Fisheries and Oceans Canada
Pêches et Océans Canada

Ecosystems and Oceans Science
Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2021/059

Quebec Region

Gulf of St. Lawrence (4RST) Greenland Halibut Stock Status in 2020: Commercial Fishery and Research Survey Data

J. Gauthier, M.-C. Marquis, and L. Isabel

Fisheries and Oceans Canada
Maurice Lamontagne Institute
850 Route de la Mer
Mont-Joli, Quebec G5H 3Z4

November 2021

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-0-660-40400-4 Cat. No. Fs70-5/2021-059E-PDF

Correct citation for this publication:

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.

Aussi disponible en français :

Gauthier, J., Marquis, M.-C. et Isabel, L. 2021. L'état du stock de flétan du Groenland du golfe du Saint-Laurent (4RST) en 2020 : données de la pêche commerciale et des relevés de recherche. Secr. can. de consult. sci. du MPO. Doc. de rech. 2021/059. v + 140 p.

TABLE OF CONTENTS

ABSTRACT v

INTRODUCTION 1

BIOLOGY 1

THE ECOSYSTEM.................... 2

METHODOLOGY.................... 3

COMMERCIAL FISHERY DATA.................... 3

Statistics on landings and effort 3
Catch per unit effort (CPUE) 4
Commercial catch sampling and size structure.................... 5
Bycatch in the directed Greenland halibut gillnet fishery 6
Greenland halibut bycatch in the directed shrimp fishery 6
Relative exploitation rate.................... 7

RESEARCH SURVEY DATA 7

Description of surveys.................... 7
Abundance index 8
Geographic distribution 8
Distribution of catches by depth, temperature and, oxygen level.................... 9
Area of occupancy 9
Recruitment.................... 9
Demographic structure.................... 9
Condition 10
Size at sexual maturity 10

DIET DESCRIPTION.................... 10

RESULTS 13

COMMERCIAL FISHERY 13

Participants 14
Management measures 14
Depth of gillnet deployment in the directed Greenland halibut fishery 15
Soak time 15
Location of directed Greenland halibut gillnet fishing.................... 15
Landings and effort 16
Daily catch per unit effort 16
Fishing effort, catches and CPUE 16
Standardised catch per unit effort – fishery performance index.................... 16
Composition of catches.................... 17
Bycatch in the directed Greenland halibut gillnet fishery 18
Greenland halibut bycatch in the directed shrimp fishery 18

RESEARCH SURVEYS 19

Spatial distribution.................... 19
Annual distribution of Greenland halibut biomass in relation to depth, temperature and oxygen saturation level 20
Recruitment and demographic structure 20
Abundance and biomass indices 21
Standardised indices.................... 22

Exploitation rates....22
Condition index....23
Length at 50% maturity (L_{50}) and maturity ogive....23
PRECAUTIONNARY APPROACH – REFERENCE POINTS....23
DIET DESCRIPTION....24
Periods....24
Size classes....25
Estuary versus nGSL....26
Size of redfish ingested by Greenland halibut....27
Comparison of Greenland halibut and redfish diets....27
CONCLUSION....28
ACKNOWLEDGMENTS....28
REFERENCES CITED....28
TABLES....32
FIGURES....76

ABSTRACT

The Gulf of St. Lawrence Greenland halibut (*Reinhardtius hippoglossoides*) stock (NAFO Divisions 4RST) is assessed and managed on a two-year cycle. The indicators used for this assessment are taken from fishery statistical data, sampling of commercial catches and research surveys. This document presents the data, techniques, analyses and results used in a peer review meeting held on February 23 and 24, 2021 via the Zoom platform (virtual meeting).

The directed Greenland halibut fishery developed in the late 1970s. Since the closure of the mobile gear fishery in 1993, this fishery has been carried out almost exclusively with gillnets. Fishing effort is deployed in three main sectors: the western Gulf of St. Lawrence, the area north of Anticosti Island and Esquiman Channel. During the 2000-2020 period, the proportion of the fishing effort deployed in each of these three sectors was 67%, 6% and 24% respectively. The total allowable catch (TAC) remained fixed at 4,500 t between the management years 2004-2005 and 2017-2018. Landings have declined since the 2011-2012 season. In 2018, following a full assessment of the stock status in an interim year, the TAC was reduced at 3,750 t for the 2018-2019 fishing season. The TAC was further reduced for the 2020-2021 fishing season to 2,250 t and preliminary landings totaled 1,330 t. From 2019 to 2020, the commercial fishing performance indices were stable for the western Gulf and Esquiman sectors, while it was increasing in the north Anticosti sector. The indices of the three sectors are below the average of their respective series. According to scientific surveys by DFO and mobile sentinel program, the abundance and biomass indices of Greenland halibut generally showed a downward trajectory from the end of the 2000s to 2019. These indices increased slightly between 2019 and 2020 to levels well below the peaks of the 2000s. This increase is caused by the arrival of the strong 2018 cohort.

The Gulf of St. Lawrence is undergoing major changes: deep waters are warming and becoming depleted of oxygen. These changes can lead to habitat degradation, decreased growth, increased natural mortality and can negatively affect the productivity of Greenland halibut. In addition, changes in the structure of the community (high abundance of redfish and low abundance of shrimp) can modify the interactions of competition for food resources or for habitat. Current environmental conditions and climate projections suggest that the situation is likely to worsen.

INTRODUCTION

BIOLOGY

The Greenland halibut is a flatfish in the Pleuronectidae family, also known by the names black halibut and turbot. The second part of its Latin name *Reinhardtius hippoglossoides* refers to its resemblance to a horse's tongue. Like other flatfish, the Greenland halibut undergoes significant physiological changes over its lifetime. At hatching, its body is bilaterally symmetrical, and it swims upright like a roundfish; shortly afterward, it turns over on its side to swim. Gradually, the eye on the lower side migrates to the upper side and its skull twists. The fact that its left eye does not migrate completely gives it extensive peripheral vision. After this metamorphosis, its diamond-shaped body becomes laterally compressed and asymmetrical. The eyed (upper) side is blackish, dark brown or gray with lighter splotches, while the blind side is usually pale grey. Principal distinguishing features include a straight lateral line and caudal fin, large mouth and large, pointed teeth (Figure 1).

According to our current knowledge of the Gulf of St. Lawrence (GSL) stock, spawning occurs in winter (between January and March), in the deep part of the Laurentian Channel southwest of Newfoundland (Templeman 1973, Ouellet et al. 2011). In this low-fecundity species, the female lays large eggs (3.4-4.7 mm in diameter) (Kennedy et al. 2009, Dominguez-Petit et al. 2012). The Greenland halibut spawns only once a year and some individuals may not reproduce every year (Kennedy et al. 2009). Recent histological studies (Kennedy et al. 2011, Rideout et al. 2012) conclude to an unusual reproduction strategy for Greenland halibut in which the simultaneous development of two cohorts of oocytes is observed. A cohort of larger oocytes develops for the upcoming spawning season and a second cohort of smaller oocytes develops for the next year's spawning. This strategy allows Greenland halibut to spawn annually although each cohort requires more than a year to complete vitellogenesis.

The eggs, owing to their specific density, are mesopelagic; during most of their development, they are found at depths of around 300 m but, in the final days before hatching, rise to shallower depths to hatch due to a substantial change in specific density (Ouellet et al. 2011). After the yolk sac is resorbed, the pelagic larvae are primarily found in the surface layer at depths of 0 m to 50 m, where larval development occurs. When development has been completed, which takes up to four months, the larvae settle on the bottom to undergo metamorphosis.

The main nursery area for Greenland halibut in the Gulf of St. Lawrence (GSL) is in the lower estuary, with a secondary nursery area north of Anticosti Island (Youcef et al. 2013). One- and two-year old juveniles appear to be fairly sedentary in these two areas and are generally found at shallower depths than adults. Growth is continuous in juveniles and length increments between ages 1 and 2 are affected by temperature, oxygen levels and fish density (Youcef et al. 2015). The species is considered a strong swimmer; it makes significant daily migrations and spends nearly 25% of its time in the water column (Albert et al. 2011).

Greenland halibut exhibit size dimorphism due to slower growth upon reaching sexual maturity. Males who reach sexual maturity at smaller sizes than females, around 36 cm compared to 46 cm for females, are smaller in size.

The Greenland halibut has a circumpolar distribution, with the GSL representing the southern limit of its range. Blood parasite studies in the early 1990s showed that the GSL population is an isolated stock, distinct from the main population in the northwestern Atlantic, which is found east and north of the Grand Banks of Newfoundland (Arthur and Albert 1993). This study concluded that the GSL Greenland halibut stock completes its life cycle within the GSL, which is a single management area for this species (Figure 2). Several other studies have aimed to document the extent of genetic connectivity of Greenland halibut in the western Atlantic with conflicting results (Roy et al. 2014, Westgaard et al. 2017). A recent study, using the sequencing genotyping technique, showed that after removal of gender markers, GSL Greenland halibut represent a unique stock genetically distinct from Atlantic Greenland halibut around Newfoundland (Carrier et al. 2020). However, the low value of the differentiation factor suggests that there is some gene flow between fish from the Gulf and those from Newfoundland.

THE ECOSYSTEM

The deep-water layer (>150 m) in the GSL is made up of water from the Labrador Current (cold, less salty and well oxygenated) that has mixed with water from the Gulf Stream (warm, salty and less well oxygenated). These mixed waters enter through the Laurentian Channel and flow up to the heads of the Laurentian, Anticosti, and Esquiman channels. It takes about three to four years for this bottom water to flow between the Cabot Strait and the head of the Laurentian Channel. In recent decades, Gulf Stream water has made up a greater proportion of the mix, resulting in higher temperatures and oxygen depletion in the deep waters of the GSL (Galbraith et al 2020).

In 2020, deep water temperatures have globally increased in the Gulf. The average temperature at 150 m was lower than the record highs of 2015, but remains above normal at 3.7 °C. New records are observed at 200, 250 and 300 m for a series which began in 1915. At 300 m the temperature nearly reached 6.8 °C, 1.5 °C higher than the temperature recorded in 2009 (P. Galbraith personal communication, Galbraith et al. 2020). The area of the seabed covered by temperatures above 6 °C has reached an all-time high in the northwest, northeast and central Gulf and in the Cabot Strait. For the first time, in the northeast of the Gulf, a deep water zone is observed with a temperature of 7 to 8 °C. According to forecasts, temperatures in the deep waters of the GSL will continue to be high in the next few years. The cold intermediate layer (CIL) was much warmer in 2020 than in 2019, except in the estuary where it remained stable. These conditions may be unfavourable to Greenland halibut, which prefer waters between 1°C and 4 °C.

A laboratory study of juvenile Greenland halibut caught in GSL showed that the fish mortality rate increased with increasing temperature from 4.5% at 4.0 °C to 15.2% at 7.5 °C. Relative growth was also lower in individuals maintained at 7.5 °C (Ghinter et al. 2021).

During the progression of deep water between Cabot Strait and the head of the channels, *in situ* respiration and oxidation of organic matter reduce the dissolved oxygen (DO) levels. Since this water travels a greater distance to reach the head of the Laurentian Channel, the lowest levels of DO are found in the lower estuary of the St. Lawrence, where DO levels declined by 50% between 1930 and 1980 (Gilbert et al. 2007, Gilbert et al. 2005). Since 2016, saturation levels in the lower estuary have been below 18% (Blais et al. 2018), which is well below the 30% hypoxic threshold for certain species, including Atlantic cod (*Gadus morhua*).

According to research on hypoxia tolerance and the effects of low oxygen levels on the metabolic capacity of Greenland halibut, at a temperature of 5°C, juveniles have a higher critical oxygen threshold than adults (15% versus 11% saturation), indicating that they are less tolerant of hypoxia (Dupont-Prinet et al. 2013). In this study, severe hypoxia increased the duration of digestive processes in juveniles, putting them on the edge of their metabolic capacity at levels close to those currently found in the lower St. Lawrence estuary. As noted earlier, the Estuary is the main nursery area for Greenland halibut. Consequently, any worsening of hypoxic conditions could affect the growth and distribution of Greenland halibut. Another study on juvenile fish showed that the rate of growth between ages 1 and 2 varied inversely with DO levels and decreased significantly at a saturation level of less than 25% saturation (Youcef et al.

2015). However, the study also observed a greater number of juveniles in the deep waters of the Estuary, which are characterized by low oxygen levels, as well as continuous growth in juveniles throughout the year. These observations suggest that the negative effects of low DO levels are likely limited or are mostly offset by other physical or biological characteristics in the lower estuary such as food abundance and availability and/or low predator density. DO levels in the lower estuary at the time of the Youcef study were 20%, and have decrease to 15.1% in 2020 (M. Blais personal communication).

Species distribution models were used to predict the impact of multiple scenarios of warming and oxygen depletion in the deep waters of the GSL on the local density of northern shrimp (*Pandalus borealis*), Atlantic cod and Greenland halibut (Stortini et al. 2017). These models predict substantial changes within 20-40 years. Of the three species studied, Greenland halibut seems to be the one that will be most affected by these changes and is projected to lose roughly 55% of its high-density areas under the combined impacts of warming and oxygen depletion.

In the 1980s, the northern Gulf of St. Lawrence (nGSL) ecosystem was dominated by groundfish. In the early 1990s, the major groundfish stocks in the ecosystem, including Atlantic cod (Brassard et al. 2019) and redfish (*Sebastes* spp.), collapsed (Senay et al. 2021). The resulting decline in large predators favoured an increase in forage species, including various shrimp species. Both Greenland halibut biomass and northern shrimp biomass increased, while the abundance of large groundfish species declined. In recent years, a simultaneous decrease has been observed in the biomass of northern shrimp and Greenland halibut, while groundfish biomass, dominated by the mass arrival of redfish, is increasing (Bourdages et al. 2019).

The arrival of three exceptionally abundant cohorts (2011 to 2013) of redfish could result in, and/or contribute to intensify direct (for food) or indirect (for habitat) interspecific competitive interactions with Greenland halibut in the GSL ecosystem. These species feed on some of the same prey, including northern shrimp and pink glass shrimp (*Pasiphaea multidentata*). The abundance of redfish is at the highest level ever observed in the GSL since 1984 (Senay et al. 2021). In 2020, the combined biomass of the two redfish species, *Sebastes mentella* and *Sebastes fasciatus*, represented 81% of the biomass of all organisms captured during the DFO research survey, while it averaged 15% between 1995 and 2012 (Figure 3). Since these are long-lived species, redfish will share the GSL ecosystem with Greenland halibut for many years.

Overall, the ecosystem conditions observed in the GSL indicate that the structure of this ecosystem is changing, which could be favourable for some species such as redfish but unfavourable for other species such as northern shrimp and Greenland halibut.

METHODOLOGY

COMMERCIAL FISHERY DATA

Statistics on landings and effort

Since 1996, Greenland halibut harvesters have been required to complete logbooks, including all vessels in Quebec and vessels over 35 feet in Newfoundland. Along with the estimated weight of the catch, information such as the date and fishing area, type of gear, effort (amount of gear), soak time and position are noted for each day at sea.

In Newfoundland, harvesters in the under-35-foot fleet must complete a science logbook, which is then sent to the DFO Science Sector for analysis. The level of compliance with this requirement is not very high. This fleet accounts for less than 5% of annual landings in the directed Greenland halibut gillnet fishery.

Under the Dockside Monitoring Program, all harvesters are required to have their landings weighed at dockside at designated ports. Logbook data are validated using processors' purchase slips and dockside weigh-out summaries that are entered by teams in charge of gathering fishery statistics for each DFO region. Each region then makes these data available in a ZIFF (Zonal Interchange File Format) file. The resulting files are consolidated at Maurice Lamontagne Institute and contain information on all the fleets. Since these files are not generally considered to be final until two years after the fishing activities in question, the data for the current stock assessment year are therefore considered to be preliminary.

Data on Greenland halibut landings before 1985 come from NAFO Statistical Bulletins (Bernier and Chabot 2013), while those on landings from 1985 to 2020 were collated from ZIFF files (Tables 1, 2 and 3). The 1985-1997 data differ from those published in Bernier and Chabot (2013) and Morin and Bernier (2003). Landing values based on the ZIFF data are slightly higher than the previously published data. The differences between these two data sources are less than 1%, except for the years 1989, 1993 and 1997 when the difference was 2%, 6% and 7% respectively.

Maps showing the spatial distribution of fishing activities in the GSL were generated using data on locations (latitude and longitude) and fishing grids extracted from the ZIFF files. In the ZIFF files for the current year, which are considered to be preliminary, fishing location information is sometimes missing, which is exacerbated in the case of data from the Newfoundland Region.

Since 2013, another source of data has been available for illustrating the spatial distribution of directed Greenland halibut fishing operations in the GSL: the Vessel Monitoring System (VMS). The use of the VMS has been gradually implemented in Quebec since 2013 and has been mandatory on all vessels since 2017. In Newfoundland, the use of the VMS is not required for the fleet of less than 35 feet, the fleet of vessels over 35 feet used for the inshore crab fishery, and vessels based in 3Pn, 4R, and which are used only in groundfish fixed gear fishing. This system tracks vessels' locations by satellite every 30 minutes during fishing trips. The information gathered includes the Canadian Fishing Vessel Number (CFV), location (latitude and longitude), date and time, but the system does not provide information on whether the vessel is actually fishing. To exclude fishing activities not directed at Greenland halibut, we compared the logbook data (ZIFF files) with the CFV information and the dates in the VMS data. All positions that overlap within plus or minus one day when a Greenland halibut catch was recorded in the logbooks are retained. The VMS data are then selected based on the speed of the vessels determined by the distance between two positions. Positions where the vessel was traveling (speeds over 2.5 knots) or was stationary at sea or at dockside (speeds less than 0.5 knot) were eliminated from the analyses. The positions of vessels travelling at speeds between 0.5 and 2.5 knots are kept. These speeds, deemed to represent directed Greenland halibut fishing activities, were validated with harvesters. The resulting Greenland halibut fishing locations were aggregated annually in grid squares of one minute longitude by one minute latitude for mapping purposes.

Catch per unit effort (CPUE)

Data for calculating catch per unit effort (CPUE) (kg/net) were extracted from the consolidated ZIFF files. For this subset of data, only activities involving the use of gillnets as fishing gear and directed at Greenland halibut were retained. Over 98% of landings in the directed Greenland halibut fishery are obtained with gillnets. The catch and effort data were validated and fishing activities with erroneous or missing values for catch or effort were excluded from the subsequent analyses.

The CPUE values presented cover the years from 1999 to 2020. Data before 1996 were not included, mainly due to the change in gillnet mesh size from 140 to 152 mm (5.5 inches to 6 inches) in the directed Greenland halibut fishery. In addition, the data for 1996 to 1998 were excluded because they are incomplete.

CPUE values are presented for the entire Gulf (4RST) and for the three fishing sectors (western Gulf, north Anticosti and Esquiman), which represent areas containing concentrations of Greenland halibut. The non-standardized CPUE values correspond to the total annual landings divided by the annual effort (sum of nets deployed) (Table 4).

The total catch does not represent total landings since some observations had to be removed from the analyses because they were erroneous or incomplete. The total effort corresponding to the same observations therefore does not represent the total effort expended by the fleets to catch the total landings. In addition, the fishing effort data in the preliminary ZIFF file for the current year are often incomplete. However, the total fishing effort (nominal effort) corresponding to the total landings can be estimated by using the catch per unit effort estimated from the subset of validated observations (Table 4). Similarly, the monthly catch and monthly effort can be estimated by fishing sector and by year (Table 5).

CPUE standardization

Annual CPUE values were standardized using a multiplicative model (Gavaris 1980), to take account of changes in the fishing season (month), differences between unit areas and differences in fishing practices (soak time). Multiple linear regressions were performed between the logarithm of the CPUE values and the variables of month, sector, soak time and year to isolate the annual effect from the effects of the other variables. The model weighs the effects of these three factors, making CPUE values comparable across years. The analyses were carried out using the GLM procedure in SAS software (SAS 1996). Standardization was done separately for each fishing sector and for the entire Gulf (4RST).

The models were validated by analyzing the residuals against the predicted values and categories of factors studied. The analyses of variance were all significant ($p<0.0001$), as was the contribution of each category to the multiple regression ($p<0.0001$), except for the unit area category ($p=0.2928$) in the Esquiman sector. The model explains 20% of the variance for the Gulf, 56% for the Esquiman sector, 49% for the north Anticosti sector and 26% for the western Gulf sector.

The standardized CPUE values obtained are shown in Table 6. The CPUE values correspond to a reference fishing activity carried out in July with a soak time of three days. The referenced unit areas are 4Si for the entire GSL and the western Gulf sector, 4Rb for the Esquiman sector and 4Sx for the northern Anticosti sector.

The data used to calculate soak times and the deployment depth for gillnets were extracted from the validated data files used to calculate CPUE values. Exact depth data have been available in the ZIFF files since 2008; previously only depth classes were reported.

Commercial catch sampling and size structure

Commercial catches are sampled under two different programs: the DFO's port sampling program and the At-Sea Observer Program. In the first program, which was established in the early 1980s, DFO samplers are spread over the entire territory. Their work consists, among other things, of gathering data on the size and sex of fish landed, either at dockside or at the processing plant. The At-Sea Observer Program allows detailed information to be collected on fishing activities at sea (since 1994), including data on the target species, bycatch and discards. The information gathered in these two programs, at dockside and at sea, enable the average fish size and sex ratio in landings to be determined annually. This information was extracted from the databases for the two programs and then validated. Samples were rejected when fish were not sexed, the proportion of females was questionable (females are more numerous in gillnet hauls), the average length of males was greater than that of females, or measurements were made on only a small number of fish. When sample weights were not available or were greater than the catch weight, they were corrected by using length-weight relationships.

The number of fish measured per sample varies greatly between the data collected by DFO samplers (sample of 250 fish prior to 2005, and since 150) and the observer program (150,200 fish per sample and several tows sampled per trip). First, for each sex separately, relative length frequency per DFO sample and per observer trip (many tows) was calculated. Secondly, the average of the relative frequencies in the samples for the same combination of NAFO division, year and quarter was calculated. Length frequency distributions were then weighted by annual landings per NAFO division and quarter to generate an annual size structure. Average size and the proportion of females caught in the fishery were calculated from the numbers at length obtained (Tables 7 and 8). In 2020, due in part to the situation with the pandemic, no information was available on the size structure of Greenland halibut landed in 4R and the information was partial for Divisions 4S and 4T.

Bycatch in the directed Greenland halibut gillnet fishery

Data from two sources—ZIFF files and the At-Sea Observer Program—were combined to give an overall picture of bycatch. The ZIFF files provide comprehensive information on total reported landings. The At-Sea Observer Program covers a certain percentage of fishing trips and therefore provides only partial information on bycatch, but is the only source of data on discards at sea, which are not recorded in the ZIFF files.

Greenland halibut harvesters are required to take an at-sea observer on board when requested by DFO. The targeted minimum coverage under the program is 5% of all directed fishing trips, although this percentage may reach 15% in some fleets such as the Quebec longliners' fleet. Coverage required for Newfoundland fleet is 10%. Observers record detailed information on gillnet hauls (position, duration, catch by species or taxon and length of specimens for certain species). In this study, data from the At-Sea Observer Program collected between 2000 and 2020 in the directed GSL Greenland halibut fishery were used to estimate bycatch.

The methodology used to process the bycatch data from the At-Sea Observer Program is similar to that described in Savard et al. (2013). Since 2000, 10,000 fishing activities have been sampled. Weighting factors (the ratio between the Greenland halibut catch by harvesters and the Greenland halibut catch in the observed activities) were calculated to scale the bycatch results obtained from the observer program database to the totality of fishing activities carried out by the Greenland halibut fleet (Table 9).

Greenland halibut bycatch in the directed shrimp fishery

Shrimpers are also required to take an at-sea observer on board at DFO's request. The At-Sea Observer Program aims for 5% coverage of all fishing trips by shrimpers. The information collected is the same as for the Greenland halibut fishery. The data processing methodology used is described in Savard et al. (2013). Since 2000, 22,000 tows have been sampled under the program. Weighting factors (Σ shrimpers effort/Σ observer effort) were calculated and used to scale the results of observer data to the total effort expended by the shrimper fleet.

Relative exploitation rate

A relative indicator of the annual exploitation rate was obtained by dividing the total weight of the commercial catch in the directed Greenland halibut gillnet fishery by the biomass of fish > 40 cm estimated with data from the DFO nGSL research survey. This method does not allow an absolute exploitation rate to be estimated, nor for it to be related to target exploitation rates. However, it does enable changes to be tracked over time.

RESEARCH SURVEY DATA

Description of surveys

DFO survey in the northern Gulf of St. Lawrence

Since 1990, a research survey has been conducted annually in August in the lower estuary and northern Gulf of St. Lawrence (nGSL) to estimate the abundance of groundfish and northern shrimp (Bourdages et al. 2020). This survey is carried out by DFO's Quebec Region and covers NAFO Divisions 4R, 4S and part of 4T (northern part of GSL) (Figures 2 and 4).

From 1990 to 2003 and in 2005, the survey was conducted on board the *CCGS Alfred Needler*, equipped with a URI 81'/114' (University of Rhode Island) shrimp trawl with a 19-mm lining. Since 2004, it has been done from on board the *CCGS Teleost* with a Campelen 1800 shrimp trawl with a 12.7-mm lining. Since these vessels and trawls are very different, comparative fishing experiments were conducted in 2004 and 2005 to evaluate differences in catchability between the two vessel-gear tandems and to establish conversion factors for about 20 species caught (Bourdages et al. 2007). These experiments produced a merged series by adjusting the catches of the CCGS Needler into equivalent catches of the CCGS Teleost.

The standard tows performed in the survey last 15 minutes, starting from the time the trawl touches the sea floor as determined by the Scanmar™ hydroacoustic system. Towing speed is 3 knots. Fishing operations are conducted 24 hours a day.

A stratified random sampling plan is used for this survey. The study area is divided into 54 strata based on depth, NAFO Division and substrate type. The stratification scheme used for the allocation of fishing stations is shown in Figure 4.

DFO survey in the southern Gulf of St. Lawrence

Every fall since 1971, researchers in DFO's Gulf Region have conducted bottom-trawl surveys on board a research vessel in the southern Gulf of St. Lawrence (sGSL) (NAFO Division 4T) (Figure 4). The primary objective of the survey is to obtain abundance indices for the main groundfish species in this region.

A stratified random sampling plan is used in this survey. Figure 4 shows the areas covered by the nGSL and sGSL surveys. There is some partial or complete overlap between certain strata covered by the two surveys along the southern edge of the Laurentian Channel.

From 1971 to 1985, the sGSL survey was conducted on board the *E.E. Prince* using a Yankee 36 trawl. Subsequently, this gear was replaced by a Western IIA trawl, which has been used since then. Surveys were performed on board the *Lady Hammond* from 1985 to 1991, the *CCGS Alfred Needler* in 1992-2002 and 2004-2005, the *Wilfred Templeman* in 2003 and the *CCGS Teleost* since 2004. At each change of vessel and/or type of gear, comparative fishing experiments were conducted to generate conversion factors, which have allowed a continuous and consistent time series to be maintained since 1971 (Swain et al. 1995, Benoît 2006). A standard tow, which is carried out at a speed of 3.5 knots, lasts 30 minutes. The Western IIA trawl is equipped with a 19-mm mesh codend liner.

Mobile gear sentinel surveys in the nGSL

Mobile gear surveys conducted in July in the nGSL since 1995 under the Sentinel Fishery Program (MSP) are also used to assess the status of the GSL Greenland halibut stock. The sampling plan and fishing protocol are similar to those used in the DFO's nGSL research surveys. This survey covers NAFO areas 3Pn, 4RS and a portion of 4T, but not the lower estuary (strata 411 to 414). The Estuary hosts on average 22% of Greenland halibut numbers in summer, including the greatest concentration of juveniles. Annually, the six to nine trawlers from Newfoundland and Quebec participating in the survey split nearly 300 fishing stations. The vessels participating in the survey all use the same type of gear, a Star Balloon 300 trawl with rockhopper footgear. This trawl has 145-mm mesh and a 40-mm lining in the codend. The standard tow is carried out at a speed of 2.5 knots for 30 minutes. The total Greenland halibut catch is weighed at the end of each tow and a maximum sample of 200 individuals is taken to determine certain biological characteristics, including size (fork length) and sex. A description of the mobile gear sentinel survey is available at SLGO.

Abundance index

For the DFO's nGSL survey and the MSP survey, a multiplicative model (Gavaris 1980) was used to correct number and weight estimates of catch rate indices for some strata not sampled by a minimum of two tows in a given year. This model predicts the values for these inadequately covered strata by using the data from the current year and the previous three years. Consequently, the indicators presented for a given series are representative of a standard total area, the sum of the area of all strata sampled—116,115 km^2 in the nGSL survey and 111,855 km^2 in the MSP survey.

The number and weight indices for each size class were obtained by converting number-at-length values to weight-at-length values for each tow using annual length-weight relationships derived from DFO surveys. Differences of between roughly 1% and 10% can be observed between the total biomass values obtained from catch weights and those calculated from catch numbers converted to weight using length-weight relationships. A ratio was then applied to the weight-at-length values to convert them to the equivalent of the total biomass obtained with catch weights. The weight-at-length values obtained were then combined by size class.

Geographic distribution

The geographical distribution of the catch rates obtained in the DFO and MSP surveys in the nGSL, presented as weight and numbers per tow, was compiled for four- or five-year periods. The interpolation of CPUEs was performed on a grid covering the study area and using weighting inversely proportional to the distance (R version 2.13.0, Rgeos library; R Development Core Team 2011). The isoline contours were then plotted for four catch rate levels approximating the 20th, 40th, 60th and 80th percentiles of the non-zero values. The geographic distribution of Greenland halibut is presented in terms of total biomass; spatial distribution maps showing numbers per tow are also provided for each of the following length classes: 0-20 cm, 20-30 cm, 30-40 cm and > 40 cm.

For the sGSL survey, contour maps showing the geographic distribution of Greenland halibut were created for periods of nearly ten years using ACON software (ACON Win95 8.37, Fisheries and Oceans Canada). Interpolation in the contour plots was based on Delaunay triangles. The contour levels used for the mapping are the 10th, 25th, 50th, 75th and 90th percentiles based on non-zero catches. To prevent the inappropriate formation of Delaunay triangles between distant points and points topologically separated by barriers, a blanking distance of 0.7 degrees was used as the distance limit between the data points at which Delaunay triangles were removed.

Distribution of catches by depth, temperature and, oxygen level

The relative cumulative frequency of catches (in weight) was compiled according to depth and temperature, all years combined, using data collected in the DFO's nGSL survey. This relationship was depicted in graph form, in combination with the relative cumulative frequency of the number of stations sampled by depth in the study area. The 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of this distribution are also presented in Table 10.

The annual distribution of the total biomass of Greenland halibut and of biomass by size class as a function of depth, temperature and percentage of dissolved oxygen are presented for the entire Gulf (4RST) and by fishing sector with box-plots.

Area of occupancy

Three descriptors, or indices, of spatial distribution were calculated with data from the DFO survey in the nGSL: the design-weighted area of occupancy (DWAO), the D95 and the Gini index.

Design-weighted area of occupancy (DWAO)

The design-weighted area of occupancy is the area of the study zone where the Greenland halibut is found (Smedbol et al. 2002).

D95

The D95 index describes geographic concentration. This descriptor corresponds to the minimum area containing 95% of the Greenland halibut biomass (Swain and Sinclair 1994).

Gini index

The Gini index quantifies the degree of homogeneity of Greenland halibut distribution. This index is calculated using the Lorenz curve (Myers and Cadigan 1995). Values for the index range from 0 to 1, where 0 corresponds to a perfectly homogenous distribution and 1, to a very concentrated distribution.

Recruitment

Recruitment strength is estimated from the annual abundance of fish in the 12 cm to 21 cm size class caught in the DFO's nGSL or sGSL surveys. This length class corresponds to one-year-old Greenland halibut. For the 2014 cohort, the range of lengths corresponding to one-year-old fish was reduced to lessen contamination from the 2013 cohort, in which growth was less than expected. The recruitment strength of the 2014 cohort was estimated by the abundance of fish from 12 cm to 18 cm long.

Demographic structure

Length frequency distributions are presented in two different forms. The first figure shows the distributions for the last two years of the series (2019 and 2020) as well as the average distribution for the reference period (1990-2019 for the nGSL survey and 1995-2019 for the MSP survey). Frequency values are expressed as the average number of individuals caught per tow in one-centimeter increments.

The second figure consists of a bubble chart where bubble diameter is proportional to the number of individuals caught of a given size.

Condition

The Fulton condition index for the Greenland halibut (K= weight [g]/length^3 [cm]), determined using data from the DFO's nGSL survey (1990 to 2020), is used as an indicator of the condition of Greenland halibut in August. It is calculated based on the total weight of the fish. Using somatic weight (the fish's total weight, minus gonad weight and stomach content weight) to calculate this index is generally preferable, in order to eliminate the variability that can be caused by feeding intensity and/or different degrees of gonad maturation in fish (Dutil et al. 1995). However, since somatic weight was not available in this study, total weight was deemed adequate for determining this index, given that the index was calculated in the same period every year (August), outside of the spawning period.

An analysis of covariance (ANCOVA) was used to compare values for this index from year to year. Using ANCOVA allows the linear effects of fish length on the condition index to be removed and the year effect to be assessed. The condition index is estimated by size intervals: 10-20 cm, 20-30 cm, 30-40 cm and over 40 cm. The model predicts a condition index for each year for length values of 15, 25, 35 and 45 cm. These annual predictions are then compared with each other.

Size at sexual maturity

Information has been collected in the DFO's nGSL survey every year since 1996 to determine size at sexual maturity in Greenland halibut. The stage of sexual maturity is determined by the visual inspection of the gonads using morphological criteria in individuals over 22 cm long, in up to 100 fish per tow. The size at which 50% of fish are mature (L_{50}) is determined separately for males and females. The SAS PROBIT procedure using a logistic distribution is used to estimate L_{50}.

DIET DESCRIPTION

Greenland halibut stomachs obtained in the DFO's nGSL survey were used for this analysis. Stomachs were thawed just before analysis in the laboratory. Each taxon *d* found in a given stomach *j* was then weighed and identified to the most precise taxonomic level possible. The mass of taxon *d* in a given stomach (M_{dj}) was then entered in the database field corresponding to the state of digestion of the prey item. An undigested taxon was entered in the state 1 field, a partially digested taxon that was still identifiable to species was entered in the state 2 field and all others were entered in the state 3 field. For this study, data from prey items at all states of digestion were used. However, taxa corresponding to parasites or various types of debris (e.g., rocks, sand, liquid, mucus) were excluded, as were everted stomachs and stomachs that could not be matched with a fish length value.

Five measurements taken from the method presented in Bernier and Chabot (2013) and Ouellette-Plante et al. (2020) were used to classify the importance of different taxa to the diet of Greenland Halibut. These measures are:

The percentage of empty stomach (PES)

The mass contribution (MC)

The partial fullness index (FI)

The contribution to the total fullness index (CFI)

The frequency of occurrence (FO)

For a sample of NS_s stomachs containing NES_s empty stomachs, the percentage of empty stomachs (PES_s) is calculated as follows:

$$PES_s = \frac{NES_s}{NS_s} \times 100 \tag{1}$$

For a taxon *d* of mass M_{dj} found in the stomach *j* of a sample of NS_s stomachs, the sum of the masses M_{dj} in this sample corresponds to M_d and contributes to MC_d% of the total stomach contents M_{tot} found in these NS_s stomachs. *D* corresponds to the number of different taxa present in sample *s*.

$$M_d = \sum_{j=1}^{NS_s} M_{dj} \tag{2}$$

$$M_{tot} = \sum_{d=1}^{D} M_d \tag{3}$$

$$MC_d = \frac{M_d}{M_{tot}} \times 100 \tag{4}$$

As highlighted in the study by Bernier and Chabot (2013), using MC_d on its own involves certain risks:

1. For a sample of NS_s stomachs, the sum of the values of MC_d for the *D* prey items found totals 100%. This therefore implies an interdependence between the values of MC_d for the different taxa, where a high value obtained for a given taxon *d* may reflect a decrease in the abundance of alternative prey rather than an increase in the abundance of taxon *d* in the diet of the predator.
2. Taxa found in small stomachs may be disadvantaged relative to those found in large stomachs and, proportionately to the capacity of their predator, could be heavier and therefore represent a substantial proportion of M_{tot}.
3. MC_d does not take account of empty stomachs.

To reduce these potential risks, a fullness index (*FI*) was added to the metrics. FI_{dj} is calculated using the M_{dj} of the taxon, the length of the fish associated with the stomach *j* (L_j, in mm), the allometric exponent *b* and a constant (10^7). In this study, the allometric exponent *b* (3.24) was calculated using the stomach data available for Greenland halibut and corresponds to the slope of the linear relation *log(mass)~log(length)* expressed in the form *mass* = aL^b, where length is expressed in centimetres and mass in grams.

For a given taxon *d* in a sample, the taxon's contribution to the fullness index FI_d corresponds to $CTFI_d$. For a given sample *s*, the total fullness index (*TFI*) is the sum of the values for FI_d resulting from the *D* taxa present in *s*.

$$FI_{dj} = M_{dj} \times L^{-b} \times 10^7 \tag{5}$$

$$FI_d = \frac{\sum_{j=1}^{NS_s} FI_{dj}}{NS_s} \tag{6}$$

$$TFI = \sum_{d=1}^{D} FI_d \quad (7)$$

$$CTFI_d = \frac{FI_d}{TFI} \times 100 \quad (8)$$

For a given sample of the size NS_s where NS_{sd} stomachs contain the taxon *d*, the frequency of occurrence ($Focc_d$) of this taxon is calculated as follows:

$$Focc_d = \frac{NS_{sd}}{NS_s} \times 100 \quad (9)$$

The detailed dietary analysis was performed by incorporating the following variables:

- period: 2004-2009, 2015-2019, 2020 and 2004-2020. Note that no Greenland halibut stomachs were obtained from samples during the 2010-2014 ecosystem-focused research missions.
- length class: <20, 20-30, 30-40 and >40 cm
- region: lower estuary (strata 411-414, 851-852, 854-855) and the rest of the nGSL.

For each taxon observed, the values of $Focc$, MC and $CTFI$ were calculated. The same values were also calculated for the following broad prey groups: *Fish, Shrimp, Zooplankton* (calanoid copepods, euphausiids, gammarids, hyperiids and mysids), *Other Invertebrates* (invertebrates other than shrimp and zooplankton) and *Unidentified Prey*. To make the tables clearer, *FI* values are not shown for each taxon. However, the *FI* value can be obtained for a taxon and a given period, length class or region by multiplying the values for the corresponding *CTFI* and *TFI.*

Since many different taxa were found in the stomach contents of Greenland halibut, 14 broad taxonomic groups were created to simplify the graphic analysis of the species' diet. These groups were selected based on the *FI* value and the prey type.

In addition, the $\text{length}_{\text{prey}} \sim \text{length}_{\text{Greenland halibut}}$ relation was investigated for redfish ingested by Greenland halibut. The data used were extracted from all the data available in the databases, regardless of the type of mission and the year when the data were gathered. Since digestion quickly makes it impossible to collect valid length data on redfish found in the stomach contents of Greenland halibut, very few data are available. However, a few otolith lengths (*OL*) from these redfish were available and were used to calculate redfish lengths using the equation developed by Clay and Clay (1980):

$$L = -2.13 + 2.48 \times OL \quad (10)$$

Lastly, the diets of Greenland halibut and redfish were compared graphically. The same broad taxonomic groups and length classes used for Greenland halibut were employed for redfish. Only the stomachs from the 2015-2019 *CCGS Teleost* campaigns were selected, since the stomach content data for redfish in 2020 were not completed.

RESULTS

COMMERCIAL FISHERY

Until the mid-1970s, landings of Greenland halibut in the GSL occurred mainly in the form of bycatch from trawlers in the shrimp- or cod-directed fisheries (Table 3, Figures 5 and 6). The directed Greenland halibut gillnet fishery began to develop in 1978. A total allowable catch (TAC) of 7,500 t was set for the 1982 fishing season (Table 1, Figures 6 and 7). At that time and until 1992, GSL Greenland Halibut was managed as a component of the Atlantic stock. During this period, the TAC ranged from 5,000 t to 10,500 t. The highest landings, over 8,000 t, were recorded in 1979 and 1987, when the resource was beginning to be exploited (Figures 5, 6 and 7). These high landing values were followed by sharp declines.

From 1988 to 1992, the status of the GSL Greenland halibut stock was not assessed, owing to the uncertainty surrounding its stock structure at the time. During these five years, the TAC remained fixed at 10,500 t, with landings declining from 7,585 t to 3,417 t.

In the early 1990s, parasite species composition studies allowed separate Greenland halibut populations to be identified and demonstrated that the GSL population was distinct (Arthur and Albert 1993). Assessments of the GSL Greenland halibut stock resumed in 1993 and the TAC was decreased to 4,000 t. It was lowered further to 2,000 t in 1996 and then increased to 3,000 t and 4,000 t in 1997 and 1998. Landings fluctuated between 1,945 t and 3,945 t during the 1993-1998 period. For the 1999-2000 to 2001-2002 management years, the TAC was set at 4,500 t and landings declined from 3,674 t to 1,288 t. The TAC was reduced to 3,500 t for the two following management years (2002-2003 and 2003-2004).

From the late 1970s to the early 1990s, the mobile gear (MG) fishery accounted for over 30% of landings (Table 3, Figures 5 and 6). Since 1993, recorded catches from mobile gear have been very low (< 1% in 2020), due to the closure of the directed mobile gear fishery and the mandatory use of the Nordmore grate by shrimpers (1994) (Hurtubise et al. 1991, Fréchet et al. 2006). Since then, the only Greenland halibut landings using mobile gear (1% to 5% of the total catch) have originated from bycatch in other fisheries (directed redfish fishery and research surveys).

Since the closure of the MG fishery, only a fraction of the TAC that used to be allocated to it has been transferred to the fixed gear fleet and consequently a portion of the TAC is no longer fished. In this document, the term “fishing allocation” (abbreviated F-ALL) is used to indicate the sum of catch allocated to each GSL fleet that represents the portion of the TAC that can be caught by fixed gear harvesters (Tables 1 and 2, Figures 6 and 7). Currently, the Greenland halibut fishery is conducted by boats equipped with gillnets with home ports in Quebec or along the west coast of Newfoundland. The fishing allocation is divided between the two provinces, 82% for Quebec and 18% for Newfoundland.

Until 1998, a calendar-year cycle was used to manage this resource and the TAC was set for the period January 1 to December 31 of the same year. Since 2000, the management cycle has been defined as from May 15 of a given year to May 14 of the following year. In 1999, to bridge the gap between the two management cycle, the TAC was established for the period January 1, 1999 to May 14, 2000.

The TAC remained fixed at 4,500 t for the 2004-2005 to 2017-2018 fishing seasons, with a fixed gear fishing allocation of 3,751 t (Tables 1 and 3, Figures 6 and 7). This F-ALL was completely fished until the 2011-2012 season. The greatest gap between the F-ALL and landings was observed during the 2017-2018 season, with landings totalling 1,767 t, which is much lower than the average of 3,678 t recorded in the previous ten years.

The update of stock status indicators for GSL Greenland halibut in the fall of 2017 concluded that the trigger point for a complete stock assessment in an interim year had been crossed (DFO 2018a). Based on the conclusions drawn in the peer review (DFO 2018b), the decision was made to reduce the TAC by 25% to 3,375 t for the 2018-2019 fishing season, with a F-ALL of 2,813 t.

The TAC was further reduced to 2,250 t for the 2020-2021 fishing season with a fishing allocation of 1,875 t. As of December 2020, landings totaled 1,330 t or 71% of the fishing allocation and represent the lowest landings since the 2001-2002 season. (Tables 1 and 2, Figure 5). The fixed gear fleets of Quebec and Newfoundland landed respectively 66% and 96% of their allocation, for the 2020-2021 season. These landings data are preliminary, but should not increase significantly with the continued fishing in Quebec next spring.

In 2020, nearly 99% of landings were from gillnet catches (Table 3, Figure 5). Almost all Greenland halibut landings come from the directed fishery for this species. Between 2005 and 2020, less than 1% of Greenland halibut landings originated from the directed fisheries for redfish, Atlantic halibut (*Hippoglossus hippoglossus*) and Atlantic cod.

Fishing is carried out in the three NAFO Divisions of the GSL : 4R, 4S and 4T (Table 2, Figure 7). The proportion of annual landings from each Division has varied over time. Between the 2010-2011 and 2017-2018 fishing seasons, these proportions were 26%, 45% and 29% for 4R, 4S and 4T respectively. In 2019 and 2020, 26% of landings were from 4R, 27% from 4S and 47% from 4T. The fishing effort has shifted from 4S to 4T in the past two years.

Participants

In accordance with ministerial decisions in recent decades, the only fleets participating in the directed Greenland halibut commercial fishery in the GSL are fixed gear groundfish fleets from the Gaspé Peninsula and North Shore regions of Quebec and the west coast of Newfoundland.

This fishery was conducted mainly under a competitive regime prior to 1999, after which an individual transferable quota (ITQ) system was put in place (Table 1). In 2020, the majority of fishermen in Quebec were under ITQs, while all fishermen in Newfoundland were under competitive conditions.

The number of active fishermen in this fishery has been decreasing in recent years. An average of 93 fishermen from Quebec were active for the 2014-2016 period against 64 for the 2017-2020 period. For those same periods, the number of active fishermen in Newfoundland decreased from an average of 61 to 37. This is a decrease in the number of fishermen active in the directed Greenland halibut fishery of almost 35% for both provinces combined. This decrease could be due to lower catch rates in recent years and the possibility of more lucrative fisheries and the management measures in place.

Management measures

Many different management and conservation measures are used to manage the fishery (Table 1). They include the closure of fishing areas, restrictions on fishing periods, restrictions on fishing gear (mesh and hook size), fleet quotas and a minimum size for the different groundfish species as part of a small fish protocol. A maximum number of gillnets are allowed and this number has varied over time and between regions (Table 1). Since the 2015-2016 fishing season, Quebec fishermen are authorized to use 120 nets and Newfoundland fishermen 90.

The measures currently in place in the fishery include harvesters' obligation to complete a logbook (100%), to have their catches weighed at dockside (100%) and to agree to take an at-sea observer on board at the request of DFO (5% to 15% coverage, depending on the fleet). In addition, the use of the VMS has been mandatory for all Quebec fleets since 2017. In Newfoundland, the use of the VMS is not required for all fleets.

Depth of gillnet deployment in the directed Greenland halibut fishery

Three main sectors in the GSL where the directed Greenland halibut fishery takes place were considered: the western Gulf, north Anticosti and Esquiman sectors, which correspond to the species' concentration areas (Figure 8).Some of the indicators used to assess the state of the population are presented for the entire Gulf (4RST) as well as for each of these three sectors in order to determine the presence of spatial variability that can be attributed to differing inter-region environmental dynamics or fishing practices.

In the directed Greenland halibut gillnet fishery, the median depth at which gillnets were deployed during the period 2010-2020 was nearly 294 m for the entire Gulf (4RST), 296 m in the western Gulf, 265 m in north Anticosti and 302 m in Esquiman (Figure 9A). The difference in the depth of deployment of the devices between the western Gulf, Esquiman and North Anticosti reflects the bathymetry specific to each of these sectors..

For the 2020-2021 season, fishing for Greenland Halibut has been prohibited in water depth less than 229 meters (125 fathoms) in Division 4S, for all fixed gear fleets less than 19.81 m from the Quebec region due to the high number of cod bycatch. This new temporary closure is clearly visible when the depth data of fishing activities are represented according to the NAFO Division (Figure 9B). A ban on fishing in waters less than 229 meters has also been in place in Division 4R since 2001, and it was increased to 256 meters in 2014. Figure 9B also shows that fishing activities were carried out at greater depth in 4T in 2019 and 2020.

Soak time

The license conditions for the Greenland halibut gillnet fishery in Quebec and Newfoundland indicate that the period of time between the setting in the water and the lifting of the nets (soak time) must not exceed 72 hours (3 days). Inclement weather or vessel breakdown are some of the factors that are taken into account in allowing a soak time of longer than 72 hours. Figure 10A shows the annual proportions of gillnet soak times in the categories of 1, 2, 3, or 4 or more (4+) days of soak time. The 4+ category involves four to eight days of soak time. The proportion of activities in the 4+ category (which exceeds the three days of soak time allowed under the licence conditions) ranged from 13% to 32% during the 1999-2020 with an average of 23%. In 2020, the proportion of fishing activities that exceed 72 hours was 24%. When the soak times are analyzed by fishing sector, the western Gulf and North Anticosti sectors show on average nearly 20% of activities that have soak times of more than 72 hours and this percentage increases to almost 40% in the Esquiman sector (Figure 10B). Prolonged soak times could reduce the quality of the fish landed and increase unaccounted fishing mortality due to the loss of degraded fish when hauling gillnets.

Location of directed Greenland halibut gillnet fishing

Directed Greenland halibut gillnet fishing is carried out in three sectors (Figure 11). The western Gulf and Esquiman sectors are fished annually while the north Anticosti sector is fished sporadically (Figures 11, 12a and 12b). In years when the northern Anticosti sector was not fished, the fishing effort shifted to the western Gulf. Between 1999 and 2020, an average of 67%, 25% and 6% of the fishing effort was deployed in the western Gulf, Esquiman and north Anticosti sectors respectively. Almost 10% of the fishing effort was deployed in the northern Anticosti sector from 2018 to 2020, this sector was neglected from 2015 to 2017. The proportion of the fishing effort deployed in Esquiman represented 30% in 2019 and 20% in 2020.

Landings and effort

The directed Greenland halibut gillnet fishery occurs from April to November across the Gulf (Table 5 and Figure 13). The highest proportion of landings are generally recorded in June and July, with these two months representing close to 60% of the annual catch. From 2018 to 2020, the highest proportion of landings occurred later in the season, in July and August.

Figure 14 shows fishing effort and cumulative landings in the western Gulf by day of the year, beginning with the first day of the fishing season, May 15 (day 135), for the 2010 to 2020 fishing seasons. The 2018-2019 and 2019-2020 fishing seasons are distinguished from other seasons by a slower start in the deployment of fishing effort and later landings.

Daily catch per unit effort

The graphs of daily CPUE values for the western Gulf show different annual patterns (Figure 15). In some years, daily CPUE values remained fairly stable throughout the fishing season (2011, 2016, 2019 and 2020) while, in others, there is an overall downward trend in values from the beginning to the end of the fishing season (2012, 2017). Lastly, in some years (2014 and 2018), CPUE values show an overall rising trend throughout the fishing season.

Fishing effort, catches and CPUE

For the GSL as a whole (4RST), annual fishing effort was fairly stable and below the series average from 2015 to 2019, with nearly 130,000 nets deployed annually. This number dropped to 101,500 in 2020, the lowest value observed since 2002 (Figure 16). Annual landings, which had fallen by nearly 50% between 2016 and 2017, remained low but fairly stable until 2019, and then declined to 1,452 t in 2020, the lowest value recorded since 2002.

In the western Gulf, the situation was similar to elsewhere in the Gulf, with fishing effort and landings in 2020 being among the lowest in the series.

Frequentation of the northern Anticosti sector (Figure 12A and 12B) by Greenland halibut harvesters is sporadic. This sector experienced a substantial increase in effort and landings from 2006 to 2010, followed by high and sustained effort and landings between 2009 and 2013 (Figure 16). Landings and effort subsequently declined, and harvesters withdrew from the sector from 2015 to 2017. Fishing activities resumed between 2018 and 2020. Effort remained fairly stable between 2019 and 2020 while landings increased, totalling 232 t for fishing effort of more than 11,000 nets.

Landings in the Esquiman sector fell sharply between the peaks in 2011–2012 and 2017, despite the sustained level of effort. Landings and fishing effort decreased from 2019 to 2020. CPUEs showed a substantial and continuous decline from 2011 to 2017; they then increased and remained stable from 2018 to 2020, but have remained below the series average since 2013 (Figure 16).

Standardised catch per unit effort – fishery performance index

The standardised CPUE for the commercial fishery, or commercial catch rate, is used as an index of fishery performance rather than an index of abundance of exploitable stock (Table 6). Trends for the standardized and non-standardized CPUE series are similar (Figures 16 and 17).

The trajectory of the indices is similar for the entire Gulf and for the western Gulf sector. These indices showed a decrease of more than 50% between 2015 and 2018 and fell below the series average in 2017. In 2019 and 2020, the indices are stable.

In the north Anticosti and Esquiman sectors, the fishing performance indices have decreased by more than 75% between 2012 and 2017 and are below the average of their series since 2013. Between 2019 and 2020, the index is increasing in north Anticosti and stable in Esquiman. In 2020, for the entire Gulf (4RST) and for the three fishing sectors, the fishing performance indices were below the average of their respective series (Figure 17).

Composition of catches

The average size of Greenland halibut caught in the commercial fishery increased from 44 cm to 47.6 cm between 1995 and 1996, owing to the increase in the minimum mesh size from 140 mm (5.5 inches) to 152 mm (6.0 inches) (Table 7, Figures 18 and 19). An experimental fishery using 140-mm mesh contributed to the reduction in average size recorded in 2002 (Morin and Bernier 2003).

These annual variations in average commercial size can be explained in part by the strength of the cohorts recruited to the fishery : a strong cohort entering the fishery will reduce the average size of the fish caught. The average sizes decreased between 1997 and 2002 (48 cm to 45 cm) and then increased steadily to reach 49 cm in 2012, the highest value in the series (Figure 18). This increase is due to the growth of the strong cohorts of 1997 and 1999, which made up a large part of the catches between 2003 and 2006, as well as by the growth of the large cohorts of 2001 and 2002, which began to be recruited to the fishery around 2006 and were present in catches in 2010 (estimated length at approximately more than 50 cm) (Figure 18). Another factor is the decrease in the proportion of individuals smaller than 44 cm in the catch from 20% to 11% between 2008 and 2010 (Figure 20). The average size fluctuated between 2012 and 2016 and reached the second highest value in the series. Subsequently, the average size decreased markedly from 2018 to 2019 when it was 45.3 cm, more than 1.5 cm lower than the average for the 1996-2019 series. The 2020 data is not discussed here as it was partial due to health measures related to the pandemic.

The analysis of data by division indicated that the mean length of the Greenland halibut caught in Division 4R was greater than that of the individuals caught in 4S and 4T from 2003 to 2015 (Table 7, Figure 18). From 2016 to 2019, the average size of the fish caught in Division 4R was comparable to that in 4S. No data were available for 4R in 2020. The fish caught in 4T are the smallest on average. This difference can be explained by the fact that the main Greenland halibut nursery area is located in the lower estuary of the St. Lawrence, which is in Division 4T.

According to the length frequency distributions by sex, the average size of the females caught is greater than that of males (Table 7, Figure 18). Annual fluctuations in the average sizes of males and females are generally in phase. The size of Greenland halibut caught in gillnets with the regulation 52-mm mesh ranges from 37 cm to 61 cm for females and from 37 cm to 53 cm for males (Figure 18). In 2019, the average sizes of male and female fish decreased and were among the lowest values observed since 1996. The average length of males stood at 41 cm, which is 3 cm less than the series average and below the minimum legal size of 44 cm. The average length of females, 46 cm, was nearly 2 cm less than the series average. The decrease in average fish size has a significant impact on the number of fish landed for a given landing by weight. Between 2017 and 2020, annual landings in tonnes decreased by 16% whereas the number of fish landed decreased by 9%.

During the 1996-2018 period, 17% of fish caught in the Greenland halibut directed gillnet fishery were less than 44 cm long on average, compared with 30% in 2019 (Figures 19 and 20). These are the largest proportions of small fish observed since 2002. The size 44 cm is the minimum legal size identified in the existing conservation measures.

Sexual dimorphism in Greenland halibut explains the large proportion of females in catches and the difference observed in the maximum sizes of the two sexes. The mesh size used in the fishery targets sexually mature individuals so that the fish can reproduce before being caught and thus contribute to recruitment to the population. The proportion of females in commercial catches has been higher on average since the increase in mesh size in 1996 (Table 8, Figure 21). Before this change, the average proportion of females was 60%; it rose to 80% during the 1996–2019 period. In 2018 and 2019, females made up 85% of catches. The corresponding proportion is lower in 4R, 74% on average compared to 81% and 84% for 4S and 4T, respectively. In 2019 and 2020, the proportion of females in commercial catches increased to nearly 91% in Divisions 4S and 4T. These are the highest proportions of females recorded in catches since the time series began.

Bycatch in the directed Greenland halibut gillnet fishery

Although the commercial fishery endeavors to maximize the target species catch, bycatch of non-targeted marine species is common. Bycatch in the directed Greenland halibut gillnet fishery was estimated for the 2000-2020 period using data from the At-Sea Observer Program. Bycatch in this fishery averages slightly over 480 t annually (Figure 22). Nearly one third of bycatch is landed, with the remainder being discarded at sea. Bycatch represents 19% of Greenland halibut landed weight on average (Table 11, Figure 23). A decrease in Greenland halibut landings and increased bycatch levels pushed this percentage up to 24% and 32% in 2019 and 2020 respectively. The most common bycatch species are, in order of importance, American plaice (*Hippoglossoides platessoides*), redfish, snow crab (*Chionoecetes opilio*), thorny skate (*Amblyraja radiata),* northern stone crab (*Lithodes maja*), Atlantic halibut, various other species of skates and witch flounder (*Glyptocephalus cynoglossus*) (Table 12 and Figure 24). The occurrence of redfish in the bycatch increased in 2019 and in 2020 compared to the series average, reflecting the increased abundance of this species in the GSL ecosystem. Discards at sea include species that can be released by the harvesters such as black dogfish (*Centroscyllium fabricii*), Lumpfish (*Cyclopterus lumpus*), Atlantic hagfish (*Myxine glutinosa*) and Atlantic wolffish (*Anarhichas lupus*); mandatory release species such as Atlantic halibut under 85 cm, snow crab and skates; and taxa of no current commercial value such as starfish, skate eggs and polychaetes.

Greenland halibut bycatch in the directed shrimp fishery

The shrimp fishery uses small-meshed trawls that catch and retain many species of fish and marine invertebrates. Although large fish can escape from trawls due to the mandatory use of separator grates installed inside the trawl, shrimpers' catches still contain a certain number of small specimens. Greenland halibut bycatch in the shrimp fishery from 2000 to 2020 was examined using the at-sea observer database (Table 13). Data from 2000 to 2017 are also published in Bourdages and Marquis (2019).

The spatial distribution of Greenland halibut bycatch in the directed shrimp fishery obtained from at-sea observer data is shown for the 2000-2020 period (Figure 25). The average catch (kg/tow) in all tows within a 5-minute square is shown for the 2000-2019 period and on an annual basis for 2019 and 2020. Greenland halibut were present on average in 92% of sampled activities.

Greenland halibut bycatch generally accounts for less than 3 kg per tow and mainly consists of 1-year-old juveniles, and to a lesser extent, 2-year-old juveniles (Figure 26). Between 2000 and 2019, the estimated average annual Greenland halibut bycatch in the directed shrimp fishery in the Estuary and Gulf was roughly 92 t (Figure 27). In 2019 and 2020, the estimated bycatch was 212 t and 73 t respectively, which represents approximately 1.18% and 0.22% of the biomass of

Greenland halibut less than 31 cm (biomass estimated in the DFO's nGSL survey) (Table 13 and Figure 28).

RESEARCH SURVEYS

Spatial distribution

The range of the GSL Greenland halibut population is fairly well represented by the study area of the DFO nGSL survey takes place in August. At that time of year, the largest halibut concentrations are found in the St. Lawrence lower estuary, in the Sept-Îles Basin, the Laurentian Channel south of Anticosti Island, and at the heads of Anticosti and Esquiman channels. Figure 29 shows the spatial distribution of the species by 5- and 6-year blocks. An increase in catch rates from the 1990-1994 period to the 2005-2009 period, followed by a decrease during the 2015-2020 period, is observed. The distribution of Greenland halibut catch rates obtained in the mobile gear sentinel program (MSP) survey in July shows a similar pattern, although this survey does not cover the lower estuary (Figure 30).

Greenland halibut in the 0-20 cm length class (i.e., ≤1 year) are found mainly in the Lower Estuary, the Sept-Îles Basin and north of Anticosti Island (Figure 31). Studies have shown that the Estuary is the main nursery area for GSL Greenland halibut, with a secondary nursery located north of Anticosti Island (Youcef et al. 2013, Ouellet et al. 2012). Maps show the distribution of Greenland halibut by size classes (0-20, 20-30, 30-40 and > 40 cm) based on data from DFO's nGSL surveys and the mobile gear sentinel survey (Figures 32 to 38).

The spatial distribution of catch rates for Greenland halibut (number per tow) obtained in DFO's sGSL survey is presented in 10-year blocks between 1971 and 2019 and for 2020 (Figure 39). In the area covered by this survey in the 1970s, Greenland halibut was only found off the tip of Gaspé Peninsula, along with a few individuals caught in Chaleur Bay. In the 1980s, the species' abundance increased, although its spatial distribution remained similar to that in the 1970s. Then, in the 1990s and 2000s, as the abundance of Greenland halibut continued to increase, it expanded its range along the south side of Laurentian Channel and in the Cape Breton Trough. This expansion continued during the years between 2010 and 2019 with the observation of a new concentration of Greenland halibut in Shediac Valley. Its spatial distribution in 2020 was similar to that in 2010-2019.

The historical perspective provided by the sGSL survey suggests that, in the 20 years before the nGSL survey (i.e., from 1971 to 1989), the conditions leading to the expansion of the Greenland halibut stock and its increased abundance in the southern GSL had not yet materialized, suggesting that the species' occupation of the sGSL is recent.

Spatial distribution indices calculated from the DFO nGSL survey data indicate that the Greenland halibut occurs in over 85,000 km^2 of the northern Gulf of St. Lawrence, with 95% of its biomass concentrated in less than 50,000 km^2. In recent years, there has been a downward trend in its area of occupancy (DWAO) and in the minimum area occupied by 95% (D95) of the stock biomass. At the same time, the Gini index of aggregation has increased, indicating a concentration of the Greenland halibut population within its range (Figure 40). In August, it is found mainly in channels at depths ranging from 200 m to 400 m, with over 80% of the biomass occurring at depths between 229 m and 366 m, at bottom temperatures ranging from 4.4°C to 5.7°C (Table 10, Figure 41).

Annual distribution of Greenland halibut biomass in relation to depth, temperature and oxygen saturation level

The annual distribution of Greenland halibut biomass by size classes ([0-20] cm, [20-30] cm, [30-40] cm and > 40 cm) was examined relative to the water temperature and oxygen saturation level in areas where fish were caught during DFO's nGSL survey (Figure 42ABC).

Biomass distribution by size class in relation to depth varies somewhat, but is generally similar from year to year. On average, individuals in the ([0-20] cm size class were found at shallower depths (274 m) than large individuals (nearly 300 m) (Figure 42A).

This was not the case for the distribution of biomass relative to water temperature and the dissolved oxygen (DO) saturation level (Figure 42BC). Since 2010, all size classes of Greenland halibut have been found in increasingly warm waters. Since 2016, these fish have been found in waters with lower and lower oxygen levels.

Between 2010 and 2020, the median temperature of the waters where fish longer than 40 cm are found increased from 5.2°C to 6.2°C (Figure 43A). This increase is most pronounced in the Esquiman sector, where the median water temperature increased from 4.9°C to 6.4°C. For the same size class, the DO saturation level decreased from 29% to 21% over a period of six years. The largest decrease occurred in the western Gulf, which had a median DO saturation level of 20% in 2020.

When these analyses are limited to the Lower Estuary, the water temperature in locations where Greenland halibut biomass was found increased from 4.9°C to 5.9°C during the last decade while the DO level decreased from 20% to 16% in the same period (Figure 43C). Greenland halibut in the Estuary are exposed to waters with the lowest oxygen saturation levels.

Recruitment and demographic structure

Recruitment varies greatly from year to year, and since the late 1990s, strong and weak cohorts have alternated (Figure 44). Recruitment indices estimated from DFO's nGSL and sGSL surveys generally show a fairly good correlation (Figure 44B). According to information provided by the sGSL survey, recruitment was not strong in the area covered by the survey between 1971 and 1996. Both surveys identify the 1997, 1999, 2001, 2004, and 2010 cohorts as substantial. The abundance of the 2013 and 2017 cohorts was above average according to the nGSL survey, but lower according to the sGSL survey. The 2018 cohort is the most recent one with high abundance.

The length frequency distributions for Greenland halibut observed in the nGSL, sGSL and mobile gear sentinel surveys are shown in Figures 45 and 48. The three surveys show a similar overall pattern, but due to the selectivity of the different trawls used and the different areas sampled, smaller Greenland halibut are better represented in the nGSL survey and larger individuals, in the sGSL and mobile gear sentinel surveys. The nGSL survey uses a trawl with a smaller mesh size, allowing for more effective sampling of small, one-year-old individuals (modal size ~ 16 cm). In addition, unlike the other two surveys, this survey covers part of the Estuary, which is the species' main nursery area. The mobile gear sentinel survey allows a higher proportion of large individuals to be sampled.

The three surveys accurately depict the arrival of two extraordinarily strong cohorts in the history of this stock, the 1997cohort (modal size ~ 16 cm at age 1 in 1998) and the 1999 cohort (modal size ~ 16 cm at age 1 in 2000). These cohorts were responsible for the substantial increase in the stock's abundance in the 2000s, and the arrival of the strong cohorts of 2001, 2002, 2004 and 2007 supported a major fishery. Significant numbers of individuals larger than 40 cm were also noted from 2003 to 2008, but their abundance declined from 2009 to 2013 and they have been rare since 2015 (Figure 45).

According to the normal growth curve, Greenland halibut are generally recruited to the fishery at an average age of 6 years for females and 7 years for males. The strong 2010 cohort had a modal size of 16 cm in 2011, 27 cm in 2012, 35 cm in 2013, and between 40 and 44 cm in 2014. This cohort seems to have had a more rapid growth rate than the 1997 and 1999 cohorts. It may have begun recruiting to the fishery in 2014, which would explain the decreasing size of Greenland halibut in the commercial catch (Figure 18). The cohort still stood out at more than 44 cm in 2015. The entry of this cohort into the fishery in 2014 increased catch rates (Figures 16 and 17).

The situation of the abundant 2013 cohort is worrisome. The size frequency distributions show a very high abundance in 2014, with the cohort reaching a modal size of 16 cm, and a high abundance in 2015, but with a modal size of 20 cm compared to the expected size of close to 27 cm. This represents a reduction in the rate of growth of about 45% between ages 1 and 2, compared to the average growth rate for this stock. The slowing of growth observed for this cohort has delayed its recruitment to the fishery. Since the reading of otoliths cannot currently be used for age determination in this stock, it is difficult to track cohorts effectively after age 2.

The abundance of the 2018 cohort at ages 1 and 2 is among the highest in the series and the growth rate is normal (Figures 44 and 45). These fish could begin to recruit to the fishery around 2024.

Abundance and biomass indices

Abundance (mean number per tow) and biomass (mean weight per tow) indices based on the data from the sGSL, nGSL and, MSP surveys are presented in Tables 14AB and 15, as well as in Figure 46.

The sGSL survey encompasses a longer time period (1971-2020) than the nGSL (1990-2020) and MSP (1995-2020) surveys, but covers a limited portion of the Greenland halibut's overall range in the GSL (Figures 29 and 39). From a historical viewpoint, the sGSL survey indicates that Greenland halibut abundance and biomass were low from 1971 to 1997 in the portion of the GSL sampled (Figure 46). In 1998, the abundance index suddenly jumped from 2.6 to 13 fish per tow whereas biomass increased more gradually. From 1998 to 2010, abundance and biomass indices fluctuated, although values were still high relative to survey averages. The trend in biomass and abundance indices was downward from 2011 to 2019 with values below the series average. The indices increased from 2019 to 2020 to reach values near the series average. The increase is more pronounced in the abundance indicator and is caused by the recruitment of small individuals from the 2018 cohort.

Of the two surveys carried out in the nGSL, the DFO survey covers the largest area of Greenland halibut habitat (Figures 29 and 30). The area sampled in the MSP survey is included in that of the DFO survey, except that it does not cover the lower estuary. Similar trends were found in the abundance and biomass indices from 1995 to 2008 in these two surveys: a substantial rising trend until 2004 followed by a stable trend until 2008 (Figure 46). Subsequently, while the abundance index from the DFO nGSL survey showed some stability, the biomass index as well as the abundance and biomass indices from the MSP survey showed a continuing downward trend until 2018 or 2019. During the period 2006-2019, the biomass index of the nGSL survey decreased by 56%. The abundance and biomass indices from the nGSL and PSM surveys increased slightly from 2019 to 2020. In 2020, the nGSL indices were at their mean and the PSM indices were below their mean.

When the abundance index (mean number per tow) obtained from the nGSL survey is broken down by size class (0–20, 20–30, 30–40 and > 40 cm), it can be seen that the 0–20 cm size class (1-year-old individuals) was abundant in 2019 and the 20–30 cm size class (2-year-old individuals) was abundant in 2020 (Table 16, Figure 47). The nGSL survey shows a close correlation between the abundance of a given cohort at age 1 and at age 2 the following year (Figure 48). The abundance of fish in the 30–40 cm size class declined slightly between 2017 and 2019 but increased in 2020 to the average level. The abundance of fish over 40 cm, which had been declining, has stabilized since 2017 but was below the series average in 2020. The nGSL data indicate that the abundance of fish in the 20–40 cm size class is greater than the series average (Figures 47 and 48).

The abundance indices derived from the mobile gear sentinel survey show that the abundance of fish in all size classes except the 20–30 cm class was below their respective series averages in 2020 (Table 17, Figures 47 and 48).

According to growth estimates for the individuals in this stock, fish in the abundant cohorts of 2012, 2013 and 2014 should have reached a modal size of about 49, 47 and 44 cm respectively in 2020. An increase in the abundance of fish > 40 cm was expected, but did not materialize (Figures 47 and 48). These abundant juvenile cohorts have not given rise to subsequent increases in the abundance indices for the largest individuals.

Standardised indices

Biomass indices for fish > 40 cm derived from DFO's sGSL and nGSL surveys and the mobile gear sentinel survey show similar trends for the 1995 to 2020 period which is common to the three surveys (Figure 49). A large increase occurred in the early 2000s and then stabilized at peak biomass levels for this stock. This was followed by a downward trend, with decreases of 84%, 68% and 79% being observed between 2008 and 2019 in the sGSL, nGSL and mobile gear sentinel surveys, respectively. A less pronounced decrease in the indices was seen from 2018 to 2019, followed by a slight increase in 2020 in all three surveys. The sGSL survey showed that in the 20 years before the nGSL survey (from 1971 to 1989), the biomass of Greenland halibut > 40 cm was low in the sGSL survey. The trends in the fishery performance index are comparable to the trends in the biomass indices for fish > 40 cm based on DFO's scientific surveys and the mobile gear sentinel surveys (Figure 50).

Exploitation rates

The nGSL survey strata used to determine biomass by fishing sector are shown in Figure 51. Relative exploitation rates were calculated for the entire Gulf (4RST) and by fishing sector (Table 18, Figure 52).

In 2020, the exploitation rate for the Gulf as a whole (4RST) was 5.9% lower than the average (6.5%) for the 1996–2020 series (Figure 52). The average exploitation rate was 4.8% for the 2001–2008 period, a period during which the stock increased and remained abundant. The 2009–2020 period, which saw an exploitation rate near the average, corresponds to a period with a fairly steady decrease in the biomass of fish > 40 cm (Figure 52). This could indicate that exploitation rates have been too high in the last 10 years.

The exploitation rate index for the western Gulf showed a rising trend between 2012 and 2017, and then oscillated around the average. Due to a decrease in landings and fairly stable biomass levels, the exploitation rate for this region declined in 2020 to slightly below the series average. In the north Anticosti and Esquiman sectors, exploitation rates have followed an upward trend since 2017 and were well above the respective series averages in 2020. For the northern Anticosti region, the exploitation rate in 2020 was the second highest rate in the series. The

Esquiman region posted the highest exploitation rate since 1996 and the lowest biomass index value for fish > 40 cm estimated from DFO's nGSL survey.

Condition index

The Fulton condition index for Greenland halibut, which was determined using data from the DFO's nGSL survey, was estimated for four length classes: 15 cm (~1 year old); 25 cm (~2 years old); 35 cm (3-5 years old) and 45 cm (> 5 years old) (Table 19, Figure 53). The condition of 1-year-old fish fluctuated from 1990 to 2020, often inversely related to the abundance of the different cohorts. In strong cohorts, the condition of fish is likely to be below average. The abundant 1999 and 2010 cohorts, 1-year-old (15 cm) respectively in 2000 and 2011, had a Fulton condition index lower than the series average. Recently, there were three consecutive years, 2012 to 2014, during which the abundance of cohorts ranged from medium to high, which also had Fulton condition indices below the series average at 15 cm (2013–2015). These low values were maintained as the fish in these different cohorts grew (25 cm, 35 cm and 45 cm series in 2015–2017). Another factor that may have affected the condition of these cohorts is potential competition for food and habitat with the mass arrival of juvenile redfish in the GSL between 2011 and 2013. The condition index estimated for the different size classes of Greenland halibut increased to the series average level in 2020.

Length at 50% maturity (L_{50}) and maturity ogive

The size at which 50% of Greenland halibut are sexually mature (L_{50}) decreased sharply in males between 1997 and 2001, and in females between 1998 and 2004. It remained fairly stable at close to average values from 2004 to 2014. Subsequently, the L_{50} followed a generally decreasing trend, reaching the lowest values in the series in 2019 and 2020 for both sexes (Figure 54). In 2020, the L_{50} was estimated at 37 cm in females (series average of 45 cm) and 31 cm in males (series average of 36 cm). Greenland halibut experience a slowdown in growth after they reach sexual maturity. Since the L_{50} is declining, the stock is likely to have fewer large fish in the coming years. In addition, since females have higher L_{50} values, they reach larger sizes than the males. This characteristic, combined with the selectivity of 152 mm gillnets, contributes to a larger proportion of females in commercial catches. In 2018 and 2019, females made up 85% of commercial catches, which is higher than the 1996–2020 series average of 80%.

PRECAUTIONNARY APPROACH – REFERENCE POINTS

In general, the use of the precautionary approach (PA) in fisheries management aims to prevent serious harm to fish stocks or their ecosystems, and involves being cautious when scientific knowledge is uncertain and not using the absence of adequate scientific information as a reason to postpone or fail to take action. This approach is widely accepted nationally and internationally as an essential part of sustainable fisheries management.

A precautionary approach is under development for the GSL Greenland halibut stock. A stock status monitoring indicator and a limit reference point (LRP) have been defined (DFO 2018c). The biomass of fish > 40 cm estimated from DFO's survey of the nGSL (the survey which best covers the range of the stock) has been chosen as the monitoring indicator for the status of this stock. This indicator represents a proxy for spawning stock biomass.

The selected LRP is the geometric mean of the indicator for the 1990–1994 period, which corresponds to the period when the population was at its lowest level and from which a recovery of the stock was observed. The LRP was estimated at 10,000 t (Figure 55).

An initial upper stock reference point (USR) was proposed for this stock in 2018. This USR was based on the concept of stable biomass during the 2004–2012 productive period. The stock's high productivity during this period was largely due to the excellent recruitment that occurred in the late 1990s (Figure 55A).

The stock status indicator shows a decrease beginning from about 2008, with a more rapid decline between 2014 and 2016. This period of severe decline appears to be linked to a drop in stock productivity, which may be due to rapid climate change in the deep waters of the GSL since 2010. These unfavourable changes for Greenland halibut include an increase in deep water temperatures, decreased oxygen levels and an enormous influx of redfish, which are potential competitors.

Recent research showing the long-term impacts of climate change on stock productivity suggests that a USR based on the biomass from the 2004–2012 period of high productivity may no longer be achievable, even without fishing. Another USR proposal was based on the biomass from the 1996–2002 period, which can be considered more realistic since it was not the product of a single, unusually large recruitment event. However, given that the environment of the GSL is undergoing rapid change, it is unclear what would be the most appropriate USR point for the stock.

Under these conditions, a new USR was proposed to consider the significant ecosystem changes currently taking place in the GSL and the decline in stock productivity. This new USR is based on distinct periods of stock productivity, i.e. the 1996–2002 period of average productivity and the 2004–2012 period of high productivity (Figure 55B). In this proposal, the biomass at maximum sustainable yield (B_{msy}) is the mean of the biomasses of the two periods, i.e. 47,170 t. The USR corresponds to 80% of this B_{msy}, i.e. 37,740 t.

The development of this precautionary approach is based on the best data currently available and on the principle that the absence of scientific information is not a reason for postponing or failing to take measures to avoid serious harm to the resource. The proposed points (B_{msy}, LRP and USR) must be re-assessed as new data are acquired which may allow these points to be replaced with more appropriate values.

A working group, consisting of representatives from fixed gear fleets, the provincial governments of Quebec and Newfoundland and Labrador, and Indigenous groups, was formed in fall 2018 to participate in the development of a proposed precautionary approach. At the most recent workshop in February 2020, the group accepted the proposed USR of 37,740 t. The current precautionary approach framework for the GSL Greenland halibut stock is defined by a LRP of 10,000 t separating the critical zone from the cautious zone, and a USR of 37,740 t separating the cautious zone from the healthy zone. The development of decision rules remains difficult, owing to the current stock status, which is in the cautious zone (Figure 55B).

The stock status indicator showed a declining trend, decreasing over 60% between 2008 and 2017 and moving from the healthy zone into the cautious zone. The indicator was relatively stable from 2017 to 2020 and is in the cautious zone, at the mid-point between the LRP and the USR.

DIET DESCRIPTION

Periods

The description of the diet is based on the analysis of 8,800 Greenland halibut stomachs, i.e. 5,470 stomachs from the 2004–2009 period and 3,330 stomachs from the 2015–2020 period (Table 20, Figure 56). The number of stomachs collected annually ranged from 378 to 1,041.

These numbers have changed somewhat since the last research document (Gauthier *et al*. 2020) and since the stomach content databases were updated. The fish collected for this study were well distributed across each of the length classes considered (Table 21) and throughout the study area (Table 22 and Figure 57).

When length classes are excluded, and for all periods considered, the main prey of Greenland halibut is fish (Tables 23 and 24). A total of 32 different taxa of fish have been identified in Greenland Halibut stomach contents since 2004, with the average occurrence of fish being nearly 20%. The Fish group accounts for a significant part of the Greenland halibut diet, with an average CTFI of 55%. Aside from capelin (*Mallotus villosus*), Atlantic soft pout (*Melanostima atlanticum*) and redfish, no other fish taxa identifiable to at least genus were observed in > 1% of stomachs in the 2004–2020 series. Capelin, the most prevalent prey item in the diet of Greenland halibut, has been increasing in halibuts' stomachs, according to TFI percentage values for all periods studied: the frequency of occurrence of capelin increased from 2.8% to 4.9% between the 2004–2009 and 2015–2019 periods (Table 23 and Figure 58).

During the 2004–2009 period, redfish was not a prevalent prey item in the diet of Greenland halibut, with a frequency of occurrence (FO) of < 1% (Table 23). However, during the 2015–2019 period, its FO increased to 4.8%, before dropping to 1.2% in 2020. This decline in the FO of redfish as a prey item of Greenland halibut in 2020 contributed to the decrease in the TFI, which was less than half of the values recorded during the 2015–2019 period (Table 23).

Since 2004, 15 shrimp taxa have been reported in the stomachs of Greenland halibut (Table 23), among which only four taxa identifiable to at least genus were observed during the 2004–2009, 2015–2019 and 2020 periods: pink glass shrimp (*Pasiphaea multidentata*, also known as white shrimp), northern shrimp (*Pandalus borealis*) and *Pandalus spp.* shrimp. In all periods studied, northern shrimp was the most important shrimp taxon in the Greenland halibut's diet. Overall, the frequency of occurrence of shrimp in the stomach contents of Greenland halibut declined during the 2015–2019 and 2020 periods relative to the 2004–2009 period, decreasing from 17.8% to nearly 10%. In terms of mass contribution, the percentage of shrimp in the diet fell by more than half between the 2004–2009 (25.2%) and 2015–2019 (11.8%) periods. This percentage increased to 19.1% in 2020 (Table 23).

A total of 28 taxa were identified in the zooplankton group. This prey group had a frequency of occurrence of over 10% in the Greenland halibut stomachs analyzed since 2004 (Table 23). Hyperiids belonging to the genus *Themisto* and euphausiids are the most prevalent zooplankton taxa in the Greenland halibut's diet (Table 23 and Figure 58).

The Other Invertebrates group, which is made up of 22 taxa other than shrimp and zooplankton, shows a decline in the importance of these prey items in the Greenland halibut's diet between the 2004–2009 period and 2020 (Table 23). This decline may be attributable to the expertise in taxonomic identification acquired over the years. Digested invertebrate species which were identified as being Other Invertebrates in previous years can now be assigned to a more precise taxonomic group, thus reducing the importance of the Other Invertebrates group in the diet of Greenland halibut.

Size classes

A substantial number of samples were obtained in each size class of Greenland halibut studied (> 1,000, Table 21). The length class with the greatest percentage of empty stomachs (57%) was the 20–30 cm class, while the < 20 cm class had the smallest percentage of empty stomachs (36%). The < 20 cm size class is also the one that feeds the most: its TFI (0.33) was twice as great as the average for the series (0.16, Tables 20 and 21 and Figure 59).

The diet of < 20 cm Greenland halibut mainly consists of invertebrates (Table 24, Figures 59 and 60), while larger Greenland halibut feed primarily on fish. For halibut in the < 20 cm size class, the proportion of zooplankton in the diet is slightly less than that of fish (35.16% versus 41.34% of TFI, Table 24). Capelin, euphausiids and *Themisto* hyperiids were the three most important prey groups in the diet of halibut in this length class (Table 24 and Figure 61).

The diet of Greenland halibut in the 20–30 cm size class is made up of larger prey than that in the < 20 cm size class. The importance of zooplankton decreases in this size class, while that of fish and shrimp increases, according to TFI values (Table 24 and Figure 60). Capelin is the most important prey species in this size class; in addition, capelin is the only species in the Fish group whose contribution to the diet of Greenland halibut is at least 10% in all the length classes studied (Table 24). Among the Shrimp group, pink glass shrimp and northern shrimp are the two most important taxa in the diet of Greenland halibut in the 20–30 cm size class (Table 24). Both the frequency of occurrence and the mass contribution of northern shrimp to the diet increase with the length of Greenland halibut (Table 24).

Greenland halibut in the 30–40 cm length class have an even greater proportion of shrimp in their diet (32.4% of TFI), primarily northern shrimp (Table 24). The importance of redfish in the diet increases with the size of Greenland halibut, going from < 1% of TFI for the 0–20 cm size class to 15.78% for the > 40 cm size class.

The diet of Greenland halibut in the > 40 cm length class is based primarily on fish (66% according to TFI values, Table 24). Although capelin remains one of the main prey for this size class, redfish make the greatest contribution to this class's diet (Table 24).

Estuary versus nGSL

In this study, 1,497 Greenland halibut stomachs from the Estuary and 7,303 from the nGSL were analyzed (Table 22). Feeding intensity was similar in both regions and corresponded to that found in the entire space-time series (Tables 20 and 22). However, empty stomachs occurred less frequently in the Estuary (40.5%) than in the nGSL (52.3%). This could be attributable to the fact that the Estuary is shallower than the rest of the nGSL and, consequently, less regurgitation by Greenland halibut occurs, which is due to rapid changes in pressure when the tow is hauled in (Bernier and Chabot, 2013). Another possible cause is the smaller size of Greenland halibut sampled in the Estuary from which the stomachs were collected. Indeed, the Estuary halibut are much smaller (median and mean of 298 mm and 302 mm, respectively) than the nGSL halibut (median and mean of 350 mm and 342 mm, Table 22), and smaller Greenland halibut were found to have fewer empty stomachs (Table 21).

The diet of Greenland halibut harvested from the Estuary is based mainly on invertebrates (Table 25 and Figure 62). Among these, the zooplankton group is predominant, making up 29.4% of the species' diet, according to TFI values. Hyperiids belonging to the genus *Themisto* and euphausiids were the most prevalent prey items in this group. In the years 2018 and 2019, the contribution of hyperiids to the diet was greater in the Anticosti Channel area (Figure 63). The contribution of euphausiids, which accounted for a large portion of the diet of Greenland halibut in the Estuary (Figure 64), declined in the Estuary but increased in the Esquiman Channel in 2020. In Figures 63 to 68, only full stomachs and specimens in the length classes consuming the prey in question were included in the data used to produce the maps. Greenland halibut in the Estuary consume little shrimp (10.6% of TFI), compared with halibut in the nGSL (21.2% of TFI, Table 25). According to FI values, the contributions of the northern shrimp and pink glass shrimp to the diet of Greenland halibut were greater in fish outside the Estuary (Figures 65 and 66). Capelin is the fish taxon that contributes the most to the diet of Greenland halibut in the Estuary (21.8% of TFI) and the nGSL (23.7% of TFI, Table 25). Figure 67 shows that the contribution of capelin in the stomachs of Greenland halibut in the Estuary has increased since 2018.

Redfish are an important prey item for Greenland halibut, and their contribution to the diet appears to be greater for halibut in the nGSL than for those in the Estuary (Table 25 and Figure 68).

Size of redfish ingested by Greenland halibut

Data on the size of redfish found in Greenland halibut stomachs were obtained from 40 halibut stomachs. Among the 40 length values obtained, most (27) came from measurements of complete specimens of redfish found in halibut stomachs. The other length values (13) were estimated based on the size of redfish otoliths recovered from stomach contents. The relation between the length of the redfish ingested and that of the Greenland Halibut predator is significant ($p < 0.0001$) and accounts for 54% of the variability found (Figure 69). The length of redfish ingested by Greenland Halibut ranged from 6.5 cm to 23.2 cm. The longest redfish (23.2 cm, length estimated by otolith) was found in the stomach of a 76.6 cm halibut.

Comparison of Greenland halibut and redfish diets

A total of 2,650 Greenland halibut stomachs and 3,834 redfish stomachs were retained for this comparison (Table 26 and Figure 70). Few stomachs from redfish over 40 cm were available. Invertebrates made up a significant proportion of the diet of redfish throughout their development in comparison with Greenland halibut (Figure 70). The importance of invertebrates in the diet of redfish is also reflected in the number of invertebrate taxa found in the stomach contents of this species (Table 26).

No herring (*Clupea harengus*) or fourbeard rockling (*Enchelyopus cimbrius*) were found in the stomach contents of redfish harvested in 2015–2019, and capelin were only found three times in the predator's stomach contents during the same period. In the Other Fishes taxonomic group (Figure 71), 10 and 18 fish taxa are represented in the stomach contents of redfish and Greenland halibut, respectively. Three of these taxa—white barracudina (*Arctozenus risso*), Atlantic soft pout (*Melanostigma atlanticum*) and marlin-spike grenadier (*Nezumia bairdi*)—were found in the stomach contents of both predators. The digested flatfish group is present in the stomach contents of both redfish and Greenland halibut. The importance of the Other Fishes taxonomic group increased with the length of redfish specimens, while the contribution of this group to the diet of Greenland halibut was greatest for halibut < 20 cm. The importance of this group then declines to its lowest contribution for halibut in the 30–40 cm length class, increasing thereafter for individuals belonging to the > 40 cm length class. The large contribution of the Other Fish group to the diet of small Greenland halibut was due to a high abundance of sand lance in the diet in 2019. Redfish as a prey species contributed to higher CTFI values in Greenland halibut than in redfish itself, and these values increased with Greenland halibut length. As for the Digested Fish taxonomic group, which includes fish taxa too well digested to be identified, its importance is greater in the diet of Greenland halibut than in that of redfish.

Among shrimp species, pink glass shrimp plays a much more important role in the diet of redfish than in that of Greenland halibut. The prevalence of shrimp in the redfish diet increased with the size of the redfish. The proportions of northern shrimp, as well as that of the taxa in the Other Shrimps group, were similar in the diets of both predators across the various length classes. Among the Other Shrimps group, only *Pandalus spp.* shrimps, striped pink shrimp and digested shrimp were observed in the stomach contents of both redfish and Greenland halibut.

For all size classes studied, the contribution of hyperiids to the diet was consistently greater in redfish than in Greenland halibut. The same trend is observed for euphausiids, except in the

< 20 cm size class; similar amounts of euphausiids are consumed by both Greenland halibut and redfish in this length class. In redfish in the < 20 cm length class, 36 taxa in the Other Zooplankton group are consumed, compared with only 11 in Greenland halibut of the same size. In this size class, 28 taxa were found in the stomach contents of redfish only.

CONCLUSION

The outlook for the Greenland halibut stock in the GSL is worrisome, given the ecosystem changes observed and the decrease in the abundance and biomass indices for fish > 40 cm. These indices have stabilized over the past four years.

Between 2019 and 2020, the commercial fishery performance indices were stable for the western Gulf and Esquiman sectors, but increasing in the northern Anticosti sector. The indices for the three sectors were below the average of their respective series.

The cohorts (2014, 2015 and 2016) that are expected to recruit and contribute to the fishery in 2021 and 2022 have a medium to low abundance. The recent strong cohort of 2018 seems promising and shows a normal growth rate. The cohort is expected to begin recruiting to the fishery in 2024.

The exploitation rate index for the GSL Greenland halibut stock declined from 2019 to 2020 and remained near the series average. This index is declining in the western Gulf, but sharply increasing in the northern Anticosti and Esquiman sectors.

The stock status indicator (biomass of fish > 40 cm) showed a declining trend, decreasing over 60% between 2008 and 2017 and moving from the healthy zone into the cautious zone. The indicator was relatively stable from 2017 to 2020 and was in the cautious zone at the mid-point between the LRP and the USR in 2020.

According to the fishery decision-making framework incorporating the precautionary approach, when a stock is in the cautious zone and shows a recent trajectory that is stable, management measures should favour short-term stock growth. In accordance with the framework, since the current state of the GSL Greenland halibut stock meets these conditions, reducing catches to below recent levels could lower the exploitation rate and promote an increase in the stock. However, the adverse environmental conditions for Greenland halibut in the GSL could be determining factors for the stock trajectory.

ACKNOWLEDGMENTS

We extend our thanks to Caroline Senay and Mathieu Boudreau for reviewing this document as well as to the biologists and technicians who participated in gathering data and samples. The authors would also like to thank the crews of the Canadian Coast Guard’s scientific research vessels as well as the participants in the Sentinel Fishery Program for their exemplary work. We would also like to highlight the excellent work of the teams of port samplers from Quebec and Newfoundland. A special thanks goes to Denis Chabot for his important contribution to the diet analyses.

REFERENCES CITED

Albert, O. T., Lambert, Y., Vollen, T., Freitas, C. and Heggebakken, L. 2011. Distinguishing Pelagic and Demersal Swimming of Deepwater Flatfish by Recording of Body Angles. Am. Fish. Soc. Symposium 76, 2011.

Arthur, J.R. and Albert, E. 1993. Use of parasites for separating stocks of Greenland halibut (*Reinhardtius hippoglossoides)* in the Canadian northwest Atlantic. Can. J. Fish. Aquat. Sci. 50: 2175-2181.

Benoît, H.P. 2006. Standardizing the southern Gulf of St. Lawrence bottom trawl survey time series: Results of the 2004-2005 comparative fishing experiments and other recommendations for the analysis of the survey data. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/008: 80 p.

Bernier, B. and Chabot, D. 2013. Évaluation de l'état du stock de flétan du Groenland (*Reinhardtius hippoglosoides*) du golfe du Saint-Laurent (4RST) en 2010 et description de son régime alimentaire. Secr. can. de consult. sci. du MPO. Doc. de rech. 2012/140. viii + 85 p.

Blais, M., Galbraith, P.S., Plourde, S., Devine, L. and Lehoux, C. 2021. Chemical and Biological Oceanographic Conditions in the Estuary and Gulf of St. Lawrence during 2019. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/002. iv + 66 p.

Bourdages, H., Savard, L. Archambault, D. and Valois, S. 2007. Results from the August 2004 and 2005 comparative fishing experiments in the northern Gulf of St. Lawrence between the CGS Alfred Needler and the CCGS Teleost. Can. Tech. Rep. Fish. Aquat. Sci., 2750 : ix + 57 p.

Bourdages, H., Brassard, C., Desgagnés, M., Galbraith, P., Gauthier, J., Nozères, C., Scallon-Chouinard, P.-M. and Senay, C. 2020. Preliminary results from the ecosystemic survey in August 2019 in the Estuary and northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/009. iv + 93 p.

Brassard, C., Lussier, J-F., Benoît, H, Way, M. and Collier, F. 2020. The status of the northern Gulf of St. Lawrence (3Pn, 4RS) Atlantic cod (*Gadus morhua*) stock in 2018. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/075. x + 117 p.

Carrier, E., Ferchaud. A.-L., Normandeau, E., Sirois, P. et Bernatchez, L. 2020. Estimating the contribution of Greenland Halibut (*Reinhardtius hippoglossoides*) stocks to nurseries by means of genotypingby- sequencing: Sex and time matter. *Evol Appl*. 2020;00:1– 13.

Clay, H. and Clay, D. 1980. Age, growth and removals at age of Atlantic redfish (*Sebastes marinus, mentella*) from the Scotian shelf. DFO Can. Sci. Advis. Sec. Sci. Res. Doc. 1980/032.

DFO. 2018a. 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.

DFO. 2018b. Assessment of the Greenland Halibut stock in the Gulf of St. Lawrence (4RST) in 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/035.

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

DFO. 2019. Assessment of the Gulf of St. Lawrence (4RST) Greenland Halibut stock in 2018. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/023.

Dominguez-Petit, R., Ouellet, P. and Lambert, Y. 2012. Reproductive strategy, egg characteristics and embryonic development of Greenland halibut (*Reinhardtius hippoglossoides*). ICES J. Mar. Sci., 70: 342–351.

Dupont-Prinet, A., Vagner, M., Chabot, D. and Audet, C. 2013. Impact of hypoxia on the metabolism of Greenland halibut (*Reinhardtius hippoglossoides*). Can. J. Fish. Aquat. Sci. 70: 461–469.

Dutil, J.D., Lambert, Y., Chouinard, G.A. et Fréchet. A. 1995. Fish condition: what should we measure in cod (*Gadus morhua*)? DFO Can. Sci. Advis. Sec., Res. Doc 1995/011. 26 pp.

Fréchet, A. Savenkoff, C. and Gauthier, J. 2006. Updates concerning unaccounted fishing mortalities. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/086.

Gauthier, J., Marquis, M.-C., Bourdages, H., Ouellette-Plante, J. and Nozères, C. 2020. Gulf of St. Lawrence (4RST) Greenland Halibut Stock Status in 2018: Commercial Fishery and Research Survey Data. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/016. v + 127 p.

Gavaris, S. 1980. Use of multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Galbraith, P.S., Chassé, J., Shaw, J.-L., Dumas, J., Caverhill, C., Lefaivre, D. and Lafleur, C. 2020. Physical Oceanographic Conditions in the Gulf of St. Lawrence during 2019. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/030. iv + 88 p.

Ghinter, L., Lambert, Y. ant Audet, C. 2021. Juvenile Greenland halibut (*Reinhardtius hippoglossoides*) growth in the context of rising temperature in the Estuary and Gulf of St. Lawrence. Fish. Res. 233.

Gilbert, D., Chabot, D., Archambault, P., Rondeau, B. and Hébert, S. 2007. Appauvrissement en oxygène dans les eaux profondes du Saint-Laurent marin: causes possibles et impacts écologiques. Nat. Can. 131, 67–75.

Gilbert, D., Sundby, B., Gobeil, C., Mucci, A. and Tremblay, G.-H., 2005. A seventy-two year record of diminishing deep-water oxygen in the St. Lawrence estuary: the northwest Atlantic connection. Limnol. Oceanogr. 50, 1654–1666.

Hurtubise, S., Fréchet A. and Savard, L.1991. Les captures accessoires sur les crevettiers et les sébastiers du golfe du St-Laurent. Secr. can. de consult. sci. du MPO. Doc. de rech. 1992/060. 14 p.

Kennedy, J., Gundersen, A. C. and Boje, J. 2009. When to count your eggs: Is fecundity in Greenland halibut (*Reinhardtius hippoglossoides* W.) down-regulated? Fish. Res. 100: 260–265.

Kennedy, J., Gundersen , A. C. Høines, Å. and Kjesb, O. S. 2011. Greenland halibut (*Reinhardtius hippogolossoides*) spawn annually but successive cohorts of oocytes develop over two years, complicating correct assessment of maturity. Can. J. Fish. Aquat. Sci. 68:201–209.

Morin, B. and Bernier, B. 2003. Assessment of Greenland Halibut (*Reinhardtius hippoglossoides*) in the Gulf of St. Lawrence (4RST) in 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/088. 73 p.

Myers, R. A. and Cadigan, N. G. 1995. Was an increase in natural mortality responsible for the collapse of northern cod? Can. J. Fish. Aquat. Sci. 52: 1274–1285.

Ouellet, P., Bui, A. O. V. and Bernier, B. 2011. Greenland halibut (*Reinhardtius hippoglossoides* Walbaum, 1792) early stage distribution in the Gulf of St. Lawrence. J. Northw. Atl. Fish. Sci. 43: 121–129.

Ouellette-Plante, J., Chabot, D., Nozères, C. and Bourdages, H. 2020. Diets of demersal fish from the CCGS Teleost ecosystemic surveys in the estuary and northern Gulf of St. Lawrence, August 2015-2017. Can. Tech. Rep. Fish. Aquat. Sci. 3383: v + 121 p.

R Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. (Accédé le 30 novembre 2017).

Rideout, R. M., Morgan, M. J., Lambert, Y., Cohen, A. M., Banoub, J. H. and Treble, M. 2012. Oocyte development and vitellogenin production in Northwest Atlantic Greenland halibut *Reinhardtius hippoglossoides*. J. Northw. Atl. Fish. Sci., Vol. 44: 15–29.

Roy, D., Hardie, D. C., Treble, M. A., Reist, J. D. and Ruzzante, D. E. 2014. Evidence supporting panmixia in Greenland halibut (*Reinhardtius hippoglossoides*) in the Northwest Atlantic. Can. J. Fish. Aquat. Sci., 71(5), 763–774.

SAS. 1996. Spatial Prediction Using the SAS System. SAS/STAT Technical Report, SAS Institute Inc., Cary, NC. 80 p.

Savard, L., Gauthier, J., Bourdages, H. and Desgagnés, M. 2013. Bycatch in the Estuary and Gulf of St. Lawrence Northern shrimp fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/151. ii+ 56 p.

Senay, C., Ouellette-Plante, J., Bourdages, H., Bermingham, T., Gauthier, J., Parent, G., Chabot, D., and Duplisea, D. 2021. Unit 1 Redfish (*Sebastes mentella* and *S. fasciatus*) stock status in 2019 and updated information on population structure, biology, ecology, and current fishery closures. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/015. xi + 119 p.

Smedbol, R. K., Shelton, P. A., Swain, D. P., Fréchet, A. and Chouinard, G. A. 2002. Review of population structure, distribution and abundance of cod (*Gadus morhua*) in Atlantic Canada in a species-at-risk context. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/082. 134 p.

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. Glob. Chang. Biol. 23, 2284–2296.

Swain, D. P. and Sinclair, A. F. 1994. Fish distribution and catchability: what is the appropriate measure of distribution? Can. J. Fish. Aquat. Sci. 51: 1046–1054.

Swain, D. P., Nielsen, G. A. and McKay, D. E. 1995. Incorporating depth-dependent differences in fishing efficiency among vessels in the research survey time series for Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. Can. MS Rep. Fish. Aquat. Sci. 2317: 20 p.

Templeman, W. 1973. Distribution and Abundance of the Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. ICNAF Res. Bull. No. 10:83-99.

Westgaard, J. I., Saha, A., Kent, M., Hansen, H. H., Knutsen, H., Hauser, L., Cadrin, S. X., Albert, O. T. et Johansen, T. 2017. Genetic population structure in Greenland halibut (*Reinhardtius hippoglossoides*) and its relevance to fishery management. Can. J. Fish. Aquatic Sc. 74:4

Youcef, W. A., Lambert, Y. and Audet, C. 2013 Spatial distribution of Greenland halibut *Reinhardtius hippoglossoides* in relation to abundance and hypoxia in the estuary and Gulf of St. Lawrence. Fish. Oceanogr. 22:1, 41–60.

Youcef, W. A., Lambert, Y. and Audet, C. 2015. Variations in length and growth of Greenland Halibut juveniles in relation to environmental conditions. Fish. Res. 167, 38–47.

TABLES

Table 1. History of the main management measures put in place for the directed Greenland halibut fishery. Comp: Competitive Regime; ITQ: Individual Transferable Quota; Bo : Boat

Management year	TAC (t)	F-ALL	Landing (t)	Fishing Regime	Mesh size (inch)	Number of net	Minimum size[4] (cm)
1980	-	-	7,006	*Freeze on the issuance of groundfish licenses*			
1981	-	-	3,176	-	-	-	-
1982	7,500	-	2,269	*Establishment of a management plan*			
1983	5,000	-	1,105	-	-	-	-
1984	5,000	-	2,126	-	-	-	-
1985	5,000	-	2,369	-	-	-	-
1986	5,000	-	6,595	-	-	-	-
1987	8,900	-	11,080	*Problem of high bycatch by MG > 65 feet*			
1988	10,500	-	7,569	-	-	-	-
1989	10,500	-	5,136	-	-	-	-
1990	10,500	-	2,445	-	-	-	-
1991	10,500	-	2,293	-	-	-	-
1992	10,500	-	3,419	Comp.	5.5	>120	-
1993	4,000	-	2,602	Comp.	5.5	>120	-
	Recognition than GSL Greenland halibut is distinct from the Atlantic one. Stop of mobile gear directed fishery. Progressive use of Nordmore grid by shrimpers to reduce bycatch of Greenland halibut > 30cm						
1994	4,000	-	3,620	Comp.	5.5	120 (Bo < 45 ft.) 160 (Bo > 45 ft.)	-
1995	4,000 (-,900[1])	-	2,426	Comp.	70% 5.5 30% 5.7	120	-
1996	2,000	-	1,962	Comp.	30% 5.7 70% 6.0	80 = QC 120 = NL	42
1997	3,000	-	2,633	Comp.	6.0	80 = QC 120 = NL	44
1998	4,000	-	3,945	Comp.	6.0	80 = QC 120 = NL	44
1999-2000	4,500	-	3,674	QC = ITQ + Comp. NL = Comp.	6.0	80 = QC 120 = NL	44
2000-2001	4,500	-	2,078	Idem	6.0	80/100 = QC [3] 120 = NL	44
2001-2002[9]	4,500	-	1,288	Idem	6.0	120	44
2002-2003	3,500	-	1,752	Idem	QC[2] = 5.5 et 6.0 NL : 6.0	120	44
2003-2004	3,500	2,917	3,573	Idem	QC[2] = 5.5 et 6.0 NL : 6.0	120	44
2004-2005	4,500	3,751	3,952	Idem	6.0	120	44
2005-2006	4,500	3,751	4,048	Idem	6.0	120	44
2006-2007	4,500	3,751	3,868	Idem	6.0	120	44
2007-2008	4,500	3,751	3,921	Idem	6.0	120	44
2008-2009	4,500	3,751	3,770	ITQ + Comp. = QC Comp. = NL	6.0	120	44

Management year	TAC (t)	F-ALL	Landing (t)	Fishing Regime	Mesh size (inch)	Number of net	Minimum size[4] (cm)
2009-2010	4,500	3,751	4,268	Idem	6.0	120	44
2010-2011[5]	4,500	3,751	3,972	Idem	6.0	120	44
2011-2012	4,500	3,751	3,872	Idem	6.0	QC = 120 NL = 90	44
2012-2013	4,500	3,751	3,481	Idem	6.0	QC = 120 NL = Option A- 80 and 3 fishing days, or Option B- 35 and 5 fishing days	44
2013-2014[6]	4,500	3,751	2,774	Idem	6.0	QC = 120 NL = Option A- 80 and 3 fishing days, or Option B- 35 and 5 fishing days	44
2014-2015[10]	4,500	3,751	3,179	Idem	6.0	QC = 120 NL = 80	44
2015-2016	4,500	3,751	3,410	Idem	6.0	QC = 120 NL = 90	44
2016-2017	4,500	3,751	3,300	Idem	6.0	QC = 120 NL = 90	44
2017-2018[7]	4,500	3751	1,765	Idem	6.0	QC = 120 NL = 90	44
2018-2019	3,375	2,813	1,604	Idem	6.0	QC = 120 NL = 90	44
2019-2020[8]	3,375	2,813	1,896	Idem	6.0	QC = 120 NL = 90	44
2020-2021[8,11]	2,250	1,875	1,330	Idem	6.0	QC = 120 NL = 90	44

1 TAC reduction to protect juvenile fish.
2 QC experimental fishery (4T4 et 4T3a): fishery with 5,5 inches mesh size gillnet allowed to catch 30% du IQ of traditional fishers. The other fishers used 6 inches.
3 The maximum number of nets was increased from 80 to 100 from July 17, 2000 to May 14, 2001 for QC fishers.
4 Minimum size of small fish protocol.
5 Establishment of quota reconciliation.
6 Mandatory use of Vessel Monitoring System (VMS) for some QC fleet.
7 Mandatory use of VMS for all QC fleet.
8 Landing data are preliminary.
9 Ban on fishing in depth less than 125 fathoms in Division 4R from 2001 to 2013.
10 Ban on fishing in depth less than 140 fathoms in Division 4R since 2014.
11 Ban on fishing in depth less than 125 fathoms in Division 4S, measure implemented in 2020.

Table 2. Landings (t) by NAFO Divisions and Total Allowable Catch (TAC) of Greenland halibut by management year. Fishing allocation (F-ALL) is shown from 2003 onwards.

Management year	NAFO Division 4R	4S	4T	n. d.**	Total	TAC	F-ALL
1970	381	496	255	-	1132	-	-
1971	300	450	204	-	954	-	-
1972	199	379	105	-	683	-	-
1973	216	431	116	-	763	-	-
1974	167	752	92	-	1011	-	-
1975	195	1,102	247	-	1544	-	-
1976	517	1,367	135	-	2019	-	-
1977	1,108	2,298	555	-	3,961	-	-
1978	1,344	3,549	1,354	-	6247	-	-
1979	2,920	1,889	3,982	-	8791	-	-
1980	1,631	2,063	3,312	-	7,006	-	-
1981	533	803	1,840	-	3,176	-	-
1982	158	548	1,563	-	2,269	7,500	-
1983	205	444	456	-	1,105	5,000	-
1984	200	571	1,355	-	2,126	5,000	-
1985	213	863	1,292	-	2,369	5,000	-
1986	148	2,161	4,286	-	6,595	5,000	-
1987	229	4,395	6,456	-	11,080	8,900	-
1988	366	2,366	4,838	-	7,569	10,500	-
1989	389	1,872	2,875	-	5,136	10,500	-
1990	304	828	1,313	-	2,445	10,500	-
1991	627	877	789	-	2,293	10,500	-
1992	751	856	1,811	-	3,419	10,500	-
1993	398	709	1,495	-	2,602	4,000	-
1994	507	795	2,318	-	3,620	4,000	-
1995	320	425	1,681	-	2,426	4,000	-
1996	359	532	1,071	-	1,962	2,000	-
1997	549	439	1,645	-	2,633	3,000	-
1998	690	879	2,376	-	3,945	4,000	-
1999-2000	553	837	2,283	-	3,674	4,500	-
2000-2001	513	483	1,082	-	2,078	4,500	-
2001-2002	408	233	647	-	1,288	4,500	-
2002-2003	567	298	888	-	1,752	3,500	-
2003-2004	1,062	807	1,704	-	3,573	3,500	2,917
2004-2005	1,035	1,097	1,820	-	3,952	4,500	3,751
2005-2006	1,192	1,201	1,656	-	4,048	4,500	3,751
2006-2007	1,032	1,696	1,140	-	3,868	4,500	3,751
2007-2008	944	2,107	866	3	3,921	4,500	3,751
2008-2009	739	1,746	1,272	12	3,770	4,500	3,751
2009-2010	1,320	1,890	1,044	15	4,268	4,500	3,751
2010-2011	1,193	1,920	841	18	3,972	4,500	3,751
2011-2012	1,636	1,822	397	17	3,872	4,500	3,751
2012-2013	1,457	1,334	676	13	3,481	4,500	3,751
2013-2014	793	1,387	573	21	2,774	4,500	3,751
2014-2015	488	1,396	1,275	20	3,179	4,500	3,751
2015-2016	477	1,726	1,187	19	3,410	4,500	3,751
2016-2017	519	1,453	1,328	11	3,311	4,500	3,751
2017-2018	210	823	732	8	1,773	4,500	3,751
2018-2019	549	574	475	-	1,493	3,375	2,813
2019-2020*	536	460	893	-	1,888	3,375	2,813
2021-2022*	310	388	635	-	1,333	2,250	1,875

*Preliminary data, **n. d. not determined

Table 3. Landings (t) of Greenland halibut by fishing gear and management year.

Management year	Gillnet	Longline	Bottom trawl	Seine	Shrimp trawl	Other	Total
1977	1,329	3	1,626	0	993	10	3,961
1978	3,450	0	1,577	0	1,210	10	6,247
1979	3,373	1,901	2,888	0	609	20	8,791
1980	5,239	39	1,042	0	686	0	7,006
1981	2,464	7	409	0	286	10	3,176
1982	1,771	3	165	0	330	0	2,269
1983	469	94	231	0	311	0	1,105
1984	1,026	36	582	0	457	25	2,126
1985	1,451	61	97	1	650	108	2,369
1986	4,941	122	231	1	1,299	0	6,595
1987	8,350	147	1,199	4	1,376	4	11,080
1988	5,793	52	694	19	1,010	1	7,569
1989	4,193	22	404	0	517	0	5,136
1990	1,937	39	178	0	290	0	2,445
1991	1,372	74	141	4	700	2	2,293
1992	2,401	112	156	16	733	0	3,419
1993	2,334	59	62	8	127	12	2,602
1994	3,436	86	18	5	10	66	3,620
1995	2,330	17	10	14	1	54	2,426
1996	1,811	34	93	23	1	0	1,962
1997	2,456	57	89	30	1	0	2,633
1998	3,765	34	117	27	1	0	3,945
1999-2000	3,384	28	188	71	2	1	3,674
2000-2001	1,875	78	99	26	1	0	2,078
2001-2002	1,156	66	39	24	2	0	1,288
2002-2003	1,568	87	54	34	1	8	1,752
2003-2004	3,413	49	66	43	2	0	3,573
2004-2005	3,801	48	40	61	1	0	3,952
2005-2006	3,837	39	49	122	0	0	4,048
2006-2007	3,722	47	48	49	2	0	3,868
2007-2008	3,743	47	15	111	2	4	3,921
2008-2009	3,627	47	28	55	2	12	3,770
2009-2010	4,159	28	52	14	1	15	4,268
2010-2011	3,904	20	18	11	1	18	3,972
2011-2012	3,791	20	27	16	1	18	3,872
2012-2013	3,417	15	19	16	1	13	3,481
2013-2014	2,722	5	11	14	1	21	2,774
2014-2015	3,139	6	3	10	1	20	3,179
2015-2016	3,363	5	7	15	1	19	3,410
2016-2017	3,277	3	8	11	1	0	3,311
2017-2018	1,744	7	1	14	1	8	1,773
2018-2019	1,575	6	3	12	1	2	1,598
2019-2020*	1,873	7	2	7	1	-	1,888
2020-2021*	1,320	8	0,2	3	1	-	1,333

*Preliminary data

Table 4. Number of observations (obs), catch (t), effort (number of gillnets), catch per unit effort (CPUE, kg/net) and its standard error (SE), percentage (%) of landings corresponding to observations, landings (t) and nominal effort for gillnets by fishing sector and calendar year.

4RST

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	1332	1198	79096	15.2	0.3	37	3,254	214,935
2000	1221	918	83688	11.0	0.2	47	1,973	179,974
2001	405	249	23182	10.8	0.4	21	1,175	109,349
2002	658	434	29200	14.9	0.5	30	1,450	97,659
2003	1161	1407	63856	22.0	0.5	41	3,462	156,894
2004	2586	2811	152127	18.5	0.3	75	3,775	204,197
2005	2664	2834	163802	17.3	0.3	73	3,871	223,773
2006	2291	2986	148991	20.0	0.3	84	3,573	178,219
2007	1898	3199	121159	26.4	0.4	85	3,762	142,540
2008	1986	3091	131091	23.6	0.3	88	3,518	149,137
2009	2027	3481	130865	26.6	0.4	82	4,244	159,591
2010	2002	3552	143085	24.8	0.4	90	3,970	159,872
2011	1851	3222	132475	24.3	0.5	88	3,650	150,028
2012	1777	3001	121075	24.8	0.5	86	3,504	141,443
2013	2192	2235	159792	14.0	0.2	90	2,474	176,957
2014	2002	3141	148411	21.2	0.3	91	3,454	163,268
2015	1759	3130	118439	26.4	0.4	91	3,425	129,583
2016	1814	2980	121245	24.6	0.4	91	3,286	133,677
2017	1,513	1,564	111,986	14.0	0.2	91	1,720	123,197
2018	1,569	1,452	112,797	12.9	0.2	92	1,572	122,075
2019*	1,769	1,687	121,664	13.9	0.2	91	1,845	133,112
2020*	1,258	1,230	85,948	14.3	0.3	85	1,452	101,473

Western Gulf

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	836	731	39,775	18.4	0.4	29	2,555	139,073
2000	825	531	49,497	10.7	0.3	39	1,360	126,915
2001	362	218	21,007	10.4	0.4	30	727	70,023
2002	614	358	26,636	13.4	0.4	45	793	59,060
2003	1,003	1,010	51,384	19.7	0.4	47	2,167	110,266
2004	2,386	2,277	136,695	16.7	0.2	90	2,526	151,547
2005	2,532	2,451	155,761	15.7	0.2	96	2,562	162,760
2006	1,912	2,100	118,994	17.7	0.3	94	2,225	126,053
2007	1,516	2,371	92,910	25.5	0.4	93	2,538	99,475
2008	1,547	2,240	98,796	22.7	0.3	95	2,371	104,546
2009	1,546	2,047	99,791	20.5	0.3	90	2,282	111,250
2010	1,349	1,836	94,447	19.4	0.3	95	1,927	99,105
2011	1,097	1,265	79,591	15.9	0.3	98	1,290	81,133
2012	954	1,145	67,249	17.0	0.4	91	1,262	74,144
2013	1,208	1,090	95,171	11.5	0.2	95	1,144	99,865
2014	1,484	2,679	117,635	22.8	0.3	94	2,851	125,144

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
2015	1,282	2,790	92,716	30.1	0.4	95	2,937	97,596
2016	1,255	2,560	86,004	29.8	0.4	94	2,723	91,494
2017	1,240	1,408	92,332	15.3	0.2	94	1,500	98,330
2018	967	777	69,288	11.2	0.2	96	809	72,175
2019*	1,108	1,118	79,063	14.1	0.3	95	1,181	83,488
2020*	916	871	66,542	13.1	0.3	96	908	69,387

North Anticosti

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	136	103	8,027	12.8	0.6	92	113	8,773
2000	73	72	4,446	16.2	1.0	98	74	4,551
2001	40	29	1,927	15.1	1.4	65	45	2,988
2002	31	70	1,985	35.2	4.2	78	90	2,551
2003	33	66	2,329	28.2	2.6	97	67	2,394
2004	7	13	532	-	-	95	13	562
2005	3	6	150	-	-	89	6	169
2006	111	243	9,702	25.0	1.1	94	259	10,365
2007	65	129	5,506	23.4	1.5	97	133	5,676
2008	89	162	5,968	27.2	1.9	100	162	5,968
2009	172	499	15,748	31.7	1.1	95	527	16,629
2010	299	667	25,831	25.8	1.0	99	672	26,013
2011	279	458	22,764	20.1	0.8	96	475	23,614
2012	201	442	16,002	27.6	1.1	89	499	18,061
2013	359	424	31,367	13.5	0.4	97	436	32,237
2014	113	104	8,921	11.7	0.7	98	106	9,066
2015	-	-	-	-	-	-	0	-
2016	8	5	357	13.2	1.8	89	5	403
2017	7	5	541	8.6	1.7	95	5	569
2018	184	209	15,921	13.2	0.6	100	210	15,969
2019*	143	126	10,127	12.5	0.6	99	128	10,271
2020*	135	220	10,475	21.0	1.1	95	232	11,038

Esquiman

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	358	361	31,101	11.6	0.4	62	581	50,082
2000	322	314	29,672	10.6	0.4	59	537	50,635
2001	1	2	102	-	-	0	397	25,500
2002	13	6	579	11.1	1.9	1	562	52,636
2003	125	331	10,143	32.7	1.5	27	1,226	37,567
2004	192	520	14,820	35.1	1.5	42	1,234	35,202
2005	125	373	7,652	48.7	2.5	29	1,297	26,569
2006	268	643	20,295	31.7	1.2	59	1,083	34,167
2007	317	699	22,743	30.7	1.2	64	1,091	35,536
2008	349	688	26,293	26.2	0.7	70	980	37,454
2009	309	935	15,326	61.0	1.7	65	1,435	23,506

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
2010	347	1,037	22,167	46.8	1.4	76	1,360	29,052
2011	473	1,497	29,957	50.0	1.3	80	1,879	37,587
2012	620	1,413	37,740	37.4	1.0	81	1,741	46,535
2013	622	720	32,984	21.8	0.5	81	893	40,872
2014	403	355	21,685	16.4	0.6	72	495	30,202
2015	477	341	25,723	13.2	0.4	70	488	36,852
2016	550	414	34,817	11.9	0.3	74	557	46,797
2017	266	151	19,113	7.9	0.3	72	211	26,657
2018	418	466	27,588	16.9	0.5	85	551	32,610
2019*	518	442	32,474	13.6	0.3	83	535	39,315
2020*	205	138	8,841	15.6	0.9	44	310	19,912

*Preliminary data

Table 5. Monthly gillnet catch (t) for the entire Gulf (4RST), by sector and calendar year.

4RST

Year	J	F	M	A	M	J	J	A	S	O	N	D
1985	0	0	0	30	221	249	188	323	252	178	8	0
1986	-	-	-	149	766	770	792	612	1193	641	18	0
1987	-	-	-	487	1088	1484	1879	2343	1034	33	1	0
1988	-	-	5	307	668	1064	1588	1105	707	340	9	0
1989	-	-	4	183	809	1127	1079	603	247	106	34	1
1990	-	-	2	69	413	456	392	270	163	148	21	2
1991	-	-	-	47	190	382	285	233	167	61	8	0
1992	-	-	-	98	417	595	609	377	229	72	5	-
1993	-	-	-	35	184	521	583	550	295	128	38	-
1994	-	-	-	42	540	714	719	657	276	-	-	-
1995	-	-	-	-	665	826	794	46	-	-	1	-
1996	-	-	-	-	117	995	588	89	11	10	-	-
1997	-	-	-	-	822	1374	252	2	3	3	-	-
1998	-	-	-	-	25	273	2323	465	596	82	2	-
1999	-	-	-	-	10	1222	828	566	448	155	25	1
2000	-	-	-	33	249	452	664	441	114	15	5	-
2001	-	-	-	8	41	185	581	264	57	25	14	-
2002	-	-	-	7	22	254	501	420	155	69	21	-
2003	-	-	1	43	369	1030	1245	521	193	54	5	-
2004	-	-	-	57	694	1155	966	648	210	45	0	-
2005	-	-	-	43	743	1514	757	534	199	80	1	-
2006	-	-	-	43	396	1387	863	645	207	31	1	-
2007	-	-	-	118	726	1538	697	545	95	43	0	-
2008	-	-	-	87	615	1208	893	480	184	49	2	-
2009	-	-	-	130	661	2032	934	317	145	25	-	-
2010	-	-	-	131	561	2066	671	392	111	38	0	-
2011	-	-	-	55	618	1589	970	269	109	40	0	-
2012	-	-	-	95	719	1165	955	376	179	15	0	-
2013	-	-	-	71	319	595	767	386	185	147	4	-
2014	-	-	-	109	799	1,080	637	521	247	60	-	-
2015	-	-	-	23	726	1,238	769	386	211	72	-	-
2016	-	-	-	45	436	1,274	782	430	207	69	40	3
2017	-	-	-	35	280	559	399	282	110	44	10	-
2018	-	-	-	56	85	293	501	377	138	84	38	-
2019*	-	-	-	48	120	430	549	434	182	82	0	-
2020*	-	-	-	71	157	369	403	183	142	126	1	-

Western Gulf

Year	J	F	M	A	M	J	J	A	S	O	N	D
1999	-	-	-	-	2	1049	671	378	316	116	24	1
2000	-	-	-	32	236	294	377	307	98	11	5	-
2001	-	-	-	8	41	119	382	148	22	5	0	-
2002	-	-	-	2	13	53	181	341	140	46	18	-

Year	J	F	M	A	M	J	J	A	S	O	N	D
2003	-	-	-	43	359	542	608	362	193	54	5	-
2004	-	-	-	57	256	603	708	648	209	44	0	-
2005	-	-	-	43	307	652	752	530	197	80	1	-
2006	-	-	-	40	61	570	721	598	203	31	1	-
2007	-	-	-	118	632	573	586	493	94	42	-	-
2008	-	-	-	87	562	537	618	374	164	26	2	-
2009	-	-	-	130	601	578	500	308	141	24	-	-
2010	-	-	-	131	435	697	357	253	48	5	-	-
2011	-	-	-	55	433	306	230	138	87	40	-	-
2012	-	-	-	79	435	329	269	96	40	14	-	-
2013	-	-	-	61	260	191	263	203	112	54	-	-
2014	-	-	-	107	794	654	522	478	239	58	-	-
2015	-	-	-	23	726	1,018	633	311	169	57	-	-
2016	-	-	-	45	432	1,063	651	341	162	29	-	-
2017	-	-	-	35	280	486	372	239	71	16	1	-
2018	-	-	-	56	85	76	179	219	112	63	19	-
2019*	-	-	-	48	118	160	367	287	142	58	0	-
2020*	-	-	-	69	153	183	258	84	81	80	-	-

North Anticosti

Year	J	F	M	A	M	J	J	A	S	O	N	D
1999	-	-	-	-	-	2	8	39	53	11	-	-
2000	-	-	-	1	1	2	41	27	1	-	-	-
2001	-	-	-	-	0	0	13	25	7	-	-	-
2002	-	-	-	5	1	-	5	70	9	-	-	-
2003	-	-	-	-	3	5	46	13	-	-	-	-
2004	-	-	-	-	-	9	5	-	-	-	-	-
2005	-	-	-	-	6	-	0	1	-	-	-	-
2006	-	-	-	3	-	114	93	45	4	-	-	-
2007	-	-	-	-	8	-	74	51	-	-	-	-
2008	-	-	-	-	-	25	46	89	2	-	-	-
2009	-	-	-	-	3	115	403	5	-	-	-	-
2010	-	-	-	-	1	243	212	126	60	31	-	-
2011	-	-	-	-	20	184	165	87	19	-	-	-
2012	-	-	-	-	12	108	235	92	51	-	-	-
2013	-	-	-	-	23	34	241	119	18	-	-	-
2014	-	-	-	3	1	46	35	21	-	-	-	-
2015	-	-	-	-	-	-	0	-	-	-	-	-
2016	-	-	-	-	-	2	1	3	-	-	-	-
2017	-	-	-	-	1	4	1	-	-	-	-	-
2018	-	-	-	-	-	35	106	55	15	-	-	-
2019*	-	-	-	-	2	10	45	49	22	-	-	-
2020*	-	-	-	2	-	23	64	46	54	43	1	-

Esquiman

Year	J	F	M	A	M	J	J	A	S	O	N	D
1999	-	-	-	-	7	172	146	148	78	28	1	-
2000	-	-	-	-	11	156	244	106	15	4	0	-
2001	-	-	-	-	-	65	183	89	28	19	14	-
2002	-	-	-	-	8	201	311	9	7	23	4	-
2003	-	-	1	-	7	483	590	146	-	-	-	-
2004	-	-	-	-	437	541	253	0	1	1	-	-
2005	-	-	-	-	429	861	3	2	1	1	-	-
2006	-	-	-	-	331	703	48	1	0	0	0	-
2007	-	-	-	-	86	966	37	0	1	1	0	-
2008	-	-	-	-	52	645	227	15	18	23	-	-
2009	-	-	-	-	57	1,338	30	3	4	1	-	-
2010	-	-	-	-	125	1,123	100	6	3	2	0	-
2011	-	-	-	-	164	1,096	572	43	3	-	0	-
2012	-	-	-	16	271	728	449	188	88	1	0	-
2013	-	-	-	10	36	369	262	63	55	93	4	-
2014	-	-	-	-	4	380	78	22	9	2		-
2015	-	-	-	-	-	220	136	75	42	15	-	-
2016	-	-	-	-	3	208	131	86	45	40	40	3
2017	-	-	-	-	-	68	26	43	36	28	9	-
2018	-	-	-	-	-	183	215	102	11	21	19	-
2019*	-	-	-	-	-	260	136	98	18	23		-
2020*	-	-	-	-	4	163	81	53	7	2	-	-

*Preliminary data

Table 6. Standardized annual catch per unit effort (CPUE) and its standard error (SE) for the gillnet fishery for the whole Gulf (4RST) and by fishing sector.

Year	4RST		Western Gulf		North Anticosti		Esquiman	
	CPUE	SE	CPUE	SE	CPUE	SE	CPUE	SE
1999	21.48	0.48	28.42	0.72	16.82	0.97	11.23	0.39
2000	14.12	0.31	14.51	0.35	22.01	1.52	11.24	0.38
2001	14.40	0.50	13.78	0.47	19.01	1.75	12.96	1.99
2002	19.40	0.57	18.32	0.52	40.37	3.98	33.11	1.69
2003	30.39	0.69	29.35	0.67	33.28	3.04	31.75	1.38
2004	25.45	0.45	24.26	0.42	-	-	48.44	2.82
2005	23.29	0.41	21.84	0.37	-	-	33.56	1.36
2006	25.69	0.45	23.34	0.41	42.66	2.64	30.35	1.11
2007	34.83	0.66	34.15	0.66	57.14	2.61	26.42	0.89
2008	32.99	0.61	33.10	0.63	42.56	1.72	66.41	2.45
2009	35.86	0.67	29.45	0.57	34.24	1.41	52.91	1.89
2010	32.83	0.62	27.69	0.56	44.11	1.93	66.43	2.04
2011	29.18	0.56	20.25	0.44	21.34	0.77	48.78	1.40
2012	32.30	0.64	23.33	0.54	17.39	0.96	23.28	0.62
2013	18.54	0.34	15.38	0.32	13.75	2.59	15.71	0.51
2014	29.35	0.55	34.49	0.67	10.24	2.01	13.47	0.39
2015	34.86	0.68	46.91	0.96	-	-	11.19	0.33
2016	31.29	0.60	44.45	0.91	-	-	7.57	0.29
2017	18.97	0.38	21.84	0.44	-	-	17.06	0.51
2018	16.81	0.34	15.18	0.34	16.82	0.97	14.63	0.41
2019*	18.42	0.36	19.20	0.42	22.01	1.52	14.32	0.59
2020*	19.28	0.43	19.06	0.45	19.01	1.75	11.23	0.39

*Preliminary data

Table 7. *Average length (cm) of fish caught in the commercial gillnet fishery by sex (Male, Female and Total) and NAFO Division.*

Year	4RST			4R			4S			4T		
	M	F	T	M	F	T	M	F	T	M	F	T
1987	42.2	44.5	43.5	43.0	45.3	44.2	43.0	45.3	44.2	41.5	44.1	43.1
1988	42.5	45.1	44.0	43.3	45.5	44.6	43.2	45.6	44.6	42.2	44.8	43.7
1989	44.0	47.8	46.4	43.2	46.4	44.5	43.3	46.1	44.7	45.9	48.8	48.2
1990	44.6	48.5	46.2	44.9	49.7	46.9	44.5	48.9	46.3	44.6	47.9	46.0
1991	43.9	47.0	45.3	43.5	45.8	44.5	43.5	45.8	44.4	45.2	48.9	47.4
1992	43.4	44.8	44.3	48.2	49.2	48.7	41.2	44.3	43.1	42.2	44.2	43.5
1993	42.2	44.0	43.3	46.1	48.0	47.0	42.4	44.6	43.9	41.0	43.1	42.4
1994	40.2	43.9	43.1	43.2	44.2	43.9	40.8	44.0	43.4	40.0	43.8	43.0
1995	41.8	44.9	44.0	41.9	43.1	42.6	42.1	44.8	43.9	41.7	45.2	44.3
1996	45.1	48.2	47.6	45.0	47.6	46.6	45.6	48.5	48.0	44.7	48.3	47.9
1997	44.5	48.9	48.1	44.5	48.4	47.5	44.7	48.7	47.8	44.5	49.1	48.4
1998	44.5	49.0	47.3	44.4	49.2	47.9	44.6	48.3	46.7	44.5	49.1	47.4
1999	44.7	47.4	46.8	43.7	46.1	45.5	44.6	48.0	47.4	44.9	47.6	46.9
2000	43.7	47.1	46.4	43.0	46.4	45.7	44.3	48.3	47.3	43.7	47.1	46.4
2001	43.6	46.9	46.2	44.6	46.4	46.0	43.5	49.2	48.5	42.8	46.4	45.6
2002	42.6	45.2	44.8	43.2	46.0	45.6	41.5	47.2	46.4	42.5	44.2	43.9
2003	43.9	46.1	45.7	46.4	48.0	47.5	41.3	46.1	45.5	41.2	45.4	44.9
2004	42.6	46.6	46.1	45.4	48.4	47.9	41.9	46.5	45.8	41.2	45.8	45.3
2005	43.6	46.7	46.1	46.0	48.1	47.5	42.7	47.2	46.5	40.8	45.7	45.1
2006	44.2	47.4	46.9	45.7	48.8	48.0	44.0	47.7	47.2	42.6	45.9	45.4
2007	43.6	47.8	47.0	45.9	50.0	48.6	42.0	47.7	46.6	43.1	46.8	46.4
2008	43.9	47.4	46.8	45.3	48.6	47.9	44.0	47.5	46.8	42.4	46.8	46.1
2009	44.4	47.7	47.2	46.8	49.7	49.0	43.0	47.4	46.8	42.9	46.5	46.0
2010	45.5	48.8	48.2	47.1	50.0	49.2	45.0	48.9	48.1	43.0	47.5	46.9
2011	46.3	49.1	48.4	47.4	50.8	49.6	45.1	48.5	47.9	44.3	46.8	46.3
2012	46.6	49.5	48.8	47.9	51.7	50.3	45.8	49.4	48.7	42.7	47.3	46.7
2013	45.6	48.4	47.8	47.4	50.3	49.4	44.4	48.0	47.4	44.4	47.0	46.5
2014	44.4	47.3	46.7	46.2	48.6	47.9	43.8	47.1	46.4	44.4	47.2	46.7
2015	45.1	48.8	48.3	47.3	50.8	50.3	45.1	48.9	48.3	43.9	48.2	47.8
2016	45.0	49.6	48.7	45.1	49.8	48.9	45.5	50.2	49.0	44.2	49.0	48.3
2017	44.1	48.4	47.4	43.8	47.1	46.2	44.4	48.7	47.7	43.7	48.4	47.6
2018	44.4	48.4	47.8	44.9	48.3	47.5	43.9	48.6	48.1	43.6	48.4	47.9
2019*	41.0	45.9	45.2	42.6	46.2	45.3	42.8	47.2	46.8	38.7	45.2	44.3
2020*	41.1	46.0	45.6	-	-	-	42.9	47.5	47.1	40.1	44.8	44.4

*Preliminary data

Table 8. Number (thousand) of males (M) and females (F) Greenland halibut caught and proportion (Prop) of females in the gillnet fishery by NAFO Division.

Year	4RST			4R			4S			4T		
	M	F	Prop.	M	F	Prop.	M	F	Prop.	M	F	Prop.
1987	6250	8127	0.565	144	141	0.495	2776	2718	0.495	3329	5268	0.613
1988	4023	5473	0.576	181	259	0.588	1151	1681	0.594	2691	3533	0.568
1989	1992	3317	0.625	277	195	0.413	1143	1104	0.491	572	2018	0.779
1990	1550	1065	0.407	183	123	0.403	527	347	0.397	840	595	0.414
1991	1405	1223	0.465	446	324	0.421	639	443	0.410	321	457	0.587
1992	1636	2725	0.625	396	329	0.454	457	716	0.610	782	1679	0.682
1993	1216	2241	0.648	206	201	0.494	301	613	0.671	710	1426	0.668
1994	902	3472	0.794	7	15	0.666	222	873	0.797	673	2584	0.793
1995	851	2163	0.718	189	247	0.566	176	361	0.673	486	1555	0.762
1996	351	1533	0.814	149	223	0.600	87	413	0.826	115	897	0.887
1997	440	1952	0.816	117	402	0.775	95	313	0.767	227	1237	0.845
1998	1375	2383	0.634	181	450	0.713	377	495	0.567	817	1438	0.638
1999	881	2823	0.762	144	494	0.774	160	654	0.803	577	1676	0.744
2000	505	1866	0.787	120	473	0.797	117	385	0.766	267	1007	0.790
2001	297	1117	0.790	110	350	0.761	30	189	0.863	158	578	0.786
2002	301	1661	0.847	95	549	0.853	39	269	0.873	167	843	0.835
2003	691	3285	0.826	347	697	0.668	120	790	0.868	224	1798	0.889
2004	560	3700	0.869	165	835	0.835	165	1029	0.862	229	1836	0.889
2005	799	3571	0.817	366	810	0.689	194	1054	0.844	239	1706	0.877
2006	672	3142	0.824	243	740	0.753	238	1414	0.856	190	989	0.838
2007	779	3237	0.806	285	590	0.674	379	1743	0.821	114	903	0.888
2008	709	3108	0.814	171	547	0.762	351	1414	0.801	187	1147	0.860
2009	756	3657	0.829	283	919	0.765	304	1700	0.849	170	1038	0.859
2010	748	3000	0.800	292	757	0.721	347	1477	0.810	108	766	0.876
2011	842	2577	0.754	488	917	0.653	288	1351	0.824	66	308	0.825
2012	785	2455	0.758	443	758	0.631	252	1038	0.805	91	659	0.879
2013	531	1889	0.781	211	493	0.700	218	972	0.817	101	425	0.807
2014	767	2771	0.783	121	330	0.732	371	1344	0.784	275	1096	0.800
2015	427	2761	0.87	54	326	0.86	274	1384	0.83	99	1051	0.91
2016	585	2395	0.80	88	367	0.81	321	972	0.75	176	1056	0.86
2017	387	1384	0.78	60	174	0.74	193	629	0.76	134	581	0.81
2018	237	1276	0.84	124	417	0.77	59	468	0.89	53	391	0.88
2019*	338	1812	0.84	151	476	0.76	46	449	0.91	142	887	0.86
2020*	132	1488	0.92	-	-	-	33	372	0.92	81	829	0.91

*Preliminary data

Table 9. Percentage of Greenland halibut catches covered by at-sea observers in the directed Greenland halibut gillnet fishery by combinations of NAFO unit areas. Weighting factor used to scale the at-sea observer coverage to the total fishing effort of the fleet.

Sector	Western Gulf				North Anticosti	Esquiman
	4Tp 4Tq	4Sz	4Si 4Ss 4Sy	4Tk 4Tn 4To	4Ss 4Sv 4Sx 4Sy	4R 4Rb 4Rc 4Sv
2000	18.33	8.83	3.41	11.52	-	2.62
2001	14.26	4.01	1.35	5.75	1.98	1.11
2002	17.50	5.46	3.31	14.81	-	1.75
2003	16.75	14.53	10.04	10.73	-	2.52
2004	3.47	7.23	4.79	5.53	-	0.39
2005	3.28	5.80	3.75	4.48	-	3.03
2006	4.60	4.90	3.19	4.20	5.26	3.99
2007	5.78	3.32	5.28	6.55	-	2.89
2008	5.23	1.32	4.97	6.80	25.16	5.84
2009	3.45	7.07	4.93	4.20	3.18	1.38
2010	3.66	4.02	6.32	4.54	4.75	4.78
2011	1.67	4.42	3.09	6.38	5.56	5.52
2012	2.71	3.69	4.28	7.46	13.79	10.80
2013	6.34	5.43	6.66	4.54	11.43	2.88
2014	5.84	13.07	8.04	5.78	13.54	3.12
2015	5	12	10	4	-	0
2016	6	8	9	4	-	1
2017	5	9	7	5	-	2
2018	7	9	4	6	11	4
2019*	3	4	2	5	8	2
2020*	2	7	1	4	8	-

*Preliminary data

Table 10. Cumulative distribution of Greenland halibut catches (percentile) from the nGSL survey by depth and temperature.

Centile	Depth (m)	Temperature (°C)
5	208	4.0
10	229	4.4
25	256	4.9
50	301	5.3
75	332	5.5
90	366	5.7
95	387	5.8

Table 11. Bycatch (t) and ratio (%) of bycatch to total catch of Greenland halibut by year and area for all species combined.

Sector	Bycatch (t)				Ratio (%)			
	West Gulf	North Anticosti	Esquiman	4RST	West Gulf	North Anticosti	Esquiman	4RST
2000	210	-	71	281	37.2	-	13.1	25.4
2001	176	19	37	232	63.8	44.2	8.7	31.1
2002	143	-	18	161	29.8	-	3.1	15.1
2003	176	-	65	241	13.5	-	5.2	9.5
2004	488	-	107	595	18.9	-	8.4	15.4
2005	423	-	20	442	15.4	-	-	15.4
2006	317	29	67	414	13.7	11.1	6.2	11.3
2007	310	-	191	500	11.7	-	17.4	13.4
2008	252	62	322	637	10.2	37.7	29.2	17.0
2009	280	46	21	346	11.5	8.6	1.5	7.9
2010	275	113	84	472	13.6	16.76	6.2	11.7
2011	247	86	74	408	17.6	17.9	3.7	10.5
2012	234	101	274	609	17.3	19.4	15.0	16.5
2013	299	155	231	685	23.2	32.4	25.4	25.6
2014	325	23	177	525	10.8	21.0	32.0	14.3
2015	239	0	185	425	7.5	-	36.5	11.5
2016	258	0	242	500	8.5	-	30.8	13.1
2017	604	0	234	837	35.2	-	85.8	42.1
2018	347	73	104	523	38.3	32.5	16.6	29.8
2019*	388	63	41	492	43.9	7.0	23.9	388
2020*	347	37	-**	384	15.4	-**	31.6	347
Mean 2000-2019	303	38	136	478	25.0	21.0	19.0	303

*Preliminary data

Table 12. Average Occurrence and bycatch for the period 2000 to 2018 and for the years 2019 and 2020.

	Occurrence (%)			Catch (kg)		
Taxon	2000-2018	2019	2020	2000-2018	2019	2020
Greenland halibut	99.7	100.0	100.0	3 053 350	2 055 841	1 213 400
American plaice	76.8	82.0	81.3	44 795	72 538	61 761
Redfishes	59.5	95.3	70.6	26 741	59 457	23 781
Snow crab	59.4	29.0	18.7	66 115	15 334	9 113
Thorny skate	50.3	71.4	66.3	61 743	76 079	33 877
Norway king crab	48.7	38.4	28.9	23 475	13 395	6 866
Atlantic halibut	48.4	53.7	41.2	104 585	93 909	40 652
Skates	40.5	31.0	37.4	44 936	17 874	35 659
Witch flounder	37.5	86.3	81.8	7 960	37 833	32 267
Anthozoan	25.0	52.2	36.9	6 045	7 956	6 721
Atlantic cod	19.9	11.0	9.6	17 811	18 486	1 945
Monkfish	18.5	27.8	43.3	6 750	6 205	12 590
White hake	17.7	54.5	57.8	8 080	19 202	15 175
Smooth skate	15.0	17.3	10.7	8 453	11 144	1 231
Black dogfish	13.0	7.5	16.6	23 954	1 229	91 298
Sea stars	8.4	16.5	8.0	1 193	1 259	330
Atlantic hagfish	7.6	11.4	8.6	722	823	713
Scyphozoans	6.9	20.4	19.8	1 246	4 557	1 326
Spiny dogfish	5.8	1.2	0.5	4 851	117	47
Sea pen	5.4	22.7	22.5	580	1 542	2 217
Silver hake	4.5	18.4	10.7	647	1 357	974
Skate eggs	3.4	10.6	4.8	266	689	285
Sea star	2.9	2.4	5.3	321	177	873
Sculpins	1.9	0.0	0.0	425	0	0
Wrymouth	1.9	5.5	0.5	538	575	233
Winter flounder	1.9	0.8	0.0	625	116	0
Atlantic herring	1.8	1.6	0.0	705	116	0
Whelks	1.6	5.9	0.0	132	414	0
Sponges	1.2	7.5	4.3	114	533	160
Righteye flounders	1.0	0.0	0.0	583	0	0
Longfin hake	0.9	5.5	3.2	127	3 461	1 931
Sea raven	0.9	1.2	0.5	196	67	25
American lobster	0.8	3.9	3.7	101	992	320
Sharks	0.7	0.8	0.0	8 574	375	0
Northern shrimp	0.7	0.0	0.0	134	0	0
Lumpfish	0.6	0.0	0.0	49	0	0
Eelpouts	0.6	0.0	0.0	92	0	0
Brittle stars	0.5	2.0	4.3	45	120	377
Toad crabs	0.5	1.6	0.0	96	65	0

Taxon	Occurrence (%)			Catch (kg)		
	2000-2018	2019	2020	2000-2018	2019	2020
Grenadiers	0.4	1.2	2.7	39	83	273
Sea peach	0.4	0.0	0.0	73	0	0
Crabs	0.4	0.0	0.0	66	0	0
Yellowtail flounder	0.4	0.4	0.0	161	250	0
Finfishes (ns)	0.4	0.0	0.0	318	0	0
Pollock	0.3	0.4	1.1	95	92	122
Marlin-spike	0.3	1.2	0.0	26	147	0
Haddock	0.3	0.0	0.5	42	0	94
Squids	0.3	0.0	1.1	19	0	50
Atlantic mackerel	0.3	0.8	0.5	31	63	117
Sea cucumbers	0.3	0.0	0.0	27	0	0
Comb jellies	0.2	0.0	0.0	9	0	0
Porbeagle	0.2	0.0	0.0	2 227	0	0
Eels	0.2	0.0	0.0	58	0	0
Spotted wolffish	0.2	0.0	0.0	65	0	0
Harbour porpoise	0.2	0.0	0.0	965	0	0
Sea urchins	0.2	0.0	0.5	10	0	47
Sea spiders	0.1	1.2	0.0	15	70	0
Purple sunstar	0.1	0.0	0.0	55	0	0
Greenland cod	0.1	0.0	0.0	34	0	0
Blue mussel	0.1	0.0	0.0	5	0	0
Gannet	0.1	0.0	0.0	28	0	0
Arctic cod	0.1	0.0	0.0	22	0	0
Shads	0.1	0.0	0.0	19	0	0
Blue shark	0.1	0.0	0.0	807	0	0
Atlantic wolffish	0.1	2.7	0.0	95	652	0
Alewife	0.1	0.0	0.0	11	0	0
Decapods	0.1	0.0	0.0	7	0	0
Basket stars	0.1	0.4	0.5	12	42	25
North atlantic octopus	0.1	0.0	0.0	7	0	0
Mud star	0.1	3.1	0.0	8	228	0
Sea potato	0.1	0.0	0.0	17	0	0
Capelin	0.1	0.0	0.0	5	0	0
Common sunstar	0.0	0.0	0.0	5	0	0
Fourbeard rockling	0.0	0.0	0.0	4	0	0
Greenland shark	0.0	0.0	0.0	1 194	0	0
Dogfishes	0.0	0.0	0.0	14	0	0
Waved whelk eggs	0.0	0.8	0.0	3	58	0
Molluscs	0.0	0.0	0.0	3	0	0
Gull, larus sp.	0.03	0.00	0.00	2	0	0
Harp seal	0.03	0.39	0.00	167	2 860	0

	Occurrence (%)			Catch (kg)		
Taxon	2000-2018	2019	2020	2000-2018	2019	2020
Seals	0.03	0.00	0.00	232	0	0
Incirrata octopuses	0.03	0.00	0.54	2	0	25
Northern pipefish	0.03	0.00	0.00	14	0	0
Atlantic argentine	0.02	0.00	0.00	3	0	0
Basking shark	0.02	0.39	0.00	692	17 820	0
Blood star	0.02	0.00	0.00	1	0	0
Fulmar, northern (noddy)	0.02	0.00	0.00	1	0	0
Dolphin	0.02	0.00	0.00	85	0	0
Blue whiting	0.02	0.00	0.00	3	0	0
Atlantic salmon	0.01	0.00	0.00	2	0	0
Blueback herring	0.01	0.00	0.00	2	0	0
Shrimp	0.01	0.00	0.00	2	0	0
Gull, herring	0.01	0.00	0.00	1	0	0
Kittiwake, black-legged	0.01	0.00	0.00	2	0	0
Alcids	0.01	0.00	0.00	15	0	0
Atlantic sturgeon	0.01	0.00	0.00	26	0	0
Longfin snailfish	0.01	0.00	0.00	2	0	0
Crustaceans	0.01	0.00	0.00	1	0	0
Isopods	0.01	0.00	0.00	0	0	0
Balanidae	0.01	0.00	0.00	1	0	0
Northern wolffish	0.01	0.00	0.00	8	0	0
Atl. white sided dolphin	0.01	0.00	0.00	62	0	0
Barnacles	0.01	0.39	0.00	1	29	0
Polychaetes	0.01	0.78	0.00	0	50	0
Northern moonsnail	0.01	0.00	0.00	0	0	0
Heart urchin	0.01	0.00	0.00	1	0	0
Windowpane	0.01	0.00	0.00	1	0	0
Whales	0.01	0.00	0.00	71	0	0
Mussels	0.01	0.00	0.00	1	0	0
Stimpson's surf clam	0.01	0.00	0.00	0	0	0
Striped bass	0.01	0.39	0.00	1	554	0
American shad	0.01	0.00	0.00	1	0	0
Pandalids	0.01	0.00	0.00	0	0	0

Table 13. Estimated Greenland halibut bycatch in number and weight by shrimpers in the GSL. abundance and biomass (Survey) of Greenland halibut less than 31 cm estimated in the DFO nGSL survey. and ratio (Ratio %) of bycatch to survey estimate.

Year	Number (x1000)		Weight (t)		Ratio (%)	
	Bycatch	Survey	Bycatch	Survey	N	Weight
2000	2,281	422,177	123	42,439	0.54	0.29
2001	831	267,550	87	31,954	0.31	0.27
2002	1,577	203,433	104	19,048	0.78	0.55
2003	1,099	457,484	92	55,438	0.24	0.17
2004	642	152,257	62	21,968	0.42	0.28
2005	1,241	211,082	41	13,699	0.59	0.30
2006	1,135	271,862	83	35,617	0.42	0.23
2007	1,275	210,047	83	19,560	0.61	0.42
2008	2,130	270,492	122	25,755	0.79	0.47
2009	834	187,252	66	20,672	0.45	0.32
2010	841	163,592	72	20,005	0.51	0.36
2011	2,323	300,873	84	20,365	0.77	0.41
2012	508	266,470	51	34,176	0.19	0.15
2013	2,750	199,356	95	12,317	1.37	0.77
2014	3,812	415,041	117	28,787	0.92	0.41
2015	2,552	461,880	132	39,432	0.56	0.34
2016	2,339	237,130	133	30,755	1.01	0.43
2017	1,403	160,799	109	22,336	0.87	0.49
2018	2,147	197,051	76	13,750	1.09	0.55
2019*	6,723	287,457	212	17,980	2.34	1.18
2020**	1,372	274,432	73	34,210	0.5	0.21

*Data from the at-sea observer program are preliminary
**No data for the Estuary.

Table 14a. Mean number and mean weight per 15-minute tow observed in the DFO nGSL survey for Greenland halibut and the 95% confidence interval (C.I.).

Year	Number/tow		Weight (kg)/tow	
	Mean	C.I. 95%	Mean	C.I. 95%
1990	18.9	(14.2 - 23.6)	4.3	(3.6 - 5)
1991	31.4	(25.7 - 37.1)	7.6	(6.1 - 9.1)
1992	31.1	(25 - 37.2)	7.9	(6.4 - 9.4)
1993	12.1	(8.5 - 15.7)	4.0	(3 - 4.9)
1994	20.7	(15.9 - 25.6)	7.2	(5.6 - 8.9)
1995	18.8	(15.1 - 22.5)	8.6	(6.8 - 10.4)
1996	31.4	(23.7 - 39.1)	10.8	(6.9 - 14.7)
1997	38.3	(29.1 - 47.5)	11.8	(10.2 - 13.4)
1998	61.7	(50.7 - 72.7)	11.3	(9.8 - 12.7)
1999	68.4	(60.6 - 76.1)	17.0	(15.2 - 18.7)
2000	136.7	(118.3 - 155.1)	30.0	(25.4 - 34.6)
2001	113.7	(89.5 - 137.8)	27.4	(21.7 - 33)
2002	77.3	(66.3 - 88.4)	21.6	(18.1 - 25.1)
2003	162.7	(137.1 - 188.3)	49.8	(42.1 - 57.5)
2004	75.5	(61.6 - 89.5)	30.9	(24.6 - 37.2)
2005	90.4	(81.5 - 99.4)	29.3	(26.8 - 31.8)
2006	93.0	(78.9 - 107.1)	31.8	(28 - 35.6)
2007	95.5	(79.7 - 111.4)	33.0	(26.9 - 39.2)
2008	101.7	(87.4 - 116.1)	31.2	(25.5 - 36.9)
2009	67.6	(55.1 - 80.1)	21.3	(18 - 24.6)
2010	73.1	(61.5 - 84.7)	26.7	(22.6 - 30.9)
2011	97.7	(82.2 - 113.3)	25.5	(22.3 - 28.7)
2012	89.5	(74.3 - 104.7)	25.3	(22.3 - 28.3)
2013	74.2	(63.1 - 85.4)	20.0	(16.2 - 23.8)
2014	110.1	(93.8 - 126.3)	24.2	(20.1 - 28.4)
2015	120.6	(94.1 - 147.2)	24.7	(21.4 - 27.9)
2016	77.6	(62 - 93.2)	23.1	(18.5 - 27.7)
2017	59.5	(47.3 - 71.7)	17.1	(14.4 - 19.8)
2018	62.4	(45.6 – 79.1)	15.0	(12.7 – 17.3)
2019	78.0	(64.2 – 91.8)	14.2	(12.1 – 16.2)
2020	83.9	(67.9 – 99.8)	20.4	(16.7 – 24.1)

Table 14b. Mean number and mean weight per 30-minute tow observed in the DFO sGSL survey for Greenland halibut and the 95% confidence interval.

Year	Number/tow		Weight (kg)/tow	
	Mean	C.I. 95%	Mean	C.I. 95%
1971	0.1	(0 - 0.1)	0.1	(0 - 0.2)
1972	0.0	(0 - 0.1)	0.0	(0 - 0.1)
1973	0.1	(0 - 0.1)	0.1	(0 - 0.2)
1974	0.3	(0.2 - 0.3)	0.0	(0 - 0)
1975	0.3	(0.2 - 0.4)	0.2	(0.1 - 0.3)
1976	0.5	(0.3 - 0.7)	0.3	(0.1 - 0.4)
1977	0.4	(0.3 - 0.5)	0.5	(0.4 - 0.7)
1978	0.3	(0.2 - 0.4)	0.6	(0.3 - 0.8)
1979	0.2	(0.1 - 0.2)	0.3	(0.2 - 0.4)
1980	0.1	(0.1 - 0.1)	0.2	(0.1 - 0.2)
1981	0.0	(0 - 0)	0.1	(0 - 0.1)
1982	0.3	(0.2 - 0.4)	0.3	(0.2 - 0.4)
1983	0.7	(0.4 - 1.1)	0.2	(0.1 - 0.3)
1984	0.3	(0.2 - 0.5)	0.2	(0.2 - 0.2)
1985	1.5	(1 - 2)	0.9	(0.7 - 1.2)
1986	2.4	(1.7 - 3.1)	2.0	(1.4 - 2.5)
1987	1.9	(1.3 - 2.4)	1.4	(1 - 1.8)
1988	0.7	(0.5 - 0.8)	0.7	(0.6 - 0.7)
1989	0.2	(0.1 - 0.3)	0.2	(0.1 - 0.2)
1990	1.1	(0.8 - 1.4)	0.6	(0.4 - 0.9)
1991	1.2	(0.8 - 1.6)	0.5	(0.3 - 0.6)
1992	2.0	(1.6 - 2.5)	1.0	(0.9 - 1.2)
1993	2.9	(2.1 - 3.8)	1.6	(1.1 - 2)
1994	2.6	(2 - 3.3)	1.2	(0.8 - 1.5)
1995	2.8	(1.9 - 3.8)	1.9	(1.3 - 2.5)
1996	2.9	(2.1 - 3.7)	1.8	(1.3 - 2.3)
1997	2.6	(2.1 - 3.1)	1.9	(1.6 - 2.3)
1998	13.3	(11.5 - 15.2)	4.1	(3.3 - 4.9)
1999	10.5	(8.3 - 12.8)	3.4	(2.7 - 4.1)
2000	20.1	(16.4 - 23.9)	7.4	(6.1 - 8.7)
2001	18.8	(13.6 - 24)	7.5	(5.4 - 9.6)
2002	16.2	(12.4 - 20)	6.1	(4.3 - 7.9)
2003	19.2	(13.9 - 24.5)	11.5	(7.6 - 15.3)
2004	10.9	(8.8 - 13.1)	6.5	(5.2 - 7.8)
2005	23.3	(17.6 - 28.9)	13.0	(9.5 - 16.6)
2006	12.9	(10.8 - 14.9)	6.3	(5.1 - 7.5)
2007	19.2	(14.8 - 23.6)	10.2	(7.4 - 13)
2008	22.3	(17.8 - 26.8)	10.7	(8.5 - 12.9)
2009	10.9	(8.4 - 13.4)	4.9	(3.7 - 6.2)
2010	15.4	(12.7 - 18.1)	7.8	(6.3 - 9.4)
2011	17.5	(14.1 - 20.9)	9.1	(6.6 - 11.6)

Year	Number/tow		Weight (kg)/tow	
	Mean	C.I. 95%	Mean	C.I. 95%
2012	10.7	(8.3 - 13.2)	5.1	(3.6 - 6.7)
2013	11.0	(9.1 - 12.8)	4.5	(3.3 - 5.7)
2014	7.0	(4.9 - 9.1)	3.5	(2.2 - 4.8)
2015	7.1	(5.7 - 8.5)	3.4	(2.6 - 4.1)
2016	7.5	(6 - 9.1)	3.1	(2.4 - 3.7)
2017	7.0	(5.7 - 8.2)	3.0	(2.4 - 3.5)
2018	5.0	(3.7 - 6.3)	1.9	(1.4 - 2.4)
2019	4.8	(4.0 – 5.7)	1.5	(1.0 – 2.0)
2020	8.9	(6.0 – 11.9)	2.7	(2.0 – 3.6)

Table 15. Mean number and mean weight per 30-minute tow observed in the MSP survey for Greenland halibut and the 95% confidence interval.

Year	Number/tow		Weigth (kg)/tow	
	Mean	C.I. 95%	Mean	C.I. 95%
1995	4.2	(3 - 5.3)	2.3	(1.7 - 2.9)
1996	7.3	(5.4 - 9.1)	4.8	(3.5 - 6.1)
1997	7.9	(6.5 - 9.3)	4.6	(3.8 - 5.4)
1998	10.7	(8.8 - 12.5)	6.2	(5.1 - 7.2)
1999	17.3	(14.2 - 20.4)	7.2	(6 - 8.4)
2000	22.9	(13.9 - 32)	7.3	(3.3 - 11.3)
2001	16.2	(12.5 - 19.8)	6.3	(5.1 - 7.5)
2002	12.0	(8.3 - 15.8)	6.0	(4.2 - 7.7)
2003	17.2	(14.8 - 19.6)	8.0	(6.9 - 9.1)
2004	16.8	(14.4 - 19.3)	9.3	(7.8 - 10.7)
2005	23.5	(16.6 - 30.3)	13.2	(9.7 - 16.7)
2006	21.6	(18.2 - 25)	11.4	(9.9 - 12.8)
2007	24.2	(20 - 28.4)	13.5	(11.1 - 15.9)
2008	23.3	(19.4 - 27.1)	12.1	(10.6 - 13.5)
2009	12.4	(10.5 - 14.2)	7.3	(6.3 - 8.3)
2010	15.4	(13.4 - 17.4)	9.1	(8 - 10.3)
2011	8.7	(6.8 - 10.5)	5.4	(4.3 - 6.5)
2012	9.5	(7.6 - 11.3)	5.3	(4.4 - 6.3)
2013	7.6	(5.9 - 9.3)	4.2	(3.2 - 5.2)
2014	13.3	(10.8 - 15.9)	8.6	(7.2 - 10)
2015	10.0	(8.2 - 11.7)	5.3	(4.5 - 6.1)
2016	6.2	(4.3 - 8)	4.0	(3.2 - 4.8)
2017	7.6	(5.8 - 9.3)	3.6	(2.9 - 4.3)
2018	4.7	(3.6 - 5.8)	2.8	(2.8 - 3.4)
2019	6.2	(4.8 – 7.7)	2.7	(2.0 - 3.5)
2020	9.3	(7.3 – 11.4)	4.0	(3.1 - 4.8)

Table 16. Mean number per 15-minute tow observed in the DFO nGSL survey for different size categories of Greenland halibut.

Year	Number/tow			
	0 – 20 cm	20 – 30 cm	30 - 40 cm	> 40 cm
1990	11.04	4.00	1.94	1.89
1991	6.89	16.79	4.90	2.75
1992	5.69	9.94	13.60	1.88
1993	0.41	4.41	5.56	1.73
1994	3.19	2.59	10.08	3.31
1995	3.08	3.76	5.16	6.73
1996	13.65	3.96	5.79	7.94
1997	8.78	15.34	6.53	7.57
1998	42.13	4.83	9.38	5.34
1999	7.18	43.84	9.32	8.45
2000	47.50	24.78	56.07	8.43
2001	16.12	35.64	51.93	8.54
2002	24.77	12.68	32.12	7.75
2003	31.79	54.07	54.55	22.32
2004	5.52	20.20	33.78	16.08
2005	33.15	8.23	30.93	18.15
2006	12.90	39.23	21.89	18.96
2007	21.11	17.24	37.52	18.76
2008	26.78	25.59	31.34	18.02
2009	11.36	24.27	20.57	11.36
2010	9.35	19.18	30.25	14.27
2011	42.00	16.29	25.61	13.83
2012	3.90	46.66	23.21	15.75
2013	32.61	5.11	26.49	10.02
2014	54.01	28.78	11.20	16.07
2015	32.40	56.97	19.16	12.10
2016	6.04	37.36	24.23	9.95
2017	6.87	21.18	25.15	5.95
2018	27.26	9.81	18.86	6.34
2019	41.52	16.48	15.04	5.34
2020	9.16	43.68	24.60	5.72

Table 17. Mean number per 30-minute tow observed during the MSP survey for different size classes of Greenland halibut.

Year	Number/tow			
	0 – 20 cm	20 – 30 cm	30 - 40 cm	> 40 cm
1995	0.38	1.04	0.99	1.74
1996	0.75	0.93	2.09	3.47
1997	0.03	2.66	1.44	3.75
1998	1.46	0.90	4.16	4.11
1999	0.64	7.71	3.61	5.32
2000	4.67	4.87	10.03	3.38
2001	1.11	4.84	7.61	2.51
2002	1.02	2.14	5.66	3.23
2003	0.24	4.64	6.88	5.42
2004	0.37	2.50	8.35	5.65
2005	2.18	1.82	11.62	7.73
2006	1.07	7.24	4.95	8.30
2007	0.60	2.81	11.98	8.80
2008	1.89	4.19	8.69	8.49
2009	0.45	2.27	4.43	5.19
2010	0.25	2.29	6.86	5.95
2011	0.66	1.03	3.25	3.73
2012	0.03	2.19	3.59	3.64
2013	1.14	0.55	3.12	2.82
2014	0.99	2.79	2.93	6.64
2015	0.73	3.25	2.09	3.90
2016	0.07	1.42	2.23	2.45
2017	0.38	2.04	3.16	1.97
2018	0.24	0.60	2.44	1.51
2019	0.84	1.49	2.23	1.69
2020	0.69	3.08	3.52	2.03

Table 18. Annual landing and biomass of Greenland halibut > 40 cm and relative exploitation rate for the Gulf (4RST) and, by fishing sector.

4RST

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
1996	1,811	34,994	5.18
1997	2,456	34,239	7.17
1998	3,765	23,462	16.05
1999	3,254	33,852	9.61
2000	1,973	33,869	5.83
2001	1,175	28,804	4.08
2002	1,450	30,522	4.75
2003	3,462	87,143	3.97
2004	3,775	65,736	5.74
2005	3,871	71,870	5.39
2006	3,573	76,437	4.67
2007	3,762	74,926	5.02
2008	3,518	68,668	5.12
2009	4,244	46,960	9.04
2010	3,970	58,836	6.75
2011	3,650	55,939	6.53
2012	3,504	56,109	6.24
2013	2,474	39,192	6.31
2014	3,454	66,308	5.21
2015	3,425	54,935	6.23
2016	3,286	45,559	7.21
2017	1,720	25,445	6.76
2018	1,572	27,509	5.71
2019*	1,845	22,143	8.33
2020*	1,452	24,515	5.92

Western Gulf

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
1996	1,488	23,651	6.29
1997	1,905	22,448	8.49
1998	2,893	14,845	19.49
1999	2,555	19,467	13.13
2000	1,360	20,788	6.54
2001	727	14,724	4.94
2002	793	18,031	4.40
2003	2,167	49,939	4.34
2004	2,526	35,177	7.18
2005	2,562	38,380	6.67
2006	2,225	38,231	5.82
2007	2,538	35,592	7.13
2008	2,371	39,057	6.07
2009	2,282	21,909	10.42
2010	1,927	27,214	7.08
2011	1,290	22,430	5.75
2012	1,262	30,014	4.20
2013	1,144	18,065	6.33
2014	2,851	44,458	6.41
2015	2,937	39,159	7.50

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
2016	2,723	29,233	9.32
2017	1,500	14,542	10,31
2018	809	15,978	5,06
2019*	1,181	14,187	8,32
2020*	908	16,033	5,66

North Anticosti

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
1997	2	3,073	0.07
1998	52	1,482	3.48
1999	113	3,031	3.71
2000	74	2,941	2.51
2001	45	619	7.26
2002	90	4,186	2.14
2003	67	3,359	2.01
2004	13	3,329	0.40
2005	6	6,636	0.09
2006	259	9,553	2.71
2007	133	7,188	1.85
2008	162	4,658	3.48
2009	527	5,203	10.13
2010	672	10,650	6.31
2011	475	7,765	6.12
2012	499	7,155	6.97
2013	436	7,117	6.12
2014	106	4,427	2.39
2015	0	3,982	0.00
2016	5	2,721	0.20
2017*	5	3,744	0.13
2018*	210	3,673	5.71
2019*	128	1,607	7.98
2020*	232	2,391	9.70

Esquiman

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
1996	315	2,835	11.11
1997	546	2,847	19.18
1998	746	2,313	32.24
1999	581	4,554	12.75
2000	537	2,622	20.47
2001	397	5,598	7.10
2002	562	2,508	22.42
2003	1,226	13,101	9.36
2004	1,234	11,279	10.94
2005	1,297	16,023	8.09
2006	1,083	15,898	6.81
2007	1,091	13,022	8.38
2008	980	9,964	9.84
2009	1,435	11,246	12.76
2010	1,360	11,914	11.41

Year	Landing (t)	Biomass (t)	Exploitation rate (%)
2011	1,879	16,823	11.17
2012	1,741	10,243	17.00
2013	893	4,158	21.47
2014	495	6,546	7.56
2015	488	4,338	11.25
2016	557	2,598	21.42
2017	211	2,213	9.52
2018	551	3,274	16.83
2019*	535	2,054	26.07
2020*	310	560	55.41

*Landings data are preliminary

Table 19. Annual Fulton condition index for 15, 25, 35, and, 45 cm Greenland halibut estimated with DFO nGSL survey data.

Year	Condition index			
	15 cm	25 cm	35 cm	45 cm
1990	0.77	0.78	0.85	0.91
1991	0.77	0.78	0.82	0.88
1992	0.80	0.78	0.82	0.88
1993	0.76	0.76	0.84	0.91
1994	0.78	0.76	0.81	0.88
1995	0.71	0.75	0.84	0.93
1996	0.77	0.78	0.85	0.93
1997	0.76	0.78	0.84	0.93
1998	0.74	0.78	0.87	0.94
1999	0.73	0.75	0.81	0.89
2000	0.70	0.75	0.82	0.89
2001	0.74	0.76	0.83	0.89
2002	0.74	0.78	0.85	0.90
2003	0.75	0.78	0.84	0.92
2004	0.76	0.78	0.84	0.91
2005	0.75	0.78	0.85	0.92
2006	0.72	0.77	0.84	0.90
2007	0.75	0.76	0.83	0.90
2008	0.72	0.76	0.83	0.89
2009	0.71	0.76	0.83	0.90
2010	0.74	0.78	0.84	0.90
2011	0.70	0.77	0.84	0.90
2012	0.74	0.76	0.82	0.89
2013	0.72	0.76	0.84	0.90
2014	0.70	0.77	0.85	0.93
2015	0.69	0.74	0.82	0.91
2016	0.71	0.75	0.81	0.90
2017	0.76	0.75	0.80	0.87
2018	0.74	0.77	0.82	0.89
2019	0.72	0.76	0.81	0.89
2020	0.74	0.77	0.83	0.91

Table 20. Number of Greenland halibut stomachs according to the different period investigated. Information on the size of the fish from which the stomachs were obtained as well as information on the total stomach contents after removal of waste, parasites and empty stomachs are provided.

Parameter		2004-09	2015-19	2020	Total
	Nb. of stomachs	5,470	2,650	680	8,800
	Nb. of empty stomachs	2,592	1,434	403	4,429
	% empty stomachs	47	54	59	50
	TFI*	0.14	0.21	0.15	0.16
Length (mm)	Min	56	63	120	56
	Median	354	309	297	340
	Mean	344	319	319	335
	Max	700	767	675	767
Total stomach content (g)	Min	0.002	0.001	0,002	0,001
	Median	1.47	1.49	1,89	1,50
	Mean	5.1	7.1	7,73	5,82
	Max	363	317	162	363

*TFI = Total fullness index

Table 21. Summary of the sampling effort for Greenland halibut stomachs according to the different length classes considered in the study. A description of the length of the fish from which the stomachs were obtained is provided as well as the weight of the total stomach contents after removal of waste, parasites and empty stomachs.

Parameter		<20	[20-30]	[30-40]	>40
	Nb. of stomachs	1,430	2,069	2,635	2,666
	Nb. of empty stomachs	514	1,183	1,434	1,298
	% empty stomachs	36	57	54	49
	TFI*	0.33	0.17	0.10	0.12
Length (mm)	Min	56	200	300	401
	Median	169	262	355	452
	Mean	167	259	353	466
	Max	199	299	400	767
Total stomach content (g)	Min	0.001	0.002	0.001	0.002
	Median	0.54	1.22	1.67	5.03
	Mean	0.86	2.70	4.02	12.74
	Max	9.2	185.3	61.8	363.2

*TFI = Total fullness index

Table 22. Summary of the sampling effort for Greenland halibut stomachs according to the different regions considered in the study. A description of the length of the fish from which the stomachs were obtained is provided. The same is true for the total stomach contents after removal of waste, parasites and empty stomachs.

Parameter		**Estuary**	**Gulf**
Nb. of stomachs		1,497	7,303
Nb. of empty stomachs		606	3,823
% of empty stomachs		40.5	52.3
TFI*		0.16	0.16
Length (mm)	Min	121	56
	Median	298	350
	Mean	302.3	341.5
	Max	700	767
Total stomach content (g)	Min	0.001	0.001
	Median	0.75	1.89
	Mean	2.69	6.62
	Max	113	363

*TFI = Total fullness index

Table 23. Diet of Greenland halibut in the estuary and nGSL for the periods 2004-09, 2015-19, 2020 and, 2004-20. For each taxon found in the stomach contents. the frequency of occurrence (Focc), the contributions in mass (MC. as % of the mass of all taxa) and in fullness index (CTFI. as % of the TFI of all taxa) were calculated.

Prey	F_{occc}				MC				CTFI			
	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20
Winter skate (*Leucoraja ocellata*)	<1	-	-	<1	0.05	-	-	0.03	0.11	-	-	0.06
Atlantic hagfish (*Myxine glutinosa*)	-	<1	-	<1	-	1.1	-	0.37	-	0.26	-	0.1
Bony fish (*Actinopterygii*)	<1	-	-	<1	0.07	-	-	0.04	0.06	-	-	0.03
Atlantic herring (*Clupea harengus*)	<1	<1	<1	<1	10.08	5.33	4.07	7.96	2.57	1.09	1.87	1.94
Capelin (*Mallotus villosus*)	2.8	4.9	4.6	3.6	15.09	19.99	12.64	16.55	19.13	28.11	29.39	23.41
White barracudina (*Arctozenus risso*)	<1	<1	<1	<1	0.35	2.2	0.17	0.96	0.16	0.89	0.09	0.44
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	<1	-	0.01	-	<0.01	-	0.04	-	0.02
Codfish (*Gadidae*)	<1	<1	-	<1	0.1	<0.01	-	0.06	0.04	<0.01	-	0.02
Atlantic cod (*Gadus morhua*)	<1	<1	<1	<1	0.22	0.22	4.17	0.55	0.09	0.11	1.67	0.22
Silver rockling (*Gaidropsarus argentatus*)	<1	-	-	<1	0.03	-	-	0.02	0.02	-	-	0.01
Fourbeard rockling (*Enchelyopus cimbrius*)	<1	1.4	<1	<1	2.43	7.54	6.04	4.47	1.45	3.47	2.59	2.32
Marlin-spike (*Nezumia bairdii*)	<1	<1	-	<1	2.09	1.75	-	1.8	1.05	0.71	-	0.84
Mackrel (*Scomber scombrus*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Sand lance (*Ammodytidae*)	<1	-	-	<1	0.02	-	-	0.01	0.26	-	-	0.14
Sand lance (*Ammodytes sp.*)	-	2.2	-	<1	-	1.25	-	0.43	-	7.84	-	3.08
Shannie (*Lumpenus sp,*)	-	-	<1	<1	-	-	0.09	<0.01	-	-	0.17	0.01
Snakeblenny (*Lumpenus lampretaeformis*)	<1	-	-	<1	0.08	-	-	0.05	0.05	-	-	0.03
Daubed Shanny (*Leptoclinus maculatus)*	-	<1	<1	<1	-	0.02	0.1	0.01	-	0.04	0.18	0.03
Eelpout (*Zoarcidae*)	<1	-	-	<1	0.14	-	-	0.08	0.11	-	-	0.06
Eelpout (*Lycodes sp.*)	<1	-	-	<1	0.04	-	-	0.02	0.04	-	-	0.02
Atlantic soft pout (*Melanostigma atlanticum*)	3.9	1.5	-	2.9	1.74	0.63	-	1.21	2.54	0.67	-	1.62
Redfish (*Sebastes spp.*)	<1	4.8	1.2	2.1	4.32	33.21	14.74	15.03	1.59	8.12	3.56	4.3

Prey	Focc				MC				CTFI			
	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20
Sculpin (*Cottidae*)	-	<1	-	<1	-	0.16	-	0.05	-	0.04	-	0.01
Atlantic hookear sculpin (*Artediellus atlanticus*)	<1	-	-	<1	0.03	-	-	0.02	<0.01	-	-	<0.01
Sea tadpole (*Careproctus reinhardti*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Skate (*Rajidae*)	-	<1	-	<1	-	0.07	-	0.02	-	0.04	-	0.01
Flatfish (*Pleuronectiformes*)	<1	<1	-	<1	0.62	0.05	-	0.38	0.22	0.02	-	0.12
Righteye flounder (*Pleuronectidae*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
American plaice (*Hippoglossoides platessoides*)	-	<1	<1	<1	-	0.26	0.29	0.11	-	0.09	0.18	0.05
Witch flounder (*Glyptocephalus cynoglossus*)	-	<1	<1	<1	-	0.43	0.06	0.15	-	0.15	0.03	0.06
Greenland halibut (*Reinhardtius hippoglossoides*)	-	<1	<1	<1	-	0.8	8.02	0.95	-	0.43	1.27	0.26
Thorny skate (*Amblyraja radiata*)	-	<1	-	<1	-	0.15	-	0.05	-	0.04	-	0.02
Digested roundfish	2.6	4.4	1.8	3.1	8.23	5.89	5.64	7.22	8.21	7.62	5.56	7.79
Fish (spawn) egg	<1	<1	-	<1	0.05	0.32	-	0.14	0.04	0.7	-	0.3
Digested fish	9	3.8	9.3	7.4	10.54	1.75	9.19	7.44	10.15	2.86	13.19	7.51
Fishes. total	**18.2**	**23.3**	**18.8**	**19.8**	**56.33**	**83.13**	**65.24**	**66.2**	**47.9**	**63.35**	**59.74**	**54.83**
Digested shrimp	10.4	1.6	2.2	7.1	12.07	0.77	1.93	7.37	10.48	0.68	1.55	5.98
Scarlet sergestid (*Sergia robusta*)	-	<1	-	<1	-	0.04	-	0.01	-	0.04	-	0.02
Glass shrimp (*Pasiphaeidae*)	<1	-	-	<1	0.42	-	-	0.24	0.4	-	-	0.21
Pink glass shrimp (*Pasiphaea multidentata*)	3	2.6	3.5	2.9	3.67	1.8	3.18	2.99	4.11	3.46	4.89	3.91
Eualid (*Eualus sp.*)	<1	-	-	<1	<0.01	-	-	<0.01	0.02	-	-	0.01
Circumpolar eualid (*Eualus gaimardii*)	<1	-	-	<1	<0.01	-	-	<0.01	0.03	-	-	0.01
Friendly blade shrimp (*Spirontocaris liljeborgii*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Lebbeids (*Lebbeus sp.*)	<1	-	-	<1	<0.01	-	-	<0.01	0.01	-	-	<0.01
Polar lebbeid (*Lebbeus polaris*)	<1	-	-	<1	0.02	-	-	<0.01	<0.01	-	-	<0.01
Boreal red shrimps (*Pandalus sp.*)	<1	1	<1	<1	0.43	0.6	0.52	0.5	0.41	0.66	2.21	0.64
Northern shrimp (*Pandalus borealis*)	5.3	5	4	5.1	14.06	8.74	9.3	11.85	9.32	6.82	10.25	8.41
Striped pink shrimp (*Pandalus montagui*)	<1	<1	<1	<1	0.41	0.09	0.04	0.27	0.36	0.08	0.08	0.23

Prey	Focc				MC				CTFI			
	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20
Crangon shrimp (*Crangonidae*)	<1	-	-	<1	0.02	-	-	<0.01	<0.01	-	-	<0.01
Sars shrimp (*Sabinea sarsii*)	<1	-	<1	<1	<0.01	-	0.06	<0.01	<0.01	-	0.13	0.01
Norwegian shrimp (*Pontophilus norvegicus*)	-	<1	-	<1	-	0.06	-	0.02	-	0.03	-	0.01
Shrimps. total	**17.8**	**10**	**10.4**	**14.9**	**31.1**	**12.11**	**15.03**	**23.29**	**25.16**	**11.78**	**19.1**	**19.47**
Copepod (*Copepoda*)	-	<1	-	<1	-	<0.01	-	<0.01	-	0.01	-	<0.01
Calanoid copepod (*Calanoida*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Calanoid copepod (*Temora longicornis*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Calanoid copepod (*Paraeuchaeta norvegica*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Calanoid copepod (*Metridia lucens*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Amphipod (*Amphipoda*)	<1	-	<1	<1	0.08	-	<0.01	0.05	0.63	-	<0.01	0.34
Hyperiid (*Hyperiidae*)	1.6	<1	<1	1.1	0.78	<0.01	0.03	0.45	1.52	0.02	0.2	0.84
Hyperiids (*Themisto sp.*)	1.2	4.9	<1	2.3	0.47	0.43	0.05	0.42	1.27	4.02	0.34	2.28
Hyperiid (*Themisto abyssorum*)	<1	<1	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hyperiid (*Themisto compressa*)	<1	<1	<1	<1	<0.01	0.05	0.04	0.02	<0.01	0.75	0.05	0.3
Hyperiid (*Themisto libellula*)	1.9	2.2	1.3	1.9	1.2	0.29	0.3	0.81	3.41	2.44	3.19	3.01
Hyperiid (*Scina borealis*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Gammarid (*Gammaridea*)	<1	<1	-	<1	<0.01	<0.01	-	<0.01	0.01	0.09	-	0.04
Gammarid (*Byblis gaimardi*)	-	<1	-	<1	-	<0.01	-	<0.01	-	0.06	-	0.02
Gammarid (*Maera loveni*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Gammarid (*Tmetonyx cicada*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Gammarid (*Oedicerotidae*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Gammarid (*Wimvadocus torelli*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Gammarid (*Stegocephalus inflatus*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Mysid (*Mysidae*)	2	<1	-	1.3	0.15	<0.01	-	0.09	0.36	<0.01	-	0.2
Mysid (*Boreomysis sp.*)	<1	<1	<1	<1	0.05	0.03	<0.01	0.04	0.11	0.05	0.02	0.08
Mysid (*Boreomysis tridens*)	<1	-	-	<1	0.04	-	-	0.02	0.04	-	-	0.02

Prey	F_{occ}				MC				CTFI			
	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20
Mysid (*Boreomysis arctica*)	2.5	<1	<1	1.6	0.19	<0.01	0.02	0.11	0.41	<0.01	0.02	0.22
Mysid (*Boreomysis nobilis*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Mysid (*Mysis sp.*)	-	-	<1	<1	-	-	<0.01	<0.01	-	-	0.14	0.01
Mysid (*Mysis mixta*)	<1	-	-	<1	<0.01	-	-	<0.01	0.04	-	-	0.02
Euphausiid (*Euphausiacea*)	<1	-	-	<1	<0.01	-	-	<0.01	0.1	-	-	0.05
Euphausiid (*Euphausiidae*)	1.5	3.5	1.2	2.1	0.38	0.51	0.39	0.42	3.33	5.76	3.11	4.27
Northern krill (*Meganyctiphanes norvegica*)	<1	2.6	2.6	1.5	0.15	0.31	0.47	0.23	0.79	2.64	3.5	1.72
Euphausiid (*Thysanoessa sp.*)	<1	1.2	<1	<1	0.02	0.43	<0.01	0.16	0.14	2.99	0.01	1.25
Euphausiid (*Thysanoessa inermis*)	<1	<1	-	<1	0.02	<0.01	-	0.01	0.17	0.02	-	0.1
Arctic krill (*Thysanoessa raschii*)	<1	<1	<1	<1	<0.01	0.02	0.04	0.01	0.05	0.18	0.17	0.11
Zooplankton. total	**10.7**	**13.6**	**7.6**	**11.3**	**3.56**	**2.11**	**1.35**	**2.88**	**12.39**	**19.07**	**10.77**	**14.89**
Flatworm (*Platyhelminthes*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Mollusc (*Mollusca*)	-	<1	<1	<1	-	0.02	0.12	0.02	-	0.2	0.67	0.13
Gastropod (*Gastropoda*)	<1	-	-	<1	0.06	-	-	0.04	0.01	-	-	<0.01
Bivalve (*Bivalvia*)	<1	<1	-	<1	<0.01	<0.01	-	<0.01	<0.01	<0.01	-	<0.01
Cephalopod (*Cephalopoda*)	<1	-	-	<1	0.16	-	-	0.09	0.06	-	-	0.03
Bobtail (*Rossia sp.*)	-	<1	-	<1	-	0.22	-	0.07	-	0.17	-	0.07
Lesser bobtail squid (*Semirossia tenera*)	<1	-	-	<1	0.17	-	-	0.1	0.08	-	-	0.04
Squid (*Teuthida*)	<1	-	-	<1	0.27	-	-	0.15	0.08	-	-	0.04
Northern shortfin squid (*Illex illecebrosus*)	<1	<1	<1	<1	1.18	0.54	14.68	2.09	0.42	0.17	4.1	0.59
Polychaete (*Polychaeta*)	<1	<1	<1	<1	0.04	<0.01	0.01	0.02	<0.01	0.02	0.04	0.02
Crustacean (*Crustacea*)	13.8	3.7	6.6	10.2	3.37	0.45	0.57	2.14	9.01	2.34	3.85	6.01
Water Fleas (*Cladocera*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Cumacean (*Cumacea*)	-	<1	<1	<1	-	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01
Isopod (*Isopoda*)	<1	-	-	<1	0.02	-	-	<0.01	<0.01	-	-	<0.01
Isopod (*Syscenus infelix*)	<1	-	-	<1	0.04	-	-	0.02	0.03	-	-	0.02

Prey	Focc				MC				CTFI			
	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20	2004-09	2015-19	2020	2004-20
Crustacean decapod (*Decapoda*)	-	<1	<1	<1	-	<0.01	<0.01	<0.01	-	<0.01	0.05	<0.01
Echinoderm (*Echinodermata*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Sea urchin (*Echinoidea*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Mud heart urchin (*Brisaster fragilis*)	-	<1	-	<1	-	0.14	-	0.05	-	0.03	-	0.01
Brittle star (*Ophiuroidea*)	<1	<1	-	<1	0.01	<0.01	-	<0.01	0.02	<0.01	-	0.01
Other invertebrates. total	**14.2**	**4.1**	**7.6**	**10.7**	**5.32**	**1.38**	**15.39**	**4.83**	**9.73**	**2.93**	**8.7**	**6.99**
Invertebrates. total	**36.5**	**26.1**	**23.7**	**32.4**	**39.99**	**15.69**	**31.83**	**31.03**	**47.28**	**34.13**	**38.66**	**41.49**
Unidentified digested material	11.4	4	2.4	8.5	3.68	1.18	2.93	2.77	4.8	2.52	1.6	3.67
Unidentified egg	<1	<1	-	<1	0.01	<0.01	-	<0.01	0.01	<0.01	-	<0.01
Unidentified prey. total	**11.5**	**4.1**	**2.4**	**8.6**	**3.69**	**1.18**	**2.93**	**2.77**	**4.81**	**2.52**	**1.6**	**3.68**
Total	**-**	**-**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 24. Diet of Greenland halibut from the estuary and nGSL according to the different length classes considered in the study and for the entire period investigated (2004-2020). For each taxon found in the stomach contents, the frequency of occurrence (Focc), the contributions in mass (MC, as % of the mass of all taxa) and in fullness index (CTFI. as % of the TFI of all taxa) were calculated.

	F_{occ}				MC				CTFI			
Prey	**<20**	**[20-30[**	**[30-40[**	**>40**	**<20**	**[20-30[**	**[30-40[**	**>40**	**<20**	**[20-30[**	**[30-40[**	**>40**
Winter skate (*Leucoraja ocellata*)	-	<1	-	-	-	0.28	-	-	-	0.23	-	-
Atlantic hagfish (*Myxine glutinosa*)	-	-	-	<1	-	-	-	0.55	-	-	-	0.44
Bony fish (*Actinopterygii*)	-	<1	<1	<1	-	<0.01	0.14	0.02	-	<0.01	0.14	0.03
Atlantic herring (*Clupea harengus*)	-	-	<1	<1	-	-	1.07	11.32	-	-	0.73	7.77
Capelin (*Mallotus villosus*)	3.8	4.5	3.5	2.8	22.64	31.57	29.54	10.61	19.74	32.9	30.45	12.59
White barracudina (*Arctozenus risso*)	-	-	<1	<1	-	-	0.59	1.24	-	-	0.78	1.26
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	-	-	0.05	-	-	-	0.07	-	-
Codfish (*Gadidae*)	-	-	<1	<1	-	-	<0.01	0.08	-	-	<0.01	0.09
Atlantic cod (*Gadus morhua*)	-	-	<1	<1	-	-	0.11	0.78	-	-	0.1	0.85
Silver rockling (*Gaidropsarus argentatus*)	-	<1	-	<1	-	0.02	-	0.02	-	0.02	-	0.03
Fourbeard rockling (*Enchelyopus cimbrius*)	-	<1	<1	1.9	-	2.3	1.19	5.88	-	1.6	1.27	7.26
Marlin-spike (*Nezumia bairdii*)	-	-	<1	<1	-	-	1.13	2.32	-	-	0.9	2.9
Mackrel (*Scomber scombrus*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Sand lance (*Ammodytidae*)	<1	-	-	-	0.43	-	-	-	0.42	-	-	-
Sand lance (*Ammodytes sp.*)	3.1	<1	<1	<1	7.6	1.65	0.18	<0.01	7.62	2.16	0.17	<0.01
Shannie (*Lumpenus sp,*)	-	<1	-	-	-	0.08	-	-	-	0.05	-	-
Snakeblenny (*Lumpenus lampretaeformis*)	-	-	-	<1	-	-	-	0.07	-	-	-	0.11
Daubed Shanny (*Leptoclinus maculatus)*	-	<1	<1	-	-	0.11	0.02	-	-	0.1	0.02	-
Eelpout (*Zoarcidae*)	-	-	<1	<1	-	-	0.34	0.03	-	-	0.28	0.03
Eelpout (*Lycodes sp.*)	-	-	<1	-	-	-	0.12	-	-	-	0.12	-
Atlantic soft pout (*Melanostigma atlanticum*)	<1	2.5	3.9	3.4	1.09	2.33	2.51	0.7	0.73	2.5	2.72	1.02
Redfish (*Sebastes spp.*)	<1	<1	<1	5.7	0.05	0.55	2.88	21.06	0.05	0.54	2.59	15.78
Sculpin (*Cottidae*)	-	-	<1	<1	-	-	<0.01	0.08	-	-	<0.01	0.06

Prey	Focc				MC				CTFI			
	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40
Atlantic hookear sculpin (*Artediellus atlanticus*)	-	-	-	<1	-	-	-	0.03	-	-	-	0.02
Sea tadpole (*Careproctus reinhardti*)	-	-	-	<1	-	-	-	<0.01	-	-	-	0.01
Skate (*Rajidae*)	-	-	-	<1	-	-	-	0.04	-	-	-	0.06
Flatfish (*Pleuronectiformes*)	-	-	<1	<1	-	-	0.12	0.52	-	-	0.11	0.44
Righteye flounder (*Pleuronectidae*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
American plaice (*Hippoglossoides platessoides*)	-	-	-	<1	-	-	-	0.16	-	-	-	0.2
Witch flounder (*Glyptocephalus cynoglossus*)	-	-	-	<1	-	-	-	0.22	-	-	-	0.26
Greenland halibut (*Reinhardtius hippoglossoides*)	<1	-	-	<1	0.11	-	-	1.38	0.12	-	-	0.95
Thorny skate (*Amblyraja radiata*)	-	-	-	<1	-	-	-	0.07	-	-	-	0.07
Digested roundfish	3.1	2.8	2.8	3.6	6.83	13.45	5.97	6.72	6.57	11.87	6.26	6.35
Fish (spawn) egg	<1	<1	<1	<1	0.64	0.02	0.49	0.03	0.6	0.03	0.44	0.05
Digested fish	4.8	8.1	7.9	7.9	5.96	10.52	8.2	6.87	5.49	9.7	8.24	7.41
Fishes. total	**15.5**	**17.9**	**18.4**	**24.8**	**45.34**	**62.92**	**54.61**	**70.8**	**41.34**	**61.76**	**55.33**	**66.04**
Digested shrimp	2.9	4.8	7.7	10.7	2.96	5.64	10.68	6.89	2.63	5.11	9.86	8.51
Scarlet sergestid (*Sergia robusta*)	-	-	<1	-	-	-	0.08	-	-	-	0.08	-
Glass shrimp (*Pasiphaeidae*)	-	<1	<1	<1	-	0.41	0.38	0.19	-	0.32	0.42	0.24
Pink glass shrimp (*Pasiphaea multidentata*)	1.2	3	3.4	3.4	2.59	6.23	4.91	2.04	2.2	6.7	5.08	2.37
Eualid (*Eualus sp.*)	<1	-	-	-	0.05	-	-	-	0.04	-	-	-
Circumpolar eualid (*Eualus gaimardii*)	<1	-	-	-	0.06	-	-	-	0.04	-	-	-
Friendly blade shrimp (*Spirontocaris liljeborgii*)	-	<1	-	-	-	0.02	-	-	-	0.01	-	-
Lebbeids (*Lebbeus sp.*)	<1	-	-	-	0.02	-	-	-	0.02	-	-	-
Polar lebbeid (*Lebbeus polaris*)	-	-	-	<1	-	-	-	0.01	-	-	-	0.02
Boreal red shrimps (*Pandalus sp.*)	<1	<1	<1	<1	<0.01	1.51	0.65	0.34	<0.01	1.69	0.71	0.36
Northern shrimp (*Pandalus borealis*)	<1	2.3	5.2	9.8	0.31	8.47	16.77	11.47	0.41	8.02	15.86	14.09
Striped pink shrimp (*Pandalus montagui*)	-	<1	<1	<1	-	0.24	0.25	0.29	-	0.28	0.3	0.45
Crangon shrimp (*Crangonidae*)	-	-	-	<1	-	-	-	0.01	-	-	-	0.01

Prey	Focc				MC				CTFI			
	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40
Sars shrimp (*Sabinea sarsii*)	-	<1	-	<1	-	0.06	-	<0.01	-	0.04	-	0.01
Norwegian shrimp (*Pontophilus norvegicus*)	-	-	<1	<1	-	-	0.05	0.02	-	-	0.04	0.02
Shrimps. total	**4.4**	**11.1**	**16.2**	**22.3**	**5.99**	**22.56**	**33.77**	**21.26**	**5.33**	**22.15**	**32.35**	**26.08**
Copepod (*Copepoda*)	<1	<1	-	-	0.02	<0.01	-	-	0.01	<0.01	-	-
Calanoid copepod (*Calanoida*)	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01	-	-
Calanoid copepod (*Temora longicornis*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Calanoid copepod (*Paraeuchaeta norvegica*)	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01	-	-
Calanoid copepod (*Metridia lucens*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Amphipod (*Amphipoda*)	1.2	<1	<1	<1	0.85	0.18	0.03	<0.01	0.89	0.14	0.04	<0.01
Hyperiid (*Hyperiidae*)	1.5	1.6	1.3	<1	0.57	1.43	1.25	0.09	0.58	1.44	1.39	0.11
Hyperiids (*Themisto sp.*)	9.2	2.1	<1	<1	4.79	1.03	0.64	0.08	5.45	1.34	0.7	0.09
Hyperiid (*Themisto abyssorum*)	<1	-	-	-	0.02	-	-	-	0.02	-	-	-
Hyperiid (*Themisto compressa*)	1.5	<1	<1	-	0.58	<0.01	0.02	-	0.9	<0.01	0.02	-
Hyperiid (*Themisto libellula*)	5.4	2.4	1.4	<1	5	2.62	2.02	0.04	5.75	2.78	2.19	0.06
Hyperiid (*Scina borealis*)	-	<1	-	-	-	<0.01	-	-	-	<0.01	-	-
Gammarid (*Gammaridea*)	<1	<1	-	<1	0.06	0.03	-	<0.01	0.11	0.02	-	<0.01
Gammarid (*Byblis gaimardi*)	<1	-	-	-	0.09	-	-	-	0.08	-	-	-
Gammarid (*Maera loveni*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Gammarid (*Tmetonyx cicada*)	-	-	-	<1	-	-	-	<0.01	-	-	-	<0.01
Gammarid (*Oedicerotidae*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Gammarid (*Wimvadocus torelli*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Gammarid (*Stegocephalus inflatus*)	-	<1	-	-	-	<0.01	-	-	-	<0.01	-	-
Mysid (*Mysidae*)	<1	1.4	1.9	<1	0.25	0.19	0.21	0.03	0.29	0.21	0.2	0.04
Mysid (*Boreomysis sp.*)	<1	<1	<1	<1	0.13	0.09	0.1	0.02	0.1	0.1	0.09	0.03
Mysid (*Boreomysis tridens*)	-	<1	<1	<1	-	0.01	0.06	0.02	-	0.02	0.06	0.02
Mysid (*Boreomysis arctica*)	<1	1	2.7	1.3	0.31	0.15	0.31	0.04	0.34	0.15	0.29	0.07

Prey	F_{occ}				MC				CTFI			
	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40
Mysid (*Boreomysis nobilis*)	-	-	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01
Mysid (*Mysis sp.*)	<1	-	-	-	0.02	-	-	-	0.03	-	-	-
Mysid (*Mysis mixta*)	<1	<1	-	-	0.02	<0.01	-	-	0.06	<0.01	-	-
Euphausiid (*Euphausiacea*)	<1	-	-	-	0.11	-	-	-	0.16	-	-	-
Euphausiid (*Euphausiidae*)	9.6	<1	<1	<1	10.35	0.74	0.1	0.02	12.21	0.92	0.1	0.03
Northern krill (*Meganyctiphanes norvegica*)	5.5	1.4	<1	<1	3.83	0.56	0.12	0.05	4.56	0.69	0.14	0.07
Euphausiid (*Thysanoessa sp.*)	1.8	<1	-	-	3.45	0.52	-	-	3.03	1.03	-	-
Euphausiid (*Thysanoessa inermis*)	<1	<1	<1	-	0.29	0.03	<0.01	-	0.27	0.03	0.01	-
Arctic krill (*Thysanoessa raschii*)	<1	<1	<1	<1	0.35	0.03	<0.01	<0.01	0.31	0.03	<0.01	<0.01
Zooplankton. total	**31.8**	**9.7**	**8.6**	**4.3**	**31.1**	**7.63**	**4.89**	**0.4**	**35.16**	**8.89**	**5.25**	**0.54**
Flatworm (*Platyhelminthes*)	-	<1	-	-	-	<0.01	-	-	-	<0.01	-	-
Mollusc (*Mollusca*)	<1	<1	-	-	0.23	0.11	-	-	0.23	0.19	-	-
Gastropod (*Gastropoda*)	-	-	-	<1	-	-	-	0.05	-	-	-	0.03
Bivalve (*Bivalvia*)	-	-	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01
Cephalopod (*Cephalopoda*)	-	-	-	<1	-	-	-	0.14	-	-	-	0.14
Bobtail (*Rossia sp.*)	-	-	<1	-	-	-	0.39	-	-	-	0.36	-
Lesser bobtail squid (*Semirossia tenera*)	-	-	-	<1	-	-	-	0.14	-	-	-	0.18
Squid (*Teuthida*)	-	-	-	<1	-	-	-	0.22	-	-	-	0.19
Northern shortfin squid (*Illex illecebrosus*)	-	-	-	<1	-	-	-	3.06	-	-	-	2.55
Polychaete (*Polychaeta*)	<1	<1	<1	<1	0.03	0.01	<0.01	0.03	0.02	0.01	<0.01	0.02
Crustacean (*Crustacea*)	19.1	8.9	9.3	7.3	11.84	3.32	3.54	1.16	12.54	3.47	3.7	1.41
Water Fleas (*Cladocera*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Cumacean (*Cumacea*)	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01	-	-
Isopod (*Isopoda*)	-	-	<1	<1	-	-	<0.01	0.01	-	-	<0.01	0.02
Isopod (*Syscenus infelix*)	-	-	<1	<1	-	-	0.08	0.01	-	-	0.07	0.02
Crustacean decapod (*Decapoda*)	<1	<1	-	<1	<0.01	<0.01	-	<0.01	<0.01	<0.01	-	<0.01

Prey	F_{occ}				MC				CTFI			
	<20	[20-30[	[30-40]	>40	<20	[20-30[	[30-40]	>40	<20	[20-30[	[30-40]	>40
Echinoderm (*Echinodermata*)	-	-	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01
Sea urchin (*Echinoidea*)	-	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01	-
Mud heart urchin (*Brisaster fragilis*)	-	-	-	<1	-	-	-	0.07	-	-	-	0.05
Brittle star (*Ophiuroidea*)	<1	<1	<1	-	<0.01	0.02	0.03	-	<0.01	0.02	0.03	-
Other invertebrates. total	**19.3**	**9.1**	**9.8**	**8.1**	**12.1**	**3.46**	**4.05**	**4.9**	**12.8**	**3.71**	**4.17**	**4.59**
Invertebrates. total	**49.6**	**26.1**	**29.8**	**30.6**	**49.61**	**33.65**	**42.78**	**26.58**	**53.7**	**34.75**	**41.82**	**31.23**
Unidentified digested material	9.7	8.1	8.5	8.1	5.04	3.41	2.59	2.62	4.96	3.47	2.83	2.73
Unidentified egg	<1	<1	<1	<1	<0.01	0.01	0.02	<0.01	<0.01	0.01	0.02	<0.01
Unidentified prey. total	**9.7**	**8.3**	**8.6**	**8.1**	**5.05**	**3.42**	**2.61**	**2.62**	**4.97**	**3.48**	**2.85**	**2.74**
Total	**-**	**-**	**-**	**-**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 25. Diet of Greenland halibut in the estuary and nGSL in the different study areas and for the entire study period (2004-2018). For each taxon found in the stomach contents. the frequency of occurrence (Focc). the contributions in mass (MC. as % of the mass of all taxa) and in fullness index (CTFI. as % of the TFI of all taxa) were calculated.

Prey	**F_{occ}**		**MC**		**CTFI**	
	Estuary	**NGSL**	**Estuary**	**NGSL**	**Estuary**	**NGSL**
Atlantic hagfish (*Myxine glutinosa*)	-	<1	-	0,41	-	0,12
Skate (*Rajidae*)	-	<1	-	0,03	-	0,02
Thorny skate (*Amblyraja radiata*)	-	<1	-	0,06	-	0,02
Winter skate (*Leucoraja ocellata*)	<1	-	0,28	-	0,35	-
Bony fish (*Actinopterygii*)	<1	<1	0,29	0,01	0,16	<0,01
Atlantic herring (*Clupea harengus*)	-	<1	-	8,79	-	2,32
Capelin (*Mallotus villosus*)	2,3	3,8	24,5	15,72	21,84	23,71
White barracudina (*Arctozenus risso*)	<1	<1	1,05	0,95	0,24	0,48
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	<0,01	-	0,02
Codfish (*Gadidae*)	<1	<1	<0,01	0,06	<0,01	0,02
Atlantic cod (*Gadus morhua*)	-	<1	-	0,61	-	0,26
Silver rockling (*Gaidropsarus argentatus*)	<1	<1	0,16	<0,01	0,05	<0,01
Fourbeard rockling (*Enchelyopus cimbrius*)	<1	<1	4,88	4,43	1,38	2,51
Marlin-spike (*Nezumia bairdii*)	<1	<1	1,05	1,88	0,35	0,94
Mackrel (*Scomber scombrus*)	-	<1	-	<0,01	-	<0,01
Sand lance (*Ammodytidae*)	<1	<1	0,08	<0,01	0,47	0,07
Sand lance (*Ammodytes sp.*)	<1	<1	0,43	0,42	0,55	3,57
(Lumpenus sp.)	-	<1	-	<0,01	-	0,01
Snakeblenny (*Lumpenus lampretaeformis*)	<1	-	0,51	-	0,16	-
Lompénie tachetée (Leptoclinus maculatus)	-	<1	-	0,02	-	0,03
Eelpout (Zoarcidae)	<1	<1	0,69	0,02	0,32	<0,01
Eelpout (*Lycodes sp.*)	<1	<1	0,01	0,02	0,01	0,02
Atlantic soft pout (*Melanostigma atlanticum*)	8,4	1,8	6,73	0,64	5,32	0,89
Redfish (*Sebastes spp.*)	1,1	2,3	7,81	15,78	2,59	4,63
Sculpin (*Cottidae*)	-	<1	-	0,06	-	0,02
Atlantic hookear sculpin (*Artediellus atlanticus*)	-	<1	-	0,02	-	<0,01
Sea tadpole (*Careproctus reinhardti*)	<1	-	0,04	-	0,01	-
Flatfish (*Pleuronectiformes*)	-	<1	-	0,42	-	0,15
Righteye flounder (*Pleuronectidae*)	-	<1	-	<0,01	-	<0,01
American plaice (Hippoglossoides platessoides)	-	<1	-	0,12	-	0,06
Witch flounder (*Glyptocephalus cynoglossus*)	-	<1	-	0,17	-	0,07
Greenland halibut (*Reinhardtius hippoglossoides*)	-	<1	-	1,05	-	0,31
Digested roundfish	1	3,5	2,95	7,66	1,59	9
Fish (spawn) egg	<1	<1	0,1	0,14	0,07	0,34
Digested fish	11,6	6,6	5,29	7,66	5,19	7,97
Fishes, total	**23,2**	**19**	**56,85**	**67,17**	**40,65**	**57,61**

Prey	Focc		MC		CTFI	
	Estuary	NGSL	Estuary	NGSL	Estuary	NGSL
Digested shrimp	4,1	7,8	6,02	7,51	4,41	6,29
Scarlet sergestid (*Sergia robusta*)	-	<1	-	0,02	-	0,02
Glass shrimp (*Pasiphaeidae*)	<1	<1	0,04	0,26	0,02	0,25
Pink glass shrimp (*Pasiphaea multidentata*)	<1	3,4	1,06	3,2	1,06	4,47
Eualid (*Eualus sp.*)	-	<1	-	<0,01	-	0,01
Circumpolar eualid (*Eualus gaimardii*)	-	<1	-	<0,01	-	0,02
Friendly blade shrimp (*Spirontocaris liljeborgii*)	-	<1	-	<0,01	-	<0,01
Lebbeids (*Lebbeus sp.*)	-	<1	-	<0,01	-	<0,01
Polar lebbeid (*Lebbeus polaris*)	-	<1	-	0,01	-	<0,01
Boreal red shrimps (*Pandalus sp.*)	<1	<1	0,16	0,53	0,21	0,72
Northern shrimp (*Pandalus borealis*)	1,9	5,7	9,35	12,11	4,06	9,26
Striped pink shrimp (*Pandalus montagui*)	<1	<1	1,42	0,15	0,82	0,12
Crangon shrimp (*Crangonidae*)	-	<1	-	0,01	-	<0,01
Sars shrimp (*Sabinea sarsii*)	-	<1	-	<0,01	-	0,01
Norwegian shrimp (*Pontophilus norvegicus*)	-	<1	-	0,02	-	0,01
Shrimps, total	**6,9**	**16,5**	**18,04**	**23,84**	**10,57**	**21,21**
Water flee (*Copepoda*)	-	<1	-	<0,01	-	<0,01
Copépode calanoide (Calanoida)	-	<1	-	<0,01	-	<0,01
Calanoid copepod (*Temora longicornis*)	-	<1	-	<0,01	-	<0,01
Calanoid copepod (*Paraeuchaeta norvegica*)	-	<1	-	<0,01	-	<0,01
Calanoid copepod (*Metridia lucens*)	-	<1	-	<0,01	-	<0,01
Amphipode (Amphipoda)	<1	<1	0,01	0,05	<0,01	0,4
Hyperiid (*Hyperiidae*)	3,3	<1	3,29	0,16	2,96	0,42
Hyperiids (*Themisto sp.*)	<1	2,6	0,65	0,4	0,52	2,62
Hyperiid (*Themisto abyssorum*)	<1	<1	<0,01	<0,01	0,01	<0,01
Hyperiid (*Themisto compressa*)	-	<1	-	0,02	-	0,36
Hyperiid (*Themisto libellula*)	3,5	1,6	4,73	0,41	5,68	2,49
Hyperiid (*Scina borealis*)	<1	-	<0,01	-	<0,01	-
Gammarid (*Gammaridea*)	<1	<1	0,02	<0,01	0,23	<0,01
Gammarid (*Byblis gaimardi*)	-	<1	-	<0,01	-	0,03
Gammarid (*Maera loveni*)	-	<1	-	<0,01	-	<0,01
Gammarid (*Tmetonyx cicada*)	<1	-	0,01	-	<0,01	-
Gammarid (*Oedicerotidae*)	-	<1	-	<0,01	-	<0,01
Gammarid (*Wimvadocus torelli*)	-	<1	-	<0,01	-	<0,01
Gammarid (*Stegocephalus inflatus*)	-	<1	-	<0,01	-	<0,01
Mysid (*Mysidae*)	3,6	<1	0,37	0,06	0,71	0,1
Mysid (*Boreomysis sp.*)	<1	<1	0,06	0,04	0,14	0,07
Mysid (*Boreomysis tridens*)	<1	<1	0,03	0,02	0,01	0,02
Mysid (*Boreomysis arctica*)	4,2	1	0,5	0,07	0,67	0,13
Mysid (*Boreomysis nobilis*)	-	<1	-	<0,01	-	<0,01

Prey	F_{occ}		MC		CTFI	
	Estuary	NGSL	Estuary	NGSL	Estuary	NGSL
Mysidacé (*Mysis sp.*)	-	<1	-	<0,01	-	0,01
Mysid (*Mysis mixta*)	-	<1	-	<0,01	-	0,03
Euphausiid (*Euphausiacea*)	-	<1	-	<0,01	-	0,06
Euphausiid (*Euphausiidae*)	4,3	1,6	1,87	0,27	9,91	3,16
Northern krill (*Meganyctiphanes norvegica*)	2,7	1,3	0,91	0,16	4,52	1,17
Euphausiid (*Thysanoessa sp.*)	<1	<1	0,68	0,1	3,41	0,83
Euphausiid (*Thysanoessa inermis*)	<1	<1	0,02	0,01	0,01	0,11
Arctic krill (*Thysanoessa raschii*)	<1	<1	0,11	<0,01	0,57	0,02
Zooplankton, total	**19,2**	**9,7**	**13,28**	**1,8**	**29,38**	**12,06**
Flatworm (*Platyhelminthes*)	-	<1	-	<0,01	-	<0,01
Mollusc (*Mollusca*)	-	<1	-	0,02	-	0,15
Gastropod (*Gastropoda*)	<1	-	0,38	-	0,04	-
Bivalve (*Bivalvia*)	<1	-	<0,01	-	<0,01	-
Cephalopod (*Cephalopoda*)	-	<1	-	0,1	-	0,04
Bobtail (*Rossia sp.*)	-	<1	-	0,08	-	0,08
Lesser bobtail squid (*Semirossia tenera*)	-	<1	-	0,11	-	0,05
Squid (*Teuthida*)	-	<1	-	0,17	-	0,05
Northern shortfin squid (*Illex illecebrosus*)	-	<1	-	2,31	-	0,71
Polychaete (*Polychaeta*)	<1	<1	0,23	<0,01	0,03	0,01
Crustacean (*Crustacea*)	16	9	5,04	1,84	13,13	4,62
Cladocère (Cladocera)	-	<1	-	<0,01	-	<0,01
Cumacean (*Cumacea*)	-	<1	-	<0,01	-	<0,01
Isopod (*Isopoda*)	<1	<1	<0,01	0,01	<0,01	<0,01
Isopod (*Syscenus infelix*)	-	<1	-	0,03	-	0,02
Crustacean decapod (*Decapoda*)	-	<1	-	<0,01	-	<0,01
Echinoderm (*Echinodermata*)	<1	<1	<0,01	<0,01	<0,01	<0,01
Sea urchin (*Echinoidea*)	<1	-	<0,01	-	<0,01	-
Mud heart urchin (*Brisaster fragilis*)	<1	-	0,52	-	0,07	-
Brittle star (*Ophiuroidea*)	<1	<1	0,07	<0,01	0,06	<0,01
Other invertebrates, total	**16,8**	**9,4**	**6,25**	**4,68**	**13,33**	**5,74**
Invertebrates, total	**36,3**	**31,6**	**37,56**	**30,35**	**53,29**	**39,18**
Unidentified digested material	19,9	6,1	5,52	2,48	6,01	3,21
Unidentified egg	1	<1	0,06	<0,01	0,05	<0,01
Unidentified preys, total	**20,3**	**6,2**	**5,58**	**2,48**	**6,06**	**3,21**
Total	**-**	**-**	**100**	**100**	**100**	**100**

Table 26. Summary of Greenland halibut and redfish stomach sampling effort for the period 2015-2019 by length class. Statistics on length, total stomach contents (after waste/parasite/empty stomachs are removed) and taxonomic diversity are provided.

Parameter		**Redfish**					**Greenland halibut**				
		<20	**[20-30[**	**[30-40]**	**>40**	**Total**	**<20**	**[20-30[**	**[30-40]**	**>40**	**Total**
	Nb. of stomachs	1,787	1,131	745	171	3,834	603	665	661	721	2,650
	Nb. of empty stomachs	627	499	331	52	1,509	182	432	428	392	1,434
	% empty stomachs	35	44	44	30	39	30	65	65	54	54
	TFI	0.15	0.08	0.15	0.29	0.14	0.42	0.18	0.13	0.15	0.21
Length (mm)	Min	42	200	300	401	42	63	200	300	401	63
	Median	162	233	347	416	209	166	256	355	463	309
	Mean	153	240	348	422	229	165	255	351	478	319
	Max	199	299	400	501	501	199	299	400	767	767
Total stomach content (g)	Min	0.001	0.001	0.001	0.013	0.001	0.001	0.003	0.001	0.002	0.001
	Median	0.08	0.12	1.28	3.81	0.14	0.59	1.50	2.87	7.89	1.49
	Mean	0.22	0.85	4.44	11.99	1.74	0.97	2.93	6.49	18.39	7.12
	Max	6.46	19.77	74.67	88.33	88.33	9.20	23.74	61.81	316.92	316.92
Nb. of taxa	Fish	3	8	12	7	15	8	10	15	20	24
	Shrimp	10	6	6	5	12	4	6	7	6	8
	Zooplancton	48	34	29	11	53	20	14	6	8	26
	Other invertabrates	10	2	7	2	13	6	1	3	5	11
	Non-identifiable prey	2	2	1	1	2	1	1	2	2	2

FIGURES

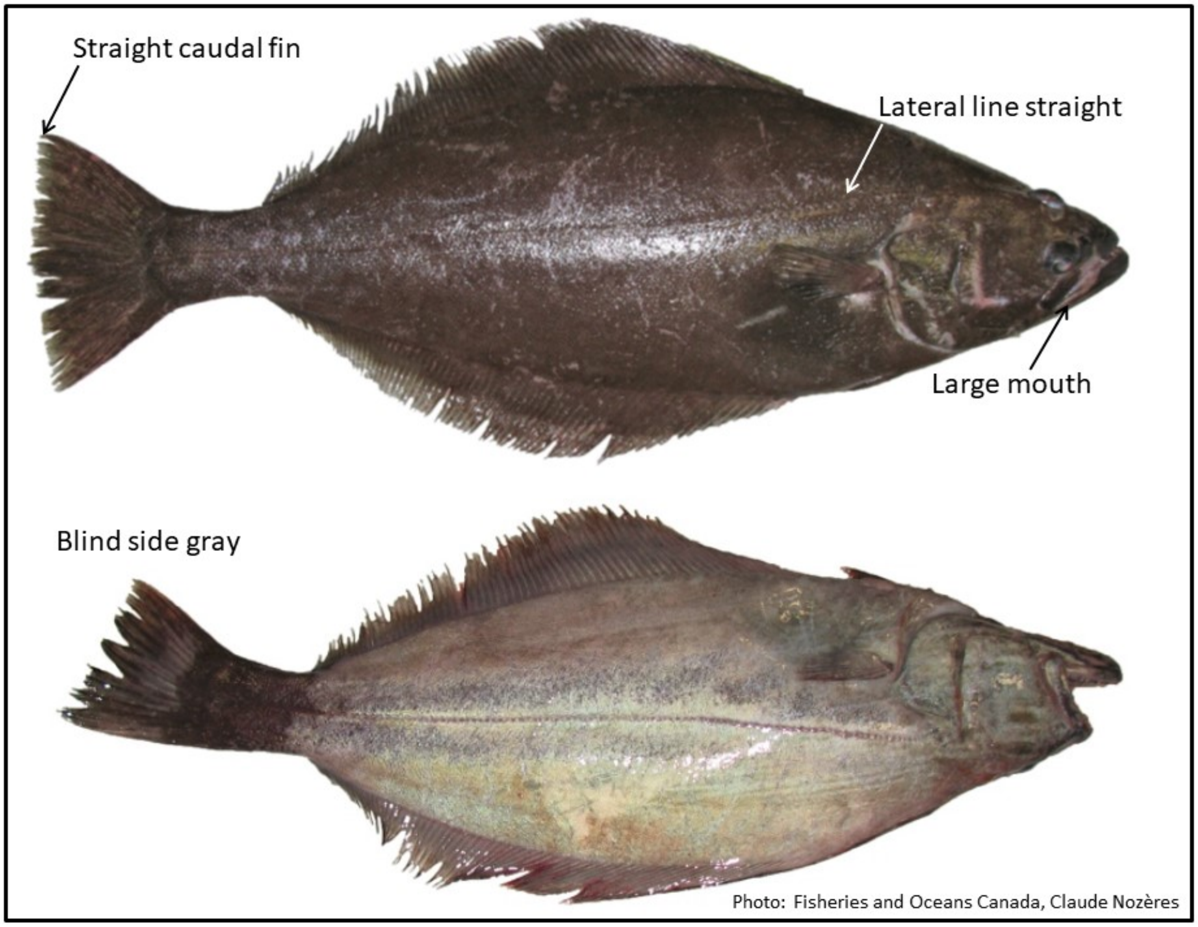
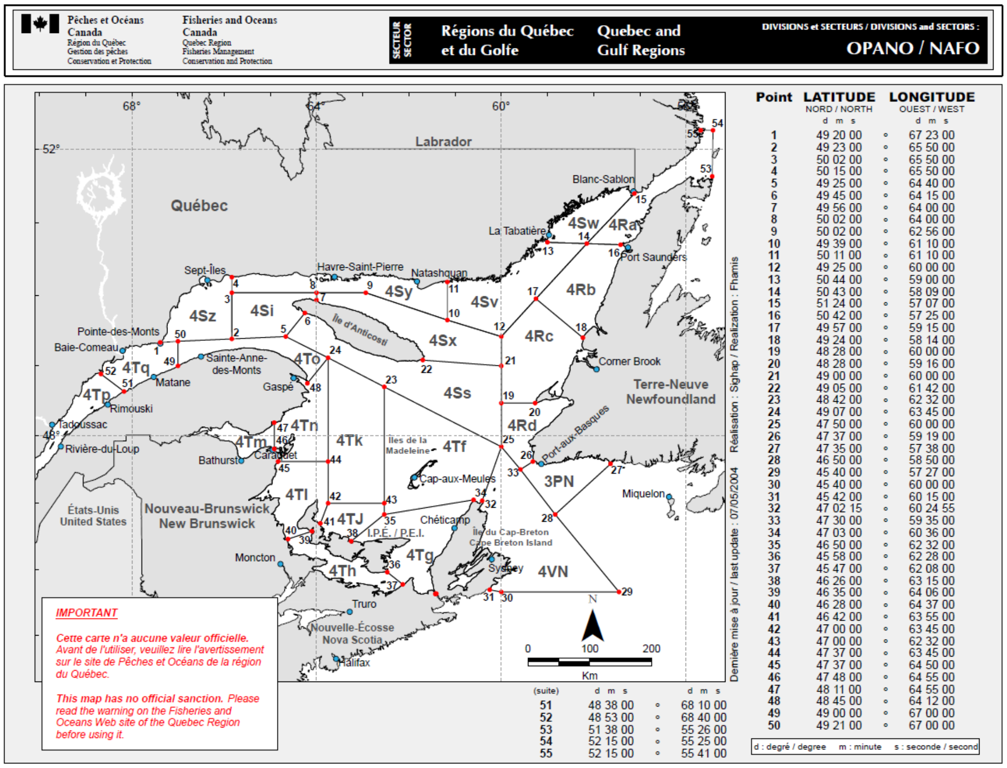


Figure 1. Greenland halibut morphology.



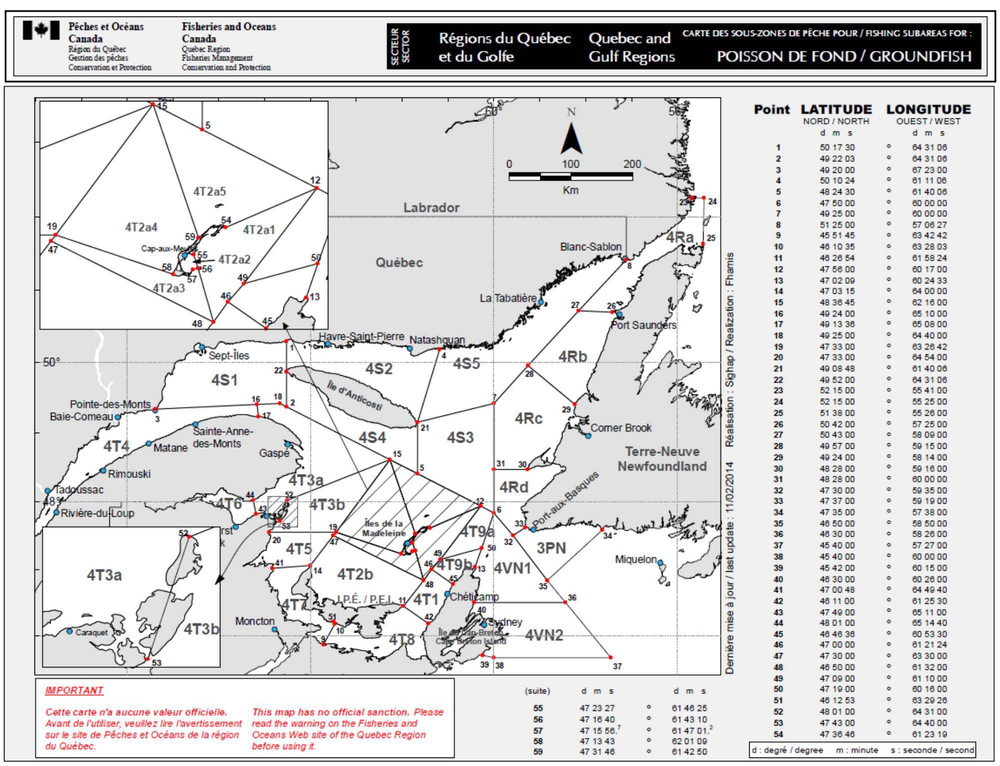


Figure 2. Unit Areas in the Gulf of St. Lawrence (top map). Map of Gulf of St. Lawrence Groundfish Sub-Areas (bottom map).

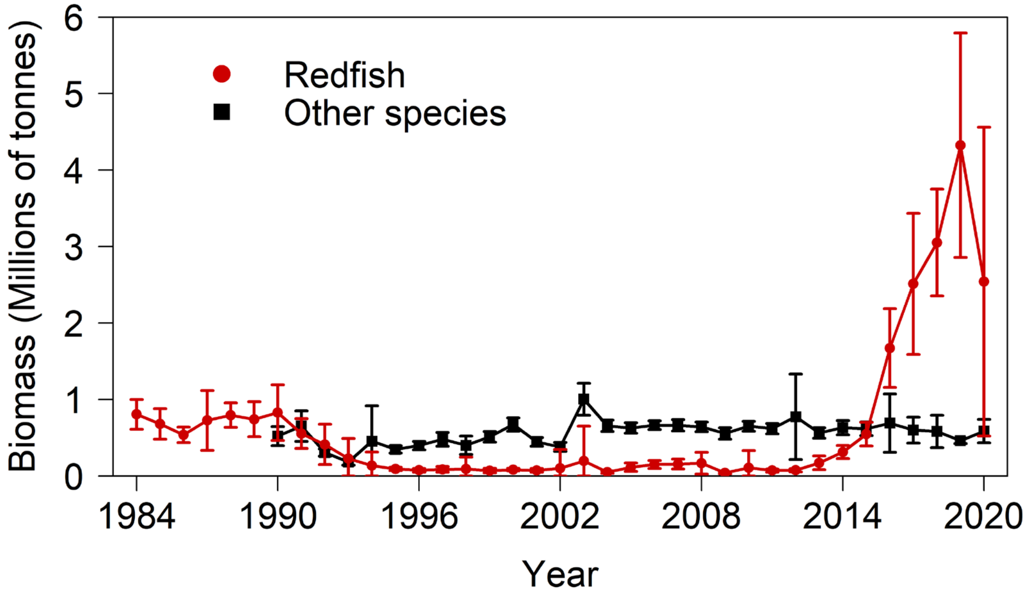


Figure 3. Biomass indices (million tonnes) estimated for the two redfish species combined and for all other species caught during the DFO survey in the nGSL.

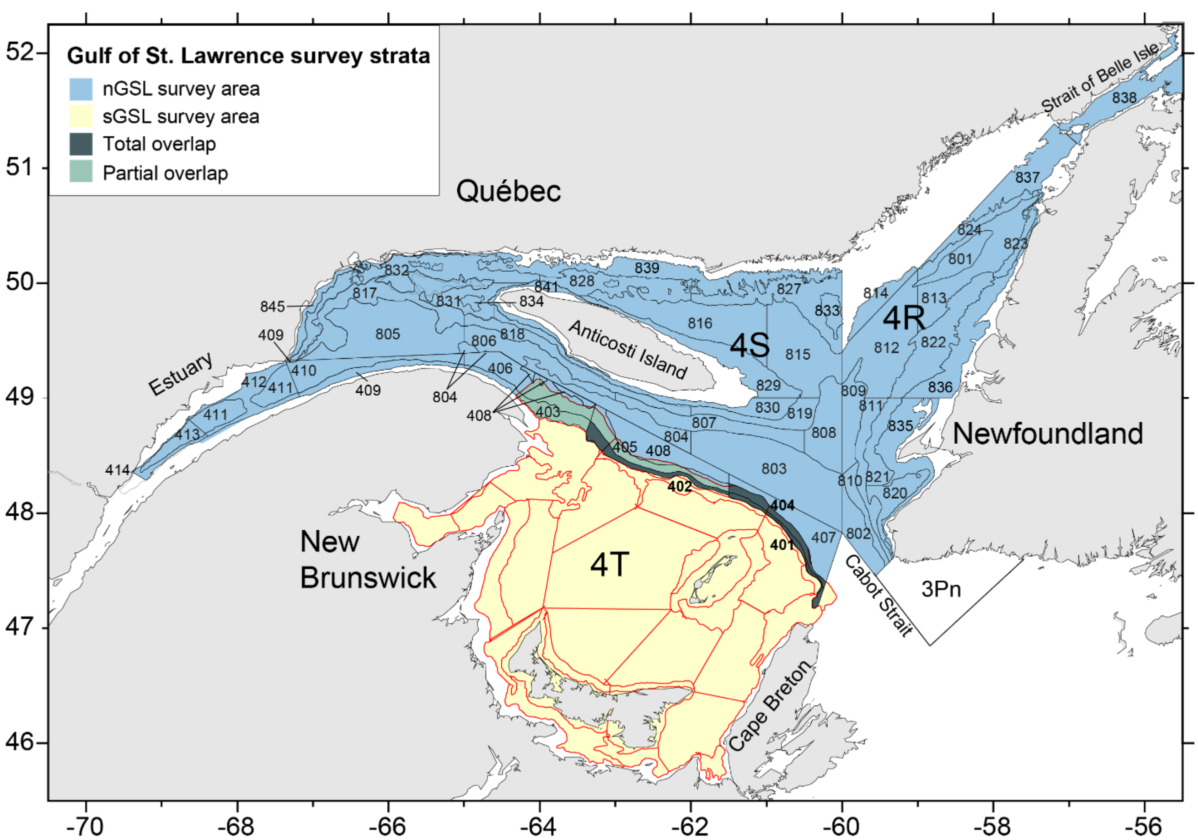


Figure 4. Map illustrating the stratification scheme of the groundfish and shrimp research survey in the Lower Estuary and northern Gulf of St. Lawrence (nGSL) (blue) and the southern Gulf of St. Lawrence survey (sGSL) (yellow. 4T). The areas of partial (light green) and total (dark green) overlap at the boundary between these two surveys are also identified.

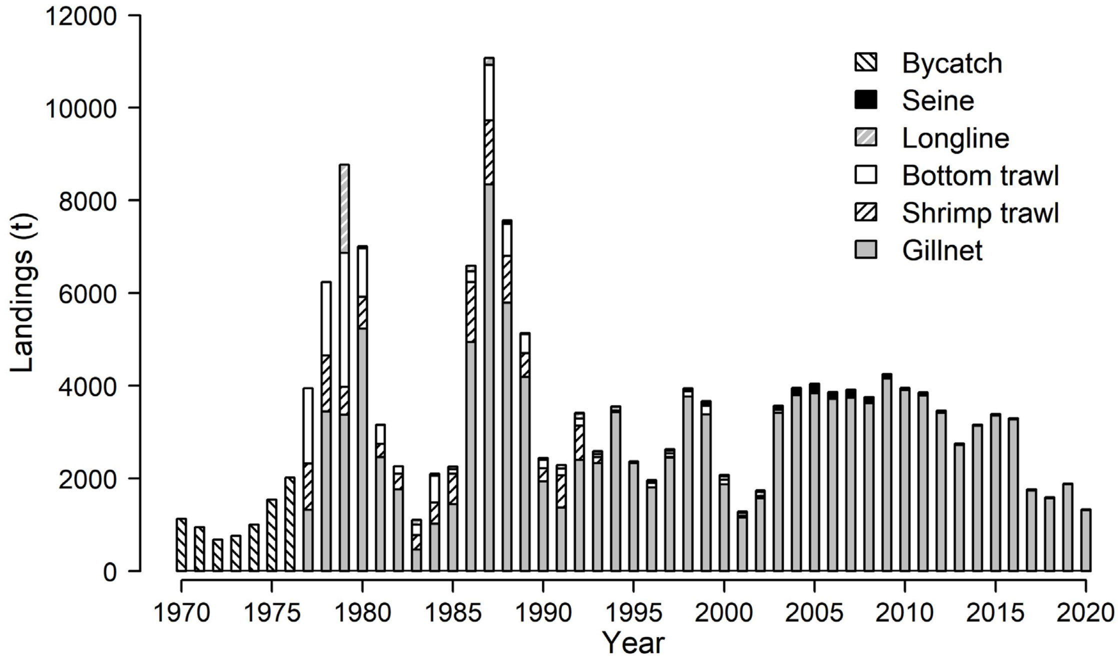


Figure 5. Greenland halibut landings (t) as bycatch, and by gear and management year.

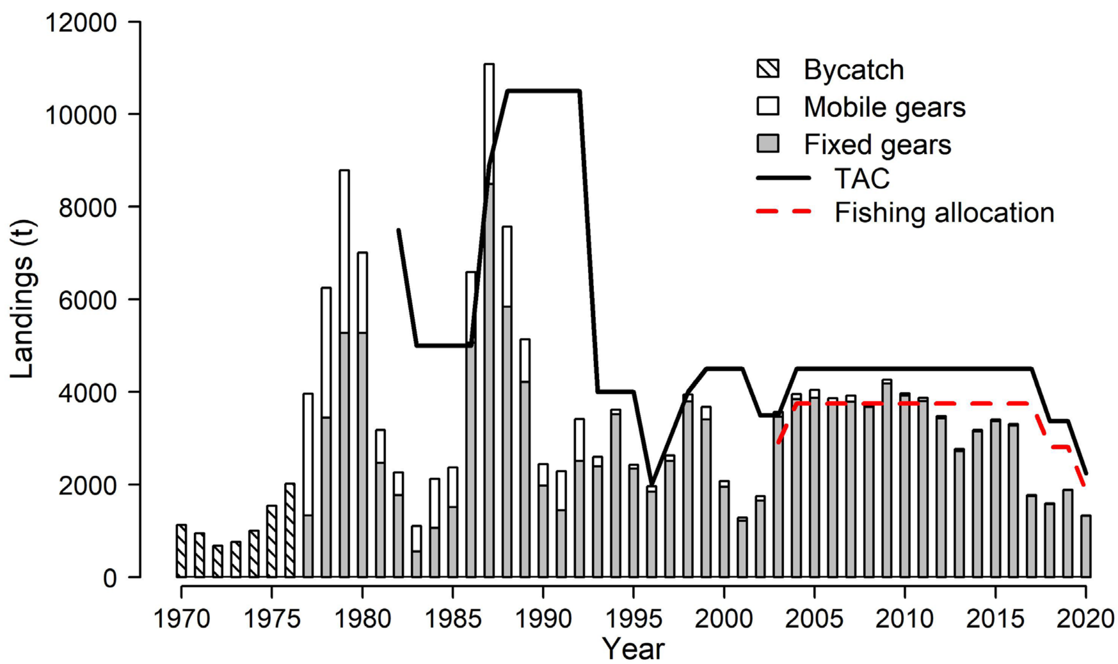


Figure 6. Greenland halibut landings (t) for fixed and mobile gears by management year. Total Allowable Catch (TAC) and Fishing allocation are indicated.

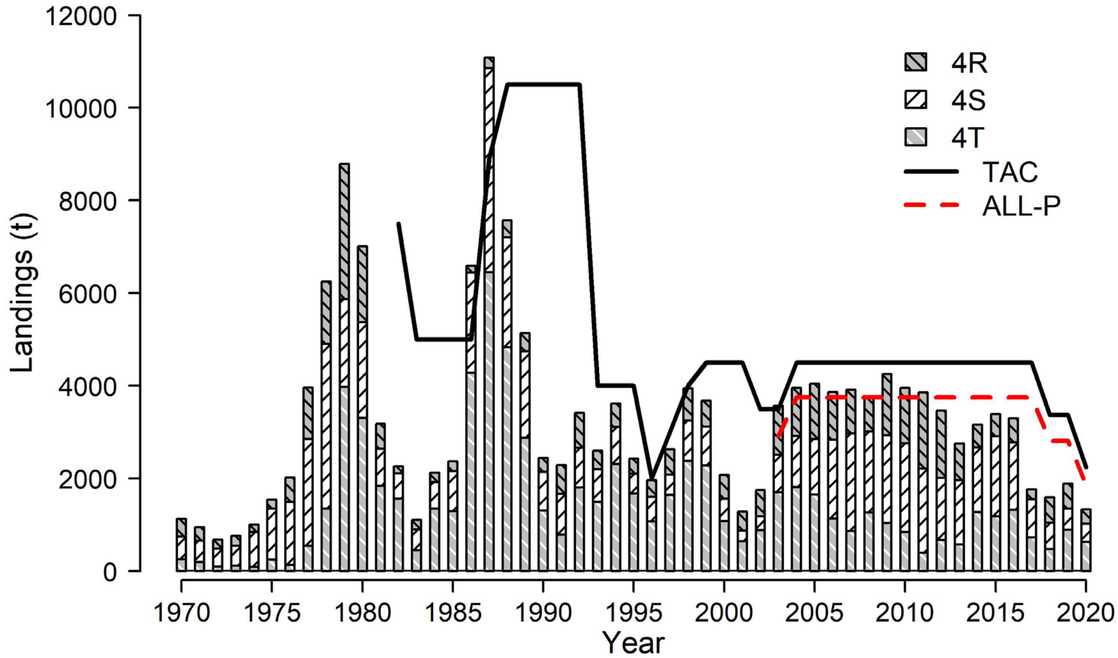


Figure 7. Greenland halibut landings (t) by NAFO Divisions and management year. Total Allowable Catch (TAC) and Fishery Allocation (F-ALL) are indicated.

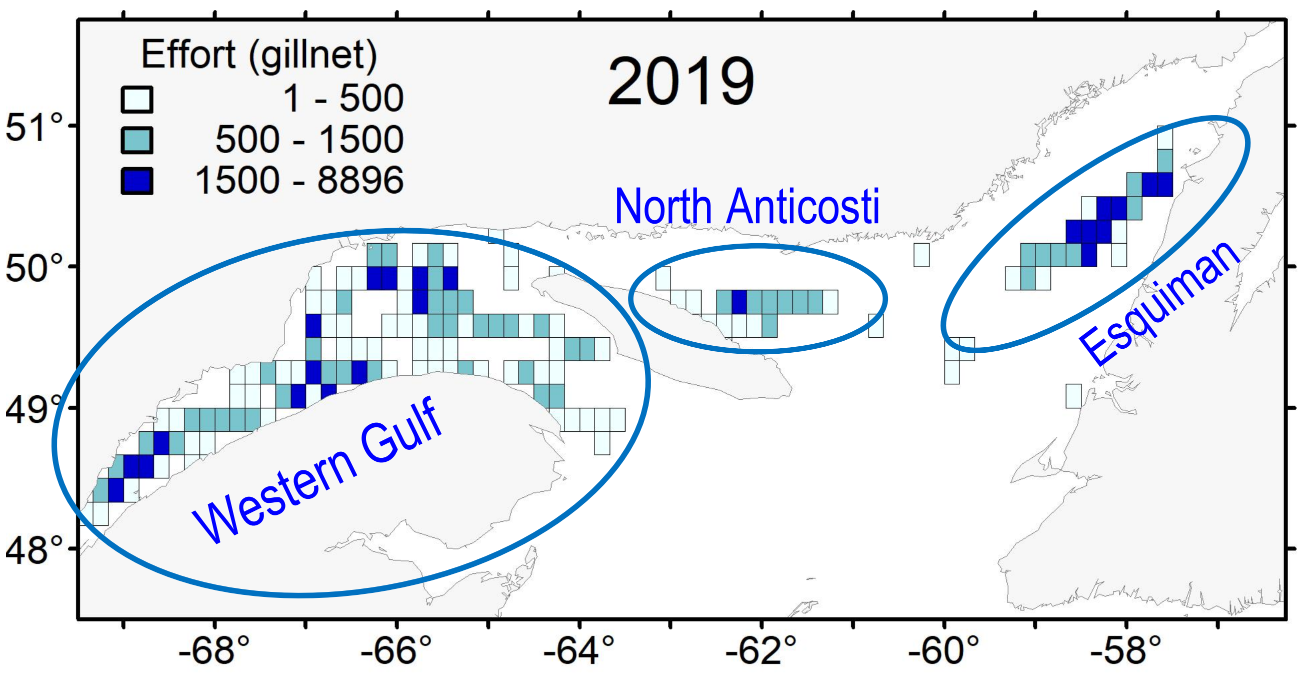


Figure 8. Fishing effort deployed in total number of nets per fishing statistical square for 2019. Fishing effort concentrations define three sectors: Western Gulf, north Anticosti and, Esquiman.

A) B)

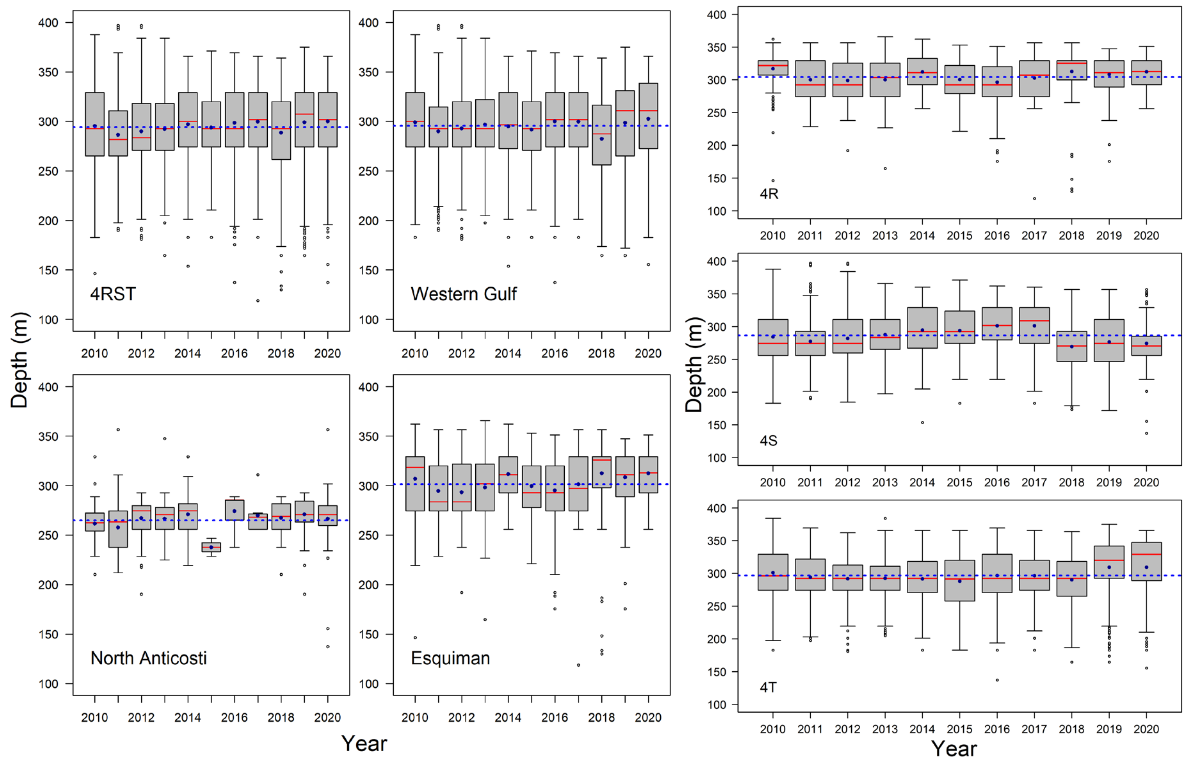
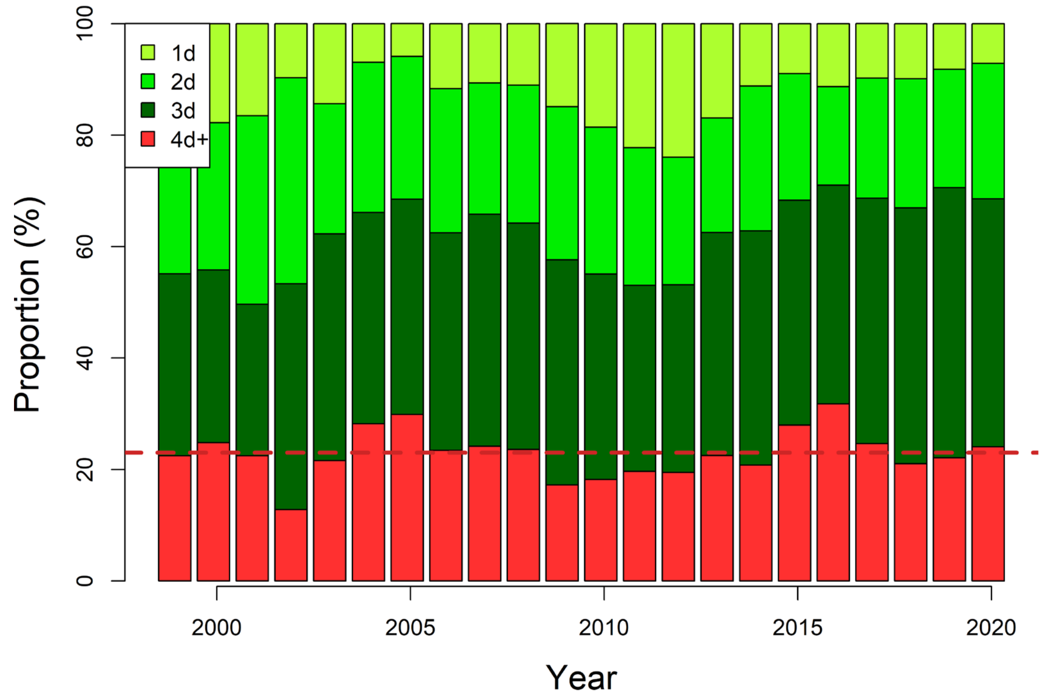


Figure 9. Annual deployment depth of directed Greenland halibut gillnet fishery in A) the Gulf (4RST) and by fishing sector B) by NAFO Division. Box and whiskers plot; box extends from percentile 25 to 75, line in the box represents the median, full circle represents the mean, whiskers extend from percentile 5 to 95 and open circles represent extreme values. Horizontal lines are average of each series.

A)



B)

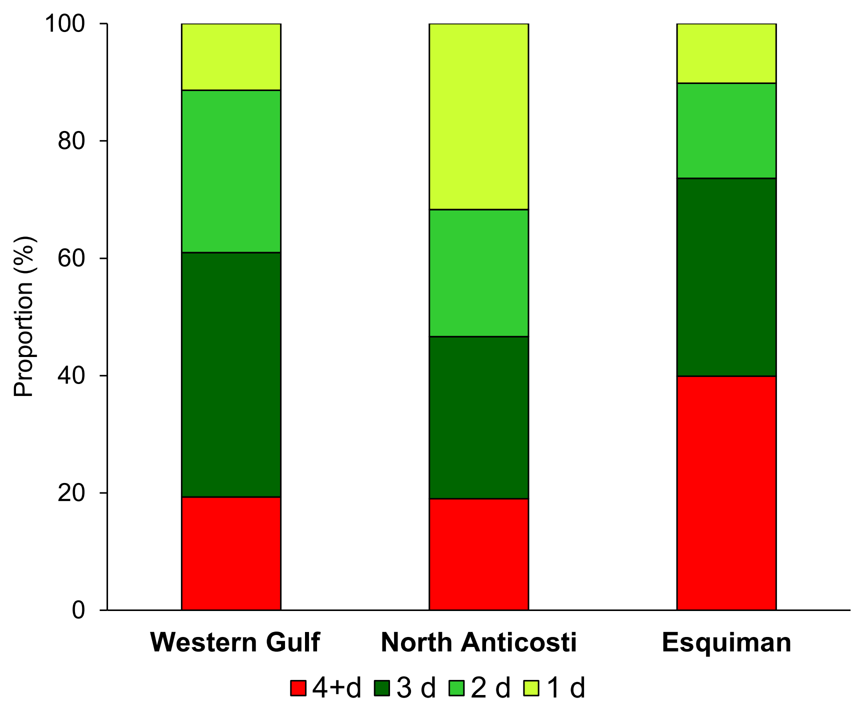


Figure 10. A) Annual proportion (%) of immersion times (1 to 4 days and over) of gillnets in the directed commercial Greenland halibut fishery from 1999 to 2020. The horizontal line represents the average (23%) for immersion of 4 days and over. B) Average proportion (1999-2020) of gillnet immersion times in the directed commercial Greenland halibut fishery by fishing sector.

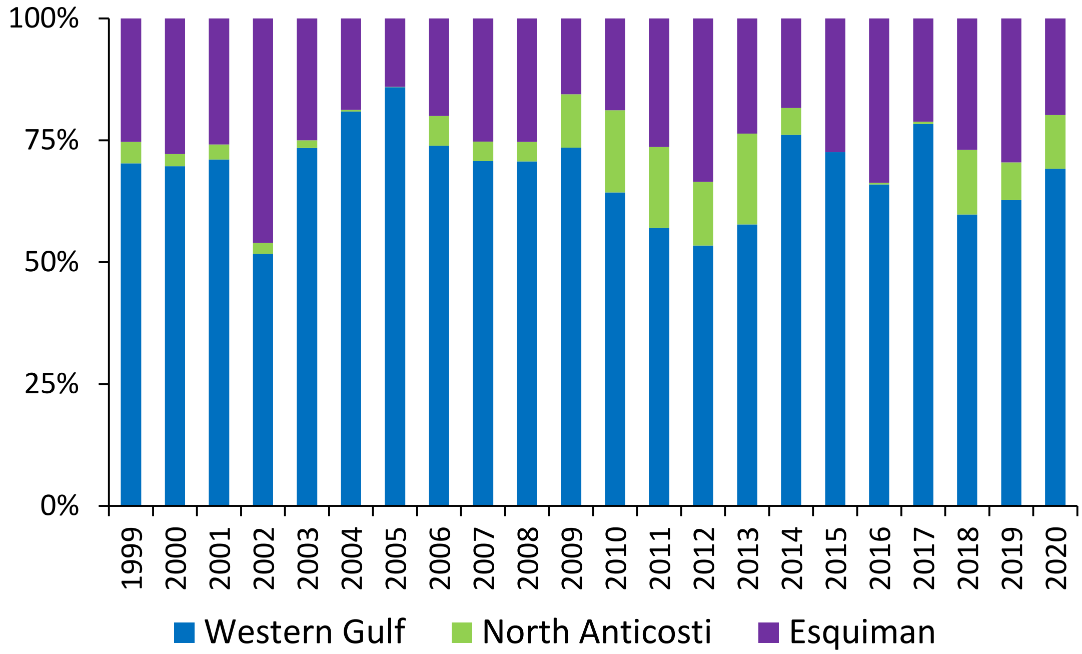


Figure 11. Proportion of fishing effort deployed by fishing sector in the directed Greenland halibut gillnet fishery from 1999 to 2020.

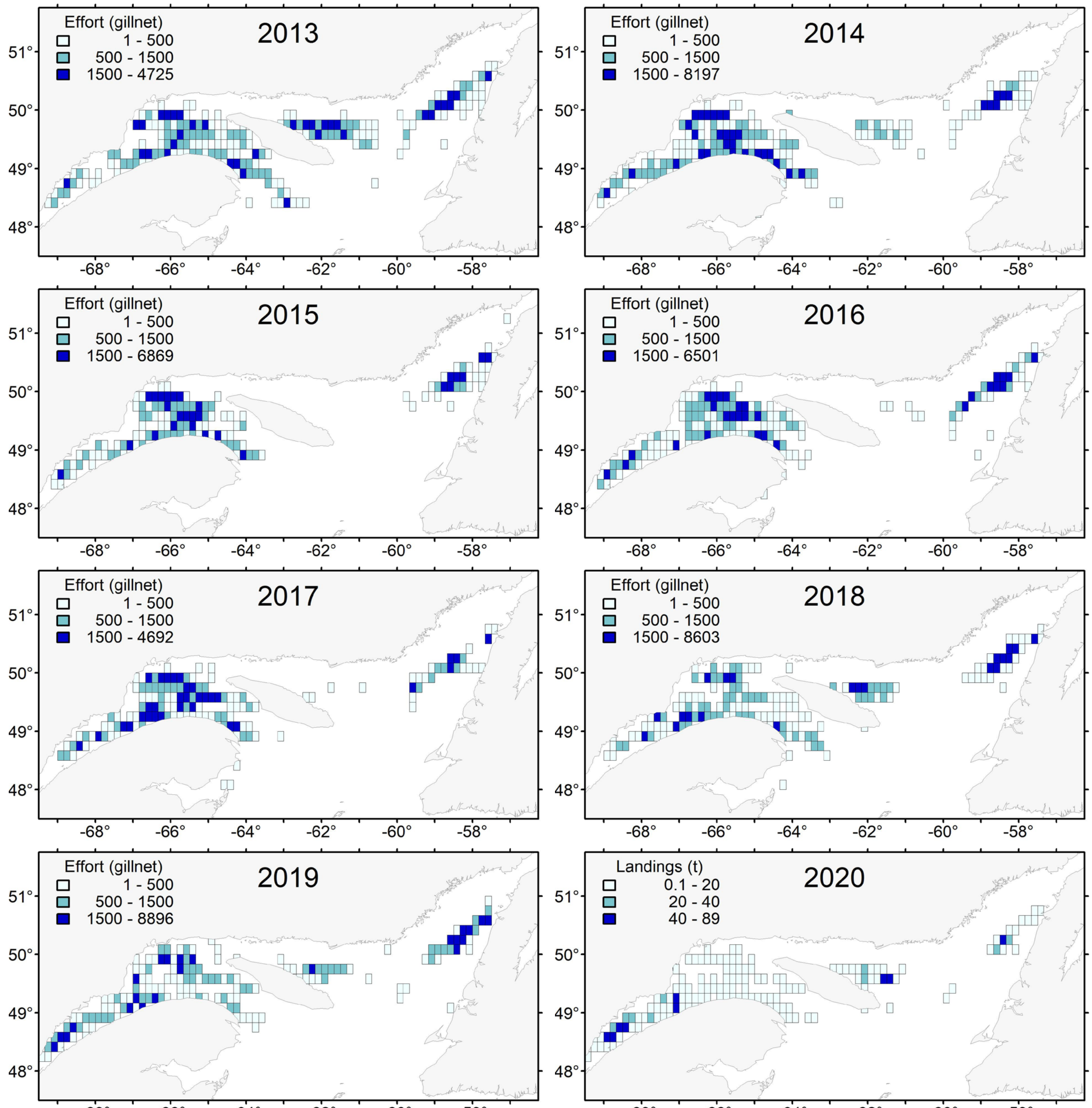


Figure 12a. Annual fishing effort (number of gillnets) by statistical square. 2013 to 2020. Information is from ZIFF files and 2020 data are preliminary. The information is from ZIFF files and the 2020 data are preliminary. From 2013 to 2020, fishing effort data are available for more than 95% of landings in the western Gulf and northern Anticosti sector. For the Esquiman sector, data are available for nearly 80% of landings from 2013 to 2019 and nearly 45% for 2020.

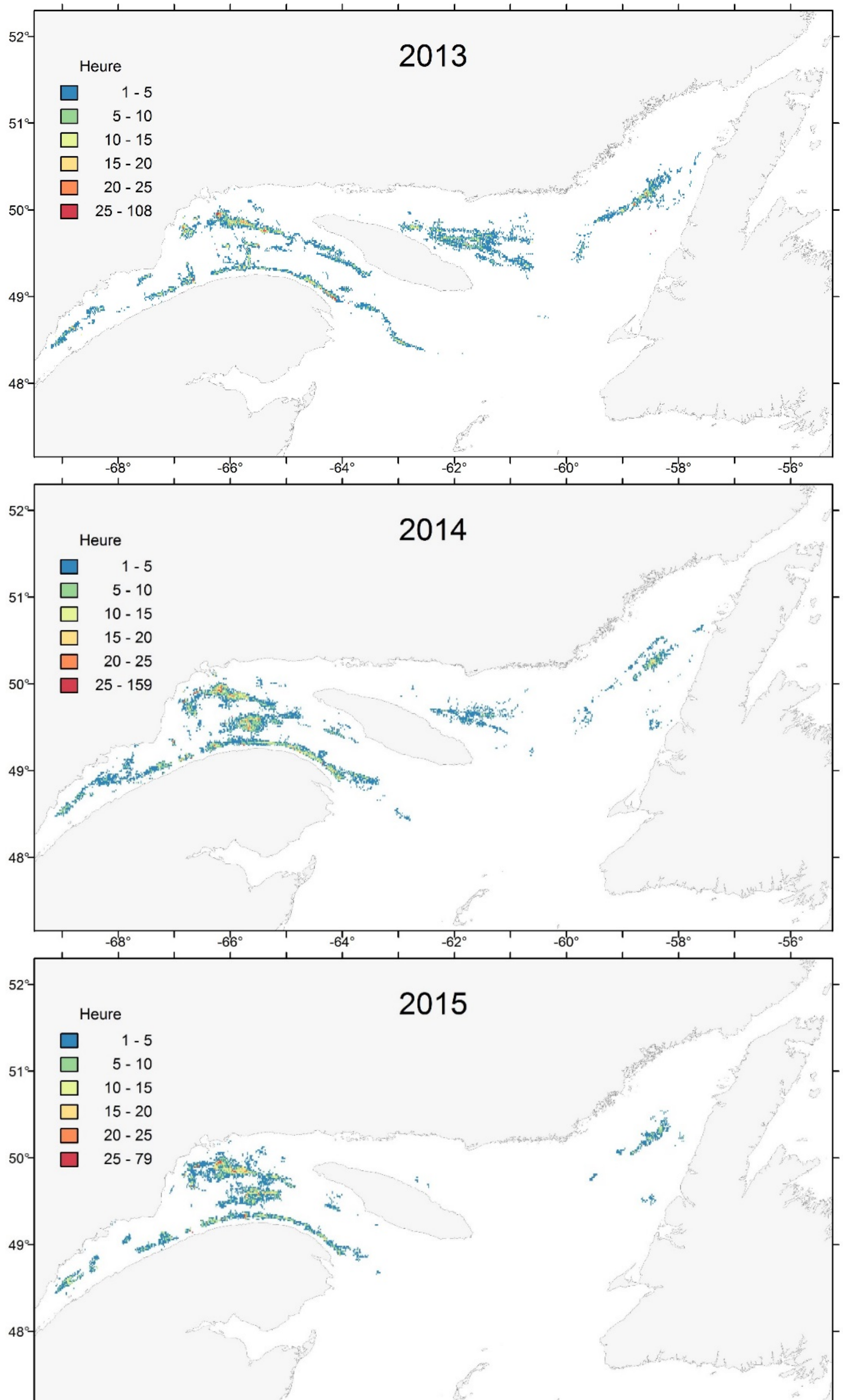


Figure 12b. Distribution of directed fishing effort for Greenland halibut in the Gulf of St. Lawrence from 2013 to 2020 according to Vessel Monitoring System (VMS) data, number of hours per 1 minute square. Since 2017, data has been available for nearly 100% of the activities of the Quebec fleets. The proportion is less than 50% for the Newfoundland and Labrador fleets.

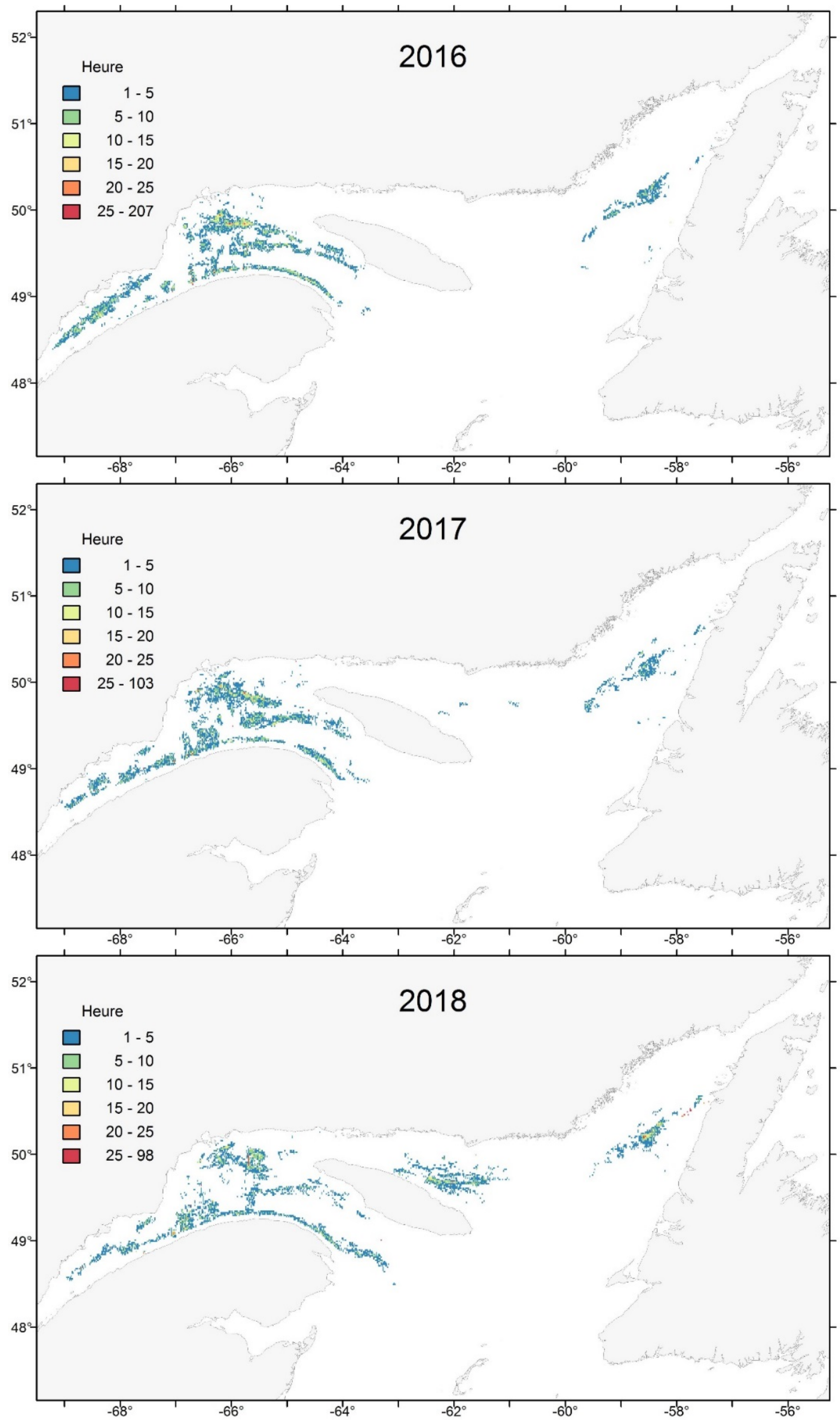
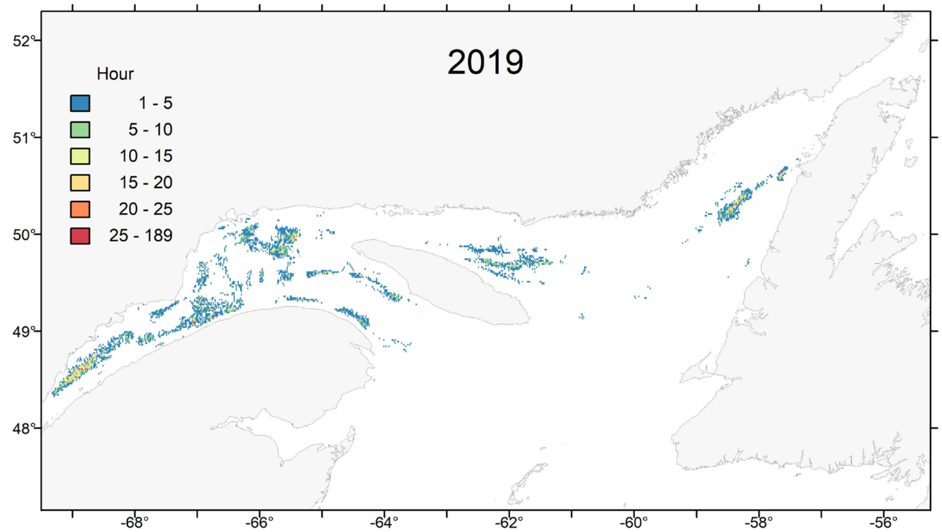
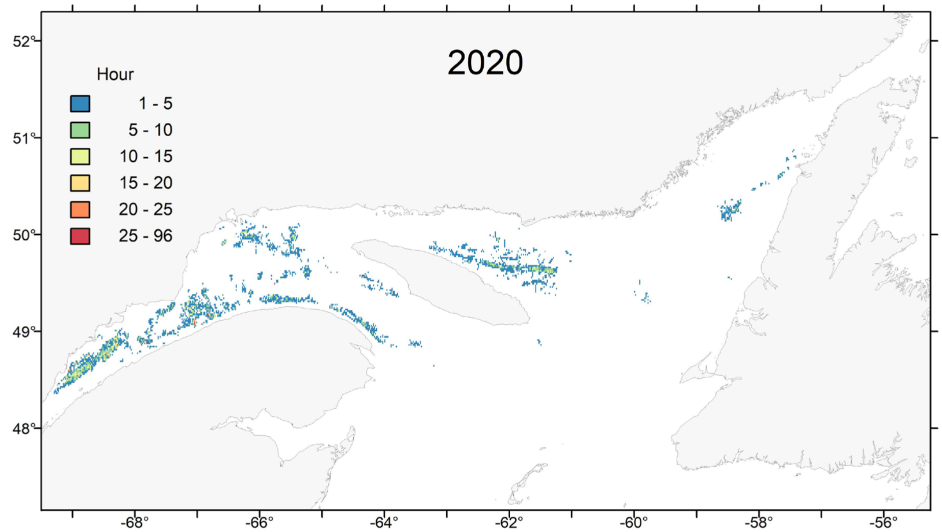


Figure 12b. (Continued).





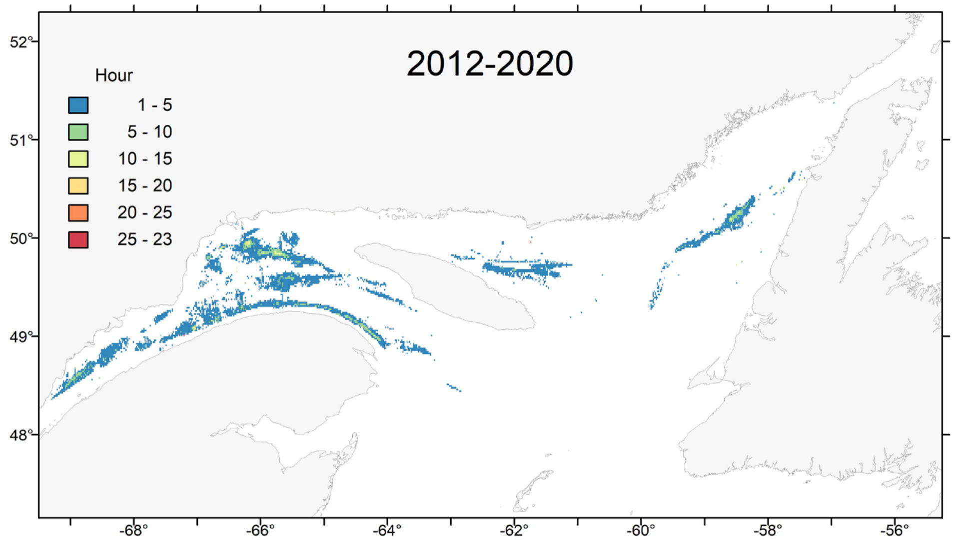


Figure 12b. (Continued).

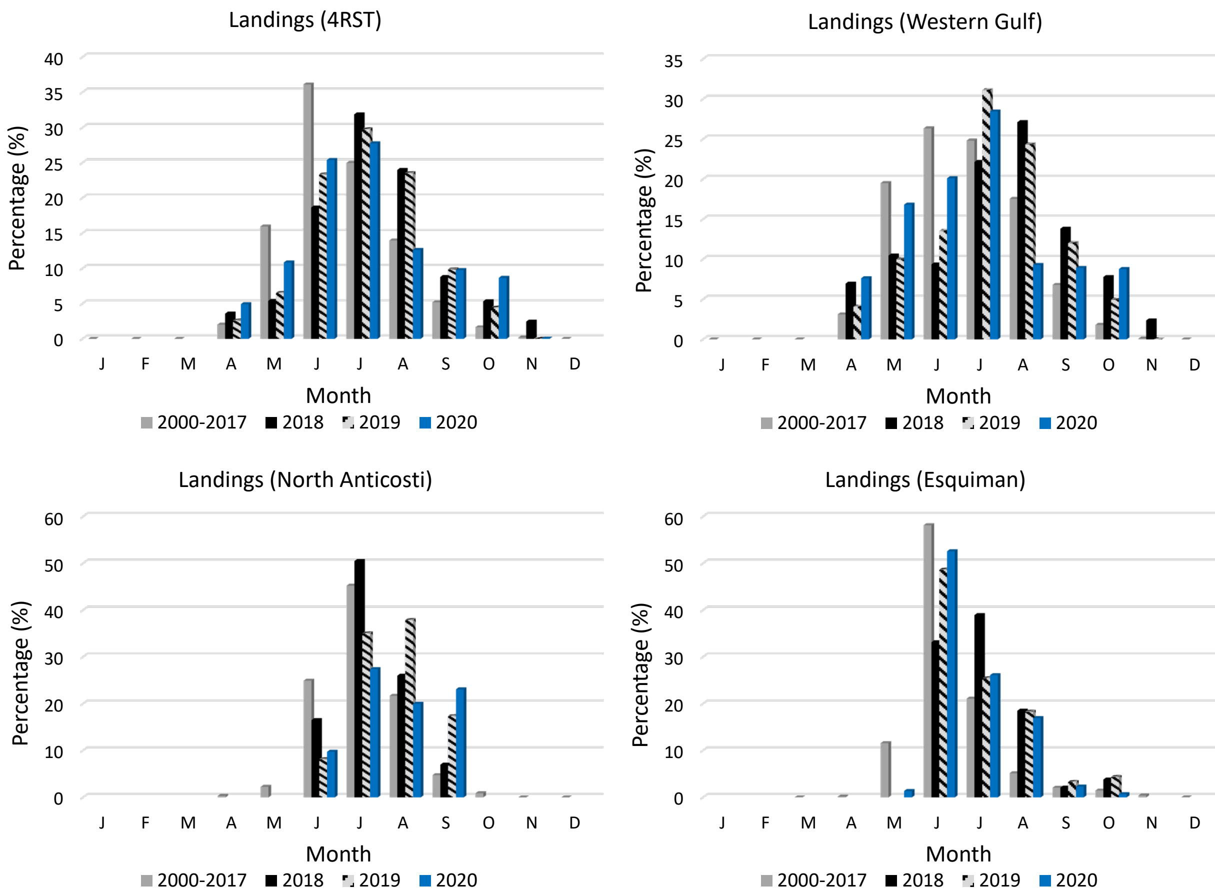


Figure 13. Proportion of monthly landings for the Gulf as a whole (4RST) and by fishing sector. Average for the periods 2000-2017 and for the year 2018, 2019 and 2020.

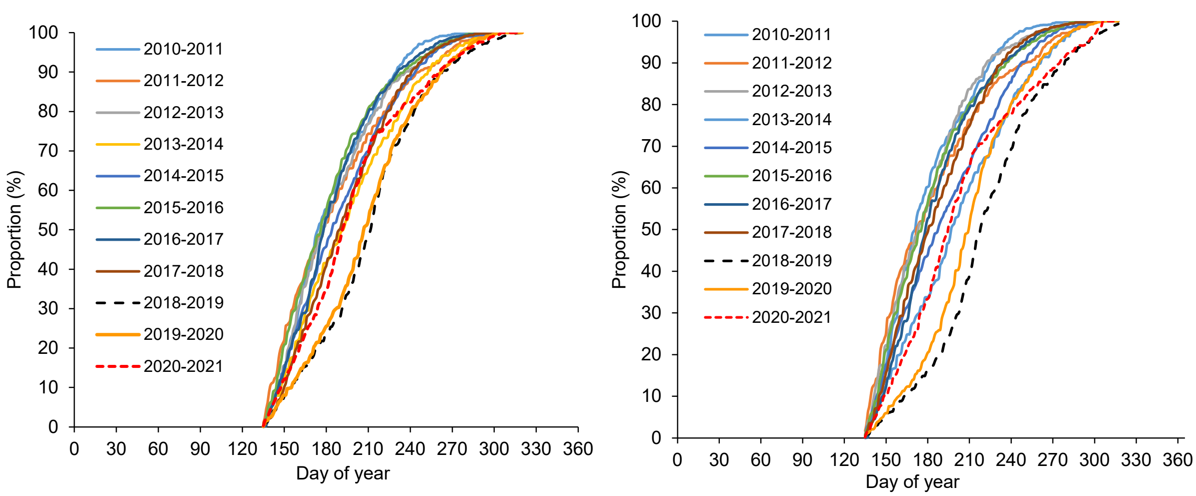


Figure 14. Cumulative fishing effort (%) (left) and cumulative landings (%) (right) based on the day of the year for the western Gulf sector for the 2010-2011 to 2020-2021 fishing seasons. The day 135 corresponds to May 15, which is the start date of the management year.

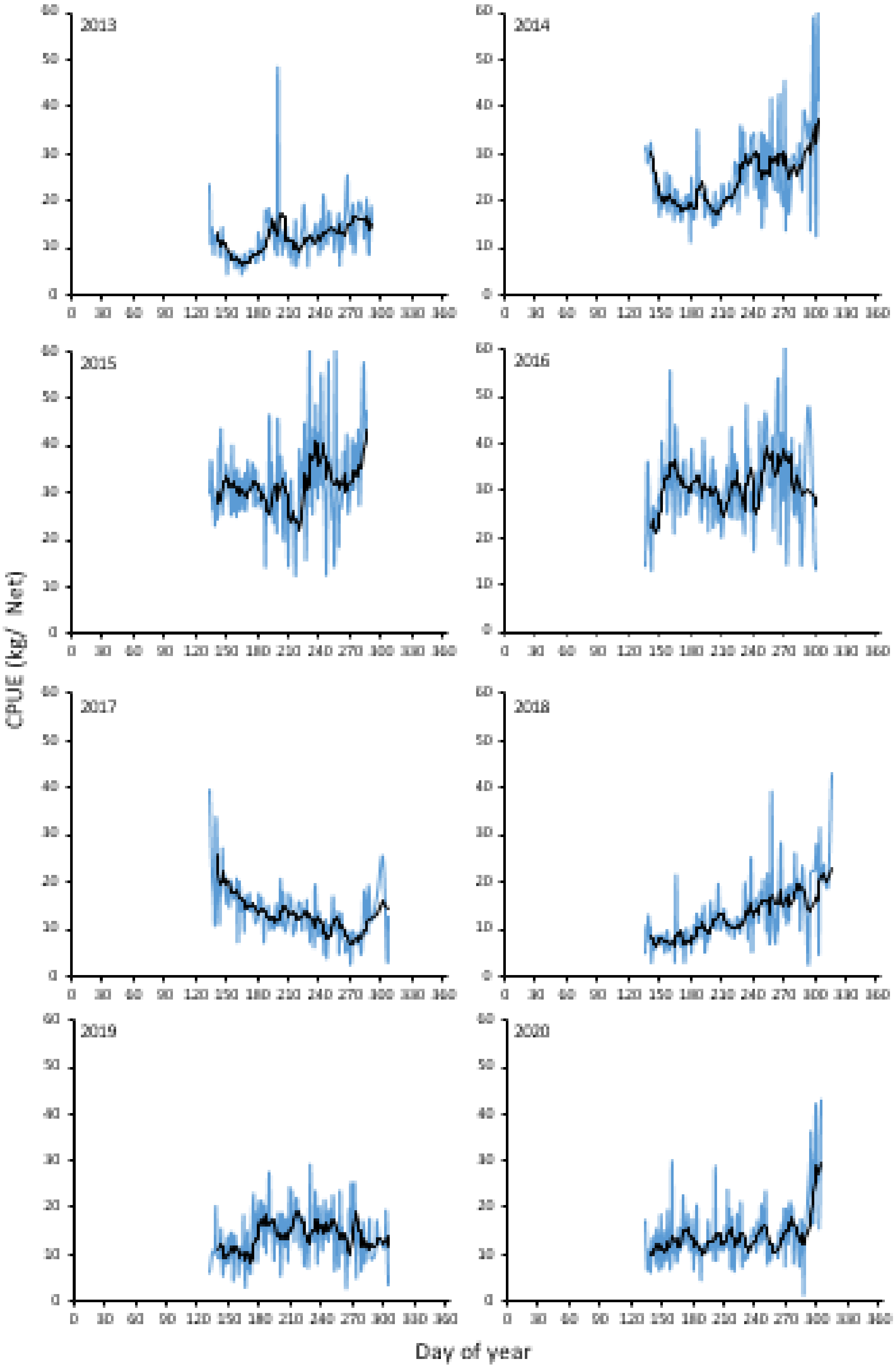


Figure 15. Daily catch per unit effort (CPUE kg/net) for the western Gulf sector for the years 2013 to 2020. The black line represents a moving average over 7 days.

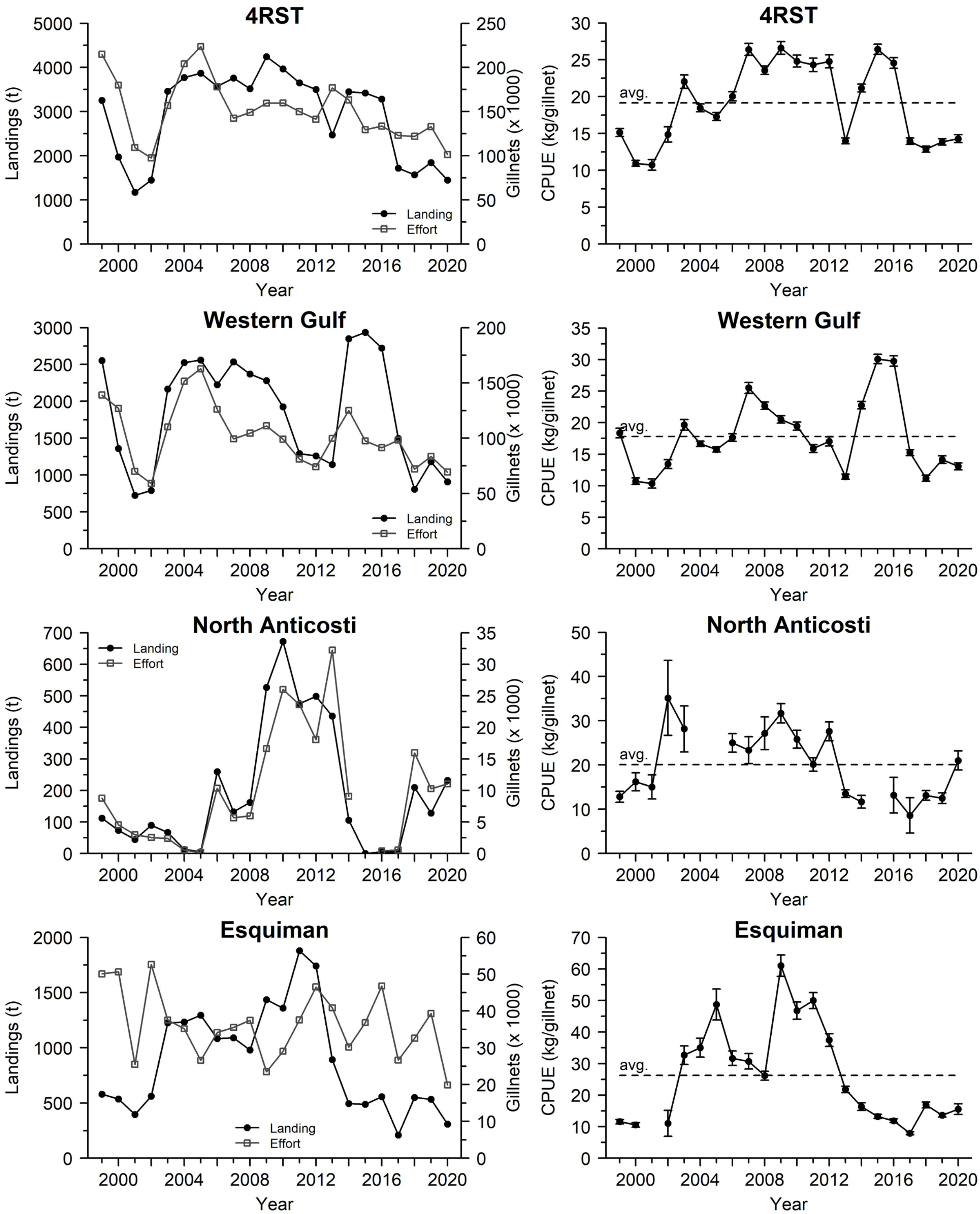


Figure 16. Landing, nominal effort and catch per unit effort (CPUE) ± 95% confidence interval, by year and fishing sector.

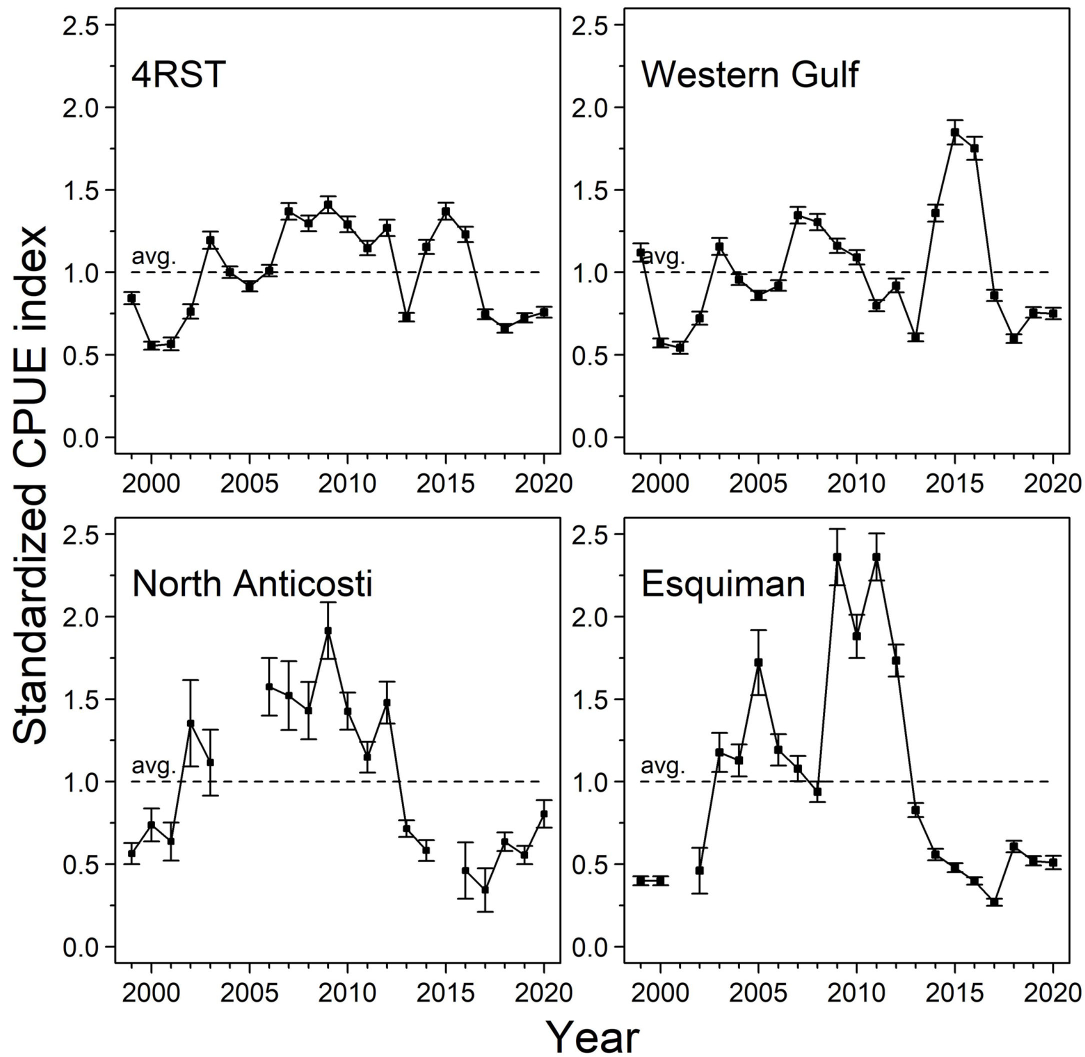


Figure 17. Annual fishing performance index (standardized CPUE) ± 95% confidence interval for the Gulf as a whole (4RST) and by fishing sector.

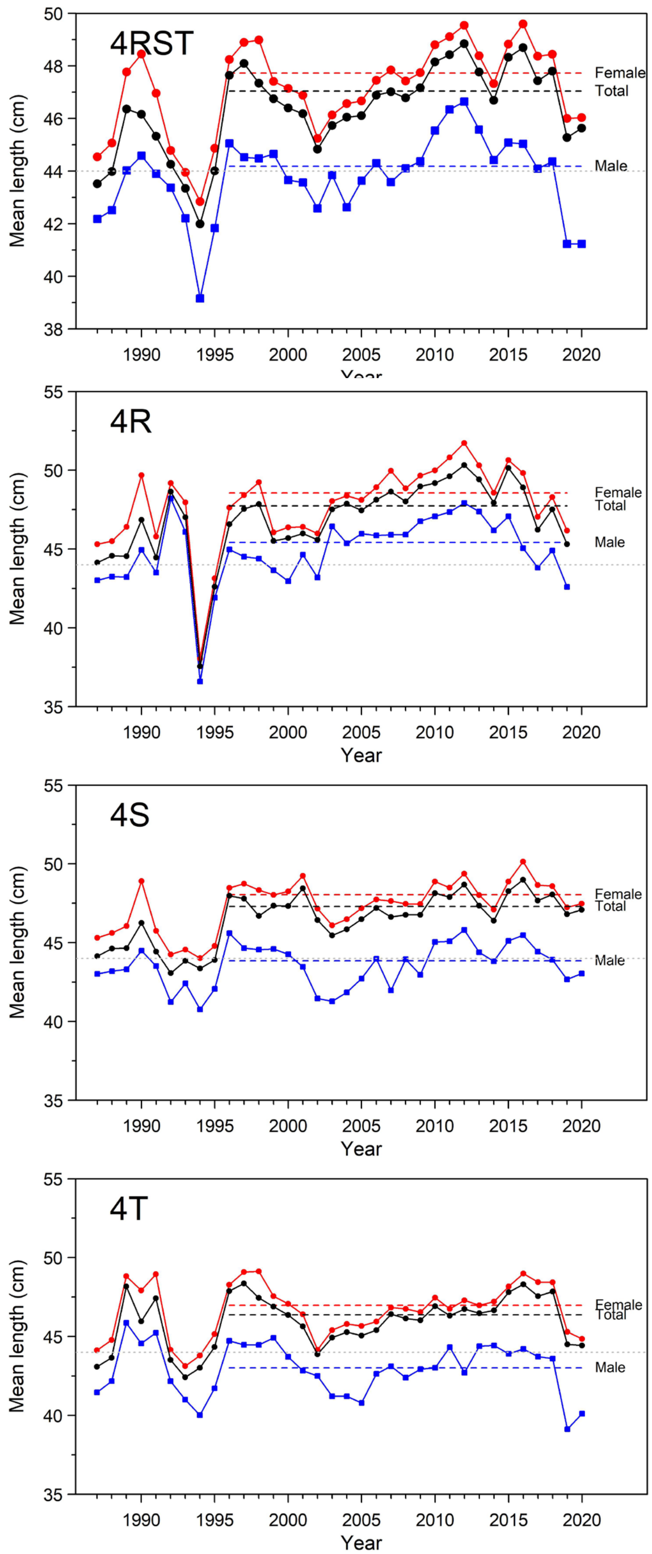


Figure 18. Average annual length of Greenland halibut caught in the commercial gillnet fishery by sex and NAFO Division from 1987 to 2020. The dotted lines represent the average for each series since the change in mesh size in 1996. Due to the sanitary conditions associated with the pandemic, data for 2020 were partial for Divisions 4S and 4T and no data was available for Division 4R.

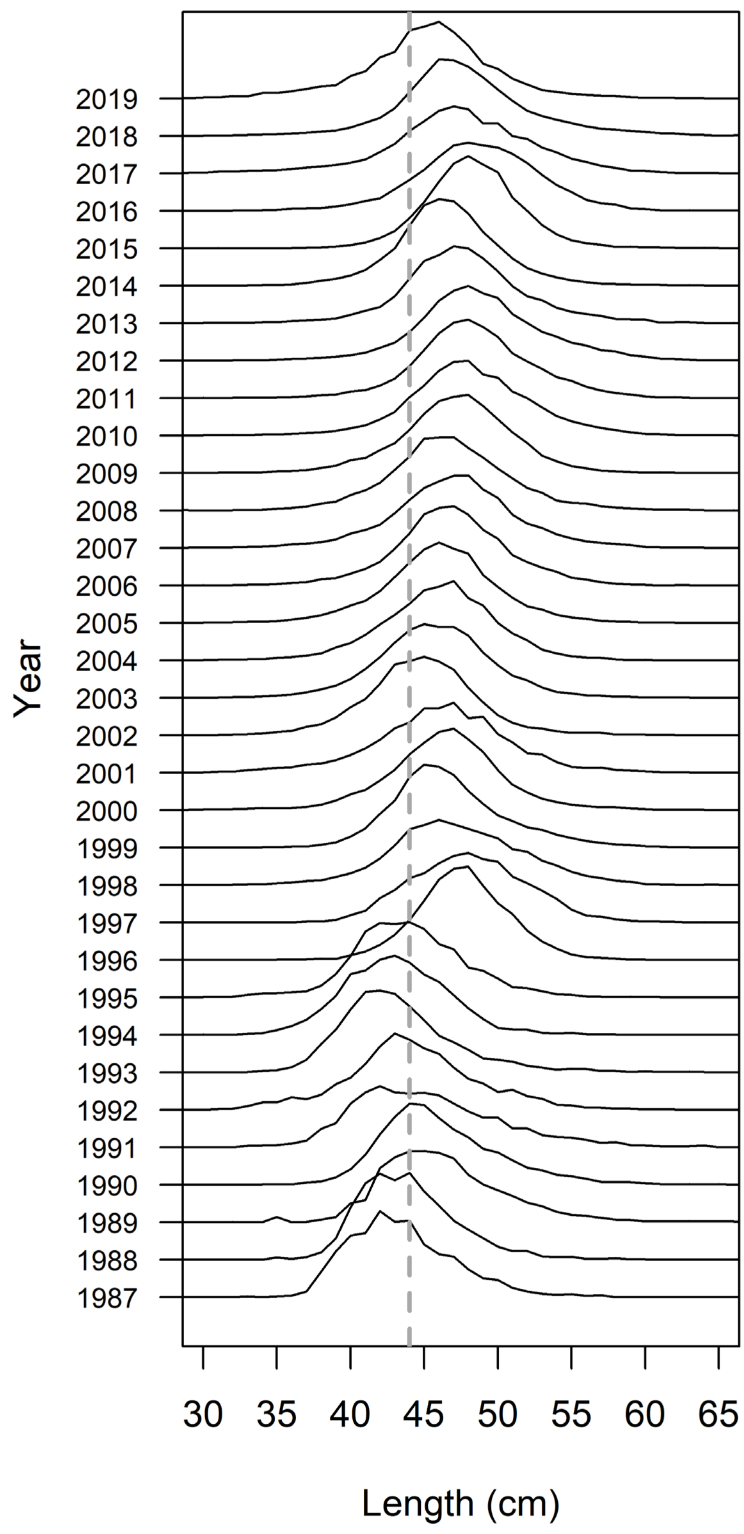


Figure 19. Size frequency distribution of Greenland halibut caught in the commercial gillnet fishery from 1987 to 2020. In 1996, the mesh size increased from 127 à 152 mm. The vertical line intersects the graph at 44 cm which is the minimum size of the small fish protocol.

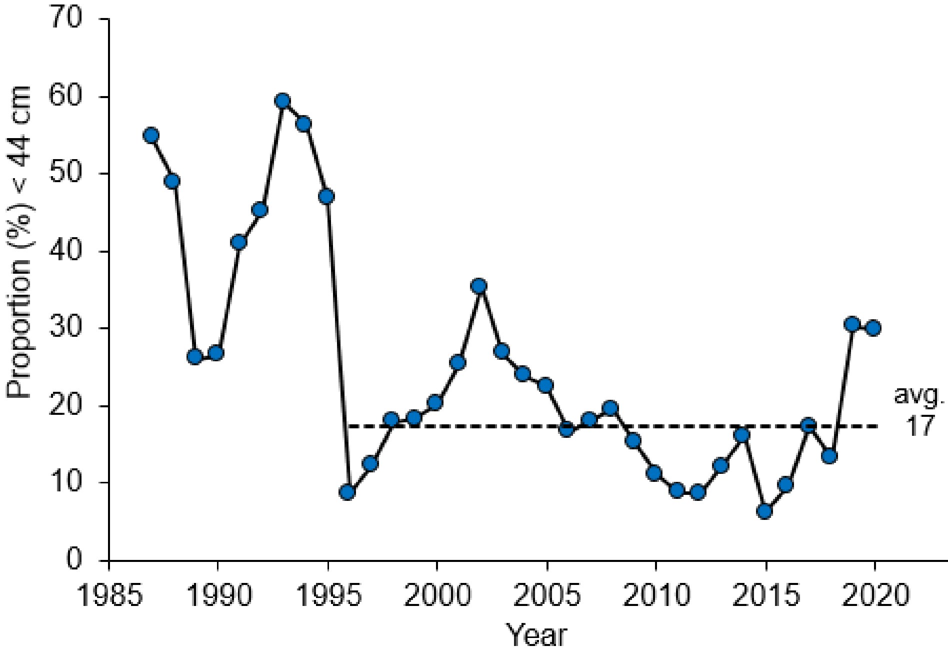


Figure 20. Annual proportion of Greenland halibut less than the minimal size of 44 cm in the commercial catch. The dotted line represents the average 1996-2019. i.e. after the change in gillnet mesh size. Due to the sanitary conditions linked to the pandemic, the data for 2020 was partial.

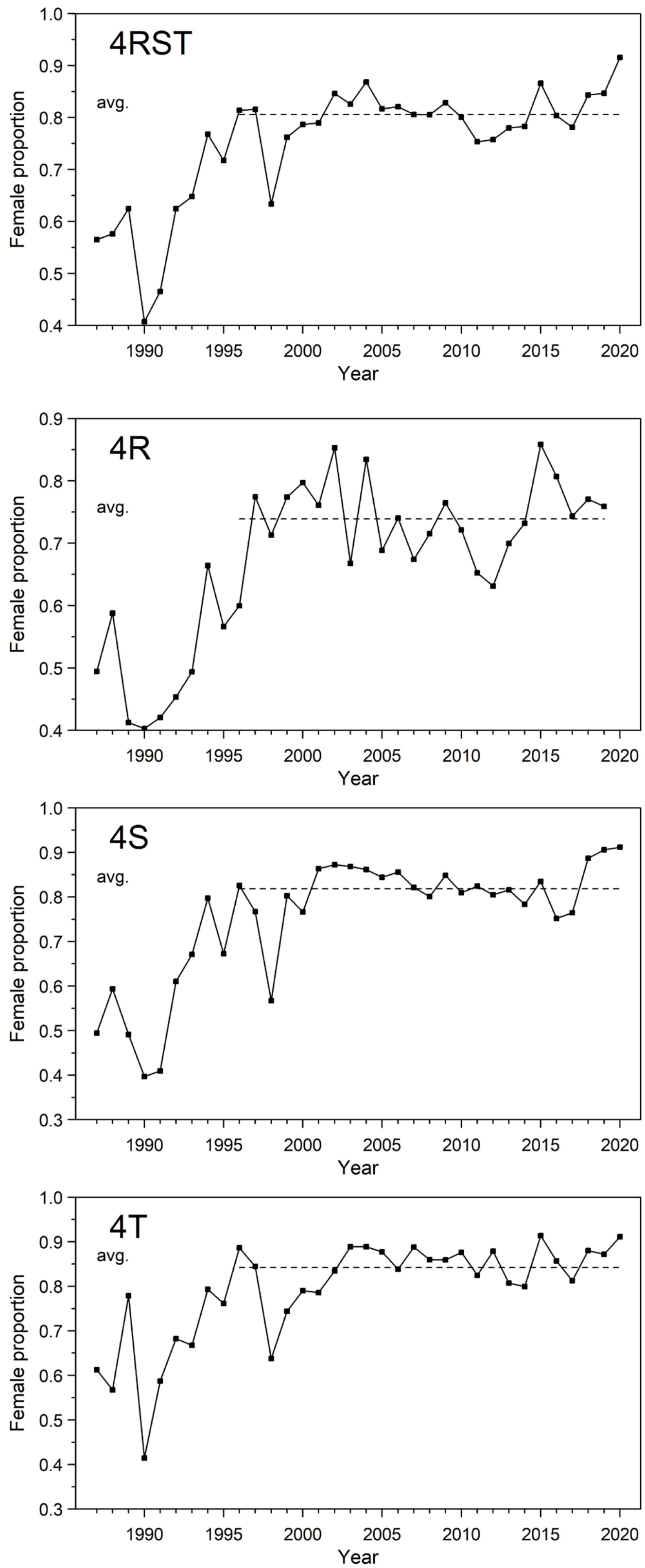


Figure 21. Proportion of females in gillnet catches by NAFO Division. The dotted line represents the average starting in 1996, the year of the change in mesh size from 5.5 to 6 inches. Due to the sanitary conditions linked to the pandemic, the data for 2020 was partial.

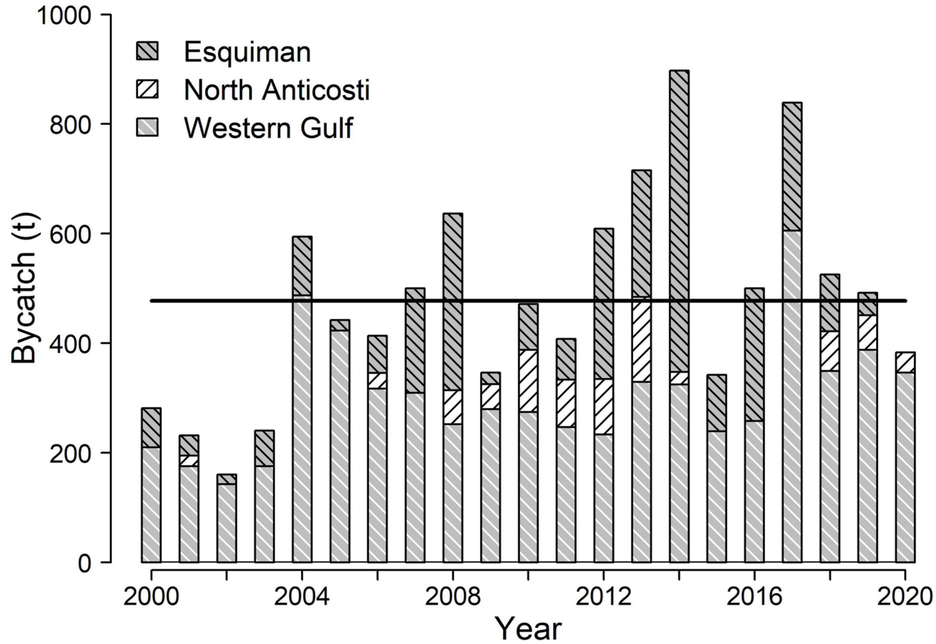


Figure 22. Total bycatch (t) of all species in the directed Greenland halibut gillnet fishery by year and fishing area estimated with data from the at-sea observer program. Solid line indicates the average for the years 2000-2020. Data for 2020 are preliminary and no data were available for Esquiman. Data is preliminary for 2020 and no at-sea observer program data was available for the Esquiman sector in 2020 at the time of writing.

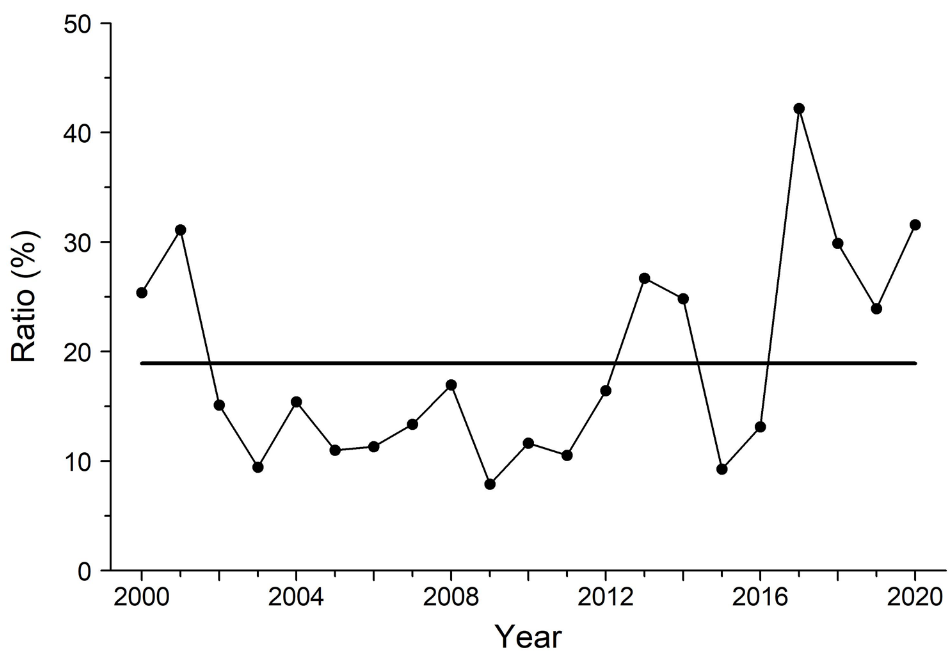


Figure 23. Ratio (%) of bycatch for all species combined to total Greenland halibut catch. Solid line indicates the average for the years 2000-2020. Data for 2020 are preliminary and no data were available for Esquiman.

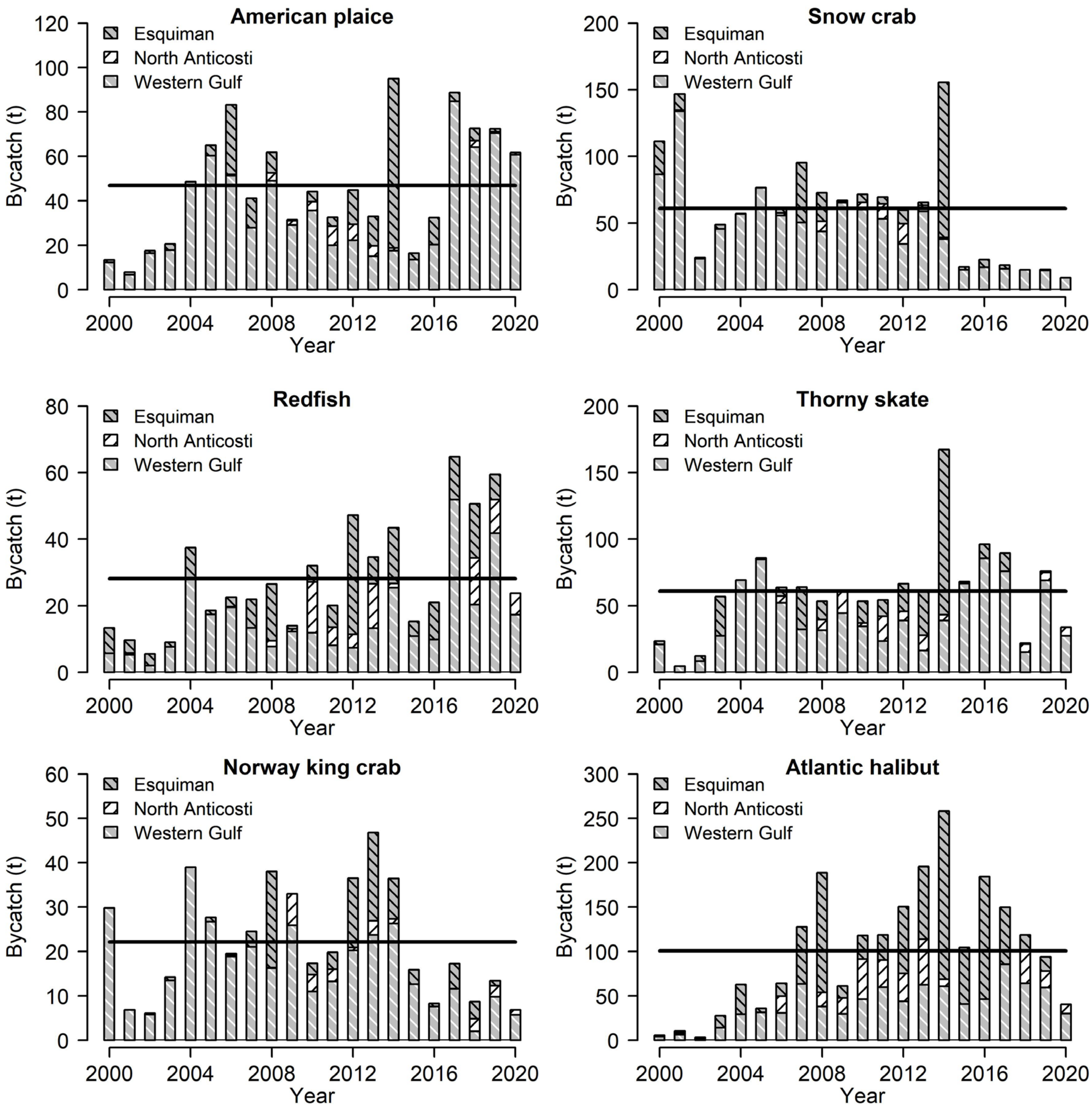


Figure 24. Annual bycatch in the directed Greenland halibut gillnet fishery, estimated for six species per fishing sector based on data from the at-sea observer program. The solid line indicates the average for the years 2000-2020. Data are preliminary for 2020 with no data available for Esquiman.

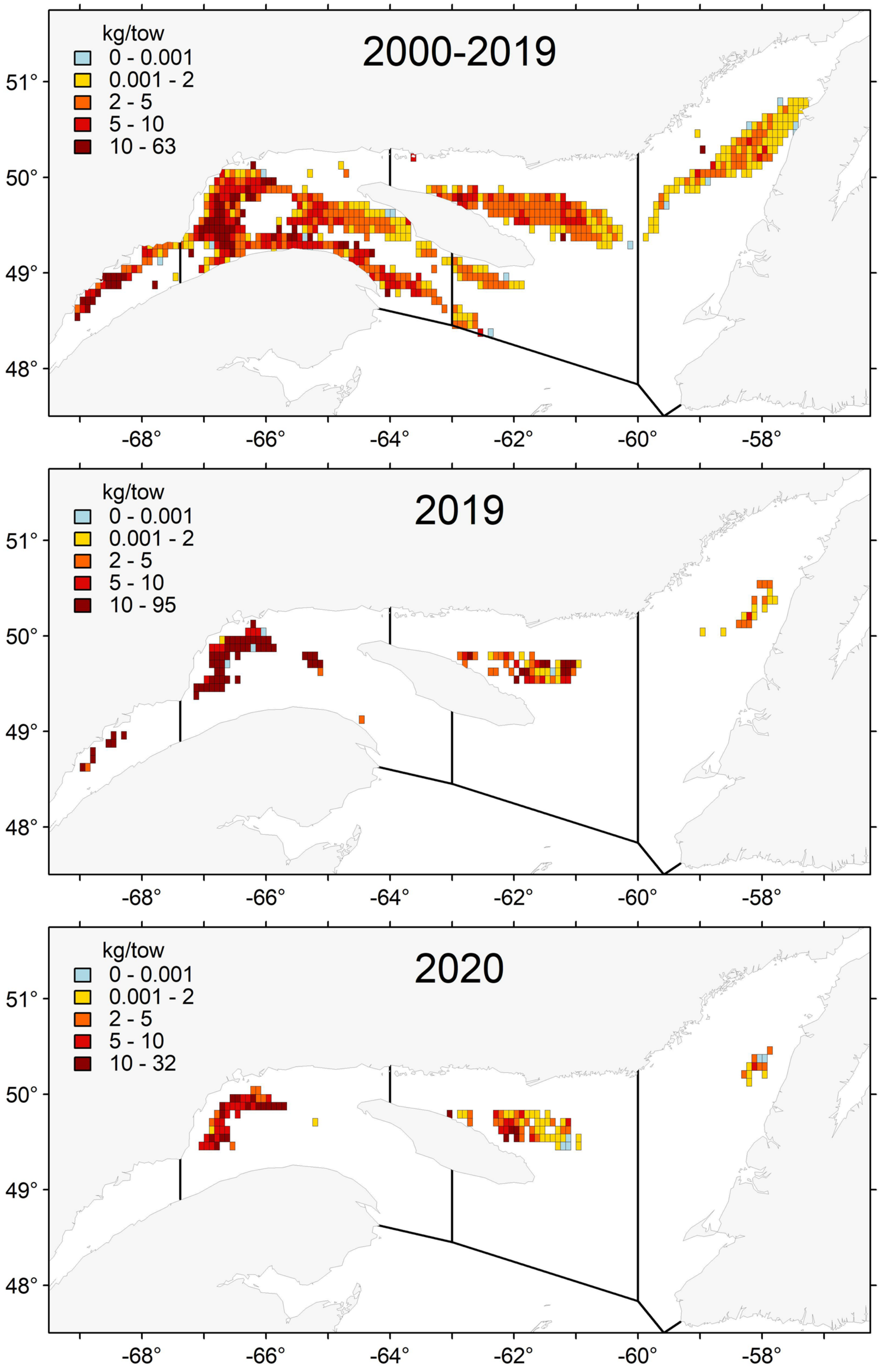


Figure 25. Spatial distribution of Greenland halibut bycatch averaged per 5-minute square in directed shrimp fisheries in the presence of an at-sea observer. Average for 2000-2019 and data for 2019 and 2020.

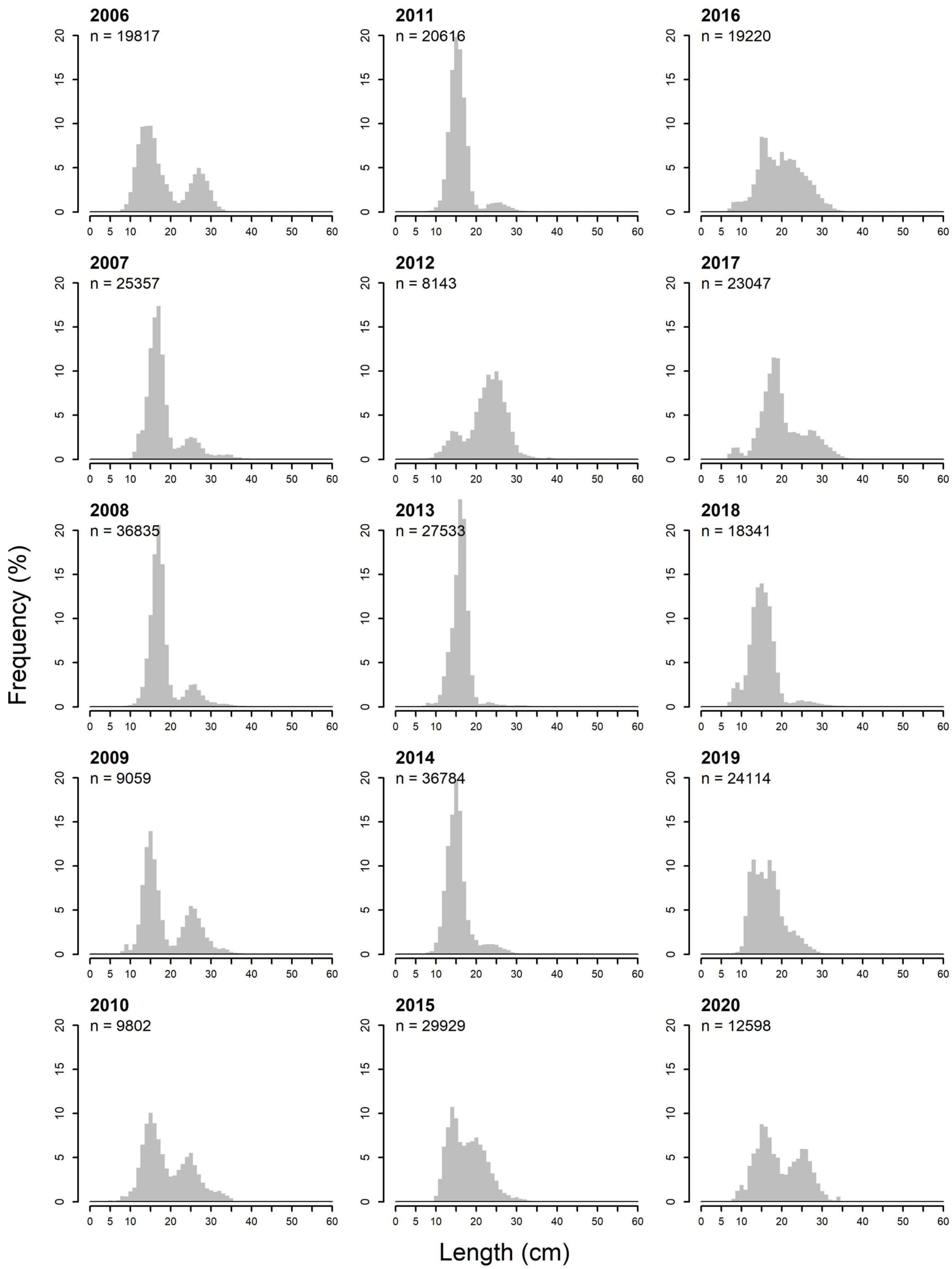


Figure 26. Length frequency distribution of Greenland halibut sampled by at-sea observers from 2006 to 2020 in the directed shrimp fishery. The number (n) of specimens measured is indicated.

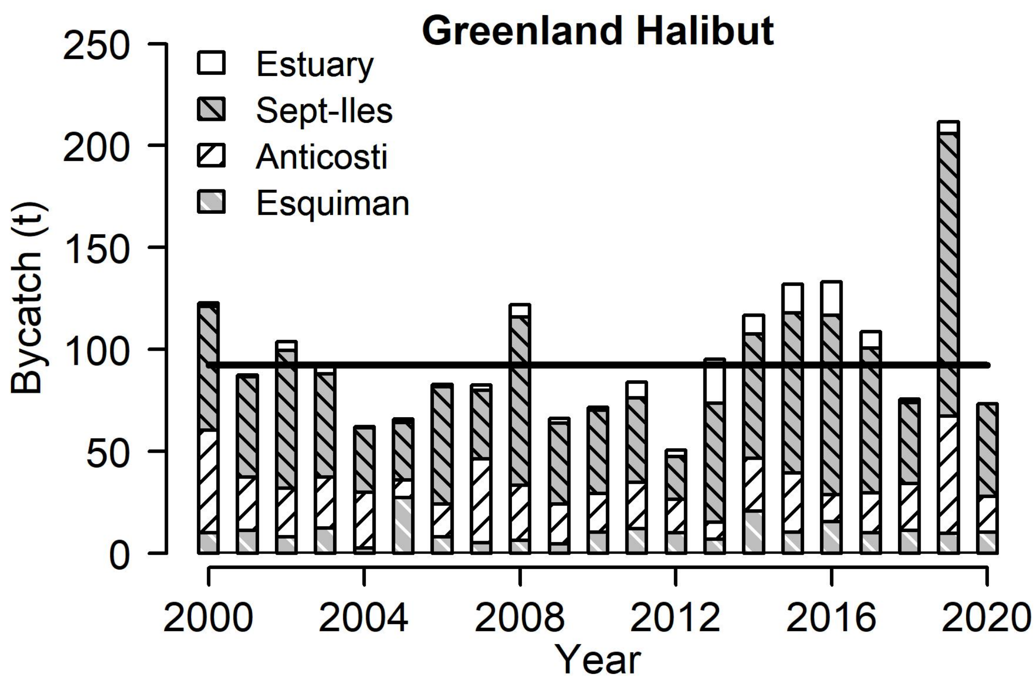


Figure 27. Bycatch of Greenland halibut in the directed shrimp fishery, estimated annually by at-sea observers according to shrimp fishing areas. The solid line indicates the average for the years 2000-2020. No data were available for the Estuary in 2020.

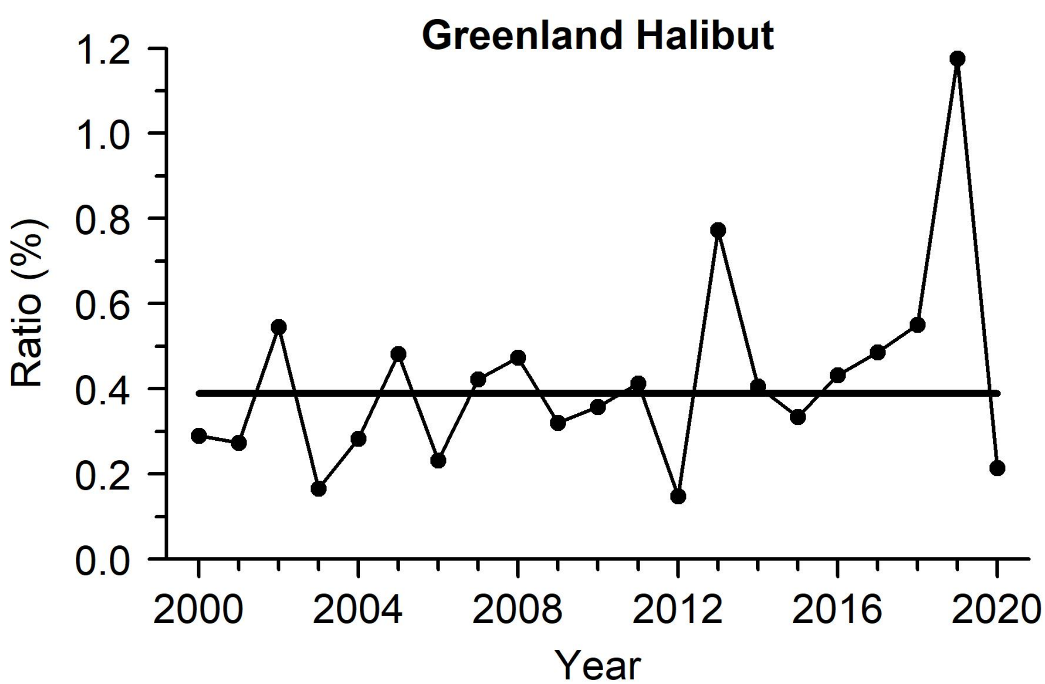


Figure 28. Ratio (%) of shrimp bycatch to estimated Greenland halibut biomass estimated by the Northern Gulf of St. Lawrence Groundfish Survey data. Solid line indicates the average for the years 2000-2020. No data were available for the Estuary in 2020.

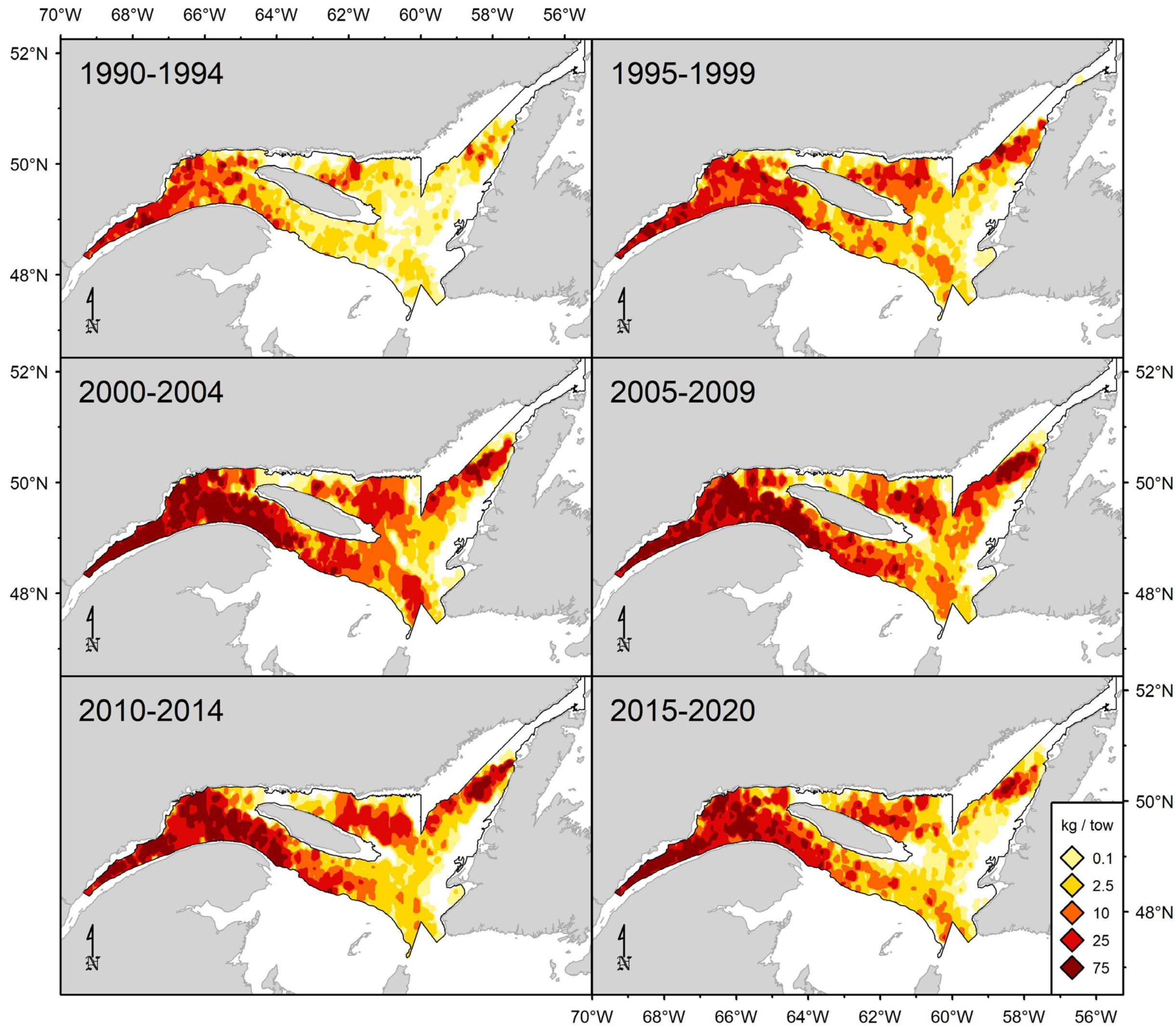


Figure 29. Spatial distribution of catch rates (kg / 15-minute tow) of Greenland halibut during the DFO nGSL survey over four or five year periods.

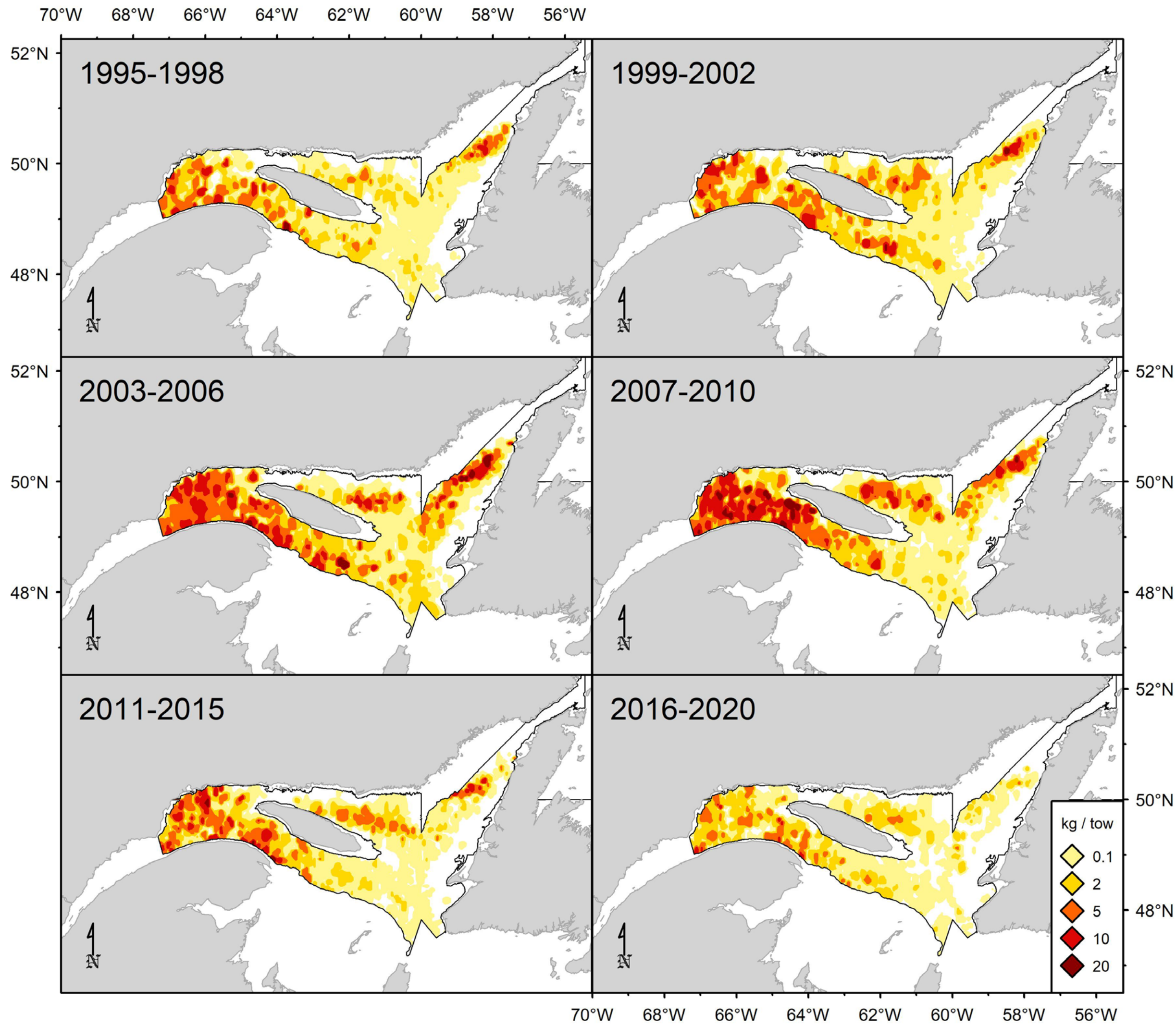


Figure 30. Spatial distribution of catch rates (kg / 30-minute tow) of Greenland halibut in the mobile sentinel survey over four to five year periods.

≤ 20 cm

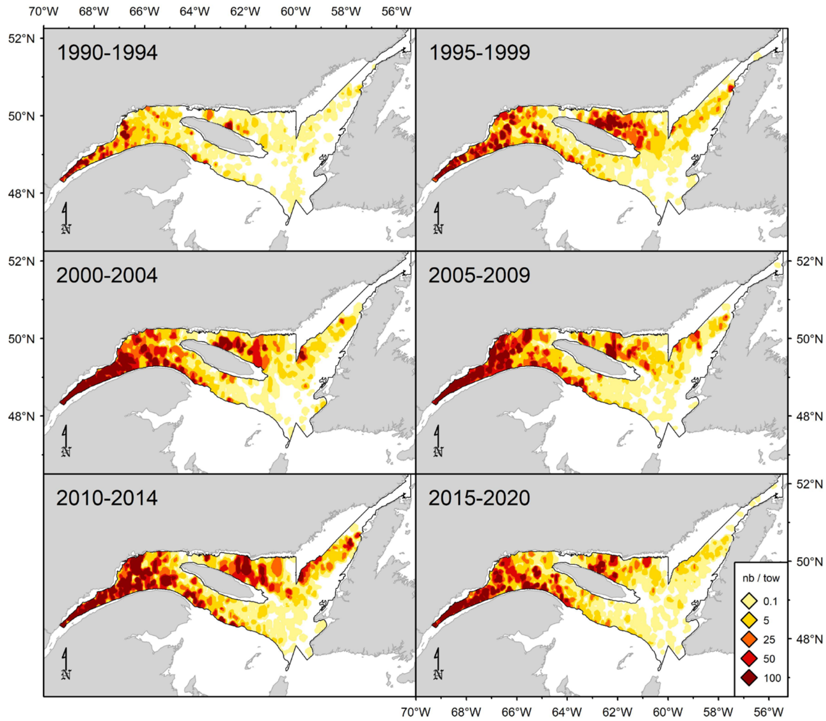


Figure 31. Spatial distribution of catch rates (number / 15 minute tow) of Greenland halibut ≤ 20 cm in the DFO nGSL survey over five or six year periods.

20 – 30 cm

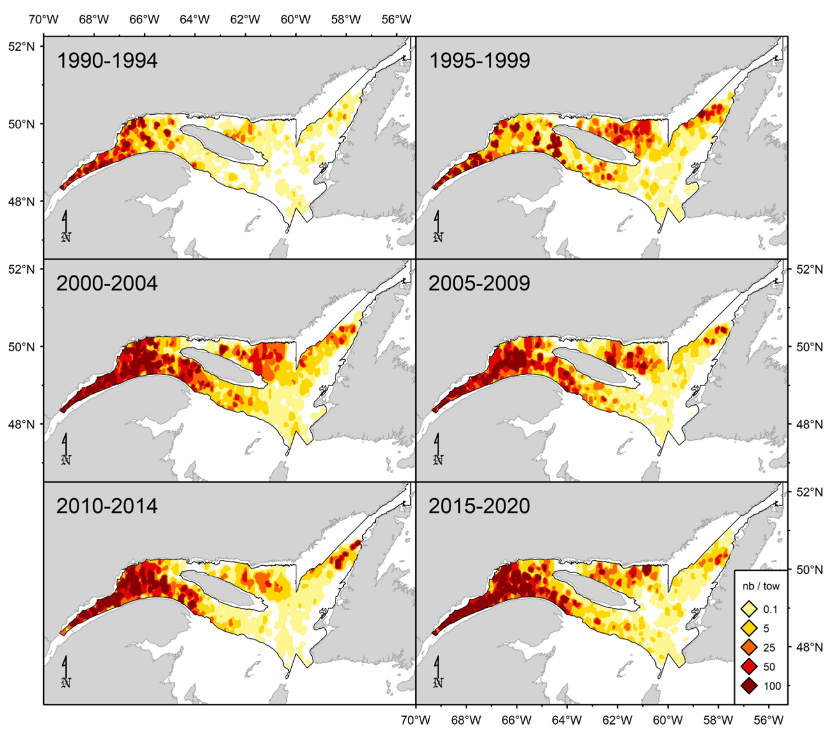


Figure 32. Spatial distribution of catch rates (number / 15 minute tow) of 20 to 30 cm Greenland halibut in the DFO nGSL survey five or six year periods.

30 – 40 cm

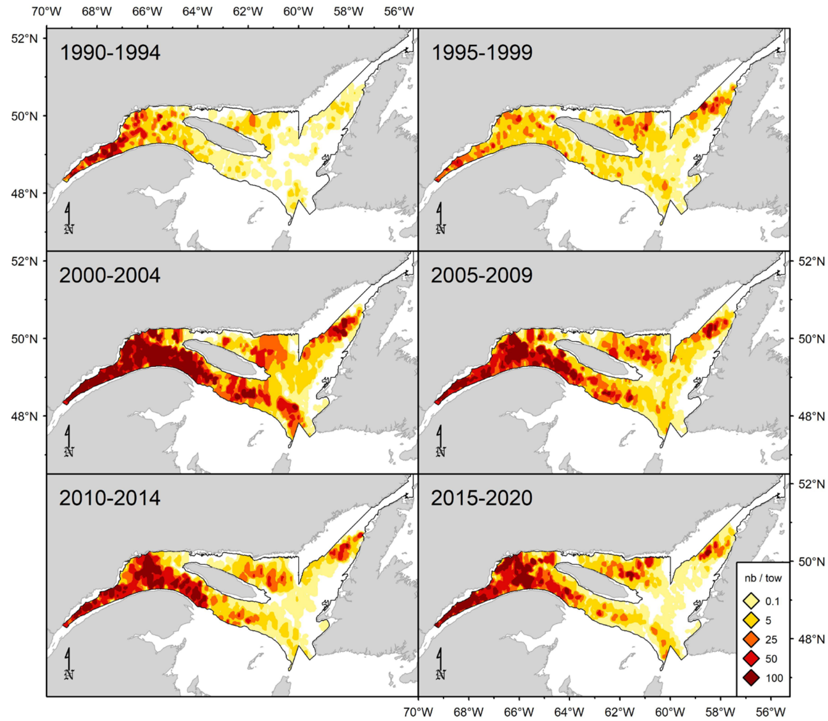


Figure 33. Spatial distribution of catch rates (number / 15 minute tow) of 30 to 40 cm Greenland halibut in the DFO nGSL survey over five or six year periods.

> 40 cm

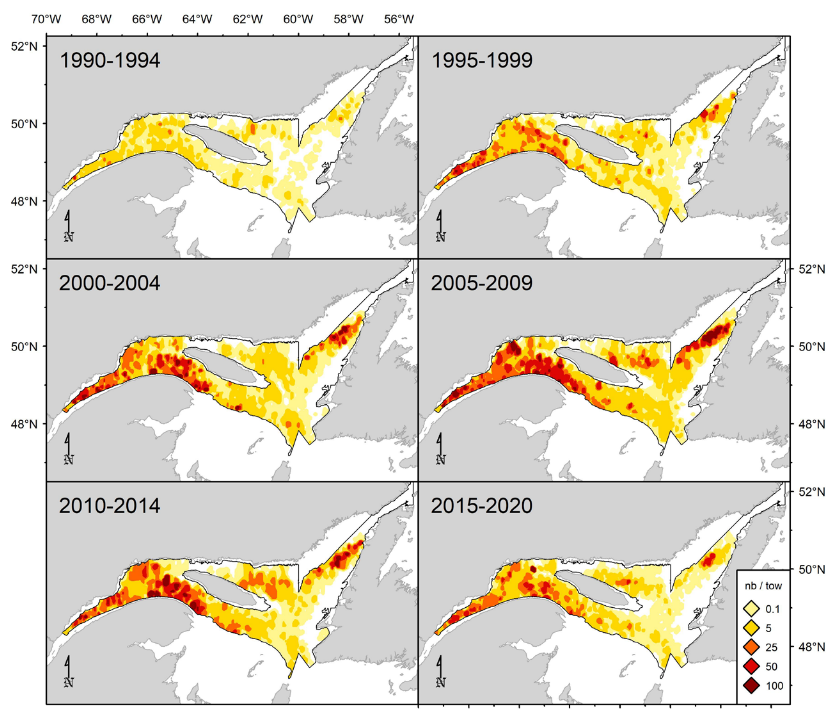


Figure 34. Spatial distribution of catch rates (number / 15 minute tow) of Greenland halibut 40 cm and greater in the DFO nGSL survey over five or six year periods.

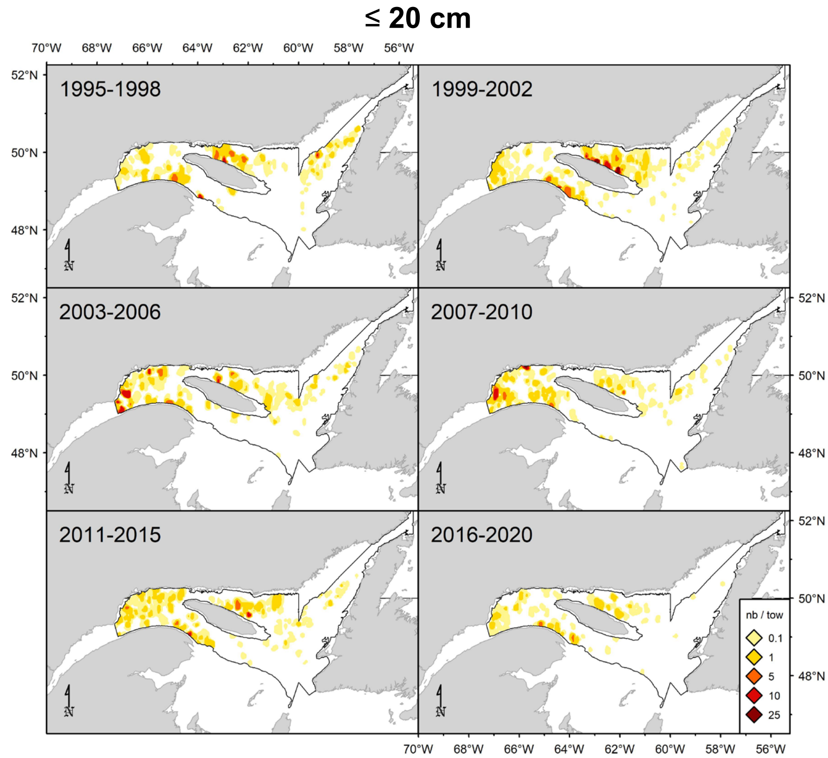


Figure 35. Spatial distribution of catch rates (number / 30-minute tow) of Greenland halibut less than 20 cm in July mobile sentinel survey over four to five year periods.

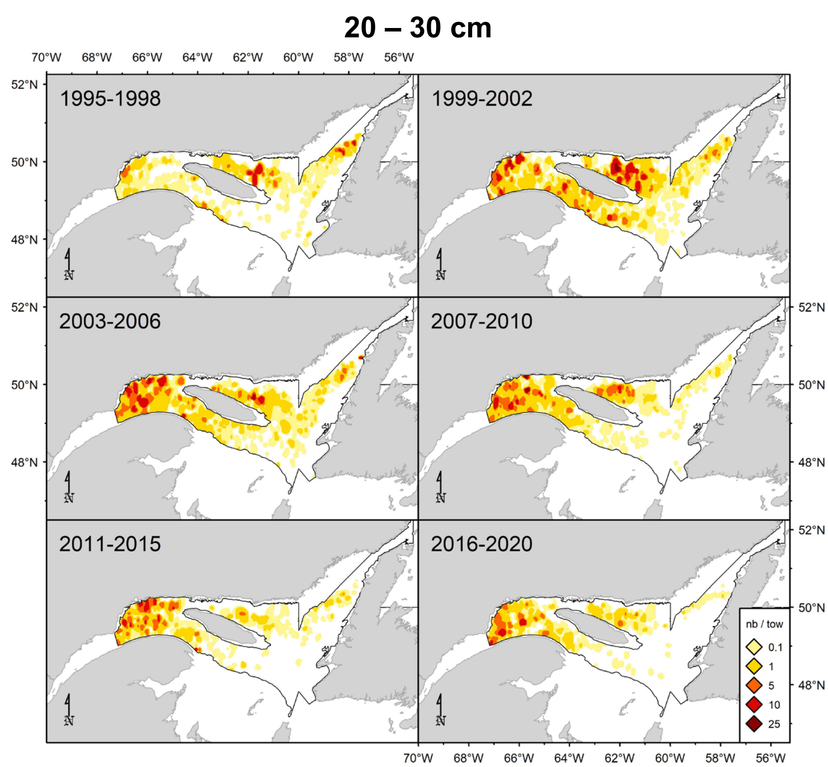


Figure 36. Spatial distribution of catch rates (number / 30 minute tow) of Greenland halibut 20 to 30 cm in July mobile sentinel survey over four to five year periods.

30 – 40 cm

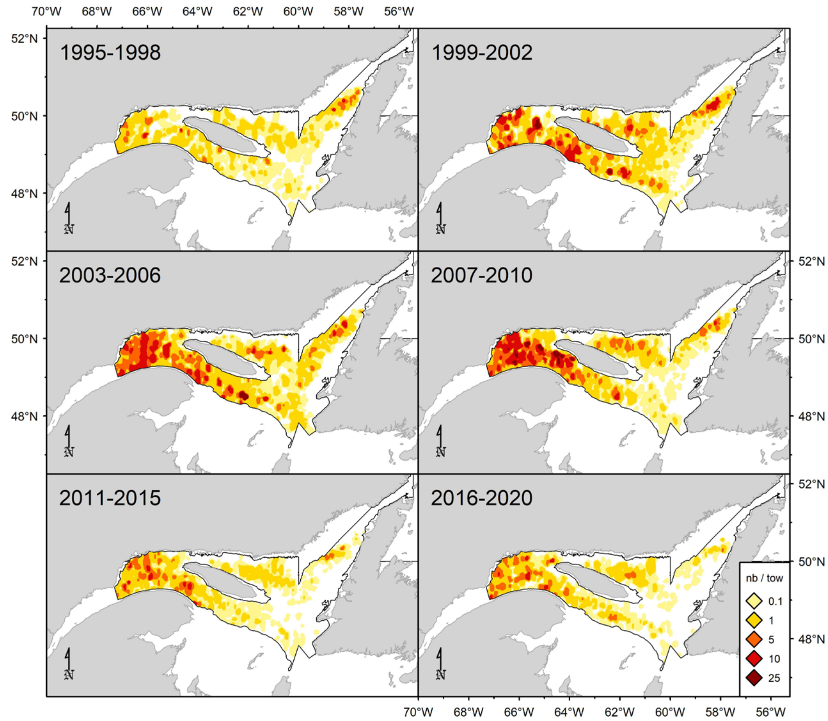


Figure 37. Spatial distribution of catch rates (number / 30 minute tow) of Greenland halibut 30 to 40 cm in July mobile sentinel survey over four to five year periods.

> 40 cm

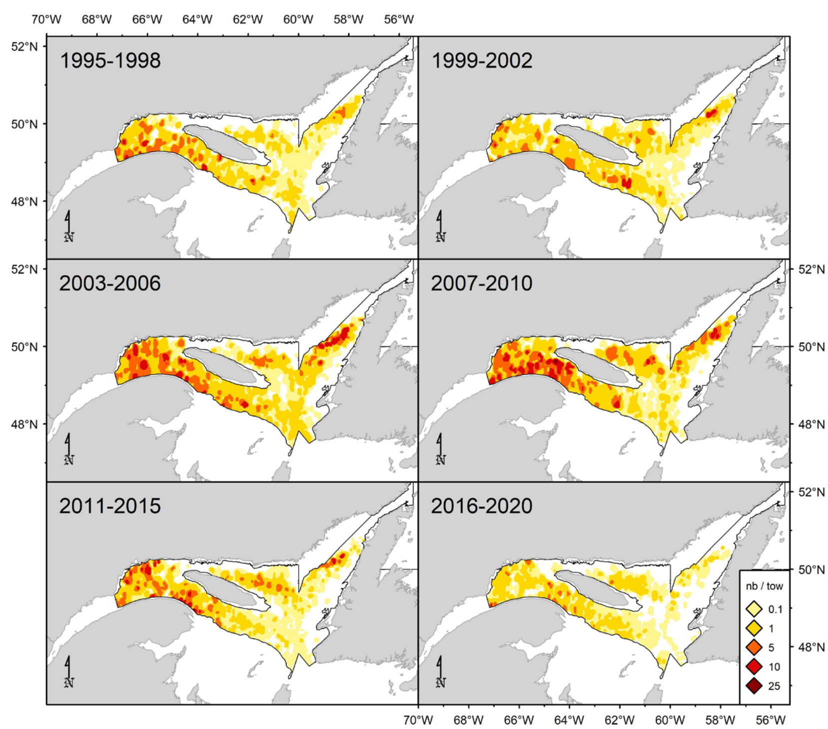


Figure 38. Spatial distribution of catch rates (number / 30-minute tow) of Greenland halibut 40 cm and greater in July mobile sentinel survey over four to five year periods.

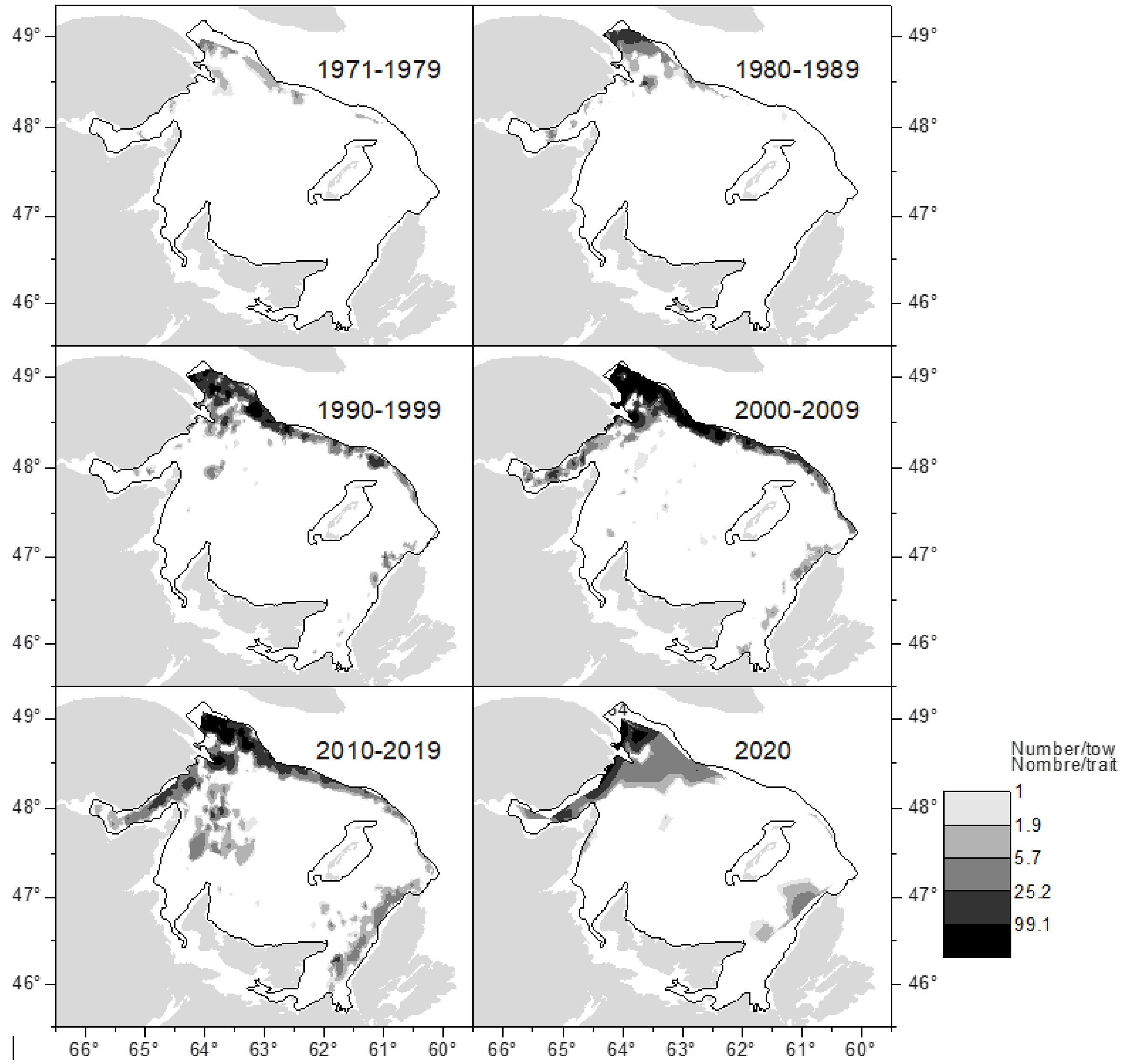


Figure 39. Spatial distribution of Greenland halibut catches (all sizes) in number per tow in DFO's sGSL survey. The contours are based on the 10th. 25th. 50th. 75th and 90th percentiles of non-zero catches over the period 1971-2020. Note that the panel for 2020 is based on less data and therefore the contours involve more smoothing than in the other panels.

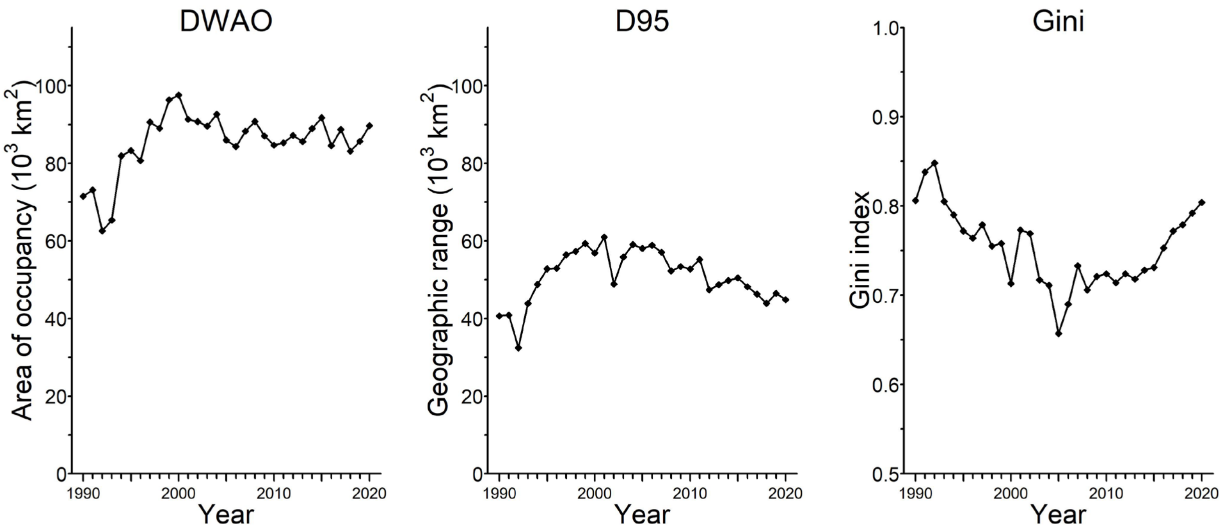


Figure 40. Spatial distribution indices: 1) DWAO, weighted area of occupancy. 2) D95, minimum area where 95% of the biomass is concentrated, and 3) Gini index. The total DFO nGSL surveyed area is 116,115 km^2.

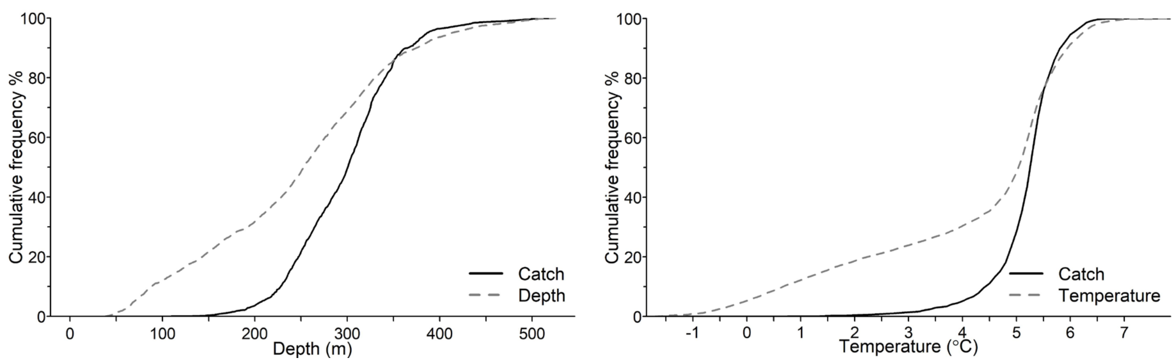


Figure 41. Cumulative frequency of Greenland halibut catches (weight per tow) and number of stations sampled as a function of depth (left graph) and a function of bottom temperature (right graph) in the DFO nGSL survey from 1990 to 2020.

A) B)

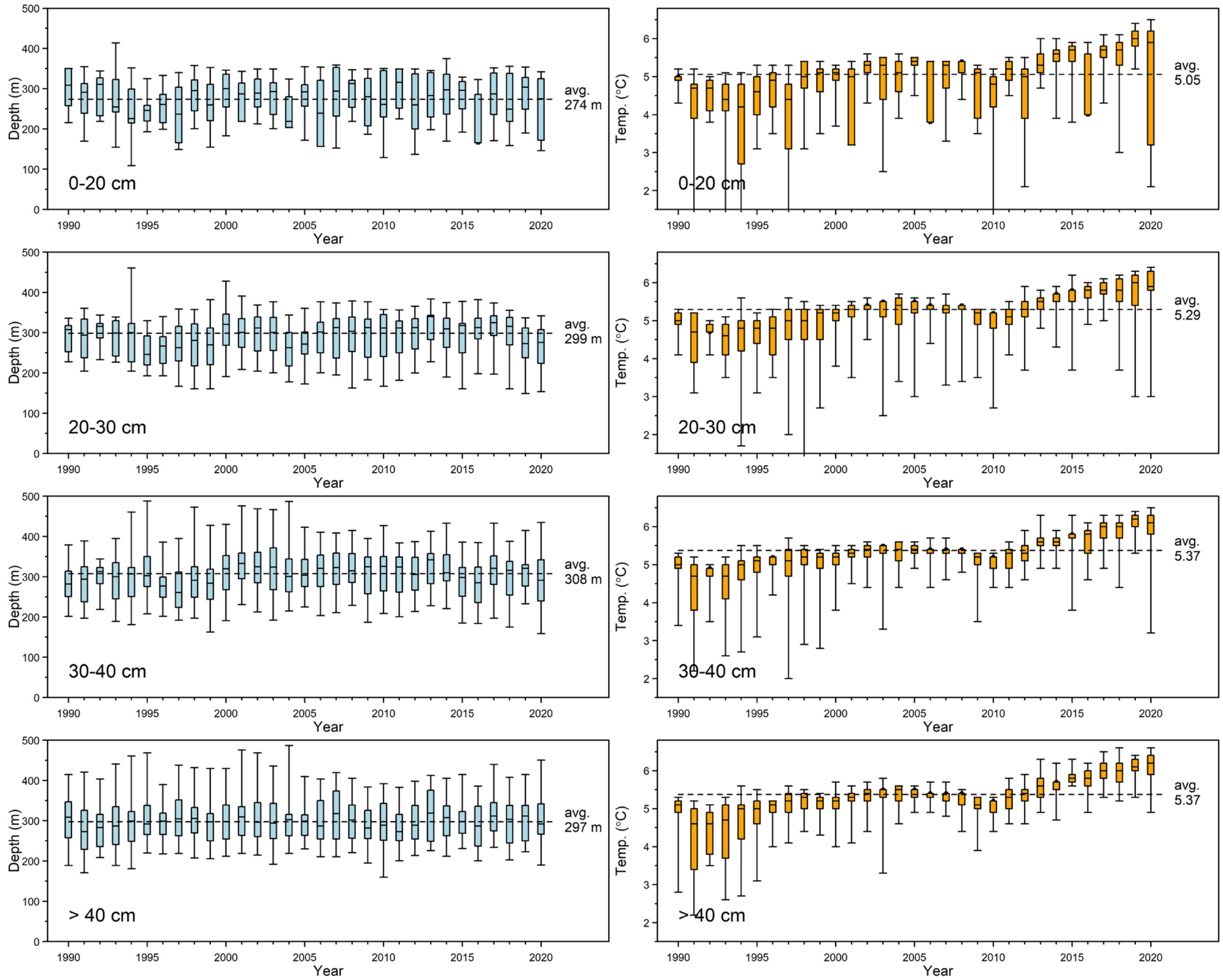
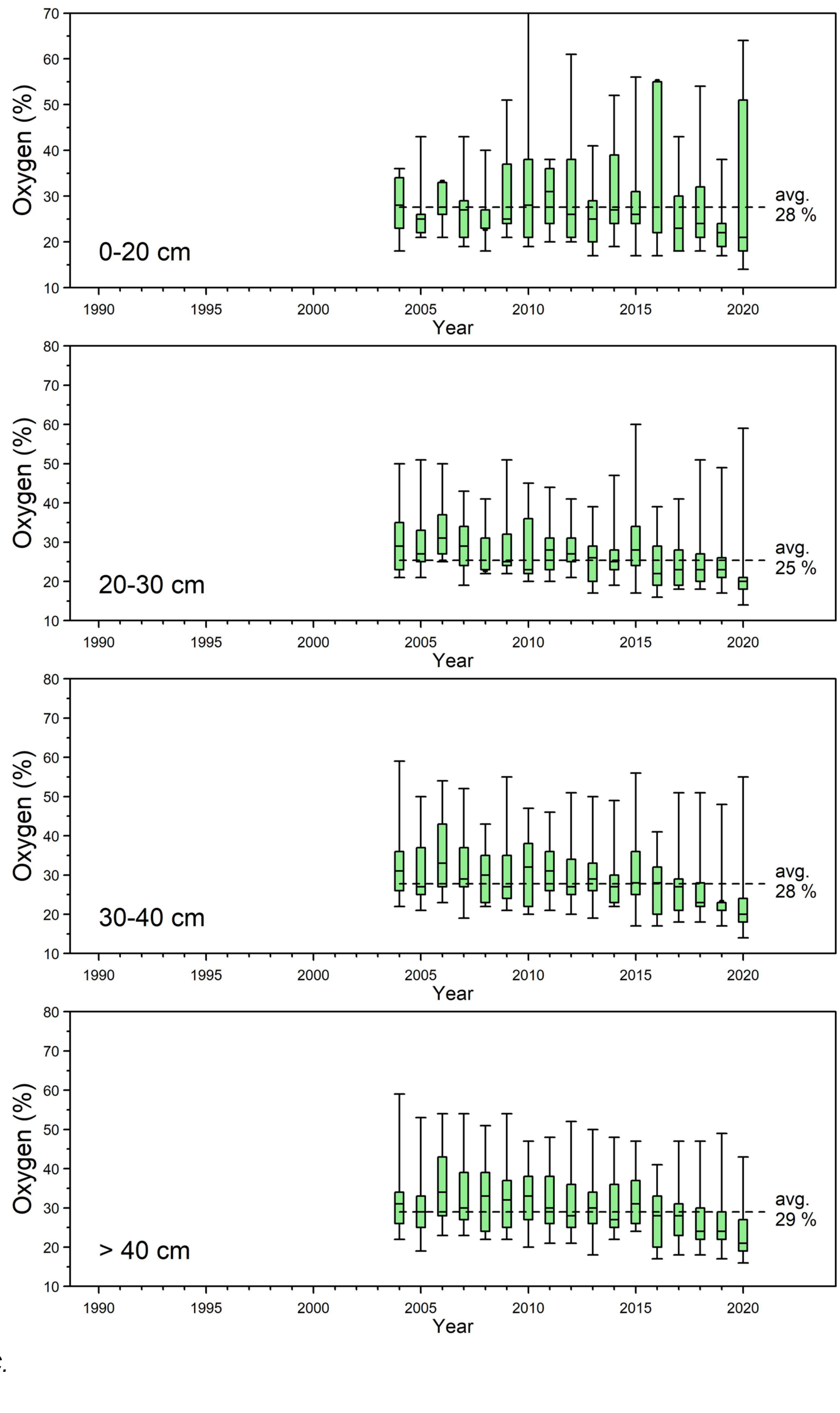


Figure 42. Distribution of Greenland halibut biomass as a function of A) depth B) temperature and C) oxygen saturation level for different size categories observed in the DFO nGSL survey. Box and whiskers plot: the line inside the box represents the median. the box extends from percentiles 25 to 75 and the whiskers (vertical lines on either side of the box) extend from percentiles 5 to 95. The horizontal dotted line on each graph shows the average of the series.



Oxygen (%)
0-20 cm
avg. 28 %
20-30 cm
avg. 25 %
30-40 cm
avg. 28 %
> 40 cm
avg. 29 %
Year
1990
1995
2000
2005
2010
2015
2020

Figure 42C.

A) B)

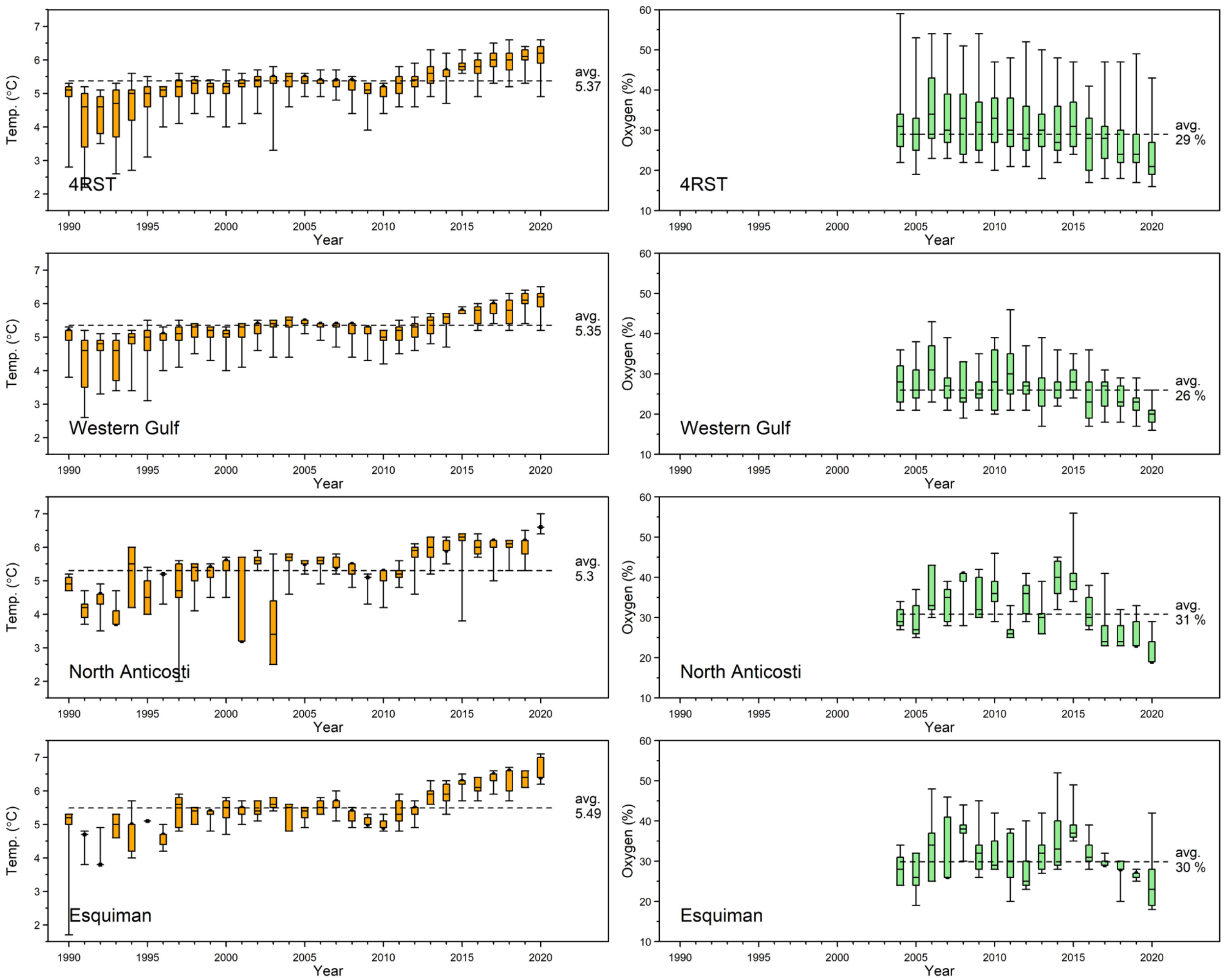


Figure 43. Distribution of Greenland halibut biomass as a function of A) bottom temperature, B) oxygen saturation level by fishing sector for fish larger than 40 cm observed in the DFO nGSL survey. Box and whiskers plot: the line inside the box represents the median, the box extends from percentiles 25 to 75 and the whiskers (vertical lines on either side of the box) extend from percentiles 5 to 95. The horizontal dotted line on each graph shows the average of the series.

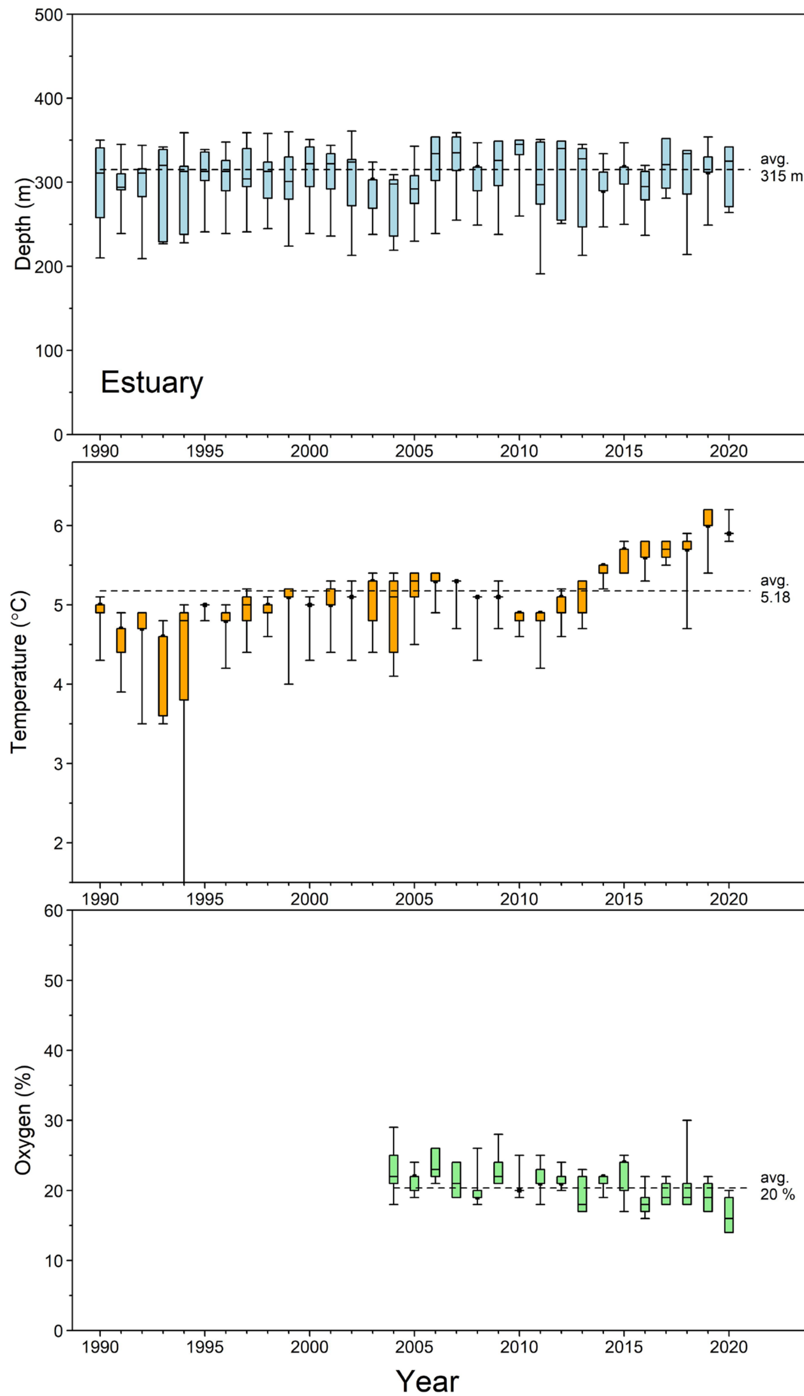
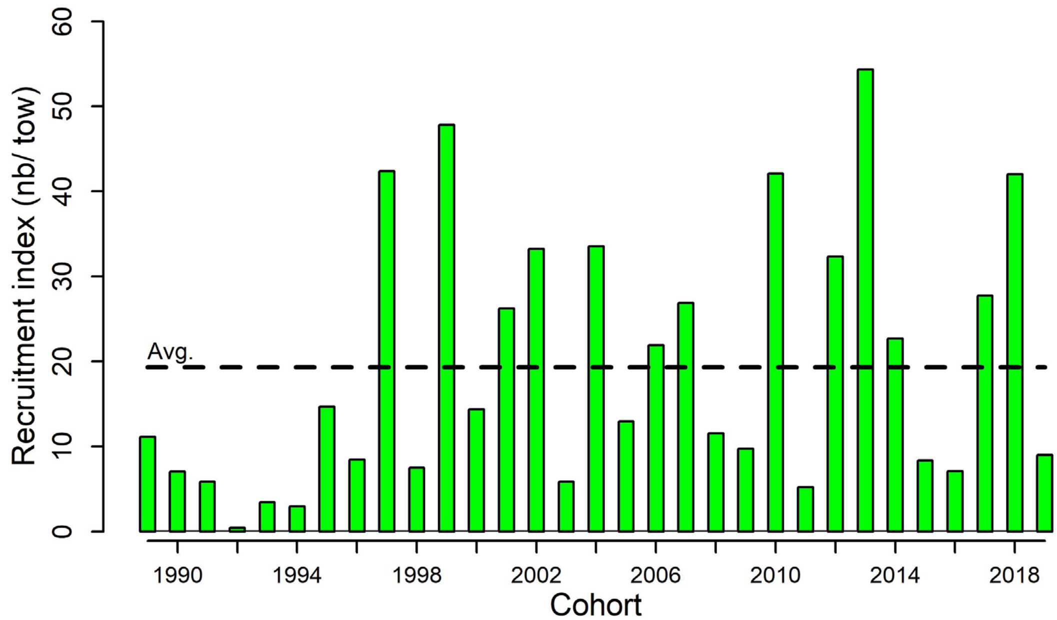


Figure 43 C. Greenland halibut biomass distributions in the Lower Estuary as a function of depth, bottom temperature and oxygen saturation level based on DFO nGSL survey data. Boxplot graphical representation: the line inside the box represents the median, the box extends from the 25th to 75th percentiles, and the whiskers (vertical lines on either side of the box) extend from the percentiles 5 to 95. The dashed horizontal line on each of the graphs represents the series mean.

A)



B)

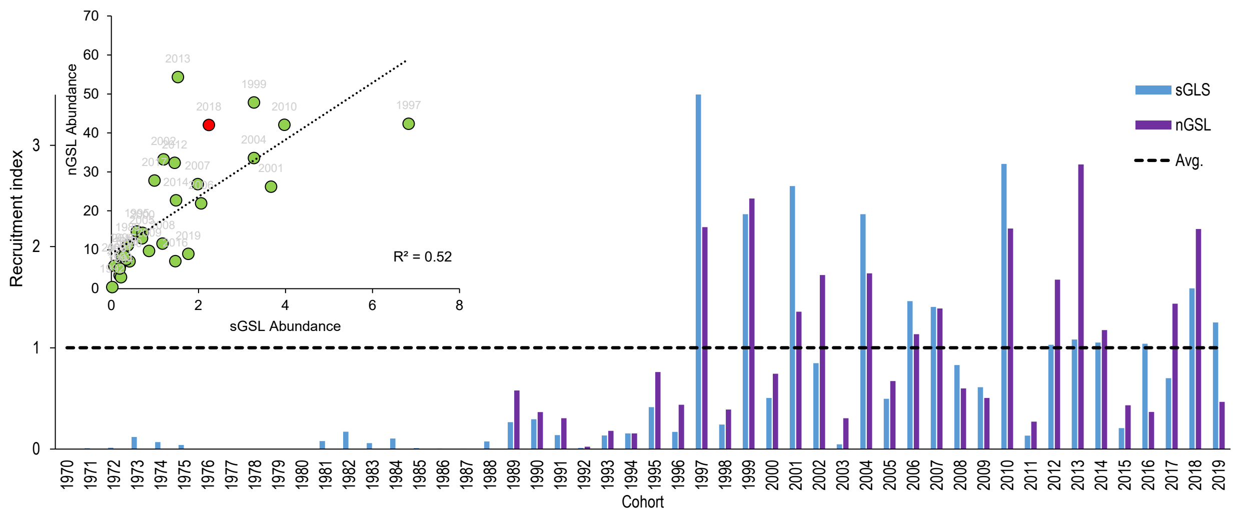


Figure 44. Recruitment indices for Greenland halibut estimated by the annual abundance of 12-21 cm (age 1) fish on the DFO A) nGSL survey. B) Comparison of recruitment indices for Greenland halibut from the DFO nGSL and sGSL surveys. The box shows the relationship between the annual cohort abundance estimated by each survey.

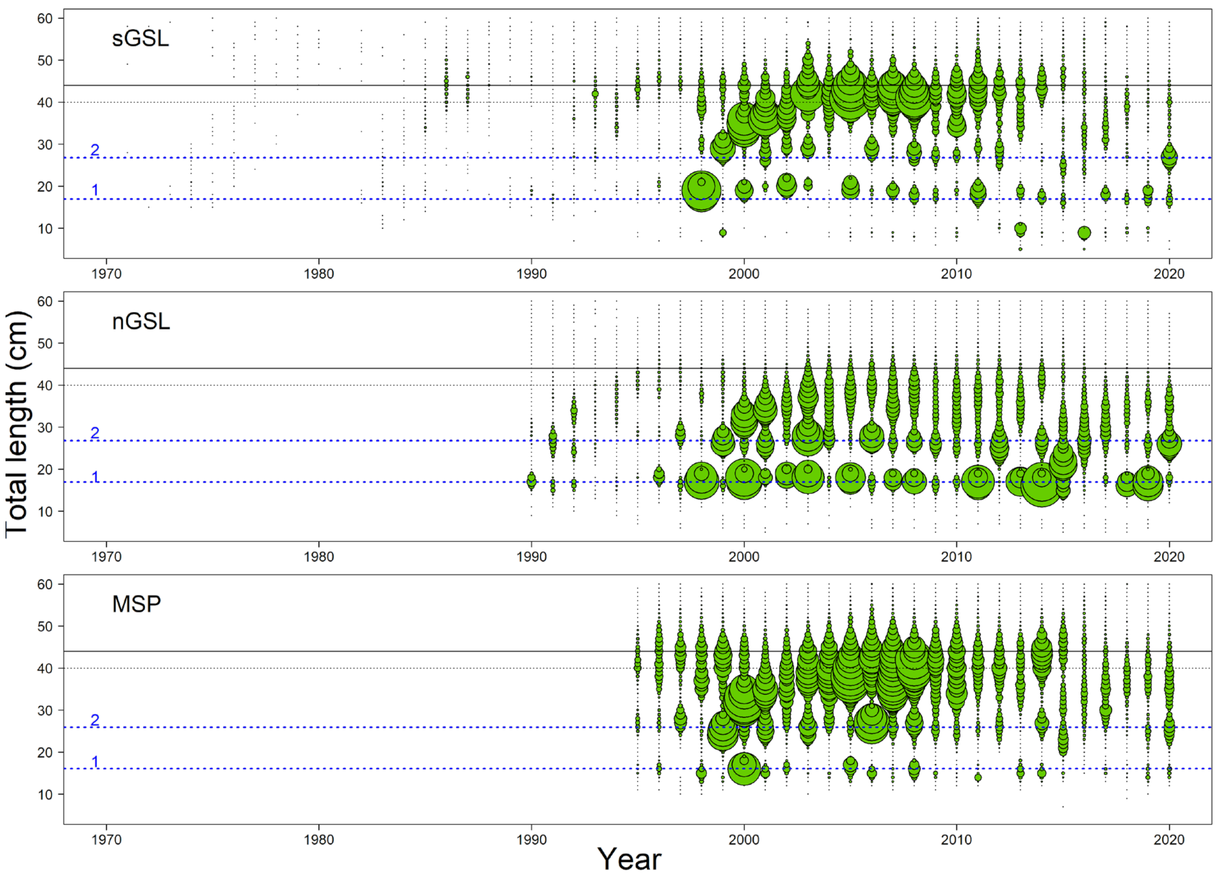


Figure 45. Length frequency distributions observed during DFO sGSL, and nGSL surveys and MSP survey. Bubble size is proportional to the abundance in a given survey. Blue dashed lines indicate average sizes for 1. 2 and 3 year old fish. Black dashed lines at 40 cm indicate the limit for fish biomass indices for fish larger than 40 cm. Black solid lines at 44 cm indicate the minimum size for the small fish protocol.

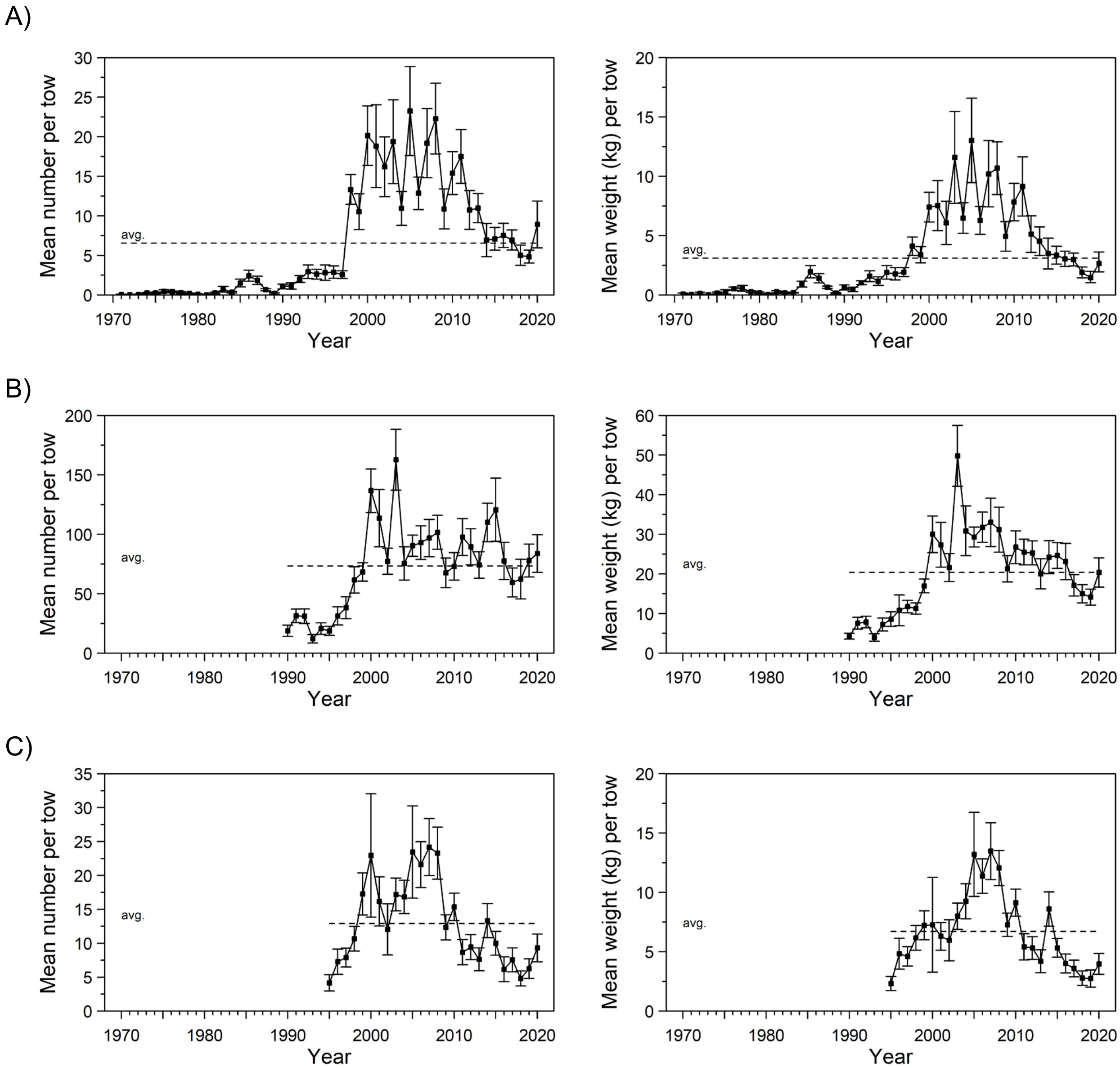


Figure 46. Mean number and weight per tow for Greenland halibut observed in A) the sGSL (1971-2020) survey, B) the nGSL (1990-2020)survey and, C) the mobile sentinel (1995-2020) surveys. Error bars indicate the 95% confidence interval. Horizontal lines indicate average for each series.

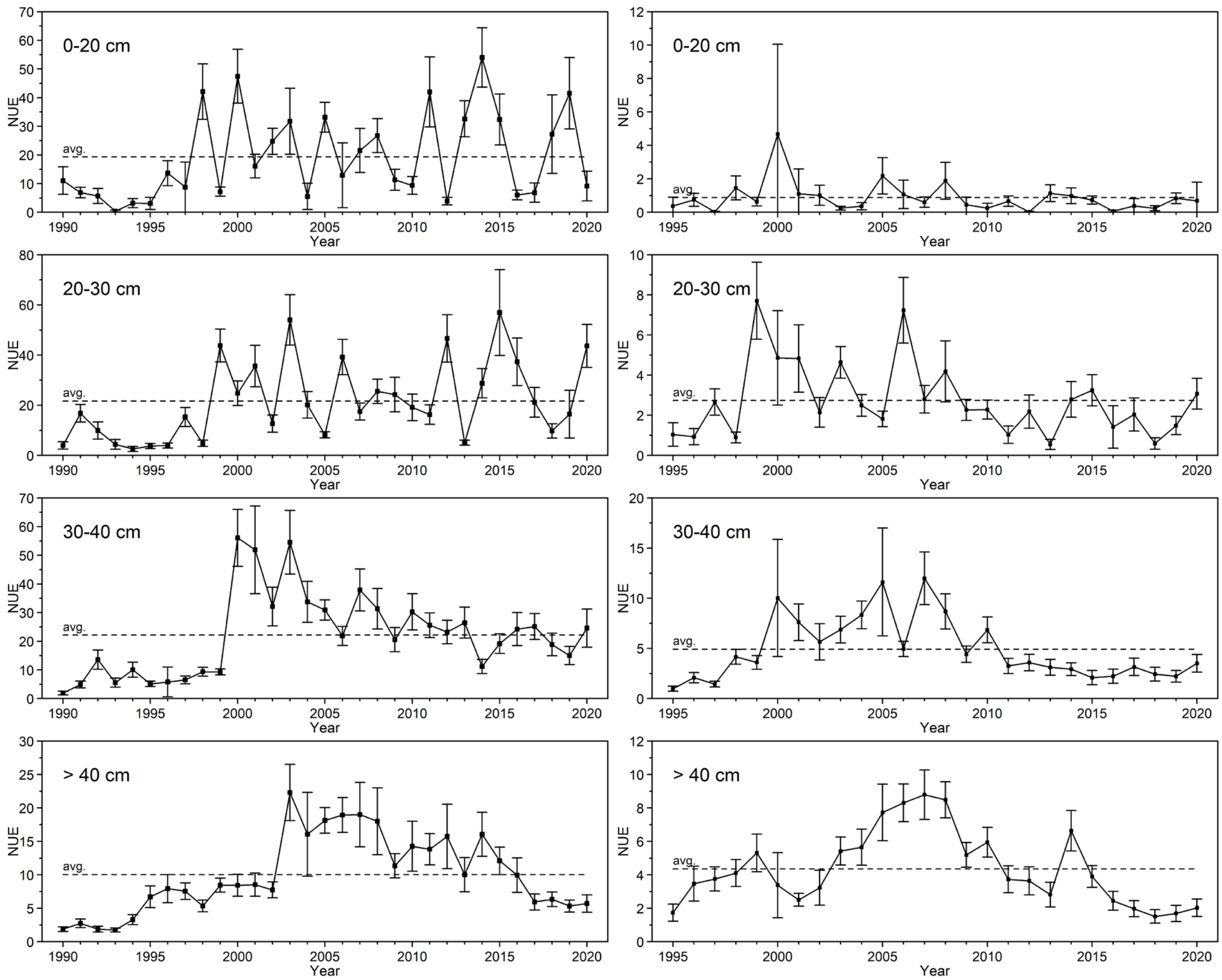


Figure 47. Greenland halibut abundance indices (mean number per tow) for different size categories observed in the nGSL (left) and mobile sentinel (right) surveys.

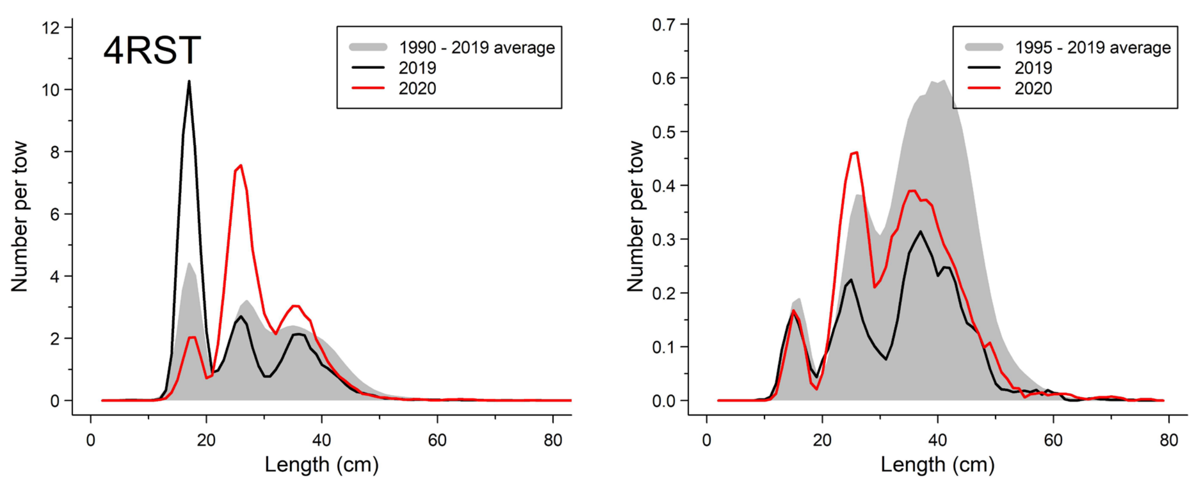


Figure 48. Length frequency distributions (mean number per tow) observed in the DFO nGSL (left) and mobile sentinel (right) surveys for Greenland halibut.

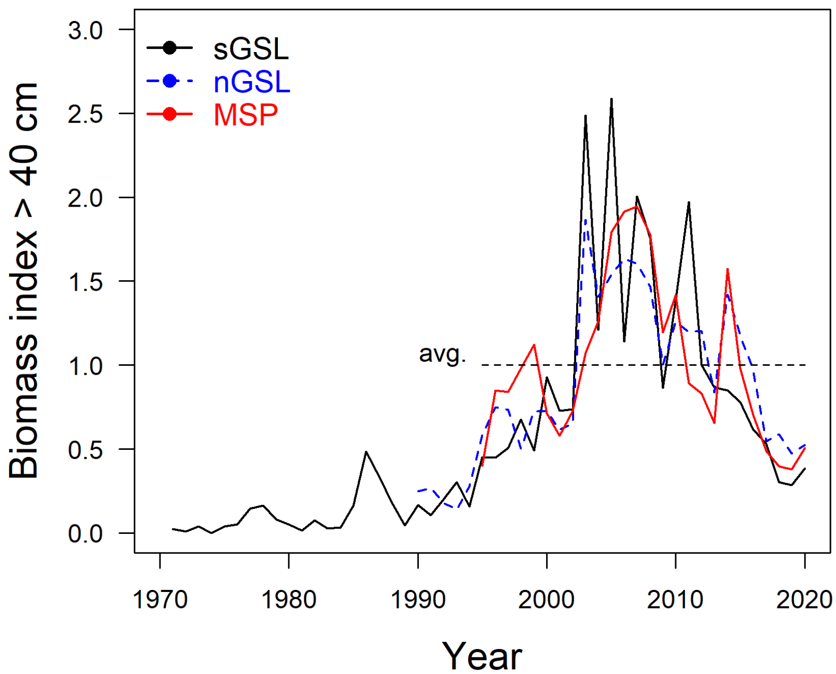


Figure 49. Standardized biomass indices for Greenland halibut > 40 cm calculated from DFO sGSL, nGSL surveys and MSP surveys. The dotted line indicates the average for the common period of the three surveys.

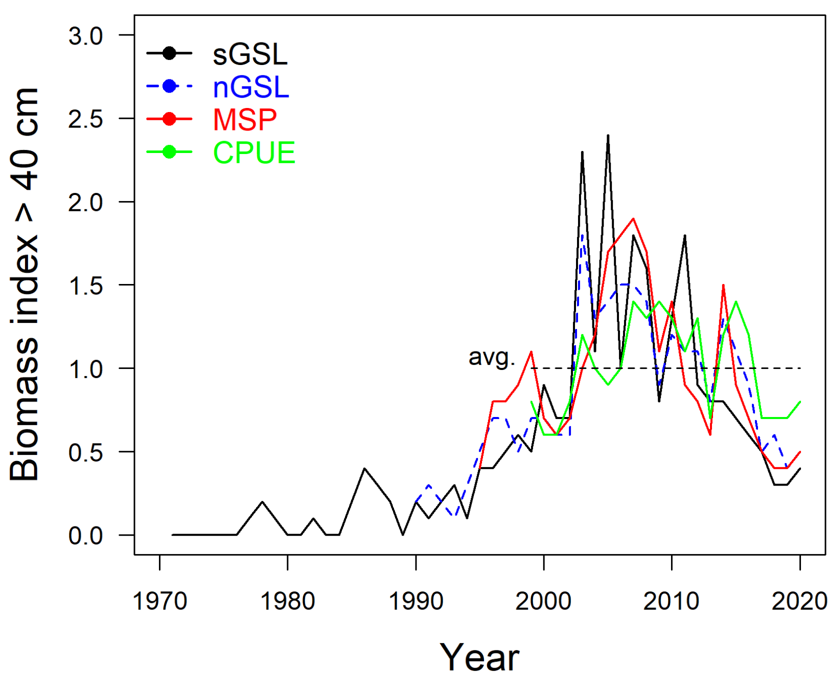


Figure 50. Comparison of standardized biomass indices from the sGSL, nGSL and mobile sentinel (MSP) surveys for Greenland halibut > 40 cm, with the commercial fishery performance index (standardized CPUE). The dotted line indicates the average for the common period of the three surveys and fishery performance index.

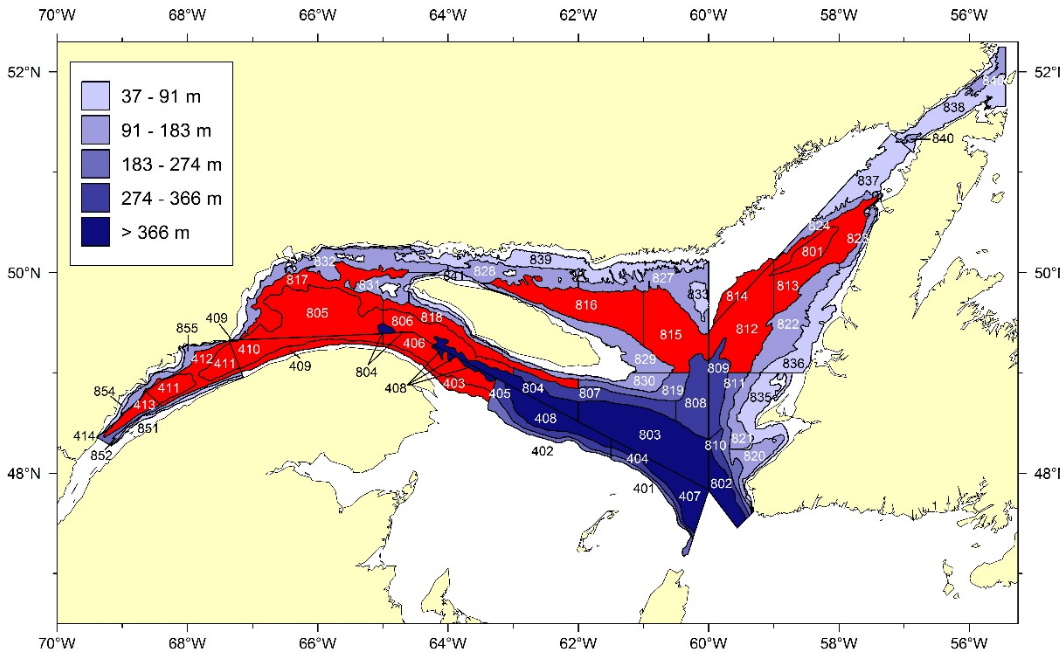


Figure 51. Identification of nGSL DFO survey strata corresponding to the commercial fishing sectors (Western Gulf (403, 406, 409, 410, 411, 412, 413, 805, 806, 817, 818), north Anticosti (815, 816) and, Esquiman (801, 812, 813, 814)).

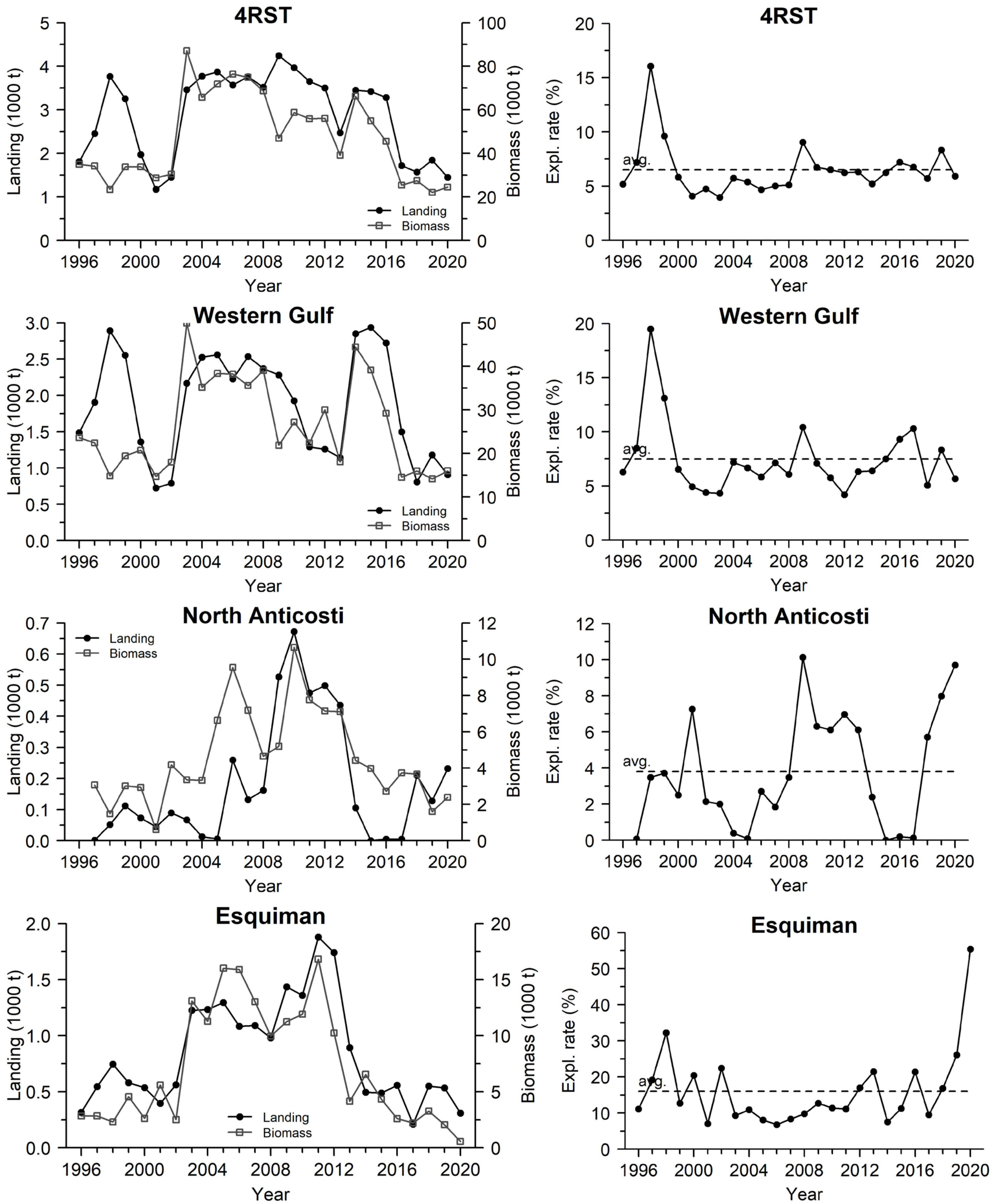


Figure 52. Annual landing and biomass of Greenland halibut > 40 cm and relative exploitation rate (Expl. Rate (%)) for the entire Gulf (4RST) and by fishing sector.

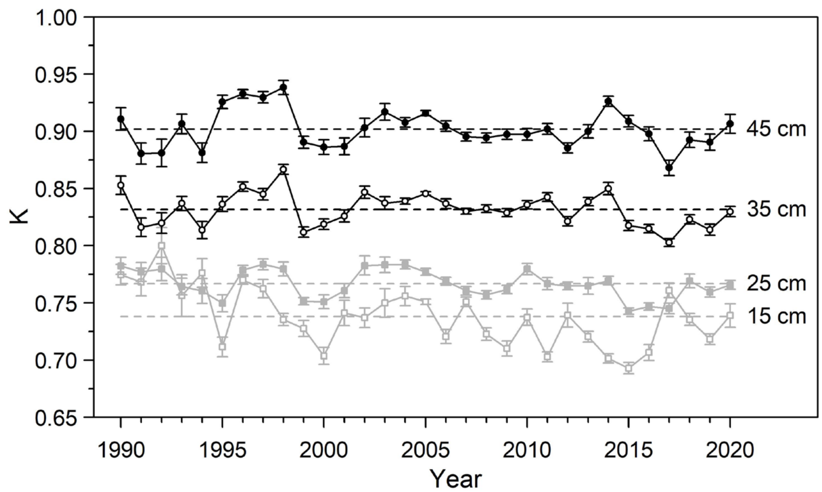


Figure 53. Annual Fulton condition index for 15, 25, 35 and, 45 cm Greenland halibut measured during the DFO nGSL survey. Dotted lines represent time series averages.

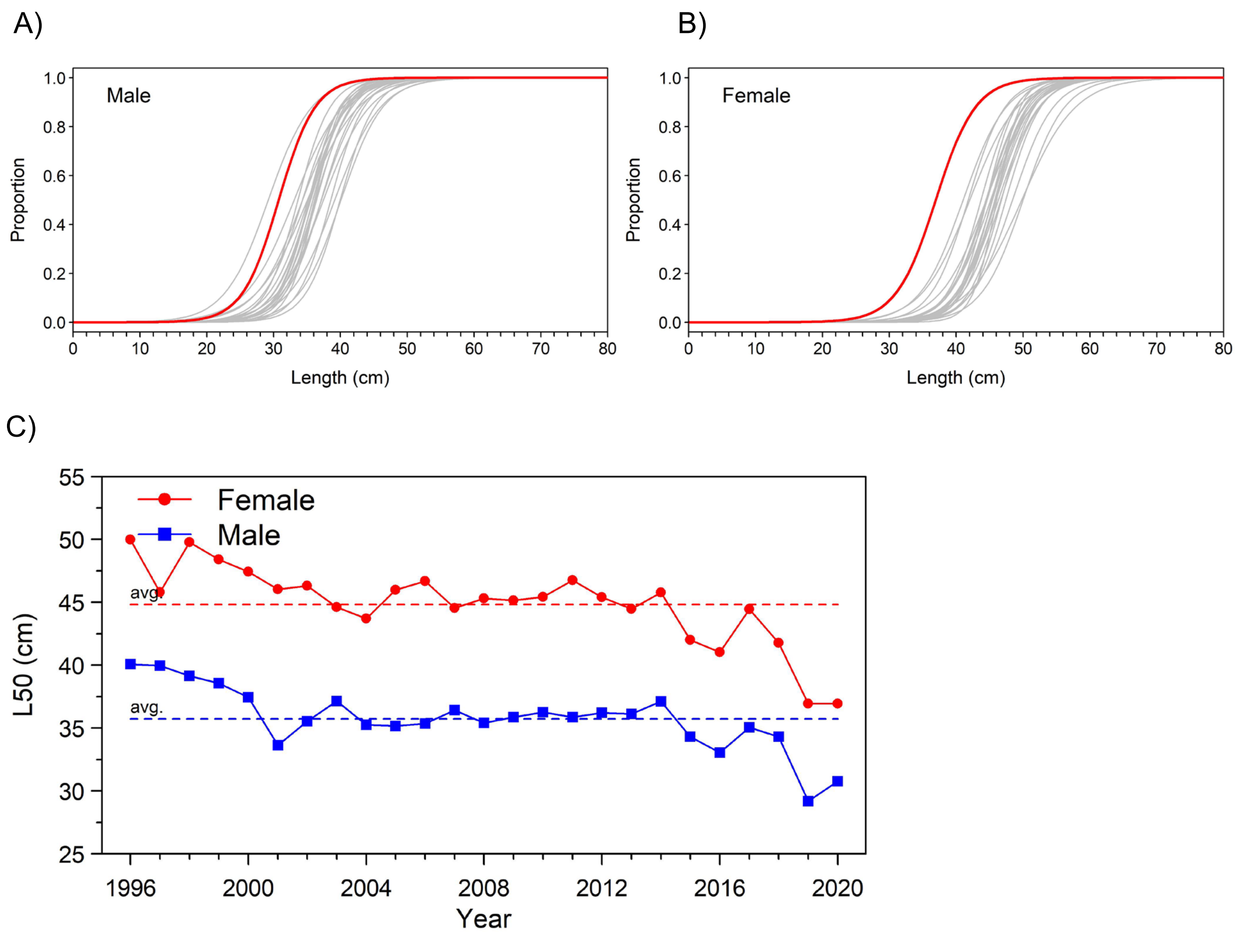
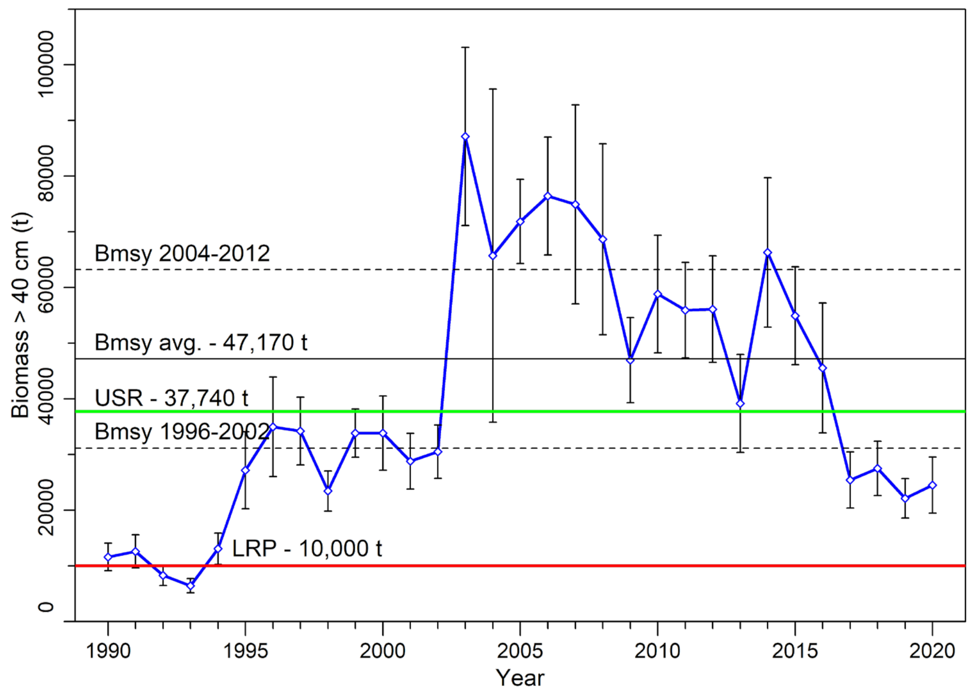


Figure 54. Maturity ogive for male (A) and female (B) Greenland halibut, the red line represents the year 2020 and the grey lines represent the years 1996 to 2019. Length at which 50% of male and female fish are sexually mature (L50) (C). This information is collected during the DFO nGSL survey by visual examination of the gonads.

A)



B)

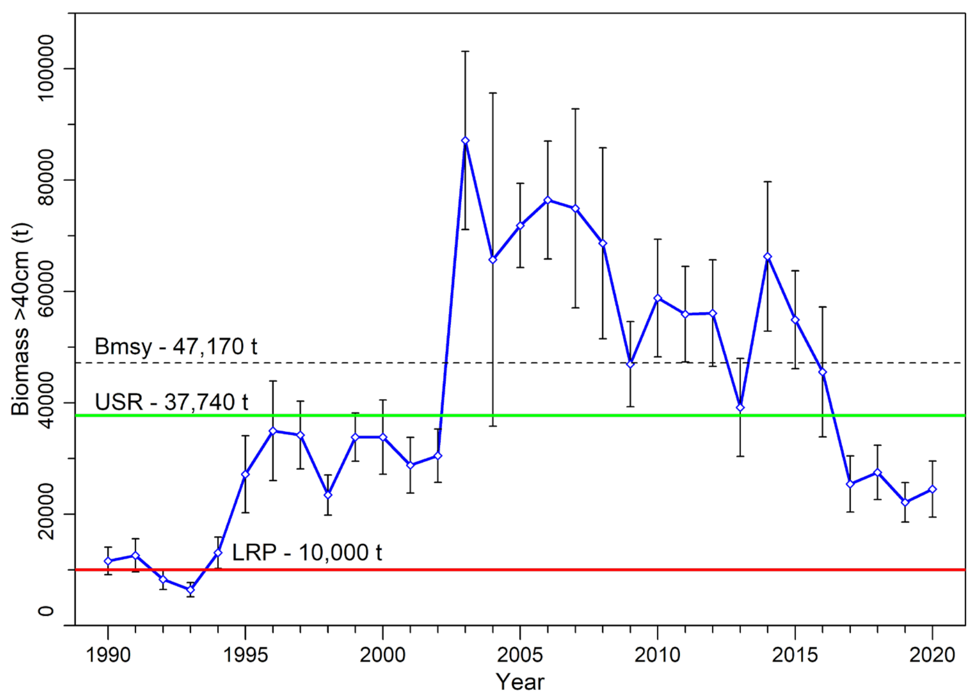


Figure 55. Reference points for the GSL Greenland halibut stock (4RST) based on the fish biomass index > 40 cm from the DFO nGSL survey. PRL : Limit Reference Point, USR : Upper Stock Reference point, Bmsy : Maximum Sustainable Yield Biomass. A) Graph showing the Bmsy for two productivity periods 1996-2002 and 2004-2012. B) Proposal for a USR at 37,740 t.

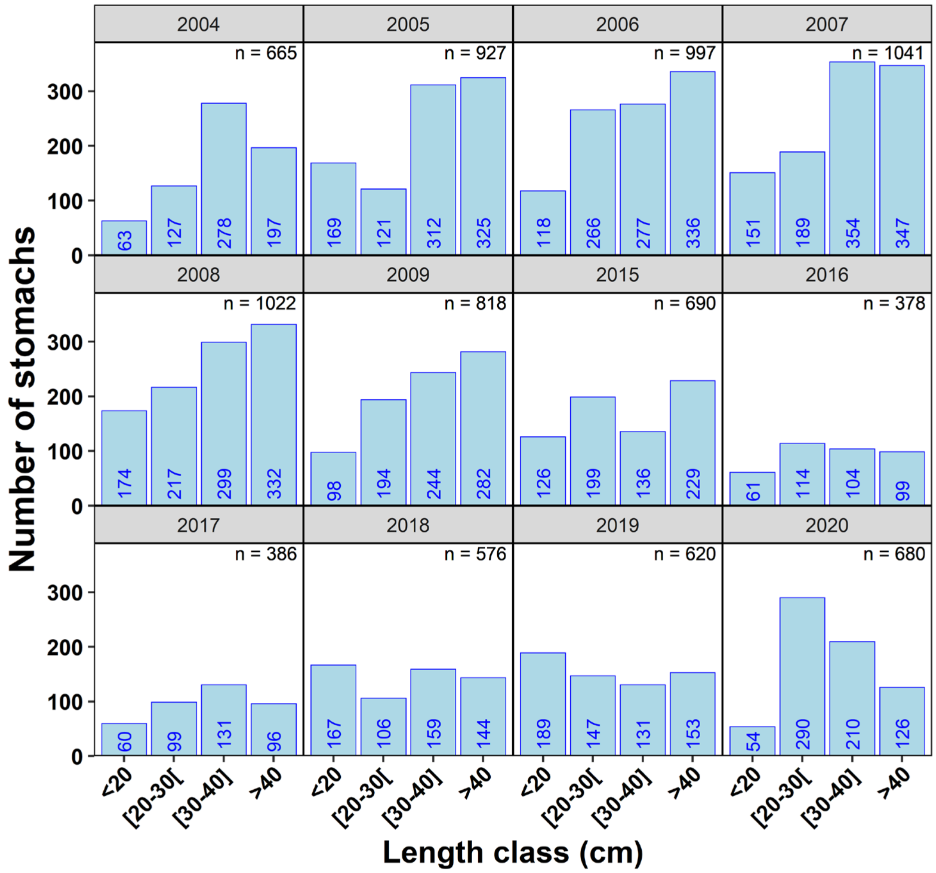


Figure 56. Number of Greenland halibut stomachs by length class and year.

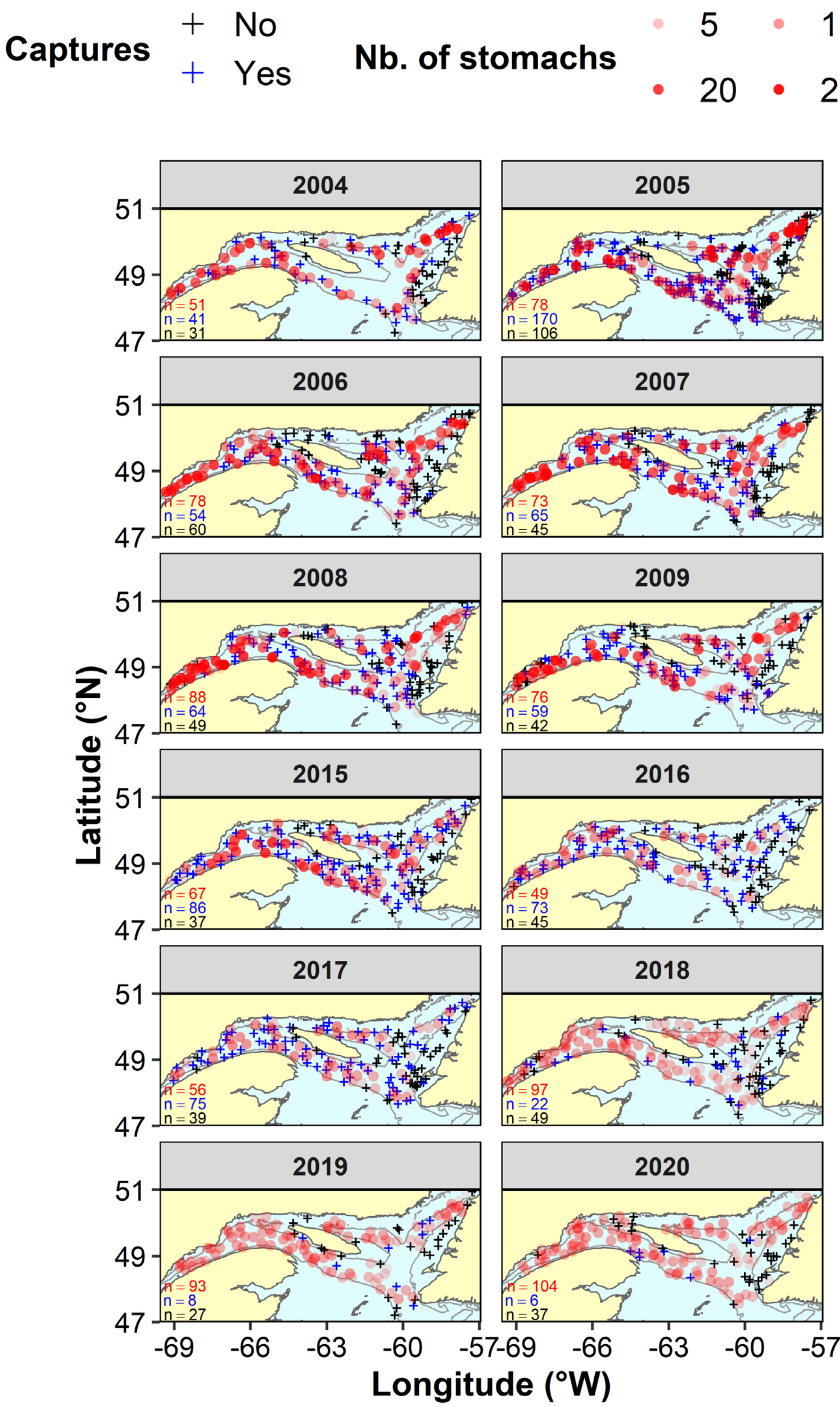


Figure 57. Location of Greenland halibut stomachs retained for analysis by year of capture. The dots on the map reflect the number of stomachs available for analysis. The black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches. The numbers for each type of tow are provided in the lower left corners of each year.

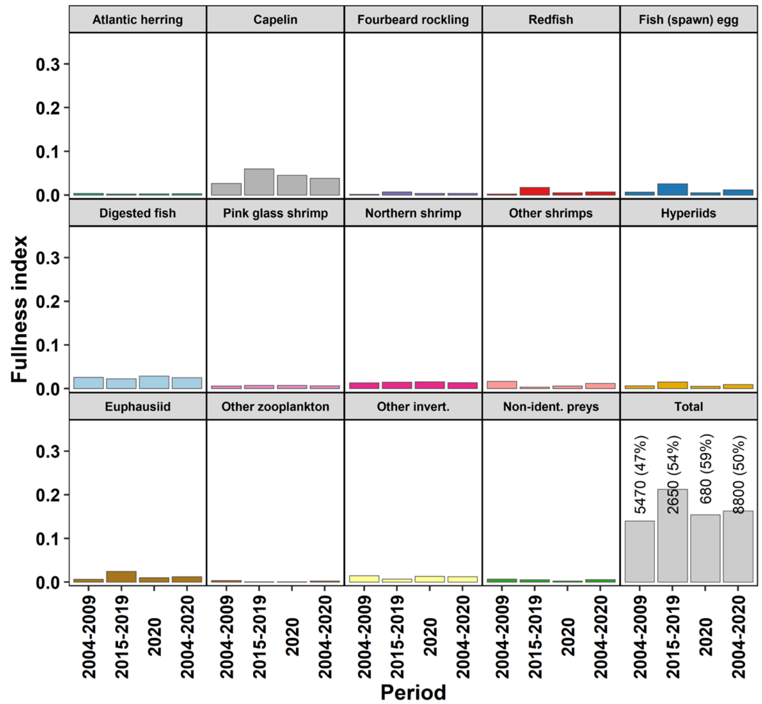


Figure 58. Fullness index of Greenland halibut stomachs by period considered, broken down by prey group. No stomachs are available for the period 2010-2014. The values above the bars are the sample size and percentage of empty stomachs.

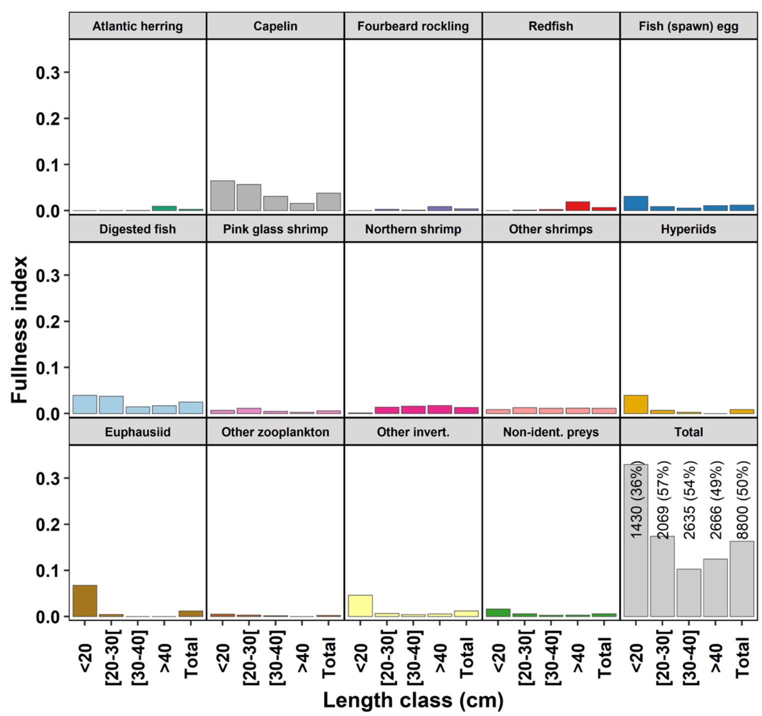


Figure 59. Fullness index of Greenland halibut stomach by length class. broken down by prey group and for all selected years (2004-2020). The values above the bars are the sample size and the percentage of empty stomachs.

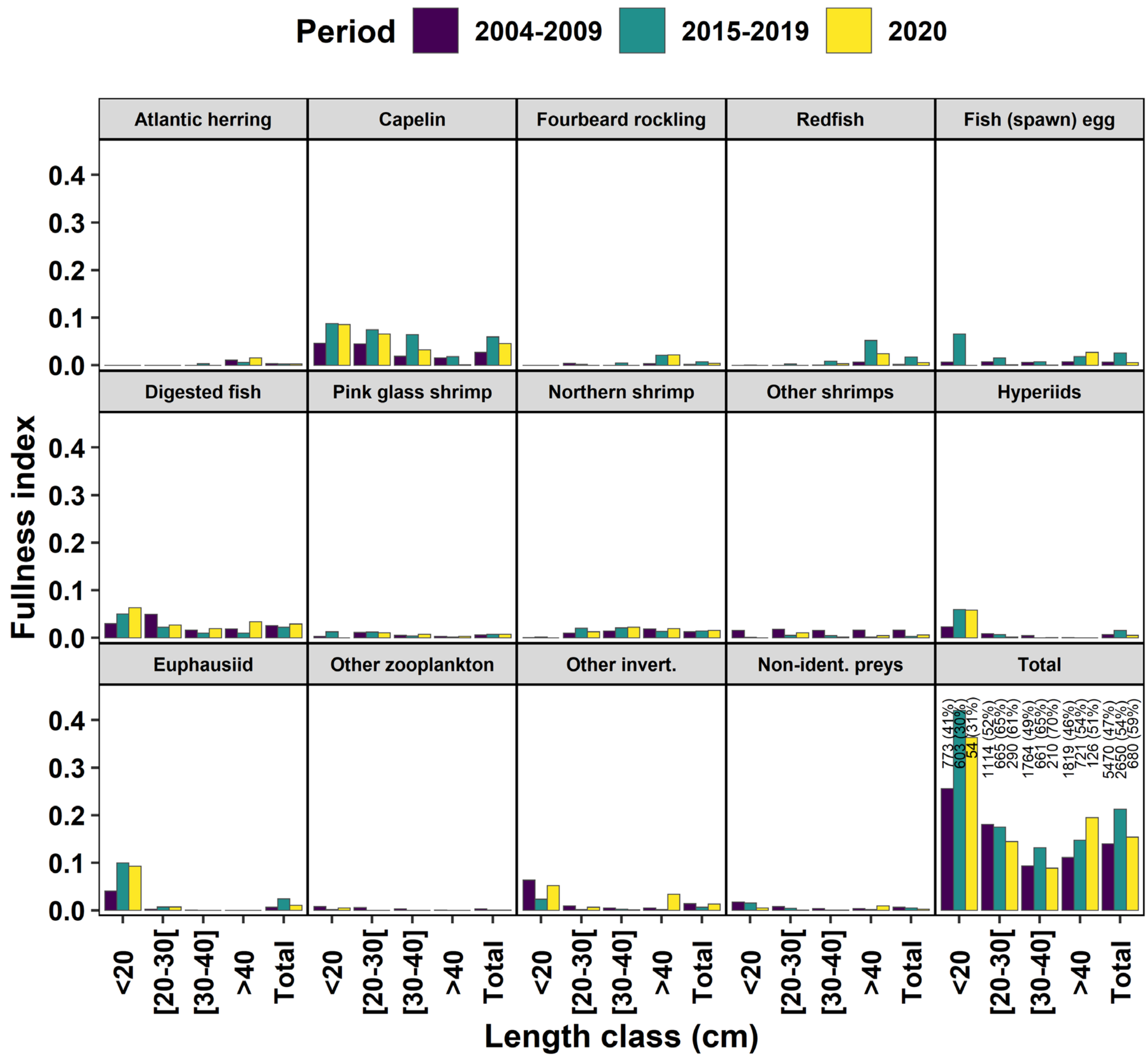


Figure 60. Fullness index of Greenland halibut stomach by length class, broken down by prey group and time period. The panel identified Total shows the total stomach fullness index for each length class. The values above the bars are the sample size and the percentage of empty stomachs.

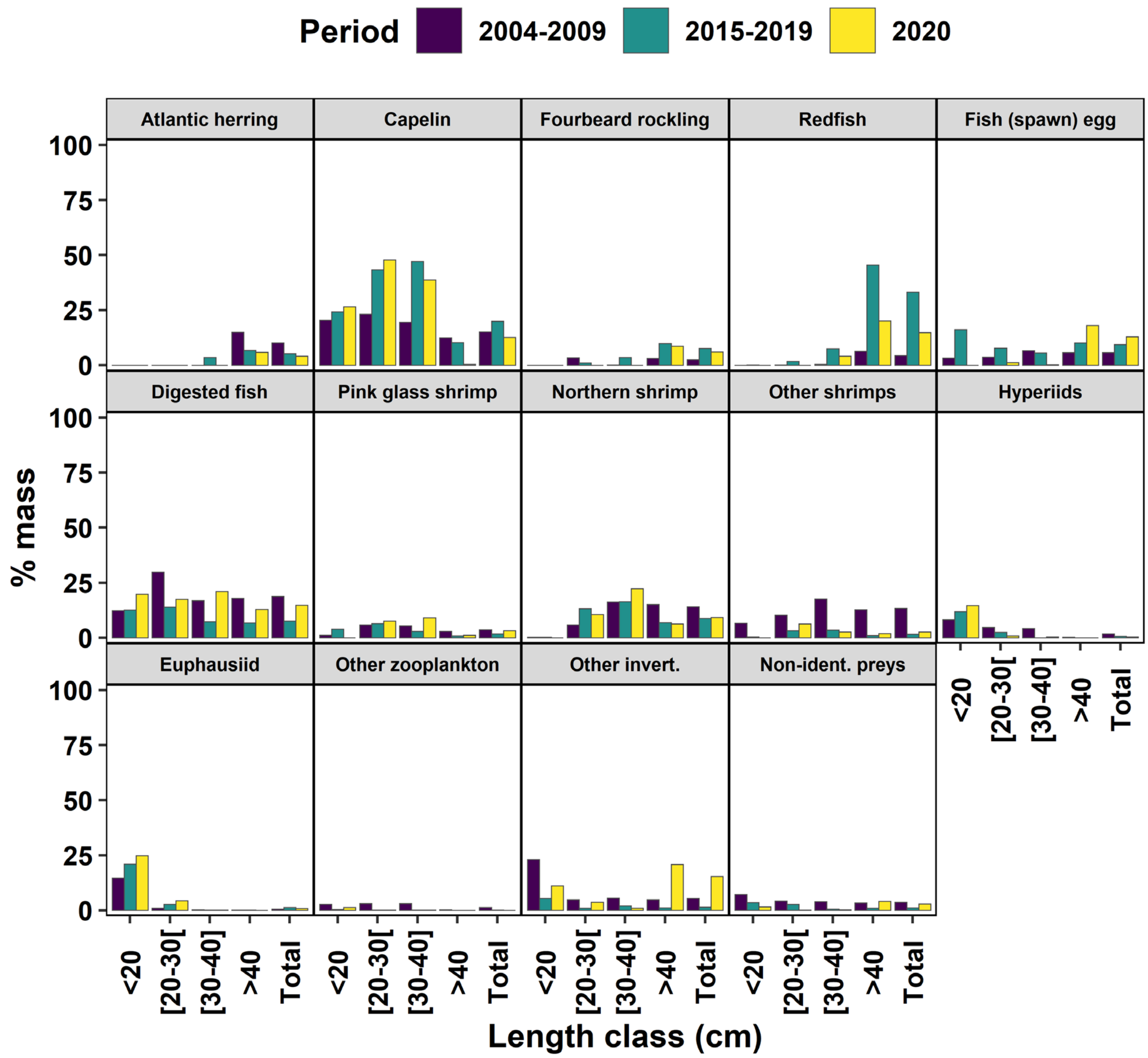


Figure 61. Percentage of mass of stomach contents of Greenland halibut by length class, broken down by prey group and, time period.

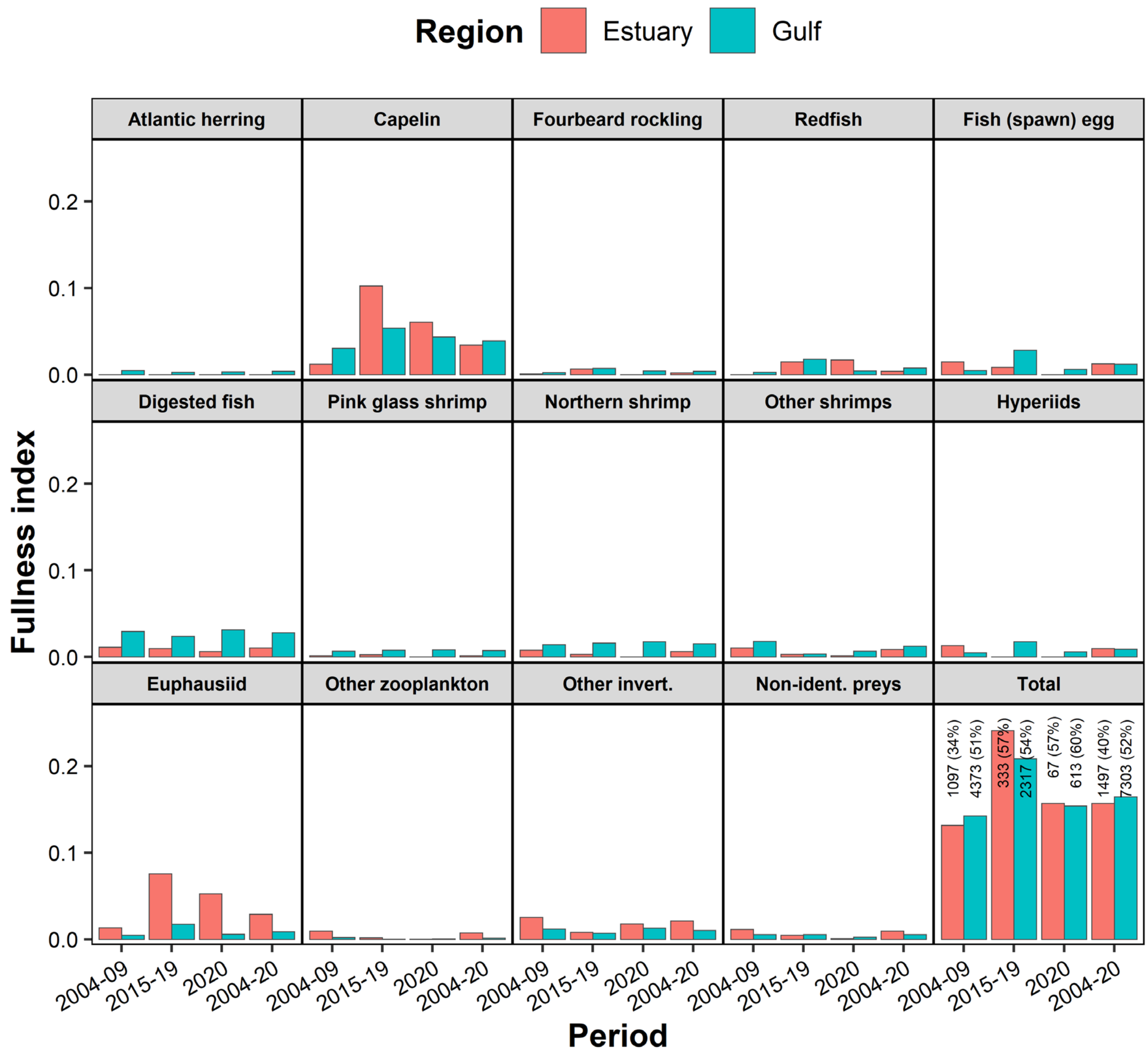


Figure 62. Greenland halibut stomach fullness index by region, broken down by prey group and time period. The lower right panel shows the total stomach fullness index for each period. The values above the bars are the number of stomachs and the percentage of empty stomachs.

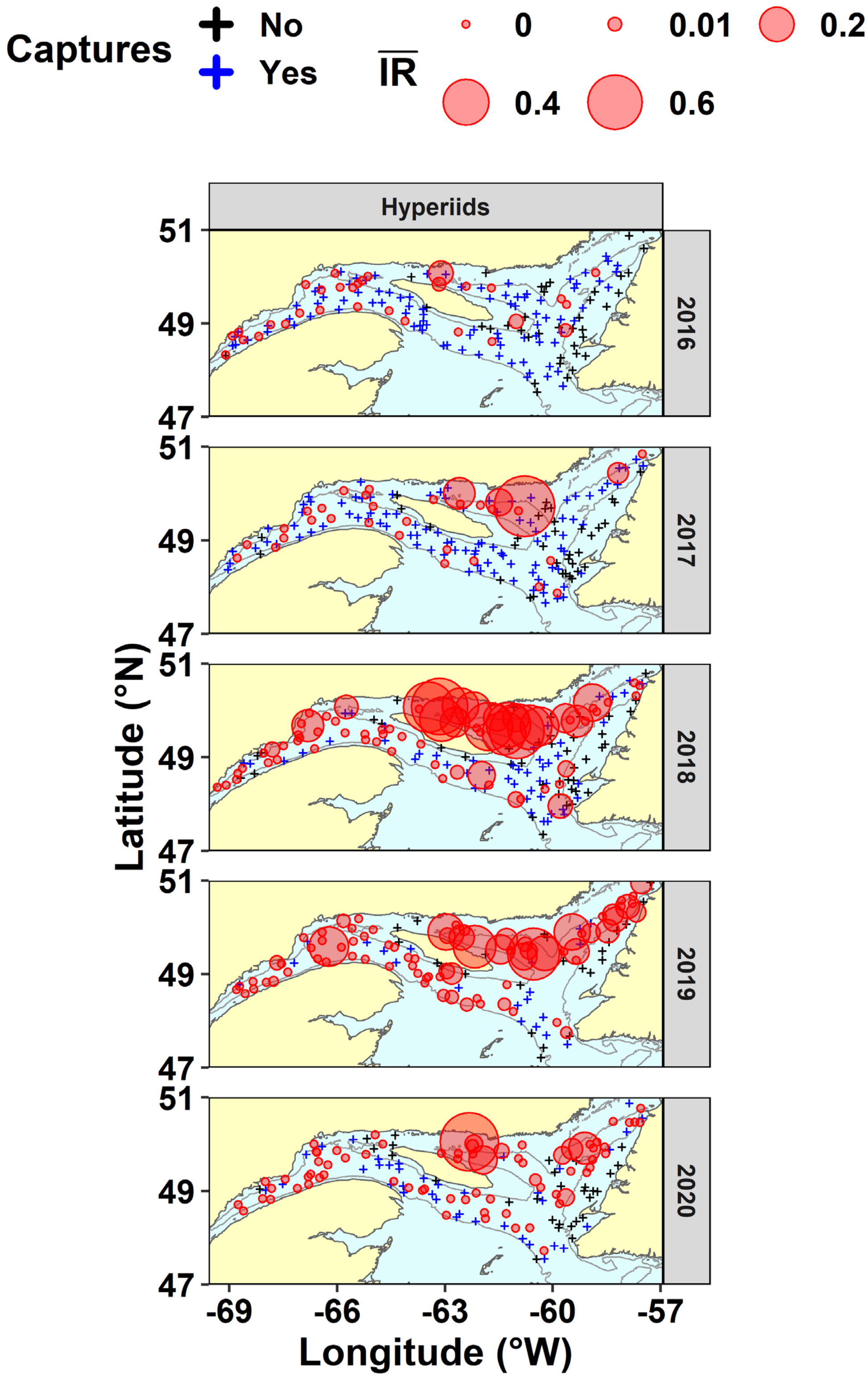


Figure 63. Average fullness index per tow in hyperiids Themisto sp. for the years 2016-2020. Only stomachs from Greenland halibut < 30 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

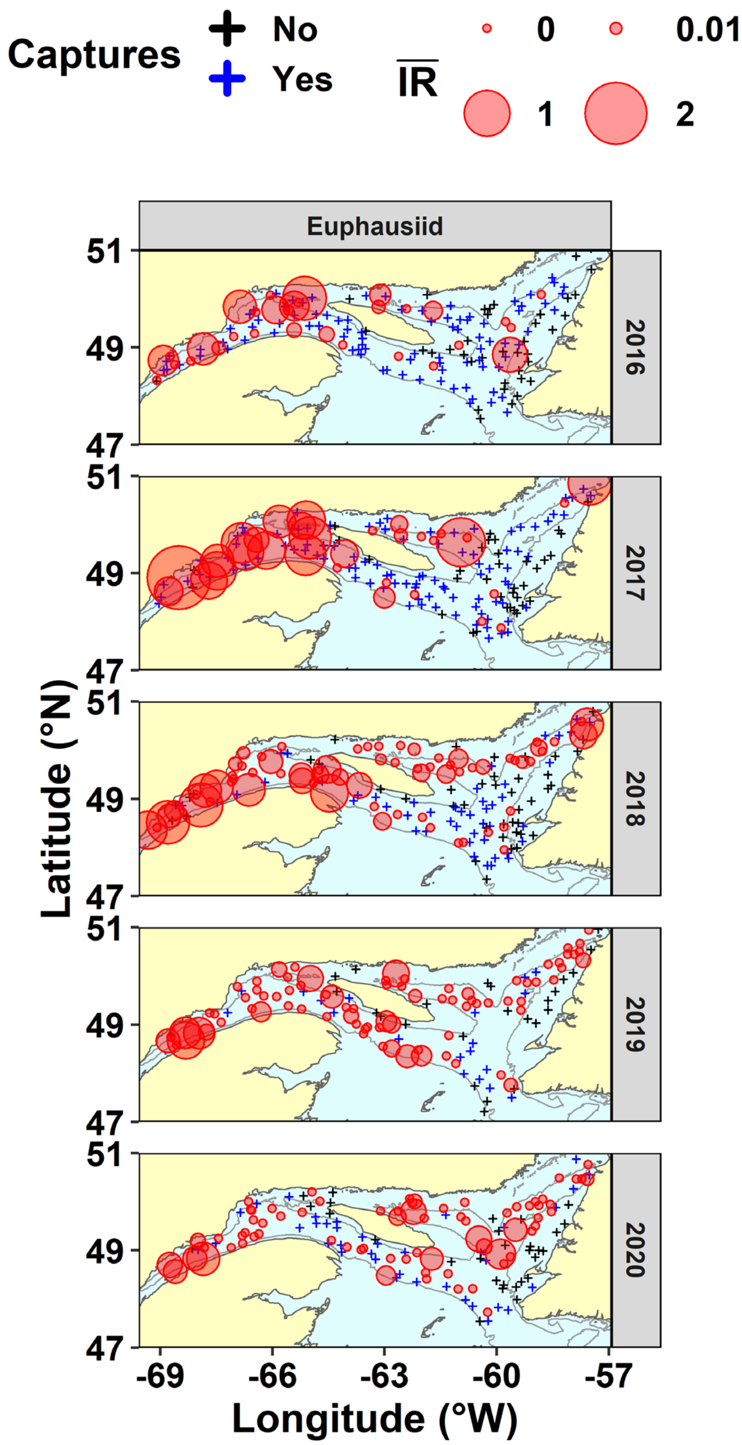


Figure 64. Average fullness index per tow in euphausiid for the years 2016-2020. Only stomachs from Greenland halibut <30 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

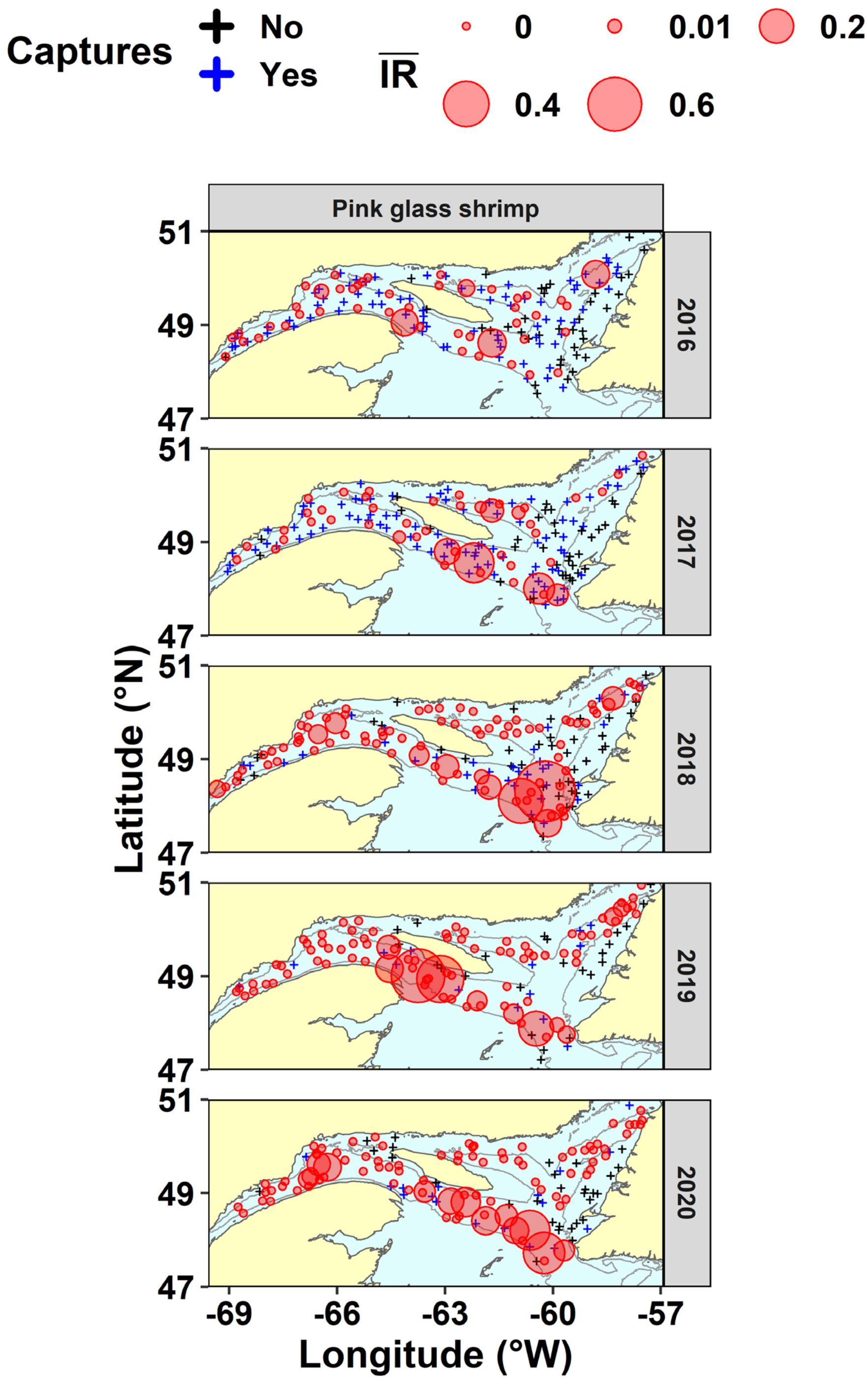


Figure 65. Average fullness index per tow in pink glass shrimp for the years 2016-2020. Stomachs from Greenland halibut of all sizes were selected. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

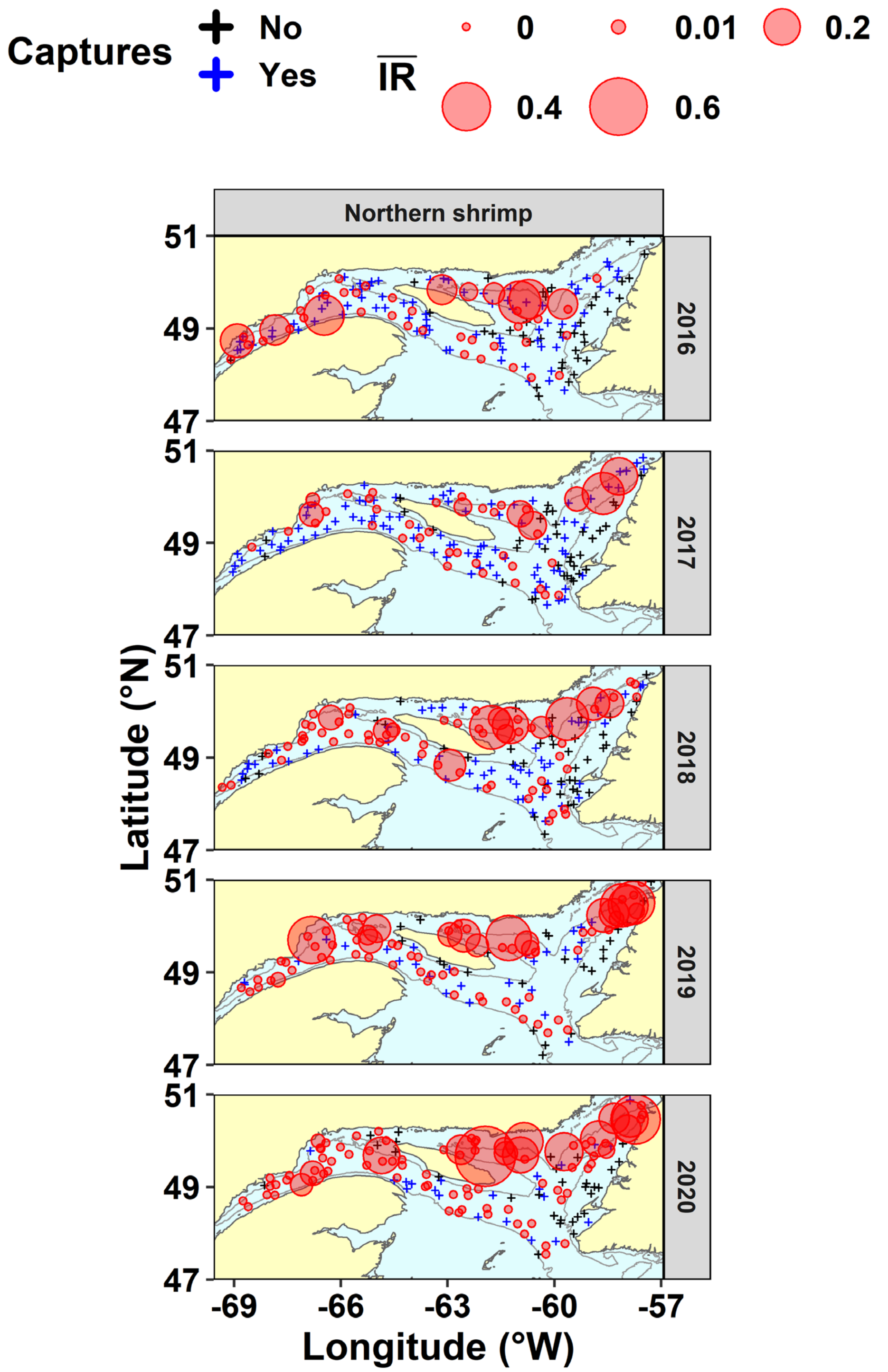


Figure 66. Average fullness index per tow for northern shrimp for the years 2016-2020. Only stomachs from Greenland halibut ≥ 20 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

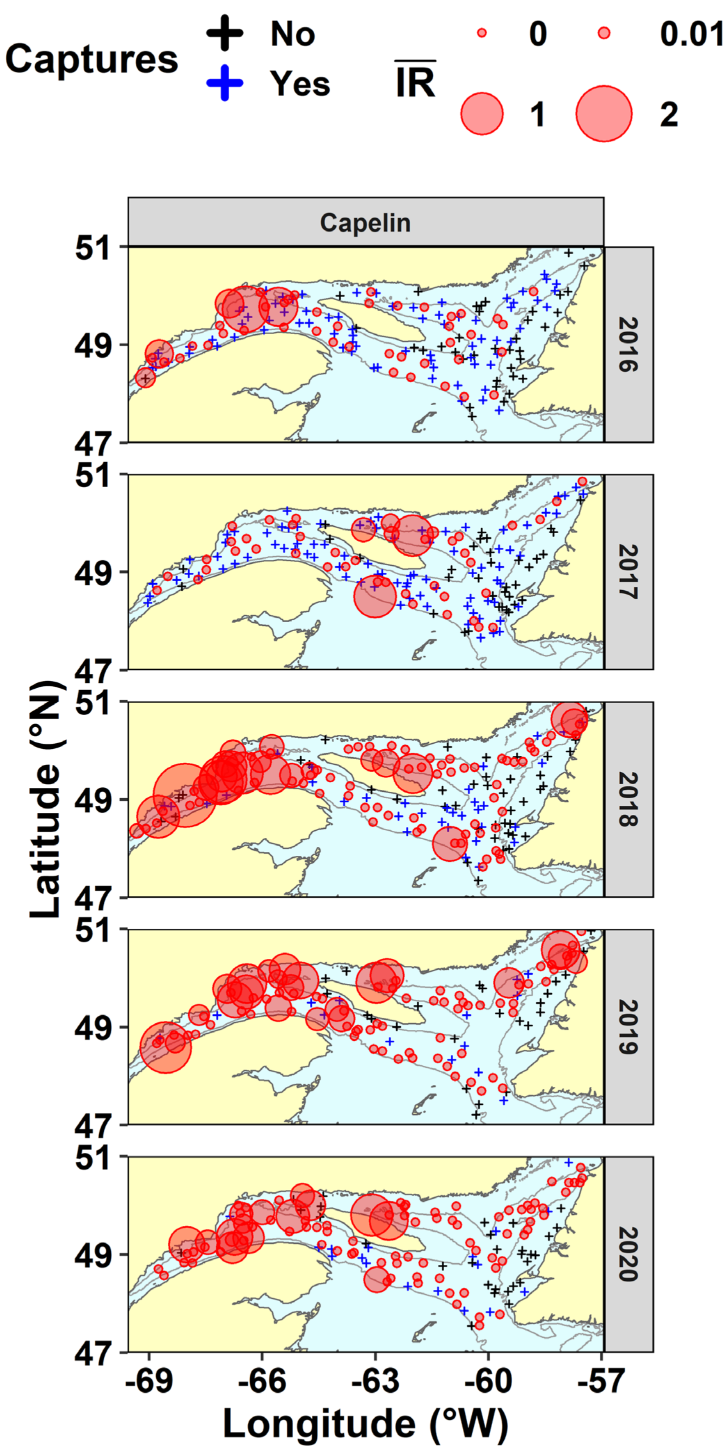


Figure 67. Average fullness index per tow in capelin for the years 2016-2020. Stomachs from Greenland halibut of all sizes were selected. Black and blue crosses respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

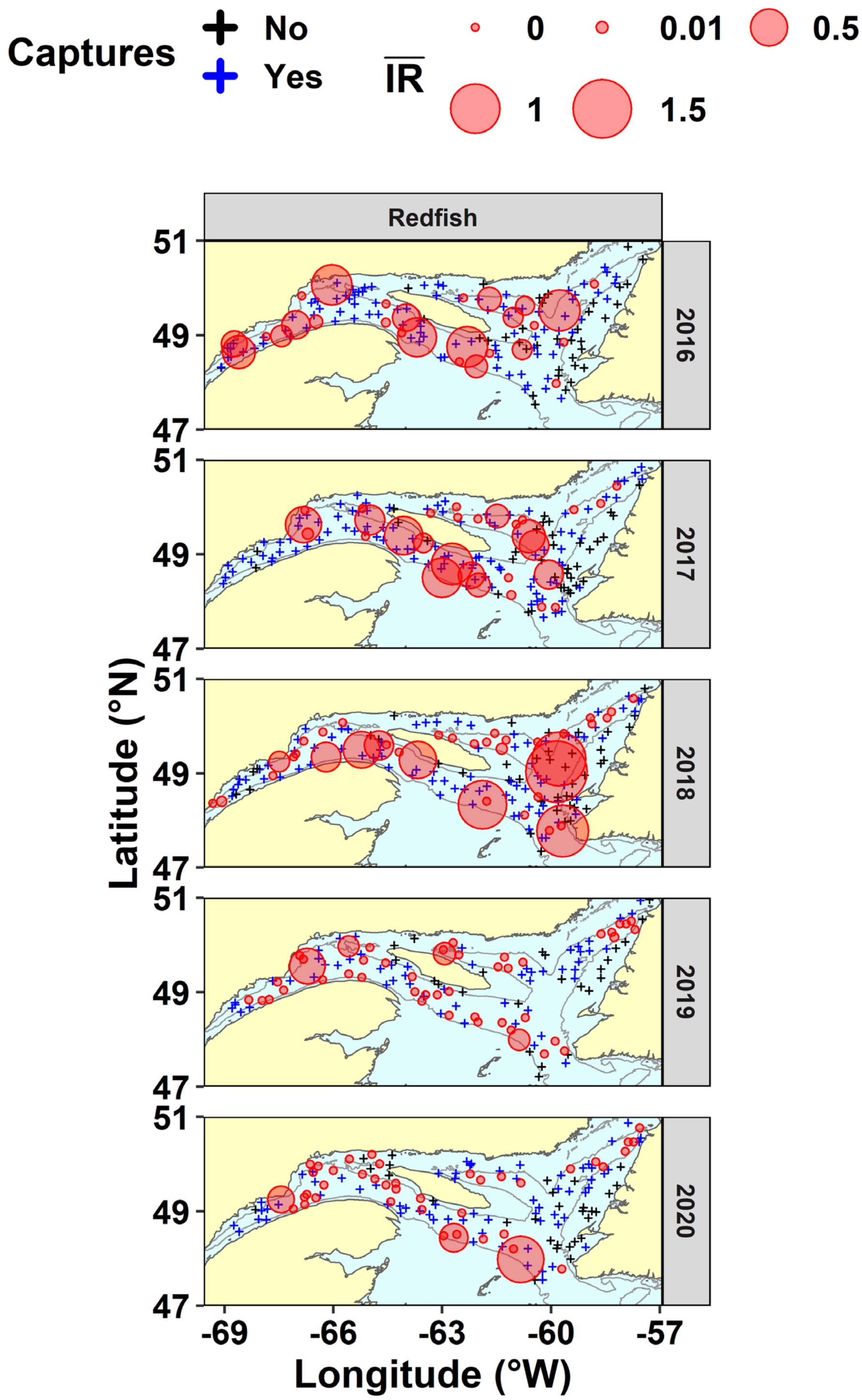


Figure 68. Average fullness index per tow in redfish for the years 2016-2020. Only stomachs from Greenland halibut > 40 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested although captures have been made.

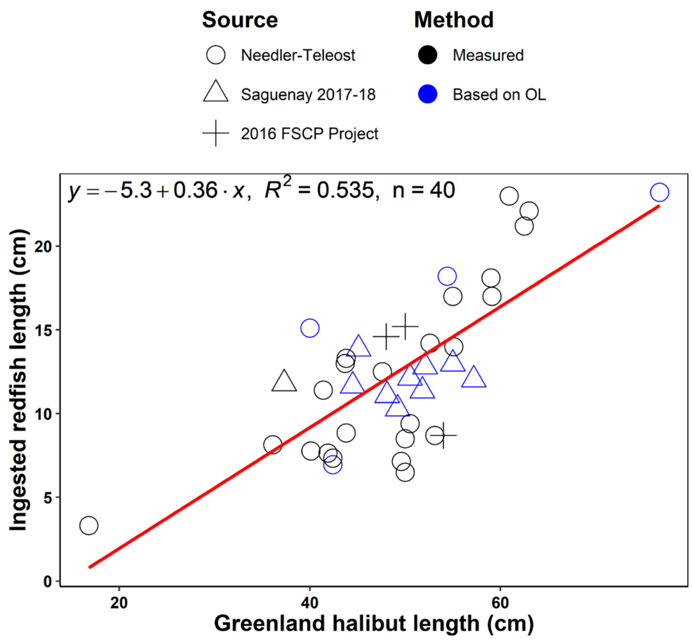


Figure 69. Relationship between the size of the predator (Greenland halibut) and the size of ingested redfish prey. Methods used to calculate redfish lengths and data sources are provided in the methodology section description of the diet.

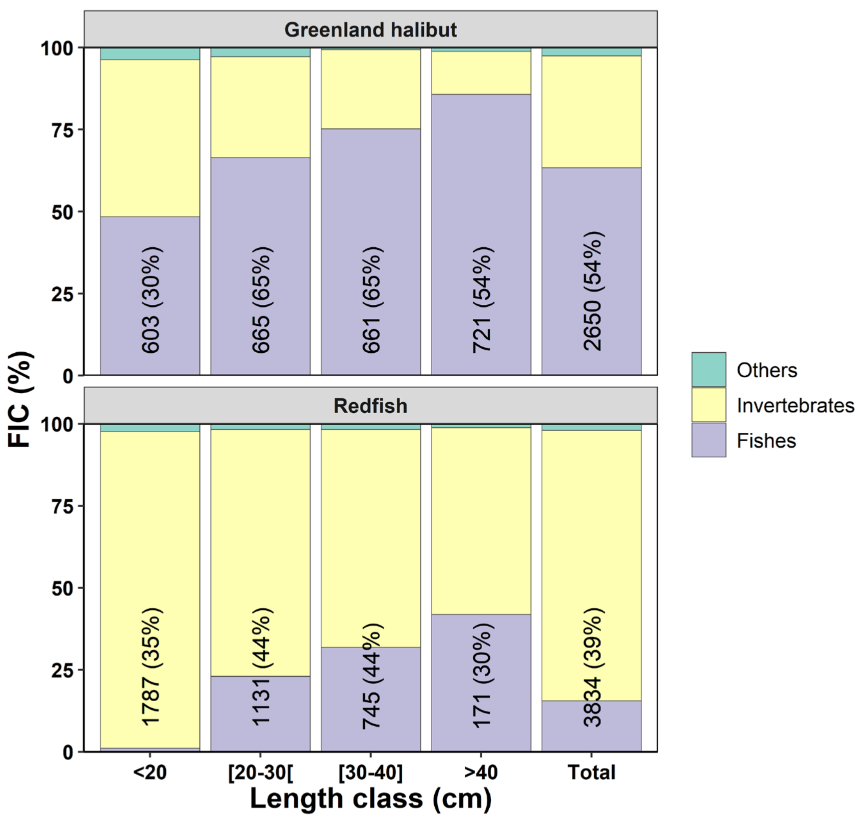


Figure 70. Contribution to the fullness index of major prey classes for the period 2015-2019, by predator, Greenland halibut and redfish, and length class. The values in the bars are the number of stomach and percentage of empty stomachs.

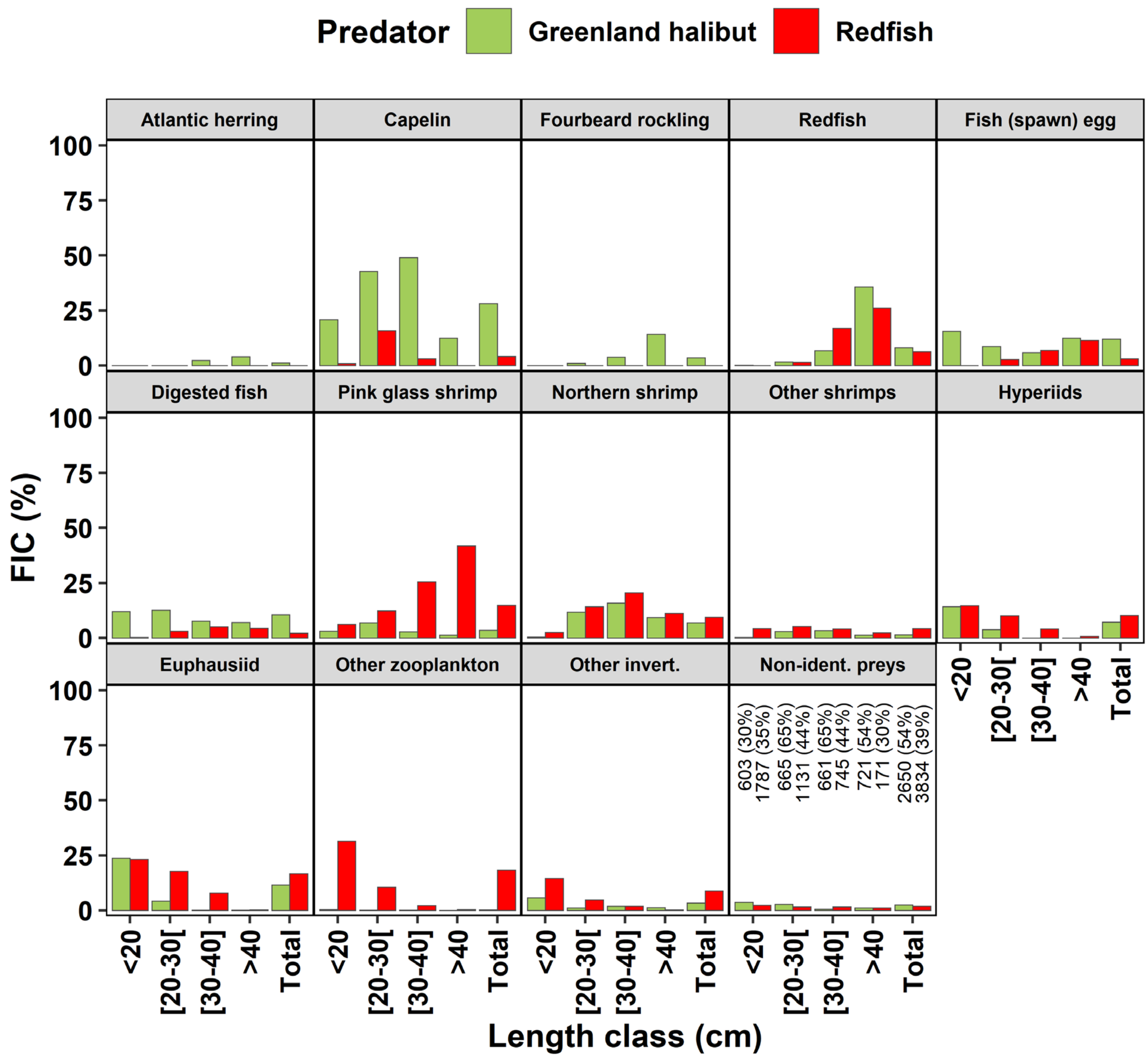


Figure 71. Contribution to the predator fullness index (FIC). Greenland halibut and redfish, for the period 2015-2019, broken down by taxonomic grouping and length class.