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Assessment of northern shrimp stocks in the Estuary and Gulf of St. Lawrence in 2021: 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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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The Estuary and Gulf of St. Lawrence northern shrimp (*Pandalus borealis*) stock status is determined every year by examining many indicators from the commercial fishery and the research survey. This document presents the data and methods that were used to produce the commercial fishery statistics from 1982 to 2021 and the indicators from the survey from 1990 to 2021. In addition, the document presents some ecosystem characteristics observed in the estuary and the northern Gulf of St. Lawrence. These can have an impact on the dynamics of northern shrimp stocks through, among other things, effects on spatial distribution, growth, reproduction and trophic relationships. The elements of the precautionary approach are also presented in this document.

INTRODUCTION

The northern shrimp (*Pandalus borealis*) fishery began in the Gulf of St. Lawrence in 1965. The exploitation is conducted by trawlers in four shrimp fishing areas (SFA): Estuary (SFA 12), Sept-Iles (SFA 10), Anticosti (SFA 9) and Esquiman (SFA 8) (Figure 1). The number of active licences for northern shrimp fishing in the Estuary and Gulf was 114 in 2021. Operators are from five provinces and seven First Nations communities.

Resource status is assessed by looking at various indicators from the commercial fishery and the DFO research survey for each of the four northern shrimp fishing areas. This document provides an update on the data and methods that were used to produce commercial fishery statistics between 1982 and 2021 and survey indicators between 1990 and 2021. The previous research paper was that of Bourdages et al. (2020).

Shrimpers must also keep a log book, have their catches weighed at dockside, and agree to have an observer on board at the Department's request (5% coverage). The season begins on April 1 and ends on December 31. The fishery has been managed by TAC (total allowable catches) since 1982, and the traditional fishers have had individual quotas since the mid-1990s. The fishery management measures include the imposition of a minimum mesh size (40 mm) and, since 1993, the compulsory use of the Nordmore grate, which significantly reduces groundfish bycatches and a protocol to limit small fish bycatch is in place since 2014 for the small groundfish (cod (*Gadus morhua*), redfish (*Sebastes spp.*) and Greenland halibut (*Reinhardtius hippoglossoides*)). Use of the Vessel Monitoring System (VMS) has been mandatory since 2012. These different data sources are used to describe fishery statistics, the distribution of fishing effort, the catch per unit effort, the numbers at length in the commercial fishery and the bycatches.

Every year since 1990, a trawl research survey is conducted in the Estuary and northern Gulf of St. Lawrence (nGSL) from a Department of Fisheries and Oceans (DFO) vessel to assess the abundance of several species, including shrimp. This ecosystemic survey aims to describe the biodiversity of Gulf species and the physical and biological oceanographic conditions. It is the main source of fishery-independent data for the stock assessment of northern shrimp in the nGSL. It also describes northern shrimp distribution, estimates its stock abundance and biomass, and reveals its population dynamics. The survey is deemed to effectively cover the entire distribution range of *P. borealis* in the nGSL. Northern shrimp is typically confined to bottoms lying below the cold intermediate water layer at depths greater than 150 m.

The essential elements for establishing a precautionary approach were adopted in 2012 (Savard 2012). The main stock status indicator is calculated using the male and female indices obtained from the commercial fishery in the summer (number per unit effort for June, July and August) and from the research survey (abundance in August). Reference points were determined and harvest guidelines were established according to the main indicator and its position in relation to the stock status classification zones (healthy, cautious and critical). The guidelines are in keeping with the precautionary approach. Once the harvest has been projected, Fisheries Management applies decision rules to calculate the TAC (Desgagnés and Savard 2012; Bourdages and Desgagnés 2014).

This document also describes several environmental and ecosystem characteristics observed in the nGSL which can have an impact on the dynamics of northern shrimp stocks by affecting spatial distribution, growth, reproduction and trophic relationships.

BIOLOGY AND ENVIRONMENT

Out of the 27 shrimp species listed in the Estuary and northern Gulf of St. Lawrence, the northern shrimp is by far the most abundant (Savard and Nozères 2012). Shrimps are forage species (Policy on New Fisheries for Forage Species). They play a key role in the ecosystem, acting as an intermediary in the transfer of energy from the lower trophic levels (e.g., zooplankton) to the higher ones (predators such as fish, marine mammals and seabirds). Ecological relationships (e.g., predator-prey and competition) must be maintained among the species affected directly or indirectly by the fishery within the bounds of natural fluctuations in these relationships.

LIFE CYCLE

The northern shrimp, *Pandalus borealis*, is a protandrous hermaphrodite species. In other words, individuals first reach sexual maturity as males, then change sex and become females. This feature of the life cycle is very important for the development of harvest strategies since larger individuals targeted by the fishery are the bigger male and female.

In the GSL, shrimp larvae hatch in the spring, in April or May and remain pelagic for several months (Figure 2). At the end of the summer, larvae increasingly resemble adults and adopt suprabenthic (bottom-based) behaviour. These postlarvae and juveniles are too small to be caught by commercial fishing trawls. Juveniles reach male sexual maturity during their second year. Spawning occurs in the fall and males may spawn 2 or 3 years prior to changing sex, which occurs in winter at age 4 or 5, at around 21 mm carapace length. Newly transformed females are easily recognized in spring and summer commercial catches as they have retained some male sexual traits. These females are called primiparous females and spawn the very next fall (September or October) after the sex change. Females carry their fertilized eggs under their abdomen during the incubation period which lasts about 8 months. The larvae hatch the following spring. Spawning females that survive reproduction are recognizable to those who have never spawned and are called multiparous females (Hansen et Aschan 2001). In fact, primiparous and multiparous females can be distinguished by morphological characteristics (sternal spines) that disappear in the prenuptial moult. Females can spawn at least twice and the estimated longevity of GSL shrimp is about 7 years.

REPRODUCTIVE CYCLE

Environmental conditions influence the reproductive cycle of shrimp. Spring hatching must be synchronized with the spring phytoplankton bloom. In addition, bottom water temperatures influence the duration of egg development on the female abdomen. Different populations of northern shrimp (*P. borealis*) have adapted to local temperatures and bloom times, matching egg hatching to food availability under average conditions (Koeller et al. 2009). However, this strategy is vulnerable to interannual oceanographic variability and long-term climate change.

Monitoring of the reproductive cycle in the area of Sept-Iles is made from samples collected during fishing (see section commercial catch sampling). The proportion of egg-bearing females (females carrying eggs under the abdomen), the number of egg-bearing females on the total number of females, is determined for each sample. As the proportion of females in maturation is determined by comparing the number of female with green head compared to the number of females excluding egg-bearing females. The date in fall when 50% of females are carrying eggs (spawning) as well as the date in spring when 50% of females have released their eggs (hatching) are determined based on the adjustment of the logistic function (Figure 3). The date when 50% of females are undergoing maturation is also determined (Figure 3).

The bottom waters of the GSL where the northern shrimp are found have warmed in recent years, so we expected to see changes in the reproductive cycle. Maturation of females normally takes place at the end of June, from 2013 maturation began to be delayed in time and in 2021 maturation took place at the end of July, which is one month later than normal (Figure 4). Thereafter, normally spawning takes place at the end of September, but it was delayed by more than 25 days in 2015 to 2017. From 2018 to 2021, maturation and spawning took place two weeks earlier than in 2017, a return to dates closer to normal. We know that in August of the last four years, part of the female population has moved to shallower depths where the water is colder, which could perhaps explain this return to normal. The hatching of larvae in the spring is more stable in time, around the end of April to coincide with the start of the spring phytoplankton bloom.

Changes in shrimp phenology appear to be related to increasing deep water temperature. Maturation and spawning are delayed by several days and larval development time is shorter. Thus, the timing of larval hatching varies little and remains synchronized with the spring bloom of phytoplankton.

BEHAVIOUR

Shrimp start being caught by commercial trawls when they are males and reach a carapace length (CL) of about 15 mm. The probability of trawl capture increases with size, and individuals are fully recruited to the fishery at about 22 mm (LC). Therefore, the proportion of male and female individuals caught by fishers varies according to the catch period and location. Indeed, shrimp migratory movements are well known to fishers, who have adapted their fishing patterns to their benefit. Fishers typically try to maintain high catch rates and maximize catches of large shrimp while minimizing bycatch of other species.

Every year, shrimp migrate to reproduce. In late fall and early winter, berried females (females carrying eggs under the abdomen) begin to migrate to the shallower areas of their distribution range. In spring, they gather at sites suitable for releasing the larvae while the males are still scattered throughout the distribution range. Fishers take full advantage of this spring gathering of berried females to obtain high yields. Once the larvae have been released, the females molt and then disperse to deeper areas (200 to 300 meters) of the distribution range. Shrimp are also distributed differently according to the age of individuals. Typically, young shrimp are found in shallower areas, often at the heads of channels, whereas older individuals, females, are found in deeper waters. Young shrimp concentrations in shallower water are also denser than large shrimp concentrations in deep water.

The composition of spring commercial catches often closely reflects this distribution pattern. Because spring catches occur in shallower water, they often consist of 2 groups of individuals: berried females and very small males.

Shrimp also perform daily vertical migrations. They leave the bottom at night to rise in the water column to feed on plankton, and then return to the bottom during the day. The scale of vertical migrations varies depending on the individual's developmental stage and local conditions. For example, small shrimp appear to leave the bottom earlier and rise higher in the water column than do larger females. Although yields may be lower at night, the mean catch size should be higher because of the lower proportion of males in catches. What’s more, it may be advantageous to fish at night to avoid bycatch of capelin, which also leaves the bottom at night.

The variations in female sizes follow an east-west gradient, the smallest being observed in the Esquiman Channel and the largest, in the Estuary. It is worth noting that, as individual fecundity increases with size, egg production by an equal number of females will theoretically be lower in the east. The number of individuals for a single unit of weight also varies by SFA. The number of shrimp per kg depends on 2 factors: the fishing pattern influencing the proportion of males in catches; and, the mean size of females. The number of shrimp per kg is increasing from west to east because the proportion of males in commercial catches is increasing while the size of females is decreasing.

PREDATORS

The ecosystem, dominated by groundfish until the early 1990s, has transitioned to an ecosystem dominated by forage species. Thus, following the decline in the abundance of large groundfish species, the shrimp population increased from the 1990s to the 2010s. Redfish and Atlantic halibut are currently increasing in abundance whereas northern shrimp and Greenland halibut are declining (Figure 5). Three strong cohorts (2011, 2012 and 2013) of deepwater redfish (*Sebastes mentella*) have contributed to the increase in redfish abundance since 2013. The redfish population now has a higher biomass than in the early 1990s (Figure 6-7). The 2011 cohort, which is the most abundant, now has a modal length of 24 cm and is distributed throughout the deep channels of the northern Gulf and to a lesser extent in the Estuary (Figure 8-9).

Trophic changes could be observed in the coming years, with shrimp forming part of the diet of many species.

Predator diets

Redfish (species not specified) and Greenland halibut are the two main predators of northern shrimp in the GSL (Savenkoff et al. 2006). Stomachs from these predators were collected at different times during missions on board DFO vessels. The stomachs were analyzed in the laboratory and the data archived in a database. Diet analysis was conducted according to the methodology detailed in Ouellette-Plante et al. (2020).

Greenland halibut has a diverse diet. The composition of the diet of these fish varies with their size (Gauthier et al. 2021). Nearly 20,500 stomachs of Greenland halibut have been collected over the past three decades. For the diet analysis, the stomachs were sorted into three groups by period (1990s, 2000s and 2015–2021) to determine whether consumption of northern shrimp has changed over time. Findings showed that northern shrimp comprise a very small part of the diet of one-year-old Greenland halibut (less than 20 cm long), contributing <1% to the total fullness index (TFI), regardless of the period (Table 1, Figure 10). Northern shrimp are more commonly observed in the stomach contents of two-year-old Greenland halibut (20–30 cm). This increasing frequency of occurrence is observed across the periods studied, rising from 1% in the 1990s to 3% in the 2015–2021 period. The TFI follows a similar pattern: 3% during the 1990s, 5% in the 2000s and 9% in the most recent period. For Greenland halibut ≥3 years old (longer than 30 cm), northern shrimp alone accounts for more than 10% of the Greenland halibut’s total fullness index, which is significant, considering the tens of different prey items that have been observed in halibut stomachs over the years. Northern shrimp was a more important component of the diet of Greenland halibut during the 2000s than during the other two periods. It should be noted that the abundance of northern shrimp in the GSL was at a peak in the 2000s (Gauthier et al. 2021).

The diet of small redfish is based on zooplankton, with redfish consuming progressively more shrimp and fish as their length increases. (Senay et al. 2021). Unlike the case for Greenland halibut, no redfish stomach content data are available for the 2000s. The number of stomachs reported in the ecosystem surveys conducted during the 1990s, 2015–2018 and 2019-2021 periods were 3,321 3,120 and 2,050 stomachs, respectively (Table 1, Figure 11). The recent period (2015-2021) has been divided into two to help visualize potential changes in the diet of redfish according to the evolution of the size of the stock.

For redfish less than 25 cm long, northern shrimp were present in less than 1% of the stomachs analyzed, regardless of the period. For redfish 25 cm and longer, during the 1990s the occurrence of northern shrimp in the diet increased with the size of the fish, from 1.5% to over 20% for fish longer than 45 cm. For redfish > 25 cm, the occurrence varies between 5.5% and 10% for 2015-2018 and between 2.6% and 14.5% for 2019-2021. Shrimp consumption increases with length only for the 2019-2021 period with a maximum occurrence of shrimp in fish of 35 to 40 cm in length. A significant decrease in occurrence is then observed for redfish over 40 cm. The mass contribution (MC) and TFI of northern shrimp were low (< 6%) in the diet of redfish less than 25 cm long. For redfish longer than 25 cm, during the 1990s the TFI increased with length from 10 to 21%. For the most recent period, the TFI of Northern Shrimp for 2015-2018 is the highest for the 25-35 cm and 30-35 cm length classes. It is estimated at 26.5% and 29% respectively, while it is less than 13% for redfish over 35 cm. For 2019-2021, the TFI of northern shrimp for redfish less than 35 cm is slightly lower than for 2015-2018 but increases thereafter to reach 56% for redfish between 35 and 40 cm. It then decreases for 40 to 45 cm fish to reach a similar value (~25%) for the 25 to 30 cm and 30 to 35 cm classes. Northern shrimp seems to play a more important role in redfish over 35 cm for the 2019-2021 period than the 2015-2018 period.

Based on the diet of redfish, annual consumption of northern shrimp (Q) was estimated for the years 2015 to 2021 in comparison with the 1997 to 1999 period (before the advent of the strong 2011 to 2013 cohorts). Consumption was calculated using the following equation:

$$Q = B \cdot P \cdot \frac{Q}{B}$$

where *B* is the redfish biomass estimate (based on the DFO ecosystem survey), *P* is the proportion (based on MC) of northern shrimp in the redfish diet and *Q/B* is a theoretical redfish consumption ratio. The *Q/B* ratio values stem from the ecosystem models available for the nGSL for different periods: 1.036 for the 1990s and 0.75 for recent years (Savenkoff et al. 2004; Savenkoff and Rioual [DFO, unpublished data]).

Redfish captured for the purpose of studying their diet are representative of the entire northern Gulf and the Estuary, which encompasses the areas fished by shrimpers (Figure 12). Consumption estimates were derived on the basis of redfish length classes (5 cm intervals), and were then added together to obtain a value for total consumption. Consumption was roughly 10,000 t between 1997 and 1999; since 2017, this value has risen every year, increasing from 44,800 t to 214,000 t in 2021 with the exception of 2020 where consumption was lower than the previous year (Figure 13 and Figure 14). This difference can be explained by the increase in length of strong redfish cohorts and the increasing proportion of northern shrimp in the diet of redfish. The level of uncertainty surrounding these estimates is high. Sampling redfish stomach contents is difficult owing to the regurgitation issues caused by rapid changes in pressure that occur as the trawl is raised from the depths. In addition, redfish biomass estimates from the scientific survey are relative, as the values are not adjusted for trawl catchability. Lastly, the values of the *Q/B* ratios used to estimate consumption derive from ecosystem model estimates, not from actual measurements of redfish energy requirements based on length. Although these numbers are not precise, it is clear that northern shrimp consumption has increased in recent years. Moreover, because the redfish population is continuing to expand, redfish predation will continue to have an impact on northern shrimp in the coming years. However, the impact of this phenomenon may be lessened if the spatial overlap between northern shrimp and redfish diminishes owing to the expected migration of adults *S. mentella* individuals to depths of over 300 m.

ENVIRONMENTAL CONDITIONS

The deep-water layer (>150 m) of the GSL originates from the mixing of cold, less saline and well-oxygenated waters from the Labrador Current and warmer, more saline and less well-oxygenated waters from the Gulf Stream. These waters meet outside the Gulf of St. Lawrence, entering through the Laurentian Channel and flowing to the heads of the Esquiman, Anticosti and Laurentian Channels. The flow of water between Cabot Strait and the head of the Laurentian Channel takes around three to four years. In recent decades, waters from the Gulf Stream have comprised a larger proportion of the mix of waters entering the Gulf, which has led to an increase in water temperature and oxygen depletion in the bottom waters of the GSL (Galbraith et al. 2021).

In 2021, temperatures at 150, 200, 250 and 300 m have warmed reaching new records since 1915 in the four ecoregions that cover nGSL shrimp stocks (Figure 15). The area of the seabed covered by waters with a temperature greater than 6°C has increased throughout the nGSL. Part of the bottom area along the Anticosti and Esquiman channels has even been covered by waters warmer than 7°C since 2020 (Figure 16). Before 2009, bottom temperatures in these channels ranged from 5°C to 6°C.

The cold intermediate layer was much warmer in August 2021 than in August 2020, reaching the warmest values in modern CTD data. Surface water temperatures were near normal in July-August.

At 200 and 250 m, the Anticosti and Esquiman stocks are found in warmer waters than the Sept-Iles and Estuary stocks. On the other hand, at 150 m, the opposite is observed, the waters are colder in Anticosti and Esquiman since the cold intermediate layer (CIL) is colder in these regions compared to Sept-Iles and Estuary.

In recent years, deep water warming and dissolved oxygen depletion have had effects on shrimp distribution. Temperature and dissolved oxygen conditions on the seabed have changed over the last 15 years, with the magnitude of this trend varying from one area to another (Table 2, Figure 17 and Figure 18). During the 2018–2021 period, the range of depths occupied by shrimp decreased in the Estuary, Sept-Iles and Anticosti. These changes suggest a movement of shrimp from warmer, oxygen-poor bottoms to colder, oxygenated water layers, but always in association with the bottom to avoid unfavorable environmental conditions. As example, in the Estuary, from 2008 to 2017, warming (from 2.5°C to 4.2°C) and a decrease in dissolved oxygen (from 50% to 37%) occurred in the waters in which female shrimp used to be found, specifically at depths of between 110 m and 320 m. Beginning in 2018, a significant shift of shrimp to new depths was observed. They are now found closer to the CIL at depths of between 70 m and 170 m, in colder (1.4°C to 4.0°C), more oxygenated (40% to 80%) waters. The changes in depth have been less dramatic in Sept-Iles and Anticosti, where shrimp that used to be found at greater depths are also moving to shallower depths. The median depth of distribution has decreased by roughly 15 m to 20 m as the environmental conditions in which the shrimp find themselves continue to warm and deplete in oxygen in both area. Over a period of 15 years, the median temperature has increased by about 1.0°C, to over 6.0°C, and the dissolved oxygen saturation level has decreased from 30% to 23% in Sept-Iles and from 43% to 25% in Anticosti. Warming and declining oxygen levels have also been observed in Esquiman. Since 2008, the water temperature has risen from 5.1°C to 6.7°C in the areas used by females, and the dissolved oxygen saturation level has decreased from 38% to 27%. Despite these changes, no migration of concentrations of shrimp to shallower depths has been observed in this area, and the depth occupied by shrimp has not changed.

As the deep waters travel between the mouth of the Laurentian Channel and its head (located in the Estuary), in situ respiration and oxidation of organic matter cause a decrease in dissolved oxygen. Therefore, the lowest levels of dissolved oxygen are found in the bottom waters of the Estuary. In 2020, concentrations of dissolved oxygen at 300 m were again well below normal everywhere along the Laurentian Channel, reaching time-series record lows in the Estuary and at Rimouski station (Blais et al. 2021). Oxygen saturation has decreased to less than 15% and water temperatures have increased by nearly 1°C. Although northern shrimp is particularly well adapted to withstand hypoxia, female shrimp are less tolerant than male shrimp. At 5°C, the lethal threshold is 9% saturation for males and 15% saturation for females (Dupont-Prinet et al. 2013). It should be noted that both sexes of shrimp become more sensitive to hypoxia as temperatures increase; at 8°C, the lethal threshold is 14% and 22% saturation for males and females, respectively (Dupont-Prinet et al. 2013). In addition to being able to tolerate severe hypoxia, shrimp can adapt to oxygen levels that remain chronically near the lethal threshold (Dupont-Prinet et al. 2013; Pillet et al. 2016). Part of the Sept-Iles, Anticosti and Esquiman populations therefore live in conditions approaching lethal thresholds.

Recent studies have shown that oxygen depletion and warming of deep waters could result in a loss of habitat for northern shrimp (Stortini et al. 2016). It is expected that deep-water temperatures in the GSL will remain high in the coming years. These conditions are not favourable to northern shrimp, given that it is a cold-water species.

RECRUITMENT

Environmental conditions affect northern shrimp recruitment from the larval stage until juveniles settle on the bottom. For the Sept-Iles, Anticosti and Esquiman stocks, Brosset et al. (2018) showed that from 2001 to 2016 northern shrimp recruitment appeared to be linked to phytoplankton bloom characteristics and the associated zooplankton phenology, as well as to northern shrimp abundance, rather than to fish predator biomass. It is important to note that the significant variables explaining recruitment were stock-specific and depended on the area considered. The Esquiman area might show increasing northern shrimp recruitment in the future under moderate warming, but recruitment in the Sept-Iles area might be adversely affected. These findings provide a better understanding of stock-specific recruitment in a changing environment and can ultimately improve management of northern shrimp in the GSL. This model had been updated by adding the 2017 and 2018 data during the last assessment and the results are presented in Figure 19. This model could not be updated for the present assessment because some variables were not available because the 2020 spring AZMP survey could not be carried out due to the context of the Covid-19 pandemic.

COMMERCIAL FISHERY

FISHERY STATISTICS

The shrimp fishing licence holders have to describe their fishing operations in a logbook. Information on the estimated catch, the number of hours of trawling, and the location of the fishing tows are noted for each day at sea. The catch data are validated with the processing plant purchase slips or with the dock side monitoring program. The dock side monitoring program has been running since 1991; all fishermen have to have their landings weighted by observers who are based in designated ports.

The resolution of the information noted in the logbook and recorded in a zonal file (ZIFF, *Zonal Interchange File Format*) corresponds to one fishing day at a given location. Every day, the fisherman has to note the total of the estimated catches and the total of hours of trawling for each location. The official landing (coming from the dock side weighting), that happens often after many days at sea, is then attributed proportionally to the daily catches.

DFO official statistics on landings by fishing area are derived from the Canadian Atlantic Quota Report (CAQR) and are available in the Gulf Quota Report.

Northern shrimp landings in the Estuary and Gulf of St. Lawrence have risen gradually since the fishery began. Landings increased from about 1,000 t in the early 1970s to more than 35,000 t by the end of 2010 (Figure 20). Landings decreased thereafter to 17,217 t in 2021. The preliminary statistics indicate 2021 landings of 607 t in the Estuary, 4,907 t in Sept-Iles, 6,205 t in Anticosti, and 5,498 t in Esquiman (Figure 21).

In 2020, the TACs were increased by 154% in Estuary, by 20% in Sept-Iles and decreased by 8% in Anticosti and remained the same in Esquiman (Table 3). Those TACs had been set for 2 years of management, i.e. 2020 and 2021. As of January 6, 2022, the TAC has been reached at 100% in Estuary, at 96% in Sept-Iles, at 98% in Anticosti and at 92% in Esquiman, those data are considered preliminary.

In 2020 and 2021, there was almost no fishing effort in the spring due to the context of the Covid-19 pandemic and the market context. Normally, the proportion of fishing effort between the spring, summer and fall seasons seems consistent over the years (Figure 22).

DISTRIBUTION OF FISHING EFFORT

The harvest site position that the fisher notes in the logbook is used to identify the shrimp fishing area in which fishing operations are conducted. Depending on the type of form issued to the fisher's fleet, the position is expressed either as latitude and longitude or by identifying the fishing square (a square measuring 10 minutes by 10 minutes, Figure 23). The harvest site may, on occasion, be missing. In such a case, it possible to identify the shrimp fishing area by NAFO subdivision of (Figure 24) find in the logbook.

The spatial distributions of catches, effort and catch per unit of effort (CPUE) by grid square are shown in Figure 25 to Figure 27. They are shown by decade and grid square mean, or for 2018 to 2021.

Use of the Vessel Monitoring System (VMS) has been a license condition since 2012. During shrimp fishing trips, vessels were positioned by satellite at a 60-minute frequency and, since 2016, every 30 minutes. The information collected consisted of the vessel number (CFVN), position (latitude and longitude), date and time. There is no information on whether a vessel was in a shrimp fishing situation or when the trawl was set. In order to distinguish non-directed shrimp fishery activities, we compared the dates and CFVN in the VMS data with the logbook data. We retained all positions that more or less corresponded to a day when a shrimp catch was recorded in logbooks. It was impossible for another directed-species activity to be conducted in that time interval. Next, we eliminated positions that a vessel travelled through towards the harvest site, and positions where a vessel was stationary (at sea or dockside). To accomplish this, we calculated vessel speed starting from the positions and the time interval between two positions. We retained speeds between 1.8 and 2.6 knots as shrimp trawling speeds and validated this information with fishers. Shrimp fishing positions were aggregated annually in grid squares of 1 minute longitude by 1 minute latitude for charting. With this methodology, the fishing effort retained with the VMS data, i.e. when the shrimpers are fishing, corresponds to more than 95% of the total fishing effort declared by the fishermen in their logbook.

The use of fishing activity positions in logbooks (Figure 28) and the VMS (Figure 29) helped delineate fishing activities in the GSL. The sectors that sustain fishing in the 4 areas have barely changed in recent years and correspond to the spots where high concentrations of shrimp were observed during the research survey. In recent years, certain traditional fishing grounds have been abandoned because of the low abundance of shrimp: for example, the area east of the Manicouagan Peninsula in the Estuary, the northeastern tip of the Gaspé Peninsula, the southeast of Anticosti Island, and the southwest of the Esquiman Channel.

CATCH AND FISHING EFFORT COMPILATION

An observation given by fishermen in their logbook corresponds to a catch and an effort realised by a vessel for a fishing day in a given location. A first validation of the observations is done in eliminating missing or improbable data for essential variables (fishing vessel, catch, effort, date of the catch, shrimp fishing area). Following the validation, the sum of catches does not represent the total of the landings given that some observations had to be removed from the analyses because they were missing or incomplete. The sum of the effort corresponding to the same observations neither represents the total effort put by the fleets to catch the total landing. However, it is possible to estimate the total fishing effort corresponding to the total landing by using the catch per unit of effort estimated from the validated observation subset (Table 4, Figure 30). Similarly, it is possible to estimate the monthly catch and effort by fishing area and by year (Table 5 and Table 6).

The total annual fishing effort of shrimpers has decreased in recent years, from more than 100,000 fishing hours to less than 80,000 hours since 2018 (Figure 31). The effort of the last two years (69,400 and 75,400 hours) is below the historical average of 108,900 hours and corresponds to the lowest annual fishing effort observed since 1982. The decrease in fishing effort is noticeable in the four fishing areas, but the scope is greater in the Estuary and Sept-Iles areas.

CATCH PER UNIT OF EFFORT STANDARDIZATION

The annual catches per unit of effort (CPUE) are standardized to take into account the changes in the fishing capacity and in the seasonal fishing patterns (Gavaris 1980). Multiple linear regressions were performed between the logarithm of CPUE and the variables vessel length and propulsion power (to reflect changes in fishing power), month (to take account changes in the fishing season) and year (to isolate the annual effect without any effect from the other variables). The analyses were performed with the GLM procedure of the SAS software (SAS 1996). The analyses were done separately for each fishing area.

The important variables were first examined to determine if the number of observations in each category was sufficient to be representative of the fleet behaviour. The length and the propulsion power of the vessels were grouped into classes. The lengths were grouped into 6 classes of 10 feet, from 30 to 89 feet, identified by the middle of the class. The powers were grouped into 9 classes of 100 hp, from 100 to 999 hp, identified also by the middle of the class. Given that one observation corresponds to one (or less) fishing day, it is considered that the fishing effort in a given category is representative when many observations (and thus many fishing days) are associated with it.

The conditions for which the fishing effort is considered representative have already been presented in Savard (2011). They are the following:

- a vessel had to be active during at least 3 years and had to have at least 7 observations per year;
- a length or power class had to be present during at least 3 years and had to have at least 7 observations per year;
- the months that were kept were those during which there were activities for at least 3 years and for which there are at least 7 observations (5 observations for the Estuary area) per year and per fishing area;
- an observation would be considered as significant if it corresponds to an effort greater than one hour and a catch greater than 50 kg;
- the sub-categories representing less than 1% of the total observations were not used in the analyses because it was considered that they were little representative of the behaviour of the fleets.

The validation of these models is done by analyzing the residuals against the predicted values and categories of factors studied. The analyses of variance are all significant ($p<0.0001$) as well as the contribution of the categories to the regression ($p<0.0001$) except for the length category ($p=0.0120$) in the Estuary area. The model explains 53% of the variance in Estuary, 51% in Sept-Iles, 58% in Anticosti and 58% in Esquiman.

The standardized CPUEs correspond to a standard vessel with a length class of 60-69 ft and a propulsion power class of 500-599 hp and the month is June. CPUE values have varied widely over time and have followed similar trends since 1982 in all four fishing areas. CPUEs were low from 1983 to 1995; they began increasing in 1995 and peaked around 2005, after which they remained high for a few more years (Table 7 and Figure 32). From 2014 to 2017, CPUEs decreased. In 2020 and 2021, CPUEs improved in the Estuary, Sept-Iles and Anticosti compared to 2018 and 2019, while those in Esquiman have been more variable over the past four years. The CPUEs of the four areas are comparable to those observed in the early 2000s and higher than those observed in the early 1990s.

COMMERCIAL CATCH SAMPLING

Samples from commercial catches have been collected at landing since 1982 (Table 8). The samples are brought back to the laboratory where the individuals are sexed and measured (cephalothorax length, CL) to the closest 0.1 mm. The individuals are sexed according to the characteristic of the endopod of the first pleopod (Rasmussen 1953) and the maturity stage is determined by the presence or absence of sternal spines (McCrary 1971) and by the presence or absence of eggs.

Commercial catch samples are combined by area and by month. The monthly length frequency distributions are weighted by the month landing (Table 9) and the numbers at length are calculated by applying the weight-length relationships estimated from the survey (see section DFO research survey). The annual commercial catches are estimated by summing the monthly numbers at length (Table 10). The numbers per unit of effort are calculated by dividing the numbers at length by the fishing effort (Figure 33 and Figure 34).

The main indicator of the stock status is estimated using data from the commercial fishery and research survey. Indices used from commercial fishing are numbers per unit of effort (NPUE) during the summer for the male and female components. These indices have been restricted to the summer (June, July and August) due to seasonal variations in catchability. The male and female NPUE are estimated from length frequency of summer months by fishing area (Table 11 and Figure 35).

Mean lengths of female carapace shrimps harvested in the summer by fishing area and year are presented in Figure 36. The general trend in the four areas indicates that the female shrimp caught are getting smaller and smaller over the years. The average lengths of 2021 are all smaller than those of 2020.

DFO RESEARCH SURVEY

DESCRIPTION OF THE SURVEY

A ecosystemic research survey has been conducted annually in the nGSL since 1990 to estimate the abundance of northern shrimp and groundfish species. The survey is conducted with a shrimp trawl following a stratified random sampling plan. Fishing operations take place 24 hours a day. A description of the 2021 survey and sampling protocols is presented in Bourdages et al. (2022).

The stratification used for the allocation of fishing stations is presented in Figure 37. In the Gulf, the grounds located at depths greater than 37 m (20 fathoms) are covered by the survey (with the exception of the Mecatina Trough). In the Estuary, the survey covered the grounds at depths greater than 183 m (100 fathoms) from 1990 to 2007. In 2008, it was decided to add strata to cover depths from 37 to 183 m in this sector to obtain a better coverage of the northern shrimp spatial distribution. The surface of the study area has increased from 116,115 km^2 to 118,391 km^2.

In 2021, 149 fishing stations were successfully sampled, specifically 41 in 4R, 69 in 4S and 39 in 4T, which represent 40 stations less than what has been achieved on average since 1990 (Table 12, Figure 38). The decrease in the number of stations completed is due to the fact that the ship had to go to the wharf three times for medical or mechanical reasons. A lot of effort was made to cover the entire study area. Six strata were not sampled with a minimum of two stations, two of which were not visited. These partially or uncovered strata were distributed throughout the study area and not located in a particular sector.

For each fishing tow, the trawl catch is sorted by species or by taxon. The total catch of shrimp is weighted and a sample of about 2 kg is collected to determine the proportion of *Pandalus borealis* compared to other shrimp species and its biological characteristics as well. The maturity stage (male, primiparous or mutiparous female with or without gonads in maturation and egg bearing female) is identified for each individual. The cephalothorax length is measured with an electronic calliper with a precision of 0.1 mm. The individual weight is recorded with a precision of 0.1 g following a stratified sampling design (about ten individuals per sex per 1 mm length class) for each fishing area. In 2020 and 2021, surveys were carried out with a reduced number of scientific personnel in order to comply with working protocols at sea in the context of the Covid-19 pandemic. The shrimp samples were therefore frozen and processed in the laboratory in the fall. Only the individual weights could not be made in the laboratory following the freezing of the samples because the weight following thawing is not comparable to the fresh weight.

The area swept by the trawl is estimated from the duration of the tow, the speed of the vessel and the wingspread of the trawl. The *P. borealis* catch for each tow is estimated from its proportion in the sample and is standardized to an area of 1 km^2 taking into account the swept surface (Table 13 and Figure 39).

DISTRIBUTION

Geographic distribution of catches

The geographical distribution of catches by weight per tow (kg/15 minutes tow) was made for periods of four or five years (Figure 40). The interpolation of catches was performed on a grid covering the study area using a ponderation 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 biomass levels which approximate the 20th, 40th, 60th and 80th percentiles of the non-zero values. The catch rates distribution of males and females from 2018 to 2021 are also presented in a bubbles type map (Figure 41).

The survey is deemed to effectively cover the entire distribution range of northern shrimp in the nGSL. The spatial distribution of northern shrimp shows that the best catch rates were observed along the Esquiman, Anticosti, and Laurentian channels, as well as west of Anticosti Island through the Estuary. Typically, young shrimp are found in shallower areas, often at the heads of channels, whereas older individuals, females, are found in deeper waters. Northern shrimp occurs only rarely in the southern Gulf.

Distribution of catches by depth, temperature and dissolved oxygen

The relative cumulative frequency of catches (in weight) was compiled according to depth, temperature and dissolved oxygen for the periods 1995-2010 and 2018-2021 (Figure 42). 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. This figure illustrates the depth windows in which the shrimp is likely to be caught in August in the study area.

Research survey data indicated that from 1995 to 2010 more than 80% of the cumulative northern shrimp biomass was found between 190 and 331 m at bottom temperatures ranging between 4.0 and 5.9ºC and oxygen concentrations dissolved between 24 and 48%. With the warming of deep water temperatures in recent years, we observe that shrimp are now found at shallower depths. From 2018 to 2021, more than 80% of the cumulative biomass was found between 164 and 302 m at bottom temperatures varying between 3.0 and 6.4ºC and dissolved oxygen concentrations between 20 and 48%. In general, the northern shrimp is associated with the deep water mass and is found mainly in channels at depths ranging from 200 to 300 m where the sediments are fine and consolidated (Dutil et al. 2011).

Area of occupancy

Three spatial indices were selected: the design-weighted area of occupancy, the D95 and the Gini index.

Design-weighted area of occupancy

The design-weighted area of occupancy (DWAO) (Smedbol et al. 2002) is the area of the study zone in which the shrimp is found.

D95

The D95 index describes geographic concentration. This descriptor corresponds to the minimum area containing 95% of the shrimp biomass. Calculation details are described in Swain and Sinclair (1994).

Gini index

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

In 2021, northern shrimp was distributed over more than 90,000 km^2 in the nGSL, the study area was 116,115 km^2 (Table 14, Figure 43 and Figure 44). Since 2008, the northern shrimp has been increasingly concentrated (increase in the Gini index) and there is a decrease in the area where the highest concentrations of shrimp are observed, i.e. the area where more than 95% of the biomass is distributed. Since 2010, the minimum area (D95) has fallen from more than 50,000 km^2 to less than 30,000 km^2, i.e. a decrease of almost 50% in the area occupied by the population.

BIOMASS ESTIMATION BY GEOSTATISTICS

The biomass (kg/km²) calculated at all stations of the study area is kriged separately for males and females. First, the positions of sampling stations, expressed in latitude and longitude, are transformed into a Cartesian coordinate system according to the Lambert Conformal Conic projection using parallels 48^{0}N and 50^{0}N as a reference and 46.5^{0}N and 70^{0}O as point of origin. This conversion is carried out using libraries "sp" and "rgdal" (2013a Pebesma, Bivand 2013) of R (R Development Core Team 2008).

As a first step, a variogram is calculated for each survey. To highlight the spatial structure of the data, it is sometimes necessary to remove outliers. The values of cuts are shown in the Table 15. Likewise, values lower than 5 kg/km^2 are not used for estimating the variogram. From 1990 to 2012, annual variograms were estimated with the procedure "VARIO" of SAS software (SAS 1996). From 2013, the variograms were performed with the library "gstat" of R (Pebesma 2013b). The semivariances were calculated between all pairs of stations. The distance (h) between them was discrete and semivariances were averaged for different distance classes with intervals of 15 km and a maximum distance of 225 km.

In a second step, the annual variogram is standardized, that is to say that semivariances are divided by the observed variance of the data used to construct the variogram. Subsequently, a pluriannual variogram is constructed from the average of the last three variograms, that of the current year and the two preceding years. The pluriannual variogram corresponds to the mean of the semivariances for each distance *h* of the annual variograms, weighted by the number of pairs associated with these distances. The use of a pluriannual variogram reduces the variability of the spatial structure which is observed in some years, allowing a better fit of the model.

From 1990 to 2012, the various parameters of the multi-year variograms (the nugget, the sill and the range) were set manually in order to obtain the best possible fit (Table 16). Although other variogram models were examined, the exponential model was selected because it produced the best fit. Since 2013, the parameters of the exponential variogram were fitted with the function "fit.variogram" from the library "gstat" of R (Pebesma 2013a). To minimize the least squares, the adjustment was performed by weighting the data by N_j/h_j^2 order to give more weight to the adjustment of the first points of the variogram (Figure 45).

Thereafter, the values of catches were spatially interpolated in the study area using kriging. To do this, all survey observations were used including low and extreme values. The pluriannual variogram was adjusted to represent the variance of the observations of the study area. The nugget (C_0) and sill parameters (C) were multiplied by the variance of all observations in the study area. The interpolation was performed on a regular grid with nodes separated by distances of 5 km in both directions. The local estimations were made using the catches of the eight nearest stations that are present within a maximum search radius of 200 km.

From 1990 to 2012, the kriging, the estimates of the mean and variance estimation were performed using the toolbox "Kriging" of MATLAB (Lafleur and Gratton 1998). Since 2013, the kriging was performed with the function "krige" of the library "gstat" of R (Pebesma 2013a) and the estimates of the kriging mean and variance estimation were calculated using a function developed by Sébastien Durand (pers. comm.).

The mean biomass (kg/km²) of each fishing area is then calculated by doing the mean of the local estimations in the area. The total biomass of a given fishing area is obtained by multiplying the mean biomass by the surface of the area. The surfaces of the fishing areas are as followed: Estuary, 4,000 km² from 1990 to 2007 and 6,325 km² from 2008 to 2017; Sept-Iles, 29,775 km² from 1990 to 2007 and 29,975 km² from 2008 to 2017; Anticosti, 46,400 km²; Esquiman, 32,350 km².

Maps of total biomass distribution are shown for each year in Figure 46 and maps of the distribution of male and female shrimp are shown in Figure 47 and Figure 48. Indices of total biomass (Figure 49) and of male and female biomass (Figure 50, Table 17 and Table 20) in the Sept-Iles, Anticosti and Esquiman areas showed upward trends in the1990s, but declining trends have been observed since 2003. The biomass observed since 2017 are comparable to the low values of the early 1990s. For the Estuary zone, the interannual variations are large, the biomass observed in 2020 and 2021 are among the lowest in the chronological series while the estimate for 2019 was among the highest.

Biomass estimates are generally more accurate for females than for males. The coefficient of variation is approximately 20% to 30% for males and 10% to 20% for females in the Sept-Iles, Anticosti and Esquiman fishing areas (Table 18 and Table 19). The coefficient of variation is higher in the Estuary.

ABUNDANCE ESTIMATION

Biomasses estimated by kriging are converted into abundance from the weight-length relationships and from the length frequency distributions. Length frequencies of each sample are first bumped to the total catch of the station and then, standardized to a 1 km² swept area. The frequencies (n/km²) are regrouped into 0.5 mm size class.

The mean distribution of frequencies (in n/km²) per size class is estimated for each fishing area, for males and females. The mean distribution is estimated from all stations that were sampled in the fishing area. The mean distribution is then converted into weight by applying a weight-length relationship that is estimated for each area (Table 21, Figure 51). The weight-length relationship estimated in 1993 is used for the 1990-2004 period. Since 2005, the relationship estimated annually is used for the current year. The same relationship is used for both sexes. In 2020 and 2021, there was no biological measurement on individual shrimps, so the relationship estimated in 2019 was applied to these missing years.

The stock biomass estimated by kriging is distributed among the size classes following the proportions in weight of the mean distribution of the stock. The abundance of each size class is obtained by dividing the biomass by the mean weight of the class. The total stock abundance is then obtained by adding the abundance of all size classes. The exercise is done separately for males and females. Given that the numbers are not kriged, it is not possible to obtain an estimate of the variance of the abundance by kriging. Therefore, the coefficient of variation of the biomass is used to estimate the 95% confidence interval of the abundance.

The female abundance could be separated into maturity stages for the years when the identification of the stage was done for each individual. The abundance of primiparous and multiparous females was calculated from 1990 to 2000 and then from 2009 to 2021.

The population structures for each fishing area derived from the DFO survey are presented for males and females in Figure 52 and Figure 53. In 2021, the abundance of small males is very low in the four areas, while the largest males are above the average for the series in the Estuary and below the average in the other three areas. The abundances of females are very low in Sept-Iles, Anticosti and Esquiman, while in Estuary, they are above average whereas they were below average in 2020.

It is possible to obtain an index of recruitment by estimating the abundance of juveniles for which the cephalothorax length is smaller than 12.5 mm. The individuals of these sizes are aged of about fifteen months (Daoud et al. 2010). The estimation of abundance of the juveniles is obtained by adding the abundance of the size classes that are included in the first mode. In 2021, the abundance of juveniles (carapace length between 8 and 12 mm) was very low in the four areas. In 2020, recruitment was also very low in areas with the exception of Anticosti where it was average (Figure 54, Table 23).

After showing downward trends for more than ten years, the abundance indices for males and females in the Sept-Iles, Anticosti and Esquiman areas seem to have stabilized at very low values since 2017 (Table 22 and Figure 55). The 2021 abundances for these three stocks are low compared to the values observed between the years 2000 and 2010. The values for Sept-Iles and Anticosti are compared to the lowest values observed in the early 1990s. The abundance indices for males and females in the Estuary, for the surface covered by the survey since 1990, are very low in 2020 and 2021 whereas they were high in 2019. When looking at the estimates coming from the surface enlarges with the shallower strata in 2008, the 2021 male and female estimates are high compared to the low values observed in 2020.

The allocation of additional stations in the shallow area of the St. Lawrence Estuary since 2008 has had a very significant impact on the number of males and females surveyed in the Estuary fishing area and to a lesser extent in the Sept-Iles area (Figure 55). After 14 surveys with this increased coverage, the inter-annual coherence between the shrimp abundance measured according to the original area and the extended survey area indicates that the biomass was largely underestimated and the exploitation rate index significantly overestimated for the Estuary area. In the short term, shallow strata should be integrated into estimates of the main indicator of stock status.

The variations in shrimp sizes follow an east-west gradient, the smallest being observed in the Esquiman Channel and the largest, in the Estuary. In all four areas, the average size of male and female shrimp showed a downward trend over the 1990–2021 time series. In 2021, the average size of males and females in the Estuary, Anticosti and females in Esquiman were larger than the sizes recorded in 2020 (Figure 56). The survey has collected individual weight data since 2006. Shrimp weight estimates for males of 14 and 20 mm and females of 22 and 26 mm seem to increase over the years (Figure 57). The weight of the shrimp was higher than average in the Esquiman and Anticosti areas from 2010 to 2018, and has been higher in the Sept-Iles area since 2012 and in the Estuary since 2015, following a gradient that began earlier in the east. These indices were not estimated in 2020 and 2021.

PRECAUTIONARY APPROACH

The precautionary approach (PA) for northern shrimp in the GSL was adopted in 2012 in accordance with the fishery decision-making framework incorporating the precautionary approach (DFO 2006).

MAIN STOCK STATUS INDICATOR AND REFERENCE POINTS

The stock assessment is descriptive and focuses on the review of indices from the commercial fishery and research survey. These two sources of data are independent and allow the estimation of catch rates or densities which are considered as good indices of shrimp abundance. During the PA development, it was decided to use them both equally (with the same weight) in the constitution of the main indicator of the stock status (Savard 2012). However, given the seasonal variations in catchability the estimation of the fishery indicators is restricted to summer (in June, July and August), the season during which catchability for males and females is considered constant.

Given that the northern shrimp changes sex, it is important to protect at the same time the male (recruitment to the female component) and the female components (spawning stock) of the stocks. Although no specific study was realized, we assume that the abundance of males is not a factor limiting the success of reproduction. The proportion of reproductive females carrying fertilized eggs early in spring before the hatching of larvae had always been very high (98% or more in the Sept-Iles area since 1992). However, the number of recruit females (primiparous) in a given year depends on the number of males which undertook the process of sex change in the previous winter. The abundance of primiparous females is directly proportional to the abundance of all males of the previous year.

Also, the abundance of the reproductive females in spring can be predicted from the estimation of the spawning stock of the previous summer. The spawning stock estimated in summer consists of primiparous females which have completed the sex change and of multiparous females which survive the reproduction and the release of larvae.

Male and female abundance indices are calculated from indices for each sex obtained from the fishery in summer (number per unit of effort in June, July, and August) and from the research survey (abundance). The combination of these indices constitutes the main indicator of the stock status. To be able to combine them, each index is first standardized to a period of reference (1990-1999, except for Estuary 1995-1999). The main indicator of stock status is the average of the four standardized indices. For the Estuary, the survey indices are based on the sampling area covered since 1990, specifically the four strata corresponding to depths greater 183 m.

Like the main stock status indicator, the limit reference point (LRP) and the upper stock reference point (USR) were developed in fall 2011 (Savard 2012; DFO 2011).

Stocks increased from a relatively low abundance level in the mid-1980s and mid-1990s due to the production of abundant year-classes. During the 1980s, predator abundance was high and likely had a major impact on the maximum abundance level reached by the stocks. In the 1990s, abundant cohorts were produced at a time when predator abundance was declining. It appears that the spawning stock was large enough to produce abundant cohorts, which had a noticeable effect on stock condition. Stock status corresponding to these low abundance levels, which have since increased, represents the limit reference point (LRP). The stocks’ behaviour in the critical zone is uncertain, however, because such a situation has never been observed during the period under study.

The production of very abundant year-classes allowed stocks to begin increasing again in the early 2000s when predation mortality was likely low. However, stock status has been declining since 2003 and exploitation rate indices have been increasing. It is therefore uncertain whether the abundance levels observed since 2003 can be maintained. The 1996 to 2002 period appears to have been a stable period characterized by sustainable catch levels. The average stock status for this productive and stable period represents a biomass approximation based on the maximum sustainable yield. The value of the upper stock reference (USR) point was set to 80% of the mean value of the indicator for the 1996 to 2002 period. The values assigned to the limit reference point and the upper stock reference point, in keeping with the fishery decision-making framework incorporating the precautionary approach, are presented in the Table 24.

The standardized abundance indices for male and female shrimp derived from the fishery and the research survey show similar trends for the Sept-Iles, Anticosti and Esquiman stocks since the 1980s to 2005. The indices were low in the 1980s and the early 1990s (Table 25 and Figure 58). The indices showed an upward trend from the mid-1990s until 2003. Commercial fishery indices remained fairly stable and high in subsequent years, whereas the survey indices began to decline. Fishery indices began to decrease in 2015. In 2021, we observe very low abundance indices while the fishery indices are average. The Estuary area indices are much more variable from one year to the next. The abundance indices are low in 2020 and 2021 while they are high in the fishery.

In 2021, the main stock status indicator decreased slightly in all four areas. The indicators of the four areas are very close to the upper reference point. The Estuary, Anticosti and Esquiman stocks are in the healthy zone, while the Sept-Iles stock is still in the cautious zone (Figure 59). Even though the Sept-Iles stock indicator has improved compared to 2018, this stock remains in the cautious zone for a fifth consecutive year.

When the PA was developed in the early 2010s, the commercial catch rate and the research survey abundance index were relatively consistent. From 1993 to 2005, the stocks were growing and the fishery and survey indices followed the same trend. From 2005 onward, the research survey index began to decline, while the commercial catch rate remained stable at relatively high levels. The fishery indices began to decline in 2015, ten years after those of the scientific survey. This time lag is consistent with the dynamics observed for other exploited species, where harvesting is focusing on areas of high concentration after an effective search for these areas has been conducted. The pattern observed in the NPUEs is described as “hyperstability,” or a maintenance of commercial catch NPUEs as the population abundance declines (Harley et al. 2001; Walters 2003). The two indices are therefore not sampling the same fraction of the population. The research survey covers the shrimp’s entire range in the Estuary and northern Gulf of St. Lawrence, while the commercial fishery targets the highest concentrations of shrimp at the channel heads.

Technological developments in the fishery, such as the use of seabed mapping, echo sounding and new trawls, have improved fish harvesters’ efficiency. This means that, given the same abundance, a recent NPUE will be greater than an older NPUE. As a result, the comparison of these NPUEs in a historical series will be skewed.

The area of occupied shrimp habitat is shrinking every year. As their habitat becomes increasingly concentrated in a smaller and smaller area, shrimp are becoming more vulnerable to fishing. Today, given the same abundance, shrimp are more densely concentrated on the seabed.

If the goal is to have an indicator to monitor population trends, these factors indicate that the use of commercial fishery NPUEs has overestimated stock abundance during the most recent period of decline.

The average size of male and female shrimp has been declining in all four stocks since the early 1990s. This trend can be observed in both the commercial fishery data (Figure 36) and the DFO research survey data (Figure 56). For populations of similar abundance, a decrease in the average size of individuals will have a negative impact on the stock's reproductive potential since fewer eggs will be produced per female (Parsons and Tucker 1986). The main stock status indicator is calculated from indices based on number of shrimp, which are related to harvests expressed in weight. Continuing to use a decision rule based on this relation could increase the rate at which the spawning component of the stock is exploited

For these reasons, the main stock status indicator is considered overestimated for the most recent period

HARVEST GUIDELINES AND DECISION RULES

Harvest guidelines were established according to the main indicator and its position in relation to the stock status classification zones (healthy, cautious and critical) in accordance with the precautionary approach. These guidelines were established based on the historical relationship observed between the main stock status indicator for a given year and the following year's harvest level. This relationship was modified based on the stock status zones to adjust the exploitation rate according to the status of the resource. The exploitation rate is constant when the stock is in the healthy zone; the value used is equal to the mean rate observed between 1990 and 2010. The harvest rate decreases through the cautious zone to the critical zone, where the exploitation rate is set a constant value that is four times lower than that for the healthy zone. The guidelines for the four fishing areas are presented in the Table 26.

A simulation model was developed to test these guidelines and compare the performance of various harvest adjustment rules (Desgagnés and Savard 2012; Bourdages and Desgagnés 2014). The operational model adapted to the dynamics of a northern shrimp stock successfully captured the evolution of a model population and supported the testing of multiple assumptions concerning stock dynamics. The model can be viewed as a powerful tool for simulating stock trajectory and assessing risks and uncertainties as part of the evaluation of management strategies.

Fisheries Management will set the TACs for the coming year on the basis of the projected harvest levels by applying the decision rules of the current precautionary approach. To minimize TAC adjustments between two consecutive years, decision rules apply a threshold and a cap to TAC adjustments. If the difference between the TAC and the projected harvest level is less than 5%, no adjustment will be made. If the stock is in the healthy zone and the difference between the TAC and the projected harvest level is greater than 5%, a cap will be applied and the TAC adjustment (positive or negative) will not exceed 15%.

The TACs were adjusted annually from 2012 to 2018 in keeping with the precautionary approach, even though northern shrimp in the Estuary and Gulf is managed on a two-year cycle. In 2019, in response to requests from industry and the First Nations, DFO agreed to adopt biennial decision rules, a scenario that was assessed in 2014 and found to meet conservation objectives. The main justification for their request was that redfish predation was having a greater impact than the fishery in terms of causing a decrease in the shrimp population. The TACs were therefore adjusted in 2018 and 2020, following the stock assessment review, and were established for period of 2 years.

According to the guidelines established as part of the precautionary approach, the projected harvest levels for 2022 are 558 t for Estuary, 6,242 t for Sept-Iles, 5,424 t for Anticosti and 5,079 t for Esquiman (Figure 60 and Table 27). Fisheries Management will set the TACs for

2022 based on these harvest levels by applying the decision rules of the precautionary approach and the advisory committee findings.

EXPLOITATION RATE

An exploitation rate index is obtained by dividing the commercial catches in number by the abundance value estimated from the research survey. This method does not allow the absolute exploitation rate to be estimated or the index to be related to target exploitation rates. However, it does permit tracking of relative changes over the years. The exploitation rate in the Estuary is highly variable, as are the abundance indices from the survey, in 2021 it was below average (Figure 61). Exploitation rates in the Sept-Iles, Anticosti and Esquiman areas show an increasing trend since 2005. In 2021, they increased in Sept-Îles and Anticosti and decreased in Esquiman. In these three areas, the exploitation rate is above the historical average and is among the highest values in their respective series.

CONDITIONING THE PRECAUTIONARY APPROACH FOR OBSERVED CHANGES IN THE ECOSYSTEM

The GSL northern shrimp PA assumes that the environment varies randomly within the envelope of conditions that prevailed during the time period considered to define the reference points and harvest control rule for each stock (from 1990 to 2010). However, the directional changes observed over the last decade in the GSL ecosystem no longer allow these conditions to be met. The sustained increase in bottom water temperature, the decrease in oxygen in the deep layer, and the significant increase in redfish biomass (predation) indicate that the ecosystem framework within shrimp stocks and their fishing has changed. This deviation from 1990-2010 conditions increases the level of uncertainty in assessing the shrimp stock status, as well as the risks associated with harvests projected by the current PA. Not taking this increased risk into account would be equivalent to deviate from the initial intentions of the PA in terms of caution.

In this context, an adjustment of the degree of exposure of stocks to fishing pressure is proposed. This adjustment consists of formulating a "conditioned" opinion on the observed, anticipated or projected effects of environmental changes on the state of the stocks, so as to maintain an equivalent level of risk (Duplisea et al. 2021; Roux et al. 2022). Various approaches to adjust the degree of exposure of fish stocks to fishing pressure to account for ecosystem changes have emerged in recent years (Dorn and Zador 2020; Bentley et al. 2021; Duplisea et al. 2021 Howell et al. 2021). These approaches can be adapted to the practices and methods in place in order to formulate without delay scientific advice conditioned to better integrate climate, ecosystem or environmental changes. These approaches are applicable regardless of the type of data and knowledge available (i.e. qualitative, semi-quantitative or quantitative data, and experiential, empirical or analytical knowledge).

Indicator to the state of the environment for northern shrimp in the GSL

Bottom water temperature was selected as an indicator of the state of the environment for northern shrimp. This choice was made in consideration of the following factors:

1. demonstrated effects of water temperature on shrimp productivity (Apollonio et al. 1986; Wieland 2005; Koeller et al. 2009; Richards et al. 2012; Arnberg et al. 2013);
2. the availability of temperature time series covering the reference period considered to define the PA;

3. the depth corresponding to the median value of the shrimp biomass distribution in each fishing area in 2021 (150 m in the Estuary and 250 m in the other areas);
4. the positive correlation between bottom water temperature and redfish biomass (predation pressure) in the ecosystem (Pearson's r coefficient = 0.71, p<0.001 over the period from 1990 to 2019); and
5. the anticipated decrease in oxygen availability with increasing water temperature (Davis 1975).

The evolution of temperature conditions during the reference period (1990-2010) until today (2020-2021), are illustrated for each fishing area in Figure 62. These data confirm that the fishery operates presently outside the environmental conditions that prevailed at the time of defining the PA parameters for the northern shrimp of the GSL.

Conditioning factors

Conditioning advice for fisheries on the state of the environment consists of mobilizing available knowledge and information in order to determine ecosystem or environmental conditioning factors (ECFs). These factors correspond to the ratio of the 'adjusted' advice for the demonstrated, anticipated or projected effects of changes in the environment, on the 'status quo' advice developed by assuming that the environment is stationary or varies randomly at within the conditions observed over the reference period. Depending on the data and knowledge available, ECFs are determined semi-quantitatively, empirically or analytically (Roux et al. 2022). The difference is in the proportion of uncertainty associated with environmental change that is quantified within the assessment process.

For northern shrimp in the GSL, there is currently no empirical or analytical model to quantify the effects of fishing on stocks, nor an empirical or analytical model of the effects of temperature and other ecosystem conditions (eg predation mortality) on stocks. The sum of the evidence, however, suggests direct negative effects (eg impact on physiology and on the availability of optimal thermal habitat) and indirect (eg increase in natural mortality caused following the increase in the abundance of redfish in response to deep water warming) from the increase in water temperature for shrimp. Under these circumstances, a semi-quantitative conditioning factor, based only on temperature, has been proposed:

$$ECF_{i,E,F} = \left(S_{i,E} \times \frac{E_{current}}{E_{base}}\right) \times k_{i,E,F} \qquad \text{(Eq. 1)}$$

This ECF corresponds to the product of the sensitivity of northern shrimp to water temperature (S) and the ratio of current temperatures compared to the average observed during the reference period ($\mathrm{Ecurrent/Ebase}$), multiplied by a parameter d scale (k) expressing the severity of the anticipated consequences of the increase in temperature for fishing. An ECF is calculated for each stock (i), the selected environmental variable (E) (bottom water temperature) and the fishing activity (F) subject to the advisory (targeted shrimp fishery).

The sensitivity parameter expresses the response, avoidance and adaptation capacity of the shrimp to temperature changes. The value of S used corresponds to the water temperature sensitivity scores of northern shrimp determined in a climate change vulnerability analysis (Hare et al. 2016; NOAA 2020). These scores, based on expert knowledge, have an average value of 3.2 out of a maximum of 4.0. The variability between the scores of different experts was taken into account by randomly sampling values of S from a uniform distribution with S_{min}=2.8 and S_{max}=4.0 (which corresponds approximately to the shape of the distribution and the range of sensitivity scores in the study). The median value of S obtained from this sampling was used for each stock in the GSL.

The ratio $\mathrm{Ecurrent/Ebase}$ expresses the amplitude of the current deviation of the temperature compared to the reference conditions (state of the environment). The normalized value of the ratio of the average bottom temperature in 2020-21 ($\mathrm{Ecurrent}$) to the average observed in 1990-2010 (Ebase) in each fishing area is used.

The value of the consequence parameter (k) is currently unknown. An arbitrary value randomly sampled from a uniform distribution between k_{min}= 0.1 and k_{max}= 0.3 is used. This approach has the effect of constraining the anticipated consequences of the change in temperature on fishing not to exceed 30% of the product of sensitivity and state of the environment (while remaining greater than or equal to 10% of this same product). The median value of k (around 0.2) is comparable to the arbitrary value of the 'precautionary buffer' used in Europe to adjust fisheries advice when available data and knowledge are limited (ICES 2021). Simulations have shown that lower conditioning (reduction of catches) by 20% can limit the increase in risk in advice on data-poor stocks (ICES 2017).

The ECFs obtained for each shrimp stock are presented in Table 28. Given the similar values of sensitivity (S) and consequence (k) used for each stock, there is little contrast in the ECFs between fishing areas. Only the state of the environment (Ecurrent/Ebase) differs more or less pronounced between the stocks. This approach is considered appropriate given the uncertainties relating to the structure of northern shrimp stocks and their degree of spatial connectivity, particularly with regard to recruitment processes (Le Corre et al. 2020).

Conditioned harvest on the state of the environment

The harvest control rule (HCR) of the PA is used to determine the level of sustainable harvest in year x+1 depending on the state of the stock in year x. The HCR parameters are therefore an approximation of the response of shrimp stocks to fishing removals, as determined by simulations (Desgagnés and Savard 2012). The conditioned harvest for the state of the environment are obtained by multiplying the parameters of the HCR by the ECF calculated for each stock (Figure 63). The inverse value of the ECF (1- ECF) is used because the increase in water temperature corresponds to unfavorable environmental conditions for northern shrimp.

The result of conditioning is a reduction of harvests of 15% in Estuary and Sept-Iles, and 17% in Anticosti and Esquiman compared to projected harvest according to the current PA (status quo) (Table 28, Figure 63). This downward adjustment allow to minimize an increase in biological and ecological risks for shrimp stocks in the context of an environment unfavorable to their productivity. In other words, the conditioning serves to maintain a level of safety consistent with the original intentions of the PA.

The ECF calculated for each stock allow to use the knowledge and information available in order to condition the advice on fisheries on the state of the environment. Additional research work (simulations) is needed to inform the value of the consequence parameter (k) for northern shrimp, as well as to alleviate the linearity constraint imposed by equation 1. Such work will increase the robustness of semi-quantitative ECFs proposed to condition fishery advice for GSL northern shrimp stocks.

IMPACT OF THE FISHERY ON THE ENVIRONMENT

IMPACT ON HABITAT

The use of the vessel monitoring system (VMS) since 2012 has made it possible to determine the locations of fishing grounds and the trawling footprint on the seabed (Figure 64). Since 2012, total annual fishing effort has amounted to about 82,000 hours, which corresponds to a maximum annual footprint of approximately 7,000 km^2, assuming that the trawl tows do not overlap (Table 29). This effort is concentrated in an area of 23,000 km^2 where fishing intensity is variable (Figure 64). The fishing zone with the most intense activity corresponds to an area of 1,300 km^2 where 26% of fishing effort is deployed.

The fishing effort of shrimpers in the Estuary and northern Gulf of St. Lawrence is concentrated and the fishers return to the same fishing grounds year after year. Moritz et al. (2016) suggested that, in this long-exploited ecosystem, a critical level of disturbance was already reached at the time of the first gear passages, which occurred decades ago and had irreversible impacts on the seabed by removing vulnerable taxa and structures providing three-dimensional habitats. These authors also indicated that it is likely that benthic communities subsequently reached a disturbed state of equilibrium on which current trawling has limited or no further impacts.

Fishing effort has declined over the past six years, going from more than 110,000 hours of fishing to fewer than 70,000 hours. This effort has been more concentrated on shrimp holes. The area of the zone in which trawling is carried out has decreased from 15,000 km^2 to 10,000 km^2. This points to a potential decline in the impact of the fishery on habitat.

Fisheries management measures aimed at conserving corals and sponges in the Estuary and Gulf of St. Lawrence were put in place in 11 areas totalling 8,571 km^2 on December 15, 2017. The use of bottom-contact gear, such as the bottom trawls used by shrimpers, is prohibited in these areas. This type of gear poses a risk to these important benthic communities, given that cold-water corals and sponges are fragile biogenic species that recover very slowly. The analysis of VMS data has shown that fishers are respecting these areas: no fishing effort was observed in these zones since 2018 (Figure 64).

BYCATCHES

Harvesters are obliged to have an at-sea observer on board at the Department's request. The At-Sea Observer Program aims at 5% coverage of all shrimper fishing trips. These observers record detailed information on tows (position, duration, and catch per species or taxon and, for some species, specimen length). Data from the At-Sea Observer Program that were used for this study were collected between 2000 and 2021 during the northern shrimp fishing in the Estuary and Gulf of St. Lawrence with the goal to estimate the bycatches.

The methodology for data processing of bycatches is presented in Savard et al. (2013). Since 2000, 24,197 tows were sampled. The positions of the observed tows from 2019 to 2021 are presented in Figure 65. Weighting factors (∑shrimper effort/∑observer effort) were calculated and used to scale the bycatch results to the total effort deployed by the fleet (Table 30 and Table 31).

From 2000 to 2012, average annual bycatches totalled about 500 t (Table 32 and Figure 66). Since 2013, these bycatches have increased rapidly, reaching a historical peak of over 1,500 t in 2016 before beginning to decline again. Bycatches were 470 t and 449 t in 2020 and 2021 respectively, values comparable to those observed before 2012. The upward trend that began in 2013 can be explained by the increase in catches of small redfish as a result of the strong redfish recruitment observed in recent years (Senay et al. 2019). Redfish catches have nonetheless been declining since 2018 (Figure 69). The decrease in redfish bycatches is attributable to the fact that the fish are now larger and cannot fit through the openings in the Nordmore grate. In 2019, Greenland halibut catches rose to 203 t compared with an average level of less than 100 t (Figure 71). The majority of Greenland halibut catches were made in the Sept-Iles area and this increase corresponded to a year of strong recruitment, i.e. the 2018 cohort (Gauthier et al. 2021). These catches decreased in 2020 and 2021 to less than 80 t, i.e. values below the historical average. Witch flounder (*Glyptocephalus cynoglossus*) catches have been above average since 2016 (Figure 73) and can be explained by an increase in the abundance of this population in the nGLS (Bourdages et al. 2022).

The bycatch estimate is compared with shrimp catches to obtain a ratio of bycatches to the total shrimp catch (Table 32 and Figure 67). From 2000 to 2012, the ratios varied between 1% and 2%. The ratio began to increase in 2013 and has remained at a level of over 4% from 2016 to 2019. This upward trend is mainly due to a significant increase in catches of small redfish. In 2020 and 2021, the ratio has decreased and stands at 2.6%.

In 2021, the main species in bycatches were, in order of importance, redfish, Greenland halibut, capelin, witch flounder, herring (*Clupea harengus*), American plaice (*Hippoglossoides platessoides*) and white barracudina (*Arctozenus risso*) (Table 33 and Table 34). These species are commonly caught in the shrimp fishery and are present in more than 70% of tows. Fish bycatches were mostly in the range of 1 kg or less per species per sampled tow.

Bycatches are compared to the biomass and population estimates derived from DFO's annual trawl survey in the Estuary and northern Gulf of St. Lawrence between 2000 and 2021 (Bourdages et al. 2022). The total estimated bycatch by species nonetheless represents less than 1% of their respective estimated biomass based on the DFO survey results (Table 35).

The geographical distributions of bycatches during fishing activities directed on shrimp in presence of an at-sea observer are presented for Atlantic cod, redfishes, Atlantic halibut, Greenland halibut, American plaice, witch flounder and capelin. The average of catches (kg/tow) of all tows in a same square of 5 minutes is made annually (2020 and 2021) (Figure 68 to Figure 74). Length frequencies are available for Atlantic cod, redfishes, Atlantic halibut, Greenland halibut, American plaice and witch flounder (Figure 68 to Figure 74).

Catches of other shrimp species during commercial fishing activities are very low compared to northern shrimp catches. Two shrimp species are common in catches: white shrimp (*Pasiphaea multidentata*) and Aesop shrimp (*Pandalus montagui*). From 2000 to 2021, the percentage in the total *P. multidentata* catch observed at sea was 0.08% (Table 33) and in landings, 0.78% (Table 36); for *P. montagui*, the percentages observed were 0.02% at sea and 0.17% in landings.

RESEARCH

The different scientific research projects can be linked to various components of the integrated fisheries management plan (IFMP) for shrimp in the GSL. The issues identified in the consultations held in connection with IFMP development are as follows:

- Sustainable harvesting of shrimp;
- Impacts of fishing on the ecosystem;
- Governance of the fishery;
- Economic prosperity in the fishery.

The issues the fishery faces have helped define the objectives of the integrated management plan and the research projects were developed to provide possible solutions for these issues.

The scientific research projects carried out on northern shrimp by scientists with the Maurice Lamontagne Institute are funded in whole or in part under DFO's national programs and presented in Appendix 1. They are directly aligned with the priority directions set out in the scientific framework documents and are part of the strategic research program of the Ecosystem Science sector. These projects will be complemented by initiatives funded by the

DFO Core Program (research surveys, dockside and at-sea sampling, logbooks and vessel monitoring system) which are directly linked to monitoring of stock status, the ecosystem and the fishery.

CONCLUSION

With warming and oxygen depletion in deep waters in recent years, a shift of northern shrimp to shallower depths has been observed. They are closer to the CIF to find colder and oxygenated waters. The northern shrimp therefore finds itself trap between the deep layer which is warming and the CIL. With this shift, there is a reduction in the realised habitat by the shrimp of more than 50% throughout the nGSL. By concentrating on smaller areas, it is therefore more vulnerable to predation and the impact of fishing. Fishermen have successes to maintain or improve CPUE in recent years when the population biomass is at its lowest historical level. Commercial fishery data does not reflect stock status and exploitation rates are increasing.

Changes observed in the ecosystem, the increase in the exploitation rate and uncertainty surrounding the stock status indicator indicate that there is an increased risk of undesirable biological and ecological consequences for the sustainability of the stocks and ecosystem (Table 37). Currently, the risk to stock sustainability is greater than it was during the reference period used in establishing the PA. Warming and oxygen depletion in deep waters, combined with heavy predation by redfish, are not expected to improve in the short to medium term.

The current ecosystem conditions differ from the conditions that existed when the precautionary approach was developed in the early 2010s. The uncertainties are greater. The sum of evidence indicates that we are currently working outside of the framework in which the PA was developed. In order to reduce the biological risks for these populations and the ecological risk, fishing pressure should be reduced. The harvests projected by the PA should be conditioned downwards considering the sensitivity of the shrimp and that we are at the extreme of the preferential conditions for this species.

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TABLES

Table 1. Importance of northern shrimp in the Greenland halibut and redfish diets, according on the period and length class considered. For each period / length class combination, the frequency of occurrence (Focc), the mass contribution (MC, in %), the partial fullness index (PFI) and the contribution to the TFI (% TFI) of the northern shrimp in the N stomachs available are provided.

Greenland halibut

Period	Length (cm)	N	% empty	F_{occ}	MC	PFI	TFI
Years 90'	< 15	182	20.3	0.00	0.00	0.00	0.00
	[15-20[	1296	26.9	0.31	0.44	0.01	0.52
	[20-25[	440	43.4	0.00	0.00	0.00	0.00
	[25-30[	1310	49.2	1.30	4.16	0.03	4.40
	[30-35[	922	57.4	2.39	8.63	0.04	8.17
	[35-40[	1310	59.1	3.36	9.56	0.04	9.21
	[40-45[	1510	56.1	5.43	13.71	0.05	13.66
	[45-50[	741	55.7	7.42	16.09	0.06	15.89
	[50-55[	311	59.2	7.40	10.81	0.04	10.41
	[55-60[	96	51.0	8.33	3.97	0.04	4.08
	≥ 60	28	57.1	7.14	3.96	0.04	4.41
Years 90'	<20	1478	26.1	0.27	0.41	0.00	0.43
	[20-30[	1750	47.7	0.97	3.32	0.02	3.06
	≥30	4918	57.2	4.80	11.17	0.03	10.89
Years 2000'	< 15	106	43.4	0.00	0.00	0.00	0.00
	[15-20[	1108	34.4	0.09	0.22	0.00	0.24
	[20-25[	503	43.9	0.99	3.17	0.02	2.95
	[25-30[	1311	50.9	1.75	5.56	0.04	5.75
	[30-35[	1234	47.7	2.92	10.48	0.04	10.21
	[35-40[	1576	46.6	6.28	19.92	0.08	19.96
	[40-45[	1362	45.9	9.99	20.66	0.09	20.79
	[45-50[	759	44.5	13.57	22.05	0.11	22.21
	[50-55[	291	48.1	11.34	13.57	0.07	14.13
	[55-60[	114	36.0	15.79	7.40	0.07	7.73
	≥ 60	41	36.6	19.51	5.28	0.07	5.57
Years 2000'	<20	1214	35.2	0.08	0.21	0.00	0.22
	[20-30[	1814	49.0	1.54	5.11	0.03	4.95
	≥30	5377	46.2	8.05	16.64	0.08	17.16
2015-2021	< 15	137	21.9	1.46	2.48	0.03	2.06
	[15-20[	588	32.5	0.00	0.00	0.00	0.00
	[20-25[	455	60.2	2.42	8.46	0.06	7.83
	[25-30[	686	65.2	3.06	11.26	0.06	10.59
	[30-35[	461	69.0	4.34	13.16	0.07	12.97
	[35-40[	634	63.7	6.31	14.47	0.07	15.26
	[40-45[	409	62.8	7.82	15.29	0.07	15.06
	[45-50[	293	51.9	11.26	10.95	0.08	11.52
	[50-55[	129	51.2	6.98	5.62	0.04	5.79
	[55-60[	66	45.5	4.55	0.94	0.01	1.00
	≥ 60	72	37.5	2.78	0.91	0.01	1.02
2015-2021	<20	725	30.5	0.28	0.26	0.01	0.39
	[20-30[	1141	63.2	2.80	10.26	0.06	9.29
	≥30	2064	60.8	6.73	8.53	0.07	11.62

Redfish

Period	Length (cm)	N	% empty	F_{occ}	MC	PFI	TFI
	< 10	164	39.0	0.61	1.10	0.04	2.14
	[10-15[	331	52.3	0.91	2.98	0.02	2.71
	[15-20[	579	60.6	0.17	0.51	0	0.74
	[20-25[	193	65.3	1.04	2.63	0.01	3.00
	[25-30[	399	69.9	1.50	9.89	0.04	10.19
	[30-35[	753	68.8	1.59	11.84	0.04	11.93
	[35-40[	648	47.2	7.56	15.45	0.12	14.94
	[40-45[	235	30.6	11.91	11.76	0.14	11.88
Years 90'	≥ 45	19	26.3	21.05	20.69	0.24	21.21
	< 20	1074	54.7	0.47	1.07	0.01	1.77
	[20-30[	592	68.4	1.35	8.70	0.03	8.17
Years 90'	≥ 30	1655	54.4	5.62	13.81	0.09	13.57
	< 10	193	30.6	0.00	0.00	0.00	0.00
	[10-15[	429	31.7	0.23	5.00	0.04	6.30
	[15-20[	954	39.2	0.10	0.39	0.00	0.47
	[20-25[	476	44.3	0.21	2.28	0.00	1.97
2015-2018	[25-30[	291	50.9	5.50	26.61	0.12	26.54
	[30-35[	315	45.1	8.25	29.17	0.10	28.82
	[35-40[	305	42.0	3.61	11.76	0.08	11.50
	[40-45[	142	28.9	9.86	13.10	0.16	13.70
	≥ 45	15	40.0	0.00	0.00	0.00	0.00
	< 20	1576	36.1	0.13	1.49	0.01	2.50
2015-2018	[20-30[	767	46.8	2.22	20.90	0.05	17.17
	≥ 30	777	40.8	6.56	14.14	0.10	15.60
	< 10	151	27.8	0.00	0.00	0.00	0.00
	[10-15[	313	39.0	0.00	0.00	0.00	0.00
	[15-20[	261	37.9	0.38	2.11	0.01	1.90
	[20-25[	768	40.8	0.26	4.31	0.01	5.28
2019-2021	[25-30[	270	43.0	2.59	19.59	0.04	18.67
	[30-35[	176	41.5	11.36	22.06	0.17	22.04
	[35-40[	83	36.1	14.46	56.51	0.28	56.13
	[40-45[	26	38.5	3.85	25.69	0.14	25.12
	≥ 45	2	0.0	0.00	0.00	0.00	0.00
	< 20	725	36.3	0.14	1.28	0.00	0.49
2019-2021	[20-30[	1038	41.3	0.87	10.85	0.02	9.27
	≥ 30	287	39.4	11.50	28.79	0.20	28.60

Table 2. Percentile of the cumulative distribution of male and female shrimp biomass per four-year period and per fishing area as a function of depth (m), bottom water temperature and dissolved oxygen saturation.

Depth (m)

Northern Gulf

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	176	191	218	245	277	302	332	197	208	226	255	291	325	336
1994-1997	163	174	213	241	277	309	340	193	205	238	274	308	373	417
1998-2001	166	196	230	263	304	333	372	163	195	243	282	322	374	401
2002-2005	147	152	206	249	277	311	350	154	178	235	268	308	351	389
2006-2009	138	151	195	245	279	318	357	123	151	204	258	305	350	378
2010-2013	127	139	200	246	267	303	348	129	160	229	256	299	350	379
2014-2017	164	192	221	251	279	314	329	167	197	226	259	295	327	340
2018-2021	119	132	159	222	260	275	298	67	124	185	240	270	294	306

Estuary

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008-2009	84	87	110	148	151	168	238	110	110	122	151	179	290	313
2010-2013	89	116	125	162	169	255	282	116	125	130	155	251	282	306
2014-2017	48	72	113	130	152	290	318	113	113	118	158	290	318	318
2018-2021	66	66	119	124	132	136	144	70	80	119	124	132	144	171

Sept-Iles

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	175	176	202	230	284	332	335	181	202	222	260	309	332	336
1994-1997	155	168	208	244	286	326	339	175	199	238	289	324	349	380
1998-2001	167	196	232	282	319	333	358	175	196	246	297	325	344	358
2002-2005	135	147	157	258	289	311	331	142	157	226	291	316	344	351
2006-2009	138	147	172	231	281	313	325	147	162	211	276	314	346	362
2010-2013	139	139	167	233	272	313	342	158	214	230	267	326	350	358
2014-2017	192	213	231	252	294	321	331	185	212	235	274	310	331	339
2018-2021	155	155	193	233	266	285	316	155	181	224	250	283	312	326

Anticosti

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	208	208	235	254	278	287	291	207	208	230	256	280	301	373
1994-1997	161	166	203	241	281	324	418	193	203	232	270	324	418	444
1998-2001	160	163	219	271	294	401	428	160	163	238	282	377	414	430
2002-2005	137	154	204	247	280	387	423	160	173	228	269	327	413	423
2006-2009	90	151	196	258	287	379	394	73	135	171	258	307	384	404
2010-2013	81	81	199	255	280	376	390	81	129	232	268	296	384	410
2014-2017	182	196	221	252	275	317	386	184	203	226	258	280	375	406
2018-2021	146	154	165	220	245	270	279	67	67	179	243	267	279	279

Esquiman

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	205	214	225	247	265	291	310	208	214	227	251	273	302	312
1994-1997	207	207	222	238	275	293	305	208	217	238	259	293	309	328
1998-2001	206	216	234	250	269	304	309	214	221	248	255	286	310	324
2002-2005	228	232	238	249	263	272	297	228	232	240	256	267	297	304
2006-2009	211	217	236	251	262	299	308	211	229	236	255	273	308	316
2010-2013	200	201	222	247	261	286	302	200	201	229	250	269	296	309
2014-2017	190	203	221	251	264	289	307	201	207	222	253	268	301	326
2018-2021	201	203	216	253	265	298	306	203	203	224	249	273	306	306

Bottom water temperature (^oC)

Northern Gulf

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	2.8	2.9	3.6	4.7	5.0	5.2	5.2	2.8	3.3	3.9	4.7	5.1	5.2	5.3
1994-1997	2.2	3.2	4.3	5.0	5.4	5.9	5.9	3.3	4.0	4.7	5.2	5.5	5.8	5.9
1998-2001	3.0	4.0	5.0	5.2	5.4	5.5	5.6	3.1	4.0	5.0	5.3	5.4	5.5	5.7
2002-2005	2.1	2.5	4.6	5.3	5.5	5.6	5.8	2.5	3.3	5.2	5.4	5.5	5.7	5.8
2006-2009	1.4	2.1	3.9	5.1	5.4	5.5	5.7	1.4	2.5	4.4	5.2	5.4	5.5	5.7
2010-2013	2.3	2.6	4.2	5.1	5.4	5.7	6.0	2.6	3.0	4.8	5.2	5.5	5.9	6.0
2014-2017	3.5	4.7	5.4	5.7	6.0	6.2	6.4	3.9	4.7	5.5	5.7	6.0	6.3	6.4
2018-2021	2.0	2.0	3.0	5.8	6.2	6.6	6.9	2.0	2.4	4.4	6.1	6.4	6.8	6.9

Estuary

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008-2009	0.1	0.1	0.9	2.9	3.0	3.2	4.7	0.9	0.9	0.9	2.5	3.2	5.1	5.3
2010-2013	0.8	1.1	2.2	3.1	3.8	4.8	4.9	1.4	2.2	2.5	3.1	4.8	4.9	5.2
2014-2017	0.1	0.3	0.8	3.9	4.2	5.5	5.7	0.5	0.5	3.5	4.2	5.5	5.7	5.8
2018-2021	1.4	2.0	2.0	2.1	2.7	3.0	3.0	1.4	1.8	2.0	2.1	3.0	3.0	4.0

Sept-Iles

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	2.1	2.8	3.1	4.0	5.0	5.2	5.2	2.8	3.0	3.5	4.7	5.1	5.2	5.3
1994-1997	2.2	2.2	3.8	4.8	5.2	5.3	5.4	2.7	3.4	4.5	5.1	5.3	5.5	5.5
1998-2001	2.9	4.0	4.6	5.2	5.3	5.4	5.4	3.2	4.0	5.0	5.2	5.3	5.4	5.4
2002-2005	2.1	2.1	4.4	5.3	5.4	5.5	5.6	1.6	2.6	4.9	5.4	5.5	5.5	5.6
2006-2009	1.4	2.1	3.4	4.8	5.3	5.4	5.4	2.1	3.3	4.4	5.3	5.4	5.4	5.4
2010-2013	1.5	3.0	3.1	4.9	5.3	5.4	5.5	3.1	4.2	4.8	5.2	5.4	5.5	5.6
2014-2017	4.6	4.7	5.2	5.7	5.8	5.9	6.0	4.6	4.7	5.2	5.7	5.8	5.9	6.0
2018-2021	1.5	2.0	4.4	5.9	6.2	6.4	6.4	2.0	4.0	5.6	6.0	6.3	6.4	6.5

Anticosti

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	2.2	3.5	4.1	4.9	5.0	5.2	5.2	3.0	3.5	4.2	4.8	5.1	5.2	5.4
1994-1997	1.1	2.2	4.3	5.2	5.4	5.8	5.9	3.1	4.1	4.8	5.2	5.5	5.6	5.8
1998-2001	1.7	3.3	4.9	5.3	5.4	5.5	5.6	2.8	3.5	5.0	5.3	5.4	5.6	5.7
2002-2005	2.5	2.5	3.2	5.2	5.5	5.7	5.8	2.5	3.0	5.2	5.4	5.6	5.8	5.8
2006-2009	-0.1	1.4	3.5	5.2	5.4	5.5	5.7	-0.1	1.4	4.3	5.2	5.4	5.6	5.7
2010-2013	2.6	2.6	3.1	5.2	5.5	5.9	6.0	2.6	2.6	4.8	5.3	5.7	6.0	6.1
2014-2017	3.8	4.9	5.5	5.9	6.2	6.4	6.4	4.0	5.3	5.5	5.9	6.2	6.4	6.4
2018-2021	3.0	3.0	3.9	5.3	6.2	6.8	6.9	2.4	2.4	4.4	6.2	6.6	6.9	7.0

Esquiman

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	3.6	3.7	4.1	4.8	5.1	5.2	5.3	3.4	3.6	4.2	4.8	5.1	5.3	5.3
1994-1997	4.2	4.2	4.7	5.2	5.9	5.9	5.9	4.2	4.5	4.9	5.2	5.8	5.9	5.9
1998-2001	4.8	5.0	5.2	5.3	5.4	5.7	5.7	4.8	5.0	5.2	5.4	5.5	5.7	5.7
2002-2005	4.8	5.2	5.3	5.5	5.6	5.8	5.9	4.9	5.2	5.3	5.5	5.7	5.8	5.9
2006-2009	4.9	5.0	5.1	5.2	5.5	5.8	5.8	4.9	5.0	5.1	5.3	5.6	5.8	5.8
2010-2013	4.8	4.8	4.9	5.4	5.6	5.9	6.1	4.8	4.9	5.1	5.4	5.8	6.0	6.2
2014-2017	4.9	5.6	5.7	6.0	6.2	6.3	6.4	5.3	5.4	5.7	6.0	6.3	6.4	6.5
2018-2021	5.4	5.7	6.1	6.2	6.6	6.9	7.1	5.7	5.7	6.1	6.4	6.7	6.9	7.1

Dissolved oxygen saturation (%)

Northern Gulf

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006-2009	26	28	31	38	50	60	72	25	26	29	35	45	60	83
2010-2013	24	26	28	35	44	58	96	23	24	27	33	41	51	82
2014-2017	24	26	29	33	40	48	57	22	24	27	32	39	46	51
2018-2021	19	21	24	29	52	66	74	19	20	23	28	43	66	81

Estuary

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008-2009	28	42	42	43	68	78	80	22	26	42	50	67	68	68
2010-2013	22	24	30	42	53	69	82	20	22	24	42	53	55	68
2014-2017	22	25	37	43	81	88	90	21	22	22	37	47	84	84
2018-2021	48	48	52	58	66	81	81	41	48	52	58	66	78	78

Sept-Iles

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006-2009	25	26	28	33	43	53	69	24	25	28	30	35	45	53
2010-2013	24	26	28	30	46	47	69	23	24	26	29	36	42	46
2014-2017	22	23	27	28	32	36	41	20	23	26	28	31	36	40
2018-2021	19	19	22	24	36	63	74	19	19	20	23	25	39	63

Anticosti

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006-2009	31	31	37	44	53	83	84	30	31	35	43	55	84	85
2010-2013	26	28	32	41	51	96	96	26	27	32	40	49	96	96
2014-2017	29	31	35	40	44	48	57	24	28	33	39	42	48	56
2018-2021	20	22	24	33	48	61	61	20	21	24	25	48	93	93

Esquiman

Period	Male							Female						
	P5	P10	P25	P50	P75	P90	P95	P5	P10	P25	P50	P75	P90	P95
1990-1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994-1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998-2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002-2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006-2009	27	31	31	35	45	49	51	26	30	31	36	45	49	52
2010-2013	24	25	27	33	37	41	44	24	25	27	32	37	42	45
2014-2017	28	28	31	34	40	48	54	29	30	32	36	40	45	50
2018-2021	21	24	27	28	30	38	40	20	21	26	28	31	38	39

Table 3. Landing (L) and total of allowable catch (TAC) by shrimp fishing areas: Estuary (SFA 12); Sept-Iles (SFA 10), Anticosti (SFA 9) and Esquiman (SFA 8).

Year	Estuary		Sept-Iles		Anticosti		Esquiman		Total	
	D	TAC	D	TAC	D	TAC	D	TAC	D	TAC
1965	-	-	11	-	-	-	-	-	11	-
1966	-	-	95	-	-	-	-	-	95	-
1967	-	-	278	-	-	-	-	-	278	-
1968	-	-	271	-	-	-	-	-	271	-
1969	-	-	273	-	-	-	-	-	273	-
1970	-	-	413	-	-	-	159	-	572	-
1971	-	-	393	-	-	-	691	-	1084	-
1972	-	-	481	-	-	-	184	-	665	-
1973	-	-	1273	-	-	-	520	-	1793	-
1974	-	-	1743	-	980	-	594	-	3317	-
1975	-	-	2135	-	1025	-	1368	-	4528	-
1976	-	-	1841	-	1310	-	1494	-	4645	-
1977	-	-	2746	-	1185	-	1249	-	5180	-
1978	-	-	2526	-	1460	-	2166	-	6152	-
1979	-	-	3207	-	1108	-	3226	-	7541	-
1980	539	-	2978	-	1454	-	2441	-	7412	-
1981	27	-	3680	-	1385	-	3014	-	8106	-
1982	152	**500**	3774	**3800**	2464	**4400**	2111	**4200**	8501	**12900**
1983	158	**500**	3647	**3800**	2925	**5000**	2242	**6000**	8972	**15300**
1984	248	**500**	4383	**4800**	1336	**5000**	1578	**6000**	7545	**16300**
1985	164	**500**	4399	**4600**	2786	**3400**	1421	**6000**	8770	**14500**
1986	262	**500**	4216	**4600**	3340	**3500**	1592	**3500**	9410	**12100**
1987	523	**500**	5411	**5600**	3422	**3500**	2685	**3500**	12041	**13100**
1988	551	**500**	6047	**5600**	2844	**3500**	4335	**3500**	13777	**13100**
1989	629	**500**	6254	**5700**	4253	**4200**	4614	**4500**	15750	**14900**
1990	507	**500**	6839	**6400**	4723	**4200**	3303	**4700**	15372	**15800**
1991	505	**500**	6411	**6400**	4590	**5000**	4773	**4700**	16279	**16600**
1992	489	**500**	4957	**6400**	4162	**5000**	3149	**4700**	12757	**16600**
1993	496	**500**	5485	**6400**	4791	**5000**	4683	**4700**	15455	**16600**
1994	502	**500**	6165	**6400**	4854	**5000**	4689	**4700**	16210	**16600**
1995	486	**500**	6386	**6400**	4962	**5000**	4800	**4700**	16634	**16600**
1996	505	**500**	7014	**7040**	5469	**5500**	5123	**5170**	18111	**18210**
1997	549	**550**	7737	**7744**	6058	**6050**	5957	**5687**	20301	**20031**
1998	634	**633**	8981	**8966**	6932	**7004**	6554	**6584**	23101	**23187**
1999	646	**633**	9239	**8966**	7022	**7004**	6732	**6584**	23639	**23187**
2000	739	**709**	10160	**10042**	7941	**7844**	7396	**7374**	26236	**25969**
2001	832	**786**	10965	**11136**	5399	**8700**	7815	**8178**	25011	**28800**
2002	799	**786**	11493	**11136**	8638	**8700**	8250	**8178**	29180	**28800**
2003	796	**802**	11357	**11360**	8742	**8874**	6773	**6674**	27668	**27710**
2004	1033	**995**	15932	**15611**	10429	**10226**	8593	**8502**	35987	**35334**
2005	1001	**995**	12793	**15611**	8047	**10226**	8867	**9351**	30708	**36183**
2006	1029	**995**	15312	**15611**	8754	**10226**	8957	**9351**	34052	**36183**
2007	1022	**995**	15645	**15611**	10180	**10226**	9208	**9352**	36055	**36184**
2008	1017	**1020**	15972	**15995**	9635	**10478**	9110	**9409**	35734	**36902**
2009	993	**1018**	15873	**15970**	9644	**10461**	9473	**9567**	35983	**37016**
2010	906	**917**	15756	**15969**	10099	**10461**	9541	**9567**	36302	**36914**
2011	880	**916**	14376	**15172**	9831	**9938**	9177	**9091**	34264	**35117**
2012	956	**1053**	12516	**12896**	8267	**8447**	10244	**10452**	31983	**32848**
2013	1117	**1211**	14217	**14830**	7681	**7676**	9149	**9395**	32164	**33112**
2014	984	**1029**	12416	**12606**	8738	**8827**	8408	**8249**	30546	**30711**
2015	1075	**1183**	12415	**12606**	9171	**9511**	8220	**8249**	30881	**31549**
2016	1027	**1084**	12139	**12606**	8681	**9511**	7081	**7012**	28928	**30213**
2017	899	**921**	6939	**10715**	6935	**8084**	7024	**7012**	21797	**26732**
2018	214	**239**	4175	**4266**	6300	**6871**	5971	**5959**	16660	**17335**
2019	199	**239**	3999	**4266**	6861	**6871**	5981	**5959**	17040	**17335**
2020	570	**606**	5096	**5123**	6187	**6311**	5992	**5959**	17845	**17999**
2021	607	**606**	4907	**5123**	6205	**6311**	5498	**5959**	17217	**17999**

2021: as in January 6, 2022

Table 4. Number of observations, catch (kg), effort (h), catch per unit of effort (kg/h) and its standard error (SE), percentage (%) of the landing corresponding to the observations, landing (t) and nominal effort (h) by fishing area (SFA) and by year.

Estuary (SFA 12)

SFA	Year	n obs	∑catch	∑effort	CPUE	SE	%	Landing	Nominal effort
12	1982	108	120	1628	73.9	4.34	79.1	152	2058
12	1983	59	57	1093	52.0	4.18	36.0	158	3039
12	1984	217	207	3254	63.7	3.75	83.6	248	3895
12	1985	46	51	705	73.0	6.35	31.4	164	2246
12	1986	182	154	3058	50.5	2.43	58.9	262	5189
12	1987	268	319	5097	62.5	2.42	60.9	523	8369
12	1988	264	457	4327	105.5	6.49	82.9	551	5222
12	1989	314	506	5576	90.8	3.27	80.5	629	6929
12	1990	229	450	3592	125.3	5.88	88.7	507	4048
12	1991	161	495	2144	230.9	23.31	98.0	505	2187
12	1992	300	486	4463	108.9	7.41	99.4	489	4491
12	1993	183	486	3092	157.1	9.47	97.9	496	3158
12	1994	166	490	2247	217.9	21.10	97.6	502	2303
12	1995	144	478	1718	278.2	20.39	98.3	486	1748
12	1996	129	490	1528	320.7	26.38	97.0	505	1575
12	1997	163	535	1903	280.9	13.90	97.4	549	1954
12	1998	164	646	1760	366.8	22.24	101.8	634	1729
12	1999	143	647	1708	378.6	25.63	100.1	646	1707
12	2000	188	728	2022	360.2	18.90	98.5	739	2052
12	2001	246	822	3253	252.6	9.40	98.7	832	3294
12	2002	260	803	3667	219.1	8.21	100.6	799	3647
12	2003	197	797	1939	411.3	20.65	100.2	796	1935
12	2004	215	1033	2627	393.2	15.60	100.0	1033	2627
12	2005	225	1009	2498	404.0	13.15	100.8	1001	2478
12	2006	209	1036	2293	451.6	17.40	100.6	1029	2278
12	2007	232	1022	2745	372.2	13.43	100.0	1022	2746
12	2008	210	1016	2829	359.2	12.68	99.9	1017	2831
12	2009	257	994	3485	285.3	10.81	100.1	993	3481
12	2010	255	914	3563	256.5	9.34	100.9	906	3532
12	2011	277	879	4405	199.6	4.76	99.9	880	4408
12	2012	253	956	4240	225.4	6.40	100.0	956	4242
12	2013	333	1117	6269	178.2	3.72	100.0	1117	6268
12	2014	236	984	4293	229.1	5.98	100.0	984	4294
12	2015	235	1091	4254	256.3	9.13	101.5	1075	4193
12	2016	267	1027	5084	201.9	4.27	100.0	1027	5086
12	2017	274	899	5288	170.0	3.75	100.0	899	5289
12	2018	62	214	966	221.8	16.43	100.1	214	965
12	2019	47	199	637	312.6	31.09	100.1	199	637
12	2020	136	570	1818	313.6	13.84	100.0	570	1818
12	2021	138	607	1918	316.2	14.40	99.9	607	1919

2021: as in January 6, 2022

Sept-Iles (SFA 10)

SFA	Year	n obs	∑catch	∑effort	CPUE	SE	%	Landing	Nominal effort
10	1982	2247	2554	31755	80.4	1.50	67.7	3774	46932
10	1983	1532	2058	21767	94.6	1.73	56.4	3647	38573
10	1984	3593	4011	51114	78.5	1.12	91.5	4383	55860
10	1985	3297	4305	50343	85.5	0.99	97.9	4399	51444
10	1986	2888	4179	43386	96.3	1.43	99.1	4216	43775
10	1987	3540	5151	56227	91.6	1.09	95.2	5411	59070
10	1988	4079	5401	65130	82.9	0.95	89.3	6047	72918
10	1989	3477	5326	55785	95.5	1.05	85.2	6254	65501
10	1990	2784	6043	45941	131.5	1.62	88.4	6839	51994
10	1991	3336	6206	53084	116.9	1.46	96.8	6411	54842
10	1992	3921	4923	65510	75.2	0.96	99.3	4957	65961
10	1993	4066	5295	72394	73.1	0.81	96.5	5485	74995
10	1994	3841	6212	73030	85.1	0.92	100.8	6165	72472
10	1995	2303	6457	44583	144.8	2.11	101.1	6386	44094
10	1996	2120	7105	40423	175.8	2.51	101.3	7014	39908
10	1997	2275	7819	41477	188.5	2.56	101.1	7737	41040
10	1998	2427	9102	43620	208.7	2.76	101.3	8981	43042
10	1999	2589	9228	46399	198.9	2.50	99.9	9239	46457
10	2000	2819	10075	51683	194.9	2.06	99.2	10160	52118
10	2001	3486	10829	66553	162.7	1.75	98.8	10965	67389
10	2002	3068	11433	57315	199.5	1.86	99.5	11493	57616
10	2003	2156	11226	37844	296.6	3.84	98.8	11357	38285
10	2004	2928	15803	51634	306.1	3.11	99.2	15932	52054
10	2005	2353	12605	40791	309.0	2.91	98.5	12793	41400
10	2006	2951	15576	50950	305.7	2.79	101.7	15312	50087
10	2007	2240	14242	39794	357.9	3.76	91.0	15645	43715
10	2008	2543	15669	44761	350.1	4.11	98.1	15972	45626
10	2009	2785	15540	48891	317.8	3.28	97.9	15873	49940
10	2010	2932	15662	54879	285.4	2.65	99.4	15756	55207
10	2011	2964	14920	54696	272.8	2.60	103.8	14376	52703
10	2012	2474	12523	44402	282.0	2.89	100.1	12516	44376
10	2013	3172	14564	56533	257.6	2.34	102.4	14217	55186
10	2014	2439	12172	42496	286.4	2.83	98.0	12416	43350
10	2015	2310	12250	41253	296.9	2.76	98.7	12415	41809
10	2016	3250	11940	59815	199.6	1.76	98.4	12139	60810
10	2017	2934	7183	54177	132.6	1.13	103.5	6939	52337
10	2018	1807	4233	33273	127.2	1.69	101.4	4175	32814
10	2019	1724	4028	25463	158.2	2.01	100.7	3999	25280
10	2020	1979	5078	25653	197.9	2.05	99.6	5096	25746
10	2021	1769	4737	24829	190.8	2.10	96.5	4907	25718

2021: as in January 6, 2022

Anticosti (SFA 9)

SFA	Year	n obs	∑catch	∑effort	CPUE	SE	%	Landing	Nominal effort
9	1982	1725	2259	24987	90.4	0.95	91.7	2464	27252
9	1983	1890	2252	25894	87.0	1.06	77.0	2925	33626
9	1984	1482	1243	20206	61.5	0.85	93.1	1336	21710
9	1985	2292	2570	30665	83.8	0.76	92.2	2786	33243
9	1986	2980	3181	40802	78.0	0.70	95.2	3340	42841
9	1987	2354	3051	36176	84.3	0.85	89.1	3422	40580
9	1988	1624	2367	24137	98.1	1.14	83.2	2844	28999
9	1989	1901	3662	27630	132.5	1.51	86.1	4253	32089
9	1990	1983	4244	30474	139.3	1.80	89.9	4723	33917
9	1991	2280	4611	37598	122.7	1.09	100.5	4590	37425
9	1992	2416	4113	40742	101.0	0.79	98.8	4162	41226
9	1993	2460	4554	44786	101.7	0.63	95.0	4791	47121
9	1994	2295	4897	41169	119.0	0.88	100.9	4854	40804
9	1995	1874	5024	34810	144.3	1.08	101.3	4962	34379
9	1996	2039	5480	38038	144.1	1.32	100.2	5469	37958
9	1997	1923	6052	37455	161.6	1.55	99.9	6058	37491
9	1998	2128	6991	40955	170.7	1.26	100.9	6932	40609
9	1999	2355	6880	44971	153.0	1.19	98.0	7022	45899
9	2000	2181	7680	41171	186.5	1.40	96.7	7941	42571
9	2001	1579	5155	30727	167.8	1.89	95.5	5399	32184
9	2002	2129	8476	40843	207.5	1.89	98.1	8638	41625
9	2003	1693	8442	32173	262.4	2.53	96.6	8742	33317
9	2004	2077	10058	39541	254.4	2.27	96.4	10429	40999
9	2005	1277	7551	23618	319.7	4.69	93.8	8047	25170
9	2006	1377	7830	24554	318.9	4.67	89.4	8754	27452
9	2007	1721	9496	32155	295.3	2.93	93.3	10180	34472
9	2008	1480	8999	27803	323.7	3.25	93.4	9635	29767
9	2009	1529	9591	28114	341.2	3.73	99.5	9644	28268
9	2010	1713	9720	32106	302.8	3.09	96.2	10099	33358
9	2011	1575	9603	29598	324.4	3.37	97.7	9831	30302
9	2012	1492	8012	28011	286.0	3.15	96.9	8267	28901
9	2013	1129	7480	20496	364.9	4.48	97.4	7681	21048
9	2014	1195	8473	21590	392.4	5.05	97.0	8738	22266
9	2015	1501	8809	26863	327.9	3.38	96.1	9171	27967
9	2016	2058	8628	37820	228.1	2.08	99.4	8681	38051
9	2017	1874	6997	34796	201.1	2.11	100.9	6935	34490
9	2018	1657	6444	31006	207.8	2.36	102.3	6300	30315
9	2019	1822	6273	29019	216.2	2.17	91.4	6861	31741
9	2020	1955	6245	26461	236.0	2.69	100.9	6187	26217
9	2021	1779	5473	26596	205.8	2.55	88.2	6205	30156

2021: as in January 6, 2022

Esquiman (SFA 8)

SFA	Year	n obs	∑catch	∑effort	CPUE	SE	%	Landing	Nominal effort
8	1982	1281	1617	13095	123.5	1.93	76.6	2111	17093
8	1983	2038	1929	20289	95.1	1.64	86.0	2242	23584
8	1984	742	846	7902	107.1	3.14	53.6	1578	14733
8	1985	164	231	2796	82.7	1.78	16.3	1421	17189
8	1986	952	1060	10412	101.8	2.04	66.6	1592	15643
8	1987	948	1139	11312	100.7	1.41	42.4	2685	26665
8	1988	1029	1656	13405	123.5	2.04	38.2	4335	35101
8	1989	1468	2659	16708	159.1	2.52	57.6	4614	28997
8	1990	1918	3465	22220	155.9	2.40	104.9	3303	21184
8	1991	2440	4630	29256	158.3	1.83	97.0	4773	30158
8	1992	1775	3063	24622	124.4	1.36	97.3	3149	25314
8	1993	2307	4256	31074	137.0	1.18	90.9	4683	34190
8	1994	1764	4264	26917	158.4	1.77	90.9	4689	29601
8	1995	2198	4548	30429	149.5	1.42	94.8	4800	32114
8	1996	1647	4964	22288	222.7	2.92	96.9	5123	23003
8	1997	1558	5273	20994	251.2	3.02	88.5	5957	23716
8	1998	2088	6345	25383	250.0	2.55	96.8	6554	26218
8	1999	2107	6249	24804	252.0	2.81	92.8	6732	26719
8	2000	2189	6980	23690	294.6	3.62	94.4	7396	25101
8	2001	1937	6888	23970	287.4	2.95	88.1	7815	27196
8	2002	2336	7621	27017	282.1	2.34	92.4	8250	29248
8	2003	1817	6018	18111	332.3	3.32	88.9	6773	20382
8	2004	1858	7806	17232	453.0	4.62	90.8	8593	18969
8	2005	1681	7830	17152	456.5	5.38	88.3	8867	19424
8	2006	1608	8155	17062	478.0	6.18	91.0	8957	18740
8	2007	2068	8035	21910	366.7	3.97	87.3	9208	25110
8	2008	1783	8307	20972	396.1	4.91	91.2	9110	22998
8	2009	3263	9022	20344	443.5	4.34	95.2	9473	21362
8	2010	2952	8715	17872	487.6	5.15	91.3	9541	19566
8	2011	2951	8822	16139	546.7	5.84	96.1	9177	16788
8	2012	3086	9637	16950	568.5	5.88	94.1	10244	18018
8	2013	2911	9169	19008	482.4	5.46	100.2	9149	18966
8	2014	2382	7793	14849	524.8	5.18	92.7	8408	16020
8	2015	2597	7540	17159	439.4	4.04	91.7	8220	18706
8	2016	2698	6520	16247	401.3	4.23	92.1	7081	17644
8	2017	2790	6030	18676	322.9	3.65	85.9	7024	21753
8	2018	2103	5807	14496	400.6	5.46	97.3	5971	14904
8	2019	2387	5338	15334	348.1	3.52	89.3	5981	17180
8	2020	2283	5632	14700	383.1	3.83	94.0	5992	15640
8	2021	2105	4408	13976	315.4	4.10	80.2	5498	17433

2021: as in January 6, 2022

Table 5. Catch (t) per month by fishing area (SFA) and by year.

Estuary (SFA 12)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
12	1982	0	0	0	50	19	3	24	3	51	2	0	0
12	1983	0	0	0	14	7	45	85	7	0	0	0	0
12	1984	0	0	0	18	36	47	51	5	20	58	10	3
12	1985	0	0	0	50	21	0	5	18	42	28	0	0
12	1986	0	0	18	17	18	5	28	62	70	45	0	0
12	1987	0	0	0	14	80	58	189	181	0	0	0	0
12	1988	0	0	0	347	80	86	39	0	0	0	0	0
12	1989	0	0	205	133	35	49	141	66	0	0	0	0
12	1990	0	0	212	125	171	0	0	0	0	0	0	0
12	1991	0	0	0	386	45	3	5	13	40	11	1	0
12	1992	0	0	0	314	99	17	7	15	14	10	14	0
12	1993	0	0	0	264	146	2	2	3	2	69	7	0
12	1994	0	0	50	390	34	2	2	3	6	8	7	0
12	1995	0	0	0	340	40	6	7	71	11	0	12	0
12	1996	0	0	0	404	20	6	6	15	40	11	3	0
12	1997	0	0	0	333	95	4	30	73	6	3	5	2
12	1998	0	0	0	265	151	23	72	40	38	43	2	0
12	1999	0	0	0	373	77	3	41	105	41	5	1	0
12	2000	0	0	0	448	79	6	1	77	71	54	3	0
12	2001	0	0	0	220	377	0	3	5	46	127	54	0
12	2002	0	0	0	188	278	0	2	86	208	27	11	0
12	2003	0	0	0	314	138	44	0	93	168	31	8	0
12	2004	0	0	0	213	299	52	0	90	237	129	13	0
12	2005	0	0	0	363	240	168	48	85	13	67	18	0
12	2006	0	0	0	418	128	209	12	49	150	18	46	0
12	2007	0	0	0	261	100	79	0	270	265	19	29	0
12	2008	0	0	0	106	475	57	100	100	114	30	37	0
12	2009	0	0	0	322	200	0	0	183	221	51	16	0
12	2010	0	0	0	497	118	0	0	78	117	80	16	0
12	2011	0	0	0	107	96	0	0	263	314	81	20	0
12	2012	0	0	0	15	304	61	215	79	160	103	18	0
12	2013	0	0	0	26	84	13	227	257	273	148	90	0
12	2014	0	0	0	0	270	133	23	224	248	76	11	0
12	2015	0	0	0	61	431	170	56	81	233	28	16	0
12	2016	0	0	0	37	276	89	99	120	166	197	43	0
12	2017	0	0	0	107	72	55	63	259	104	213	25	0
12	2018	0	0	0	110	29	0	27	0	0	42	6	0
12	2019	0	0	0	83	0	0	0	49	47	16	5	0
12	2020	0	0	0	0	2	45	114	187	190	6	27	0
12	2021	0	0	0	0	61	139	72	92	162	56	24	0

2021: as in January 6, 2022

Sept-Iles (SFA 10)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
10	1982	0	0	87	834	1015	422	451	433	209	250	73	0
10	1983	0	0	0	698	1484	536	60	595	237	37	0	0
10	1984	0	0	17	776	1040	760	232	886	432	129	93	19
10	1985	0	0	143	1174	671	865	829	643	45	24	3	2
10	1986	0	0	92	1588	1093	633	684	22	86	20	0	0
10	1987	0	0	93	1329	1342	1028	25	54	1085	456	0	1
10	1988	0	0	79	999	1404	968	1321	349	728	199	0	0
10	1989	0	0	221	1555	1541	935	899	0	1103	0	0	0
10	1990	0	0	0	1310	1881	1676	1023	0	949	0	0	0
10	1991	0	0	0	1651	1435	891	655	771	595	373	40	1
10	1992	0	0	0	903	771	460	400	625	891	718	175	16
10	1993	0	0	0	931	964	283	733	844	1063	452	179	38
10	1994	0	0	181	888	1346	891	520	757	1037	392	113	41
10	1995	0	0	0	2018	1806	1216	325	650	269	84	16	2
10	1996	0	0	0	3151	2161	814	310	428	112	26	9	4
10	1997	0	0	0	3097	1897	1310	765	588	71	6	0	4
10	1998	0	0	0	2797	2242	677	1229	985	756	244	51	2
10	1999	0	0	0	3641	2175	1671	666	603	359	74	31	19
10	2000	0	0	0	2970	2410	1281	1103	1483	437	348	127	2
10	2001	0	0	0	3513	1182	395	277	1141	1913	1214	1163	167
10	2002	0	0	0	2047	2759	2979	1170	1042	1012	268	178	39
10	2003	0	0	0	4076	2828	1154	830	1450	864	92	39	25
10	2004	0	0	0	5375	3595	1784	896	2254	1735	275	19	0
10	2005	0	0	0	4760	3508	1439	1305	504	449	721	107	0
10	2006	0	0	0	1967	3665	2700	1300	1138	2745	1301	362	134
10	2007	0	0	0	2196	4533	4045	2521	781	476	546	473	75
10	2008	0	0	25	4719	3958	2952	1463	1234	1032	303	204	82
10	2009	0	0	0	4021	3868	1211	1002	2569	2755	438	8	0
10	2010	0	0	0	4405	4052	762	1516	2081	1783	899	257	2
10	2011	0	0	0	4151	3167	618	1811	2194	1531	737	167	0
10	2012	0	0	0	4484	2250	674	2067	1681	995	310	55	0
10	2013	0	0	0	4069	2239	847	2342	2601	1364	698	53	4
10	2014	0	0	0	4171	1720	539	2067	2203	1274	362	20	61
10	2015	0	0	0	3746	2562	735	1336	2023	1326	483	204	0
10	2016	0	0	0	2725	2056	629	659	1653	2008	1607	708	94
10	2017	0	0	0	639	608	407	767	816	1797	1293	555	57
10	2018	0	0	0	1034	300	358	603	630	647	484	117	2
10	2019	0	0	0	1172	329	248	539	719	667	167	159	0
10	2020	0	0	0	121	98	203	842	1020	1312	1102	400	0
10	2021	0	0	0	140	124	286	604	841	1086	1341	486	0

2021: as in January 6, 2022

Anticosti (SFA 9)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
9	1982	0	0	0	14	185	680	524	505	469	84	5	0
9	1983	0	0	0	45	108	912	592	365	543	327	33	0
9	1984	0	0	0	15	283	249	307	99	179	185	19	0
9	1985	0	0	0	15	100	490	791	577	607	206	0	0
9	1986	0	0	0	8	101	800	770	1027	418	216	0	0
9	1987	0	0	0	13	584	602	1047	827	236	113	0	0
9	1988	0	0	0	27	84	484	393	1065	354	425	12	0
9	1989	0	0	0	1	187	1173	827	544	380	1083	59	0
9	1990	0	0	0	6	22	965	1372	1919	439	0	0	0
9	1991	0	0	0	24	373	1055	1537	762	495	306	39	1
9	1992	0	0	0	1	152	1336	1375	777	479	41	3	0
9	1993	0	0	0	0	269	1908	1676	689	189	45	14	0
9	1994	0	0	0	12	95	891	2305	1141	305	99	6	0
9	1995	0	0	0	4	310	1085	2515	841	165	41	1	0
9	1996	0	0	0	30	349	1934	1902	773	348	98	37	0
9	1997	0	0	0	309	560	2007	2659	419	104	0	0	0
9	1998	0	0	0	153	1141	2494	1867	1052	181	43	0	0
9	1999	0	0	0	42	540	1546	3117	1206	396	74	62	40
9	2000	0	0	0	11	647	2547	3217	1081	369	50	19	0
9	2001	0	0	0	2	215	737	1448	2021	870	75	29	2
9	2002	0	0	0	15	892	1590	3344	2155	541	88	0	15
9	2003	0	0	0	368	834	2351	3669	1165	235	73	44	3
9	2004	0	0	0	94	699	2121	4824	1866	683	128	15	0
9	2005	0	0	0	120	1428	3486	1704	420	647	236	7	0
9	2006	0	0	0	40	1119	2348	2483	1536	925	274	30	0
9	2007	0	0	0	0	1153	1953	3254	2293	1309	108	47	63
9	2008	0	0	0	0	1216	2734	3248	1861	498	80	0	0
9	2009	0	0	0	69	1378	4463	2552	824	133	84	143	0
9	2010	0	0	0	1	930	4748	3329	1019	47	24	0	0
9	2011	0	0	0	22	1240	5359	2474	549	162	22	5	0
9	2012	0	0	0	23	1855	3983	1602	442	211	73	78	0
9	2013	0	0	0	93	1678	4652	670	294	228	50	17	0
9	2014	0	0	0	63	2283	4658	1173	307	132	122	0	0
9	2015	0	0	0	197	1500	3887	2213	808	398	97	21	50
9	2016	0	0	0	36	647	3127	2513	1696	578	84	0	0
9	2017	0	0	0	0	626	2935	1657	1069	549	55	44	0
9	2018	0	0	0	15	2161	2063	960	685	335	73	8	0
9	2019	0	0	0	152	1603	2485	1485	735	289	113	0	0
9	2020	0	0	0	0	0	2162	1884	969	780	338	54	0
9	2021	0	0	0	0	327	2295	1658	975	680	252	18	0

2021: as in January 6, 2022

Esquiman (SFA 8)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
8	1982	0	0	0	242	832	138	193	277	129	299	0	0
8	1983	0	142	345	696	187	382	159	111	149	59	12	0
8	1984	0	8	9	572	273	244	84	122	101	140	24	0
8	1985	0	0	0	5	236	378	176	419	208	0	0	0
8	1986	0	0	0	527	203	97	296	215	147	98	9	0
8	1987	0	0	78	213	344	753	219	539	204	238	76	22
8	1988	0	0	0	379	1203	960	881	445	0	300	123	45
8	1989	0	0	0	121	1292	1178	377	624	424	253	331	15
8	1990	0	0	0	0	860	532	1048	339	308	215	0	0
8	1991	0	0	0	720	1498	1283	875	240	101	28	29	0
8	1992	0	0	0	0	634	1615	686	72	102	40	1	0
8	1993	0	0	0	2	1338	1172	1334	621	171	36	10	0
8	1994	0	0	0	0	455	1660	1896	411	200	68	0	0
8	1995	4	0	0	9	2651	1460	38	114	316	206	3	0
8	1996	0	0	0	0	1834	2073	815	263	91	48	0	0
8	1997	0	0	0	3	1448	2596	1133	322	170	204	64	17
8	1998	0	0	0	1023	2433	1080	567	204	548	360	201	137
8	1999	0	0	0	1761	2393	1578	412	99	213	82	130	64
8	2000	0	0	0	2427	1875	1136	815	890	199	53	1	0
8	2001	0	0	0	1810	1629	1828	839	218	592	900	0	0
8	2002	0	0	0	1595	1488	2637	1772	478	182	68	31	0
8	2003	0	0	0	6	2495	2807	441	534	218	84	182	7
8	2004	0	0	6	39	2398	4296	1050	348	285	171	0	0
8	2005	0	0	0	1	2289	2608	639	1534	1113	675	8	0
8	2006	0	0	0	505	2344	1938	944	1261	1248	653	65	0
8	2007	0	0	3	870	4231	1053	855	618	899	434	225	22
8	2008	0	0	0	1093	3452	1931	2107	430	41	7	50	0
8	2009	0	0	0	874	3727	1344	2610	418	402	88	10	0
8	2010	0	0	0	304	4426	3548	557	535	106	18	47	0
8	2011	0	0	0	125	6666	1996	172	113	7	58	40	0
8	2012	0	0	0	123	5631	2914	802	389	306	80	0	0
8	2013	0	0	0	66	3716	2947	1398	404	255	307	51	6
8	2014	0	0	0	0	4141	2179	811	877	336	57	6	0
8	2015	0	0	0	0	3695	2401	1018	935	171	0	0	0
8	2016	0	0	0	279	1234	3894	1347	70	89	63	99	8
8	2017	0	0	0	240	1166	1120	2794	976	449	264	15	0
8	2018	0	0	0	96	3444	1387	626	220	185	14	0	0
8	2019	0	0	0	0	3681	1430	518	310	42	0	0	0
8	2020	0	0	0	0	0	44	709	3131	1675	433	0	0
8	2021	0	0	0	0	0	514	2751	1608	561	36	28	0

2021: as in January 6, 2022

Table 6. Effort (h) per month by fishing area (SFA) and by year.

Estuary (SFA 12)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
12	1982	0	0	0	423	284	54	334	39	876	47	0	0
12	1983	0	0	0	200	78	473	2010	278	0	0	0	0
12	1984	0	0	0	57	266	598	1036	117	430	1064	279	48
12	1985	0	0	0	331	323	0	67	341	672	512	0	0
12	1986	0	0	239	149	188	48	507	1051	1339	1668	0	0
12	1987	0	0	0	188	920	663	3290	3309	0	0	0	0
12	1988	0	0	5	2631	957	943	687	0	0	0	0	0
12	1989	0	0	1982	1669	587	512	1420	761	0	0	0	0
12	1990	0	0	1640	715	1693	0	0	0	0	0	0	0
12	1991	0	0	0	1097	262	51	125	173	308	157	14	0
12	1992	0	0	0	1716	1015	333	202	224	349	329	322	0
12	1993	0	0	0	1086	1110	14	29	86	47	692	94	0
12	1994	0	0	492	1035	364	57	50	110	42	93	61	0
12	1995	0	0	0	875	286	69	53	351	71	0	42	0
12	1996	0	0	0	959	80	69	63	127	222	45	10	0
12	1997	0	0	0	1056	317	42	114	348	43	11	16	6
12	1998	0	0	0	485	370	105	265	175	140	170	20	0
12	1999	0	0	0	604	269	32	227	360	180	26	9	0
12	2000	0	0	0	875	336	43	7	295	282	183	30	0
12	2001	0	0	0	731	1526	0	31	22	181	529	274	0
12	2002	0	0	0	892	1587	22	8	319	709	75	36	0
12	2003	0	0	0	524	319	146	0	308	498	120	21	0
12	2004	0	0	0	340	749	306	8	233	628	330	33	0
12	2005	0	0	0	819	547	334	158	273	51	243	54	0
12	2006	0	0	0	632	310	548	48	130	446	49	115	0
12	2007	0	0	0	371	290	248	0	757	889	103	88	0
12	2008	0	0	0	221	1299	109	227	335	465	88	88	0
12	2009	0	0	0	591	684	8	0	817	1062	259	59	0
12	2010	0	0	0	1500	686	0	0	274	640	358	73	0
12	2011	0	0	0	483	497	0	0	1321	1505	458	143	0
12	2012	0	0	0	74	1174	168	672	387	933	680	155	0
12	2013	0	0	0	138	506	88	1266	1465	1647	689	468	0
12	2014	0	0	0	0	916	567	143	937	1291	355	85	0
12	2015	0	0	0	195	1279	524	254	411	1233	178	120	0
12	2016	0	0	0	142	1424	567	442	452	843	1021	195	0
12	2017	0	0	0	426	395	308	433	1668	661	1222	176	0
12	2018	0	0	0	456	269	0	67	0	0	149	24	0
12	2019	0	0	0	380	0	0	0	125	67	47	18	0
12	2020	0	0	0	0	17	155	234	562	648	17	185	0
12	2021	0	0	0	0	163	528	239	317	358	194	121	0

2021: as in January 6, 2022

Sept-Iles (SFA 10)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
10	1982	0	0	286	4463	11798	6931	6455	7815	3712	4036	1437	0
10	1983	0	0	0	4232	13263	6619	1331	7963	4290	875	0	0
10	1984	0	0	20	4796	10256	10622	4614	13360	7420	2845	1579	348
10	1985	0	0	675	8552	11779	11199	10197	7432	920	577	101	12
10	1986	0	0	496	9100	13371	8793	9394	481	1639	503	0	0
10	1987	0	0	1098	11281	13818	11303	760	940	12941	6919	0	11
10	1988	0	0	710	8988	16241	13148	15584	4830	10116	3302	0	0
10	1989	0	0	1480	13855	16688	12002	10585	0	10892	0	0	0
10	1990	0	0	0	7846	14371	14732	6620	0	8426	0	0	0
10	1991	0	0	0	8627	14533	9253	6294	6367	5495	3852	407	15
10	1992	0	0	0	5533	10946	6752	5598	9830	12584	10535	3907	277
10	1993	0	0	0	7117	14800	3907	8837	11330	14416	10305	3869	415
10	1994	0	0	338	9482	18330	11207	5914	9101	10538	5276	1820	466
10	1995	0	0	0	10587	16141	9248	2146	3618	1694	514	126	21
10	1996	0	0	0	16102	13612	4582	1795	2587	769	193	138	131
10	1997	0	0	0	13644	12577	7978	3568	2785	385	81	0	22
10	1998	0	0	0	10287	9397	3430	6796	6367	4644	1795	316	10
10	1999	0	0	0	13598	13069	9021	2907	3734	3072	640	246	170
10	2000	0	0	0	12742	13636	7109	4735	7518	2797	2621	950	9
10	2001	0	0	0	13816	7547	2587	1259	6058	14404	11011	9742	964
10	2002	0	0	0	10989	15878	14503	4502	5187	4455	1187	740	175
10	2003	0	0	0	10113	9973	5175	3183	5459	3669	438	178	99
10	2004	0	0	0	12923	14212	7215	3163	7167	6375	919	81	0
10	2005	0	0	0	13928	12540	4536	3944	1758	1373	2876	445	0
10	2006	0	0	0	4823	12427	9411	4070	3310	9136	5315	1324	273
10	2007	0	0	0	4135	13444	12285	6180	1961	1700	2342	1537	132
10	2008	0	0	73	7123	13043	9716	5017	4453	4241	1337	455	167
10	2009	0	0	0	7524	14878	5097	2991	8968	9026	1417	37	0
10	2010	0	0	0	11974	13988	2975	5276	7808	7714	4371	1087	17
10	2011	0	0	0	12017	12519	2464	7249	9010	6360	2641	443	0
10	2012	0	0	0	13697	9421	2395	7185	5696	4141	1668	173	0
10	2013	0	0	0	13113	10195	3538	8917	9952	6622	2689	111	48
10	2014	0	0	0	12580	7225	2317	7659	7073	4905	1393	76	120
10	2015	0	0	0	9764	8954	2992	4941	7071	5572	1967	548	0
10	2016	0	0	0	9794	10226	3433	3593	8209	11138	9400	4463	554
10	2017	0	0	0	3544	4121	2901	5909	6390	12367	10958	5688	459
10	2018	0	0	0	7937	2644	2322	5372	6578	5781	1767	401	11
10	2019	0	0	0	7915	3479	1396	3532	4507	3229	737	487	0
10	2020	0	0	0	324	222	729	3666	5624	7336	5960	1884	0
10	2021	0	0	2	602	403	1367	2809	4621	5932	6791	3191	0

2021: as in January 6, 2022

Anticosti (SFA 9)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
9	1982	0	0	0	96	1712	7053	5827	5324	5852	1333	56	0
9	1983	0	0	0	297	854	8374	7357	4696	6462	4874	712	0
9	1984	0	0	0	114	3096	3198	5188	1913	3276	4403	523	0
9	1985	0	0	0	178	1543	5685	8043	6771	7752	3272	0	0
9	1986	0	0	0	43	788	8150	8962	12658	7032	5209	0	0
9	1987	0	0	0	237	5778	6675	13167	10103	3135	1485	0	0
9	1988	0	0	0	248	969	4756	3665	11186	3662	4294	218	0
9	1989	0	0	0	43	1364	7771	5939	4734	3180	8490	570	0
9	1990	0	0	0	3	162	4131	10263	15492	3865	0	0	0
9	1991	0	0	0	97	2417	7393	12883	7208	4184	2857	379	7
9	1992	0	0	0	11	1645	12063	13909	8080	4909	565	44	0
9	1993	0	0	0	0	2605	17805	16191	7780	1919	643	179	0
9	1994	0	0	0	158	1081	7464	18731	9976	2393	921	79	0
9	1995	0	0	0	34	2753	7377	16147	6459	1141	444	22	0
9	1996	0	0	0	170	2794	10794	13540	6447	3043	811	358	0
9	1997	0	0	0	1612	4761	12891	14924	2516	786	0	0	0
9	1998	0	0	0	818	5801	13953	11332	6822	1386	497	0	0
9	1999	0	0	0	236	3749	9160	18387	8630	3998	737	705	298
9	2000	0	0	0	62	3795	13629	16300	5939	2342	371	132	0
9	2001	0	0	0	17	1445	3342	6295	12708	7472	674	216	16
9	2002	0	0	0	90	4110	6259	14975	11610	3862	597	0	121
9	2003	0	0	0	1467	2766	10081	13890	3868	734	319	168	25
9	2004	0	0	0	434	2370	7929	18566	7808	3170	630	91	0
9	2005	0	0	0	295	3826	9264	6440	1554	2771	999	21	0
9	2006	0	0	0	141	3701	5063	6956	5535	4631	1221	204	0
9	2007	0	0	0	0	3331	5380	11669	9096	4178	476	147	195
9	2008	0	0	0	0	3377	6579	9640	7503	2178	490	0	0
9	2009	0	0	0	282	3843	11510	9008	2964	295	218	150	0
9	2010	0	0	0	7	2083	14995	11976	3962	220	114	0	0
9	2011	0	0	0	97	3003	14947	9773	2025	281	108	68	0
9	2012	0	0	0	100	5639	13161	6177	1928	958	369	570	0
9	2013	0	0	0	481	4314	11419	2410	1187	972	197	69	0
9	2014	0	0	0	226	6336	11491	2483	924	439	367	0	0
9	2015	0	0	0	417	3974	10338	7775	3052	1324	587	166	334
9	2016	0	0	0	188	2761	10895	11913	8883	3109	304	0	0
9	2017	0	0	0	0	2205	12488	8983	6997	3044	443	329	0
9	2018	0	0	0	41	8797	9122	6011	4196	1772	314	62	0
9	2019	0	0	0	945	7318	10376	7533	3689	1397	484	0	0
9	2020	0	0	0	0	0	7291	8808	4848	3794	1244	231	0
9	2021	0	0	0	0	1382	10179	8406	5698	2994	1373	125	0

2021: as in January 6, 2022

Esquiman (SFA 8)

SFA	Year	J	F	M	A	M	J	J	A	S	O	N	D
8	1982	0	0	0	1509	5781	1487	1557	2608	1382	2767	0	0
8	1983	0	835	2237	6240	1665	4107	2065	2124	2762	1277	272	0
8	1984	0	60	52	3558	2651	2386	781	1334	1455	2098	359	0
8	1985	0	0	0	105	2976	4583	2007	5140	2380	0	0	0
8	1986	0	0	0	2981	2307	1060	3368	2702	1901	1184	141	0
8	1987	0	0	685	2324	2926	6898	2671	5273	2413	2557	668	253
8	1988	0	0	0	2323	9413	8124	7428	3639	0	2831	914	429
8	1989	0	0	0	350	7698	6783	2616	3968	3185	1910	2392	96
8	1990	0	0	0	0	5311	2843	5389	2818	2846	1977	0	0
8	1991	0	0	0	2659	9839	7467	7021	1802	907	240	223	0
8	1992	0	0	0	0	4648	11777	6316	884	1192	488	8	0
8	1993	0	0	0	13	10057	7553	8839	5487	1746	359	134	0
8	1994	0	0	0	0	3589	9781	11505	2392	1699	635	0	0
8	1995	29	0	0	34	16989	9255	241	822	2573	2132	40	0
8	1996	0	0	0	0	6933	9020	4504	1830	428	288	0	0
8	1997	0	0	0	10	6003	9920	4078	1408	707	1118	404	67
8	1998	0	0	0	3810	9685	3552	2227	697	2286	1941	1371	650
8	1999	0	0	0	5994	10597	5343	1277	431	1262	511	910	394
8	2000	0	0	0	7610	7399	2701	2580	3577	985	239	11	0
8	2001	0	0	0	5715	6214	4734	2629	1009	2579	4316	0	0
8	2002	0	0	0	5088	5392	8005	7236	2192	792	433	110	0
8	2003	0	0	0	7	6961	8458	1438	1869	718	297	615	19
8	2004	0	0	15	159	5437	9416	1996	896	693	357	0	0
8	2005	0	0	0	1	4327	4641	1767	3549	3007	2111	22	0
8	2006	0	0	0	865	4385	2890	1650	3168	3695	1903	183	0
8	2007	0	0	3	1769	11775	2469	1579	1591	3108	1591	1047	180
8	2008	0	0	0	3173	9777	3277	4857	1396	240	36	242	0
8	2009	0	0	0	1799	8209	2762	5888	1202	1173	295	34	0
8	2010	0	0	0	905	8720	6426	1334	1623	419	42	97	0
8	2011	0	0	0	407	12450	2761	508	365	44	144	110	0
8	2012	0	0	0	367	9434	5006	1584	894	566	168	0	0
8	2013	0	0	0	243	6029	6014	3615	1378	599	905	166	19
8	2014	0	0	0	0	7910	3547	1365	2042	910	210	38	0
8	2015	0	0	0	0	7386	5557	2510	2745	509	0	0	0
8	2016	0	0	0	758	2587	9210	3674	218	279	273	584	61
8	2017	0	0	0	549	3139	2696	7886	4088	2014	1282	100	0
8	2018	0	0	0	396	6760	3948	2206	791	747	57	0	0
8	2019	0	0	0	0	9997	4290	1579	1130	185	0	0	0
8	2020	0	0	0	0	0	72	1553	8185	4432	1397	0	0
8	2021	0	0	0	0	0	1179	8027	5603	2231	269	124	0

2019 : as in December 9, 2019

Table 7. Standardised catch per unit of effort and its standard error, landing and standardised effort, by fishing area and by year.

Estuary (SFA 12)

SFA	Year	CPUE std	SE	Landing (t)	Effort std
12	1982	73.35	5.79	152	2072
12	1983	54.86	5.11	158	2880
12	1984	68.67	3.85	248	3612
12	1985	72.53	7.53	164	2261
12	1986	58.83	3.53	262	4454
12	1987	69.10	3.73	523	7569
12	1988	89.35	4.62	551	6166
12	1989	88.01	4.87	629	7147
12	1990	137.17	8.80	507	3696
12	1991	139.67	8.68	505	3616
12	1992	74.89	3.85	489	6530
12	1993	147.04	9.17	496	3373
12	1994	129.95	8.41	502	3863
12	1995	201.52	13.38	486	2412
12	1996	219.92	15.11	505	2296
12	1997	239.14	15.28	549	2296
12	1998	387.54	24.12	634	1636
12	1999	380.57	25.32	646	1697
12	2000	341.17	20.11	739	2166
12	2001	270.80	14.99	832	3072
12	2002	212.75	11.46	799	3756
12	2003	413.19	23.70	796	1926
12	2004	443.72	24.43	1033	2328
12	2005	415.18	22.66	1001	2411
12	2006	485.69	25.90	1029	2119
12	2007	456.72	24.35	1022	2238
12	2008	422.87	23.47	1017	2405
12	2009	323.28	17.15	993	3072
12	2010	252.13	13.49	906	3593
12	2011	233.64	12.27	880	3767
12	2012	285.29	15.05	956	3351
12	2013	230.51	11.56	1117	4846
12	2014	305.63	16.00	984	3220
12	2015	306.14	15.94	1075	3511
12	2016	261.74	13.56	1027	3924
12	2017	220.76	11.32	899	4072
12	2018	234.01	20.34	214	914
12	2019	327.26	32.69	199	608
12	2020	391.26	25.23	570	1457
12	2021	330.36	19.95	607	1837

Sept-Iles (SFA 10)

SFA	Year	CPUE std	SE	Landing (t)	Effort std
10	1982	90.74	1.37	3774	41594
10	1983	110.72	1.87	3647	32938
10	1984	88.96	1.04	4383	49268
10	1985	89.51	1.05	4399	49144
10	1986	99.64	1.22	4216	42311
10	1987	100.12	1.15	5411	54048
10	1988	89.61	0.97	6047	67481
10	1989	98.75	1.12	6254	63331
10	1990	144.76	1.75	6839	47242
10	1991	122.85	1.40	6411	52186
10	1992	81.61	0.89	4957	60743
10	1993	79.00	0.86	5485	69428
10	1994	91.18	1.00	6165	67615
10	1995	143.45	1.89	6386	44518
10	1996	166.17	2.31	7014	42209
10	1997	184.58	2.49	7737	41917
10	1998	210.47	2.80	8981	42672
10	1999	200.69	2.54	9239	46037
10	2000	209.17	2.62	10160	48572
10	2001	184.24	2.18	10965	59513
10	2002	218.77	2.58	11493	52534
10	2003	323.55	4.48	11357	35101
10	2004	333.19	4.11	15932	47817
10	2005	344.38	4.65	12793	37148
10	2006	367.87	4.54	15312	41624
10	2007	422.36	5.70	15645	37042
10	2008	397.65	5.11	15972	40166
10	2009	360.54	4.56	15873	44025
10	2010	319.13	3.98	15756	49372
10	2011	301.94	3.75	14376	47613
10	2012	295.97	3.91	12516	42289
10	2013	275.00	3.30	14217	51699
10	2014	305.54	4.08	12416	40636
10	2015	330.55	4.48	12415	37559
10	2016	233.99	2.81	12139	51879
10	2017	157.81	2.01	6939	43972
10	2018	130.02	1.95	4175	32111
10	2019	156.01	2.41	3999	25634
10	2020	228.70	3.50	5096	22282
10	2021	230.54	3.70	4907	21285

Anticosti (SFA 9)

SFA	Year	CPUE std	SE	Landing (t)	Effort std
9	1982	115.02	1.43	2464	21422
9	1983	111.62	1.32	2925	26205
9	1984	78.68	1.03	1336	16980
9	1985	107.12	1.14	2786	26007
9	1986	99.57	0.97	3340	33544
9	1987	107.08	1.13	3422	31956
9	1988	137.13	1.68	2844	20740
9	1989	180.08	2.04	4253	23617
9	1990	170.78	1.89	4723	27655
9	1991	151.34	1.58	4590	30330
9	1992	121.87	1.21	4162	34151
9	1993	121.69	1.19	4791	39371
9	1994	146.93	1.52	4854	33035
9	1995	176.58	1.97	4962	28101
9	1996	170.51	1.84	5469	32074
9	1997	186.54	2.07	6058	32476
9	1998	201.24	2.11	6932	34446
9	1999	183.17	1.87	7022	38335
9	2000	224.81	2.37	7941	35323
9	2001	209.10	2.56	5399	25821
9	2002	253.63	2.70	8638	34058
9	2003	306.95	3.63	8742	28480
9	2004	303.53	3.28	10429	34359
9	2005	364.64	4.81	8047	22069
9	2006	382.15	4.91	8754	22907
9	2007	355.77	4.18	10180	28614
9	2008	381.65	4.75	9635	25246
9	2009	384.03	4.67	9644	25112
9	2010	340.09	3.90	10099	29695
9	2011	361.69	4.31	9831	27180
9	2012	319.09	3.91	8267	25908
9	2013	398.98	5.54	7681	19252
9	2014	433.63	5.83	8738	20151
9	2015	374.88	4.62	9171	24464
9	2016	267.89	2.88	8681	32405
9	2017	224.52	2.54	6935	30888
9	2018	221.76	2.65	6300	28410
9	2019	235.73	2.71	6861	29106
9	2020	270.79	3.04	6187	22848
9	2021	240.03	2.80	6205	25851

Esquiman (SFA 8)

SFA	Year	CPUE std	SE	Landing (t)	Effort std
8	1982	172.79	2.77	2111	12217
8	1983	103.31	1.47	2242	21703
8	1984	121.85	2.46	1578	12950
8	1985	128.77	4.95	1421	11035
8	1986	134.05	2.25	1592	11877
8	1987	140.41	2.47	2685	19123
8	1988	169.06	2.80	4335	25641
8	1989	235.46	3.39	4614	19596
8	1990	203.13	2.54	3303	16261
8	1991	192.43	2.14	4773	24803
8	1992	155.37	1.94	3149	20268
8	1993	186.17	2.13	4683	25155
8	1994	220.61	2.88	4689	21254
8	1995	206.45	2.47	4800	23250
8	1996	289.85	3.74	5123	17675
8	1997	331.62	4.41	5957	17963
8	1998	332.95	4.02	6554	19684
8	1999	308.12	3.69	6732	21849
8	2000	353.79	4.26	7396	20905
8	2001	360.62	4.50	7815	21671
8	2002	352.10	4.00	8250	23431
8	2003	430.39	5.37	6773	15737
8	2004	579.20	7.02	8593	14836
8	2005	652.03	8.47	8867	13599
8	2006	675.24	8.97	8957	13265
8	2007	470.57	5.67	9208	19568
8	2008	445.34	5.64	9110	20456
8	2009	519.21	5.22	9473	18245
8	2010	572.73	5.70	9541	16659
8	2011	615.50	6.36	9177	14910
8	2012	661.03	6.72	10244	15497
8	2013	563.75	5.74	9149	16229
8	2014	607.53	6.79	8408	13840
8	2015	518.33	5.50	8220	15859
8	2016	446.90	4.58	7081	15845
8	2017	411.97	4.54	7024	17050
8	2018	489.25	5.78	5971	12205
8	2019	417.89	4.69	5981	14312
8	2020	576.27	7.29	5992	10398
8	2021	430.07	5.44	5498	12784

Table 8. Number of samples of the commercial catches and number of samples per 1,000 tons of landing, by fishing area (SFA) and by year.

Year	Number of samples					N. samples / 1,000 tons			
	SFA					SFA			
	12	10	9	8	*Total*	12	10	9	8
1982	1	29	21	15	66	6.6	7.7	8.5	7.1
1983	7	27	49	27	110	44.3	7.4	16.8	12.0
1984	-	43	16	29	88	-	9.8	12.0	18.4
1985	-	56	52	40	148	-	12.7	18.7	28.1
1986	2	28	35	29	94	7.6	6.6	10.5	18.2
1987	1	21	28	39	89	1.9	3.9	8.2	14.5
1988	2	42	16	38	98	3.6	6.9	5.6	8.8
1989	-	39	25	39	103	-	6.2	5.9	8.5
1990	3	32	11	28	74	5.9	4.7	2.3	8.5
1991	-	26	16	26	68	-	4.1	3.5	5.4
1992	3	30	12	23	68	6.1	6.1	2.9	7.3
1993	4	34	21	29	88	8.1	6.2	4.4	6.2
1994	7	31	10	42	90	13.9	5.0	2.1	9.0
1995	11	50	36	46	143	22.6	7.8	7.3	9.6
1996	10	33	52	50	145	19.8	4.7	9.5	9.8
1997	9	38	49	44	140	16.4	4.9	8.1	7.4
1998	15	46	47	56	164	23.7	5.1	6.8	8.5
1999	16	39	36	49	140	24.8	4.2	5.1	7.3
2000	12	57	34	49	152	16.2	5.6	4.3	6.6
2001	11	60	37	37	145	13.2	5.5	6.9	4.7
2002	14	69	38	45	166	17.5	6.0	4.4	5.5
2003	14	74	36	48	172	17.6	6.5	4.1	7.1
2004	19	73	40	34	166	18.4	4.6	3.8	4.0
2005	16	66	34	48	164	16.0	5.2	4.2	5.4
2006	18	71	36	58	183	17.5	4.6	4.1	6.5
2007	23	64	36	56	179	22.5	4.1	3.5	6.1
2008	22	65	27	50	164	21.6	4.1	2.8	5.5
2009	22	56	33	26	137	22.2	3.5	3.4	2.7
2010	17	67	32	37	153	18.8	4.3	3.2	3.9
2011	21	61	33	40	155	23.9	4.2	3.4	4.4
2012	18	59	38	37	152	18.8	4.7	4.6	3.6
2013	26	64	30	50	170	23.3	4.5	3.9	5.5
2014	18	59	27	59	163	18.3	4.8	3.1	7.0
2015	28	55	39	52	174	26.0	4.4	4.3	6.3
2016	20	68	40	55	183	19.5	5.6	4.6	7.8
2017	27	60	38	54	179	30.0	8.6	5.5	7.7
2018	12	58	43	57	170	56.1	13.9	6.8	9.5
2019	8	56	43	49	156	40.2	14.0	6.3	8.2
2020	11	41	40	44	136	19.3	8.0	6.5	7.3
2021	21	50	25	33	129	34.6	10.2	4.0	6.0

Table 9. *Weighting factors used to estimate the numbers at length by fishing area (SFA), by year and by month. The catch corresponds to the landing that is adjusted for the proportion (ratio) of P. borealis in the samples. The origin (month, year) of the samples used for the estimated is also indicated.*

				Samples			From :						Samples			From :	
SFA	Year	Month	Landing (t)	N individuals	Ratio *P. borealis*	Catch estimate (t)	Month	Year	SFA	Year	Month	Landing (t)	N individuals	Ratio *P. borealis*	Catch estimate (t)	Month	Year
8	2019	1	0.0	-	-	-	-	-	9	2019	1	0.0	-	-	-	-	-
8	2019	2	0.0	-	-	-	-	-	9	2019	2	0.0	-	-	-	-	-
8	2019	3	0.0	-	-	-	-	-	9	2019	3	0.0	-	-	-	-	-
8	2019	4	0.0	-	-	-	-	-	9	2019	4	151.7	1010	0.999	151.5	4	2019
8	2019	5	3681.1	5726	0.995	3663.9	5	2019	9	2019	5	1603.0	1538	0.995	1595.2	5	2019
8	2019	6	1429.8	3349	0.997	1426.1	6	2019	9	2019	6	2484.5	3266	0.993	2466.0	6	2019
8	2019	7	517.7	512	0.991	513.3	7	2019	9	2019	7	1484.9	3295	0.981	1457.1	7	2019
8	2019	8	310.4	1815	0.994	308.6	8	2019	9	2019	8	734.7	1035	0.995	731.0	8	2019
8	2019	9	42.1	799	0.992	41.7	9	2019	9	2019	9	288.9	510	0.999	288.6	9	2019
8	2019	10	0.0	260	1.000	0.0	10	2019	9	2019	10	113.2	520	1.000	113.2	10	2019
8	2019	11	0.0	-	-	-	-	-	9	2019	11	0.0	-	-	-	-	-
8	2019	12	0.0	-	-	-	-	-	9	2019	12	0.0	-	-	-	-	-
8	2020	1	0.0	-	-	-	-	-	9	2020	1	0.0	-	-	-	-	-
8	2020	2	0.0	-	-	-	-	-	9	2020	2	0.0	-	-	-	-	-
8	2020	3	0.0	-	-	-	-	-	9	2020	3	0.0	-	-	-	-	-
8	2020	4	0.0	-	-	-	-	-	9	2020	4	0.0	-	-	-	-	-
8	2020	5	0.0	-	-	-	-	-	9	2020	5	0.0	-	-	-	-	-
8	2020	6	44.4	-	-	44.3	7	2020	9	2020	6	2162.4	2252	0.986	2131.5	6	2020
8	2020	7	709.0	884	0.997	707.1	7	2020	9	2020	7	1883.8	2674	0.968	1824.3	7	2020
8	2020	8	3130.8	5908	0.995	3115.4	8	2020	9	2020	8	968.8	1229	0.990	959.5	8	2020
8	2020	9	1674.9	3900	0.996	1668.3	9	2020	9	2020	9	779.8	1862	0.991	772.9	9	2020
8	2020	10	433.0	528	0.998	432.2	10	2020	9	2020	10	337.9	868	0.996	336.5	10	2020
8	2020	11	0.0	-	-	-	-	-	9	2020	11	54.3	523	1.000	54.3	11	2020
8	2020	12	0.0	-	-	-	-	-	9	2020	12	0.0	-	-	-	-	-
8	2021	1	0.0	-	-	-	-	-	9	2021	1	0.0	-	-	-	-	-
8	2021	2	0.0	-	-	-	-	-	9	2021	2	0.0	-	-	-	-	-
8	2021	3	0.0	-	-	-	-	-	9	2021	3	0.0	-	-	-	-	-
8	2021	4	0.0	-	-	-	-	-	9	2021	4	0.0	-	-	-	-	-
8	2021	5	0.0	-	-	-	-	-	9	2021	5	325.6	823	0.988	321.7	5	2021
8	2021	6	513.8	807	0.996	511.7	6	2021	9	2021	6	2283.6	1057	0.999	2280.9	6	2021
8	2021	7	2749.9	3943	0.996	2739.7	7	2021	9	2021	7	1649.7	1074	0.991	1634.7	7	2021
8	2021	8	1607.6	2664	0.992	1595.1	8	2021	9	2021	8	970.6	2155	0.999	970.1	8	2021
8	2021	9	560.9	1691	0.999	560.3	9	2021	9	2021	9	676.2	1085	0.999	675.5	9	2021
8	2021	10	36.1	-	-	36.1	9	2021	9	2021	10	251.1	543	1.000	251.1	10	2021
8	2021	11	27.6	-	-	27.6	9	2021	9	2021	11	18.1	-	-	18.1	10	2021
8	2021	12	0.0	-	-	-	-	-	9	2021	12	0.0	-	-	-	-	-
10	2019	1	0.0	-	-	-	-	-	12	2019	1	0.0	-	-	-	-	-
10	2019	2	0.0	-	-	-	-	-	12	2019	2	0.0	-	-	-	-	-
10	2019	3	0.0	-	-	-	-	-	12	2019	3	0.0	-	-	-	-	-
10	2019	4	1172.1	3098	0.985	1154.3	4	2019	12	2019	4	82.8	769	0.993	82.2	4	2019
10	2019	5	328.8	1947	0.995	327.0	5	2019	12	2019	5	0.0	-	-	-	-	-

				Samples			From :						Samples			From :	
SFA	Year	Month	Landing (t)	N individuals	Ratio *P. borealis*	Catch estimate (t)	Month	Year	SFA	Year	Month	Landing (t)	N individuals	Ratio *P. borealis*	Catch estimate (t)	Month	Year
10	2019	6	247.5	1354	0.998	246.9	6	2019	12	2019	6	0.0	-	-	-	-	-
10	2019	7	538.5	1818	0.997	537.1	7	2019	12	2019	7	0.0	-	-	-	-	-
10	2019	8	719.1	2055	0.995	715.2	8	2019	12	2019	8	48.9	1101	0.995	48.6	8	2019
10	2019	9	667.1	1771	0.995	664.0	9	2019	12	2019	9	47.0	258	1.000	47.0	9	2019
10	2019	10	167.3	1448	0.987	165.2	10	2019	12	2019	10	15.6	-	-	15.6	9	2019
10	2019	11	158.8	779	0.998	158.6	11	2019	12	2019	11	4.7	-	-	4.7	9	2019
10	2019	12	0.0	-	-	-	-	-	12	2019	12	0.0	-	-	-	-	-
10	2020	1	0.0	-	-	-	-	-	12	2020	1	0.0	-	-	-	-	-
10	2020	2	0.0	-	-	-	-	-	12	2020	2	0.0	-	-	-	-	-
10	2020	3	0.0	-	-	-	-	-	12	2020	3	0.0	-	-	-	-	-
10	2020	4	120.7	-	-	119.4	5	2020	12	2020	4	0.0	-	-	-	-	-
10	2020	5	97.6	499	0.989	96.5	5	2020	12	2020	5	2.2	257	0.986	2.2	5	2020
10	2020	6	202.9	843	0.991	201.1	6	2020	12	2020	6	44.8	309	0.997	44.7	6	2020
10	2020	7	842.0	1844	0.998	840.2	7	2020	12	2020	7	113.5	264	0.997	113.1	7	2020
10	2020	8	1020.0	2048	0.994	1013.8	8	2020	12	2020	8	187.0	271	0.986	184.5	8	2020
10	2020	9	1311.5	1698	0.993	1301.8	9	2020	12	2020	9	190.3	1566	0.995	189.3	9	2020
10	2020	10	1101.6	1770	0.992	1092.9	10	2020	12	2020	10	5.8	-	-	5.8	9	2020
10	2020	11	399.7	1359	0.993	397.0	11	2020	12	2020	11	26.5	-	-	26.4	9	2020
10	2020	12	0.0	-	-	-	-	-	12	2020	12	0.0	-	-	-	-	-
10	2021	1	0.0	-	-	-	-	-	12	2021	1	0.0	-	-	-	-	-
10	2021	2	0.0	-	-	-	-	-	12	2021	2	0.0	-	-	-	-	-
10	2021	3	0.2	-	-	0.2	4	2021	12	2021	3	0.0	-	-	-	-	-
10	2021	4	136.7	1447	0.999	136.6	4	2021	12	2021	4	0.0	-	-	-	-	-
10	2021	5	121.2	1099	0.995	120.5	5	2021	12	2021	5	60.7	830	0.988	60.0	5	2021
10	2021	6	279.4	1344	0.990	276.5	6	2021	12	2021	6	139.1	1558	0.981	136.5	6	2021
10	2021	7	590.6	1747	0.998	589.3	7	2021	12	2021	7	72.4	268	0.921	66.7	7	2021
10	2021	8	821.6	2128	0.992	815.0	8	2021	12	2021	8	92.4	938	0.997	92.1	8	2021
10	2021	9	1061.0	1854	0.994	1055.0	9	2021	12	2021	9	162.1	762	0.999	161.9	9	2021
10	2021	10	1310.8	2392	0.996	1305.1	10	2021	12	2021	10	56.1	697	0.995	55.8	10	2021
10	2021	11	474.5	1281	0.996	472.4	11	2021	12	2021	11	24.4	263	0.996	24.3	11	2021
10	2021	12	0.0	-	-	-	-	-	12	2021	12	0.0	-	-	-	-	-

Table 10. Commercial catches (in million) by fishing area and by year. M: males, Fp: primiparous females, Fm: multiparous females.

ESTUARY	M	Fp	Fm	Total	SEPT-ILES	M	Fp	Fm	Total
1982	13.810	2.877	3.781	20.468	1982	375.282	53.857	170.848	599.987
1983	26.289	3.431	2.544	32.264	1983	485.454	58.186	138.521	682.161
1984	0.000	0.000	0.000	0.000	1984	390.134	48.936	192.620	631.690
1985	0.000	0.000	0.000	0.000	1985	315.398	84.758	207.568	607.724
1986	21.947	8.923	5.832	36.702	1986	293.776	70.364	267.590	631.730
1987	44.606	18.122	10.868	73.596	1987	538.326	88.080	290.142	916.548
1988	32.501	5.390	38.175	76.066	1988	611.767	108.888	266.561	987.216
1989	0.000	0.000	0.000	0.000	1989	410.861	154.875	311.362	877.098
1990	42.153	3.426	27.542	73.121	1990	489.744	111.135	360.979	961.858
1991	0.000	0.000	0.000	0.000	1991	476.345	73.968	323.239	873.552
1992	9.026	3.216	43.162	55.404	1992	505.295	117.119	160.793	783.207
1993	10.958	1.634	39.891	52.483	1993	514.300	175.244	156.151	845.695
1994	7.262	1.315	42.146	50.723	1994	632.719	195.742	156.810	985.271
1995	8.841	4.545	40.014	53.400	1995	535.856	237.542	196.221	969.619
1996	3.998	5.703	42.644	52.345	1996	608.578	287.066	173.234	1068.878
1997	14.492	8.706	39.940	63.138	1997	510.236	198.577	337.013	1045.826
1998	12.334	9.810	45.413	67.557	1998	515.923	211.279	395.123	1122.325
1999	16.843	12.260	43.412	72.515	1999	541.918	269.191	405.233	1216.342
2000	15.806	11.172	55.032	82.010	2000	738.989	348.368	387.798	1475.155
2001	39.214	20.743	52.503	112.460	2001	661.354	299.342	578.698	1539.394
2002	47.265	24.545	43.310	115.120	2002	787.058	653.214	318.475	1758.747
2003	26.301	15.553	55.642	97.496	2003	530.773	282.130	720.734	1533.637
2004	40.626	15.917	74.884	131.427	2004	764.002	465.282	953.292	2182.576
2005	28.446	20.274	77.983	126.703	2005	696.846	335.327	790.340	1822.513
2006	37.700	15.053	80.898	133.651	2006	859.492	471.118	835.223	2165.833
2007	35.852	18.826	69.653	124.331	2007	806.439	364.161	855.166	2025.766
2008	38.022	18.765	65.636	122.423	2008	895.364	395.833	935.740	2226.937
2009	60.346	20.336	57.901	138.583	2009	958.749	468.496	854.031	2281.276
2010	43.176	11.771	68.848	123.795	2010	1326.559	338.655	943.957	2609.171
2011	121.495	22.225	32.463	176.183	2011	1143.480	488.737	802.924	2435.141
2012	131.421	26.400	27.511	185.332	2012	918.065	389.976	648.460	1956.501
2013	99.101	45.315	28.464	172.880	2013	808.862	546.955	624.876	1980.693
2014	96.012	21.016	36.053	153.081	2014	802.315	262.678	674.389	1739.382
2015	94.993	24.228	45.106	164.327	2015	828.098	321.193	612.193	1761.484
2016	115.139	17.648	38.924	171.711	2016	808.547	297.562	670.517	1776.626
2017	92.446	21.644	31.214	145.304	2017	554.541	270.779	255.520	1080.840
2018	14.438	5.726	11.921	32.085	2018	399.363	103.339	196.596	699.298
2019	24.070	3.682	5.322	33.074	2019	419.779	105.245	159.438	684.462
2020	54.767	13.369	15.621	83.757	2020	418.890	158.845	199.650	777.385
2021	59.929	17.435	17.520	94.884	2021	541.712	120.223	189.911	851.846

ANTICOSTI	M	Fp	Fm	Total	ESQUIMAN	M	Fp	Fm	Total
1982	354.331	55.094	61.002	470.427	1982	215.494	49.492	91.256	356.242
1983	375.077	54.539	78.453	508.069	1983	211.819	37.740	91.560	341.119
1984	151.252	36.732	38.081	226.065	1984	145.040	15.549	85.196	245.785
1985	320.703	78.089	76.269	475.061	1985	151.231	37.706	46.987	235.924
1986	442.183	114.163	89.859	646.205	1986	120.045	31.901	89.999	241.945
1987	518.113	125.330	59.129	702.572	1987	493.459	42.252	68.386	604.097
1988	381.706	98.655	75.004	555.365	1988	656.047	119.061	102.194	877.302
1989	637.523	105.404	118.282	861.209	1989	577.444	124.477	156.915	858.836
1990	497.342	196.956	73.961	768.259	1990	387.893	86.160	98.431	572.484
1991	556.637	112.013	107.116	775.766	1991	566.111	76.143	201.893	844.147
1992	406.097	197.015	17.839	620.951	1992	420.714	102.085	73.063	595.862
1993	597.755	222.650	16.018	836.423	1993	698.498	165.563	86.800	950.861
1994	634.086	203.387	22.730	860.203	1994	619.205	252.483	37.162	908.850
1995	660.898	193.718	21.759	876.375	1995	667.039	241.633	130.037	1038.709
1996	534.054	252.672	48.925	835.651	1996	721.922	250.670	75.166	1047.758
1997	578.694	239.342	73.004	891.040	1997	707.747	323.717	80.080	1111.544
1998	576.832	324.173	92.946	993.951	1998	724.994	192.660	287.530	1205.184
1999	794.582	306.487	52.019	1153.088	1999	708.681	284.961	292.935	1286.577
2000	808.052	367.987	102.416	1278.455	2000	886.107	301.021	277.073	1464.201
2001	693.367	256.858	31.371	981.596	2001	1060.451	350.249	272.424	1683.124
2002	983.521	494.299	53.328	1531.148	2002	1123.099	374.999	267.882	1765.980
2003	830.157	444.364	131.779	1406.300	2003	828.602	407.706	150.114	1386.422
2004	820.917	529.865	252.313	1603.095	2004	1032.410	373.656	329.239	1735.305
2005	787.549	364.186	194.474	1346.209	2005	1296.424	406.123	305.434	2007.981
2006	887.003	309.751	232.736	1429.490	2006	1412.634	290.951	441.742	2145.327
2007	1011.710	571.822	269.490	1853.022	2007	1428.017	391.336	510.623	2329.976
2008	1193.729	507.026	188.343	1889.098	2008	1432.250	596.220	261.960	2290.430
2009	1141.609	574.811	180.627	1897.047	2009	1552.270	575.361	223.377	2351.008
2010	1396.917	492.835	182.825	2072.577	2010	1363.004	438.653	217.868	2019.525
2011	1169.269	521.825	133.595	1824.689	2011	1089.972	440.064	352.035	1882.071
2012	1143.131	370.874	134.592	1648.597	2012	1454.742	464.186	310.682	2229.610
2013	804.858	443.428	112.650	1360.936	2013	1010.397	509.913	272.635	1792.945
2014	1005.601	282.055	245.113	1532.769	2014	942.368	241.082	357.338	1540.788
2015	1288.560	450.533	164.674	1903.767	2015	849.969	474.463	263.068	1587.500
2016	1104.315	456.713	180.456	1741.484	2016	847.166	223.337	328.676	1399.179
2017	785.255	300.686	161.650	1247.591	2017	797.286	298.394	271.073	1366.753
2018	718.039	317.757	147.455	1183.251	2018	630.610	210.157	297.065	1137.832
2019	1065.267	310.880	184.868	1561.015	2019	707.353	218.528	312.711	1238.592
2020	659.669	307.961	138.316	1105.946	2020	635.551	265.436	246.308	1147.295
2021	724.499	388.054	130.887	1243.440	2021	646.604	225.328	215.479	1087.411

Table 11. Number per unit of effort by fishing area and by year for the summer season (months of June, July and August). M: males, Fp: primiparous females, Fm: multiparous females.

ESTUARY	M	Fp	Fm	Total	SEPT-ILES	M	Fp	Fm	Total
1982	6465	1347	1770	9583	1982	6275	1417	1743	9435
1983	8435	991	857	10284	1983	9649	1796	2264	13708
1984	-	-	-	-	1984	7100	979	2193	10272
1985	-	-	-	-	1985	7744	2306	2246	12297
1986	5470	2313	793	8576	1986	10652	2301	2016	14969
1987	5484	2320	795	8599	1987	13195	1592	2713	17500
1988	7115	3009	1032	11156	1988	9917	1612	2725	14255
1989	-	-	-	-	1989	7485	2007	2860	12352
1990	-	-	-	-	1990	13117	3048	3482	19647
1991	-	-	-	-	1991	10696	1952	3787	16435
1992	3098	670	3083	6851	1992	6995	3359	399	10753
1993	3735	808	3717	8260	1993	6247	4017	468	10732
1994	2721	1038	1283	5042	1994	8657	3990	458	13104
1995	12903	7825	4440	25168	1995	12601	7250	1368	21220
1996	3796	4645	3863	12304	1996	14788	8670	1673	25131
1997	5604	11664	6747	24015	1997	16246	7931	2136	26313
1998	12660	12423	5316	30398	1998	14161	8296	1197	23654
1999	9080	15353	2912	27346	1999	17787	9366	873	28026
2000	20801	11217	5935	37953	2000	19615	9240	2883	31738
2001	20153	3901	3771	27824	2001	14256	9250	3027	26533
2002	17055	16888	1254	35197	2002	18087	16085	502	34673
2003	11332	17082	7439	35852	2003	20197	12708	3442	36348
2004	14925	14730	5850	35505	2004	19842	15694	5170	40707
2005	20553	18474	14103	53130	2005	25579	17658	3608	46844
2006	27826	10207	16060	54093	2006	21576	13349	9776	44700
2007	20957	9713	15123	45793	2007	25084	12255	10899	48239
2008	28113	17973	6243	52330	2008	29816	13617	4563	47995
2009	15330	12757	3832	31919	2009	23531	14322	5137	42990
2010	10830	17148	7349	35328	2010	35723	11764	3693	51180
2011	38310	6002	1791	46103	2011	23800	15000	3157	41957
2012	47641	9304	3037	59982	2012	33134	13308	3376	49818
2013	12601	13200	648	26449	2013	20547	14899	2022	37468
2014	19738	6898	7573	34209	2014	27574	8134	6911	42619
2015	20873	7620	8736	37229	2015	27621	9730	5306	42658
2016	27043	5762	4753	37558	2016	17469	6809	6129	30407
2017	15800	6279	3036	25115	2017	10606	6419	3342	20367
2018	29268	19249	10582	59099	2018	11656	3537	3355	18549
2019	28873	11266	13217	53357	2019	16512	4746	5142	26400
2020	27284	12455	10405	50144	2020	19431	7514	5636	32582
2018	29268	19249	10582	59099	2018	11656	3537	3355	18549

ANTICOSTI	M	Fp	Fm	Total	ESQUIMAN	M	Fp	Fm	Total
1982	12448	2336	2423	17207	1982	12845	3109	2785	18739
1983	11304	2082	2187	15573	1983	7388	1212	3290	11890
1984	7215	1936	1847	10999	1984	10046	1241	4306	15594
1985	9881	2858	2372	15112	1985	8216	2521	2599	13337
1986	11746	2935	2292	16973	1986	6013	2566	4022	12601
1987	13311	2975	1153	17440	1987	18988	1741	1938	22667
1988	11465	4238	1991	17694	1988	18766	2993	2238	23996
1989	15232	5124	3246	23601	1989	18650	6186	3793	28628
1990	14924	5914	2262	23099	1990	20201	4240	5913	30353
1991	13039	3674	2512	19225	1991	19909	2325	4616	26850
1992	9235	5243	157	14635	1992	19400	5080	970	25450
1993	12824	4845	254	17923	1993	24667	5944	587	31198
1994	15577	5283	346	21206	1994	21693	9218	1190	32101
1995	19813	5720	610	26143	1995	23299	9163	1844	34305
1996	15377	6929	1018	23324	1996	30285	10395	1656	42336
1997	17070	7210	915	25194	1997	31723	15112	1996	48831
1998	14271	8853	915	24038	1998	39532	13661	1393	54586
1999	19195	7293	630	27118	1999	31478	19599	2607	53684
2000	19433	8993	2212	30638	2000	43491	16741	3256	63488
2001	25007	8770	940	34717	2001	50206	20202	3349	73757
2002	24207	12776	665	37648	2002	40244	18016	1033	59292
2003	25963	13545	2663	42170	2003	41526	20380	3342	65247
2004	19862	13586	5731	39179	2004	54096	23890	12614	90600
2005	34693	17068	3695	55456	2005	59383	32072	8299	99754
2006	37762	14506	7190	59457	2006	78243	26079	16361	120683
2007	28765	15828	7128	51721	2007	69907	26955	11435	108297
2008	38572	18139	6536	63247	2008	70932	32166	10507	113605
2009	41083	20515	4628	66225	2009	70258	26883	6299	103440
2010	40380	14448	5500	60328	2010	74142	20590	11163	105896
2011	36740	16992	3839	57571	2011	88551	33294	12418	134263
2012	40257	12878	3619	56754	2012	82286	28248	9209	119744
2013	39695	20823	5302	65820	2013	43104	28621	8329	80054
2014	50890	11516	12117	74522	2014	55346	16728	22699	94773
2015	47910	14413	5649	67972	2015	41183	21346	13321	75850
2016	29956	12089	4714	46758	2016	49116	12525	18153	79793
2017	21751	8773	4627	35151	2017	36587	14215	13047	63849
2018	21320	8907	4667	34894	2018	33180	11242	13492	57915
2019	33506	10070	5345	48921	2019	42509	12531	12512	67552
2020	25721	12991	4027	42739	2020	45716	18027	12249	75993
2021	24597	13121	3591	41309	2021	38748	13415	12596	64759

Table 12. Mean catch (kg/km²) and standard error by year, for males and females for the whole studied area (n: number of stations).

Year	N	Males		Females	
		Mean	Standard error	Mean	Standard error
1990	219	349.17	54.36	482.36	52.28
1991	250	265.82	50.53	412.06	50.09
1992	239	155.81	26.40	243.78	29.20
1993	214	203.54	32.87	184.91	22.54
1994	176	201.97	33.29	302.52	38.02
1995	182	339.35	47.62	408.28	44.58
1996	217	439.20	61.95	680.02	57.96
1997	185	602.86	92.43	715.33	82.08
1998	206	352.77	40.84	722.97	73.51
1999	224	472.82	64.43	659.18	62.95
2000	209	527.95	64.46	971.07	82.90
2001	183	572.65	100.28	631.87	67.30
2002	171	470.10	88.08	797.65	88.41
2003	164	1429.82	303.30	1339.34	135.13
2004	133	726.31	136.25	1177.82	144.64
2005	354	536.26	72.52	931.05	68.46
2006	192	477.51	73.83	942.67	111.71
2007	183	610.36	101.27	1141.59	158.19
2008	189	489.42	84.41	762.88	82.69
2009	164	586.99	89.54	686.90	78.53
2010	154	484.47	70.62	750.55	88.77
2011	156	357.29	54.43	637.67	74.19
2012	178	506.20	114.22	533.69	75.38
2013	141	390.40	80.87	661.56	99.84
2014	177	475.57	86.94	688.79	88.40
2015	182	415.61	66.81	611.87	77.04
2016	159	305.16	65.30	456.09	75.91
2017	163	198.28	36.84	297.75	51.08
2018	160	131.13	30.19	269.46	62.23
2019	124	301.63	68.16	381.46	69.53
2020	143	192.85	47.03	301.39	55.11
2021	142	170.50	40.94	236.66	43.56
2008+	201	488.34	80.51	842.41	90.62
2009+	177	594.42	83.94	758.18	83.23
2010+	166	518.46	79.86	778.54	89.04
2011+	166	408.66	59.41	669.28	77.29
2012+	188	517.62	109.33	550.83	74.19
2013+	152	384.16	75.31	722.18	103.66
2014+	185	490.24	84.08	706.65	87.51
2015+	190	414.40	65.07	604.02	74.68
2016+	167	351.33	68.84	517.99	82.87
2017+	170	203.19	35.72	301.18	49.65
2018+	168	175.65	46.16	314.67	73.05
2019+	128	305.93	66.83	415.89	75.65
2020+	147	195.13	45.84	309.09	54.39
2021+	149	283.52	76.32	374.65	83.82

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 13. Mean catch (kg/km²) and standard error by year, for males and females by fishing area (n: number of stations).

Estuary (SFA 12)

Year	n	Males		Females	
		Mean	Standard error	Mean	Standard error
1990	12	156.25	77.65	233.61	82.82
1991	11	31.24	15.15	308.55	140.68
1992	11	83.54	64.96	187.46	120.92
1993	12	102.41	77.20	229.50	142.70
1994	8	119.91	83.71	398.97	271.60
1995	18	33.17	15.68	44.57	18.74
1996	17	134.76	53.69	663.28	244.99
1997	16	31.88	13.05	146.68	94.02
1998	16	34.63	18.54	158.71	62.10
1999	21	124.25	90.37	595.89	201.85
2000	17	54.87	20.71	440.12	129.51
2001	19	13.15	3.83	271.47	99.18
2002	12	10.37	6.37	125.36	81.22
2003	11	30.04	12.65	346.47	251.44
2004	9	140.28	109.56	722.38	367.21
2005	24	35.03	17.05	466.44	138.59
2006	12	5.88	2.02	208.70	76.78
2007	12	18.39	14.15	144.45	62.56
2008	10	17.15	6.47	379.29	159.29
2009	10	43.51	24.17	405.86	193.34
2010	12	77.14	42.62	240.66	137.05
2011	12	200.40	89.92	459.64	168.07
2012	11	168.99	104.58	541.06	296.08
2013	10	85.86	56.47	236.72	121.54
2014	8	119.40	54.11	890.30	385.24
2015	7	125.22	87.82	384.42	216.65
2016	8	36.36	15.19	172.74	70.07
2017	7	12.08	8.71	76.32	36.47
2018	9	2.58	1.55	25.35	16.73
2019	6	590.64	588.16	867.40	847.99
2020	6	0.44	0.20	1.39	0.59
2021	9	69.99	68.06	79.25	64.35
2008+	21	276.83	141.95	1377.73	446.43
2009+	23	407.83	121.58	1113.27	320.00
2010+	24	515.89	328.56	689.18	259.33
2011+	22	659.27	231.84	779.10	272.71
2012+	20	439.15	174.31	715.64	248.12
2013+	20	209.10	63.28	939.43	368.62
2014+	15	497.78	171.42	1057.50	334.67
2015+	14	283.77	174.33	435.04	185.95
2016+	15	696.15	329.79	1024.49	447.92
2017+	14	164.73	75.91	228.77	111.45
2018+	17	503.02	357.29	587.02	430.42
2019+	10	530.09	366.59	1113.65	641.80
2020+	10	110.84	62.37	234.63	160.71
2021+	16	1166.43	582.22	1433.09	637.01

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Sept-Iles (SFA 10)

Year	n	Males		Females	
		Mean	Standard error	Mean	Standard error
1990	73	368.74	93.59	651.33	98.58
1991	71	556.17	162.63	828.80	150.54
1992	60	205.76	56.56	366.15	78.75
1993	47	376.53	94.10	378.57	73.66
1994	49	360.66	97.71	605.40	103.66
1995	56	466.30	96.10	576.97	95.30
1996	74	580.37	108.36	998.29	93.68
1997	53	827.35	159.76	1096.30	125.72
1998	48	533.44	86.71	1478.68	219.66
1999	62	715.15	119.52	989.22	102.19
2000	51	1011.01	164.56	1854.23	159.49
2001	58	1148.13	272.57	1132.31	155.61
2002	56	871.07	228.82	1693.13	194.24
2003	48	3127.78	919.28	2586.03	228.81
2004	43	1248.81	289.40	2115.14	274.29
2005	65	1216.63	286.98	1907.67	135.04
2006	50	655.37	157.80	1878.57	259.06
2007	50	1063.62	313.79	2293.54	339.10
2008	44	1015.41	288.14	2035.73	203.68
2009	44	823.43	240.35	1186.57	194.23
2010	40	644.76	150.85	1410.73	191.62
2011	40	416.78	86.94	1003.53	145.39
2012	42	1156.22	382.07	936.69	113.12
2013	41	548.73	212.81	995.85	251.10
2014	40	815.56	259.68	1549.82	245.80
2015	41	780.17	175.09	1327.24	166.93
2016	45	502.34	163.93	884.77	207.47
2017	45	235.67	58.65	386.31	96.26
2018	36	159.48	57.11	317.85	89.73
2019	39	259.33	117.55	301.24	66.27
2020	42	390.96	142.36	503.06	111.92
2021	35	213.10	74.47	254.89	52.58
2008+	45	993.14	282.54	1990.49	204.18
2009+	44	823.43	240.35	1186.57	194.23
2010+	40	644.76	150.85	1410.73	191.62
2011+	40	416.78	86.94	1003.53	145.39
2012+	43	1135.94	373.63	919.52	111.79
2013+	42	536.20	208.06	973.82	246.03
2014+	41	795.84	254.03	1513.84	242.41
2015+	42	761.60	171.87	1295.72	165.93
2016+	46	491.44	160.70	865.56	203.82
2017+	45	235.67	58.65	386.31	96.26
2018+	36	159.48	57.11	317.85	89.73
2019+	39	259.33	117.55	301.24	66.27
2020+	42	390.96	142.36	503.06	111.92
2021+	35	213.10	74.47	254.89	52.58

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Anticosti (ZPC 9)

Year	n	Males		Females	
		Mean	Standard error	Mean	Standard error
1990	85	418.56	105.94	390.75	86.97
1991	82	185.46	37.18	257.11	41.09
1992	82	211.64	59.86	232.16	43.47
1993	76	207.97	64.32	141.47	25.94
1994	64	161.65	36.65	184.99	33.22
1995	57	378.61	87.89	470.25	71.13
1996	63	494.88	135.38	729.94	125.45
1997	60	489.24	105.34	608.32	86.48
1998	78	338.21	56.43	608.26	76.82
1999	78	381.33	67.30	566.39	68.19
2000	77	394.01	73.62	850.58	104.51
2001	36	203.38	60.44	373.76	59.71
2002	49	473.84	119.72	630.48	110.74
2003	46	802.28	297.96	852.30	205.04
2004	32	603.73	293.42	754.31	230.89
2005	134	515.13	96.85	972.22	112.60
2006	64	390.93	113.07	665.50	135.86
2007	66	581.38	106.72	1072.18	308.50
2008	66	287.94	59.28	392.16	72.02
2009	60	560.53	125.19	496.13	91.53
2010	54	522.60	121.99	564.85	114.99
2011	52	202.74	59.32	338.23	84.79
2012	59	190.57	45.90	338.13	62.69
2013	49	229.97	58.75	464.64	112.20
2014	62	341.98	101.97	398.96	94.07
2015	74	339.59	106.39	435.86	116.17
2016	56	139.59	57.20	253.35	71.04
2017	62	204.87	72.09	289.98	94.90
2018	60	131.16	47.87	182.27	72.89
2019	41	200.52	83.16	215.00	70.68
2020	41	146.82	55.77	211.44	91.88
2021	55	138.00	80.01	189.72	77.50

Esquiman (ZPC 8)

Year	n	Males		Females	
		Mean	Standard error	Mean	Standard error
1990	49	246.89	73.44	450.48	94.34
1991	86	132.72	36.35	229.00	41.98
1992	86	76.95	20.47	176.71	38.87
1993	79	111.73	23.94	104.72	20.01
1994	55	119.45	37.17	155.42	36.81
1995	51	264.14	85.29	282.15	79.76
1996	63	299.84	100.71	260.78	58.81
1997	56	675.28	236.46	631.91	215.63
1998	64	314.53	87.65	437.06	104.71
1999	63	463.80	172.20	470.35	162.91
2000	64	429.80	124.03	553.29	164.08
2001	70	437.61	105.14	447.79	92.32
2002	54	153.06	68.92	170.08	53.91
2003	59	798.67	221.02	889.93	221.41
2004	49	455.49	171.87	715.51	219.18
2005	131	312.11	78.31	489.47	102.90
2006	66	512.48	138.68	635.87	191.06
2007	55	362.25	106.21	395.21	106.46
2008	69	415.18	116.38	361.40	100.03
2009	50	519.38	133.70	532.32	135.96
2010	48	409.84	126.00	536.80	167.72
2011	52	502.29	132.68	696.77	158.63
2012	66	430.91	171.38	450.81	170.26
2013	41	498.07	161.40	666.24	181.72
2014	67	438.73	137.78	418.88	123.42
2015	60	294.12	88.82	366.66	116.09
2016	50	356.13	127.48	342.68	114.00
2017	49	182.21	62.05	257.86	81.58
2018	55	133.57	60.26	372.87	151.18
2019	38	408.49	139.20	566.68	154.02
2020	54	95.09	29.14	246.16	90.62
2021	43	198.42	63.85	314.82	93.94

Table 14. Spatial distribution indices: 1) DWAO, design-weighted area of occupation; 2) D95, minimum area containing 95% of individuals; and 3) Gini's index.

Northern Gulf (area 116 115 km²)

Year	DWAO (km²)	D95 (km²)	Gini
1990	66829	37650	0.768
1991	76544	45188	0.792
1992	69198	41655	0.763
1993	79691	45611	0.765
1994	92549	56248	0.710
1995	89731	57812	0.677
1996	86153	63704	0.731
1997	91681	61514	0.733
1998	81142	53531	0.707
1999	86329	57032	0.716
2000	94199	63076	0.668
2001	88823	64082	0.732
2002	86324	51191	0.715
2003	93722	53175	0.692
2004	89324	60130	0.688
2005	95338	54306	0.655
2006	93317	53765	0.708
2007	99162	53402	0.707
2008	94027	57528	0.647
2009	98626	52528	0.672
2010	98602	54107	0.704
2011	90686	48871	0.685
2012	92254	48785	0.751
2013	97735	39801	0.773
2014	94593	44122	0.747
2015	99204	41316	0.742
2016	98110	37690	0.795
2017	97602	33062	0.806
2018	90841	27036	0.844
2019	91751	35561	0.852
2020	90118	34755	0.821
2021	93155	26700	0.839

Estuary (area 6 537 km²)

Year	DWAO (km²)	D95 (km²)	Gini
2008	6537	3736	0.678
2009	6537	3934	0.704
2010	5673	2890	0.761
2011	6537	4164	0.631

Year	DWAO (km^2)	D95 (km^2)	Gini
2012	6385	2749	0.667
2013	6537	3098	0.711
2014	6537	4299	0.520
2015	6537	3937	0.542
2016	6537	3477	0.789
2017	6171	2855	0.716
2018	5358	675	0.889
2019	4838	1610	0.876
2020	6199	1431	0.773
2021	6171	1387	0.774

Sept-Iles (area 26 787 km^2)

Year	DWAO (km^2)	D95 (km^2)	Gini
1990	20545	12111	0.635
1991	21623	14346	0.739
1992	20537	14683	0.614
1993	23858	15714	0.614
1994	26243	19369	0.576
1995	26787	18247	0.568
1996	25569	21500	0.580
1997	25731	18674	0.488
1998	25970	20652	0.470
1999	24349	20119	0.494
2000	25970	21539	0.416
2001	24650	20619	0.560
2002	25916	18467	0.507
2003	25569	21629	0.537
2004	25569	20097	0.385
2005	25970	20074	0.446
2006	25970	19976	0.478
2007	26243	17854	0.533
2008	26379	21418	0.422
2009	25970	17883	0.542
2010	24980	19646	0.529
2011	26243	20397	0.446
2012	25970	19028	0.546
2013	26243	13331	0.718
2014	25970	18912	0.521
2015	25388	18121	0.453
2016	26787	16100	0.632
2017	25970	15248	0.651
2018	24751	11422	0.700

Year	DWAO (km²)	D95 (km²)	Gini
2019	24894	14332	0.678
2020	25416	12717	0.704
2021	25678	12408	0.650

Anticosti (area 49 164 km²)

Année	DWAO (km²)	D95 (km²)	Gini
1990	27090	13865	0.818
1991	33830	18689	0.804
1992	28027	13962	0.824
1993	35642	20399	0.815
1994	41564	24221	0.703
1995	42893	28427	0.657
1996	39331	24951	0.763
1997	44930	32955	0.727
1998	36009	22158	0.705
1999	40373	27246	0.672
2000	43010	29171	0.657
2001	40499	31036	0.525
2002	40391	24666	0.660
2003	45208	25845	0.611
2004	41847	29187	0.699
2005	41230	24841	0.650
2006	42872	25706	0.710
2007	45050	24816	0.678
2008	40537	25061	0.622
2009	46620	23879	0.615
2010	44455	26380	0.676
2011	39975	20273	0.749
2012	41221	22374	0.648
2013	47142	18355	0.741
2014	43997	18606	0.764
2015	44712	15559	0.822
2016	45354	14409	0.838
2017	42624	10100	0.846
2018	43844	9500	0.822
2019	40790	13892	0.870
2020	39582	13417	0.829
2021	40083	6751	0.909

Esquiman (area 35 904 km^2)

Année	DWAO (km^2)	D95 (km^2)	Gini
1990	16041	10763	0.793
1991	16830	11604	0.750
1992	17248	10841	0.782
1993	16678	9819	0.801
1994	20883	11905	0.720
1995	16035	11997	0.773
1996	16992	11856	0.822
1997	17582	9704	0.852
1998	15518	10752	0.855
1999	17919	8939	0.888
2000	20959	11627	0.846
2001	19997	12188	0.814
2002	17173	10299	0.781
2003	18686	8507	0.786
2004	17747	9432	0.781
2005	24023	9235	0.809
2006	20344	9103	0.817
2007	23609	11452	0.812
2008	22852	13162	0.769
2009	21797	9376	0.800
2010	25771	7231	0.841
2011	20209	11901	0.715
2012	20804	6964	0.885
2013	20091	9520	0.779
2014	20366	7290	0.848
2015	24844	9012	0.845
2016	21710	7982	0.819
2017	25113	6912	0.828
2018	19165	6200	0.899
2019	23506	8032	0.838
2020	21198	9337	0.851
2021	23500	7640	0.825

Table 15. Catches (kg/km^2) above which the data were removed from the variogram estimation.

	2019	2020	2021
Male	2 000	4 000	1 500
Female	3 000	3 000	1 300
Total	4 000	4 000	2 700

Table 16. Parameters of the variograms by sex used for kriging biomass. An exponential model was used each year.*

Male

Year	Period	Parameters		
		Nugget (c_0)	Sill (c_0 + c)	Range (a_0)
1990	1990-1991-1992	0.50	1.05	35
1991	1990-1991-1992	0.50	1.05	35
1992	1990-1991-1992	0.50	1.05	35
1993	1991-1992-1993	0.20	1.05	30
1994	1992-1993-1994	0.20	1.05	30
1995	1993-1994-1995	0.20	1.00	20
1996	1994-1995-1996	0.20	1.00	20
1997	1995-1996-1997	0.20	0.95	18
1998	1996-1997-1998	0.20	0.90	20
1999	1997-1998-1999	0.40	0.90	20
2000	1998-1999-2000	0.40	0.90	20
2001	1999-2000-2001	0.40	0.90	17
2002	2000-2001-2002	0.30	1.00	25
2003	2001-2002-2003	0.20	1.00	25
2004	2002-2003-2004	0.20	1.00	25
2005	2003-2004-2005	0.30	1.00	30
2006	2004-2005-2006	0.30	1.00	25
2007	2005-2006-2007	0.30	1.00	25
2008	2006-2007-2008	0.30	1.00	20
2009	2007-2008-2009	0.25	1.00	25
2010	2008-2009-2010	0.30	1.00	25
2011	2009-2010-2011	0.40	1.00	30
2012	2010-2011-2012	0.30	1.00	22
2013	2011-2012-2013	0.00	0.96	15,68
2014	2012-2013-2014	0.00	0.96	15,65
2015	2013-2014-2015	0.00	0.92	15,09
2016	2014-2015-2016	0.00	0.92	12,25
2017	2015-2016-2017	0.00	0.92	11,21
2018	2016-2017-2018	0.50	0.97	43.61
2019	2017-2018-2019	0.67	6.30	2728
2020	2018-2019-2020	0.00	0.89	13.81
2021	2019-2020-2021	0.00	0.95	12.42

* Exponential model : (where h = distance) $\gamma(h) = c_0 + c\left[1 - exp\left(-\frac{h}{a_0}\right)\right]$

Female

Year	Period	Parameters		
		Nugget (c_0)	Sill (c_0 + c)	Range (a_0)
1990	1990-1991-1992	0.45	0.95	30
1991	1990-1991-1992	0.45	0.95	30
1992	1990-1991-1992	0.45	0.95	30
1993	1991-1992-1993	0.25	0.85	20
1994	1992-1993-1994	0.30	0.85	25
1995	1993-1994-1995	0.30	0.80	20
1996	1994-1995-1996	0.15	0.95	17
1997	1995-1996-1997	0.15	0.95	17
1998	1996-1997-1998	0.20	0.95	20
1999	1997-1998-1999	0.35	0.90	25
2000	1998-1999-2000	0.35	0.90	30
2001	1999-2000-2001	0.40	0.90	35
2002	2000-2001-2002	0.30	0.90	30
2003	2001-2002-2003	0.20	0.85	35
2004	2002-2003-2004	0.15	0.95	35
2005	2003-2004-2005	0.20	1.05	60
2006	2004-2005-2006	0.20	1.05	50
2007	2005-2006-2007	0.20	1.05	60
2008	2006-2007-2008	0.20	1.00	60
2009	2007-2008-2009	0.20	0.90	40
2010	2008-2009-2010	0.25	0.90	45
2011	2009-2010-2011	0.15	0.90	28
2012	2010-2011-2012	0.15	0.90	27
2013	2011-2012-2013	0.60	1.52	441,11
2014	2012-2013-2014	0.51	0.80	53,25
2015	2013-2014-2015	0.48	1.10	175,07
2016	2014-2015-2016	0.41	0.82	42,47
2017	2015-2016-2017	0.58	86.10	43661
2018	2016-2017-2018	0.59	0.95	97.79
2019	2017-2018-2019	0.52	0.88	78.89
2020	2018-2019-2020	0.20	0.84	19.36
2021	2019-2020-2021	0.05	0.90	16.01

* Exponential model : (where h = distance) $\gamma(h) = c_0 + c\left[1 - exp\left(-\frac{h}{a_0}\right)\right]$

Total (male and female)

Year	Period	Parameters		
		Nugget (c_0)	Sill ($c_0 + c$)	Range (a_0)
1990	1990-1991-1992	0.40	1.00	35
1991	1990-1991-1992	0.40	1.00	35
1992	1990-1991-1992	0.40	1.00	35
1993	1991-1992-1993	0.30	0.95	40
1994	1992-1993-1994	0.30	0.95	32
1995	1993-1994-1995	0.30	0.95	25
1996	1994-1995-1996	0.20	1.05	20
1997	1995-1996-1997	0.20	1.00	20
1998	1996-1997-1998	0.20	1.00	25
1999	1997-1998-1999	0.30	0.90	25
2000	1998-1999-2000	0.35	0.90	30
2001	1999-2000-2001	0.50	1.00	80
2002	2000-2001-2002	0.45	1.00	70
2003	2001-2002-2003	0.40	1.00	70
2004	2002-2003-2004	0.20	1.00	40
2005	2003-2004-2005	0.25	1.05	60
2006	2004-2005-2006	0.30	1.05	60
2007	2005-2006-2007	0.30	1.05	60
2008	2006-2007-2008	0.30	1.05	55
2009	2007-2008-2009	0.30	1.05	55
2010	2008-2009-2010	0.35	1.00	40
2011	2009-2010-2011	0.25	1.00	30
2012	2010-2011-2012	0.20	0.95	20
2013	2011-2012-2013	0.00	0.87	11,49
2014	2012-2013-2014	0.00	0.86	11,46
2015	2013-2014-2015	0.00	0.82	12,13
2016	2014-2015-2016	0.00	0.84	12,06
2017	2015-2016-2017	0.61	1.24	153,34
2018	2016-2017-2018	0.71	2.70	770.56
2019	2017-2018-2019	0.66	2.48	613.54
2020	2018-2019-2020	0.62	1.24	127.78
2021	2019-2020-2021	0.25	0.97	22.67

* Exponential model : (where h = distance) $\gamma(h) = c_0 + c\left[1 - exp\left(-\frac{h}{a_0}\right)\right]$

Table 17. Mean biomass (kg/km²) estimated by kriging, by fishing area and by year, for males (M) and females (F).

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	M	F	M	F	M	F	M	F
1990	188.6	310.4	390.5	652.2	402.4	404.3	234.2	402.2
1991	44.3	514.4	566.7	774.9	207.0	300.6	185.5	285.3
1992	100.1	365.0	219.6	358.7	264.7	276.9	92.4	202.5
1993	88.9	274.7	336.2	442.0	207.7	150.0	114.3	107.1
1994	102.6	426.1	376.1	598.4	165.3	179.5	175.6	196.0
1995	33.1	52.9	426.2	559.7	392.7	509.3	334.5	327.7
1996	116.6	598.7	467.0	880.3	659.8	931.3	329.5	299.2
1997	69.7	375.4	777.1	999.6	456.7	552.9	747.2	693.7
1998	28.5	159.8	551.5	1547.1	269.5	566.0	366.8	481.2
1999	136.2	575.2	788.0	1098.1	345.9	551.8	455.2	457.9
2000	141.1	702.3	1005.3	1777.0	403.7	832.1	439.2	536.7
2001	22.2	439.9	1273.0	1141.8	331.2	508.2	452.4	452.5
2002	22.0	312.8	980.1	1713.4	594.6	739.3	197.3	217.5
2003	105.8	691.4	2952.5	2767.2	966.3	1232.6	873.0	998.5
2004	92.5	626.6	1444.4	2312.4	564.3	905.2	434.7	767.7
2005	44.5	554.1	925.6	1978.1	655.3	1141.8	596.3	853.3
2006	45.8	419.7	631.4	1872.6	385.9	685.5	713.6	847.1
2007	221.4	592.0	945.0	2363.8	623.5	1223.2	517.6	462.7
2008	23.6	617.7	835.7	2112.6	361.7	481.1	492.9	426.4
2009	49.0	356.0	1031.0	1336.2	593.7	532.2	547.0	536.9
2010	98.7	341.0	715.6	1527.8	534.5	570.9	447.7	568.0
2011	185.9	496.6	488.8	1024.7	218.0	432.3	624.7	831.8
2012	160.7	658.3	1223.6	1015.0	268.4	473.3	452.8	507.7
2013	110.2	367.9	669.0	1037.5	236.1	508.9	435.1	659.9
2014	149.8	1139.1	942.1	1709.5	380.6	478.7	482.0	479.9
2015	169.3	711.5	848.9	1382.2	333.2	483.5	298.7	395.5
2016	65.4	276.9	532.3	915.0	172.0	298.6	397.6	382.2
2017	15.2	89.2	267.8	444.3	239.9	347.1	247.4	349.7
2018	9.9	54.1	174.1	321.2	158.6	253.1	127.5	407.1
2019	423.7	571.2	323.4	345.4	194.1	222.2	301.2	415.5
2020	21.3	68.1	412.2	519.6	196.2	283.3	102.4	250.5
2021	58.1	88.7	181.4	215.5	128.8	199.8	170.4	279.5
2008+	284.6	1405.4	833.4	2103.8	-	-	-	-
2009+	421.3	1157.2	1028.8	1334.6	-	-	-	-
2010+	540.0	709.0	714.2	1526.1	-	-	-	-
2011+	557.9	588.7	490.2	1014.4	-	-	-	-
2012+	490.8	779.4	1220.6	1007.8	-	-	-	-
2013+	226.7	795.7	666.2	1029.1	-	-	-	-
2014+	534.4	1098.0	937.3	1693.6	-	-	-	-
2015+	261.6	589.7	843.7	1369.0	-	-	-	-
2016+	449.0	708.4	529.4	908.4	-	-	-	-
2017+	159.6	223.4	267.1	443.1	-	-	-	-
2018+	474.0	591.7	175.1	322.1	-	-	-	-
2019+	489.9	1065.9	327.1	360.4	-	-	-	-
2020+	120.9	253.6	411.5	519.5	-	-	-	-
2021+	831.3	990.2	180.1	215.5	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 18. Variance of the estimation of the kriged biomass, by fishing area and by year, for males (M) and females (F).

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	M	F	M	F	M	F	M	F
1990	4593	4834	8401	8656	10171	6348	4803	7277
1991	190	15114	22197	17747	1265	1436	1228	1519
1992	3381	10859	2757	4974	3327	1636	343	1145
1993	3482	12624	5229	3335	3118	497	367	267
1994	4252	44887	6502	7158	1106	856	1031	987
1995	135	191	6029	5480	6483	3642	6979	5122
1996	1724	35077	9532	6893	17463	14585	7608	2547
1997	91	4508	18807	11438	12013	8093	44216	36384
1998	218	1728	5003	33605	2811	5478	4864	7254
1999	6043	27056	13218	9064	4150	4019	24527	20394
2000	292	9848	21632	17931	4676	8496	11177	16974
2001	11	6582	58555	16209	3886	4715	8744	5870
2002	28	4021	36174	22907	13616	10274	4047	2162
2003	126	39123	671578	32617	77033	28572	41275	32368
2004	7524	65553	72132	50945	93148	55313	21248	27467
2005	207	8972	84841	13234	11480	11319	6845	8114
2006	3	2762	16012	29251	12705	14893	15130	20125
2007	186	2686	72080	54547	8341	45769	9290	6329
2008	33	12784	69789	21424	2994	2624	12120	5643
2009	372	17218	42898	21100	15001	6168	14323	10689
2010	1352	10110	17455	20606	13020	8386	11540	14446
2011	5748	14016	6343	14156	2980	4768	14629	16123
2012	9148	55186	110879	7274	2112	3311	24943	18554
2013	2024	10692	34932	46665	3019	9645	20207	24445
2014	2597	103697	41212	37862	6934	6131	11649	10530
2015	4503	27811	18634	16393	6845	8083	4709	8565
2016	198	3195	17971	26066	2219	2993	11045	8234
2017	40	843	2188	6032	3611	5995	2828	4834
2018	2	2	2380	2540	1547	1723	2891	3119
2019	270150	221625	10353	8507	5486	4497	20921	17084
2020	0	0	12541	14567	2244	2410	558	641
2021	3262	3438	4202	4908	4760	5017	3297	3407
2008+	16392	102556	67828	21841	-	-	-	-
2009+	8170	40838	42864	21071	-	-	-	-
2010+	70574	31642	17444	20582	-	-	-	-
2011+	39732	39001	6354	14200	-	-	-	-
2012+	24374	36177	106422	7136	-	-	-	-
2013+	2488	103622	33892	45328	-	-	-	-
2014+	18238	72156	39632	37108	-	-	-	-
2015+	14305	19969	18156	16386	-	-	-	-
2016+	100642	153436	17313	25309	-	-	-	-
2017+	2926	7873	2189	6029	-	-	-	-
2018+	81837	94804	2379	2537	-	-	-	-
2019+	101218	83113	10347	8502	-	-	-	-
2020+	2457	2855	12535	14562	-	-	-	-
2021+	238887	247487	4207	4911	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 19. Coefficient of variation of the kriged biomass, by fishing area and by year, for males (M) and females (F).

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	M	F	M	F	M	F	M	F
1990	35.9	22.4	23.5	14.3	25.1	19.7	29.6	21.2
1991	31.1	23.9	26.3	17.2	17.2	12.6	18.9	13.7
1992	58.1	28.5	23.9	19.7	21.8	14.6	20.1	16.7
1993	66.4	40.9	21.5	13.1	26.9	14.9	16.8	15.2
1994	63.5	49.7	21.4	14.1	20.1	16.3	18.3	16.0
1995	35.1	26.1	18.2	13.2	20.5	11.9	25.0	21.8
1996	35.6	31.3	20.9	9.4	20.0	13.0	26.5	16.9
1997	13.7	17.9	17.6	10.7	24.0	16.3	28.1	27.5
1998	51.8	26.0	12.8	11.8	19.7	13.1	19.0	17.7
1999	57.1	28.6	14.6	8.7	18.6	11.5	34.4	31.2
2000	12.1	14.1	14.6	7.5	16.9	11.1	24.1	24.3
2001	15.1	18.4	19.0	11.2	18.8	13.5	20.7	16.9
2002	24.0	20.3	19.4	8.8	19.6	13.7	32.2	21.4
2003	10.6	28.6	27.8	6.5	28.7	13.7	23.3	18.0
2004	93.7	40.9	18.6	9.8	54.1	26.0	33.5	21.6
2005	32.3	17.1	31.5	5.8	16.4	9.3	13.9	10.6
2006	3.6	12.5	20.0	9.1	29.2	17.8	17.2	16.7
2007	6.2	8.8	28.4	9.9	14.6	17.5	18.6	17.2
2008	24.4	18.3	31.6	6.9	15.1	10.6	22.3	17.6
2009	39.4	36.9	20.1	10.9	20.6	14.8	21.9	19.3
2010	37.3	29.5	18.5	9.4	21.3	16.0	24.0	21.2
2011	40.8	23.8	16.3	11.6	25.0	16.0	19.4	15.3
2012	59.5	35.7	27.2	8.4	17.1	12.2	34.9	26.8
2013	40.8	28.1	27.9	20.8	23.3	19.3	32.7	23.7
2014	34.0	28.3	21.5	11.4	21.9	16.4	22.4	21.4
2015	39.6	23.4	16.1	9.3	24.8	18.6	23.0	23.4
2016	21.5	20.4	25.2	17.6	27.4	18.3	26.4	23.7
2017	41.8	32.6	17.5	17.5	25.0	22.3	21.5	19.9
2018	12.6	25.6	28.0	23.6	24.8	23.9	42.2	33.1
2019	122.7	122.7	31.5	15.1	38.2	26.4	48.0	36.3
2020	0.7	0.7	27.2	16.8	24.1	26.8	23.1	28.9
2021	98.4	56.8	35.7	20.4	53.6	31.6	33.7	28.6
2008+	45.0	22.8	31.2	7.0	-	-	-	-
2009+	21.5	17.5	20.1	10.9	-	-	-	-
2010+	49.2	25.1	18.5	9.4	-	-	-	-
2011+	35.7	33.5	16.3	11.7	-	-	-	-
2012+	31.8	24.4	26.7	8.4	-	-	-	-
2013+	22.0	40.5	27.6	20.7	-	-	-	-
2014+	25.3	24.5	21.2	11.4	-	-	-	-
2015+	45.7	24.0	16.0	9.4	-	-	-	-
2016+	70.7	55.3	24.9	17.5	-	-	-	-
2017+	33.9	39.7	17.5	17.5	-	-	-	-
2018+	60.3	59.9	27.9	23.6	-	-	-	-
2019+	64.9	48.7	31.1	14.5	-	-	-	-
2020+	41.0	49.8	27.2	16.8	-	-	-	-
2021+	58.8	50.0	36.0	20.4	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 20. Stock biomass (ton) estimated by kriging by fishing area and by year, for males (M) and females (F).

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	M	F	M	F	M	F	M	F
1990	755	1241	11627	19418	18670	18758	7577	13011
1991	177	2057	16874	23073	9606	13948	6000	9228
1992	400	1460	6538	10681	12284	12850	2989	6551
1993	356	1099	10011	13161	9636	6962	3698	3465
1994	410	1704	11198	17818	7670	8331	5681	6340
1995	133	212	12689	16667	18222	23630	10822	10602
1996	466	2395	13906	26212	30616	43214	10658	9680
1997	279	1501	23139	29763	21191	25653	24171	22443
1998	114	639	16421	46063	12503	26263	11867	15566
1999	545	2301	23464	32695	16051	25605	14724	14812
2000	564	2809	29934	52910	18732	38608	14207	17364
2001	89	1760	37905	33996	15366	23580	14635	14640
2002	88	1251	29184	51016	27590	34304	6382	7036
2003	423	2766	87909	82392	44836	57195	28242	32301
2004	370	2506	43008	68852	26182	42000	14062	24836
2005	178	2216	27558	58899	30406	52977	19292	27603
2006	183	1679	18800	55756	17905	31806	23086	27404
2007	885	2368	28137	70382	28931	56758	16745	14969
2008	94	2471	24883	62904	16781	22321	15944	13794
2009	196	1424	30697	39786	27549	24693	17697	17369
2010	395	1364	21308	45490	24802	26489	14483	18374
2011	744	1987	14555	30511	10115	20060	20209	26907
2012	643	2633	36433	30222	12456	21963	14648	16425
2013	441	1471	19919	30891	10955	23614	14076	21349
2014	599	4556	28051	50902	17662	22212	15591	15526
2015	677	2846	25277	41155	15461	22435	9662	12794
2016	262	1107	15850	27243	7981	13857	12864	12365
2017	61	357	7974	13229	11131	16107	8005	11312
2018	40	217	5183	9564	7359	11743	4125	13170
2019	1695	2285	9631	10283	9005	10309	9744	13440
2020	85	272	12272	15471	9103	13145	3313	8105
2021	232	355	5400	6417	5976	9271	5512	9041
2008+	1800	8889	24898	62852	-	-	-	-
2009+	2665	7319	30734	39873	-	-	-	-
2010+	3415	4484	21337	45591	-	-	-	-
2011+	3529	3724	14644	30305	-	-	-	-
2012+	3104	4930	36466	30108	-	-	-	-
2013+	1434	5033	19902	30745	-	-	-	-
2014+	3380	6945	28003	50595	-	-	-	-
2015+	1654	3730	25206	40899	-	-	-	-
2016+	2840	4480	15817	27138	-	-	-	-
2017+	1010	1413	7980	13238	-	-	-	-
2018+	2998	3742	5232	9622	-	-	-	-
2019+	3098	6742	9772	10766	-	-	-	-
2020+	764	1604	12293	15519	-	-	-	-
2021+	5258	6263	5381	6439	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 21. Parameters for the weight-length relationships by fishing area and by year. Length in mm and weight in g.

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	a	b	a	b	a	b	a	b
1993	0.000713	2.945	0.000658	2.978	0.000593	3.018	0.000939	2.864
2005	0.001175	2.777	0.000654	2.960	0.000659	2.957	0.000754	2.904
2006	0.000682	2.945	0.000694	2.934	0.000527	3.040	0.000933	2.849
2007	0.001071	2.800	0.000724	2.930	0.000735	2.918	0.000767	2.904
2008	0.000561	3.016	0.000704	2.934	0.000769	2.908	0.000820	2.887
2009	0.000628	2.977	0.000897	2.864	0.000800	2.893	0.000767	2.911
2010	0.000759	2.920	0.000716	2.931	0.000585	3.011	0.000706	2.953
2011	0.000760	2.911	0.000685	2.942	0.000616	3.001	0.000544	3.036
2012	0.000733	2.931	0.000725	2.936	0.000771	2.923	0.000814	2.908
2013	0.000624	2.979	0.000643	2.976	0.000561	3.028	0.000672	2.967
2014	0.000657	2.962	0.000854	2.880	0.000741	2.933	0.000663	2.969
2015	0.000804	2.914	0.000894	2.870	0.000651	2.975	0.000763	2.924
2016	0.000699	2.963	0.001016	2.831	0.000750	2.945	0.000991	2.832
2017	0.000897	2.884	0.000951	2.862	0.000687	2.986	0.000614	2.985
2018	0.001031	2.839	0.000973	2.853	0.000600	3.005	0.000596	3.003
2019	0.000494	3.068	0.000726	2.935	0.000631	2.983	0.000670	2.963

Model: Weight = a Length ^{b}

Table 22. Stock abundance (in million) by fishing area and by year, for males (M) and females (F).

Year	Estuary		Sept-Iles		Anticosti		Esquiman	
	M	F	M	F	M	F	M	F
1990	156	115	2266	1822	4686	2077	1661	1394
1991	26	196	3871	2278	1948	1458	1210	972
1992	87	128	2113	961	2928	1252	630	660
1993	85	92	2894	1264	2648	671	866	358
1994	87	163	3292	1918	1888	919	1471	716
1995	40	20	2920	1707	4854	2682	2681	1368
1996	86	226	3017	2667	7387	4769	3197	1207
1997	48	132	4939	2830	5852	2603	6497	2791
1998	30	54	3447	4212	2605	2563	3099	1808
1999	118	205	5797	3112	3910	2560	4112	1846
2000	114	257	6531	5329	4957	4008	4020	2137
2001	18	162	8559	3503	3604	2424	4610	1921
2002	20	125	6661	5543	7995	3898	1741	907
2003	219	271	17561	8982	12628	6741	8046	4298
2004	62	238	8521	7715	7070	5149	3740	3421
2005	29	222	6280	6498	6319	6441	4885	3913
2006	28	164	3806	6132	4322	3781	7165	3669
2007	141	226	6171	7251	8128	7224	5890	2243
2008	19	222	5613	6530	4809	2839	4938	2199
2009	43	133	7937	4311	9970	3258	5374	2529
2010	79	129	5942	5273	6481	3254	3634	2470
2011	178	231	3753	3639	2629	2421	5916	3404
2012	131	306	8345	3632	2961	2558	4310	2083
2013	143	158	4251	3513	2556	2787	3670	2741
2014	109	456	6422	5444	4907	2474	4067	1892
2015	138	274	5644	4362	4548	2799	2831	1619
2016	55	116	3698	3347	2278	1866	3245	1729
2017	12	39	1917	1650	3402	2074	1999	1488
2018	8	24	1421	1125	2676	1420	1259	1580
2019	293	224	2314	1137	2818	1336	2908	1739
2020	28	28	2823	1749	3327	1816	966	1056
2021	34	31	1331	728	1662	1202	1474	1262
2008+	456	831	5626	6525	-	-	-	-
2009+	1253	732	7946	4321	-	-	-	-
2010+	1073	467	5950	5284	-	-	-	-
2011+	1070	433	3776	3614	-	-	-	-
2012+	822	586	8355	3619	-	-	-	-
2013+	455	611	4249	3497	-	-	-	-
2014+	992	744	6414	5412	-	-	-	-
2015+	658	378	5628	4335	-	-	-	-
2016+	631	486	3690	3334	-	-	-	-
2017+	303	167	1918	1651	-	-	-	-
2018+	711	465	1435	1132	-	-	-	-
2019+	557	678	2348	1191	-	-	-	-
2020+	199	168	2828	1755	-	-	-	-
2021+	1140	623	1327	731	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 23. Abundance (in million) for juveniles (J), primiparous (Fp) and mutiparous (Fm) females, by fishing area and by year.

Year	Estuary			Sept-Iles			Anticosti			Esquiman		
	J	Fp	Fm	J	Fp	Fm	J	Fp	Fm	J	Fp	Fm
1990	11	48	67	123	965	858	73	1486	590	4	1157	237
1991	0	57	138	349	773	1505	87	837	621	70	535	437
1992	0	43	85	342	556	404	394	843	408	50	554	106
1993	1	78	14	113	1031	234	29	580	92	23	234	124
1994	0	130	33	172	1600	318	19	802	118	98	627	90
1995	12	14	5	188	1496	211	493	2408	273	30	1182	185
1996	1	132	94	166	2011	656	1249	4048	721	637	881	327
1997	0	110	22	45	2294	535	609	2377	226	76	2063	728
1998	8	32	22	705	3498	714	204	2171	392	553	1567	241
1999	1	158	47	14	2707	405	26	2067	492	128	1284	563
2000	1	181	76	234	4544	785	688	3457	551	654	1612	525
2001	0	-	-	82	-	-	20	-	-	268	-	-
2002	0	-	-	77	-	-	444	-	-	25	-	-
2003	114	-	-	222	-	-	553	-	-	193	-	-
2004	0	-	-	84	-	-	64	-	-	17	-	-
2005	0	-	-	85	-	-	103	-	-	366	-	-
2006	0	-	-	54	-	-	248	-	-	101	-	-
2007	2	-	-	505	-	-	478	-	-	443	-	-
2008	2	-	-	127	-	-	349	-	-	58	-	-
2009	2	27	105	125	2022	2289	1258	2115	1144	127	1811	717
2010	0	60	69	64	3392	1880	83	1836	1418	146	1077	1393
2011	1	118	113	22	2058	1581	126	1709	712	533	2516	887
2012	2	258	48	203	2611	1022	35	1997	561	87	1591	492
2013	39	119	39	392	2735	779	138	2331	456	123	2331	410
2014	0	417	39	507	5141	303	444	2131	343	302	1613	279
2015	1	235	39	102	3996	366	172	2566	233	236	1172	447
2016	6	72	44	74	2274	1073	42	1462	403	11	1259	469
2017	0	26	13	39	1255	394	271	1550	524	65	922	566
2018	0	11	13	31	446	679	175	858	563	105	780	800
2019	0	84	141	210	621	516	101	765	571	363	1100	638
2020	4	8	20	90	885	864	419	1136	680	41	709	347
2021	0	8	23	24	465	264	6	845	357	39	730	532
2008+	136	-	-	136	-	-	-	-	-	-	-	-
2009+	519	347	385	125	2026	2294	-	-	-	-	-	-
2010+	17	321	146	64	3400	1884	-	-	-	-	-	-
2011+	82	237	196	22	2044	1571	-	-	-	-	-	-
2012+	78	442	144	206	2600	1019	-	-	-	-	-	-
2013+	94	504	107	392	2722	775	-	-	-	-	-	-
2014+	20	708	36	508	5109	303	-	-	-	-	-	-
2015+	39	345	33	102	3972	363	-	-	-	-	-	-
2016+	13	366	120	74	2265	1069	-	-	-	-	-	-
2017+	30	115	51	39	1256	395	-	-	-	-	-	-
2018+	5	370	95	31	449	684	-	-	-	-	-	-
2019+	6	276	402	213	651	540	-	-	-	-	-	-
2020+	8	90	78	91	888	867	-	-	-	-	-	-
2021+	5	236	387	24	466	265	-	-	-	-	-	-

+: From 2008, the sampling was increased with the addition of strata in shallow waters (37 to 183 m) in the Estuary.

Table 24. Limit reference points (LRP) and upper stock reference point (USR) of Precautionary Approach for northern shrimp in the Estuary and Gulf of St. Lawrence.

Stock	LRP	USR
Estuary (SFA 12)	0.65	1.12
Sept-Iles (SFA 10)	0.53	1.33
Anticosti (SFA 9)	0.60	1.18
Esquiman (SFA 8)	0.45	1.34

Table 25. Standardized indices for the main indicator of stock status calculated from commercial fishery indices (NUE) and from the DFO (Abd) by fishing area.

Estuary (SFA 12)

Year	Index				Standardized index				Index
	NUE male	NUE female	Abd male	Abd female	NUE male	NUE female	Abd male	Abd female	
1982	6465	3117	-	-	0.814	0.216	-	-	0.515
1983	8435	1849	-	-	1.062	0.128	-	-	0.595
1984	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-
1986	5470	3107	-	-	0.689	0.216	-	-	0.452
1987	5484	3115	-	-	0.691	0.216	-	-	0.453
1988	7115	4041	-	-	0.896	0.280	-	-	0.588
1989	-	-	-	-	-	-	-	-	-
1990	-	-	156	115	-	-	2.762	1.251	2.006
1991	-	-	26	196	-	-	0.468	2.137	1.302
1992	3098	3753	87	128	0.390	0.260	1.534	1.396	0.895
1993	3735	4525	85	92	0.470	0.314	1.495	1.009	0.822
1994	2721	2321	87	163	0.343	0.161	1.540	1.783	0.957
1995	12903	12265	40	20	1.625	0.851	0.699	0.214	0.847
1996	3796	8508	86	226	0.478	0.590	1.516	2.463	1.262
1997	5604	18412	48	132	0.706	1.277	0.855	1.442	1.070
1998	12660	17739	30	54	1.594	1.231	0.528	0.588	0.985
1999	9080	18265	118	205	1.144	1.267	2.090	2.234	1.684
2000	20801	17152	114	257	2.620	1.190	2.010	2.802	2.155
2001	20153	7671	18	162	2.538	0.532	0.311	1.766	1.287
2002	17055	18142	20	125	2.148	1.259	0.348	1.366	1.280
2003	11332	24520	219	271	1.427	1.701	3.862	2.954	2.486
2004	14925	20580	62	238	1.880	1.428	1.090	2.598	1.749
2005	20553	32577	29	222	2.589	2.260	0.515	2.424	1.947
2006	27826	26267	28	164	3.505	1.822	0.500	1.794	1.905
2007	20957	24836	141	226	2.640	1.723	2.493	2.467	2.331
2008	28113	24217	19	222	3.541	1.680	0.331	2.423	1.994
2009	15330	16590	43	133	1.931	1.151	0.758	1.451	1.323
2010	10830	24497	79	129	1.364	1.699	1.400	1.411	1.469
2011	38310	7793	178	231	4.825	0.541	3.137	2.527	2.758
2012	47641	12340	131	306	6.000	0.856	2.307	3.338	3.125
2013	12601	13848	143	158	1.587	0.961	2.524	1.727	1.700
2014	19738	14471	109	456	2.486	1.004	1.917	4.984	2.598
2015	20873	16356	138	274	2.629	1.135	2.444	2.992	2.300
2016	27043	10515	55	116	3.406	0.729	0.965	1.270	1.593
2017	15800	9315	12	39	1.990	0.646	0.217	0.431	0.821
2018	29268	29831	8	24	3.686	2.069	0.141	0.257	1.539
2019	28873	24484	293	224	3.637	1.698	5.166	2.449	3.238
2020	27284	22860	28	28	3.436	1.586	0.492	0.311	1.456
2021	19137	20105	34	31	2.410	1.395	0.595	0.339	1.185

Sept-Iles (SFA 10)

Year	Index				Standardized index				Index
	NUE male	NUE female	Abd male	Abd female	NUE male	NUE female	Abd male	Abd female	
1982	6275	3160	-	-	0.546	0.458	-	-	0.502
1983	9649	4060	-	-	0.839	0.588	-	-	0.714
1984	7100	3172	-	-	0.617	0.460	-	-	0.538
1985	7744	4553	-	-	0.673	0.660	-	-	0.667
1986	10652	4317	-	-	0.926	0.625	-	-	0.776
1987	13195	4305	-	-	1.147	0.624	-	-	0.886
1988	9917	4338	-	-	0.862	0.629	-	-	0.745
1989	7485	4866	-	-	0.651	0.705	-	-	0.678
1990	13117	6530	2266	1822	1.141	0.946	0.687	0.870	0.911
1991	10696	5739	3871	2278	0.930	0.832	1.173	1.087	1.005
1992	6995	3758	2113	961	0.608	0.545	0.640	0.459	0.563
1993	6247	4485	2894	1264	0.543	0.650	0.877	0.603	0.668
1994	8657	4448	3292	1918	0.753	0.644	0.997	0.915	0.827
1995	12601	8618	2920	1707	1.096	1.249	0.885	0.814	1.011
1996	14788	10343	3017	2667	1.286	1.499	0.914	1.273	1.243
1997	16246	10067	4939	2830	1.413	1.459	1.496	1.350	1.429
1998	14161	9493	3447	4212	1.231	1.376	1.044	2.010	1.415
1999	17787	10239	5797	3112	1.547	1.484	1.756	1.485	1.568
2000	19615	12123	6531	5329	1.706	1.757	1.978	2.543	1.996
2001	14256	12277	8559	3503	1.240	1.779	2.593	1.671	1.821
2002	18087	16587	6661	5543	1.573	2.403	2.018	2.645	2.160
2003	20197	16150	17561	8982	1.756	2.340	5.320	4.286	3.426
2004	19842	20865	8521	7715	1.725	3.023	2.581	3.681	2.753
2005	25579	21266	6280	6498	2.224	3.081	1.902	3.101	2.577
2006	21576	23125	3806	6132	1.876	3.351	1.153	2.926	2.327
2007	25084	23154	6171	7251	2.181	3.355	1.870	3.460	2.717
2008	29816	18179	5613	6530	2.593	2.634	1.700	3.116	2.511
2009	23531	19459	7937	4311	2.046	2.820	2.405	2.057	2.332
2010	35723	15456	5942	5273	3.106	2.240	1.800	2.516	2.416
2011	23800	18157	3753	3639	2.069	2.631	1.137	1.736	1.893
2012	33134	16684	8345	3632	2.881	2.418	2.528	1.733	2.390
2013	20547	16921	4251	3513	1.787	2.452	1.288	1.677	1.801
2014	27574	15045	6422	5444	2.398	2.180	1.946	2.598	2.280
2015	27621	15036	5644	4362	2.402	2.179	1.710	2.081	2.093
2016	17469	12938	3698	3347	1.519	1.875	1.120	1.597	1.528
2017	10606	9761	1917	1650	0.922	1.414	0.581	0.787	0.926
2018	11656	6893	1421	1125	1.014	0.999	0.431	0.537	0.745
2019	16512	9888	2314	1137	1.436	1.433	0.701	0.543	1.028
2020	19431	13150	2823	1749	1.690	1.906	0.855	0.835	1.321
2021	25269	11432	1331	728	2.197	1.657	0.403	0.348	1.151

Anticosti (SFA 9)

Year	Index				Standardized index				Index
	NUE male	NUE female	Abd male	Abd female	NUE male	NUE female	Abd male	Abd female	
1982	12448	4759	-	-	0.840	0.689	-	-	0.764
1983	11304	4269	-	-	0.763	0.618	-	-	0.690
1984	7215	3784	-	-	0.487	0.548	-	-	0.517
1985	9881	5230	-	-	0.667	0.757	-	-	0.712
1986	11746	5227	-	-	0.793	0.757	-	-	0.775
1987	13311	4128	-	-	0.898	0.597	-	-	0.748
1988	11465	6229	-	-	0.774	0.902	-	-	0.838
1989	15232	8369	-	-	1.028	1.211	-	-	1.120
1990	14924	8175	4686	2077	1.007	1.183	1.334	1.113	1.159
1991	13039	6186	1948	1458	0.880	0.895	0.555	0.782	0.778
1992	9235	5399	2928	1252	0.623	0.781	0.834	0.671	0.727
1993	12824	5099	2648	671	0.865	0.738	0.754	0.360	0.679
1994	15577	5629	1888	919	1.051	0.815	0.537	0.493	0.724
1995	19813	6330	4854	2682	1.337	0.916	1.382	1.437	1.268
1996	15377	7947	7387	4769	1.038	1.150	2.103	2.556	1.712
1997	17070	8125	5852	2603	1.152	1.176	1.666	1.395	1.347
1998	14271	9767	2605	2563	0.963	1.414	0.742	1.374	1.123
1999	19195	7923	3910	2560	1.295	1.147	1.113	1.372	1.232
2000	19433	11205	4957	4008	1.311	1.622	1.411	2.148	1.623
2001	25007	9710	3604	2424	1.687	1.405	1.026	1.299	1.354
2002	24207	13441	7995	3898	1.633	1.945	2.276	2.089	1.986
2003	25963	16208	12628	6741	1.752	2.346	3.595	3.613	2.826
2004	19862	19317	7070	5149	1.340	2.796	2.013	2.760	2.227
2005	34693	20762	6319	6441	2.341	3.005	1.799	3.452	2.649
2006	37762	21696	4322	3781	2.548	3.140	1.231	2.027	2.236
2007	28765	22956	8128	7224	1.941	3.323	2.314	3.872	2.862
2008	38572	24675	4809	2839	2.603	3.571	1.369	1.522	2.266
2009	41083	25142	9970	3258	2.772	3.639	2.839	1.747	2.749
2010	40380	19947	6481	3254	2.725	2.887	1.845	1.744	2.300
2011	36740	20831	2629	2421	2.479	3.015	0.749	1.298	1.885
2012	40257	16497	2961	2558	2.716	2.388	0.843	1.371	1.830
2013	39695	26125	2556	2787	2.678	3.781	0.728	1.494	2.170
2014	50890	23632	4907	2474	3.434	3.420	1.397	1.326	2.394
2015	47910	20062	4548	2799	3.233	2.904	1.295	1.500	2.233
2016	29956	16803	2278	1866	2.021	2.432	0.648	1.000	1.525
2017	21751	13400	3402	2074	1.468	1.939	0.969	1.112	1.372
2018	21320	13574	2676	1420	1.439	1.965	0.762	0.761	1.232
2019	33506	15415	2818	1336	2.261	2.231	0.802	0.716	1.503
2020	25721	17018	3327	1816	1.735	2.463	0.947	0.974	1.530
2021	24597	16712	1662	1202	1.660	2.419	0.473	0.644	1.299

Esquiman (SFA 8)

Year	Index				Standardized index				Index
	NUE male	NUE female	Abd male	Abd female	NUE male	NUE female	Abd male	Abd female	
1982	12845	5894	-	-	0.504	0.545	-	-	0.524
1983	7388	4502	-	-	0.290	0.416	-	-	0.353
1984	10046	5548	-	-	0.394	0.513	-	-	0.453
1985	8216	5120	-	-	0.322	0.473	-	-	0.398
1986	6013	6588	-	-	0.236	0.609	-	-	0.422
1987	18988	3679	-	-	0.745	0.340	-	-	0.542
1988	18766	5231	-	-	0.736	0.483	-	-	0.610
1989	18650	9979	-	-	0.731	0.922	-	-	0.827
1990	20201	10153	1661	1394	0.792	0.938	0.821	1.229	0.945
1991	19909	6941	1210	972	0.781	0.642	0.598	0.857	0.719
1992	19400	6050	630	660	0.761	0.559	0.311	0.582	0.553
1993	24667	6531	866	358	0.967	0.604	0.428	0.315	0.579
1994	21693	10408	1471	716	0.851	0.962	0.727	0.631	0.793
1995	23299	11007	2681	1368	0.914	1.017	1.326	1.206	1.116
1996	30285	12051	3197	1207	1.188	1.114	1.581	1.064	1.237
1997	31723	17108	6497	2791	1.244	1.581	3.212	2.461	2.125
1998	39532	15054	3099	1808	1.550	1.391	1.532	1.594	1.517
1999	31478	22206	4112	1846	1.234	2.052	2.033	1.628	1.737
2000	43491	19997	4020	2137	1.705	1.848	1.987	1.884	1.856
2001	50206	23551	4610	1921	1.969	2.177	2.279	1.694	2.030
2002	40244	19048	1741	907	1.578	1.761	0.861	0.799	1.250
2003	41526	23721	8046	4298	1.628	2.192	3.978	3.790	2.897
2004	54096	36505	3740	3421	2.121	3.374	1.849	3.016	2.590
2005	59383	40371	4885	3913	2.329	3.731	2.415	3.450	2.981
2006	78243	42440	7165	3669	3.068	3.923	3.542	3.235	3.442
2007	69907	38391	5890	2243	2.741	3.548	2.912	1.977	2.795
2008	70932	42673	4938	2199	2.782	3.944	2.442	1.939	2.776
2009	70258	33182	5374	2529	2.755	3.067	2.657	2.229	2.677
2010	74142	31754	3634	2470	2.907	2.935	1.797	2.178	2.454
2011	88551	45712	5916	3404	3.473	4.225	2.925	3.001	3.406
2012	82286	37457	4310	2083	3.227	3.462	2.131	1.836	2.664
2013	43104	36951	3670	2741	1.690	3.415	1.815	2.417	2.334
2014	55346	39427	4067	1892	2.170	3.644	2.011	1.668	2.373
2015	41183	34667	2831	1619	1.615	3.204	1.400	1.428	1.912
2016	49116	30678	3245	1729	1.926	2.835	1.604	1.524	1.972
2017	36587	27263	1999	1488	1.435	2.520	0.988	1.312	1.564
2018	33180	24735	1259	1580	1.301	2.286	0.623	1.393	1.401
2019	42509	25044	2908	1739	1.667	2.315	1.438	1.533	1.738
2020	45716	30276	966	1056	1.793	2.798	0.478	0.931	1.500
2021	38748	26011	1474	1262	1.519	2.404	0.729	1.112	1.441

Table 26. Guidelines defining removal rates (P) based on the main stock status indicator (I) of Precautionary Approach for northern shrimp in the Estuary and Gulf of St. Lawrence.

Stock	Critical zone	Cautious zone	Healthy zone
Estuary (SFA 12)	*P* = 117.7*I*	*P* = -551.8 + 962.4*I*	*P* = 470,7*I*
Sept-Iles (SFA 10)	*P* = 1469.7*I*	*P* = -3910.5 + 8819.4*I*	*P* = 5868.9*I*
Anticosti (SFA 9)	*P* = 1044.1*I*	*P* = -419.6 + 7819.1*I*	*P* = 4176.4*I*
Esquiman (SFA 8)	*P* = 881.0*I*	*P* = -1808.8 + 4871.1*I*	*P* = 3524.0*I*

Table 27. Projected harvest for 2020 by the main stock status indicator.

Fishing area	SFA	Main indicator	Classification zone	Projected harvest (t)
Estuary	12	1.185	Saine	558
Sept-Iles	10	1.151	Prudence	6242
Anticosti	9	1.299	Saine	5425
Esquiman	8	1.441	Saine	5079

Table 28. Environmental conditioning factors (ECFs) for GSL northern shrimp stocks with projected harvests conditioned for a changing environment or following the current precautionary approach (status quo).

Fishing area	ECF (1-ECF)	Harvests 2022 (t) conditioned for a changing environment	Projected harvests 2022 (t) (status quo)
Estuary	0.85 (0.15)	474	558
Sept-Iles	0.85 (0.15)	5306	6242
Anticosti	0.83 (0.17)	4513	5425
Esquiman	0.83 (0.17)	4224	5079

Table 29. Spatial distribution of fishing effort in hours and trawl surface according to VMS data according to the trawl footprint of the northern shrimp fishery. An intensity of 50% means that the area of a square of 1 degree longitude-latitude has been trawled at 50% in a year.

Fishing effort (hour)

Year	Footprint					
	Low		Medium		High	
	> 0 %	> 10 %	> 25 %	> 50 %	> 100 %	> 200 %
2012	82253	79975	73978	60924	35382	10896
2013	88311	85972	80739	70492	49650	19154
2014	72403	70231	64674	53821	33209	10759
2015	79748	77717	72357	59458	36327	10114
2016	111035	108708	104701	95944	72808	36853
2017	110974	109058	105673	97274	72763	33119
2018	77362	76007	72941	66110	45344	14533
2019	67563	66239	63371	54757	34643	9942
2020	65359	64141	61283	53022	30102	7081
2021	64033	62631	59249	52027	33858	13026
2012-2021	81904	78456	72198	56876	21247	2217

Trawled surface (km2)

Year	Footprint					
	Low		Medium		High	
	> 0 %	> 10 %	> 25 %	> 50 %	> 100 %	> 200 %
2012	6601	6417	5935	4884	2829	867
2013	7069	6882	6463	5643	3974	1533
2014	5820	5646	5200	4328	2672	866
2015	6493	6328	5891	4839	2953	822
2016	9100	8908	8578	7857	5959	3017
2017	9120	8962	8683	7992	5978	2722
2018	6315	6204	5954	5395	3698	1186
2019	5593	5484	5245	4529	2862	822
2020	5392	5291	5055	4374	2487	588
2021	5298	5182	4900	4300	2798	1079
2012-2021	6680	6400	5890	4640	1734	181

Surface of the area (km^2)

Year	Footprint					
	Low		Medium		High	
	> 0 %	> 10 %	> 25 %	> 50 %	> 100 %	> 200 %
2012	14305	10437	7532	4666	1762	321
2013	13560	9413	6850	4611	2305	571
2014	12759	9036	6353	3962	1645	325
2015	13822	10070	7460	4567	1890	321
2016	14916	9647	7659	5679	3085	997

Year	Footprint					
	Low		Medium		High	
	> 0 %	> 10 %	> 25 %	> 50 %	> 100 %	> 200 %
2017	13993	9566	7886	5999	3263	901
2018	10781	7568	6062	4574	2258	460
2019	10366	7445	6064	4131	1794	322
2020	10363	7524	6127	4300	1698	235
2021	10047	6998	5330	3685	1637	362
2012-2021	23237	11813	8718	5375	1282	76

Table 30. Sum of the duration (hours) of fishing tows realised with an observer on board and total fishing effort (hours) of shrimpers by fishing area and by NAFO unit area for 2020 and 2021.

Fishing area	NAFO area	2020 Hour (h)		2021 Hour (h)	
		Observer	Fishery	Observer	Fishery
Estuary	4TP	-	334	-	369
Estuary	4TQ	-	1483	353	1550
Total Estuary		**0**	**1817**	**353**	**1920**
Sept-Iles	4SI	132	691	345	4291
Sept-Iles	4SS	-	-	-	6
Sept-Iles	4SY	-	20	-	-
Sept-Iles	4SZ	1870	24991	1054	21371
Sept-Iles	4TK	-	-	-	-
Sept-Iles	4TN	-	-	-	-
Sept-Iles	4TO	-	43	-	50
Sept-Iles	4TQ	-	-	-	-
Total Sept-Iles		**2002**	**25745**	**1399**	**25718**
Anticosti	4SS	-	44	-	78
Anticosti	4SV	-	882	54	371
Anticosti	4SX	1709	24093	915	28897
Anticosti	4SY	19	1199	59	811
Anticosti	4TF	-	-	-	-
Anticosti	4TK	-	-	-	-
Total Anticosti		**1728**	**26217**	**1028**	**30156**
Esquiman	4R	-	-	-	-
Esquiman	4RA	-	448	-	670
Esquiman	4RB	182	15185	-	16711
Esquiman	4RC	-	-	-	27
Esquiman	4SV	-	6	-	24
Total Esquiman		**182**	**15639**	**0**	**17432**

Table 31. Weighting factor (fleet fishing effort / fishing effort with an observer) by cell (combination of shrimp fishing area (SFA) and NAFO subdivisions) used to scale the at-sea observer results to the total fishing effort of the shrimper fleet.

ZPC	Estuary	Sept-Iles				Anticosti			Esquiman
	12	10	10	10	10	9	9	9	8
NAFO	4Tp 4Tq	4To 4Tn 4Tk	4Tq 4Sz	4Si 4Sy	4Ss	4Tf 4Tk	4Ss	4Sx 4Sy 4Sv	4Sv 4Ra 4Rb 4Rc 4R
Year									
2000	21.17	15.45	26.98	17.97	11.56	12.21	14.11	39.28	29.55
2001	16.97	23.73	28.01	18.46	22.22	82.75	15.36	25.75	29.33
2002	12.38	14.05	10.72	50.50	43.30	5.88	16.73	23.06	26.54
2003	54.00	14.36	12.20	19.96	14.77	79.10	22.24	25.83	19.30
2004	19.69	24.38	23.86	8.14	14.02	29.34	24.20	23.82	36.28
2005	9.18	14.29	12.83	21.18	21.72	1.72	22.73	20.15	44.65
2006	18.94	12.21	16.06	14.25	27.41	28.96	16.22	30.55	26.08
2007	8.95	11.03	23.84	20.28	44.99	9.96	13.59	20.12	27.96
2008	9.13	15.43	20.18	16.88	28.37	3.50	19.95	17.48	34.87
2009	12.00	11.72	29.47	21.77	28.91	1.28	23.40	11.94	68.48
2010	12.59	18.20	16.45	15.10	27.97	-	11.77	16.23	24.23
2011	6.85	37.42	26.91	19.08	28.51	-	9.56	13.46	24.51
2012	15.24	11.08	19.22	39.18	23.65	0.41	14.49	20.49	16.79
2013	9.31	14.23	22.48	15.10	22.52	1.66	11.79	24.61	20.14
2014	14.83	7.39	22.42	18.88	21.38	-	-	24.40	30.96
2015	80.99	11.12	21.88	8.08	9.54	-	-	20.72	65.41
2016	43.35	5.98	24.54	21.03	2.11	-	-	15.07	20.97
2017	15.30	10.93	13.45	11.99	9.67	-	-	17.52	32.14
2018	9.41	31.27	14.71	13.7	11.71	-	55.53	29.26	21.97
2019	5.84	5.96	13.16	8.4	-	-	-	28.46	20.89
2020	-	-	13.36	5.39	-	-	-	15.14	85.77
2021	5.43	-	20.27	12.45	-	-	-	29.27	-

Table 32. Bycatch (t) and ratio (%) of the bycatch on the northern shrimp catch by year and by fishing area for all species combined.

ZPC	Bycatch (t)					Ratio (%)				
	8	9	10	12	Total	8	9	10	12	Total
Year										
2000	80	168	227	20	495	1.08	2.12	2.24	2.71	1.89
2001	125	70	152	6	353	1.60	1.29	1.39	0.69	1.41
2002	316	107	225	9	657	3.83	1.24	1.96	1.19	2.25
2003	85	85	276	11	456	1.25	0.97	2.43	1.42	1.65
2004	165	105	324	8	601	1.92	1.01	2.03	0.73	1.67
2005	175	60	158	17	410	1.98	0.75	1.23	1.66	1.34
2006	42	108	187	8	345	0.47	1.24	1.22	0.82	1.01
2007	94	124	145	10	373	1.02	1.21	0.93	1.02	1.04
2008	86	113	206	43	448	0.95	1.17	1.29	4.18	1.25
2009	283	124	169	25	599	2.98	1.28	1.06	2.49	1.67
2010	111	176	176	41	505	1.16	1.75	1.12	4.53	1.39
2011	66	137	329	23	555	0.72	1.40	2.29	2.60	1.62
2012	69	147	260	12	488	0.68	1.78	2.08	1.25	1.53
2013	144	89	533	71	837	1.57	1.16	3.75	6.37	2.60
2014	192	307	588	22	1109	2.28	3.52	4.73	2.28	3.63
2015	128	353	427	51	959	1.56	3.85	3.44	4.72	3.11
2016	293	290	911	55	1549	4.15	3.34	7.50	5.35	5.36
2017	197	262	491	62	1013	2.80	3.78	7.08	6.90	4.65
2018	83	156	365	49	652	1.38	2.47	8.73	22.80	3.91
2018	80	217	337	42	676	1.34	3.16	8.44	21.07	3.97
2018	59	127	239	45*	470	0.98	2.05	4.69	7.89*	2.63*
2019	69*	121	231	27	449	1.26*	1.95	4.71	4.51	2.61*
Mean 2000-2019	**141**	**160**	**324**	**29**	**654**	**1.74**	**1.92**	**3.25**	**4.74**	**2.35**

*: No observer coverage (Estuary in 2020) or data not available at the time of the assessment (Esquiman 2021). By-catch value estimated by the average of the previous 2 years.

Table 33. Occurrence and total catch of sampled tows by observers (24,197 tows) for 98 taxa for the 2000-2021 period.

	Occurrence		Catch (kg)
Taxa	n tows	%	
Northern shrimp	24165	99.868	30901077
Greenland halibut	22070	91.210	121715
Capelin	20140	83.233	153997
Redfishes	19193	79.320	245662
Atlantic herring	17000	70.257	54647
American plaice	14385	59.450	27896
Witch flounder	12945	53.498	27394
White barracudina	12281	50.754	22287
Thorny skate	9696	40.071	13754
Atlantic hagfish	7973	32.950	8792
Marlin-spike	6823	28.198	7424
Eelpouts	5302	21.912	6826
Atlantic cod	5150	21.284	12418
Fourbeard rockling	3664	15.142	4192
Silver hake	2866	11.844	2949
Squids	2631	10.873	3384
Pink glass shrimp	2503	10.344	25599
Sand lances	2301	9.509	3358
White hake	2168	8.960	2332
Poachers	1566	6.472	1636
Atlantic soft pout	1444	5.968	1460
Octopoda	1443	5.964	1453
Smooth skate	1334	5.513	1492
Anthozoan	1296	5.356	1347
Sea stars	1147	4.740	1168
Scyphozoans	987	4.079	1634
Arctic cod	921	3.806	1346
Snow crab	749	3.095	780
Wrymouth	628	2.595	710
Spinytail skate	594	2.455	700
Sea pen	593	2.451	608
Atlantic halibut	555	2.294	5537
Seasnails	554	2.290	554
Lantern-fishes	439	1.814	444
Sculpins	411	1.699	412
Lumpfish	398	1.645	416
Bobtails	374	1.546	375
Lumpfishes	352	1.455	360
Eelpouts	344	1.422	548
Rocklings	336	1.389	429
Winter flounder	335	1.384	566
Striped pink shrimp	332	1.372	5943
Sea urchins	288	1.190	314
Hookear sculpins	267	1.103	277
Shrimp-Like	227	0.938	3090
Longfin hake	205	0.847	208
Hatchetfishes	200	0.827	200
Fourline snakeblenny	174	0.719	203
Sculpins	173	0.715	174
Atlantic mackerel	146	0.603	224
Atlantic wolffish	138	0.570	150
Black dogfish	132	0.546	2027

	Occurrence		Catch (kg)
Taxa	n tows	%	
Winter skate	128	0.529	216
Ocean pout	126	0.521	130
Rainbow smelt	122	0.504	2274
Greenland cod	102	0.422	169
Toad crabs	98	0.405	98
Sticklebacks	81	0.335	81
Slender snipe eel	78	0.322	78
Sponges	78	0.322	79
Brittle stars	75	0.310	75
Spiny dogfish	67	0.277	112
Monkfish	59	0.244	64
Spotted wolffish	56	0.231	62
Bivalves	49	0.203	49
Yellowtail flounder	47	0.194	49
Haddock	46	0.190	46
Sea lamprey	33	0.136	33
Lightfishes	25	0.103	25
Sea cucumbers	25	0.103	41
Pollock	24	0.099	35
Atlantic tomcod	19	0.079	36
Stout sawpalate	19	0.079	19
Basket stars	19	0.079	19
Norway king crab	18	0.074	18
Blue whiting	17	0.070	17
Arctic staghorn sculpin	17	0.070	17
Atlantic argentine	16	0.066	2622
American shad	14	0.058	16
Manylight viperfish	13	0.054	13
American eel	11	0.045	11
Boa dragonfish	10	0.041	10
Slatjaw cutthroat eel	8	0.033	8
Northern wolffish	7	0.029	9
Atlantic saury	6	0.025	6
Atlantic rock crab	6	0.025	7
Rock gunnel	5	0.021	5
Atlantic salmon	4	0.017	5
Anglers	4	0.017	4
Sea raven	4	0.017	4
Scaleless dragonfishes	4	0.017	8
Butterfish	4	0.017	4
Polar sculpin	3	0.012	3
Fish doctor	3	0.012	3
Striped bass	2	0.008	3
Round skate	2	0.008	2
Sculpins	1	0.004	1
Mummichog	1	0.004	1

Table 34. Occurrence and bycatch means for the 2000-2019 period and for the years 2020 and 2021.

Taxa	Occurrence (%)			Bycatch (kg)		
	2000-2019	2020	2021	2000-2019	2020	2021
Greenland halibut	91.178	92.828	95.818	98425	78203	58139
Capelin	83.836	60.081	80.909	146452	87179	46300
Redfishes	78.904	94.317	97.818	202385	129123	165418
Atlantic herring	70.248	60.487	72.909	48044	11585	13849
American plaice	58.401	74.696	82.909	20395	12381	10340
Witch flounder	52.486	80.514	74.545	19637	23742	26206
White barracudina	50.205	56.563	78.545	15497	3229	8138
Thorny skate	39.559	58.999	39.273	7559	3561	2883
Atlantic hagfish	33.054	40.054	23.273	3224	1720	820
Marlin-spike	27.716	48.309	31.091	1981	2372	2020
Atlantic cod	22.338	2.165	7.455	8922	170	166
Eelpouts	21.900	12.043	29.818	4024	591	1426
Fourbeard rockling	14.507	28.552	27.273	1055	1068	2649
Silver hake	10.472	44.926	53.636	586	1219	1322
Squids	9.753	53.315	14.727	2394	12732	2124
Pink glass shrimp	9.603	16.103	31.091	23335	3929	1259
Sand lances	9.428	10.014	7.455	3509	1179	675
White hake	9.120	9.202	7.818	836	345	473
Poachers	6.626	0.000	2.000	1477	0	98
Atlantic soft pout	6.131	3.518	2.545	118	29	17
Octopoda	5.618	11.502	14.727	60	46	87
Smooth skate	5.319	7.848	8.545	439	179	352
Anthozoan	5.142	8.390	5.091	207	131	85
Sea stars	4.323	16.238	7.273	56	53	25
Scyphozoans	3.909	8.931	11.818	903	174	220
Arctic cod	3.522	4.060	12.000	750	424	478
Snow crab	3.107	2.030	6.182	102	18	59
Spinytail skate	2.605	0.000	0.364	374	0	27
Seasnails	2.388	0.271	0.545	411	27	16
Atlantic halibut	2.272	0.947	3.636	4920	7610	1009
Sea pen	2.234	5.548	4.545	415	575	723
Wrymouth	2.072	12.991	11.273	115	152	838
Lantern-fishes	1.740	3.924	3.636	341	1774	312
Sculpins	1.717	0.000	0.727	346	0	22
Lumpfish	1.644	3.383	1.273	53	33	13
Eelpouts	1.484	0.000	0.000	667	0	0
Lumpfishes	1.474	0.406	1.091	326	40	62
Winter flounder	1.310	4.465	0.000	456	309	0
Bobtails	1.295	5.007	8.727	294	760	953
Rocklings	1.219	0.000	8.000	349	0	620
Sea urchins	1.182	0.812	0.182	235	80	12
Hookear sculpins	1.133	0.000	0.000	248	0	0
Striped pink shrimp	1.127	10.284	4.545	3896	8582	648
Shrimp-Like	0.884	0.135	5.818	2315	15	282
Longfin hake	0.871	2.436	0.364	175	242	50
Hatchetfishes	0.811	0.677	1.273	166	67	104
Fourline snakeblenny	0.762	0.000	0.000	247	0	0
Sculpins	0.761	0.000	0.182	137	0	5
Atlantic wolffish	0.566	0.000	0.000	93	0	0
Black dogfish	0.540	0.135	0.545	2247	6	21
Winter skate	0.538	0.000	0.000	71	0	0
Atlantic mackerel	0.532	3.924	0.000	133	809	0
Rainbow smelt	0.510	0.947	0.000	1852	94	0

Taxa	Occurrence (%)			Bycatch (kg)		
	2000-2019	2020	2021	2000-2019	2020	2021
Toad crabs	0.405	0.135	0.545	72	13	31
Greenland cod	0.403	0.000	0.182	104	0	16
Ocean pout	0.371	0.000	6.364	17	0	188
Slender snipe eel	0.347	0.271	0.000	69	29	0
Sticklebacks	0.308	0.000	2.000	64	0	192
Spiny dogfish	0.281	0.000	0.182	90	0	8
Sponges	0.279	0.541	1.273	66	61	196
Brittle stars	0.265	0.812	1.818	43	80	143
Spotted wolffish	0.258	0.000	0.000	54	0	0
Monkfish	0.235	0.135	0.364	60	15	33
Yellowtail flounder	0.220	0.000	0.000	51	0	0
Haddock	0.174	0.406	0.182	32	44	29
Bivalves	0.174	0.541	0.545	37	57	71
Sea lamprey	0.151	0.135	0.000	35	86	0
Sea cucumbers	0.105	0.000	0.000	32	0	0
Pollock	0.102	0.000	0.000	19	0	0
Lightfishes	0.096	0.271	0.000	18	27	0
Atlantic tomcod	0.083	0.000	0.000	24	0	0
Blue whiting	0.082	0.000	0.000	15	0	0
Stout sawpalate	0.080	0.000	0.000	16	0	0
Arctic staghorn sculpin	0.075	0.000	0.000	16	0	0
Basket stars	0.075	0.135	0.000	24	13	0
Norway king crab	0.073	0.135	0.000	14	15	0
Atlantic argentine	0.064	0.000	0.182	3472	0	41
Manylight viperfish	0.057	0.000	0.000	12	0	0
American shad	0.047	0.406	0.000	12	42	0
American eel	0.040	0.135	0.000	9	15	0
Slatjaw cutthroat eel	0.035	0.000	0.000	6	0	0
Northern wolffish	0.029	0.000	0.000	15	0	0
Atlantic rock crab	0.029	0.000	0.000	7	0	0
Boa dragonfish	0.025	0.000	0.727	6	0	58
Atlantic saury	0.023	0.135	0.000	6	86	0
Rock gunnel	0.022	0.000	0.000	4	0	0
Anglers	0.019	0.000	0.000	4	0	0
Atlantic salmon	0.018	0.000	0.000	6	0	0
Scaleless dragonfishes	0.018	0.000	0.000	8	0	0
Sea raven	0.017	0.000	0.000	2	0	0
Butterfish	0.017	0.135	0.000	2	13	0
Polar sculpin	0.014	0.000	0.000	5	0	0
Fish doctor	0.014	0.000	0.000	3	0	0
Striped bass	0.008	0.000	0.000	2	0	0
Mummichog	0.005	0.000	0.000	1	0	0
Round skate	0.004	0.000	0.182	1	0	20
Sculpins	0.004	0.000	0.000	0	0	0

Table 35. DFO survey abundance and biomass estimates, bycatches in number and biomass from at-sea observers and ratio of the bycatch on the survey estimate.

Year	Survey		Bycatch		Ratio (%)	
	N (x1000)	Biomass (t)	N (x1000)	Biomass (t)	N	Biomass
Atlantic cod (< 30 cm)						
2000-2019	84596	9933	108.86	8.92	0.135	0.104
2020	227995	30790	0.19	0.17	0.000	0.001
2021	126022	20709	0.57	0.17	0.000	0.001
Redfishes (< 20 cm)						
2000-2019	4312165	255901	9058.42	202.39	0.187	0.179
2020	1023347	65282	9024.53	129.12	0.882	0.198
2021	1367361	67576	11297.95	165.42	0.826	0.245
Greenland halibut (< 31 cm)						
2000-2019	267164	26303	1926.30	98.43	0.739	0.429
2020	274432	34210	1327.47	78.20	0.484	0.229
2021	75057	12101	2921.31	58.14	3.892	0.480
American plaice (< 30 cm)						
2000-2019	299021	16513	307.41	20.39	0.137	0.154
2020	342859	18621	147.95	12.38	0.043	0.066
2021	315616	20268	101.89	10.34	0.032	0.051
Witch flounder (< 30 cm)						
2000-2019	62145	3873	289.52	19.64	0.466	0.541
2020	58333	3578	47.48	23.74	0.081	0.663
2021	59108	3202	420.77	26.21	0.712	0.818
White hake (< 30 cm)						
2000-2019	-	459	-	0.84	-	0.268
2020	-	282	-	0.34	-	0.122
2021	-	251	-	0.47	-	0.189
Atlantic halibut						
2000-2019	-	12131	-	4.92	-	0.078
2020	-	21482	-	7.61	-	0.035
2021	-	50207	-	1.01	-	0.002
Fourbeard rockling						
2000-2019	-	1725	-	1.06	-	0.070
2020	-	1415	-	1.07	-	0.076
2021	-	1293	-	2.65	-	0.205
Thorny skate (< 30 cm)						
2000-2019	-	1957	-	7.56	-	0.420
2020	-	1695	-	3.56	-	0.210
2021	-	1461	-	2.88	-	0.197
Smooth skate (< 30 cm)						
2000-2019	-	372	-	0.44	-	0.149
2020	-	124	-	0.18	-	0.145
2021	-	115	-	0.35	-	0.307
Atlantic hagfish						
2000-2019	-	4564	-	3.22	-	0.152

Year	Survey		Bycatch		Ratio (%)	
	N (x1000)	Biomass (t)	N (x1000)	Biomass (t)	N	Biomass
2020	-	3503	-	1.72	-	0.049
2021	-	7698	-	0.82	-	0.011
Marlin-spike						
2000-2019	-	2782	-	1.98	-	0.079
2020	-	4307	-	2.37	-	0.055
2021	-	4383	-	2.02	-	0.046
Lumpfish						
2000-2019	-	815	-	0.05	-	0.012
2020	-	3667	-	0.03	-	0.001
2021	-	1723	-	0.01	-	0.001
Atlantic soft pout						
2000-2019	-	122	-	0.12	-	0.146
2020	-	27	-	0.03	-	0.108
2021	-	39	-	0.02	-	0.043
Silver hake						
2000-2019	-	890	-	0.79	-	0.194
2020	-	425	-	1.22	-	0.287
2021	-	1440	-	1.32	-	0.092
Atlantic wolffish						
2000-2019	-	2831	-	0.08	-	0.003
2020	-	2595	-	0.00	-	0.000
2021	-	4336	-	0.00	-	0.000
Spotted wolffish						
2000-2019	-	594	-	0.03	-	0.004
2020	-	870	-	0.00	-	0.000
2021	-	1162	-	0.00	-	0.000
Arctic cod						
2000-2019	-	42	-	0.65	-	7.629
2020	-	64	-	0.42	-	0.665
2021	-	2	-	0.48	-	20.178
Longfin hake						
2000-2019	-	1831	-	0.22	-	0.012
2020	-	2391	-	0.24	-	0.010
2021	-	3063	-	0.05	-	0.002
Rocklings						
2000-2019	-	2	-	0.28	-	59.077
2020	-	0	-	0.00	-	
2021	-	0	-	0.62	-	1723.326
Sculpins						
2000-2019	-	752	-	0.12	-	0.018
2020	-	510	-	0.00	-	0.000
2021	-	855	-	0.01	-	0.001
Sculpins						
2000-2019	-	2995	-	0.26	-	0.011

Year	Survey		Bycatch		Ratio (%)	
	N (x1000)	Biomass (t)	N (x1000)	Biomass (t)	N	Biomass
2020	-	1765	-	0.00	-	0.000
2021	-	2943	-	0.02	-	0.001
Hookear sculpins						
2000-2019	-	41	-	0.31	-	0.861
2020	-	69	-	0.00	-	0.000
2021	-	62	-	0.00	-	0.000
Poachers						
2000-2019	-	147	-	1.55	-	1.196
2020	-	239	-	0.00	-	0.000
2021	-	81	-	0.10	-	0.122
Seasnails						
2000-2019	-	16	-	0.48	-	5.277
2020	-	14	-	0.03	-	0.194
2021	-	10	-	0.02	-	0.168
Lumpfishes						
2000-2019	-	18	-	0.28	-	61.643
2020	-	1	-	0.04	-	4.722
2021	-	1	-	0.06	-	11.861
Eelpouts						
2000-2019	-	497	-	0.86	-	0.138
2020	-	337	-	0.00	-	0.000
2021	-	428	-	0.00	-	0.000
Wrymouth						
2000-2019	-	205	-	0.13	-	0.069
2020	-	53	-	0.15	-	0.288
2021	-	120	-	0.84	-	0.699
Eelpouts						
2000-2019	-	1702	-	4.02	-	0.233
2020	-	470	-	0.59	-	0.126
2021	-	1128	-	1.43	-	0.126

Table 36. Percentage (Pct) of Pandalus montagui and Pasiphaea multidentata in the shrimp samples at landing.

Year	Number of samples	Pct *P. montagui* *(%)*	Pct *P. multidentata* *(%)*
2000	152	0.130	1.001
2001	145	0.080	0.962
2002	166	0.098	0.380
2003	172	0.035	0.448
2004	166	0.046	0.414
2005	164	0.152	0.172
2006	183	0.248	0.461
2007	179	0.139	0.406
2008	164	0.267	0.932
2009	137	0.724	1.365
2010	153	0.276	1.397
2011	155	0.350	0.813
2012	152	0.380	0.770
2013	170	0.390	0.668
2014	163	0.078	0.943
2015	174	0.009	1.113
2016	183	0.092	1.070
2017	179	0.188	1.304
2018	170	0.014	1.025
2019	156	0.023	0.456
2020	136	0.016	0.525
2021	129	0.012	0.451
Mean	**161**	**0.170**	**0.776**

Table 37. Evaluation of the risk and anticipated consequences for northern shrimp stocks due to ecosystem changes observed in recent years.

Observations	Anticipated consequence	Risk evaluation
↓ Shrimp distribution range	↑ Shrimp vulnerability to predation and fishing	↑
↑ Uncertainty surrounding the accuracy and representativeness of the main indicator	↑ Potential bias	↑
↑ Predation (redfish)	↑ Natural mortality	↑
↑ Exploitation rate	↑ Fishing mortality	↑
↑ Water temperature	↓ Productivity	↑
↓ Dissolved oxygen	↓ Productivity	↑

FIGURES

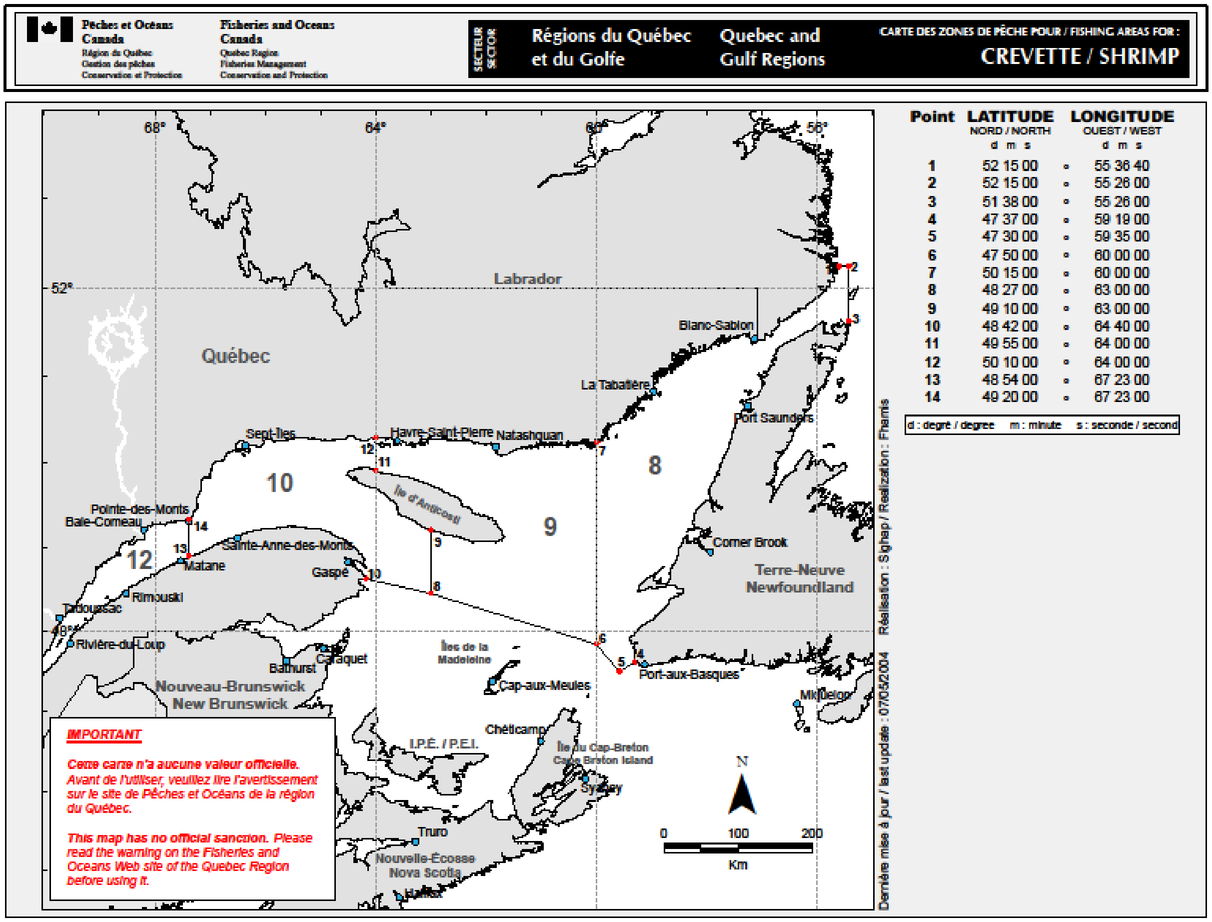


Figure 1. Shrimp fishing areas (SFA) in the northern Gulf of St. Lawrence: Estuary (SFA 12); Sept-Iles (SFA 10); Anticosti (SFA 9); Esquiman (SFA 8).

	PRINTEMPS / SPRING		ÉTÉ / SUMMER			AUTOMNE / FALL			HIVER / WINTER			
	A	M	J	J	A	S	O	N	D	J	F	M
Age												
0	ÉCLOSION / HATCHING		Larves / Larvae			Post-larves / Post-larvae						
1	Juvéniles / Juveniles											
2	Mâles / Males					REPRODUCTION		Mâles / Males				
3	Mâles / Males					REPRODUCTION		Mâles / Males				
4	Mâles / Males					REPRODUCTION			CHANGEMENT DE SEXE / SEX CHANGE			
5	Femelles primipares / Primiparous females					PONTE / SPAWNING		Femelles oeuvées / Berried females				
6	ÉCLOSION / HATCHING		Femelles multipares / Multiparous females			PONTE / SPAWNING		Femelles oeuvées / Berried females				
7	ÉCLOSION / HATCHING											

Figure 2. Life cycle of northern shrimp in the Gulf of St. Lawrence.

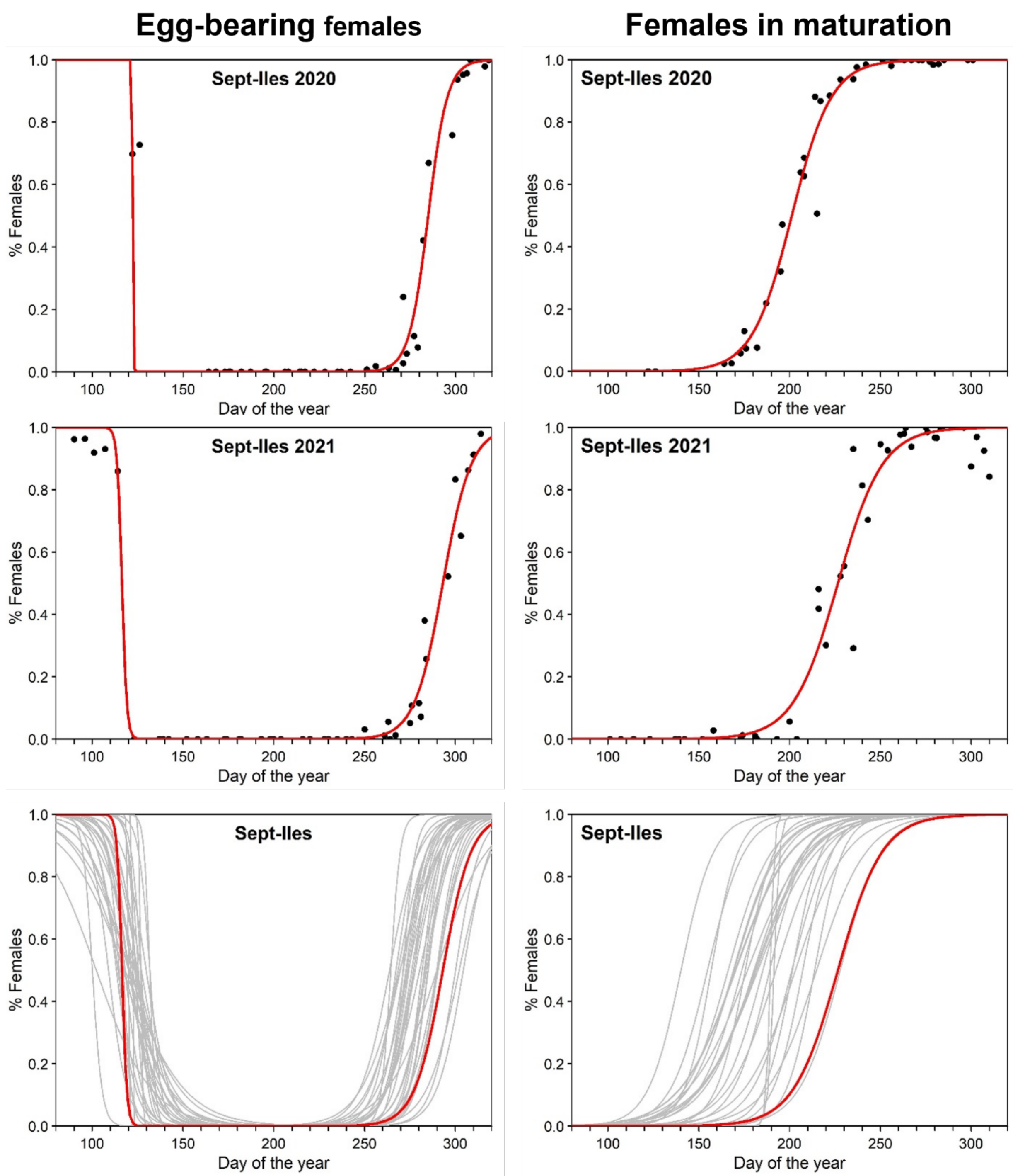


Figure 3. Proportion of egg-bearing females and females in maturation in the catch of females depending on the day of the year for the samples collected in 2020 and 2021 in the area of Sept-Iles. The bottom panel shows the years 1990-2020 in gray and 2021 in red.

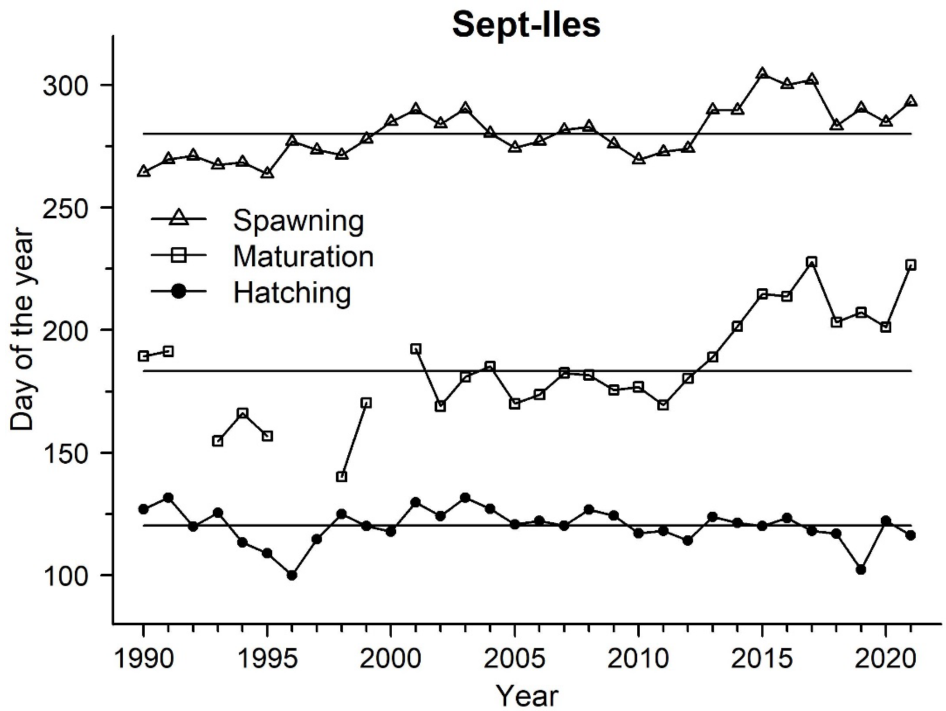


Figure 4. Day of the year where 50% of female shrimp were maturing (maturation), where 50% had spawn there eggs (spawning) and where 50% of females had released larvae (hatching) from samples collected in the area of Sept-Iles from 1990 to 2021. The solid horizontal lines represent the average for the 1990-2019 period.

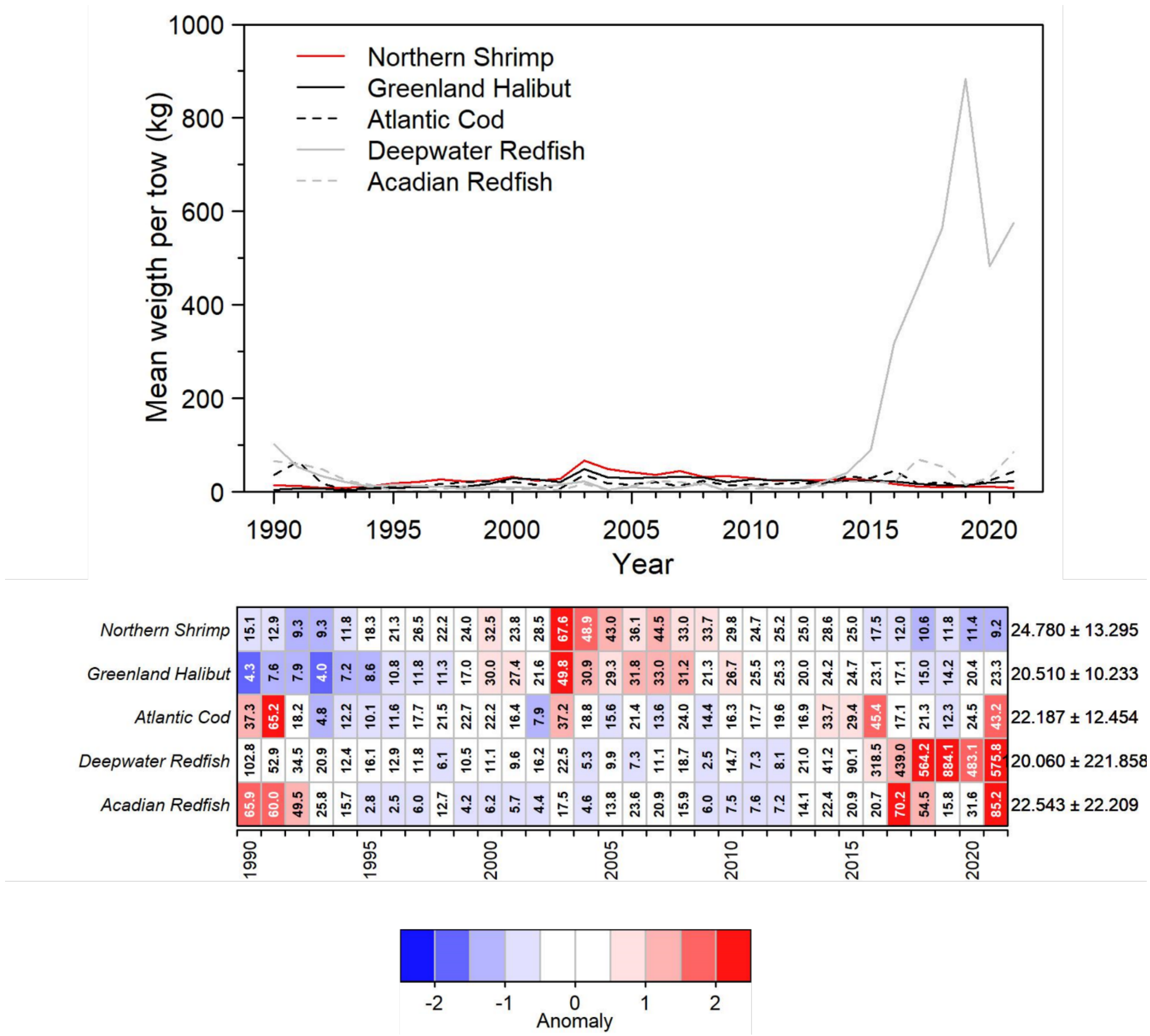


Figure 5. Biomass (kg per tow) of the main predators of northern shrimp in the northern Gulf of St. Lawrence. The color code represents the value of the anomaly, which is the difference between the weight the CPUE and the average of the time series divided by the standard deviation of that average for each species.

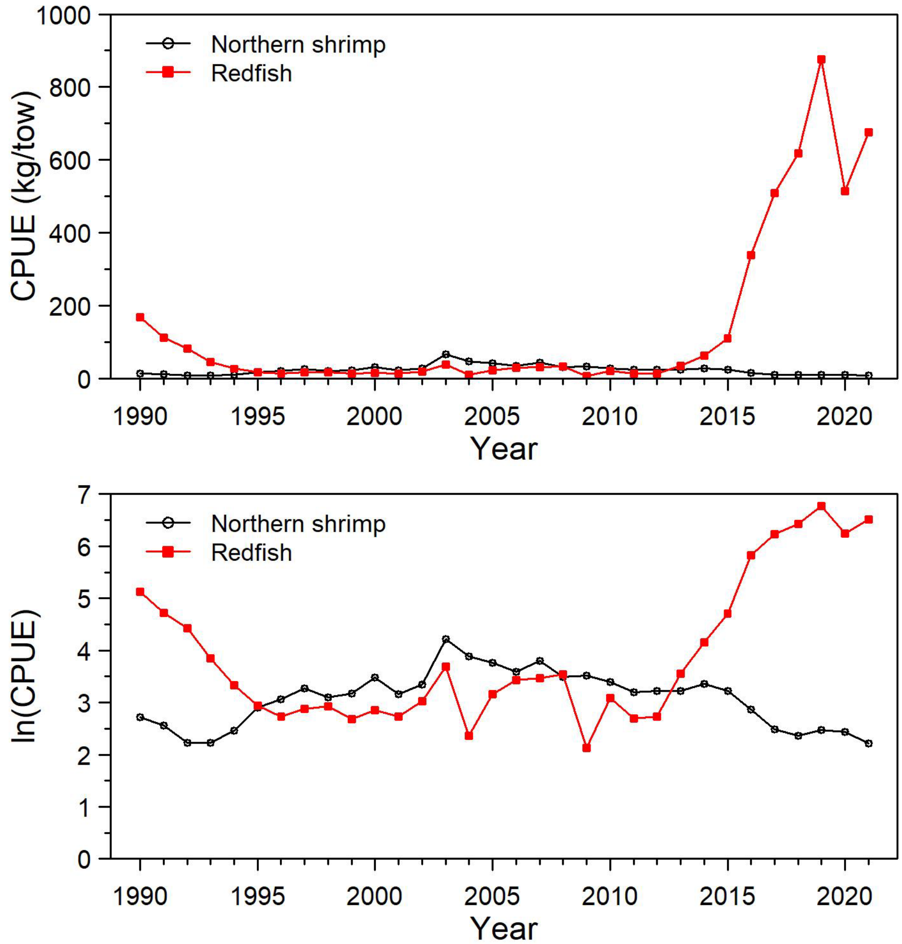


Figure 6. Mean weights per 15 minutes tow observed during the survey in August in the northern gulf for northern shrimp and redfish.

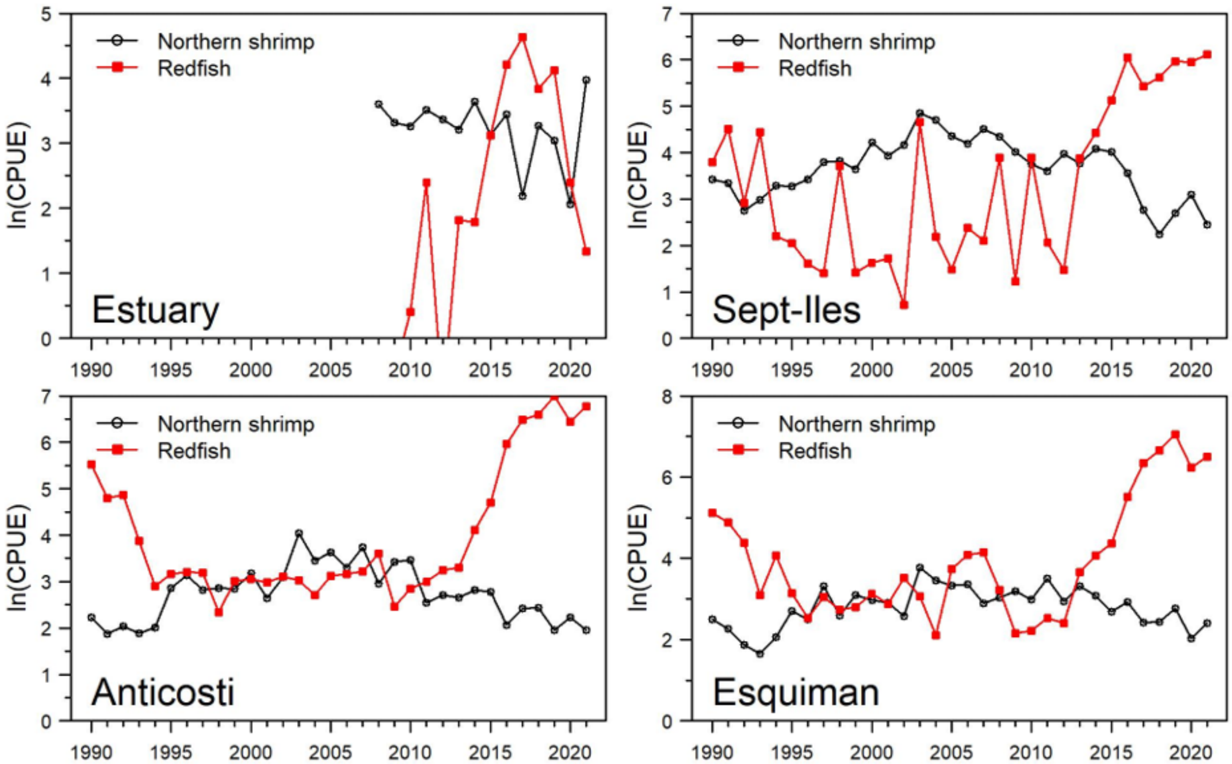
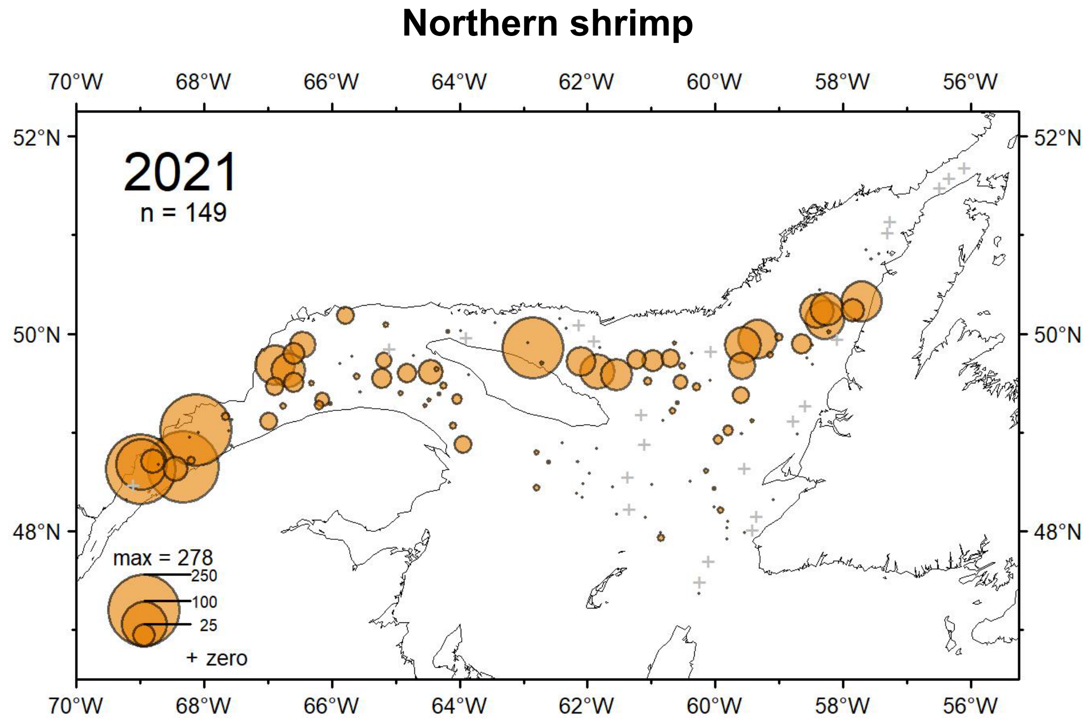


Figure 7. Mean weights per 15 minutes tow observed during the survey in August in the northern gulf for northern shrimp and redfish per fishing areas.



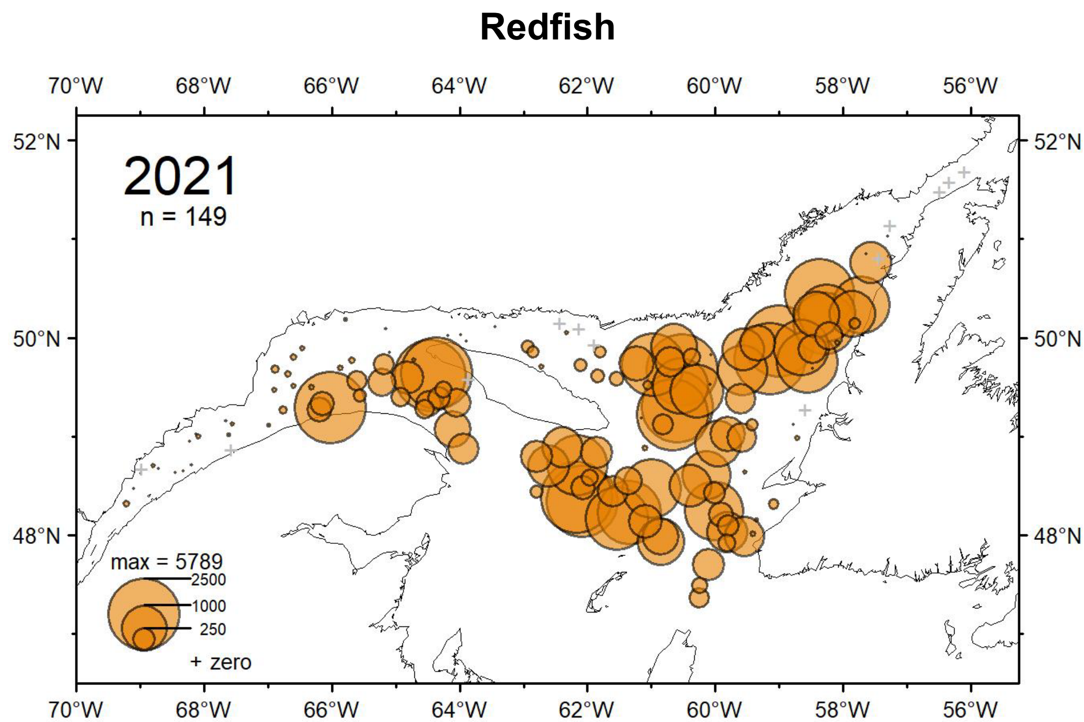


Figure 8. Northern shrimp and redfish catch rates (kg/15 minutes tow) distribution during the survey in August 2021 in the northern gulf.

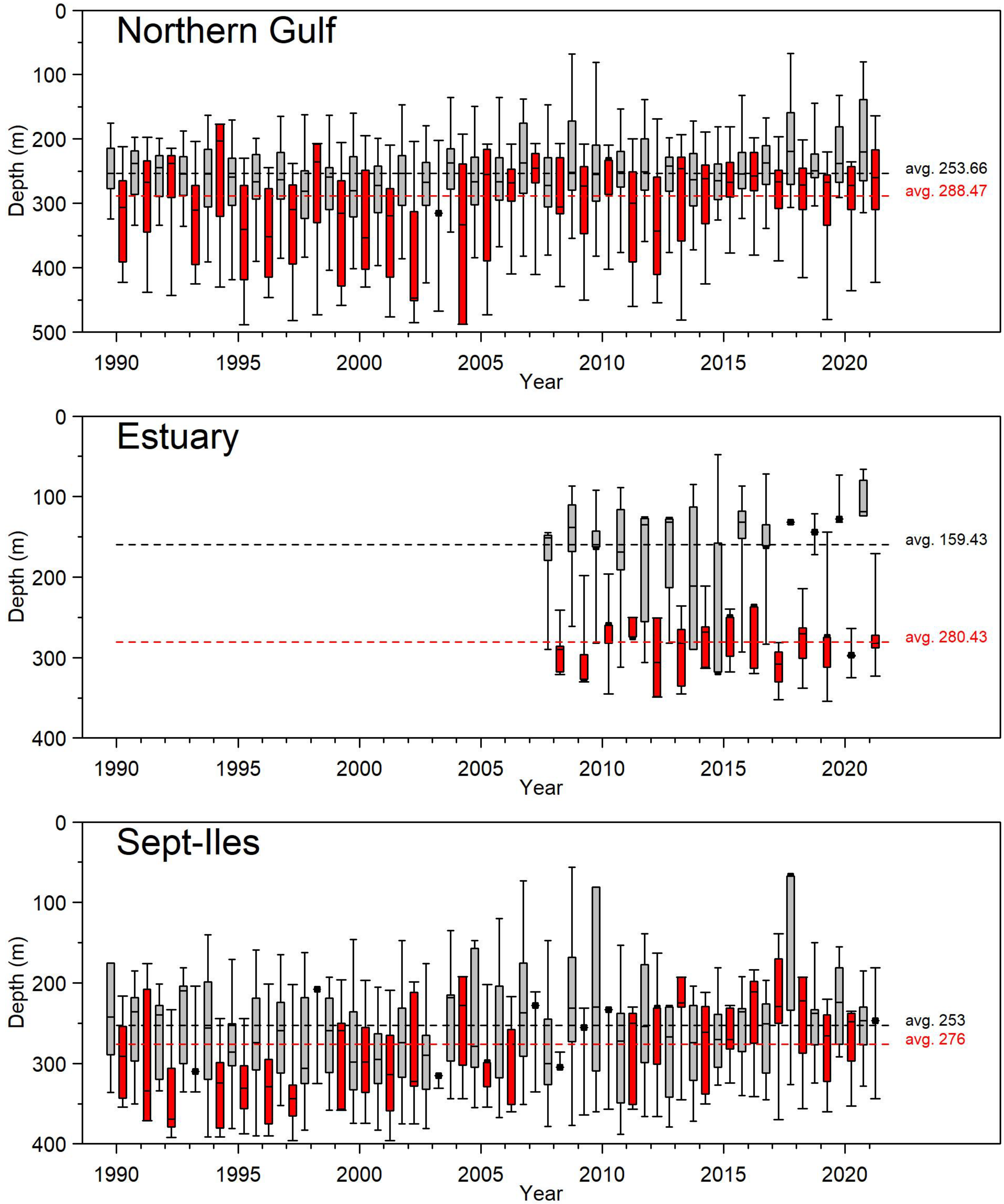


Figure 9. Biomass distributions of northern shrimp (in grey) and redfish (in red) as a function of depth observed during the August DFO survey by fishing area.

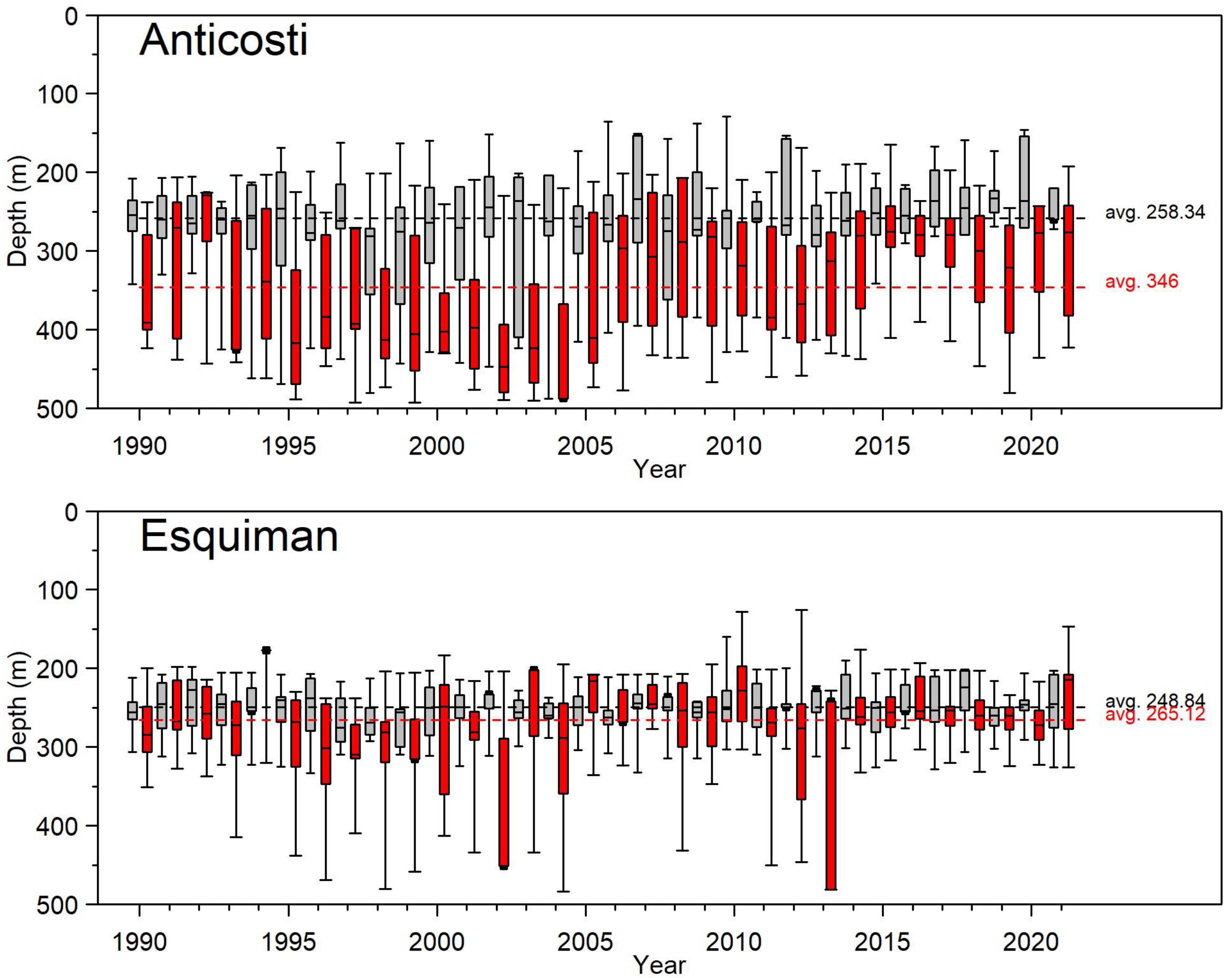


Figure 9. Continued.

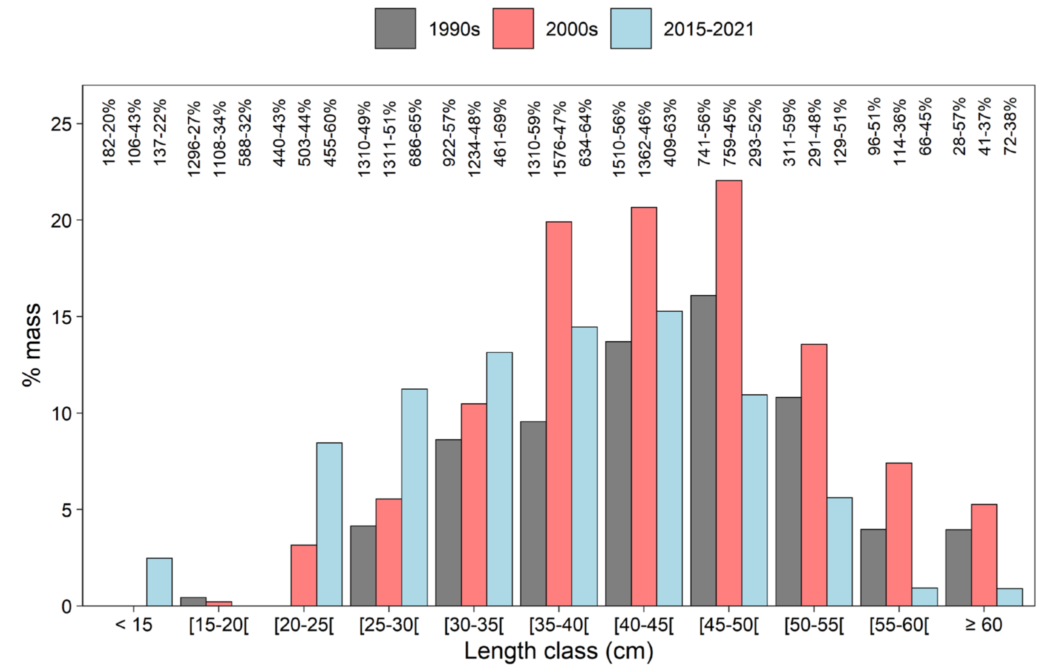


Figure 10. Mean mass contribution (% mass) of northern shrimp to the Greenland halibut diet, according to the period and length class considered. The values above the bars correspond to the number of stomachs used for the analysis with the percentage of those being empty.

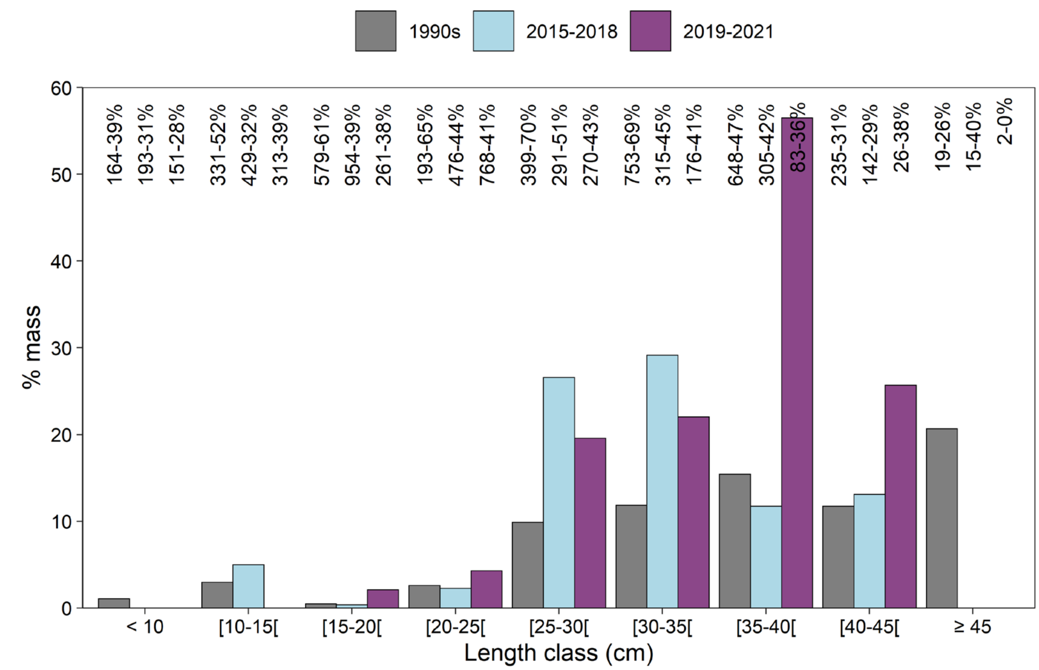


Figure 11. Mean mass contribution (% mass) of northern shrimp to the redfish diet, according to the period and length class considered. The values above the bars correspond to the number of stomachs used for the analysis with the percentage of those being empty.

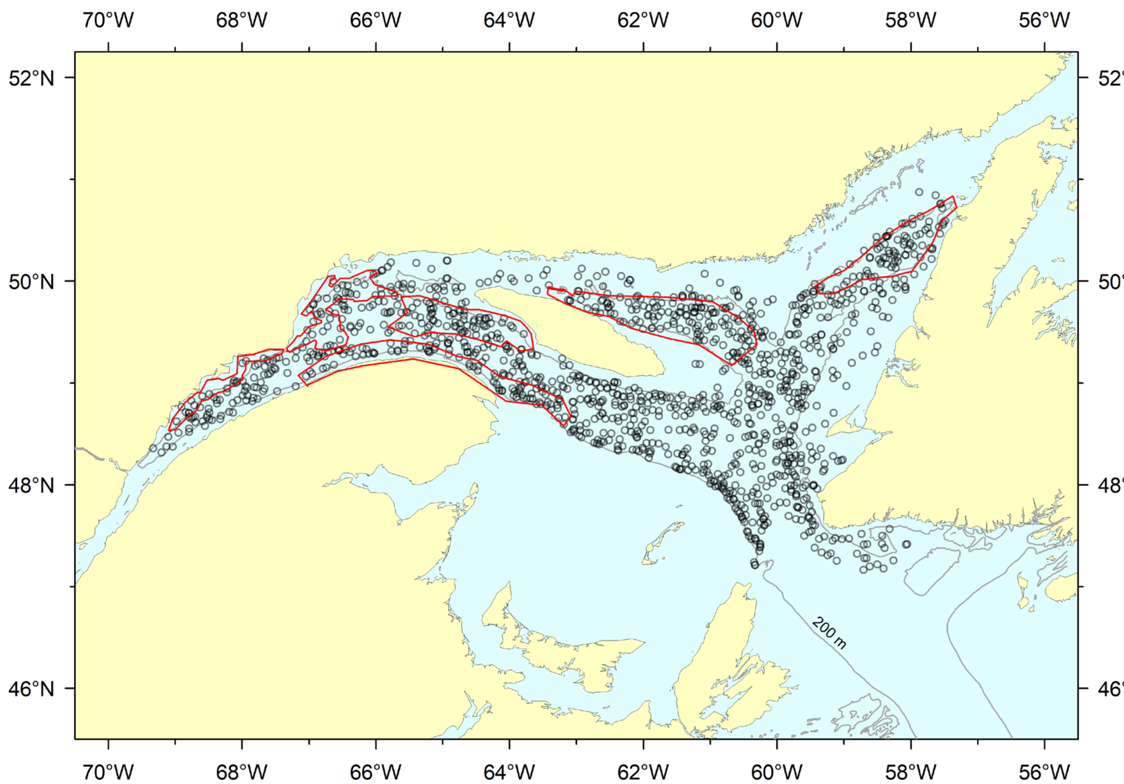


Figure 12. Fishing sets where redfish stomachs were collected for the period 1993-2021. A total of 8,491 stomachs were used for the analysis. The geographic location of each of them allowed the spatial analysis of the redfish diet. Red polygons represent the contours of the commercially fished northern shrimp fishing areas calculated from VMS data.

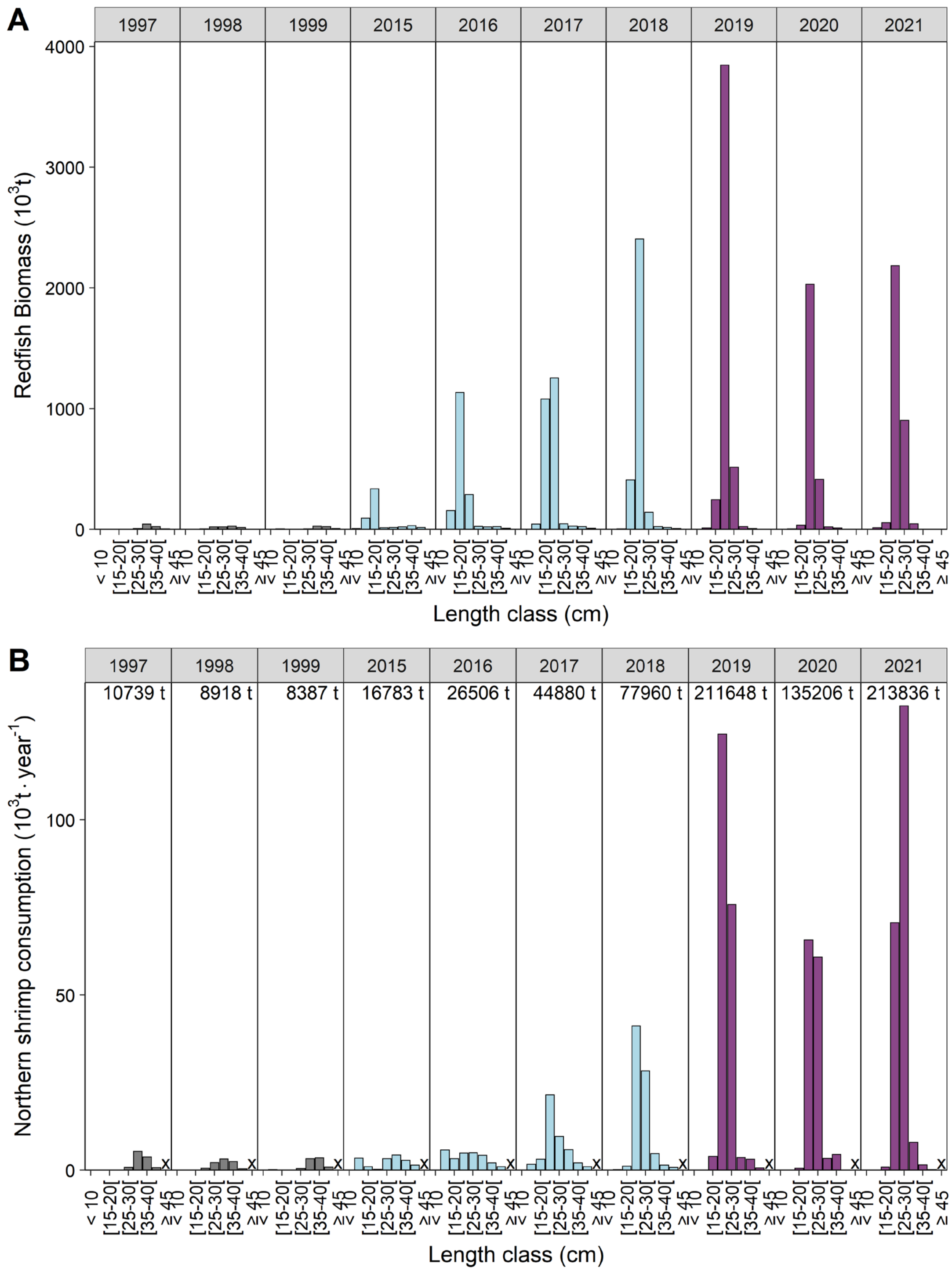


Figure 13. Estimated a) annual Redfish biomass and b) Redfish consumption of Northern Shrimp by length class for the following periods: 1997-1999, 2015-2018 and 2019-2021. The values provided in the upper part of the panels are total estimated consumption for a given year. An "x" symbol denotes < 20 stomachs collected for a given length class. Estimating annual consumption for these length classes was identified as not representative due to small sample sizes.

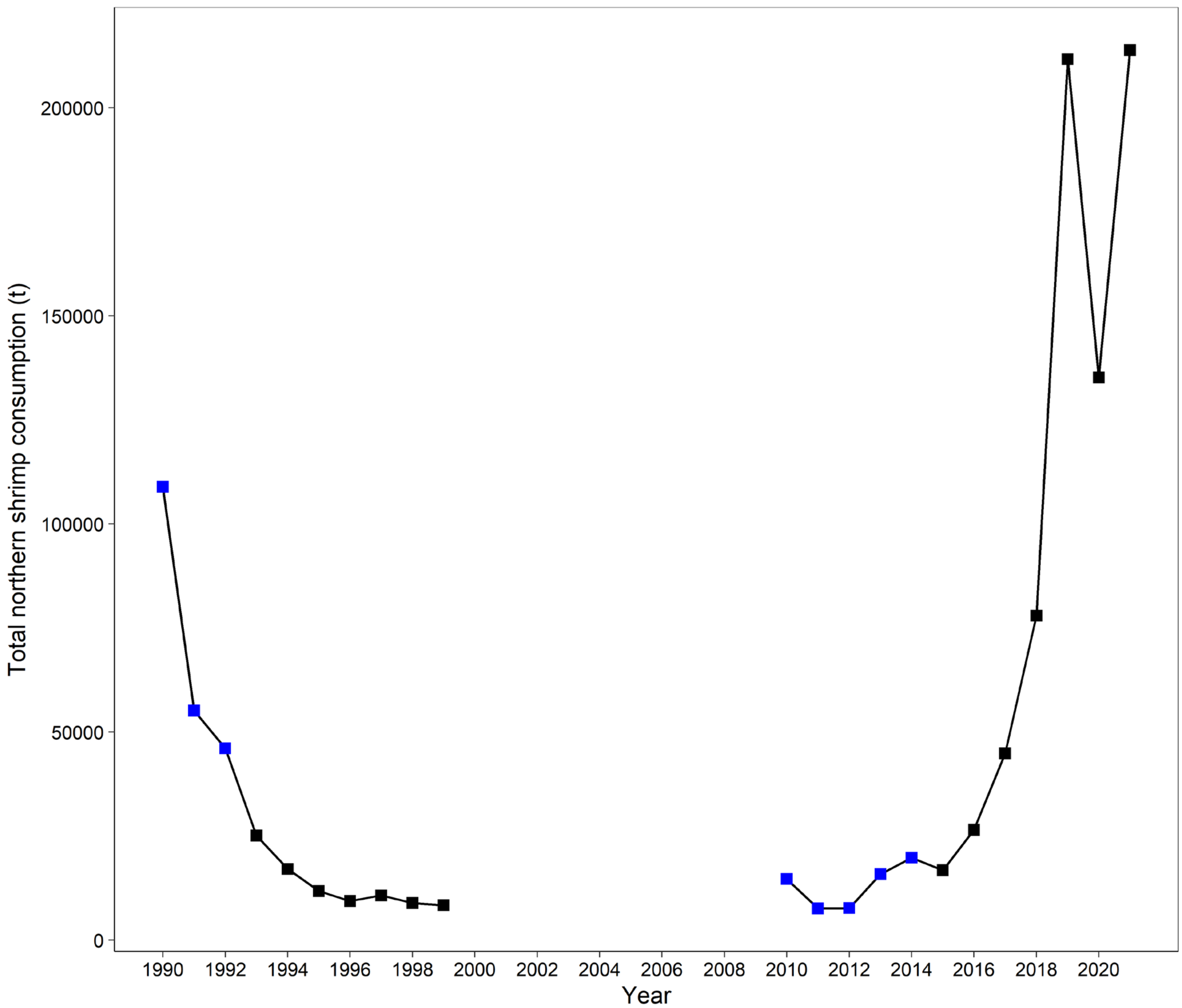


Figure 14. Total annual consumption estimated of northern shrimp by redfish. For the dots in blue, shrimp consumption was estimated from consumption data for the closest period since no stomach contents were available.

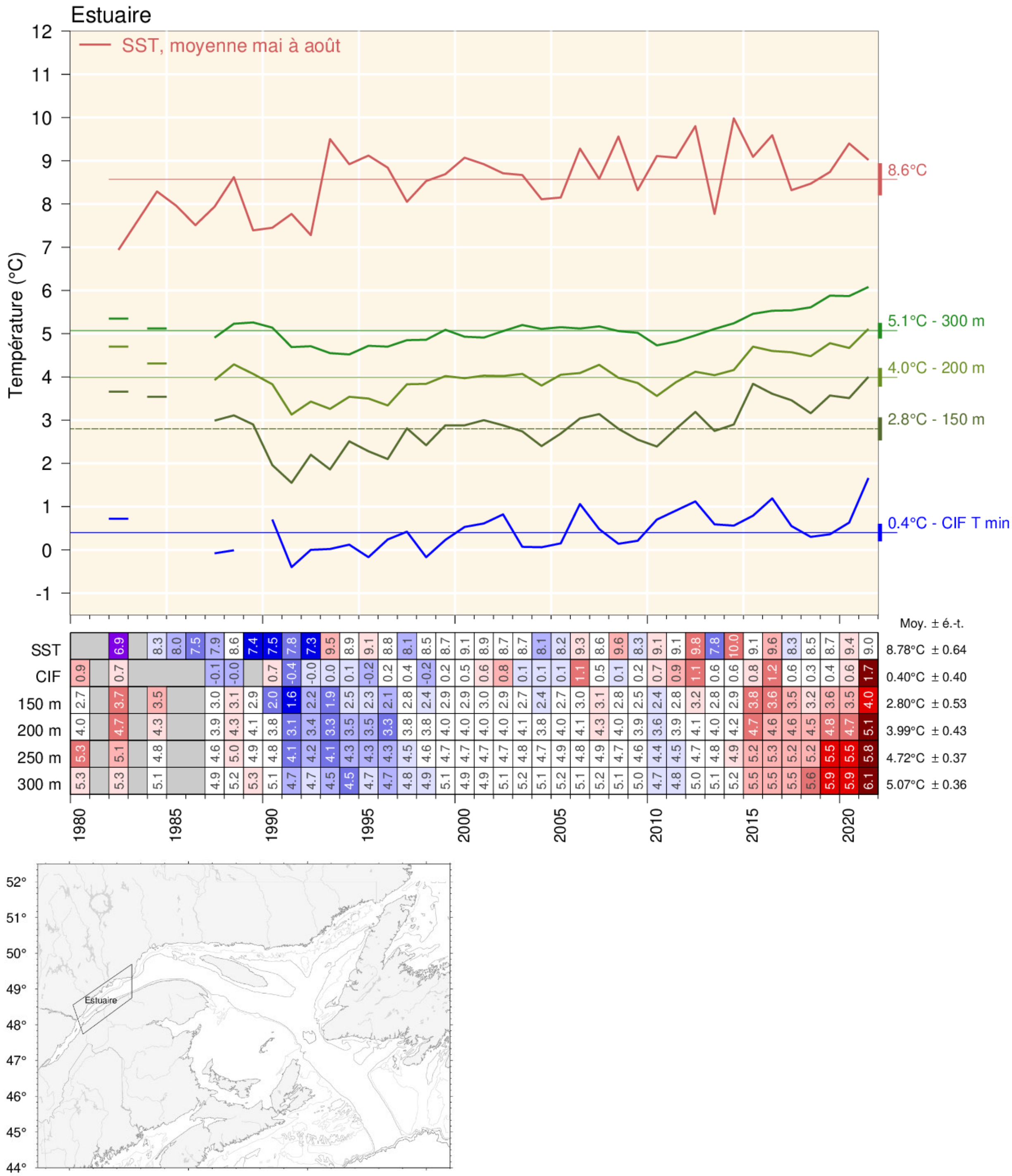
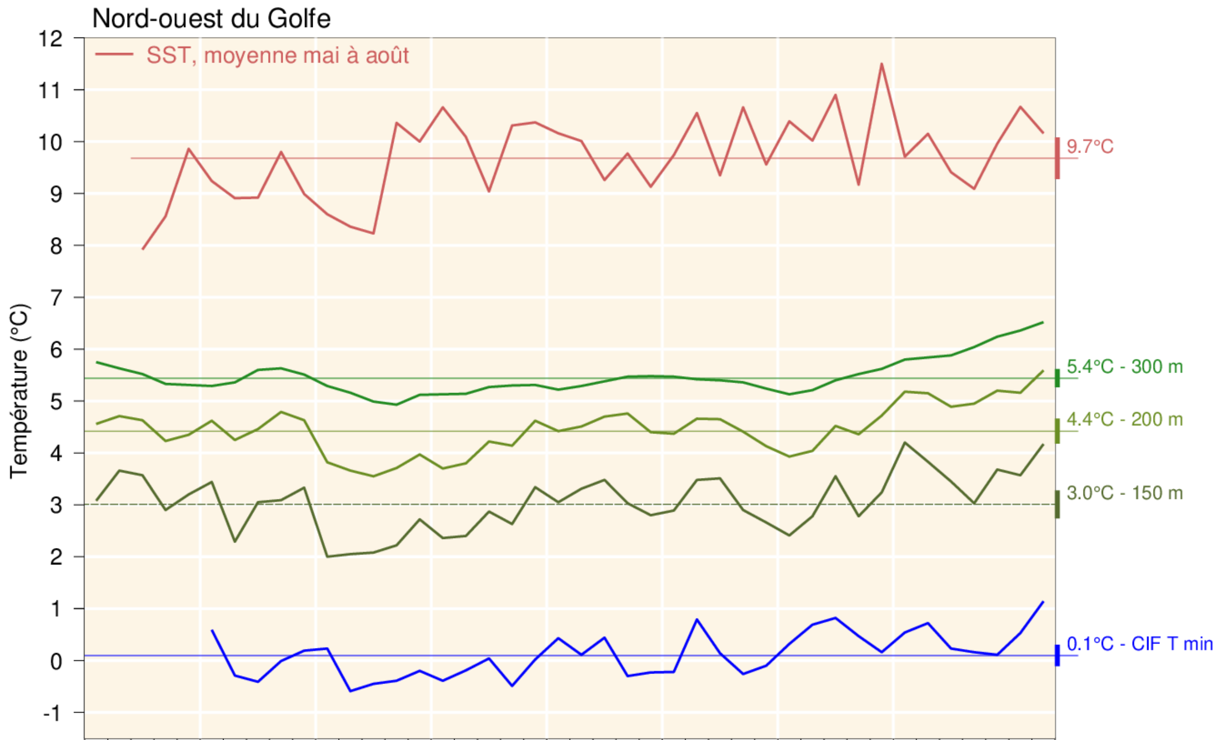


Figure 15. Water temperatures in the Gulf by bio-region. Average surface temperature for the months of May to August (1982–2021) (red lines). Average temperature per layer, at 150, 200 and 300 m (green lines). Index of the minimum temperature of the cold intermediate layer adjusted to July 15 (blue line).



	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
SST			7.9	8.6	9.9	9.2	8.9	8.9	9.8	9.0	8.6	8.4	8.2	10.4
CIF						0.6	-0.3	-0.4	-0.0	0.2	0.2	-0.6	-0.5	-0.4
150 m	3.1	3.7	3.6	2.9	3.2	3.4	2.3	3.0	3.1	3.3	2.0	2.0	2.1	2.2
200 m	4.6	4.7	4.6	4.2	4.3	4.6	4.2	4.5	4.8	4.6	3.8	3.7	3.5	3.7
250 m	5.5	5.5	5.3	5.0	5.0	5.1	5.2	5.4	5.5	5.4	4.9	4.7	4.6	4.6
300 m	5.8	5.6	5.5	5.3	5.3	5.3	5.4	5.6	5.6	5.5	5.3	5.2	5.0	4.9

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SST	10.0	10.7	10.1	9.0	10.3	10.4	10.2	10.0	9.3	9.8	9.1	9.7	10.6	9.3
CIF	-0.2	-0.4	-0.2	0.0	-0.5	0.0	0.4	0.1	0.4	-0.3	-0.2	-0.2	0.8	0.1
150 m	2.7	2.4	2.4	2.9	2.6	3.3	3.0	3.3	3.5	3.0	2.8	2.9	3.5	3.5
200 m	4.0	3.7	3.8	4.2	4.1	4.6	4.4	4.5	4.7	4.8	4.4	4.4	4.7	4.7
250 m	4.8	4.7	4.7	5.0	5.0	5.1	5.0	5.1	5.2	5.3	5.2	5.2	5.2	5.3
300 m	5.1	5.1	5.1	5.3	5.3	5.3	5.2	5.3	5.4	5.5	5.5	5.5	5.4	5.4

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Moy. ± é.-t.
SST	10.7	9.6	10.4	10.0	10.9	9.2	11.5	9.7	10.2	9.4	9.1	10.0	10.7	10.2	9.89°C ± 0.73
CIF	-0.3	-0.1	0.3	0.7	0.8	0.5	0.2	0.5	0.7	0.2	0.2	0.1	0.5	1.1	0.10°C ± 0.41
150 m	2.9	2.7	2.4	2.8	3.5	2.8	3.2	4.2	3.8	3.5	3.0	3.7	3.6	4.2	3.01°C ± 0.54
200 m	4.4	4.1	3.9	4.0	4.5	4.4	4.7	5.2	5.2	4.9	5.0	5.2	5.2	5.6	4.42°C ± 0.48
250 m	5.2	5.0	4.8	4.9	5.2	5.3	5.4	5.6	5.6	5.6	5.7	5.9	5.9	6.3	5.16°C ± 0.36
300 m	5.4	5.2	5.1	5.2	5.4	5.5	5.6	5.8	5.8	5.9	6.0	6.2	6.4	6.5	5.44°C ± 0.35

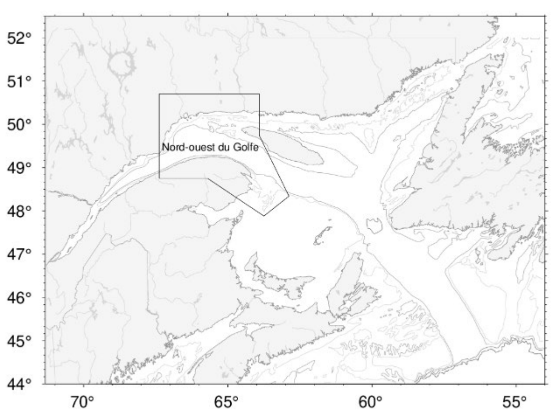
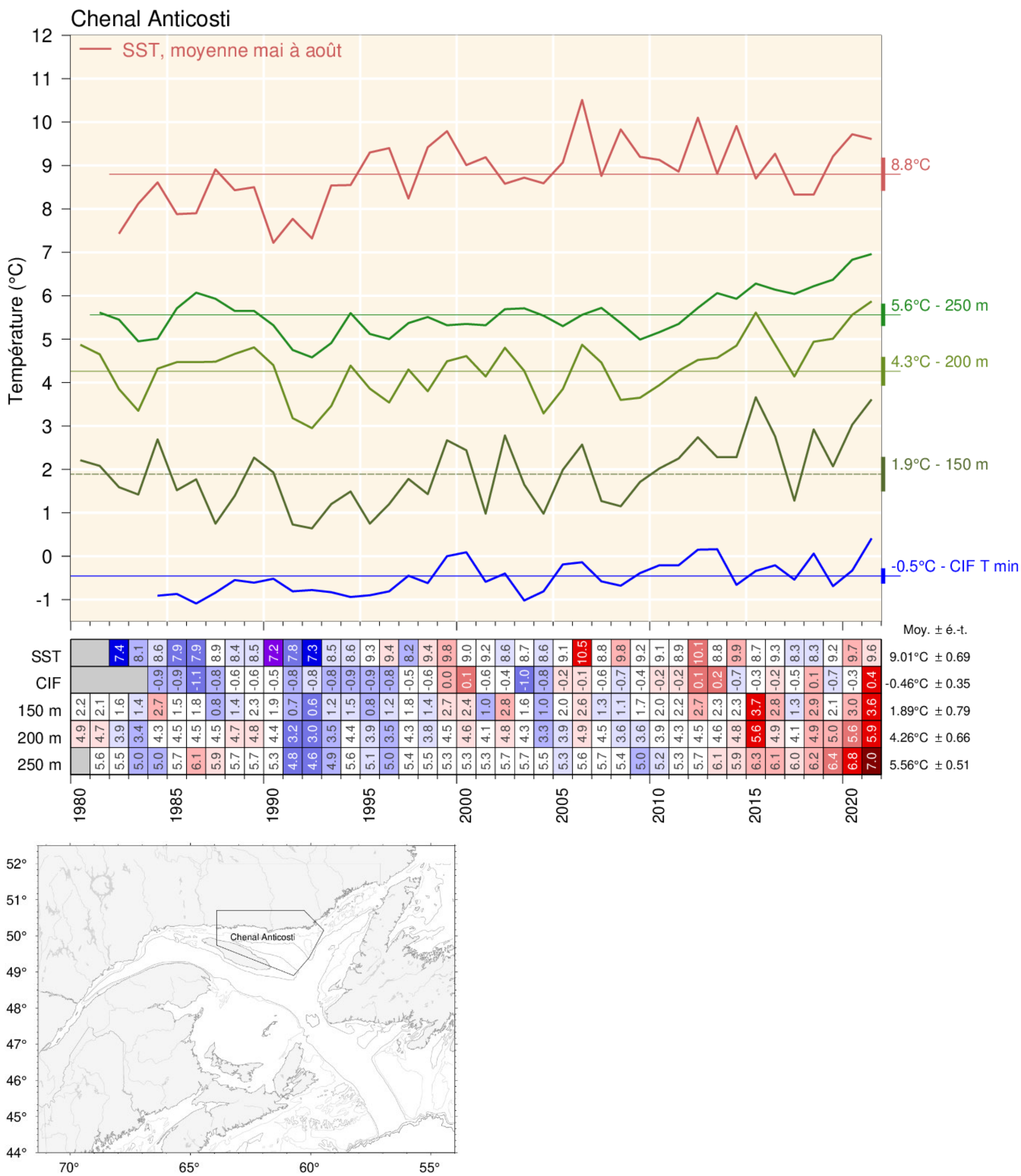


Figure 15. Continued.



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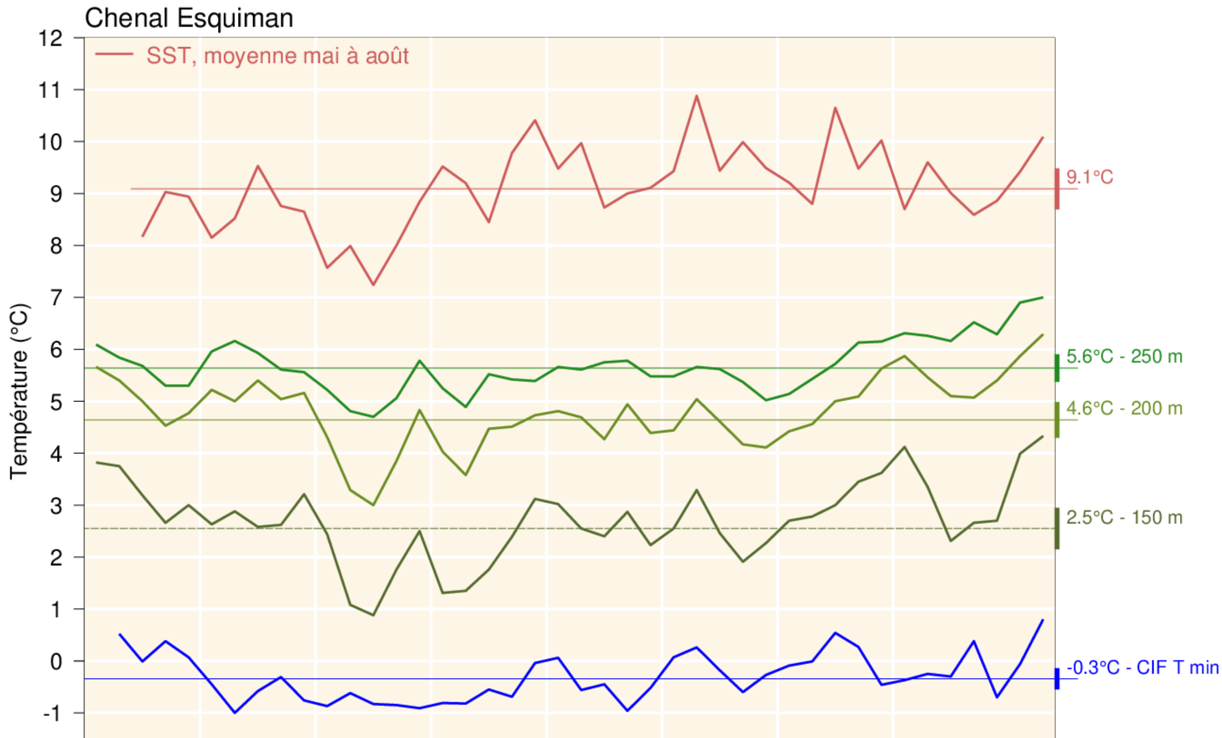
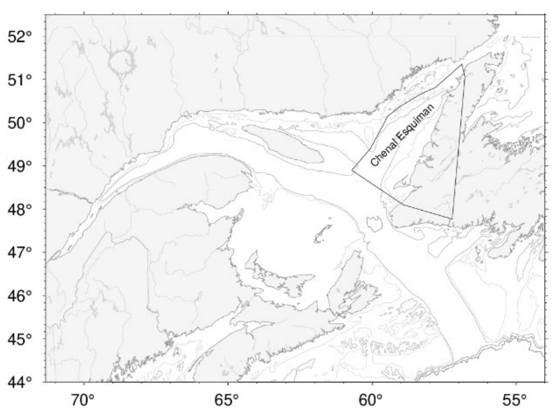


	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
SST			8.2	9.0	8.9	8.2	8.5	9.5	8.8	8.7	7.6
CIF		0.5	-0.0	0.4	0.1	-0.5	-1.0	-0.6	-0.3	-0.8	-0.9
150 m	3.8	3.8	3.2	2.7	3.0	2.6	2.9	2.6	2.6	3.2	2.4
200 m	5.7	5.4	5.0	4.5	4.8	5.2	5.0	5.4	5.0	5.2	4.3
250 m	6.1	5.8	5.7	5.3	5.3	6.0	6.2	5.9	5.6	5.6	5.2

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
SST	8.0	7.2	8.0	8.8	9.5	9.2	8.4	9.8	10.4	9.5	10.0
CIF	-0.6	-0.8	-0.8	-0.9	-0.8	-0.8	-0.6	-0.7	-0.0	0.1	-0.6
150 m	1.1	0.9	1.8	2.5	1.3	1.4	1.8	2.4	3.1	3.0	2.5
200 m	3.3	3.0	3.9	4.8	4.0	3.6	4.5	4.5	4.7	4.8	4.7
250 m	4.8	4.7	5.1	5.8	5.2	4.9	5.5	5.4	5.4	5.7	5.6

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
SST	8.7	9.0	9.1	9.4	10.9	9.4	10.0	9.5	9.2	8.8
CIF	-0.5	-1.0	-0.5	0.1	0.3	-0.2	-0.6	-0.3	-0.1	-0.0
150 m	2.4	2.9	2.2	2.5	3.3	2.5	1.9	2.3	2.7	2.8
200 m	4.3	4.9	4.4	4.4	5.0	4.6	4.2	4.1	4.4	4.6
250 m	5.8	5.8	5.5	5.5	5.7	5.6	5.4	5.0	5.1	5.4

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Moy. ± é.-t.
SST	10.7	9.5	10.0	8.7	9.6	9.0	8.6	8.9	9.4	10.1	9.24°C ± 0.78
CIF	0.5	0.3	-0.5	-0.4	-0.2	-0.3	0.4	-0.7	-0.1	0.8	-0.34°C ± 0.41
150 m	3.0	3.5	3.6	4.1	3.4	2.3	2.7	2.7	4.0	4.3	2.55°C ± 0.80
200 m	5.0	5.1	5.6	5.9	5.5	5.1	5.1	5.4	5.9	6.3	4.64°C ± 0.69
250 m	5.7	6.1	6.2	6.3	6.3	6.2	6.5	6.3	6.9	7.0	5.64°C ± 0.53



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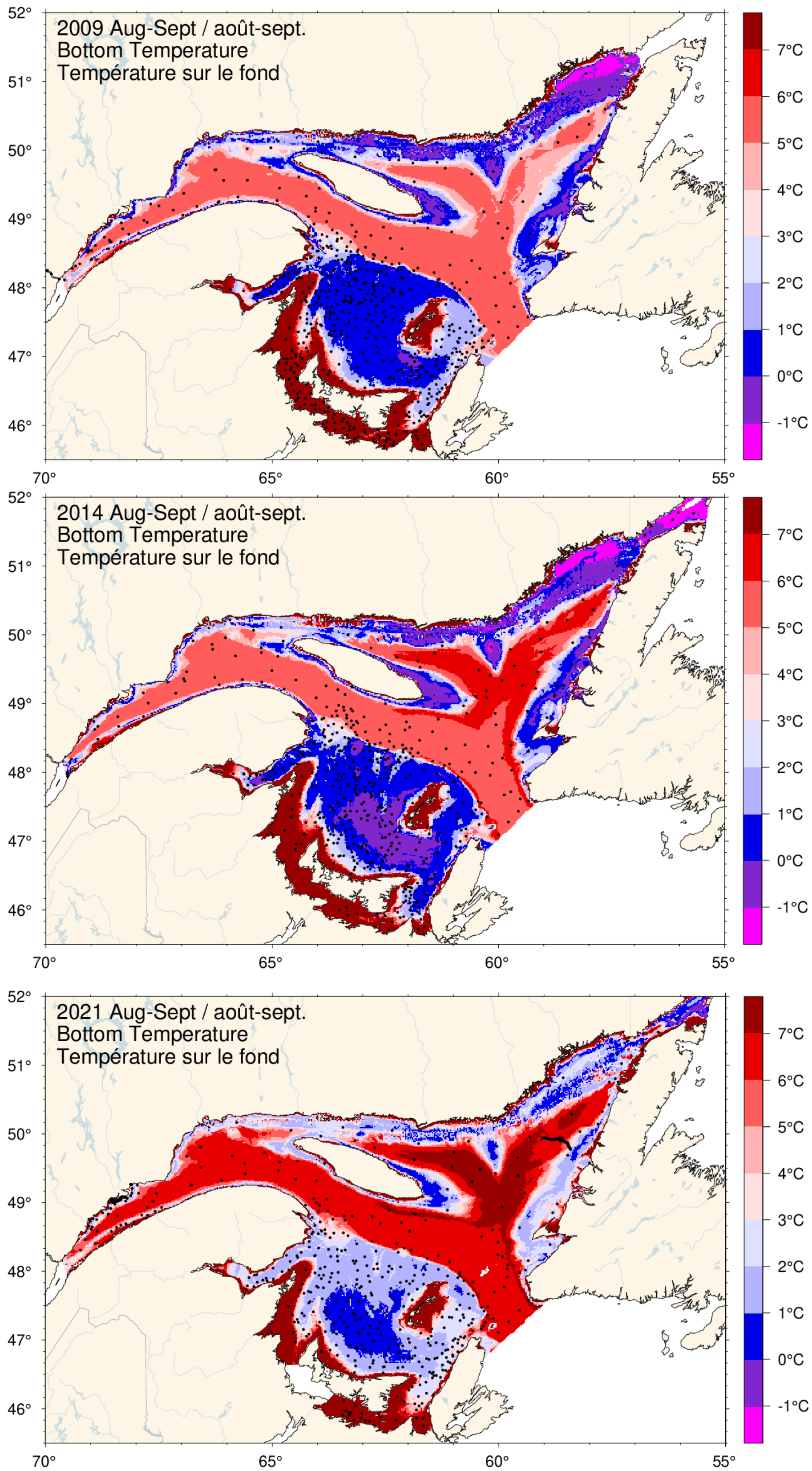


Figure 16. Bottom temperature observed in August-September in 2009, 2014 and 2021.

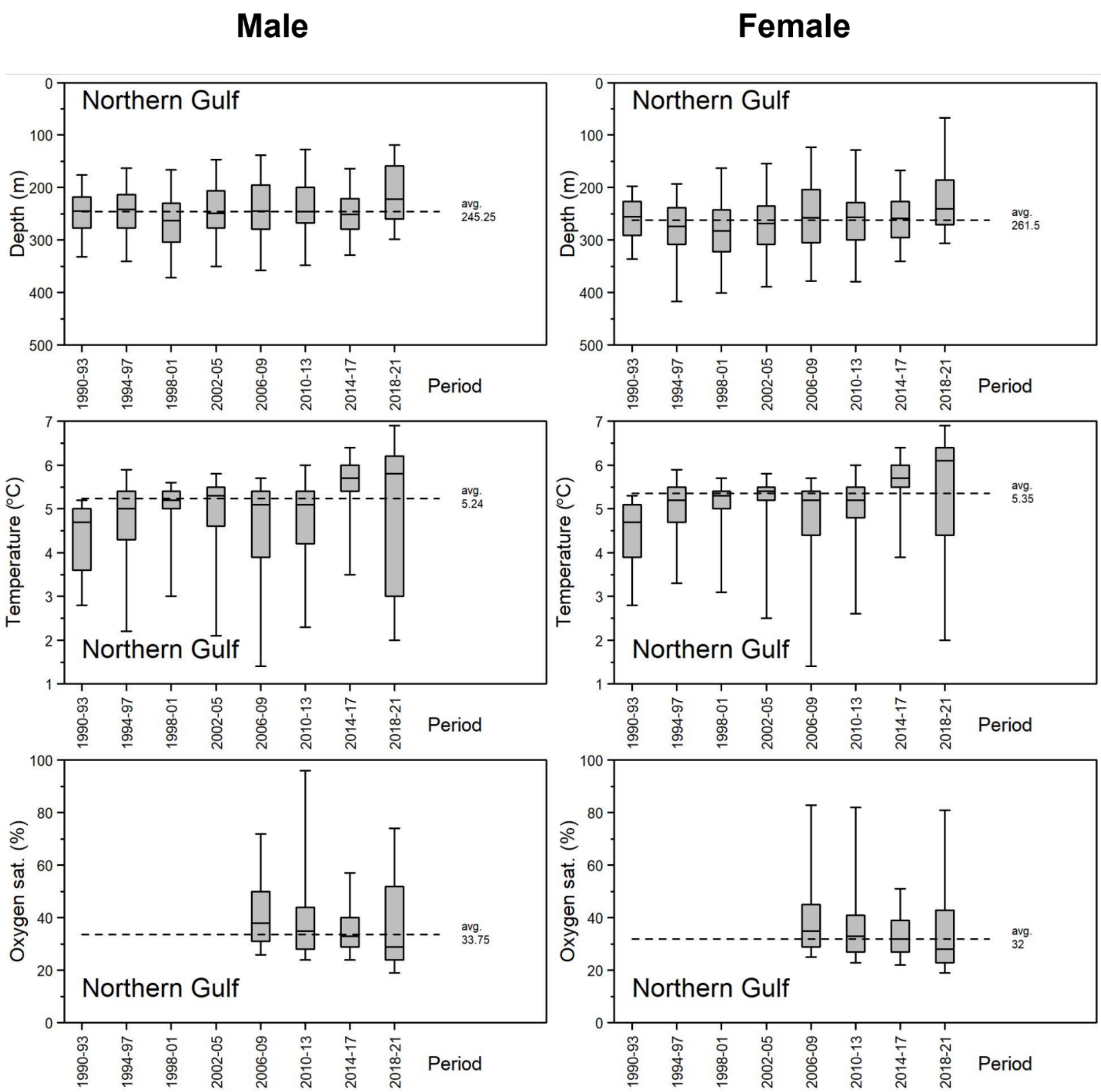


Figure 17. Biomass distributions of northern shrimp male and female as function of depth, bottom water temperature and saturation of dissolved oxygen per 4 years period observed in the August DFO survey.

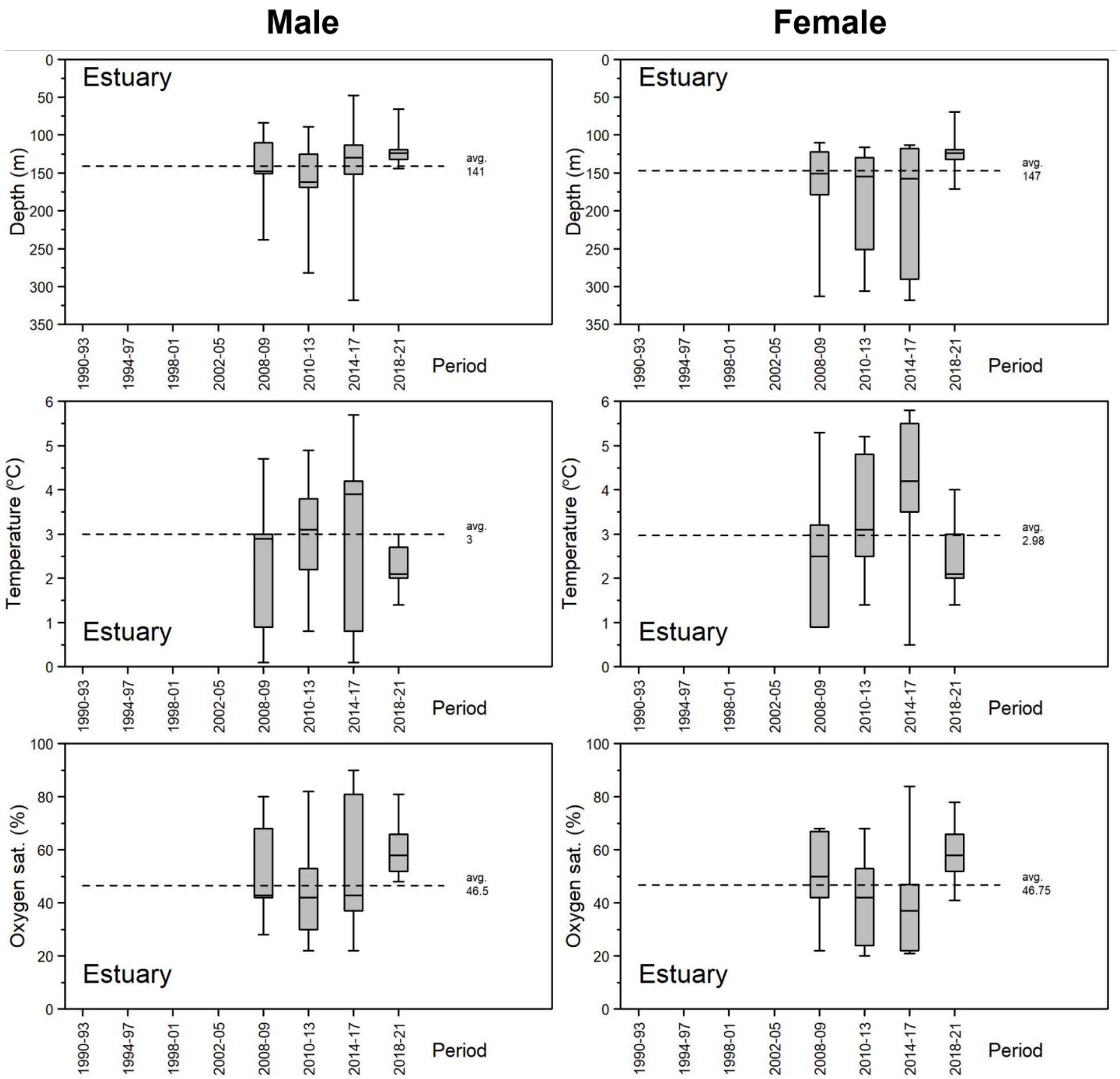
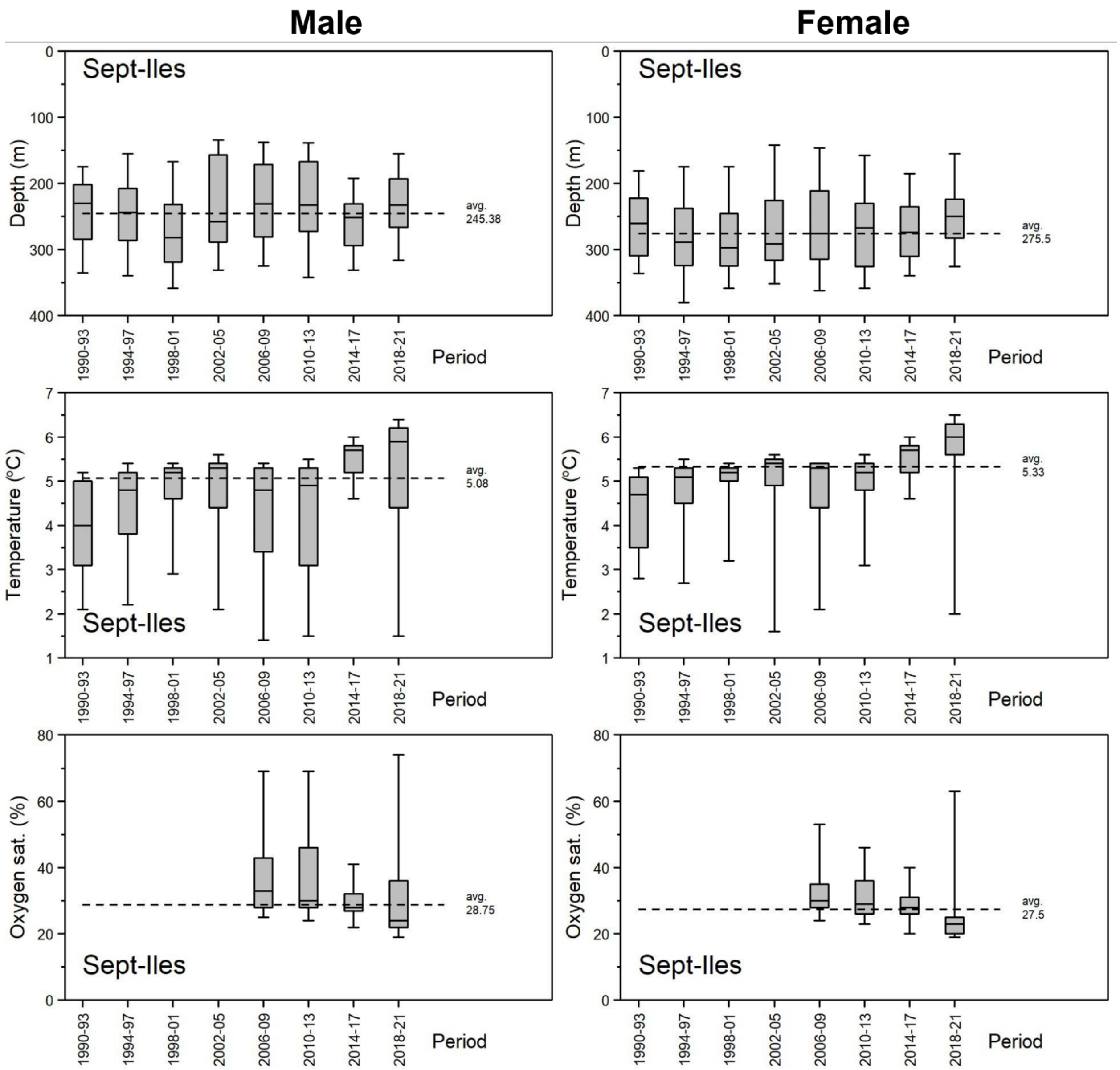


Figure 18. Biomass distributions of northern shrimp male and female as function of depth, bottom water temperature and saturation of dissolved oxygen per 4 years period observed in the August DFO survey in the four fishing areas.



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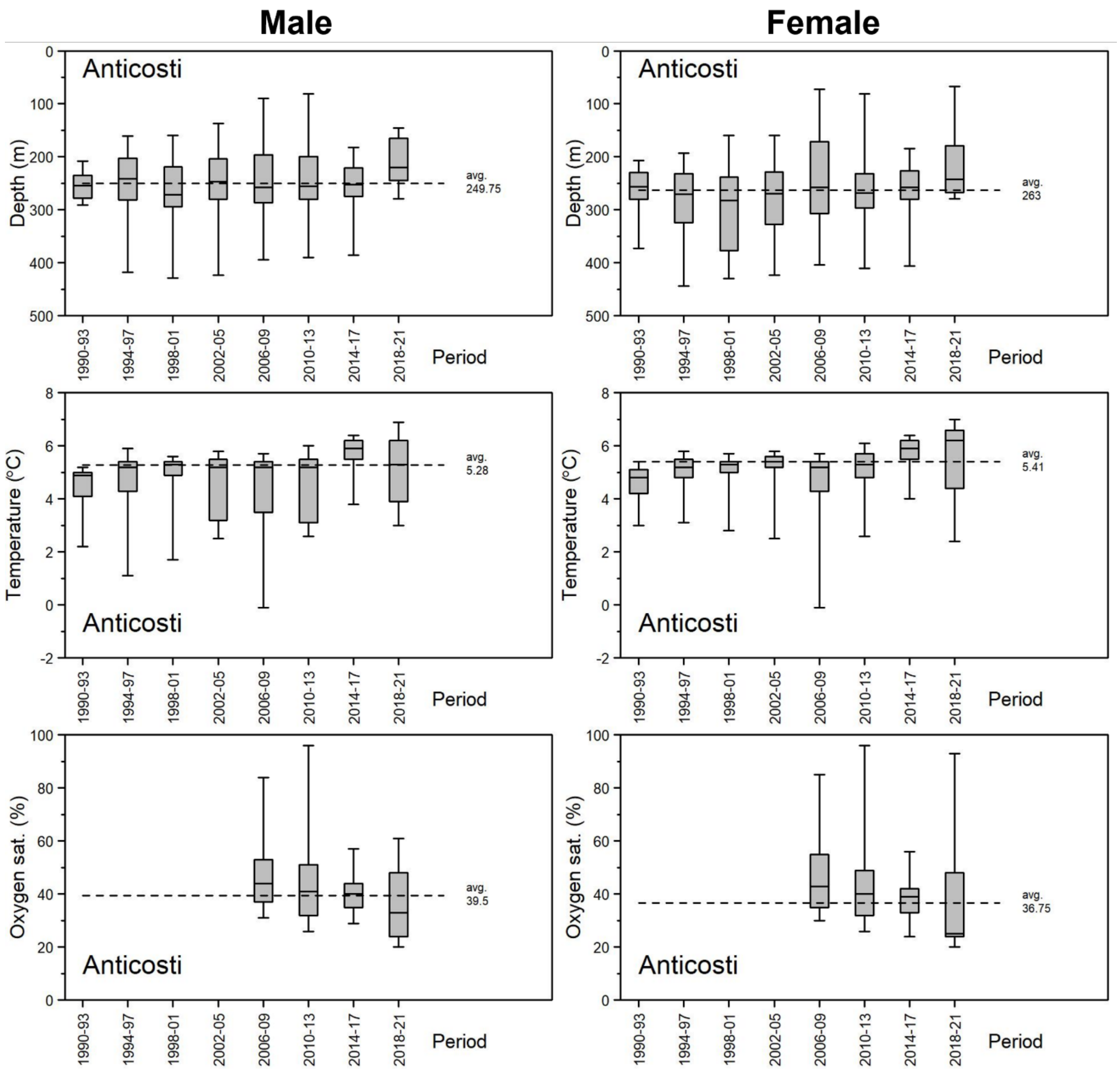

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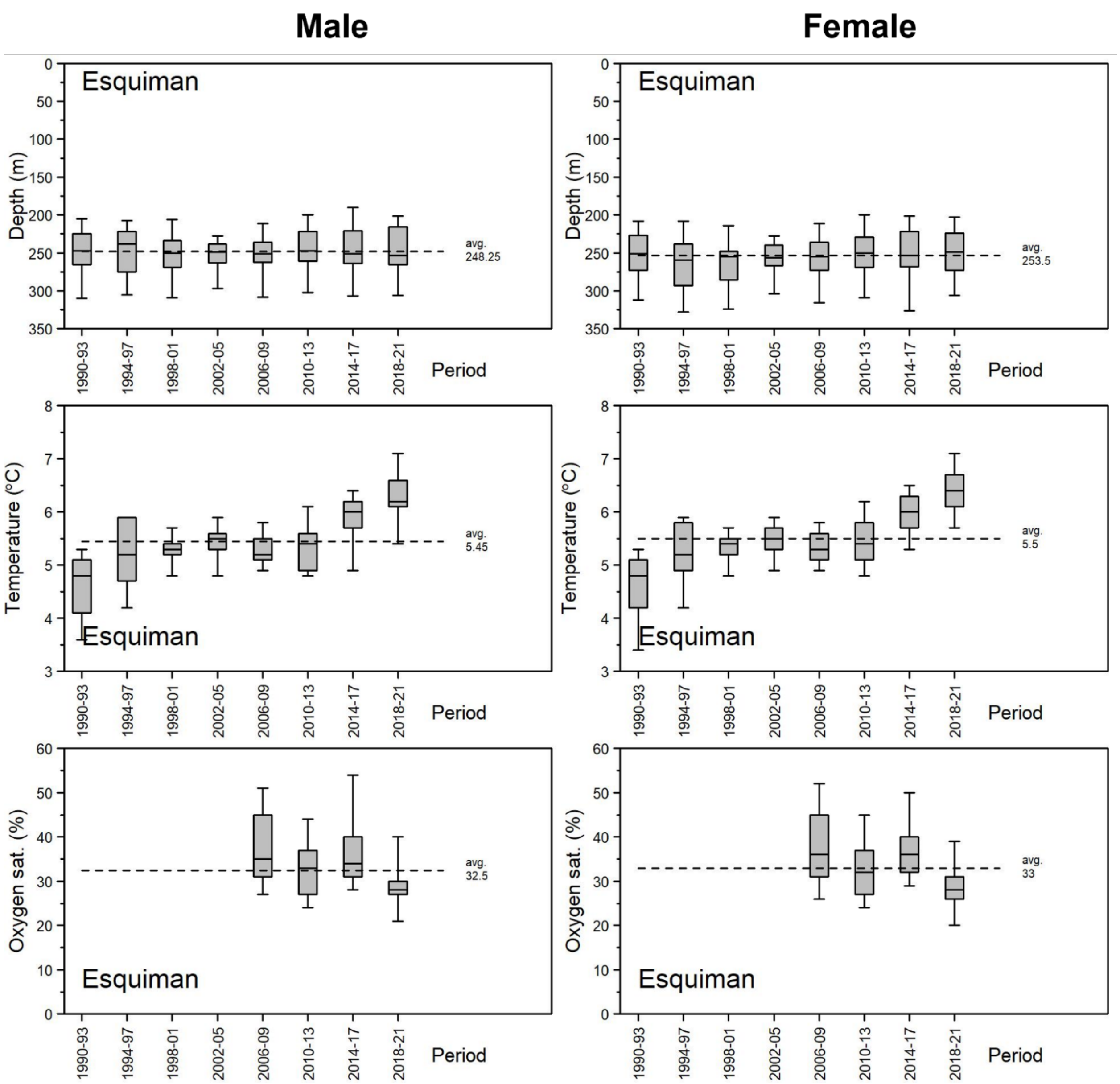


Figure 18. Continued.

Sept-Iles

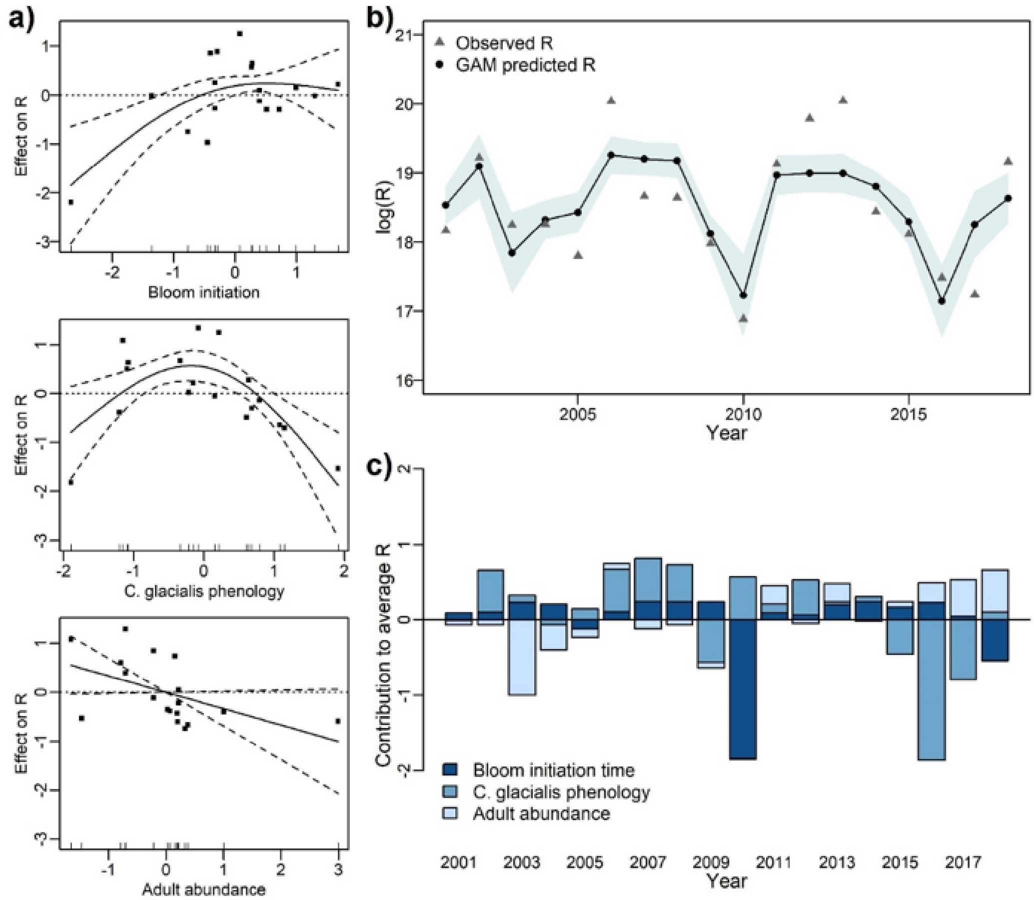
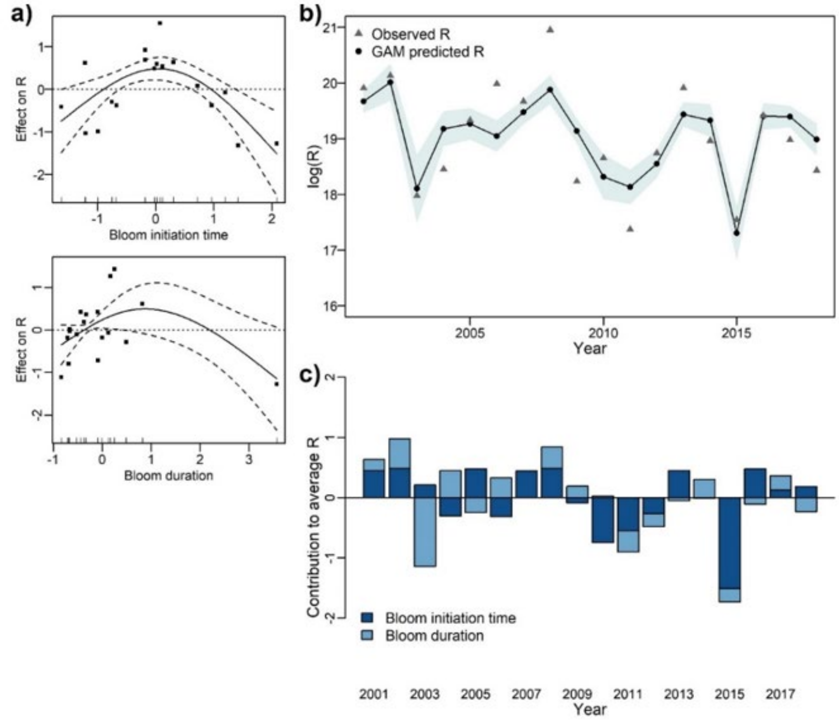


Figure 19. Local environment effects on northern shrimp recruitment (R) for the stocks Sept-Iles, Anticosti and Esquiman. Panels a), b) and c) show the results of the optimal GAMs with significant effect of explicative variables on R. Panel d) denotes observed R vs GAM-predicted R (95% confidence interval in blue). Panel e) displays the contribution of the significant variables of the optimal GAM to predicted R, with the 0 line corresponding to mean recruitment over all the time-series..

Anticosti



Esquiman

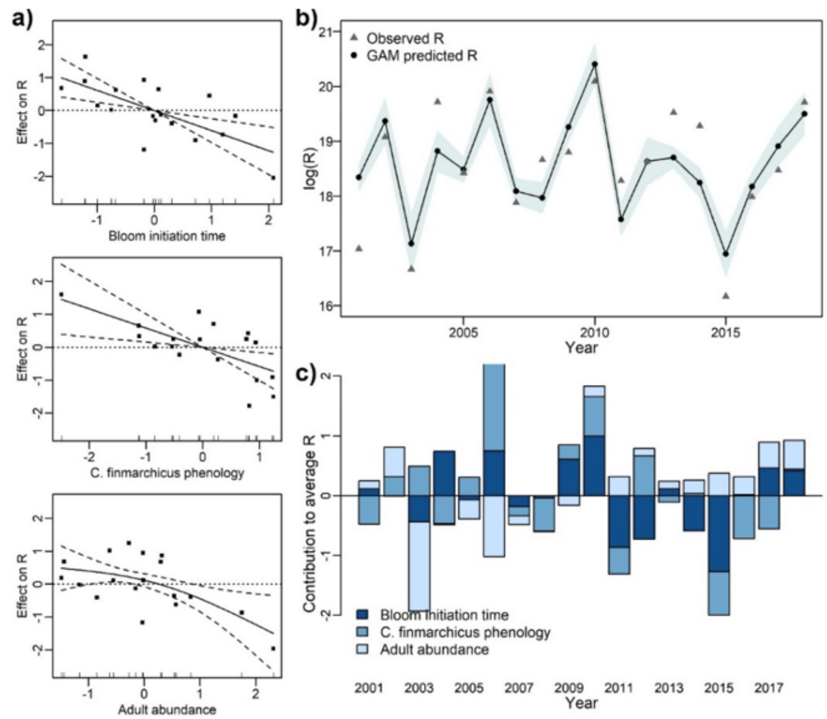


Figure 19. Continued.

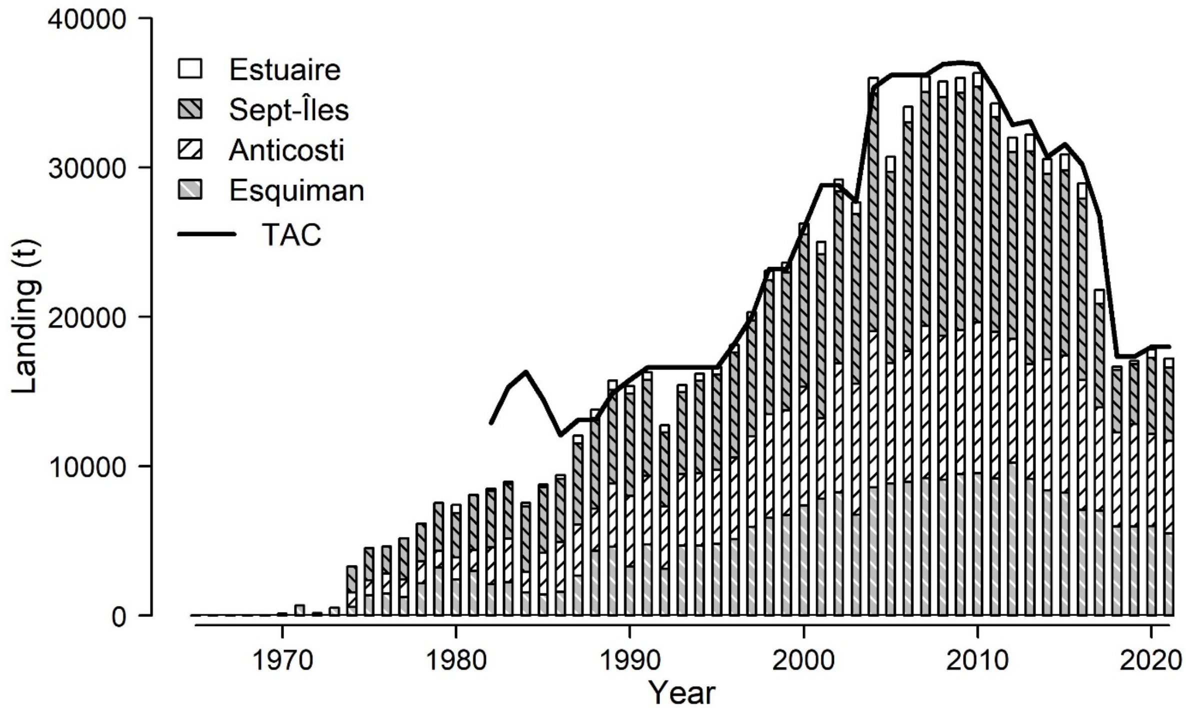


Figure 20. Landing and total allowable catches (TAC) in the Estuary and Gulf of St. Lawrence.

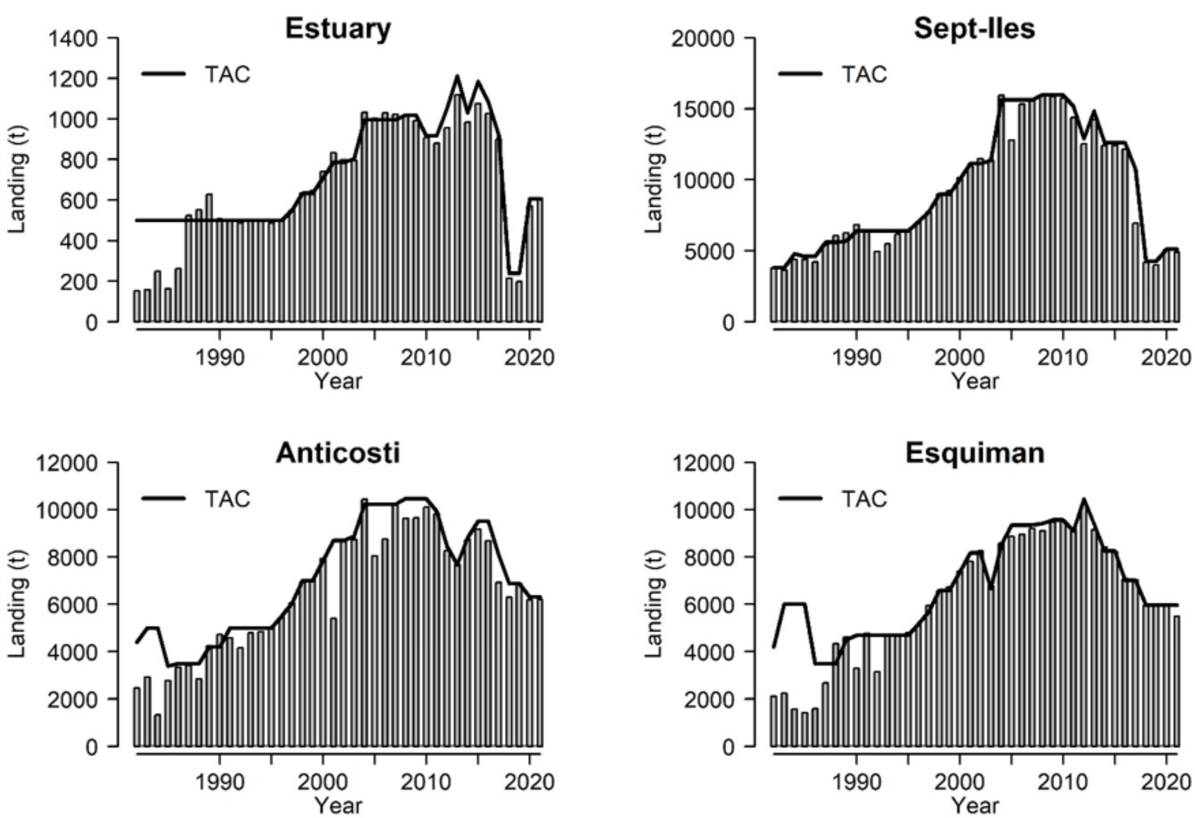


Figure 21. Landing and total allowable catches (TAC) by shrimp fishing area.

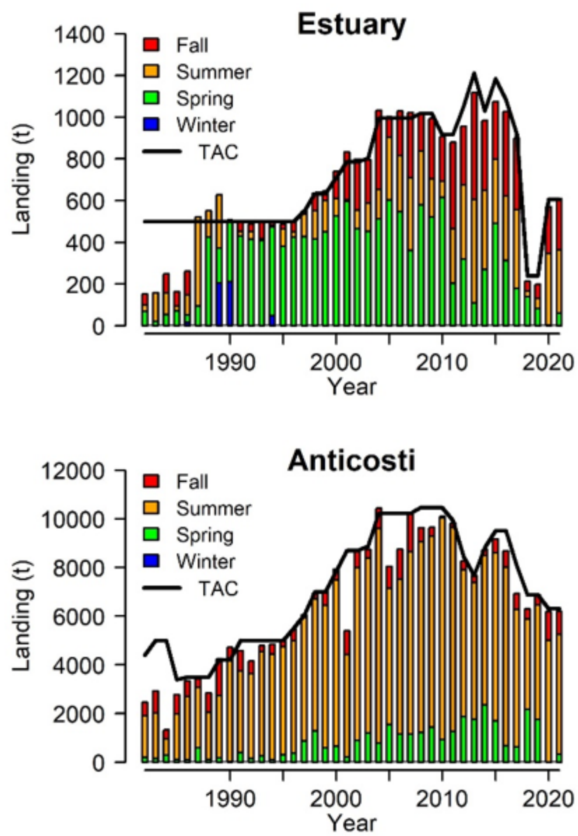


Figure 22. Seasonal landing and total allowable catches (TAC) by shrimp fishing area.

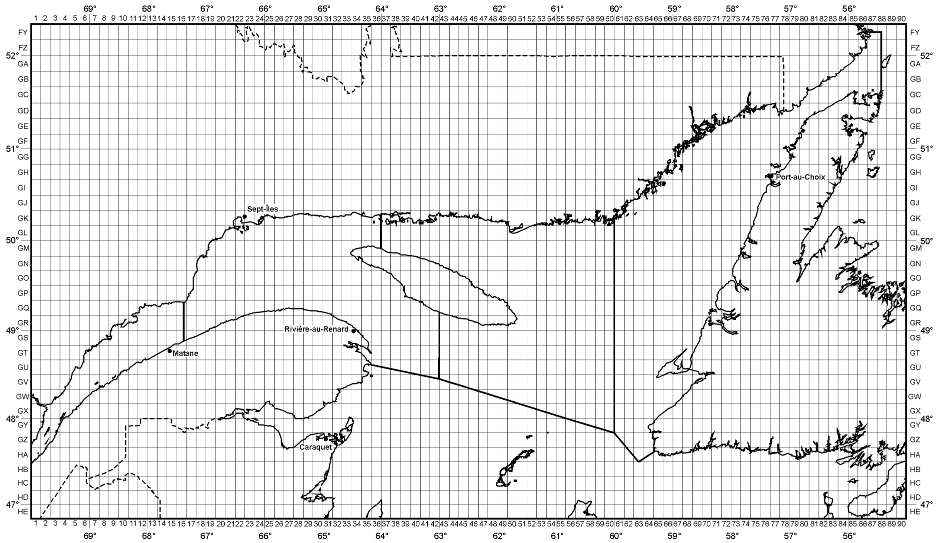


Figure 23. Statistical squares used to list the fishing effort the Estuary and Gulf of St. Lawrence.

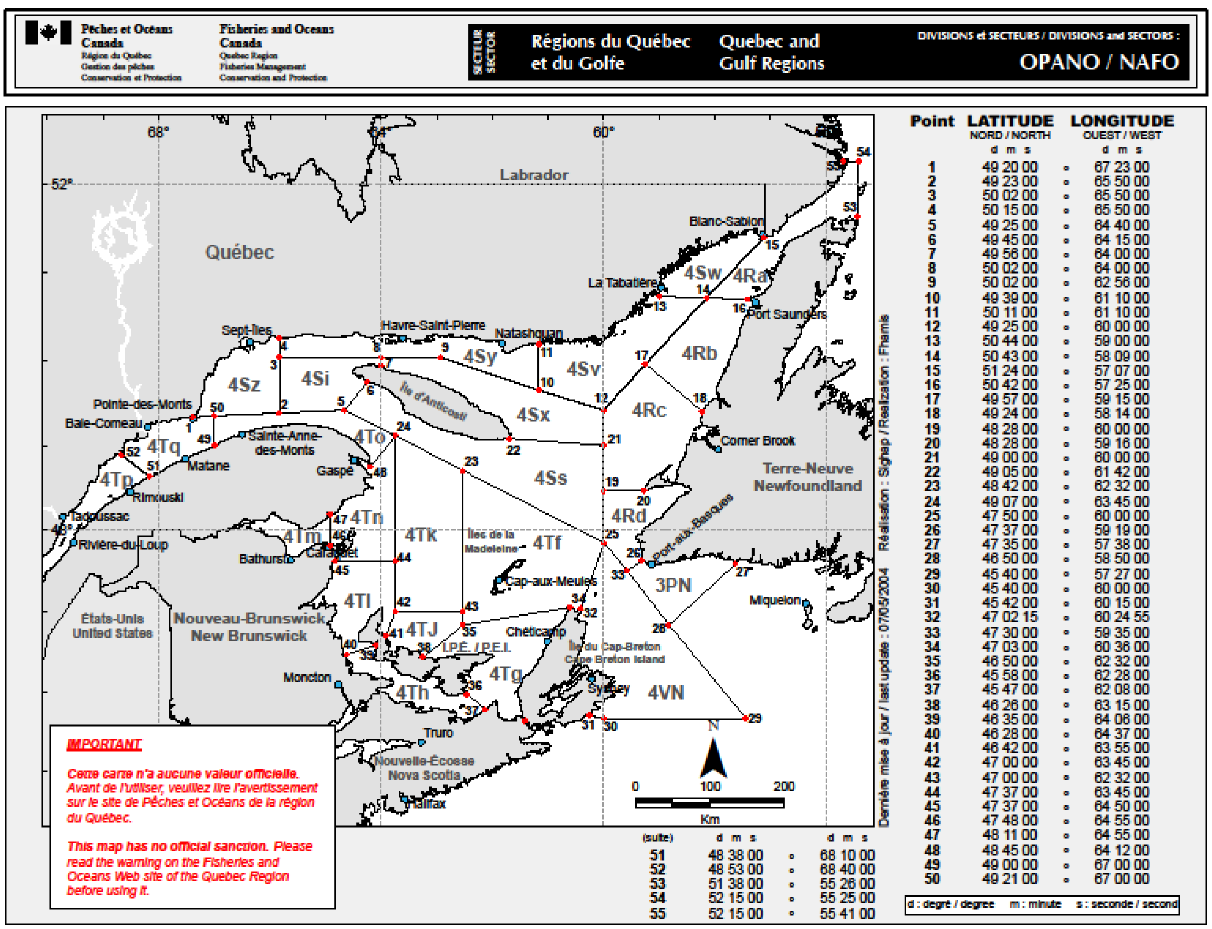


Figure 24. NAFO unit areas in the Estuary and Gulf of St. Lawrence.

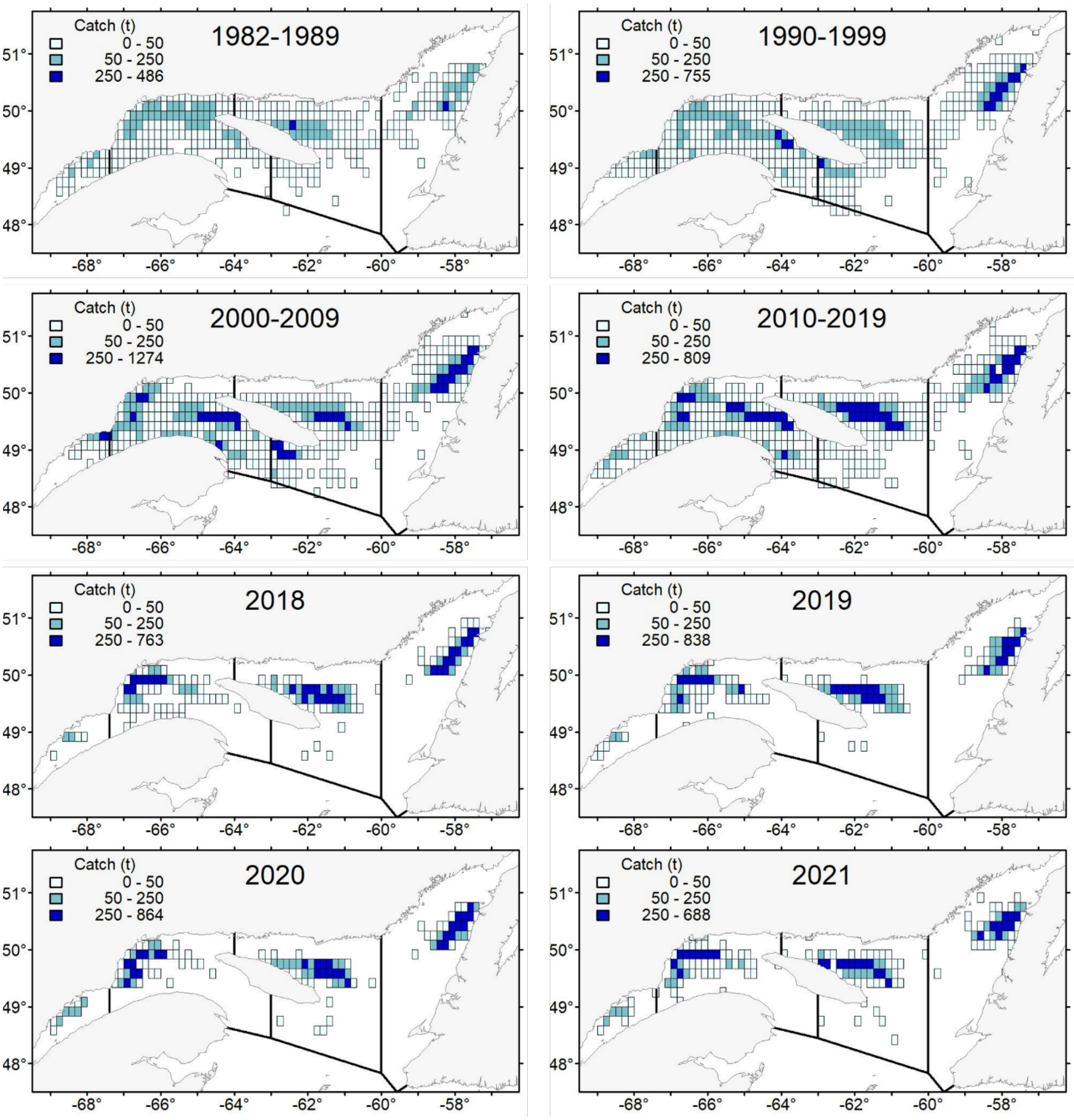


Figure 25. Catches (t) by statistical square by decade (annual mean) and from 2018 to 2021.

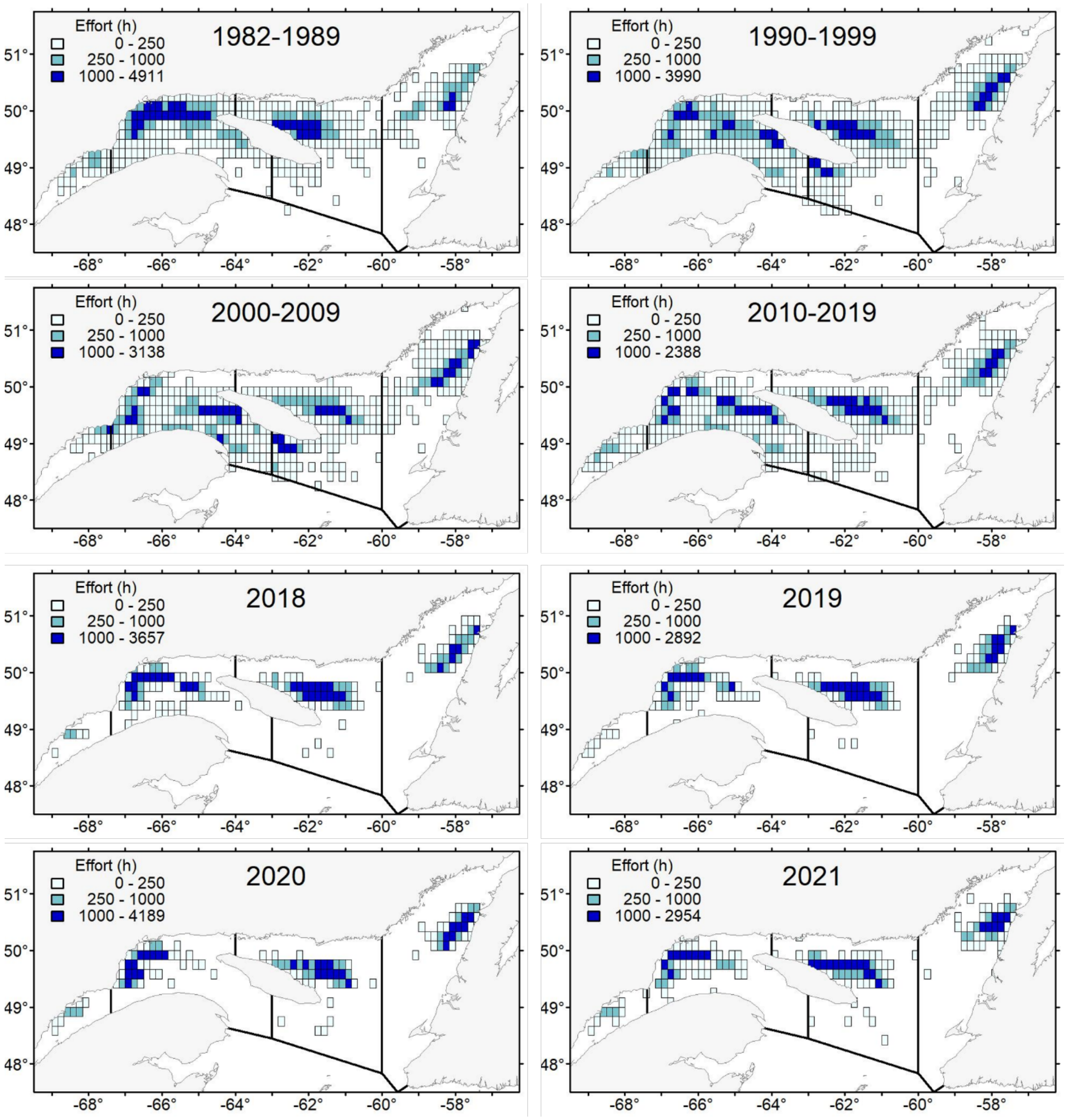


Figure 26. Fishing effort (t) by statistical square by decade (annual mean) and from 2018 to 2021.

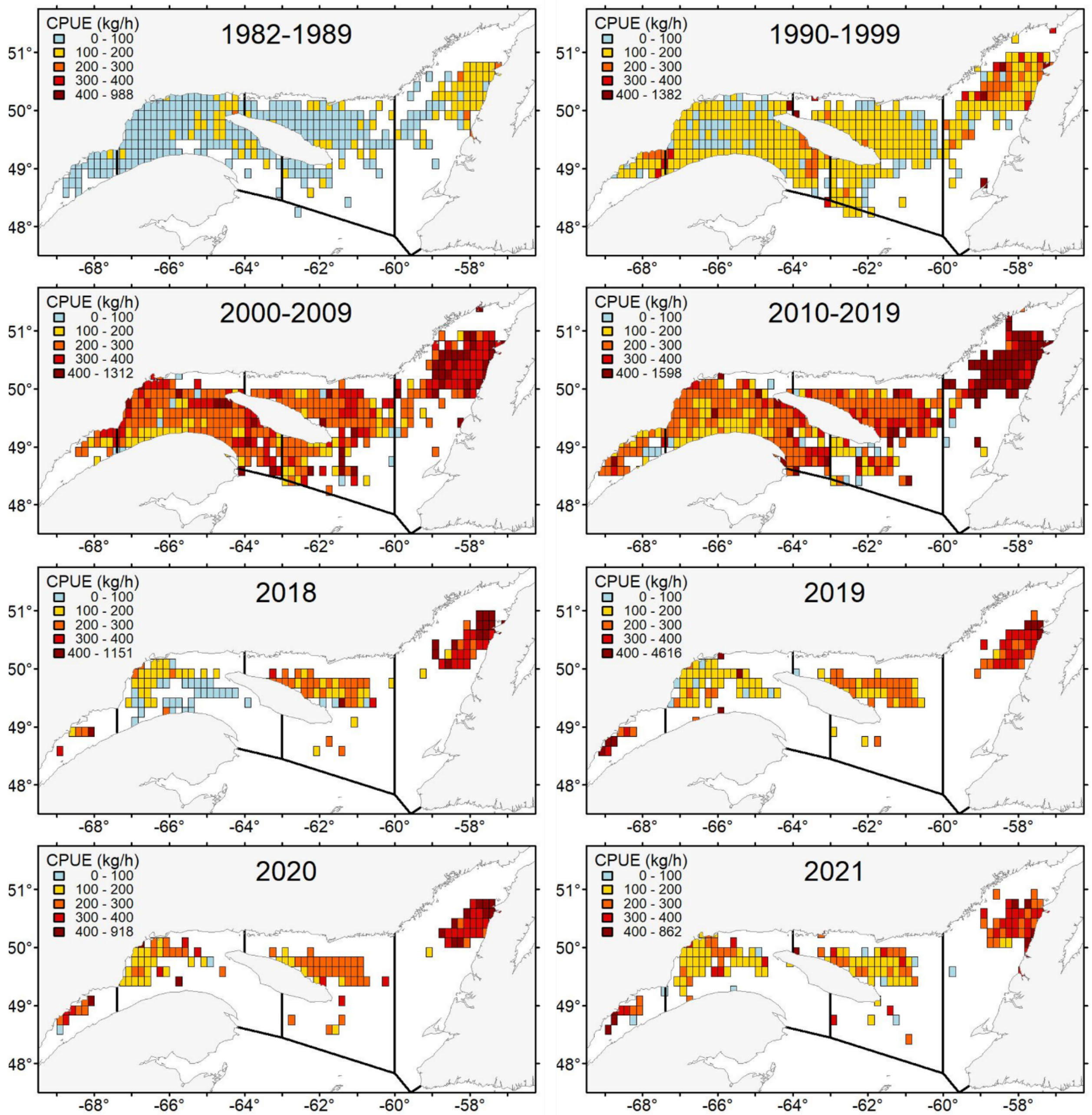


Figure 27. Catch per unit of effort by statistical square by decade (annual mean) and from 2018 to 2021.

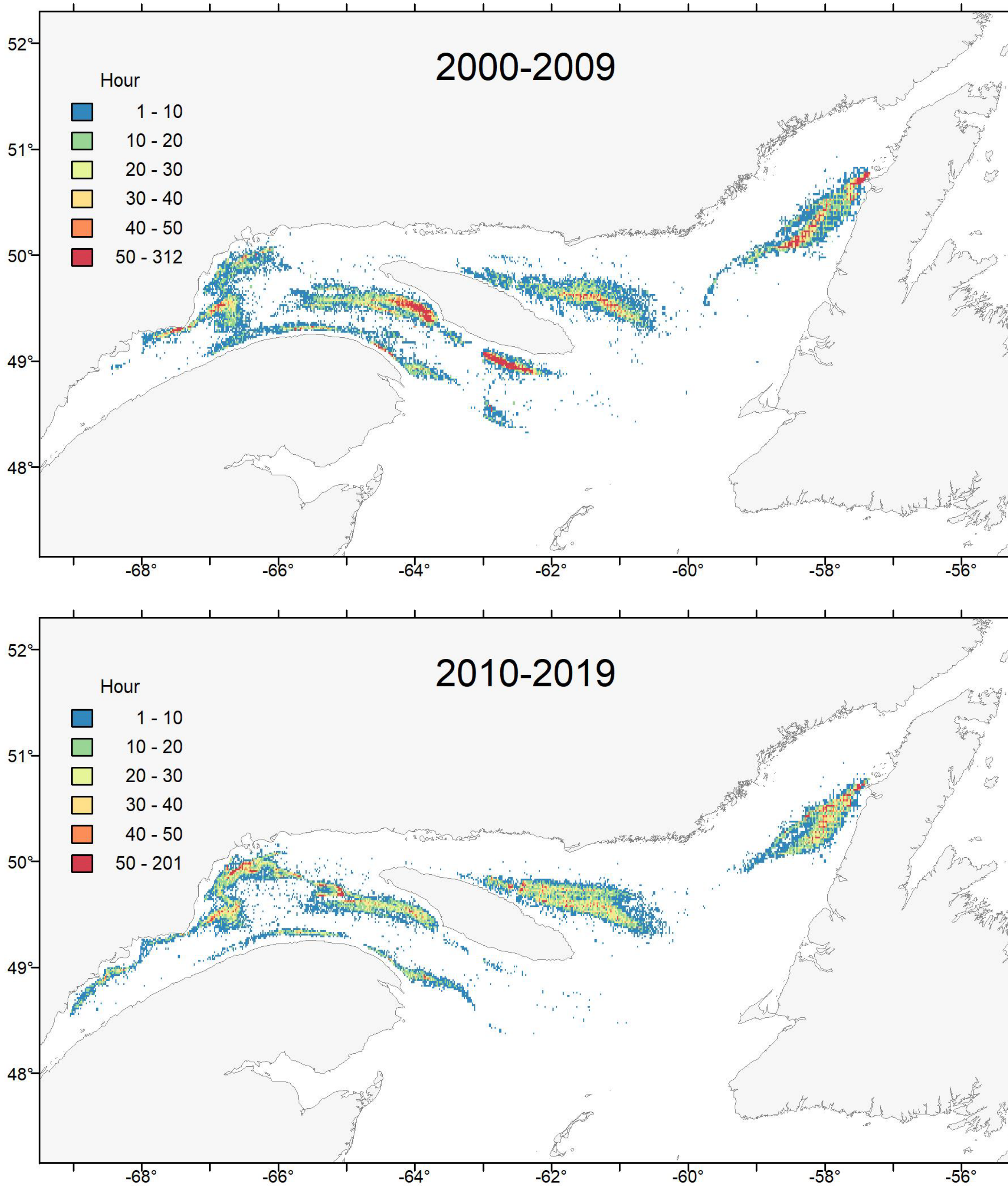


Figure 28. Average distribution of annual shrimp fishing effort in the Gulf of St. Lawrence by decade for the periods 2000 to 2009, 2010 to 2019 and 2020 to 2021 (number of hours per square of 1 minute) from logbook data.

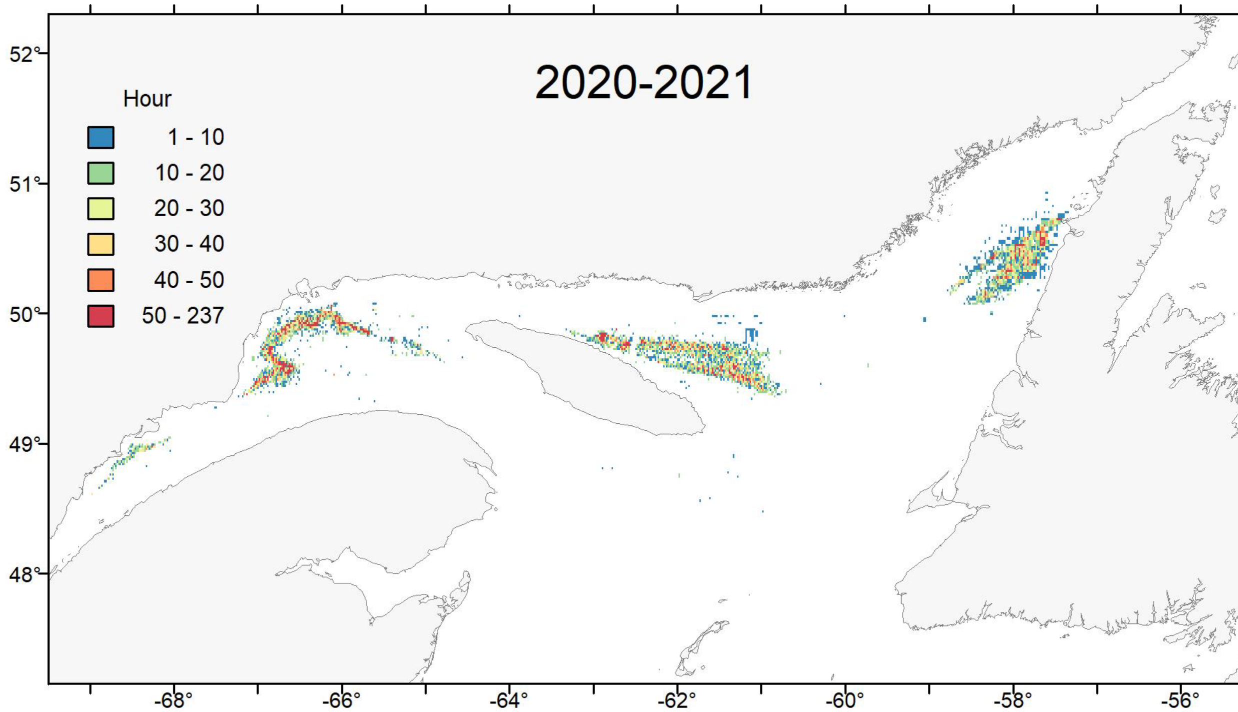


Figure 28. Continued.

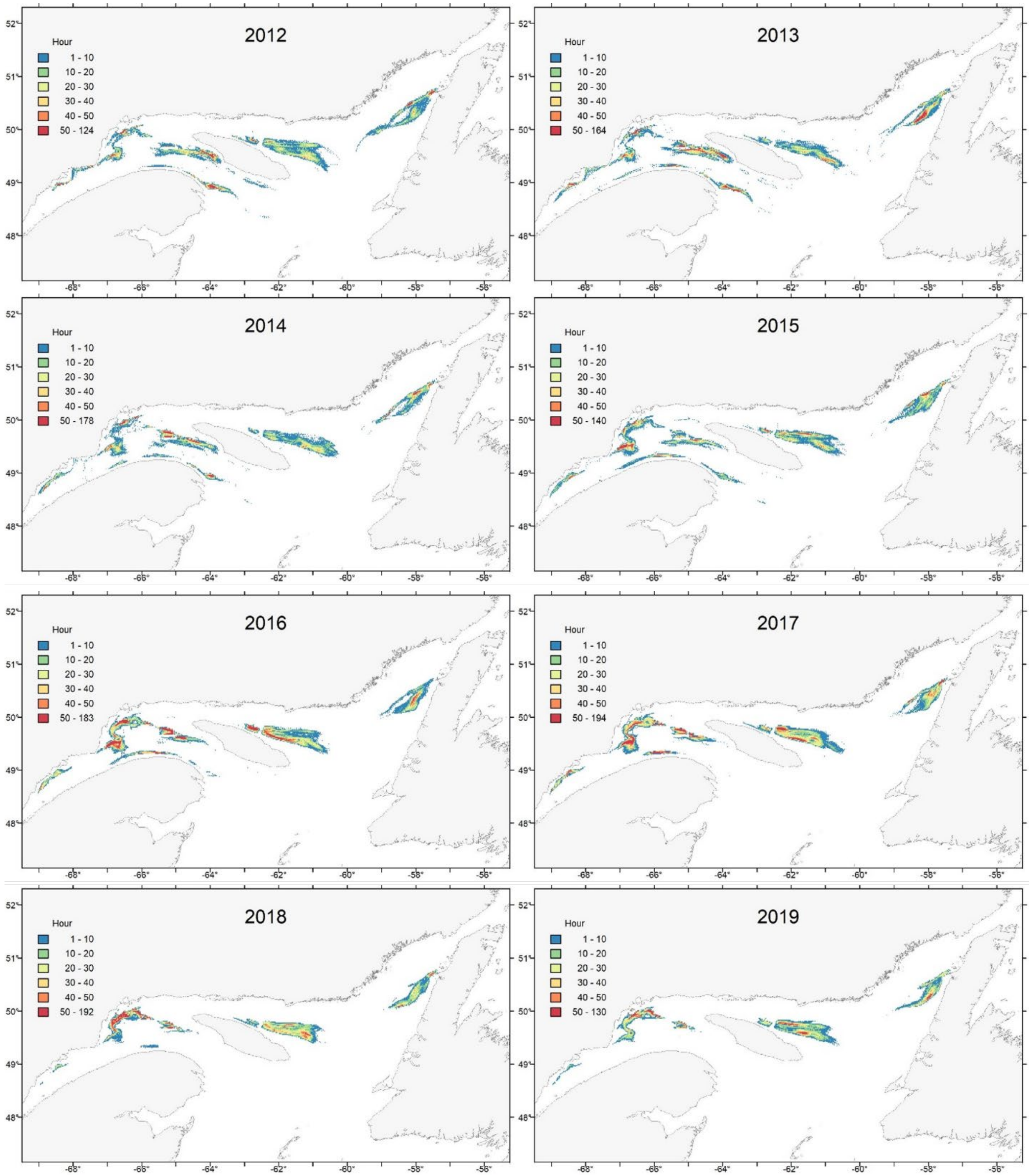


Figure 29. Distribution of shrimp fishing effort in the Gulf of St. Lawrence from 2012 to 2021 based on Vessel Monitoring System (VMS) data, number of hours in a directed shrimp fishery per 1 minute square.

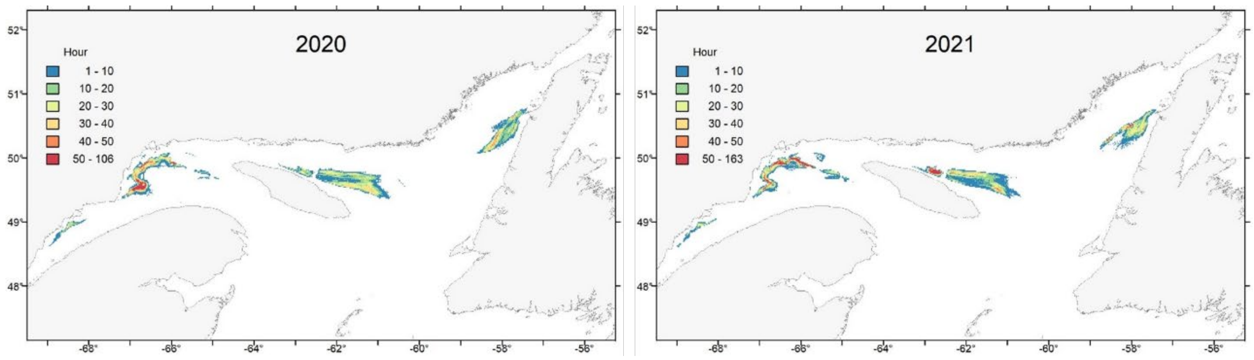


Figure 29. Suite.

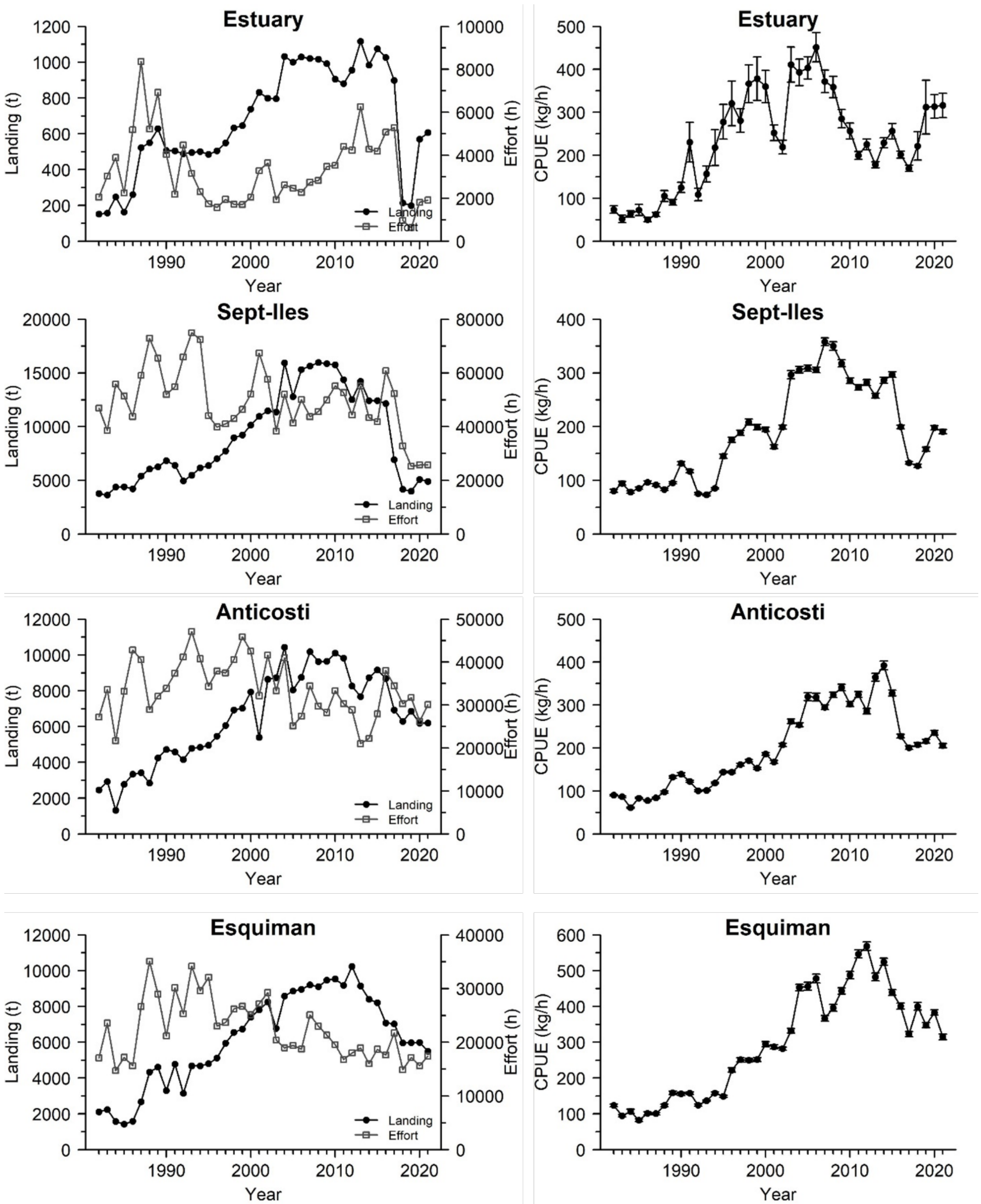


Figure 30. Landing, nominal effort and catch per unit of effort ± confidence interval (95%), by year and by fishing area.

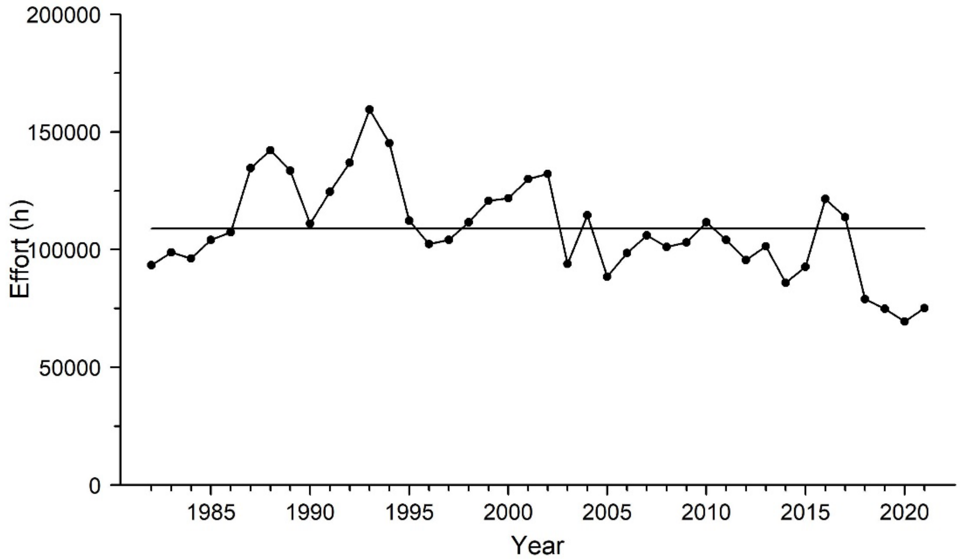


Figure 31. Total effort of fishing by year for the Estuary and Gulf of St. Lawrence. The full line indicates the mean of the series.

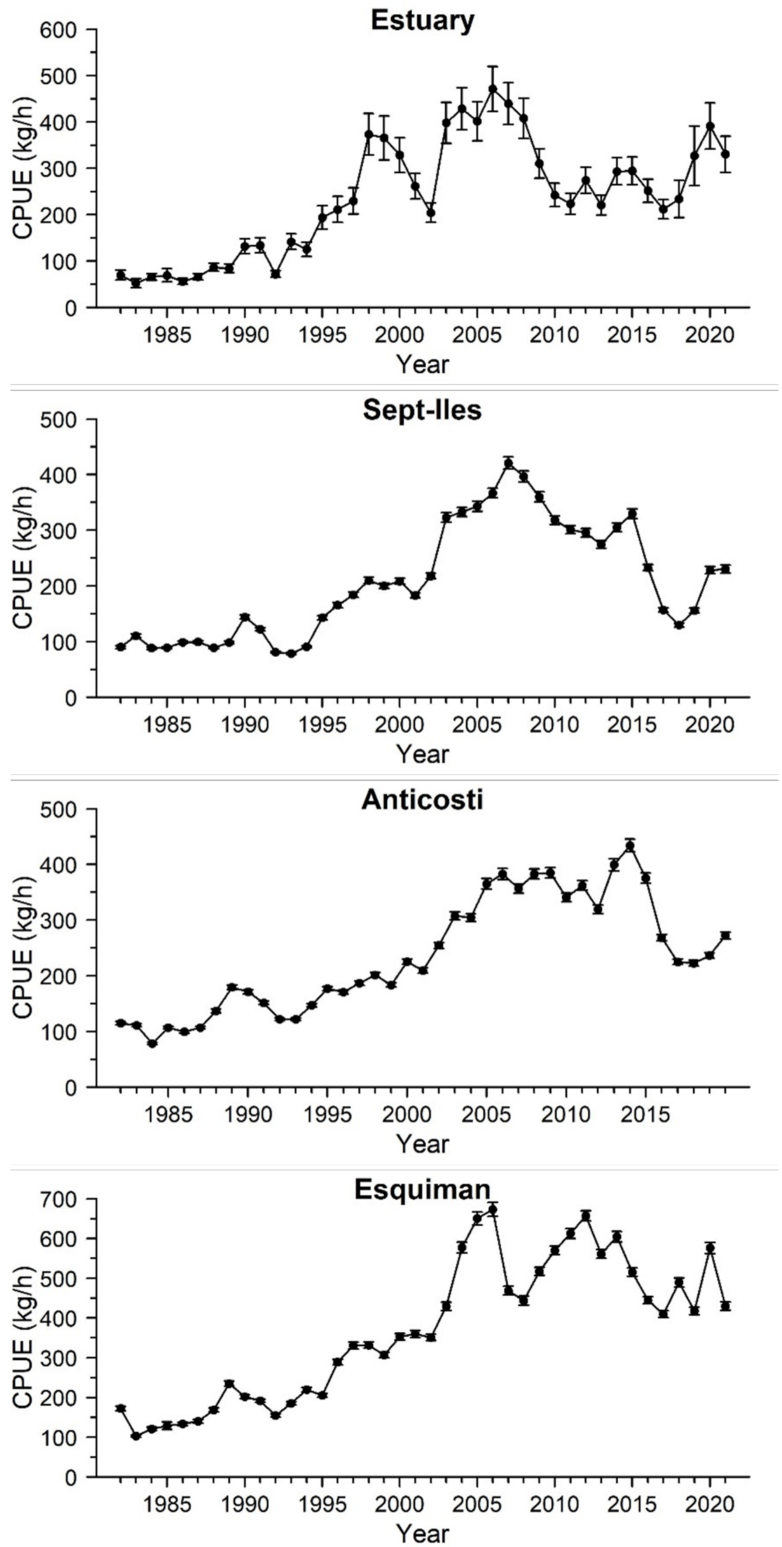


Figure 32. Standardized catch per unit of effort ± confidence interval (95 %) by fishing area and by year.

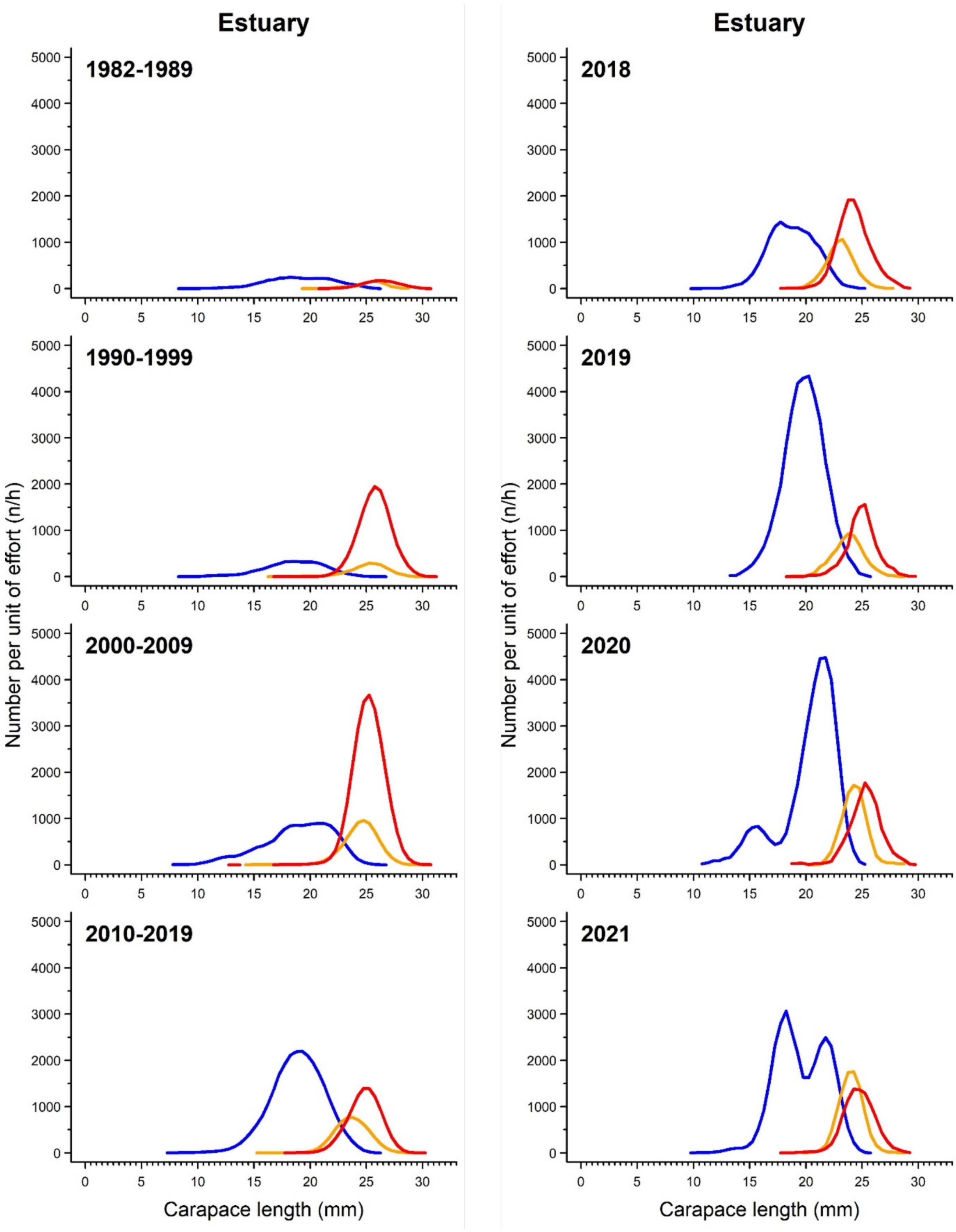


Figure 33. Number per unit of effort by carapace length class (0.5 mm) by fishing area for the fishing season per 10 years period and for 2018 to 2021. Males in blue, primiparous females in orange and multiparous females in red.

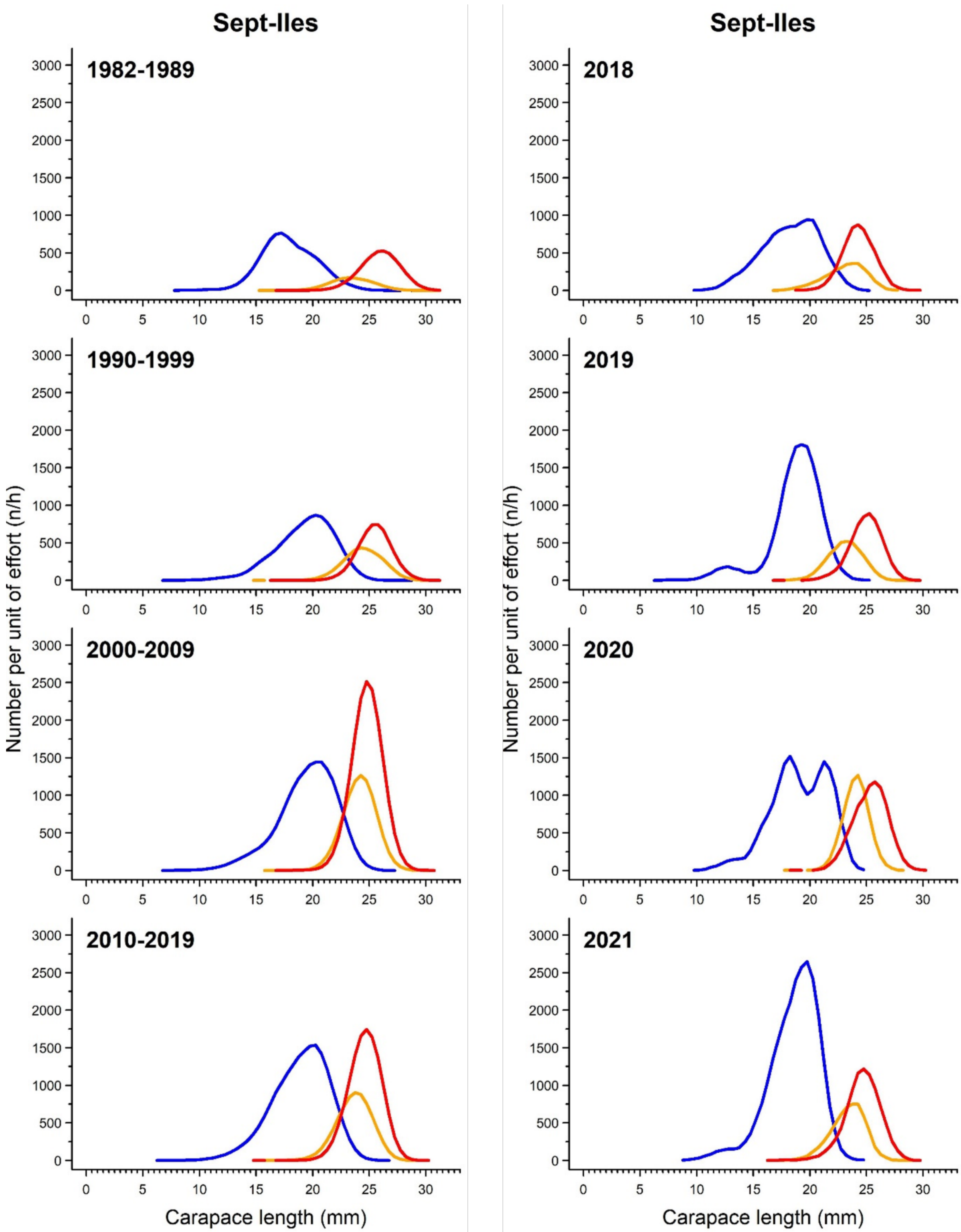


Figure 33. Continued.

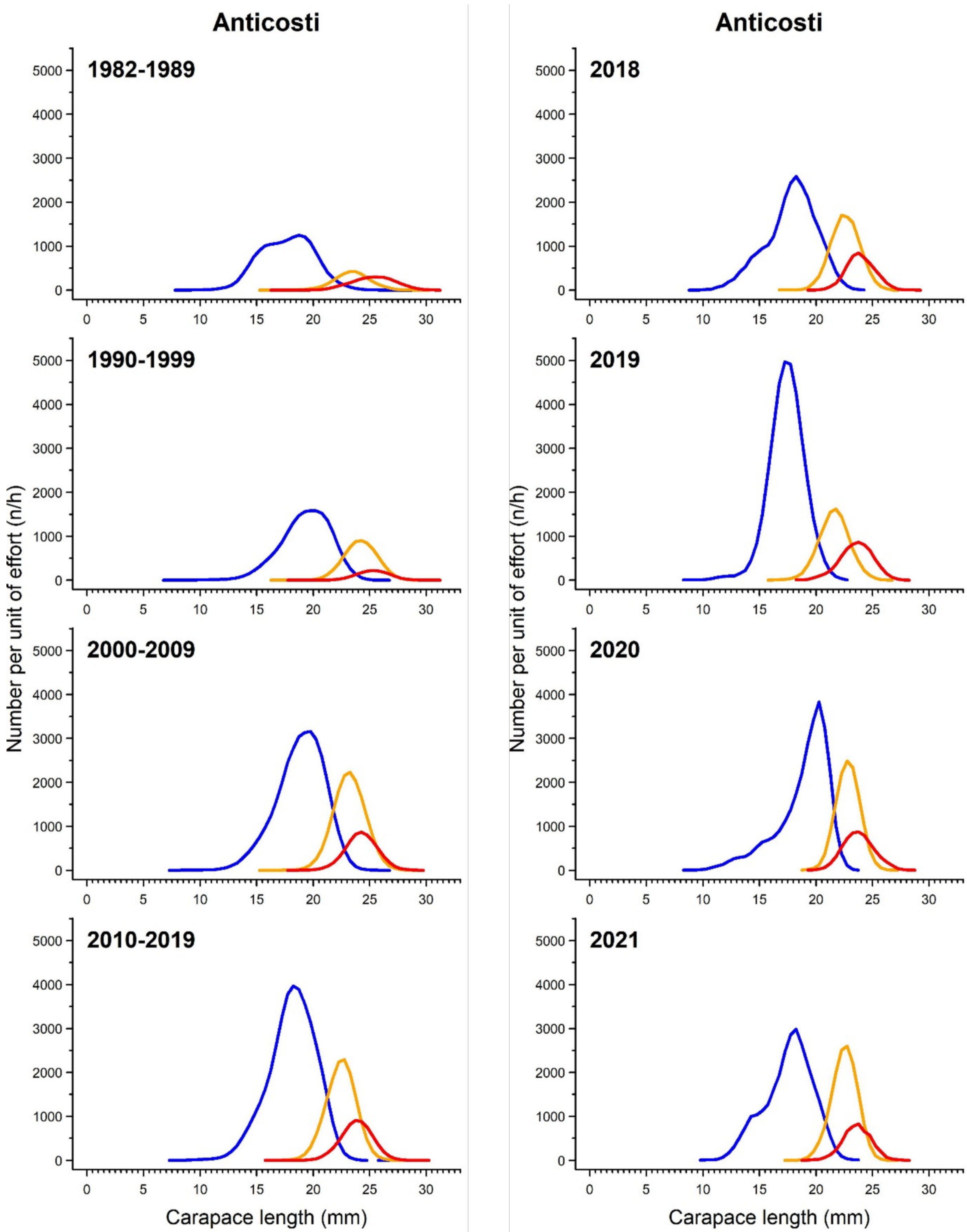


Figure 33. Continued.

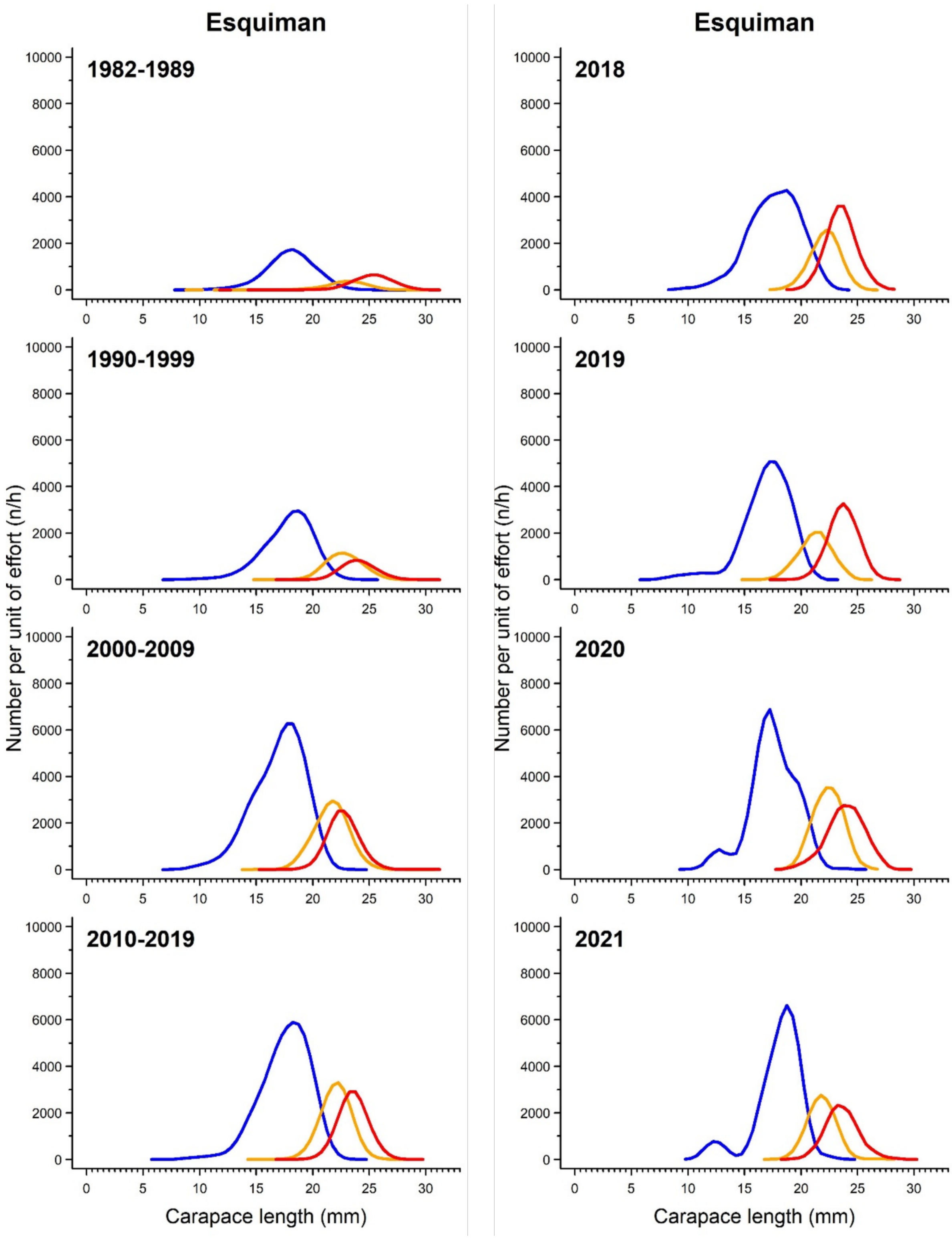


Figure 33. Continued.

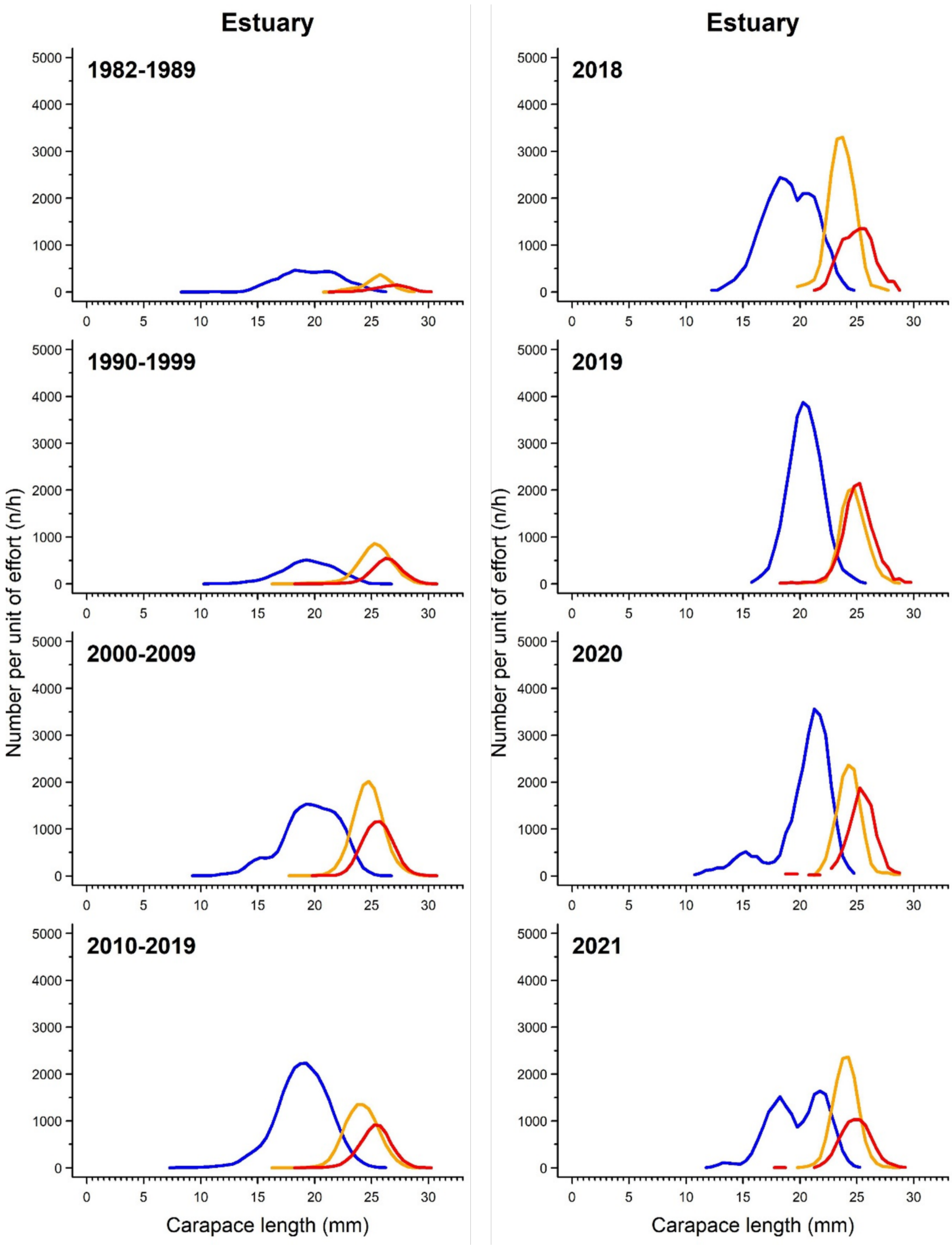


Figure 34. Number per unit of effort by carapace length class (0.5 mm) by fishing area for the summer season (June, July and August) per 10 years period and for 2018 to 2021. Males in blue, primiparous females in orange and multiparous females in red.

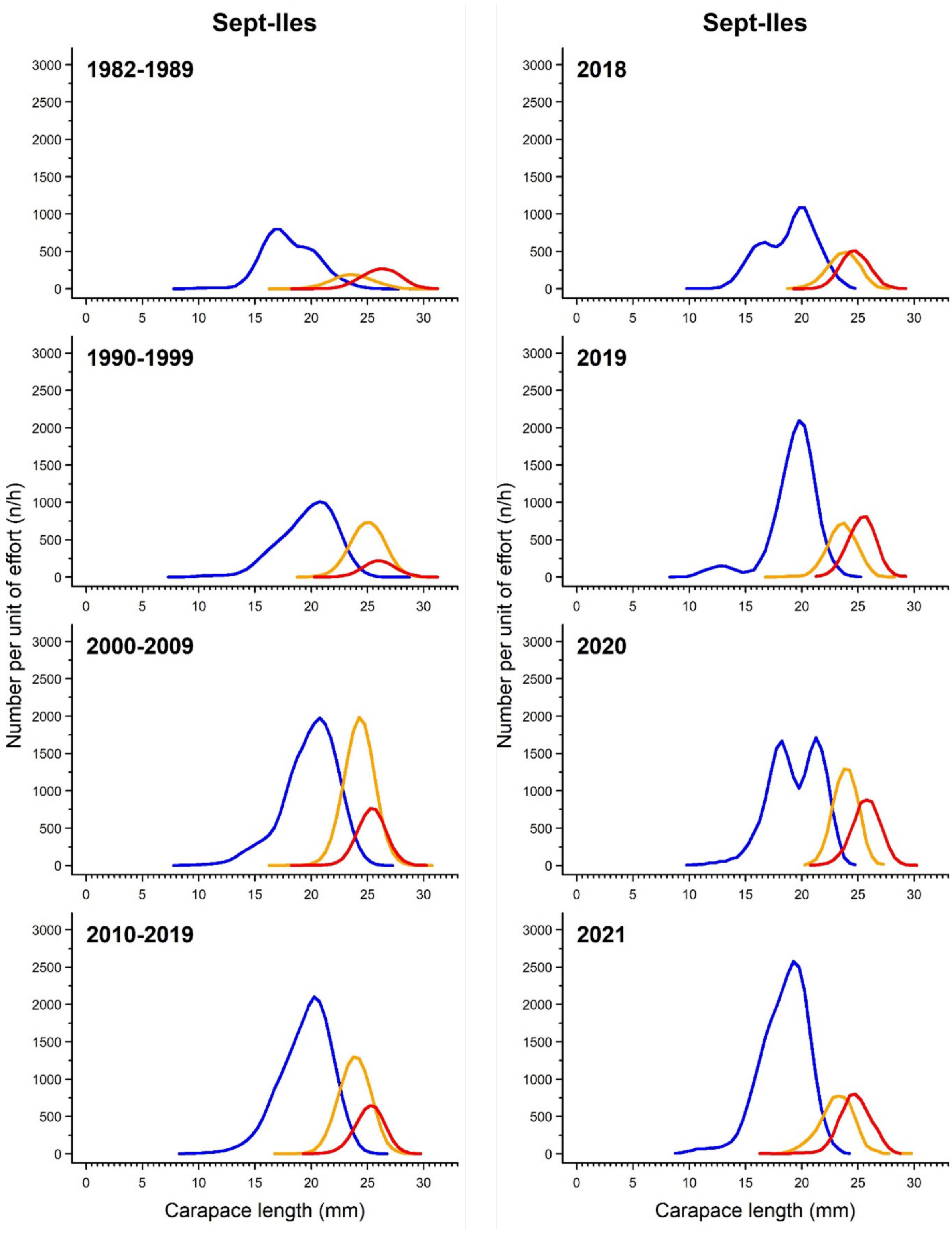


Figure 34. Continued.

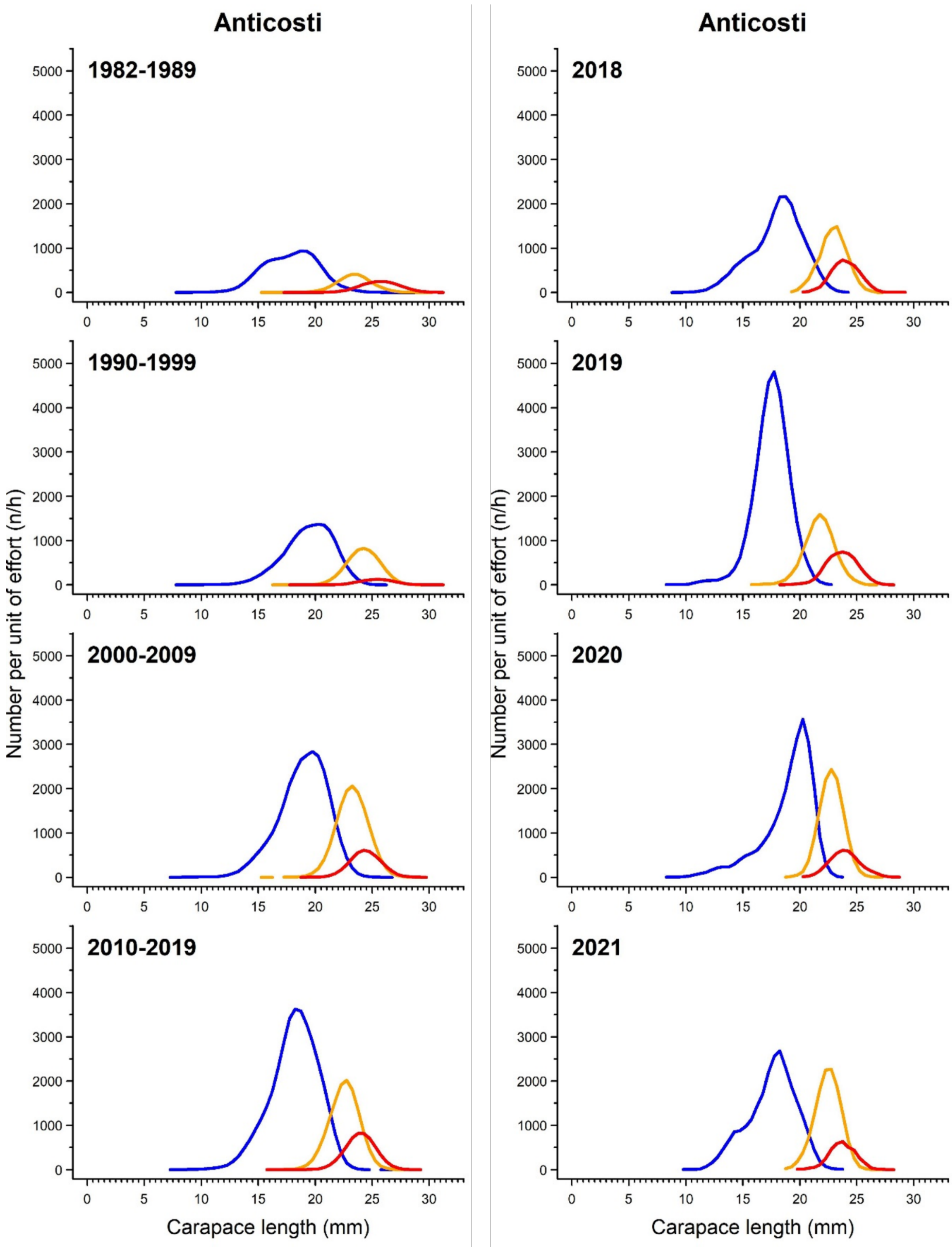


Figure 34. Continued.

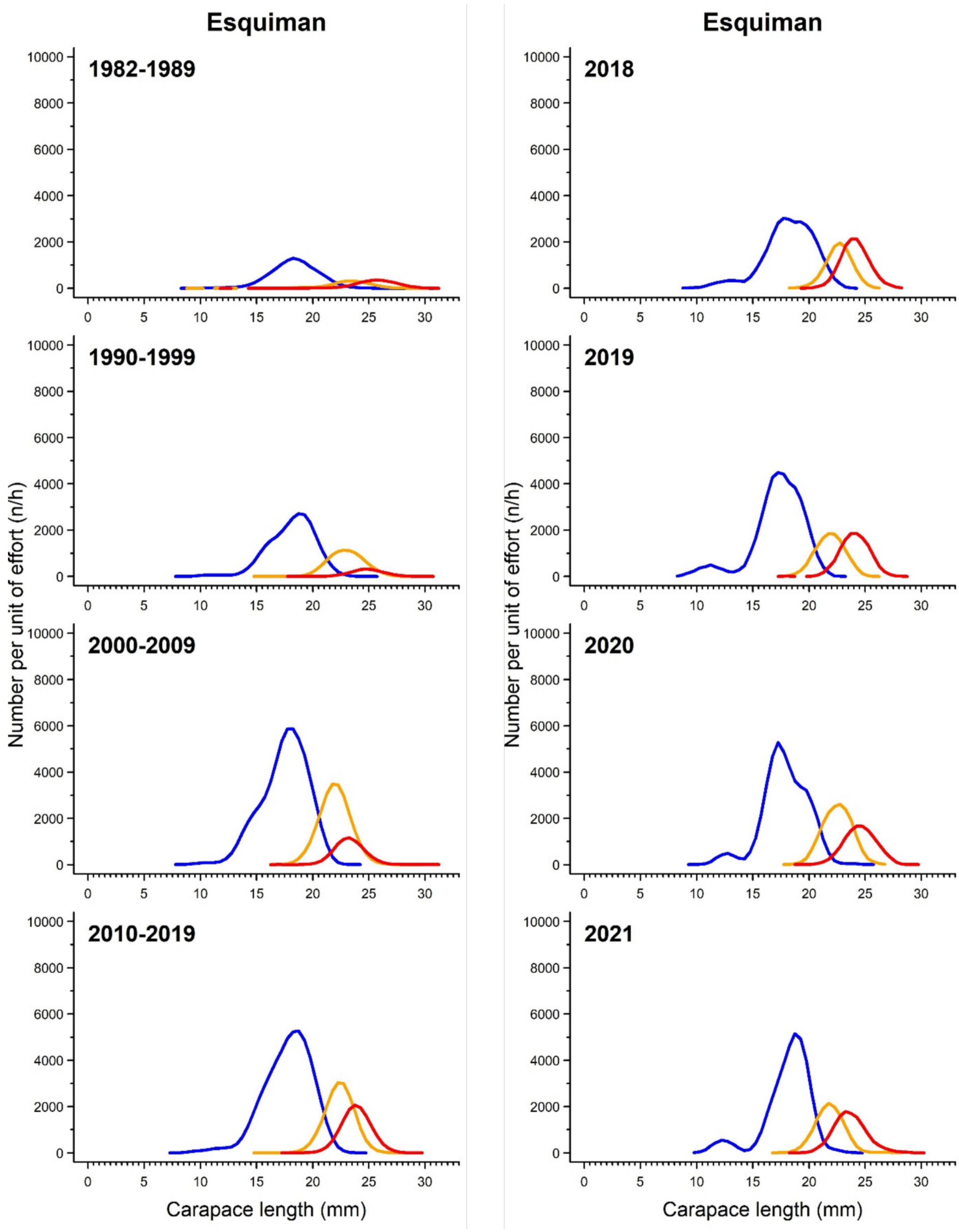


Figure 34. Continued.

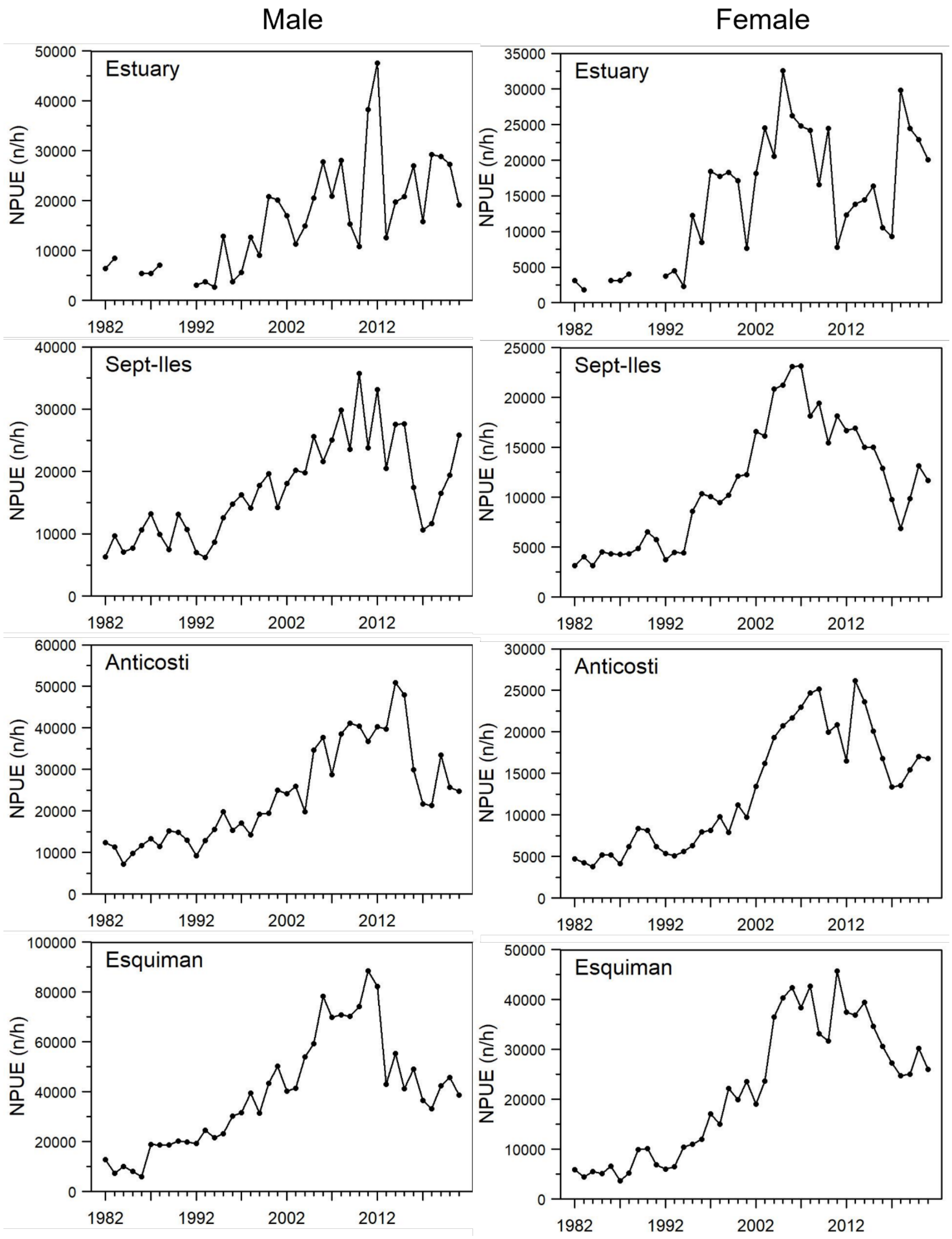


Figure 35. Number per unit of effort for the summer months (June, July and August) for the male and female shrimps, by fishing area and by year.

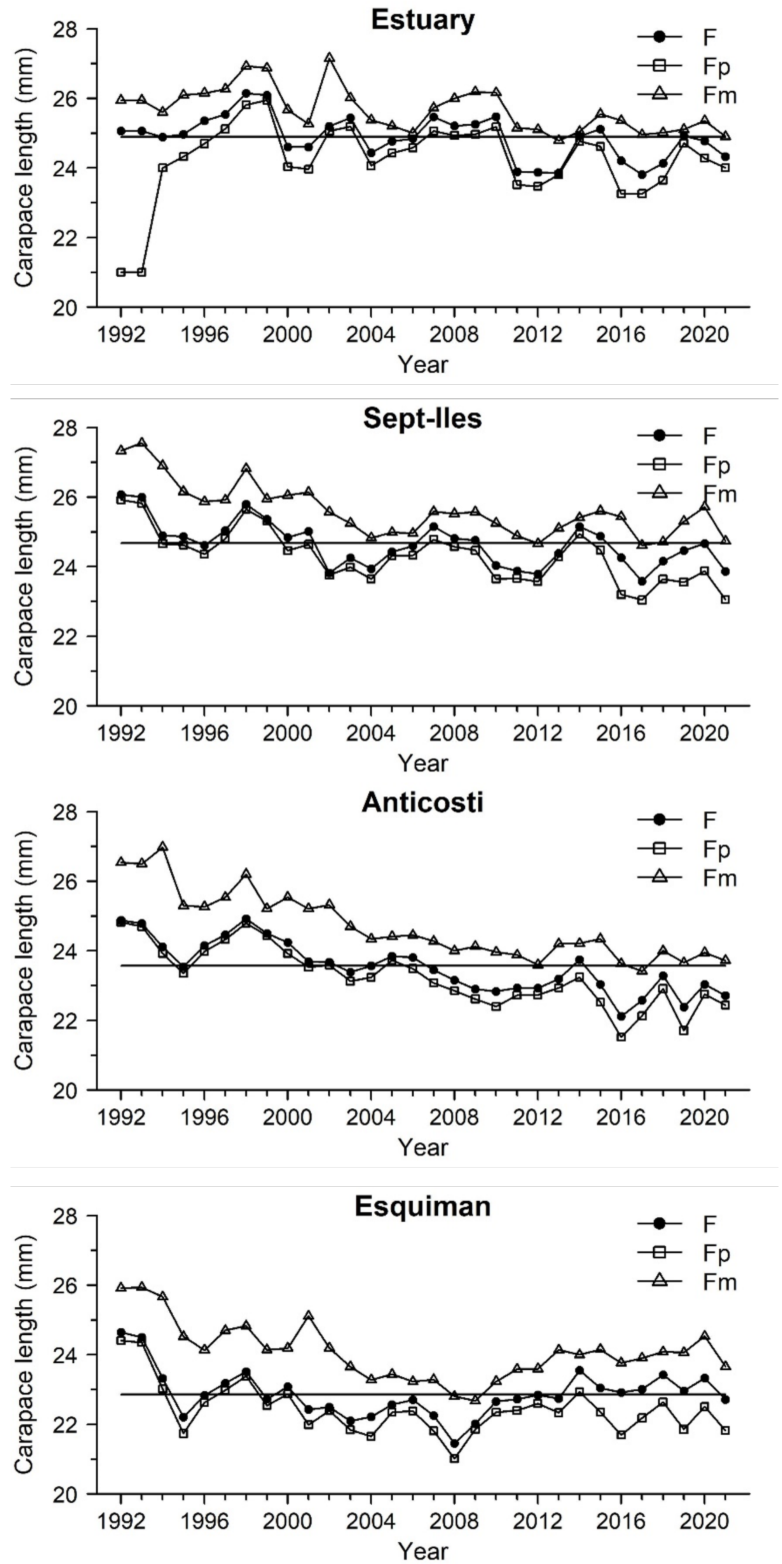


Figure 36. Average carapace length of female shrimps harvested in the summer by fishing area and year (F: female, Fp: primiparous female and Fm: female multiparous). The solid horizontal line represents the 1992-2019 mean.

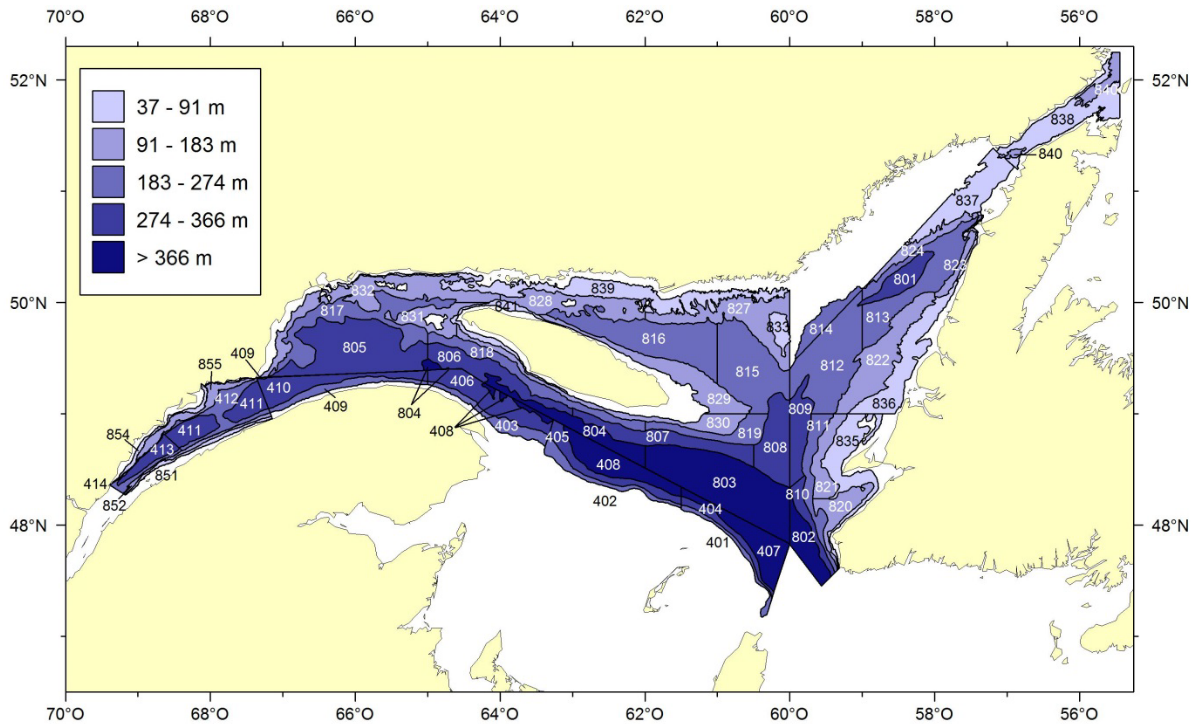


Figure 37. Stratification used for the allocation of fishing stations of the survey in the northern Gulf of St. Lawrence. The strata 851, 852, 854 and 855 were added in 2008.

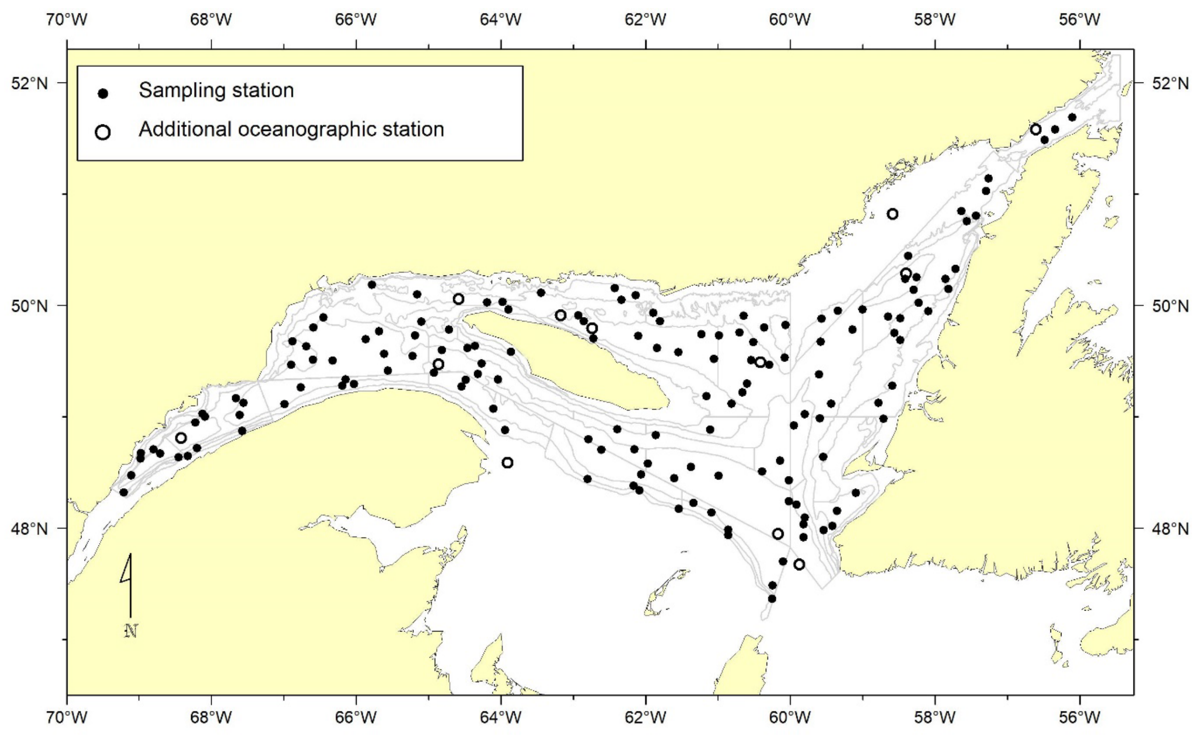


Figure 38. Locations of successful sampling stations (trawl and oceanography) and additional oceanographic stations for the 2021 survey.

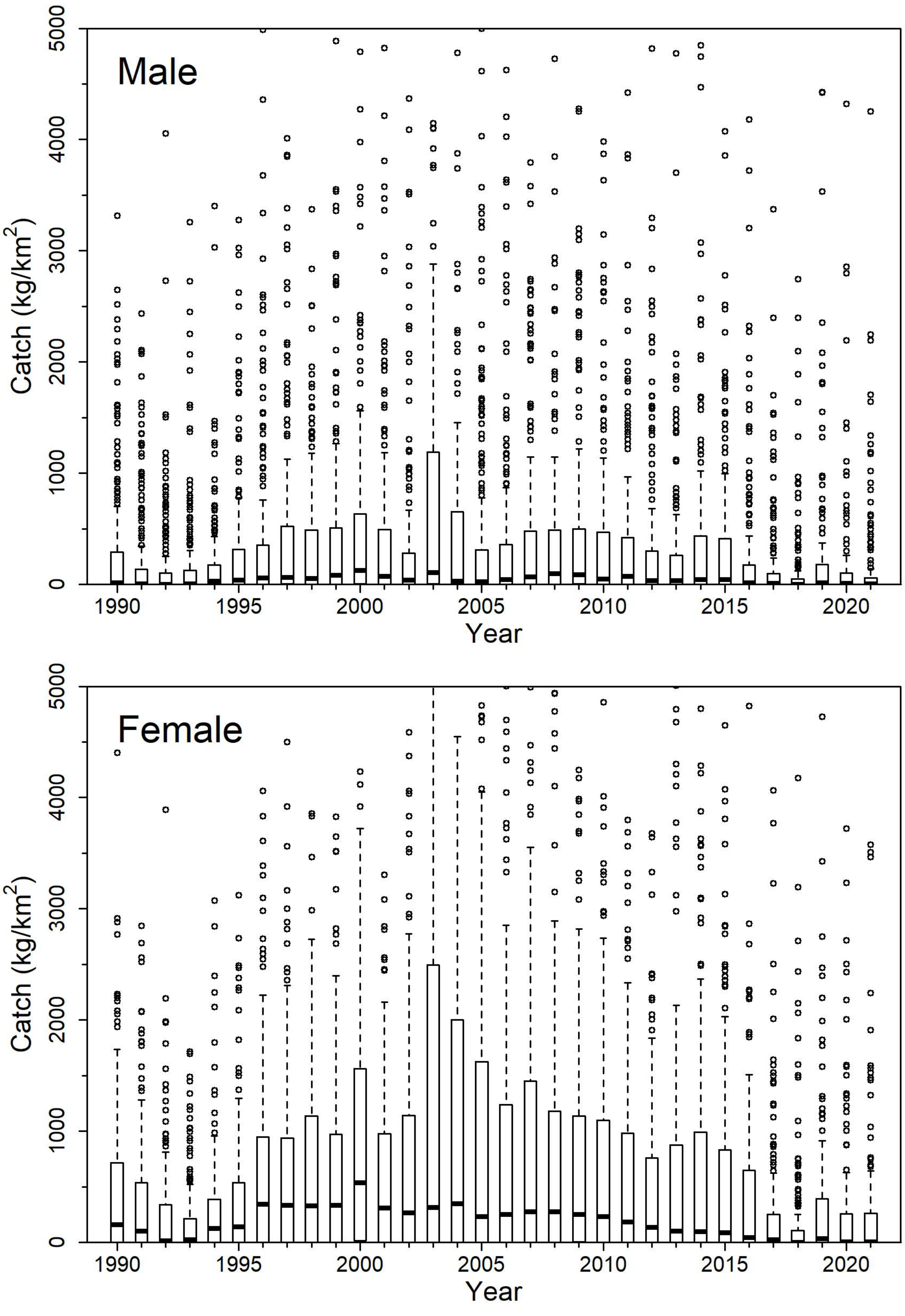


Figure 39. Boxplot of male and female shrimp catches (kg/km²) obtained from the surveys conducted from 1990 to 2021. The lower, middle, and upper horizontal lines of the boxplots represent the 25th, 50th (median), and 75th percentiles, respectively. The upper whisker extends from the box to the highest value not exceeding 1.5 times the interquartile range. The lower whisker follows the same principle, but with lower values. The dots correspond to captures judged to be aberrant.

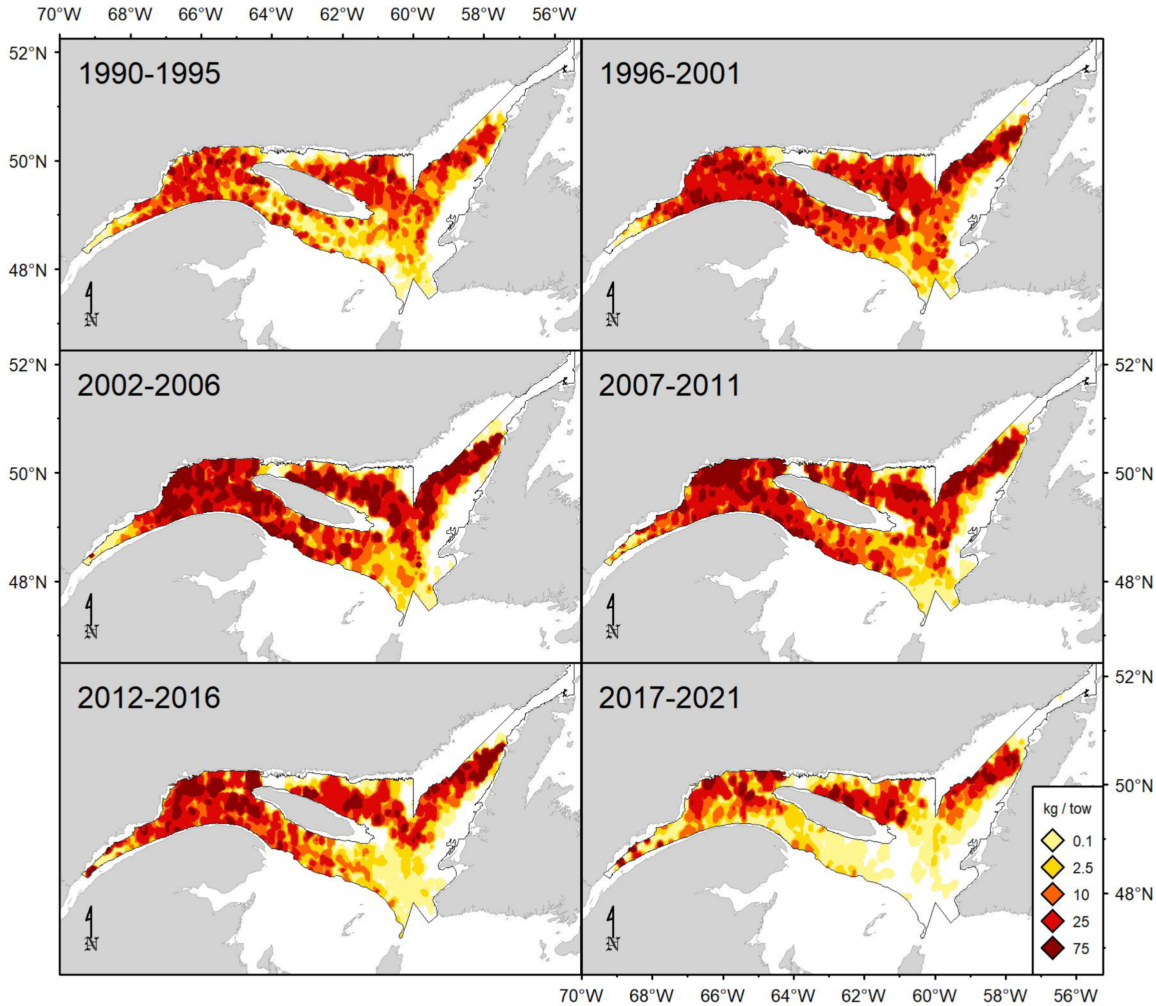


Figure 40. Northern shrimp catch rates (kg/15 minutes tow) distribution.

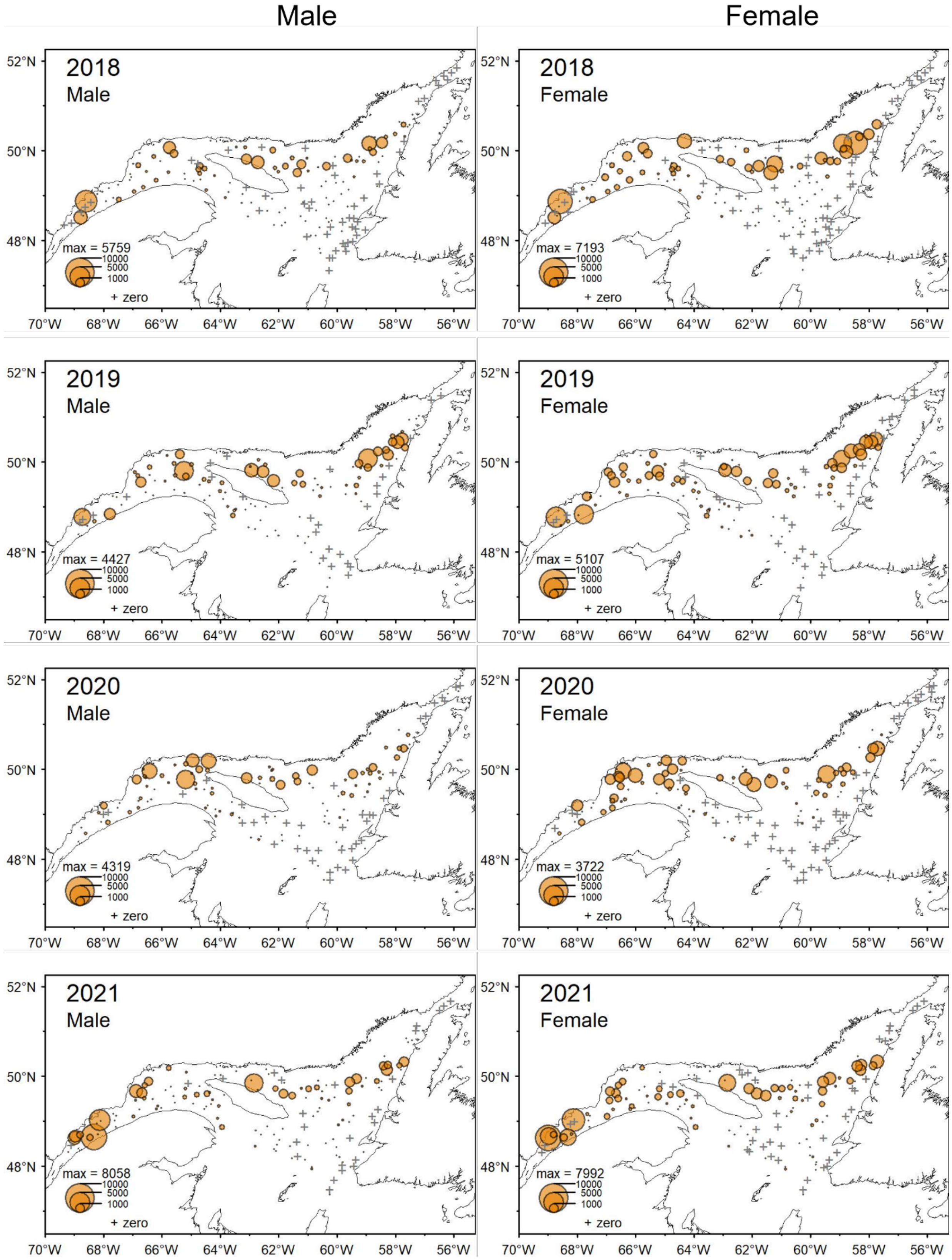
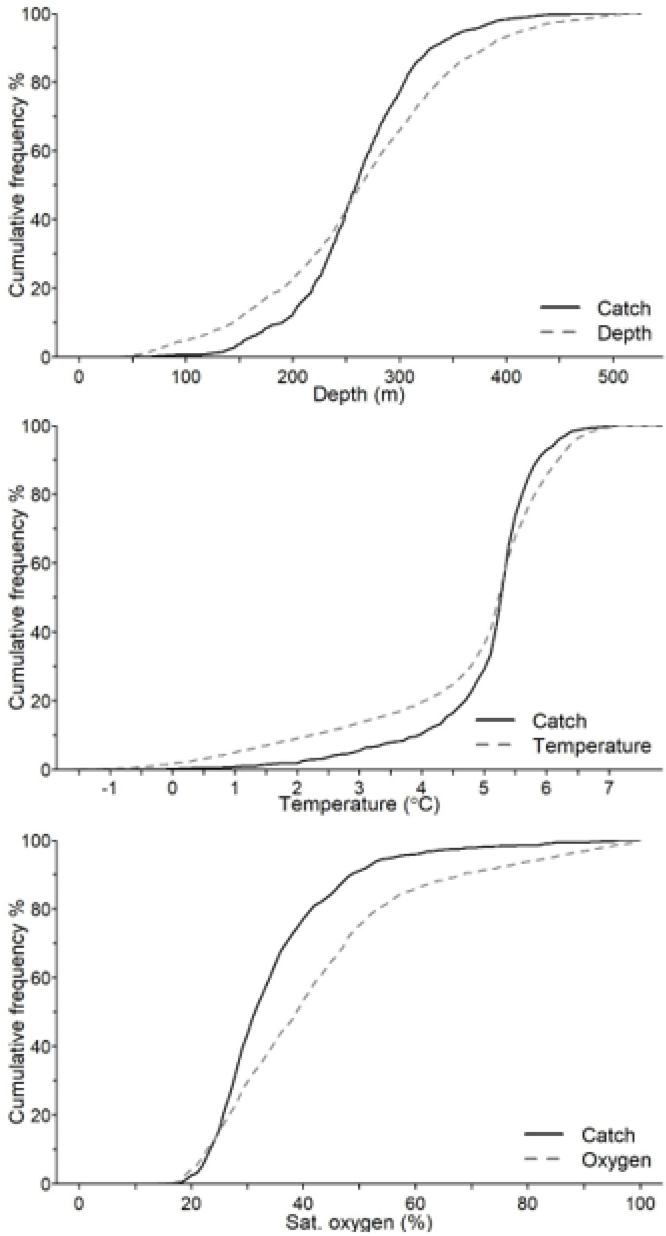


Figure 41. Northern shrimp catch rates (kg/15 minutes tow) distribution for male and female from 2018 to 2021.

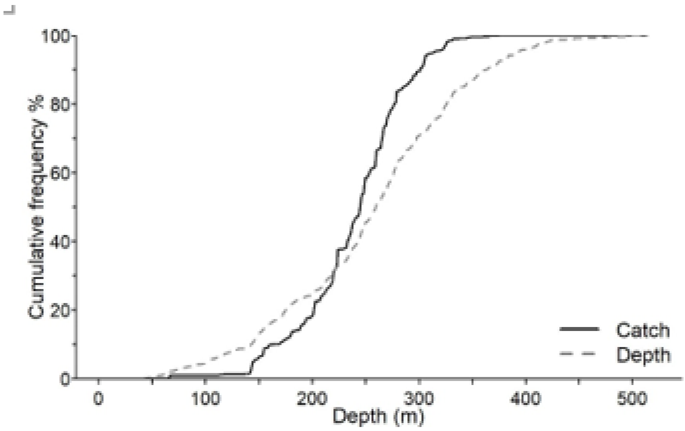


Centile	Depth
5ᵉ	157
10ᵉ	190
25ᵉ	228
50ᵉ	260
75ᵉ	297
90ᵉ	331
95ᵉ	362

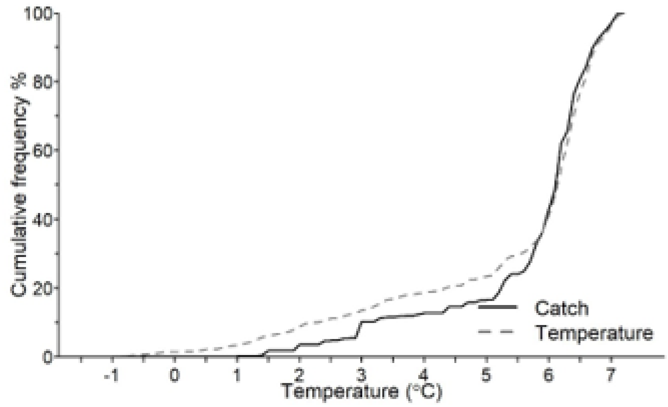
Centile	Temperature
5ᵉ	3.0
10ᵉ	4.0
25ᵉ	4.9
50ᵉ	5.3
75ᵉ	5.5
90ᵉ	5.9
95ᵉ	6.1

Centile	Oxygen
5ᵉ	22
10ᵉ	24
25ᵉ	26
50ᵉ	31
75ᵉ	39
90ᵉ	48
95ᵉ	56

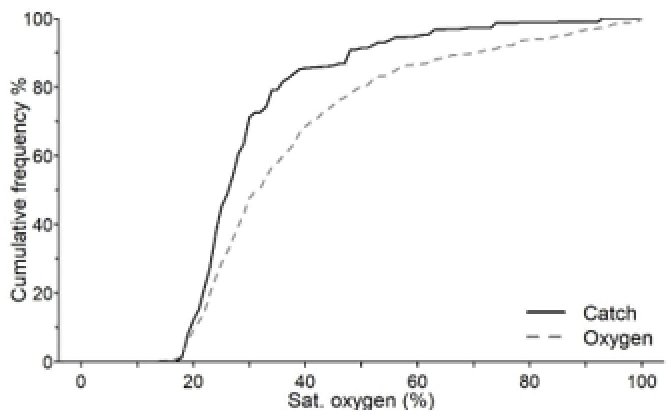
Figure 42. Cumulative relative frequency distribution of catches (weight per tow) and number of sampled stations as a function of depth, temperature and dissolved oxygen on bottom in the DFO survey the periods 1995 to 2010 and 2018 to 2021.



Centile	Depth
5e	146
10e	164
25e	213
50e	245
75e	270
90e	302
95e	314



Centile	Temperature
5e	2.7
10e	3.0
25e	5.7
50e	6.2
75e	6.4
90e	6.8
95e	7.0



Centile	Oxygen
5e	19
10e	20
25e	23
50e	27
75e	34
90e	48
95e	61

Figure 42. Continued.

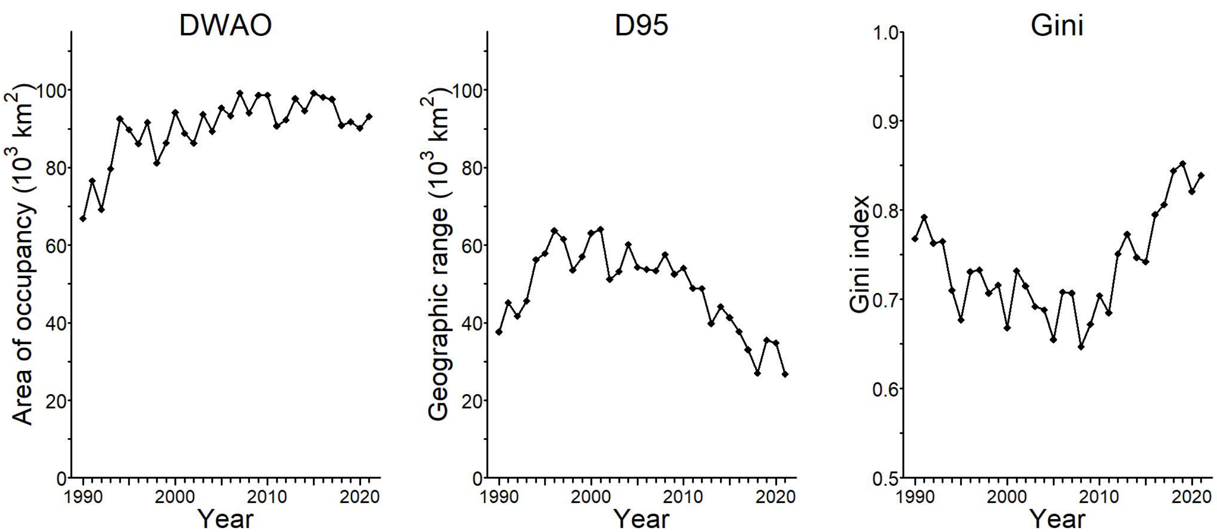
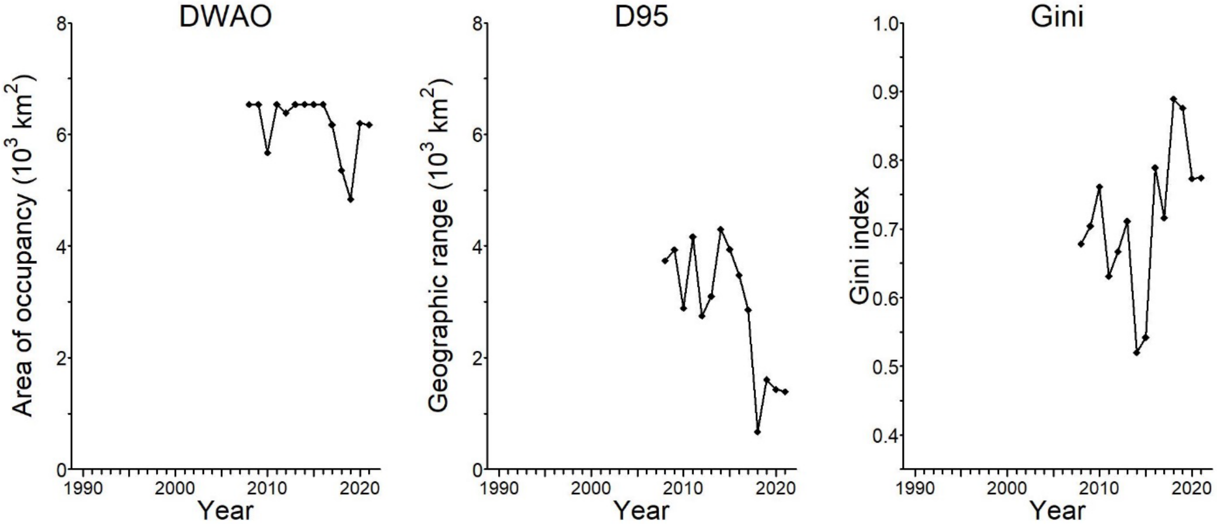


Figure 43. Spatial distribution indices: 1) DWAO, design-weighted area of occupation; 2) D95, minimum area containing 95% of individuals; and 3) Gini's index. The total area of the study zone is of 116,115 km^2.

Estuary (Area of the study zone: 6 537 km^2)



Sept-Iles (Area of the study zone: 26 787 km^2)

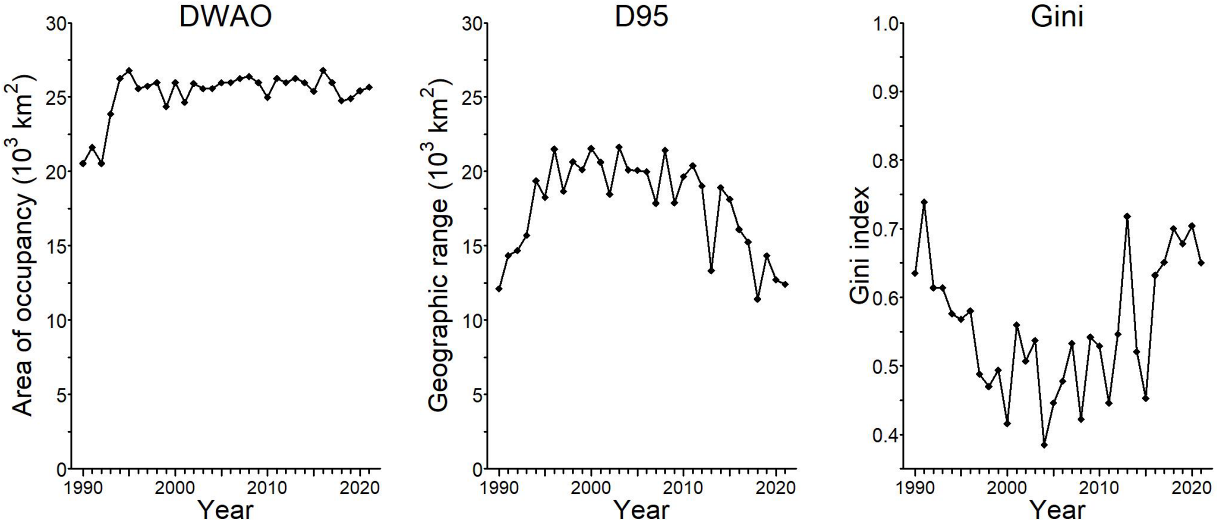
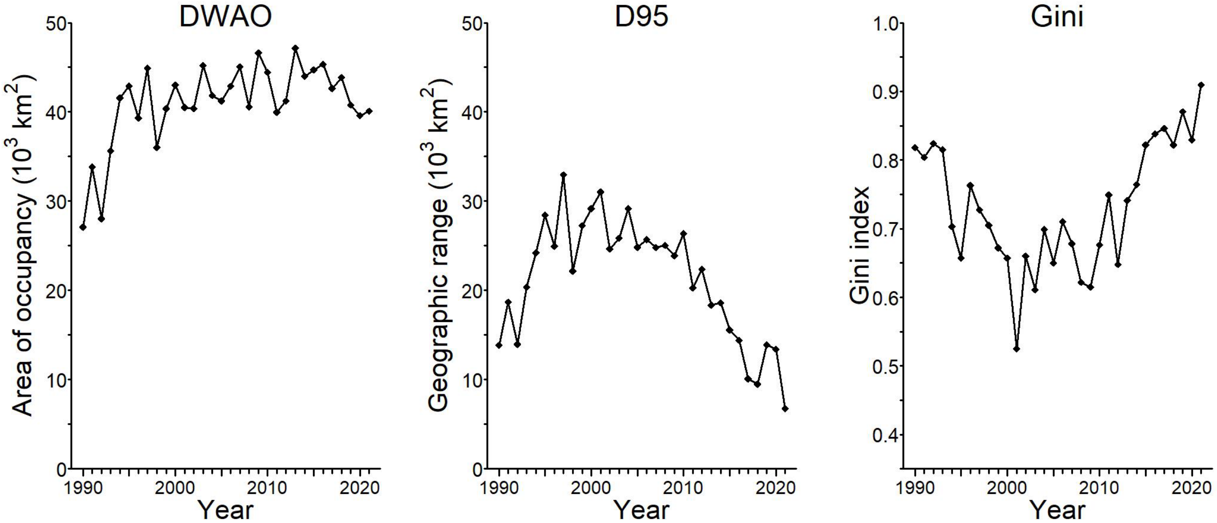


Figure 44. Spatial distribution indices: 1) DWAO, design-weighted area of occupation; 2) D95, minimum area containing 95% of individuals; and 3) Gini's index.

Anticosti (Area of the study zone: 49 164 km²)



Esquiman (Area of the study zone: 35 904 km²)

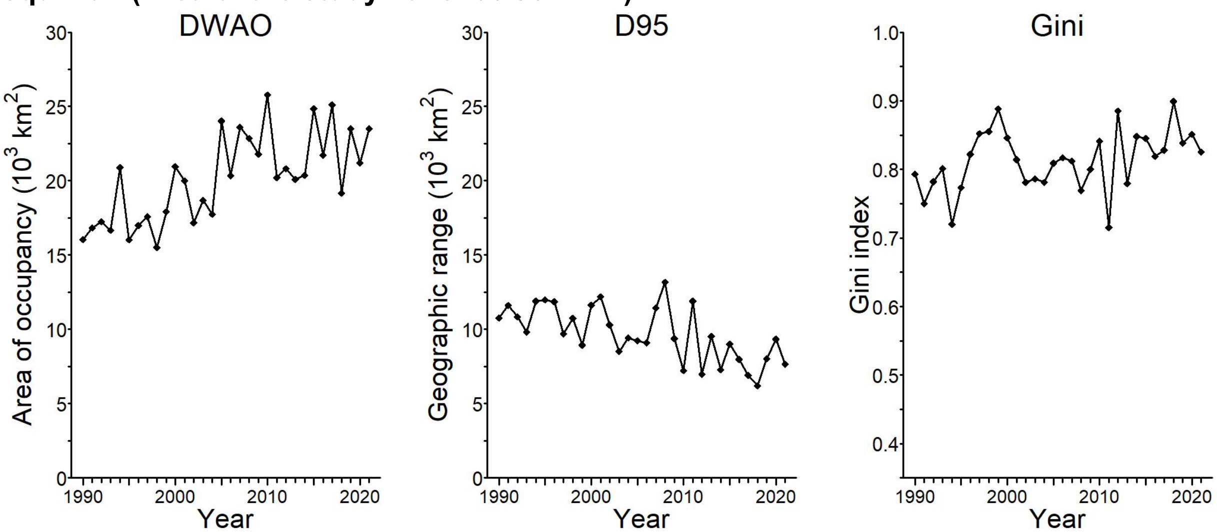


Figure 44. Continued.

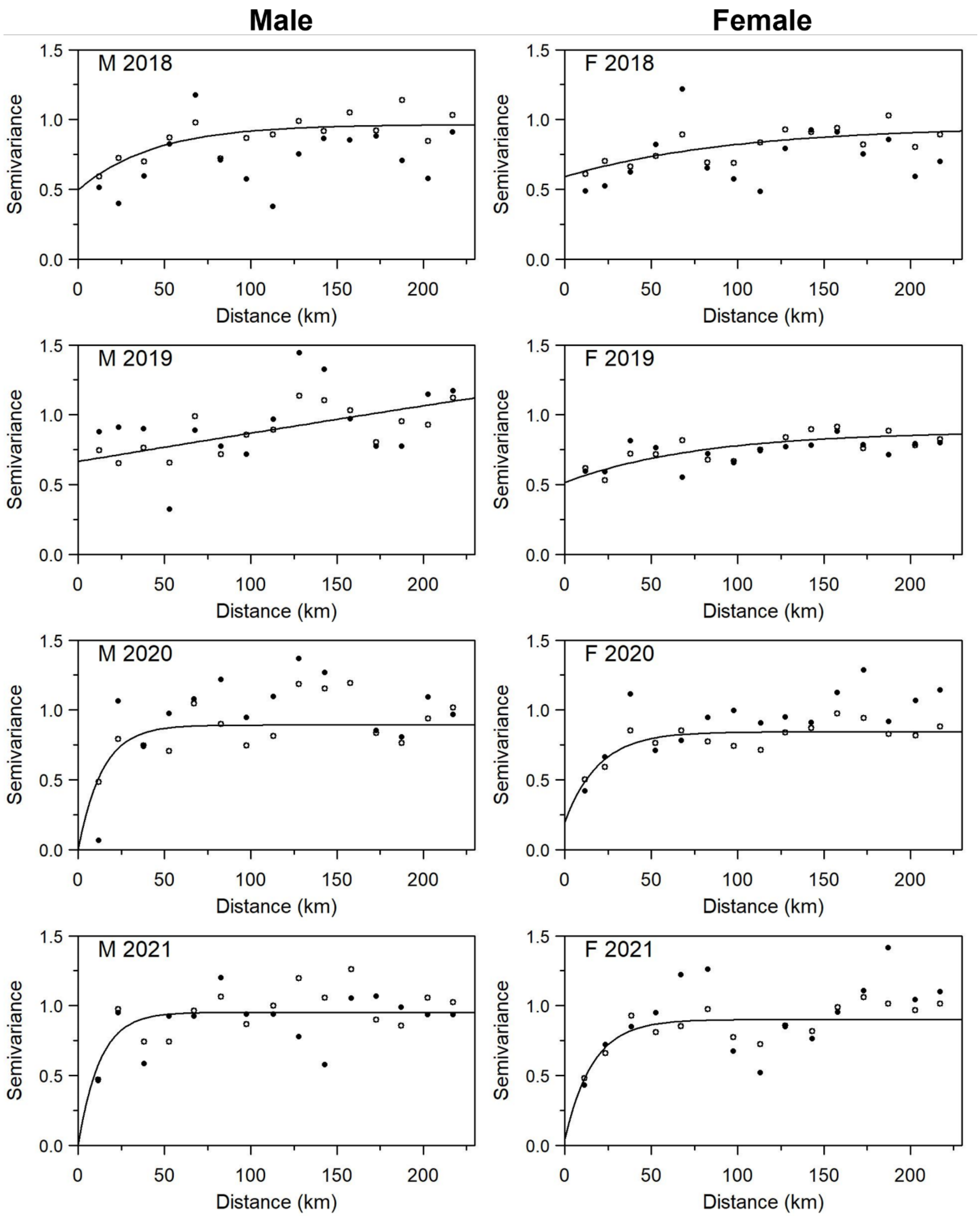


Figure 45. Isotropic variograms of the biomasses (kg/km²) for the years 2018 to 2021. Filled circles: current year. Open circles: mean over three years. Curve: variogram adjusted on the 3 year mean.

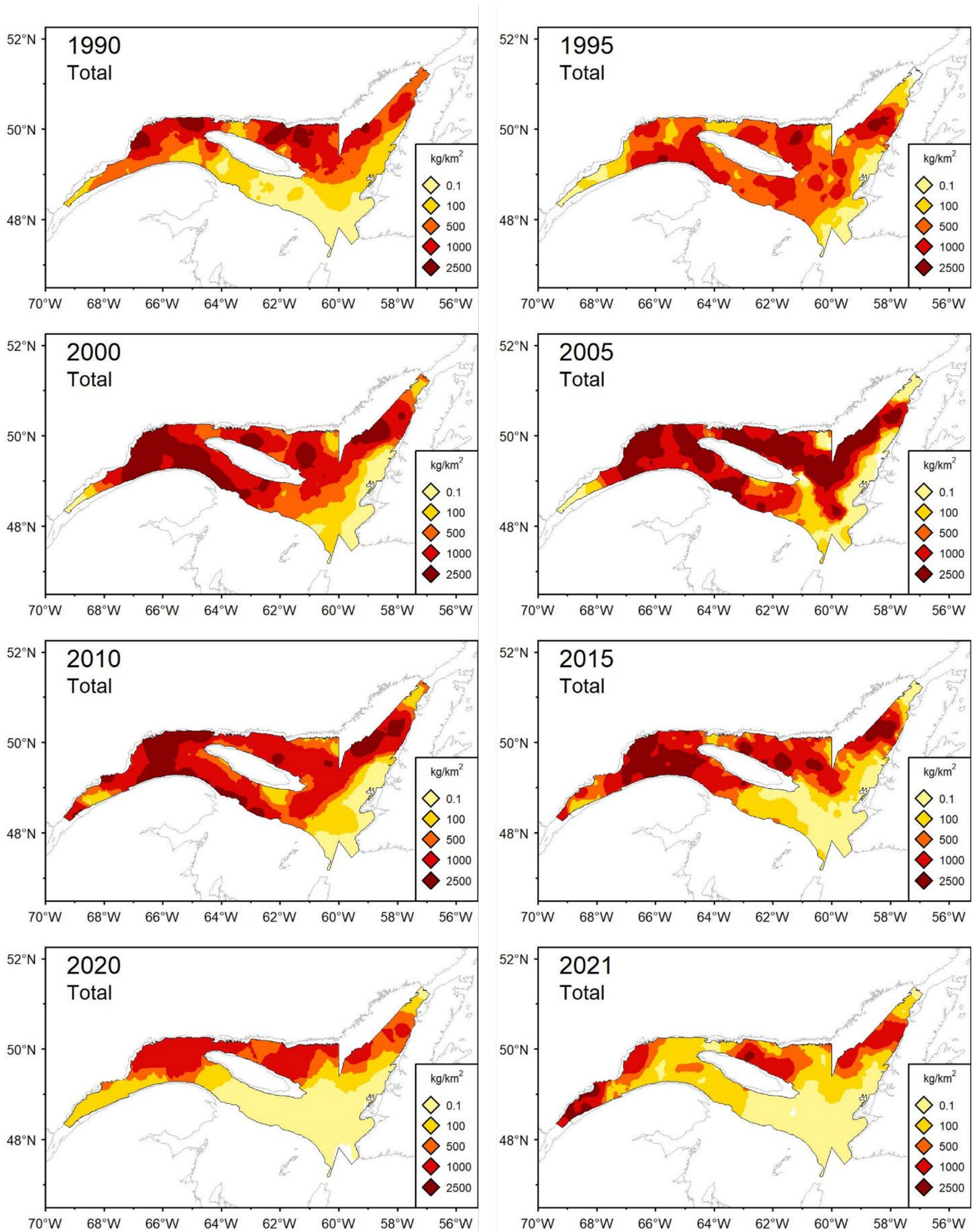


Figure 46. Distribution of the biomass (kg/km²) obtained by kriging for years 1990, 1995, 2000, 2005, 2010, 2015, 2020 and 2021.

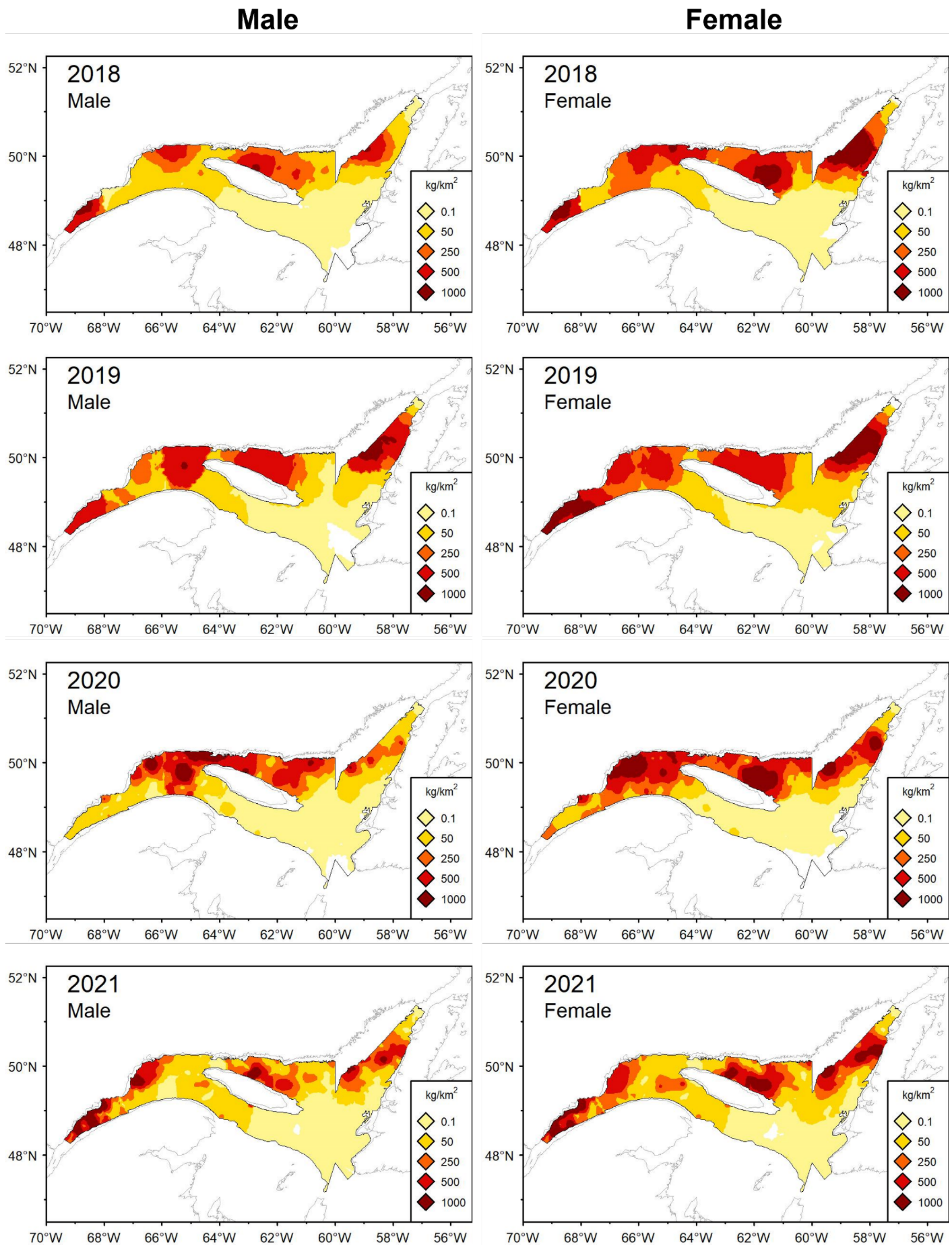
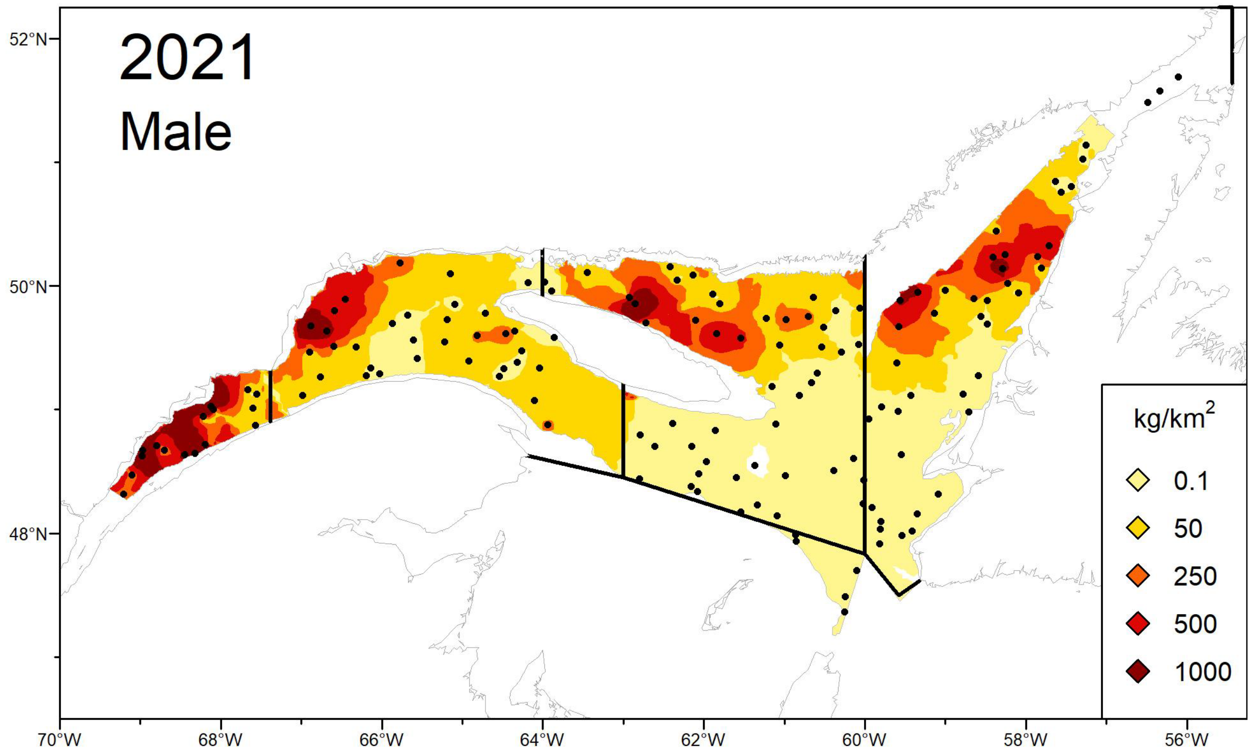


Figure 47. Distribution of the biomass (kg/km²) obtained by kriging from 2018 to 2021 for males and females.



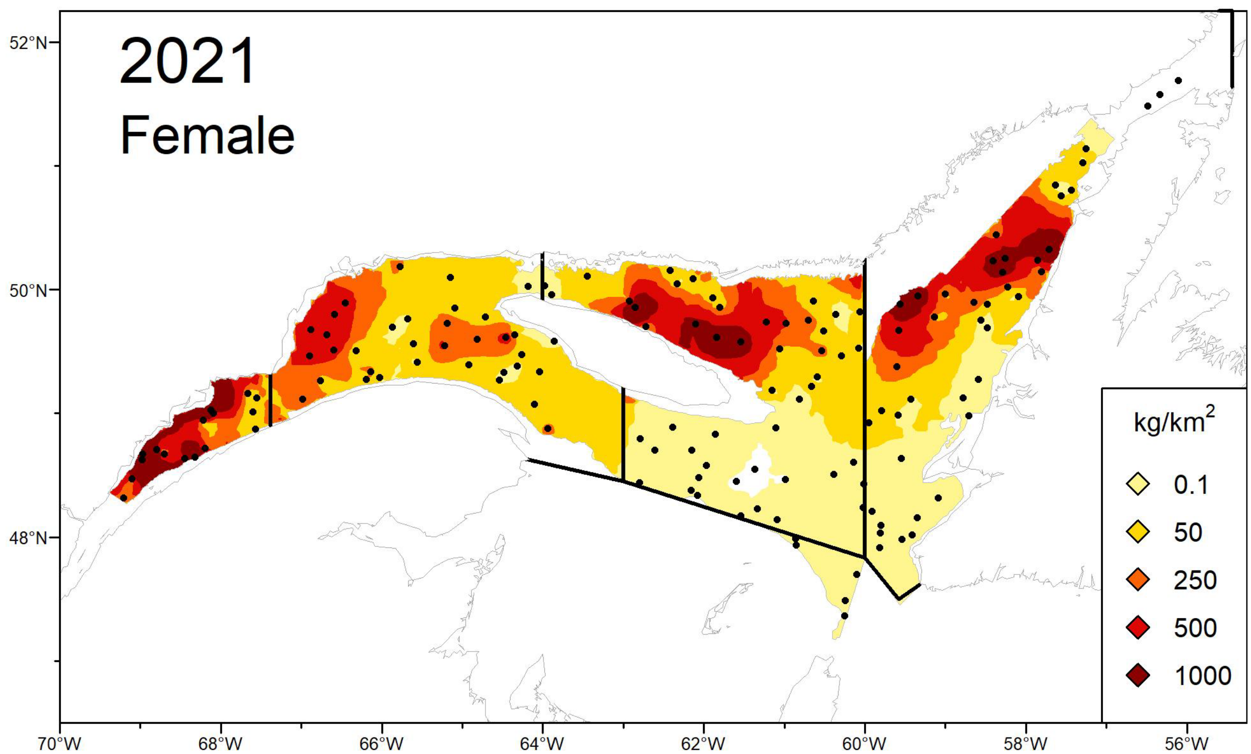


Figure 48. Distribution of the biomass (kg/km²) obtained by kriging in 2021 for males and females. The dots represent the sampled tows.

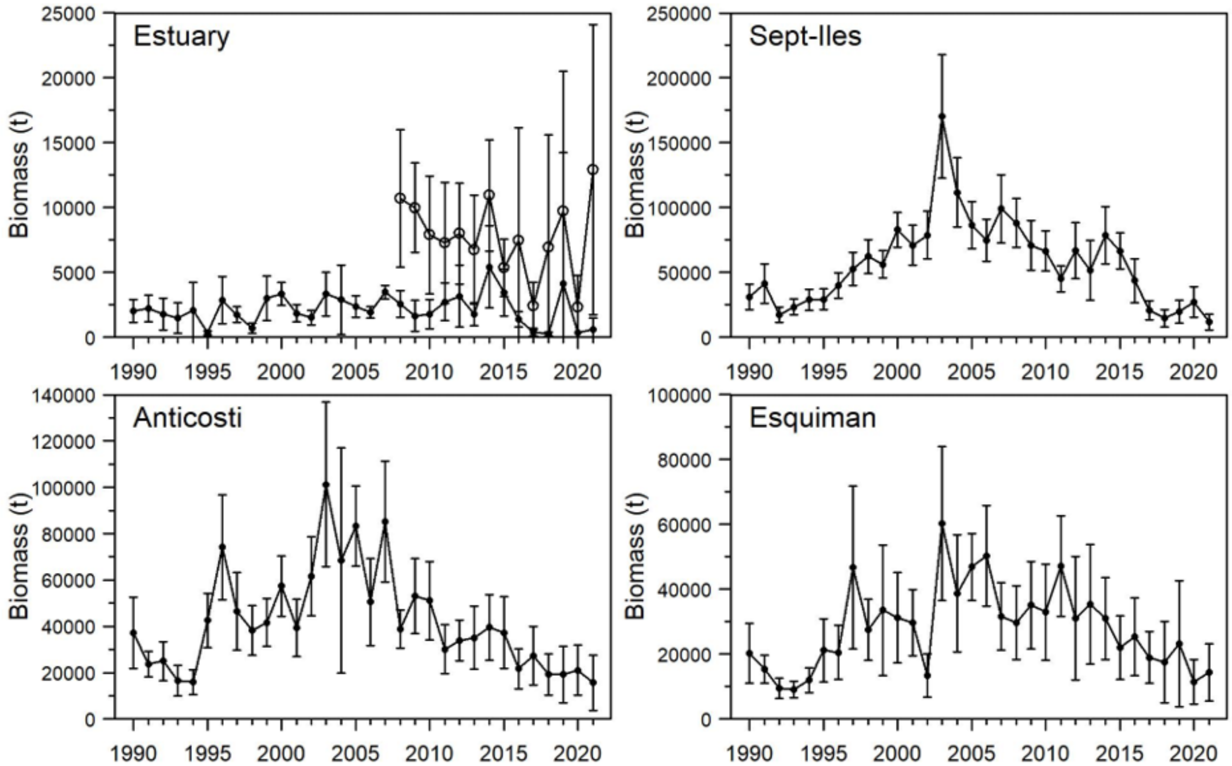


Figure 49. Biomass (in ton) by fishing area and by year. The open circles from 2008 to 2021 show the results obtained when adding strata in shallow waters (37-183 m) of the estuary. Error bars indicate the 95% confidence interval.

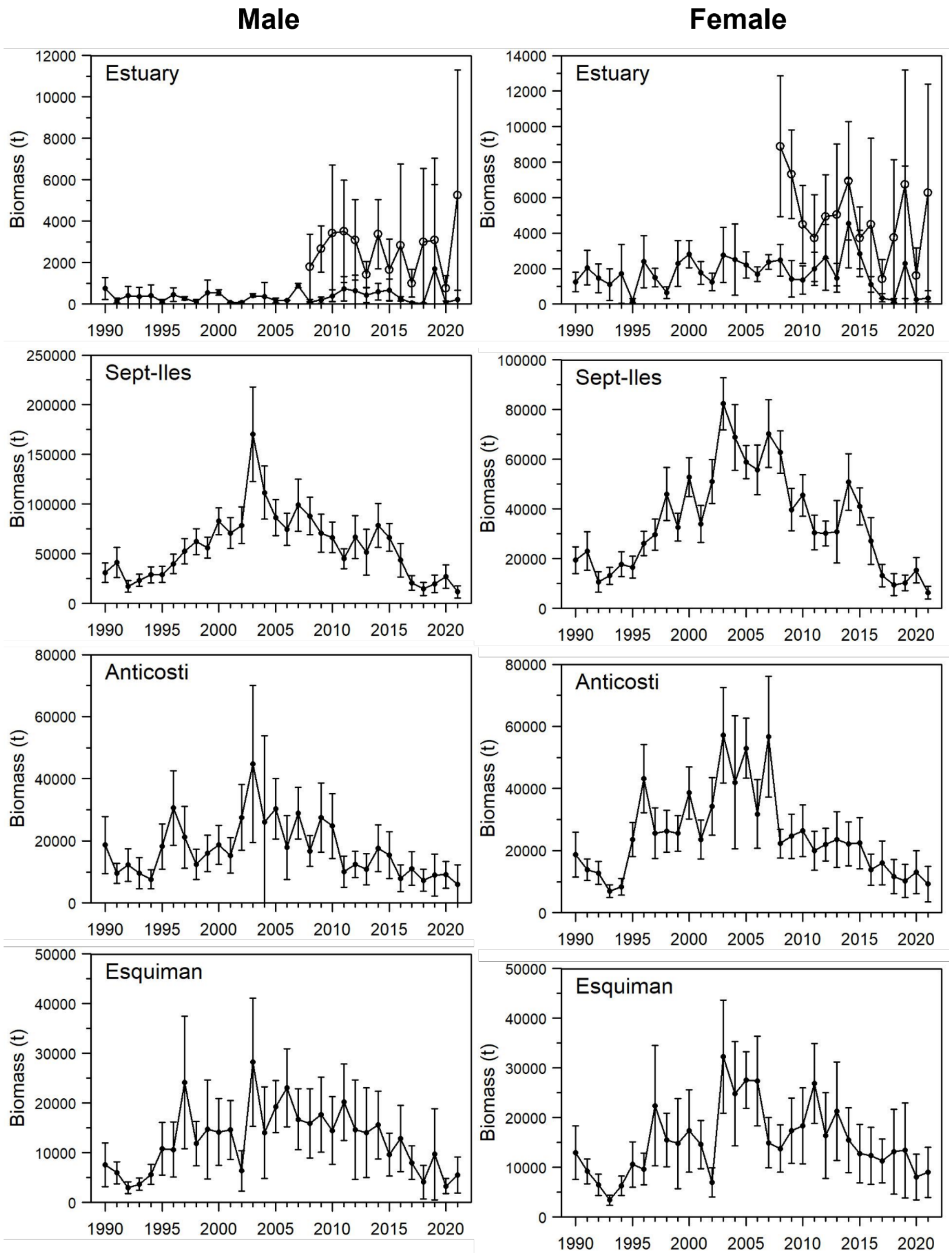


Figure 50. Biomass (in ton) by fishing area and by year, for males and females. The open circles from 2008 to 2021 show the results obtained when adding strata in shallow waters (37-183 m) of the estuary. Error bars indicate the 95% confidence interval.

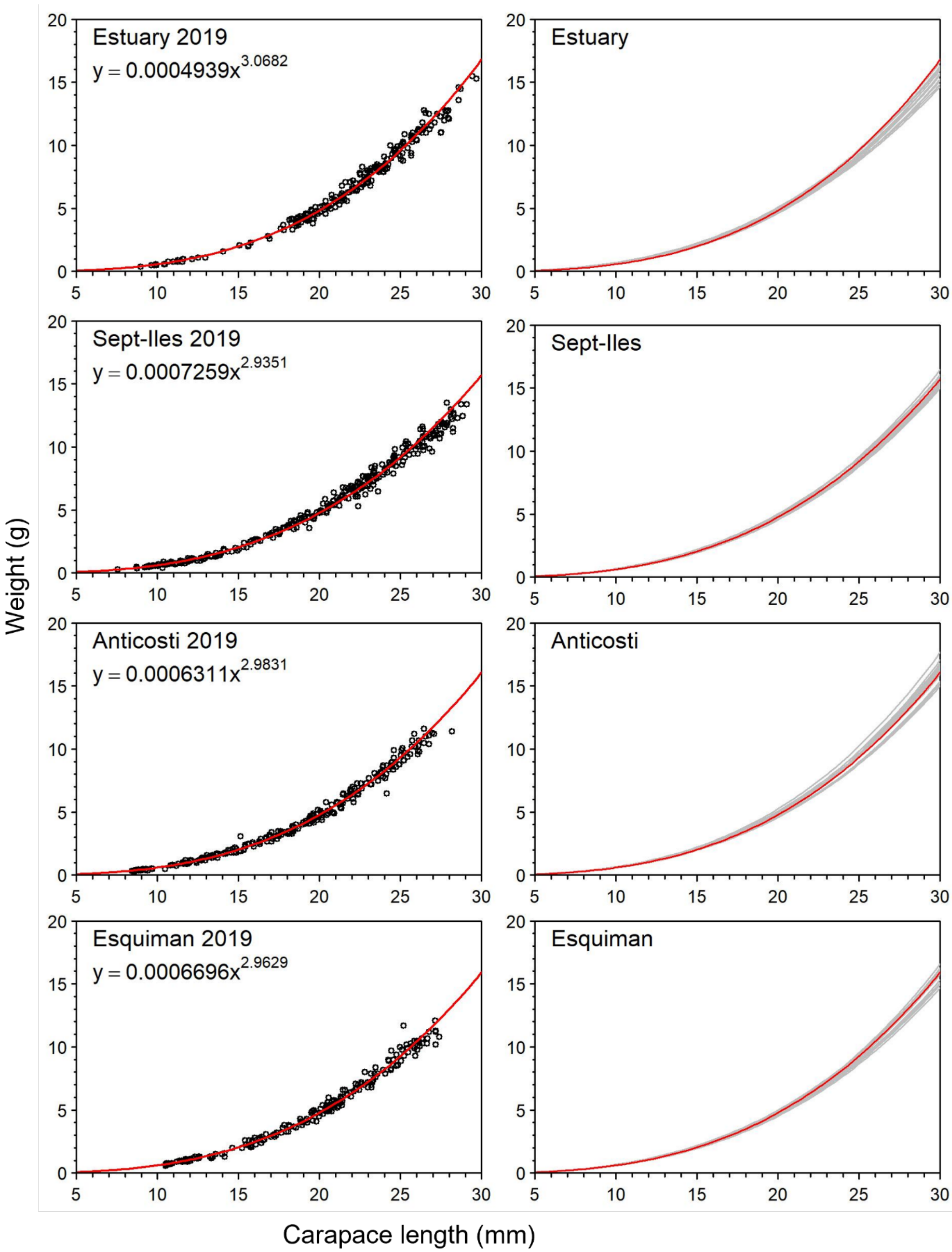


Figure 51. Weight-length relationships by fishing area. In the right panels, the red line represents the year 2019 and the gray lines 1993 and 2005 to 2018.

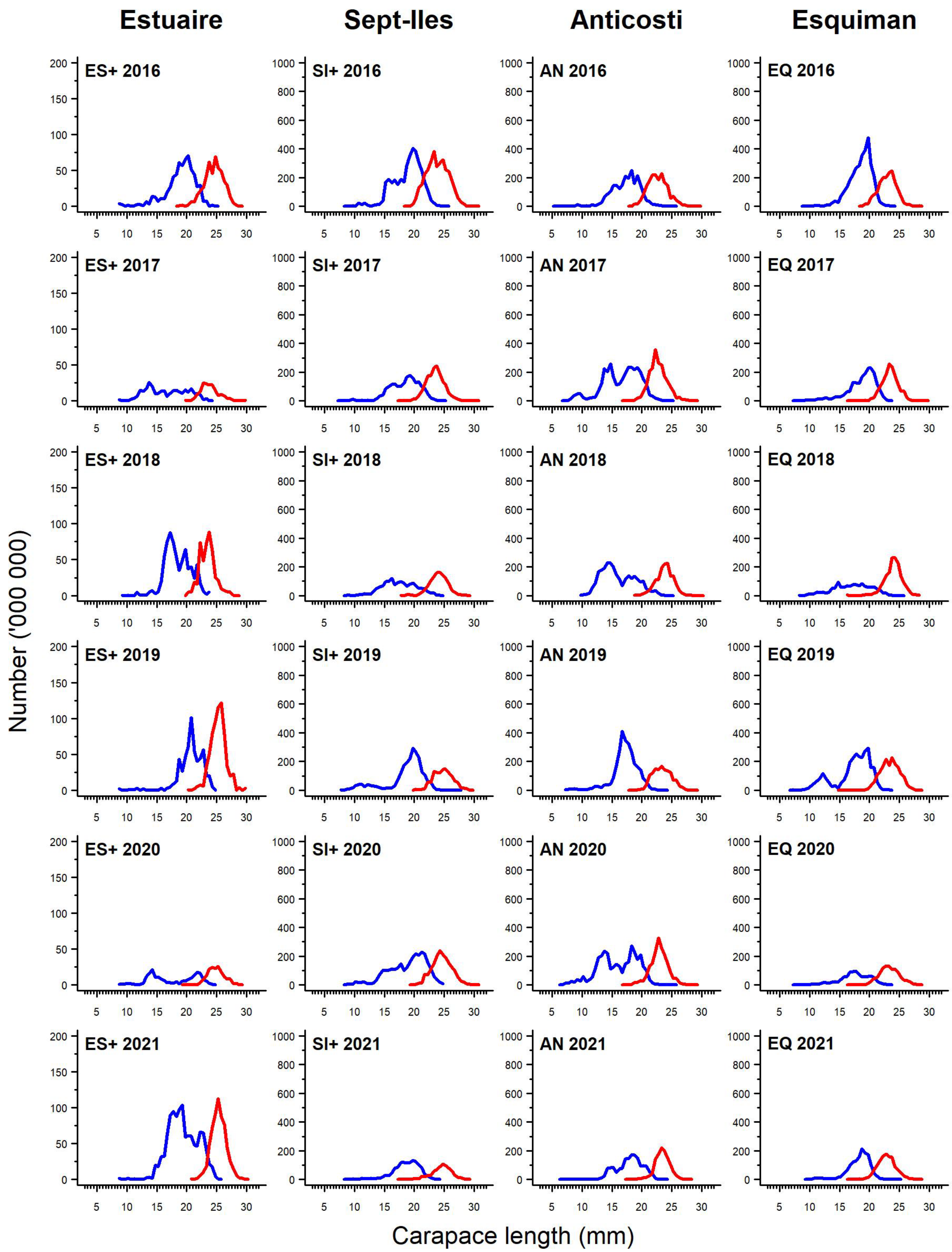


Figure 52. Abundance (in million) by carapace length class (classes of 0.5 mm) by fishing area from 2016 to 2021 for males (in blue) and females (in red). The + placed beside the area shows the results obtained when adding strata in shallow waters (37-183 m) of the estuary.

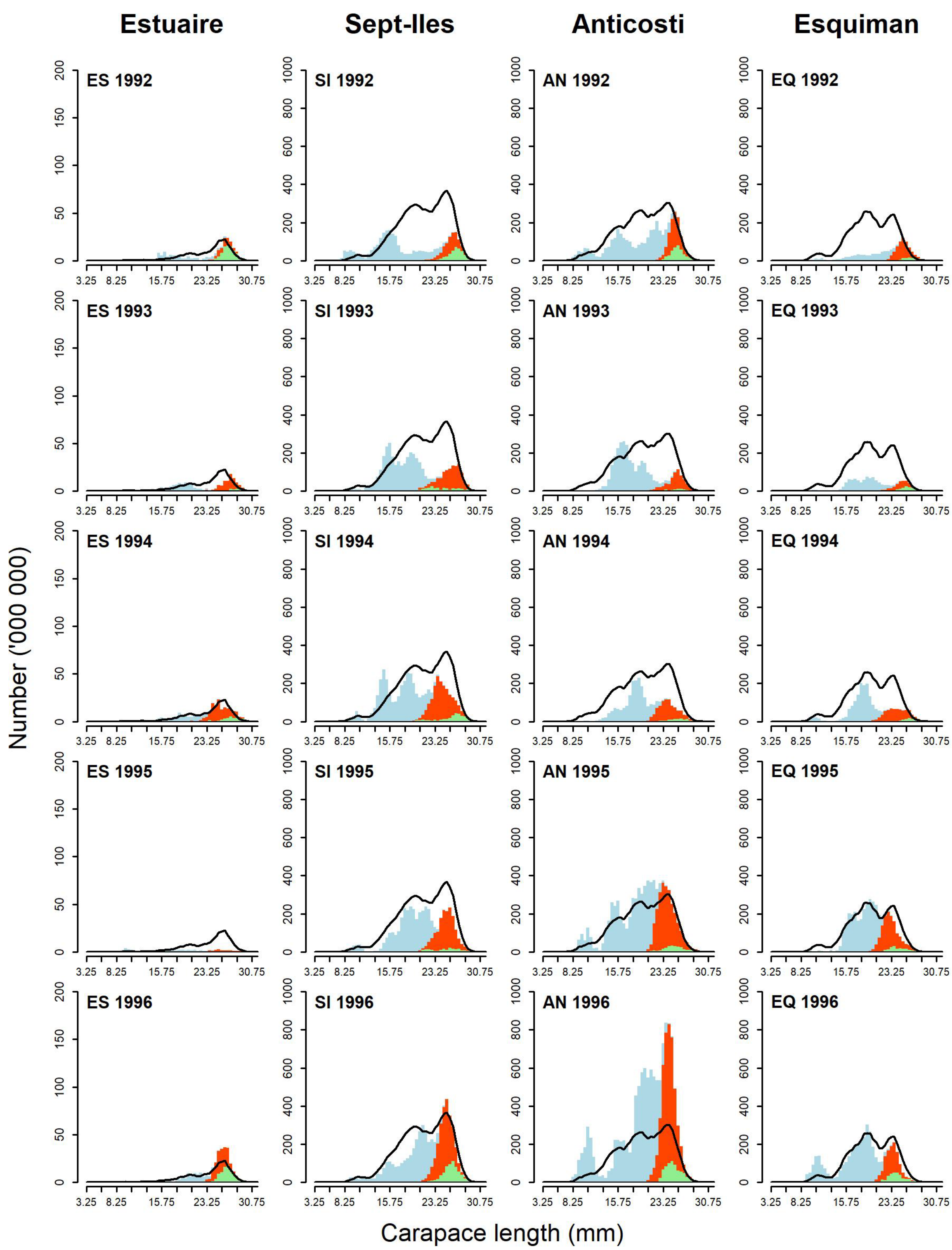


Figure 53. Abundance (in million) by carapace length class (classes of 0.5 mm) by fishing area for males (in blue), primiparous females (in red), multiparous females (in green) and females (in pink, 2001 to 2008 period). The straight line indicates the average for 1990-2020 or 2008-2020 if a + is placed beside the area. The + placed beside the area shows the results obtained when adding strata in shallow waters (37-183 m) of the estuary.

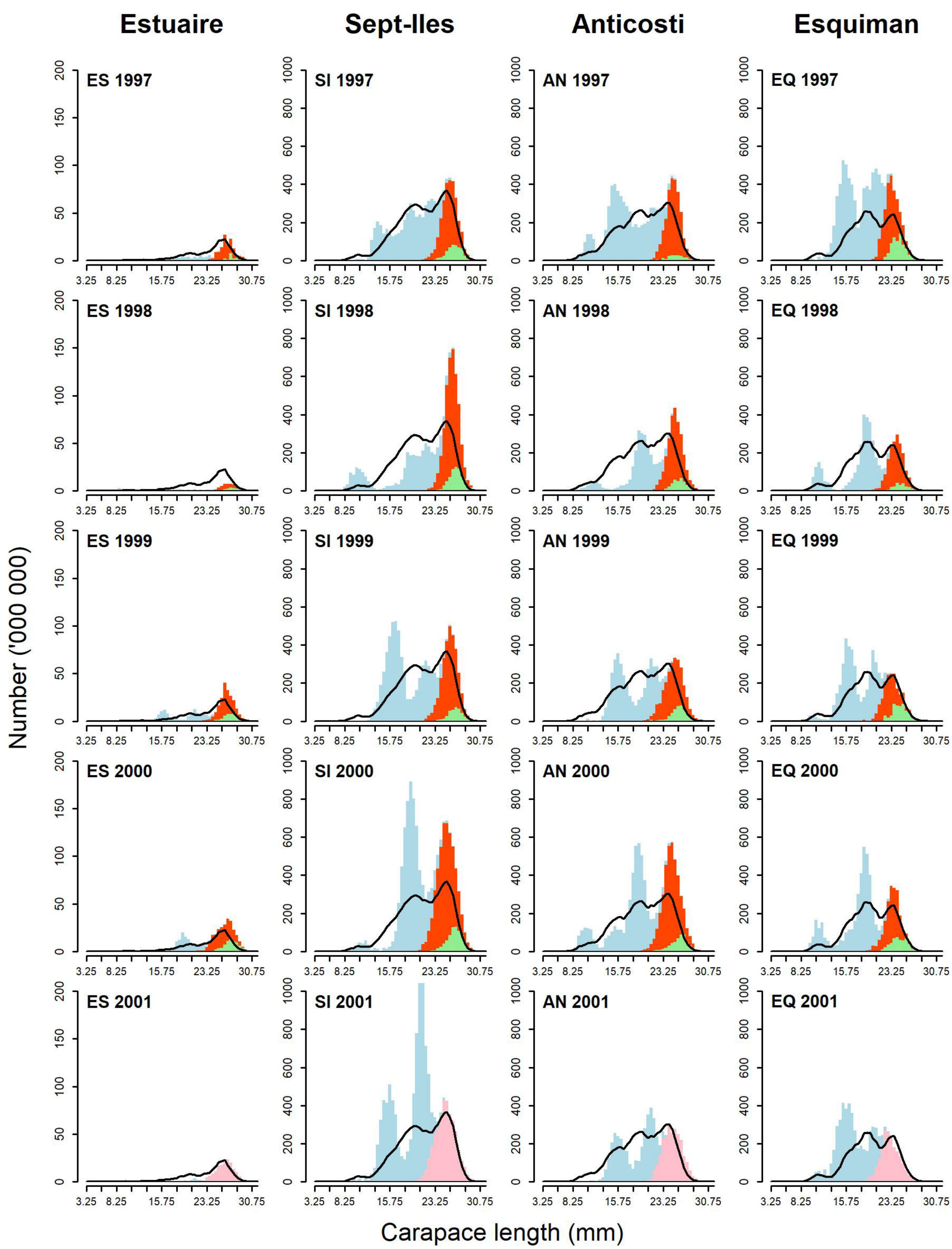


Figure 53. Continued.

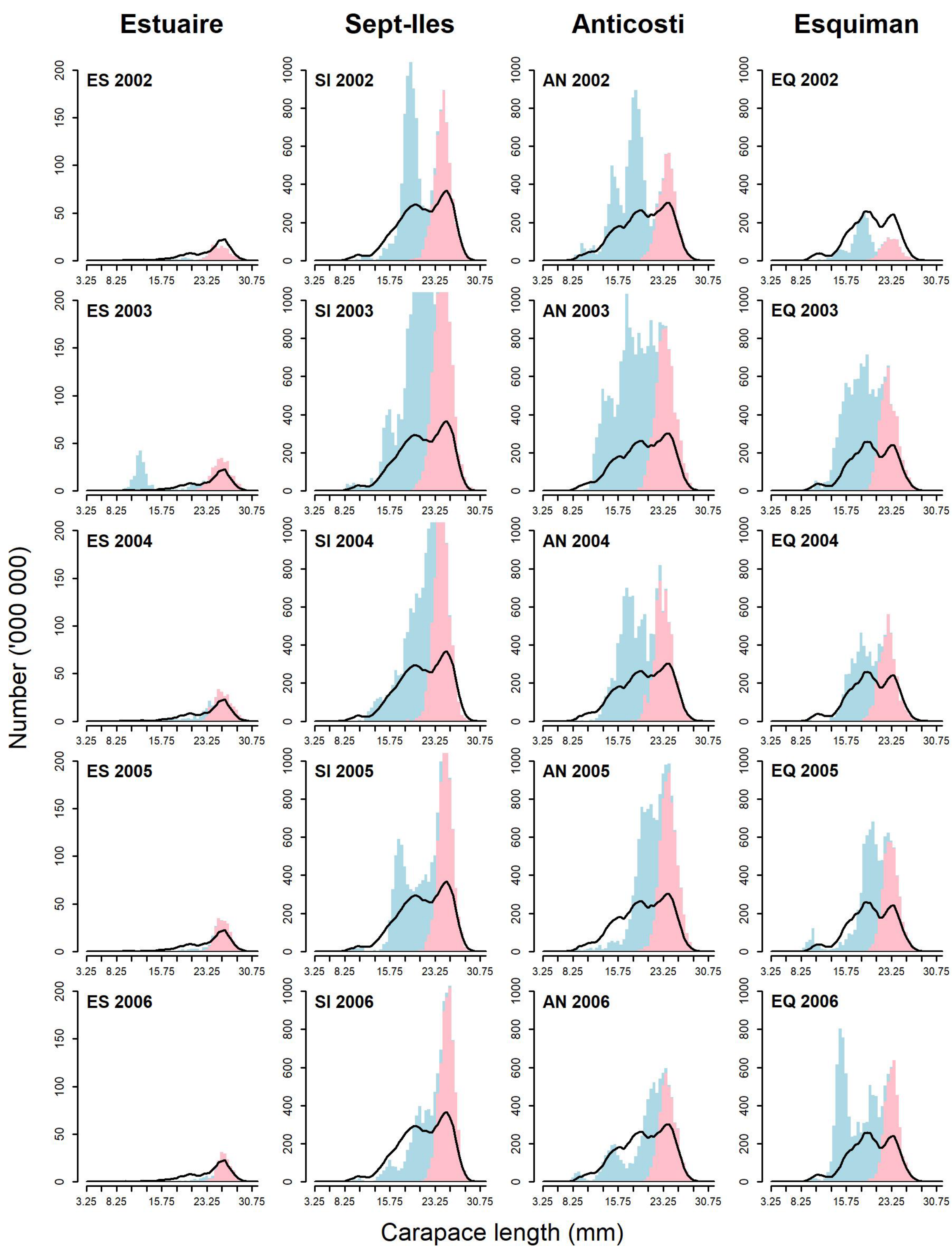


Figure 53. Continued.

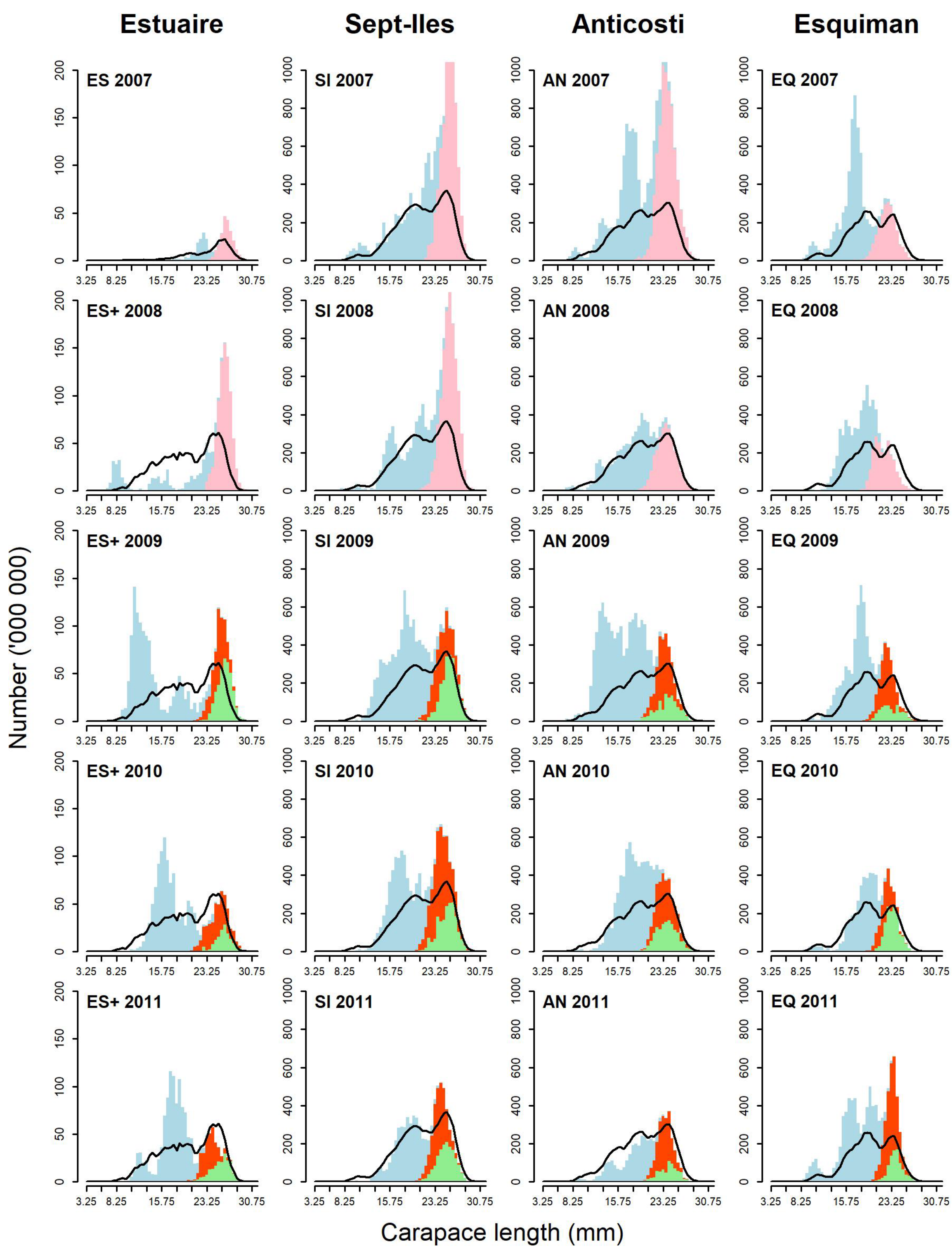


Figure 53. Continued.

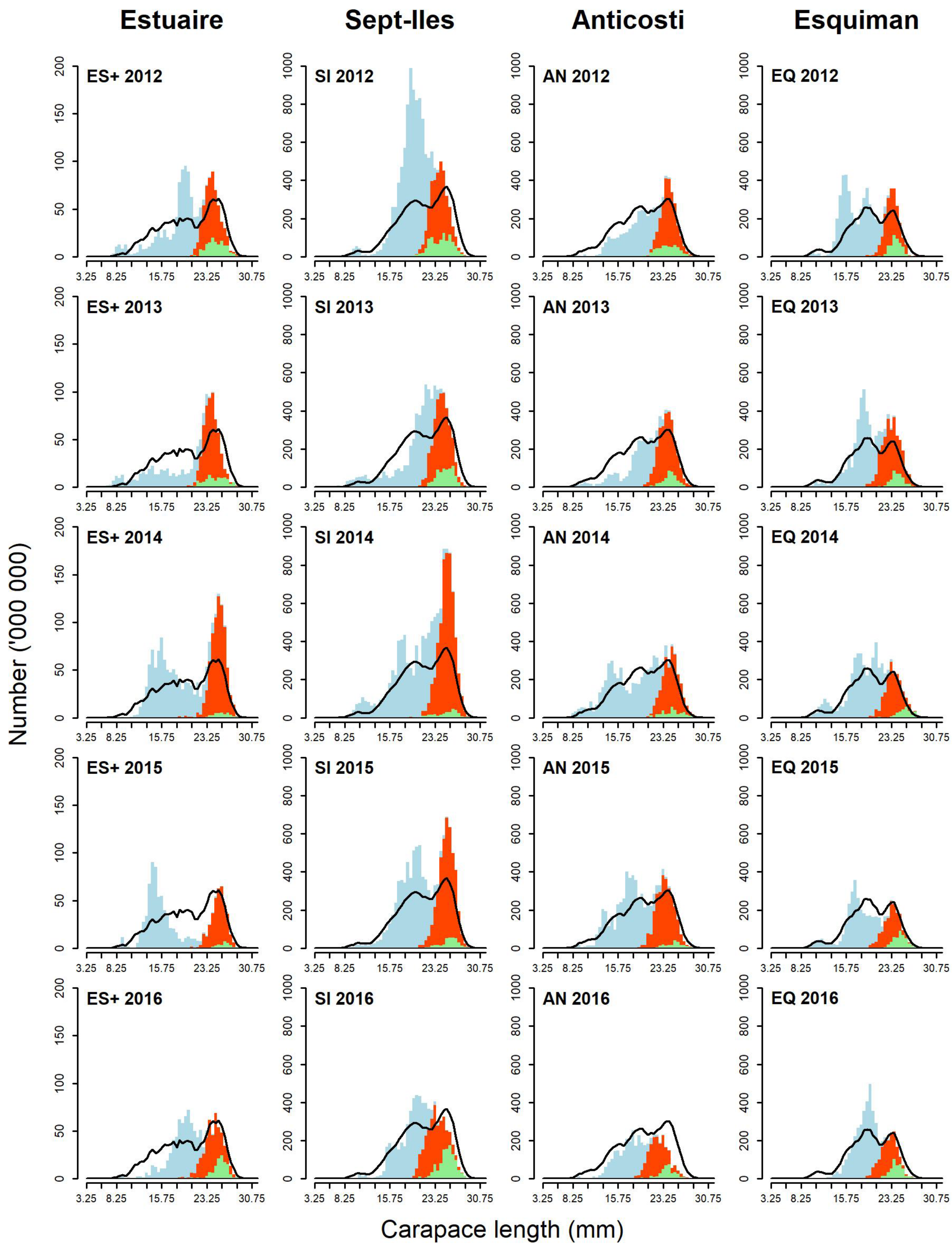


Figure 53. Continued.

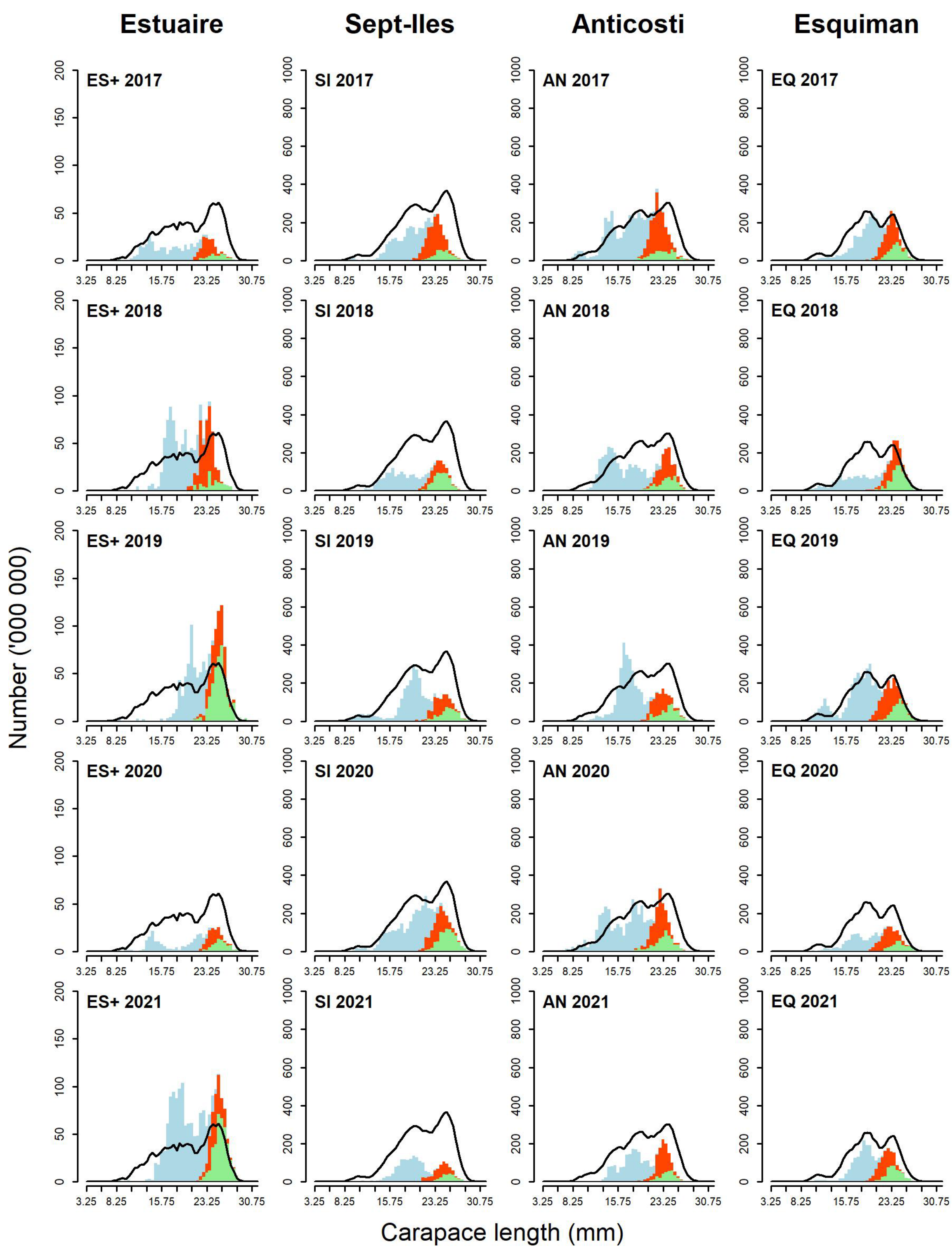


Figure 53. Continued.

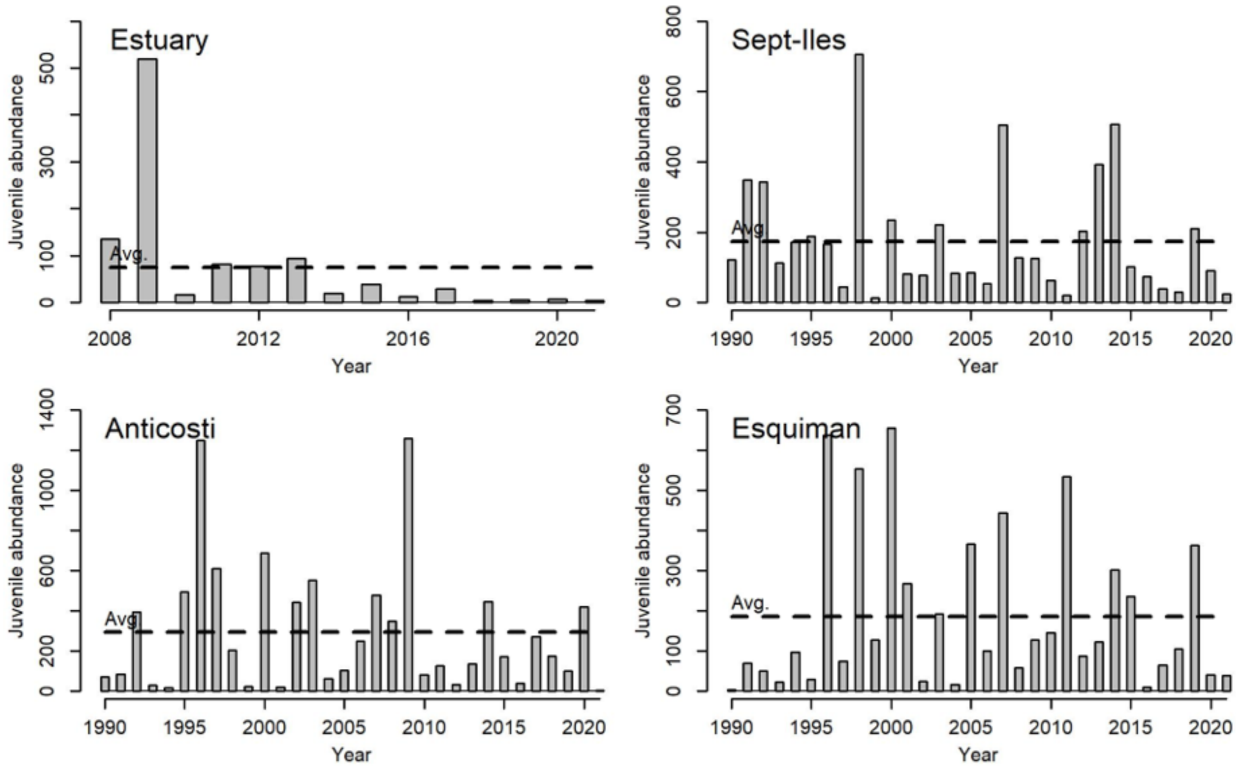


Figure 54. Juvenile abundance (in million) by fishing area and by year. Results for Estuary were obtained with adding strata in shallow waters (37-183 m). The dashed horizontal line corresponds to the average of the 2008-2020 or 1990-2020 series, depending on the fishing area.

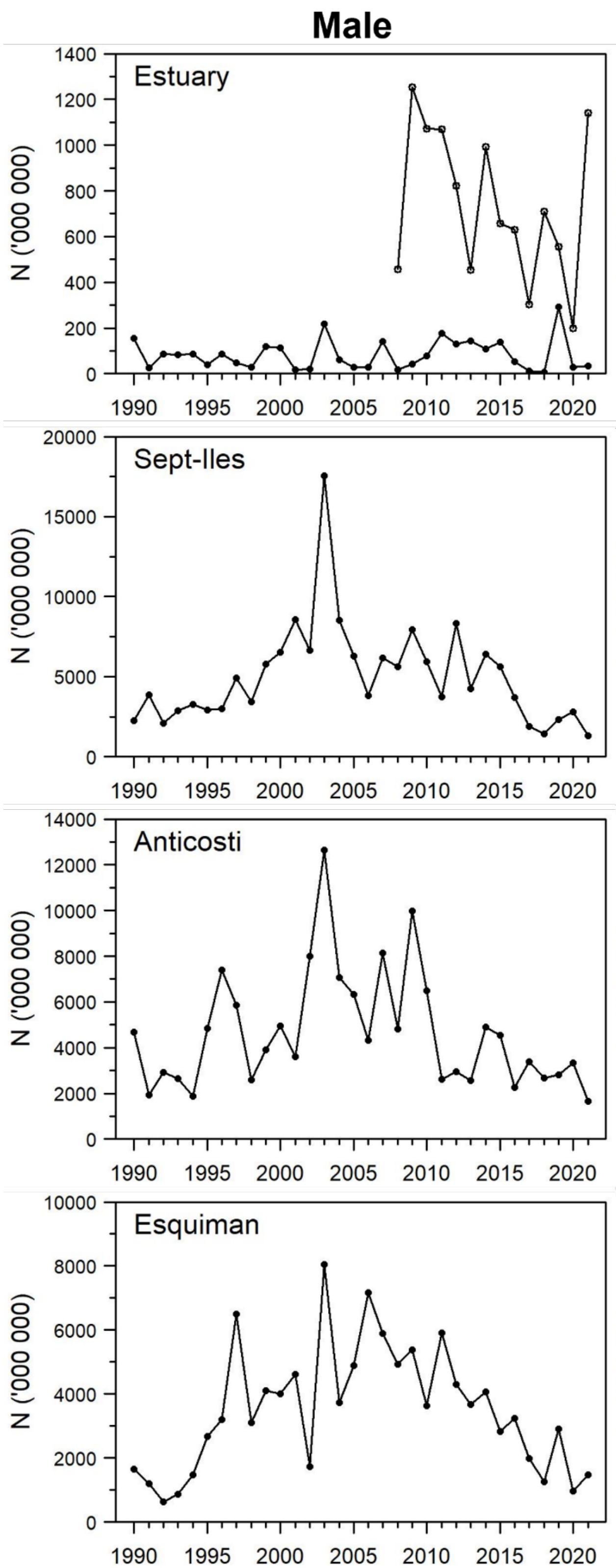


Figure 55. Abundance (in million) by fishing area and by year, for males and females. The open circles from 2008 to 2021 show the results obtained when adding strata in shallow waters (37-183 m) of the estuary.

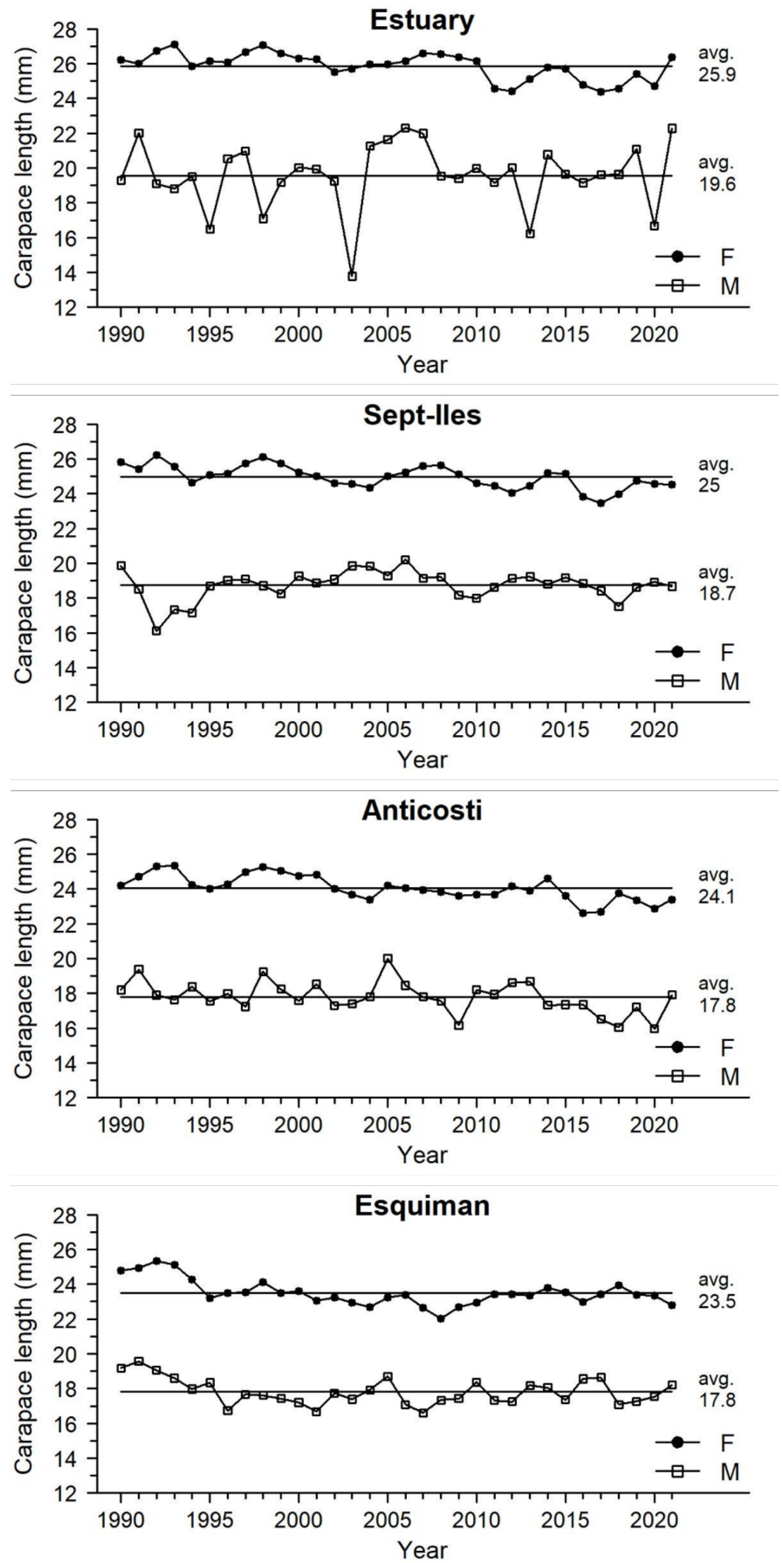


Figure 56. Mean carapace length of male and female shrimp by fishing area in the DFO survey.

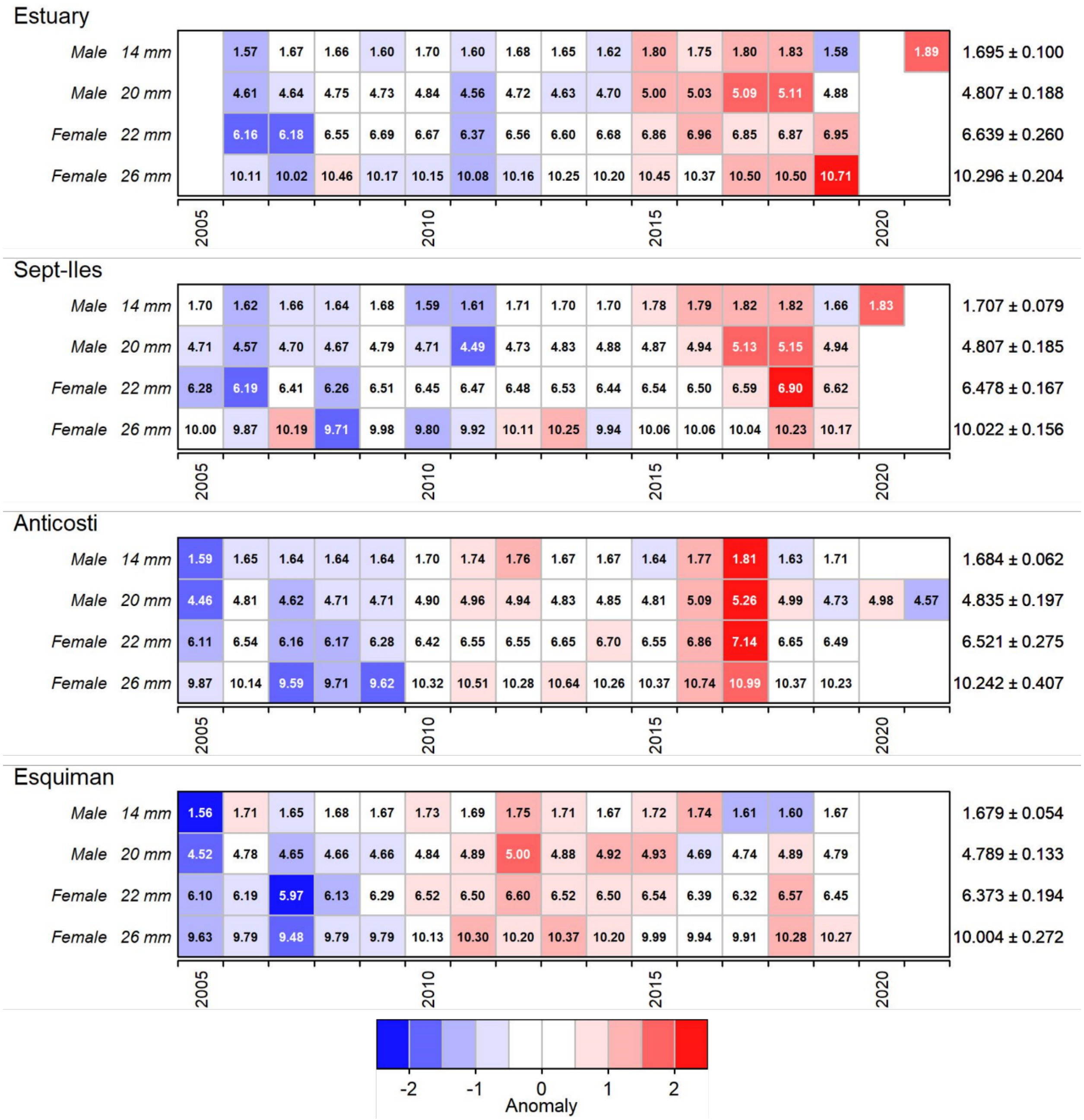


Figure 57. Biomass (kg per tow) of the main predators of northern shrimp in the northern Gulf of St. Lawrence. The color code represents the value of the anomaly, which is the difference between the weight the CPUE and the average of the time series divided by the standard deviation of that average for each species.

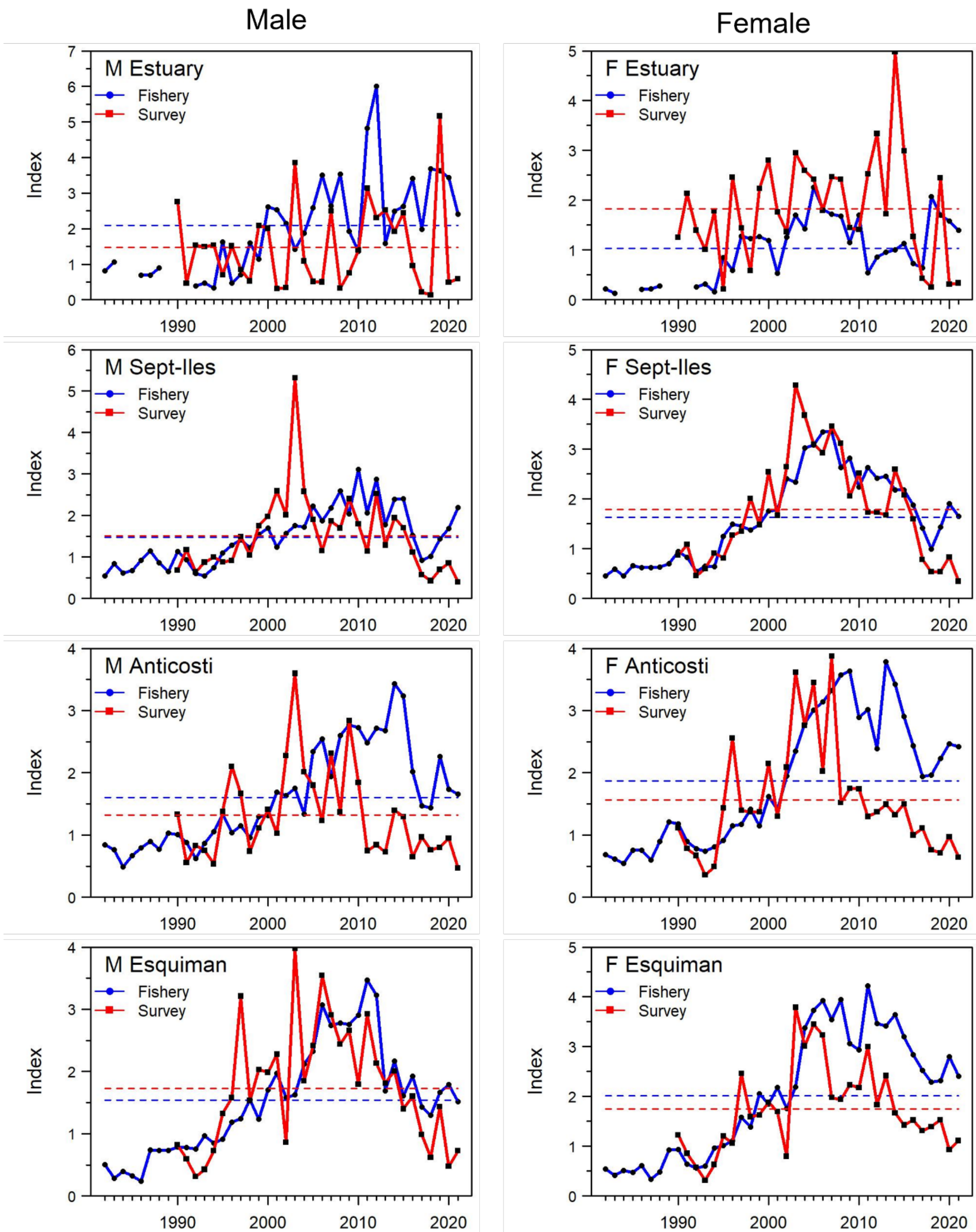


Figure 58. Standardized indices from the main indicator of stock status, which is the abundance of male and female shrimp from the DFO survey and the catch per unit effort of male and female shrimp in the summer commercial fishery. The horizontal lines represent the average of the time series.

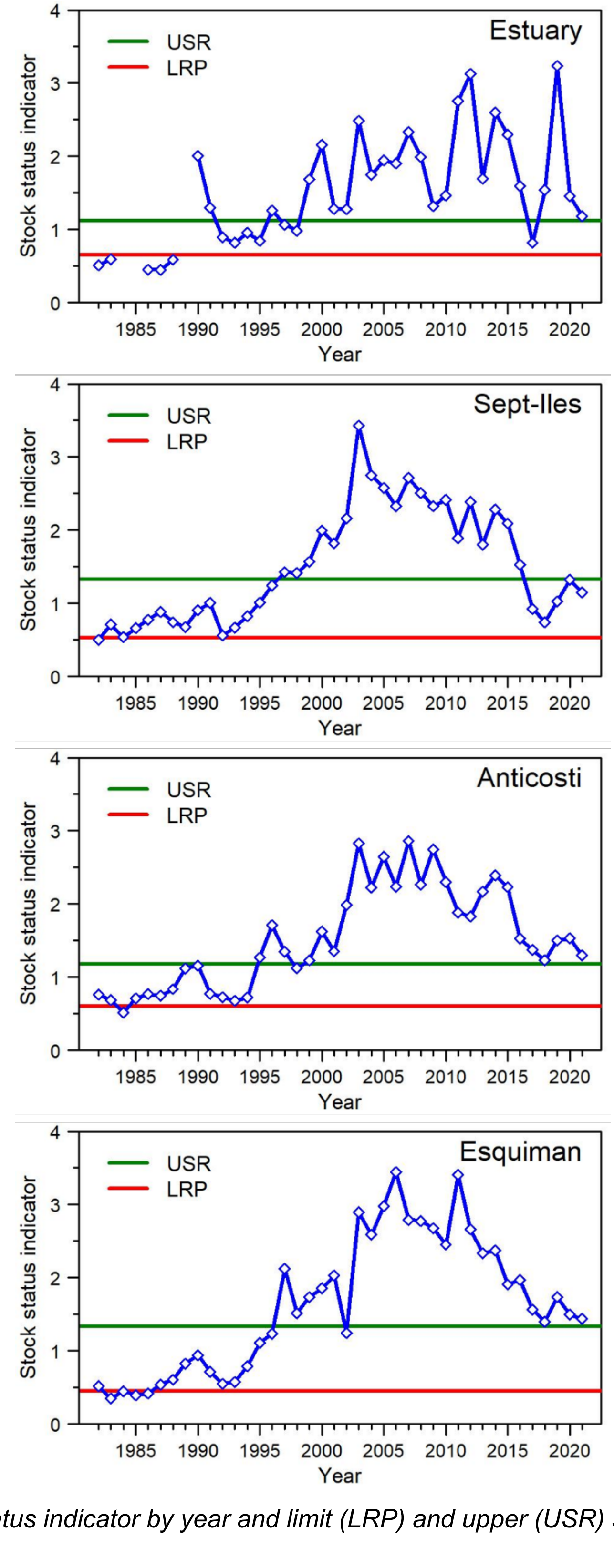


Figure 59. Main stock status indicator by year and limit (LRP) and upper (USR) stock reference points for each fishing area.

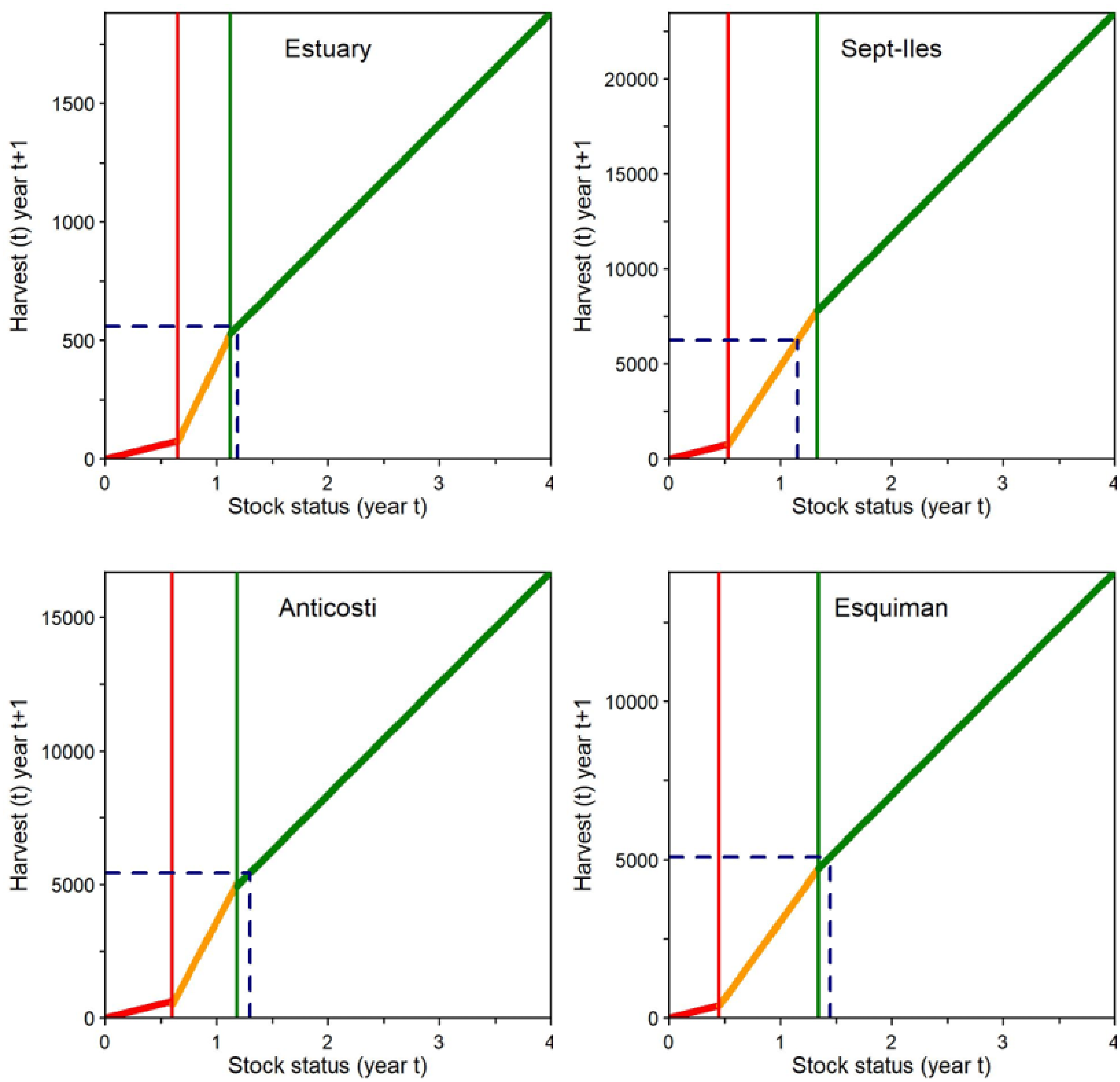


Figure 60. Harvest guidelines by fishing area. The projected harvest for 2022 is shown in view of the main stock indicator in 2021.

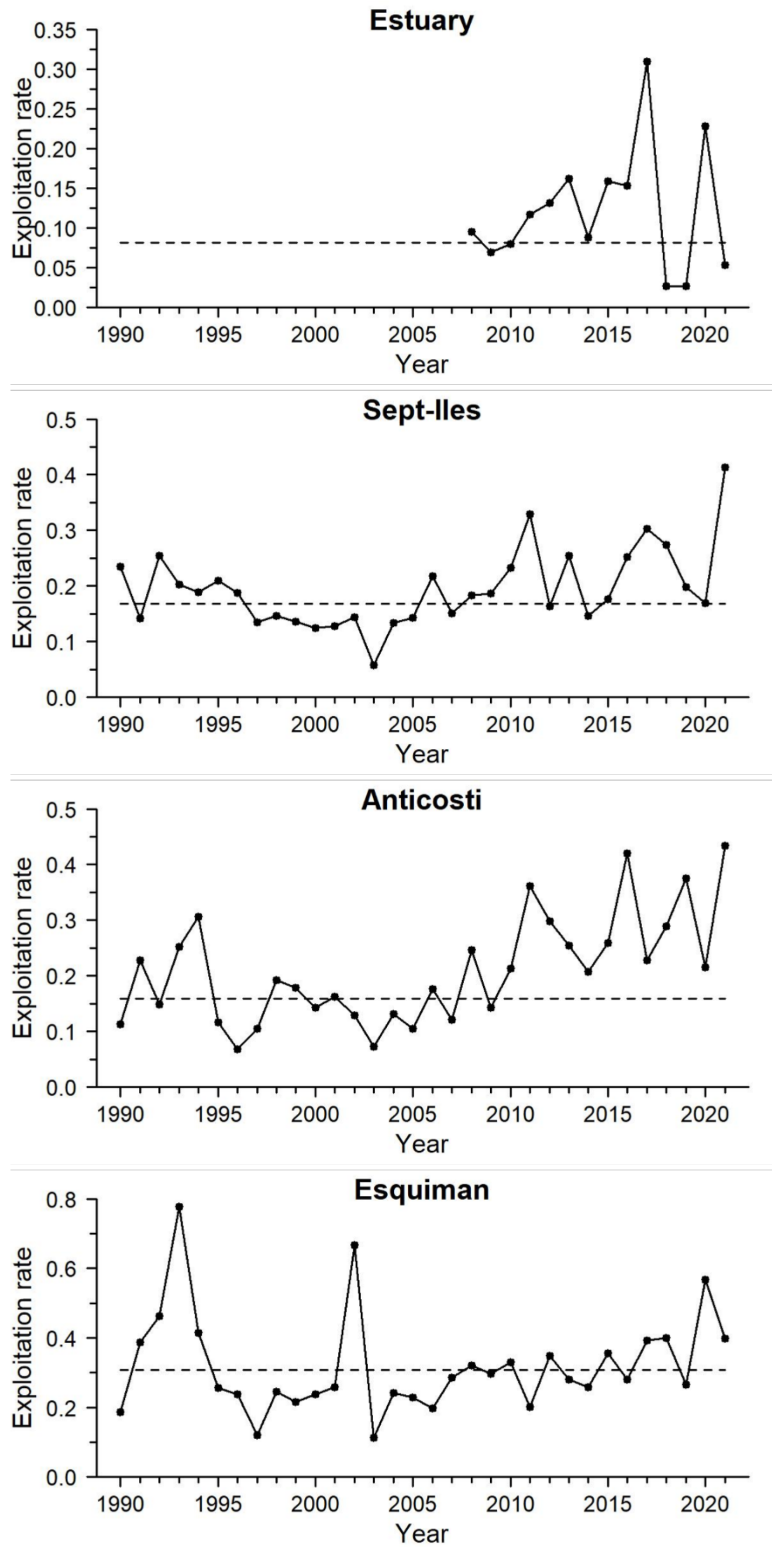
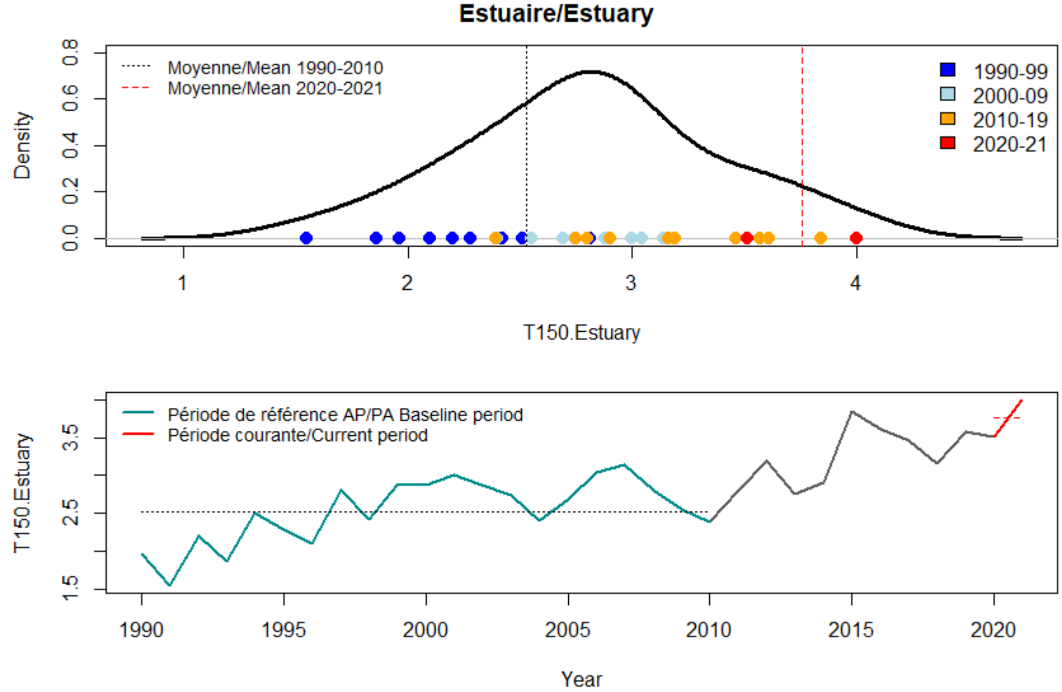


Figure 61. Index of the exploitation rate by fishing area and by year. The solid horizontal line represents the 1990-2010. For Estuary, the index includes shallow strata added in 2008.

A) Estuary



B) Sept-Iles

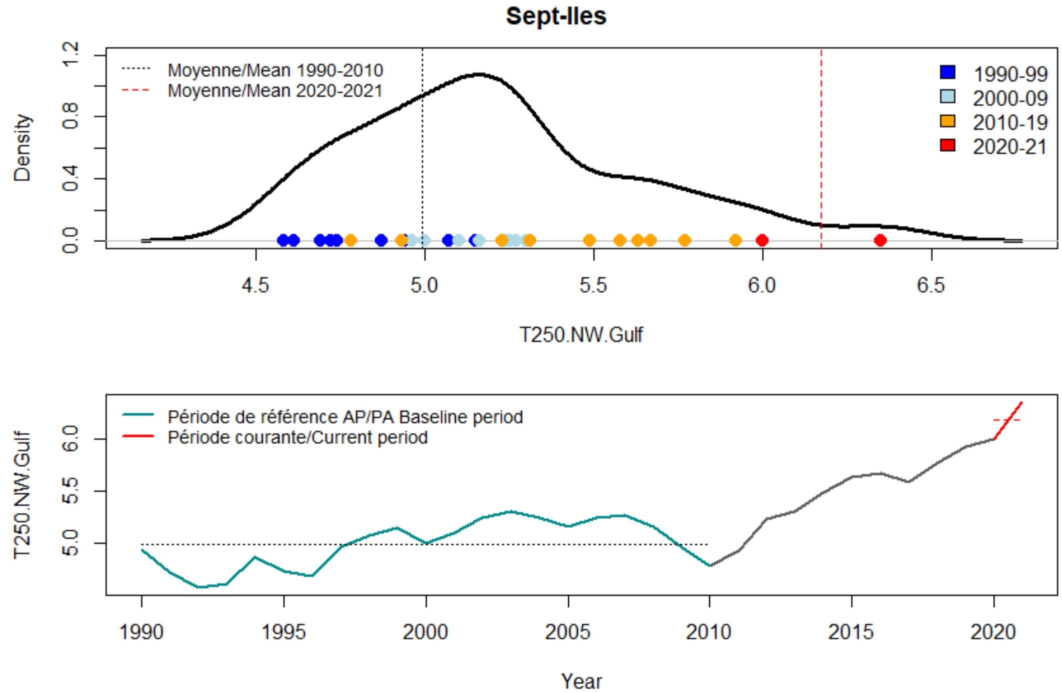
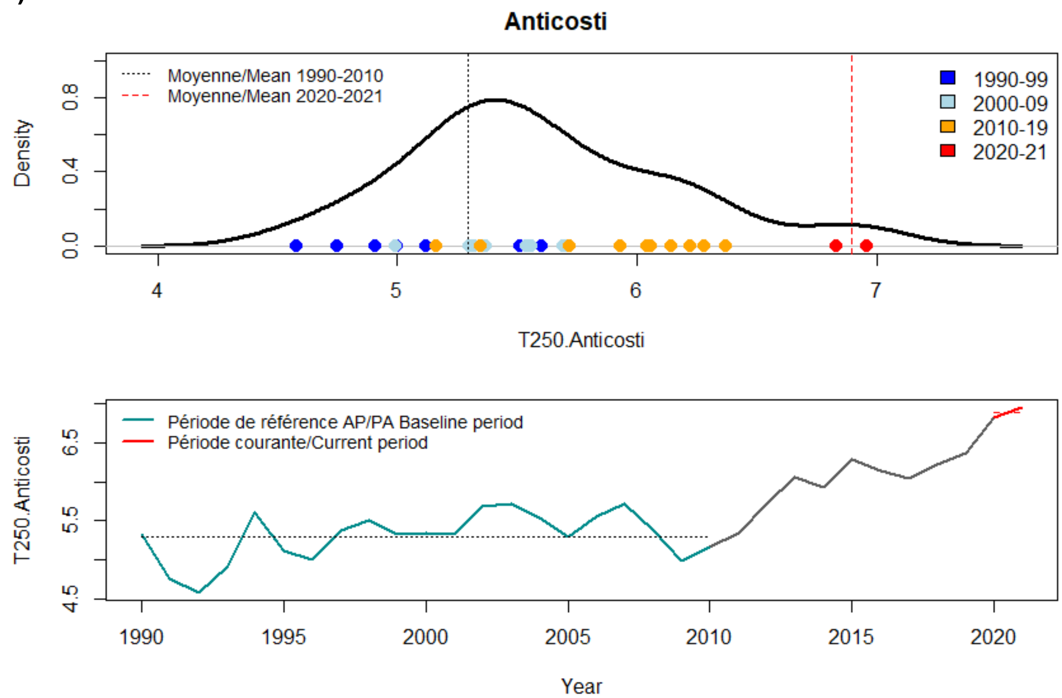


Figure 62. Current state (2020-21) of the environment for the different northern shrimp stock of the GSL (A-D) compared to the conditions observed during the period considered to define the precautionary approach (1990-2010). The water temperature at the depth corresponding to the median value of the shrimp biomass distribution (150 m in the Estuary and 250 m in the other areas, dotted horizontal line) is used as an indicator variable of the state of the environment. For each stock (A-D), the top figure presents the density distribution of temperature values over the period considered for the stock assessment (1990 to 2021), while the bottom figure presents the temporal variations/trends in temperature over the same period.

C) Anticosti



D) Esquiman

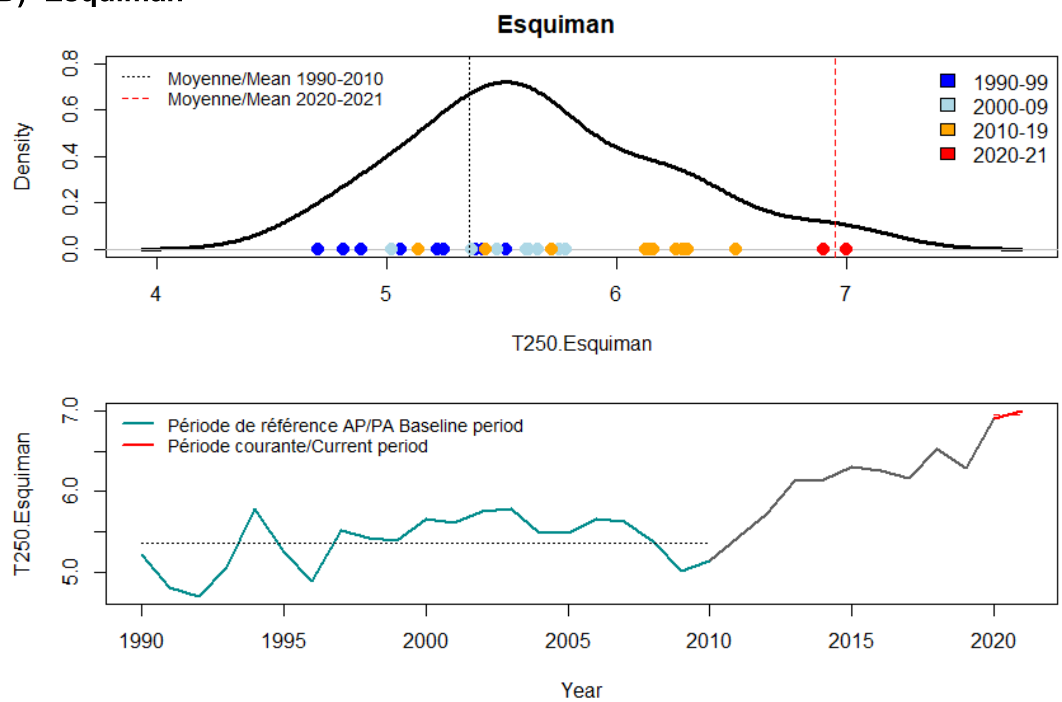


Figure 62. Continued.

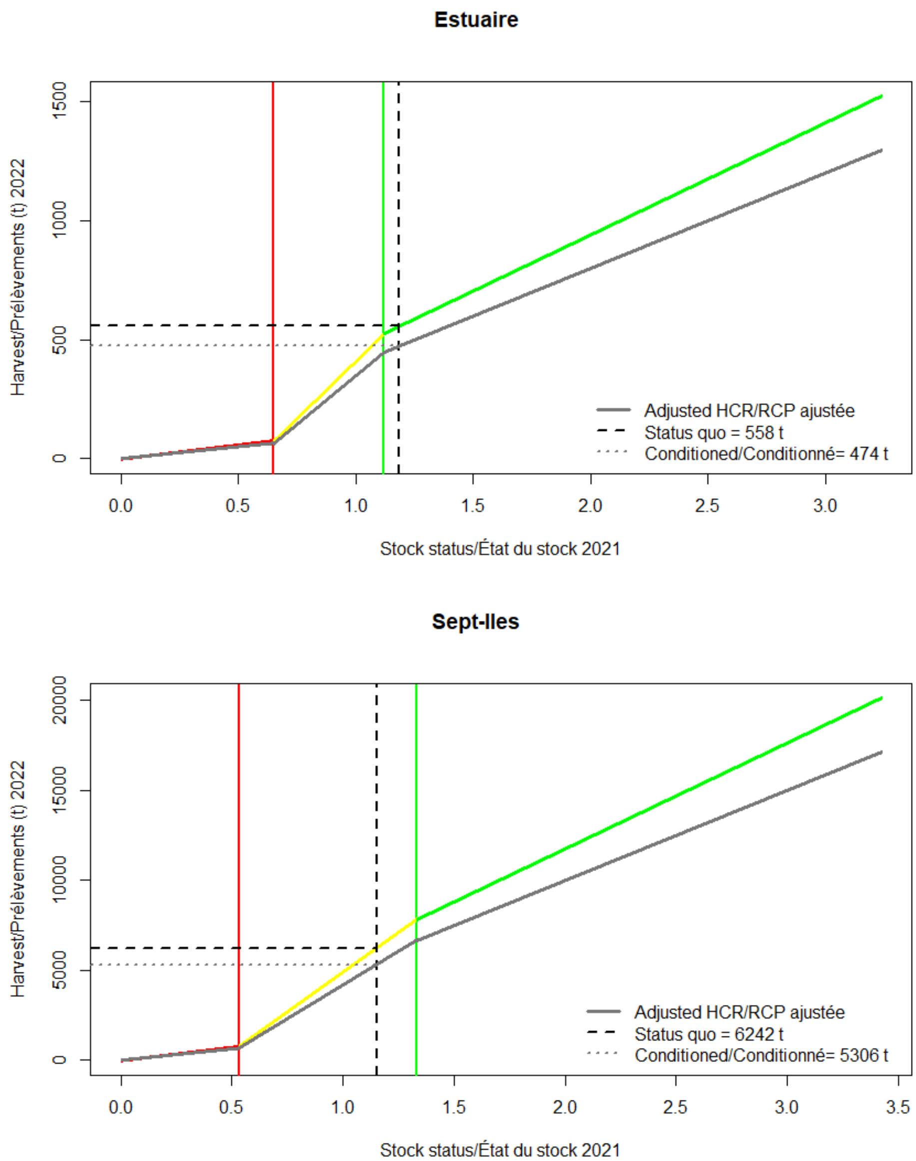
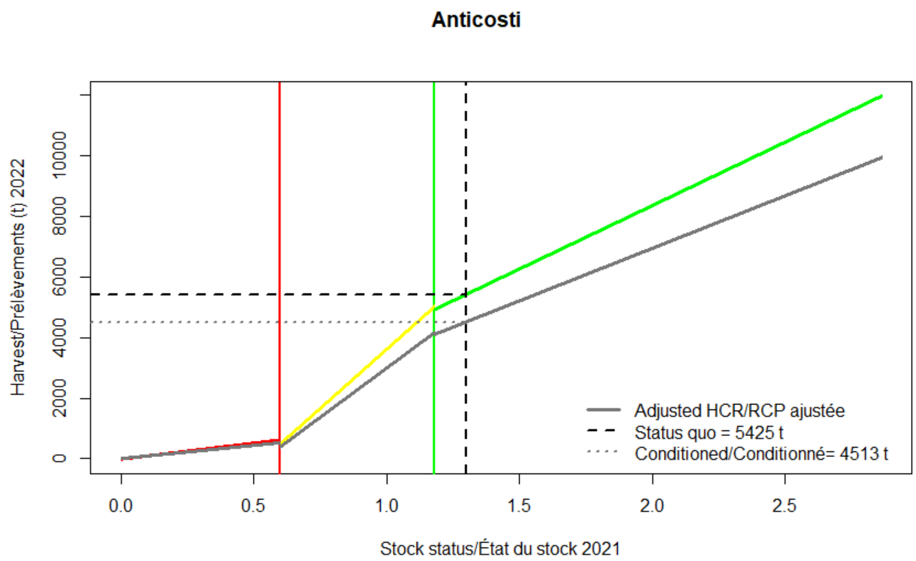


Figure 63. Precautionary approach for GSL northern shrimp stocks. The current harvest control rule (HCR) (red, yellow and green cross line) is used to determine projected harvests in 2022 without considering changes in the environment (status quo). The adjusted HCR for the increase in bottom water temperature (grey cross-sectional line) is obtained by multiplying the current HCR parameters by the environmental conditioning factor (ECF) calculated for each stock (Table 25). The adjusted HCR is used to determine the harvest conditioned on the state of the environment in 2020-21. The vertical lines represent the limit reference point (red line), the upper reference point (green line) and the stock status in 2021 (hatched black line).



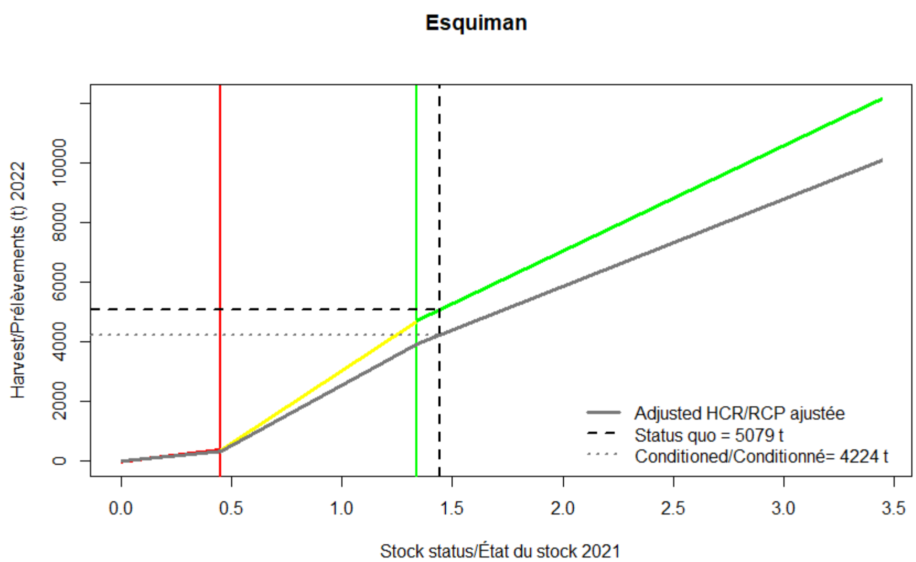


Figure 63. Continued.

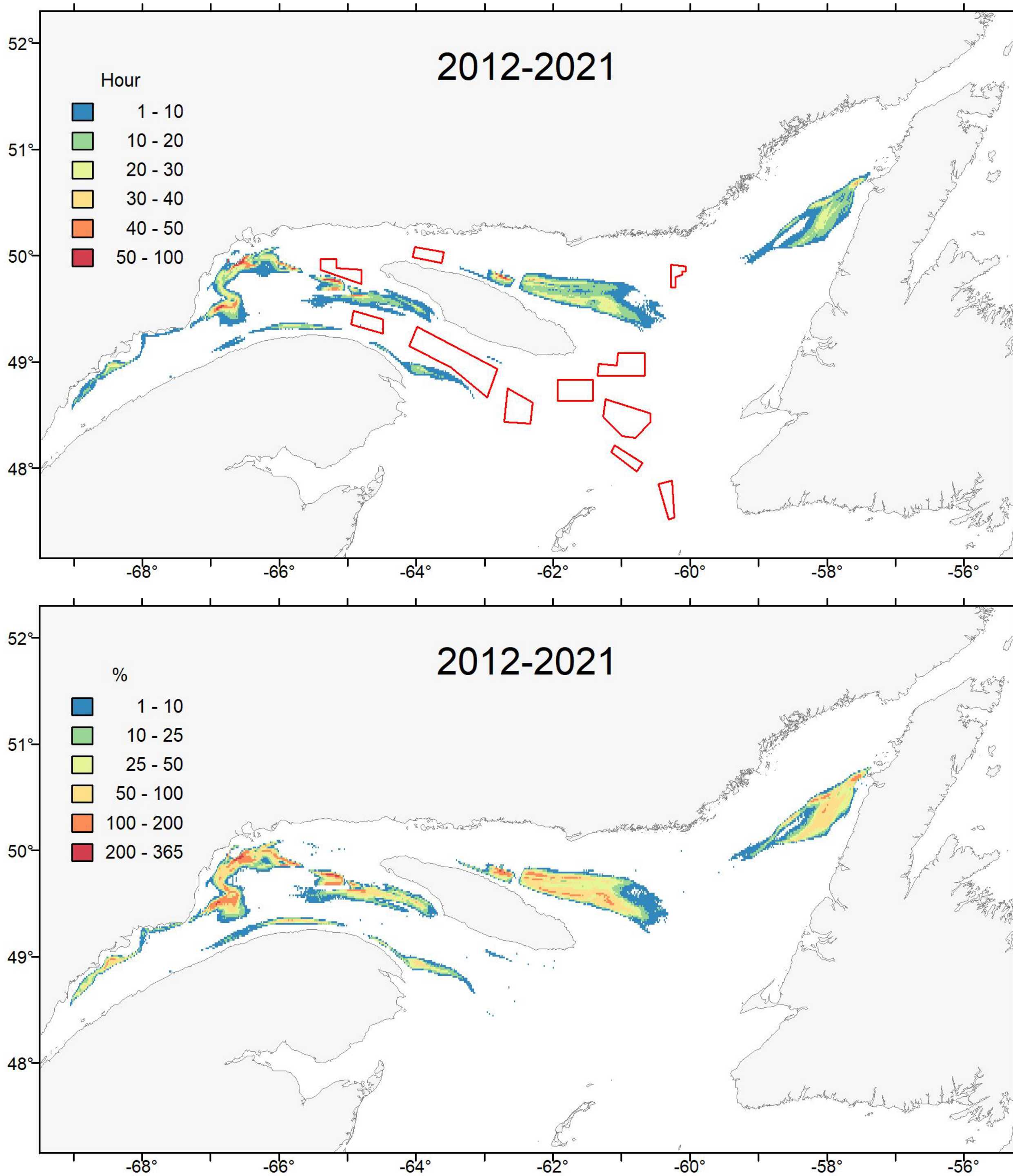


Figure 64. Average annual fishing effort distribution for shrimp boats in the Gulf of St. Lawrence from 2012 to 2021 (number of hours per square of 1 minute, upper panel) and bottom trawl footprint (percent recovery) according to system data Vessel Monitoring System (VMS) (bottom panel). The red polygons represent the 11 areas for the conservation of corals and sponges in the Estuary and Gulf of St. Lawrence.

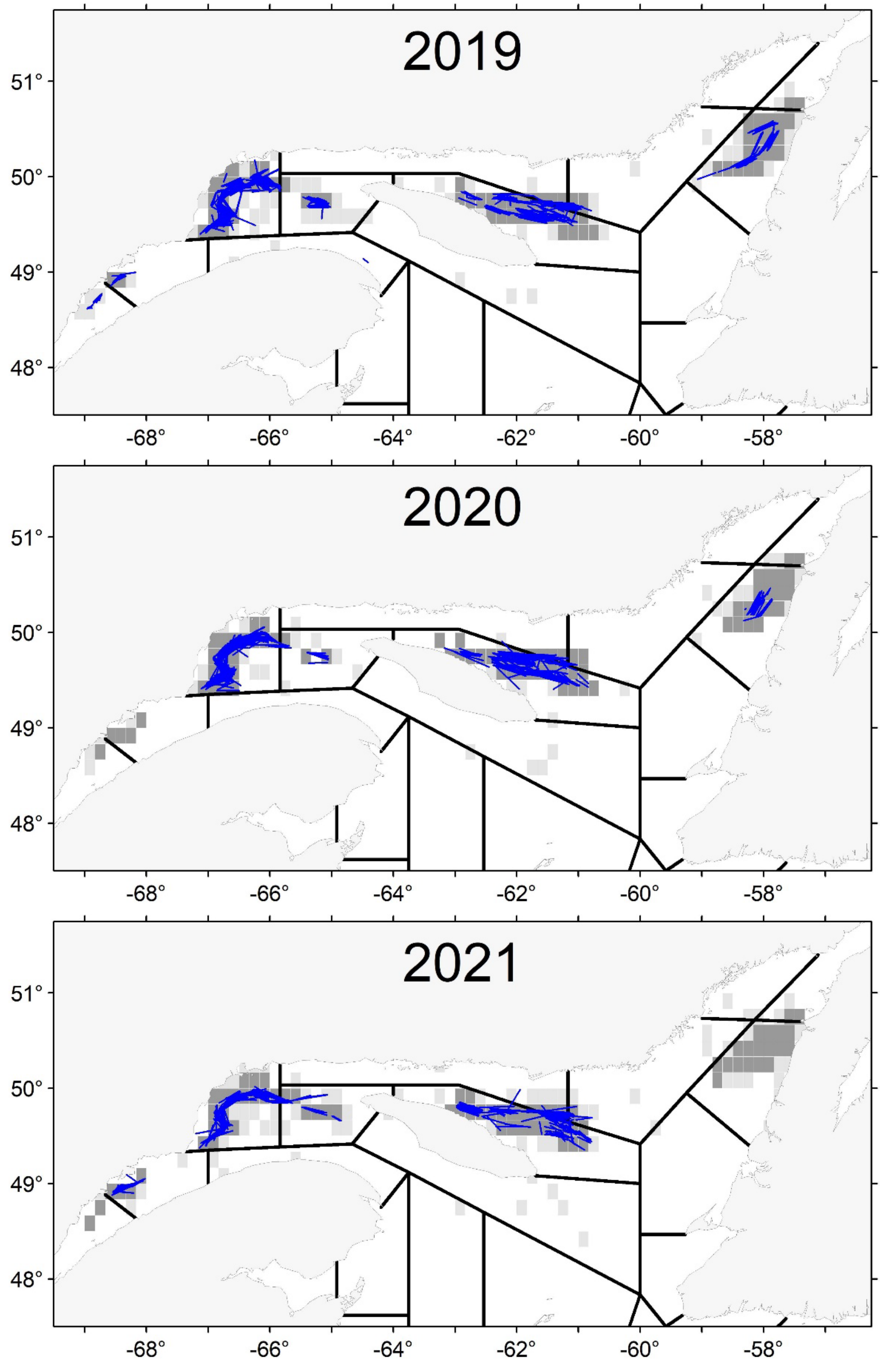


Figure 65. Geographic distribution of annual fishing effort by statistical square (gray squares: pale < 100h, dark > 100h) and fishing tows (blue lines) realised with an observer on board. The NAFO unit areas are also shown.

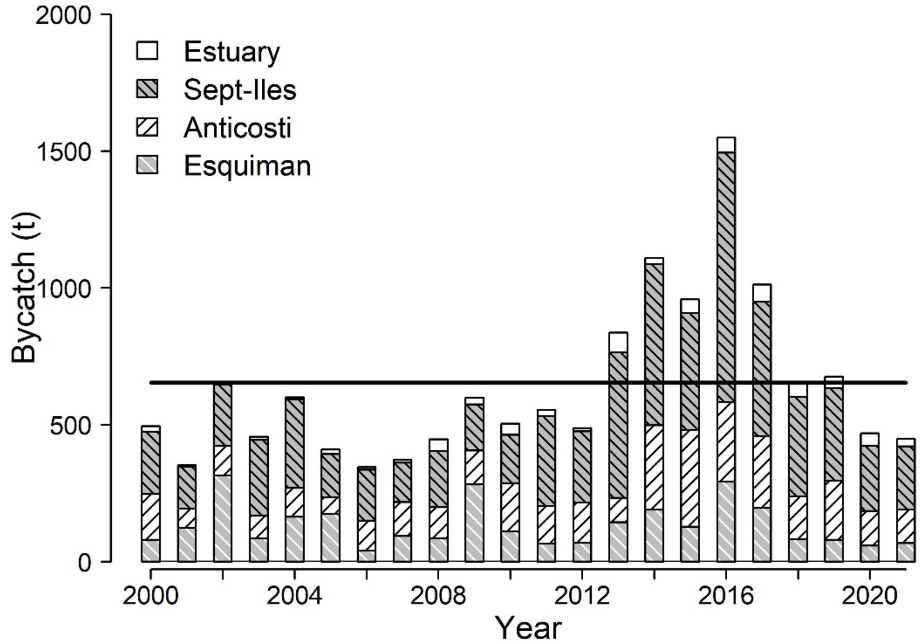


Figure 66. Bycatches for all species by year and by fishing area estimate by at-sea observers. Solid line indicates the average for the years 2000-2019.

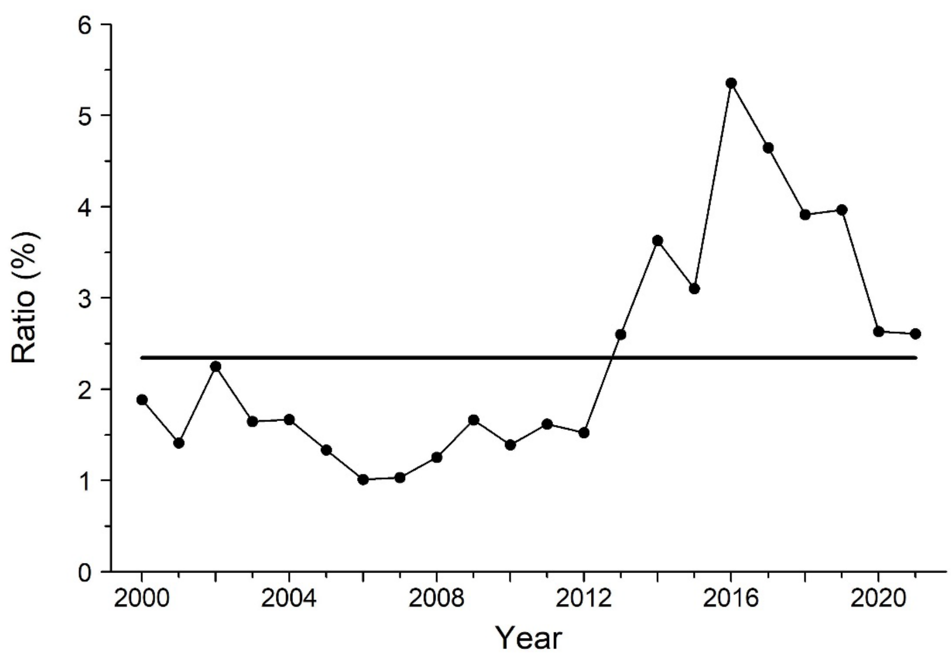


Figure 67. Ratio (%) of the bycatch of all species on the northern shrimp catch by year and by fishing area. Solid line indicates the average for the years 2000-2019.

Atlantic cod

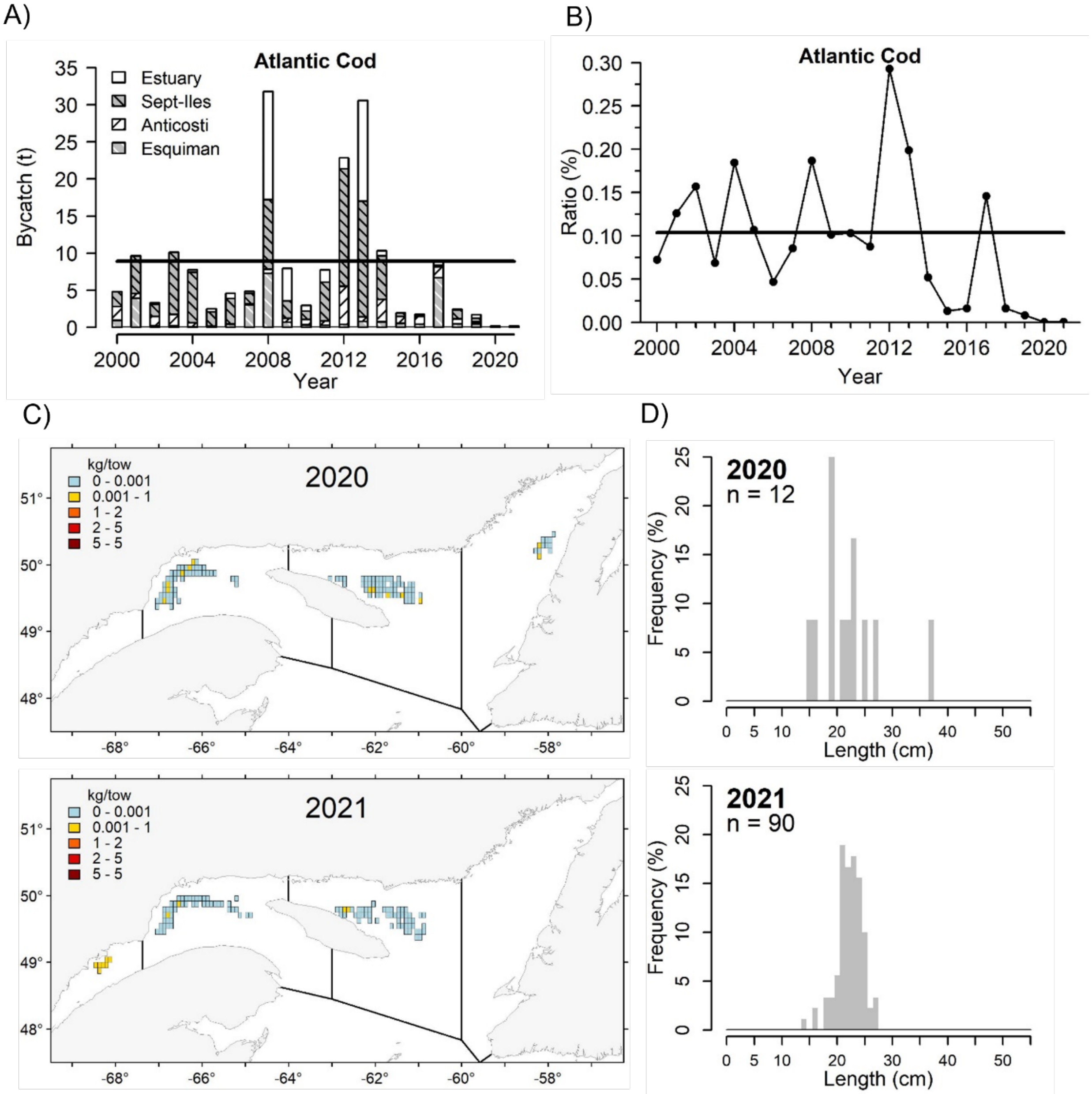


Figure 68. Bycatches of Atlantic cod estimate by year and by fishing area from the at-sea observers program. A) Bycatches and B) ratio (%) of the bycatch on the biomass estimate from DFO survey (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

Redfishes

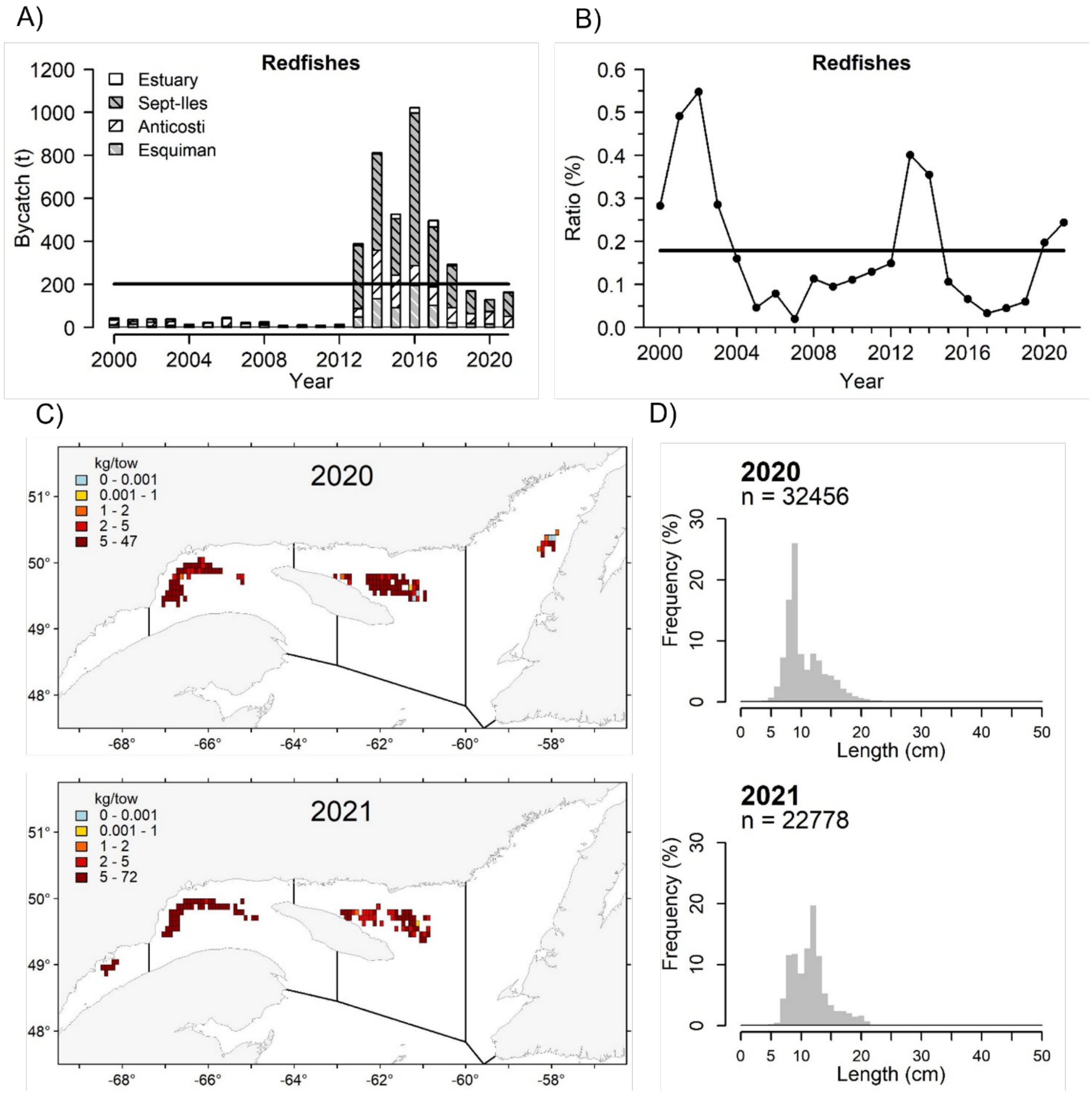


Figure 69. Bycatches of redfishes estimate by year and by fishing area from the at-sea observers program. A) Bycatches and B) ratio (%) of the bycatch on the biomass estimate from DFO survey (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

Atlantic halibut

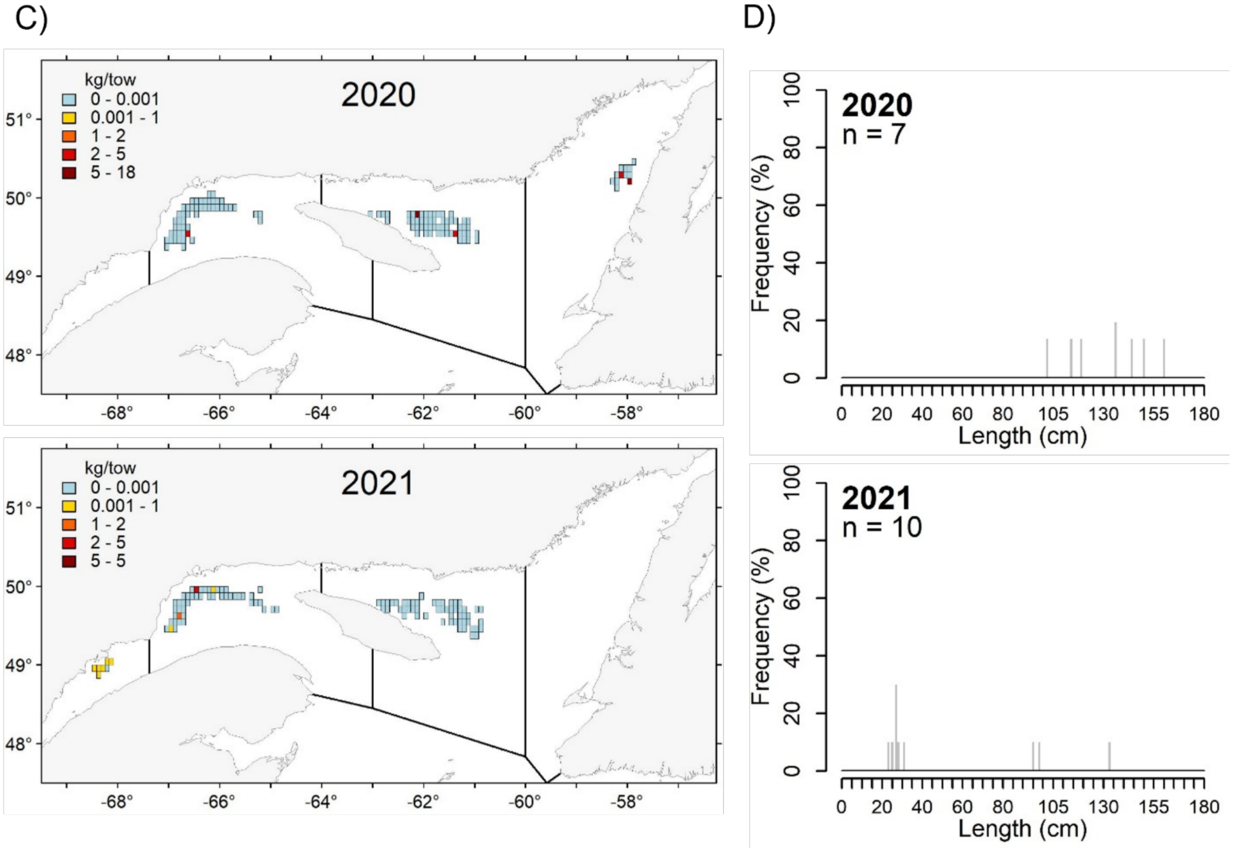


Figure 70. Bycatches of Atlantic halibut estimate by year and by fishing area from the at-sea observers program. C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

Greenland halibut

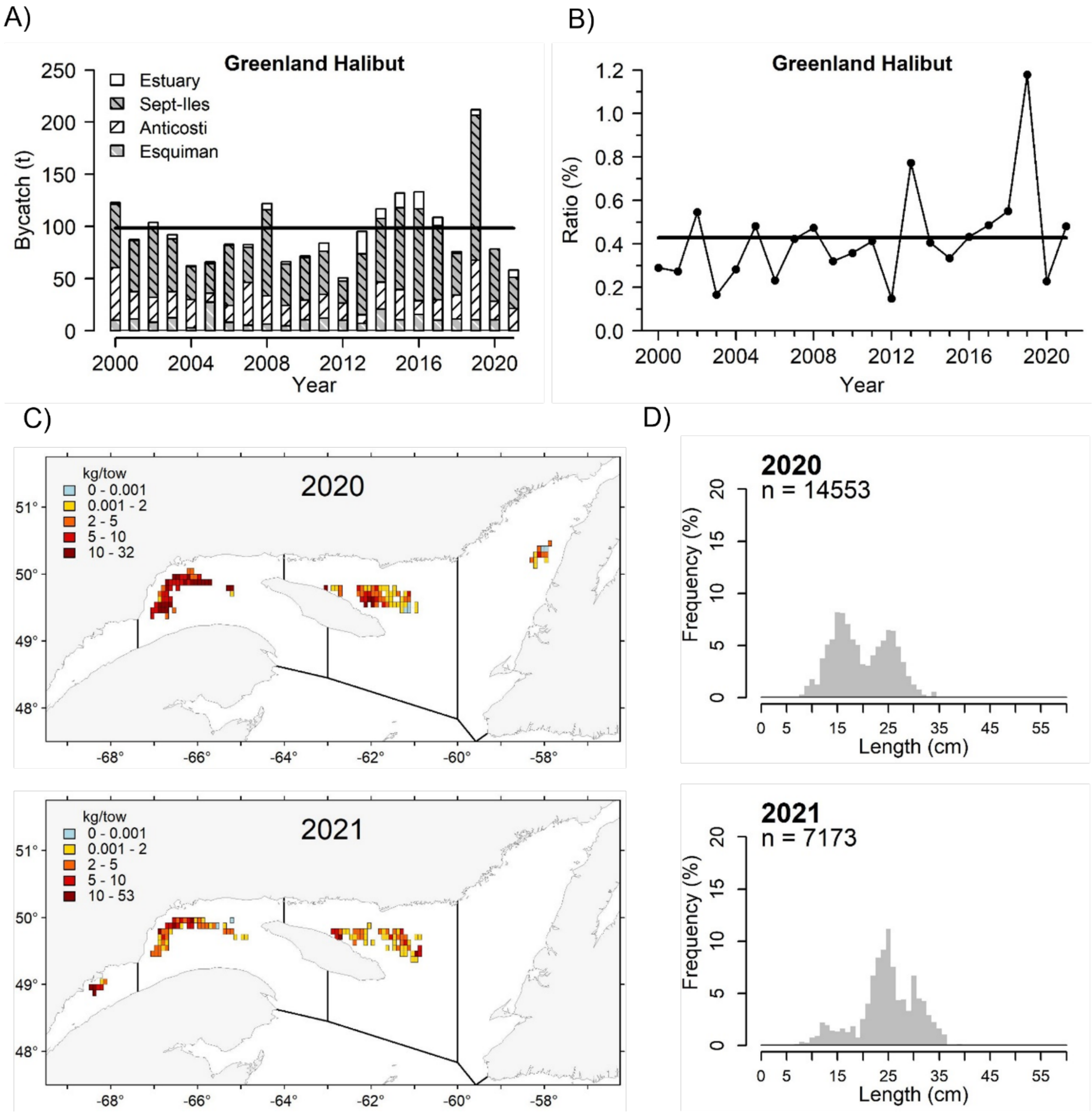


Figure 71. Bycatches of Greenland halibut estimate by year and by fishing area from the at-sea observers program. A) Bycatches and B) ratio (%) of the bycatch on the biomass estimate from DFO survey (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

American plaice

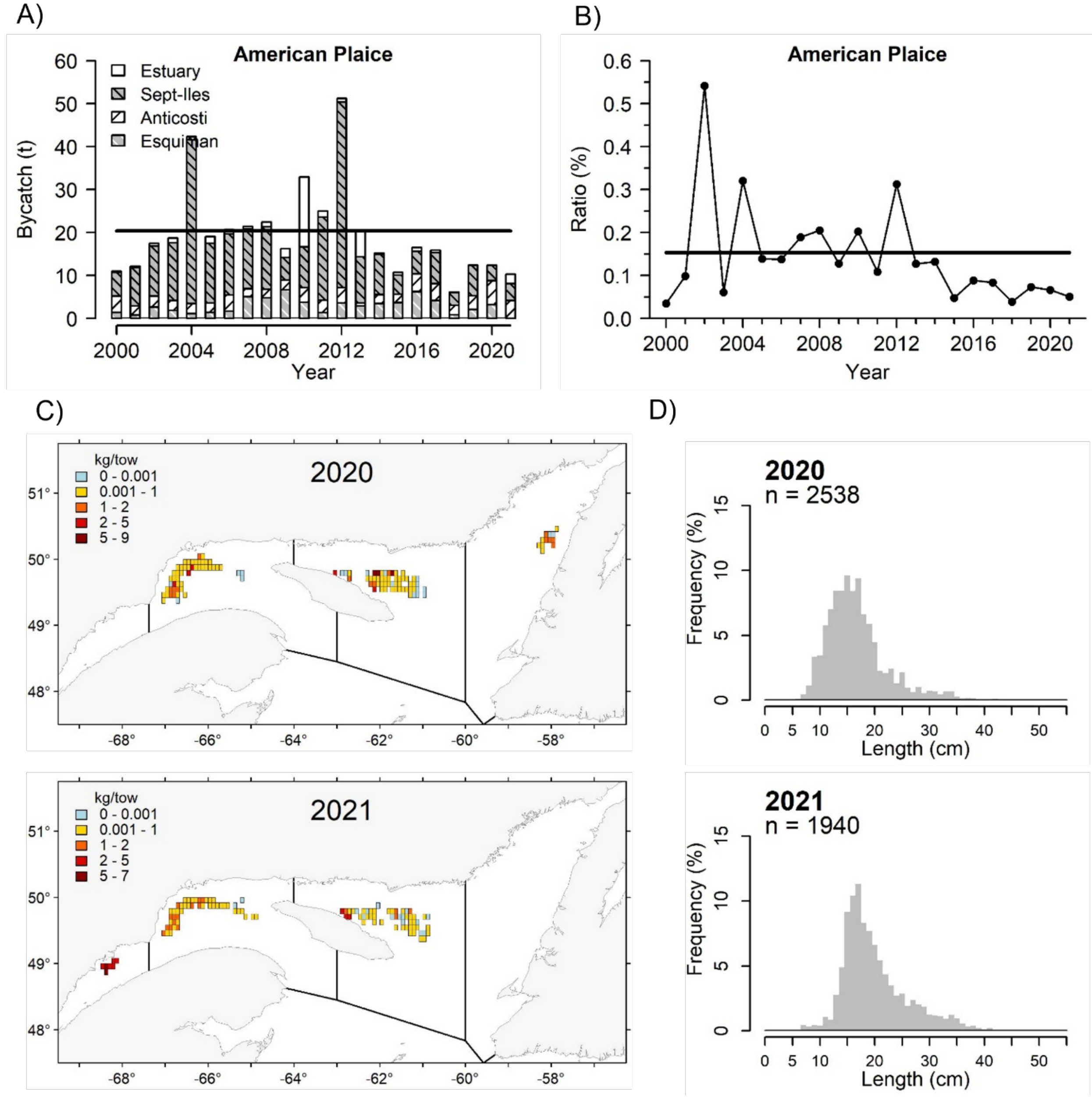


Figure 72. Bycatches of American plaice estimate by year and by fishing area from the at-sea observers program. A) Bycatches and B) ratio (%) of the bycatch on the biomass estimate from DFO survey (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

Witch flounder

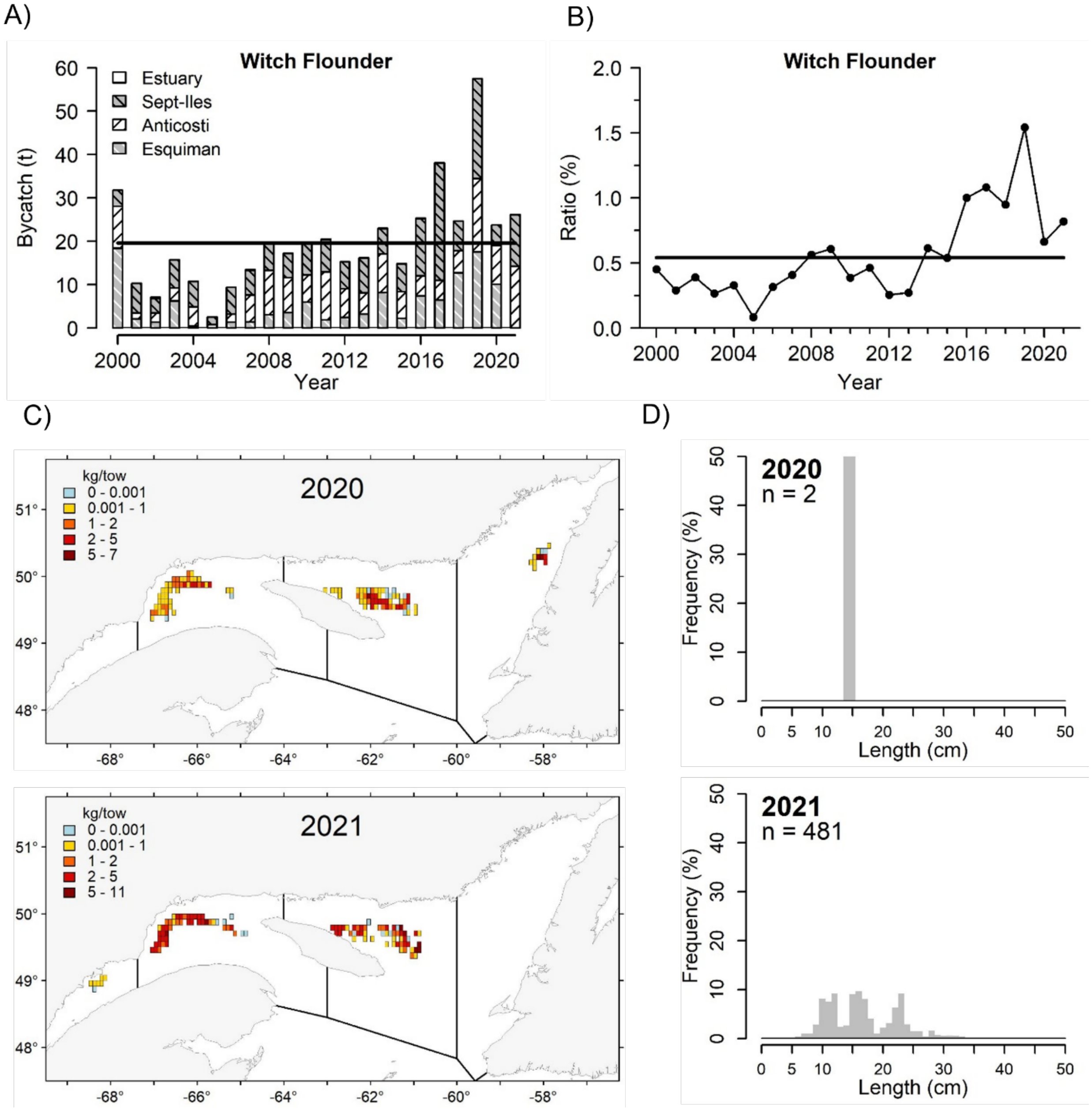
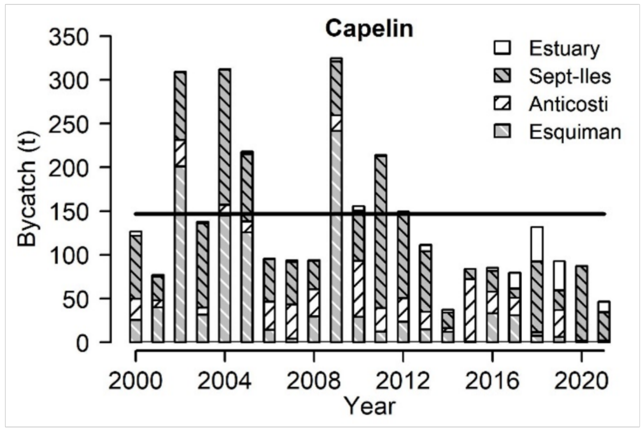


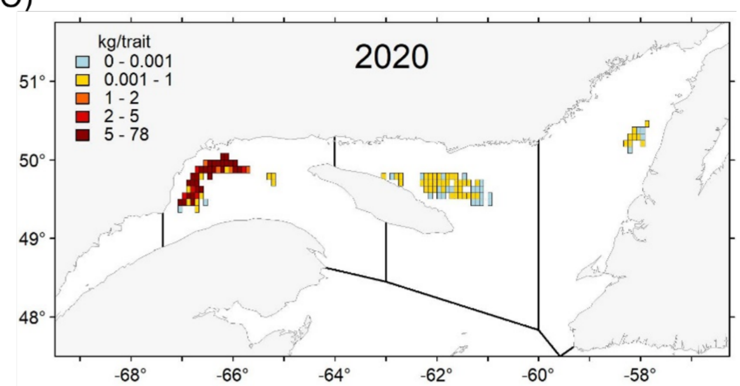
Figure 73. Bycatches of witch flounder estimate by year and by fishing area from the at-sea observers program. A) Bycatches and B) ratio (%) of the bycatch on the biomass estimate from DFO survey (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes. D) Length frequency distributions of fishes sampled (number (n) of specimens that were measured is shown).

Capelin

A)



C)



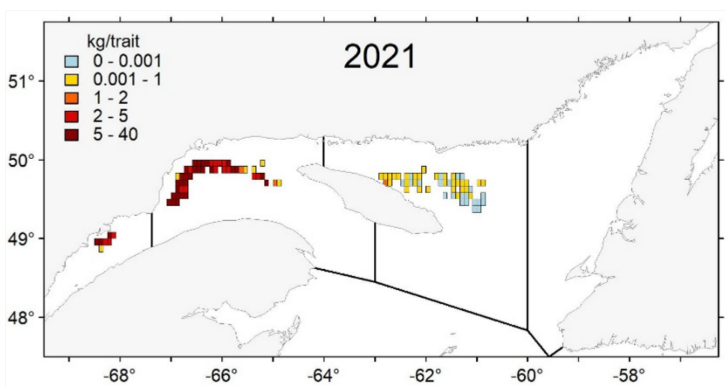


Figure 74. Bycatches of capelin estimate by year and by fishing area from the at-sea observers program. A) Bycatches (solid line indicates the average for the years 2000-2019). C) Geographical distribution of catches per averaged by statistical squares of 5 minutes.

APPENDICES

Appendix 1. DFO Strategic Research Plan for Northern Shrimp in the Estuary and Gulf of St. Lawrence.

The various scientific research projects can be associated with various components of the integrated management plan for the shrimp fishery in the Estuary and Gulf of St. Lawrence. The issues identified at the end of the consultations to develop the IFMP are as follows:

- sustainable harvest of shrimp;
- the impacts of the fishery on the ecosystem;
- fishery governance;
- the economic prosperity of the fishery.

The issues facing the fishery have allowed us to define the objectives of the integrated management plan and the research projects have been developed to provide potential solutions to these issues.

Scientific projects conducted on the northern shrimp by scientists from the Maurice Lamontagne Institute (MLI) are funded in whole or in part by DFO national programs. They respond directly to priority directions presented in the scientific frameworks and are part of the Ecosystem Science strategic research program. These projects are completed by initiatives funded by the DFO's core program (research surveys, dockside and at-sea sampling, logbook and Vessel Monitoring System) directly related to monitoring the status of stocks, the ecosystem and the fishery.

Theme A. Shrimp productivity and their sustainable harvesting

To effectively manage the fisheries, an in-depth understanding of the productivity of the population being harvested is required. Changes in the productivity and resiliency of key species can have serious consequences on the overall dynamics of all ecosystems and on the sustainability of fisheries. These changes may be triggered by a number of biological, physical and environmental factors as well as by human activities.

Sub-topic A1. The abundance of shrimp stocks in the Estuary and Gulf

- Status assessment of shrimp stocks by ongoing monitoring activities intended to calculate stock status indicators and determine the appropriate fishery catch shares consistent with the precautionary approach.
  DFO core program
  Hugo Bourdages and collaborators

Sub-topic A2. The trophic relationships between the shrimp and its predators

- Study of the diets of the main groundfish.
  DFO core program
  Denis Chabot and collaborators
- Winter survey in the Laurentian channel and the northern gulf of St. Lawrence.
  DFO (C-68)
  Hugo Bourdages and Jenni McDermid

Sub-topic A3. Environmental factors influencing the shrimp's productivity

- Status assessment of the physical and biochemical oceanographic environment of the Gulf of St. Lawrence by continuing the Atlantic Zone Monitoring Program to detect, monitor and predict changes in productivity and marine environment status.
  DFO core program
  Peter Galbraith and collaborators
- Assessment of synergic effects of various environmental stressors combined with acidification on the physiology, the growth or the survival of invertebrates that are harvested commercially in the St. Lawrence.
  Strategic Program for Ecosystem-Based Research and Advice, DFO, 2014-2023
  Denis Chabot and collaborators
- Linking physiology to biogeography of Northern shrimp to facilitate adaptation to climate change.
  Strategic Program for Ecosystem-Based Research and Advice, DFO, 2017-2023
  Denis Chabot, Piero Calosi (UQAR) and collaborators
- PANOMICS: Integrating genomics to current and future spatial management of northern shrimp (Pandalus borealis) along the Canadian coast.
  Genomics Research and Development Initiative, DFO, 2019-2022
  Geneviève Parent and collaborators
- Groundfish return in the Estuary and Gulf of St. Lawrence.
  Partnership Fund, 2017-2020
  DFO : Hugo Bourdages, Hughes Benoît, Denis Chabot, Daniel Duplisea, Marie-Julie Roux and collaborators
  Ressources Aquatiques Québec : Céline Audet, Dominique Robert, Steve Plante, Pascal Sirois , Louis Bernatchez and collaborators
- REDTANKS : Understand the environmental needs and the consumption of shrimp by redfish (Sebastes spp.) with experiments in tanks.
  Results funds, DFO, 2019-2022
  Denis Chabot, Caroline Senay, Geneviève Parent and collaborators
- Development of a qualitative network modeling tool
  Ecosystemic approach, DFO, 2019-2021
  Marie-Julie Roux and Daniel Duplisea
- Development of risk conditioning factors associated to fishing removals in a context of climate change.
  DFO, 2019-2022
  Marie-Julie Roux and Daniel Duplisea

Theme B. The fishery's impact on the ecosystem

Fisheries Management's decisions must take into consideration targeted and non-targeted species, the ecosystems of which they are a part and the impact of fishing on these ecosystems. This is the basis of an ecosystem-based approach to fisheries management, which, along with a precautionary approach, constitutes the key to the new sustainable development framework of Fisheries and Oceans Canada. In compliance with the United Nations Food and Agriculture Organization's (FAO) Code of Conduct for Responsible Fisheries, DFO promotes responsible fishing aimed at reducing bycatch and mitigating impacts on habitat wherever biologically justifiable and cost effective.

Sub-topic B1. Vulnerable benthic habitats and communities

- Study of the distribution, spatial structure, reproduction, ecosystem function and vulnerability to trawling of sea pen fields in the Gulf of St. Lawrence in support of the “Eastern Canadian Coral and Sponge Conservation Strategy”.
  Strategic Program for Ecosystem-Based Research and Advice, DFO, 2014-2017
  Bernard Sainte-Marie, Hugo Bourdages, Catherine Couillard, Claude Savenkoff

Sub-topic B2. Species not targeted by the fishery

- Assessment of the significance of shrimpers’ bycatch by analyzing data from the At-Sea Observer Program activity monitoring.
  DFO core program
  Hugo Bourdages and collaborators