draft working paper for peer review only

Georges Bank Atlantic cod

2024 Management Track Assessment Report

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National Oceanic and Atmospheric Administration
National Marine Fisheries Service
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Compiled 06-10-2024

This assessment of the Georges Bank Atlantic cod (Gadus morhua) stock is the first management track (MT) assessment following the 2023 research track (RT) assessment (NEFSC In Prep.) and adopts the new RT stock definition. This assessment updates the RT assessment model, catch and index data, and reference points through 2023. These updates included: recalibrated NEFSC indices, revised weight-at-age and Canadian commercial landings-at-age, and updating US landings and discards using the Catch Accounting and Monitoring System (CAMS). Additionally, short-term projections were updated through 2027.

State of Stock: Based on this updated assessment, the Georges Bank Atlantic cod (*Gadus morhua*) stock is overfished and overfishing is not occurring (Figures 1-2). Retrospective adjustments were not made to the model results because the retrospective pattern was minor. Spawning stock biomass (SSB) in 2023 was estimated to be 2,668 (mt) which is 32% of the biomass target (SSB_{MSY} *proxy* = 8,290; Figure 1). The 2023 fully selected fishing mortality was estimated to be 0.13 which is 56% of the overfishing threshold proxy (F_{MSY} *proxy* = 0.233; Figure 2).

Table 1: Catch and status table for Georges Bank Atlantic cod. All weights are in (mt) recruitment is in (000s) and F_{Full} is the fishing mortality on fully selected ages (9+). Model results are from the current updated WHAM assessment.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
				Data						
US Landings	842	783	626	196	221	236	216	174	87	80
US Discards	9	22	19	9	7	3	9	10	11	7
Canadian Landings	430	472	428	474	510	388	362	420	309	321
Canadian Scallop Discards	15	13	9	7	5	5	11	5	10	8
Canadian Groundfish Discards	13	7	3	7	2	3	4	6	7	0
Combined total catch (US and Canada)	1,310	1,298	1,085	693	745	634	603	615	423	417
				Model Results						
Spawning Stock Biomass	4,528	4,365	6,519	9,598	9,065	5,783	3,984	3,490	3,111	2,668
F_{Full}	0.3	0.28	0.182	0.066	0.081	0.107	0.137	0.156	0.131	0.13
Recruits	498	203	181	261	660	552	633	1,114	1,180	605

Table 2: Reference points estimated in the current Management Track assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold and estimates are reported with 95% confidence bounds.

	2023	2024
F_{MSY} *proxy*		0.23 (0.22 - 0.25)
SSB_{MSY} (mt)		8290 (4678 - 14690)
MSY (mt)		1930 (1084 - 3438)
Median recruits (age 1) (000s)		646
Overfishing	Unknown	No
Overfished	Unknown	Yes

Projections: Short term projections of biomass and catch were conducted in WHAM (Stock and Miller, 2021) using the standard projection approach. Following the 2023 RT decision, projections used terminal year fishery selectivity and a recent 5 year average of the maturity ogive and weights-at-age. Interim catch in 2024 was assumed to be equal to catch in 2023 (417 mt), and fishing was projected at F_{MSY} *proxy* for 2025-2027. Retrospective adjustments were not applied in the projections because the retrospective pattern was minor.

Table 3: Short term projections of total fishery catch and spawning stock biomass for Georges Bank Atlantic cod based on a harvest scenario of fishing at F_{MSY} *proxy* between 2025 and 2027. Catch in 2024 was assumed to be 417 (mt).

Year	Catch (mt)	SSB (mt)	F_{Full}
2024	417	2486 (929 - 6653)	0.152

Year	Catch (mt)	SSB (mt)	F_{Full}
2025	518	2089 (499 - 8739)	0.233
2026	419	1658 (277 - 9937)	0.233
2027	400	1567 (170 - 14457)	0.233

Special Comments:

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

  Recruitment is the largest source of uncertainty for this assessment. There were persistent trends in recruitment residuals that could not be fully resolved in this assessment. Additionally, insufficent port sampling, gaps in surveys, and age truncation in the NEFSC fall index terminal years make it more difficult to characterize age composition for this stock.

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

  The 7-year Mohn's ρ, relative to SSB, was 0.389 in the RT assessment and was 0.19 in 2023. The 7-year Mohn's ρ, relative to F, was -0.238 in the RT assessment and was -0.134 in 2023. The retrospective pattern was considered minor in this assessment because the ρ adjusted estimates of 2023 SSB (SSB_{ρ}=2242) and 2023 F (F_{ρ}=0.15) were within the approximate 90% confidence regions around SSB (1,528 - 4,660) and F (0.073 - 0.233). Therefore, a retrospective adjustment was not made for the determination of stock status or projections of catch. No retrospective adjustment of spawning stock biomass or fishing mortality in 2023 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?

  The reliability of population projections for Georges Bank Atlantic cod, can not be determined because of major differences between the data and methods used in the prior RT and current MT assessments. This includes a change in the survival process error assumptions, which impact how these errors propagate in projections. This stock is not yet in a rebuilding plan.

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

  Both spring and fall NEFSC bottom trawl indices were re-calibrated which had a large effect on model fit and diagnostics. Other updates with smaller effects included: updating US landings and discards in 2022-2023 from CAMS (including lobster discards) and revising WAA and Canadian commercial landings-at-age data for the entire time series. Specifications for estimating initial numbers-at-age and numbers-at-age random effects were also updated in this MT assessment. Exclusion of the lognormal adjustment for process and observation errors was adopted with minimal impacts on model fit, diagnostics and stock status, but had a relatively large impact on model results. In addition, the following data gaps occurred: the DFO spring index was not available in 2022 following a vessel change in that year, the NEFSC spring index was not available in 2023 due to sampling interruptions and insufficient nighttime sampling, and no US catch age composition was available in 2022-2023 due to insufficient port sampling so only Canadian catch composition was fit. All changes and their impacts on model fit and diagnostics are described at length in the supplemental materials.

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

  This is the first MT assessment for the new Georges Bank Atlantic codstock definition, so official stock status was unknown prior to this assessment. However, the overfished status is consistent with the qualitatively determined stock status from the last Georges Bank cod MT assessment (NEFSC 2022) which was based on the prior stock definition.

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

  The Georges Bank Atlantic cod stock continues to show a truncated age structure and in the terminal two years of the assessment (2022-2023). All surveys indicate fewer old fish in recent years, but the age truncation is particularly evident in the NEFSC fall bottom trawl survey which did not observe any fish older than age 4 in the terminal two years of the assesesment. SSB estimates have remained low over the terminal four years of the assessment (2019-2023), with the 2023 estimate representing an all time low for the time series.

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

  The Georges Bank Atlantic cod assessment could be improved with increased port sampling to characterize catch for all market categories.

- Are there other important issues?

  Survey sampling interruptions could be a potential problem if they persist in future years. Shifting the MT assessment timeline to spring (June) rather than fall (September) for this stock, resulted in shortened timeframes for compiling data and completing assessment models compared to prior years. If this timing is retained in future MT assessments, data delays may continue to limit model development.

References:

[NEFSC] Northeast Fisheries Science Center. In Prep. Research Track Assessment of Atlantic Cod. US Dept Commer, Northeast Fish Sci Cent Ref Doc. XX-XX; XXX p.

[NEFSC] Northeast Fisheries Science Center. 2022. Management Track Assessments Fall 2021. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 22-07; 53 p.

Stock, B.C. and T.J. Miller. 2021. The Woods Hole Assessment Model (WHAM): A general state-space assessment framework that incorporates time- and age-varying processes via random effects and links to environmental covariates. Fisheries Research, 240, p.105967. https://doi.org/10.1016/j.fishres.2021.105967.

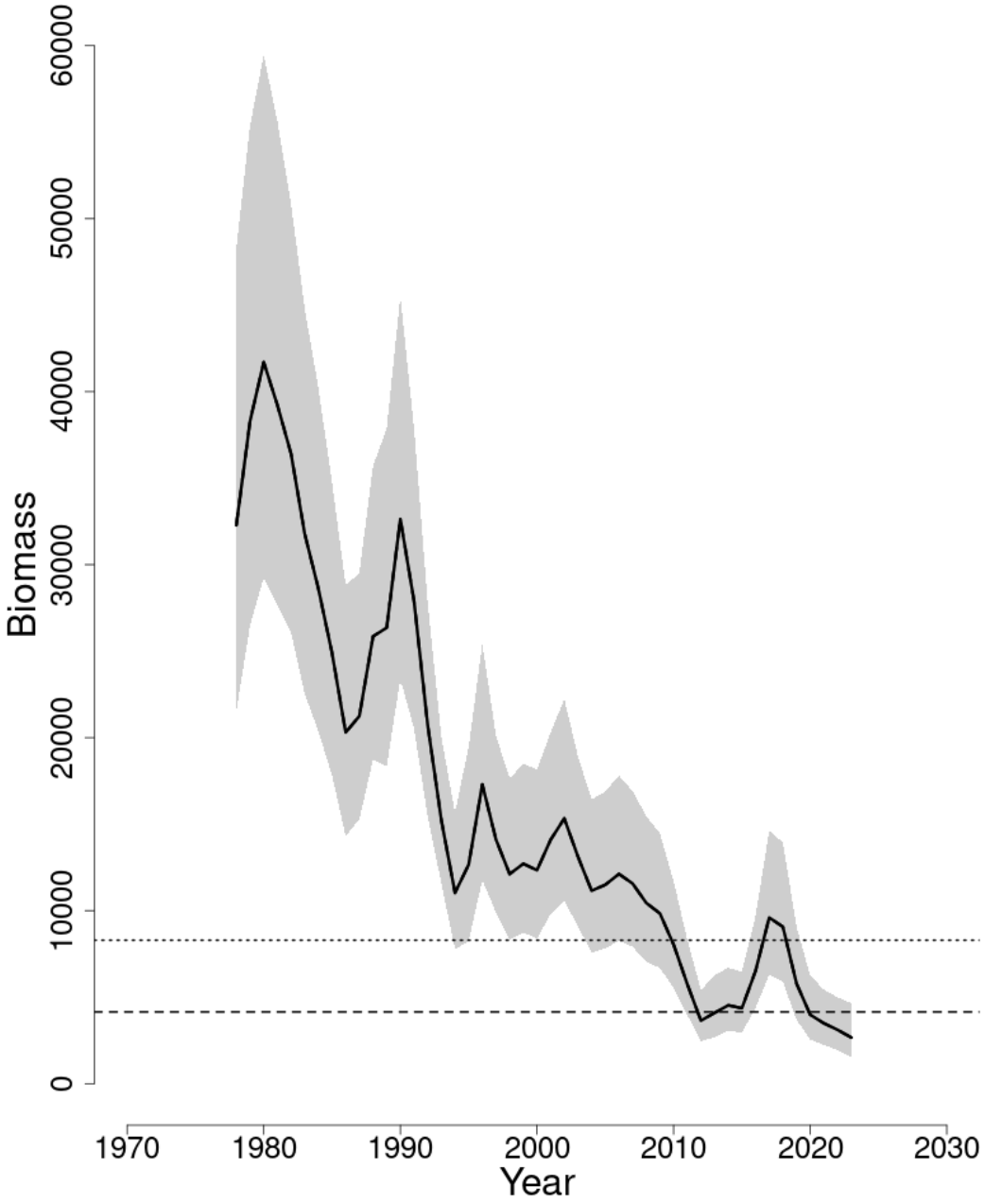

Figure 1: Trends in spawning stock biomass of Georges Bank Atlantic cod between 1978 and 2023 from the current Management Track (solid line). The corresponding $SSB_{Threshold}$ ($\frac{1}{2}$ SSB_{MSY} *proxy*; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} *proxy*; horizontal dotted line) are based on the 2024 assessment. The approximate 90% lognormal confidence intervals are shown.

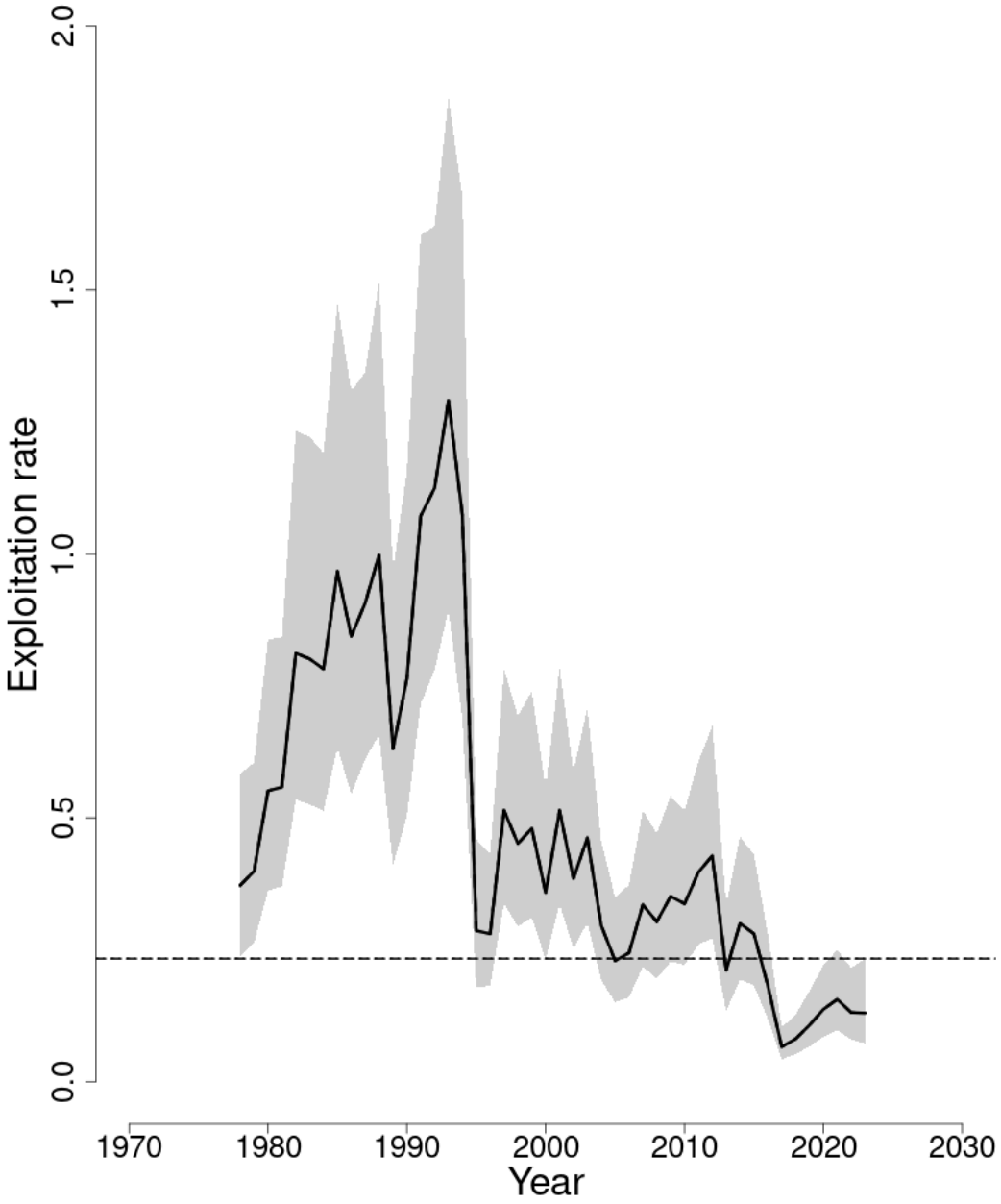

Figure 2: Trends in the fully selected fishing mortality (F_{Full}) of Georges Bank Atlantic cod between 1978 and 2023 from the current Management Track (solid line) and the corresponding $F_{Threshold}$ (F_{MSY} *proxy*=0.233; horizontal dashed line). The approximate 90% lognormal confidence intervals are shown.

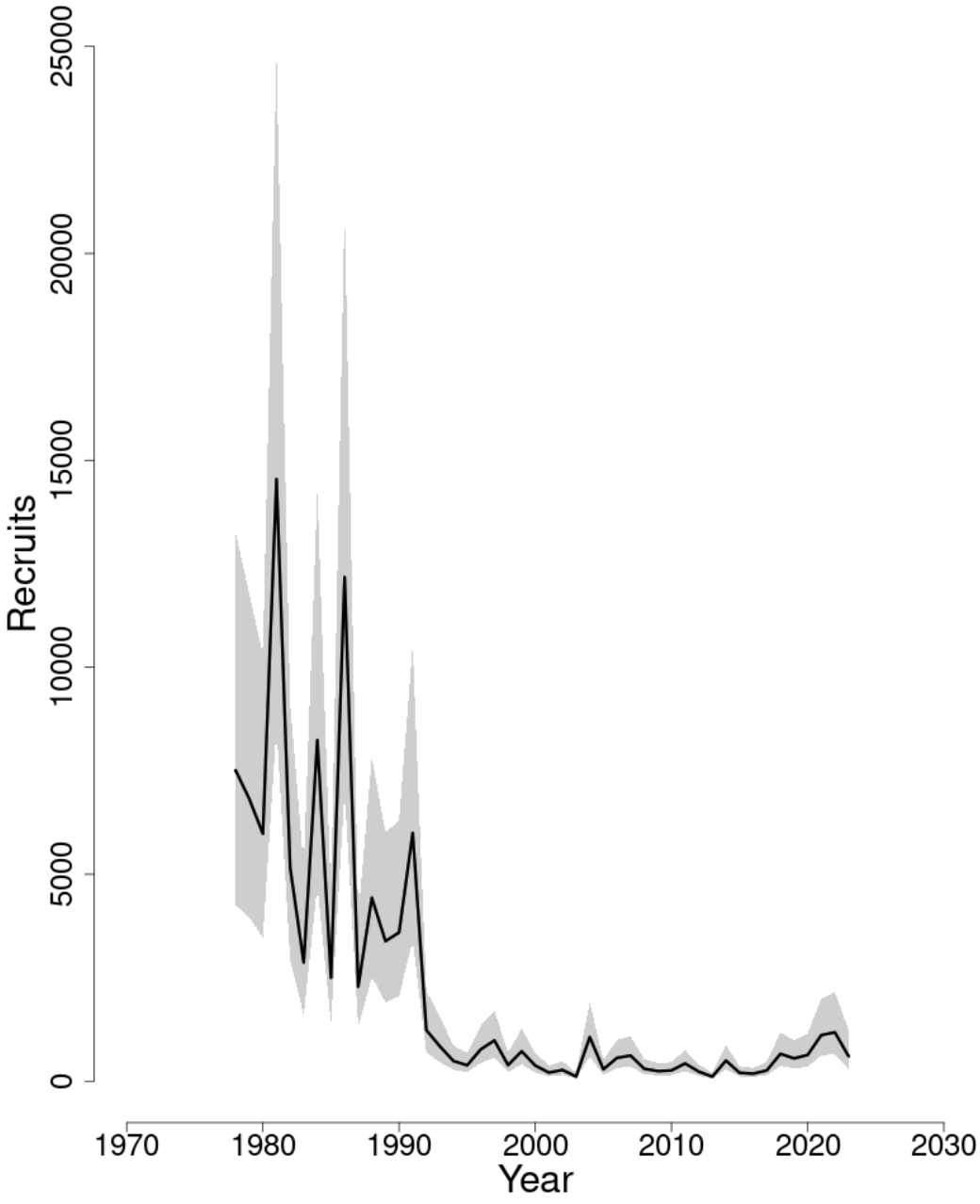

Figure 3: Trends in Recruits (000s) of Georges Bank Atlantic cod between 1978 and 2023 from the current Management Track (solid line). The approximate 90% lognormal confidence intervals are shown.

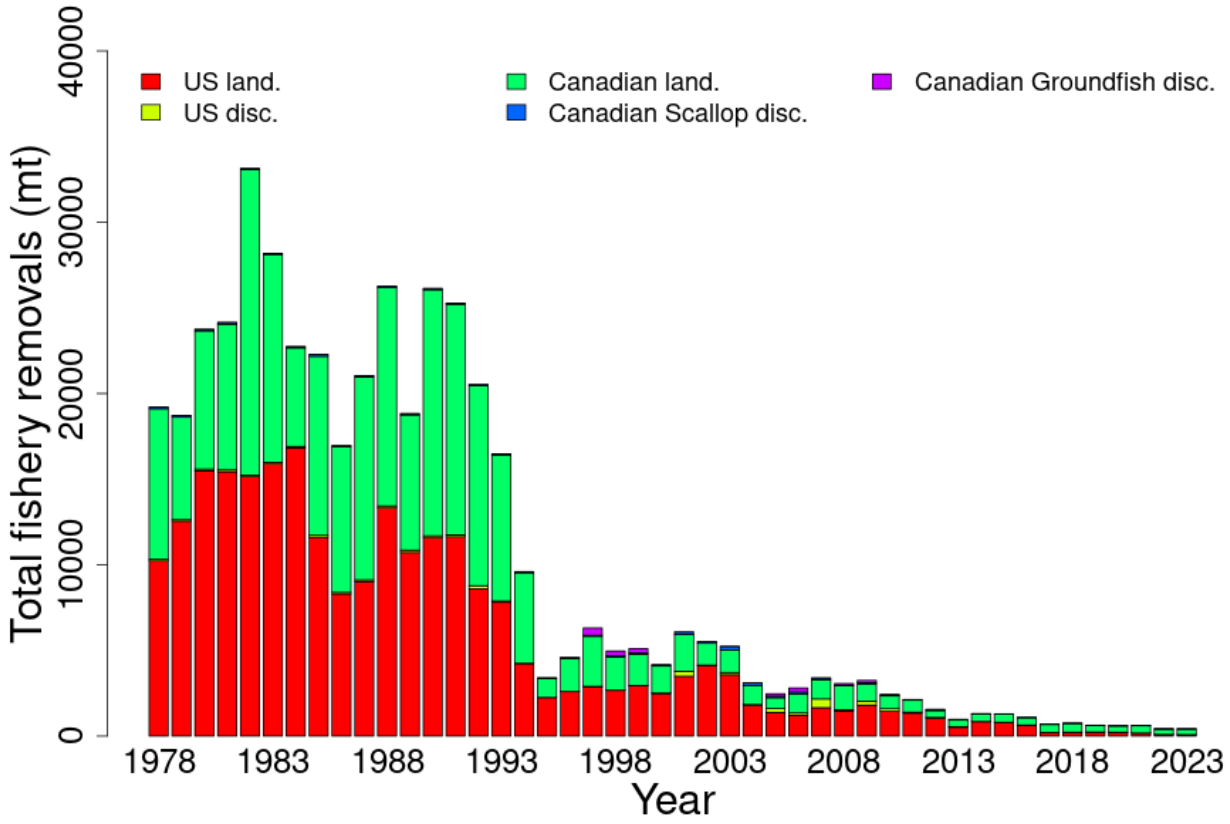

Figure 4: Total catch of Georges Bank Atlantic cod between 1978 and 2023 by fleet component (commercial US and Canadian) and disposition (landings and discards).

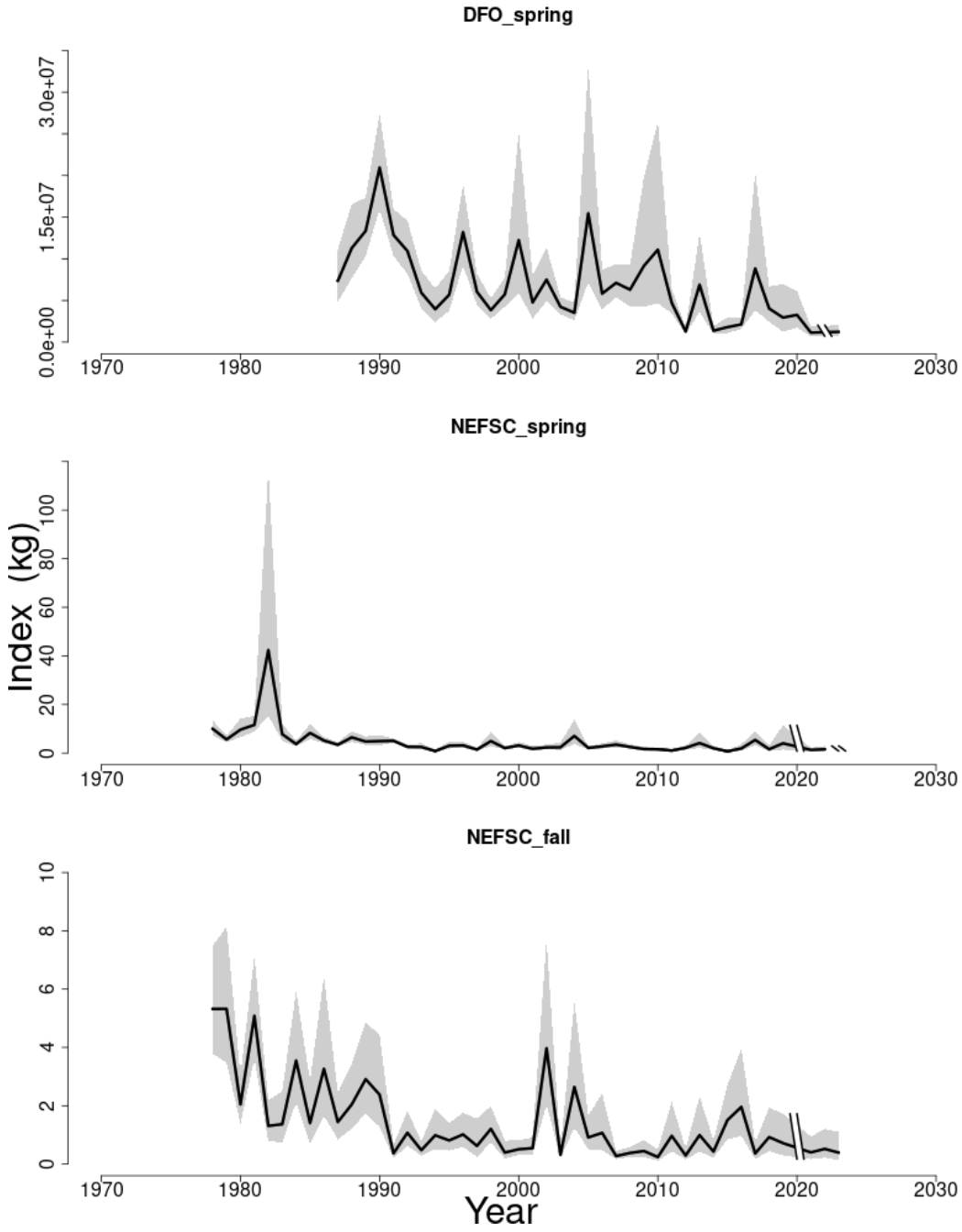

Figure 5: Indices of biomass for the Georges Bank Atlantic cod between 1978 and 2023 for the Department of Fisheries and Oceans Canada (DFO) spring (top), Northeast Fisheries Science Center (NEFSC) spring (middle) and fall (bottom) bottom trawl surveys. Gaps where data is not available are indicated by parallel breaks in the time series. The approximate 90% lognormal confidence intervals are shown.