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Quebec Region

ASSESSMENT OF THE GREENLAND HALIBUT STOCK IN THE GULF OF ST. LAWRENCE (4RST) IN 2017

Photo : Claude Nozères

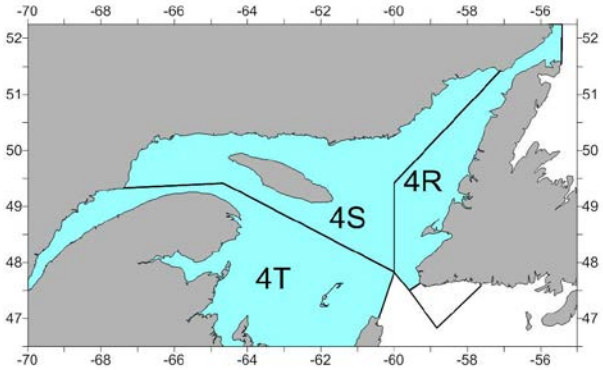

Figure 1. Management zone for Gulf of St. Lawrence Greenland Halibut, NAFO Divisions 4RST.

Context:

Stock status monitoring indicators for the Greenland Halibut (Reinhardtius hippoglossoides) in the Gulf of St. Lawrence (NAFO Divisions 4RST) were updated in December 2017 (DFO 2018) and showed significant decreases in Fisheries and Oceans Canada (DFO) research survey indicators and in commercial fishery landings. The analysis showed that trigger values warranting a stock assessment during an interim year had been reached. Consequently, DFO's Fisheries Management team requested that a full assessment of the Greenland Halibut stock be conducted in winter 2018. The next scheduled full assessment will be in winter 2019.

Until the mid-1970s, Greenland Halibut (commonly called black Halibut or turbot) from the Gulf of St. Lawrence (4RST) were not subjected to any directed fishery. At the end of the 1970s, a Greenland Halibut fishery developed using gillnets and bottom trawls. Following the closure of the Atlantic cod mobile gear in 1993, any mobile gear directed fishery for Greenland Halibut has been prohibited. This fishery is currently carried out by boats equipped with gillnets, whose home ports are mainly located in Quebec or on the west coast of Newfoundland.

The fishery is subject to several management measures including catch control by a total allowable catch (TAC) to limit the exploitation of the stock and a minimum size of 44 cm which aims to protect the reproductive potential of the population.

The main indicators used for the assessment are taken from fishery statistical data, sampling of commercial catches and research surveys.

A science peer review meeting was conducted March 13, 2018 in Mont-Joli, Qc. Participants at the science review were from DFO Science, DFO Fisheries Management, fishing industry, provincial governments, Academia and Aboriginal organisations. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- For the 2017-2018 fishing season, landings of Greenland Halibut reached 1,665 t (preliminary 31 December) for a fishing allocation of 3,750 t (4,500 t TAC). These landings are well below the 3,358 t average for the last 10 years for the period May 15 to December 31.
- Across the Gulf, gillnet effort targeting Greenland Halibut has been decreasing and is below the series average since 2015. This reduction is related to the abandonment of the northern Anticosti sector and a drop in effort in the Esquiman sector. The effort has remained stable in the western Gulf sector since 2015 and accounted for more than 80% of the total fishing effort deployed in 2017.
- Between 2016 and 2017, the performance index in the commercial fishery (CPUE) over the entire Gulf decreased by 36% and is now below the 1999-2016 series average. Of the three sectors, the western Gulf suffered the largest decline in the index, equivalent to more than 50% compared to historical highs of 2015 and 2016. In the northern Anticosti and Esquiman sectors, the index has been declining since 2009 and is below the average of each series since 2013.
- In 2017, the biomass indices for fish over 40 cm in the DFO and sentinel surveys decreased by 44% and 30% respectively compared to 2016 and are below the average of their respective series. These indices follow a downward trend since more than 10 years.
- At the scale of the Gulf, the 2017 exploitation rate indicator remains close to the time series average despite low landings. However, this indicator is increasing in the western Gulf sector.
- The strong cohorts of 2012 and 2013 grew slower than average and their recruitment to the fishery is uncertain. The abundance of the 2014 cohort is within average while the abundance of the 2015 and 2016 cohorts is low.
- Fish of the 2012 to 2015 cohorts have below-average condition indices. The condition index for the 2016 cohort at 1 year is above average.
- An upper stock reference point (USR) of stock status was proposed in accordance with the precautionary approach. According to this USR, the status of the Greenland Halibut stock from the Gulf of St. Lawrence would be in the cautious zone since two years.
- The Gulf of St. Lawrence ecosystem is undergoing significant changes in recent decades. Deeper water layers are warming up and becoming poorer in oxygen. These factors can lead to habitat loss and reduced growth for Greenland Halibut. Deepwater temperatures will remain high for the coming years. The arrival of three very strong cohorts (2011-2013) of redfish increases interspecific competition with Greenland Halibut, which occupies a similar ecological niche.
- The short-term outlook for the Greenland Halibut stock in the Gulf of St. Lawrence is concerning given ecosystem changes, poor recruitment, decreasing indices of abundance and biomass of fish over 40 cm, and the reduction in the fishery performance index. As a result, withdrawals should be reduced for the 2018-19 fishing season to avoid an increase in the exploitation rate.

INTRODUCTION

Overview of oceanographic conditions and ecosystems

The deep-water area (> 150 m) in the Gulf of St. Lawrence (GSL) is sourced from water from the Labrador Current (cold, less salty and well oxygenated) that has mixed with water from the Gulf Stream (warm, salty and not as well oxygenated). These mixed waters enter from the Laurentian Channel and flow up to the head of the Esquiman, Anticosti and Laurentian channels. It takes about three to four years for this water to flow between the Cabot Strait and the head of the Laurentian Channel. In recent decades, water from the Gulf Stream has made up a greater proportion of the mix, resulting in higher temperatures and oxygen depletion in the deep waters of the GSL.

In recent decades, water temperatures at all depths have increased throughout the Gulf. Temperatures at depths of 150 m, 200 m and 250 m remained above normal in 2017. A new record high of 6.3 °C was reached at 300 m. The seabed area covered by waters at temperatures above 6 °C has increased in the centre and north-west of the Gulf, but has decreased in the Anticosti and Esquiman channels, although this area remains large in both locations.

While these deep waters flow between the mouth and head of the Laurentian Channel, in the Estuary, *in situ* respiration and oxidation of organic matter reduce dissolved oxygen levels. As a result, the deep waters of the Estuary have the lowest dissolved oxygen levels. The last three years have seen the lowest oxygen concentrations in the St. Lawrence Estuary in the past 90 years. Saturation levels are below 18%, which is well below the 30% hypoxic threshold.

Recent studies have shown that the increase in deep-water temperatures and oxygen depletion could result in a loss of habitat for the Greenland Halibut and could partially explain their reduced growth rates in recent years. According to forecasts, deep-water temperatures in the GSL will remain high in the coming years. These are adverse conditions for the Greenland Halibut as a cold-water species.

In the 1980s, the ecosystem in the northern Gulf of St. Lawrence (nGSL) was dominated by groundfish. In the early 1990s, the main groundfish stocks in that ecosystem (e.g. the Atlantic cod and the redfish) collapsed. The resulting lack of large predators facilitated a rise in the populations of forage species, including various shrimp species (Figure 2). The Greenland Halibut's biomass increased alongside that of the northern shrimp, while large groundfish species were in decline (Figure 2). For the past few years, a decrease in the various shrimp species has been observed along with an increase in the biomass of groundfish species, largely marked by the massive arrival of the redfish in the nGSL.

The arrival of three very strong cohorts of redfish (2011 to 2013) increased interspecies competition with the Greenland Halibut, which occupies a similar ecological niche. Both species' diets are made up of common prey, like the northern shrimp. Redfish abundance is at its highest recorded level in the GSL. This species has a long life expectancy and will prove to be competition for the Greenland Halibut in both the short and long term. Overall, ecosystem signals observed in the GSL indicate that the ecosystem's structure is changing, which could create favourable conditions for some species (like the redfish), but adverse conditions for other species (like the northern shrimp and Greenland Halibut).

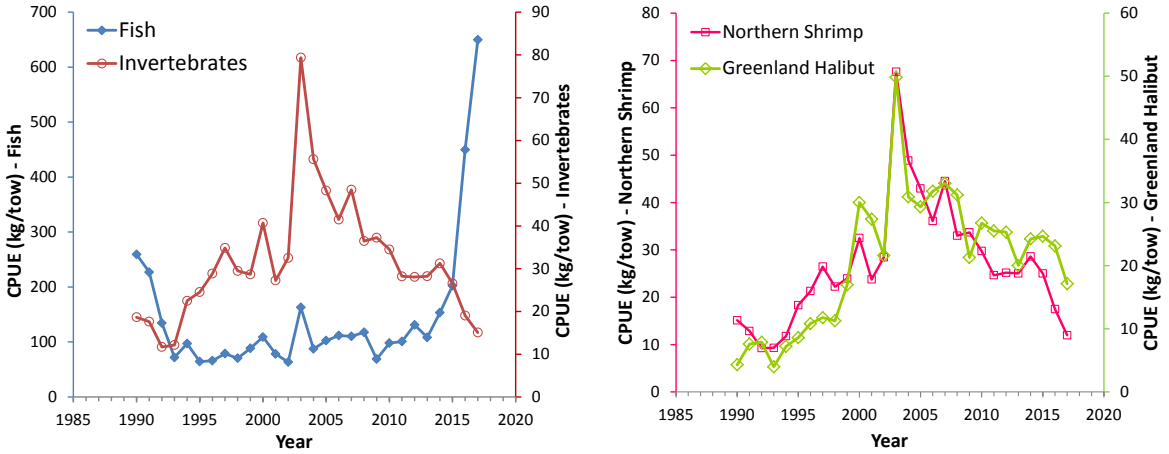

Figure 2. Estimated biomass indices (kg/tow) from DFO's survey of the main groundfish and invertebrates (left) and of the Greenland Halibut and northern shrimp (right) in the nGSL.

Biology

In the early 1990s, parasite studies demonstrated that Greenland Halibut population of the Gulf of St. Lawrence (GSL) is a stock isolated from the main population of the northwestern Atlantic found east and west of the Grand Banks of Newfoundland. These studies concluded that GSL Greenland Halibut complete their life cycle within the Gulf. The GSL is a single management area for this species.

Spawning occurs in winter between January and March, possibly in the depths of the Laurentian Channel southwest of Newfoundland. Males reach sexual maturity at a smaller size than females, at about 36 cm for males compared to 46 cm for females. Spawning takes place in winter, mainly between January and March. This difference helps explain why females grow to be larger than males and make up the majority of commercial catches.

The diet of the Greenland Halibut varies depending on its size. The diet of individuals under 20 cm in length consists of zooplankton, like hyperiid amphipods, krill, and other invertebrates. As Greenland Halibut grow, their diets begin to consist mainly of fish and shrimp. Capelin make up the majority of the fish in their diet. In recent years (2015-2017), redfish have become an important part of the diet of Greenland Halibut over 30 cm in length. Larger turbot over 40 cm eat mainly shrimps, herring, small demersal fishes, redfish and capelin. The turbot's main predators are Harp, Grey and Hooded seals and Atlantic Halibut.

Greenland Halibut in the Gulf of St. Lawrence

The DFO research survey data indicate that Greenland Halibut occupy more than 85,000 km^2 in the northern Gulf of St. Lawrence (nGSL) and 95% of its biomass is concentrated over less than 50,000 km^2. It is mainly found in the channels of the GSL at depths ranging between 200 and 400 m (Figure 3) with more than 80% of the cumulative biomass of Greenland Halibut found between 229 and 366 m in areas with bottom temperature ranging from 4.4 and 5.7°C (Figure 4). This is the population living in the warmest waters of the Atlantic. Greenland Halibut is generally associated to the channels where sediments are fine and consolidated. Juveniles are predominant in the Estuary and north of Anticosti and are generally found at shallower depths than adults.

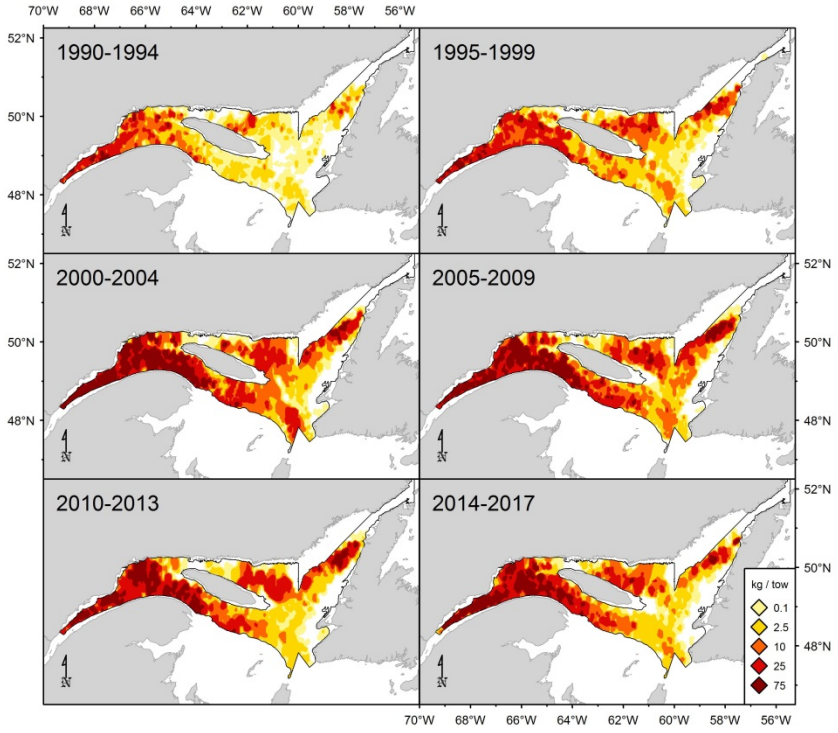

Figure 3. Greenland Halibut catch rates (kg/15 minutes tow) distribution during the nGSL DFO survey.

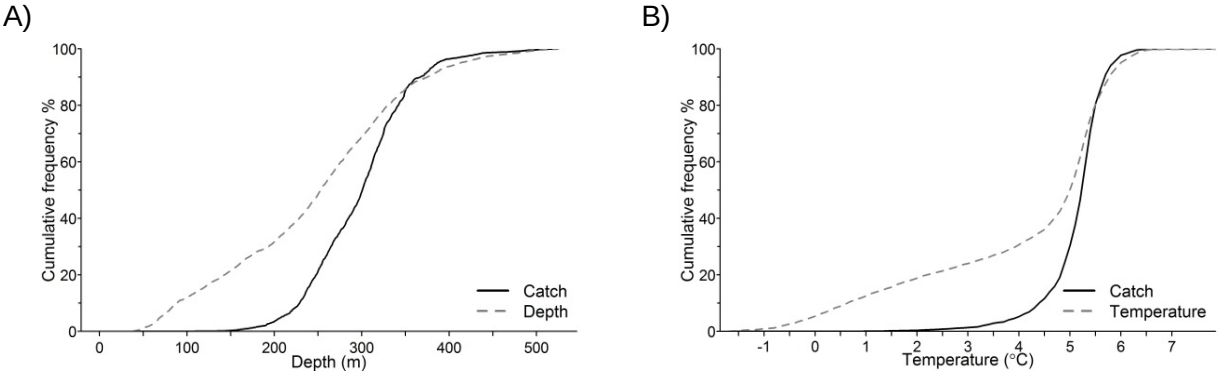

Figure 4. Cumulative frequency of catches (in weight) and of the number of tows sampled based on depth (A) and temperature (B) in the nGSL DFO survey from 1990 to 2017.

The Greenland Halibut is a strong swimmer that makes significant daily migrations and spends about 25% of its time in the water column. It uses the water column at different stages of its life. Eggs released and fertilized near the river bottom spend about 30 days in the water column before hatching within the first 50 metres of the surface. Larval development occurs at that surface level and can last up to four months. Larvae then settle on the bottom, where metamorphosis occurs.

Fishery

Until the mid-1970s, Greenland Halibut landings in the Gulf of St. Lawrence consisted mainly of by-catches from other fisheries (Figure 5). The directed Greenland Halibut gillnet fishery was then developed. A total allowable catch (TAC) of 7,500 t was introduced in 1981. It has varied between 10,500 t and 2,000 t. Landings fluctuated substantially, exceeding 8,000 t in 1979 and

1987. These peaks were both followed by sharp drops. Catches remained between 2,000 t and 4,000 t from 1989 to 1998. Landings decreased between 1999 and 2001, dropping from 3,700 tons to less than 1,300 tons. Landings increased to 3,900 tons between 2001 and 2004. Since the 2004-2005 management year (May 15 of the current year to May 14 of the following year), TAC has remained at 4,500 t. For this period, the allocation for the fixed gear directed fishery for Greenland Halibut was set at 3,751 t. This allocation was reached up until 2011 and has not been reached since. In 2017, a more significant gap was noted between TAC and preliminary landings (1,665 t, according to the December 31 quota report) (Figure 5). These landings are much lower than the 3,358 t average over the past 10 years for the period from May 15 to December 31.

Between 2016 and 2017, the number of active fishers involved in the Greenland Halibut directed fishery dropped from 96 to 75 in Quebec, and from 61 to 44 in Newfoundland. The fishery management measures include the imposition of a minimum mesh size of 152 mm (6.0 inches) and a minimum size of 44 cm for Greenland Halibut as part of a small fish tolerance protocol in commercial catches. Fishermen must also keep a logbook (100%), have their catches weighted by a dockside monitoring program (100%) and agree to have an observer on board at the DFO's request (5-15% coverage). Use of a vessel monitoring system (VMS) has been mandatory since 2013 on all vessels except for those of the less than 35 foot vessel sector in Newfoundland. Some fishermen have individual quotas while others are under competitive regime.

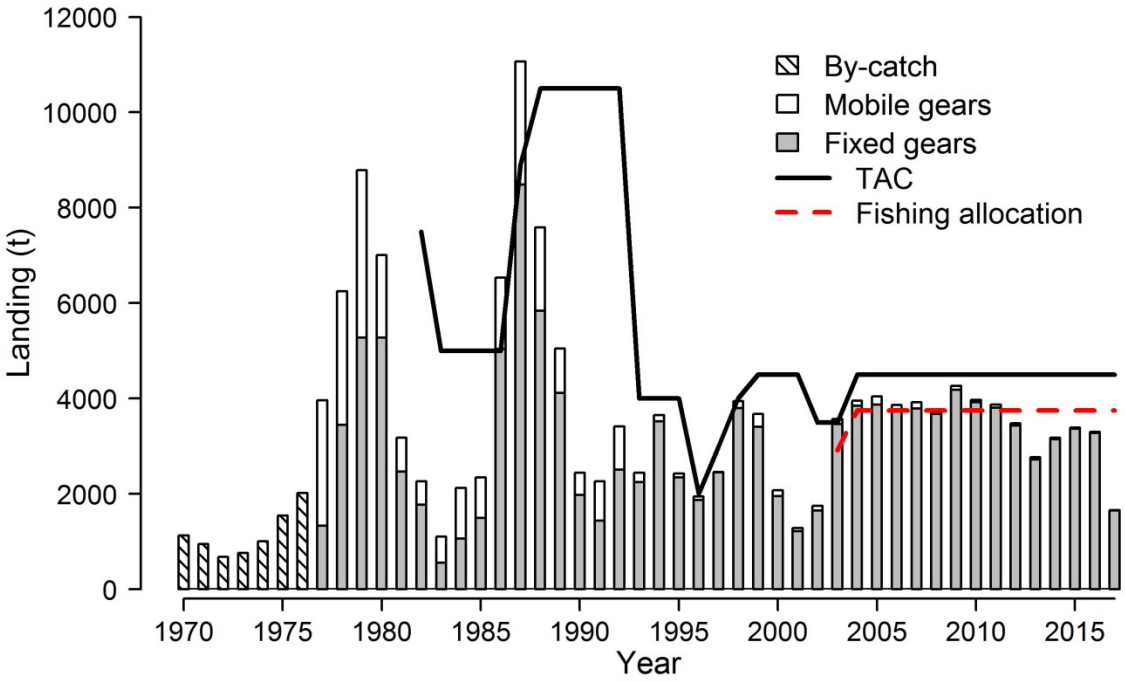

Figure 5. Reported landings (t) for the Greenland Halibut since 1970, and total allowable catch (TAC). In 2000, the management year was changed from the calendar year to the quota year (May 15 of the current year to May 14 of the following year). *2017 data are preliminary. Allocation for the fixed gear fishery (red dotted line) has been 3,751 t since the 2004-2005 fishing season.*

Table 1. Landings (t) by gear type and total allowable catch (TAC). Average by period and annual landings per fishing season.

	Gears			
Period	Fixed	Mobile	Total	TAC
1980-1989	3,612	1,215	4,827	7,175
1990-1999	2,558	309	2,868	5,700
2000-2010	3,144	108	3,252	4,300
2010-2015	3,408	48	3,456	4,500
2015-2016	3,373	23	3,396	4,500
2016-2017[1]	3,280	20	3,300	4,500
2017-2018[1]	1,649	15	1,665	4,500

[1] *Preliminary data as of December 31st 2017.*

RESOURCE ASSESSMENT

Sources of information

The assessment of the Greenland Halibut stock (4RST) is mostly based on analysis of commercial fishery data and from research surveys. The fishery data come from three different sources of information; purchase slip, fisherman's daily logbook and samples of commercial catches. Two research surveys with trawl were conducted annually in the nGSL. The first one in July with the Sentinel program and the second in August with a DFO vessel. These two surveys were conducted using bottom trawl, according to a random, stratified sample design. During sampling of commercial and survey catches, the fish are measured and sexed. In addition, data on sexual maturity of males and females and the condition of the fish are collected during the DFO survey.

Biological data

Size at 50% maturity

The size at which 50% (L_{50}) of Greenland Halibut are mature, determined during the DFO survey, decreased considerably for males and females between 1999 and 2001, and remained relatively stable from 2004 to 2013. Subsequently, L_{50} decreased to reach its lowest point from the series in the 2016 (Figure 5A). In 2017, male and female L_{50} increased to near the series average (1990-2017). It was 44 cm for females, and 35 cm for males. In the commercial fishery, the minimum size for the small-fish tolerance protocol is set at 44 cm to protect a significant proportion of the Greenland Halibut's reproductive potential. That said, fish growth decreases after sexual maturity, resulting in size dimorphism between males and females. A larger proportion of females reach the commercial size (44 cm), which explains why their catch numbers are higher. In 2017, the proportion of females in commercial catches was nearly 80%, which is comparable to the 1996-2016 series average.

The average size of Greenland Halibut caught in the commercial fishery increased from 2002 to 2012, from 45 cm to 49 cm (Figure 6B). Then it fluctuated between 47 and 49 cm. The average size of Greenland Halibut caught in 2017 was 44 cm and 48 cm for males and females respectively. These annual variations in commercial average sizes can be explained in part by

the strength of recruiting cohorts to fishing; a large cohort entering the fishery could decrease the average size of the fish caught.

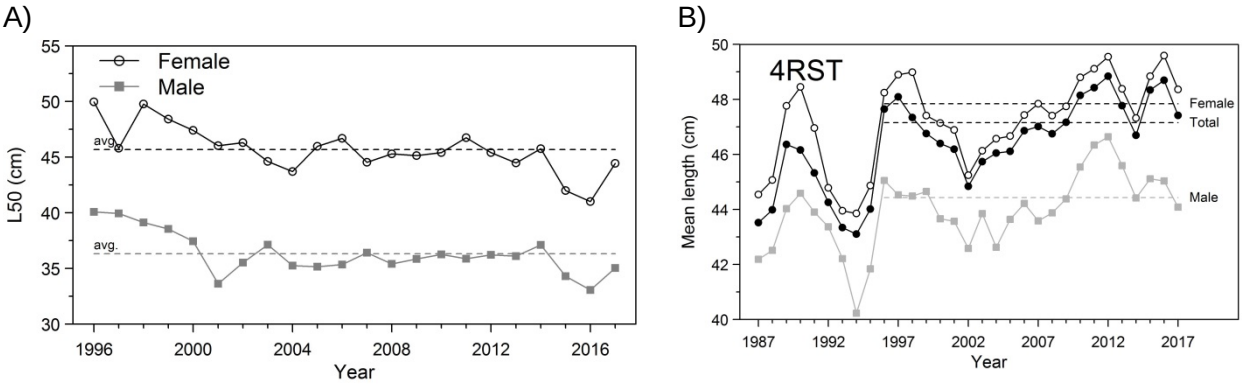

Figure 6. Size at which 50% of Greenland Halibut caught during the DFO research survey were sexually mature (L_{50}) (A) and average size of fish caught in the commercial gillnet fishery (B). The horizontal dotted lines indicate the average of each series. Regulated mesh size for the commercial fishery went from 5.5 to 6 inches in 1996.

Recruitment

Juvenile abundance varies significantly from one year to the next (Figure 7). Stock abundance is impacted by the strength of the various year-classes, their growth, and environmental conditions. These fluctuations in stock abundance affect the success of the fishery. According to growth estimates, females and males reach commercial size (44 cm) at age 6 and 7, respectively.

The 2012 and 2013 cohorts were very strong; abundance was average for the 2014 cohort; and the 2015 and 2016 cohorts were weak (Figure 7).

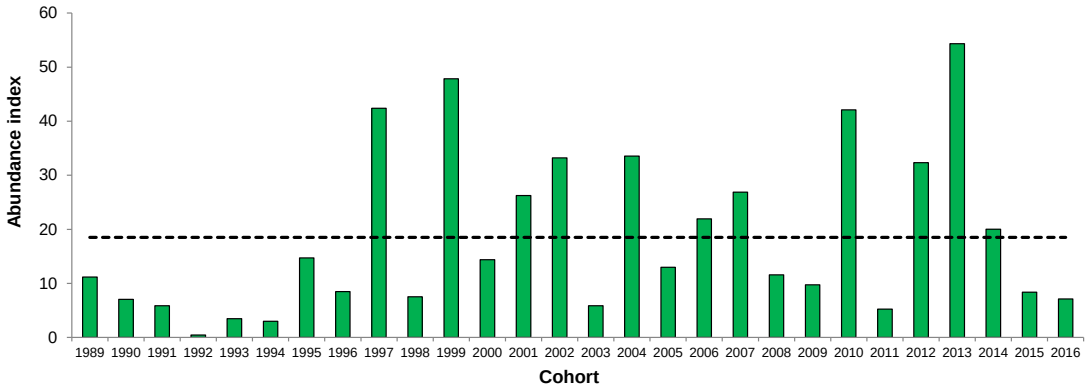

Figure 7. Annual recruitment index. Abundance of Greenland Halibut determined for each cohort at age 1 during the DFO survey. The dotted line represents the series average.

Growth and size structure

The structure and size of Greenland Halibut caught during the DFO and mobile gear sentinel survey (MSS) surveys show marked differences. The selectivity of trawls used in these surveys partially explains this divergence. The DFO survey uses a smaller mesh size, allowing for more effective sampling of small, 1-year-old individuals (~16 cm) (Figure 8, left). Conversely, the MSS survey sampled a higher proportion of large individuals (Figure 8, right). In Figure 8, bubble size indicates abundance at a given size.

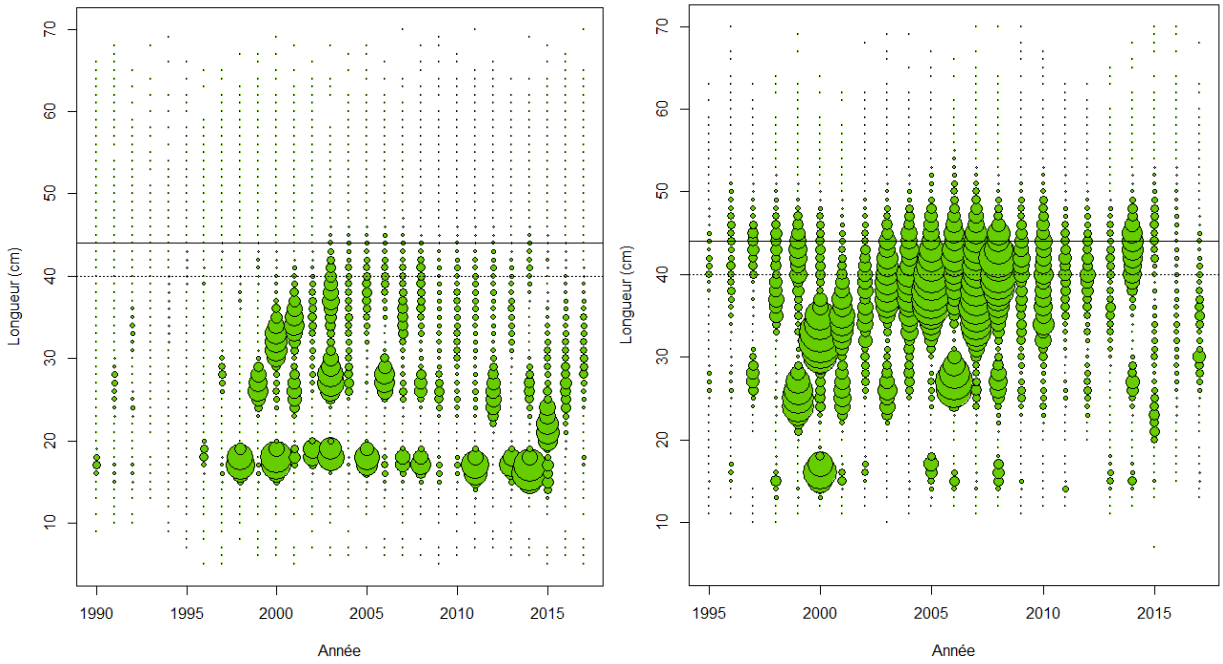

Figure 8. Distribution of length frequencies noted in the DFO survey (mean number per 15-minute tow) (left) and the mobile gear sentinel survey (mean number per 30-minute tow) (right) for the Greenland Halibut. The solid black lines indicate commercial size (44 cm), while the dotted black lines delimit the >40 cm size class.

Figure 8 depicts the arrival of two very strong cohorts in the history of this stock: the 1997 cohort (average modal size ~16 cm at 1 year in 1998) and the 1999 cohort (average modal size ~16 cm at 1 year in 2000). Fish from these cohorts contributed to the significant increase in stock abundance in the 2000s and supported the fishery. Abundance of fish over 40 cm in size has decreased since 2009, and they have been a rare find since 2015.

These size frequency distributions also suggest an about 40% slowdown in the growth of Greenland Halibut from the 2012 and 2013 cohorts, which will delay their recruitment to the fishery. This was the first time in 25 years that this phenomenon has been observed.

Condition

Fulton's condition index for the Greenland Halibut (i.e., the ratio between length and weight) indicates lower-than-average series values for the 2012 to 2015 cohorts (15 cm series from 2013 to 2016) (Figure 9). These low condition indices have remained unchanged with the growth of the fish in these different cohorts (25 cm, 35 cm, and 45 cm series from 2015 to 2017). Individuals from the 2016 cohort, which was not abundant, had a higher-than-average condition index (Figure 9, fish from 15 cm series in 2017).

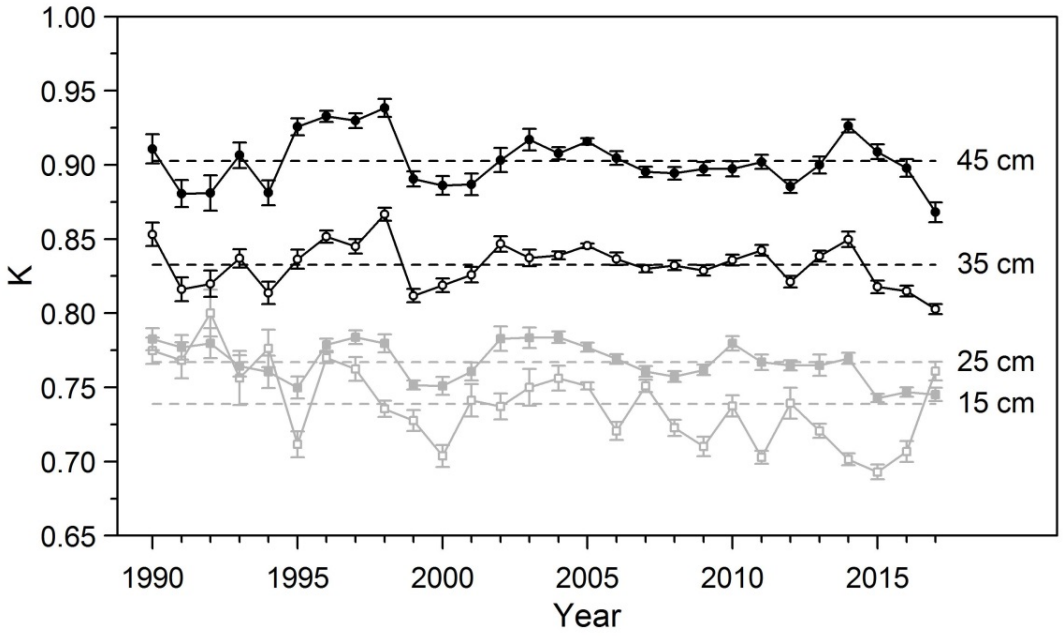

Figure 9. Fulton condition index by year for Greenland Halibut of 15, 25, 35 and 45 cm measured during the DFO survey. The dotted lines represent the chronological series average.

Fishing effort and catches

The directed Greenland Halibut gillnet fishery takes place in three main areas: the western Gulf, northern Anticosti and Esquiman areas (Figure 10). Fishing effort throughout the Gulf (4RST) is falling and has been below the series average since 2015 (Figure 11). This decrease is the result of abandoning the northern Anticosti area in addition to decreased efforts in the Esquiman area (Figures 10 and 11). The fishing effort has remained stable in the western Gulf since 2015 and and accounted for more than 80% of the total fishing effort deployed in 2017.

Landings for the entire Gulf (4RST) fell by nearly 50% in 2017. Landings in the western Gulf fell by nearly 45% compared to 2016, and the value of these landings was below the series average. Landings in the Esquiman area have been decreasing since 2011 and reached their lowest series value in 2017. There have been very few landings from the area north of Anticosti since 2015. In 2017, those landings totalled under 5 t.

Fishery performance

The commercial catch rate is used as an index of fishery performance and not as an index of abundance of exploitable stock. This index is standardized to account for changes based on NAFO subarea, soak time and seasonal pattern. Between 2016 and 2017, the commercial fishery performance indicator (catch per unit effort, or CPUE) for the entire Gulf fell by 36% and was under the 1999-2016 series average (Figure 12). Of these three areas, the western Gulf has had the biggest indicator drop with an over 50% decrease compared to historic highs in 2015 and 2016. In the north of Anticosti and Esquiman areas, the indicator has been falling since 2009 and been below each series average since 2013.

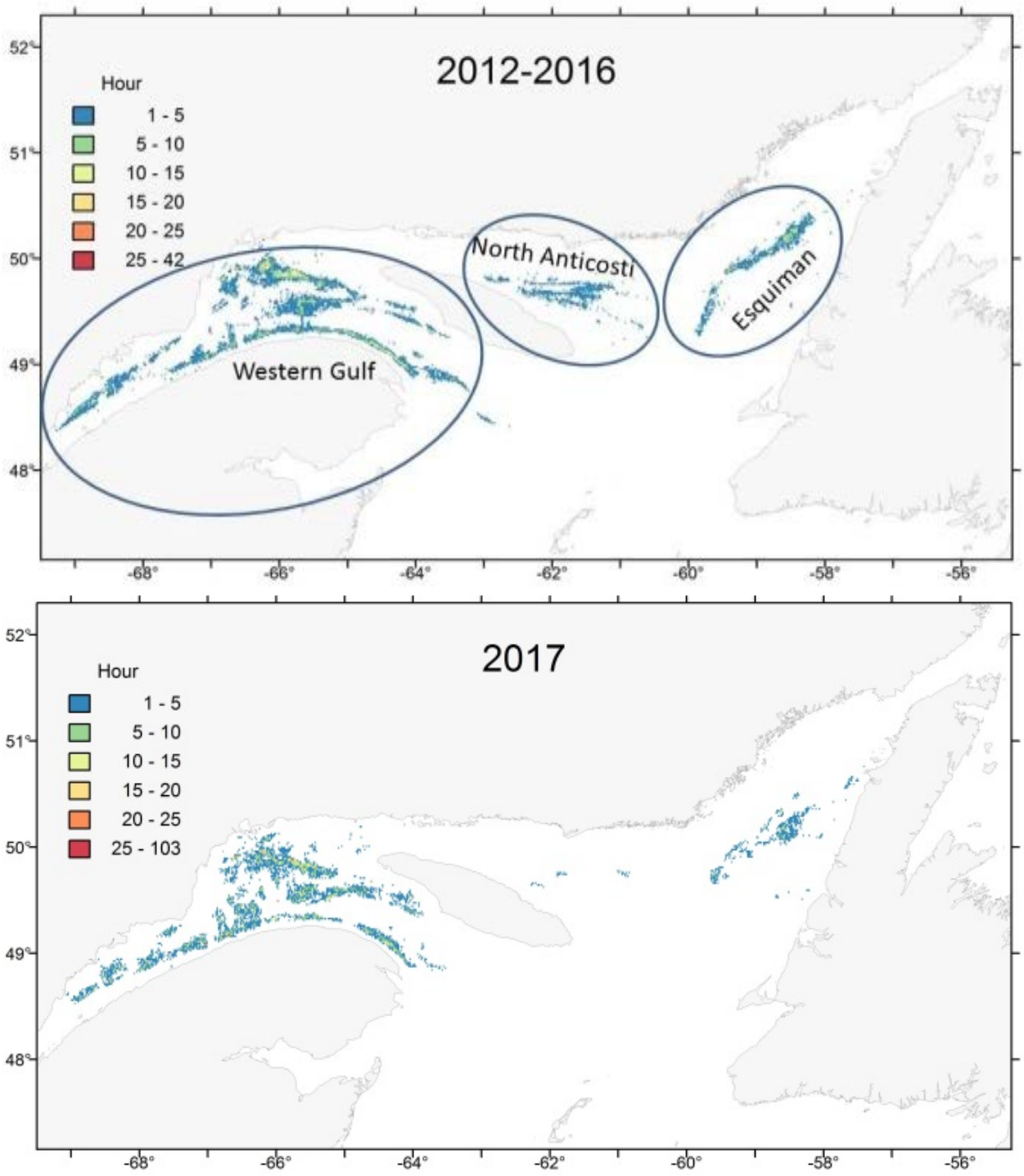

Figure 10. Distribution of the directed Greenland Halibut gillnet fishing effort. Average total number of hours positioning vessels for fishing from 2012 to 2016 (upper panel) and number of hours for 2017 (bottom panel). This data was obtained using the vessel monitoring system (VMS).

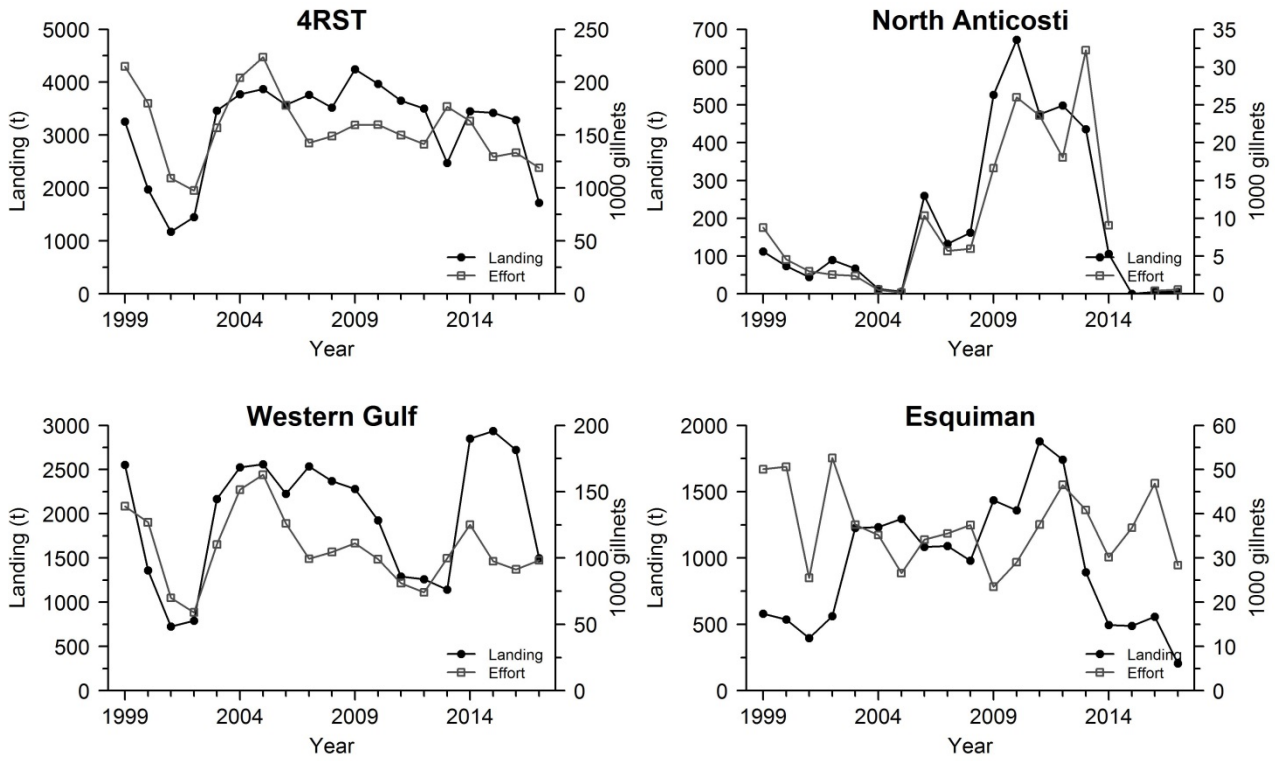

Figure 11. Landings (t) and fishing effort (number of gillnet) for the Gulf (4RST) and by fishing sector: Western Gulf, North Anticosti and Esquiman.

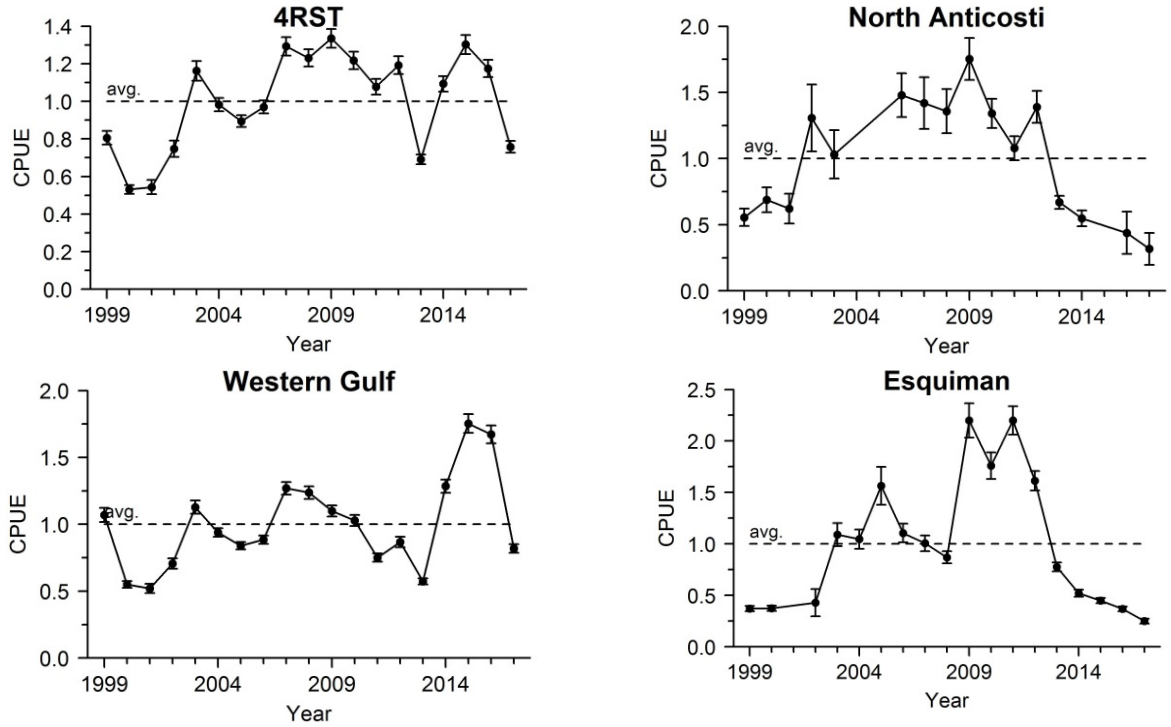

Figure 12. Standardized indices of fishing performance (CPUE) for the Gulf (4RST) and per fishing regions. The dotted lines represent the average of the series.

Stock status indicators

Total biomass indicators for the Greenland Halibut from DFO and MSS surveys show a general downward trend over the past decade. In 2017, these indicators were below their respective series average (Figure 13). From 1995 to 2008, these two indicators showed similar trends, i.e. a significant increase until 2004, followed by stability until 2008. Subsequently, as the DFO indicator showed some stability, the MSS indicator decreased rapidly. This difference can be explained two ways: (1) the MSS survey did not cover the Estuary, which houses 17 to 46% of the biomass sampled annually by the DFO survey; and (2) the trawl used for the MSS survey was ineffective at catching small fish (Figure 8). A significant proportion of biomass sampled by the DFO survey is therefore not captured by the MSS survey.

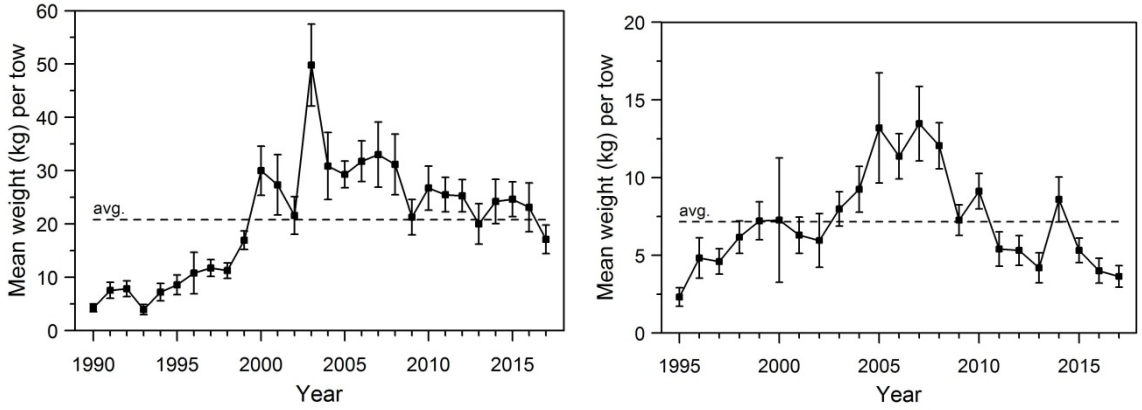

Figure 13. Indices of mean weights per tow estimated from the August DFO research survey (Left) and the July mobile Sentinel survey (Right). The dotted lines represent the average of each series.

In 2017, biomass indicators for fish over 40 cm in DFO and MSS surveys fell by 44% and 30% respectively compared to 2016, and were below their respective series average. These indicators have shown a general downward trend over the past decade.

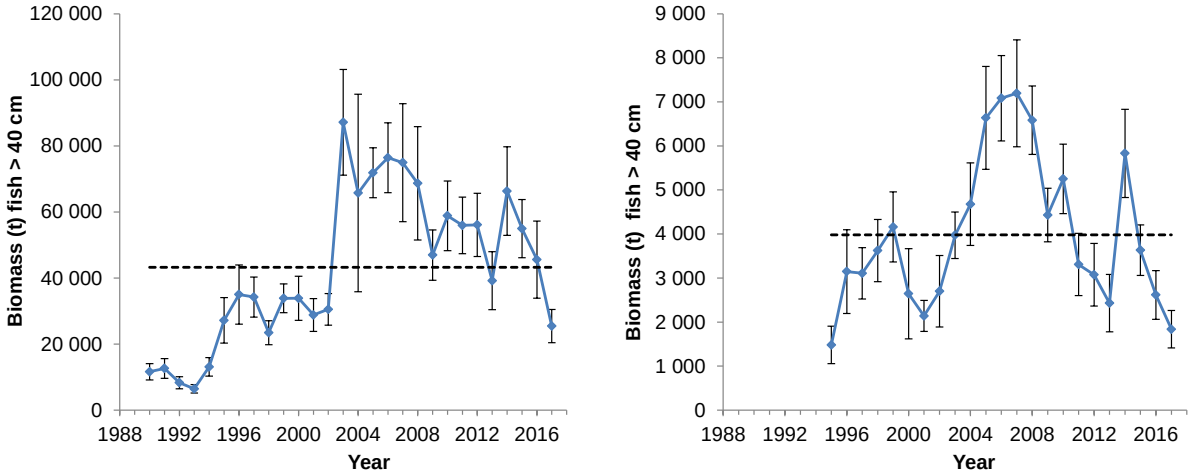

Figure 14. Biomass indicators for the Greenland Halibut over 40 cm from the August DFO research survey (left) and for the July mobile Sentinel survey (right). The dotted lines indicate the average of each series.

When decomposing the index of total mean number per tow in size classes, it is noticeable that the decrease in the total abundance of Greenland Halibut in 2017 is due to the decrease abundance of fish 20-30 cm as well as those larger than 40 cm (Figure 15). The abundance of fish 0-20 cm (1 year) is low and under the series average for 2016 and 2017, while individuals 20-30 cm and 30-40 cm in size have had average abundance rates (Figure 15). Abundance of fish over 40 cm in size has been decreasing since 2015 and was below the 2017 series average. Abundance indicators from the MSS surveys indicate below-average numbers for the four size classes.

Based on normal growth estimates for individuals from this stock, fish from the 2012, 2013 and 2014 cohorts should have reached a modal size of 41 cm, 37 cm and 33 cm respectively in 2017. A significant increase in the abundance of fish 30-40 cm in size should have been expected, as well as a more modest increase for fish over 40 cm in 2017. Data from the DFO survey indicates otherwise (Figure 15). The indicator for 30-40 cm fish shows that abundance is increasing slightly but that the value is near the series average, while abundance for fish over 40 cm is decreasing.

Exploitation rate indicator

An exploitation rate index is obtained by dividing the commercial catches in weight by the biomass of fish over 40 cm estimated using the DFO research survey data. This method cannot be used to estimate the absolute exploitation rate or to relate it to target exploitation rates. However, the method makes it possible to track relative changes over time. In the Gulf (4RST), the 2017 exploitation rate indicator was near the series average despite lower landings. That said, this indicator has been on the rise since 2012 in the western Gulf and has been above the series average for the last two years (Figure 16).

Precautionary approach - reference points

A precautionary approach is being developed for the Gulf of St. Lawrence Greenland Halibut stock. During the 2017 peer review, a stock status monitoring indicator was defined, along with a limit reference point (LRP). The biomass of fish larger than 40 cm estimated during the DFO summer survey was chosen as the indicator of the Greenland Halibut stock status. This indicator corresponds to the longest time series available (1990-2017) and represents a proxy for mature stock biomass. During this period, the stock experienced significant variations in productivity and biomass, these variations are taken into account in the establishment of reference points.

The selected LRP corresponds to the geometric mean of the estimated mature biomass for the period 1990 to 1994, which is the lowest level of population where a recovery of the stock was observed. This LRP has been estimated at 10,056 t (Figure 17).

During the winter 2018 peer review, an upper stock reference (USR) was proposed by the Science Sector. This USR represents 80% of biomass at maximum sustainable yield (B_{msy}). The proposed proxy for B_{msy} is the geometric average of the indicator for the 2004-2012 productive period, namely 63,211 t. That puts the USR at 50,569 t. According to this USR, the GSL Greenland Halibut stock has been in the cautious zone for the last two years. Fishery managers at DFO, with support from the Science Sector, should hold consultations with the fishing industry and other interest groups to adopt a USR. Harvest control rules for adjusting catches should also be elaborated during these consultations.

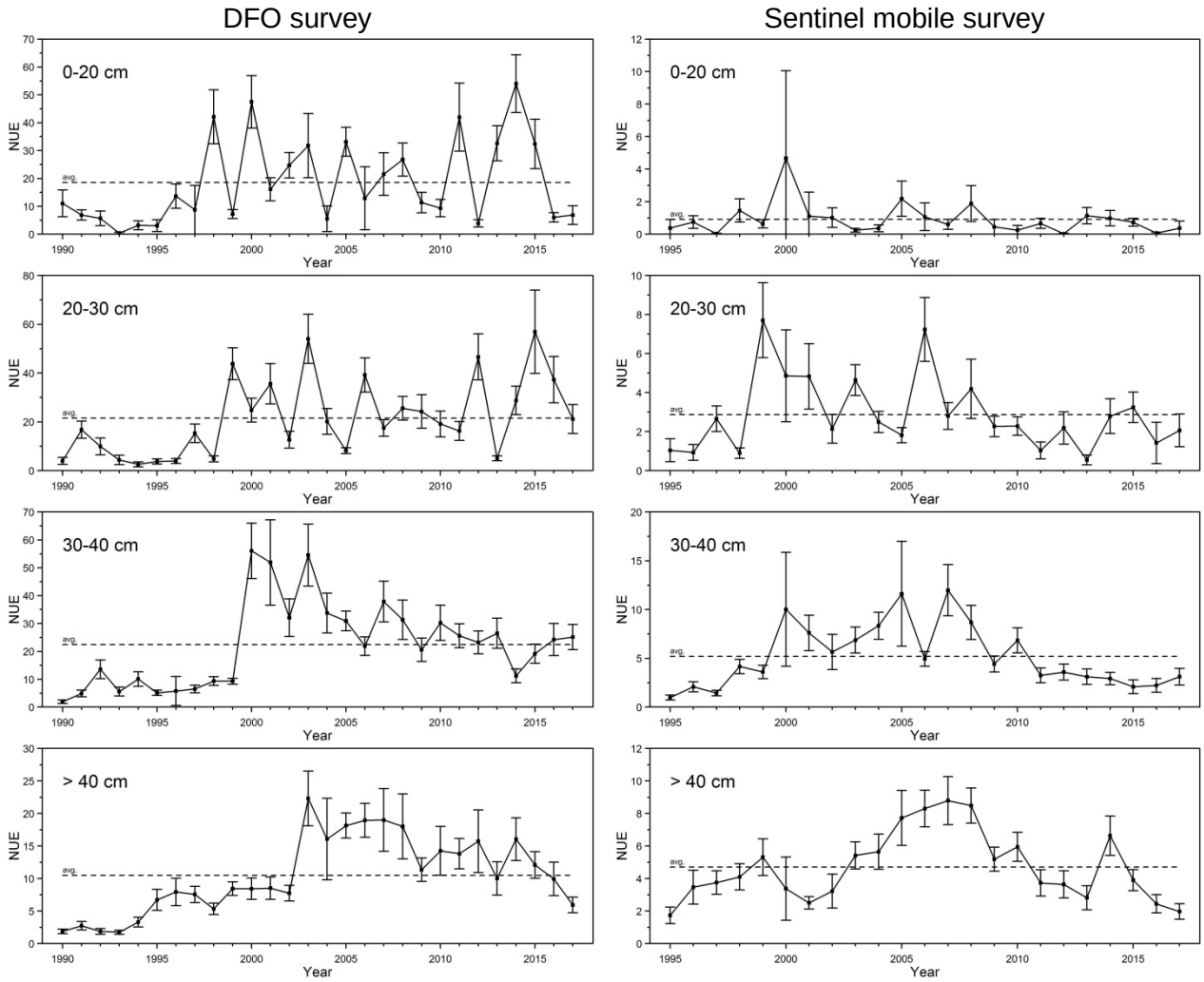

Figure 15. Indices of number per unit of effort (average number per tow) of Greenland Halibut for the different size categories observed in the DFO survey (Left) and in the July Sentinel mobile survey (Right). The dotted lines represent the average of each series.

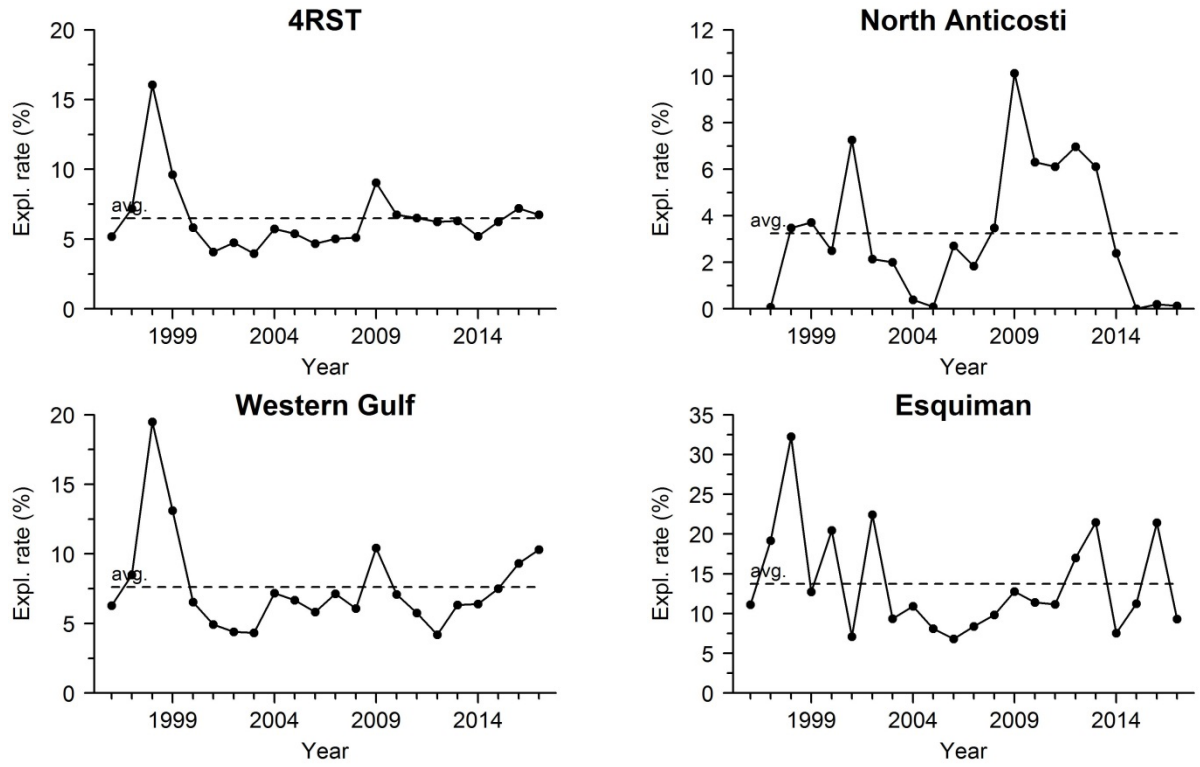

Figure 16. Indices of the relative exploitation rate for the Gulf (4RST) and per fishing sectors. The dotted lines represent the average of each series.

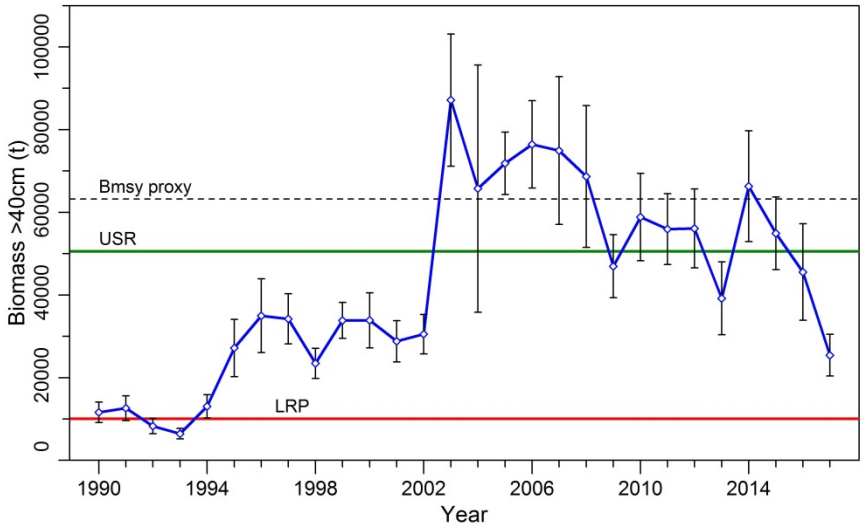

Figure 17. Annual biomass indicator for Greenland Halibut over 40 cm from the DFO survey series. The red horizontal line at the bottom indicates the limit reference point (LRP) as part of the precautionary approach. The LRP is the boundary between the critical and cautious zones. The green horizontal line at the top indicates the upper stock reference (USR) proposed by the Science Sector. The USR is the boundary between the cautious and healthy zones. The dotted black line indicates the proxy for biomass at maximum sustainable yield (B_{msy}).

Assessment schedule and trigger for a full assessment during an interim year

The 4RST Greenland Halibut stock is currently assessed and managed on a two-year cycle. In the interim years, an update of key resource indicators is prepared to provide fisheries management with an overview of the most recent stock status. The indicators used to monitor the status of the stock are landings and abundance indices from the DFO survey. The element that could trigger a re-assessment is a decrease of more than 30% in the biomass index of fish greater than 40 cm in the DFO survey when this biomass is in the caution or critical zone defined according to the precautionary approach. This assessment was conducted following an update (DFO 2018a) where the trigger was reached. According to the regular schedule, the next GSL Greenland Halibut stock assessment is set to occur in winter 2019.

Sources of Uncertainty

The length at which 50% of Greenland Halibut are mature is determined through a visual inspection of gonads during the DFO research survey in August. Since spawning occurs from January to March, the timing of the DFO survey is not ideal for this kind of work. A more detailed histological study would be more appropriate for determining L_{50} for males and females of this species.

The population dynamics model (based on length) that was being developed for this stock could not be used because of recent observed changes in the GSL Greenland Halibut's growth rate. Other population dynamics models could be evaluated.

CONCLUSIONS AND ADVICE

Short-term prospects for the GSL Greenland Halibut stock are worrisome, given ecosystem changes, low recruitment, decreases in abundance and biomass indicators for fish over 40 cm, and the fishery's lower performance indicator. As a result, removals should be decreased for the 2018-2019 season to avoid increasing exploitation rates.

OTHER CONSIDERATIONS

The GSL ecosystem has undergone significant changes in recent decades. Its deep waters are warming up, and the oxygen there is being depleted. These factors could result in a loss of habitat and lower growth rates for the Greenland Halibut. Deep-water temperatures will remain high in the coming years. The arrival of three very strong cohorts of redfish (2011–2013) increased interspecies competition with the Greenland Halibut, which occupies a similar ecological niche.

Slower growth rates were observed for the 2012-2014 cohorts, and condition indices were lower than average for these fish. These lower growth rates and condition indices could delay fish recruitment for the fishery.

Bycatch in the Greenland Halibut fishery

Bycatch in the gillnet directed Greenland Halibut fishery was estimated for the period 2000 to 2017 using data from the at-sea observer program. Bycatch in this fishery averages slightly over 400 t (Figure 18) which represent 15% of Greenland Halibut landed weight. In 2017, a sharp decrease in Greenland Halibut landings and higher bycatch levels pushed this percentage up to nearly 45%. The most common species are, in order of importance, American Plaice, Snow Crab, Redfish, Spiny Crab, Thorny Skate, Atlantic Halibut, Skates and Witch Flounder (Table 2). Approximately one third of the bycatch is landed, the rest being discarded at sea.

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 are released from trawls due to the mandatory use of a separator grate, catches still contain a certain number of small specimens. Greenland Halibut bycatch from the shrimp fishery from 2000 to 2017 were examined using the at-sea observer database. Greenland Halibut were present on average in 89% of the activities observed. Greenland Halibut bycatch are mostly of the order of 3 kg or less per tow and are mostly made up of 1 year-old individuals, and in a lesser extent 2 year-old individuals. The average annual Greenland Halibut bycatch from the shrimp fishery in the Estuary and Gulf from 2000 to 2016 are around 91 tons. In 2017, they were estimated at 97 t, representing approximately 0.43% of the Greenland Halibut biomass of small turbot (<30 cm) estimated from the DFO survey.

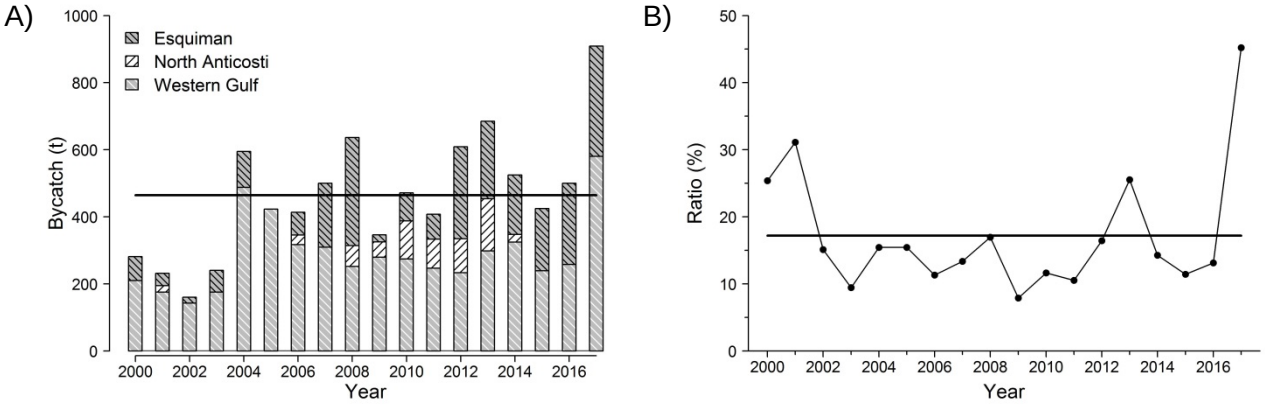

Figure 18. A) Bycatch for all species combined by year and fishing sector during the Greenland Halibut gillnet directed fishery in the presence of an at-sea observer. B) Ratio (%) of bycatch weight over the weight of total catch of Greenland Halibut. The solid lines indicate the average for the series. Data for 2017 are preliminary.

Table 2. Occurrence and bycatch of the most common species (occurrence > 10%) in the Greenland Halibut directed gillnet fishery in 2016 and 2017 and average values for the period 2000 to 2015.

	Occurrence (%)			Bycatch (t)		
Taxon	2000-2015	2016	2017	2000-2015	2016	2017
*Greenland Halibut	100	100	99	3,079	3,806	2,010
*American Plaice	77	77	79	37	33	93
Snow Crab	62	59	52	69	23	20
*Redfish	55	67	84	23	21	57
Spiny Crab	49	42	52	26	8	22
Thorny Skate	48	82	74	55	96	101
*Atlantic Halibut	45	52	69	87	184	184
Skates	41	19	38	43	42	160
*Witch Flounder	31	72	86	5	13	43
Anthozoan	20	59	60	6	9	8
*Atlantic Cod	19	21	31	14	23	44
*Monkfish	18	18	22	6	6	10
Smooth Skate	15	13	30	10	3	10
White Hake	14	23	36	5	7	9
Black Dogfish	12	21	18	18	8	127

* Species landed in commercial fisheries.

SOURCES OF INFORMATION

This Science Advisory Report is from the meeting of March 13, 2018 on the Assessment of Greenland Halibut stock in the Gulf of St. Lawrence (4RST). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Bernier, B. and Chabot, D. 2012. Assessment of Greenland Halibut (Reinhardtius hippoglossoides) stock status in the Gulf of St. Lawrence (4RST) in 2010 and diet description for this population. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/140, 93 p.

DFO. 2018a. Assessment of Greenland Halibut in the Gulf of St. Lawrence (4RST) in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/049.

DFO. 2018b. Update of stock status indicators for Greenland Halibut in the Gulf of St. Lawrence (4RST) in 2017. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/004.

Stortini, C.H., Chabot, D. and Shackell, N.L. 2016. Marine species in ambient low-oxygen regions subject to double jeopardy impacts of climate change. Global Change Biology (2016), doi: 10.1111/gcb.13534.

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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

Telephone: (418) 775-0825
E-Mail: bras@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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MPO. 2018. Évaluation du stock de flétan du Groenland du golfe du Saint-Laurent (4RST) en 2017. Secr. can. de consult. sci. du MPO, Avis sci. 2018/035.