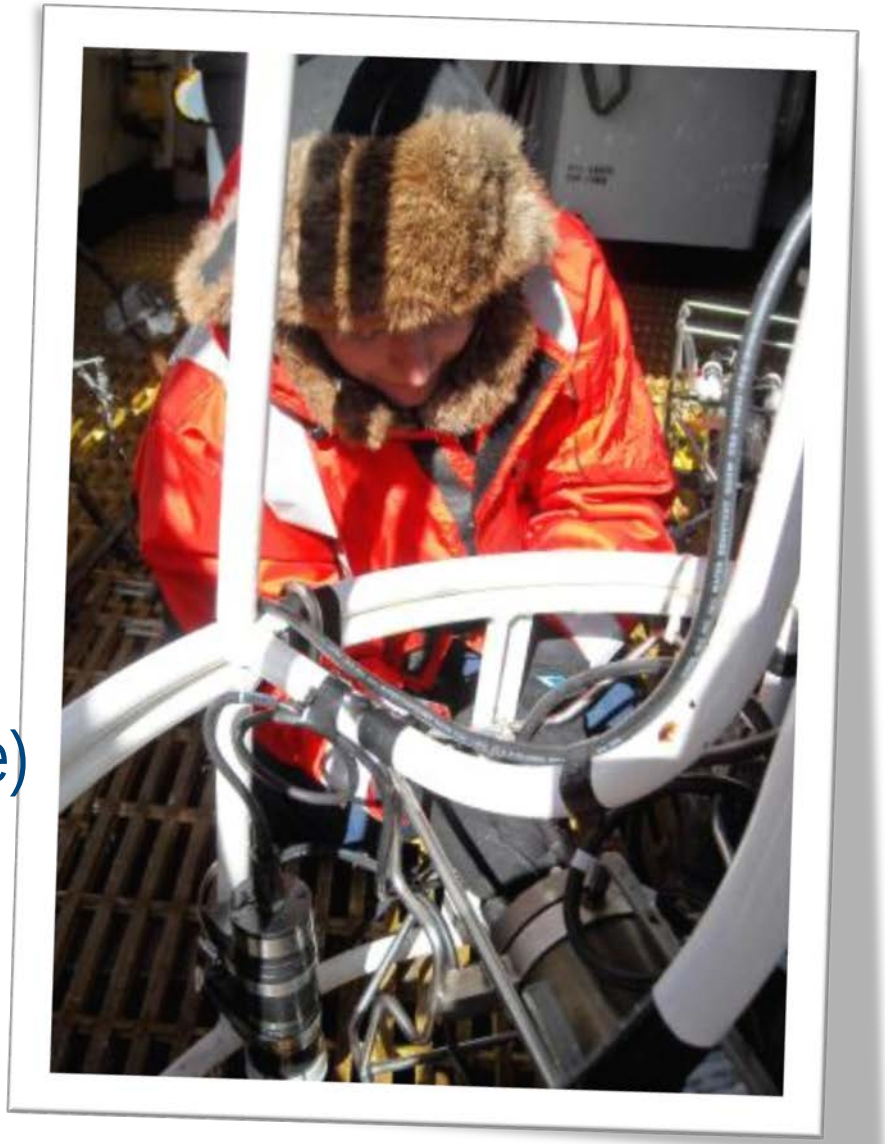
Do we have the analytical tools for integration?

Do we have an effective process for integration?

Successes, Challenges, Solutions

# Yes. Lots.

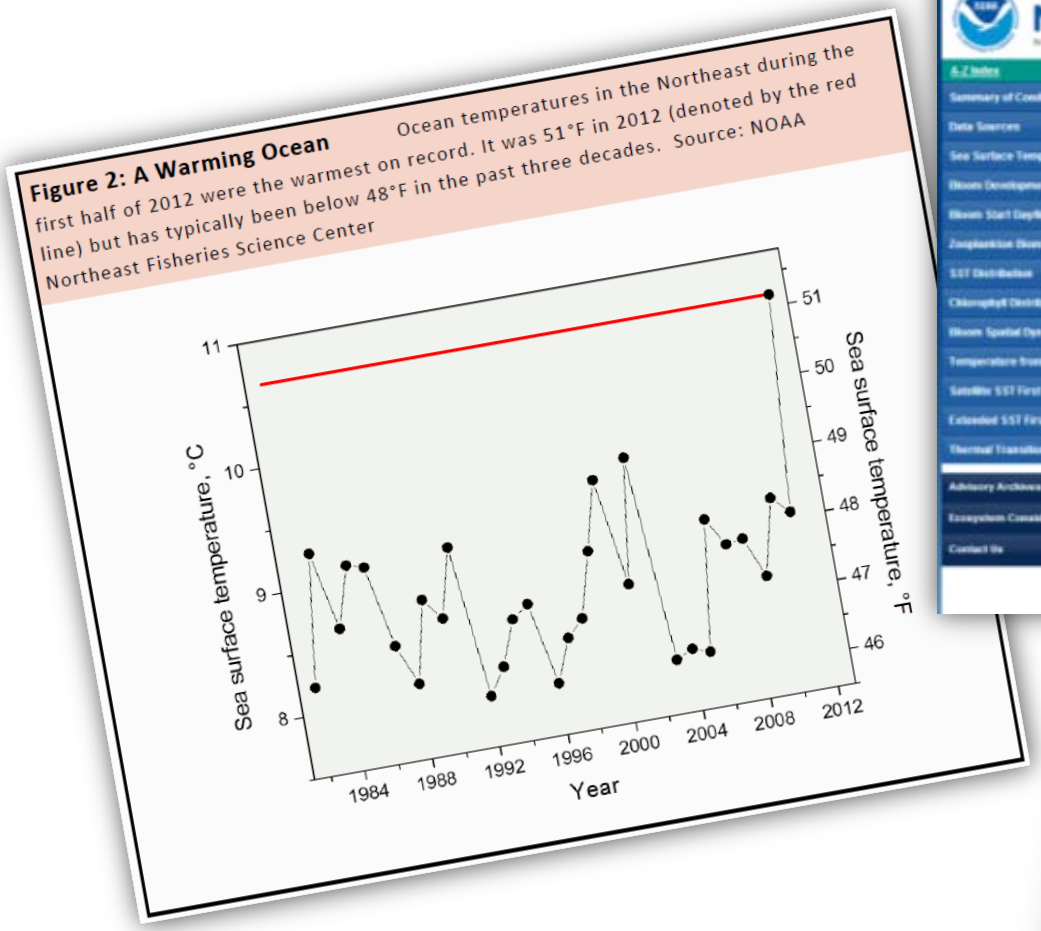
- Oceanographic (physical, chemical)
- Plankton (phyto-, zoo-)
- Fish food habits
- Fish range shifts
- Seabirds & marine mammals
- Synthetic products
  - Data (much publicly available)
  - Peer-reviewed papers
  - Ecosystem advisories
  - Ecosystem Status Report
  - Climate website



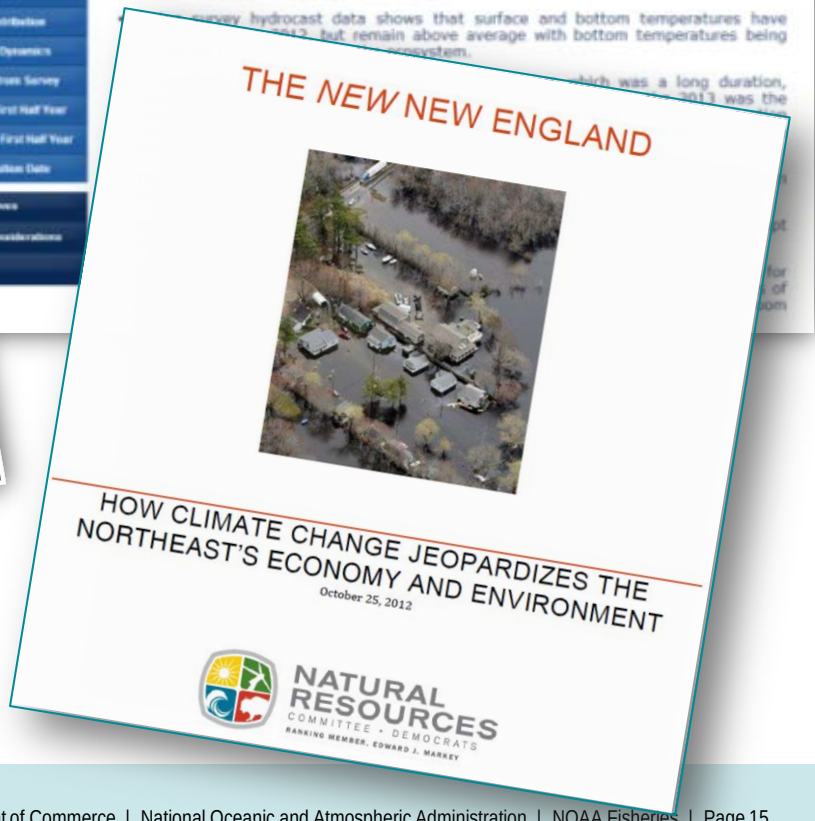
# Climate and ecosystem data

- Past (and current) states based on observations
- Summarized in NEFSC Ecosystem Status Report and Ecosystem Advisories
- Many NEFSC observation programs affected by recent budget shortfalls

# Ecosystem advisories: in use



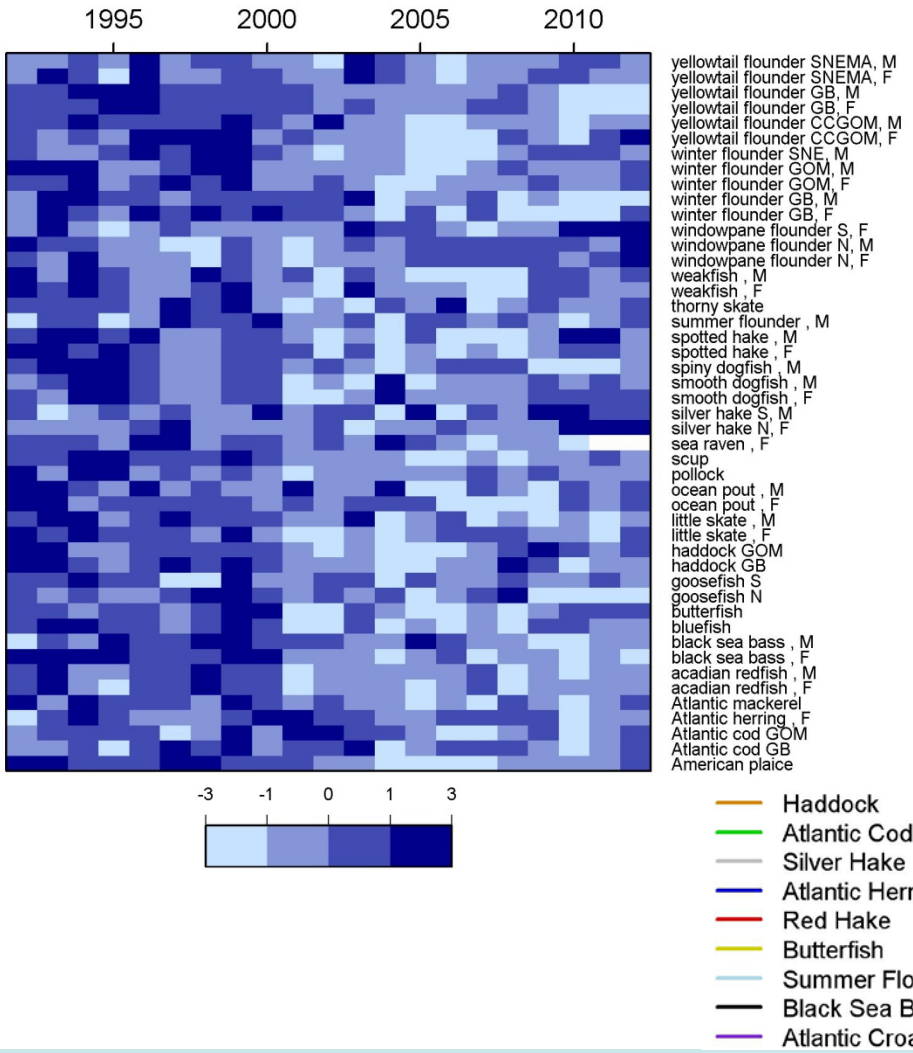


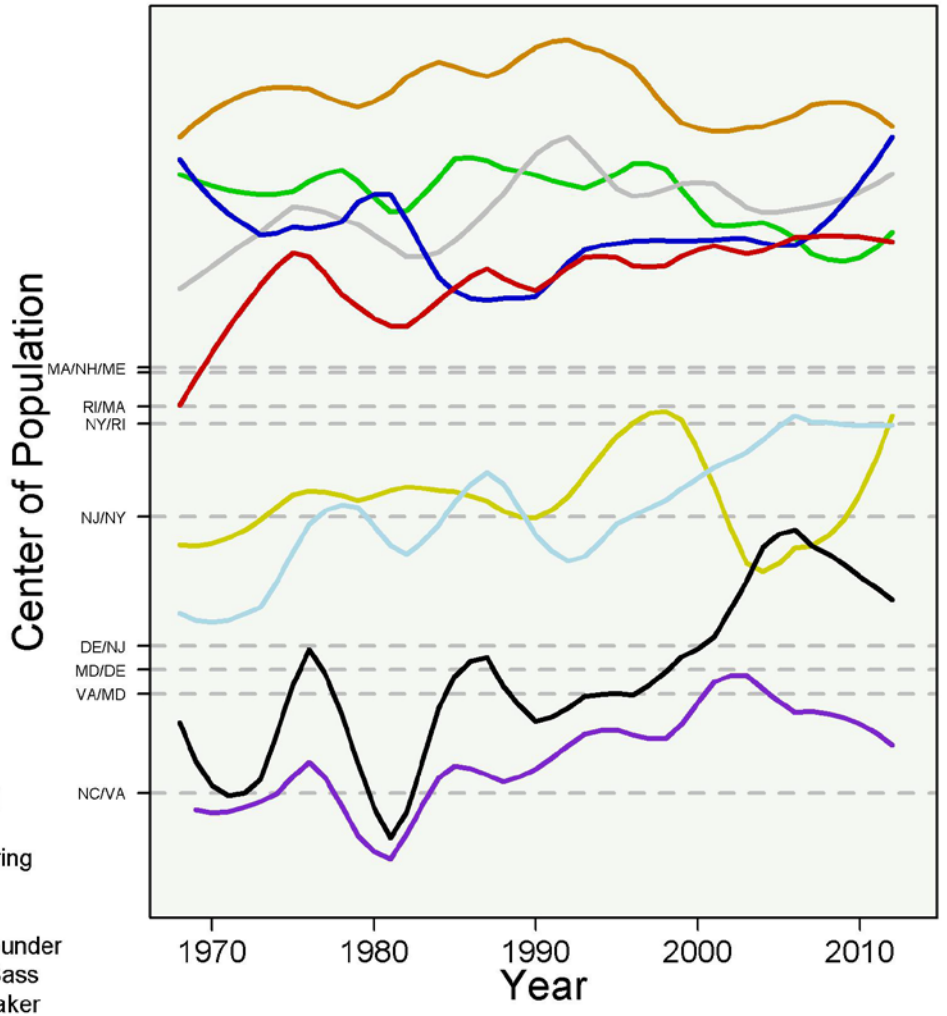


# Fish food habits data extensive

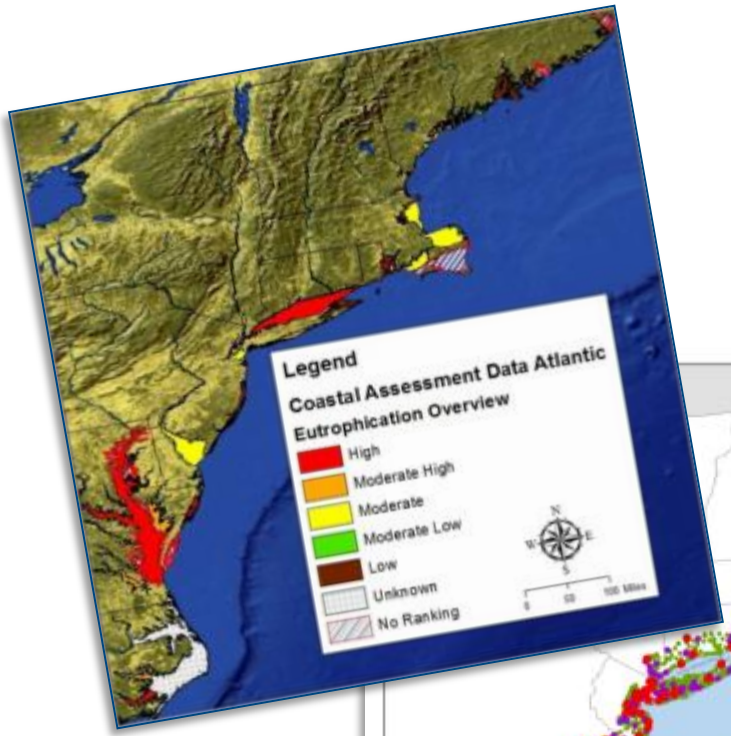
- External program review 2009
- Quantitative data 1973 → present from surveys
- Cape Hatteras, NC → Nova Scotia, Canada
- 150+ species, 40+ with >1000 stomachs
- 550,000+ stomach samples in database
- 1,300+ prey items
- Predator size range 1 cm to 2 m
- Prey size range 0.1 mm to 1 m

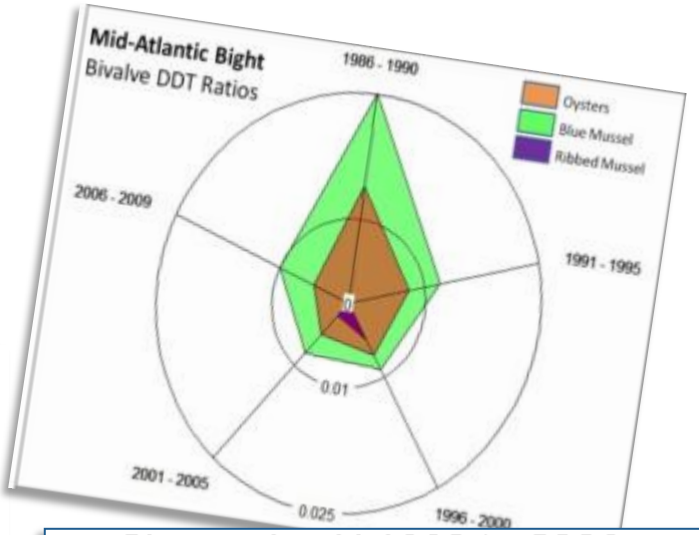
# Fish condition, distribution changes in ESR

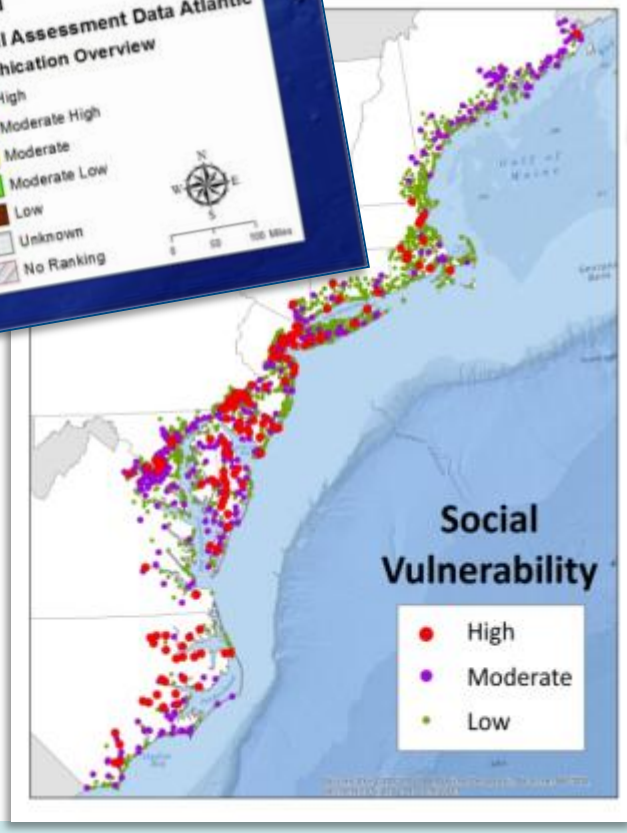


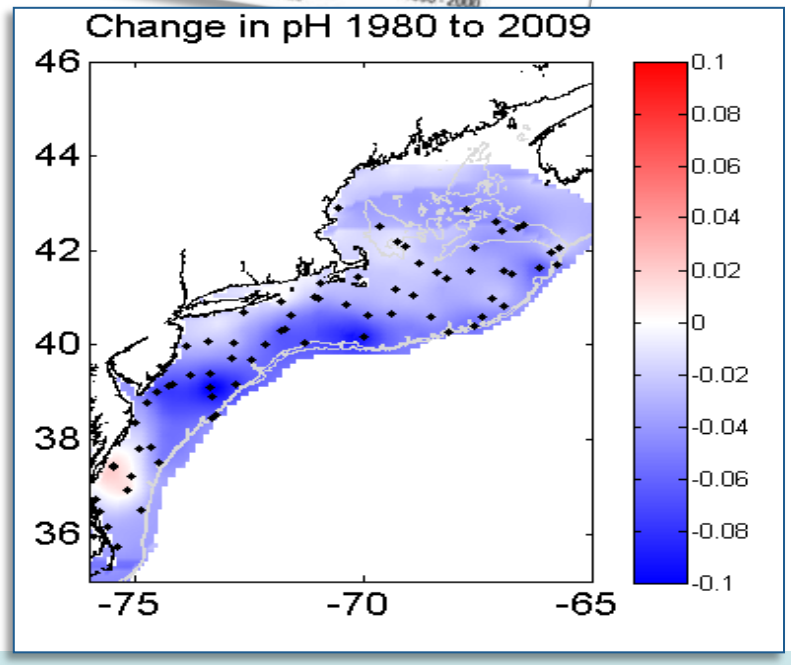



# Other ecosystem data summarized in ESR



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Ecosystem and climate processes: overview

Do we have the data for integration?

**Do we have the analytical tools for integration?**

Do we have an effective process for integration?

Successes, Challenges, Solutions

# A spectrum of tools, a spectrum of uses

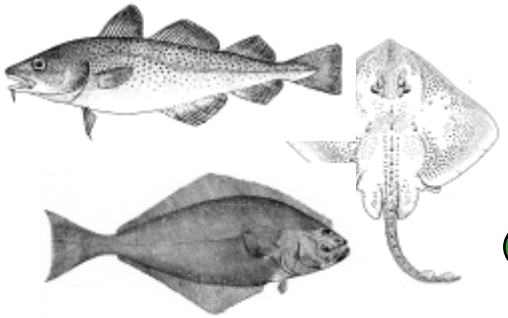
## Stock/Single Species

SS models

SS assessments with add-ons: explicit M2 or habitat or climate considerations

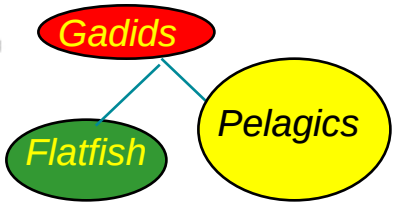
Multiple SS assessments in “harmony”

## Multi-species



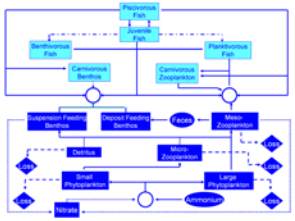
Multi-species assessments

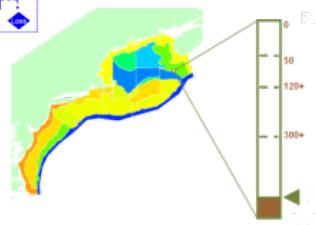
## Aggregate Biomass




Functional group models

## Ecosystem



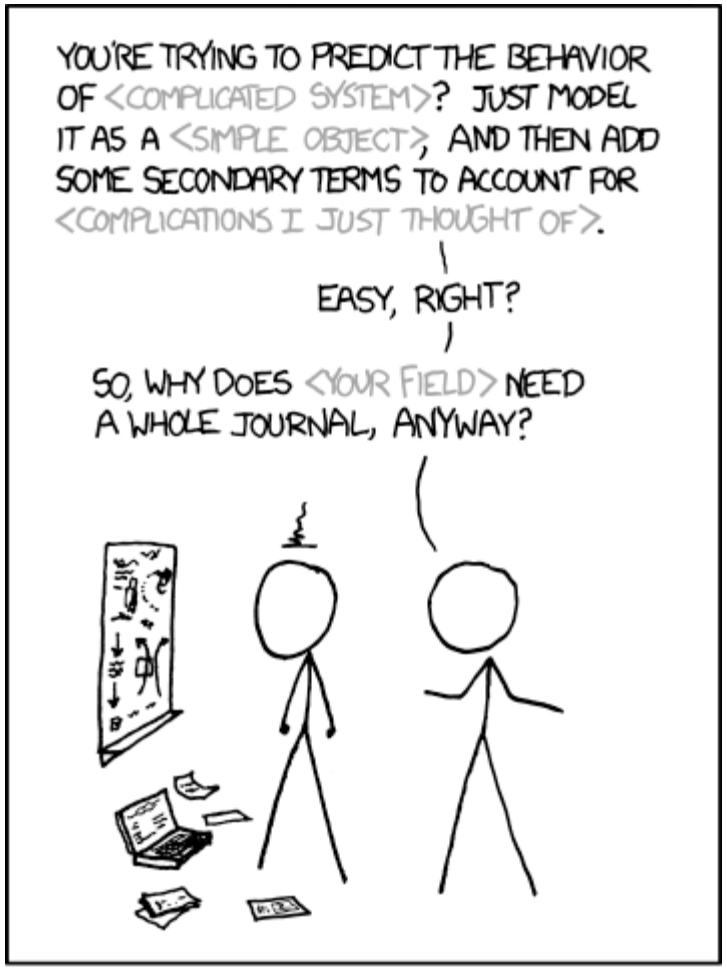


Whole system models

Integrated ecosystem assessments

# Many exist at NEFSC, more in development

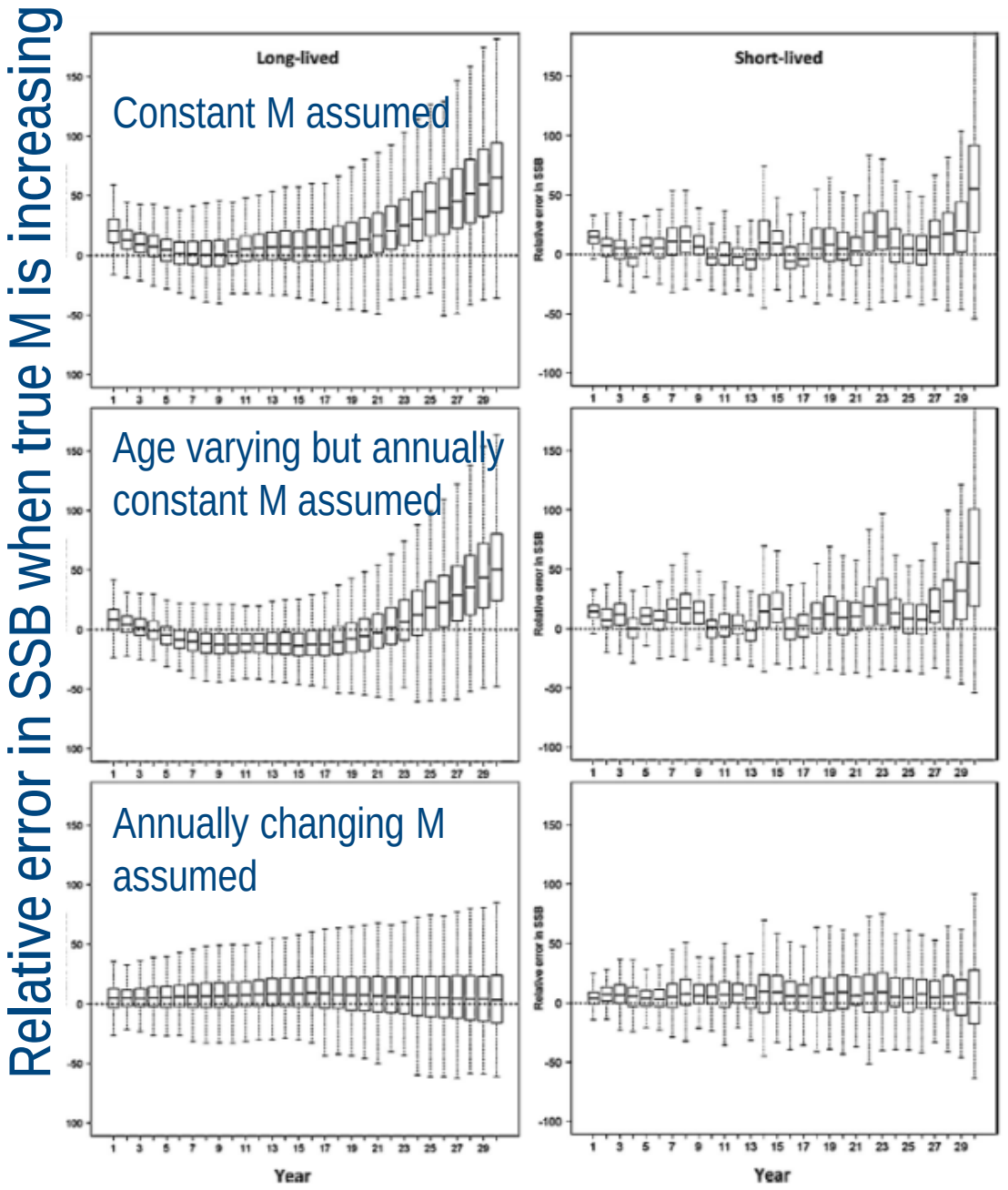
- Multispecies and ecosystem models CIE review 2011
- Single species with add-ons
  - Herring
  - Butterfish
  - SNE Yellowtail
- Multispecies assessment: pilot project for Georges Bank




http://xkcd.com/793/

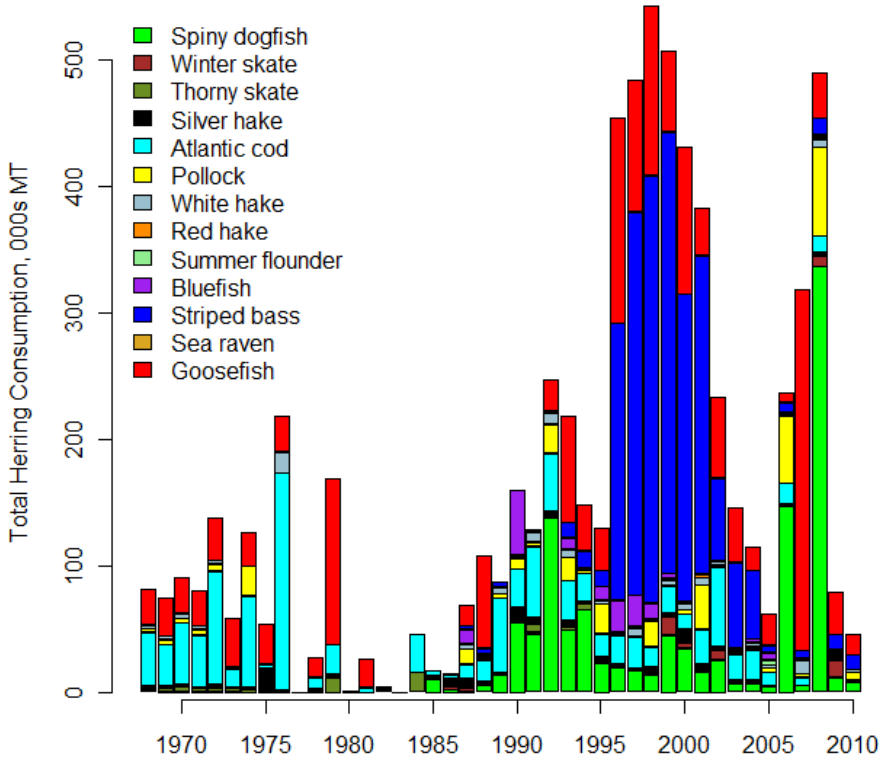
# Is changing natural mortality important?

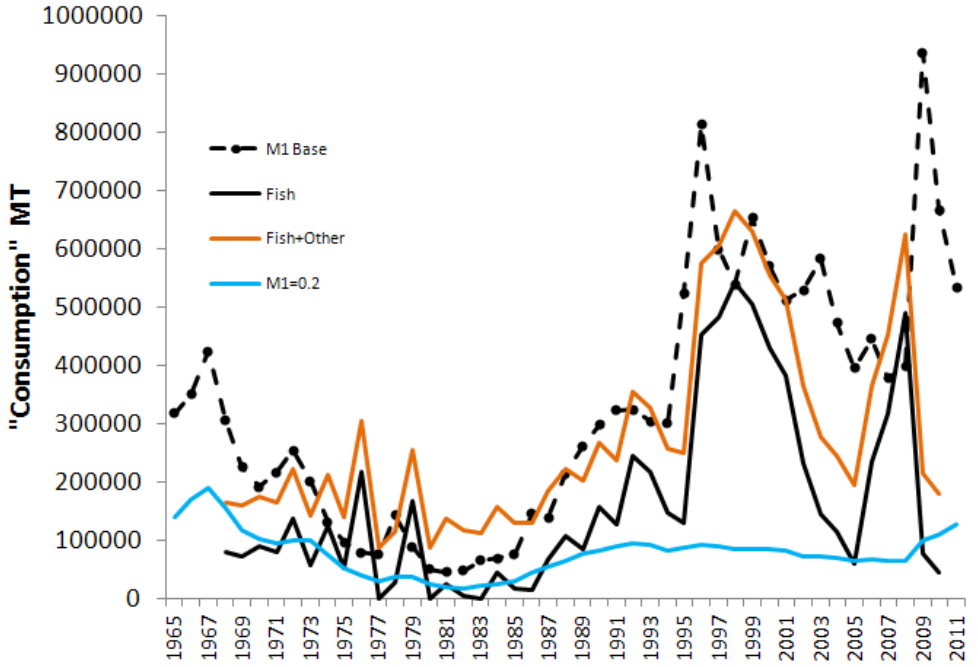
Yes!




Deroba and Schueller 2013 Fish Res

# Herring assessment:
## predation evidence → increased recent M

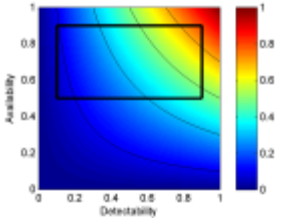


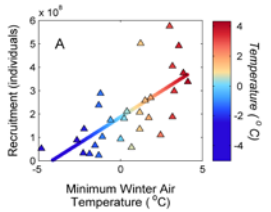



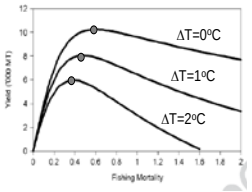

Deroba et al. 2012 SAW /SARC 54

# Climate effects research for assessments

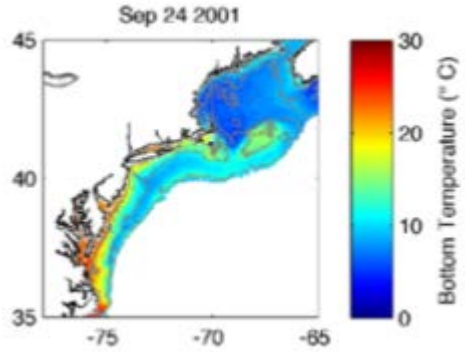
- Butterfish – temperature driven q's
- MA-SNE yellowtail flounder - cold pool volume and recruitment
- Northern shrimp – temperature dependent distribution and productivity
- Atlantic croaker – temperature dependent recruitment
- Atlantic cod – temperature dependent recruitment and distribution
- GOM Atlantic cod – change in prey changed catchability in the fishery

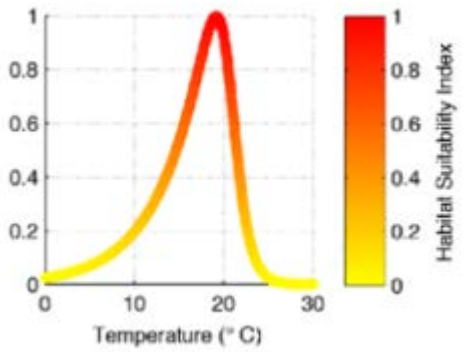


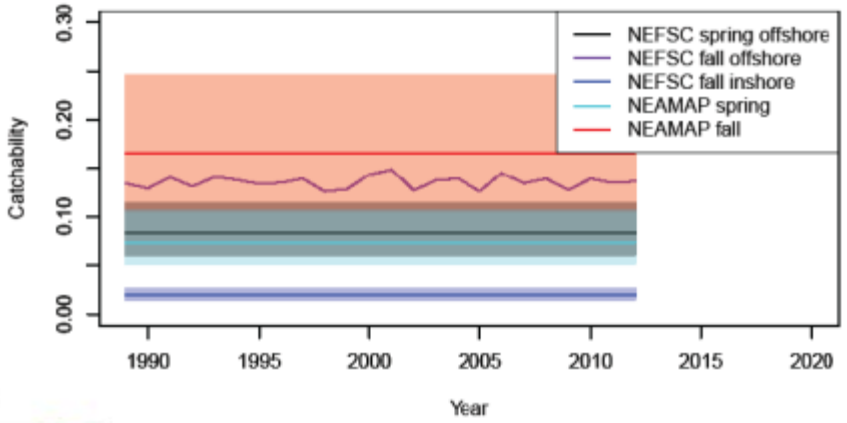



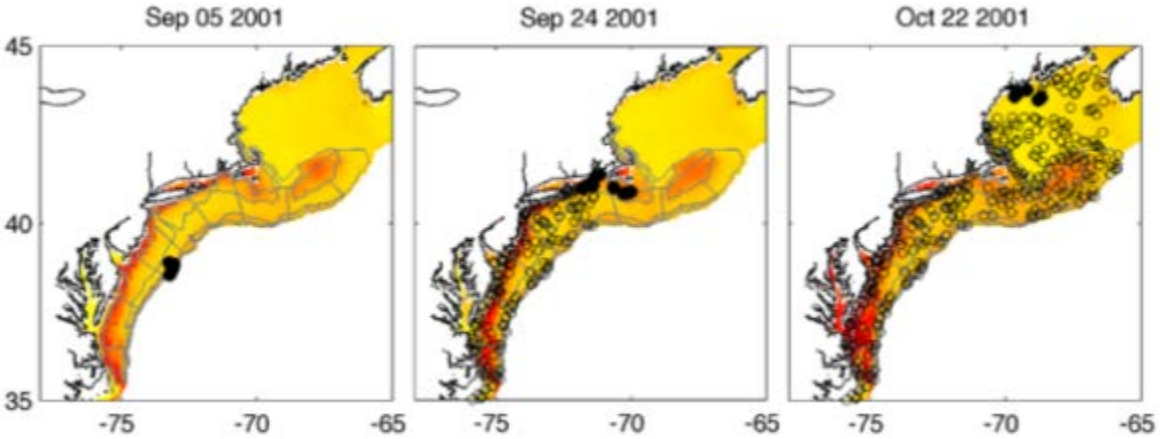




# Butterfish assessment: thermal habitat change → survey q




Adams et al. 2014 SAW /SARC 58

# MA SNE Yellowtail Flounder Assessment: Reference points shift under climate change?

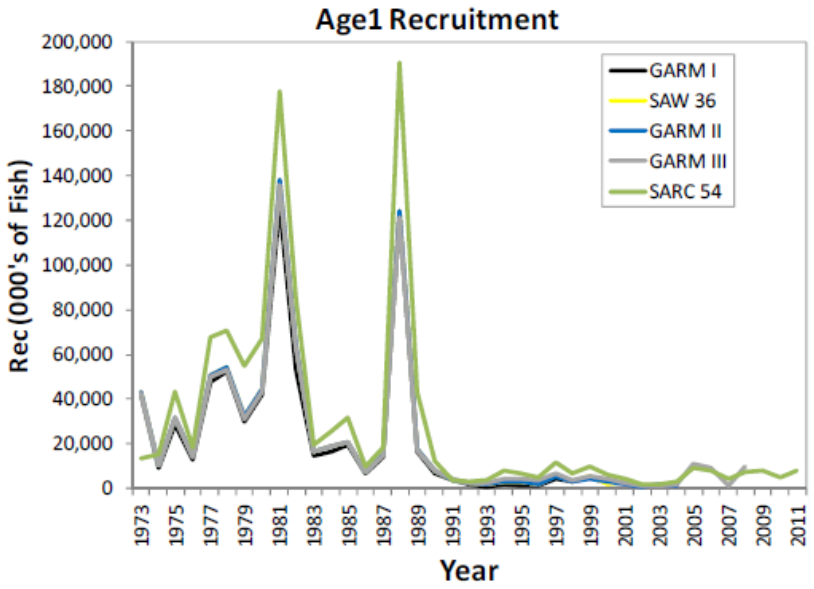
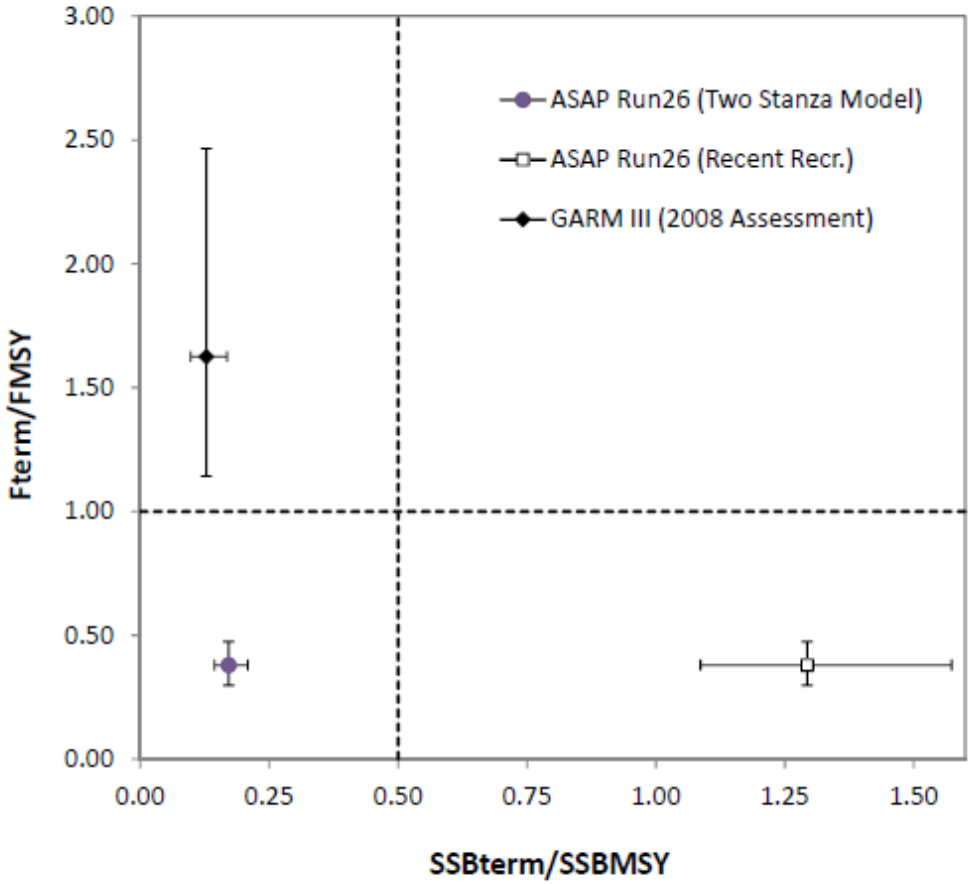


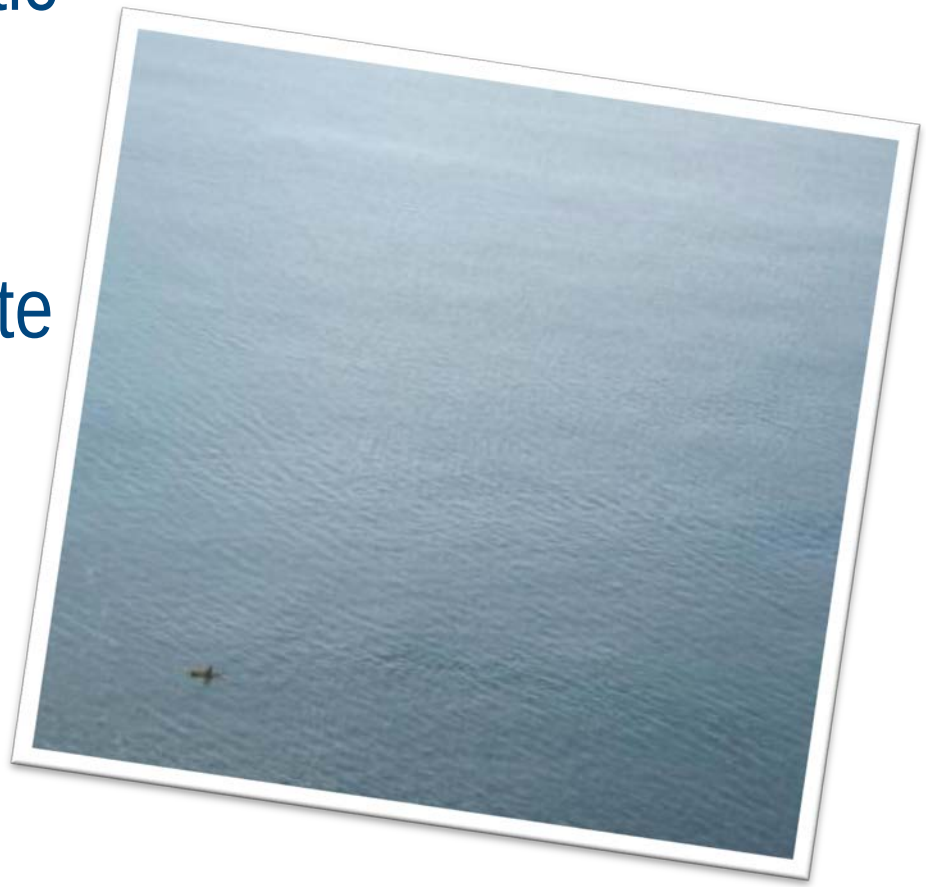

Figure B104. Comparison of age 1 recruitment from previous Southern New England mid-Atlantic yellowtail stock assessments including estimates from the 2012 ASAP base Model 26 model assessment updates.




Alade et al. 2012 SAW /SARC 54

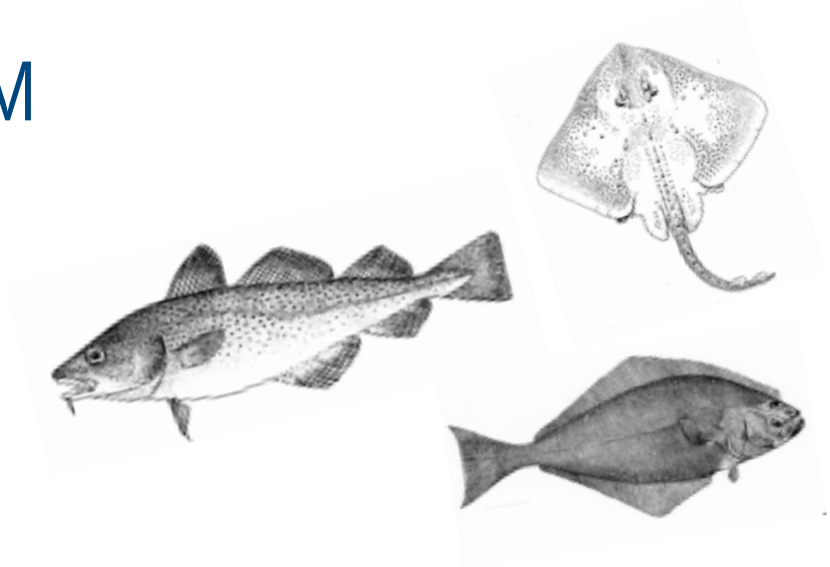
# Single-species assessments with add-ons

- Useful but limited by resources and mechanistic understanding
- 50+ managed fishery species; numerous climate and ecosystem factors
- Adding on to each single species assessment is a HUGE task



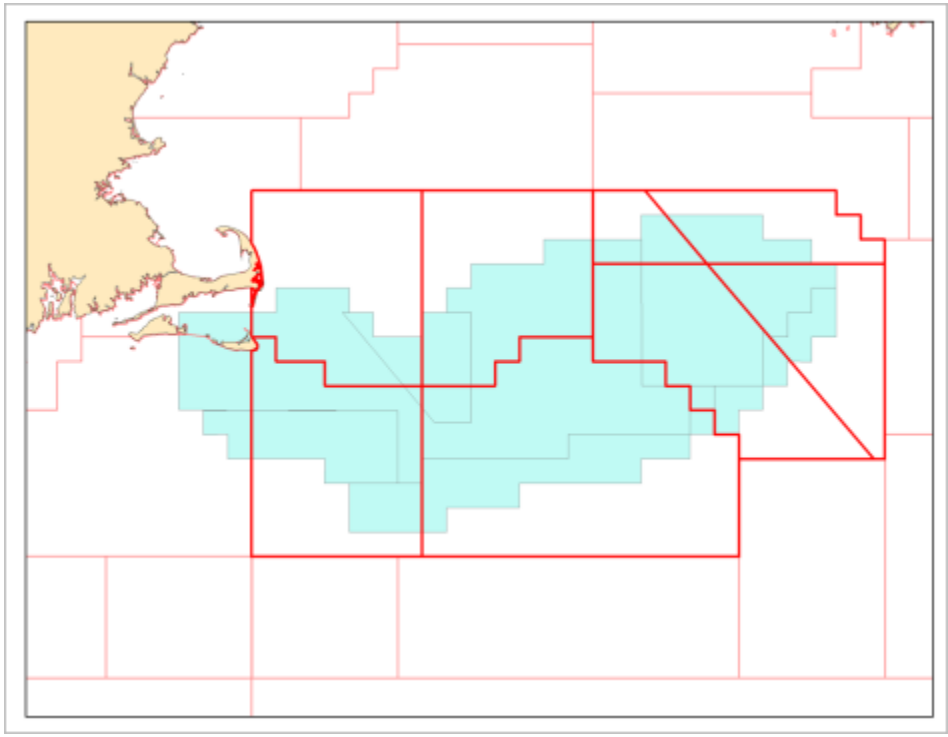
# Why Take a Multispecies Approach?

- Bridge from traditional assessment → ecosystem
- Includes biological and technological interactions
- Can't get single species OY from all simultaneously
- More efficient use of resources–reduce workload
- Councils interested in EBFM

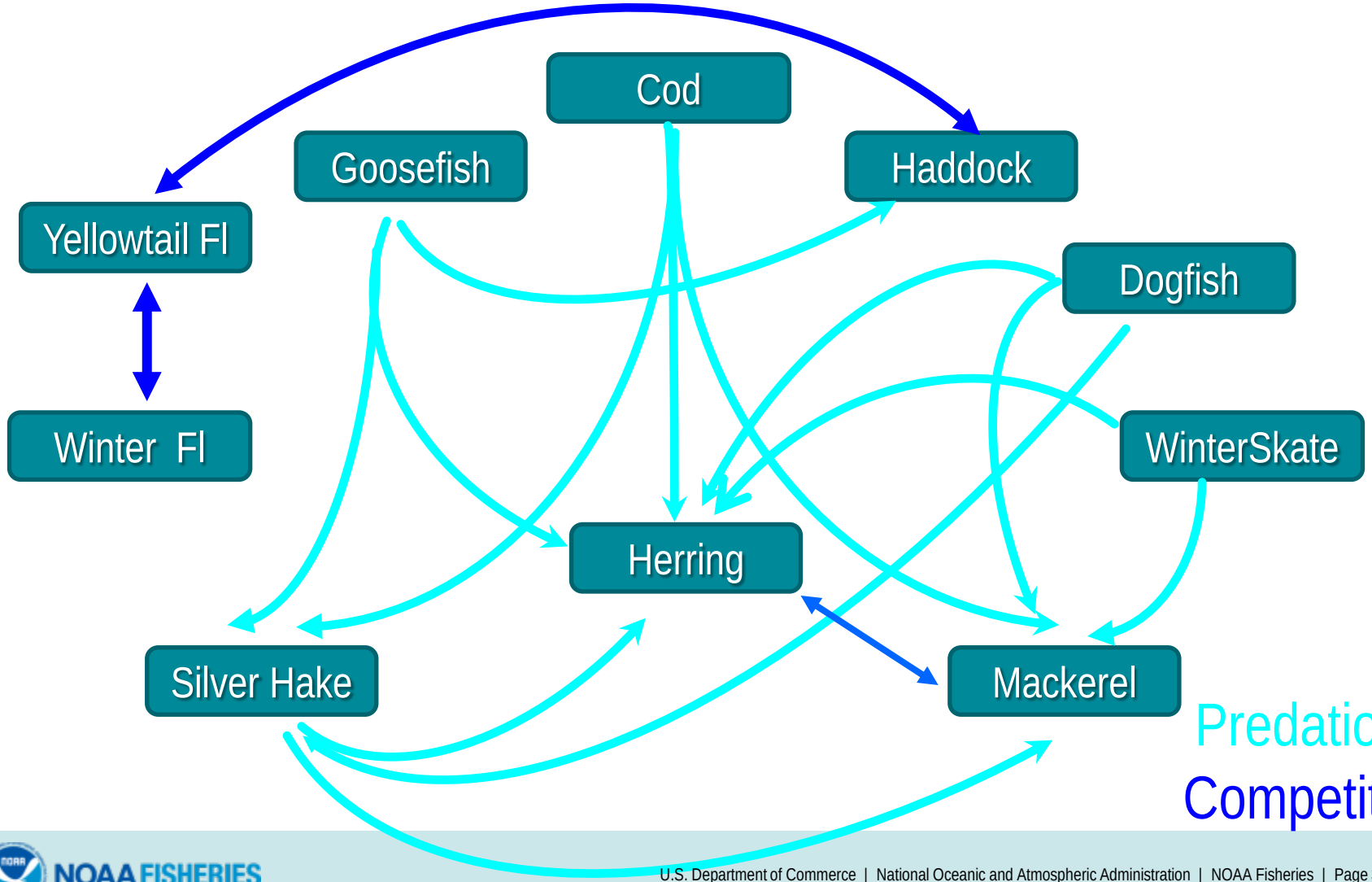


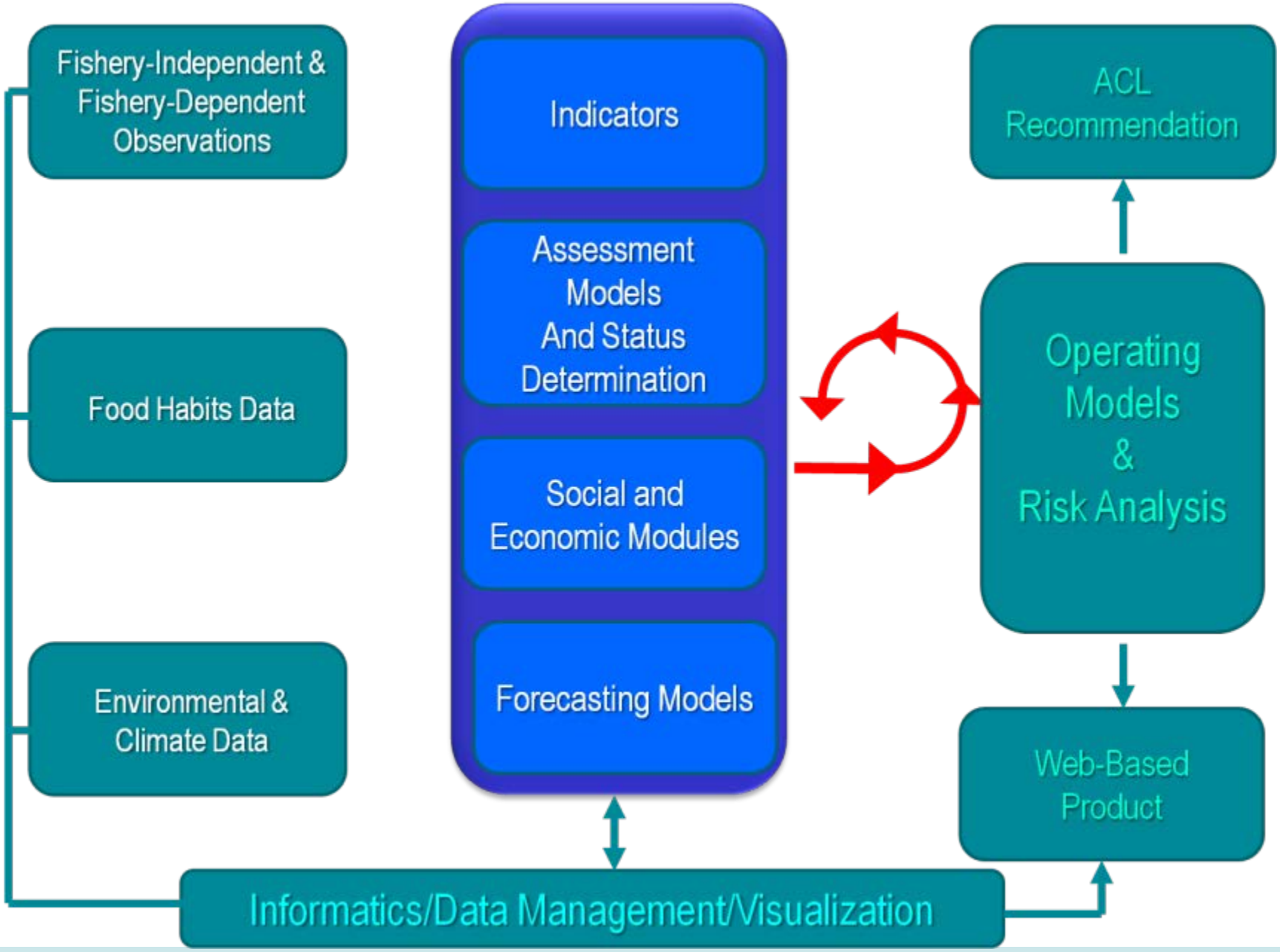
# Multispecies assessment: Georges Bank

- 10 interacting species, 1 spatial footprint
- Standardized data pulls
- Simulation testing of
  - Each assessment model (multiple structures)
  - Multi-model inference
  - Ecosystem indicators
  - Management procedures
- Harvest advice ultimate goal



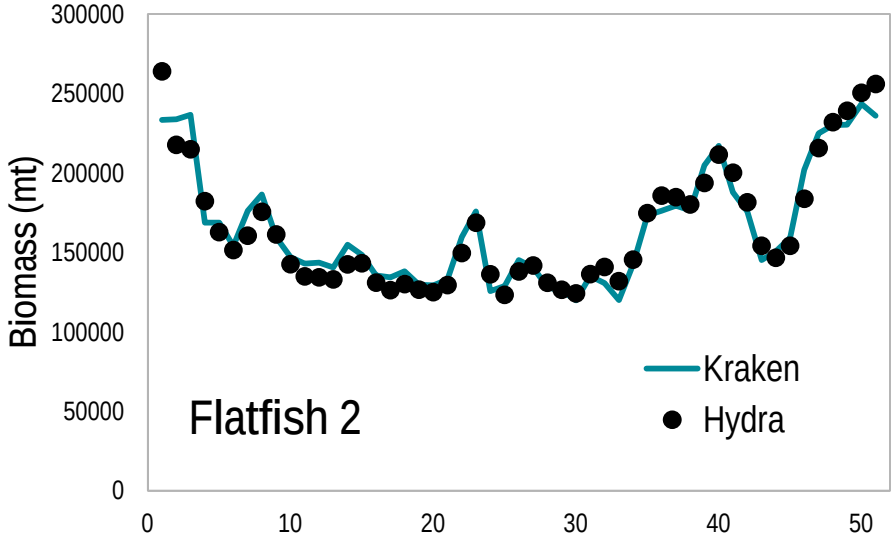
# Food Habits Data to Guide Model Structure, Model Inputs, Auxiliary Data

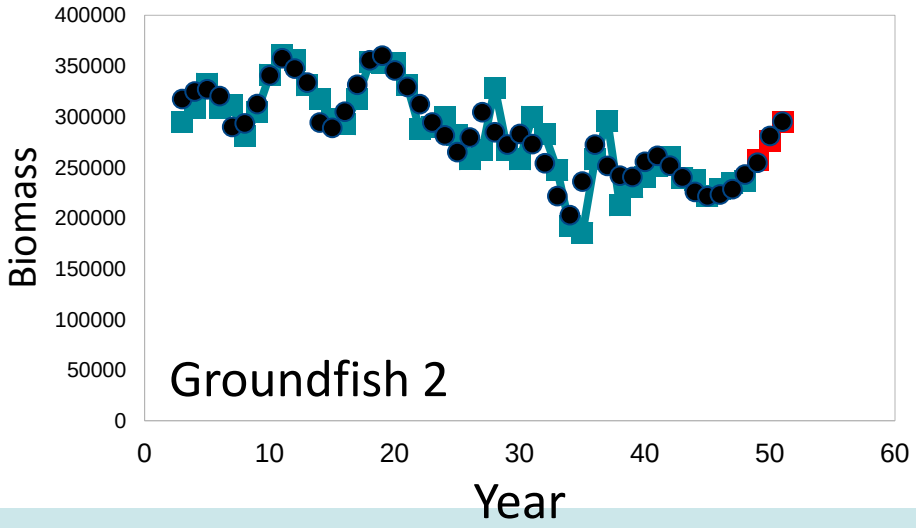



Fishery-Independent & Fishery-Dependent Observations
Food Habits Data
Environmental & Climate Data
Indicators
Assessment Models And Status Determination
Social and Economic Modules
Forecasting Models
ACL Recommendation
Operating Models & Risk Analysis
Web-Based Product
Informatics/Data Management/Visualization

# Preliminary fits to simulated data—no error

- Production model fit to size structured operating model output
- Non-linear time series prediction from size structured operating model output



# Presentation outline

Ecosystem and climate processes: overview

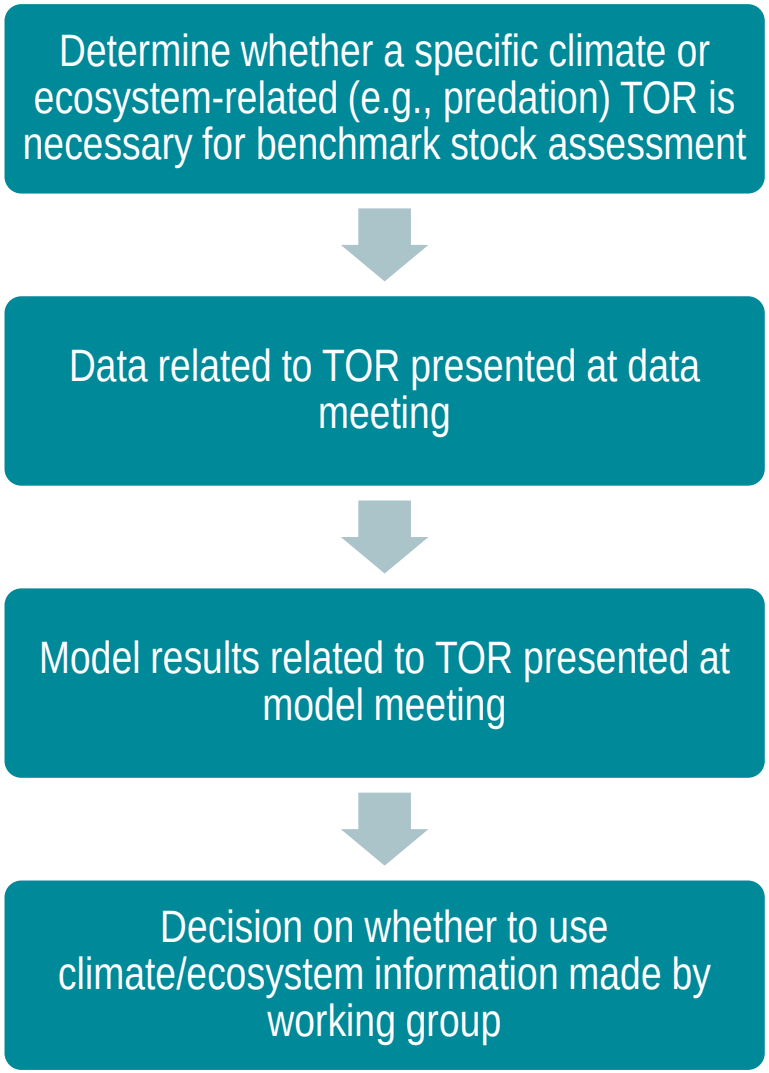
Do we have the data for integration?

Do we have the analytical tools for integration?

**Do we have an effective process for integration?**

Successes, Challenges, Solutions

# Current integration process: a Center-wide effort




NEFSC is developing generic climate and ecosystem TORs for consideration in EVERY assessment

# By the numbers (benchmark SAW/SARC)

| Year | Assessments with ecosystem/climate specific TORs | Assessments with ecosystem/climate effects integrated | Total assessments |
|---|---|---|---|
| 2014 | 3 | 1 | 3 |
| 2013 | 0 (+3*) | 0 | 4 |
| 2012 | 2 (+2*) | 2 | 4 |
| 2011 | 3 (+1*) | 0 | 5 |
| 2010 | 4 (+1*) | 0 | 7 |

*no explicit TORs for ecosystem or climate information, but could integrate based on TORs regarding M change, stock id, migration, etc.

# Some explanation

- "Integrated" = used in assessment, altering outcome
- Ecosystem/climate TORs nonstandard to date
  - Some were information-only
  - Most phrased "If possible…" "If time permits…"
- Nationwide, assessments formally integrating ecosystem and climate effects are rare
- One assessment is a lot of work already, and this is an (often large) addition of data, analysis, review

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Do we have the data for integration?

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Do we have an effective process for integration?

**Successes, Challenges, Solutions**

# TOR 6

## Does the Center have in place an effective process for taking ecosystem and climate change factors into consideration in the stock assessment process?

Having a formal process is a good start.
There is a lot of room for improvement…

# Successes

- NEFSC Ecosystem and climate data are excellent
- Spectrum of high quality analytical tools
- Already integrated in several stock assessments
- Ecosystem/climate scientists in Council processes
- Collaborative multispecies assessment in progress

# Challenges

- Climate change critical here, difficult to predict
- Ecological interactions → reference points, advice?
- Budget cuts to ecosystem observation surveys
- Assessment production system at (over) capacity
- Management / review system already complex

# Solutions

Stabilize funding for ecosystem monitoring surveys

More joint research ecosystem/climate ←→ assessment

Pilot projects testing alternative assessment methods:

- Multispecies approaches streamline assessments
- Multimodel inference addresses uncertainty
- Simpler, indicator-based management procedures
- Simulations and management strategy evaluations for model & alternative reference point performance
- Address spatial issues (data, models, management)


Questions?
Thank you