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Eastern Georges Bank Cod (*Gadus morhua*) Assessment to 2024

Irene Andrushchenko, Caira M. Clark, and Nathan E. Hebert

Fisheries and Oceans Canada
Saint Andrews Biological Station
125 Marine Science Drive
St. Andrews, New Brunswick, E5B 0E4

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

Fisheries and Oceans Canada (DFO) completed the development of the Canadian stock assessment framework for eastern Georges Bank (5Zjm) Atlantic Cod in May 2025. This document details the first application of the framework to provide stock status and catch advice for eastern Georges Bank (EGB) Cod. The fishery and survey information have been updated to 2024, with conversion factors applied to the 2022 DFO Winter Ecosystem Research Vessel Survey data to make it comparable to the rest of the time series. Presence of fish in deeper water strata around Georges Bank in 2022 and 2024 prompted attempts to incorporate these into the assessment. The parameterization of the population model used to assess the stock (EGB model) is identical to that approved at the framework. Stock status for 2024 is provided alongside projections under various fishing scenarios.

INTRODUCTION

Fisheries and Oceans Canada (DFO) completed the development of the Canadian stock assessment framework for transboundary (5Zjm) Atlantic Cod in May 2025 (Andrushchenko et al. 2026a, 2026b, 2026c). This document details the first application of the approved modeling framework with data updated to 2024 to provide stock status and catch advice for eastern Georges Bank (EGB) Cod.

DATA

The fishery and survey data times series were extended to include the 2024 calendar year. The updated fishery information, including total removals by the Canadian and United States (US) fisheries are available in Table 1. The Canadian fishery catch at age (CAA), as well as the sampling used to characterize the catch are shown in Table 2 and Table 3. The 2024 US fishery CAA is not available; the model continues to treat it as missing since 2020 (Table 4). The updated total biomass index, coefficient of variation (CV), and abundance at age indices for the three surveys (DFO Winter Ecosystem Research Vessel Survey [herein referred to as DFO Winter Survey], National Marine Fisheries Service (NMFS) Spring and Fall surveys) are available in Table 5, Table 6, and Table 7. The DFO Winter Survey data products including stratum 5Z9 (see DFO Deepwater Stratum section) are provided in Table 8.

All data processing follows the methodology accepted at the assessment framework peer review. Two new data considerations are outlined in subsequent sections, DFO Conversion Factors and DFO Deepwater Strata.

DFO CONVERSION FACTORS

Starting in 2025, the Canadian Coast Guard ship (*CCGS) Capt. Jacques Cartier* deploying a Northeast Fisheries Science Center Ecosystem Survey Trawl (NEST) has become the primary survey vessel and gear used for the DFO Winter Survey. The 2022 DFO Winter Survey was carried out using the Cartier and NEST, but when it became clear that conversion factors would not be available for a few years, the 2023 and 2024 surveys were conducted using the old vessel and gear. Consequently, the DFO Winter Survey time series used during framework model development was missing DFO Winter Survey data from the 2022 year. The methodology for estimating conversion factors has been peer-reviewed (Yin et al. In Prep[1]) and preliminary conversion factors for the DFO Winter Survey are now available.

Although the methodology has been peer-reviewed and accepted, the DFO Winter Survey conversion factor for Cod shows some season and area-specific trends (Figure 1). Candidate conversion factors differ with respect to the comparative survey data sets included. The ‘base’ conversion factor uses comparative survey data from the DFO Winter Survey plus comparative sets on Georges Bank conducted during the DFO Summer Survey. The ‘sens’ conversion factor includes the ‘base’ data sets plus the comparative sets on the Scotian Shelf conducted during the DFO Summer Survey. The ‘base’ and ‘sens’ conversions are consistent across most lengths, except at the smallest (<10cm) and largest (>65 cm) sizes (Figure 1). Given that the

[1] Yin, Y., Benoît, H., and Martin, R. In Prep. Calibration of Bottom Trawl Survey Vessels: Results of Comparative Fishing Between the CCGS *Teleost* and CCGS *John Cabot*/ CCGS *Captain Jacques Cartier* on and around Georges Bank in 2022–2024. DFO Can. Sci. Advis. Sec. Res. Doc.

DFO Winter Survey routinely catches fish at lengths in excess of 65 cm, particularly in stratum 5Z9, the choice of conversion factor has a greater impact on the abundance of fish with larger lengths (Figure 2).

The 2022 data used in the model implements the ‘base’ conversion (see ‘base’ in Figure 1 and Figure 3), as it is deemed the most appropriate (see Outputs and Discussion section). The sensitivity of the model to the two conversion factors are shown in Table 9.

DFO WINTER SURVEY DEEPWATER STRATUM (5Z9)

DFO Winter Survey coverage in the deeper water north of EGB began in 2010, with four sets allocated to stratum 5Z9 each year since then (Figure 4). Inclusion of stratum 5Z9 sets in the DFO Winter Survey index requires assumptions about the fish abundance in the area prior to 2010. During the framework review, it was shown that inclusion of the stratum 5Z9 sets from available years (2010–2021, 2023) would not substantially change the signals in the index and the age compositions, and so additional work to incorporate stratum 5Z9 information into the index was not pursued.

The 2024 model run included the addition of both 2022 and 2024 information into the DFO Winter Survey biomass index and survey CAA (Table 5). A routine check of survey catches in 5Z9 showed that the survey encountered a notable amount of fish in this deeper stratum in 2022 and 2024 (Figure 5, Figure 6). In both years, the catches consisted of older fish (ages 5+, Figure 7) and the inclusion of stratum 5Z9 resulted in a notable increase in the survey biomass index (30% and 53% increase in 2022 and 2024 respectively, Figure 3). It was also noted that 2022 and 2024 coverage of stratum 5Z9 exceeded the minimum requirement of four sets observed in other years (six sets in 2022 and 13 sets in 2024; Figure 5, Figure 6).

MODEL

The parameterization of the EGB population model for this assessment is identical to that approved during the assessment framework peer review using a high number of simulations (n=2000) in the projections to capture uncertainty in model parameter estimates.

OUTPUTS AND DISCUSSION

The base model run uses data updated to 2024, including the 2022 DFO Winter Survey converted using the preliminary ‘base’ conversion. The impact of implementing either conversion on model outputs is minimal and the Mohn’s rho for recruitment, spawning stock biomass (SSB), and fishing mortality (F) are effectively equivalent (Table 9). The proposed run uses the ‘base’ conversion factor, as the decline and subsequent incline in the catch efficiency at larger sizes in the ‘sens’ conversion factor seems unrealistic given gear mechanics and fish behaviour (Figure 1).

In 2024, a wide range of ages (0–8 in strata 5Z1–4; 0–9 in strata 5Z1–4 and 5Z9, Figure 7) were observed in the DFO Winter Survey, including a notable number of Age 0 fish. Interestingly, Age 0 fish were also observed in the 2025 DFO Winter Survey, although neither the 2025 data nor the Age 0 index are included in the current model run. The NMFS Spring and Fall surveys both had a fairly truncated age structure, with maximum ages of 5 and 4, respectively (Table 6, Table 7). For all three surveys and the Canadian fishery CAA, the 2021 year class (Age 3) comprises the bulk of the 2024 numbers at age (Table 3, Table 5, Table 6, Table 7). The low number of fish aged 2 and 4 in all three of the 2024 surveys and the Canadian fishery CAA means that the above average recruitment event for the 2020 and 2022 year class estimated in

the 2023 model run is not materializing in the current model run, resulting in less optimistic projections compared to those from the 2023 model.

The presence of older fish in stratum 5Z9, particularly in the two additional years of data (2022 and 2024), creates uncertainty about the best way forward. First, it is currently unclear whether the presence of older fish in the deeper waters in 2022 and 2024 are year effects, or a consequence of higher survey coverage. Sets from the NMFS Spring Survey in that area are allocated within a much larger stratum, so coverage of the smaller area is sporadic (0–3 sets per year) and cannot be used to corroborate year effects (Figure 8). A request to increase DFO Winter Survey coverage of stratum 5Z9 to six primary stations was submitted to the DFO surveys program that, if approved, would take effect in winter 2026.

If older fish have begun to move off the bank during the DFO Winter Survey and the survey indices exclude stratum 5Z9, then a flat top selectivity assumption may not be appropriate for the DFO Winter Survey. Alternatively, inclusion of stratum 5Z9 data in the inputs would maintain the flat-top selectivity assumption, but requires additional investigation into the distribution of older fish in stratum 5Z9 prior to 2010. Given the time constraints for the current assessment, the only run which included stratum 5Z9 data assumed the contribution of 5Z9 to the DFO indices prior to 2010 was negligible (Table 8).

Inclusion of stratum 5Z9 indices results in lower natural mortality (M) plus process error estimates in the terminal years and lower estimates of survey catchability (q), resulting in slightly higher biomass compared to the run where 5Z9 is excluded (Table 9, Figure 9, Figure 10). In addition, inclusion of 5Z9 improves the Mohn's rho for recruitment, SSB, and F (seven year peel, Table 9). Finally, inclusion of the 5Z9 data results in model outputs, parameter estimates, and diagnostics which are more similar to the 2023 run (Figure 10). Consequently, the proposed run for projections and stock advice includes 5Z9.

PROJECTIONS

Projections are provided using the proposed base model run ('base' conversion factor for 2022, and inclusion of stratum 5Z9 in the DFO index with flat top selectivity) under three fishing scenarios:

1. Median catch at F_{recent}, defined as the average fishing mortality (F) over the terminal six years (2019–2024).
2. F=0.
3. Fpd: the maximum fishing mortality associated with a very low probability (<5%) of preventable decline (i.e., decline relative to F=0 scenario) in two generations (2032).

The first two scenarios were originally requested by resource managers. The third scenario was added during the assessment peer review and is consistent with current rebuilding plan guidelines for no tolerance for preventable decline when the stock is in the critical zone (DFO 2022).

The 2024 model run results in F_{recent}=0.03. During the framework, the specified F value was used to estimate removals in all projected years, including the first one. The current assessment provides projections for 2025–2027, but is taking place in the 2025 fishing year, so maximum removals for the 2025 fishing year are already known (452 mt). Consequently, the removals in the first projected year have been set to the maximum value (452 mt), while the subsequent years follow the various F scenarios (Figure 11). The projected SSB distribution, median SSB, and catch distribution under the various fishing scenarios are provided in Figures 12–14. Note

that advice is only provided for 2026 (i.e., projected year 2); all other projected years are shown for information.

STOCK STATUS AND ADVICE

The limit reference point (LRP) for EGB Cod has been defined as the SSB below which surplus production is not significantly different from zero, which was estimated as the intersection of the lower 95% confidence interval of a generalized additive model (GAM) fit to the historical surplus production versus SSB plot (Andrushchenko et al. 2026c). The 2024 median SSB (10.4 kt) is at 42% of the LRP (24.9 kt), and there is a very high probability that the stock remains in the critical zone (>98%, Figure 15).

The EGB Atlantic Cod stock has declined since the 1990s and remains in the critical zone. Despite signs of improved recruitment and growth in the early 2020s, the productivity of the stock remains low with the annual rate of fish loss (combined annual natural mortality and process error) for older ages remaining above one. There is a very high probability that SSB remains in the critical zone in the projections under all fishing scenarios, including in the absence of fishing.

ECOSYSTEM AND CLIMATE CHANGE CONSIDERATIONS

Loss of fish, parameterized as M and process error on numbers at age, is a driving factor for this stock. The combination of the two is hypothesized to reflect principally changes in natural mortality (particularly in older fish), though some movement of fish in and out of the unit was detected in 2015–2017 (Andrushchenko et al. 2026b, 2026c). The presence of older fish in stratum 5Z9, an area previously not included in the assessment inputs, in recent years indicates that fish movement off the bank after spawning may be occurring more rapidly compared to the past, and inputs may need to be adjusted to account for this. Although the mechanism driving changes in movement has not been explicitly investigated, it is likely related to ecosystem changes occurring in the area (e.g., temperature, predation, competition). Adjusting inputs to include other strata within the assessment unit should account for movement of fish between strata within the unit. If evidence of increased movement outside of the EGB Cod assessment unit appears, the combination of M and process error will implicitly account for these changes in the model. Explicitly accounting for movement of fish outside of the unit would require teasing apart loss of fish due to mortality and loss of fish due to movement, as well as coordination of adjacent assessments (i.e., 5Zjm and 4X5Y Cod stocks).

SOURCES OF UNCERTAINTY

Projections make assumptions about how various aspects of stock dynamics are expected to unfold in the near future and are informed by historic trends. There is inherent uncertainty associated with assuming that recent trends will persist in the future.

Due to time constraints, data from stratum 5Z9 was included in the DFO Winter Survey data index with the assumption that stratum 5Z9 contribution to the indices prior to 2010 was negligible. Additional work is required to check the validity of this assumption and explore alternative hypotheses.

The US fishery CAA is treated as missing in the model for the terminal five years (2020–2024). The models handle missing fishery CAA by assuming that fishery selectivity remains unchanged during this time. Currently, it is not possible to verify whether that assumption remains valid.

RESEARCH RECOMMENDATIONS

Currently, stock dynamics are projected using the numbers at age process errors which accounts for the uncertainty in M. However, should a version of the Woods Hole assessment model (WHAM) that addresses the confounding between process error on recruitment and deviations on M be made available, estimating a time- and age-varying M within the model should be pursued.

Conversion factors for a survey index can be applied forward (i.e., conversion of new data to 'old boat/gear' units) or backwards (i.e., conversion of old data to 'new boat/gear' units). Due to the recent timing of the assessment framework review, conversions for the DFO Winter Survey were applied forward. It is recommended that future work be completed to run a sensitivity with the conversion factor applied backwards and check the resulting survey catchabilities. The same sensitivity should be run for the NMFS vessel/gear switch in 2010.

Further investigation is needed into the contribution of deeper waters around the bank to the survey indices. If older fish are starting to move off the bank during the DFO Winter Survey timing (February–March), then the same effect may also be true for the NMFS Spring Survey (April–May). Given that the NMFS Spring Survey sampling intensity in the deeper waters off Georges Bank (but within the assessment/management unit) is fairly low, additional work needs to be done to see whether there are consequences to assuming a flat-top selectivity while excluding deeper water strata for the NMFS Spring Survey as well.

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TABLES

Table 1. Eastern Georges Bank (EGB) Cod landings (Land) and discards (Disc) from various sources by the US and Canadian fisheries. Units are metric tonnes. Values prior to 2010 are available in (Andrushchenko et al. 2026c. Can_ScDisc=discards from the Canadian scallop fishery; Can_GFDisc=discards from the Canadian groundfish fishery. TAC – total allowable catch. Dash – no data.

YEAR	US_Land	US_Disc	US_Total	Can_Land	Can_ScDisc	Can_GFDisc	Can_Total	EGB_TAC
2010	357	97	454	748	44	48	840	1350
2011	267	20	287	702	29	13	744	1050
2012	96	52	148	395	42	31	468	675
2013	24	16	40	385	18	21	424	600
2014	114	2	116	430	15	13	458	700
2015	111	5	116	472	13	7	492	650
2016	92	5	97	428	9	3	440	624
2017	34	4	38	474	7	7	488	730
2018	47	2	49	510	5	2	517	951
2019	30	1	31	388	5	3	396	650
2020	64	3	67	362	11	4	377	650
2021	39	2	41	420	5	6	431	635
2022	34	4	38	309	10	7	326	571
2023	30	2	32	321	9	0	329	–
2024	38	12	51	315	11	2	327	–

Table 2. Length frequency and age sample sizes used to characterize the catch for the eastern Georges Bank (EGB) Cod Canadian and US fisheries. Numbers indicate the number of fish measured (lengths) or aged (ages) from various data sources for each year. The highlighted numbers include samples from western Georges Bank. Dashes indicate commercial data not available for use in this analysis. US data are from TRAC 2023. Values prior to 2010 are available in Andrushchenko et al. 2026c).

YEAR	Canadian Lengths	Canadian Ages	US Lengths	US Ages
2010	31,354	1,455	1,446	333
2011	41,898	1,628	1,203	213
2012	51,444	1,115	598	746
2013	74,378	1,334	2,951	842
2014	60,298	1,141	547	85
2015	75,650	970	4,677	1,049
2016	78,702	938	715	149
2017	52,114	1,302	4,120	1,150
2018	58,057	1,205	1,695	412
2019	63,568	1,340	1,180	288
2020	46,002	1,157	-	-
2021	34,784	1,140	-	-
2022	32,557	1,188	-	-
2023	25,657	778	-	-
2024	43,179	1,445	-	-

Table 3. Commercial fishery abundance catch at age for the Canadian groundfish fishery on eastern Georges Bank. Units are in thousands of fish. a1–a16 are fish aged 1 to 16.

Year	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
1978	16.1	113.3	1946.6	465.3	158.5	86.3	65.6	18.4	17.7	5.0	3.0	3.6	0.6	0.3	1.0	0.6
1979	8.5	348.9	436.1	398.6	209.8	64.6	31.8	14.4	8.9	3.4	0.8	0.9	0.2	0.5	0.0	0.0
1980	6.2	659.5	844.3	170.4	502.6	158.8	36.1	5.7	27.6	16.4	1.3	0.1	0.1	0.0	0.0	0.0
1981	25.3	184.8	564.1	572.4	157.4	296.3	107.7	67.3	31.6	11.2	1.1	1.1	0.0	0.0	0.2	0.0
1982	16.3	1512.9	1401.0	936.1	659.3	165.1	269.6	101.9	36.4	17.3	25.8	1.8	0.1	2.7	0.7	0.0
1983	26.7	340.9	1288.6	828.8	347.8	199.9	78.5	92.5	46.3	3.9	13.4	2.0	0.2	0.6	0.3	0.1
1984	9.4	81.9	122.0	222.9	216.6	260.2	133.5	22.0	31.4	13.2	11.2	1.0	0.1	0.1	0.3	0.0
1985	8.6	1473.3	587.8	397.3	555.9	218.4	71.3	49.6	13.7	11.9	7.2	1.7	0.8	0.3	0.0	0.1
1986	108.1	364.9	1273.4	329.1	157.0	214.4	41.2	21.6	12.4	3.6	1.9	1.0	0.0	0.0	0.0	0.0
1987	24.8	2115.8	517.8	838.6	106.8	87.6	126.0	25.0	18.3	4.8	2.9	0.1	0.0	0.0	0.0	0.0
1988	22.7	237.4	2114.4	346.5	435.2	58.5	63.4	129.6	27.4	17.7	14.4	7.1	2.2	0.0	0.2	0.0
1989	4.7	194.6	229.5	903.8	133.1	184.2	33.1	27.0	39.9	9.8	6.3	3.3	0.1	0.3	0.0	0.0
1990	9.0	407.3	1800.5	652.8	804.4	93.0	88.4	5.8	10.4	18.1	2.7	3.1	0.6	0.0	0.6	0.0
1991	33.7	509.2	565.6	1194.6	558.6	470.3	69.4	50.9	15.0	10.5	7.7	3.5	2.4	0.2	0.6	0.0
1992	29.3	1200.7	756.9	289.6	603.4	236.0	213.0	30.8	25.5	2.8	4.8	0.6	1.0	0.1	0.0	0.0
1993	6.1	174.1	943.0	558.7	193.8	244.9	98.8	73.7	21.9	13.2	1.9	0.0	0.4	0.0	0.0	0.0
1994	3.9	122.9	282.4	604.0	233.6	40.1	52.6	24.8	17.3	1.4	0.6	0.0	0.0	0.0	0.0	0.0
1995	0.6	24.1	108.0	57.7	67.5	14.1	5.4	3.7	2.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1996	4.1	18.9	125.6	249.4	61.1	46.3	11.3	2.9	2.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0
1997	5.3	87.7	128.7	275.8	276.4	76.5	34.1	10.9	4.1	0.9	0.4	0.0	0.0	0.0	0.0	0.0
1998	2.9	73.5	230.7	112.1	113.8	88.1	15.5	10.0	3.1	0.7	0.5	0.5	0.1	0.0	0.0	0.0
1999	2.5	33.8	282.1	200.4	61.5	35.3	27.2	9.4	2.3	0.3	0.2	0.6	0.0	0.0	0.0	0.0
2000	2.0	34.6	69.8	233.1	88.1	27.7	18.8	9.3	1.5	0.4	0.3	0.0	0.0	0.1	0.0	0.0
2001	3.2	11.6	193.2	109.6	219.9	66.3	22.6	12.2	3.7	0.3	0.1	0.0	0.0	0.1	0.0	0.0
2002	0.4	5.8	39.8	162.1	45.0	80.6	17.5	5.0	2.2	0.9	0.2	0.2	0.0	0.1	0.0	0.0

Year	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2003	0.1	8.4	72.1	89.0	150.4	30.4	46.5	10.9	2.8	1.1	0.4	0.0	0.0	0.0	0.0	0.0
2004	19.0	6.7	82.4	74.0	60.8	78.4	18.2	21.2	5.2	1.1	0.5	0.2	0.0	0.0	0.0	0.0
2005	3.4	18.1	27.4	126.8	32.2	23.3	26.3	11.1	4.4	1.4	0.0	0.1	0.2	0.0	0.0	0.0
2006	1.7	16.5	168.2	65.6	160.7	39.8	16.9	18.1	1.7	1.4	0.3	0.0	0.0	0.0	0.0	0.0
2007	0.2	28.7	58.8	255.6	21.9	57.8	12.0	7.3	7.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0
2008	0.8	32.6	101.8	53.9	220.8	16.5	31.4	4.7	2.3	0.7	0.1	0.0	0.0	0.0	0.0	0.0
2009	0.5	20.0	110.7	82.4	27.7	114.4	9.9	9.3	1.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0
2010	1.5	14.8	48.4	120.8	50.3	11.8	31.0	3.7	2.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0
2011	6.7	27.9	56.2	59.2	82.9	16.5	11.2	6.2	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0
2012	2.0	39.3	69.8	31.5	22.2	24.0	6.1	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.6	19.6	89.1	45.6	11.2	8.4	2.2	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2014	3.5	10.2	68.6	82.7	20.9	2.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.2	48.3	25.9	54.8	44.0	5.9	0.6	0.1	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
2016	3.9	12.5	81.2	9.2	26.3	19.5	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2017	0.4	9.9	36.4	79.2	9.0	17.2	5.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2018	2.4	10.0	22.6	42.1	66.0	5.8	6.4	3.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2019	2.9	27.8	31.8	32.1	19.8	24.4	1.6	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2020	7.6	26.9	61.9	26.0	16.9	6.1	5.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2021	9.7	21.3	49.7	55.8	15.0	4.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	10.0	20.1	28.7	31.5	17.5	3.0	1.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	2.3	26.5	62.4	18.9	5.9	2.5	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2024	3.6	15.5	68.3	34.6	5.4	1.4	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4. Commercial fishery abundance catch at age for the US fishery on eastern Georges Bank. Values prior to 2010 are available in Andrushchenko et al. (2026c). Units are in thousands of fish. a1–a16 are fish aged 1 to 16. Dash indicates no data.

Year	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2010	1.3	29.2	37.1	60.1	22.4	2.9	12.8	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	1.9	11.6	17.3	31.6	29.7	8.7	2.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.1	28.2	32.1	16.5	6.7	2.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.4	5.9	11.8	5.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.8	1.7	16.0	27.8	8.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.6	10.5	10.8	18.9	7.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	1.2	9.2	25.4	4.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2017	0.1	0.2	1.8	8.6	1.1	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2018	1.7	0.8	0.7	8.6	4.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2019	0.0	2.1	3.0	3.2	1.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2020	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2021	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2022	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2023	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2024	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 5. Total area-swept biomass index (metric tonnes), the associated coefficient of variation (CV) and age-specific abundance (thousands of fish) of eastern Georges Bank Cod for the DFO Winter RV Survey since 2010. Indices are generated for strata 5Z1, 5Z2, 5Z9 and western portion of 5Z3–5Z4. Values prior to 2010 are available in Andrushchenko et al (2026c). The 2022 and 2025 indices are converted using the preliminary 'base' conversion. 2025 is included for information purposes and not included in the current model run. Dash indicates no data.

Year	Biomass	CV	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11
2010	26,352	0.65	4.6	91.9	955.8	4,105.4	1,781.2	702.8	1,827.7	64.6	83.8	4.9	0.0
2011	8,437	0.25	192.5	271.4	766.2	951.9	1,323.8	255.8	67.2	112.1	14.4	7.9	1.6
2012	2,449	0.20	8.7	149.4	326.7	315.0	195.0	158.2	6.8	18.2	4.1	0.0	0.0
2013	11,113	0.49	0.0	430.9	3753.6	2,173.1	285.5	81.0	52.5	9.8	0.0	0.0	0.0
2014	2,409	0.27	75.6	8.5	360.0	538.0	169.4	34.9	0.0	26.9	0.0	0.0	0.0
2015	3,594	0.38	0.0	476.4	152.3	598.0	438.5	97.2	7.5	0.0	0.0	0.0	0.0
2016	3,656	0.23	8.3	196.7	1,003.9	199.1	272.9	147.0	16.3	4.1	0.0	0.0	0.0
2017	14,566	0.60	4.7	52.4	1,660.2	5,897.0	193.7	269.5	188.5	0.0	0.0	0.0	0.0
2018	7,198	0.36	39.4	149.5	519.7	1,059.6	1,609.9	76.6	50.3	7.4	0.0	0.0	0.0
2019	4,059	0.60	9.5	268.6	1,004.9	573.9	388.6	283.8	0.0	0.0	6.4	6.4	0.0
2020	4,214	0.44	32.0	465.7	1,752.5	620.0	330.0	49.3	19.6	5.3	0.0	0.0	0.0
2021	1,821	0.35	62.5	189.2	296.7	393.8	101.0	43.4	6.5	27.3	0.0	0.0	0.0
2022	2,095	0.23	119.4	405.9	424.6	329.9	84.2	17.1	6.4	0.0	0.0	0.0	0.0
2023	1,891	0.35	18.9	301.0	575.8	189.0	58.2	26.9	2.7	7.2	3.5	0.0	0.0
2024	1,406	0.30	38.6	36.6	317.1	191.7	38.8	15.9	6.4	4.9	0.0	0.0	0.0
2025	2,225	–	1.6	168.4	814.7	448.7	50.2	9.7	0.0	0.0	0.0	0.0	0.0

Table 6. Total area-swept biomass index (metric tonnes), the associated coefficient of variation (CV) and age-specific abundance (thousands of fish) of eastern Georges Bank Cod for the NMFS Spring Survey since 2010. Values prior to 2010 are available in Andrushchenko et al. (2026c). The 2020 and 2023 indices are treated as missing (dash) due to survey not occurring (2022) or only fishing day tows (2022). Dash indicates no data.

Year	Biomass	CV	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11
2010	3,587	0.19	11.5	89.6	336.6	691.4	171.9	45.7	145.6	0.0	12.6	0.0	0.0
2011	1,724	0.33	37.9	106.5	143.9	268.1	149.7	57.5	9.8	23.2	0.0	0.0	0.0
2012	4,864	0.22	1.4	287.4	664.3	870.0	211.7	130.7	12.9	0.0	0.0	0.0	0.0
2013	9,616	0.61	0.0	472.9	3,300.7	1,140.4	135.4	67.6	13.4	0.0	0.0	0.0	0.0
2014	3,254	0.29	25.1	41.5	496.2	801.5	145.6	26.0	0.0	0.0	0.0	0.0	0.0
2015	1,748	0.19	4.6	101.1	50.1	227.7	339.4	25.0	0.0	0.0	0.0	0.0	0.0
2016	3,579	0.53	1.8	134.7	1,192.5	152.9	166.0	81.9	9.2	0.0	0.0	0.0	0.0
2017	13,479	0.44	19.3	35.0	401.4	2,655.2	827.8	495.2	158.0	0.0	0.0	0.0	0.0
2018	3,097	0.65	47.5	106.8	537.2	515.9	347.7	0.0	0.0	0.0	17.8	0.0	0.0
2019	9,228	0.84	49.8	822.9	880.5	1,853.2	838.4	211.7	8.0	0.0	0.0	0.0	0.0
2020	–	–	–	–	–	–	–	–	–	–	–	–	–
2021	2,819	0.34	20.0	260.4	574.6	378.0	82.7	0.0	11.1	0.0	0.0	0.0	0.0
2022	3,686	0.42	42.4	306.4	862.0	333.2	101.4	28.3	0.0	0.0	0.0	0.0	0.0
2023	–	–	–	–	–	–	–	–	–	–	–	–	–
2024	2,761	0.25	10.9	68.4	823.1	403.1	49.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 7. Total area-swept biomass index (metric tonnes), the associated coefficient of variation (CV) and age-specific abundance (thousands of fish) of eastern Georges Bank Cod for the NMFS Fall Survey since 2010. Values prior to 2010 are available in Andrushchenko et al. (2026c). The 2020 indices are treated as missing (dash) due to survey not occurring.

Year	Biomass	CV	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11
2010	732	0.39	20.3	89.7	95.5	144.0	24.4	0.0	0.0	0.0	0.0	0.0	0.0
2011	2,304	0.66	216.3	283.3	239.2	184.4	115.9	31.9	0.0	0.0	0.0	0.0	0.0
2012	609	0.35	11.6	220.2	129.3	21.3	24.0	0.0	0.0	0.0	0.0	0.0	0.0
2013	2,566	0.60	30.2	536.6	597.8	264.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	1,376	0.40	168.2	64.2	215.1	333.7	41.1	12.7	0.0	0.0	0.0	0.0	0.0
2015	3,570	0.38	192.2	1,444.6	109.0	192.2	146.7	0.0	0.0	0.0	0.0	0.0	0.0
2016	5,438	0.29	7.2	487.0	5,579.3	126.9	353.3	126.0	0.0	0.0	0.0	0.0	0.0
2017	653	0.68	42.6	58.0	60.2	94.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2018	2,549	0.52	236.5	187.9	279.3	326.8	200.4	0.0	0.0	0.0	0.0	0.0	0.0
2019	1,621	0.68	112.1	333.9	502.1	236.8	181.0	145.3	0.0	0.0	0.0	0.0	0.0
2020	–	–	–	–	–	–	–	–	–	–	–	–	–
2021	1,114	0.62	322.5	94.0	66.7	37.8	13.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	1,122	0.60	318.9	211.6	67.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	1,042	0.83	326.2	133.5	34.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2024	620	0.61	5.3	52.7	167.2	52.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8. Total area-swept biomass index (mt), the associated coefficient of variation (CV) and age-specific abundance (thousands of fish) of eastern Georges Bank Cod for the DFO Winter Research Vessel Survey since 2010. Indices are generated for strata 5Z1, 5Z2, 5Z9 and western portion of 5Z3-5Z4. Values prior to 2010 are available in Andrushchenko et al. (2026c). Dash indicates not calculated.

Year	Biomass	CV	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11
2010	26,943	0.65	4.6	91.9	974.8	4,143.5	1,819.2	730.5	1,876.5	64.6	87.1	4.9	0.0
2011	8,437	0.25	192.5	271.4	766.2	951.9	1,323.8	255.8	67.2	110.6	12.9	6.3	1.6
2012	2,903	0.20	8.7	149.8	350.6	358.5	239.7	198.2	6.8	18.2	4.1	0.0	0.0
2013	11,798	0.49	0.0	430.9	3,894.6	2,288.5	295.2	92.2	62.0	9.8	0.0	0.0	0.0
2014	3,315	0.27	75.6	9.0	447.2	685.2	245.7	53.5	0.0	19.8	0.0	0.0	0.0
2015	4,405	0.38	0.0	476.4	165.7	733.0	552.3	113.4	7.5	0.0	0.0	0.0	0.0
2016	3,886	0.23	8.3	196.7	1,004.9	205.0	288.5	156.7	18.0	18.2	0.0	0.0	0.0
2017	15,995	0.60	4.7	52.4	1,662.1	6,066.6	240.9	334.7	244.0	0.0	0.0	0.0	0.0
2018	8,491	0.36	45.4	183.7	577.0	1,152.0	1,808.2	98.4	97.3	9.4	0.0	0.0	0.0
2019	4,980	0.60	9.5	268.6	1011.5	628.7	450.1	363.8	0.0	0.0	10.0	6.4	0.0
2020	4,767	0.44	32.0	465.7	1,762.2	627.9	365.8	84.8	58.3	5.3	0.0	0.0	0.0
2021	1,821	0.35	62.5	189.2	296.7	393.8	101.0	43.4	6.5	27.3	0.0	0.0	0.0
2022	3,013	0.23	119.4	410.8	485.6	414.0	136.1	60.3	34.3	17.3	0.0	0.0	0.0
2023	1,937	0.35	18.9	301.0	581.7	197.7	61.1	26.9	2.7	8.7	3.5	0.0	0.0
2024	2,984	0.30	38.6	37.7	363.9	278.7	217.2	38.2	20.8	7.8	2.2	0.0	0.0
2025	2,302	–	1.6	177.3	831.9	456.9	51.2	9.7	0.0	0.0	0.0	0.0	0.0

Table 9. Total area-swept biomass index (metric tonnes) and age-specific abundance (thousands of fish) of eastern Georges Bank Cod for the DFO Winter Research Vessel Survey since in 2022 and 2025. The indices are converted using the preliminary 'sens' conversion. The indices are shown without stratum 5Z9 and with 5Z9 included. The year 2025 is included for information purposes, as it is not included in the current model run. Dash indicates not calculated.

Year	Biomass	CV	Age1	Age 2	Age 3	Age 4	Age 5	Age6	Age7	Age8	Age9	Age 10	Age 11
2022 without 5Z9	1,757	0.23	66.7	296.9	347.1	300.6	70.8	12.5	6.0	0.0	0.0	0.0	0.0
2025 without 5Z9	1,752	–	0.4	124.8	602.9	381.9	45.8	7.4	0.0	0.0	0.0	0.0	0.0
2022 with 5Z9	2,416	0.23	66.7	300.6	400.8	364.7	102.2	43.4	32.2	10.5	0.0	0.0	0.0
2025 with 5Z9	1,819	–	0.4	124.8	602.9	381.9	45.8	7.4	0.0	0.0	0.0	0.0	0.0

Table 10. Values of Mohn's rho (seven-year peel), estimates of survey q (catchability) and Akaike information criterion (AIC) estimates for various model runs. Note that the 2023_Base AIC (*) is not comparable to the other three. Bolded run is the proposed for stock status and advice. See text for description of the model runs and parameters. SSB – spawning stock biomass, Fbar=mean fishing mortality

Model Run	Recruitment rho	SSB rho	Fbar rho	DFO survey q	NMFS spring survey q	NMFS Fall survey q	AIC
2023_Base	0.1134	0.2045	-0.1205	0.434	0.223	0.109	*-6073.3
2024_DFObase_no5Z9	0.404	0.316	-0.215	0.459	0.244	0.117	-6183.2
2024_DFObase_w5Z9	**0.331**	**0.244**	**-0.166**	**0.437**	**0.216**	**0.103**	**-6201.6**
2024_DFOsens_w5Z9	0.328	0.248	-0.161	0.435	0.217	0.103	-6200.8

FIGURES

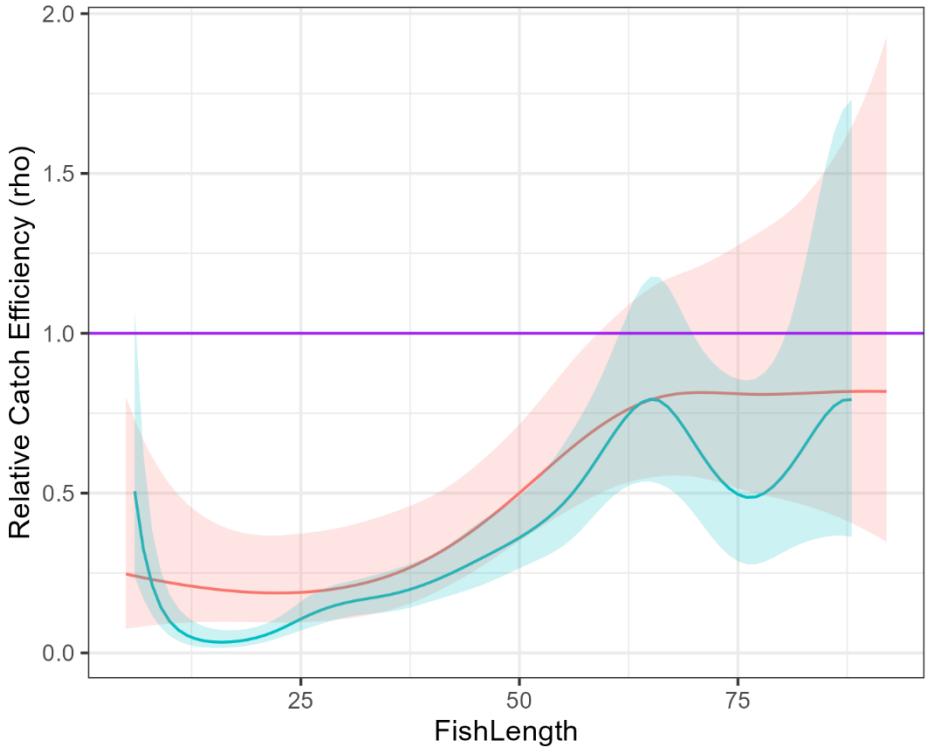


Figure 1. Candidate conversion factors (Relative Catch Efficiency) at fish length (cm) for the vessel-gear switch for DFO research vessel (RV) surveys. The base (red) conversion factor uses comparative survey data from the DFO Winter RV Survey plus comparative sets on Georges Bank conducted during the DFO Summer RV Survey. The sens (blue) conversion factor includes the base data sets plus the comparative sets on the Scotian Shelf conducted during the DFO Summer RV Survey Horizontal line denotes 1. FishLength-Cod length in cm.

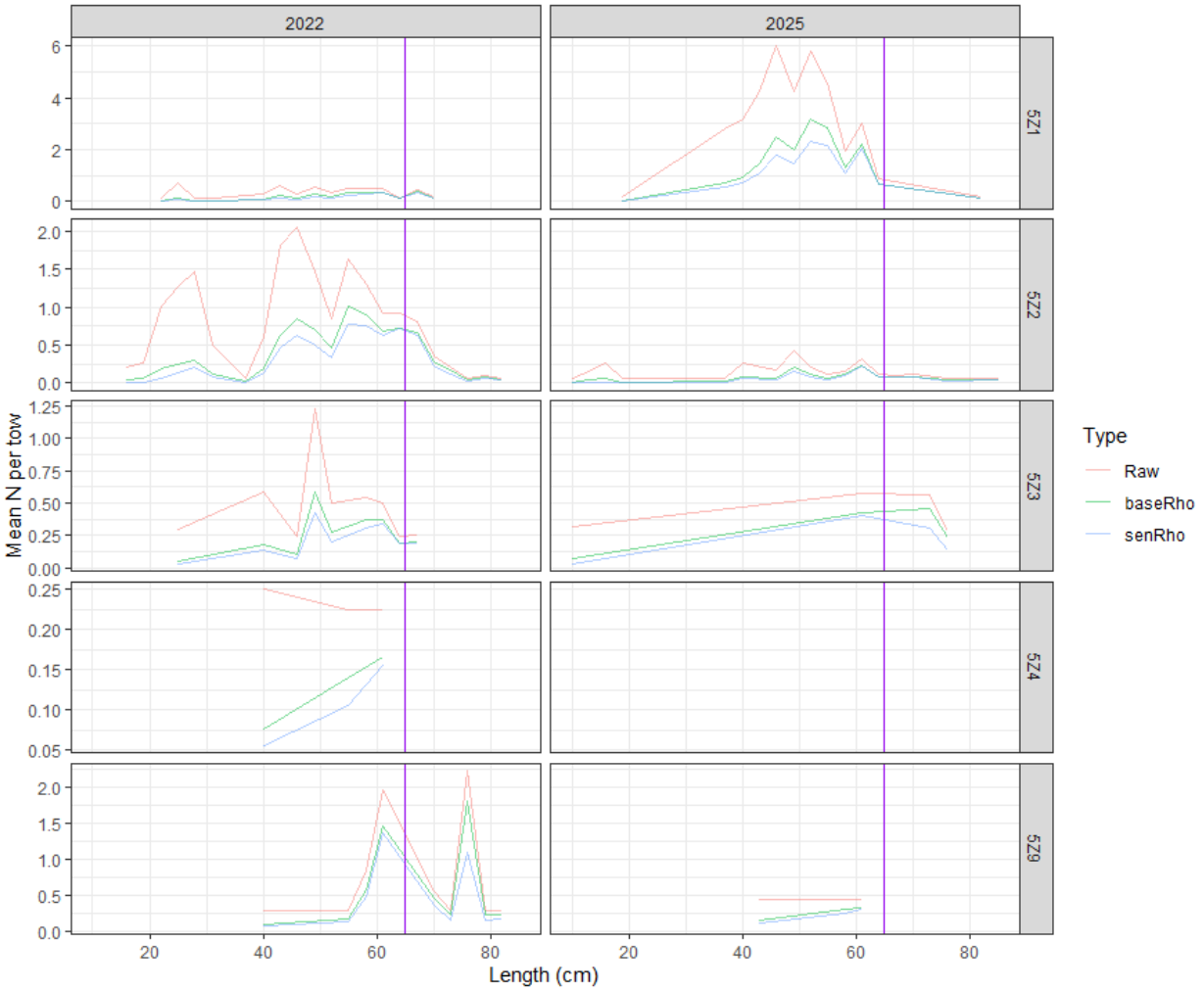


Figure 2. Mean number (N) per tow at length of eastern Georges Bank Cod by stratum (facet) for the 2022 and 2025 DFO Winter RV Survey. Vertical line at 65 cm is provided for reference. Colours indicate conversion applied; Raw (red =no conversion, see Figure 1 caption for definition of baseRho (green) and senRho (blue).

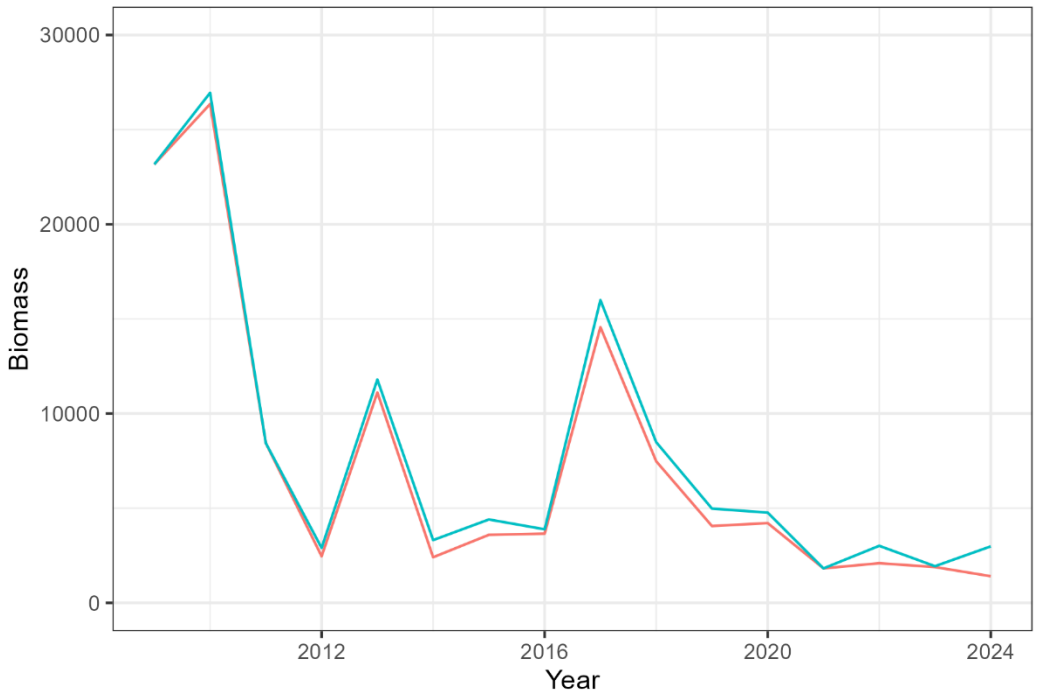


Figure 3. Biomass index from the DFO Winter Survey since 2010. Colours indicate inclusion (blue) or exclusion (red) of the 5Z9 stratum. The 2022 year was carried out by the CCGS Cartier and was converted using the preliminary 'base' conversion to the Teleost/Needler/NEST series.

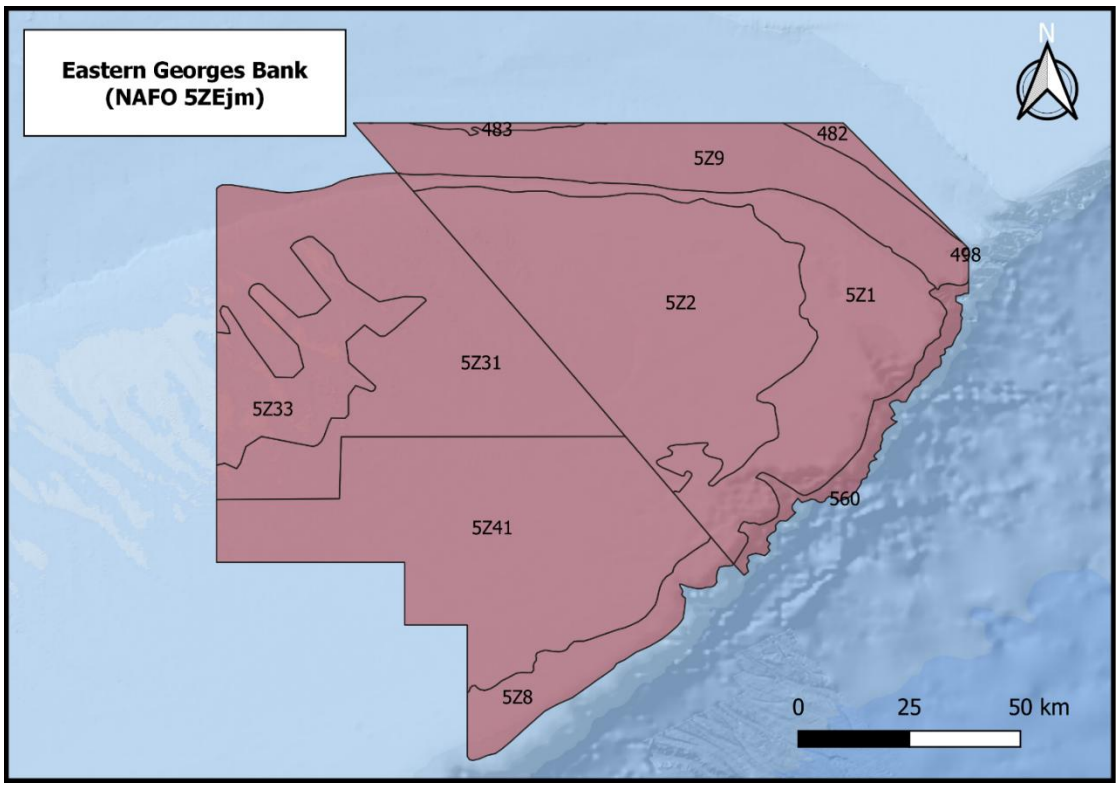


Figure 4. DFO survey strata on Georges Bank falling within the eastern Georges Bank management unit. Text identifies the name of the DFO survey stratum.

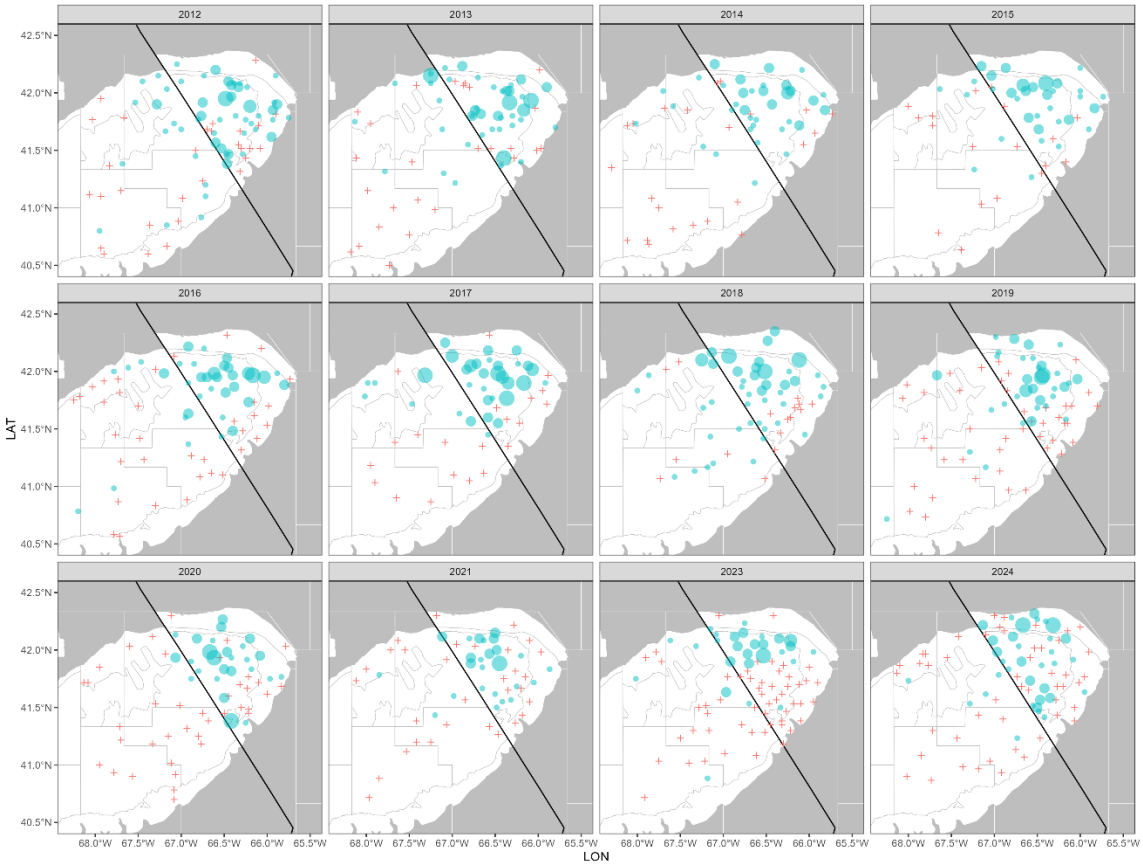


Figure 5. Catch distribution (kg/tow) of Cod during the DFO Winter Research Vessel Survey on Georges Bank for 2010–2021, 2023, and 2024 using the Western IIA trawl. Red plus marks show null catches. Size of blue circles is indicative of size of catch (standardized catch per tow). White areas indicate the standard winter survey strata.

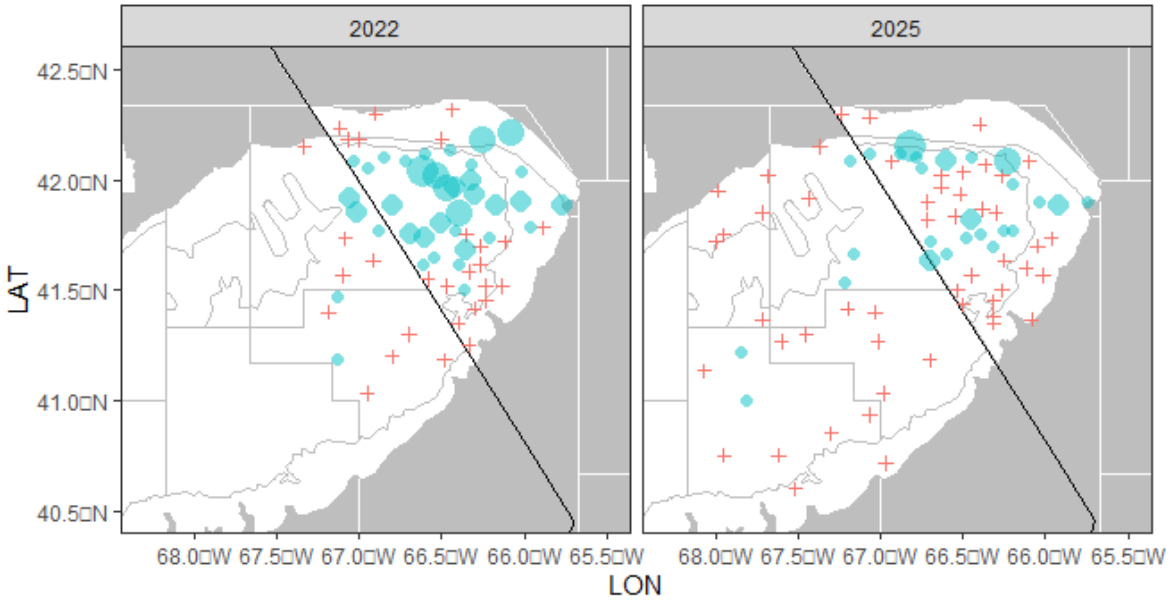


Figure 6. Catch distribution (kg/tow) of Cod during the DFO Winter Research Vessel Survey on Georges Bank in 2022 and 2025 using the NEST trawl. Red plus marks indicate null catches. Size of blue circles is indicative of size of catch. White areas indicate standard winter survey strata. LAT – latitude; LON – longitude.

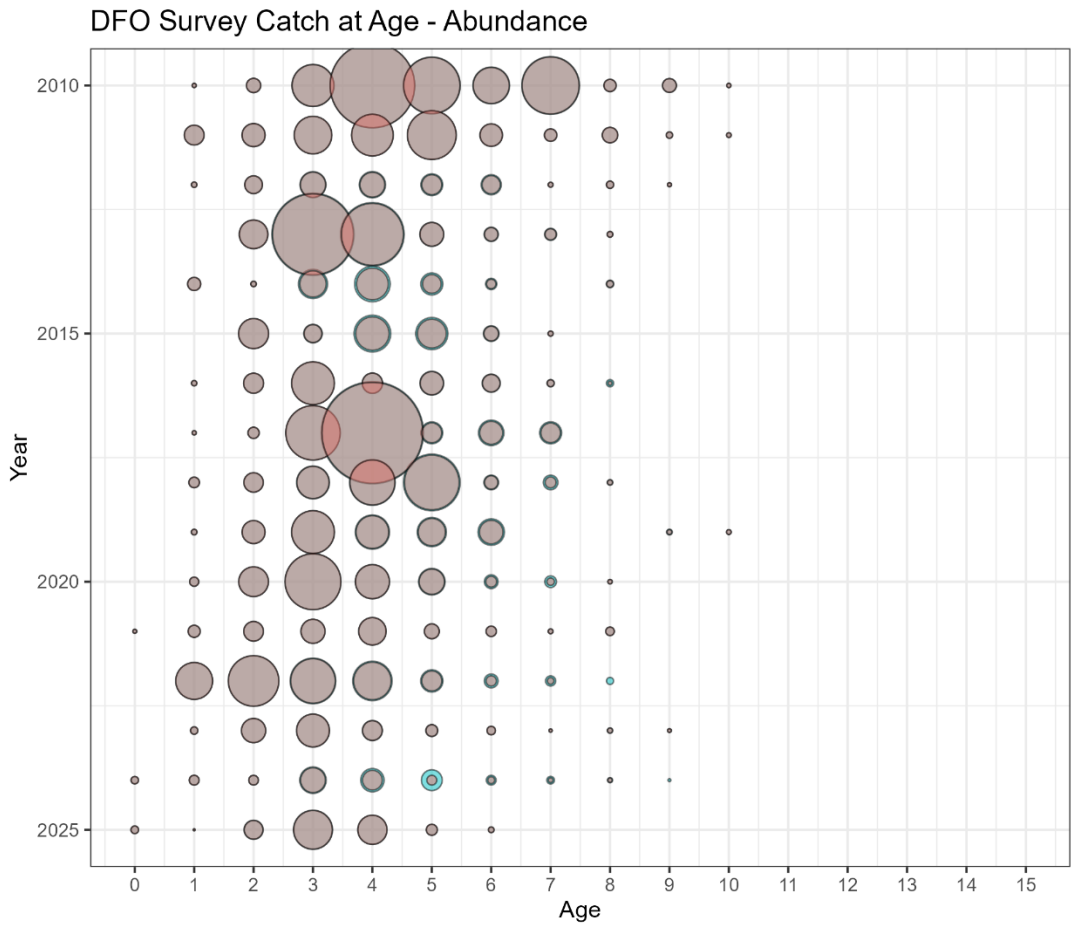


Figure 7. Catch at age (abundance) for the DFO Winter Research Vessel survey eastern Georges Bank Cod index. Indices at age including (blue) and excluding (red) sets in stratum 5Z9 are overlaid on top of another. Preliminary 'base' conversion factors (see Figure 1 caption for definition of 'base') are applied to the 2022 and 2025 years to make them comparative to other years. The 2025 year is included in the plot for information purposes (but is not used in the current model, which ends in 2024).

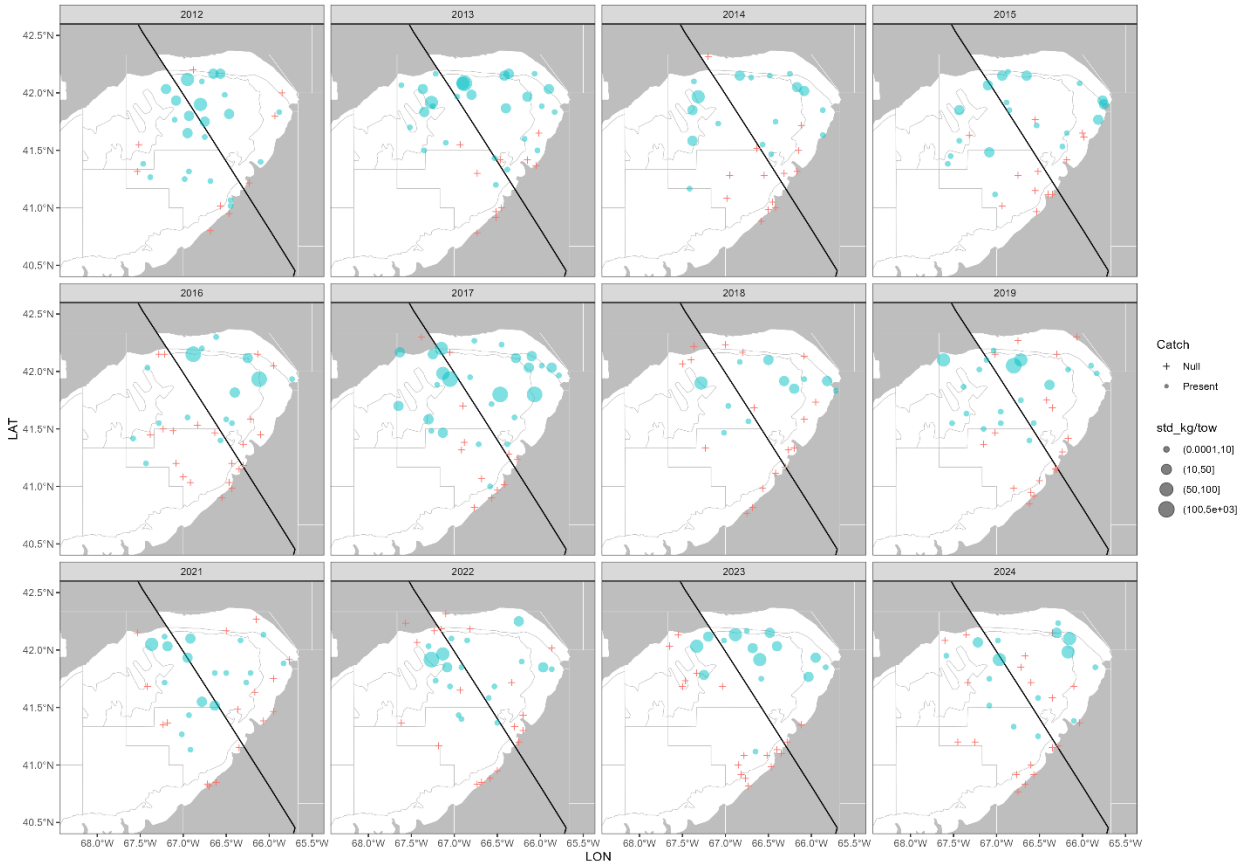


Figure 8. Catch distribution (kg/tow) of Cod in the NMFS Spring Survey on Georges Bank for 2022 and 2025 using the NEST trawl. Red plus marks show null catches. Size of blue circles is indicative of size of catch. White areas indicate standard winter survey strata. LAT – latitude; LON – longitude.

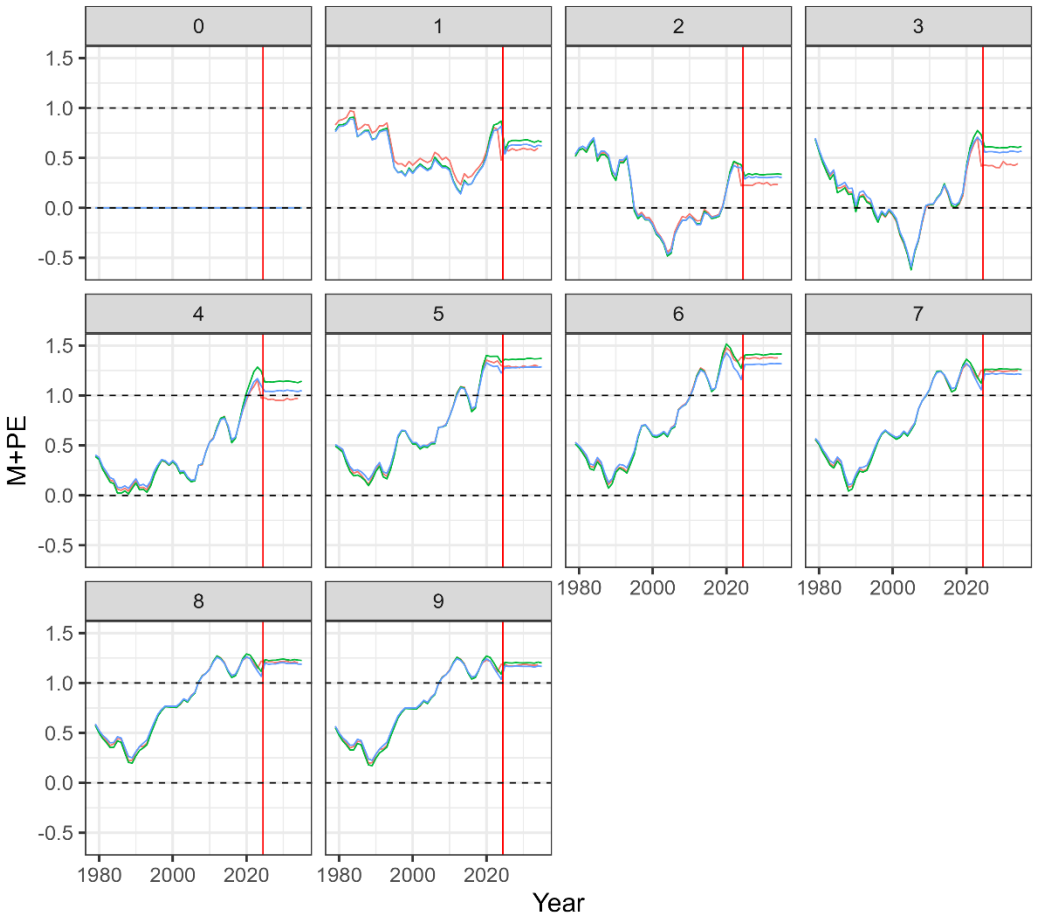


Figure 9. Median estimate of natural mortality (M) and process error (PE) across ages (facets) across the time series. Colours indicate the model: the red lines are the 2023=model updated to 2023; green lines are the model updated to 2024 without stratum 5Z9 data and blue lines are the model updated to 2024 and including stratum 5Z9 data. Vertical red line denotes the transition between the last historic and the first projected year.

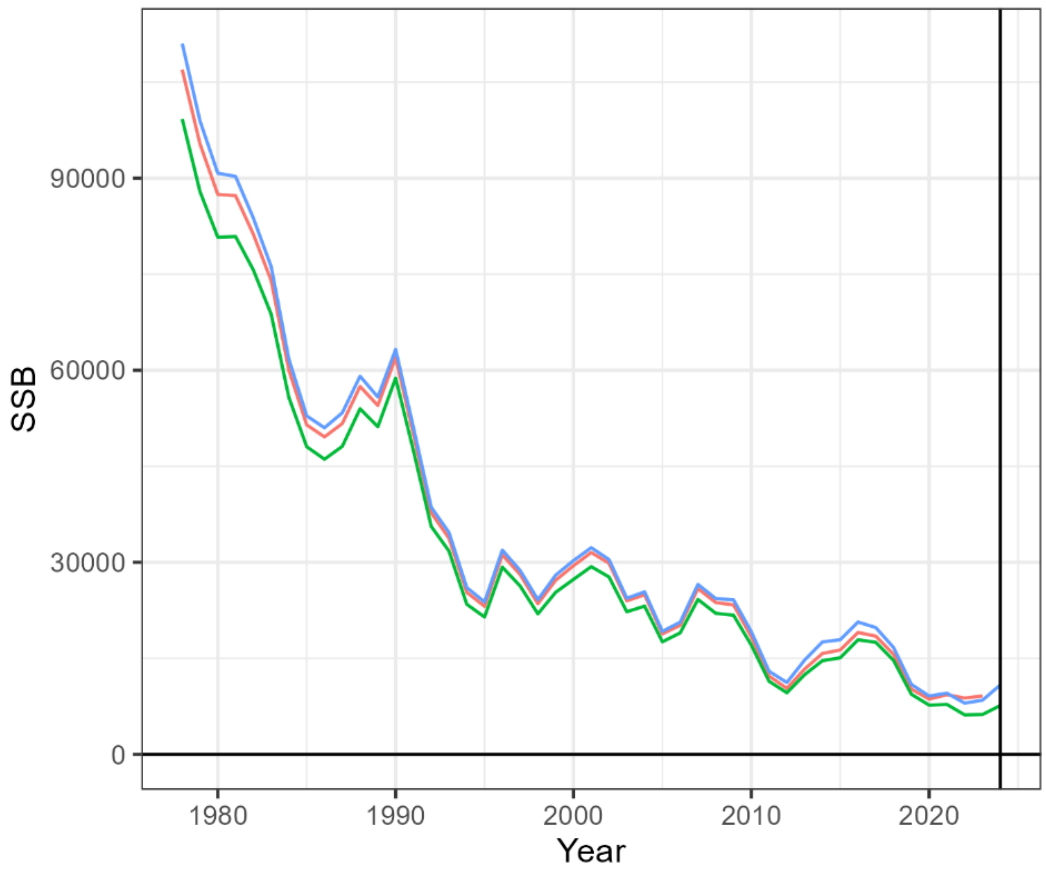


Figure 10. Median estimate of spawning stock biomass (SSB, mt) across the time series. Colours indicate the models: red line is the model updated to 2023; green line is the model updated to 2024 without stratum 5Z9 data; and blue line is the model updated to 2024 and including 5Z9 data).

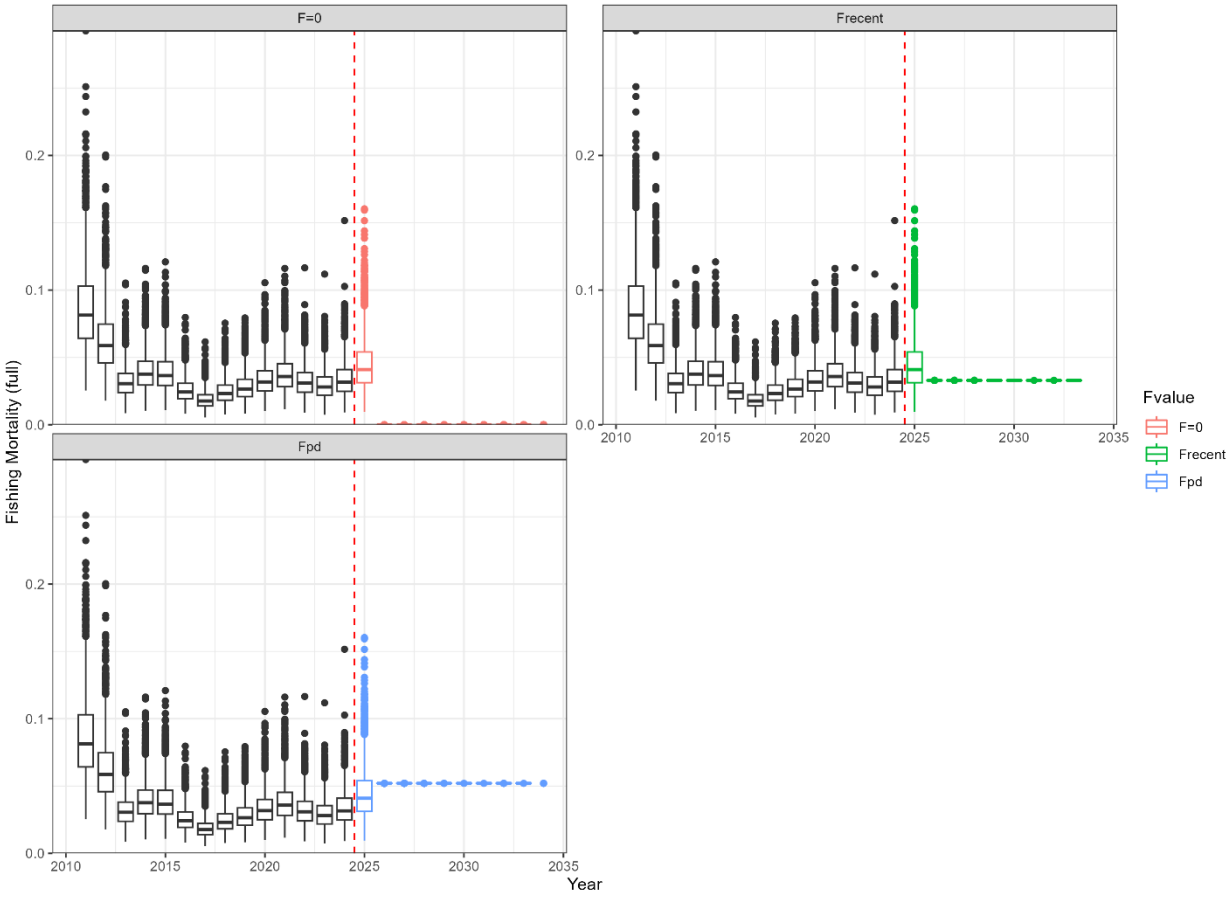


Figure 11. Fishing mortality (F) under various scenarios. Vertical dashed red line indicates transition from historic to projected years. The first projected boxplot shows F distribution based on a catch of 452 mt.

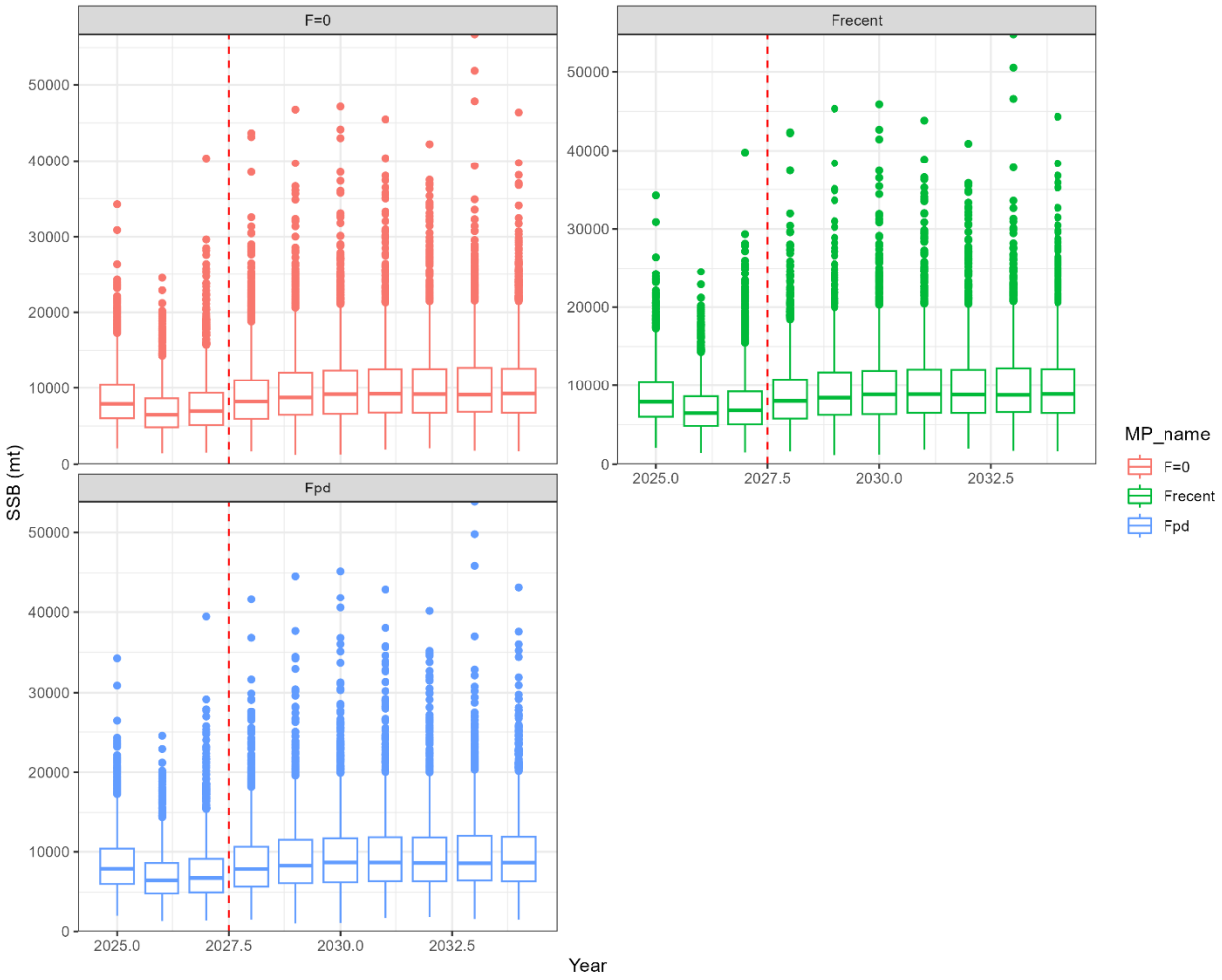


Figure 12. Projected spawning stock biomass (SSB, mt) under various fishing mortality (F) scenarios. Vertical dashed red line indicates the three year projection. Horizontal line indicates the 2024 estimate of the limit reference point.

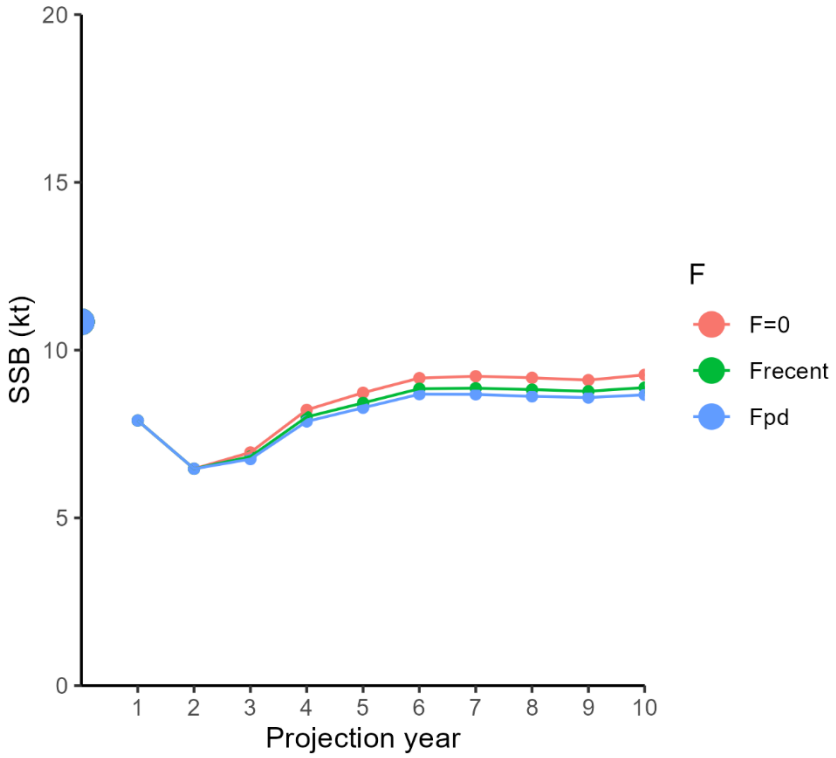


Figure 13. Projected median spawning stock biomass (SSB) under various fishing mortality (F) scenarios. The purple point on the y-axis shows median SSB in the terminal year.

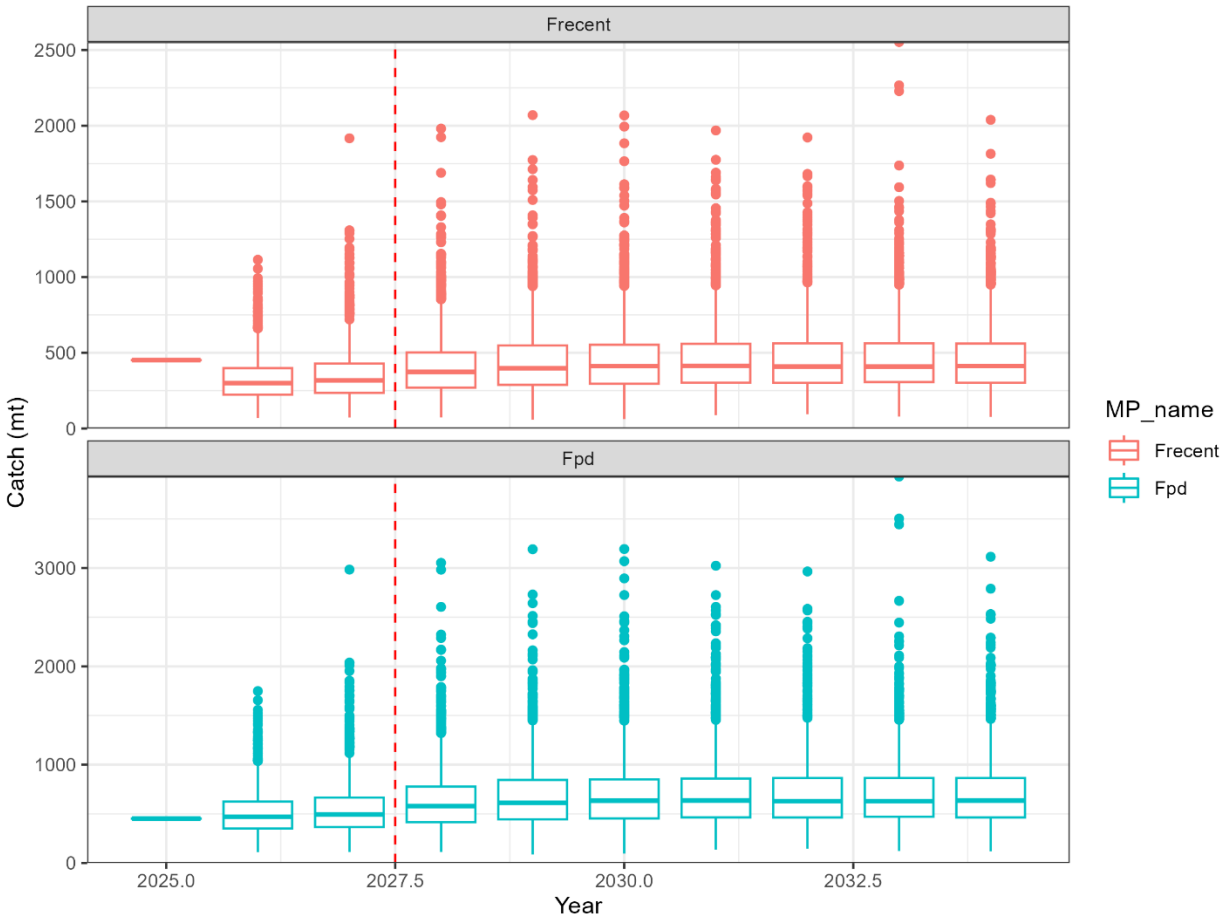


Figure 14. Projected catch (mt) under various fishing mortality (F) scenarios. Vertical dashed red line indicates the three year projection.

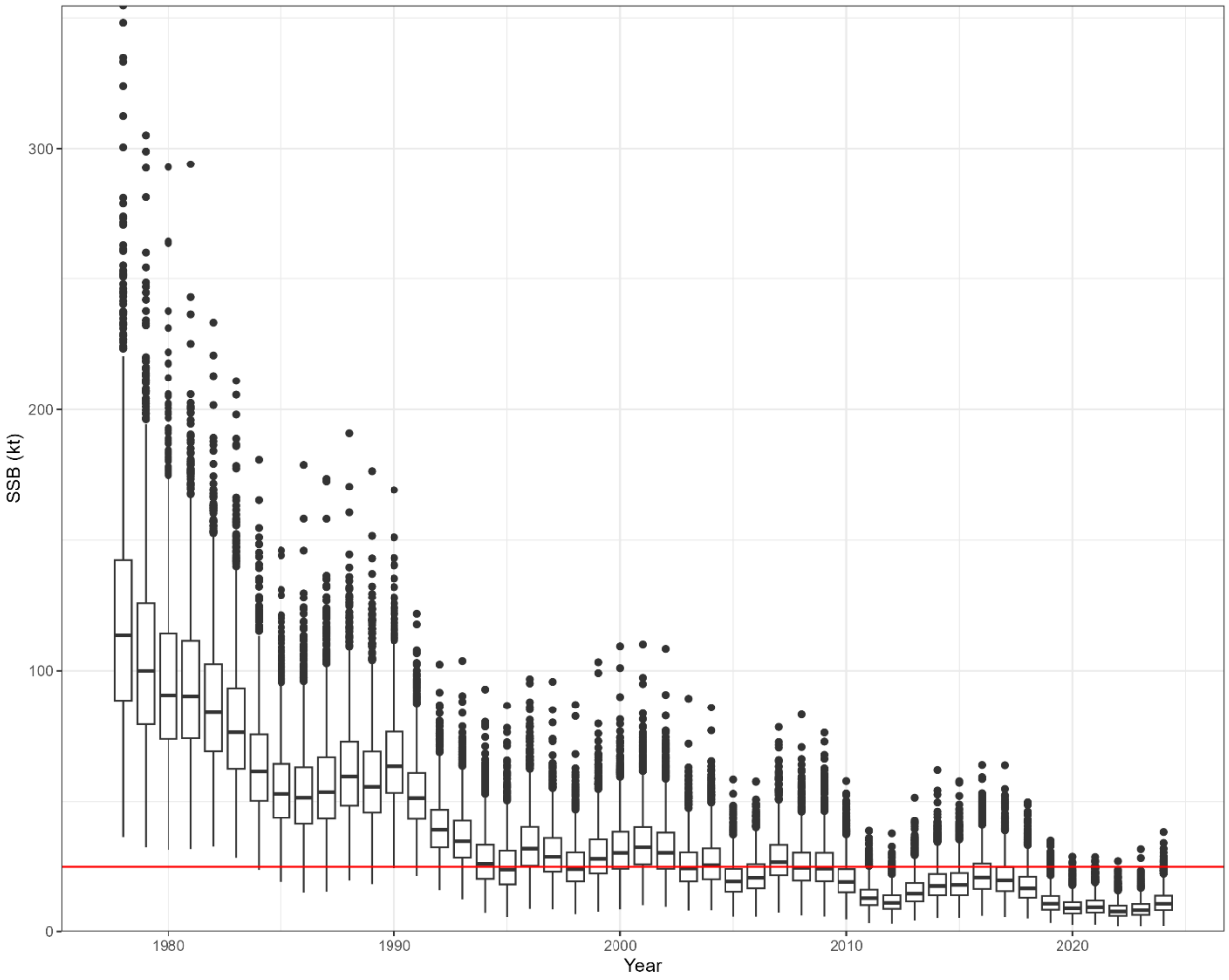


Figure 15. Spawning stock biomass for eastern Georges Bank Cod from the 2024 model run. Horizontal red line denotes the limit reference point.