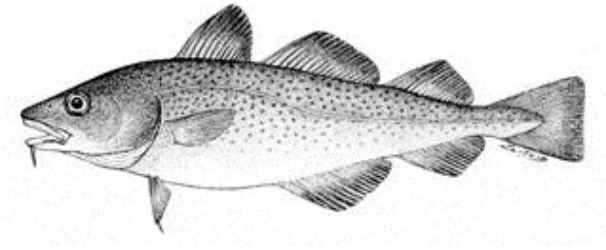
Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Gulf Region

Canadian Science Advisory Secretariat
Science Advisory Report 2024/033

SCIENCE ADVICE TO SUPPORT THE REBUILDING PLAN FOR ATLANTIC COD (*GADUS MORHUA*) IN THE SOUTHERN GULF OF ST. LAWRENCE, NAFO DIVISION 4T-4VN (NOVEMBER-APRIL)



*Atlantic Cod (*Gadus morhua*)*
Credit: Food and Agriculture Organization of the United Nations

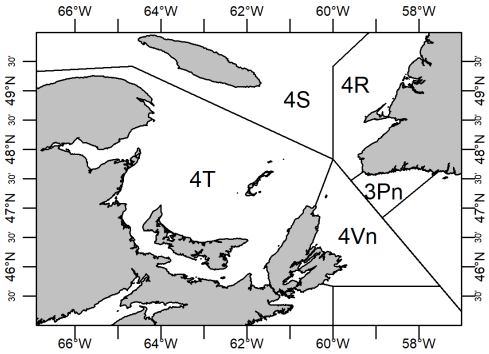


Figure 1. NAFO Divisions in the Gulf of St. Lawrence and Cabot Strait

Context:

*The Atlantic Cod (*Gadus morhua*) stock in the southern Gulf of St. Lawrence (NAFO Division 4T-4Vn (November-April)) is below its limit reference point and in the Critical Zone of the Fisheries and Oceans Canada (DFO) Precautionary Approach framework. The new Fish Stocks Provisions and the amended Fisheries Act legally require DFO to develop a rebuilding plan for this stock. A rebuilding plan comprises several elements that require DFO Science sector advice including: (i) stock status, (ii) causes of stock decline, (iii) rebuilding target and timeline, (iv) additional measurable objectives, (v) likelihood of management measures meeting rebuilding objectives, (vi) how to track rebuilding progress, and (vii) frequency of the periodic review of the rebuilding plan.*

*This Science Advisory Report is from regional peer review of February 22-23, 2024 on Science Advice to Support the Rebuilding Plan for Atlantic Cod (*Gadus morhua*) in the Southern Gulf of St. Lawrence, NAFO Division 4T-4Vn (November-April). Participants at the meeting included DFO Science (Gulf, Maritimes, Québec, National Capital regions), DFO Fisheries Management (Gulf, Québec regions), academia, provincial governments, Indigenous organizations, ENGOs, and the fishing industry. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

June 2024 (Erratum: November 2024)

SUMMARY

- Southern Gulf of St. Lawrence Atlantic Cod biomass was stable and relatively high from 1917 to the late 1940s. Biomass declined in the 1950s as catches increased and fishing mortality was high. The 2018 biomass was 2.4% of the 1917 biomass, which is consistent with the scale of depletion found for adjacent Cod stocks.
- The main source of serious harm to stock productivity and cause of decline was overfishing starting in 1955. High natural mortality associated with predation by Grey seal has prevented the stock from recovering since the fishery moratorium.
- Other sources of serious harm include a lasting state of low production and low biomass, recruitment overfishing, high natural mortality, a predation-driven Allee effect, low growth and body condition, and a decrease in age at maturity.
- A review of the spawning stock biomass (SSB) reference points identified a new Limit Reference Point (LRP) of initial $0.25B_{0.}$ A proposed Upper Stock Reference was $0.8BMSY_{proxy}$ and a target reference point of $BMSY_{proxy}$.
- The stock crossed the LRP into the Critical Zone of Fisheries and Oceans Canada (DFO) Precautionary Approach framework in 1990.
- The definition of the rebuilding target, where the stock has a 75% probability of being at or above the LRP, should be amended to include that the stock must be at or above this level for 4 consecutive years and population projections must show the stock is likely to continue its positive trajectory under harvest for 4 years after the rebuilt state has been achieved.
- Even in the absence of fishing mortality, the SSB is unlikely to increase to the rebuilding target under prevailing conditions or under various stock projections using natural mortality and recruitment rates consistent with historical levels.
- At annual removals of 200 tonnes (t) or less, the stock trajectory is indistinguishable from projections under zero fishing. At 300 t, SSB is reduced 10% in 10 years compared to zero fishing; at 500 t, SSB is reduced 16%.
- The main sources of Cod bycatch are the Atlantic Halibut, Witch Flounder, and Greenland Halibut commercial fisheries, as well as the experimental and index fisheries that target Redfish.
- Implementing dynamic closures (seasonal and/or annual) of specific areas and fishing depth restrictions reduced species distribution model-predicted bycatch.
    - Bycatch was reduced 18% in the Atlantic Halibut fishery in NAFO 4T, and 14% in the Cod overwintering area in 4Vn,
    - 98% in the NAFO 4T Witch Flounder fishery, and
    - 81% to 84% in the NAFO 4T Greenland Halibut fishery[1].
- As the commercial Redfish fishery reopens, bycatch of Atlantic Cod is expected to increase. Implementing an area closure and a minimum fishing depth restriction of 300 m and limiting fishing to June through August reduced predicted bycatch of Cod by at least 56% compared to historical fishing and at least 46% compared to current fishing in NAFO 4T. In NAFO 4Vn, an area closure combined with a minimum latitude limit in winter reduced predicted Cod

[1] Erratum November 2024: Applied an updated bathymetry reference for the Gulf of St. Lawrence Estuary.

bycatch by at least 22% compared to historical fishing and at least 14% compared to current fishing.

- Although a winter (November to April) Redfish fishery had greater potential bycatch compared to a summer (June to August) fishery, the proposed area closures for NAFO 4T and NAFO 4Vn combined with a 300 m minimum fishing depth in NAFO 4T reduced predicted bycatch by at least 96% compared to without these restrictions.
- Additional measurable objectives of the rebuilding plan include; increase the proportion of larger fish, increase size and condition at length, recover the spatial distribution in shallow waters, and promote recruitment by protecting spawning grounds.
- Rebuilding progress will be tracked using the stock assessment model. The periodic review of the rebuilding plan should be set to the 4-year stock assessment cycle with an interim update at the halfway point. Objectives should be revised and models should be updated if stock productivity or external factors influencing stock dynamics change.

INTRODUCTION

Under the Fish Stocks Provisions (FSP) section 6.2 in the amended Fisheries Act (2019) and section 70 of the Fishery General Regulations, it is a legislated requirement to develop and implement a rebuilding plan for a prescribed major fish stock, within 24 months of the day on which the Minister first has knowledge the stock has declined to or below its limit reference point (LRP). If a stock is already at or below its LRP when it is prescribed under the FSP, the 24-month timeline to develop a rebuilding plan for the stock starts the day the stock is prescribed in regulation, which occurred April 4, 2022 for Atlantic Cod (*Gadus morhua*) in the southern Gulf of St. Lawrence (hereafter; sGSL Cod).

The management unit for the sGSL Cod stock consists of the Northwest Atlantic Fisheries Organization (NAFO) Division 4T as well as subdivision 4Vn from November to April (Figure 1). This stock has been fished at least since the sixteenth century. Following the stock collapse in the 1990s, the fishery was closed from September 1993 to May 1998, re-opened as an index-fishery in 1999, to be closed again since 2009. A total allowable catch (TAC) of 300 tonnes (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. The main sources of sGSL Cod bycatch are fisheries targeting Atlantic Halibut, Greenland Halibut, Witch Flounder, and Redfish.

Both the last assessment and the interim update confirmed that the stock has remained below the LRP and in the Critical Zone of the Precautionary Approach (PA). Therefore, a rebuilding plan was developed. The specific objectives of this document are to: (1) review and update the LRP and establish the stock status and trajectory, (2) provide advice on the rebuilding target, (3) calculate and evaluate the likelihood of achieving the rebuilding target in a specified timeline under various environmental and fishery management scenarios, (4) propose additional measurable objectives, (5) identify indicators for tracking rebuilding progress, and (6) provide guidance on the frequency of the periodic review of the rebuilding plan.

ANALYSIS

Serious harm and cause of decline

The sources of serious harm to stock productivity of sGSL Cod are multiple, including overfishing, a lasting state of low production-low biomass, recruitment overfishing, high natural

mortality and a predation-driven Allee effect, low growth and body condition and a decrease of age at maturity.

A surplus production model, using catch between 1917 and 2018 and the DFO sGSL multispecies bottom trawl survey, was used to estimate Cod biomass between 1971 and 2018. Cod biomass exceeded B_{MSY} between 1917 and the late 1940s when catch averaged 31,000 t per year and fishing mortality was below F_{MSY}. Catch started increasing (averaging 57,000 t per year between 1945 to 1991) and fishing mortality was above F_{MSY} by 1955. The stock biomass then started to decrease and was below B_{MSY} by 1960. According to this model, the sGSL Cod biomass in 2018 was 2.4% of the biomass in 1917, which is consistent with the scale of depletion found for adjacent Cod stocks. The source of serious harm for sGSL Cod was overfishing that was initiated in the 1950s and occurred onwards. High natural mortality associated with predation by grey seal has prevented the stock from recovering since the fishery moratorium.

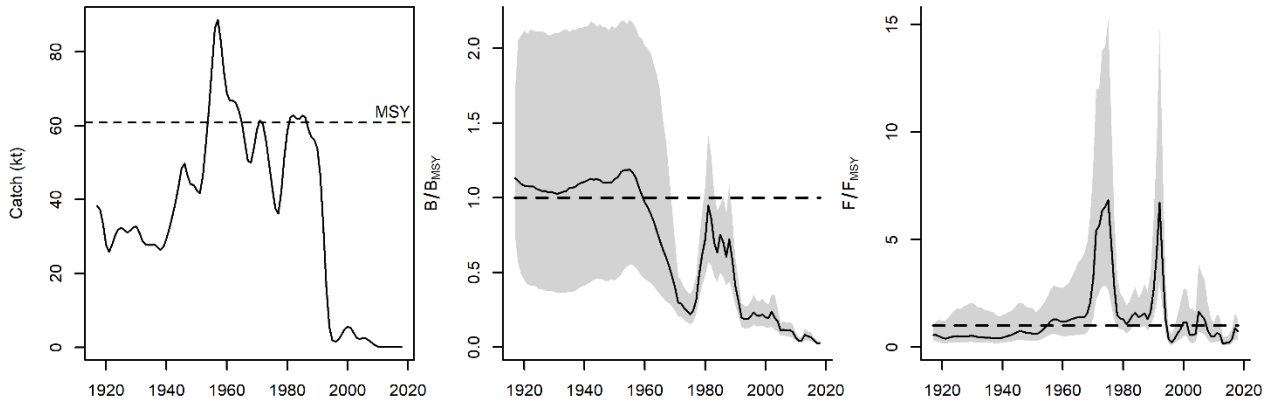


Figure 2. Left panel: Southern Gulf of St. Lawrence Atlantic Cod catch (kilotonnes; kt) between 1917 and 2018 (black line). The horizontal dashed black line is the maximum sustainable yield (MSY) value. Middle panel: biomass relative to biomass at maximum sustainable yield (B/BMSY; y axis), between 1917 and 2018. Black line is the median estimate and grey shading is the 95% confidence interval. Horizontal dashed black line is the BMSY value. Right panel: fishing mortality relative to fishing mortality at maximum sustainable yield (F/FMSY; y axis), between 1917 and 2018. Black line is the median estimate and grey shading is the 95% confidence interval. The horizontal dashed black line is the FMSY value.

Biomass reference points and stock status

An evaluation of 15 different candidate LRPs identified initial $0.25B_0$ as the best candidate LRP for sGSL Cod. Its value was estimated at 210,000 t of SSB. Using the default rules suggested by the PA, a USR and TRP can be calculated from B_0 when considered a proxy for B_{MSY}. The USR ($0.8BMSY_{proxy}$) was estimated at 336,000 t of SSB and the TRP ($BMSY_{proxy}$) was estimated at 420,000 t of SSB. Using the newly defined LRP and proposed USR from this study, the 2018 stock status remains in the Critical Zone (no change from previous assessment). With this new LRP, the stock crossed the LRP into the Critical Zone in 1990, whereas it was 2005 with the former LRP.

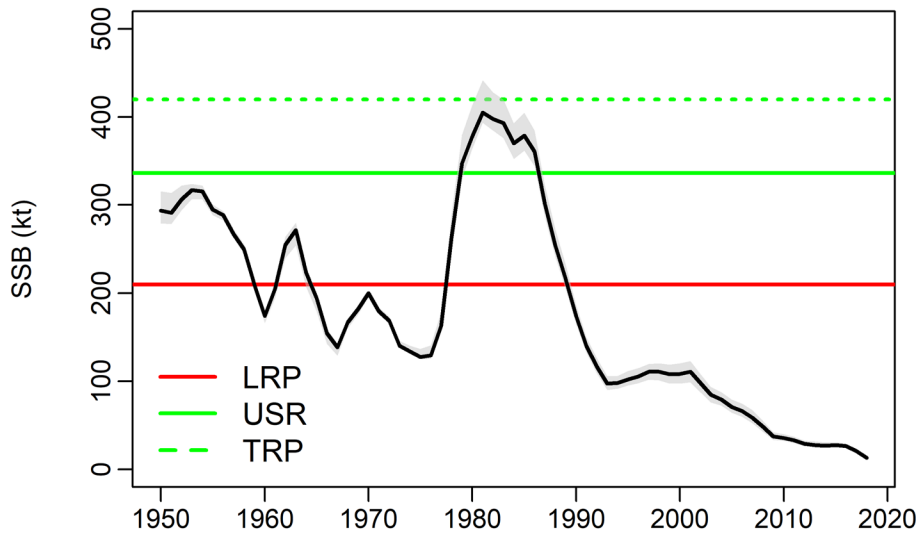


Figure 3. Reference points for southern Gulf of St. Lawrence Atlantic Cod (Limit reference point 0.25B_0, red line; Upper stock reference 0.8BMSYproxy, green full line; Target reference point BMSYproxy, green dashed line). Black line is the median SSB estimate (kt) and grey shading is the 95% confidence interval.

Rebuilding target and timeline

The DFO science guidelines to support development of rebuilding plans states that the rebuilding target should be set far enough above the LRP such that there is a low probability of falling below the LRP in the short to medium term (DFO 2021). The current rebuilding target proposed for this stock is being at or above the LRP with 75% probability. The uncertainty in SSB estimates for sGSL Cod are relatively small, therefore the rebuilding target is very near the LRP. As such, this target theoretically offers a higher probability of the stock falling below the LRP than a target set closer to the USR or the TRP for example. If this rebuilding target is retained, it should be amended to include that the stock must be at or above this level for 4 consecutive years, and population projections must show the stock is likely to continue its positive trajectory under harvest for 4 years after the rebuilt state has been achieved. Four years was selected since a rebuilding timeline could not be calculated or used to inform the choice of the number of years of growth that would minimize the probability of the stock falling below the LRP in the short to medium term. The number of years has consequently been set to the multi-year assessment cycle and projection timeline for advice for this stock. This is also the frequency of review of the rebuilding plan.

A rebuilding plan also requires that the timeline to rebuild be identified in order to track rebuilding progress with respect to the objectives and management measures. The international standard and the approach recommended by DFO (2021) is to estimate the time to reach the rebuilding target in the absence of all fishing (T_{min}). In the absence of fishing mortality and under current average recruitment rates and high natural mortality conditions, the stock is not expected to recover, and is expected to continue to decline. Irrespective of the combination of natural mortality and recruitment levels used in of population projections, the stock was unable to exceed the LRP with a probability of 75% within a 40 year time period. Hence, the stock is unlikely to rebuild to the rebuilding target, even in the absence of fishing mortality. If T_{min} cannot be calculated, an estimate of an alternative such as generation time provided by DFO Science can be used by Fisheries and Harbour Management to define a rebuilding timeline. The generation time for sGSL Cod is 12 years (Swain et al. 2012).

Fisheries and Harbour Management requested that Science test a scenario where the small fish protocol catch size limit would be increased above 43 cm to determine if increasing this size limit for sGSL Cod could have an impact on current population trends. Projections showed no impact of increasing the legal size on population processes and stock trajectory.

Bycatch mitigation

Reducing bycatch of sGSL Cod is unlikely to rebuild the stock, since population projections with F = 0 showed that the stock would remain in the Critical Zone in the long term. At bycatch rates up to 200 t annually, the stock trajectory is indistinguishable from projections under zero fishing. Projections showed that at 300 t of bycatch, Cod SSB in 10 years would be reduced by 10% compared to F=0. At 500 t of bycatch, Cod SSB in 10 years would be reduced by 16%.

The current sources of sGSL Atlantic Cod bycatch are in order of importance the Atlantic Halibut, Witch Flounder, and Greenland Halibut commercial fisheries, as well as the experimental and index fisheries that target Redfish. To assess the species spatial overlap and potential for bycatch in these fisheries, species distribution models were fit to fisheries-independent survey data and fishery-dependent landings data in NAFO Division 4T and NAFO 4Vn (November to April). Depending on the model predictor variables included geographic location, year, month, and depth.

Atlantic halibut fishery

The Atlantic Halibut fishery accounts for the vast majority of sGSL Cod bycatch (average 82% of Atlantic Cod bycatch from 2013 to 2017). Predicted bycatch from species distribution models in NAFO Division 4T was reduced by 18% by implementing dynamic closures (seasonal and/or annual) as well as a seasonal fishing depth closure between 100 and 280 m. Model-predicted bycatch in NAFO Division 4Vn was reduced by 14% by implementing an area closure.

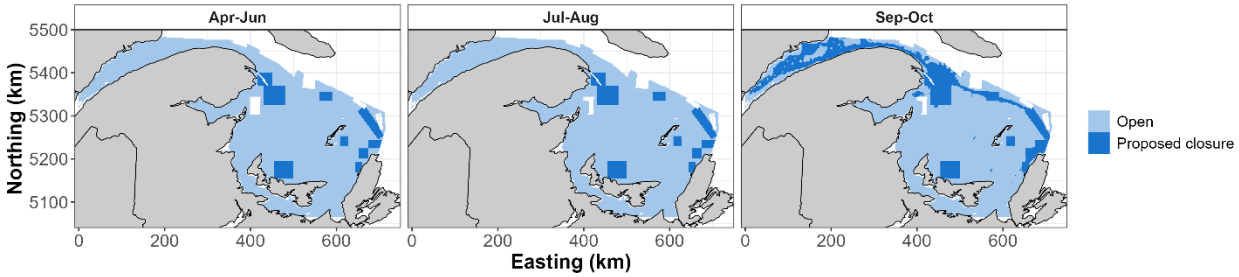


Figure 4. Proposed closures for Atlantic Halibut-directed fishing in NAFO 4T to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

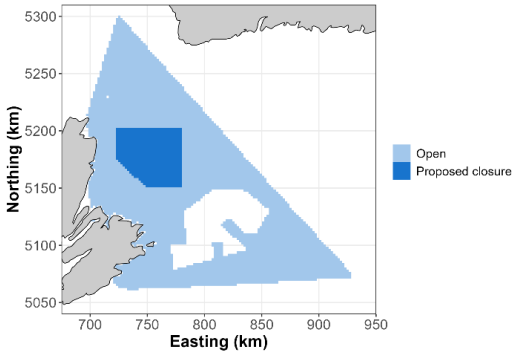


Figure 5. Proposed closures for Atlantic Halibut-directed fishing in NAFO 4Vn to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

Witch Flounder fishery

The Witch Flounder fishery accounts for the second largest Cod bycatch (average 11% of Atlantic Cod bycatch from 2013 to 2017). Predicted bycatch from species distribution models was reduced by 98% by implementing a minimum fishing depth restriction of 200 m.

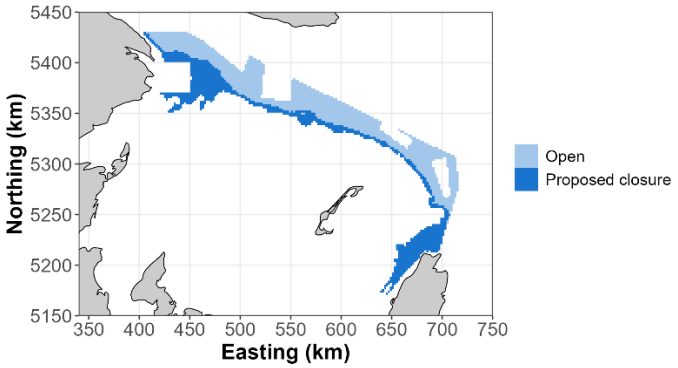


Figure 6. Proposed closures for Witch Flounder-directed fishing in NAFO 4T to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

Greenland Halibut

The Greenland Halibut fishery accounts for the third largest Cod bycatch (average 4% of Atlantic Cod bycatch from 2013 to 2017). Predicted bycatch from species distribution models was reduced by 81% to 84% by implementing a minimum fishing depth restriction of 200 m combined with a new latitude limit east of Gaspé (48.9164°N)[1].

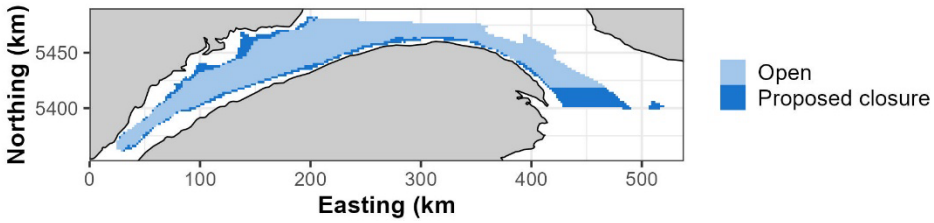


Figure 7. Proposed closures for Greenland Halibut-directed fishing in NAFO 4T to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

Redfish fishery

The experimental and index Redfish fisheries accounted for an average of 3% of Atlantic Cod bycatch from 2013 to 2017. As the commercial Redfish fishery reopens, bycatch of Atlantic Cod is expected to increase. Predicted bycatch from species distribution models in NAFO Division 4T was reduced by at least 56% compared to historical fishing and at least 46% compared to current fishing by limiting fishing to months June through August, implementing an area closure, and implementing a minimum depth restriction of 300 m (Figure 8, Table 1). Under the current fishing grid, model-predicted bycatch of Atlantic Cod across months ranged from 30 t to 528 t with a Redfish catch of 5,000 t, from 59 t to 1,057 t with a Redfish catch of 10,000 t, and from 119 t to 2,113 t with a Redfish catch of 20,000 t. Under the proposed scenario, model-predicted bycatch of Atlantic Cod ranged from 27 t to 36 t, from 54 t to 72 t, and from 107 t to 144 t, given the same Redfish catch options.

Model-predicted bycatch in NAFO Division 4Vn was reduced at least 22% compared to historical fishing, and at least 14% compared to current fishing by implementing an area closure

and a closure south of the latitude 45.9000°N (Figure 9, Table 2). Under the current fishing grid, model-predicted bycatch of Atlantic Cod across months ranged from 32 t to 5,214 t with a Redfish catch of 5,000 t, from 64 t to 10,429 t with a Redfish catch of 10,000 t, and from 129 t to 20,858 t with a Redfish catch of 20,000 t. Under the proposed scenario, model-predicted bycatch of Atlantic Cod ranged from 22 t to 310 t, from 44 t to 621 t, and from 87 t to 1,241 t the same Redfish catch options.

Although a winter (November to April) Redfish fishery had greater potential bycatch compared to a summer (June to August) fishery, the proposed area closures for NAFO 4T and NAFO 4Vn combined with a 300 m minimum fishing depth in NAFO 4T reduced predicted bycatch by at least 96% compared to without these restrictions (Figure 10, Table 3).

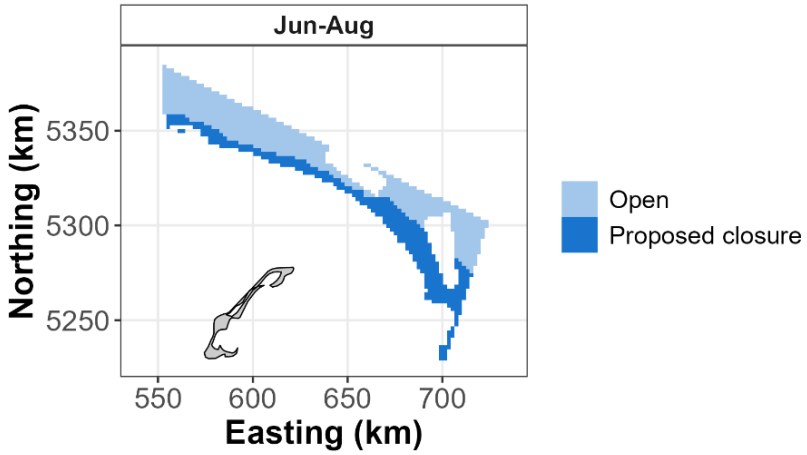


Figure 8. Proposed closure for Redfish-directed fishing in NAFO 4T to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

Table 1. NAFO 4T predicted tonnes (t) of sGSL Atlantic Cod bycatch with monthly Redfish TACs of 5,000 t, 10,000 t, and 20,000 t under current and proposed fishing areas. Bold values indicate bycatch weights that exceed the current annual quota of 152.2 t of Atlantic Cod bycatch across all commercial groundfish fisheries. In each scenario, tonnes of Atlantic Cod were estimated assuming the full Redfish TAC was caught in a single month, and that the Redfish TAC was evenly distributed across the available spatial area. Graphical depictions of each scenario appear in Figure 8. Table from Sutton et al. 2024.

Model	Month	Scenario	TAC 5,000	TAC 10,000	TAC 20,000	Total bycatch (%)
Autumn RV Landings 4T	Sep	Current	**528**	**1,057**	**2,113**	9.56
		Proposed	.	.	.	Closed
	Jun	Current	34	68	136	0.68
		Proposed	31	61	123	0.61
	Jul	Current	30	59	119	0.59
		Proposed	27	54	107	0.54
	Aug	Current	40	80	**159**	0.79
		Proposed	36	72	144	0.71
	Sep	Current	90	**180**	**361**	1.77
		Proposed	.	.	.	Closed
	Oct	Current	**163**	**326**	**652**	3.16
		Proposed	.	.	.	Closed

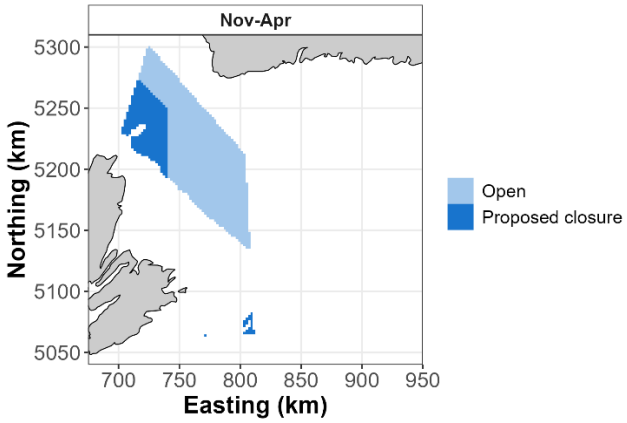


Figure 9. Proposed closure for Redfish-directed fishing in NAFO 4Vn to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod.

Table 2. NAFO 4Vn predicted tonnes (t) of sGSL Atlantic Cod bycatch with monthly Redfish TACs of 5,000 t, 10,000 t, and 20,000 t under current and proposed fishing areas. Bold values indicate bycatch weights that exceed the current annual quota of 152.2 t of Atlantic Cod bycatch across all commercial groundfish fisheries. In each scenario, tonnes of Atlantic Cod were estimated assuming the full Redfish TAC was caught in a single month, and that the Redfish TAC was evenly distributed across the available spatial area. Graphical depictions of each scenario appear in Figure 9. Data from Sutton et al. 2024.

Model	Month	Scenario	TAC 5,000	TAC 10,000	TAC 20,000	Total bycatch (%)
Winter RV Landings 4Vn	Jan/Feb	Current	**5,214**	**10,429**	**20,858**	51.05
		Proposed	9	19	37	0.18
	Nov	Current	32	64	129	0.64
		Proposed	20	40	80	0.40
	Dec	Current	**178**	**357**	**714**	3.44
		Proposed	146	**291**	**583**	2.83
	Jan	Current	101	**201**	**402**	1.97
		Proposed	65	129	**259**	1.28
	Feb	Current	**326**	**652**	**1,305**	6.12
		Proposed	**236**	**472**	**943**	4.51
	Mar	Current	**382**	**764**	**1,529**	7.10
		Proposed	**275**	**549**	**1,098**	5.21
	Apr	Current	**177**	**353**	**707**	3.41
		Proposed	131	**262**	**524**	2.55

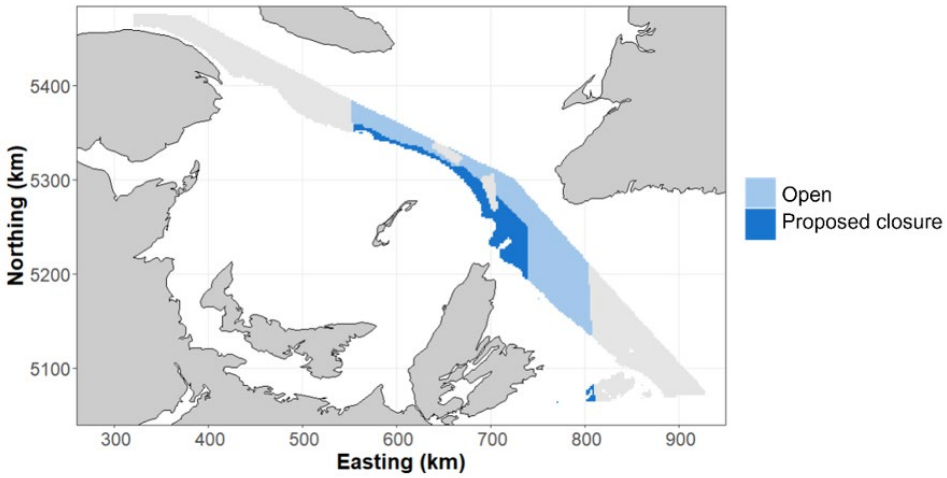


Figure 10. Proposed winter (Nov-Apr) closure for Redfish-directed fishing in NAFO 4TVn to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod. The shaded region indicates the historical fishing area based on landings records. The blue region indicates the area open to the index and experimental fishery. The dark blue region indicates the proposed closures. Proposed closures include one area closure that overlaps part of NAFO 4T and part of NAFO 4Vn north of Cape Breton, along with a 300 m minimum fishing depth in NAFO 4T.

Table 3. Winter fishing scenario NAFO 4TVn predicted tonnes (t) of sGSL Atlantic Cod bycatch with monthly Redfish TACs of 5,000 t, 10,000 t, and 20,000 t under current and proposed fishing areas. Predictions were made with a Winter RV model, which was the only model that was able to include winter fishing data spanning both NAFO 4T and NAFO 4Vn. Bold values indicate bycatch weights that exceed the current annual quota of 152.2 t of Atlantic Cod bycatch across all commercial groundfish fisheries. In each scenario, tonnes of Atlantic Cod were estimated assuming the full Redfish TAC was caught in a single month, and that the Redfish TAC was evenly distributed across the available spatial area. Graphical depictions of each scenario appear in Figure 10.

Model	Month	Scenario	TAC 5,000	TAC 10,000	TAC 20,000	Total bycatch (%)
Winter RV	Jan/Feb	Historical 4TVn	**12,247**	**24,494**	**48,987**	71.01
		Current 4TVn	**23,351**	**46,703**	**93,405**	82.36
		Proposed 4TVn	**487**	**974**	**1947**	8.87

Additional measurables objectives

Additional objectives of the rebuilding plan could be to increase the percentage of large Cod (greater than 43 cm) to averages observed historically, observe an increased size and body condition at length and to observe the distribution of Cod return to the shallow, inshore waters of the sGSL.

Another measurable objective of the rebuilding plan could be to promote recruitment by protecting the sGSL Cod spawning grounds. The Shediac Valley, especially the area east of Miscou, has still been used in the last decades as a spawning ground for Cod (Figure 11). The Miscou Bank area has been permanently closed by variation order to all groundfish fisheries from January 1 to December 31 where there were concentrations of sGSL Cod. A further section of Miscou Bank has a seasonal closure until the end of June to protect Cod during the spawning period (DFO 2017; Figure 11). However, the closed area is not the exact location where samples of spawning Cod have been found to aggregate. Updating the coordinates of the

closed area accordingly (box coordinates, degrees decimal: 48.133; 47.716; -63.750; -64.200), to let fish spawn without disturbance and prevent spawning fish removals are objectives towards promoting recruitment. Information is currently lacking to state whether the area currently closed is used for spawning, further sampling in the area would be required.

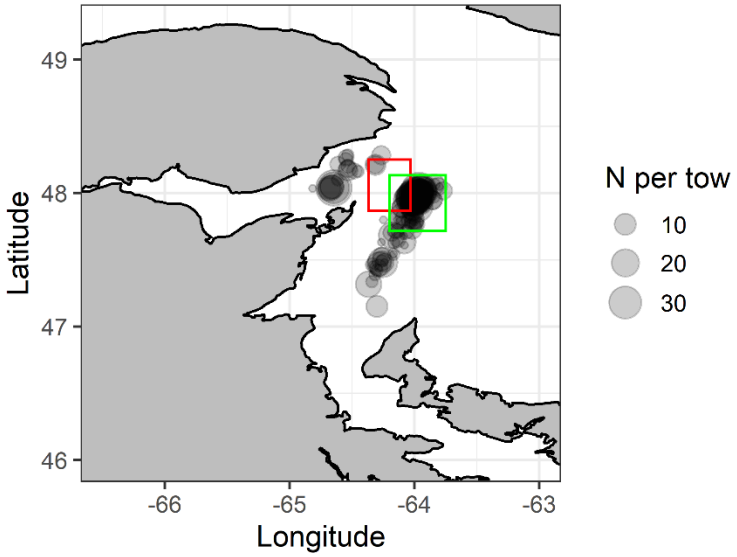


Figure 11. Abundance per tow (N per tow) of spawning southern Gulf of St. Lawrence Atlantic Cod (gonad maturity stage 4-5) between May and July from the cod condition sampling program database. Red box is closed area, green box is proposed closed area.

How to track rebuilding progress

Rebuilding progress will be tracked using the sGSL Cod stock assessment model and monitoring of productivity parameters (natural mortality, recruitment, and growth) and the associated uncertainty of the model results. Projections and decision tables will be provided to monitor the progress towards attaining objectives of the rebuilding plan. Rebuilding plan progress should be tracked as part of the multi-year assessment cycle. Objectives should be revised and models should be updated if stock productivity or external factors influencing stock dynamics change.

Frequency of periodic review of the plan

The periodic review of the rebuilding plan should be set to the 4 year stock assessment cycle for sGSL Cod with an interim update at the half way point. As established in the multi-year assessment cycle for sGSL Cod a full assessment would be triggered if during the interim update the stock indicator is above the LRP-proxy. Regardless of when a new stock assessment is to be initiated, at least 6-12 months lead time is required before the new stock assessment is initiated to allow for sample processing and that landings data are available that will be needed for the interpretation of the population trajectory.

Sources of Uncertainty

Model-predicted bycatch was estimated based on proportions of Cod in the combined Cod and target species catch and assuming equal fishing effort across spatial areas. In future, expectations about effort and target species catch rates could be incorporated in outcomes for

fisheries where this information exists. Similar considerations of specific TAC allocations, fleets, and/or seasons could also be incorporated where available.

Fisheries-independent surveys were limited to a few months each year, and may not accurately reflect species distributions at other times of the year. Fisheries-dependent data (i.e., landings), include additional months, but tend to focus on specific spatial areas, which may not reflect either full species distributions, or areas that could be considered as possible locations to open or expand fisheries. There are also challenges with the quality of fishery-dependent landing data and they require more corrections.

Differences in bycatch predictions between fisheries-independent and fisheries dependent models could be due to a variety of factors, including differences in data quality, time of year, gear used, selectivity, model structure, response variable, and reporting. For each fishery, we used the best available model(s) as the basis for identifying bycatch mitigation strategies, but this choice is subject to change as data and models are updated.

The rebuilding target considerations regarding the number of years to be at or above the target and number of years to display positive stock trajectory in population projections under harvest, are arbitrary. As the current stock production and trajectory are mostly negative, estimating the number of years that would minimize the likelihood of the stock falling back into the Critical Zone after rebuilding is not feasible. If the stock was to approach the target, the number of years and conditions of stock trajectory to be considered rebuilt should be re-evaluated.

CONCLUSIONS AND ADVICE

The Science Advisory Report provides advice for elements of the rebuilding plan for sGSL Cod.

Stock status and causes of stock decline

The LRP for the stock has been revised as $0.25B_0$. The stock has been below the LRP and in the Critical Zone since 1990.

The primary cause of stock decline was overfishing starting in 1955, however grey seal predation and the associated high natural mortality has prevented the stock from recovering since the moratorium.

The stock also suffers from a lasting state of low production and low biomass, recruitment overfishing, high natural mortality, a predation-driven Allee effect, low growth and body condition, and a decrease in age at maturity.

Rebuilding target and timeline

The rebuilding target, where the stock has a 75% probability of being at or above the LRP, should be amended to include that the stock must be at or above this level for 4 consecutive years and population projections must show the stock is likely to continue its positive trajectory under harvest for 4 years after the rebuilt state has been achieved.

A timeline to rebuild could not be calculated since even in the absence of fishing mortality, the stock is unlikely to rebuild under prevailing conditions. The timeline should be set to the 12 year generation time of sGSL Cod.

Irrespective of which scenario of natural mortality and recruitment rates examined, the stock was still unable to rebuild.

Likelihood of management measures meeting rebuilding objectives

Bycatch less than or equal to 200 t annually has negligible impacts on the stock trajectory under zero fishing, however annual catch of 300 t or greater the stock declines further.

Management measures to decrease bycatch can be achieved by implementing dynamic closures of specific areas and depths in fisheries targeting Atlantic Halibut, Greenland Halibut, Witch Flounder, and Redfish.

Additional measurable objectives

Additional measurable objectives of the rebuilding plan could include; increase the proportion of larger fish, increase size and condition at length, recover the spatial distribution in shallow waters and promote recruitment by protecting spawning grounds.

Rebuilding progress

Rebuilding progress will be tracked using the stock assessment models and associated uncertainty.

The frequency of review should be set to the 4-year stock assessment cycle with an interim update at the halfway point.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Barrett, Tim	DFO Science – Maritimes
Boudreau, Cyril	Nova Scotia Department of Fisheries and Aquaculture
Carroll, Lindsay	The Confederacy of Mainland Mi'kmaq
Chamberland, Jean-Martin	DFO Science -Québec Region
Chlebak, Ryan	DFO Science – National
Clancey, Lewis	Nova Scotia Dept. of Fisheries and Aquaculture
Cormier, Julien	DFO Fisheries and Harbour Management – Gulf Region
Eddy, Tyler	Memorial University
Everly, Flynn	DFO Strategic Policy - National
Ferguson, Louis	Maritimes Fishermen's Union
Giffin, Melanie	Prince Edward Island Fishermen's Association
Jubinville, Isabelle	Oceana
Labbé-Giguère, Stéphanie	DFO Fisheries and Harbour Management – Québec Region
Lagacé, Nicolas	Government of New Brunswick
Landry, Lysandre	DFO Science – Gulf Region
MacDonald, Reagan	Government of Prince Edward Island
McDermid, Jenni	DFO Science – Gulf Region
McGee, Dennis	Northumberland Fishermen's Association
Olmstead, Melissa	DFO Science – National
Olsen, Léa	DFO Fisheries and Harbour Management – Gulf Region
Ramsay, Laura	Prince Edward Island Fishermen's Association
Rayner, Gemma	Oceans North
Ricard, Daniel	DFO Science – Gulf Region
Rolland, Nicolas	DFO Science – National
Rondeau, Amélie	DFO Science – Gulf Region
Roy, Mélanie	DFO Science – Gulf Region
Senay, Caroline	DFO Science – Québec Region
Sonier, Rémi	DFO Science – Gulf Region
Sutton, Jolene	DFO Science – Gulf Region
Sylvain, François-Étienne	DFO Science – Gulf Region
Turcotte, François	DFO Science – Gulf Region

SOURCES OF INFORMATION

This Science Advisory Report is from the regional peer review of February 22-23, 2024 on Science Advice to Support the Rebuilding Plan for Atlantic Cod (*Gadus morhua*) in the Southern Gulf of St. Lawrence, NAFO Division 4T-4Vn (November-April). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2017. Integrated Fisheries Management Plan Gulf of St. Lawrence Groundfish (NAFO Subdivisions 3Pn, 4Vn and Divisions 4RST).

DFO. 2021. Science Guidelines to Support Development of Rebuilding Plans for Canadian Fish Stocks. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/006.

Sutton, J.T., McDermid, J.L., Landry, L. and Turcotte, F. 2024. Spatiotemporal analysis provides solutions to mitigate bycatch of southern Gulf of St. Lawrence Atlantic Cod in an expanding Redfish fishery. Fisheries Research, In press.

Swain, D.P., Savoie, L. and Aubry, É. 2012. Recovery Potential Assessment for the Laurentian South designatable unit of Atlantic Cod (*Gadus morhua*): the southern Gulf of St. Lawrence Cod stock (NAFO Div. 4T-4Vn(Nov-Apr)). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/052. iii + 51 p.

THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Gulf Region
Fisheries and Oceans Canada
P.O. Box 5030, Moncton, NB, E1C 9B6

E-Mail: DFO.GLFCSA-CASGLF.MPO@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
ISBN 978-0-660-71618-3 Cat. No. Fs70-6/2024-033E-PDF

Correct Citation for this Publication:

DFO. 2024. Science Advice to Support the Rebuilding Plan for Atlantic Cod (*Gadus morhua*) in the Southern Gulf of St. Lawrence, NAFO Division 4T-4Vn (November-April). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2024/033. (Erratum: November 2024)

Aussi disponible en français :

*MPO. 2024. Avis scientifique en appui au plan de rétablissement de la morue franche (*Gadus morhua*) dans le sud du golfe du Saint-Laurent, division 4T et sous-division 4Vn de l'OPANO (de novembre à avril). Secr. can. des avis sci. du MPO. Avis sci. 2024/033. (Erratum : novembre 2024)*