



SOUTHERN GULF OF ST. LAWRENCE, NAFO DIVISION 4T-4VN (NOVEMBER-APRIL), ATLANTIC COD (*GADUS MORHUA*) STOCK ASSESSMENT TO 2023

CONTEXT

The Fisheries and Harbour Management sector of Fisheries and Oceans Canada (DFO) has requested a stock status for the southern Gulf of St. Lawrence (sGSL) (Northwest Atlantic Fisheries Organization (NAFO) Division 4T-4Vn (November-April)) Atlantic Cod (*Gadus morhua*). The commercial directed fishery has been under moratorium since 2009 and a 300 tonnes allowance has been set. The last scientific assessment for the Atlantic cod stock was completed in February 2019 (DFO 2019). This Science Advisory Report is from the February 20-21, 2024 regional peer review on the Southern Gulf of St. Lawrence, NAFO Division 4T-4Vn (November-April), Atlantic Cod (*Gadus morhua*) Stock Assessment to 2023. 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

- Spawning Stock Biomass (SSB) of southern Gulf of St. Lawrence Atlantic Cod has been in the Critical Zone of the Precautionary Approach (PA) Framework for several decades.
- The SSB of Atlantic Cod in 2023 is 12 kilotons (kt) and has a very high probability (100%) of still being in the Critical Zone.

Trends

- SSB varied between 100 and 370 kt in the early 1980s, but then decreased until the mid-1990s. Following a slightly increasing trend between the mid-1990s to the early 2000s, SSB declined until 2020 and has remained at low levels without trend.
- Natural mortality of older age classes (5+) has been increasing steadily since the mid-1980s.
- Recruitment steadily declined between the mid-1980s and 2016, showed a positive trend between 2016 and 2020, and was followed by low recruitment in the most recent years.

Ecosystem and Climate Change Considerations

- Elevated natural mortality of older individuals is most likely caused by predation from grey seals.

Stock Advice

- Although there have been increasing recruitment levels in recent years, under current conditions of high natural mortality, the probability that SSB will increase over the Lower Reference Point by 2028 is 0%, even in the absence of fishery removals.
- Projected SSB over the next five years continues to decline with a high probability of the SSB decreasing below 1 kt in the next 50 years.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

The population model developed and adopted for the 2012 assessment (Swain 2012; Swain, Savoie, and Aubry 2012) was updated at the 2015 (Swain et al. 2015) and 2019 (Swain et al. 2019) assessments. The same population model is used again for the current assessment.

Assessment Type

Full Assessment: Full peer-review stock assessment.

Most Recent Assessment Date

1. Last Full Assessment: March 2019 (DFO 2019; Swain et al. 2019)
2. Last Interim Year Update: April 2021 (DFO 2021)

Assessment Approach

1. Broad category: single stock assessment model
2. Specific category: Statistical catch-at-age (SCA)

Stock Structure Assumption

The determination of stock structure was the focus of much research in the 1990s and early 2000s. A number of surveys and data analyses took place to ascertain that 4T Atlantic Cod migrated to overwintering grounds in 4Vn, and to also examine the presence of Cod from other nearby areas (4RS, 4T, 4Vs, 4Vw and 3P) at the mouth of the Gulf of St. Lawrence (south of the Cabot Strait) during the winter months. Otolith elemental fingerprints indicated that 4T Cod was present in the western side of the Cabot Strait during the winter months. The stock structure initially considered that the 4Vn portion was used from January to April, and this was revised to be from November to April.

Reference Points

- Limit Reference Point (LRP):
 - The previous LRP was determined around the convergence of estimates from various methods (RK_{50} , BH_{50} , $SB_{50/90}$, $B_{recover}$, NP_{50}) and was estimated to be 80 kt in the 2003 stock assessment (Chouinard et al. 2003)

- $0.25SSB_0$: The LRP was revisited as part of the CSAS rebuilding plan process (Turcotte, McDermid, and Ricard In preparation¹). The revised LRP is derived from the SCA model and is estimated to be 210 kt.
- Upper Stock Reference (USR):
 - The USR is estimated at 200 kt of SSB (Mohn and Chouinard 2004)
- Removal Reference (RR): not defined
- Target Reference (TRP): not defined

SSB is currently estimated to be 12 kt (median estimate), well below the LRP with no chance that it is at or above that level. Projections indicate that it will remain below that level with high probability (100%) at current productivity and levels of fishery removals.

Data

Inputs to the population model are:

- Commercial catches (1950 to 2023)
- Age distribution from catch sampling (proportions-at-age, 1950 to 2023)
- Mobile sentinel survey index (2003 to 2019)
- Longline sentinel survey index (1995 to 2017)
- Multispecies bottom trawl research vessel survey (RV) abundance index (1971 to 2023)
- Age distribution (proportions-at-age), weight-at-age, maturity-at-age from the trawl survey (1971 to 2023)

Data changes:

- The sentinel surveys ended in 2019.
- The vessel and gear used in the annual September trawl survey changed from CCGS *Teleost* using a Western IIA trawl to CCGS *Capt. Jacques Cartier* using a NEST trawl in 2023. Comparative fishing experiments were conducted in 2021 and 2022 to estimate differences in fishing efficiency between the two survey platforms. Important length-dependent differences in fishing efficiency were observed between the two platforms and the estimated conversion factors (Benoît and Yin 2023) were applied to Atlantic Cod survey catch data to maintain the continuity of the survey time-series.

¹ Turcotte, F., J. McDermid, and D. Ricard. In prep. Scientific Requirement for the Rebuilding Plan of Southern Gulf of St. Lawrence (NAFO Division 4T and 4Vn November to April) Atlantic Cod (*Gadus Morhua*). DFO Can. Sci. Advis. Sec. Res. Doc.

ASSESSMENT

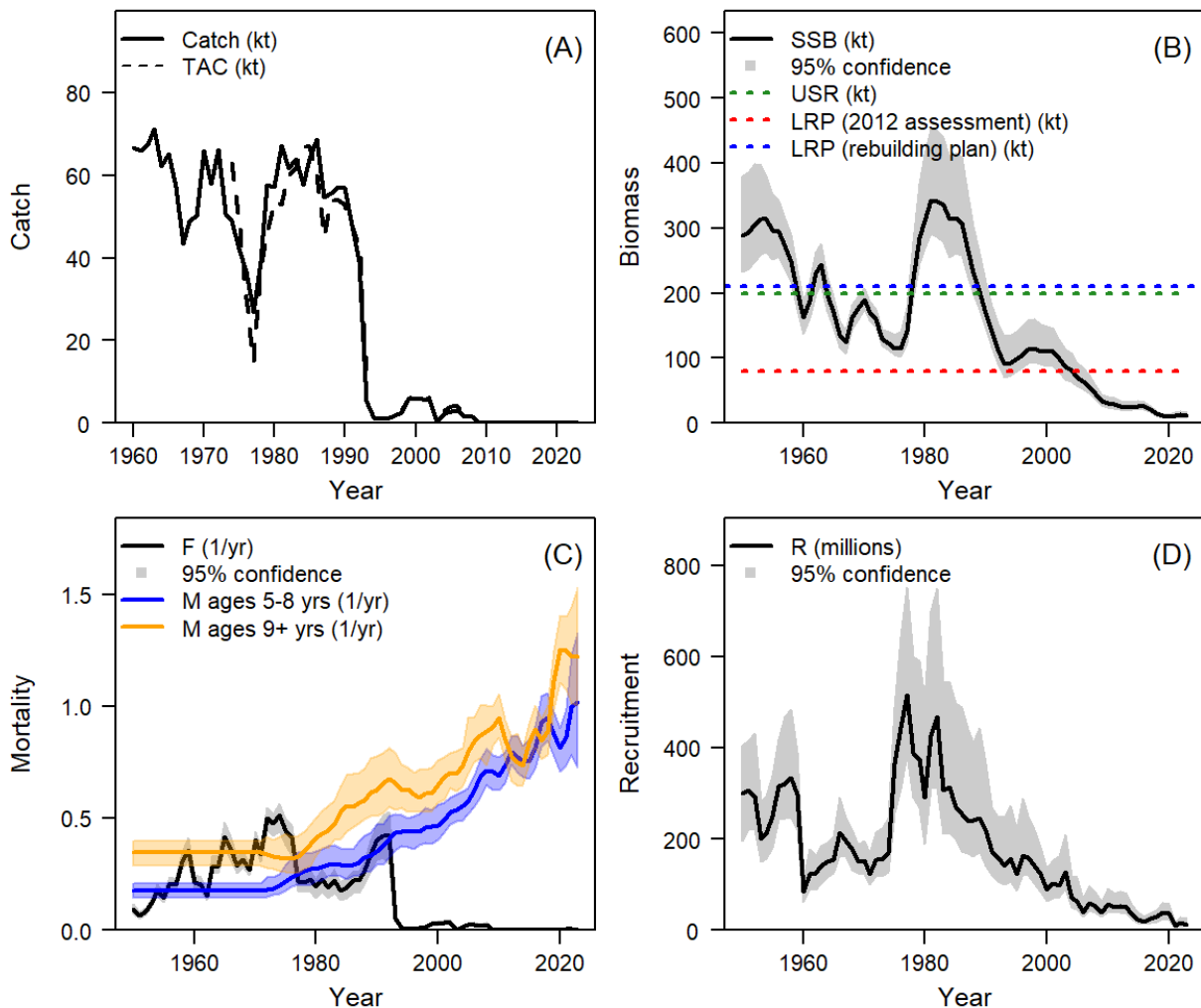


Figure 1: (A) Catch and Total Allowable Catch in kilotonnes (kt), (B) Spawning Stock Biomass (SSB) in relation to the Limit Reference Point (LRP) and Upper Stock Reference (USR) in kt, (C) Fishing Mortality (F) and Natural Mortality (M) in yr^{-1} , (D) Recruitment (numbers in millions).

Historical and Recent Stock Trajectory and Trends

Biomass

Estimated SSB peaked at about 320 kt in the mid-1950s, declining to 120 kt in the mid-1970s. Biomass rapidly recovered in the late 1970s, reaching a peak of 370 kt in 1981. Biomass then collapsed equally rapidly between about 1987 and 1993, when the directed fishery was closed at a SSB of 102 kt. Estimated biomass increased slightly to 120 kt during the 1994 to 1997 moratorium on directed commercial fishing for Cod. The directed fishery then re-opened at a low level and the stock decline resumed, declining to 36 kt by 2009, when a moratorium was again imposed on directed commercial Cod fishing. The stock decline slowed following the imposition of this moratorium, with SSB estimated to be 27 kt at the start of 2016. However, estimated SSB dropped rapidly over the next five years, with biomass estimated to be 12 kt at the start of 2023 (95% CI: 10,5 to 21,6 kt). Estimated SSB at the beginning of 2019 and 2020 each set a new

record for the lowest biomass observed. SSB at the start of 2023 was estimated to be 12% of the biomass at the end of the moratorium in 1997, 13% of the previous low value in 1975, 5% of the average level in the 1980s and 3% of the estimated average SSB in the 1950s (Figure 1B). Estimated trends in biomass of individuals aged 5 and older (approximately equal to adult or commercial biomass) were similar to those described above for SSB.

The composition of the SSB is still dominated by young fish.

Recruitment

The catch-at-age information coming from the RV survey suggests that a few good recruitment events occurred since the last assessment (Figure 1D), where pulses of young fish (less than 4 years old) were observed in the stock.

Mortality

Instantaneous natural mortality rate of adult Cod (5 years and older) has increased over the past 40 years and is now very high at greater than 0.8 yr^{-1} (Figure 1C). This value is much greater than in the early time series when values were more at standard levels of 0.2 yr^{-1} . This high level of natural mortality is now the main factor preventing this stock from recovering.

The fishing mortality exerted by the limited removals is negligible and marginal compared to natural mortality (Figure 1C).

History of TAC & Catch Advice

The first total allowable catch (TAC) for this stock was established at 63 kt in 1974, declining to 15 kt in 1977 (Figure 1A). The TAC then increased to a peak of 67 kt in 1984 and 1985. The fishery was closed in September 1993 due to low Cod abundance. Following an “index” fishery in 1998 (3 kt TAC), the directed cod fishery re-opened in 1999 with a TAC of 6 kt. The fishery was closed a second time in 2003. The directed fishery re-opened again in 2004 but was closed in 2009. The TAC varied between 2 and 4 kt during the re-opening. The directed commercial Cod fishery has remained closed since 2009 (Table 1). A TAC of 300 t remains to allow for bycatch in other groundfish fisheries, catch in a limited recreational fishery, catch for scientific purposes and Indigenous food, social and ceremonial fisheries.

Table 1: Cod in NAFO 4T-4VN(Nov. to Apr.). Landings and TAC for 2003 to 2023. All weights are in tonnes.

Year	4T	4VN (Nov.-Dec.)	4VN (Jan.-Apr.)	Total landings	TAC
2003	288	1	0	288	moratorium
2004	2,257	43	0	2,300	3000
2005	2,819	1	14	2,835	4000
2006	3,010	0	0	3,010	4000
2007	1,342	0	135	1,478	2000
2008	1,552	0	110	1,662	2000
2009	148	0	0	148	moratorium
2010	105	0	0	105	moratorium
2011	109	1	5	115	moratorium
2012	150	0	22	172	moratorium
2013	109	1	2	111	moratorium
2014	110	0	3	114	moratorium
2015	101	3	0	104	moratorium
2016	99	4	11	115	moratorium
2017	54	0	3	58	moratorium
2018	60	0	0	61	moratorium
2019	53	1	1	54	moratorium
2020	58	2	0	61	moratorium
2021	79	3	4	87	moratorium
2022	110	4	3	117	moratorium
2023	31	0	0	31	moratorium

Projections

Short-term (5 years) projections indicate the continued decline in SSB (Figure 2). The long-term (50 years) stock projections indicate that the stock has a very high probability (97%) of commercial extinction (SSB < 1,000 t), even with no fishing, due to the high level of natural mortality (Figure 3).

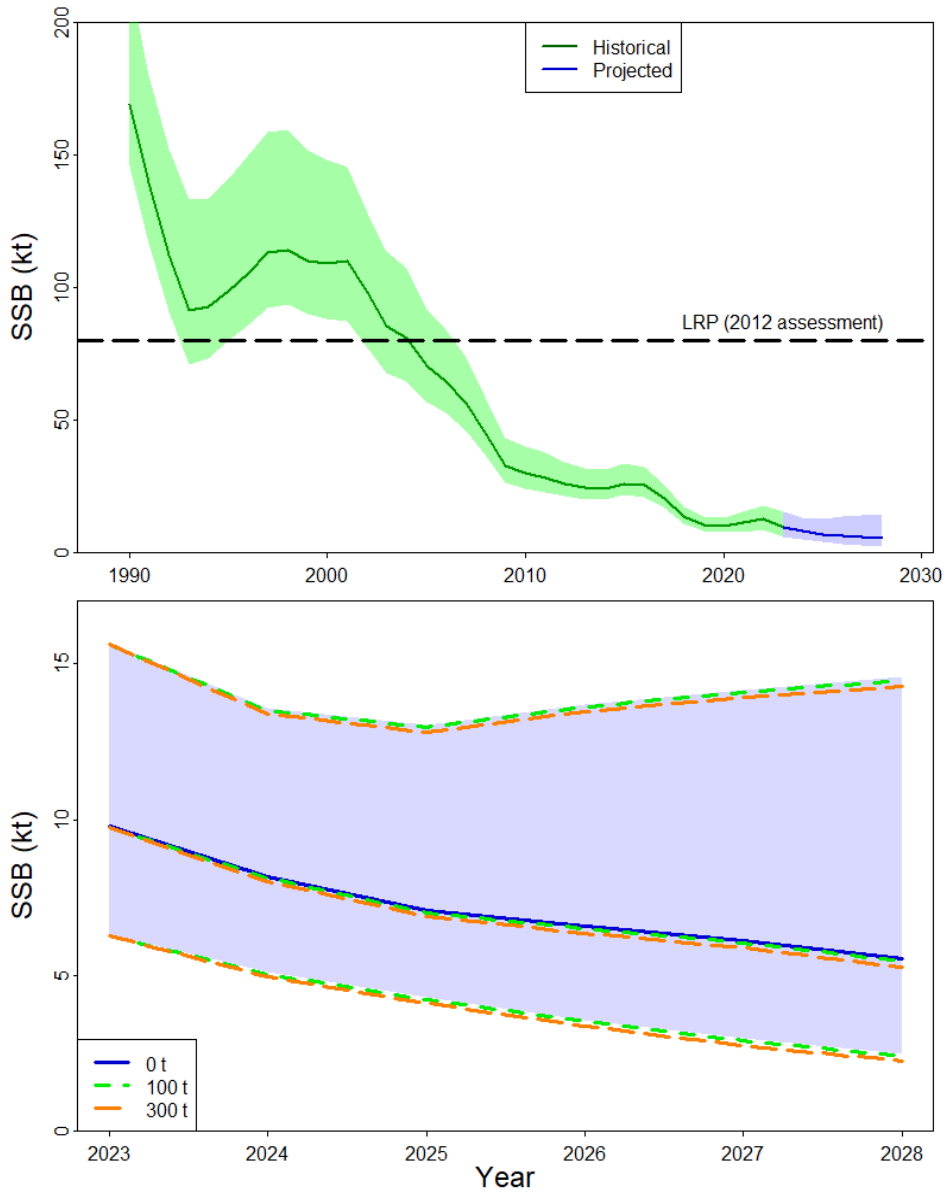


Figure 2: Estimated (green) and projected (blue) SSB of Atlantic Cod from the southern Gulf of St. Lawrence based on the population model. Projections assume that recent productivity conditions persist during the projection. Lines show the median estimate and shading the 95% credible intervals based on MCMC sampling of the posterior distribution. Line colours indicate annual catches of 0 t (solid blue line and shading), 100 t (short dashed green lines), or 300 t (long dashed orange lines) were used during the projection. The heavy black horizontal line is the LRP of 80 kt defined in the 2012 assessment. The lower panel focuses on the 5-year projection period.

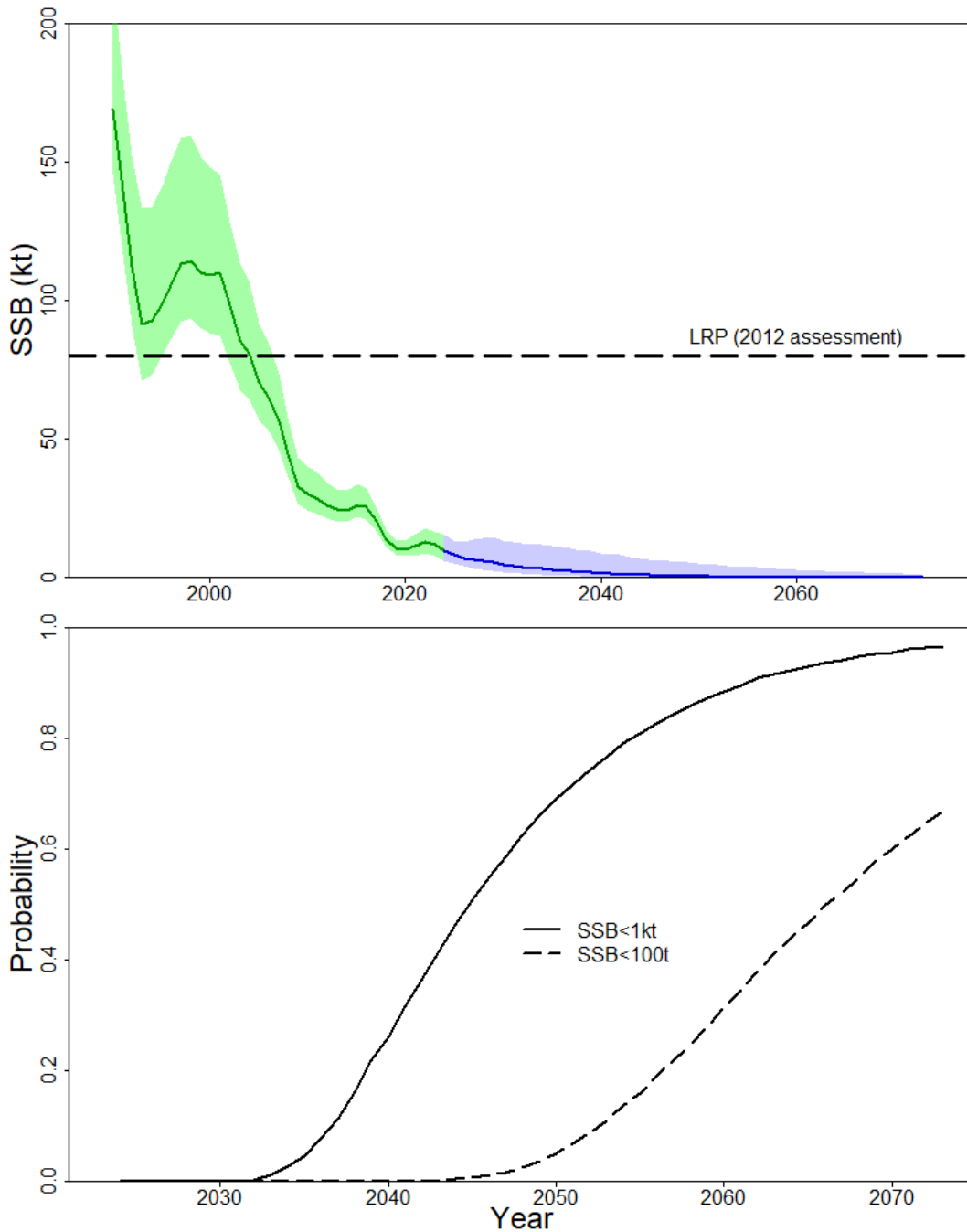


Figure 3: Projected SSB of Atlantic Cod from the southern Gulf of St. Lawrence over a 50-year projection (upper panel) and the probability that SSB declines below extinction proxies (lower panel). Projections assume that recent productivity conditions persist during the projection and that fishery catch is null over the projection period. In the upper panel, lines and shading show the median estimate of SSB and its 95% credible interval, colour denotes the historical (green) and projection (blue) periods, and the horizontal line is the LRP of 80 kt defined in the 2012 assessment. In the lower panel, the lines show the probability that SSB is below 1 kt (solid line) or 100 t (dashed line) extinction proxies.

Ecosystem and Climate Change Considerations

Predation by grey seals is the most probable cause of the increase in natural mortality estimated for this stock (DFO 2019). The most recent estimates indicate that the abundance of the grey seal Gulf herd is leveling off, however other herds foraging in the Gulf continue to increase (Hammill et al. 2023).

Evaluation of Exceptional Circumstances/Assessment Triggers

A stock status indicator based on the annual RV survey can be computed in the interim years (e.g. DFO 2021). An assessment would be triggered if the re-scaled value of the RV index exceeds the re-scaled value of the LRP.

BYCATCH

The stock is captured as bycatch in a number of other fisheries including Atlantic Halibut, Greenland Halibut, Witch Flounder and Redfish. While the magnitude of bycatch does not exceed the allocated bycatch quota, there is a possibility that bycatch will increase with the re-opening of the commercial Redfish fishery. Close monitoring of Atlantic Cod bycatch and appropriate management measures may become necessary if bycatch levels exceed the allocated bycatch quota.

SOURCES OF UNCERTAINTY

The sentinel survey program has not been conducted since 2020. The only available fishery-independent index now relies on the annual RV survey. While the sentinel indices were highly correlated with the RV indices, the impact of not having the sentinel data for model fitting has not been assessed.

The limited amount of landings and associated fishery catch samples provide little information on stock dynamics. However, under current stock condition, the perception of stock status is not influenced by this missing information.

A shift in the summer distribution of Cod to deeper waters could impact the assumption of constant catchability to the sGSL RV survey. An examination of Cod catches in 4T from the northern GSL RV survey could shed light on this topic.

Temporal changes in body condition have been identified for this stock, and this may impact fecundity, recruitment and natural mortality.

In light of the patterns in model residuals in the current assessment, changes in the fisheries affecting this stock, and other issues identified above, a review of the assessment framework could be considered.

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