# There is no I in EAFM:

## Adapting Integrated Ecosystem Assessment for Mid-Atlantic Fisheries Management

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# An integrated ecosystem assessment success story (in progress)

Diverse stakeholders agreed that an ecosystem approach was necessary. Developing and implementing an ecosystem approach to fishery management was done in collaboration between managers, stakeholders, and scientists.

*Outline*

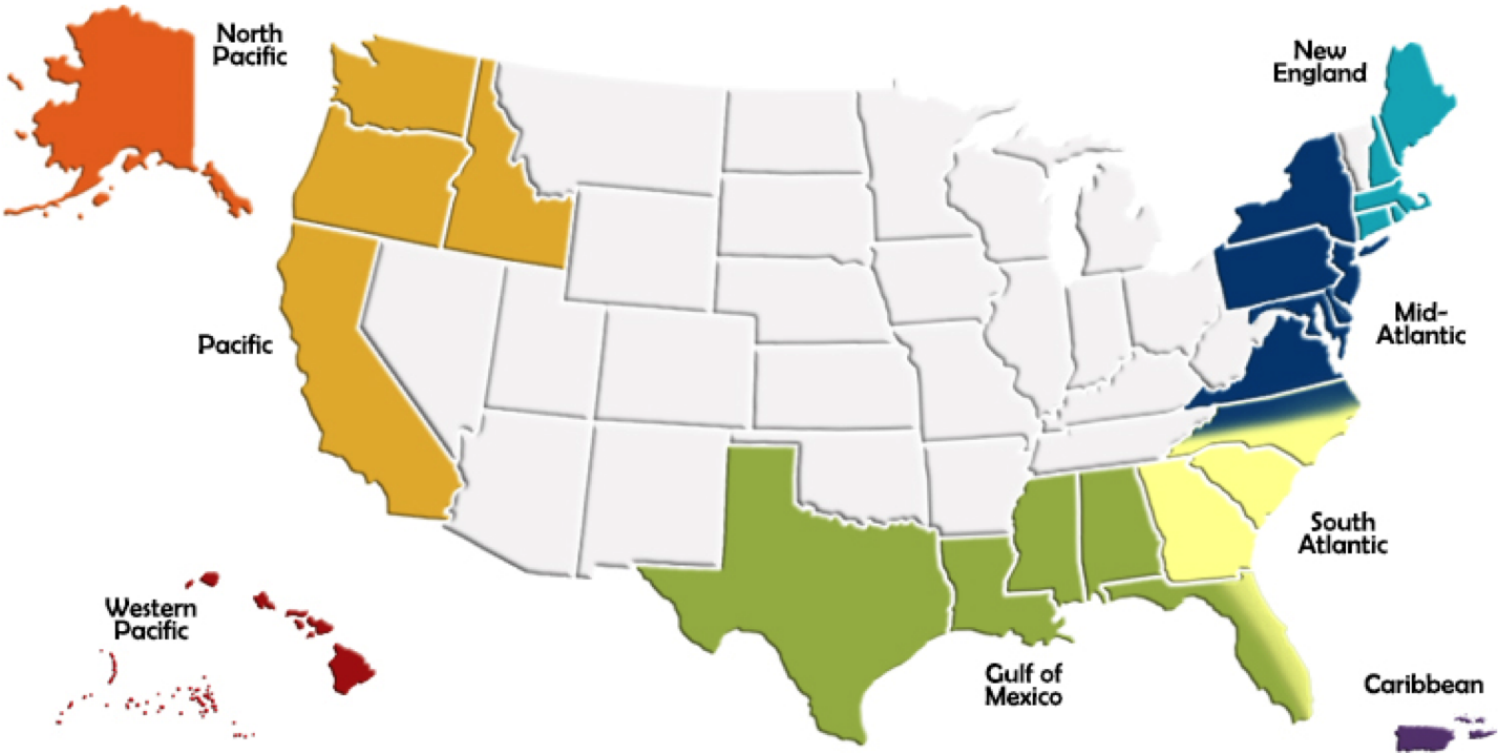
- Mid-Atlantic Fishery Management Council Ecosystem Approach (EAFM)
- Tailoring ecosystem reporting for fishery managers
- Mid-Atlantic EAFM risk assessment
- Mid-Atlantic EAFM conceptual modeling (towards MSE)
- Improvements: open-source data and technical documentation

*Integrated Ecosystem Assessment*


https://www.integratedecosystemassessment.noaa.gov/national/IEA-approach

# Fishery management in the US

Eight regional Fishery Management Councils establish plans for sustainable management of stocks within their jurisdictions. All are governed by the same law, but tailor management to their regional stakeholder needs.




More information: http://www.fisherycouncils.org/
https://www.fisheries.noaa.gov/topic/laws-policies#magnuson-stevens-act

# The Mid-Atlantic Fishery Management Council (MAFMC)


Summer Flounder, Scup, Black Sea Bass

Spiny Dogfish

Atlantic Mackerel, Squid, Butterfish

Bluefish

Surfclam and Ocean Quahog

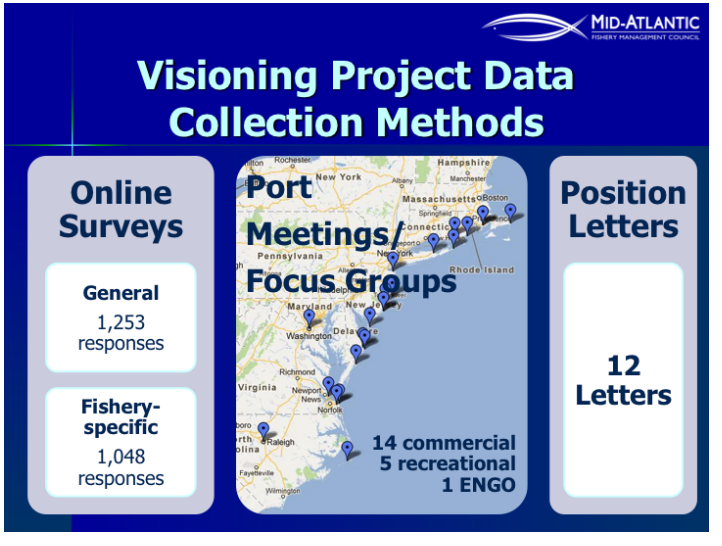
Tilefish

Source:
http://www.mafmc.org/fishery-management-plans

# Why an ecosystem approach?

*"We rebuilt all the stocks, so why is everyone still pissed off?" --Rich Seagraves*

in 2011, the Council asked:


And many people answered, from commercial fishery, recreational fishery, environmental organization, and interested public perspectives.

Visioning report:

http://www.mafmc.org/s/MAFMC-stakeholder-input-report-p7b9.pdf

## Common themes among all stakeholder groups:

> • There is a lack of confidence in the data that drive fishery management decisions.
>
> • Stakeholders are not as involved in the Council process as they can and should be.
>
> • Different jurisdictions and regulations among the many fishery management organizations result in complexity and inconsistency.
>
> • There is a need for increased transparency and communications in fisheries management.
>
> • The dynamics of the ecosystem and food web should be considered to a greater extent in fisheries management decisions.
>
> • Stakeholders are not adequately represented on the Council.
>
> • Pollution is negatively affecting the health of fish stocks.

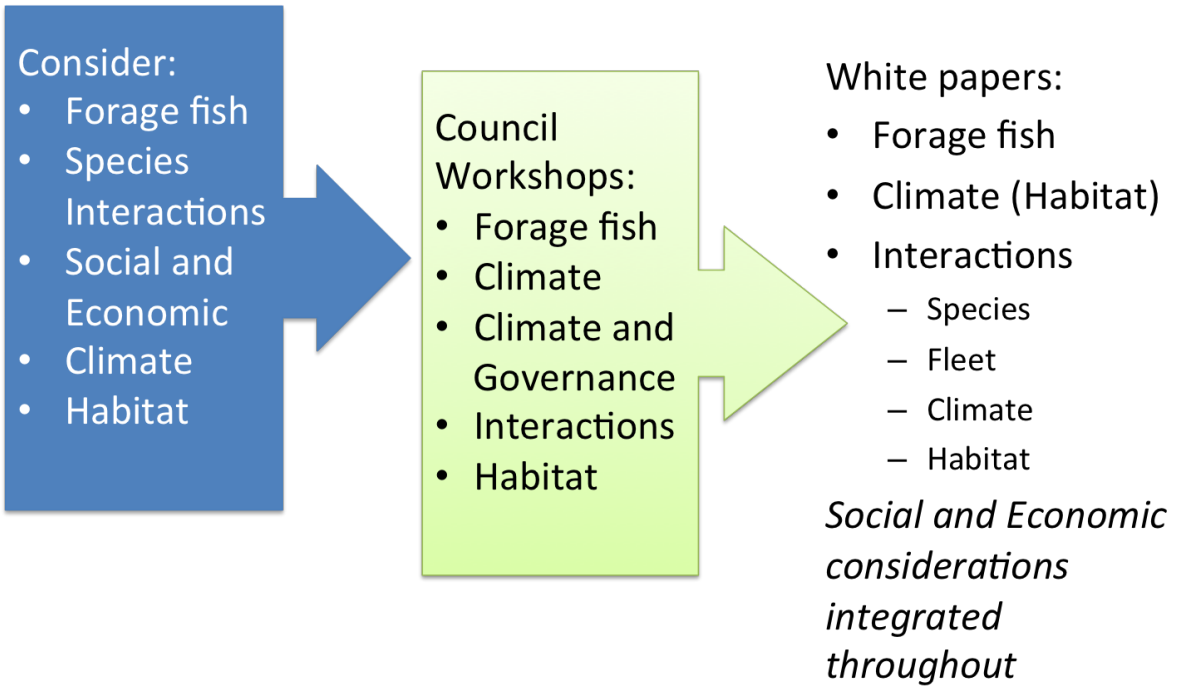
Visioning report, p. 3:

http://www.mafmc.org/s/MAFMC-stakeholder-input-report-p7b9.pdf

# How did MAFMC develop their ecosystem approach?

Visioning Project → Strategic Plan with one objective to develop

> "A non-regulatory umbrella document intended to guide Council policy with respect to ecosystem considerations across existing Fishery Management Plans"

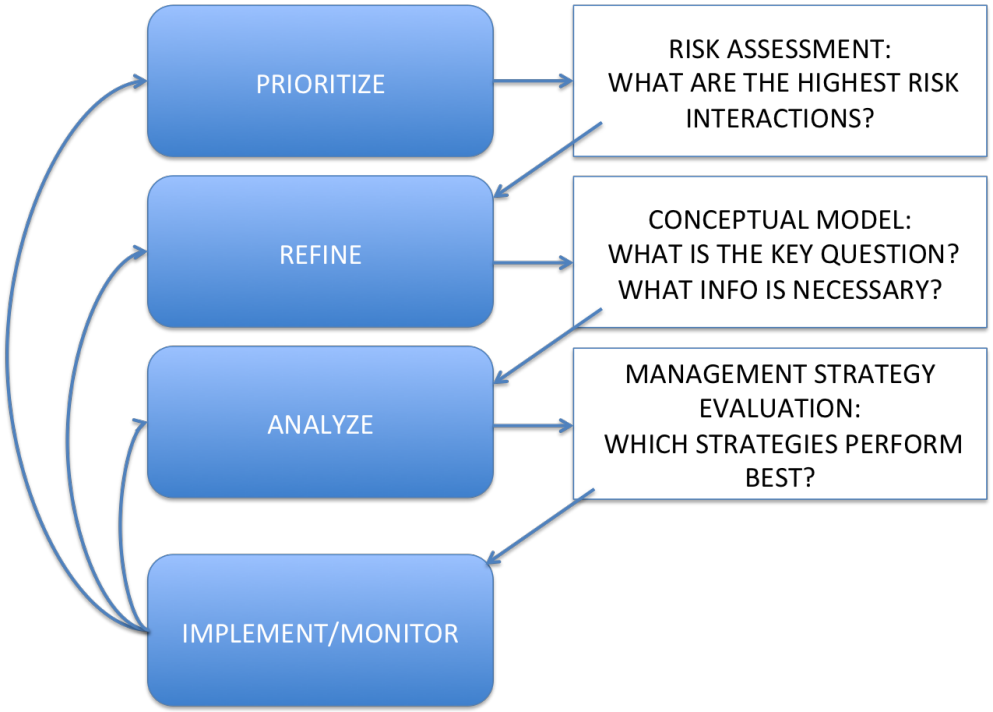



Details, including workshop presentations and white papers:
http://www.mafmc.org/eafm

# Mid-Atlantic Council Ecosystem Approach

- 2016 Ecosystem Approach to Fishery Management (EAFM) Policy Guidance document: http://www.mafmc.org/s/EAFM-Doc-Revised-2019-02-08.pdf

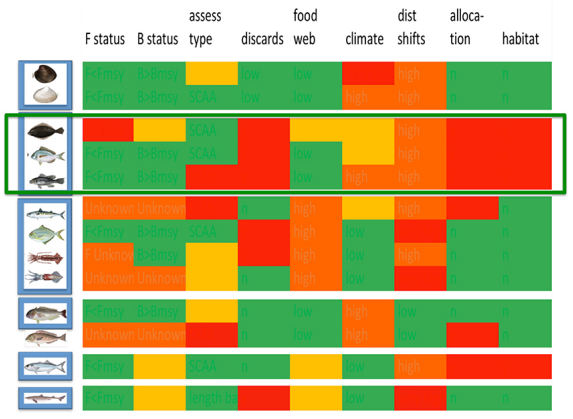
- Mid-Atlantic EAFM framework[1]:




https://www.frontiersin.org/articles/10.3389/fmars.2016.00105/full

[1] Gaichas, S., Seagraves, R., Coakley, J., DePiper, G., Guida, V., Hare, J., Rago, P., et al. 2016. A Framework for Incorporating Species, Fleet, Habitat, and Climate Interactions into Fishery Management. Frontiers in Marine Science, 3.

# Examples illustrating the use of the framework

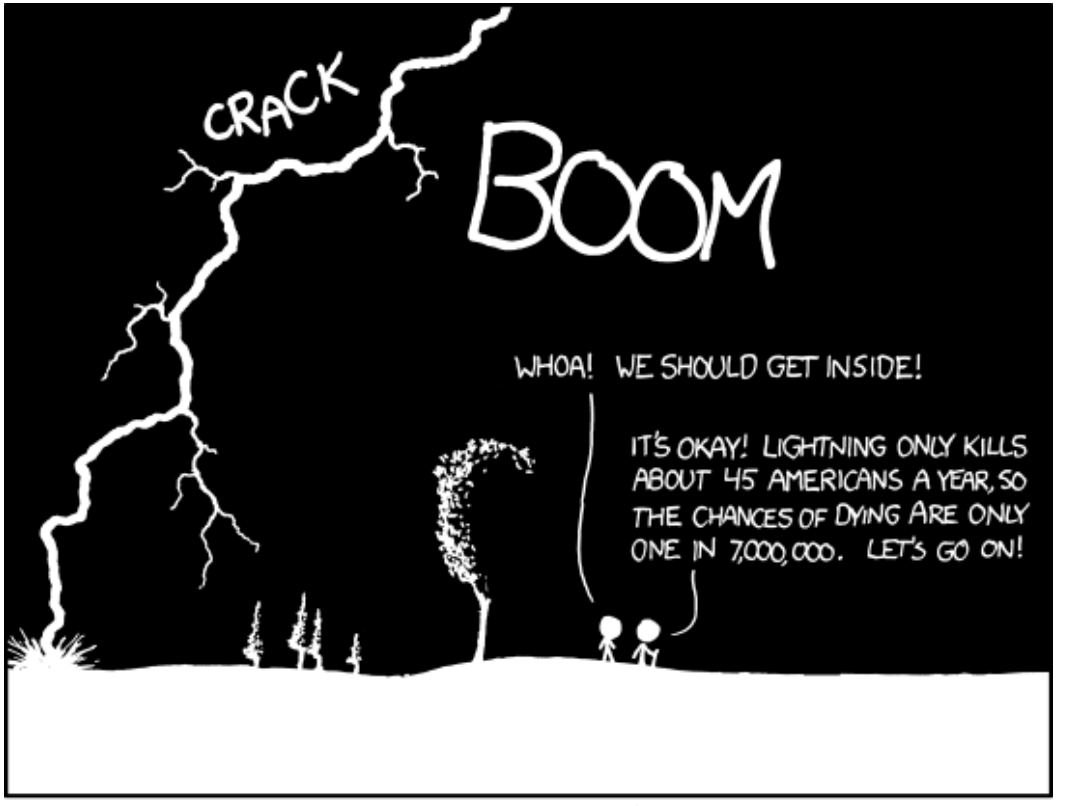



Risk assessment highlights prority species/issues for more detailed evaluation

A conceptual model maps out key interactions for high risk fisheries, specifies quantitative management strategy evaluation

## Why risk assessment?

Common framework across industry, science, business; but methods matter. Assessing the risks correctly is essential to good decision making.




https://xkcd.com/795/

# Mid-Atlantic Council risk assessment framework

Clarify exactly what we are assessing and why

- *What are we measuring?* → **Risk Element**
- *Why are we measuring it?* → **Risk Definition**
- *How are we measuring it?* → **Indicator**
- *What is the risk?* → **Risk Ranking Criteria**

Iterative process starting with the Council workshops

- Council staff and scientists create examples based on Council input

  ↑ ↓ ↑ ↓ ↑ ↓ ↑ ↓ ↑ ↓ ↑ ↓ ...

- Council discusses, clarifies, revises with public input

Risk assessment paper[1]:
https://www.frontiersin.org/articles/10.3389/fmars.2018.00442/full

[1] Gaichas, S. K., DePiper, G. S., Seagraves, R. J., Muffley, B. W., Sabo, M., Colburn, L. L., and Loftus, A. L. 2018. Implementing Ecosystem Approaches to Fishery Management: Risk Assessment in the US Mid-Atlantic. Frontiers in Marine Science, 5.

# Council-defined risk elements: Ecological

| Element | Definition | Indicators |
|---|---|---|
| **Ecological** | | |
| Assessment performance | Risk of not achieving OY due to analytical limitations | Current assessment method/data quality |
| F status | Risk of not achieving OY due to overfishing | Current F relative to reference F from assessment |
| B status | Risk of not achieving OY due to depleted stock | Current B relative to reference B from assessment |
| Food web (MAFMC Predator) | Risk of not achieving OY due to MAFMC managed species interactions | Diet composition, management measures |
| Food web (MAFMC Prey) | Risk of not achieving OY due to MAFMC managed species interactions | Diet composition, management measures |
| Food web (Protected Species Prey) | Risk of not achieving protected species objectives due to species interactions | Diet composition, management measures |
| Ecosystem productivity | Risk of not achieving OY due to changing system productivity | Four indicators, see text |
| Climate | Risk of not achieving OY due to climate vulnerability | Northeast Climate Vulnerability Assessment |
| Distribution shifts | Risk of not achieving OY due to climate-driven distribution shifts | Northeast Climate Vulnerability Assessment + 2 indicators |
| Estuarine habitat | Risk of not achieving OY due to threats to estuarine/nursery habitat | Enumerated threats + estuarine dependence |
| Offshore habitat | Risk of not achieving OY due to changing offshore habitat | Integrated habitat model index |

# Risk elements: Economic, Social, and Food Production

| Element | Definition | Indicators |
|---|---|---|
| **Economic** | | |
| Commercial Revenue | Risk of not maximizing fishery value | Revenue in aggregate |
| Recreational Angler Days/Trips | Risk of not maximizing fishery value | Numbers of anglers and trips in aggregate |
| Commercial Fishery Resilience (Revenue Diversity) | Risk of reduced fishery business resilience | Species diversity of revenue |
| Commercial Fishery Resilience (Shoreside Support) | Risk of reduced fishery business resilience due to shoreside support infrastructure | Number of shoreside support businesses |
| **Social** | | |
| Fleet Resilience | Risk of reduced fishery resilience | Number of fleets, fleet diversity |
| Social-Cultural | Risk of reduced community resilience | Community vulnerability, fishery engagement and reliance |
| **Food Production** | | |
| Commercial | Risk of not optimizing seafood production | Seafood landings in aggregate |
| Recreational | Risk of not maintaining personal food production | Recreational landings in aggregate |

# Risk elements: Management

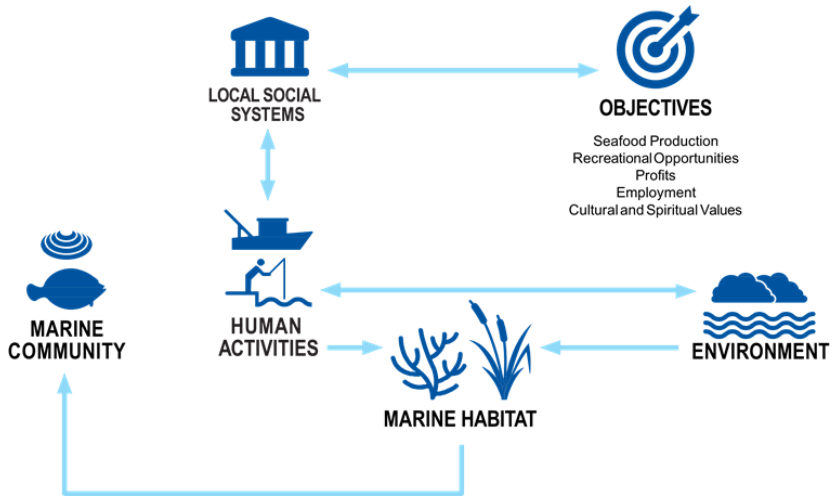
| Element | Definition | Indicators |
|---|---|---|
| **Management** | | |
| Control | Risk of not achieving OY due to inadequate control | Catch compared to allocation |
| Interactions | Risk of not achieving OY due to interactions with species managed by other entities | Number and type of interactions with protected or non-MAFMC managed species, co-management |
| Other ocean uses | Risk of not achieving OY due to other human uses | Fishery overlap with energy/mining areas |
| Regulatory complexity | Risk of not achieving compliance due to complexity | Number of regulations by species |
| Discards | Risk of not minimizing bycatch to extent practicable | Standardized Bycatch Reporting |
| Allocation | Risk of not achieving OY due to spatial mismatch of stocks and management | Distribution shifts + number of interests |

# But where will the risk assessment indicators come from?

# Meanwhile, scientists were improving ecosystem reports:

*"So what?" --John Boreman, September 2016*

1. Clear linkage of ecosystem indicators with management objectives
2. Synthesis across indicators for big picture
3. Objectives related to human-well being placed first in report
4. Short (< 30 pages), non-technical (but rigorous) text
5. Emphasis on reproducibility



# Revised ecosystem status reporting

## Report structure

1. Synthetic overview
2. Human dimensions
3. Protected species
4. Fish and invertebrates (managed and otherwise)
5. Habitat quality and ecosystem productivity

Ecosystem-scale objectives and indicators on the Northeast US shelf

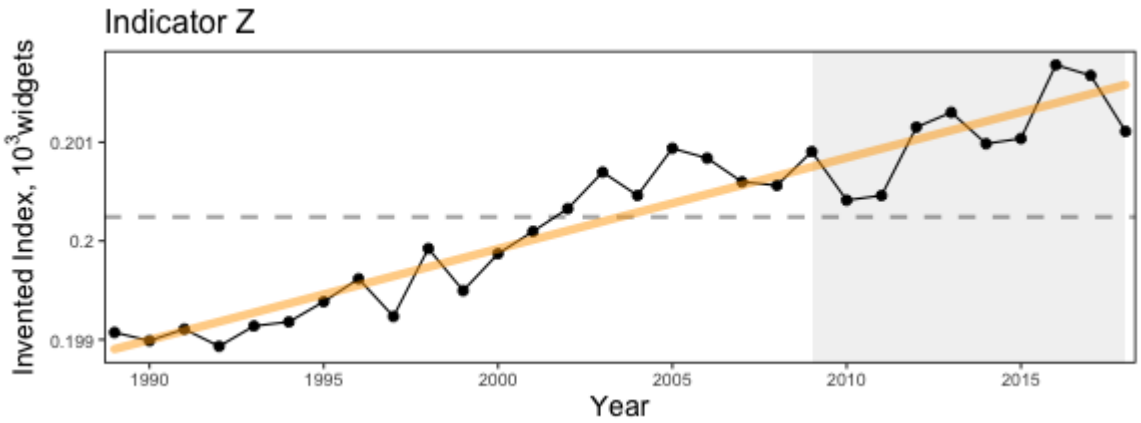
| Objective Categories | Indicators |
|---|---|
| Seafood Production | Landings by feeding guild |
| Profits | Revenue by feeding guild |
| Recreation | Number of anglers and trips; recreational catch |
| Stability | Diversity indices (fishery and species) |
| Social & Cultural | Commercial and recreational reliance |
| Biomass | Biomass or abundance by feeding guild from surveys |
| Productivity | Condition and recruitment of managed species |
| Trophic structure | Relative biomass of feeding guilds, primary productivity |
| Habitat | Estuarine and offshore habitat conditions |

# Standardized indicator visualization in reports

Status (short-term) and trend (long-term) of components are measured as **indicators** and plotted in a standardized way

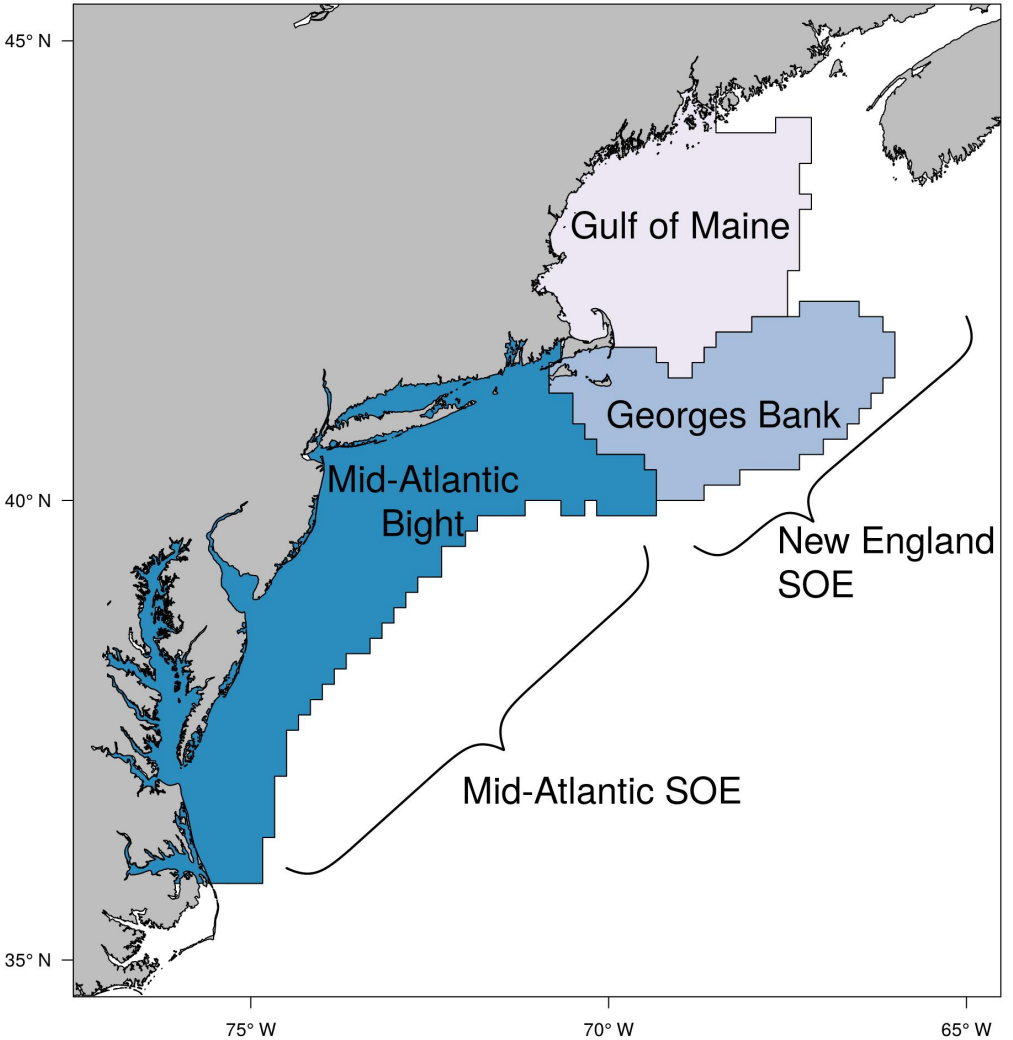
Indicators are selected to

1. Be broadly informative about a component in a management context[1-3]
2. Minimize redundancy of information
3. Be responsive to ecosystem change




[1] Rice J. C.Rochet M. J. "A framework for selecting a suite of indicators for fisheries management." ICES Journal of Marine Science 62 (2005): 516–527.
[2] Link J. 2010. Ecosystem-Based Fisheries Management: Confronting Tradeoffs . Cambridge University Press, New York.
[3] Zador, Stephani G., et al. "Ecosystem considerations in Alaska: the value of qualitative assessments." ICES Journal of Marine Science 74.1 (2017): 421-430.

# Indicator spatial scales–already Mid-Atlantic specific

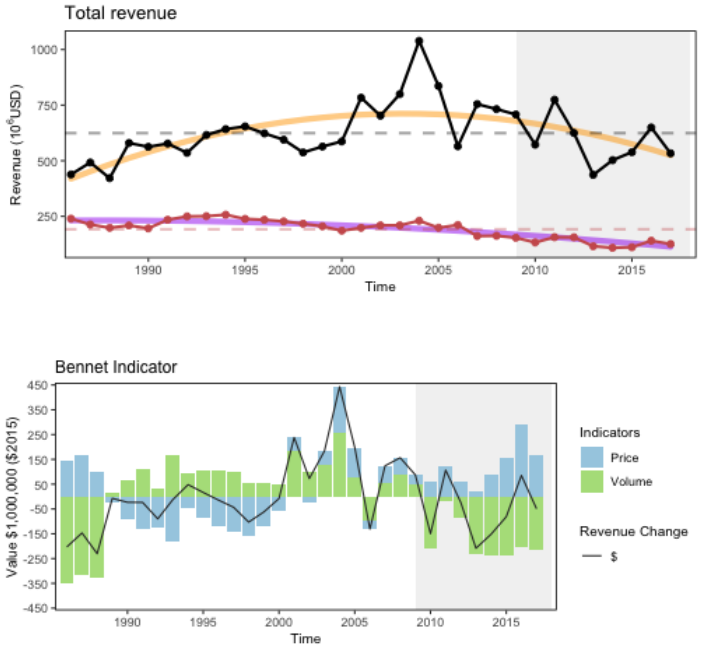



https://noaa-edab.github.io/tech-doc/epu.html

# Risk assessent indicators and ranking criteria: Commercial revenue

This element is applied at the ecosystem level. Revenue serves as a proxy for commercial profits.

| Risk Level | Definition |
|---|---|
| Low | No trend and low variability in revenue |
| Low-Moderate | Increasing or high variability in revenue |
| Moderate-High | Significant long term revenue decrease |
| High | Significant recent decrease in revenue |




Ranked moderate-high risk due to the significant long term revenue decrease for Mid-Atlantic managed species (red points in top plot)

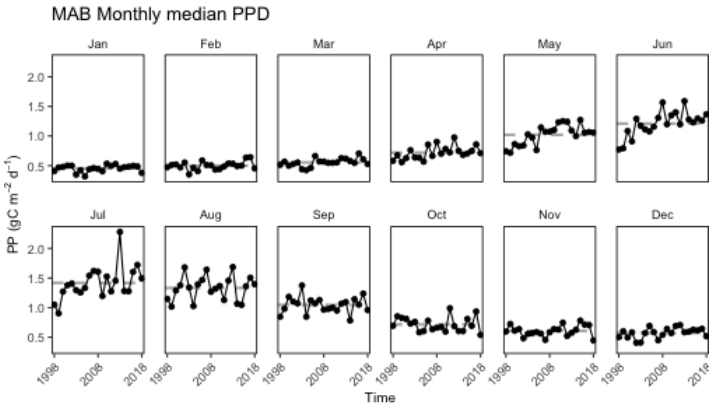
## Risk assessent indicators and ranking criteria: System productivity

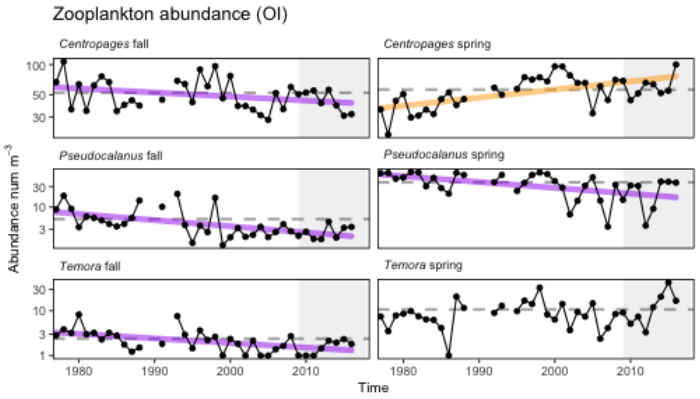
This element is applied at the ecosystem level, and ranks the risk of not achieving optimum yield due to changes in ecosystem productivity at the base of the food web.

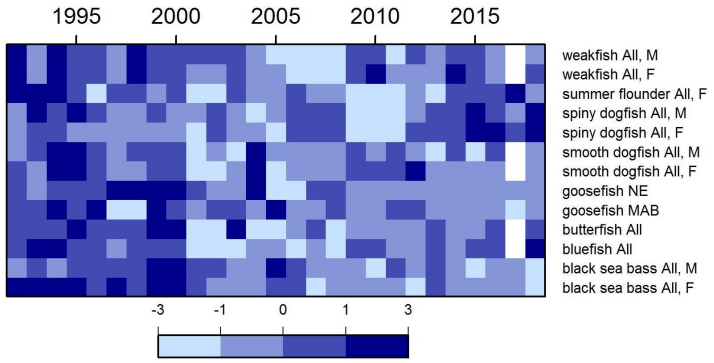
Four indicators are used together to assess risk of changing ecosystem productivity: primary production, zooplankton abundance, fish condition and fish recruitment.

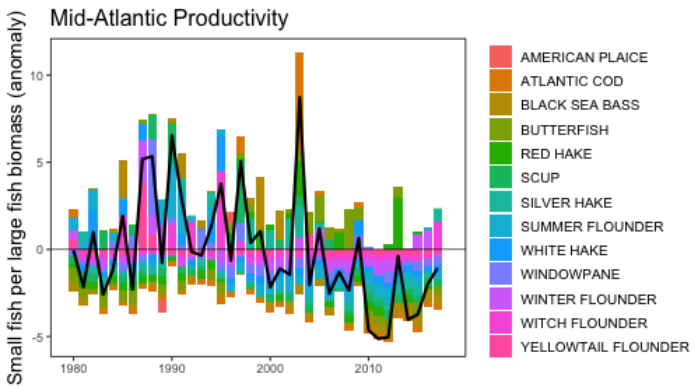
| Risk Level | Definition |
|---|---|
| Low | No trends in ecosystem productivity |
| Low-Moderate | Trend in ecosystem productivity (1-2 measures, increase or decrease) |
| Moderate-High | Trend in ecosystem productivity (3+ measures, increase or decrease) |
| High | Decreasing trend in ecosystem productivity, all measures |

# Risk assessent indicators and ranking criteria: System productivity



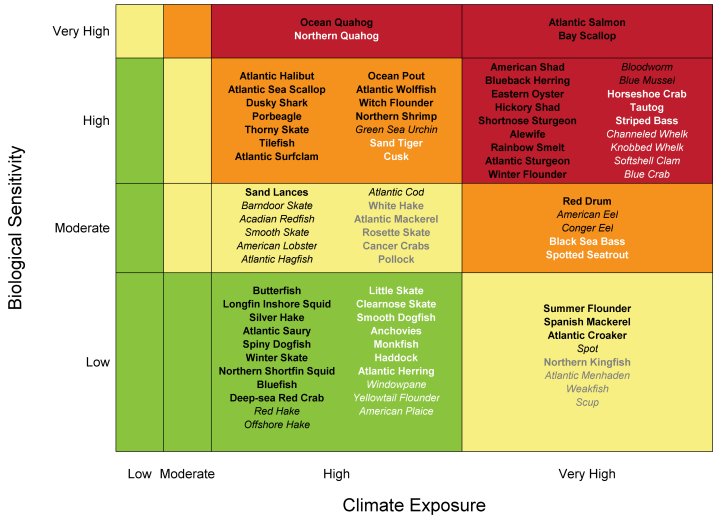




Ranked low-moderate risk due to the significant long term trends in zooplankton abundance for major species (top right plot)

# Risk assessent indicators and ranking criteria: Climate

This element is applied at the species level. Risks to species productivity (and therefore to achieving optimum yield) due to projected climate change in the Northeast US were evaluated in a comprehensive assessment[1].

| Risk Level | Definition |
|---|---|
| Low | Low climate vulnerability ranking |
| Low-Moderate | Moderate climate vulnerability ranking |
| Moderate-High | High climate vulnerability ranking |
| High | Very high climate vulnerability ranking |




Each species ranked according to position/color in the plot on the right

[1] Hare, J. A., Morrison, W. E., Nelson, M. W., Stachura, M. M., Teeters, E. J., Griffis, R. B., Alexander, M. A., et al. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLOS ONE, 11: e0146756. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0146756.

# Risk assessment results: *Species and sector level elements*[1]

| Species | MgtControl | TecInteract | OceanUse | RegComplex | Discards | Allocation |
|---|---|---|---|---|---|---|
| Ocean Quahog-C | lowest | lowest | lowmod | lowest | lowest | lowest |
| Surfclam-C | lowest | lowest | lowmod | lowest | lowest | lowest |
| Summer flounder-R | modhigh | lowest | lowmod | highest | highest | highest |
| Summer flounder-C | lowmod | modhigh | lowmod | modhigh | lowmod | highest |
| Scup-R | lowest | lowest | lowmod | modhigh | modhigh | lowest |
| Scup-C | lowest | modhigh | lowmod | modhigh | modhigh | lowest |
| Black sea bass-R | highest | lowest | modhigh | highest | modhigh | highest |
| Black sea bass-C | lowmod | lowmod | highest | modhigh | lowmod | highest |
| Atl. mackerel-R | lowest | lowest | lowest | lowest | lowest | highest |
| Atl. mackerel-C | lowest | lowmod | modhigh | highest | lowmod | highest |
| Butterfish-C | lowest | lowmod | modhigh | highest | modhigh | lowest |
| Longfin squid-C | lowest | modhigh | highest | highest | highest | highest |
| Shortfin squid-C | lowest | lowmod | lowmod | lowmod | lowest | lowest |
| Golden tilefish-R | na | lowest | lowest | lowest | lowest | lowest |
| Golden tilefish-C | lowest | lowest | lowest | lowest | lowest | lowest |
| Blueline tilefish-R | lowest | lowest | lowest | modhigh | lowest | highest |
| Blueline tilefish-C | lowest | lowest | lowest | modhigh | lowest | highest |
| Bluefish-R | lowmod | lowest | lowest | lowest | modhigh | highest |
| Bluefish-C | lowest | lowest | lowmod | lowmod | lowmod | highest |
| Spiny dogfish-R | lowest | lowest | lowest | lowest | lowest | lowest |
| Spiny dogfish-C | lowest | modhigh | modhigh | modhigh | lowmod | highest |
| Unmanaged forage | na | na | na | na | na | na |
| Deepsea corals | na | na | modhigh | na | na | na |

[1] Gaichas, S. K., DePiper, G. S., Seagraves, R. J., Muffley, B. W., Sabo, M., Colburn, L. L., and Loftus, A. L. 2018. Implementing Ecosystem Approaches to Fishery Management: Risk Assessment in the US Mid-Atlantic. Frontiers in Marine Science, 5.

# Risk assessment results updated with 2019 indicators

## *Species level risk elements*

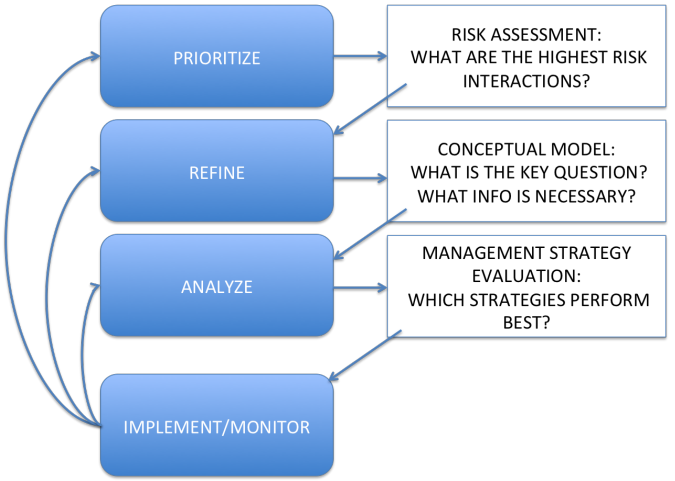
| Species | Assess | Fstatus | Bstatus | FW1Pred | FW1Prey | FW2Prey | Climate | DistShift | EstHabitat |
|---|---|---|---|---|---|---|---|---|---|
| Ocean Quahog | lowest | lowest | lowest | lowest | lowest | lowest | highest | modhigh | lowest |
| Surfclam | lowest | lowest | lowest | lowest | lowest | lowest | modhigh | modhigh | lowest |
| Summer flounder | lowest | lowest | lowmod | lowest | lowest | lowest | lowmod | modhigh | highest |
| Scup | lowest | lowest | lowest | lowest | lowest | lowest | lowmod | modhigh | highest |
| Black sea bass | lowest | lowest | lowest | lowest | lowest | lowest | modhigh | modhigh | highest |
| Atl. mackerel | lowest | highest | highest | lowest | lowest | lowest | lowmod | modhigh | lowest |
| Butterfish | lowest | lowest | lowest | lowest | lowest | lowest | lowest | highest | lowest |
| Longfin squid | lowmod | lowmod | lowmod | lowest | lowest | lowmod | lowest | modhigh | lowest |
| Shortfin squid | lowmod | lowmod | lowmod | lowest | lowest | lowmod | lowest | highest | lowest |
| Golden tilefish | lowest | lowest | lowmod | lowest | lowest | lowest | modhigh | lowest | lowest |
| Blueline tilefish | highest | highest | modhigh | lowest | lowest | lowest | modhigh | lowest | lowest |
| Bluefish | lowest | lowest | lowmod | lowest | lowest | lowest | lowest | modhigh | highest |
| Spiny dogfish | lowmod | lowest | lowmod | lowest | lowest | lowest | lowest | highest | lowest |
| Monkfish | highest | lowmod | lowmod | lowest | lowest | lowest | lowest | modhigh | lowest |
| Unmanaged forage | na | na | na | lowest | lowmod | lowmod | na | na | na |
| Deepsea corals | na | na | na | lowest | lowest | lowest | na | na | na |

## *Ecosystem level risk elements*

| System | EcoProd | CommRev | RecVal | FishRes1 | FishRes4 | FleetDiv | Social | ComFood | RecFood |
|---|---|---|---|---|---|---|---|---|---|
| Mid-Atlantic | lowmod | modhigh | highest | lowest | modhigh | lowest | lowmod | highest | modhigh |

# How is MAFMC using the risk assessment? What's next?

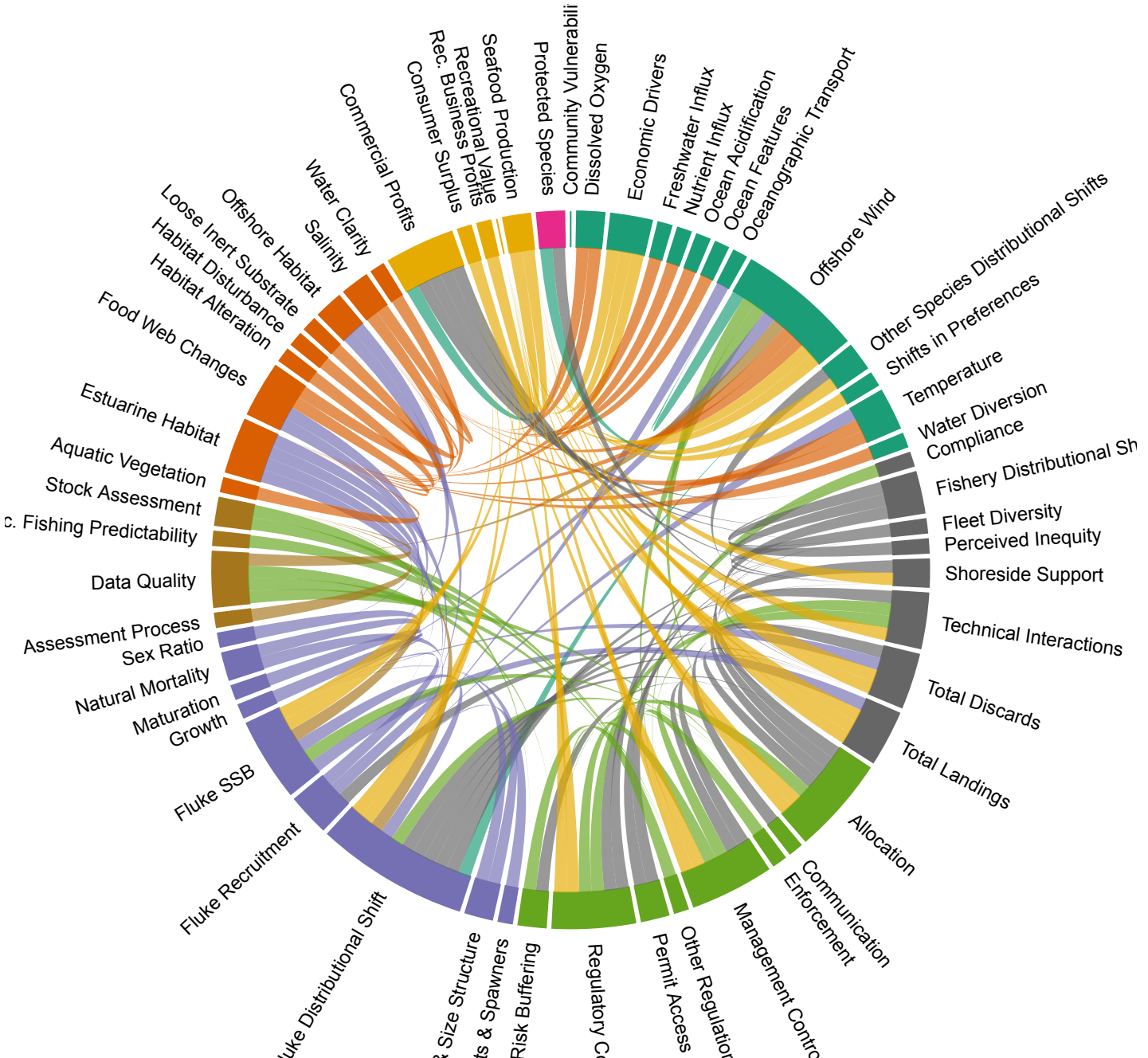
- Based on risk assessment, the Council selected summer flounder as high-risk fishery for conceptual modeling




- Working group of habitat, biology, stock assessment, management, economic and social scientists developed:
  - draft conceptual models of high risk elements, linkages
  - dataset identification and gap analysis for each element and link
  - draft questions that the Council could persue with additional work

- Final conceptual model and supporting information at December 2019 Council meeting

- Council to proceed with management strategy evaluation (MSE) using the information from conceptual modeling as a basis. Topic: addressing recreational fishery discards with EAFM


Protected Species
Community Vulnerabili
Dissolved Oxygen
Economic Drivers
Freshwater Influx
Nutrient Influx
Ocean Acidification
Ocean Features
Oceanographic Transport
Offshore Wind
Other Species Distributional Shifts
Shifts in Preferences
Temperature
Water Diversion
Compliance
Fishery Distributional Sh
Fleet Diversity
Perceived Inequity
Shoreside Support
Technical Interactions
Total Discards
Total Landings
Allocation
Communication
Enforcement
Management Control
Other Regulation
Permit Access
Regulatory C
Risk Buffering
ts & Spawners
Size Structure
Fluke Distributional Shift
Fluke Recruitment
Fluke SSB
Growth
Maturation
Natural Mortality
Sex Ratio
Assessment Process
Data Quality
c. Fishing Predictability
Stock Assessment
Aquatic Vegetation
Estuarine Habitat
Food Web Changes
Habitat Alteration
Habitat Disturbance
Loose Inert Substrate
Offshore Habitat
Salinity
Water Clarity
Commercial Profits
Consumer Surplus
Rec. Business Profits
Recreational Value
Seafood Production

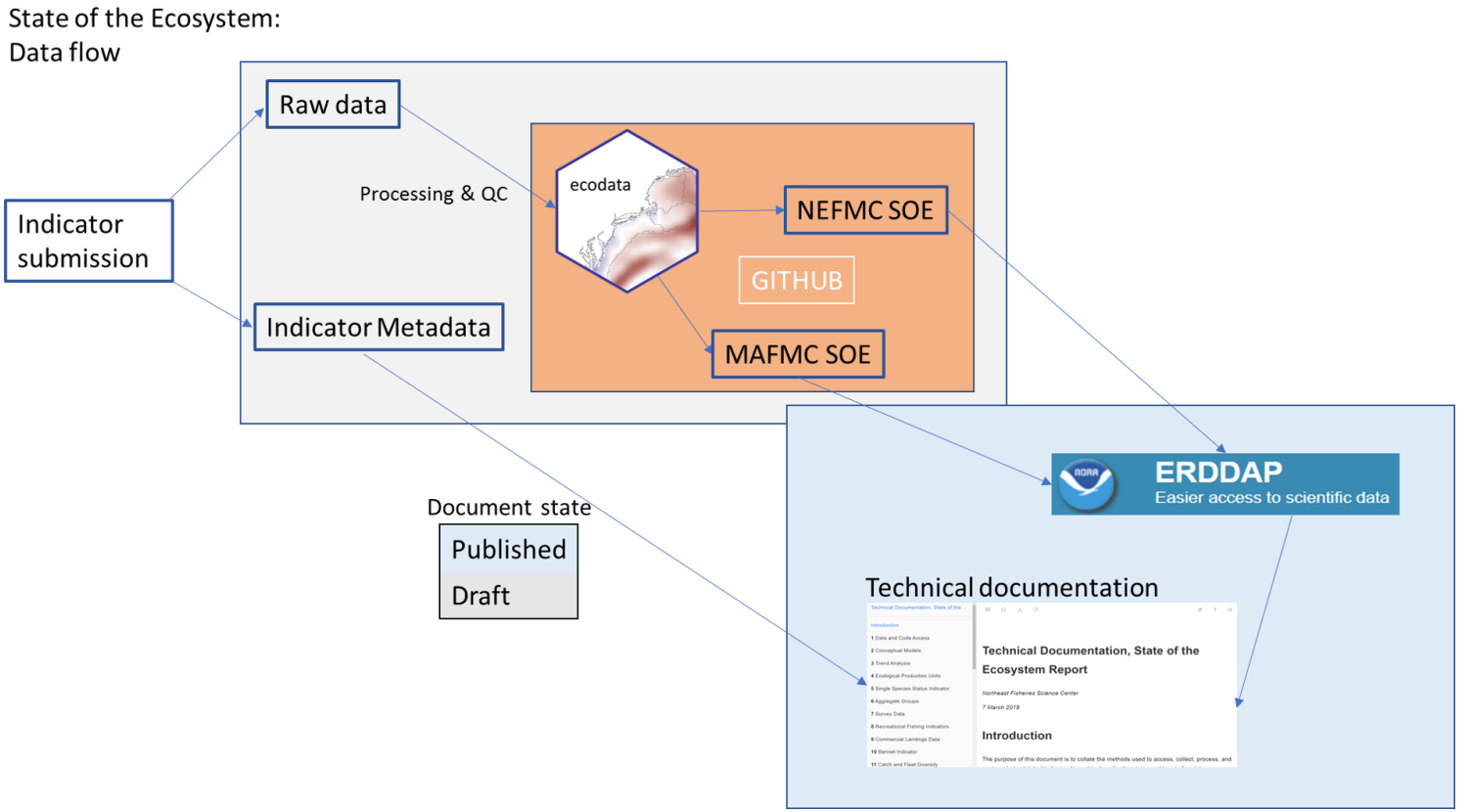
## Conclusions

Integrated ecosystem assessment is a valuable framework for the general implementation of ecosystem approaches to natural resource management

- The Council's rapid progress in implementing EAFM resulted from positive collaboration between managers, stakeholders, and scientists. Collaboration is essential to IEA and to the success of EAFM.
- Ecosystem indicators and reporting can be tailored to specific regional objectives.
- Risk assessment is a rapid, familiar, scaleable, and transparent method to move forward with EAFM within a real-world operational fishery management context.
- This EAFM process highlights certain species and certain management issues as posing higher cumulative risks to meeting Council-derived management objectives when considering a broad range of ecological, social, and economic factors.
- Conceptual modeling links the key factors for high risk fisheries and scopes more detailed integrated analysis and management strategy evaluation.

# Footnote: Improvements to reproducibility and provenance

- Reporting the information is not enough
- Managers appreciate the concise format, but back-end critical for describing collection, analyses, and processing
- Streamlined workflow allowed scientists to meet management deadlines



## If you want all the details

- Mid-Atlantic Council EAFM paper
- Mid-Atlantic Council Risk Assessment paper
- Mid-Atlantic Council Summer Flounder conceptual model and support tables
- 2019 Mid-Atlantic State of the Ecosystem report
- State of the Ecosystem Technical Documentation
- ecodata R package
    - Macrofauna indicators
    - Human Dimensions indicators
    - Lower trophic level indicators
- Slides available at https://noaa-edab.github.io/presentations

# Contributors - THANK YOU!

The New England and Mid-Atlantic Ecosystem reports made possible by (at least) 38 contributors from 8 institutions

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NOAA FISHERIES
National Oceanic and Atmospheric Administration

IEA
INTEGRATED ECOSYSTEM ASSESSMENT

# Questions? Thank you!

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