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Gulf of St. Lawrence (4RST) Greenland Halibut Stock Status in 2018: Commercial Fishery and Research Survey Data

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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.

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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 20 and 21, 2019 at the Maurice Lamontagne Institute.

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 2000-2018 period, the proportion of the effort expended 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 comprehensive interim-year assessment of the stock, the TAC was reduced by 25% for the 2018-2019 fishing season. Preliminary landings in that year totalled 1,496 t, the lowest value in the last 16 years. The commercial fishery performance index shows a downward trend, with a 48% decrease in 2018 from the 2014-2016 peak, reaching the low values observed in 1999-2000. The biomass indices for fish over 40 cm—based on fishery independent data obtained from DFO's mobile gear surveys and the sentinel fisheries program—also point to a declining trend over the last ten years or so, with decreases of 62% and 77% respectively from the peak observed in the mid-2000s.

The Gulf of St. Lawrence ecosystem has undergone significant changes in recent decades. Warming and oxygen depletion of the deep waters of the Gulf could result in habitat loss and the degradation of habitat quality for Greenland halibut. Furthermore, the arrival of three exceptionally strong cohorts of redfish (2011 to 2013) could increase interspecific competition. These ecosystem conditions are not expected to change in the short term.

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 in certain years (Kennedy et al. 2009). The eggs, owing to their specific gravity, are likely 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 gravity (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 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 are sexually dimorphic due to a slowdown in growth once they reach sexual maturity. Males attain sexual maturity at a smaller size than females, about 36 cm compared to 46 cm for females, and therefore do not grow as large.

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). These studies 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).

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. 2019).

In 2018, water temperatures at depths of 150°m and 200°m remained at above normal values. A record high of 6.39°C was recorded at a depth 300°m, which is almost 1°C warmer than the average of 5.48°C during the 1981-2010 period (Galbraith et al. 2019). The bottom area covered by waters warmer than 6°C remained quite large in 2018 in the Anticosti and Esquiman channels and the central Gulf, and expanded substantially in the northwestern Gulf. According to forecasts, temperatures in the deep waters of the GSL will continue to be high in the next few years. These conditions may be unfavourable to Greenland halibut, which prefer waters between 1°C and 4°C.

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 levels. Since this water travels a greater distance to reach the head of the Laurentian Channel, the lowest levels of dissolved oxygen (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 18% in 2018.

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 and redfish (*Sebastes* spp.), collapsed. The resulting decline in large predators favoured an increase in forage species, including various shrimp species (Figure 3). Both Greenland halibut biomass and northern shrimp biomass increased, while the abundance of large groundfish species declined (Figure 3). 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 (Senay et al. 2018) could result in, and/or contribute to, the intensification of interspecific competition with Greenland halibut in the nGSL ecosystem, including direct competition for food resources and indirect competition for habitat. 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 and since they are long-lived species, they will share the ecosystem with Greenland halibut over the short and long term.

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) format. The resulting files are consolidated at Maurice Lamontagne Institute (IML) 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 2018 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). This system tracks vessels' locations by satellite every 30 minutes during fishing trips. The information gathered includes the Canadian Fishing Vessel Number (CFVN), 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 CFVN information and the dates in the VMS data. We retained all positions that overlap within plus or minus one day when a Greenland halibut catch was recorded in the logbooks. We then cleaned up the VMS data using each vessel's speed, 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. We retained the positions of vessels travelling at speeds between 0.5 and 2.5 knots. 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 2018. Data before 1996 were not included, mainly due to the change in gillnet mesh size from 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, northern 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 (total 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 NAFO 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 NAFO category ($p=0.4005$) in the Esquiman sector. The model explains 57% of the variance for the Esquiman sector, 50% for the northern Anticosti sector and 26% for the western Gulf.

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 NAFO subareas referred to are 4Si for the entire GSL and the western Gulf sector, 4Rb for the Esquiman area 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 in the samplers program (250 fish/sample before 2005, and 150 fish/sample afterward) and in the At-Sea Observer Program (150-200 fish/sample, and many tows per trip) varied substantially. 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).

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. 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 2018 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, 10,082 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, 21,697 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. 2019). It 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 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 on the GSLO website.

Abundance index

For the DFO's nGSL survey and the mobile gear sentinel 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 mobile gear sentinel 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 mobile gear sentinel 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 and temperature

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 in terms of depth and temperature 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: 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 (DWAO) 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 of is estimated from the annual abundance of fish in the 12 cm to 21 cm size class caught in the DFO's nGSL and 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 (2017 and 2018) as well as the average distribution for the reference period (1990-2017 for the nGSL survey and 1995-2017 for the mobile gear sentinel 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 2018), 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).

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 metrics (PES, MC, FI, $CTFI$ and $Focc$) were used to characterize the importance of the various taxa in the diet of Greenland halibut. These variables are taken from the method described by Bernier and Chabot (2013). For a sample of NS_s stomachs containing NES_s empty stomachs, the percentage of empty stomachs (PES_s) is calculated as follows:

$$PES_s = \frac{NES_s}{NS_s} \times 100 \quad (1)$$

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.

$$M_d = \sum_{j=1}^{NS_s} M_{dj} \quad (2)$$

$$M_{tot} = \sum_{d=1}^{D} M_d \quad (3)$$

$$MC_d = \frac{M_d}{M_{tot}} \times 100 \quad (4)$$

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*.

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

$$FI_d = \frac{\sum_{j=1}^{NS_s} FI_{dj}}{NS_s} \quad (6)$$

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

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

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, 2015-2017, 2018 and 2004-2018. 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 $length_{prey} \sim length_{Greenland\ halibut}$ 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):

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

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 2015-2017 *CCGS Teleost* campaigns were selected, since the stomach content analyses for redfish in 2018 are still under way.

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). Subsequently, the GSL Greenland halibut stock was managed as a component of the Atlantic stock, until 1992. During this period, the TAC ranged from 5,000 t to 10,500 t. 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. 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.

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 2018), 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 mobile gear 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 fishers (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 from 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 types of management, the TAC was established for the period from 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 an F-ALL of 2,813 t.

In 2018, landings (preliminary figures as of December 31, 2018) totalled 1,493 t, or 53% of the F-ALL (Tables 1 and 2, Figure 5), the lowest since 2001-2002. Quebec’s fixed gear fleets, which receive the bulk of the fixed gear fishing allocation, landed 999 t out of a possible 2,331 t, or 43% of their allocation. The Newfoundland fixed gear fleets completely fished their allocation of 482 t.

In 2018, 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 2018, less than 1% of Greenland halibut landings originated from the directed fisheries for Atlantic cod (annual average of 27 t), Redfish (26.4 t), Atlantic halibut (14.6 t) and Witch flounder (3.6 t).

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 2016-2017 fishing seasons, these proportions were 27%, 46% and 27% for 4R, 4S and 4T respectively. In 2018, 12% of landings came from 4R, 47% from 4S and 42% from 4T.

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). On average, on an annual basis between 2004 and 2015, 155 harvesters from the Quebec region—including 79 fishers from the fleet under the ITQ system, 50 fishers from the Lower North Shore fleet under a competitive regime and 26 fishers under a competitive regime but from outside the Lower North Shore—participated in the directed Greenland halibut fishery. From Newfoundland, an average of 80 fishers, all under a competitive regime, participated in this fishery each year between 2010 and 2015.

The number of active harvesters in this fishery has been declining in recent years, from 103 to 56 in Quebec and from 60 to 29 in Newfoundland for the 2015-2016 to 2018-2019 seasons. This represents a decrease of nearly 50% in both provinces combined. The decline could be due to the lower catch rates in recent years and the opportunity to participate in more lucrative fisheries.

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.

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). The use of the Vessel Monitoring System (VMS) has been mandatory since 2013 on all vessels except those in the Newfoundland under-35-foot fleet and the Lower North Shore fleet.

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, northern Anticosti and Esquiman sectors, which correspond to the species' concentration areas (Figure 8). Certain indicators are presented for the GSL as a whole (4RST) as well as for each of these three sectors individually, in order to determine if spatial variability occurs that is attributable to different environmental dynamics or fishing practices in the regions.

In the directed Greenland halibut gillnet fishery, the median depth at which gillnets were deployed during the period 2008-2017 was nearly 296 m in the western Gulf and Esquiman sectors, compared to 265 m in the northern Anticosti sector (Figure 9). This difference reflects the different bathymetry in each of these sectors. In 2018, the median deployment depth for fixed gear was 287 m, or roughly 10 m shallower than the median value in the ten previous years.

Soak time

The licence conditions for the Greenland halibut gillnet fishery include the provision that the period of time between the setting and the raising of the fishing gear must not exceed 72 hours (three 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 10 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 1999-2017 period and was 18% in 2018. A decrease in the percentage of activities in the 4+ category was noted between 2016 and 2018, although no clear trend could be established for the series.

A trend can be observed in the relation between soak times and catch rates: soak times tended to be short in the years with higher catch rates, with an increase in the proportion of activities involving soak times of three days in years with lower catch rates. The percentage of activities involving soak times of one day increased between 2008 and 2012, when catch rates were high. In 2017 and 2018, when catch rates were lower, the percentage of activities with soak times of three days was greater.

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 northern Anticosti sector is fished sporadically (Figures 11, 12a and 12b). Between 1999 and 2017, an average of 67%, 25% and 6% of the fishing effort was expended in the western Gulf, Esquiman and northern Anticosti sectors respectively. In years when the northern Anticosti sector was not fished, the fishing effort shifted to the western Gulf. In 2018, 61% of the fishing effort occurred in the western Gulf, compared to 78% in 2017. During the same period, the percentage of effort deployed in the Esquiman sector remained roughly the same, at 26% (2018) and 21% (2017). The northern Anticosti sector was not fished in 2017 and accounted for 13% of the fishing effort in 2018.

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. In 2018, the highest proportion of landings occurred later in the season, in July and August, in all sectors.

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 2018 fishing seasons. The 2018 fishing season stands out from the other seasons, due to the slower start in the deployment of fishing effort and the 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) 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. The upward trend noted in the 2018 season reflects the comments received from harvesters.

Fishing effort, catches and CPUE

In the Gulf as a whole (4RST), fishing effort has been stable since 2015 with nearly 129,000 gillnets deployed annually, below the 1999-2017 series average of close to 158,000 gillnets (Table 4, Figure 16). Landings, which fell by nearly 50% between 2016 and 2017, were down even further in 2018, totalling 1,572 t. These are the lowest recorded landings since 2002. The CPUE for the entire GSL decreased by 43% in 2017 and continued to trend downward in 2018, with a decline of 13%. CPUE values have been below the series average since 2017, with values comparable to those in the early 2000s, when the strong cohorts of 1997 and 1999 had not yet been recruited to the fishery.

The decline in landings throughout the Gulf in 2018 is attributable to the significant decrease in landings in the western Gulf. Landings in this sector fell by close to 45% between 2016 and 2017. In 2018, the downward trend continued, with a decline of 46% from 2017 and a decline of 71% from the high values recorded in 2016. The effort expended in this sector was more or less stable from 2015 to 2017, but fell in 2018. This decline in effort can be ascribed to the shift in effort to the northern Anticosti sector. The decrease in landings, which was more pronounced than the decrease in effort in this sector, resulted in a decline in CPUE, which has been below the series average since 2017 (Figure 16).

Frequentation of the northern Anticosti sector by Greenland halibut harvesters is sporadic (Figures 12a and 12b). 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). The sector was then abandoned until 2018, when landings totalled 209 t for a fishing effort of over 15,500 nets. The CPUE in 2018 was greater than that in 2017, but has been below the series average since 2013.

Landings in the Esquiman sector fell sharply between the peaks in 2011-2012 and 2017, despite a sustained level of effort, resulting in a substantial and continuous decline in CPUE values from 2011 to 2017. CPUE values fell below the series average in 2013 and, despite an increase in 2018, still remain below average (Figure 16).

Standardized catch per unit effort – index of fishery performance

The standardized 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). Standardized CPUE values for the entire Gulf were lower in the early 2000s, increased between 2001 and 2003 and then remained fairly stable until 2012. In 2013, the CPUE fell significantly but rose again the following year to values similar to those during the period of stability (2003-2012). Between 2016 and 2017, the index of fishery performance (standardized CPUE) for the entire Gulf (4RST) decreased by 36%. In 2018, it was still trending downward, with a decline of 48% from its peak in 2014-2016, approaching the low values of 2000-2001 (Figure 17). When CPUE values are analyzed by fishing sector, in 2018, only the CPUE for the western Gulf shows a decline from 2017. In this sector, the cumulative declines in 2017 and 2018 represent a drop of over 67% from the historical peaks of 2015 and 2016. The respective indices for the northern Anticosti and Esquiman sectors have been falling steadily since 2010 and have been below their respective series averages since 2013. Although these two indices rose between 2017 and 2018, they are still below their respective series averages (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. Generally speaking, average sizes fell 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 approximate lengths of over 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 highest values for average size in Greenland halibut in this series were observed in 2012 and 2016, but fluctuated in the interval between these two years. Average size then decreased again and was stable in 2017 and 2018, with average lengths of 44.4 cm for males, 48.4 cm for females and 47.8 cm for both sexes.

According to the length frequency distributions in each NAFO Division (1996-2017), the average length of individuals caught in 4R surpasses those caught in 4S and 4T (Table 7, Figure 18). Halibut caught in 4T are the smallest on average. This difference is attributable to the fact that the main Greenland halibut nursery area in the GSL is in the lower estuary of the St. Lawrence, which is located in Division 4T. In 2018, the average size of Greenland halibut caught in the commercial fishery was similar in all three divisions, at around 48 cm.

According to the length frequency distributions by sex obtained, the average size of females caught in the commercial fishery 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 152-mm mesh ranges from 37 cm to 61 cm for females and from 37 cm to 53 cm for males (Figure 18).

During the 1996-2017 period, on average, 17% of fish caught in the directed Greenland halibut gillnet fishery were less than 44 cm long, compared with 14% in 2018 (Figures 19 and 20). The 44 cm size is the minimum size identified in the conservation measures.

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% but rose to 80% in the subsequent period (1996 to 2017). In 2018, the percentage of females in GSL commercial catches was 84%, which is above the series average. This proportion was lower in 4R (average of 74%), compared to 81% and 84% in 4S and 4T respectively. In 2018, the proportion of females in commercial catches increased in all divisions, to 77%, 89% and 88% in 4R, 4S and 4T respectively. These are among the highest percentages for females in Divisions 4S and 4T in the series.

Sexual dimorphism in Greenland halibut explains the higher proportions of females in catches and the differences observed in the maximum sizes of the two sexes. The mesh size used in the fishery targets sexually mature individuals as much as possible so that the fish can reproduce before being caught and thus contribute to recruitment to the population.

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 2000-2018 period using data from the At-Sea Observer Program. Bycatch in this fishery averages slightly over 460 t annually (Figure 22). Nearly one third of bycatch is landed, with the remainder being discarded at sea. Bycatch represents 18% 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 42% and 30% in 2017 and 2018 respectively. The most common bycatch species are, in order of importance, American plaice (*Hippoglossoides platessoides*), snow crab (*Chionoecetes opilio*), redfish (*Sebastes* spp.), thorny skate (*Amblyraja radiata),* northern stone crab (*Lithodes maja*), Atlantic halibut (*Hippoglossus hippoglossus*), various other species of skates and witch flounder (*Glyptocephalus cynoglossus*) (Table 12 and Figure 24). The occurrence of redfish and Atlantic halibut in the bycatch increased in 2017 and in 2018 compared to the series average, reflecting the increased abundance of these species in the GSL ecosystem. Landed bycatch included American plaice, redfish, Atlantic halibut, Atlantic cod and monkfish. 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 2018 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 2000-2016 period, as well as for 2017 and 2018 (Figure 25). The average catch (kg/tow) in all tows within a 5-minute square is shown for the 2000-2016 period and on an annual basis for 2017 and 2018. Greenland halibut were present on average in 89% 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 2017, the estimated average annual Greenland halibut bycatch in the directed shrimp fishery in the Estuary and Gulf was roughly 91 t (Figure 27). In 2018, the estimated bycatch was 78 t, which represents approximately 0.57% 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 represented fairly well by the study area for DFO's nGSL survey, which takes place in August. At that time of year, the largest halibut concentrations are found in the lower estuary of the St. Lawrence, in the Sept Îles Basin, the Laurentian Channel south of Anticosti Island, and in the heads of Anticosti and Esquiman channels. Figure 29 shows the spatial distribution of the species by 4- and 5-year blocks. An increase in catch rates from the 1990-1994 period to the 2005-2009 period, followed by a decrease in rates during the 2015-2018 period, is observed. The distribution of Greenland halibut catch rates obtained in the mobile gear sentinel 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 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 area located north of Anticosti Island (Youcef et al. 2013, Ouellet et al. 2011). 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 2018 (Figure 39). In the study 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 2017 with the observation of a new concentration of Greenland halibut in Shediac Valley. Its distribution in 2018 was similar to that in 2010-2017.

The historical perspective provided by the sGSL survey suggests that, in the 20 years before the nGSL survey (i.e., from 1971 to 1989), all 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 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% of the stock biomass (D95). 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, with 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 and temperature

The annual distribution of Greenland halibut biomass by size classes (0-20, 20-30, 30-40 and > 40 cm) was examined relative to the water temperature and depth where fish were caught during DFO's nGSL surveys (Figure 42). On average, individuals in the 0-20 cm size class were found at shallower depths (273 m) than larger individuals (near 300 m). Biomass by size class in relation to depth varies somewhat, but is generally similar from year to year. However, this was not the case for biomass distribution in relation to temperature (Figure 42). Since 2010, all size classes of Greenland halibut have been found in increasingly warm waters. According to these data, Greenland halibut of all sizes have continued to occupy the same depths since 1990, although the temperatures in this environment have been increasing. Between 2010 and 2018, the median temperature of the waters occupied by fish over 40 cm has increased from 5.2°C to 6°C (Figure 43). This increase is most pronounced in the Esquiman sector, where the median water temperature has increased from 4.9°C to 6.6°C between 2010 and 2018.

Recruitment and demographic structure

Recruitment varies greatly from year to year (Figure 44). The first large cohort observed was the 1997 cohort, which was followed by another strong cohort in 1999. Since the late 1990s, strong and weak cohorts have alternated. The recent 2010 and 2013 cohorts were very strong and similar to the 1997 cohort, while the 2017 cohort was of average size.

Recruitment indices estimated from the DFO's nGSL and sGSL surveys show a fairly good correlation between the two surveys (r^2 = 056) (Figure 44). Both surveys identify the 1997, 1999, 2001, 2004, 2010 and 2012 cohorts as substantial. The 2013 cohort was particularly abundant, and comparable to the 1997 cohort, according to the nGSL survey, but of average abundance according to the sGSL survey. The abundance of the 2017 cohort also differed according to the two surveys, with the nGSL survey indicating above-average abundance and the sGSL, below-average abundance. According to the information provided by the sGSL survey, recruitment was not strong in the study area between 1971 and 1997.

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 in the surveys, smaller Greenland halibut are better represented in the nGSL survey, while larger individuals are better represented 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, 1-

year-old individuals (modal size ~16 cm). In addition, this survey covers the lower estuary, unlike the other two surveys. The mobile gear sentinel survey allows a higher proportion of large individuals to be sampled.

These three surveys accurately depict the arrival of two extraordinarily strong cohorts in the history of this stock: the 1997 cohort (modal size ~16 cm at 1 year in 1998) and the 1999 cohort (modal size ~16 cm at 1 year in 2000). These cohorts were responsible for the substantial increase in stock abundance in the 2000s and supported the fishery for several years. 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.

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

The status of the strong 2013 cohort is worrisome. Size frequency distributions show a very high abundance in 2014 with the cohort reaching a modal size of 16 cm, followed by still 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 age 1 and 2 compared to the average growth rate for this stock. The slowing of growth observed in the 2013 cohort will delay 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.

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 mobile gear sentinel surveys are presented in Table 14a, Table 14b, Table 15 and Figure 46.

The sGSL survey encompasses a longer time period (1971-2018) than the nGSL (1990-2018) and mobile gear sentinel (1995-2018) 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 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; biomass increased more gradually. From 1998 to 2010, abundance and biomass indices fluctuated, although values were still high relative to survey averages. Subsequently, the two indices fell and, in 2018, they were slightly below their respective series averages.

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 mobile gear sentinel survey is the same as that covered in 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, although the abundance index in the DFO's nGSL survey was relatively stable, the biomass index trended downward sharply, as did the abundance and biomass indices in the mobile gear sentinel survey. The biomass and abundance indices in the mobile gear sentinel survey have been below their respective series averages since 2015, while the two indices from the DFO's nGSL survey have been below their series averages since 2017.

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 shows that only the 0-20 cm size class (individuals ≤ 1 year) has increased relative to 2017 and is more abundant than the series average (Table 16, Figure 47). The abundance of fish in the 20-30 cm size class (age 2) has declined since 2017, which was to be expected since the abundance of this size class was low in 2017 at age 1. The nGSL survey shows a close correlation between the abundance of a given cohort at age 1 and 2. The abundance of fish in the 30-40 cm class has been stable and close to the series average since 2015. The abundance of fish over 40 cm, which had been declining since 2015, stabilized in 2018 and is below the series average. In 2018, except for 1-year-old fish (0-20 cm), the nGSL data indicate that the abundance of fish in all size classes over 20 cm was below their respective series averages (Figures 47 and 48).

According to the abundance indices obtained from the mobile gear sentinel survey, the abundance of Greenland halibut of all size classes is below their respective series averages (Table 17, Figures 47 and 48). The abundance of fish over 40 cm has continued to decrease, reaching the lowest value ever recorded in this survey.

According to growth estimates for individuals of this stock, fish in the abundant 2010, 2012 and 2013 cohorts should have reached a modal size of 47 cm, 43 cm and 40 cm respectively in 2018. Consequently, a significant increase in the abundance of fish over 40 cm would be expected. Data from the surveys indicate otherwise (Figures 47 and 48), with stable or declining indices relative to 2017 that are also below their respective series averages.

Biomass indices for fish over 40 cm derived from the DFO's nGSL mobile gear survey and the mobile gear sentinel survey point to a downward trend in the last ten years. The declines were 62% and 77% respectively from the peak biomass values observed in the mid-2000s. Estimated biomass in 2018 was similar to that in 2017 (Figure 49).

Comparison of abundance data from the DFO surveys in the northern and southern Gulf

Abundance indices (total, 0-20 cm and > 40 cm) from the DFO surveys in the southern and northern GSL were compared (Figure 50). Trends in total abundance, in recruit abundance (0-20 cm) and in the abundance of individuals over 40 cm were similar in both surveys. The closest correlation between the indices from the two surveys was for fish over 40 cm.

Standardized indices

Standardized indicators of fishable stock (fish > 40 cm) obtained from the DFO's sGSL and nGSL surveys and the mobile gear sentinel survey, as well as the commercial fishery performance indicator (standardized CPUE), show similar trends overall (Figure 51). A continued sizeable increase was observed until 2002, followed by a period of high stock abundance, which was fairly stable until 2011. Subsequently, a downward trend was noted until 2018. The four indicators are below the standardized series averages.

Exploitation rates

Relative exploitation rates were calculated for the entire Gulf (4RST) and by fishing sector (Table 18, Figure 53). The nGSL survey strata used to determine biomass by fishing sector are shown in Figure 52.

The average exploitation rate for the entire Gulf (4RST) was 6.49% for the 1996-2017 series. This is compared to the average of 4.8% obtained during the 2001-2008 period, when the stock increased and remained abundant. Beginning in 2009, biomass indices for fish > 40 cm declined and the exploitation rate increased, with average values comparable to the series average. This could indicate that exploitation rates in the last ten years were too high.

In the Gulf as a whole (4RST), the significant decrease in landings in 2017 and 2018 maintained the exploitation rate at or near the average for the 1996-2017 series (Figure 53). The exploitation rate index for the western Gulf showed a rising trend between 2012 and 2017. Due to a significant drop in landings and stable biomass levels, the exploitation rate in the sector declined in 2018 to below the series average. In the northern Anticosti and Esquiman sectors, where landings increased in 2018, exploitation rates also increased and were above the average for their respective series.

Condition index

The Fulton condition index for Greenland halibut, which was determined using data from the DFO's nGSL survey, was estimated for four size 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 54). The condition of 1-year-old fish fluctuated from 1990 to 2018, which may be linked to the abundance of the various cohorts. In strong cohorts, the condition of fish is likely to be below average. In 2000, the abundant 1999 cohort, which was a year old (15 cm), had a Fulton condition index lower than the series average. The same situation occurred in the abundant 2010 cohort, which had a below-average condition index in 2011, at age 1. Recently, there were three consecutive years (2012-2014) in which cohorts with high to moderate abundance were present in the stock,. The Fulton condition index indicated lower-than-average series values for these cohorts between 2013 and 2015 (15 cm series) (Figure 54). 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 affect the condition of recent cohorts of Greenland halibut is the potential competition for food and habitat resulting from the mass arrival of juvenile redfish in the Gulf of St. Lawrence between 2011 and 2015. In 2018, the condition of 15 cm and 25 cm fish was comparable to the series average, while the condition of 35 cm and 45 cm individuals was slightly below average for their respective series and reflects the condition of these same fish at age 1.

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

The size at which 50% (L_{50}) of Greenland halibut are sexually mature decreased in males during the 1998-2001 period and in females during the 1998-2004 period. It remained fairly stable from 2004 to 2014, at nearly 36 cm for males and 46 cm for females, which are close to average values. Subsequently, in 2016, the L_{50} decreased in both sexes to the lowest values of the series (Figure 55). In 2018, the L_{50} in both males and females (42 cm for females and 34 cm for males) was below average for their respective series (1996-2017). Since Greenland halibut growth decreases after individuals reach sexual maturity, a decline in the L_{50} could result in a decreased percentage of fish that reach the size of 44 cm, currently the minimum size for the small-fish protocol. Histological examinations of the gonads of Greenland halibut were carried out in 1997 to determine the stage of sexual maturity. These studies produced L_{50} values similar to those determined by visual examination during the same period. A study by Kennedy et al. (2009) concluded otherwise, that the visual examination of the gonads was not a good indicator for evaluating sexual maturity in the species. In addition, egg resorption may apparently occur before the eggs are expulsed. A comprehensive histological study of GSL Greenland halibut could provide valuable information on size at sexual maturity in this species, particularly since a slowdown in their growth rate has been observed. Since growth in this species slows after sexual maturity is reached, these data could influence the management of this resource.

PRECAUTIONARY APPROACH – REFERENCE POINTS

In general, the use of a 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 action or to fail to take action. This approach is widely accepted nationally and internationally as an essential part of sustainable fisheries management.

A PA is being developed for the GSL Greenland halibut stock. A stock status index and a limit reference point (LRP) have been defined, and were approved at the peer review meeting on February 22, 2017 (DFO 2017a, DFO 2018c).

The biomass of fish larger than 40 cm estimated from the data obtained in the DFO summer surveys was chosen as the indicator of the Greenland halibut stock status. This indicator corresponds to the longest time series available (1990-2018) and represents a proxy for mature stock biomass (MSB). During the 1990-2018 period, the stock experienced significant variations in productivity and biomass, allowing these variations to be taken into account in the establishment of reference points. In addition, this indicator provides information on the exploitable stock biomass for the following year since the Greenland halibut fishery targets fish of 44 cm and more.

The selected LRP corresponds to the lowest historical level of biomass from which a recovery of the stock has easily occurred (B_{rec}) (DFO 2002, DFO 2006, Duplisea and Grégoire 2014). It corresponds to the geometric mean of the MSB for the period 1990 to 1994, or 10,000 t (Figure 56).

During the winter 2018 peer review, an Upper Stock Reference (USR) was proposed by the DFO Science Sector. This USR represents 80% of the biomass at maximum sustainable yield (B_{msy}) (DFO 2019). The proposed proxy for B_{msy} is the geometric average of the indicator during the 2004-2012 productive period, or 63,211 t. That puts the proposed USR at 50,500 t. Based on this USR, the GSL Greenland halibut stock has been in the cautious zone since 2016. DFO Fisheries Management, with support from DFO Science, is holding consultations with the fishing industry and other interest groups in order to adopt a USR. Decision rules for adjusting catches are also being developed.

DIET DESCRIPTION

Periods

Roughly 7,233 Greenland halibut stomachs were retained for analysis to describe the species' diet: 5,220 stomachs in 2004-2009 and 2,013 stomachs in 2015-2018 (Table 20, Figure 57). The number of stomachs collected annually ranged from 386 to 971. The fish harvested for the diet study were well distributed throughout the study area (Figure 58).

Based on the total fullness index (TFI), in 2018, the feeding intensity of Greenland halibut was two times greater than the average for the entire 2004-2018 series (Table 20). When length classes are excluded and regardless of the period considered, the main prey of Greenland halibut is still fish (Table 23). A total of 31 different taxa of fish have been identified in Greenland halibut stomach contents since 2004, representing an average occurrence of fish of nearly 20%. The value of this metric climbed to over 30% in 2018, with fish playing an unequalled role in the diet of Greenland halibut that year (72% of TFI). Aside from capelin (*Mallotus villosus*), Atlantic soft pout (*Melanostima atlanticum*) and redfish (*Sebastes* spp.), no other fish taxa identifiable to at least genus were observed in >1% of stomachs in the 2004-2018 series. Capelin, the most prevalent prey item in the diet of Greenland halibut regardless of the period, were increasingly observed in halibuts' stomachs over the years, according to TFI percentage values: the frequency of occurrence of capelin was 3.5 times greater in 2018 than during the 2004-2009 period, contributing to the increased importance of this prey in the diet of halibut in 2018 (Table 23 and Figure 59).

Redfish was not a prevalent prey item in the stomach contents of Greenland halibut during the 2004-2009 period, with a frequency of occurrence of <1%. However, during the 2015-2017 period, its frequency of occurrence increased to over 7%, before dropping to 2.5% in 2018. This decline in 2018 contributed to the decrease in its percentage of TFI, which was nearly four times lower than it was during the 2015-2017 period (Table 23).

A total of 15 shrimp taxa have been reported in the stomachs of Greenland halibut since 2004 (Table 23), among which only three taxa identifiable to at least genus were observed during all of the 2004-2009, 2015-2017 and 2018 periods: pink glass shrimp (*Pasiphaea multidentata,* also known as white shrimp), northern shrimp (*Pandalus borealis*) and *Pandalus* spp. shrimp. Regardless of the period, northern shrimp is 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 by half in 2018 relative to the 2004-2009 period, with the year 2018 (9.1%) being well below average for the time series (16.1%). In 2018, shrimp made up only 5.6% of the Greenland halibut's diet according to TFI values, which is a striking decrease compared to the two previous periods, when it made up roughly 20%. In terms of mass contributions, the percentage of shrimp in the diet fell by roughly one half between the 2004-2009 (31.6%), 2015-2017 (15.6%) and 2018 (7.25%) periods (Table 23).

In the zooplankton group, the 28 taxa reported resulted in this prey group being observed in over 10% of the Greenland halibut stomachs analyzed since 2004 (Table 23). Hyperiids belonging to the genus *Themisto* and euphausiids are the most prevalent zooplankton in the Greenland halibut's diet (Table 23 and Figure 59).

In the *Other Invertebrates* group**,** made up of 22 taxa other than shrimp and zooplankton, a decline was noted in the importance of these prey items in the Greenland halibut's diet from the 2004-2009 period to 2018 (Table 23). This decline may be attributable to the increased expertise in taxonomy over the years. Our knowledge and skill in identifying various prey items at various stages of digestion has improved with time. Although many taxa in this group were commonly used in the past to describe prey that were too thoroughly digested to be identified more precisely (e.g., molluscs, crustaceans and isopods), their reduced use in recent years has resulted in a decline in this group's importance in the Greenland halibut's diet.

Length classes

A substantial number of samples were obtained in each length 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 represented the length class with the smallest percentage of empty stomachs (37%). The <20 cm length class is also the one that feeds the most: its TFI (0.32) was twice as great as the average for the series (0.16, Tables 20 and 21 and Figure 60).

Unlike the other length classes that rely primarily on fish, Greenland halibut in the <20 cm class depend mainly on invertebrates to meet their dietary needs (Table 24, Figures 60 and 61). In fact, in this <20 cm length class, the proportion of zooplankton in the diet was exactly the same as that of fish (36.86% 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 62).

The diet of Greenland halibut in the 20-30 cm length class is made up of larger prey than that in the < 20 cm length class. The importance of zooplankton plummets (-27%) in this group, while that of fish increases (+22%), as does shrimp (+17%), according to TFI values (Table 24 and Figure 61). Capelin is the most important prey species in this size class; in addition, capelin is the only species of fish whose contribution to the species' diet is at least 10% in all the length classes studied (Table 24). Among the shrimp species, pink glass shrimp and northern shrimp are the two taxa contributing the most to the Greenland halibut's diet (Table 24). Both the frequency of occurrence and mass contribution of northern shrimp increase with the length of the Greenland halibut specimens collected (Table 24).

Greenland halibut in the 30-40 cm length class are even more reliant on shrimp in their diet (11% of TFI), primarily northern shrimp (Table 24). Redfish only make up 1% or more of the Greenland halibut's diet in halibut specimens of 30 cm and more, according to TFI values.

The diet of specimens in the >40 cm length class is based primarily on fish (65% according to TFI values, Table 24). Capelin, although it is still one of the species' main prey, is replaced by redfish as the prey item making the greatest contribution to the Greenland halibut's diet in this size class (Table 24).

Estuary versus northern Gulf

In this study, 1,105 Greenland halibut stomachs from the Estuary and 6,131 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 significantly less frequently in the Estuary (40.8%) than in the nGSL (52.1%). 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 the Greenland halibut sampled in the Estuary from which the stomachs were removed. Indeed, the Estuary halibut are much smaller (median and mean of 295 mm and 300.9 mm respectively) than the nGSL halibut (median and mean of 356 mm and 346.8 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 63). Among these, the zooplankton group predominates, accounting for nearly 32% 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 last three years, the contribution of hyperiids to the diet of Greenland halibut has increased in the Anticosti Channel area (Figure 64). The contribution of euphausiids to the diet of Greenland halibut in the Estuary remained stable during the same period (Figure 65). In these two figures and the four following ones (66 to 69), both empty stomachs and stomachs that were not from specimens in the length classes consuming the prey in question were excluded from the data used to produce the maps. Based on TFI values, Greenland halibut in the Estuary consume only small numbers of shrimp (12.23%), compared with halibut in the rest of the nGSL (22.8%, 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 66 and 67). Capelin is the fish taxon making up the largest part of the species' diet in the Estuary (20.07% of the TFI, Table 25), with its contribution increasing in 2018 compared with the previous three years (Figure 68).

For Greenland halibut in the rest of the nGSL (i.e., not in the Estuary), fish (55.2%) and shrimp (22.8%) made up nearly 80% of their diet based on TFI values (compared to 50% for Greenland halibut in the Estuary, Table 25). Redfish play a greater role in the diet of these fish (Table 2 and Figure 69).

Size of redfish ingested by Greenland halibut

Data on the size of redfish found in Greenland halibut stomachs could only be obtained from 31 halibut stomachs. Among the 32 length values obtained, most (23) came from measurements of complete specimens of redfish found in halibut stomachs. The other length values (9) are estimated ones 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 43% of the variability found (Figure 70). The length of redfish ingested by Greenland halibut ranged from 6.5 cm to 23 cm. The longest redfish (23 cm) was found in the stomach of a 61-cm-long halibut.

Comparison of Greenland halibut and redfish diets

A total of 1,454 Greenland halibut stomachs and 2,146 redfish stomachs were retained for this comparison (Table 26). Very few stomachs from redfish over 40 cm were available compared to redfish in the other length classes. The first finding was that invertebrates made up a significant proportion of the diet of redfish (~75%) throughout their development compared to Greenland halibut (Figure 71). 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 or fourbeard rockling were found in the stomach contents of redfish harvested in 2015-2017, and capelin were only found three times in the predator's stomach contents during the same period. In the *Other Fishes* taxonomic group (Figure 72), six and nine fish taxa are represented in the stomach contents of redfish and Greenland halibut respectively. Two of these taxa, white barracudina (*Arctozenus risso*) and Atlantic soft pout, were found in the stomach contents of both predators. In both Greenland halibut and redfish, the importance of the *Other Fishes* taxonomic group increased with the length of specimens, but its contribution never exceeded 15% of either species' diet. 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. Cannibalism in redfish seems to level off beginning at a length of 30 cm. As for the *Digested Fish* taxonomic group, which includes fish taxa too well digested to be identified, its importance is similarly low in the diet of both species.

Among shrimp species, pink glass shrimp plays a much more important role in the diet of redfish than in that of Greenland halibut, its prevalence increasing with the size of the redfish specimen. The proportions of northern shrimp, as well as that of the taxa in the *Other Shrimps* group, are roughly speaking the same in the diets of both predators, in all length classes. Among the *Other Shrimps* group, only *Pandalus* spp. shrimps, striped pink shrimp (*Pandalus montagui*) and digested shrimp were observed in the stomach contents of both redfish and Greenland halibut.

The contribution of *Themisto* hyperiids to the diet is consistently greater in redfish than in Greenland halibut regardless of size class. This same trend is observed for euphausiids, except in the < 20 cm length class; euphausiids are consumed twice as much by Greenland halibut in this length class than by redfish of the same size. In redfish in the < 20 cm length class, 27 taxa in the *Other Zooplankton* group are consumed, compared with only seven in Greenland halibut of the same size. Among both predators of this size class, 22 taxa were found in the stomach contents of redfish only, most of which (11) were calanoid copepods.

CONCLUSION

Warming and oxygen depletion of the deep waters of the Gulf could result in habitat loss and the degradation of habitat quality for the Greenland halibut. Furthermore, the arrival of three exceptionally strong cohorts of redfish (2011 to 2013) could increase interspecific competition. These ecosystem conditions are not expected to improve in the short term.

Landings totalled 1,496 t (preliminary figures as of December 31, 2018), or 53% of the allocation available to the fishery, and are the lowest recorded in the last 16 years. The catch per unit effort (CPUE) in the commercial fishery showed a downward trend in 2018, with a 48% decrease in 2018 from the 2014-2016 peak.

A declining trend in the last ten years or so was also found in the biomass indices for fish over 40 cm, based on data from DFO's mobile gear surveys and the mobile gear sentinel survey. Decreases of 62% and 77% respectively were recorded from the peaks observed in the mid-2000s.

The decline in the abundance and biomass indices for fish > 40 cm occurred during a period of higher exploitation rates, compared to the previous period when rebuilding of the stock occurred and the species was abundant. This could indicate that exploitation rates in the last ten years were too high.

Under the proposed precautionary approach, the indicator for the status of the GSL Greenland halibut stock puts it in the cautious zone in 2018. This indicator has been on a downward trajectory in the last ten years or so.

The short-term prospects for this stock are worrisome.

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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	ITQ + Comp. = Qc Comp. = NL	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	4,500	-	1,288	Idem	6.0	120	44
2002-2003	3,500	-	1,752	Idem	Qc[2] = 5.5 and 6.0 NL : 6.0	120	44
2003-2004	3,500	2,917	3,573	Idem	Qc[2] = 5.5 and 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	120	44
2012-2013	4,500	3,751	3,481	Idem	6.0	120	44
2013-2014	4,500	3,751	2,774	Idem	6.0	120	44
2014-2015	4,500	3,751	3,179	Idem	6.0	120	44
2015-2016	4,500	3,751	3,410	Idem	6.0	120	44
2016-2017	4,500	3,751	3,300	Idem	6.0	120	44
2017-2018	4,500	3,751	1,767[6]	Idem	6.0	120	44
2018-2019	3,375	2,813	1,493[6]	Idem	6.0	120	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]Establishing quota reconciliation.

[6]Landing data are preliminary.

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	NAFO Division				Total	TAC	F-ALL
year	4R	4S	4T	n. d.**			
1970	381	496	255	-	1,132	-	-
1971	300	450	204	-	954	-	-
1972	199	379	105	-	683	-	-
1973	216	431	116	-	763	-	-
1974	167	752	92	-	1,011	-	-
1975	195	1,102	247	-	1,544	-	-
1976	517	1,367	135	-	2,019	-	-
1977	1,108	2,298	555	-	3,961	-	-
1978	1,344	3,549	1,354	-	6,247	-	-
1979	2,920	1,889	3,982	-	8,791	-	-
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	-	3,300	4,500	3,751
2017-2018*	210	823	734	-	1,767	4,500	3,751
2018-2019*	552	532	409	-	1,493	3,375	2,813

**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	3,300
2017-2018*	1,744	7	1	14	1	0	1,767
2018-2019*	1,472	5	2	11	0	2	1,493

*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	1,332	1,198	79,096	15.15	0.27	36.8	3,254	21,4935
2000	1,221	918	83,688	10.96	0.21	46.5	1,973	17,9974
2001	405	249	23,182	10.75	0.36	21.2	1,175	10,9349
2002	658	434	29,200	14.87	0.53	29.9	1,450	9,7659
2003	1,161	1,407	63,856	22.04	0.47	40.7	3,462	15,6894
2004	2,586	2,811	152,127	18.48	0.27	74.5	3,775	20,4197
2005	2,664	2,834	163,802	17.30	0.27	73.2	3,871	22,3773
2006	2,291	2,986	148,991	20.04	0.32	83.6	3,573	17,8219
2007	1,898	3,199	121,159	26.40	0.41	85.0	3,762	14,2540
2008	1,986	3,091	131,091	23.58	0.28	87.9	3,518	14,9137
2009	2,027	3,481	130,865	26.60	0.44	82.0	4,244	15,9591
2010	2,002	3,552	143,085	24.82	0.41	89.5	3,970	15,9872
2011	1,851	3,222	132,475	24.32	0.47	88.3	3,650	15,0028
2012	1,777	3,001	121,075	24.78	0.45	85.6	3,504	14,1443
2013	2,192	2,235	159,792	13.99	0.20	90.3	2,474	17,6957
2014	2,002	3,141	148,411	21.16	0.27	90.9	3,454	16,3268
2015	1,759	3,130	118,439	26.43	0.35	91.4	3,425	12,9583
2016	1,814	2,980	121,245	24.58	0.37	90.7	3,286	13,3677
2017*	1,505	1,561	111,694	13.97	0.22	90.7	1,720	12,3147
2018*	1,263	1,144	93,725	12.21	0.23	72.8	1,572	12,8743

Western Gulf

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	836	731	39,775	18.38	0.39	28.6	2,555	139,073
2000	825	531	49,497	10.73	0.26	39.0	1,360	126,915
2001	362	218	21,007	10.37	0.38	30.0	727	70,023
2002	614	358	26,636	13.44	0.37	45.1	793	59,060
2003	1,003	1,010	51,384	19.66	0.43	46.6	2,167	110,266
2004	2,386	2,277	136,695	16.66	0.21	90.2	2,526	151,547
2005	2,532	2,451	155,761	15.74	0.21	95.7	2,562	162,760
2006	1,912	2,100	118,994	17.65	0.31	94.4	2,225	126,053
2007	1,516	2,371	92,910	25.52	0.44	93.4	2,538	99,475
2008	1,547	2,240	98,796	22.67	0.30	94.5	2,371	104,546
2009	1,546	2,047	99,791	20.51	0.30	89.7	2,282	111,250
2010	1,349	1,836	94,447	19.44	0.33	95.3	1,927	99,105
2011	1,097	1,265	79,591	15.90	0.31	98.1	1,290	81,133
2012	954	1,145	67,249	17.03	0.37	90.7	1,262	74,144
2013	1,208	1,090	95,171	11.45	0.20	95.3	1,144	99,865
2014	1,484	2,679	117,635	22.77	0.30	94.0	2,851	125,144
2015	1,282	2,790	92,716	30.09	0.38	95.0	2,937	97,596
2016	1,255	2,560	86,004	29.76	0.43	94	2,723	91,494
2017*	1,240	1,408	92,332	15.25	0.24	94	1,500	98,330
2018*	963	773	69,016	11.20	0.24	96.2	804	71,742

North Anticosti

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	136	103	8,027	12.83	0.63	91.5	113	8,773
2000	73	72	4,446	16.21	1.03	97.7	74	4,551
2001	40	29	1,927	15.05	1.36	64.5	45	2,988
2002	31	70	1,985	35.16	4.16	77.8	90	2,551
2003	33	66	2,329	28.18	2.56	97.3	67	2,394
2004	7	13	532	-	-	94.6	13	562
2005	3	6	150	-	-	89.0	6	169
2006	111	243	9,702	25.00	1.06	93.6	259	10,365
2007	65	129	5,506	23.37	1.52	97.0	133	5,676
2008	89	162	5,968	27.18	1.87	100.0	162	5,968
2009	172	499	15,748	31.68	1.11	94.7	527	16,629
2010	299	667	25,831	25.84	1.03	99.3	672	26,013
2011	279	458	22,764	20.13	0.76	96.4	475	23,614
2012	201	442	16,002	27.61	1.08	88.6	499	18,061
2013	359	424	31,367	13.52	0.44	97.3	436	32,237
2014	113	104	8,921	11.70	0.71	98.4	106	9,066
2015	-	-	-	-	-	-	0	-
2016	8	5	357	13.20	1.75	88.6	5	403
2017*	7	5	541	8.62	1.69	95.1	5	569
2018*	178	209	15,608	13.41	0.58	99.7	210	15,655

Esquiman

Year	N obs	∑catch	∑effort	CPUE	SE	%	Land. (t)	Effort
1999	358	361	31,101	11.59	0.35	62.1	581	50,082
2000	322	314	29,672	10.59	0.35	58.6	537	50,635
2001	1	2	102	-	-	0.4	397	25,500
2002	13	6	579	11.07	1.89	1.1	562	52,636
2003	125	331	10,143	32.68	1.50	27.0	1,226	37,567
2004	192	520	14,820	35.06	1.50	42.1	1,234	35,202
2005	125	373	7,652	48.74	2.47	28.8	1,297	26,569
2006	268	643	20,295	31.70	1.18	59.4	1,083	34,167
2007	317	699	22,743	30.73	1.23	64.0	1,091	35,536
2008	349	688	26,293	26.16	0.71	70.2	980	37,454
2009	309	935	15,326	61.03	1.70	65.2	1,435	23,506
2010	347	1,037	22,167	46.79	1.40	76.3	1,360	29,052
2011	473	1,497	29,957	49.97	1.30	79.7	1,879	37,587
2012	620	1,413	37,740	37.43	1.03	81.1	1,741	46,535
2013	622	720	32,984	21.83	0.51	80.7	893	40,872
2014	403	355	21,685	16.38	0.61	71.8	495	30,202
2015	477	341	25,723	13.24	0.35	69.8	488	36,852
2016	550	414	34,817	11.89	0.30	74.4	557	46,797
2017*	258	148	18,821	7.87	0.25	70.3	211	26,772
2018*	122	162	9,101	17.77	0.87	29.2	554	31,168

*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	1,193	641	18	0
1987	-	-	-	487	1,088	1,484	1,879	2,343	1,034	33	1	0
1988	-	-	5	307	668	1,064	1,588	1,105	707	340	9	0
1989	-	-	4	183	809	1,127	1,079	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	1,374	252	2	3	3	-	-
1998	-	-	-	-	25	273	2,323	465	596	82	2	-
1999	-	-	-	-	10	1,222	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	1,030	1,245	521	193	54	5	-
2004	-	-	-	57	694	1,155	966	648	210	45	0	-
2005	-	-	-	43	743	1,514	757	534	199	80	1	-
2006	-	-	-	43	396	1,387	863	645	207	31	1	-
2007	-	-	-	118	726	1,538	697	545	95	43	0	-
2008	-	-	-	87	615	1,208	893	480	184	49	2	-
2009	-	-	-	130	661	2,032	934	317	145	25	-	-
2010	-	-	-	131	561	2,066	671	392	111	38	0	-
2011	-	-	-	55	618	1,589	970	269	109	40	0	-
2012	-	-	-	95	719	1,165	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*	-	-	-	57	84	291	498	382	138	84	38	-

Western Gulf

Year	J	F	M	A	M	J	J	A	S	O	N	D
1999	-	-	-		2	1,049	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	-
2003	-	-	-	43	359	542	608	362	193	54	5	-

Year	J	F	M	A	M	J	J	A	S	O	N	D
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	1018	633	311	169	57	-	-
2016	-	-	-	45	432	1063	651	341	162	29	-	-
2017*	-	-	-	35	280	486	372	239	71	16	1	-
2018*	-	-	-	57	84	76	179	219	110	63	15	-

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	103	58	15	-	-	

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	-

Year	J	F	M	A	M	J	J	A	S	O	N	D
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	1338	30	3	4	1	-	-
2010	-	-	-	-	125	1123	100	6	3	2	0	-
2011	-	-	-	-	164	1096	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*	-	-	-	-	-	180	216	104	13	21	19	-

*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	21.78	0.50	28.48	0.72	18.06	1.06	11.25	0.40
2000	14.41	0.32	14.75	0.36	22.37	1.54	11.25	0.40
2001	14.70	0.52	13.97	0.48	20.20	1.85	12.73	2.00
2002	20.06	0.59	18.80	0.53	42.10	4.13	33.01	1.73
2003	31.38	0.72	30.10	0.68	33.61	3.03	32.23	1.45
2004	26.53	0.48	25.06	0.44	48.04	2.71	48.40	2.90
2005	24.18	0.43	22.46	0.38	46.05	3.19	33.86	1.42
2006	26.23	0.47	23.68	0.42	43.90	2.71	30.83	1.17
2007	35.12	0.67	34.13	0.66	57.42	2.62	26.73	0.93
2008	33.44	0.63	33.26	0.64	43.59	1.78	67.28	2.59
2009	36.28	0.69	29.58	0.57	35.07	1.46	53.62	2.00
2010	33.11	0.64	27.69	0.56	45.31	1.98	66.95	2.14
2011	29.37	0.58	20.23	0.44	21.74	0.79	48.87	1.46
2012	32.54	0.66	23.39	0.54	17.76	0.97	23.57	0.65
2013	18.78	0.35	15.44	0.32	14.26	2.66	15.93	0.54
2014	29.67	0.57	34.56	0.68	10.39	2.01	13.61	0.42
2015	35.33	0.70	47.11	0.96	20.11	0.92	11.27	0.35
2016	31.85	0.63	44.91	0.92	18.06	1.06	7.53	0.31
2017*	19.32	0.39	21.99	0.45	22.37	1.54	17.21	0.92
2018*	16.60	0.37	15.31	0.35	20.20	1.85	11.25	0.40

*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	48.4	47.5	43.9	48.6	48.1	43.6	48.4	47.9

*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	0.866	54	326	0.857	274	1384	0.835	99	1051	0.914
2016	585	2395	0.804	88	367	0.807	321	972	0.752	176	1056	0.857
2017*	388	1386	0.781	60	175	0.744	194	629	0.765	134	583	0.813
2018*	237	1276	0.843	125	419	0.771	59	466	0.887	53	391	0.880

*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	4.94	11.60	10.33	4.45	-	3.91
2016	5.93	7.75	9.44	4.13	-	1.4
2017*	5.38	9.28	7.21	5.03	-	2.04
2018*	7.35	9.11	4.49	6.01	10.87	3.94

*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
Mean 2000-2017	292	35	133	461	20.0	23.2	19.3	18

*Preliminary data

Table 12. Average Occurrence and bycatch for the period 2000 to 2016 and for 2017 and 2018.

	Occurrence (%)			Catch (kg)		
Taxon	2000-2016	2017	2018	2000-2016	2017	2018
Greenland halibut	99.75	99.19	99.72	3,121,339	1,988,758	1,754,773
American plaice	76.95	69.98	81.84	36,595	88,677	72,214
Snow crab	62.02	45.03	29.89	66,061	18,582	15,052
Redfishes	55.88	87.02	92.46	22,861	64,894	50,682
Thorny skate	49.90	66.13	42.18	57,526	89,559	21,827
Norway king crab	48.97	50.71	41.34	24,906	17,346	8,713
Atlantic halibut	45.90	65.31	74.30	92,277	149,552	118,462
Skates	39.52	43.41	54.75	42,646	110,737	45,736
Witch flounder	33.75	86.82	52.24	5,669	41,380	18,554
Anthozoan	22.64	59.84	30.17	5,915	10,529	3,769
Atlantic cod	19.53	26.17	19.83	14,627	33,742	63,905
Monkfish	18.17	18.05	24.30	6,290	6,682	7,658
White hake	14.99	34.69	46.65	5,011	39,860	23,565
Smooth skate	14.73	23.94	9.78	9,340	8,951	2,001
Black dogfish	12.23	25.76	13.13	17,196	124,432	36,032
Sea stars	7.94	10.14	15.36	1,061	794	838
Spiny dogfish	6.30	0.00	3.63	3,293	0	514
Atlantic hagfish	5.62	29.41	20.11	574	2,915	1,065
Scyphozoans	4.79	18.26	32.12	915	2,697	5,471
Silver hake	3.14	17.85	13.69	571	1,995	1,026
Sea pen	3.03	29.01	21.23	395	3,088	1,147
Sea star	2.67	7.51	2.79	294	954	155
Skate eggs	2.62	5.48	13.69	237	426	610
Wrymouth	2.07	0.00	1.68	567	0	147
Winter flounder	2.00	1.42	0.00	928	339	0
Atlantic herring	1.95	0.20	0.28	792	14	9
Sculpins	1.89	0.41	4.47	446	25	416
Longfin hake	1.05	0.00	0.00	581	0	0
Whelks	1.05	6.69	6.43	92	619	320
Sponges	0.89	1.42	5.59	89	172	485
Sea raven	0.88	1.01	0.84	130	72	42
Northern shrimp	0.68	1.22	0.28	154	65	9
Righteye flounders	0.67	0.00	6.70	591	0	1,060
Sharks	0.67	0.81	1.12	8,201	12,076	19,040
American lobster	0.59	2.84	2.79	92	400	189
Brittle stars	0.52	1.22	0.00	43	118	0
Eelpouts	0.51	1.22	0.56	459	216	127
Toad crabs	0.49	0.41	0.28	105	25	17
Lumpfish	0.45	0.81	3.35	58	46	253

	Occurrence (%)			Catch (kg)		
Taxon	2000-2016	2017	2018	2000-2016	2017	2018
Yellowtail flounder	0.43	0.00	0.00	202	0	0
Grenadiers	0.42	0.61	0.56	52	112	27
Crabs	0.41	0.20	0.28	65	139	14
Sea peach	0.35	1.62	0.28	73	131	17
Squids	0.31	0.00	0.00	21	0	0
Atlantic mackerel	0.30	0.00	0.00	35	0	0
Pollock	0.29	0.00	1.12	105	0	128
Sea cucumbers	0.29	0.00	0.00	31	0	0
Finfishes (ns)	0.29	0.41	1.96	337	28	283
Porbeagle	0.24	0.20	0.00	2,418	1,185	0
Spotted wolffish	0.24	0.00	0.00	86	0	0
Eels	0.23	0.00	0.28	64	0	17
Harbour porpoise	0.22	0.00	0.00	1,079	0	0
Marlin-spike	0.20	1.83	0.56	21	125	18
Greenland cod	0.15	0.00	0.00	38	0	0
Blue mussel	0.14	0.20	0.00	5	14	0
Sea spiders	0.14	0.00	0.28	16	0	17
Purple sunstar	0.13	0.20	0.28	59	20	9
Haddock	0.12	2.43	1.12	22	327	95
Sea urchins	0.12	1.01	0.00	6	85	0
Shads	0.11	0.00	0.00	21	0	0
Arctic cod	0.11	0.00	0.00	25	0	0
Blue shark	0.10	0.00	0.00	901	0	0
Gannet	0.09	0.41	0.28	19	125	83
Decapods	0.08	0.00	0.00	8	0	0
Alewife	0.08	0.00	0.00	12	0	0
Mud star	0.08	0.00	0.00	9	0	0
Atlantic wolffish	0.07	0.41	0.00	14	1,569	0
Capelin	0.06	0.00	0.00	6	0	0
Basket stars	0.06	0.41	0.00	9	79	0
Fourbeard rockling	0.05	0.00	0.00	4	0	0
Greenland shark	0.05	0.00	0.00	3,442	0	0
North atlantic octopus	0.05	0.61	0.00	5	53	0
Dogfishes	0.04	0.00	0.00	15	0	0
Sea potato	0.04	0.41	0.00	17	31	0
Molluscs	0.04	0.00	0.00	3	0	0
Common sunstar	0.04	0.00	0.28	5	0	9
Gull	0.04	0.00	0.00	2	0	0
Harp seal	0.03	0.00	0.00	186	0	0
Seals	0.03	0.00	0.00	259	0	0
Comb jellies	0.03	0.00	4.19	2	0	138

Taxon	Occurrence (%)			Catch (kg)		
	2000-2016	2017	2018	2000-2016	2017	2018
Northern pipefish	0.03	0.00	0.00	15	0	0
Atlantic argentine	0.03	0.00	0.00	1	0	0
Basking shark	0.03	0.00	0.00	773	0	0
Blood star	0.02	0.00	0.00	1	0	0
Fulmar, northern (noddy)	0.02	0.00	0.00	3	0	0
Dolphin	0.02	0.00	0.00	95	0	0
Blue whiting	0.02	0.00	0.00	3	0	0
Waved whelk eggs	0.02	0.20	0.28	2	19	14
Shrimp	0.02	0.00	0.00	2	0	0
Incirrata octopuses	0.02	0.00	0.28	1	0	14
Kittiwake, black-legged	0.02	0.00	0.00	2	0	0
Alcids	0.02	0.00	0.00	16	0	0
Atlantic salmon	0.01	0.00	0.00	2	0	0
Blueback herring	0.01	0.00	0.00	2	0	0
Gull, herring	0.01	0.00	0.00	1	0	0
Atlantic sturgeon	0.01	0.00	0.00	29	0	0
Longfin snailfish	0.01	0.00	0.00	2	0	0
Crustaceans	0.01	0.00	0.00	2	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	9	0	0
Atl. white sided dolphin	0.01	0.00	0.00	70	0	0
Barnacles	0.01	0.00	0.00	1	0	0
Polychaetes	0.01	0.00	0.00	1	0	0
Northern moonsnail	0.01	0.00	0.00	1	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	79	0	0
Mussels	0.01	0.00	0.00	1	0	0
Stimpson's surf clam	0.01	0.00	0.00	1	0	0
Striped bass	0.01	0.00	0.00	1	0	0
American shad	0.01	0.00	0.00	1	0	0
Pandalids	0.01	0.00	0.00	2	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*	2,148	197,051	76	13,750	1.09	0.55

*****Data from the at-sea observer program are preliminary

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)

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)

Year	Number/tow		Weight (kg)/tow	
	Mean	C.I. 95 %	Mean	C.I. 95 %
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)
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)

Table 15. Mean number and mean weight per 30-minute tow observed in the July mobile sentinel 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)

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

Table 17. Mean number per 30-minute tow observed during the July mobile sentinel 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	0.20	0.58	2.39	1.53

Table 18. Landings and biomass of Greenland halibut greater than 40 cm and relative exploitation rate by fishing sector and year.

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*	1,719	25,445	6.76
2018*	1,572	27,509	5.71

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
2016	2,723	29,233	9.32
2017*	1,500	14,542	10.31
2018*	804	15,978	5.03

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

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
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*	554	3,274	16.91

*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	0.775	0.782	0.853	0.911
1991	0.768	0.777	0.816	0.881
1992	0.800	0.780	0.820	0.881
1993	0.756	0.764	0.837	0.907
1994	0.776	0.760	0.814	0.881
1995	0.712	0.750	0.836	0.926
1996	0.770	0.779	0.852	0.933
1997	0.763	0.784	0.845	0.930
1998	0.736	0.780	0.867	0.938
1999	0.728	0.752	0.812	0.890
2000	0.704	0.751	0.819	0.886
2001	0.742	0.761	0.826	0.887
2002	0.738	0.783	0.847	0.903
2003	0.750	0.783	0.837	0.917
2004	0.756	0.784	0.839	0.908
2005	0.751	0.777	0.846	0.916
2006	0.721	0.769	0.837	0.905
2007	0.751	0.761	0.830	0.895
2008	0.723	0.757	0.832	0.894
2009	0.710	0.762	0.829	0.897
2010	0.738	0.780	0.836	0.897
2011	0.703	0.767	0.842	0.902
2012	0.739	0.765	0.821	0.885
2013	0.721	0.765	0.839	0.900
2014	0.702	0.770	0.850	0.926
2015	0.693	0.743	0.818	0.909
2016	0.707	0.747	0.815	0.898
2017	0.761	0.745	0.803	0.868
2018	0.736	0.769	0.823	0.893

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	2015-17	2018	Total
	Nb. of stomachs	5,220	1,454	559	7,233
	Nb. of empty stomachs	2,517	878	251	3,646
	% empty stomachs	48.2	60.4	44.9	50.4
	TFI*	0.14	0.15	0.35	0.16
Length (mm)	Min	56	64	63	56
	Median	355.5	316	311	347
	Mean	345.8	328.3	312	339.7
	Max	688	725	696	725
Total stomach content (g)	Min	0.002	0.001	0.001	0.001
	Median	1.56	1.45	1.94	1.56
	Mean	5.3	6.3	9.9	5.9
	Max	363.2	108.7	175.8	363.2

*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 cm	[20-30[cm	[30-40] cm	>40 cm
	Nb. of stomachs	1,135	1,567	2,208	2,323
	Nb. of empty stomachs	425	898	1,178	1,145
	% empty stomachs	37	57	53	49
	TFI*	0.32	0.18	0.10	0.12
Length (mm)	Min	56	200	300	401
	Median	169	265	355	452
	Mean	167	261	353	465
	Max	199	299	400	725
Total stomach content (g)	Min	0.001	0.002	0.001	0.003
	Median	0.54	1.26	1.62	5.14
	Mean	0.85	2.86	3.95	12.23
	Max	9.20	185.28	61.81	363.23

*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		1,105	6,127
Nb. of empty stomachs		451	3,194
% of empty stomachs		41	52
TFI*		0.17	0.16
Length (mm)	Min	121	56
	Median	295	356
	Mean	301	347
	Max	612	725
Total stomach content (g)	Min	0.001	0.001
	Median	0.75	1.94
	Mean	2.88	6.52
	Max	113	363

*TFI = Total fullness index

Table 23. Diet of Greenland halibut in the estuary and nGSL for the periods 2004-09, 2015-17, 2018 and 2004-18. 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. Taxa present in more than 1% in the year 2018 are in bold.

Prey	F_{occ}				MC				CTFI			
	2004-09	2015-17	2018	2004-18	2004-09	2015-17	2018	2004-18	2004-09	2015-17	2018	2004-18
Winter skate (*Leucoraja ocellata*)	<1	-	-	<1	0.05	-	-	0.03	0.11	-	-	0.07
Atlantic hagfish (*Myxine glutinosa*)	-	<1	<1	<1	-	0.93	2.03	0.45	-	0.23	0.49	0.13
Bony fish (*Actinopterygii*)	<1	-	-	<1	0.07	-	-	0.05	0.06	-	-	0.04
Atlantic herring (*Clupea harengus*)	<1	<1	-	<1	10.29	1.43	-	7.28	2.66	0.93	-	1.89
Capelin (*Mallotus villosus*)	**2.8**	**2.1**	**9.7**	**3.2**	**15.32**	**7.55**	**36.39**	**17.02**	**19.47**	**20.32**	**35.5**	**22.35**
White barracudina (*Arctozenus risso*)	**<1**	**<1**	**<1**	**<1**	**0.35**	**1.52**	**4.1**	**1.1**	**0.16**	**0.83**	**1.63**	**0.53**
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	<1	-	0.03	-	<0.01	-	0.11	-	0.02
Codfish (*Gadidae*)	<1	-	<1	<1	0.1	-	<0.01	0.07	0.04	-	<0.01	0.03
Atlantic cod (*Gadus morhua*)	<1	-	-	<1	0.23	-	-	0.15	0.1	-	-	0.06
Silver rockling (*Gaidropsarus argentatus*)	<1	-	-	<1	0.03	-	-	0.02	0.02	-	-	0.02
Fourbeard rockling (*Enchelyopus cimbrius*)	**<1**	**<1**	**2.1**	**<1**	**2.24**	**4.03**	**6.61**	**3.18**	**1.36**	**1.63**	**3.28**	**1.74**
Marlin-spike (*Nezumia bairdii*)	<1	<1	<1	<1	2.14	0.24	1.07	1.66	1.09	0.07	0.31	0.77
Sand lance (*Ammodytidae*)	<1	-	-	<1	0.02	-	-	0.02	0.27	-	-	0.17
Sand lance (*Ammodytes sp.*)	**-**	**<1**	**3**	**<1**	**-**	**0.22**	**1.21**	**0.21**	**-**	**0.2**	**7.93**	**1.38**
Snakeblenny (*Lumpenus lampretaeformis*)	<1	-	-	<1	0.08	-	-	0.06	0.05	-	-	0.03
Eelpout (*Zoarcidae*)	<1	-	-	<1	0.15	-	-	0.1	0.12	-	-	0.07
Eelpout (*Lycodes sp.*)	<1	-	-	<1	0.04	-	-	0.03	0.04	-	-	0.03
Atlantic soft pout (*Melanostigma atlanticum*)	3.2	1.8	2	2.8	1.27	0.97	0.58	1.12	2.01	0.91	0.91	1.62
Redfish (*Sebastes spp.*)	**<1**	**7.2**	**2.5**	**2.3**	**4.42**	**54.57**	**24.4**	**15.95**	**1.65**	**16.43**	**4.06**	**4.82**
Sculpin (*Cottidae*)	-	-	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<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

Prey	Focc 2004-09	Focc 2015-17	Focc 2018	Focc 2004-18	MC 2004-09	MC 2015-17	MC 2018	MC 2004-18	CTFI 2004-09	CTFI 2015-17	CTFI 2018	CTFI 2004-18
Skate (*Rajidae*)	-	<1	-	<1	-	0.17	-	0.03	-	0.1	-	0.02
Flatfish (*Pleuronectiformes*)	<1	-	<1	<1	0.64	-	0.15	0.46	0.23	-	0.05	0.15
Righteye flounder (*Pleuronectidae*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Witch flounder (*Glyptocephalus cynoglossus*)	-	-	<1	<1	-	-	1.24	0.18	-	-	0.42	0.07
Greenland halibut (*Reinhardtius hippoglossoides*)	-	<1	<1	<1	-	0.02	2.19	0.32	-	0.27	0.93	0.21
Thorny skate (*Amblyraja radiata*)	-	<1	-	<1	-	0.35	-	0.06	-	0.11	-	0.02
Digested roundfish	**2.7**	**2.4**	**11.1**	**3.3**	**8.33**	**5.28**	**7.56**	**7.69**	**8.39**	**4.78**	**14.05**	**8.68**
Fish (spawn) egg	**<1**	**-**	**2.1**	**<1**	**0.04**	**-**	**0.91**	**0.16**	**0.03**	**-**	**2.04**	**0.36**
Digested fish	8.5	3.2	<1	6.8	10.38	1.93	0.02	7.43	10.15	2.65	0.19	7.06
Fishes, total	**17.4**	**17.5**	**31.5**	**18.5**	**56.22**	**79.26**	**88.45**	**64.85**	**48.03**	**49.56**	**71.79**	**52.34**
Digested shrimp	10.7	2.1	2	8.3	12.1	0.95	0.98	8.57	10.57	1.12	0.69	7.13
Scarlet sergestid (*Sergia robusta*)	-	<1	-	<1	-	0.1	-	0.02	-	0.11	-	0.02
Glass shrimp (*Pasiphaeidae*)	<1	-	-	<1	0.43	-	-	0.29	0.41	-	-	0.27
Pink glass shrimp (*Pasiphaea multidentata*)	**3.2**	**2.8**	**2.9**	**3.1**	**3.75**	**2.67**	**1**	**3.17**	**4.25**	**5.88**	**1.38**	**4.07**
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	-	-	0.02
Friendly blade shrimp (*Spirontocaris liljeborgii*)	-	<1	-	<1	-	0.01	-	<0.01	-	0.02	-	<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	0.44	0.88	0.37	0.51	0.41	1.26	0.28	0.55
Northern shrimp (*Pandalus borealis*)	**5.5**	**5**	**4.1**	**5.3**	**14.28**	**10.77**	**4.82**	**12.3**	**9.56**	**10.81**	**3.19**	**8.71**
Striped pink shrimp (*Pandalus montagui*)	<1	<1	-	<1	0.42	0.15	-	0.31	0.37	0.19	-	0.28
Crangon shrimp (*Crangonidae*)	<1	-	-	<1	0.02	-	-	0.01	<0.01	-	-	<0.01
Sars shrimp (*Sabinea sarsii*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Norwegian shrimp (*Pontophilus norvegicus*)	-	<1	<1	<1	-	0.08	0.08	0.03	-	0.03	0.05	0.01
Shrimps, total	**18.4**	**10.5**	**9.1**	**16.1**	**31.46**	**15.62**	**7.25**	**25.23**	**25.66**	**19.42**	**5.6**	**21.1**

Prey	Focc 2004-09	Focc 2015-17	Focc 2018	Focc 2004-18	MC 2004-09	MC 2015-17	MC 2018	MC 2004-18	CTFI 2004-09	CTFI 2015-17	CTFI 2018	CTFI 2004-18
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
Hyperiid (*Hyperiidae*)	1.7	<1	-	1.3	0.8	<0.01	-	0.54	1.57	0.06	-	1.02
Hyperiids (*Themisto sp.*)	**1.3**	**3.6**	**6.8**	**2.2**	**0.48**	**0.28**	**0.56**	**0.46**	**1.31**	**2.79**	**5.76**	**2.34**
Hyperiid (*Themisto abyssorum*)	<1	<1	<1	<1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Hyperiid (*Themisto compressa*)	<1	1.3	-	<1	<0.01	0.12	-	0.02	<0.01	1.94	-	0.36
Hyperiid (*Themisto libellula*)	**2**	**<1**	**4.5**	**1.9**	**1.22**	**0.09**	**0.41**	**0.91**	**3.48**	**0.63**	**3.57**	**2.96**
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	0.25	-	0.05
Gammarid (*Byblis gaimardi*)	-	<1	-	<1	-	0.02	-	<0.01	-	0.17	-	0.03
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*)	1.8	-	-	1.3	0.14	-	-	0.09	0.36	-	-	0.23
Mysid (*Boreomysis sp.*)	<1	1	<1	<1	0.05	0.06	0.02	0.05	0.08	0.08	0.06	0.07
Mysid (*Boreomysis tridens*)	<1	-	-	<1	0.04	-	-	0.03	0.04	-	-	0.02
Mysid (*Boreomysis arctica*)	2.4	<1	-	1.7	0.18	<0.01	-	0.12	0.4	<0.01	-	0.26
Mysid (*Boreomysis nobilis*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Mysid (*Mysis mixta*)	<1	-	-	<1	<0.01	-	-	<0.01	0.04	-	-	0.03
Euphausiid (*Euphausiacea*)	<1	-	-	<1	<0.01	-	-	<0.01	0.1	-	-	0.06
Euphausiid (*Euphausiidae*)	**1.5**	**4.3**	**3.2**	**2.2**	**0.38**	**0.82**	**0.29**	**0.44**	**3.41**	**10.1**	**3.39**	**4.65**
Northern krill (*Meganyctiphanes norvegica*)	**<1**	**1.5**	**5**	**1.3**	**0.14**	**0.16**	**0.41**	**0.18**	**0.7**	**1.96**	**4.13**	**1.52**
Euphausiid (*Thysanoessa sp.*)	**<1**	**1.2**	**1.6**	**<1**	**0.02**	**0.77**	**0.19**	**0.17**	**0.15**	**5.54**	**1.67**	**1.41**

Prey	F_{occc} 2004-09	F_{occ} 2015-17	F_{occ} 2018	F_{occ} 2004-18	MC 2004-09	MC 2015-17	MC 2018	MC 2004-18	CTFI 2004-09	CTFI 2015-17	CTFI 2018	CTFI 2004-18
Euphausiid (*Thysanoessa inermis*)	<1	-	-	<1	0.02	-	-	0.01	0.18	-	-	0.11
Arctic krill (*Thysanoessa raschii*)	<1	-	<1	<1	<0.01	-	0.02	<0.01	0.05	-	0.19	0.06
Zooplankton, total	**10**	**11.5**	**18.2**	**11**	**3.48**	**2.37**	**1.91**	**3.06**	**11.87**	**23.55**	**18.78**	**15.22**
Flatworm (*Platyhelminthes*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Mollusc (*Mollusca*)	-	-	<1	<1	-	-	0.06	<0.01	-	-	0.56	0.1
Gastropod (*Gastropoda*)	<1	-	-	<1	0.06	-	-	0.04	0.01	-	-	<0.01
Bivalve (*Bivalvia*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Cephalopod (*Cephalopoda*)	<1	-	-	<1	0.17	-	-	0.11	0.06	-	-	0.04
Bobtail (*Rossia sp.*)	-	-	<1	<1	-	-	0.62	0.09	-	-	0.5	0.08
Lesser bobtail squid (*Semirossia tenera*)	<1	-	-	<1	0.17	-	-	0.12	0.08	-	-	0.05
Squid (*Teuthida*)	<1	-	-	<1	0.27	-	-	0.19	0.09	-	-	0.06
Northern shortfin squid (*Illex illecebrosus*)	<1	-	<1	<1	1.2	-	1.33	1.01	0.44	-	0.44	0.35
Polychaete (*Polychaeta*)	<1	<1	-	<1	0.04	<0.01	-	0.03	<0.01	0.05	-	0.01
Crustacean (*Crustacea*)	**13.6**	**2.7**	**2.1**	**10.5**	**3.31**	**0.45**	**0.19**	**2.37**	**8.59**	**2.46**	**1.37**	**6.22**
Cumacean (*Cumacea*)	-	<1	-	<1	-	<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	-	-	0.03	0.03	-	-	0.02
Amphipod (*Amphipoda*)	<1	-	-	<1	0.09	-	-	0.06	0.65	-	-	0.42
Crustacean decapod (*Decapoda*)	-	<1	-	<1	-	<0.01	-	<0.01	-	<0.01	-	<0.01
Crab (*Brachyura*)	-	<1	<1	<1	-	0.02	<0.01	<0.01	-	0.3	0.01	0.06
Snow crab (*Chionoecetes opilio*)	<1	<1	-	<1	<0.01	0.12	-	0.02	<0.01	0.59	-	0.11
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	-	0.34	-	0.06	-	0.08	-	0.01
Brittle star (*Ophiuroidea*)	<1	-	-	<1	<0.01	-	-	<0.01	<0.01	-	-	<0.01
Other invertebrates, total	**14.5**	**3.2**	**2.9**	**11.3**	**5.38**	**0.94**	**2.21**	**4.15**	**9.97**	**3.48**	**2.88**	**7.56**

Prey	F_{occ}				MC				CTFI			
	2004-09	2015-17	2018	2004-18	2004-09	2015-17	2018	2004-18	2004-09	2015-17	2018	2004-18
Invertebrates, total	**36.7**	**23.7**	**28.6**	**33.5**	**40.31**	**18.93**	**11.36**	**32.44**	**47.5**	**46.45**	**27.27**	**43.88**
Unidentified digested material	10.2	4.3	1.8	8.4	3.46	1.81	0.19	2.7	4.46	3.99	0.94	3.77
Unidentified egg	<1	<1	-	<1	<0.01	<0.01	-	<0.01	0.01	<0.01	-	<0.01
Unidentified prey, total	**10.3**	**4.5**	**1.8**	**8.5**	**3.47**	**1.81**	**0.19**	**2.71**	**4.47**	**3.99**	**0.94**	**3.78**
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 (2004-2018). 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			
	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40
Winter skate (*Leucoraja ocellata*)	-	<1	-	-	-	0.35	-	-	-	0.29	-	-
Atlantic hagfish (*Myxine glutinosa*)	-	-	-	<1	-	-	-	0.66	-	-	-	0.52
Bony fish (*Actinopterygii*)	-	<1	<1	<1	-	<0.01	0.17	0.02	-	<0.01	0.17	0.03
Atlantic herring (*Clupea harengus*)	-	-	<1	<1	-	-	1.27	10.25	-	-	0.87	7.08
Capelin (*Mallotus villosus*)	3.1	3.8	3.2	2.9	21.86	27.65	27.37	12.49	18.66	29.63	28.64	14.59
White barracudina (*Arctozenus risso*)	-	-	<1	<1	-	-	0.7	1.4	-	-	0.93	1.44
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	-	-	0.06	-	-	-	0.09	-	-
Codfish (*Gadidae*)	-	-	<1	<1	-	-	<0.01	0.1	-	-	<0.01	0.1
Atlantic cod (*Gadus morhua*)	-	-	-	<1	-	-	-	0.22	-	-	-	0.26
Silver rockling (*Gaidropsarus argentatus*)	-	<1	-	<1	-	0.03	-	0.03	-	0.02	-	0.04
Fourbeard rockling (*Enchelyopus cimbrius*)	-	<1	<1	1.3	-	2.64	1.18	3.95	-	1.75	1.13	4.47
Marlin-spike (*Nezumia bairdii*)	-	-	<1	<1	-	-	1.25	2.06	-	-	0.97	2.38
Sand lance (*Ammodytidae*)	<1	-	-	-	0.56	-	-	-	0.55	-	-	-
Sand lance (*Ammodytes sp.*)	1.3	<1	<1	<1	3.06	0.96	0.18	<0.01	3.38	1.16	0.18	<0.01
Snakeblenny (*Lumpenus lampretaeformis*)	-	-	-	<1	-	-	-	0.08	-	-	-	0.13
Eelpout (*Zoarcidae*)	-	-	<1	<1	-	-	0.41	0.03	-	-	0.33	0.04
Eelpout (*Lycodes sp.*)	-	-	<1	-	-	-	0.14	-	-	-	0.14	-
Atlantic soft pout (*Melanostigma atlanticum*)	<1	2.7	3.8	3	1.22	2.54	2.14	0.63	0.83	2.79	2.28	0.91
Redfish (*Sebastes spp.*)	-	<1	<1	6	-	0.65	2.61	22.42	-	0.63	2.48	17.19
Sculpin (*Cottidae*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Atlantic hookear sculpin (*Artediellus atlanticus*)	-	-	-	<1	-	-	-	0.03	-	-	-	0.03
Sea tadpole (*Careproctus reinhardti*)	-	-	-	<1	-	-	-	<0.01	-	-	-	0.01
Skate (*Rajidae*)	-	-	-	<1	-	-	-	0.04	-	-	-	0.08

Prey	Focc				MC				CTFI			
	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40	<20	[20-30[	[30-40[	>40
Flatfish (*Pleuronectiformes*)	-	-	<1	<1	-	-	0.14	0.62	-	-	0.13	0.53
Righteye flounder (*Pleuronectidae*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Witch flounder (*Glyptocephalus cynoglossus*)	-	-	-	<1	-	-	-	0.26	-	-	-	0.3
Greenland halibut (*Reinhardtius hippoglossoides*)	<1	-	-	<1	0.15	-	-	0.46	0.16	-	-	0.65
Thorny skate (*Amblyraja radiata*)	-	-	-	<1	-	-	-	0.09	-	-	-	0.08
Digested roundfish	3	3	2.9	3.9	7.81	15.8	6.4	6.98	7.54	13.9	6.71	6.49
Fish (spawn) egg	<1	<1	<1	<1	0.83	0.02	0.58	0.04	0.78	0.02	0.51	0.05
Digested fish	4.1	7.7	7.3	7.2	5.44	10.37	7.03	7.23	4.97	9.2	7.05	7.61
Fishes, total	**12.3**	**16.6**	**17.8**	**23.4**	**40.92**	**61.06**	**51.58**	**70.11**	**36.86**	**59.49**	**52.51**	**65.01**
Digested shrimp	3	5.9	8.8	11.9	3.55	6.78	12.21	7.99	3.13	6.29	11.27	9.75
Scarlet sergestid (*Sergia robusta*)	-	-	<1	-	-	-	0.09	-	-	-	0.1	-
Glass shrimp (*Pasiphaeidae*)	-	<1	<1	<1	-	0.51	0.45	0.23	-	0.4	0.49	0.28
Pink glass shrimp (*Pasiphaea multidentata*)	1.2	3.1	3.5	3.5	2.75	6.56	4.9	2.24	2.18	7.16	5.12	2.53
Eualid (*Eualus sp.*)	<1	-	-	-	0.06	-	-	-	0.05	-	-	-
Circumpolar eualid (*Eualus gaimardii*)	<1	-	-	-	0.07	-	-	-	0.05	-	-	-
Friendly blade shrimp (*Spirontocaris liljeborgii*)	-	<1	-	-	-	0.02	-	-	-	0.02	-	-
Lebbeids (*Lebbeus sp.*)	<1	-	-	-	0.03	-	-	-	0.03	-	-	-
Polar lebbeid (*Lebbeus polaris*)	-	-	-	<1	-	-	-	0.02	-	-	-	0.03
Boreal red shrimps (*Pandalus sp.*)	-	<1	<1	<1	-	1.31	0.61	0.39	-	1.26	0.71	0.41
Northern shrimp (*Pandalus borealis*)	<1	2.2	5.1	9.9	0.41	7.84	17.01	12.06	0.53	7.65	15.89	14.46
Striped pink shrimp (*Pandalus montagui*)	-	<1	<1	<1	-	0.27	0.28	0.34	-	0.33	0.34	0.53
Crangon shrimp (*Crangonidae*)	-	-	-	<1	-	-	-	0.02	-	-	-	0.02
Sars shrimp (*Sabinea sarsii*)	-	-	-	<1	-	-	-	<0.01	-	-	-	0.01
Norwegian shrimp (*Pontophilus norvegicus*)	-	-	<1	<1	-	-	0.06	0.02	-	-	0.05	0.02
Shrimps, total	**4.6**	**11.9**	**17.1**	**23.5**	**6.88**	**23.3**	**35.6**	**23.32**	**5.97**	**23.12**	**33.97**	**28.04**
Calanoid copepod (*Temora longicornis*)	<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
Calanoid copepod (*Paraeuchaeta norvegica*)	<1	<1	-	-	<0.01	<0.01	-	-	<0.01	<0.01	-	-
Calanoid copepod (*Metridia lucens*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Hyperiid (*Hyperiidae*)	1.8	1.9	1.6	<1	0.7	1.75	1.48	0.11	0.72	1.78	1.64	0.13
Hyperiids (*Themisto sp.*)	8.8	2	<1	<1	4.91	1.14	0.76	0.09	5.67	1.52	0.83	0.11
Hyperiid (*Themisto abyssorum*)	<1	-	-	-	0.02	-	-	-	0.02	-	-	-
Hyperiid (*Themisto compressa*)	1.7	<1	-	-	0.74	<0.01	-	-	1.16	<0.01	-	-
Hyperiid (*Themisto libellula*)	5.1	2.4	1.5	<1	5.06	2.94	2.37	0.05	5.42	3.02	2.55	0.07
Hyperiid (*Scina borealis*)	-	<1	-	-	-	<0.01	-	-	-	<0.01	-	-
Gammarid (*Gammaridea*)	<1	<1	-	<1	0.08	0.04	-	<0.01	0.15	0.02	-	<0.01
Gammarid (*Byblis gaimardi*)	<1	-	-	-	0.12	-	-	-	0.1	-	-	-
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	1.7	1.9	<1	0.32	0.22	0.23	0.03	0.38	0.25	0.21	0.05
Mysid (*Boreomysis sp.*)	<1	<1	1.1	<1	0.07	0.1	0.12	0.02	0.05	0.11	0.11	0.03
Mysid (*Boreomysis tridens*)	-	<1	<1	<1	-	0.02	0.06	0.02	-	0.02	0.06	0.03
Mysid (*Boreomysis arctica*)	1.1	1.2	2.8	1.3	0.39	0.18	0.32	0.05	0.43	0.18	0.29	0.07
Mysid (*Boreomysis nobilis*)	-	-	<1	<1	-	-	0.01	<0.01	-	-	<0.01	<0.01
Mysid (*Mysis mixta*)	<1	<1	-	-	0.03	<0.01	-	-	0.08	<0.01	-	-
Euphausiid (*Euphausiacea*)	<1	-	-	-	0.15	-	-	-	0.21	-	-	-
Euphausiid (*Euphausiidae*)	10.6	<1	<1	<1	11.91	0.65	0.12	0.03	14.07	0.85	0.12	0.04
Northern krill (*Meganyctiphanes norvegica*)	4.5	1.1	<1	<1	3.34	0.36	0.12	0.04	4.35	0.43	0.15	0.06
Euphausiid (*Thysanoessa sp.*)	2	<1	-	-	4.01	0.63	-	-	3.5	1.29	-	-
Euphausiid (*Thysanoessa inermis*)	<1	-	<1	-	0.38	-	0.01	-	0.36	-	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
Arctic krill (*Thysanoessa raschii*)	<1	-	-	-	0.22	-	-	-	0.2	-	-	-
Zooplankton, total	**30.4**	**9.5**	**8.9**	**4.4**	**32.46**	**8.05**	**5.61**	**0.45**	**36.86**	**9.5**	**5.99**	**0.61**
Flatworm (*Platyhelminthes*)	-	<1	-	-	-	<0.01	-	-	-	<0.01	-	-
Mollusc (*Mollusca*)	<1	-	-	-	0.3	-	-	-	0.3	-	-	-
Gastropod (*Gastropoda*)	-	-	-	<1	-	-	-	0.06	-	-	-	0.03
Bivalve (*Bivalvia*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Cephalopod (*Cephalopoda*)	-	-	-	<1	-	-	-	0.17	-	-	-	0.17
Bobtail (*Rossia sp.*)	-	-	<1	-	-	-	0.46	-	-	-	0.42	-
Lesser bobtail squid (*Semirossia tenera*)	-	-	-	<1	-	-	-	0.17	-	-	-	0.21
Squid (*Teuthida*)	-	-	-	<1	-	-	-	0.27	-	-	-	0.23
Northern shortfin squid (*Illex illecebrosus*)	-	-	-	<1	-	-	-	1.48	-	-	-	1.46
Polychaete (*Polychaeta*)	<1	-	<1	<1	0.03	-	<0.01	0.04	0.03	-	<0.01	0.02
Crustacean (*Crustacea*)	19.3	9.1	10.1	7.6	12.54	3.34	4.03	1.34	13.17	3.54	4.2	1.6
Cumacean (*Cumacea*)	<1	-	-	-	<0.01	-	-	-	<0.01	-	-	-
Isopod (*Isopoda*)	-	-	<1	<1	-	-	<0.01	0.02	-	-	<0.01	0.02
Isopod (*Syscenus infelix*)	-	-	<1	<1	-	-	0.1	0.01	-	-	0.08	0.02
Amphipod (*Amphipoda*)	1.5	<1	<1	<1	1.1	0.22	0.03	<0.01	1.17	0.18	0.04	<0.01
Crustacean decapod (*Decapoda*)	-	-	-	<1	-	-	-	<0.01	-	-	-	<0.01
Crab (*Brachyura*)	<1	-	-	-	0.15	-	-	-	0.19	-	-	-
Snow crab (*Chionoecetes opilio*)	<1	-	<1	<1	0.39	-	0.05	<0.01	0.33	-	0.03	<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	-	-	-	0.09	-	-	-	0.06
Brittle star (*Ophiuroidea*)	-	-	<1	-	-	-	<0.01	-	-	-	<0.01	-
Other invertebrates, total	**21.3**	**9.4**	**10.7**	**8.3**	**14.52**	**3.57**	**4.68**	**3.65**	**15.19**	**3.72**	**4.79**	**3.83**
Invertebrates, total	**50**	**26.9**	**31.6**	**31.6**	**53.86**	**34.91**	**45.89**	**27.42**	**58.01**	**36.34**	**44.75**	**32.48**

Prey	F_{occ}				MC				CTFI			
	<20	[20-30[	[30-40]	>40	<20	[20-30[	[30-40]	>40	<20	[20-30[	[30-40]	>40
Unidentified digested material	8.9	8.8	8.5	7.7	5.22	4.01	2.52	2.47	5.12	4.15	2.73	2.5
Unidentified egg	<1	<1	<1	<1	<0.01	0.02	0.01	<0.01	<0.01	0.02	<0.01	<0.01
Unidentified prey, total	**8.9**	**9**	**8.6**	**7.7**	**5.22**	**4.03**	**2.53**	**2.48**	**5.13**	**4.17**	**2.74**	**2.51**
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	-	0.5	-	0.15
Skate (*Rajidae*)	-	<1	-	0.03	-	0.02
Thorny skate (*Amblyraja radiata*)	-	<1	-	0.07	-	0.02
Winter skate (*Leucoraja ocellata*)	<1	-	0.35	-	0.45	-
Bony fish (*Actinopterygii*)	<1	<1	0.36	0.02	0.21	<0.01
Atlantic herring (*Clupea harengus*)	-	<1	-	8	-	2.25
Capelin (*Mallotus villosus*)	1.7	3.5	25.04	16.23	20.07	22.78
White barracudina (*Arctozenus risso*)	<1	<1	1.33	1.07	0.3	0.58
Threespine stickleback (*Gasterosteus aculeatus*)	-	<1	-	<0.01	-	0.03
Codfish (*Gadidae*)	<1	<1	<0.01	0.07	<0.01	0.03
Atlantic cod (*Gadus morhua*)	-	<1	-	0.17	-	0.08
Silver rockling (*Gaidropsarus argentatus*)	<1	<1	0.21	<0.01	0.06	<0.01
Fourbeard rockling (*Enchelyopus cimbrius*)	<1	<1	1.34	3.36	0.45	1.98
Marlin-spike (*Nezumia bairdii*)	<1	<1	1.34	1.69	0.45	0.83
Sand lance (*Ammodytidae*)	<1	<1	0.11	<0.01	0.61	0.09
Sand lance (*Ammodytes sp*.)	<1	<1	0.39	0.2	0.22	1.6
Snakeblenny (*Lumpenus lampretaeformis*)	<1	-	0.64	-	0.2	-
Eelpout (Zoarcidae (*Zoarcidae*)	<1	<1	0.88	0.02	0.41	0.01
Eelpout (*Lycodes sp.*)	<1	<1	0.02	0.03	0.01	0.03
Atlantic soft pout (*Melanostigma atlanticum*)	7.1	2.1	4.71	0.76	4.34	1.1
Redfish (*Sebastes spp.*)	1.1	2.5	7.72	16.76	2.69	5.22
Sculpin (*Cottidae*)	-	<1	-	<0.01	-	<0.01
Atlantic hookear sculpin (*Artediellus atlanticus*)	-	<1	-	0.03	-	<0.01
Sea tadpole (*Careproctus reinhardti*)	<1	-	0.06	-	0.02	-
Flatfish (*Pleuronectiformes*)	-	<1	-	0.5	-	0.18
Righteye flounder (*Pleuronectidae*)	-	<1	-	<0.01	-	<0.01
Witch flounder (*Glyptocephalus cynoglossus*)	-	<1	-	0.2	-	0.09
Greenland halibut (*Reinhardtius hippoglossoides*)	-	<1	-	0.35	-	0.25
Digested roundfish	1.3	3.6	3.7	8.09	2	9.94
Fish (spawn) egg	<1	<1	0.09	0.17	0.04	0.43
Digested fish	10.9	6.1	4.49	7.71	4.73	7.5
Fishes, total	**21.2**	**18**	**52.79**	**66.04**	**37.27**	**55.2**
Digested shrimp	4.4	9	6.17	8.81	4.54	7.62
Scarlet sergestid (*Sergia robusta*)	-	<1	-	0.02	-	0.02
Glass shrimp (*Pasiphaeidae*)	<1	<1	0.05	0.32	0.02	0.31
Pink glass shrimp (*Pasiphaea multidentata*)	<1	3.5	1.35	3.35	1.36	4.59

Prey	F_{occ}		MC		CTFI	
	Estuary	NGSL	Estuary	NGSL	Estuary	NGSL
Eualid (*Eualus sp.*)	-	<1	-	<0.01	-	0.02
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	0.2	0.54	0.26	0.6
Northern shrimp (*Pandalus borealis*)	2.4	5.8	11.35	12.4	5.01	9.41
Striped pink shrimp (*Pandalus montagui*)	<1	<1	1.78	0.17	1.03	0.13
Crangon shrimp (*Crangonidae*)	-	<1	-	0.01	-	<0.01
Sars shrimp (*Sabinea sarsii*)	-	<1	-	<0.01	-	<0.01
Norwegian shrimp (*Pontophilus norvegicus*)	-	<1	-	0.03	-	0.02
Shrimps, total	**7.9**	**17.6**	**20.88**	**25.65**	**12.23**	**22.78**
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
Hyperiid (*Hyperiidae*)	4.3	<1	4.17	0.19	3.76	0.5
Hyperiids (*Themisto sp.*)	<1	2.4	0.82	0.42	0.64	2.66
Hyperiid (*Themisto abyssorum*)	<1	<1	<0.01	<0.01	0.02	<0.01
Hyperiid (*Themisto compressa*)	-	<1	-	0.02	-	0.43
Hyperiid (*Themisto libellula*)	4.5	1.4	5.96	0.41	7.07	2.18
Hyperiid (*Scina borealis*)	<1	-	<0.01	-	<0.01	-
Gammarid (*Gammaridea*)	<1	<1	0.03	<0.01	0.29	<0.01
Gammarid (*Byblis gaimardi*)	-	<1	-	<0.01	-	0.04
Gammarid (*Maera loveni*)	-	<1	-	<0.01	-	<0.01
Gammarid (*Tmetonyx cicada*)	<1	-	0.02	-	<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*)	3.5	<1	0.35	0.07	0.84	0.12
Mysid (*Boreomysis sp.*)	<1	<1	0.03	0.05	0.01	0.08
Mysid (*Boreomysis tridens*)	<1	<1	0.02	0.03	<0.01	0.03
Mysid (*Boreomysis arctica*)	4.4	1.2	0.48	0.09	0.75	0.16
Mysid (*Boreomysis nobilis*)	-	<1	-	<0.01	-	<0.01
Mysid (*Mysis mixta*)	-	<1	-	<0.01	-	0.03
Euphausiid (*Euphausiacea*)	-	<1	-	<0.01	-	0.08
Euphausiid (*Euphausiidae*)	4.7	1.8	1.83	0.31	10.23	3.6
Northern krill (*Meganyctiphanes norvegica*)	2.3	1.1	0.69	0.13	4.03	1.04
Euphausiid (*Thysanoessa sp.*)	<1	<1	0.7	0.12	3.49	1.02
Euphausiid (*Thysanoessa inermis*)	<1	<1	0.02	0.01	0.02	0.13
Arctic krill (*Thysanoessa raschii*)	<1	<1	0.06	<0.01	0.35	<0.01

Prey	F_{occ}		MC		CTFI	
	Estuary	NGSL	Estuary	NGSL	Estuary	NGSL
Zooplankton, total	**20**	**9.3**	**15.19**	**1.87**	**31.51**	**12.14**
Flatworm (*Platyhelminthes*)	-	<1	-	<0.01	-	<0.01
Mollusc (*Mollusca*)	-	<1	-	<0.01	-	0.11
Gastropod (*Gastropoda*)	<1	-	0.48	-	0.05	-
Bivalve (*Bivalvia*)	<1	-	<0.01	-	<0.01	-
Cephalopod (*Cephalopoda*)	-	<1	-	0.13	-	0.05
Bobtail (*Rossia sp.)*	-	<1	-	0.1	-	0.1
Lesser bobtail squid (*Semirossia tenera*)	-	<1	-	0.13	-	0.06
Squid (*Teuthida*)	-	<1	-	0.21	-	0.07
Northern shortfin squid (*Illex illecebrosus*)	-	<1	-	1.11	-	0.42
Polychaete (*Polychaeta*)	<1	<1	0.29	<0.01	0.03	0.01
Crustacean (*Crustacea*)	16.5	9.4	5.19	2.09	13.08	4.92
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
Amphipod (*Amphipoda*)	<1	<1	0.01	0.06	<0.01	0.5
Crustacean decapod (*Decapoda*)	-	<1	-	<0.01	-	<0.01
Crab (*Brachyura*)	-	<1	-	<0.01	-	0.07
Snow crab (*Chionoecetes opilio*)	-	<1	-	0.03	-	0.13
Echinoderm (*Echinodermata*)	-	<1	-	<0.01	-	<0.01
Sea urchin (*Echinoidea*)	<1	-	<0.01	-	<0.01	-
Mud heart urchin (*Brisaster fragilis*)	<1	-	0.66	-	0.09	-
Brittle star (*Ophiuroidea*)	<1	-	0.01	-	<0.01	-
Other invertebrates, total	**17.2**	**10.2**	**6.65**	**3.91**	**13.27**	**6.47**
Invertebrates, total	**38.3**	**32.6**	**42.72**	**31.43**	**57.01**	**41.39**
Unidentified digested material	18	6.6	4.43	2.53	5.67	3.41
Unidentified egg	<1	<1	0.05	<0.01	0.05	<0.01
Unidentified prey, total	**18.5**	**6.7**	**4.49**	**2.53**	**5.72**	**3.41**
Total	**-**	**-**	**100**	**100**	**100**	**100**

Table 26. Summary of Greenland halibut and redfish stomach sampling effort for the period 2015-17 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	1,182	394	452	118	2,146	247	412	371	424	1,454
	Nb. of empty stomachs	390	177	183	32	782	89	288	258	243	878
	% empty stomachs	33	45	41	27	36	36	70	70	57	60
	TFI	0.14	0.09	0.12	0.27	0.14	0.33	0.13	0.08	0.10	0.14
Length (mm)	Min	66	200	300	401	66	64	200	300	401	64
	Median	155	249	352	415.5	190	165	255	350	470	316
	Mean	149	247	351	422	225	161	253	348	481	328
	Max	199	299	400	484	484	199	299	400	725	725
Total stomach content (g)	Min	0.001	0.001	0.002	0.066	0.001	0.006	0.003	0.001	0.008	0.001
	Median	0.09	0.20	1.31	4.60	0.17	0.45	1.26	2.12	8.21	1.45
	Mean	0.21	1.11	3.91	11.97	1.83	0.89	2.38	4.57	14.73	6.28
	Max	2.97	19.77	46.46	71.80	71.80	8.72	15.96	51.90	108.69	108.69
Nb. of taxa	Fish	2	5	9	7	10	5	6	9	12	15
	Shrimp	7	5	6	4	8	3	6	5	6	8
	Zooplancton	34	21	17	8	38	14	11	5	5	19
	Other invertabrates	12	3	6	2	14	5	1	2	3	7
	Non-identifiable prey	2	1	1	1	2	1	1	2	2	2

FIGURES

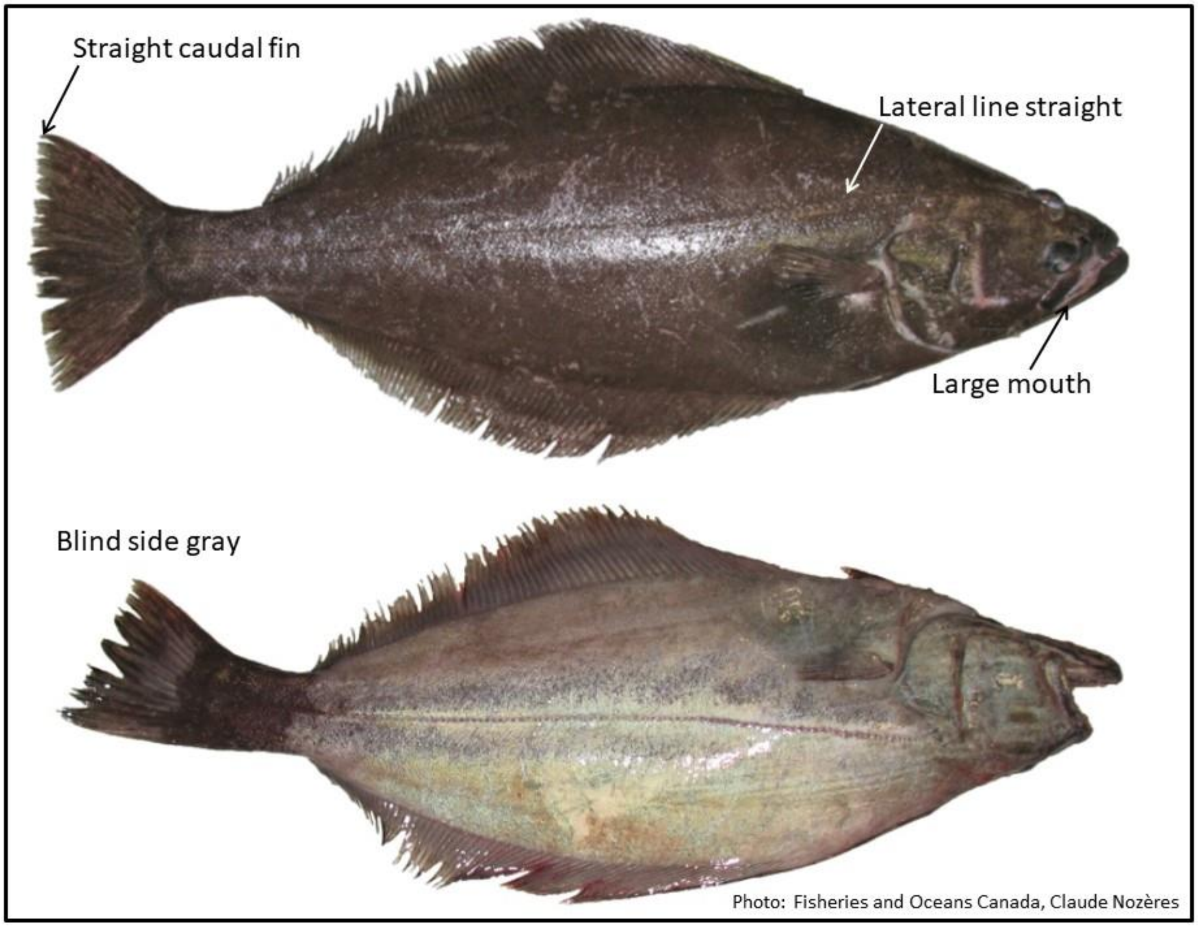
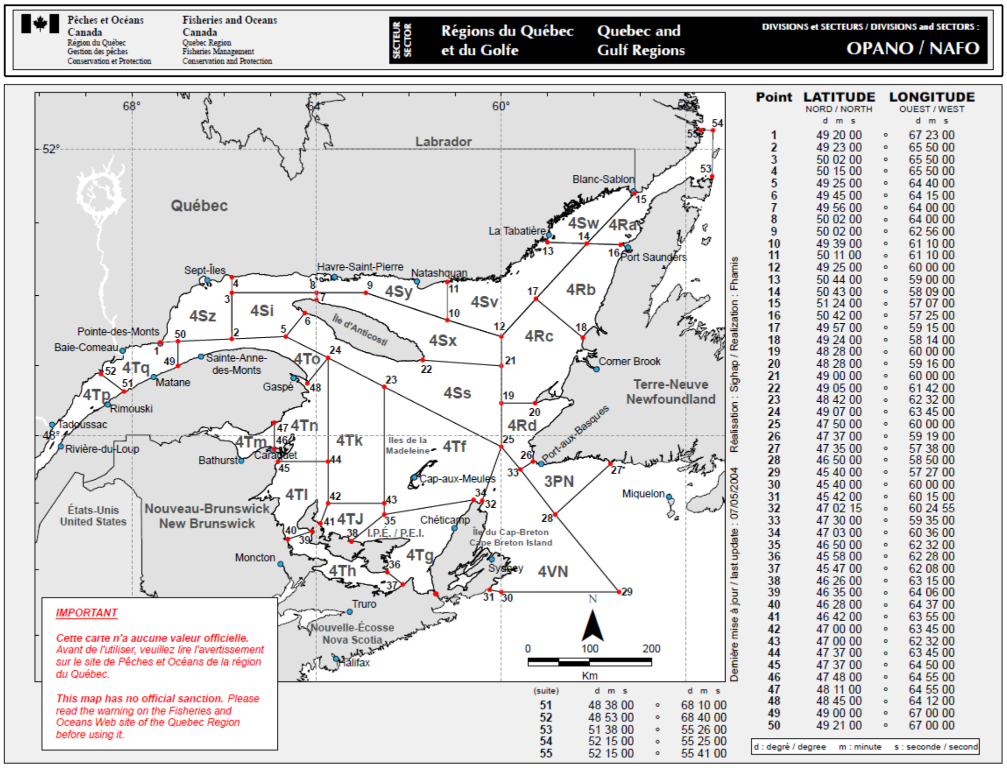


Figure 1. Greenland halibut.



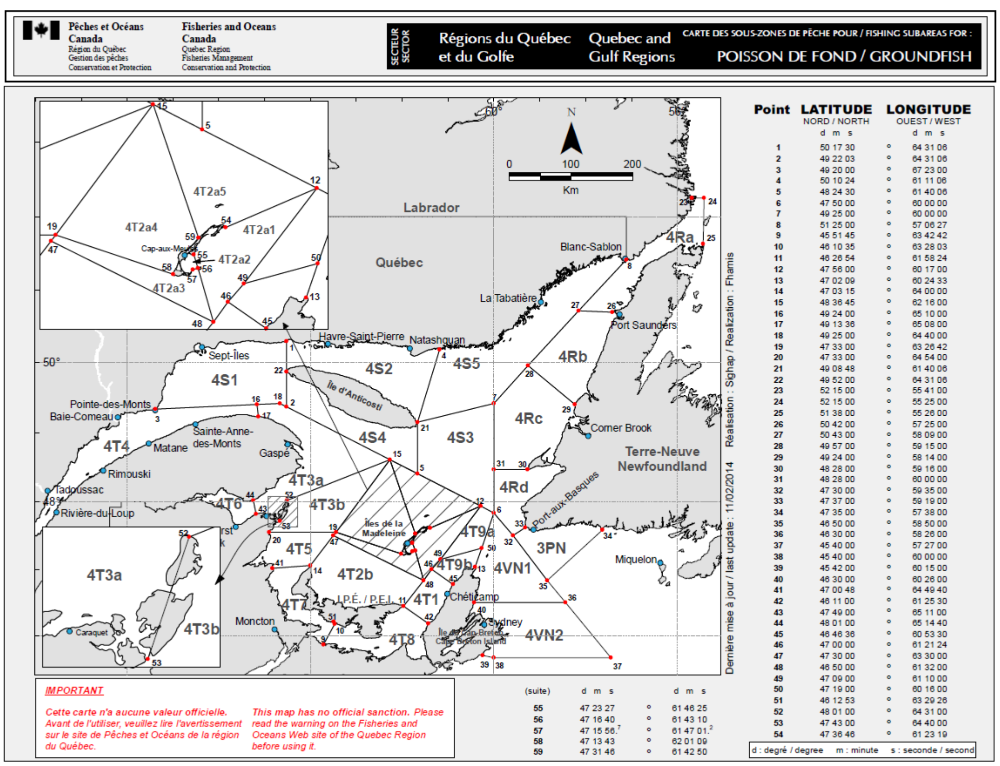


Figure 2. NAFO Unit Areas in the Gulf of St. Lawrence (top map). Map of Gulf of St. Lawrence Groundfish Sub-Areas (bottom map).

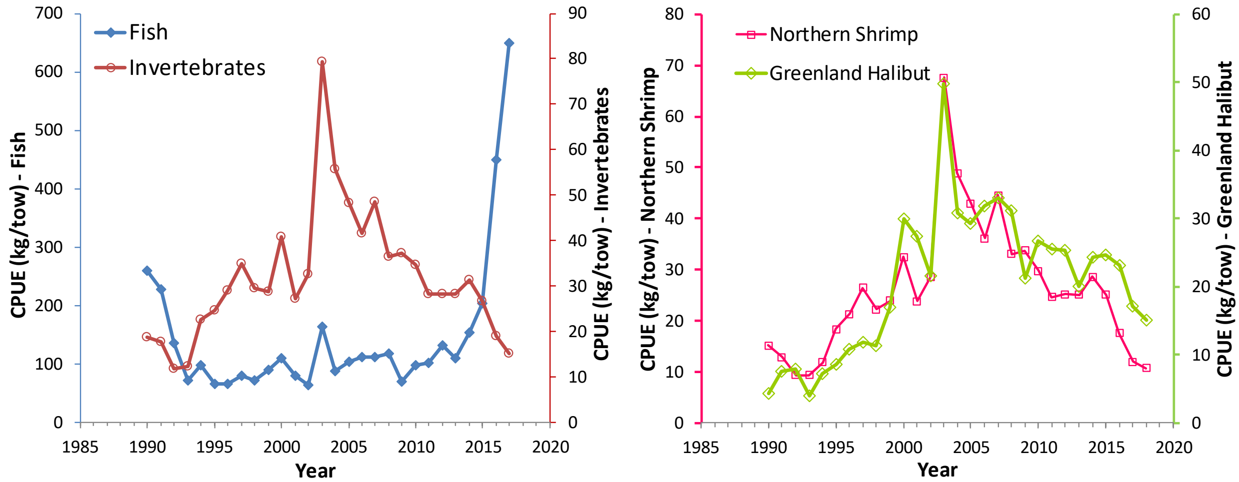


Figure 3. Biomass indices (kg/tow) estimated in the DFO nGSL survey for major groundfish and invertebrates (left) and biomass indices for Greenland halibut and northern shrimp (right).

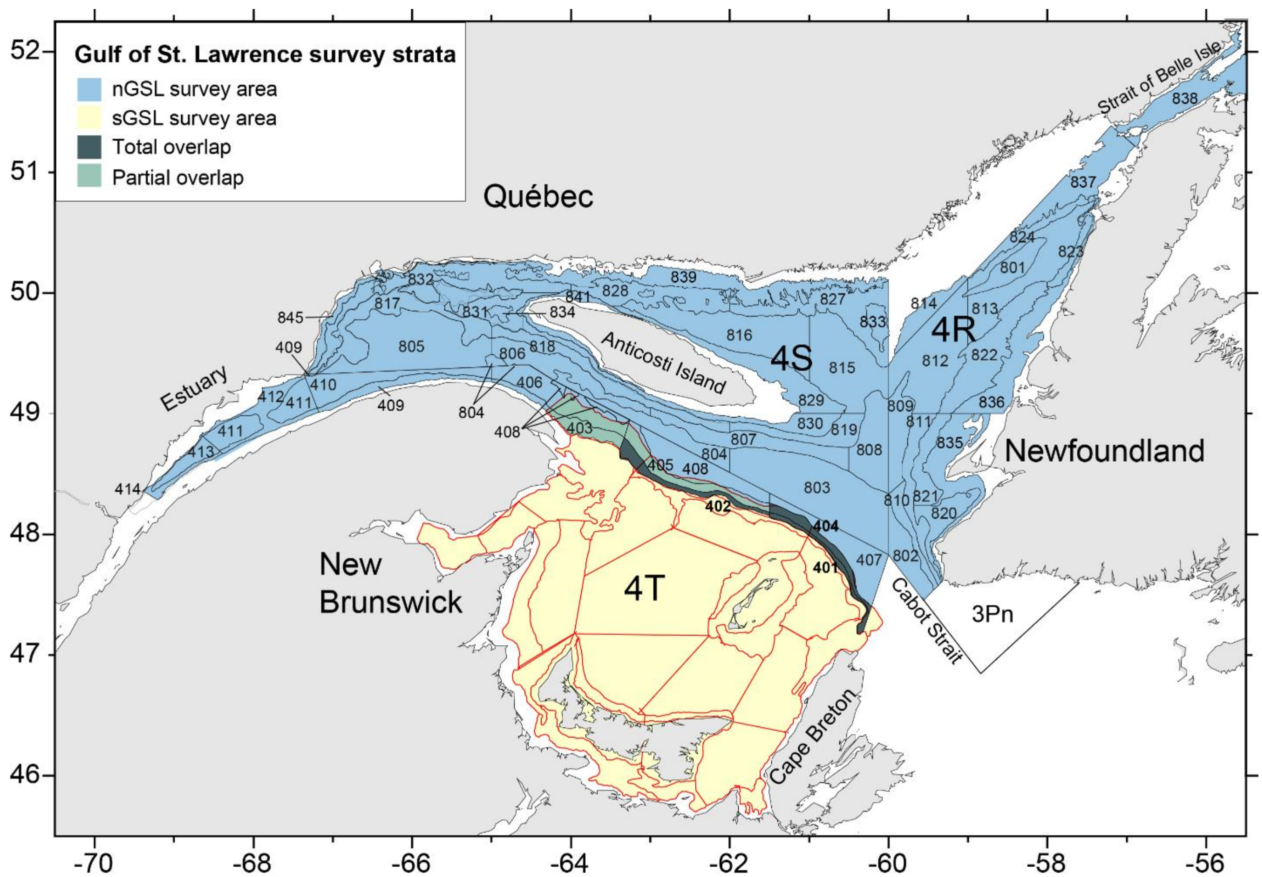


Figure 4. Map illustrating the stratification scheme of the groundfish and shrimp research survey in the Lower Estuary and Northern Gulf of St. Lawrence (nGSL) (blue) and the Southern Gulf of St. Lawrence survey (sGSL) (yellow, 4T). The areas of partial (light green) and total (dark green) overlap at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

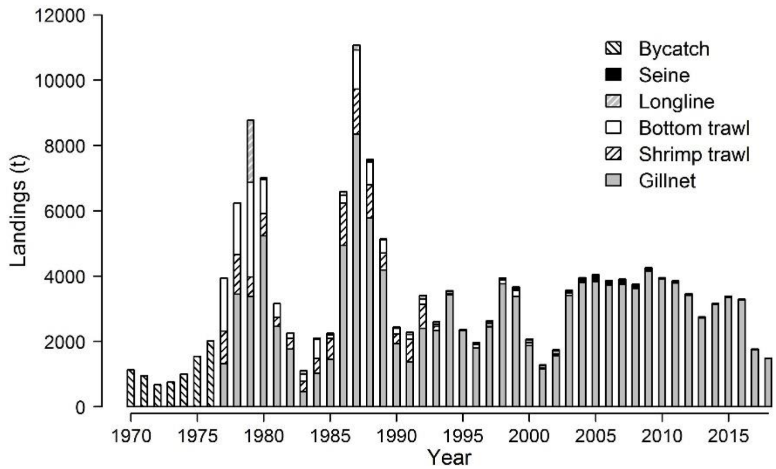


Figure 5. Greenland halibut landings (t) by gear and management year.

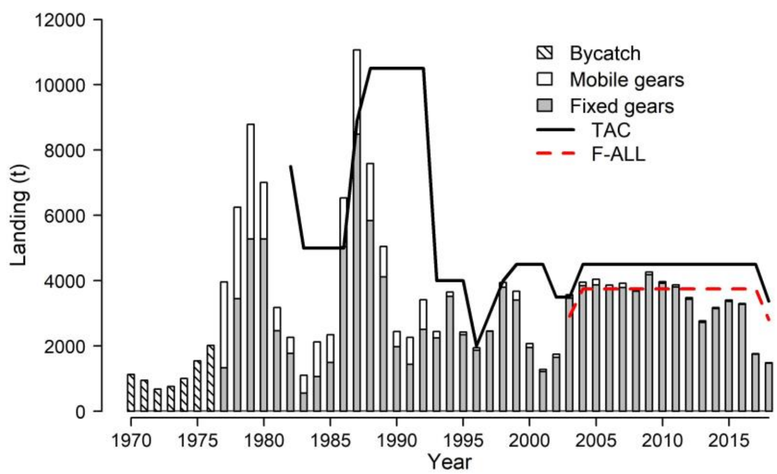


Figure 6. Greenland halibut landings (t) for fixed and mobile gears by management year. Total Allowable Catch (TAC) and Fishery Allocation (F-ALL) are indicated.

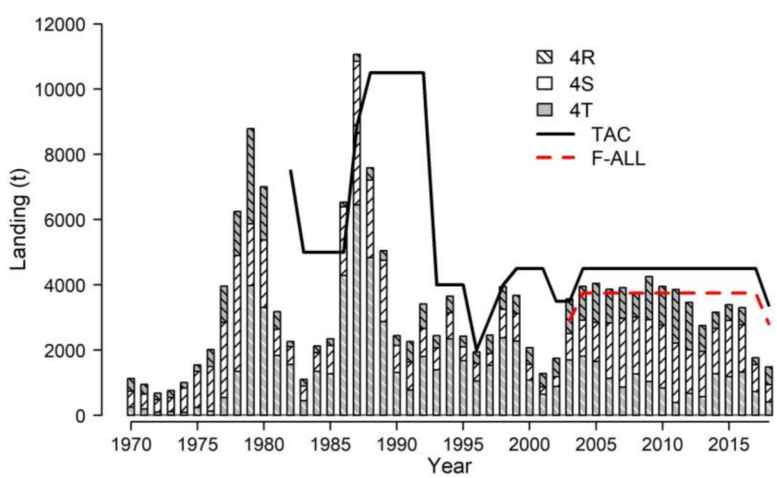


Figure 7. Greenland halibut landings (t) by NAFO Divisions and management year. Total Allowable Catch (TAC) and Fishery Allocation (F-ALL) are indicated.

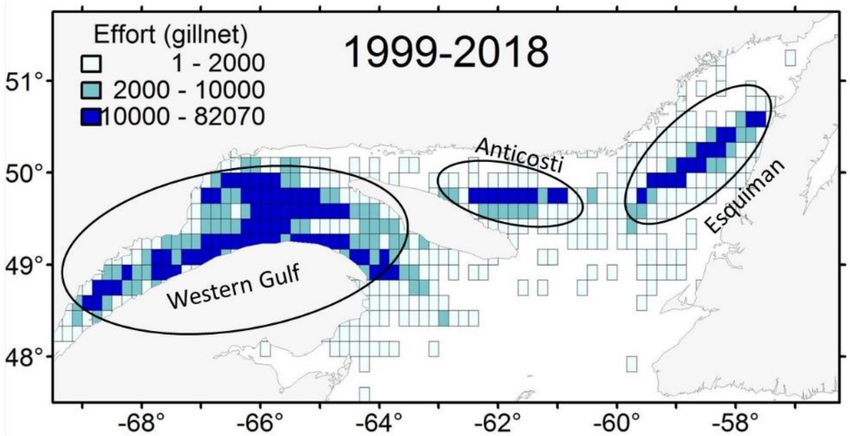


Figure 8. Fishing effort deployed in total number of nets per fishing statistical square from 1999 to 2018. Fishing effort concentrations define three sectors: Western Gulf, Anticosti and Esquiman.

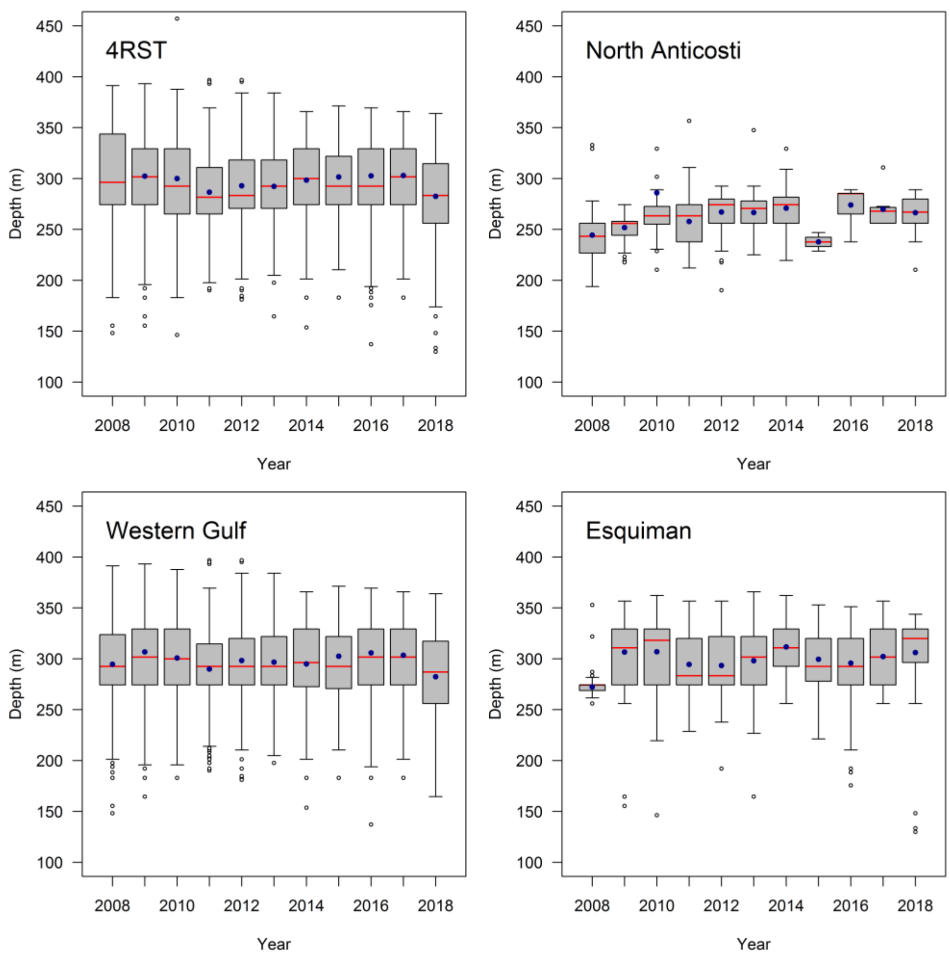


Figure 9 . Annual deployment depth of gillnet in the Gulf (4RST) directed Greenland halibut fishery and by fishing sector. Box and whiskers plot; box extends from percentile 25 to 75, line in the box represents the median, full circle represents the mean, whiskers extend from percentile 5 to 95 and open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

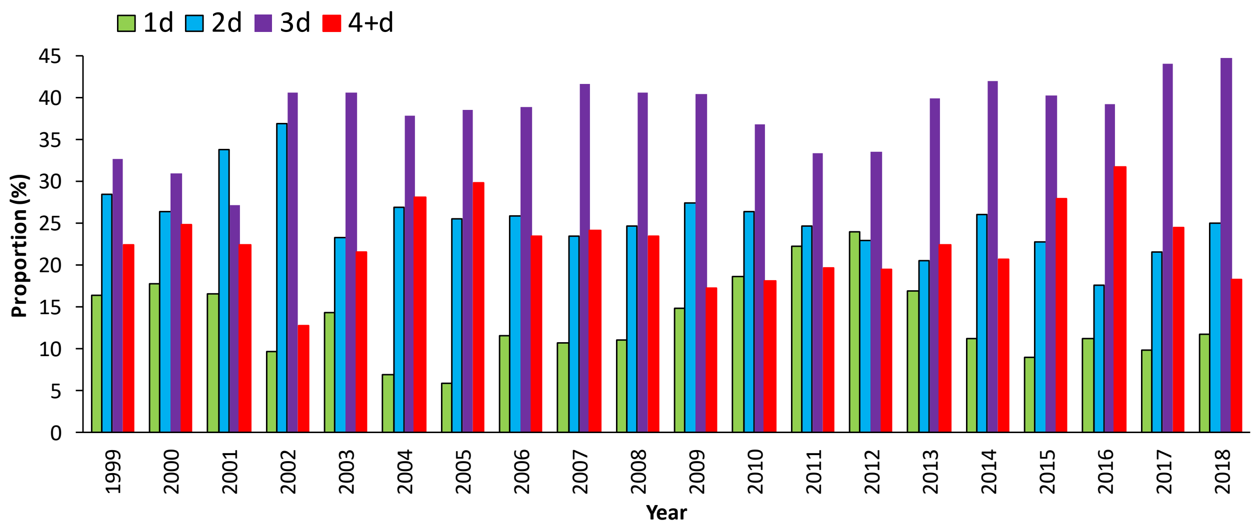


Figure 10. Annual proportion (%) of immersion times (1-4 days and over) of gillnets in the directed commercial Greenland halibut fishery from 1999 to 2018.

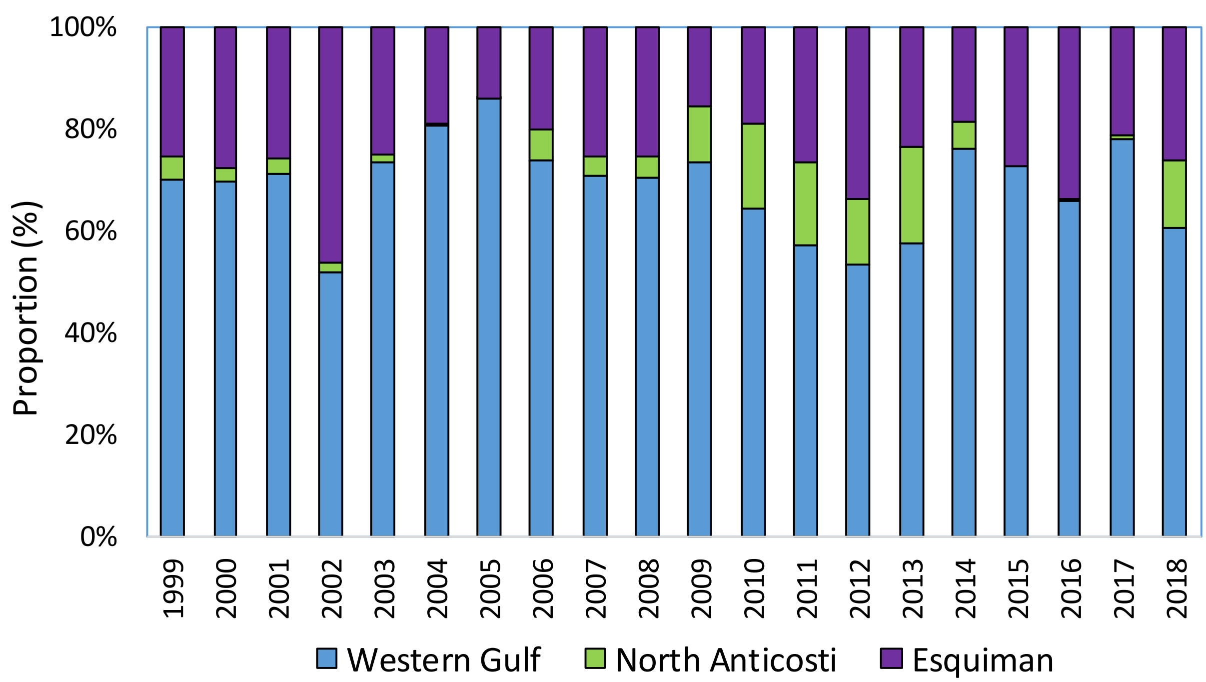


Figure 11. Proportion of fishing effort deployed by fishing sector in the directed Greenland halibut gillnet fishery from 1999 to 2018.

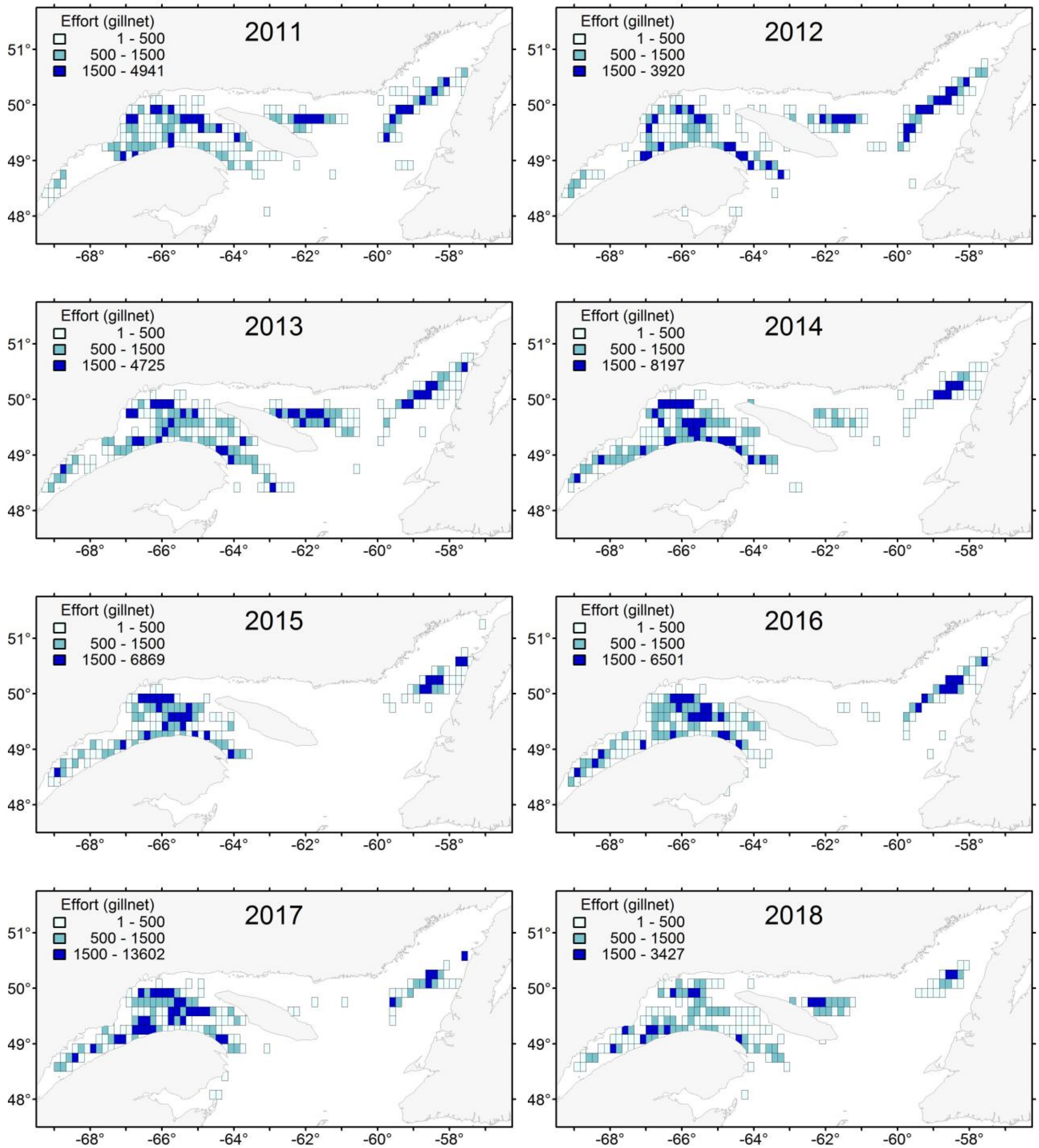


Figure 12a. Annual fishing effort (number of gillnets) by statistical square, 2011 to 2018. Information is from ZIFF files and 2018 data are preliminary.

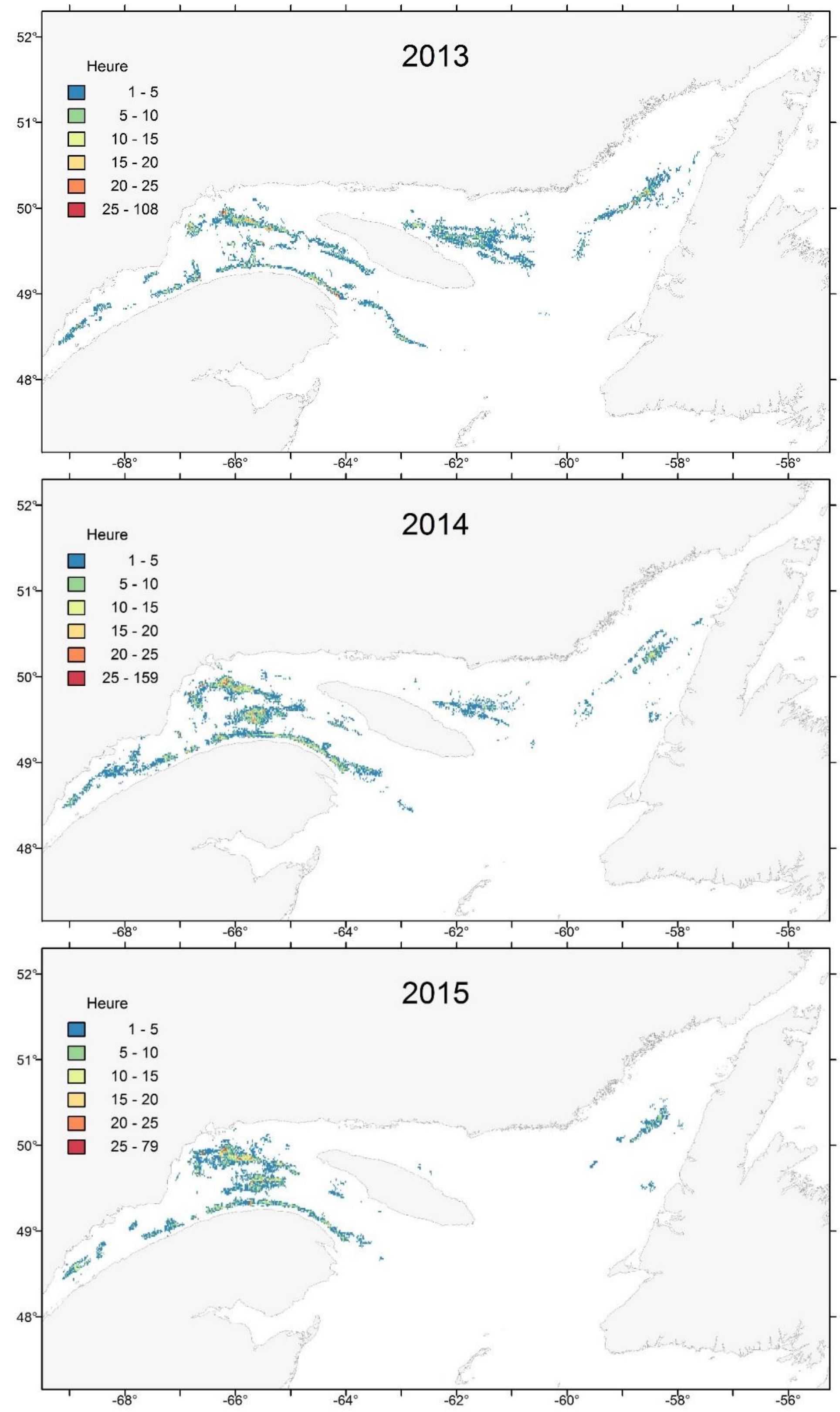


Figure 12b. Distribution of directed fishing effort for Greenland halibut in the Gulf of St. Lawrence from 2013 to 2018 according to Vessel Monitoring System (VMS) data, number of hours per 1 minute square.

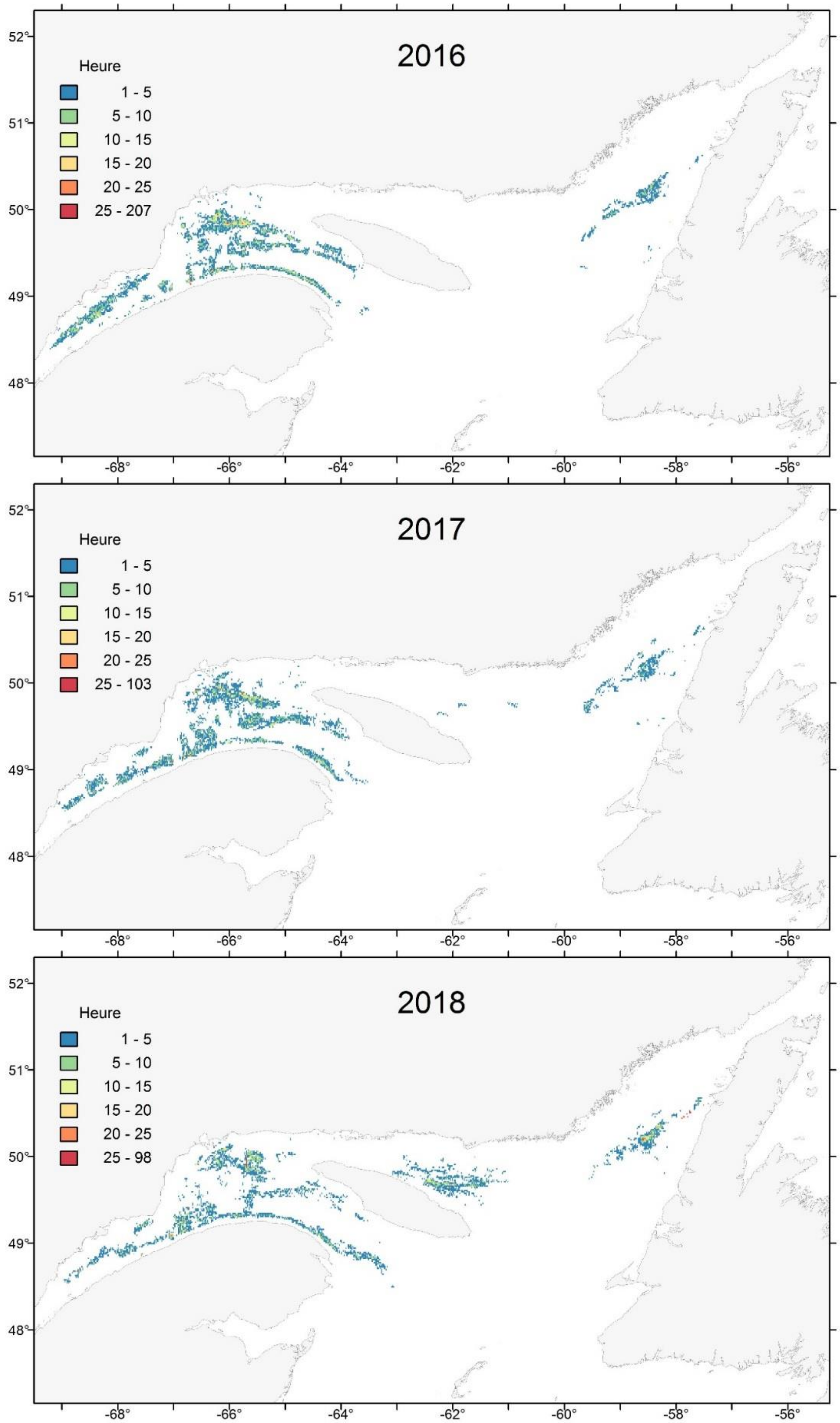


Figure 12b. (Continued).

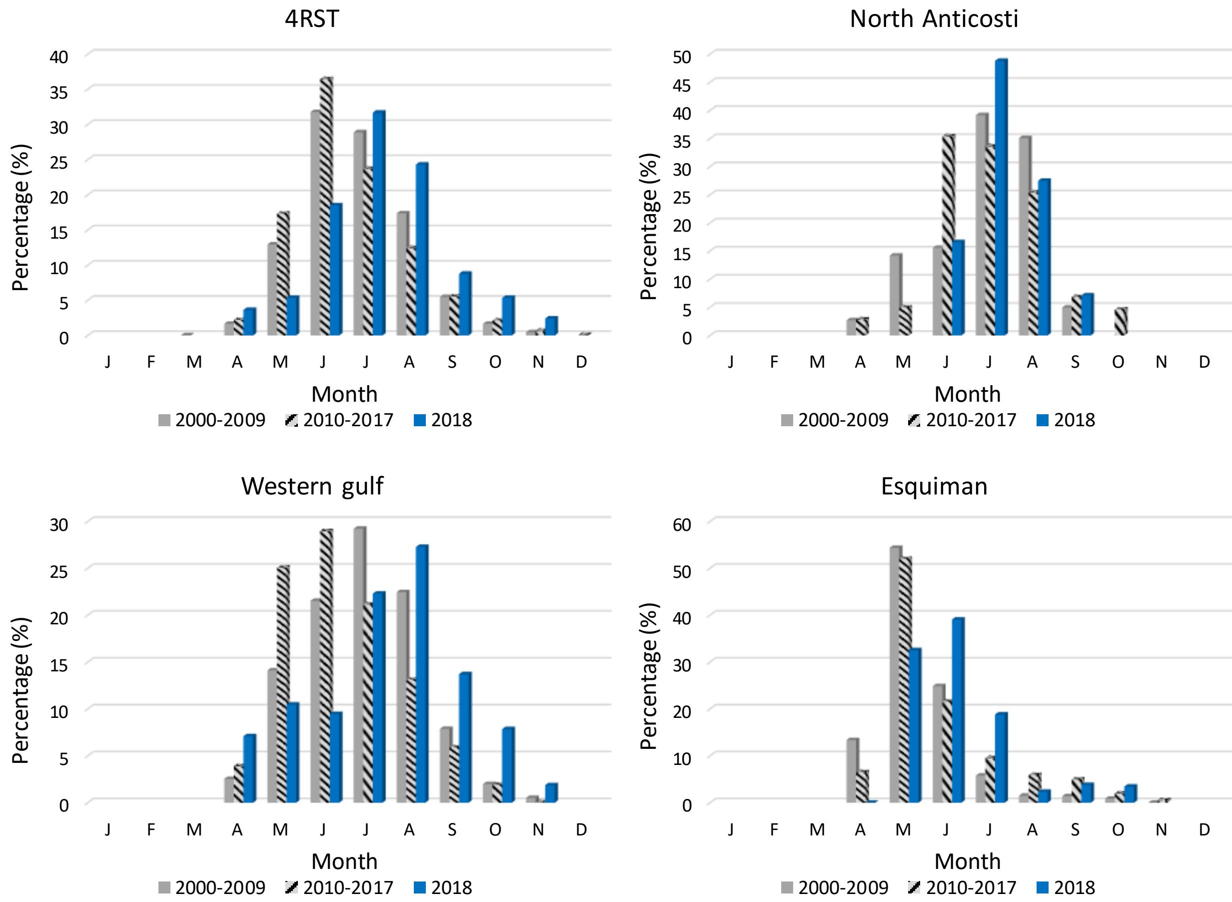


Figure 13. Proportion of monthly landings for the Gulf as a whole (4RST) and by fishing sector. Average for the periods 2000-2009, 2010-2017 and for the year 2018.

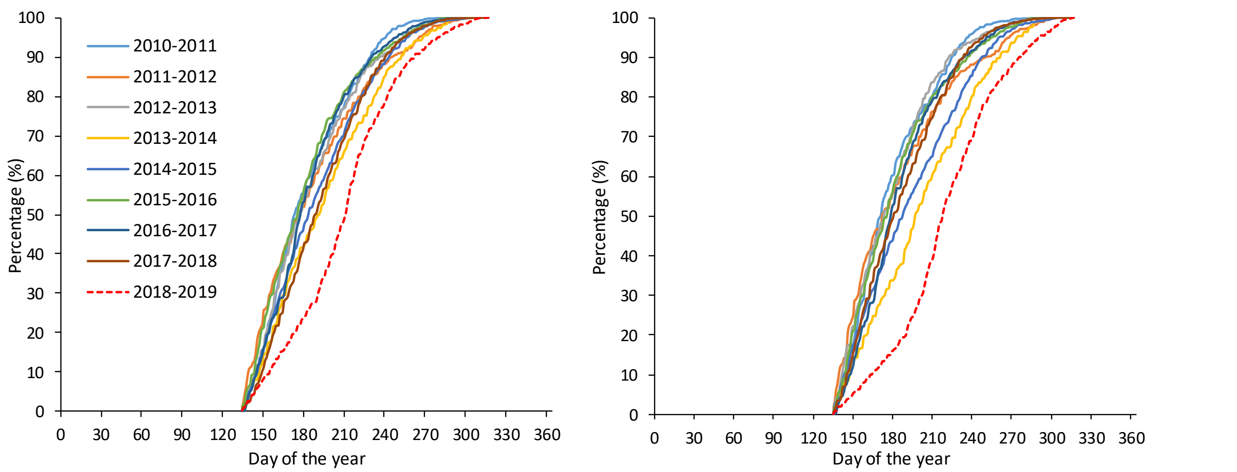


Figure 14. Cumulative fishing effort (%) (left) and cumulative landings (%) (right) based on the day of the year for the western Gulf sector for the 2010-2011 to 2018-2019 fishing seasons. The day 135 corresponds to May 15, which is the start date of the management year.

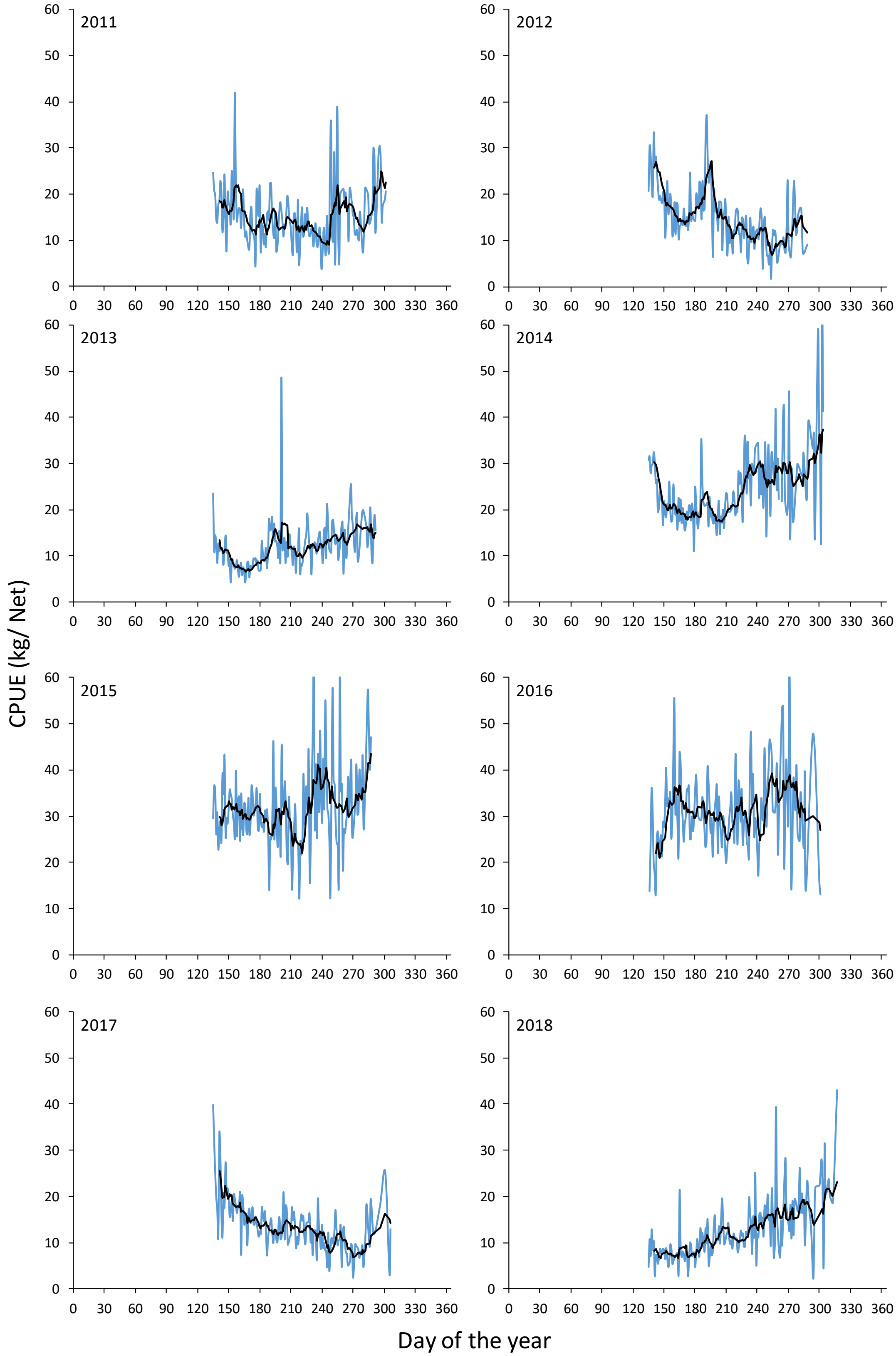


Figure 15. Daily catch per unit effort (CPUE kg/net) for the western Gulf sector for the years 2011 to 2018.

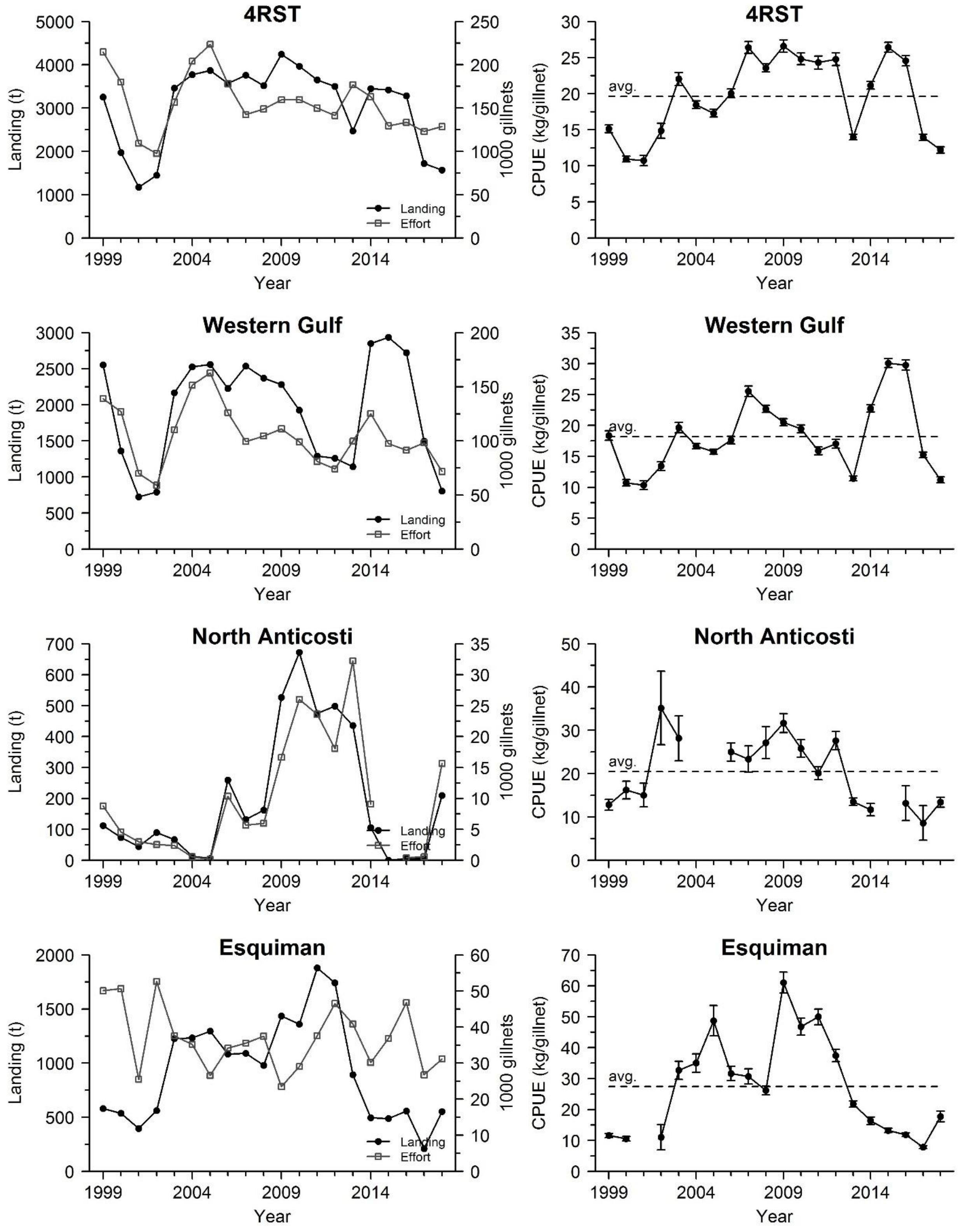


Figure 16. Landing, nominal effort and catch per unit effort (CPUE) ± 95% confidence interval, by year and fishing sector.

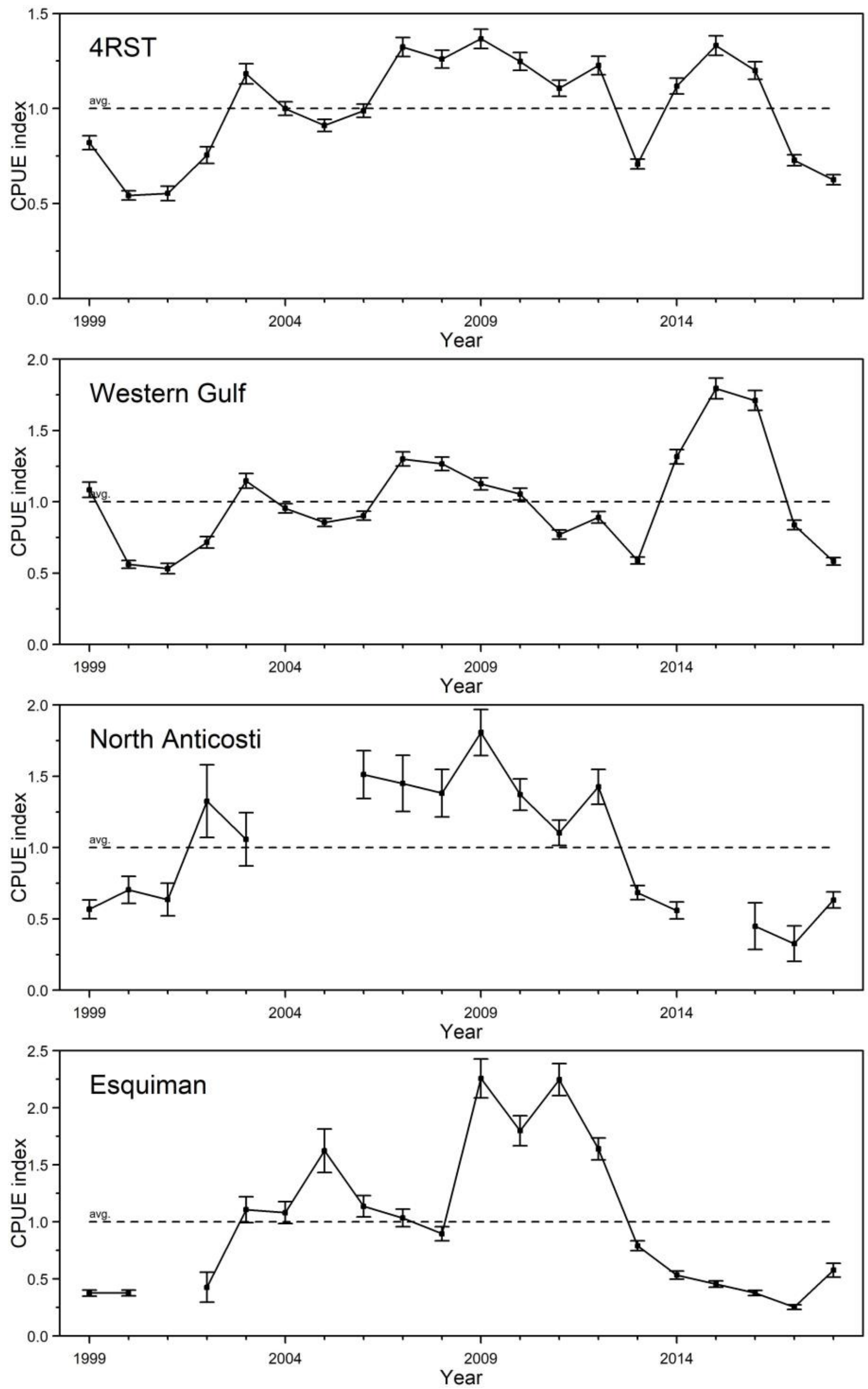


Figure 17. Annual fishing performance index (standardized CPUE) ± 95% confidence interval for the Gulf as a whole (4RST) and by fishing sector.

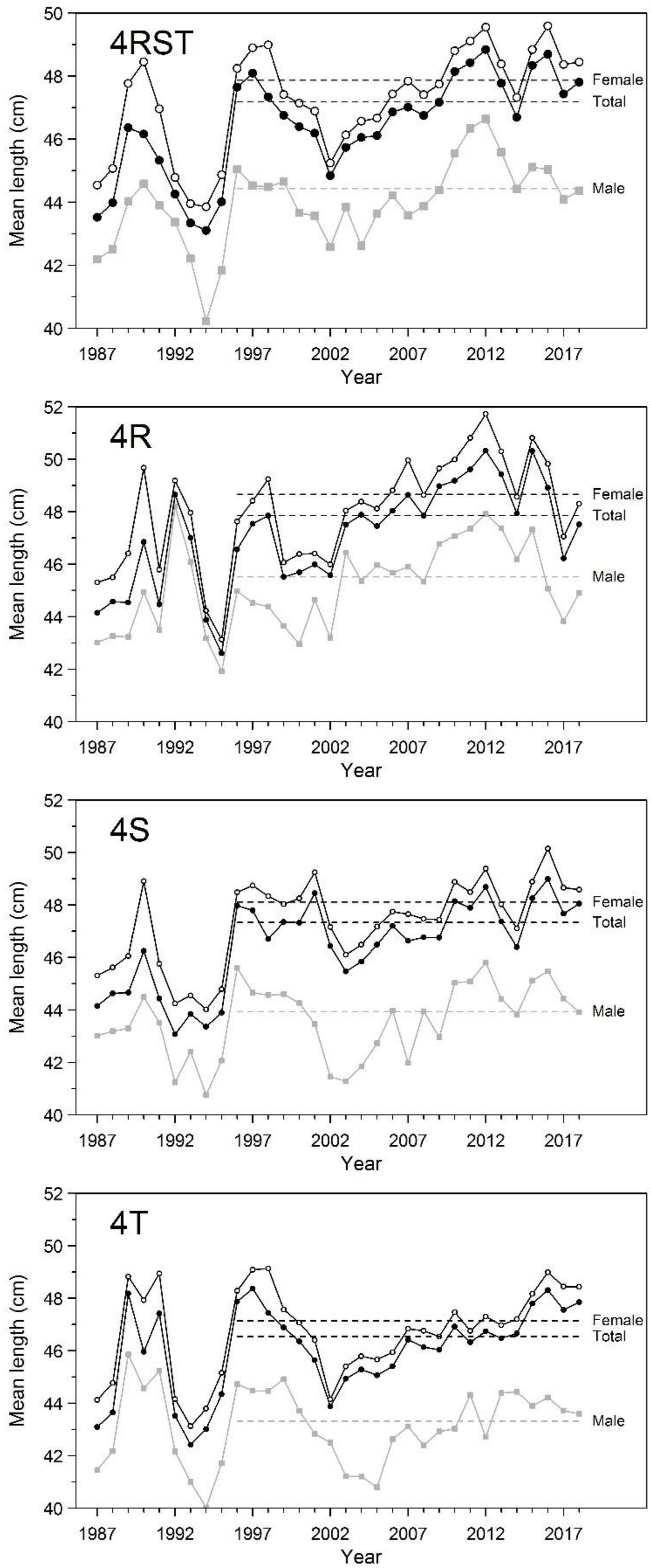


Figure 18. Average annual length of Greenland halibut caught in the commercial gillnet fishery by sex and NAFO Division from 1987 to 2018. The dotted lines represent the average for each series since the change in mesh size in 1996.

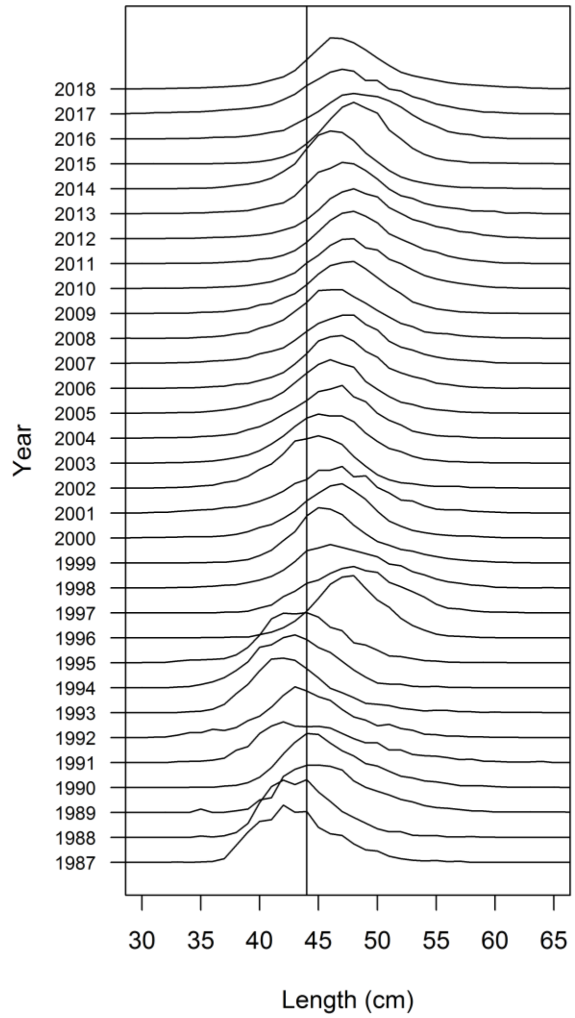


Figure 19. Size frequency distribution of Greenland halibut caught in the commercial gillnet fishery from 1987 to 2018. In 1996, the mesh size increased from 5.5 to 6 inches. The vertical line intersects the graph at 44 cm which is the minimum size of the small fish protocol.

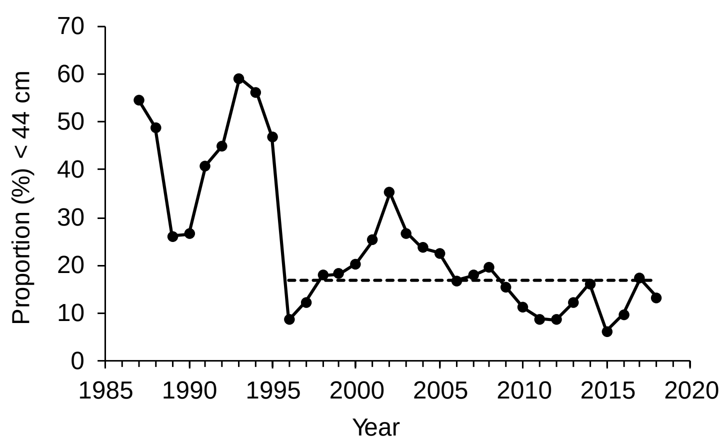


Figure 20. Annual proportion of Greenland halibut less than 44 cm in the commercial catch. The dotted line represents the average 1996-2017, i.e. after the change in mesh size.

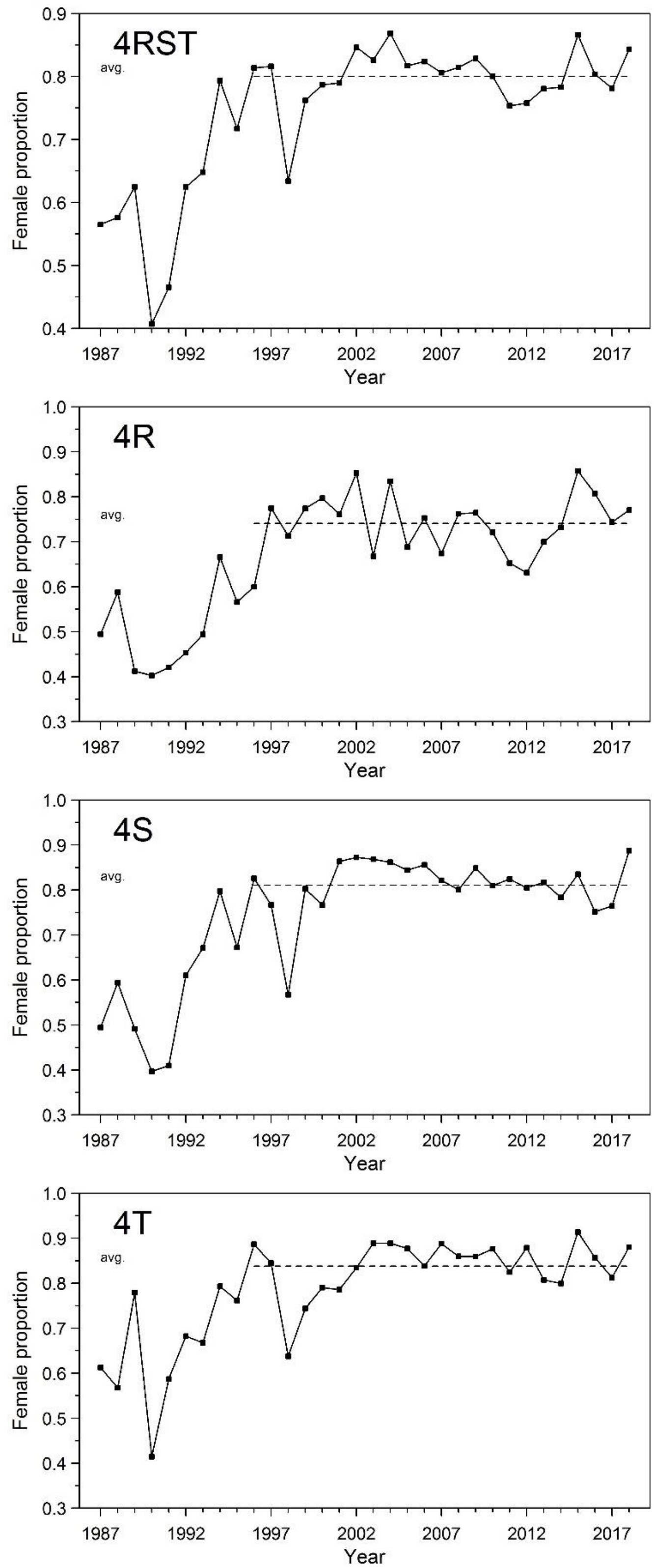


Figure 21. Proportion of females in gillnet catches by NAFO Division. The dotted line represents the average starting in 1996, the year of the change in mesh size from 5.5 to 6 inches.

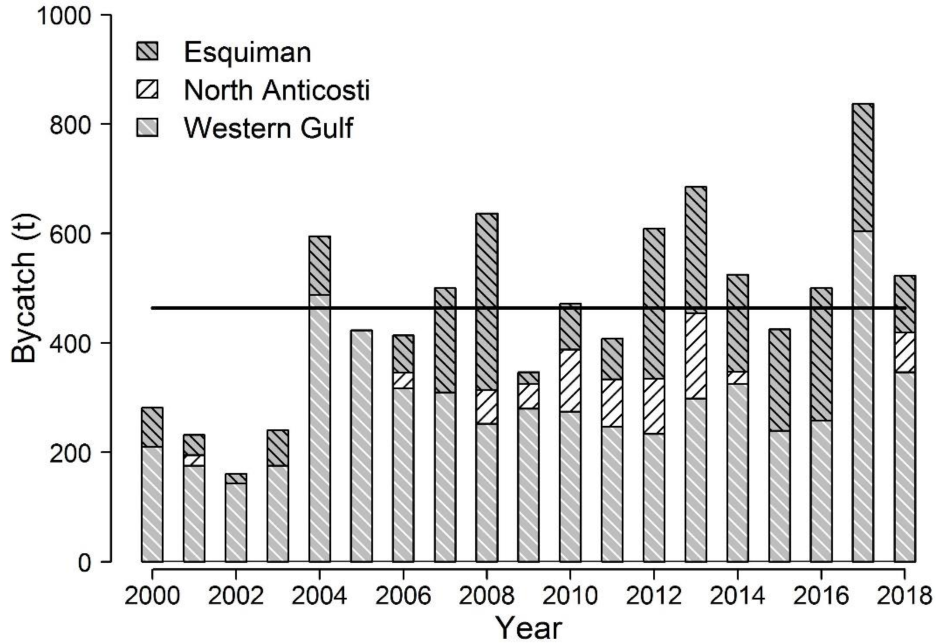


Figure 22. Total bycatch (t) of all species in the directed Greenland halibut gillnet fishery by year and fishing area estimated with data from the at-sea observer program. Solid line indicates the average for the years 2000-2018.

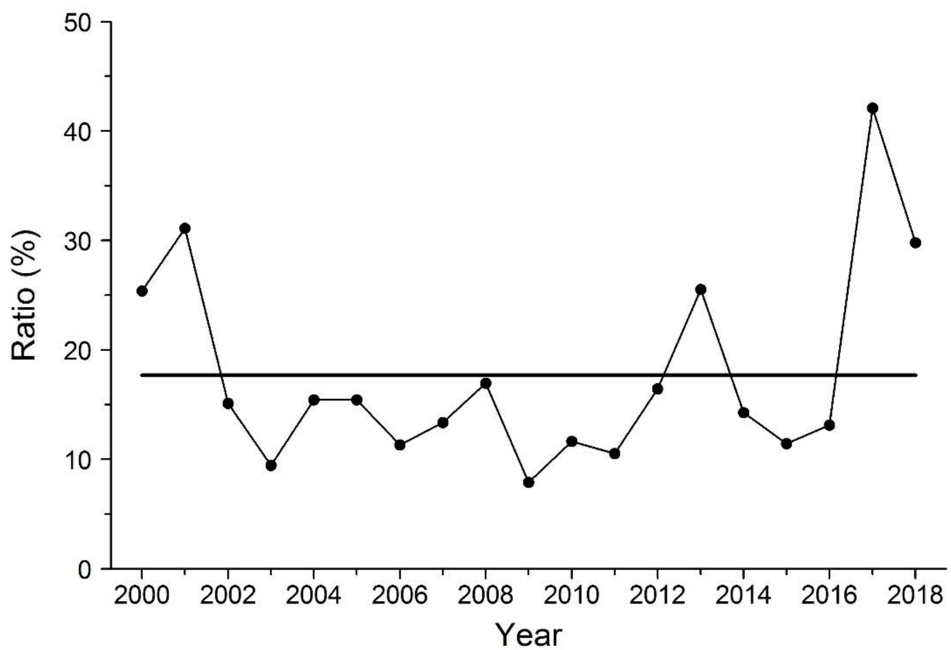


Figure 23. Ratio (%) of bycatch for all species combined to total Greenland halibut catch. Solid line indicates the average for the years 2000-2018.

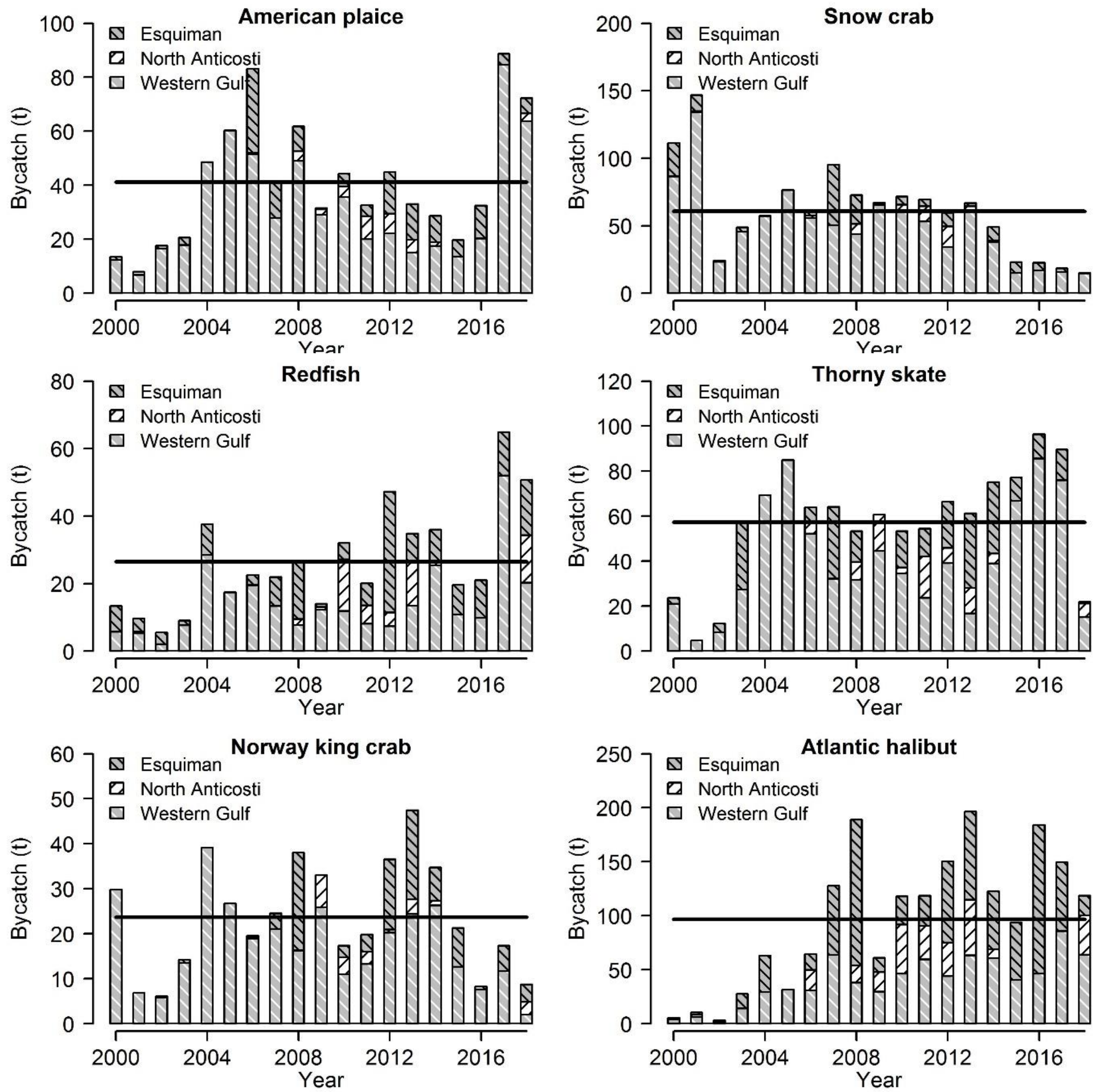


Figure 24. Annual bycatch in the directed Greenland halibut gillnet fishery, estimated for six species per fishing sector based on data from the at-sea observer program. The solid line indicates the average for the years 2000-2018.

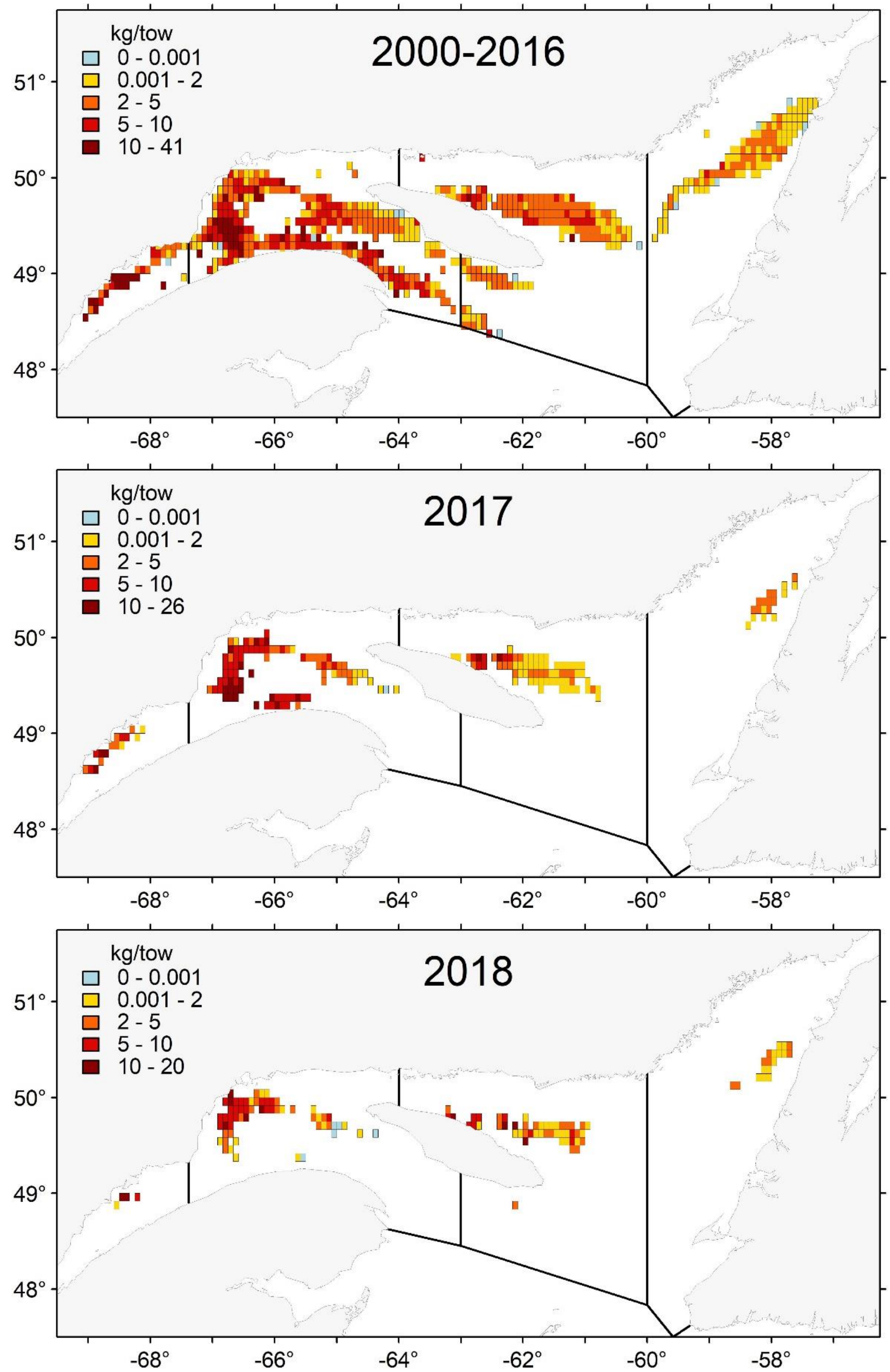


Figure 25. Spatial distribution of Greenland halibut bycatch averaged per 5-minute square in directed shrimp fisheries in the presence of an at-sea observer.

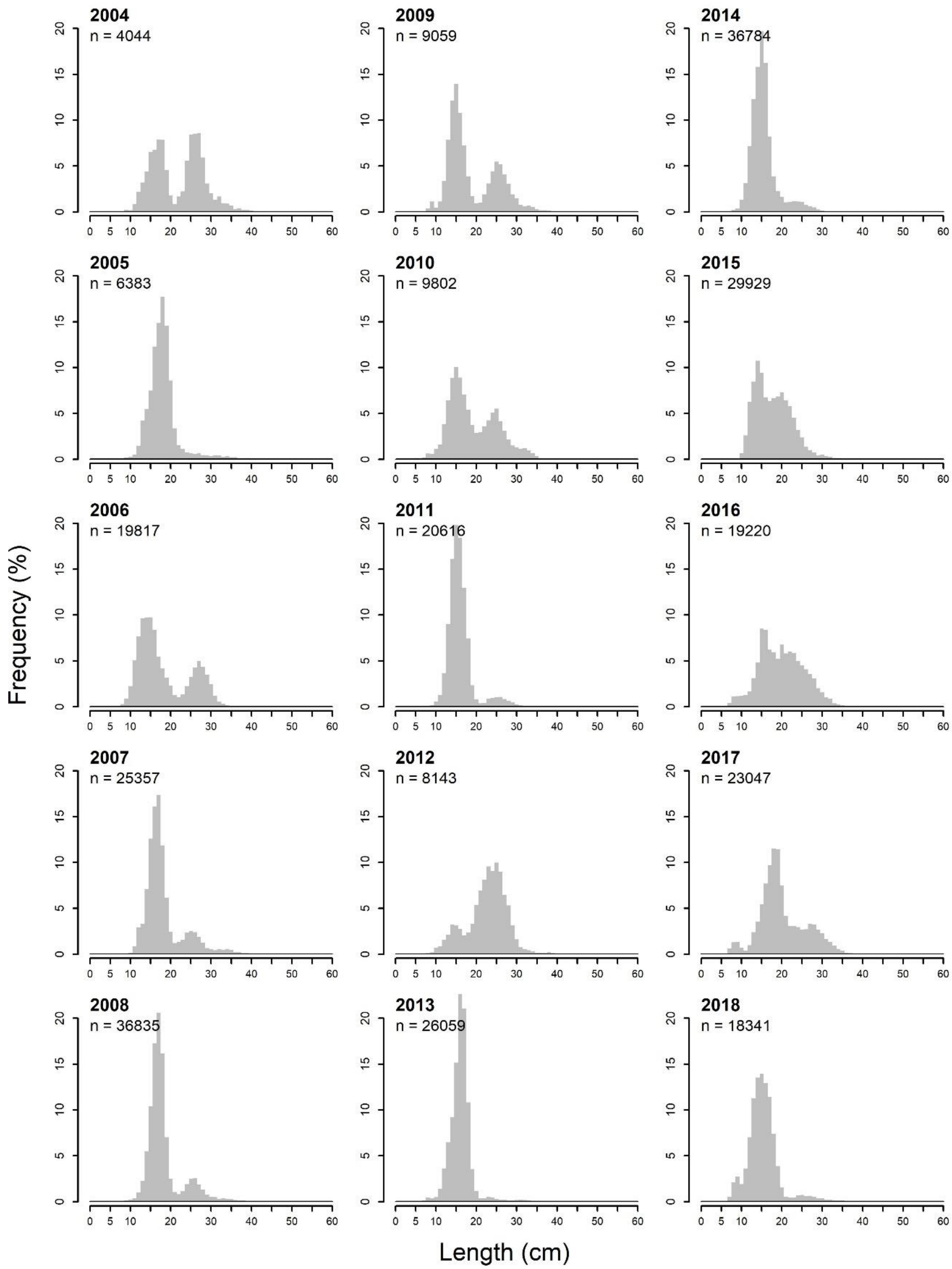


Figure 26. Length frequency distribution of Greenland halibut sampled by at-sea observers from 2002 to 2017 in the directed shrimp fishery. The number (n) of specimens measured is indicated.

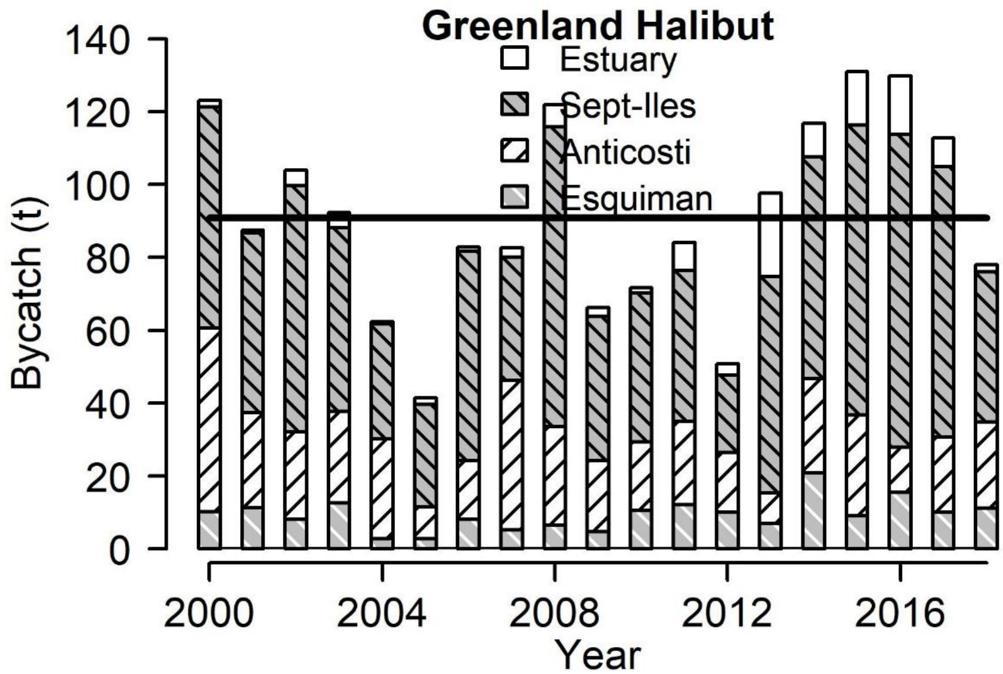


Figure 27. Bycatch of Greenland halibut in the directed shrimp fishery, estimated annually by at-sea observers according to shrimp fishing areas. The solid line indicates the average for the years 2000-2017.

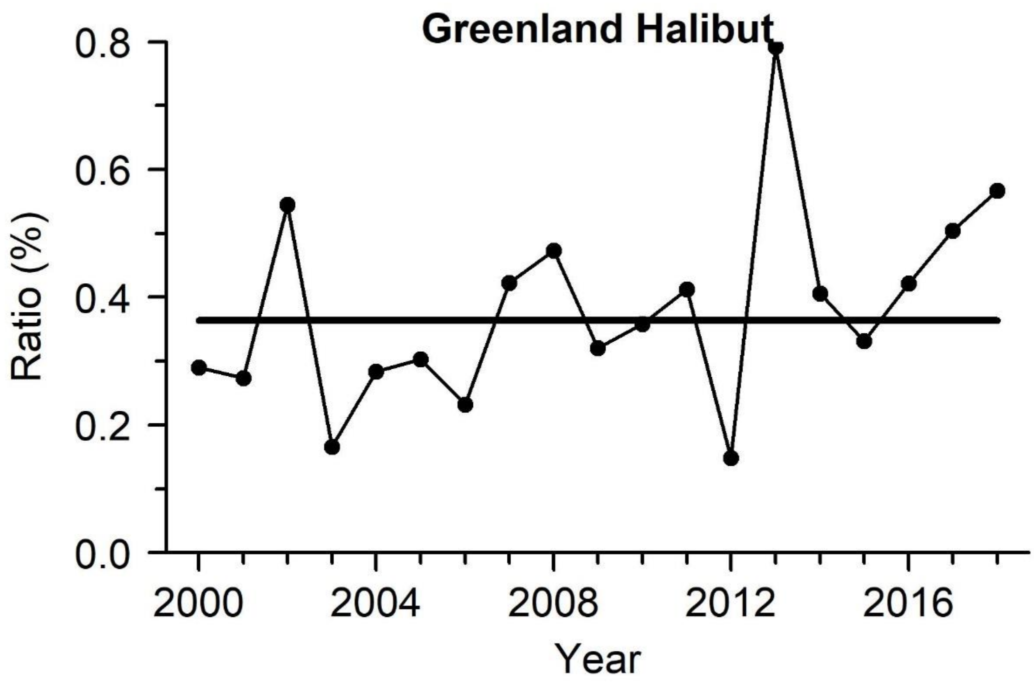


Figure 28. Ratio (%) of shrimp bycatch to estimated Greenland halibut biomass estimated by the Northern Gulf of St. Lawrence Groundfish Survey data. Solid line indicates the average for the years 2000-2018.

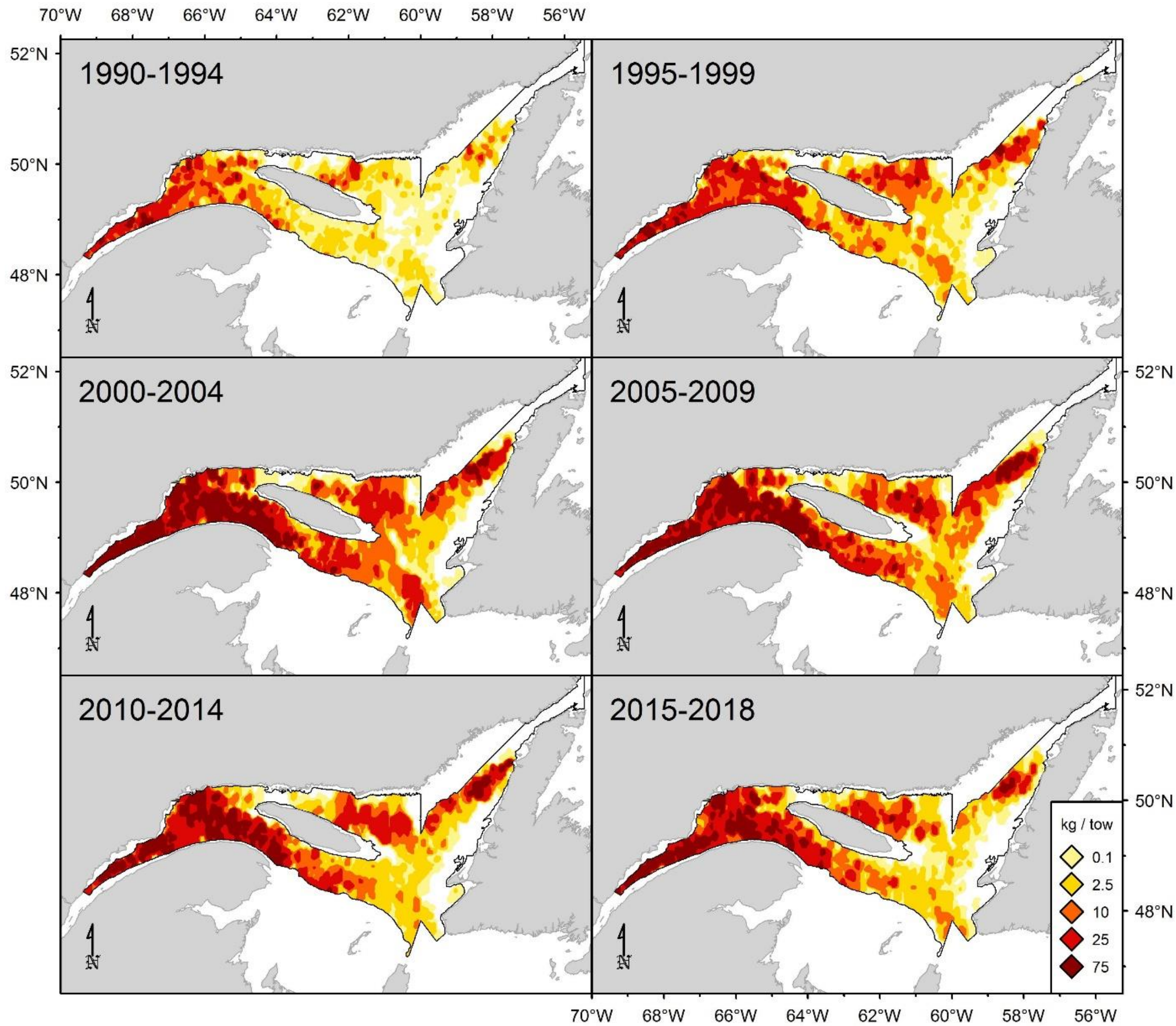


Figure 29. Spatial distribution of catch rates (kg / 15-minute tow) of Greenland halibut during the DFO survey in the northern Gulf of St. Lawrence over four or five year periods.

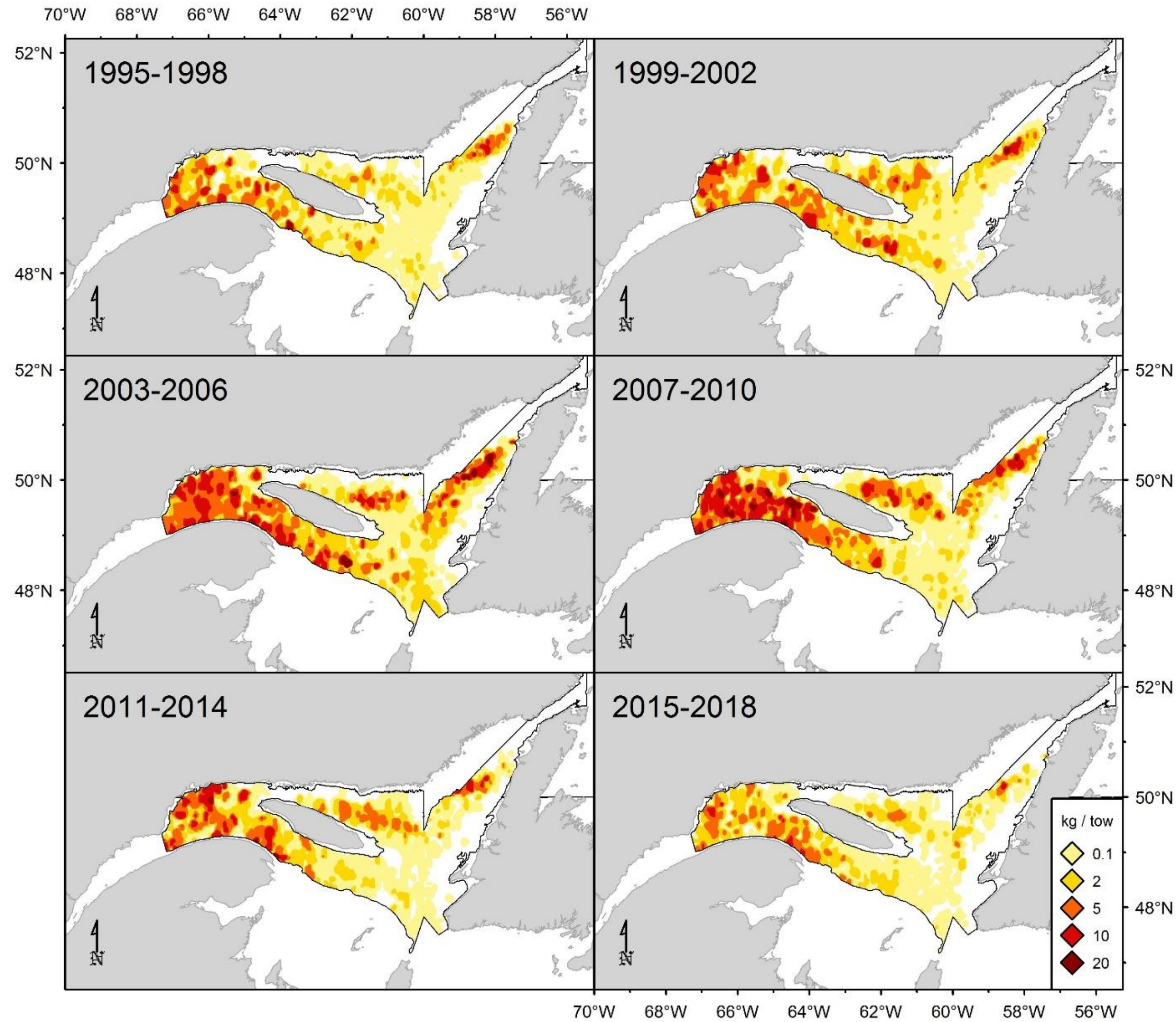


Figure 30. Spatial distribution of catch rates (kg / 30-minute tow) of Greenland halibut in July mobile sentinel survey over three to four year periods.

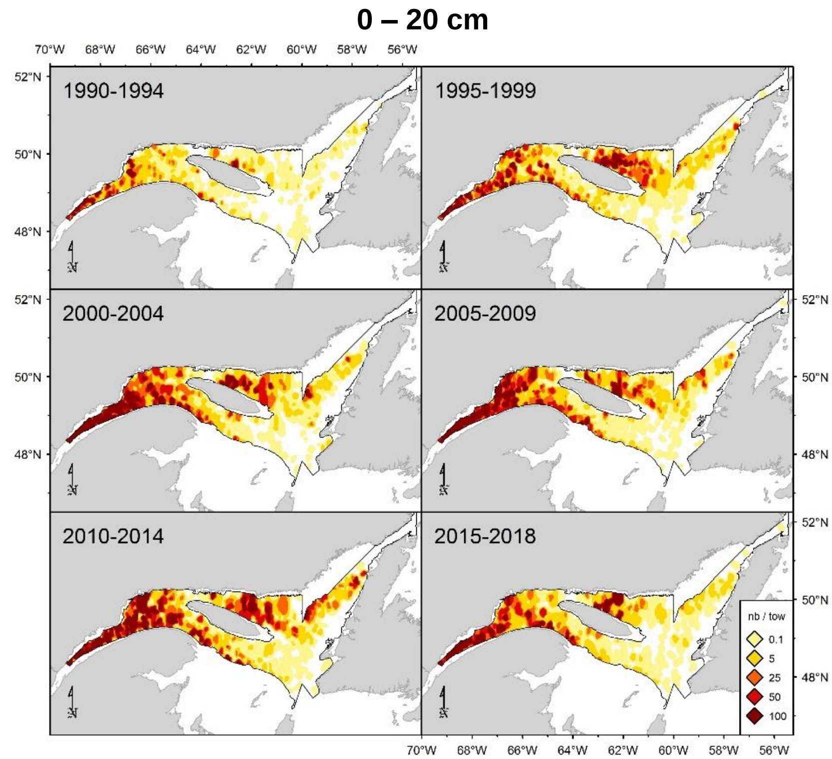


Figure 31. Spatial distribution of catch rates (number / 15 minute tow) of Greenland halibut less than 20 cm in the DFO nGSL survey over four or five year periods.

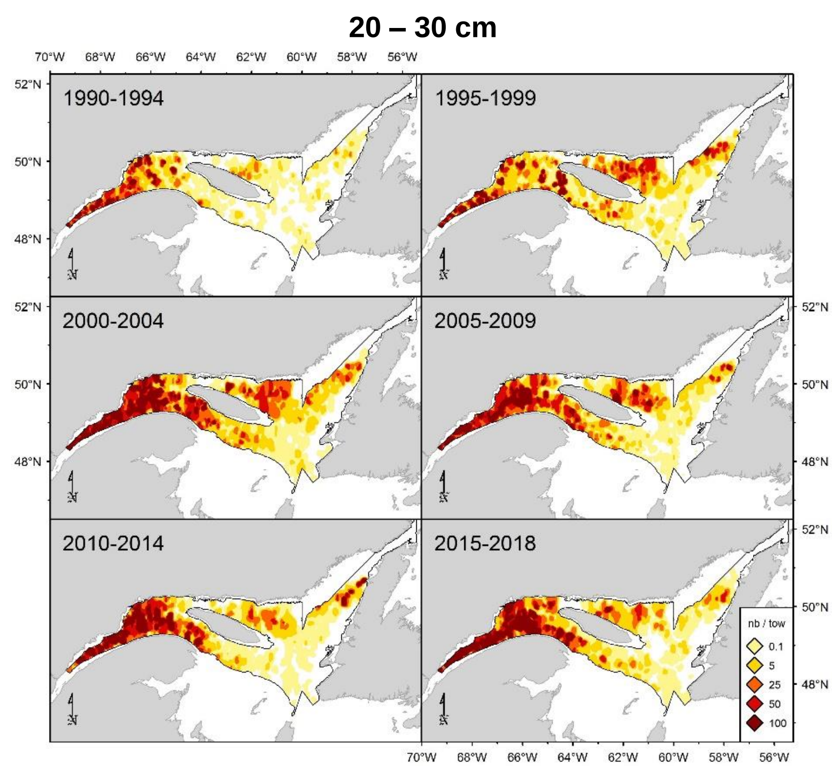


Figure 32. Spatial distribution of catch rates (number / 15 minute tow) of 20 to 30 cm Greenland halibut in the DFO nGSL survey over four or five year periods.

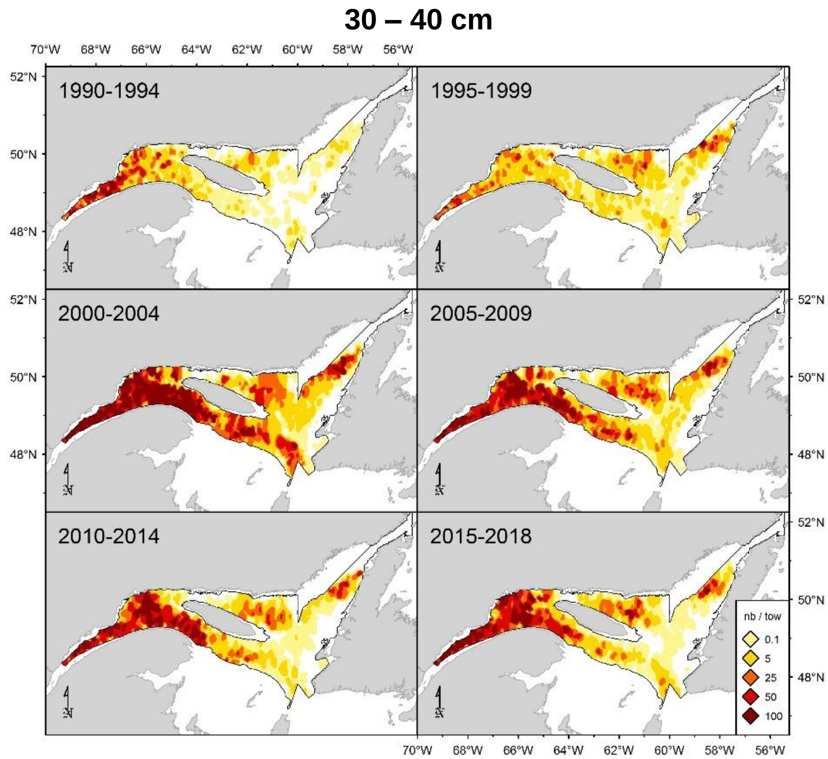


Figure 33. Spatial distribution of catch rates (number / 15 minute tow) of 30 to 40 cm Greenland halibut in the DFO nGSL survey over four or five year periods.

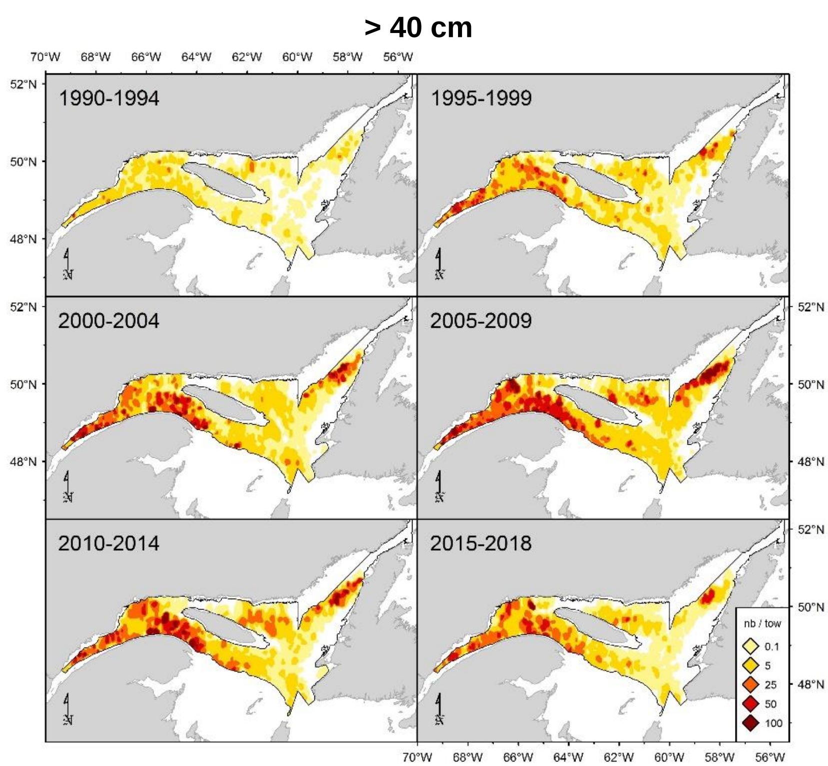


Figure 34. Spatial distribution of catch rates (number / 15 minute tow) of Greenland halibut 40 cm and greater in the DFO nGSL survey over four or five year periods.

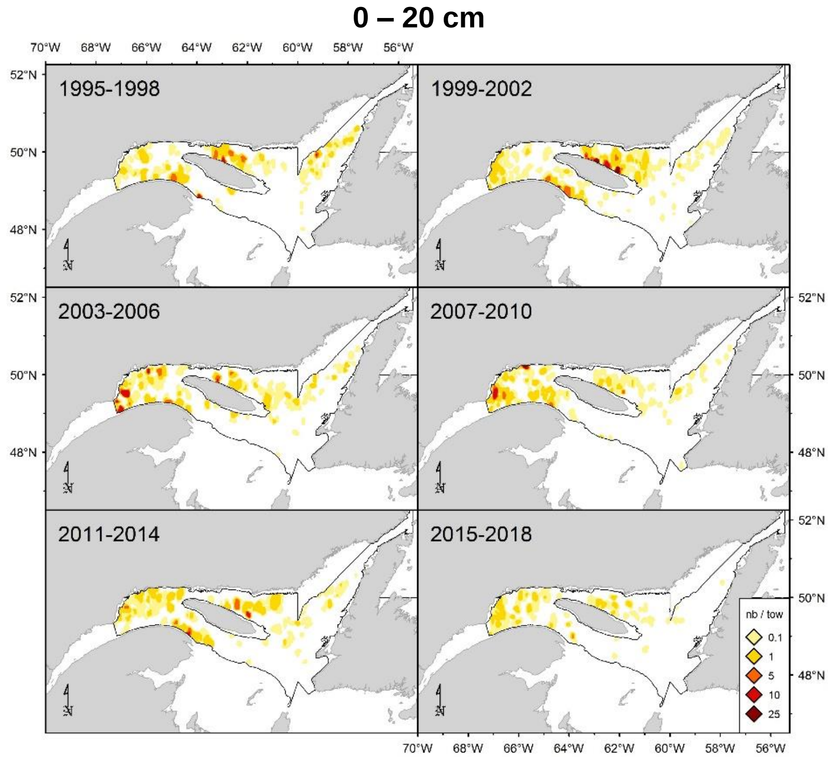


Figure 35. Spatial distribution of catch rates (number / 30-minute tow) of Greenland halibut less than 20 cm in July mobile sentinel survey over three or four year periods.

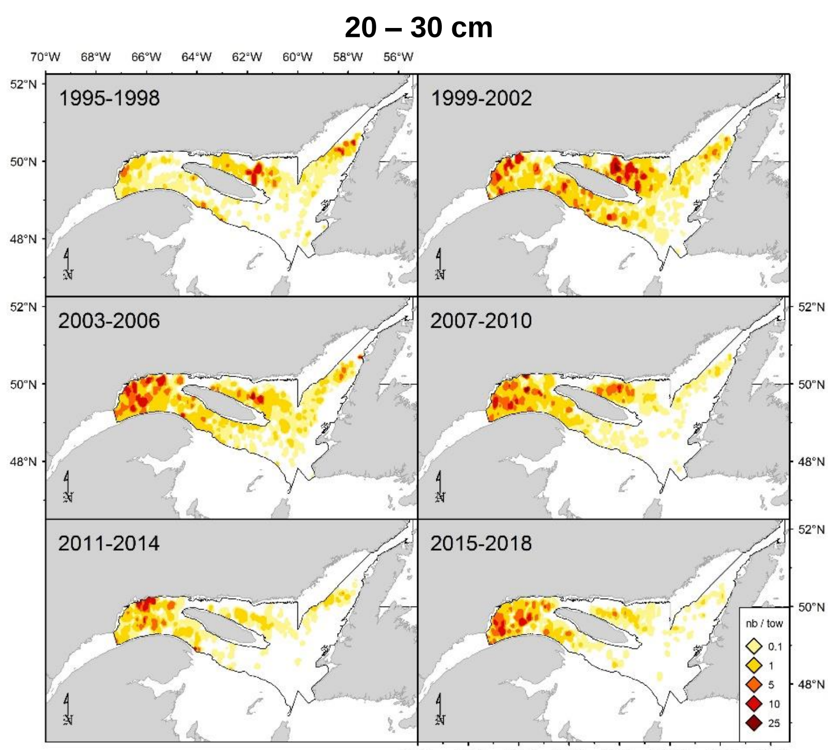


Figure 36. Spatial distribution of catch rates (number / 30 minute tow) of Greenland halibut 20 to 30 cm in July mobile sentinel survey over three to four year periods.

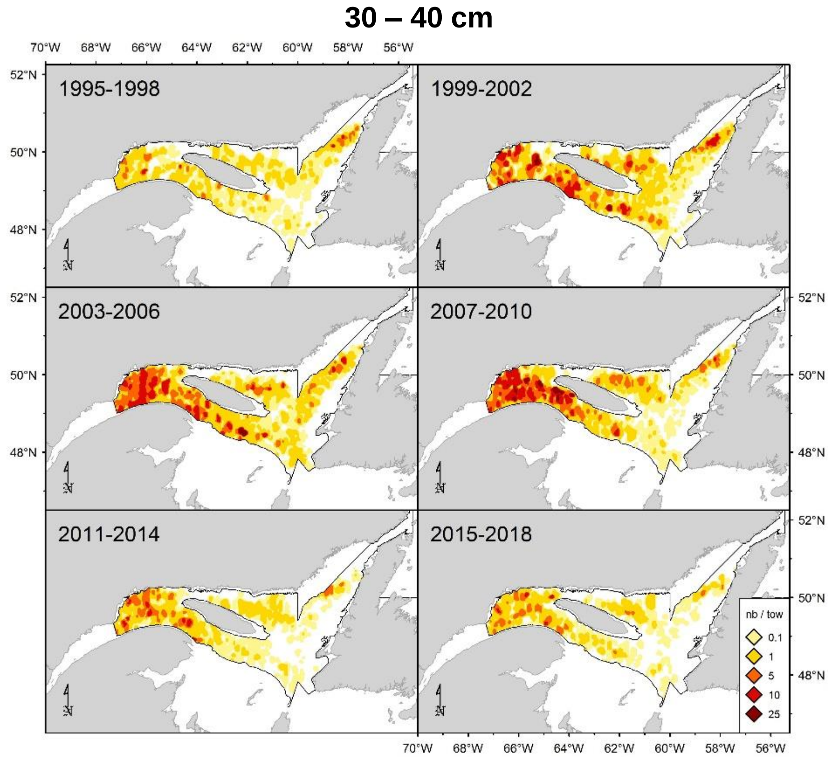


Figure 37. Spatial distribution of catch rates (number / 30 minute tow) of Greenland halibut 30 to 40 cm in July mobile sentinel survey over a three to four year periods.

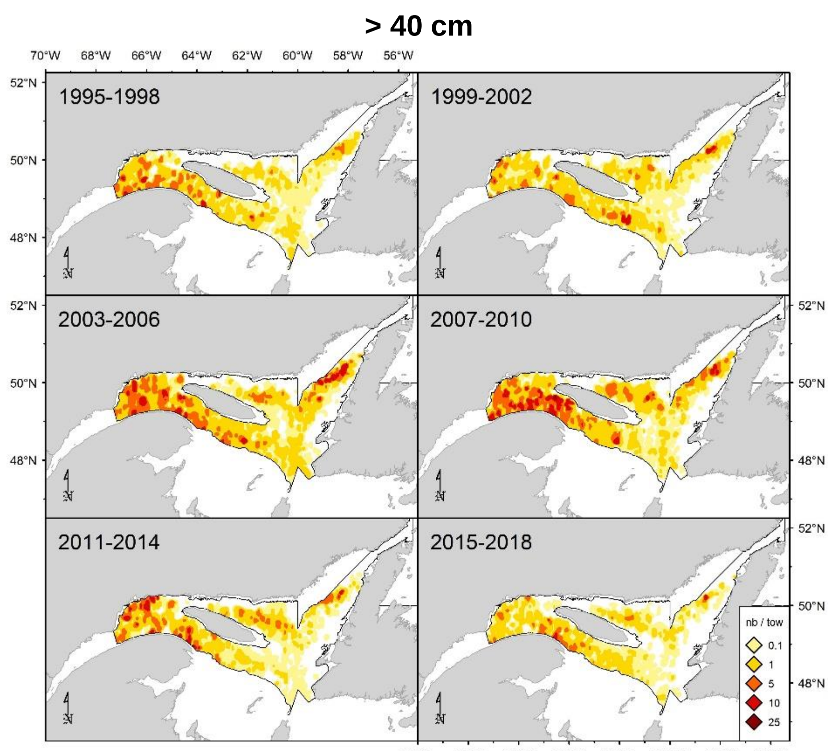


Figure 38. Spatial distribution of catch rates (number / 30-minute tow) of Greenland halibut 40 cm and greater in July mobile sentinel survey over a three to four year periods.

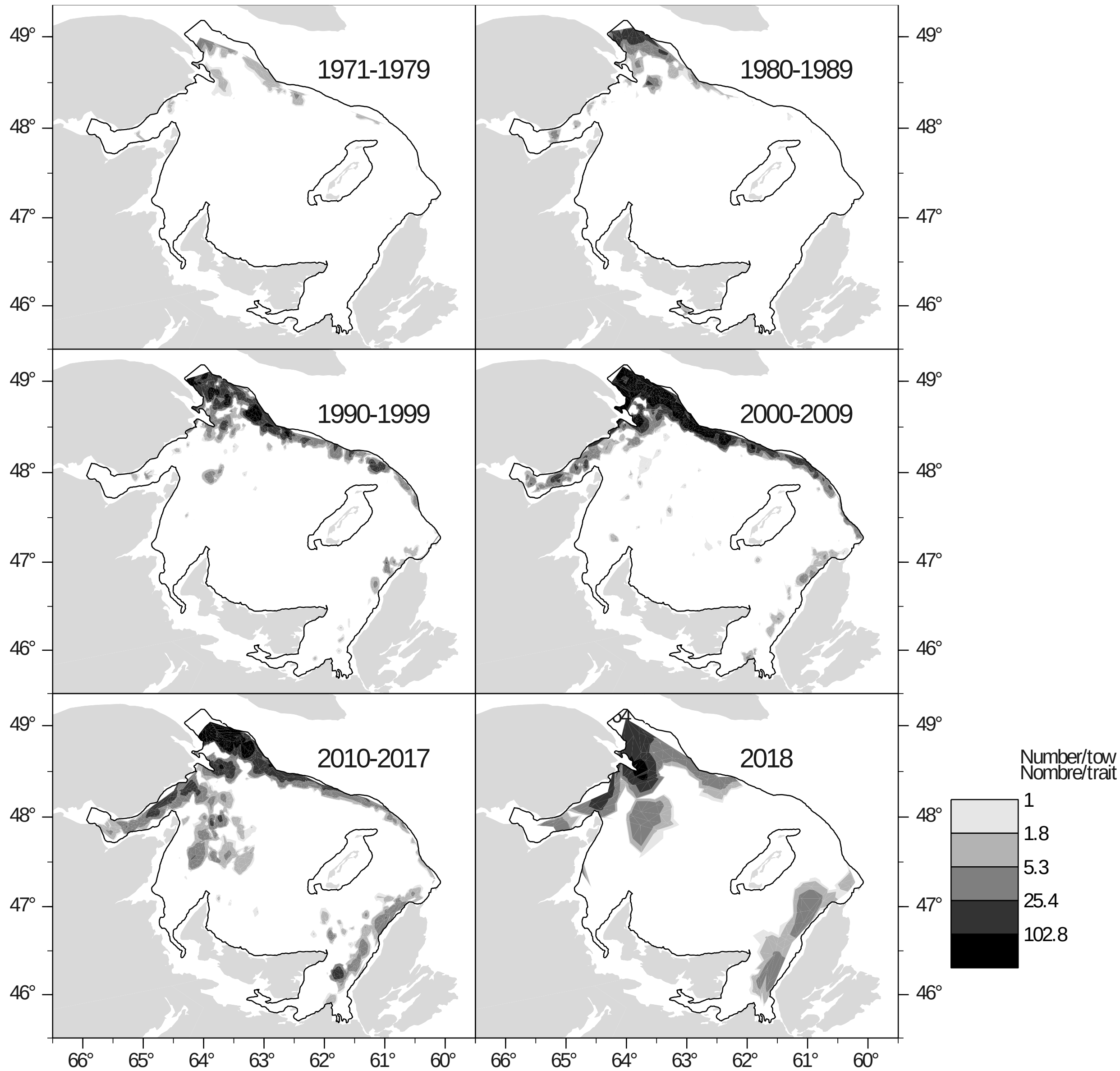


Figure 39. Spatial distribution of Greenland halibut catches (all sizes) in number per tow in DFO's sGSL survey. The contours are based on the 10th, 25th, 50th, 75th and 90th percentiles of non-zero catches over the period 1971-2018. Note that the panel for 2018 is based on less data and therefore the contours involve more smoothing than in the other panels.

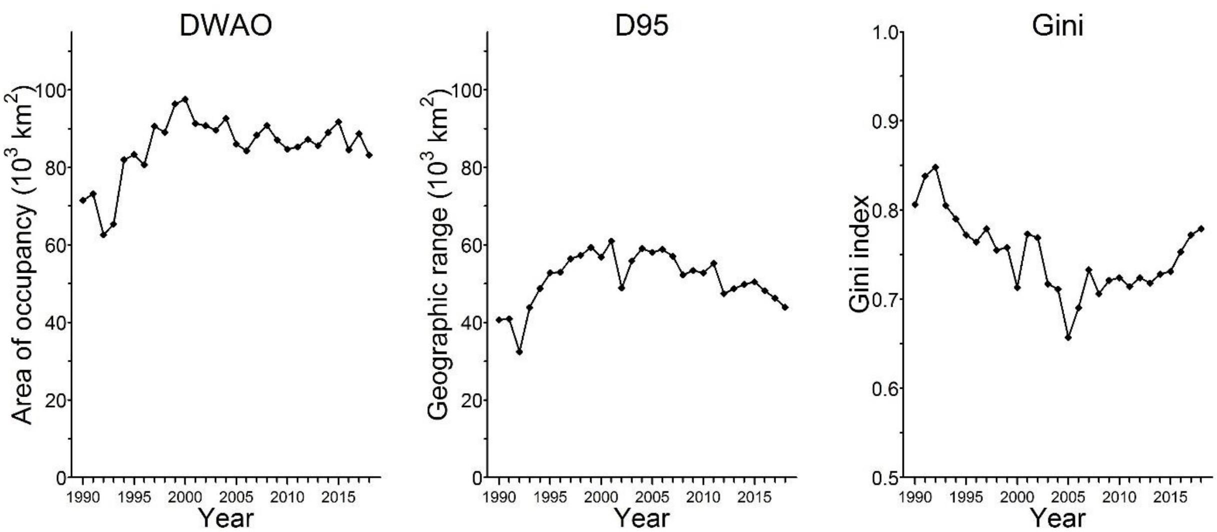


Figure 40. Spatial distribution indices: 1) DWAO, weighted area of occupancy, 2) D95, minimum area where 95% of the biomass is concentrated, and 3) Gini index. The total surveyed area is 116,115 km².

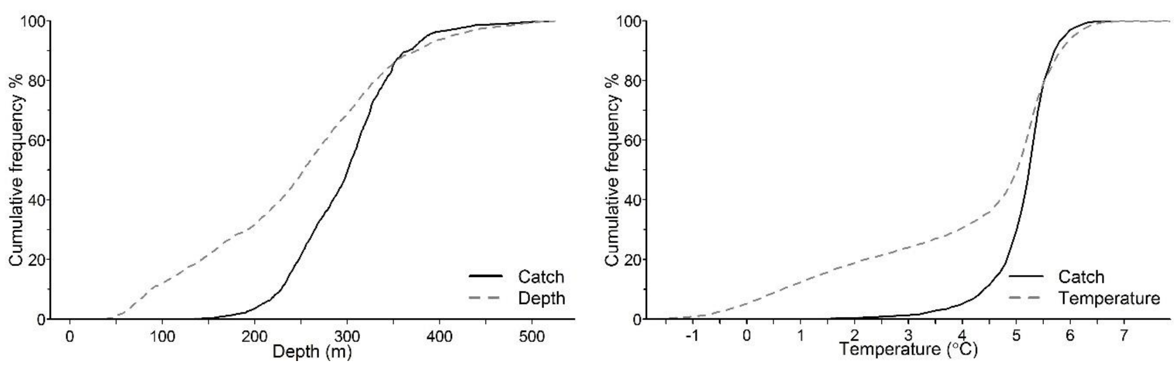


Figure 41. Cumulative frequency of Greenland halibut catches (weight per tow) and number of stations sampled as a function of depth (left graph) and function of bottom temperature (right graph) in the DFO nGSL survey from 1990 to 2018.

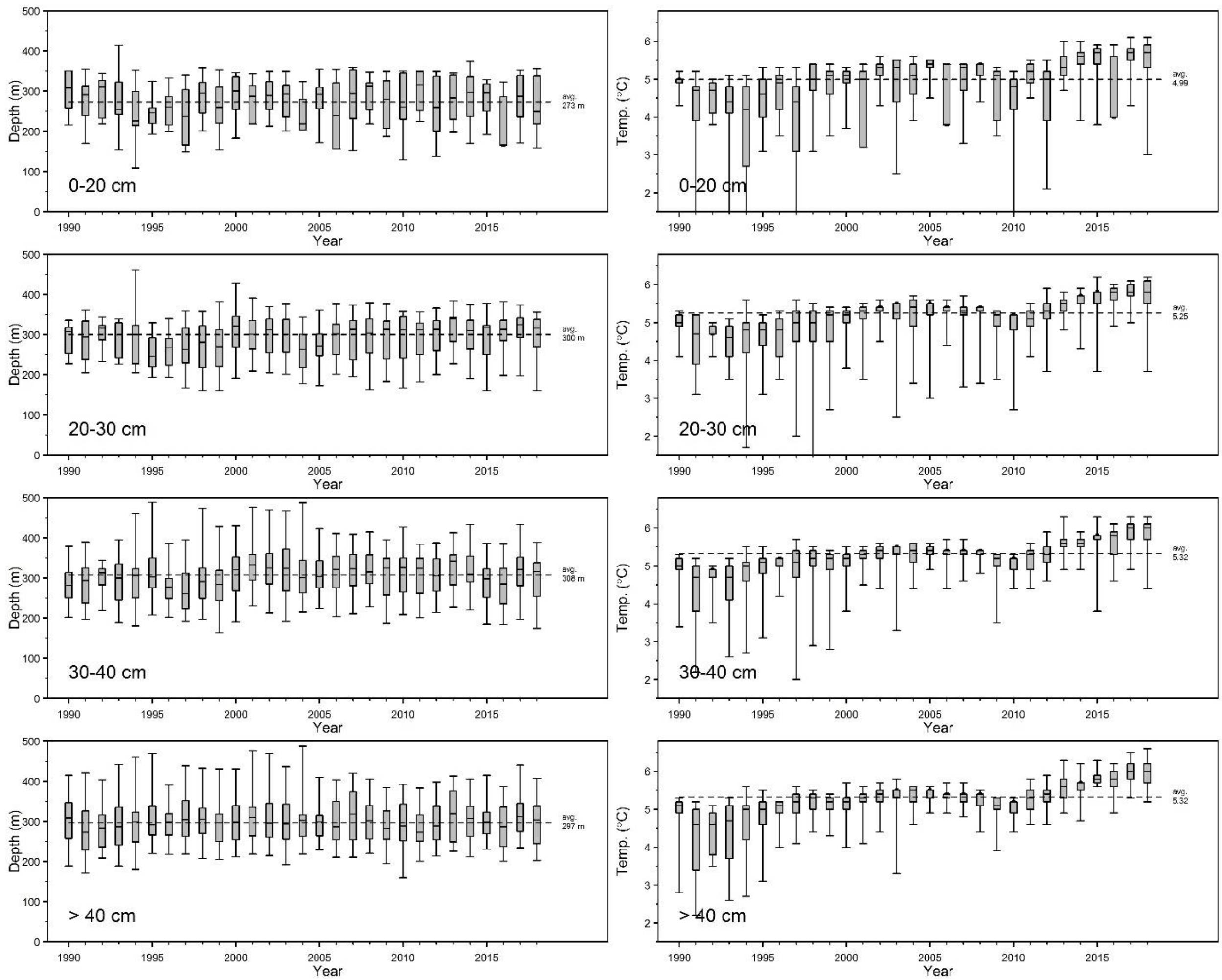


Figure 42. Distribution of Greenland halibut biomass as a function of depth (left) and temperature (right) for different size categories observed in the DFO nGSL survey. Box and whiskers plot: the line inside the box represents the median, the box extends from percentiles 25 to 75 and the whiskers (vertical lines on either side of the box) extend from percentiles 5 to 95.

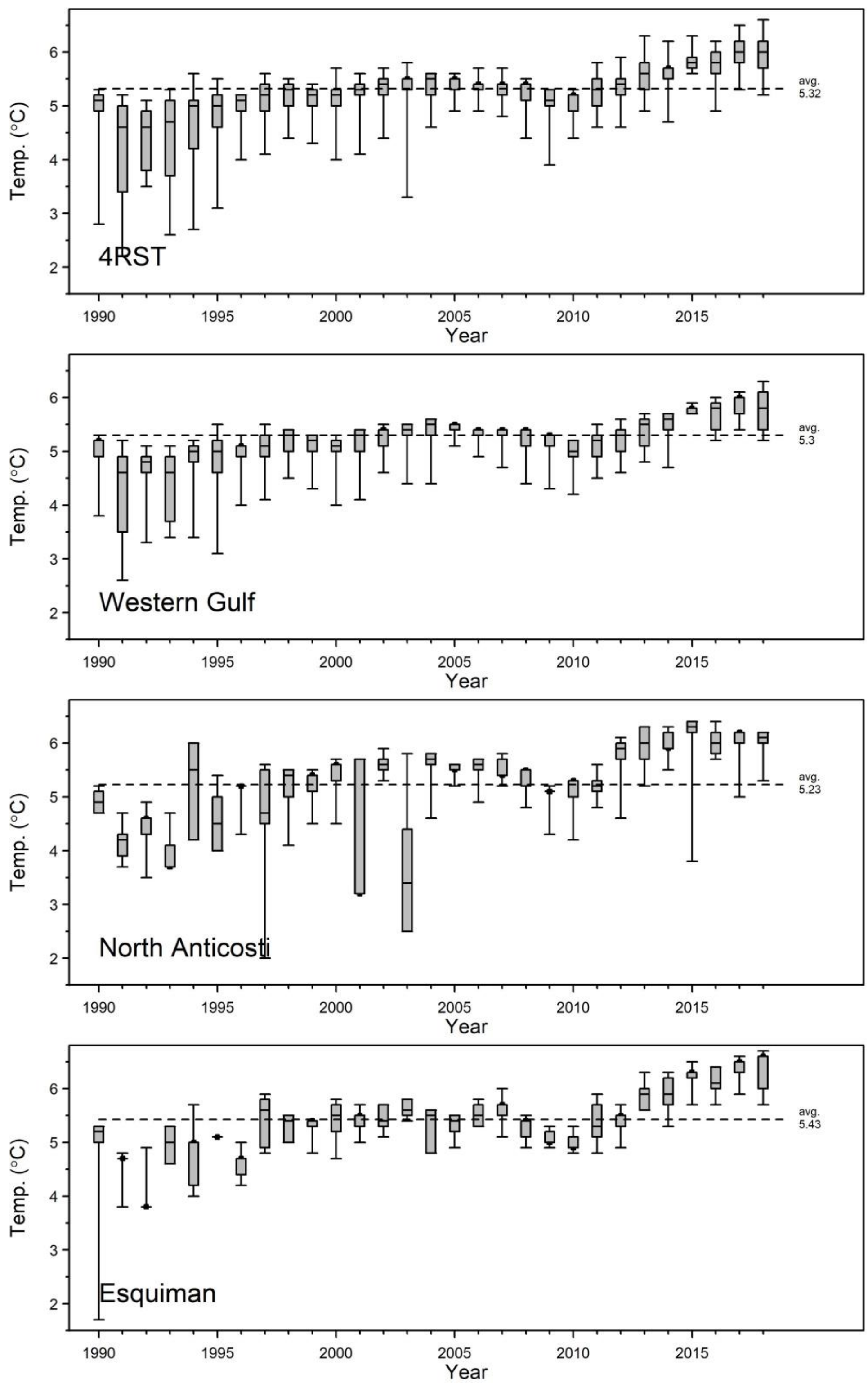


Figure 43. Distribution of Greenland halibut biomass as a function of bottom temperature by area for fish greater than 40 cm observed in the DFO nGSL survey. Box and whiskers plot: the line inside the box represents the median, the box extends from percentiles 25 to 75 and the whiskers (vertical lines on either side of the box) extend from percentiles 5 to 95.

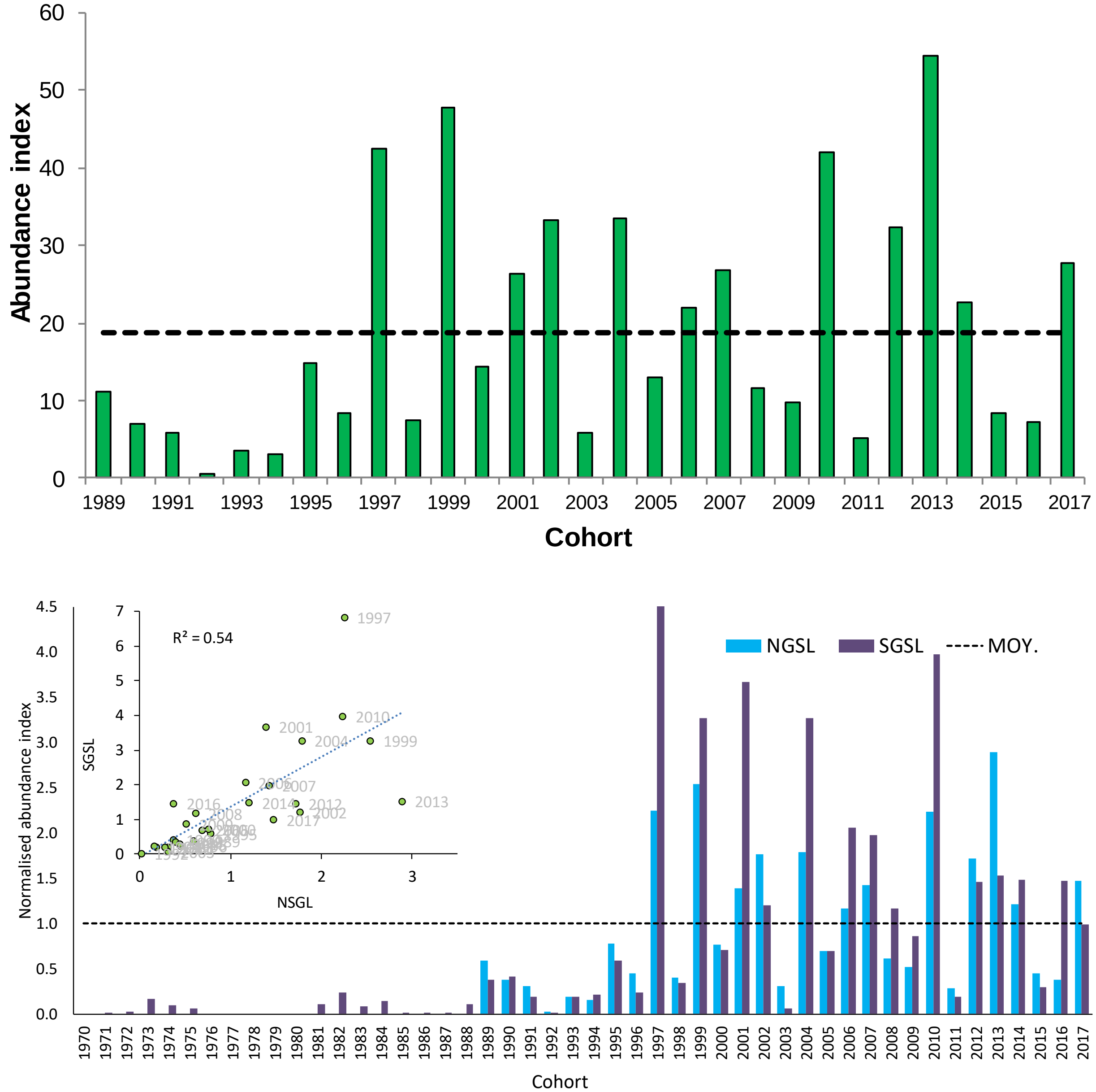


Figure 44. Recruitment indices for Greenland halibut estimated by the annual abundance of 12-21 cm (age 1) fish on the DFO nGSL survey (top). Comparison of recruitment indices for Greenland halibut from the DFO nGSL and sGSL surveys (bottom). The box shows the relationship between the annual cohort abundance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

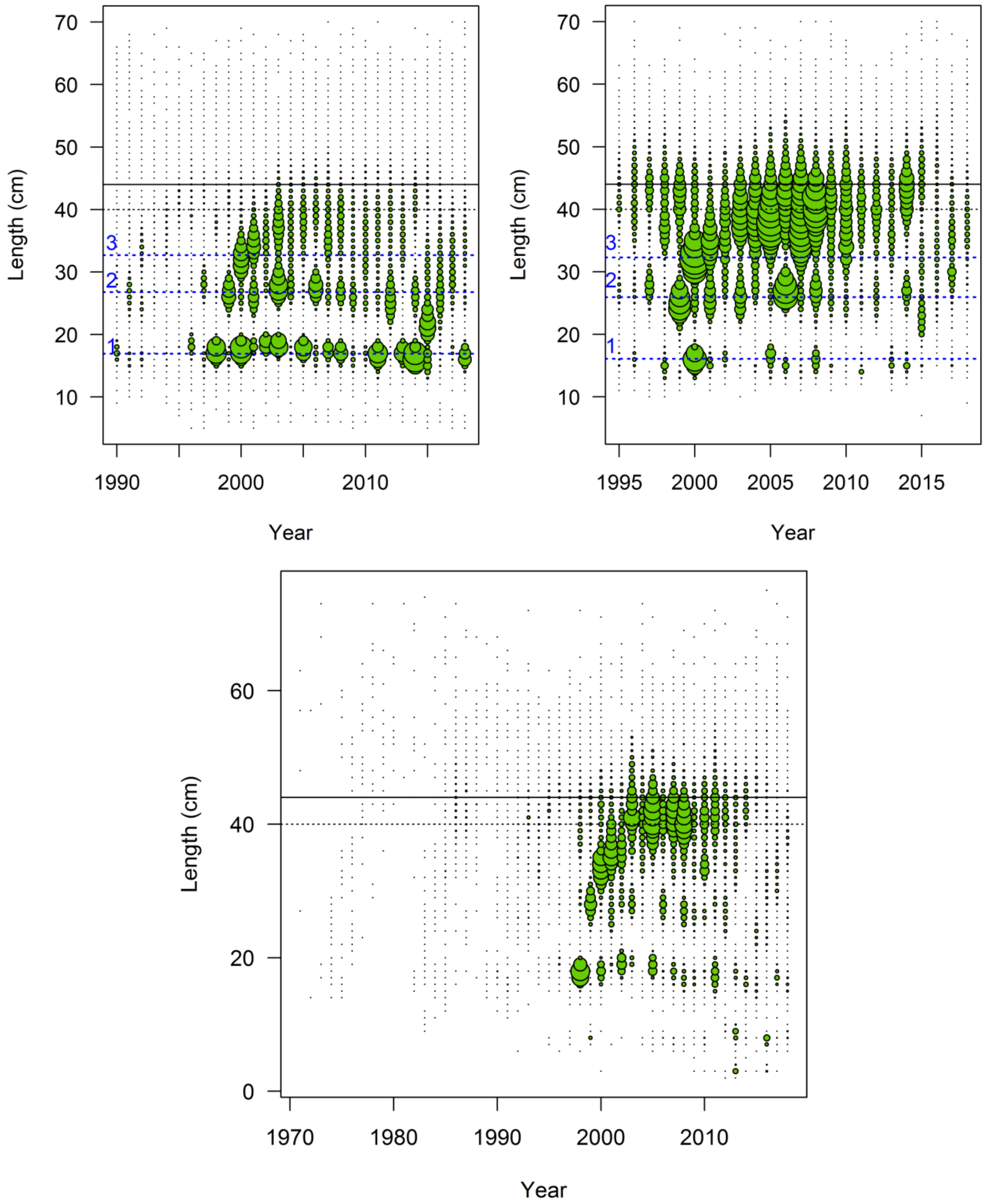


Figure 45. Length frequency distributions observed during nGSL (top left),July mobile sentinel (top right) and sGSL (bottom) surveys. Bubble size is proportional to the abundance in a given survey. Blue dashed lines indicate average sizes for 1, 2 and 3 year old fish. Black dashed lines at 40 cm indicate 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.

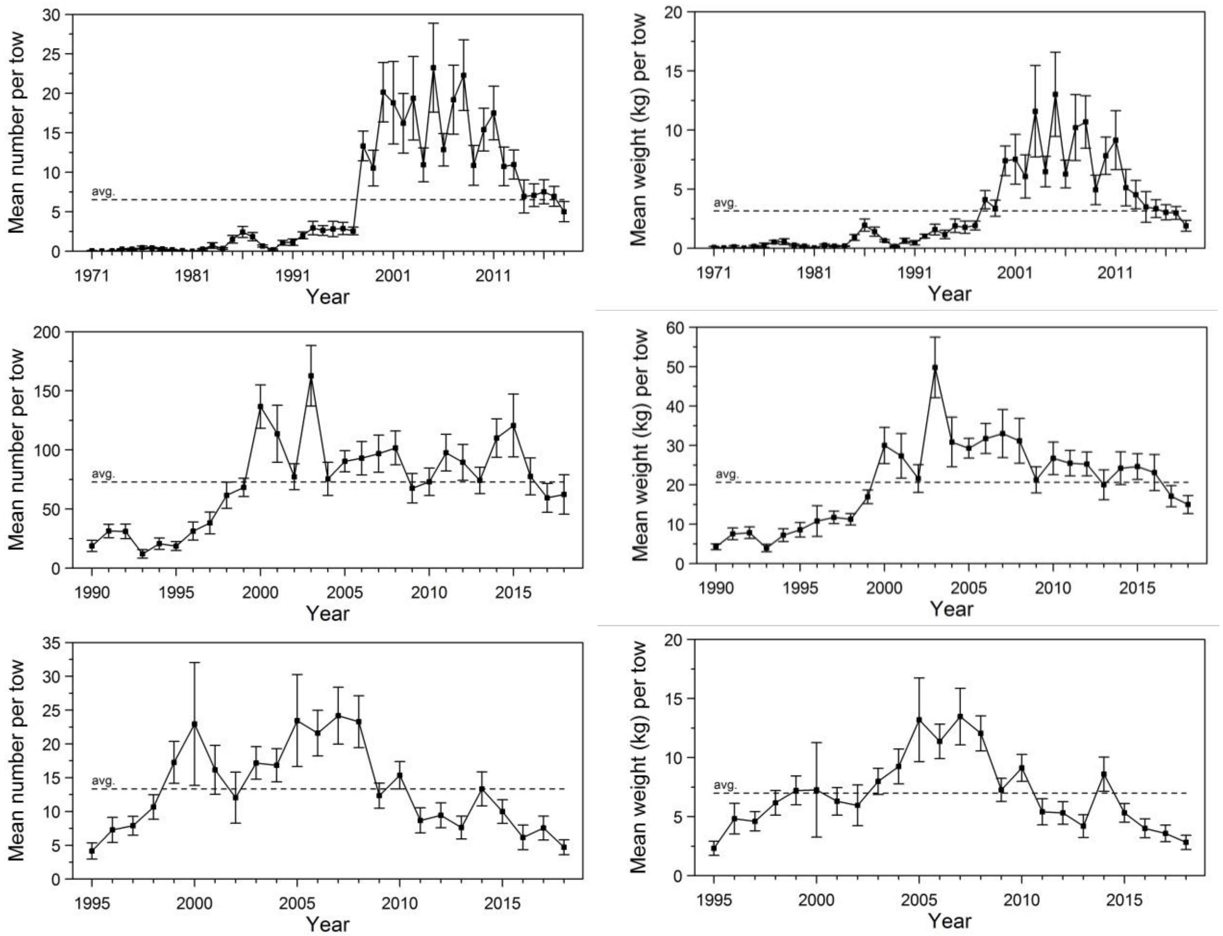


Figure 46. Mean number and weight per tow observed in the sGSL (1971-2018, top), nGSL (1990-2018, centre) and mobile sentinel (1995-2018, bottom) surveys for Greenland halibut. Error bars indicate the 95% confidence interval.

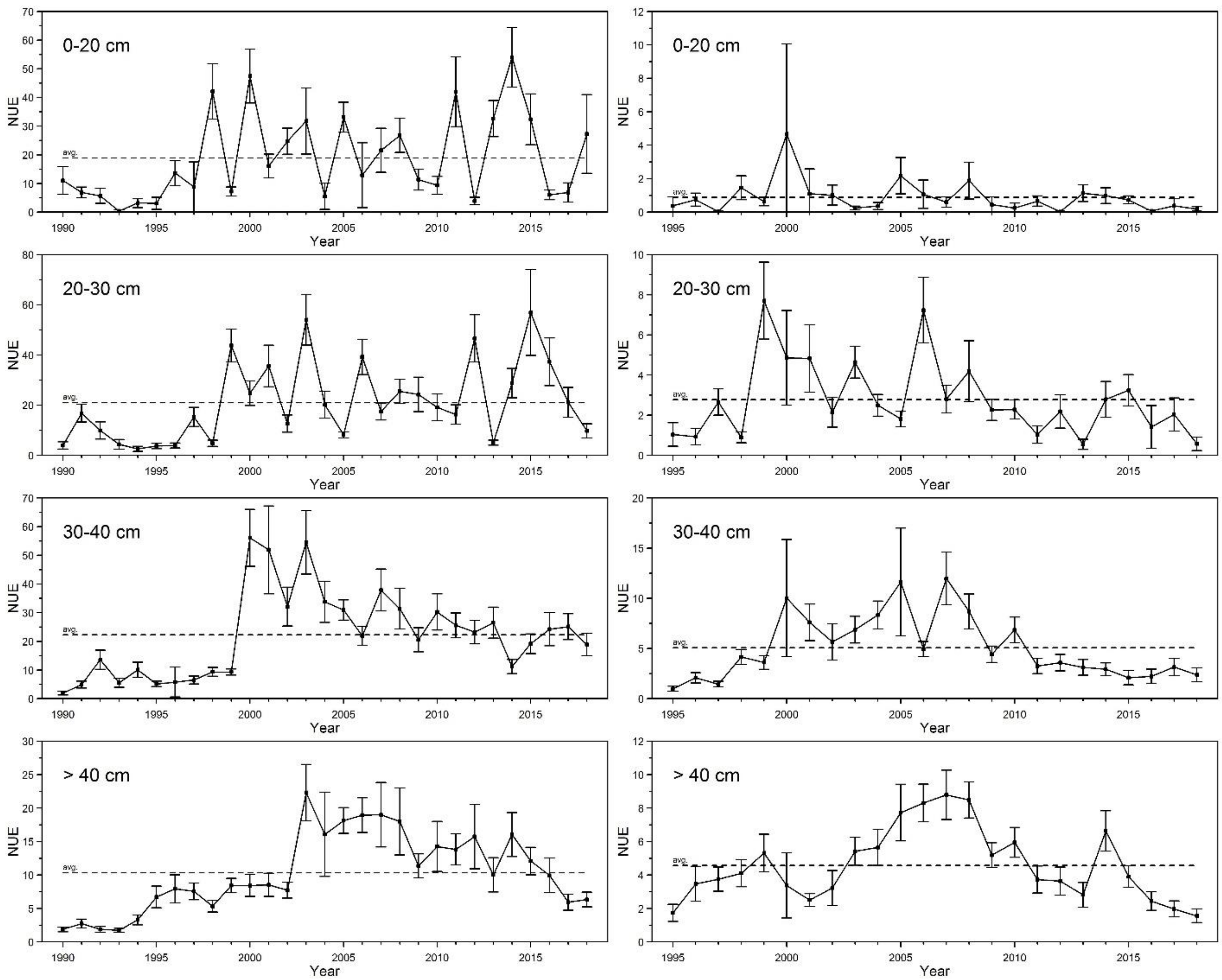


Figure 47. Greenland halibut abundance indices (mean number per tow) for different size categories observed in the nGSL (left) and mobile sentinel (right) surveys.

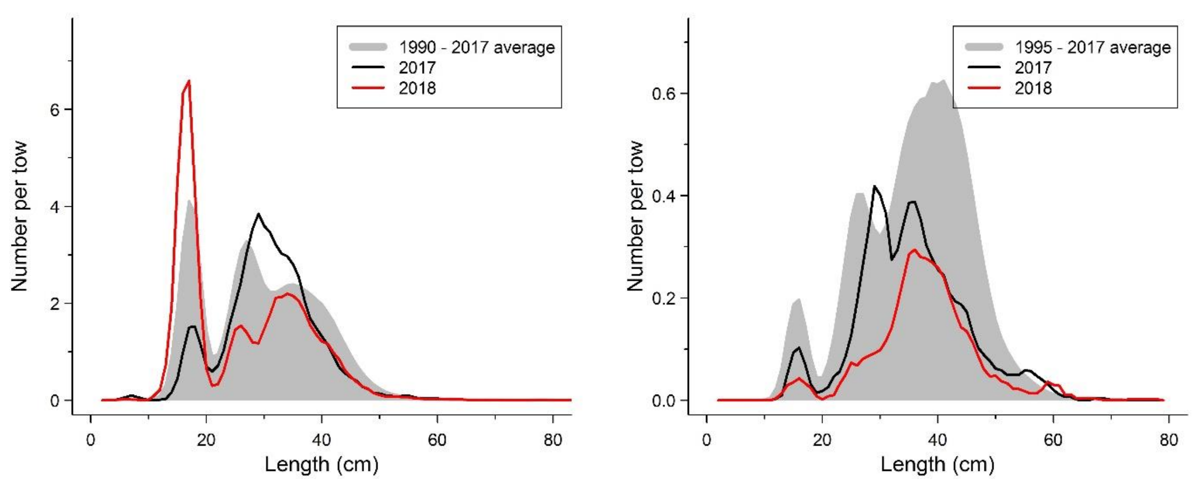


Figure 48. Length frequency distributions (mean number per tow) observed in the nGSL (left) and mobile sentinel (right) surveys for Greenland halibut.

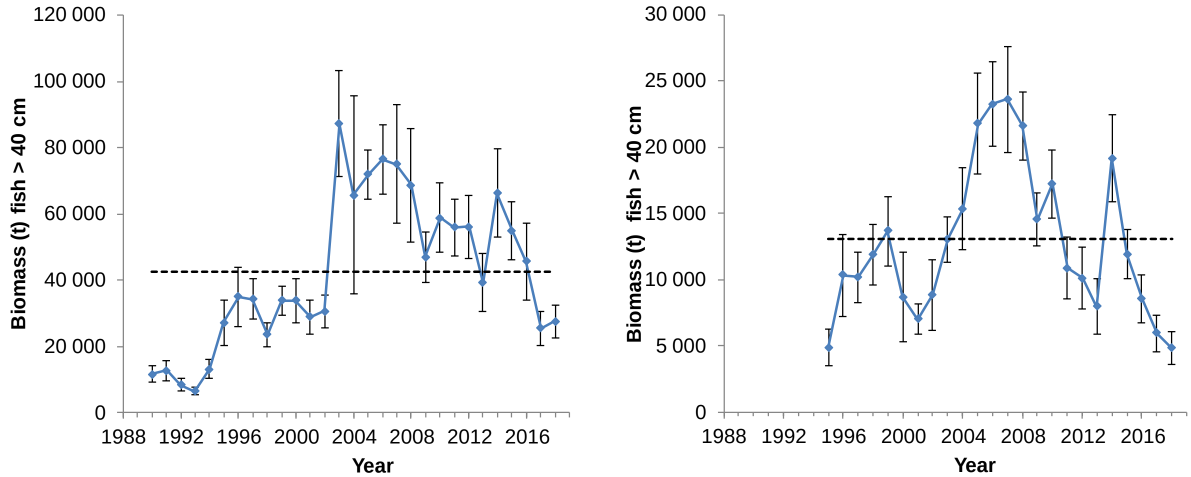


Figure 49. Biomass indices (t) for Greenland halibut greater than 40 cm calculated from DFO nGSL (left) and mobile sentinel (right) surveys. Dotted lines indicate the average for each series.

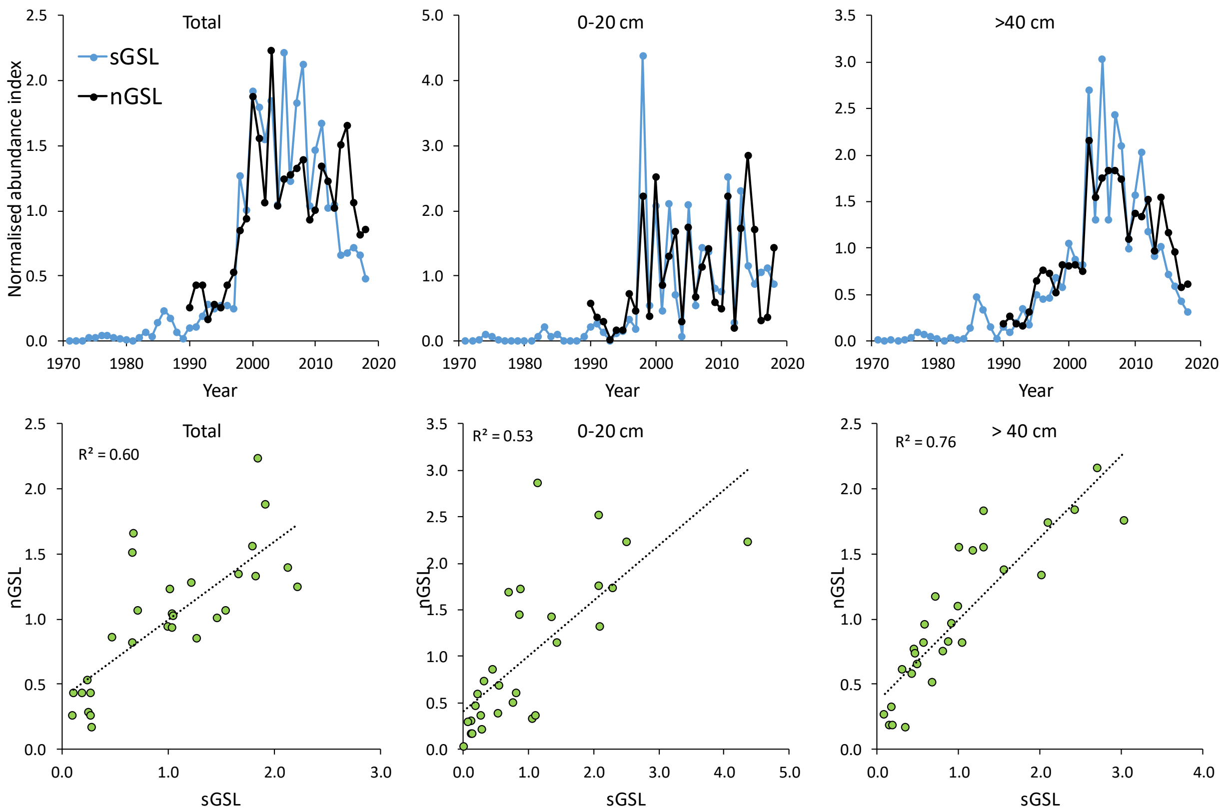


Figure 50. Comparison of trends in abundance indices from DFO's sGSL and nGSL surveys. The indices have been normalized to put them on the same scale. The indices in mean number per tow for the total population (top left), recruits (top centre) and fish greater than 40 cm (top right) are presented. The bottom panels show the relationship between the nGSL and sGSL indices.

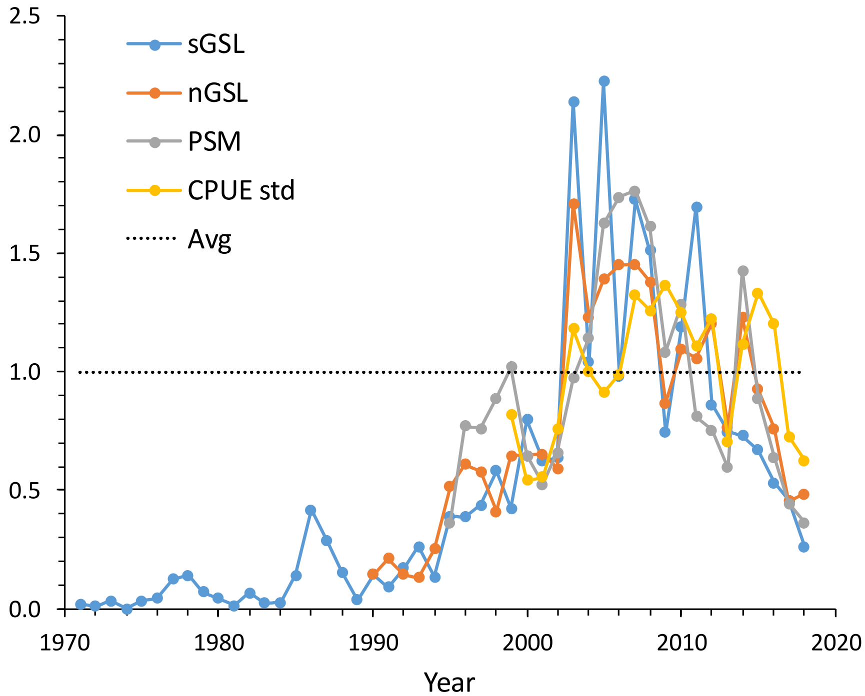


Figure 51. Comparison of standardized indices from the nGSL, sGSL and mobile sentinel surveys for Greenland halibut greater than 40 cm with the commercial fisheries performance index (standardized CPUE).

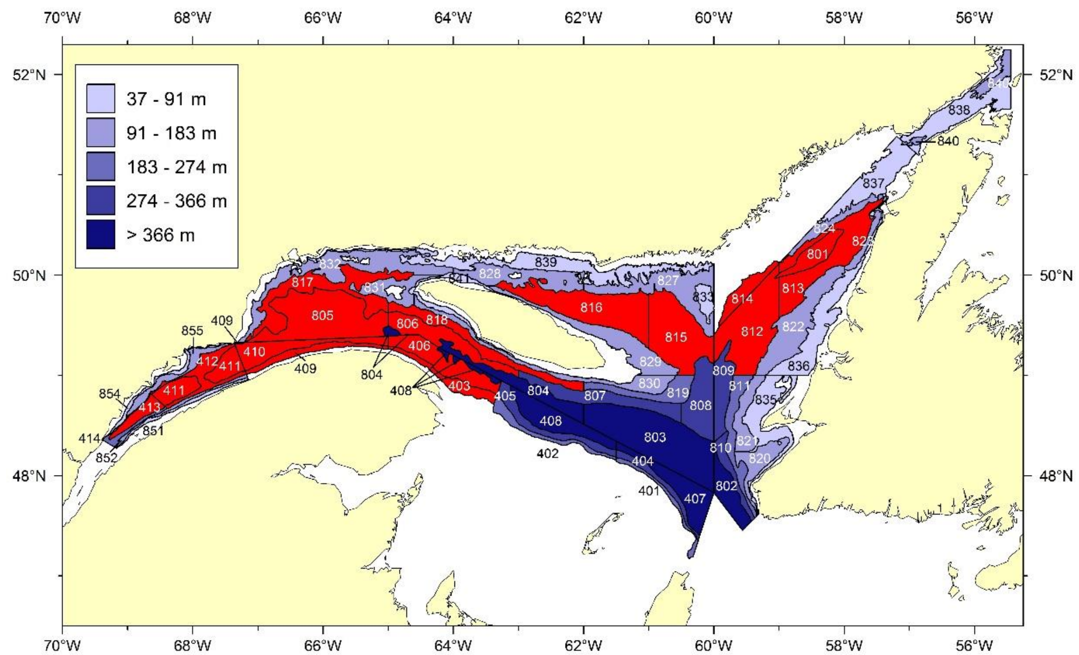


Figure 52. Identification of nGSL DFO survey strata corresponding to the commercial fishing sectors (Western Gulf (403,406,409,410,411,412,413,805,806,817,818), North Anticosti (815,816) and Esquiman (801,812,813,814).

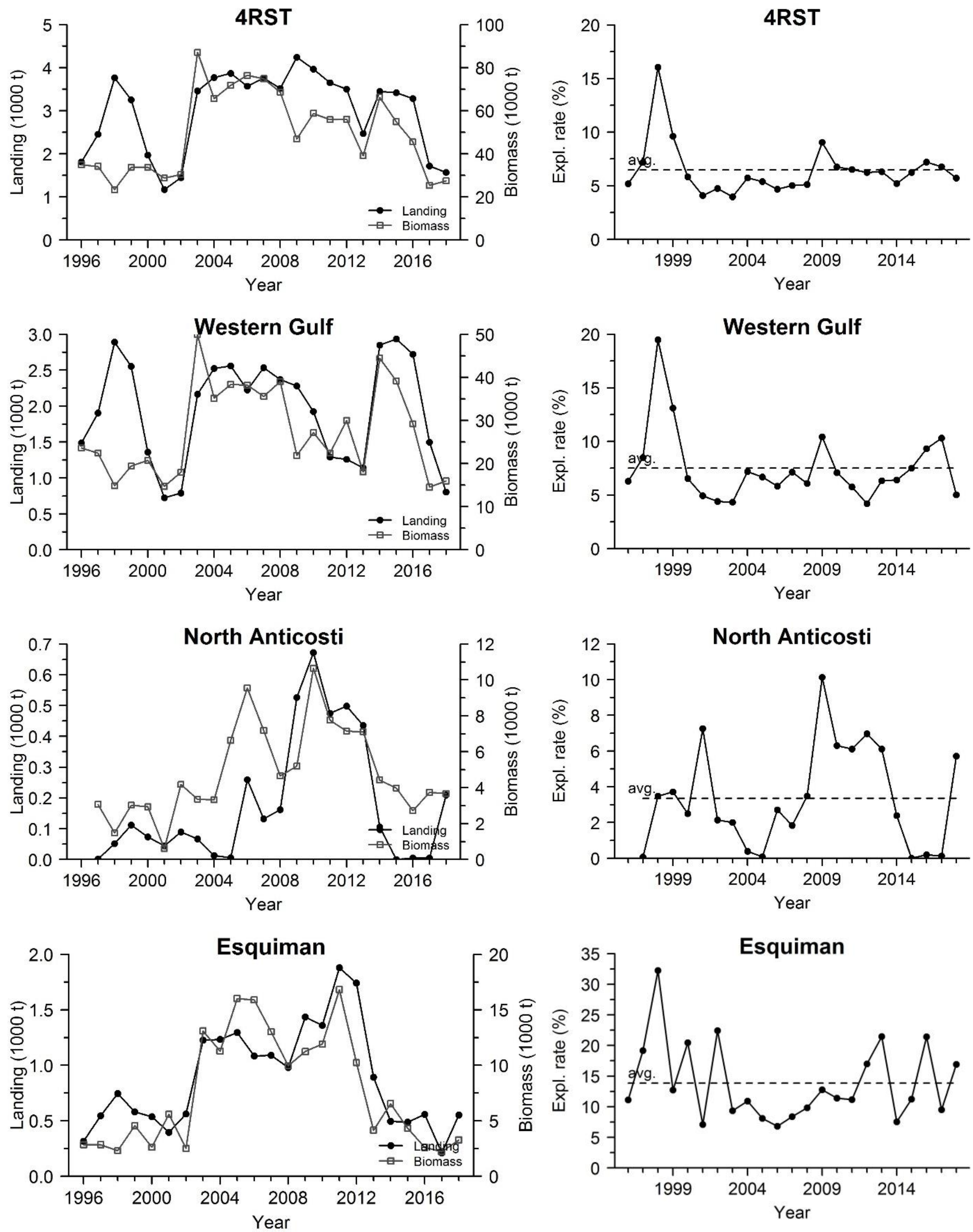


Figure 53. Annual landing and biomass of Greenland halibut greater than 40 cm and relative exploitation rate (Expl. Rate (%)) for the entire Gulf (4RST) and by fishing sector.

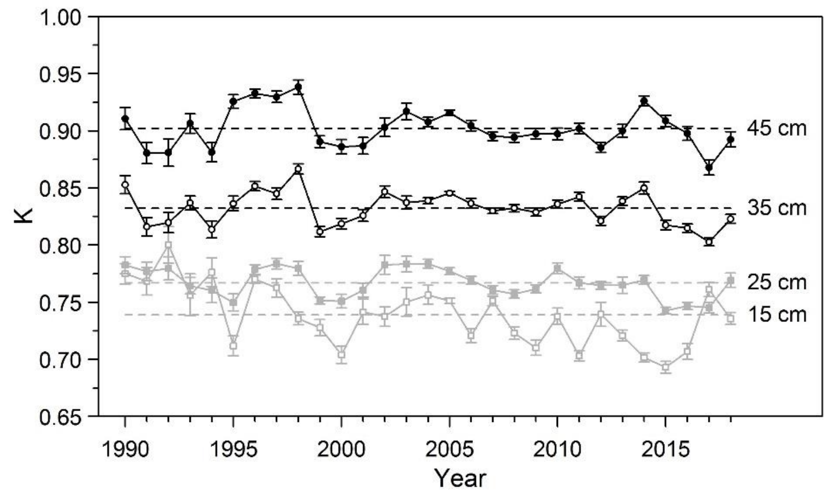


Figure 54. Annual Fulton condition index for 15, 25, 35 and 45 cm Greenland halibut measured during the DFO nGSL survey. Dotted lines represent time series averages.

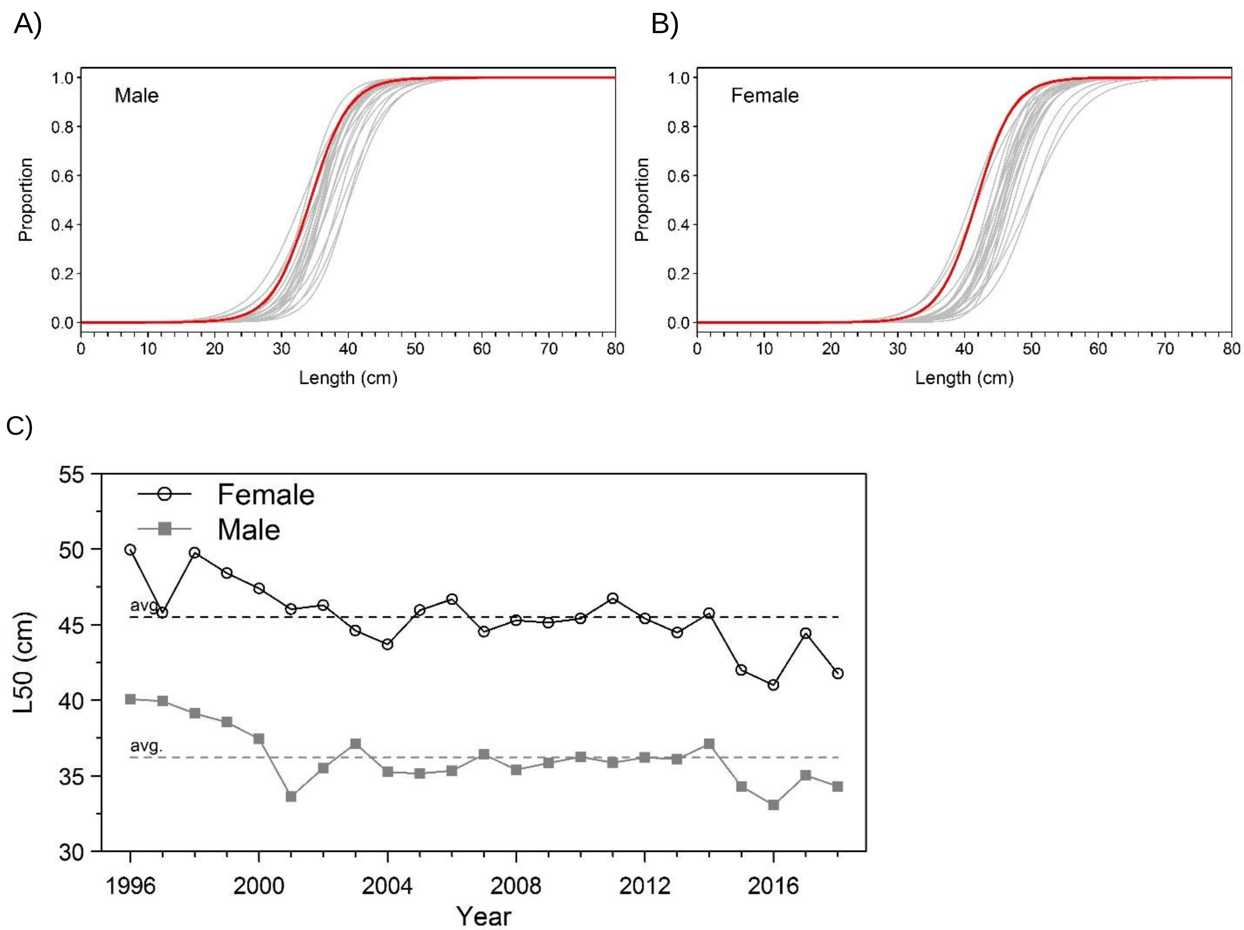


Figure 55. Maturity ogive for male (A) and female (B) Greenland halibut, the red line represents the year 2018 and the grey lines represent the years 1996 to 2017. Length at which 50% of male and female fish are sexually mature (L50) (C). This information is collected during the DFO nGSL survey.

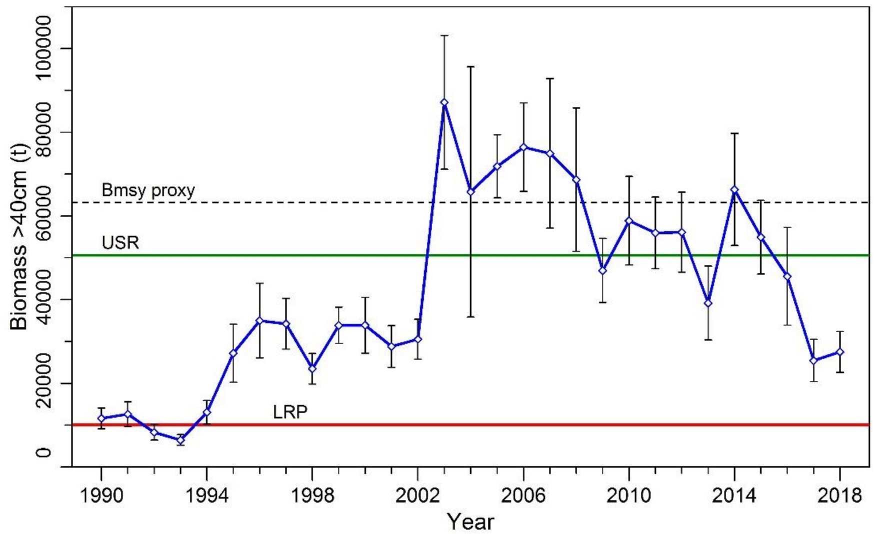


Figure 56. Annual biomass indicator for Greenland halibut larger than 40 cm based on data from the DFO nGSL research survey. The error bars indicate the 95 % confidence interval. The bottom horizontal solid line (red) locates the limit reference point (LRP, 10,000 t) as part of the precautionary approach and delineates the critical and cautious zone. The upper horizontal solid line (green) locates the upper stock reference point (USR, 50,500 t) proposed by Science and delineates the caution and healthy zone. The black dotted line indicates the proxy of biomass at maximum sustainable yield (B_{msy}).

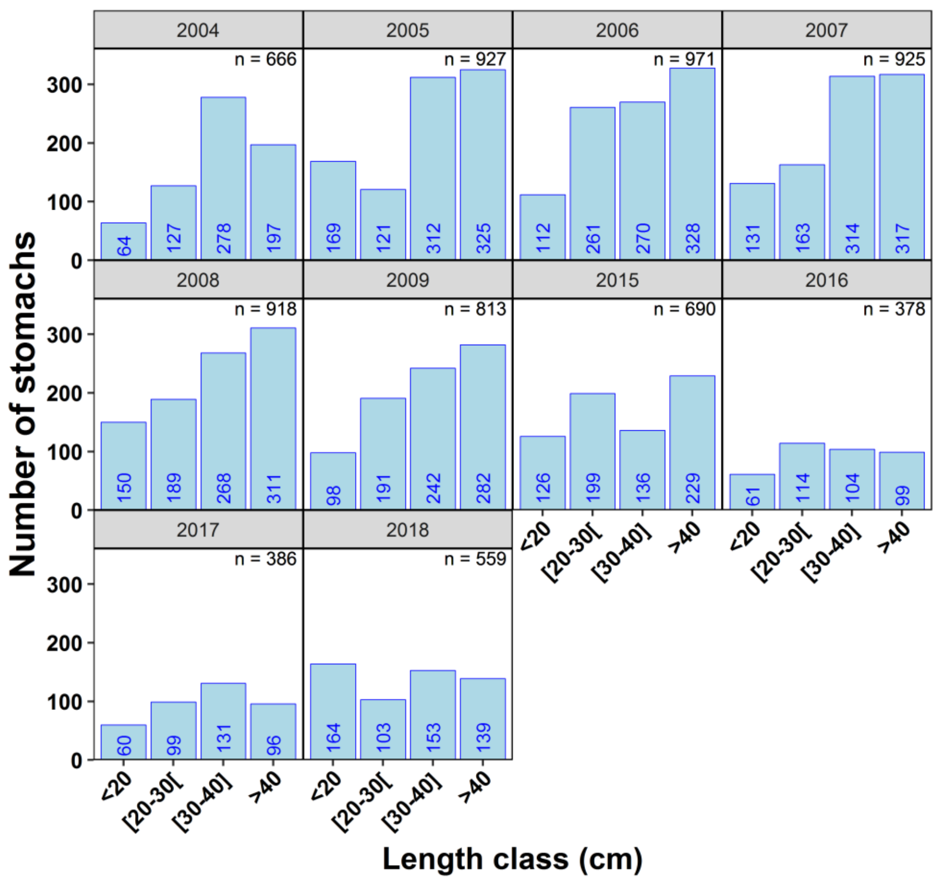


Figure 57. Number of Greenland halibut stomachs by length class and year of harvest.

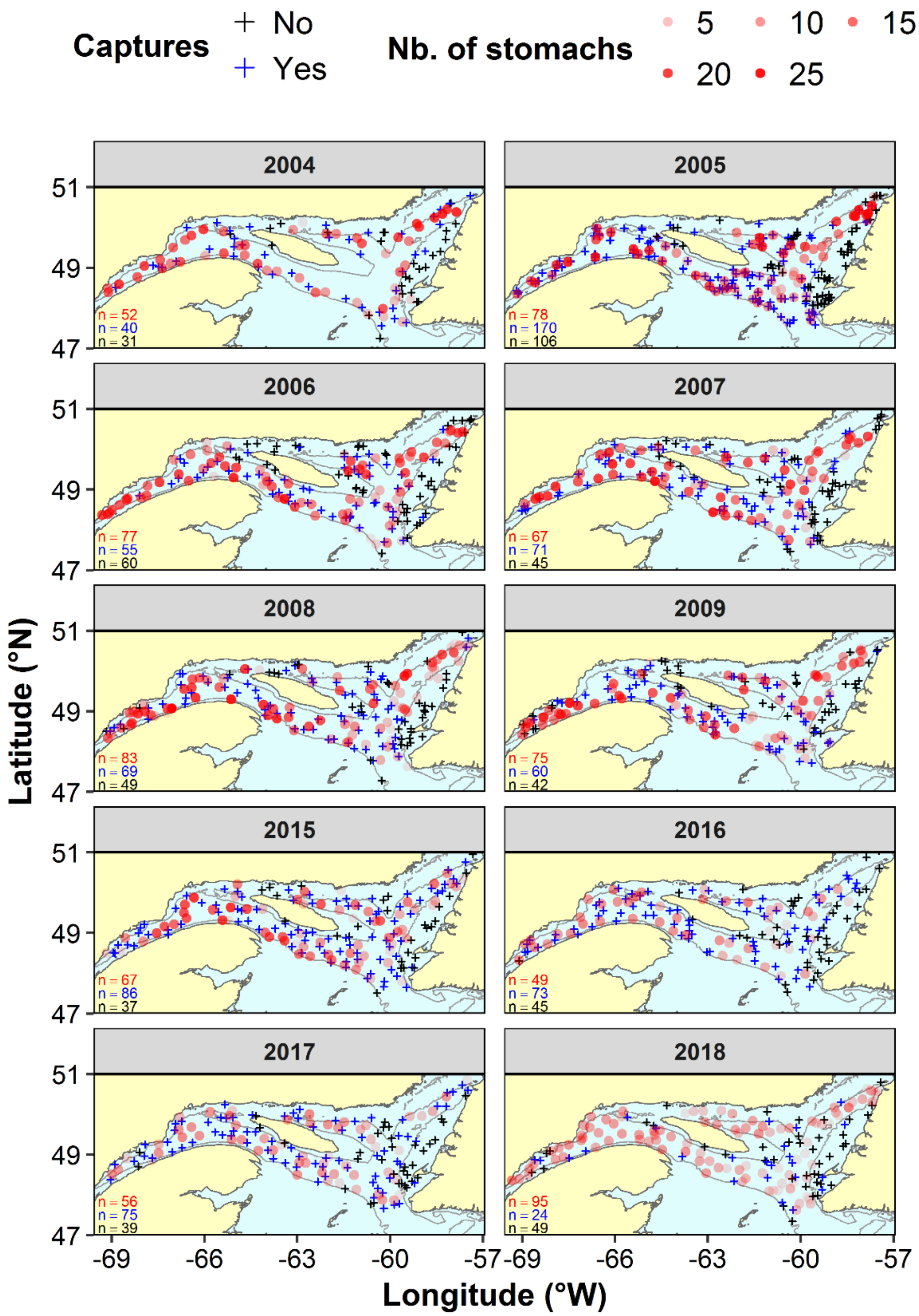


Figure 58. Sampling location of Greenland halibut stomachs retained for analysis, by year of capture. The transparency of the dots on the map reflects the number of stomachs available for analysis. The black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches. The numbers for each type of tow are provided in the lower left corners of each year.

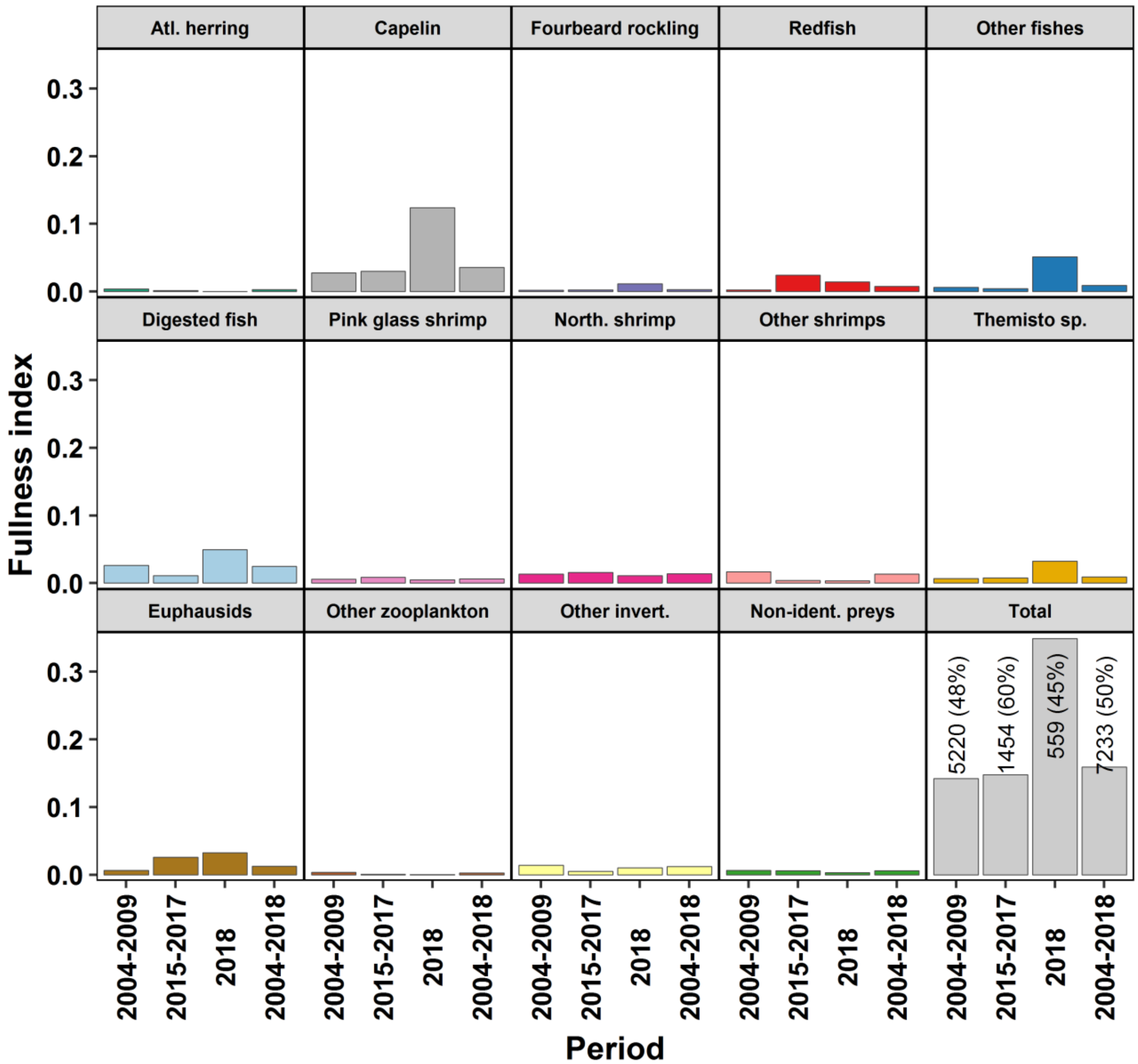


Figure 59. Fullness index of Greenland halibut stomachs by period considered, broken down by prey group. No stomachs are available for the period 2010-2014. The panel identified Total shows the total stomach fullness index for each period. The values above the bars are the sample size and percentage of empty stomachs.

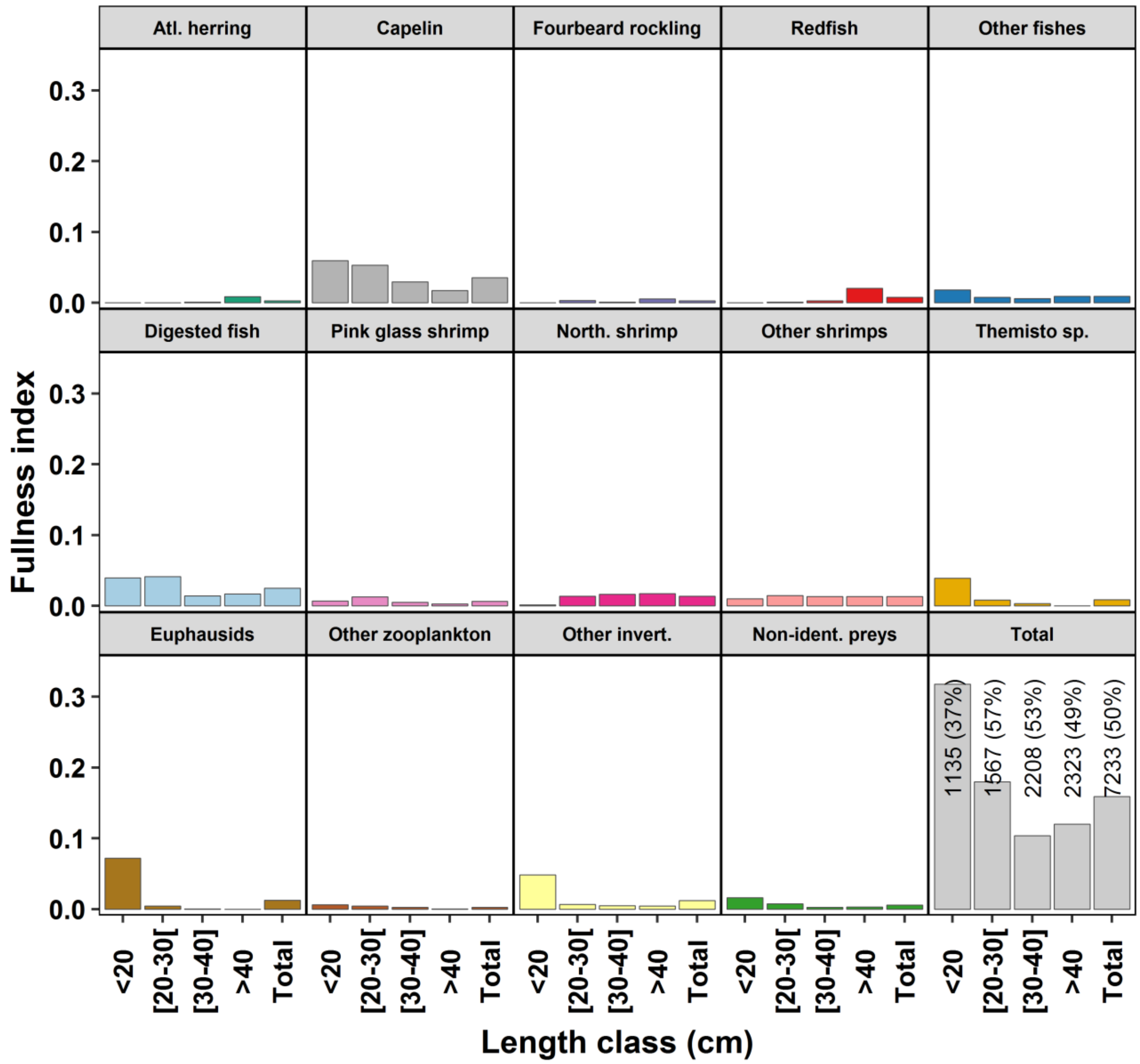


Figure 60. Fullness index of Greenland halibut stomach by length class, broken down by prey group and for all selected years (2004-2018). The panel identified Total shows the total stomach fullness index for each length class. The values above the bars are the sample size and the percentage of empty stomachs.

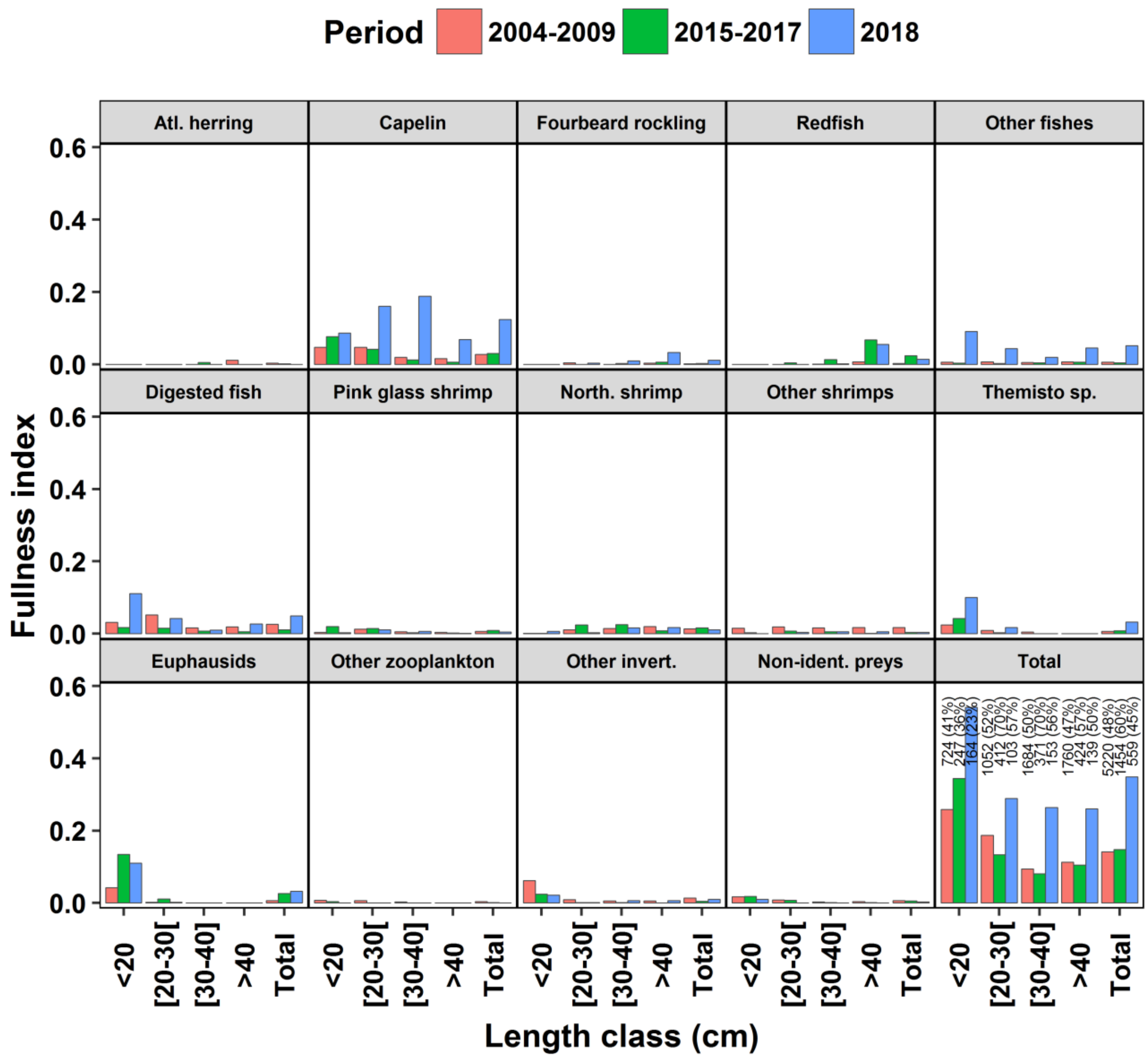


Figure 61. Fullness index of Greenland halibut stomach by length class, broken down by prey group and time period. The panel identified Total shows the total stomach fullness index for each length class. The values above the bars are the sample size and the percentage of empty stomachs.

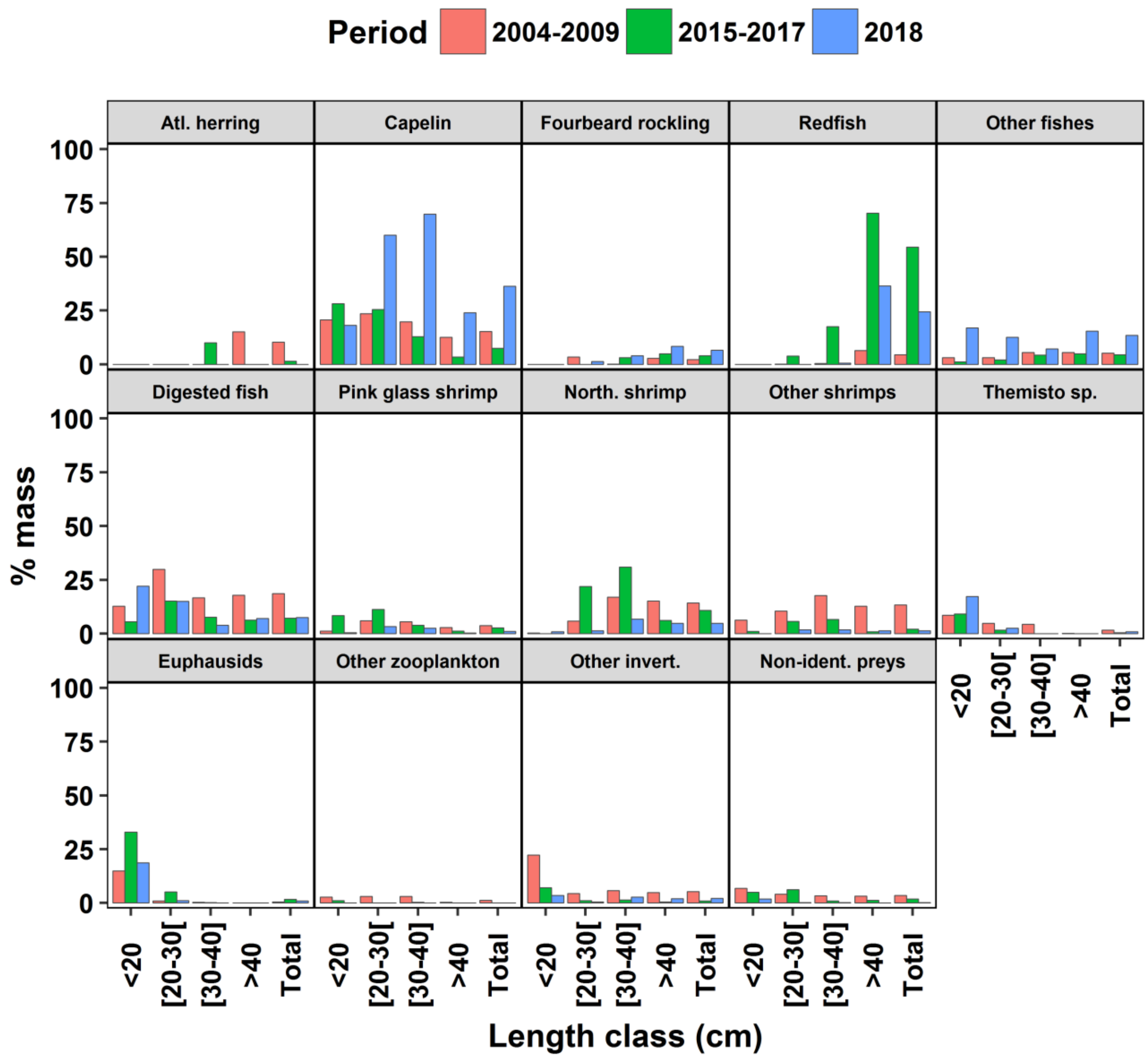


Figure 62. Percentage of mass of stomach contents of Greenland halibut by length class, broken down by prey group and time period.

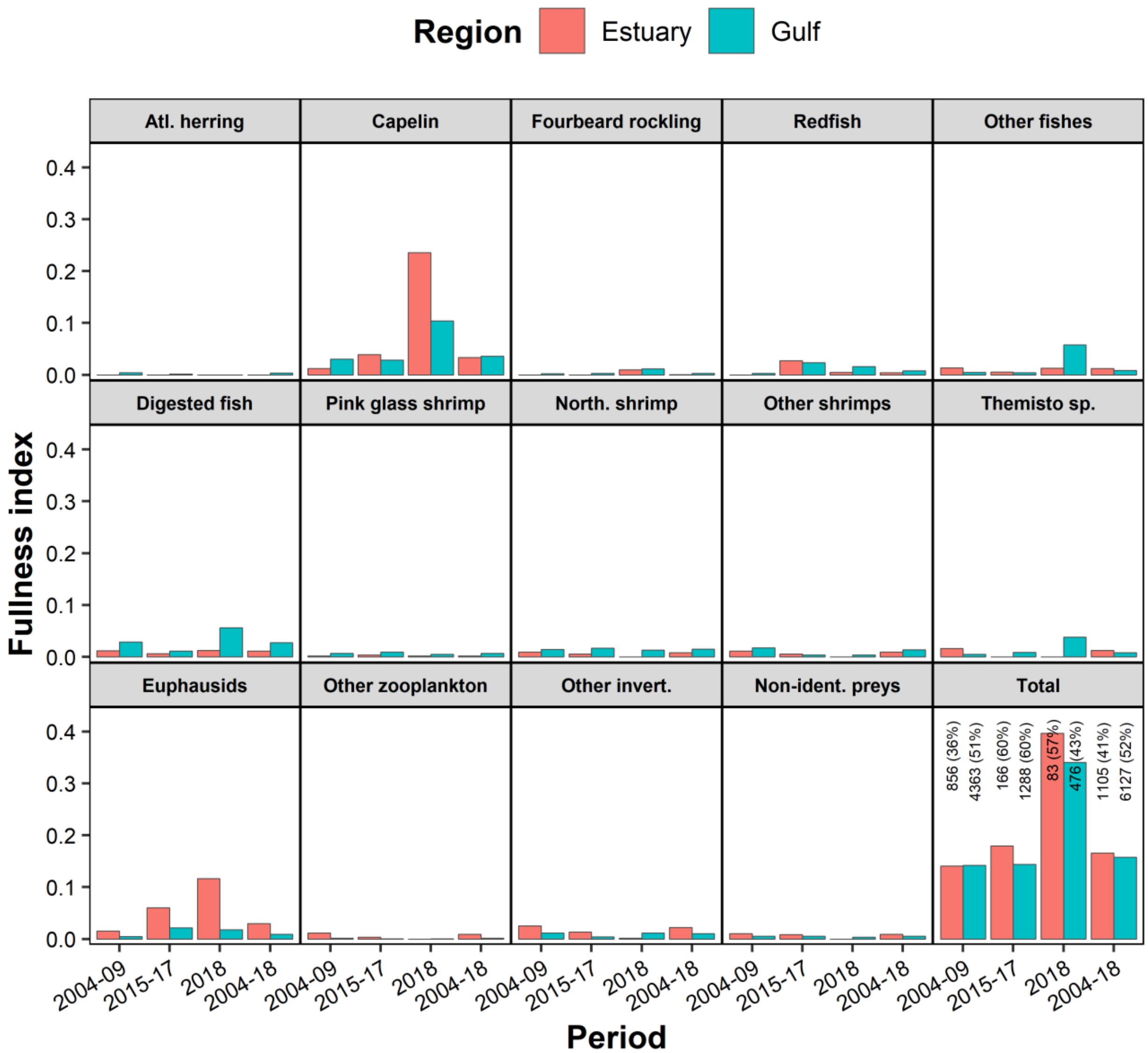


Figure 63. Greenland halibut stomach fullness index by region, broken down by prey group and time period. The lower right panel shows the total stomach fullness index for each period. The values above the bars are the number of stomachs and the percentage of empty stomachs.

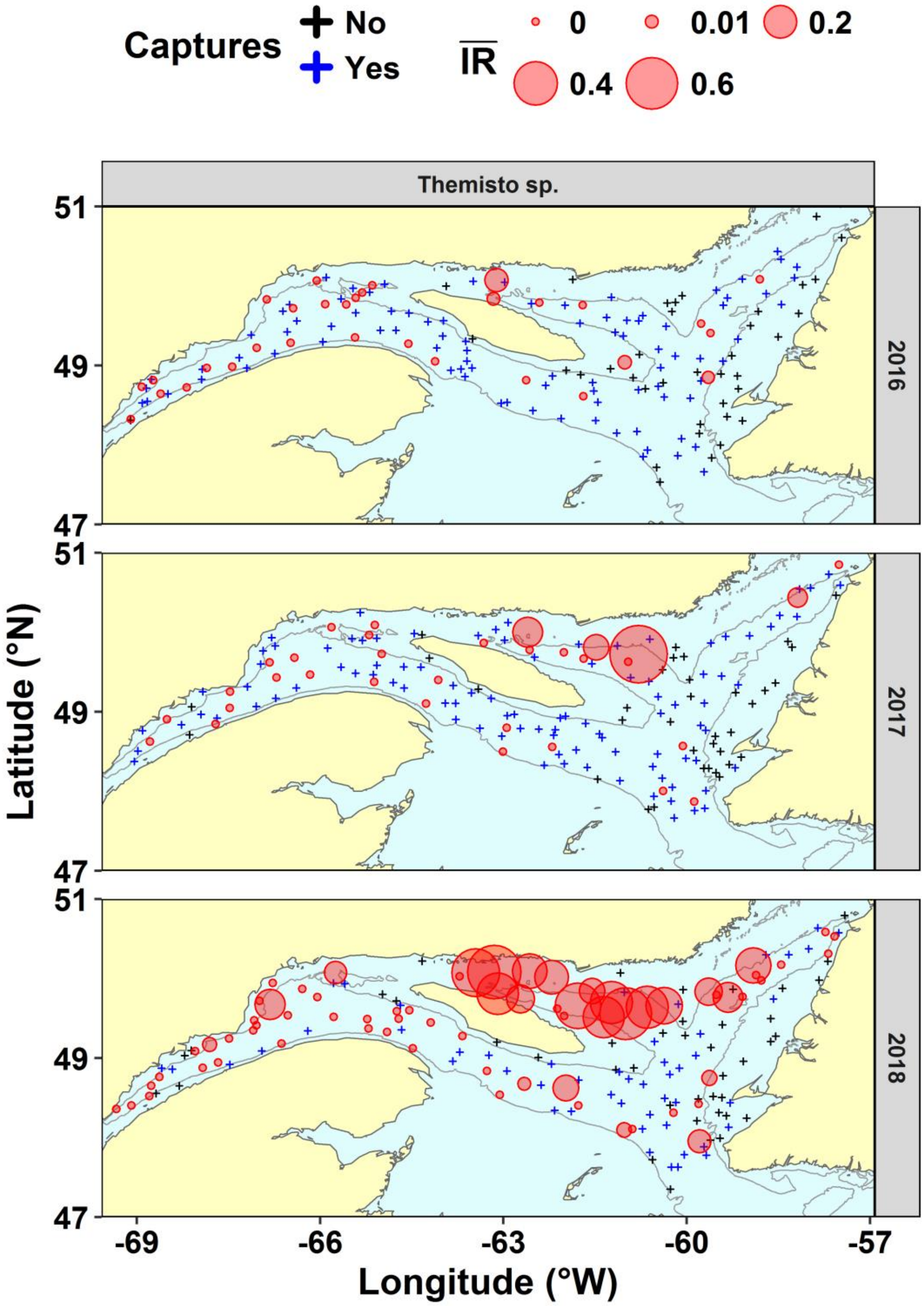


Figure 64. Average fullness index per tow in hyperides Themisto sp. for the years 2016-2018. Only stomachs from Greenland halibut <30 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

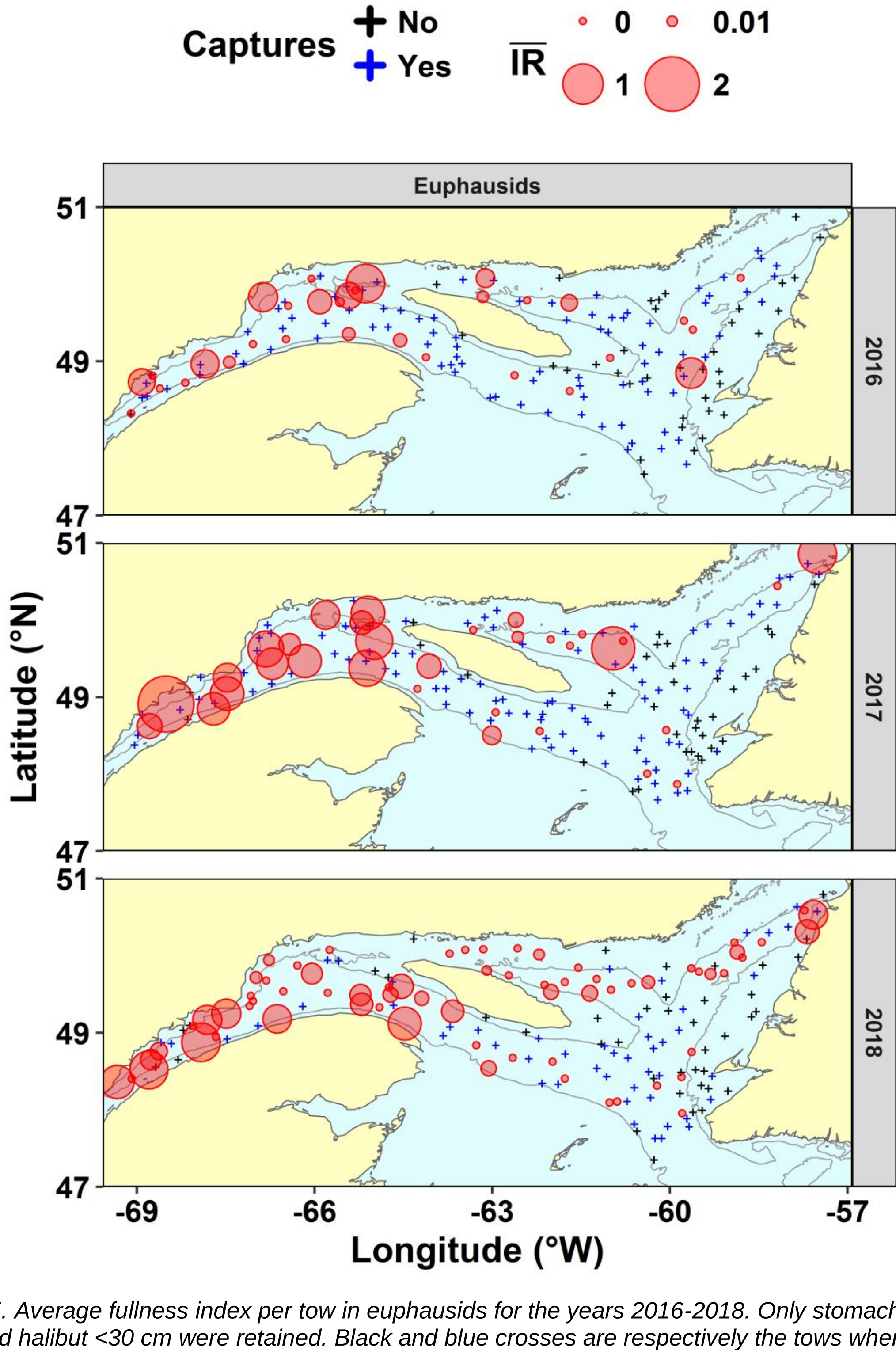


Figure 65. Average fullness index per tow in euphausids for the years 2016-2018. Only stomachs from Greenland halibut <30 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

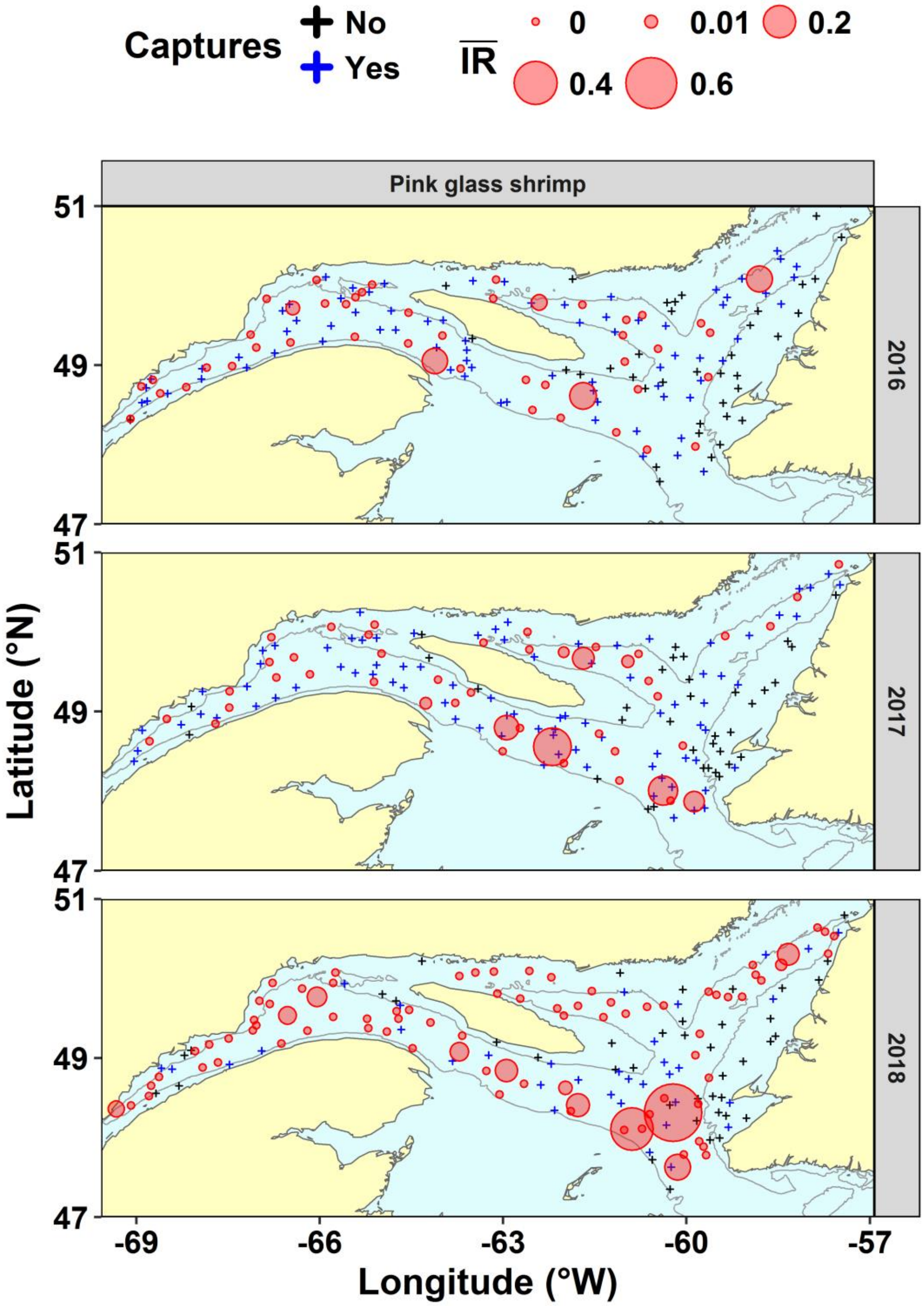


Figure 66. Average fullness index per tow in pink glass shrimp for the years 2016-2018. Stomachs from Greenland halibut of all length ranges were selected. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

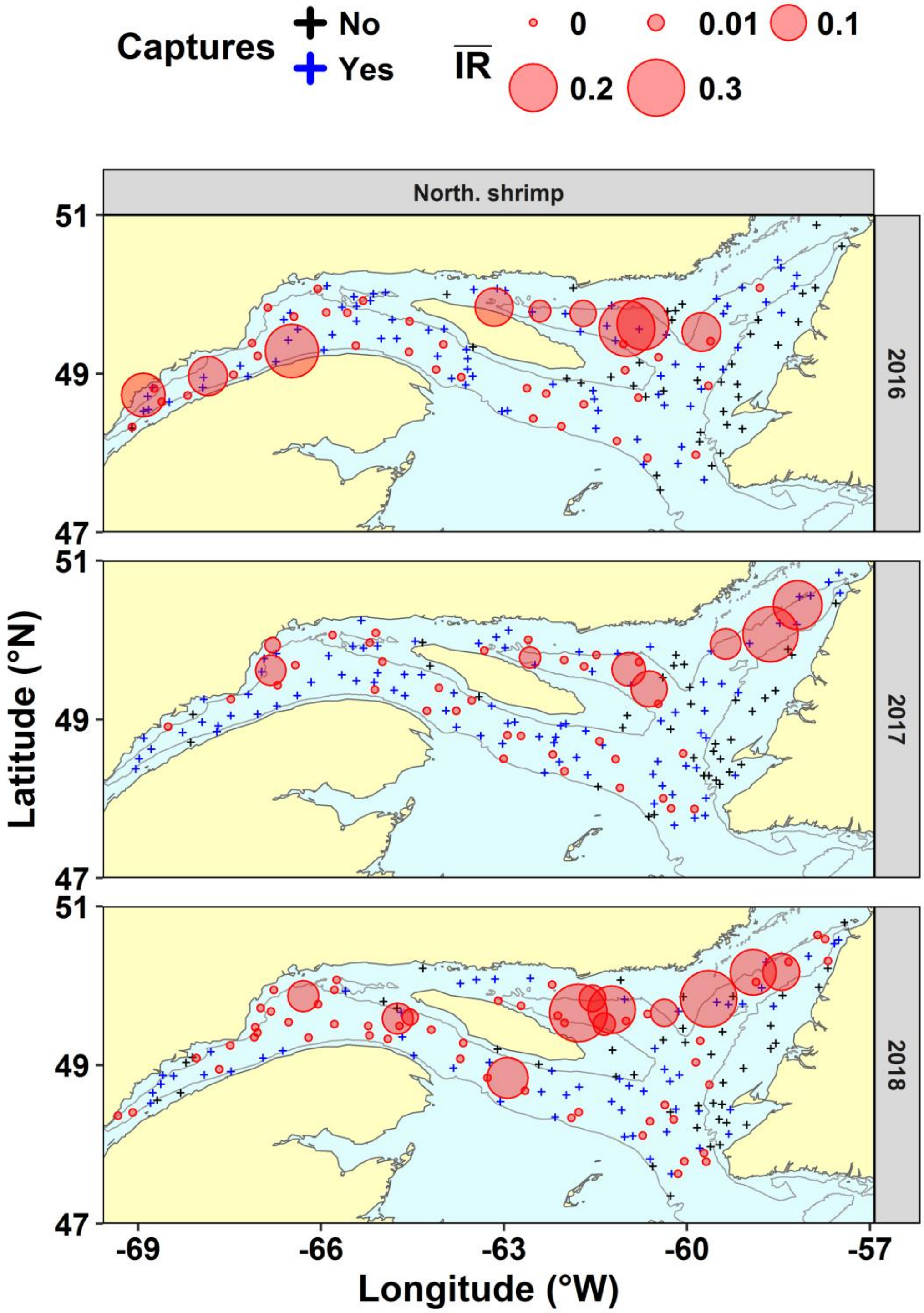


Figure 67. Average fullness index per tow for northern shrimp for the years 2016-2018. Only stomachs from Greenland halibut ≥20 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

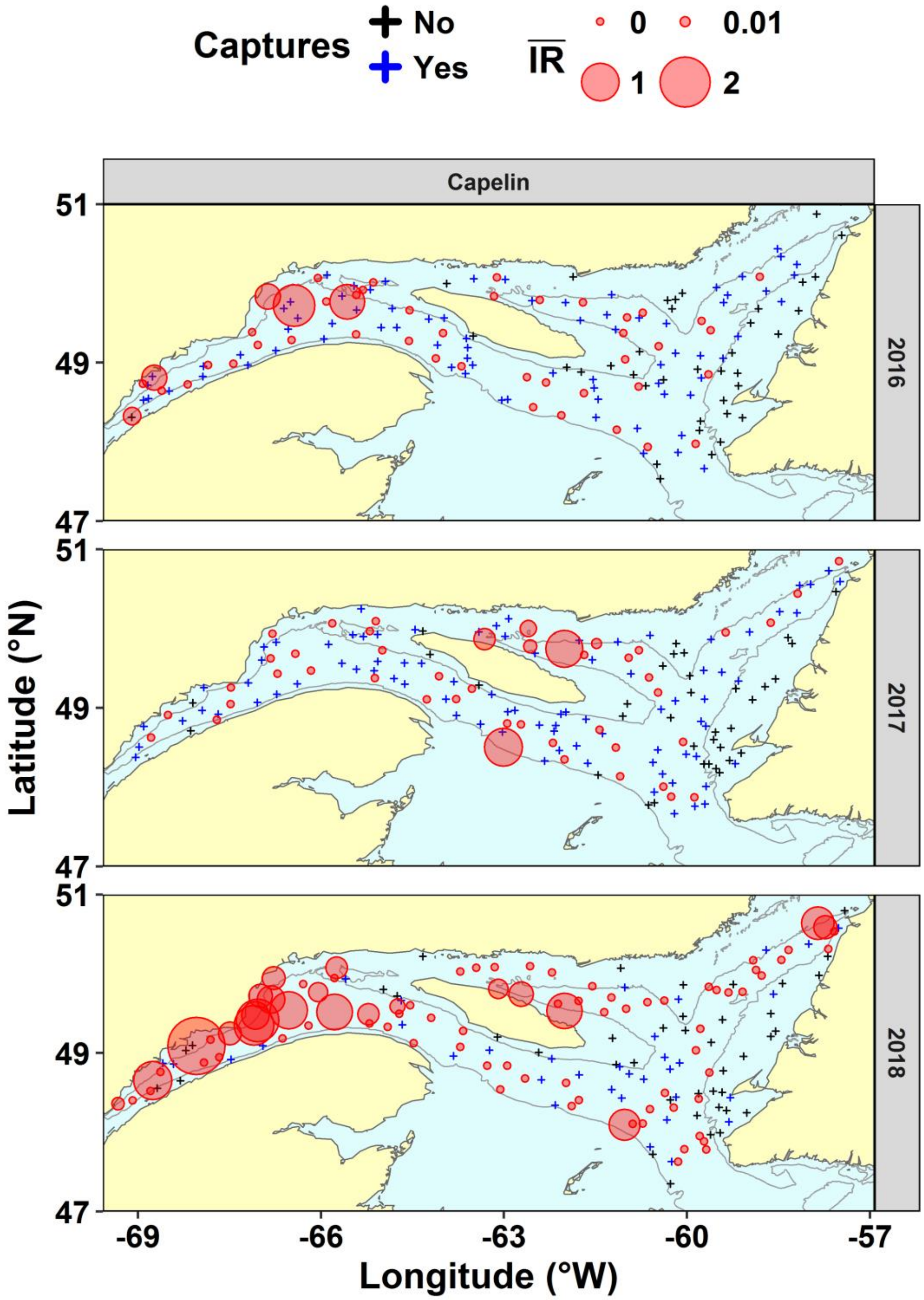


Figure 68. Average fullness index per tow in capelin for the years 2016-2018. Stomachs from Greenland halibut of all length ranges were selected. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

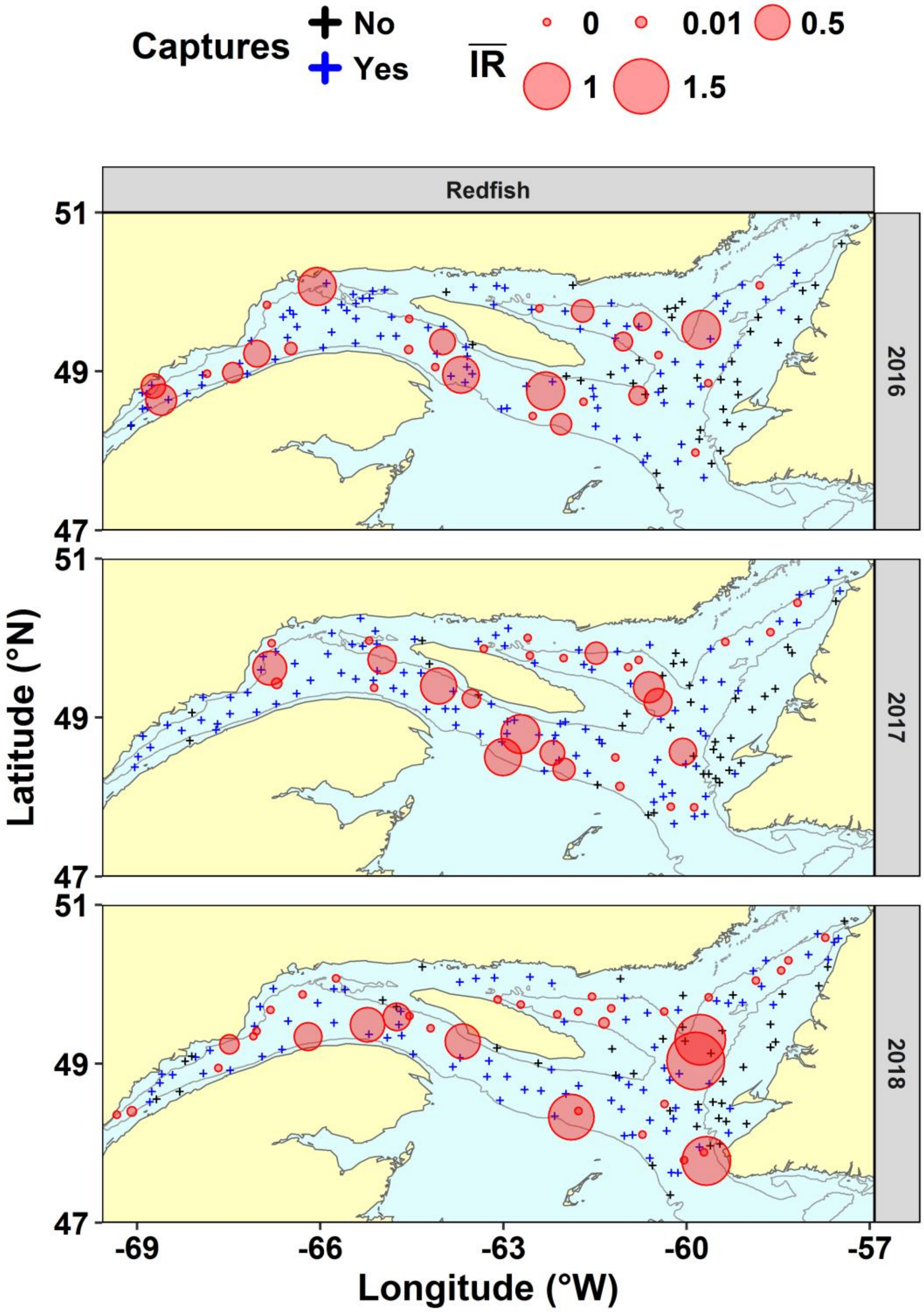


Figure 69. Average fullness index per tow in redfish for the years 2016-2018. Only stomachs from Greenland halibut >40 cm were retained. Black and blue crosses are respectively the tows where no Greenland halibut were caught and where no stomachs were harvested despite catches.

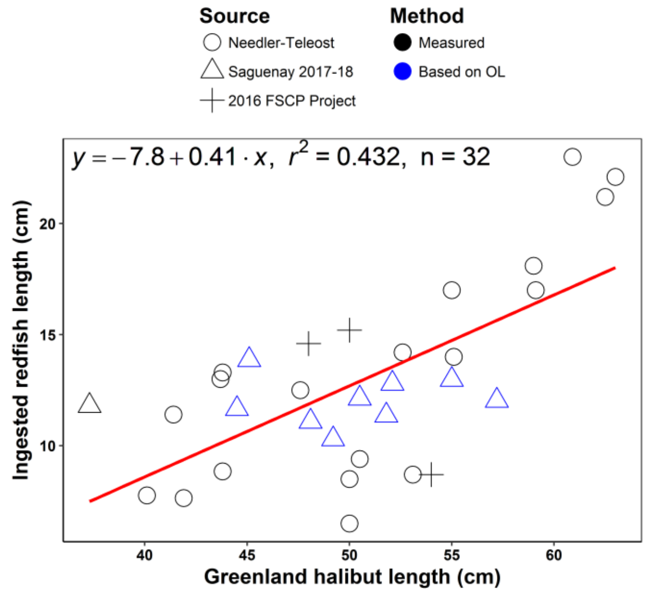


Figure 70. Relationship between the size of the predator (Greenland halibut) and the size of ingested redfish prey. Methods used to calculate redfish lengths and data sources are provided in the methodology section description of the diet.

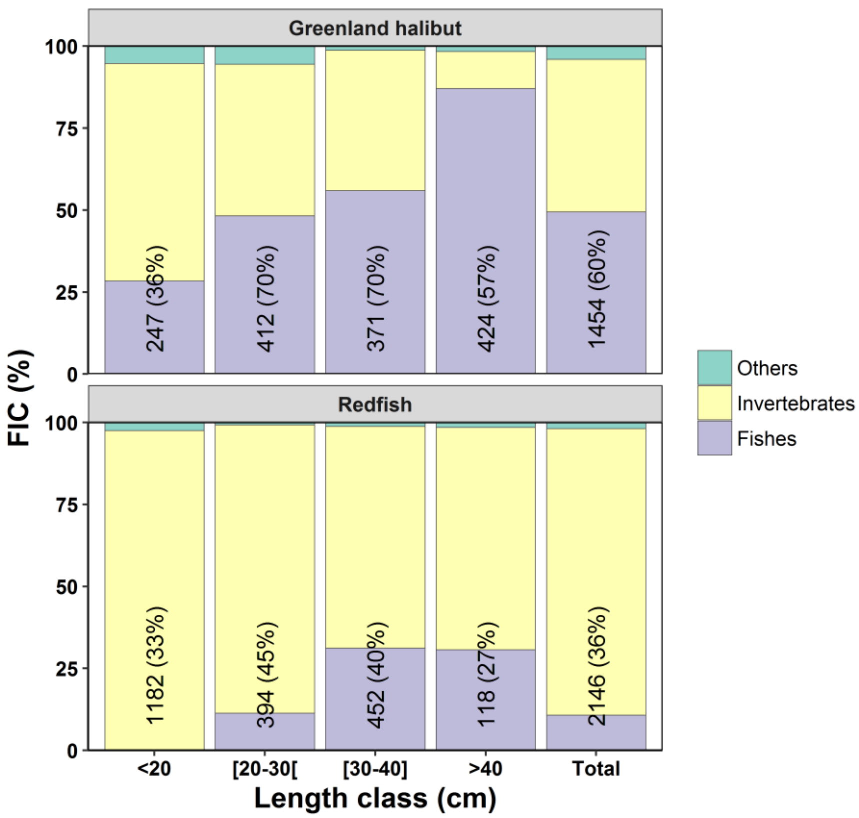


Figure 71. Contribution to the fullness index of major prey classes for the period 2015-2017, by predator, Greenland halibut and redfish, and length class. The values in the bars are the number of stomach and percentage of empty stomachs.

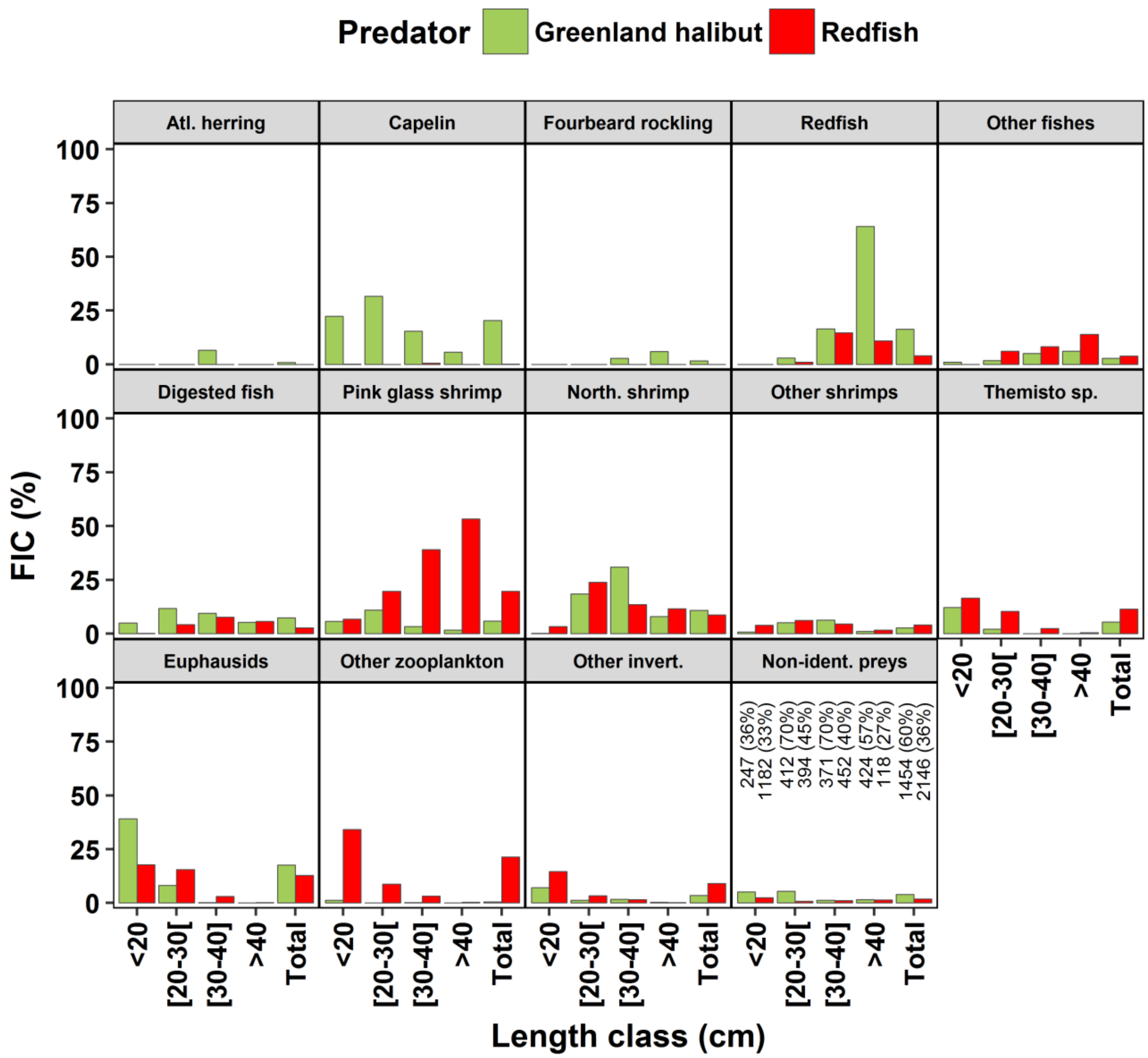


Figure 72. Contribution to the predator fullness index (FIC), Greenland halibut and redfish, for the period 2015-2017, broken down by taxonomic grouping and length class.