#11

State of the Ecosystem New England

New England Fishery Management Council
15 April 2021

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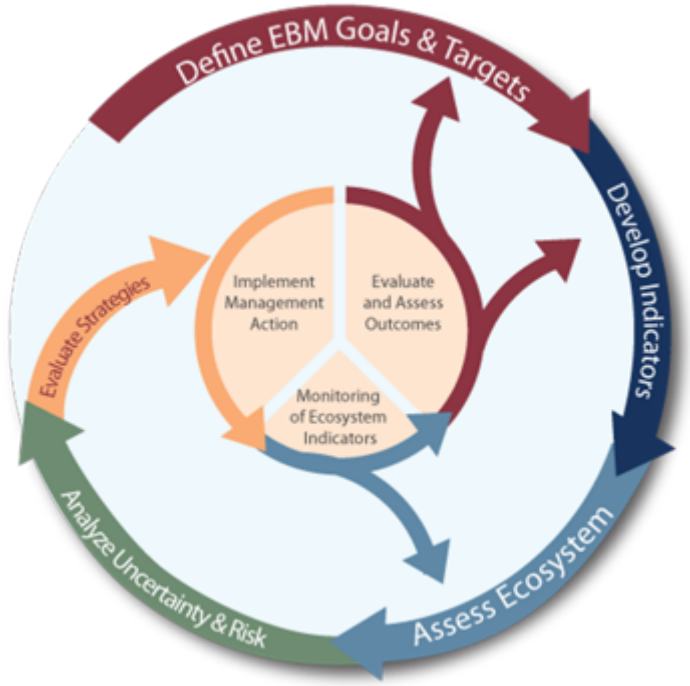
Many thanks to:
Kimberly Bastille, Geret DePiper,
Sarah Gaichas, Kimberly Hyde, Scott Large,
and all SOE contributors

State of the Ecosystem (SOE) reporting

Improving ecosystem information and synthesis for fishery managers

- Ecosystem indicators linked to management objectives (DePiper, et al., 2017)
  - Contextual information
  - Report evolving since 2016
  - Fishery-relevant subset of full Ecosystem Status Reprorts
- Open science emphasis (Bastille, et al., 2020)



The IEA Loop[1]

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

State of the Ecosystem: Updated structure

2020 Report

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

2021 Report

1. Graphical summary
    - Page 1 report card re: objectives →
    - Page 2 risk summary bullets
    - Page 3 synthesis themes
2. Performance relative to management objectives
3. Risks to meeting management objectives

Example ecosystem-scale fishery management objectives

Objective Categories	Indicators reported here
Provisioning and Cultural Services	
Seafood Production	Landings; commercial total and by feeding guild; recreational harvest
Profits	Revenue decomposed to price and volume
Recreation	Days fished; recreational fleet diversity
Stability	Diversity indices (fishery and ecosystem)
Social & Cultural	Community engagement/reliance status
Protected Species	Bycatch; population (adult and juvenile) numbers, mortalities
Supporting and Regulating Services	
Biomass	Biomass or abundance by feeding guild from surveys
Productivity	Condition and recruitment of managed species, Primary productivity
Trophic structure	Relative biomass of feeding guilds, Zooplankton
Habitat	Estuarine and offshore habitat conditions

Report card page 1 and 2

Performance Relative to Fishery Management Objectives

Trends and status of indicators related to broad, ecosystem-level fishery management objectives, with implications for the New England Fishery Management Council (NEFMC)

Gulf of Maine (GOM)

OBJECTIVE (INDICATOR)	Seafood production (total and NEFMC managed landings)	Commercial profits (NEFMC managed revenue)	Stability (fishery and ecosystem diversity maintained over time)
30 YEAR TREND	↘	Total: ↔ Managed: ↘	Fishery: ↘ Ecosystem: ⤭
CURRENT STATUS	−	Total: + Managed: −	Fishery: Comm: − Rec: • Ecosystem: +
IMPLICATIONS	Driven by management due to poor/unknown stock status; Currently no ecosystem overfishing is occurring. Recommend to continue monitoring climate indicators as they continue trending toward uncharted territory which affects stock distributions and will generate other ecosystem changes.	Driven by a single species which is in turn driven by availability and market conditions. Total regional revenue is high due to high lobster prices, despite lower volume.	Fishery: Commercial fleet diversity indicates a shift toward reliance on fewer species, as noted under revenue. Recreational species diversity is increasing due to increases in southerly species and decreased limits on traditional regional species. Ecosystem: Overall indicators suggest stability but several metrics are increasing and should be monitored as warning signs for potential regime shift or ecosystem restructuring.

Georges Bank (GB)

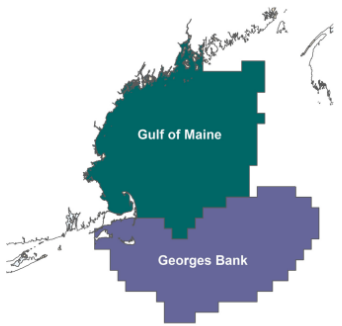
OBJECTIVE (INDICATOR)	Seafood production (total and NEFMC managed landings)	Commercial profits (NEFMC managed revenue)	Stability (fishery and ecosystem diversity maintained over time)
30 YEAR TREND	↘	↔	Fishery: ↘ Ecosystem: ⤭
CURRENT STATUS	−	+	Fishery: Comm: − Rec: • Ecosystem: +
IMPLICATIONS	Driven by management due to poor/unknown stock status; Currently no ecosystem overfishing is occurring. Recommend to continue monitoring climate indicators as they continue trending toward uncharted territory which affects stock distributions and will generate other ecosystem changes.	Driven by a single species which is in turn driven by availability and market conditions. High revenue caused by high volume/price from scallops but no trend due to fluctuations associated with rotational management areas	Fishery: Commercial fleet diversity indicates a shift toward reliance on fewer species, as noted under revenue. Recreational species diversity is increasing due to increases in southerly species and decreased limits on traditional regional species. Ecosystem: Overall indicators suggest stability but several metrics are increasing and should be monitored as warning signs for potential regime shift or ecosystem restructuring.

2021 STATE OF THE ECOSYSTEM | New England

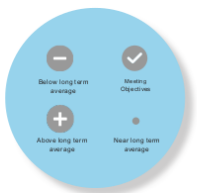
Performance Relative to Fishery Management Objectives

Common to both regions

OBJECTIVE (INDICATOR)	Recreational opportunities (total and NEFMC managed landings)	Social and cultural (fishery engagement and reliance, and social vulnerability)	Protected species (coastwide bycatch, population numbers, mortalities)
30 YEAR TREND	Effort: ↔ Diversity: ↔	More moderately to highly engaged fishing communities (2020 report)	Bycatch — Harbor porpoise: − Gray seal: +
CURRENT STATUS	Effort: • Diversity: •	Range of individual community status shown as baseline	Populations — NARW: − Gray seal: +
IMPLICATIONS	Relative stability in the overall number of recreational opportunities in the region	Highlighted communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities are also experiencing social vulnerability, they may have lower ability to successfully respond to change. These indicators may also point to communities that are vulnerable to environmental justice issues.	Bycatch trends are related to fishery management, shifts in population distribution combined with fishery shifts, and population increase for seals. Population drivers for North Atlantic Right Whales (NARW) include combined fishery interactions/ship strikes, distribution shifts, and copepod availability. Unusual mortality events continue for 3 large whale species, harbor and gray seals.



Current Status



Trend

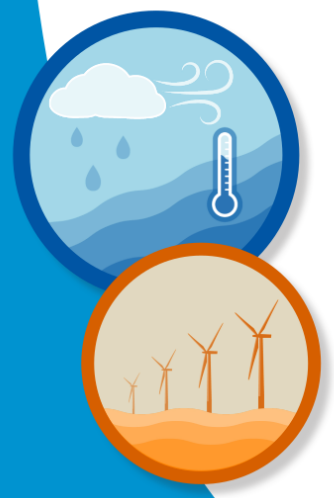
Risk summary bullets page 3

Risks to Meeting Fishery Management Objectives

Climate and Ecosystem Productivity Risks

Climate change, most notably ocean warming, continues in the New England and is affecting the ecosystem in various ways:

- Ocean warming and changes in major currents continue.
- Frequent marine heatwaves occurred, with Georges Bank experiencing the warmest event on record at 4.3 degrees above average.
- We continue to observe little to no Labrador Slope Water entering the Gulf of Maine.
- Several biological diversity metrics are above average.
- Primary production continues to be high. Years with large fall phytoplankton blooms, such as 2020, have been linked to large haddock recruitment events on Georges Bank.
- A new habitat climate vulnerability analysis shows some New England managed species depend on high to very highly vulnerable habitats.
- Temperature and zooplankton changes impact fish condition for different species, impacts to fisheries and markets are under investigation.



Other Ocean Uses: Offshore Wind Risks

More than 20 offshore wind development projects are proposed for construction over the next decade in the Northeast. Offshore wind areas may cover more than 1.7 million acres by 2030. While most of this development is in the Mid-Atlantic, the development of multiple offshore wind sites still poses a number of risks and impacts to fisheries including:

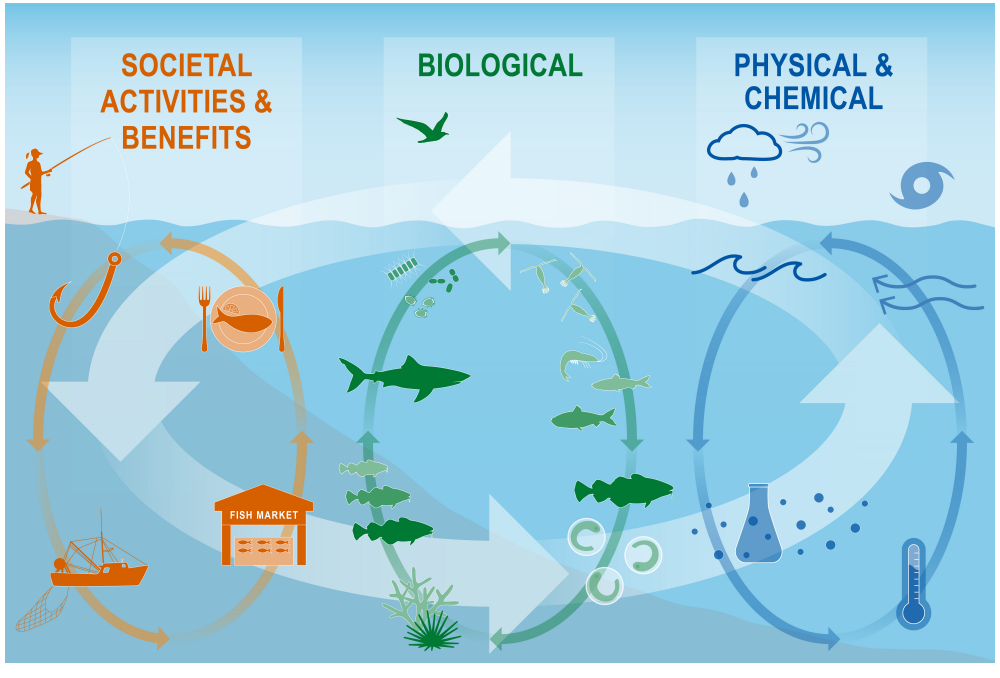
- If all sites are developed, 1-12% of total revenue for major New England species could be displaced in lease areas.
- Displaced fishing effort can alter fishing methods and change habitat, which can in turn change habitat, species (managed and protected), and fleet interactions.
- Right whales may be displaced and altered local oceanography could affect distribution of their zooplankton prey.
- Rapid buildout according to current plans will have greater impact to the Mid-Atlantic than New England, although some lease areas are in RI and MA; it is possible floating offshore technologies may be utilized in GOM in the future.
- Scientific surveys collecting data for ocean and ecosystem conditions, fish, and protected species will be altered, potentially increasing uncertainty for management decision-making.

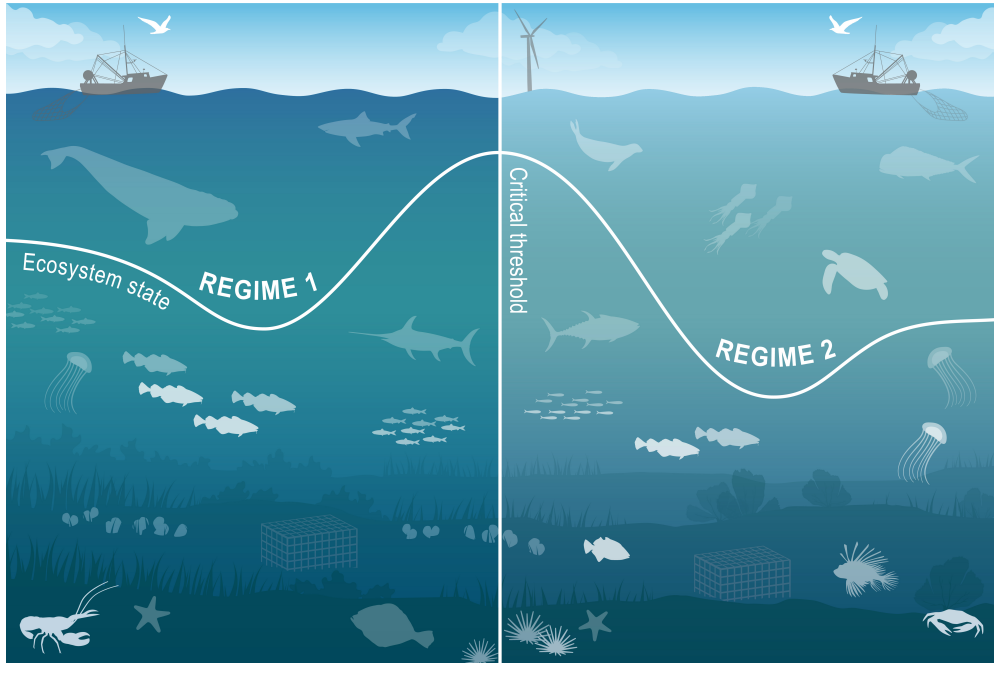
COVID-19 affected both fisheries and data collection in 2020 (see the NOAA Fisheries economic assessment of COVID-19 effects on the U.S. fishing and seafood industry report). We will continue to evaluate the impacts in the Northeast for future reports.

Graphical summary of ecosystem synthesis themes, page 4

Characterizing ecosystem change for fishery management

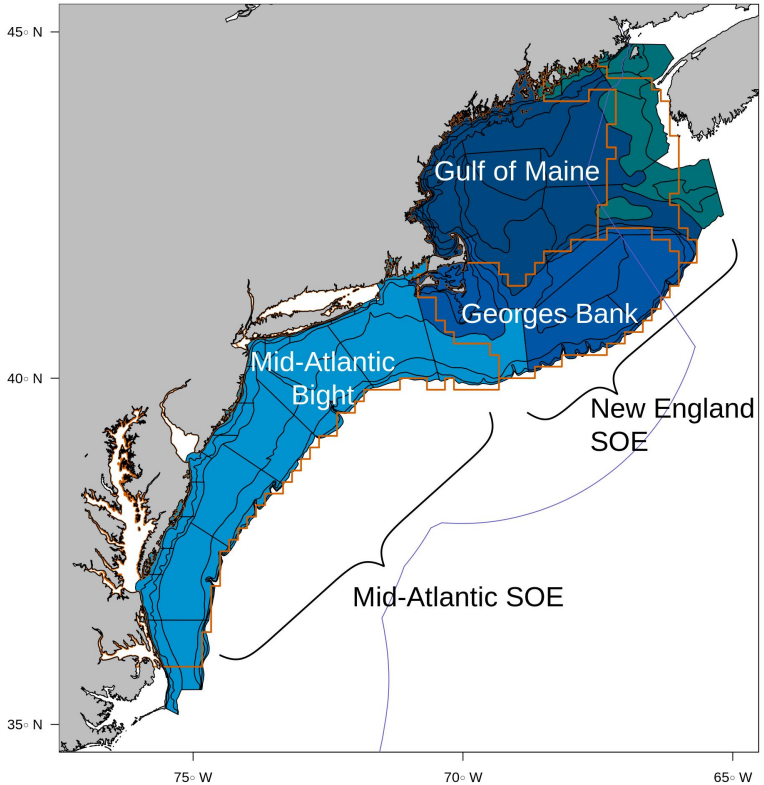
- Societal, biological, physical and chemical factors comprise the **multiple system drivers** that influence marine ecosystems through a variety of different pathways.
- Changes in the multiple drivers can lead to **regime shifts** — large, abrupt and persistent changes in the structure and function of an ecosystem.
- Regime shifts and changes in how the multiple system drivers interact can result in **ecosystem reorganization** as species and humans respond and adapt to the new environment.





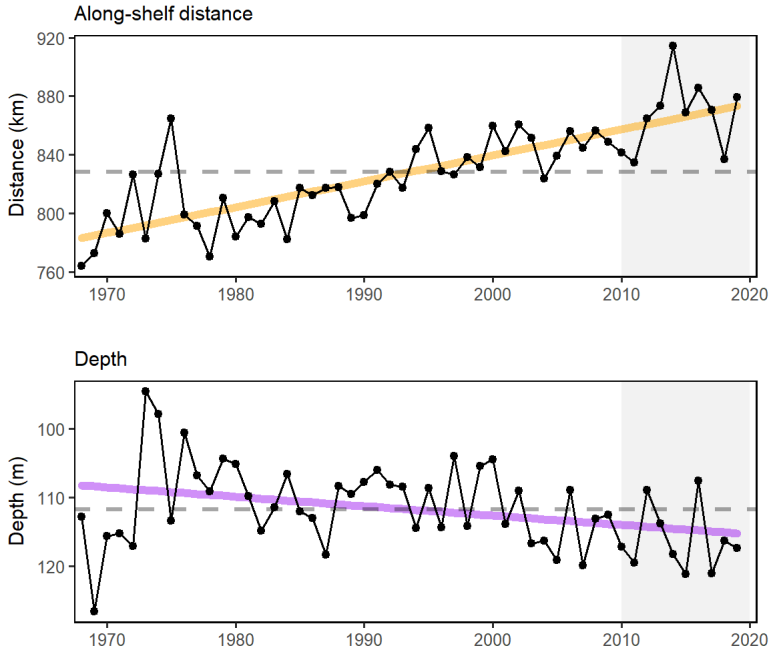
Document Orientation

Spatial scale



A glossary of terms, detailed technical methods documentation and indicator data are available online.

Key to figures



Trends assessed only for 30+ years: more information

Orange line = significant increase

Purple line = significant decrease

No color line = not significant or < 30 years

Grey background = last 10 years

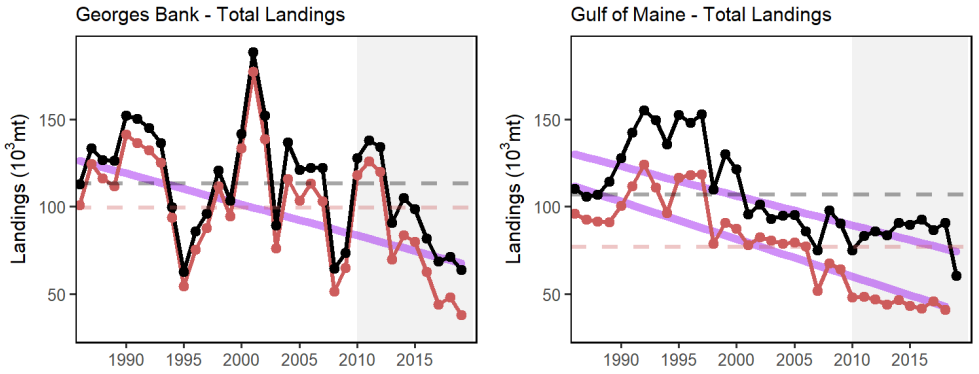
Revised structure to address Council requests and improve synthesis

- Performance relative to management objectives
  - *What* does the indicator say--up, down, stable?
  - *Why* do we think it is changing: integrates synthesis themes
    - Multiple drivers
    - Regime shifts
    - Ecosystem reorganization
- Objectives
  - Seafood production
  - Profits
  - Recreational opportunities
  - Stability
  - Social and cultural
  - Protected species
- Risks to meeting fishery management objectives
  - *What* does the indicator say--up, down, stable?
  - *Why* this is important to managers: integrates synthesis themes
    - Multiple drivers
    - Regime shifts
    - Ecosystem reorganization
- Risk categories
  - Climate: warming, ocean currents, acidification
    - Habitat changes (incl. vulnerability analysis)
    - Productivity changes (system and fish)
    - Species interaction changes
    - Community structure changes
  - Other ocean uses
    - Offshore wind development

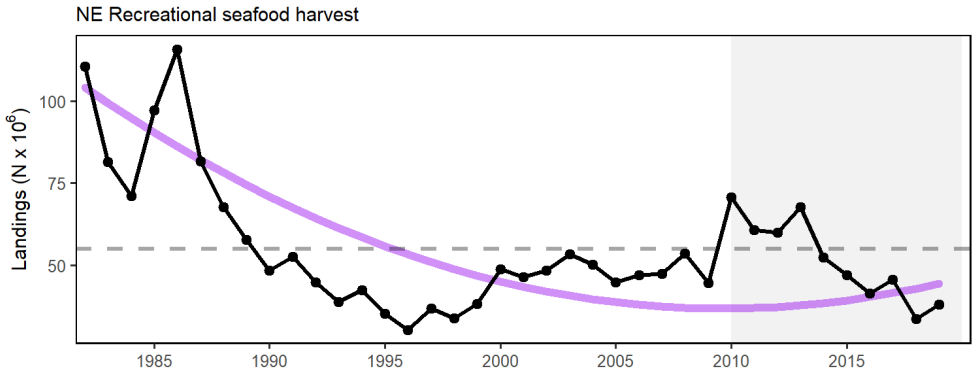
Performance relative to management objectives

Objective: Seafood production

Indicators: Commercial landings



Recreational landings

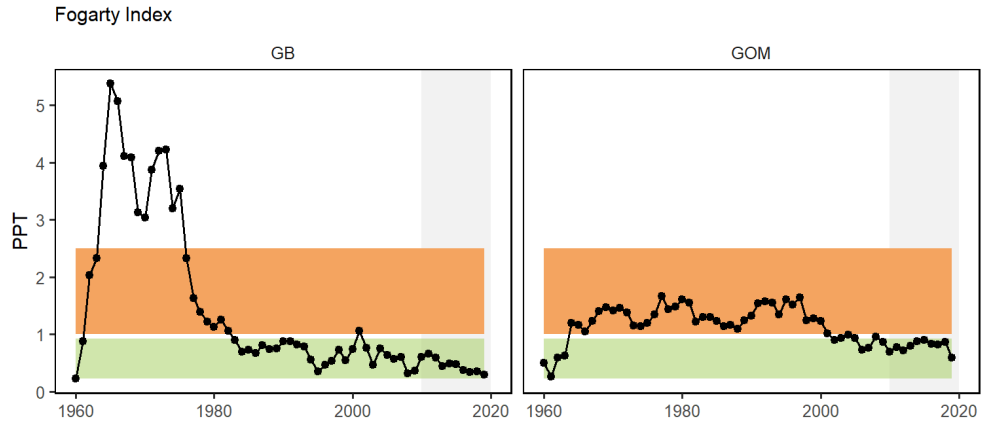


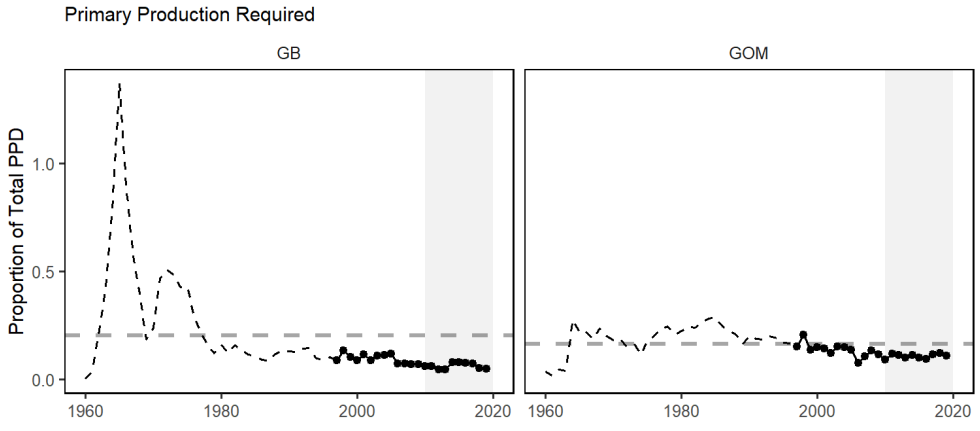
Key: Black = Landings of all species combined;

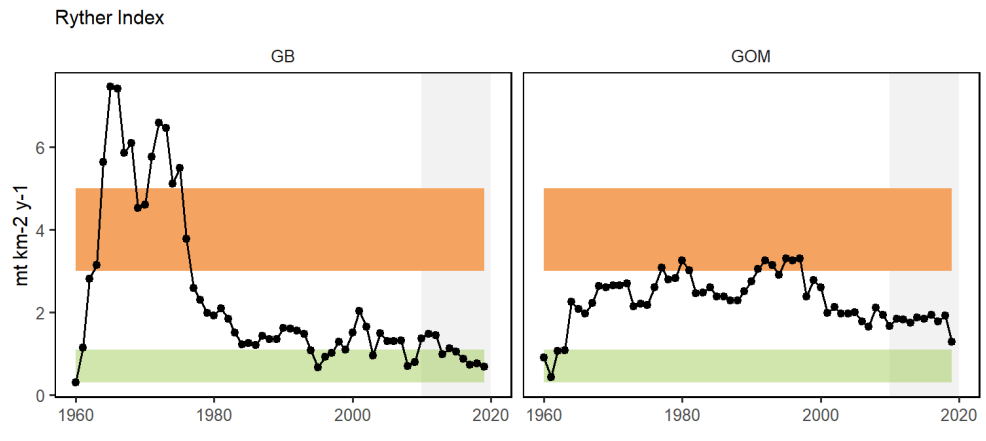
Red = Landings of NEFMC managed species

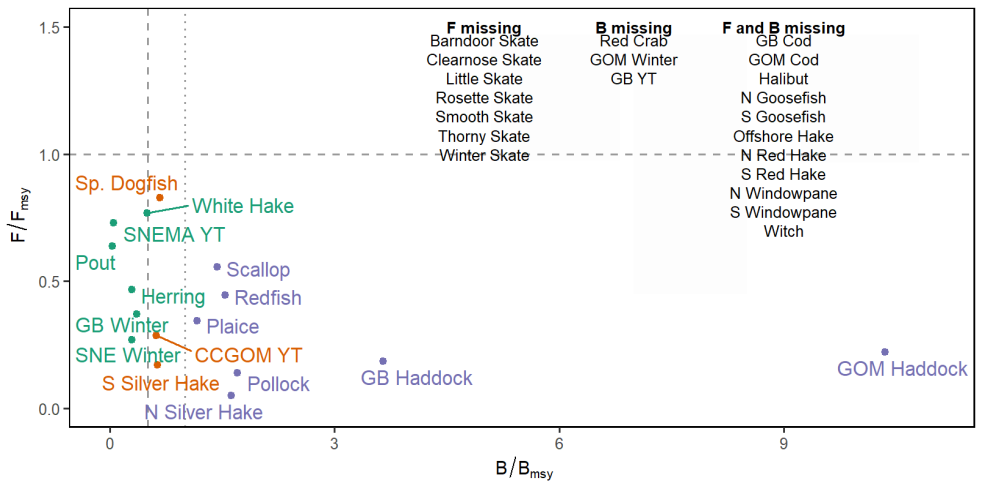
Multiple drivers: ecosystem and stock production, management, market conditions, and environment

Landings drivers: Ecosystem and stock production?









Key:

Orange background = Tipping point overfishing threshold, Link and Watson 2019

Green background = Optimal range, Link and Watson 2019

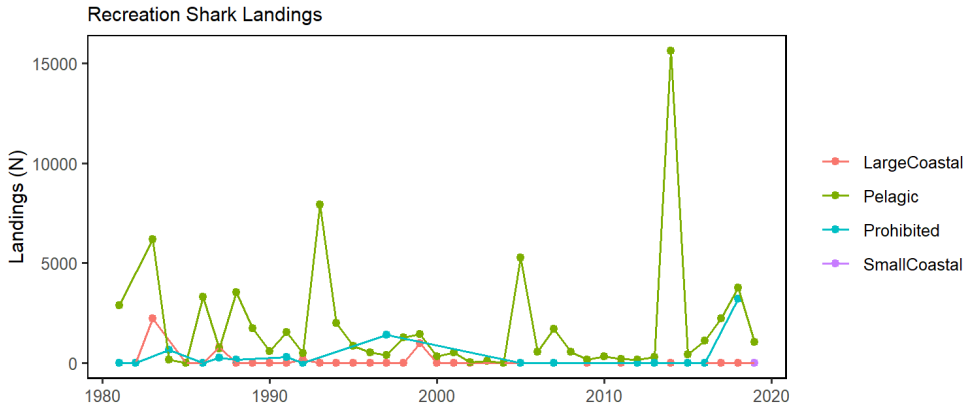
Implications: Seafood Production

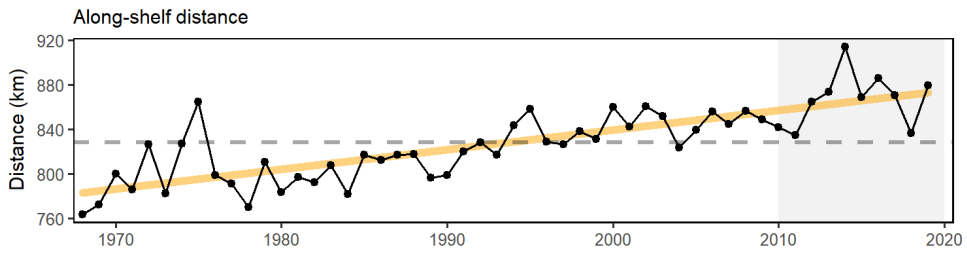
Drivers:

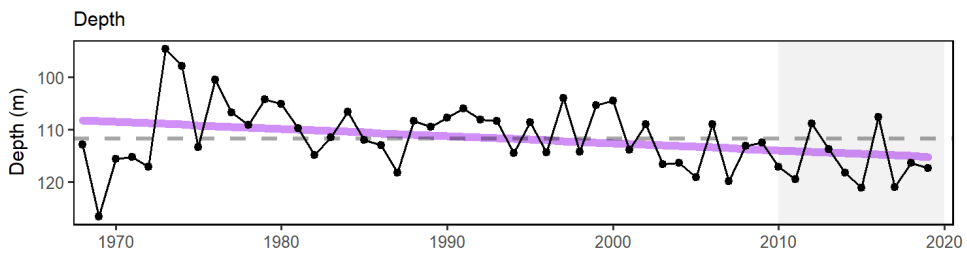
- decline in commercial landings is most likely driven by the requirement to rebuild individual stocks as well as market dynamics
- other drivers affecting recreational landings: shark fishery management, possibly survey methodology

Monitor:

- climate risks including warming, ocean acidification, and shifting distributions
- ecosystem composition and production changes
- fishing engagement

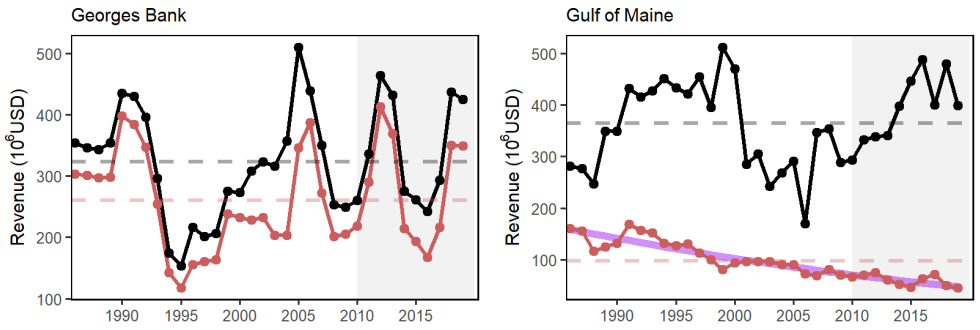






Objective: Commercial Profits

Indicator: Commercial Revenue



Key: Black = Revenue of all species combined;

Red = Revenue of NEFMC managed species

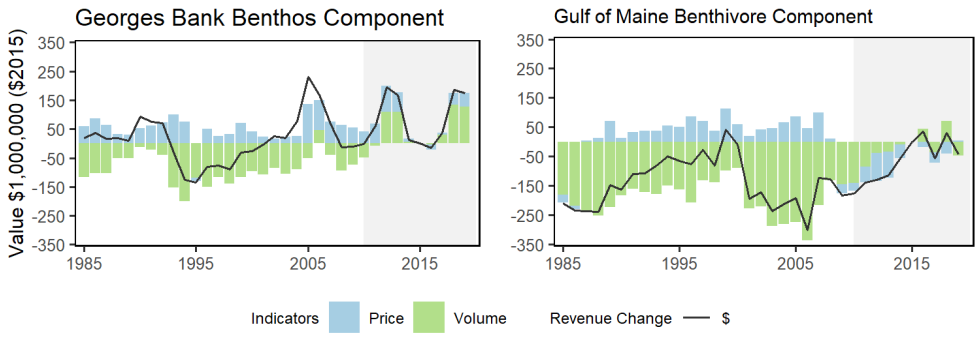
Both regions driven by single species

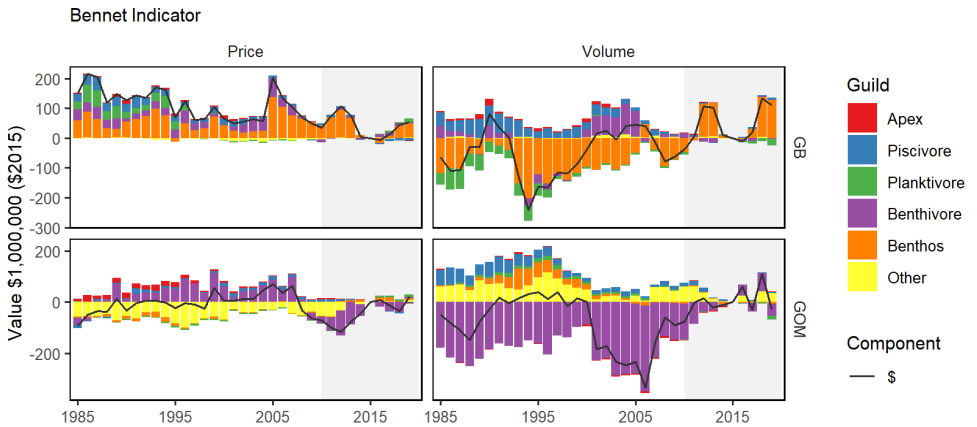
- GOM high revenue despite low volume
- Fluctuations in GB due to rotational management

Monitor changes in climate and landings drivers:

- Sea scallops and lobsters are sensitive to ocean warming and acidification

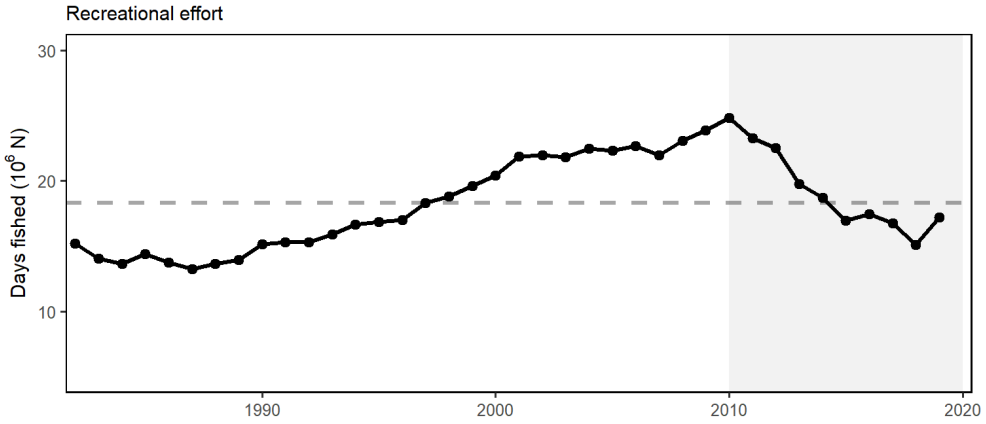
Indicator: Bennet--price and volume indices

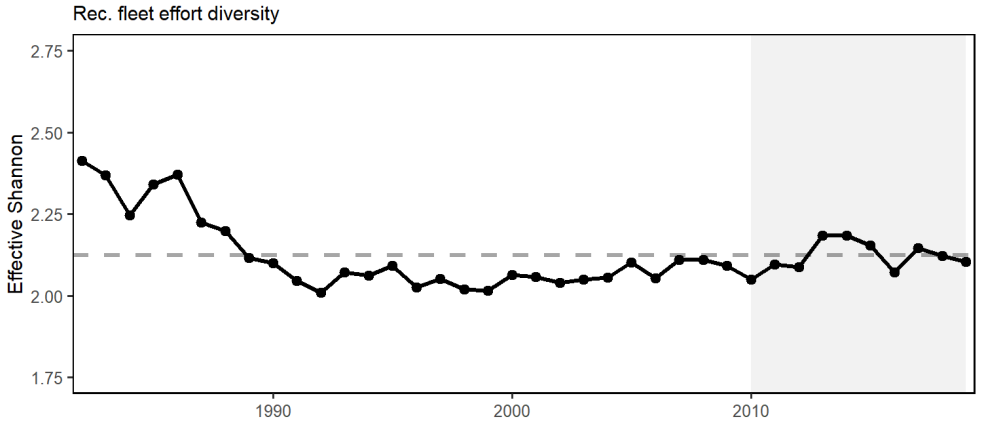




Objective: Recreational opportunities

Indicators: Recreational effort and fleet diversity



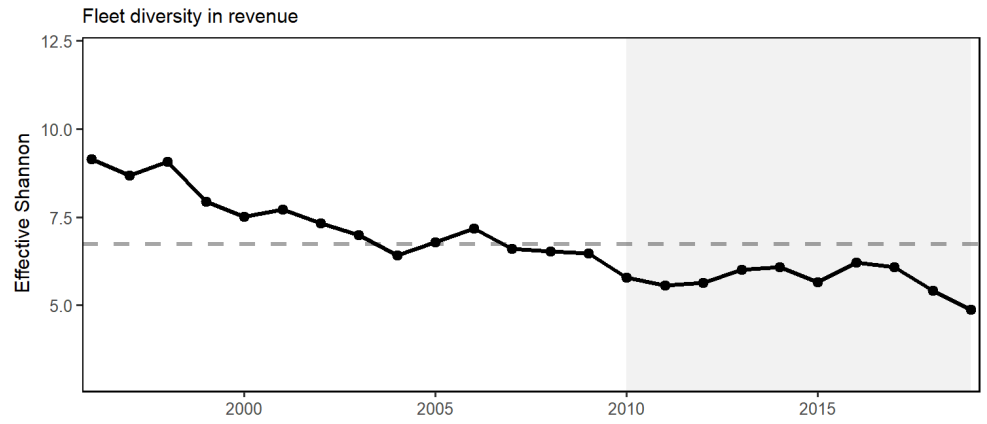


Implications

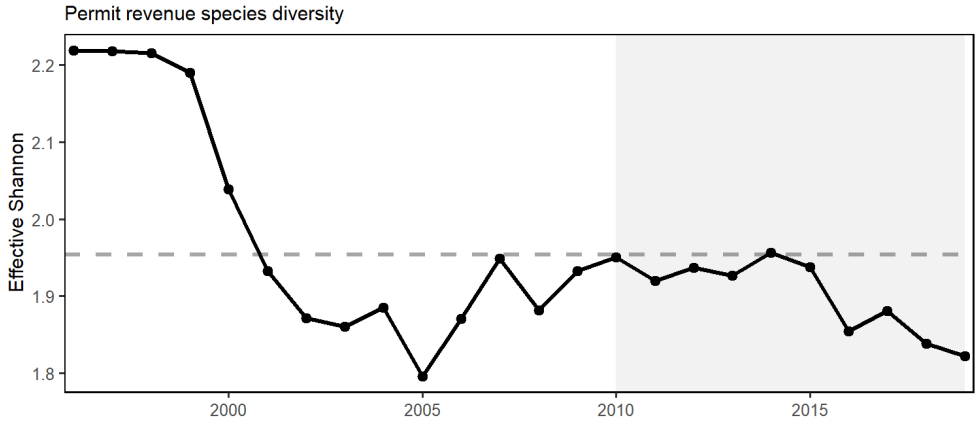
- Absence of a long-term trend in recreational effort suggests relative stability in the overall number of recreational opportunities in New England
- Cumulative weather index and management complexity drivers under construction

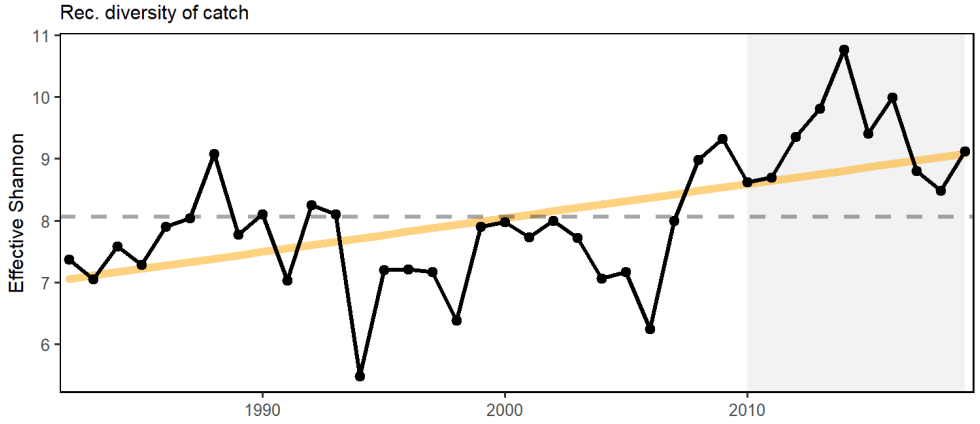
Objective: Stability ↘ Com −; Rec ●

Fishery Indicators: Commercial fleet count, fleet diversity



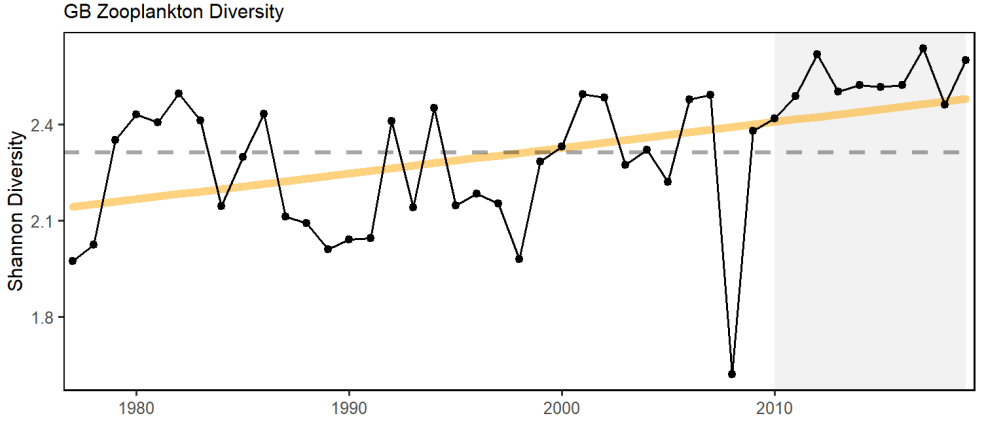
Fishery Indicators: commerical species revenue diversity, recreational species catch diversity

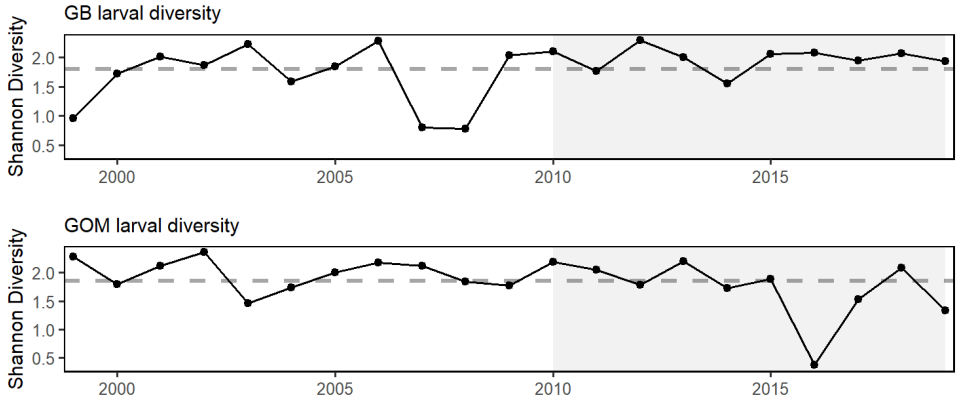




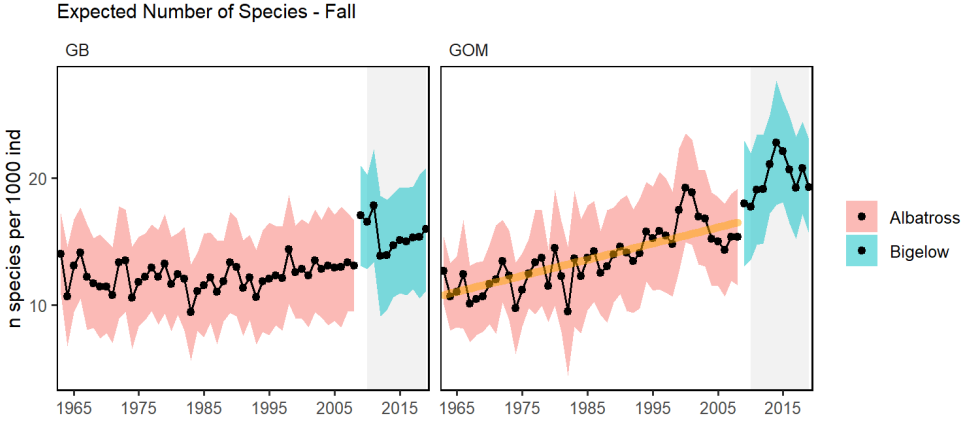
Objective: Stability

Ecological Indicators: zooplankton and larval fish diversity





Ecological Indicator: expected number of species, NEFSC bottom trawl survey

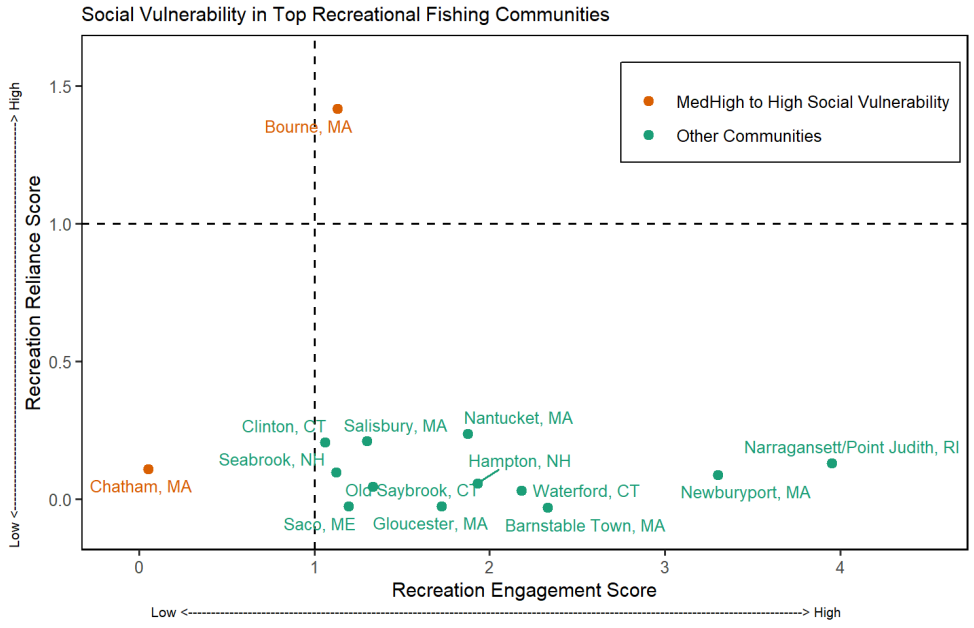


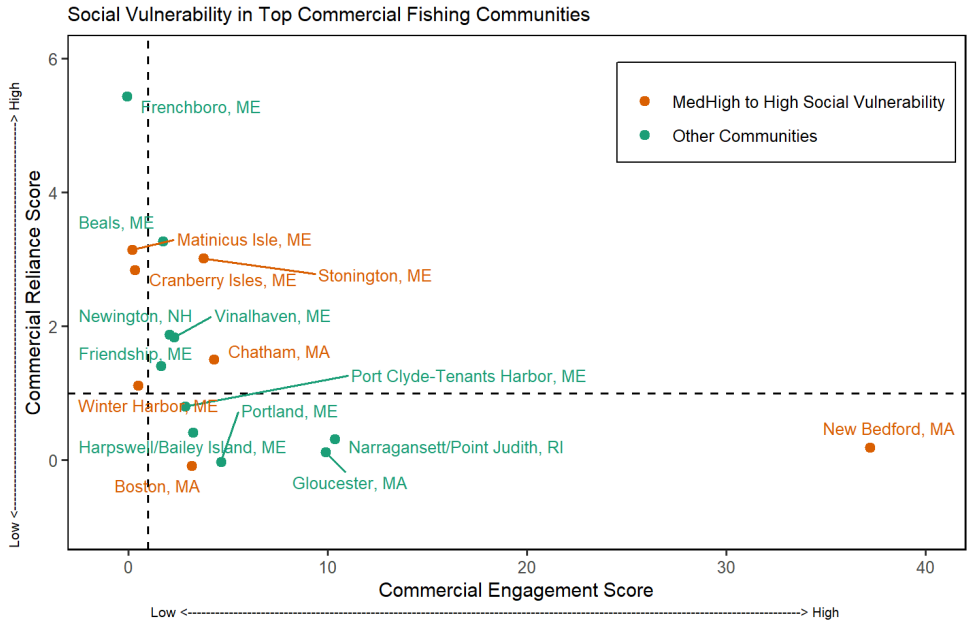
Implications:

- commercial fishery diversity driven by small number of species
- diminished capacity to respond to future fishing opportunities
- recreational diversity due to species distributions and regulations
- adult diversity in GOM suggests increase in warm-water species

Objective: Fishing community status

Indicators: Social vulnerability, fishery engagement and reliance





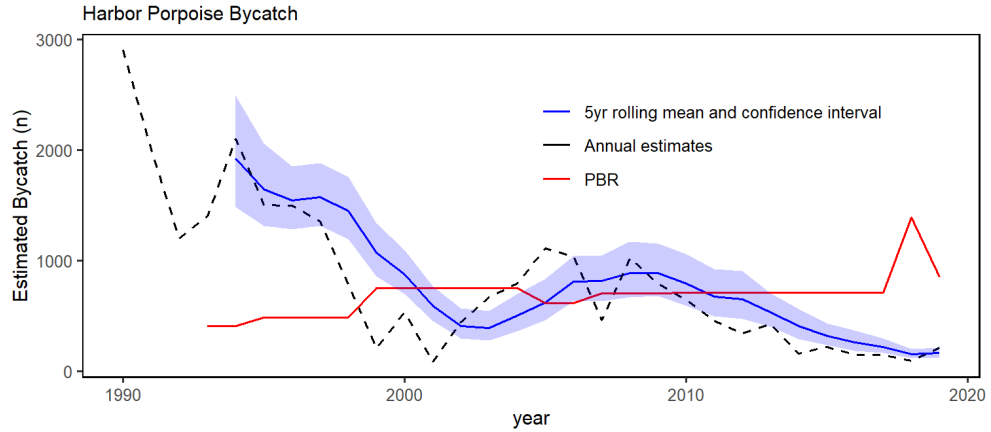
New England recreational fishing communities

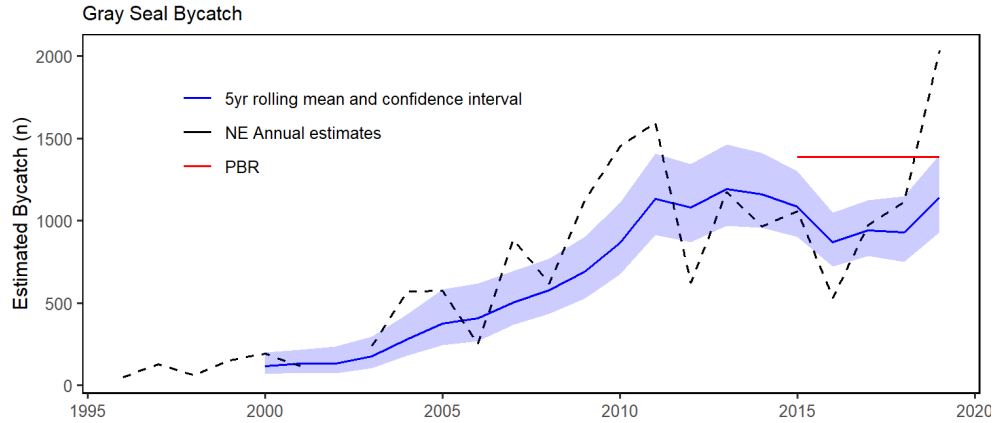
New England commercial fishing communities

Implications: Highlighted communities may be vulnerable to changes in fishing patterns due to regulations and/or climate change. When any of these communities are also experiencing social vulnerability, they may have lower ability to successfully respond to change. These indicators may also point to communities that are vulnerable to environmental justice issues.

Objectives: Protected species *Maintain bycatch below thresholds*

Indicators: Harbor porpoise and gray seal bycatch



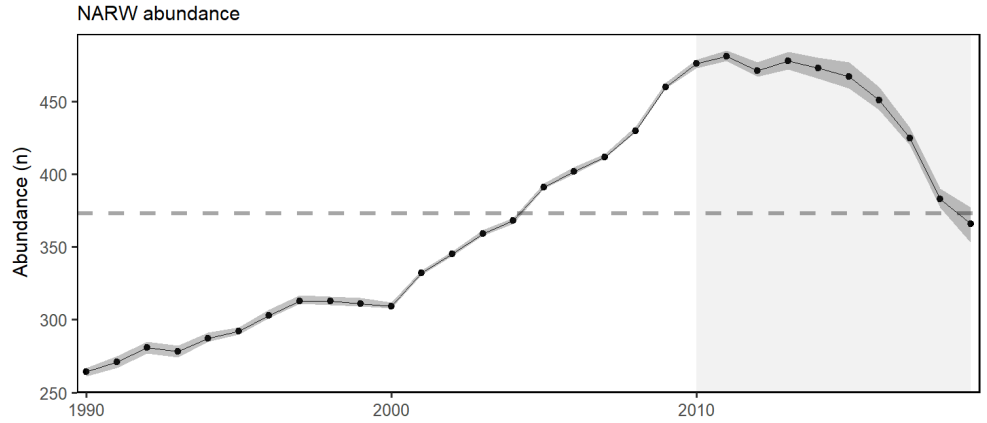


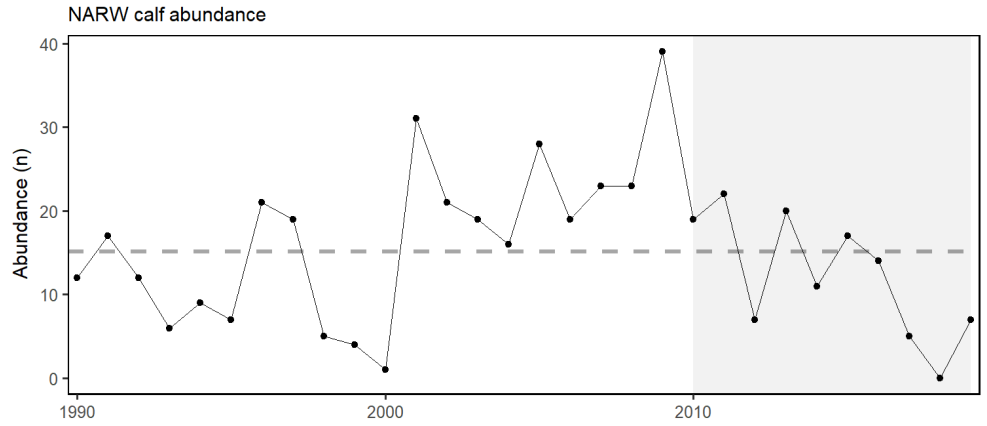
Implications:

- Currently meeting objectives
- The downward trend in harbor porpoise bycatch can also be due to a decrease in harbor porpoise abundance in US waters, reducing their overlap with fisheries, and a decrease in gillnet effort.
- The increasing trend in gray seal bycatch may be related to an increase in the gray seal population (U.S. pup counts).

Objectives: Protected species *Recover endangered populations*

Indicators: North Atlantic right whale population, calf counts

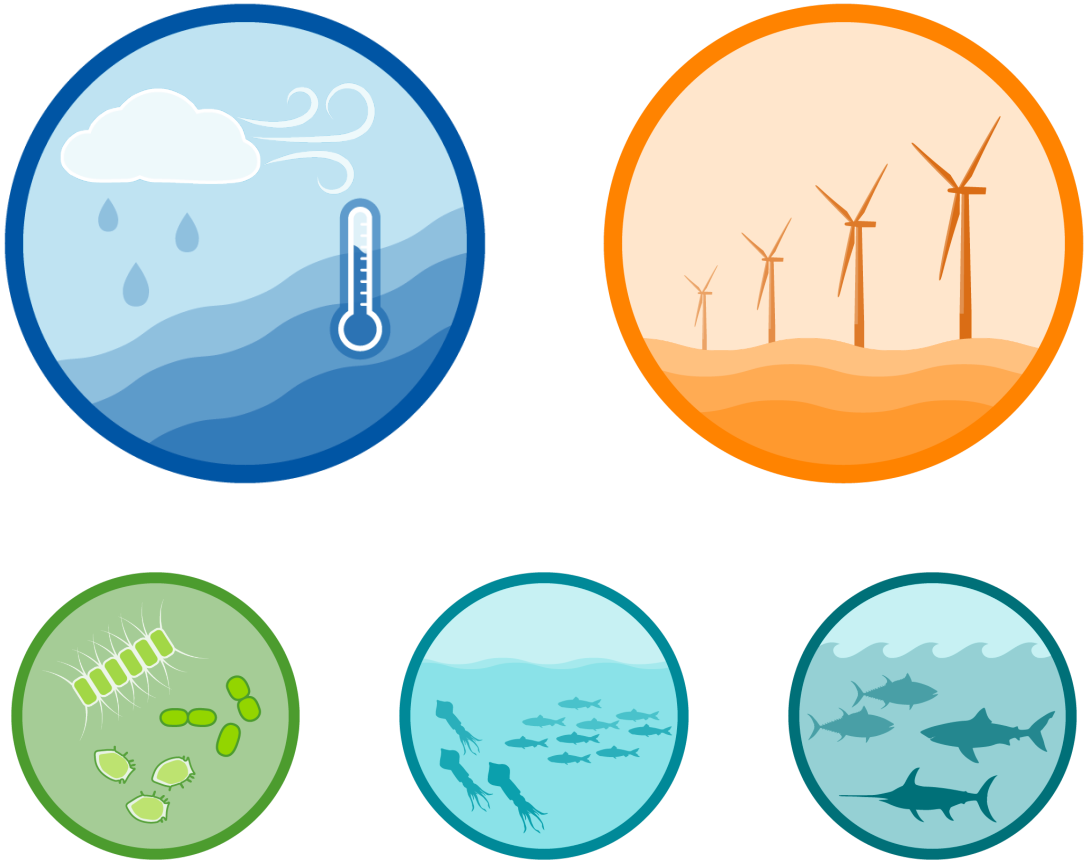




Implications:

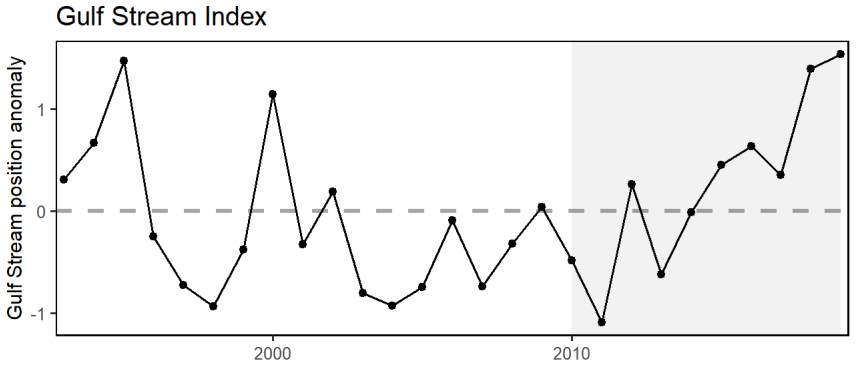
- Population drivers for North Atlantic Right Whales (NARW) include combined fishery interactions/ship strikes, distribution shifts, and copepod availability.
- Unusual mortality events continue for 3 large whale species, harbor and gray seals.

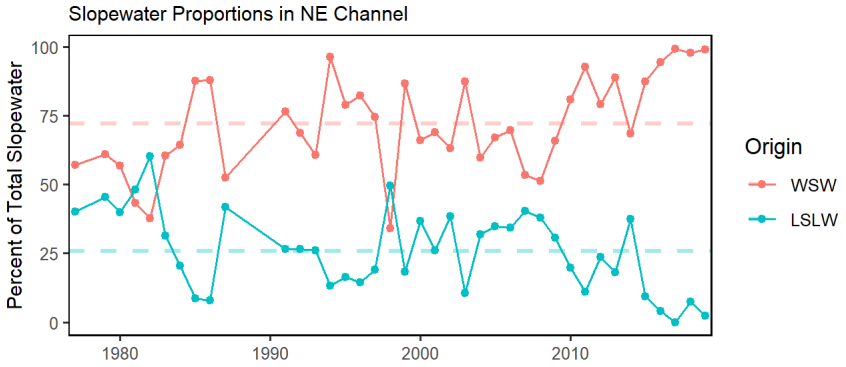
Risks to meeting fishery management objectives



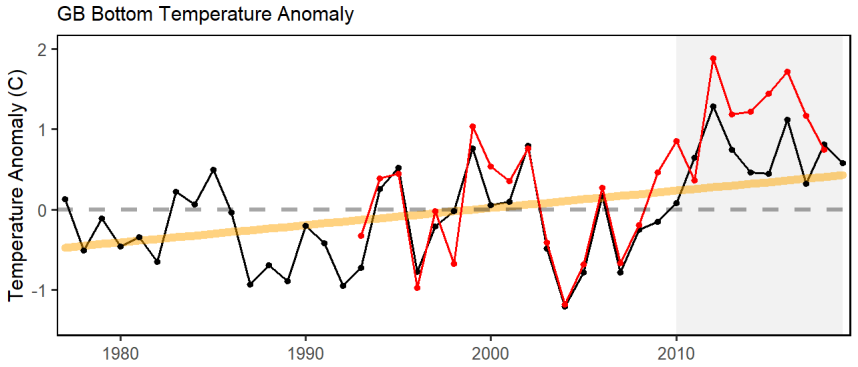
Risks: Climate change

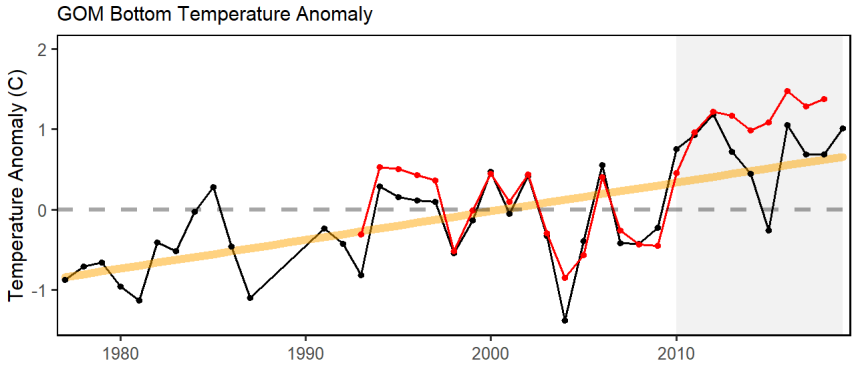
Indicators: ocean currents





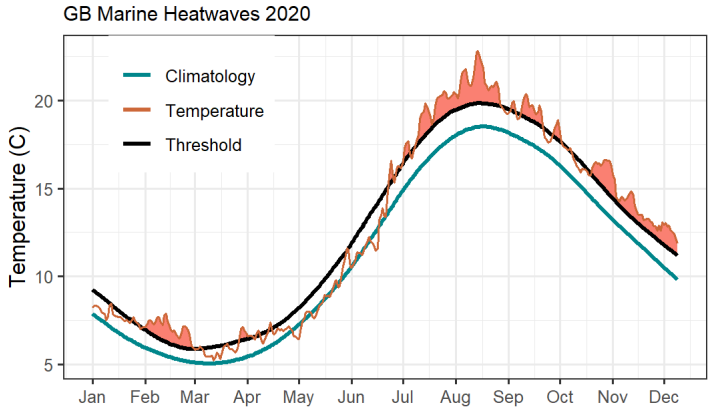
Indicators: bottom temperatures

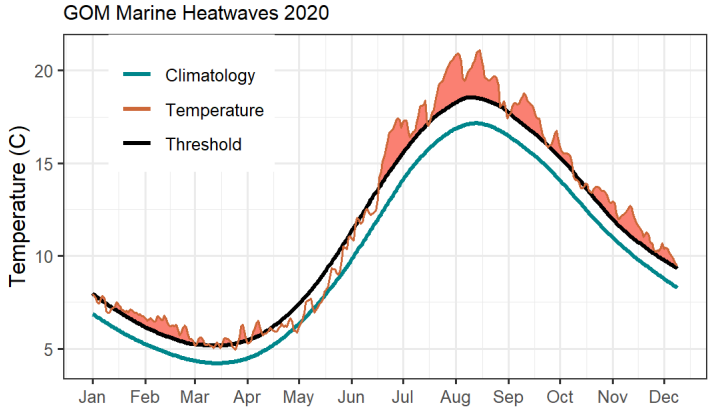


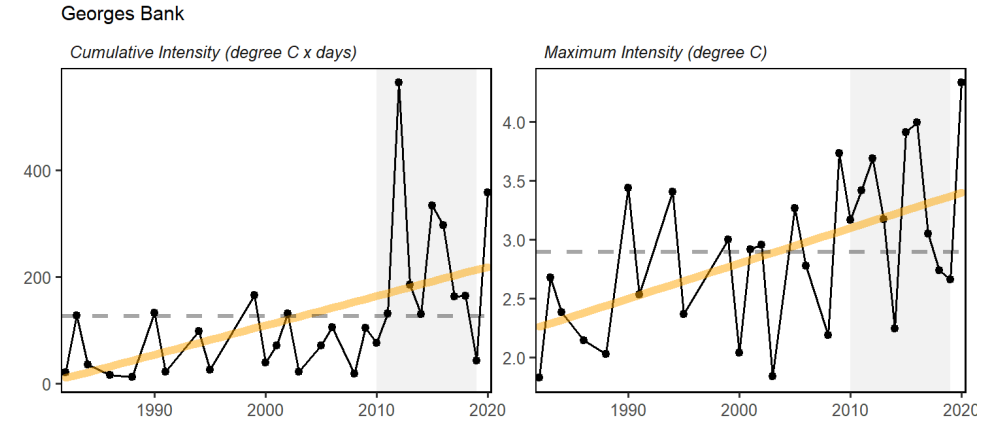


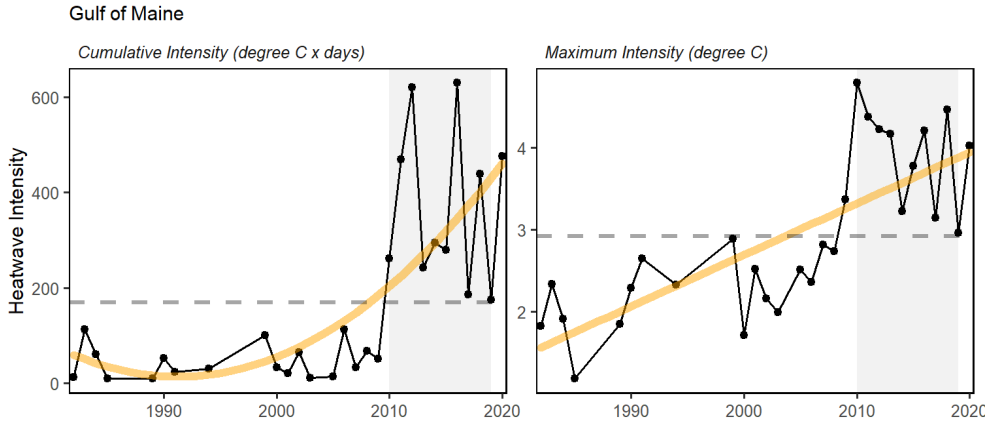
Risks: Climate change

Indicators: marine heatwaves



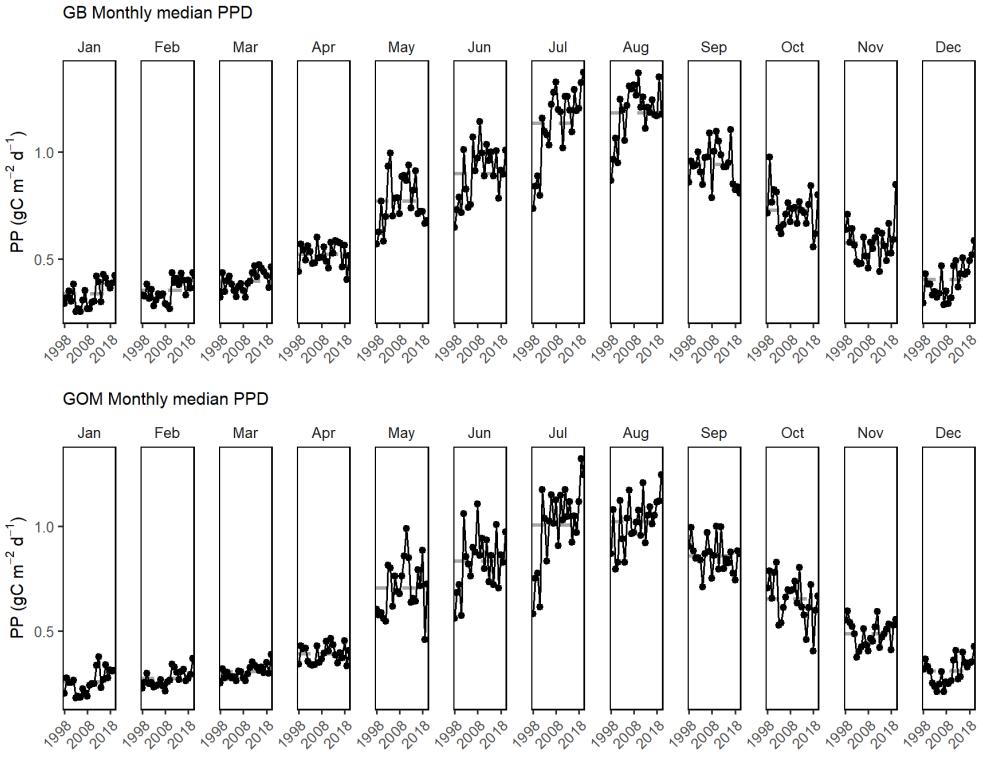


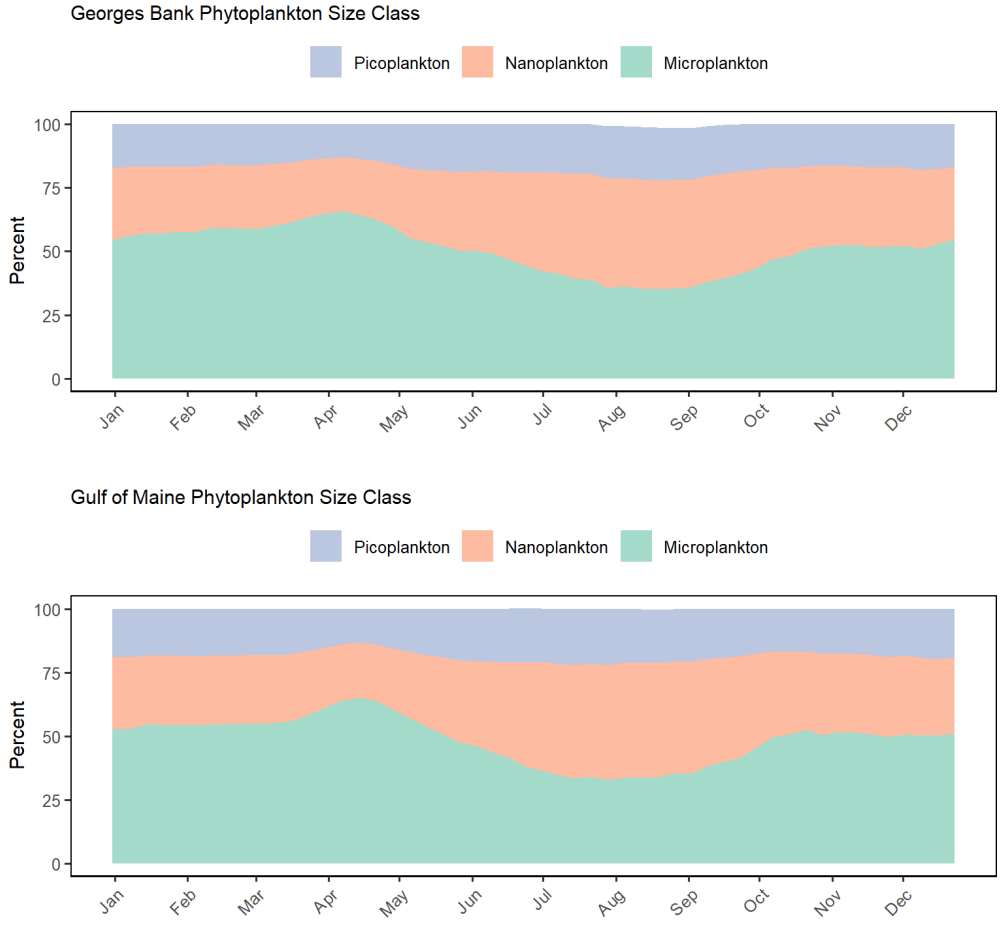




Risks: Ecosystem productivity

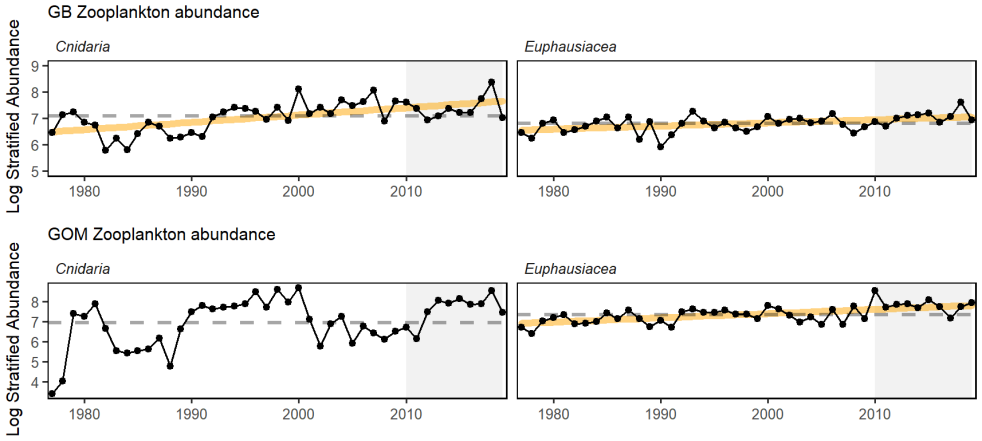
Indicators: primary production

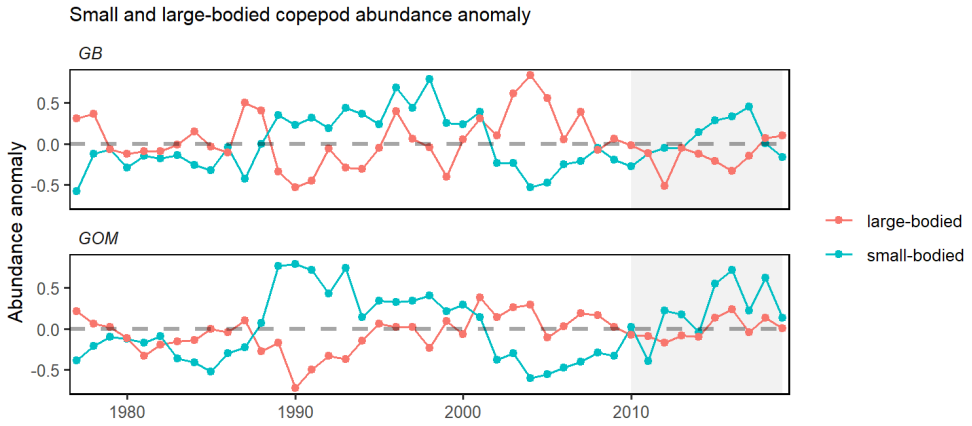


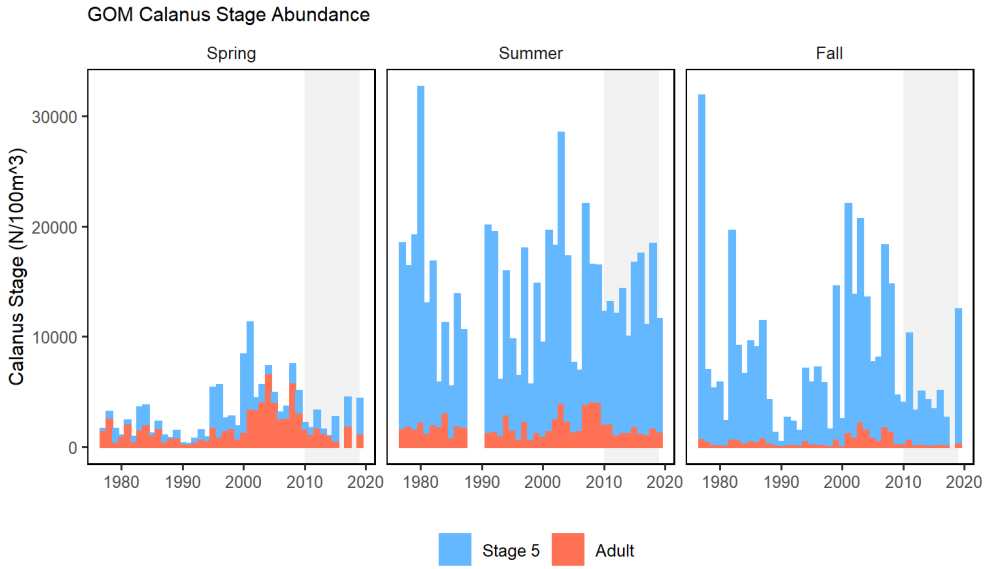


Risks: Ecosystem productivity

Indicators: zooplankton



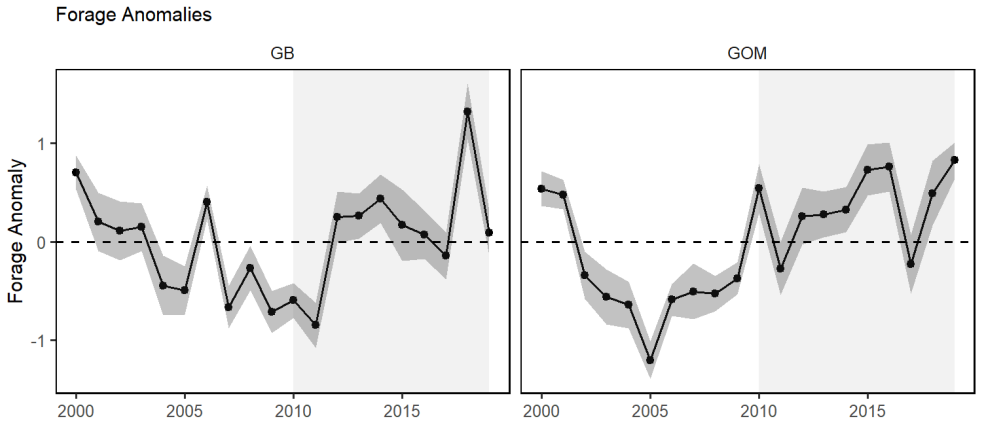


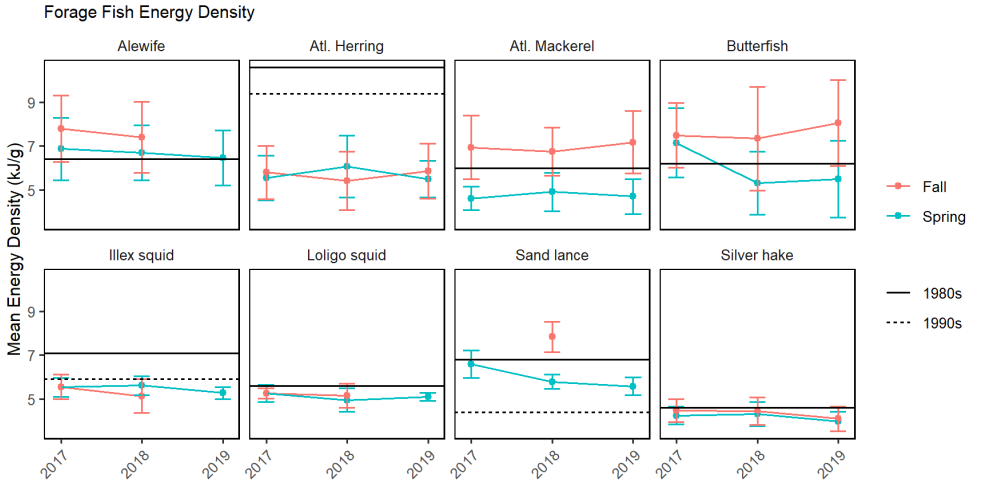


Implications: increased production by smaller phytoplankton implies less efficient transfer of primary production to higher trophic levels. Monitor implications of increasing gelatinous zooplankton and krill.

Risks: Ecosystem productivity

Indicators: plankton-based forage anomaly and forage fish energy content

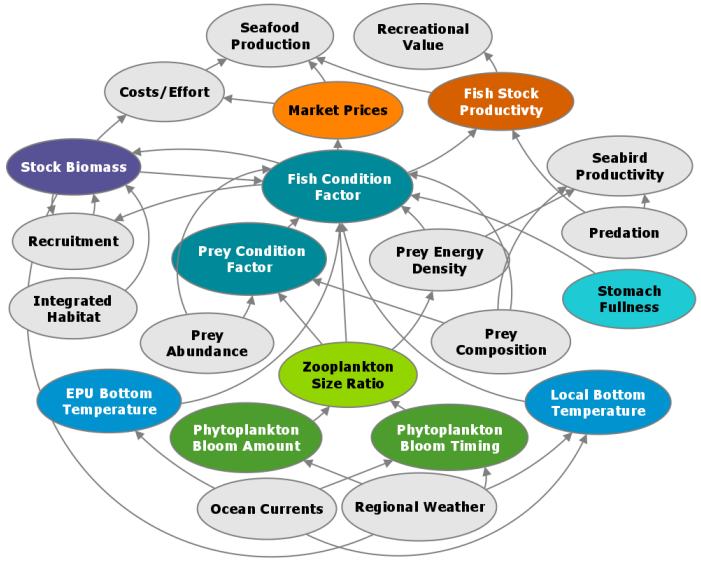




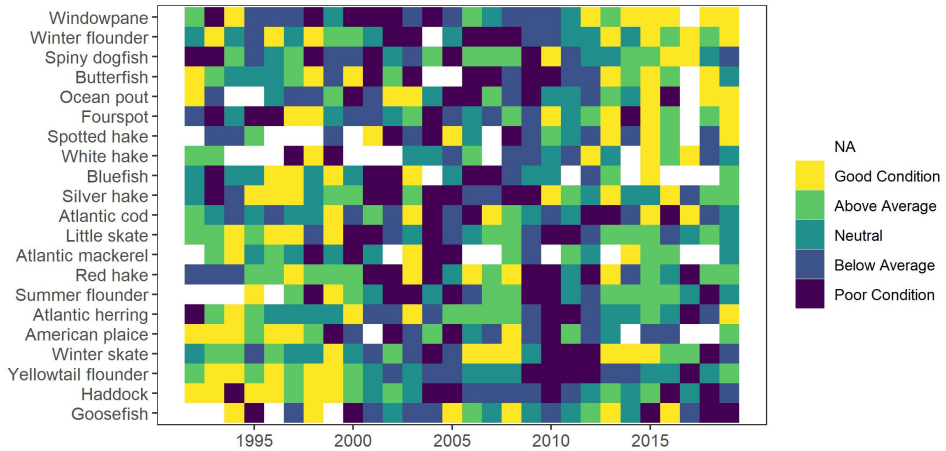
Implications: fluctuating environmental conditions and prey for forage species affect both abundance and energy content. Energy content varies by season, and has changed over time most dramatically for Atlantic herring

Risks: Ecosystem productivity

Indicators: fish condition



Georges Bank

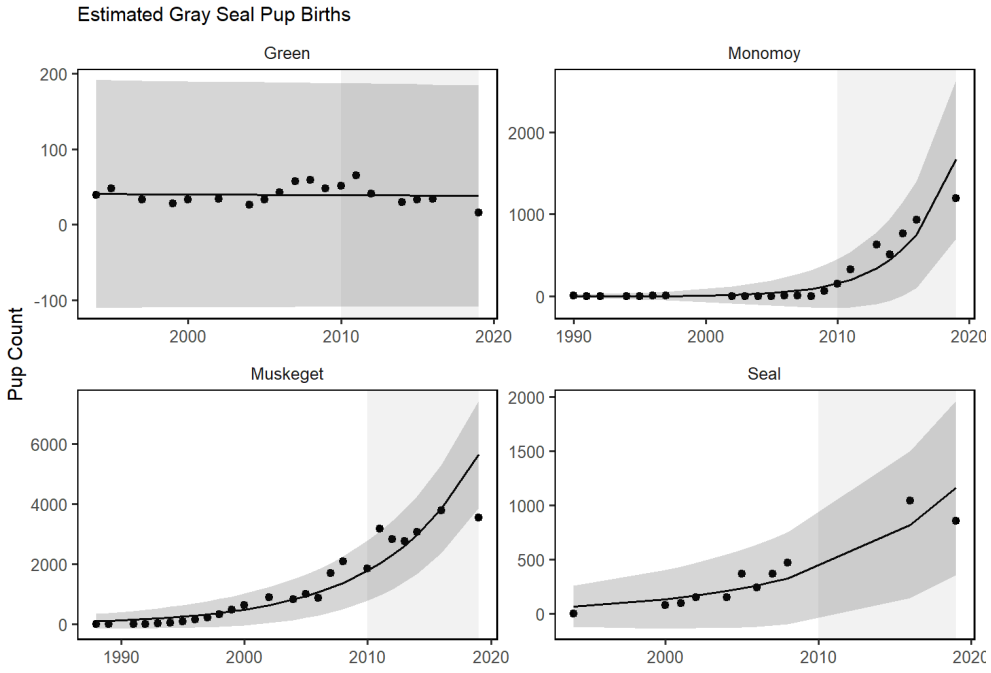


Preliminary results:

- Multiple, different condition drivers by species
- Acadian redfish, butterfish and winter flounder more affected by fishing pressure and stock size
- Weakfish, windowpane flounder, and American plaice more affected by local bottom temperatures and zooplankton

Risks: Ecosystem structure

Indicators: distribution shifts (slide 13), diversity (slide 17), predators



Gray seals increasing

- Breeding season ~ 27,000 US gray seals, Canada's population ~ 425,000 (2016)
- Canada's population increasing at ~ 4% per year
- U.S. pupping sites increased from 1 (1988) to 9 (2019)
- Harbor and gray seals are generalist predators that consume more than 30 different prey species: red, white and silver hake, sand lance, yellowtail flounder, four-spotted flounder, Gulf-stream flounder, haddock, herring, redfish, and squids.

Implications: stable predator populations suggest stable predation pressure on managed species, but increasing predator populations may reflect increasing predation pressure.

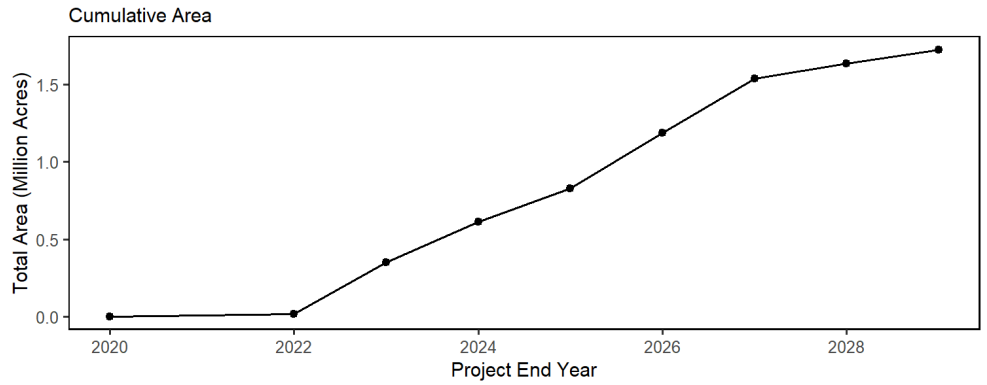
Risks: Habitat climate vulnerability

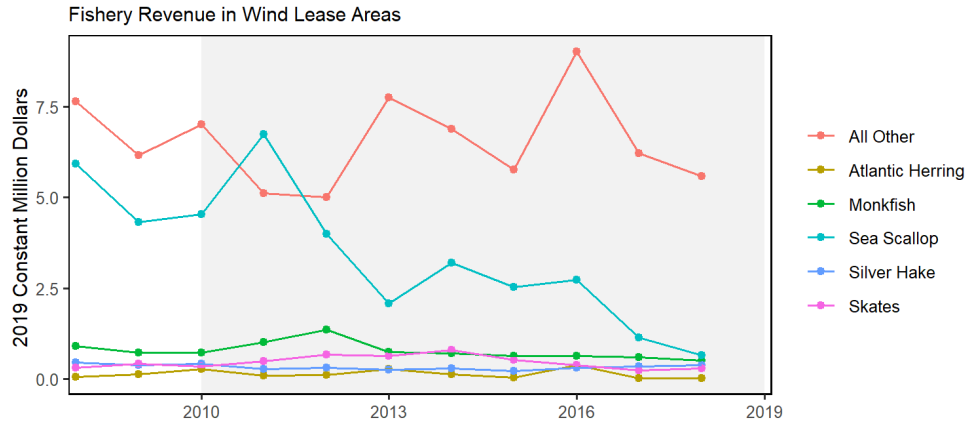
Indicators: climate sensitive species life stages mapped to climate vulnerable habitats

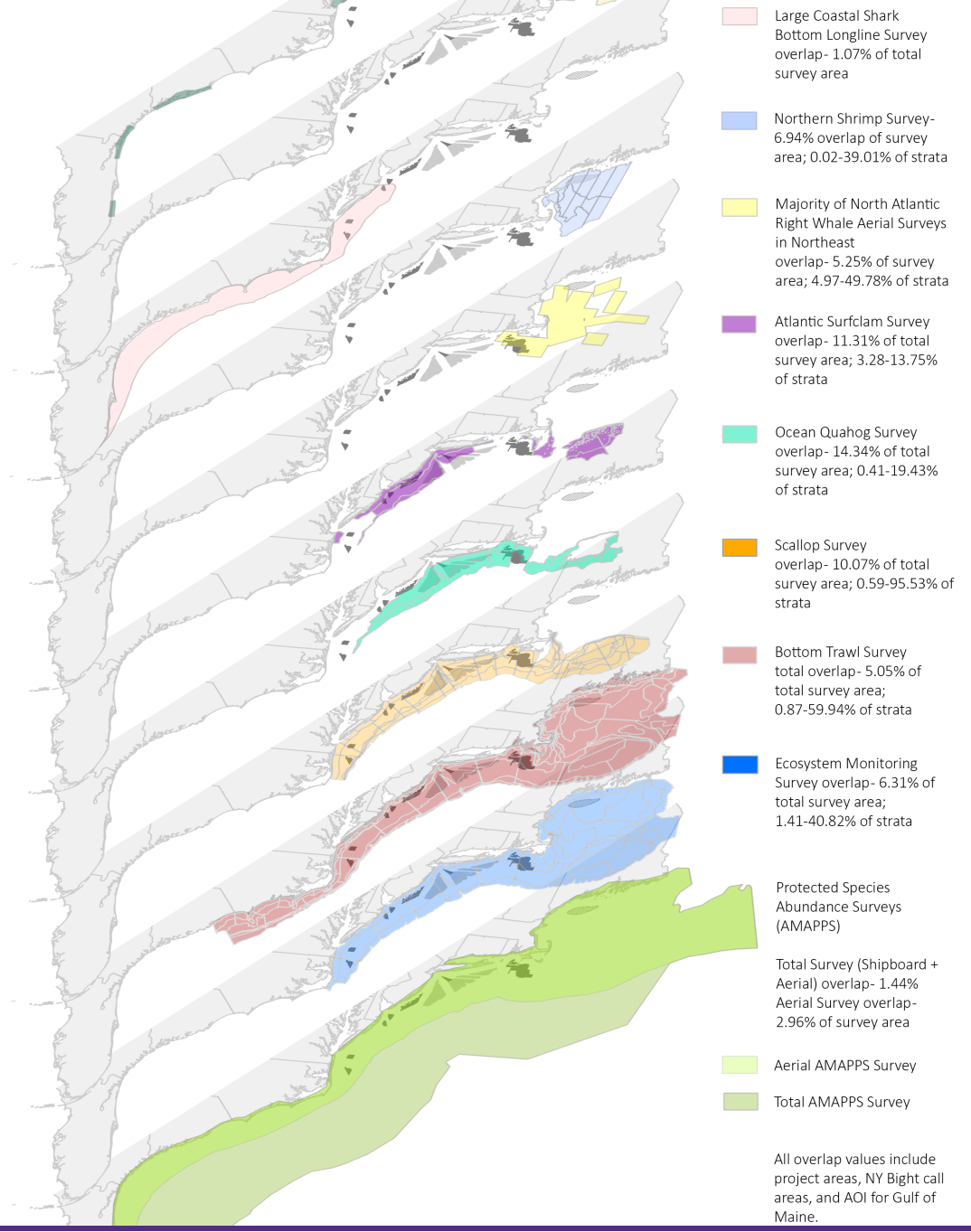
Species	Stage	New England native salt marsh	Marine/estuarine intertidal shellfish reef	Marine/estuarine submerged aquatic vegetation	Marine kelp	Marine intertidal rocky bottom	Marine intertidal sand	Marine intertidal mud
Alewife	Eggs/Larva							
Alewife	Juvenile/YOY							
Alewife	Adult							
Alewife	Spawning Adult							
Atlantic cod	Eggs/Larva							
Atlantic cod	Juvenile/YOY			High		High	High	
Atlantic cod	Adult			High			High	
Atlantic cod	Spawning Adult			High			High	
Black sea bass	Eggs/Larva							

Risks: Offshore Wind Development

Indicators: development timeline, revenue in lease areas, survey overlap (full map)



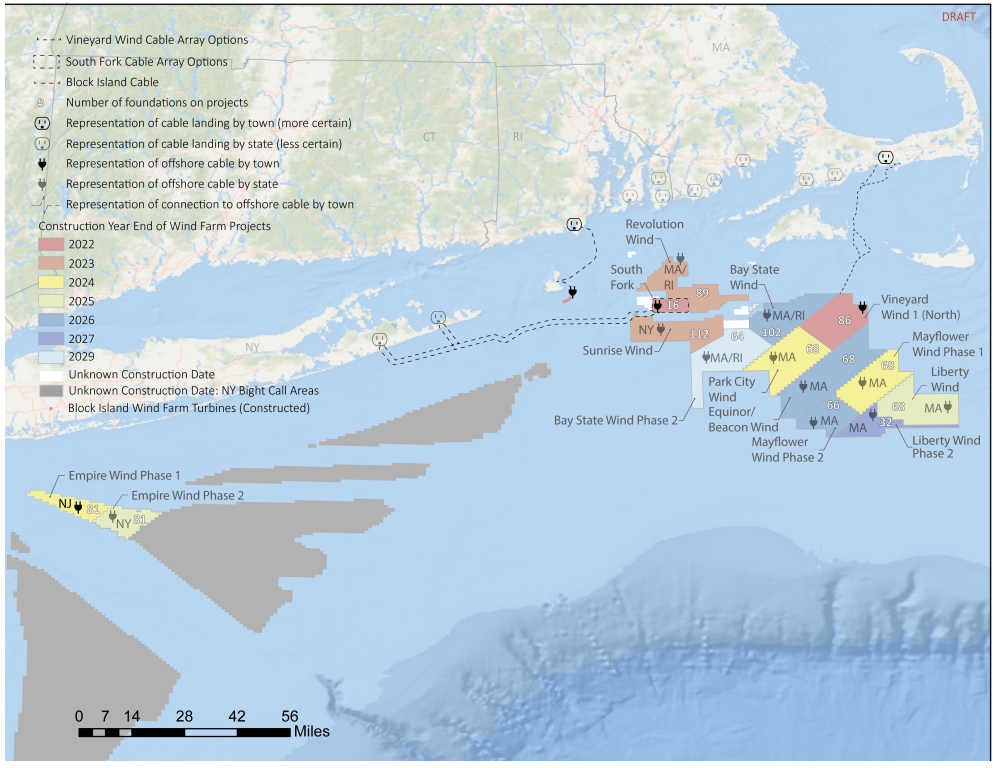




Risks: Offshore Wind Development

Implications:

- Current plans for rapid buildout of offshore wind in a patchwork of areas spreads the impacts differentially throughout the region
- 1-12% of total average revenue for major New England commerical species in lease areas could be displaced if all sites are developed. Displaced fishing effort can alter fishing methods, which can in turn change habitat, species (managed and protected), and fleet interactions.
- Right whales may be displaced, and altered local oceanography could affect distribution of their zooplankton prey.
- Scientific data collection surveys for ocean and ecosystem conditions, fish, and protected species will be altered, potentially increasing uncertainty for management decision making.



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IEA
INTEGRATED ECOSYSTEM ASSESSMENT

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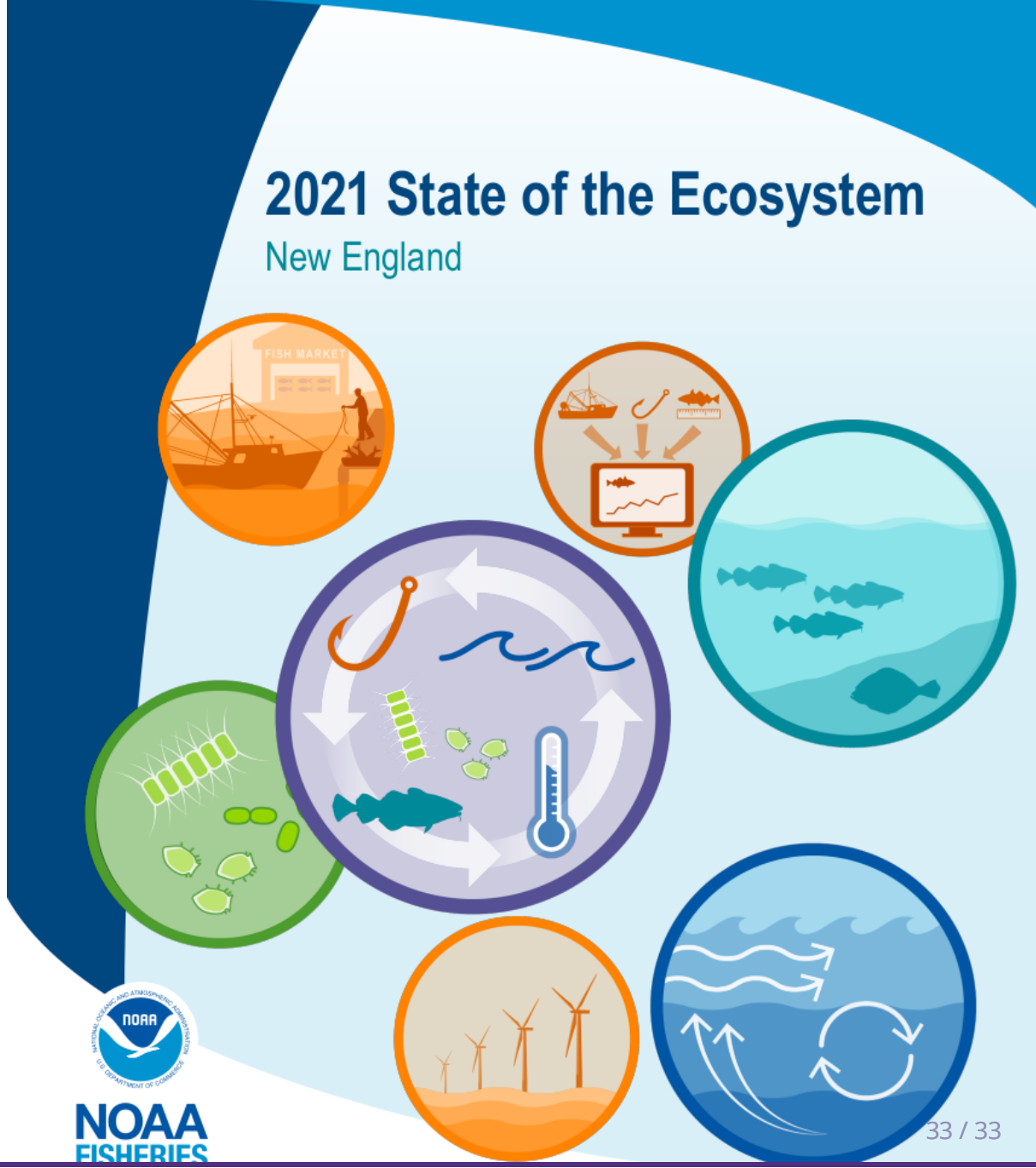
Additional resources

- ecodata R package
- Visualizations:
  - New England Human Dimensions indicators
  - New England Macrofauna indicators
  - New England Lower trophic level indicators
- SOE Technical Documentation
- Draft indicator catalog

- Slides available at https://noaa-edab.github.io/presentations
- Contact: Sean.Lucey@noaa.gov

Discussion

Thank you!



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