Northeast Fisheries Science Center Reference Document 19-XXXX

FallMT Operational Assessments 2020

by Northeast Fisheries Science Center

April 2020

Northeast Fisheries Science Center Reference Document

19-XXXX

FallMT Operational Assessments 2020

by Northeast Fisheries Science Center

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

April 2020

Northeast Fisheries Science Center Reference Documents

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Abbreviations and Acronyms

Albatross IV Research vessel NOAAS Albatross IV, in service until November 2008 vi, x, 11, 59, 139

AOP Assessment Oversight Panel 1, 2, 9, 20, 22, 32, 46, 57, 76, 86, 132

ASAP Age-Structured Assessment Program 29, 32, 33, 41, 42, 44, 46, 47, 85, 132, 133

ASMFC Atlantic States Marine Fisheries Commission 4, 5

CRD Center Research Document CLIX

CSE Council of Science Editors CLIX

CT LISTS Connecticut Long Island Sound Trawl Survey 40

DFO Department of Fisheries and Oceans, Canadian 18, 20, 28

FishWatch.Gov NOAA FishWatch.gov: seafood facts 139

FSD Fisheries Statistics Division 65–67, 69, 70

GARFO Greater Atlantic Regional Fisheries Office 4, 5

GARM Groundfish Assessment Review Meeting 84

GARM III 3rd Groundfish Assessment Review Meeting, 2008 41, 48, 78, 88, 95

Henry B. Bigelow Research vessel NOAAS Henry B. Bigelow, with specialised trawling net mechanisms; commissioned July 2007, used for surveys 2009–2019 x, 116, 139

ISO International Organization for Standardization viii, CLIX

Karen Elizabeth Fishing vessel F/V Karen Elizabeth, can tow two nets at once, making it the perfect platform for examining net performance under different conditions. 134, 139

LLC Limited Liability Company 1

MA DMF Massachusetts Division of Marine Fisheries 4, 6, 11, 15, 40, 57, 64

ME DMR Maine Department of Marine Resources 4, 5

MIT Massachusetts Institute of Technology 4

MRIP Marine Recreational Information Program 7, 9, 29, 31, 32, 55, 57, 58, 103, 113

NDPSWG Northeast Data Poor Stocks Working Group 54, 55, 59

NEAMAP Northeast Area Monitoring and Assessment Program 31–33, 86

NEFMC New England Fisheries Management Council 4, 5, 31, 124, 134

NEFSC Northeast Fisheries Science Centre III, 1, 2, 4–7, 9, 11, 15, 16, 18–21, 23, 28, 29, 34, 40, 41, 43–46, 53–57, 59, 64, 67, 72, 73, 76–78, 82, 83, 86, 88, 89, 92–95, 99, 103, 105, 109, 113, 116, 120–123, 125, 126, 128–133, 135, 136, 138, CLIX, CLX

NMFS National Marine Fisheries Service CLX

NOAA National Oceanographic and Atmospheric Administration vi–ix, 1, 4, 5, 65, 78, 88, 95, 105, 116, 124, 134, 139, 140, CLX

NOAAS NOAA ship or fishing vessel vii, x, 11, 116, 139

PDF Portable Document Format, ISO 32000 III

PDT Plan Development Team 21, 30, 42, 47

PRP Peer Review Panel 1, 2, 9, 20–22, 57

RI DFW Rhode Island Department of Fish and Wildlife 40

SARC Stock Assessment Review Committee 3, 103–105, 113–115, 132

SARC 52 52nd Stock Assessment Review Committee meeting 6, 7, 9, 10

SASINF Stock Assessment Support Information 19, 65, 68

SAW Stock Assessment Workshop 11, 35, 105, 116, 121, 129

SMAST School for Marine Science and Technology (New Bedford, Maine) 4, 5

SSC Scientific and Statistical Committee 2, 10, 22, 31, 34, 47, 58, 78, 87, 105, 115, 133

SUNY State University of New York 34

VIMS Virginia Institute of Marine Science 4

WHOI Woods Hole Oceanographic Institute 5, 139

Abbreviations for fish stocks reviewed

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

CATUNIT Atlantic wolffish ix, 54–64

FLDGMGB windowpane flounder from Gulf of Maine to Georges Bank ix, 73–82

FLDSNEMA windowpane flounder from Southern New England to Mid-Atlantic ix, 83–92

FLWGB winter flounder from the Georges Bank ix, 16–28

FLWGM winter flounder from the Gulf of Maine ix, 6–15

FLWSNEMA winter flounder from Southern New England to Mid-Atlantic ix, 29–40

HALUNIT Atlantic halibut ix, 65–72

HKRGM Northern red hake ix, 100–109

HKRSNEMA Southern red hake ix, 110–120

HKSGM Northern silver hake ix, 121–128

HKSSNEMA Southern silver hake ix, 129–138

OPTUNIT ocean pout ix, 93–99

REDUNIT Acadian redfish ix, 41–53

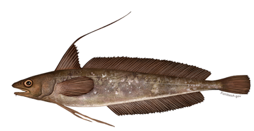
Atlantic Wolffish

Windowpane Flounder

Atlantic Sea Scallop

Winter Flounder

Atlantic Halibut



Red Hake

Silver Hake

Ocean Pout

Acadian Redfish

Images from NOAA Fisheries and FishWatch.gov.

Statistical/review concepts, parameters, etc.

ABC acceptable biological catch 111

ADAPT sum-of-squares approach to fitting VPA models 17, 21

AIM An Index Model 2, 73–78, 83–87, 100, 101, 103, 104, 110, 111, 113, 114

Albatross refers to activities of the vessel NOAAS Albatross IV 55, 58, 76, 86, 103, 113

A/L keys keys to Age at Length data, within a database 18

AMELIA II R package for the multiple imputation of multivariate incomplete data 132

B–H Beverton–Holt (model for stock-recruitment) 31

Bigelow refers to activities of the vessel NOAAS Henry B. Bigelow 55, 58, 59, 74, 76, 77, 84, 100–104, 110–114

B biomass 93

B_{MSY} biomass maximum sustainable yield 6, 47, 77, 93, 110

$B_{MSY\,proxy}$ proxy estimate for biomass maximum sustainable yield 73, 83, 86, 87, 89, 100, 121, 129

BRP biological reference point 31, 103, 113, 122, 130, 133

BRPs biological reference points 10, 21, 34, 47, 58, 77, 87, 103, 104, 113, 114

BSIA Best Scientific Information Available 9, 20, 32, 57, 103, 113

$B_{\text{Threshold}}$ threshold for biomass that indicates overfished status 83, 86, 89, 102, 112

CAR Conditional Auto-Regressive model 133

cdf cumulative distribution function 16, 31

CI confidence interval 29–31

cm centimeters, fish length 6, 7, 9–11, 19, 55, 57

+cm mt metric tonnes of catch at least of specified length in centimeters 6, 9, 10

CV coefficient of variation 44, 74, 84, 122

DWS Data Weighting Scenario model 41–44, 48, 50, 51

E_{Full} exploitation mortality on fully selected ages 6, 13

$E_{MSY\,proxy}$ the exploitation rate commensurate with fishing at the proxy for maximum sustainable yield 6, 7, 9, 10, 13

ESS Expeditionary Support Ship 44

$E_{40\%}$ exploitation rate at 40% of the total catch 6, 7, 10

F (instantaneous) fishing mortality rate 7, 16–21, 30–32, 34, 41–43, 45, 50, 55, 58, 66, 73, 74, 77, 78, 83–85, 94, 101, 105, 111, 115, 122, 130

F_{Full} fishing mortality on fully selected ages 7, 16–18, 25, 29–31, 37, 41–43, 50, 54, 55, 61, 74, 84, 94, 100, 101, 110, 111, 122, 130

$F_{50\%}$ the instantaneous fishing mortality rate commensurate with fishing at fifty percent of maximum sustainable yield 41, 42

F_{2019} fishing mortality rate in year 2019 16, 20, 21, 32

FMP fishery management plan 124, 134

F_{MSY} fishing mortality for maximum sustainable yield 9, 10, 16–18, 20–22, 25, 29, 31, 32, 34, 37, 41, 47, 74, 77, 78, 86, 93, 111

$F_{MSY\,proxy}$ proxy estimate of fishing rate for maximum sustainable yield 16, 21, 29, 30, 32, 41, 42, 47, 50, 54, 57, 58, 61, 65, 73, 77, 83, 84, 87, 90, 93, 97, 100, 110, 111, 121, 129

F_{Rebuild} fishing mortality rate consistent with the stock rebuilding plan 73, 74, 77

F_{ρ} Mohn's rho-adjusted value for the fishing rate 18, 43

F_{Target} Theoretically ideal fishing mortality level for sustainability 25

$F_{\text{Threshold}}$ threshold fishing mortality level that indicates overfishing status 13, 25, 37, 50, 61, 97

$F_{40\%}$ fishing rate at 40% of the total catch 9, 10, 16, 19–22, 29, 31, 32, 34, 41, 47, 54

kg kilograms 121, 122, 129, 130

kg/tow kilograms per tow 73, 76, 82, 83, 85–87, 89, 90, 92, 93, 96, 99, 100, 103, 104, 110, 113, 114, 121, 122, 125, 129, 130, 135

kt kiloton = thousand metric tons 73, 83, 86, 87, 90, 100, 110, 122, 130

log-normal probability distribution whose logarithm is normally distributed 15, 36–38, 40, 48, 50, 51, 53, 56, 64, 72, 82, 92, 99, 109, 120, 128, 138

L_{50} Length at 50% maturity 55

M (instantaneous) natural mortality rate 9, 10, 45, 47, 105, 115

MCMC Markov Chain Monte Carlo analysis 55, 56

000s thousands 16, 26, 29, 38, 41, 51, 121, 129

$\boldsymbol{\rho}$ Mohn's rho parameter: the average relative bias of retrospective estimates 18, 21, 31, 32, 42, 43, 55, 58

$\boldsymbol{MSP}$ maximum spawning potential 19, 22

$\boldsymbol{MSY}$ maximum sustainable yield 6, 16, 20, 29, 34, 41, 47, 54, 58, 59, 65, 73, 77, 93, 94, 121, 129

$\boldsymbol{MSY_{proxy}}$ proxy value for maximum sustainable yield 83, 84, 87

$\boldsymbol{MSY_{40\%}}$ forty percent of maximum sustainable yield 34

mt metric ton 6, 7, 9, 10, 16, 17, 20, 21, 24, 27, 29, 30, 32–34, 41–43, 45–47, 54, 57, 58, 65, 73, 76, 83, 84, 86, 87, 93, 94, 100, 103, 110, 111, 113, 121, 122, 129, 130, 132

NA not applicable 41, 65

OFL overfishing limit 7, 73, 111

$\boldsymbol{q}$ catchability coefficient 6, 7, 9, 10

R-INLA R package for Integrated Nested Lagrange Approximation 133

R statistical software application x, xii

SCALE Statistical Catch at Length model 54–58

scall dr scallop dredge 16

S–K Saltonstall–Kennedy competitive grant 56, 58

SPR spawning potential ratio 34, 104, 105, 114, 115

S–R stock–recruitment data or process 31

$\boldsymbol{SSB}$ spawning stock biomass 7, 16–21, 29–32, 34, 41–43, 45, 54, 55, 57–59, 65, 74, 84, 94, 101, 105, 111, 115, 122, 130

$\boldsymbol{SSB_{2019}}$ spawning stock biomass for year 2019 20, 21, 32

$\boldsymbol{SSB_{MSY}}$ spawning stock biomass consistent with maximum sustainable yield 16, 20, 21, 24, 29, 32–34, 41, 54, 58, 59, 65, 93, 100, 110

$\boldsymbol{SSB_{MSY\,proxy}}$ proxy value for spawning stock biomass estimation for maximum sustainable yield 16, 36, 41, 48, 54, 57, 59, 93, 96

$\boldsymbol{SSB_{\rho}}$ spawning stock biomass level adjusted according to Mohn's ρ value 18, 43

$\boldsymbol{SSB_{\text{Target}}}$ theoretically ideal spawning stock biomass level 24, 36, 48, 59, 96

$\boldsymbol{SSB_{\text{Threshold}}}$ threshold for spawning stock biomass that indicates overfished status 24, 29, 32, 36, 48, 59, 96

$SSB_{40\%}$ the approximate equilibrium spawning stock biomass that results from fishing at forty percent of maximum sustainable yield 19, 20, 34, 105, 115

Stockeff Stock Assessment Efficiency Initiative 7

TOR Term of Reference 9, 10, 20, 21, 33, 34, 46, 47, 57, 58, 76, 77, 86, 87, 103, 104, 113, 114, 132, 133

VPA virtual population analysis x, 16–18, 20–22

Y_c catch years 17

YoY young of the year or age 0 40

YPR Yield Per Recruit 9, 10

The reason behind it all.

Locations/regions: state, country, etc.

CA Canada xiv, 16, 18, 65

CT Connecticut xiv

GB Georges Bank xiv, 18

GOM Gulf of Maine xiv

MA Massachusetts III, xiv, 5, 11, 35, 48, 68, 78, 88, 139, CLX

MAB Mid-Atlantic Bight xiv

ME Maine xiv

ME/NH Maine and New Hampshire 6, 11, 15

MA Mid-Atlantic (Bight) 31

NE Northeast CLX

NH New Hampshire xiv

NJ New Jersey xiv, 40

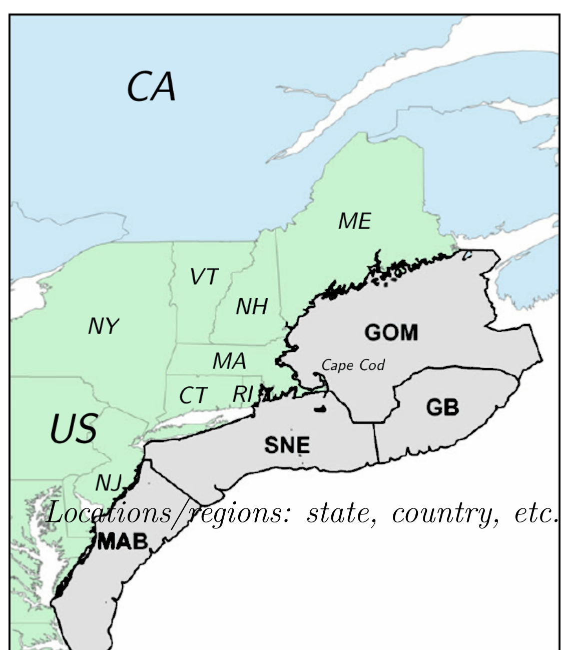
NY New York State xiv

RI Rhode Island xiv

SNE Southern New England xiv, 31

US United States xiv, 11, 16, 18, 20, 35, 48, 59, 68, 78, 88, 95, 98, 105, 116, 124, 134

VT Vermont xiv



2020 Management Track Peer Review Panel Report

Jean-Jacques Maguire[1] (chair), Richard Merrick[2], Patrick Sullivan[3] and Cate O'Keefe[4]

Executive Summary

Thirteen groundfish and one scallop stock assessments were scheduled to be reviewed in the Autumn 2020 Management Track process. The Assessment Oversight Panel (AOP) reviewed the assessment plans and recommended that three assessments be direct delivery (Level 1): Ocean pout, Atlantic halibut and Northern silver hake. Of the remaining eleven, six were expedited reviews (Level 2) and five were enhanced reviews (Level 3).

The eleven assessments with expedited or enhanced peer review included in this report are:
1) Atlantic wolffish, 2) Acadian redfish, 3) Atlantic sea scallops, 4) Northern window pane flounder,
5) Southern window pane flounder, 6) Georges Bank winter flounder, 7) Gulf of Maine winter flounder,
8) Southern New England Mid-Atlantic winter flounder, 9) Northern red hake, 10) Southern red hake,
11) Southern silver hake/Offshore hake.

Peer Review Panel Report

The Peer Review Panel (PRP) for the September 2020 Management Track Assessments met via webinar on September 14–18, 2020. Attendance at the meeting is provided below. The assessments were prepared under guidelines provided by the 2020 Assessment Oversight Panel (AOP). These guidelines provide a pathway for continuing development of previously accepted assessments for each species including incorporation of the most recent data and understanding of biology of the species being assessed.

We thank Russ Brown (Population Dynamics Branch Chief) and Michele Traver (Assessment Process Lead) for their support during the meeting. We thank the staff of the Population Dynamics Branch at NEFSC for the open and collaborative spirit with which they engaged the PRP. Our thanks extend not only to the analysts for each assessment, but also to the rapporteurs for taking extensive notes during the meeting and to staff of the New England Fishery Management Council, Atlantic States Marine Fisheries Commission, and NOAA Fisheries/Greater Atlantic Regional Fisheries Office who provide context and additional background. We also thank the other participants for helping make the meeting productive and collegial. Finally, the PRP thanks the staff at NEFSC for supporting the logistics during the meeting.

Recommendations for Future Management Track Reviews

The PRP has suggestions for improvements that could be made for the next Management Track Assessments.

[1] Halieutikos inc.
[2] NOAA Fisheries Service (retired)
[3] Cornell University
[4] Fishery Applications Consulting Team, LLC

With respect to information needs:

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

2. It would be useful if changes between the previous method(s) and the currently proposed method were documented in assessment summary reports. For example, the northern windowpane report did not document updated AIM model output, and the red hake reports did not document the results of the Red Hake Stock Structure Workshop (a 'Research Track' exercise).

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

With respect to process:

1. The Panel should be provided with a clear summary of what each Management Track review level allows.

2. The implications of going to a 'Plan B' should also be explained. To that end, the Panel is concerned that rejection of a 'Plan A' assessment, and acceptance of the 'Plan B' approach, obligates the analyst to continue to use the 'Plan B' approach until a research track assessment can be completed. It may be more expedient to allow the analyst to retable an improved 'Plan A' assessment for a Level 3 review at the next assessment cycle.

3. It should also be made clear that the Panel is not expected to provide ad hoc management advice, but is to focus on reviewing the assessment and its results.

4. The NEFSC should consider allowing analysts to be cited as authors of their assessments.

5. An appendix should be added to the Management Track Assessment Peer Review Panel Report that compiles all relevant AOP background information, specifically the summaries of each stock's management track assessment proposal to the AOP and the Summary of the AOP Meeting.

Finally, the missing 2020 spring and fall surveys will create problems in the next set of assessments. As such, the next PRP should be made aware that these missing data will need to be handled in appropriate ways. A table or tables, documenting survey completeness for the previous ten years, should be provided in the background documents.

Table 1: Assessment lead analyst and Review Panel's conclusion for each stock.

Stock	Analyst/Presenter	Peer review conclusion
Atlantic Wolffish – Expedited review	Charles Adams	Concurs with the assessment that Atlantic wolffish are overfished and overfishing is not occurring.
Acadian Redfish – Expedited review	Brian Linton	Concurs with the assessment that Acadian redfish are not overfished and overfishing is not occurring.
Atlantic Sea Scallops – Enhanced review	Dvora Hart	Concurs with the assessment that Atlantic sea scallops are not overfished and overfishing is not occurring.
Northern Window Pane Flounder – Expedited review	Toni Chute	Concludes that northern windowpane overfished and overfishing status are unknown.
Southern Window Pane Flounder – Expedited review	Toni Chute	Concurs with the assessment that southern windowpane flounder are not overfished and overfishing is not occurring.
Georges Bank Winter Flounder – Enhanced review	Daniel Hennen	Concurs with the assessment that Georges Bank winter flounder are overfished and overfishing is not occurring.
Gulf of Maine Winter Flounder – Expedited review	Paul Nitschke	Concurs with the assessment that Gulf of Maine winter flounder overfished status is unknown and overfishing is not occurring.
Southern New England Mid-Atlantic Winter Flounder – Enhanced review	Anthony Wood	Concurs with the assessment that Southern New England/ Mid-Atlantic winter flounder are overfished and overfishing is not occurring.
Northern Red Hake – Enhanced review	Toni Chute	Concurs with the SARC that northern red hake overfished and overfishing status are unknown, but not likely overfished and overfishing is not likely occurring.
Southern Red Hake – Enhanced review	Toni Chute	Concurs with the SARC that southern red hake overfished and overfishing status are unknown, but overfishing is not likely occurring.
Southern Silver Hake/Offshore Hake – Expedited review	Larry Alade	Concurs with the assessment that Southern silver/offshore hake are not overfished and overfishing is not occurring.

September 2020 management track peer review meeting attendees

Key:

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

Panel:

J-J Maguire – Chair
Catherine O'Keefe – Reviewer
Richard Merrick – Reviewer
Pat Sullivan – Reviewer

Attendees and Presenters:

Russ Brown – NEFSC
Michele Traver – NEFSC
Alex Hansell – MA DMF
Alejandro Gonzalez
Alicia Miller – NEFSC
Andy Applegate – NEFMC Staff
Andrew Jones – NEFSC
Andrew Ray
Brian Linton – NEFSC
Brian Stock – NEFSC
Burton Shank – NEFSC
Carolina Bastidas – MIT Sea Grant
Chad Keith – NEFSC
Charles Adams – NEFSC
Charles Perretti – NEFSC
Charles Keith – NEFSC
Chris Kellogg – NEFMC Staff
Chris Legault – NEFSC
Chris Tholke – NEFSC
Dan Hennen – NEFSC
Dave McElroy – NEFSC
Dave Rudders – VIMS
Drew Minkiewicz – Kelly Drye I & Warren LLP
Dustin Colson Leaning – ASMFC
Dvora Hart – NEFSC
Elizabeth Fairchild – University of New Hampshire
George Lapointe – GARFO
Georgette L
Halle Berger – University of Connecticut
Jamie Cournane – NEFMC
Jaz Bonnin
Jeff Kaelin – Lund's Fisheries
Jennie Rheuban – Woods Hole Sea Grant
Jennifer Couture – NEFMC
Jessica Blaylock – NEFSC
Jon Deroba – NEFSC
Jonathan Duquette – NEFSC
Jonathan Peros – NEFMC Staff
Jui-Han Chang – NEFSC
Juliet Simpson – MIT Sea Grant
Kaitlyn Clark – VIMS
Katherine Sosebee – NEFSC
Kelly Whitmore – MA DMF
Kyle Molton – GARFO
Larry Alade – NEFSC
Libby Etrie – NEFMC Member

Lisa Hendrickson – NEFSC
Liz Sullivan – GARFO
Louise Cameron – Northeastern University
M Smith
Maggie Raymond – Associated Fisheries of Maine
Mark Terceiro – NEFSC
Matthew Cieri – ME DMR
Megan Ware – ME DMR
Melissa Errend – NEFMC Staff
Michael Bergman – NEFSC
Nancy McHugh – NEFSC
Nicole Charriere – NEFSC
Pat Thames – NOAA
Paul Nitschke – NEFSC
Rebecca Peters – ME DMR
Rich Powell – NEFSC
Richard McBride – NEFSC
Robin Frede – NEFMC Staff
Samuel Asci – NEFSC
Shannah Jaburek – GARFO
Spencer Talmage – GARFO
Steve Cadrin – SMAST
Susan Wigley – NEFSC
Tara Trinko Lake – NEFSC
Tom Nies – NEFMC Executive Director
Toni Chute – NEFSC
Toni Kerns – ASMFC
Tony Wood – NEFSC
Travis Ford – GARFO
Z. Aleck Wang – Woods Hole Oceanographic Inst.

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

1. GULF OF MAINE WINTER FLOUNDER

Paul Nitschke

This assessment of the Gulf of Maine winter flounder (Pseudopleuronectes americanus) stock is a management track assessment of the existing 2017 area-swept operational assessment (NEFSC 2017). 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, MA DMF, and ME/NH surveys.

State of Stock: Based on this updated assessment, the Gulf of Maine winter flounder (*Pseudopleu ronectes americanus*) stock biomass status is unknown and overfishing is not occurring (Figures 1–2). Retrospective adjustments were not made to the model results. Biomass (30+ cm mt) in 2019 was estimated to be 2,862 mt (Figure 1). The 2019 30+ cm exploitation rate was estimated to be 0.052 which is 23% of the overfishing exploitation threshold proxy ($E_{MSY\ proxy} = 0.23$; Figure 2).

Table 2: 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-overlapping strata from three different fall surveys (ME/NH, MA DMF, NEFSC) using an updated q estimate of 0.71 on the wing spread from the sweep study (Miller et al., 2017).

	2014	2015	2016	2017	2018	2019
Data						
Recreational discards	5	5	11	5	2	2
Recreational landings	89	85	41	161	80	42
Commercial discards	5	2	3	3	3	4
Commercial landings	215	179	185	210	158	102
Catch for Assessment	315	271	241	378	244	150
Model Results						
30+ cm Biomass	3,924	2,815	3,156	3,380	2,898	2,862
E_{Full}	0.08	0.096	0.076	0.112	0.084	0.052

Table 3: 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.

	2017	2020
$E_{MSY\ proxy}$	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 terminal year fall area-swept estimate assuming $q = 0.71$ on the wing spread which was updated using the average efficiency from 2009–2019 from the sweep experiment (Miller et al., 2017). Updated 2019 fall $30+$ cm area-swept biomass (2,862 mt) implies an OFL of 658 mt based on the $E_{MSY\,proxy}$ and a catch of 494 mt for 75% of the $E_{MSY\,proxy}$. Alternatively, using the average updated 2018 and 2019 fall $30+$ cm area-swept biomass (2,880 mt) implies an OFL of 662 mt based on the $E_{MSY\,proxy}$ and a catch of 497 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 2020 update does incorporate the use of a re-estimated q through an average estimate of efficiency from 2009–2019 ($q = 0.71$) from the sweep study for the NEFSC survey. This updated q assumption (0.71) results in a higher estimate of 30+ cm biomass (2,862 mt) relative to the 2017 estimate $q = 0.87$ assumption (2,343 mt) from the updated 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}.)

  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 inter-annual variability in the surveys. Consideration should be given to using multiple surveys to stabilize the biomass estimates and catch advice.

- 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.

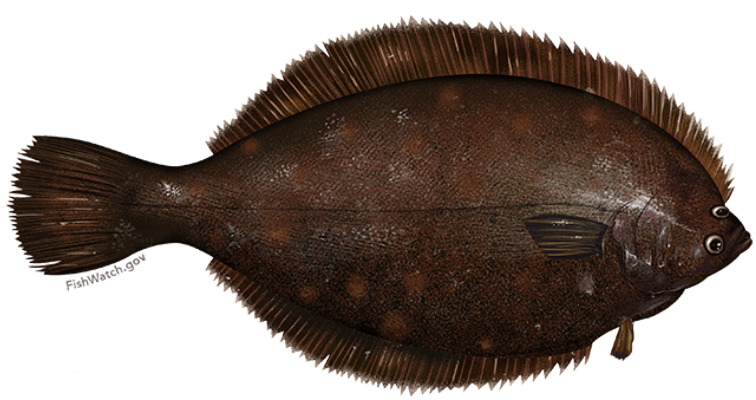
  The assumption on q changed from 0.87 to 0.71 using information from the updated sweep experiment (Miller et al., 2017) and incorporation of new survey data were made to this Gulf of Maine winter flounder management track assessment. The new MRIP calibrated catch time series *was also updated in this assessment. In addition there were some changes with updated commercial landings data with the switch to using Stockeff data which are mostly due to the changes in the proration with regards to unknown areas from Massachusetts state landings of winter flounder. However, changes in total removals will not affect the biomass or catch advice and total removals still remain far below the overfishing definition.*

- 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 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.



Pseudopleuronectes americanus, Winter Flounder.

1.1. Reviewer Comments: Gulf of Maine winter flounder

The 2020 assessment update for Gulf of Maine winter flounder is an expedited review (Level 2) in accord with the decision at the 27 May 2020 meeting of the Assessment Oversight Panel (AOP). The AOP discussed the issue of changing to a two-year average of biomass and whether the changes may be significant enough to warrant the elevation of the proposed level 2 review to a level 3, but ultimately recommended an expedited review.

This assessment of the Gulf of Maine winter flounder stock is an update of the existing 2017 area-swept operational assessment to include 2018–2019 catch and survey data.

Using the length-based Yield Per Recruit (YPR) relationship from SARC 52 and an $M = 0.3$, the $F_{MSY} = F_{40\%} = 0.31$. The 2019 30+ cm exploitation rate was estimated to be 0.052 which is 23% of the overfishing exploitation threshold proxy ($E_{MSY\ proxy} = 0.23$). Biomass (30+ cm mt) in 2019 was estimated to be 2,862 mt.

The Peer Review Panel (PRP) concludes that the 2020 assessment update for Gulf of Maine winter flounder is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes. It concurs that Gulf of Maine winter flounder's overfished status is unknown and overfishing is not occurring.

Gulf of Maine Winter Flounder Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial landings and discard data were estimated for 2009–2019 by adding 2018 and 2019 data to those used in the 2017 operational assessment. Recent MRIP data were used to update recreational discard and landings for 2009–2019.

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

   This TOR was satisfactorily addressed. All three of the survey indices used in the 2017 operational assessment (NEFSC fall bottom trawl survey, Massachusetts Division of Marine Fisheries fall trawl survey, and Maine–New Hampshire fall trawl survey) were updated for 2009–2019. Additional tows were also available from the NEFSC's twin trawl experiment for revised estimates of q.

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

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

(b) *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

This TOR was satisfactorily addressed. The assessment was based on the 30+ cm Survey Area-Swept Calculation used in the 2017 Operational Assessment (developed in SARC 52 (2011)) and also used in the 2014 and 2015 Operational assessments. The major difference was in the re-estimated q value (fall $= 0.709$, spring $= 0.623$), both of which are lower than the q from the 2017 survey ($q = 0.866$). The impact of this change in q would be a relative increase of swept area biomass compared to that which would be calculated from the previous q. A 'Plan B' assessment was unnecessary because the area swept approach was accepted.

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

   This TOR was satisfactorily addressed. Using the length based YPR from SARC 52 and an $M = 0.3$ the $F_{MSY} = F_{40\%} = 0.31$. The 2019 30+ cm exploitation rate was estimated to be 0.052 which is 23% of the overfishing exploitation threshold proxy ($E_{MSY\,proxy} = 0.23$). Biomass (30+ cm mt) in 2019 was estimated to be 2,862 mt.

   Based on this updated assessment, the Gulf of Maine winter flounder stock's overfished status is unknown and overfishing is not occurring.

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

   This TOR was satisfactorily addressed. However, projections are not possible with area-swept based assessments. The Peer Review Panel agrees that catch advice be based on 75% of $E_{40\%}$ (75% $E_{MSY\,proxy}$) using the most recent two years of information from fall surveys for the biomass estimate and catch advice.

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

   a. Additional studies on federal and state survey gear efficiency would be useful. For example, quantifying the degree of herding between the doors and escapement under the footrope and/or above the headrope for state surveys is warranted.
   b. Studies quantifying winter flounder abundance and distribution among habitat types and within estuaries could improve biomass estimates.
   c. A moving average approach to estimating catch advice (rather than based on a single year) should be considered to stabilize catch advice. This was completed in this assessment.

Additional Recommendations

1. Consider using both spring and fall surveys to provide catch advice in the next assessment.

2. Evaluate using $q = 1.0$ for the two state surveys in the next assessment.

References:

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; 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. https://repository.library.noaa.gov/view/noaa/16091

Northeast Fisheries Science Center. 2011. 52nd Northeast Regional Stock Assessment Workshop (52nd 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

Research vessel NOAAS Albatross IV, 2005

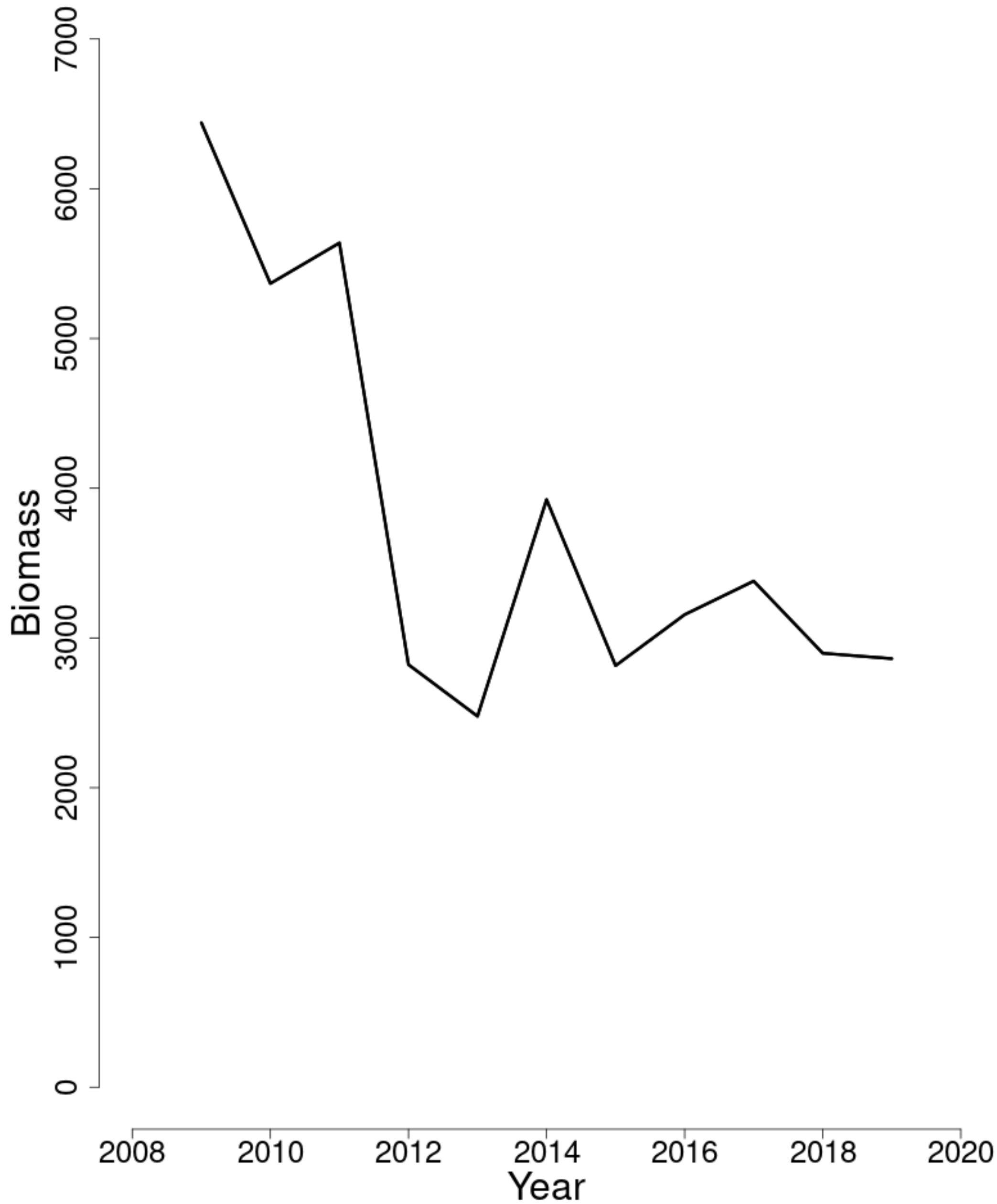


Figure 1: Trends in 30+ cm area-swept biomass of Gulf of Maine winter flounder between 2009 and 2019 from the current assessment based on the fall (ME/NH, MA DMF, NEFSC) surveys.

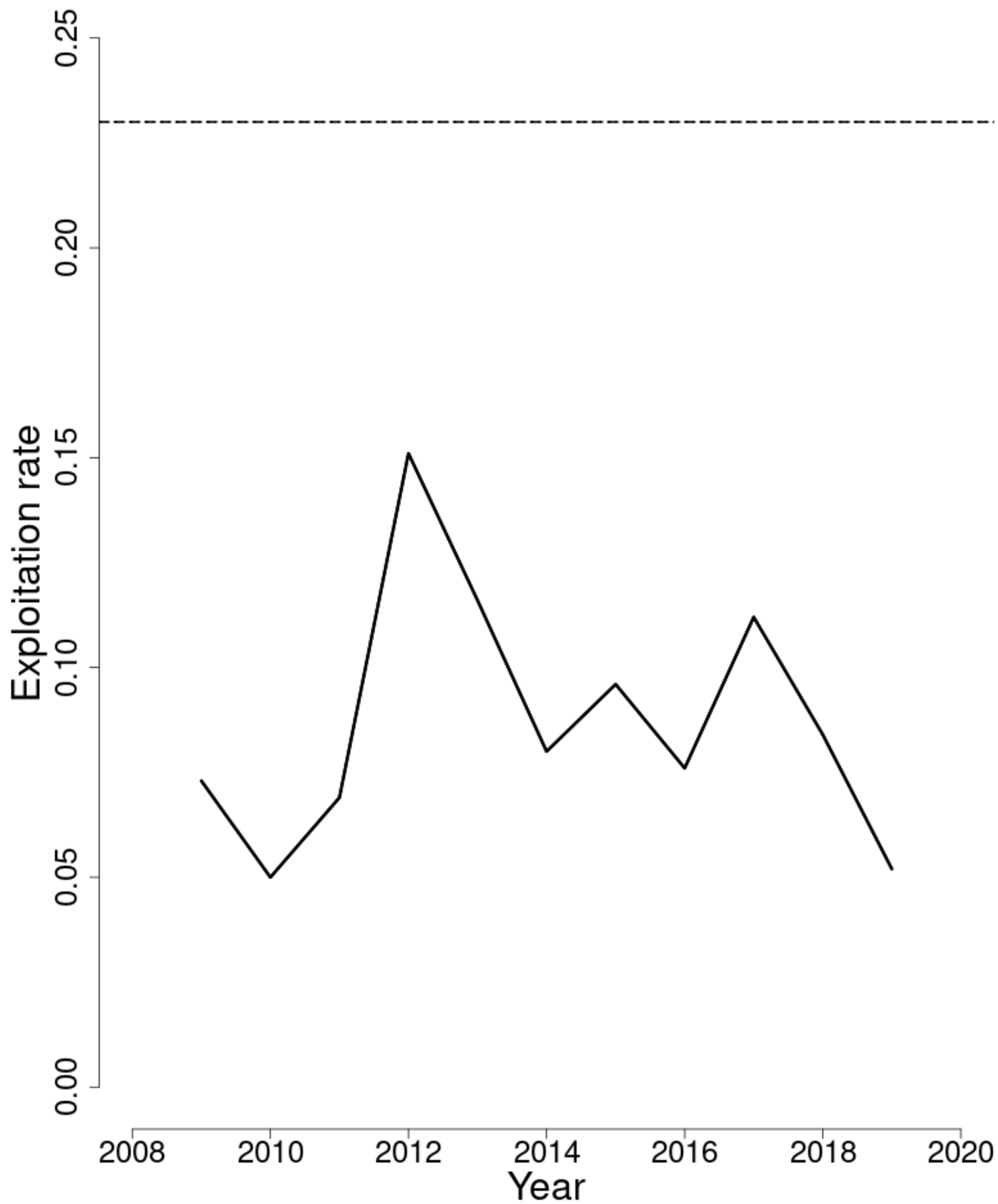


Figure 2: Trends in the exploitation rates (E_{Full}) of Gulf of Maine winter flounder between 2009 and 2019 from the current assessment and the corresponding $F_{\text{Threshold}}$ ($E_{MSY\ proxy} = 0.23$; horizontal dashed line).

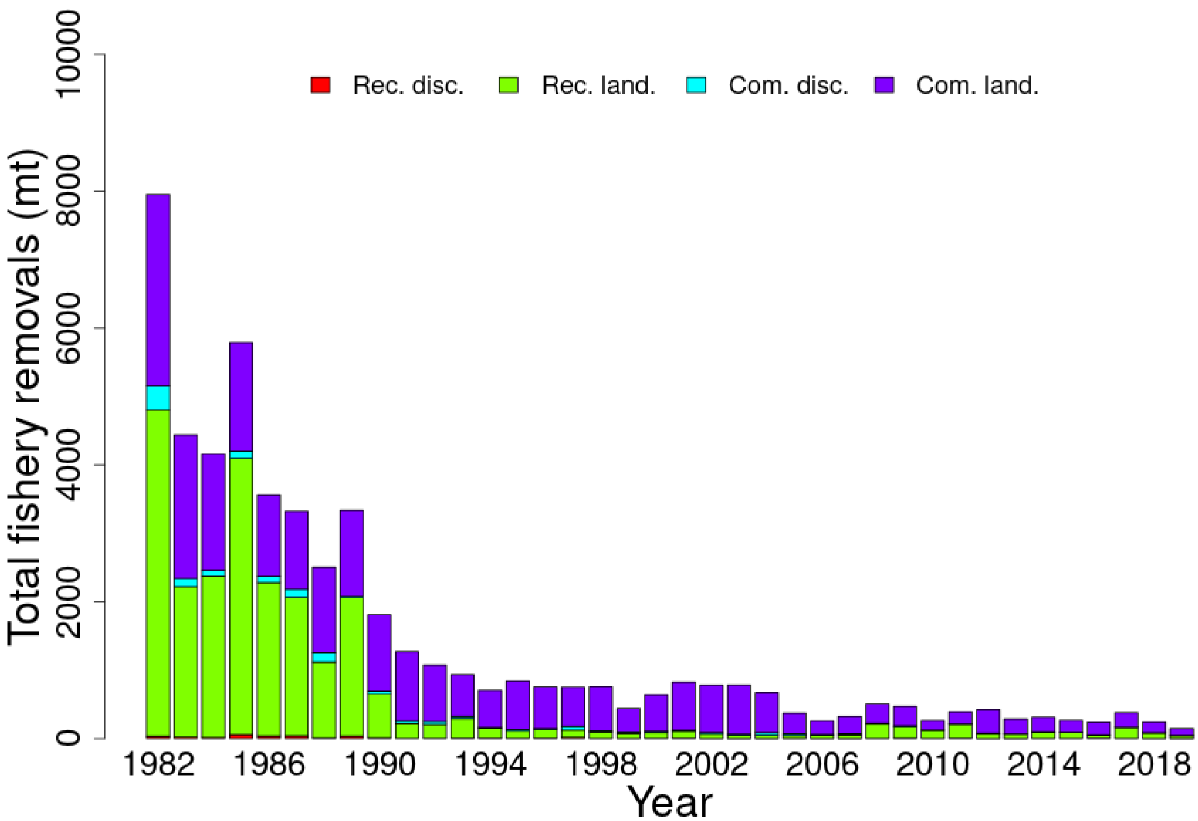


Figure 3: Total catch of Gulf of Maine winter flounder between 2009 and 2019 by fleet (commercial and recreational) and disposition (landings and discards). A 15% mortality rate is assumed on recreational discards and a 50% mortality rate on commercial discards.

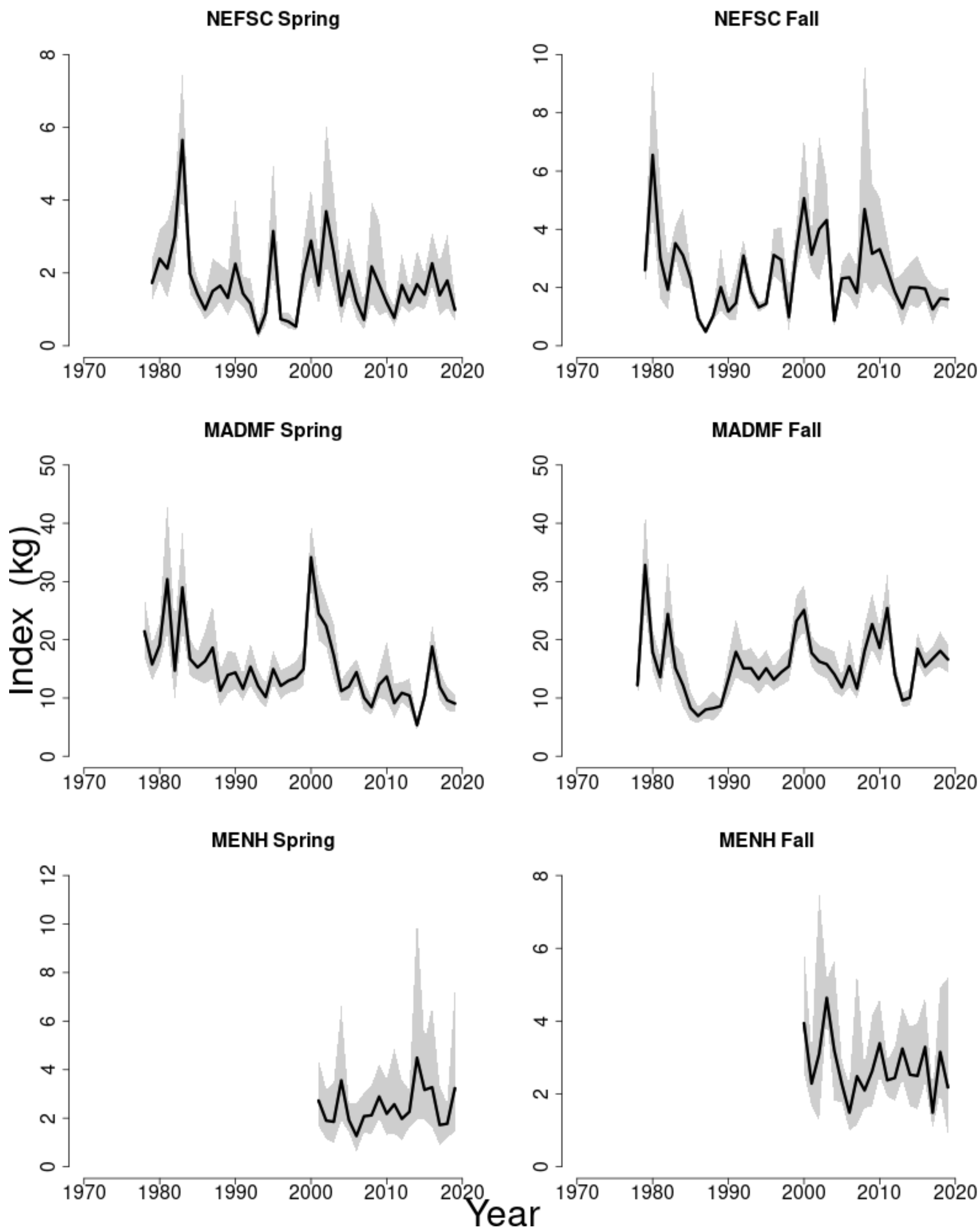


Figure 4: Indices of biomass for the Gulf of Maine winter flounder between 1978 and 2019 for the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MA DMF), and the Maine New Hampshire (ME/NH) spring and fall bottom trawl (strata 1–3) surveys. NEFSC indices are calculated with gear and vessel conversion factors where appropriate. The approximate 90% log-normal confidence intervals are shown.

2. GEORGES BANK WINTER FLOUNDER

Daniel Hennen

This assessment of the Georges Bank winter flounder (Pseudopleuronectes americanus) stock is a management track update of the existing 2018 operational VPA assessment which included data for 1982–2018 (NEFSC 2019). Based on the previous assessment the stock was not overfished and overfishing was not occurring. This assessment updates commercial fishery catch data, research survey biomass indices, and the analytical VPA assessment model and reference points through 2019. Additionally, stock projections have been updated through 2023.

State of Stock: Based on this updated assessment, the Georges Bank winter flounder (*Pseudopleuronectes americanus*) stock is overfished and overfishing is not occurring (Figures 5–6). Retrospective adjustments were made to the model results. Spawning stock biomass (SSB) in 2019 was estimated to be 4061 (mt). The 2019 fully selected fishing mortality (F) was estimated to be 0.088. However, the 2019 point estimate of SSB and F, when adjusted for retrospective error (0.57% for SSB and –0.34% for F), are outside the 90% confidence intervals of the unadjusted 2019 point estimates. Therefore, the values used in the stock status determination were the retrospective-adjusted values of $F_{2019} = 0.133$ which is 37% of overfishing threshold ($F_{MSY} = 0.358$; Figure 6), and $SSB_{2019} = 2{,}587$ (mt) which is 36% of the biomass target for an overfished stock ($SSB_{MSY} = 7{,}267$ with a threshold of 50% of SSB_{MSY}; Figure 5).

Table 4: 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 (2010–2019) of the current updated VPA assessment.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
US landings	1,252	1,801	1,911	1,675	1,114	866	462	364	416	280
CA landings	45	52	83	12	12	13	4	6	9	0
US discards	110	127	126	46	46	19	5	14	41	20
CA scall dr discards	116	88	79	28	47	42	21	16	22	19
Catch for Assessment	1,523	2,068	2,199	1,761	1,219	940	492	400	488	319
Model Results										
Spawning Stock Biomass	4,585	4,758	4,531	3,818	3,760	3,905	3,600	3,290	3,578	4,061
F_{Full}	0.335	0.509	0.509	0.518	0.418	0.201	0.152	0.113	0.151	0.088
Recruits (age-1)	6,043	5,646	3,834	3,039	3,370	2,265	3,682	2,924	5,244	132

Table 5: Comparison of reference points estimated in the 2018 assessment and the current assessment update and stock status during 2018 and 2020, respectively. A proxy for $F_{MSY\ proxy}$ ($F_{40\%}$) was used for the overfishing threshold and was based on long-term stochastic projections of the stock based on the 2015–2019 means for selectivity-, maturity- and mean weights-at-age, and a cdf of estimated recruitments (using the entire time series). $SSB_{MSY\ proxy}$ was used as the biomass target and was based on long-term stochastic projections of the stock fished at $F_{40\%}$.

	2018	2020
F_{MSY}	0.519	0.358
SSB_{MSY} (mt)	8,910 (4,196 – 21,143)	7,267 (4,143 – 11,113)
MSY (mt)	4,260 (2,049 – 9,632)	2,573 (1,520 – 3,835)
Median recruits (age-1) (000s)	8,608	8,470
Overfishing	No	No
Overfished	Yes	Yes

Projections: Short-term projections of biomass were derived by sampling from a cumulative distribution function of recruitment estimates (1982–2018 Y_c) 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 (2015–2019). An SSB retrospective adjustment factor of 0.637 was applied in the projections.

Table 6: 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 2021 and 2023. Catch in 2020 was estimated to be 386 (mt) by the Groundfish Plan Development Team.

Year	Catch (mt)	SSB (mt)	F_{Full}
2020	386	2,966 (2,252 – 3,400)	0.141

Year	Catch (mt)	SSB (mt)	F_{Full}
2021	859	2,325 (1,702 – 3,247)	0.358
2022	905	2,157 (1,880 – 2,799)	0.358
2023	1,314	3,397 (2,149 – 5,850)	0.358

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 probably 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 to be constant over time. Natural mortality affects the scale of the biomass and fishing mortality estimates.

VPA assumes catch is known without error, which in the case of Georges Bank winter flounder is certainly not true. 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. In addition, there are no length or age composition data for the Canadian landings or discards of GB winter flounder. Finally, the lack of age data for the Canadian spring survey catches requires the use of the US spring survey A/L keys keys for several disparate data streams, including the CA scallop discards, US otter trawl and scallop discards, despite selectivity differences. Various other gaps in catch data at age or length have been filled using decisions based on expert opinion and are difficult, if not impossible, to reproduce. Different decisions produce different model inputs and result in different outcomes. The direction and magnitude of the bias associated with filling gaps using expert opinion is unknown, but likely common in VPA assessments.

Another potentially important uncertainty is the lack of a 2020 NEFSC spring survey. Without that data, the 2019 spring NEFSC age at length data and 2020 Canadian survey data were merged to provide some data in the spring of the bridge year of the assessment.

The estimate of age-1 fish in 2019 is very low. This is likely an artefact of the model as there is very little information the model can leverage to estimate the abundance of age-1 fish in the terminal year. Allowing the model to estimate age-2 fish in 2020 increases the estimate of 2019 age-1 fish to a level comparable to other recent estimates of age-1 fish. Allowing the model to estimate age-2 abundance in 2020 is however, a structural change to the model and it introduces other diagnostic problems, such as an increased retrospective pattern. The base case model therefore does not estimate age-2 abundance in 2020 and the low age-1 abundance in 2019 is an uncertainty that may particularly affect the later projection 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 90% confidence intervals for SSB and F_{Full}

  The 7-year Mohn's ρ, relative to SSB, was 0.555 in the 2018 assessment and was 0.57 in 2019. The 7-year Mohn's ρ, relative to F, was −0.347 in the 2018 assessment and was −0.34 in 2019. There was a major retrospective pattern for this assessment because the ρ-adjusted estimates of 2019 SSB ($SSB_\rho = 2{,}587$) and 2019 F ($F_\rho = 0.133$) were outside the 90% confidence limits for SSB (3,248 – 4,944) and F (0.075 – 0.114). A retrospective adjustment was made for both the determination of stock status and for projections. The retrospective adjustment changed the 2019 SSB from 4,061 to 2,587 and the 2019 F_{Full} from 0.088 to 0.133.

- 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 confidence bounds for projected biomass estimates from the previous assessment assessment captured the terminal estimate of biomass from this one. This stock was required to be rebuilt by 2017, but this did not occur. The stock is in a revised rebuilding plan, based on fishing at 70% of F_{MSY}, with rebuilding by 2029.

- 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.

Changes made to the Georges Bank winter flounder assessment included updating the most recent five-year averages (2015–2019) of fishery selectivity-, proportion mature-, stock weights-, catch weights-, and spawning stock weights-at-age.

The reference points were altered for this assessment. The new F reference point $F_{40\%}$ is the F at 40% of MSP, and the corresponding SSB reference point, $SSB_{40\%}$ is the long term SSB associated with fishing at $F_{40\%}$. These changes make the basis for Georges Bank winter flounder reference points similar to the basis for reference points for other winter flounder stocks and make them consistent with other groundfish managed in the New England region. The Covid-19 epidemic caused the cancelation of the 2020 NEFSC spring survey. The loss of the terminal data point in one survey index as well as the loss of associated age at length data affected results, though this affect was probably minor (see GBFLWupdate2020Extras.pdf, available at SASINF for discussion of sensitivity testing on this and other potential issues).

In the 2020 assessment of Georges Bank winter flounder, data from the catch efficiency studies were not used because the studies were not focused on this stock. As a result, the winter flounder length composition from the studies does not reflect the length composition of the Georges Bank stock; i.e., the studies included few fish > 38 cm *total length, see (Miller et al., 2017).*

- 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 not changed.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The 'Plan B' assessment results (available at SASINF) indicate that due to declining trends in the survey indices, the fishing pressure on the stock should be reduced in the next year (catch multiplier < 1.0*). There are however some indications of improvement in stock condition. Catch weight-at-age has been increasing for the last few years and there are indications of a better than average recruitment class in 2020 in the Canadian spring survey.*

- 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 a shift to a model that incorporates statistical fits to commercial length and age composition and deprecates the requirement that catch be known without error.

- Are there other important issues?
  2020 commercial data, in addition to survey data, was likely affected by the Covid-19 outbreak. Commercial vessels may have carried fewer observers and fished fewer days. The lack of consistency in commercial data may reduce the precision and accuracy of the Georges Bank winter flounder assessment in the near term.

2.1. Reviewer Comments: Georges Bank winter flounder

The 2020 assessment update for Georges Bank winter flounder received a Level 3 Enhanced Review in accord with the decision at the 27 May 2020 meeting of the Assessment Oversight Panel (AOP). The lead analyst proposed to the AOP to transition the current MSY biological reference points (calculated from the model stock-recruitment relationship) to proxy-based reference points ($F_{40\%}$, $SSB_{40\%}$) to match the Gulf of Maine winter flounder stock and recommendations of a panel review in 2019. The AOP discussed the potential impact of changing reference points given that the stock is in a rebuilding plan and recommended that the old method should also be calculated for continuity. The AOP agreed that the Level 3 Enhanced Review recommended by the lead analyst is appropriate given the proposed change to reference points.

The 2020 assessment of the Georges Bank winter flounder stock is an update of the existing 2019 operational VPA assessment which included data for 1982–2018. This assessment updates commercial fishery catch data, research survey biomass indices, and the analytical VPA assessment model and new $F_{40\%}$, $SSB_{40\%}$ reference points proxies through 2019. Stock projections have been updated through 2023.

The Peer Review Panel (PRP) concludes that the 2020 assessment update for Georges Bank winter flounder is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes.

Spawning stock biomass (SSB) in 2019 was estimated to be 4,061 mt. The 2019 fully selected fishing mortality (F) was estimated to be 0.088. However, the 2019 point estimate of SSB and F, when adjusted for retrospective error (0.57% for SSB and –0.34% for F), are outside the 90% confidence intervals of the unadjusted 2019 point estimates. Therefore, the values used in the stock status determination were the retrospective-adjusted values of $F_{2019} = 0.133$ which is 37% of the overfishing threshold ($F_{MSY} = 0.358$), and $SSB_{2019} = 2{,}587$ mt, which is 36% of the biomass target for an overfished stock ($SSB_{MSY} = 7{,}267$ mt, with a threshold of 50% of SSB_{MSY}).

The PRP concurs with the assessment that Georges Bank winter flounder stock is overfished but that overfishing is not occurring.

Georges Bank Winter Flounder Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial (US and Canadian) landings and discard data from 2019 were added to those used in the 2019 operational assessment.

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

   This TOR was satisfactorily addressed. All three of the survey indices used in the benchmark assessment (NEFSC spring bottom trawl survey, NEFSC fall bottom trawl survey (lagged forward one year and age), Canadian spring trawl survey) were updated through 2019 (DFO through 2020). Commercial catch at age, and catch weight at age data from 2019 were added to those used in the 2019 operational assessment.

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

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

   (b) *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

   This TOR was satisfactorily addressed. The same VPA model configuration used in the 2019 operational assessment was used in the 2020 update. However, there was concern about the absence of the spring 2020 NEFSC trawl survey (not conducted on Georges Bank because of Covid-19) and the effect of a new stock assessment analyst. As a result, two bridge runs were prepared to compare with the 2020 assessments results (i.e., rerunning the 2019 assessment with the new analyst's data decisions, rerunning the 2019 assessment without the spring 2019 NEFSC survey, and the 2020 assessments). Results suggest neither had a significant impact on the assessment results.

   As in the 2019 assessment, there was a major retrospective pattern (Mohn's ρ = 0.57 for SSB, –0.34 for F, and 0.45 for recruitment). Because the 2019 point estimate of SSB and F, when adjusted for retrospective error, were outside the 90% confidence intervals of the unadjusted 2019 point estimates it was necessary to retrospective-adjust both point estimates. A 'Plan B' assessment was not evaluated because the VPA assessment was accepted.

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

   This TOR was satisfactorily addressed with the PRP supporting the use of $F_{40\%}$ as the $F_{MSY\,proxy}$. Spawning stock biomass (SSB) in 2019 was estimated to be 4,061 mt. The 2019 fully selected fishing mortality (F) was estimated to be 0.088. The retrospective-adjusted values used in the stock status determination were $F_{2019} = 0.133$ which is 37% of the overfishing threshold ($F_{MSY} = 0.358$), and $SSB_{2019} = 2{,}587$ mt, which is 36% of the biomass target for an overfished stock ($SSB_{MSY} = 7{,}267$ mt, with a threshold of 50% of SSB_{MSY}). The stock was overfished but overfishing was not occurring in 2019.

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

   This TOR was satisfactorily addressed. Short-term projections of biomass were derived by sampling from a cumulative distribution function of recruitment estimates (1982–2018 year classes) 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 (2015–2019). An SSB retrospective adjustment factor of 0.637 was applied in the projections. The 2020 estimated catch was from the Plan Development Team (PDT) and 2021–2023 catches were projected from the F_{MSY} *proxy* ($F_{40\%}$). The PRP notes that recruitment from the 2019 year class is likely to be underestimated.

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

   The AOP commented that the completed 'Plan A' operational assessment is appropriate for assessing stock status. However, the AOP was concerned about the reference point definitions and recruitment assumptions in projections. Specifically, using a fixed steepness value may not be appropriate and a $F_{40\%}$ MSP F_{MSY} proxy might be a more stable and reliable estimator.

   - This was done in this assessment with $F_{40\%}$ recommended as an appropriate proxy.

   The residual pattern in the stock-recruitment relationship indicates that recent recruitment has been weaker than expected. Alternative projections should be considered that assume future recruitment will be similar to recent recruitment.

   - Sensitivity analyses were conducted to evaluate various recruitment scenarios

   There is poor tracking of cohorts in many of the data streams, making a VPA less suitable as a stock assessment model and suggests that changing to a statistical catch-at-age or state-space model at the next available opportunity would be appropriate.

   - This remains an issue but would need to be pursued via the Research Track process

   Explorations regarding the source of the retrospective pattern and recent poor recruitment for this stock.

   - No progress to date

   Information from other efficiency studies completed by the Northeast Trawl Advisory Panel and more directed experiments on Georges Bank for winter flounder could be conducted to allow appropriate calibration factors to be estimated for this stock.

   - No progress to date

Additional Comments

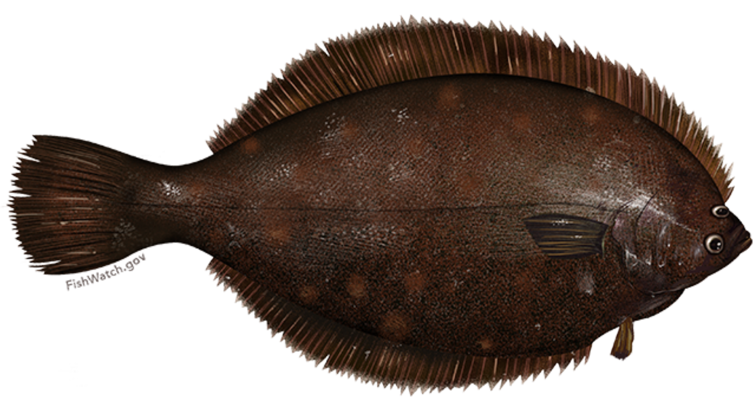
1. The PRP acknowledged the utility of having additional data provided on how the $F_{40\%}$ was calculated.

2. The PRP agrees that future analysis of the stock could be improved using a model that incorporates statistical fits to commercial length and age composition.

References:

Miller, T.J., Richardson, D., Politis, P., Blaylock, J., Manderson, J. and Roebuck, C. 2020. Relative efficiency of a chain sweep and the rockhopper sweep used for the NEFSC bottom trawl survey and biomass estimates for winter and windowpane flounder and red hake stocks. In press. U.S. Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 20-XX; 31 p.

Northeast Fisheries Science Center. 2019. Operational assessment of 14 Northeast groundfish stocks, updated through 2018. In press. U.S. Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 20-XX; 212 p.



Pseudopleuronectes americanus, Winter Flounder.

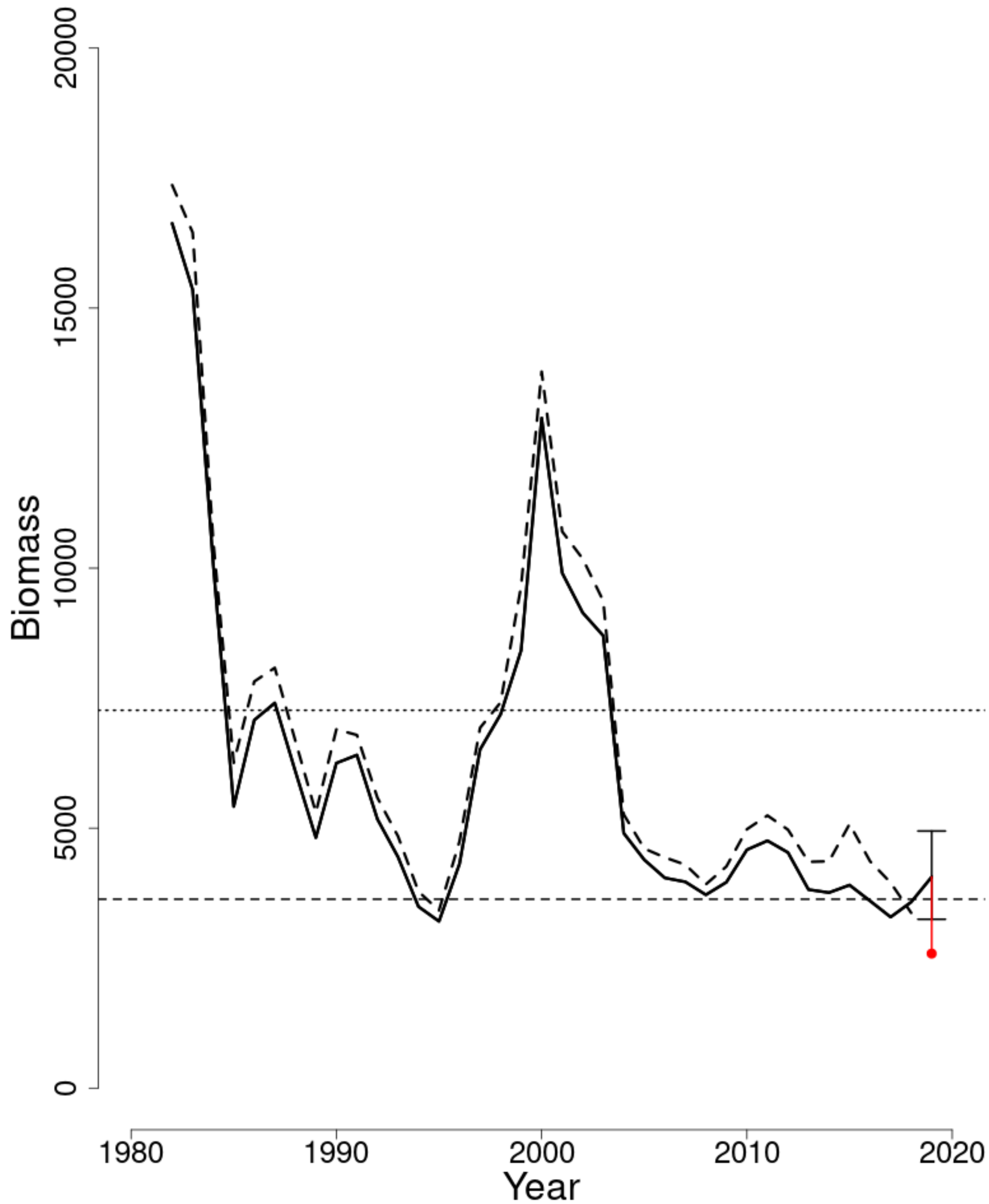


Figure 5: Trends in spawning stock biomass (mt) of Georges Bank winter flounder between 1982 and 2019 from the current (solid line) and previous (dashed line) assessments and the corresponding $SSB_{\text{Threshold}}$ ($\frac{1}{2}SSB_{MSY}$; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY}; horizontal dotted line) based on the 2020 assessment. Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The 90% normal confidence interval is shown for 2019.

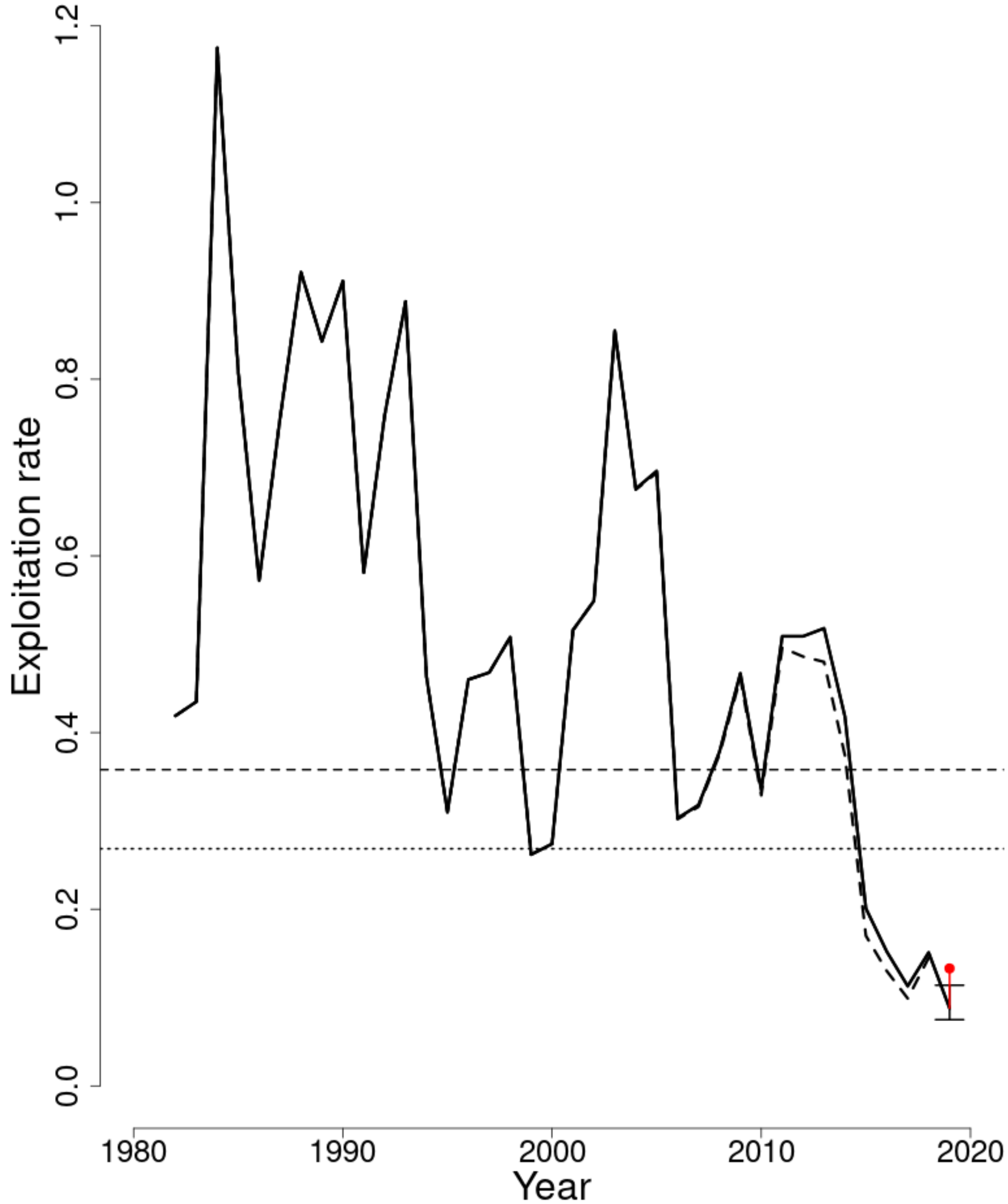


Figure 6: Trends in fully selected fishing mortality (F_{Full}) of Georges Bank winter flounder between 1982 and 2019 from the current (solid line) and previous (dashed line) assessments and the corresponding $F_{\text{Threshold}}$ ($F_{MSY} = 0.358$; horizontal dashed line) as well as ($F_{\text{Target}} = 75\%$ of F_{MSY}; 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 2019.

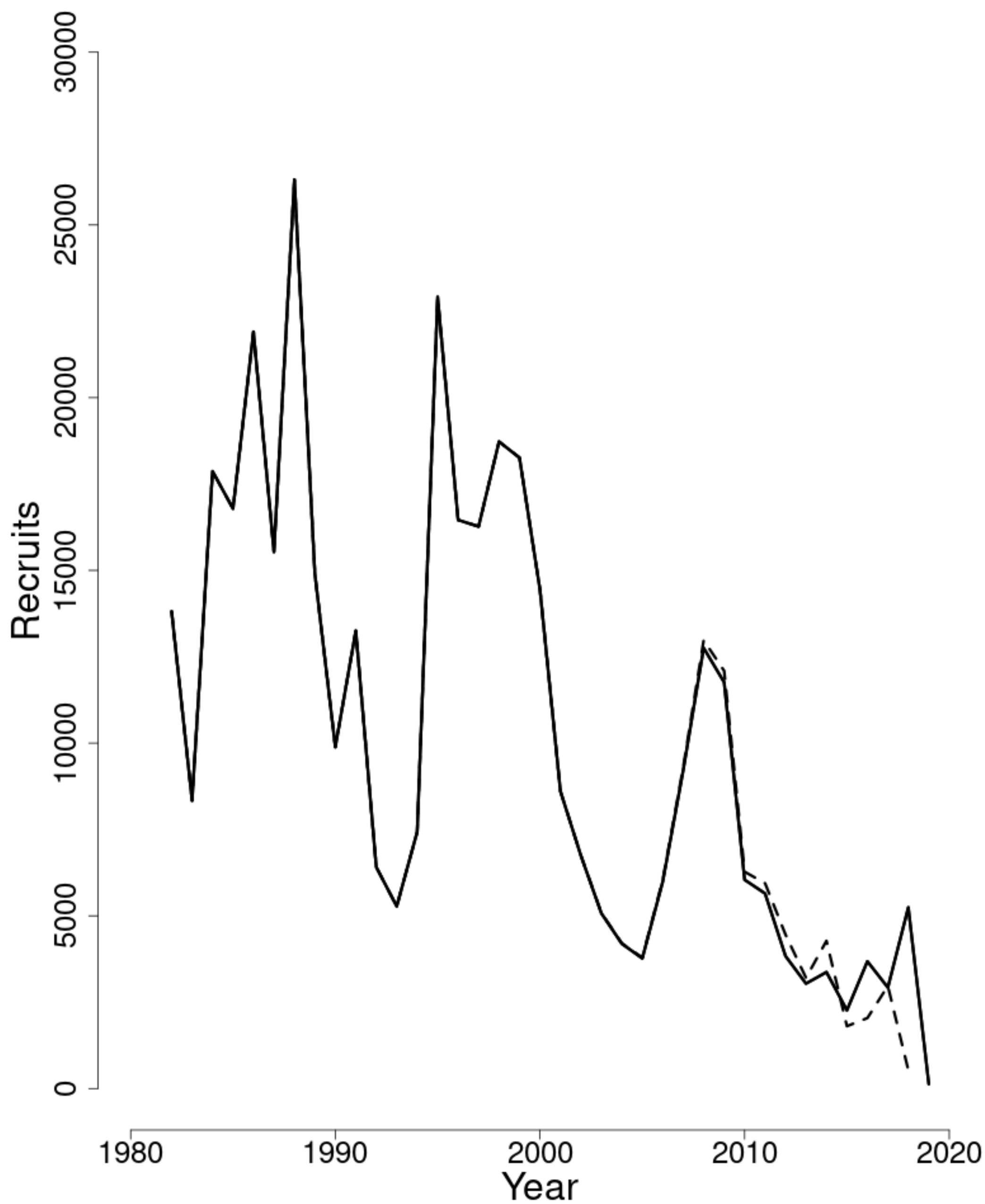


Figure 7: Trends in Recruits (age-1) (000s) of Georges Bank winter flounder between 1982 and 2019 from the current (solid line) and previous (dashed line) assessments.

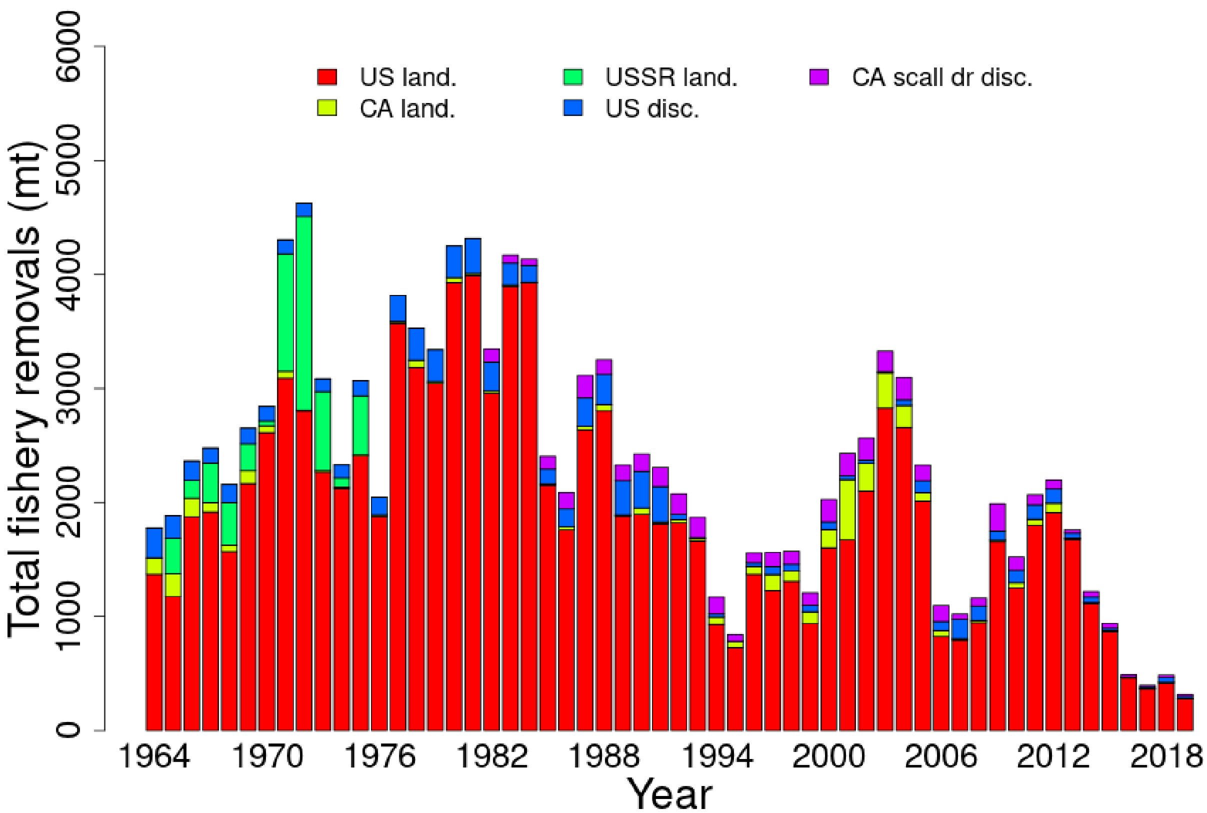


Figure 8: Total catches (mt) of Georges Bank winter flounder between 1982 and 2020 by country and disposition (landings and discards).

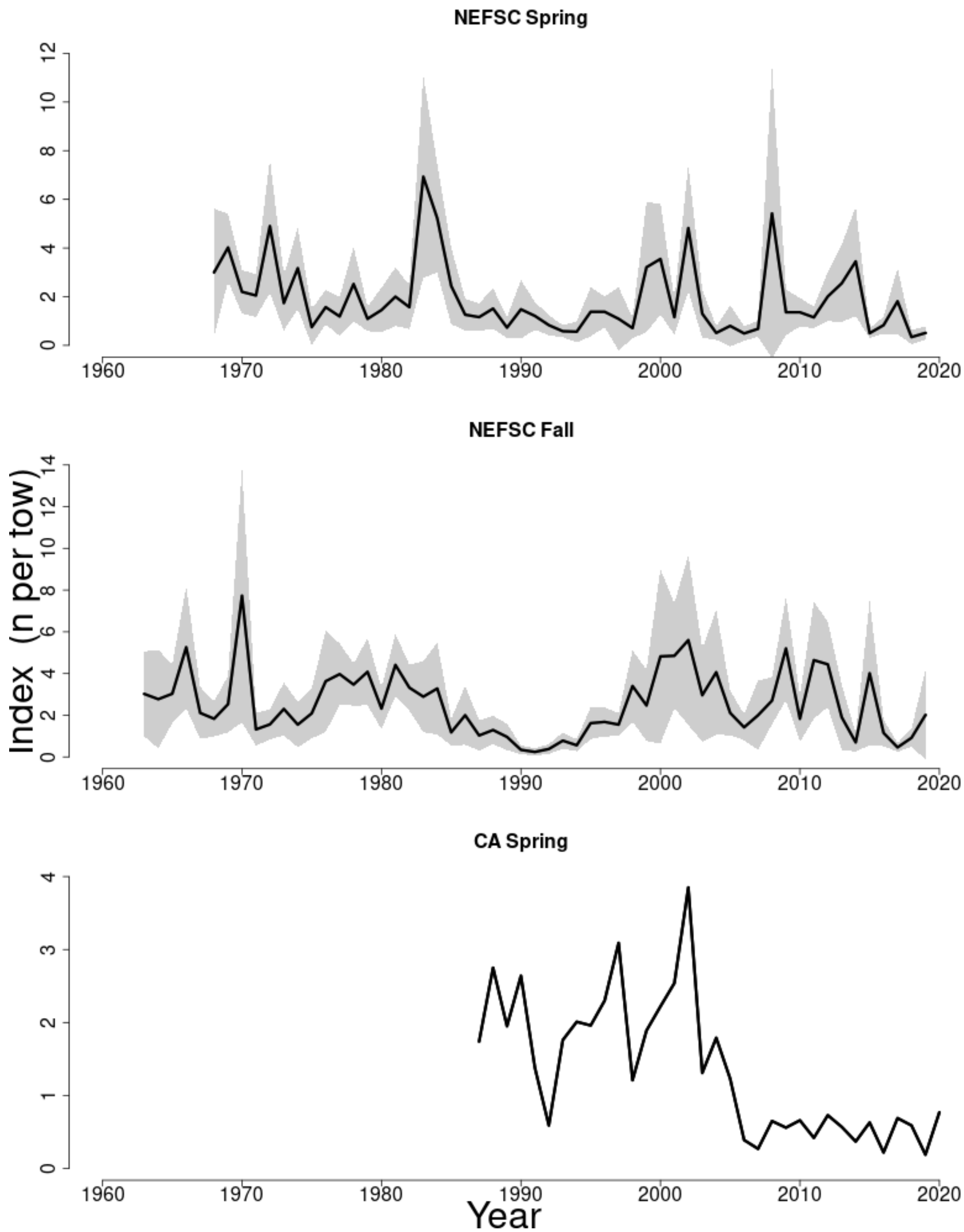


Figure 9: Indices of abundance for the Georges Bank winter flounder for the Northeast Fisheries Science Center (NEFSC) spring (1968–2019) and fall (1963–2019) bottom trawl surveys and the Canadian DFO spring survey (1987–2020). The 90% normal confidence interval is shown.

3. 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 benchmark assessment (NEFSC 2011), and follows operational updates in 2015 and 2017. In each assessment since the benchmark the stock was overfished, but overfishing was not occurring (NEFSC 2015, 2017). The current assessment updates commercial fishery catch data, recreational fishery catch data (using new MRIP calibrated data), research survey indices of abundance, and the analytical ASAP assessment models and reference points through 2019. Additionally, stock projections have been updated through 2023.

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 10–11). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2019 was estimated to be 3,638 mt which is 30% of the biomass target (12,322 mt), and 60% of the biomass threshold for an overfished stock ($SSB_{\text{Threshold}} = 6161$ mt; Figure 10). The 2019 fully selected fishing mortality was estimated to be 0.077 which is 27% of the overfishing threshold ($F_{MSY} = 0.284$; Figure 11).

Table 7: 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.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
Recreational discards	24	18	11	8	4	13	3	2	4	2
Recreational landings	119	155	126	15	99	39	61	10	10	1
Commercial discards	153	298	482	206	64	82	125	101	108	105
Commercial landings	173	149	134	859	660	661	516	495	326	202
Catch for Assessment	469	620	752	1,087	827	795	704	608	449	310
Model Results										
Spawning Stock Biomass	5,586	6,577	6,585	6,318	5,209	4,592	3,897	3,667	3,851	3,638
F_{Full}	0.076	0.094	0.117	0.189	0.176	0.178	0.186	0.158	0.111	0.077
Recruits	6,448	4,579	4,251	2,321	4,219	4,955	5,238	3,211	6,185	3,293

Table 8: Comparison of reference points estimated in the 2017 operational assessment and from the current assessment update. $F_{40\%}$ was used as a proxy for F_{MSY} and an SSB_{MSY} proxy was calculated from a long-term stochastic projection drawing from the time-series of empirical recruitment. Recruitment estimates are median values of the time-series. 90% CI are shown in parentheses.

	2017	2020
$F_{MSY\ proxy}$	0.340	0.284
SSB_{MSY} (mt)	24,687	12,322 (6,246 – 21,164)
MSY (mt)	7,532	3,906 (2,014 – 6,624)
Median recruits (000s)	15,802	16,649
Overfishing	No	No
Overfished	Yes	Yes

Projections: Short term projections of biomass were derived by sampling from a cumulative distribution function of the full time-series of recruitment estimates. 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 9: 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 $F_{MSY\ proxy}$ between 2021 and 2023. Catch in 2020 was assumed to be 251 (mt), a value provided by the groundfish PDT. 90% CI are shown next to SSB estimates.

Year	Catch (mt)	SSB (mt)	F_{Full}
2020	251	4,040 (3,310 – 4,906)	0.056

Year	Catch (mt)	SSB (mt)	F_{Full}
2021	1,434	4,313 (3,606 – 5,159)	0.284
2022	1,760	4,871 (4,222 – 5,691)	0.284
2023	2,326	6,335 (4,667 – 11,986)	0.284

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 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 the 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). For this assessment a compiled discard length distribution over all years was used to characterize the recreational discards. In addition, the paucity of recreational data going forward could be an issue for this assessment.

The population projections are sensitive to the recruitment model chosen, as well as the temporal period selected from which recruitment estimates are drawn.

- 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 retrospective patterns for both F_{Full} and SSB are minor and no retrospective adjustment in 2019 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. However, the results are sensitive to both the recruitment model and the time-period of recruitment used. In addition, while the retrospective pattern is considered minor (within the 90% CI of both F and SSB), the ρ adjusted terminal value of F and SSB are 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 plan with a rebuild date of 2023. A projection using assumed catch in 2020 and $F = 0$ through 2023 indicated about a 5% 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.

  A number of changes were made to the Southern New England Mid-Atlantic winter flounder assessment for this update. Changes were made to model settings and BRP determination in response to NEFMC SSC concerns with the methodology from the previous benchmark: 'The SSC noted a couple of issues with SNE/MA winter flounder. The first was that the projections were overly optimistic, and this was driven by over estimating recruitment. The SSC noted that we appeared to be in a period of low recruitment, therefore assuming that this recruitment will be higher in the projections was not a reasonable assumption. Additionally, the assessment for this stock was allowing for domed-shaped selectivity. This was creating an abundance of cryptic biomass, or biomass seen in the computer output of the population, but which does not show up in catch or survey data.'

  The changes made to the data input and benchmark model for this operational update were: 1. incorporated new MRIP calibrated time-series; 2. added a selectivity block from 2010 to present; 3. forced flat top selectivity for the fleet (Ages 4–7) to get rid of cryptic biomass; 4. added NEAMAP Spring Trawl survey index; 5. shifted from F_{MSY} (assumed B–H S–R relationship) to $F_{40\%}$ as a proxy; 6. used empirical cdf of recruitment time-series for projections instead of *assuming B–H stock recruit relationship.*

Overall, these changes caused a minor decrease in SSB (getting rid of some cryptic biomass) and cut the SSB reference point in half from 24,687 mt *to 12,261* mt*. Forcing a flat top selectivity for the fleet increased the SSB retro when compared to the previous operational assessment (Mohn's ρ of 0.248 vs 0.127). However, the retrospective error for both F and SSB were still considered minor for this assessment.*

- 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 updates in 2017 and 2015, and remains the same as 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 the current estimate (3959 mt*) at the time series low. Estimates of fishing mortality have been declining since 2015 and the current value (0.072) is also at a time-series low. Recruitment had a small peak in 2018 (6.4 million), however, it has again dropped below the 10-year average (4.7 million) in 2019 (3.4 million).*

- 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 as improved recreational discard length information. In addition, further investigation into the localized structure/genetics of the stock is warranted. Finally, a future shift to ASAP version 4 (during the next research track assessment) will provide the ability to model environmental factors that may influence survey catchability and help develop more informed population projections.

- Are there other important issues?
  None.

3.1. Reviewer Comments: Southern New England Mid-Atlantic winter flounder

The 2020 assessment for Southern New England Mid-Atlantic winter flounder is an enhanced review (Level 3) update of the 2017 ASAP operational assessment, as recommended by the Assessment Oversight Panel (AOP). This recommendation was made because of changes to the selectivity blocks and selectivity form, the inclusion of new MRIP data, changes to the reference points and possible inclusion of the NEAMAP data.

The Peer Review Panel concludes that the 2020 ASAP assessment update for Southern New England Mid-Atlantic winter flounder is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes. Retrospective adjustments were not made to the model results, but the retrospective adjusted value for SSB and F were close to the 90% confidence interval. In the previous assessment, the stock was considered overfished but overfishing was not occurring. In the current assessment, the $F_{MSY\,proxy}$ $(F_{40\%}) = 0.284$, $SSB_{MSY} = 12,322$ mt and $\frac{1}{2}SSB_{MSY}$ $(SSB_{\text{Threshold}}) = 6,161$ mt. $(F_{2019}/F_{MSY}) = 27\%$ and $SSB_{2019}/SSB_{\text{Threshold}} = 60\%$. The Peer Review Panel concurs with the assessment that the stock is overfished but that overfishing is not occurring.

And in the table under TOR 4 the SSB_{MSY} value needs to be changed to 12,322 mt.

Southern New England Mid-Atlantic winter flounder Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial and recreational landings and discards data were updated through 2019. Total catch in 2019 was 310 mt, a third of which were commercial discards and two thirds commercial landings. Total catches have been less than 1,000 mt since 2009 except in 2013.

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

   This TOR was satisfactorily addressed. Fishery independent indices of stock sizes for 1981–2019 and ages 0–7+ were used. In total, twelve indices were used, including two for recruits. Surveys generally showed declining stock sizes with much lower values since the early 2000s compared with previous years. The Massachusetts Division of Marine Fisheries age-0 survey showed variability without clear trend.

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

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

   b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

   This TOR was satisfactorily addressed. Bridge runs were made for each change. Adding a third selectivity block from 2010 resulted in very similar selectivities for the three blocks. Assuming flat topped selectivity rather than dome-shaped reduced the biomass estimate and increased (marginally) the retrospective. Recreational catches were small and have little influence on the ASAP results. The NEAMAP survey was included but did not produce large changes in estimates. A 'Plan B' was prepared but was not necessary.

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

   This TOR was satisfactorily addressed. In previous assessments, MSY reference points were calculated based on a stock and recruitment relationship with recent recruitments being consistently and significantly below predicted values. In addition, most other groundfish stocks assessed by the NEFSC use $F_{\%SPR}$ to estimate reference points. $F_{40\%}$ values were estimated:

	2017	2020
$F_{MSY}/F_{40\%}$	0.34	0.284
$SSB_{MSY}-SSB_{40\%}$	24687	12322
$MSY-MSY_{40\%}$	7532	3906

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

   This TOR was satisfactorily addressed. Short-term projections were made following standard protocols, without retrospective adjustment, assuming a catch of 251 mt in 2020 and fishing at $F_{40\%}$ in 2021–2023.

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

   All recommendations directly related to the assessments have been implemented. The main research recommendations for stock suggest additional studies on maximum age, maturity, movement, localized stock structure and environmental influence on recruitment. Considerable progress has been made on some of these topics since the last benchmark assessment and much of this research continues.

   There has been new research investigating maturity at the science center which can be used to update the maturity ogive during the next research track.

   A 2020 publication out of SUNY Stony Brook details work on otolith micro-chemistry that reveals new information on localized stock structure. A simulation study could be carried out to investigate the impacts on overall stock dynamics and the current stock assessment.

   An environmental model for this stock has been developed and is presented in a 2018 publication (Bell *et al.*, 2018). This model and indices were updated for this assessment cycle. However, in order to fully investigate and possibly shift to a new assessment model a research track assessment will be needed.

Additional Recommendations

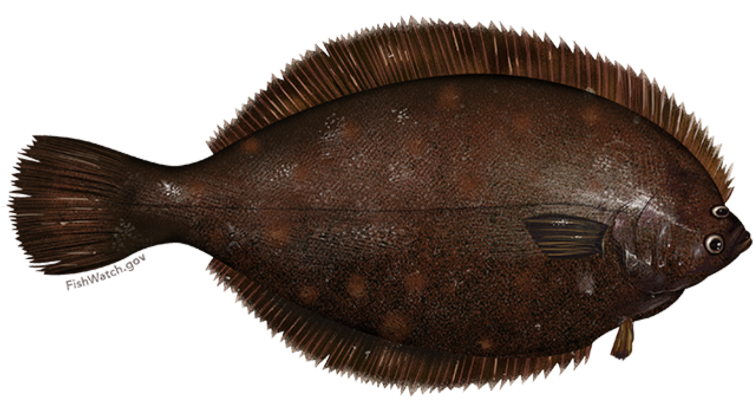
The Peer Review Panel notes, as had been done in previous reviews, that recruitment had been declining throughout the period and was currently very low. As for several other stocks under the purview of the NEFSC it would be helpful to evaluate if the previously observed high recruitment are possible; i.e., is it simply a matter of building back SSB and recruits will follow, or are there other factors at play. If the productivity of the resource(s) has decreased, it would be helpful to adjust reference points accordingly. This would be unlikely to change fisheries yield much but would be more realistic in terms of setting expectations.

References:

Northeast Fisheries Science Center. 2011. 52nd Northeast Regional Stock Assessment Workshop (52nd 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. http://www.nefsc.noaa.gov/publications/crd/crd1524/crd1524.pdf

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; 264 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. http://doi.org/10.7289/V5/RD-NEFSC-17-17.pdf



Pseudopleuronectes americanus, Winter Flounder.

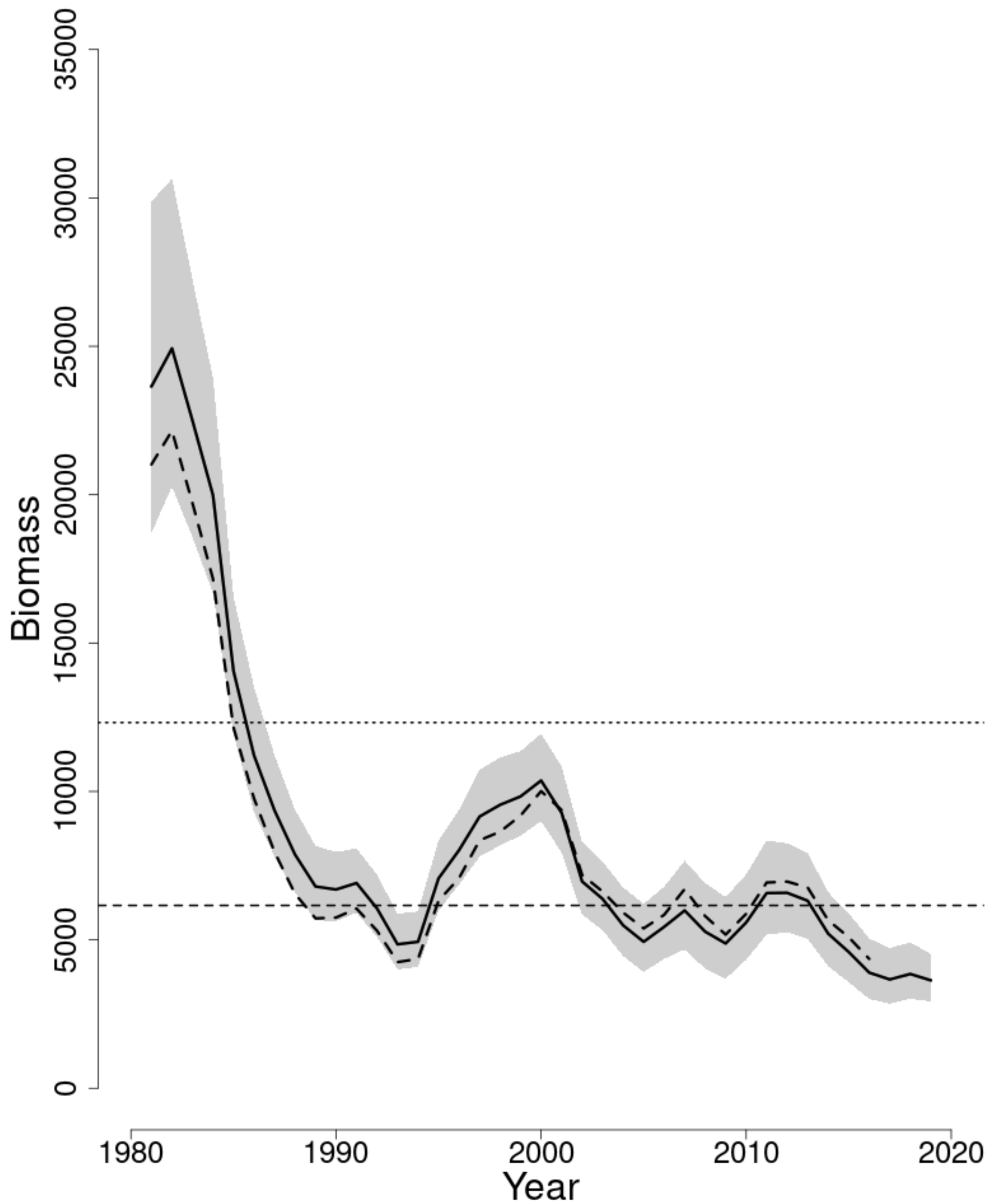


Figure 10: Trends in spawning stock biomass of Southern New England Mid-Atlantic winter flounder between 1981 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{\text{Threshold}}$ ($\frac{1}{2}SSB_{MSY\ proxy}$; horizontal dashed line) as well as SSB_{Target} ($SSB_{MSY\ proxy}$; horizontal dotted line) based on the 2020 assessment. The approximate 90% log-normal confidence intervals are shown.

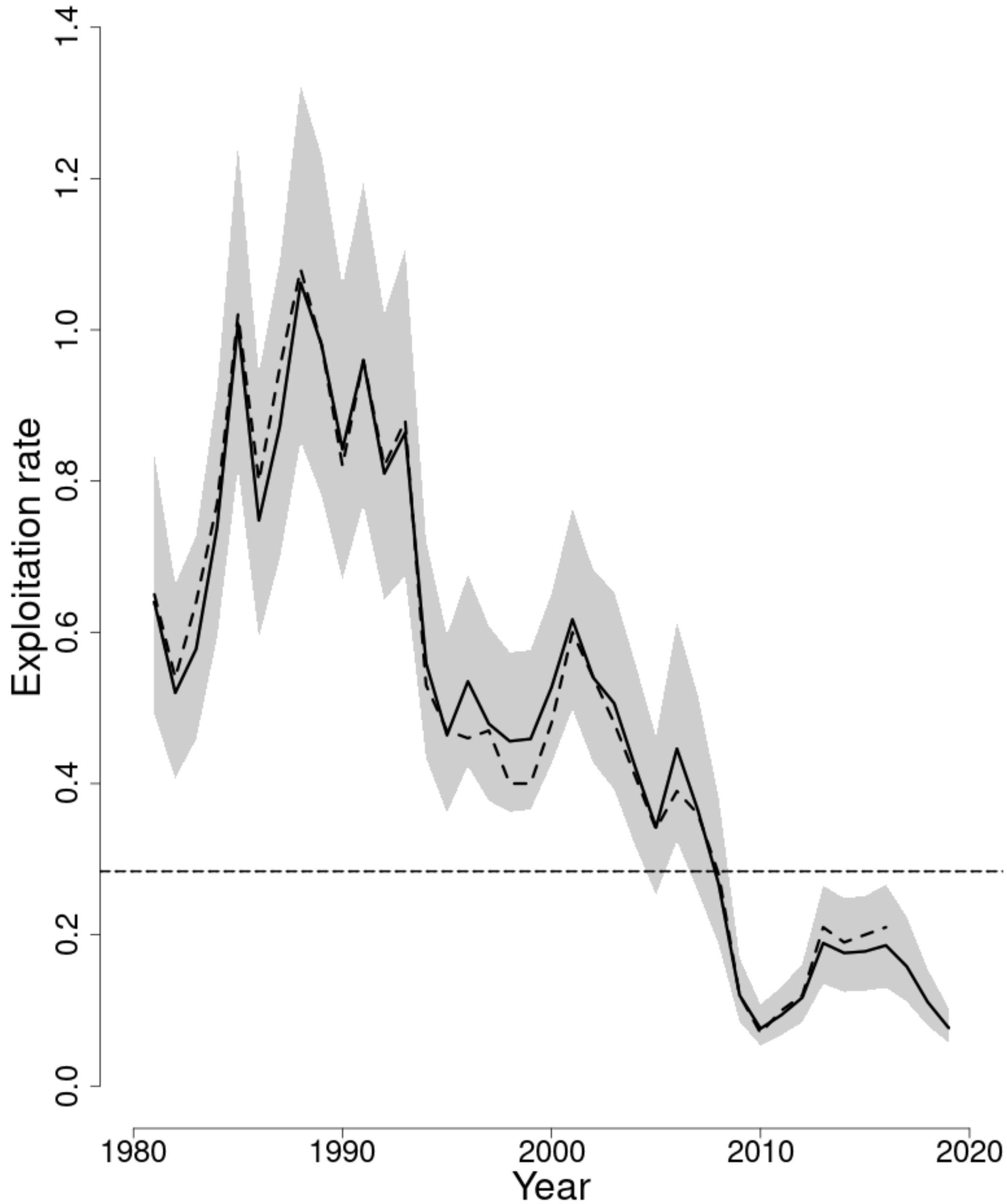


Figure 11: Trends in the fully selected fishing mortality (F_{Full}) of Southern New England Mid-Atlantic winter flounder between 1981 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{\text{Threshold}}$ ($F_{MSY} = 0.284$; horizontal dashed line) based on the 2020 assessment. The approximate 90% log-normal confidence intervals are shown.

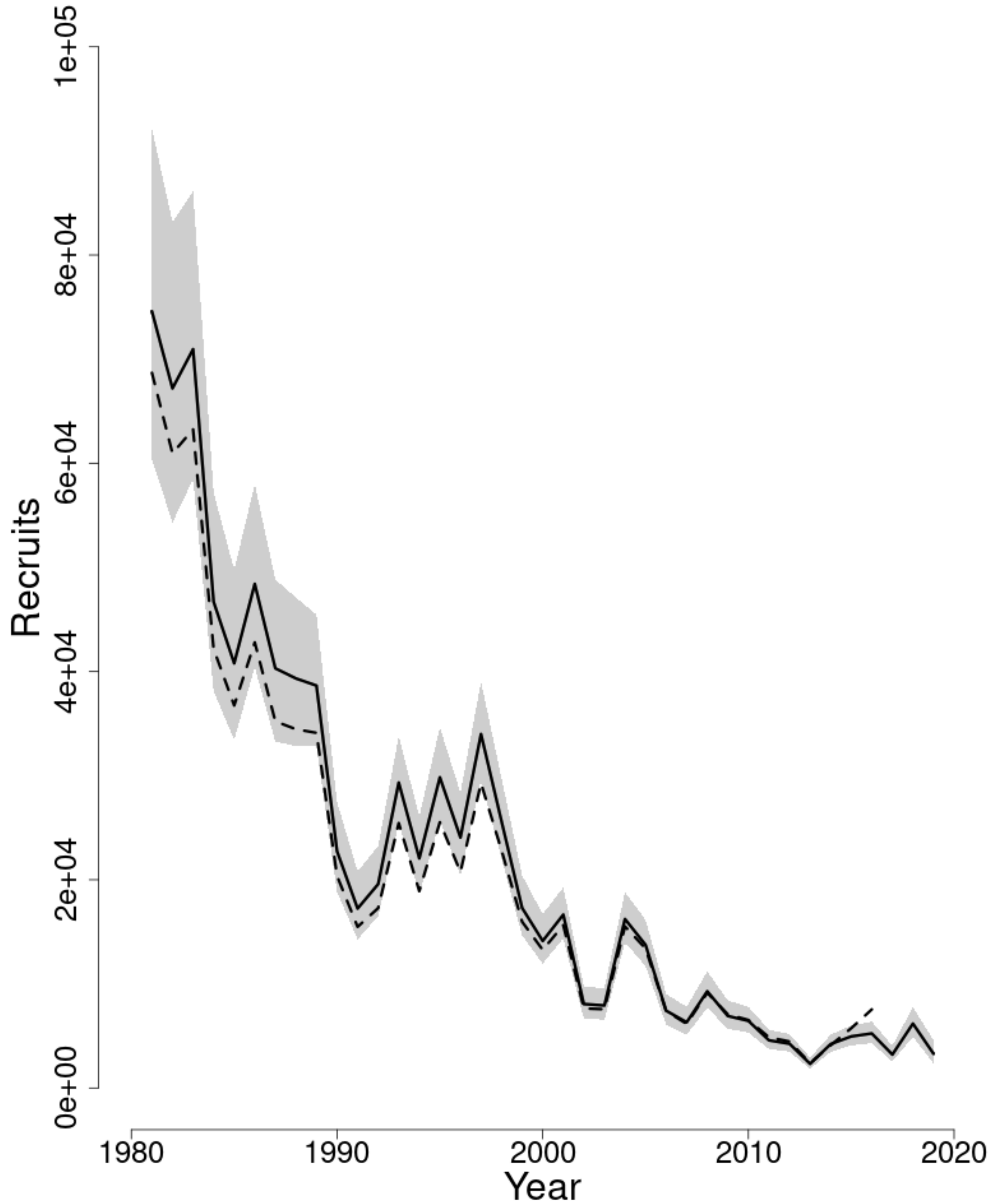


Figure 12: Trends in Recruits (000s) of Southern New England Mid-Atlantic winter flounder between 1981 and 2019 from the current (solid line) and previous (dashed line) assessment. The approximate 90% log-normal confidence intervals are shown.

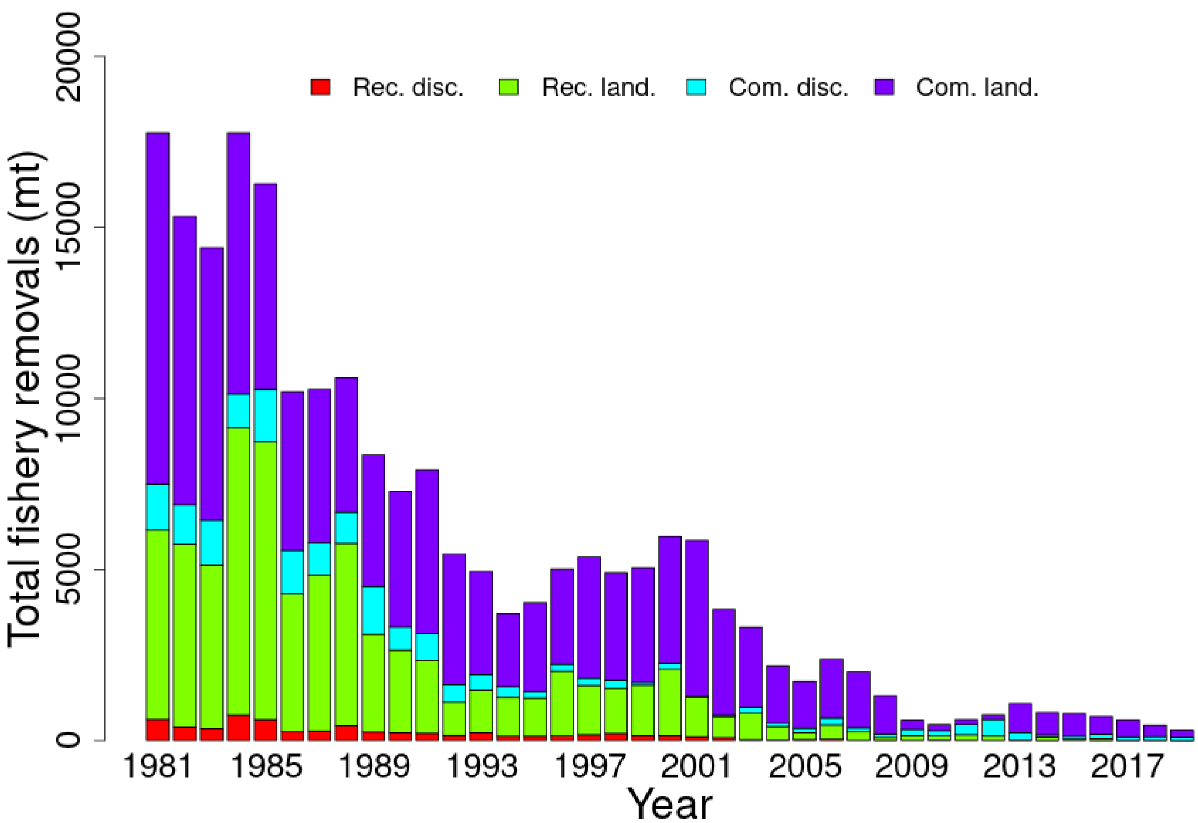


Figure 13: Total catch of Southern New England Mid-Atlantic winter flounder between 1981 and 2019 by fleet (commercial, recreational) and disposition (landings and discards).

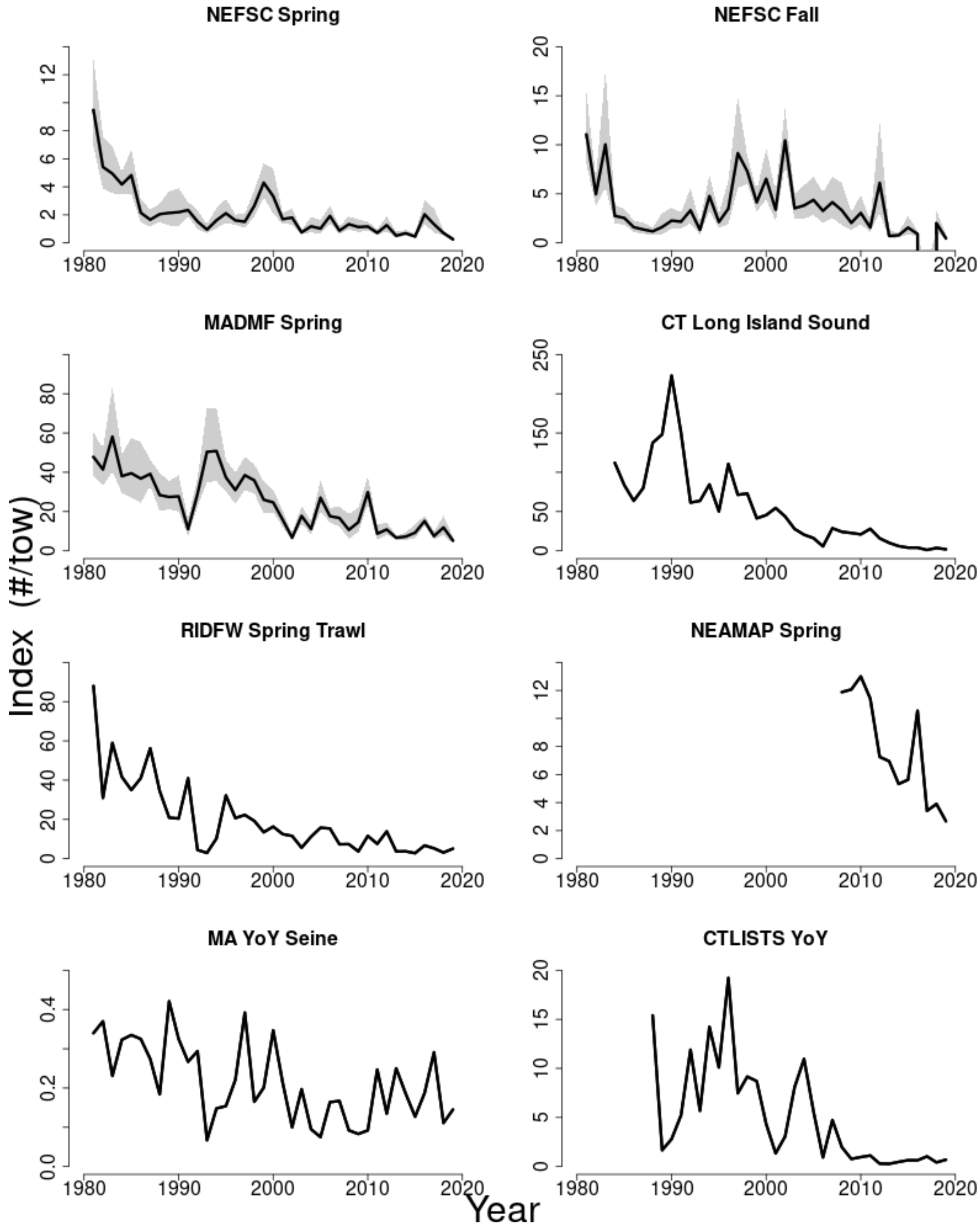


Figure 14: Indices of biomass for the Southern New England Mid-Atlantic winter flounder between 1981 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, the MA DMF spring survey, the CT LISTS survey, the RI DFW Spring Trawl survey, the NJ Ocean Trawl survey, and two YoY surveys from MA DMF and CT LISTS. Where available, the approximate 90% log-normal confidence intervals are shown. Slashes through the solid line indicate a hole in the survey time series.

4. ACADIAN REDFISH

Brian Linton

This assessment of the Acadian redfish (Sebastes fasciatus) stock is a management track assessment of the existing 2017 operational assessment (NEFSC 2017). This assessment updates commercial fishery catch data, research survey indices of abundance, the ASAP analytical model, and biological reference points through 2019. Additionally, stock projections have been updated through 2023. In what follows, there are two population assessment models: the base model (brought forward from the 2017 operational assessment), which is used to provide catch advice; and the DWS model (an alternative data weighting scenario), which is included for the sole purpose of demonstrating the sensitivity of assessment results to a data weighting scenario that better fits recent survey index trends. The DWS model is included in this report at the request of the Management Track Assessment Review Panel. 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 base model formulation.

State of Stock: The Acadian redfish (*Sebastes fasciatus*) stock is not overfished and overfishing is not occurring (Figures 15–16). Retrospective adjustments were made to the model results. Retrospective adjusted spawning stock biomass in 2019 was estimated to be 308,135 (mt) under the base model and 228,283 (mt) under the DWS model which is 154 and 149% (respectively) of the biomass target, an $SSB_{MSY\ proxy}$ of SSB at $F_{40\%}$ (200,586 and 153,337 (mt); Figure 15). Retrospective adjusted 2019 fully selected fishing mortality was estimated to be 0.017 under the base model and 0.024 under the DWS model, which is 45 and 65% (respectively) of the overfishing threshold, an $F_{MSY\ proxy}$ of $F_{50\%}$ (0.038 and 0.037; Figure 16).

Table 10: 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 base model and DWS model.

	2012	2013	2014	2015	2016	2017	2018	2019
Data								
Commercial landings	3,848	3,544	4,574	4,930	3,889	5,172	4,506	5,320
Commercial discards	347	420	523	114	38	94	62	60
Catch for Assessment	4,196	3,964	5,097	5,044	3,926	5,266	4,568	5,380
Model Results (base)								
Spawning Stock Biomass	263580	285500	308050	329400	349310	366720	380790	392600
F_{Full}	0.017	0.014	0.017	0.016	0.011	0.014	0.012	0.014
Recruits (age-1)	15078	12263	114020	17224	29940	32822	173130	97845
Model Results (DWS)								
Spawning Stock Biomass	237592	246798	255122	261637	267032	270768	272189	272281
F_{Full}	0.018	0.017	0.021	0.02	0.015	0.02	0.017	0.02
Recruits (age-1)	10704	10535	37889	14368	21048	25862	48494	44409

Table 11: Comparison of biological reference points for Acadian redfish estimated in the 2017 assessment and from the current base model and DWS model. There was no DWS model in the 2017 assessment. An $F_{MSY\ proxy}$ of $F_{50\%}$ was used for the overfishing threshold, and was based on yield per recruit analysis. F_{MSY} is reported as the fully selected F. Recruits represent the median of the predicted recruits from 1969 to the final assessment year. Intervals shown are 5th and 95th percentiles.

	2017 base	2017 DWS	base	DWS
$F_{MSY\ proxy}$	0.038	*NA*	0.038	0.037
SSB_{MSY} (mt)	247,918	*NA*	200,586 (144,433 – 270,527)	153,337 (115,231 – 198,475)
MSY (mt)	9,318	*NA*	7,561 (5,411 – 10,252)	5,647 (4,228 – 7,337)
Median recruits (age-1) (000s)	31,266	*NA*	26,426	21,048
Overfishing	No	Unknown	No	No
Overfished	No	Unknown	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 an $F_{MSY\ proxy}$ of $F_{50\%}$ between 2021 and 2023. Catch in 2020 has been estimated at 5,184 (mt) by the Groundfish PDT. Recruitments were sampled from a cumulative distribution function derived from ASAP estimated age-1 recruitment between 1969 and 2017. Recruitments in 2018 and 2019 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 same as those used in the assessment model. Retrospective adjusted SSB and fully selected F in 2019 fell outside the 90% confidence intervals of the unadjusted 2019 value under the base model (Figures 15–16). Retrospective adjusted SSB in 2019 fell outside the 90% confidence intervals of the unadjusted 2019 value under the DWS model (Figure 15). Therefore, age-specific abundance ρ values were applied to the initial numbers at age in the projections for the base model and the DWS model.

Table 12: Retrospective adjusted short term projections of median total fishery yield and spawning stock biomass for Acadian redfish from the current base model and DWS model based on a harvest scenario of fishing at an $F_{MSY\ proxy}$ of $F_{50\%}$ between 2021 and 2023. Catch in 2020 has been estimated at 5,184 (mt) by the Groundfish PDT. F_{Full} is the fully selected F.

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
		base			*DWS*	
2020	5,184	351,240	0.015	5,184	251,094	0.021

Year	Catch (mt)	SSB (mt)	F_{Full}	Catch (mt)	SSB (mt)	F_{Full}
		base			*DWS*	
2021	13,525	352,872	0.038	9,127	245,854	0.037
2022	13,235	348,222	0.038	8,788	237,640	0.037
2023	12,990	341,609	0.038	8,437	228,411	0.037

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 samples from landings were collected but not processed 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. New commercial age composition data were added to the assessment for 2017, but additional years of age data will be needed to continue addressing this source of uncertainty. Age samples from the NEFSC spring survey were collected but not processed after 1990. New spring survey age data were added to the assessment for 2018 and 2019, but additional years of age data will be needed to continue addressing this source of uncertainty.

  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. A sensitivity run was conducted using combined female and male weights at age. Time series estimates of SSB and F from the weight at age sensitivity run were similar to those from the base model, while recruitment estimates were greater than those from the base model. Biological reference points and short term projection results from the weight at age sensitivity run were similar to those from the base model.

  Some of the spikes observed in the survey indices of relative abundance should be interpreted cautiously because there is a possibility of migration into and out of the survey area.

- 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 7-year Mohn's ρ, relative to SSB, was 0.211 under the base model in the 2017 assessment and was 0.274 under the base model and 0.193 under the DWS model in 2019. The 7-year Mohn's ρ, relative to F, was −0.152 under the base model in the 2017 assessment and was −0.205 under the base model and −0.179 under the DWS model in 2019. There was a major retrospective pattern for the base model because the ρ adjusted estimates of 2019 SSB ($SSB_{\rho} = 308{,}135$ mt) and 2019 F ($F_{\rho} = 0.017$) were outside the approximate 90% confidence region around SSB (349,211 – 435,987 (mt)) and F (0.012 – 0.015). There was a major retrospective pattern for the DWS model because the ρ adjusted estimates of 2019 SSB ($SSB_{\rho} = 228{,}283$ mt) was outside the approximate 90% confidence region around SSB (243,110 – 301,450 (mt)). A retrospective adjustment was made for both the determination of stock status and for projections of catch in 2021. The base model retrospective adjustment changed the 2019 SSB from 392,600 (mt) to 308,135 (mt) and the 2019 F_{Full} from 0.014 to 0.017. The DWS model retrospective adjustment changed the 2019 SSB from 272,281 (mt) to 228,283 (mt) and the 2019 F_{Full} from 0.02 to 0.024.

- 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 for both the base model and the DWS 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.

  No changes were made to the base model as part of this update, beyond incorporating additional years of data. The DWS model was created for the sole purpose of demonstrating the sensitivity of assessment results to a data weighting scenario that better fits recent survey index trends. The DWS model is identical to the base model, except for changes to the for catch and survey indices, and the effective samples sizes (ESS) for catch and survey index age composition data. The and ESS values for the base model can be found in NEFSC (2008). The DWS model catch were set equal to 0.1, which is approximately the average catch CV from 1989 to 2019 in the base model. This time period is where total catch vary based on commercial discard in the base model. The base model spring survey index were halved for the DWS model to better fit this index. The DWS model catch, fall survey index, and spring survey index age composition ESS values were derived by applying stage 2 multipliers for multinomials (Francis 2011) to the respective base model ESS values. These suggested ESS multipliers are calculated by ASAP. The resulting age composition ESS values are 25 for catch, 16 for the fall survey index, and 20 for the spring survey index.

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

  Stock status based on the base model has not changed since the previous assessment.

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

  Total removals of Acadian redfish increased starting in the early 2000s, and have been relatively constant since the early 2010s. The NEFSC spring survey index increased in the late 1990s and has varied without trend to the present. The NEFSC fall survey index increased from the late 1990s to the early 2010s, until decreasing suddenly in 2013. The fall survey index has varied without trend at this lower level of relative abundance to the present. Fall survey data suggests the existence of relatively strong year classes in 2007–2008 and 2013. 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 including additional age data, particularly from the commercial fishery. Progress was made on this recommendation, but additional age data are needed.

  Investigate the sensitivity of biological reference points and stock projections to the mean weights at age. This recommendation was completed.

  Future assessments should explore whether it is better to estimate the stock-recruitment relationship inside the model or externally. No progress was made on this recommendation.

  An evaluation of survey trends should be conducted, including potential factors that may cause the trends to not reflect patterns in relative abundance. No progress was made on this recommendation.

An exploration of data weighting scenarios should be conducted to better reflect the completeness and reliability of available data. Progress was made on this recommendation, but additional work is needed.

- Are there other important issues?

  The base model predicts an increasing trend in SSB in recent years, while the fall and spring survey indices vary without trend over that same time period. This behavior likely is due to the fact that the model can easily add fish to the population with the strong year class signals in the fishery and survey age composition data. At the same time, the model has a difficult time removing fish from the population, due to a relatively low natural mortality rate ($M = 0.05$) and the even lower levels of F needed to fit recent observed catches.

  The addition of a new fishery selectivity time block was evaluated in response to the addition of the 2017 commercial age composition data. The new selectivity time block did not improve model fit to the data. Therefore, a new selectivity time block was not added to the current assessment.

  Survey stratum 30 was not sampled in the 2018 NEFSC fall survey. The expanded catch in biomass from stratum 30 was less than 1% of the total expanded survey catch in biomass, averaged over the last 10 years. Therefore, it was decided that no adjustment to the 2018 fall survey index value was needed to account for the missing survey stratum.

  Sublegal size Acadian redfish were landed under a maximum retention electronic monitoring exempted fish permit in 2018 and 2019, and needed to be accounted for in the assessment. Sublegal size landings in both of these years were less than 1 (mt). These sublegal size landings were included in the total removals, but were not partitioned into age-specific landings, because there were no commercial age composition data available for legal size landings in 2018 and 2019.

Sebastes fasciatus, Acadian Redfish.

4.1. Reviewer Comments: Acadian redfish

The 2020 assessment for Acadian redfish is an expedited review (Level 2) update of the 2017 ASAP based operational assessment, as recommended by the Assessment Oversight Panel (AOP). This recommendation was made based on the addition of age data, new maturity data, investigation of the usefulness of adding a selectivity block and evaluation of the necessity to make a retrospective adjustment.

The first review by Peer Review Panel observed that the two stock size indices used in the ASAP model had been declining more steeply than the estimated biomass in the assessment. The Peer Review Panel considered rejecting the assessment on that basis, but given that the ASAP modelling did not show other problems, the analyst was asked to explore ways to better fit recent survey indices. The analyst found that altering the weighting of the various data sources provided a better fit to recent indices and improved the retrospective pattern. The Peer Review Panel accepted the base case assessment but cautioned that it may overestimate stock size as indicated by the sensitivity run where a different weighting scheme was used.

The Peer Review Panel concludes that the 2020 assessment update for Acadian redfish is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available for this stock for management purposes. Retrospective adjustments were made to the model results. The Peer Review Panel concurs with the assessment that Acadian redfish are not overfished, and overfishing is not occurring.

Acadian redfish Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial landings data were updated with 2017–2019 data added to the 1913–2016 time series used in the previous assessment. Catch at age data for 2017 was added to the 1969–1985 data used in the previous assessment. Total discards for 2017–2019 were added to those for 1989–2016 used in the previous assessment. Recreational catches and discards are not used in this assessment as agreed in the benchmark assessment. Total catches have varied between 3,900 mt and 5,380 mt during 2012–2019.

   The Peer Review Panel notes that age data have been collected for the entire period but those have not been processed. Additional age data for 1986–2016 and for years post 2017 would be likely to decrease uncertainty in the next assessment.

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

   This TOR was satisfactorily addressed. The NEFSC autumn and spring bottom trawl surveys are used in the ASAP modelling. Both were updated to 2019. Indices at age were available for 1975–2019 for the autumn survey and 1975–1980, 1984–1990 and 2018–2019 for the spring survey.

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

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

   b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

   This TOR was satisfactorily addressed. The ASAP model used catches for 1913–2019 and ages 1 to 26+. Natural mortality was fixed at $M = 0.05$, selectivity was assumed to equal 1.0 for ages 10 and older. The addition of another selectivity block was found to be not warranted.

   As there were no changes to the previous model, a bridge was not necessary. A 'Plan B' was prepared but was not needed as the assessment was accepted.

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

   This TOR was satisfactorily addressed. The re-estimated BRPs include: $F_{MSY} = 0.038$, $B_{MSY} = 200{,}586$ mt, and $MSY = 7{,}561$ mt. The most recent biomass estimate is near 400,000 mt which is above B_{MSY}. The 2019 fishing mortality was estimated to be 0.014, which is lower than F_{MSY}. The stock is not overfished, and overfishing is not occurring.

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

   Projections were carried out following accepted protocols assuming that 5,184 mt would be caught in 2020 and setting fishing mortality in 2021–2023 equal to the $F_{MSY\,proxy}$ of $F_{40\%}$. A retrospective adjustment was applied. Resulting catches at $F_{40\%}$ are 13,525 mt for 2021 with 13,235 mt for 2022 and 12,990 mt for 2023. The analytical team will try to complete sensitivity projections under the alternate weighting prior to the PDT and SSC meetings.

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

   Include additional age data: this was done, but must be continued to include more years. Investigate effect of using female mean weight at age: this was done. The 2020 assessment uses female only weights at age, but a sensitivity was run using both female and male weights at age. The model predicts higher age-1 recruits when using weights from both sexes, but there is little difference in biomass and fishing mortality estimates.

   Explore estimation of stock-recruit relationship internal or external to model: no progress made.

   Evaluate survey trends and how well they reflect abundance: no progress made

   Explore data weighting scenarios to better reflect data quality: this was done during the Peer Review Panel meeting.

Additional Recommendations

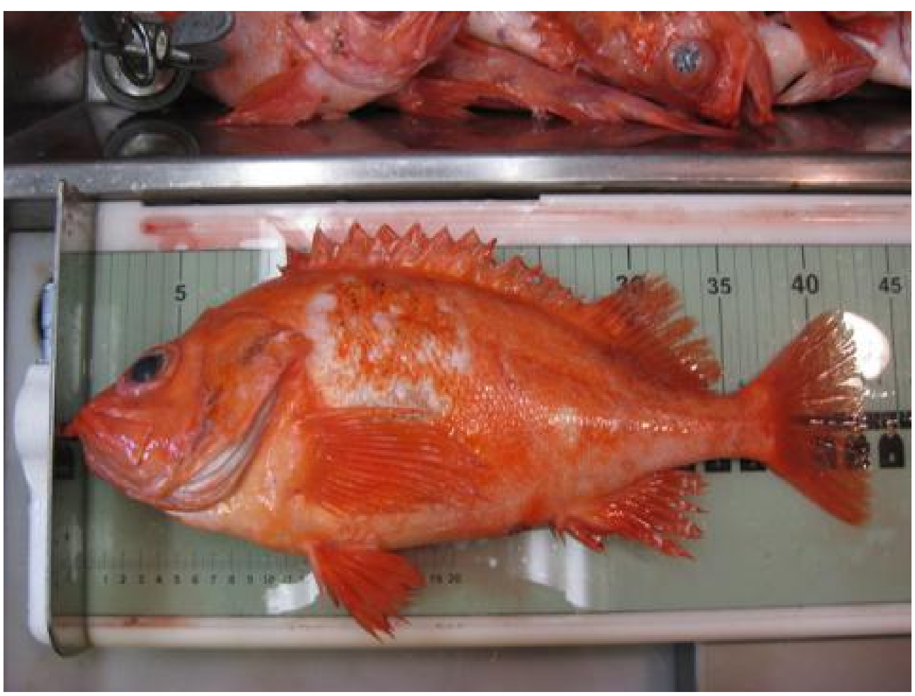
The Peer Review Panel strongly recommends that the aging material collected be processed and be made available to be used in the next assessment. Exploration of data weightings should be continued, implying an enhanced review for the next assessment.

References:

Francis, RICC. 2011. Data weighting in statistical fisheries stock assessment models. Can J Fish Aquat Sci 68(6): 1124–1138.

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 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. 2017. Operational assessment of 19 northeast groundfish stocks, updated through 2016. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-17; 264 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026. CRD17-17



Measuring an Acadian redfish.

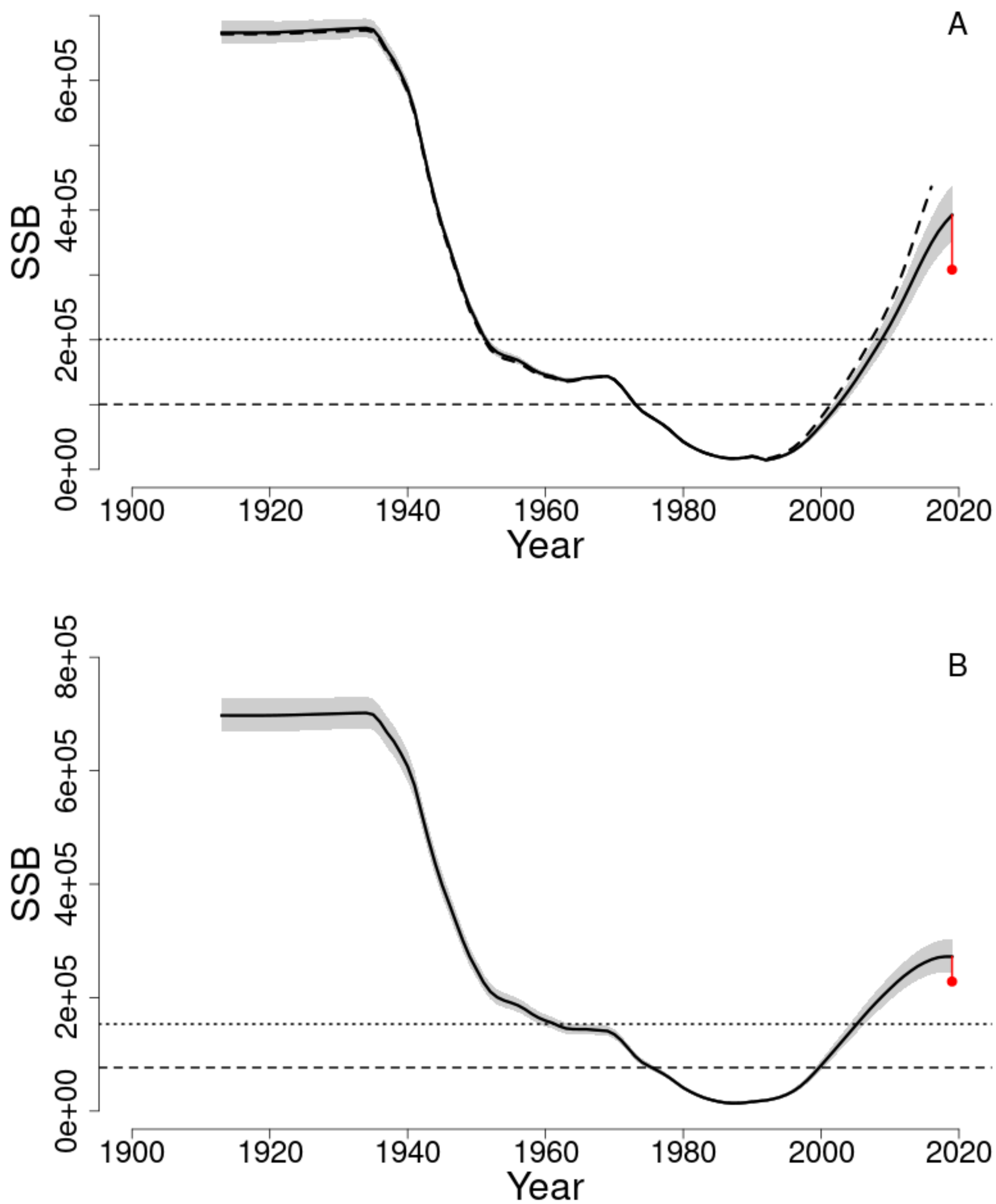


Figure 15: Estimated trends in the spawning stock biomass of Acadian redfish between 1913 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{\text{Threshold}}$ (0.5 * $SSB_{MSY\ proxy}$; horizontal dashed line) as well as SSB_{Target} ($SSB_{MSY\ proxy}$; horizontal dotted line) based on the 2020 assessment models base (A) and DWS (B). Biomass was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% log-normal confidence intervals are shown.

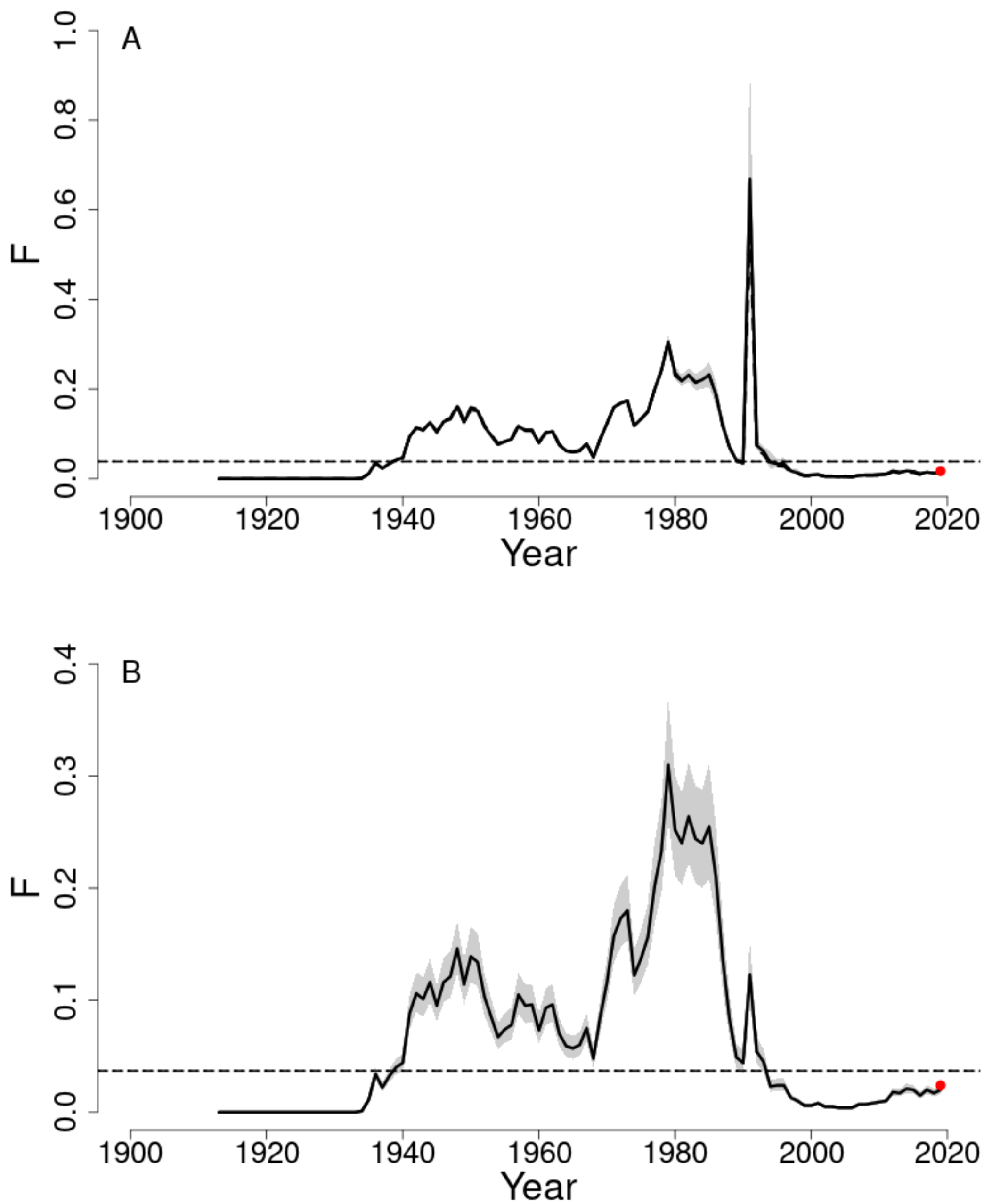


Figure 16: Estimated trends in fully selected F (F_{Full} of Acadian redfish between 1913 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{\text{Threshold}}$ ($F_{MSY\ proxy}$; dashed line) based on the 2020 assessment models base (A) and DWS (B). F_{Full} was adjusted for a retrospective pattern and the adjustment is shown in red. The approximate 90% log-normal confidence intervals are shown.

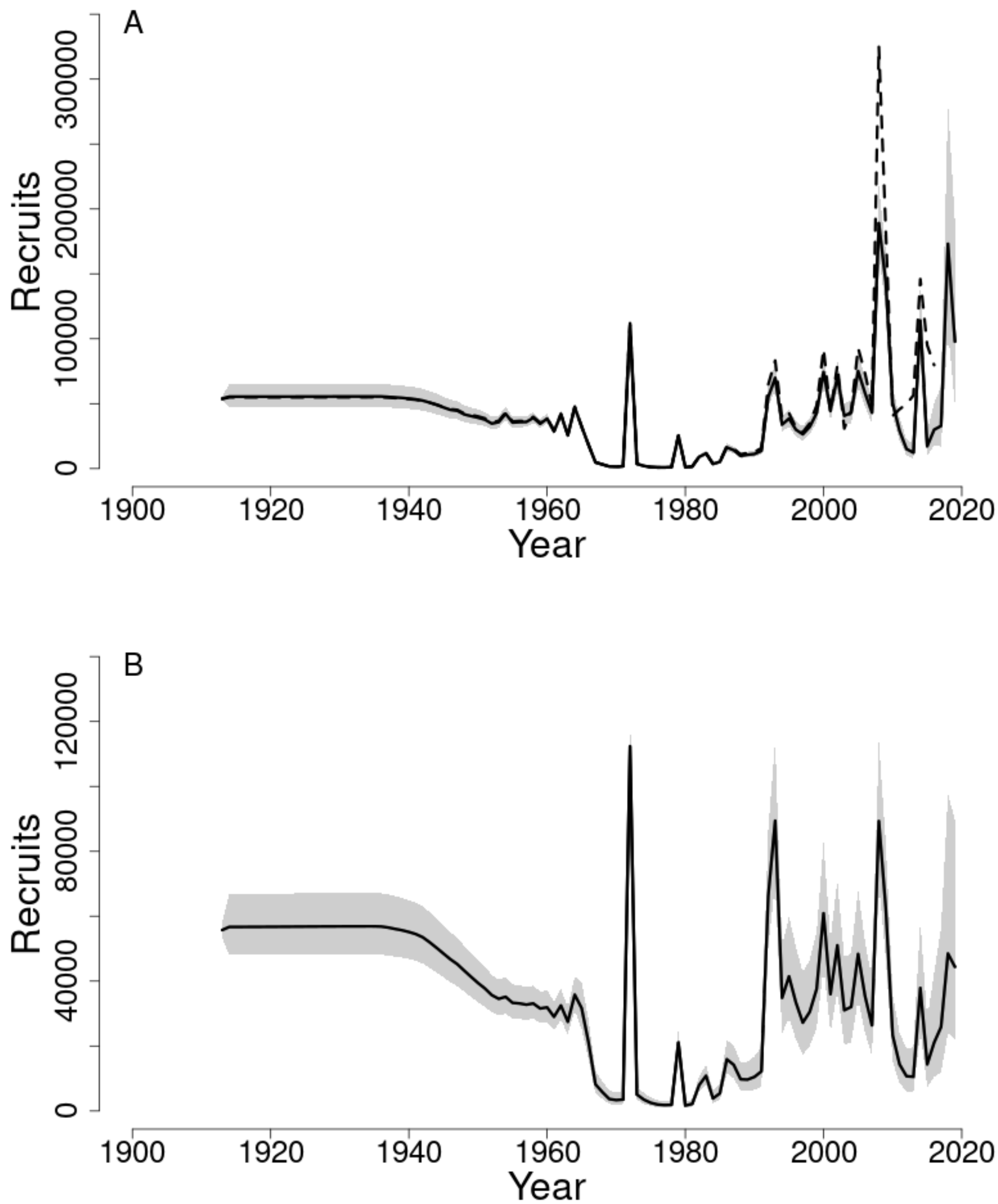


Figure 17: Estimated trends in age-1 recruitment (000s) of Acadian redfish between 1913 and 2019 from the current (solid line) and previous (dashed line) assessment for the assessment models base (A) and DWS (B). The approximate 90% log-normal confidence intervals are shown.

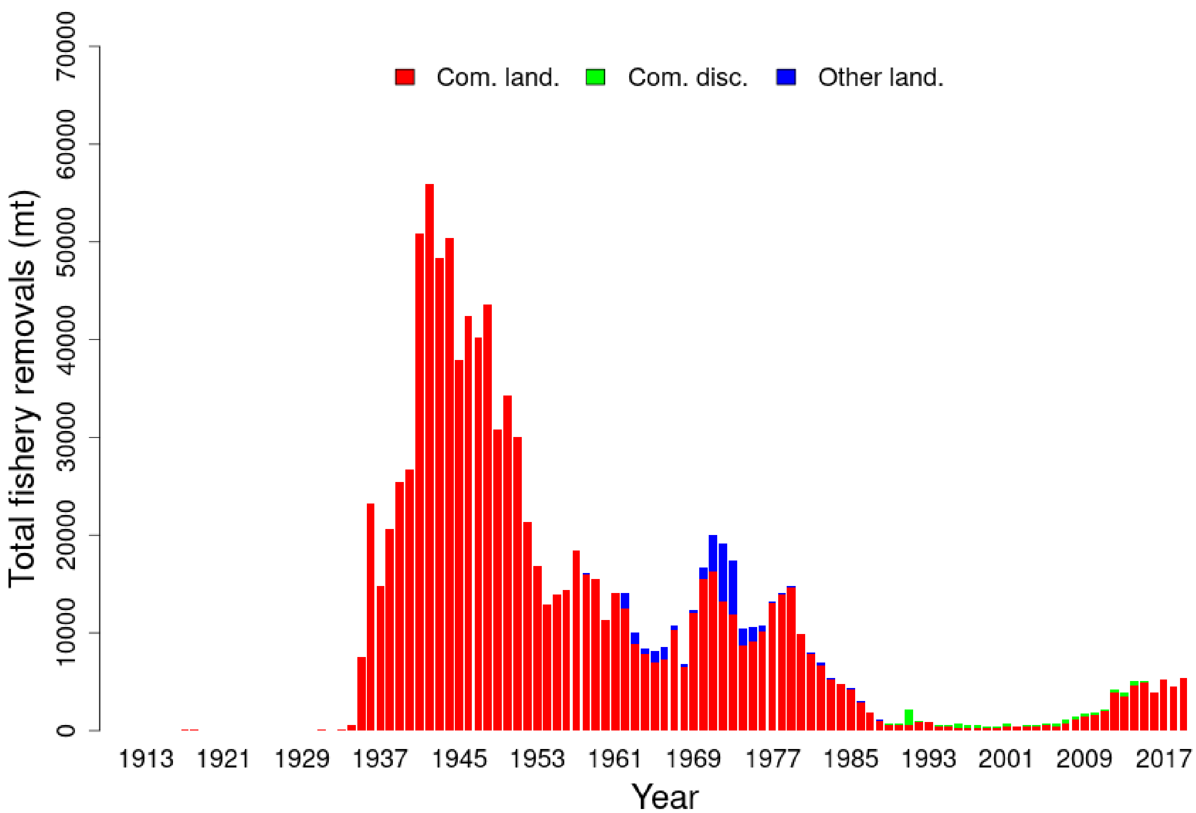


Figure 18: Total catch of Acadian redfish between 1913 and 2019 by fleet (commercial, Canadian, distant water fleet, and recreational) and disposition (landings and discards).

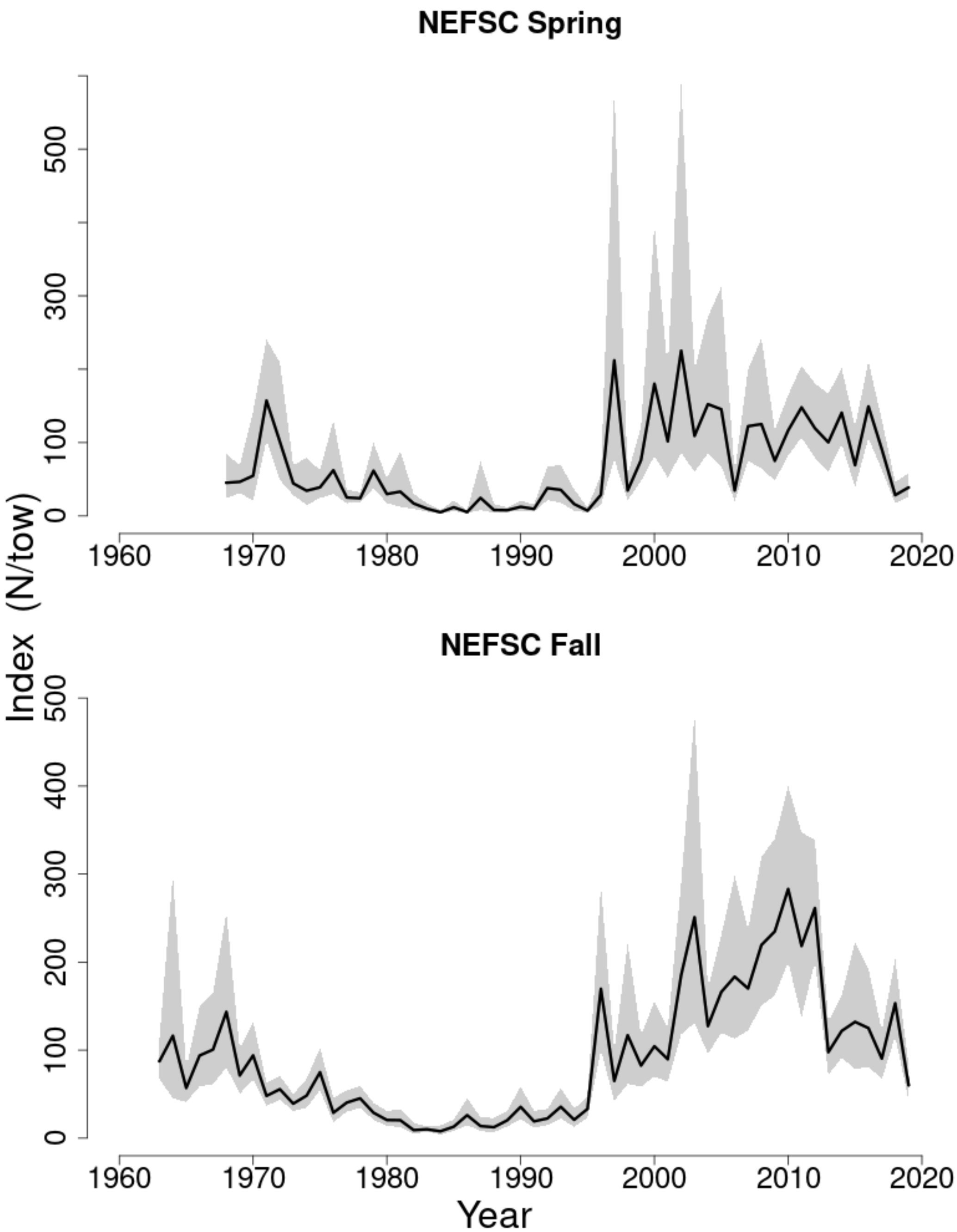


Figure 19: Indices of abundance for Acadian redfish from the Northeast Fisheries Science Center (NEFSC) spring (1968 to 2019) and fall (1963 to 2019) bottom trawl surveys. The approximate 90% log-normal confidence intervals are shown.

5. ATLANTIC WOLFFISH

Charles Adams

This assessment of the Atlantic wolffish (Anarhichas lupus) stock is a level-2 management track assessment of the existing benchmark assessment (NDPSWG 2009). Based on the previous operational assessment (NEFSC 2017) the stock was overfished, but overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices of abundance, the analytical SCALE assessment model and reference points through 2019.

State of Stock: Based on this updated assessment, the Atlantic wolffish (*Anarhichas lupus*) stock is overfished and overfishing is not occurring (Figures 20–21). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2019 was estimated to be 676 (mt) which is 44% of the biomass target ($SSB_{MSY\ proxy}$ = 1,543; Figure 20). The 2019 fully selected fishing mortality was estimated to be 0.005 which is 2% of the overfishing threshold proxy ($F_{MSY\ proxy} = 0.2$; Figure 21).

Table 13: Catch and status table for Atlantic wolffish. All weights are in (mt), recruitment is in (millions) and F_{Full} is the fully selected fishing mortality. Model results are from the current updated SCALE assessment.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
Commercial landings	3	0	0	0	0	0	0	0	0	0
Commercial discards	1	3	3	2	1	1	1	2	3	3
Recreational landings	1	3	0	0	0	0	0	0	0	0
Catch for Assessment	5	6	3	2	1	1	1	2	3	3
Model Results										
Spawning Stock Biomass	274	320	368	425	479	529	577	620	652	676
F_{Full}	0.025	0.025	0.01	0.005	0.003	0.003	0.002	0.005	0.005	0.005
Recruits (age-1)	66	57	51	46	44	73	276	280	280	280

Table 14: Comparison of reference points estimated in the 2017 assessment and from 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.

	2017	2020
$F_{MSY\ proxy}$	0.222	0.200
SSB_{MSY} (mt)	1,612	1,543
MSY (mt)	232	218
Median recruits (age-1) (millions)	235	238
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 2005 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.

  The uncertainty associated with the use of the ocean pout calibration coefficient will be addressed in the next management track by splitting the Albatross and Bigelow time series. Dropping of the recruitment index from the SCALE model will also be explored.

- 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}.)

  This assessment has retrospective patterns with Mohn's ρ = 0.27 for SSB and −0.14 for F. However, confidence intervals are not available because MCMC is not fully developed for the SCALE model.

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

  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.

- 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 time series of recreational landings was updated with the revised MRIP estimates. This resulted in only minor changes to the catch and had no effect on stock status

  The Atlantic wolffish maturity study in the Gulf of Maine has been completed. Accordingly, the L_{50} of 50 cm used in the 2017 assessment was changed to 52 cm for the current assessment to incorporate new information from the definitive maturity ogive. This resulted in only minor changes to the reference point calculations and had no effect on stock status.

- 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 2005.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  Several research needs were identified by the Peer Review Panel in the 2015 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.
  The recently completed S–K funded wolffish study included aging of wolffish; a manuscript on sex-specific growth parameters is in preparation. There was also a genetic component for which a manuscript is in preparation. Finally, tagging data area being reviewed to see if this can be published as well. There has been no progress on the use of a likelihood profile to apply the criterion for a retrospective adjustment, nor on a study of post-capture nest site fidelity.

- Are there other important issues?
  Recruitment at end of the time series increases toward the initial recruitment estimate (Table 13; Figure 22) 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% log-*normal confidence intervals are not shown in Figures 20–22 because MCMC is not fully developed for the SCALE model.*
  Discards estimates assume an 8% mortality rate based on Grant and Hiscock (2014). 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.

Anarhichas lupus, Atlantic wolffish.

5.1. Reviewer Comments: Atlantic wolffish

The 2020 assessment update for Atlantic wolffish is an expedited review (Level 2 assessment) in accord with the decision at the 27 May 2020 meeting of the Assessment Oversight Panel (AOP). This was recommended because of the need to consider the cumulative effects of updated MRIP data, and a revised knife edge maturity at 52 cm from 50 cm.

This 2020 assessment is an update of the 2008 benchmark assessment and the 2017 operational assessment. This assessment updates commercial fishery catch data, research survey indices of abundance, the analytical SCALE assessment model and reference points through 2019.

The Peer Review Panel (PRP) concludes that the 2020 assessment update for Atlantic wolffish is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available (BSIA) for this stock for management purposes. Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2019 was estimated to be 676 (mt) which is 44% of the biomass target ($SSB_{MSY\ proxy} = 1{,}543$). The 2019 fully selected fishing mortality was estimated to be 0.005 which is 2% of the overfishing threshold proxy ($F_{MSY\ proxy} = 0.2$). The PRP concurs with the assessment that Atlantic wolffish are overfished and overfishing is not occurring.

Atlantic Wolffish Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial landings data are primarily only available through 2010 after which possession was prohibited, and discard data from 2017, 2018 and 2019 were added to those used in the 2017 operational assessment. Similarly, recreational landings are available only through 2011. Recent MRIP data were used to update recreational landing data through 1981. Recreational discards for this stock were not included in the benchmark assessment.

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

   This TOR was satisfactorily addressed. All three of the survey indices used in the benchmark assessment (NEFSC spring bottom trawl survey, NEFSC fall bottom trawl survey, MA DMF spring trawl survey) were updated through 2019. Few fish were captured in any of the three surveys over the past decade. Catch length frequencies were updated as well, although the only data available since 2011 has come from commercial fishery discards.

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

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

b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

This TOR was satisfactorily addressed. The same SCALE model configuration used in the 2017 operational assessment was used in the 2020 update.

A bridge run was prepared to evaluate the impact of the revised MRIP recreational landings estimate for 1968–2016. Results using the original and revised estimates showed little difference. As a result, a final 1968–2019 assessment was conducted using the revised MRIP landings data. None of the various diagnostics showed significant differences between the predicted and observed values. The change in knife edge maturity had no influence on the trends being simply a scaling factor.

Though a moderate retrospective pattern was observed (Mohn's $\rho = 0.27$ for SSB and –0.14 for F), no retrospective adjustments were made on the assessment. Values of Mohn's ρ improved over the 2017 assessment.

A 'Plan B' assessment was unnecessary because the SCALE assessment was accepted.

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

   This TOR was satisfactorily addressed. The re-estimated BRPs are the following: $F_{MSY\,proxy} = 0.200$, $SSB_{MSY} = 1{,}543\,\text{mt}$, and $MSY = 218\,\text{mt}$. The 2019 fully selected fishing mortality was estimated to be 0.005 which is 2% of the overfishing threshold proxy ($F_{MSY\,proxy} = 0.200$). The stock is overfished but overfishing is not occurring.

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

   Due to the uncertainties in the assessment in general, the Northeast Data Poor Stocks Working Group concluded in 2009 that stock projections would be unreliable and should not be conducted.

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

   Several research needs were identified by the Peer Review Panel in the 2015 assessment:

   - 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.

   There has been no progress on the use of a likelihood profile to apply the criterion for a retrospective adjustment. A recently completed S–K funded wolffish study included ageing of wolfish and a manuscript on sex-specific growth parameters is in preparation. There was also a genetic component for which a manuscript is in preparation. Tagging data are being reviewed to see if they can be published as well. No progress has been made on a study of post-capture nest site fidelity.

   Finally, the issue of the use of the ocean pout calibration coefficient (to calibrate F/V Bigelow survey results to those of the F/V Albatross) will be addressed in the 2023 management track assessment.

Additional Recommendations

1. Evaluate longline survey data as an index for inclusion in the next assessment, or at least as a tool to evaluate the sensitivity of the assessment to changes in abundance.
2. Consider why the current SSB appears to be increasing, while the MSY and SSB_{MSY} appears to be decreasing.

References:

Grant SM, Hiscock W. 2014. Post-capture survival of Atlantic wolffish (*Anarhichas lupus*) captured by bottom otter trawl: Can live release programs contribute to the recovery of species at risk? Fish Res 151:169–176. https://doi.org/10.1016/j.fishres.2013.11.003

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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

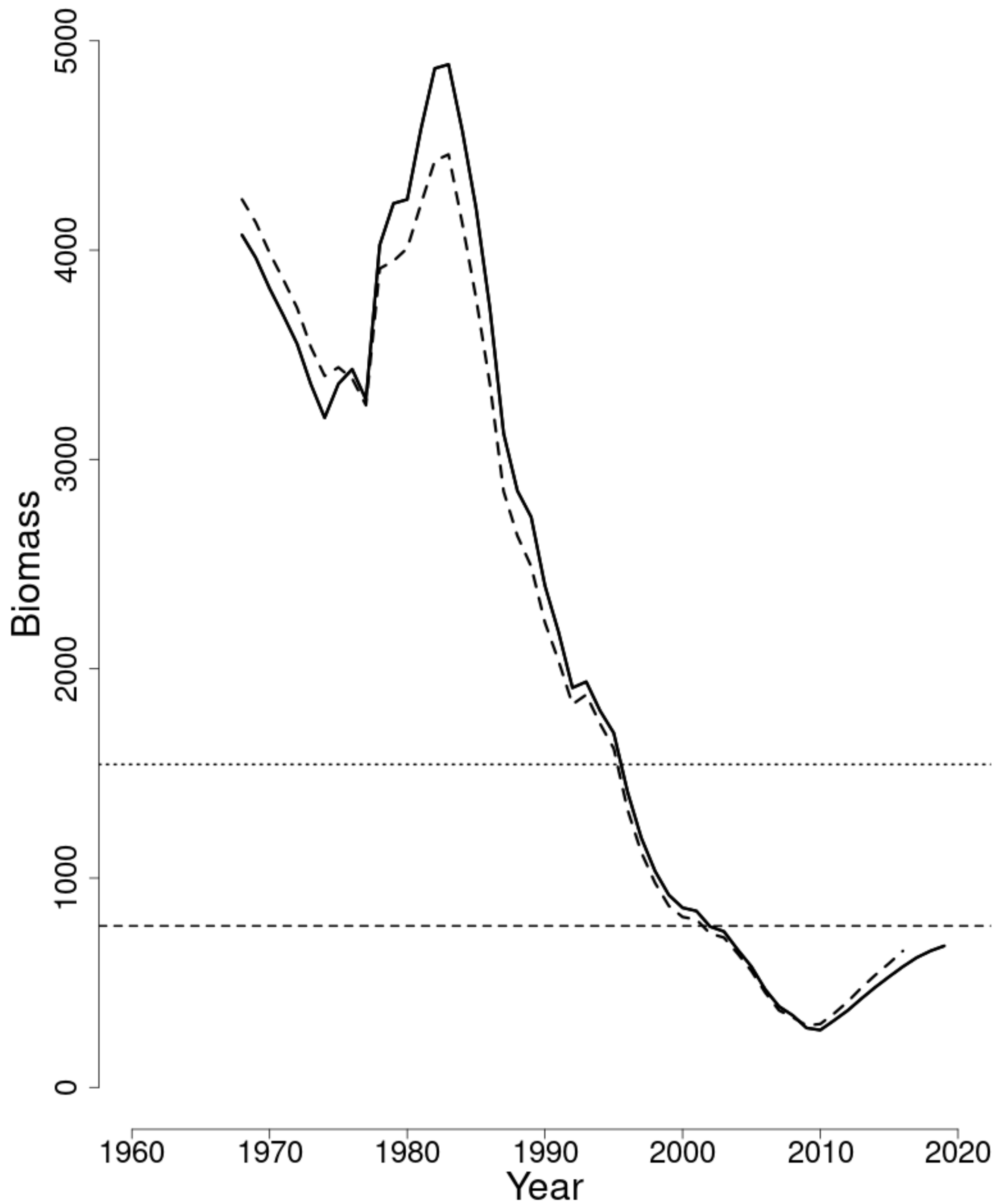


Figure 20: Trends in spawning stock biomass of Atlantic wolffish between 1968 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{\text{Threshold}}$ ($\frac{1}{2}SSB_{MSY\ proxy}$; horizontal dashed line) as well as SSB_{Target} ($SSB_{MSY\ proxy}$; horizontal dotted line) based on the 2020 assessment. Biomass was not adjusted for a retrospective pattern.

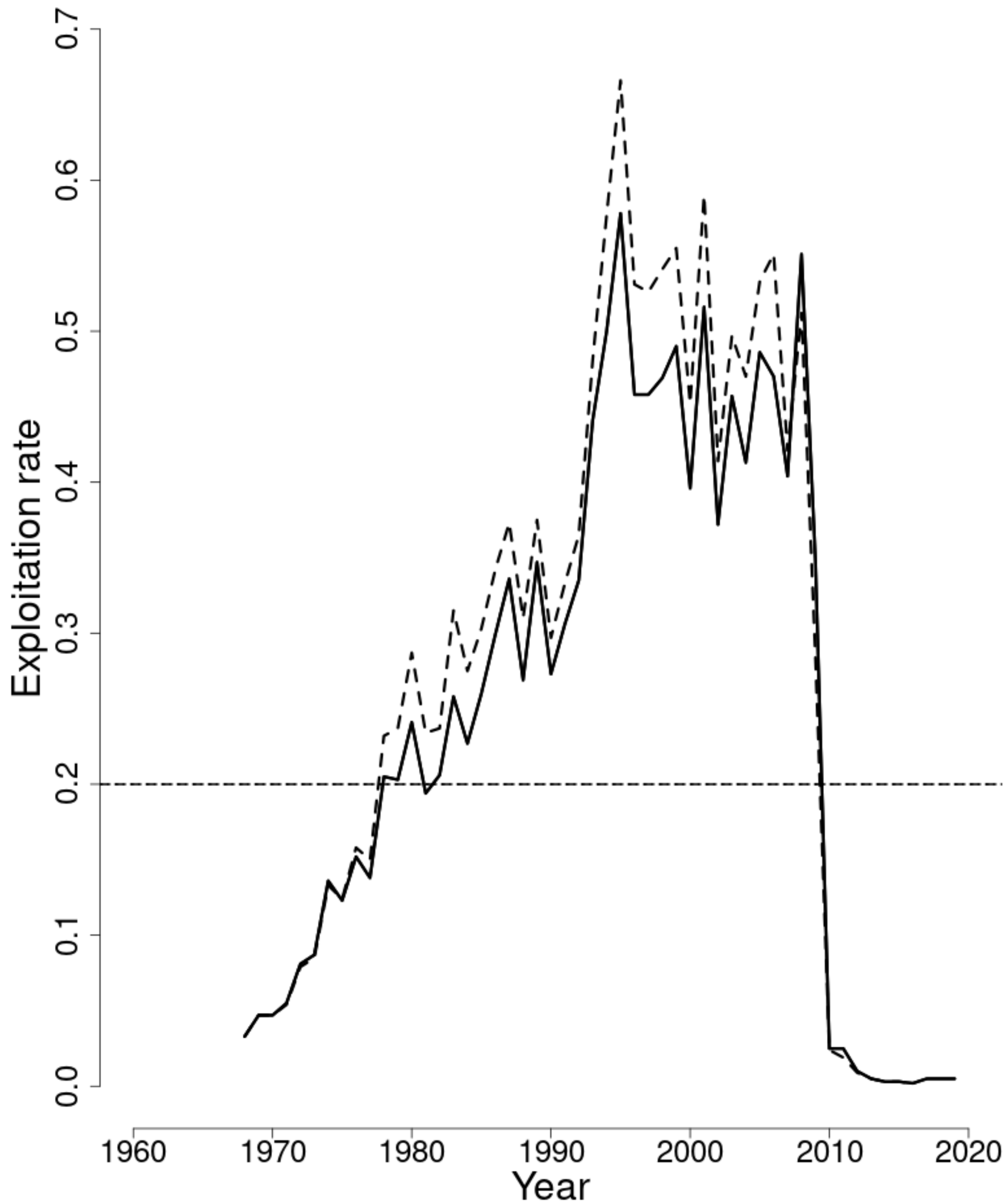


Figure 21: Trends in the fully selected fishing mortality (F_{Full}) of Atlantic wolffish between 1968 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{\text{Threshold}}$ ($F_{MSY\,proxy} = 0.2$; horizontal dashed line) based on the 2020 assessment. F_{Full} was not adjusted for a retrospective pattern

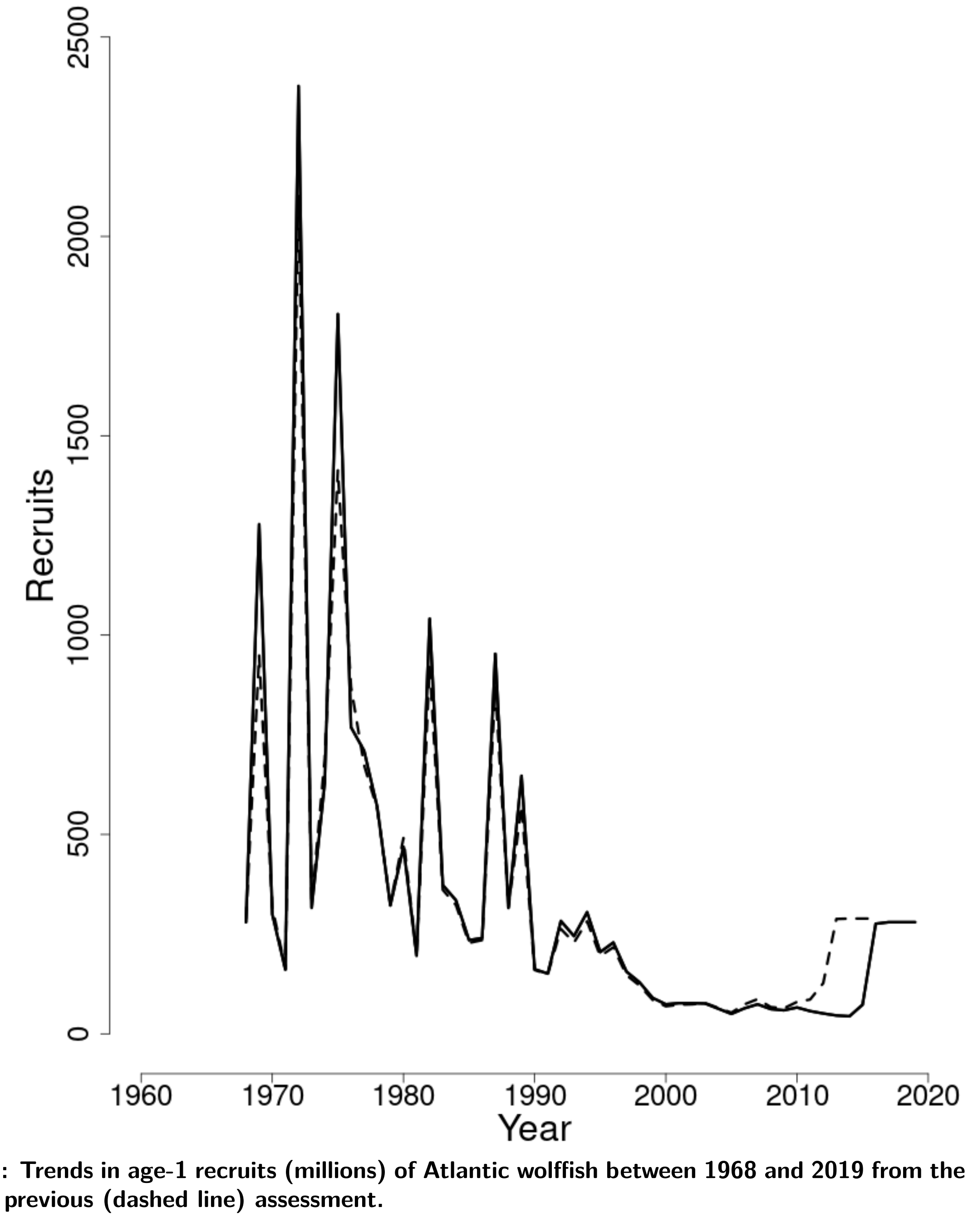


Figure 22: Trends in age-1 recruits (millions) of Atlantic wolffish between 1968 and 2019 from the current (solid line) and previous (dashed line) assessment.

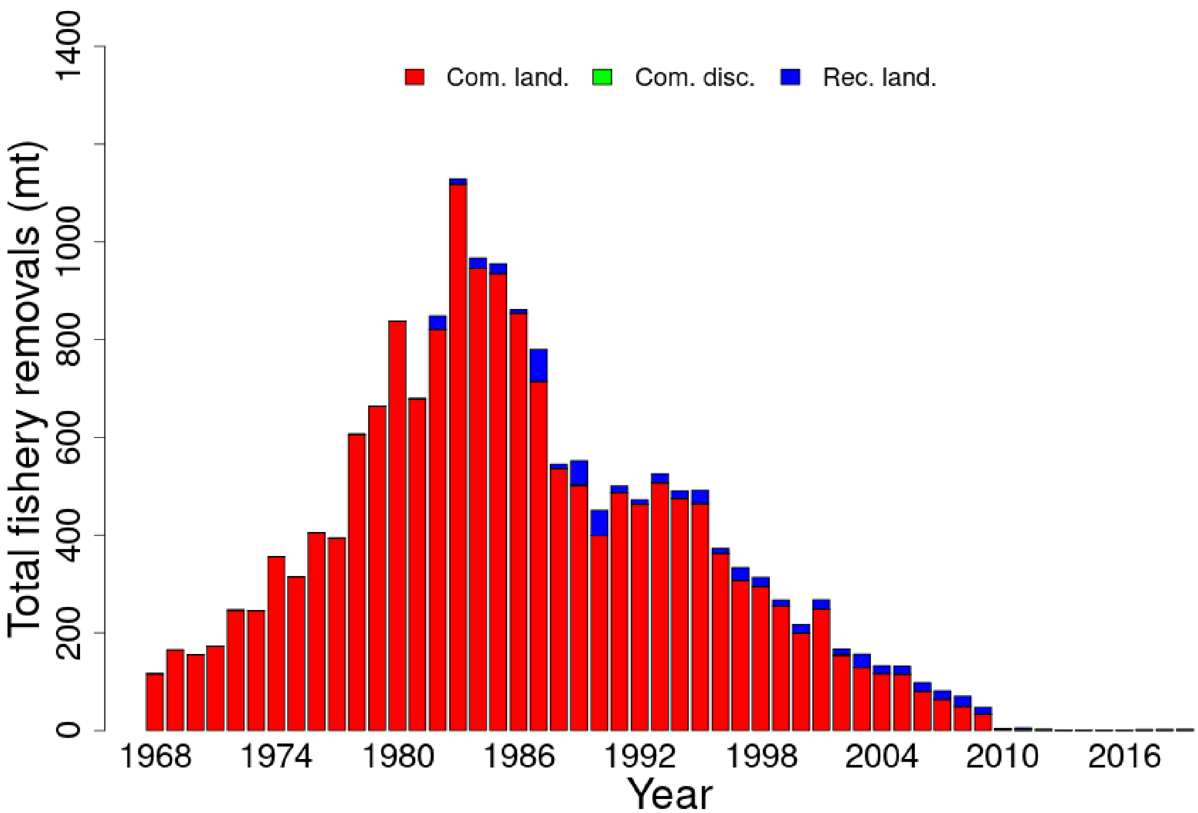


Figure 23: Total catch of Atlantic wolffish between 1968 and 2019 by fleet (commercial and recreational) and disposition (landings and discards). Note that a no possession limit was put in place in May 2010.

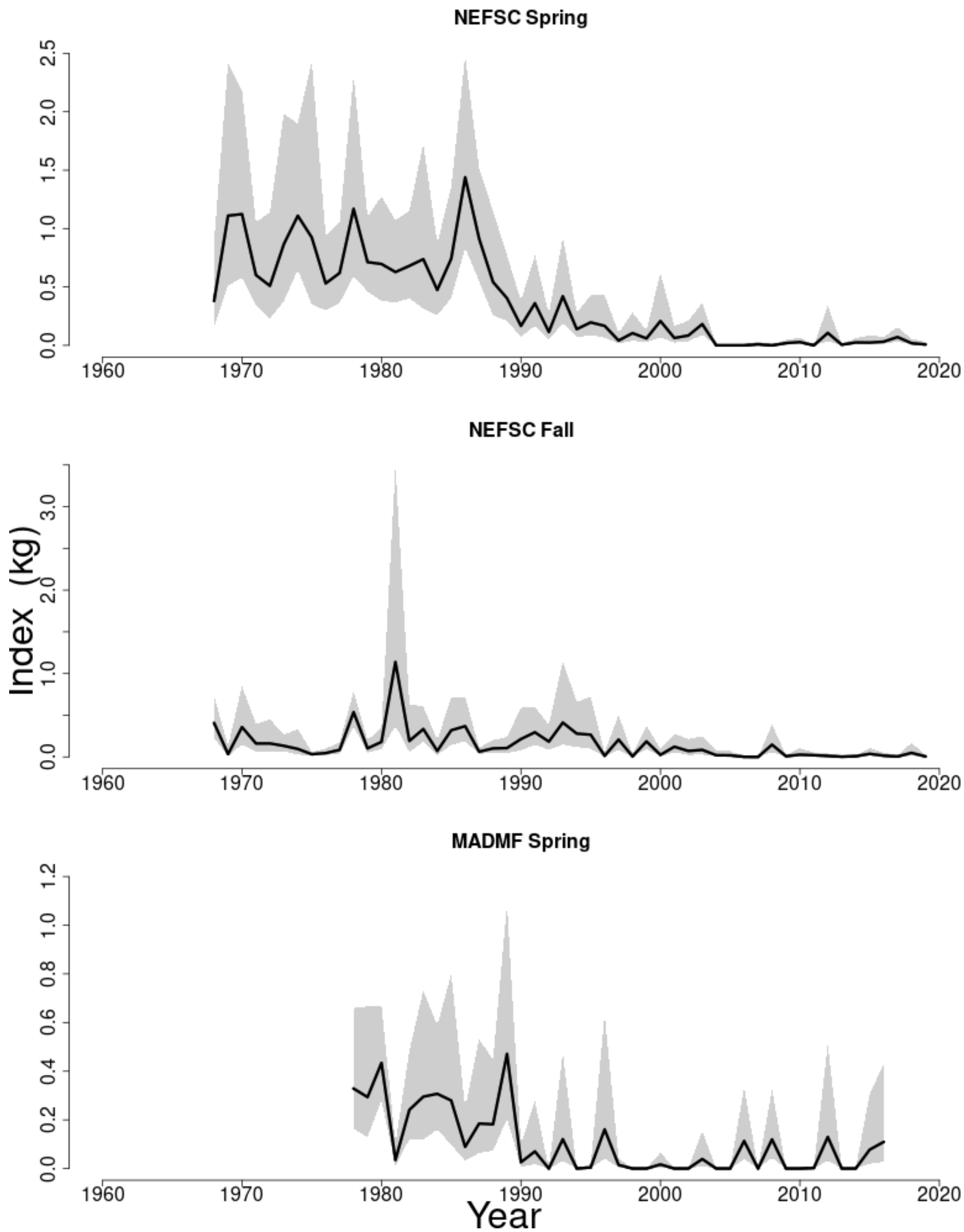


Figure 24: Indices of biomass for Atlantic wolffish between 1968 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys, and the Massachusetts Division of Marine Fisheries (MA DMF) spring bottom trawl survey. The approximate 90% log-normal **confidence intervals are shown.**

6. ATLANTIC HALIBUT

Daniel Hennen

This assessment of the Atlantic halibut (Hippoglossus hippoglossus) stock is an update of the existing 2019 'Plan B' assessment (Rago, 2018). This assessment updates commercial fishery catch data, commerical and survey indices of abundance, and the First Second Derivative (FSD) model through 2019. Reference points are unknown and have not been updated.

State of Stock: Based on this updated assessment, Atlantic halibut (*Hippoglossus hippoglossus*) stock status cannot be determined analytically due to a lack of biological reference points associated with the FSD method. Biomass (*SSB*) in 2019 was unknown. The 2019 fully selected fishing mortality was unknown.

Table 15: Catch and status table for Atlantic halibut. All weights are in (mt).

	2012	2013	2014	2015	2016	2017	2018	2019
Data								
Commercial discards	41	42	26	23	31	27	46	75
Commercial landings	35	35	45	62	67	63	54	50
CA landings	32	38	33	30	34	34	56	9
Catch for Assessment	108	115	104	115	132	124	156	134
Model Results								
Catch Multiplier	1.38	1.23	1.02	1.17	1.02	1.01	0.94	0.83
Catch Advice	104	148	142	106	135	135	126	147

Table 16: There are no current reference points for Atlantic halibut which is on a 'Plan B' assessment that does not allow for the estimation of reference points. Therefore the status of the stock relative to overfishing and overfished status is unknown. Note: based on NOAA policy, the Agency previously decided the stock status was overfished and overfishing not occurring.

	2019	2020
$F_{MSY\ proxy}$	*NA*	
SSB_{MSY} (mt)	*NA*	
MSY (mt)	*NA*	
Overfishing	Unknown	Unknown
Overfished	Unknown	Unknown

Projections: Short term projections are not possible using the FSD approach. The FSD approach is based on applying a multiplier to the catch from the previous year and cannot be projected beyond the catch time series. The catch multiplier for 2019 resulting from the FSD model is 0.83 and the estimated catch for 2019 is 134 mt, which results in catch advice of 111 mt for 2020. The FSD model is explained in (Rago, 2018) and is graphically depicted in a document called 'FSDmodelResults.pdf', both are available at SASINF.

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 assessment model (FSD) used for Atlantic halibut is a 'Plan B' assessment method. It uses recent trends in 3 abundance indices as well as recent changes in those trends to adjust the previous year's catch. For example, If the abundance indices are increasing, the catch will be adjusted up. If that increasing trend in abundance is increasing in magnitude over time, the adjustment to catch will be commensurately higher. The FSD method was rigorously tested in simulation (Rago, 2018) and should perform well for Atlantic halibut in the US. Sources of uncertainty in the FSD method include process error related to potential changes in stock productivity over time, the choice of relative weights for the control parameters used in the model and the lag in information inherent in using change in trend as one of the control parameters, which requires dropping one data point from the regression fit to generate a comparison. Other sources of uncertainty include the observation error in the abundance indices. The FSD method also relies on the assumption that abundance can be described with linear dynamics, but that assumption should be relatively unimportant if the stock abundance is well below it's theoretical carrying capacity.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major?

  The FSD model does not support retrospective analysis.

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

  The FSD model provides catch advice in the year following the terminal year of the input data. It is not intended to to project further ahead than one year. It is possible however to assume that catch in the year following the terminal year will equal the catch advice from the FSD model and that the population abundance indices will continue to follow the same trend and that the change in trend will be identical to the previous five years of data. These assumptions allow for a projection any number of years into the future. The relative quality of these projections degrades as the indices of abundance depart from the behavior of the most recent data available to the model.

- 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 beyond the inclusion of updated data. In the 2020 Atlantic halibut assessment, the catch efficiency studies and data were not used because not enough Atlantic halibut were caught to provide a comparison between the gear types and produce estimate of catchability.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  Stock status cannot be determined and remains unchanged. Rago in his 2018 report argued that because the catch multiplier estimated in the FSD model had been greater than one for several years, that overfishing was unlikely. Because the catch multiplier is now less than one, overfishing may be the more likely determination in 2020. There is however, no way to credibly determine stock status without reference points.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The Atlantic halibut assessment could be improved with more precise fishery independent indices of abundance, additional age and length composition data, and a better understanding of stock structure. These would allow for alternative assessment methods, and potential development of a more sophisticated stock assessment model.

- Are there other important issues?
  The FSD method does not allow for the estimation of traditional reference point quantities and thus the stock status cannot be determined. It is possible to infer that the stock is low relative to it's virgin biomass, which, based on historical catch records, was likely much higher than current abundances. It is unclear however, that biomass reference points based on historical abundance are useful for current management. There are indications that abundance has increased significantly over the last decade (Rago, 2018), which would support a hypothesis that the stock was not experiencing overfishing during that period. It should be noted however, that the FSD model has recently recommended reducing catch, which might be an indication that the stock no longer increasing.
  The FSD model depends on three indices of abundance (one survey and two discard indices), none of which can be expected to perform well in 2020. The COVID epidemic of 2020 has affected each index to varying degrees. Behavior of commercial vessels was affected by reduced market demand, which will have an unknown affect on discards. The 2020 NEFSC fall survey is likely to be canceled. It may be prudent to investigate other methods for determining catch advice in 2021.

Hippoglossus hippoglossus, Atlantic Halibut.

6.1. Reviewer Comments: Atlantic halibut

Atlantic halibut was not peer reviewed in 2020.

References:

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, or online at http://nefsc.noaa.gov/publications/.

Col, L.A., Legault, C.M. 2009. The 2008 Assessment of Atlantic halibut in the Gulf of Maine Georges Bank region. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 09-08; 39 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/.

Rago, P.J. 2018. Halibut Assessment Report for 2017 for New England Fishery Management Council, January 24, 2018. Unpublished, online at SASINF.

Atlantic Halibut, out of water.

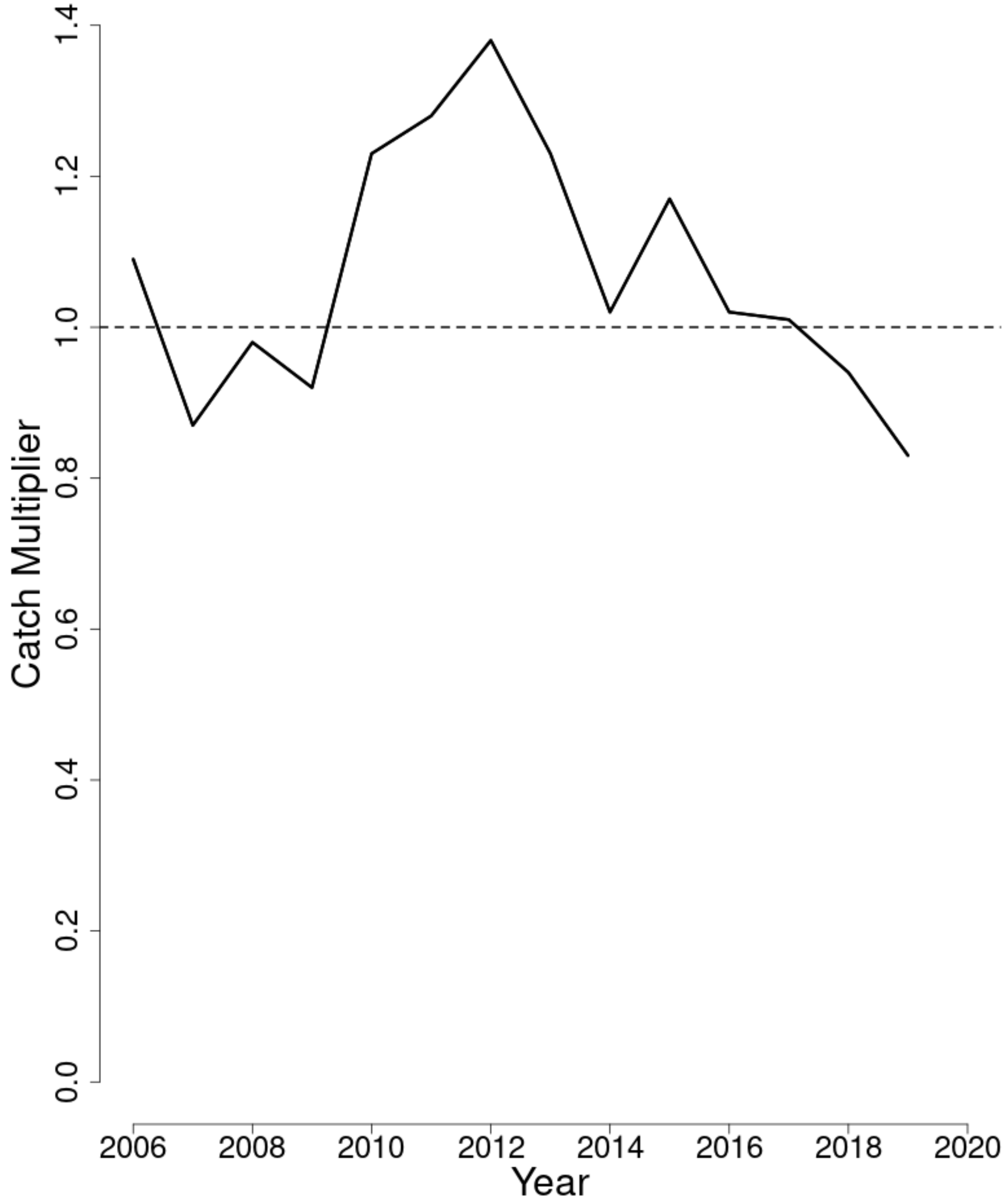


Figure 25: The catch multiplier resulting from the FSD model for Atlantic halibut between 2006 and 2020 from the current (solid line) assessment. A dashed line at 1 is added for reference.

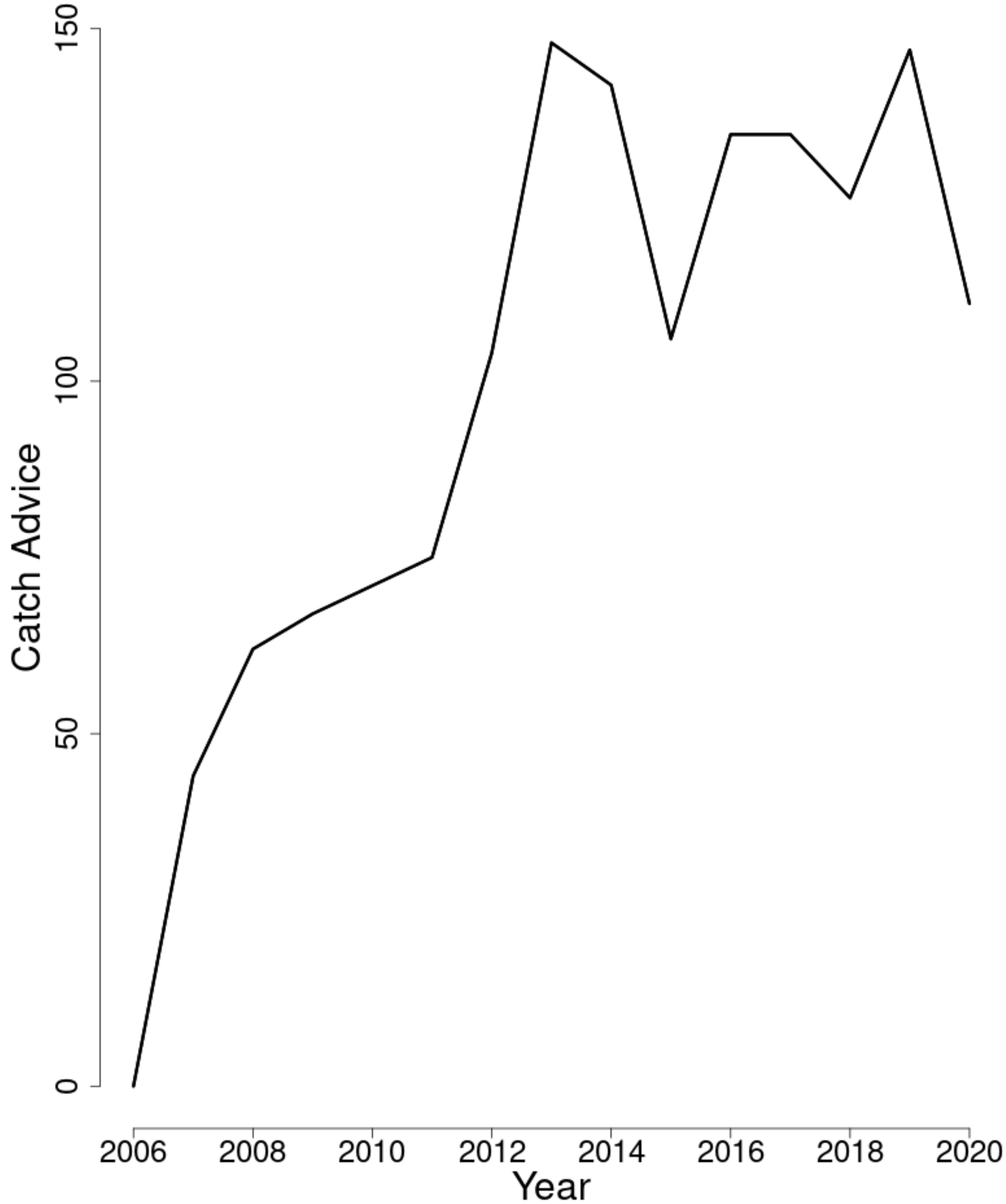


Figure 26: The catch advice resulting from multiplying catch and the catch multiplier from the FSD model for Atlantic halibut between 2006 and 2020 from the current assessment.

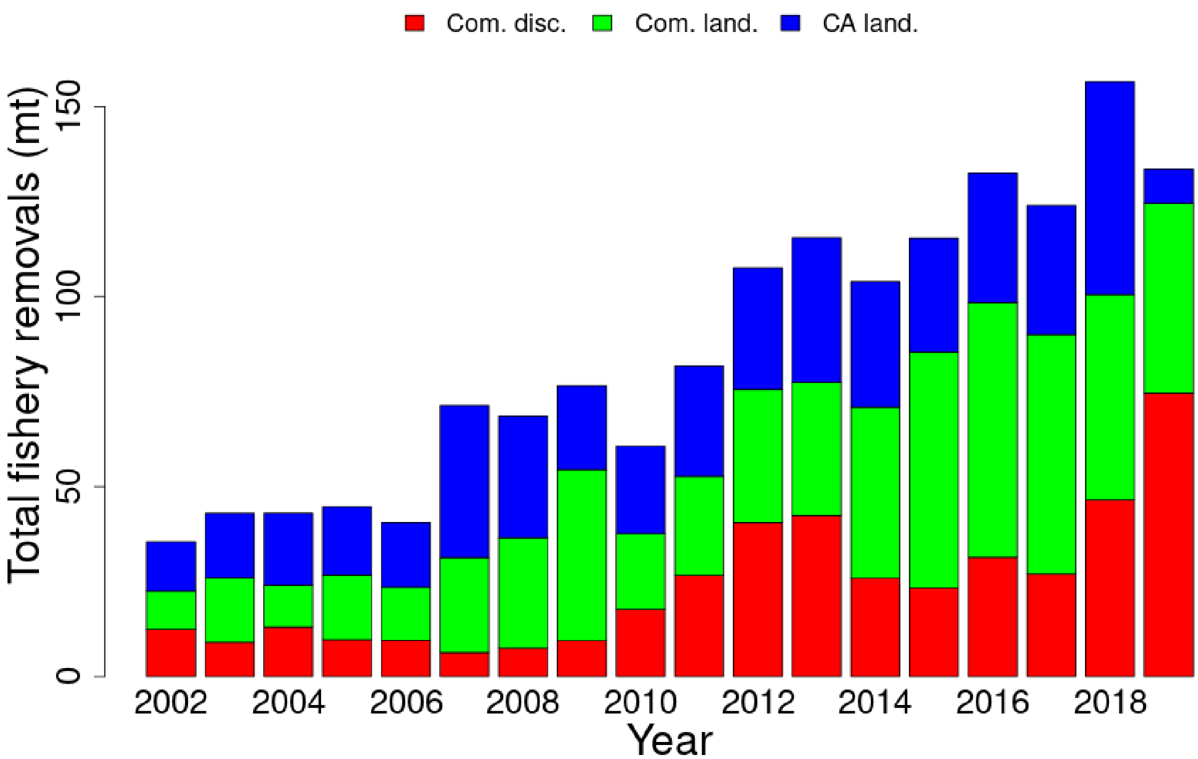


Figure 27: Total catch of Atlantic halibut between 2006 and 2020 by disposition (landings and discards).

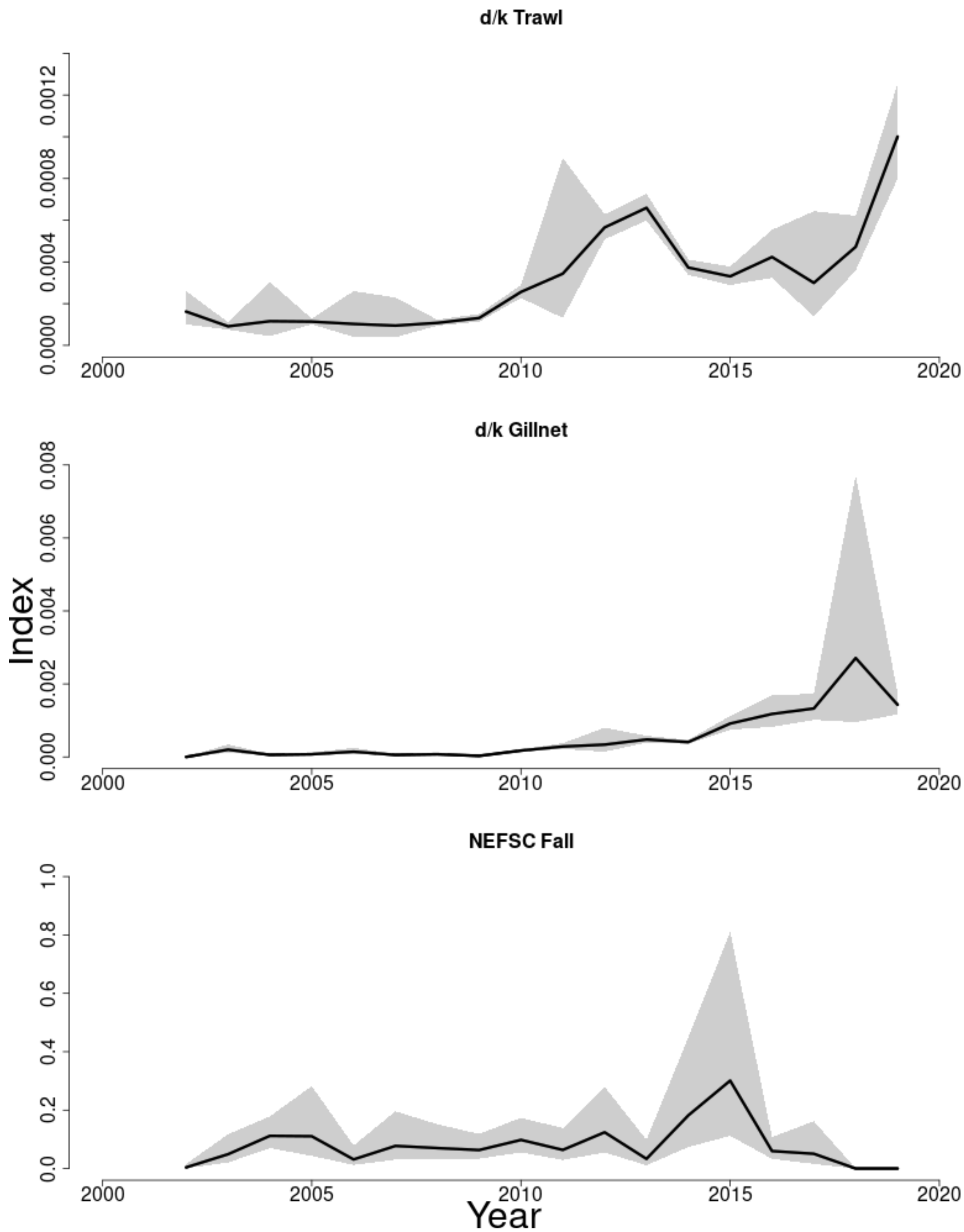


Figure 28: Indices of biomass for the Atlantic halibut between 2002 and 2019 for the Northeast Fisheries Science Center (NEFSC) fall bottom trawl survey and 2-discard ratio estimators. Discard mortality is assumed to be 0.76 for trawl gear and 0.3 for gillnet gear. The 90% log-normal confidence intervals are shown.

7. NORTHERN WINDOWPANE FLOUNDER

Toni Chute

This assessment of the northern windowpane flounder (Scophthalmus aquosus) stock is an update of the 2019 assessment which was based on survey and fishery data through 2018 (NEFSC 2019). Based on the 2019 assessment the stock was overfished, and overfishing was not occurring. This assessment updates commercial fishery catch data and survey biomass indices, but uses an empirical method based on a recent catchability study (Miller et al., 2020) to estimate swept-area biomass and annual relative exploitation rates.

State of Stock: Based on this updated assessment of northern windowpane flounder (*Scophthalmus aquosus*) overfishing status and overfished status are unknown.

Table 17: Catch and model results table for northern windowpane flounder. All landings and discard weights are rounded to the nearest metric ton. Less than half a metric ton has been landed annually since 2013. Swept area biomass is based on a survey catchability model for northern windowpane and is in metric tons. Exploitation rates are catch/biomass expressed as a percent.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
Commercial Discards	241	181	197	356	220	194	90	96	83	43
Commercial Landings	0	0	1	0	0	0	0	0	0	0
Total Catch	241	181	199	356	220	195	90	96	83	43
Model Results										
Estimated swept area biomass	9,528	7,956	7,725	16,229	12,306	10,956	9,110	4,804	10,558	12,505
Relative exploitation rate	2.53	2.27	2.57	2.19	1.79	1.78	0.99	1.99	0.79	0.34

Table 18: Reference points from the AIM model accepted at the 2019 assessment are in the 2019 column. $B_{MSY\ proxy}$ is in units of kg/tow and $F_{MSY\ proxy}$ is in units of kt per kg/tow. Biomass and F reference points from the current assessment update are unknown.

	2019	2020
$F_{MSY\ proxy}$	0.340	unknown
$B_{MSY\ proxy}$ (mt)	2.060	Unknown
Overfishing	No	Unknown
Overfished	Yes	Unknown

Projections: There were no projections made for the northern windowpane stock. Applying a 1.67 percent exploitation rate (based on the median value of the years 1995–2001, the time span used to generate an MSY estimate for the AIM model during the years it was used) to the 3-year running average (2017–2019) swept-area biomass estimate of 9,289 mt produces a catch of 155 mt. This exploitation rate could also be used as an OFL. Using 70% (aligned with the F_{Rebuild}) of the estimated value produces a catch of 108 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).

  Since there has been a 'no possession' rule in place since 2010, almost 100 percent of northern windowpane flounder catch has consisted of estimated discards. The CVs for these estimates have been reasonable, however, with a mean of 0.37 for the past 10 years, so it is unlikely discards are being severely overestimated or underestimated.

- 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 empirical approach 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 empirical method used to assess this stock does not allow projections to be made. Northern windowpane flounder was declared overfished in the 2008 assessment (terminal data year 2007), and was supposed to be rebuilt by 2017. However the 2017 Operational Update indicated that the stock was still overfished. A new rebuilding plan was developed with F_{Rebuild} equal to 70% F_{MSY} with a target of rebuilding by 2029.

- 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.

  During the 2019 operational assessment peer review process, it was determined that the AIM model no longer fit well enough to generate reliable reference points using current data, due to the fact that even though there was a substantial decrease in catch there was no positive response from the stock. The review panel rejected the 2019 AIM model results and recommended continuing to use the AIM-generated reference points from the 2017 assessment.

  For this assessment, catch efficiencies for the Bigelow trawl net derived specifically for northern windowpane (Miller et al. 2020) were used to estimate annual total swept-area biomass and exploitation rates (catch/biomass) using data updated through 2019. Since this method does not generate reference points, overfishing status and overfished status are unknown.

  The swept-area biomass method also offers a way to qualitatively assess the level of removals and stock condition. In the case of northern windowpane, the estimated exploitation rate has been around two percent in recent years.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  The AIM model used for generating reference points in previous assessments is no longer primarily used and the empirical approach does not calculate reference points, so the status of the stock is unknown.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  Since the year 2000, northern windowpane flounder has shown a decreasing trend in survey indices despite reductions in catch. In 2008 (with data through 2007) the stock was declared overfished and still remains below the biomass threshold despite recent catch estimates being the very lowest in the time series.
  According to the State of the Ecosystem Report for 2020, Georges Bank windowpane flounder are currently in good body condition. Windowpane flounder were also one of the most productive managed species on Georges Bank, although below average in 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 move away from the AIM model has been discussed as a potential improvement to this assessment for several years. Additionally, identifying any potential sources of mortality or additional removals from the population has always been mentioned as something that could improve the assessment. There may be catches (such as from Canadian fishing on Georges Bank), or incidental mortality unaccounted for in the assessment.

- Are there other important issues?
  None.

Scophthalmus aquosus, Windowpane Flounder.

7.1. Reviewer Comments: Northern windowpane flounder

The 2020 assessment for northern windowpane flounder is an expedited review (Level 2) update of the 2019 assessment, as recommended by the Assessment Oversight Panel (AOP). This recommendation was made because the AIM model used to assess the stock in previous assessments has been performing poorly and the 'Plan B' approach was anticipated as a replacement method using new chainsweep study information. The 2020 assessment updated commercial fishery catch data and survey biomass indices to update the AIM model outputs, as well as applied an empirical approach based on the recent catchability study (Miller et al., 2020) to estimate swept-area biomass and annual exploitation rates.

The Peer Review Panel concluded that the AIM model should no longer be used as the basis for catch advice due to the lack of significance in the relationship between population response and fishing mortality. The Panel concluded that the 'Plan B' approach based on estimated swept-area biomass calculated from survey catchability estimates specific to northern windowpane should be the basis of catch advice. This approach does not allow estimation of retrospective patterns, projections, or biological reference points; in the absence of reference points, overfished and overfishing status are unknown.

The Peer Review Panel concludes that the 2020 'Plan B' for Northern window pane flounder is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available for this stock for management purposes.

Northern Windowpane Flounder Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial landings data were updated through 2019, but possession of northern windowpane has been prohibited since 2010. Commercial discards are estimated from large and small mesh otter trawl gear and Limited Access and General Category scallop dredges and trawls. There are no recreational data for northern windowpane flounder. Total catch in 2019 was 43 mt, all of which was discards.

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

   This TOR was satisfactorily addressed. Due to seasonal migration of northern windowpane flounder, only the NEFSC fall bottom trawl survey is included in the assessment. The survey index (kg/tow in Albatross units) and the swept-area biomass estimates applying northern windowpane specific catchability estimates for the Bigelow survey were updated through 2019. Survey length frequencies by proportion of total survey catch were updated through 2019 showing a bimodal distribution throughout the time series.

   The 2017 NEFSC fall bottom trawl survey had a reduced number of sampled stations in some strata. The strata with incomplete sampling were examined relative to the full survey time series and only a minor effect on the overall biomass index was detected.

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

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

   b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

   This TOR was satisfactorily addressed. The AIM model was updated with commercial catch and NEFSC fall bottom trawl survey data through 2019 but continued to perform poorly as seen in previous update assessments in 2017 and 2019. The model previously suggested that the stock was not responding to very low catches and estimated increasing B_{MSY} proxies and decreasing F_{MSY} proxies. The 2020 updated proxies were marginally improved from the 2019 estimates but the relationship of biomass replacement to relative F remained uninformative. For these reasons, the AIM assessment was rejected by the Peer Review Panel.

   The 'Plan B' approach is an empirical method to estimate swept-area biomass and annual relative exploitation rates based on the recent catchability study specific to northern windowpane flounder (Miller et al., 2020). Catch efficiency was estimated annually for the Bigelow time series (2009–2019) and the mean of those estimates was applied to the prior survey time series (1975–2009). Exploitation rates are expressed as a percent of the estimated biomass removed by the fishery (catch/biomass) for each calendar year.

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

   This TOR was partially addressed. The mean exploitation rate for the years 1995–2001 (1.67%) was used as an $F_{MSY\,proxy}$. The time period corresponds to the period used to generate an MSY estimate for the AIM model. Northern windowpane flounder is currently in a rebuilding plan with an F_{Rebuild} of 70% F_{MSY}, resulting in a target exploitation rate of 1.17%. The mean exploitation rate for the most recent 3-year running average is 1.04%, with a terminal estimate of 0.34%. Based on this $F_{MSY\,proxy}$, overfishing is not occurring. The Peer Review Panel did not recommend continued use of the AIM-based $F_{MSY\,proxy}$ due to the mismatch in assessment methods and time series of exploitation rates exceeding the proxy in nearly all years. In the absence of agreed reference points, the Panel concluded that stock status is currently unknown due to the empirical assessment approach but noted that recent exploitation rates have been very low.

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

   There were no projections made for the northern windowpane flounder stock. The Peer Review Panel noted that recent exploitation rates have been constrained by management actions, specifically a no possession regulation starting in 2010. They recommended exploration of exploitation rates over different time periods with consideration of current stock conditions. The choice of exploitation rate has important implications for scientific advice to management.

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

   The 2019 Peer Review Panel rejected the updated F_{MSY} estimate from the AIM model and recommended continued use of the 2017 reference points. They recommended reconsideration of the entire assessment approach. Additionally, they noted the large amount of uncertainty associated with discard estimates for some fleets and the potential impact on this assessment due to the prohibition on landings.

   The 2020 AIM model update was rejected and the 'Plan B' approach using the recent catchability study was applied. The change in method is an improvement and addresses the previous Panel's concern about the uninformative relationship of biomass replacement to relative F.

Additional Recommendations

Include an Appendix to the 2020 report summarizing the inputs/assumptions/steps used to develop the northern windowpane flounder empirical approach.

Appropriate exploitation rates should be further explored in the next assessment.

References:

Miller, T., Richardson, D., Politis, P., Blaylock, J. 2020. Relative efficiency of a chain sweep and the rockhopper sweep used for the NEFSC bottom trawl survey and biomass estimates for winter and windowpane flounder and red hake stocks. Working paper.

Most recent assessment update:

Northeast Fisheries Science Center. 2019. Operational Assessment of 14 Northeast Groundfish Stocks, Updated Through 2018. US Dept Commer, Northeast Fisheries Science Center, Woods Hole, MA.

Most recent benchmark assessment:

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, MA, August 4–8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p.

State of the Ecosystem Reports, 2020, New England region.
Available at: https://www.integratedecosystemassessment.noaa.gov/regions/northeast/reports

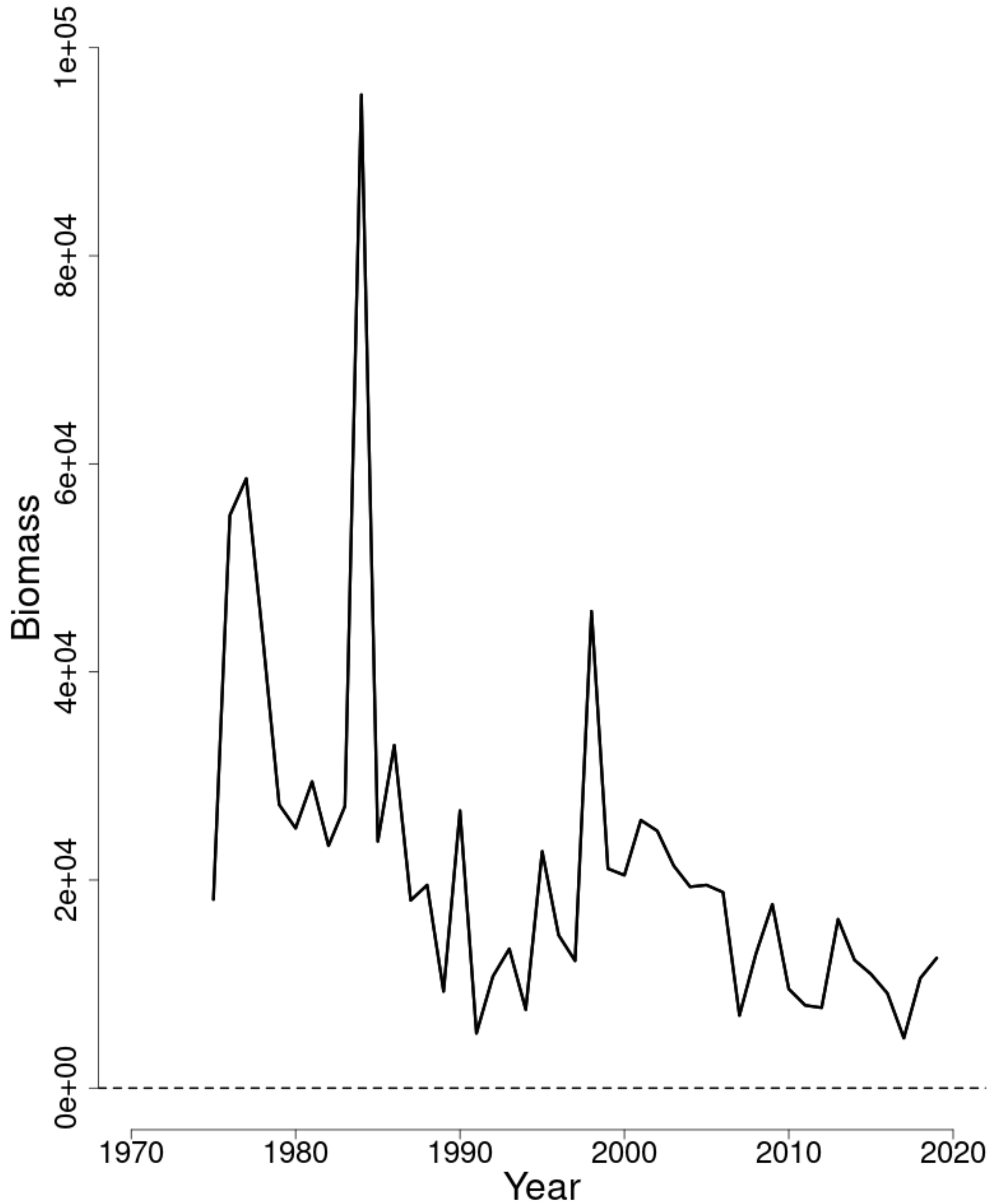


Figure 29: Trends in estimated swept area biomass of northern windowpane flounder between 1975 and 2019 from the current assessment.

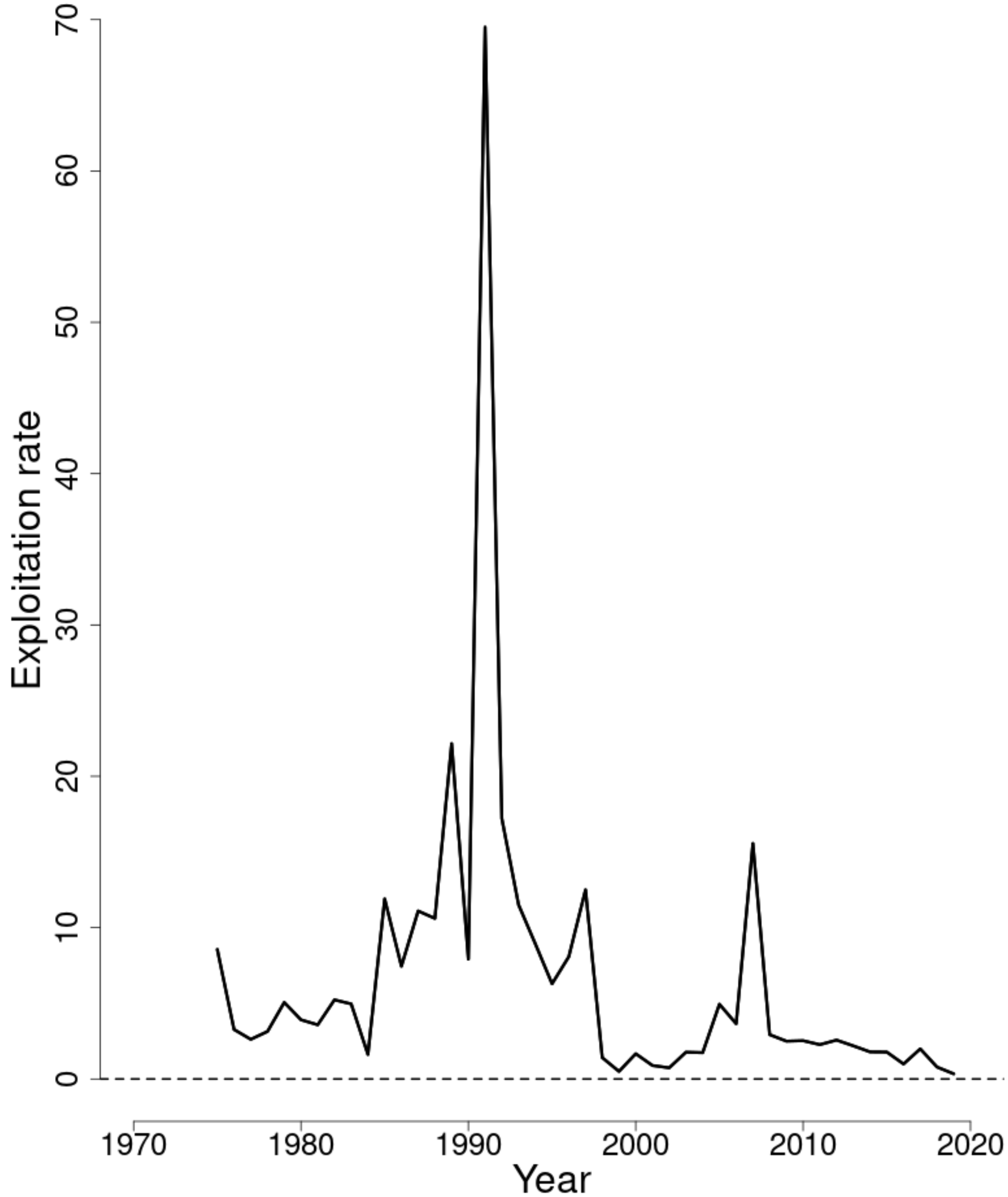


Figure 30: Trends in estimated relative exploitation rate in percent of northern windowpane flounder between 1975 and 2019 from the current assessment.

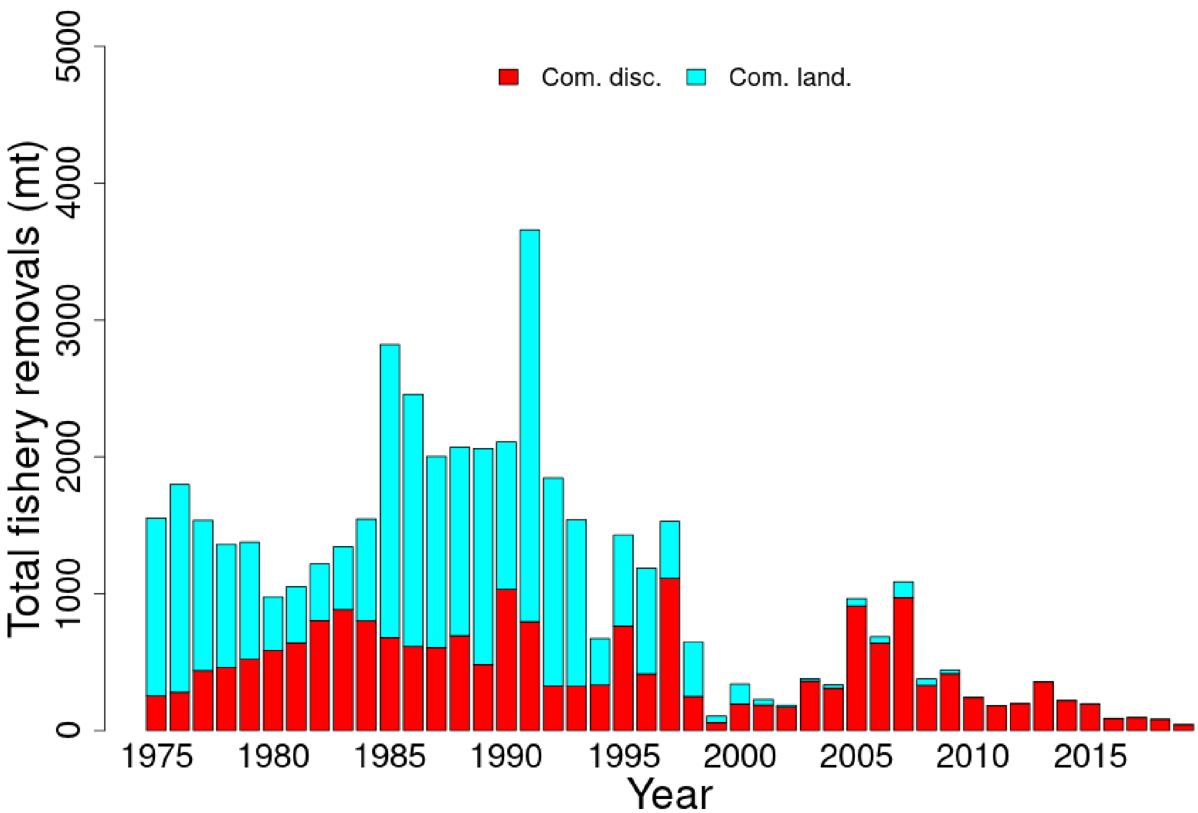


Figure 31: Total catch of northern windowpane flounder between 1975 and 2019 by disposition (landings and discards).

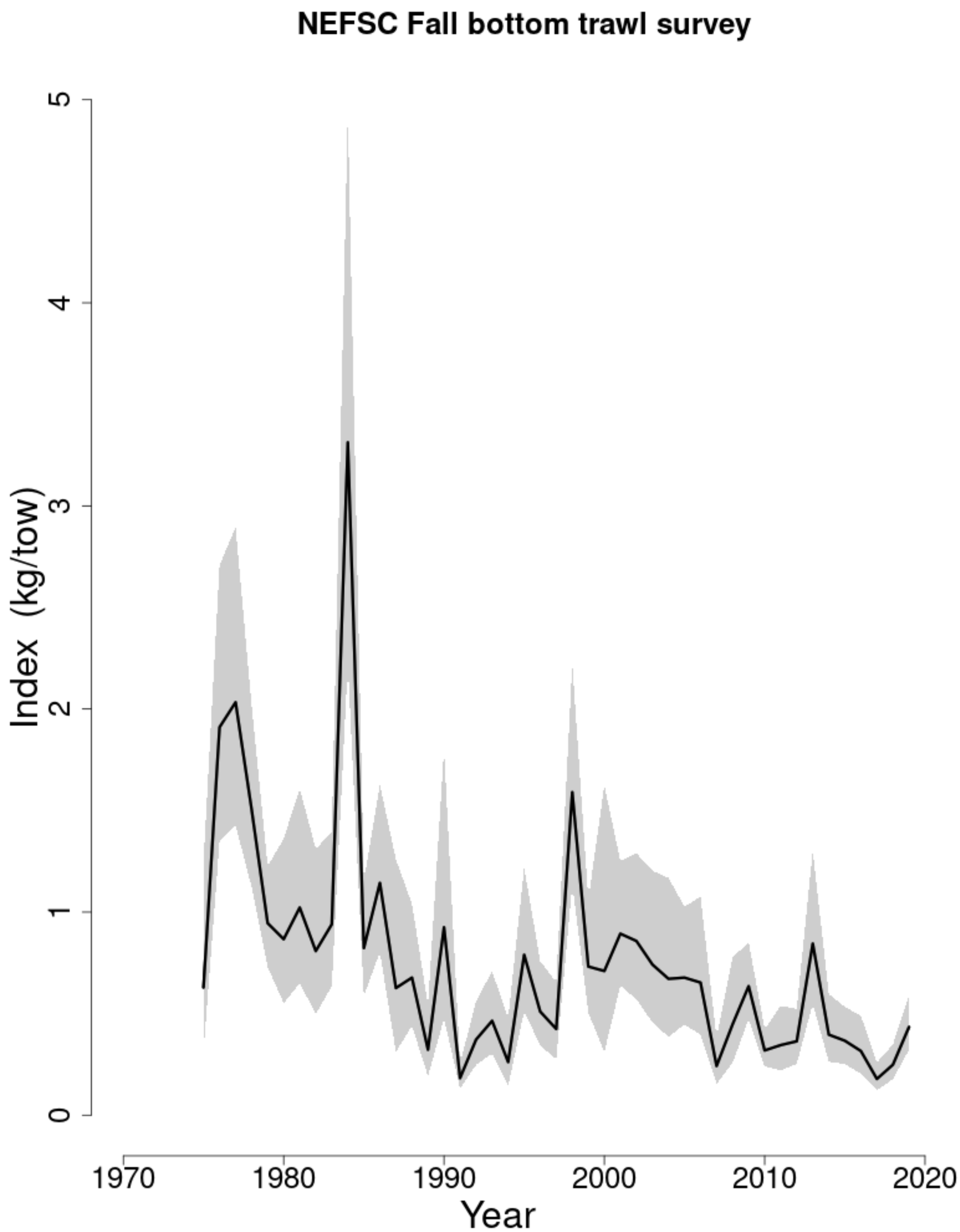


Figure 32: NEFSC fall bottom trawl survey indices in kg/tow for northern windowpane flounder between 1975 and 2019. The approximate 90% log-normal confidence intervals are shown.

8. SOUTHERN WINDOWPANE FLOUNDER

Toni Chute

This assessment of the southern windowpane flounder (Scophthalmus aquosus) stock is an update of the 2019 assessment which was based on fishery and survey data through 2018 (NEFSC 2019). Based on the 2019 assessment the stock was not overfished, and overfishing was not occurring. This assessment updates commercial fishery catch data, survey indices of abundance, AIM model results, and reference points through 2019.

State of Stock: Based on this updated assessment, the southern windowpane flounder (*Scophthalmus aquosus*) stock is not overfished and overfishing is not occurring (Figures 33–34). Retrospective adjustments were not made to the model results. The mean NEFSC fall bottom trawl survey index from years 2017, 2018, and 2019 (a 3-year moving average is used as a biomass index) was 0.288 (kg/tow) which is higher than the $B_{\text{Threshold}}$ of 0.096 (kg/tow). The 2019 relative fishing mortality was estimated to be 1.300 (kt per kg/tow) which is lower than the $F_{MSY\ proxy}$ of 1.738 (kt per kg/tow). Southern windowpane was determined to be overfished in 2005, but rebuilt by 2008.

Table 19: Catch and model results table for southern windowpane flounder. All landings and discard weights are rounded to the nearest metric ton. Biomass index (a 3-year moving average of the NEFSC bottom trawl survey 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).

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data											
Commercial Discards	410	459	466	788	709	566	547	580	545	504	364
Commercial Landings	55	53	32	29	22	14	22	13	13	17	10
Total Catch	465	513	498	817	731	580	569	593	558	520	374
Model Results											
Biomass Index	0.245	0.345	0.435	0.517	0.464	0.413	0.318	0.329	0.334	0.319	0.288
Relative F	1.902	1.484	1.144	1.581	1.573	1.406	1.791	1.802	1.672	1.631	1.3

Table 20: Reference points estimated for the 2019 assessment and for the current assessment. $F_{MSY\ proxy}$ is in units of kt per kg/tow.

	2019	2020
$F_{MSY\ proxy}$	1.780	1.738
$B_{MSY\ proxy}$ (kg/tow)	0.187	0.192
MSY_{proxy} (mt)	333	333
Overfishing	No	No
Overfished	No	No

Projections: Short term projections from the AIM model are not used. Applying the updated $F_{MSY\ proxy}$ (1.738) to the terminal year biomass index (0.288) produces a catch of 501 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).

  As there has been a 'no possession' rule in place since 2010, commercial windowpane landings have been extremely low. As a result, in recent years over 95% of the catch input to the model has been estimated discards. The CVs for these estimates have been very low, however, with a mean of 0.18 for the past 10 years, so it is unlikely discards are being severely overestimated or underestimated.

- 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 projections are not 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 for this southern windowpane flounder assessment other than updating the survey and catch time series.

  The twin trawl study that provided estimates of efficiency of the Bigelow survey trawl for windowpane flounder (Miller et al., 2020) allows us to estimate swept-area biomass and therefore relative exploitation rates for southern windowpane by year. The swept-area biomass method also offers a way to qualitatively assess the level of removals and stock status. Annual estimates of swept-area biomass from 1975–2019 ranged from a low of 1,095 mt in 1993 to a high of 49,277 mt in 1982 with a time series mean of 11,432 mt. The mean swept area biomass for 2017–2019 was 8,406 mt.

  Estimated annual exploitation rates for southern windowpane from the last ten years ranged from 3.77 to 8.88 percent. The median relative exploitation rate estimate (catch/biomass) for the time period 1995–2001 (median catch during this period serves as an MSY_{proxy} for the AIM model) was 6.95 percent. The mean 2017–2019 estimated relative exploitation rate was 5.718 percent. Catch at the 1995–2001 median rate in 2019 would have been 584 mt whereas the 2019 actual catch estimate was 374 mt.

  This empirical method was used for the northern windowpane assessment for 2020.

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  The stock status of southern windowpane flounder has not changed since the previous assessment.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  Since 2012, southern windowpane flounder fall survey biomass indices have declined from 0.596 kg/tow to 0.279 kg/tow. However, the trend has been stable or upward since the series low of 0.039 kg/tow in 1993. Catch and relative F have been stable. The replacement ratio model output has been bouncing around one since 1994, and the 2019 estimate is 0.89. The stock was declared overfished in 2005, but had recovered by the 2008 assessment update, so there is a recent history of the stock falling below reference points for biomass, but also having the ability to recover. Overfishing was occurring in 2007 (the final year of data used for the 2008 assessment) but has not been found to be occurring in any more recent assessments.
  According to the State of the Ecosystem Report for 2020, windowpane flounder in the Mid-Atlantic are showing below-average body condition and productivity.

- 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 very 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 achieve better results from this model. There has been some ageing work for southern windowpane done at Virginia Institute of Marine Science which we could use in exploring an age-based model such as ASAP.*

- Are there other important issues?
  None.

Scophthalmus aquosus, Windowpane Flounder.

8.1. Reviewer Comments: Southern windowpane flounder

The 2020 assessment for southern windowpane flounder is an expedited review (Level 2) update of the 2019 assessment, as recommended by the Assessment Oversight Panel (AOP). This recommendation was made based on the potential to rescale the survey indices to swept-area biomass estimates. The 2020 assessment updated commercial fishery catch data, survey indices of abundance, the AIM model outputs, and reference points through 2019.

The Peer Review Panel concluded that the AIM model is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available for this stock for management purposes. The mean NEFSC fall bottom trawl survey index from the most recent three-year moving average (2017–2019) was 0.288 kg/tow, which is higher than the $B_{\text{Threshold}}$ value of 0.097 kg/tow and higher than the $B_{MSY\,proxy}$ value of 0.195 kg/tow. The 2019 relative fishing mortality was estimated to be 1.210 kt per kg/tow, which is lower than the F_{MSY} *proxy* of 1.708 kt per kg/tow. The Peer Review Panel concurs with the assessment that southern windowpane flounder is not overfished and overfishing is not occurring.

Southern Windowpane Flounder Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial landings data were updated through 2019, but possession of southern windowpane has been prohibited since 2010. Commercial discards are estimated from large and small mesh otter trawl gear and Limited Access and General Category scallop dredges and trawls. There are no recreational data for southern windowpane flounder. Total catch in 2019 was 374 mt.

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

   This TOR was satisfactorily addressed. The NEFSC fall bottom trawl survey is the only index included in the assessment because it is considered more stable for southern windowpane than the spring survey. The survey index (kg/tow in Albatross units) was updated through 2019. The NEFSC fall bottom trawl survey was unable to cover any of the southern windowpane stock strata in 2017. The estimate for 2017 was imputed by averaging the mean survey biomass per tow values from 2016 and 2018 by stratum to calculate a stratum-weighted index. Information from the Northeast Area Monitoring and Assessment Program (NEAMAP) survey was qualitatively compared to the NEFSC survey time series and showed a similar value to the 2017 imputed index.

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

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

b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

This TOR was satisfactorily addressed. The same AIM model configuration used in the 2019 operational assessment was used in the 2020 update. The AIM model performs well for this stock as indicated by the significant relationship between population response and fishing mortality. Bridge runs were not needed because only the data inputs for the model were updated. The 'Plan B' assessment was reviewed but not recommended because the AIM model assessment was accepted.

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

   This TOR was satisfactorily addressed. The re-estimated BRPs include: $F_{MSY\,proxy} = 1.708$ kt per kg/tow, $B_{MSY\,proxy} = 0.195$ kg/tow, and $MSY_{proxy} = 333$ mt. The most recent three-year biomass index was estimated to be 0.288 kg/tow, which is above the $B_{MSY\,proxy}$. The 2019 relative fishing mortality was estimated to be 1.210 kt per kg/tow, which is lower than the $F_{MSY\,proxy}$. The stock is not overfished and overfishing is not occurring.

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

   There were no projections made for the southern windowpane flounder stock.

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

   The 2019 assessment for southern windowpane flounder was a direct delivery (level 1) assessment that was not reviewed. The SSC did not express concerns with the 2019 assessment.

Additional Recommendations

The Peer Review Panel noted that the AIM model has performed well for the southern windowpane stock, but not the northern stock. They recommended future analyses to determine the mechanism driving the performance of this modeling approach.

References:

Miller, T., Richardson, D., Politis, P., Blaylock, J. 2020. Relative efficiency of a chain sweep and the rockhopper sweep used for the NEFSC bottom trawl survey and biomass estimates for winter and windowpane flounder and red hake stocks. Working paper.

Most recent assessment update:

Northeast Fisheries Science Center. 2019. Operational Assessment of 14 Northeast Groundfish Stocks, Updated Through 2018. US Dept Commer, Northeast Fisheries Science Center, Woods Hole, MA.

Most recent benchmark assessment:

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, MA, August 4–8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p.

State of the Ecosystem Report, 2020, Mid-Atlantic Region.
Available at: https://www.integratedecosystemassessment.noaa.gov/regions/northeast/reports.

Windowpane flounder, over sandy bottom.

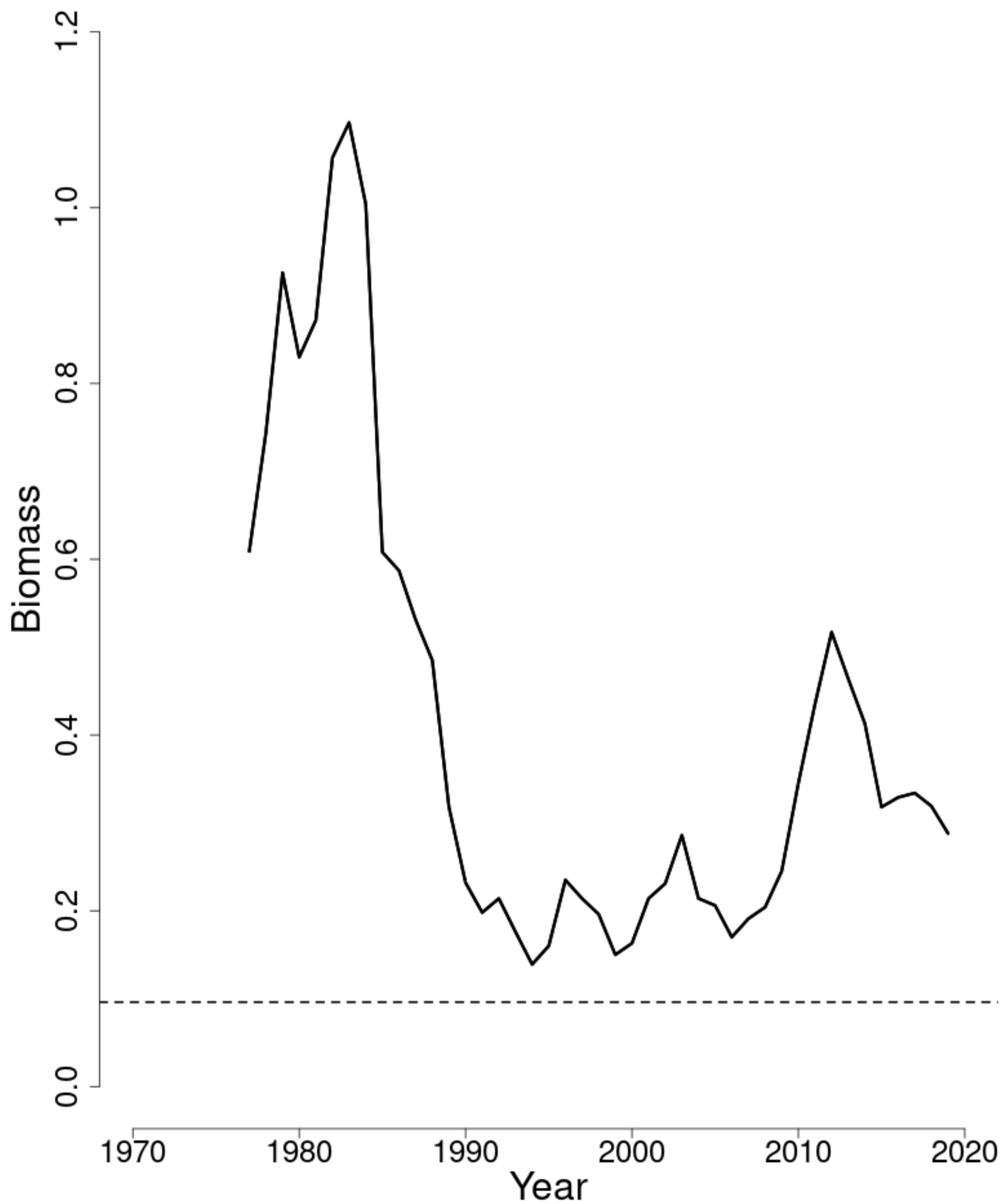


Figure 33: Trends in the biomass index (a 3-year moving average of the NEFSC fall bottom trawl survey index) of southern windowpane flounder between 1975 and 2019 from the current assessment, and the corresponding $B_{\text{Threshold}} = \frac{1}{2} B_{MSY\ proxy} = 0.096$ kg/tow (horizontal dashed line).

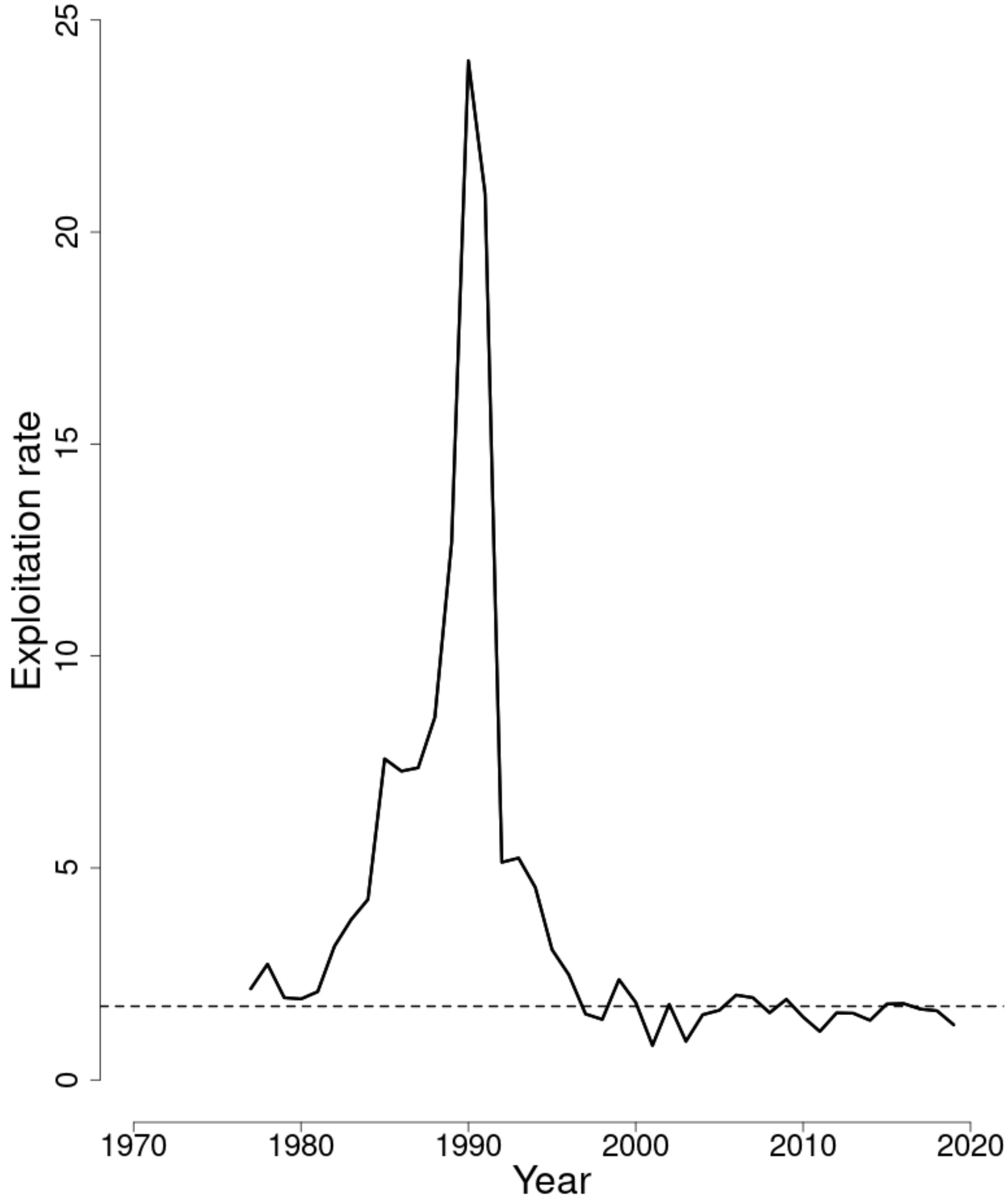


Figure 34: Trends in relative fishing mortality of southern windowpane flounder between 1975 and 2019 from the current assessment. The corresponding $F_{MSY\,proxy} = 1.738$ in units of kt per kg/tow is shown by the horizontal line.

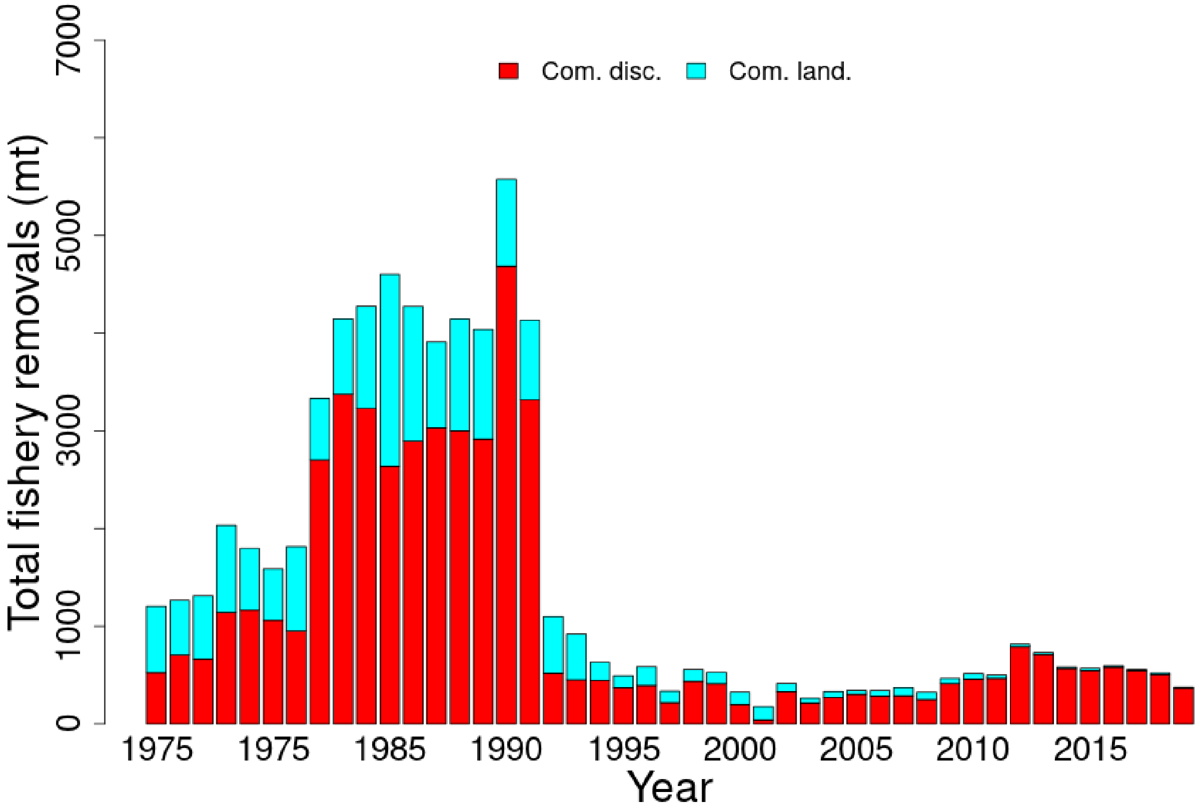


Figure 35: Total catch of southern windowpane flounder between 1975 and 2019 by disposition (landings and discards).

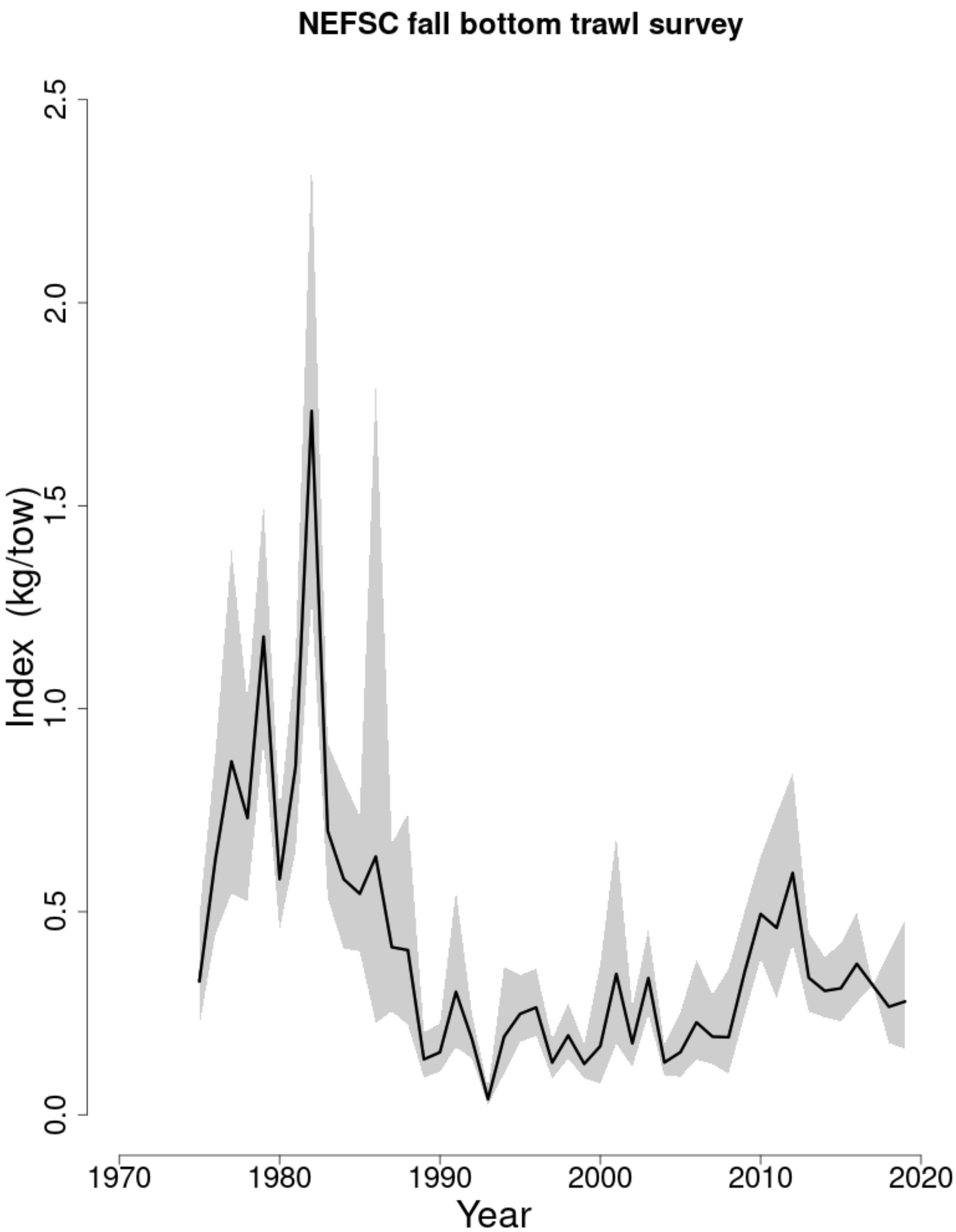


Figure 36: NEFSC fall bottom trawl survey indices in kg/tow for southern windowpane flounder between 1975 and 2019. The approximate 90% log-normal confidence intervals are shown.

9. OCEAN POUT

Charles Adams

This assessment of the ocean pout (Zoarces americanus) stock is a level-1 management track assessment of the existing benchmark assessment (NEFSC 2008). Based on the previous operational assessment (NEFSC 2017) the stock was overfished, but overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices of abundance and exploitation ratios through 2019.

State of Stock: Based on this updated assessment, the ocean pout (*Zoarces americanus*) stock is overfished and overfishing is not occurring (Figures 37–38). Retrospective adjustments were not made to the model results. Biomass proxy (B) in 2019 was estimated to be 0.164 (kg/tow) which is 3% of the biomass target ($SSB_{MSY\ proxy} = 4.94$; Figure 37). The 2019 fully selected fishing mortality was estimated to be 0.485 which is 64% of the overfishing threshold proxy ($F_{MSY\ proxy} = 0.76$; Figure 38).

Table 21: Catch and status table for ocean pout. All weights are in (mt), survey biomass is in (kg/tow) and the exploitation ratio is catch/3-year moving average of NEFSC spring survey biomass index. Model results are from the current updated index assessment.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
Commercial landings	0	0	0	0	0	0	0	0	0	0
Commercial discards	125	76	94	68	74	63	49	42	41	79
Other landings	0	0	0	0	0	0	0	0	0	0
Catch for Assessment	126	77	94	68	74	63	49	42	41	79
Model Results										
NEFSC 3-yr av. spring survey	0.44	0.343	0.298	0.357	0.29	0.317	0.223	0.232	0.183	0.164
Exploitation Ratio	0.286	0.224	0.315	0.191	0.256	0.198	0.222	0.183	0.223	0.485

Table 22: Comparison of reference points estimated in the 2017 assessment and from the current assessment update. The median 3-year moving average of NEFSC spring survey biomass index and median exploitation ratio during 1977–1985 are used as B_{MSY} and F_{MSY} proxies, respectively.

	2017	2020
$F_{MSY\ proxy}$	0.76	0.76
SSB_{MSY} (kg/tow)	4.94	4.94
MSY (mt)	3,754	3,754
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).

  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}.)

  The exploitation ratio 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?

  Projections are not available for the exploitation ratio.

- 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.

  There were no changes made to the 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.

  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 assessment could be improved with studies that explore why this stock is not rebuilding as expected.

- Are there other important issues?

  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 from 0.3 to 24.9 mt, with an average of 3.5 mt between 1968 and 2019. 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 yellowtail flounder) and gear studies have contributed to scientific research removals.

9.1. Reviewer Comments: Ocean pout

Ocean pout was not peer reviewed in 2020.

References:

Northeast Fisheries Science Center (NEFSC). 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

Northeast Fisheries Science Center (NEFSC). 2017. Operational assessment of 19 northeast groundfish stocks updated through 2016. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 17-17; 259 p. CRD17-07

Zoarces americanus, Ocean Pout.

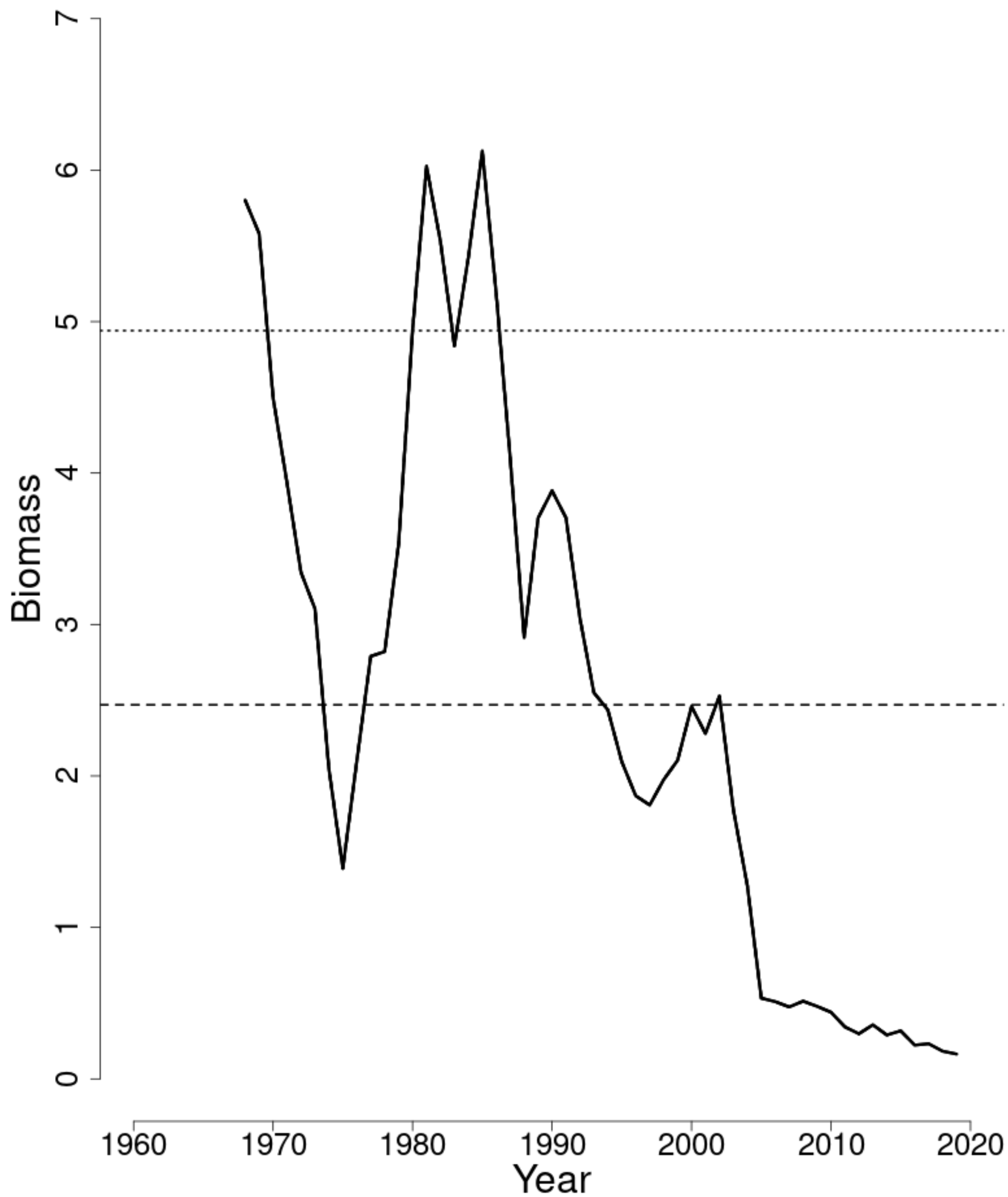


Figure 37: Trends in biomass (kg/tow) of ocean pout between 1968 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $SSB_{\text{Threshold}}(\frac{1}{2}SSB_{MSY\ proxy}$; horizontal dashed line) as well as $SSB_{\text{Target}}(SSB_{MSY\ proxy}$; horizontal dotted line) based on the 2020 assessment.

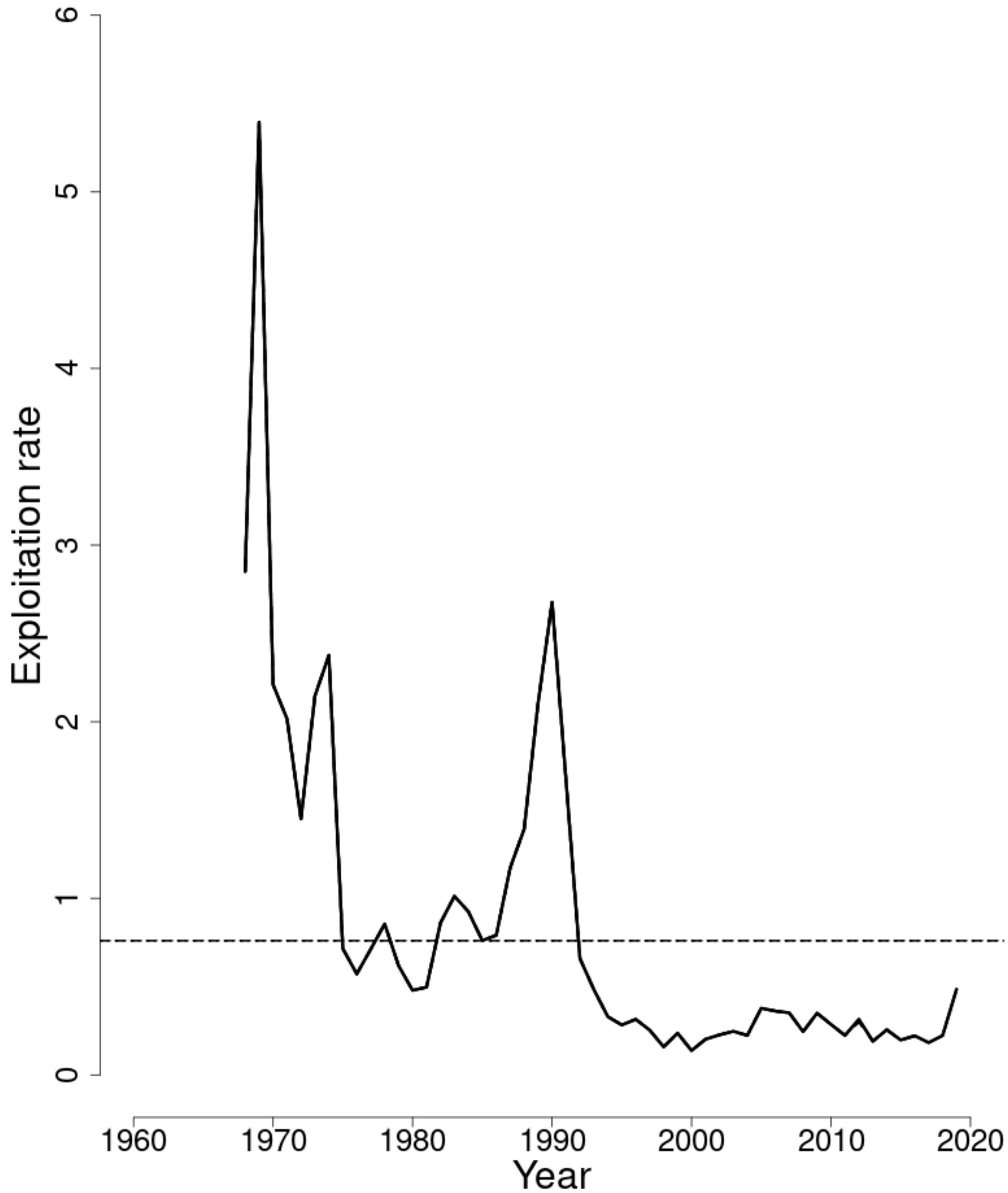


Figure 38: Trends in the exploitation ratio of ocean pout between 1968 and 2019 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{\text{Threshold}}$($F_{MSY\ proxy} = 0.76$; horizontal dashed line) based on the 2020 assessment.

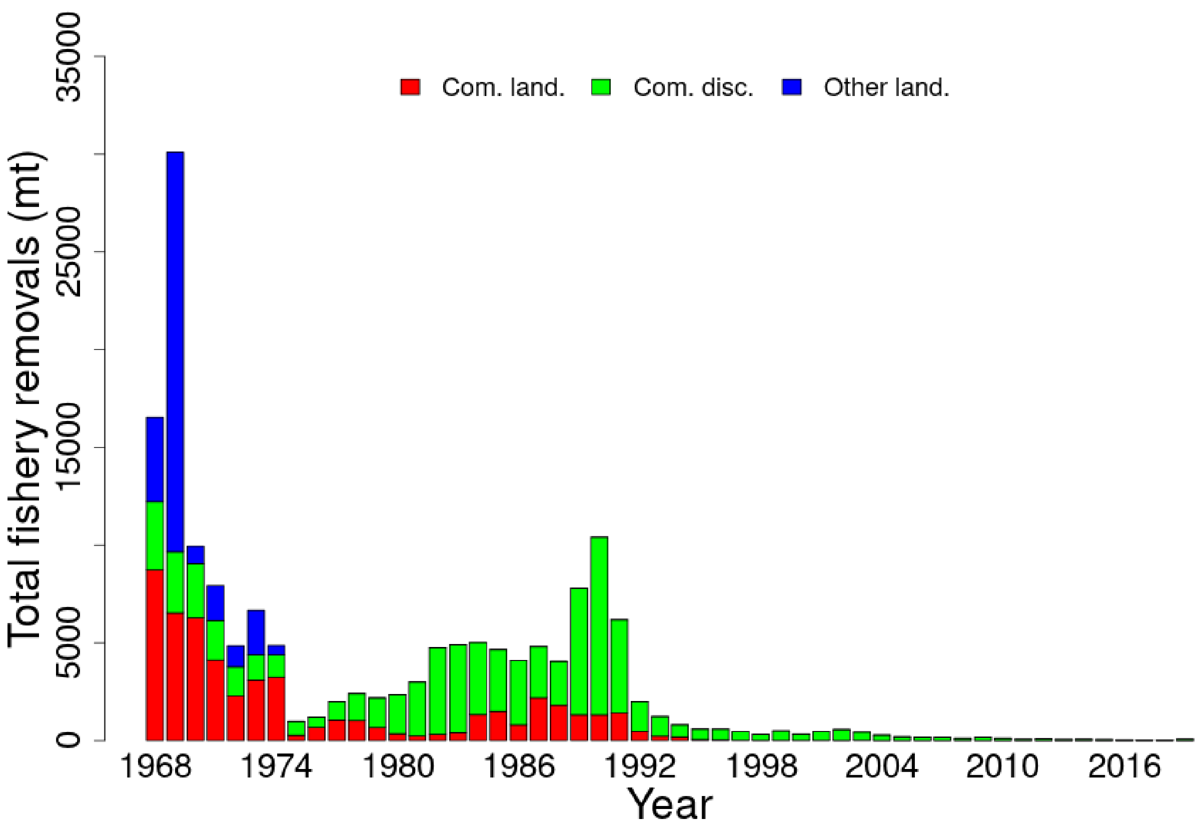


Figure 39: Total catch of ocean pout between 1968 and 2019 by fleet (US and other) and disposition (landings and discards). Note that a no possession limit was put in place in May 2010.

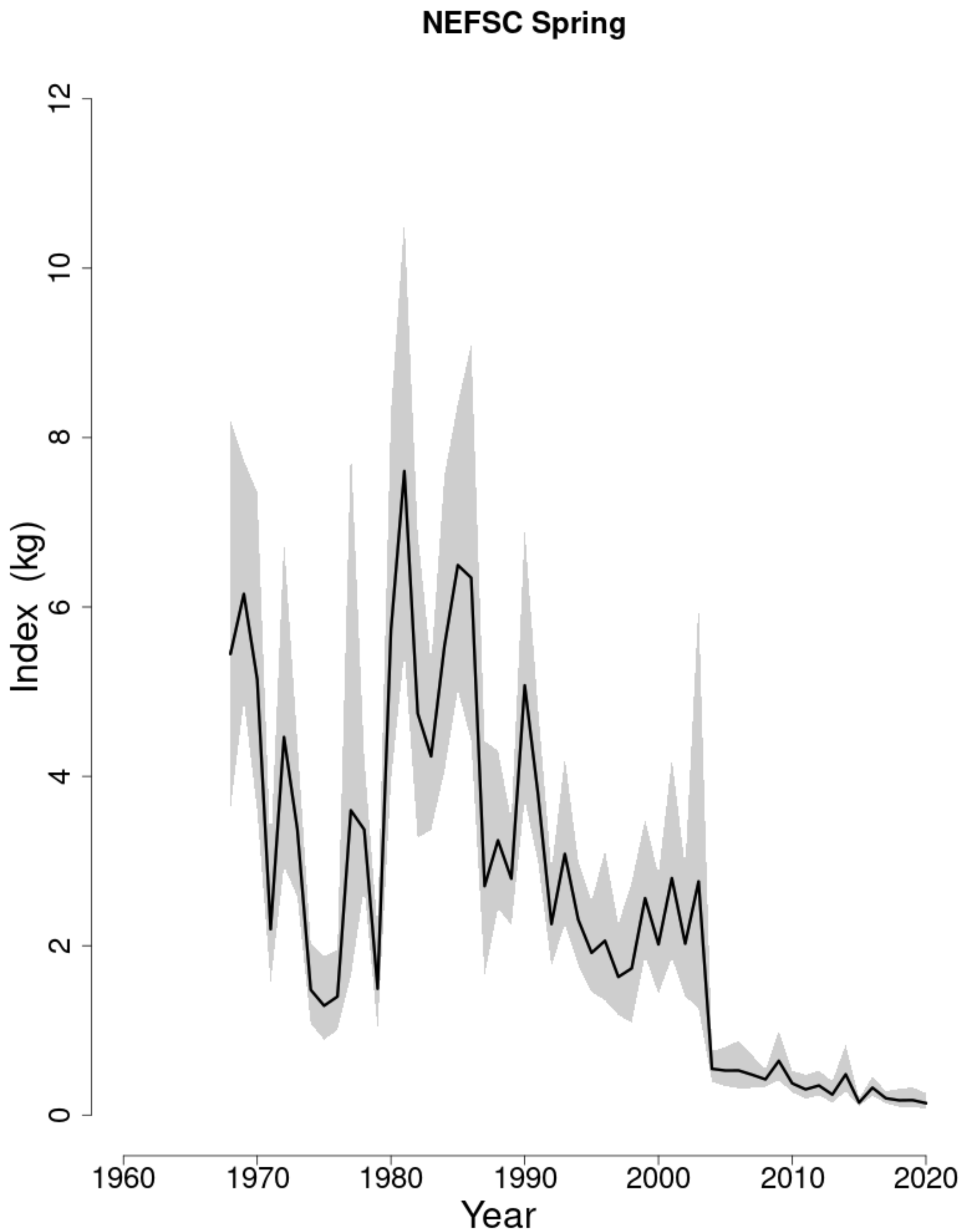


Figure 40: Indices of biomass (kg/tow) for ocean pout between 1968 and 2020 for the Northeast Fisheries Science Center (NEFSC) spring bottom trawl survey. The approximate 90% log-normal confidence intervals are shown.

10. NORTHERN RED HAKE

Toni Chute

This assessment of the northern red hake (Urophycis chuss) stock is an update of the 2017 assessment which was based on survey and fishery data through 2016 (Alade and Traver, 2018). Based on the 2017 assessment, the stock was not overfished and overfishing was not occurring. This assessment updates commercial and recreational fishery catch data and survey biomass indices, but instead of the AIM model uses an empirical method based on a recent catchability study (Miller et al., 2020) to estimate swept-area biomass and annual relative exploitation rates.

State of Stock: Based on this updated assessment, the status of the northern red hake (*Urophycis chuss*) stock is unknown. Retrospective adjustments were not made to the model results.

Table 23: Catch and status table for northern red hake. All weights are in metric tons and F_{Full} is the relative exploitation rate.

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data									
Recreational catch	0	1	5	5	9	5	13	3	18
Commercial discards	111	271	161	190	238	216	129	179	110
Commercial landings	138	97	94	67	100	147	78	98	108
Catch for Assessment	249	368	261	261	348	368	220	281	236
Model Results									
Estimated swept area biomass	104,641	113,510	78,155	159,513	267,018	254,538	239,655	255,781	194,931
F_{Full}	0.24	0.32	0.33	0.16	0.13	0.14	0.09	0.11	0.12

Table 24: Reference points from the AIM model accepted at the 2017 assessment; reference points from the current assessment update are unknown. $F_{MSY\ proxy}$ is in units of kt per kg/tow and the $B_{MSY\ proxy}$ is in units of kg/tow in 2017.

	2017	2020
$F_{MSY\ proxy}$	0.16	Unknown
SSB_{MSY} (mt)	1.27	Unknown
Overfishing	No	Unknown
Overfished	No	Unknown

Projections: There were no projections made for the northern red hake stock. Applying the mean estimated exploitation rate during the Bigelow years (2009–2019) of 0.197 percent to the 3-year running average (2017–2019) swept-area biomass estimate of 230,122 mt produces a catch of 453 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).

  Some of the reported landings are categorized as 'mixed hake' so the proportion of those landings that are red hake must be estimated. However, the mixed hake catches are quite small.

- 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 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?

  There are no projections made for the northern red hake stock, and it is not under a rebuilding plan. Catch advice is derived from applying an exploitation rate of 0.197 percent (based on the mean estimated exploitation rate during 2009–2019, the Bigelow years) to the 3-year average (2017–2019) swept area 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.

  During the Red Hake Stock Structure Research Track peer review process in early 2020, it was determined that the AIM model, used for red hake assessments since 2010, was no longer a viable alternative for stock status determination for red hake due to poor fit. For this assessment, catch efficiencies for the Bigelow trawl net derived specifically for northern red hake were used to estimate annual total swept-area biomass and exploitation rates using data updated through 2019.

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

  Since the AIM model is no longer used for stock status determination, and a method to derive reference points using an empirical method has not been fully developed, the stock status of northern red hake is unknown.

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

  Red hake in the Gulf of Maine are currently at above average body condition, according to the 2020 State of the Ecosystem report. Although the survey index has fallen in recent years, northern red hake is at a relatively high biomass.

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

  The assessment could be improved with further exploration of a method to derive reference points based on the catchability studies and the stock biomass estimates they enable us to determine. This was explored during the Red Hake Stock Structure Research Track in 2020 and was deemed promising by the review panel but needs to be developed further.

  It would be helpful to understand the changes in distribution of red hake as a species.

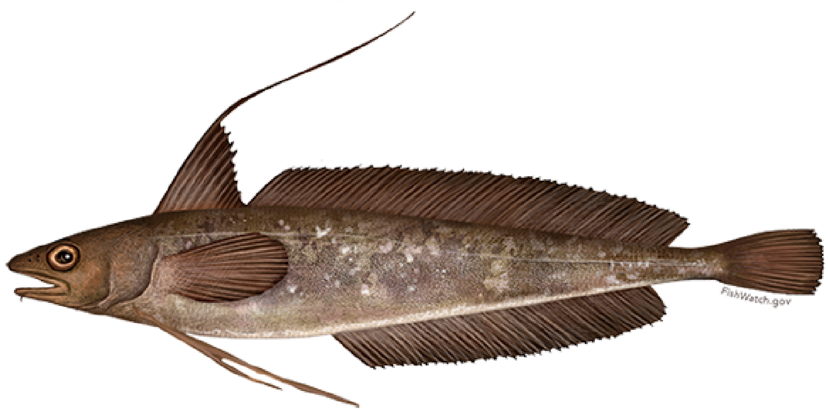
It would also be helpful to have a better understanding of the role of northern red hake in the bait market. There is some speculation it might be a good replacement for herring to use as bait in the lobster fishery.

- Are there other important issues?

  Since the empirical method does not generate analytical reference points, overfishing status could be determined by comparing current estimated exploitation rates to rates from a time period when the fishery was determined to have been sustainable, for instance. Overfished status could be determined by comparing the current estimated swept-area biomass to either the whole time series or a period of time when the stock was considered to be in good condition.

  The swept-area biomass method also offers a way to qualitatively assess the level of removals and stock status. In the case of northern red hake, the estimated exploitation rate is very low, less than one percent of the biomass is estimated to be removed every year.

  We compared 3-year running averages of the estimated swept-area biomass and exploitation rates to provisional reference points based on specific periods of time. If the 2017–2019 estimated swept area biomass is compared to half of the time series mean as a $B_{\text{Threshold}}$ *proxy, the stock would not be overfished. If the 2017–2019 mean estimated exploitation rate is compared to the mean rate that was estimated for the Bigelow years (2009–2019), overfishing would not be occurring.*



Urophycis chuss, Red Hake.

10.1. Reviewer Comments: Northern red hake

The 2020 assessment for northern red hake is an enhanced review (Level 3) of approaches described in the 2020 Red Hake Stock Structure Research Track assessment. This recommendation was made because the AIM model used to assess the stock in previous assessments was rejected by the Research Track Stock Assessment Review Committee (SARC) and a new assessment approach was not recommended. The SARC recommended using new chainsweep study information for northern red hake to estimate swept-area biomass but did not recommend an approach to determine BRPs. The 2020 assessment updated commercial and recreational fishery catch data and survey biomass indices.

The Peer Review Panel reviewed an empirical approach based on the recent survey catchability study to estimate swept-area biomass and annual relative exploitation rates. This approach has been applied and peer-reviewed for flatfish stocks. The Panel concluded that the updated swept-area biomass estimates provide qualitative information about stock trends, but the relative exploitation rates should not be used as BRP proxies and do not provide a basis for scientific advice. The Panel concurs with the SARC that the exploitation rates are currently low, and that overfishing is not likely occurring. Additionally, recent survey estimates indicate that the population is at a relatively high level and it is unlikely that the stock is overfished.

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

Northern Red Hake Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial and recreational landings data were updated through 2019. Recreational catch was based on uncalibrated MRIP data for the full time series. Commercial discards are estimated from several gear types with the majority attributed to small and large mesh otter trawl. Total catch in 2019 was 236 mt, of which 110 mt was discards.

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

   This TOR was satisfactorily addressed. The NEFSC spring and fall bottom trawl survey indices (kg/tow in Albatross units) and the swept-area biomass estimates applying northern red hake specific catchability estimates for the Bigelow survey were updated through 2019. A sensitivity analysis was conducted using the NEFSC spring bottom trawl survey only and showed only minor differences in swept-area biomass or relative exploitation rates compared to the combined survey estimates.

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

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

(b) *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

This TOR was not met. The 2020 Red Hake Stock Structure Research Track assessment SARC rejected the AIM model for northern red hake. The SARC recommended use of swept-area biomass estimates based on the chainsweep study for northern red hake and reviewed an alternative method for calculating reference points based on spawning potential ratio (SPR), but concluded that there was sufficient uncertainty in the sensitivity of reference point estimates to various assumptions made that the reference point estimates should not be used for management advice for red hake at this time. The SARC recommended additional analyses for the SPR approach and noted that methods currently used for other data-limited stocks in the region could be explored for both northern and southern red hake. The SARC did not recommend an assessment method.

The Peer Review Panel reviewed a proposed 'Plan B' approach based on an empirical method to estimate swept-area biomass and annual relative exploitation rates based on the recent catchability study specific to northern red hake (Miller et al., 2020). Catch efficiency was estimated annually for the Bigelow time series (2009–2019) and the mean of those estimates was applied to the prior survey time series (1981–2009). Exploitation rates are expressed as a percent of the estimated biomass removed by the fishery (catch/biomass) for each calendar year. The Panel concluded that the updated swept-area biomass estimates provide qualitative information about stock trends, but the relative exploitation rates do not provide a basis for scientific advice.

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

   This TOR was partially addressed. BRPs could not be estimated from the proposed 'Plan B' approach. In the absence of agreed reference points, the Panel concluded that stock status is currently unknown. The Panel reviewed the updated biomass estimates and relative exploitation rates and concluded that the exploitation rates are currently low, and that overfishing is not likely occurring. Additionally, recent survey estimates indicate that the population is at a relatively high level and it is unlikely that the stock is overfished.

   Reference points that were applied in the previous assessments were based on survey indices (kg/tow). These reference points could be evaluated for application to the updated swept-area biomass estimates and potential use in management if they were converted to swept-area biomass.

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

   There were no projections made for northern red hake. The Peer Review Panel noted that recent exploitation rates have been constrained by management actions that were based on the rejected AIM model.

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

   The 2020 Red Hake Stock Structure Research Track assessment SARC made several recommendations for further evaluation of the proposed SPR-based assessment method. The SARC noted that the SPR-based reference points could be suitable for red hake and that the 40% proxy level for F and SSB was reasonable. They suggested the following analyses:

   - A catch curve analysis on the survey data could be used to estimate M in recent years;
   - Exploration of the sensitivity of the knife-edge selectivity assumption; and
   - Expansion of the time series of recruitment estimates over longer periods and evaluation of the sensitivity of the $SSB_{40\%}$ estimates to different recruitment time series.

   The SARC also noted that decoupling between fishing pressure and population trends has been observed for other stocks in the region (e.g., Georges Bank yellowtail flounder) and suggested that methods currently used for setting catch advice for other data-limited stocks could be explored for red hake.

Additional Recommendations

The Peer Review Panel recommended additional analysis on the proposed SPR-based assessment method, as described by the SARC. They noted that due to the Research Track and Management Track process, there is not a currently accepted assessment method for the red hake stocks and no basis for scientific advice at this time. The Panel recommended a subsequent review process for a newly developed red hake assessment.

References:

Miller, T., Richardson, D., Politis, P., Blaylock, J. 2020. Relative efficiency of a chain sweep and the rockhopper sweep used for the NEFSC bottom trawl survey and biomass estimates for winter and windowpane flounder and red hake stocks. Working paper.

Most recent assessment:

Alade, L., Traver, M. 2018. 2017 northern and southern silver hake and red hake stock assessment update report. US Dept Commer, Northeast Fisheries Science Center Ref Doc 17-17, 81 p.
https://repository.library.noaa.gov/view/noaa/17249

Most recent benchmark assessment:

Northeast Fisheries Science Center. 2011. 55th Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dep Commer, NOAA Fisheries, Northeast Fisheries Science Center Ref Doc 11-01, 79 p. https://repository.library.noaa.gov/view/noaa/3766

State of the Ecosystem Report, 2020, New England region.
Available at: https://www.integratedecosystemassessment.noaa.gov/regions/northeast/reports.

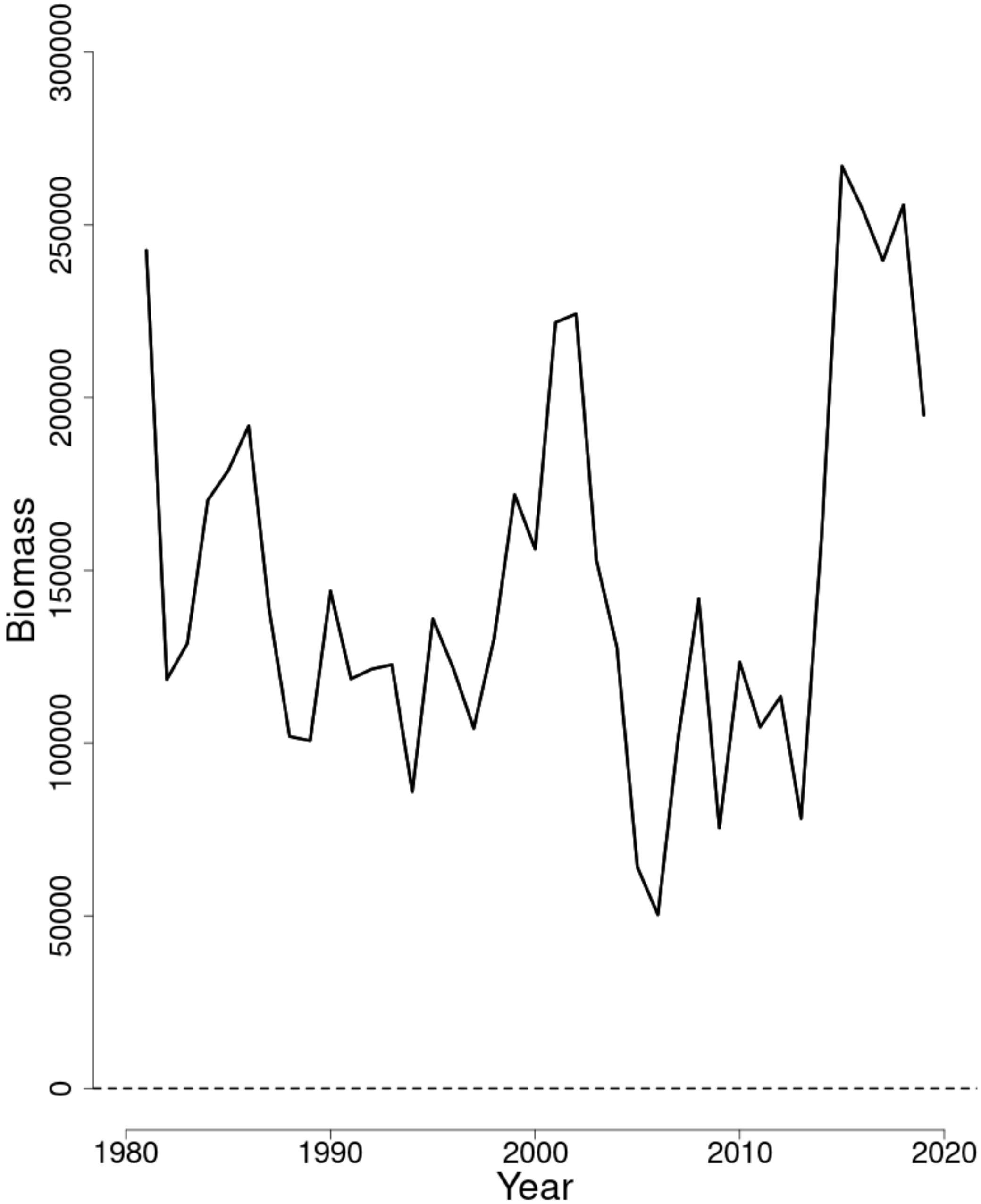


Figure 41: Trends in estimated swept area biomass of northern red hake between 1981 and 2019 from the current assessment.

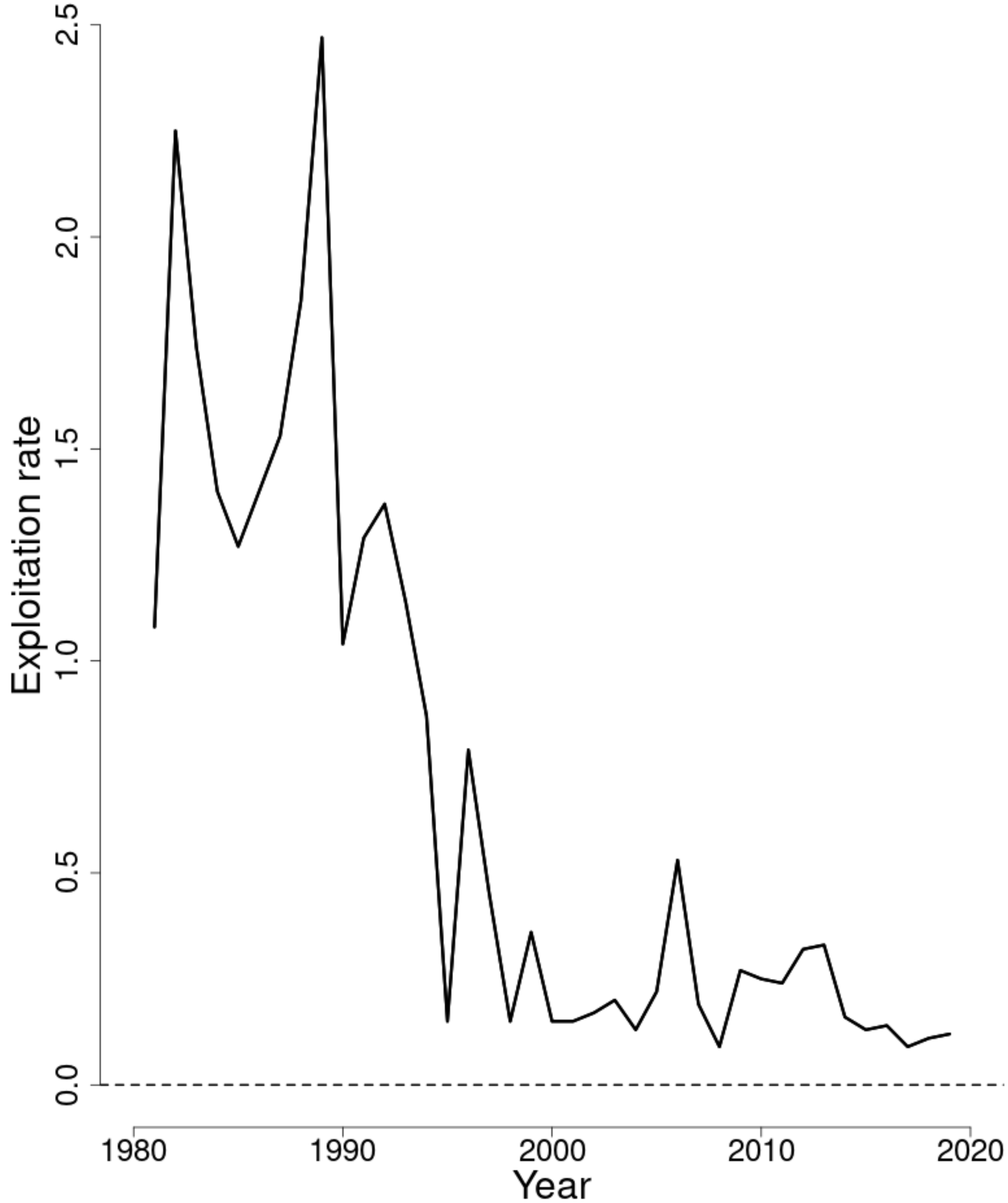


Figure 42: Trends in estimated relative exploitation rate in percent of northern red hake between 1981 and 2019 from the current assessment.

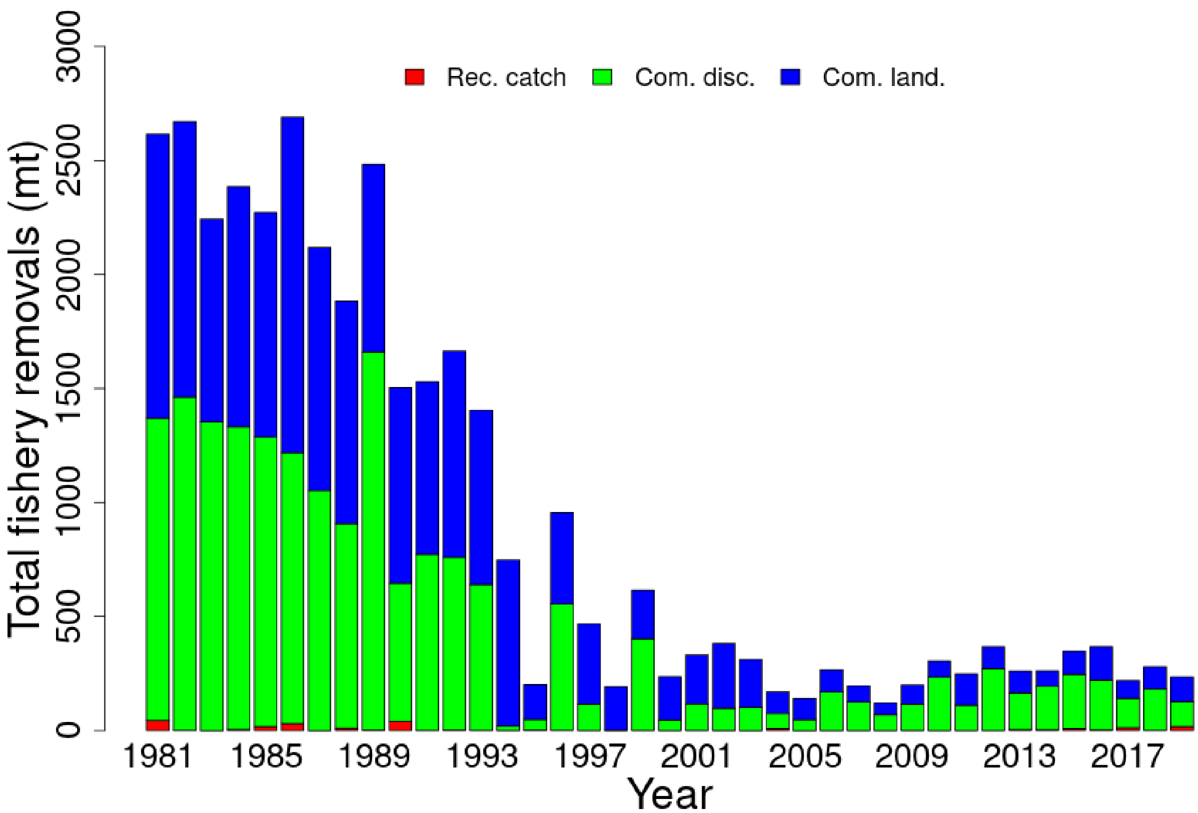


Figure 43: Total catch of northern red hake between 1981 and 2019 by the commercial (landings and discards) and recreational fleets.

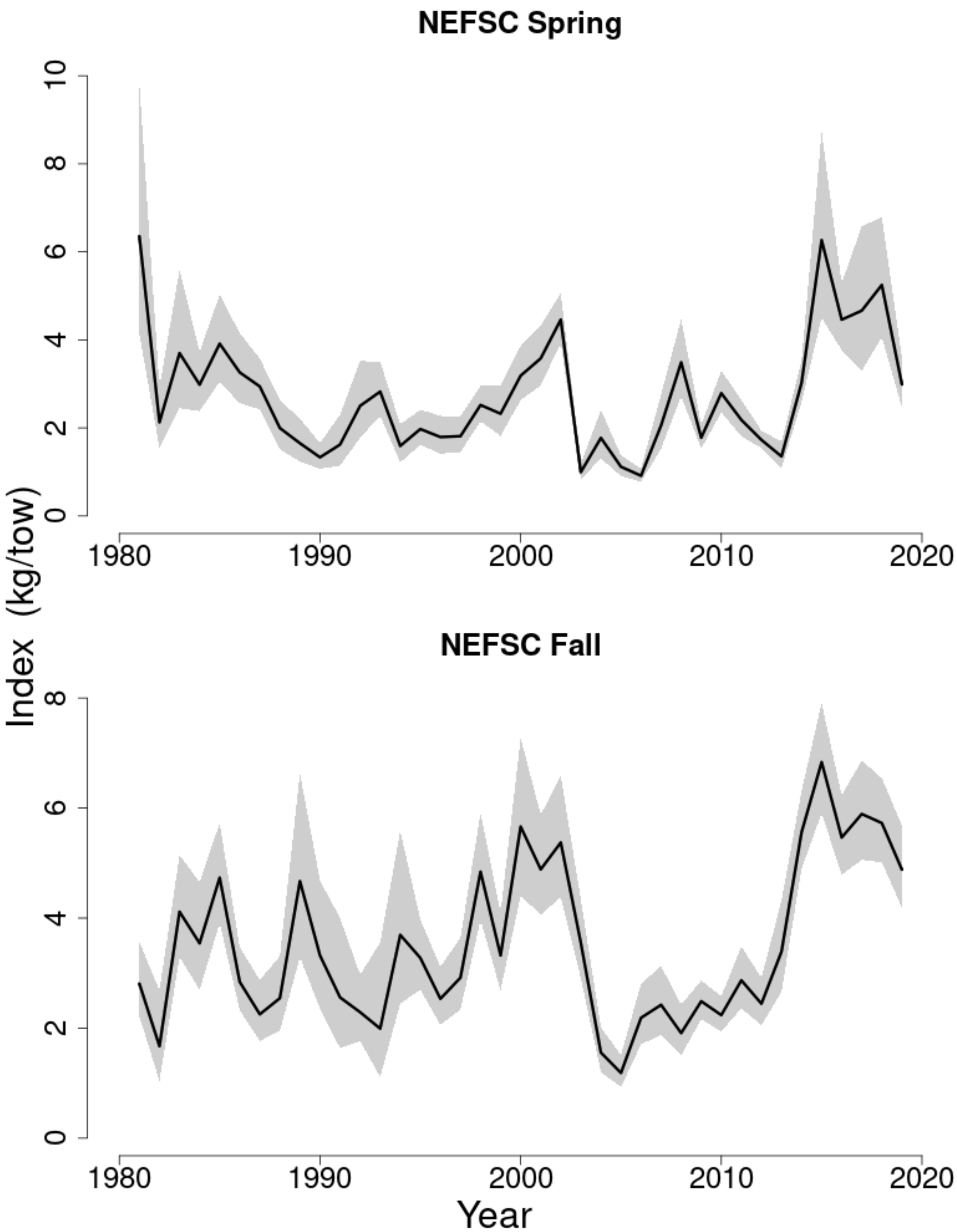


Figure 44: Indices of biomass for northern red hake between 1981 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% log-normal confidence intervals are shown.

11. SOUTHERN RED HAKE

Toni Chute

This assessment of the southern red hake (Urophycis chuss) stock is an update of the 2017 assessment which was based on survey and fishery data through 2016 (Alade and Traver, 2018). Based on the 2017 assessment, the stock was overfished and overfishing was occurring. This assessment updates commercial and recreational fishery catch data and survey biomass indices, but instead of the AIM model uses an empirical method based on a recent catchability study (Miller et al., 2020) to estimate swept-area biomass and annual relative exploitation rates.

State of Stock: Based on this updated assessment, the status of the southern red hake (*Urophycis chuss*) stock is unknown. Retrospective adjustments were not made to the model results.

Table 25: Catch and status table for southern red hake. All weights are in metric tons and F_{Full} is the relative exploitation rate.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data										
Recreational catch	128	112	124	114	105	57	342	75	98	322
Commercial discards	717	948	559	558	539	822	705	478	1,279	1,239
Commercial landings	602	491	742	445	563	396	392	322	394	327
Catch for Assessment	1,447	1,551	1,425	1,117	1,207	1,274	1,439	875	1,771	1,889
Model Results										
Estimated swept area biomass	67,379	125,578	69,764	42,450	58,929	49,021	32,622	42,619	76,932	74,591
F_{Full}	2.15	1.24	2.04	2.63	2.05	2.6	4.41	2.05	2.3	2.53

Table 26: Reference points from the AIM model accepted at the 2019 assessment; reference points from the current assessment update are unknown. $F_{MSY\,proxy}$ is in units of kt per kg/tow and the B_{MSY} proxy is in units of kg/tow.

	2017	2020
$F_{MSY\,proxy}$	3.04	Unknown
SSB_{MSY} (mt)	0.51	Unknown
Overfishing	Yes	Unknown
Overfished	Yes	Unknown

Projections: There were no projections made for the southern red hake stock. Applying the mean estimated exploitation rate during the Bigelow years (2009–2019) of 2.44 percent to the 3-year running average (2017–2019) swept-area biomass estimate of 64,714 mt produces a catch of 1580 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).

  Some of the reported landings are categorized as mixed hake so the proportion of those landings that are red hake must be estimated. However, the mixed hake catches are quite small.

- 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 method 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?

  There are no projections made for the southern red hake stock. Catch advice is derived from applying an exploitation rate of 2.44 percent (based on the mean estimated exploitation rate during 2009–2019, the Bigelow years) to the 3-year average (2017–2019) swept area biomass.

  A rebuilding plan for southern red hake will begin this year. The ABC for that plan is the catch derived from 75% of the F_{MSY} or $F_{MSY\ proxy}$. The F_{MSY} or $F_{MSY\ proxy}$ will be the OFL.

- 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.

  During the Red Hake Stock Structure Research Track peer review process in early 2020, it was determined that the AIM model, used for red hake assessments since 2010, was no longer a viable alternative for determining stock status for red hake due to poor fit. For this assessment, catch efficiencies for the Bigelow trawl net derived specifically for southern red hake were used to estimate annual total swept-area biomass and exploitation rates using data updated through 2019.

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

  Since the AIM model is no longer used for stock status determination, and a method to derive reference points using an empirical method has not been fully developed, the stock status of southern red hake is unknown.

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

  Red hake in the Mid-Atlantic are currently in neutral body condition compared to the rest of the 1992–2019 time series, and had above-average productivity in 2018, according to the 2020 State of the Ecosystem report.

  Analyses done during the Red Hake Stock Structure Research Track and for this assessment indicate that southern red hake is not necessarily driven by fishing since exploitation rates are low, at least recently. It is possible that changing environmental conditions have caused the population of southern red hake to decline as a result of physical conditions that reduce survival, or competition for the same resources by other species. There is anecdotal evidence from a fisheries observer that spotted hake are becoming more common *in mixed catches, for instance. Estimated consumption of southern red hake (by both different fish species and larger red hake) is about 1800 mt per year on average, but estimates vary substantially from year to year and there is not a clear trend over time (Smith, 2020).*

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

  The assessment could be improved with further exploration of a method to derive reference points based on the catchability studies and the stock biomass estimates they enable us to determine. This was explored during the Red Hake Stock Structure Research Track in 2020 and was deemed promising by the review panel but needs to be developed further.

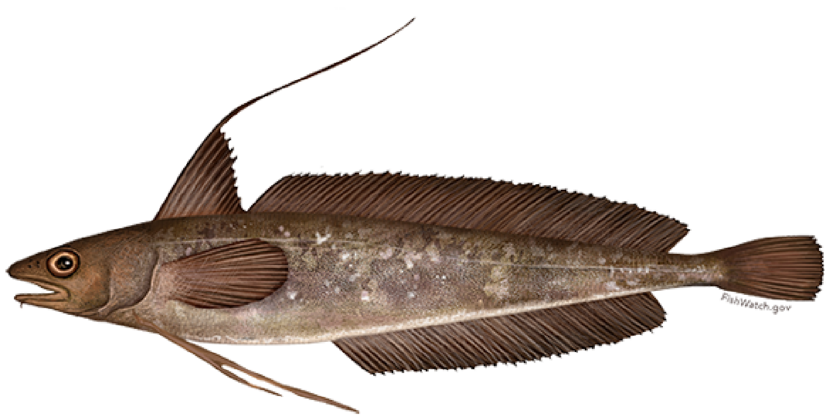
  It would be helpful to understand the changes in distribution of both southern red hake and other species that might compete with southern red hake.

- Are there other important issues?

  Since this method does not generate analytical reference points, overfishing status can be determined by comparing current estimated exploitation rates to rates from a time period when the fishery was determined to have been sustainable, for instance. Overfished status could be determined by comparing the current estimated swept-area biomass to either the whole time series or a time period when the stock was considered to be in good condition.

  The swept-area biomass method also offers a way to qualitatively assess the level of removals and stock status. In the case of southern red hake, less than five percent of the biomass is estimated to have been removed every year since 2003.

  We compared 3-year running averages of the estimated swept-area biomass and exploitation rates to provisional reference points based on specific periods of time. If the 2017–2019 estimated swept area biomass is compared to half of the time series mean as a $B_{\text{Threshold}}$ proxy, the stock would not be overfished. If the 2017–2019 mean estimated exploitation rate is compared to the mean rate that was estimated for the Bigelow years (2009–2019), overfishing would not be occurring.



Urophycis chuss, Red Hake.

11.1. Reviewer Comments: Southern red hake

The 2020 assessment for southern red hake is an enhanced review (Level 3) of approaches described in the 2020 Red Hake Stock Structure Research Track assessment. This recommendation was made because the AIM model used to assess the stock in previous assessments was rejected by the Research Track Stock Assessment Review Committee (SARC) and a new assessment approach was not recommended. The SARC recommended using new chainsweep study information for southern red hake to estimate swept-area biomass but did not recommend an approach to determine BRPs. The 2020 assessment updated commercial and recreational fishery catch data and survey biomass indices.

The Peer Review Panel reviewed an empirical approach based on the recent survey catchability study to estimate swept-area biomass and annual relative exploitation rates. This approach has been applied and peer-reviewed for flatfish stocks. The Panel concluded that the updated swept-area biomass estimates provide qualitative information about stock trends, but the relative exploitation rates should not be used as BRP proxies and do not provide a basis for scientific advice. The Panel concurs with the SARC that the exploitation rates are currently low, and that overfishing is not likely occurring. Additionally, southern stock survey indices are near the lowest in the time series, and the Panel agrees with the SARC that overfished status is unknown.

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

Southern Red Hake Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Commercial and recreational landings data were updated through 2019. Recreational catch was based on uncalibrated MRIP data for the full time series. Commercial discards are estimated from several gear types with the majority attributed to small mesh otter trawl. Total catch in 2019 was 1,889 mt, of which was 1,239 mt was discards.

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

   This TOR was satisfactorily addressed. The NEFSC spring and fall bottom trawl survey indices (kg/tow in Albatross units) and the swept-area biomass estimates applying southern red hake specific catchability estimates for the Bigelow survey were updated through 2019. A sensitivity analysis was conducted using the NEFSC spring bottom trawl survey only and showed only minor differences in swept-area biomass or relative exploitation rates compared to the combined survey estimates.

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

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

b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

This TOR was not met. The 2020 Red Hake Stock Structure Research Track assessment SARC rejected the AIM model for southern red hake. The SARC recommended use of swept-area biomass estimates based on the chainsweep study for southern red hake and reviewed an alternative method for calculating reference points based on spawning potential ratio (SPR), but concluded that there was sufficient uncertainty in the sensitivity of reference point estimates to various assumptions made that the reference point estimates should not be used for management advice for red hake at this time. The SARC recommended additional analyses for the SPR approach and noted that methods currently used for other data-limited stocks in the region could be explored for both northern and southern red hake. The SARC did not recommend an assessment method.

The Peer Review Panel reviewed a proposed 'Plan B' approach based on an empirical method to estimate swept-area biomass and annual relative exploitation rates based on the recent catchability study specific to southern red hake (Miller et al., 2020). Catch efficiency was estimated annually for the Bigelow time series (2009–2019) and the mean of those estimates was applied to the prior survey time series (1981–2009). Exploitation rates are expressed as a percent of the estimated biomass removed by the fishery (catch/biomass) for each calendar year. The Panel concluded that the updated swept-area biomass estimates provide qualitative information about stock trends, but the relative exploitation rates do not provide a basis for scientific advice.

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

   This TOR was partially addressed. BRPs could not be estimated from the proposed 'Plan B' approach. In the absence of agreed reference points, the Panel concluded that stock status is currently unknown. The Panel reviewed the updated biomass estimates and relative exploitation rates and concluded that the exploitation rates are currently low, and that overfishing is not likely occurring. Additionally, southern stock indices are near the lowest in the time series, and the overfished status is unknown.

   Reference points that were applied in the previous assessments were based on survey indices (kg/tow). These reference points could be evaluated for application to the updated swept-area biomass estimates and potential use in management if they were converted to swept-area biomass.

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

   There were no projections made for southern red hake. The Peer Review Panel noted that recent exploitation rates have been constrained by management actions that were based on the rejected AIM model.

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

   The 2020 Red Hake Stock Structure Research Track assessment SARC made several recommendations for further evaluation of the proposed SPR-based assessment method. The SARC noted that the SPR-based reference points could be suitable for red hake and that the 40% proxy level for F and SSB was reasonable. They suggested the following analyses:

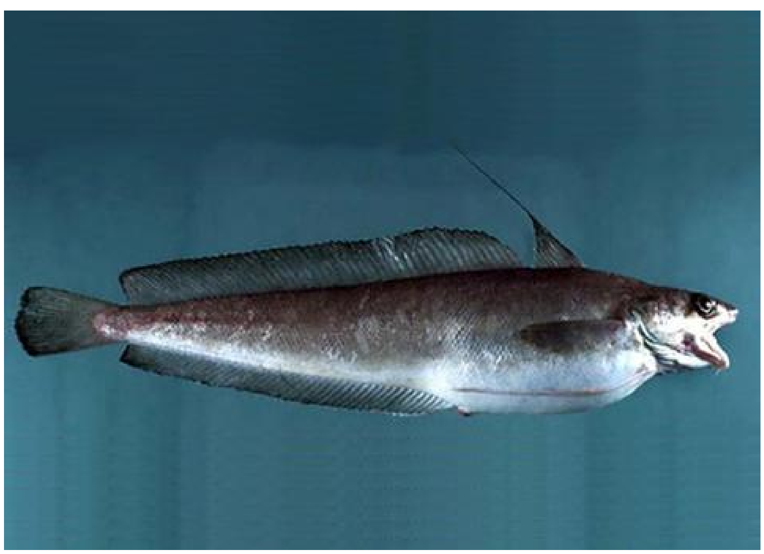
   - A catch curve analysis on the survey data could be used to estimate M in recent years;
   - Exploration of the sensitivity of the knife-edge selectivity assumption; and
   - Expansion of the time series of recruitment estimates over longer periods and evaluation of the sensitivity of the $SSB_{40\%}$ estimates to different recruitment time series.

   The SARC also noted that decoupling between fishing pressure and population trends has been observed for other stocks in the region (e.g., Georges Bank yellowtail flounder) and suggested that methods currently used for setting catch advice for other data-limited stocks could be explored for red hake.

Additional Recommendations

The Peer Review Panel recommended additional analysis on the proposed SPR-based assessment method, as described by the SARC. They noted that due to the Research Track and Management Track process, there is not a currently accepted assessment method for the red hake stocks and no basis for scientific advice at this time. The Panel recommended a subsequent review process for a newly developed red hake assessment.

Appropriate exploitation rates should be further explored in the next assessment.



Red Hake, in blue water.

References:

Miller, T., Richardson, D., Politis, P., Blaylock, J. 2020. Relative efficiency of a chain sweep and the rockhopper sweep used for the NEFSC bottom trawl survey and biomass estimates for winter and windowpane flounder and red hake stocks. Working paper.

Alade, L., Traver, M. 2018. 2017 northern and southern silver hake and red hake stock assessment update report. US Dept Commer, Northeast Fisheries Science Center Ref Doc 17-17, 81 p. https://repository.library.noaa.gov/view/noaa/17249

Most recent benchmark assessment:

Northeast Fisheries Science Center. 2011. 55th Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dep Commer, NOAA Fisheries, Northeast Fisheries Science Center Ref Doc 11-01,79 p. https://repository.library.noaa.gov/view/noaa/3766

Smith, B.E. 2020. Consumption estimates of red hake and silver hake at various life stages for northern and southern stocks of the Northeast US continental shelf. Working paper.

State of the Ecosystem Reports, 2020, mid-Atlantic region.
Available at: https://www.integratedecosystemassessment.noaa.gov/regions/northeast/reports.

Research vessel NOAAS Henry B. Bigelow underway

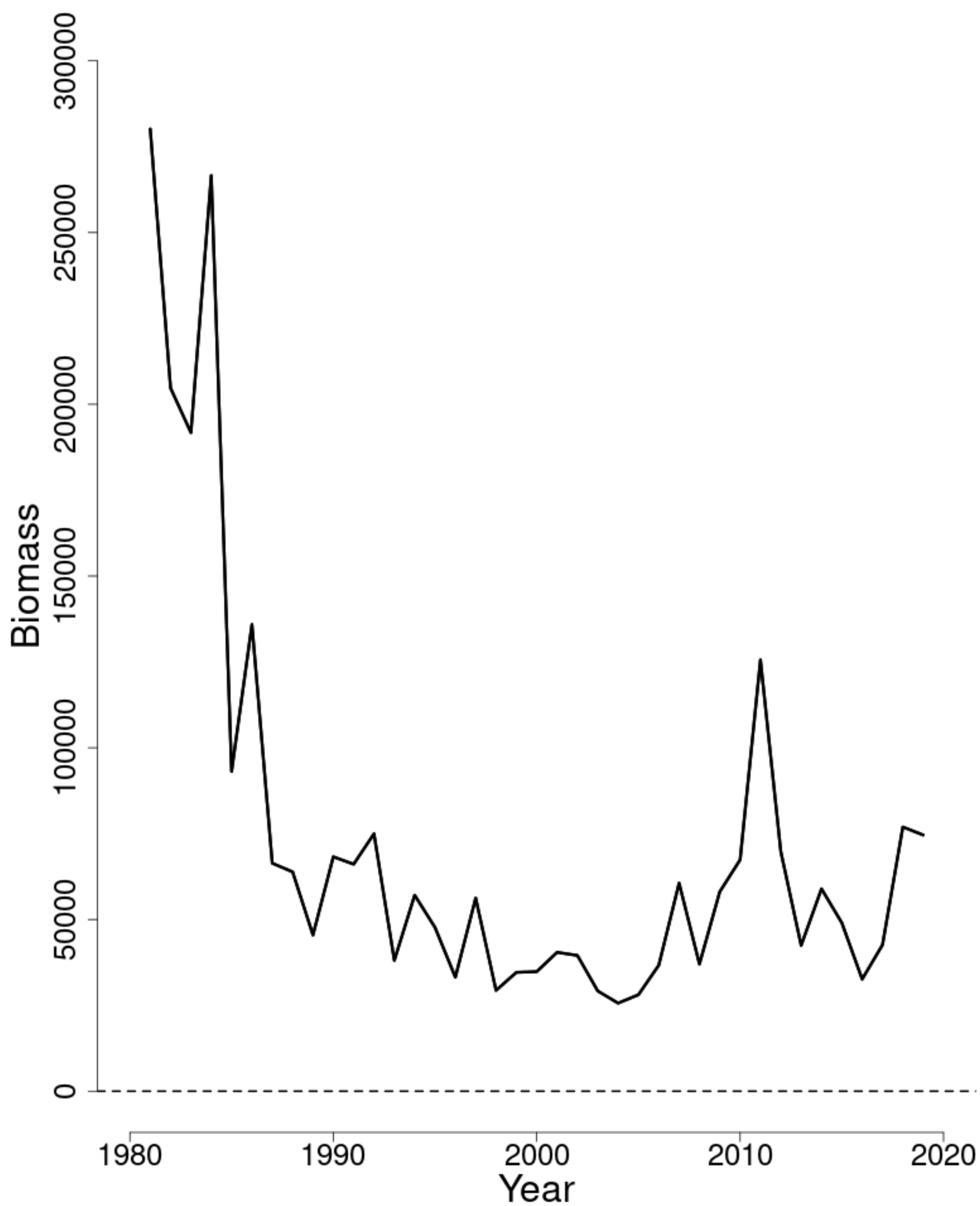


Figure 45: Trends in estimated swept area biomass of southern red hake between 1981 and 2019 from the current assessment.

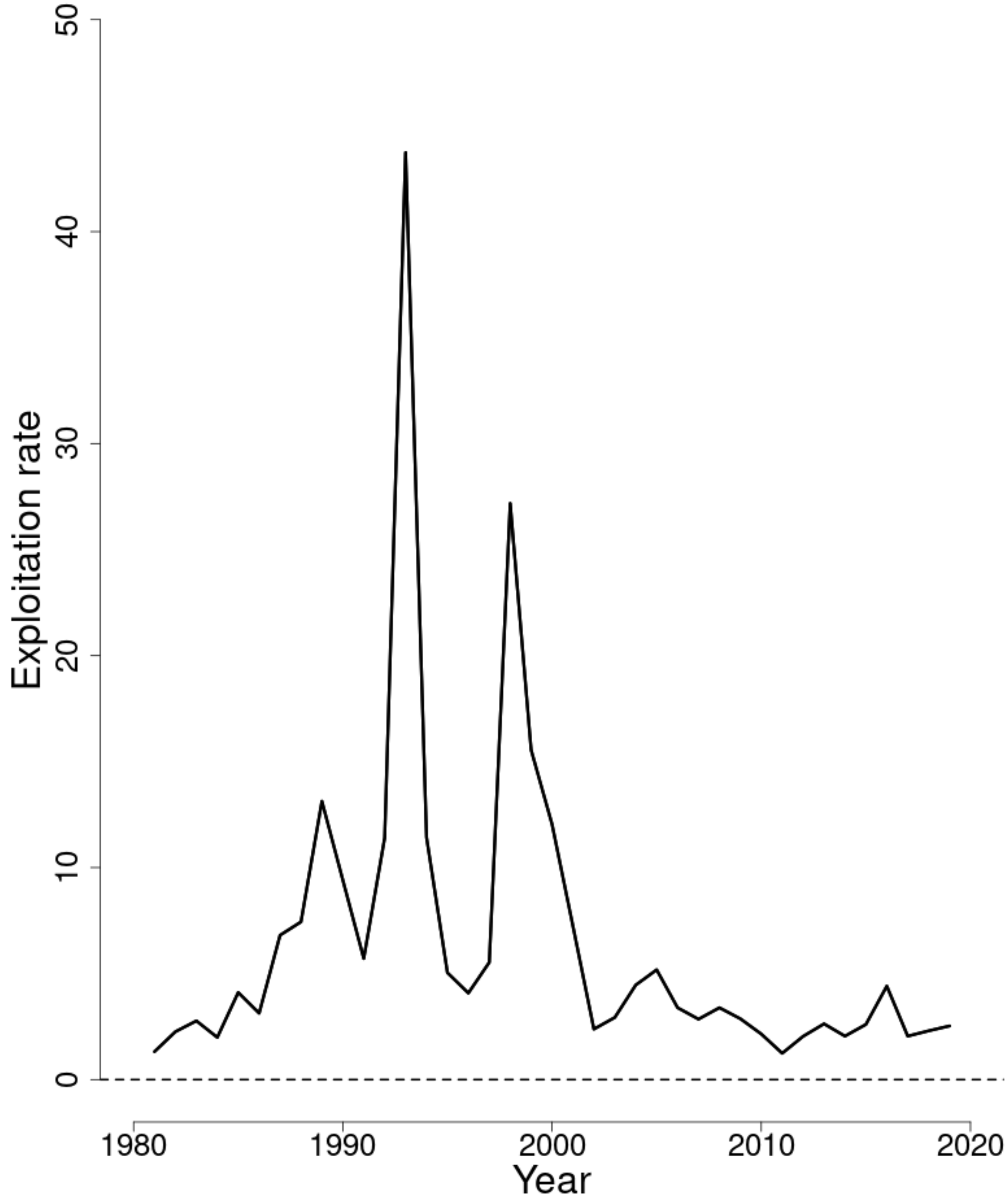


Figure 46: Trends in estimated relative exploitation rate in percent of southern red hake between 1981 and 2019 from the current assessment.

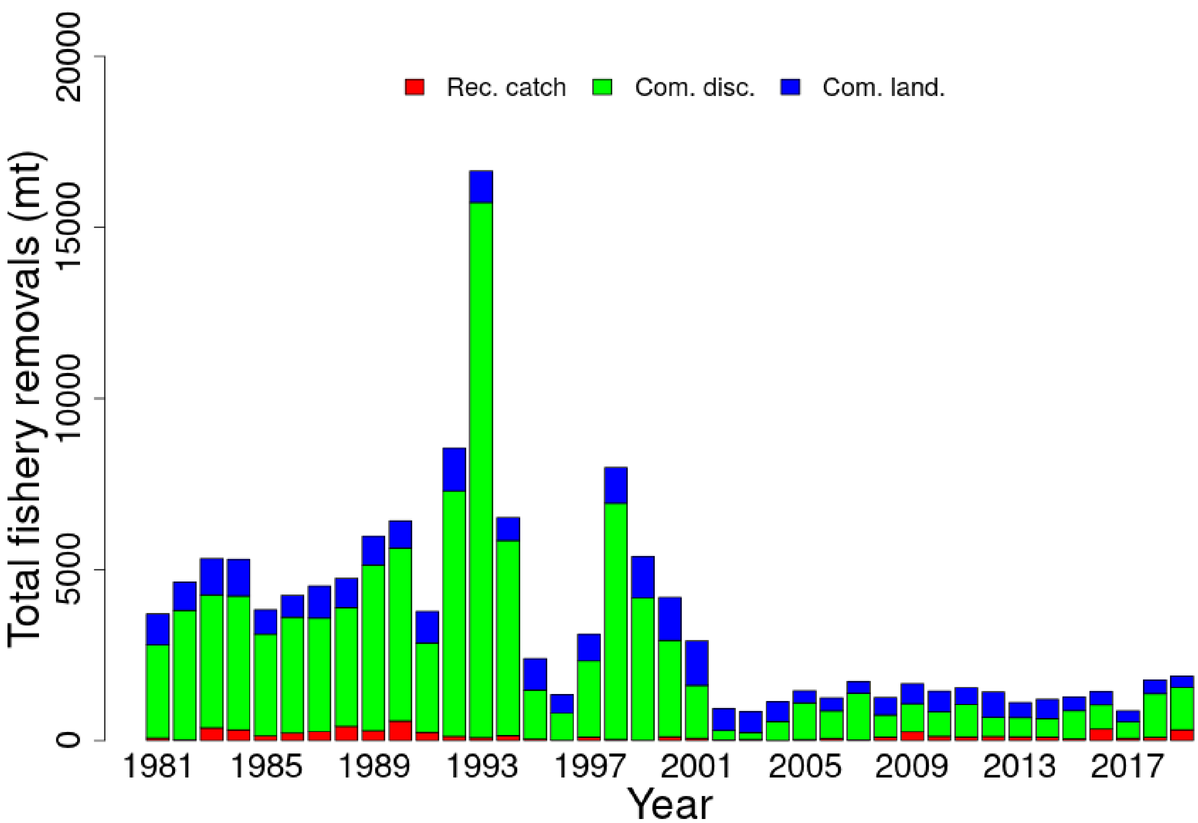


Figure 47: Total catch of southern red hake between 1981 and 2019 by the commercial (landings and discards) and recreational fleets.

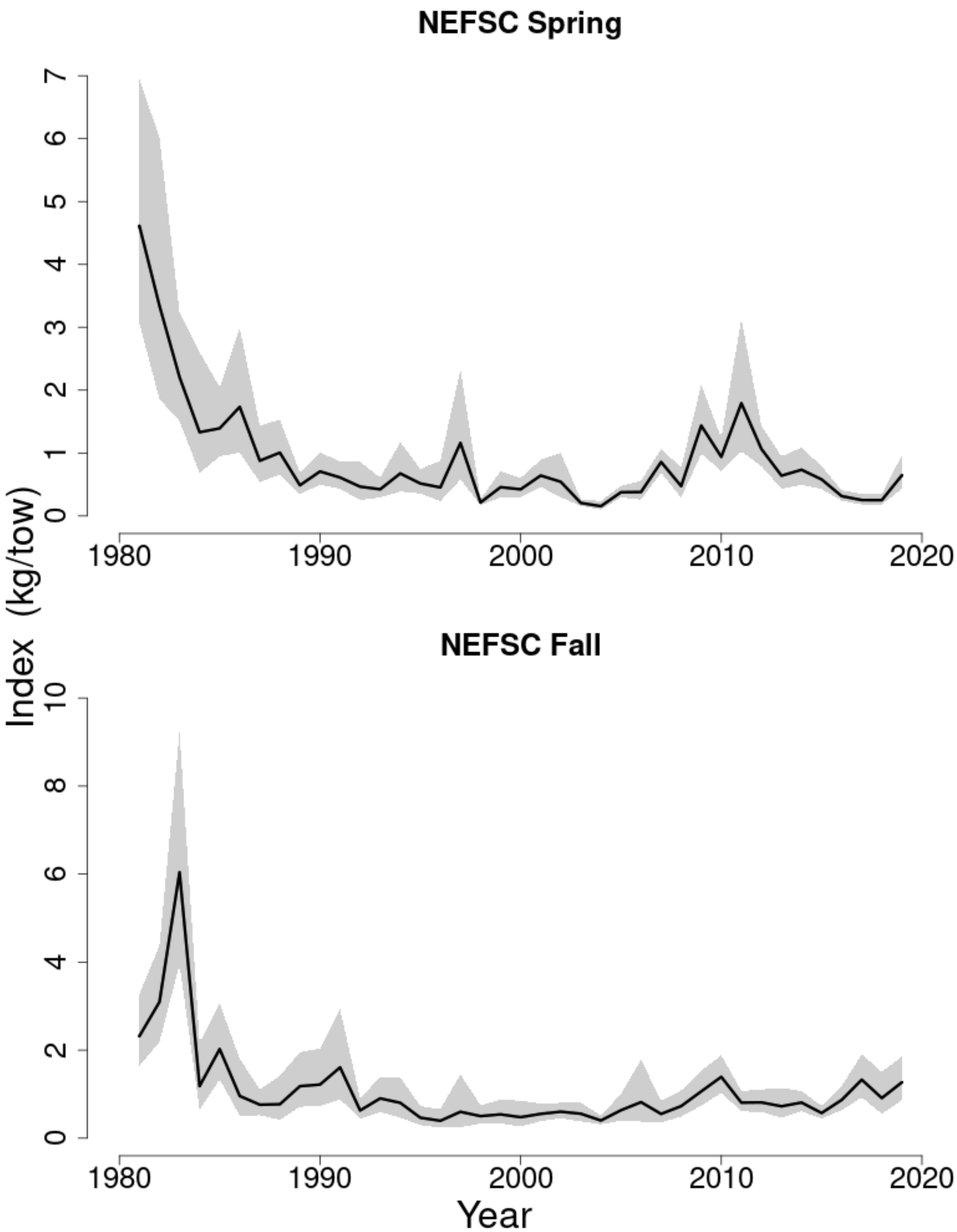


Figure 48: Indices of biomass for southern red hake between 1981 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% log-normal confidence intervals are shown.

12. NORTHERN SILVER HAKE

Larry Alade

This assessment of the Northern silver hake (Merluccius bilinearis) stock is a Level 1 Management Track Assessment update of the existing 2017 assessment (NEFSC 2017). Based on the 2017 assessment the stock status was not overfished and overfishing was not occurring. This assessment updates commercial fishery catch data through 2019 (Table 27, Figure 51), and updates research survey biomass indices and the empirical approach assessment through 2019 (Figure 52). No stock projections can be computed using the empirical approach.

State of Stock: Based on this updated assessment, Northern silver hake (*Merluccius bilinearis*) stock is not overfished and overfishing is not occurring (Figures 49–50). Retrospective adjustments were not made to the model results. The NEFSC fall biomass index (kg/tow) in 2019 (defined as the 3-yr arithmetic average for years 2017–2019), was estimated to be 14.39 (kg) which is 224% of the biomass target ($B_{MSY\ proxy} = 6.42$; Figure 49). The 2019 exploitation rate (also defined as the 3-yr arithmetic average for years 2017–2019) was estimated to be 0.15 which is 5% of the overfishing threshold proxy ($F_{MSY\ proxy} = 2.77$; Figure 50).

Table 27: Catch and model results table for northern silver hake. All weights are in mt. The NEFSC fall index (kg/tow) is the arithmetic average of the recent three years (2017–2019). The exploitation rate is the 3-yr moving average of catch divided by the fall biomass index. Model results are from the SAW 51 (NEFSC 2011) updated empirical approach assessment.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data											
Commercial landings	1,042	1,690	1,926	1,948	1,375	2,551	2,190	3,076	2,678	2,079	1,176
Commercial discards	190	788	118	294	246	469	309	305	285	223	122
Catch for assessment	1,232	2,478	2,043	2,242	1,621	3,020	2,499	3,382	2,963	2,301	1,299
Model Results											
NEFSC fall (3-yr Mean)	6.21	8.79	10.36	14.86	15.72	18.65	18.34	19.92	18.92	16.84	14.39
Exploitation rate (3-yr Mean)	0.2	0.17	0.19	0.16	0.14	0.12	0.13	0.15	0.16	0.17	0.15

Table 28: Comparison of reference points estimated in an earlier assessment and from the current assessment update.

	2017	2020
$F_{MSY\ proxy}$ (000s mt/kg)	2.77	2.77
$B_{MSY\ proxy}$ (kg)	3.208	3.208
MSY (000s mt)	8.901	8.901
Overfishing	No	No
Overfished	No	No

Projections: Short term projections cannot be computed using the empirical approach. The estimated 2019 3-yr average of NEFSC fall biomass index 14.39 kg/tow. Using accepted approach for catch advice (NEFSC 2011), application of the average exploitation rate of 2.77 kt/kg (based on nine years, 1973–1982) to the most recent 3-yr (2017–2019) moving average of the NEFSC fall biomass index (14.39 kg/tow) results in an estimated catch for 2021 of 39,930 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).

  The lack of a stock assessment analytical framework for Northern silver hake is a basic source of uncertainty for this assessment. Important population quantities such as growth, natural mortality, and recruitment cannot be explicitly considered to inform population trends within the current empirical framework. The basis for calculating biological reference points is another source of uncertainty. The existing BRP is based on a period (1973–1982) of stability in the survey trends that coincides with a steep change in the relative exploitation rates in the fishery. This approach assumes that conditions for the stock have remained relatively static and lacks contemporary measures of stock productivity. Discard estimates for the small mesh trawl in 2019 were not reliably estimated and likely due to reduced number of observed trips for the small mesh fleet in 2019. The coefficient of variance (CV) was approximately 77% for the small mesh fleet. Although the small mesh fleet constitute a major fraction of total discards, the impact of the lack of precision on total catch is likely minor due to the relatively small contribution of total discards to the total catch.

- 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 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 Northern silver hake are not computed. However, catch advice is derived from applying the mean exploitation rate of 2.27kt/kg (based on reference period 1973–1982) to the recent 3-yr average (2017–2019) of the NEFSC fall survey biomass index.

- 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 Northern silver hake assessment for this update. However, this had no impact on 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 Northern silver hake since the previous assessment.Biological reference points also remained unchanged.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The Northern silver hake continues to indicate that the stock is in good condition based on increasing trends in the NEFSC fall survey biomass index. Estimates of commercial catch have been declining in recent years, resulting in a decrease in relative exploitation rates. Age-1 abundance from the fall NEFSC survey index has consistently been above the time series average since the mid-2000 and has supported and an expanded age structure in the survey catch-at-age.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The Northern silver hake assessment could be improved with an analytical assessment that uses a full range of age data to inform population trends. A re-evaluation of the existing biological reference points could benefit the stock by considering contemporary measures of productivity of the stock.

- Are there other important issues?
  None. Additional supplementary information for Northern silver hake will made available as soon as practicable on the Stock Assessment Supplementary Information website (SASINF).

Merluccius bilinearis, Silver Hake.

12.1. Reviewer Comments: Northern silver hake

Northern silver hake was not peer reviewed in 2020.

References:

Alade L.A., Traver M.L. 2018. 2017 northern and southern silver hake and red hake stock assessment update report. Northeast Fish Sci Cent Ref Doc. 18-02; 77 p. RD-NEFSC-18-02

Smith, B.E. 2020. Consumption estimates of red hake and silver hake at various stages for northern and southern stocks of the Northeast Continental shelf. Working paper.

Northeast Fisheries Science Center. 2011. 51st Northeast Regional Stock Assessment Workshop Assessment Report, Northeast Fisheries Science Center, Woods Hole, Massachusetts, January 2011. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 11-02; 856 p. CRD11-02

NEFMC. 2012. Final Amendment 19 to the Northeast Multispecies FMP (Small-mesh Multispecies) Environmental Assessment Regulatory Impact Review and Initial Regulatory Flexibility Analyses. Approximately 308 pages. Available at: NEFMC online.

Silver Hake, in blue water.

Figure 49: Trends in the 3-year mean of the NEFSC fall Survey index (kg/tow) of Northern silver hake between 1973 and 2019 from the current assessment.

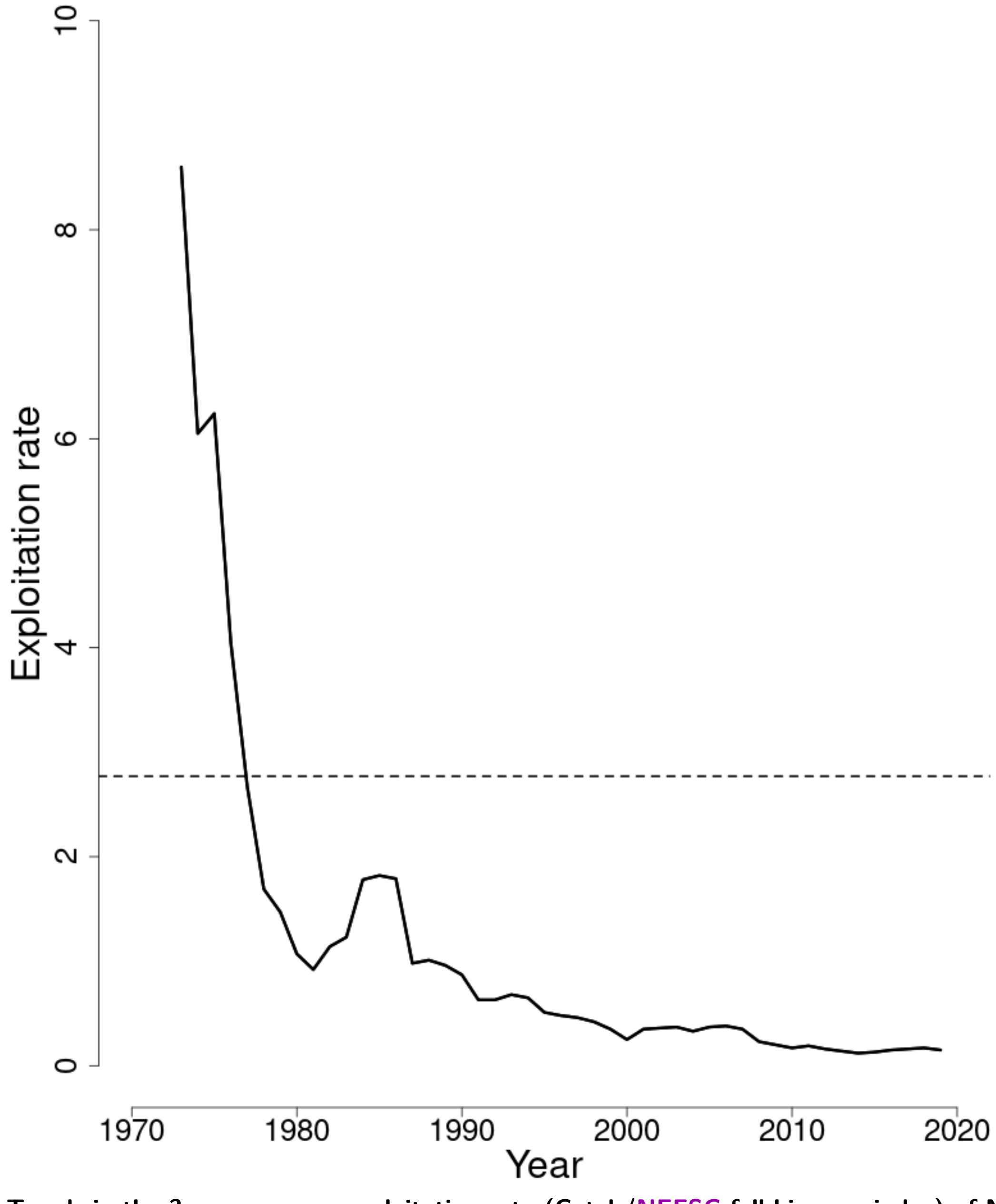


Figure 50: Trends in the 3-year average exploitation rate (Catch/NEFSC fall biomass index) of Northern silver hake between 1973 and 2018 from the current assessment.

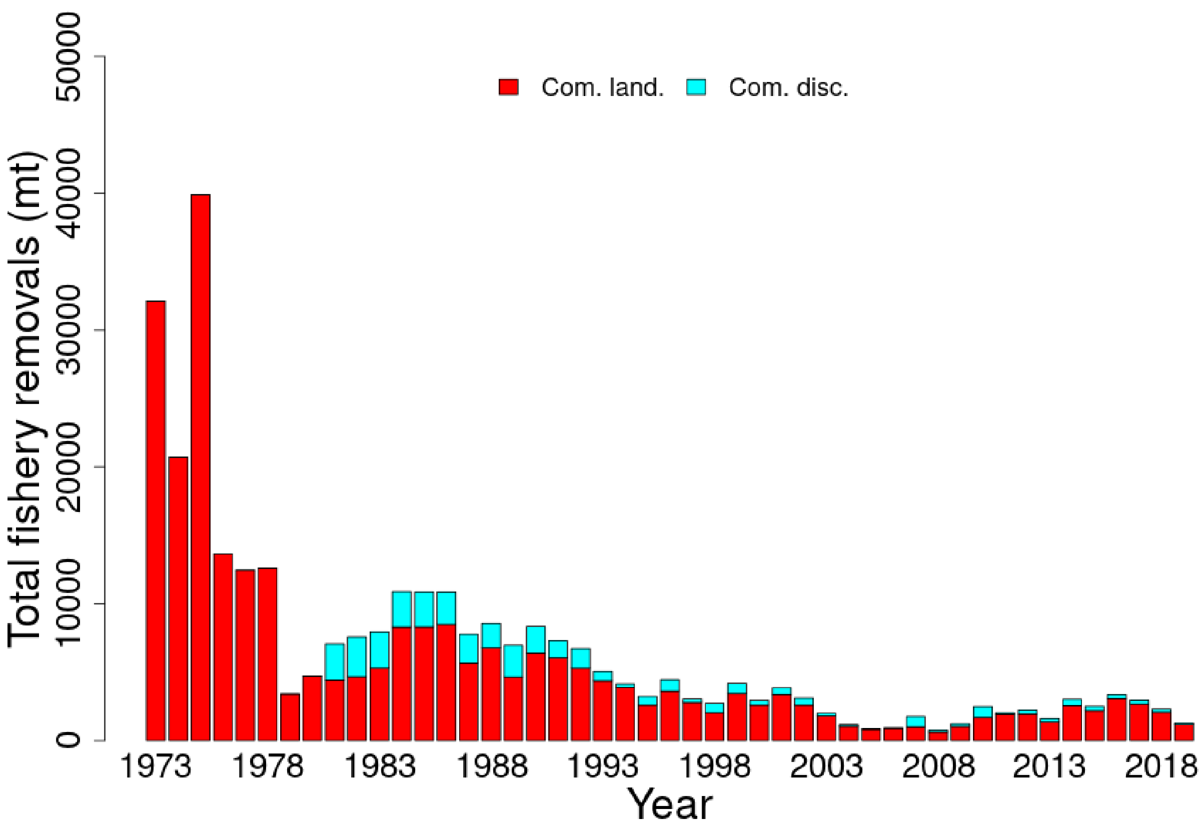


Figure 51: Total commercial catch of Northern silver hake between 1973 and 2019 and by disposition (landings and discards).

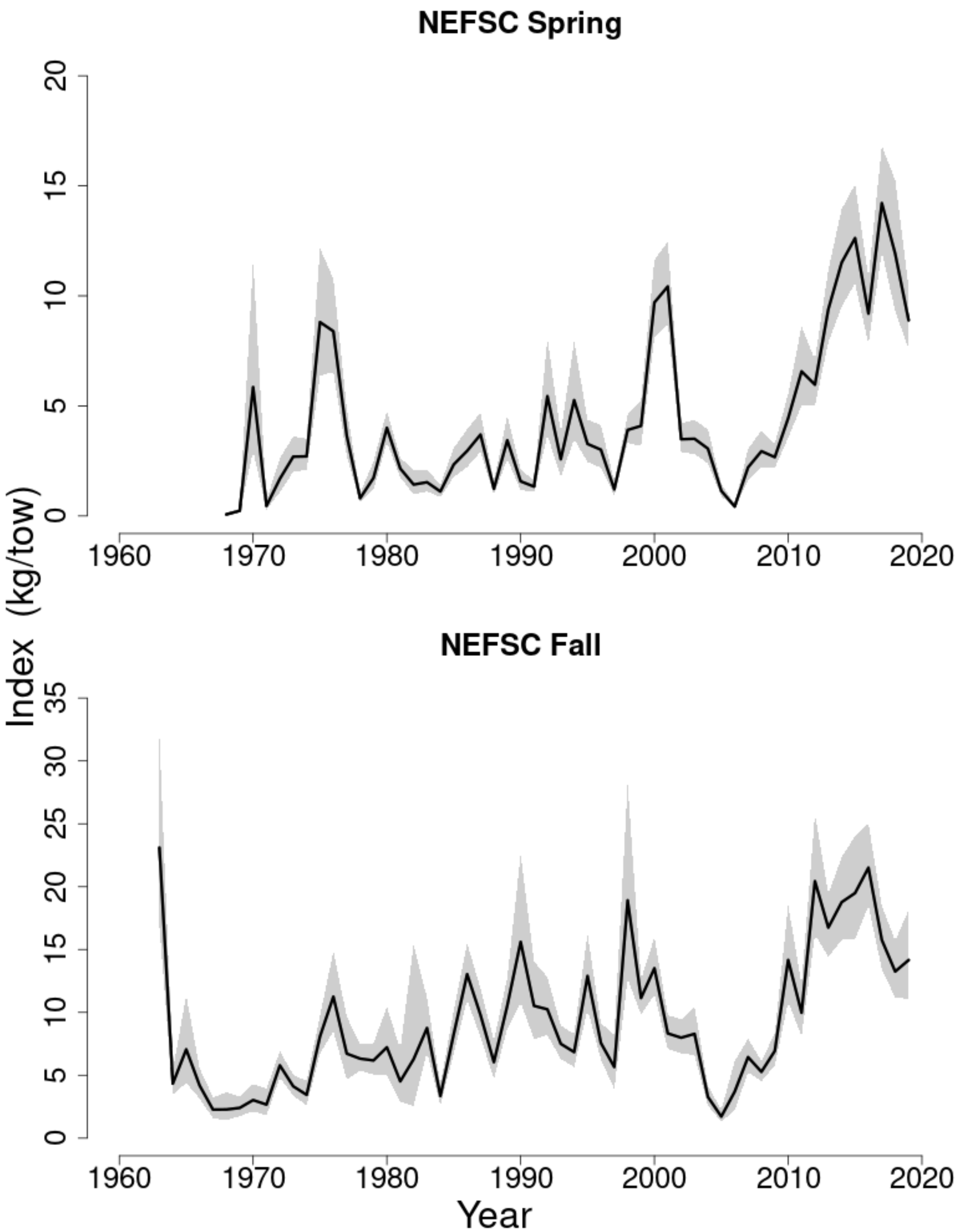


Figure 52: Indices of biomass for the Northern silver hake between 1963 and 2019 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% log-normal confidence intervals are shown.

13. SOUTHERN SILVER HAKE

Larry Alade

This assessment of the southern silver hake (Merluccius bilinearis) stock is a Level 2 Management Track Assessment update of the existing 2017 assessment (NEFSC 2017). Based on the 2017 assessment the stock status was not overfished and overfishing was not occurring. This assessment updates commercial fishery catch data through 2019 (Table 29, Figure 55), and updates research survey biomass indices and the empirical approach assessment through 2019 (Figure 56). No stock projections can be computed using the empirical approach.

State of Stock: Based on this updated assessment, southern silver hake (*Merluccius bilinearis*) stock is not overfished and overfishing is not occurring (Figures 53–54). Retrospective adjustments were not made to the model results. The NEFSC fall biomass index (kg/tow) in 2019 (defined as the 3-yr arithmetic average for years 2017–2019), was estimated to be 2.151 (kg) which is 130% of the biomass target ($B_{MSY\ proxy} = 1.65$; Figure 53). The 2019 exploitation rate (also defined as the 3-yr arithmetic average for years 2017–2019) was estimated to be 1.907 which is 6% of the overfishing threshold proxy ($F_{MSY\ proxy} = 34.17$; Figure 54).

Table 29: Catch and model results table for southern silver hake. All weights are in mt. The NEFSC fall index (kg/tow) is the arithmetic average of the recent three years (2017–2019). The exploitation rate is the 3-yr moving average of catch divided by the fall biomass index. Model results are from the SAW 51 (NEFSC 2011) updated empirical approach assessment.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Data											
Commercial landings	6,750	6,385	5,749	5,430	4,786	4,706	4,263	3,289	2,684	3,090	4,058
Commercial discards	840	780	1,810	1,019	636	661	292	543	305	775	1,339
Catch for assessment	7,590	7,165	7,559	6,449	5,422	5,367	4,555	3,832	2,988	3,865	5,397
Model Results											
NEFSC fall (3-yr Mean)	1.11	1.76	1.897	2.191	1.695	1.584	1.063	1.052	1.316	1.77	2.151
Exploitation rate (3-yr Mean)	5.92	4.767	4.57	3.355	3.863	3.686	6.223	5.85	5.051	2.153	1.907

Table 30: Comparison of reference points estimated in an earlier assessment and from the current assessment update.

	2017	2020
$F_{MSY\ proxy}$(000s mt/kg)	34.17	34.17
$B_{MSY\ proxy}$ (kg)	0.825	0.825
MSY (000s mt)	28.194	28.194
Overfishing	No	No
Overfished	No	No

Projections: Short term projections cannot be computed using the empirical approach. The estimated 2019 3-yr average of NEFSC fall biomass index 14.39 kg/tow. Using accepted approach for catch advice (NEFSC 2011), application of the average exploitation rate of 34.17 kt/kg (based on nine years, 1973–1982) to the most recent 3-yr (2017–2019) moving average of the NEFSC fall biomass index (2.15 kg/tow) results in an estimated catch for 2021 of 73,498 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).

  The lack of a stock assessment analytical framework for southern silver hake is a basic source of uncertainty for this assessment. Important population quantities such as growth, natural mortality, and recruitment cannot be explicitly considered to inform population trends within the current empirical framework. The basis for calculating biological reference points is another source of uncertainty. The existing BRP is based on a period (1973–1982) of stability in the survey trends that coincides with a steep change in the relative exploitation rates in the fishery. This approach assumes that conditions for the stock have remained relatively static and lacks contemporary measures of stock productivity. Catch is a source of uncertainty in this assessment because of the mixed reporting of landings and the poor identification to species for both silver and offshore hake. Although a length-based algorithm based on survey species proportion is used to disaggregate reported catch, scientific data (commercial or survey) for offshore hake appears unreliable because there is little to base conclusions about the trends in the offshore hake population size.

- 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 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 southern silver hake are not computed. However, catch advice is derived from applying the mean exploitation rate of 34.17 kt/kg (based on reference period 1973–1982) to the recent 3-yr average (2017–2019) of the NEFSC fall survey biomass index.

- 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 existing assessment approach. However, a number of explorations were conducted to address the reduced survey sampling coverage in the fall of 2017. In 2017, only 20% of the total survey area was covered. On average (2009–2016), the missing survey area in 2017 constituted 63% of the total survey catch in weight. Because the existing empirical approach uses the recent three-year average of the fall survey biomass, the 2017 NEFSC fall survey value plays a direct role to inform the stock status determination. All approaches explored *to address the reduced survey sampling coverage (including treating 2017 as a missing value) resulted in a broad distribution of implied survey estimates(0.86 – 2.23* kg/tow*), but none of these approaches resulted in a change in stock status determination.*

- If the stock status has changed a lot since the previous assessment, explain why this occurred.
  No change in stock status has occurred for southern silver hake since the previous assessment. Biological reference points also remained unchanged.

- Provide qualitative statements describing the condition of the stock that relate to stock status.
  The southern silver hake continues to show a steady increase in the NEFSC fall survey biomass since 2015. Relative to the northern stock, abundance of age-1 recruitment from the NEFSC fall survey has been sporadic. However, the survey seems to indicate a strong 2019 incoming year class of age-0s and the highest observed in the time-series. Several years of future observations will be needed as the fall 2019 year class continues to grow into the population to better understand its relative impact on the southern stock. Although there has been some modest increase in catches since 2017, the exploitation rate remains well below the threshold while the fall survey biomass is just above the reference target.

- Indicate what data or studies are currently lacking and which would be needed most to improve this stock assessment in the future.
  The southern silver hake assessment could be improved with an analytical assessment that uses the full range of population quantities. The existing basis for biological reference points should be re-evaluated to account for contemporary measures of productivity. The empirical approach is highly dependent on consistent time series, this assessment could benefit from continued exploration of approaches to addressing missing data.

- Are there other important issues?
  None. Additional supplementary information for southern silver hake will made available as soon as practicable on the Stock Assessment Supplementary Information website (SASINF).

Merluccius bilinearis, Silver Hake.

13.1. Reviewer Comments: Southern silver hake

The 2020 assessment for southern silver hake / offshore hake is an expedited review (Level 2) update of the 2017 assessment as recommended by the Assessment Oversight Panel (AOP) based on missing 2017 survey data and potential data imputation approaches. The last Benchmark review occurred in 2010 (SARC 51) when the ASAP model was considered and rejected and the empirical approach was adopted.

The Peer Review Panel concludes that the 2020 assessment update for southern silver hake / offshore hake is technically sufficient to evaluate stock status and provide scientific advice. The assessment represents Best Scientific Information Available for this stock for management purposes. The Peer Review Panel concurs with the assessment that the stock is not overfished and that overfishing is not occurring.

Southern Silver Hake / Offshore Hake Terms of Reference (TOR)

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

   This TOR was satisfactorily addressed. Catch, landings (foreign and domestic) and discard data for the southern silver hake / offshore hake complex were provided by year and by fleet. Landings in 2019 were 5,400 mt and well below the time series average of 32,670 mt (1955–2019) and a more recent time series average of 6,198 mt (2000–2019). The southern and offshore silver hake are combined as identification based on morphology can be difficult. There is an algorithm for separating the two species out by length category, but the proportion of offshore hake catch based on survey proportions is negligible (averaging about 4% by weight).

   In 2017, only 20% of the total southern silver hake stock area was surveyed due to ship mechanical difficulties that led to a delay in the survey. The analyst considered several imputation procedures for use to fill in the missing data gaps, including the AMELIA II method, but in the end used a simple 3-year running average to smooth the time series, with the 2017 year dropped out for runs in which that year was missing (thus 2-year averages). The review panel believes this approach provides a workable solution to the missing data problem until something more robust can be created. Future work on the feasibility of data imputation is encouraged as missing data will likely be an issue in future assessments.

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

   This TOR was satisfactorily addressed. Silver hake are observed in both the fall and spring NEFSC bottom trawl surveys, but the spring survey indicates movement of the population towards the shelf edge and so only the fall survey is used as an index. A length to age binning approach is used to help characterize age compositions, but cohort-by-cohort trends are difficult to detect using these data and partly due to high predation on young of the year (Smith B.E., 2020. Consumption estimates of red hake and silver hake at various stages for northern and southern stocks of the Northeast Continental shelf. Working paper). Nevertheless, there appears to have been some recent strong recruitment events in 2018 and 2019.

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

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

    b. *Prepare a 'Plan B' assessment that would serve as an alternate approach to providing scientific advice to management if the analytical assessment were to not pass review.*

    The empirical approach (running average of NEFSC fall survey means) was used, consequently no direct estimates of fishing mortality, recruitment or stock biomass were expected. When the ASAP assessment was rejected in 2017, this was effectively the 'Plan B' assessment that has since become 'Plan A'. No 'Plan B' was prepared.

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

    This TOR was satisfactorily addressed. Proxy biomass reference points were based on the arithmetic average of the NEFSC fall survey index (1973–1982). The exploitation reference point is based on an exploitation index calculated as the ratio of total catch to the averaged fall survey index (note the difference in units between numerator and denominator in this calculation). Given this approach it appears that the stock is not overfished and overfishing is not occurring.

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

    This is an empirical approach; no short-term projections were made.

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

    There appear to be no ongoing recommendations for changes to this approach.

Additional recommendations

The basis for the existing BRP (1973–1982) should be investigated to ensure if it is still applicable to current conditions.

The NEFSC should devote effort towards developing a quantitative analytical assessment approach that can address the information content and outstanding issues associated with modeling this stock.

Additional research should be conducted to better address missing data values in the survey data time series as discussed above. For future reference, a Bayesian spatio-temporal model that uses a Conditional Autoregressive (CAR) spatial model to account for spatial correlation in fish density and using a state-space model over time to account for temporal population dynamics implemented using R-INLA might be considered. (See for example, Blangiardo, M., and Cameletti, M. (2015). Spatial and Spatial-temporal Bayesian Models with R-INLA. Wiley, Chichester, UK. 308 p.)

Finally, if applicable, the method used here to derive biological reference points might be considered for broader application in other index-based assessments when appropriate.

References:

Alade L.A., Traver M.L. 2018. 2017 northern and southern silver hake and red hake stock assessment update report. Northeast Fish Sci Cent Ref Doc. 18-02; 77 p. RD-NEFSC-18-02

Smith, B.E. 2020. Consumption estimates of red hake and silver hake at various stages for northern and southern stocks of the Northeast Continental shelf. Working paper.

Northeast Fisheries Science Center. 2011. 51st Northeast Regional Stock Assessment Workshop Assessment Report, Northeast Fisheries Science Center, Woods Hole, Massachusetts, January 2011. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 11-02; 856 p. CRD11-02

NEFMC. 2012. Final Amendment 19 to the Northeast Multispecies FMP (Small-mesh Multispecies) Environmental Assessment Regulatory Impact Review and Initial Regulatory Flexibility Analyses. Approximately 308 pages. Available at: NEFMC online.

Research vessel F/V Karen Elizabeth

Figure 53: Trends in the 3-year mean of the NEFSC fall Survey index (kg/tow) of southern silver hake between 1973 and 2019 from the current assessment.

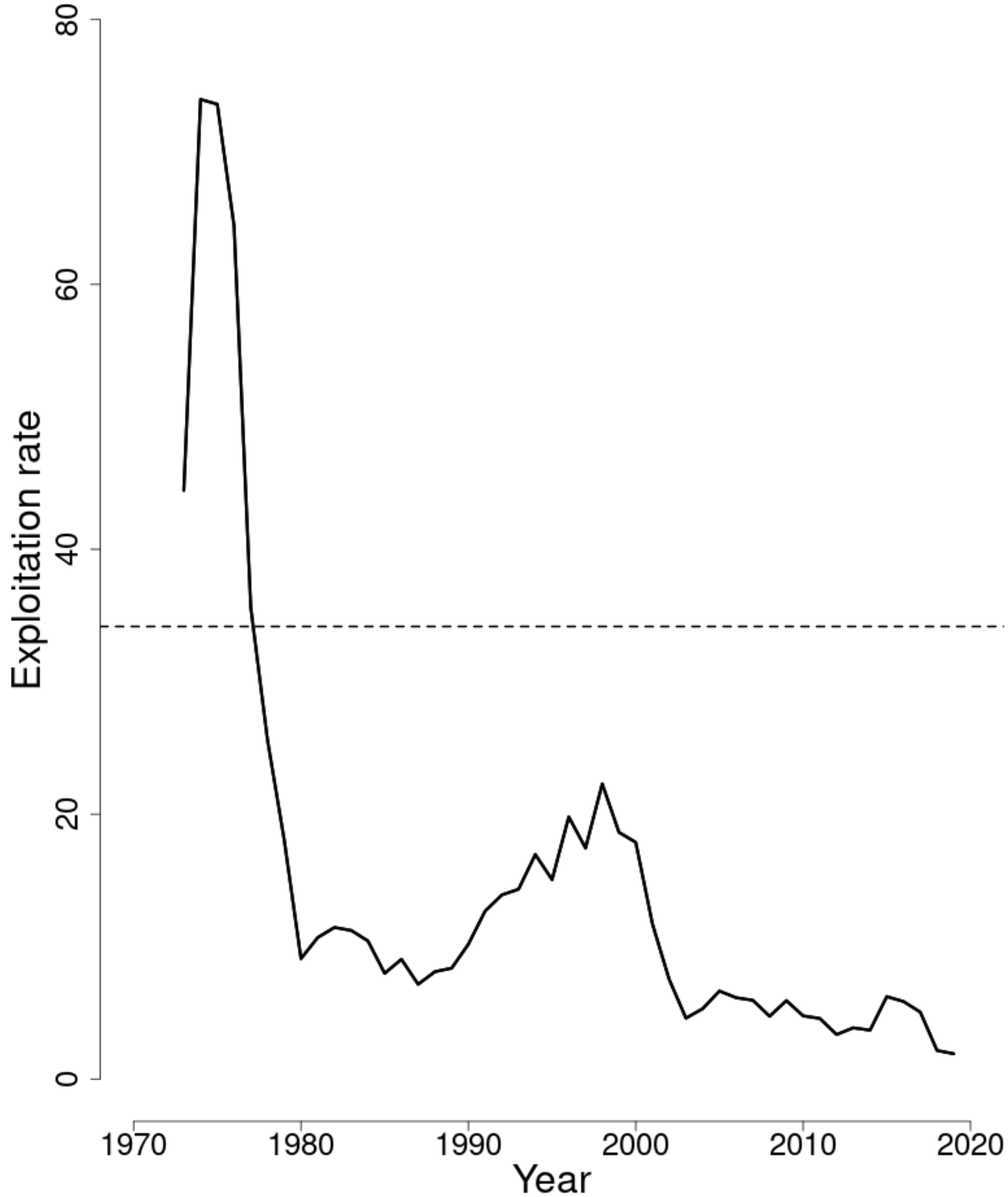


Figure 54: Trends in the 3-year average exploitation rate (Catch/NEFSC fall biomass index) of Southern silver hake between 1973 and 2018 from the current assessment.

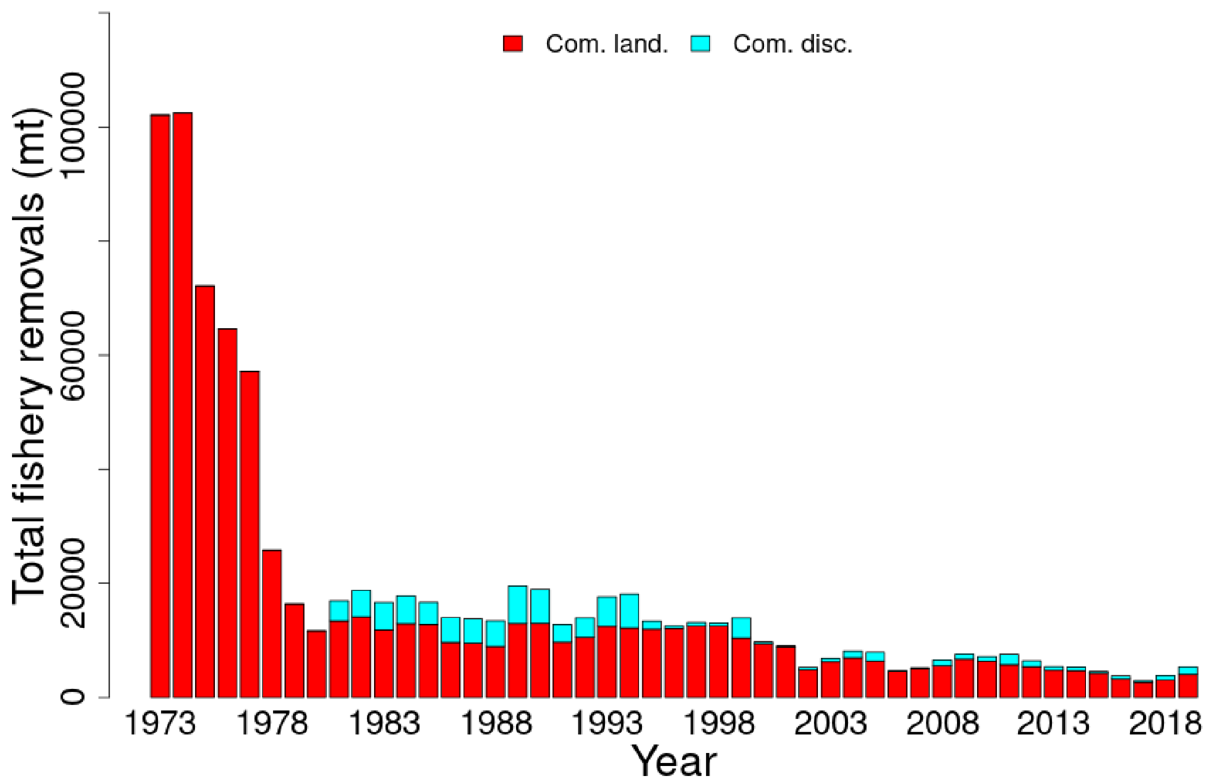


Figure 55: Total commercial catch of southern silver hake between 1973 and 2019 and by disposition (landings and discards).

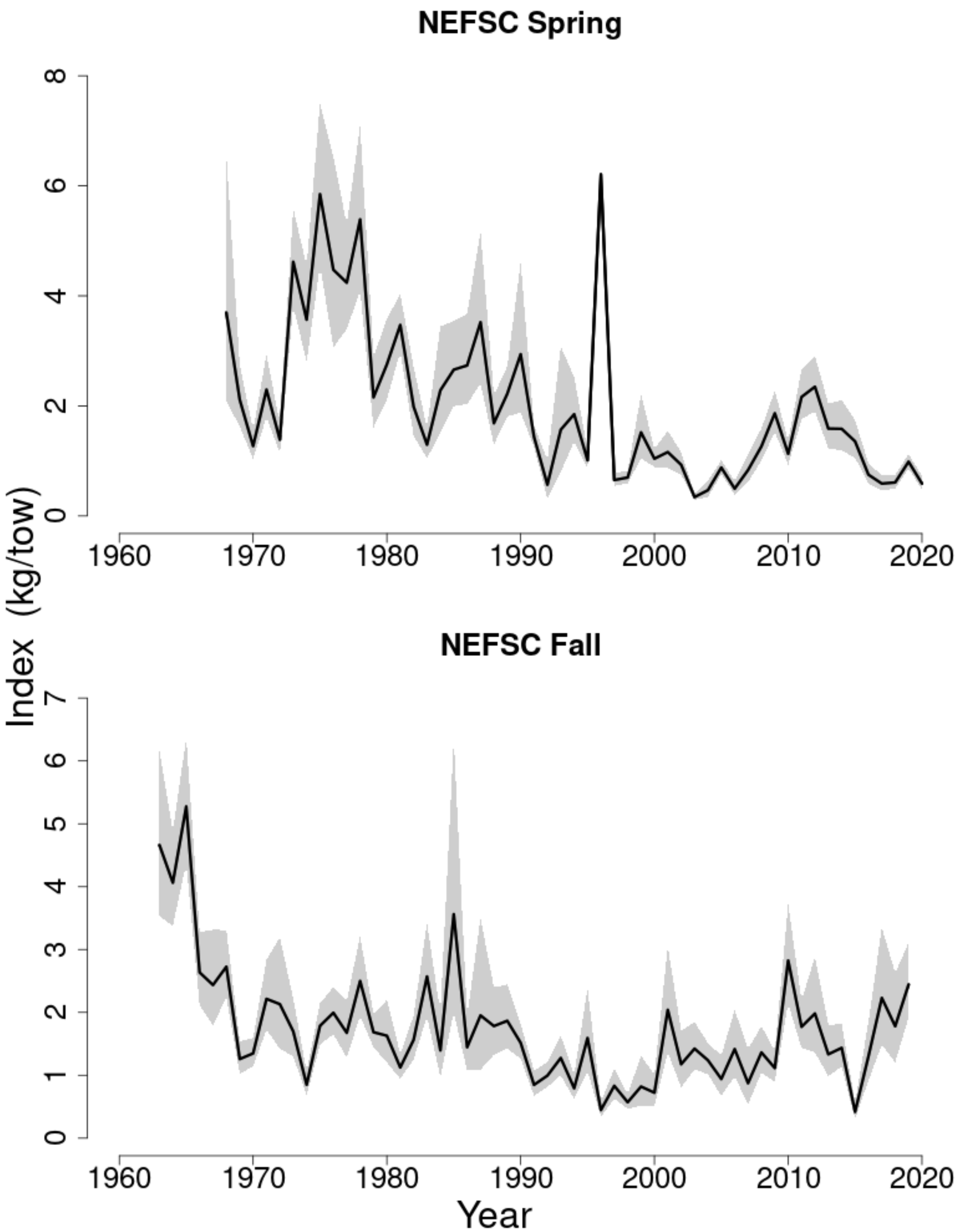


Figure 56: Indices of biomass for the southern silver hake between 1963 and 2020 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys. The approximate 90% log-normal confidence intervals are shown.

Photo Gallery

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

Measuring an Acadian redfish. Redfish can grow up to 20 inches long. Photo FishWatch.Gov. On page 48

NOAAS Albatross IV (R 342) with her trawl out astern, photographed from NOAAS Delaware II (R 445) on 22 March 2005. Public domain work of NOAA. On page 11

Albatross IV leaving Woods Hole for the last time following the decommissioning ceremony in 2008. Public domain work of NOAA. On page vi

Atlantic Halibut, out of water. Photo NOAA. On page 68

Research vessel NOAAS Henry B. Bigelow, named after Henry Bryant Bigelow (1879–1967) oceanographer and marine biologist. Photo from NOAA website. On page 116

Fishing vessel F/V Karen Elizabeth inbound from a scallop trip. The twin trawling drum wheels are visible at the rear. On page 134

Red Hake swimming in blue water. Photo NOAA. On page 115

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

Shrimp, mussels, scallop, and fish dish. Credit: iStock. On page i

Silver Hake swimming in blue water. Photo NOAA. On page 124

Aerial view of the buildings and wharves at the Woods Hole Oceanographic Institute, MA. Two research vessels are docked for re-supply. Photo WHOI. On page 5

A Windowpane flounder swimming over a sandy bottom. Photo NOAA. On page 88

Sebastes fasciatus, commonly known as Acadian Redfish, Redfish, Ocean perch, Labrador redfish; range: New England/Mid-Atlantic. Artwork from NOAA website. On page 45

Hippoglossus hippoglossus, commonly known as Atlantic Halibut, Halibut; range: New England/Mid-Atlantic. Artwork from NOAA website. On page 67

Zoarces americanus, commonly known as Ocean Pout; range: New England/Mid-Atlantic. Artwork from NOAA website. On page 95

Urophycis chuss, commonly known as Red Hake, Ling or Squirrel hake; range: New England/Mid-Atlantic, Southeast. Artwork from NOAA website. On pages 102, 112

Merluccius bilinearis, commonly known as Silver Hake, Whiting, Atlantic hake, New England hake; range: New England/Mid-Atlantic, Southeast. Artwork from NOAA website. On pages 123, 131

Scophthalmus aquosus, commonly known as Windowpane Flounder, Sand dab; range: New England/Mid-Atlantic. Artwork from NOAA website. On pages 75, 85

Pseudopleuronectes americanus, commonly known as Winter Flounder, Flounder, Sole, Lemon sole, Georges Bank flounder, Blackback flounder; range: New England/Mid-Atlantic, Southeast. Artwork from NOAA website. On pages 8, 23, 35

Anarhichas lupus, commonly known as Atlantic wolffish; range: New England/Mid-Atlantic. Artwork from NOAA website. On page 56

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