Northeast Fisheries Science Center Reference Document 17-17

Operational Assessment of 19 Northeast Groundfish Stocks, Updated Through 2016

by the Northeast Fisheries Science Center

Northeast Fisheries Science Center Reference Document 17-17

Operational Assessment of 19 Northeast Groundfish Stocks, Updated Through 2016

by the Northeast Fisheries Science Center

NOAA Fisheries, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts
October 2017

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been published electronically. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, please contact the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

Information Quality Act Compliance: In accordance with section 515 of Public Law 106-554, the Northeast Fisheries Science Center completed both technical and policy reviews for this report. These predissemination reviews are on file at the NEFSC Editorial Office.

This document may be cited as:

Northeast Fisheries Science Center. 2017. Operational Assessment of 19 Northeast Groundfish Stocks, Updated Through 2016. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-17; 259 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/publications/

Contents

1 Executive Summary

1.1 Process

Assessments for 19[1] of the 20 groundfish stocks (Table 1) in the New England Fishery Management Council's (NEFMC) Multispecies Groundfish Fisheries Management Plan were updated and reviewed during September 11-15, 2017 at the Northeast Fisheries Science Center (NEFSC), Woods Hole, MA. This represents the fifth assessment of the status of groundfish stocks since 2001. The first three assessments were produced through the Groundfish Assessment Review Meeting (GARM) process (NEFSC 2002, 2005, 2008). Thirteen of the groundfish stocks were updated through the Operational Assessment process in 2012 (NEFSC 2012). All 20 groundfish stocks were updated using operational assessments in 2015 (NEFSC 2015). Operational assessments, first described by the Northeast Regional Coordinating Council (NRCC) in 2011, rely on decisions of previous benchmarks for model formulation and definition of biological reference points (BRPs). The terms of reference for the operational assessments are provided in Section 21.1. The efficiency of the Operational Assessment process increases the frequency of assessments, but reduces the ability to modify model structure either in response to new data or external inputs. Major modifications of the assessment models are restricted to benchmark assessments that can incorporate a much greater range of information but for far fewer stocks. The scope of admissible changes in the assessment is described in Section 21.4 and in guidelines that were initially developed by the NRCC in 2015 and revised in 2017 through collaborative discussions among the NEFSC, NEFMC, and the Assessment Oversight Panel. The Assessment Oversight Panel (AOP) considered those guidelines in its July 24, 2017, review of the plans for each assessment prepared by the individual analysts, making recommendations regarding both planned changes to the assessments as well as plans for how scientific advice would be provided for each stock if the primary analytical assessment was not accepted by the peer review panel (sometimes referred to as "Plan B" assessment advice). See Section 21.3 for a summary of the AOP meeting.

Of particular note this year, newly available cooperative research on survey catchability of flatfish species was incorporated into the process, with modified catchability coefficients applied directly in several assessments that use empirical models and catchability information shared for context and diagnostic consideration for several assessments that use analytical models (Appendix 21.4). Prior to its use in these assessments, the cooperative research study was peer reviewed on July 18, 2017 (summary available online). Those reviewers concluded the cooperative research surveys were well designed, the results well supported, and sample sizes were generally appropriate for use in estimating catchability for flatfish species in the 2017 Operational Assessments. The Peer Review Panel for the Operational Assessments did not repeat this earlier peer review of the catchability studies; rather it considered how the results were applied in relevant empirical assessments and their use in diagnostic evaluations of relevant analytical assessments.

In August and September, 2017 the NEFSC held 8 port-based outreach meetings for fishermen and other stakeholders. These occurred in Maine (Portland), New Hampshire (Portsmouth), Rhode Island (Narragansett), New York (Montauk) and Massachusetts (Gloucester, Plymouth, New Bedford, and Chatham). NEFSC personnel met with attendees at each location to learn more about

[1] Atlantic halibut is being assessed separately

recent observations from the fleet and ports that might help focus future research to improve assessments and interpret patterns in the current assessments. Each meeting started with a brief introduction on the timeline for the assessments, what new information would be considered, and how the results would be reviewed before use in the fishery management process.

A summary report of the outreach meetings discusses relevant insights from those meetings, which were shared during the peer review. Much of the substantive feedback from the outreach meetings focused on future research needs and opportunities as well as stakeholder questions about process, data, and outputs.

Following the established process associated with groundfish operational assessments, the NEFSC provided a data-rich dedicated website to supplement the information provided in individual species assessment reports.

The Peer Review Panel (i.e., Panel) consisted of the following individuals:

- Pat Sullivan (Co-chair), Cornell University, NEFMC Scientific and Statistical Committee
- Patrick Lynch (Co-chair), NMFS Office of Science and Technology, Silver Spring, MD.
- Gary Nelson, Massachusetts Division of Marine Fisheries, Gloucester, MA
- Jim Berkson, NMFS Office of Science and Technology, Silver Spring, MD.

The Panel was responsible for reviewing each of the stock assessments. Primary and supporting documents for each assessment were available prior to the meeting. Each lead assessment scientist (Table 2) prepared a short presentation to describe the past and updated assessment results and address key sources of uncertainty (see agenda). Following the presentation, the Panel was responsible for addressing five terms of reference (TOR):

- Accept/ Not Accept the assessment as a basis for setting Overfishing Limit (OFL).
- If the assessment is not accepted, then recommend an alternative basis for setting OFL.
- Include qualitative written statements about the condition of the stock that will help to inform NOAA Fisheries about stock status.
- Identify key sources of uncertainty.
- Identify important research needs.

If an assessment was not considered suitable for estimation of OFL the Panel was responsible for recommending an alternative basis. Additionally, the Peer Review panel was asked to recommend what the stock status appears to be without reference to analytical assessment results. NOAA Fisheries has final responsibility for making the stock status determination based on best available scientific information, which in the absence of an accepted quantitative assessment, may be qualitative.

The individual assessment sections within this report are standardized and designed to capture the most relevant information for reviewers and fishery managers. The report structure was developed with, and approved by, a subcommittee of the NRCC, followed by NRCC feedback about the report structure. Each assessment is supported by an online set of companion tables, figures and maps, which provide primary users of the assessment information (e.g., Plan Development Teams, Science and Statistical Committee) with necessary details. The online data portal (SASINF) also contains model inputs and outputs that can be used directly in NOAA Fisheries Toolbox applications.

The meeting was broadcast as a webinar using Adobe Connect and all sessions were open to the public. The meeting agenda included a daily public comment period. Members of the audience and individuals on the phone were included in the discussions of the panel at the discretion of the Panel Co-chairs. However, the tight timeline for completing the assessments required a strong adherence to the terms of reference and the description of the operational assessment process developed by the NRCC. Onsite participants in Woods Hole are listed in Section 21.5.

1.2 Data

The groundfish updates used the following standard procedures for updating data from landings, discards and surveys (Table 3). The US commercial landings are estimated by market category from the area allocation ("AA") tables, which combine dealer and vessel trip reports to determine where fish were caught. The US commercial discards are estimated by gear types using the Standardized Bycatch Reporting Methodology (SBRM), which combines observer data (including at-sea monitors) and dealer landings. The US recreational landings and discards come from the Marine Recreational Information Program (MRIP), including recent revisions to historical data. Both commercial and recreational discards have species-specific discard mortality rates applied to the discarded fish. Catch-at-age is estimated using age-length keys applied to expanded length frequency distributions. For white hake, which is landed headed, the age-length key is applied to predicted lengths based on dorsal fin to caudal fin length. Additional sources of catch for some species come from Canadian or other foreign fishing.

The NEFSC spring and fall bottom trawl surveys are the most common source of information for population trends (Table 3). These surveys are calibrated to "Albatross units" in most cases to allow for the longest time series possible. NOAA ship *Henry B. Bigelow* replaced the *Albatross IV* as the primary bottom trawl survey vessel in spring 2009. In some instances the calibration coefficient varies by length but in others a simple scalar adjustment is applied to all length classes. Other surveys used include the Massachusetts Division of Marine Fisheries spring and fall bottom trawl surveys, the Maine-New Hampshire spring and fall bottom trawl surveys, the Canadian Department of Fisheries and Oceans February survey, and some additional state surveys. Catch per unit effort is not typically used as a source of population trends due to the many regulatory changes that have occurred over time in the Northeast that influence fishing behavior and catch rates. All updated assessments used a consistent quality assurance criterion (known as TOGA; Politis et al. 2014) for surveys conducted by the NOAA ship *Henry B. Bigelow*.

1.3 Models

Based on previous 2015 operational assessments (Table 4; NEFSC, 2015), there are 12 stocks assessed with an age-based approach. Eight use the statistical catch-at-age model ASAP while 4 others use virtual population analysis (VPA). For the 4 VPA stocks, the 2017 spring survey information was included in the model. The remaining 7 stocks are assessed with a range of model types including length-based (SCALE), index (AIM), and direct survey expansion. The reference points for the age- and length-based assessments were derived from stochastic projections of the F_{MSY} (or F_{MSY} proxy) for many years (typically 100), while the other assessment types use stock-specific rules for deriving the reference points. Technical descriptions of the biomass, fishing mortality and reference point estimators used for each stock are shown in Table 4. Information from a newly revived industry-based cod survey in the Gulf of Maine was considered for context in a few relevant assessments and discussed with the Peer Review Panel but was not directly included due to limited time series and Operational Assessment guidelines.

1.4 Results

Operational Assessments were conducted in 2017 for 19 of the 20 stocks in the Northeast Multi-species Fishery Management Plan (Table 1). The updates replicated the methods recommended in the most recent benchmark decisions, as modified by any subsequent operational assessments or updates (Table 2). Information supplemental to the assessment report for each stock can be found on the Stock Assessment Support Information (SASINF) website. The Panel accepted all of the assessments as a scientific basis for management and provided catch advice for all 19 stocks. Recommended stock status did not change for 18 of the 19 stocks, and improved for 1 stock (Table 5).

Each of the 19 species chapters contains the assessment results provided to the Panel for peer review followed by a section entitled "Reviewer Comments," which describes final Panel decisions at the conclusion of the peer review. In this Executive Summary, tables and figures related to stock status from the 2017 review reflect the Panel recommendations (Tables 5 - 6; Figures 1 - 2).

The number of stocks with retrospective adjustments (also called rho adjustments) applied increased from the last assessment from 7 to 8 (Table 7). Decisions to apply a retrospective adjustment to estimates of terminal year biomass and fishing mortality rates were based on whether the rho adjusted value was outside the 90% joint confidence region for the model estimates. This principle was supported by the AOP and was applied to adjust biomass estimates for Georges Bank haddock, Southern New England yellowtail flounder, Cape Cod/Gulf of Maine yellowtail flounder, Georges Bank winter flounder, American plaice, white hake, pollock and redfish (Table 8). Gulf of Maine cod was an exception because of earlier guidance from the SARC 55 review panel. Despite the presence of a significant retrospective pattern at that meeting no adjustments were made; the Operational Assessments panel followed that precedent.

Stock status recommendations for the 19 groundfish stocks are summarized in Tables 5 and 6. Four stocks are experiencing overfishing: Southern New England yellowtail flounder, Cape Cod Gulf of Maine yellowtail flounder, Gulf of Maine cod and Georges Bank yellowtail flounder. Ten groundfish stocks are overfished (Table 5). Based on these recommendations, the number of overfished stocks and stocks experiencing overfishing has generally decreased since GARM III in 2007 (Figure 3), and the magnitude of overfishing or depletion for several stocks has generally decreased (Figures 1 and 2).

Simultaneous assessments of 19 groundfish stocks allowed a comprehensive examination of trends in spring and fall survey indices (Figures 4 and 5, respectively). For the majority of stocks the average of the most recent 5 years is below the time series mean for that stock.

Estimates of overall (aggregate) groundfish minimum swept area biomass are at or near an all-time high (Figures 6 and 7). However, the current stock diversity of the overall groundfish biomass is less than that seen in the 1960s and 1970s. Current groundfish biomass is dominated by only a few stocks. For example, the combined biomass of the Georges Bank haddock, Gulf of Maine haddock, pollock, and redfish stocks currently constitute more than 90% of the overall groundfish biomass observed in NEFSC spring surveys (Figure 6). It is important to note that the minimum swept area biomass estimates assume a common capture efficiency of 1.0 across all years. Actual biomasses, as derived from models, are adjusted for catchability and selectivity estimates and are higher than the minimum swept area estimates. Unfortunately model-based estimates are not available for all stocks over the entire time period of the surveys (i.e. since 1963); the primary limitation is the availability of age information from the commercial catches that would be needed to support full age-based assessments.

For 12 stocks, model-based biomass estimates can be computed from 1985 onward. The striking increase in abundance since 1985 is driven primarily by redfish, Georges Bank haddock, and pollock (Figure 8). Pollock biomass from the stock assessment is much higher than the swept area estimates because of a dome-shaped selectivity pattern in both the survey and catch data. This suggests that a substantial fraction of the stock biomass is unavailable to either the fishery or survey gear. The chapter describing the pollock assessment includes a sensitivity run in which the assumption of dome-shaped selectivity is removed, resulting in a biomass estimate that is about half as large. The increase in model based estimates of overall biomass, with or without pollock, is consistent with the trends revealed in the swept area estimates (Figures 6, 7 and 8).

An advantage of conducting multiple assessments simultaneously is that measures of productivity can be compared over time. Reductions in average weight-at-age, declines in recruitment and shifts in age-at-maturity all influence the estimated biomass at maximum sustainable yield and total MSY. As such, the combined single species stock assessments provide valuable measures of ecosystem productivity, irrespective of the underlying environmental or ecological causes. Reductions in average weights-at-age have occurred for stocks at high abundance, such as Georges Bank haddock, but also for stocks at low abundance, such as witch flounder. Hence, density dependence alone is insufficient to explain this across all stocks. Reductions in recruitment are often associated with declines in stock size but inter-annual variation often masks trends. Aggregate estimates of total B_{MSY} are available for 10 stocks over the past decade (Figure 9). Total B_{MSY} for these stocks declined by 12% between 2008 and 2015 from 668 kt to 521 kt. Estimates further declined by about 7% between 2015 and 2017 to 483 kt (Figure 9).

An ecosystem report provided a climate vulnerability assessment for each of the 19 groundfish species. Current ecosystem considerations were summarized in a risk analysis framework to provide ecological context to the stock status of each species, including condition factor, productivity analyses and habitat modeling as an alternative index of biomass. Potential impacts of the recent record high fall bottom and sea surface temperatures with subsequent thermal habitat reductions and range shifts were assessed for each stock, taking into account each stock's thermal preferences and vulnerability to climate change.

1.5 Reviewer Comments: Overview

The operational assessment meeting that took place at the Northeast Fisheries Science Center September 11-15 went well and all of the individual operational assessments were approved for use in developing management decisions for the SSC and Council. However, in the process of evaluating the 19 groundfish stocks certain patterns were notable in the data and in the model responses to that data. These patterns would suggest that some higher-level integrated analysis should take place in order to improve the assessment process as a whole while maintaining the integrity of the individual assessments, which meet the requirements for the present. Among the patterns that emerge were the number of assessments that displayed some kind of retrospective pattern and that required a retrospective adjustment. Unfortunately, numerous factors can individually or in union cause retrospective patterns to emerge in assessment estimates. Examples of such influential factors include changes in natural mortality, changes in selectivity, changes in size at age, underreporting of landings or discards, immigration or emigration, as well as factors affecting recruitment.

One recognizes that the Ecosystem Group, who gave a short presentation the afternoon of the first day of the week-long groundfish meeting, are in the position of providing at least some insight on environmental factors that could influence ecosystem health as well as those which might in other ways confound the assessment. The presentations focused on some general metrics likely to influence fish health and behavior, but more proactive approaches might also be considered. During the meeting the review panel noticed general patterns in reductions in size at age across several stocks. And while such changes could be driven by density-dependent effects, these changes may also be precipitated by ecosystem level changes. The management response to these two different determinants could be very different. The panel also noted something that seemed to be common knowledge, namely that 2013 stood out as it was a good year for producing strong recruitment year classes (other years, such as 2007, may also have been conducive to recruitment across stocks). Further, the review panel observed situations where fisheries stocks seemed unable to respond positively to management restrictions on catch.

Broadly, these changes in the biology, in the ecosystem and in contrast to what is happening in management suggest that an integrated approach that not only examines ecosystem trends but also tries to account for other aspects of fisheries systems such as the quality and nature of the survey and catch data, the magnitude of unreported catch, and long term effects on fishing behavior of changing management actions would be highly beneficial. On a related cross-assessment note, working towards assessments that better represent the level of uncertainty in the estimates would also be of value. This will take time as this is an evolving area of research, but the outcome would likely benefit fisheries management as the risk in decision making given constraints in how data are collected and how the ecosystem is changing becomes better known.

The review panel was pleased to see the work coming out of the Cooperative Research Survey Program. In this review, the data were used to help validate existing model-based trends as well as provide direct input into catchability estimates for empirical approaches when no integrated model was available for use. The assessment community is encouraged to continue to use these data for such purposes. One must recognize, however, that such data are most useful when considered in the longer term. More specifically, the review panel notes that individual surveys must be viewed in the context of long-term data collection efforts and extensive integrated assessment that undergo ongoing review. One should not expect that a single experiment should overturn years of systematic analysis, but should be instrumental in providing validation and by contrast challenges to the existing methods. Such studies should also point to where additional work is needed.

References

Politis PJ, Galbraith JK, Kostovick P, Brown RW. 2014. Northeast Fisheries Science Center bottom trawl survey protocols for the NOAA Ship Henry B. Bigelow. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-06; 138 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD14-06

Miller, T.J., Richardson, D.E., Politis P.J., Blaylock, J. *In press.* Northeast Fisheries Science Center bottom trawl catch efficiency and biomass estimates for 2009-2017 for 8 flatfish stocks included in the 2017 Northeast Groundfish Operational Assessments. US Dept Commer, Northeast Fish Sci Cent Ref Doc. *In press*; 26 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. CRD15-24

Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-06; 789 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026 CRD12-06

Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA FIsheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. CRD08-15

Mayo RK, Terceiro M, editors. 2005. Assessment of 19 Northeast groundfish stocks through 2004. 2005 Groundfish Assessment Review Meeting (2005 GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, 15-19 August 2005. U.S. Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 05-13; 499 p. CRD05-13

Table 1: List of stocks included in the 2017 groundfish operational assessment and the abbreviations used for each in tables and figures in this document. Atlantic halibut has been excluded from this document because it is being reviewed in a separate forum.

Stock Abbrev	Stock Name
CODGM	Gulf of Maine cod
CODGB	Georges Bank cod
HADGM	Gulf of Maine haddock
HADGB	Georges Bank haddock
YELCCGM	Cape Cod/Gulf of Maine yellowtail flounder
YELSNEMA	Southern New England/Mid-Atlantic yellowtail flounder
FLWGB	Georges Bank winter flounder
FLWSNEMA	Southern New England/Mid-Atlantic winter flounder
REDUNIT	Acadian redfish
PLAUNIT	American plaice
WITUNIT	Witch flounder
HKWUNIT	White hake
POLUNIT	Pollock
CATUNIT	Wolffish
FLDGMGB	Gulf of Maine/Georges Bank windowpane flounder
FLDSNEMA	Southern New England/Mid-Atlantic windowpane flounder
OPTUNIT	Ocean pout
FLWGM	Gulf of Maine winter flounder
YELGB	Georges Bank yellowtail flounder

Table 2: Lead scientist for each stock (current/previous if different), information about last assessment, including: the forum for review of the last assessment (Forum), the type of assessment done (Type), publication year (Pub.), the terminal year of the catch data included (Term. yr.), overfished/overfishing status, rebuilding status, and reference. *Note: Op. Assess = Operational Assessment*

Stock	Lead	Forum	Type	Pub.	Term. yr.	Overfished?	Overfishing?	Rebuild status	Reference
CODGM	Palmer	Op. Assess	Update	2015	2014	Yes	Yes	By 2024	CRD15-24
CODGB	Legault/O'Brien	Op. Assess	Update	2015	2014	Yes	Unknown	By 2026	CRD15-24
HADGM	Palmer	Op. Assess	Update	2015	2014	No	No	Rebuilt	CRD15-24
HADGB	Brooks	Op. Assess	Update	2015	2014	No	No	Rebuilt	CRD15-24
YELCCGM	Alade	Op. Assess	Update	2015	2014	Yes	Yes	By 2023	CRD15-24
YELSNEMA	Alade	Op. Assess	Update	2015	2014	Yes	Yes	Rebuilt	CRD15-24
FLWGB	Hendrickson	Op. Assess	Update	2015	2014	Yes	Yes	By 2017	CRD15-24
FLWSNEMA	Wood	Op. Assess	Update	2015	2014	Yes	No	By 2023	CRD15-24
REDUNIT	Linton	Op. Assess	Update	2015	2014	No	No	Rebuilt	CRD15-24
PLAUNIT	Terceiro/O'Brien	Op. Assess	Update	2015	2014	No	No	By 2024	CRD15-24
WITUNIT	Wigley	SARC 62	Benchmark	2017	2016	Yes	Unknown	By 2017	CRD17-03
HKWUNIT	Sosebee	Op. Assess	Update	2015	2014	No	No	By 2014	CRD15-24
POLUNIT	Linton	Op. Assess	Update	2015	2014	No	No	Rebuilt	CRD15-24
CATUNIT	Adams	Op. Assess	Update	2015	2014	Yes	No	Unknown	CRD15-24
FLDGMGB	Chute	Op. Assess	Update	2015	2014	Yes	No	By 2017	CRD15-24
FLDSNEMA	Chute	Op. Assess	Update	2015	2014	No	No	Rebuilt	CRD15-24
OPTUNIT	Wigley	Op. Assess	Update	2015	2014	Yes	No	By 2014	CRD15-24
FLWGM	Nitschke	Op. Assess	Update	2015	2014	Unknown	No	Unknown	CRD15-24
YELGB	Legault	TRAC 2017	Update	2017	2016	Yes	Unknown	By 2032	TRAC2017

Table 3: Data used in each assessment. The column heads are US commercial landings (US c-lnd), US commercial discards (US c-dis), US recreational landings (US r-lnd), US recreational discards (US r-dis), Canadian catch (CA cat), Northeast Fisheries Science Center spring, fall and winter surveys (NE S, NE F and NE W), Massachusetts spring and fall surveys (MA S and MA F), Maine/New Hampshire spring and fall surveys (ME/NH S and ME/NH F) and Canadian Department of Fisheries and Oceans February survey (DFO S).

	Catch					**Surveys**							
Stock	US c-lnd	US c-dis	US r-lnd	US r-dis	CA Cat	NE S	NE F	NE W	MA S	MA F	ME/NH S	ME/NH F	DFO S
CODGM	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	No
CODGB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
HADGM	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
HADGB	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No	Yes
YELCCGM	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
YELSNEMA	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No	No	No	No
FLWGB	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No	Yes
FLWSNEMA	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	No	No
REDUNIT	Yes	Yes	No	No	No	Yes	Yes	No	No	No	No	No	No
PLAUNIT	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	No	No	No
WITUNIT	Yes	Yes	No	No	No	Yes	Yes	No	No	No	No	No	No
HKWUNIT	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No	No
POLUNIT	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No
CATUNIT	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	No	No
FLDGMGB	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No
FLDSNEMA	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No
OPTUNIT	Yes	Yes	No	No	No	Yes	No	No	No	No	No	No	No
FLDWGM	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
YELGB	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No	Yes

Table 4: Assessment type and reference points from 2015 operational assessment CRD15-24. Biomass and yield values are in metric tons. *Note: sp=stochastic projection and surv. B = survey biomass.*

Stock	Assess.	Type	F def.	B def.	F_{MSY} type	F_{MSY} value	B_{MSY} type	B_{MSY} value	MSY type	MSY value
CODGM(M=.2)	ASAP	age-based	F_{Full}	SSB	$F_{40\%SPR}$	0.18	sp	40,187	sp	6,797
CODGM(M_{ramp})	ASAP	age-based	F_{Full}	SSB	$F_{40\%SPR}$	0.18	sp	59,045	sp	10,043
CODGB	empirical	smoothed survey	$\frac{catch}{surv.B}$	surv. B	NA	NA	NA	NA	NA	NA
HADGM	ASAP	age-based	F_{Full}	SSB	$F_{40\%SPR}$	0.468	sp	4,623	sp	1,083
HADGB	VPA	age-based	avg F ages 5-7	SSB	$F_{40\%SPR}$	0.39	sp	108,300	sp	24,900
YELCCGOM	VPA	age-based	avg F ages 4-6	SSB	$F_{40\%SPR}$	0.279	sp	5,259	sp	1,285
YELSNEMA	ASAP	age-based	avg F ages 4-5	SSB	$F_{40\%SPR}$	0.349	sp	1,959	sp	541
FLWGB	VPA	age-based	avg F ages 4-6	SSB	Fmsy	0.536	sp	6,700	sp	2,840
FLWSNEMA	ASAP	age-based	avg F ages 4-5	SSB	Fmsy	0.325	sp	26,928	sp	7,831
REDUNIT	ASAP	age-based	F_{Full}	SSB	$F_{50\%SPR}$	0.038	sp	281,112	sp	10,466
PLAUNIT	VPA	age-based	avg F ages 6-9	SSB	$F_{40\%SPR}$	0.196	sp	13,107	sp	2,675
WITUNIT	empirical	survey expansion	$\frac{catch}{surv.B}$	surv. B	NA	NA	NA	NA	NA	NA
HKWUNIT	ASAP	age-based	F_{Full}	SSB	$F_{40\%SPR}$	0.188	sp	32,550	sp	5,422
POLUNIT(base)	ASAP	age-based	avg F ages 5-7	SSB	$F_{40\%SPR}$	0.27	sp	105,22	sp	19,67
POLUNIT(flat)	ASAP	age-based	avg F ages 5-7	SSB	$F_{40\%SPR}$	0.25	sp	54,90	sp	10,99
CATUNIT	SCALE	length-based	F_{Full}	SSB	$F_{40\%SPR}$	0.243	sp	1,663	sp	244
FLDGMGB	AIM	index	$\frac{catch}{surv.B}$	surv. B	replacement ratio	0.450	$\frac{MSY_{proxy}}{F_{MSY proxy}}$	1.554	median catch 1995-2001	700
FLDSNEMA	AIM	index	$\frac{catch}{surv.B}$	surv. B	replacement ratio	2.027	$\frac{MSY_{proxy}}{F_{MSY proxy}}$	0.247	median catch 1995-2001	500
OPTUNIT	index	index	$\frac{catch}{surv.B}$	surv. B	med. $F_{1977-1985}$	0.76	med. surv. $B_{1977-1985}$	4.94	F_{MSY} * B_{MSY}	3,754
FLWGM	empirical	survey expansion	$\frac{catch}{B_{30+cm}}$	surv. B	$F_{40\%}$ from YPR	0.23	NA	NA	NA	NA
YELGB	empirical	survey expansion	$\frac{catch}{surv.B}$	surv. B	NA	NA	NA	NA	NA	NA

Table 5: Synopsis of recommended status by stock from the 2017 peer review. These recommendations will be considered by NMFS in making final status determinations.

		Recommended Status	
Stock	Stock Name	Overfishing?	Overfished?
CODGM	Gulf of Maine cod	Yes	Yes
CODGB	Georges Bank cod	Unknown	Yes
HADGM	Gulf of Maine haddock	No	No
HADGB	Georges Bank haddock	No	No
YELCCGM	Cape Cod/Gulf of Maine yellowtail flounder	Yes	Yes
YELSNEMA	S. New Eng./Mid-Atl. yellowtail flounder	Yes	Yes
FLWGB	Georges Bank winter flounder	No	No
FLWSNEMA	S. New Eng./Mid-Atl. winter flounder	No	Yes
REDUNIT	Acadian redfish	No	No
PLAUNIT	American plaice No	No	No
WITUNIT	Witch flounder	Unknown	Yes
HKWUNIT	White hake	No	No
POLUNIT	Pollock	No	No
CATUNIT	Wolffish	No	Yes
FLDGMGB	Gulf of Maine/Georges Bank windowpane flounder	No	Yes
FLDSNEMA	S. New Eng./Mid-Atl. windowpane flounder	No	No
OPTUNIT	Ocean pout	No	Yes
FLWGM	Gulf of Maine winter flounder	No	Unknown
YELGB	Georges Bank yellowtail flounder	Yes	Yes

Table 6: Summary of Operational Assessment estimates of biomasses and fishing mortality rates in 2016 and biological reference points for groundfish stocks. Reference points are not estimable for some stocks. Terminal biomass estimates for CODGB and YELGB are for 2017 rather than 2016.

Stock	Model type	B_{2016} (mt)	B_{MSY} (mt)	$\frac{B_{2016}}{B_{MSY}}$	F_{2016}	F_{MSY}	$\frac{F_{2016}}{F_{MSY}}$	MSY (mt)	ρ adj?	Comments
CODGM	ASAP (M=0.2)	3,046	40,604	0.08	0.228	0.17	1.31	7,049	No	
CODGM	ASAP (M-ramp)	3,262	59,714	0.05	0.237	0.18	1.34	10,502	No	
CODGB	Empirical	7.237			0.174				No	Smoothed survey indices used to estimate biomass
HADGB	VPA	290,324	104,312	2.78	0.309	0.35	0.88	24,372	Yes	
HADGM	ASAP	47,821	6,769	7.06	0.137	0.46	0.30	1,547	No	
YELCCGM	VPA	1,191	4,640	0.26	0.314	0.27	1.15	1,154	Yes	
YELSNEMA	ASAP	152	1,860	0.08	1.09	0.34	3.20	511	Yes	
FLWGB	VPA	3,946	7,600	0.52	0.117	0.52	0.22	3,500	Yes	
FLWSNEMA	ASAP	4,360	24,687	0.18	0.21	0.34	0.62	7,532	No	
PLAUNIT	VPA	13,351	13,503	0.99	0.111	0.22	0.51	2,924	Yes	
WITUNIT	Empirical	14,563			0.035				No	Average survey biomass, exploitation ratio used
REDUNIT	ASAP	359,970	247,918	1.45	0.011	0.04	0.29	9,318	Yes	
HKWUNIT	ASAP	21,276	30,948	0.69	0.066	0.18	0.36	4,867	Yes	
POLUNIT	ASAP (base)	183,907	105,510	1.74	0.036	0.26	0.14	19,427	Yes	Flat top selectivity model was used for sensitivity testing
POLUNIT	ASAP (flat top)	72,889	60,738	1.20	0.079	0.25	0.32	11,692	Yes	see above
CATUNIT	SCALE	652	1,612	0.40	0.002	0.22	0.01	232	No	
FLDGMGB	AIM	0.36	2.06	0.17	0.222	0.34	0.65	700	No	Biomass in kg/tow. F values reflect exploitation rate
FLDSNEMA	AIM	0.329	0.253	1.30	1.733	1.92	0.90	500	No	Biomass in kg/tow. F values reflect exploitation rate
OPTUNIT	Index-based	0.223	4.94	0.05	0.221	0.76	0.29	3,754	No	Biomass in kg/tow. F values reflect exploitation rate
FLWGM	Empirical	2,585			0.086	0.23	0.37		No	30+ cm biomass, exploitation ratio used
YELGB	Empirical	3,118			0.009				No	Average survey biomass, exploitation ratio used

Table 7: Comparison of biomass (B) and fishing mortality rate (F) Mohn's rho values (ρ) by stock between the previous assessment (ρ_{last}) and the 2017 (ρ_{2016}) updates. The biomass (B_{2016}) and fishing mortality rate (B_{2016}) point estimates and ρ adjusted values (Adj.) are provided for the 2017 operational assessments. Stocks using ρ adjusted values in the last assessment and the 2017 assessments (ρ adj. vs. pt. est. for those stocks that did not use the ρ adjustment) are identified, along with the type of ρ adjustment used in the 2017 assessment (NAA=numbers at age, SSB=spawning stock biomass applied to all ages), are also provided. Only age-based and length-based stocks that could exhibit retrospective patterns are included in this table. Missing ρ values indicate a minor retrospective pattern was found and no retrospective adjustments were made.

Stock	Model type	ρ_{last}	ρ_{2016}	B_{2016}	Adj.	ρ_{last}	ρ_{2016}	F_{2016}	Adj.	Last Assess.	2017	Proj. Adj.
CODGM	ASAP (M=0.2)	0.54	0.53	3046	1,997	-0.31	-0.31	0.23	0.33	pt. est.	pt. est.	none
CODGM	ASAP (M-ramp)	0.20	0.30	3262	2,502	-0.08	-0.17	0.24	0.28	pt. est.	pt. est.	none
HADGM	ASAP	-0.04		47821	NA	0.03		0.14		pt. est.	pt. est.	none
HADGB	VPA	0.50	0.89	549938	290,324	-0.34	-0.63	0.11	0.31	ρ adj.	ρ adj.	SSB
YELCCGM	VPA	0.98	0.76	2093	1,191	-0.45	-0.39	0.19	0.31	ρ adj.	ρ adj.	NAA
YELSNEMA	ASAP	1.06	0.97	300	152	-0.53	-0.47	0.58	1.09	pt. est.	ρ adj.	NAA
FLWGB	VPA	0.83	0.54	6083	3,946	-0.51	-0.31	0.08	0.12	ρ adj.	ρ adj.	SSB
FLWSNEMA	ASAP	0.21		4360	NA	-0.25		0.21		pt. est.	pt. est.	none
REDUNIT	ASAP	0.26	0.21	435852	359,970	-0.19	-0.18	0.01	0.01	ρ adj.	ρ adj.	NAA
PLAUNIT	VPA	0.32	0.14	15148	13,351	-0.32	-0.32	0.07	0.11	ρ adj.	ρ adj.	NAA
HKWUNIT	ASAP	0.18	0.20	25638	21,276	-0.13	-0.12	0.06	0.07	pt. est.	ρ adj.	NAA
POLUNIT	ASAP (base)	0.28	0.23	226371	183,907	-0.28	-0.28	0.03	0.04	ρ adj.	ρ adj.	NAA
POLUNIT	ASAP (flat)		0.41	102571	72,889		-0.35	0.05	0.08	ρ adj.	ρ adj.	NAA

Table 8: The biomass (B) and exploitation rate (F) values used for status determination may be adjusted to account for a retrospective pattern in some stocks. In general, when the B or F values adjusted for restrospective pattern (B_ρ and F_ρ) were outside of the approximate 90% confidence interval (Conf. limits) of the model-estimated B_{2016} and F_{2016}, the adjusted values were used to determine stock status (Adj. = Yes). There can be exceptions however, such as YELSNEMA and CODGM(M=0.2) in OA 2017 and details regarding each decision can be found in the report and reviewer comments sections for each stock in OA 2017. Only stocks that had both an estimable 7-year Mohn's ρ for B and F and estimable approximate 90% confidence limits on terminal year B and F values are included here.

Stock	B_{2016}	B_ρ	Conf. limits	F_{2016}	F_ρ	Conf. limits	Adj?
CODGM(M=0.2)	3,046	1,997	2,464 - 4,025	0.228	0.332	0.169 - 0.316	No
CODGM(M ramp)	3,262	2,502	2,487 - 4,270	0.237	0.285	0.172 - 0.331	No
HADGB	549,938	290,324	383,166 - 801,643	0.113	0.309	0.079 - 0.164	Yes
YELSNEMA	300	152	217 - 459	0.58	1.09	0.362 - 0.843	Yes
YELCCGM	2,093	1,191	1,722 - 2,626	0.193	0.314	0.15 - 0.26	Yes
FLWGB	6,083	3,946	4,898 - 7,812	0.081	0.117	0.064 - 0.106	Yes
PLAUNIT	15,148	13,351	13,582 - 17,009	0.075	0.111	0.065 - 0.088	Yes
HKWUNIT	25,638	21,276	21,466 - 30,052	0.058	0.066	0.048 - 0.07	Yes
POLUNIT(base)	226,371	183,907	76,914 - 293,256	0.026	0.036	0.037 - 0.034	Yes
REDUNIT	435,852	359,970	394,927 - 481,018	0.009	0.011	0.008 - 0.01	Yes

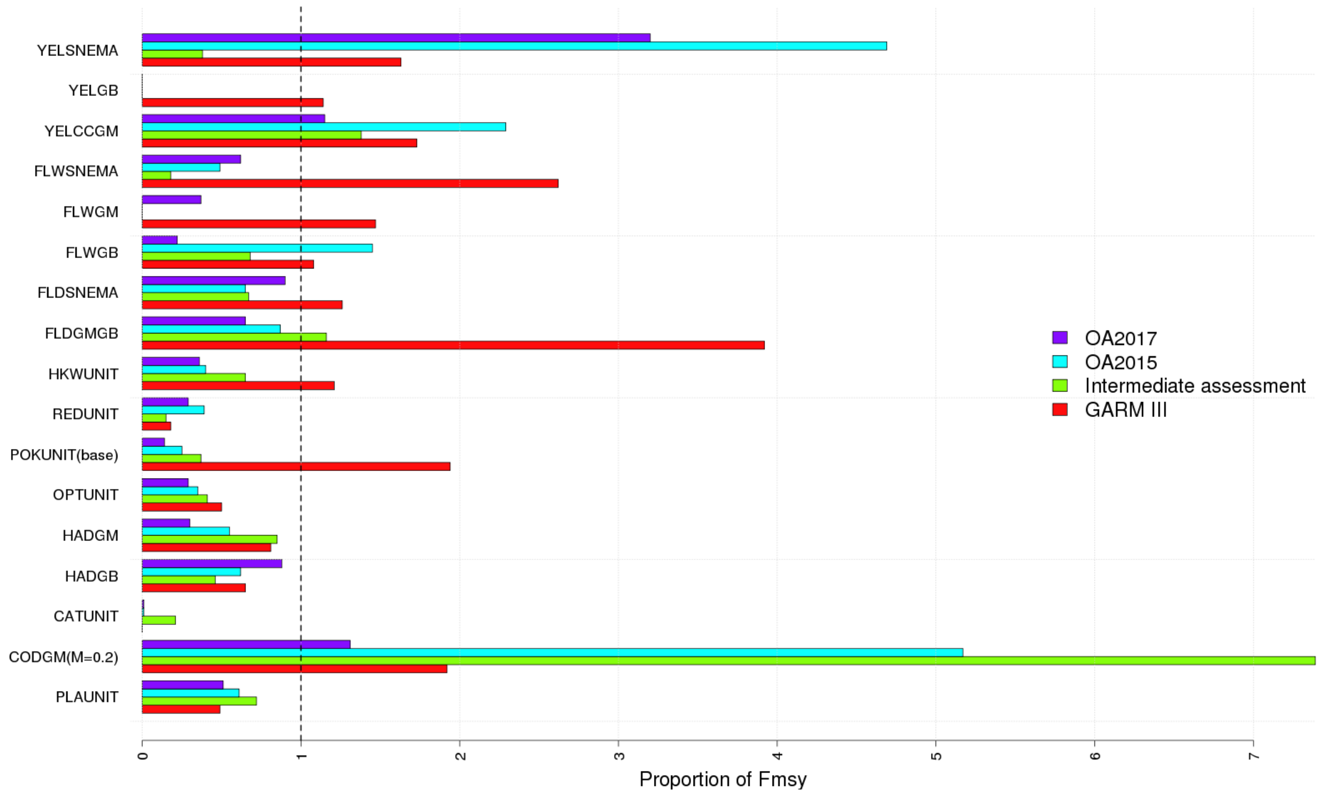

Figure 1: Changes in the ratio of fishing mortality to FMSY proxy from 2007 (GARM III) to 2016 (OA 2017) for selected Northeast Multispecies Fishery Management Plan groundfish stocks. The results from the assessment prior to the OA 2015 assessment are shown for each stock to provide 'Intermediate' values. Stocks on which overfishing is occurring are those where the $\frac{F_{terminal}}{F_{MSY proxy}}$ ratio is greater than 1. *Notes: (1) the GARM III assessments did not include wolffish; (2) stock status in the 'Intermediate' assessment could not be determined for Gulf of Maine winter flounder or Georges Bank yellowtail flounder; and, (3) based on the OA 2015 assessments stock status could not be determined for Gulf of Maine winter flounder, Georges Bank yellowtail flounder and Georges Bank cod; (4) the Gulf of Maine cod assessment values shown here are for the M=0.2 model. (5) based on the SARC 62 benchmark assessment, status for witch flounder status could not be determined.* Because current overfishing status for Georges Bank cod and witch flounder are unknown, they were not included in this figure.

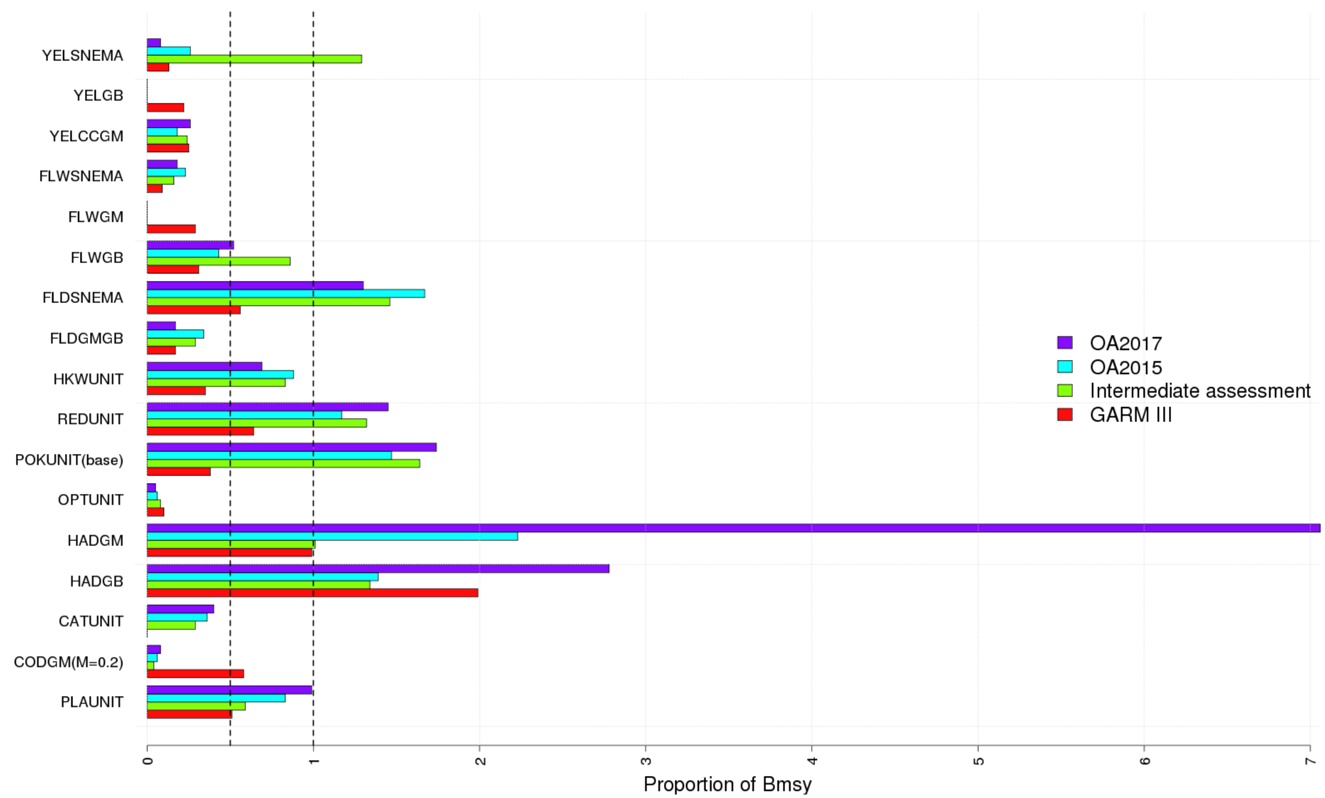

Figure 2: Changes in the ratio of stock biomass to B_{MSY} proxy from 2007 (GARM III) to 2016 (OA 2017) for selected Northeast Multispecies Fishery Management Plan groundfish stocks. The results from the assessment prior to the OA 2015 assessment are shown for each stock to provide 'Intermediate' values. Stocks that are overfished stocks are those where the $\frac{B_{terminal}}{B_{MSY proxy}}$ ratio is less than 0.5. *Notes: (1) the GARM III assessments did not include wolffish; (2) stock status in the 'Intermediate' assessment could not be determined for Gulf of Maine winter flounder or Georges Bank yellowtail flounder; and, (3) based on the OA 2015 assessments stock status could not be determined for Gulf of Maine winter flounder, Georges Bank yellowtail flounder and Georges Bank cod; (4) the Gulf of Maine cod assessment values shown here are for the M=0.2 model. (5) based on the SARC 62 benchmark assessment, status for witch flounder status could not be determined.* Because Georges Bank cod and witch flounder do not currently have quantitative biomass reference points, they were not included in this figure.

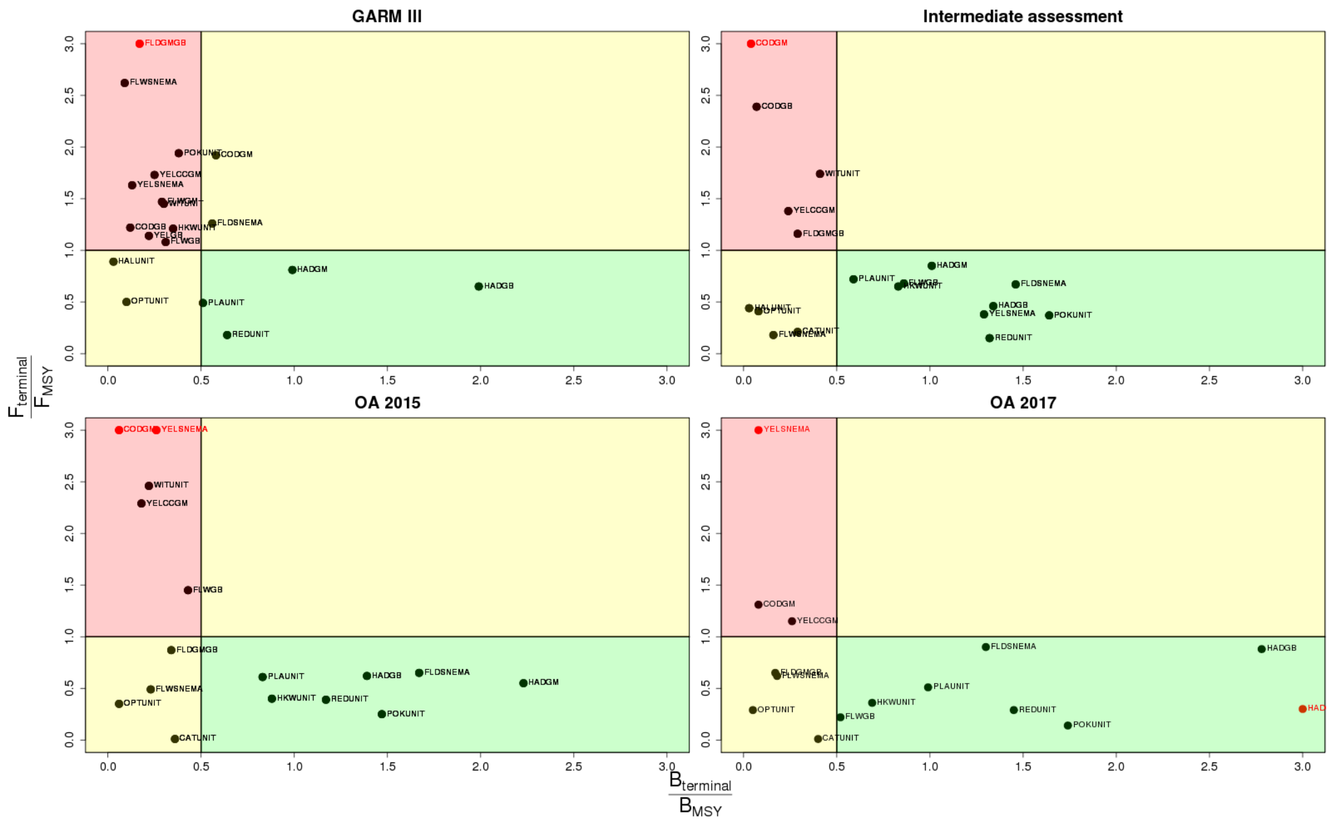

Figure 3: Status of the Northeast Multispecies Fishery Management Plan groundfish stocks in 2007 (GARM III) and 2016 (OA 2017) with respect to the F_{MSY} and B_{MSY} proxies. The 'Intermediate assessment' represents the last stock assessment conducted prior to the OA 2015 assessment (year varies by stock). Stocks on which overfishing is occurring are those where the $\frac{F_{terminal}}{F_{MSYproxy}}$ ratio is greater than 1 and overfished stocks are those where the $\frac{B_{terminal}}{B_{MSYproxy}}$ ratio is less than 0.5. The scale of the axes was restricted to allow for comparison between years. Stocks with red markers and text exceeded these limits (values are available in Table 6). *Notes: (1) the GARM III assessments did not include wolffish; (2) for the intermediate assessments stock status could not be determined for Gulf of Maine winter flounder (OA 2014) or Georges Bank yellowtail (TRAC 2015); and, (3) based on the OA 2015 assessments stock status could not be determined for Gulf of Maine winter flounder and Georges Bank yellowtail flounder; (4) the Gulf of Maine cod assessment values shown here are for the M=0.2 model. In the OA 2015 assessment, the stock status for Georges Bank cod remained overfished and overfishing is occurring; however, since the assessment was not accepted, ratios of terminal conditions to reference points cannot be determined.* Only stocks with known reference points are included in this figure.

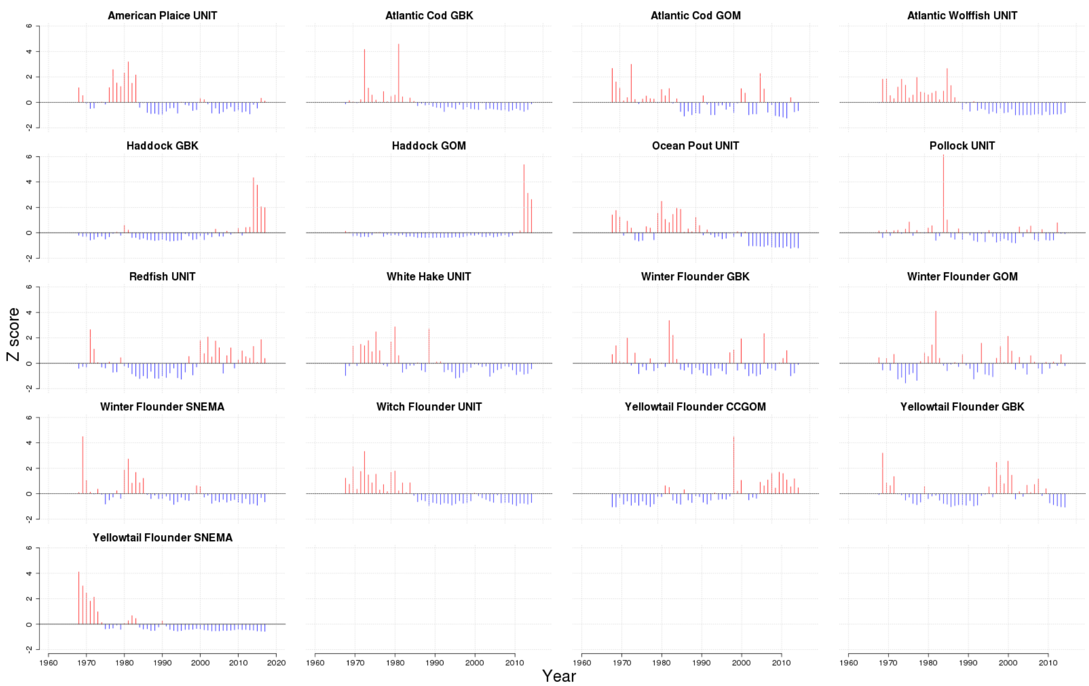

Figure 4: NEFSC spring bottom trawl survey index standardized anomalies (Z-score) for the Northeast Multispecies Fishery Management Plan groundfish stocks from 1968 to 2017. *Note that both the Georges Bank/Gulf of Maine and Southern New England/Mid-Atlantic windowpane flounder stocks are not included since the spring survey is uninformative as an index of abundance and not used in the stock assessment.*

Figure 5: NEFSC fall bottom trawl survey index standardized anomalies (Z-score) for the Northeast Multispecies Fishery Management Plan groundfish stocks from 1963 to 2016. *Note that ocean pout is not included since the fall survey is uninformative as an index of abundance and not used in the stock assessment.*

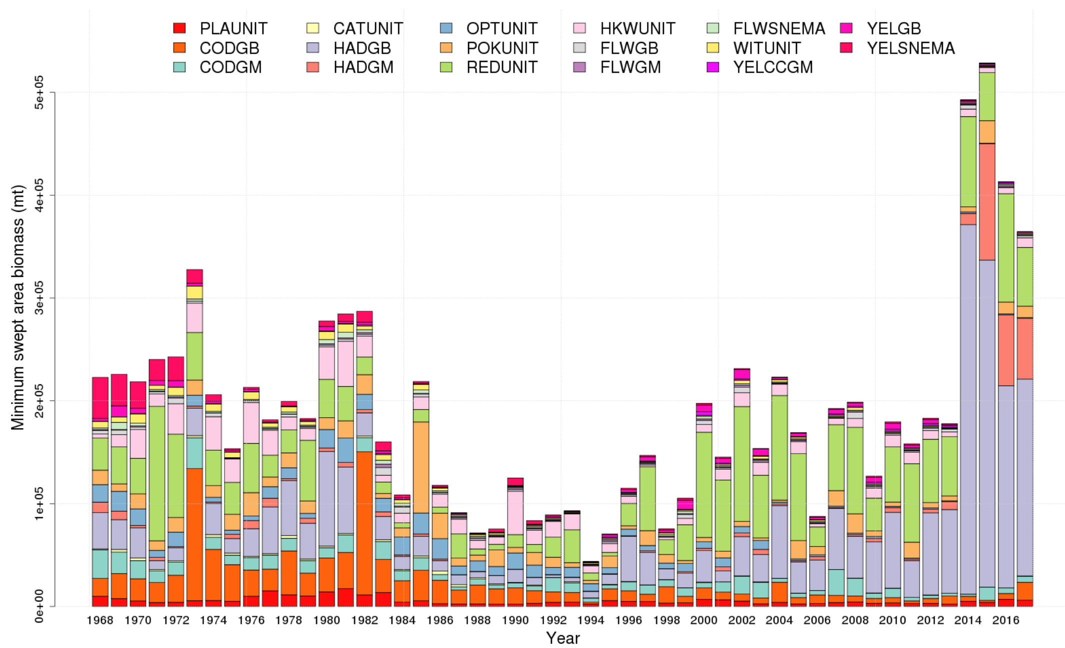

Figure 6: NEFSC spring bottom trawl survey minimum swept area biomass (mt) for the Northeast Multispecies Fishery Management Plan groundfish stocks from 1968 to 2017, by stock. Minimum swept area estimates assume a trawl swept area of 0.0112 nm^2) (0.0384 km^2) based on the wing spread of the trawl net. *Note that both the Georges Bank/Gulf of Maine and Southern New England/Mid-Atlantic windowpane flounder stocks are not included since the spring survey is uninformative as an index of abundance and not used in the stock assessment.*

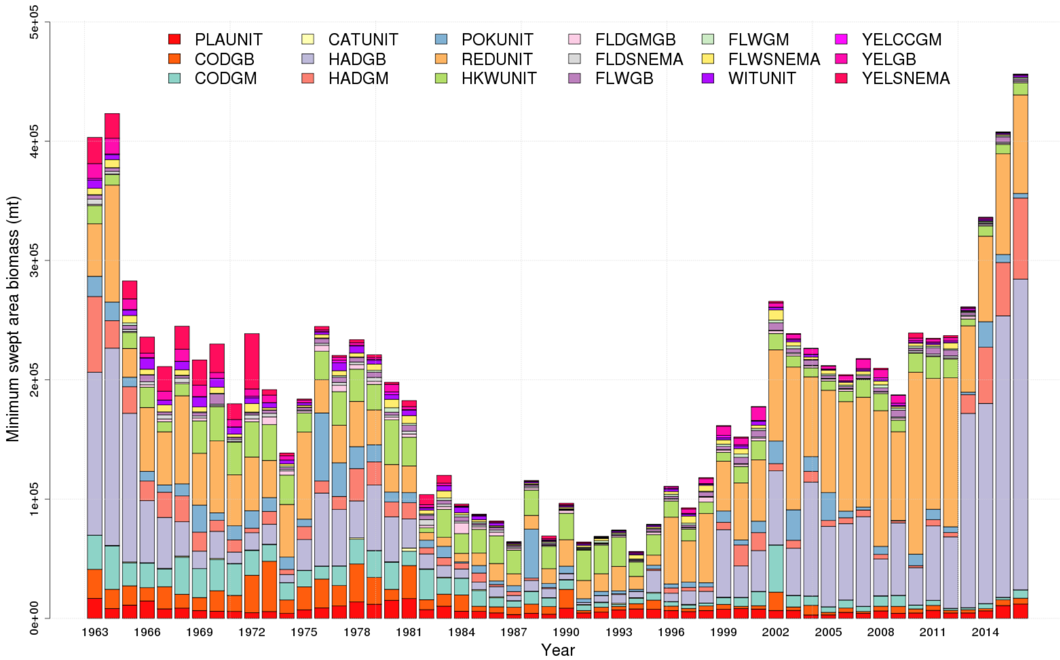

Figure 7: NEFSC fall bottom trawl survey minimum swept area biomass (mt) for for the Northeast Multispecies Fishery Management Plan groundfish stocks from 1963 to 2016, by stock. Minimum swept area estimates assume a trawl swept area of 0.0112 nm^2 (0.0384 km^2) based on the wing spread of the trawl net. *Note that ocean pout is not included since the fall survey is uninformative as an index of abundance and not used in the stock assessment.*

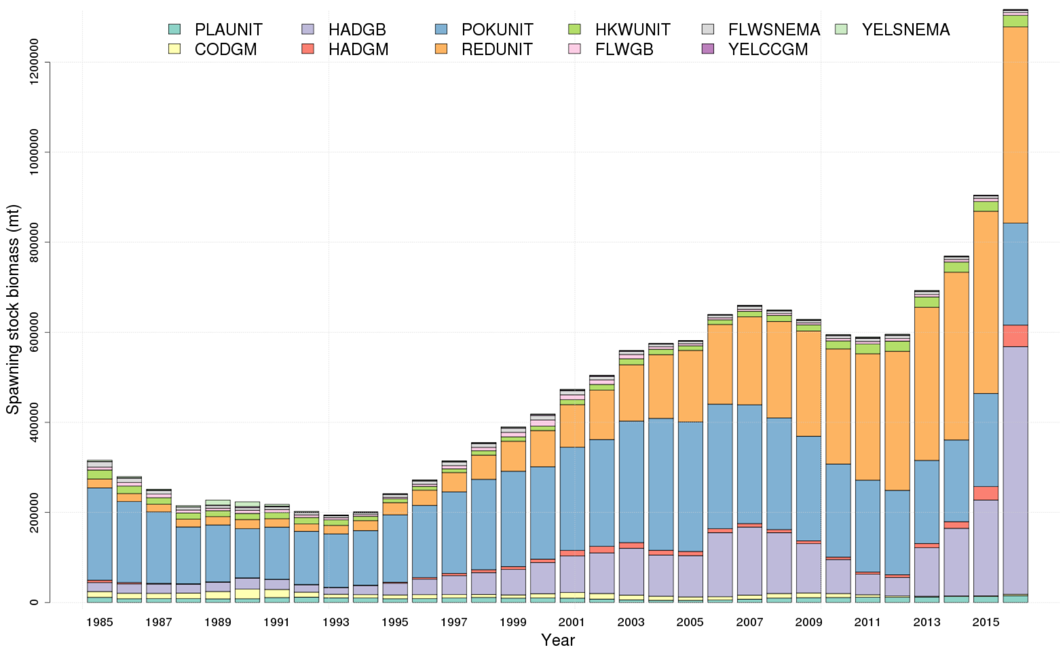

Figure 8: Model-based spawning stock biomass estimates for 11 groundfish stocks, 1985-2016 based on the Operational Assessments in 2017. Models without model-based biomass estimates are excluded.

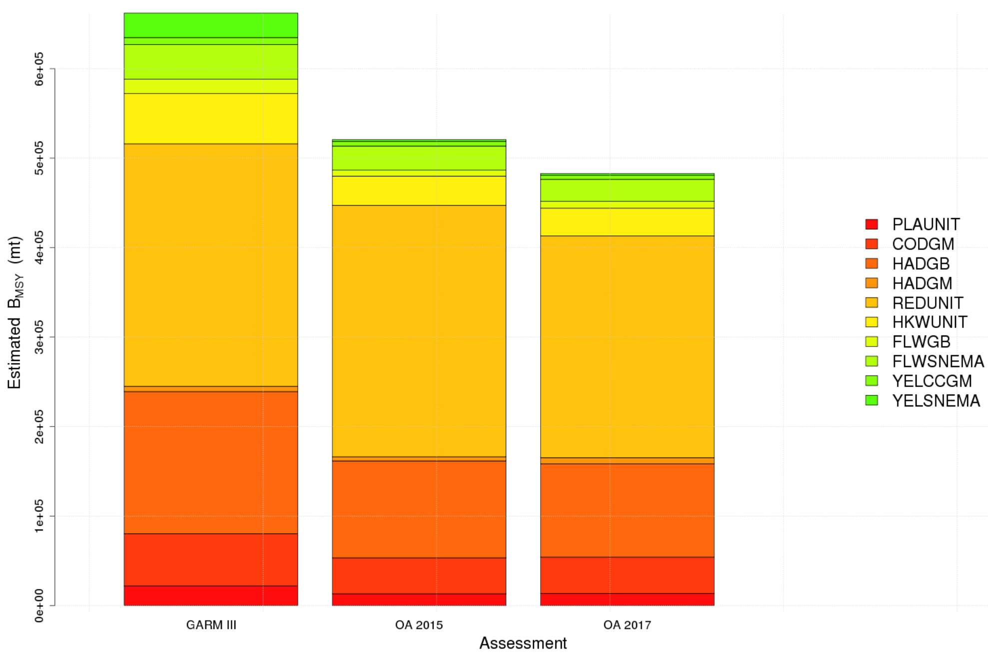

Figure 9: Sum of B_{MSY} estimates for nine stocks which had B_{MSY} estimates in 2008 (662,166 mt), 2015 (520,725 mt) and 2017 (482,841 mt) assessments. Pollock is not included since biomass targets not established until 2010 at SARC 50. B_{MSY} estimates for Gulf of Maine winter flounder, witch flounder and Georges Bank yellowtail flounder are not available as both stock assessments are based on swept area expansions. The assessment model for Georges Bank cod was not accepted for catch advice in 2015 and is currently based on smoothed survey estimates.

2 Gulf of Maine Atlantic cod

Michael Palmer

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 2015 (NEFSC 2015). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical ASAP assessment models through 2016. Additionally, stock projections have been updated through 2020. In what follows, there are two population assessment models brought forward from the most recent benchmark assessment (2012), 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 (Figures 10-11). Retrospective adjustments were not made to the model results (see Special Comments section of this report). Spawning stock biomass (SSB) in 2016 was estimated to be 3,046 (mt) under the M=0.2 model and 3,262 (mt) under the M-ramp model scenario (Table 9) which is 8% and 5% (respectively) of the biomass target, SSB_{MSY} *proxy* (40,604 (mt) and 59,714 (mt); Figure 10). The 2016 fully selected fishing mortality was estimated to be 0.228 and 0.237 which is 131% and 134% of the F_{MSY} *proxy*($F_{40\%}$; 0.174 and 0.177; Figure 11).

Table 9: 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.

	2009	2010	2011	2012	2013	2014	2015	2016
Data								
Recreational discards	142	188	164	48	69	85	80	176
Recreational landings	1,399	1,803	1,813	571	705	528	4	95
Commercial discards	752	171	99	93	52	26	14	8
Commercial landings	5,953	5,356	4,598	2,759	951	832	227	320
Catch for Assessment	8,247	7,517	6,673	3,472	1,777	1,471	325	599
Model Results (M=0.2)								
Spawning Stock Biomass	10490	8881	5703	2836	1661	1449	1897	3046
F_{Full}	1	1.045	1.542	1.844	1.673	1.634	0.21	0.228
Recruits $age1$	2025	1188	1233	1526	842	3129	1215	457
Model Results (M-ramp)								
Spawning Stock Biomass	13390	10931	6805	3451	2118	1896	2366	3262
F_{Full}	0.824	0.886	1.335	1.585	1.412	1.361	0.188	0.237
Recruits $age1$	3955	2289	2405	3010	1606	5590	1999	699

Table 10: 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 - 2012. Intervals shown reflect the 5th and 95th percentiles.

	2015 M=0.2	2015 M-ramp	M=0.2	M-ramp
F_{MSY}	0.185	0.187	0.174	0.177
SSB_{MSY} (mt)	40,187 (27,551 - 58,228)	59,045 (44,976 - 76,525)	40,604 (27,631 - 58,553)	59,714 (44,732 - 77,611)
MSY (mt)	6,797 (4,608 - 9,990)	10,043 (7,560 - 13,130)	7,049 (4,699 - 10,380)	10,502 (7,734 - 13,822)
Median recruits age-1) (000s)	4,406 (1,458 - 14,450)	8,965 (2,489 - 15,908)	4,377 (1,161 - 14,434)	8,464 (2,353 - 15,934)
Overfishing	Yes	Yes	Yes	Yes
Overfished	Yes	Yes	Yes	Yes

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 FMSY proxy between 2018 and 2020. Catch in 2017 was estimated at 428 mt. Recruitment was sampled from a cumulative distribution function derived from ASAP estimated age-1 recruitment between 1982 and 2014. The projection recruitment model declines linearly to zero when SSB is below 6.3 kmt under the M=0.2 model and 7.9 kmt under the M-ramp model. The 2017 age-1 recruitment was estimated from the geometric mean of the 2012-2016 ASAP recruitment estimates. No retrospective adjustments were applied in the projections as the retrospective patterns are similar to the 2015 update for which no retrospective adjustments were made; however, the 2015 assessment review panel recommended that that M=0.2 projections with retrospective adjustments be brought forward to the SSC for consideration in the evaluation of uncertainty when setting catch advice (provided in the Supplemental Information Report, SASINF). Assumed weights are based on an average of the most recent three years. For the M-ramp model, projections are shown under two assumptions of short-term natural mortality: M=0.2 and M=0.4.

Table 11: 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 2018 and 2020. Catch in 2017 has been estimated at 428 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
	M=0.2			*Retrospective adjustment*		
2017	428	4,648	0.092	428	3041	0.142

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
	M=0.2			*Retrospective adjustment*		
2018	1,084	5,574	0.174	693	3569	0.174
2019	1,181	6,553	0.174	758	4214	0.174
2020	1,326	8,401	0.174	855	5426	0.174

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
	M-ramp(M=0.2)			*M-ramp(M=0.4)*		
2017	428	4,470	0.100	428	4,245	0.110

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
	M-ramp(M=0.2)			*M-ramp(M=0.4)*		
2018	1,066	5,558	0.177	791	4,312	0.177
2019	1,215	7,070	0.177	741	4,572	0.177
2020	1,505	10,046	0.177	769	5,529	0.177

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).

  An important source of uncertainty is the estimate of natural mortality. Past investigations into changes in natural mortality over time have been inconclusive (NEFSC 2013). Different assumptions about natural mortality affect the scale of the biomass, recruitment, and fishing mortality estimates, though terminal estimates (2016) of biomass, fishing mortality and recruitment are similar under both models. Other areas of uncertainty include the retrospective error in the M=0.2 model, residual patterns in the model fits to some of the survey series, stock structure, and the veracity of fishery catch data. A recent report indicated that contemporary commercial landings of Gulf of Maine cod may have been underestimated (Palmer 2017). Additional work is needed to investigate the accuracy and completeness of not only of commercial landings, but all sources of anthropogenic removals (e.g., commercial discards, recreational catch, scientific removals).

- 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}; see Table 8).

  The M=0.2 model has a major retrospective pattern (7-year Mohn's rho SSB=0.53, F=-0.31) and the M-ramp model has a minor retrospective pattern (7-year Mohn's rho SSB=0.30, F=-0.17). The 7-year Mohn's rho values from the current assessment are similar to those from the 2015 assessment (M=0.2: SSB=0.54, F=-0.31; M-ramp: SSB=0.20, F=-0.08) where the M=0.2 model had a major retrospective pattern and the M-ramp model had a minor pattern. No retrospective adjustments have been applied to the terminal model results or in the base catch projections following the recommendations of the SARC 55 (NEFSC 2013) and 2014 assessment review panels (Palmer 2014). The 2015 assessment review panel (NEFSC 2015) supported this decision, noting that the most recent retrospective 'peel' suggested that an adjustment using the 7-year average may not be appropriate. However, the 2015 review panel highlighted the retrospective error in the M=0.2 model as a source of uncertainty - it should be noted that the retrospective error of the most recent peel is larger for the M-ramp model. Should the retrospective patterns continue then the models may have overestimated spawning stock size and underestimated fishing mortality.

- 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 from the last assessment did not fall within the confidence bounds of the biomass estimated in the current assessment. Multiple factors likely contributed to this including underestimation of the initial stock size and fishery catches in the projection bridge year (2015). 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.

  The only change to update was to use an automated procedure to fill holes in the survey age-legth keys rather than using visual imputation which was subjective and generally not *reproducible. The procedure relies on a multinomial logistic model to describe the proportions at age for a given length in situations where no age samples are available for that length bin (Gerritsen et al. 2006). This change had neglible impacts on the survey indices-at-age. A summary of the impacts of these changes are provided in the Supplemental Information Report (SASINF).*

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

  There has been no change in stock status since the 2014 udpate assessment.

- 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. Additionally, there are no positive 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, stock structure, 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 poor performance of previous stock projections. Additionally, it is unclear which level of natural mortality (M=0.2 or 0.4) to assume for the short-term projections under the M-ramp model.

2.1 Reviewer Comments: Gulf of Maine Atlantic cod

Assessment Recommendation:

The panel concluded that the operational assessment with no adjustment for retrospective bias as per the Stock Assessment Review Committee (SARC) 55 recommendation was acceptable as a scientific basis for management advice, including the two-model approach (M fixed at 0.2 and M-ramp) as well as using the suite of projection approaches for the Scientific and Statistical Committee (SSC) to consider in their development of catch advice.

Alternative Assessment Approach:

Not applicable.

Status Recommendation:

Based on this updated assessment, the panel agreed with the recommendation that the stock status for the Gulf of Maine Atlantic cod stock is overfished and overfishing is occurring. The Gulf of Maine Atlantic cod stock shows a truncated size and age structure, consistent with a population experiencing high mortality. Additionally, there are no positive 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.

Key Sources of Uncertainty:

An important source of uncertainty with this stock is the estimate of natural mortality. Other areas of uncertainty include the retrospective error in the M=0.2 model, residual patterns in the model fits to some of the survey series, stock structure, and the accuracy of fishery catch data.

Research Needs:

The panel recommends additional studies on natural mortality, stock structure, approaches to characterizing overall uncertainty, possible biases in the fishery catch estimates, and research into potential causes of low stock productivity (i.e., low recruitment). The uncertainty in catch should certainly be evaluated in the context of the retrospective pattern. Further, the panel recommends researching whether the M-ramp model continues to be useful as the retrospective bias is increasing.

References:

Gerritsen HD, McGrath D, Lordan C. 2006. A simple method for comparing age-length keys reveals significant regional differences within a single stock of haddock (Melanogrammus aeglefinus). ICES J. Mar. Sci. 63: 1096-1100.

Northeast Fisheries Science Center. 2013. 55^{th} Northeast Regional Stock Assessment Workshop (55^{th} SAW) Assessment Summary Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-11; 41 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD13-11

Palmer MC. 2014. 2014 Assessment update report of the Gulf of Maine Atlantic cod stock. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-14; 119 p. Available from: National Marine Fisheries Service,166 Water Street, Woods Hole, MA 02543-1026. CRD14-14

Palmer MC. 2017. Vessel trip reports catch-area reporting errors: Potential impacts on the monitoring and management of the Northeast United States groundfish resource. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-02; 47 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD17-02

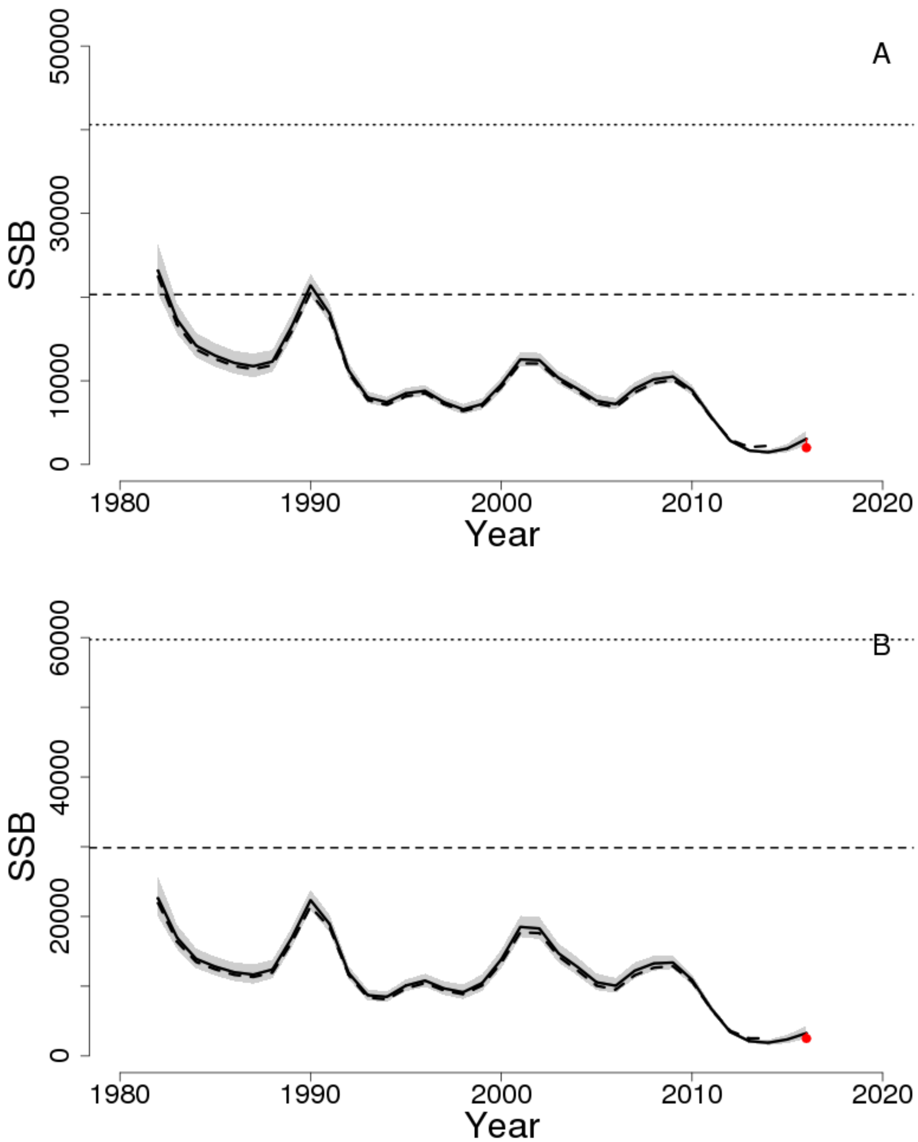

Figure 10: Estimated trends in the spawning stock biomass (SSB) of Gulf of Maine Atlantic cod between 1982 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY}; horizontal dashed line) as well as SSB_{Target} SSB_{MSY}; horizontal dotted line) based on the 2017 M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown. The red dot indicates the rho-adjusted SSB values that would have resulted had a retrospective adjusment been made to either model (see Special Comments section).

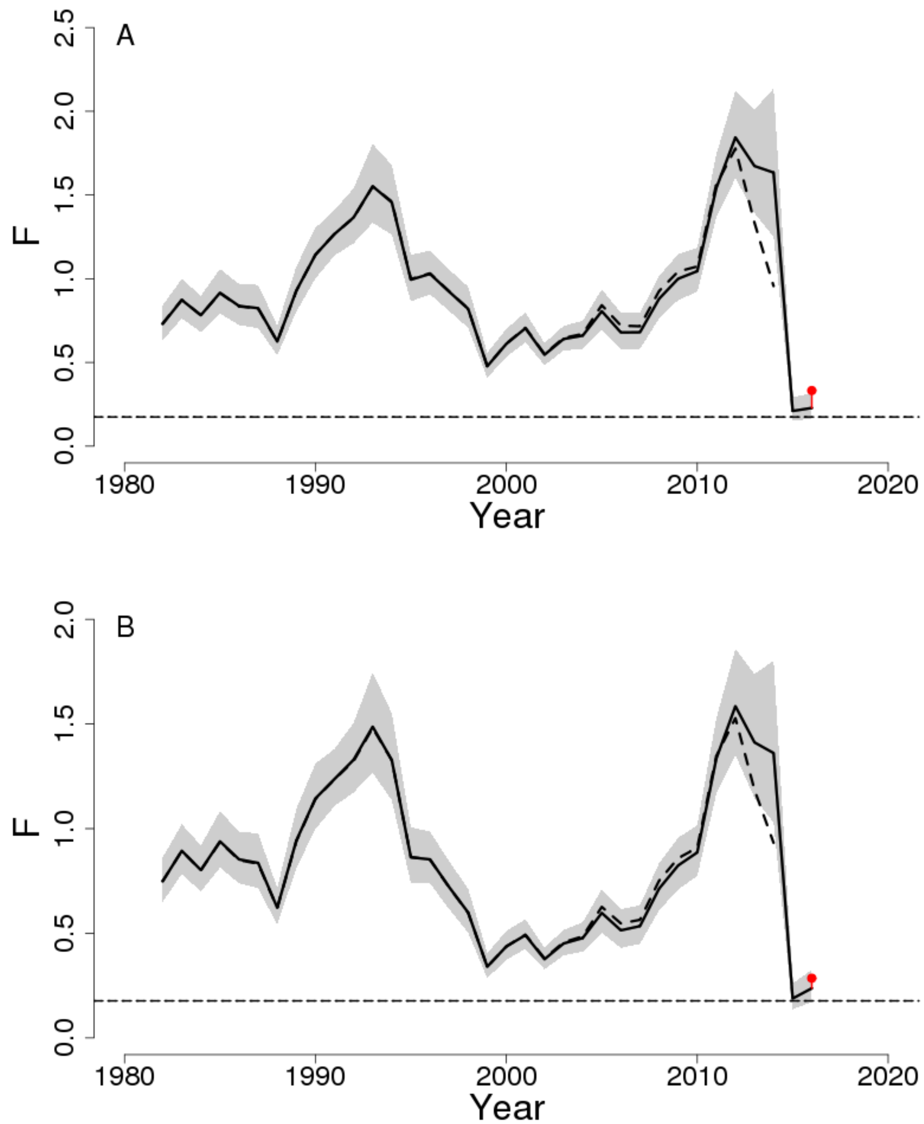

Figure 11: Estimated trends in the fully selected fishing mortality (F) of Gulf of Maine Atlantic cod between 1982 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (0.174 (M=0.2), 0.177 (M-ramp); dashed line) based on the 2017 M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown. The red dot indicates the rho-adjusted F values that would have resulted had a retrospective adjusment been made to either model (see Special Comments section).

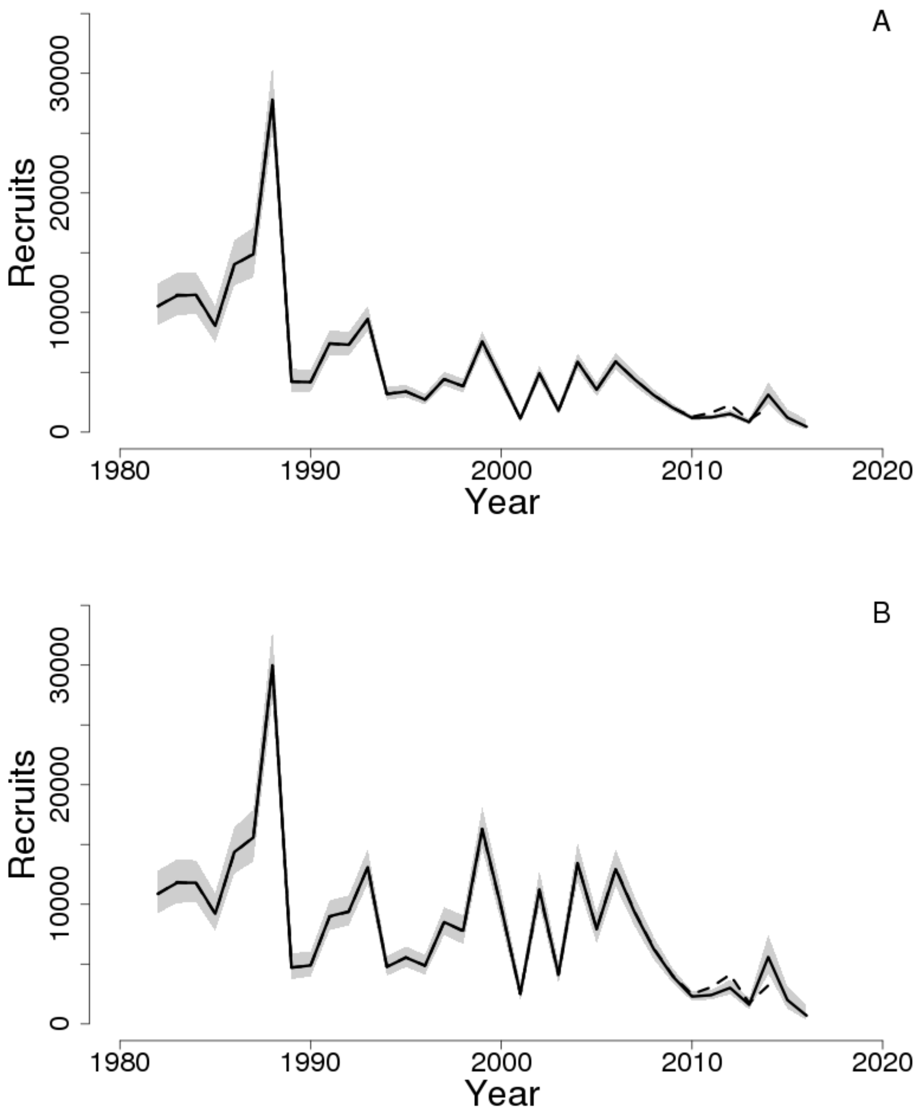

Figure 12: Estimated trends in age-1 recruitment (000s) of Gulf of Maine Atlantic cod between 1982 and 2016 from the current (solid line) and previous (dashed line) M=0.2 (A) and M-ramp (B) assessment models. The 90% lognormal confidence intervals are shown.

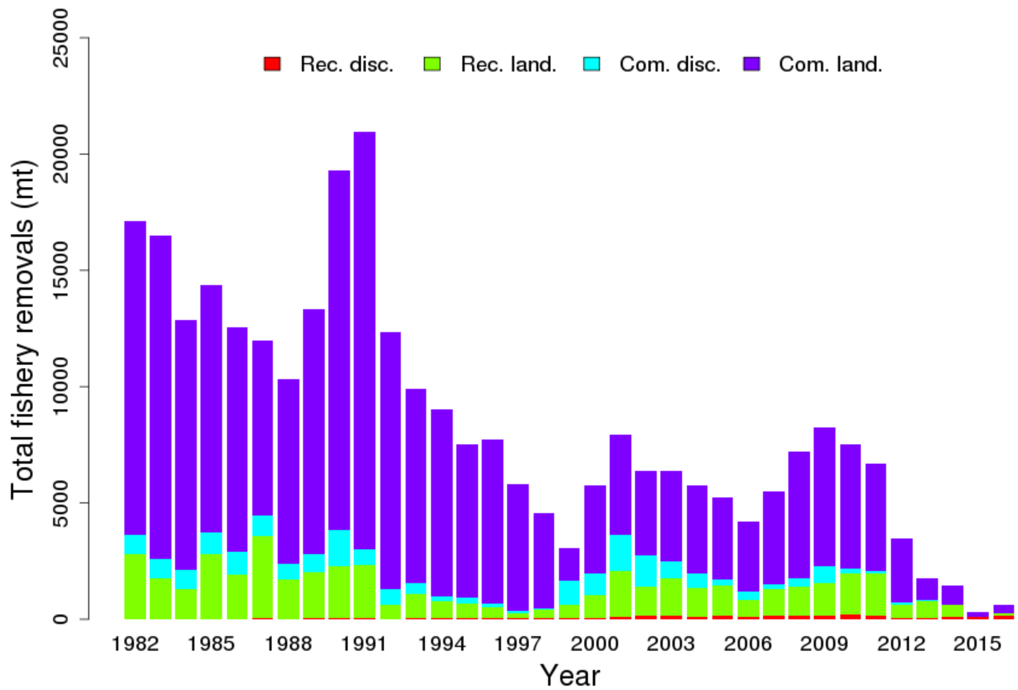

Figure 13: Total catch of Gulf of Maine Atlantic cod between 1982 and 2016 by fleet (commercial and recreational) and disposition (landings and discards).

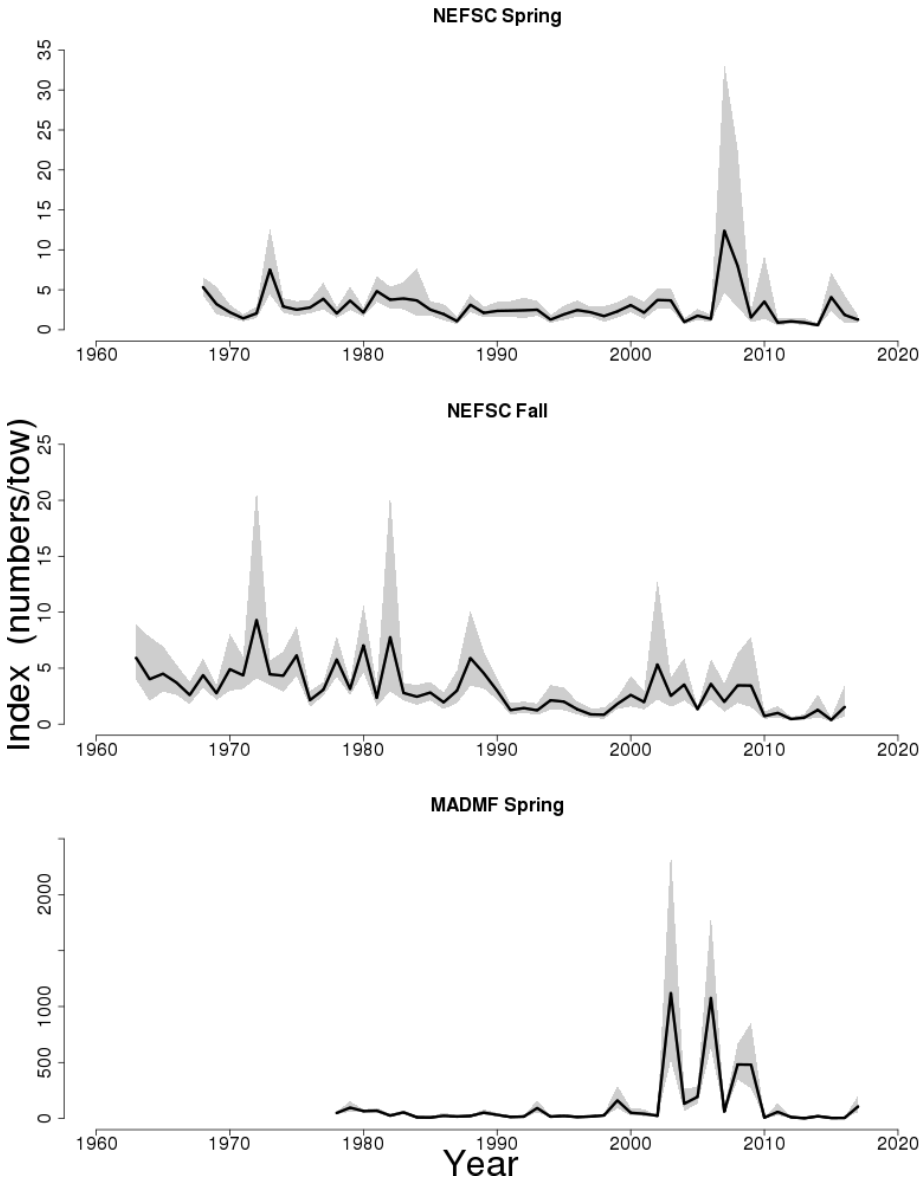

Figure 14: Indices of biomass for the Gulf of Maine Atlantic cod between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and Massachusetts Division of Marine Fisheries (MADMF) spring bottom trawl survey. The 90% lognormal confidence intervals are shown.

3 Georges Bank Atlantic cod

Chris Legault

This assessment of the Georges Bank Atlantic cod (Gadus morhua) stock is an operational assessment of the existing 2015 operational update assessment (NEFSC 2015). Based on the previous 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 13 Legend). This 2017 assessment updates commercial fishery catch data through 2016 (Table 12, Figure 17) and updates research survey indices of abuandance and the PlanBsmooth assessment model through 2017 (Figure 18).

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 13). Retrospective adjustments were not made to the model results. The survey biomass in 2017 (the arithmetic average of the 2017 NEFSC spring and 2016 NEFSC fall surveys smoothed using a loess) was estimated to be 7.237 (kg/tow) (Figure 15). The 2016 relative exploitation rate (2016 catch divided by 2016 smoothed survey biomass) was estimated to be 0.174 (Figure 16).

Table 12: 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.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Data										
Commercial landings	3,699	3,255	2,999	2,688	3,387	2,007	1,312	1,514	1,300	1,109
Commercial discards	728	309	385	253	122	120	83	19	31	33
Recreational landings	11	69	48	153	177	56	6	88	124	369
Recreational discards	3	1	5	23	17	1	1	2	15	30
CA landings	1,107	1,390	1,003	748	702	395	384	430	472	428
CA discards	117	140	206	94	43	75	39	28	20	12
Catch for Assessment	5,665	5,164	4,646	3,959	4,449	2,653	1,824	2,081	1,962	1,982
Model Results										
Biomass	3.27	3.223	3.227	3.107	3.13	3.175	3.022	2.474	3.144	4.696
Rel. Exploit. Rate	0.716	0.662	0.595	0.526	0.587	0.345	0.249	0.347	0.258	0.174

Table 13: 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.

	2015	2017
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 1.517. This multiplier is applied to the average of the recent three years of catch (2,008 mt) to produce the catch advice for 2018 of 3,047 mt. The PlanBsmooth approach is fully described in NEFSC (2015) and available as an R package.

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.

- 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.

- 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 Georges Bank Atlantic cod 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 increasing, 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.
  No major changes, other than the addition of recent years of data, were made to the Georges Bank Atlantic cod assessment for this update.

- 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 continues to show a truncated age structure. Despite an increase in the smoothed survey biomass the last two years, the most recent survey values remain below the mean of their time series. The 2013 year class is larger than recent year classes, but still below the average from the 1970s at ages 1-3 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.

3.1 Reviewer Comments: Georges Bank Atlantic cod

Assessment Recommendation:

The panel concluded that the operational assessment was acceptable as a scientific basis for management advice. However, a relatively large increase in catch advice results from this approach, and this should be approached with caution, because previous recruitment events were not always realized in the fishery. The Scientific and Statistical Committees (SSCs) approach to buffering catch advice in determining an acceptable biological catch should consider this uncertainty.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the Georges Bank Atlantic cod stock is in poor condition. The assessment approach is not able to provide quantitative values and biological references points on which a stock status determination could be made; however, current stock status is considered overfished with overfishing occurring based on the previous benchmark assessment. The panel agrees with the 2015 operational assessment that the stock remains overfished. For instance, the Georges Bank Atlantic cod continues to show a truncated age structure. Despite an increase in the smoothed survey biomass the last two years, the most recent survey values remain below the mean of their time series. The 2013 year class appears larger than recent year classes, but concurrent increases in ages 4-6 suggest the increase in the 2013 year class may be artificial and the results should be treated with caution.

Key Sources of Uncertainty:

The major source of uncertainty with this stock 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.

Research Needs:

The panel recommends 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.

References:

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. Northeast Fisheries Science Center Reference Document 15-24; 251 p. CRD15-24

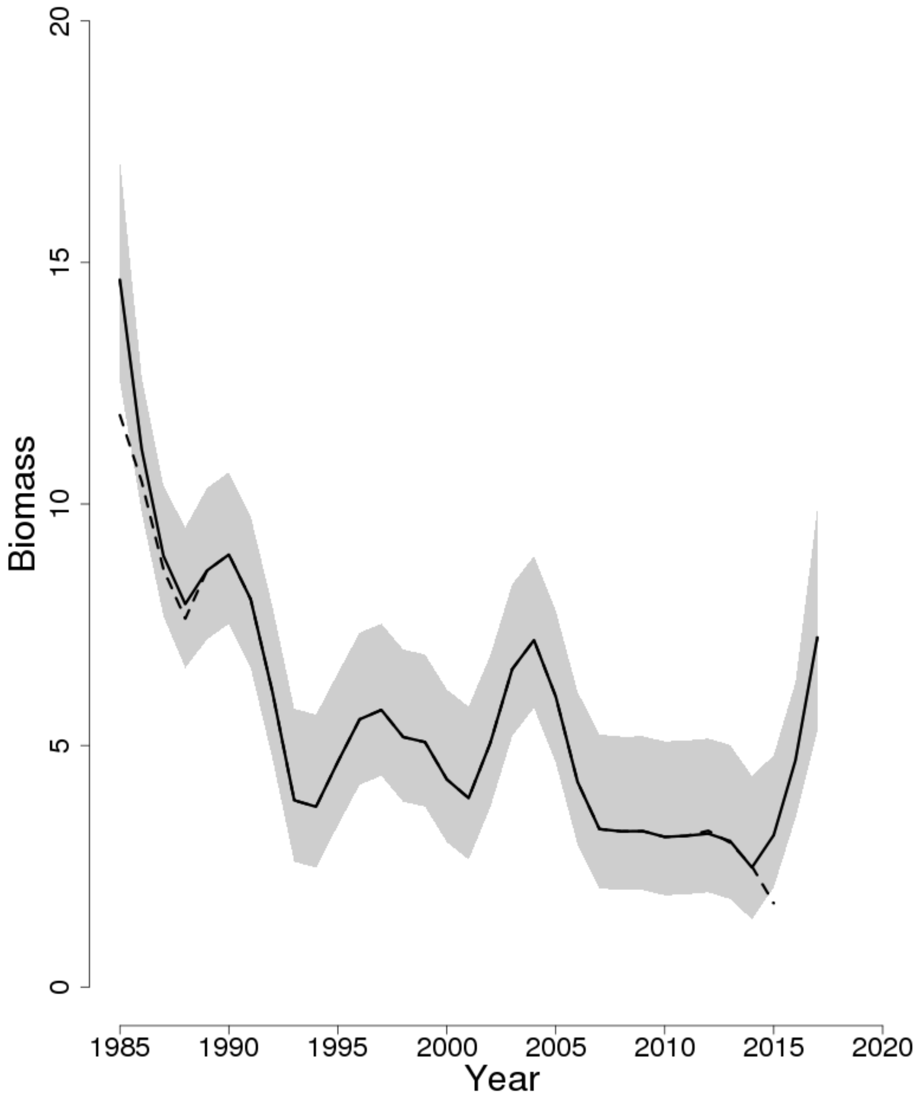

Figure 15: Trends in smoothed survey biomass (kg/tow) of Georges Bank Atlantic cod between 1985 and 2017 from the current (solid line) and previous (dashed line) assessment based on the 2017 assessment. The approximate 90% lognormal confidence intervals are shown.

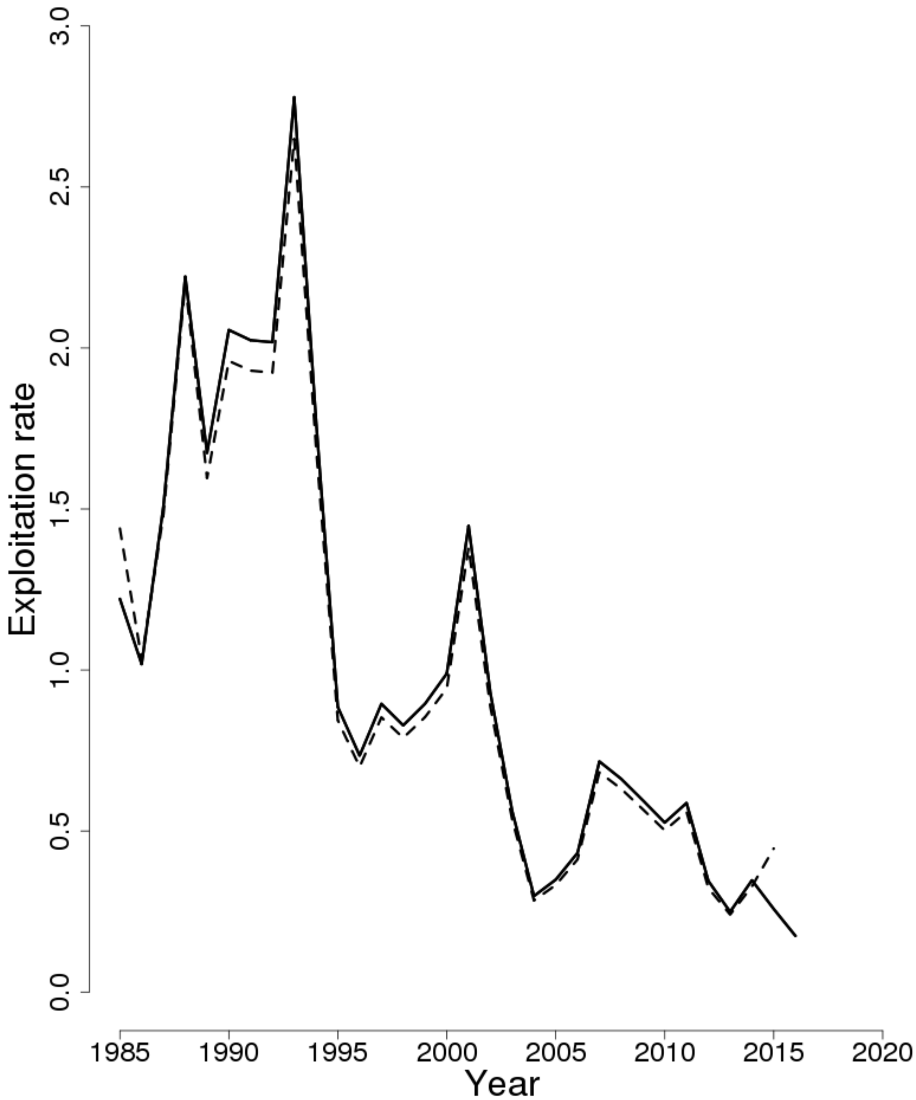

Figure 16: Trends in the relative exploitation rate (catch/smoothed survey) of Georges Bank Atlantic cod between 1985 and 2017 from the current (solid line) and previous (dashed line) assessment based on the 2017 assessment.

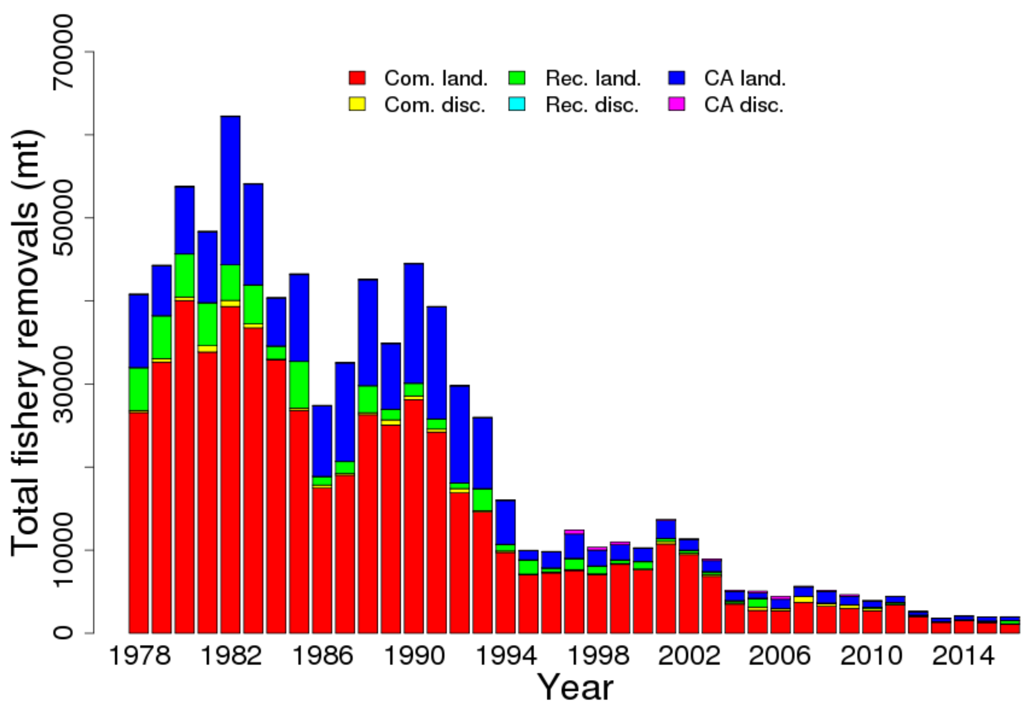

Figure 17: Total catch of Georges Bank Atlantic cod between 1978 and 2016 by fleet (US commercial, US recreational, or Canadian) and disposition (landings and discards).

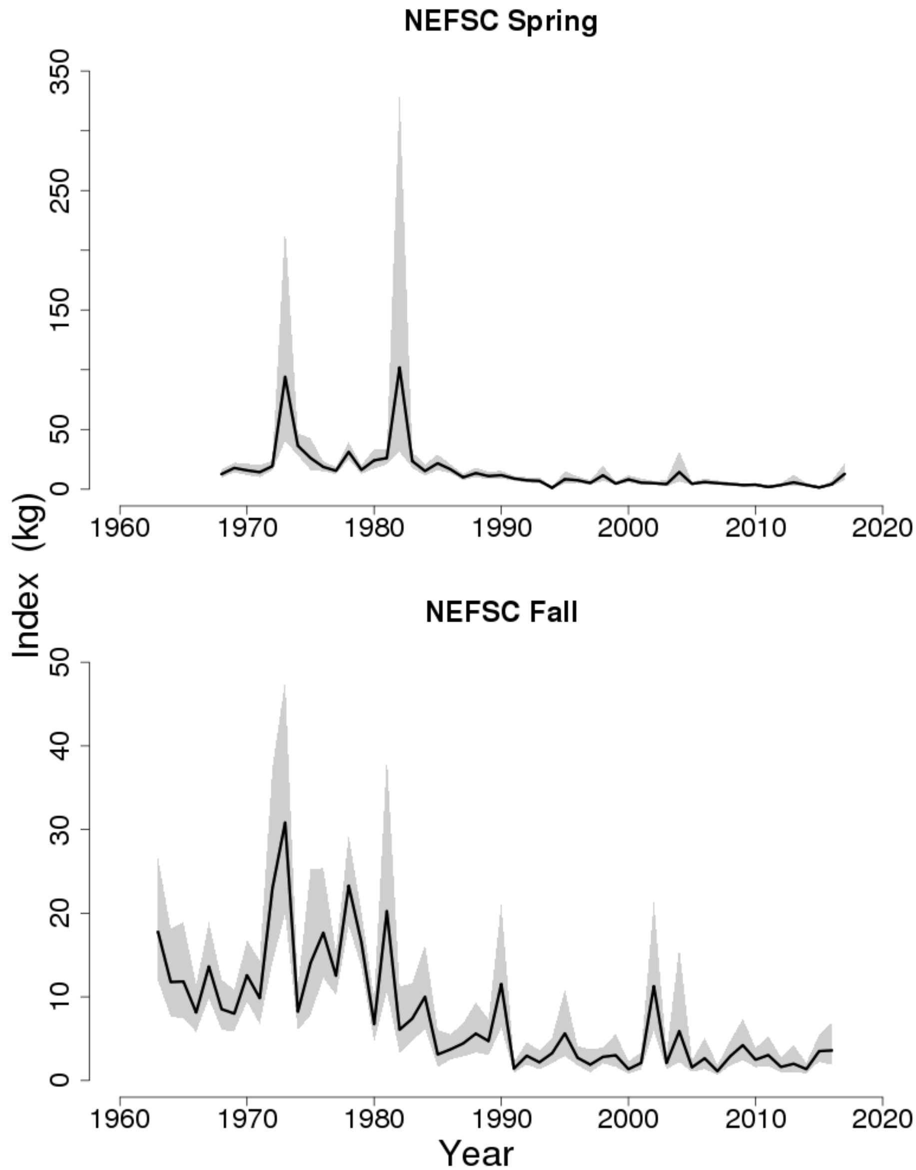

Figure 18: Indices of biomass for the Georges Bank Atlantic cod between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall trawl surveys. The approximate 90% lognormal confidence intervals are shown.

4 Georges Bank haddock

Liz Brooks

This assessment of the Georges Bank haddock (Melanogrammus aeglefinus) stock is an operational update of the existing 2015 update VPA assessment (NEFSC, 2015). The last benchmark for this stock was in 2008 (Brooks et al., 2008). Based on the previous assessment in 2015, the stock was not overfished, and overfishing was not ocurring. This assessment updates commercial fishery catch data, research survey indices of abundance, weights and maturity at age, and the analytical VPA assessment model and reference points through 2016. Stock projections have been updated through 2020. This report reflects decisions made during the Peer Review September 11, 2017.

State of Stock: Based on this updated assessment, the Georges Bank haddock (*Melanogrammus aeglefinus*) stock is not overfished, and overfishing is not occurring (Figures 19-20). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 290,324 (mt) which is 278% of the biomass target (SSB_{MSY} *proxy* = 104,312; Figure 19). The 2016 numbers weighted average fishing mortality on ages 5-7 was estimated to be 0.309 which is 88% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.353; Figure 20). The F_{MSY} *proxy* is expressed as a numbers weighted average F on ages 5-7 for compariability with the VPA estimated F.

Table 14: Catch and status table for Georges Bank haddock. All weights are in (mt), recruitment is in (000s), and $\bar{F}_{5-7}$ is the numbers weighted average fishing mortality on ages 5 to 7. Model results are from the current updated VPA assessment. A rho adjustment was not applied to values in this Table.

	2009	2010	2011	2012	2013	2014	2015	2016
			Data					
US Commercial discards	142	130	212	321	538	1,409	1,552	1,880
US Commercial landings	5,335	9,180	5,210	1,550	1,659	4,240	4,762	3,682
Canadian Catch	17,648	16,592	11,248	5,064	4,631	12,953	14,374	11,713
Catch for Assessment	23,126	25,903	16,670	6,935	6,828	18,601	20,687	17,274
			Model Results					
Spawning Stock Biomass	109,334	75,519	45,732	41,227	107,671	150,185	212,734	549,938
$\bar{F}_{5-7}$	0.226	0.394	0.485	0.537	0.468	0.34	0.141	0.113
Recruits (age 1)	1,773	6,366	278,296	41,319	23,598	1,839,273	48,629	88,436

Table 15: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold (numbers weighted average for the current assessment, simple average for the previous assessment). The medians and 90% probability intervals are reported for MSY, SSBMSY, and RMSY, based on long-term stochastic projections with fishing mortality fixed at $F_{40\%}$.

	2015	2017
F_{MSY} *proxy*	0.39	0.35
SSB_{MSY} (mt)	108,300	104,312 (52,248 - 209,377)
MSY (mt)	24,900	24,372 (12,404 - 48,332)
Median recruits (age 1) (000s)	53,400	52,249 (2,378 - 174,419)
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of biomass were derived by sampling from a cumulative distribution function (cdf) of recruitment estimates from ADAPT VPA (corresponding to SSB>75,000 mt and dropping the two most recent year class estimates for 2015 and 2016). The extremely large 1963, 2003, 2010, and 2013 year classes were included in the cdf. The annual fishery selectivity was a recent 5 year average. Selectivity for the 2013 year class was not assigned the same selectivity at age as the 2010 year class, because the projected selectivity at ages 5 and 6 (in years 2018 and 2019) appeared unreasonably low. The maturity ogive was a recent 5 year average. Mean weights at age were a recent 2 year average, except for the 2010 and 2013 year classes, where recent trends in growth were assumed to continue. Retrospective adjustments were applied to the starting numbers at age (2017) in the projections.

Table 16: Short term projections of total fishery catch and spawning stock biomass for Georges Bank haddock based on a harvest scenario of fishing at F_{MSY} *proxy* between 2018 and 2020. Catch in 2017 was assumed to be 18,920 mt.

Year	Catch (mt)	SSB (mt)	$\bar{F}_{5-7}$
2017	18,920	308,304 (214,535 - 454,442)	0.140 (0.098 - 0.197)

Year	Catch (mt)	SSB (mt)	$\bar{F}_{5-7}$
2018	94,274 (64,109 - 141,160)	324,547 (220,458 - 481,224)	0.414
2019	93,569 (62,519 - 138,829)	329,516 (221,969 - 487,070)	0.414
2020	85,292 (57,025 - 127,046)	246,774 (163,125 - 382,012)	0.414

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 largest sources of uncertainty include the retrospective bias, and future assumptions *about weights and selectivity at age. The 2013 year class accounts for a substantial portion of catch and SSB in projections. The rho adjusted projections reduce all starting numbers at age to 53% of unadjusted values (i.e., all 2017 numbers at age are multiplied by 0.528). The assumed values for selectivity and weights at age in the 2015 update were mostly overestimates when comparing to the observed weights and estimated selectivity for 2015 and 2016. The assumptions for this update try to refine assumptions for those values in the current projections. Catch at age in 2016 is another source of uncertainty. Specifically, the catch at age 7 seems larger than one would expect for such a small year class. The catch at age 6 in 2016 is a small fraction of the large 2010 year class. In relative terms, the large proportion of fish caught at age 7 drives the average fishing mortality calculated for ages 5-7. Given the large difference in magnitude of ages 5, 6, and 7, it was decided that use of a numbers weighted average F was a more appropriate reflection of the fishing mortality experienced by the stock. Therefore, all fishing mortalities in this report refer to numbers weighted F on ages 5-7 (including the reference points and retrospective bias).*

- 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 $\bar{F}_{5-7}$ lies outside of the approximate joint confidence region for SSB and $\bar{F}_{5-7}$).

  The 7-year Mohn's ρ, relative to SSB, was 0.50 in the 2015 assessment and was 0.89 in 2016. The 7-year Mohn's ρ, relative to F, was -0.34 in the 2015 assessment and was -0.55 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=290,324) and 2016 F (F_ρ=0.309) were outside the approximate 90% confidence regions around SSB (383,166 - 801,643) and F (0.079 - 0.164). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 549,938 to 290,324 and the 2016 $\bar{F}_{5-7}$ from 0.113 to 0.309.

- 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?

  As noted in (1) above, population projections for Georges Bank haddock are uncertain due to the retrospective bias and assumed future values of selectivity and weights at age. This stock is not in a rebuilding plan.

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

  No changes, other than the incorporation of new data, were made to the Georges Bank haddock assessment for this update. However, recent years where the DFO survey did not sample the full Georges Bank strata (2012, 2013, 2015, 2017) were dropped from the VPA analysis. For this update, fishing mortality is reported as a numbers weighted average of ages 5-7 to deal with catch of two adjacent year classes of very different magnitude. In previous assessments, a simple average F on ages 5-7 was reported.

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

  The stock status of Georges Bank haddock has not changed.

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

The Georges Bank haddock shows a broad age structure, and broad spatial distribution. This stock has produced several exceptionally strong year classes in the last 15 years, leading to record high SSB in recent years. Catches in recent years have been well below the total quota (US+Canada). While indices support the finding that this stock is at an all-time high, weights at age have been declining since the large 2003 year class, and show further declines with the most recent data.

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

  Projection advice and reference points for Georges Bank haddock are strongly dependent on recruitment. A decade ago, extremely large year classes were considered anomalies (e.g., 1963 and 2003). However, since 2003, there have been two more extremely large (2010 and 2013) and one very large (2012) year classes. Future work could focus on recruitment forecasting and providing robust catch advice. Assumptions about weights at age and selectivity are very influential in short term projections. As multiple large year classes move through the population, it is difficult to predict how strong the density dependent response will be, but future work could continue examining performance of projected values with realized values. For this assessment, reference points are estimated with a recent 5 year average for selectivity, maturity, and weights at age, whereas short-term projections use year-specific decisions to deal with the current large year classes. Considering that estimated population abundance at MSY is much less than the current population abundance, recent average biological and fishery parameters may not reflect MSY conditions. Calculating per recruit statistics on an annual basis demonstrates the dynamic range of reference points in response to density dependent changes in growth (see Model Results pdf).

- Are there other important issues?

  The Georges Bank haddock assessment has developed a major retrospective pattern in recent years. This stock assessment has historically performed very consistently. This should continue to be monitored. Density-dependent responses in growth should also continue to be monitored. On an annual basis, known research removals account for 0-0.7% of annual catch removals by weight, and 0-4.6% of annual catch removals by number; this level is insufficient to cause the observed retrospective pattern.

4.1 Reviewer Comments: Georges Bank haddock

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice. The panel provided recommendations that were adopted, including the use of a numbers-weighted average to calculate the fishing mortality rate (as opposed to an unweighted average), and supported the projection scenario that assumes slow growth and the recent 5-year average for selectivity.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this updated assessment, the panel supports the conclusion that the Georges Bank haddock stock is not overfished, and overfishing is not occurring. The Georges Bank haddock stock shows a broad age structure, and broad spatial distribution. This stock has produced several exceptionally strong year classes in the last 15 years, leading to record high spawning stock biomass in recent years. Also, catches in recent years have been well below the total quota (US and Canada). While indices support the finding that this stock is at an all-time high, weights at age have been declining since the large 2003 year class, and show further declines with the most recent data.

Key Sources of Uncertainty:

The largest sources of uncertainty for this stock include the retrospective bias, and assumptions in the projections about weights and selectivity at age.

Research Needs:

The panel recommends that future work focus on recruitment forecasting and providing robust catch advice. Additional future work could continue examining performance of projected values with realized values.

References:

Brooks, E.N, M.L. Traver, S.J. Sutherland, L. Van Eeckhaute, and L. Col. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. http://www.nefsc.noaa.gov/publications/crd/crd0815/

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p.

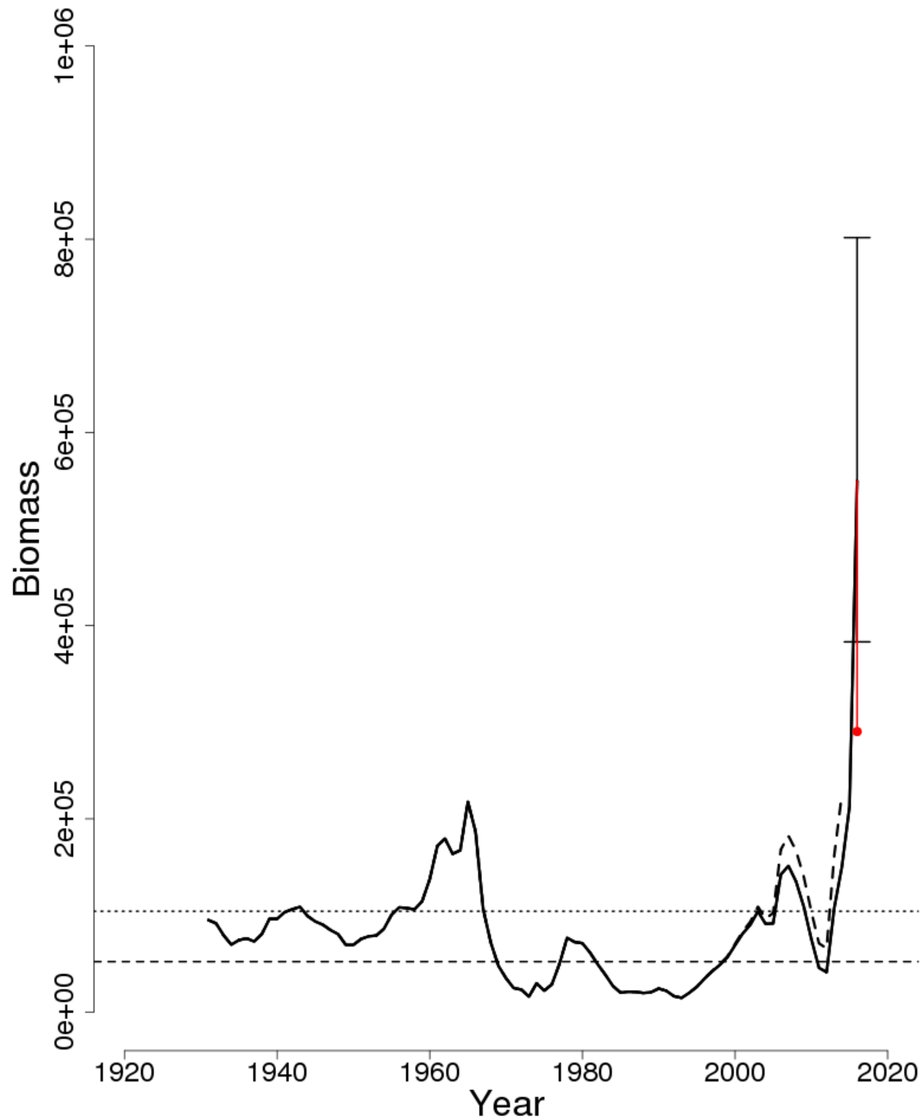

Figure 19: Trends in spawning stock biomass of Georges Bank haddock between 1931 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2015 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

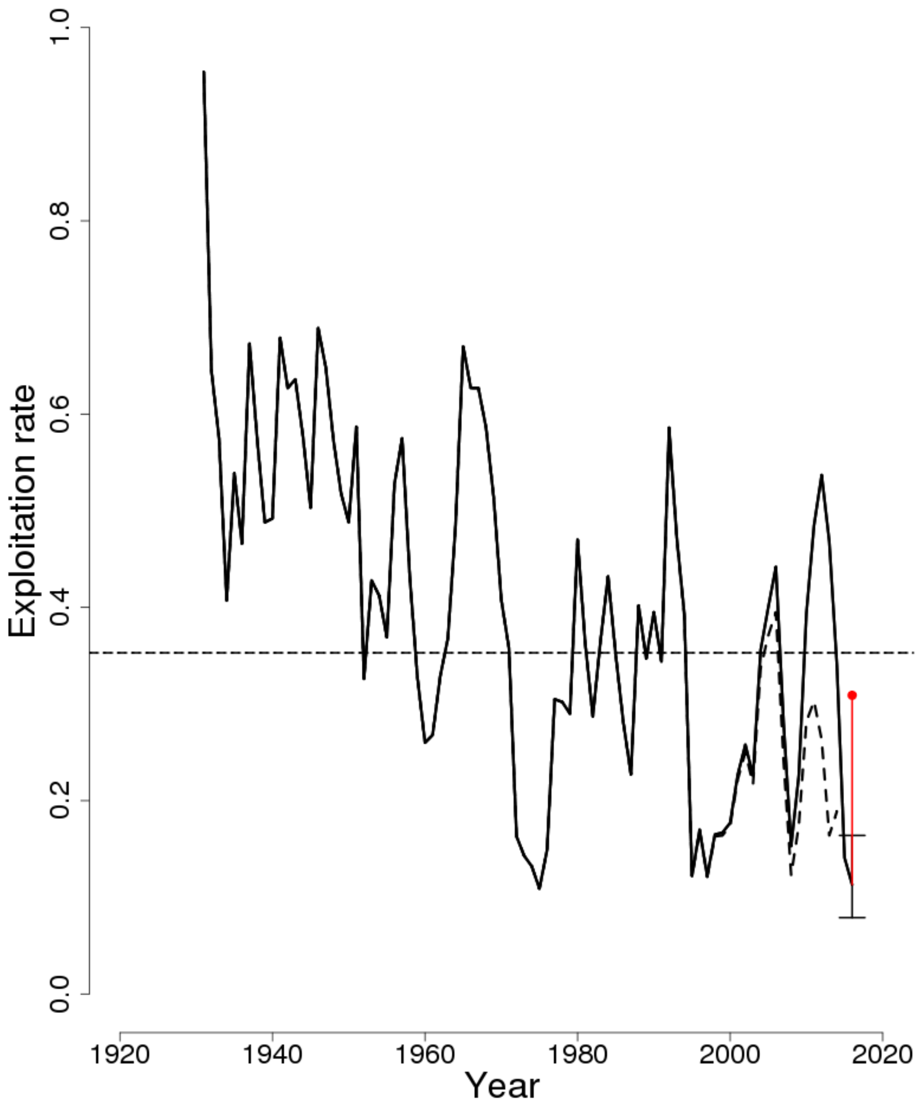

Figure 20: Trends in the numbers weighted fishing mortality ($\bar{F}_{5-7}$) of Georges Bank haddock between 1931 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.353; horizontal dashed line) based on the 2015 assessment. $\bar{F}_{5-7}$ was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

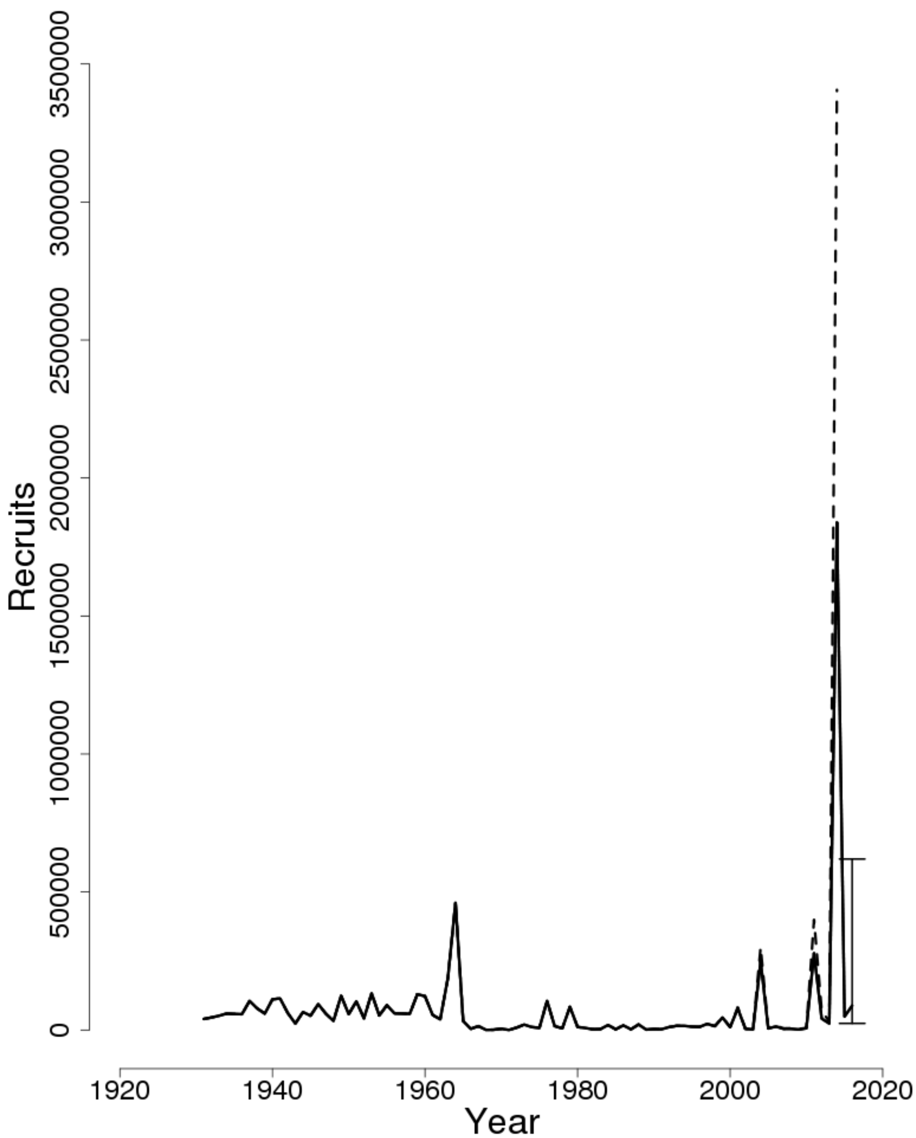

Figure 21: Trends in Recruits (age 1) (000s) of Georges Bank haddock between 1931 and 2016 from the current (solid line) and previous (dashed line) assessment. The 90% bootstrap probability intervals are shown.

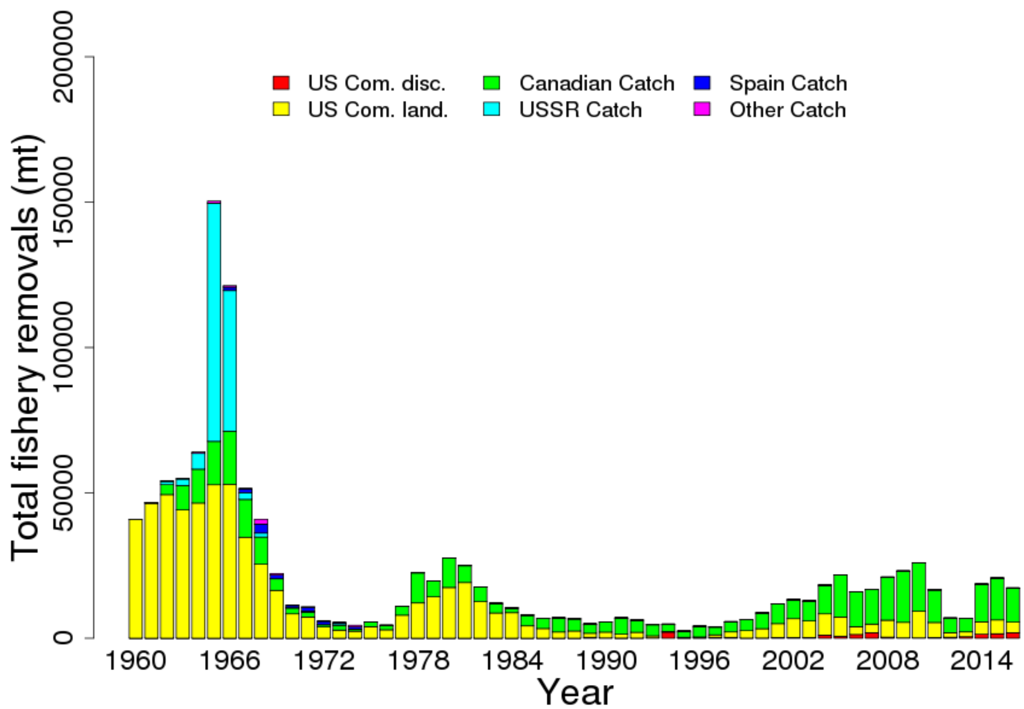

Figure 22: Total catch of Georges Bank haddock between 1931 and 2016 by fleet (US Commercial, Canadian, or foreign fleet) and disposition (landings and discards).

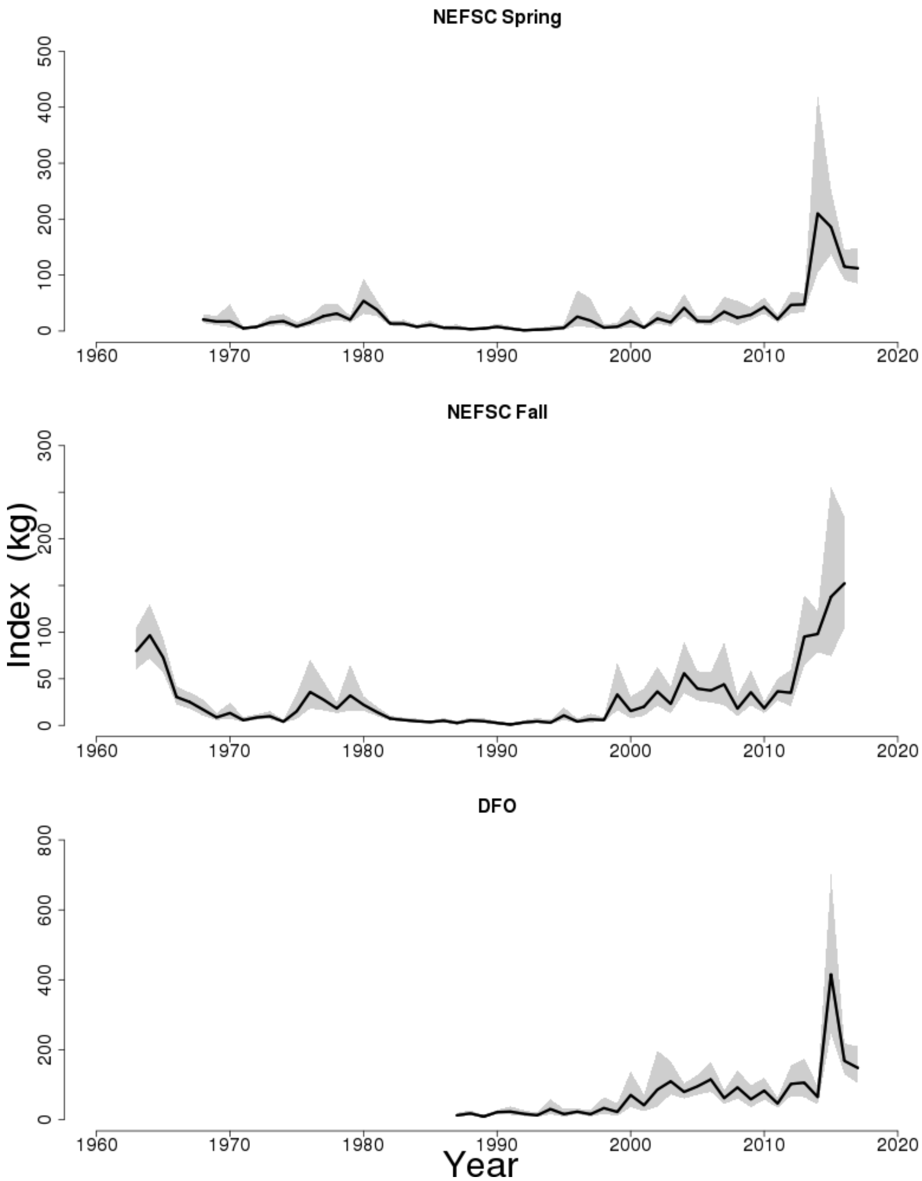

Figure 23: Indices of biomass (Mean kg/tow) for the Georges Bank haddock stock between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and the DFO winter bottom trawl survey. The approximate 90% lognormal confidence intervals are shown.

5 Gulf of Maine haddock

Michael Palmer

This assessment of the Gulf of Maine haddock (Melanogrammus aeglefinus) stock is an operational assessment of the existing benchmark assessment (NEFSC 2014). Based on the previous assessment (NEFSC 2015), the stock was not overfished, and overfishing was not occurring. This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the analytical ASAP assessment model and reference points through 2016. Additionally, stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, the stock status for the Gulf of Maine haddock (*Melanogrammus aeglefinus*) stock is not overfished and overfishing is not occurring (Figures 24-25). Retrospective adjustments were not made to the model results (see Special Comments section of this report). Spawning stock biomass (SSB) in 2016 was estimated to be 47,821 (mt) which is 706% of the biomass target (SSB_{MSY} *proxy* = 6,769; Figure 24). The 2016 fully selected fishing mortality was estimated to be 0.137 which is 30% of the overfishing threshold proxy (F_{MSY} *proxy* = $F_{40\%}$ = 0.455; Figure 25).

Table 17: Catch and status table for Gulf of Maine haddock. All weights are in (mt) recruitment is in (000s) and F_{Full} is the fully selected fishing mortality. Model results are from the current updated ASAP assessment.

	2009	2010	2011	2012	2013	2014	2015	2016
				Data				
Recreational discards	27	20	11	66	273	359	176	345
Recreational landings	409	320	230	250	298	317	238	554
Commercial discards	12	3	6	18	32	22	42	72
Commercial landings	500	623	499	417	212	314	650	1,342
Foreign landings	0	0	0	0	0	0	0	0
Catch for Assessment	948	966	745	751	816	1,012	1,106	2,313
				Model Results				
Spawning Stock Biomass	6,263	5,401	4,667	5,733	9,325	14,775	29,833	47,821
F_{Full}	0.226	0.264	0.23	0.293	0.239	0.191	0.116	0.137
Recruits (age 1)	519	1,590	15,858	5,496	25,080	93,341	4,724	3,638

Table 18: Comparison of reference points estimated in an earlier assessment and from the current operational assessment. 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 1977 - 2012. Intervals shown reflect the 5th and 95th percentiles.

	2015	2017
F_{MSY} *proxy*	0.468 (0.391 - 0.547)	0.455 (0.380 - 0.538)
SSB_{MSY} (mt)	4,623 (2,036 - 9,283)	6,769 (2,525 - 27,545)
MSY (mt)	1,083 (489 - 2,148)	1,547 (584 - 6,160)
Median recruits (age 1) (000s)	1,335 (253 - 8,198)	1,498 (275 - 17,307)
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of median total fishery yield and spawning stock biomass for Gulf of Maine haddock were conducted based on a harvest scenario of fishing at the F_{MSY} *proxy* between 2018 and 2020. Catch in 2017 has been estimated at 2,306 mt. Recruitment was sampled from a cumulative distribution function of model estimated age-1 recruitment from 1977-2014. The age-1 estimate in 2017 was generated from the geometric mean of the 1977-2016 recruitment series. The annual fishery selectivity, maturity ogive, and mean weights at age used in the projections were estimated from the most recent 5 year averages; retrospective adjustments were not applied in the projections.

Table 19: Short term projections of total fishery catch and spawning stock biomass for Gulf of Maine haddock based on a harvest scenario of fishing at F_{MSY} *proxy* ($F_{40\%}$) between 2018 and 2020. Catch in 2017 was assumed to be 2,306 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	2,306	68,429	0.077

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	16,954	65,130	0.455
2019	15,023	49,069	0.455
2020	11,289	34,123	0.455

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 strength of terminal year classes had been a large source of uncertainty in previous assessments. The 2012 and 2013 year classes are now reasonably well estimated and the relative size of more recent year classes is expected to be near average and unlikely to have *much impact on the terminal estimates of stock size or in the performance of stock projections. The largest current source of uncertainty in the assessment is the veracity of fishery catch data. A recent report indicated that contemporary commercial landings of Gulf of Maine haddock may have been underestimated (Palmer 2017). Additional work is needed to investigate the accuracy and completeness not only of commercial landings, but all sources of anthropogenic removals (e.g., commercial discards, recreational catch, scientific removals).*

- 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} lie outside of the approximate joint confidence region for SSB and F_{Full}).

  This assessment exhibits a minor retrospective pattern and therefore no retrospective adjustments were made to the terminal model results or the short-term catch projections. The 7-year Mohn's rho values on SSB (-0.18) and F (0.20) are small.

- 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 haddock are reasonably well determined. The projected biomass from the last assessment is near the lower confidence bound of the biomass estimated in the current assessment; however, this is primarily due to the positive rescaling of the 2012 and 2013 year classes in this most recent assessment which was informed by additional catch and survey data. This stock is not currently in a rebuilding plan.

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

  Recreational catch estimates were re-estimated as part of this update to account for any updates to the MRIP data, and more importantly, to adjust the recreational post-release discard mortality rate. Previous assessments have assumed 50% post-release mortality, but this current assessment has introduced season- and size-specific post-release discard mortality estimates from Mandelman et al. (2017) for the years 2004-2016. No changes were made prior to 2004 due to the sparseness of avaialble length samples. These changes had minimal impact on the estimates of total fishery removals (see Palmer 2017 for a full description of the methods and impact analysis). Additionally, an automated procedure was used to fill holes in the survey age-legth keys rather than using visual imputation which was subjective and generally not reproducible. The procedure relies on a multinomial logistic model to describe the proportions at age for a given length in situations where no age samples are available for that length bin (Gerritsen et al. 2006). Summaries of the impacts of all changes are provided in the Supplemental Information Report (SASINF).

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

  There has been no change in stock status since the previous assessment (2015).

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

  The Gulf of Maine haddock has experienced several large recruitment events since 2010. The population biomass is currently at an all time high and overall, the population is experiencing low mortatity.

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

  Better information is needed on overall uncertainty and possible biases in the fishery catch estimates. Additionally, a better understanding of recruitment processes may help to improve recruitment forecasting.

- Are there other important issues?

  None.

5.1 Reviewer Comments: Gulf of Maine haddock

Assessment Recommendation:

The panel concluded that the operational assessment with no adjustment for retrospective bias was acceptable as a scientific basis for management advice with minor changes in the approach, including the revised recreational discard mortality estimates and automated approach to interpolating missing length-at-age.

Alternative Assessment Approach: Not applicable

Status Recommendation:

The panel supports the conclusion that the stock status for the Gulf of Maine haddock stock is not overfished and overfishing is not occurring. The Gulf of Maine haddock stock has experienced several large recruitment events since 2010. The population biomass is currently at an all-time high and overall, the population appears to be experiencing low mortality.

Key Sources of Uncertainty:

The largest source of uncertainty with this stock is in the quality of recreational and commercial landings and discard estimates. The Marine Recreational Information Program (MRIP) estimates of historical recreational harvest and releases are expected to change in 2018. The commercial discard estimates from the observer program may be biased due to potential changes in fisher behavior when observers are onboard vessels. Another source of uncertainty may be attributed to the ability to accurately estimate recent/terminal recruitment.

Research Needs:

The panel recommends research be conducted to reduce uncertainty and address possible biases in the fishery catch estimates. Additionally, a better understanding of recruitment processes may help to improve recruitment forecasting.

References:

Gerritsen HD, McGrath D, Lordan C. 2006. A simple method for comparing age-length keys reveals significant regional differences within a single stock of haddock (Melanogrammus aeglefinus). ICES J. Mar. Sci. 63: 1096-1100.

Mandelman JW, Zemeckis DR, Hoffman WS, Dean MJ, Cadrin SX, Sulikowski JA. 2017. Addendum to Determining the post-release mortality rate and best capture and handling methods for haddock (Melanogrammus aeglefinus) discarded in the Gulf of Maine recreational fisheries. Final Report to the Northeast Consortium. Grant: FNA10NMF4410008. Award Period: March 1, 2015 February 29, 2016. 30 p.

Northeast Fisheries Science Center. 2014. 59^{th} Northeast Regional Stock Assessment Workshop (59^{th} SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 14-09; 782 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD14-09

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-24

Palmer MC. 2017. Vessel trip reports catch-area reporting errors: Potential impacts on the monitoring and management of the Northeast United States groundfish resource. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-02; 47 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD17-02

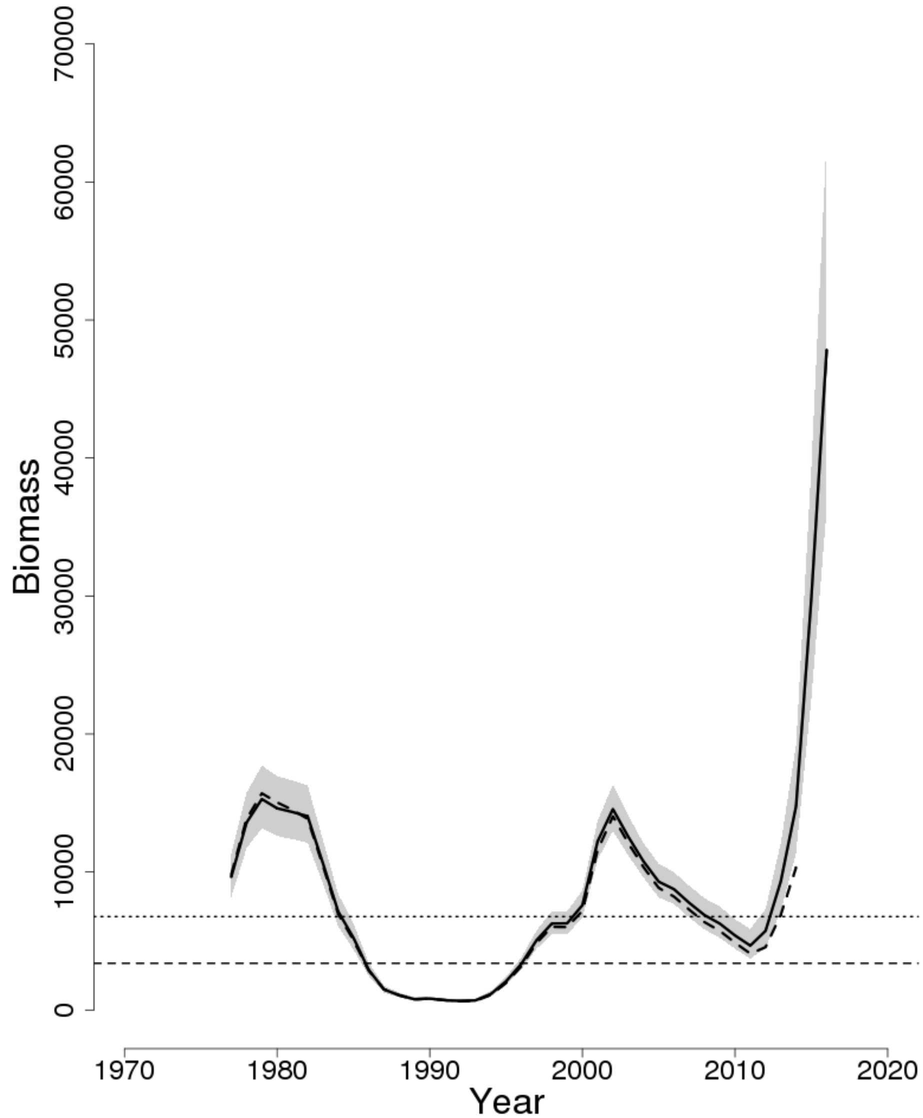

Figure 24: Trends in spawning stock biomass (SSB) of Gulf of Maine haddock between 1977 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. The approximate 90% lognormal confidence intervals are shown. The red dot indicates the rho-adjusted SSB values that would have resulted had a retrospective adjusment been made to either model (see Special Comments section).

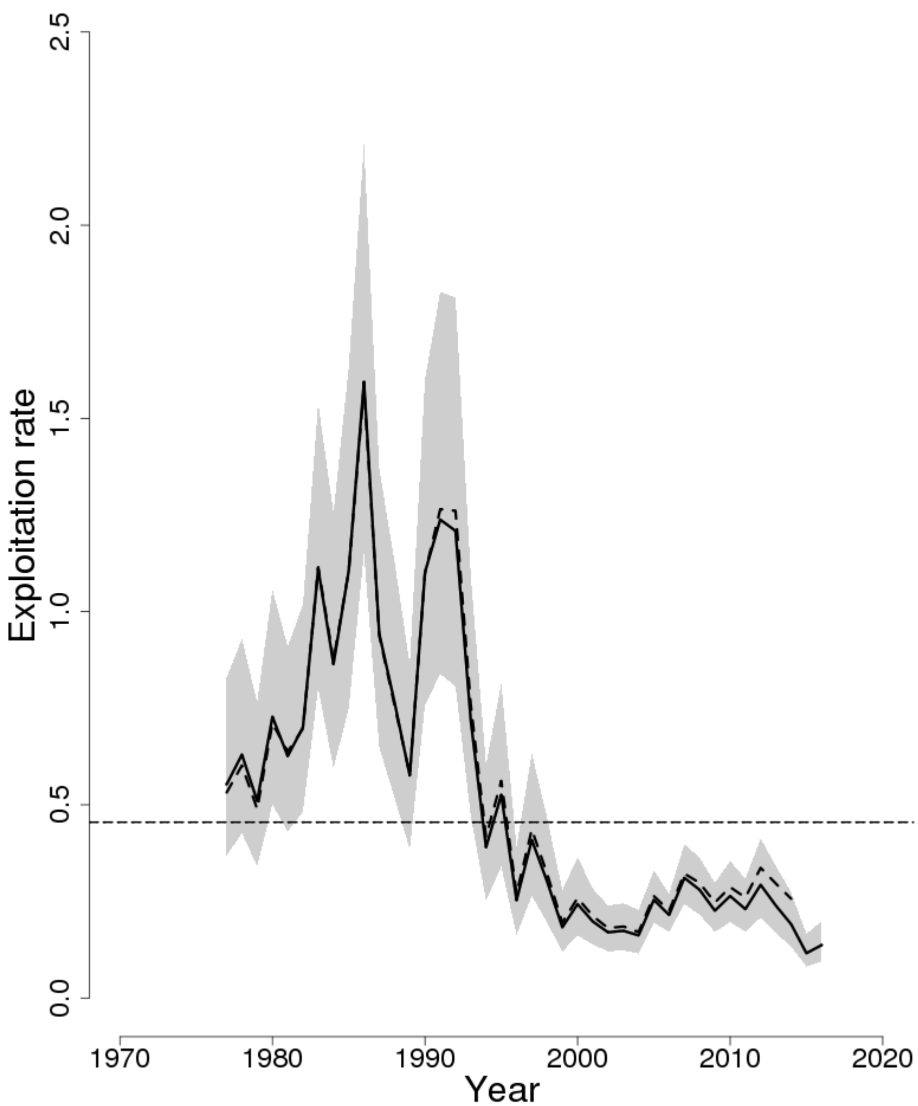

Figure 25: Trends in the fully selected fishing mortality (F) of Gulf of Maine haddock between 1977 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.455; horizontal dashed line) from the 2017 assessment model. The approximate 90% lognormal confidence intervals are shown. The red dot indicates the rho-adjusted F values that would have resulted had a retrospective adjusment been made to either model (see Special Comments section).

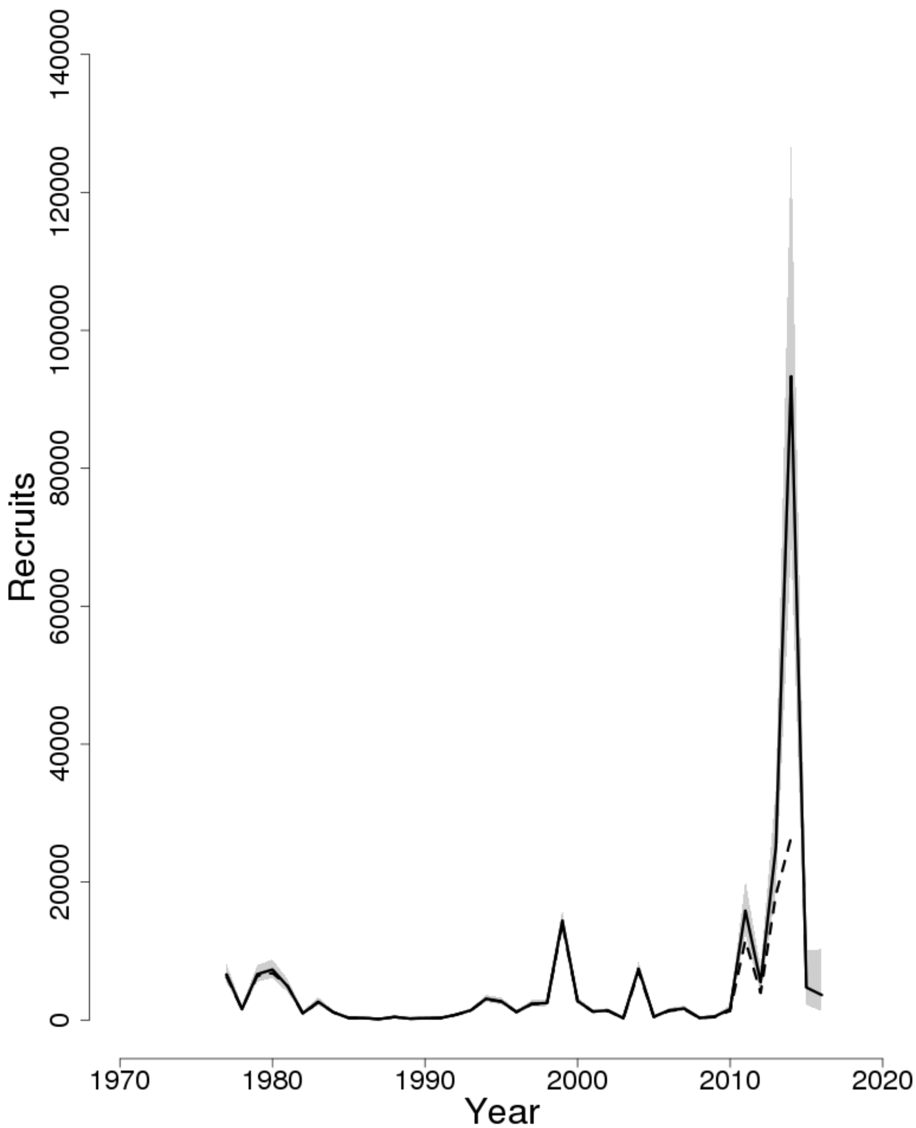

Figure 26: Trends in Recruits (age 1) (000s) of Gulf of Maine haddock between 1977 and 2016 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

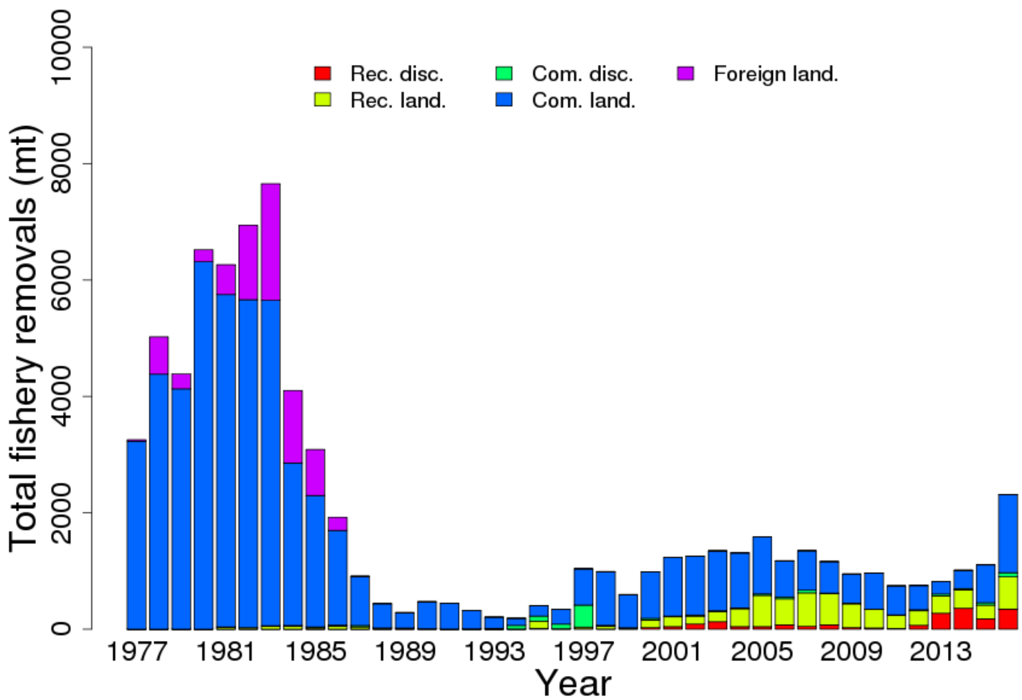

Figure 27: Total catch of Gulf of Maine haddock between 1977 and 2016 by fleet (commercial, recreational, or foreign) and disposition (landings and discards).

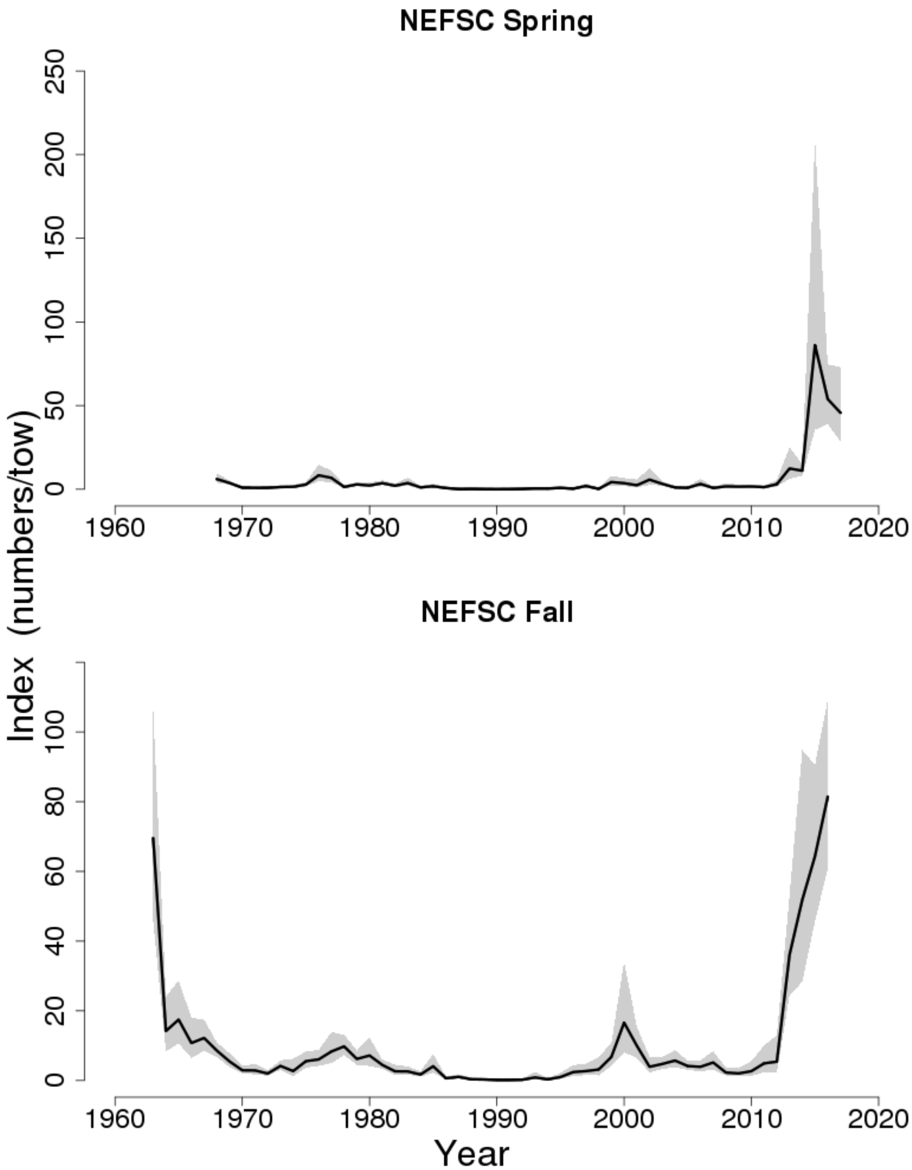

Figure 28: Indices of biomass for the Gulf of Maine haddock between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

6 Cape Cod-Gulf of Maine yellowtail flounder

Larry Alade

This assessment of the Cape Cod-Gulf of Maine yellowtail flounder (Limanda ferruginea) stock is an operational assessment of the existing 2015 VPA assessment (Alade 2015). The last benchmark for this stock was in 2008 (Legault et al., 2008). Based on the previous assessment the stock was overfished, and overfishing was occurring. This 2017 assessment updates commercial fishery catch data, research survey indices of abundance, weights at age, and the analytical VPA assessment model and reference points through 2016. Additionally, stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, Cape Cod-Gulf of Maine yellowtail flounder (*Limanda ferruginea*) stock is overfished and overfishing is occurring (Figures 29-30). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 1,191 (mt) which is 26% of the biomass target (SSB_{MSY} $proxy$ = 4,640; Figure 29). The 2016 fully selected fishing mortality was estimated to be 0.314 which is 115% of the overfishing threshold proxy (F_{MSY} $proxy$ = 0.273; Figure 30).

Table 20: Catch and model results for Cape Cod-Gulf of Maine yellowtail flounder. All weights are in (mt), recruitment is in (000s) and F_{Full} is the average fishing mortality on ages (ages 4 and 5). Model results are from the current updated VPA assessment **without** any retrospective adjustment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
				Data						
Commercial discards	141	156	175	87	74	146	86	54	45	66
Commercial landings	492	543	464	546	684	946	590	421	306	302
Total Catch for Assessment	633	699	639	633	758	1,092	676	475	351	368
				Model Results						
Spawning Stock Biomass	740	869	1,040	1,357	1,499	1,117	873	941	1,439	2,093
F_{Full}	1.058	1.17	0.756	0.504	0.677	1.093	1.102	0.521	0.259	0.193
Recruits (age 1)	3,411	3,735	3,959	3,251	2,988	2,685	4,046	5,728	7,774	10,165

Table 21: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on long-term stochastic projections. The medians and 90% probability intervals are reported for MSY and SSB_{MSY}. The median recruits are descriptive and do not reflect the R_{MSY} proxy.

	2015	2017
F_{MSY} *proxy*	0.279	0.273
SSB_{MSY} (mt)	5,259	4,640 (3,499 - 6,342)
MSY (mt)	1,285	1,154 (873 - 1,570)
Median recruits (age 1) (000s)	6,562	6,186
Overfishing	Yes	Yes
Overfished	Yes	Yes

Projections: Short term projections of biomass were derived by sampling an empirical cumulative distribution function of 38 recruitment estimates from the VPA model results. Recruitment estimates were hindcasted based on a simple linear regression between the NEFSC Fall survey abundance at age 1 and the VPA estimate at age-1. The most recent two years (2015 and 2016) were not included in the series of recruitment values due to high uncertainty in these estimates. This resulted in a total of 38 recruitment values: 8 from the hindcast predictions (years 1977-1984) and 30 from the VPA (years 1985-2014). The annual fishery selectivity, maturity ogive, and mean weights at age used in projection are the most recent 5 year averages; retrospective adjustments were applied in the projections.

Table 22: Short term projections of total fishery catch and spawning stock biomass for Cape Cod-Gulf of Maine yellowtail flounder based on a harvest scenario of fishing at F_{MSY} *proxy* between 2019 and 2020. Catch in 2017 was assumed to be 353 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	353	2,226 (1,747 - 2,853)	0.183

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	662 (508 - 876)	2,723 (2,052 - 3,655)	0.273
2019	701 (544 - 924)	2,758 (2,172 - 3,579)	0.273
2020	775 (600 - 1,016)	3,230 (2,436 - 4,312)	0.273

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).

  Retrospective pattern remains a source of uncertainty in this assesment. This has persisted for a number of years, causing SSB estimates to decrease and F estimates to increase as more years of data are added. Other sources of uncertainty include the *patterning in the survey residuals (although the magnitude of the residuals are small) and the application the NEFSC survey age-length keys to the Maine-New Hampshire state survey to derive survey abundance-at-age as tunning index in the VPA model. Finally, catchability is a source of uncertainty. Catchability estimates derived from the cooperative research study are substantially different from those estimated in the model.*

- 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}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.98 in the 2015 assessment and was 0.76 in 2016. The 7-year Mohn's ρ, relative to F, was -0.45 in the 2015 assessment and was -0.38 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=1,191) and 2016 F (F_ρ=0.314) were outside the approximate 90% confidence region around SSB (1,722 - 2,626) and F (0.15 - 0.26). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 2,093 to 1,191 and the 2016 F_{Full} from 0.193 to 0.314.

- Based on this stock assessment, are population projections well determined or uncertain?

  Population projections for Cape Cod-Gulf of Maine yellowtail flounder are reasonably well determined with the 2018 estimates of SSB and yield from this assessment well within the bounds of values projected in the 2015 operational assessment.

- 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.

  No major changes, other than the incorporation of new data, were made to the Cape Cod-Gulf of Maine yellowtail flounder assessment for this update.

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

  As in recent assessments for Cape Cod-Gulf of Maine yellowtail flounder the stock status remains as overfished and overfishing is occurring.

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

  The current fishing mortality rate in this assessment is low. The recent above average recruitment has contiributed to the increase in spawning stock biomass (SSB).

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

  The Cape Cod-Gulf of Maine yellowtail flounder assessment could potentially benefit from updated growth and maturity studies. The current values are based on GARM III estimates (NEFSC 2008) which are apprximately 10 years old. Future modeling efforts should consider forward-projecting statistical catch-at-age models to account for uncertainty in the data inputs.

- Are there other important issues?

  No.

6.1 Reviewer Comments: Cape Cod-Gulf of Maine yellowtail flounder

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice, although noting that there are appreciable model fitting issues and uncertainties to consider.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel agrees with the recommendation that the Cape Cod-Gulf of Maine yellowtail flounder stock is overfished and overfishing is occurring. However, recent recruitment is above average, and spawning stock biomass has increased.

Key Sources of Uncertainty:

A retrospective pattern remains a source of uncertainty in this assessment as well as patterning in some residuals. The application of National Marine Fisheries Service trawl survey age-length keys to the Maine-New Hampshire survey is another source of uncertainty. Catchability is a source of uncertainty. Catchability estimates derived from the cooperative research study are substantially different from those estimated in this assessment.

Research Needs:

The panel recommends studies to update estimates of growth and maturity. The current estimates are based on Groundfish Assessment Review Meeting (GARM) III estimates which are approximately 10 years old. Future modeling efforts should consider forward-projecting statistical catch-at-age models to account for uncertainty in the data inputs. Also, given recent low recruitment, there should be future research to evaluate potential causes of low recruitment, and whether a regime shift should be considered, particularly in the calculation of reference points. Finally, the panel recommends further research and consideration of survey catchability estimates.

References:

Legault, C, L. Alade, S. Cadrin, J. King, and S. Sherman. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. CRD08-15

Legault, C, L. Alade, S. Emery, J. King, and S. Sherman. 2012. In. Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 12-06.; 789 p. CRD12-06

Alade, L. 2015. In Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci CentRef Doc. 15-24; 251 p.

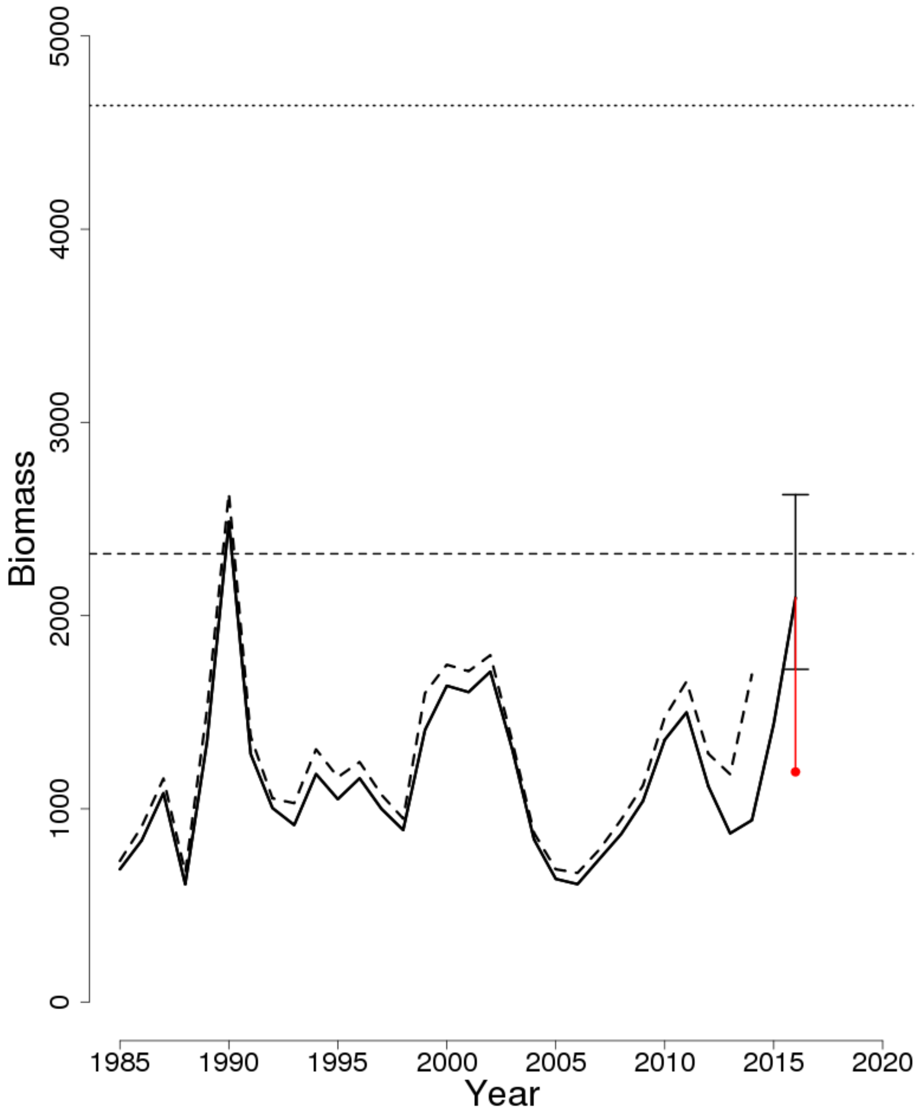

Figure 29: Trends in spawning stock biomass of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% bootstrap probability intervals are shown.

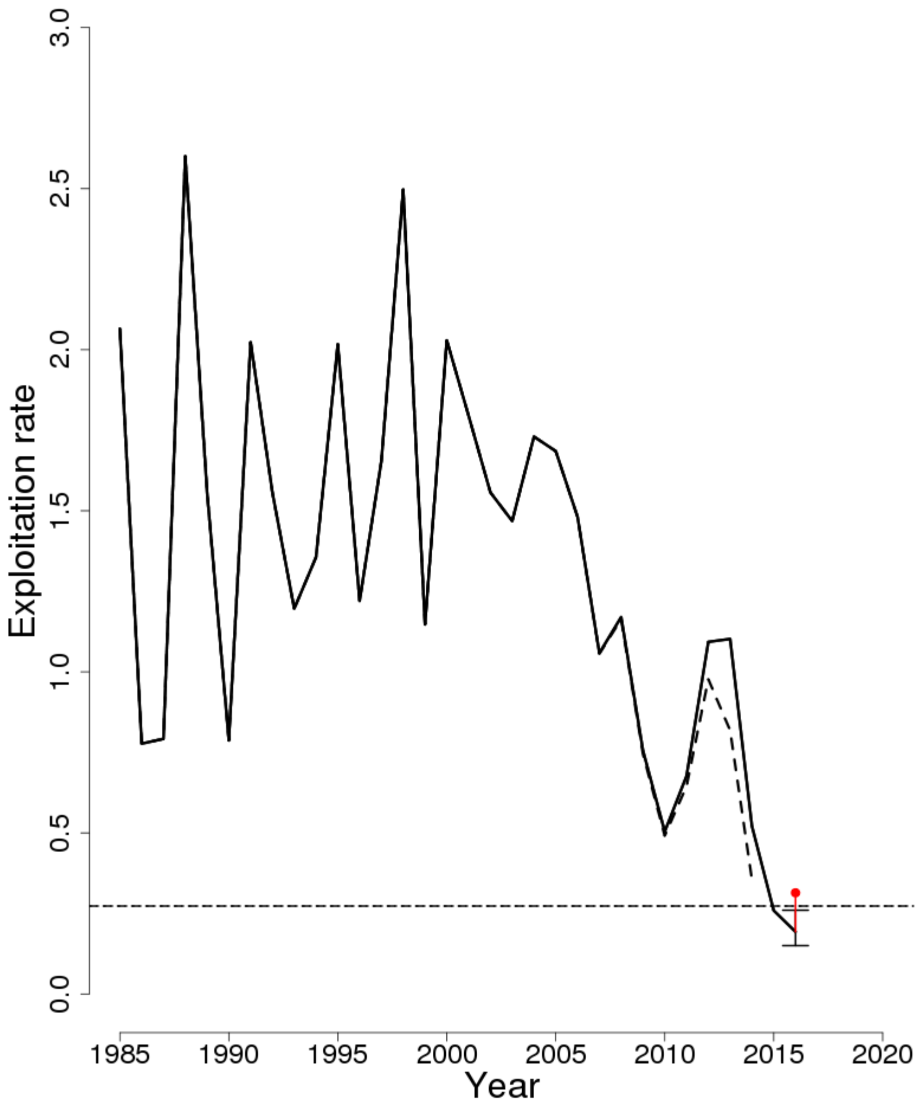

Figure 30: Trends in the fully selected fishing mortality (F_{Full}) of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.273; horizontal dashed line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red based on the 2017 assessment. The 90% bootstrap probability intervals are shown.

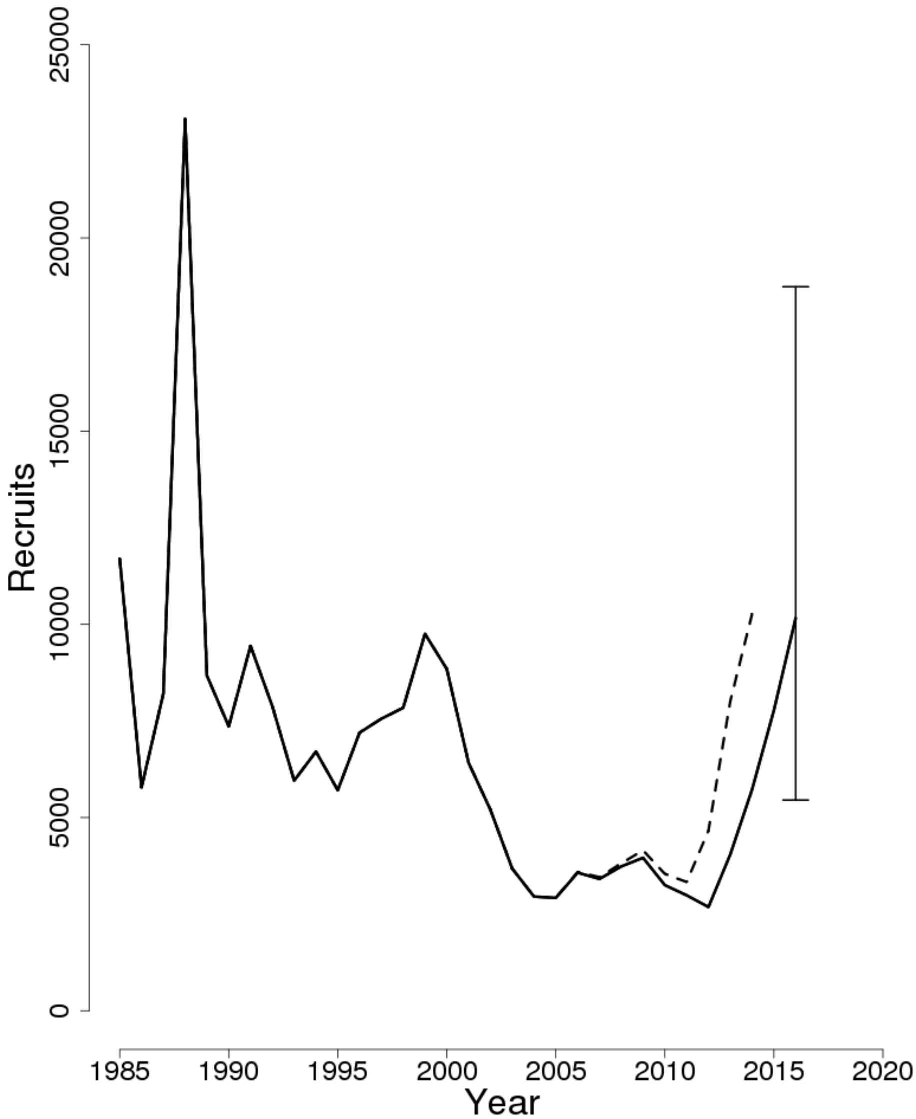

Figure 31: Trends in Recruits (age 1) (000s) of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2016 from the current (solid line) and previous (dashed line) assessment. The 90% bootstrap probability intervals are shown.

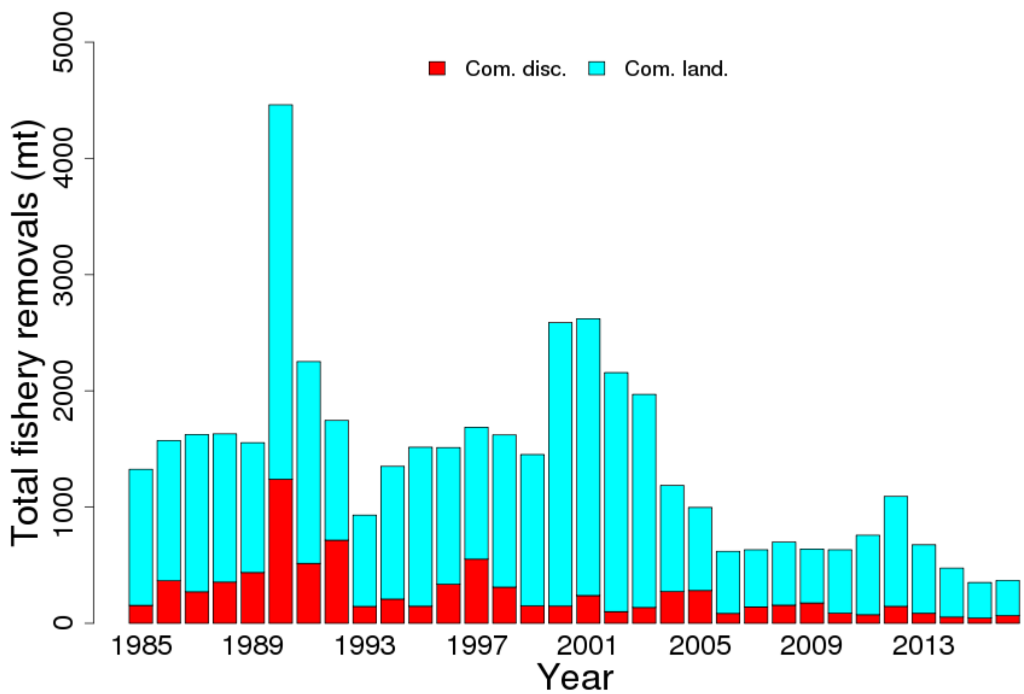

Figure 32: Total catch of Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2016 by disposition (landings and discards).

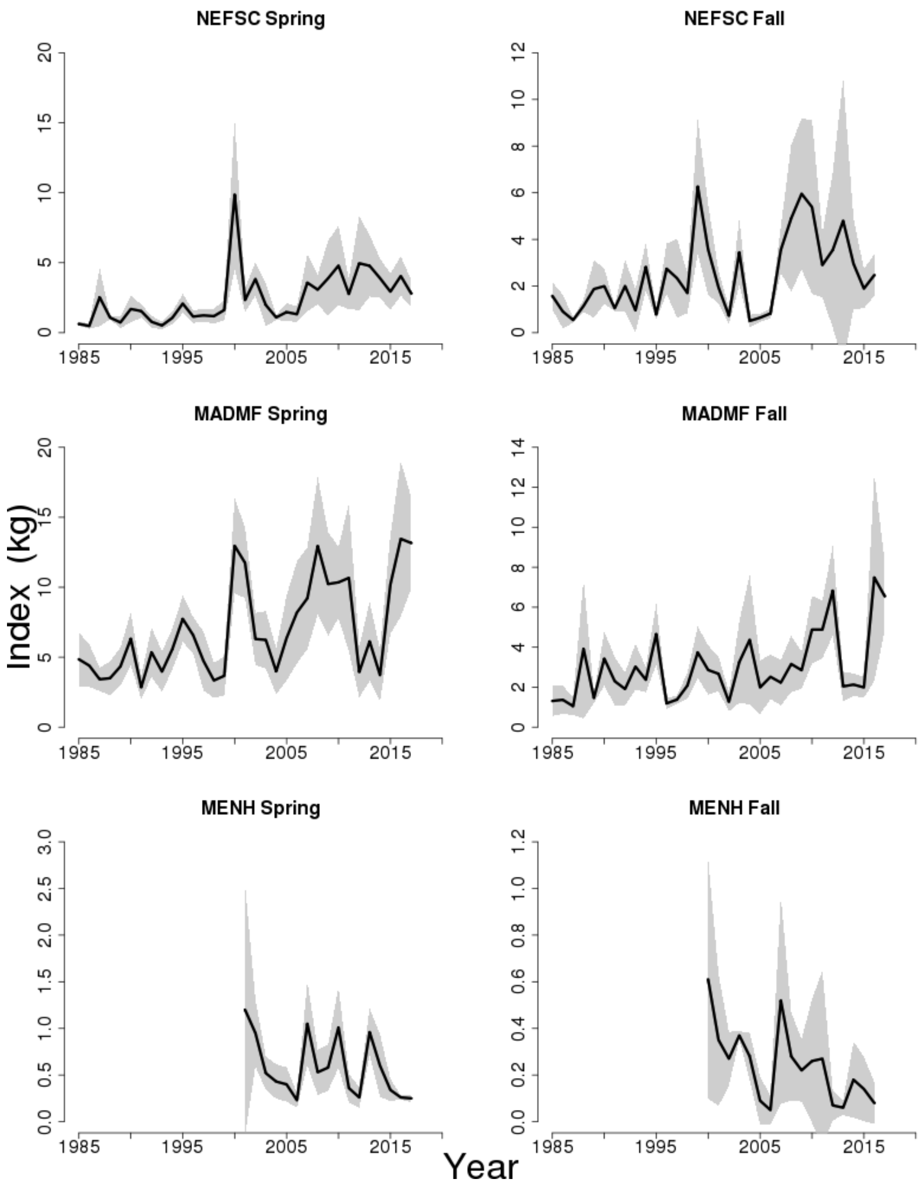

Figure 33: Indices of biomass for the Cape Cod-Gulf of Maine yellowtail flounder between 1985 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, Massachusetts Department of Marine Fisheries (MADMF) inshore state spring and fall bottom trawl surveys,and the Maine New Hampshire inshore state spring and fall state surveys. The 90% bootstrap probability intervals are shown.

7 Southern New England-Mid Atlantic yellowtail flounder

Larry Alade

This assessment of the Southern New England-Mid Atlantic yellowtail flounder (Limanda ferruginea) stock is an operational assessment update of the existing 2012 benchmark assessment (NEFSC 2012). Based on the last operational assessment (Alade 2015), the stock was overfished and overfishing was occurring. This assessment updates commercial fishery catch data, research survey indices of abundance, weights at age and the analytical ASAP assessment model and reference points through 2016. Additionally, stock projections have been updated through 2020. This report reflects decisions made during the Peer review meeting on September 12, 2017.

State of Stock: Based on this updated assessment, Southern New England-Mid Atlantic yellowtail flounder (*Limanda ferruginea*) stock is overfished and overfishing is occurring (Figures 34-35). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 152 (mt) which is 8% of the biomass target (SSB_{MSY} $proxy$ = 1,860; Figure 34). The 2016 fully selected fishing mortality was estimated to be 1.09 which is 320% of the overfishing threshold proxy (F_{MSY} $proxy$ = 0.341; Figure 35).

Table 23: Catch and model results for Southern New England-Mid Atlantic yellowtail flounder. All weights are in (mt) recruitment is in (000s) and F_{Full} is the average fishing mortality on ages (ages 4 and 5). Model results are from the current updated ASAP assessment. Note: Terminal year estimates of SSB and F reflect the unadjusted values for retrospective error.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
			Data							
Commercial discards	296	391	268	177	145	221	185	109	53	26
Commercial landings	205	192	185	113	243	342	461	516	284	126
Total Catch for Assessment	502	583	453	291	388	563	646	625	337	152
			Model Results							
Spawning Stock Biomass	1,433	1,533	1,480	1,614	1,712	1,671	1,437	942	541	300
F_{Full}	0.58	0.51	0.38	0.24	0.32	0.53	0.7	0.84	0.77	0.58
Recruitment (age 1)	2,592	3,981	3,550	3,279	6,502	1,665	1,384	521	326	902

Table 24: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on long-term stochastic projections.

	2015	2017
F_{MSY} *proxy*	0.349	0.341
SSB_{MSY} (mt)	1,959	1,860 (1,149 - 2,725)
MSY (mt)	541	511 (319 - 742)
Median recruitment (age 1) (000s)	7,634	7,242
Overfishing	Yes	Yes
Overfished	Yes	Yes

Projections: Short term projections of biomass were derived by sampling from an empirical cumulative distribution function of 26 recruitment estimates from the ASAP model results. Following the previous and accepted benchmark formulation, recruitment was based on recent estimates of recruitments from the model time series (i.e. corresponding to year classes 1990 through 2015) to reflect the low recent pattern of recruitment in the stock. The annual fishery selectivity, maturity ogive, and mean weights at age used in projection are the most recent 5 year averages; retrospective adjustments were applied in the projections.

Table 25: Short term projections of total fishery catch and spawning stock biomass for Southern New England-Mid Atlantic yellowtail flounder based on a harvest scenario of fishing at F_{MSY} *proxy* between 2019 and 2020. Catch in 2017 was assumed to be 90 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	90	187 (127 - 272)	0.541

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	45 (28 - 69)	151 (93 - 235)	0.341
2019	81 (44 - 145)	406 (179 - 819)	0.341
2020	186 (84 - 356)	912 (381 - 1,737)	0.341

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).

  Recruitment remains a major source of uncertainty in this assessment. The choice of recruitment assumption (i.e. historical recruitment values or contemporary recruitment values) will influence stock status determination and short-term forecast of the stock. Although, contemporary recruitment is likely to reflect curent conditions for the stock, the underlying mechanism for the recent low recruitment is not clearly understood. Another source of uncertainty is the retrospective pattern that has persisted since the last operational *assessment. It should be noted that this operational assessment resulted in a reduction of retrospective bias(22% for F and 42% for SSB) due to the revision of the 2009-2014 NEFSC survey indices.*

- 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}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 1.06 in the 2015 assessment and was 0.98 in 2016. The 7-year Mohn's ρ, relative to F, was -0.53 in the 2015 assessment and was -0.47 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=152) and 2016 F (F_ρ=1.09) were outside the approximate 90% confidence region around SSB (217 - 459) and F (0.362 - 0.843).

- Based on this stock assessment, are population projections well determined or uncertain?

  Following the panel's recommendation from the 2015 operational assessment to use the Rho unadjusted projections as an upper bound for estimating OFL, the performance of the population projections for Southern New England-Mid Atlantic yellowtail flounder cannot be determined due to different approaches used in the projections for this assessment and the previous operational assessment. Projections in this assessment were Rho adjusted to account for a major retrospective pattern, and therefore is not comparable to the panel's recommendation from 2015 operational assessment.

- 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.

  In addition to data updates through 2016, this assessment revises the NEFSC fall and spring survey data for years 2009-2014 to be consistent with the NEFSC level of acceptable survey tow criteria. The revision to the NEFSC survey indices resulted in a slight upward scaling of estimated spawning stock biomass and a downward scaling of fishing mortality estimates for the recent years in the model (2008-2014). Further, sensitivity analyses were conducted to relax the input variance in the catch data time series as a scalar from a CV = 0.1 to CV = 0.2 to better account for the level of uncertainty in the catch data. Input effective sample sizes for both the catch and survey indices were also modified (See Supplemental information in the data Portal) in attempt to improve the quality of the model fit to the observed data. Overall, the changes in the sensitivity assessment model resulted in an improved model diagnostic (i.e. reduced retrospective bias but minimal difference in model parameter precision estimates). The sensitivity analyses were brought forward to the peer review panel for consideration, but due to the minimal influence of the sensitivity analyses on the assessment results and stock status determination, the panel agreed to accept the base model without changes as basis for catch advice. It was recognized that the range of changes made in the sensitivity model were outside of the scope of permissible changes in an operational assessment framework. However, the panel recommended that future work on the sensitivity analyses (i.e. determinnng the appropriate model weighting) should be pursued as an avenue to potentially improve model disgnostics.

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

  Stock status for Southern New England-Mid Atlantic yellowtail flounder remains *unchanged since the last 2015 operational assessment as overfished and overfishing occuring. Recruitment of young fish continues to be low, resulting in declining trends in the SSB.*

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

  Fishing mortality has been declining in recent years but still above the fishing reference point. Recent below average recruitment has resulted in declining Spawning Stock Biomass(SSB) with 2016 SSB lowest in the time series. Spawning Stock Biomass is projected to decrease in the short term, even at current level of catches (Note: 2016 catches was estimated to be second lowest in the time series).

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

  Recruitment of Southern New England-Mid Atlantic yellowtail flounder continues to be weak. Should this pattern of poor recruitment continue into the future, the ability of the stock to recover could be compromised. Therefore, future studies should build on current knowledge to further investigate some of the underlying ecological mechanisms of poor recruitment in the stock as it may relate to the physical environment. Recent studies on evaluating environmental effects on Southern New England yellowtail stock productivity suggest that oceanographic features, such as the cold pool and Gulf Stream are likely important predictors of recruitment (Miller et al.2016, Xu et al. 2017), however the mechanisms driving these predictions are not well known. Other areas of future work should continue to address the retrospective bias, including further work on the sensitivity analyses (i.e. determination of appropriate input data weighting by evaluating the CV and effective sample sizes in the model).

- Are there other important issues?

  None.

7.1 Reviewer Comments: Southern New England-Mid Atlantic yellowtail flounder

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice. The panel received an initial presentation for this stock exploring sensitivity to data-weighting in the model. However, the panel felt that these changes exceeded what was stated as permissible in this operational assessment cycle. Further, the results of the two methods were nearly identical; thus, the panel recommends the original base model be used for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel agrees with the conclusion that the Southern New England-Mid Atlantic yellowtail flounder stock is overfished and overfishing is occurring. Recent below average recruitment has resulted in declining spawning stock biomass. Spawning stock biomass is projected to decrease in the short term, even at current level of catches (2016 catch was estimated to be the second lowest in the time series). Recruitment of Southern New England-Mid Atlantic yellowtail flounder continues to be weak and if this pattern of poor recruitment continues into the future, the ability of the stock to recover could be compromised.

Key Sources of Uncertainty:

Underlying mechanisms for the recent low recruitment is not clearly understood. Another source of uncertainty is the retrospective pattern that has persisted since the last operational assessment. Catchability is a source of uncertainty. Catchability estimates derived from the cooperative research study are substantially different from those estimated in this assessment.

Research Needs:

The panel recommends future studies that build on current knowledge to further investigate some of the underlying ecological mechanisms of poor recruitment in the stock as it may relate to the physical environment. Recent studies that evaluated environmental effects on Southern New England yellowtail productivity suggest that oceanographic features, such as the cold pool and Gulf Stream are likely important predictors of recruitment. Future work should continue to address the retrospective bias, including the proposed changes to the catch CV and effective sample sizes that were provided in the initial assessment presentation, among other factors. Finally, the panel recommends further research and consideration of survey catchability estimates.

References:

Alade, L, C. Legault, S. Cadrin. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. CRD08-15

Richardson, D, J. Hare, W. Overholtz, D. Johnson. 2009. Development of long-term larval indices for Atlantic herring (*Clupea harengus*) on the northeast US continental shelf. ICES Journal of Marine Science, Volume 67, Issue 4, 1 May 2010, Pages 617627.

Northeast Fisheries Science Center. 2012. 54^{th} Northeast Regional Stock Assessment Workshop (54^{th} SAW) Assessment Report. US Dept Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 12-18.; 600 p. CRD12-18

Alade, L. 2015. In Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p.

Miller, T.J., J. Hare, L. Alade. 2016. A State-Space approach to Incorporating Environmental Effects on Recruitment in Age-Structured Assessment Model with an Application to Southern New England Yellowtail Flounder. Canadian Journal of Fisheries and Aquatic Sciences. Vol. 73(8): pp1261-1270

Xu, H., T.J. Miller, S. Hameed, L.A. Alade, J. Nye. (2017). Evaluating the Utility of the Gulf Stream Index for Predicting Recruitment of Southern New England- Mid Atlantic yellowtail flounder. Fisheries Oceanography. DOI: 10.1111/fog.12236

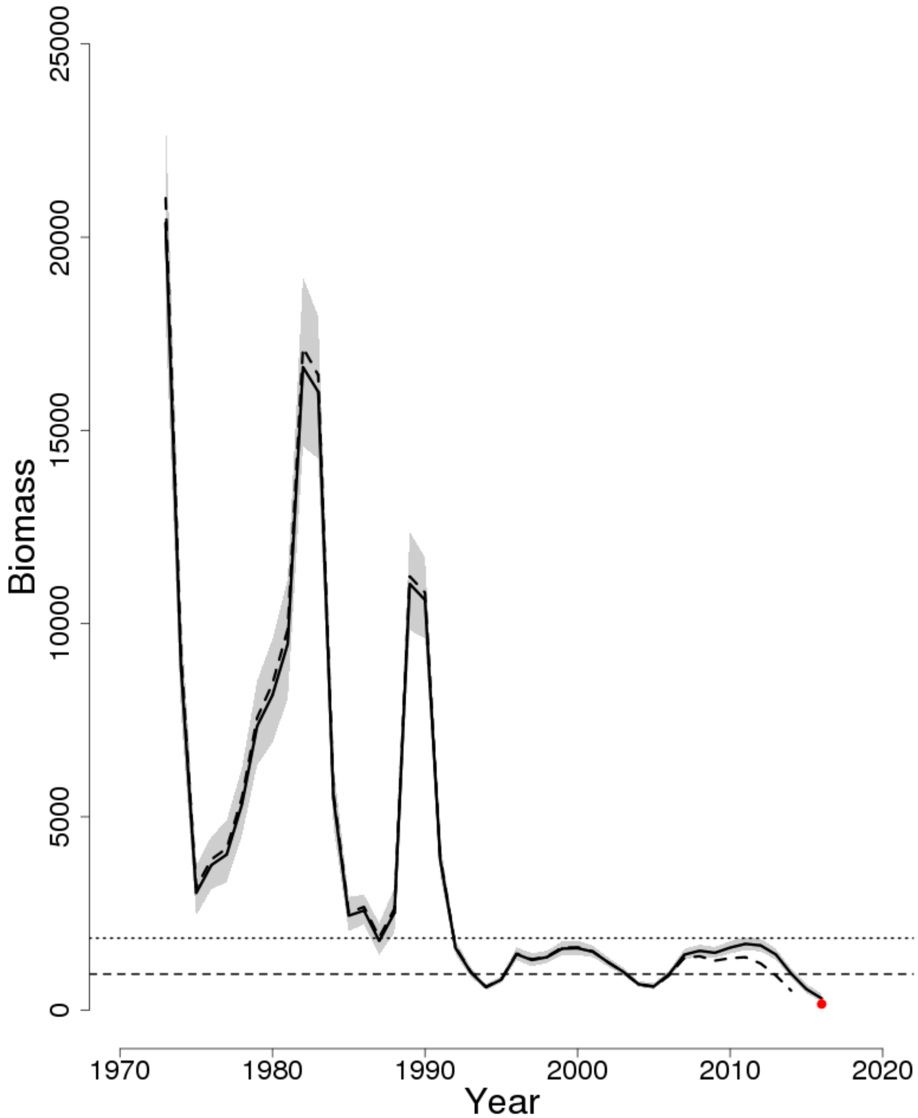

Figure 34: Trends in spawning stock biomass of Southern New England-Mid Atlantic yellowtail flounder between 1973 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

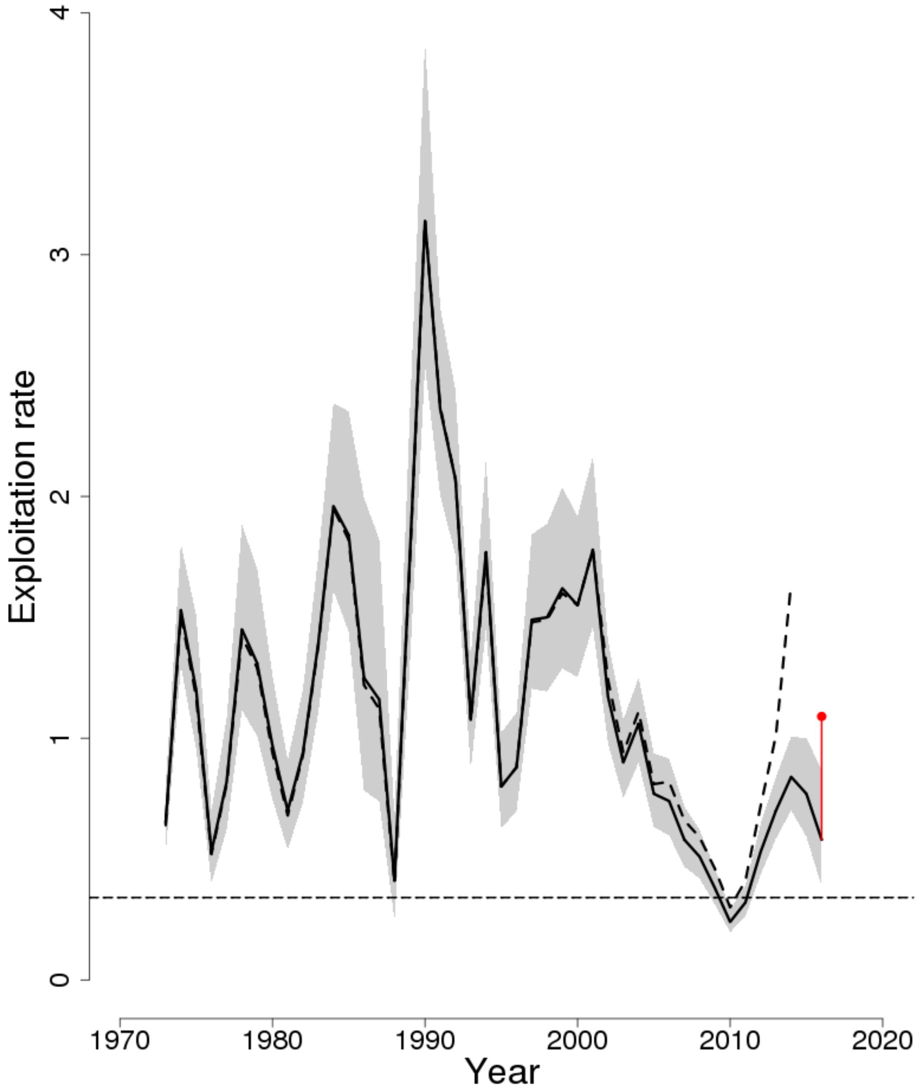

Figure 35: Trends in the fully selected fishing mortality (F_{Full}) of Southern New England-Mid Atlantic yellowtail flounder between 1973 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.341; horizontal dashed line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red based on the 2017 assessment. The approximate 90% lognormal confidence intervals are shown.

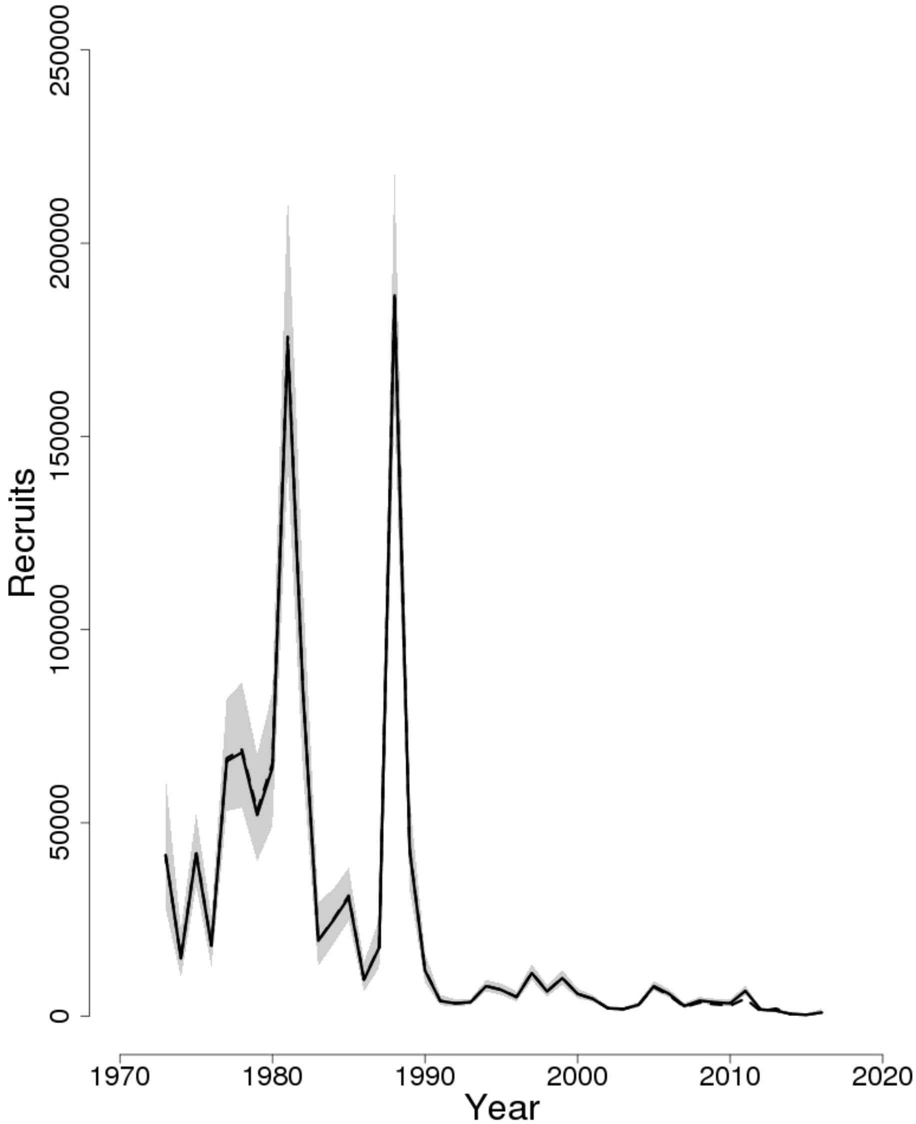

Figure 36: Trends in Recruitment (age 1) (000s) of Southern New England-Mid Atlantic yellowtail flounder between 1973 and 2016 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

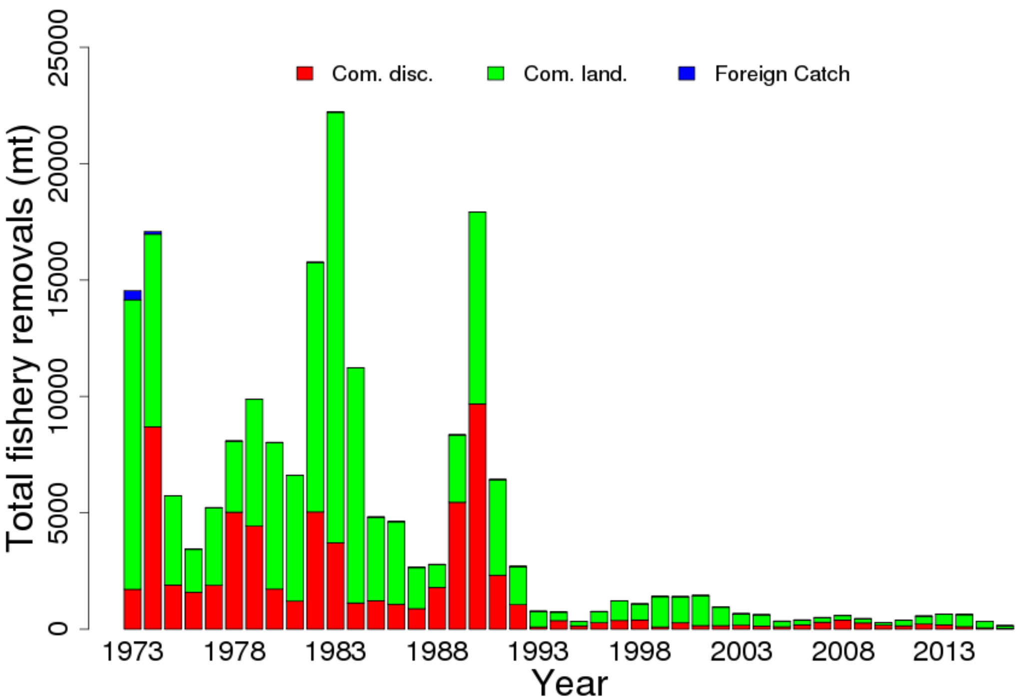

Figure 37: Total catch of Southern New England-Mid Atlantic yellowtail flounder between 1973 and 2016 by fleet (US domestic and foreign catch) and disposition (landings and discards).

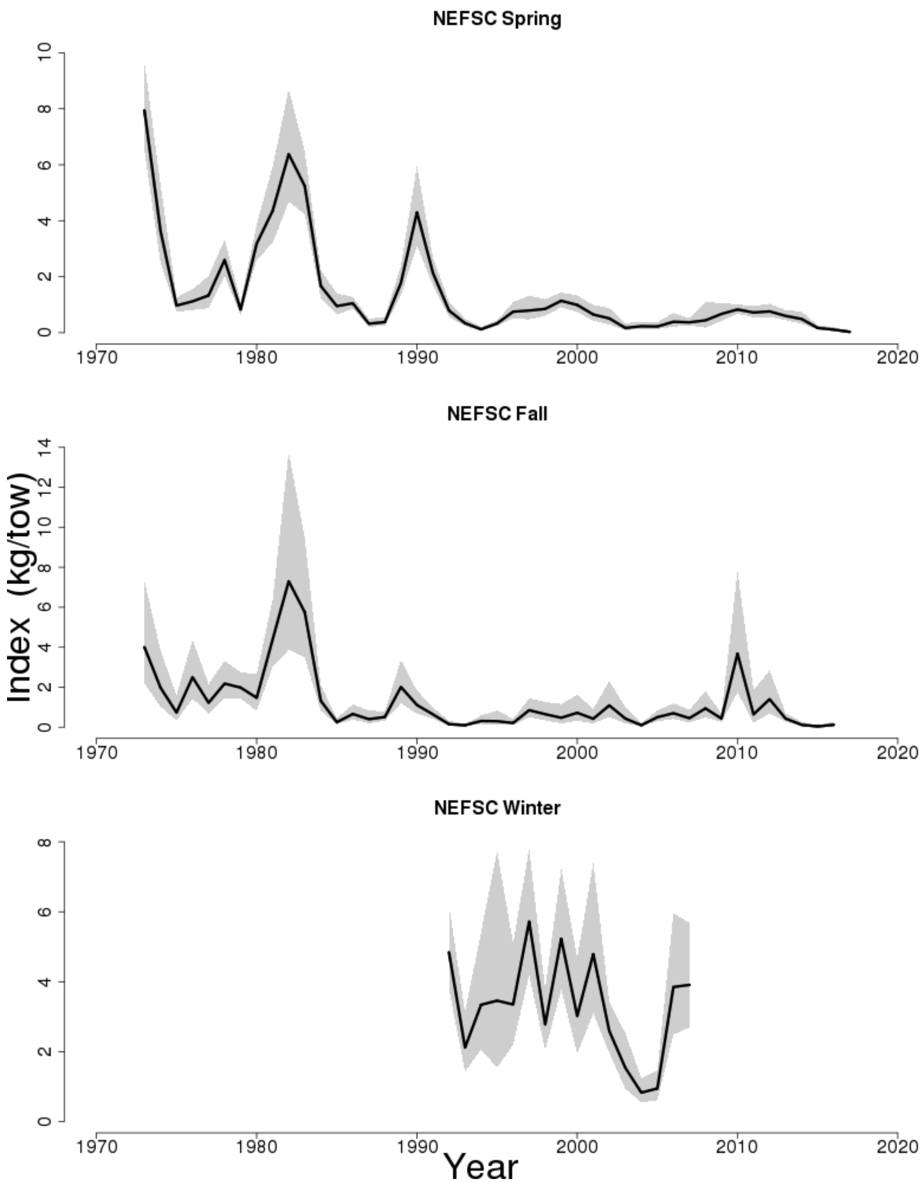

Figure 38: Indices of biomass for the Southern New England-Mid Atlantic yellowtail flounder between 1973 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring, fall and winter bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown. Note: Larval index based on Richardson et al (2009) was also used in this assessment and is available in the supplemental documentation.

8 Georges Bank Winter Flounder

Lisa Hendrickson

This assessment of the Georges Bank Winter Flounder (Pseudopleuronectes americanus) stock is an operational update of the existing 2015 operational VPA assessment which included data for 1982-2014 (NEFSC 2015). Based on the previous assessment the stock was overfished and overfishing was ocurring. This assessment updates commercial fishery catch data, research survey biomass indices, and the analytical VPA assessment model and reference points through 2016. Additionally, stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, the Georges Bank Winter Flounder (*Pseudopleuronectes americanus*) stock is not overfished and overfishing is not occurring (Figures 39-40). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 3,946 (mt) which is 52% of the biomass target for an overfished stock (SSB_{MSY} = 7,600 with a threshold of 50% of SSBMSY; Figure 39). The 2016 fully selected fishing mortality (F) was estimated to be 0.117 which is 22% of the overfishing threshold (F_{MSY} = 0.522; Figure 40). However, the 2016 point estimate of SSB and F, when adjusted for retrospective error (54% for SSB and -31% for F), is outside the 90% confidence interval of the unadjusted 2016 point estimate. Therefore, the 2016 F and SSB values used in the stock status determination were the retrospective-adjusted values of 0.117 and 3,946 mt, respectively.

Table 26: Catch input data and VPA model results for Georges Bank Winter Flounder. All weights are in (mt), recruitment is in (000s) and F_{Full} is the fishing mortality on fully selected ages (ages 4-6). Catch and model results are only for the most recent years (2007-2016) of the current updated VPA assessment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
					Data					
US landings	795	947	1,658	1,252	1,801	1,911	1,675	1,114	866	462
CA landings	12	20	12	45	52	83	12	12	13	4
US discards	188	143	91	138	129	113	47	46	20	6
CA scall dr discards	45	68	250	113	88	79	29	44	42	21
Catch for Assessment	1,040	1,178	2,011	1,548	2,070	2,185	1,763	1,216	941	493
					Model Results					
Spawning Stock Biomass	4,411	4,061	4,448	5,291	5,691	5,625	5,281	5,800	7,116	6,083
F_{Full}	0.3	0.364	0.441	0.318	0.457	0.424	0.398	0.28	0.122	0.081
Recruits (age 1)	9,677	13,702	13,318	6,795	7,258	5,346	5,668	3,391	800	2,556

Table 27: Comparison of reference points estimated in the 2015 assessment and the current assessment update and stock status during 2014 and 2016, respectively. An estimate of F_{MSY} was used for the overfishing threshold and was based on long-term stochastic projections.

	2015	2017
F_{MSY}	0.536	0.522
SSB_{MSY} (mt)	6,700	7,600 (4,170 - 14,690)
MSY (mt)	2,840	3,500 (1,940 - 6,720)
Median recruits (age 1) (000s)	9,880	9,677
Overfishing	Yes	No
Overfished	Yes	No

Projections: Short-term projections of biomass were derived by sampling from a cumulative distribution function of recruitment estimates (1982-2015 YC) from the final run of the ADAPT VPA model. The annual fishery selectivity, maturity ogive (a 3-year moving window), and mean weights-at-age used in the projection are the most recent five-year averages (2012-2016). An SSB retrospective adjustment factor of 0.649 was applied in the projections.

Table 28: Short-term projections of catch (mt) and spawning stock biomass (mt) for Georges Bank Winter Flounder based on a harvest scenario of fishing at F_{MSY} between 2018 and 2020. Catch in 2017 was assumed to be 574 (mt)

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	574	3,026 (2,307 - 3,875)	0.158

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	1,083	2,380 (1,780 - 3,091)	0.522
2019	1,095	2,313 (1,707 - 3,571)	0.522
2020	1,600	3,454 (1,916 - 7,841)	0.522

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 largest source of uncertainty is the estimate of natural mortality, which is based on longevity (max. age = 20). Natural mortality is not well studied in Georges Bank Winter Flounder and is assumed constant over time. Natural mortality affects the scale of the biomass and fishing mortality estimates. Other sources of uncertainty include the underestimation of catches. Discards from the Canadian bottom trawl fleet were not provided by the CA DFO and the precision of the Canadian scallop dredge discard estimates, with only 1-2 trips per month, are uncertain. The lack of age data for the Canadian spring survey catches requires the use of the US spring survey A/L keys despite selectivity differences. In addition, there are no length or age composition data for the Canadian landings or discards of GB winter flounder.

- 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 90% confidence intervals for SSB and F_{Full}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.830 in the 2015 assessment and was 0.540 in 2016. The 7-year Mohn's ρ, relative to F, was -0.513 in the 2015 assessment and was -0.308 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=3,946) and 2016 F (F_ρ=0.117) were outside the 90% confidence limits for SSB (4,898 - 7,812) and F (0.064 - 0.106). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 6,083 to 3,946 and the 2016 F_{Full} from 0.081 to 0.117.

- 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 Georges Bank Winter Flounder were reasonably well determined and projected biomass from the last assessment was within the confidence bounds of the biomass estimated in the current assessment. This stock was required to be rebuilt by 2017.

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

  The only change made to the Georges Bank Winter Flounder assessment, other than the incorporation of additional data for 2015 and 2016 and updating the most recent five-year averages for fishery selectivity-, proportion mature-, stock weights-, catch weights-, and spawning stock weights-at-age, were the Canadian scallop dredge discard estimates for 2004-2014. The Canadian scallop dredge discards were re-esitmated by the CA DFO staff to reflect the discard estimation method they use for the TRAC stock assessments (Sameoto et al. 2013). This change resulted in discard estimates that differed from those included in the most recent GB winter flounder assessment by -8% to 14%. In addition, the updated 2004 CA scallop drdege discard estimate now includes all months of the year; representing an increase of 85%.

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

  The stock status of Georges Bank Winter Flounder has changed from overfished and overfishing is occurring to not overfished and overfishing is not occurring.This change was attributable to a rapid decline in F, from near 75% of FMSY (= 0.392) in 2013 to 0.081 in 2016, and a gradual increase in SSB from near the SSBMSY threshold (= 3,800 mt) in 2008 to slightly below SSBMSY (= 7,600 mt) in 2015 (7,116 mt). However, SSB then declined to 6,083 mt in 2016. In addition, the Mohn's rho values used to adjust the 2016 F and SSB values were 60% and 65% lower, respectively, than the values from the previous assessment.

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

  Fishing mortality declined rapidly between 2013 and 2016 and is at the lowest level of the time series. Following a decline in the catch mean weights-at-age for the older fish (ages 4-7+), during 2007-2014, mean weights for these ages increased during 2015-2016. The mean length and weight of fish caught in the NEFSC fall and spring bottom trawl surveys *has been increasing since 2008 and 2009, respectively. Spawning stock biomass estimates increased during 2008-2015 with a slight decrease in 2016. However, recruitment declined after 2008 and reached a time series low in 2015. Although recruitment increased during 2016-2017, it remained below average and the 2017 estimate is uncertain because it is based solely on the geometric mean of recruitment during 2009-2015.*

- 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 Winter Flounder assessment could be improved with discard estimates from the Canadian bottom trawl fleet and age data from the Canadian spring bottom trawl surveys.

- Are there other important issues?

  None.

8.1 Reviewer Comments: Georges Bank Winter Flounder

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice, including the decision to use updated Canadian scallop dredge discard estimates for 2004-2014.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the Georges Bank winter flounder stock is not overfished and overfishing is not occurring. This conclusion results in a change from the 2015 operational assessment, indicating that the stock was overfished and that overfishing was occurring. The deadline for rebuilding this stock is 2017. As of 2016 the stock remains well below target biomass. Fishing mortality declined rapidly between 2013 and 2016 and is at the lowest level of the time series. Following a decline in the catch mean weights-at-age for the older fish (ages 4-7+), during 2007-2014, mean weights for these ages increased during 2015-2016. The mean length and weight of fish caught in the National Marine Fisheries Service (NMFS) fall and spring bottom trawl surveys has been increasing since 2008 and 2009, respectively. Spawning stock biomass estimates increased during 2008-2015 but declined slightly in 2016. However, recruitment declined after 2008 and reached a time series low in 2015.

Key Sources of Uncertainty:

The largest source of uncertainty is the retrospective bias and the estimate of natural mortality, which is based on longevity (max. age = 20). Other sources of uncertainty include the underestimation of catches. Discards from the Canadian bottom trawl fleet were not provided by the Canadian Department of Fisheries and Oceans (DFO) and the precision of the Canadian scallop dredge discard estimates, with only 1-2 trips per month, are uncertain. The lack of age data for the Canadian spring survey catches requires the use of the US spring survey age-length keys despite selectivity differences. In addition, there are no length or age composition data for the Canadian landings or discards of Georges Bank winter flounder.

Research Needs:

The panel recommends that future work be conducted to consider discard estimates from the Canadian bottom trawl fleet and age data from the Canadian spring bottom trawl surveys. Also, the assessment may be improved by converting from a Virtual Population Analysis (VPA) to a statistical catch-at-age model.

References:

Sameoto, J., B. Hubley, L. Van Eeckhaute and A. Reeves. 2013. A Review of the standardization of effort for the calculation of discards of Atlantic cod, haddock and yellowtail flounder from the 2005 to 2011 Canadian scallop fishery on Georges Bank. Transboundary Resources Assessment Committee (TRAC) Reference Document 2013/04, 22 pp.

Northeast Fisheries Science Center. 2015. Operational assessment of 20 Northeast groundfish stocks, updated through 2014. U.S. Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 15-24; 251 p.

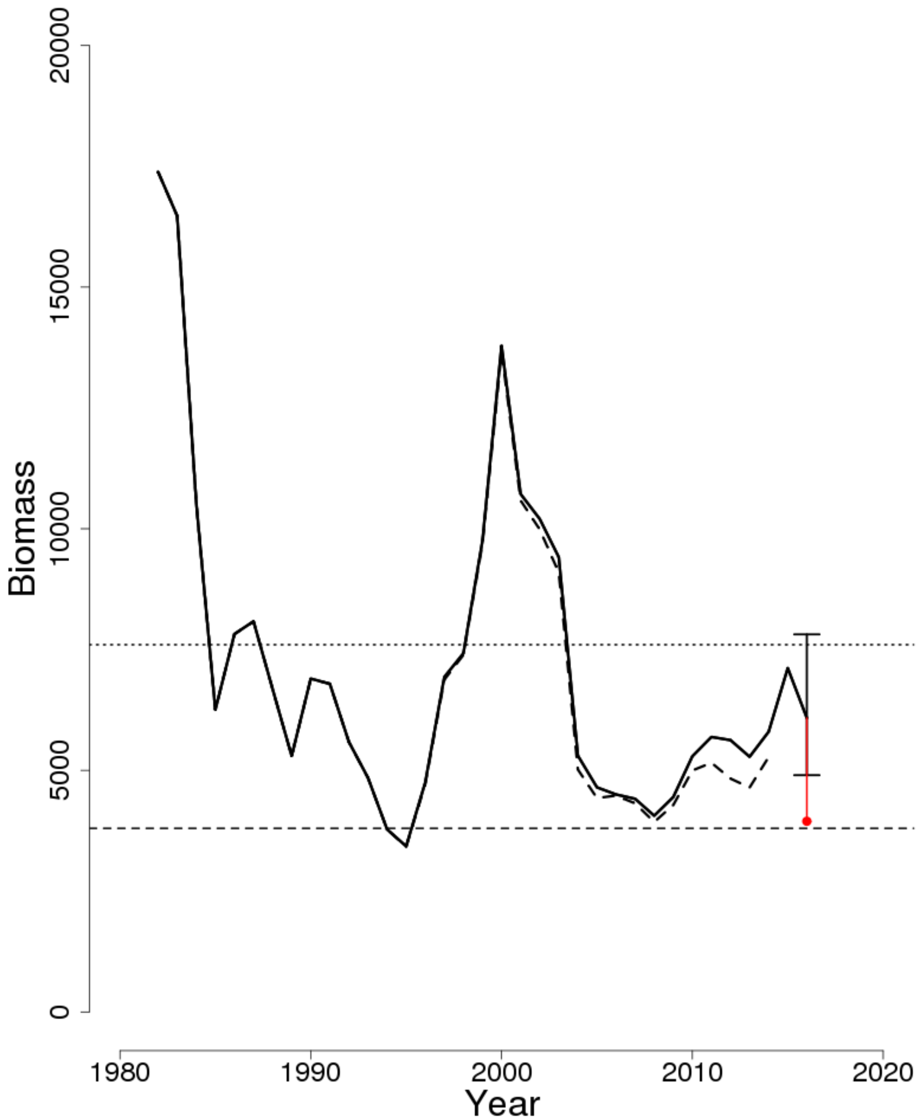

Figure 39: Trends in spawning stock biomass (mt) of Georges Bank Winter Flounder between 1982 and 2016 from the current (solid line) and previous (dashed line) assessments and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY}; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY}; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% normal confidence interval is shown for 2016.

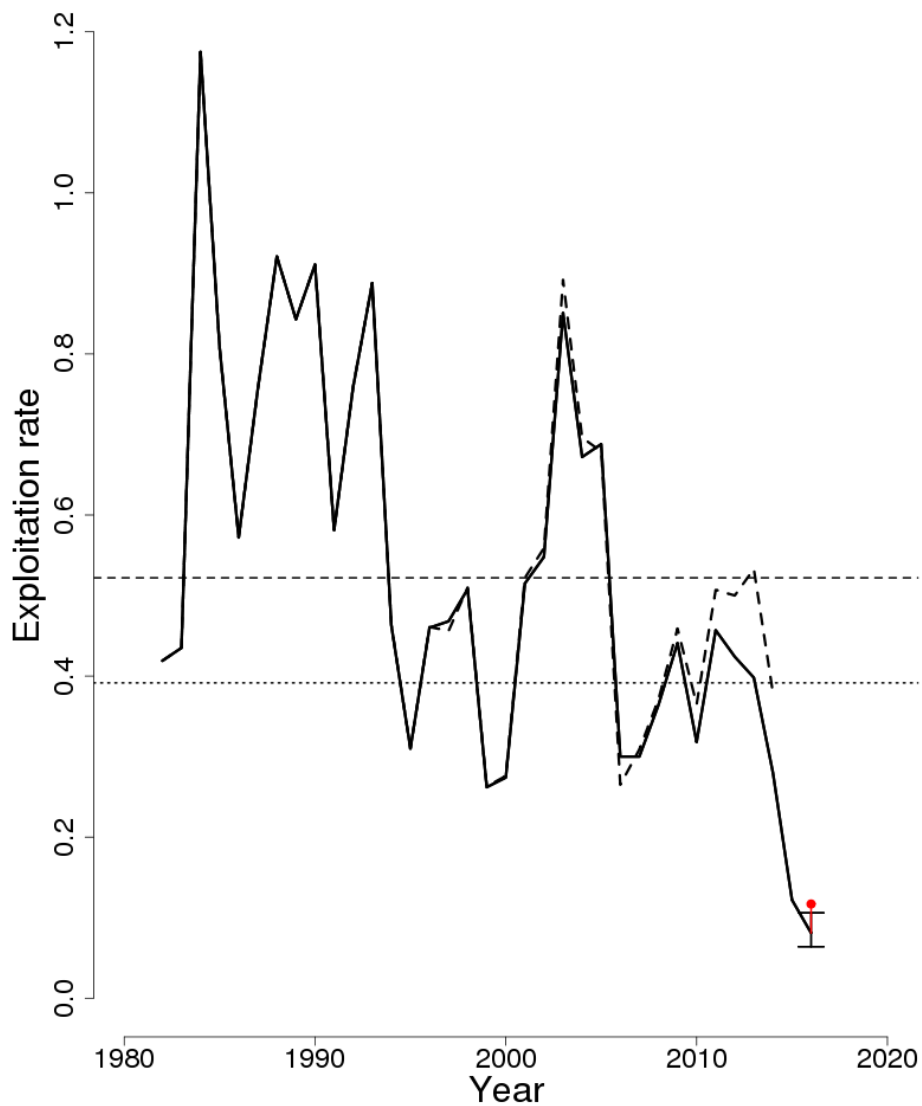

Figure 40: Trends in fully selected fishing mortality (F_{Full}) of Georges Bank Winter Flounder between 1982 and 2016 from the current (solid line) and previous (dashed line) assessments and the corresponding $F_{Threshold}$ (F_{MSY}=0.522; horizontal dashed line) as well as (F_{Target}= 75% of FMSY; horizontal dotted line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% normal confidence interval is shown for 2016.

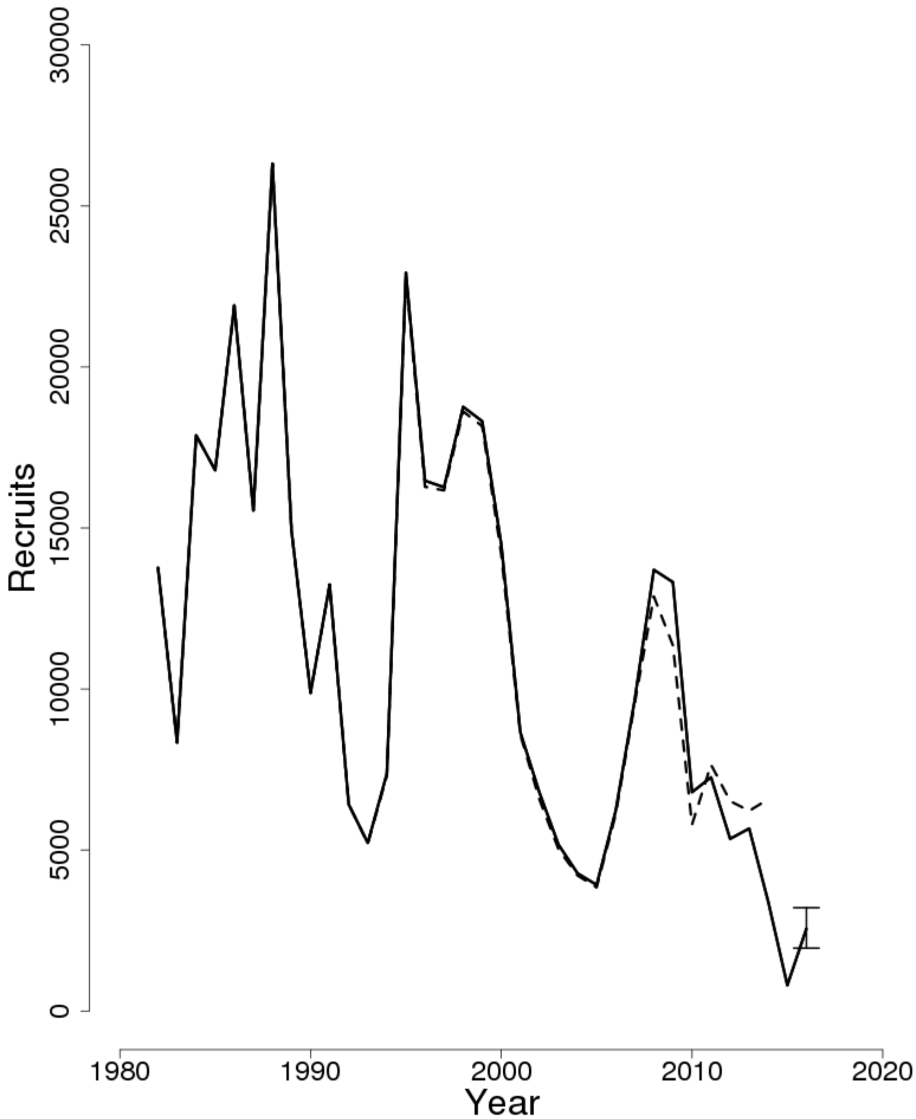

Figure 41: Trends in Recruits (age 1) (000s) of Georges Bank Winter Flounder between 1982 and 2016 from the current (solid line) and previous (dashed line) assessments. The 90% normal confidence interval is shown for 2016.

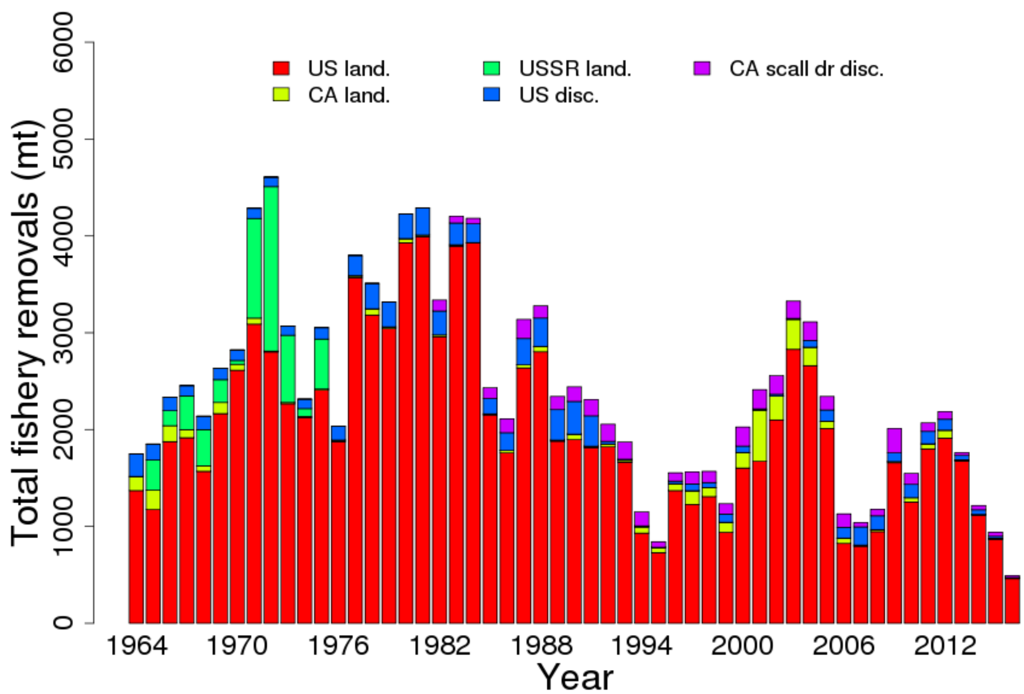

Figure 42: Total catches (mt) of Georges Bank Winter Flounder between 1982 and 2017 by country and disposition (landings and discards).

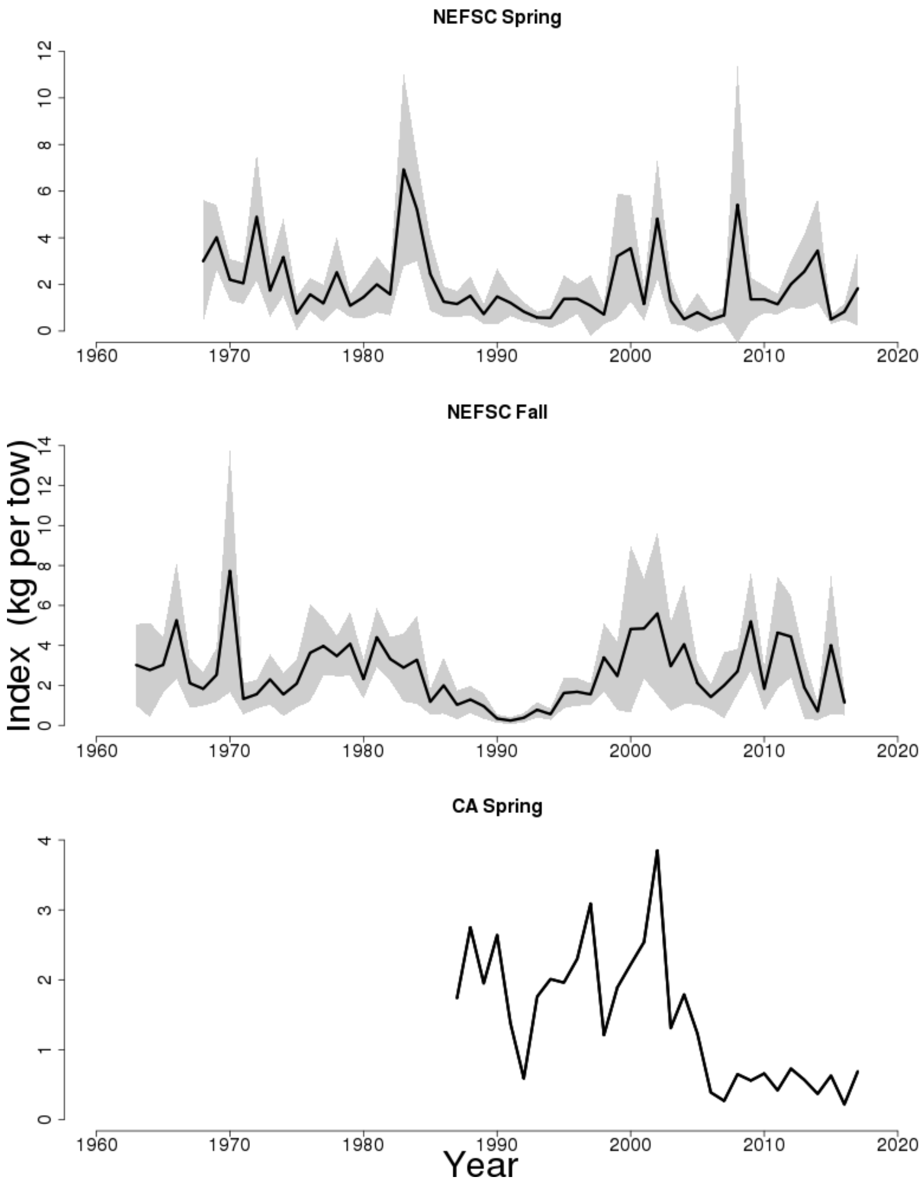

Figure 43: Indices of biomass for the Georges Bank Winter Flounder for the Northeast Fisheries Science Center (NEFSC) spring (1968-2017) and fall (1963-2016) bottom trawl surveys and the Canadian DFO spring survey (1987-2017). The 90% normal confidence interval is shown.

9 Southern New England Mid-Atlantic winter flounder

Anthony Wood

This assessment of the Southern New England Mid-Atlantic winter flounder (Pseudopleuronectes americanus) stock is an operational assessment of the existing 2011 banchmark assessment (NEFSC 2011). This assessment follows a previous operational update in 2015 where the stock was overfished, but overfishing was not occurring (NEFSC 2015). This assessment updates commercial fishery catch data, recreational fishery catch data, and research survey indices of abundance, and the analytical ASAP assessment models and reference points through 2016. Additionally, stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, the Southern New England Mid-Atlantic winter flounder (*Pseudopleuronectes americanus*) stock is overfished but overfishing is not occurring (Figures 44-45). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 4,360 (mt) which is 18% of the biomass target (24,687 mt), and 36% of the biomass threshold for an overfished stock ($SSB_{Threshold}$ = 12343.5 (mt); Figure 44). The 2016 fully selected fishing mortality was estimated to be 0.21 which is 62% of the overfishing threshold (F_{MSY} = 0.34; Figure 45).

Table 29: Catch and status table for Southern New England Mid-Atlantic winter flounder. All weights are in (mt), recruitment is in (000s), and F_{Full} is the fishing mortality on fully selected ages (ages 4 and 5). Model results are from the current updated ASAP assessment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Data										
Recreational discards	5	3	9	8	18	2	4	1	2	2
Recreational landings	116	73	87	28	65	31	7	30	10	33
Commercial discards	118	109	165	153	298	483	206	64	82	124
Commercial landings	1,628	1,113	271	174	150	134	857	658	655	519
Catch for Assessment	1,867	1,298	532	363	531	650	1,074	753	749	678
Model Results										
Spawning Stock Biomass	6,710	5,801	5,178	5,878	6,932	6,964	6,763	5,661	5,090	4,360
F_{Full}	0.36	0.28	0.12	0.07	0.1	0.12	0.21	0.19	0.2	0.21
Recruits (age 1)	6,157	9,140	7,075	6,532	4,873	4,464	2,390	4,102	5,742	7,549

Table 30: Comparison of reference points estimated in the 2015 operational assessment and from the current assessment update. F_{MSY} was generated assuming a Beverton-Holt S-R relationship and an SSB_{MSY} proxy was used for the overfished threshold and was based on long-term stochastic projections. Recruitment estimates are median values of the time-series. 90% CI are shown in parentheses.

	2011	2017
F_{MSY}	0.325	0.34
SSB_{MSY} (mt)	26,928	24,687 (16,919 - 36,693)
MSY (mt)	7,831	7,532 (4,991 - 11,570)
Median recruits (age 1) (000s)	16,448	15,802
Overfishing	No	No
Overfished	Yes	Yes

Projections: Short term projections of biomass were derived by sampling from a cumulative distribution function of recruitment estimates assuming a Beverton-Holt stock recruitment relationship. The annual fishery selectivity, maturity ogive, and mean weights at age used in the projection are the most recent 5 year averages; The model exhibited a minor retrospective pattern in F and SSB so no retrospective adjustments were applied in the projections.

Table 31: Short term projections of total fishery catch and spawning stock biomass for Southern New England Mid-Atlantic winter flounder based on a harvest scenario of fishing at F_{MSY} between 2018 and 2020. Catch in 2017 was assumed to be 625 (mt), a value provided by GARFO (Dan Caless pers. comm.). 90% CI are shown next to SSB estimates.

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	625	4,058 (3,238 - 5,029)	0.190

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	1,228	4,336 (3,490 - 5,327)	0.340
2019	1,326	4,177 (3,411 - 5,091)	0.340
2020	1,736	4,889 (3,647 - 7,192)	0.340

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).

  A large source of uncertainty is the estimate of natural mortality based on longevity, which is not well studied in Southern New England Mid-Atlantic winter flounder, and assumed constant over time. Natural mortality affects the scale of the biomass and fishing mortality estimates. Natural mortality was adjusted upwards from 0.2 to 0.3 during the last benchmark assessment (2011) assuming a max age of 16. However, there is still uncertainty in the true max age of the population and the resulting natural mortality estimate. Other *sources of uncertainty include length distribution of the recreational discards. The recreational discards are a small component of the total catch, but the assessment suffers from very little length information used to characterize the recreational discards (1 to 2 lengths in recent years).*

- 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}; see Table 8).

  The retrospective patterns for both Ffull and SSB are minor and no retrospective adjustment in 2016 was required.

- 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 Southern New England Mid-Atlantic winter flounder are reasonably well determined. There is uncertainty in the estimates of M. In addition, while the retrospective pattern is considered minor (within the 90% CI of both F and SSB), the rho adjusted terminal value of F is close to falling outside of the bounds which would indicate a major retrospective pattern. This would lead to retrospective adjustments being needed for the projections. The stock is in a rebuilding with a rebuild date of 2023. A projection using assumed catch in 2017 and F = 0 through 2023 indicated a less than 1% chance of reaching the SSB target.

- 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.

  No changes, other than the incorporation of new data, were made to the Southern New England Mid-Atlantic winter flounder assessment for this update.

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

  The stock status of Southern New England Mid-Atlantic winter flounder has not changed since the previous operational update in 2015 and remains the same as during the last benchmark assessment in 2011.

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

  The Southern New England Mid-Atlantic winter flounder stock shows an overall declining trend in SSB over the time series, with current estimates near the time series low. Estimates of fishing mortality have remained steady since 2012 and recruitment has steadily increased since an all time low in 2013. Current recruitment estimates are above the ten year average and are the highest since 2008.

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

  The Southern New England Mid-Atlantic winter flounder assessment could be improved with additional studies on maximum age, as well additional recreational discard lengths. In addition, further investigation into the localized struture/genetics of the stock is warranted. Also, a future shift to ASAP version 4 will provide the ability to model envirionmental factors that may influence both survey catchability and the modeled S-R relationship.

- Are there other important issues?
  None.

9.1 Reviewer Comments: Southern New England Mid-Atlantic winter flounder

Assessment Recommendation:

The panel concluded that the operational assessment with no adjustment for retrospective bias was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the Southern New England Mid-Atlantic winter flounder stock is overfished but overfishing is not occurring. The Southern New England Mid-Atlantic winter flounder stock shows an overall declining trend in spawning stock biomass over the time series, with current estimates near the time series low. Estimates of fishing mortality have remained steady since 2012 and recruitment has steadily increased since an all-time low in 2013. Current recruitment estimates are above the ten year average and are the highest since 2008. The stock is currently in a rebuilding plan with a deadline of 2023; however, this assessment suggests a low probability of meeting the rebuilding deadline.

Key Sources of Uncertainty:

A large source of uncertainty is the estimate of natural mortality based on longevity, which is not well studied in Southern New England Mid-Atlantic winter flounder, and assumed constant over time. There is still uncertainty in the true max age of the population and the resulting natural mortality estimate. Other sources of uncertainty include the fixed steepness value assumed in the stock-recruit relationship, and the length distribution of the recreational discards. Recreational discards are a small component of the total catch, but the assessment suffers from very little length information used to characterize the recreational discards (1 to 2 lengths in recent years).

Research Needs:

The panel recommends additional studies to improve estimates of natural mortality, including studies on maximum age. The panel suggests considering the incorporation of additional recreational discard lengths. In addition, studies to update and investigate migration and movement rates and patterns, as well as further investigation into the localized structure/genetics of the stock is warranted. Also, a future shift to a model that will provide the ability to model environmental factors that may influence both survey catchability and the modeled stock-recruitment relationship. Finally, the panel recommends further examination of the patterns observed in the residuals from fits to the survey indices.

References:

Northeast Fisheries Science Center. 2011. 52^{nd} Northeast Regional Stock Assessment Workshop (52^{nd} SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-17; 962 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

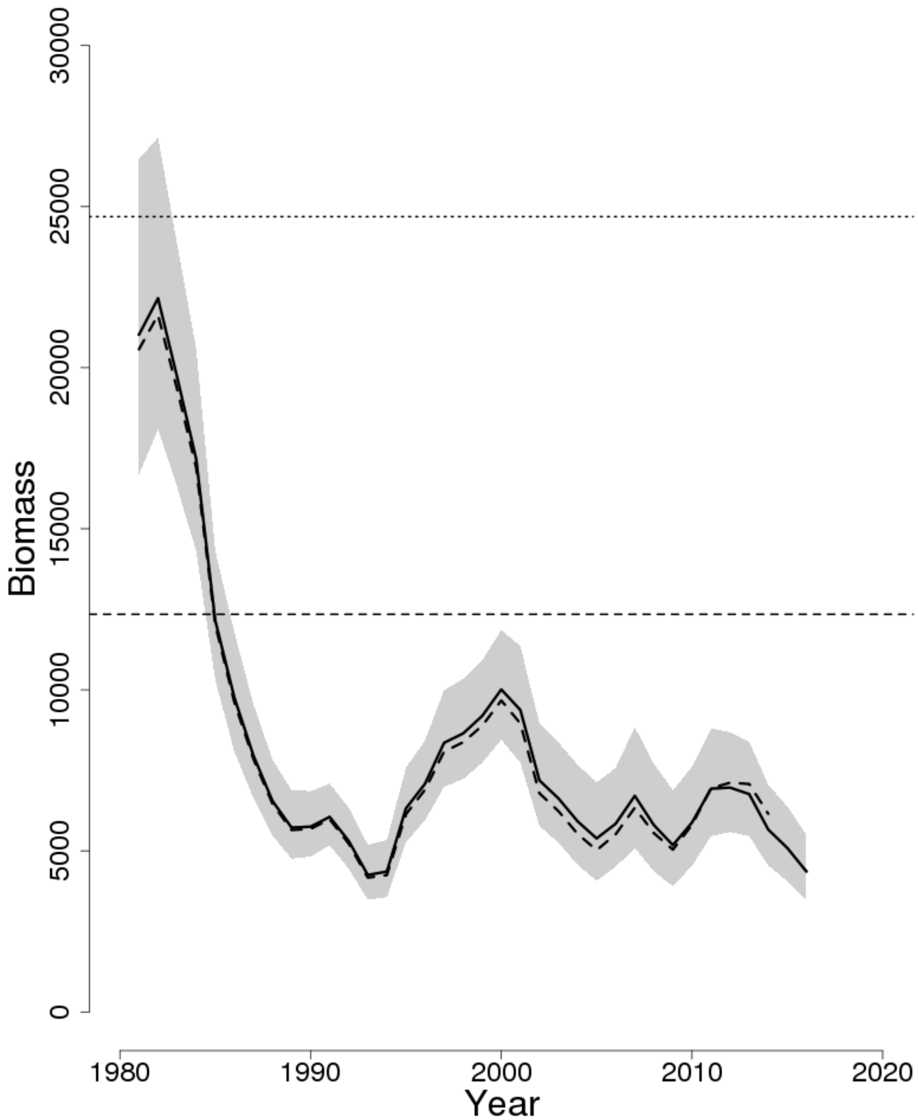

Figure 44: Trends in spawning stock biomass of Southern New England Mid-Atlantic winter flounder between 1981 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. The approximate 90% lognormal confidence intervals are shown.

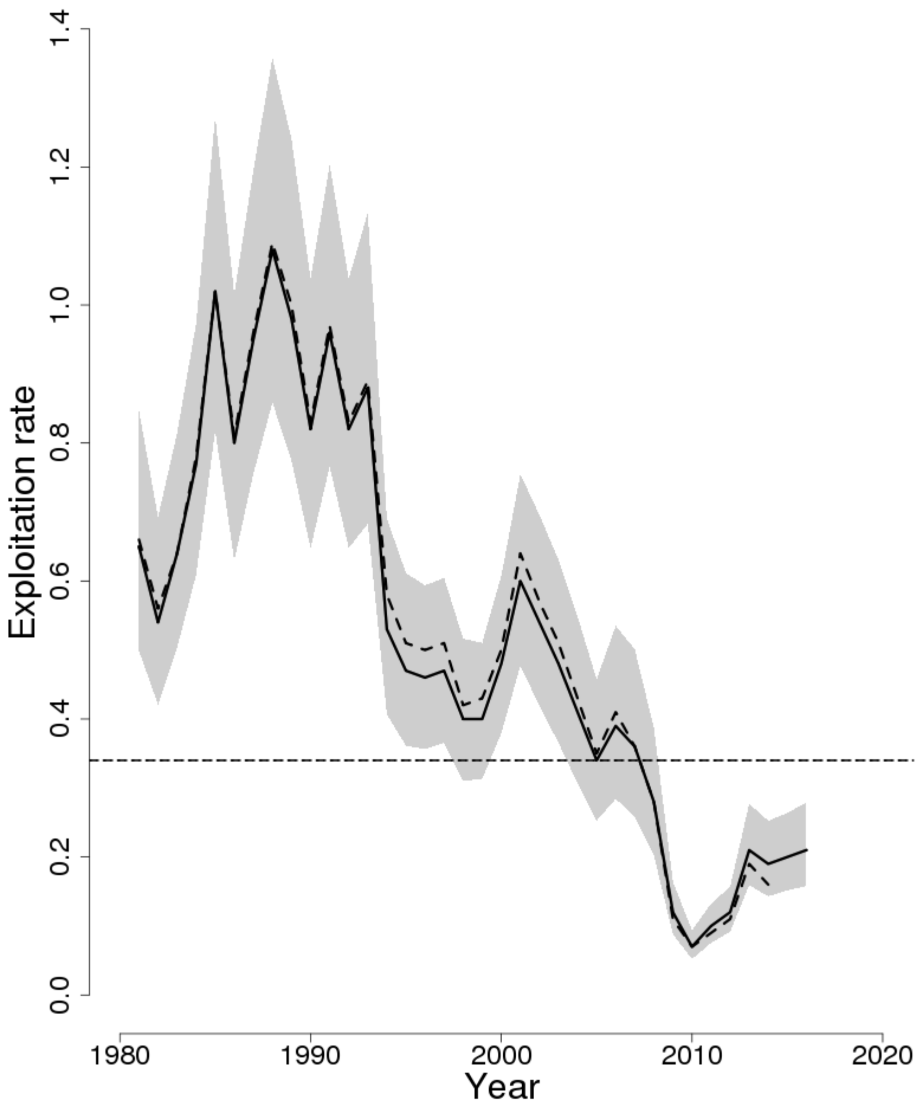

Figure 45: Trends in the fully selected fishing mortality (F_{Full}) of Southern New England Mid-Atlantic winter flounder between 1981 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY}=0.34; horizontal dashed line) based on the 2017 assessment. The approximate 90% lognormal confidence intervals are shown.

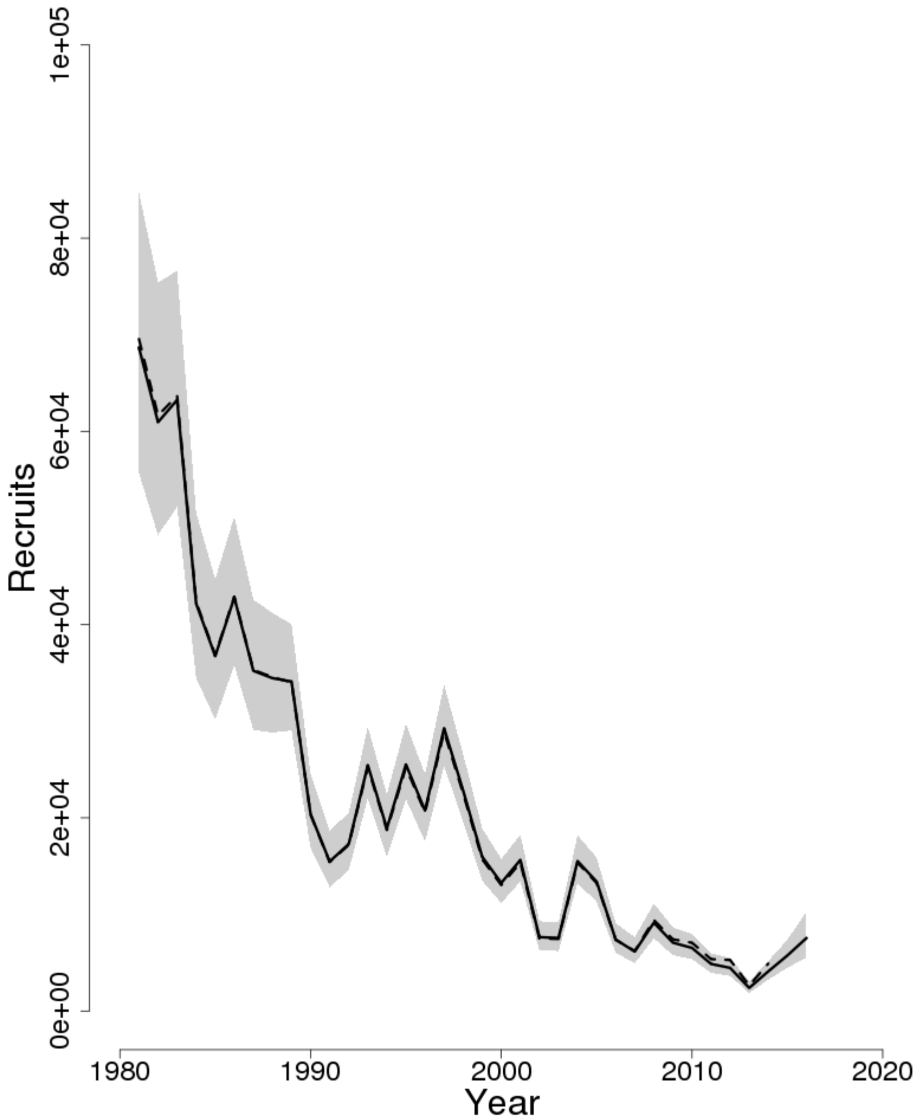

Figure 46: Trends in Recruits (age 1) (000s) of Southern New England Mid-Atlantic winter flounder between 1981 and 2016 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

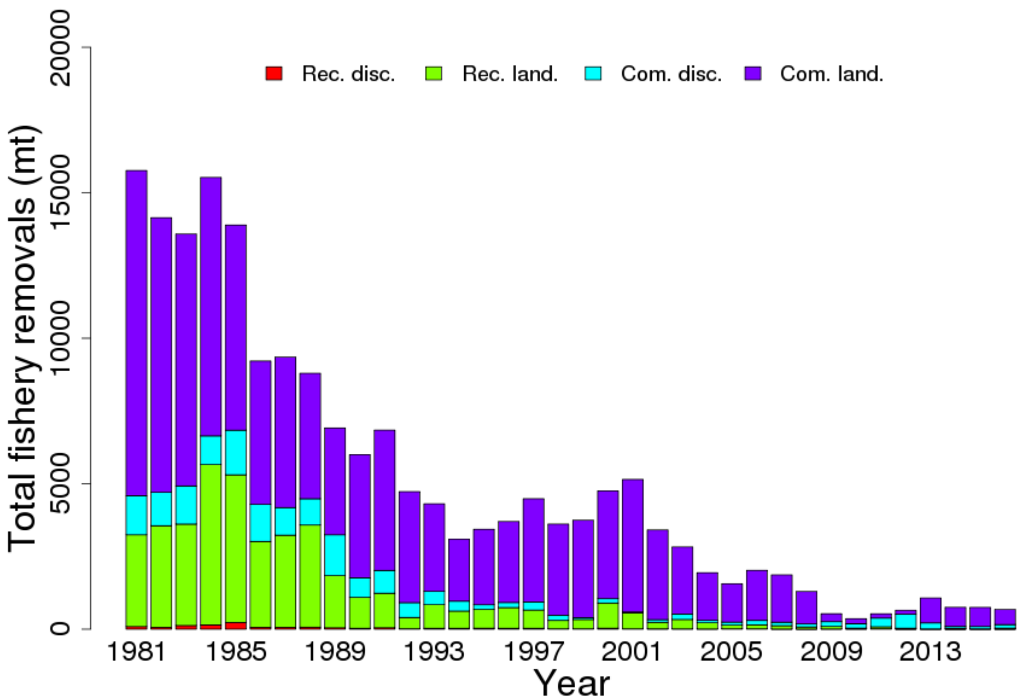

Figure 47: Total catch of Southern New England Mid-Atlantic winter flounder between 1981 and 2016 by fleet (commercial, recreational) and disposition (landings and discards).

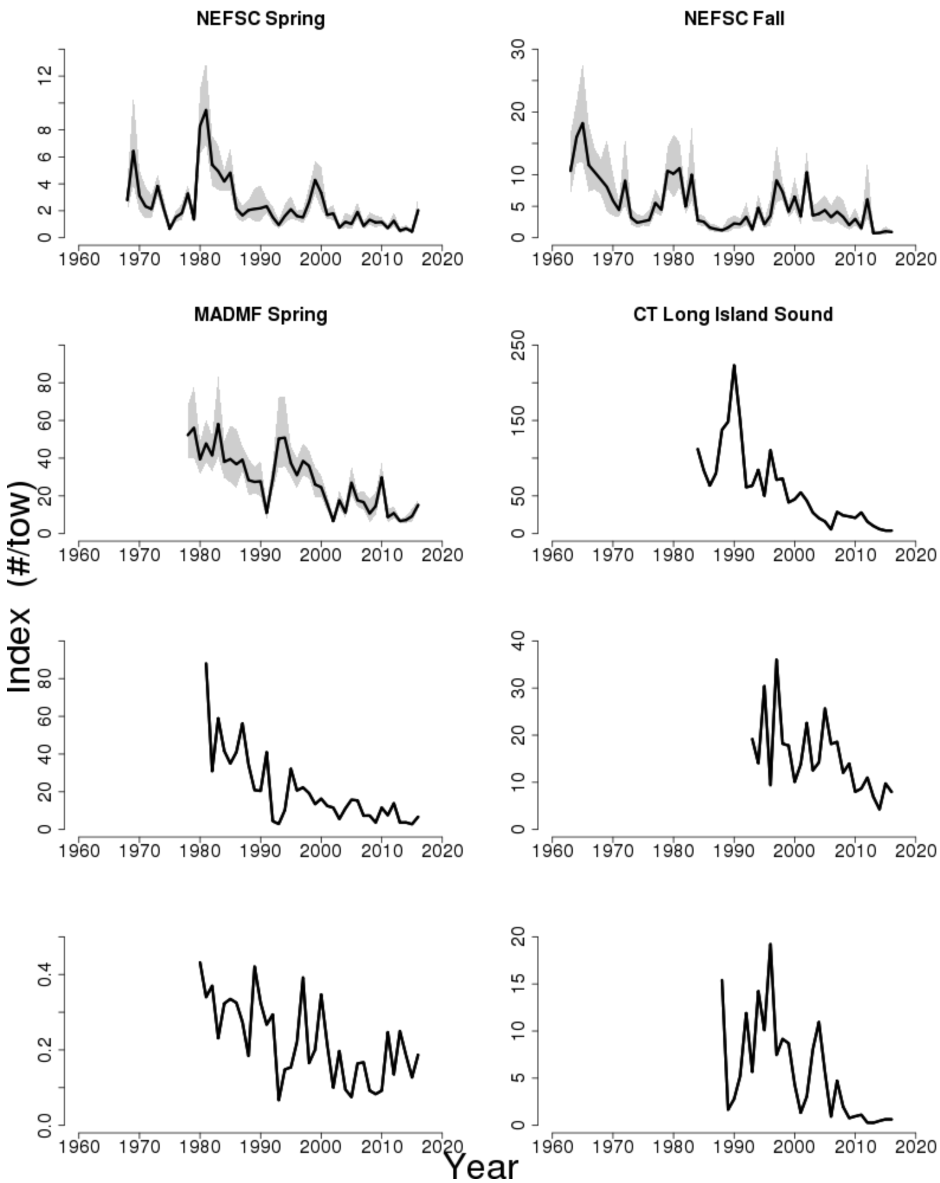

Figure 48: Indices of biomass for the Southern New England Mid-Atlantic winter flounder between 1963 and 2016 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, the MADMF spring survey, the CT LISTS survey, the RIDFW Spring Trawl survey, the NJ Ocean Trawl survey, and two YoY surveys from MADMF and CT LISTS. Where available, the approximate 90% lognormal confidence intervals are shown.

10 Gulf of Maine-Georges Bank American plaice

Mark Terceiro

This assessment of the Gulf of Maine-Georges Bank American plaice (Hippoglossoides platessoides) stock is an operational update of the existing 2012 benchmark assessment (O'Brien et al. 2012). Based on the previous assessment the stock was not overfished, and overfishing was not ocurring. This 2017 assessment updates commercial fishery catch data, research survey indices of abundance, the analytical VPA assessment model, and reference points through 2016. Additionally, stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, the Gulf of Maine-Georges Bank American plaice (*Hippoglossoides platessoides*) stock is not overfished and overfishing is not occurring (Figures 49-50). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 13,351 mt which is 99% of the biomass target for this stock (SSB_{MSY} *proxy* = 13,503; Figure 49). The 2016 fully selected fishing mortality was estimated to be 0.111 which is 51% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.216; Figure 50).

Table 32: Catch and model results for Gulf of Maine-Georges Bank American plaice. All weights are in (mt), recruitment is in (000s), and F_{Full} is the fishing mortality on fully selected ages (ages 6-9). Model results are unadjusted values from the current updated VPA assessment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
					Data					
GM Commercial landings	601	703	866	901	771	762	764	738	828	718
GM Commercial discards	82	113	115	239	96	161	88	36	42	60
GB Commercial landings	377	388	501	492	595	699	528	498	400	287
GB Commercial discards	164	144	274	152	102	123	64	53	44	40
SNE landings	12	9	13	11	3	1	5	3	2	3
CA landings	2	0	0	0	1	0	0	0	0	0
Catch for Assessment	1,238	1,357	1,770	1,795	1,569	1,747	1,449	1,328	1,316	1,108
					Model Results					
Spawning Stock Biomass	7,149	9,783	10,726	11,038	11,415	11,635	12,214	13,073	12,952	15,148
F_{Full}	0.146	0.198	0.248	0.176	0.152	0.173	0.133	0.091	0.098	0.075
Recruits (age 1)	13,509	29,350	15,837	9,813	13,530	10,127	12,548	30,813	7,889	9,201

Table 33: Comparison of reference points estimated in the previous assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on long-term stochastic projections.

	2015	2017
F_{MSY} *proxy*	0.196	0.216
SSB_{MSY} (mt)	13,107	13,503 (10,398 - 17,611)
MSY (mt)	2,675	2,924 (2,249 - 3,815)
Median recruits (age 1) (000s)	23,059	21,969
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of biomass were derived by sampling from an empirical cumulative distribution function of 36 recruitment estimates from VPA model results. The annual fishery selectivity, maturity ogive, and mean weights at age used in projections are the most recent 5 year averages; retrospective adjustments were applied in the projections.

Table 34: Short term projections of total fishery catch and spawning stock biomass for Gulf of Maine-Georges Bank American plaice based on a harvest scenario of fishing at F_{MSY} *proxy* between 2018 and 2020. Catch in 2017 was assumed to be 1,226 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	1,226	9,913 (8,717 - 11,155)	0.120

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	2,260	10,640 (9,112 - 12,364)	0.216
2019	2,010	9,641 (8,216 - 11,269)	0.216
2020	1,794	8,421 (7,144 - 9,970)	0.216

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).

  A source of uncertainty in this assessment are the estimates of historical landings at age, prior to 1984, and the magnitude of historical discards, prior to 1989. Both of these affect the scale of the biomass and fishing mortality estimates, and influence reference point estimations.

- 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}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.32 in the 2015 assessment and was 0.35 in

2016. The 7-year Mohn's ρ, relative to F, was -0.32 in the 2015 assessment and was -0.33 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=13,351) and 2016 F (F_ρ=0.111) were outside the approximate 90% confidence regions around SSB (13,582 - 17,009) and F (0.065 - 0.088). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 15,148 to 13,351 and the 2016 F_{Full} from 0.075 to 0.111.

- 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-Georges Bank American plaice are reasonably well determined.

- 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.
  No major changes, other than the addition of recent years of data, were made to the Gulf of Maine-Georges Bank American plaice assessment for this update. A new version of VPA was used (V3.4.5) which gave nearly identical results to the 2015 VPA V3.3.0 run.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  As in recent assessments for Gulf of Maine-Georges Bank American plaice the stock status remains as not overfished and overfishing not occurring.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The current fishing mortality rate is relatively low, and so recent above average recruitment has resulted in an increase in SSB. SSB is projected to decrease in the short term, however, even at current fishing rates.

- 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-Georges Bank American plaice assessment could be improved with updated studies on growth of Georges Bank and Gulf of Maine fish.

- Are there other important issues?
  A difference in growth between GM and GB fish has been documented, however, historical catch data information for GB may not be sufficient to conduct a separate assessment. Also, the growth difference may not persist in the most recent years. This could all be explored further in an benchmark review.

10.1 Reviewer Comments: Gulf of Maine-Georges Bank American plaice

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this updated assessment, the panel supports the conclusion that the Gulf of Maine-Georges Bank American plaice stock is not overfished and overfishing is not occurring. In addition to the current fishing mortality being relatively low, a spike in recruitment in one year (2013) has contributed to an increase in spawning stock biomass. This stock is currently in a rebuilding plan with a deadline of 2024, and was very close to target biomass in 2016. However, spawning stock biomass is projected to decrease in the short term, even at current fishing rates.

Key Sources of Uncertainty:

A source of uncertainty in this assessment is the estimates of historical landings at age, prior to 1984, and the magnitude of historical discards, prior to 1989 as well as the historical age composition of the surveys. The retrospective pattern remains a sources of uncertainty. Also, there is evidence of growth differences between Georges Bank and Gulf of Maine fish. Finally, the inconsistent recent trends between the National Marine Fisheries Service surveys and Massachusetts Department of Marine Fisheries survey constitutes uncertainty in the assessment. Catchability is a source of uncertainty. Catchability estimates derived from the cooperative research study are substantially different from those estimated in this assessment.

Research Needs:

The Gulf of Maine-Georges Bank American plaice assessment could be improved with updated studies on growth of Georges Bank and Gulf of Maine fish. A difference in growth rates between Gulf of Maine and Georges Bank fish has been documented; however, historical catch data for Georges Bank may not be sufficient to conduct a separate assessment. The panel recommends continuation of research on growth rates and implications for stock structure. The growth rate difference actually may not persist in the most recent years so this could all be explored further in a benchmark review. Finally, the panel recommends further research and consideration of survey catchability estimates.

References:

O'Brien, L. and J. Dayton (2012). E. Gulf of Maine - Georges Bank American plaice Assessment for 2012 in Northeast Fisheries Science Center, 2012, Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-06; 789 p. http://www.nefsc.noaa.gov/publications/crd/crd1206/.

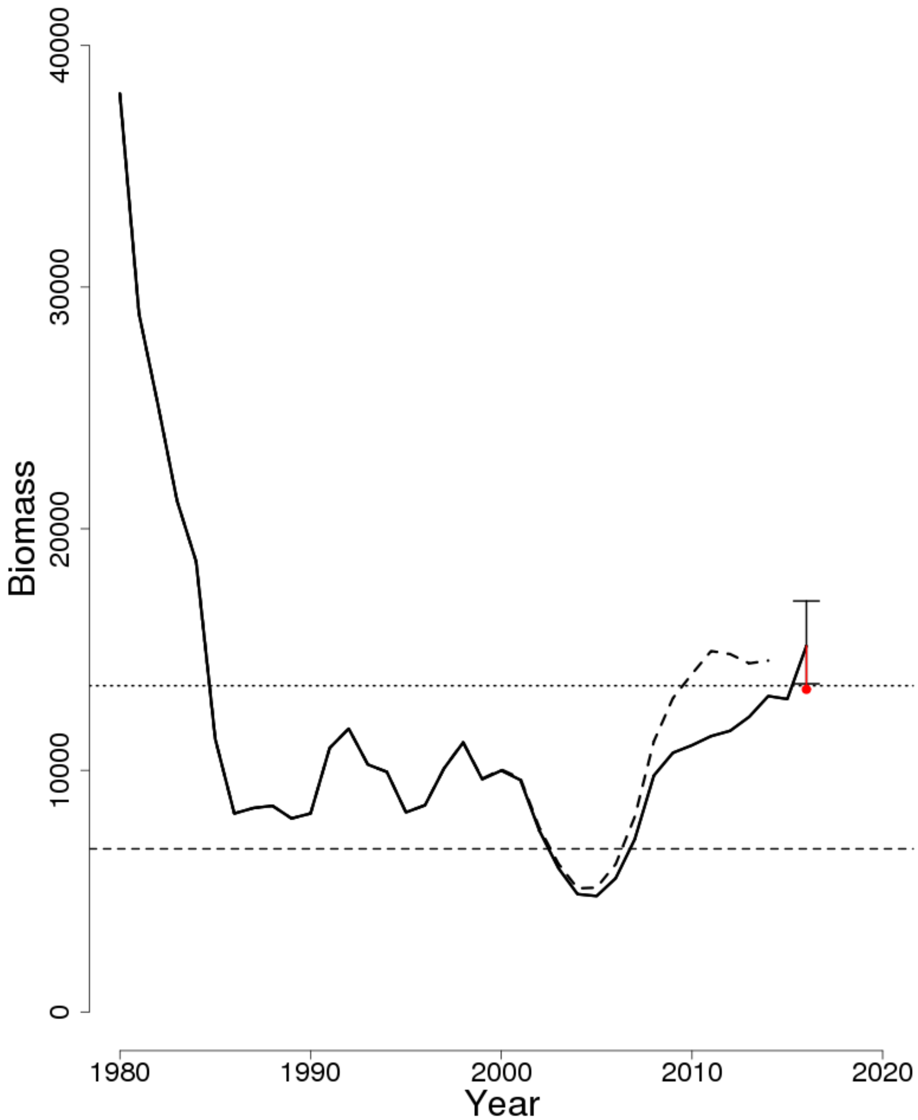

Figure 49: Trends in spawning stock biomass of Gulf of Maine-Georges Bank American plaice between 1980 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% normal confidence intervals are shown.

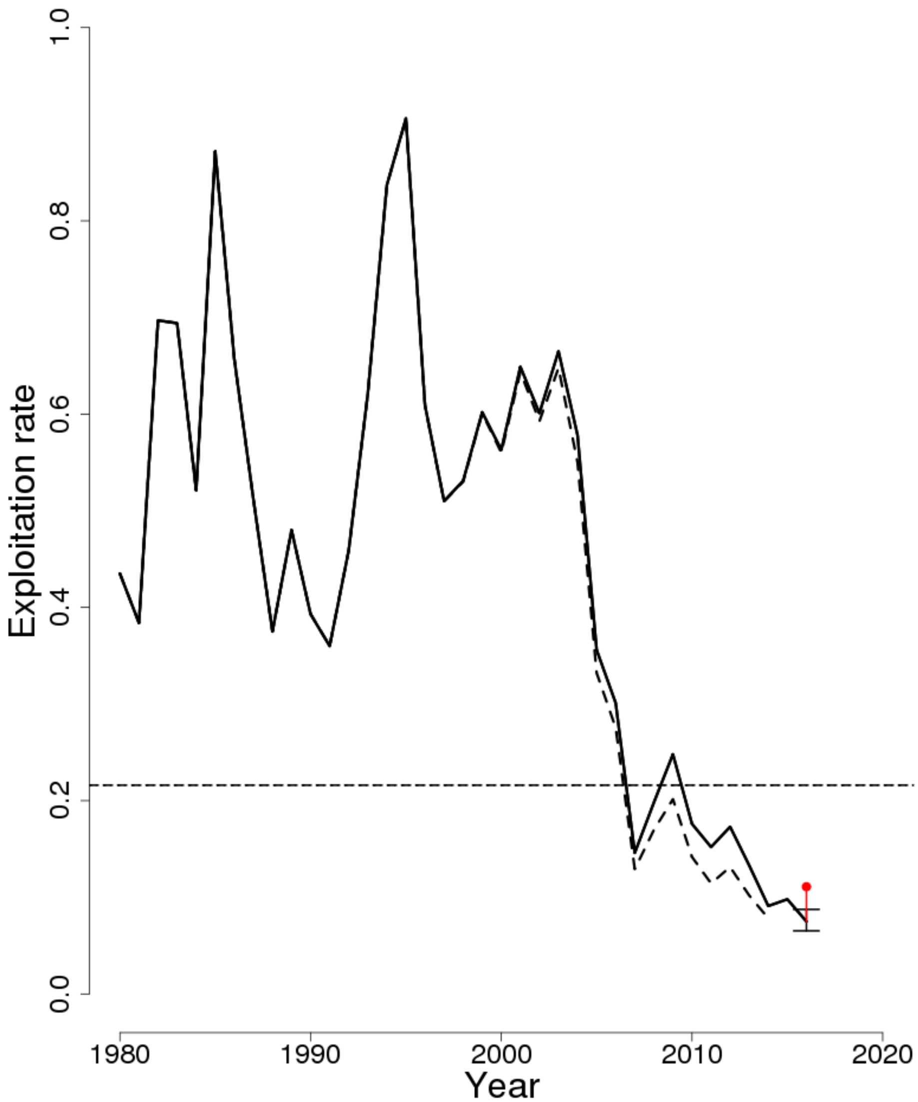

Figure 50: Trends in the fully selected fishing mortality (F_{Full}) of Gulf of Maine-Georges Bank American plaice between 1980 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.216; horizontal dashed line). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red, based on the 2017 assessment. The approximate 90% normal confidence intervals are shown.

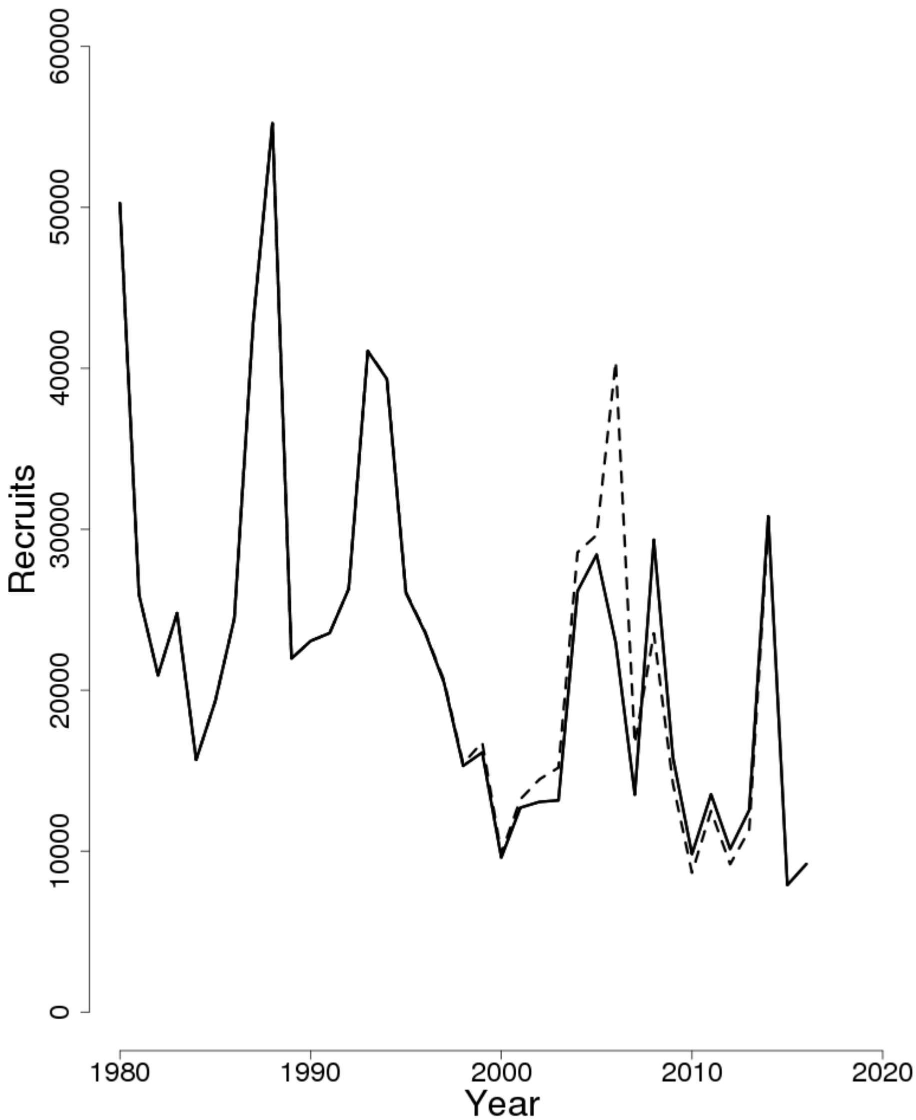

Figure 51: Trends in Recruits (age 1) (000s) of Gulf of Maine-Georges Bank American plaice between 1980 and 2016 from the current (solid line) and previous (dashed line) assessment.

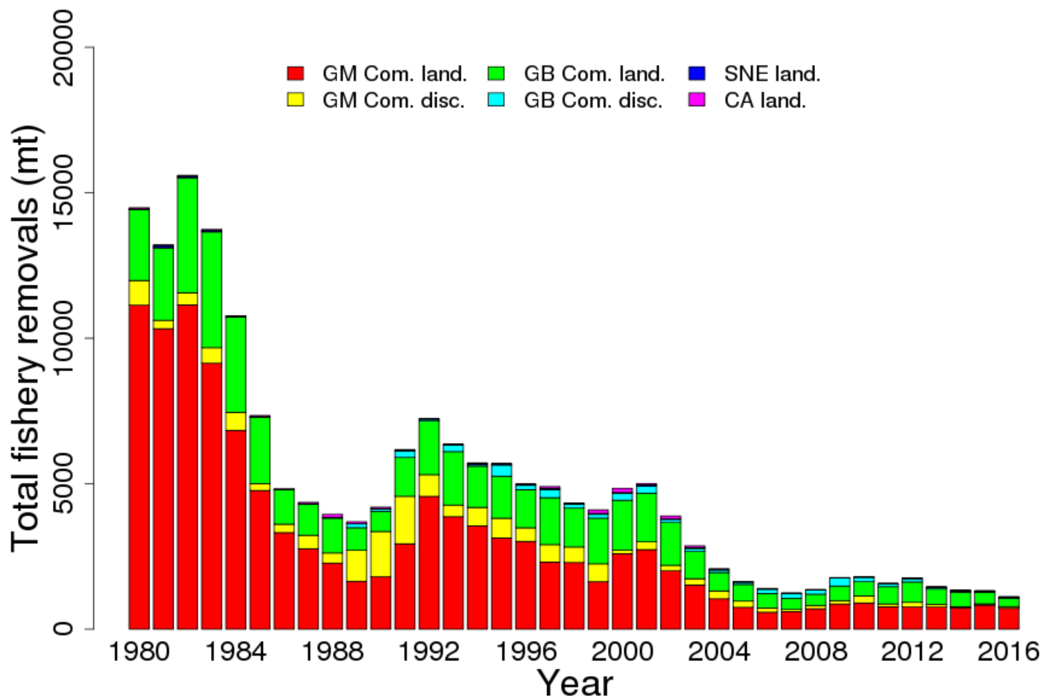

Figure 52: Total catch of Gulf of Maine-Georges Bank American plaice between 1980 and 2016 by fleet (Gulf of Maine, Georges Bank, Southern New England, and Canadian) and disposition (landings and discards).

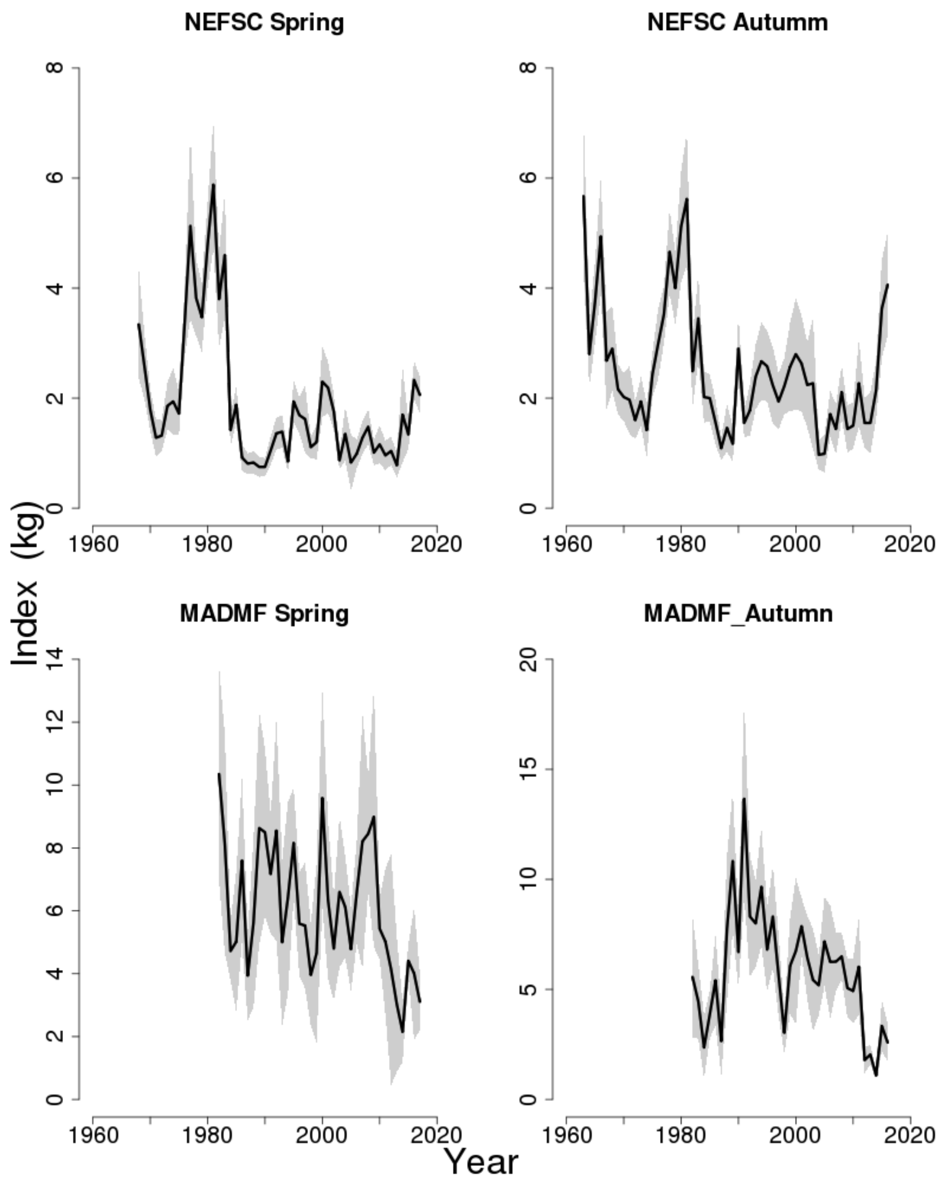

Figure 53: Indices of biomass for the Gulf of Maine-Georges Bank American plaice between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (MADMF) spring and autumn research bottom trawl surveys. The approximate 90% normal confidence intervals are shown.

11 Witch flounder

Susan Wigley

This assessment of the witch flounder (Glyptocephalus cynoglossus) stock is an operational assessment of the existing 2016 benchmark assessment (NEFSC 2017). Based on the 2016 assessment the stock status was overfished and overfishing unknown, and stock condition was poor. This assessment updates commercial fishery catch data through 2016 (Table 35, Figure 56), and updates research survey biomass indices and the empirical approach assessment through 2016 (Figure 57). No stock projections can be computed using the empirical approach.

State of Stock: Based on this updated assessment, witch flounder (*Glyptocephalus cynoglossus*) recommended stock status is overfished and overfishing is unknown due to a lack of biological reference points associated with the empirical approach; stock condition remains poor. Retrospective adjustments were not made to the model results. The exploitable biomass in 2016 (defined as the arithmetic average of the 2016 NEFSC spring and 2015 NEFSC fall surveys population biomass estimates and converted to exploitable biomass using 0.9 based on examination of survey and fishery selectivity patterns) was estimated to be 14,563 (mt) (Figure 54). The 2016 exploitation rate (2016 catch divided by 2016 exploitable biomass) was estimated to be 0.035 (Figure 55).

Table 35: Catch and model results table for witch flounder. All weights are in (mt). The exploitable biomass in year y is the arithmetic average of the year y NEFSC spring and year y-1 NEFSC fall surveys then converted to exploitable biomass using 0.9. The exploitation rate is the year y catch divided by the year y exploitable biomass. Model results are from the current updated empirical approach assessment.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
					Data						
Commercial Landings	1,863	1,076	1,009	954	759	870	1,038	686	570	492	397
Commercial Discards	211	135	127	203	153	201	230	124	106	93	115
Catch for Assessment	2,075	1,210	1,136	1,158	912	1,071	1,268	810	675	585	512
					Model Results						
Exploitable Biomass	18,082	16,728	31,661	18,756	16,380	14,834	16,817	10,617	13,486	15,862	14,563
Exploitation Rate	0.115	0.072	0.036	0.062	0.056	0.072	0.075	0.076	0.05	0.037	0.035

Table 36: Comparison of reference points estimated in an earlier assessment and from the current assessment update.

	2016	2017
F_{MSY} *proxy*	NA	NA
SSB_{MSY} (mt)	NA	NA
MSY (mt)	NA	NA
Overfishing	Unknown	Unknown
Overfished	Yes	Yes

Projections: Short term projections cannot be computed using the empirical approach. The estimated 2017 exploitable biomass is 19,202 mt. Using the January 2017 NEFMC PDT/SSC approach for catch advice, application of the mean exploitation rate of 6.0% (based on nine years, 2007-2015) to the 3 year (2015- 2017) moving average of exploitable biomass (16,543 mt) results in an estimated catch for 2018 of 993 mt.

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).
  Uncertainty in the catch has increased due to recent reports/allegations of catch misreporting currently under litigation.

- 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}; see Table 8).
  The model used to estimate status of this stock does not allow estimation of a 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 witch flounder are not computed. Catch advice is derived from applying a mean exploitation rate of 0.060 (based on nine years, 2007-2015) to the 3 year average (2015-2017) of the exploitable biomass.

- 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.
  Recent landings and discards were updated and the time series of survey indices was updated; however, this has no impact on the stock status.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  No change in stock status has occurred for witch flounder since the previous assessment. Biological references points remain unknown.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The witch flounder stock condition remains poor. Fishery landings and survey catch by age indicate truncation of age structure and a reduction in the number of older fish in the population. NEFSC relative indices of abundance and biomass remain below their time series average.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The witch flounder assessment could be improved with accurate catch statistics. Additional research recommendations are given in NEFSC 2017.

- Are there other important issues?

  Minimum estimates of scientific research removals of witch flounder ranged between 0.1 and 15.9 mt, with an average of 1 mt between 1963 and 2016. The NEFSC bottom trawl surveys, Massachusetts Division of Marine Fisheries inshore surveys, Atlantic States Marine Fisheries Commission summer shrimp surveys, and various Cooperative Research surveys (e.g., such as Industry-based surveys for cod and for yellowtail flounder) and gear studies have contributed to scientific research removals. The August 2016 Gear Efficiency Study removed 14.0 mt of witch flounder.

11.1 Reviewer Comments: Witch flounder

Assessment Recommendation:

The panel concluded that the operational assessment with the August 2016 cooperative research catchability estimates was acceptable as a scientific basis for management advice. At the previous 2016 benchmark assessment, where the analytical model was rejected, an empirical approach was adopted as a basis for management advice. The panel affirmed the approach to developing a catch recommendation as described in the assessment report was adequate.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the witch flounder stock status remains overfished with overfishing unknown due to a lack of biological reference points associated with the empirical approach. The witch flounder stock condition remains poor. Fishery landings and survey catch by age indicate truncation of age structure and a reduction in the number of older fish in the population. Catch is at a time-series low and relative indices of abundance and biomass from the National Marine Fisheries Service survey remain below their time series average.

Key Sources of Uncertainty:

Uncertainty in the catch has increased due to recent reports/allegations of catch misreporting currently under litigation, which creates additional uncertainty surrounding the exploitation rate estimate. Additional uncertainties with the empirical approach applied to witch flounder include the survey indices, catchability estimates, catch efficiency, and the consequent swept-area-biomass expansion methods.

Research Needs:

The witch flounder assessment could be improved with research into the veracity of catch statistics. Additional research recommendations were provided in the recent benchmark stock assessment report and these should be addressed in an attempt to return to an analytical model. Work was conducted by the Plan Development Team, following the 2016 benchmark assessment on the relationships between the survey indices, catchability estimates, and resulting swept-area-biomass estimates. Further work exploring the validity of the swept-area-biomass estimates, catch efficiency, and the approach to developing catch advice is warranted.

References:

Northeast Fisheries Science Center. 2017. 62^{nd} Northeast Regional Stock Assessment Workshop Assessment Report, Northeast Fisheries Science Center, Woods Hole, Massachusetts, January 2017. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 17-03; 822 p. CRD17-03

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated through 2014. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. CRD15-24

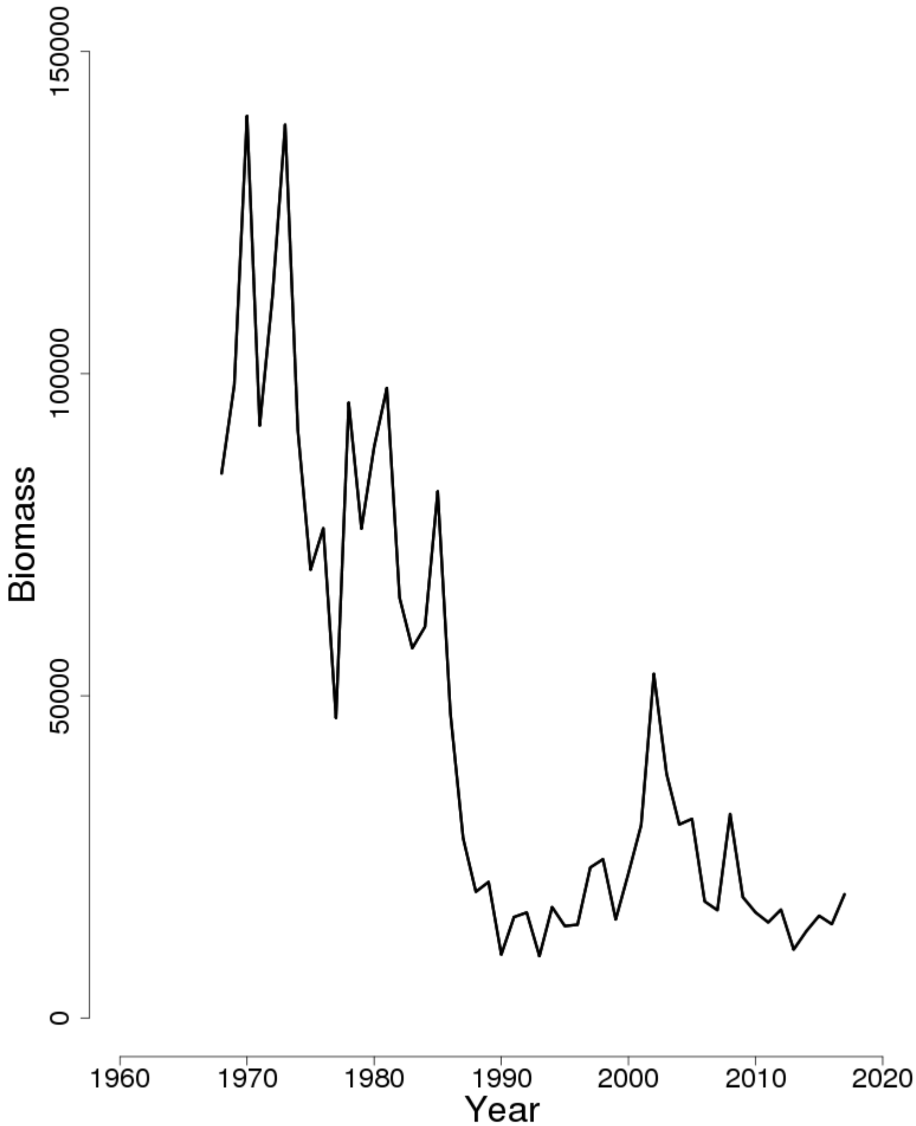

Figure 54: Trends in exploitable biomass (mt) of witch flounder between 1968 and 2017 from the current assessment.

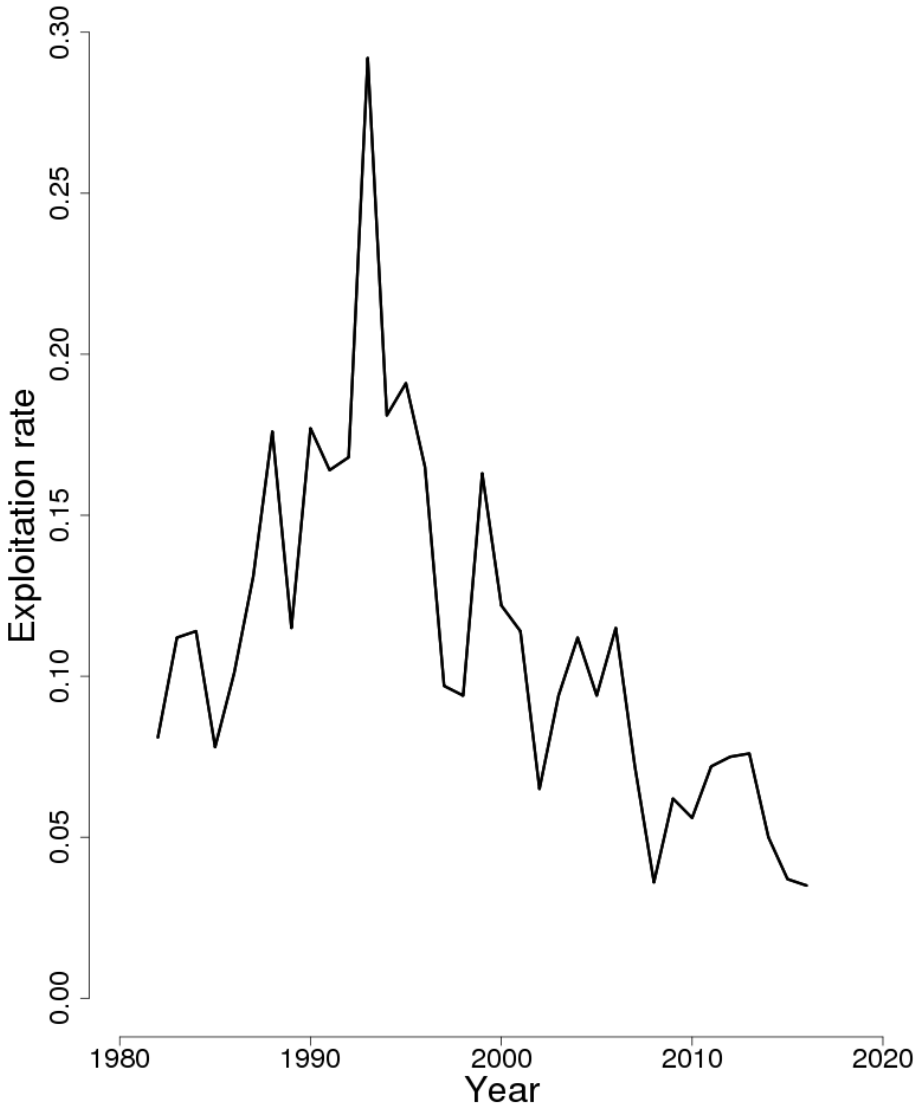

Figure 55: Trends in the exploitation rate (catch/ exploitable biomass) of witch flounder between 1982 and 2016 from the current assessment.

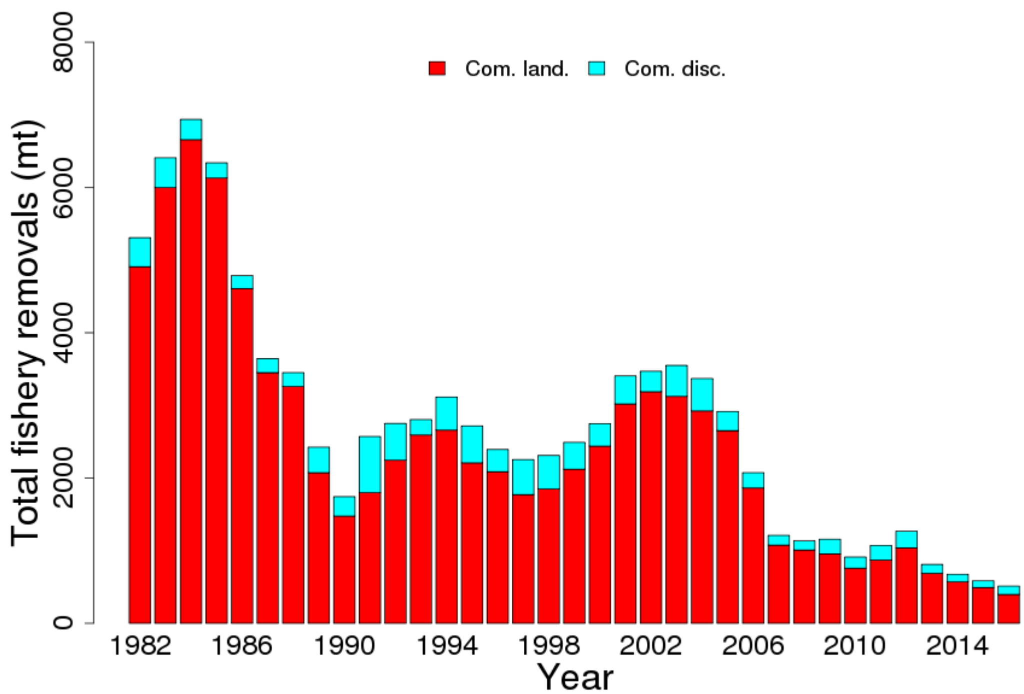

Figure 56: Total catch of witch flounder between 1982 and 2016 by fleet (commercial) and disposition (landings or discards).

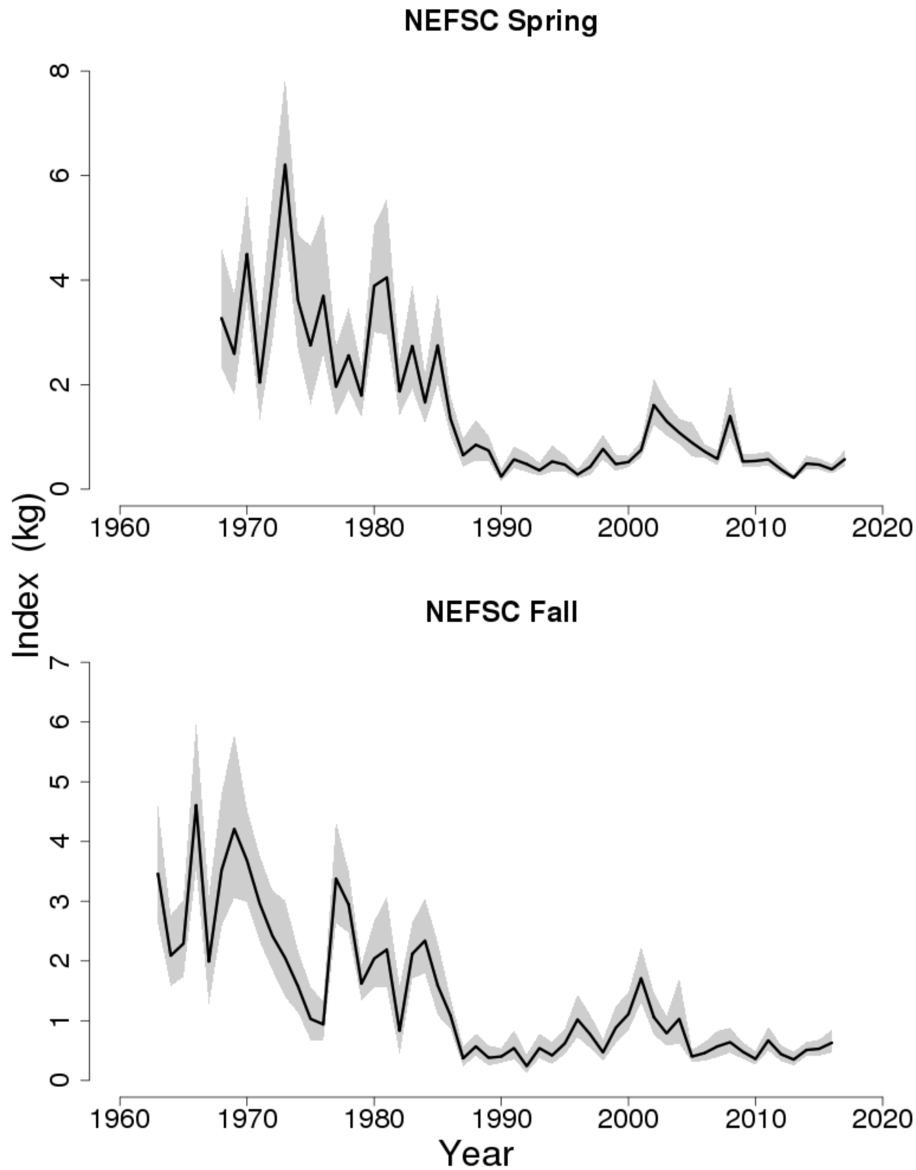

Figure 57: Indices of biomass for the witch flounder between 1963 (Fall) and 2017 (Spring) for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

12 Acadian redfish

Brian Linton

This assessment of the Acadian redfish (Sebastes fasciatus) stock is an operational assessment of the existing 2015 operational assessment (NEFSC 2015). This assessment updates commercial fishery catch data, research survey indices of abundance, the ASAP analytical model, and biological reference points through 2016. Additionally, stock projections have been updated through 2020. The most recent benchmark assessment of the Acadian redfish stock was in 2008 as part of the 3rd Groundfish Assessment Review Meeting (GARM III; NEFSC 2008), which includes a full description of the model formulations.

State of Stock: Based on this updated assessment, the Acadian redfish (*Sebastes fasciatus*) stock is not overfished and overfishing is not occurring (Figures 58-59). Retrospective adjustments were made to the model results. Retrospective adjusted spawning stock biomass (SSB) in 2016 was estimated to be 359,970 (mt) which is 145% of the biomass target (SSB_{MSY} *proxy* of SSB at $F_{50\%}$ = 247,918; Figure 58). The retrospective adjusted 2016 fully selected fishing mortality (F) was estimated to be 0.011 which is 29% of the overfishing threshold (F_{MSY} *proxy* of $F_{50\%}$ = 0.038; Figure 59).

Table 37: Catch and status table for Acadian redfish. All weights are in (mt), and F_{Full} is the fishing mortality on fully selected ages. Unadjusted SSB and F estimates are reported. Model results are from the current updated ASAP assessment.

	2009	2010	2011	2012	2013	2014	2015	2016
Data								
Commercial landings	1,461	1,644	2,015	3,848	3,544	4,574	4,930	3,889
Commercial discards	202	206	212	341	422	509	110	36
Catch for Assessment	1,663	1,850	2,227	4,189	3,966	5,083	5,040	3,925
Model Results								
Spawning Stock Biomass	233,719	255,536	280,625	308,901	339,804	372,523	404,690	435,852
F_{Full}	0.007	0.007	0.008	0.015	0.012	0.014	0.013	0.009
Recruits (age 1)	184,196	40,650	45,719	49,695	56,379	145,953	94,951	79,711

Table 38: Comparison of biological reference points for Acadian redfish estimated in the 2015 assessment and from the current assessment update. An F_{MSY} *proxy* of $F_{50\%}$ was used for the overfishing threshold, and was based on yield per recruit analysis. Recruits represent the median of the predicted recruits from 1969 to the final assessment year. Intervals shown are 5^{th} and 95^{th} percentiles.

	2015	2017
F_{MSY} *proxy*	0.038	0.038
SSB_{MSY} (mt)	281,112	247,918 (173,856 - 347,655)
MSY (mt)	10,466	9,318 (6,489 - 13,160)
Median recruits (age 1) (000s)	31,391	31,266
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of median total fishery yield and spawning stock biomass for Acadian redfish were conducted based on a harvest scenario of fishing at the F_{MSY} *proxy* between 2018 and 2020. Catch in 2017 has been estimated at 4,630 (mt). Recruitments were sampled from a cumulative distribution function derived from ASAP estimated age 1 recruitment between 1969 and 2014. The annual fishery selectivity, natural mortality, maturity ogive, and mean weights used in projections are the same as those used in the assessment model. Retrospective adjusted SSB and fully selected F in 2016 fell outside the 90% confidence intervals of the unadjusted 2016 values. Therefore, age-specific abundance rho values were applied to the initial numbers at age in the projections.

Table 39: Retrospective adjusted short term projections of median total fishery yield and spawning stock biomass for Acadian redfish based on a harvest scenario of fishing at an F_{MSY} *proxy* of $F_{50\%}$ between 2018 and 2020. Catch in 2017 has been estimated at 4,630 (mt). F_{Full} is the fully selected F.

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	4,630	382,980	0.012

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	15,451	400,038	0.038
2019	15,614	406,382	0.038
2020	15,677	410,365	0.038

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 largest source of uncertainty in the Acadian redfish assessment is the lack of age data, particularly from the commercial fishery. Age measurements from landings were not collected after 1985 due to relatively low landings. Current landings have increased to levels *seen in the mid-1980s. If landings continue to increase, then age data from the fishery will become increasingly important. Dimorphic growth is another source of uncertainty in this assessment, with females growing faster than males. The use of female weights at age in the stock projections may lead to overestimation of stock productivity, as well as having an unknown effect on biological reference points.*

- 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}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.256 in the 2015 assessment and was 0.211 in 2016. The 7-year Mohn's ρ, relative to F, was -0.190 in the 2015 assessment and was -0.152 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimates of 2016 SSB (SSB_ρ=359,970) and 2016 F (F_ρ=0.011) were outside the approximate 90% confidence region around SSB (394,927 - 481,018) and F (0.008 - 0.01). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 435,852 to 359,970 and the 2016 F_{Full} from 0.009 to 0.011.

- 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 Acadian redfish appear to be reasonably well determined. The stock is not in a rebuilding plan.

- 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.

  Only one major change was made to the Acadian redfish assessment as part of this update. A multinomial logistic model was used to estimate proportions at age for length bins where no age samples were available (Gerritsen et al. 2006) in survey-age length keys. Survey age-length key holes were filled manually based on the expert judgment of the assessment analyst in previous assessments. There was little difference in the survey indices at age produced by the multinomial filling method compared to the indices at age produced by the manual filling method. The multinomial filling method is part of an effort by Northeast Fisheries Science Center (NEFSC) staff to standardize construction of survey indices.

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

  There has been no change in the stock status of Acadian redfish since the previous assessment.

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

  Total removals of Acadian redfish generally have increased since the early 2000s. The spring survey index has varied without trend since the late 1990s, while the fall survey index in 2013 through 2016 has been at a lower level than in previous years. Fall survey data suggests the exisitence of relatively strong year classes in 2008 and 2009. Fall survey data suggests that older fish have begun to reappear in the stock since the 1990s.

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

The Acadian redfish assessment could be improved by 1) including additional age data, particularly from the commercial fishery, and 2) investigating the sensitivity of biological reference points and stock projections to the mean weights at age.

- Are there other important issues?

  NEFSC fall bottom trawl index values for 2013 through 2016 are lower than in previous years (Figure 62), but the current assessment model continues to predict an increase in SSB for the last four years (Figure 58). If future index values remain low (i.e., if the index is responding to a change in abundance, rather than interannual variability), then the predicted trend in SSB may change abruptly in a future assessment. Such an abrupt change may lead to an increase in the retrospective pattern.

12.1 Reviewer Comments: Acadian redfish

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel agrees with the conclusion that the Acadian redfish stock is not overfished and overfishing is not occurring. Total removals of Acadian redfish generally have increased since the early 2000s. Fall survey data show relatively strong year classes in 2007 and 2008. Fall survey data also show that older fish have begun to reappear in the stock since the 1990s.

Key Sources of Uncertainty:

The largest source of uncertainty in the Acadian redfish assessment is the lack of age data, particularly from the commercial fishery. Dimorphic growth is another source of uncertainty in this assessment, with females growing faster than males. The use of female weights at age in the stock projections may lead to overestimation of stock productivity, as well as having an unknown effect on biological reference points. Some of the spikes observed in the survey should be interpreted cautiously because there is a possibility of immigration/emigration into and out of the survey area. Overall, these assessment results are highly precise, yet there are notable data gaps, so this precision should also be interpreted cautiously.

Research Needs:

The Acadian redfish assessment could be improved by including additional age data, particularly from the commercial fishery, and by investigating the sensitivity of biological reference points and stock projections to the mean weights at age. Future assessments should explore whether it is better to estimate the stock-recruit relationship inside the model or externally. Also, the panel recommends an evaluation of the survey trends, including potential factors that may cause the trends to not reflect patterns in relative abundance and the validity of the fall survey trend. Finally, the precision of the results appears to be high, and the panel suggests exploring data weighting scenarios to better reflect the completeness and reliability of available data.

References:

Gerritsen, H.D., D. McGrath, and C. Lordan. 2006. A simple method for comparing age-length keys reveals significant regional differences within a single stock of haddock (*Melanogrammus aeglefinus*). ICES J Mar Sci 63: 1096-1100.

Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD08-15

Northeast Fisheries Science Center. 2015. 2014 Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-24

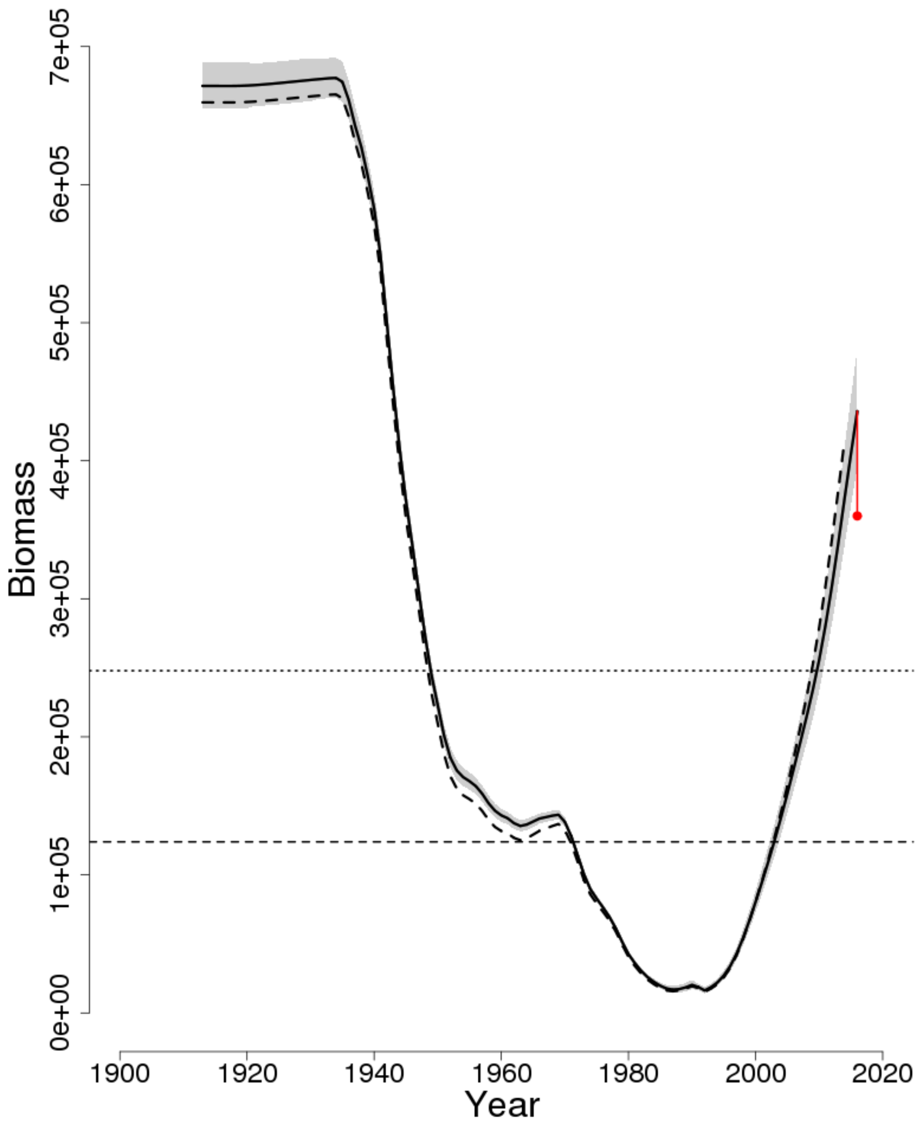

Figure 58: Trends in spawning stock biomass of Acadian redfish between 1913 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ (0.5 * SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

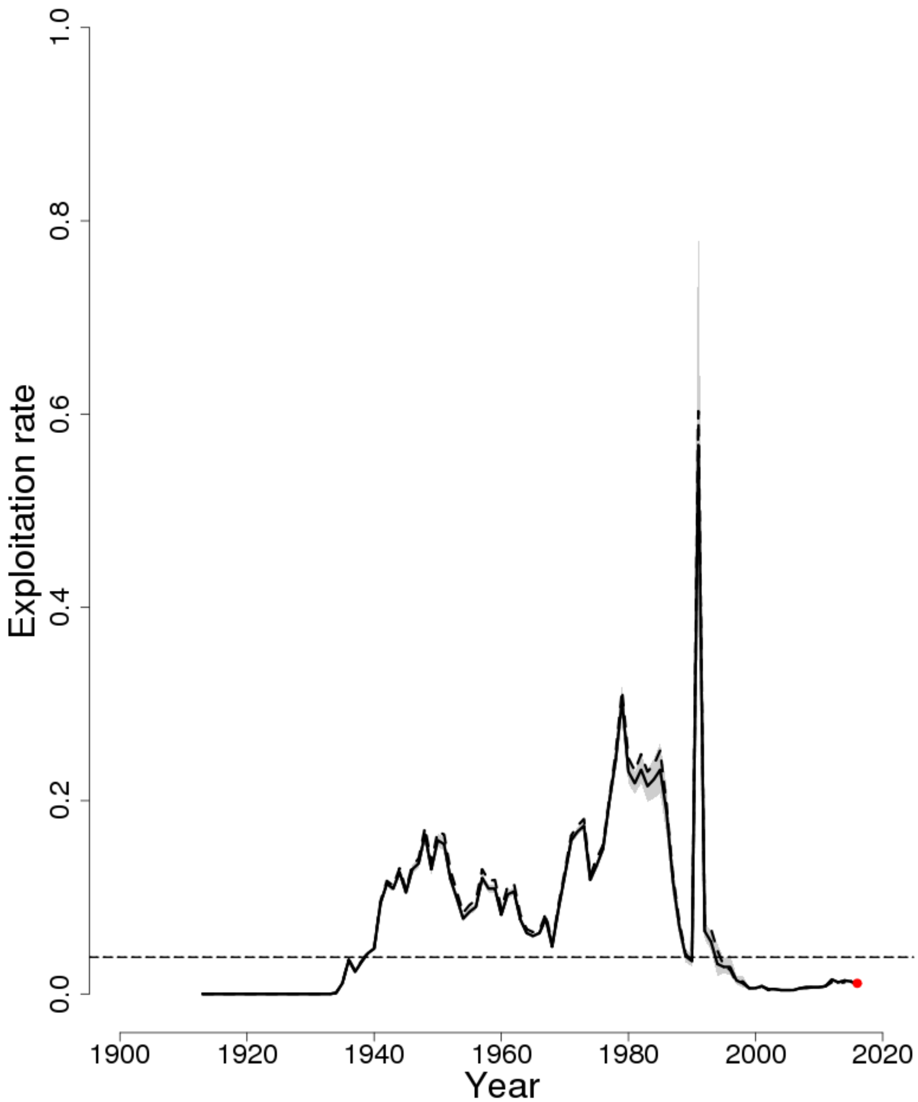

Figure 59: Trends in the fully selected fishing mortality (F_{Full}) of Acadian redfish between 1913 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.038; horizontal dashed line) based on the 2017 assessment. F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

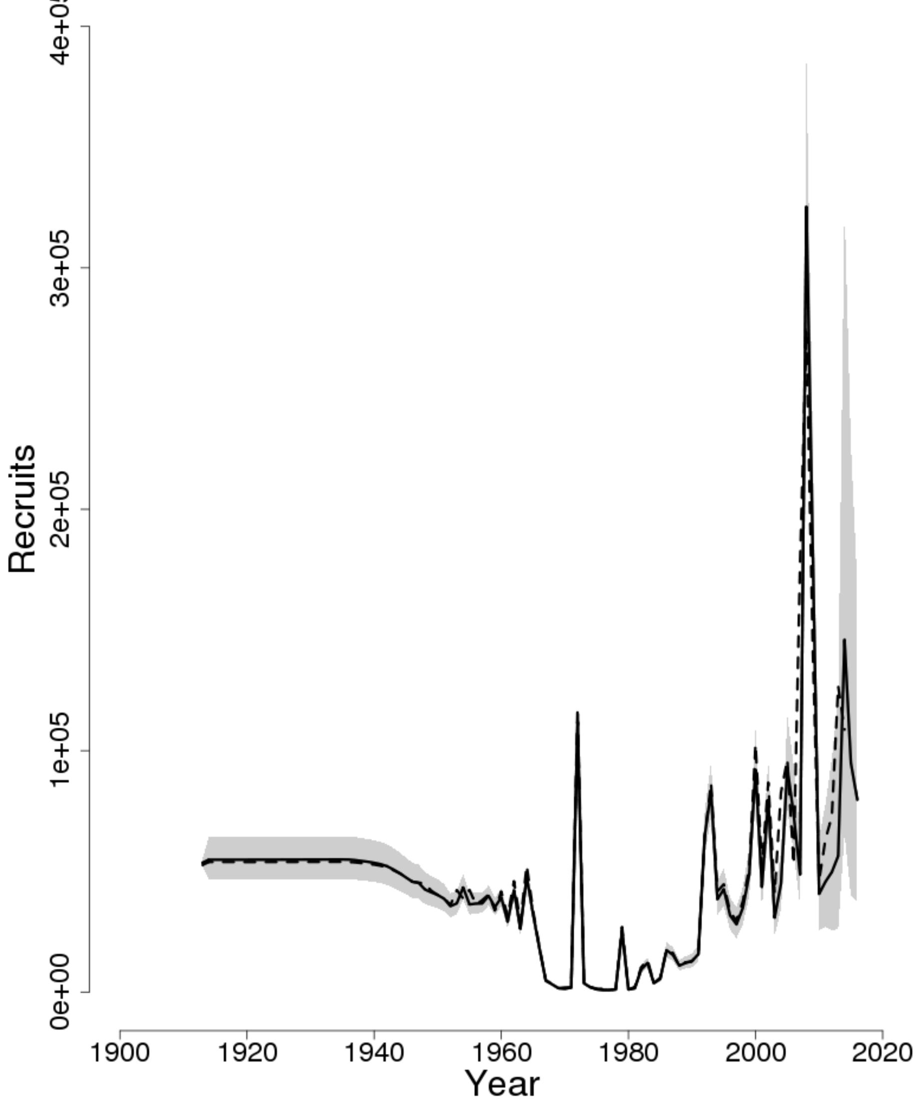

Figure 60: Trends in Recruits (age 1) (000s) of Acadian redfish between 1913 and 2016 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

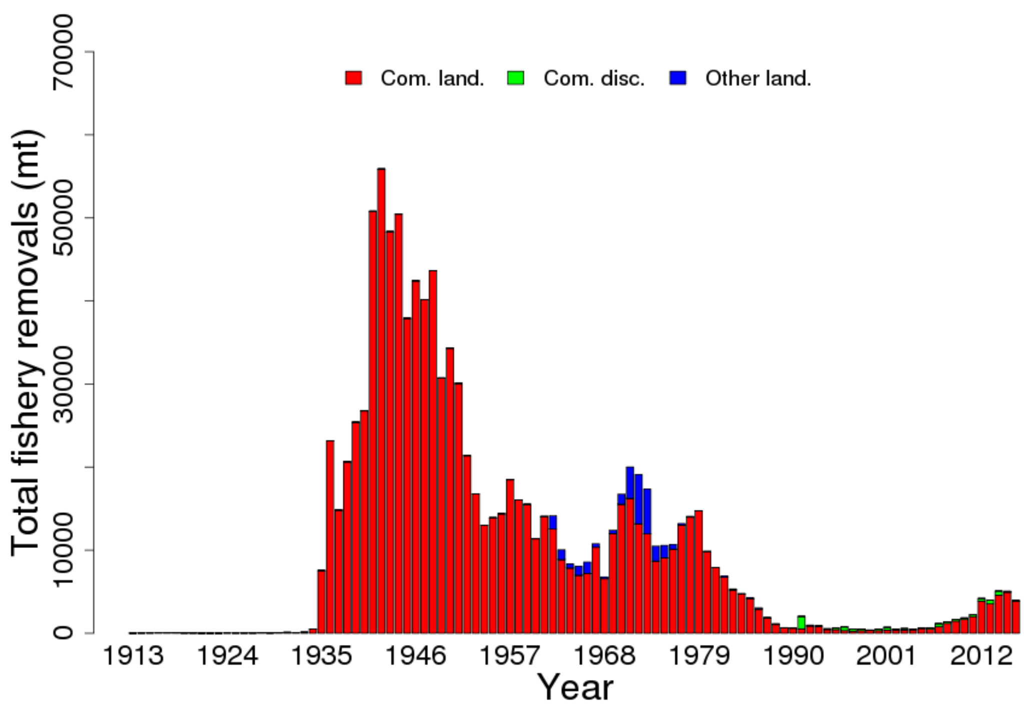

Figure 61: Total catch of Acadian redfish between 1913 and 2016 by fleet (commercial and other) and disposition (landings and discards).

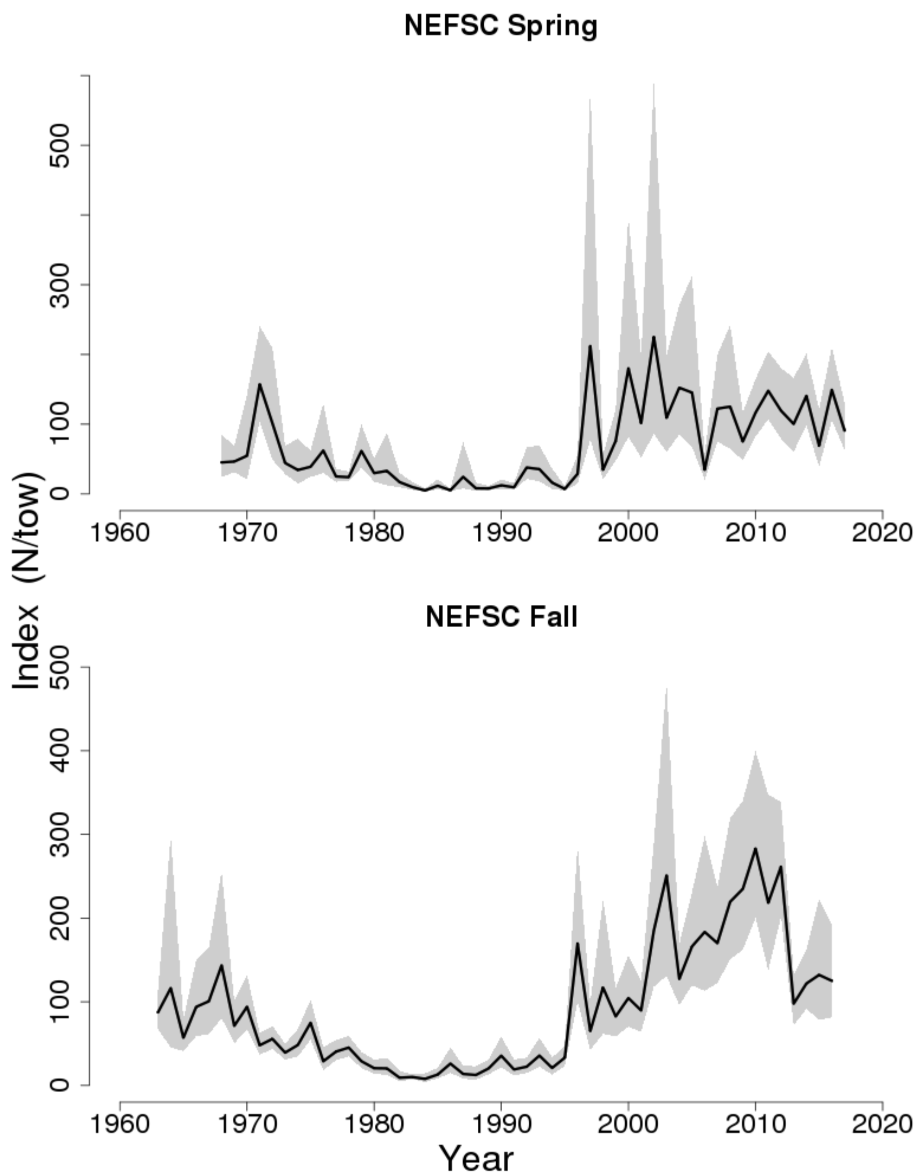

Figure 62: Indices of abundance for Acadian redfish from the Northeast Fisheries Science Center (NEFSC) spring (1963 to 2017) and fall (1963 to 2016) bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

13 White hake

Katherine Sosebee

This assessment of the white hake (Urophycis tenuis) stock is an operational update of the 2015 operational assessment (NEFSC 2015) and the last benchmark assessment (NEFSC 2013). Based on the previous assessment the stock was not overfished and overfishing was not ocurring. This assessment updates commercial fishery catch data, research survey indices of biomass, and the ASAP assessment model and reference points through 2016. Stock projections have been updated through 2020.

State of Stock: Based on this updated assessment, the white hake (*Urophycis tenuis*) stock is not overfished and overfishing is not occurring (Figures 63-64). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 21,276 (mt) which is 69% of the biomass target (SSB_{MSY} *proxy* = 30,948; Figure 63). The 2016 fully selected fishing mortality was estimated to be 0.066 which is 36% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.1839; Figure 64).

Table 40: Catch and ASAP results table for white hake. All weights are in (mt) recruitment is in (000s) and F_{Full} is the fishing mortality on fully selected ages (ages 6 - 9+). Model results are from the current ASAP assessment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
					Data					
Commercial discards	36	171	83	91	54	34	28	33	24	32
Commercial landings	1,530	1,340	1,712	1,820	2,899	2,771	2,235	1,887	1,632	1,325
Canadian landings	56	39	79	104	86	83	43	35	25	39
Other landings	0	0	0	0	0	0	0	0	0	0
Catch for Assessment	1,621	1,543	1,859	2,002	3,039	2,887	2,306	1,980	1,680	1,396
					Model Results					
Spawning Stock Biomass	12,351	13,678	13,801	17,836	21,517	22,534	23,221	22,652	21,600	25,638
F_{Full}	0.148	0.133	0.16	0.127	0.163	0.152	0.115	0.099	0.085	0.058
Recruits (age 1)	3,335	3,822	3,858	3,359	3,072	2,746	2,820	2,896	5,497	4,925

Table 41: Comparison of reference points estimated in the 2015 assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on long-term stochastic projections which sampled from a cumulative distribution function of recruitment estimates from ASAP from 1963-2014. The annual fishery selectivity, maturity ogive, and mean weights at age used in the projection are the most recent 5 year averages.

	2015	2017
F_{MSY} *proxy*	0.188	0.1839
SSB_{MSY} (mt)	32,550	30,948 (24,833 - 39,004)
MSY (mt)	5,422	4,867 (3,907 - 6,133)
Median recruits (age 1) (000s)	4,608	4,616
Overfishing	No	No
Overfished	No	No

Projections: Short term projections of catch and SSB were derived by sampling from a cumulative distribution function of recruitment estimates from ASAP from 1995-2014. The annual fishery selectivity, maturity ogive, and mean weights at age used in the projection are the most recent 5 year averages. The numbers-at-age used to start the projections were adjusted for retrospective bias using age-specific rho estimates.

Table 42: Short term projections of total fishery catch and spawning stock biomass for white hake based on a harvest scenario of fishing at F_{MSY} *proxy* between 2018 and 2020. Catch in 2017 was assumed to be 1,634 (mt) which is 34% of the 2017 OFL.

Year	Catch (mt)	SSB (mt)	F_{Full}
2017	1,634	23,553 (19,971 - 27,472)	0.077

Year	Catch (mt)	SSB (mt)	F_{Full}
2018	3,885	24,720 (21,017 - 28,888)	0.1839
2019	3,753	23,936 (20,521 - 27,863)	0.1839
2020	3,645	22,963 (19,929 - 26,483)	0.1839

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).

  1. Catch at age information is not well characterized due to possible mis-identification of species in the commercial and observer data, particularly in early years, low sampling of commercial landings in some years, and sparse discard length data, particularly in early years.

  2. Since the commercial catch is aged primarily with survey age/length keys, there is considerable augmentation required, mainly for ages 5 and older. The numbers at age and *mean weights at age in the catch for these ages may therefore not be well specified.*

3. White hake may move seasonally into and out of the defined stock area.

4. There are no commercial catch at age data prior to 1989 and the catchability of older ages in the surveys is very low. This results in a large uncertainty in starting numbers at age.

5. Since 2003, dealers have apparently been culling extra-large fish out of the large category. However, there was no market category for landings until June 2014. The length compositions are distinct from fish characterized as large and have been identified since 2011. This may bias the age composition of the landings, particularly in 2014 when 2000 of the 5000 large samples were these extra-large fish.

6. A pooled age/length key is used for 1963-1981 and fall 2003 (second half of commercial key).

- 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}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.18 in the 2015 assessment and was 0.22 in 2016. The 7-year Mohn's ρ, relative to F, was -0.12 in the 2015 assessment and was -0.15 in 2016. There was a major retrospective pattern for this assessment because the ρ adjusted estimate of 2016 SSB (SSB_ρ=21276) was outside the approximate 90% confidence regions around SSB (21,466 - 30,052). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The retrospective adjustment changed the 2016 SSB from 25,638 to 21,276 and the 2016 F_{Full} from 0.058 to 0.066.

- 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 white hake are not well determined and projected biomass from the last assessment was outside the confidence bounds of the biomass estimated in the current assessment. The rebuilding deadline for this stock was 2014 and the stock is not yet rebuilt.

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

  The 2014 catches-at-age were re-estimated for landings, discards, and both surveys. The annual spring and fall age/length keys were completed and used to estimate the catches-at-age.

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

  While stock status of white hake has not changed, the stock has not rebuilt even with a very low fishing mortality. The change in the 2014 catch-at-age by using annual age/length keys resulted in a lower SSB in 2014 before additional years were added.

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

  The white hake stock shows no truncation of age structure. There may be a year class (2015 Age 1) that is above average. Estimates of commercial landings and discards have decreased over time.

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

  Age structures collected by the observer program are available and should be aged to augment the survey keys. They are also available from the ASMFC shrimp survey and would allow another survey to be added to the model. Otoliths are currently being collected from the market category for heads and these should also be aged.

- Are there other important issues?

  None.

13.1 Reviewer Comments: White hake

Assessment Recommendation:

The panel concluded that the operational update assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this updated assessment, the panel agrees with the recommendation that the white hake stock is not overfished and overfishing is not occurring. The white hake stock shows no truncation of age structure. There may be a year class (2015 Age 1) that is above average. Also, estimates of commercial landings and discards have decreased over time.

Key Sources of Uncertainty:

The primary sources of uncertainty affecting this stock are as follows:

Catch at age information is not well characterized due to possible mis-identification of species in the commercial and observer data, particularly in early years, low sampling of commercial landings in some years, and sparse discard length data, particularly in early years.

Since the commercial catch is aged primarily with survey age/length keys, there is considerable augmentation required, mainly for ages 5 and older. The numbers at age and mean weights at age in the catch for these ages may therefore not be well specified.

White hake may move seasonally into and out of the defined stock area.

There are no commercial catch at age data prior to 1989 and the catchability of older ages in the surveys is very low. This results in a large uncertainty in starting numbers at age.

Since 2003, dealers have apparently been culling extra-large fish out of the large category. However, there was no market category for landings until June 2014. The length compositions are distinct from fish characterized as large and have been identified since 2011. This may bias the age composition of the landings, particularly in 2014 when 2000 of the 5000 large samples were these extra-large fish.

A pooled age/length key is used for 1963-1981 and fall 2003 (second half of commercial key).

Research Needs:

The panel recommends that the age structures collected by the observer program should be aged to augment the survey keys. Ages are also available from the Atlantic States Marine Fisheries Commission (ASMFC) shrimp survey and this would allow another survey to be added to the model. Otoliths are currently being collected from the sow market category and these should also be aged. The panel also recommends considering and evaluating the addition of recreational catch and discards in a future assessment. Another recommendation is to consider market categories and how landings are aggregated in the model. Finally, the longline survey should be considered for inclusion in a future assessment.

References:

NEFSC. 2013. 56^{th} Northeast Regional Stock Assessment Workshop (56^{th} SAW) Assessment Report.US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 13-10; 868 p. http://www.nefsc.noaa.gov/publications/crd/crd1310/

NEFSC. 2015. Operational Assessment of 20 Northeast Groundfish Stocks Updated Through 2014.US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. http://www.nefsc.noaa.gov/publications/crd/crd1524/

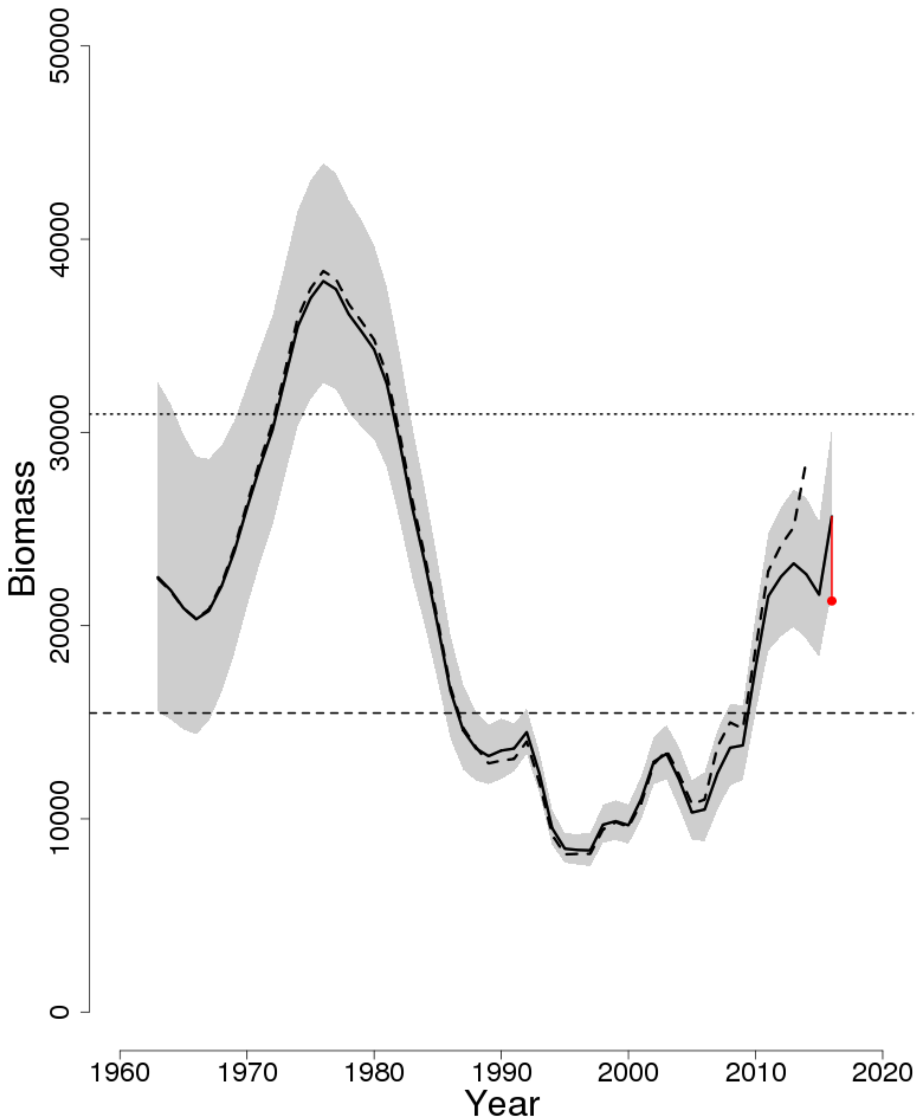

Figure 63: Trends in spawning stock biomass of white hake between 1963 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the 2017 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

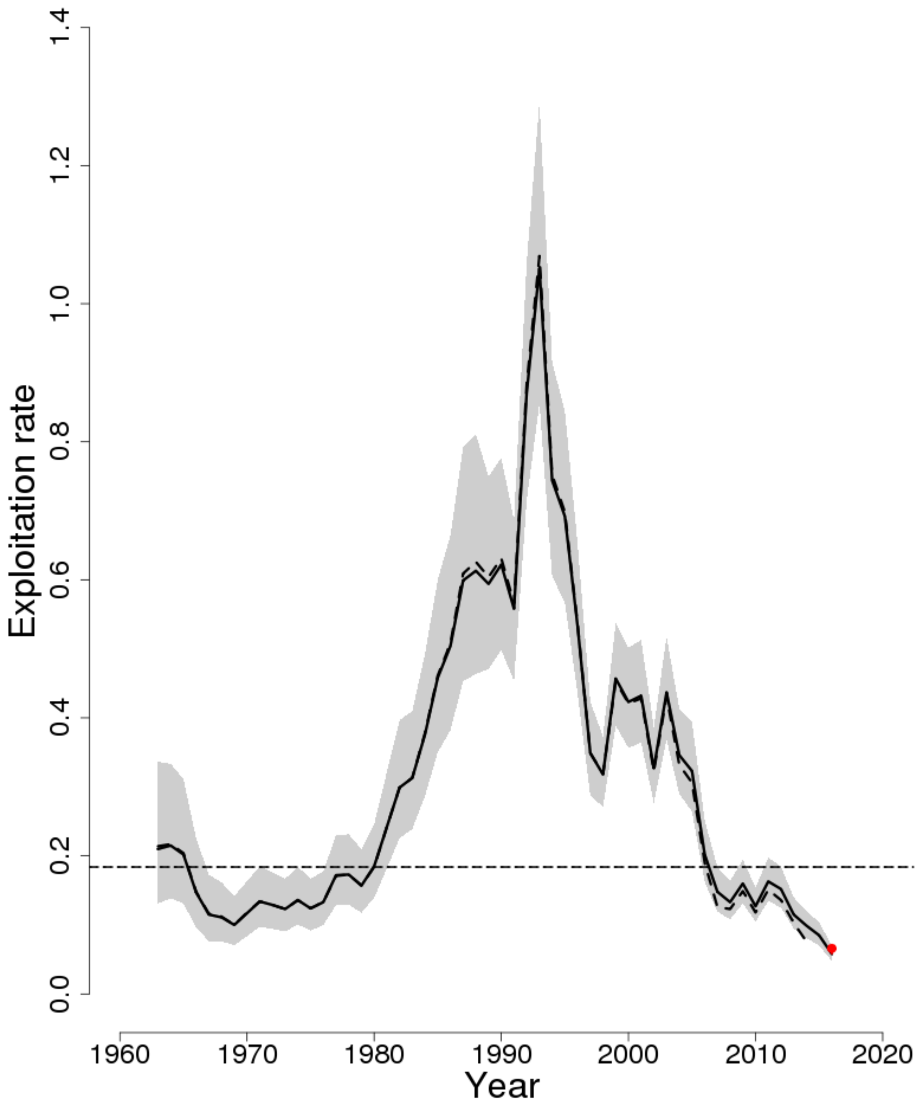

Figure 64: Trends in the fully selected fishing mortality (F_{Full}) of white hake between 1963 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.1839; horizontal dashed line). based on the 2017 assessment.The F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

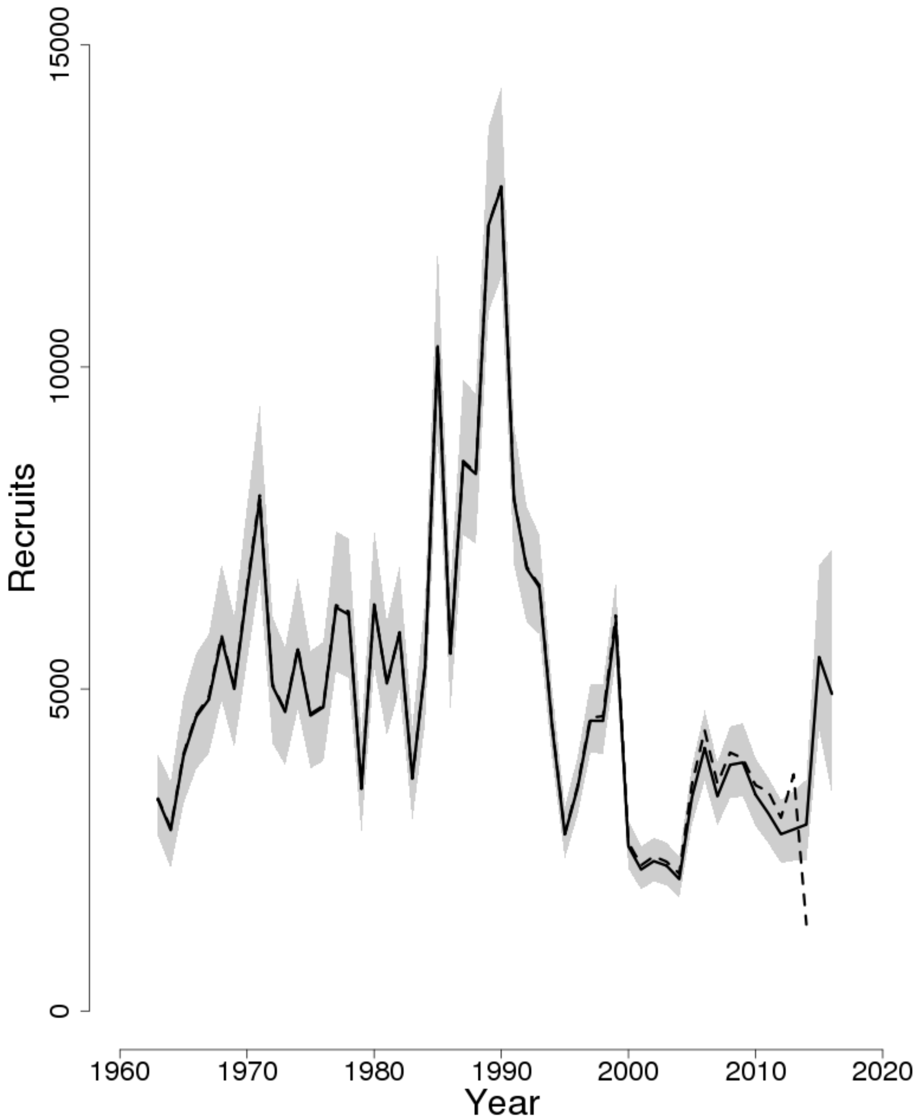

Figure 65: Trends in Recruits (age 1) (000s) of white hake between 1963 and 2016 from the current (solid line) and previous (dashed line) assessment. The approximate 90% lognormal confidence intervals are shown.

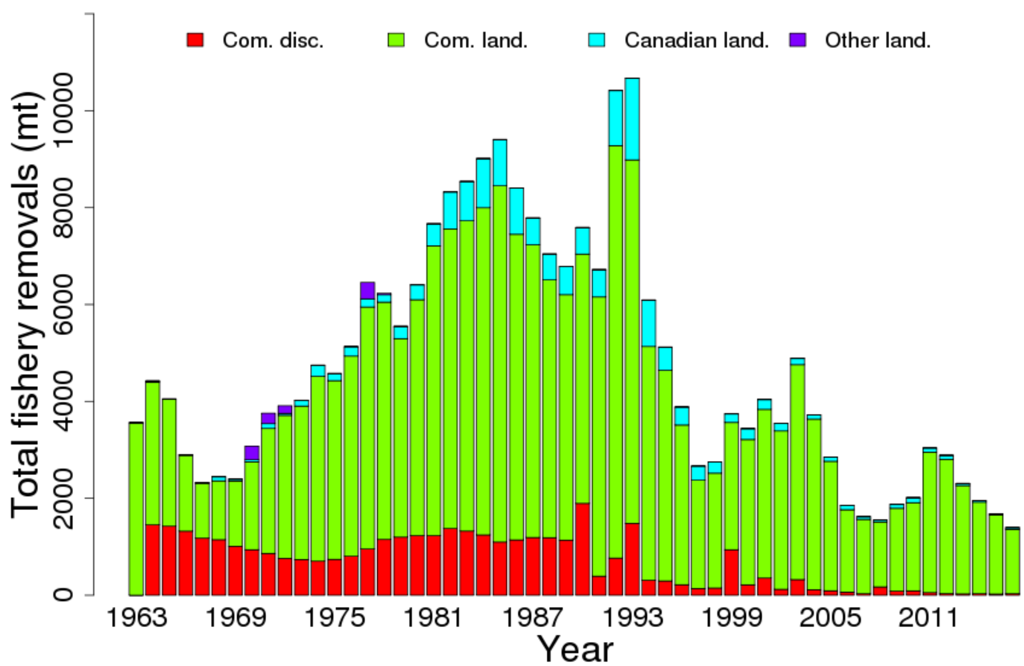

Figure 66: Total catch of white hake between 1963 and 2016 by fleet (commercial, recreational, or Canadian) and disposition (landings and discards).

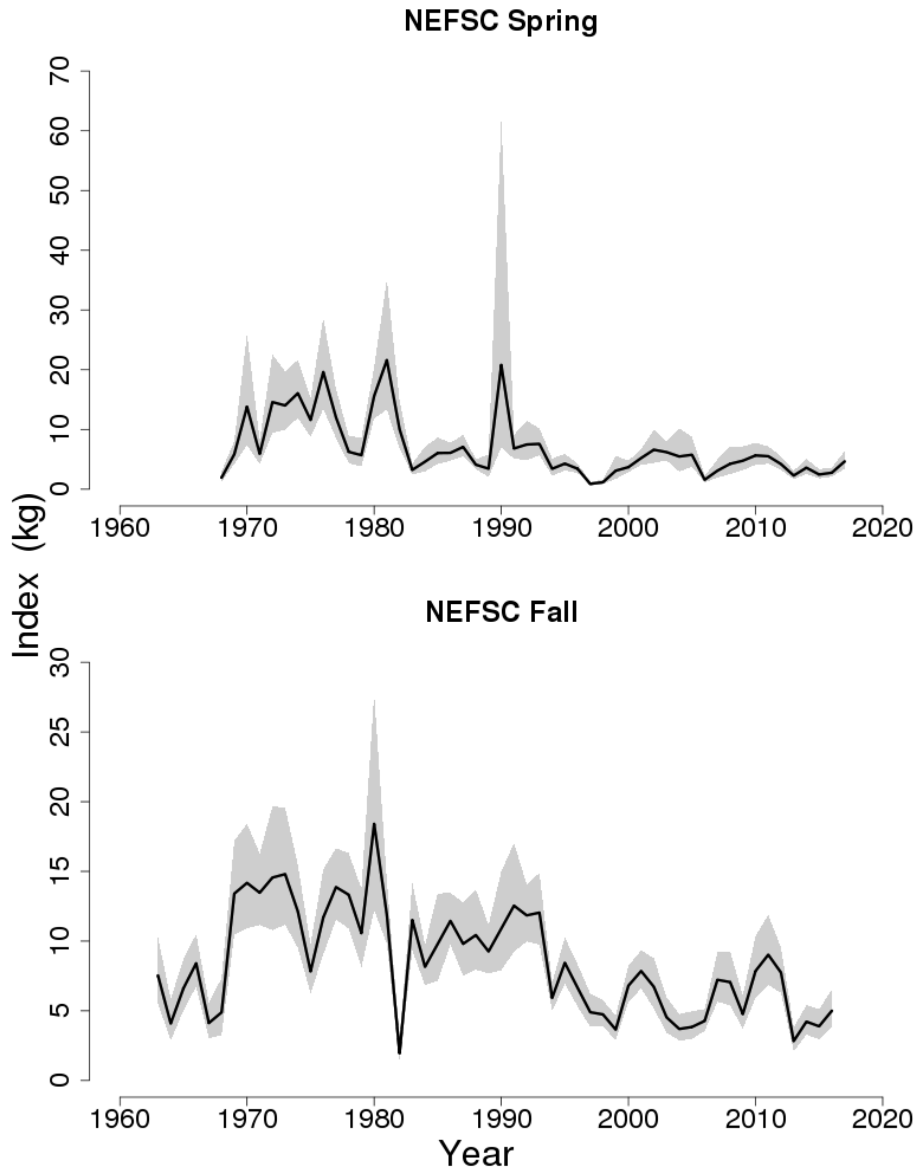

Figure 67: Indices of biomass for the white hake between 1963 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

14 Pollock

Brian Linton

This assessment of the pollock (Pollachius virens) stock is an operational assessment of the existing 2015 operational assessment (NEFSC 2015). This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, the ASAP analytical models, and biological reference points through 2016. Additionally, stock projections have been updated through 2020. In what follows, there are two population assessment models brought forward from the 2015 operational assessment: the base model (dome-shaped survey selectivity), which is used to provide management advice; and the flat sel sensitivity model (flat-topped survey selectivity), which is included for the sole purpose of demonstrating the sensitivity of assessment results to survey selectivity assumptions. The most recent benchmark assessment of the pollock stock was in 2010 as part of the 50th Stock Assessment Review Committee (SARC 50; NEFSC 2010), which includes a full description of the model formulations.

State of Stock: The pollock (*Pollachius virens*) stock is not overfished and overfishing is not occurring (Figures 68-69). Retrospective adjustments were made to the model results. Retrospective adjusted spawning stock biomass (SSB) in 2016 was estimated to be 183,907 (mt) under the base model and 72,889 (mt) under the flat sel sensitivity model which is 174 and 120% (respectively) of the biomass target, an SSB_{MSY} proxy of SSB at $F_{40\%}$ (105,510 and 60,738 (mt); Figure 68). Retrospective adjusted 2016 age 5 to 7 average fishing mortality (F) was estimated to be 0.036 under the base model and 0.079 under the flat sel sensitivity model, which is 14 and 32% (respectively) of the overfishing threshold, an F_{MSY} proxy of $F_{40\%}$ (0.26 and 0.249; Figure 69).

Table 43: Catch and status table for pollock. All weights are in (mt), recruitment is in (000s), and F_{AVG} is the age 5 to 7 average F. Unadjusted SSB and F estimates are reported. Model results are from the current base model and flat sel sensitivity model.

	2009	2010	2011	2012	2013	2014	2015	2016
				Data				
Commercial landings	7,504	5,153	7,211	6,742	5,058	4,545	3,043	2,582
Commercial discards	282	99	176	121	169	135	155	96
Recreational landings	551	1,202	1,411	544	1,404	458	324	352
Recreational discards	399	762	937	836	1,534	639	690	646
Catch for Assessment	8,735	7,217	9,736	8,243	8,164	5,777	4,212	3,676
				Model Results (base)				
Spawning Stock Biomass	232340	206689	204222	187597	184690	181430	206701	226371
F_{AVG}	0.065	0.062	0.083	0.07	0.072	0.05	0.033	0.026
Recruits $age1$	14285	23335	35624	60593	46443	103664	43328	20065
				Model Results (flat sel sensitivity)				
Spawning Stock Biomass	91786	81413	80219	73151	71337	71400	87152	102571
F_{AVG}	0.136	0.126	0.174	0.15	0.157	0.108	0.069	0.051
Recruits $age1$	7994	13105	20282	34744	26876	60273	25391	12000

Table 44: Comparison of biological reference points for pollock estimated in the 2015 assessment and from the current base model and flat sel sensitivity model. An F_{MSY} proxy of $F_{40\%}$ was used for the overfishing threshold, and was based on yield per recruit analysis. F_{MSY} is reported as the age 5 to 7 average F. Recruits represent the median of the predicted recruits. Intervals shown are 5th and 95th percentiles.

	2015 base	2015 flat sel sensitivity	base	flat sel sensitivity
F_{MSY}	0.277	0.252	0.260	0.249
SSB_{MSY} (mt)	105,226	54,900	105,510 (81,832 - 145,426)	60,738 (47,146 - 84,524)
MSY (mt)	19,678	10,995	19,427 (14,312 - 29,682)	11,692 (8,701 - 17,748)
Median recruits (age 1) (000s)	25,299	12,879	22,183	13,067
Overfishing	No	No	No	No
Overfished	No	No	No	No

Projections: Short term projections of median total fishery yield and spawning stock biomass for pollock were conducted based on a harvest scenario of fishing at an F_{MSY} proxy of $F_{40\%}$ between 2018 and 2020. Catch in 2017 has been estimated at 4,296 (mt). Recruitments were sampled from a cumulative distribution function derived from ASAP estimated age 1 recruitment between 1970 and 2014. Recruitments in 2015 and 2016 were not included due to uncertainty in those estimates. The annual fishery selectivity, natural mortality, maturity ogive, and mean weights used in projections are the most recent 5 year averages. Retrospective adjusted age 5 to 7 average F in 2016 fell outside the 90% confidence intervals of the unadjusted 2016 value under the base model (Figure 69). Retrospective adjusted SSB and age 5 to 7 average F in 2016 fell outside the 90% confidence intervals of the unadjusted 2016 values under the flat sel sensitivity model (Figures 68-69). Therefore, age-specific abundance rho values were applied to the initial numbers at age in the projections for the base model and the flat sel sensitivity model.

Table 45: Retrospective adjusted short term projections of median total fishery yield and spawning stock biomass for pollock from the current base model and flat sel sensitivity model based on a harvest scenario of fishing at an F_{MSY} proxy of $F_{40\%}$ between 2018 and 2020. Catch in 2017 has been estimated at 4,296 (mt). F_{AVG} is the age 5 to 7 average F.

Year	Catch (mt)	SSB (mt)	F_{AVG}	Catch (mt)	SSB (mt)	F_{AVG}
		base			*flat sel sensitivity*	
2017	4,296	243,345	0.025	4,296	100,184	0.056

Year	Catch (mt)	SSB (mt)	F_{AVG}	Catch (mt)	SSB (mt)	F_{AVG}
		base			*flat sel sensitivity*	
2018	51,680	286,640	0.260	23,408	121,667	0.249
2019	51,216	267,301	0.260	24,167	117,037	0.249
2020	52,269	236,653	0.260	25,974	105,719	0.249

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 largest source of uncertainty in the pollock assessment is selectivity, as the base model with dome-shaped survey and fishery selectivities implies the existence of a large cryptic biomass that neither current surveys nor the fishery can confirm. Assuming that survey selectivity is flat-topped leads to lower estimates of SSB and higher estimates of F (Figures 68-69). Stock status is insensitive to the shape of the survey selectivity patterns at older ages. The strength of the 2013 year class is a source of uncertainty in the projections. The uncertainty in year class strength should decrease as additional years of data are added to the 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_{AVG} lies outside of the approximate joint confidence region for SSB and F_{AVG}; see Table 8).

  The 7-year Mohn's ρ, relative to SSB, was 0.284 under the base model and 0.789 under the flat sel sensitivity model in the 2015 assessment and was 0.231 and 0.407, respectively, in 2016. The 7-year Mohn's ρ, relative to F, was -0.276 under the base model and -0.43 under the flat sel sensitivity model in the 2015 assessment and was -0.278 and -0.35, respectively, in 2016. There was a major retrospective pattern for the base model because the ρ adjusted estimate of 2016 F (F_ρ=0.036) was outside the approximate 90% confidence region around F (0.018 - 0.034). There was a major retrospective pattern for the flat sel sensitivity model because the ρ adjusted estimates of 2016 SSB (SSB_ρ=72,889) and 2016 F (F_ρ=0.079) were outside the approximate 90% confidence region around SSB (76,914 - 128,228 (mt)) and F (0.037 - 0.066). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2018. The base model retrospective adjustment changed the 2016 SSB from 226,371 to 183,907 and the 2016 F_{AVG} from 0.026 to 0.036. The flat sel sensitivity model retrospective adjustment changed the 2016 SSB from 102,571 to 72,889 and the 2016 F_{AVG} from 0.051 to 0.079.

- 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 pollock appear to be reasonably well determined for both the base model and the flat sel sensitivity model. The stock is not in a rebuilding plan.

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

  Only one change was made to the pollock assessment as part of this update. A multinomial logistic model was used to estimate proportions at age for length bins where no age samples were available (Gerritsen et al. 2006) in survey age-length keys. Survey age-length key holes were filled manually based on the expert judgment of the assessment analyst in previous assessments. There was little difference in the survey indices at age produced by the multinomial filling method compared to the indices at age produced by the manual filling method. The multinomial filling method is part of an effort by Northeast Fisheries Science Center (NEFSC) staff to standardize construction of survey indices.

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

  Stock status based on the base and flat sel sensitivity models has not changed since the previous assessment.

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

  Total removals of pollock have declined since 2008. The spring survey index has increased since 2013, while the fall survey index has decreased since 2014. Survey data suggests the exisitence of a relatively strong 2014 year class, which has yet to enter the commercial fishery. Survey data suggests that older fish have begun to reappear in the stock since the 1990s.

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

  The pollock assessment could be improved with additional studies on gear selectivity. These studies could cover topics such as physical selectivity (e.g., multi-mesh gillnet), behavior (e.g., swimming endurance, escape behavior), geographic and vertical distribution by size and age, tag-recovery at size and age, and evaluating information on length-specific selectivity at older ages.

- Are there other important issues?

  As in the previous assessment, the pollock assessment models had difficulty converging on a solution in some of the retrospective peels. One possible explanation for this convergence issue is that the model may be overparameterized, because the commercial and recreational fleets are modeled separately in this assessment. The possibility of combining the two fleets into a single fleet should be explored during the next benchmark assessment.

14.1 Reviewer Comments: Pollock

Assessment Recommendation:

The panel concluded that the operational assessment with adjustments for retrospective bias was acceptable as a scientific basis for management advice using the approved base model with dome-shaped selectivity on all fleets and surveys.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this assessment, the panel supports the conclusion that the pollock stock is not overfished and overfishing is not occurring. Total removals of pollock have declined since 2008. The spring survey index has increased since 2013, while the fall survey index has decreased since 2014. Survey data suggests the existence of a relatively strong 2013 year class, which has yet to enter the commercial fishery. Survey data suggests that older fish have begun to reappear in the stock since the 1990s.

Key Sources of Uncertainty:

The largest source of uncertainty in the pollock assessment is selectivity, as the base model with dome-shaped survey and fishery selectivities implies the existence of a large cryptic biomass that neither current surveys nor the fishery can confirm. Assuming that survey selectivity is flat-topped leads to lower estimates of spawning stock biomass and higher estimates of F. For that reason, it is relatively risk-prone to manage assuming dome-shaped selectivity, if in fact, flat-topped selectivity is occurring. Stock status is insensitive to the shape of the survey selectivity patterns at older ages. There are convergence issues in conducting the retrospective analysis; perhaps the model is overparameterized due to separate commercial and recreational fleets. Also, the actual strength of 2013 year class is yet to be realized in the fishery and therefore remains a source of uncertainty. Due to the risk-prone nature of managing under the assumption of dome-shaped selectivity, the panel recommends a decision table be used to communicate the results of the base assessment model and the sensitivity model.

Research Needs:

The pollock assessment could be improved with additional studies on gear selectivity. These studies could cover topics such as physical selectivity (e.g., multi-mesh gillnet), behavior (e.g., swimming endurance, escape behavior), geographic and vertical distribution by size and age, tag-recovery at size and age, and evaluating information on length-specific selectivity at older ages. Given the convergence issues, alternative model configurations should be explored, such as combining the two fleets into a single fleet. Consider exploring the age composition of the survey and its ability to track cohorts relative to the strong cohorts present in the fishery compositional data as this could also be a potential source of the convergence issues.

References:

Gerritsen, H.D., D. McGrath, and C. Lordan. 2006. A simple method for comparing age-length keys reveals significant regional differences within a single stock of haddock (*Melanogrammus aeglefinus*). ICES J Mar Sci 63: 1096-1100.

Northeast Fisheries Science Center. 2010. 50^{th} Northeast Regional Stock Assessment Workshop (50^{th} SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 10-17; 844 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD10-17

Northeast Fisheries Science Center. 2015. 2014 Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-24

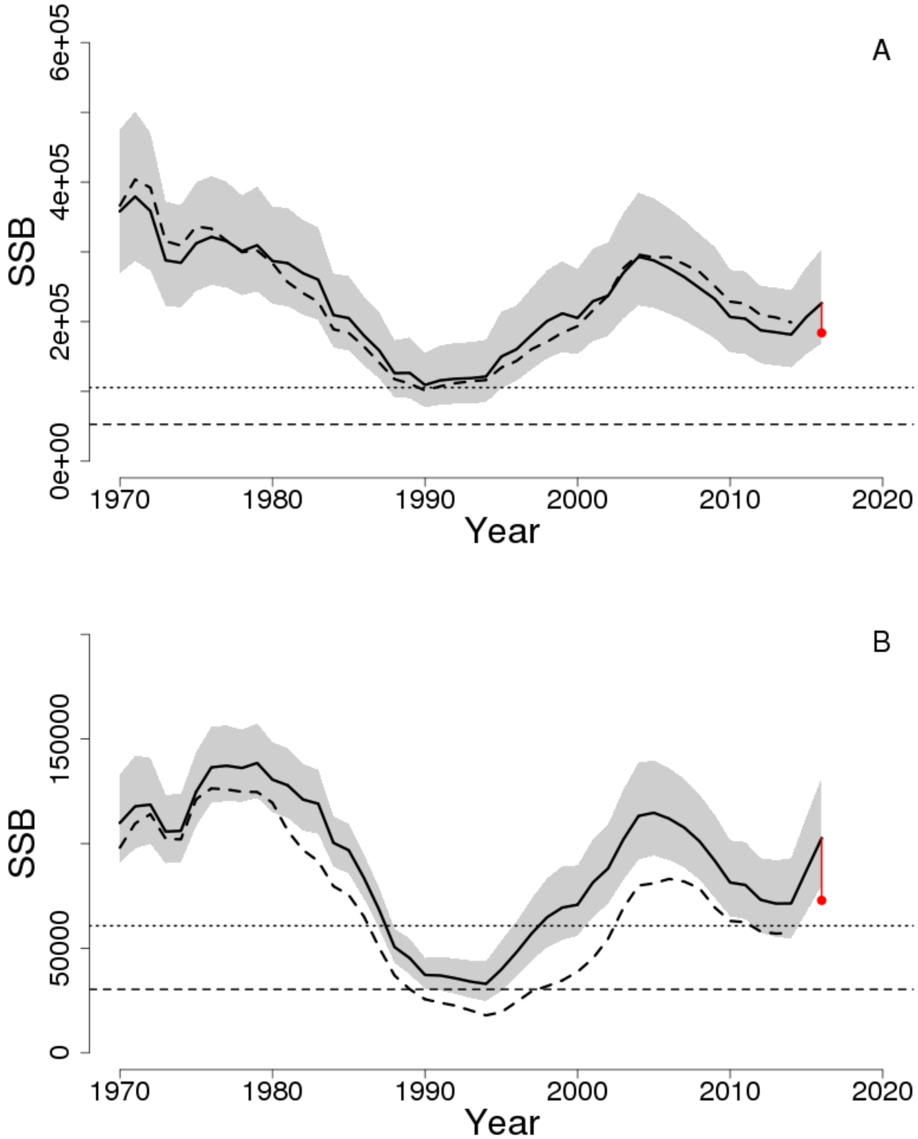

Figure 68: Estimated trends in the spawning stock biomass of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ (0.5 * SSB_{MSY} proxy; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} proxy; horizontal dotted line) based on the 2017 assessment models base (A) and flat sel sensitivity (B). Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

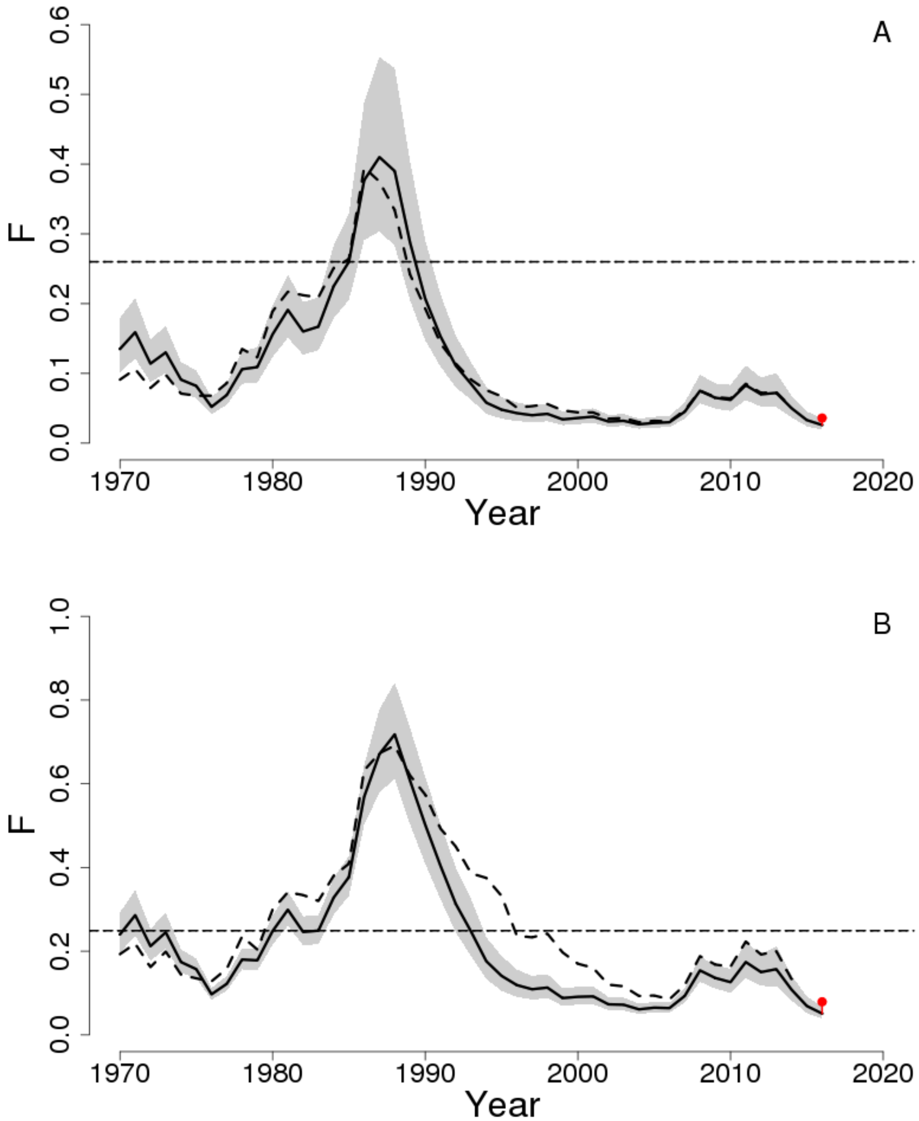

Figure 69: Estimated trends in age 5 to 7 average F (F_{AVG}) of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} proxy; dashed line) based on the 2017 assessment models base (A) and flat sel sensitivity (B). F_{AVG} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% lognormal confidence intervals are shown.

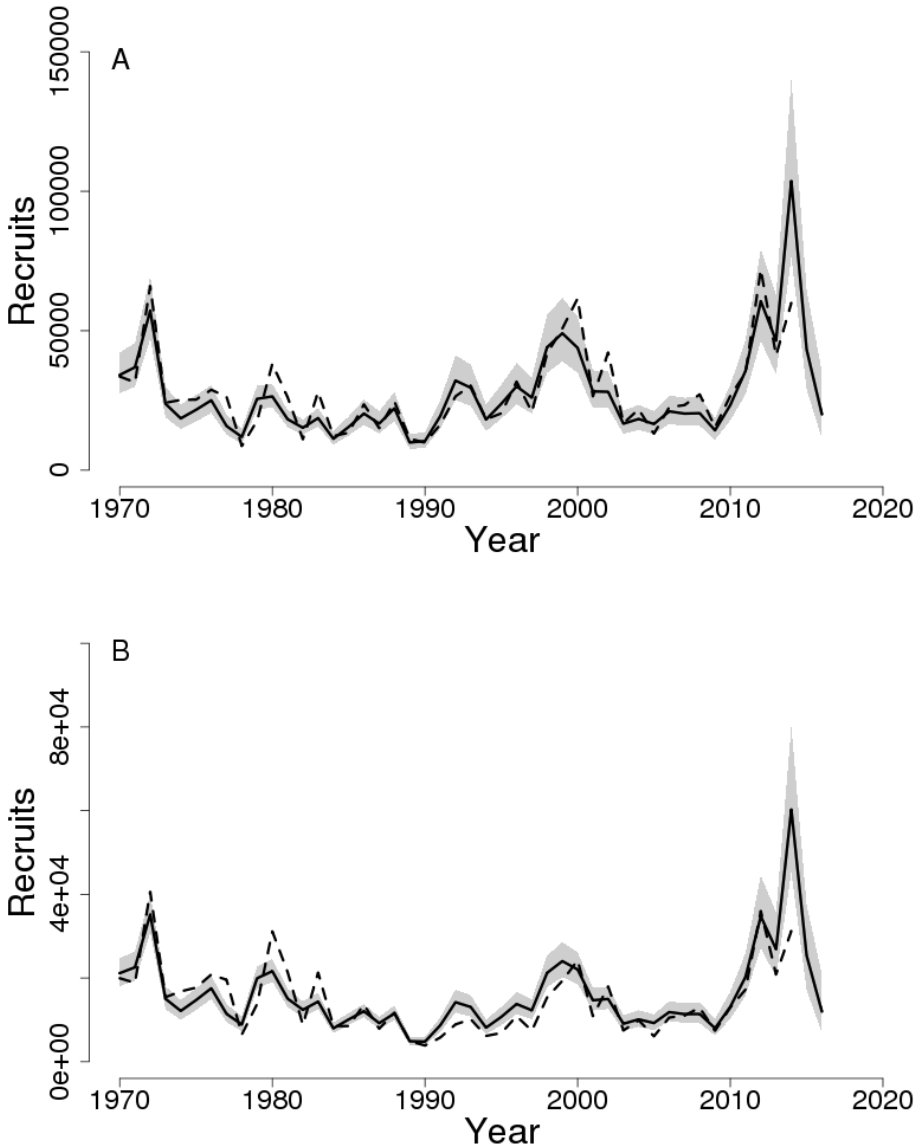

Figure 70: Estimated trends in age 1 recruitment (000s) of pollock between 1970 and 2016 from the current (solid line) and previous (dashed line) assessment for the assessment models base (A) and flat sel sensitivity (B). The approximate 90% lognormal confidence intervals are shown.

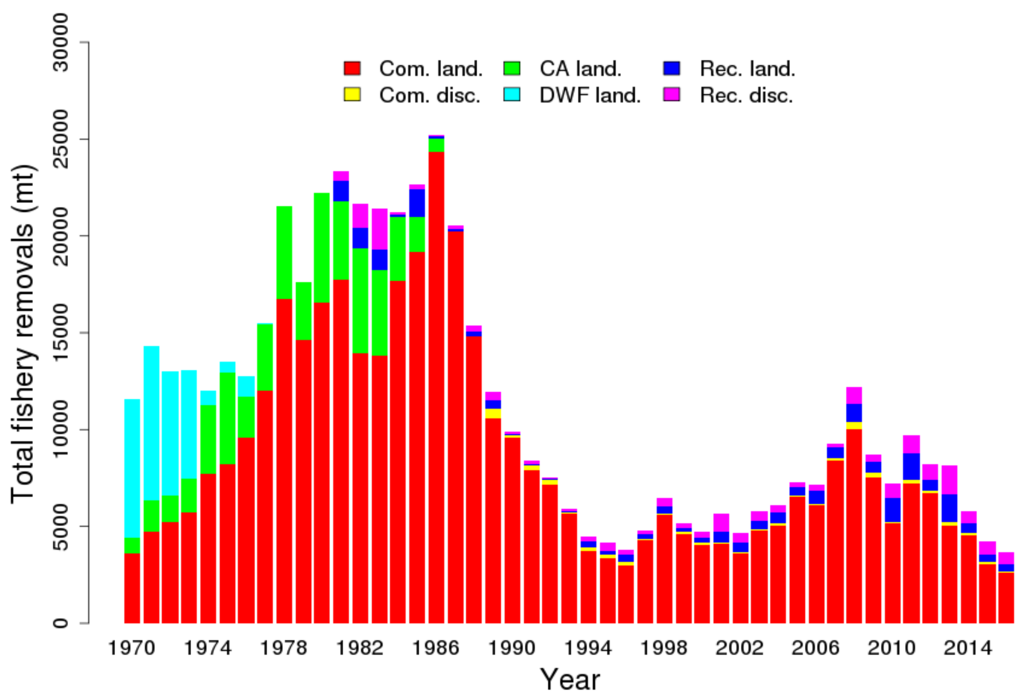

Figure 71: Total catch of pollock between 1970 and 2016 by fleet (commercial, Canadian, distant water fleet, and recreational) and disposition (landings and discards).

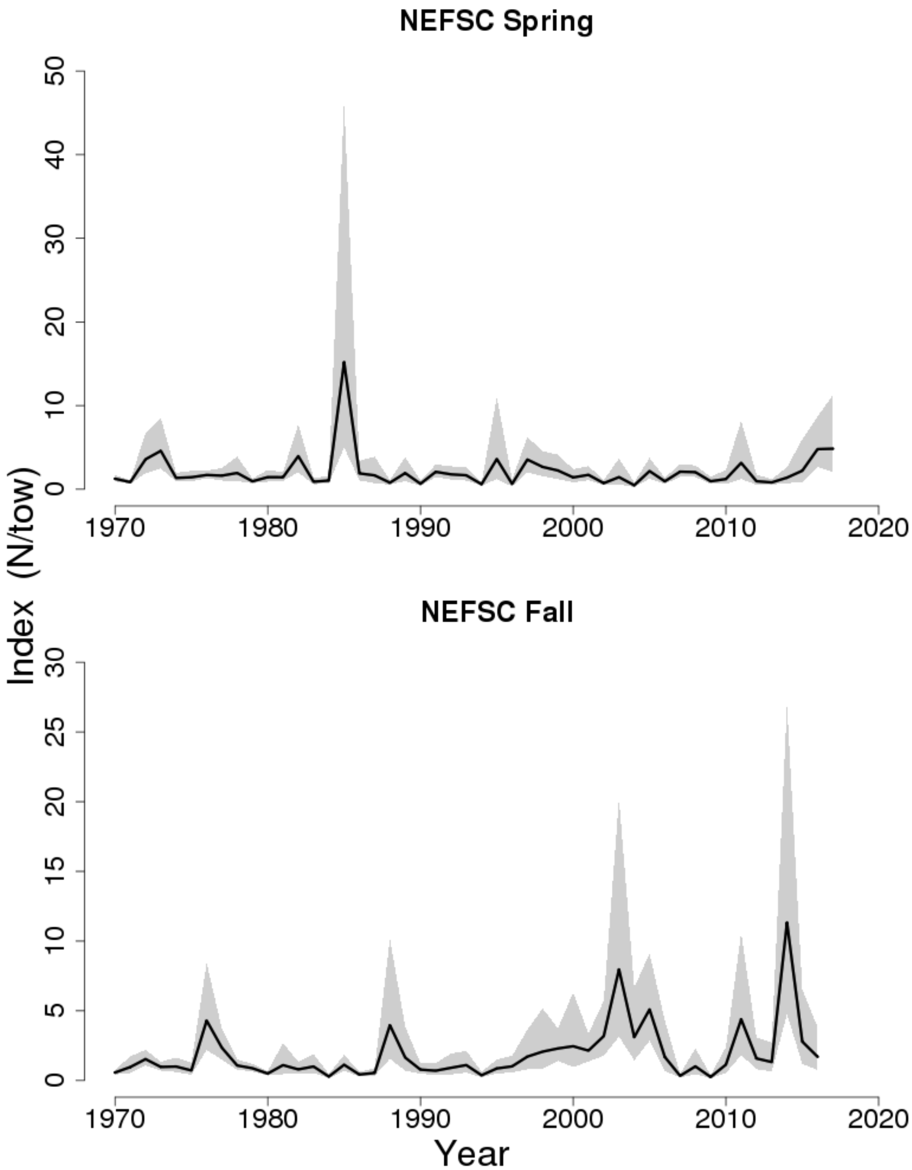

Figure 72: Indices of abundance for pollock from the Northeast Fisheries Science Center (NEFSC) spring (1970 to 2017) and fall (1970 to 2016) bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

15 Atlantic wolffish

Charles Adams

This assessment of the Atlantic wolffish (Anarhichas lupus) stock is an operational assessment of the existing 2015 operational assessment (NEFSC 2015). Based on the previous assessment the stock was overfished, but overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices of abundance, and the analytical assessment models and reference points through 2016.

State of Stock: Based on this updated assessment, the Atlantic wolffish (*Anarhichas lupus*) stock is overfished and overfishing is not occurring (Figures 73-74). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2016 was estimated to be 652 (mt) which is 40% of the biomass target (SSB_{MSY} *proxy* = 1,612; Figure 73). The 2016 fully selected fishing mortality was estimated to be 0.002 which is 1% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.222; Figure 74).

Table 46: Catch and status table for Atlantic wolffish. All weights are in (mt) recruitment is in (mt) and F_{Full} is the fully selected fishing mortality. Model results are from the current updated SCALE assessment.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Data										
Commercial landings	63	49	33	3	0	0	0	0	0	0
Commercial discards	0	0	0	1	3	2	2	1	1	1
Recreational landings	12	14	7	1	2	0	0	0	0	0
Catch for Assessment	75	64	40	5	5	2	2	1	1	1
Model Results										
Spawning Stock Biomass	368	335	296	303	353	410	477	537	593	652
F_{Full}	0.421	0.512	0.284	0.024	0.019	0.009	0.005	0.003	0.003	0.002
Recruits (age 1)	87	67	64	80	86	127	288	289	289	289

Table 47: Comparison of reference points from the previous assessment and the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and was based on yield per recruit calculations within the SCALE model.

	2015	2017
F_{MSY} *proxy*	0.243	0.222
SSB_{MSY} (mt)	1,663	1,612
MSY (mt)	244	232
Median recruits (age 1) (mt)	252	235
Overfishing	No	No
Overfished	Yes	Yes

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 primary sources of uncertainty are the use of the ocean pout calibration coefficient (Atlantic wolffish coefficients are unknown), and the change to a no possession limit in May 2010. The ocean pout calibration coefficient (4.575) is one of the largest for any species (Miller et al. 2010), and results in lower biomass estimates. The change to a no possession limit places greater importance on discard mortality. Additionally, it is unclear whether the lack of a recruitment index since 2004 is due to an actual decrease in recruitment, or a change in catchability resulting from the increase in liner mesh size associated with the switch to the Bigelow. Other sources of uncertainty were identified in previous Atlantic wolffish assessments (NDPSWG 2009, NEFSC 2012): the surveys may have reached the limit of wolffish detectability due to the decline in abundance; and the lack of commercial length information results in model estimation difficulties for fishery selectivity.

- 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}; see Table 8).

  This assessment has retrospective patterns with Mohn's rho = 0.47 for SSB and -0.21 for F. Confidence intervals are not available because MCMC is not fully developed for the SCALE model. Thus, retrospective adjustments were not done for this assessment.

- 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 Atlantic wolffish were not done. Due to the uncertainties in the assessment, the Northeast Data Poor Stocks Working Group (NDPSWG 2009) concluded that stock projections would be unreliable and should not be conducted. This stock was not in a rebuilding plan.

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

  There were no changes since the previous assessment.

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

  Stock status has not changed since the previous assessment.

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

  Catch has been limited almost exclusively to discards since the implementation of the no possession rule in May 2010. No age 1 recruits have been caught in the NEFSC spring survey since 2004. Both NEFSC adult indices (spring and fall) declined in 2016. In contrast, the spring MADMF adult index has increased over the past two years.

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

The Atlantic wolffish maturity study in the Gulf of Maine has been expanded through funding by a Saltonstall-Kennedy grant. Sampling in summer 2017 should provide sufficient histological data to allow for the development of a definitive maturity ogive that can be used in the next assessment.

Other research needs were identified by the Peer Review Panel in the previous assessment (NEFSC 2015): potential use of a likelihood profile to apply the criterion for a retrospective adjustment; further studies on growth parameters; a tagging study to provide information on stock structure and movement; and a study of post-capture nest site fidelity.

- Are there other important issues?

  Recruitment at the end of the time series increases toward the initial recruitment estimate (Table 1; Figure 3) because there is no information in the model to inform these estimates. There is no indication in the data that recruitment has increased recently.

  Approximate 90% lognormal confidence intervals are not shown in Figures 1-3 because MCMC is not fully developed for the SCALE model.

  An 8% discard mortality rate was adopted by the Peer Review Panel in the previous assessment (NEFSC 2015). This results in very low removals under the no possession rule. Future model updates should see a population response from these low removals. However, if no change is observed in the data inputs (e.g. increased survey indices) then the diagnostics may worsen.

15.1 Reviewer Comments: Atlantic wolffish

Assessment Recommendation:

The panel concluded that the operational assessment with no adjustment for retrospective bias was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel agrees with the conclusion that the Atlantic wolffish stock is overfished and overfishing is not occurring. Catch has been limited almost exclusively to discards since the implementation of the no possession rule in May 2010. No age-1 recruits have been caught in the National Marine Fisheries Service spring survey since 2004. Both adult survey indices (spring and fall) declined in 2016. In contrast, the Massachusetts Division of Marine Fisheries spring survey began catching wolffish again after 2014.

Key Sources of Uncertainty:

The primary sources of uncertainty are the use of the ocean pout calibration coefficient (Atlantic wolffish coefficients are unknown), and effects due to the change to a no possession limit in May 2010, which causes discards to represent the only source of fishing mortality. The ocean pout calibration coefficient is one of the largest for any species, and results in lower biomass estimates. Additionally, a possible contributor to the apparent lack of a recruitment since 2004 may be due to a change in catchability resulting from the increase in liner mesh size associated with the switch to the new survey net, which occurred in 2009. The surveys may have reached the limit of wolffish detectability due to the decline in abundance; and the lack of commercial length information results in model estimation difficulties for fishery selectivity. Other sources of uncertainty were identified in previous Atlantic wolffish assessments.

Research Needs:

An Atlantic wolffish maturity study in the Gulf of Maine has been expanded through funding by a Saltonstall-Kennedy grant. Sampling in summer 2017 should provide sufficient histological data to allow for the development of a definitive maturity ogive that can be used in the next assessment. Other research needs were identified by the peer review panel in the previous assessment, such as the potential use of a likelihood profile to apply the criterion for a retrospective adjustment, further studies on growth parameters, a tagging study to provide information on stock structure and movement, and a study of post-capture nest site fidelity.

References:

Miller TJ, Das C, Politis PJ, Miller AS, Lucey SM, Legault CM, Brown RW, Rago PJ. 2010. Estimation of Albatross IV to Henry B. Bigelow calibration factors. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 10-05; 233 p. CRD10-05

Northeast Fisheries Science Center (NEFSC). 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 12-06; 789 p. CRD12-06

Northeast Fisheries Science Center (NEFSC). 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. CRD15-24

Northeast Data Poor Stocks Working Group (NDPSWG). 2009. The Northeast Data Poor Stocks Working Group Report, December 8-12, 2008 Meeting. Part A. Skate species complex, deep sea red crab, Atlantic wolffish, scup, and black sea bass. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 09-02; 496 p. CRD09-02

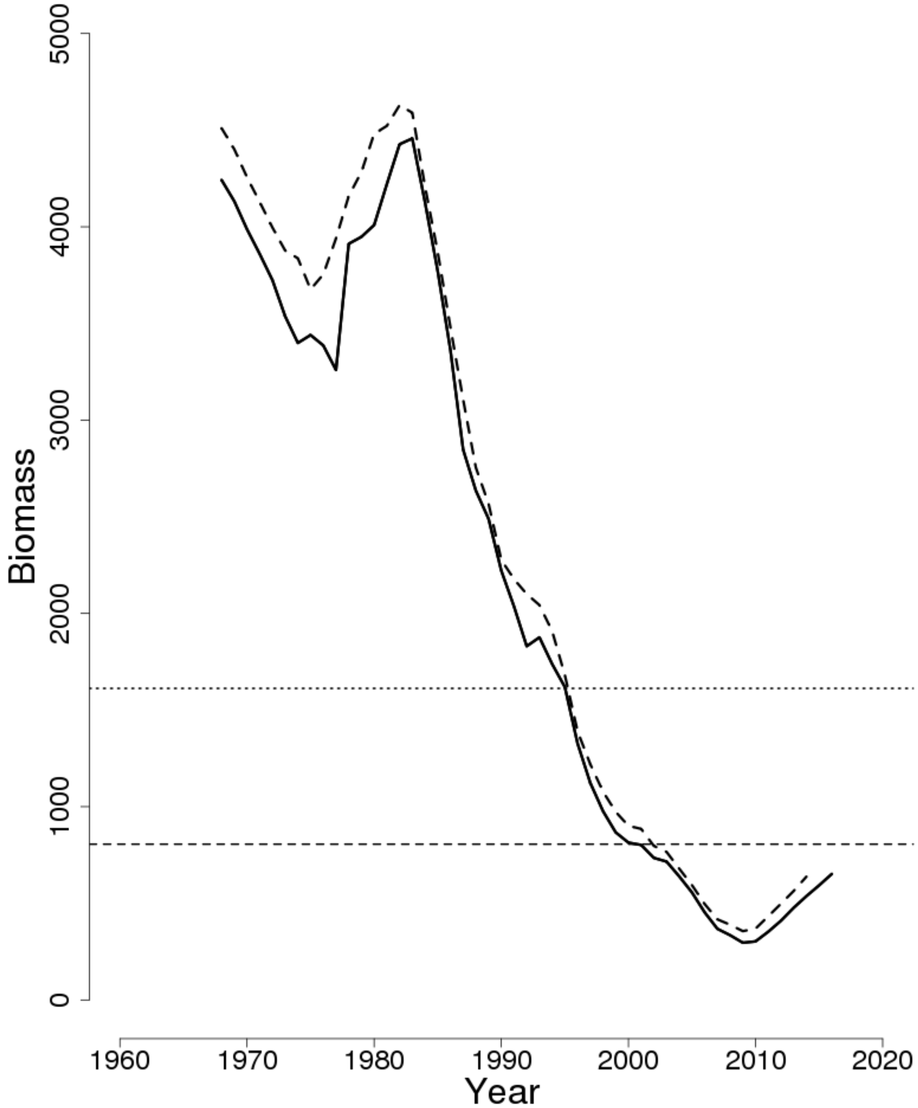

Figure 73: Trends in spawning stock biomass of Atlantic wolffish between 1968 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) based on the current assessment.

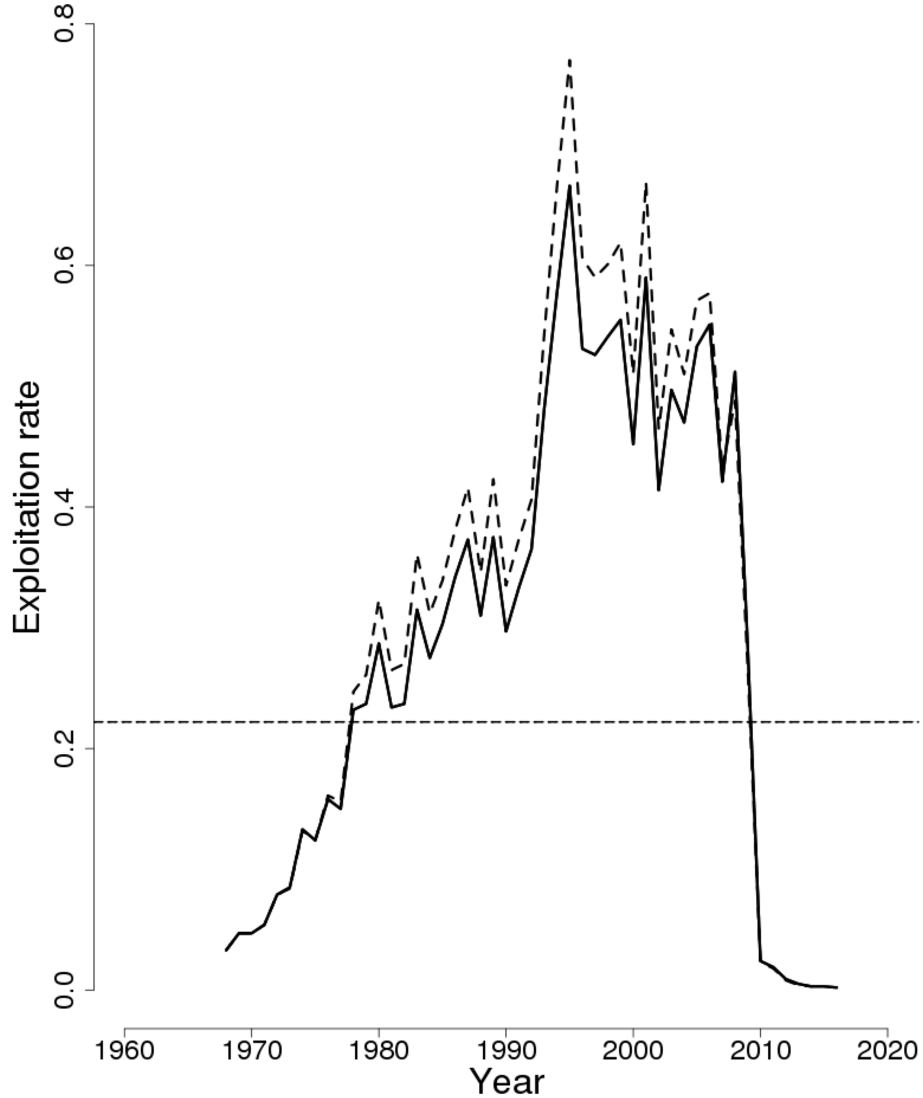

Figure 74: Trends in the fully selected fishing mortality (F_{Full}) of Atlantic wolffish between 1968 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.222; horizontal dashed line).

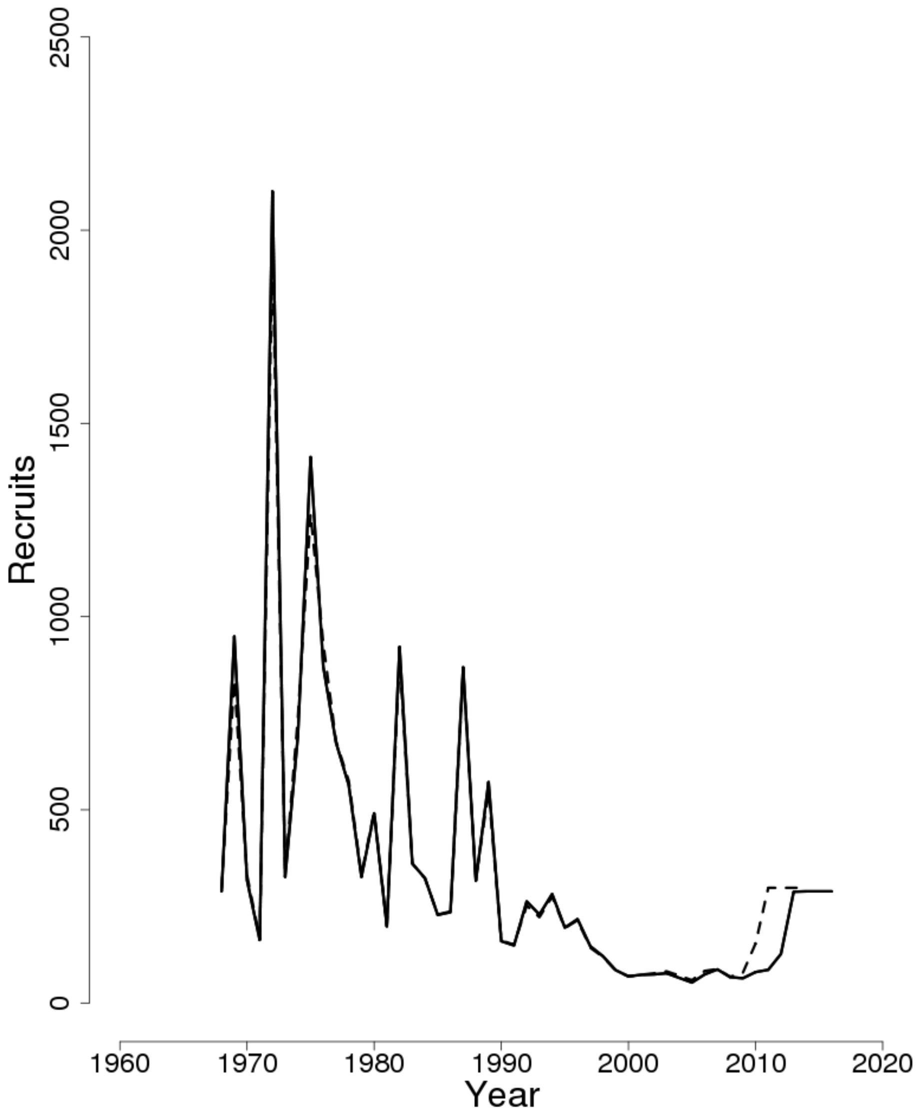

Figure 75: Trends in age 1 recruits of Atlantic wolffish between 1968 and 2016 from the current (solid line) and previous (dashed line) assessment.

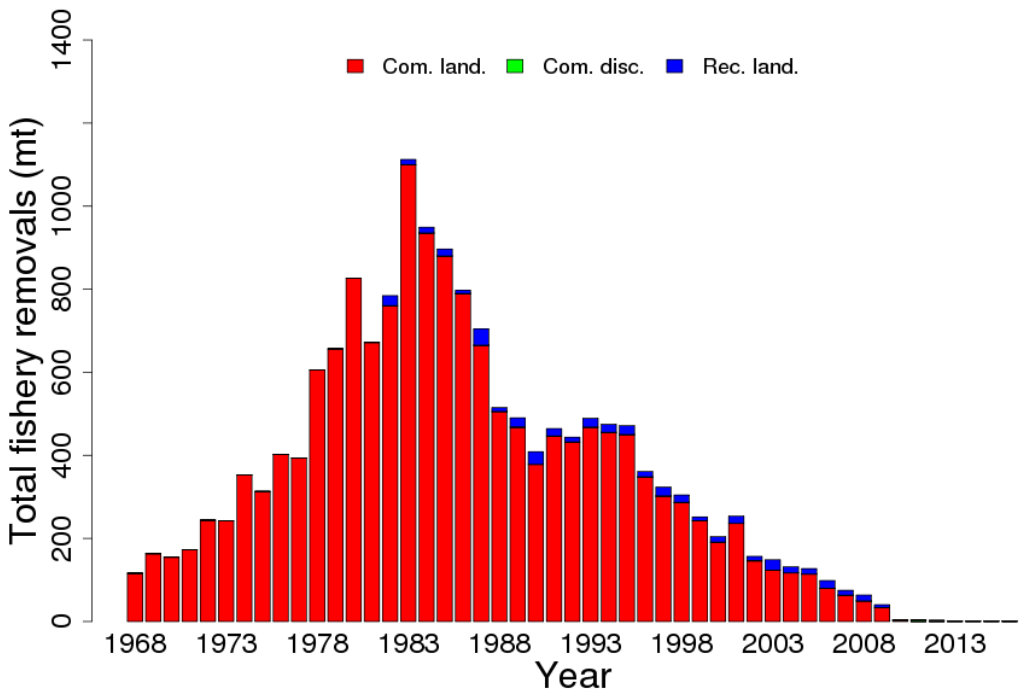

Figure 76: Total catch of Atlantic wolffish between 1968 and 2016 by fleet (commercial and recreational) and disposition (landings and discards). Note that a no possession limit was put in place in May 2010.

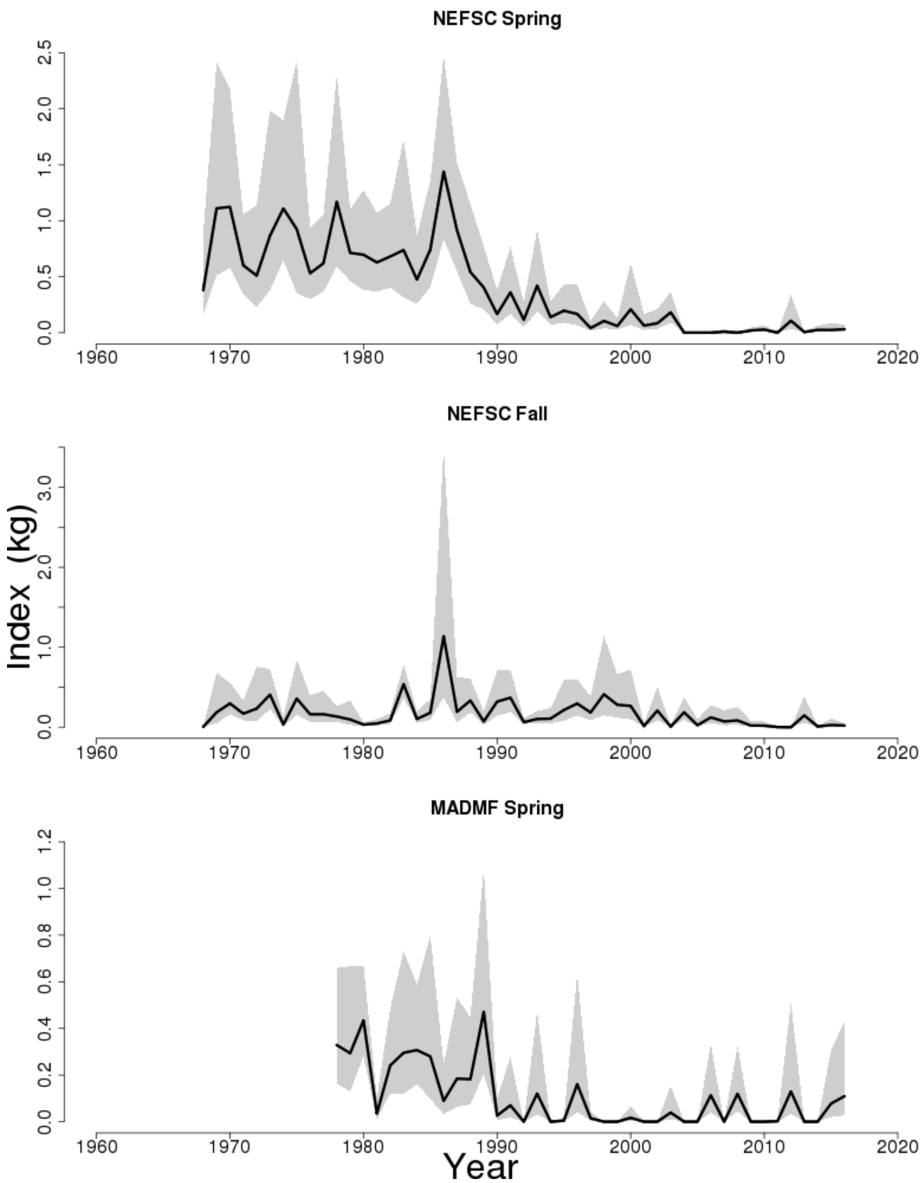

Figure 77: Indices of biomass for the Atlantic wolffish between 1968 and 2016 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, and the Massachusetts Division of Marine Fisheries (MADMF) spring bottom trawl survey. The approximate 90% lognormal confidence intervals are shown. NEFSC indices for 2009-2015 are calibrated using the ocean pout coefficient from Miller et al. (2010).

16 Gulf of Maine - Georges Bank windowpane flounder

Toni Chute

This assessment of the Gulf of Maine - Georges Bank windowpane flounder (Scophthalmus aquosus) stock is an operational update of the 2015 assessment which was based on survey and fishery data through 2014 (NEFSC 2015). Based on the 2015 assessment the stock was overfished, but overfishing was not ocurring. This assessment updates commercial fishery catch data, survey biomass indices, AIM model results, and reference points through 2016.

State of Stock: Based on this updated assessment, the Gulf of Maine - Georges Bank windowpane flounder (*Scophthalmus aquosus*) stock is overfished but overfishing is not occurring (Figures 78-79). Retrospective adjustments were not made to the model results. The mean NEFSC fall bottom trawl survey index from years 2014, 2015 and 2016 (a 3-year moving average is used as a biomass index) was 0.359 kg/tow which is lower than the $B_{Threshold}$ of 1.030 kg/tow. The 2016 relative fishing mortality was estimated to be 0.222 kt per kg/tow which is lower than the F_{MSY} *proxy* of 0.340 kt per kg/tow.

Table 48: Catch and model results table for Gulf of Maine - Georges Bank windowpane flounder. All landings and discard weights are rounded to the nearest metric ton. Biomass index is in units of kg/tow, and relative F is in units of kt per kg/tow (catch in kt per kg/tow of the survey index).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Data										
Commercial discards	974	329	412	235	180	198	355	215	187	85
Commercial landings	117	46	28	0	0	1	0	0	0	0
Total catch	1,091	376	440	236	180	199	355	215	188	85
Model Results										
Biomass index	0.524	0.448	0.442	0.467	0.433	0.343	0.518	0.535	0.536	0.36
Relative F	2.079	0.849	0.996	0.514	0.416	0.584	0.676	0.393	0.354	0.222

Table 49: Reference points estimated in the 2015 assessment and in the current assessment update. F_{MSY} *proxy* is in units of kt per kg/tow.

	2015	2017
F_{MSY} *proxy*	0.450	0.340 (0.009 - 0.659)
B_{MSY} *proxy* (kg/tow)	1.554	2.060
MSY proxy (mt)	700	700
Overfishing	No	No
Overfished	Yes	Yes

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).

  Even though estimated catch has decreased in recent years, the survey index has not shown any resulting increase despite evidence of regular recruitment from survey length frequencies. Since there has been a 'no possession' rule in place since 2010, almost 100% of catch has consisted of estimated discards. These estimates have a higher CV than those for the southern stock but are still fairly low at a mean of 0.124 since 2010 so it is unlikely discards are being poorly estimated. Removals by Canadian fisheries occur from the northern stock area and are not used as a catch component in the model. Using them, especially if they have changed over time, might improve the model fit, which is not as good as the southern stock.

- 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 AIM (An Index Model) model used to estimate status of this stock does not allow estimation of a 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?

  The GARM benchmark indicated that projections should not be made based on discards, so no projections are run for windowpane flounder. Northern windowpane flounder was supposed to be rebuilt by 2017, however the 2008 GARM report states 'Given that current catch is mostly incidental and also given the high uncertainty of index based assessments, it was concluded that it was not appropriate to calculate F rebuild for this stock'.

- 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.

  No changes were made to the Gulf of Maine - Georges Bank windowpane flounder assessment for this update other than the incorporation of 2015 and 2016 NEFSC fall bottom trawl survey data and 2015 and 2016 U.S. commercial landings and discard data.

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

  The stock status of Gulf of Maine - Georges Bank windowpane flounder has not changed since the previous assessment. In 2015, the F status changed from overfishing to no overfishing.

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

  Since the year 2000, Gulf of Maine - Georges Bank windowpane flounder has shown decreasing survey indices despite reductions in catch and relative F levels, and the model output replacement ratio for 2016 was only 0.68. The stock was declared overfished in 2007 (the final year of data for GARM 2008) and was scheduled to be rebuilt by 2017, but the stock still remains below the biomass threshold. According to 21.6, windowpane flounder has low *overall climate vulnerability and both males and females are currently showing high condition indices. There are also new recruits regularly present in the fall bottom trawl survey catches.*

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

  While the Gulf of Maine - Georges Bank windowpane flounder AIM model fit is reasonable (the relationship between ln(relative F) and ln(replacement ratio), a measure of the relationship between catch and survey index values, has a p-value of 0.11) there may be catches (such as from the Canadian groundfishery on Georges Bank), discards, or incidental mortality unaccounted for in the model. The fit might be improved in the future by estimating additional sources of mortality or removal from the population that may be increasing over recent years. There may also be value in looking carefully at the windowpane stock definitions to see if there might be reason to change them. For the last several years the NEFSC has been collecting otoliths from northern windowpane during the fall survey and we now have several year's worth of ages, enough to explore an age-based model such as ASAP which could provide insight into the population dynamics of northern windowpane.

- Are there other important issues?

  None.

16.1 Reviewer Comments: Gulf of Maine - Georges Bank windowpane flounder

Assessment Recommendation:

The panel concluded that the operational assessment was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this updated assessment, the panel agrees with the conclusion that the Gulf of Maine-Georges Bank windowpane flounder stock is overfished but overfishing is not occurring. Since the year 2000, Gulf of Maine-Georges Bank windowpane flounder has shown decreasing survey indices despite reductions in catch and relative F levels. The stock was declared overfished in 2007 (the final year of data for Groundfish Assessment Review Meeting 2008) and was scheduled to be rebuilt by 2017, but the stock still remains below the biomass threshold. Windowpane flounder has low overall climate vulnerability, the larval index has been stable over many years, and both males and females are currently showing high condition indices. There are also new recruits regularly present in the fall bottom trawl survey catches.

Key Sources of Uncertainty:

Even though estimated catch has decreased in recent years, the survey index has not shown any resulting increase despite evidence of regular recruitment from survey length frequencies. There are uncertainties around discard estimates. Removals by Canadian fisheries occur from the Gulf of Maine-Georges Bank stock area and are not used as a catch component in the model. The model fit is notably poor and is worse than in the 2015 operational assessment.

Research Needs:

The panel recommends research focused on estimating additional sources of mortality or removal from the population that may be increasing over recent years. There may also be value in looking carefully at the windowpane stock definitions to see if there might be reason to change them. For the last several years the National Marine Fisheries Service has been collecting otoliths from Gulf of Maine-Georges Bank windowpane during the fall survey and now has several years' worth of ages, enough to explore a statistical catch-at-age model, which could provide insight into the population dynamics of Gulf of Maine-Georges Bank windowpane.

References:

Most recent assessment update:
Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, updated through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. Available online at http://nefsc.noaa.gov/publications/crd/crd1524

Most recent benchmark assessment:
Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA FIsheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii.

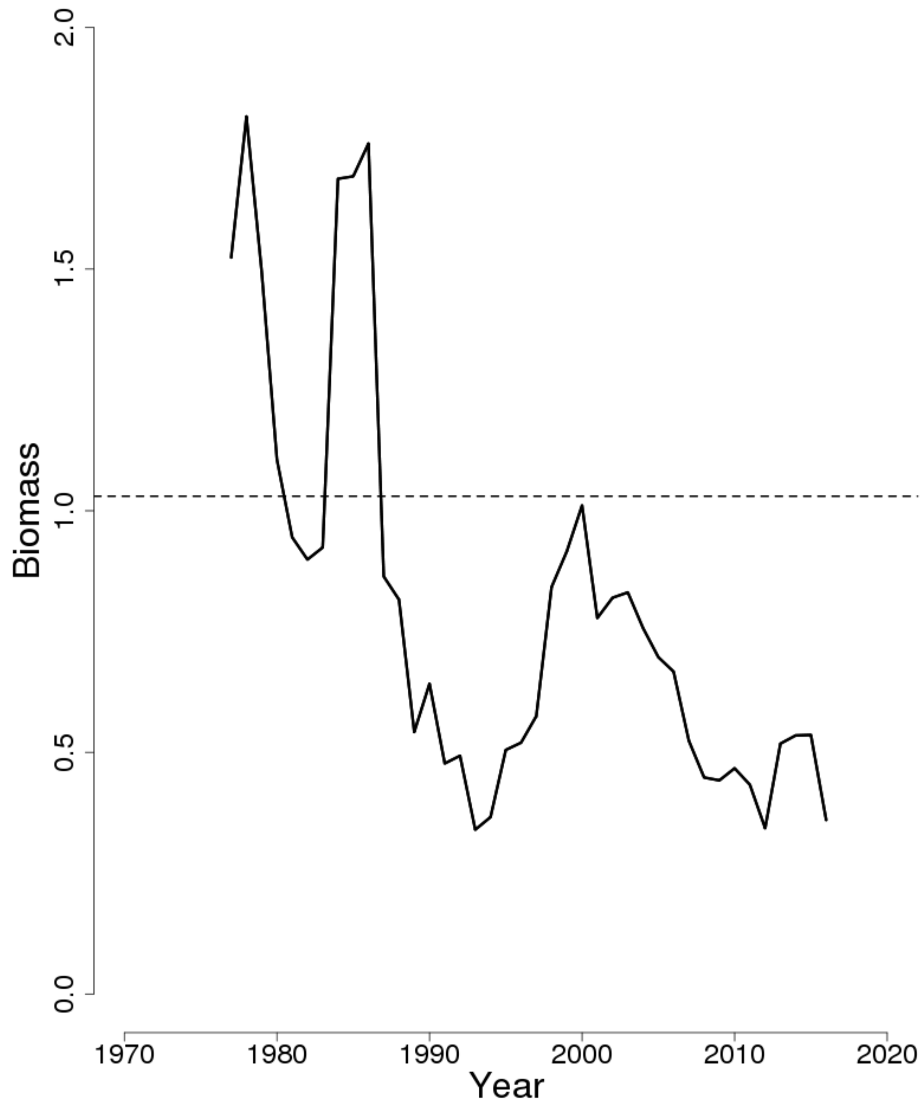

Figure 78: Trends in the biomass index (a 3-year moving average of the NEFSC fall bottom trawl survey index) of Gulf of Maine - Georges Bank windowpane flounder between 1975 and 2016 from the current assessment, and the corresponding $B_{Threshold} = \frac{1}{2}\ B_{MSY}$ *proxy* $=$ 1.030 kg/tow (horizontal dashed line).

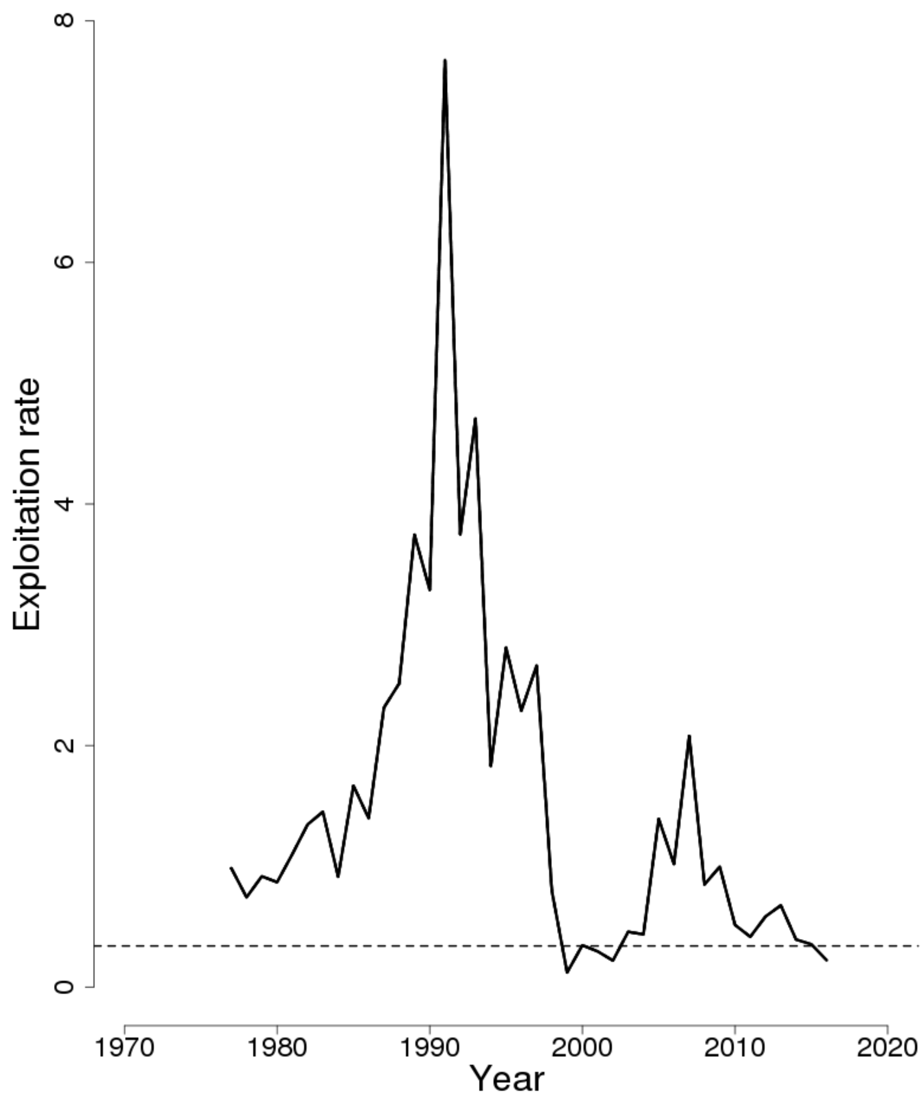

Figure 79: Trends in estimated relative fishing mortality of Gulf of Maine - Georges Bank windowpane flounder between 1975 and 2016 from the current assessment, and the corresponding F_{MSY} *proxy* = 0.34 (horizontal dashed line).

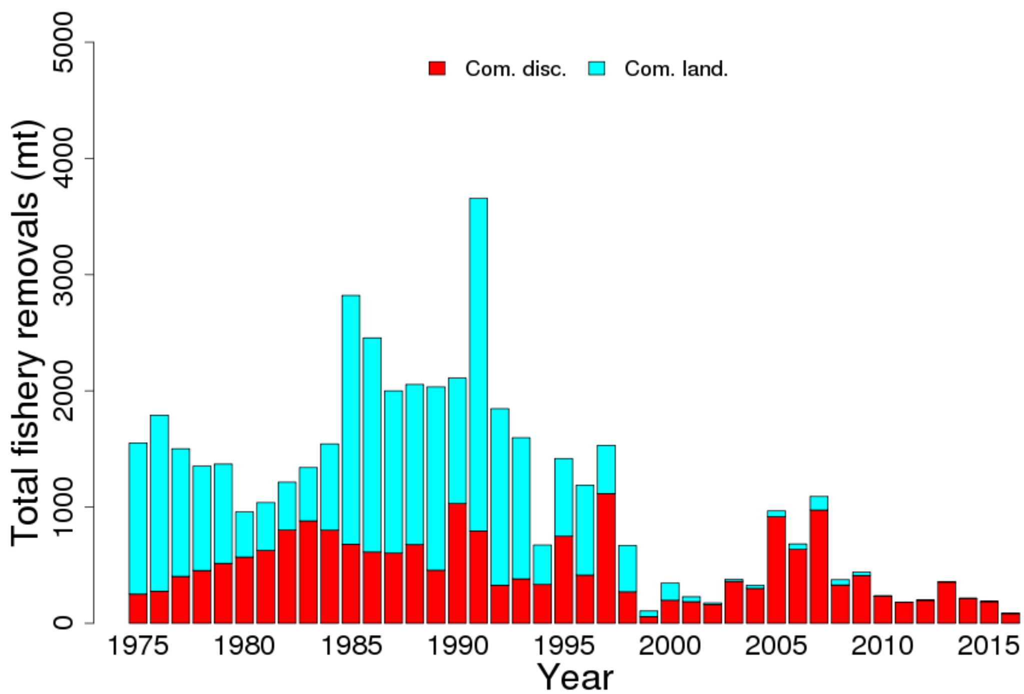

Figure 80: Total catch of Gulf of Maine - Georges Bank windowpane flounder between 1975 and 2016 by disposition (landings and discards).

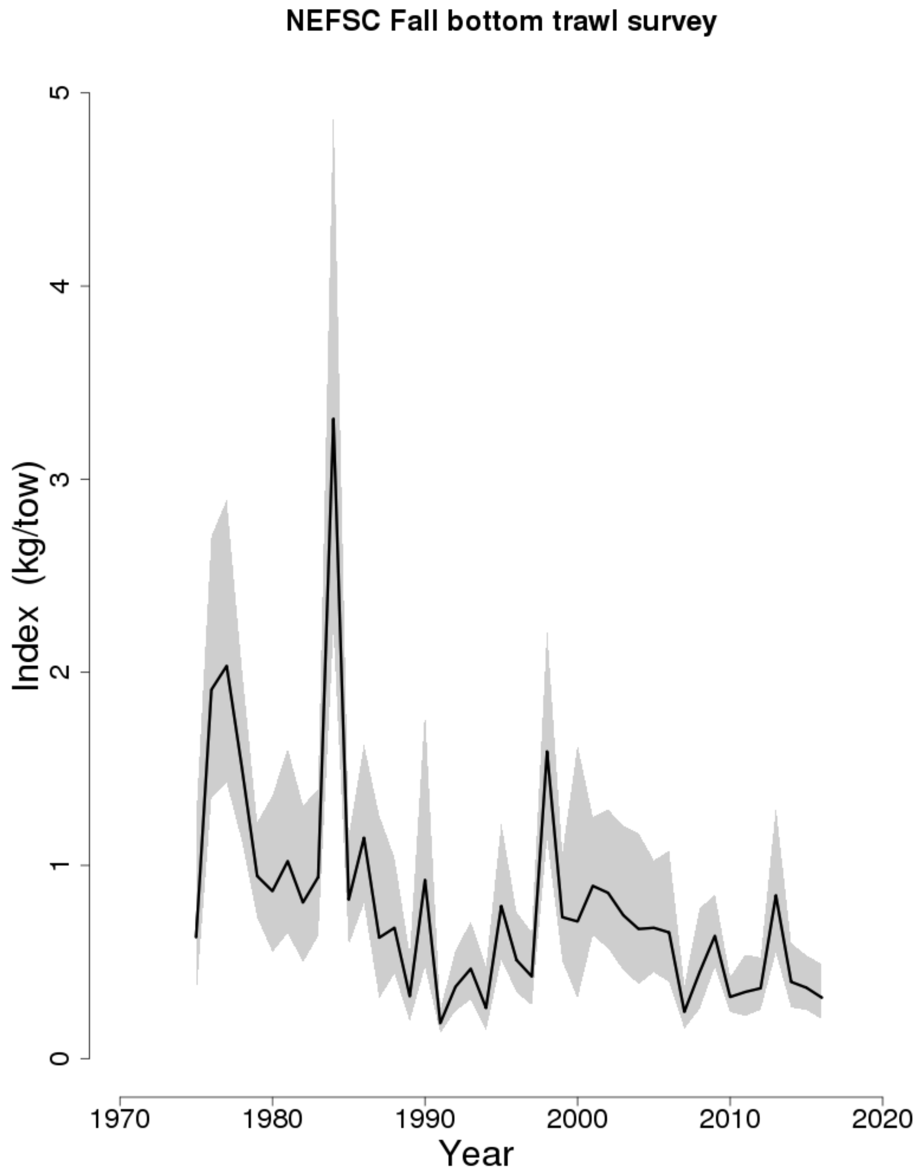

Figure 81: NEFSC fall bottom trawl survey indices in kg/tow for Gulf of Maine - Georges Bank windowpane flounder between 1975 and 2016. The approximate 90% lognormal confidence intervals are shown.

17 Southern New England - mid-Atlantic windowpane flounder

Toni Chute

This assessment of the southern New England - mid-Atlantic windowpane flounder (Scophthalmus aquosus) stock is an operational update of the 2015 assessment which was based on fishery and survey data through 2014 (NEFSC 2015). Based on the 2015 assessment the stock was not overfished, and overfishing was not ocurring. This assessment updates commercial fishery catch data, survey indices of abundance, AIM model results, and reference points through 2016.

State of Stock: Based on this updated assessment, the southern New England - mid-Atlantic windowpane flounder (*Scophthalmus aquosus*) stock is not overfished and overfishing is not occurring (Figures 82-83). Retrospective adjustments were not made to the model results. The mean NEFSC fall bottom trawl survey index from years 2014, 2015, and 2016 (a 3-year moving average is used as a biomass index) was 0.329 (kg/tow) which is higher than the $B_{Threshold}$ of 0.126 (kg/tow). The 2016 relative fishing mortality was estimated to be 1.733 (kt per kg/tow) which is lower than the F_{MSY} *proxy* of 1.918 (kt per kg/tow).

Table 50: Catch and model results table for southern New England - mid-Atlantic windowpane flounder. All landings and discard weights are rounded to the nearest metric ton. Biomass index is in units of kg/tow, and relative F is in units of kt per kg/tow (catch in kt per kg/tow of the survey index).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
				Data						
Commercial discards	266	246	405	435	445	701	681	525	516	557
Commercial landings	83	74	53	53	32	29	22	14	22	13
Catch for Assessment	349	321	458	489	477	730	703	539	539	571
				Model Results						
Biomass index	0.191	0.204	0.245	0.345	0.435	0.517	0.464	0.413	0.318	0.329
Relative F	1.83	1.572	1.88	1.419	1.103	1.413	1.507	1.308	1.694	1.733

Table 51: Reference points estimated in the 2012 assessment and in the current assessment update. F_{MSY} *proxy* is in units of kt per kg/tow.

	2015	2017
F_{MSY} *proxy*	2.027	1.918 (0.972 - 2.420)
B_{MSY} *proxy* (kg/tow)	0.247	0.253
MSY proxy (mt)	500	500
Overfishing	No	No
Overfished	No	No

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).

  Since there has been a 'no posession' rule in place since 2010, commercial windowpane landings have been essentially zero. As a result, in recent years almost 100% of the catch input to the model has been estimated discards. The CVs for these estimates have been small, however, with a mean of 0.93 since 2010, so it is unlikely discards are being severely overestimated or underestimated or the trend over time has been obscured. Discard estimates from the general category scallop fleet (operating largely in the southern stock area) are not included in the model. Using these estimated discards would add about 3% to the catch, but does not change the results of the model.

- 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 AIM (An Index Model) model used to estimate status of this stock does not allow estimation of a 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?

  The GARM benchmark indicated that projections should not be made based on discards, so no projections are run for windowpane flounder.

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

  No changes were made to the southern New England - mid-Atlantic windowpane flounder assessment for this update other than the incorporation of two years of new NEFSC fall bottom trawl survey data and two years of new U.S. commercial landings and discard data (2015 and 2016).

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

  The stock status of southern New England - mid-Atlantic windowpane flounder has not changed since the previous assessment.

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

  Since the year 2000, southern New England - mid-Atlantic windowpane flounder has shown increased survey indices and fairly stable catch and relative F levels. There is some noise in the replacement ratio model output, but the 2016 estimate of 0.92, although lower than desired, exceeds the estimates from the previous three years. The stock was declared overfished in 2005 (although the AIM model was not used) and recovered in 2008, so there is a recent history of the stock falling below reference points for biomass, but also having the ability to recover within a fairly short time period. Overfishing was occurring in 2007 (the final year of data used for the 2008 assessment) but has not occurred in the two most recent assessment updates. According to 21.6, windowpane has low overall climate vulnerability and females are currently showing high condition indices.

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

  The AIM model fit is presently good with a randomization test indicating the correlation between ln(relative F) and ln(replacement ratio), a measure of the relationship between catch and survey index values, is significant (p = 0.002) so it is not clear what new information would help acheive better results with the AIM model. There has been some ageing work for southern windowpane done at VIMS which we are currently exploring for use in an age-based model such as ASAP which might provide insight into the population dynamics of southern windowpane.

- Are there other important issues?

  None.

17.1 Reviewer Comments: Southern New England - mid-Atlantic windowpane flounder

Assessment Recommendation:

The panel concluded that the operational assessment was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the Southern New England-Mid-Atlantic windowpane flounder stock is not overfished and overfishing is not occurring. Since the year 2000, Southern New England-Mid-Atlantic windowpane flounder has shown increased survey indices, fairly stable catch and relative F levels. The stock was declared overfished in 2005 and recovered in 2008, so there is a recent history of the stock falling below reference points for biomass, but also having the ability to recover within a fairly short time period. Overfishing was occurring in 2007 (the final year of data used for the 2008 assessment) but has not occurred in the two most recent assessment updates. Southern New England-Mid-Atlantic windowpane has low overall climate vulnerability and are currently showing high condition indices (only females were analyzed).

Key Sources of Uncertainty:

There is some noise in the replacement ratio model output, but the 2016 estimate exceeds the estimates from the previous three years and is close to 1. Discard estimates from the general category scallop fleet (operating largely in the Southern New England-Mid-Atlantic stock area) are not included in the model. Using these estimated discards would add about 3% to the catch, but does not change the overall results of the model.

Research Needs:

The panel recommends considering incorporation of the ageing work for Southern New England-Mid-Atlantic windowpane done by the Virginia Institute of Marine Science (Northeast Area Monitoring and Assessment Program - NEAMAP) for use in an age-based model. This might provide further insight into the population dynamics of Southern New England-Mid-Atlantic windowpane.

References:

Most recent assessment update:
Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-06; 789 p. Available online at http://nefsc.noaa.gov/publications/

Most recent benchmark assessment:
Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3^{rd} Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, MA, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p.

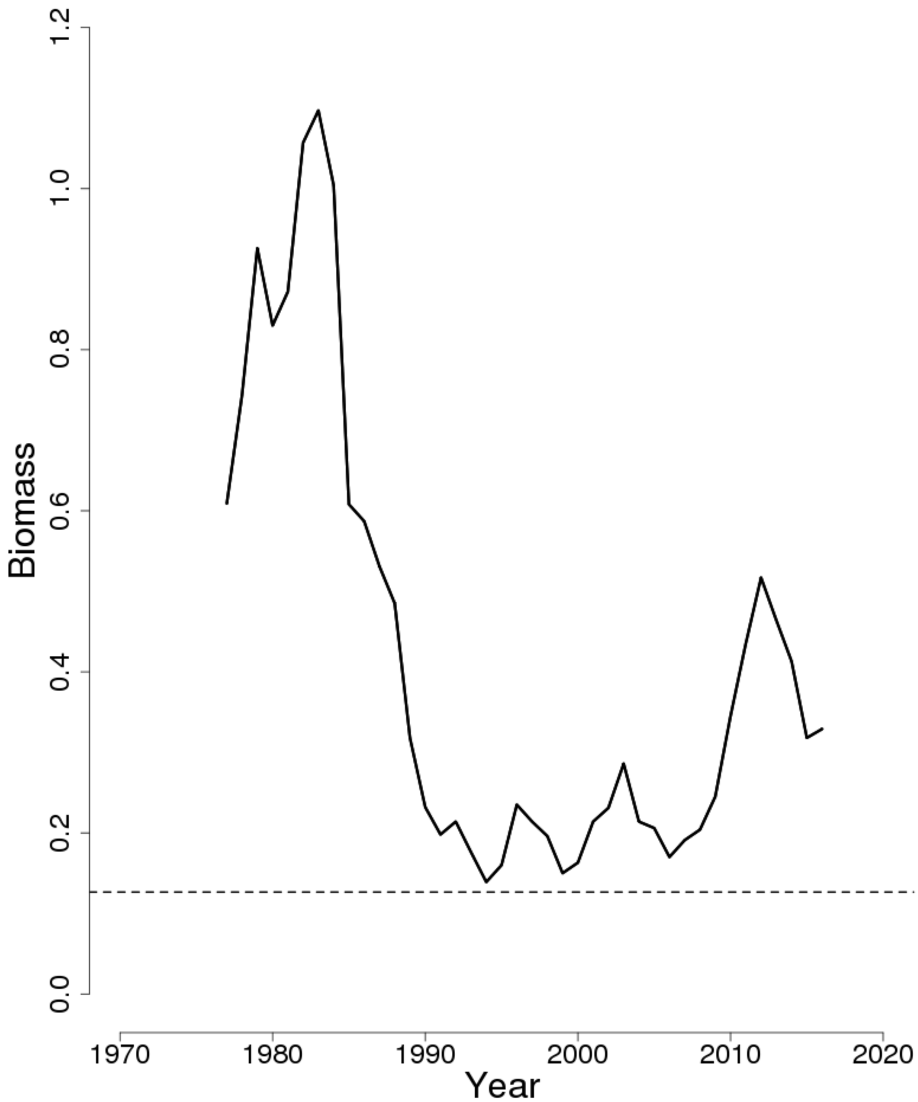

Figure 82: Trends in the biomass index (a 3-year moving average of the NEFSC fall bottom trawl survey index) of southern New England - mid-Atlantic windowpane flounder between 1975 and 2016 from the current assessment, and the corresponding $B_{Threshold} = \frac{1}{2}\ B_{MSY}$ *proxy* $= 0.126$ kg/tow (horizontal dashed line).

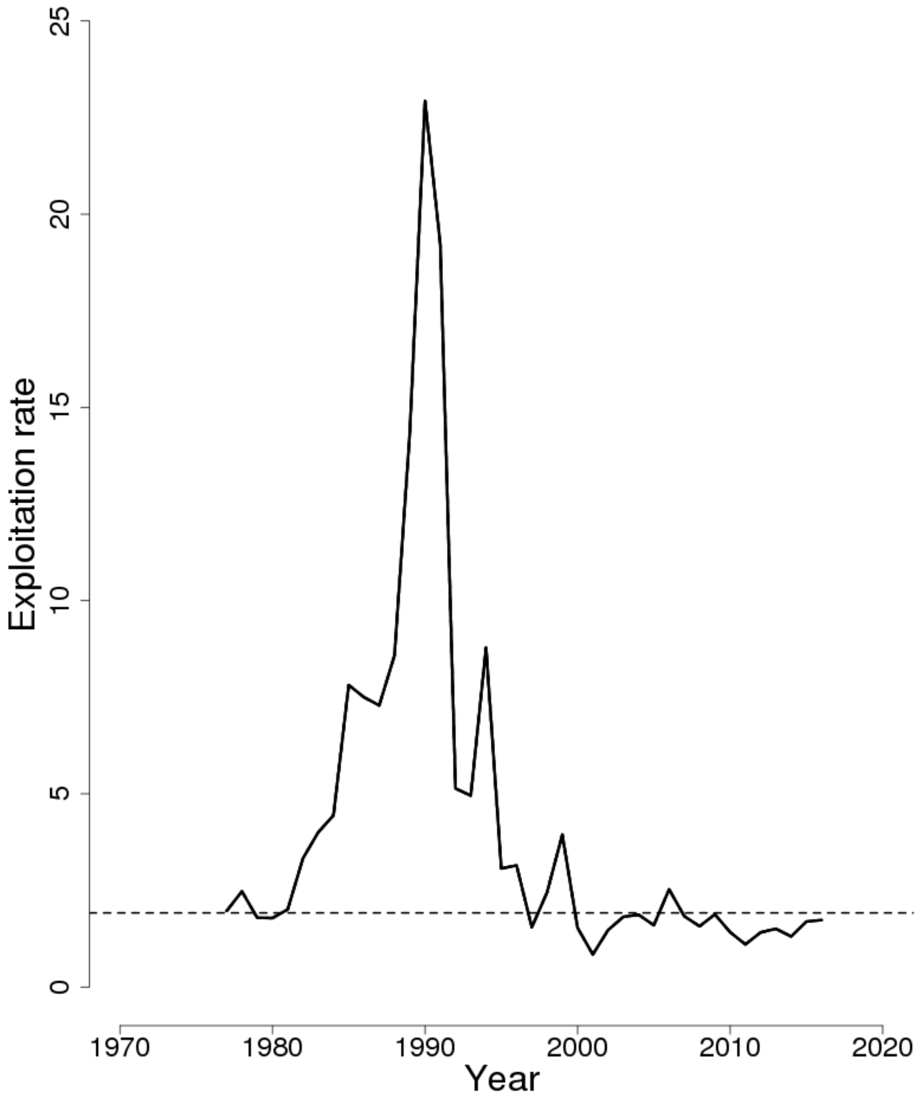

Figure 83: Trends in relative fishing mortality of southern New England - mid-Atlantic windowpane flounder between 1975 and 2016 from the current assessment, and the corresponding F_{MSY} *proxy*=1.918 (horizontal dashed line).

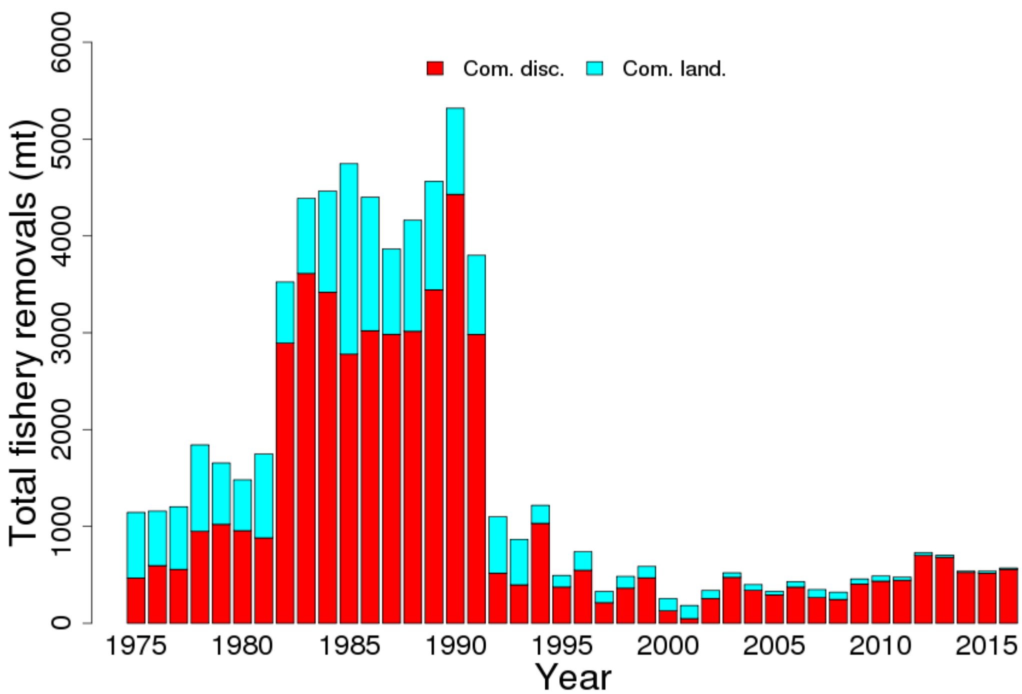

Figure 84: Total catch of southern New England - mid-Atlantic windowpane flounder between 1975 and 2016 by disposition (landings and discards).

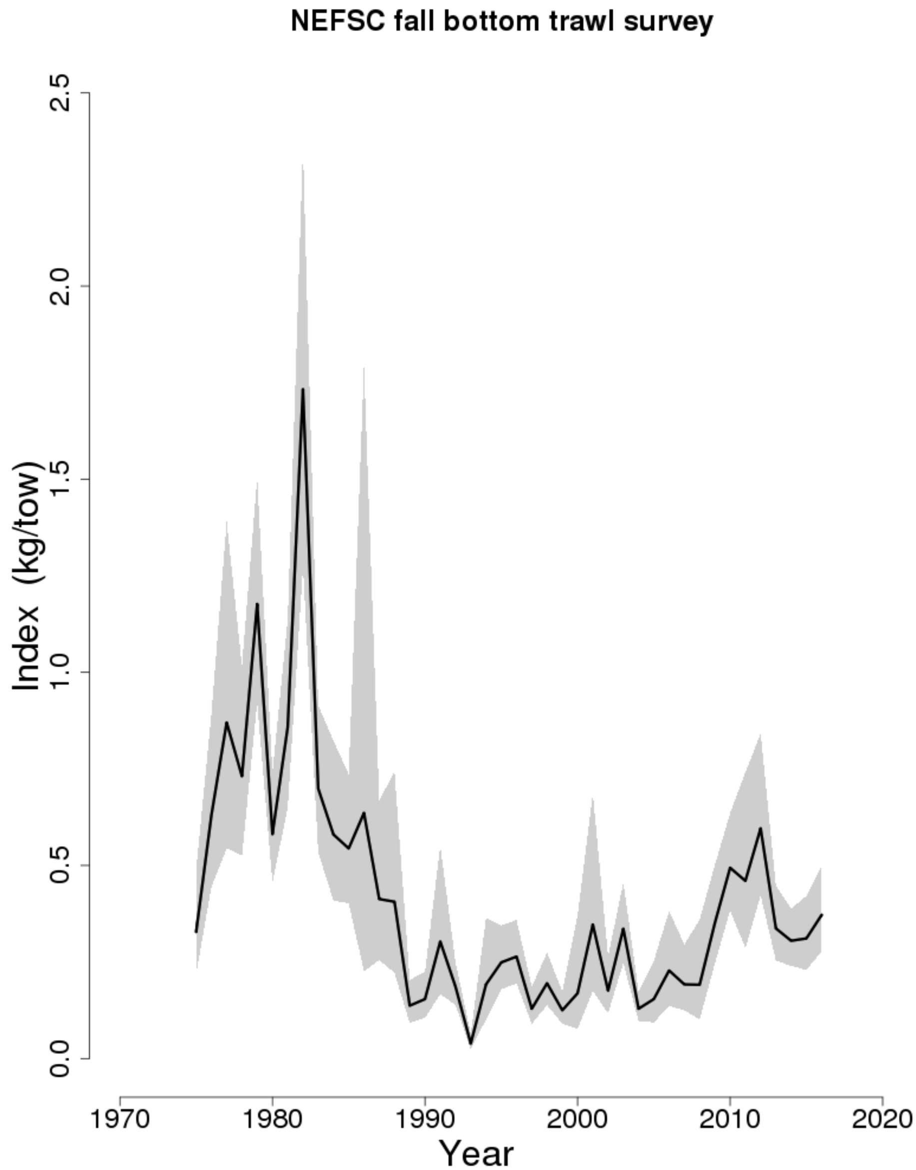

Figure 85: NEFSC fall bottom trawl survey indices in kg/tow for southern New England - mid-Atlantic windowpane flounder between 1975 and 2016. The approximate 90% lognormal confidence intervals are shown.

18 Ocean pout

Susan Wigley

This assessment of the ocean pout (Zoarces americanus) stock is an operational assessment of the 2015 operational assessment (NEFSC 2015). Based on the 2015 assessment, the stock was overfished but overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices and the exploitation ratios through 2016. There are no stock projections.

State of Stock: Based on the current assessment, the ocean pout (*Zoarces americanus*) stock is overfished and overfishing is not occurring (Figures 86-87). Retrospective adjustments were not made to the model results. Biomass proxy (B) in 2016 was estimated to be 0.223 (kg/tow) which is 5% of the biomass target (B_{MSY} *proxy* = 4.94; Figure 86). The 2016 fully selected fishing mortality was estimated to be 0.221 which is 29% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.76; Figure 87).

Table 52: Catch and model results table for ocean pout. Catch weights are in (mt), survey biomass is in (kg/tow), and the relative exploitation ratio is the total catch / NEFSC 3 year average spring biomass index. Model results are from the current updated index assessment. Note: A 2014 landings database correction was made.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Data										
US Commercial discards	164	118	165	125	76	94	68	74	63	49
US Commercial landings	4	7	3	0	0	0	0	0	0	0
Other landings	0	0	0	0	0	0	0	0	0	0
Catch for Assessment	167	126	168	126	77	90	68	74	63	49
Model Results										
NEFSC 3 yr average Spring Survey	0.475	0.513	0.479	0.44	0.343	0.298	0.357	0.29	0.317	0.223
Relative Exploitation Ratio	0.352	0.245	0.35	0.286	0.224	0.302	0.191	0.256	0.197	0.221

Table 53: Comparison of reference points estimated in an earlier assessment and from the current updated assessment. For ocean pout, median NEFSC 3 year average Spring survey biomass and median exploitation ratio during 1977-1985 are used as B_{MSY} and F_{MSY} proxies, respectively.

	2015	2017
F_{MSY} *proxy*	0.76	0.76
B_{MSY} *proxy* (kg/tow)	4.94	4.94
MSY (mt)	3,754	3,754
Overfishing	No	No
Overfished	Yes	Yes

Projections: The index-based assessment approach does not support catch projections; catch advice for ocean pout has been based on the target exploitation rate and the most recent centered 3-year average biomass index from the NEFSC spring survey.

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).
  An important source of uncertainty is the stock has not responded to low catch as expected.

- 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}; see Table 8).
  The model used to estimate status of this stock does not allow estimation of a 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?
  N/A

- Describe any changes that were made to the current stock assessment, beyond incorporating additional years of data and the effect these changes had in the assessment and stock status.
  A database correction was made to the 2014 ocean pout landings. This change had a negligible effect on the assessment. Recreational landings were updated and were found to be negligible (time series average of recreational landings to total catch was less than 1%) and therefore not included in this assessment.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  Ocean pout stock status has not changed since the previous assessment.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  Discards comprise most of the catch since the no possession regulation was implemented in May 2010. The NEFSC survey indices remain at near-record low levels; there are few large fish in the population. The ocean pout stock remains in poor condition.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The ocean pout assessment could be improved with studies that explore why this stock is not rebuilding as expected.

- Are there other important comments?
  Biological reference points are based on catch; the estimated discards used in the catch are based on a mix of direct (1989 onward) and indirect (1988 and back) methods. The catch

used to determine MSY is based on indirect methods. Minimum estimates of scientific research removals of ocean pout ranged between 0.2 and 24.9 mt, with an average of 3 mt between 1963 and 2016. The NEFSC bottom trawl surveys, Massachusetts Division of Marine Fisheries inshore surveys, Atlantic States Marine Fisheries Commission summer shrimp surveys, and various Cooperative Research surveys (e.g., such as Industry-based surveys for cod and for yellowtail flounder) and gear studies have contributed to scientific research removals.

18.1 Reviewer Comments: Ocean pout

Assessment Recommendation:

The panel concluded that the operational assessment was acceptable as a scientific basis for management advice.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on the operational assessment, the panel agrees with the conclusion that the ocean pout stock is overfished and overfishing is not occurring. Discards comprise most of the catch since the no possession regulation was implemented in May 2010. The National Marine Fisheries Service survey indices remain at near-record low levels, and there are few large fish in the population. The ocean pout stock remains in poor condition.

Key Sources of Uncertainty:

An important source of uncertainty is that the stock size has not increased as a result of catch reductions. The majority of catch is comprised of discards, which are estimated using both direct and indirect methods. There are questions over whether the current perspective of the stock is due to environmental drivers influencing stock abundance.

Research Needs:

The ocean pout assessment could be improved with studies that explore why this stock is not rebuilding, in particular an exploration of whether fishing mortality, biological dynamics, or environmental drivers may be causing this issue.

References:

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks,Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; 251 p. CRD15-24

Northeast Fisheries Science Center. 2012. Assessment or Data Updates of 13 Northeast Groundfish Stocks through 2010. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 12-06; 789 p. CRD12-06

Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii. CRD08-15

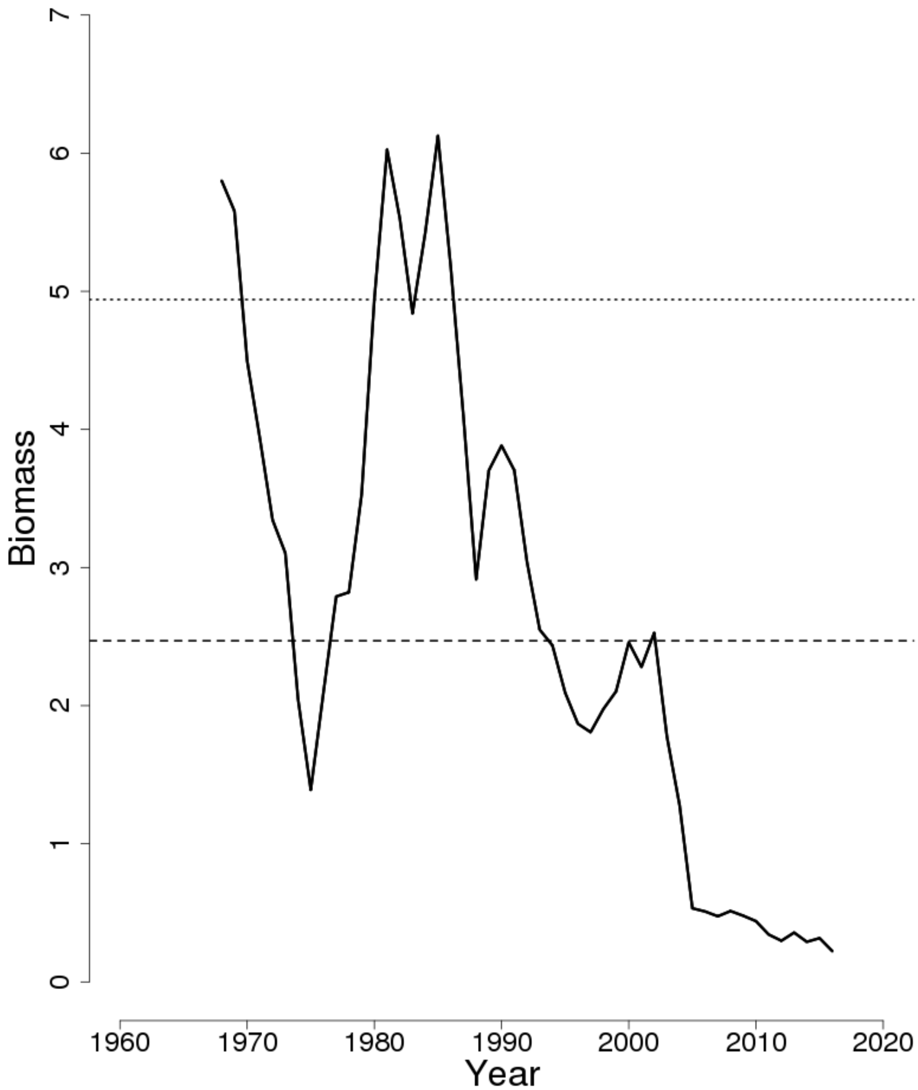

Figure 86: Trends in biomass (kg/tow) of ocean pout between 1968 and 2016 from the current (solid line) and previous (dashed line) assessment, and the corresponding $B_{Threshold}$ ($\frac{1}{2}$ B_{MSY} *proxy*; horizontal dashed line) as well as B_{Target} (B_{MSY} *proxy*; horizontal dotted line) based on the current assessment.

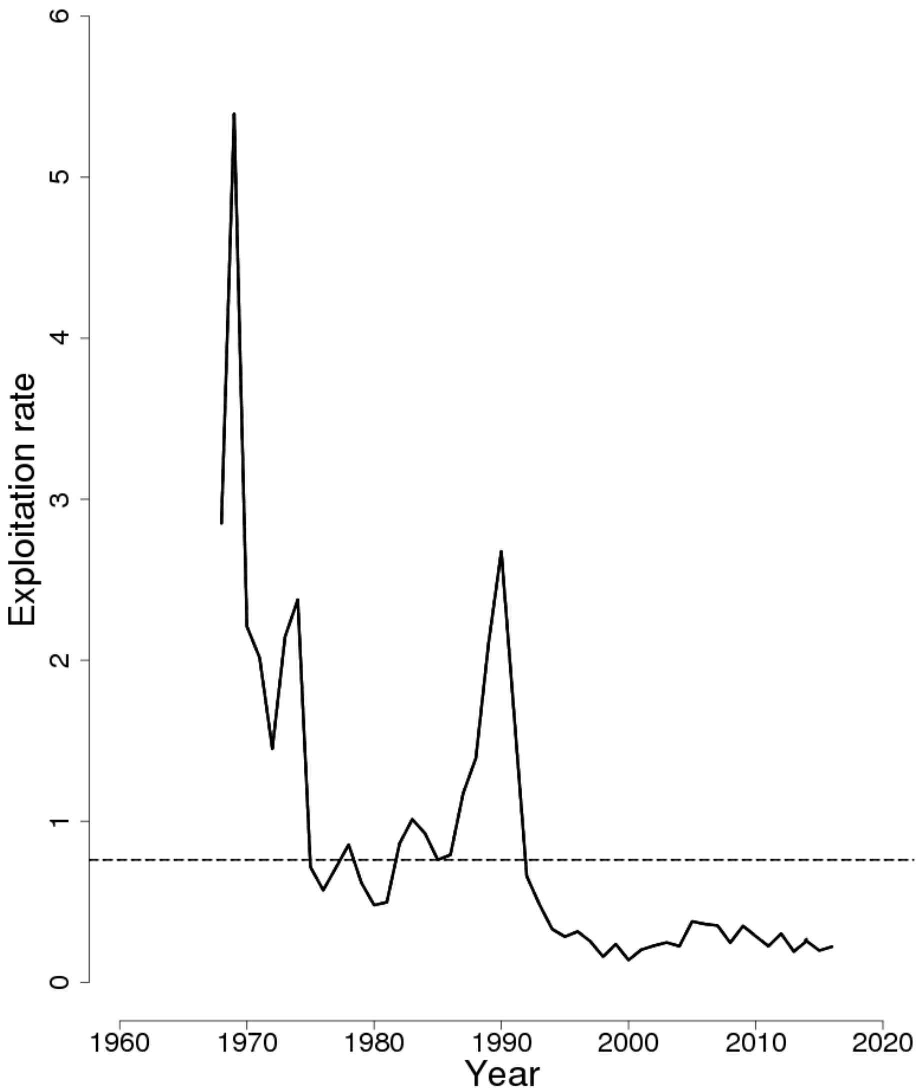

Figure 87: Trends in the exploitation rate of ocean pout between 1968 and 2016 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.76; horizontal dashed line) based on the current assessment.

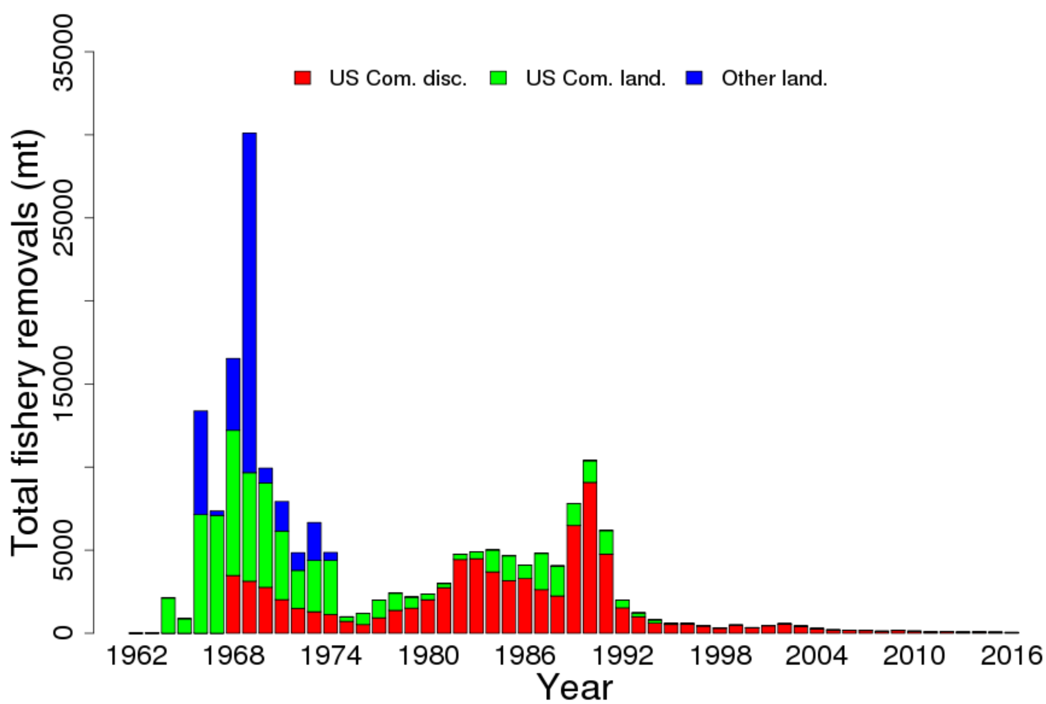

Figure 88: Total catch of ocean pout between 1968 and 2016 by fleet (US and Other) and disposition (landings and discards).

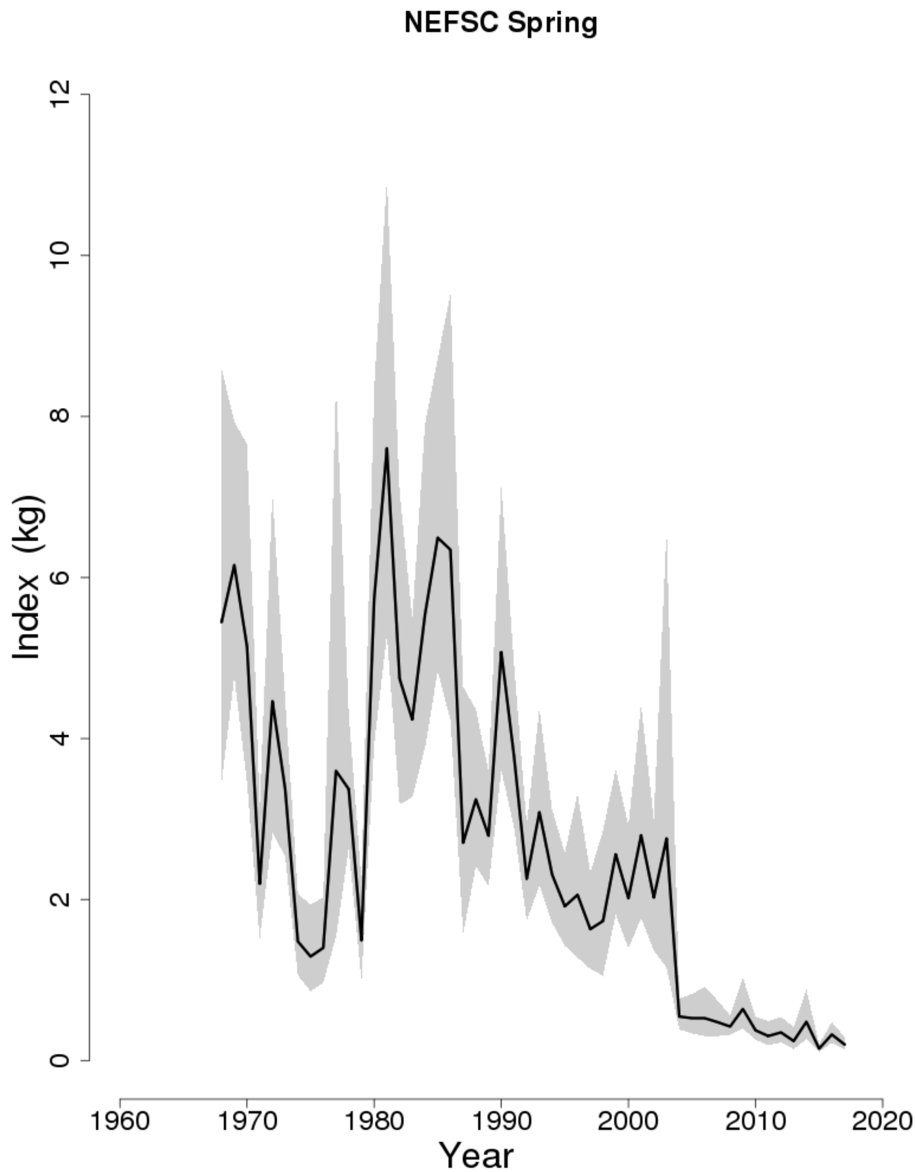

Figure 89: Indices of biomass (kg/tow) for ocean pout between 1968 and 2017 for the Northeast Fisheries Science Center (NEFSC) spring survey. The approximate 90% lognormal confidence intervals are shown.

19 Gulf of Maine winter flounder

Paul Nitschke

This assessment of the Gulf of Maine winter flounder (Pseudopleuronectes americanus) stock is an operational assessment of the existing 2015 operational assessment area-swept assessment (NEFSC 2015). Based on the previous assessment the biomass status is unknown but overfishing was not occurring. This assessment updates commercial and recreational fishery catch data, research survey indices of abundance, and the area-swept estimates of 30+ cm biomass based on the fall NEFSC, MDMF, and MENH surveys.

State of Stock: Based on this updated assessment, the Gulf of Maine winter flounder (*Pseudopleuronectes americanus*) stock biomass status is unknown and overfishing is not occurring (Figures 90-91). Retrospective adjustments were not made to the model results. Biomass (30+ cm mt) in 2016 was estimated to be 2,585 mt (Figure 90). The 2016 30+ cm exploitation rate was estimated to be 0.086 which is 37% of the overfishing exploitation threshold proxy (E_{MSY} *proxy* = 0.23; Figure 91).

Table 54: Catch and status table for Gulf of Maine winter flounder. All weights are in (mt) and E_{Full} is the exploitation rate on 30+ cm fish. Biomass is estimated from survey area-swept for non-overlaping strata from three different fall surveys (MENH, MDMF, NEFSC) using an updated q estimate of 0.87 on the wing spread from the sweep study (Miller et al., 2017).

	2011	2012	2013	2014	2015	2016
Data						
Recreational discards	4	1	1	2	1	6
Recreational landings	38	22	29	55	27	24
Commercial discards	4	10	6	5	2	3
Commercial landings	173	348	218	213	186	188
Catch for Assessment	219	381	254	275	217	221
Model Results						
30+ cm Biomass	4,618	2,312	2,032	3,225	2,307	2,585
E_{Full}	0.047	0.165	0.125	0.085	0.094	0.086

Table 55: Comparison of reference points estimated in an earlier assessment and from the current assessment update. An $E_{40\%}$ exploitation rate proxy was used for the overfishing threshold and was based on a length based yield per recruit model from the 2011 SARC 52 benchmark assessment.

	2015	2017
E_{MSY} *proxy*	0.23	0.23
B_{MSY}	Unknown	Unknown
MSY (mt)	Unknown	Unknown
Overfishing	No	No
Overfished	Unknown	Unknown

Projections: Projections are not possible with area-swept based assessments. Catch advice was based on 75% of $E_{40\%}$(75% E_{MSY} *proxy*) using the fall area-swept estimate assuming q=0.87 on the wing spread which was updated using the average efficiency from 2009-2016 from the sweep experiment (Miller et al., 2017). Updated 2016 fall 30+ cm area-swept biomass (2,585 mt) implies an OFL of 595 mt based on the E_{MSY} *proxy* and a catch of 446 mt for 75% of the E_{MSY} *proxy*.

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 largest source of uncertainty with the direct estimates of stock biomass from survey area-swept estimates originates from the survey gear catchability (q). Biomass and exploitation rate estimates are sensitive to the survey q assumption. However this 2017 update does incorporate the use of an estimated q through an average estimate of efficiency from 2009-2016 (q=0.87) from the sweep study for the NEFSC survey. This updated q assumption (0.87) results in a lower estimate of 30+ biomass (2,585 mt) relative to the original q=0.6 assumption (3,731 mt) from the fall surveys. Another major source of uncertainty with this method is that biomass based reference points cannot be determined and overfished status is unknown.

- 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}; see Table 8).
  The model used to determine status of this stock does not allow estimation of a retrospective pattern. An analytical stock assessment model does not exist for Gulf of Maine winter flounder. An analytical model was no longer used for stock status determination at SARC 52 (2011) due to concerns with a strong retrospective pattern. Models have difficulty with the apparent lack of a relationship between a large decrease in the catch with little change in the indices and age and/or size structure over time.

- 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 winter flounder do not exist for area-swept assessments and stock biomass status is unknown. Catch advice from area-swept estimates tend to vary with interannual variability in the surveys. Stabilizing the catch advice may also be desired and could be obtained through the averaging of the area-swept fall and spring survey estimates or through the use of a moving average across years.

- 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 assumption on q changed from 0.6 to 0.87 using information from the sweep experiment (Miller et al., 2017) and incorporation of new survey data were made to this Gulf of Maine winter flounder assessment update.

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

  The overfishing status of Gulf of Maine winter flounder has not changed.

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

  The Gulf of Maine winter flounder has relatively flat survey indices with little change in the size structure over time. There have been large declines in the commercial and recreational removals since the 1980s. However, this large decline over the time series does not appear to have resulted in a response in the stock's size structure within the catch and surveys nor has it resulted in a change in the survey indices of abundance.

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

  Direct area-swept assessments could be improved with additional studies on federal and state survey gear efficiency. Quantifying the degree of herding between the doors and escapement under the footrope and/or above the headrope for state surveys is needed to improve the area-swept biomass estimates. Studies quantifying winter flounder abundance and distribution among habitat types and within estuaries could improve the biomass estimate.

- Are there other important issues?

  The general lack of a response in survey indices and age/size structure are the primary sources of concern with catches remaining far below the overfishing level.

19.1 Reviewer Comments: Gulf of Maine winter flounder

Assessment Recommendation:

The panel concluded that the operational assessment was acceptable as a scientific basis for management advice, including the decision to use a revised average catchability estimate from the recent cooperative research project on fall survey catchability.

Alternative Assessment Approach:

Not applicable

Status Recommendation:

Based on this operational assessment, the panel supports the conclusion that the Gulf of Maine winter flounder stock biomass status is unknown and overfishing is not occurring. The Gulf of Maine winter flounder has relatively flat survey indices with little change in the size structure over time. There have been large declines in the commercial and recreational removals since the 1980s. However, this large decline over the time series does not appear to have resulted in a response in the stock's size structure within the catch and surveys nor has it resulted in a change in the survey indices of abundance.

Key Sources of Uncertainty:

The largest source of uncertainty concerns the direct estimates of stock biomass from survey area-swept estimates originating from the survey gear catchability (q), in part due to small sample sizes and application to different gear types and other surveys. Another major source of uncertainty with this method is that biomass based reference points cannot be determined and overfished status is unknown. The general lack of a response in survey indices and age/size structure are the primary sources of concern with catches remaining far below the overfishing level.

Research Needs:

The panel recommends additional studies on federal and state survey gear efficiency. Quantifying the degree of herding between the doors and escapement under the footrope and/or above the headrope for state surveys is also warranted. Studies quantifying winter flounder abundance and distribution among habitat types and within estuaries could improve biomass estimates. The panel further recommends consideration of including additional surveys (e.g., spring trawl survey). Finally, a moving average approach to estimating catch advice (rather than based on a single year) should be considered to stabilize catch advice.

References:

Northeast Fisheries Science Center. 2015. Operational Assessment of 20 Northeast Groundfish Stocks, Updated Through 2014. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 15-24; Commer, Northeast Fish Sci Cent Ref Doc. 15-01; 251 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD15-24

Northeast Fisheries Science Center. 2011. 52^{nd} Northeast Regional Stock Assessment Workshop (52^{nd} SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-17; 962 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD11-17

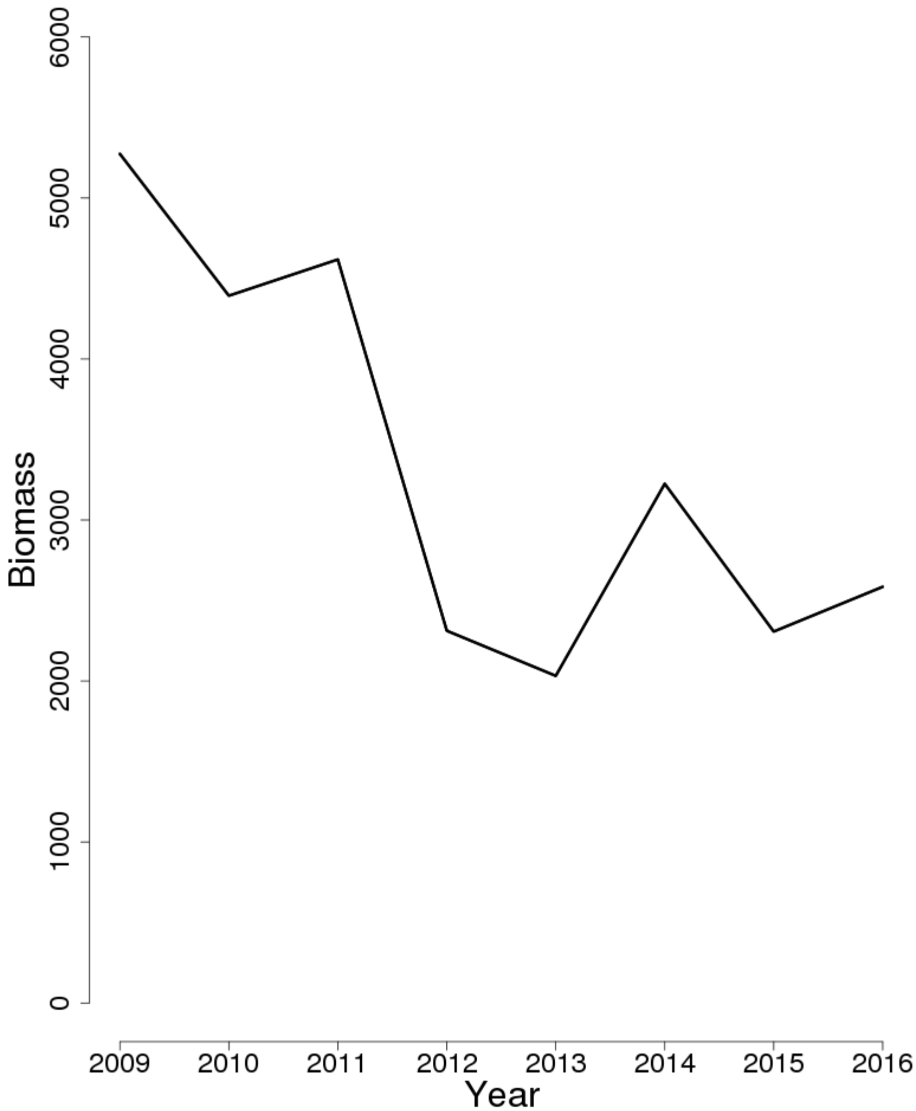

Figure 90: Trends in 30+ cm area-swept biomass of Gulf of Maine winter flounder between 2009 and 2016 from the current assessment based on the fall (MENH, MDMF, NEFSC) surveys.

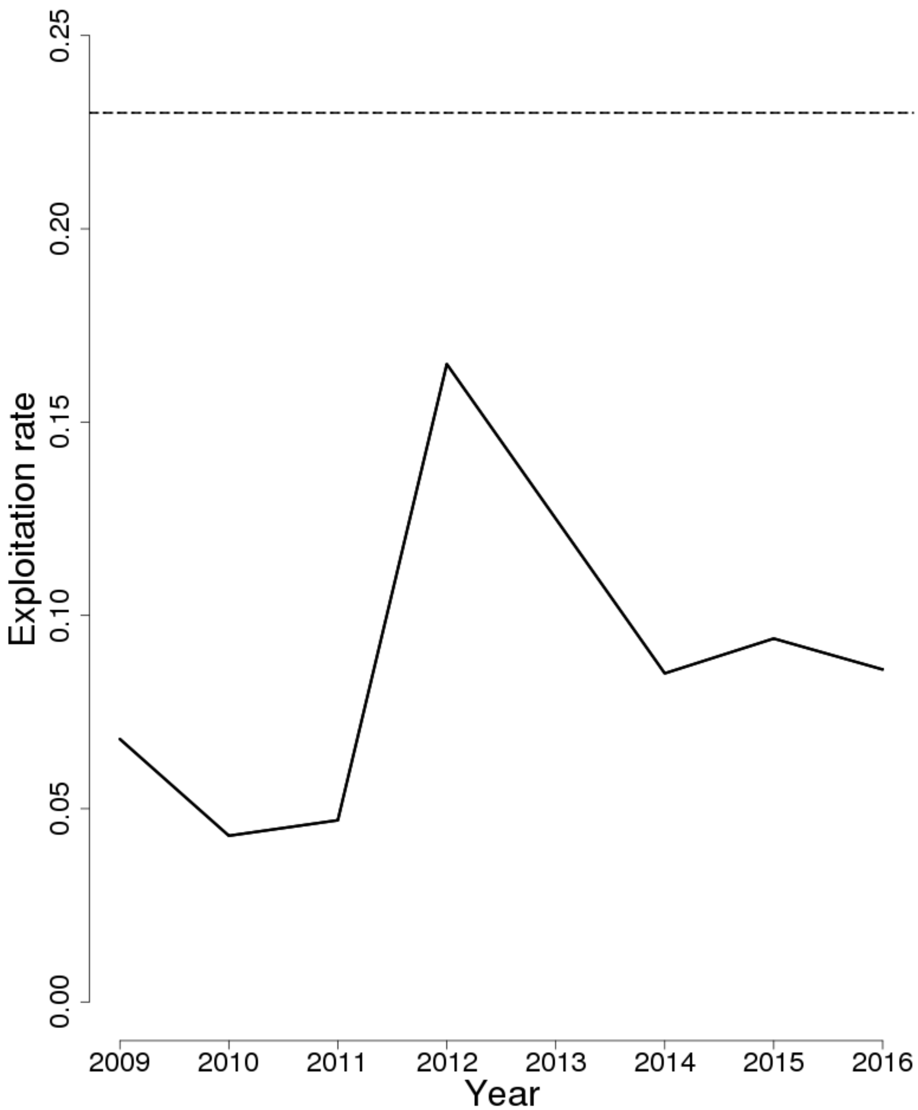

Figure 91: Trends in the exploitation rates (E_{Full}) of Gulf of Maine winter flounder between 2009 and 2016 from the current assessment and the corresponding $F_{Threshold}$ (E_{MSY} *proxy*=0.23; horizontal dashed line).

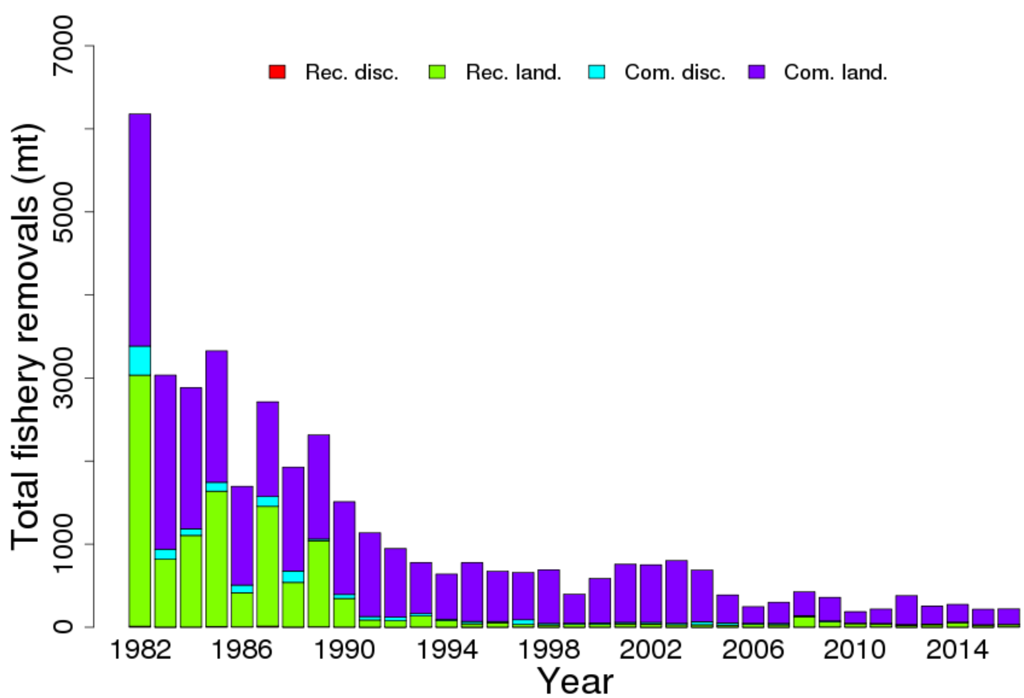

Figure 92: Total catch of Gulf of Maine winter flounder between 2009 and 2016 by fleet (commercial and recreational) and disposition (landings and discards). A 15% mortality rate is assumed on recreational discards and a 50% mortality rate on commercial discards.

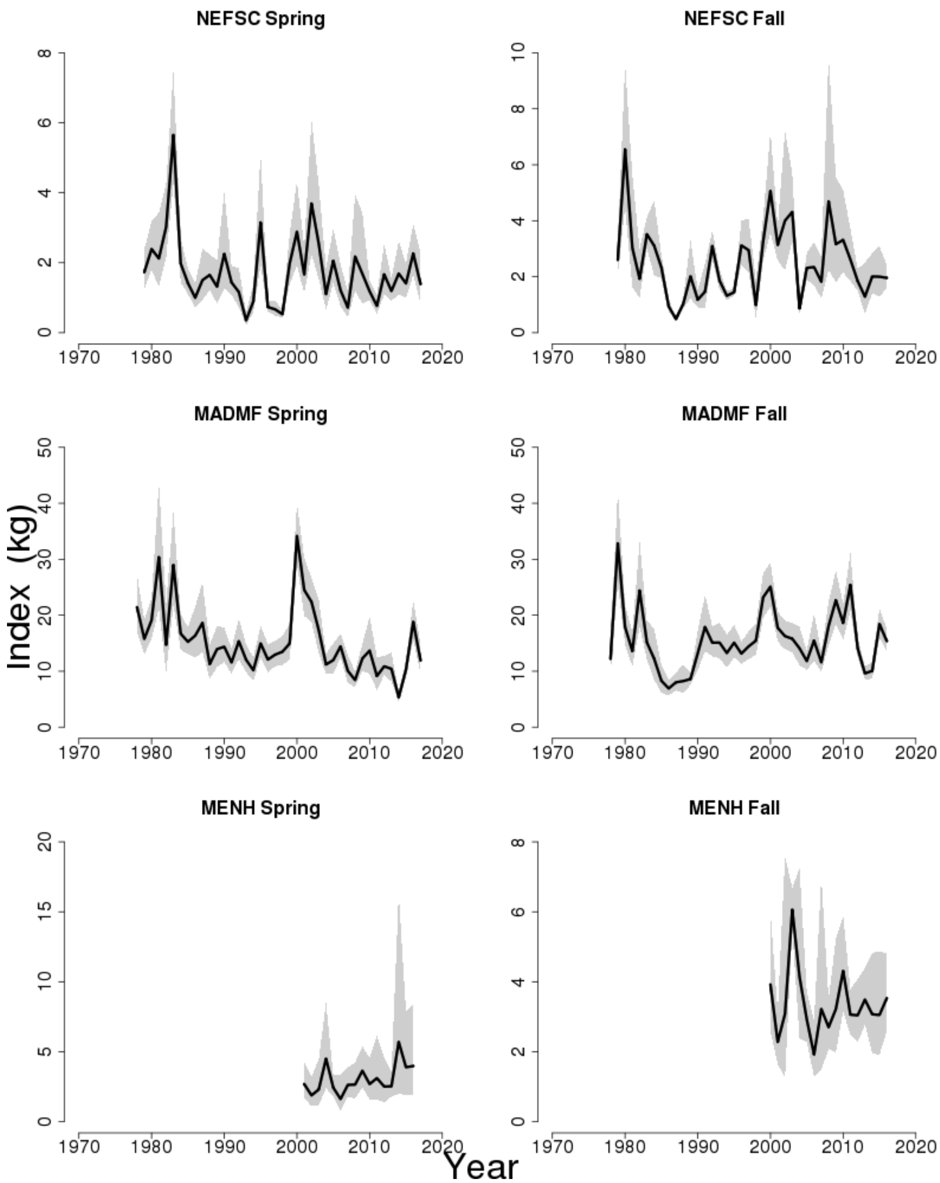

Figure 93: Indices of biomass for the Gulf of Maine winter flounder between 1978 and 2017 for the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MDMF), and the Maine New Hampshire (MENH) spring and fall bottom trawl surveys. NEFSC indices are calculated with gear and vessel conversion factors where appropriate. The approximate 90% lognormal confidence intervals are shown.

20 Georges Bank yellowtail flounder

Chris Legault

This assessment of the Georges Bank yellowtail flounder (Limanda ferruginea) stock was reviewed during the July 2017 TRAC meeting (Legault and McCurdy 2017, TRAC 2017). It is an operational assessment of the existing 2016 update assessment (Legault and Busawon 2016). Based on the previous TRAC assessment the stock status was unknown, but stock condition was poor. However, NMFS determined that the status of Georges Bank yellowtail flounder will remain overfished with overfishing ocurring based on the 2013 assessment update for this stock (TRAC 2013). This 2017 assessment updates commercial fishery catch data through 2016 (Table 56, Figure 96) and updates research survey indices of abundance and the empirical approach assessment through 2017 (Figure 97). No stock projections can be computed using the empirical approach.

State of Stock: Based on this updated assessment, Georges Bank yellowtail flounder (*Limanda ferruginea*) stock status is recommended to be unknown due to a lack of biological reference points associated with the empirical approach (Table 57), but stock condition is poor. Retrospective adjustments were not made to the model results. The average survey biomass in 2017 (the arithmetic average of the 2017 DFO, 2017 NEFSC spring, and 2016 NEFSC fall surveys) was estimated to be 3,118 (mt) (Figure 94). The 2016 exploitation rate (2016 catch divided by 2016 average survey biomass) was estimated to be 0.009 (Figure 95).

Table 56: Catch and model results table for Georges Bank yellowtail flounder. All weights are in (mt). The average survey biomass in year y is the arithmetic average of the year y DFO, year y NEFSC spring, and year y-1 NEFSC fall surveys. The exploitation rate is the catch divided by the average survey biomass. Model results are from the current updated empirical approach assessment.

	2010	2011	2012	2013	2014	2015	2016
		Data					
US landings	654	904	443	130	70	63	26
US discards	289	192	188	49	74	41	7
Canadian landings	17	22	46	1	1	3	1
Canadian discards	210	53	48	39	14	11	10
Other catch	0	0	0	0	0	0	0
Catch for Assessment	1,170	1,171	725	218	159	118	44
		Model Results					
Average Survey Biomass	60,565	23,262	31,559	15,404	7,015	7,064	4,997
Exploitation Rate	0.019	0.05	0.023	0.014	0.023	0.017	0.009

Table 57: Comparison of reference points estimated in an earlier assessment and from the current assessment update. But note that status based on NMFS determination remains overfished with overfishing ocurring.

	2016	2017
F_{MSY} *proxy*	NA	NA
SSB_{MSY} (mt)	NA	NA
MSY (mt)	NA	NA
Overfishing	Unknown	Unknown
Overfished	Unknown	Unknown

Projections: Short term projections cannot be computed using the empirical approach. Application of an exploitation rate of 2% to 6% to the 2017 average survey biomass (3,118 mt) results in catch advice for 2018 of 62 mt to 187 mt. This was the recommendation of the TRAC external reviewers and science members. The NEFMC SSC recommended the ABC should not exceed 300 mt, an amount of catch equivalent to a 10% exploitation rate. The TMGC will meet September 5-8, 2017 to negotiate the 2018 quota for Georges Bank yellowtail flounder.

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 largest source of uncertainty is the appropriate exploitation rate to apply to this stock, which has seen continued decline in survey biomass despite low exploitation rates.

- 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 model used to assess this stock does not allow estimation of a 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 Georges Bank yellowtail flounder are not computed. Catch advice is derived from applying an exploitation rate to the current estimate of survey biomass. The survey indices continue to decline, indicating the stock is not rebuilding.

- 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.

  Based on a TRAC intersessional meeting, the survey catchability for all three surveys was changed from 0.37 (a literature value) to 0.31 based on experimental results for this stock and the NEFSC survey net. The area of a tow was changed to use wing width instead of door width based on a separate experiment conducted using the NEFSC survey net. Under these changes average survey biomass is approximately three times higher, but the trend does not change.

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

  The stock status of Georges Bank yellowtail flounder remains unknown and stock condition continues to be poor.

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

  All three surveys for Georges Bank yellowtail flounder are at (DFO and NEFSC spring) or near (NEFSC fall) time series low values and show truncated age structure. The declining trend in average survey biomass to low levels, despite reductions in catch to historical low amounts, indicates a poor state of the resource. Recent catch is low relative to the biomass estimated from the surveys but catch curve analyses indicate high total mortality rates (Z above 1 for most years). Recent recruitment has generally been below average, survey recruits per biomass indicate low reproductive success recently, and condition (weight at length) has been poor recently. The TRAC concluded stock biomass is low and productivity is poor.

- 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 yellowtail flounder assessment could be improved with studies on appropriate exploitation rates or control rules for stocks that are not recovering despite low catches.

- Are there other important issues?

  None.

20.1 Reviewer Comments: Georges Bank yellowtail flounder

Recommendation:

The panel received a presentation on the recent Georges Bank yellowtail flounder assessment. However, because this assessment was reviewed through the Transboundary Resources Assessment Committee (TRAC) process, no additional review was conducted here. The information provided in this assessment was useful in the panels review of the other yellowtail flounder stocks. Overall, stock biomass is low and productivity is poor.

References:

Legault, C.M. and D. Busawon. 2016. Stock Assessment of Georges Bank Yellowtail Flounder for 2016. TRAC Ref. Doc. 2016/01. 63 p. TRAC2016

Legault, C.M. and Q.M. McCurdy. 2017. Stock Assessment of Georges Bank Yellowtail Flounder for 2017. TRAC Working Paper 2017/03. 58 p. TRAC2017

TRAC. 2013. Georges Bank Yellowtail Flounder. TRAC Status Report 2013/01. TSR2013

TRAC. 2017. Georges Bank Yellowtail Flounder. TRAC Status Report 2017/03. TSR2017

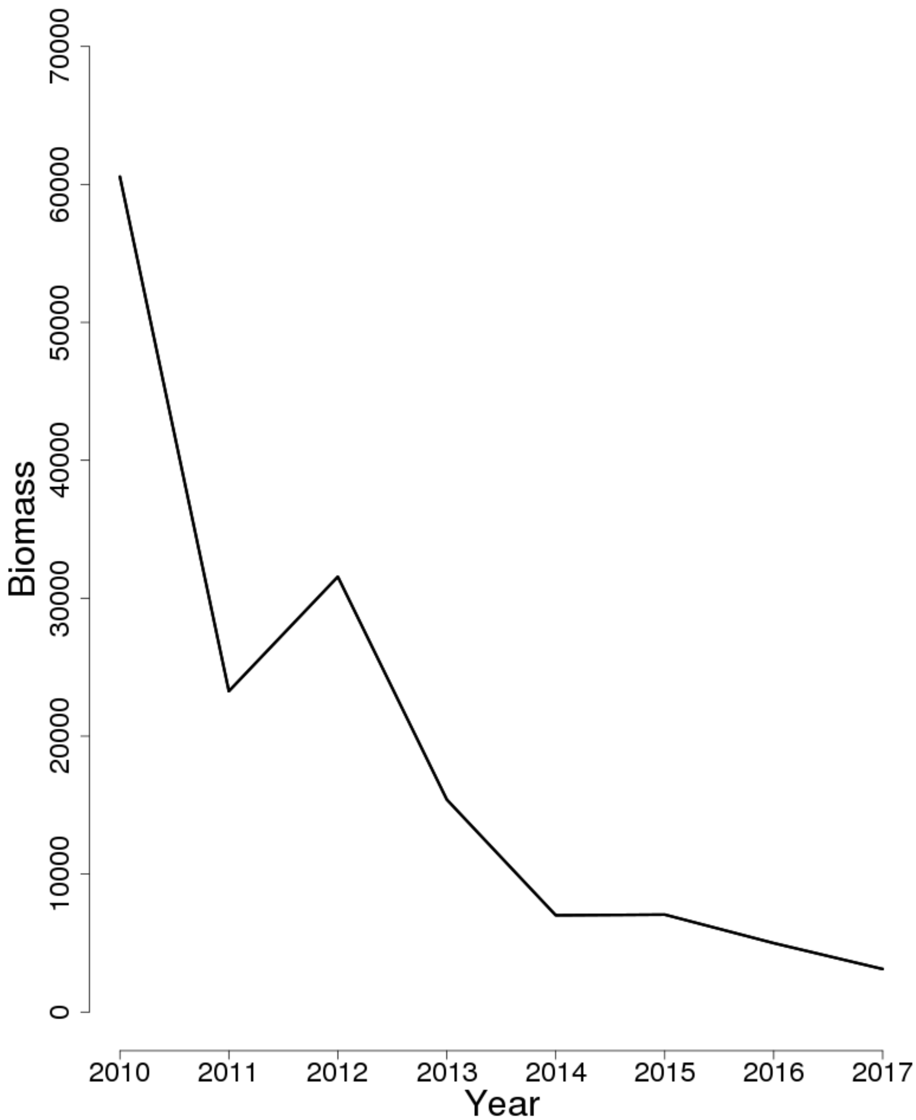

Figure 94: Trends in average survey biomass (mt) of Georges Bank yellowtail flounder between 2010 and 2017 from the current assessment.

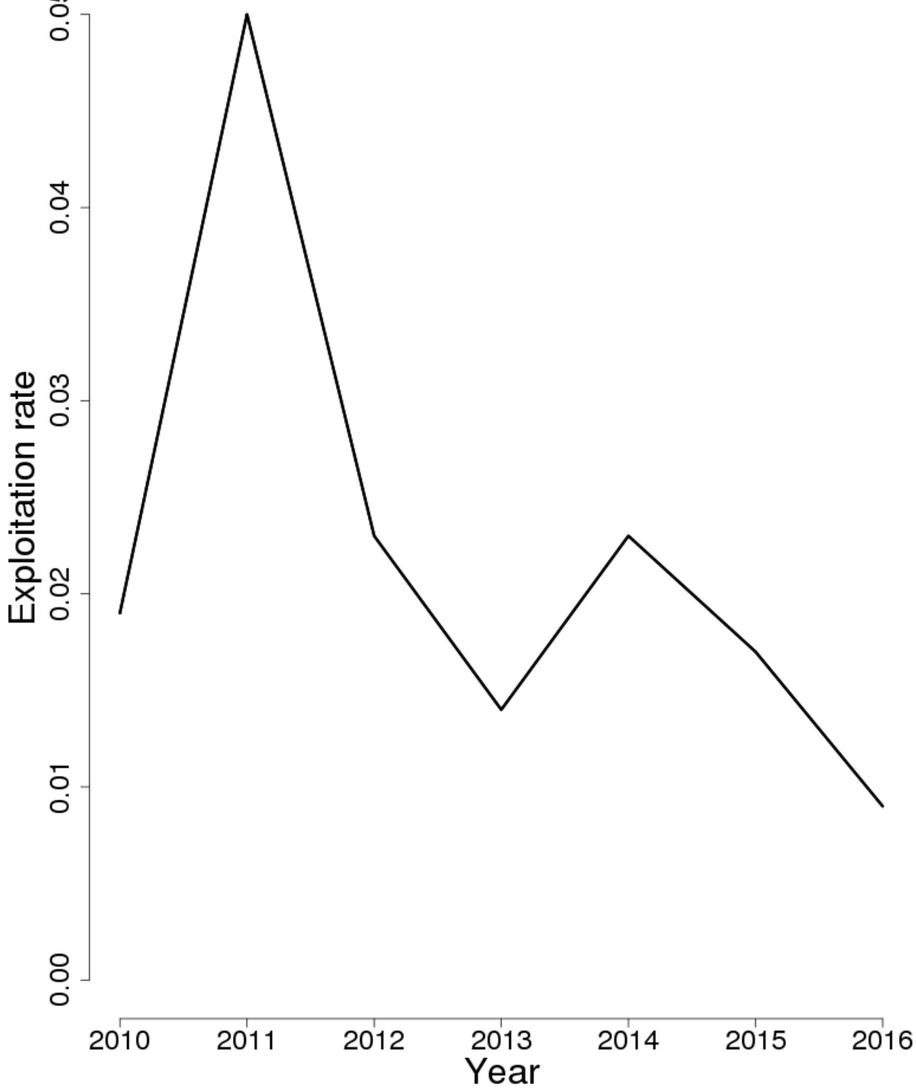

Figure 95: Trends in the exploitation rate (catch/average survey biomass) of Georges Bank yellowtail flounder between 2010 and 2016 from the current assessment.

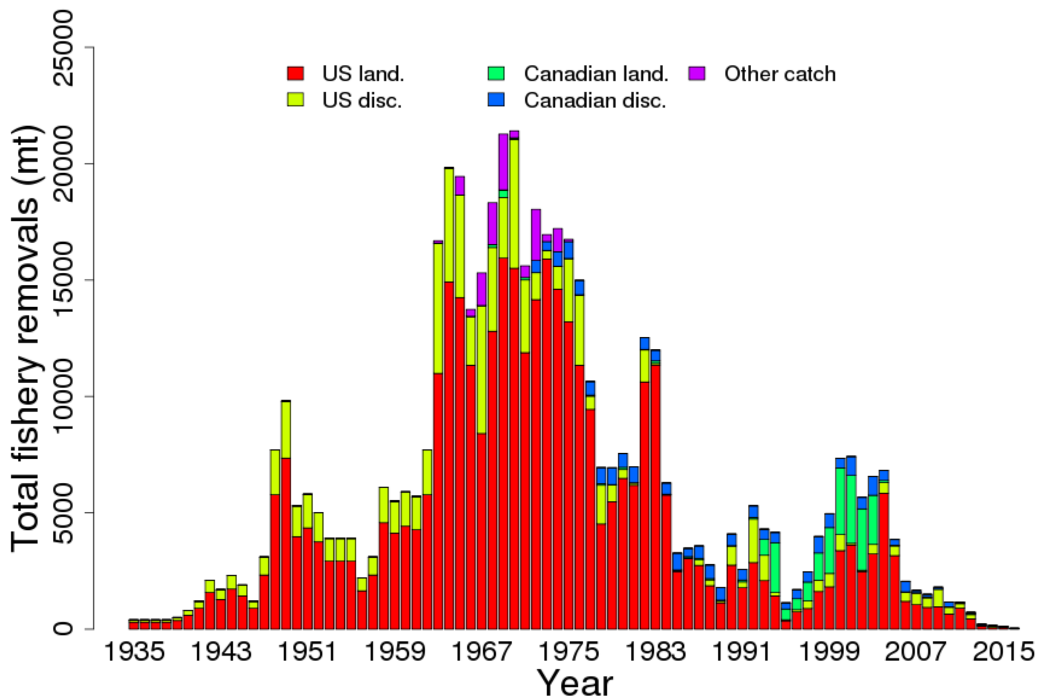

Figure 96: Total catch of Georges Bank yellowtail flounder between 1935 and 2016 by fleet (US, Canadian, or Other) and disposition (landings or discards).

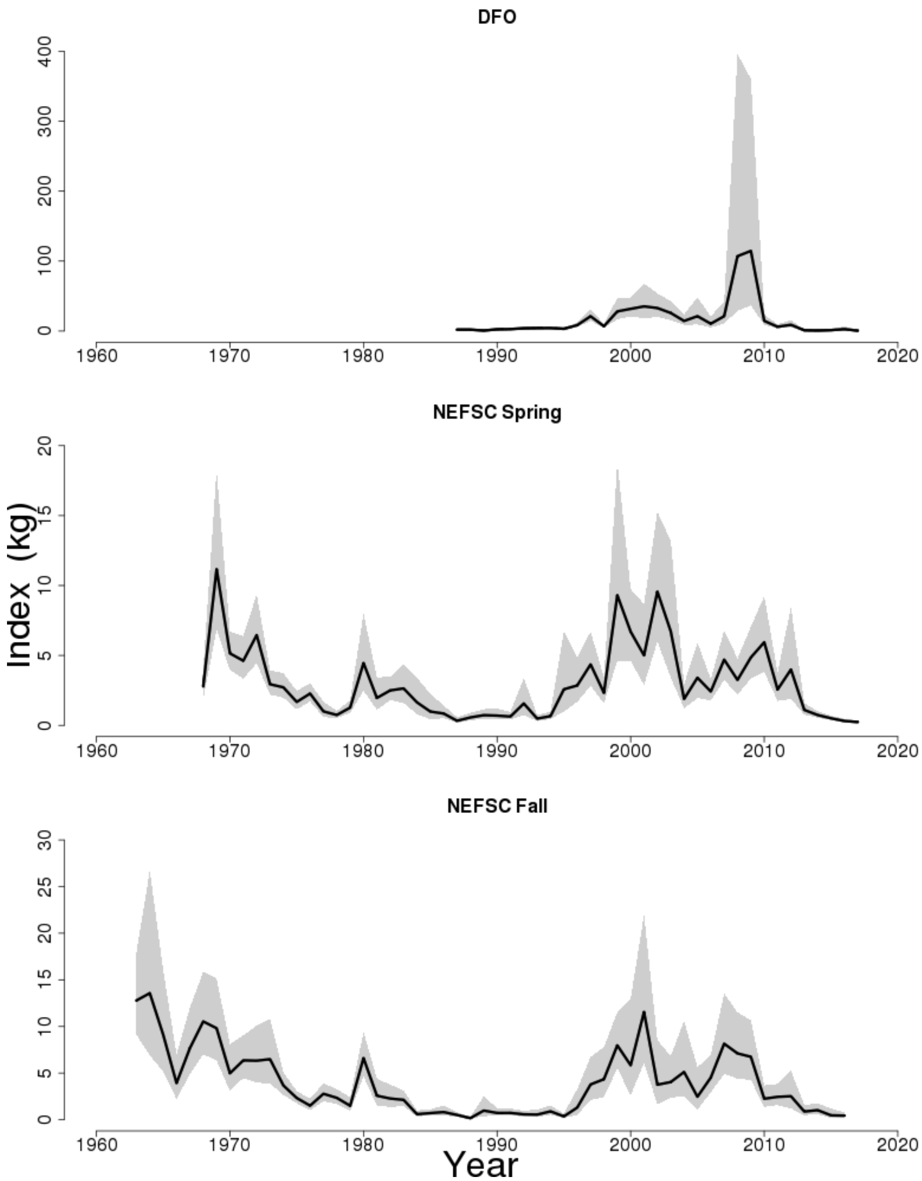

Figure 97: Indices of biomass for the Georges Bank yellowtail flounder between 1963 and 2017 for the Canadian DFO and Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% lognormal confidence intervals are shown.

21 Appendix

21.1 Generic terms of reference for operational assessments

1. Update all fishery dependent data (landings, discards, catch at age, etc.) and all fishery independent data (research survey information) used as inputs in the baseline model or in the last operational assessment.
2. Estimate fishing mortality and stock size for the current year, and update estimates of these parameters in previous years, if these have been revised.
3. Identify and quantify data and model uncertainty that can be considered for setting Acceptable Biological Catch limits.
4. If appropriate, update the values of biological reference points (BRPs).
5. Evaluate stock status with respect to updated status determination criteria.
6. Perform short term projections; compare results to rebuilding schedules.
7. Comment on whether assessment diagnosticsor the availability of new types of assessment input data indicate that a new assessment approach is warranted (i.e., referral to the research track).
8. Should the baseline model fail when applied in the operational assessment, provide guidance on how stock status might be evaluated. In that guidance, include qualitative written statements about the condition of the stock that will help to inform NOAA Fisheries about stock status[2]. Should an alternative assessment approach not be readily available, provide guidance on the type of scientific and management advice that can be.

Source: NRCC. 2011. A new process for assessment of managed fishery resources off the Northeastern United States. Internal Report. With edits made by NEFSC on 6/16/2017.

[2]The Peer Review panel is asked to recommend what the stock status appears to be. NOAA Fisheries still has final responsibility for making the stock status determination based on best available scientific information.

21.2 Outreach on 2017 groundfish operational assessments

OVERVIEW

In 2011, the Northeast Regional Coordinating Council determined that operational assessments were most appropriate for providing regular stock updates for the 20 stocks within the Northeast Multispecies Fishery Management Plan. This strategy was first implemented in 2015 and was a change from prior years, when benchmark assessments were used to update groundfish status. These do not occur every year, or for all species/stocks in the same year, but operational assessments could be completed and provide information more frequently.

In order to make this new process more easily understood and transparent, the Northeast Fishery Science Center (NEFSC) hosted several simultaneous webinars/onsite seminars for sector managers, the New England Fishery Management Council staff, members of the fishing industry at five ports, and the general public on July 22, 2015. It also built a data-rich website dedicated to the operational stock assessments.

During 2017, the NEFSC expanded upon this outreach effort to conduct a series of outreach meetings at eight ports that allowed an exchange between fishery scientists and the fishing industry. From August 15 to September 7, 2017, scientists from the NEFSC met with fishermen, industry representatives, and other stakeholders to educate and solicit feedback about the stock assessment process and opportunities for cooperative research with the NEFSC. The meeting objectives were to:

1. Explain the types of stock assessments, the stock assessment process and the stock assessment schedule.
2. Highlight examples that demonstrate when industry concerns led to new data inputs into stock assessments through cooperative research efforts.
3. Offer a space for the fishing industry and their representatives to ask questions, raise concerns, and learn about opportunities for input.

This structure allowed stakeholders to ask questions and raise concerns about the stock assessment process, and allowed the Cooperative Research Program to highlight work they have done with the industry and how that has been used.

While this is not the first outreach done about the stock assessment process, we felt that this format moved beyond reporting and recording fishermens concerns, to offering information about how the NEFSC is working to develop research with fishermen that can be used to improve stock assessments.

The intended audience for these meetings was fishery stakeholders. This included fishermen (captains, crew, and vessel owners), sector managers, dealers, members of commercial fishing organizations, members of nonprofit organizations, and the general public.

The audience for this report is the 2017 Groundfish Operational Stock Assessment Peer Review Panel. This summary of the themes and topics expressed in the port outreach meetings will be included in documents presented to the peer review panel and in the 2017 Operational Assessment Report.

This report is a summary and is not intended to capture every comment made at the eight port meetings. We also recognize that we only captured the thoughts of those who were present. People who attended these meetings were self-selecting, and the attendance was not comprehensive or large. Nonetheless, this work furthered our outreach efforts, and offers insights on how to improve them.

Follow-ups with attendees at each of these port meetings include written questions and answers based on those raised at the meetings that will be distributed via email, and specific follow-ups with some individuals by the Cooperative Research Branch.

PORT MEETING DEVELOPMENT

Using an iterative process to develop the port meeting agenda and outreach materials allowed the NEFSC to introduce information about how the stock assessment process works and answer questions that were port specific, species specific, or process specific. It also allowed for more stakeholder participation and interaction, and for the center to be more responsive to questions and concerns from those present at the meetings.

To schedule these meetings, we first solicited feedback from NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) port agents about when and where we should hold them. The port agents are located in fishing ports from Maine to North Carolina, but we focused on those within the geographic range of major groundfish fleet activity.

The agents provided a list of contacts in each port, suggestions for ways to effectively provide information to the stakeholders (fishermen and industry representatives), suggestions for locations, and topics outside of the stock assessment process that might come up during the meetings. Port agents also suggested that we reach out to the industry - dealers, representatives, and fishermen to ask for input about an appropriate day and time for meetings.

The outreach coordinator reached out to dealers, groundfish sector managers, industry organization representatives, and NGO representatives. She solicited information about best dates and times for each port. This was an important step, because dates and times varied by port. For example, in Portland, Maine, most groundfish permit holders land at the Portland Fish Exchange, which is closed on Fridays. The Portland Fish Exchange owner suggested Thursday. Dealers and port agents in Gloucester suggested Friday mornings since business was done for the week, and fishermen would be available. Other ports were not as easily committed to a day or time and responded that it just depended on the weather; any day was as good (or bad) as any other day.

ORGANIZATION

NOAA Fisheries staff at each meeting included stock assessment scientists, scientists and staff from the Cooperative Research Branch, port agents and others from GARFO, and the NFEFSC outreach coordinator. The typical agenda followed this plan:

- Operational Stock Assessments - timelines and process - Population Dynamics Branch

- 15 minute presentation - questions during and after

- What is Cooperative Research/ Research projects with a stock assessment component - Cooperative Research Program
  - two-part part presentation –questions during and after

RESULTS

Attendance

The eight port outreach meetings attracted 118[3] attendees.

Port	Meeting Date	Attendees
Chatham, MA	8/15/2017	9
New Bedford, MA	8/16/2017	17
Portland, ME	8/17/2017	12
Gloucester, MA	8/18/2017	23
Narragansett/Point Judith, RI	8/28/2017	13
Montauk, NY	8/30/2017	18
Portsmouth, NH	9/6/2017	13
Plymouth, MA	9/7/2017	13

[3]This number is the number of people that attended who were not NEFSC staff or GARFO Port Agents assigned to attend. This number does include staff/contractors from other branches who chose to come. It does include fishermen and their families who attended more than one port meeting. In those cases those individuals were counted twice.

Role[a]	Chatham	New Bedford	Gloucester	Portland	Point Judith	Montauk	Portsmouth	Plymouth
Commercial Fisherman	x	x[b]	x	x	x	x	x	x
Recreational (for hire) Fisherman			x			x	x	x
Council Member/Staff	x	x	x	x			x	
Sector Manager	x	x	x	x			x	
Dealer/Processor				x	x		x	
MADMF	x	x	x					
NGOs[c]			x	x			x	
Press	x	x			x			x
City Reps		x						
Academics		x	x			x	x	x
General Public	x		x					
Other[d]		x	x	x				
Fishery Orgs[e]			x	x	x			
GARFO Fisheries Management Staff			x					

[a] Roles are general categories of participants. While efforts were made to capture all who attended, roles capture the types of attendees.
[b] The commercial fishermen present in New Bedford do not actively fish or land in the Port of New Bedford. There were no fishermen from the New Bedford area present at the New Bedford port meeting. The fishing family that was present at the New Bedford meeting also returned to the Plymouth port meeting.
[c] For example, the North Atlantic Marine Alliance, The Nature Conservancy.
[d] "Other" consists of people who worked in the fishing industry - as biologist in some capacity. Generally these were staff from NEFSC that came to observe, or contracting companies. This included contractors from AIS, port samplers, and one person from the NEFSC Social Science Branch.
[e] Commercial Fishery organization staff-for example, the Gulf of Maine Research Institute and Commercial Fishing Research Foundation

Port Meeting Questions and Concerns across All Meetings

Stock Assessment Data, Methods, and Process

Generally, stakeholders wanted to know when the assessments take place, the differences among assessment types and what data are used. Across all meetings fishermen expressed frustration with a long lag-time between data collection and reporting, and frustration between what they see on the water every day and what the NEFSC reports. Fishermen were also frustrated with the inflexible assessment schedule that limits the introduction of new information. They explained that they can not wait for the science and management advice to catch up with current conditions and consequently the industry is contracting and "collapsing" in many ports.

In many fisheries, historical catches are higher than the current total allowable catch. Some fishermen were concerned that this has been interpreted as a change in abundance when it is actually a change in fishing effort owing to management measures that govern groundfish. They are concerned that this will both lower quotas and keep them low.

One repeated example given was about closed areas. Fishermen argued that if there are no commercial catch samples or vessel trip reports from those areas, then it could be interpreted to mean that there are no fish in those areas. This would be shown as a decline in abundance. They felt that if no one is fishing there, and those areas arent surveyed, then we dont know what fish are present. To them, this lack of data would lead people to think there was less fish in the system than are present.

In Portland, some questioned the Operational Assessment review plan. They were concerned about NOAA scientists serving on the panel not being sufficiently independent as reviewers. There was discussion of how the peer review panel works and how disagreements are documented. There was also an opportunity to talk about how the final reports are developed and used. There was also discussion about "Plan B" options for assessments (a fall-back option for providing catch advice if an assessment is not accepted) and in one port it was suggested that the Council should decide to either use Plan A or Plan B not the stock assessment scientists.

Fishermen across most ports expressed frustration about the presence of retrospective patterns. This ranged from expressing a need to create more real-time management (Chatham) to suggesting that the data are unreliable (New Bedford, Gloucester, Portland), to stating that there needs to be a major overhaul in the way that the modeling is done (Portsmouth and New Bedford). In New Bedford, it was suggested that as a research track project, the entire groundfish modeling process should be examined systematically because there has been such a large amount of retrospective patterning.

In Portland and Plymouth, fishermen suggested that misreporting was strong driver of retrospective patterns, and wanted frank discussion about Carlos Rafael, a major figure in Northeast fisheries who is recently pled guilty in a criminal case that involved misreporting groundfish catch. In these ports, fishermen commented that Raphael was responsible for lowering their quota on yellowtail flounder. In Portland, one stakeholder asked if NOAA was going to release the information from that investigation in order to allow the stock assessment scientists to use more accurate data. She expressed concern that not having access to that data would skew the results of the assessment and then affect the fishing quota for yellowtail flounder.

In New Bedford, the stakeholders were resistant to the conversation about poor data inputs. There, stakeholders felt that the data was biased against fishermen that the NEFSC should be in the business of keeping fishermen fishing, and that when the discussion led to discussing poor data inputs, that the NEFSC was accusing the fishermen of lying. A similar sentiment was expressed in Gloucester, when a fisherman said "you act as if fishermen are the bad guys." In Gloucester and Portsmouth fishermen expressed that they thought the models were flawed since they have failed multiple times. Many fishermen expressed that they feel the modeling process is not reliable, or does not have enough industry input.

In Chatham one fisherman asked if there could be real-time management. He gave an example in which he catches a large amount of a species with a small quota and then the fishery is closed as a protection measure by managers because the total allowable catch limit for that species is close to being reached. He suggested that making the information about landings in relation to total allowable catch available in real time would help everybody. He also said that type of real-time data "Im out there, and I see a large number of fish" could help with the assessments.

In Plymouth, one fisherman raised the point that even stock assessments going on now use the data through 2016, and the rules that result from them wont be put into place until Fishing Year 18. He also raised the point that if a benchmark is needed for a groundfish species, then it wont be done for at least two years. That is a much longer time than an in-person observation. In Gloucester, several fishermen repeatedly said they are seeing more cod abundance than the NEFSC is reporting, and they were frustrated that the science center cant “catch up”.

Fishermen in Point Judith were also frustrated with the slow nature of the science and management processes. They felt like their observations were not taken into consideration in a real-time manner, and that maybe the people to address these concerns were not present. In Point Judith, fishermen also said they were noticing a change in the distribution of black sea bass and summer flounder.

Fishermen in Gloucester were particularly concerned about cod, that assessments and managers are misinformed that based on their observations the cod stock is larger than the stock assessment shows. They also feel that this has provoked a catastrophic response to a problem that isnt occurring. Comments included “you say we are like Newfoundland, Ive been hearing that for years, but we arent.” Recreational party/charter and headboat captains and owners who attended the Portsmouth and Gloucester meetings were concerned that cod recreational catch limits are impacting their bookings and reducing their economic viability.

Many fishermen at the Gloucester meeting expressed that they feel like the bad guys. The GARFO representatives present felt like fishermen want to be a more active part of the scientific process, but that they arent. There were also concerned citizens in the room who expressed frustration and distrust of science, and who expressed that within the management system science is “privileged,” and across the board in the US they felt that this is wrong. In Pt Judith and Montauk, there was more discussion of black sea bass and summer flounder, which are not assessed in the updates. In Point Judith, fishermen said they were noticing a change in the distribution of black sea bass and summer flounder. Montauk attendees were concerned about fishery closures and lower quotas despite relatively healthy stocks.

Fishery Monitoring

Fishermen were concerned with the amount of observer and at-sea coverage they receive. They expressed concern and frustration about the accuracy of the data, whether the data are used, and the cost of collecting that data. Several fishermen said that people fish differently with an observer or at-sea monitor onboard, and asked how the science center might account for this bias. Fishermen also expressed concern about the cost of observers and dismay at the fact that “observers get paid even when we dont catch, so I take an observer on my boat, I get charged to catch cod $.07 lb, and the observer gets paid. The observer gets paid whether I make any money or not.” One fishermen in Point Judith recommended that it would be valuable for the Science Center and the Industry if observers could have an additional data collection field that allowed them to capture industry observations or shared knowledge. This fishermen remarked that on some specific instances he wanted the observer to document a specific condition or characteristic regarding a trip and was dismissed by the observer saying there is no way for me to capture that information within our current data system.

NEFSC Fishery-Independent Survey

Concerns expressed about the survey included the reliability of the survey data and the estimates that result from those data, what will happen this year during the fall survey since the primary survey vessel (NOAA Ship Henry B. Bigelow) is in dry dock. Stock assessment scientists explained how the survey was conducted, how stations are selected, and the area covered. Scientists also explained that a number of fishery-independent surveys are conducted in the region, the majority by states, and that these data are also used in many assessments.

Fishermen were concerned with localized fish abundance and the way that this might be missed by the survey, or bias the survey either positively or negatively. In Gloucester, Portland, and Portsmouth fishermen were concerned with the abundance of cod that they are seeing. They felt that the cod abundance in that area was not adequately reflected in their quota, and linked this to the survey areas.

Many fishermen at these meetings expressed that conducting the survey aboard commercial vessels would be more reliable and relevant than doing it aboard the *Bigelow*.

Across the ports, people were concerned with the reliability of survey data. This included concerns about station density in the survey, use of a standard set of gear that was not good at catching all species it encounters, concerns about how standard the tows are and how quality is monitored for tows. This allowed for further discussion of the survey design.

In several ports we were able to talk about protocols for evaluating each tow, what happens when there is a "bad" tow, and supplemental surveys we are doing to address gaps. Examples included the Gulf of Maine longline survey on rocky bottom, and gear efficiency comparisons for flatfish catchability in collaboration with the Northeast Trawl Advisory Panel. In some ports, people were interested in seeing comparisons of survey data results over time. This provided an opportunity to show the animated plots of distribution and abundance by species developed from survey data by the NEFSC.

Ecosystem Concerns

Another area of general interest in several ports was moving toward comprehensive assessments that take into account ecosystem effects, and toward ecosystem-based fishery management. Some of this discussion centered on recent changes in fish distribution that might be a result of climate change.

Fishermen in Plymouth from Sector 10 expressed real concern and frustration about Amendment 16, and the broader efforts to plan out the uses for the ocean. They felt that these efforts, which they believed to be led by large NGOs, are pushing them out of the fishing industry.

Other fishermen noted that they feel that the groundfish sector-based management is a cap-and-trade system that is really driving fishing, and that the economics of fishing is speaking through the fishery-dependent data. One fisherman suggested controls in the marketplace to correct allocation errors.

The fishermen in Plymouth also wanted more information on the seal population on Cape Cod and their effects on the natural mortality of groundfish species.

Cooperative Research

The Cooperative Research Branch gave a programmatic overview at these meetings. They explained that they were undergoing an evolution from a program to a distinct branch at NEFSC. As they do this, a number of internal and future external efforts are underway to better integrate and design cooperative research at NEFSC. During this process, the Cooperative Research Branch will be reaching out to the industry to gain input about their research priorities and feedback about how to engage them for future NEFSC studies. They also took this opportunity to highlight cooperative research projects that theyve conducted with fishermen over the years, and reinforced that the branchs work is designed to address spatial and temporal gaps in the NEFSCs data collection efforts in partnership with industry. These current projects included:

- Study Fleet
- Electronic vessel trip report system
- Industry-based longline survey
- Catchability work aboard the F/V Karen Elizabeth through the Northeast Trawl Advisory Panel

A considerable number of fishermen perceived that the NEFSC did not use Northeast Study Fleet data or observer data in assessments. NEFSC staff clarified how some study fleet data (electronic vessel trip reports) are used and pointed out that their desire to utilize industry-based CPUE does have challenges that the Center needs to overcome. There was also discussion of past attempts to start new data series that addressed industry concerns that were unable to be fully incorporated into the data. In a few instances these projects were unable to capture a full time series because of changes in cooperative research funding and/or research priorities.

Many attendees said that cooperative research opportunities were too limited and seem to be directed toward a small number of vessels. This point was made in Portsmouth and Portland. In Portsmouth, one fisherman said that “the research money always seems to go to the same few people” while in Portland, one stakeholder reported that they had submitted a proposal, but that “the people who always get the money got the money in that case, too.”

Several fishermen in Pt Judith also had concerns about who gets access to cooperative research dollars. The Cooperative Research Branch explained that they use a network approach to funding due to fluctuations in funding for cooperative research. Several fishermen in room were part of the study fleet, and part of the cooperative research network. Many fishermen expressed that they were pleased with the work that was being done through the Cooperative Research Branch. As part of this discussion other funding mechanisms were discussed. One was the Staltonstall- Kennedy program. This group of fishermen felt that it was unlikely that they would receive those funds since it was a national program and not reflective of regional priorities, and felt that there needed to be more research on Black Sea Bass that was species specific. One suggestion by a member of the group was that in order to do more localized species-specific work, it would be really helpful if the Mid-Atlantic Fishery Management Council brought back more research set-aside programs.

In a few ports, there was also discussion about the Cooperative Research Branch use of “networks” to leverage their research dollars. In Portland, the REDNET project was a topic of concern. One constituent in Portland gave an example of the REDNET project, and said that it took six years to receive a report from that project. This was too long. There was also concern that a network approach to cooperative research projects isnt the most effective way to get work done, and that it privileges who gets to work on those projects.

In Portsmouth, however, where many fishermen work with the Cooperative Research Branch, they felt like the use of networks was appropriate, and that the Cooperative Research Branch was working well with them. In Gloucester, a number of participants were given an opportunity to talk about the work they have done with the Cooperative Research Branch .Several participants expressed favorable views of the Cooperative Research Branch and the staff. Several participants at every meeting had been or are actively involved in cooperative research.

Suggested areas for future research included further investigating bariatric trauma mitigation devices. Also, the issue of declining weight-at-age in cod was raised, along with the hypothesis that this was related to larger parasite loads caused by longer period of warmer water temperatures during recent years.

21.3 Assessment Oversight Panel summary

July 24, 2017 Woods Hole, Massachusetts

As part of the Operational Assessment process for the 20 Groundfish stock assessments, the Assessment Oversight Panel (AOP) met in Woods Hole to review the assessment plans for each stock. The meeting was also broadcast as a Webinar.

The AOP consisted of:

Jason McNamee, Chair NEFMC Scientific and Statistical Committee, RI Division of Environmental Management

John Boreman, Chair MAMFC Scientific and Statistical Committee, North Carolina State University

Russell W. Brown, Northeast Fisheries Science Center, Woods Hole

Meeting Participants:
The participants in Woods Hole included: Tom Nies (NEFMC), Jamie Courname (NEFMC), Jim Weinberg (NEFSC), Michael Simpkins (NEFSC), Sheena Steiner (NEFSC), Mark Terceiro (NEFSC), Chris Legault (NEFSC), Gary Shepherd (NEFSC), Larry Jacobson (NEFSC), Liz Brooks (NEFSC), Tony Wood (NEFSC), Toni Chute (NEFSC), Tim Miller (NEFSC), Kathy Sosebee (NEFSC), Lisa Hendrickson (NEFSC), Larry Alade (NEFSC), Chuck Adams (NEFSC), Susan Wiley (NEFSC), Brian Linton (NEFSC), Richard McBride (NEFSC), Geret Depiper (NEFSC)

Remote participants via webinar included: Patrick Sullivan (Cornell University), Patrick Lynch (NOAA Fisheries, Science & Technology), Jim Berkson (NOAA Fisheries, Science & Technology), Gary Nelson (Massachusetts Division of Marine Fisheries), Chris Kellogg (NEFMC) and Rachel Feeney (NEFMC).

The meeting began at 10:00 am. The 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 some cases the stock was already being assessed using an “index-based” or “empirical” approach. In these cases there was no second approach proposed for review. Presentations ranged from 10 to 25 minutes and we were able to address 19 of 20 stocks before 4:30pm (Atlantic halibut did not have a scheduled presentation and will be reviewed via a separate process by the NEFMC SSC).

Three background documents were provided to the Panel: (1) an updated prospectus for each stock; (2) an overview summary 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.

The meeting served as a valuable forum for standardizing methods across assessments and resolving potentially contentious issues. The overarching issues addressed include:

- To clarify communication regarding assessments, the term "current assessment approach" refers to the last assessment method accepted at either the 2015 Groundfish Operational Assessments workshop or benchmark assessments conducted since then (e.g., 2016 benchmark assessment for Witch Flounder). These assessment approaches cover a range of assessment approaches, including analytic assessments (e.g., Gulf of Maine Cod, Georges Bank Haddock, American Plaice), index-based assessments (e.g., Ocean Pout), and empirical approaches (e.g., Georges Bank Cod and Witch Flounder).
- A 90% confidence interval for fishing mortality and spawning stock biomass will be used as an objective criteria for knowing when to apply a retrospective adjustment to terminal year stock size estimates. When the Mohns rho adjusted F and SSB lie outside the joint 90% confidence interval of the terminal year estimates, the terminal year abundance estimates will be adjusted by the SSB rho estimate for stock status determination and catch advice projections.
- New or revised estimates of survey catchability were derived for some flatfish species (Yellowtail Flounder, Winter Flounder, Witch Flounder, American Plaice, and Windowpane Flounder). These new estimates will not be incorporated in cases where analytic models are used, but will be presented for comparison purposes in the operational assessment document. This comparison is not straight forward as the new estimates are calculated relative to the experimental chain sweep gear, but NEFSC analysts will offer the information in a way that will be informative as to the estimates being produced by the analytical model. For stocks where new information is available and that utilized an index based or empirical approach, updated catchability (q) estimates will be used.
- New, objective and repeatable methods for filling in incomplete age length keys have been developed by the Population Dynamics Branch. Utilization of the Branchs approach is expected to result in minor changes to age-based catch estimates. The AOP endorsed the use of this approach as an acceptable change to ensure consistency relative to the use of age keys.
- Exploitation rate should be estimated in a consistent and scientifically defensible manner for stocks using empirical approaches. Assessments with empirical approaches should present a range of estimates and a scientific rationale for the preferred method.
- Projections for stock size and catches will be based on the F_{msy} proxy and 75% F_{msy} (or $F_rebuild$ if this rate is already in effect as the default for management).
- Estimates of catch in 2017 will be provided by the GARFO and will be used in all projections.

- Values of all assessment reference points will be updated and based on updated growth and maturation values for reference point determination. Biological information will be averaged over the same time period (e.g., 3 or 5 years) as in the last assessment. However, there will be no adjustments to the basis for biological reference points (e.g., changing from $F_{40\%}$ to $F_{30\%}$ will not be allowed).
- The SSC will determine the most appropriate method for determining the OFL and ABC.
- No alternative analytic models will be applied in the event that the operational model for a given stock that was approved in the most recent benchmark assessment does not pass the upcoming peer review. Development and application of an alternative model for assessment generally requires a benchmark assessment, requiring a greater scope for review and participation than an Operational Assessment.
- In cases where an analytical model is not accepted for management use during the peer review, the alternate approach that was developed and presented at the AOP meeting will be reviewed and proposed as the preferred approach to develop catch advice.
- Recommendations for benchmark assessments should be expected for assessments that reveal either the need for a revised status determination or poor agreement between data and model fits (i.e., lack of fit or strong retrospective patterns). Decisions on benchmarks and their scheduling will be made by the Northeast Regional Coordinating Council.

In general, the AOP approved the plans presented, but highlighted a number of clarifications that are summarized below:

Stock	Lead	Major Recommendations
Overview of the Process	Russell Brown	Terms of Reference in the overview presentation will be used.
Gulf of Maine Cod	Michael Palmer	The Massachusetts industry-based bottom trawl survey results will not be included in the analytical model because its inclusion would represent a new data source which is outside the focus of an operational stock assessment. A working paper will be made available to the peer reviewers as auxiliary information.
Georges Bank Cod	Chris Legault	The current method, based on smoothed survey trends, and no Plan B approach were accepted by the AOP.
Gulf of Maine Haddock	Michael Palmer	New recreational discard estimates will be applied beginning in 2014 when MRFSS size composition data are available because they are size and season-specific.
Georges Bank Haddock	Liz Brooks	This stock has a unique issue in that catches have been small ($\sim$ 10%) of allowable catch, so a Plan B approach would probably understate the potential catch and lead to potentially large reductions in catches that are already small. Stock biomass is at historically record high levels, although declines are expected soon due to the ageing of recent year classes that may complicate use of some Plan B approaches. Information about the trend in stock biomass should be made available to the SSC. Use of recent average catch as a Plan B does not provide any information about the stock. A constrained LOESS smoothing approach, as is employed for Georges Bank Cod, is recommended.
White Hake	Kathy Sosebee	If the current assessment is rejected, the proposed alternative is the AIM model. AOP suggested using AIM as Plan B and with a LOESS smoothing approach (as is currently used for Georges Bank Cod) as an alternative.
Pollock	Brian Linton	If the current assessment is rejected, the alternate plan is the LOESS smoothing approach (as is currently used for Georges Bank Cod).
Cape Cod/Gulf of Maine Yellowtail Flounder	Larry Alade	Make the time period for exploitation rate calculations consistent that used for Winter Flounder and other flatfish stocks. This assessment should utilize new catchability estimates from recently reviewed research.
Georges Bank Yellowtail Flounder	Chris Legault	This assessment was updated as part of the TRAC. No further revisions will be done in the Operational Assessment process.

Stock	Lead	Major Recommendations
Southern New England Yellowtail Flounder	Larry Alade	Make the time period for exploitation rate calculations consistent with that used for Winter Flounder and other flatfish stocks. This assessment should utilize new catchability estimates from recently reviewed research.
Gulf of Maine Winter Flounder	Paul Nitschke	The current approach for this stock is using a swept-area biomass estimate with an assumed q for non-overlapping surveys that cover the stock range. It may be necessary to make different adjustments to the q values for the three surveys based on the recent research and review that suggests wing spread is a better measurement of effective area swept than door spread for the R/V Bigelow. Make the time period for exploitation rate calculations consistent that used for Winter Flounder and other flatfish stocks.
Georges Bank Winter Flounder	Lisa Hendrickson	In the event that the VPA assessment is rejected, the alternate approach will be AIM or the survey swept area approach. The catchability study has limited sample size for Winter Flounder, but recommend still comparing the VPA-fit q to the tow study q, noting that this comparison is not necessarily straight forward. Make the time period for exploitation rate calculations consistent that used for Winter Flounder and other flatfish stocks.
Southern New England Winter Flounder	Tony Wood	In the event that the assessment is rejected, the alternate approach will be AIM or the survey swept area approach. The catchability study has limited sample size for Winter Flounder, but recommend still comparing VPA-fit q to the tow study q. Make the time period for exploitation rate calculations consistent that used for Winter Flounder and other flatfish stocks.
American Plaice	Mark Terceiro	If the current assessment approach is rejected, the alternate approach will be the survey swept area approach. Make the time period for exploitation rate calculations consistent that used for Winter Flounder and other flatfish stocks. This assessment should utilize new catchability estimates from recently reviewed research.
Gulf of Maine / Georges Bank Windowpane Flounder	Toni Chute	If the current AIM model is rejected the alternate approach will be a survey swept area approach using recently estimate catchability. The AOP reiterated concerns expressed by the catchability research review panel about the limited amount of data available to estimate survey q; however, there may be enough information available for use.

Stock	Lead	Major Recommendations
Southern New England / Mid-Atlantic Windowpane Flounder	Toni Chute	If the current AIM model is rejected the alternate approach will be a survey swept area approach using recently estimate catchability. The AOP expressed concerns about the limited amount of data available to estimate survey q.
Witch Flounder	Susan Wigley	The current empirical approach (biomass estimated from survey results and survey catchability estimates) should be utilized. The most current estimates of catchability should be used.
Redfish	Brian Linton	If the current assessment is rejected the proposed alternative is a LOESS smoothing approach (as is used for Georges Bank Cod).
Wolffish	Chuck Adams	The AOP accepted the model run that uses knife-edge 50cm maturity. If the current assessment is rejected, the alternate plan is AIM and then the LOESS smoothing approach (as is used for Georges Bank Cod).
Ocean Pout	Susan Wigley	Index based assessment, current survey analyses will be made available to the reviewers.

The meeting concluded at 4:30 pm. Draft assessment reports will be made available on Friday, September 1, 2017. The peer review panel will meet from September 11-15, 2017 to complete their review. In addition to the short summary reports, all of the model inputs and outputs, and supporting tables, figures, and graphs will be made available via a web-based tool.

21.4 Guidelines for allowable changes to operational assessments

2017 Operational Groundfish Assessments (vers. Aug. 28, 2017)

This document is intended to serve as guidance to assessment leads as they develop and carry out operational assessments for groundfish stocks in 2017. This guidance was developed in consultation with assessment staff and members of the Assessment Oversight Panel.

Factors Considered when Evaluating Potential Admissible Changes

- Departure from Benchmark model configuration
- Magnitude of impact in terms of scale/ status determination
- Novelty of data or measures (i.e., new vs updated data/measures)
- Experimental evidence vs anecdotal
- Management considerations

Change	Acceptable	Notes
Measures in Trend		
Survey Indices	NOT OK	
LPUE Indices	NOT OK	
Measures of Scale		
New or Revised Measures of Catchability	OK	Peer Review of white papers on catchability for Witch Flounder and Yellowtail Flounder was challenging due to time constraints. The catchability estimates will be used as follows: i.) Plan B assessments (i.e., empirical approach assessments) will incorporate new Q, presuming peer review approves methods/application ii.) Plan A assessment will not incorporate new Q, but new Q will be provided alongside the assessment, with relevant context to enable review panel to appropriately interpret (or not) the Q information.
Discard Mortality	OK	
Recalibrated Catch Estimates	NOT OK	This is NOT OK for use in the 2017 groundfish assessments because it is specifically referring to MRIP data that are being reestimated and will not be available for use in assessments until 2018. Recalibrated estimates will be applied for use in 2018/19 operational assessments to address MRIP issues. This row is not referring to updated catch streams that result from applying new approved discard mortality estimates, database corrections, etc., which are allowed.
Bases for Reference Points		
Change in values but not change basis of reference points	OK	
Updated model priors	OK	Only if from peer reviewed sources, and specifically NOT OK for changes in steepness.
Regime Change (e.g., truncated SR time series, use of environmental predictors)	NOT OK	
Changes in Model Configuration/Identification		
Selectivity Stanzas		
Historical selectivity stanzas	NOT OK	
Most recent selectivity stanza	OK	
Changes in selectivity function	NOT OK	
Differential weighting of likelihood	NOT OK	

Change	Acceptable	Notes
Introduction of retrospective adjustment for terminal B, F	OK	Strive for consistent application of adjustments across stock assessments.
Downweighting of information (e.g., year classes)	NOT OK	Individual researchers can make marginal changes to weighting for purposes of convergence, but these must be documented and accepted by AOP.
Splitting survey indices	NOT OK	
New Models	NOT OK	
Biological Information		
Natural Mortality	NOT OK	
Updating Growth (i.e., data only, not the model)	OK	
Updating Maturation (.e. data only, not the model	OK	
Updating age at length (i.e., data only, not method)	OK	
Projection Inputs	Depends	Generally, marginal changes to data quality and data updates are admissible. But a major deviation from the benchmark method would be inadmissible.

21.5 Onsite participants

2017 Groundfish Operational Assessments Attendee List

Name	Affiliation	Email
Pat Sullivan	Cornell U	pjs31@cornell.edu
Patrick Lynch	NMFS	Patrick.lynch@noaa.gov
Gary Nelson	Mass. DMF	gary.nelson@state.ma.us
Jim Berkson	NMFS	jim.berkson@noaa.gov
Jamie Cournane	NEFMC	jcournane@nefmc.org
Russ Brown	NEFSC	russell.brown@noaa.gov
Jim Weinberg	NEFSC	james.weinberg@noaa.gov
Mike Simpkins	NEFSC	Michael.simpkins@noaa.gov
Sheena Steiner	NEFSC	sheena.steiner@noaa.gov
Tom Nies	NEFMC	tnies@nefmc.org
Vito Giacalone	NSC	vitofish@gmail.com
Thomas Orrell (Gloucester)	Yankee Fleet	tom@yankeefleet.com
Mark Terceiro	NEFSC	mark.terceiro@noaa.gov
Chris Legault	NEFSC	chris.legault@noaa.gov
Gary Shepherd	NEFSC	gary.shepherd@noaa.gov
Mike Palmer	NEFSC	Michael.palmer@noaa.gov
Liz Brooks	NEFSC	liz.brooks@noaa.gov
Tony Wood	NEFSC	Anthony.wood@noaa.gov
Toni Chute	NEFSC	toni.chute@noaa.gov
Paul Nitschke	NEFSC	paul.nitschke@noaa.gov
Alicia Miller	NEFSC	Alicia.miller@noaa.gov
Tim Miller	NEFSC	timothy.j.miller@noaa.gov
Laurel Smith	NEFSC	laurel.smith@noaa.gov
Kathy Sosebee	NEFSC	Katherine.sosebee@noaa.gov
Lisa Hendrickson	NEFSC	lisa.hendrickson@noaa.gov
Larry Alade	NEFSC	larry.alade@noaa.gov
Chuck Adams	NEFSC	Charles.adams@noaa.gov
Susan Wigley	NEFSC	susan.wigley@noaa.gov
Brian Linton	NEFSC	brian.linton@noaa.gov
Dan Hennen	NEFSC	daniel.hennen@noaa.gov
Kiersten Curti	NEFSC	Kiersten.curti@noaa.gov
Dave McElroy	NEFSC	dave.mcelroy@noaa.gov
Charles Perretti	NEFSC	Charles.perretti@noaa.gov
Dominique St. Amand	NEFSC	Dominique.st.amand@noaa.gov
Rich McBride	NEFSC	Richard.mcbride@noaa.gov
Mark Grant	GARFO	mark.grant@noaa.gov
Greg DeCelles	MADMF	Gregory.decelles@state.ma.us
Chris McGuire	TNC	cmcguire@tnc.org
Steve Cadrin	SMAST	scadrin@umassd.edu
Liz Duskey	Cornell U	epd48@cornell.edu
Robin Frede	NEFMC	rfrede@nefmc.org
Kevin Kertscher	Big Ocean Media	kevin@bigocean.com
Libby Etrie	NESSN	Libby.Etrie@gmail.com
Mary Hudson	GMRI	mhudson@gmri.org
Liese Siemann	Coonamessett Farm	lsiemann@cfarm.org
Amy Carlson	Coonamessett Farm	acarlson@cfarm.org
Luisa Garcia	Coonamessett Farm	lgarcia@cfarm.org
Mary Newton Lima	Coonamessett Farm	mary@cfarm.org

Ecosystem Considerations for the 2017 Groundfish Operational Assessment

Executive Summary

This report provides ecosystem considerations for the 2017 Groundfish Operational Assessment stocks. These stocks are affected by environmental forcing factors and trophic interactions in addition to fishing. The data presented here are provided as qualitative information to help provide context on stock status for management consideration, specifically as information that can be incorporated into Term of Reference 8: "…include qualitative written statements about the condition of the stock that will help to inform NOAA Fisheries about stock status." Indicator variables are presented in a risk analysis framework and summarized with respect to the vulnerability of each species and probable response (favorable, unfavorable, neutral or unknown) to the current status of that indicator.

Our main findings are:

- Only 8 of the Operational Assessment stocks have a low overall climate vulnerability. 7 of the stocks have at least a high overall climate vulnerability (Gulf of Maine, Georges Bank, and Southern New England/Mid-Atlantic winter flounder stocks, witch flounder, Atlantic halibut, ocean pout, and Atlantic wolfish, (Figure 13).
- Mean fall bottom temperatures have increased in the Gulf of Maine and on Georges Bank. This temperature increase is expected to have highly negative impacts on Georges Bank cod and Georges Bank haddock. Negative impacts are also expected for Gulf of Maine cod, Gulf of Maine haddock, Georges Bank yellowtail, Southern New England/Mid-Atlantic yellowtail, and Atlantic halibut (Figure 14).
- Sea surface temperature (SST) has increased over the Northeast US Shelf. This increase is expected to have highly negative impacts on the 7 stocks which have a high overall climate vulnerability and negative impacts on 5 other stocks (Figure 14).
- In recent years, warm thermal habitats have increased and cool thermal habitats have decreased. These changes are expected to have highly negative impacts on 8 stocks (GB & GM cod, GB & GM haddock, American plaice, Atlantic halibut, pollock and Acadian redfish) and negative impacts on a further 9 stocks (Figure 14).
- Recent distribution changes show a general movement of species to the northeast and into deeper waters. This may have slightly negative effects on ocean pout and Atlantic wolffish, and negative effects on the rest of the Operational Assessment stocks (Figure 14).
- Experimental habitat modeling work indicates positive population trends for GB & GM haddock, American plaice, and Acadian redfish, and highly negative trends for ocean pout (Figure 14). This analysis is largely driven by recent distributions and abundance estimates from the NEFSC survey data, and implies that the biomass of some species (e.g. haddock) may not be influenced by the current unfavorable temperatures.
- One indication of health is a fish condition index, which is currently highly positive for 4 stocks (GM haddock, American plaice, Northern windowpane, and ocean pout) with another 4 stocks being positive. 6 stocks are currently below average, but none are highly negative in the most recent year (Figure 14).
- Three-year productivity, expressed as a ratio of small fish abundance to large fish biomass, is highly positive for 2 stocks (GB haddock and GM winter flounder) and highly negative for 8 stocks (GB & GM cod, all three yellowtail stocks, GB winter flounder, pollock and Acadian redfish, Figure 14).

- We also summarize the current status of indices that we recommend to be explored further in research track assessments. These include predation, habitat, and the effect of the fall bloom on Operational Assessment stocks.

For more information on the historical spatial distributions of these and other species, visit: https://www.nefsc.noaa.gov/ecosys/spatial-analyses/
And for projected future species spatial distributions, visit: https://www.nefsc.noaa.gov/ecosys/climate-change/projected-thermal-habitat/
For a more comprehensive overview of current conditions, refer to the Ecosystem Status Report for the Northeast Large Marine Ecosystem: https://www.nefsc.noaa.gov/ecosys/ecosystem-status-report/
and the State of the Ecosystem – Gulf of Maine and Georges Bank: http://s3.amazonaws.com/nefmc.org/2_2016-State-of-the-Ecosystem-Report.pdf.

Climate Vulnerability

Although fishing remains the dominant driver of population abundance for most stocks, there is increasing evidence that climate change and decadal variability affect fish (Bell at al. 2014, Fogarty et al. 2008, Hare and Able 2007, Perry et al. 2005, Pinsky and Fogarty 2012). Hare et al. (2016) assessed both the environmental variables that are expected to change which could impact species (climate exposure) and the species intrinsic sensitivity to change (biological sensitivity) in the Northeast fish and shellfish climate vulnerability assessment (Figure 1). Winter flounder stood out as having very high climate exposure as well as high biological sensitivity, indicating that this species could be most negatively impacted by climate change (Figure 1). Atlantic halibut, ocean pout, Atlantic wolffish and witch flounder also had high biological sensitivity, and all species in the Operational Assessment had at least high climate exposure (Figure 1).

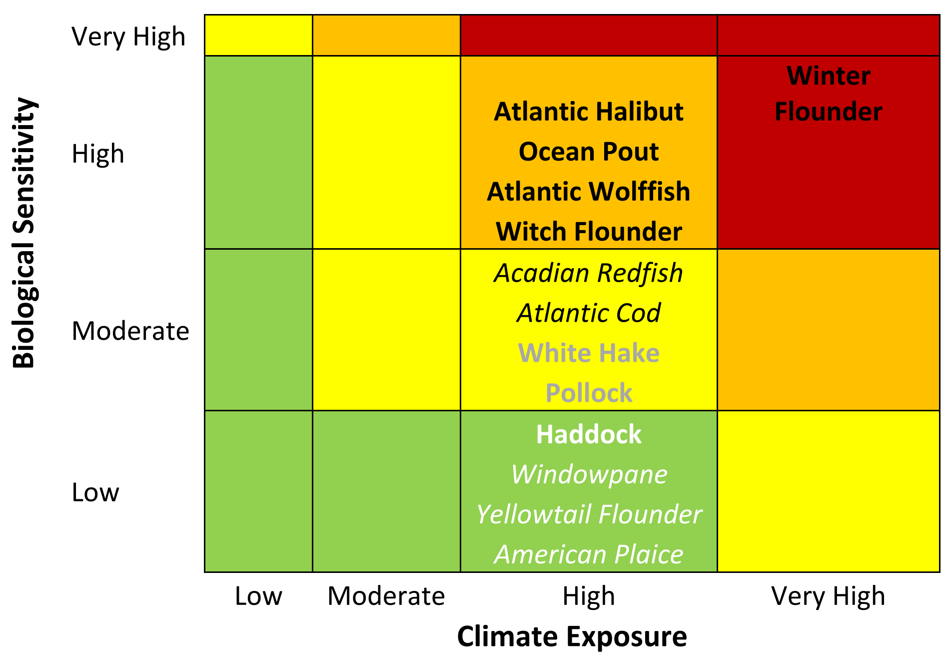

Figure 1. Overall climate vulnerability score denoted by color: low (green), moderate (yellow), high (orange), and very high (red). Certainty in score is denoted by text font and color: very high certainty

(>95%, black, bold font), high certainty (90-95%, black, italic font), moderate certainty (66-90%, white or gray, bold font), low certainty (<66%, white or gray, italic font) (Hare et al. 2016).

Many groundfish stocks on the Northeast U.S. shelf have shown distribution changes in response to climate and population changes (Nye et al. 2009). Most stocks in the Operational Assessment have life history attributes that suggest a high potential for distribution changes (Figure 2, Hare et al. 2016). Only ocean pout and Atlantic wolffish were determined to have a moderate potential for distribution changes (Figure 2).

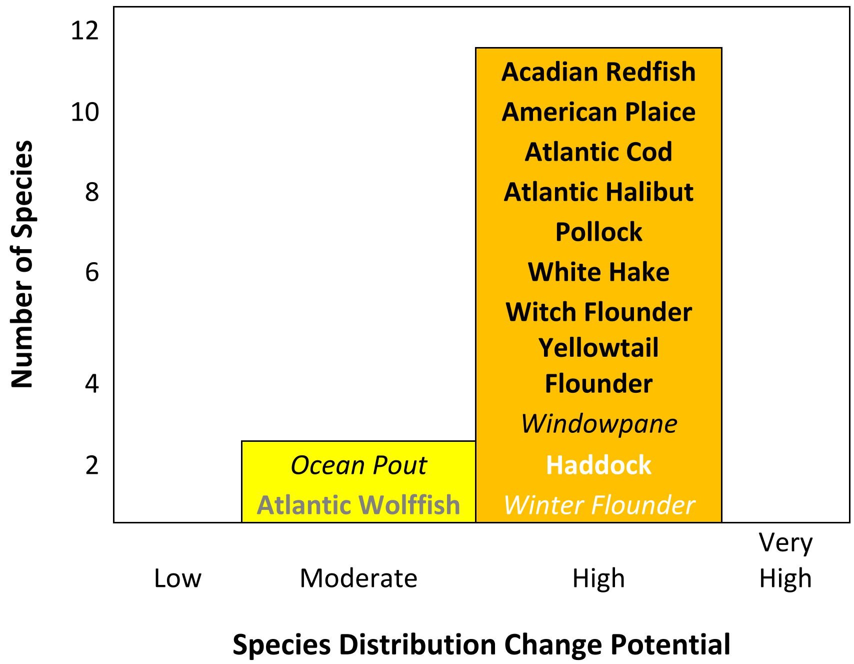

Figure 2. Potential for a change in species distribution denoted by color: low (green), moderate (yellow), high (orange), and very high (red). Certainty in score is denoted by text font and color: very high certainty (>95%, black, bold font), high certainty (90-95%, black, italic font), moderate certainty (66-90%, white or gray, bold font), low certainty (<66%, white or gray, italic font) (Hare et al. 2016).

Hare et al. (2016) determined that most Operational Assessment groundfish species would experience a negative effect from climate change due to decreased productivity or shifts out of the region (Figure 3). Windowpane flounder is the only species that was determined to have a neutral effect from climate change.

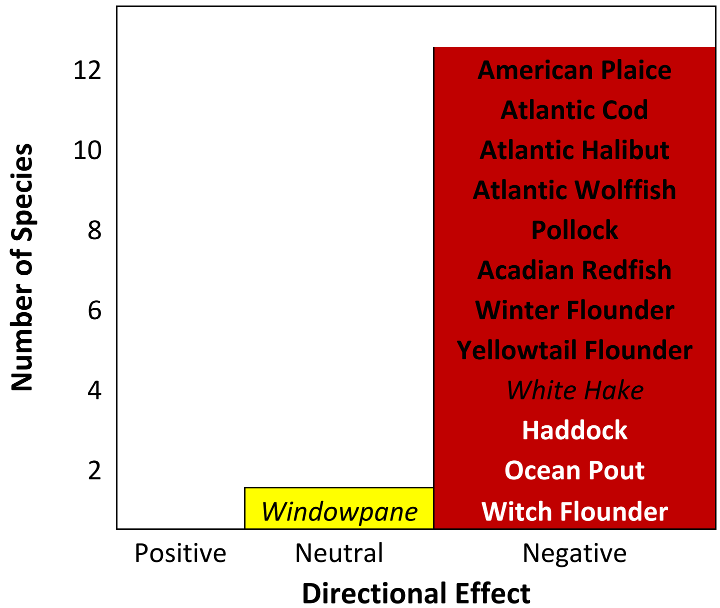

Figure 3. Directional effect of climate change denoted by color: positive (green), neutral (yellow), negative (red). Certainty in score is denoted by text font and color: very high certainty (>95%, black, bold font), high certainty (90-95%, black, italic font), moderate certainty (66-90%, white or gray, bold font), low certainty (<66%, white or gray, italic font) (Hare et al. 2016).

Temperature

The thermal conditions at the bottom of the water column are extremely important in defining the habitats for the majority of resource species. Unlike sea surface temperatures that can be measured synoptically with satellite telemetry, bottom temperatures must be measured directly from ship surveys and other means. Thus, we often have incomplete spatial and temporal sample coverage to describe bottom temperature conditions. Recently, scientists at the NEFSC developed an interpolation approach that provides a more accurate depiction of spring and fall bottom temperatures. Bottom temperatures from the survey are corrected for date of collection to a standard date in April for the spring survey time frame and in October for fall. From these standardized data, a mean temperature anomaly field is developed, which represents the long term average of bottom temperature. The data for an individual survey is then used as the basis of the annual bottom temperature field after it is mathematically combined with the mean field. The time series of April (Figure 4a&b, panel A) bottom temperature in the Gulf of Maine and Georges Bank suggest no trend over time, whereas the October (Figures 4b, Panel B) temperatures steadily increased over the past half century to historic highs in both regions for 2016 (Figure 4). Species that are at the southern end of their range such as Atlantic cod can be particularly vulnerable to increases in bottom temperature (Drinkwater 2005).

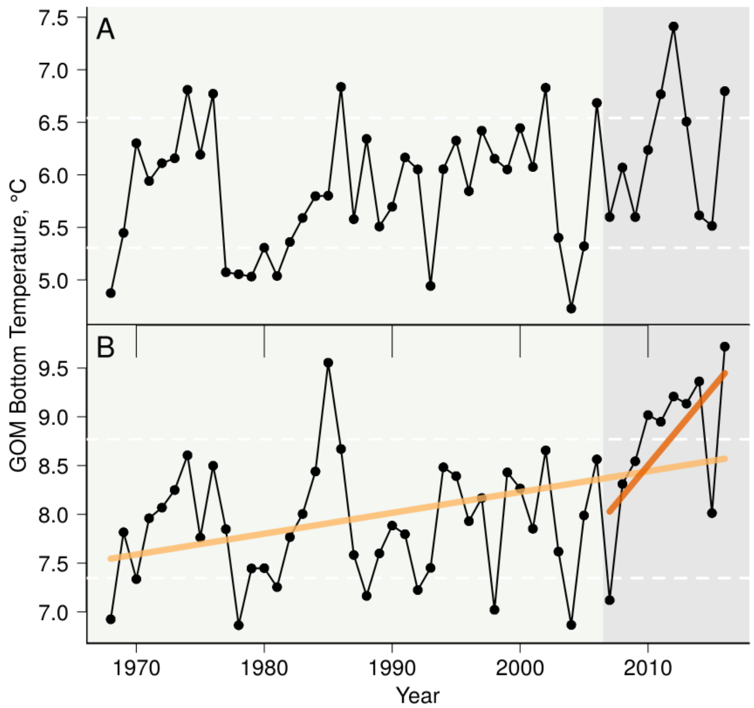

Figure 4a. Bottom temperatures from NEFSC bottom trawl surveys in the Gulf of Maine standardized to a date in April (A) and October (B).

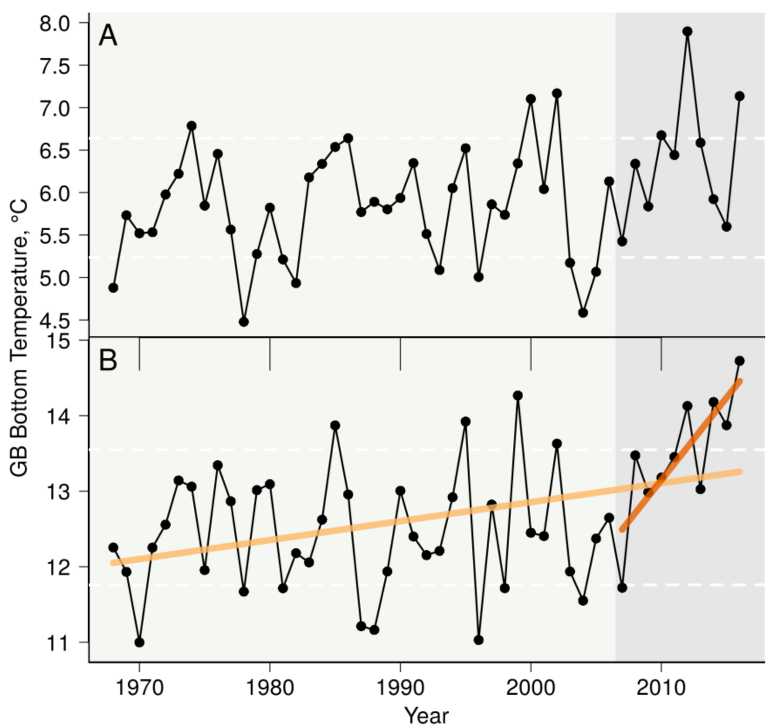

Figure 4b. Bottom temperatures from NEFSC bottom trawl surveys on Georges Bank standardized to a date in April (A) and October (B).

Table 1. Thermal ranges and preferred temperatures for Operational Assessment species from literature. The current Georges Bank mean fall temperature (14.7 degrees C) or Gulf of Maine mean fall temperature (9.7 degrees C) in 2016 exceeds preferred temperature ranges in orange cells and exceeds thermal ranges in red cells. Yellow cells are stocks that span the Georges Bank and Gulf of Maine regions, and have thermal preferences below the average of the Georges Bank and Gulf of Maine mean fall bottom temperatures.

	Thermal Range in Literature			Preferred Temperature	
Species	min	max	Ref	min	max
GM cod*	0	13	1	2	9
GB cod*	0	13	1	2	9
GM haddock	0	13	2	4	7
GB haddock	0	13	2	4	7
CCGM yellowtail	2	17	3	5	12
GB yellowtail	2	17	3	5	12
SNEMA yellowtail	2	17	3	5	12
GM winter fl	0.6	23	4	12	15
GB winter fl	0.6	23	4	12	15
SNEMA winter fl	0.6	23	4	12	15
American Plaice	-0.5	13	5	1	4
Witch flounder	-0.6	16	6	4	11
Halibut	-0.5	13.6	7	3	9
Pollock	0	14	8	6	10
Redfish	4	13	9	5	10
N windowpane	0	24	10	4	19
S windowpane	0	24	10	4	19
Ocean Pout	3	14	11	2	10
White hake*	5	14	12	5	10
Wolffish					

1 (Lough 2004), 2 (Brodziak 2005), 3 (Johnson *et al.* 1999), 4 (Pereirra *et al.* 1999), 5 (Johnson 2005), 6 (Cargnelli *et al.* 1999a), 7 (Cargnelli *et al.* 1999b), 8 (Cargnelli *et al.* 1999c), 9 (Pikanowski *et al.* 1999), 10 (Chang *et al.* 1999a), 11 (Steimle *et al.* 1999), 12 (Chang *et al.* 1999b).
*Preferred temperatures from Species Distribution Model in Selden *et al.* 2017.

Thermal ranges from the literature have been reported in Essential Fish Habitat reports (Table 1). The 2016 mean fall bottom temperatures of 14.7 degrees C on Georges Bank and 9.7 degrees C in the Gulf of Maine were compared to the thermal ranges and preferred temperatures according to stock region. The current mean bottom temperatures exceeded the preferred temperature ranges for Atlantic cod, haddock, GB and SNEMA yellowtail, and Atlantic halibut, potentially exerting a negative impact of temperature on these stocks (Table 1). Additionally, the thermal ranges reported in the literature for Georges Bank cod and Georges Bank haddock were exceeded by the 2016 Georges Bank mean fall bottom temperature (Table 1), potentially exerting a highly negative impact on these stocks. For stocks that spanned the Georges Bank and Gulf of Maine regions, the average of the Georges Bank and Gulf of Maine mean bottom temperatures were compared to the thermal ranges and preferred temperatures, and although more uncertain, there may at least be a slight negative impact of preferred temperature ranges being exceeded for American plaice, witch flounder, ocean pout and white hake (Table 1). Note that there is no Essential Fish Habitat report for Atlantic wolffish.

Long-term temperature data records for the Northeast Shelf Ecosystem show a significant increase in sea surface temperature since the 1850s and a dramatic increase in temperature over the most recent decade (Figure 5). This depiction of thermal conditions is based on the Extended Reconstructed Sea Surface Temperature (ERSST) dataset that includes temperature records back to 1854. The Northeast Shelf Ecosystem was at a record high SST in 2012, the 2016 annual mean level was among the highest values in the time series.

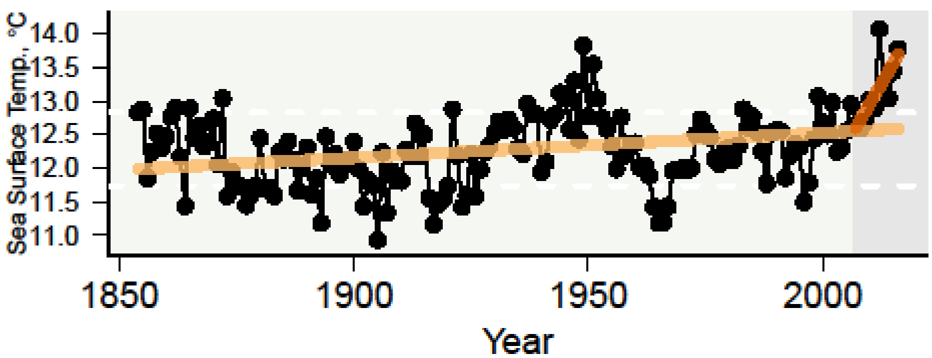

Figure 5. Extended Reconstructed Sea Surface Temperature (ERSST) for the Northeast Shelf Ecosystem.

Climate change involves not only the change in level of climate parameters, it also involves change in system variability that can be seen in more dramatic shifts in weather in terrestrial systems and in ocean parameters on the Northeast Shelf. In an examination of daily sea surface temperatures in the Gulf of Maine (A) and Georges Bank (B), system variability has increased as evidenced by the increase in the annual standard deviation of sea surface temperature, going from approximately 4.0 to 5.0 over the time period, indicating organisms have experienced greater day to day temperature excursions (Figure 6).

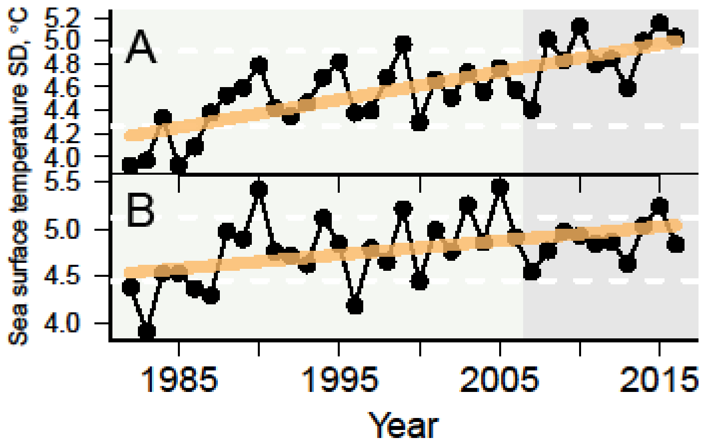

Figure 6. Standard deviation of sea surface temperature on the Northeast Shelf, Gulf of Maine (A) and Georges Bank (B).

The combination of warming thermal conditions with increased variability of sea surface temperature (Figure 6) may be particularly difficult for certain species to adapt to. The vulnerability assessment indicates that all of the groundfish species are likely to be negatively impacted by this kind of environmental perturbation, except windowpane flounder which may have a more neutral response (Figure 3). In an effort to categorize these impacts on the stocks, we suggest scaling up the overall climate vulnerability score (Figure 1) by one level for each stock except for windowpane flounder to reflect the likely neutral (for windowpane) and slightly negative to highly negative impacts of this environmental shift on the groundfish species.

Temperature Habitats

Thermal conditions have the potential to affect the behavior and physiology of marine organisms through growth, reproduction, and survival (Neuheimer et al. 2011). Additionally, Selden et al. (2017) found that both historical and projected future warming reduced the spatial overlap of Atlantic cod with its prey and reduced cod's ability to exert top-down control on prey. Hence, it is one of the more important factors defining the extent of fish and shellfish habitat on the Northeast Shelf. One way of characterizing the thermal habitat for fishes is through the summation of the area of the shelf within specific thermal ranges. The reasoning applied is that as these areas expand and contract they would be variously limiting for a range of species with differing thermal requirements. The shelf ecosystem can be divided into three thermal ranges. The area of cold water habitats (1-4°C) show no time series trend despite extremely low values in recent years (Figure 7). Cold water habitats in 2016 were approximately 5,000 km^2 (2016 value marked over the time series with dashed red line, linear trend shown with blue line, regression model significance shown in upper left). Cool water habitats (5-15°C) show a negative trend over time declining on the order of 531 km^2 yr^{-1}, which is matched by a corresponding increase in warm water habitats (16-27°C) at a rate of 545 km^2 yr^{-1} (Figure 7).

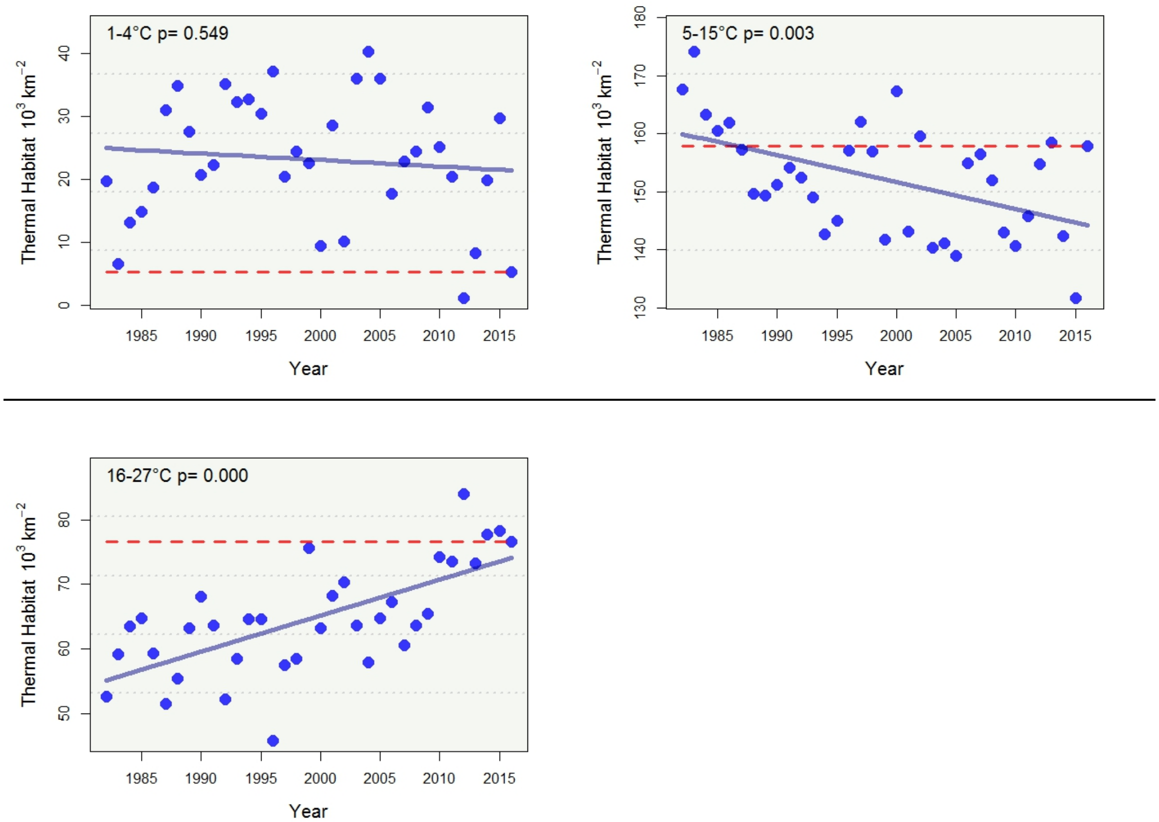

Figure 7. Thermal habitats as the summation of area on the shelf with specified temperature ranges.

All Operational Assessment species had preferred temperature ranges that were lower than the currently increasing warm water habitat of 16-27 degrees C, except for windowpane flounder (Table 1). Whereas all Operational Assessment species had preferred temperature ranges that included the currently decreasing cool water habitat of 5-15 degrees C (Table 1). Additionally, reported thermal ranges from the literature for Atlantic cod, haddock, American plaice, Atlantic halibut, pollock, Acadian redfish, ocean pout and white hake did not include the warm water habitat (Table 1). These reductions of habitat could be causing spatial contraction of ranges as well as negative impacts to the health of these species. We therefore suggest that windowpane flounder may have a neutral response to shifts in temperature habitats, whereas stocks whose thermal ranges were lower than the warm habitat may have highly negative impacts and stocks with preferred temperature ranges below the warm habitat may have negative impacts.

Habitat Models

Random forest habitat models using both static and dynamics variables have been developed for many of the resource species on the Northeast Shelf. These models estimate spring and fall habitat for the time series 1992 to 2016 reflecting the use of the ecosystem based on the biomass and distribution of each species from the NEFSC bottom trawl survey. The variables evaluated for use in these models included station salinity, station temperature, benthic complexity, satellite derived chlorophyll concentration and sea surface temperature, the gradient magnitude (front structure) of the satellite data, and zooplankton bio-volume and taxa abundance with station depth included in all models. The random forest approach differentiates variables with strong predictive power and was used to reduce the variable set to 11 variables for each species. The models were used to estimate spring and fall habitat scores over the entire shelf over the time series. From these estimates, a swept area estimate (SAE) of species abundance was developed for species based on 10 habitat intervals where SAE is the sum of the products of habitat in each interval (km^2) times the biomass CPUE in that interval (Figure 8). This initial analysis has been done on a species basis, which makes interpretation difficult for multi-stock species. Additionally, some stocks exclude certain survey seasons in the assessment due to availability issues. Further collaborative work needs to be completed to address these considerations and decide whether the habitat scores and corresponding SAE would be relevant on a stock basis.

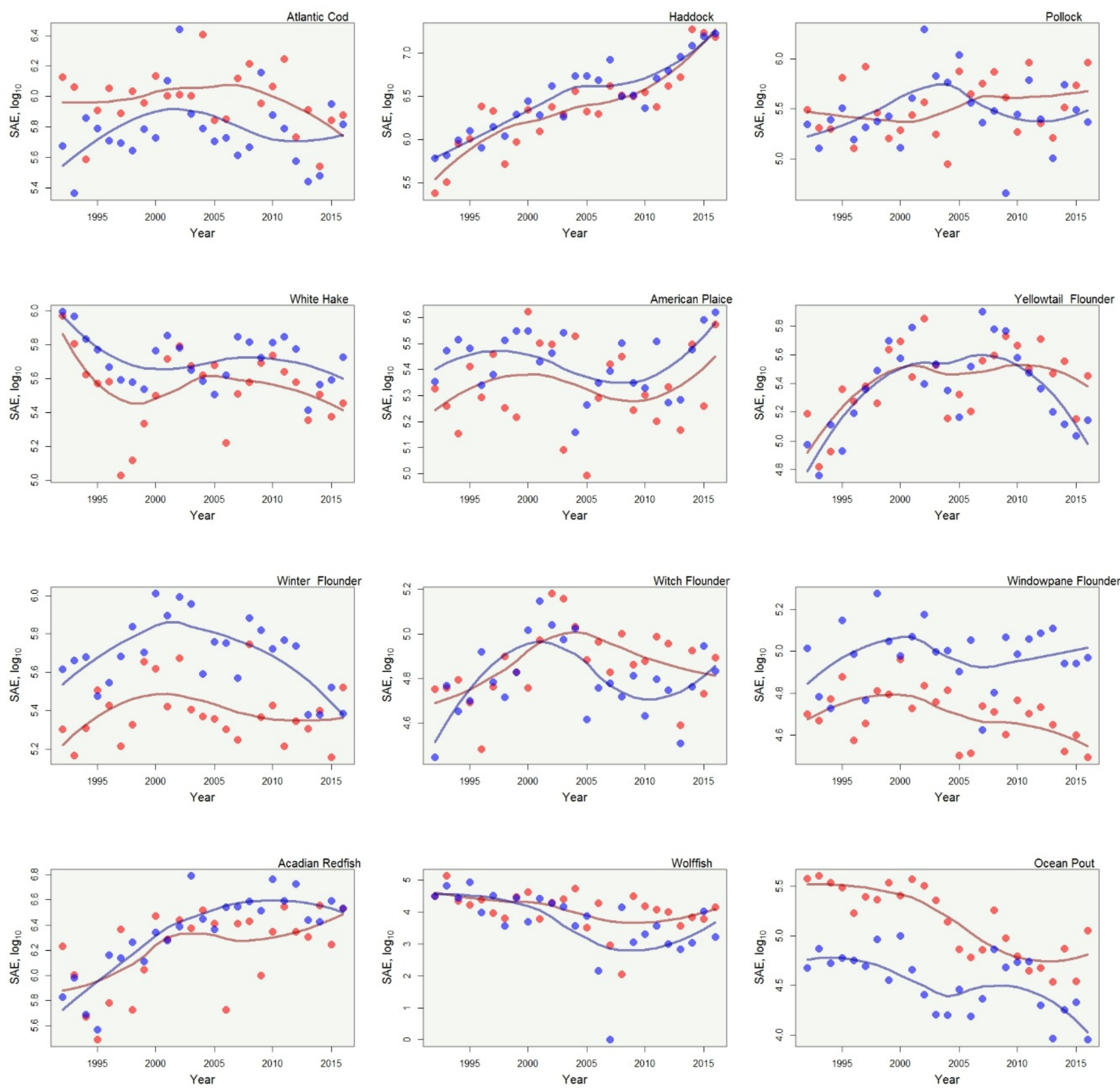

Figure 8. Swept area estimate (SAE) of species abundance based on 10 habitat intervals. SAE is the sum of the products of habitat in each interval (km^2) times the biomass CPUE in that interval. Spring time series in red and fall in blue. Line is loess smoother with span=0.8.

Most species show a concordance between spring and fall SAE estimates. The most dramatic increases in abundance appear in the time series of haddock and Acadian redfish SAE, as well as American plaice in recent years. Ocean pout has the strongest negative trend in SAE over time, whereas white hake, yellowtail flounder, winter flounder, and windowpane flounder have at least slightly negative trends in at least one season. Atlantic cod, pollock, witch flounder and Atlantic wolffish have neutral trends over time.

Distribution Shifts

The species of the Northeast Shelf ecosystem have shown changes in distribution over recent decades (Kleisner et al 2016, Nye et al 2009). Individual species have shifted distribution due to a number of reasons and these shifts can be characterized in a number of different ways. Two metrics that have been used to characterize distribution on the NE Shelf include: 1) the position in the ecosystem along an axis oriented from the southwest to the northeast referred to as the along shelf distance; and, 2) the depth of occurrence. Along shelf distances range from 0 to 1360, which relates to positions along the axis from the origin in southwest to northeast in kilometer units. Depth ranges from 0 to -260, which relates to depth of occurrence in meters. The mean along shelf distance and depth of occurrence for all species by year are shown (Figure 10). As a group, these species had an along shelf distance of approximately 870 km during the time period 1968-2016, they now have a distance of over 930 km. For most of the time series, the species averaged a depth of 100 m, they now average approximately 113 m. In general, the operational assessment species inhabit a more northern distribution and deeper depths than this larger subset of species, but show the same temporal pattern of recent shifts further to the north and into deeper waters.

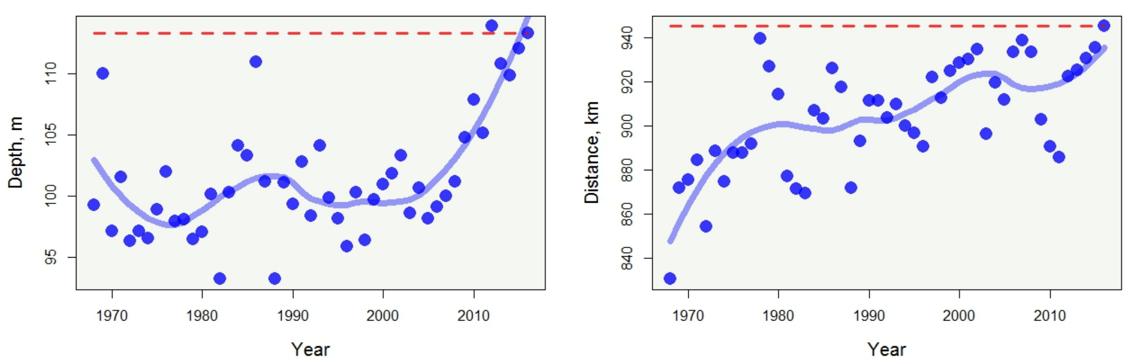

Figure 10. The mean depth and along shelf distance for all species by year. The 2016 values are marked with a dashed red line.

Based on the vulnerability to distribution changes (Figure 2), ocean pout and Atlantic wolffish may have slightly negative impacts from these changes, and all other Operational Assessment stocks may have negative impacts.

Condition

Condition is related to health and reproductive potential of fish (Peig and Green 2009). Changes in fish weight can be due to fishing pressure, prey availability, competition or other environmental changes. A reference length-weight relationship was used to calculate anomalies of fish weight for a given length, and this relative weight was used as an index of condition. Trends in condition were analyzed for 40 finfish stocks caught on the NEFSC autumn bottom trawl survey during 1992-2016, and genders were analyzed separately for species with sexually dimorphic growth rates. 50% of the stocks declined in weight over the time series, whereas only 22% increased in weight.

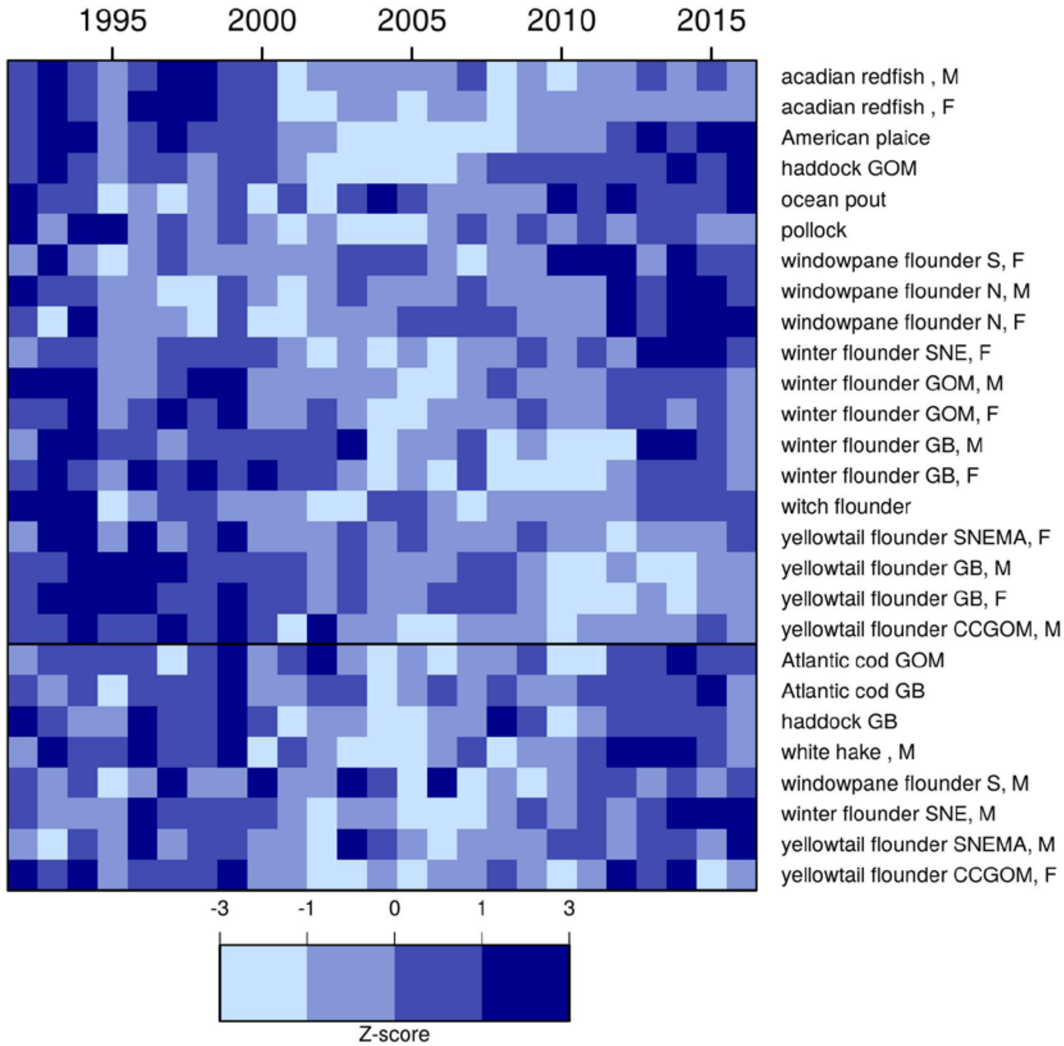

Figure 11. Condition index anomalies for Operational Assessment stocks. Stocks that have changed significantly over time are above the black line and stocks that have not changed significantly over time are below the line.

Condition declined for many Operational Assessment stocks during the 2000s, but has improved again for most species since 2012. American plaice, GOM haddock, ocean pout, Northern and Southern windowpane flounder, SNE winter flounder, witch flounder, and SNEMA yellowtail flounder all have positive condition anomalies in the current year, indicating positive or highly positive impacts on these stocks. Despite recent increases in condition, Acadian redfish, pollock, GOM and GB winter flounder, and GB and CCGOM yellowtail still have negative condition anomalies, indicating that this may have negative impacts on the stocks. No stocks currently have z-scores of condition anomalies that are more than 1 standard deviation below the mean. No significant changes were seen for the stocks and sexes below the line on Figure 11, although similar non-linear patterns of decline and recovery are apparent. Data were too sparse to perform the condition analyses for Atlantic halibut or Atlantic wolffish.

Productivity

Stock productivity was estimated using the NEFSC spring and fall bottom trawl survey data. Productivity for year *t* (P_t) is defined as the abundance of age-1 fish in year *t+1* ($A1_{t+1}$) divided by the biomass of age-2+ fish in year *t* ($B2+_t$), i.e., $P_t = A1_{t+1} / B2+_t$. Age-1 fish were identified as those with length less than the expected length of an age-2 fish, where expected length-at-age was estimated using a generalized linear model. Individual biomass was calculated using length–weight relationships estimated from the survey data following Wigley et al. (2003). Abundance-at-length selectivity conversions from Albatross to Henry Bigelow were applied following Miller (2013). Detailed methods can be found in Perretti et al. (2017).

For species with unit stocks, productivity was calculated over the entire NEFSC survey area. For species with regional stocks, the EPU that most closely matched the area of the stock was used to calculate productivity. The z-score of the fall and spring productivity for each species was then calculated, and the two indices were averaged to create an annual index of productivity.

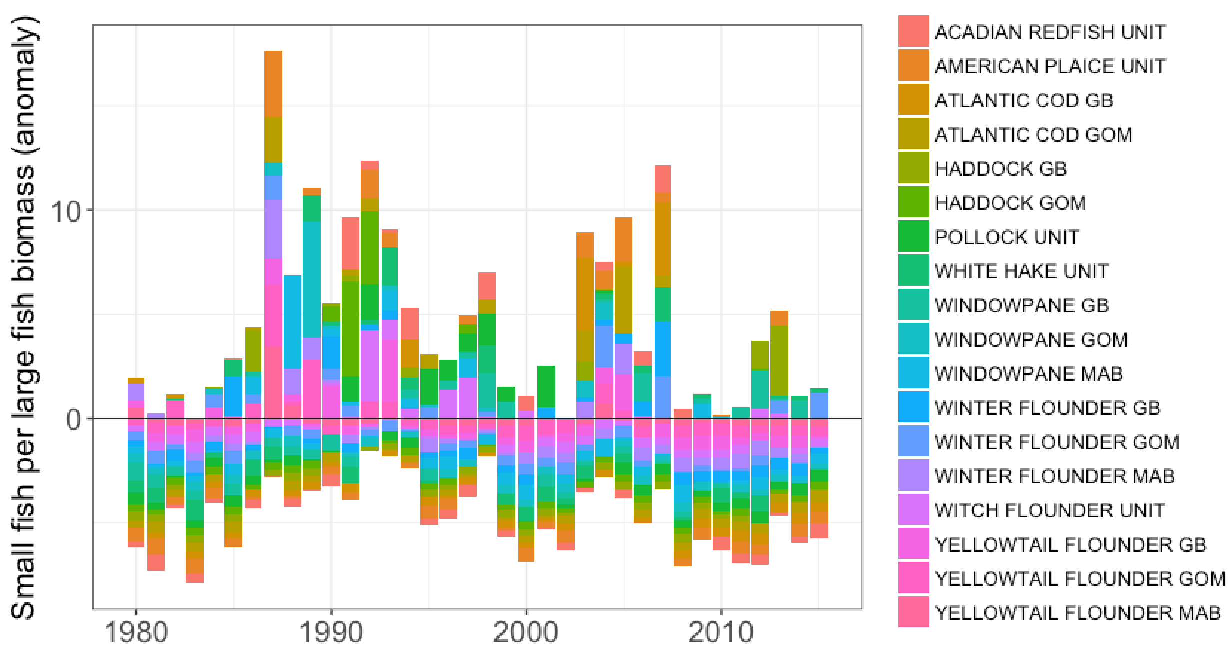

Figure 12: Fish productivity: Anomalies of age-1 fish abundance per age 2+ fish biomass, 1980-2015. Annual anomalies shown are the average of spring and fall anomalies.

Classification of recent productivity (ending in 2015) for each species (Figure 14) was estimated by comparing the most recent three year mean productivity anomaly to all historical three year means. Color classifications were assigned based on the quartile in which the most recent three year mean fell (highest quartile = dark green, 50-75th quartile = green, 25-50th quartile = orange and lowest quartile =

red). Note that Atlantic halibut, ocean pout and Atlantic wolffish were excluded because they do not have Albatross to Bigelow abundance-at-length selectivity conversions.

Eight of the seventeen stocks fell in the lowest quartile of historical three-year means (GOM cod, GB cod, CCGM yellowtail, GB yellowtail, SNEMA yellowtail, SNEMA winter flounder, pollock, and Acadian redfish). While two of the seventeen stocks fell in the highest quartile (GB haddock, GOM winter flounder).

Summary

It can be difficult to quantitatively determine what level or even direction of impact some environmental drivers will have on groundfish, especially for stocks with limited research in this area. However, the Northeast fish and shellfish climate vulnerability assessment (Hare 2016) provides qualitative guidance on the vulnerability of each stock in the Operational Assessment (Figure 13).

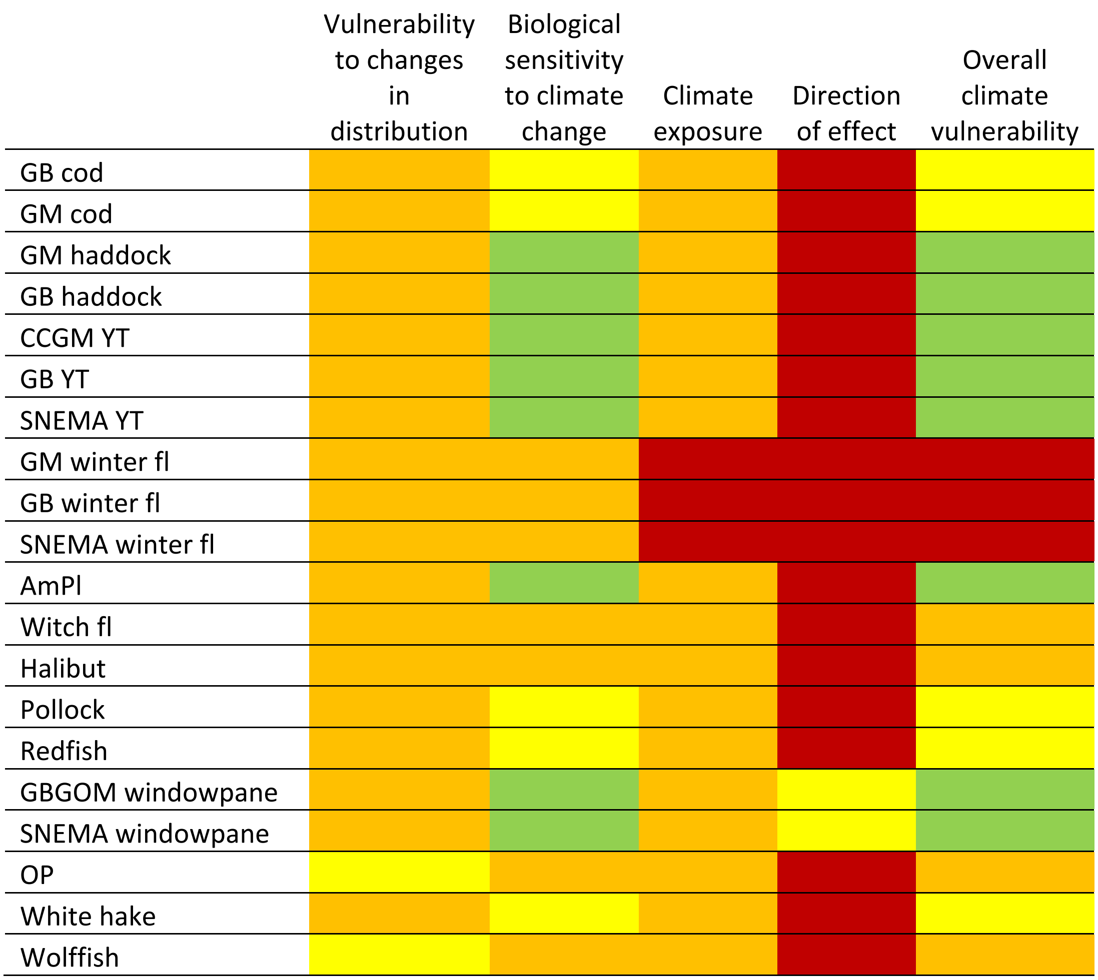

Figure 13. Summary of climate vulnerability of Operational Assessment stocks denoted by color: low vulnerability (green), moderate vulnerability (yellow), high vulnerability (orange), very high vulnerability (red) from Hare et al. (2016).

The potential impacts that environmental drivers may have on stocks are categorized in Figure 14, as described in corresponding sections above.

Stock	Fall bottom temperature increasing[1]	SST increasing[2]	Cool habitats decreasing, warm habitats increasing[1]	Habitat models[3]	Fall survey distribution to Northeast and deeper waters[2]	Fish condition[4]	Productivity[5]
GM cod	orange	orange	red	gray	orange	gray	red
GB cod	red	orange	red	gray	orange	gray	red
GM haddock	orange	yellow	red	light green	orange	dark green	light green
GB haddock	red	yellow	red	light green	orange	gray	dark green
CCGM yellowtail	gray	yellow	orange	yellow	orange	orange	red
GB yellowtail	orange	yellow	orange	yellow	orange	orange	red
SNEMA yellowtail	orange	yellow	orange	yellow	orange	light green	red
GM winter fl	gray	red	orange	yellow	orange	orange	dark green
GB winter fl	gray	red	orange	yellow	orange	orange	red
SNEMA winter fl	gray	red	orange	yellow	orange	light green	orange
American Plaice	yellow	yellow	red	light green	orange	dark green	orange
Witch flounder	yellow	red	orange	gray	orange	light green	light green
Halibut	orange	red	red	white	orange	white	white
Pollock	gray	orange	red	gray	orange	orange	red
Redfish	gray	orange	red	light green	orange	orange	red
N windowpane	gray	gray	gray	yellow	orange	dark green	orange
S windowpane	gray	gray	gray	yellow	orange	light green	orange
Ocean Pout	yellow	red	orange	red	yellow	dark green	white
White hake	yellow	orange	orange	yellow	orange	gray	light green
Wolffish	white	red	white	gray	yellow	white	white

Figure 14. Summary of potential impacts of ecosystem indicators on Operational Assessment stocks. Potential impacts are categorized as highly positive (dark green), positive (light green), neutral (gray), slightly negative (yellow), negative (orange), highly negative (red), or unknown (white). Potential impacts on stocks were categorized based on 1) temperature preferences, 2) vulnerability assessments, 3) trend of index, 4) current time period compared to historical quantiles, or 5) current 3-yr mean compared to quantiles of historical 3-yr means.

Other Ecosystem Considerations Needing Collaborative Development

A broad spectrum of other ecosystem drivers are available, but need further collaboration between departments and guidance from stock assessment leads. These include bottom up drivers from chlorophyll and lower trophic levels, top down drivers from predation, and multi-dimensional information relating to habitat. These are included as they may be useful to specific stocks if developed further during a research track assessment.

Fall Bloom

The fall bloom in the Gulf of Maine and on Georges Bank may play a role in haddock recruitment through a provisioning effect on spawning fish that enhances reproductive output (Friedland et al. 2015). The fall bloom on the Northeast Shelf was well developed in the Gulf of Maine, and, though chlorophyll concentrations on Georges Bank were elevated, a distinct bloom was not detected because of cloud cover issues limiting the satellite data (Current conditions summary from Ecosystem Status Report). The index is therefore not reliable for the current year in predicting impacts on recruitment for the Georges Bank haddock stock.

Predation

The groundfish species in the Operational Assessment have many predators including fish, marine mammals, sharks and sea birds. The NEFSC has an extensive fish diet database, although due to the predominant macroscopic examination of stomachs at sea and advanced digestion state, the fishes considered here are not often identified to species when prey. Therefore, with the few instances of the Operational Assessment species as prey, estimating consumption by fish predators is highly uncertain. However, considering these species, predation can be quantified with diet compositions for all prey taxa to identify feeding guilds, dietary overlap, and competition (i.e. their “ecological footprints”) in addition to understanding patterns and processes of trophic interactions across numerous factors (see Smith and Link 2010).

Published diet studies for seals generally identify prey to species using otoliths, although consumption estimates were not conducted due to uncertainty or a lack of 1) recent population abundance estimates, 2) seasonal variation of residency of seals in U.S. waters, 3) temporal and seasonal changes in diet and consumption rates, 4) daily per capita consumption rates, and 5) knowledge of foraging ground usage between groundfish stock areas. Harbor and gray seals are the two most abundant seal populations in Northeast U.S. waters. Harbor seal populations in U.S. waters may be fairly stable in recent years (Waring et al. 2015) and they primarily prey on sandlance (25%), small gadids (hakes, 20%), flatfish (13%), and clupeids (13%) (Smith et al. 2015). The gray seal population is increasing at a rate of 4.5% in Canadian waters and is likely increasing in U.S. waters as well (DFO 2014, Hayes et al. 2017), although it is unknown if the rate may differ. Gray seals primarily prey on sandlance (34%), large gadids (Atlantic cod, haddock, pollock, 19%), flatfish (14%), clupeids (10%) and small gadids (hakes, 9%) (Smith et al. 2015). Without stock-specific predation estimates for seals, the impact of any potential increases in seal populations is unknown.

Trends in estimated habitat scores

Trends in spring and fall habitat scores were estimated from models developed for Northeast Shelf species over the time period 1992 to 2016. These models were fit using machine learning and based on a suite of environmental and lower trophic level predictor variables that were fit to species biomass as an indicator of habitat score or quality. For each species, spring and fall trends in habitat estimates are represented with linear slope estimates for grid locations constrained to the segment of the shelf used by each species. These segments were based on an overall occupancy model from a kernel density function calibrated at the 99% confidence level. (Figures 15a and 15b).

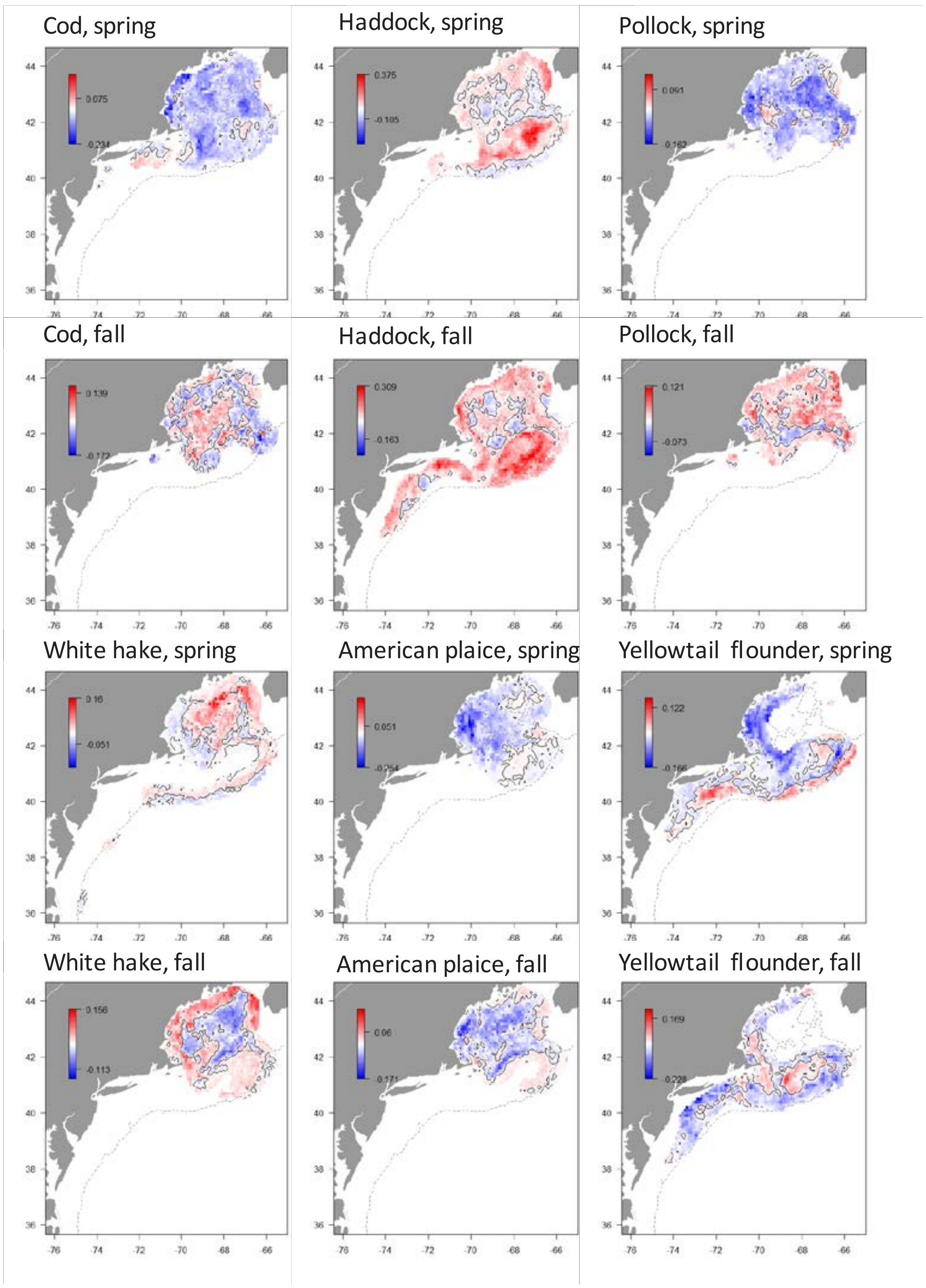

Figure 15a. Spring and fall estimated habitat score trends for Northeast Shelf species over the time period 1992 to 2016. The blue represents a negative trend in the habitat variable, the red represents a positive trend, and the black line marks zero trend.

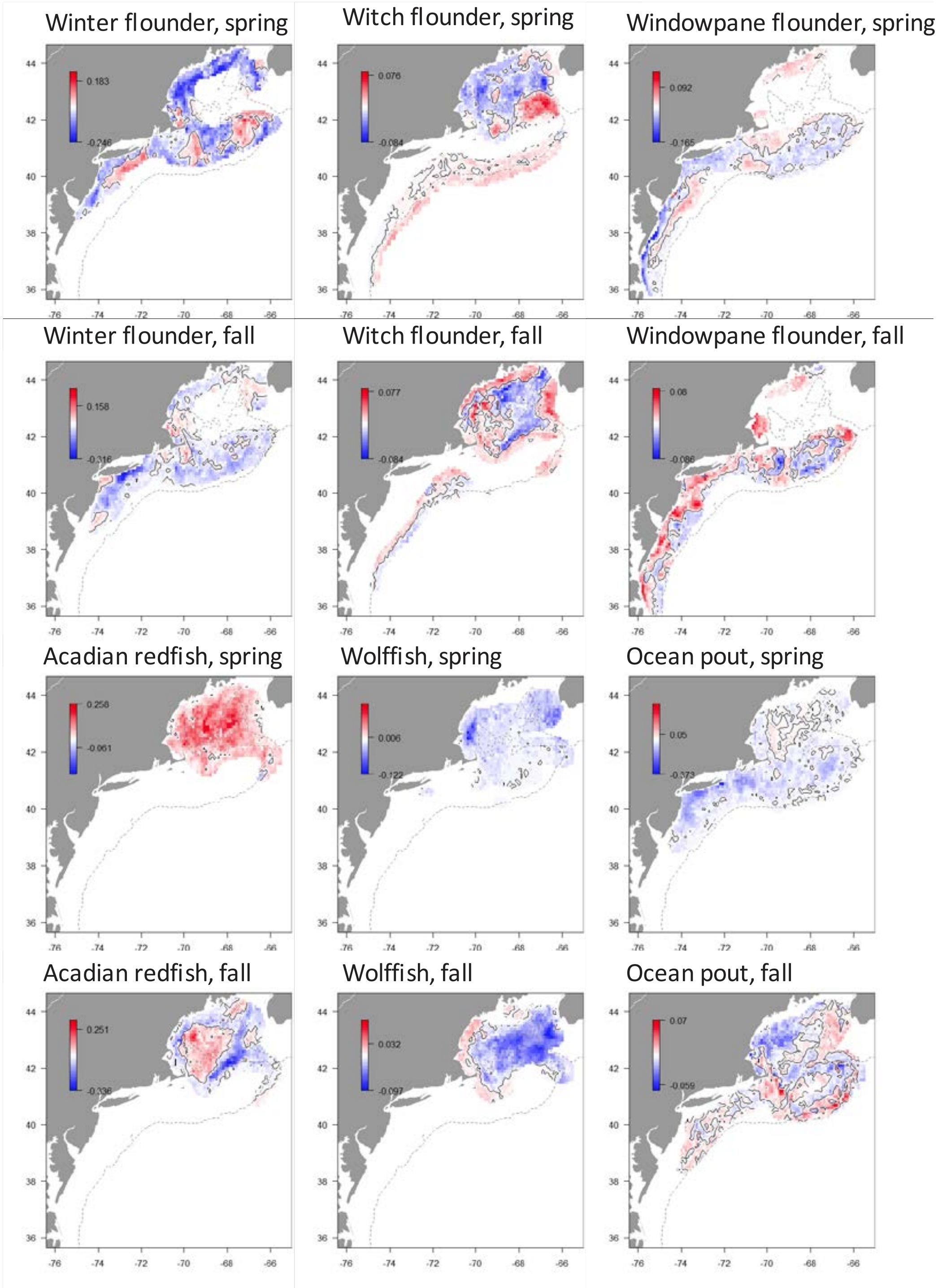

Figure 15b. Spring and fall estimated habitat score trends for Northeast Shelf species over the time period 1992 to 2016. The blue represents a negative trend in the habitat variable, the red represents a positive trend, and the black line marks zero trend.

Many species had concordant habitat changes between seasons, either indicating that habitat was increasing or decreasing in both seasons (Figures 15a and 15b). Interestingly, some species had reciprocal changes, for example, white hake and pollock appear to have opposite habitat trends between seasons.

Literature Cited:

Bell RJ, Hare JA, Manderson JP, Richardson DE. Externally driven changes in the abundance of summer and winter flounder. ICES J. Mar. Sci. 2014; 71(9): 2416–2428.

Brodziak JKT. 2005. Essential fish habitat source document: Haddock, *Melanogrammus aeglefinus*, life history and habitat characteristics. 2nd edition. NOAA Tech Memo NMFS NE 196; 64 p.

Cargnelli LM, Griesbach SJ, Morse WW. 1999b. Essential fish habitat source document: Atlantic halibut, Hippoglossus hippoglossus, life history and habitat characteristics. NOAA Tech Memo NMFS NE 125; 17 p.

Cargnelli LM, Griesbach SJ, Packer DB, Berrien PL, Johnson DL, Morse WW. 1999c. Essential fish habitat source document: Pollock, Pollachius virens, life history and habitat characteristics. NOAA Tech Memo 131; 30 p.

Cargnelli LM, Griesbach SJ, Packer DB, Berrien PL, Morse WW, Johnson DL. 1999a. Essential fish habitat source document: Witch flounder, Glyptocephalus cynoglossus, life history and habitat characteristics. NOAA Tech Memo NMFS NE 139; 29 p.

Chang S, Berrien PL, Johnson DL, Morse WW. 1999a. Essential fish habitat source document: Windowpane, Scophthalmus aquosus, life history and habitat characteristics. NOAA Tech Memo NMFS NE 137; 32 p.

Chang S, Morse WW, Berrien PL. 1999b. Essential Fish Habitat Source Document: White Hake, Urophycis tenuis, Life history and habitat characteristics. NOAA Technical Memorandum ERL GLERL, NMFS-NE-136.

DFO, 2014. Stock assessment of Canadian grey seals (Halichoerus grypus). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/010.

Drinkwater KF. The response of Atlantic cod (Gadus morhua) to future climate change. ICES J Mar Sci. 2005; 62(7): 1327-1337.

Fogarty M, Incze L, Hayhoe K, Mountain D, Manning J. Potential climate change impacts on Atlantic cod (Gadus morhua) off the northeastern USA. Mitig Adapt Strat Glob Change. 2008; 13(5–6): 453–466.

Friedland, K.D., Leaf, R.T., Kristiansen, T. & Large, S.I. 2015. Layered effects of parental condition and larval survival on the recruitment of neighboring haddock stocks. *Canadian Journal of Fisheries and Aquatic Sciences*, **72**, 1672-1681.

Hare JA, Able KW. Mechanistic links between climate and fisheries along the east coast of the United States: explaining population outbursts of Atlantic croaker (Micropogonias undulatus). Fish Oceanogr. 2007; 16(1): 31–45.

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, Griffis RB et al. 2016. A vulnerability assessment of fish and invertebrates to climate change on the Northeast U.S. Continental Shelf. PLoS ONE 11(2): e0146756.

Hayes SA, Josephson E, Maze-Foley K, Rosel, PE, editors. 2017. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2016. NOAA Tech Memo NMFS NE 241; 274 p.

Johnson DL. 2005. Essential fish habitat source document: American plaice, Hippoglossoides platessoides, life history and habitat characteristics. 2nd edition. NOAA Tech Memo NMFS NE 187; 72 p.

Johnson DL, Morse WW, Berrien PL, Vitaliano JJ. 1999. Essential fish habitat source document: Yellowtail flounder, Limanda ferruginea, life history and habitat characteristics. NOAA Tech Memo NMFS NE 140; 29 p.

Kleisner KM, Fogarty MJ, McGee S, Barnett A, Fratantoni P, Greene J, et al. 2016. The Effects of Sub-Regional Climate Velocity on the Distribution and Spatial Extent of Marine Species Assemblages. PLoS ONE 11(2): e0149220.

Lough RG. 2004. Essential Fish Habitat Source Document: Atlantic Cod, Gadus morhua, Life History and Habitat Characteristics. NOAA Technical Memorandum, NMFS-NE-190.

Miller TJ. 2013. A comparison of hierarchical models for relative catch efficiency based on paired-gear data for US Northwest Atlantic fish stocks. Can J Fish Aquat Sci 70, 1306–1316.

Neuheimer, A.B., Thresher, R.E., Lyle, J.M. & Semmens, J.M. 2011. Tolerance limit for fish growth exceeded by warming waters. *Nature Clim. Change*, **1**, 110-113.

Nye JA, Link JS, Hare JA, Overholtz WJ. 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. Mar Ecol Prog Ser. 393: 111–129.

Peig, J. & Green, A.J. 2009. New perspectives for estimating body condition from mass/length data: the Scaled mass index as an alternative method. Oikos, 118, 1883–1891.

Pereira JJ, Goldberg R, Ziskowski JJ, Berrien PL, Morse WW, Johnson DL. 1999. Essential fish habitat source document: Winter flounder, Pseudopleuronectes americanus, life history and habitat characteristics. NOAA Tech Memo NMFS NE 138; 39 p.

Perretti CT, Fogarty MJ, Friedland KD, Hare JA, Lucey SM, McBride RS, Miller TJ, Morse RE, O'Brien L, Pereira JJ, Smith LA, Wuenschel MJ. 2017. Regime shifts in fish recruitment on the Northeast US Continental Shelf. Marine Ecology Progress Series 574:1–11.

Perry RI, Cury P, Brander K, Jennings S, Möllmann C, Planque B. 2010. Sensitivity of marine systems to climate and fishing: concepts, issues and management responses. J Mar Syst. 79(3): 427–435.

Pikanowski RA, Morse WW, Berrien PL, Johnson DL, McMillan DG. 1999. Essential fish habitat source document: Redfish, Sebastes spp., life history and habitat characteristics. NOAA Tech Memo NMFS NE 132; 19 p.

Pinsky ML, Fogarty M. 2012. Lagged social-ecological responses to climate and range shifts in fisheries. Climatic change. 115(3–4): 883–891.

Selden RL, Batt RD, Saba VS, Pinsky ML. *Accepted.* The role of warming in present and future piscivore dominance in a large marine ecosystem. Global Change Biology.

Smith, L.A., Link, J.S., Cadrin, S.X., Palka, D.L. 2015. Consumption by marine mammals on the Northeast U.S. continental shelf. Ecological Applications 25(2): 373 – 389.

Smith B, Link J. 2010. The Trophic Dynamics of 50 Finfish and 2 Squid Species on the Northeast US Continental Shelf . NOAA Technical Memorandum NMFS NE 216 640 p.

Steimle FW, Morse WW, Berrien PL, Johnson DL, Zetlin CA. 1999. Essential fish habitat source document: Ocean pout, Macrozoarces americanus, life history and habitat characteristics. NOAA Tech Memo NMFS NE 129; 26 p.

Wigley SE, McBride HM, McHugh NJ. 2003. Length-weight relationships for 74 fish species collected during NEFSC research vessel bottom trawl surveys, 1992-1999. NOAA Tech Memo NMFS NE 171; 26 p.

Procedures for Issuing Manuscripts in the *Northeast Fisheries Science Center Reference Document* (CRD) Series

Clearance

All manuscripts submitted for issuance as CRDs must have cleared the NEFSC's manuscript/abstract/webpage review process. If any author is not a federal employee, he/she will be required to sign an "NEFSC Release-of-Copyright Form." If your manuscript includes material from another work which has been copyrighted, then you will need to work with the NEFSC's Editorial Office to arrange for permission to use that material by securing release signatures on the "NEFSC Use-of-Copyrighted-Work Permission Form."

For more information, NEFSC authors should see the NEFSC's online publication policy manual, "Manuscript/abstract/webpage preparation, review, and dissemination: NEFSC author's guide to policy, process, and procedure," located in the Publications/Manuscript Review section of the NEFSC intranet page.

Organization

Manuscripts must have an abstract and table of contents, and (if applicable) lists of figures and tables. As much as possible, use traditional scientific manuscript organization for sections: "Introduction," "Study Area" and/or "Experimental Apparatus," "Methods," "Results," "Discussion," "Conclusions," "Acknowledgments," and "Literature/References Cited."

Style

The CRD series is obligated to conform with the style contained in the current edition of the United States Government Printing Office Style Manual. That style manual is silent on many aspects of scientific manuscripts. The CRD series relies more on the CSE Style Manual. Manuscripts should be prepared to conform with these style manuals.

The CRD series uses the American Fisheries Society's guides to names of fishes, mollusks, and decapod crustaceans, the Society for Marine Mammalogy's guide to names of marine mammals, the Biosciences Information Service's guide to serial title abbreviations, and the ISO's (International Standardization Organization) guide to statistical terms.

For in-text citation, use the name-date system. A special effort should be made to ensure that all necessary bibliographic information is included in the list of cited works. Personal communications must include date, full name, and full mailing address of the contact.

Preparation

Once your document has cleared the review process, the Editorial Office will contact you with publication needs – for example, revised text (if necessary) and separate digital figures and tables if they are embedded in the document. Materials may be submitted to the Editorial Office as email attachments or intranet downloads. Text files should be in Microsoft Word, tables may be in Word or Excel, and graphics files may be in a variety of formats (JPG, GIF, Excel, PowerPoint, etc.).

Production and Distribution

The Editorial Office will perform a copy-edit of the document and may request further revisions. The Editorial Office will develop the inside and outside front covers, the inside and outside back covers, and the title and bibliographic control pages of the document.

Once the Web version of the CRD is ready, the Editorial Office will contact you to review and submit corrections or changes before the document is posted online.

A number of organizations and individuals in the Northeast Region will be notified by e-mail of the availability of the document online.

Research Communications Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

MEDIA
MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review and most issues receive copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a regularly-issued, quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. This report undergoes internal review, but receives no technical or copy editing.

TO OBTAIN A COPY of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2350) or consult the NEFSC webpage on "Reports and Publications" (http://www.nefsc.noaa.gov/nefsc/publications/). To access *Resource Survey Report*, consult the Ecosystem Surveys Branch webpage (http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/).