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

Quebec Region

Canadian Science Advisory Secretariat
Science Advisory Report 2023/022

ASSESSMENT OF THE GULF OF ST. LAWRENCE (4RST) GREENLAND HALIBUT STOCK IN 2022

*Greenland halibut (*Reinhardtius hippoglossoides*).*
Photo credit: Claude Nozères, DFO.

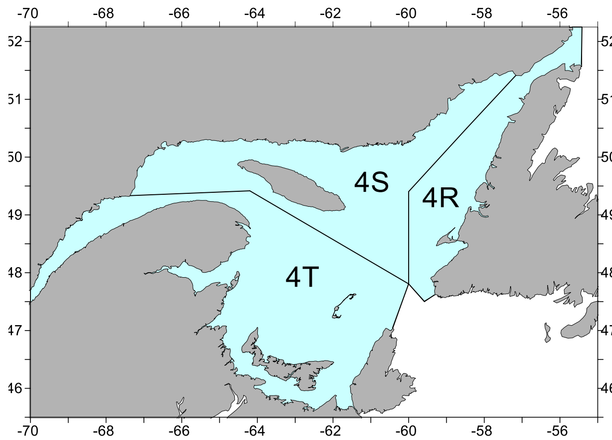


Figure 1. Map of the Gulf of St. Lawrence Greenland halibut Stock Management Area, showing Northwest Atlantic Fisheries Organization (NAFO) Divisions 4RST.

Context:

*Greenland halibut (*Reinhardtius hippoglossoides*) in the Gulf of St. Lawrence (Figure 1) has been considered a separate stock from the Atlantic population since 1993. It is assessed and managed on a two-year cycle. An update of the stock status is produced during the interim years.*

Until the mid-1970s, Greenland halibut (commonly called turbot) from the Gulf of St. Lawrence (4RST) were not subjected to any directed fishery. It was in the late 1970s that a directed gillnet and bottom trawl fishery developed. Since 1993, directed fishing has been prohibited for mobile gear. It is currently authorized for the inshore fixed gear fleets of Quebec and the west coast of Newfoundland.

In the current situation, the Total Allowable Catch (TAC) cannot be caught since mobile gear fleets do not have access to the directed Greenland halibut fishery. Part of the TAC allocated to them is transferred to the fixed gear fleet, while the rest is no longer fished. In this document, the terminology "fishing allocation" is used to indicate the portion of the TAC that can be caught by fixed gear fleets.

The fishery is subject to several management measures, including a fishing season, characteristics of fishing gears and control of catches by a TAC to limit exploitation of the stock.

The present science advisory report results from the peer review meeting for the Assessment of the Gulf of St. Lawrence (4RST) Greenland halibut stock held February 13th and 14st, 2023. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

SUMMARY

- During the 2022-23 fishing season, preliminary landings in the Gulf of St. Lawrence totalled 930 t, representing 46% of the fixed gear allocation and the lowest value observed since 1970.
- Fishing effort shows a downward trend across the Gulf since 2013 and has reached the lowest level observed of the 1999-2022 period. More than 80% of estimated fishing effort was located in the western Gulf in 2022.
- The fishery performance index in the western Gulf has been increasing since 2018 and was around the series average in 2022. The index for the North Anticosti sector appears to be stable since 2020 and was slightly below average in 2022, while for the Esquiman sector, the index has been well below average since 2014.
- The length composition of landings was stable from 2019 to 2022, with the mean below the long-term average and the proportion of fish below the minimum legal size above average at about 30%.
- According to the three scientific surveys, the abundance and biomass indices have been on a downward trajectory since the mid-2000s.
- Cohorts expected to contribute to the fishery in 2023 and 2024 range from low (2016) to high (2017-2018) abundance. These cohorts have displayed a normal growth rate but their low condition in 2022 could negatively affect their growth.
- According to scientific surveys, the low abundance of 1-year-old individuals observed from 2020 to 2022 would have a negative impact on the biomass available for fishing in the medium term.
- At the Gulf scale, the exploitation rate indicator was at the lowest levels observed in 2021 and 2022.
- Under the precautionary approach, the stock status indicator, estimated at 33,366 t, placed the stock at the top of the cautious zone in 2022. Under the harvest control rule, all sources of removals should not exceed 2,002 t in 2023-24 and 2024-25.
- The Gulf of St. Lawrence is undergoing major changes: the deep waters are warming and become depleted of oxygen. In addition, changes in the structure of the community (high abundance of redfish and low abundance of prey) are observed. These changes could negatively affect the productivity of Greenland halibut. Current environmental conditions and climate projections suggest that the situation is likely to remain unfavourable.

INTRODUCTION

Overview of oceanographic conditions and the ecosystem

The ecosystem of the Gulf of St. Lawrence (GSL, NAFO Divisions 4RST) has undergone significant changes in recent decades. Deep waters have been warming and dissolved oxygen levels have decreased. In 2022, deep-water temperatures continued to rise in the Gulf and new records were set for water at 150, 200, 250 and 300 m for a series that began in 1915. Water temperature at 300 m exceeded 7.0 °C in 2022, 1.8 °C above the temperature recorded in 2009. Since 1930, the dissolved oxygen (DO) level has decreased by more than 50% in the

GSL channels. The lowest levels (15% saturation in 2022) are recorded in the lower estuary, site of the main nursery area for Greenland halibut.

Despite these changes, Greenland halibut have occupied comparable depth annually from 1984 to 2022 based on a DFO summer research survey (Figure 2). As a result, they are found in increasingly warmer and hypoxic waters. Increasing deep water temperature and oxygen depletion could lead to loss of habitat quality for Greenland halibut. The GSL deep water temperature is forecasted to remain elevated for the next several years and DO levels may decline further.

The abundance of redfish (*Sebastes mentella* and *S. fasciatus*) in the GSL is at an unprecented high level. Redfish are potential competitors for food with Greenland halibut as they share common prey species, including northern shrimp (*Pandalus borealis*) and pink glass shrimp (*Pasiphaea multidentata*). Competitive interactions may persist for many years as redfish are long-lived.

Overall, the current unfavourable conditions for Greenland halibut are expected to continue in the coming years.

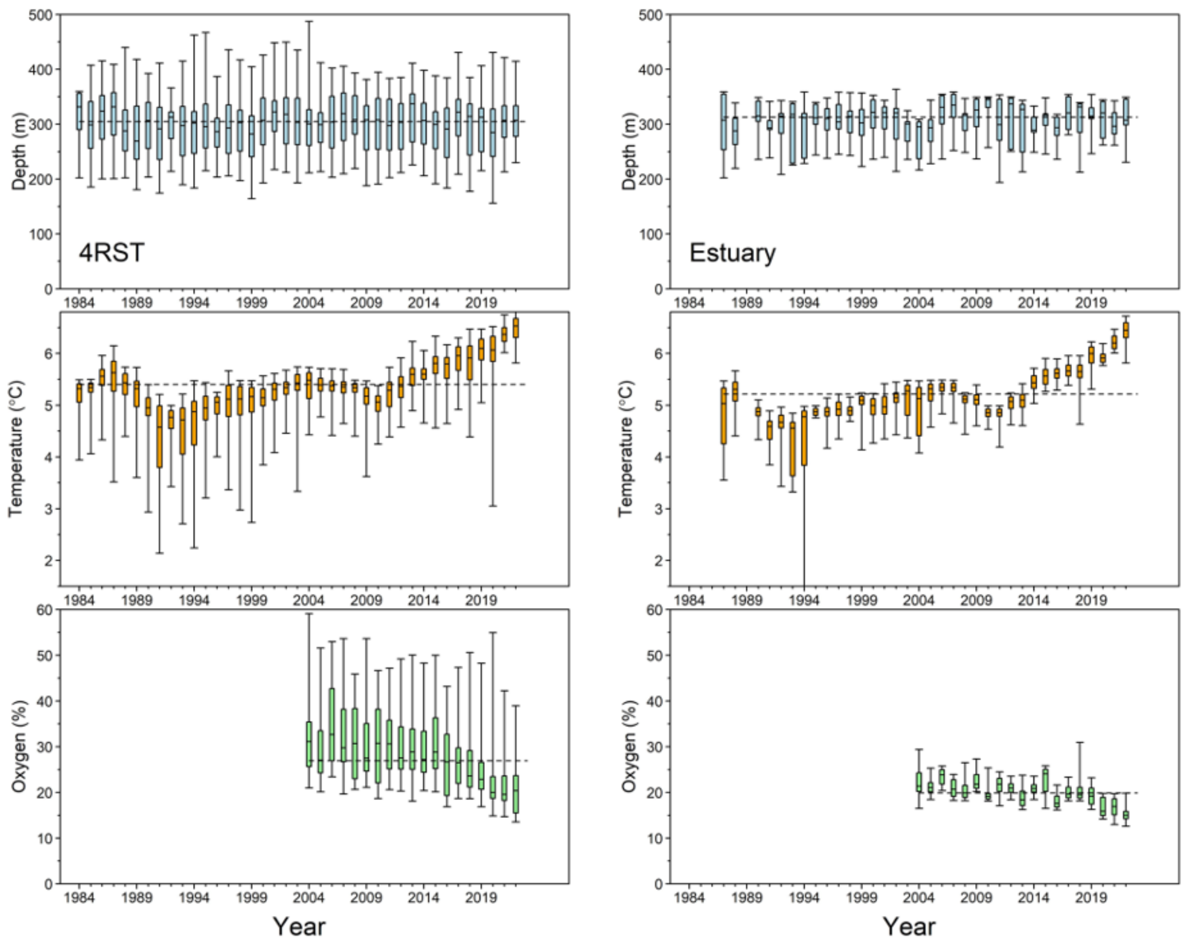


Figure 2. Distribution of Greenland halibut biomass as a function of depth, temperature and oxygen saturation level for the entire Gulf (4RST) and the Lower Estuary based on the DFO nGSL survey. Box and whisker plot: the line inside the box represents the median, the box extends from percentiles 25 to 75, and the whiskers (vertical lines on either side of the box) extend from percentiles 5 to 95. The dotted horizontal line on each of the graphs represents the series average.

Biology

Greenland halibut occupies more than 85,000 km^2 in the northern Gulf of St. Lawrence (nGSL) (Figure 3). It is mainly found in channels at depths varying from 200 to 400 m (Figure 3). Amongst Atlantic populations, the GSL stock occupies some of the warmest waters. Juveniles are predominant in the Lower Estuary and north of Anticosti Island and are generally found at shallower depths than adults. In August, an average of 23% of the Greenland halibut abundance is found in the Lower Estuary.

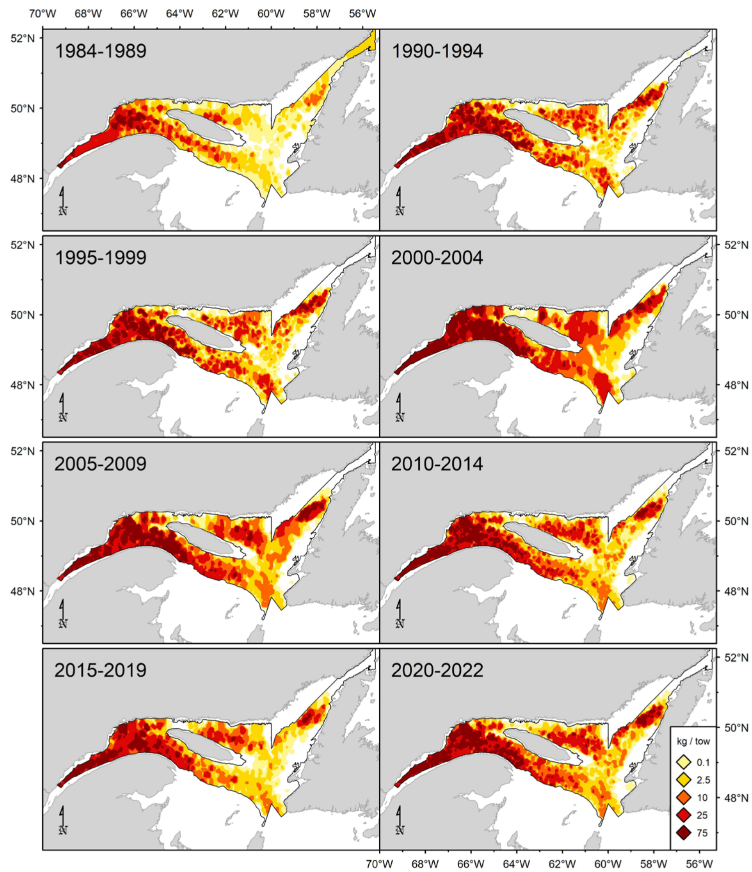


Figure 3. Spatial distribution of catch rates (kg / 15-minute tow) of Greenland halibut during the DFO nGSL survey over five or six year periods.

Spawning occurs in winter between January and March, in the depths of the Laurentian Channel southwest of Newfoundland. Greenland halibut is characterized by low fecundity, it produces large eggs (3,4 – 4,7 mm in diameter) and spawns only once a year. The eggs, released and fertilized near the bottom, spend about 30 days in the water column before hatching within 50 m of the surface. Larval development occurs in this surface layer and could last up to four months. Subsequently, the larvae settle on the bottom at metamorphosis.

In this species, males reach sexual maturity at smaller sizes and achieved smaller adult sizes than females. Greenland halibut is a vigorous swimmer, making large daily vertical migrations and spending nearly 25% of its time in the water column.

The Greenland halibut diet varies depending on its size. Individuals smaller than 20 cm have a mixed diet consisting of zooplankton (hyperid amphipods and euphausids) and small fish. As

Greenland halibut grow, their diet begins to comprise mainly fish and shrimp. The dominant fish species in the diet is capelin (*Mallotus villosus*). In recent years (2015-2020), redfish have become more important in the diet of Greenland halibut larger than 30 cm. Individuals larger than 40 cm consume mainly shrimp, herring (*Clupea harengus*), small demersal fish, redfish and capelin. The main predators of Greenland halibut are seals (Harp seal (*Phoca groenlandica*), Hooded seal (*Cystophora cristata*), Grey seal (*Halichoerus grypus*)) and Atlantic halibut (*Hippoglossus hippoglossus*).

The fishery

Until the mid-1970s, landings of Greenland halibut in the GSL were primarily bycatch from trawlers targeting shrimp and groundfish (Figure 4). The directed gillnet fishery for Greenland Halibut developed from 1977. A first TAC of 7,500 t was established in 1982. From 1982 to 1992, GSL Greenland halibut was managed as a component of the Atlantic stock. The highest landings exceeded 8,000 t in 1979 and 1987. These high landings were followed by steep declines. Based on studies of parasites conducted in the early 1990s, the GSL population was defined as a distinct stock. A TAC of 4,000 t was put in place for this stock in 1993.

The TAC remained fixed at 4,500 t with a fishing allocation of 3,751 t between the management years 2004-2005 and 2017-2018 (Figure 4). The fishing allocation was completely fished annually until the 2011-2012 fishing season and was subsequently never reached. The greatest difference between the fishing allocation and the landings occurred in the 2017-2018 fishing season. The TAC was gradually reduced until 2021-22 and was adjusted upwards to a 2,400 t (2,000 t fishing allocation) value for the 2022-23 season using the harvest control rule for the first time (DFO 2022a). As of January 12, 2023, landings from fixed gear fleets totalled 930 t, or 46% of the fishing allocation.

The fishing allocation is divided between the Quebec (82%) and the Newfoundland (18%) fleets. Based on data available on January 12, 2023, the Quebec and Newfoundland fixed gear fleets landed 49% and 37% of their respective fishing allocation for 2022-2023. These landings data are preliminary, but should not increase significantly with the continuation of fishing by the Quebec fleets during spring 2023.

The number of active harvesters in the directed Greenland halibut fishery decreased by more than 50% between the 2014-2016 and 2021-2022 seasons, from an average of 150 to about 75 harvesters. The decrease is similar for the Quebec and Newfoundland fleets. Several factors might explain this decrease, including participation in more lucrative fisheries, the cost of fuel and the management measures in place.

Fishery management measures include the imposition of a minimum mesh size of 152 mm (6.0 inches) and a minimum size for Greenland halibut of 44 cm in commercial catches as part of a small fish protocol. Quebec harvesters are allowed a maximum of 120 gillnets while the maximum is 90 in Newfoundland. Harvesters are required to complete a logbook (100%), have their catches weighted at dockside (100%) and agree to take an at-sea observer on board at the request of DFO (5 to 15% coverage of trips, depending on the fleet). The use of the vessel monitoring system (VMS) has been gradually implemented in Quebec since 2013 and has been mandatory on all vessels since 2017. In Newfoundland, the use of VMS is not required for the entire fleet. The majority of Quebec harvesters hold individual transferable quotas while all Newfoundland harvesters are under a competitive regime.

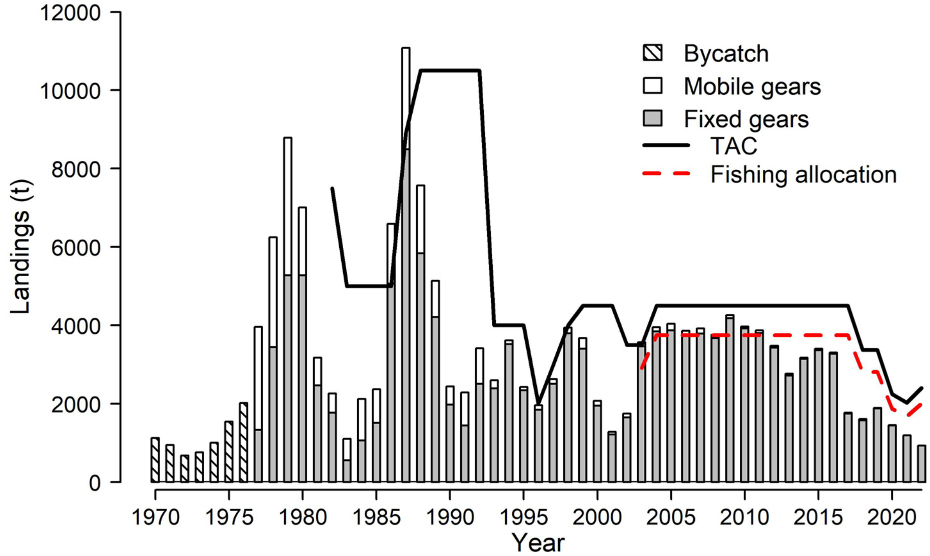


Figure 4. Greenland halibut reported landings (t) since 1970, TAC, and fixed gear fishing allocation. In 2000, the management year was changed from the civil year to management year (May 15 of the current year to May 14 of the following year). Data for 2022 are preliminary.

Bycatch in the Greenland halibut fishery

Bycatch in the Greenland halibut gillnet fishery was estimated for the period 2000 to 2022 using data from the at-sea observer program. No observers were deployed in this fishery on the west coast of Newfoundland in 2021 and 2022. Close to 460 t of bycatch were caught annually, representing on average 19 % of the weight of Greenland halibut landings. Total bycatch estimates were well below the series average in 2021 and 2022, respectively 193 and 123 t, due to reduced fishing effort. The most frequent bycatch species are, in order of importance, American plaice (*Hippoglossoides platessoides*), Redfish, Snow crab (*Chionoecetes opilio*), Thorny skate (*Amblyraja radiata)*, Spiny crab (*Lithodes maja*), Atlantic halibut, skates and Witch flounder (*Glyptocephalus cynoglossus*, Table 1). More than a third of all bycatch is landed, the rest is discarded at sea. Discards at sea include species that can be released by the harvesters such as Black dogfish (*Centroscyllium fabricii)*, Atlantic lumpfish (*Cyclopterus lumpus*), Hagfish (*Myxine glutinosa*) and Atlantic wolfish (*Anarhichas lupus*); mandatory release species such as Atlantic halibut < 85 cm, Snow crab and skates; and species of no commercial value such as starfish, skate eggs, and polychaetes.

Greenland halibut bycatch in the shrimp fishery

The shrimp fishery is carried out using small-meshed trawls that catch and retain several fish and marine invertebrate species. Although large fish escape from trawls due to the mandatory use of a separator grate, catches still contain a certain number of small specimens. Greenland halibut bycatch in the shrimp fishery from 2000 to 2021 was examined using data from at-sea observers. Greenland halibut were present on average in 91% of the observed activities, constituting 3 kg or less per tow, comprising mostly 1 year-old individuals, and to a lesser extent 2 year-old individuals. The average annual Greenland halibut bycatch from the shrimp fishery in the Estuary and GSL for 2000 to 2021 was around 96 t. Estimates for 2020 and 2021were 78 t and 58 t respectively, representing approximately 0.23 and 0.48% of the biomass of small Greenland halibut (< 31 cm) estimated from the nGSL DFO survey.

Table 1. Occurrence, Greenland halibut catch, and bycatch of the most frequent species (occurrence > 10%) caught during directed gillnet fishing activities for Greenland halibut in 2021 and 2022 and average for the period 2000 to 2020 according to at-sea observer program.

Taxon	Occurrence (%)			Catch (t)		
	2000-2020	2021	2022	2000-2020	2021	2022
Greenland halibut*	100	99	100	2,942	1,002	847
American plaice*	77	96	100	47	49	25
Redfish*	62	82	56	29	13	1
Snow crab	56	19	9	61	4	1
Thorny skate	52	85	47	62	32	15
Atlantic halibut*	48	43	28	103	31	11
Spiny crab	47	19	0	23	3	0
Witch flounder*	42	64	100	11	6	17
Skates	40	29	61	43	12	13
Anthozoan	27	17	47	6	2	4
White hake	21	65	86	9	17	22
Monkfish*	20	37	30	7	8	9
Atlantic cod*	19	7	0	17	3	0
Smooth skate	15	3	2	8	0	0
Black dogfish	13	21	12	26	4	0

**Species landed in the Greenland halibut fishery.*

ASSESSMENT

Sources of information

This assessment is based on the analysis of commercial fishery and scientific research survey data. The fishery data come from four sources: purchase slips, landings weighed dockside, logbooks and commercial catch sampling. Catch sampling is undertaken by two separate programs, the at-sea observer program and the DFO port sampling program. Three fishery-independent bottom-trawl research surveys are conducted annually in the GSL: a mobile sentinel fishery program (MSP) survey undertaken every July since 1995, a DFO survey in the nGSL undertaken each August since 1984 and a DFO survey in the southern Gulf of St. Lawrence (sGSL) undertaken each September since 1971. The MSP and DFO nGSL surveys cover nearly the entire distributional area for 4RST Greenland halibut. Although the DFO sGSL survey covers only the southern portion of the distributional area, trends in that survey reflect those from the broader area.

Commercial fishery fishing effort and catches

More than 98% of Greenland halibut landings are from the gillnet fishery directed at this species. The fishing effort is deployed in three main sectors (Figure 5). The Western Gulf and Esquiman sectors are frequented annually, while the North Anticosti sector is frequented more sporadically (Figure 6). In years when the North Anticosti sector is not frequented, the fishing effort shifts mainly to the Western Gulf sector. In 2021, the proportion of effort deployed in the Western Gulf, North Anticosti and Esquiman was 76%, 8%, and 16% respectively. No effort data from the Esquiman sector were available in 2022.

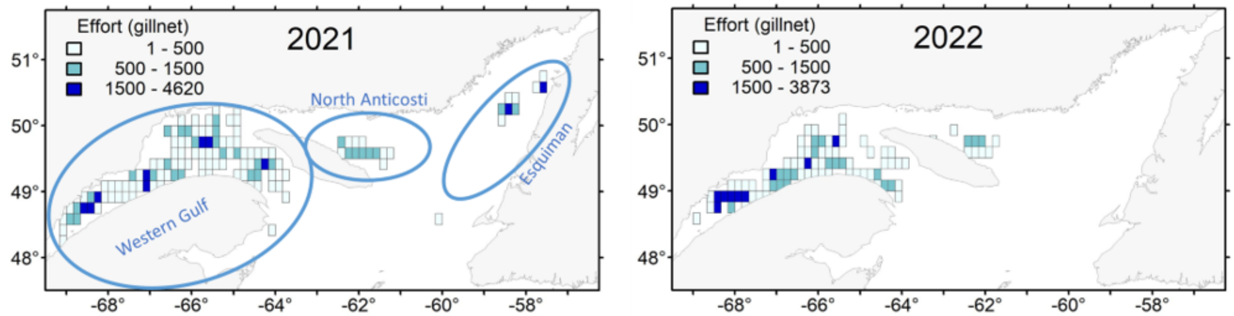


Figure 5. Distribution of fishing effort (number of gillnets) by fishing statistical square for 2021 and 2022. Effort data are available for more than 94% of landings in the Western Gulf and North Anticosti sectors. For the Esquiman sector, effort data are available for 54% of landings in 2021 and no effort data were available in 2022 for this sector.

Fishing effort and landings have been decreasing since at least 2019 for the entire Gulf (4RST) and by sector (Figure 6). In all cases, recent landings and efforts values are at or amongst the lowest in their respective series.

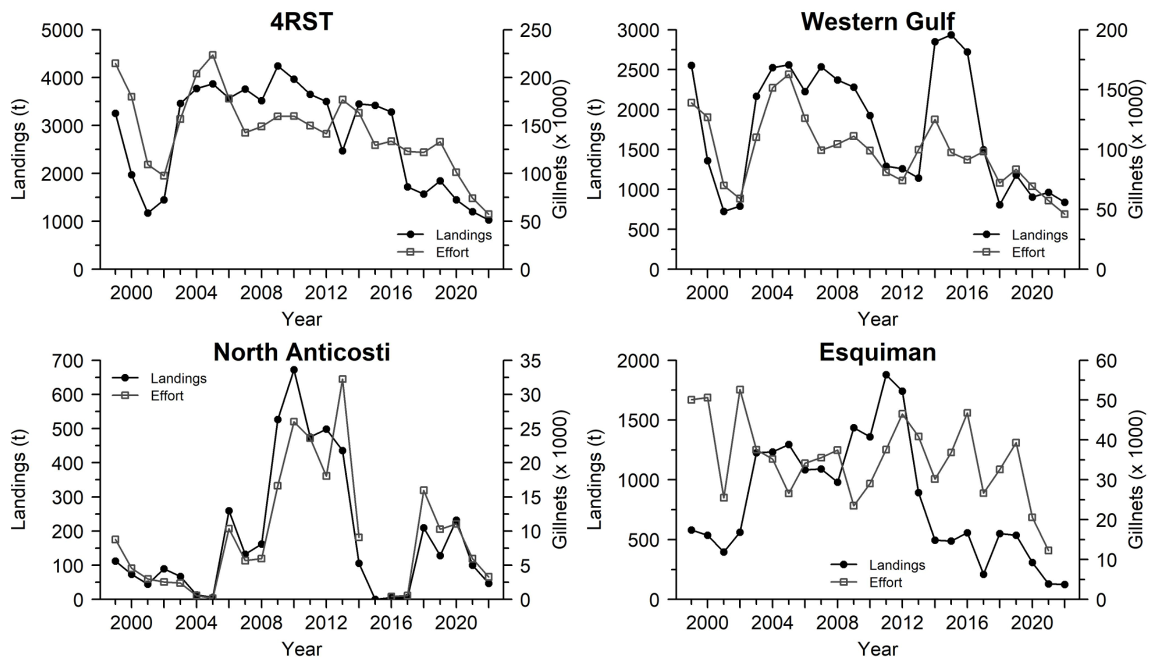


Figure 6. Landings (t) and fishing effort (number of gillnets) for the Gulf (4RST) and by fishing sector.

Commercial fishery performance index

The annual commercial catch per unit effort (CPUE) is used as an indicator of the performance of the fishery and not as an index of abundance of the exploitable stock. This index is standardized to take into account the variability that could be attributable to various factors such as the gear soak time, changes in fishing area and the seasonal fishing pattern. The trajectory of the indices is similar for the Gulf and the Western Gulf sector (Figure 7). The indices decreased by more than 50% between 2015 and 2018, and increased to the series average in 2022.

In the North Anticosti and Esquiman sectors, the fishery performance indices decreased by more than 75% between 2012 and 2017 and have been below their series average since 2013 (Figure 7). In North Anticosti in 2021 and 2022, the index was stable and below the series average. In Esquiman, the index decreased from 2018 to 2021. Effort data were not available for this sector in 2022.

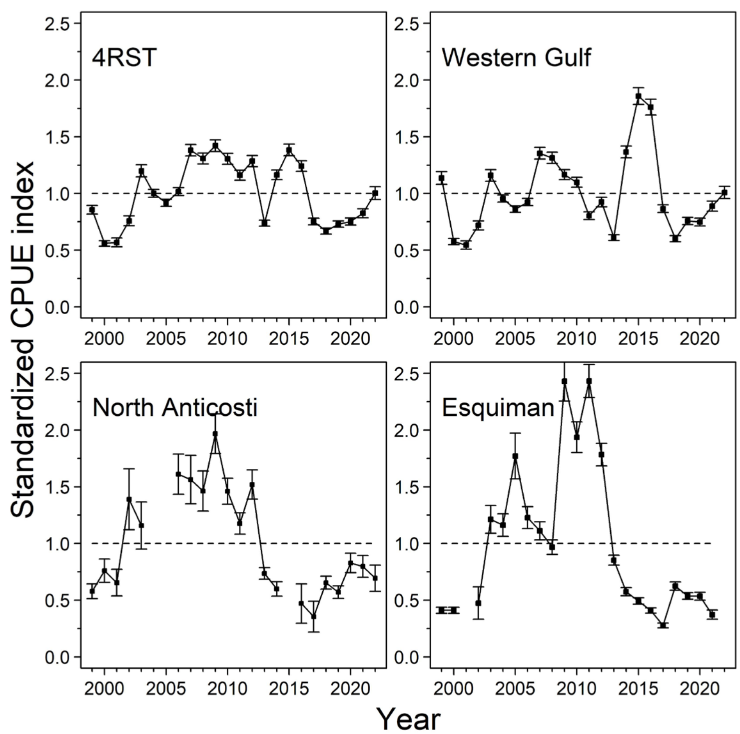


Figure 7. Commercial fishery performance indices (standardized CPUE) for the GSL (4RST) and by fishing sector. Error bars indicate the 95% confidence interval. The horizontal lines represent each series average.

Length composition of fish in commercial fishery catches

The average length of Greenland halibut caught in the commercial fishery increased steadily from 2002 to 2012, from 44.8 cm to 48.8 cm (Figure 8). This increase is attributable in part to the growth of fish from the strong 1997 and 1999 cohorts which made up a large part of the catches. Between 2012 and 2018, the average length fluctuated and was at or above the series average. Since 2019, average lengths for males, females and for both sexes combined are 41, 46 and 45 cm, below their respective series average. These values are among the lowest since the mesh size change in 1996.

For the 1996-2020 period, an average of 19% of fish caught in the directed gillnet fishery for Greenland halibut were smaller than the 44 cm regulated size limit, compared to around 31% in 2021 and 2022 (Figure 8).

The decrease in average fish length has a significant impact on the number of fish landed for a given landed weight. Between 2016 and 2022, annual landings in tonnes decreased by 72% while the number of fish landed decreased by 58%.

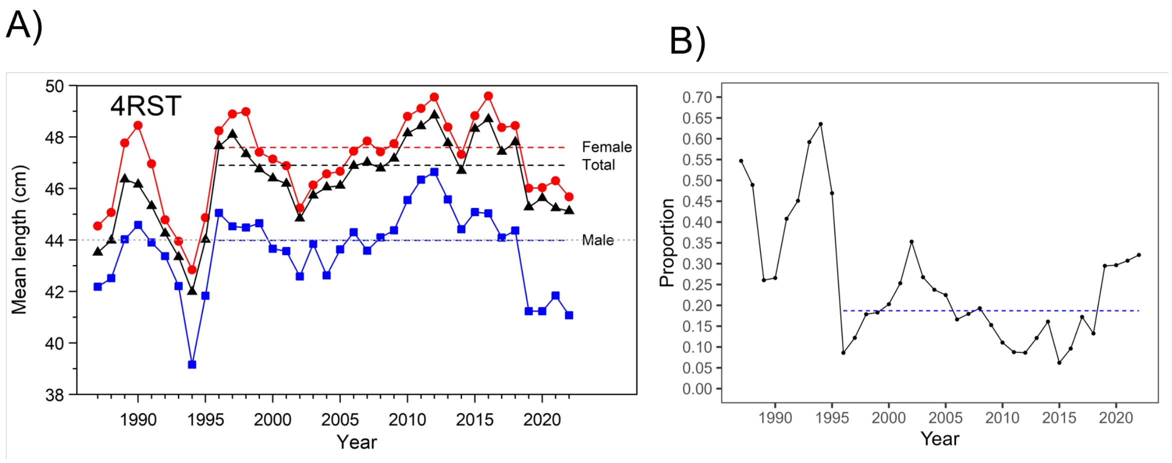


Figure 8. (A) Average length of Greenland halibut landed in the commercial fishery by sex, and combined. The horizontal lines indicate the 1996-2022 average for each series. The dotted horizontal line across the graph indicates the minimum size of 44 cm. (B) Annual proportion of individuals caught below the minimal legal size. The regulatory mesh size in the commercial fishery increased from 140 to 152 mm (5.5 to 6 inches) in 1996.

Abundance and biomass indicators

The abundance and biomass indices of fish from the DFO and MSP research surveys showed similar trends for the 1995-2022 period common to the three surveys (Figure 9). The indices showed a significant increase from the mid-1990s to the mid-2000s, a period of stability, and then a general downward trend from the late 2000s to 2022. The sGSL survey indicates that in the 13 years preceding the DFO nGSL survey, from 1971 to 1983, the biomass and abundance of Greenland halibut were low in this ecosystem.

Biological data

Demographic structure and recruitment

The demographic structure of Greenland halibut observed in the DFO nGSL survey is very consistent from year to year and it is possible to track the progression of cohorts over time (Figure 10). The abundance of the different year classes, their growth and the prevailing environmental conditions influence the abundance of the stock and are directly related to the future success of the fishery. Based on their normal growth curve, Greenland halibut generally recruit to the fishery at a length of 44 cm at an average age of 6 years for females and 7 years for males.

The strength of the new cohorts is estimated by the annual abundance of fish measuring 12 to 21 cm, which represent 1-year-old fish (Figures 10 and 11). Since the late 1990s, this stock has produced alternating high and low abundance cohorts. The first strong cohorts observed, those of 1997, 1999, 2001 and 2002 led to a significant increase in the abundance of the stock and supported the fishery until the early 2010s. Subsequently, abundant cohorts of the mid 2000s generated a significant biomass of individuals > 40 cm in 2014, increasing the catch rates of the commercial fishery from 2014 to 2016. The recruitment of these cohorts to the fishery generated a decrease in fish size in commercial catches in 2014 (Figure 8).

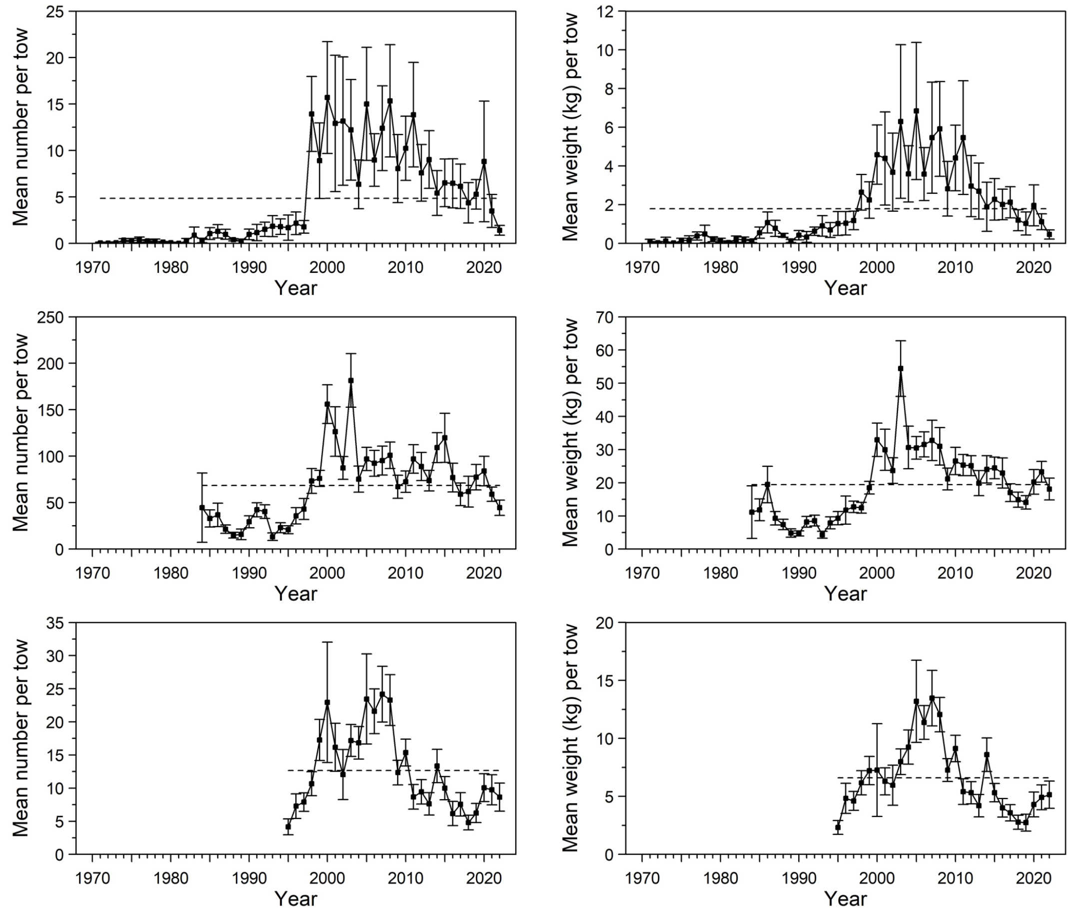


Figure 9. Greenland halibut abundance (mean number per tow) and biomass (mean weight per tow) indices observed during the scientific surveys of the sGSL (top), the nGSL (middle) and the MSP (bottom). Error bars indicate the 95% confidence interval. The dotted lines represent the average of each series.

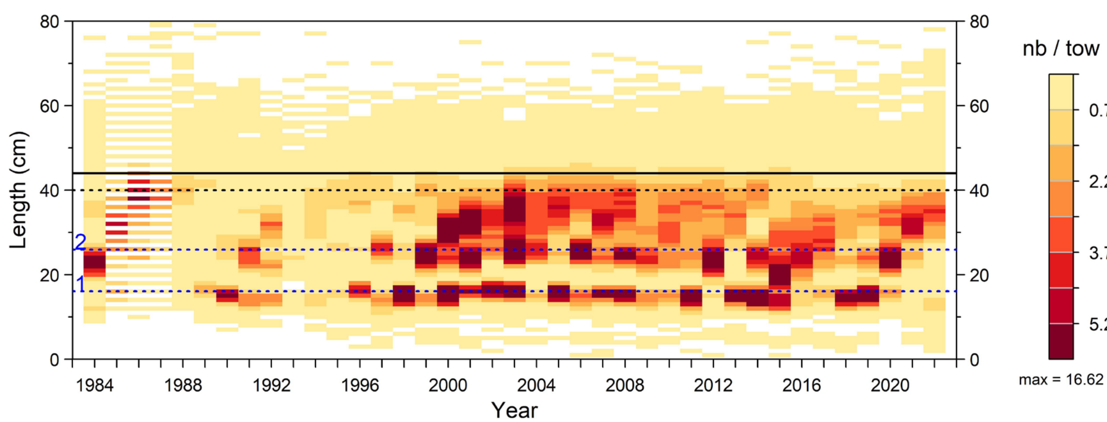


Figure 10. Greenland halibut length frequency distributions observed in the DFO nGSL survey (1984-2022). The blue dotted lines indicate the average lengths expected for 1- and 2-year-old fish. Black dotted lines indicate the limit for biomass indices for fish over 40 cm. Black solid lines at 44 cm indicate the minimum size of the small fish protocol. Note that lengths were recorded in 2 cm intervals from 1985 to 1987.

In the history of the stock, the 2013 cohort appeared to be among the most abundant in the series and was preceded and followed by cohorts of high abundance (Figure 11). These cohorts were expected to generate a significant increase in the abundance of larger fish, as was observed in the early 2000s. Instead, a decrease of about 45% in the growth rate of the 2013 cohort between one and two years was observed. Since then, the abundance of these cohorts has declined significantly. They could have started to recruit to the fishery in 2019-2020, which could in part explain the significant decrease in the average size of fish in commercial catches (Figure 8).

Although abundance of the 2017 cohort was above average at age one (Figure 11), it decreased significantly by age 2 years and in 2020 it was below average (Figure 10). Abundance of the 2018 cohort was elevated at ages one and two years, and growth appears to have been normal. This cohort could start recruiting to the fishery in 2024. However, the low abundance of individuals less than 30 cm in 2022 due to low recruitment (1 year old individuals) from 2020 to 2022 will have a negative impact on the biomass available for fishing in the medium term.

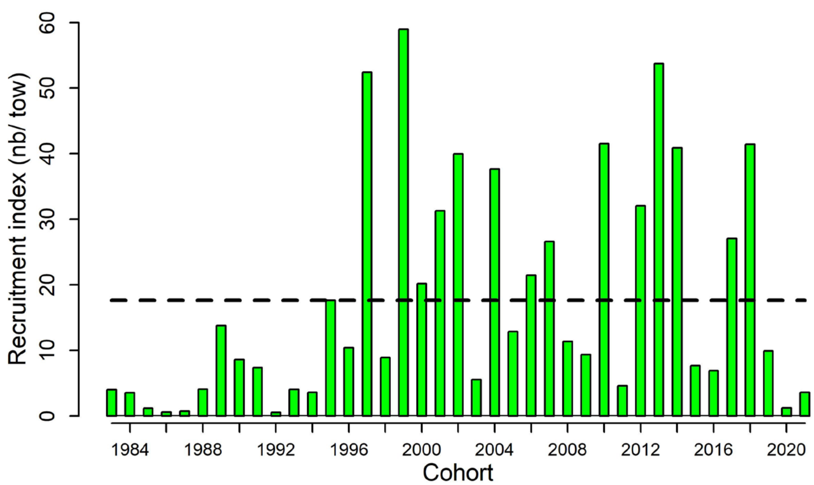


Figure 11. Recruitment index (number / tow) of Greenland halibut estimated by annual abundance of 12- 21 cm fish (age 1) from the DFO nGSL survey. The dotted horizontal line represents the series mean.

Condition

The Fulton condition index is estimated for four sizes of Greenland halibut: 15 cm (~ 1 year); 25 cm (~ 2 years); 35 cm (3 to 5 years) and 45 cm (≥ 6 years) (Figure 12). The condition of 1-year-old fish fluctuated from 1990 to 2021, often varying inversely to the abundance of different cohorts. Another factor that could have affected the condition of the recent cohorts of Greenland halibut is a possible competition for food with the massive arrival of juvenile redfish in the GSL between 2011 and 2013.

The estimated condition index for each of the Greenland halibut sizes declined sharply and was well below average in 2022. The mechanism that generated the 2022 drop in condition factor is unknown and many factors could explain it such has record temperatures in the deep water layer (Figure 2), low dissolved oxygen levels, low stomach fulness indices and low abundance or biomass of its main prey items, namely capelin and northern shrimp (Ouellette-Plante et al. 2020).

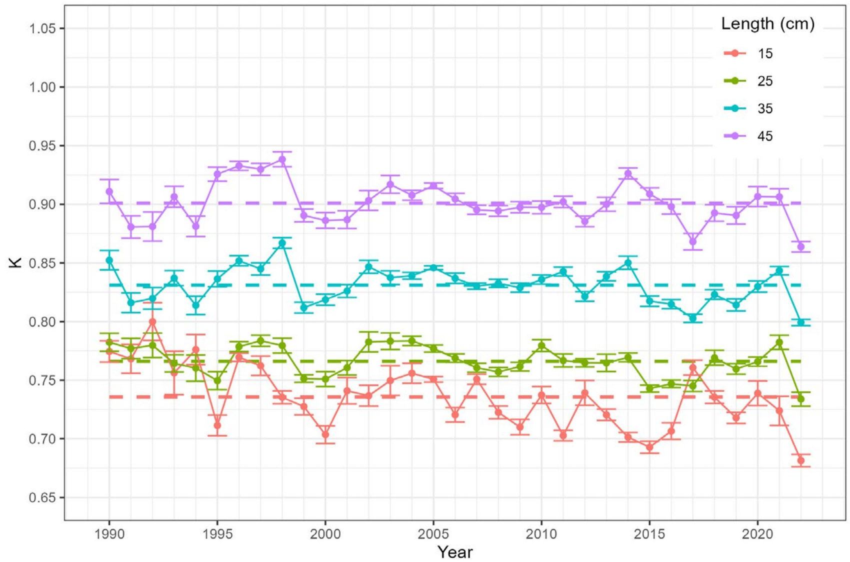


Figure 12. Annual Fulton (K) condition indices estimated for 15, 25, 35 and 45 cm Greenland halibut captured during the nGSL survey. Error bars indicate the 95% confidence interval. The horizontal lines represent the average of each series.

Exploitation rate indicator

An indicator of annual (calendar year) exploitation rate was obtained by dividing the weight of the landings by the biomass of fish > 40 cm estimated by the DFO nGSL survey. The method does not allow to estimate an absolute exploitation rate. However, it tracks changes over time and between fishing areas.

Following a rapid increase and decrease in the late 1990s, this indicator gradually increased until 2009 to above the long-term average of 6.3% (Figure 13). It then varied around the average during the 2010-2019 period. In 2021 and 2022, exploitation rates for the entire Gulf (4RST) decreased to values of 3.4 and 3.1% in response to decreased landings and increased biomass of fish > 40 cm (Figure 13).

In the western Gulf sector, the exploitation rate indicator increased between 2012 and 2017. Following a decrease in landings and a stable or increasing biomass level, the exploitation rate for this sector decreased in 2021 and 2022 to well below the series average. For the North Anticosti and Esquiman sectors, exploitation rates were increasing and reached some of the highest levels in the series in 2020. They subsequently decreased in 2021 and 2022. For the Esquiman sector, the estimated biomass of fish > 40 cm from the nGSL survey, which has been showing a downward trend since 2011, reached its lowest value in the series in 2020 and its highest exploitation rate. The estimated biomasses for this sector in 2021 and 2022 were among the three lowest values in the series, but low landings for these years resulted in low exploitation rates for this sector (Figure 13).

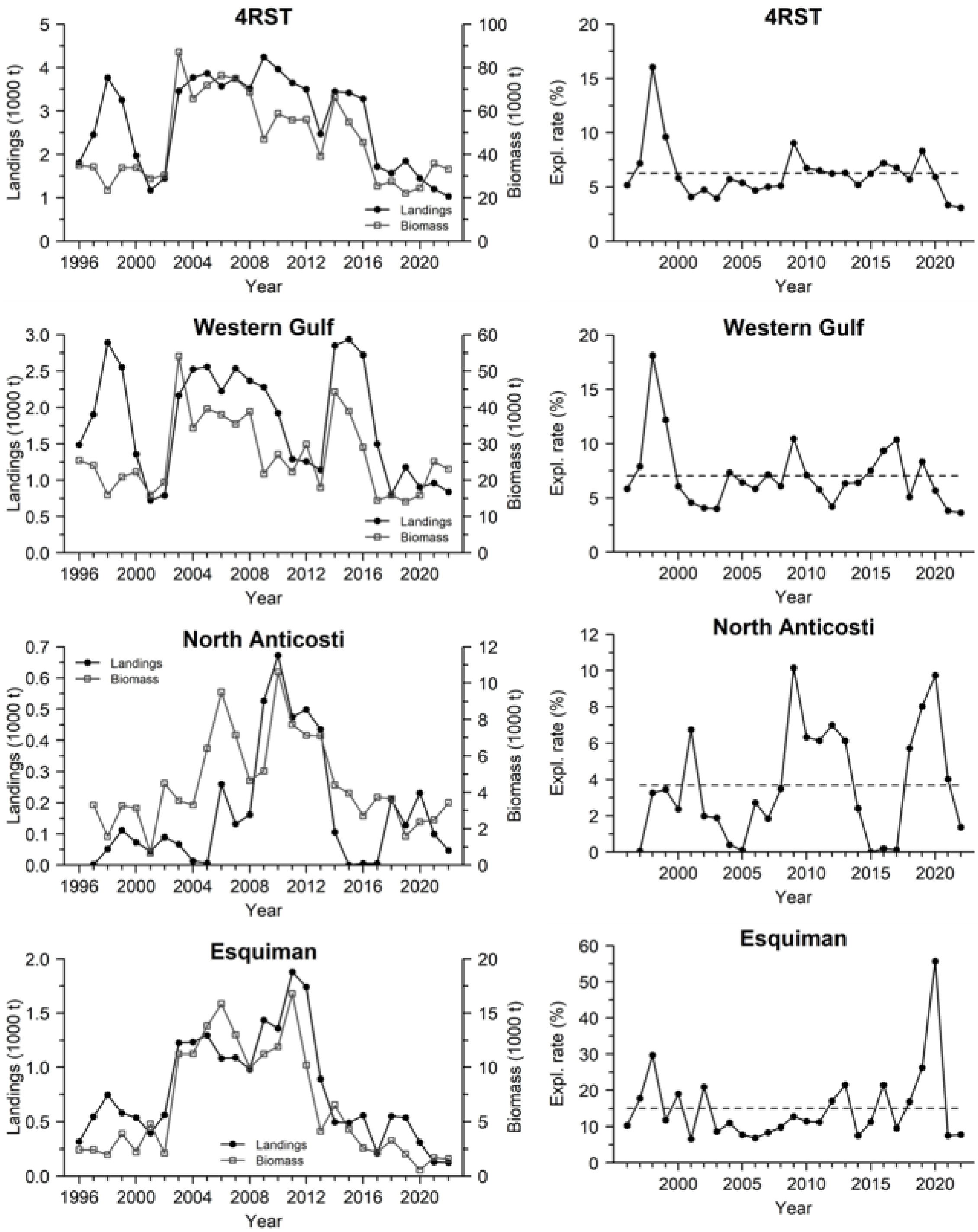


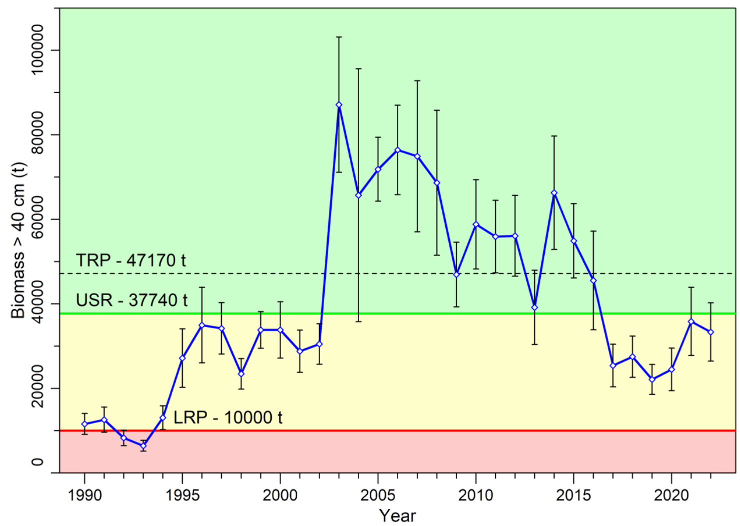
Figure 13. Landings, fish biomass > 40 cm, and exploitation rate index for the GSL (4RST) and by fishing sector. The dotted lines represent the average exploitation rate for each series.

Precautionary approach

A first precautionary approach was completed for the GSL Greenland halibut stock in 2022 (DFO 2022b). It is based on empirical reference points and a harvest control rule (HCR). The indicator selected to monitor the status of the stock is the biomass of fish > 40 cm estimated from the nGSL survey.

The stock status indicator decreased by over 60% between 2008 and 2017, moving from the healthy zone to the cautious zone. The indicator was stable in the middle of the cautious zone from 2017 to 2020. It then increased to a value of 35,859 t in 2021, just below USR, and remained in the cautious zone in 2022 at a value of 33,366 t (Figure 14a). According to the HCR, removals should be limited to a maximum of 2,002 t for the 2023-2024 and 2024-2025 management years (Figure 14b).

A)



B)

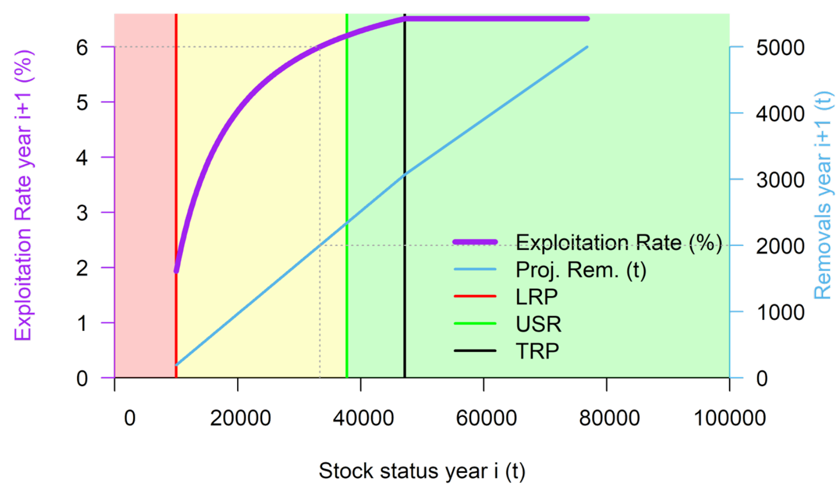


Figure 14. (A) Biomass index of Greenland halibut > 40 cm estimated from the nGSL survey, with 95% confidence interval. The horizontal red line marks the Limit Reference Point (LRP) that delimits the critical (red) and cautious (yellow) zones. The horizontal green line marks the Upper Stock Reference point (USR) that delimits the cautious and healthy (green) zones. The black line indicates the Target Reference Point (TRP). (B) Harvest control rule in terms of projected exploitation rate (purple) and removals (blue). The gray dashed lines indicate the projected exploitation rate and removals for the upcoming fishing seasons.

According to the PA currently adopted (DFO 2022b), the decision regarding the TAC will be applied for 2 years. During interim years, an update of the stock status indicator will be produced. In the event of exceptional circumstances during an interim year, such as a variation of more than 30% in the biomass indicator, the projected removals from the HCR will be recalculated.

Sources of Uncertainty

A large proportion of gillnet fishing trips use prolonged immersion periods exceeding the maximum regulatory duration of 72 hours. These long soak times have been associated with degradation of catches to the point where some fish may fall out of the nets or be decomposed before the nets are retrieved. This drop-out loss represents unaccounted fishing mortality, the extent of which is unknown. A research project initiated in 2022 aims to estimate it.

The biological parameters that present some uncertainty are the length at maturity and growth. The determination of the length at maturity is done by macroscopic evaluation of gonads during the nGSL survey in August, which is less precise than histological data or data collected during the spawning period. A study on the maturity of Greenland halibut is underway to determine maturity curves based on histological data. No recent data on age determination and therefore growth is currently available for this stock. Acquisition of data on maturity and age will inform biological processes determining stock productivity and will be an asset for developing a population dynamics model.

The Gulf of St. Lawrence is undergoing significant changes: deep waters are warming and becoming depleted in oxygen. In addition, changes in the community structure (high abundance of redfish and low abundance of prey) are observed. These modifications could have a negative effect on the productivity of Greenland halibut. On the other hand, the effect of temperature and DO level of deep waters on the duration and frequency of vertical movements of Greenland halibut is unknown. The variable availability of fish to scientific surveys would have implications for catchability and abundance and biomass indices.

At the time of writing this scientific advice, no fishing effort and fishing activity location data were available for vessels from Newfoundland in 2022, preventing, among other things, the calculation of the fishery performance index for the Esquiman sector. In addition, there appears to have been no at-sea observer coverage of directed fishery trips in this province in 2021 and 2022. This has a direct impact on the ability to estimate bycatch and unaccounted mortality (discards at sea and drop-out) in this fishery. This situation is particularly problematic since participants in the directed fishery in this sector often employ soak times that exceed the allowed limit. Discards and drop-outs tend to increase with long soak times (Humborstad et al. 2005, Patterson et al. 2017).

CONCLUSIONS AND ADVICE

The long-term prospects for the GSL Greenland halibut stock are uncertain due to observed ecosystem changes. From 2021 to 2022, commercial fishing performance indices increased in the western GSL, remained stable in North Anticosti, and decreased in Esquiman. The index for the entire GSL was at the average level in 2022. Commercial fishing landings continued to decline in 2021 and 2022, reaching the lowest values observed since the 1980s. The biomass of individuals > 40 cm, on the other hand, increased in 2021 compared to 2020 and remained stable in 2022. As a result, there was a significant decrease in the exploitation rate indicator in 2021 and 2022, representing the lowest values observed since 1996.

Abundance in cohorts that should recruit and contribute to the fishery in 2023 and 2024 vary from low (2016) to high (2017-2018). The 2018 cohort appears to have a normal growth rate, although the low condition value observed in 2022 could be associated with slower growth. The low recruitment from 2020 to 2022 will have a negative impact on the available biomass to fishing after 2024.

In 2022, the stock status indicator was estimated at 33,366 t, slightly below the upper stock reference point. The stock is therefore in the top of the cautious zone. According to the harvest control rule, removals should not exceed 2,002 t in 2023-2024 and 2024-2025.

OTHER CONSIDERATIONS

The distributional areas of redfish and Greenland halibut in NAFO 4RST overlap to some extent. The forthcoming reopening of the commercial redfish fishery will result in a significant increase in fishing effort that could increase Greenland halibut bycatch. The effectiveness of management measures such as spatio-temporal closures and the selectivity of redfish fishing gear should be assessed in order to minimize Greenland halibut bycatch.

LIST OF MEETING PARTICIPANTS

Name	Affiliation	Febr. 13	Febr.14
Beaudry-Sylvestre, Manuelle	DFO – Science	x	x
Benoit, Hugues	DFO – Science	x	x
Bernier, Denis	DFO – Science	x	-
Bois, Samantha	ACPG	x	x
Bouchard, Donald	Essipit First Nation	x	-
Boucher, Jean-René	RPPNG-OPFGQ	x	x
Boudreau, Mathieu	DFO – Science	x	x
Boudreau, Sophie	DFO – Science	x	x
Bourdages, Hugo	DFO – Science	x	x
Bourbonnière, Jean-Patrick	DFO – Science	x	x
Brûlé, Caroline	DFO – Science	x	x
Byrne, Vanessa	Prov. of Newfoundland and Labrador	x	x
Chabot, Denis	DFO – Science	x	-
Chamberland, Jean-Martin	DFO – Science	x	x
Chlebak, Ryan	DFO – Science Ottawa	x	x
Condo, Jaime	Micmacs of Gesgapegiag Band	x	x
Cormier, Julien	DFO – Fisheries Management Gulf	x	x
Cyr, Charley	DFO – Science	x	x
Denis, Marcel	ACPG	x	-
Dennis, Olivia	Prov. of Newfoundland and Labrador	x	x
Desgagnés, Mathieu	DFO – Science	x	x
Devine, Brynn	Oceans North	x	x
Dubé, Frank	Fisher	x	-
Dubé, Sonia	MPO – Sciences	x	x
Dugas, Franky	Fisher	x	-
Duplisea, Daniel	DFO – Science	x	x
Dwyer, Shelley	DFO – Fisheries Management NL	x	x
Émond, Kim	DFO – Science	x	x
Gianasi, Bruno	DFO – Science	x	-
Laurie, Isabel	DFO – Science	x	-
Langelier, Serge	AMIK	x	x

Name	Affiliation	Febr. 13	Febr.14
Lussier, Jean-François	DFO – Science	x	-
Marquis, Marie-Claude	DFO – Science	x	x
Martin, Lucas	UQAR	x	-
Miville, Emmanuel	Fisher	x	-
Monger, Julie	LNSFA	x	-
Nadeau, Paul	LNSFA	x	x
Nicolas, Pierre	OPFGQ	x	-
Ouellette-Plante, Jordan	DFO – Science	x	x
Parent, Lyndsey	Listugug First Nation	x	x
Pond, Nancy	DFO – Fisheries Management NL	x	x
Pinette, Majoric	Conseil des Innus Pessamit	x	x
Rondeau, Marie-Maude	DFO – Science	x	x
Roux, Marie-Julie	DFO – Science	x	-
Sandt-Duguay, Emmanuel	AGHAMW	x	x
Senay, Caroline	DFO – Science	x	x
Sigouin, Evelyne	PNWW - AGHAMW	x	-
Smith, Andrew	DFO – Science	x	x
Solberg, Abe	FFAW	x	x
Tremblay, Yan	UAPAN	x	-
Trottier, Steeve	DFO – Fisheries Management Québec	x	x

SOURCES OF INFORMATION

This Science Advisory Report is from the regional peer review meeting of February 13-14, 2023 on the Assessment of the Gulf of St. Lawrence (4RST) Greenland Halibut stock. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2022a. Update of stock status indicators for Greenland Halibut in the Gulf of St. Lawrence (4RST) in 2021. DFO Can. Sci. Advis. Sec. Sci. Resp. 2022/016.

DFO. 2022b. Development of a precautionary approach for the Gulf of St. Lawrence (4RST) Greenland halibut stock. DFO Can. Sci. Advis. Sec. Sci. Resp. 2022/002.

Galbraith, P.S., Chassé, J., Dumas, J., Shaw, J.-L., Caverhill, C., Lefaivre, D. and Lafleur, C. 2022. Physical Oceanographic Conditions in the Gulf of St. Lawrence during 2021. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/034. iv + 83 p

Gauthier, J., Marquis, M.-C., and Isabel, L. 2021. Gauthier, J., Marquis, M.-C., and Isabel, L. 2021. Gulf of St. Lawrence (4RST) Greenland Halibut Stock Status in 2020: Commercial Fishery and Research Survey Data. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/059. v + 135 p.

Humborstad, O.-B., Løkkeborg, S., Hareide, N.-R., and Furevik, D. M. 2003. Catches of Greenland halibut (*Reinhardtius hippoglossoides*) in deepwater ghost-fishing gillnets on the Norwegian continental slope. Fish. Res. 64:163-170.

Ouellette-Plante, J., Chabot, D., Nozères, C. et Bourdages, H. 2020. Régimes alimentaires de poissons démersaux provenant des relevés écosystémiques du NGCC Teleost dans l'estuaire et le nord du golfe du Saint-Laurent, août 2015-2017. Rapp. tech. can. sci. halieut. aquat. 3383: v + 124 p.

Patterson, D.A., Robinson, K.A., Lennox, R.J., Nettles, T.L., Donaldson, L.A., Eliason, E.J., Raby, G.D., Chapman, J.M., Cook, K.V., Donaldson, M.R., Bass, A.L., Drenner, S.M., Reid, A.J., Cooke, S.J., and Hinch, S.G. 2017. Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/010. ix + 155 p.

THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
850 route de la Mer
P.O. Box 1000
Mont-Joli (Quebec)
Canada G5H 3Z4

E-Mail: dfo.csaquebec-quebeccas.mpo@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
ISBN 978-0-660-48910-0 N° cat. Fs70-6/2023-022E-PDF

Correct Citation for this Publication:

DFO. 2023. Assessment of the Gulf of St. Lawrence (4RST) Greenland halibut stock in 2022. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2023/022.

Aussi disponible en français :

MPO. 2023. Évaluation du stock de flétan du Groenland du golfe du Saint-Laurent (4RST) en 2022. Secr. can. des avis sci. du MPO. Avis sci. 2023/022.