



## 4X5Y ATLANTIC COD (*GADUS MORHUA*) STOCK ASSESSMENT IN 2024

### CONTEXT

The Fisheries Management Branch of Fisheries and Oceans Canada (DFO) has requested a review of the resource status for 4X5Y Atlantic Cod in support of decision-making, incorporating available cod bycatch estimates from lobster fisheries into the 4X5Y Atlantic Cod assessment model.

This Fisheries Science Advisory Report is from the regional peer review of December 9–10, 2025 on the Stock Assessment for Atlantic Cod in NAFO Divisions 4X5Y. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

### SCIENCE ADVICE

#### Status

- The 2025 spawning stock biomass (2,666 mt) is at 24% of the limit reference point, indicating that the 4X5Y Atlantic Cod stock remains in the critical zone with a very high probability (>99%).

#### Trends

- Cod landings from the groundfish fishery for the 2024–2025 management year were 466 mt, the lowest in the time series, and below the total allowable catch of 660 mt.
- The catch-at-age from the commercial groundfish fishery and survey continue to show the truncation in age structure that has occurred since the 1990s.
- The model-estimated recruitment for 2024 is 0.94 million fish, representing the lowest value in the time series.
- The model estimated mean fishing mortality for ages 2–5 for 2024 is 0.118 for the most optimistic and 0.214 for the most pessimistic cod bycatch mortality assumptions (24.8% and 100%, respectively) in the lobster fisheries.
- Natural mortality (M) has increased over time for older fish (ages 5+) and appears to have stabilized at high levels, with the latest average M (2024) for these ages estimated at 1.24.

#### Ecosystem and Climate Change Considerations

- Ecosystem and climate change considerations were taken into account in the most recent assessment framework review and were not further updated or reviewed during this assessment.

## Stock Advice

- The 4X5Y Atlantic Cod stock has declined since the 1990s and remains in the critical zone. Despite decreases in fishing mortality, the productivity of the stock remains low.
- Across all groundfish fishery harvest scenarios and levels of bycatch reduction in the lobster fisheries, the projections indicate a moderate to moderately high (39–75%) probability of decline by 2027 relative to 2025, even in the absence of removals by the groundfish fishery.

## BASIS FOR ASSESSMENT

### Assessment Details

#### Year Assessment Approach was Approved

2025 (Andrushchenko and Hebert In prep.<sup>1</sup>)

#### Assessment Type

Full Assessment

#### Most Recent Assessment Date

1. Last Full Assessment: 2019 (DFO 2019)
2. Last Interim-Year Update: 2024 (DFO 2025b)

#### Stock Assessment Approach

1. Broad category: single stock assessment model
2. Specific category: Statistical Catch At Age (SCAA)

The assessment approach was changed from a Virtual Population Analysis (VPA) model to a Woods Hole Assessment Model (WHAM) to allow the incorporation of the cod bycatch estimates from the lobster fisheries (Andrushchenko and Hebert In prep.<sup>1</sup>).

### Stock Structure Assumption

Although assessed together, Cod in the Bay of Fundy (DFO statistical unit areas 4Xqrs5Yb) and Scotian Shelf (DFO statistical unit areas 4Xmno) components of the management unit exhibit distinctly different growth rates, with western fish (Bay of Fundy) growing faster than those from the east (Scotian Shelf). In general, a two-stock component structure within 4X5Y seems to persist, with a mixing area in 4Xp and some movement taking place between adjacent management areas.

### Reference Points

- Limit Reference Point (LRP): 11,150 mt ( $S_{b_{50/90}}$ ; Wang and Irvine 2022)
- Upper Stock Reference (USR): 48,000 mt (DFO 2012)
- Removal Reference (RR): NA

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<sup>1</sup> Andrushchenko, I., and Hebert, N.E. In Prep. Incorporating Atlantic Cod Bycatch Estimates from Lobster Fisheries into the 4X5Y Stock Assessment Model. DFO Can. Sci. Adv. Sec. Res. Doc.

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Data

Inputs to the population model are:

- Maritimes Summer Ecosystem Research Vessel Survey (1983–2024)
- Canadian commercial fishery catch data (1983–2024)

Data changes: Incorporation of cod bycatch estimates from lobster fisheries (2018–2023; Yin et al. In press).

ASSESSMENT

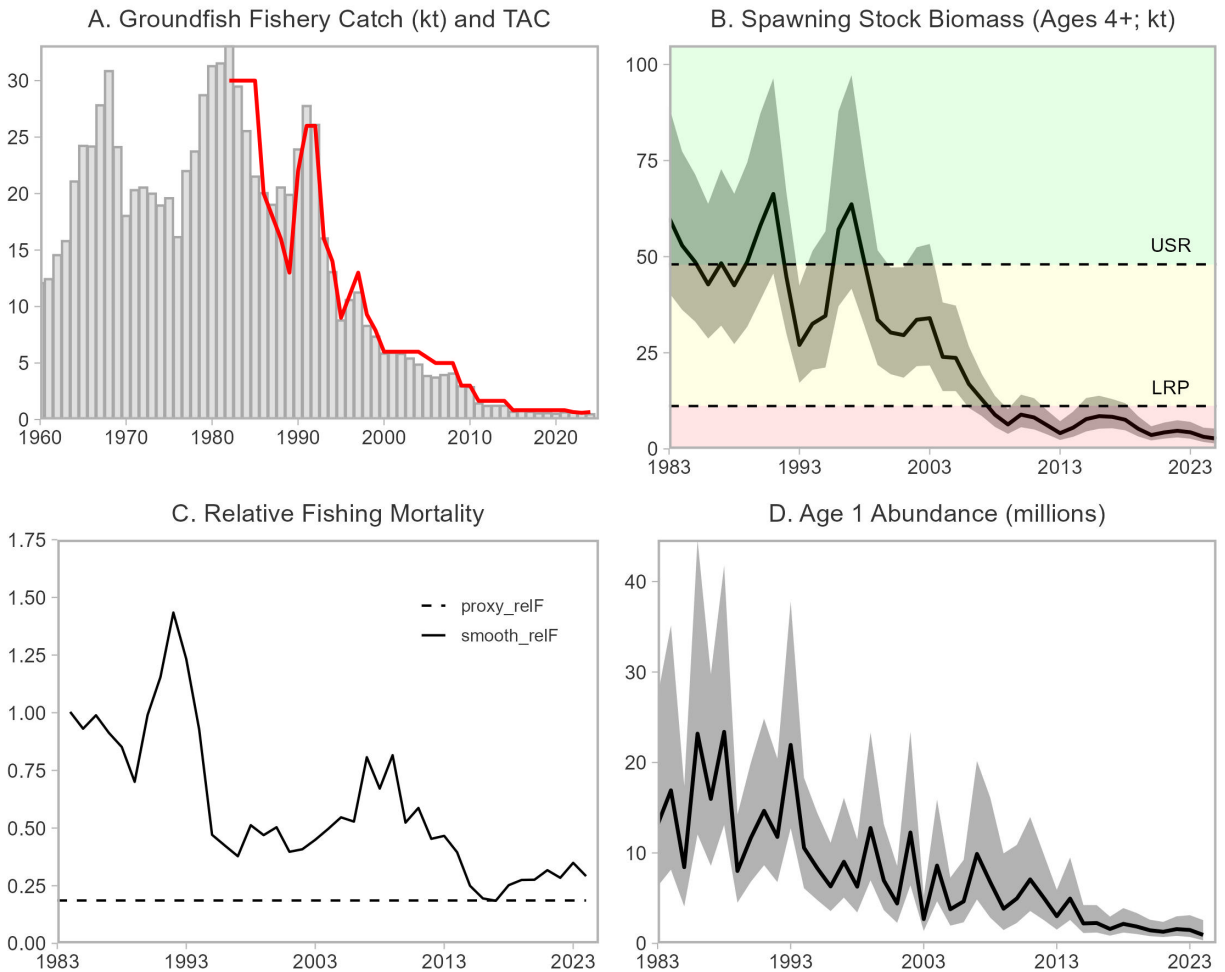


Figure 1. (A) 4X5Y Cod groundfish fishery catch (2024 catch=466 mt, bars) and total allowable catch (TAC for 2024=660 mt, red line), (B) spawning stock biomass ages 4+ (2025=2,666 mt; grey shading represents 95% confidence intervals) in relation to the limit reference point (LRP=11,150 mt) and upper stock reference (USR=48,000 mt), (C) relative F (smooth relF for 2024=0.35, solid line) and proxy relative F (proxy relF for 2024=0.19, dashed line) for the groundfish fishery, and (D) age 1 abundance (0.94 million in 2024; grey shading represents 95% confidence intervals).

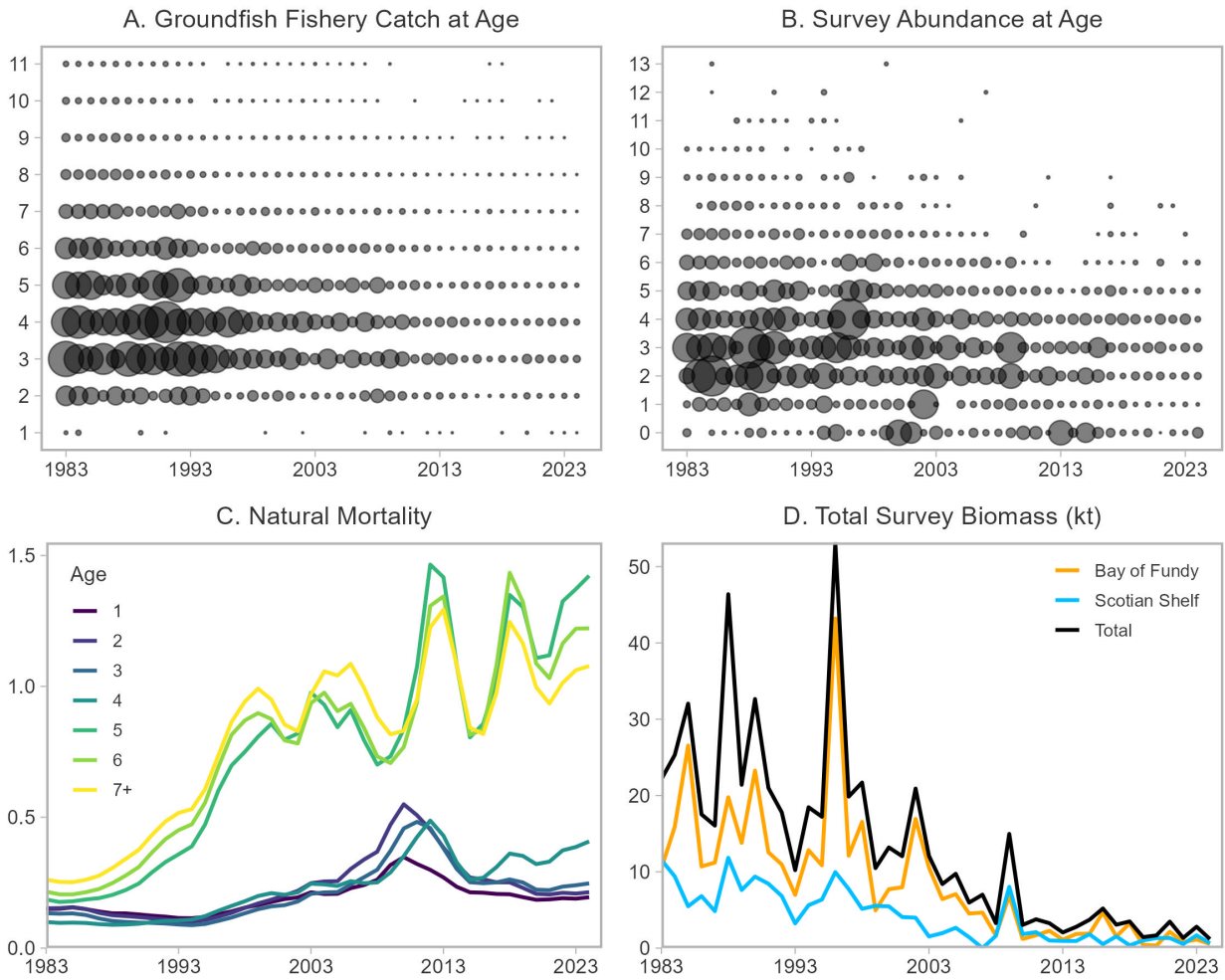


Figure 2. (A) Groundfish fishery catch at age, (B) survey abundance at age (combined Bay of Fundy and Scotian Shelf), (C) natural mortality at age, and (D) total survey biomass (black line) with breakdown of total survey biomass between the Bay of Fundy (orange line; 547 mt in 2024) and the Scotian Shelf (blue line; 636 mt in 2024).

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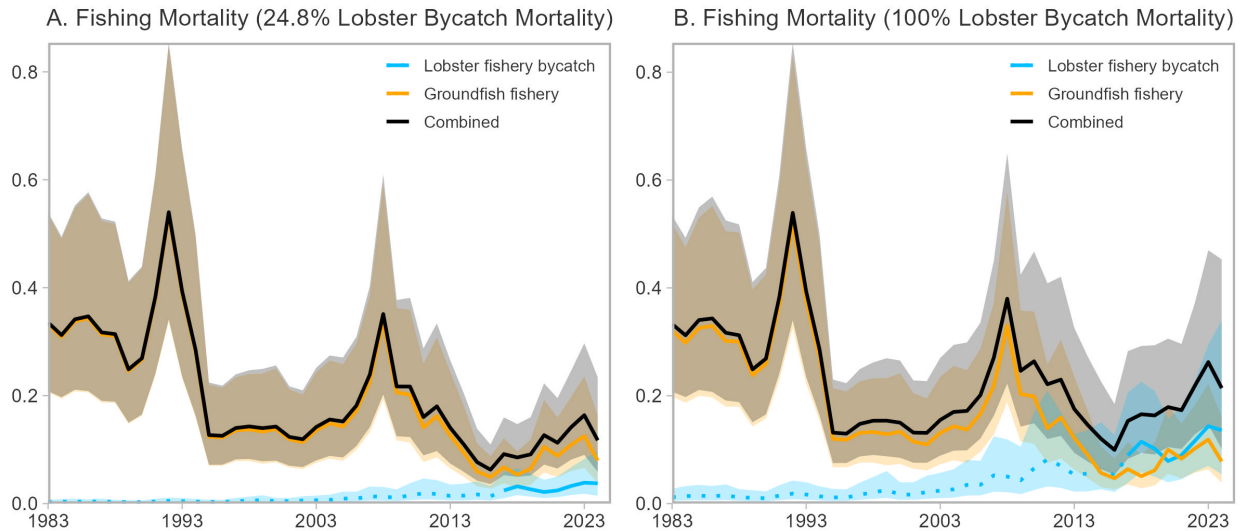


Figure 3. A) Mean fishing mortality for ages 2–5, assuming a lobster bycatch mortality of 24.8%, B) mean fishing mortality for ages 2–5, assuming a lobster bycatch mortality of 100%. Dotted lines associated with the lobster fishery bycatch denote years for which reliable estimates of cod bycatch were unavailable.

**Stock Status and Trends**

**Abundance**

Both the commercial groundfish and survey catches at age have shown a truncation in age structure since the 1990s (Figure 2A and 2B). From then on, older fish (ages 6+) have become rare in the survey. The decline reached its lowest point in 2013–2014, when there were no fish older than age 5 in the survey and age 9 in the groundfish fishery. In 2024, the groundfish fishery included ages 1 to 8, with age 3 being the dominant contributor. The survey included ages 0 to 6, with the same dominant cohort. Cod caught as bycatch in the lobster fisheries were primarily 2 or 3 years old in 2024.

**Biomass**

The modelled spawning stock biomass (SSB) first dropped below the LRP in 2008, and has remained below the LRP since that time. The 2025 spawning stock biomass (2,666 mt) is at 24% of the LRP (Figure 1B).

**Fishing Mortality**

In the absence of an RR, relative fishing mortality (relF) for the groundfish fishery (Figure 1C), calculated as annual groundfish landings (Figure 1A) over the 3-year mean survey biomass, is compared to the relF of 0.19 which was determined by DFO Resource Management in 2019 as a proxy (SFGAC 2019, DFO 2021). RelF declined around 1994, corresponding to a large decrease in total allowable catch (TAC). Following a series low in 2016–2017, relF for the groundfish fishery has increased since then.

Fishing mortality from the model shows a similar trend, with a series low in 2015–2016, followed by a gradual increase. It is assumed that historically, cod bycatch from the lobster fishery was a small proportion of overall fishing mortality in 4X5Y; however, its relative role has increased in recent years due to low 4X5Y Cod stock biomass and decreases in groundfish fishery removals. Given that the true level of cod bycatch mortality in the lobster fisheries is uncertain, two mortality levels were used in the analysis: 24.8% as the most optimistic assumption and 100%

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as the most pessimistic. The 2024 mean F estimate for ages 2–5 is 0.118 for 24.8% mortality (0.080 from the groundfish fishery, 0.038 from the lobster fisheries; Figure 3A) and 0.214 for 100% mortality (0.078 from the groundfish fishery, 0.136 from the lobster fisheries; Figure 3B). As noted, the F is reported for ages 2–5, a change from the F reported for ages 4–7+ in previous years (Andrushchenko and Hebert In prep. Error! Bookmark not defined.).

**Recruitment**

The model-estimated recruitment for 2024 is 0.94 million fish, representing the lowest value in the time series (Figure 1D). Overall, recruitment levels remain low which is consistent with fewer spawning fish observed in the population.

**Natural Mortality**

Model estimates indicate that natural mortality (M) has increased over time to high levels for older fish (ages 5+). For 2024, the model estimates an average M of 0.26 for ages 1–4 and 1.24 for ages 5–7+ (Figure 2C).

**Current Status**

The 2025 spawning stock biomass (2,666 mt) is at 24% of the LRP (11,150 mt), indicating that the 4X5Y Cod stock remains in the critical zone with a high probability (>99%).

**History of Landings and Total Allowable Catch**

Before the late 1990s, the proportion of Cod landings from the Scotian Shelf was greater than that from the Bay of Fundy. In the late 1990s, this proportion switched with the redistribution of fishery efforts, followed by a shift to similar proportions of the two components in the 2010s.

In the past three years, removals of Cod from the Bay of Fundy have decreased substantially, resulting in Scotian Shelf landings accounting for 70% of the total fishery removals in 4X5Y. Landings in the 4Xp mixing area increased starting in the 1980s and have remained at, or below, 30% of landings since the early 2010s (Table 1).

Cod quotas and catches have declined throughout the time series, with quota year catches remaining below the TAC in all years (Figure 1A). Cod landings from the groundfish fishery for the 2024–2025 management year were 466 mt, the lowest in the time series.

*Table 1. Historic landings and total allowable catch (TAC; in metric tons, mt) for 4X5Y Cod from the groundfish fishery. Landings for 2001 and prior are based on the calendar year, while landings post-2001 are based on the management year (April–March).*

Fishing Year	Average 1982-1991	Average 1992-2001	Average 2002-2011	Average 2012-2021	2021/22	2022/23	2023/24	2024/25
TAC (mt)	23,500	11,821	4,615	1,072	825	660	594	660
Landings (mt)	24,075	11,178	3,887	801	630	599	533	466

**Projections**

Requested scenarios are summarized in Tables 2, 3, and 4. For Tables 2 and 3, annual cod bycatch in the lobster fishery was assumed to be the recent five-year average of cod bycatch estimates (657.7 mt). For Table 4, the removals of Cod by the groundfish fishery were assumed to be 660 mt. All scenarios are provided for the most optimistic (24.8%) and most pessimistic

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(100%) cod bycatch mortality assumptions in the lobster fisheries, understanding that the true mortality lies between those extremes.

The projected scenarios in Tables 2 and 3 indicate a moderate to moderately high (39–75%) probability of decline by 2027 relative to 2025, even in the absence of removals by the groundfish fishery. The projected scenarios in Table 4 indicate a moderately high probability of decline (67–75%) by 2027 relative to 2025, under all reduction scenarios shown.

Third-year projections are no longer provided due to elevated levels of uncertainty in the third year.

*Table 2. Short-term projection outputs under three groundfish fishery harvest scenarios, obtained from two model runs which assume differing mortality rates for cod bycatch from the lobster fisheries. These projections assume that the total allowable catch (TAC) for 2025 (660 mt) was taken in full, and allow for varying harvest levels for 2026 and 2027. Projected cod bycatch from the lobster fisheries is set equal to the mean of the estimates for 2020–2024. Numbers in parentheses indicate the 95% confidence interval. Abbreviations: mt=metric tonnes;  $\bar{F}_{2-5}$ =fishing mortality on ages 2–5.*

Assumed bycatch mortality rate	Groundfish fleet scenario	2026 SSB (mt)	2027 SSB (mt)	2026 $\bar{F}_{2-5}$	2027 $\bar{F}_{2-5}$	P(2026 SSB < 2025 SSB)	P(2027 SSB < 2025 SSB)
24.8%	Current TAC–660 mt	3,019 (1,266–7,199)	2,261 (693–7,372)	0.23 (0.09–0.63)	0.30 (0.07–1.25)	0.21	0.68
24.8%	Half of current TAC–330 mt	3,019 (1,266–7,199)	2,562 (895–7,330)	0.13 (0.05–0.34)	0.16 (0.04–0.55)	0.21	0.55
24.8%	No catch–0 mt	3,019 (1,266–7,199)	2,867 (1,114–7,376)	0.05 (0.02–0.12)	0.05 (0.01–0.18)	0.21	0.39
100%	Current TAC–660 mt	2,794 (1,027–7,603)	1,840 (376–9,001)	0.42 (0.13–1.43)	0.61 (0.07–4.95)	0.38	0.75
100%	Half of current TAC–330 mt	2,794 (1,027–7,603)	2,139 (537–8,520)	0.30 (0.10–0.96)	0.38 (0.06–2.23)	0.38	0.68
100%	No catch–0 mt	2,794 (1,027–7,603)	2,443 (720–8,283)	0.20 (0.06–0.61)	0.22 (0.04–1.16)	0.38	0.58

*Table 3. Projected probability of change in SSB relative to 2025 under various groundfish fishery total allowable catch (TAC) scenarios, obtained from two model runs which assume differing bycatch mortality rates. Projections assume the full 2025 TAC (660 mt) was taken and explore varying harvest levels for 2026. Projected cod bycatch from the lobster fisheries is set equal to the mean of the estimates for 2020–2024. Abbreviations: mt=metric tonnes.*

Assumed bycatch mortality rate	Groundfish fishery harvest levels (mt)	P(2027 SSB < 2025 SSB)
24.8%	660	0.68
24.8%	594	0.66
24.8%	528	0.64
24.8%	462	0.61
24.8%	396	0.58
24.8%	330	0.55

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<b>Assumed bycatch mortality rate</b>	<b>Groundfish fishery harvest levels (mt)</b>	<b>P(2027 SSB &lt; 2025 SSB)</b>
24.8%	264	0.52
24.8%	198	0.49
24.8%	132	0.46
24.8%	66	0.42
24.8%	0	0.39
100%	660	0.75
100%	594	0.74
100%	528	0.73
100%	462	0.71
100%	396	0.70
100%	330	0.68
100%	264	0.67
100%	198	0.65
100%	132	0.63
100%	66	0.61
100%	0	0.58

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*Table 4. Short-term projection outputs under four scenarios of cod bycatch reduction in lobster fisheries, obtained from two model runs which assume differing cod bycatch mortality rates. These projections assume cod bycatch from the lobster fisheries in 2025 is equal to the 2020–2024 mean, and allow for varying cod bycatch levels relative to the mean thereafter. They further assume that the 2025 groundfish fleet total allowable catch of Cod (TAC; 660 mt) is maintained for 2026 and 2027 and fully taken in all three years. Numbers in parentheses indicate the 95% confidence interval. Abbreviations: mt=metric tonnes;  $\bar{F}_{2-5}$ =fishing mortality on ages 2–5.*

Assumed cod bycatch mortality rate	Cod bycatch reduction in 2026 and 2027 from 2020–2024 mean	2026 SSB (mt)	2027 SSB (mt)	2026 $\bar{F}_{2-5}$	2027 $\bar{F}_{2-5}$	P(2026 SSB < 2025 SSB)	P(2027 SSB < 2025 SSB)
24.8%	30%	3,019 (1,266–7,199)	2,298 (717–7,362)	0.22 (0.08–0.58)	0.27 (0.07–1.09)	0.21	0.67
24.8%	20%	3,019 (1,266–7,199)	2,286 (709–7,365)	0.22 (0.08–0.59)	0.28 (0.07–1.14)	0.21	0.67
24.8%	10%	3,019 (1,266–7,199)	2,273 (701–7,368)	0.23 (0.09–0.61)	0.29 (0.07–1.19)	0.21	0.68
24.8%	0% (no reduction)	3,019 (1,266–7,199)	2,261 (693–7,372)	0.23 (0.09–0.63)	0.30 (0.07–1.25)	0.21	0.68
100%	30%	2,794 (1,027–7,603)	1,990 (453–8,731)	0.35 (0.11–1.12)	0.45 (0.07–2.75)	0.38	0.72
100%	20%	2,794 (1,027–7,603)	1,940 (427–8,811)	0.37 (0.11–1.21)	0.50 (0.07–3.31)	0.38	0.73
100%	10%	2,794 (1,027–7,603)	1,890 (401–8,901)	0.40 (0.12–1.32)	0.55 (0.07–4.03)	0.38	0.74
100%	0% (no reduction)	2,794 (1,027–7,603)	1,840 (376–9,001)	0.42 (0.13–1.43)	0.61 (0.07–4.95)	0.38	0.75

**Ecosystem and Climate Change Considerations**

Ecosystem and climate change considerations were taken into account in the most recent assessment framework review and were not further updated or reviewed during this assessment (DFO 2025b, Andrushchenko et al 2022).

**PROCEDURE FOR INTERIM-YEAR UPDATES**

The proposed assessment cycle includes a model run to update the assessment of stock status and projections in 2028–2029. In the interim years, there will be an evaluation of assessment triggers.

**Evaluation of Assessment Triggers**

The trigger mechanisms defined during the 2018 framework review (DFO 2019) are as follows:

1. The 3-year median abundance for ages 7 through 9 is above 0 for all three ages.
2. The q-adjusted, 3-year median survey SSB falls outside of the 95% confidence interval of the projection.
3. The 3-year median of the age 7+ group abundance index falls outside of the 95% confidence interval of the projection.
4. The q-adjusted 3-year median survey biomass index exceeds Blim.

Meeting at least one of the four conditions above would trigger an assessment for the following year. In addition, a model review would happen if an improved estimate of historical Cod-lobster fishery interaction becomes available, updated cod bycatch mortality estimates from the lobster fisheries are available, perception of stock structure changes, or a framework is developed for incorporating ecosystem information into the stock assessment.

**SOURCES OF UNCERTAINTY**

Several data gaps and uncertainties were identified during the last modelling assessment framework (Wang and Irvine 2022) and stock assessment (DFO 2019), which continue to persist for the 4X5Y Cod stock.

With the incorporation of cod bycatch estimates from the lobster fisheries, additional uncertainties include the assumption of the magnitude of historical cod bycatch in lobster fisheries in 4X5Y, the mortality assumptions for the cod bycatch used for projections, and the magnitude of cod bycatch in 2024 (Andrushchenko and Hebert In prep.<sup>1</sup>).

While these uncertainties and data gaps have been identified, it is unlikely that they impact the relative stock trajectory and status.

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**SOURCES OF INFORMATION**

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APPENDIX

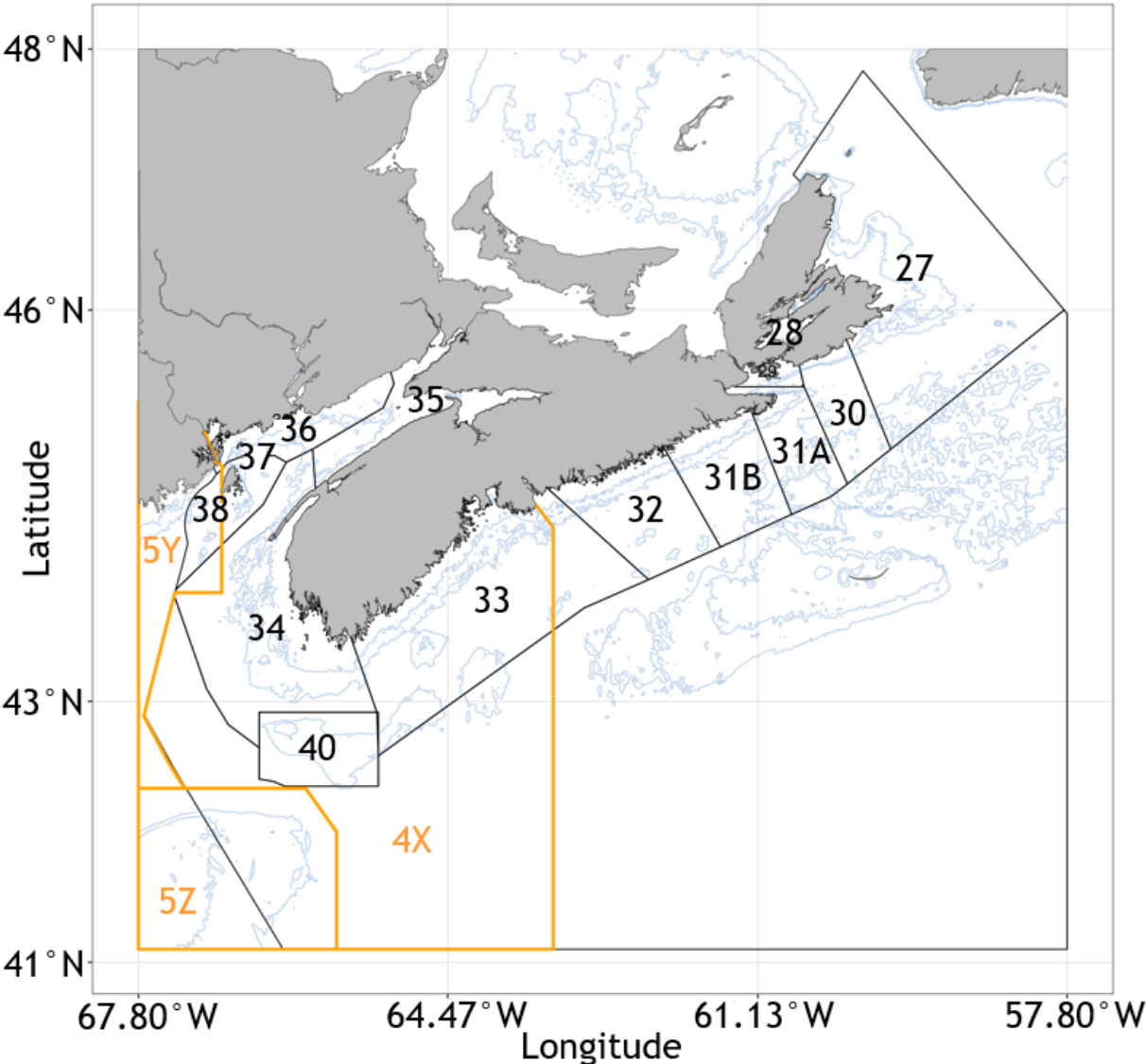


Figure A1. Map of DFO Maritimes Region lobster fishing areas (LFA labelled with numbers and outlined by black lines) and Northwest Atlantic Fisheries Organization Divisions (yellow lines). Blue lines represent depth contours. Originally published in DFO 2025.

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