Northeast Fisheries Science Center Reference Document 22-07

Management Track Assessments Fall 2021

April 2022

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Management Track Assessments Fall 2021

Northeast Fisheries Science Center[1]

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

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Northeast Fisheries Science Center (NEFSC)
Reference Documents

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abbreviations and Acronyms

AOP Assessment Oversight Panel 1, 3, 8, 9, 11–15, 21, 23, 32

ASAP Age-Structured Assessment Program 11–13, 23, 28, 32, 33

ASMFC Atlantic States Marine Fisheries Commission 6

CRD Center Research Document LII

CSE Council of Science Editors LII

GARFO Greater Atlantic Regional Fisheries Office 6, 7, 13

ISO International Standardization Organization iii, LII

MA DMF Massachusetts Division of Marine Fisheries 6, 7, 9, 13, 31, 32, 41

MAFMC Mid-Atlantic Fisheries Management Council 9, 13

ME DMR Maine Department of Marine Resources 6, 7

MRIP Marine Recreational Information Program 23, 31, 33

NEFMC New England Fisheries Management Council 3, 6, 7, 13, 34, 36

NEFSC Northeast Fisheries Science Centre III, 1, 3, 6, 7, 9, 11–13, 18, 19, 21–23, 27, 28, 30, 32, 41, LII, LIII

NMFS National Marine Fisheries Service 22, 31, LIII

NOAA National Oceanographic and Atmospheric Administration iv, 1, 6, 9, 13, 19, 42, LIII

NRCC Northeast Regional Coordinating Council 5, 9, 11, 13

NYDEC New York Department of Environmental Conservation 13

PDF Portable Document Format, ISO 32000 III

PDT Plan Development Team 32

RI DEM Rhode Island Department of Environmental Management 9, 13

SARC 55 55th Stock Assessment Review Committee meeting 30

SAW Stock Assessment Workshop 36

SAW 55 55th Stock Assessment Workshop 11

SMAST School for Marine Science and Technology (New Bedford, Maine) 6, 13

SSC Scientific and Statistical Committee 1, 3, 5, 9, 11, 13, 23, 35

TRAC Transboundary Resources Assessment Committee 20

Abbreviations for fish stocks reviewed

These are the abbreviations for fish stock names, as seen in the footers of each of the fish stock reports.

BASUNIT Black Sea Bass iv

CODGB cod from the Georges Bank iv, 18–27

CODGM cod from the Gulf of Maine iv, 28–41

Black Sea Bass

Atlantic Cod

Images from NOAA Fisheries and FishWatch.gov.

The reason behind it all.

Statistical/review concepts, parameters, etc.

ABC acceptable biological catch 11–13, 23

BRP biological reference point 3, 4, 14, 16, 22, 34, 35

BSB black sea bass 12, 13

BSIA Best Scientific Information Available 21, 32

CDF cumulative distribution function 34

Covid refers to coronavirus pandemic years, 2020–2021 33

CPUE catch per unit effort 35

F (instantaneous) fishing mortality rate 4, 12, 19, 30, 31, 33, 34, 38

F_{Full} fishing mortality on fully selected ages 19, 28, 30

F_{MSY} fishing mortality for maximum sustainable yield 28, 32, 34

$F_{MSY\,proxy}$ proxy estimate of fishing rate for maximum sustainable yield 19, 28, 30

$F_{\mathsf{Threshold}}$ threshold fishing mortality level that indicates overfishing status 38

$F_{40\%}$ fishing rate at 40% of the total catch 28, 30, 32, 34

kg/tow kilograms per tow 18, 19, 21, 23

kt kiloton = thousand metric tons 28

Loess LOESS curve fitting (local polynomial regression) vi, 12, 18, 21

log-normal probability distribution whose logarithm is normally distributed 23, 27, 37–39, 41

M (instantaneous) natural mortality rate 1, 6, 15, 16, 28, 30–35, 37–39

000s thousands 28, 39

M-ramp model: natural mortality has ramped increase with time 1, 10, 28, 30–35, 37–39

ρ Mohn's rho parameter: the average relative bias of retrospective estimates 4, 10–13, 30, 33, 34, 38

MSY maximum sustainable yield 19, 28

mt metric ton 18, 19, 21, 22, 28, 30, 32, 34

NA not applicable 19

OFL overfishing limit 12, 13

PlanBsmooth 'Plan B' model using log-linear regression and Loess smoothing 12, 18, 19, 21–23

QA/QC quality assurance and quality control 3

SSB spawning stock biomass 4, 19, 28, 30–34, 36, 37

SSB_{MSY} spawning stock biomass consistent with maximum sustainable yield 19, 28, 32–34, 37

$SSB_{MSY\ proxy}$ proxy value for spawning stock biomass estimation for maximum sustainable yield 28

SSB_{Target} theoretically ideal spawning stock biomass level 37

$SSB_{\mathsf{Threshold}}$ threshold for spawning stock biomass that indicates overfished status 37

TOR Term of Reference 21, 22, 32–34

Locations/regions: state, country, etc.

CA Canada 18

GB Georges Bank vi

GOM Gulf of Maine vi, 10, 11

MA Massachusetts III, vi, 8, 36, 42, LIII

ME Maine vi

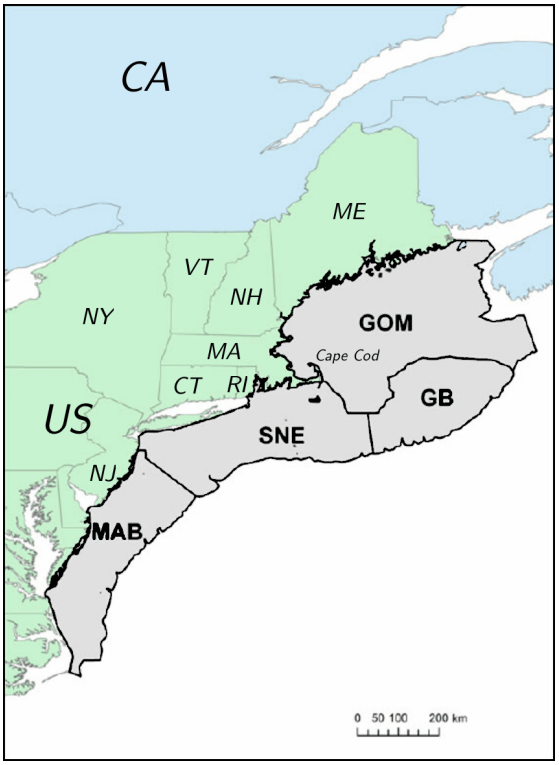
NE Northeast LIII

NY New York vi

RI Rhode Island vi

US United States 12, 18, 20, 21, 26, 36

WHOI Woods Hole Oceanographic Institute, MA 8, 42



1. 2021 MANAGEMENT TRACK PEER REVIEW PANEL REPORT

Richard Merrick[1] (chair), Adrian Jordaan[2] and Conor McManus[3]

1.1. Executive Summary

Two groundfish stock assessments were reviewed by the September 2021 Management Track peer review: Gulf of Maine Atlantic cod (*Gadus morhua*) and Georges Bank Atlantic cod. As per the recommendation of the Assessment Oversight Panel (AOP), Gulf of Maine cod was subject to an enhanced peer review (Level 3, see Appendix A: §1.2), while Georges Bank cod received an expedited review (Level 2).

The Peer Review Panel (Panel) for the September 2021 Management Track Assessments met via webinar on September 13–15, 2021. Attendance at the meeting is provided in Appendix B: §1.3, with the Agenda shown in Appendix C: §1.4. The assessments were prepared under guidelines provided by the May 2021 Assessment Oversight Panel (AOP, Appendix D: §1.5). These guidelines provide a pathway for continuing development of previously accepted assessments for each species including incorporation of the most recent data and understanding of biology of the species being assessed.

We thank Russ Brown (Population Dynamics Branch Chief) and Michele Traver (Assessment Process Lead) for their support during the meeting. We thank the staff of the Population Dynamics Branch at NEFSC for the open and collaborative spirit with which they engaged the Panel. Our thanks extend not only to the analysts for each assessment, but also to the rapporteurs for taking extensive notes during the meeting, to staff of the New England Fishery Management Council/NOAA Fisheries Greater Atlantic Regional Fisheries Office, and to representatives of the fishing industry who provide context and additional background.

The Panel has suggestions for improvements that could be made for the next Management Track Assessments. With respect to information needs:

1. It was very helpful to have all background documents, information, and presentations available prior to the beginning of a stock's review. This should include the full AOP report and summary, documentation of the current assessment, documentation of the preceding assessments back to the most recent benchmark (including peer review reports and relevant SSC reports), the most recent benchmark research track assessment (if different from the preceding), a table of the stock's status and reference points, and at least a draft version of the Powerpoint presentations.

2. Assessment update reports should match the requirements laid out in the Management Track Assessment Terms of Reference. For example, the analyst should list and respond to any review panel or SSC concerns relevant to the most recent prior assessments.

[1]NOAA Fisheries Service (retired)
[2]Department of Environmental Conservation, University of Massachusetts Amherst
[3]Rhode Island Department of Environmental Management Division of Marine Fisheries

Table 1: Stocks reviewed at September 2021 Management Track Assessment Peer Review meeting

Stock	Lead Analyst/Presenter	Peer review conclusion
Gulf of Maine cod –Enhanced review	Charles Perretti	Under retro-adjusted M=0.2 model stock is overfished and overfishing is occurring. Under M-ramp model stock is overfished but overfishing is not occurring
Georges Bank cod –Expedited review	Kathy Sosebee	Stock is overfished but overfishing unknown

1.2. Appendix A: New England and Mid-Atlantic Management Track Stock Assessments Levels of Peer Review

Level 1: Direct delivery

A Level 1 management track assessment is essentially a simple update of the previously approved assessment with new data. This level of assessment update will be delivered directly from the NEFSC to the appropriate Council or Commission technical body (e.g., SSC) and will not undergo peer review beyond that conducted by those technical bodies. Furthermore, although there will be opportunities for public input on assessments in advance during the input phase described below, there will be limited opportunity for public engagement during the assessment review, which will occur during the public comment period of the technical body's meeting.

Given the limited peer review and public engagement, only minor changes, such as those detailed below, are permissible:

- model that has been updated with revised data, with minor changes (such as small adjustments to data weights, fixing parameters estimated at bounds, correcting minor errors in previous model);
- incorporation of updated data from recent years in the estimation of biological information (growth, maturity, length-weight relationship);
- Calculate updated values for the existing BRPs using same methods.
- evaluating effects of delayed seasonal surveys or missing strata on fishery-independent measures of abundance;
- If adding or revising data reveals problems in model performance, analyst should identify concerns that may need further analyses and/or review
- If adding or revising data and implementing a Level 1 assessment after the AOP meeting results in a proposed change in stock status, the assessment warrants additional peer review and therefore qualifies for a Level 2, expedited peer review. This upgrade from Level 1 to Level 2 does not require additional AOP review, though the AOP should be informed.
- standard QA/QC procedures employed by the NEFSC.

Level 2: Expedited review

A Level 2 management track assessment can involve a little more flexibility for deviations from the previously accepted assessment, but that flexibility is limited to allow for efficient peer review of multiple assessments in one peer review meeting, similar to what previously had been carried out for Page 7 of 16 groundfish operational assessments for the NEFMC. Level 2 assessments will undergo a formal, but expedited (1–2 hour maximum), peer review by a small panel of SSC members from the relevant

Council(s), along with additional external experts if desired, before submission to the appropriate Council or Commission technical body. In addition to opportunities for public input on assessments in advance, opportunities for public engagement will occur during the public comment periods of the public review meeting and the subsequent meeting of the Council or Commission technical body. Given the moderate level of peer review and engagement, Level 2 assessments will generally use the same assessment structure and data as the previously accepted assessment, but some changes are permitted (detailed below) that warrant review by an external body. In this level, the cumulative impacts of the number of changes should also be considered; any individual change may be minor, but if there are several changes, the overall impact could be substantial and may warrant shifting an assessment to Level 3 and providing enhanced peer review.

Changes permitted in Level 2 assessments include those noted in Level 1, and:

- updated discard mortality estimates, when based on peer-reviewed experimental evidence;
- evaluating effects of delayed seasonal surveys or missing strata on fishery independent measures of abundance if significant analysis is required to characterize the effects;
- recalibrated catch estimates (e.g., transition to Marine Recreational Information Program, area allocation tables, conversion factors (whole to gutted weight))
- simple changes, corrections, or updates to selectivity, including but not limited to:
- changes to most recent selectivity stanza;
- changes to historical selectivity stanza if they are corrections or reinterpretations of previously used block time-frames;
- retrospective adjustment to management metrics following established retrospective adjustment protocols. Technically, when either the ρ-adjusted SSB or F (point estimate$/(1+\rho)$) falls outside the 90% confidence interval of the terminal year estimate, the retrospective adjustment is applied for both status determination and to the starting population for projections.
- adjustment of method for estimating biological information (growth, maturation, sex ratio, changes to length–weight relationships, etc.), when based on methods developed with sufficient peer review or justification for its use.
- Calculate new values for the existing BRPs using new or modified approach (e.g., new methods, different assumptions, etc.).
- changes in stock status, even if the underlying assessment structure and data are largely unchanged from prior assessments.

Level 3: Enhanced review

A Level 3 management track assessment will permit more extensive changes than a Level 2 assessment and therefore requires a more extensive peer review (one-half to a one full day). The flexibility in Level 3 provides an opportunity to make progress within the management track toward the Next Generation Assessments envisioned in the Stock Assessment Improvement Plan, by including more detailed spatial, temporal, environmental and species interactions within existing model frameworks. It is important to Page 8 of 16 note, however, that full achievement of Next Generation Assessments will likely require research track efforts as well. As in Level 2 assessments, public engagement opportunities will occur during the public comment periods of both the public review and the subsequent meeting of the Council or Commission technical body, as well as during the input phase of the assessment process as described below. Level 3 assessments will be reviewed by a small panel of SSC members from the relevant Council(s) as well as additional external experts as needed; any external reviewers outside of the SSC will be nominated by the Council or Commission and confirmed by the NRCC Deputies. Given the enhanced peer review, changes to most assessment elements, with the exception of stock structure, would be permitted in Level 3 assessments; however, cumulative impacts should be considered when making a determination between the changes permissible within the "enhanced review" level and changes that would require switching to the research track process.

Changes permitted in Level 3 assessments include those noted in Levels 1 and 2, and:

- inclusion of new or alternate interpretations of existing indices;
- changes to estimation method of catchability, including but not limited to:
  - empirical estimations
  - changes in habitat/availability/distribution on catchability
  - use of informed priors on catchability in a model;
- updating of priors based on new research if done on a previously approved model;
- Recommend significant changes to biological reference points, including but not limited to:
  - change in the recruitment stanza
  - number of years to include for recent means in biological parameters
  - suggestions of alternate reference points if based off a similar modeling approach (e.g., age-based, length-based, etc.).
- updating of historical selectivity stanzas;
- changing recruitment option used, meaning using a stock-recruitment relationship, or cumulative distribution function, etc.;
- changes to selectivity functional form (i.e., such as a new selectivity model) if supported by substantial empirical evidence;

- changes to fleet configuration;
- changes to natural mortality (M);
- new modeling framework. If the new framework was evaluated during a previous research track topic investigation, and the species in question was one of the examples evaluated. Through research track topics focused on methods, new models could be implemented in parallel with an accepted model and provide a basis for eventual shift to a new model through a Level 3 management track assessment. This would allow model evolution, technical innovations, and testing without the penalty of forgoing research on stock dynamics until a new Research Track process is scheduled.

1.3. Appendix B. September 2021 management track peer review meeting attendees.

Key:

ASMFC – Atlantic States Marine Fisheries Commission
NEFSC – Northeast Fisheries Science Center
NEFMC – New England Fisheries Management Council
MA DMF – Massachusetts Division of Marine Fisheries
ME DMR – Maine Department of Marine Resources
SMAST – School of Marine Science and Technology, Univ. of Massachusetts, Dartmouth
GARFO – Greater Atlantic Regional Fisheries Office
NOAA – National Oceanic and Atmospheric Administration

Panel:

Richard Merrick – Chair, NOAA Retired
Adrian Jordaan – Reviewer, University of Massachusetts Amherst
Conor McManus – Reviewer, Rhode Island Division of Marine Fisheries

NEFSC Leadership:

Russ Brown – NEFSC
Michele Traver – NEFSC

Attendees and Presenters:

Alex Dunn – NEFSC
Alex Hansell – NEFSC
Alison Frey – NEFSC
Allison Lorenc – Conservation Law Foundation
Brian Linton – NEFSC
Cate O'Keefe – Fishery Applications Consulting Team
Charles Adams – NEFSC

Charles Perretti – NEFSC
Chris Legault – NEFSC
Chris Kellogg – NEFMC Staff
Chris Tholke – NEFSC
Dan Caless – GARFO
Dave McElroy – NEFSC
Gareth Lawson – Conservation Law Foundation
Jackie O'Dell – Northeast Fisheries Coalition
Jamie Cournane – NEFMC Staff
Janice Plante – NEFMC Staff
Jessica Blaylock – NEFSC
Julie Nieland – NEFSC
Kathy Sosebee – NEFSC
Kelly Whitmore – MA DMF
Kyle Molton – GARFO
Larry Alade – NEFSC
Laura Solinger – University of Southern Maine
Libby Etrie – NEFMC Member
Lindsey Nelson – NEFSC
Liz Sullivan – GARFO
Maggie Raymond – Associated Fisheries of Maine
Mark Grant – GARFO
Mark Terceiro – NEFSC
Matt Cutler – NEFSC
Paul Nitschke – NEFSC
Rebecca Peters – ME DMR
Robin Frede – NEFMC Staff
Scott Steinbeck – NEFSC
Spencer Talmage – NEFSC
Steve Cadrin – School of Marine Science and Technology, University of Massachusetts, Dartmouth
Susan Wigley – NEFSC
Tom Nies – NEFMC Director
Toni Chute – NEFSC

1.4. Appendix C. Realized Agenda for September 2021 management track peer review

Day/Date	Time	Activity	Lead
Monday, September 13	9:00 am	Welcome/Introductions	Michele Traver
	9:15 am	Background/AOP Review	Russ Brown
	10:00 am	Gulf of Maine Cod	Charles Perretti
	11:00 am	Review/Discussion	Review Panel
	11:15 pm	Public Comment	Public
	11:30 pm	Lunch	
	12:30 pm	Gulf of Maine Cod cont.	Charles Perretti
	2:30 pm	Public comments	Public
	3:00 pm	Adjourn	
Tuesday, September 14	9:00 am	Welcome/Logistics	Michele Traver
	9:15 am	Georges Bank Cod	Kathy Sosebee
	10:30 am	Break	
	1:00 pm	Georges Bank Cod cont.	Kathy Sosebee
	2:30 pm	Adjourn	Review Panel
Wednesday, September 15	10:30 am	Review Panel findings	Review Panel
	12:00 pm	Georges Bank Cod	Kathy Sosebee

Aerial view of Woods Hole Oceanographic Institute, MA; photo ©WHOI

1.5. Appendix D. Summary of May 20, 2021 Assessment Oversight Panel Meeting

The NRCC Assessment Oversight Panel (AOP) met to review the operational stock assessment plans for 2 Atlantic Cod stocks and reviewed the revised management track stock assessment plan for Black Sea Bass on May 27, 2020 (original plan was reviewed during the February 25th AOP meeting). The Black Sea Bass stock assessment will be reviewed during the Spring Management Track peer review meeting from June 28–30, 2021 and the Atlantic Cod stock assessments will be reviewed during the Fall Management Track peer review meeting from September 13–15, 2021.

The AOP members were:

Jason McNamee – RI DEM, representing the New England Fisheries Management Council
Gary Nelson – MA DMF, representing the Atlantic States Marine Fisheries Commission
Paul Rago, Ph.D., member of the MAFMC SSC, NOAA Fisheries (retired)
Russell W. Brown, Ph.D. (Chair) – NEFSC, Woods Hole, Massachusetts.

Meeting Details

This meeting implemented the stock assessment plan reviews outlined in the NRCC stock assessment guidance document. Three background documents were provided to the Panel:

(1) an updated prospectus for each stock;

(2) an overview summary of all the salient data and model information for each stock; and

(3) the NRCC Guidance memo on the Operational Assessments.

The NRCC guidance memo was recognized as particularly relevant during the deliberations of the AOP. Prior to the meeting, each assessment lead prepared a plan for their assessments. The reports reflected both the past assessment and initial investigations. At the meeting, each lead scientist for each stock gave a presentation on the data to be used, model specifications, evaluation of model performance, the process for updating the biological reference points, the basis for catch projections, and an alternate assessment approach if their analytic assessment was rejected by the peer review panel. In one case (Georges Bank Atlantic Cod), the assessment was already being assessed using an 'index-based' or 'empirical' approach.

1.5.1. Major Recommendations for Review of Individual Stocks:

The AOP recommended several revisions to recommended review levels as summarized in the table below.

Stock	Lead	Recommended Review Level	Major Comments and Recommendations
Atlantic Cod Gulf of Maine	Charles Perretti	Level 3 Expanded Review	- Research Track peer review is planned for March 2023. - Examine the impact of following through with a ρ-adjustment. - Potentially explore, possibly through a sensitivity analysis, the inclusion of the GOM long line survey as an index. - Investigate developing a separate set of reference points for the M-ramp model. - Investigate the hinge point for the recruitment model and see where we currently are in relation to it. - Catch assumptions for projections need review.
Atlantic Cod Georges Bank	Chris Legault	Level 2 Expedited Review	- Research Track peer review is planned for March 2023. - Perform a retrospective examination of missing data points and how a modified 'Plan B' performs.
Black Sea Bass	Gary Shepherd / Kiersten Curti	Level 2 Expedited Review	- Research Track peer review is planned for November 2022. - Look into discards to see if there are any trends in recent years. - Catch assumptions for projections need review, impact of large cohort entering plus group could use review, and retrospective adjustments could use additional review.

1.5.2. Stock Discussion Summaries:

Atlantic Cod — Gulf of Maine (AOP: Jason McNamee)

The current stock assessment for GOM cod uses the ASAP assessment software program. There are two variations of the model used that differ based on the natural mortality assumptions. In the past these two models have been averaged to produce catch advice as a way to account for scientific uncertainty. The assessments exhibit retrospective patterns that have worsened over the past several updates of the model.

The assessment will be updated with 2019 catch and survey indices, with no other modifications proposed. Since the last benchmark of the assessment during SAW 55, the retrospective has gotten progressively worse with each update. It is unknown if that pattern will persist, however if it does, the retrospective would likely warrant a ρ-adjustment. ρ-adjustments have not been performed to date as they were not used for the SAW 55 assessment, and that procedure had been followed in each update since. The overall magnitude and impact of the retrospective pattern is not known for the current management track assessment but concerns about the need for potential ρ-adjustments suggest an additional level of peer review was appropriate.

The AOP recommended that the GOM cod assessment be increased to a Level 3 review. Several aspects of the assessment update were discussed by the AOP. Although the NRCC agreed that use of incomplete catch or survey data for 2020 would not be used in the 2021 update assessments, both the 2020 catch and assumptions about 2021 catch must be used when conducting projections. The typical assumption that the bridge year catch would be equal to the ABC is not a viable assumption for 2020 due to the impacts of the pandemic, and due to the fact that two bridge years are needed in this case, an estimate for 2020 and projection for 2021 must be supplied. Generating recreational catch estimates for 2020 is another uncertainty that can be attributed to generating catch estimates during the pandemic year. The Plan Development Team will likely offer some bridge year catch options for consideration. These choices warrant additional review.

Additionally, the key finding from the Index-Based Methods Working Group and Review was that ρ-adjusted age-based models typically outperformed all of the candidate index-based methods. Should the current GOM cod models continue to exhibit large retrospective patterns, rather than defaulting to the alternative index-based model, a ρ-adjusted ASAP model could be used for stock status and for initializing projections per these findings. The choice of using a ρ-adjustment versus an alternative assessment warrants additional review.

The AOP also discussed the addition of the GOM long-line survey into the assessment with the analyst, though he stated his preference would be to leave that for an upcoming benchmark assessment. And finally, the AOP discussed the difficulty the NEFSC SSC has had with generating catch advice for this stock due to the complexity of having multiple models. Whether or not unique reference points could be generated for each model was discussed and whether that might provide additional information into the catch advice process. The only way this could be accomplished would be through a Level 3 review. Collectively, these uncertainties and discussions at the AOP meeting compelled the AOP to recommend a Level 3 Review as the most appropriate level of review for this stock.

Atlantic Cod — Georges Bank (AOP: Gary Nelson)

Available catch data include US commercial and recreational landings and discards, and Canadian commercial landings and discards will be updated through 2019. The Georges Bank Atlantic Cod assessment will employ a 'PlanBsmooth' approach which fits a log-linear regression to the last three years of Loess smoothed values of the average of the NEFSC spring $(t+1)$ and autumn (t) survey index updated through 2019. The slope parameter of the regression is then back-transformed to obtain a multiplier which is applied to the average catch of the three most recent years to obtain the ABC.

Due to the COVID pandemic, an update of the model is hampered by lack of NEFSC bottom trawl surveys and limited catch sampling in 2020. It was proposed that the 2019 autumn survey index represent the average survey value for 2020, and that the 2021 spring survey index represent the average for 2021. The Loess smooth would be fitted through 2021. If the New England Fishery Management Council Plan Development Team can develop a catch estimate for 2020, the average catch from 2018–2020 would be used to determine the ABC otherwise, only catches from 2018–2019 will be used. The PlanBsmooth approach does not produce biological reference points, so the OFL is unknown for this stock. The stock is considered overfished due to low abundance despite lack of a reference point. There is no alternative assessment plan for this stock.

The Assessment Oversight Panel recommends moving the assessment review to Level 2 because they believe that retrospective analyses are required to examine the sensitivity of the model output to the proposed changes in calculation of the survey time series, and that the analytical results should be reviewed before the ABC for the Georges Bank cod stock is updated. Note: shortly after the AOP meeting, a retrospective analysis was conducted and shared with AOP (available at Github:PlanBsmooth). The members of the AOP felt this analysis demonstrated that the PlanBsmooth approach produces similar results when both surveys in a calendar year are missing at the end of the time series compared to having these survey values.

Black Sea Bass (AOP: Paul Rago)

The AOP had previously reviewed the Black Sea Bass (BSB) at its Feb. 25, 2021 meeting. At that time a Level 1 review (direct delivery) was recommended but it was noted that the presence of the retrospective pattern was problematic, particularly if it increased above the levels observed at the previous assessment. Gary Shepherd, lead assessment scientist for BSB, notified the AOP of the emerging problem for the Northern component of the stock, which led to further consideration of the proposed review level by the AOP at this meeting. The current stock assessment for BSB is based on Northern and Southern component models using the ASAP software. Both components exhibit retrospective patterns but they are in opposite directions. In the North a positive value of Mohn's ρ indicated consistent over estimation of F whereas the opposite pattern held in the south. The derived average F for both areas was below the threshold F and overfishing was not occurring.

The updated assessment with 2019 catch and survey indices resulted in an increase in the magnitude of the retrospective pattern in the North. The overall impact of the increased retrospective pattern for status determination is not known but concerns about the need for potential adjustments to model structure or outputs suggest an additional level of peer review was appropriate.

The AOP recommended that the BSB assessment be increased to a Level 2 review. Three other aspects of the assessment update are noteworthy. First, the 2020 recreational catch exceeded its catch limit. Although the NRCC agreed that use of incomplete catch data for 2020 would not be used in assessments, both the 2020 and 2021 catches must be used when forecasting the 2022 OFL. The typical assumption that the bridge year catches equaled the ABC is not tenable for 2020, so an overall estimate for 2020 and projection for 2021 must be supplied. Second, a key finding from the Index-Based Methods Working Group and Review was that the ρ-adjusted age-based model typically outperformed all of the candidate index based methods. Should the current BSB model be judged unacceptable due to its retrospective pattern, one could argue that an index based alternative model would be inferior to the ρ-adjusted ASAP model. Third, the large 2011 cohort entered the plus group in 2019 for the first time. This resulted in a change in average weight at age for this group of fish of age 8 and older. Past experience suggests that entry of large year classes can induce changes in model behavior. Collectively, these considerations suggested a Level 2 review was appropriate.

AOP Process Discussion and Summary:

The NEFSC continues to seek meaningful stakeholder engagement in formulating stock assessment plans for management track assessments. In summary, the meetings were productive and an effective implementation of the new assessment planning document. The peer review panel will meet from September 13–15, 2021 to complete their review.

Meeting Participation:

Russ Brown – NEFSC, AOP Chair
Gary Nelson – MA DMF, AOP member
Paul Rago – MAFMC SSC, AOP member
Jason McNamee – RI DEM, AOP member
Michele Traver – NEFSC
Alex Dunn – NEFSC
Alex Hansell – MA DMF
Anthony Wood – NEFSC
Cate O'Keefe – Fishery Applications Consultant
Charles Adams – NEFSC
Charles Perretti – NEFSC
Chris Kellogg – NEFMC
Chris Legault – NEFSC
Dave McElroy – NEFSC
Fred Serchuk – NOAA Fisheries (retired)
Gareth Lawson – Conservation Law Foundation
Gary Shepherd – NEFSC
Greg DiDomenico – Lunds Fisheries
Jacqueline O'Dell – Northeast Seafood Coalition
Jamie Cournane – NEFMC
Janice Plante – NEFMC
Jessica Blaylock – NEFSC
John Maniscalco – NYDEC
Julie Nieland – NEFSC
Kathy Sosebee – NEFSC
Kelly Whitmore – MA DMF
Kiersten Curti – NEFSC
Liz Sullivan – GARFO
Lucy McGinnis – SMAST
Mark Grant – GARFO
Max Grezlik – SMAST
Melanie Griffin – MA DMF
Paul Nitschke – NEFSC
Robin Frede – NEFMC
Steve Cadrin – SMAST
Susan Wigley – NEFSC
Tara Trinko Lake – NEFSC

1.5.3. Assessment Oversight Panel related guidelines.

Overarching statement from the Guidance Document. "If a change proposed by an analyst is not detailed below, the AOP will determine whether the modification is permissible and which level of peer review would be required."

The following list describes elements considered by the Panel. The Panel may comment on the most appropriate level of review for each element irrespective of the suggested Guidance Level. The final recommendation should be based on the panel comments. Synthesis of these comments could potentially shift the review level even if an element from the list below does not meet the threshold for a particular recommendation.

Guidance Template for Deriving Recommended Level of Assessment Review

1. Level 1 Direct Delivery
    - Model has been updated with revised data, with minor changes (such as small adjustments to data weights, fixing parameters estimated at bounds, correcting minor errors in previous model)
    - Incorporation of updated data from recent years in the estimation of biological information (growth, maturity, length-weight relationship)
    - Effects of delayed seasonal surveys or missing strata on fishery-independent measures of abundance
    - Identification by lead analyst on potential problems of adding or revising data on model performance
2. Level 2 Expedited Review
    - Updated discard mortality estimates, when based on peer-reviewed experimental evidence
    - Evaluating effects of delayed seasonal surveys or missing strata on fishery independent measures of abundance if significant analysis is required to characterize the effects
    - Recalibrated catch estimates (e.g., transition to Marine Recreational Information Program, area allocation tables, conversion factors (whole to gutted weight))
    - Simple changes, corrections, or updates to selectivity, including but not limited to: – Changes to most recent selectivity stanza. Changes to historical selectivity stanza if they are corrections or reinterpretations of previously used block time frames
    - Retrospective adjustment to management metrics following established retrospective adjustment protocols
    - Adjustment of method for estimating biological information (growth, maturation, sex ratio, changes to length–weight relationships, etc.), when based on methods developed with sufficient peer review or justification for its use.
    - Calculate new values for the existing BRPs.

3. Level 3 Enhanced Review

    - Inclusion of new or alternate interpretations of existing indices
    - Changes to estimation method of catchability, including but not limited to:
        - Empirical estimations
        - Changes in habitat/availability/distribution on catchability
        - Use of informed priors on catchability in a model
    - Updating of priors on parameter estimates based on new research AND if done on a previously approved model
    - Recommend significant changes to biological reference points, including but not limited to:
        - Change in the recruitment stanza
        - Number of years to include for recent means in biological parameters
        - Suggestions of alternate reference points if based off a similar modeling approach (e.g., age-based, length-based, etc.)
    - Updating of historical selectivity stanzas
    - Changing recruitment option used, meaning using a stock-recruitment relationship, or cumulative distribution function, etc.
    - Changes to selectivity functional form (i.e., such as a new selectivity model) if supported by substantial empirical evidence.
    - Changes to fleet configuration
    - Changes to natural mortality (M)
    - New modeling framework, if the new framework was evaluated during a previous research track topic investigation, and the species in question was one of the examples evaluated.

1.5.4. Assessment Oversight Panel Guidance Template.

Overarching statement from the Guidance Document. "If a change proposed by an analyst is not detailed below, the AOP will determine whether the modification is permissible and which level of peer review would be required."

Table elements in the columns 3 to 5 would be factors considered by the Panel. The Panel would put its comments in the most appropriate box irrespective of the Guidance Level (column 2). The final recommendation would be based on the preponderance of the evidence of comments in each column. A summary of the cumulative effects within each Guidance Level is a row following each level. This would be an opportunity for synthesis of the evidence regarding the above factors.

Guidance Template for Deriving Recommended Level of Assessment Review

Task	Guidance Level	Direct Delivery (1)	Expedited Review (2)	Enhanced Review (3)
Model has been updated with revised data, with minor changes (such as small adjustments to data weights, fixing parameters estimated at bounds, correcting minor errors in previous model)	1			
Incorporation of updated data from recent years in the estimation of biological information (growth, maturity, length–weight relationship)	1			
Effects of delayed seasonal surveys or missing strata on fishery-independent measures of abundance	1			
Identification by lead analyst on potential problems of adding or revising data on model performance	1			
Cumulative Impact of Level 1 changes				
Updated discard mortality estimates, when based on peer-reviewed experimental evidence	2			
Evaluating effects of delayed seasonal surveys or missing strata on fishery independent measures of abundance if significant analysis is required to characterize the effects	2			
Recalibrated catch estimates (e.g., transition to Marine Recreational Information Program, area allocation tables, conversion factors (whole to gutted weight))	2			
Simple changes, corrections, or updates to selectivity, including but not limited to: – Changes to most recent selectivity stanza. – Changes to historical selectivity stanza if they are corrections or reinterpretations of previously used block time frames	2			
Retrospective adjustment to management metrics following established retrospective adjustment protocols	2			
Adjustment of method for estimating biological information (growth, maturation, sex ratio, changes to length–weight relationships, etc.), when based on methods developed with sufficient peer review or justification for its use.	2			
Calculate new values for the existing BRPs	2			
Cumulative Impact of Level 2 changes				

Guidance Template (continued)

Inclusion of new or alternate interpretations of existing indices	3			
Changes to estimation method of catchability, including but not limited to: – Empirical estimations – Changes in habitat/availability/distribution on catchability – Use of informed priors on catchability in a model	3			
Updating of priors on parameter estimates based on new research AND if done on a previously approved model	3			
Recommend significant changes to biological reference points, including but not limited to: – Change in the recruitment stanza – Number of years to include for recent means in biological parameters – Suggestions of alternate reference points if based on a similar modeling approach (e.g., age-based, length-based, etc.)	3			
Updating of historical selectivity stanzas	3			
Changing recruitment option used, meaning using a stock-recruitment relationship, or cumulative distribution function, etc.	3			
Changes to selectivity functional form (i.e., such as a new selectivity model) if supported by substantial empirical evidence.	3			
Changes to fleet configuration	3			
Changes to natural mortality (M)	3			
New modeling framework, if the new framework was evaluated during a previous research track topic investigation, and the species in question was one of the examples evaluated.	3			
Cumulative Impact of Level 3 changes. *Determine if Research Track is warranted.*				
Overall recommendation of Assessment Oversight Panel				

2. GEORGES BANK ATLANTIC COD

Katherine Sosebee

This assessment of the Georges Bank Atlantic cod (Gadus morhua) stock is a Management Track assessment of the existing 2019 operational update assessment (NEFSC in press). In the 2019 assessment the stock status could not be quantitatively determined but was qualitatively determined to be overfished based on poor stock condition, while overfishing status remained unknown (see Table 4 Legend). This 2021 assessment updates commercial fishery catch data through 2020 (Table 3, Figure 3) and updates research survey indices of abuandance and the PlanBsmooth assessment model through 2021 (Figure 4).

State of Stock: Based on this updated assessment, the Georges Bank Atlantic cod (*Gadus morhua*) stock status cannot be quantitatively determined due to a lack of biological reference points associated with the PlanBsmooth approach but is recommended to be overfished due to poor stock condition, while recommended overfishing status is unknown (Table 4). Retrospective adjustments were not made to the model results. The survey biomass in 2021 (normally the arithmetic average of the 2021 NEFSC spring and 2020 NEFSC fall surveys smoothed using a Loess, however there is no fall survey in 2020) was estimated to be 1.409 (kg/tow) (Figure 1). The 2020 relative exploitation rate (2020 catch divided by 2020 smoothed survey biomass) was estimated to be 0.19 (Figure 2).

Table 3: Catch and model results for Georges Bank Atlantic cod. Catch weights are in (mt), Biomass is the average survey biomass in (kg/tow) smoothed using a Loess, and Rel. Exploit. Rate is the relative exploitation rate (catch/smoothed survey). Model results are from the PlanBsmooth assessment.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
					Data					
US Catch	3,659	2,209	1,403	1,795	1,838	2,227	1,277	666	948	676
CA Catch	745	470	424	458	492	440	488	517	396	377
Catch for Assessment	4,404	2,679	1,827	2,253	2,330	2,667	1,765	1,183	1,344	1,053
					Model Results					
Biomass	3.13	3.175	3.022	2.428	2.919	4.257	5.09	4.532	3.768	2.698
Rel. Exploit. Rate	0.683	0.409	0.293	0.45	0.387	0.304	0.168	0.127	0.173	0.19

Table 4: Comparison of reference points estimated in the previous assessment and from the current assessment update. Note: based on NOAA's policy, the Agency decided after the 2015 assessment that the stock status would remain as overfishing occurring and overfished based on an earlier benchmark assessment.

	2019	2021
$F_{MSY\ proxy}$	*NA*	*NA*
SSB_{MSY} (kg/tow)	*NA*	*NA*
MSY (mt)	*NA*	*NA*
Overfishing	Unknown	Unknown
Overfished	Yes	Yes

Projections: Short term projections cannot be computed using the PlanBsmooth approach. The PlanBsmooth approach estimates the rate of change in the recent three years of the smoothed survey biomass to be 0.611. This multiplier is applied to the average of the recent three years of catch (1,193 mt) to produce the catch advice for 2022 of 729 mt. The PlanBsmooth approach is fully described in NEFSC (2015) and available as an R package. A Shiny app demonstrating the performance of the PlanBsmooth approach is also available. Simulations were run to examine the impact of missing survey data on the performance of PlanBsmooth. There were no large impacts found. This analysis and code are available on GitHub. An additional sensitivity run was conducted filling in the missing surveys by using fall 2019 as fall 2020 and averaging spring 2019 and 2021 to fill in spring 2020. The results of this sensitivity run changed the multiplier to 0.632 and resulted in a change in catch advice of 25 mt. The missing data code referenced above was also updated to evaluate the impact of filling in missing values. The result was that there does appear to be some general improvement using filled over missing surveys, but when the data fill approach is in error it can be wildly in error.

Special Comments:

- What are the most important sources of uncertainty in this stock assessment? Explain, and describe qualitatively how they affect the assessment results (such as estimates of biomass, F, recruitment, and population projections).

  The major source of uncertainty is the cause of the retrospective pattern that led to the analytical assessment of this stock not being accepted during the 2015 operational update meeting. The missing 2020 spring and fall surveys are also a source of uncertainty in the 2021 assessment.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or F_{Full} lies outside of the approximate joint confidence region for SSB and F_{Full}).

  No retrospective adjustment of spawning stock biomass or fishing mortality was required because there is not an accepted analytical model.

- Based on this stock assessment, are population projections well determined or uncertain? If this stock is in a rebuilding plan, how do the projections compare to the rebuilding schedule?

Population projections for the Georges Bank Atlantic cod stock are not computed. Catch advice is derived from applying an estimate of recent change in the smoothed survey biomass to the average of the recent three years of catch and thus is influenced by uncertainty in survey estimates. The smoothed survey biomass is decreasing, but without a biomass reference point it is not known if rebuilding is on schedule.

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the effect these changes had on the assessment and stock status.
  The US catches were estimated by the Groundfish Plan Development Team for the 2021 assessment of Georges Bank Atlantic cod and could not be broken down by catch disposition as has been done in past assessments.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  The stock status for Georges Bank Atlantic cod remains overfished based on a qualitative evaluation of poor stock condition.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The Georges Bank Atlantic cod stock continues to show a truncated age structure. The most recent survey values remain below the mean of their time series. The 2013 year class was larger than recent year classes, but has not continued to be large as it ages and is below the average from the 1970s at every age in both surveys.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The Georges Bank Atlantic cod assessment could be improved with additional studies on natural mortality, the potential for missing catch, and other possible sources of retrospective patterns in analytical assessments.

- Are there other important issues?
  The differences in modeling approaches between the full Georges Bank cod assessment (reported here) and the TRAC cod assessment of eastern Georges Bank (a portion of the whole bank) remain a potential problem.

2.1. Reviewer Comments: Georges Bank Atlantic cod

The 2021 assessment for Georges Bank Atlantic cod is an expedited review (Level 2) of the update to the 2019 operational assessment, as recommended by the Assessment Oversight Panel (AOP). This 2021 assessment updates commercial fishery catch data through 2020 and updates research survey indices of abundance and the PlanBsmooth approach through 2021.

The Peer Review Panel concurs with the 2021 updated assessment that stock status cannot be quantitatively determined due to a lack of biological reference points associated with the PlanBsmooth approach, but it is recommended the stock remain considered as overfished due to poor stock condition. Overfishing status remains unknown.

The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes.

Georges Bank Atlantic Cod Terms of Reference

1. *Estimate catch from all sources including landings and discards.*

   This TOR was satisfactorily addressed. US and Canadian commercial landings and discard data and US recreational landings and discard were updated with 2019–2020 data added to the time series used in the previous assessment. US recreational and commercial catches were aggregated in the reporting.

   Total catches have declined from 4,404 mt in 2011 to 1,053 in 2020.

2. *Evaluate indices used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.).*

   This TOR was satisfactorily addressed. The survey biomass index in 2021 was estimated as 1.409 kg/tow; however, the 2021 value is based only on the spring 2021 survey. Normally the arithmetic average of the 2020 NEFSC fall and 2021 NEFSC spring surveys Loess smoothed would be used, but there was no fall 2020 survey. There is a potential for bias here compared to the earlier averages because spring surveys typically show higher biomasses than fall surveys and each survey is depended on in different years. Please see below for further discussion on dealing with missing survey information.

3. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) as possible (depending on the assessment method) for the time series using the approved assessment method and estimate their uncertainty. Include retrospective analyses if possible (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.*

   (a) *Include bridge runs to sequentially document each change from the previously accepted model to the updated model proposed for this peer review.*

   (b) *Prepare a backup assessment approach that would serve as an alternative for providing scientific advice to management if the analytical assessment were to not pass review*

This TOR was satisfactorily addressed. The 2020 relative exploitation rate (2020 catch divided by 2020 smoothed survey biomass) was estimated to be 0.19.

As there were no changes to the previous assessment, neither a bridge run nor a backup assessment approach were necessary. This is the backup assessment approach, and as such, development of an analytical assessment in the next research track assessment is recommended as a priority for this stock.

4. *Re-estimate or update the BRPs as defined by the management track level and recommend stock status. Also, provide qualitative descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc.).*

   This TOR was partially addressed. BRPs cannot be computed using the PlanBsmooth approach. In the absence of BRPs, the Panel accepted a qualitative determination that the stock is overfished based on continued poor stock condition, while overfishing status remains unknown.

5. *Conduct short-term stock projections when appropriate.*

   This TOR was partially addressed. While short term projections cannot be computed using the PlanBsmooth approach, catch advice for 2022 was provided following accepted protocols.

   The PlanBsmooth approach estimates the rate of change in the recent three years (2018 Fall through 2021 Spring surveys) of the smoothed survey biomass to be 0.611. This multiplier is applied to the average of the catch during 2018–2020 (1,193 mt) to produce the catch advice for 2022 of 729 mt.

   Missing 2020 survey data could be somewhat problematic for this approach, particularly if the years smoothed are biased towards one season or the other (as spring surveys have traditionally observed more biomass than fall surveys). Because of this, the NMFS assessor was asked to conduct an exploratory analysis with imputed values for the two missing surveys (spring and fall 2020). Results with the missing 2020 fall survey set equal to the 2019 fall survey and the missing 2020 spring survey set equal to the average of the 2019 and 2021 spring surveys suggested that there would be a small increase in the catch advice (25 mt).

   NEFSC staff was also able to add the filled surveys approach to their GitHub site (Github:PlanBsmooth). The result was that there does appear to be some general improvement by substituting survey data compared to simply missing surveys, but with the risk that the data fill approach can produce values with significant error. While the approach appears promising for future use, given the greater risk and uncertainty with this data fill approach, NEFSC staff suggested using the original missing data approach until further exploration of what is causing both the missing and filled approaches to deviate from the full data. As such, the Panel accepts the PlanBsmooth results but recommends that the NEFSC continue to evaluate the impact that approaches to replacing missing data have on this and other assessments. This is not a problem confined to this stock, as the 2022 assessment for all other groundfish stocks will be affected by the loss of the 2020 spring and fall bottom trawl surveys. The Center needs to provide a consistent approach to dealing with this issue.

6. *Respond to any review panel comments or SSC concerns from the most recent prior research or management track assessment.*

   The 2017 Peer Review Panel recommended additional studies to address potential causes of the severe retrospective pattern, including studies on natural mortality, the potential effects of missing catch data, and other possible sources of retrospective patterns in analytical assessments.

   Similarly, the 2021 AOP recommended that "retrospective analyses are required to examine the sensitivity of the model output to the proposed changes in calculation of the survey time series, and that analytical results should be reviewed before the ABC for the Georges Bank cod stock is updated."

   These were responded to with results shown on the github.com site and discussed above. A concern with the retrospective pattern is not that there is a systematic bias as there is in ASAP models, but rather the inconsistent outcomes that result.

Additional Recommendations

1. The upcoming Research Track investigations for Atlantic cod should be used to evaluate whether an analytic assessment can replace the PlanBsmooth approach for this stock (or the stock defined to replace it).

2. The handling of missing survey data has the potential to significantly affect the catch advice provided by PlanBsmooth, and NEFSC staff are encouraged to continue to evaluate alternative approaches to dealing with missing survey data. It is recommended that there be follow-up analyses on how missing survey years and survey strata/trawl locations where high catches are possible, in this case generally along the northwest edge of Georges Bank, will influence the multiplier used to generate catch advice.

3. It is also suggested that diagnostics for the PlanBsmooth be incorporated into the approach to dealing with missing data so as to understand when model results may be misleading.

4. Revised (and increased) amounts of recreational catch that has arisen from the current version of MRIP suggests that recreational catch should always be shown separately from commercial catch in tables and figures.

5. Discontinuity between the spatial domains of survey data used for the assessment and the fishery (e.g., Southern New England waters) should be evaluated, and addressed in the context of the new stock structure information. Significant new survey effort may be required should a new stock be identified for those waters. These surveys and the assessment they support may be compromised by wind farm development activities in the Southern New England region.

References:

Northeast Fisheries Science Center. In press. Operational Assessment of 14 Northeast Groundfish Stocks, Updated Through 2018.

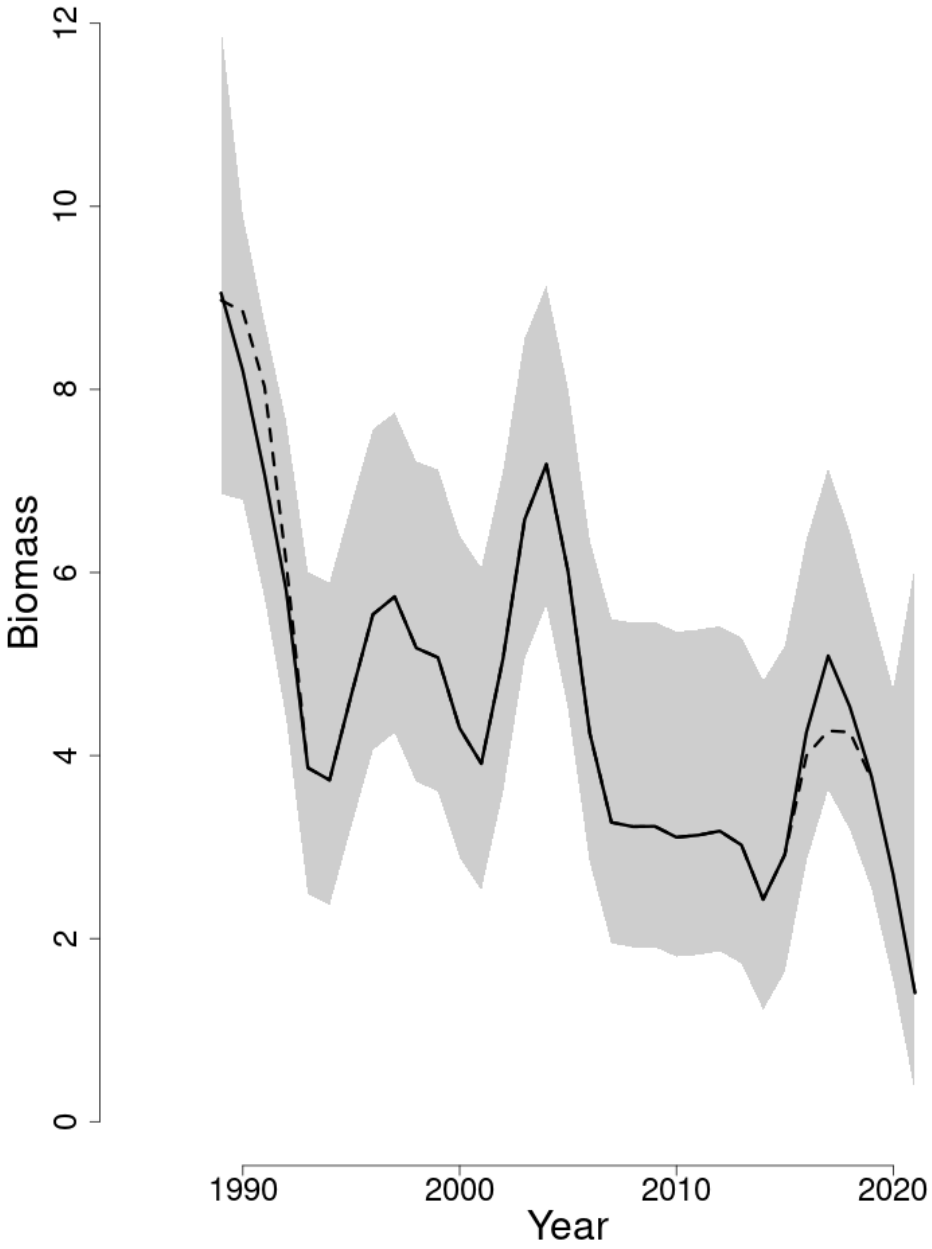


Figure 1: Trends in smoothed survey biomass (kg/tow) of Georges Bank Atlantic cod between 1989 and 2021 from the current (solid line) and previous (dashed line) assessment. The approximate 90% log-normal confidence intervals are shown. The 2020 value is based only on the 2019 fall survey while the 2021 value is based only on spring 2021.

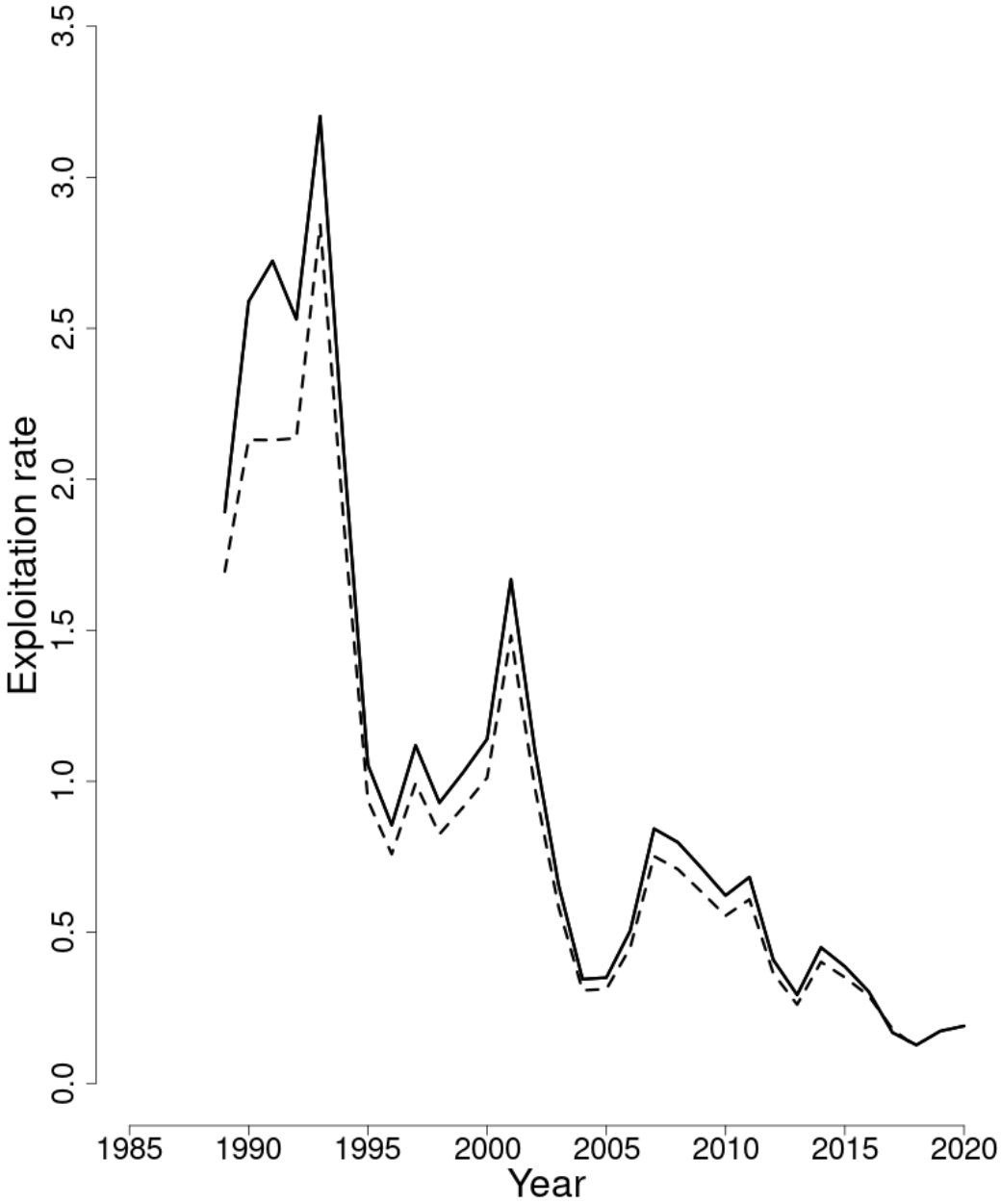


Figure 2: Trends in the relative exploitation rate (catch/smoothed survey) of Georges Bank Atlantic cod between 1989 and 2020 from the current (solid line) and previous (dashed line) assessment.

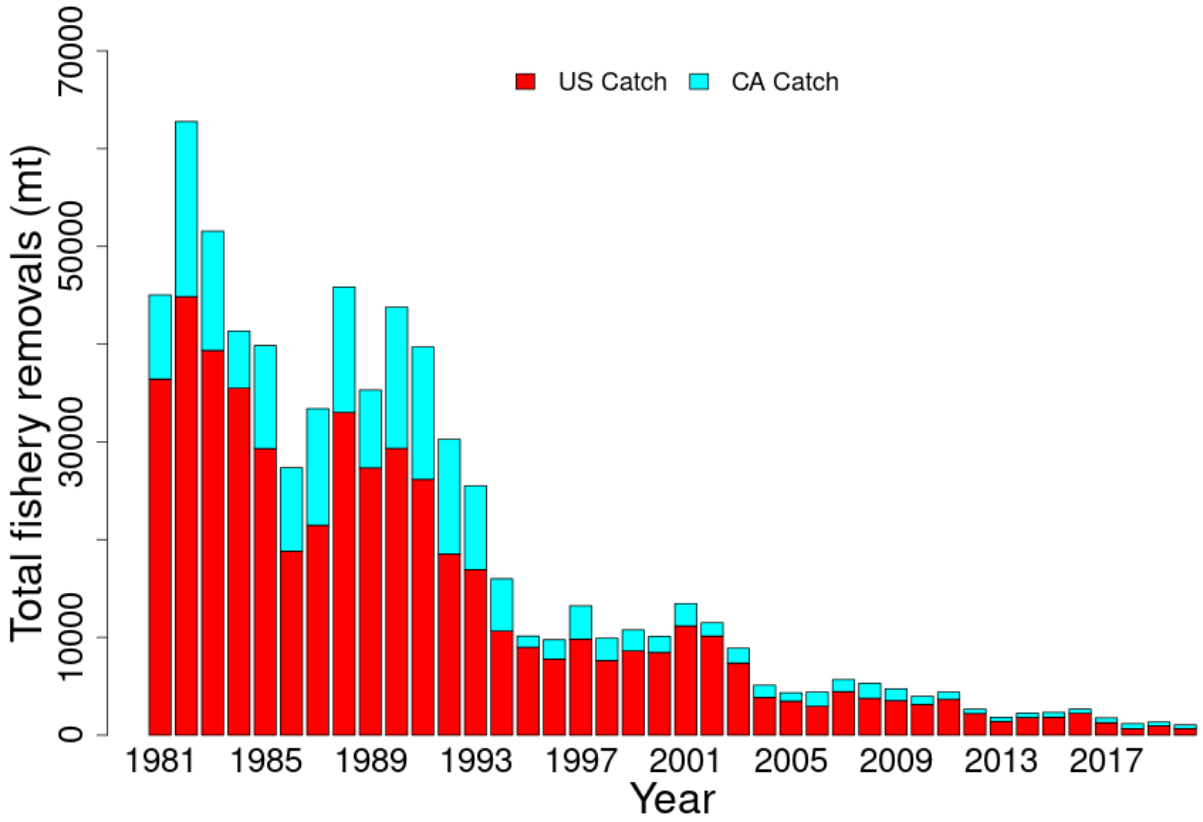


Figure 3: Total catch of Georges Bank Atlantic cod between 1981 and 2020 by fleet (US or Canadian). 2020 catches were estimated by the Groundfish Plan Development Team.

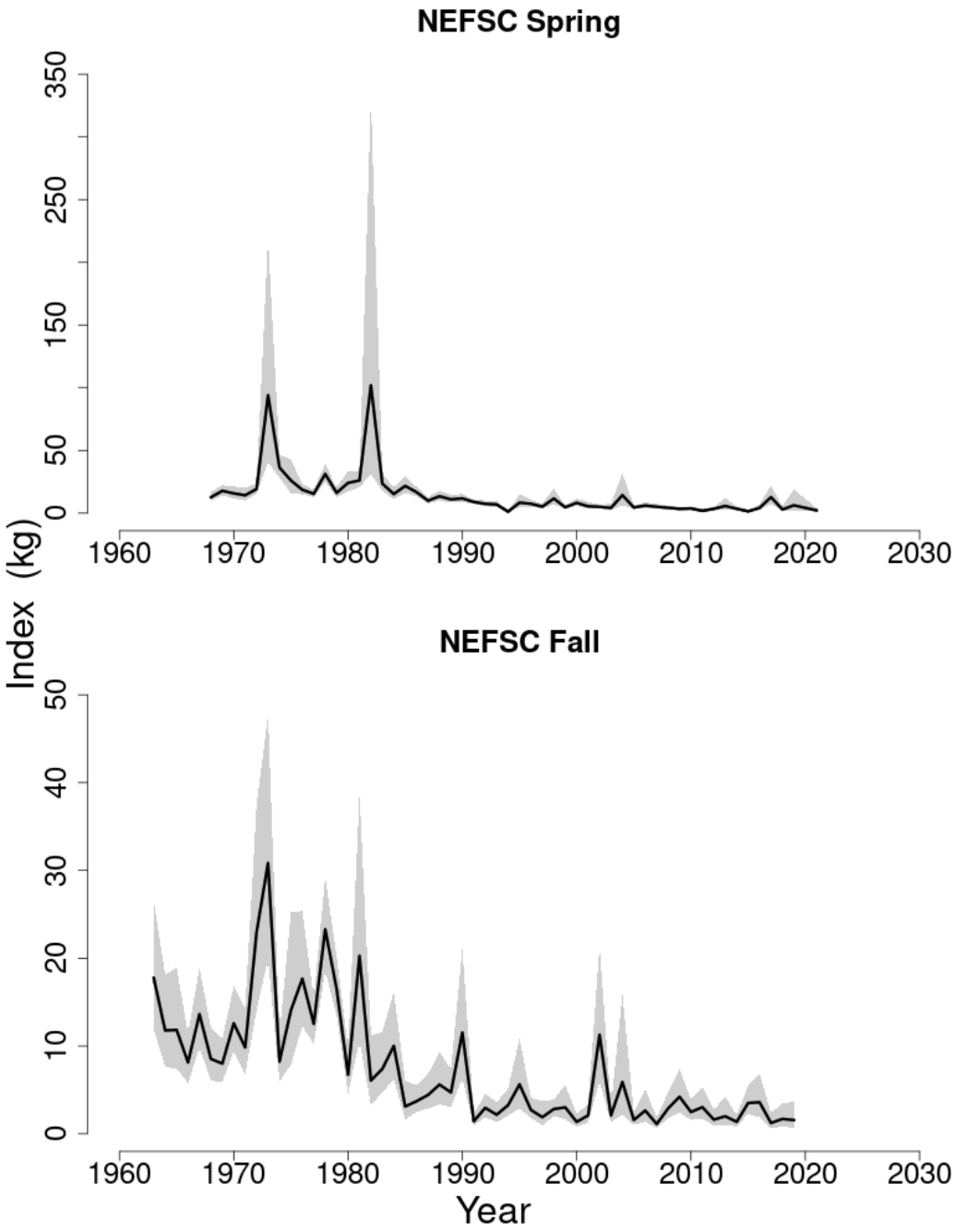


Figure 4: Indices of biomass for the Georges Bank Atlantic cod between 1963 and 2021 for the Northeast Fisheries Science Center (NEFSC) spring and fall trawl surveys. The approximate 90% log-normal confidence intervals are shown. The 2020 spring and fall surveys are missing even though the spring survey line goes through 2020.

3. GULF OF MAINE ATLANTIC COD

Charles Perretti

This assessment of the Gulf of Maine Atlantic cod (Gadus morhua) stock is an operational assessment of the existing benchmark assessment (NEFSC 2013). This stock was most recently assessed in 2019. This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical ASAP assessment models through 2019. Additionally, stock projections have been updated through 2024. In what follows, there are two population assessment models brought forward from the most recent benchmark assessment (NEFSC 2013): the M=0.2 (natural mortality = 0.2) and the M-ramp (M ramps from 0.2 to 0.4) assessment models (see NEFSC 2013 for a full description of the model formulations).

State of Stock: Based on this updated assessment, the stock status for the Gulf of Maine Atlantic cod (*Gadus morhua*) stock is overfished and overfishing is occurring for the M=0.2 model, and overfished and overfishing is not occurring for the M-ramp model (Figures 5–6). Retrospective adjustments were made to the M=0.2 model results because the retrospective pattern was major (a major retrospective pattern occurs when the adjusted SSB or F_{Full} lies outside of the approximate joint confidence region for SSB and F_{Full}). Retrospective adjustments were not made to the M-ramp model because the retrospective pattern was minor. Spawning stock biomass (SSB) in 2019 was estimated to be 1969 (mt) under the retro-adjusted M=0.2 model and 3223 (mt) under the M-ramp model scenario (Table 5) which is 5% and 5% (respectively) of the biomass target, $SSB_{MSY\ proxy}$(39,912 (mt) and 60,010 (mt); Figure 5). The 2019 fully selected fishing mortality was estimated to be 0.249 under the retro-adjusted M=0.2 model and 0.172 under the M-ramp model, which is 144% and 98% of the $F_{MSY\ proxy}$($F_{40\%}$; 0.173 and 0.175; Figure 6).

Projections: Short term projections of median total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod were conducted based on a harvest scenario of fishing at the F_{MSY} proxy between 2022 and 2024. Catch in 2020 and 2021 was estimated at 409 and 523 mt, respectively. Recruitment was sampled from a cumulative distribution function derived from ASAP estimated age-1 recruitment between 1982 and 2017. The projection recruitment model declines linearly to zero when SSB is below 6.3 kt under the M=0.2 model and 7.9 kt under the M-ramp model. The 2020 age-1 recruitment was estimated from the geometric mean of the 2015–2019 ASAP recruitment estimates. A retrospective adjustment was applied to the M=0.2 model. Assumed weights are based on an average of the most recent three years. For the M-ramp model, projections are shown under the assumption of M=0.4 short-term natural mortality.

Table 5: Catch and status table for Gulf of Maine Atlantic cod. All weights are in (mt), recruitment is in (000s), and F_{Full} is the fishing mortality on fully selected ages. Note terminal year SSB and F_{Full} is not retro-adjusted in this table.

	2012	2013	2014	2015	2016	2017	2018	2019
				Data				
Recreational discards	103	195	151	168	334	617	340	111
Recreational landings	1,245	1,524	796	11	187	169	11	43
Commercial discards	97	54	27	14	8	16	17	7
Commercial landings	2,759	951	832	227	320	376	398	335
Catch for Assessment	4,204	2,723	1,806	420	850	1,177	766	497
				Model Results (M=0.2)				
Spawning Stock Biomass	3494	1826	1145	1184	1736	2126	2314	3083
F_{Full}	1.66	2.16	2.37	0.43	0.59	0.61	0.32	0.16
Recruits (age-1)	1606	667	2119	804	530	966	3141	1298
				Model Results (M-ramp)				
Spawning Stock Biomass	4174	2288	1655	1859	2485	2776	2726	3223
F_{Full}	1.46	1.85	1.74	0.3	0.44	0.49	0.28	0.17
Recruits (age-1)	3285	1484	4739	1699	1024	1717	5160	1981

Table 6: Comparison of reference points estimated in an earlier assessment and from the current assessment update. The overfishing threshold is the $F_{MSY\ proxy}$ ($F_{40\%}$). The biomass target, ($SSB_{MSY\ proxy}$) was based on long-term stochastic projections of fishing at the$F_{MSY\ proxy}$. Median recruitment reflects the median estimated age-1 recruitment from 1982–2017. Intervals shown reflect the 5$^{\text{th}}$ and 95$^{\text{th}}$ percentiles.

	2019 M=0.2	2019 M-ramp	M=0.2	M-ramp
F_{MSY}	0.173	0.175	0.173	0.175
SSB_{MSY} (mt)	42,692 (27,916–62,785)	63,867 (46,144–84,098)	39,912 (25,472–59,589)	60,010 (41,916–80,517)
MSY (mt)	7,580 (4,853–11,366)	11,420 (8,149–15,268)	7,171 (4,462–11,023)	10,873 (7,439–14,841)
Median recruits (age-1) (000s)	4,377 (1,161–14,434)	8,464 (2,353–15,934)	4,677 (1,064–16,392)	9,249 (2,129–18,031)
Overfishing	Yes	Yes	Yes	No
Overfished	Yes	Yes	Yes	Yes

Table 7: Short term projections of total fishery catch and spawning stock biomass for Gulf of Maine Atlantic cod based on a harvest scenario of fishing at the $F_{MSY\,proxy}$ ($F_{40\%}$) between 2022 and 2024. Catch in 2020 and 2021 has been estimated at 409 (mt) and 523 (mt), respectively. For the M=0.2 model, a retrospective adjustment has been appiled. For the M-ramp model, projections are shown under the assumption of M=0.4 short-term natural mortality.

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
		M=0.2			M-ramp	
2020	409	2,635	0.162	409	3,925	0.119

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
		M=0.2			M-ramp	
2021	523	3,599	0.137	523	4,759	0.113
2022	821	4,508	0.173	919	5,254	0.175
2023	959	5,488	0.173	1,017	5,707	0.175
2024	1,244	7,279	0.173	1,306	6,802	0.175

Special Comments:

- What are the most important sources of uncertainty in this stock assessment? Explain, and describe qualitatively how they affect the assessment results (such as estimates of biomass, F, recruitment, and population projections).

  The existence of two models with differing assumptions of natural mortality is an important source of uncertainty. Past investigations into changes in natural mortality over time have been inconclusive (NEFSC 2013), however the M-ramp model exhibited lower retrospective error in the last benchmark (NEFSC 2013), although the difference in retrospective error has been reduced in recent updates. Ultimately, both the M=0.2 and M-ramp model were accepted as final models in the SARC 55 review (NEFSC 2013). The different assumptions about natural mortality affect the scale of the biomass, recruitment, fishing mortality estimates, and the overfishing status, though terminal estimates (2019) of biomass, fishing mortality and recruitment are similar under both models. Other areas of uncertainty include the increasing amount of retrospective error in both models, stock structure, ecosystem effects, and the veracity of fishery catch data.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or F_{Full} lies outside of the approximate joint confidence region for SSB and F_{Full}).

  The M=0.2 model has a major retrospective pattern (7-year Mohn's ρ: SSB=0.73, F=−0.35), while the M-ramp model has a minor retrospective pattern (7-year Mohn's ρ: SSB=0.42, F=−0.21). The 7-year Mohn's ρ values from the current assessment have increased from the 2019 assessment for both models (M=0.2: SSB=0.52, F=−0.29; M-ramp: SSB=0.29, F=−0.16). The terminal year M=0.2 model estimates have been retro-adjusted due to the major retrospective pattern.

- Based on this stock assessment, are population projections well determined or uncertain? If this stock is in a rebuilding plan, how do the projections compare to the rebuilding schedule?

  Population projections for Gulf of Maine Atlantic cod are reasonably well determined, though the projected biomasses for the M=0.2 model from the last assessment did not fall within the confidence bounds of the biomass estimated in the current assessment. The SSB projections for this stock have been biased high in recent years for both models. Multiple factors likely contribute to this, including overestimation of the initial stock size, underestimation of F in the projection bridge year, and reduced recruitment in recent years. Underestimation of F and overestimation of SSB is likely to have a larger impact on short-term projections than reduced recruitment because short-term projections are more strongly driven by existing biomass than future recruitment. However, an additional set of projections were performed for each model using recruitment observations from the most recent 15-year time period (2004–2018 year classes) which projected reduced SSB and catch estimates compared to the projections using the full recruitment time series. This stock is not on target to rebuild by 2024.

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the effect these changes had on the assessment and stock status.

  Recreational catch estimates for 2017 and 2018 were updated due to a change in the MRIP code and database. This resulted in a small ($< 3\%$) change to the recreational catch estimates in those years. No other changes were made beyond incorporating an additional year of data (2019).

- If the stock status has changed a lot since the previous assessment, explain why this occurred.

  Overfished status has not changed. Overfishing is still occuring according to the retro-adjusted M=0.2 model, however it is no longer occurring according to the M-ramp model.

- Provide qualitative statements describing the condition of the stock that relate to stock status.

  The Gulf of Maine Atlantic cod shows a truncated size and age structure, consistent with a population experiencing high mortality. There are only limited signs of incoming recruitment, continued low survey indices, and the current spatial distribution of the stock is considerably less than its historical range within the Gulf of Maine.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.

  The Gulf of Maine Atlantic cod assessment could be improved with additional studies on natural mortality, a characterization of the overall uncertainty and possible biases in the fishery catch estimates, and research into potential causes of low stock productivity (i.e., low recruitment).

- Are there other important issues?

  When setting catch advice, careful attention should be given to the retrospective error present in both models, particularly given the over-predictions of SSB in previous projections. Also of note is that the 2021 Spring NMFS Bottom Trawl Survey and the 2021 Spring MA DMF Bottom Trawl Survey both show declining biomass and abundance, which is not able to be incorporated into this year's assessment or Figure 9.

3.1. Reviewer Comments: Gulf of Maine Atlantic cod

The 2021 assessment update for Gulf of Maine Atlantic cod is an enhanced review (Level 3 assessment) in accord with the decision at the April 2021 meeting of the Assessment Oversight Panel (AOP). This is an operational assessment of the existing benchmark assessment (NEFSC 2013)1. This stock was most recently assessed in 2019. This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical ASAP assessment models through 2019. Additionally, stock projections have been updated through 2024. There were two population assessment models brought forward from the most recent benchmark assessment, the M=0.2 and the M-ramp (M ramps from 0.2 to 0.4) assessment models (see NEFSC 2013 for a full description of the model formulations).

The Peer Review Panel (Panel) concluded that the 2021 assessment update for Gulf of Maine Atlantic cod is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes. Retrospective adjustments were made to the M=0.2 model results based on the magnitude of the rho value, but not those from the M-ramp model.

Spawning stock biomass (SSB) in 2019 was estimated to be 1,969 mt under the retro-adjusted M=0.2 model and 3,223 mt under the M-ramp (M=0.4) model scenario, which are both 5% (respectively) of their corresponding biomass targets, SSB_{MSY} proxies of 39,912 mt and 60,010 mt. The 2019 fully selected fishing mortality was estimated to be 0.249 and 0.172, which are 144% and 98% of the F_{MSY} proxy ($F_{40\%}$; 0.173 and 0.175).

The Panel notes that under the retro-adjusted M=0.2 assessment that Gulf of Maine Atlantic cod are overfished but overfishing is continuing to occur. Under the M-ramp model the stock is overfished but overfishing is not occurring.

Gulf of Maine Atlantic Cod Terms of Reference

1. *Estimate catch from all sources including landings and discards.*

   This TOR was satisfactorily addressed. This assessment updates commercial and recreational fishery catch data through 2019 with the 2020–2021 catch data used for the projections provided by the Groundfish PDT.

   It is recommended that the Research Track for Atlantic cod investigate whether combining recreational and commercial fisheries into one fleet has any impact on catch at age/age-length based analyses insofar as selectivity varies between the fisheries, and the relative contribution of each to total catch has been changing over time.

2. *Evaluate indices used in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.).*

   This TOR was satisfactorily addressed. All three of the survey indices used in the benchmark assessment (NEFSC spring bottom trawl survey, NEFSC fall bottom trawl survey, MA DMF spring

trawl survey) were updated through 2019. Few fish were captured in any of the three surveys over the past decade, compared to data from decades prior.

Catch length frequencies were updated as well.

The short time series of the Longline survey were shown but were not included in this assessment. These data should be considered during the upcoming Research Track Assessment for inclusion in future assessments, but should also explore the sentinel survey in downeast Maine, and others as data needs will increase under any stock structure scenario that increases the number of stocks.

3. *Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) as possible (depending on the assessment method) for the time series using the approved assessment method and estimate their uncertainty. Include retrospective analyses if possible (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit.*

   (a) *Include bridge runs to sequentially document each change from the previously accepted model to the updated model proposed for this peer review.*

   (b) *Prepare a backup assessment approach that would serve as an alternative for providing scientific advice to management if the analytical assessment were to not pass review*

   This TOR was satisfactorily addressed. This assessment of the Gulf of Maine Atlantic cod stock is an operational assessment of the existing 2013 benchmark assessment. The same ASAP model configuration used in the 2013 benchmark, and the recent (2019) operational assessments was used in this 2021 update. Two population assessment models were brought forward from the 2013 benchmark assessment: M=0.2 (natural mortality = 0.2) and M-ramp (M ramps from 0.2 to 0.4).

   A bridge run was unnecessary, as the single data stream that changed (MRIP) only changed slightly, as the data updates were largely dealt with in the 2019 assessment.

   The M=0.2 model had a major retrospective pattern (7-year Mohn's ρ: SSB=0.73, F=−0.35), while the M-ramp model had just a minor retrospective pattern (7-year Mohn's ρ: SSB=0.42, F=−0.21) based on the criteria of the ρ-adjusted value falling within or outside of the 90% confidence limits of the original estimate. The 7-year Mohn's ρ values from the current assessment have increased from the 2019 assessment for both models (M=0.2: SSB=0.52, F=−0.29; M-ramp: SSB=0.29, F=−0.16). Note that the rho values for the M-ramp model have grown progressively larger since the model was first implemented in the 2013 assessment. The Panel hypothesized the general (pre-Covid) decline in catch may contribute to the stock being close to the threshold for a retrospective adjustment. SSB has declined as a ratio to SSB_{MSY} since the last update. In addition, catch levels in the interim period have also been affected by Covid, and thus it will be important to document the stock response to lower commercial catch and perhaps an increase from the recreational sector.

   Retrospective adjustments were made to the terminal year value and projections, but only for the M=0.2 model.

   A 'Plan B' assessment was unnecessary because the ASAP assessment model was accepted; however we believe that having that assessment prepared for future deployment would be wise, given challenges with data needs certain to come in the next assessment.

4. *Re-estimate or update the BRPs as defined by the management track level and recommend stock status. Also, provide qualitative descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc.).*

   This TOR was satisfactorily addressed.

   The Panel considered the estimation of BRPs and projections from four different models: non-retro-adjusted M=0.2 model, retro-adjusted M=0.2 model, and the M-ramp model with projections using M=0.2 and M-ramp M=0.4. Ultimately, we recommended projections only for the retro-adjusted M=0.2 model and the M-ramp model with projections using M=0.4 be forwarded for management advice.

   The Panel rejected the non-retro-adjusted M=0.2 scenario given the major retrospective patterns in the results. The guidance provided by the Center states "Technically, when either the ρ-adjusted SSB or F (point estimate$/(1+\rho)$) falls outside the 90% confidence interval of the terminal year estimate, the retrospective adjustment is applied for both status determination and to the starting population for projections." (page 7, NEFMC. 2020. Description of New England and MidAtlantic Region Stock Assessment Process. (https://www.nefmc.org/committees/northeast-regional-coordinating-council-nrcc). As this was the case for the M=0.2 model, the ρ-adjustment should be made.

   The Panel rejected the M-ramp model with projections using M=0.2 largely because the strength of the model seemed to be in its ability to capture the effects of higher M on the BRPs. In addition, the inconsistency in assuming that the mortality has increased to 0.4 for the status determination, but then has declined to 0.2 in the projections is not scientifically supported. At the current time there is no expectation that the current natural mortality will change from the status determination into the 3 projection years.

   As a result, the Panel supported the estimation of spawning stock biomass (SSB) in 2019 as 1,969 mt under the retro-adjusted M=0.2 model and 3,223 mt under the M-ramp model scenario. These are 5% of their respective biomass target SSB_{MSY} proxy (39,912 mt and 60,010 mt). The 2019 fully selected fishing mortality was estimated to be 0.249 and 0.172 which are 144% and 98% of the F_{MSY} proxy ($F_{40\%}$; 0.173 and 0.175).

   Under the retro-adjusted M=0.2 model, the stock is overfished but overfishing is occurring, while under the M-ramp (M=0.4) model the stock is overfished but overfishing is no longer occurring.

5. *Conduct short-term stock projections when appropriate.*

   Short term projections of median total fishery yield and spawning stock biomass for Gulf of Maine Atlantic cod were conducted based on a harvest scenario of fishing at the F_{MSY} proxy between 2022 and 2024. Catch in 2020 and 2021 was estimated at 409 and 523 mt, respectively.

   The Panel was concerned with the large increases and increasing trend of short-term projected catches (in this assessment as well as in the previous assessments). Further, model results from this assessment appeared to be less than those projected in the last management track assessment, suggesting a misspecification in the projections. After discussion with the assessor, it seemed that this was a result of the projection model sampling from the CDF of recruitment estimates from 1982–2017. Recruitment since ca. 2005 appears to be much lower than the years prior and below

the longer time series median value, and thus using the CDF of recruitment from 1982–2017 may not be representative of current recruitment dynamics than more recent years recruitment data only. The Panel requested that the assessor conduct a brief analysis of the affect that truncating the recruitment time series to the past 15 years would have on the projections. Initial results from this analysis suggest catches will still increase but by smaller amounts. While we did not ask for the new projections to be carried forward as options, they are important context for understanding the scientific uncertainty involved in setting catch levels.

6. *Respond to any review panel comments or SSC concerns from the most recent prior research or management track assessment.*

   The 2019 review panel recommended review of the use of the two different assessment models, addition of the longline survey results to the assessment model, updating fishery CPUE to document fishery perceptions, and consideration of a new approach for providing catch advice for stocks that are at extremely low biomass should be considered. Most of this appears to have been tabled to the Research Track exercise for Atlantic cod.

Additional Comments

1. This Panel is concerned that the uncertainty in catch should be evaluated in the context of the retrospective pattern. Further, we support the previous Panel's recommendation on researching whether the M-ramp model continues to be useful as the retrospective bias continues increasing for that model. While the rho adjusted values are an improvement to the M=0.2 model, understanding the source of the retrospective pattern would improve decision making in the future. Exploring the effect of unreported discards on mortality, fishery selectivity, and growth are recommended starting points for future investigation into addressing retrospective patterns for this stock. Improvement to the modeling framework that reduce the retrospective pattern is far superior to a post-hoc adjustment.

2. Several topics were referred for consideration in the upcoming Atlantic cod Research track assessment including

   (a) Use of the Longline survey, and other surveys, in the assessment

   (b) 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.

   (c) Impact of underestimation of age-2 catch, particularly with regards to the recreational fishery or bycatch in lobster and other fisheries.

   (d) 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).

   (e) Consider ways to adjust BRPs to deal with changes in M from 0.2 (e.g., M-ramp)

   (f) Evaluate the lobster fishery bycatch of cod

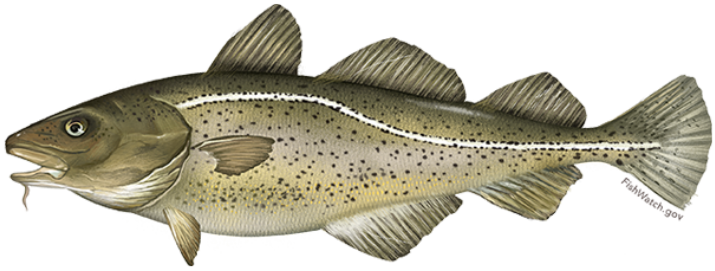
   (g) Evaluate the appropriate recruitment time series, or autocorrelation factor, to use for the projections

(h) Reassess the stock-recruitment relationship with additional years of data, and whether time variant or invariant productivity can be directly estimated.

(i) Consider the impact of changing ocean conditions on the new rebuilding plan for Atlantic cod. The stock is currently in a rebuilding plan that concludes in 2024. The stock is highly unlikely to be rebuilt within this time frame. In addition, the stock has not exceeded the *SSB* threshold at any point in the entire time series used for the assessment (1982–2019). At the same time, there have been serious economic consequences, mainly through restricting catch of haddock and other species from cod-directed management measures. There is a legitimate question as to whether there should be any expectation of rebuilding within a reasonable time frame moving forward. The Panel is aware that the NEFMC will begin developing a new rebuilding plan for the stock, and we strongly recommended that this new plan explicitly evaluate the potential of the stock to recover under the current low productivity regime in the Gulf of Maine, and how this low productivity will affect catch specifications.

References:

Northeast Fisheries Science Center. 2013. 55th Northeast Regional Stock Assessment Workshop (55th SAW). US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13–11; 849 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD13-11



Gadus morhua, Atlantic Cod.

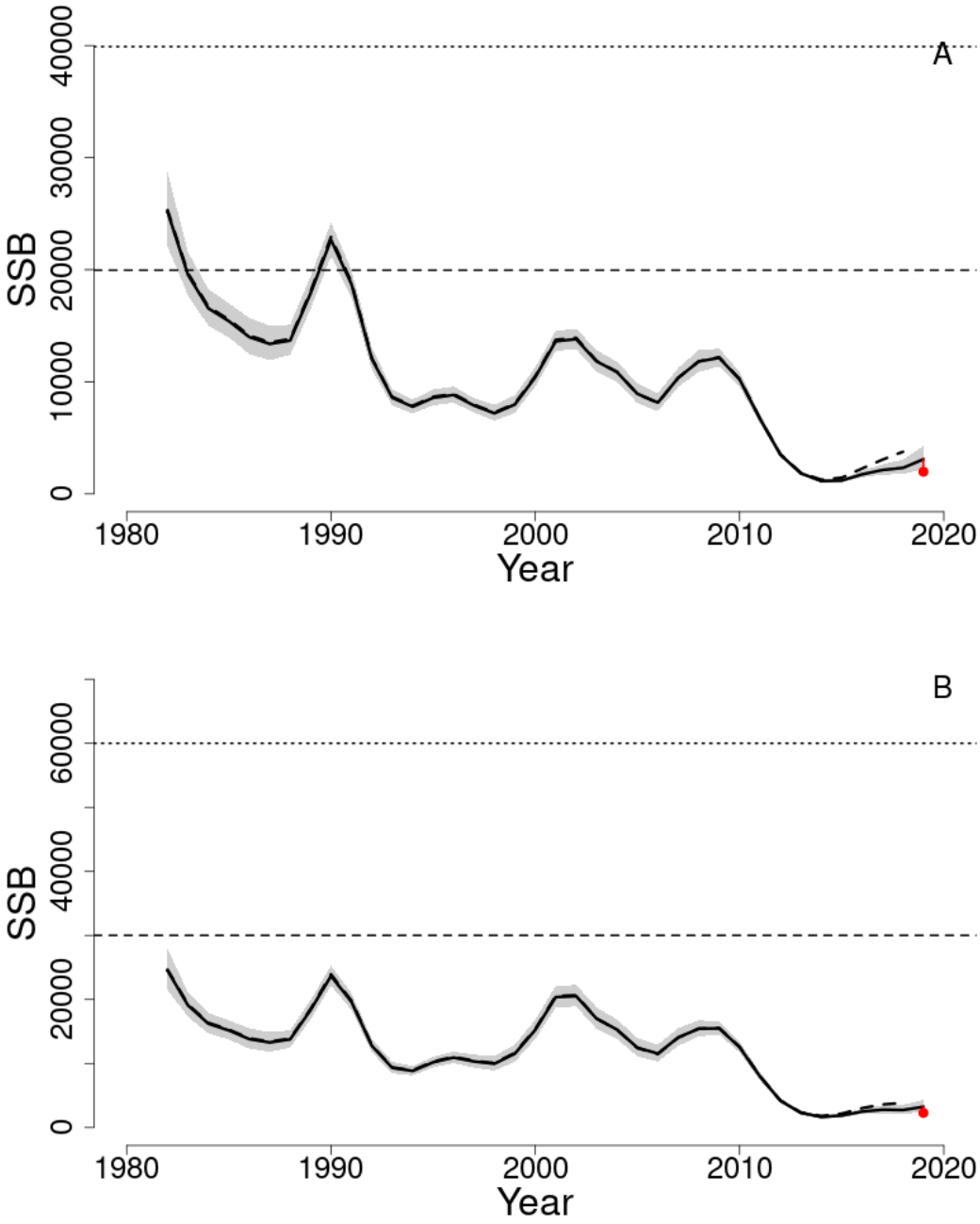


Figure 5: Estimated trends in the spawning stock biomass (SSB) of Gulf of Maine Atlantic cod between 1982 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{\text{Threshold}}$($\frac{1}{2}SSB_{MSY}$; horizontal dashed line) as well as SSB_{Target} SSB_{MSY}; horizontal dotted line) based on the 2020 M=0.2 (A) and M-ramp (B) assessment models. The 90% log-normal confidence intervals are shown. The red dot indicates the rho-adjusted SSB value that resulted for the M=0.2 model, and would have resulted had a retrospective adjustment been made to the M-ramp model.

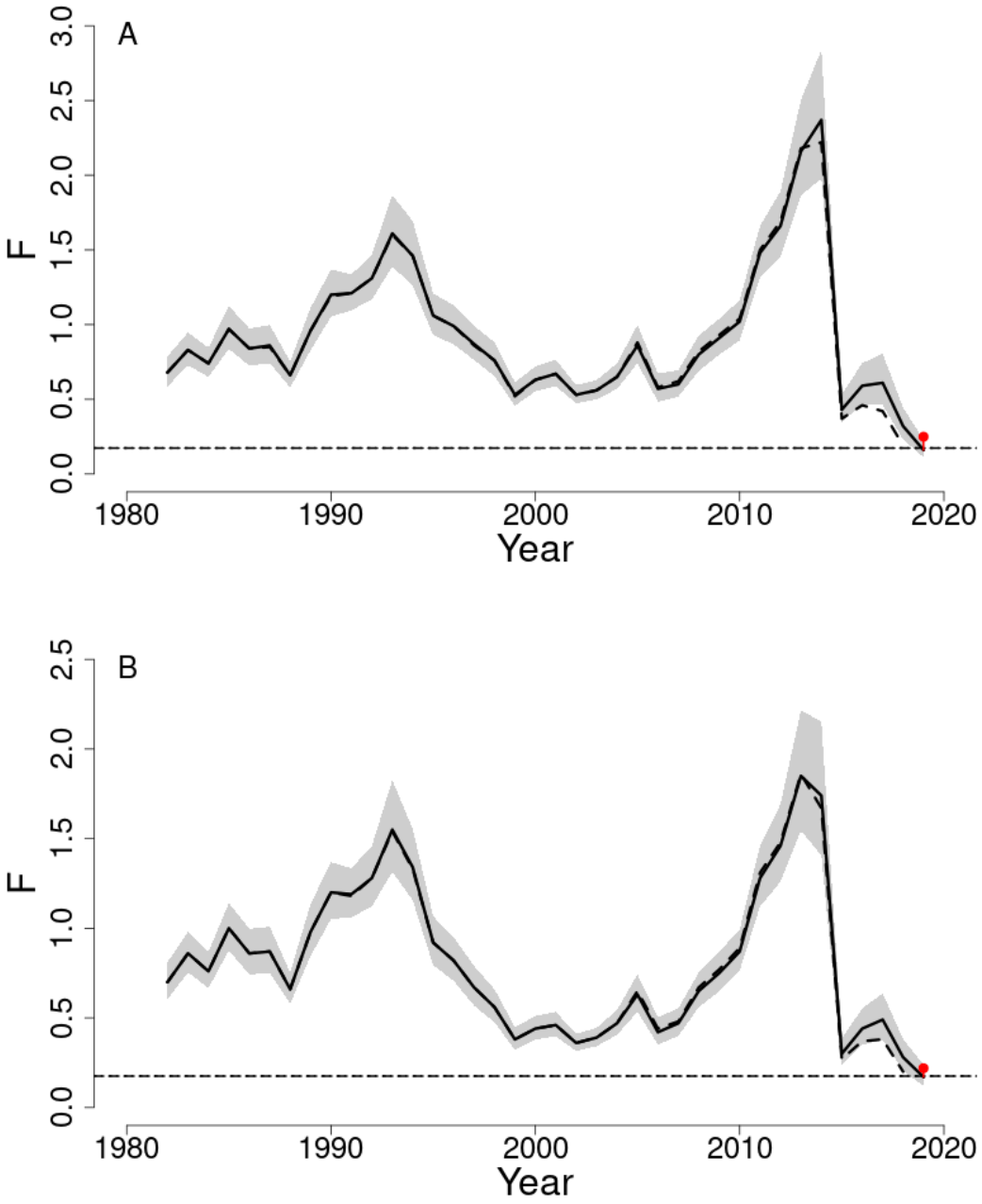


Figure 6: Estimated trends in the fully selected fishing mortality (F) of Gulf of Maine Atlantic cod between 1982 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{\text{Threshold}}$(0.173 (M=0.2), 0.175 (M-ramp); dashed line) based on the 2020 M=0.2 (A) and M-ramp (B) assessment models. The 90% log-normal confidence intervals are shown. The red dot indicates the ρ-adjusted F value that resulted for the M=0.2 model, and would have resulted had a retrospective adjustment been made to the M-ramp model.

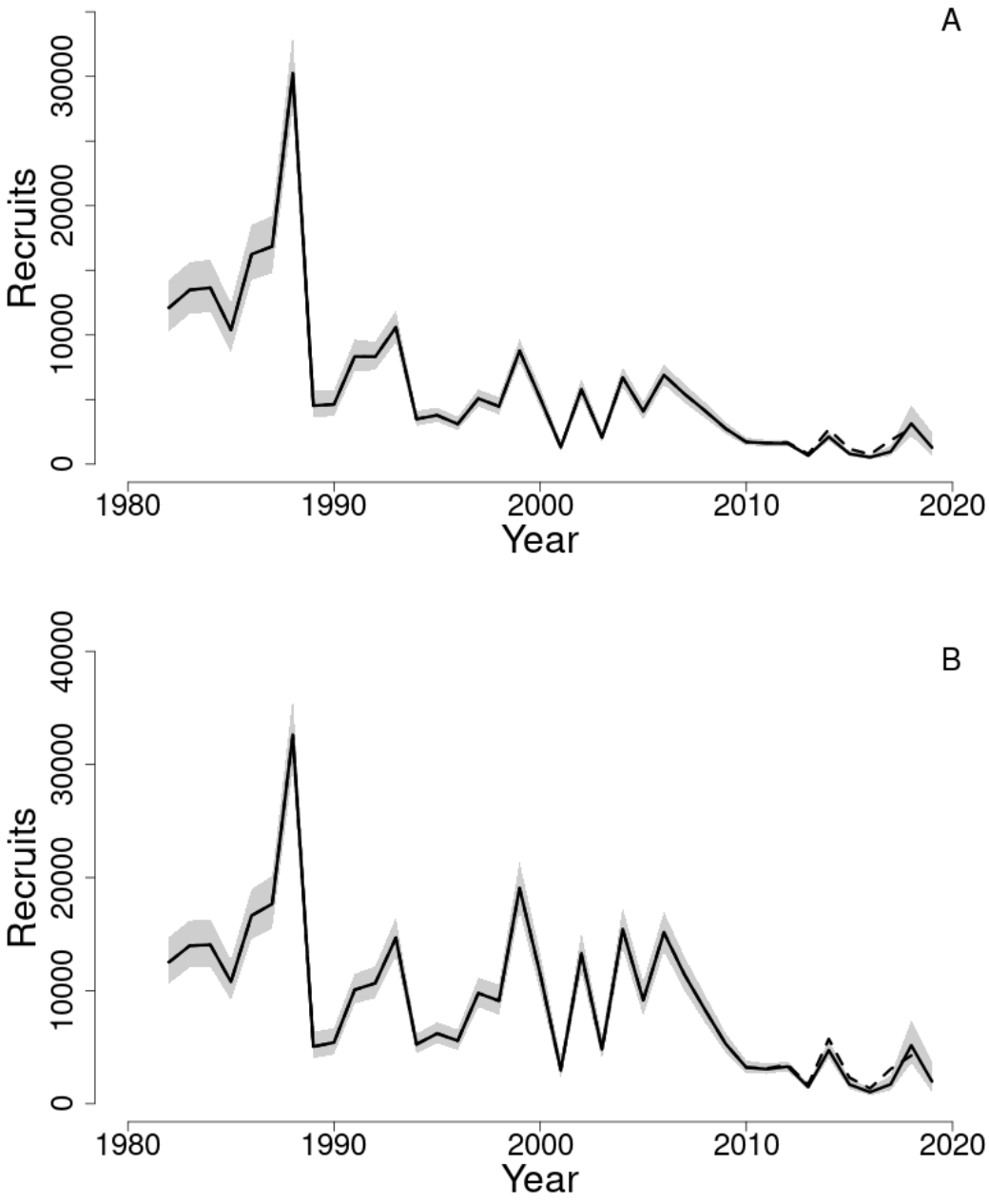


Figure 7: Estimated trends in age-1 recruitment (000s) of Gulf of Maine Atlantic cod between 1982 and 2019 from the current (solid line) and previous (dashed line) M=0.2 (A) and M-ramp (B) assessment models. The 90% log-normal confidence intervals are shown.

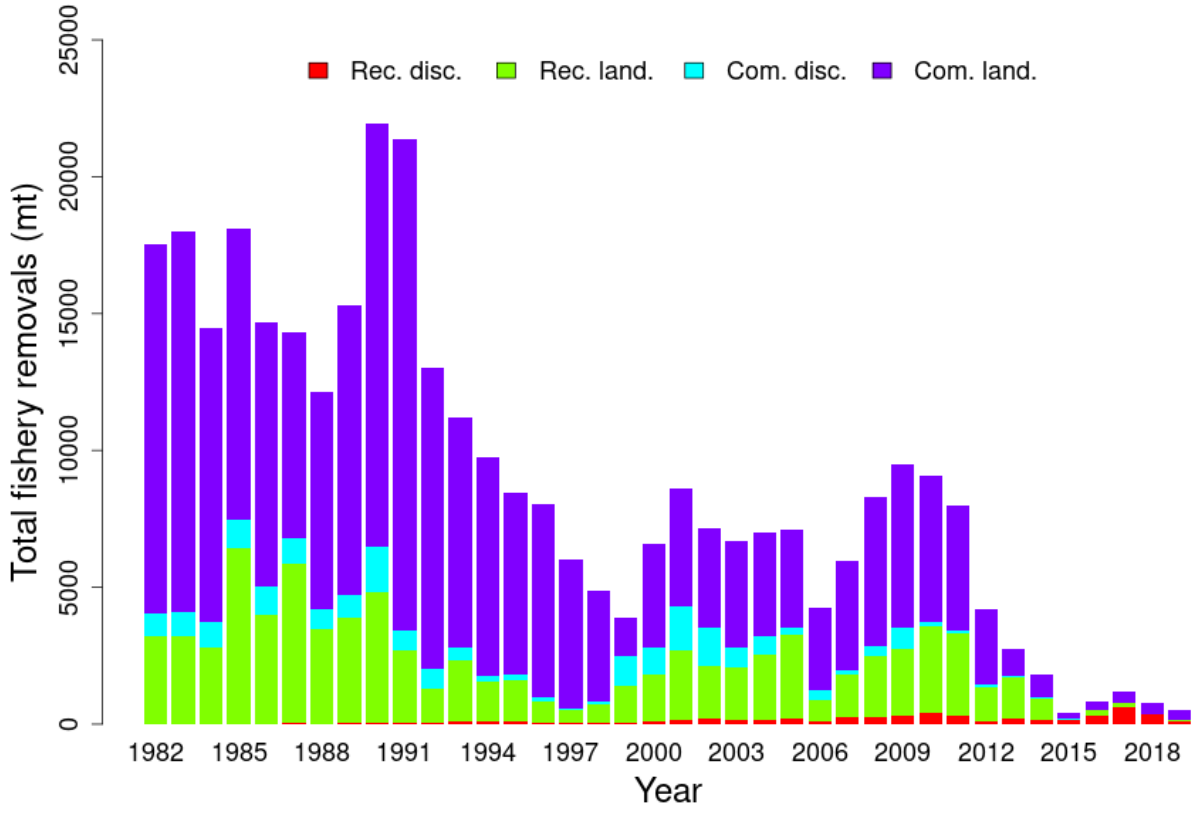


Figure 8: Total catch of Gulf of Maine Atlantic cod between 1982 and 2019 by fleet (commercial and recreational) and disposition (landings and discards).

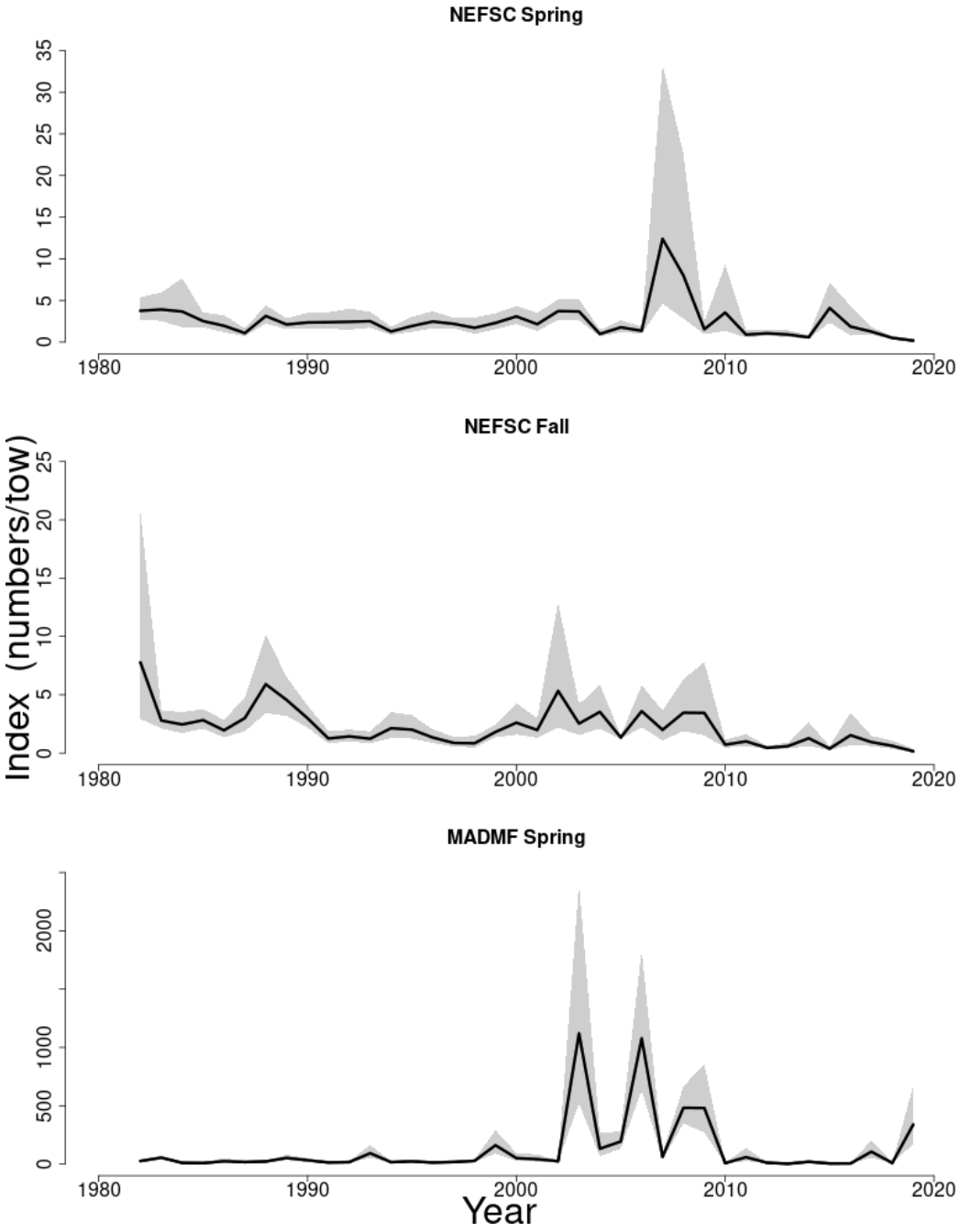


Figure 9: Indices of biomass for the Gulf of Maine Atlantic cod between 1982 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and Massachusetts Division of Marine Fisheries (MA DMF) spring bottom trawl survey. The 90% log-normal confidence intervals are shown.

Photo Gallery

Here we provide descriptive text for the photographs and artwork that are scattered throughout the preceding pages.

Atlantic Cod swimming above rocky sea-floor. Photo NOAA. On page 42

The reason behind it all: seafood display case at a local supermarket. Photo NOAA. On page iv

Aerial view of the buildings and wharves at the Woods Hole Oceanographic Institute, MA. Two research vessels are docked for re-supply. Photo WHOI. On page 8

Gadus morhua, commonly known as Atlantic Cod, Cod, Codling, Scrod cod, Markets, Steakers; range: New England/Mid-Atlantic, Southeast. Artwork from NOAA website. On pages 36

Atlantic Cod swimming above rocky sea-floor.

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