

draft working paper for peer review only



Georges Bank haddock

2022 Management Track Assessment Report

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

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This assessment of the Georges Bank haddock (*Melanogrammus aeglefinus*) stock is a Level-2 operational update of the 2021 research track assessment, which used the WHAM framework. Prior to the 2021 research track, the last benchmark for this stock was in 2008 (Brooks et al., 2008). Based on the previous update assessment in 2019 (NEFSC, 2022), the stock was not overfished, and overfishing was not occurring. Stock status was not reported for the 2021 research track, but the stock was not overfished and overfishing was not occurring. This assessment updates commercial fishery catch data, research survey indices of abundance, weights and maturity at age, and the WHAM assessment model and reference points through 2021. Stock projections have been updated through 2025. This report reflects decisions made during the Peer Review September 19-22, 2022.

State of Stock: Based on this updated assessment, the Georges Bank haddock (*Melanogrammus aeglefinus*) stock is not overfished, and overfishing is not occurring (Figures 1-2). Retrospective adjustments were not made to the model results. Spawning stock biomass (SSB) in 2021 was estimated to be 79,513 (mt) which is 66% of the biomass target ($SSB_{MSY} proxy = 120,580$; Figure 1). The 2021 average fishing mortality on ages 5-7 was estimated to be 0.137 which is 55% of the overfishing threshold proxy ($F_{MSY} proxy = 0.25$; Figure 2). The $F_{MSY} proxy$ is expressed as the average F on ages 5-7.

Table 1: Catch and status table for Georges Bank haddock. All weights are in (mt), recruitment is in (000s), and \bar{F}_{5-7} is the average fishing mortality on ages 5 to 7. Model results are from the current updated WHAM assessment. A rho adjustment was not applied to values in this Table.

	2014	2015	2016	2017	2018	2019	2020	2021
<i>Data</i>								
US Commercial discards	1,409	1,552	1,880	786	410	306	178	49
US Commercial landings	4,240	4,762	3,682	3,217	4,017	5,252	6,648	3,641
Canadian Catch	12,953	14,374	11,713	13,384	12,222	14,160	11,052	7,001
Catch for Assessment	18,601	20,687	17,274	17,387	16,647	19,719	17,878	10,691
<i>Model Results</i>								
Spawning Stock Biomass	130,266	182,309	187,864	218,393	131,917	114,415	99,365	79,513
\bar{F}_{5-7}	0.377	0.313	0.208	0.148	0.146	0.18	0.198	0.137
Recruits (age 1)	1,504,138	67,659	109,014	114,816	20,336	28,142	16,332	96,151

Table 2: Comparison of reference points estimated from the 2019 VPA assessment and from the current assessment update. An $F_{40\%}$ proxy was used for the overfishing threshold. The medians and 95% probability intervals are reported for MSY, SSB_{MSY}, and RMSY, based on WHAM projections with fishing mortality fixed at $F_{40\%}$.

	2019	2022
$F_{MSY} proxy$	0.33	0.25
SSB_{MSY} (mt)	138,924	120,580 (94,687 - 153,555)
MSY (mt)	24,400	25,494 (19,979 - 32,533)
Median recruits (age 1) (000s)	59,143	25,607 (835 - 785516)
<i>Overfishing</i>	No	No
<i>Overfished</i>	No	No

Projections: Short term projections were conducted in WHAM, which propagates uncertainty in the processes of recruitment and transitions between numbers at age. For projection specifications, the Plan Development Team supplied an estimate of total catch for 2022, and fishing mortality was set equal to F40%SPR for 2023-2025. Annual fishery selectivity and maturity were fixed at a recent 2 year average (2020-2021 values), following analyses and decisions made at the 2021 research track. Weights at age for catch and SSB that were predicted from a

Gaussian Markov Random Field (GMRF) model, rather than a recent 2 year average, were preferred by the peer reviewers for this management track, and were used in the projections summarized in this report. Retrospective adjustments were not applied. The Overfished threshold is 60,290 mt, and the stock is not projected to drop below this value in 2025.

Table 3: Short term projections of total fishery catch and spawning stock biomass (with 95% CI) for Georges Bank haddock based on a harvest scenario of fishing at 100% F_{MSY} proxy between 2023 and 2025. Catch in 2022 was assumed to be 9,914 mt (estimate provided by the Groundfish Plan Development Team).

Year	Catch (mt)	SSB (mt)	F_{5-7}
2022	9,914	79,457 (39,624 - 159,332)	0.147 (0.069 - 0.311)

Year	Catch (mt)	SSB (mt)	F_{5-7}
2023	18,482 (7,332 - 46,591)	90,073 (35,695 - 227,286)	0.272
2024	17,287 (5,680 - 52,616)	81,027 (25,060 - 261,981)	0.272
2025	14,555 (3,926 - 53,958)	69,916 (17,543 - 278,641)	0.272

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).

Sources of uncertainty include dynamics in the plus group, the magnitude of the 2020 and 2021 year classes, and future assumptions about weights and selectivity at age. The 2013 year class, the largest ever observed for this stock, accounts for 20% of the population abundance in 2021 (at age 8), and is in the plus group for all of the projections. It's contribution to catch (in biomass) in the projections is 35% in 2022, and diminishes to 17% in 2025. However, negative annual deviations have been estimated in the plus group in recent years, and it is uncertain if this will persist in projections. Catches in 2023-2025 are reliant on the 2020 year class, which constitutes 33% - 41% of the 2023-2025 catch (in biomass). The 2022 year class is not part of the model input, but initial observations in the survey suggest that it may be close to the time series average; additional observations in future surveys are needed to confirm this. Projections from the research track assessment (with data through 2019) aligned well with estimates from the current assessment model (updated with data through 2021), in spite of the projected selectivities being consistently less than the model estimated selectivities from the current assessment. The accuracy of projected weights varied based on the year and year class, with some being very accurate and others over- or underestimated. A sensitivity projection was made using weights estimated from a Gaussian Markov random field (GMRF, methodology in Nielsen, manuscript in preparation), and the review panel recommended using these for projections instead of the 2 year average weights at age. These GMRF weights at age predicted a slightly greater increase in weights at age in later years of projections (with large uncertainty bounds), and consequently produced larger estimates of catch and SSB in 2022-2025 compared to projections using a two year average for weights at age. Long range accuracy for projecting weights and selectivity is not expected, given the many factors that influence those processes.

- Does this assessment model have a retrospective pattern? If so, is the pattern minor, or major? (A major retrospective pattern occurs when the adjusted SSB or \bar{F}_{5-7} lies outside of the approximate joint confidence region for SSB and \bar{F}_{5-7}).

The 7-year Mohn's ρ , relative to SSB, was 0.70 in the 2019 assessment and was 0.26 in 2021. The 7-year Mohn's ρ , relative to F, was -0.44 in the 2019 assessment and was -0.27 in 2021. There was a minor retrospective pattern for this assessment because the ρ adjusted estimates of 2021 SSB ($SSB_{\rho}=79,513$) and 2021 F ($F_{\rho}=0.137$) were inside the estimated 95% confidence regions around SSB (46,084 - 137,174) and F

(0.073 - 0.259). No retrospective adjustment was made for either the determination of stock status or for projections of catch in 2023.

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

As noted in the first bullet, population projections for Georges Bank haddock are uncertain due to future values of selectivity and weights at age, dynamics of the plus group, and magnitude of incoming 2020 and 2021 year classes. This stock is not in a rebuilding plan.

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

No changes, other than the incorporation of new data, were made to the Georges Bank haddock assessment for this update. NEFSC indices from 2009-2021 were calculated using tow-specific swept area.

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

The stock status of Georges Bank haddock has not changed.

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

The Georges Bank haddock shows a broad age structure, and broad spatial distribution. This stock has produced several exceptionally strong year classes in the last 20 years, leading to record high SSB in the last decade. As the strong year classes age out of the population, abundance has returned to levels last observed in the early 2000s, which could potentially lead to an increase in weights at age as growth is released from density-dependent pressures. Catches in recent years have been well below the total quota (US+Canada), but projected catch levels will be substantially less than recent quotas due to declining abundance and the combined effect of re-estimated Canadian weights at age and a re-estimated length-based calibration for the NEFSC Albatross IV : H.B. Bigelow vessels.

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

The research track assessment in 2021 for Georges Bank haddock strongly recommended studies to collect data to re-estimate gutted to whole weight conversion factors, as well as measuring individual fish weight in addition to the length and otolith sampling performed on commercially landed fish.

- Are there other important issues?

The Georges Bank haddock assessment estimates that the haddock stock has declined to levels last observed in the early 2000s. Projections at F40% using GMRP weights at age predict a slight increase in SSB in 2023 but then a decline in 2024-2025. Projections at F40% using a two year average for weights at age predicted a steady decline in SSB, with the stock on the cusp of overfished in 2024, and overfished in 2025. Future stock status is very dependent on assumed weights at age. Surges in stock abundance and quotas are driven by strong year classes, creating a boom and bust cycle. The current assessment shows the stock leaving the boom phase and heading in the bust direction. If initial estimates of the 2020 and 2021 year classes are at or above the time series average, this may slow the current decline.

References:

Brooks, E.N, M.L. Traver, S.J. Sutherland, L. Van Eeckhaute, and L. Col. 2008. In. Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 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. <http://www.nefsc.noaa.gov/publications/crd/crd0815/>

Northeast Fisheries Science Center. 2022. Stock Assessment Update of 14 Northeast Groundfish Stocks Through 2018. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 22-06; 232 p.

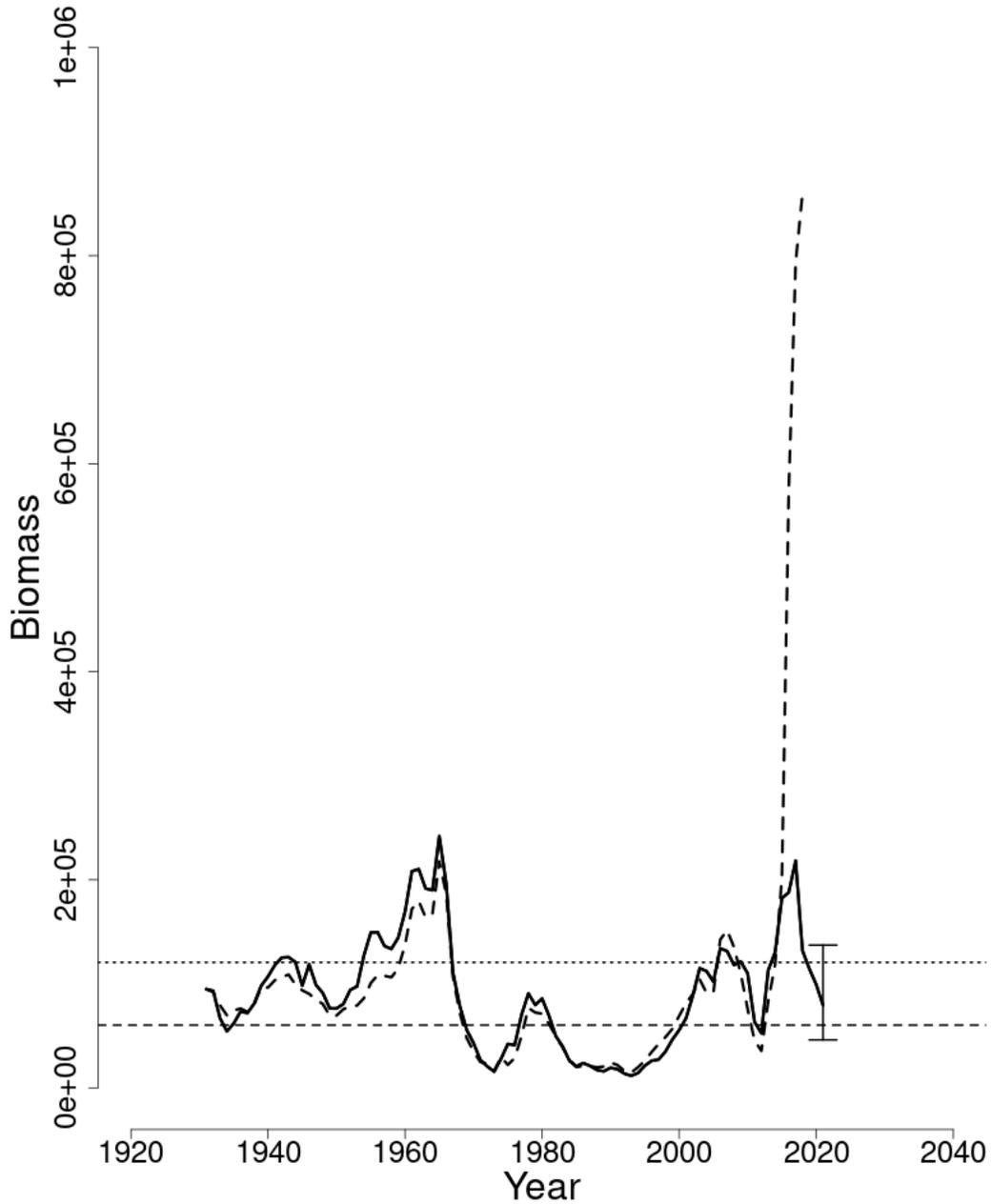


Figure 1: Trends in spawning stock biomass of Georges Bank haddock between 1931 and 2021 from the current (solid line) and previous (dashed line) 2019 assessment and the corresponding $SSB_{Threshold}$ ($\frac{1}{2} SSB_{MSY}$ proxy; horizontal dashed line) as well as SSB_{Target} (SSB_{MSY} proxy; horizontal dotted line) based on the 2021 assessment. The 95% confidence intervals are shown.

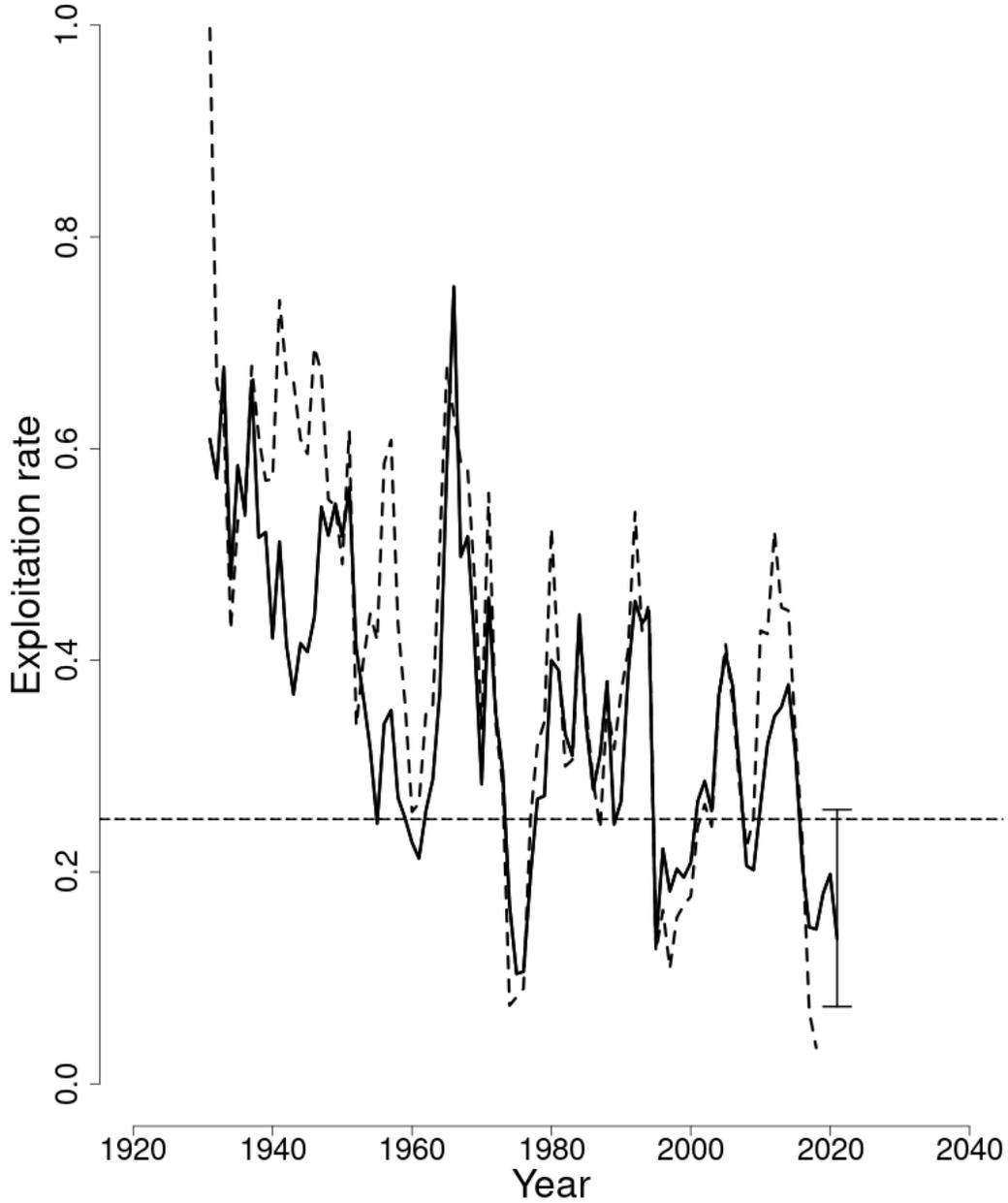


Figure 2: Trends in the average fishing mortality (\bar{F}_{5-7}) of Georges Bank haddock between 1931 and 2021 from the current (solid line) and previous (dashed line) assessment and the corresponding $F_{Threshold}$ ($F_{MSY proxy}=0.25$; horizontal dashed line) based on the 2021 assessment. \bar{F}_{5-7} was adjusted for a retrospective pattern and the adjustment is shown in red. The 95% confidence intervals are shown.

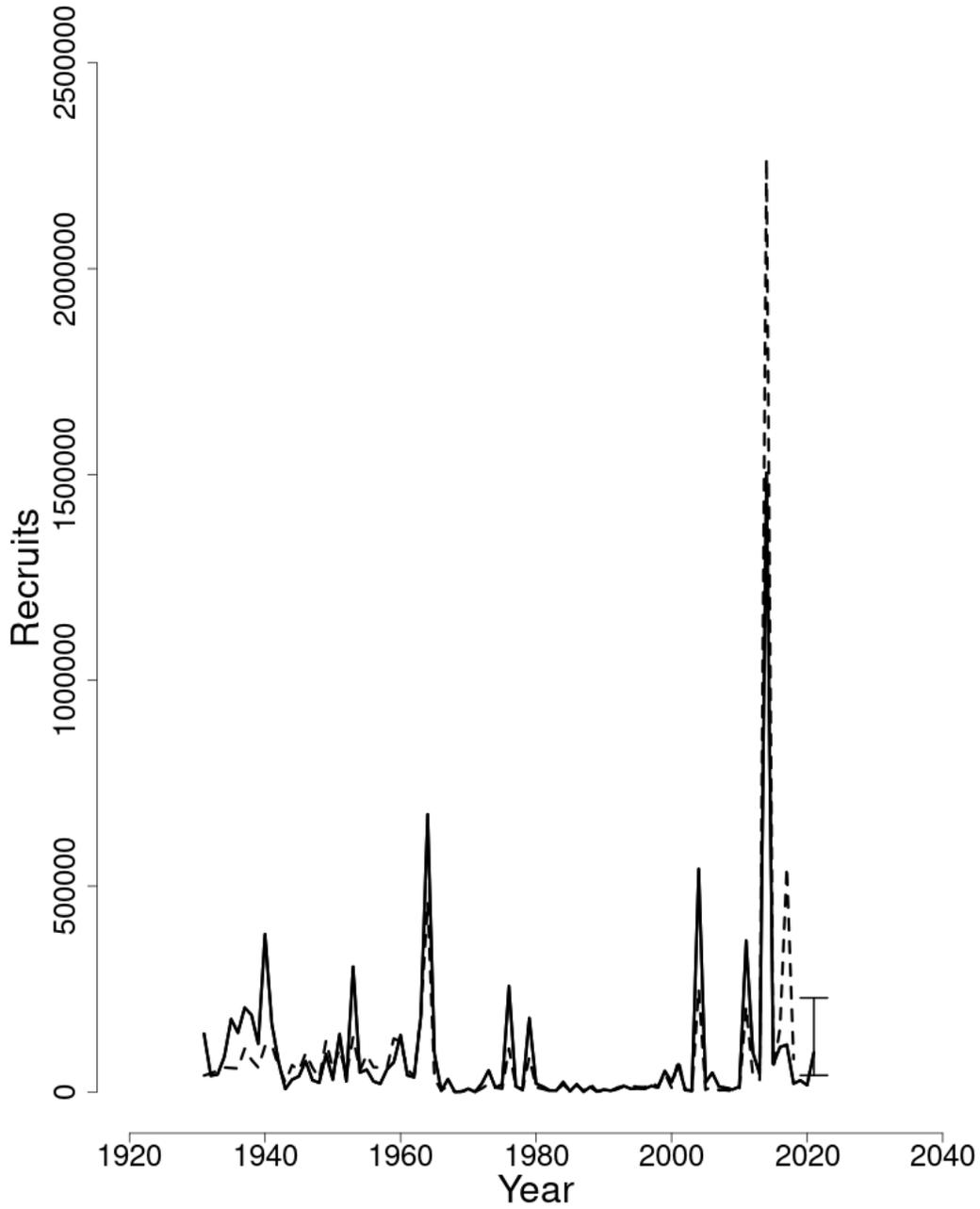


Figure 3: Trends in Recruits (age 1) (000s) of Georges Bank haddock between 1931 and 2021 from the current (solid line) and previous (dashed line) assessment. The 95% confidence intervals are shown.

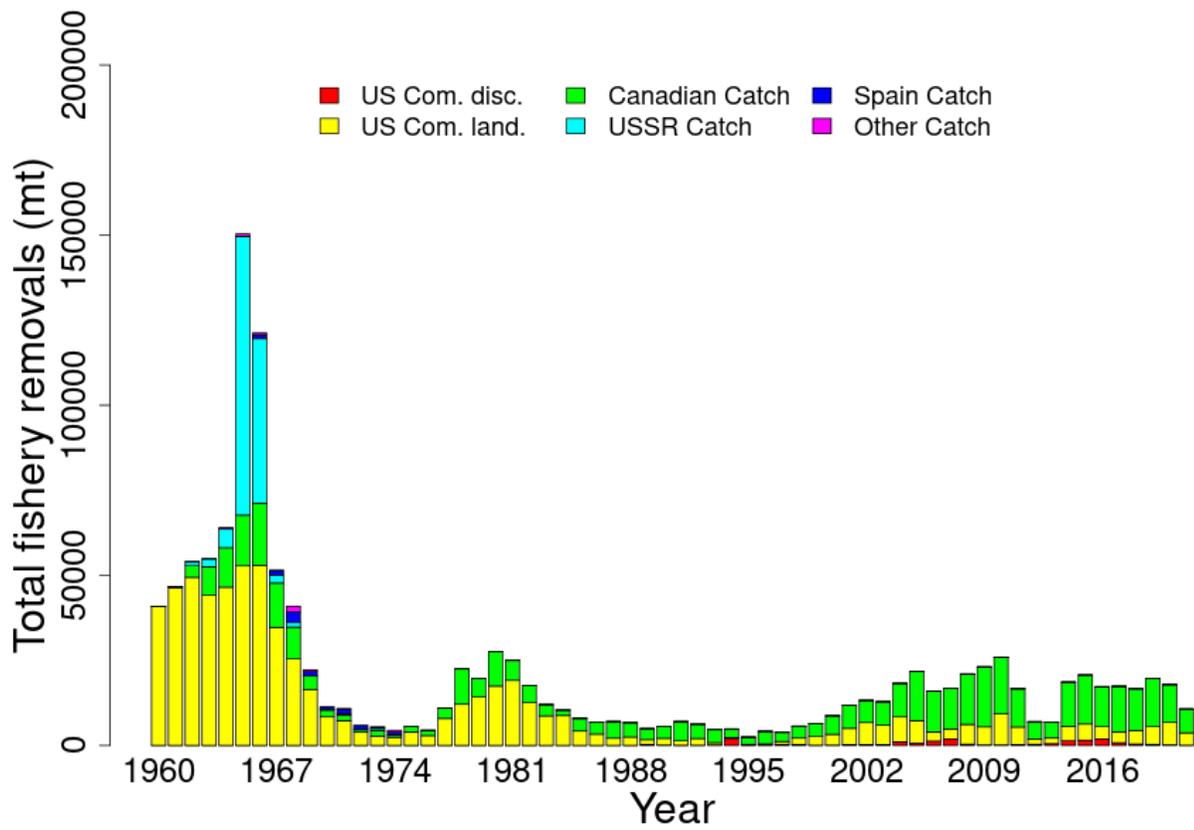


Figure 4: Total catch of Georges Bank haddock between 1931 and 2021 by fleet (US Commercial, Canadian, or foreign fleet) and disposition (landings and discards).

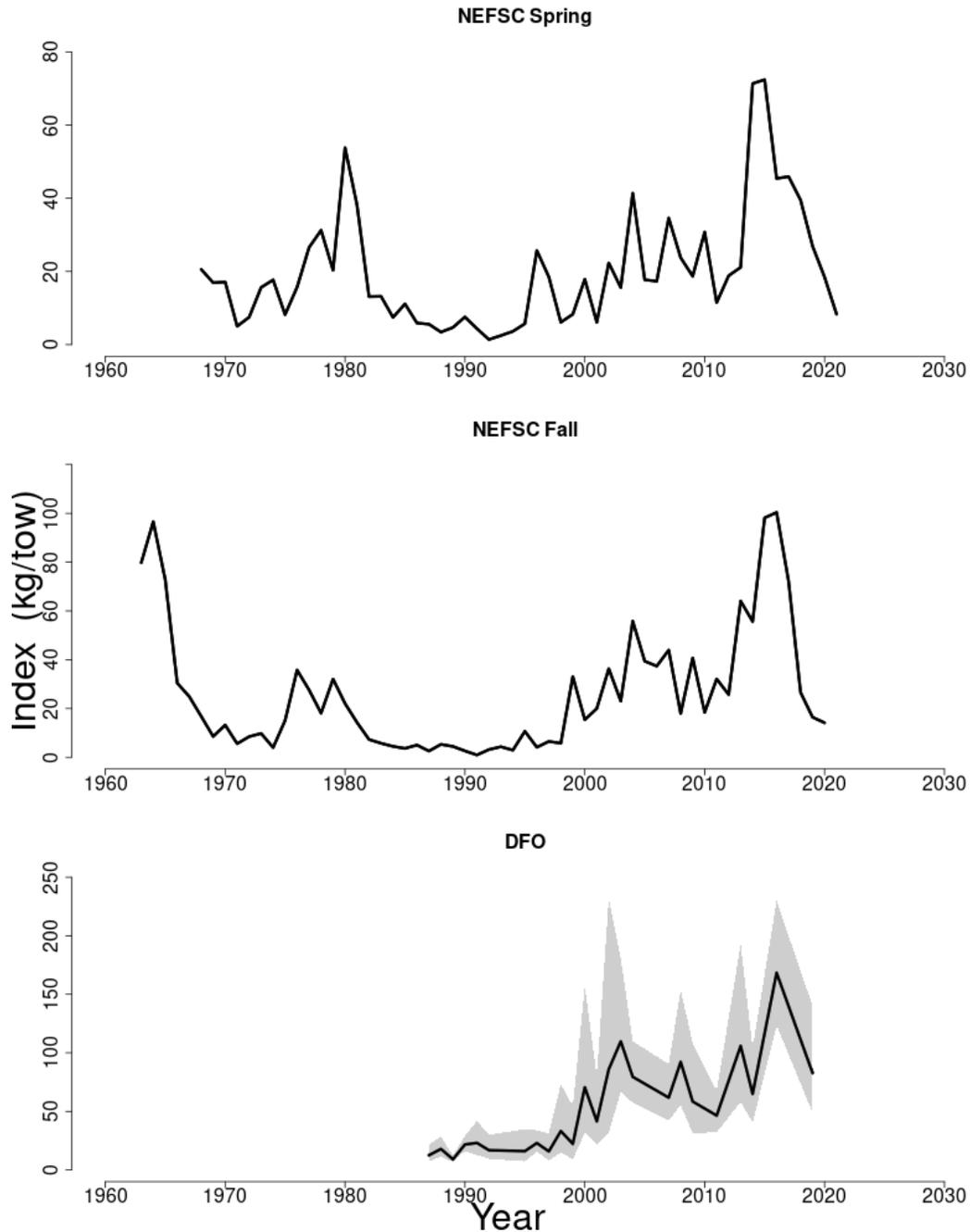


Figure 5: Indices of biomass (Mean kg/tow) for the Georges Bank haddock stock between 1963 and 2021 for the Northeast Fisheries Science Center (NEFSC) spring and fall bottom trawl surveys and the DFO winter bottom trawl survey. The approximate 95% lognormal confidence intervals are shown for DFO only. Confidence bounds for the new length-based biomass calibration are not yet available.