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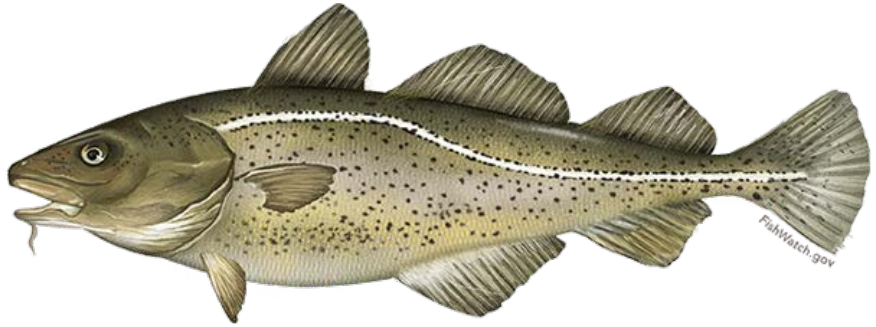
# Overview of Atlantic Cod Research Track Stock Assessment Process

Lisa Kerr (Chair-Cod RTWG)

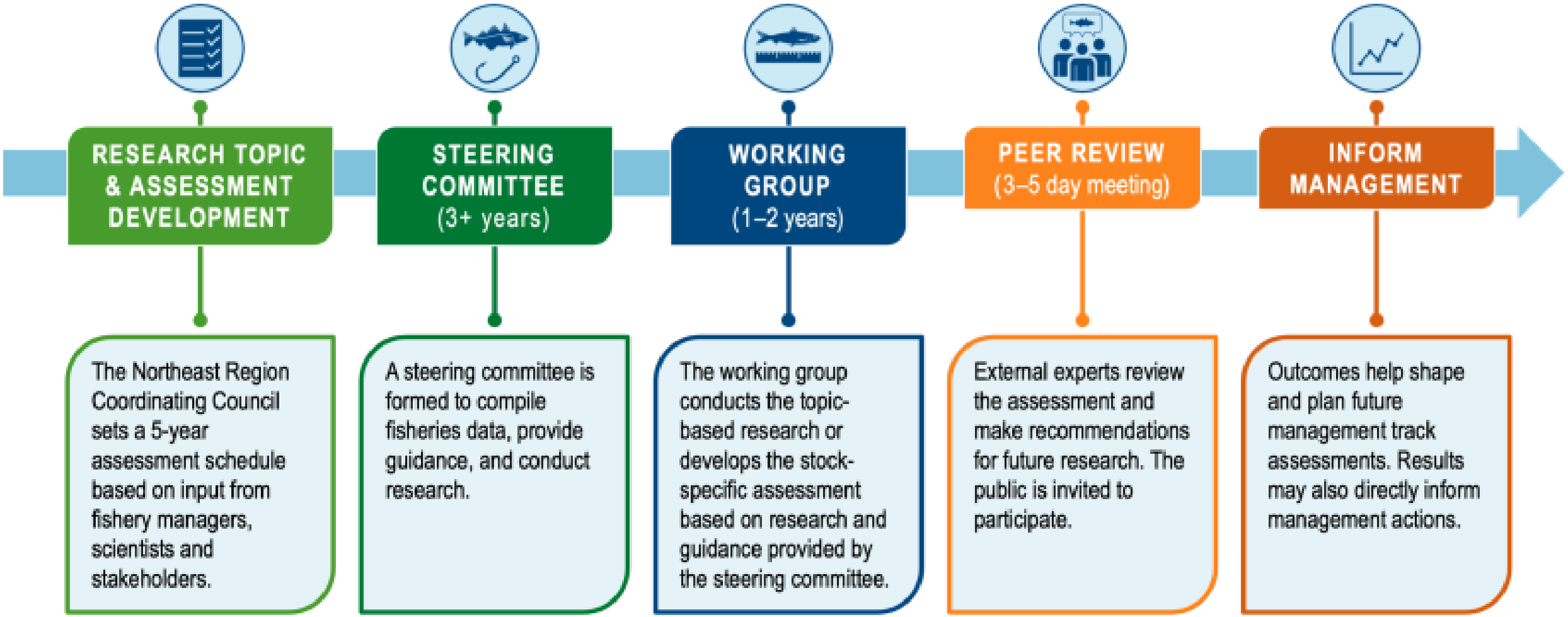
NEFMC Council Meeting

June 29, 2022



NOAA FISHERIES

# RESEARCH TRACK STOCK ASSESSMENTS



# Working Group Members

Lisa Kerr
(GMRI, Chair)

Charles Perretti
(NEFSC, GOM cod lead analyst)

Katherine Sosebee
(NEFSC, GB cod lead analyst)

Scott Large
(NEFSC)

Jamie Cournane
(NEFMC)

Kathy Cooper-MacDonald (DFO)

Steve Cadrin
(SMAST)

Alex Hansell
(NEFSC)

Rich McBride
(NEFSC)

Irene Andrushchenko
(Canada DFO)

Micah Dean
(MDMF)

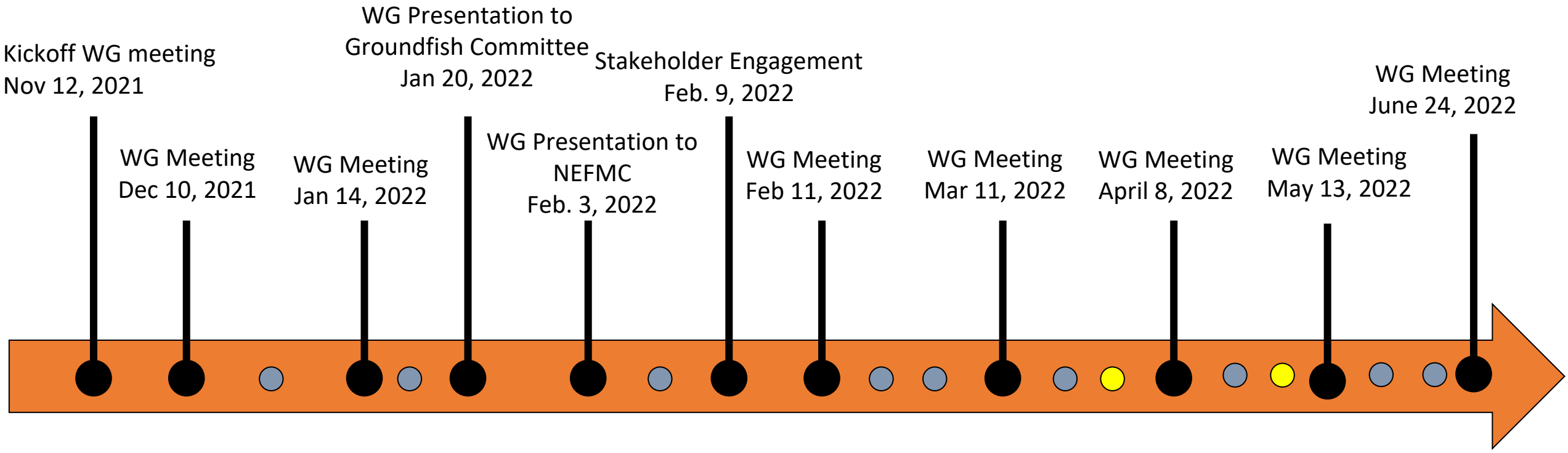
+ many more participants

# Working Group Participants

- Survey leads
- Graduate students and postdocs
- Industry representatives
- NGO representatives

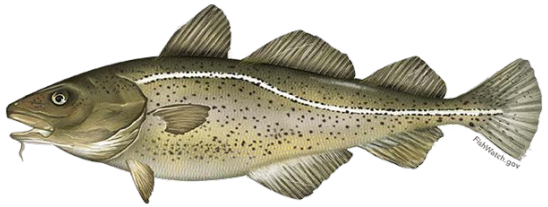
+ many more participants

# Atlantic Cod Research Track Timeline




**Upcoming WG Meetings**

- ToR 1 Subgroup meeting June 29th
- Full WG meeting July 29th
- Full WG meeting August 12th



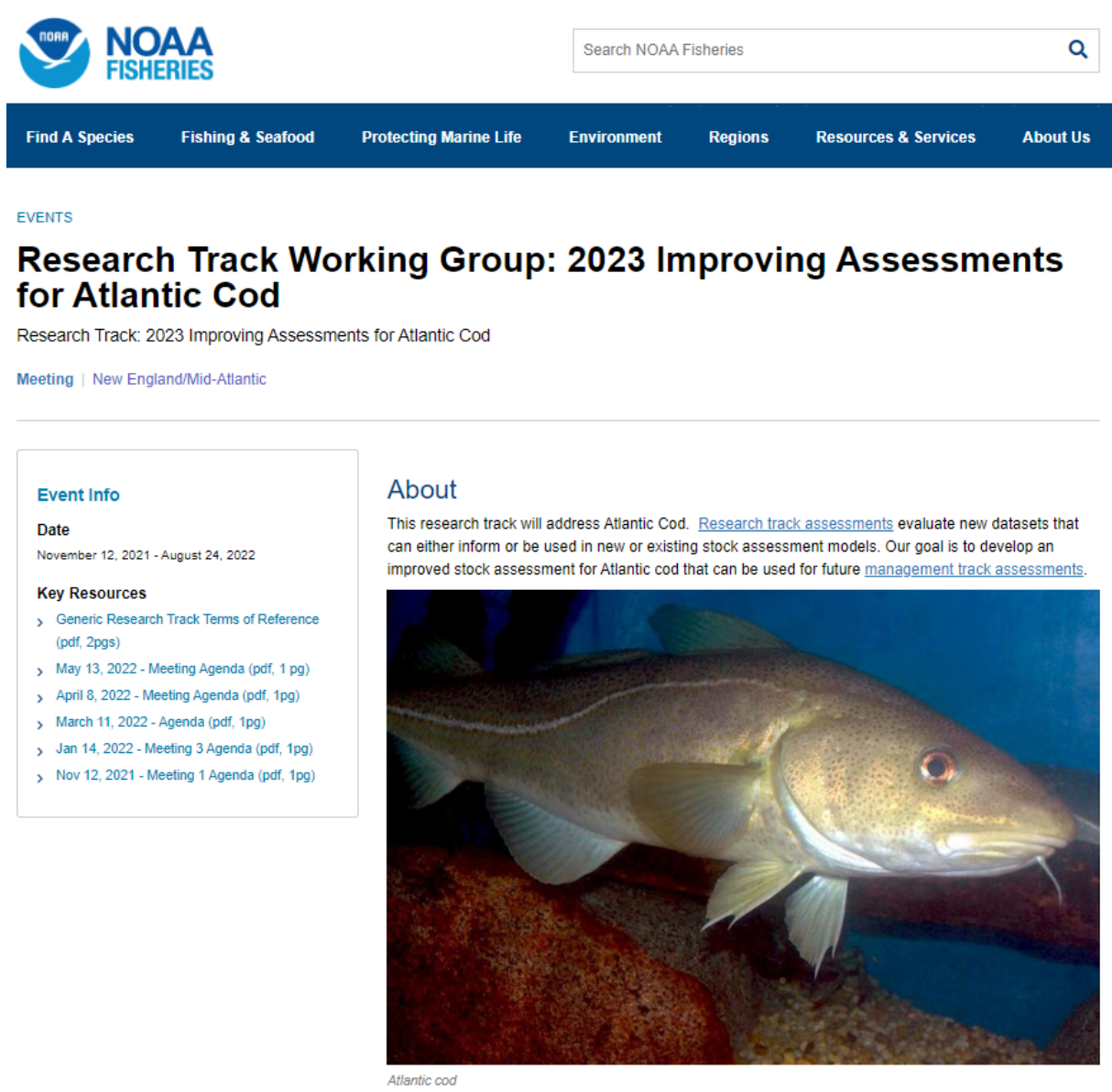
= ToR 1 subgroup meeting

= ToR 3 subgroup meeting

# How to Participate

Meetings are open and info is posted here: https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/research-track-stock-assessments

Feel free to reach out with questions: lkerr@gmri.org



# Summary of Progress on Terms of Reference

| | |
|---|---|
| Larger-scale issues and recommendations that influence how we approach other ToRs | **ToR 9. Consider new information on stock structure in defining the appropriate scale of stock assessment** |
| | **ToR 7. Review, evaluate, and report on the status of research recommendations…** |
| | **ToR 1. Identify relevant ecosystem and climate influences on the stock...** |
| | |
| Data work | **ToR 3. Present the survey data used in the assessment…** |
| | **ToR 2. Estimate catch from all sources including landings and discards** |
| | |
| Assessment work | ToR 4. Use appropriate assessment approach to estimate annual fishing mortality, recruitment and stock biomass… |
| | ToR 8. Develop a backup assessment approach… |
| | |
| Biological reference points and projections | ToR 5. Update or redefine status determination criteria… |
| | ToR 6. Define appropriate methods for producing projections… |

# ToR 9. Consider new information on stock structure in defining the appropriate scale of stock assessment

Science + Stakeholder Workshops

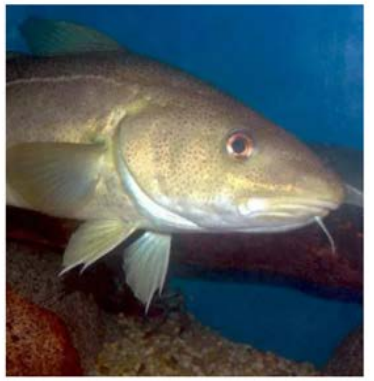
NOAA Technical Memorandum NMFS-NE-XXX

An Interdisciplinary Review of Atlantic Cod (*Gadus morhua*) Stock Structure in the Western North Atlantic Ocean

Richard S McBride[1] and R Kent Smedbol[2] (Editors)
[1]National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543
[2] Fisheries and Oceans Canada, Government of Canada

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts
Month Year

## 2021 Atlantic Cod Stock Structure Workshops

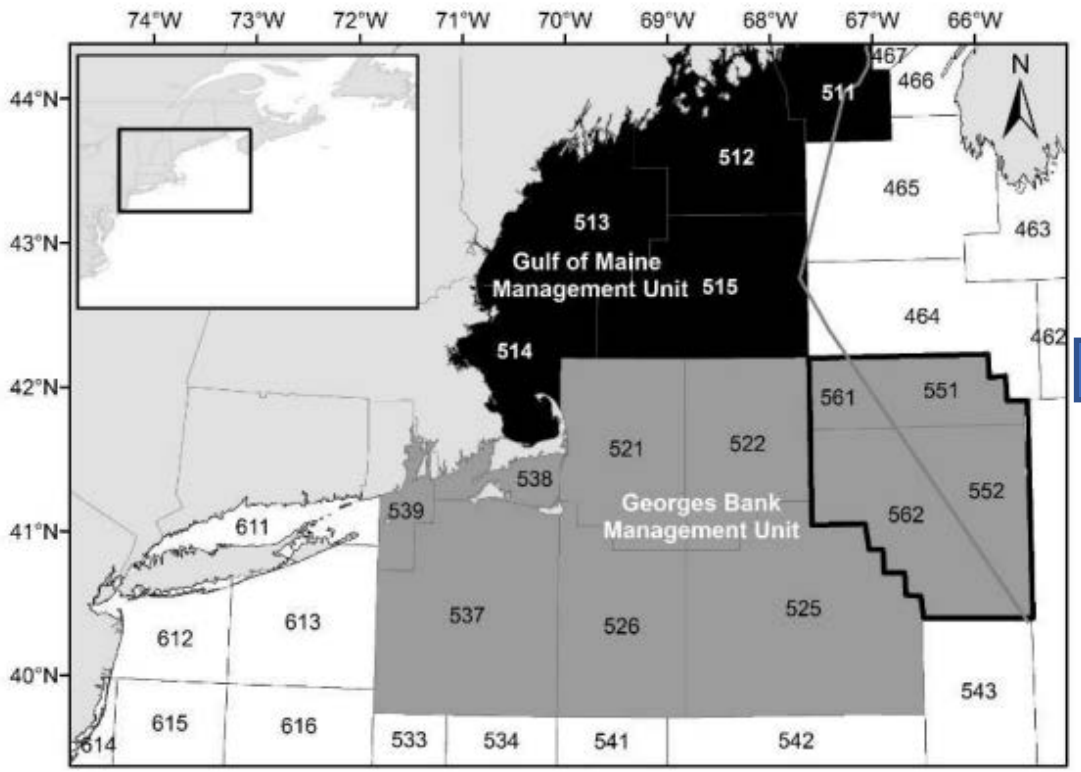


In 2020, a report by the Atlantic Cod Stock Structure Working Group (ACSSWG) concluded that the population structure of Atlantic Cod in New England waters consists of **five distinct biological stocks, instead of the two that are currently managed**. This conclusion requires a re-thinking of the current science and management approaches to the fishery. (Download a draft summary of the ACSSWG's peer-reviewed conclusions, here.)

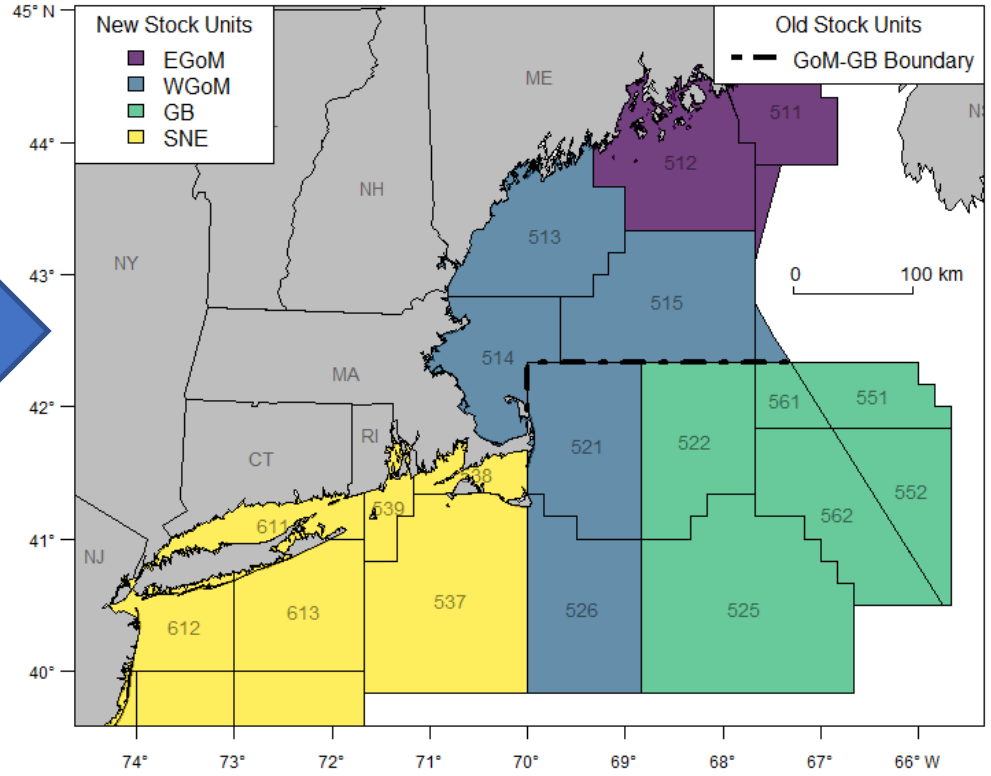
These 2021 Atlantic Cod Stock Structure Workshops, supported by the New England Fishery Management Council (NEFMC), NOAA's Northeast Fisheries Science Center (NEFSC), and NH Sea Grant, present a two-pronged approach developed to incorporate new stock definitions into existing science and management structures. Workshops will focus on **(a) Science/Assessment Prospects** and **(b) Management**. Each workshop will feature presentations by technical experts followed by discussions open to the public (outlined below) to ensure complete information is available to best inform the cod stock assessment process.

# ToR 9: Summary of Progress: WG Recommendations on Scale of Stock Assessment

2 Stock Units




4 Stock Units




Improved alignment between the scale of cod stock assessment and biological stock structure.

# ToR 7: Research Recommendations

ToR 7: Review, evaluate, and report on the status of research recommendations from the last assessment peer review, including recommendations provided by the prior assessment working group, peer review panel, and SSC.

**Documents Reviewed to Date:**

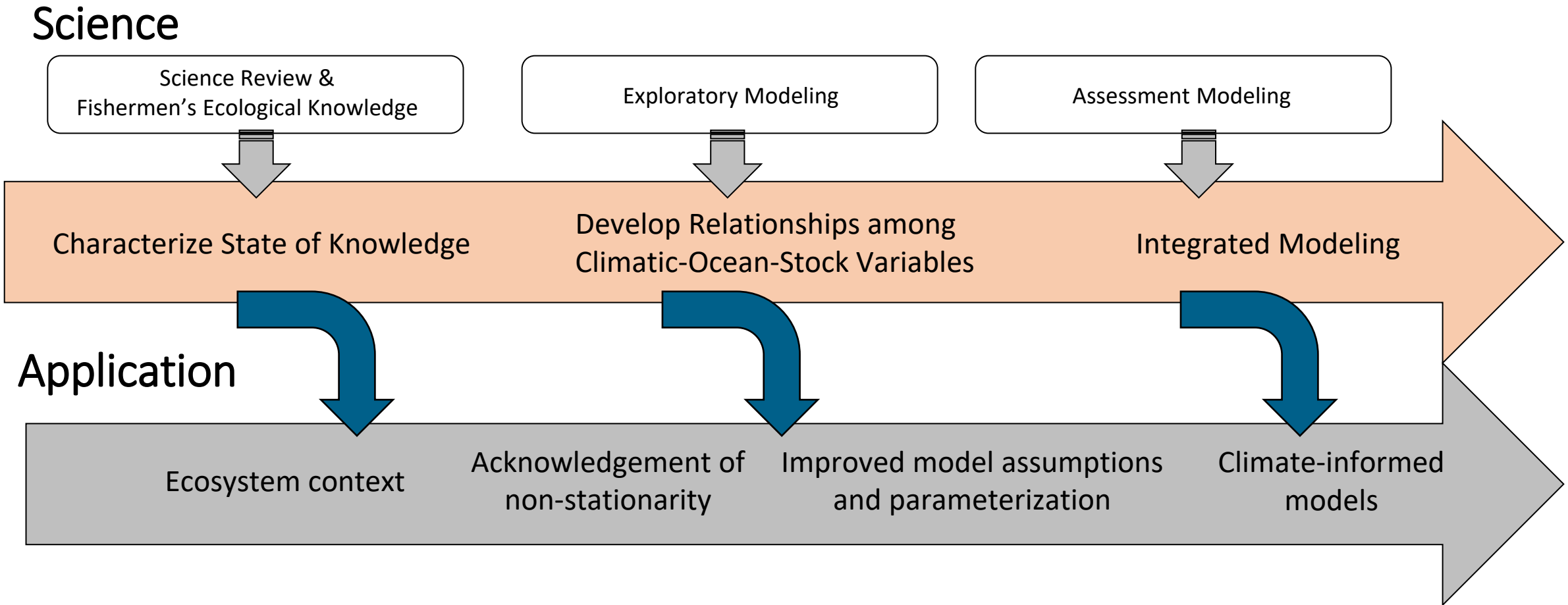
- 2021 Management Track Peer Review Panel Report
- NEFSC 2021 Management Track Assessment Reports
- SSC report 2021
- Summary of May 20, 2021 Assessment Oversight Panel Meeting

| Atlantic Cod Research Recommendations | | | | |
|---|---|---|---|---|
| **Stock** | **Research Recommendations** | **Relevant to ToR** | **Source** | **Response from WG** |
| Gulf of Maine Cod | **Survey Indices:** Use of the Longline survey, and other surveys, in the assessment | ToR 2 | 2021 Management Track Peer Review Panel Report | |
| Gulf of Maine Cod | **Assumptions of Assessment Model:** Defining fishery selectivity by individual fleets (e.g. recreational and commercial fleets) or allowing for an annual selectivity curve that accounts for the changing patterns as the catch composition shifts from commercial to recreational and recreational discards over time. | ToR 4 | 2021 Management Track Peer Review Panel Report | |
| Gulf of Maine Cod | **Catch Information:** Impact of underestimation of age-2 catch, particularly with regards to the recreational fishery or bycatch in lobster and other fisheries. | ToR 2 | 2021 Management Track Peer Review Panel Report | |
| Gulf of Maine Cod | **Assessment Model:** Consider whether it is appropriate to continue to both the M = 0.2 and M-ramp models (perhaps consider the potential for weighting the two-models like in an ensemble approach). | ToR 4 | 2021 Management Track Peer Review Panel Report | |
| Gulf of Maine Cod | **Biological Reference Points:** Consider ways to adjust BRPs to deal with changes in M from 0.2 (e.g., M-ramp) | ToR 5 | 2021 Management Track Peer Review Panel Report | |
| Gulf of Maine Cod | **Catch information:** Evaluate the lobster fishery bycatch of cod | ToR 2 | 2021 Management Track Peer Review Panel Report | |
| | **Projections:** Evaluate the appropriate recruitment time series, or | | 2021 Management Track Peer Review | |

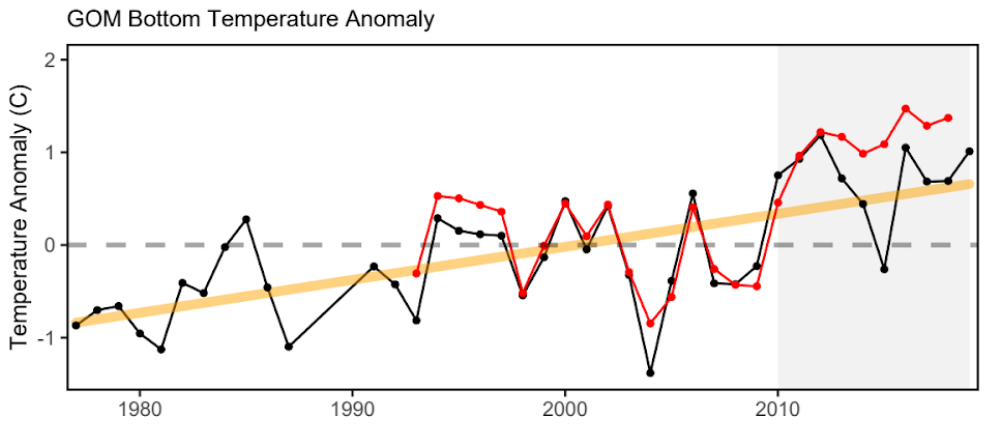
# ToR 1: Ecosystem and climate influences

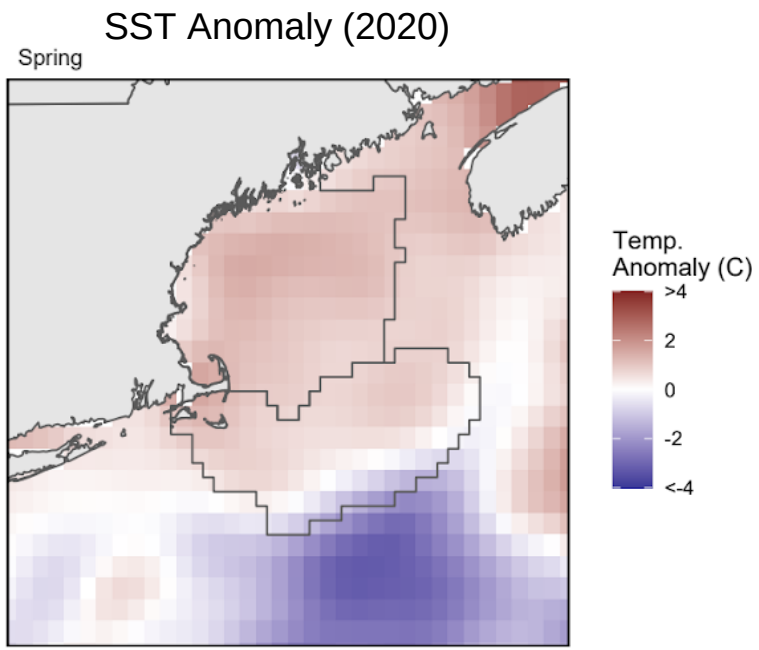
ToR 1: Identify relevant ecosystem and climate influences on the stock.

- Characterize the uncertainty in the relevant sources of data and their link to stock dynamics.
- Consider findings, as appropriate, in addressing other TORs.
- Report how the findings were considered under impacted TORs.



# Atlantic Cod Ecosystem and Climate Profile



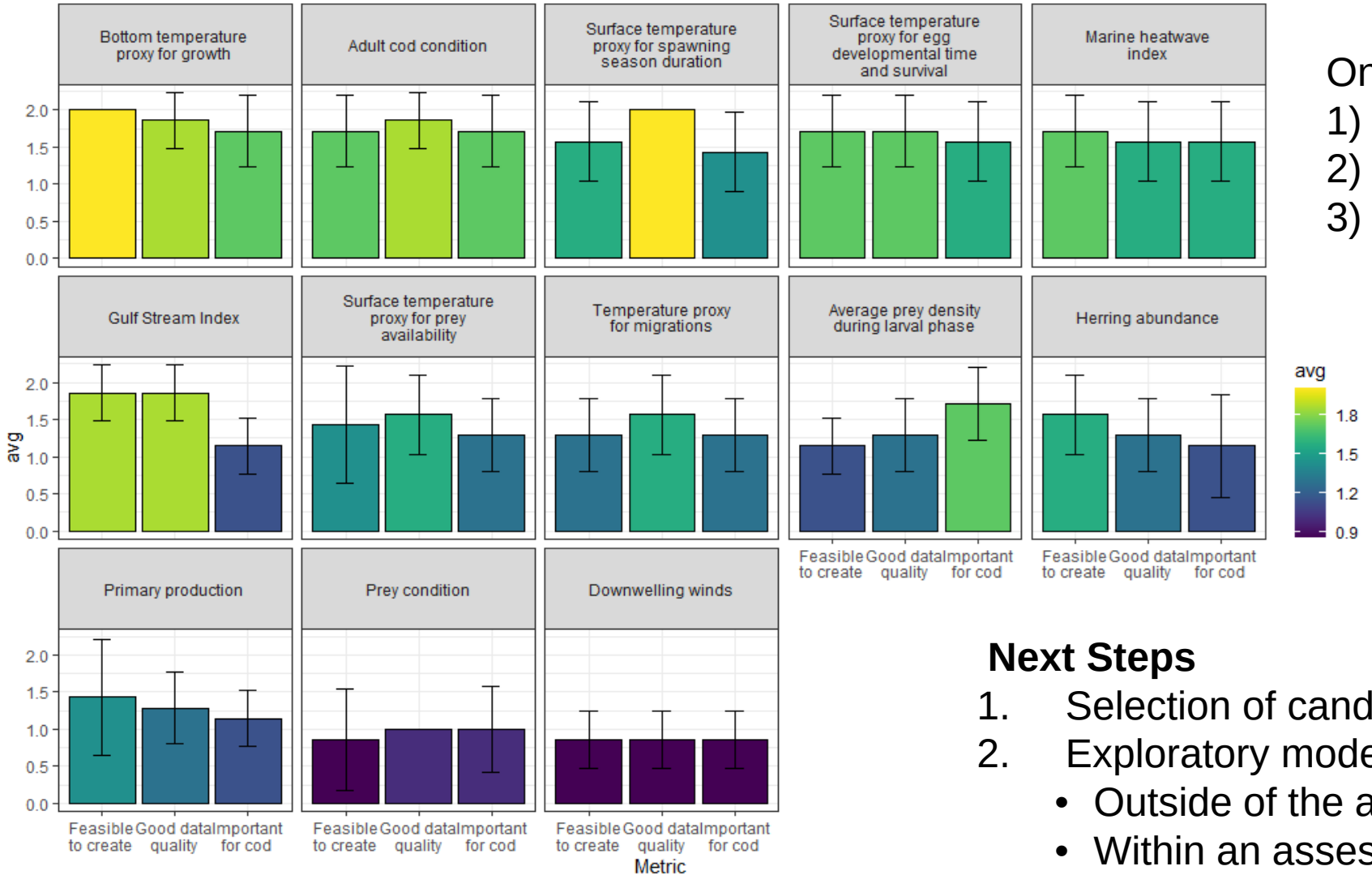

| Population Dynamic | Most frequent indicators from lit | Linkage to cod | Relevance to Management |
|---|---|---|---|
| Distribution and Habitat Use | Temperature | • Changes in Spawning location and time (bottom temp)<br>• Northward shift observed in GB and southward shift observed in GOM (AMO) | Could inform catchability as distributions change |
| | Depth | • Juveniles inhabit deeper waters<br>• Significant driver in other studies<br>• Overwinter in depths >150m | |
| | Bottom Type | • Associated with hard-bottom and coarse grain sediments, boulder reefs | |
| Recruitment | Temperature (bottom temp) | • Changes in spawning location and timing<br>• Correlation between colder waters and higher recruitment | Could help improve recruitment estimates |
| | Downwelling winds/ Gulf Stream Index | • Related to increased retention of larvae | |
| Growth and Maturity | Temperature | • Affects growth rates directly and indirectly (food availability)<br>  ○ Greatest growth rates observed between 10-15 C<br>• Age at maturity decreases with increasing temperatures (bottom temp) | Could improve maturity assumptions, impact on time-varying growth |
| Natural Mortality | Temperature | • Cold temperatures prolong time in developmental stages, increasing predation (SST)<br>• Eggs/larvae have a limit of 12 C (SST)<br>• Decreases in prey availability & increased metabolic costs under warmer temps leads to starvation (bottom temp)<br>• Warmer temps could lead to smaller sizes at maturity, which could increase susceptibility to predation (bottom temp) | Could help improve natural mortality estimates |
| | Predation | • Direct effect from seals & other fish | |

# Fishermen's Ecological Knowledge

February 9th, 2022
**Objective:** Solicit feedback from stakeholders to identify key ecosystem and climate influences on cod stock dynamics and impacts on fleet response to changing conditions.

| | |
|---|---|
| Surveys | • Survey - cod distribution location & timing mismatch |
| Environmental Changes | • Stronger tides in recent years<br>• Haddock population size influence on cod<br>• Changing temperature and stock biomass expected to impact code response to ecosystem stressors<br>• Slime in water where cod were found and decreased catch when slime was present<br>  ○ also associated with high salp abundance<br>• Increased worms in cod, haddock, gray sole & other species - linked to gray seals? |
| Temperature | • Association between temperature and biomass of cod<br>  ○ resulting effects such as effect on distribution shift (location & arrival/departure times)<br>• Cod don't emigrate from area unless winter is "very warm"<br>• Increases in temperature associated with changes in predator/prey composition |
| Predator/Prey | • Noticed increased gray seal abundance in recent decades<br>• Spiny dogfish and black sea bass also a concern as they move northward and "eat everything"<br>• Potential bias in surveys that capture spiny dogfish and they are prevalent at night<br>• "Ecosystem shift" due to notable decreased in sand lance, a prey species for cod |
| Regulatory Impacts | • Shifts in fishing location might be a response to changing target species rather than a response to environmental changes |

# Indicator Selection




Ongoing classification of indicators:

1) Feasibility to create
2) Quality of data
3) Importance for cod

**Next Steps**

1. Selection of candidate indicators
2. Exploratory modeling
   - Outside of the assessment model
   - Within an assessment model (e.g. WHAM)

# ToR 3: Survey Data

ToR 3: Present the survey data used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, application of catchability and calibration studies, etc.) and provide a rationale for which data are used.

- Describe the spatial and temporal distribution of the data.
- Characterize the uncertainty in these sources of data.

**Previous Assessments (2021):**

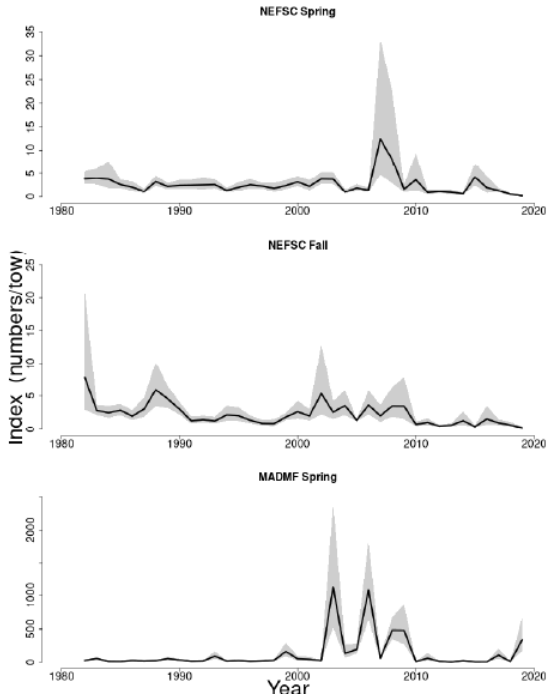
**Gulf of Maine**:

- NMFS spring and fall bottom trawl surveys
- Massachusetts Division of Marine Fisheries (MADMF) spring bottom trawl survey.

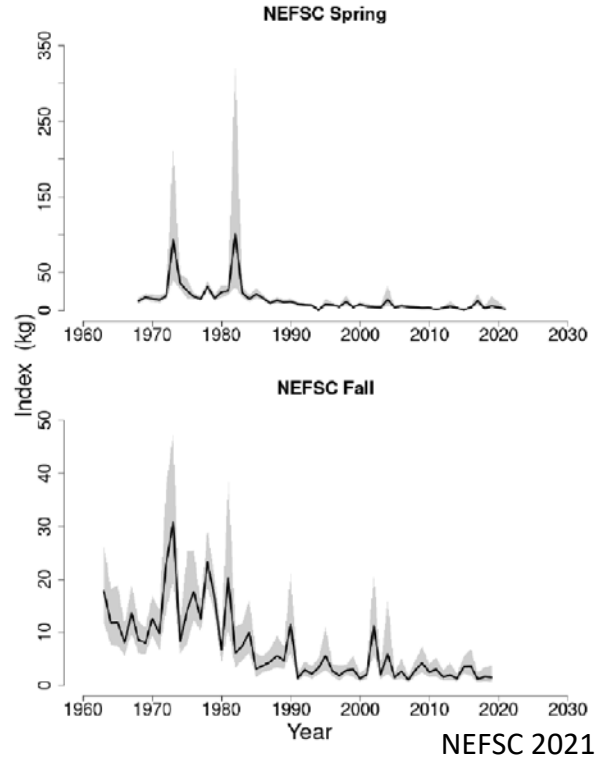
**Georges Bank:**

- NMFS spring and fall bottom trawl surveys

**Gulf of Maine cod**




**Georges Bank cod**




NEFSC 2021

# ToR 3: Survey Data

- Review of available surveys relevant to 4 stocks.
- Assessment of the utility of surveys.
- Identification of additional information needs.
- Data template created and shared out with survey leads.
- Application of NEFSC trawl survey to 4 stock areas.
  - Allocation of strata to stock area
  - Application of calibration studies
- Development of fishery dependent catch rate information.

# ToR 3: Survey Data

## Data Availability:

- WG synthesized a database of data available to support assessments that increase the alignment between the scale of stock assessment and biological stock structure of cod.

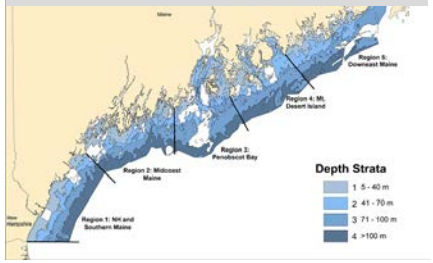
| Biological Units | Indices of abundance | | | | |
|---|---|---|---|---|---|
| | Data type | Data source | Ages sampled | Timespan | |
| EGoM | Fishery independent | ME/NH trawl survey | Primarily ages 0 & 1 | 2000+ | |
| | Fishery independent | NMFS trawl survey | Ages 0-9+ | 1963+ | |
| | Fishery independent | Eastern Gulf of Maine Sentinel Survey | Primarily ages 1 - 4 | 2012+ | |
| | Fishery dependent | Commerical LPUE | Primarily ages 2-7 | 1996+ (prior to 1996 available) | |
| | | | | | |
| | | | | | |
| WGoM (spring/winter) | Fishery independent | MADMF trawl survey | Primarily age 0 | 1978+ | |
| | Fishery independent | NMFS trawl survey | Ages 0-9+ | 1963+ | |
| | Fishery independent | ME/NH trawl survey | Primarily ages 0 & 1 | 2000+ | |
| | Fishery independent | NMFS Northern Shrimp Trawl Survey | Ages 0 - 9+ | 1984+ | |
| | Fishery independent | NMFS Bottom Longline Survey | Ages 1 - 9+ | 2014+ | |
| | Fishery independent | MADMF Cod Industry Based Survey | Ages 0 - 9+ | 2003-2007, 2016-2019 | |
| | Fishery dependent | Commerical Study fleet/Observer CPUE | Primarily ages 2-9 | 2010+ | |
| | Fishery dependent | Commercial LPUE | Primarily ages 2-9 | 1996+ | |
| | Fishery dependent | Open cod end survey | Ages 0+ | 2016-2022 | |
| | Fishery | | | | |

# ToR 3: Survey Data

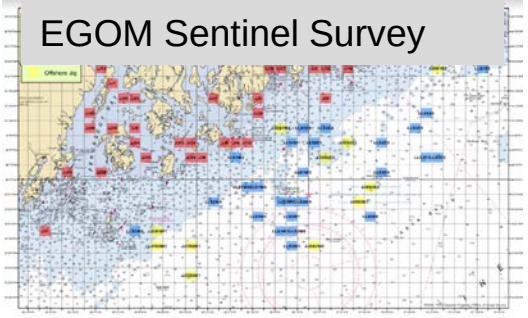
## WG reviewed available surveys:

1. Maine-New Hampshire Inshore Trawl Survey: R. Peters (Maine DMR)
2. Eastern Gulf of Maine Sentinel Survey: R. Linner (UMaine)
3. Cooperative GoM Bottom Longline survey: D. McElroy/J. Nieland (NOAA Cooperative Research Branch)
4. Rhode Island Coastal Trawl Survey: S. Olszewski/C. Parkins (RI DEM)
5. Groundfish video trawl survey: K. Stokesbury/N. Calabrese (SMAST)
6. MADMF Cod Industry Based Survey: M. Dean (MADMF)
7. MADMF trawl survey: M. Dean (MADMF)
8. Northern Shrimp Survey: K. Sosebee (NEFSC)
9. University of Rhode Island GSO Fish Trawl Survey: J. Collie (URI)
10. DFO trawl survey: I. Andrushchenko/R. Martin (DFO)
11. NEFSC bottom trawl survey: C. Perretti (NEFSC)

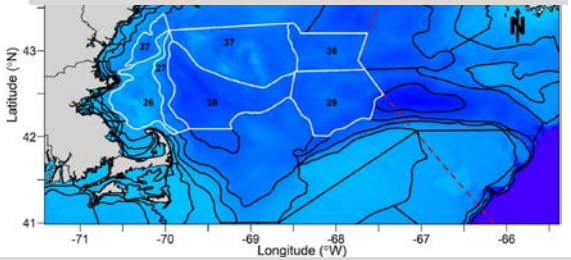
ME-NE trawl Survey



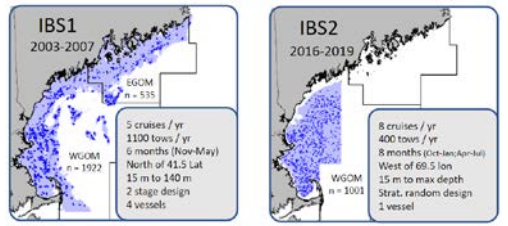

EGOM Sentinel Survey



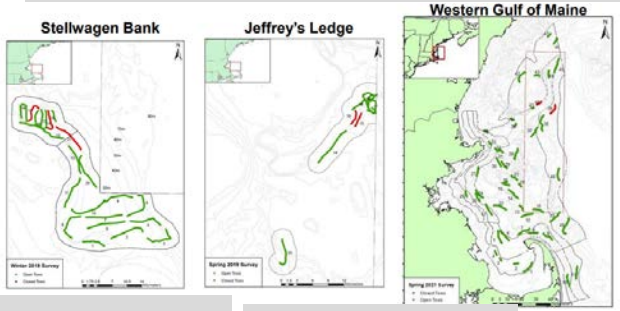
GOM Bottom Longline Survey



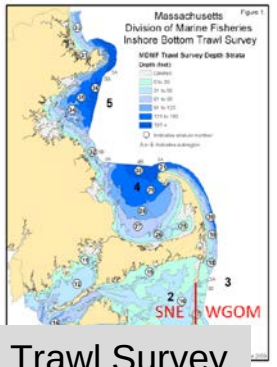

MADMF Cod Industry Based Survey




Ground Video Trawl Survey

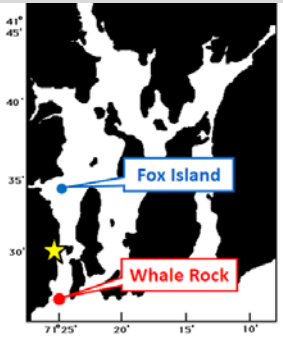



MADMF Trawl Survey



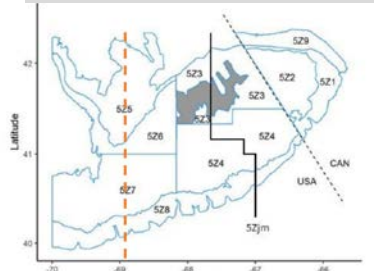

Northern Shrimp Survey

URI Trawl Survey

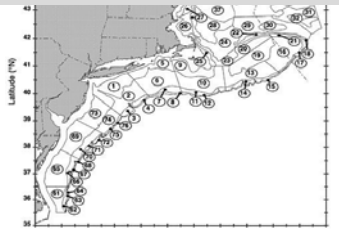



RI Coastal Trawl Survey


DFO Trawl Survey




NEFSC Trawl Survey



# ToR 3: Survey Data

**Getting to model-ready data inputs:**

Assignment of fishery independent data to stock area

- MADMF, ME-NH, DFO and NEFSC (largest undertaking)

Development of new age-length keys

- ME-NH, Cod IBS survey, Bottom long-line survey, Shrimp survey

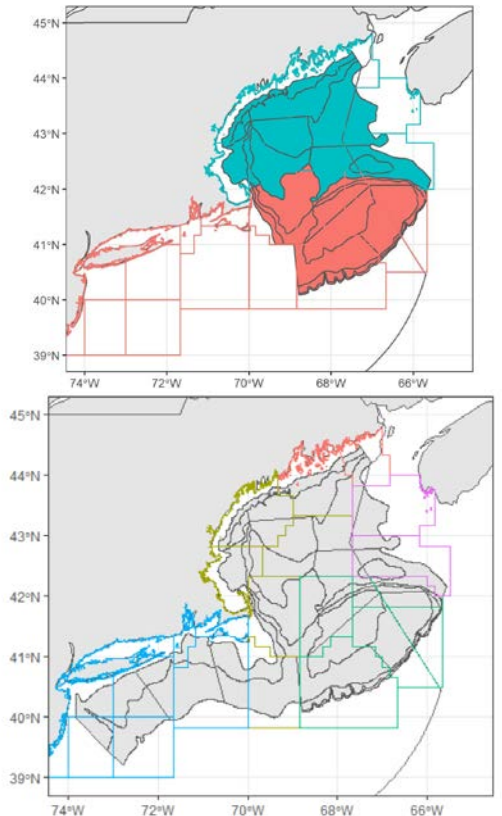
Application of Survey calibrations

- Application of revised Bigelow to Albatross calibrations, but also leaving the option to explore splitting to time series

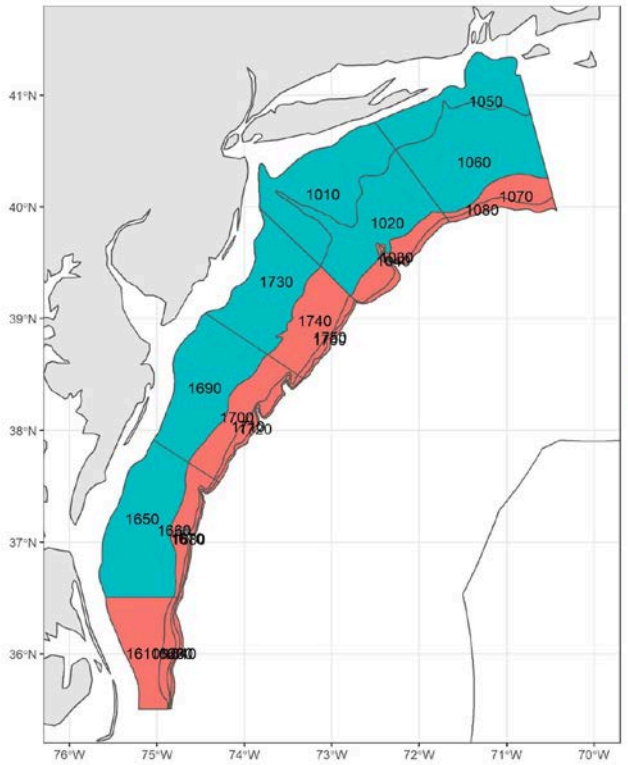
# ToR 3. Survey data

## NEFSC Trawl Survey

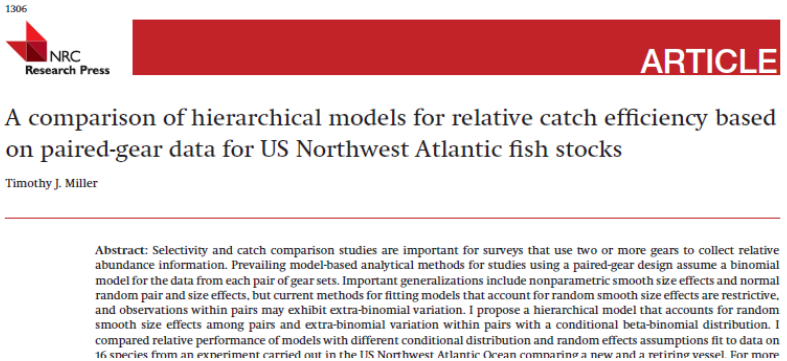
Revised Strata Assignment




Southern New England strata




Revised Bigelow:Albatross Calibrations



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NRC Research Press

ARTICLE

A comparison of hierarchical models for relative catch efficiency based on paired-gear data for US Northwest Atlantic fish stocks

Timothy J. Miller

and Oceans on 11/30/15

**Abstract:** Selectivity and catch comparison studies are important for surveys that use two or more gears to collect relative abundance information. Prevailing model-based analytical methods for studies using a paired-gear design assume a binomial model for the data from each pair of gear sets. Important generalizations include nonparametric smooth size effects and normal random pair and size effects, but current methods for fitting models that account for random smooth size effects are restrictive, and observations within pairs may exhibit extra-binomial variation. I propose a hierarchical model that accounts for random smooth size effects among pairs and extra-binomial variation within pairs with a conditional beta-binomial distribution. I compared relative performance of models with different conditional distribution and random effects assumptions fit to data on 16 species from an experiment carried out in the US Northwest Atlantic Ocean comparing a new and a retiring vessel. For more

# ToR 3: Survey Data

## Getting to model ready data inputs:

| Survey | Survey Index Metadata | Survey Data | Bio Data | Index | Length Frequency | Numbers at Age |
|---|---|---|---|---|---|---|
| Cooperative GoM Bottom Longline survey | X | X | X | X | X | X |
| Rhode Island Coastal Trawl Survey | X | X | X | In progress | In progress | In progress |
| University of Rhode Island Fish Trawl Survey | X | X | NA | X | NA | No age data, aggregate indices developed, no NAA |
| Maine-New Hampshire Inshore Trawl Survey | X | X | X | X | X | X |
| Eastern Gulf of Maine Sentinel Survey | X | X | X | X | X | In progress |
| Groundfish video trawl survey | X | X | X | X | X | No age data, aggregate indices developed, no NAA |
| MADMF Cod Industry Based Survey | X | X | X | X | X | X |
| MADMF trawl survey | X | X | X | X | X | X |
| Northern Shrimp Survey | In progress | In progress | In progress | In progress | In progress | No age data-NAA to be calculated using NEFSC ALK with IBS growth model to adjust due to summer timing of survey. |
| DFO trawl survey | X | X | X | X | X | X |
| NEFSC | X | X | X | X | X | X |

# ToR 2/3: Fishery Dependent CPUE

The WG has received updates on ongoing work by the Groundfish CPUE Project (SMAST- L. McGinnis, K. Hankowsky, M. Grezlik, G. Fay, S. Cadrin & A. Hansell )

- Exploration of fishery data to evaluate cod catch
- Develop standardized indices of abundance for each stock area
- Exploration of species co-occurrence patterns
- Relative catch efficiency of survey and fishery

# Next Steps

- Continue to get all indices compiled and model ready.
- Presentation on Atlantic Cod Research Track to the TRAC (July 12).
- Next full working group meeting: July 29, 2022.
- Shifting focus to ToR 2: Fishery data.