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2021 Atlantic Cod Stock Structure Workshops

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Acknowledgements

I.   Introduction

In 2012, the Scientific and Statistical Committee of the New England Fishery Management Council (NEFMC) recommended an effort to update the understanding of biological stock structure of Atlantic cod in New England waters based on the best available science. A two-phased approach was designed. Phase 1 brought together government, academic and non-profit scientists from the U.S. and Canada to form the Atlantic Cod Stock Structure Working Group (ACSSWG) in early 2018. The ACSSWG synthesized and summarized all relevant studies of Atlantic cod stock structure in U. S. and adjacent waters. The findings were presented, discussed and refined in two workshops organized by NH Sea Grant in 2018 and 2019 and a report was delivered to the Council in June 2020. That report concluded that evidence from multiple disciplines (life history, larval studies, tagging, and genetic and natural markers) suggests there are **five distinct biological stocks of cod, instead of the two cod stocks** that are currently managed.

This conclusion requires a re-thinking of the current science and management approaches to the fishery. In Phase 2 of this effort, the NEFMC, NOAA's Northeast Fisheries Science Center (NEFSC), and NH Sea Grant, hosted a series of Atlantic Cod Stock Structure Workshops to focus on **(a) Science/Assessment Prospects** and **(b) Management**. Each workshop featured presentations by technical experts followed by discussions open to the public to ensure complete information is available to best inform the cod stock assessment process. These workshops served to bridge the two-phased approach between the science and management. The objective was to gather input from participants on new data sources, discuss preliminary assessment prospects, and explore the socioeconomic consequences of potential management changes. The purpose of the workshops was not scoping specific management actions or making formal recommendations. Rather, they provided a platform for discussions and gathering different perspectives. This report from the workshops will be shared with the recently formed research track working group to develop an improved stock assessment for Atlantic cod and with the NEFMC.

This report is divided into two parts for each of the workshop series. The Science/Assessment Prospects workshop series (p. 3 - 12) included three workshops held in June 2021 and focused on the data availability for each stock, preliminary assessment prospects, and identifying additional information and/or upcoming projects that may prove useful for the research track. The five Management workshops (p. 13 - 31) were held in August and September 2021 to discuss how the new stock structure could be considered by NEFMC, potential management tools that could be used to manage cod differently under a new biological stock structure, and the potential impacts of any changes to the current management structure. The workshops were also used to learn how management strategy

evaluation could be applied to Atlantic cod decision making and the data needed to support this effort. Workshop summaries and presentations can be found on the [UNH Cod Stock Structure Website](#).

Due to public safety considerations related to COVID-19, the workshops were conducted by webinar.

II.   Science/Assessment Prospects Workshop Series

A. Background and Process

In early 2018, an Atlantic Cod Stock Structure Working Group (ACSSWG) was formed to synthesize and summarize all relevant peer-reviewed information about stock structure of Atlantic cod in U. S. and adjacent waters. This was part of a two-phase process to determine the biological stock structure of Atlantic cod in New England waters. Phase 1 brought together experts, including governmental, academic and non-profit scientists from the U.S. and Canada to evaluate the available evidence for the biological stock structure of cod for eventual consideration in monitoring, assessment and management. The multidisciplinary approach included structured interviews to collect fishermen's ecological knowledge, early life history (spawning-settlement), genetic markers (including adaptive and neutral markers), life history using 48 years of NEFSC bottom trawl surveys, natural markers such as otoliths, parasites, and color morphs, and applied markers (movements of cod tagged between 1923-2013).

The ACSSWG review resulted in several important findings:
1) Notable phenotypic and genotypic variability exists among statistical areas
    • Cod are not well mixed in either US management unit
2) Extensive movements by adults
    • Exchange between U.S.-U.S. management units as well as between U.S.-Canada management units
3) Larval dispersal occurs around Cape Cod
    • One-way connectivity between U.S.-U.S. management units
4) Two sympatric, genetically differentiated stocks occur in western Gulf of Maine
    • Adaptive genetic variation differentiates winter- and spring-spawning cod

In response, the ACSSWG proposed a biological stock structure that includes both an inshore-offshore separation and multiple inshore stocks. Specifically, they identified five biological stocks in U.S. waters (Fig. 1):
1. Georges Bank
2. Southern New England
3. Western Gulf of Maine and Cape Cod winter spawners
4. Western Gulf of Maine spring spawners (overlaps spatially with the Western Gulf of Maine and Cape Cod winter spawner stock)
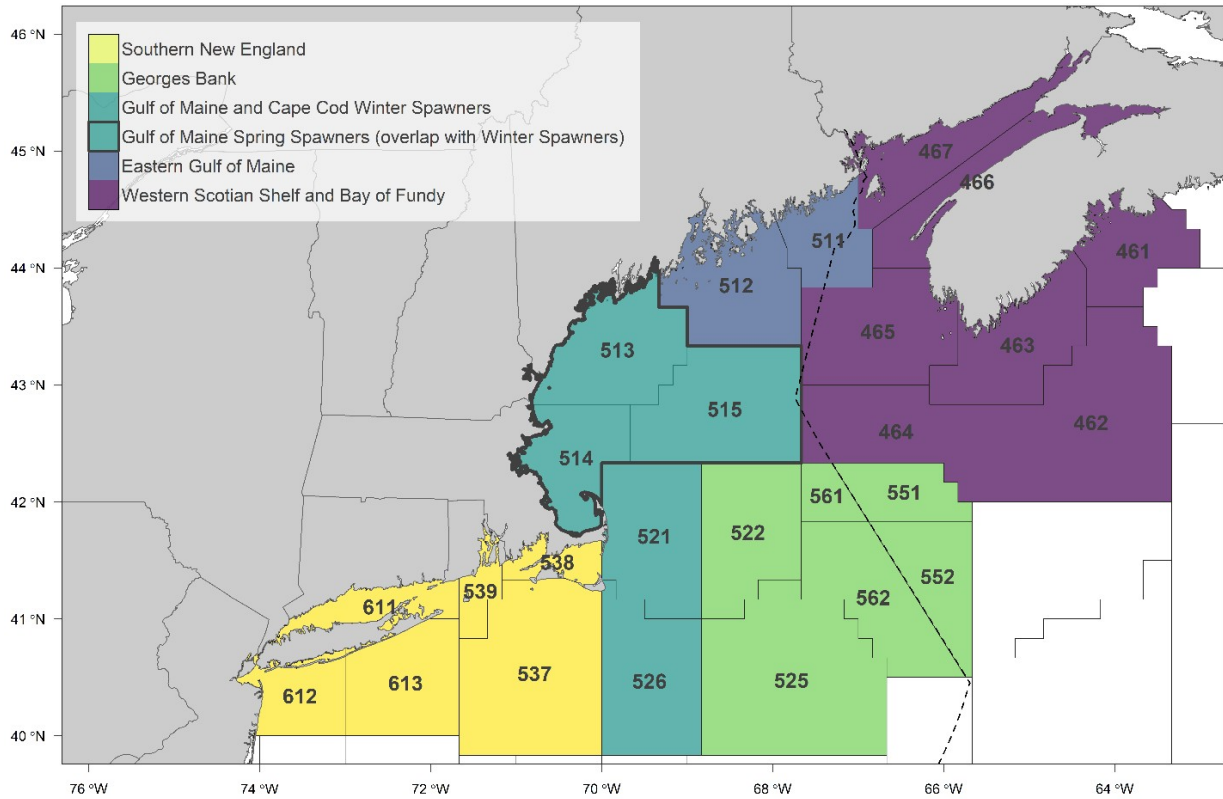5. Eastern Gulf of Maine

Figure 1. Five biological stocks in U.S. waters proposed by the ACSSWG and a sixth stock with connectivity in Canadian waters.

In 2021, the NEFSC and the NEFMC organized Phase 2 of the process through two workshop series. The workshops considered the implications of these newly proposed biological cod stocks in terms of: 1) the science and data required to support the next research track assessment for Atlantic cod, scheduled for March 2023, and 2) potential implications of management actions.

Table 1. Timeline of the Atlantic Cod Stock Structure Evaluation Process.

	Stock Structure Working Group (ACSSWG)	Science/Assessment and Management Working Groups	Research Track Stock Assessment
2018	**ACSSWG Formed**		
2019	**ACSSWG Report Completed**		
2020	**ACSSWG Peer Review (May)**		
2021		**Science/Assessment Workshops (June-July)** **Management Workshops (Aug-Sept)**	**Research Track Working Group Formed (August)**
2022			**Research Track Working Group conducts the Stock Assessment**
2023			**Research Track Peer Review (March)**

The objective of the Science/Assessment Prospects workshop series was to summarize historical and current data availability for each of the five proposed stock areas and identify additional data gaps that must be addressed to improve assessment prospects. This report summarizes the information gathered to inform the research track process. The Atlantic cod research track assessment will evaluate new datasets that can inform new or existing stock assessment models. The process is open to incorporating all pertinent data regardless of whether it has been previously considered and/or incorporated. Additionally, the process allows for application of new modeling approaches, such as state space assessment, with the objective of significantly improving estimate accuracy. This workshop series did not perform stock assessments for the proposed stock units, nor other detailed analyses. The goal was to develop an improved understanding of stock assessment strategy for Atlantic cod that can be used during future management track assessments.

The Science/Assessment Prospects workshop series included three workshops held in June 2021. The workshops focused on the data availability for each stock, preliminary assessment prospects, and identifying additional information and/or upcoming projects that may prove useful for the research track. The workshops were also used to learn how management strategy evaluation (MSE) could be applied during the Atlantic cod decision making process and the data needs to support this effort.

Each workshop included a presentation of currently available data followed by participant discussion. Workshops were divided into the following three sessions based on biological stock areas: 1) Southern New England and Georges Bank Stocks (June 1), 2) Western and Eastern Gulf of Maine Stocks (June 7) and 3) Assessment Prospects and Data Needs for all stocks (June 25). A total of 67 people participated in the workshops with most participants from academic institutions and the Northeast Fisheries Science Center (54% combined). The remainder were divided almost equally among fishing industry representatives, state government members, federal fisheries managers, council staff and non-governmental organizations. The presentations and summary of each workshop can be found on the University of New Hampshire's 2021 Atlantic Cod Stock Structure Workshops website.

B. Data Availability and Assessment Prospects
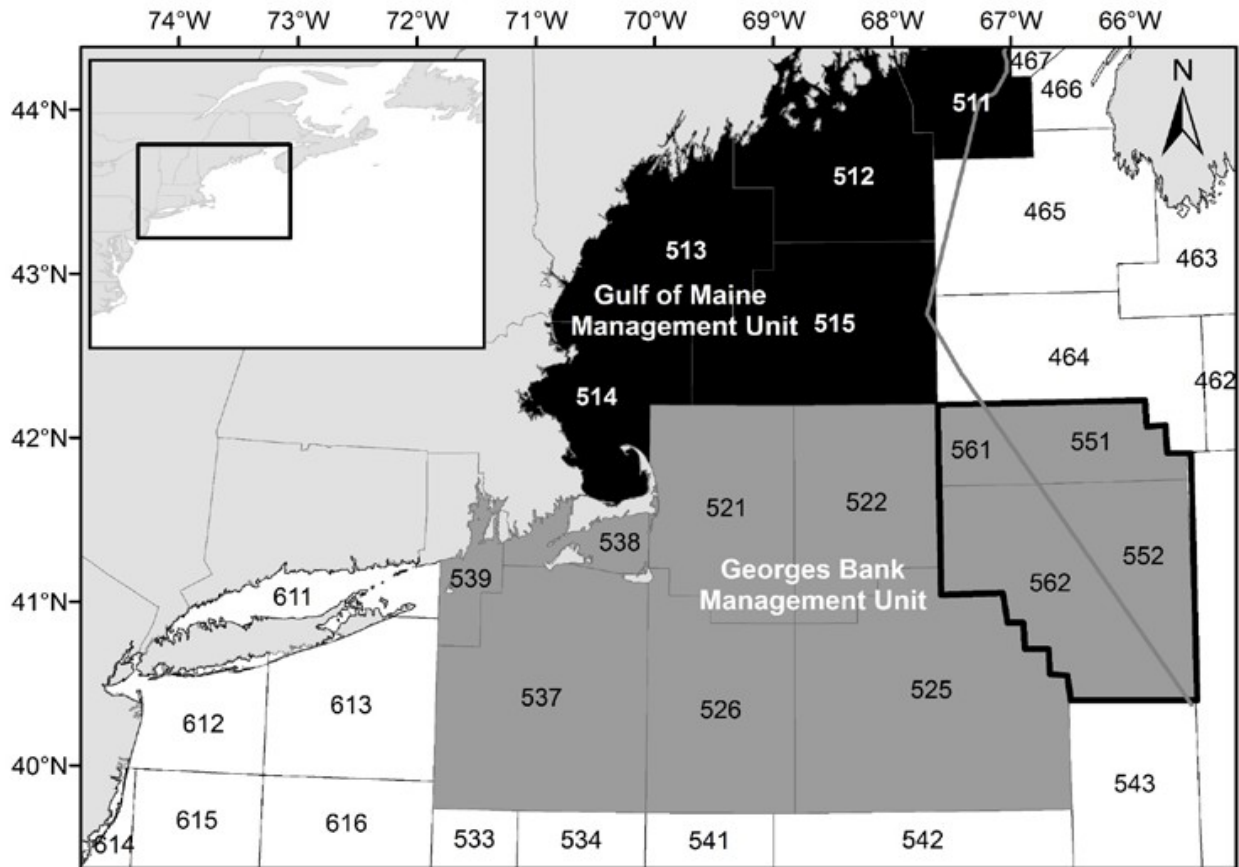
Figure 2. Current Management Areas for Atlantic Cod in U.S. waters (2 stock units) and transboundary area with shared management with Canada (bold outline).

Current Atlantic Cod Stock Assessment Framework

Gulf of Maine Management Area (Stat Areas 511-515, 464, 465)
- Last assessment 2019, Operational Assessment
- ASAP Model, two formulations (M = 0.2, M-Ramp model)

Georges Bank and South Management Area (Stat Areas 521, east and south)
- Last assessed 2019, Operational Assessment
- Plan B Smooth approach

Eastern Georges Bank Management Area (5Zj&m)
- Transboundary with Canada, Subset of the GB and South Management Area
- Last assessed 2020, Transboundary Resources Assessment Committee (TRAC) Assessment
- Migrating to a Data Limited Model approach

Southern New England (SNE)

- Data are available from commercial and recreational fisheries, NEFSC Survey Data, other surveys – state-specific, and local/regional agencies with varying degrees of complexity. These are the same general data sources for all areas, including the SNE.

- Overall, all commercial landings have declined for all areas since the 1970s. SNE has historically comprised a small proportion of the landings relative to the other stocks, although it has contributed relatively more in recent years than historically, albeit still at very low relative amounts.

- Survey-specific data gaps make SNE a difficult stock to assess. Sampling effort is allocated by catch, and without a significant catch, sampling effort has been historically limited.

- SNE is minor relative to other stock areas and there is little or no information available to characterize the size-age composition. Surveys catch primarily younger fish (age 0-3) with no fish older than 4 years.

- The NEFSC Study Fleet Program provides an additional, potentially important source of fishery-dependent data that could be mined for more detailed information from the SNE. For this program, fishermen have collected high resolution data since 2006, although there has been a decline in the number of vessels participating and the number of trips where cod were observed by this program over time.

- The recreational catch data are complex to dissect because they are collected on a state-by-state basis and landings have to be allocated to stock/area by port location. This can be more problematic for certain states, e.g., within Massachusetts catches are allocated to SNE or Gulf of Maine based on port location, which may not actually correspond to location where fishing occurred. This type of allocation division will become more complex with more stocks to assess.

- There are eight surveys that provide fishery-independent data for SNE cod, including the NEFSC Bottom Trawl Survey (spring and fall), Massachusetts DMF Inshore Trawl Survey (spring and fall), Northeast Area Monitoring and Assessment Program (NEAMAP) Survey (spring and fall), and the Rhode Island DEM monthly and seasonal trawl surveys. None provide consistent information on size and age composition of cod in this stock area.

- Additional data exploration from some fishery independent survey sources may yield more detailed information and is warranted especially for RIDEM, MADMF and the yet unexplored dataset from URI-GSO surveys.

- Additional data exploration is warranted with catch per unit effort (CPUE) and landings per unit effort (LPUE) indices for both commercial and recreational fisheries.

- Overall, Southern New England (SNE) is a data poor region where landings and discards are low from commercial catch, especially in recent years. Data (length/age) are likely insufficient to support any type of age-based assessment.

- Recreational catch will be difficult to estimate due to Massachusetts ports landing cod from multiple proposed stock areas (SNE and western Gulf of Maine). There is potential to conduct further exploration of head and charter boat data to better represent the area, but this would need to occur prior to the research track.

- The NEFSC and Mass DMR surveys (Spring and Fall), show consistent coverage but the size and age composition are not well represented.
- The NEAMAP bottom trawl surveys have insufficient cod catch to index the population, especially in the Fall when there have been no cod catches.
- The RI DEM and URI/GSO surveys (Spring and Fall) have consistent coverage but size and age data are limited to younger fish only.
- *In summary, a statistical catch at age model is not possible if SNE is considered in isolation and while aggregate production models can be attempted, an index or data limited assessment approach would likely be employed.*

Cape Cod/Great South Channel (521/526)

- Commercial and recreational catch and biological sampling has historically been, and continues to be, significant in these two statistical areas. There are some limitations with seasonality and isolating data from adjacent areas like SNE and the western Gulf of Maine in Massachusetts, which will limit the data available for characterizing length and size composition on a finer scale.
- The study fleet (NEFSC Trawl Survey) data contains over 10 years of sufficient biological data with some seasonal limitations in the Fall. Abundance and biomass have declined over the years, as is true for other stock areas.
- The MDMF spring and fall Trawl Surveys provide an additional source of fishery-independent data, but only include two strata in the stock area.
- *It remains an open question whether a sufficiently accurate stock assessment is possible considering some of these current limitations.*

Western Gulf of Maine (Gulf of Maine/Channel)

- This area contains two complex biological stocks (winter and spring spawners) that may require discrimination for assessment and/or management;
- It is otherwise considered data rich with commercial sampling input.
- Environmental data collection should be expanded to best understand shifting dynamics in the spawning populations. A recently developed Woods Hole Assessment Model (WHAM) allows for more flexibility in analyses of the Gulf of Maine by incorporating novel, environmental covariates. The working group will explore a broad range of these variables because it can't be assumed that the ecosystems are static. NEFSC is currently exploring food web dynamics as well with different potential strategies but they can be difficult to interpret.
- Recreational catch data are being collected in this area but assessments are complicated due to parsing catch in Massachusetts between the Gulf of Maine and Southern New England statistical areas.
- Overall, available data should be sufficient to enable managers to construct adequate catch at age models. If the proposed area becomes broader (adding Statistical Areas 521 and 526), it would actually result in even more available information to inform assessments.
- For fishery dependent data, the recreational catch will be difficult to estimate accurately but commercial catch, landings, and discards are well documented.

- For fishery independent surveys, the NEFSC multispecies bottom trawl survey (spring and fall) and the MDMF survey are available and are generally well represented.

- *Stock assessment prospects for assessment of the Channel area in isolation and statistical catch at age model may be possible but is highly dependent on getting better representative catch at age estimates. If statistical catch at age is not possible, an aggregate production or index-based method would need to be used.*

Eastern Gulf of Maine

- Survey trends are broadly similar across the western and eastern Gulf of Maine. The majority of the cod biomass is currently in western Gulf of Maine. The Maine/New Hampshire survey and sentinel survey catch some cod in eastern Gulf of Maine but data are limited in numbers and age distributions.

- The area is represented by sparse commercial and recreational landings with limited sampling from either fishery.

- Survey data have been consistent over time but are insufficient for age composition analyses, and the inshore surveys (NH, ME) catch only smaller, younger fish.

- *Overall, cod populations in this area are difficult to assess independently and would not be informative if based on currently available data. The eastern Gulf of Maine would likely require an index-based assessment due to limited data availability.*

Georges Bank

- Commercial catch numbers for the eastern portion of Georges Bank have been declining over time and have been shifting towards younger age classes. This still represents a data rich region where historical and biological data allow characterization of a catch at age, spawning stock biomass, and cohort tracking over time.

- There are no significant recreational fishery landings or discards for this area.

- The NEFSC Bottom Trawl Surveys show notable differences between Spring and Fall fish distributions within the area, with fall distributions concentrated on the Northeast Peak and spring distributions more widely distributed across the bank. There has been a decline in the number of study fleet vessel trips over time, making this dataset thinner than for other regions.

- There are two US Surveys (Spring and Fall) with consistent coverage and well represented size/age composition.

- The Canadian DFO Spring Trawl survey provides a third fishery-independent data source for this region and the size/age composition is also well represented. This survey does not extend all the way to the western part of the bank.

- The newly proposed stock is larger than the current stock area managed by the United States and Canada (eastern Georges Bank management unit) . It will continue to include binational catch and surveys.

- Currently the Northeast Peak is assessed along with Canada so this is one region where we would actually be adding data (areas 522 and 525) by increasing the size of a proposed stock area.

- US landings and discards are reasonably well documented and sampled, but some augmentation of length and age samples are required to estimate catch at age – adding areas 522 and 525 will likely address this.

- Canadian landings are very well documented and sampled. Canadian catch sampling is robust. U.S. landings and discards are documented and sampled. However, Canadian catches are a greater proportion of the total catch in this area than US catches.

- Managers in the US and Canada have not discussed adopting the proposed eastern GB cod area.

- *In summary, if assessed in isolation, a statistical catch at age model is possible for the eastern Georges Bank stock area. The current statistical catch at age model has been rejected and data limited approaches are currently being used to provide the management advice. If Statistical catch at age approach is not possible, it will be necessary to drop back to aggregate production or index-based methods.*

C. Other Potential Data Sources

Throughout the workshops, additional data sources to augment current assessment data were identified by participants, including the following:

- University of Massachusetts SMAST has ongoing tagging and acoustic studies that will help better understand SNE spawning activity and results will be available in the next few years.

- Recreational sources (e.g., party and charter boats) could be better utilized with improved vessel trip report (VTR) and port sampling efforts to prioritize region-specific fishing seasons and collect additional biological data. For example, winter cod fishing is popular on Cox Ledge and Block Island but poorly captured by current sampling in SNE. Similar resource adjustments could be applied in northern states where the seasonal timing of recreational surveys excludes important data.

- The University of Rhode Island Graduate School of Oceanography (GSO) bottom trawl surveys and the Rhode Island Department of Environmental Management (DEM) fixed station and offshore bottom trawl surveys represent considerable additional sources of information in SNE.

- The NMFS Northern Shrimp Survey and the NMFS Bottom Longline Survey would require summarization but offer a new data stream for western Gulf of Maine.

- The Massachusetts DMF Industry-Based Survey (IBS) represents a valuable new data source not currently considered in cod assessments.

- The University of Maine sentinel surveys for the eastern Gulf of Maine and age samples are statistically limited but have potential to provide samples from larger cod because of the techniques used to catch inshore fish.

- Although the NEAMAP survey has infrequent catches of cod in the SNE stock area, Langan et al. (2020 Fishery Bulletin 118: 145-156) reported regular catches of young cod in the RIDEM and URI GSO trawl surveys. These new sources of data were documented from the Science/Assessment workshops in relation to the proposed SNE area and will be investigated for potentially generating recruitment indices.

- Historical survey and commercial otolith collections should be investigated in the Gulf of Maine to better understand Winter and Spring spawning stock composition. This would require additional resources to process.
- Assessments could incorporate the catch from other overlapping fisheries (e.g., lobster) and create new data streams into cod estimates.
- Additional gear types (fixed gears, longline, etc.) could be included into fishery independent survey protocols, which could capture older age classes of cod in certain areas that are missed by trawls.
- Wind energy initiatives offer short-term studies that may provide information for managers to consider.

D. Data Gaps and Information Needs

- Due to climate change, the flexible consideration and incorporation of implications of changing environmental variables on Atlantic cod populations is going to be critical for sustainable, long-term stock structure estimates in many areas. This topic is especially significant in the western Gulf of Maine where Spring and Winter spawners might be shifting reproductive strategies.
- A better understanding of fine scale habitat use (e.g., timing and location of spawning aggregations) by certain stocks (e.g., SNE) would improve assessment/management efforts.
- Additional basic, biological data collected among stocks (maturation, fecundity, growth rates etc.) would aid in the application of targeted management tools like spawning closures or specific fishing gear types.
- A long-term mixed stock sampling program using genetic or otolith analyses to estimate indices of abundance for each stock is required if management intends to differentiate biological populations (spring and winter spawners in Gulf of Maine).
  - A subgroup or committee comprised of people with expertise in this area was proposed during workshops to explore the practical feasibility of using otoliths and/or genetics for stock composition analyses.
- Additional efforts to monitor area closures for their efficacy would better inform managers and build confidence within the fishing industry that these tools are justified or if they require rethinking.
- Overall, recreational reporting requires significant improvements. Historical decreases in commercial landings have created data deficiencies which could be supplemented by the recreational industry in some areas. Recent evidence from other fisheries (red snapper, tilefish) suggests that well designed and validated smartphone apps or websites can offer novel tools to collect accurate private angler data.

E. Key Conclusions and Next Steps

Overall, the potential splitting of historical data from the current two management areas into three, four, or five areas results in inadequate assessment data for some units. The currently low population levels and deficient historical data (e.g., surveys, poor age distributions, lack of ongoing biological sampling) would lead to problems with data deficiency in some areas. The proposed SNE and eastern

Gulf of Maine are particularly data deficient and will require rethinking during the research track. Data limited options, rather than age-based assessments, may offer the most feasible approach.

Southern New England and eastern Gulf of Maine proposed stock areas were particularly data deficient in terms of the representativeness of fishery independent surveys and biological sampling of the catch required to characterize commercial and recreational landings and discards.

Western Gulf of Maine proposed area would be relatively stable in terms of the input data and resulting stock assessment.

Georges Bank revised stock area would gain data and information if Statistical Areas 522 and 525 (central Georges Bank) are combined.
- The assessment would be similar to the current TRAC assessment, which has had to step back to a data limited approach in recent years.
- There is no guarantee that the binational TRAC/Transboundary Management Guidance Committee (TMGC) process will adopt the new stock area definition.

Gulf of Maine spring spawning stock are problematic to assess due to:
- Limited fishery independent survey data (NEFSC and MADMF surveys)
- Spatial overlap with Western Gulf of Maine stock area
- Need to identify Winter vs. Spring spawners in both current/future data collections and historical data. Despite available techniques (otoliths, genetics), currently there are no ongoing stock composition analyses.

The following is a short list of items that were identified during the workshop as needing revisiting with further discussion, potentially by subgroups, prior to the research track work.
- o Whether and how the eastern and western Gulf of Maine should be lumped together in assessment or management, and when this decision will be made.
- o The feasibility of using otoliths, or other methods, to assess the composition of the historical and modern fishery and survey data.
- o Whether additional data from the eastern Gulf of Maine (e.g., otoliths or other Sentinel Survey data) would provide any new, information useful for assessments moving forward.
- o Exploration of additional recreational fishery data (headboat/charter boat) from Southern New England.
- o A discussion about what scenarios will be explored by the management strategy evaluation (MSE) process.

III.   Management Workshop Series

A. Overview and Process

The Management Workshop series was designed as a bridge from the Science/Assessment Prospects workshops to the process of identifying effective and feasible management approaches that are consistent with the new understanding of stock structure. The five workshops took place from August through September 2021 and included presentations followed by guided opportunities for participant discussion and generation of ideas. These discussions will be shared with the NEFMC and the Research Track Working Group for Atlantic cod. The workshops were not intended to scope specific management actions or make formal recommendations. Rather, they offered a platform for discussions and gathering different perspectives, especially potential socioeconomic consequences. The summaries and presentations for all five workshops can be found on the [UNH Cod Stock Structure Website](#).

The three objectives of the Management Workshops were:
1. Identify potential options for management measures.
2. Examine the advantages and disadvantages of the options.
3. Identify socioeconomic impacts that should be evaluated.

Setting the Groundwork (August 12): The first workshop focused on setting the groundwork for the future workshops. This initial management workshop shared an overview of the outcomes from the June Science and Assessment workshops, provided some context on the federal management system for cod, and offered ideas for management tools and approaches to consider during the future management workshops.

Southern New England and Georges Bank (August 17): After setting the groundwork, the second workshop focused on gathering regional perspectives from Southern New England and Georges Bank. The workshop defined and discussed both available and potential new management tools that could be used to manage these two stocks differently under a new biological stock structure. During the discussion, both advantages and disadvantages of those options were addressed and participants had an opportunity to share what might be viable and practical to consider.

Gulf of Maine (August 19): The third workshop was structured similarly to the second, with a focus on the Gulf of Maine. Under the new stock structure of cod, the Gulf of Maine encompasses both an eastern and western stock. The workshop discussed management tools that are currently available and generated additional options that could be used to manage the Gulf of Maine as two stocks. Both advantages and disadvantages of various options were considered including feedback on the practical implications of management changes.

Recreational Focus (September 9, 2021): Future changes to cod management will have an impact on both commercial and recreational fishing interests. The fourth session was directed specifically at

soliciting input from the recreational stakeholders to provide an opportunity to increase their engagement in discussions. The workshop provided information on how the recreational data are currently used to inform stock assessments and the potential limitations of the data under a new stock structure. The participants offered suggestions on how to improve recreational data gathering to inform the cod stock structure and considered what might happen if cod stock boundaries are shifted.

Evaluating Tradeoffs (September 20, 2021): The fifth and final workshop integrated the discussions from the previous management workshops and explored specific management options that could be used to manage Atlantic cod differently under a new biological stock structure. Participants also learned about using Management Strategy Evaluation (MSE) as a tool for decision making and options to consider for Atlantic cod. The workshop included smaller breakouts to explore the implications and tradeoffs for a range of options to better align the current management boundaries with our new understanding of the biological stock structure.

Attendance

The Management Workshop series had a broad attendance with 105 individuals participating over the five session that took place in August and September. There were between 55 and 70 participants at each workshop. The majority (24%) of participants across all five workshops self-selected as "scientific researcher" while "NOAA/NEFMC staff" and "other" each comprised roughly 14% of the participants (see Figure 3). A very low number of active commercial fishermen participated, but a variety of fishermen's organizations were able to attend. The workshops were held during the afternoons and in the busy summer fishing months, which could have contributed to the lower industry turnout. Due to public safety considerations related to COVID-19, the workshops were conducted by webinar. In-person meetings may have yielded greater industry participation.
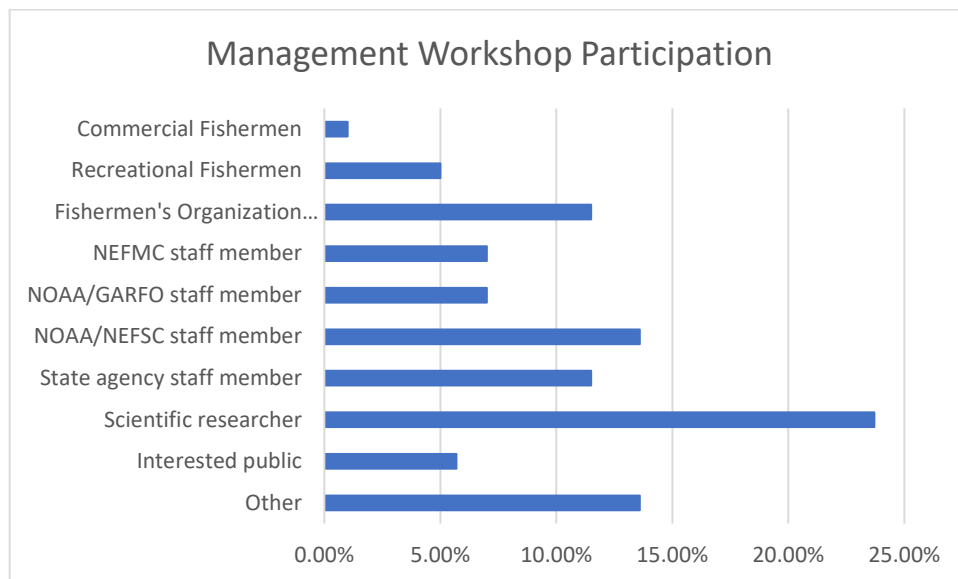

Figure 3. Distribution of workshop participant affiliations.

B. Background Information

Existing Atlantic Cod Management
Jamie Cournane (New England Fishery Management Council)

Atlantic cod is currently managed within the Northeast Multispecies Fishery Management Plan which encompasses 13 groundfish species, 20 stocks and two management units. Atlantic cod are currently managed as two stocks: Georges Bank (GB) cod and the Gulf of Maine cod (GoM) and the eastern Georges Bank cod management unit through a transboundary agreement between the US and Canada. It is a complex management system with assessments for the two stocks generally occurring every two years. The Eastern Georges Bank cod management unit is assessed annually. Based on 2019 assessments, the GoM cod and GB cod stocks are overfished with overfishing occurring, and subject to rebuilding plans with rebuild by dates of 2024 and 2026, respectively. Currently, all cod caught in U.S. waters are included in one of the two management areas, GoM and GB. GoM cod assessment data includes commercial and recreational catches in the Gulf of Maine. GB cod assessment data includes commercial and recreational catch from Georges Bank, Southern New England (SNE) and the Mid-Atlantic.

The US and Canada convene to assess and inform managers to adjust quotas on an annual basis. The final quota results are distributed for each country to apply their respective management plans, which are generally similar with some differences in gear and catch restrictions. The stock status of cod in the Eastern Georges Bank management unit is considered in "poor status" and subject to a rebuilding plan in Canada.

Commercial Fishery: The commercial groundfish fishery is managed through a quota-based system with the majority of vessels opting into a sector (i.e. harvest cooperative), while the remaining vessels are part of the common pool. The sector system assigns an allocation of cod to the sector based on each individual vessel's quota. Leasing and/or trading are allowed between vessels in a sector and between sectors. Additional regulations for sectors include accountability measures, GoM cod protection closures, spawning closures, and gear/mesh restrictions. The minimum fish size that can be kept for cod is 19 inches. Trip reporting and monitoring is also required.

The common pool represents a smaller portion of the commercial groundfish fishery with a system of trimester quotas, trip limits, area-based restrictions and in-season closures. Common pool vessels are also subject to GoM cod protection closures, spawning closures, gear/mesh restrictions and the 19 in minimum size limit. Reporting and monitoring is also required.

Recreational Fishery: The recreational groundfish fishery (e.g., angler and for-hire party and charter boats) is subjected to the minimum size limit of 21 inches, bag limits, seasons, and spawning closures. Regulations vary between stock on bag limits and duration of season. The for-hire vessels are subject to reporting requirements and the Marine Recreational Information Program (MRIP) surveys recreational anglers. On Georges Bank, recreational fishing is subject to a "catch target" but there are no consequences if that target is exceeded.

In Gulf of Maine Regulated Mesh Area
Open season:
•Private Anglers - September 15-30; April 1 - 14
•Party/Charter Anglers - September 8 - October 7; April 1 - 14
Minimum size: 21 inches
Possession limit:
•Private Anglers - 1 fish per day.
•Party/Charter Anglers - 1 fish per day

Outside of Gulf of Maine Regulated Mesh Area
Open season: All year
Minimum size: 21 inches
Possession limit:
•Private Anglers - 10 fish per day.
•Party/Charter Anglers - 10 fish per day

For details on Atlantic cod management requirements see:

NOAA/GARFO: https://www.fisheries.noaa.gov/species/northeast-multispecies-groundfish
and
NEFMC: https://www.nefmc.org/management-plans/northeast-multispecies

Alternative Management Options
Jamie Cournane (New England Fishery Management Council)

A full gradient of available management approaches could be applied to address the newly proposed biological stock structure for cod. In 2017, Lisa Kerr et al. published an article, *"Lessons learned from practical approaches to reconcile mismatches between biological pop structure and stock units of marine fish",* in which the authors use North Atlantic case studies to describe approaches currently applied to improve the assessment and management process where complex spatial structure has led to an observed mismatch between the scale of biological populations and spatially-defined stock units (https://doi.org/10.1093/icesjms/fsw188).

The approaches represent a continuum of stock assessment complexity, with examples below for application to cod management:

1) Status quo management – no change in the two stock management structure.

2) "Weakest link" management – a highly precautionary approach taken to protect a known minority component that curtails fishing effort for multiple stocks at a threshold that protects the most vulnerable stock in a species group.

3) Spatial and temporal closures – a more targeted option when additional information is available that allows for more fine scale management, informing decisions like spawning closures. Different management tools may be appropriate for different areas or within areas based on available data (e.g. winter and spring Gulf of Maine spawners).

4) Stock composition analysis – an option where an area is sampled throughout a season and then catch is proportioned between populations based on the observed ratios of stocks that mix in the area. Doing so requires using consistent monitoring tools for managers to sort proportions of catches and track biomass, in relatively real time. Tools currently available that could be used for cod include otoliths or genetic markers.

5) <u>Alteration of stock boundaries</u> - alternative boundaries could focus on two, three or four stocks, or the full five-stock model to better align management to fit the biological populations more closely than the current two management areas.

Case studies for potential management consideration:

- River herring (Alewife and Blueback) and shad are anadromous species with distinct populations that co-mingle outside of their respective spawning seasons. There is no coastwide assessment and they are currently managed together because of the difficulty of distinguishing them apart (i.e., co-catch fishery). In this example, managers know about aggregations with some biological information but not enough to discern between fish species. In this case, gear types and harvest caps are set for areas with associated penalties for exceeding quotas.

- A second example is Georges Bank cod – a fishery with a total allowable catch between the United States and Canada. Allocation is distributed each year for East and West management areas while the area is still managed as a single stock. In the US, the quota can be transferred from East to West areas under certain conditions, but the frequency of those transfers has been declining over time. The request goes to a regional administrator for approval.

- Bering Sea and Aleutian Pacific cod provide an example of time constraints placed on the catch cap. Two stocks have been identified but they are managed as one. The fishery provides an additional case study and could be a model for the spatial and temporal components being considered for Atlantic cod.

Focus on Southern New England Cod
Steve Cadrin (UMass-Dartmouth, School for Marine Science & Technology)

Recent research reviewed the Northeast Regional Cod Tagging Program (2001-2009) and Massachusetts Marine Fisheries Institute Archival Tagging & Genetics studies (2007-2011) to assess SNE as a distinct population. Genetic studies that used tissue samples from spawning cod showed that SNE is a distinct population, while recruitment studies (larval and trawl surveys) characterized the important spawning and nursery areas.

Additional Cod Spawning Studies (2019-21) undertaken by NEFSC, SMAST, MADMF and TNC are currently applying additional techniques like hydrophone arrays, acoustic transmitters, and more tagging/tracking efforts. Gonad tissue sampling is occurring throughout the region. These results demonstrate improved spawning site recognition including some regional spawning instances offshore, outside of Cox's Ledge and multi-annual site fidelity. SNE has always thought to be dominated by spawning on Cox Ledge, so this was novel additional spawning information. After spawning, cod migrate towards the continental shelf but previously spawning aggregations out there were unknown. The new information suggests relatively low density (smaller aggregations) but cod with fully hydrated eggs are being found.

SMAST is undertaking an additional project that will examine the catch rates of multiple sectors to better summarize those data for use in assessments. The researchers are working with commercial and recreational fishermen to best characterize where cod are spawning. An additional effort is working to develop a recreational catch rate series for SNE that should contribute substantial data to the research track.

For SNE, managers don't have the samples required for age composition compared to Gulf of Maine and other areas. SNE is a smaller scale fishery with overall less data availability and the offshore surveys don't catch many fish because they don't include Cox Ledge. Although some data deficiencies have been demonstrated, it would likely still be enough for a data limited assessment. Managers are hopeful that for-hire and commercial fleets will offer some additional data that can be applied in analytical models to improve their performance.

Under the current management system, catches South of Cape Cod is attributed to GB but the new stock structure considers sub-dividing that into what has been identified as SNE. This would then represent cod being caught as far South as Virginia. During the ACSSWG, SNE was proposed to include the entire mid-Atlantic resource despite its limited information. The regions may be different but based on best available data, the conclusion was that they are best grouped with SNE.

Winter and Spring Spawning Cod in the Gulf of Maine
Steve Cadrin (UMass-Dartmouth, School for Marine Science & Technology)

Extensive research has been conducted to define the complex western GoM spawning groups and their respective seasonal spawning behaviors. Genetic sampling clearly demonstrated reproductive isolation of these spawning stocks, but the challenge is applying this information to fisheries management where successful rebuilding requires conservation and protection of both distinct groups.

Although these mixed stock fisheries are complex, the tools are available to manage effectively. For example, Baltic herring have different spawning groups but are overlapping within the fishery so otolith analysis is used to proportion out catches. Similarly, Pacific salmon, which are comprised of many local populations, are routinely sampled within season for genetic stock analyses.

These same practices could be applied to cod. Otoliths are currently sampled for age composition analyses only, but growth rings could also be examined to determine population origin. Genetic tools have been validated in research to differentiate spring from winter spawners and could be made available for assessments. The results of both techniques agreed with each other in studying historical samples and showed an initial balance between stocks but shifts towards a winter dominated proportion over time.

How can we use the data for management?

1. "Status quo" continuation managing as a single stock with seasonal spawning closures.

2. Monitor the two spawning populations separately and apply a combined catch allocation based on stock composition.

3. Monitor the two spawning populations separately and apply separate catch allocations based on stock composition.

Understanding the Recreational Data to Inform Management
Scott Steinback and Charles Perretti (National Marine Fisheries Service, Northeast Fisheries Science Center)

The Marine Recreational Information Program (MRIP) surveys households, for-hire vessels, and various private anglers at random for detailed fishing reports. For-hire vessels are required to submit vessel trip reports. Together, in partnership with state data, these sources are used to produce annual mortality estimates (landings + discards) that can be broken up by stock and/or wave (2-month period) but this comes with an increased risk of uncertainty as data are further divided. Many states are limited by seasonal sampling like Maine (6 months) and New Hampshire (8 months). Catch data from North of the Cape Cod is attributed to the GoM stock and South of the Cape is attributed to the GB stock. MRIP intercept sites provide the best possible location estimates but also require some assumptions. For example, in Massachusetts, it is complicated to assign landed catch to the adjacent stock areas. The delineation North and South of the Cape Cod is completed during the assessment process and the practice is especially relevant in Massachusetts because it greatly reduces sample size and increases uncertainty in the estimates.

The recreational catch can represent about 50% of landings/discards depending on the stock area. There are no age data or tissue samples for this component of the landings. This is concerning and there have been no proposed solutions to address the recreational component.

GB Recreational Management: To develop recreational management measures for the GB cod stock, the MRIP mortality is used to produce a catch estimate which is compared to the catch target. If catch exceeds target (rare), historical data are used to predict which management measure might affect mortality. Typically, this is a reactive approach.

Gulf of Maine Recreational Management: To develop recreational management measures for the GoM cod stock, MRIP mortality and effort is combined with some available biological data into a bioecological model (since 2013) for more accurate projections of mortality that account for angler behavior and multi-species interactions (cod and haddock). This is a slightly more proactive approach, but has certain limitations (i.e., numbers-at-age estimates, incomplete data, mis-specified angler behavior). The GOM cod catch estimate is limited by strong dependencies on certain inshore regions and seasons within management areas. The GB cod estimate is overly dependent on SNE for data input. Similarly, there is very little catch in eastern GoM.

MRIP protocol suggests Percent Standard Error (PSE) should be kept below 0.3 and anything greater than 0.5 is of serious concern for accuracy. Overall, the GoM stock take-level estimates (PSE < 0.3) are considered adequate for assessment and support use at an annual scale. GB estimates (PSE ≥ 0.5) often reflect substantial uncertainty and are overly dependent on SNE data.

How can MRIP data be used to inform potential new management areas?

MRIP data extend back to 1981, with generally high sample sizes until 2014 when fishing effort decreased, resulting in lower sample sizes in recent years. Based on the current status, it is uncertain whether or not the length-age distributions, catch estimates or total biomass, etc. will be possible to generate if management areas are further divided. Once there is a better idea regarding management area changes, it can be evaluated how sub-setting the data will influence the modeling estimates.

Management Strategy Evaluation (MSE) as a Tool for Decision Making
Lisa Kerr, Gulf of Maine Research Institute

Management vs Biological structure: The ACSSWG concluded that there are five unique biological populations for Atlantic cod that are currently managed under two management units. There are several reasons why this misalignment is a concern for the management of Atlantic cod:
1) Population diversity through genetic, ecological, and demographic differences results in overall resilience and stability during volatile conditions over time (portfolio effect). For example, during a changing climate, some populations may be better adapted to cope with rising temperatures.
2) Misalignment of fishery management with biological populations and stock units can erode the population diversity.
3) Population mixing is critical to address or it will lead to misperceptions in catch estimates, indices of abundance, stock recruitment relationships, and life history parameters. If ignored, it can confound the response of a stock to management measures.

MSE modeling provides the ability to simulate the entire fishery framework. For example, if we make "X" decision, what effects does it have on the system? How might alternatives perform? MSE begins with a base "operating model" consisting of what we best understand to be happening with the fish and within the fishery. Then, simulations of data (survey and fishery) under imposed management strategies are run to generate catch advice, which flows back into the base operating model. This allows for testing of scenarios and/or management approaches, like mixed stock composition with spatial and temporal

management tools (lumping areas). Even with data poor statistical areas, there are methods to simulate the fishery dynamics depending on input goals. The MSE will still allow for unique components to be addressed.

In conclusion, meeting the goals of sustainable fishery management is difficult when statistical units do not match biology, but a range of approaches are available to best align them. The information is available from the ACSSWG and these workshops to inform alternative assessment strategies and spatial management procedures for cod. The goal is to complete the MSE analysis over the next year, in time to summarize for the research track group. The modeling framework for cod is already built, which offers a major advantage to running these simulations, so at the very least, we would be able to offer substantial insight into how alternative approaches are performing.

C. Management Tools and Themes

Several management tools and options were discussed during the five workshops. Initial ideas were presented to participants with the opportunity to add options that would be of interest. Additional themes were also raised during the discussions. Management tools and options considered included:
- Adding new spawning closures for fisheries
- Moving the western boundary line for the current US/Canada management area
- Changing trip limits/bag limits by fishery, area, and season
- Reallocating between areas and fisheries
- Adding new trip reporting requirements for fisheries
- Monitoring requirements for fisheries by sub-population
- Modifying fisheries gear
- Using sector operations plans to declare specific fishing areas
- Modifying management unit boundaries
- Monitoring the lobster fishery for cod bycatch
- Defining reference points for each stock or subpopulation

In the sections below, we provide highlights from the discussion of each topic, including questions, comments and responses from all participants.

Additional Spawning Closures

o These types of management closures require well-designed studies, often paired with input from fishermen, to best inform managers. This information can be used to target specific habitats to identify when and where cod are spawning, like the current measures in Massachusetts Bay and the Whaleback area.

o *Lessons learned:* Is there ongoing research to assess effects of current closures? Spawning closures have been in place on GB for about four decades but during that time stock status has not improved.

o Protecting spawning components may be key to managing cod's biological stock structure. The misalignment of the current management approach with the true biological nature of the sub-populations could be inhibiting rebuilding efforts.

o Spawning closures are broadly effective tools if appropriately scaled with a catch quota in mind. They protect a sensitive life stage and reduce mortality while fish are at a high density, but science

then needs to look at recruitment trends and survivorship. In addition, shifting distributions and timing of spawning activity should be considered, especially during changing ocean conditions.

o Closures must be focused if they would be established in SNE for example in waters off Point Judith, RI. Groundfish fishing in SNE is focused on flounder, as cod specific trips would be unique. The spawning closure concept has potential but it must incorporate these other fisheries in certain locations that aren't targeting cod. It can't be a mobile rolling closure.

o Since SNE cod are distinct winter spawners, a spawning closure for SNE/Cox Ledge would primarily affect the party boat fleet as there is limited fish to target with the exception of cod, at that time of year.

Gear Modification Options

o The potential benefit of gear configuration to management is that specific gear could allow the industry to access abundant fisheries while avoiding the overfished species.

o A key consideration is that some gear options that might work in GB will not work in SNE. Gear can be developed for a specific region/habitat. In SNE, the gear is designed to target flatfish and boats would need to be re-rigged to catch cod. There are no universal gear types across these management areas and there are many options to consider (haddock separator, Ruhle trawl, etc.) that each require substantial research.

o Gear modifications, instead of habitat closures, allow for continued fishing but also require support by science. For example, the recently approved large mesh belly panel on GB required evidence that certain standards for reduction in catch were met prior to approval by managers.

o An off-bottom trawl has recently been tested on GB; it has little or no bottom contact and is designed to catch haddock with less bycatch than the Ruhle trawl. Much like the Ruhle trawl, almost no cod were caught with it. A final report on this development? is currently available.

o The industry needs a gear code with a better method of reporting gear type (e.g., square vs diamond cod ends) that would help organize future data streams. Observers might be recording this information at times on boats, otherwise there is no method for reporting.

o Some general disadvantages are that gear restrictions require expensive, preliminary research and are then risky for the fishery to adopt.

Options for Improving and/or Additional Reporting Requirements

o More accurate, finer scale and timely data are required for a new management structure. Although additional outreach and active reporting might be required, the shifting strategy towards electronic trip reports provides the potential for finer spatial scale data collection with new biological information (spawning condition fish). Multiple fishing areas have always presented complications, so any new data streams would be helpful in addition to the observer data.

o Concerns about unintended consequence to the offshore fleet. Effort in the offshore fleet has diminished substantially over the years. Management should encourage opportunities for the remaining vessels to fish in offshore areas and harvest the eastern area TAC, rather than imposing additional barriers.

o High additional cost associated with increased monitoring. It is expensive to cover a trip but if we implement new sampling, there should be increased observer training for better data sets and including other fisheries (lobster) for new data sources. Some of the current observer protocols do not provide the necessary biological or spatial data and a cost benefit analysis may be required to execute more efficient sampling.

o There are concerns that the mixed-stock fishery catch would not be sampled in a representative manner that characterizes true populations. There are many challenges to monitoring, especially in real time, and the nature of the otolith technique is overly dependent on postmortem port sampling.

o There are not enough NMFS trawl survey data alone to provide a sense of the relative proportions in the ocean. Input beyond the surveys includes catch composition data from commercial and recreational fisheries. NMFS would need to differentiate between the stocks using other forms of assessment from an analysis perspective.

o The goal for monitoring subpopulations is to describe the mixture. Therefore, managers don't require overly fine-scale observer at-sea programs. Assessment relies on the assumption that the port sampling is representative of commercial catch but with subsampled fin clips (genetics), we could monitor the catch of most stocks.

o More effort should also be devoted to acoustic detection and monitoring of spawning aggregations. There is an important winter spawning aggregation on the NW corner of Stellwagen Bank that SBNMS and NEFSC have detected successfully with acoustic receivers. Spawning aggregations can be ephemeral and therefore difficult to sample with traditional techniques, whereas acoustic receivers are out there all the time listening 24/7. There is a need to deploy more of them in more areas and this requires personnel to analyze the data.

o To proactively improve reporting, some sectors are using the "Gulf of Maine Declaration" and this should be considered. The sector assessment tool allows for allocation of catch between areas from an otherwise pooled quota to minimize the risk of overages.

o Port sampling is problematic when fishing occurs in multiple stock areas. Therefore, historical data may be difficult to decipher, and future port sampling strategies should be reconsidered when there is multi-area fishing.

Improving Recreational Data Collection

o In the Mid-Atlantic Tilefish industry, recreational reporting is within strict geographic boundaries. If this required reporting strategy seems efficient, it may open the door for a similar approach with cod and improve the imprecise MRIP data.

o There is a data gap in spatial resolution for recreational fishing. This workshop series and research track process would be a great opportunity to establish new multi-stock recreational harvest data with specific boundaries. Federal vessel trip reports are capable of establishing boundaries like they have done successfully for the commercial industry. When a recreational fisherman moves between areas, they can submit a sub-report to dramatically improve on MRIP data sets. However, even if we know a trip occurred in two management areas, there are still complications with catch apportionment by area within that trip.

o Unlike some of the error proof commercial reports, a basic punch error can really make a difference in the recreational data where there is no backup or additional record of that trip. An auditing process should be put in place to ensure accuracy on any new reporting for recreational fishery.

o The idea of recreational fin clip sampling programs was proposed, which would be feasible to monitor the stock composition moving forward. NEFSC also has the capability to differentiate with samples in hand. The challenge is looking at historical data sources and establishing reference points, which is essential in management.

o A smart phone app or user-friendly website could be offered to more efficiently collect recreational data. The fishing community is always looking to be involved and provide information. This could provide data for the inshore catch within three miles, where there is little information based on the current survey design. Other states already have efforts underway with varying success among species.

  • Tools such as smartphone apps must undergo a data certification process by MRIP. Once the certification process is completed, the data can be used accurately in estimates.

  • A representative sampling strategy is critical for accurate citizen data. If it is done properly, the information can be very useful but if not, it can bias data used in assessments.

o There are discrepancies between VTRs and overall catch that should be addressed to build confidence in the system before novel citizen data collection techniques are proposed.

o Pooling catch is of interest and may help in certain situations but would require detailed validations to ensure that borrowing data across stocks is an acceptable approach.

o When MRIP data are continuously split, sample sizes are reduced, and uncertainty in estimates increases. It seems unlikely that separating the MRIP data, under the current sampling design, into five independent stocks is possible.

o Could simply adding more MRIP intercepts in SNE improve some of the GB data needs?

  • Increased, targeted sampling would significantly help the assessment. If additional intercepts were determined to be a priority in GB, sampling rates could be increased at well-known cod catch locations. This strategy may reduce estimates for other locations where those data were being assigned but that could be addressed.

  • Improved spatial and temporal sampling strategies would provide better estimates since much of the catch occurs during predictable, seasonal windows.

o Measures should be considered in future years to prevent the lack of "pay back" in the recreational fishery if catch target is exceeded.

o The recreational assessment in SNE and GB reliance on MRIP estimates of catch is concerning. Statistical strength of these estimates for targeted management recommendations is weak and should only be considered at larger spatial scales where they are more applicable.

o The recreational sampling requires significant improvement and must be done in a manner that is representative of spawning populations.

o Concern that the for-hire fleet catch is underestimated while the overall recreational harvest (for-hire plus anglers) is over-estimated. Personal fishing records are significantly different compared to

the entire state. This might be due to the mobile strategies of fleets that target the most active areas and can only be addressed through better reporting methods.

o The for-hire fleet is currently under-utilized as a data-source, and a census reporting system could be considered to free up funding for additional intercepts. Fishermen need more confirmation that the data collected are being used.

o Recreational fishermen could register for groundfish harvesting and be strategically monitored. Much of the on-board data for the for-hire fleet is useful but unclear how consistently it is collected across states.

o Recreational harvest could be better estimated by state, not stock.

Using Mixed Stock Composition Analysis in the Winter/Spring Spawning in the Western Gulf of Maine

o How would mixed composition analysis be implemented and how can it be used practically to provide cost effective and efficient, real-time information? What does it look like in terms of implementation? (and would these data be available in time for assessment?)

o Skepticism was expressed about the possibility of doing what is needed within a season because available techniques (otolith and genetics) are slow. It is logistically challenging and may be too costly.

o Cost can be high but many other fisheries have routine, in season monitoring that have proven effective for assessment. Otoliths are being used in season to age the catch, while at the same time they can be used to delineate stocks. Adrienne Kovach (UNH) has genetic markers that are also effective if implemented and the monetary costs for these technologies are continuing to improve. If samples can be collected in an efficient manner, then it is possible to do the rest in season.

o Are resources available to monitor the two western GoM stocks, with separate allocations, at commercial scale? What are the cost/benefits to the industry of doing this in a real-time manner? Many assessments have data needs on a weekly basis in terms of frequency.

o Cod would likely need to take a similar approach to salmon and herring examples where sectors could get an allocation at the end of the season.

o Any added costs would mean less fishermen would be interested in participating.

o What is the capacity of NOAA to implement this level of a sampling program in a complex industry?
- One potential approach in which NOAA would not need to significantly expand their current sampling program - Otoliths are already sampled and used for age composition, so those same samples could be used for stock composition. This may require some added time at a microscope to process individuals, but it would not be likely to require additional, large scale sampling.
- Commercial catch is already represented adequately from surveys and port samples. Real-time monitoring is less realistic but seasonal/annual assessments are doable.
- Port sampling has been cut dramatically and it's not yet clear how many samples would be available after 2020.
- It would be difficult to have separate allocation/management for spring and winter spawners. It can be factored into assessments, but not practically managed. Annual (end of season) stock

composition analysis is the most realistic approach because the resources are not available to perform it within a season.

- Are there things we still need to know to have ability to do within season stock composition analysis?
    - Startup cost, ability to analyze archived samples for historic reference points
    - Resource allocation for sampling each year
    - How would the assessment translate into management?

Changes in Management in Fishing Areas 464 and 465

- Areas 464 and 465 have a component in US waters where catch is currently considered as part of the GoM unit but it appears that is the "Scotian Shelf" biological group.

- Areas 464 and 465 are currently included in the GoM regulatory definition/assessment. All US cod catch must fall within designated stock areas to avoid mis-reporting, but we can't speak to what proposed management may account for at this time.

- This area discrepancy can be resolved during the stock assessment process and will depend on how areas are re-drawn to best incorporate accurate catches.

- Catches on the U.S. side of the Hague line in areas 464, 465, and 511 are assigned to the Gulf of Maine unit, whereas catches on the Canadian side of the Hague line in these areas are assigned to Canada.

- This topic is important to consider because many fishing out of Maine fish in these areas.

Discussion of Additional Factors to Consider

- How well can climate change and other external factors be incorporated into the MSE process and resulting decisions? Factors like climate change are complicated and will involve some assumptions, but yes, it is within the capacity of MSE models.

- Specific to Cox Ledge, the effects of offshore wind development should also be considered. It would appear we are introducing new science while simultaneously altering the area in other external ways.

- We should also focus on managing external factors like predation (seals) that are influencing the cod population.

D. Exploring Scenarios & Evaluating Tradeoffs

There are a range of possible scenarios that can be considered as alternative options to better align management boundaries with our new understanding of biological stock structure. Several options were explored to elucidate the issues that will need to be considered and weighed before changes in management of Atlantic cod are initiated. The four scenarios explored included (Fig. 4):

Option 1: Status Quo – Current two management units; Gulf of Maine and Georges Bank

Option 2: Three Unit Structure – Extending the GoM down the channel to included winter/spring, redefining Georges Bank, and adding a separate SNE unit

Option 3: Four Unit Structure - Adding a separate Eastern Gulf of Maine management unit to the above

Option 4: Two Unit Structure - Redefining the Georges Bank unit as "offshore" and defining the remainder of the management area as "inshore"

Participants were assigned to break-out rooms in which they selected their choice of two options to discuss. Some participants choose to consider a fifth option – the five biological populations identified by the ACSSWG. Discussion points from all scenarios are summarized across all break-out rooms below.
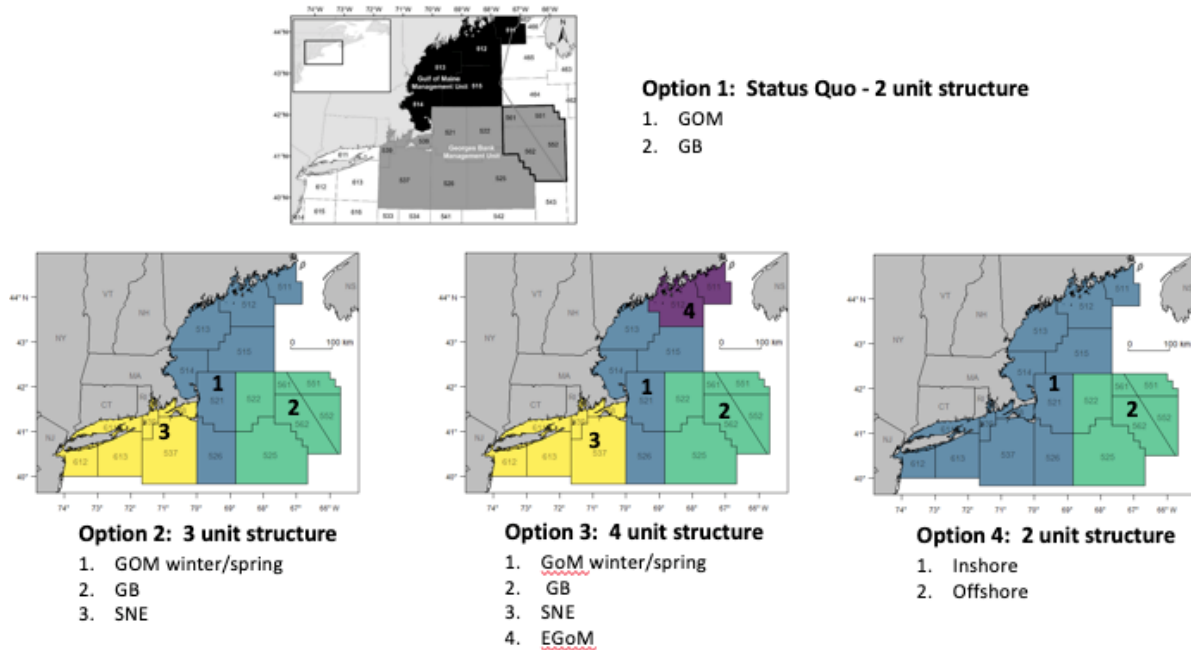

Figure 4. Four Alternate Management Scenarios discussed by participants at Management Workshop #5.

Option 1: Status Quo – Current Two Unit Structure

Advantages:
- Data are already available for this assessment process
- Keeping stock structure the same will more likely result in a robust analytical model
- Limits complexity of redefining management boundaries (i.e., more units complicates management, causes enforcement challenges, and leads to inadequate assessment data)

Limitations:
- Status quo does not take into account current understanding of the biology of cod and risks perpetuating existing ineffectiveness in the management.
- Current structure does not allow dedication of resources for data collection, although additional monitoring will take place through implementation of Amendment 23.
- May result in mis-specified stock assessments (e.g., GB retrospective patterns may be from mis-specified stocks).
- Environmental changes may alter distribution patterns within management units.

Considerations/Additional Management:
- Cod populations are in poor shape with no signs of measurable recruitment occurring. If a restructuring of management units does not occur, is there a way to preserve population structure in the current regiment?

- In principle, it would be difficult to move forward with status quo considering that the overall objectives of fisheries is to rebuild stocks. Changes must represent a balance between National Standards and practical applications with all associated tradeoffs considered.

Option 2: Three Unit Structure (GoM winter/spring, GB and SNE)

Advantages:
- Better reflects the strongest conclusions from ACSSWG. (Not lots of tagging data from eastern GoM. The eastern GoM is most likely separate, but the evidence is not as strong.)
- This is also in agreement with National Standard 3 which stated that stocks should be managed according to their biological units.
- Both options could be communicated effectively and justified to the fishing industry with practical management actions associated with each unit (spawning closures, mixed stock analysis, etc.)
- Slightly less complexity than a 4-stock option.
- Relatively easier process to compile data for the assessment (relative to option 3, four unit option).
- Fewer confusing regulations for the industry to follow (relative to option 3, four unit option).

Limitations:
- Some areas are data poor (SNE and eastern GoM) but unique units may allow better tracking of depleted population(s). It may be possible to apply weakest link approach but not easily.
- The option would require additional resources (staff capacity, funding, time etc.) for rebuilding plans and assessment across the different stocks.
- Revisions to the transboundary processes would be complicated and challenging.
- The reallocation of catch would be a major component to resolve and require further considerations.
- Challenges to differentiate/allocate catch among some boundary lines.
- Inability to tailor management to a particular stock when stocks are lumped together.

Considerations/Additional Management:
- Boundary lines are reviewed based on data availability. (In reference to the eastern GoM area, in case the stock/science changes in the future and it makes sense to add back in the eastern GoM unit).
- Additional spawning closures
- Stock composition analyses would be needed to separate the winter and spring spawning populations.
- Consider a separate recovery plan for eastern GoM.

Option 3: Four Unit Structure (GoM winter/spring, GB, SNE and eastern GoM)

Advantages:
- Closest to the ACSSWG's spatial structure of cod (i.e., most accurate to date) with the exception of separating the GoM spring and winter spawners.
- Practical advantage to additional splits (four units vs. just two - inshore/offshore).
- Does well to differentiate SNE compared to other proposed options.

- Addresses some shortfalls of the MRIP data to better capture recreational fishery catch by area or potentially broader area.
- Some areas may be data poor but defined unit allows better tracking of depleted populations. Stocks can still be assessed with index-based approaches.
- Difference in fishing effort in GoM. Virtually no commercial effort in eastern GoM. This proposal would allow us to set a quota/management practices consistent with population abundance.
- May be easier communication with industry if we can tailor management actions by area.
  - If management units are aligned with stocks we can tailor management actions by stock. E.g. managing recovery of Downeast Maine (eastern GoM) independent of western GoM where fisheries could benefit from more localized regulations. Currently overlapping management units can complicate management.
- Proposed boundary also more closely reflects relevant ecological conditions re: productivity. Headed towards ecosystem-based management.

Limitations:
- Eastern GoM and SNE are data limited and would require a data-limited assessment.
- Additional manpower required to have rebuilding plans for all the different stocks; an issue could be workload increase, more time consuming, and need for additional resources.
- Difficulty in tracking catch and reporting to the statistical areas.
  - We have a high degree of confidence about the [management] area, but we have vessel trip reports that don't match VMS or what we get from reporters because it's usually one point from what could be several weeks. Difficult to match to management area unless limiting where people fish, however, we do have good technology for doing this.
- Differentiating GoM spring and winter spawners from GB due to proximity. Considering the status of recreational reporting, MRIP would struggle to differentiate cod from along the boundary lines of proposed areas.
- Ignores the separate winter and spring spawning populations in the western GoM; would require additional management to address that.
- Self-reporting by private anglers brings up issues of representativeness, and resolution of spatial accuracy (e.g., rather than having them report by statistical area, use geographic region for increased accuracy).
- Adapting MRIP data to be more state specific spatially (e.g., Massachusetts) would be helpful but also poses challenges.
- Some areas do not have enough biological samples occurring.
- We don't know what data poor methods will produce - optimistic/pessimistic; may be more legal constraints for the fishermen.
- Reallocation would be major component.
- It could add expense to monitoring program.
- Increased management complexity would increase number of rules that fishers and managers have to keep track of.
- Potential for catch allocation issues. Might unfairly affect how much some fishermen are able to catch based on data shortcomings.
- Any revisions to the transboundary processes seem to take a lot of time/resources**.**

Considerations/Additional Management:

- For eastern GoM, we have little data, but is the lack of data a barrier to making it a management unit? Could it be a separate stock area, declared overfished and managed as a no possession or research only fishery?
- We don't have the resolution because vessels fish in multiple areas. Our current system may allow for maximum flexibility, but is that becoming a barrier to our management of the stocks? Should a trip be restricted to a single area? Would increased assessments using otoliths make it easier to attribute to different areas?
- Other management: Gear considerations and spawning time/space closures should be considered to better fit the changing areas.
- A phased approach is common and possible to cod management (e.g., start with spawning closures, then address boundary changes, and any additional measures).
- Research could be directed to support better management.
- This model would require new methods (stock composition analysis) to monitor the winter/spring spawners accurately and efficiently.
- Would require measures that consider timing and areas of these critical winter/spring spawning populations.
- How to address winter/spring overlap in western GoM: Spawning closures, stock composition. Spawning closures are the lowest hanging fruit since already in effect.
- Spawning closures could be considered in SNE and eastern GoM.
- Discards/bycatch from lobster fishery may need to be considered. Are they reported? Separating eastern GoM could make it easier to report.
- Some participants opted to discuss a *five unit management model,* consistent with the conclusions of the ACSSWG. The limitations were similar to those above, and the primary advantage was a complete alignment of biological populations with management units.

Option 4: Two Unit Structure (Inshore – Offshore)

Advantages:
- Acknowledges the connectivity between SNE around the backside of Cape Cod and GoM.
- Stock assessment is simpler just because you only have two stock areas.
- The recreational fishery regulations diverge in the GoM and the GB-SNE area; GoM is only open 4 weeks a year for 1 fish and SNE has 10 fish at a time year-round. Potential value in having consistent regulations, from an enforceability perspective and equitability. But will a singular measure across a region ignore biological structure?

Limitations:
- If there's a gradient in growth rates between inshore and offshore areas, they would need to be accounted for.
- If Council sticks with catch shares then anyone with catch shares in 521/525 may transfer into the GoM area and managers may have to deal with these shifts.
- The allocations based on catch history would look very different than they currently do. Vessels in sectors with allocation history based on SNE or close to Cape Cod could move allocation around within the sector and open the GoM to additional fishing pressure. During the transition to sectors in the first place, vessels that fished offshore got GoM quota and vessels with a lot of quota found it more profitable to stay closer to home than going to their traditional offshore grounds, which some have argued contributed to overfishing throughout 2009-2012.

- Logistical challenges and impacts of dealing with reallocation issues.

Considerations/Additional Management:
- Review previous efforts: Were there conversations in 2010 about inshore-offshore? What were the thoughts back then?
    - There was discussion just for the split occurring in the GoM as a management-based alternative but ignoring biological structure
- Have there been conversations about keeping 521 and 525 as a separate stock?
- How do you minimize the impact of choosing winners and losers which will happen with reallocation? Can you realign and allocate with creative methods to focus on equity and not demolishing businesses?
- Allocation does not need to follow management areas, but the total allocation to the area needs to match allowable catch.
- Allocation is a Council decision but could be done in various ways, including but not limited to:
    1. Apply the current approach to allocation to the new areas – re-allocation
    2. Manage the current allocation in sub-areas - allocations and sub-allocations
    3. Split up the fisheries allocations more – recreational allocation is currently only in the GoM stock areas, not other areas
    4. Develop a new approach to allocation to the new areas – complete revision and re-allocation
- Option 4 may be most appropriate than other options: Not splitting pie many ways by having 2 management units, assessment can functions "as-is"; Con is mixing biological units together. In essence some fishermen may be happy and some not when they see what is in their portfolio if the pie gets sliced even more.
- In-shore populations get lumped together including recreational and commercial vs. GB harvest primarily commercial fishery.
- It does not completely appeal to biological units but more than status quo does.

Evaluating Scenarios: Comments Specific to the Recreational Fishery

- The Council could consider managing three stocks areas (GoM, SNE, and GB) since assigning the GoM Winter and Spring spawners will be too difficult for management. The GoM season could be slightly expanded and require anglers to use a reporting app or website. SNE and GB limits should remain the same but require them to contribute into assessments (MRIP and databases).

- If there are bag limit differences (1 vs 10 fish) across fine scale, imaginary boundary lines, this could lead to enforcement challenges. Bag limits in SNE are generous so they may not be affected but other boats would be tempted to make longer distance trips.

- Boundaries are less impactful in southern states and in GB where less private angling occurs, but starting in SNE (Massachusetts) the allocation gets complicated trying to choose a statistical area.

- Management measures focused on the species biology impact states differently within stock boundaries. For example, the brief spring (April) recreational season in GoM works to protect spawners off Massachusetts, but further north that's still too early for cod in Maine. If boundary lines are adjusted, temporal and spatial measures need to consider these seasonal differences among states.

- o Estimating recreational catch has lots of uncertainty. If we take away two statistical areas we make it a smaller sample size for SNE, which will increase uncertainty.

Additional Comments Regarding Management for Consideration

- o Observer ramifications of changing stock boundaries?
    - Reallocate trips based on stock area.
    - Port sampling assignments divided by stock. E.g., additional samplers for eastern GoM would take them away from other docks.

- o Some fishermen may cross management lines and misreport what area they're in. Do we create an incentive to misreport stock area, if you don't have to go as far to cross boundaries?

- o Considering practical limitations, the five stock option should remain in the back of minds as the ultimate goal.

- o Be flexible for adaptation as assessment issues arise. Start with all best available science/data (tagging studies, genetic analyses, surveys) and don't allow for initial data limitations to deter from best possible approaches for biological populations. The four stock unit is a practical compromise but fewer management areas loses sight of the resource management goal.

- o Major issues are growth rates, maturation rates for subunits/genetic units that affects minimum size rates.

- o There needs to be consideration for unique features of populations and scales appropriately.

- o Aren't current efforts to reduce mortality through spatial and temporal closures enough?

- o Regardless of the management area, the target is to rebuild stocks by 2024. Based on all the presented available data and surveys, it is hard to see that trend occurring. If managers are not going to achieve that goal, then when/how will the new boundaries matter?