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### **The Saguenay Fjord Winter recreational groundfish fishery, 1996–2018**

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## Foreword

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

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## ABSTRACT

The status of the marine species caught in the Saguenay Fjord recreational fishery was assessed annually from 1995 to 2010 and every two years from 2012 to 2018. This assessment is based on various indicators from a monitoring program for the winter recreational fishery (also known as ice fishing) (1995–2018), a Fisheries and Oceans Canada (DFO) research survey (2000–2018) and a recent individual logbook initiative (2015–2018). This report presents the data and methods used to derive the indicators from the monitoring program for the winter recreational groundfish fishery in the Saguenay Fjord. Estimates of the number of fish per unit of effort (NUE) for more than 20 years of recreational fishery sampling (1996–2018) are presented for the following species: redfish (*Sebastes spp.*), Atlantic cod (*Gadus morhua*), Greenland cod (*Gadus ogac*) and Greenland halibut (*Reinhardtius hippoglossoides*). In addition, biological parameters of the sampled populations are indicated.

Groundfish catches in the Saguenay winter recreational fishery are composed on average of 88% redfish, 10% cod (Atlantic and Greenland cod) and 2% Greenland halibut for the 1996–2018 time series. For the Saguenay as a whole, the redfish index of abundance decreased from 1996 to 2006 and remains low since with values clearly below those at the beginning of the series. Indices of abundance for Atlantic cod, Greenland cod, and Greenland halibut are at low level. However, since 2013 there has been an increase in NUE for the Atlantic cod and Greenland halibut with values above their respective series average.

Studies published in the late 2000s (Sévigny et al. 2009, Sirois et al. 2009) suggest that groundfish populations in the Saguenay appear to be sink populations whose recruitment depends on the arrival of juveniles from the St. Lawrence Estuary (Bui et al. 2012). Although groundfish reproduction does occur in the Saguenay, larval survival of these species would be compromised by conditions in the warm, brackish surface water layer, preventing a significant local contribution to recruitment, particularly for redfish and cod (Sirois et al. 2009). Strong cohorts of redfish (*Sebastes mentella*) (2011, 2012 and 2013) were noted in the Estuary, and their abundance was at the highest level seen in the last 30 years (Bourdages et al. 2019). The presence of these new cohorts in the Saguenay Fjord has been observed since 2013, namely in the stomach contents of large redfish, during a major stranding at Saint-Fulgence in December 2014, in the smelt fishery and during research surveys (Gauthier et al. 2019). The recent high-abundance cohorts are beginning to recruit to the recreational fishery, but the fish are small in size. These redfish had a modal size of 16 cm in 2017 and of 20 cm in 2018 and made up nearly 10% of redfish catches. The medium-term outlook is encouraging for the winter recreational redfish fishery in the Saguenay Fjord.

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## INTRODUCTION

The winter recreational groundfish fishery in the Saguenay Fjord, or ice fishing, is unique in Quebec because of its size and the variety of fish species caught. The groundfish species caught in that region are periodically assessed to determine whether changes in the status of the resource might warrant adjustments to the conservation approach. The last regional peer review of this fishery was performed on November 21, 2018, at the Maurice Lamontagne Institute in Mont-Joli. The main indicators used for that review come from the sampling of the winter recreational fishery, individual logbooks and a DFO scientific survey (Gauthier and Marquis 2017, Gauthier et al. 2019, DFO 2019).

This report includes an update of the indicator data from the recreational fishery sampling in 2017 and 2018. The methodology and data from 1996 to 2016 have already been presented in Gauthier and Marquis 2017. Information from the new logbook initiative introduced in 2015 is also provided. For the conclusions on the status of groundfish populations in the Saguenay, please consult the most recent Science Advisory Report (DFO 2019).

## DESCRIPTION OF THE FISHERY

The winter recreational fishery extends throughout the entire upper watershed of the Saguenay Fjord, between Saint-Fulgence and Petit-Saguenay (Figure 1a). The main fishing villages are associated with the municipalities of L'Anse-Saint-Jean, Rivière-Éternité, Saint-Félix-d'Otis, Sainte-Rose-du-Nord, Saint-Fulgence and the La Baie borough (City of Saguenay). Until 2012, the La Baie borough included the L'Anse-à-Benjamin, Grande-Baie and Les Battures fishing villages. The latter village has been closed since 2013 as a result of a recurring problem of inadequate ice cover.

Fishing villages generally have two areas where cabins are set up: a “pelagic fish” area near the shore where mainly smelt (*Osmerus mordax*) is caught, and a “groundfish” area farther out on the ice where the species discussed in this report are caught.

Winter recreational fishing in the Saguenay is still very popular. In the 2017 and 2018 fishing seasons, an average of 1,376 cabins were set up on the pack ice between Saint-Fulgence and L'Anse-Saint-Jean (Guy Girard, Promotion Saguenay, pers. comm., Appendix 1). This represents a decrease of nearly 100 cabins compared to the average for the 1998–2016 period (Figure 1b). Annually, close to 200 cabins are set up on the sites located in the Saguenay–St. Lawrence Marine Park (SSLMP). More than 80% of the cabins set up on the Saguenay Fjord are concentrated in the La Baie sites. The “groundfish” areas account for 60% of all fishing cabins.

The regulatory length of the fishing season has varied over time, and the opening and closing dates are shown in Table 1. Following the decline in resource abundance, the fishing season was shortened in 2005 and again in 2011 from an average of 59 days between 2005 and 2009 to 43–45 days between 2011 and 2016. The season was 50 days in 2017 and 2018. Weather conditions regularly result in the actual fishing season being reduced because of late ice cover formation and/or early thaws.

No licence is required for this fishery, and only line fishing methods are permitted, i.e. tip-ups, rollers and rods. There are no limits on the number of lines and hooks, but fishing gear may not be left unattended for more than 72 hours after it has been set up. The [regulations](#) include the mandatory release of crustaceans, mollusks, Atlantic halibut (*Hippoglossus hippoglossus*), spotted wolffish (*Anarhichas minor*), Atlantic wolffish (*Anarhichas lupus*), northern wolffish (*Anarhichas denticulatus*), sharks and skates. It is also prohibited to sell, trade or waste fish.

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Two main types of gear are used in this fishery: a fishing rod and a roller. The roller consists of a line mounted on a pulley. Rollers have become very popular in recent years and have largely replaced tip-ups. They are generally set up on the pack ice outside the cabins, while rods are used primarily inside the cabins.

There are three main approaches to ice fishing. The first is characteristic of fishers who watch their gear closely. When the fish takes the hook, the fisher removes the line, unhooks the fish, and baits and sets the line again. The second approach involves social activities. The gear is baited and lowered into the water, but the fishers do not watch the gear as attentively. As a result, a fish that takes the bait can be hooked to the line for a number of hours before being pulled out. This means there is virtually no chance that another fish will be caught with the gear during this time. Lastly, the third approach involves baiting and lowering the gear in the evening, for example, and pulling it out at the beginning or end of the next day. This approach is more common for tip-ups and rollers.

## **MONITORING PROGRAM FOR THE WINTER RECREATIONAL GROUND FISH FISHERY IN THE SAGUENAY FJORD**

The winter recreational groundfish fishery in the Saguenay Fjord took off in the early 1980s. It has been the subject of monitoring coordinated by DFO since 1995 (Lambert and Bérubé 2002, Gauthier 2018). This monitoring is carried out in collaboration with the Société des établissements de plein air du Québec (Sépaq) and Parks Canada (PC), which are co-managers of the SSLMP, as well as Promotion Saguenay and fishers' associations.

This monitoring has three components. Component 1, *catch per unit of effort*, is conducted by samplers and consists of describing fishing activities by surveying recreational fishers. Component 2, carried out by index fishers, involves collecting biological data on the various species caught, including size and weight. Component 3 was added in 2015 and consists of logbooks completed by recreational fishers recruited from the main fishing sites. This component is also intended for fishers who practise their activities outside fishing villages and who are not covered by Component 1 of the monitoring.

### **MONITORING PROGRAM – COMPONENT 1 – CATCH PER UNIT OF EFFORT**

The sampling for this component is carried out by PC for the Sainte-Rose-du-Nord and Saint-Fulgence sites; Sépaq for the L'Anse-Saint-Jean, Rivière-Éternité and Saint-Félix-d'Otis sites; and Promotion Saguenay for the L'Anse-à-Benjamin, Les Battures and Grande-Baie sites. Each of these partners hires one or more samplers to visit and collect data for their respective sites in accordance with the protocol developed by DFO and enter the data after the fishing season. The data are then forwarded to DFO for processing.

The annual sampling plan for Component 1 is 20 visits per fishing site, with a maximum of 15 fishers surveyed per visit. Data are gathered on catches (species, number), fishing effort (number of lines, hooks and fishing hours) and number of active fishers at the time of the visit. The main objective is to identify trends in catches per unit of effort (CPUE). Table 2 presents the number of visits per site and per year in the groundfish area, as well as the average number of fishers surveyed per visit. The visits to each site are conducted on weekdays and weekends throughout the fishing season (Figure 2). The use of echosounders has been noted since 2010 but was not considered in the analyses. Echosounders were used by 50% of fishers surveyed between 2010 and 2018. A copy of the form used to collect data for Component 1 – *catch per unit of effort* is provided in Appendix 2.

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For the analyses, invalid or incomplete data were removed, as were data collected outside the groundfish area. Only data obtained since 1996 were used. Data with a fishing time greater than 12 hours are not used in calculating catches per unit of effort. However, these data are retained for estimating total catches.

Table 3 shows the number of catches reported in Component 1 for each species studied. From 1996 to 2018, 45,471 catches of *Sebastes spp.*, 1,317 cod spp., 3,134 Atlantic cod, 2,987 Greenland cod and 658 Greenland halibut were reported to samplers. Prior to 2001, no distinction was made between Atlantic cod and Greenland cod, which is why analyses for the different cod species began in 2001.

### **Catch per unit of effort**

The catch per unit of effort (CPUE) or catch rate of a species is considered to be proportional to its abundance. The CPUE is the number of individuals of a species caught per unit of effort. The sample unit considered is a fisher's activity between the start of the day and the time they meet with the sampler. Effort is defined as the total number of hooks used (number of hooks per line multiplied by the number of lines) multiplied by the number of fishing hours. Between 1996 and 2018, fishers used an average of 2.2 lines with an average of 2.9 hooks per line (Table 4). The average number of lines used per fisher has decreased over time. From 1996 to 2006, it was three lines, which fell to less than two between 2007 and 2018. This decrease could be explained by the introduction of sonar in this fishery and the phasing out of the use of rollers and tip-ups. The average number of hooks per line is more consistent. In addition, for a given fisher, an average of 4.8 hours elapsed between the start of fishing activity and the meeting with the sampler.

Three factors that can have an impact on fishing success are noted. These are the year, the fishing site and the day of the week. The site represents the eight different cabin villages, i.e.: Sainte-Rose-du-Nord, Saint-Félix-d'Otis, Rivière-Éternité, L'Anse-Saint-Jean, Saint-Fulgence, Grande-Baie, L'Anse-à-Benjamin and Les Battures. The winter fishery clientele is assumed to be different depending on the day of the week. Weekday fishers are considered to have a more attentive fishing approach, while weekend fishers have a more social approach. Fishing success is considered to be greater on weekdays than on weekends. Thus, the last factor describes when the activity is performed.

Standardizing the data makes it possible to account for the part of the variability of the CPUE that is attributable to these various factors. This makes it possible to focus the analysis on annual trends in the catch rate and, consequently, on changes in the population status. To determine an appropriate method for achieving this standardization, three models were explored (Desgagnés et al. 2011). The generalized linear model (GLM) with a negative binomial distribution was used for these analyses.

CPUEs by species and by year were estimated for the entire Saguenay and for two subsets, i.e. sites within the SSLMP (L'Anse-Saint-Jean, Rivière-Éternité, Saint-Félix-d'Otis and Sainte-Rose-du-Nord) and those within the Baie des Ha! Ha! (L'Anse-à-Benjamin, Grande-Baie and Les Battures) (Figures 3 to 6). It is hypothesized that the CPUE is a good indicator of stock status. Figures 3 to 6 also show the effect of factors such as the site and day of the week on estimated catch rates. The correspondence is multiplicative in base  $e$  (base of natural logarithms), so an effect of 1 does not change the estimated CPUE, and each increase in the effect of one unit multiplies the estimated CPUE by  $e$  (i.e. about 2.7183) (Desgagnés et al. 2011).

For redfish throughout the Saguenay, recreational catch rates show a continuous downward trend from 1996 to 2004, with stabilization at a low level and below the series average since

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2004 (Figure 3). Similar analyses conducted at the sites located within the SSLMP boundaries show a comparable trend, but the downward trend there is more marked. However, the situation is different if only the three Baie des Ha! Ha! sites are analyzed. The CPUE does not show a clear downward trend and is rather stable.

For Atlantic cod throughout the Saguenay, recreational catch rates are low (Figure 4). The CPUE index showed a decline between 2000 and 2007 and rebounded in 2008, followed by a decrease until 2013. Since then, it has been on the rise, and the 2018 value is above average and comparable to the numbers at the start of the series. The CPUE for the Rivière-Éternité, Sainte-Rose-du-Nord and Saint-Fulgence sites show a positive effect on the index, while the day of the week (weekday/weekend) appears to have little influence. The general trend is similar for the SSLMP sites. Catch rates for the Baie des Ha! Ha! sites show annual fluctuations without a clear trend.

For Greenland cod, recreational catch rates are generally low (Figure 5). The CPUE index showed a decrease between 2000 and 2007 throughout the Saguenay. Since 2008, the CPUE has been at a low level compared to the start of the series. The Rivière-Éternité site stands out for its high effect on the catch rate, while the timing of the fishery appears to have little influence. The decrease in the CPUE is more pronounced when only the SSLMP sites are taken into account, but the trends are similar. At the start of the series, the CPUE is significantly higher in the SSLMP than in the Baie des Ha! Ha! sites.

Greenland halibut are seldom caught in the Saguenay recreational fishery, which makes using the CPUE for this fishery as an abundance index very speculative (Figure 6 and Table 3). Since 1996, 650 Greenland halibut have been inventoried, an average of about 30 fish per year. The L'Anse-Saint-Jean and Saint-Fulgence sites stand out for their positive effect on the CPUE. Since 2010, an increase in the CPUE has been noted throughout the Saguenay and at the SSLMP sites. The 2018 value is the highest of the series.

### **Total effort deployed by fishing season**

The overall annual frequentation (number of fisher-days) is calculated as follows:

$$AF = \sum_{i=1}^{nSites} \sum_{j=1}^{sfs} nDay_{i,j} \times \overline{nFD}_{i,j}$$

Where  $nSites$  is the number of sites considered,  $sfs$  is the number of day categories (in this case, two: weekdays and weekends),  $nDay_{i,j}$  is the number of fishing days at site  $i$  and in the day category  $j$  (Table 1), and  $nFD_{i,j}$  is the average number of fishers present at site  $i$  on a given day in category  $j$  (Appendix 3).

The opening and closing dates of the fishery do not appear to be a good indicator of season length, since inadequate ice cover can prevent the establishment of fishing villages and significantly reduce the frequentation. We also have no data on the thickness of the ice cover or the dates cabins were set up on the pack ice, which could have been used as an indicator of the actual length of the fishing season. The number of days in a season is approximated by considering the number of days between the first and last sampler visit (Figure 2). The season length is assumed to be the same for all sites.

The average number of fishermen-days is calculated based on the frequentation estimated by the sampler at each visit to a site (Figure 7, Appendix 3). A significant number of fishers are inside the cabins, complicating the work of the samplers. Moreover, this estimate is largely influenced by the annual sampling frequency of fishing activities. Thus, in 2006, the significant drop in total estimated effort is largely attributable to the lack of sampling at the



L'Anse-à-Benjamin site (Table 2, Figure 7, and Appendix 3), which had only one week day visit. No data were available for weekend days. The L'Anse-à-Benjamin site accounts on average for 20% of the total annual fishing effort. No assessment was conducted of the accuracy and variability of these estimates. The average number of fishermen-days and the results of the calculations using this value should therefore be used with caution.

The frequentation average for 1996–2018 is approximately 27,000 fishermen-days (Figure 8). Variations in frequentation reflect, among other things, adverse weather conditions in some years, a shortened fishing season and the adoption of more stringent municipal bylaws to ensure safety on the ice. Fishing effort, estimated in number of fishermen-days, has decreased and is below the series average since 2016 at the La Baie sites and increased in the SSLMP, more specifically in the village of L'Anse-Saint-Jean. In 2017–2018, the estimate of the number of fishermen-days for the entire Saguenay region is below the series average.

### Total annual catch

For a given year, the total catch ( $TC$ ) is calculated as follows:

$$TC = \sum_{i=1}^{nSites} \sum_{j=1}^{sfs} nDay_{ij} \times \overline{nFD}_{ij} \times \frac{totCatch_{ij}}{nFSur_{ij}}$$

Where  $totCatch_{ij}$  is the sum of catches reported at site  $i$  on the day category  $j$ , and  $nFSur_{i,j}$  is the total number of fishers surveyed at site  $i$  and on the day category  $j$ .

During the winter recreational fishery in 2017 and 2018, redfish, Atlantic cod, Greenland cod and Greenland halibut (turbot) accounted for 76%, 14%, 2% and 8% of groundfish catches, respectively (Figure 9a). The total annual catch of each of these species is shown in Figure 9b.

Annual variations in the total catch of the species are. The total catch for each species has decreased since the start of the series. Catches of Redfish and Greenland cod come mainly from the villages of La Baie, while catches of Atlantic cod and Greenland halibut are generally higher in villages located in the PMMSL.

The information presented in this document on the number of fishermen-days and on the total annual catch by species is different from that presented in the previous documents (Desgagnés et al. 2011, Gauthier and Marquis 2017). This difference stems from an error which consisted of an inversion between the total number of weekdays (Number of weekdays) and the total number of weekend days per fishing season (Number of weekdays) (Table 1). In the previous documents, the average number of fishermen active on weekends were multiplied by the total number of weekdays for a given season and vice versa. Thus the attendance of the weekend, much larger than that of the week, had been multiplied by the total number of weekdays, a number greater than the total number of weekend days. This resulted in erroneous and larger estimates of the number of fishermen-days and the total annual catch.

Figure 10 presents the percentage of fishers surveyed based on the total number of fish they had caught when they met with the sampler. Catch categories range from 0 to 16 fish. Category 16 includes events where the number of fish caught is equal to or greater than 16. The daily catch limit was 25 until 2002, 15 in 2003 and 5 since 2004. Since 2004, fishing success has been low, and in more than 90% of activities, fishers do not catch their daily limit of five groundfish. In 2018, nearly 60% of the recreational fishers surveyed had not caught any fish at the time of their meeting with the sampler, which occurred an average of four hours after the start of their fishing activity.

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## MONITORING PROGRAM – COMPONENT 2 – BIOLOGICAL DATA

Between two and six fishers are recruited annually from each of the fishing villages to collect biological data on the various species of fish caught. These individuals are identified as index fishers. Component 1 samplers also participate in this collection. Table 5 presents the number of fish measured and weighed by species. The frequency of data collection for Component 2 is dependent on the availability of the index fishers. A copy of the form used to collect data from 1996 to 2018 is provided in Appendix 4.

### Size frequencies

Descriptive total length statistics from biological data collected in Component 2 of the monitoring program are presented in Table 6 for redfish, cod and Greenland halibut. Size frequency distributions for Greenland halibut, Atlantic cod and Greenland cod show a wide range of sizes, indicating that multiple cohorts are present in the fishery (Figure 11).

The situation is different for redfish. The slow and steady increase in the median size of redfish in the fishery since 1996 suggested that there had been no significant influx of recruits to the fishery and that it had been directed by a small number of cohorts. However, since 2016, more redfish under 23 cm have been caught, accounting for nearly 10% of catches in 2018. The total modal length of these fish was 20 cm in 2018 (Figure 12). These redfish come from the entry into the Saguenay of fish from the 2011, 2012 and 2013 cohorts, of which the abundance in the Estuary and Gulf of St. Lawrence is on a scale never seen in 30 years (Bourdages et al. 2019).

Descriptive total length statistics for fish species occasionally sampled in the winter recreational fishery are presented in Table 7 for Atlantic halibut (*Hippoglossus hippoglossus*), lycodes spp., white hake (*Urophycis tenuis*), flounder spp., skate spp. and Arctic cod (*Boreogadus saida*).

The relationship between total mass and total length is calculated for the four main species (Table 8 and Figure 13). The 2017 and 2018 values are compared to the adjusted curve for the data set. These adjustments are obtained by a non-linear regression that corresponds to an allometric relationship between the mass and length of the individuals analyzed:

$$y = ax^b$$

where  $y$  is the total mass (g) for a fish of total length  $x$  (cm),  $a$  represents the coefficient of the fish body shape, and  $b$  is the allometric coefficient.

### Condition index

The Fulton condition index ( $K$ ) of fish is calculated according to the following formula:

$$K = 100 \times \frac{W}{L^3}$$

where  $W$  is the total mass (g) and  $L$  is the total length (cm). Annual data by species are presented in Table 9.

## MONITORING PROGRAM – COMPONENT 3 – LOGBOOKS

In 2015, a new logbook initiative was implemented to collect additional data on fishing activities. Logbooks are distributed to recreational fishers who fish with lines on a regular basis. These fishers carry out their activities both inside and outside the fishing villages.

One of the main advantages of these logbooks is that fishers provide their effort and catches for all of their fishing activity. By comparison, in the Component 1 monitoring conducted by the samplers since 1995, fishers are surveyed when they meet with the sampler and have not

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necessarily completed their fishing day; they may be at the start, in the middle or at the end. Nevertheless, Component 1 monitoring provides information that is not available through logbooks, including an estimate of the total number of fishers on the ice at the time the data are collected. These two sources of information are therefore complementary. In addition, logbooks provide information on the more sport-oriented fishers who practise their activities outside fishing villages.

The logbook data are presented in Appendix 5. Appendix 6 provides information on the number of logbooks completed annually, the number of activities recorded in the logbooks, whether or not recreational fishers use sonar and the number of activities for each fishing site. Since 2015, the number of logbooks completed has varied between 18 and 24. Some of these logbooks and some fishing activities were removed from the analyses for a variety of reasons, including incomplete information. For the 2015–2018 period, between 12 and 18 logbooks were retained, representing between 229 and 333 fishing activities. On average, an activity lasts 6 hours, and each fisher uses an average of 1.7 lines with 2,6 hooks for an average total effort of 26 hook-hour (Figure 14).

### **Fishing success of logbook participants**

The fishing success of participants is increasing, and the percentage of activities where fishers caught their daily limit of five groundfish increased from 12% to close to 30% between 2016 and 2018 (Figure 15).

The total annual number of fish caught by species in Component 3 is presented in Figure 16.

### **Catch per unit of effort of logbook participants**

Logbook data indicate that recreational catch rates for the four groundfish species remained stable between 2015 and 2018 (Figure 17).

Sonar was used in 78% of fishing activities. When catch rates are calculated separately for activities with and without sonar, the catch per unit of effort (CPUE) for redfish are higher when sonar is used (Figure 18). During the peer review (DFO 2019), the recreational fishers in attendance indicated that these results were consistent with their experience of this fishery, as redfish are caught when the fish are moving through the water column and are detectable on sonar. For the other species, cod and Greenland halibut, catches are made near the bottom, where these fish are less detectable on sonar.

## **SAMPLING OF REDFISH IN THE SMELT FISHING AREA**

A valuable source of information on the arrival of new cohorts of redfish in the Saguenay was provided by the recreational smelt fishery monitoring program conducted by the provincial Department of Forests, Wildlife and Parks (Ministère des Forêts, de la Faune et des Parcs [MFFP]). Since 2014, and in greater abundance since 2016, juvenile redfish have been caught in the smelt fishery. Since 2016, while monitoring the recreational smelt fishery, the MFFP has recorded the number of fishers who reported catching small redfish. In 2016, 2017 and 2018, the percentage of surveyed fishers who had caught small redfish in the smelt area increased from 10.5% to 14.7% and then to 17.8%. The number of fishers surveyed was 267, 265 and 383, respectively, for those three years. The average size of these redfish was 7.1 cm in 2014, 8.3 cm in 2016 and 14.0 cm in 2018 (Figure 19).

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## GENETIC STUDIES ON SAGUENAY REDFISH

Studies published since the mid-2000s suggest that groundfish populations in the Saguenay and, more specifically, redfish (Valentin 2006, Campana et al. 2007, Sévigny et al. 2009, Sirois et al. 2009, Valentin et al. 2014) and cod (Sévigny et al. 2009, Sirois et al. 2009) appear to be sink populations whose recruitment depends on the arrival of juveniles from the St. Lawrence Estuary (Bui et al. 2012). Although groundfish reproduction does occur in the Saguenay, larval survival of these species would be compromised by conditions in the warm, brackish surface water layer, preventing a significant local contribution to recruitment (Sirois et al. 2009).

Since 2014, an abundance of redfish on a scale never seen in 30 years has been observed in the Estuary and Gulf of St. Lawrence (Bourdages et al. 2019). This high abundance is attributable to the large influx of the 2011, 2012 and 2013 cohorts of the redfish species *Sebastes mentella* (Senay et al. 2019). Juvenile redfish have also been observed in abundance in the Saguenay Fjord since 2014 during DFO research surveys (Gauthier et al. 2017, Gauthier et al. 2019) as well as during the winter recreational smelt and groundfish fisheries.

Two redfish species cohabitate in the Gulf of St. Lawrence: the Acadian redfish (*Sebastes fasciatus*) and the deepwater redfish (*Sebastes mentella*). Distinguishing between these species is very difficult because of their great similarity. Various meristic, morphometric and genetic tools have been evaluated to differentiate between the two species (Gascon 2003). It was microsatellite genetic markers that made it possible to distinguish the species unequivocally (Roques et al. 1999).

A total of 111 redfish ranging in size from 4.7 to 22.1 cm were harvested in the Saguenay in 2013 (n=12), 2014 (n=71) and 2015 (n=28). These fish were caught during either the winter fishery or a stranding that occurred in Saint-Fulgence in December 2014 (Appendix 7). Based on their size, it can be concluded that the majority of these redfish are from the 2011, 2012 and 2013 cohorts. A tissue sample was taken from each individual for genetic testing using microsatellite markers to determine the species of these new cohorts (Figure 20).

The methods used for DNA extraction, amplification of the 13 loci by PCR,<sup>1</sup> electrophoresis of the amplified DNA fragments and data analysis are described in Valentin et al. 2014. The following modifications were made: electrophoresis was performed using an ABI3130 (Applied Biosystems) sequencer; the LIZ 1200 size standard was used; and GeneMapper v.4.0 software was used for the analyses.

All 111 redfish analyzed were identified as deepwater redfish (*Sebastes mentella*) (Appendices 8 and 9).

These results are consistent with previous studies that had also shown the dominance of the *Sebastes mentella* redfish species in the Saguenay (Bourgeois 1993, Valentin 2006, Sévigny et al. 2009, Valentin et al. 2014).

## CONCLUSION

The Saguenay winter recreational fishery is very popular, with an annual average of nearly 1,500 cabins set up on the pack ice. Information from logbooks shows that fishing success increased between 2016 and 2018 from 12% to almost 30% of the activities where fishermen caught their daily limit of 5 groundfish.

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<sup>1</sup>. DNA polymerase chain reaction.

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Abundance indices based on the recreational fishery show a significant decline in redbfish, by far the main species caught in this fishery. However, the medium-term outlook is encouraging because high abundances of juvenile redbfish were identified in the Estuary and Gulf of St. Lawrence between 2013 and 2016 (Bourdages et al. 2019, Senay et al. 2018). These juveniles have also been observed in abundance in the Saguenay (Gauthier and Marquis 2017, Gauthier et al. 2017, Gauthier et al. 2019).

Catch rates for the winter recreational Atlantic cod, Greenland cod and Greenland halibut fisheries are low. However, since 2013, an increase has been noted in the indices for Atlantic cod and Greenland halibut, with values above their series averages. For more information on the status of groundfish populations in the Saguenay, please consult the most recent Science Advisory Report (DFO 2019).

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## TABLES

*Table 1. Regulatory opening and closing dates for the winter recreational groundfish fishery in the Saguenay Fjord and length of the season expressed in fishing days, start and end date of sampling, number of week days, number of weekend days and total number of sampling days.*

Year	Opening	Closing	Duration of the season (fishing days)	Start of sampling	End of sampling	Number of week days	Number of weekend days	Total number of sampling days
1996	Dec. 19, 1995	April 17, 1996	121	Jan. 7, 1996	Mar. 19, 1996	52	21	73
1997	Dec. 19, 1996	April 15, 1997	118	Jan. 20, 1997	Mar. 10, 1997	36	14	50
1998	Dec. 15, 1997	April 13, 1998	120	Jan. 2, 1998	Mar. 15, 1998	51	22	73
1999	Dec. 14, 1998	April 12, 1999	120	Jan. 16, 1999	Mar. 12, 1999	40	16	56
2000	Dec. 17, 1999	April 12, 2000	118	Jan. 18, 2000	Mar. 8, 2000	37	14	51
2001	Dec. 15, 2000	April 8, 2001	115	Jan. 10, 2001	Mar. 8, 2001	42	16	58
2002	Dec. 17, 2001	April 7, 2002	112	Jan. 12, 2002	Mar. 15, 2002	45	18	63
2003	Dec. 20, 2002	Mar. 31, 2003	102	Dec. 29, 2002	Mar. 15, 2003	55	22	77
2004	Dec. 20, 2003	Mar. 31, 2004	103	Dec. 24, 2003	Mar. 12, 2004	58	22	80
2005	Jan. 17, 2005	Mar. 13, 2005	56	Jan. 9, 2005	Mar. 12, 2005	45	18	63
2006	Jan. 16, 2006	Mar. 12, 2006	56	Jan. 6, 2006	Mar. 13, 2006	47	20	67
2007	Jan. 15, 2007	Mar. 19, 2007	64	Jan. 27, 2007	Mar. 18, 2007	35	16	51
2008	Jan. 14, 2008	Mar. 12, 2008	59	Jan. 8, 2008	Mar. 18, 2008	51	20	71
2009	Jan. 12, 2009	Mar. 12, 2009	60	Jan. 6, 2009	Mar. 15, 2009	49	20	69
2010	Jan. 9, 2010	Feb. 19, 2010	42	Jan. 21, 2010	Feb. 19, 2010	22	8	30
2011	Jan. 22, 2011	Mar. 6, 2011	44	Jan. 22, 2011	Mar. 6, 2011	30	14	44
2012	Jan. 21, 2012	Mar. 4, 2012	44	Jan. 21, 2012	Mar. 4, 2012	30	14	44
2013	Jan. 19, 2013	Mar. 3, 2013	44	Jan. 19, 2013	Mar. 3, 2013	30	14	44
2014	Jan. 18, 2014	Mar. 2, 2014	44	Jan. 18, 2014	Mar. 2, 2014	30	14	44
2015*	Jan. 17, 2015	Mar. 8, 2015	44	Jan. 18, 2015	Mar. 7, 2015	29	14	43
2016*	Jan. 16, 2016	Mar. 6, 2016	44	Jan. 23, 2016	Mar. 6, 2016	25	14	39
2017	Jan. 14, 2017	Mar. 5, 2017	51	Jan. 21, 2017	Mar. 5, 2017	30	14	44
2018	Jan. 13, 2018	Mar. 4, 2018	51	Jan. 14, 2018	Mar. 4, 2018	35	15	50

\*The recreational fishery was closed on Tuesdays in January and February.

Table 2. Number of visits and, in brackets, average number of fishers surveyed per visit to the groundfish area during the winter recreational fishery in the Saguenay Fjord.

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	14 (6)	24 (15.8)	20 (8.2)	16 (1.9)	29 (11.4)	21 (8.6)	27 (4.5)	0 (-)	151 (8.5)
1997	20 (8.6)	20 (15.2)	19 (8)	20 (2.5)	19 (13.8)	20 (7.3)	15 (4.9)	2 (2.5)	135 (8.6)
1998	18 (10.2)	20 (14.2)	21 (7.9)	19 (3.2)	14 (11.9)	10 (9.2)	2 (2.5)	0 (-)	104 (9.2)
1999	19 (10.2)	20 (13.8)	19 (8.6)	20 (5.3)	6 (7.3)	16 (9.1)	15 (2.9)	0 (-)	115 (8.4)
2000	14 (9.5)	19 (12.5)	14 (7.5)	16 (2.1)	21 (6.3)	20 (9.5)	14 (11.9)	10 (1.4)	128 (7.9)
2001	14 (10.2)	19 (6.8)	18 (7.7)	20 (3.8)	8 (9.2)	20 (7.5)	20 (11.6)	1 (7)	120 (7.9)
2002	14 (10)	18 (12.8)	17 (8.6)	19 (2.6)	12 (6.5)	22 (11.4)	7 (10.9)	4 (3)	113 (8.7)
2003	20 (7)	19 (12.4)	19 (6.8)	16 (1.7)	27 (8.3)	24 (6.1)	29 (6.8)	0 (-)	154 (7.1)
2004	17 (5.6)	19 (9.8)	22 (6.9)	3 (1.3)	18 (6.1)	20 (8.4)	19 (3.4)	0 (-)	118 (6.6)
2005	11 (5.1)	15 (9.7)	19 (6.6)	13 (1.9)	19 (6.2)	19 (8.8)	19 (4.6)	0 (-)	115 (6.3)
2006	1 (13)	11 (11.5)	14 (7.1)	3 (1.7)	16 (5.7)	20 (7.7)	18 (2.6)	1 (1)	84 (6.4)
2007	21 (15.4)	9 (11.4)	22 (14.5)	0 (-)	15 (7.7)	15 (6.5)	0 (-)	5 (0.6)	87 (11.1)
2008	38 (23.2)	8 (3.5)	38 (23.6)	7 (3)	12 (11.8)	12 (12.1)	0 (-)	7 (6.7)	122 (17.7)
2009	24 (17)	19 (10.4)	21 (18.5)	20 (4)	19 (9.9)	28 (9.9)	0 (-)	10 (2)	141 (11.1)
2010	8 (15)	9 (14.2)	12 (15)	11 (5)	9 (11.1)	9 (8.6)	0 (-)	0 (-)	58 (11.4)
2011	22 (15)	19 (13.4)	23 (15)	19 (5)	20 (9.8)	19 (19.9)	0 (-)	2 (1)	124 (12.9)
2012	21 (17.7)	17 (10.4)	25 (15)	20 (8.8)	20 (6.8)	19 (18.7)	0 (-)	3 (1.7)	125 (12.8)
2013	20 (22.5)	20 (12.2)	20 (14.9)	0 (-)	20 (8.4)	15 (12.4)	0 (-)	2 (0.5)	97 (13.9)
2014	42 (9.4)	19 (14)	36 (12.6)	0 (-)	20 (5.7)	20 (7.2)	0 (-)	7 (2.9)	144 (9.7)
2015	19 (23.2)	19 (13.7)	21 (14.5)	0 (-)	19 (4.8)	15 (7.6)	0 (-)	0 (-)	93 (13)
2016	19 (15)	15 (13.7)	21 (15)	0 (-)	17 (5.2)	0 (-)	0 (-)	0 (-)	72 (12.4)
2017	21 (20)	17 (14.9)	20 (15)	0 (-)	9 (4.4)	13 (7.2)	0 (-)	0 (-)	80 (13.8)
2018	20 (15)	19 (12.3)	20 (14.7)	0 (-)	11 (7.6)	11 (8.3)	0 (-)	0 (-)	81 (12.4)
<b>Total</b>	<b>437 (13.9)</b>	<b>394 (12.4)</b>	<b>481 (12.5)</b>	<b>242 (3.7)</b>	<b>380 (8.1)</b>	<b>388 (9.7)</b>	<b>185 (6)</b>	<b>54 (2.5)</b>	<b>2561 (10.1)</b>



Table 3. Number of catches reported by species, year and site collected by the samplers in Component 1 of the monitoring of the winter recreational fishery in the Saguenay Fjord.

**Redfish (*Sebastes spp.*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	217	2,377	314	21	3,249	914	313	-	7,405
1997	481	1,297	641	155	1,580	658	260	0	5,072
1998	459	210	589	155	1,261	883	47	-	3,604
1999	466	634	726	463	756	280	451	-	3,776
2000	51	179	213	67	1,099	622	751	18	3,000
2001	273	5	267	97	199	716	882	23	2,462
2002	261	8	184	74	454	928	241	39	2,189
2003	239	170	315	98	815	373	908	-	2,918
2004	224	4	264	6	168	300	110	-	1,076
2005	125	5	417	130	69	321	155	-	1,222
2006	23	1	150	4	15	96	47	0	336
2007	449	2	676	-	67	29	-	0	1,223
2008	771	20	1,199	11	46	157	-	34	2,238
2009	560	17	733	31	104	314	-	31	1,790
2010	26	9	100	10	8	67	-	-	220
2011	301	5	417	71	33	241	-	0	1,068
2012	590	72	602	278	20	302	-	1	1,865
2013	429	215	203	-	64	198	-	1	1,110
2014	300	72	324	-	21	109	-	19	845
2015	176	58	160	-	8	161	-	-	563
2016	167	45	192	-	51	-	-	-	455
2017	187	50	136	-	7	65	-	-	445
2018	186	46	225	-	33	36	-	-	526
<b>Total</b>	<b>6,961</b>	<b>5,502</b>	<b>9,047</b>	<b>1,671</b>	<b>10,129</b>	<b>7,827</b>	<b>4,165</b>	<b>169</b>	<b>45,471</b>

Table 3. (continued)

**Cod spp.**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	16	54	11	6	57	34	21	-	199
1997	12	51	29	9	225	66	41	7	440
1998	21	68	50	17	63	45	0	-	264
1999	21	128	44	46	44	120	11	-	414
<b>Total</b>	<b>70</b>	<b>301</b>	<b>134</b>	<b>78</b>	<b>389</b>	<b>265</b>	<b>73</b>	<b>7</b>	<b>1,317</b>

**Atlantic cod (*Gadus morhua*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
2000	5	50	0	0	0	77	55	0	187
2001	0	17	0	0	0	115	0	0	132
2002	31	7	3	5	37	49	0	1	133
2003	3	8	2	10	51	21	0	-	95
2004	26	0	0	1	37	18	0	-	82
2005	13	6	0	6	7	14	0	-	46
2006	1	2	0	1	7	40	1	0	52
2007	1	2	3	-	3	7	-	0	16
2008	36	14	30	3	12	34	-	9	138
2009	19	10	9	7	26	69	-	7	147
2010	4	22	7	9	5	13	-	-	60
2011	14	33	11	8	17	55	-	3	141
2012	8	12	7	17	8	49	-	2	103
2013	10	9	2	-	6	15	-	2	44
2014	15	22	3	-	5	1	-	12	58
2015	15	27	5	-	10	19	-	-	76
2016	15	34	3	-	18	-	-	-	70
2017	16	35	4	0	12	54	0	0	121
2018	16	17	5	0	9	44	0	0	91
<b>Total</b>	<b>317</b>	<b>631</b>	<b>228</b>	<b>145</b>	<b>663</b>	<b>979</b>	<b>129</b>	<b>42</b>	<b>3,134</b>

Table 3. (continued)

**Greenland cod (*Gadus ogac*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
2000	24	41	20	20	232	130	50	16	533
2001	14	4	24	31	170	14	92	8	357
2002	50	41	30	4	38	145	27	12	347
2003	12	53	26	14	84	119	18	-	326
2004	6	8	12	0	80	104	9	-	219
2005	25	46	9	12	85	144	18	-	339
2006	4	3	18	0	14	71	6	1	117
2007	4	2	15	-	7	2	-	1	31
2008	23	1	21	0	17	18	-	1	81
2009	20	12	5	17	6	34	-	1	95
2010	3	3	21	6	4	11	-	-	48
2011	18	9	7	12	12	25	-	-	83
2012	15	15	6	10	22	44	-	3	115
2013	17	10	2	-	21	4	-	-	54
2014	59	28	4	-	10	10	-	-	111
2015	9	13	4	-	7	6	-	-	39
2016	6	13	1	-	14	-	-	-	34
2017	9	6	2	0	2	2	0	0	21
2018	7	4	1	0	3	0	0	0	15
<b>Total</b>	<b>326</b>	<b>316</b>	<b>228</b>	<b>126</b>	<b>831</b>	<b>897</b>	<b>220</b>	<b>43</b>	<b>2,987</b>

Table 3. (continued)

**Greenland halibut (*Reinhardtius hippoglossoides*)**

Year	Anse-à - Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	7	39	3	17	0	18	0	-	84
1997	2	6	4	1	0	5	0	4	22
1998	7	20	14	0	1	1	0	-	43
1999	0	13	2	0	0	2	0	-	17
2000	1	6	0	0	0	2	0	0	9
2001	0	0	0	0	2	0	0	5	7
2002	0	11	0	0	2	4	0	3	20
2003	1	26	0	0	2	1	4	-	34
2004	9	4	0	0	0	0	0	-	13
2005	6	6	4	0	0	6	0	-	22
2006	2	1	7	0	0	3	0	0	13
2007	3	1	1	-	0	1	-	0	6
2008	12	2	7	0	0	0	-	5	26
2009	0	0	1	0	0	1	-	0	2
2010	1	0	2	0	1	2	-	-	6
2011	3	9	2	1	3	19	-	0	37
2012	2	15	3	-	1	12	-	0	33
2013	6	6	0	-	1	3	-	0	16
2014	3	26	5	-	3	-	-	1	38
2015	8	37	0	-	2	-	-	-	47
2016	4	38	5	-	2	-	-	-	49
2017	5	27	4	0	1	4	0	0	41
2018	3	47	3	0	9	3	0	0	65
<b>Total</b>	<b>85</b>	<b>340</b>	<b>67</b>	<b>19</b>	<b>30</b>	<b>87</b>	<b>4</b>	<b>18</b>	<b>650</b>

Table 4. Fishing effort (mean, median and percentile) in number of lines, number of hooks per line and number of hours between the start of the activity and the meeting with the sampler in the winter recreational groundfish fishery in the Saguenay Fjord.

Year	Number of lines				Number of hooks				Number of hours			
	Mean	Median	Percentile		Mean	Median	Percentile		Mean	Median	Percentile	
			99%	1%			99%	1%			99%	1%
1996	2.8	2	12	1	2.4	2	4	2	5.9	5	14	1.0
1997	2.5	2	12	1	2.8	2	6	1	4.5	4	12	0.5
1998	2.6	2	10	1	2.8	3	6	2	4.7	4	24	0.3
1999	3.3	2	14	1	2.6	2	5	2	4.7	4	12	0.5
2000	2.8	2	12	1	3.0	3	6	2	4.5	4	12	0.5
2001	3.4	2	15	1	2.7	3	5	2	4.9	4	12	0.5
2002	3.3	2	19	1	2.7	3	6	2	4.9	4	12	0.5
2003	2.9	2	15	1	2.8	3	7	1	4.6	4	12	1.0
2004	2.7	2	12	1	2.9	3	5	2	5.7	5	24	1.0
2005	2.6	2	12	1	3.0	3	6	1	5.6	4	24	1.0
2006	3.0	2	14	1	3.3	3	12	1	4.9	4	12	0.5
2007	1.9	1	8	1	3.4	3	10	1	4.5	4	24	0.5
2008	1.6	1	6	1	3.3	3	12	1	4.0	4	18	0.3
2009	1.9	1	10	1	3.2	3	12	1	5.1	4	24	0.5
2010	1.9	1	10	1	2.8	3	10	1	3.9	4	18	0.2
2011	1.8	1	10	1	3.0	3	10	1	5.0	4	18	0.5
2012	1.8	1	10	1	2.7	2	11	1	4.6	4	18	0.5
2013	1.4	1	4	1	2.6	2	9	1	4.4	4	24	0.5
2014	1.4	1	4	1	2.6	2	8	1	4.2	3	30	0.5
2015	1.5	1	6	1	2.4	2	9	1	4.3	4	22	0.3
2016	1.5	1	7	1	2.7	2	8	1	4.0	4	13	0.5
2017	1.5	1	5	1	2.7	2	8	1	4.0	3	21	0.3
2018	1.4	1	5	1	2.6	2	7	1	4.7	4	24	0.3
<b>Total</b>	<b>2.2</b>	<b>1</b>	<b>11</b>	<b>1</b>	<b>2.9</b>	<b>3</b>	<b>10</b>	<b>1</b>	<b>4.8</b>	<b>4</b>	<b>23</b>	<b>0.5</b>

Table 5. Number of individuals measured by species, year and site during Component 2 of the monitoring of the winter recreational groundfish fishery in the Saguenay Fjord.

**Redfish (*Sebastes spp.*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	255	146	128	-	382	73	95	2	1,081
1997	391	-	36	-	600	138	7	49	1,221
1998	101	23	189	75	709	177	111	30	1,415
1999	348	55	63	146	602	55	70	-	1,339
2000	119	39	139	2	497	35	69	-	900
2001	182	1	27	12	54	178	20	73	547
2002	375	2	81	25	60	189	68	24	824
2003	394	46	87	81	299	21	293	49	1,270
2004	105	-	151	43	50	3	105	3	460
2005	680	-	619	-	33	2	156	-	1,490
2006	28	-	2	-	1	1	46	-	78
2007	550	109	265	35	119	6	-	12	1,096
2008	227	-	236	-	55	-	-	-	518
2009	556	79	511	23	73	85	-	20	1,347
2010	66	-	103	8	-	-	-	-	177
2011	295	7	346	182	21	17	91	-	959
2012	474	15	445	70	11	71	-	-	1,086
2013	312	60	232	-	61	17	-	-	682
2014	132	208	181	15	25	120	-	2	683
2015	197	72	167	-	2	36	-	-	474
2016	171	50	87	-	4	-	-	-	312
2017	292	29	84	9	16	44	-	-	474
2018	323	26	244	-	5	66	-	-	664
<b>Total</b>	<b>6,573</b>	<b>967</b>	<b>4,423</b>	<b>726</b>	<b>3,679</b>	<b>1,334</b>	<b>1,131</b>	<b>264</b>	<b>19,097</b>

Table 5 (continued)

**Cod spp.**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	8	40	1	-	15	85	4	77	230
1997	-	14	2	-	21	154	19	55	265
1998	4	22	4	1	48	96	8	29	212
1999	3	82	2	-	29	129	8	10	263
2000	35	80	8	4	61	190	55	97	530
<b>Total</b>	<b>50</b>	<b>238</b>	<b>17</b>	<b>5</b>	<b>174</b>	<b>654</b>	<b>94</b>	<b>268</b>	<b>1,500</b>

**Atlantic cod (*Gadus morhua*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
2001	1	15	-	7	11	43	2	63	142
2002	1	15	-	1	7	3	3	5	35
2003	2	2	1	-	36	15	-	4	60
2004	-	6	4	1	8	10	-	-	29
2005	4	11	-	-	9	7	3	4	38
2006	-	16	-	1	-	16	-	1	34
2007	4	21	2	-	9	4	-	2	42
2008	5	-	1	-	16	-	-	-	22
2009	27	4	19	4	14	25	-	7	100
2010	8	-	2	4	-	-	-	-	14
2011	16	12	10	6	10	18	-	-	72
2012	4	24	4	5	2	28	-	-	67
2013	7	40	-	-	9	10	-	-	66
2014	7	54	2	-	6	49	-	8	126
2015	11	28	5	-	9	26	-	-	79
2016	11	-	48	-	-	-	-	-	59
2017	15	1	53	-	17	59	-	-	145
2018	14	43	14	-	7	67	-	-	145
<b>Total</b>	<b>137</b>	<b>292</b>	<b>165</b>	<b>29</b>	<b>170</b>	<b>380</b>	<b>8</b>	<b>94</b>	<b>1,275</b>

Table 5 (continued)

**Greenland cod (*Gadus ogac*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
2001	2	-	-	-	-	4	13	183	202
2002	-	27	-	-	1	12	-	64	104
2003	4	8	-	2	9	24	18	203	268
2004	21	2	-	-	5	28	7	83	146
2005	25	11	36	-	30	28	14	250	394
2006	1	5	-	-	-	1	7	47	61
2007	4	14	1	1	2	-	-	48	70
2008	5	-	4	-	12	-	-	6	27
2009	9	4	4	7	5	1	-	2	32
2010	7	-	5	3	-	-	-	-	15
2011	32	5	10	8	15	5	1	-	76
2012	8	37	5	2	12	33	-	-	97
2013	6	21	2	-	15	12	-	-	56
2014	19	36	-	-	17	20	-	2	94
2015	4	15	-	-	4	9	-	-	32
2016	4	-	11	-	-	-	-	-	15
2017	2	2	9	-	1	1	-	-	15
2018	-	3	-	-	-	3	-	-	6
<b>Total</b>	<b>153</b>	<b>190</b>	<b>87</b>	<b>23</b>	<b>128</b>	<b>181</b>	<b>60</b>	<b>888</b>	<b>1,710</b>



Table 5 (continued)

**Greenland halibut (*Reinhardtius hippoglossoides*)**

Year	Anse-à-Benjamin	Anse-Saint-Jean	Grande-Baie	Les Battures	Rivière-Éternité	Sainte-Rose-du-Nord	Saint-Félix-d'Otis	Saint-Fulgence	Total
1996	1	28	-	-	-	33	-	46	108
1997	9	6	-	-	-	16	-	51	82
1998	3	7	1	-	-	1	-	15	27
1999	-	1	-	-	-	2	-	-	3
2000	1	1	1	-	-	40	-	-	43
2001	-	-	-	-	-	4	-	16	20
2002	3	1	-	-	-	1	-	3	8
2003	7	9	-	-	-	4	-	2	22
2004	9	2	-	-	-	5	-	2	18
2005	3	3	5	-	-	1	-	-	12
2006	3	2	-	-	-	-	-	1	6
2007	-	5	2	-	-	1	-	-	8
2008	1	-	-	-	-	-	-	1	2
2009	-	5	2	-	1	-	-	-	8
2010	-	-	-	-	-	-	-	-	-
2011	1	5	-	-	-	4	-	-	10
2012	3	6	3	2	-	1	-	-	15
2013	2	5	-	-	2	-	-	-	9
2014	-	41	1	-	3	15	-	-	60
2015	1	7	-	-	-	1	-	-	9
2016	3	-	1	-	-	-	-	-	4
2017	-	7	4	-	1	3	-	-	15
2018	-	13	6	-	1	4	-	-	24
<b>Total</b>	<b>50</b>	<b>154</b>	<b>26</b>	<b>2</b>	<b>8</b>	<b>136</b>	<b>0</b>	<b>137</b>	<b>513</b>

Table 6. Descriptive statistics on the total length (cm) of fish sampled by species and by year during the winter recreational groundfish fishery in the Saguenay Fjord.

**Redfish (*Sebastes spp.*)**

	<b>Total length (cm)</b>					
	<b>n</b>	<b>Mean</b>	<b>Standard deviation</b>	<b>Median</b>	<b>Minimum</b>	<b>Maximum</b>
1996	1,079	28.1	2.4	28	17	48
1997	1,220	28.5	1.9	28	21	36
1998	1,415	28.7	2.0	29	18	48
1999	1,339	28.8	1.9	29	22	40
2000	897	29.1	2.1	29	20	37
2001	540	29.7	2.3	30	22	37
2002	825	29.4	2.2	29	20	38
2003	1,270	29.9	2.5	30	14	44
2004	463	30.3	2.5	30	20	40
2005	1,491	30.4	2.3	31	22	40
2006	78	30.0	2.4	30	25	34
2007	1,096	30.5	3.7	31	16	40
2008	518	30.8	2.2	31	23	37
2009	1,347	30.9	2.6	31	12	40
2010	177	30.8	2.5	31	21	37
2011	959	31.9	2.5	32	20	40
2012	1,086	31.3	2.5	31	20	40
2013	682	31.5	2.8	32	20	42
2014	683	32.4	2.8	32	23	41
2015	474	32.5	2.7	32	13	40
2016	313	31.0	5.1	32	8	40
2017	436	31.3	4.7	32	13	41
2018	638	32.2	5.0	33	15	43

Table 6 (continued)

**Greenland halibut (*Reinhardtius hippoglossoides*)**

Year	Total length (cm)					
	n	Mean	Standard deviation	Median	Minimum	Maximum
1996	108	49.6	7.1	49	29	76
1997	81	51.9	5.7	52	36	67
1998	27	51.8	8.7	50	38	68
1999	3	54.3	5.1	53	50	60
2000	43	53.8	3.9	54	45	64
2001	19	60.7	7.9	59	49	81
2002	8	50.5	8.1	50	41	67
2003	22	52.0	14.2	48	36	101
2004	18	46.7	7.7	48	29	57
2005	12	47.8	5.5	46.5	40	58
2006	6	42.5	4.8	40.5	38	49
2007	30	59.9	19.4	54	30	99
2008	2	39.0	2.8	39	37	41
2009	8	47.8	7.2	46.5	38	57
2011	10	41.9	4.3	43	37	48
2012	15	44.3	11.4	47	20	59
2013	9	48.3	4.1	47	42	55
2014	60	48.1	6.3	48.5	32	58
2015	9	51.2	6.7	52	41	61
2016	4	40.5	12.8	40	29	53
2017	14	50.5	10.4	53	31	65
2018	24	41.7	6.3	42	29	56

Table 6 (continued)

**Atlantic cod (*Gadus morhua*)**

Year	Total length (cm)					
	n	Mean	Standard deviation	Median	Minimum	Maximum
2001	140	50.7	17.0	44	29	112
2002	35	54.3	17.0	53	27	93
2003	60	48.3	17.7	44	26	102
2004	29	48.2	15.1	44	30	88
2005	38	54.0	18.2	49	21	92
2006	34	52.1	14.5	49	18	95
2007	42	45.0	11.9	45	29	82
2008	22	42.0	7.7	42	26	59
2009	100	49.8	13.9	48	23	112
2010	14	50.7	7.5	52	38	60
2011	72	52.1	8.2	53	31	80
2012	67	53.3	11.4	52	25	80
2013	66	55.8	11.4	58	25	79
2014	126	57.0	11.8	58	22	87
2015	79	48.9	16.6	44	28	100
2016	59	46.7	11.9	45	25	83
2017	137	51.5	10.7	49	33	99
2018	142	53.8	9.5	53	30	84

**Greenland cod (*Gadus ogac*)**

Year	Total length (cm)					
	n	Mean	Standard deviation	Median	Minimum	Maximum
2001	202	44.3	6.5	43	31	66
2002	104	46.2	8.0	45	30	67
2003	268	44.8	9.3	45	15	72
2004	146	45.5	7.5	45	30	70
2005	394	42.8	6.3	42	28	66
2006	61	42.9	6.4	42	28	59
2007	70	46.2	8.6	48	29	63
2008	30	43.5	8.0	42	33	69
2009	32	39.8	9.1	38	23	72
2010	15	43.5	5.4	42	37	52
2011	76	41.4	6.9	41	29	56
2012	97	39.9	7.7	40	22	60
2013	56	42.3	10.5	43	21	67
2014	94	41.3	7.3	40	30	72
2015	32	43.2	7.2	42	32	59
2016	15	42.1	4.3	41	36	53
2017	13	46.4	6.7	46	36	56
2018	6	37.2	4.8	37	32	45

Table 7. Descriptive statistics on the total length (cm) of fish sampled occasionally during the winter recreational groundfish fishery in the Saguenay Fjord.

Species	Total Length (cm)					
	n	mean	S.-D.	med.*	min.	max.
American eel ( <i>Anguillidae</i> )	22	47,0	12,9	51	20	66
Capelin ( <i>Mallotus villosus</i> )	20	15,5	1,1	15	14	19
Atlantic halibut ( <i>Hippoglossus hippoglossus</i> )	4	59,8	3,3	60	56	64
Lycode ( <i>Lycodes spp.</i> )	75	41,3	11,6	40	17	68
Tadpole sp. ( <i>Liparidae</i> )	10	17,9	4,0	17	15	29
White hake ( <i>Urophycis tenuis</i> )	22	40,3	9,9	39	30	61
Plaice sp. ( <i>Pleuronectidae</i> )	10	43,9	13,4	46	22	65
Skate sp. ( <i>Rajidae</i> )	45	43,0	7,8	42	28	58
Arctic cod ( <i>Boreogadus saida</i> )	63	28,8	8,3	29	15	55

\*Median

Table 8. Parameters of the relationship between the total mass (g) and total length (cm) of fish sampled by species and by year during the winter recreational groundfish fishery in the Saguenay Fjord.

Year	Redfish			Greenland halibut		
	n	a	b	n	A	b
1996	1,079	0.143	2.299	108	0.004	3.236
1997	1,220	0.067	2.513	81	0.019	2.836
1998	1,415	0.029	2.755	27	0.069	2.530
1999	1,339	0.285	2.092	3	0.009	2.982
2000	897	0.087	2.443	43	0.002	3.421
2001	540	0.075	2.496	-	-	-
2002	825	0.064	2.536	8	0.005	3.223
2003	1,270	0.325	2.053	22	0.041	2.659
2004	463	0.118	2.357	18	0.008	3.053
2005	1,491	0.156	2.273	12	0.005	3.182
2006	78	0.110	2.378	6	0.017	2.807
2007	1,096	0.022	2.829	30	0.010	3.000
2008	518	0.027	2.770	2	0.001	3.521
2009	1,347	0.062	2.531	8	0.002	3.381
2010	177	0.069	2.484	-	-	-
2011	959	0.177	2.231	-	-	-
2012	1,086	0.053	2.577	15	0.015	2.860
2013	682	0.044	2.627	9	0.011	2.931
2014	683	0.074	2.471	60	0.006	3.083
2015	474	0.038	2.664	9	0.002	3.343
2016	313	0.030	2.729	4	0.003	3.293
2017	436	0.044	2.625	14	0.002	3.391
2018	638	0.167	2.232	24	0.002	3.366
<b>1996–2018</b>	<b>19,026</b>	<b>0.124</b>	<b>2.331</b>	<b>532</b>	<b>0.014</b>	<b>2.910</b>

Table 8. (continued).

Year	Atlantic cod			Greenland cod		
	n	a	b	n	a	b
2001	140	0.040	2.698	202	0.016	2.971
2002	35	0.041	2.662	104	0.072	2.581
2003	60	0.002	3.420	268	0.095	2.494
2004	29	0.043	2.676	146	0.020	2.927
2005	38	0.003	3.272	394	0.029	2.791
2006	34	0.000	3.873	61	0.014	3.009
2007	42	0.011	2.992	70	0.080	2.547
2008	22	0.011	2.982	30	0.120	2.390
2009	100	0.005	3.164	32	0.303	2.142
2010	14	0.102	2.366	15	0.007	3.078
2011	72	0.021	2.782	76	0.007	3.128
2012	67	0.005	3.123	97	0.013	2.934
2013	66	0.025	2.750	56	0.007	3.121
2014	126	0.005	3.133	94	0.001	3.761
2015	79	0.001	3.583	32	0.004	3.247
2016	59	0.019	2.814	15	0.000	4.586
2017	137	0.003	3.279	13	0.039	2.669
2018	142	0.008	3.004	6	0.579	1.907
<b>2001–2018</b>	<b>1,262</b>	<b>0.004</b>	<b>3.184</b>	<b>1,711</b>	<b>0.025</b>	<b>2.834</b>

Table 9. Descriptive statistics on the Fulton condition index (with total mass) of fish sampled by species and by year during the winter recreational fishery in the Saguenay Fjord.

**Redfish (*Sebastes spp.*)**

Year	n	Condition Index				
		Mean	Standard deviation	Median	Minimum	Maximum
1996	1,079	1.39	0.16	1.38	0.76	2.46
1997	1,220	1.31	0.13	1.30	0.89	2.35
1998	1,415	1.30	0.15	1.28	0.77	2.25
1999	1,339	1.35	0.17	1.34	0.56	2.18
2000	897	1.34	0.15	1.34	0.67	2.39
2001	540	1.36	0.20	1.34	0.89	2.32
2002	825	1.34	0.17	1.32	0.76	2.47
2003	1,270	1.30	0.16	1.29	0.58	2.08
2004	463	1.33	0.20	1.30	0.84	2.69
2005	1,491	1.31	0.21	1.28	0.77	2.83
2006	78	1.34	0.16	1.33	0.86	1.78
2007	1,096	1.22	0.14	1.21	0.66	2.08
2008	518	1.22	0.12	1.22	0.84	1.70
2009	1,346	1.24	0.15	1.24	0.83	2.95
2010	177	1.18	0.18	1.18	0.73	2.15
2011	959	1.24	0.17	1.23	0.70	2.05
2012	1,086	1.24	0.14	1.24	0.83	2.08
2013	682	1.22	0.15	1.20	0.81	1.97
2014	683	1.18	0.15	1.17	0.75	1.88
2015	474	1.18	0.14	1.17	0.78	1.66
2016	312	1.16	0.16	1.15	0.59	2.24
2017	436	1.20	0.15	1.19	0.85	1.58
2018	638	1.14	0.19	1.15	0.57	1.93



Table 9 (continued)

**Greenland halibut (*Reinhardtius hippoglossoides*)**

Year	n	Condition index				
		Mean	Standard deviation	Median	Minimum	Maximum
1996	107	1.07	0.35	0.98	0.48	2.67
1997	81	1.01	0.20	0.96	0.64	1.98
1998	27	1.11	0.25	1.04	0.77	1.53
1999	3	0.87	0.03	0.87	0.84	0.90
2000	43	0.95	0.21	0.87	0.76	1.65
2001	19	1.23	0.36	1.20	0.65	2.03
2002	8	1.14	0.26	1.08	0.89	1.57
2003	22	1.10	0.46	0.95	0.79	2.61
2004	18	1.01	0.20	1.01	0.54	1.34
2005	12	0.94	0.17	0.88	0.71	1.21
2006	6	0.84	0.05	0.87	0.75	0.88
2007	30	0.98	0.01	0.98	0.96	1.01
2008	2	1.11	0.51	1.11	0.75	1.47
2009	8	0.97	0.11	0.96	0.79	1.15
2011	10	1.02	0.31	0.89	0.81	1.73
2012	15	0.92	0.15	0.87	0.78	1.38
2013	9	0.86	0.04	0.86	0.81	0.93
2014	60	0.88	0.13	0.88	0.54	1.37
2015	9	0.87	0.08	0.88	0.75	0.98
2016	4	0.82	0.05	0.81	0.76	0.89
2017	14	0.83	0.14	0.81	0.63	1.01
2018	24	0.79	0.12	0.80	0.39	0.96

Table 9 (continued)

**Atlantic cod (*Gadus morhua*)**

Year	n	Condition index				
		Mean	Standard deviation	Median	Minimum	Maximum
2001	140	1.22	0.27	1.17	0.63	2.13
2002	35	1.10	0.32	1.03	0.63	2.13
2003	60	1.14	0.20	1.14	0.83	2.09
2004	27	1.25	0.42	1.14	0.64	2.48
2005	37	1.09	0.34	1.01	0.63	2.55
2006	34	1.12	0.44	0.94	0.54	2.23
2007	42	1.04	0.24	1.03	0.67	1.64
2008	22	0.97	0.13	0.94	0.77	1.23
2009	100	0.94	0.16	0.93	0.58	1.47
2010	14	0.85	0.13	0.86	0.59	1.01
2011	72	0.90	0.15	0.87	0.70	1.60
2012	67	0.89	0.15	0.88	0.51	1.41
2013	66	0.91	0.13	0.88	0.60	1.39
2014	126	0.89	0.11	0.87	0.60	1.35
2015	79	0.84	0.25	0.86	0.01	1.74
2016	59	0.95	0.26	0.90	0.30	1.93
2017	137	0.84	0.14	0.84	0.38	1.24
2018	142	0.84	0.13	0.84	0.45	1.44

**Greenland cod (*Gadus ogac*)**

Year	n	Condition index				
		Mean	Standard deviation	Median	Minimum	Maximum
2001	202	1.44	0.31	1.40	0.86	2.53
2002	103	1.44	0.40	1.40	0.77	2.63
2003	268	1.35	0.28	1.31	0.62	2.06
2004	146	1.45	0.28	1.44	0.58	2.16
2005	393	1.31	0.31	1.25	0.39	2.56
2006	61	1.46	0.38	1.39	0.59	2.28
2007	70	1.39	0.43	1.23	0.76	2.76
2008	30	1.19	0.24	1.20	0.75	1.69
2009	32	1.28	0.21	1.29	0.75	1.60
2010	15	0.99	0.09	1.01	0.85	1.12
2011	76	1.14	0.26	1.09	0.52	2.38
2012	96	1.11	0.43	1.08	0.41	2.82
2013	56	1.11	0.19	1.08	0.66	1.75
2014	94	1.19	0.23	1.16	0.77	1.99
2015	32	1.07	0.20	1.10	0.49	1.49
2016	15	0.95	0.30	0.97	0.38	1.43
2017	13	1.10	0.29	1.02	0.74	1.77
2018	6	1.12	0.15	1.17	0.83	1.23

## FIGURES

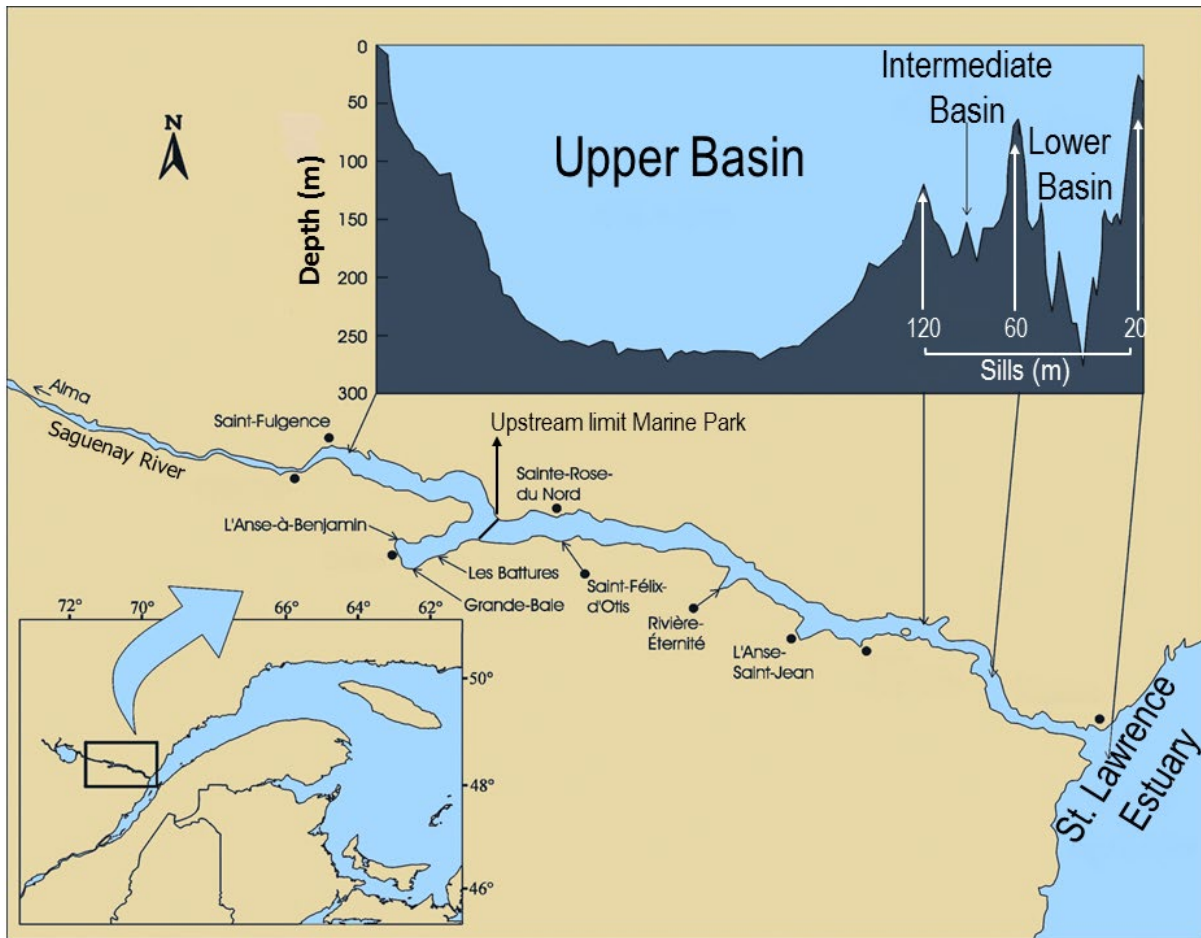


Figure 1a. Map of the Saguenay. Fishing villages on the pack ice are established at Saint-Fulgence, L'Anse-à-Benjamin, Grande-Baie, Les Battures, Sainte-Rose-du-Nord, Saint-Félix-d'Otis, Rivière-Éternité and L'Anse-Saint-Jean. The upstream boundary of the Saguenay–St. Lawrence Marine Park is identified on the map.

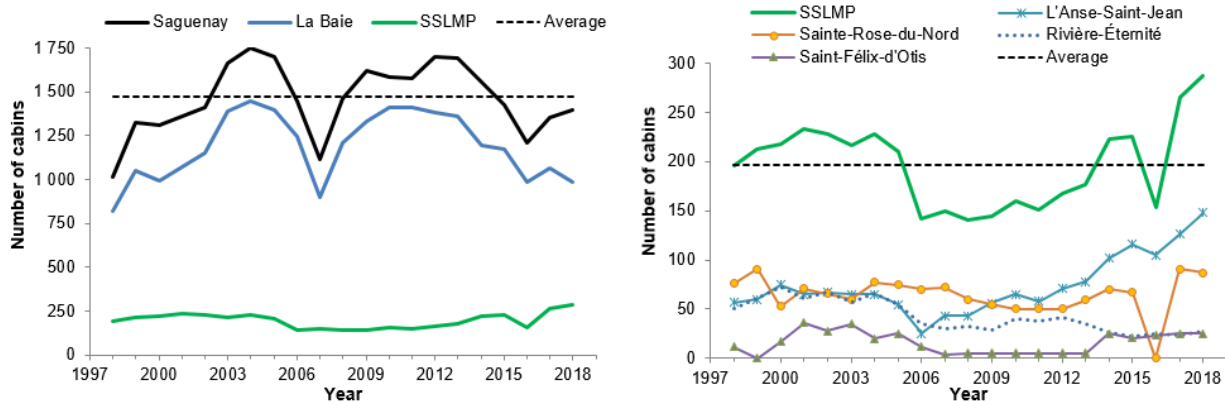


Figure 1b. Number of cabins set up on the pack ice from 1998 to 2018 during the winter recreational fishery for the smelt and groundfish areas combined. Information is presented for the entire Saguenay region on the left and for the Saguenay–St. Lawrence Marine Park (SSLMP) sites on the right.

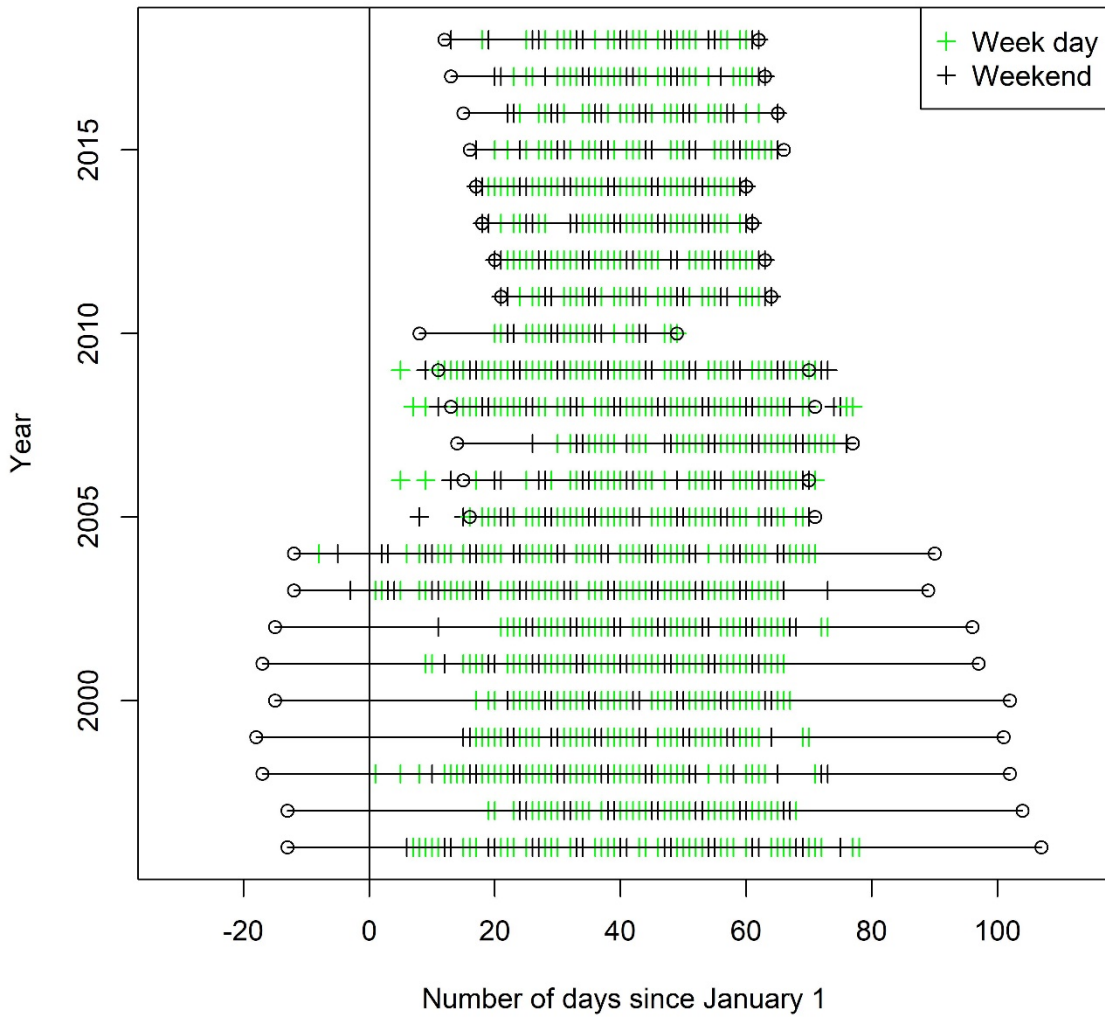


Figure 2. Annual distribution of sampling activities of the winter recreational fishery in the Saguenay Fjord for Component 1 – catch per unit of effort. The circles represent the opening and closing of the fishery and the + signs represent the sampling days.

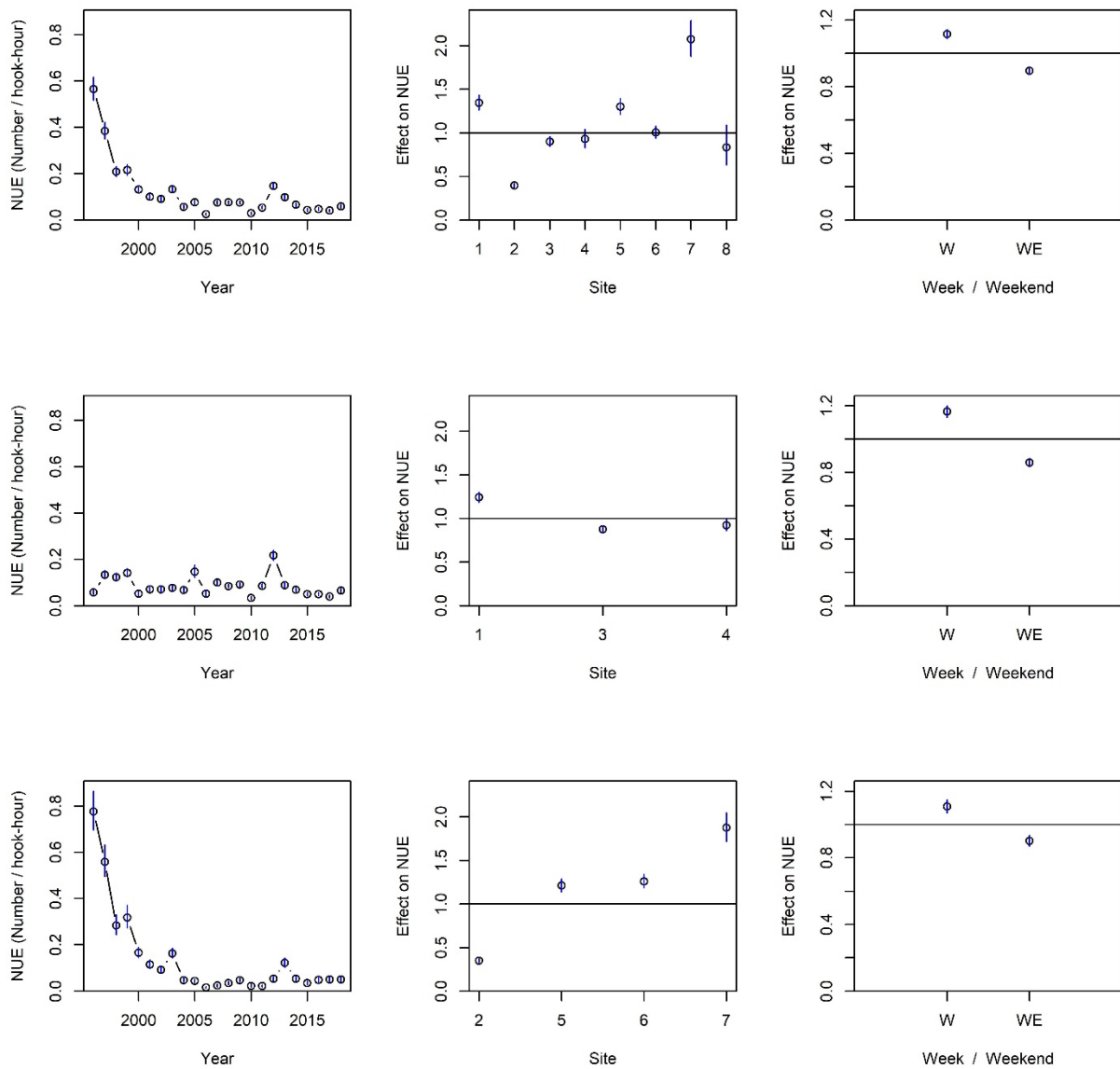


Figure 3. Annual catch rates (Number per unit of effort (NUE)  $\pm$  95% confidence interval) and the effect on the NUE of the site and time (weekday and weekend) variables for redfish during the winter recreational fishery in the Saguenay Fjord, for the entire Saguenay region (top), for the Baie des Ha! Ha! (middle) and for the SSLMP (bottom). Numbering of the sites: (1) L'Anse-à-Benjamin, (2) L'Anse-Saint-Jean, (3) Grande-Baie, (4) Les Battures, (5) Rivière-Éternité, (6) Sainte-Rose-du-Nord, (7) Saint-Félix-d'Otis and (8) Saint-Fulgence.

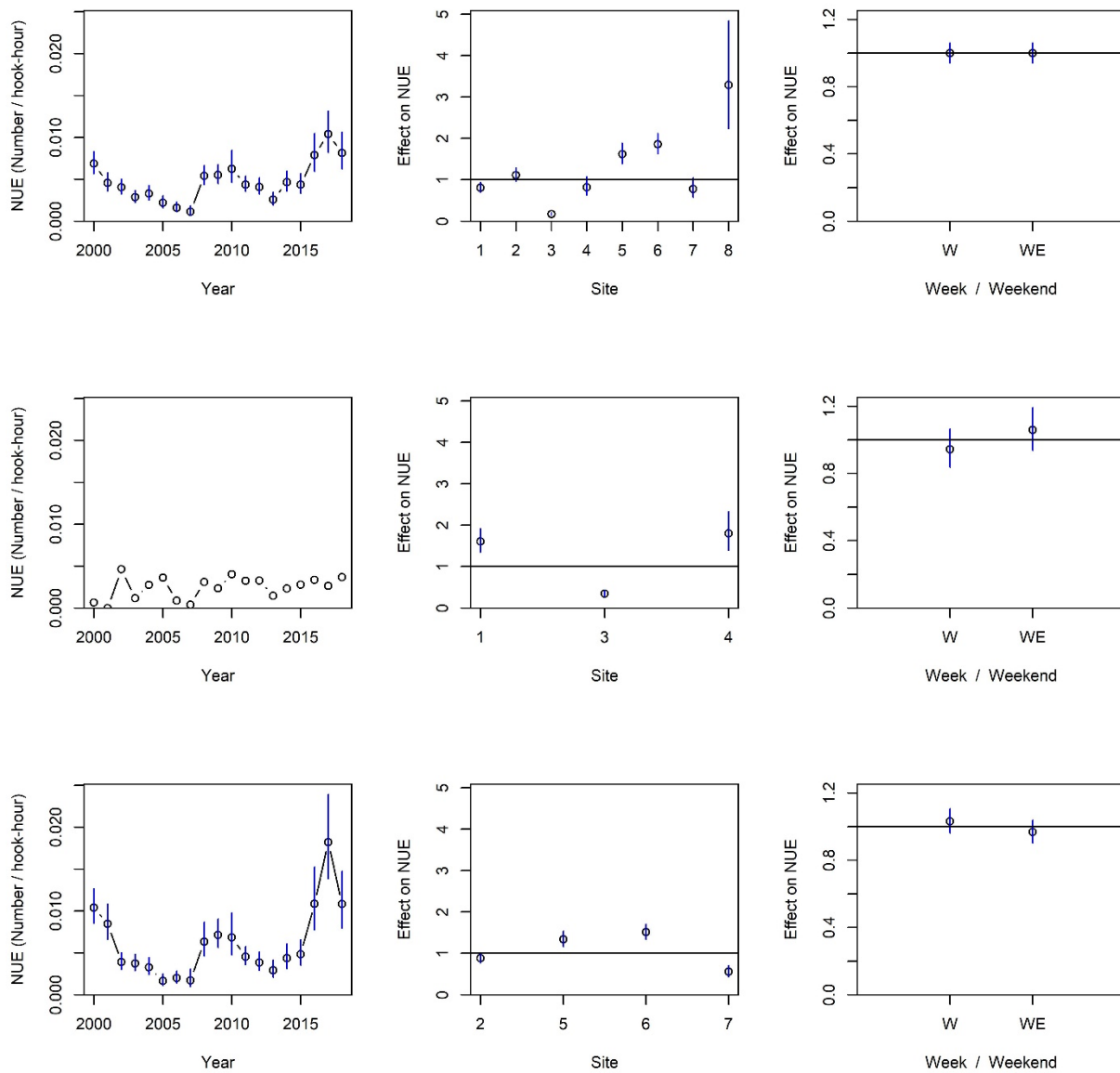


Figure 4. Annual catch rates (Number per unit of effort (NUE)  $\pm$  95% confidence interval) and the effect on the NUE of the site and time (weekday and weekend) variables for Atlantic cod during the winter recreational fishery in the Saguenay Fjord, for the entire Saguenay region (top), for the Baie des Ha! Ha! (middle) and for the SSLMP (bottom). Numbering of the sites: (1) L'Anse-à-Benjamin, (2) L'Anse-Saint-Jean, (3) Grande-Baie, (4) Les Battures, (5) Rivière-Éternité, (6) Sainte-Rose-du-Nord, (7) Saint-Félix-d'Otis and (8) Saint-Fulgence.

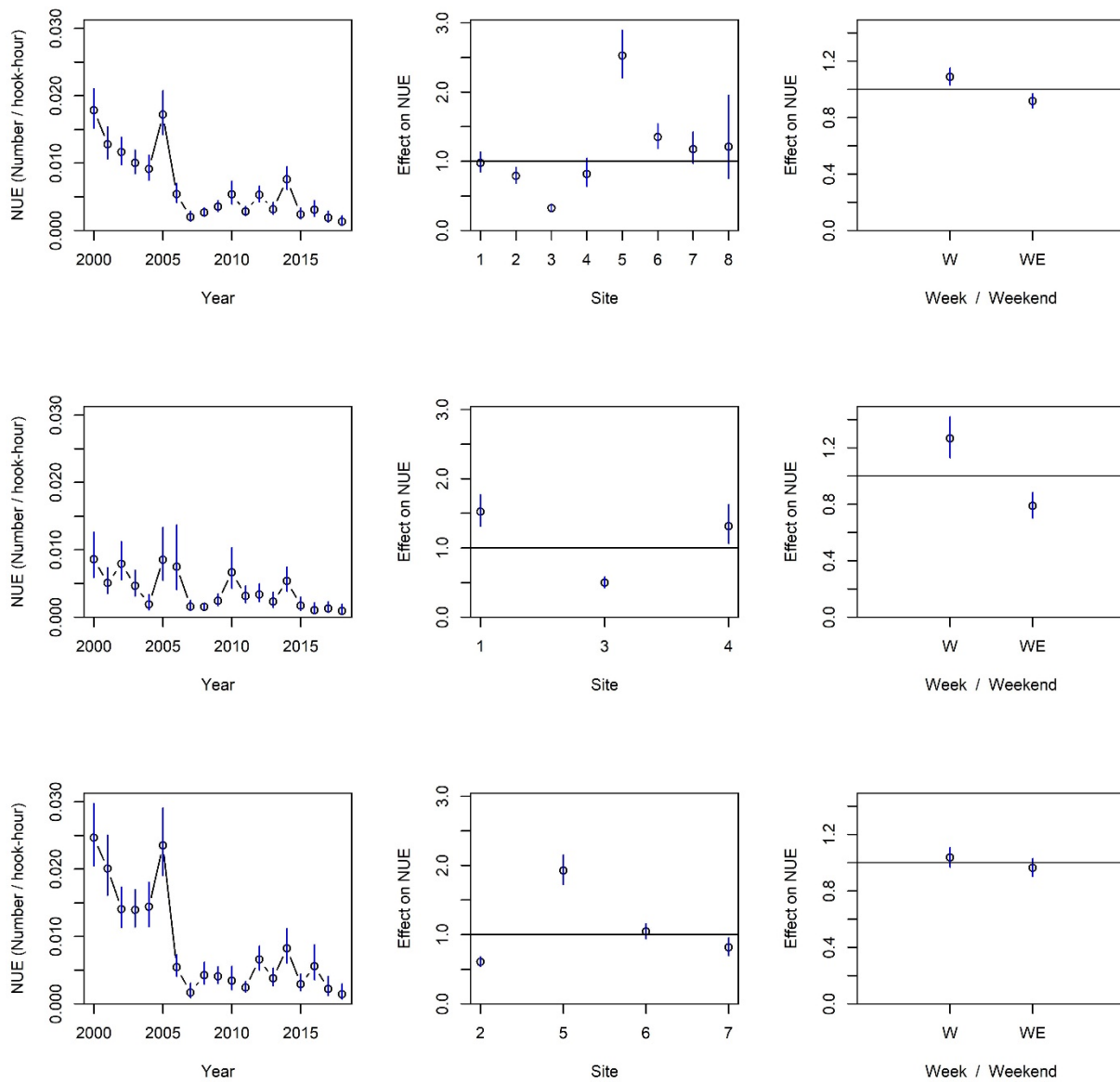


Figure 5. Annual catch rates (Number per unit of effort (NUE)  $\pm$  95% confidence interval) and the effect on the NUE of the site and time (weekday and weekend) variables for Greenland cod during the winter recreational fishery in the Saguenay Fjord, for the entire Saguenay region (top), for the Baie des Ha! Ha! (middle) and for the SSLMP (bottom). Numbering of the sites: (1) L'Anse-à-Benjamin, (2) L'Anse-Saint-Jean, (3) Grande-Baie, (4) Les Battures, (5) Rivière-Éternité, (6) Sainte-Rose-du-Nord, (7) Saint-Félix-d'Otis and (8) Saint-Fulgence.

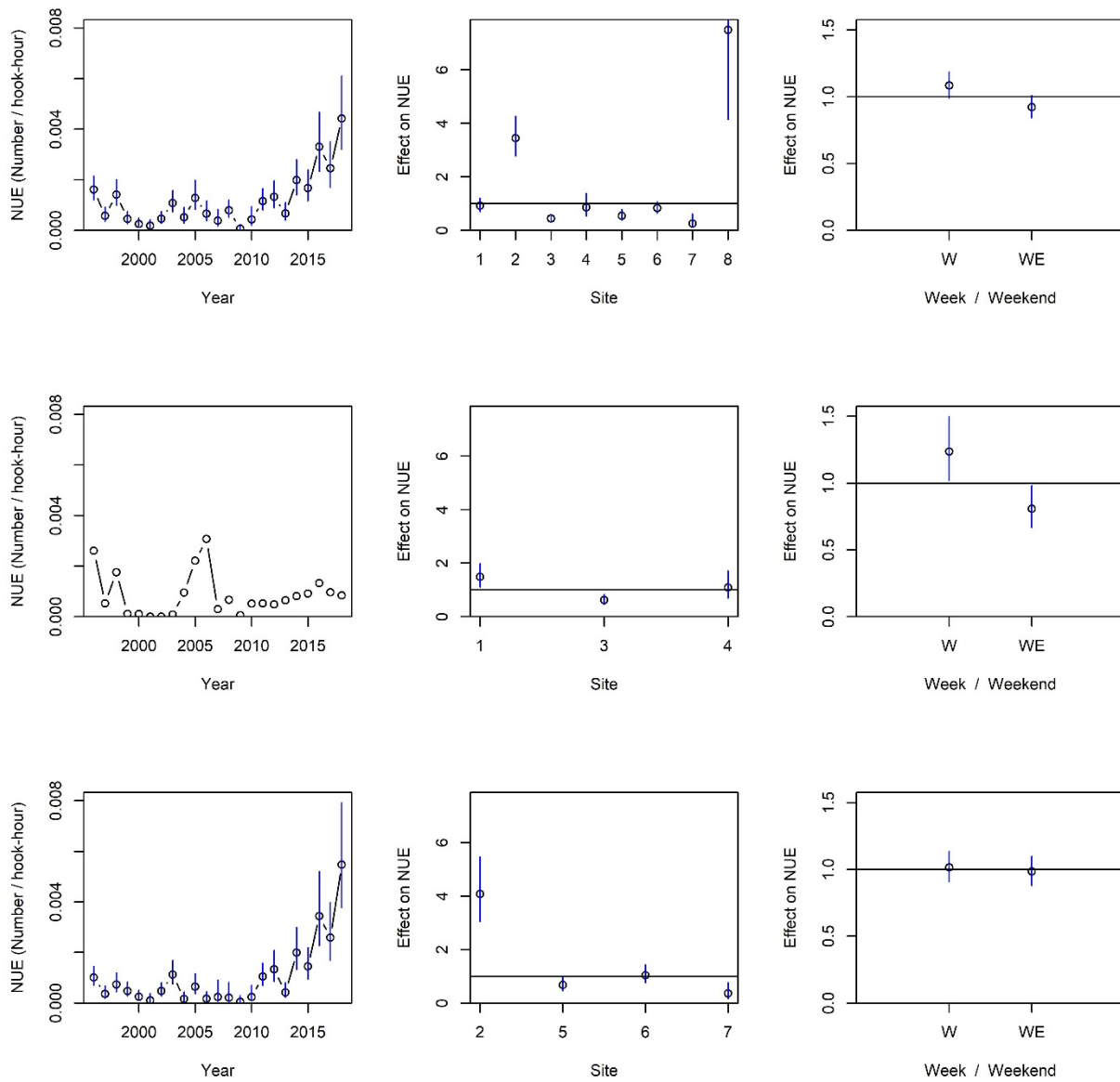


Figure 6. Annual catch rates (Number per unit of effort (NUE)  $\pm$  95% confidence interval) and the effect on the NUE of the site and time (weekday and weekend) variables for Greenland halibut during the winter recreational fishery in the Saguenay Fjord, for the entire Saguenay region (top), for the Baie des Ha! Ha! (middle) and for the SSLMP (bottom). Numbering of the sites: (1) L'Anse-à-Benjamin, (2) L'Anse-Saint-Jean, (3) Grande-Baie, (4) Les Battures, (5) Rivière-Éternité, (6) Sainte-Rose-du-Nord, (7) Saint-Félix-d'Otis and (8) Saint-Fulgence.



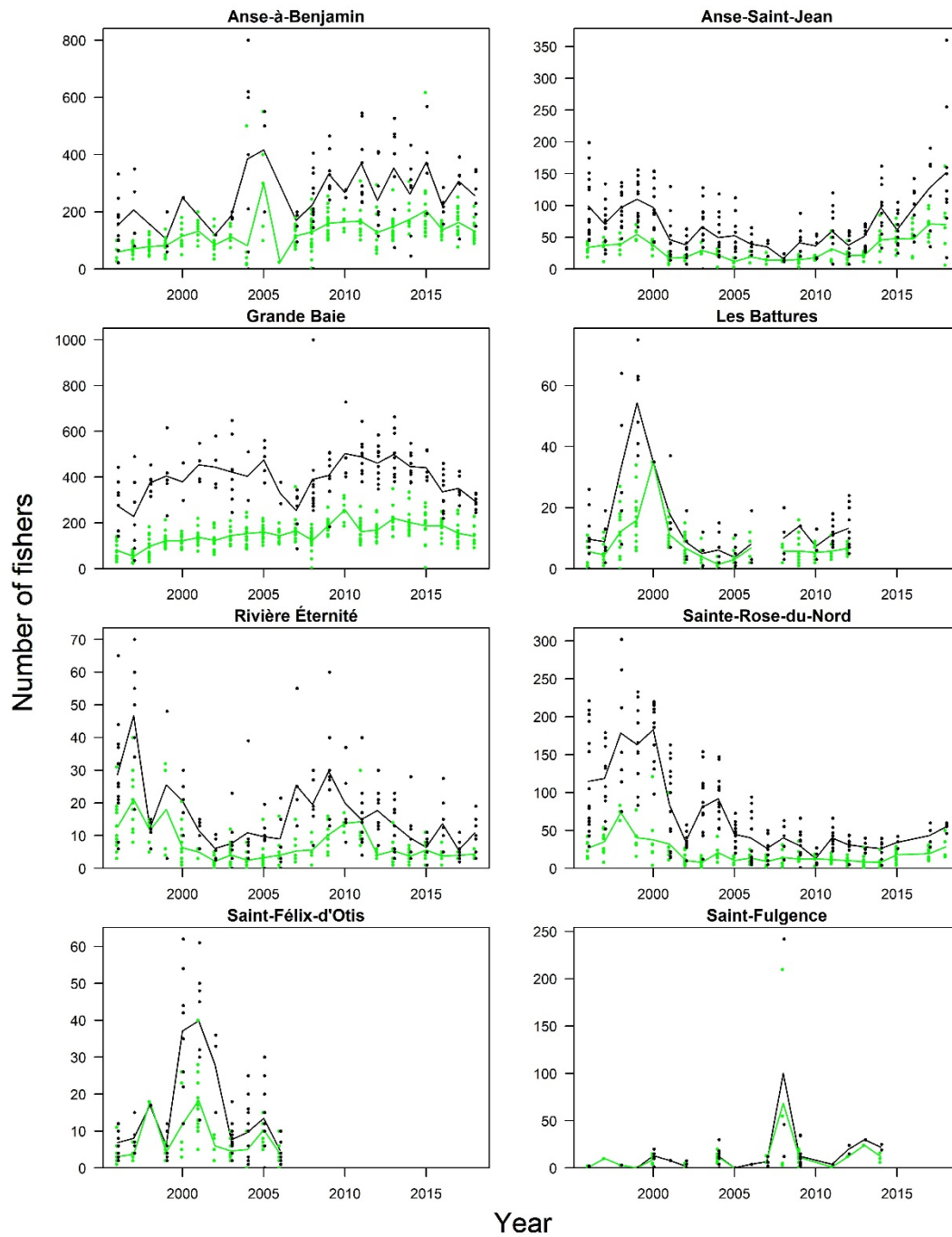


Figure 7. Weekday (green) and weekend (black) fishing site frequentation during the winter recreational groundfish fishery in the Saguenay Fjord. Each dot represents the estimated value of the number of fishers during a visit, and the line connects the annual averages.

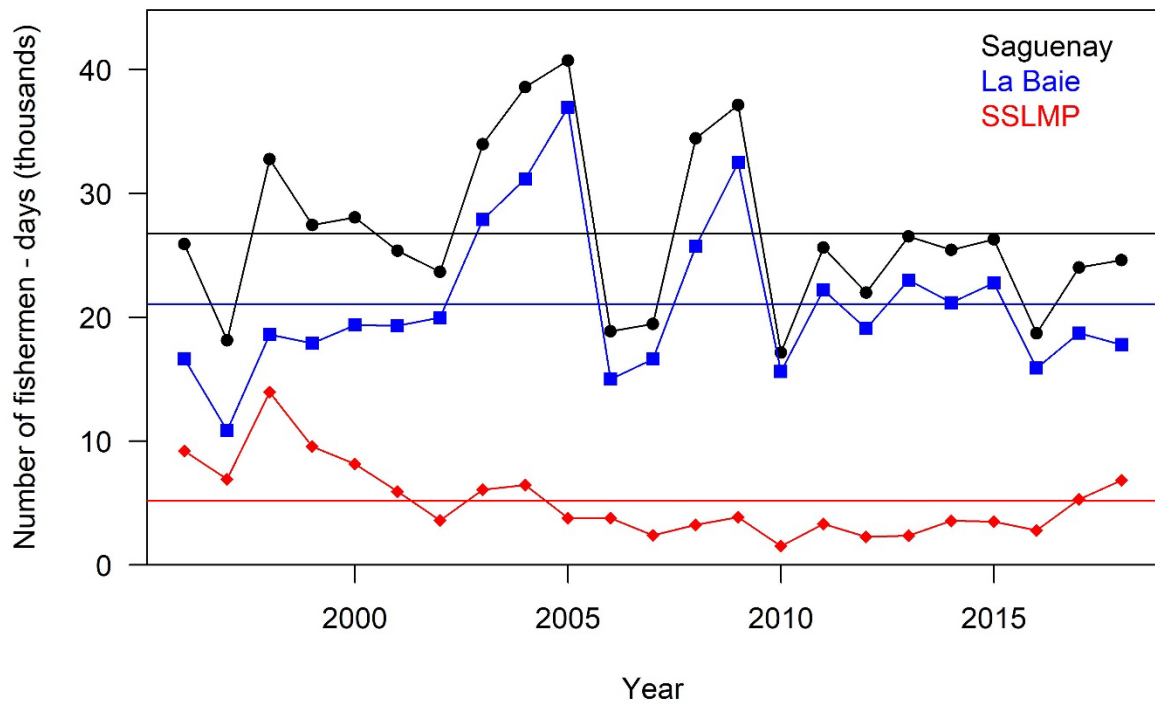
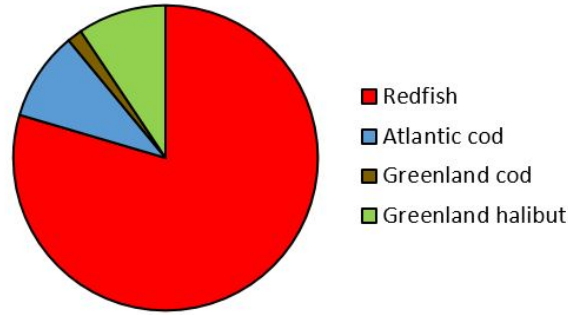


Figure 8. Annual frequentation of the recreational groundfish fishery for the entire Saguenay region (black circle), the Baie des Ha! Ha! (blue square) and the Saguenay–St. Lawrence Marine Park (red diamond). The horizontal lines represent the average for each series (1996–2018).

A)



B)

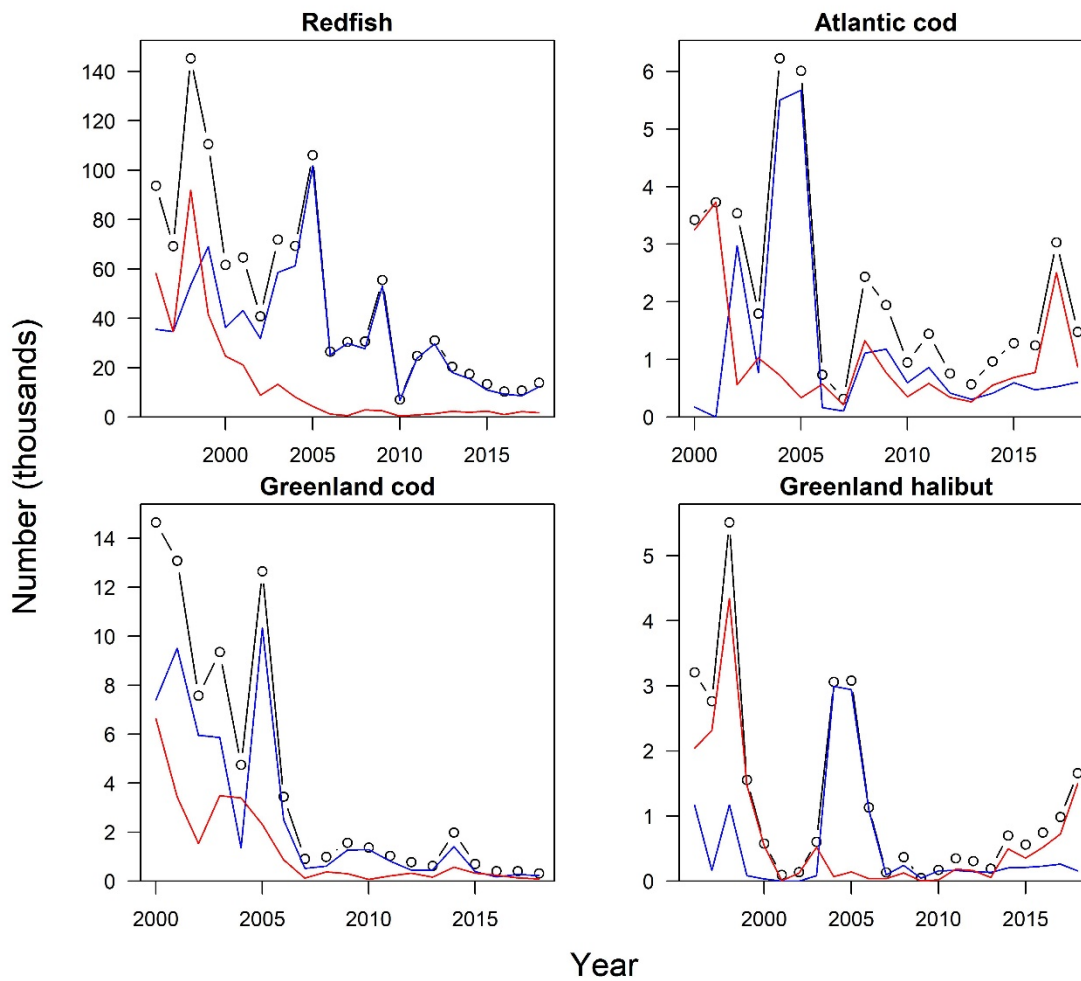


Figure 9. A) Proportion of the four main species in the Saguenay Fjord recreational groundfish fishery out of the total catch estimated in 2018. B) Estimated total catch by species and by year for the entire Saguenay region (black circle), the Baie des Ha! Ha! (blue line) and the SSLMP (red line) during the winter recreational groundfish fishery in the Saguenay Fjord.

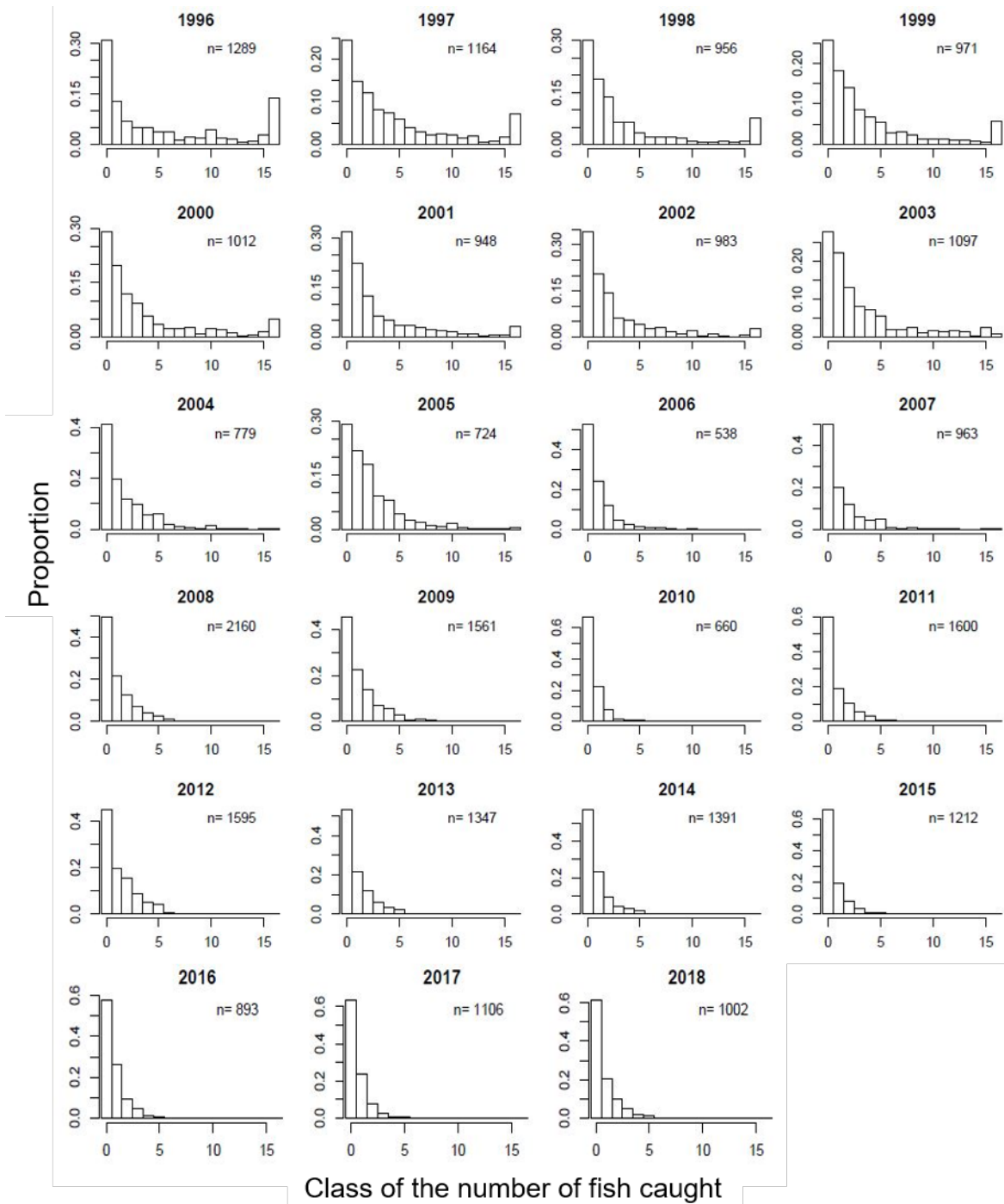


Figure 10. Proportion of fishers surveyed (Component 1) by category of the number of fish caught during the winter recreational groundfish fishery in the Saguenay Fjord.

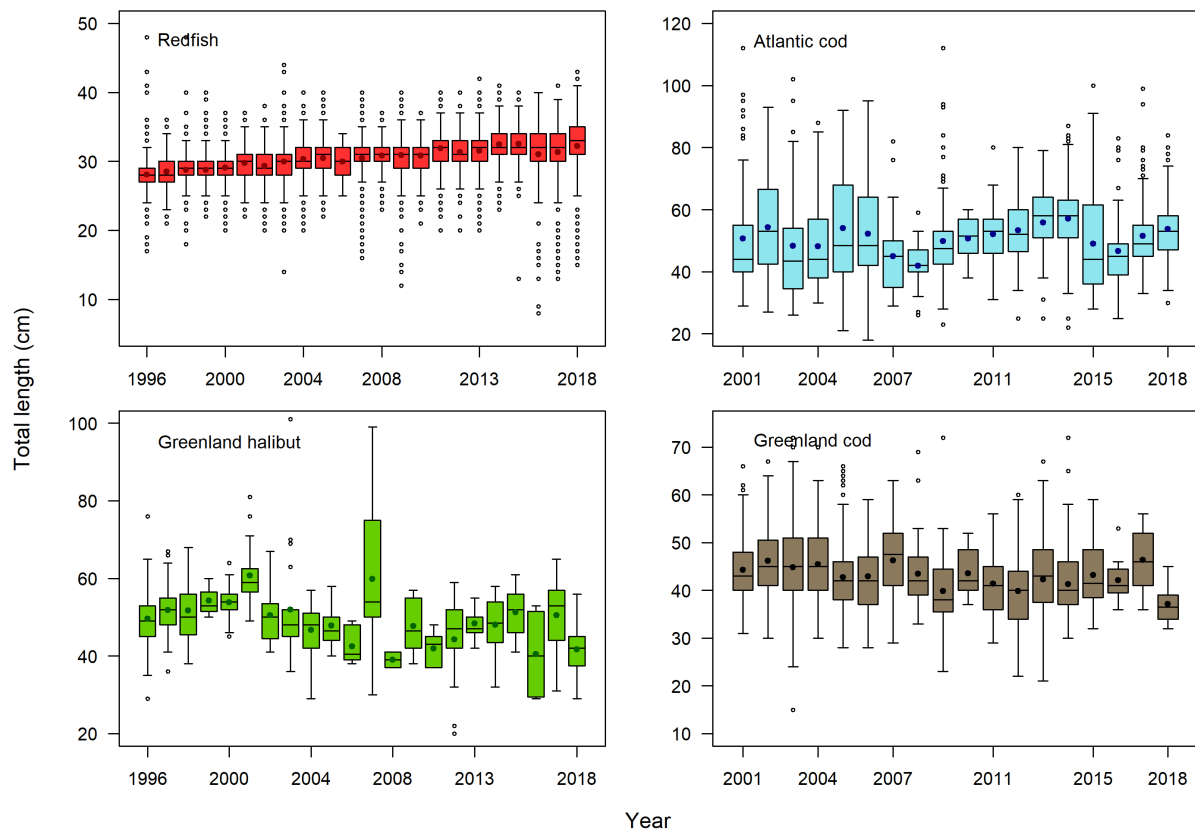
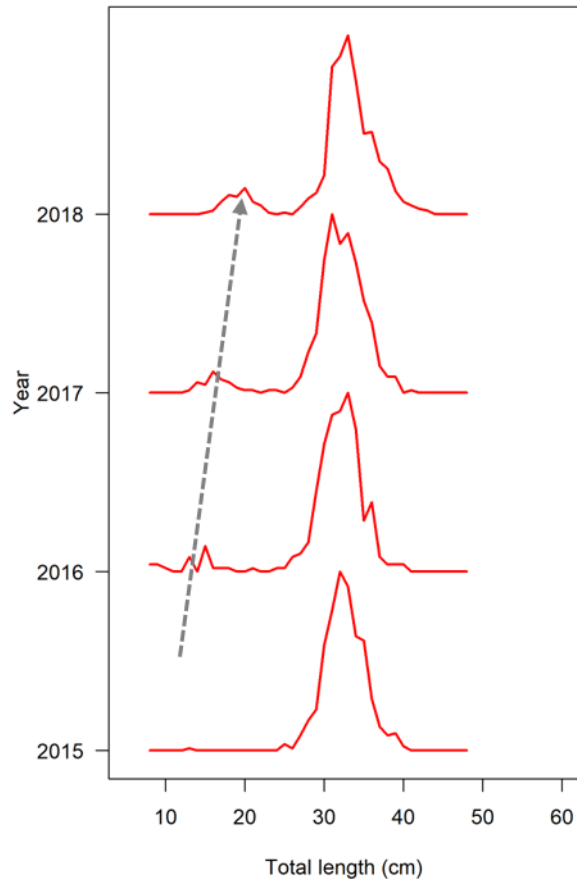


Figure 11. Size frequency distribution (total length) for redfish, Greenland halibut, Atlantic cod and Greenland cod sampled during the winter recreational groundfish fishery in the Saguenay Fjord. Graphic representation in box-and-whisker plots: the line inside the box represents the median and the solid circle is the average. The box ranges from the 25th to the 75th percentile, the whiskers range from the 5th to the 95th percentile and the empty circles represent outliers.



*Figure 12. Size frequency distribution (total length) for redfish sampled from 2015 to 2018 during the winter recreational groundfish fishery in the Saguenay Fjord.*

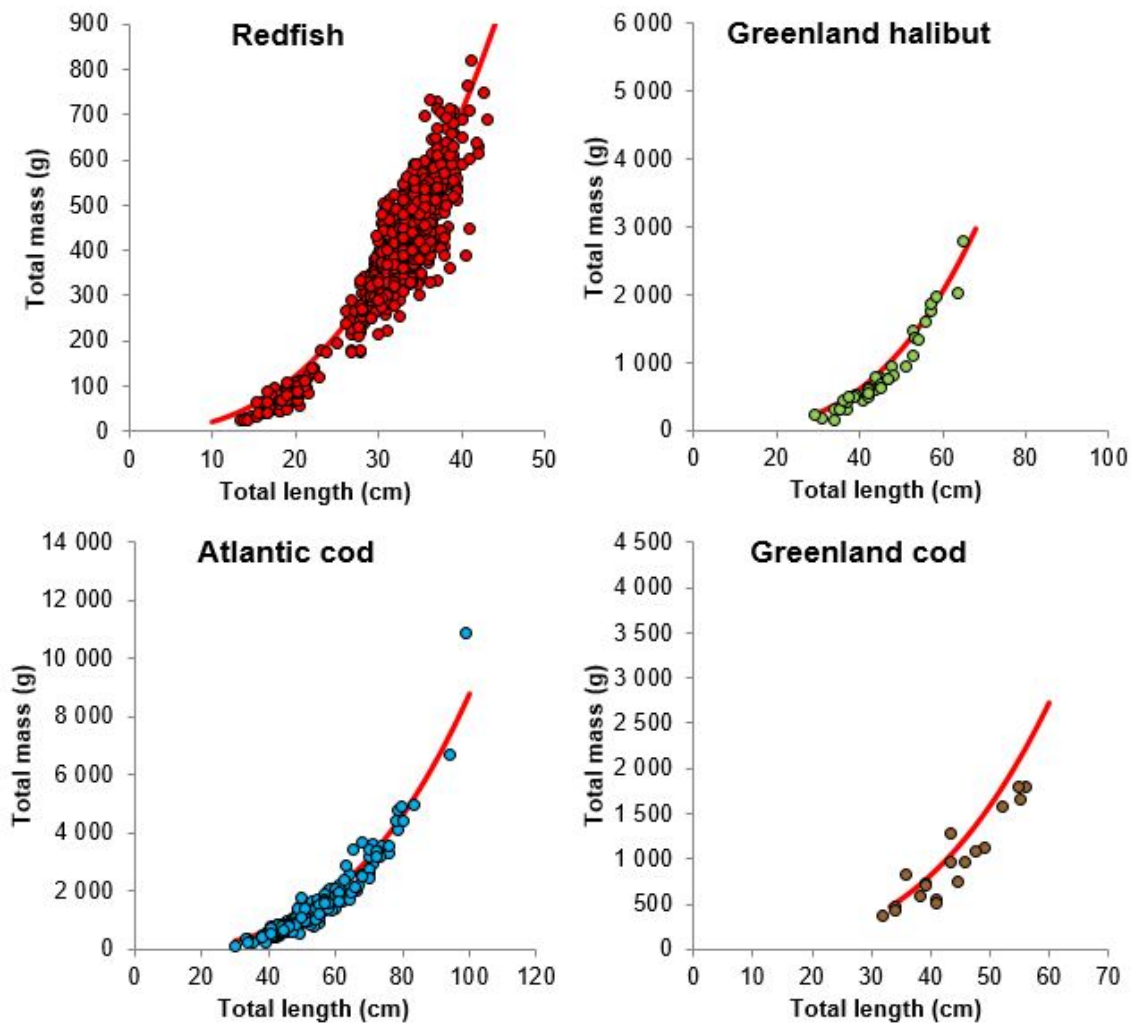


Figure 13. Relationship between total mass (g) and total length (cm) for redfish, Greenland halibut, Atlantic cod and Greenland cod sampled during the winter recreational groundfish fishery. The red line shows the regression for the years 1996–2018, and the dots represent the data for 2017 and 2018.

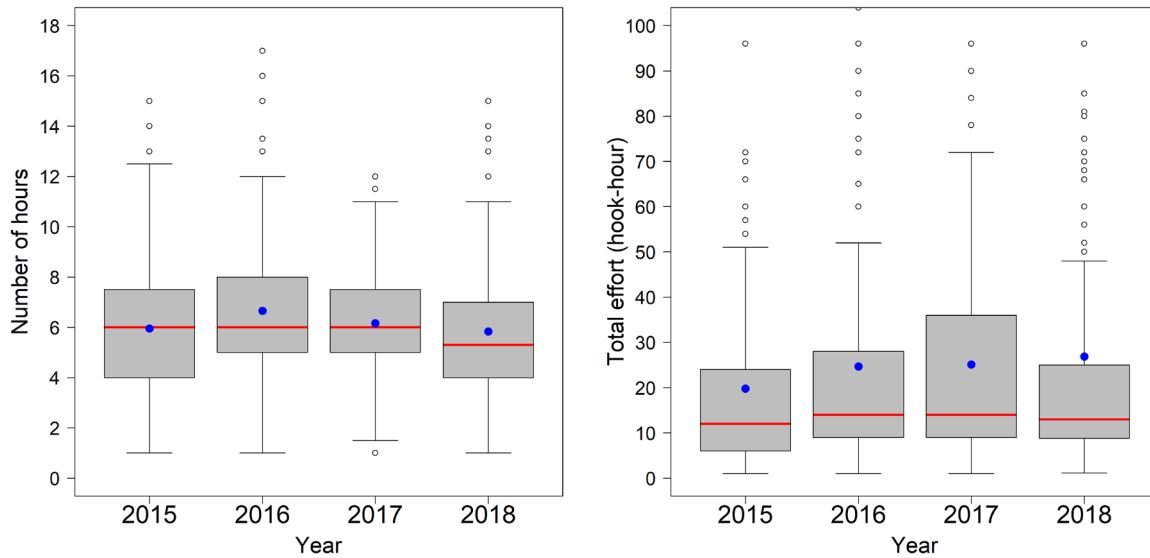


Figure 14. Information taken from logbooks from 2015 to 2018. The graph on the left represents the number of fishing hours, and the graph on the right represents the total effort (hook-hours). The information is presented in box-and-whisker plots: the line inside the box represents the median and the solid circle is the average. The box ranges from the 25th to the 75th percentile, the whiskers range from the 5th to the 95th percentile and the empty circles represent outliers.

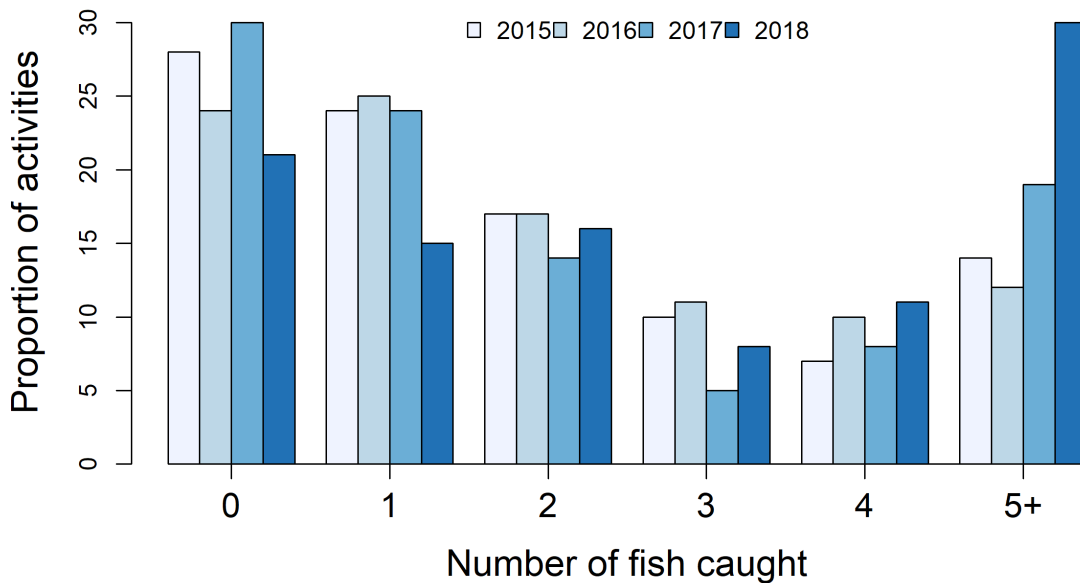
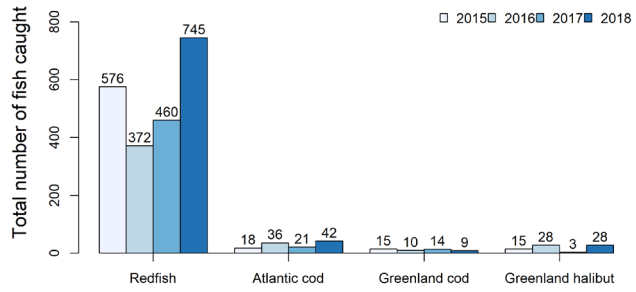


Figure 15. Fishing success, assessed against the daily catch limit of five fish based on information from logbooks. The 5+ category is explained by the fact that catch and release is permitted in this fishery with a retained daily limit of five fish.



A)



B)

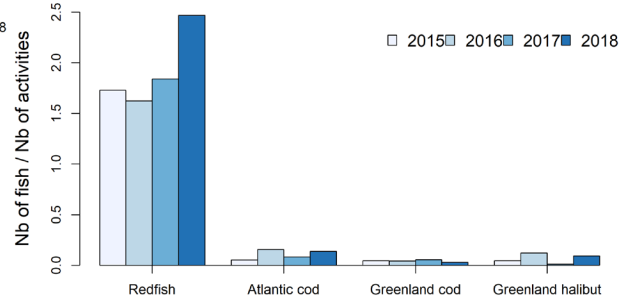


Figure 16. A) Total annual number of fish caught by species for participants in the logbook initiative. B) Number of fish caught by species divided by the number of fishing activities recorded in the logbooks.

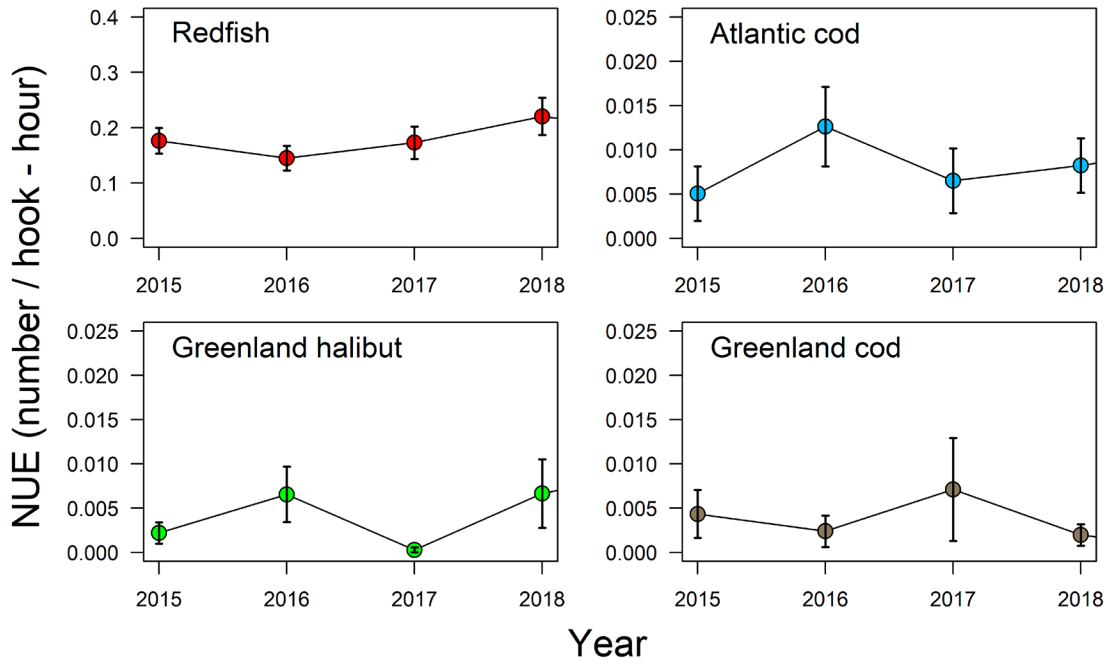


Figure 17. Catch rate in number of fish per unit of effort according to logbook data for redfish, Atlantic cod, Greenland halibut and Greenland cod.

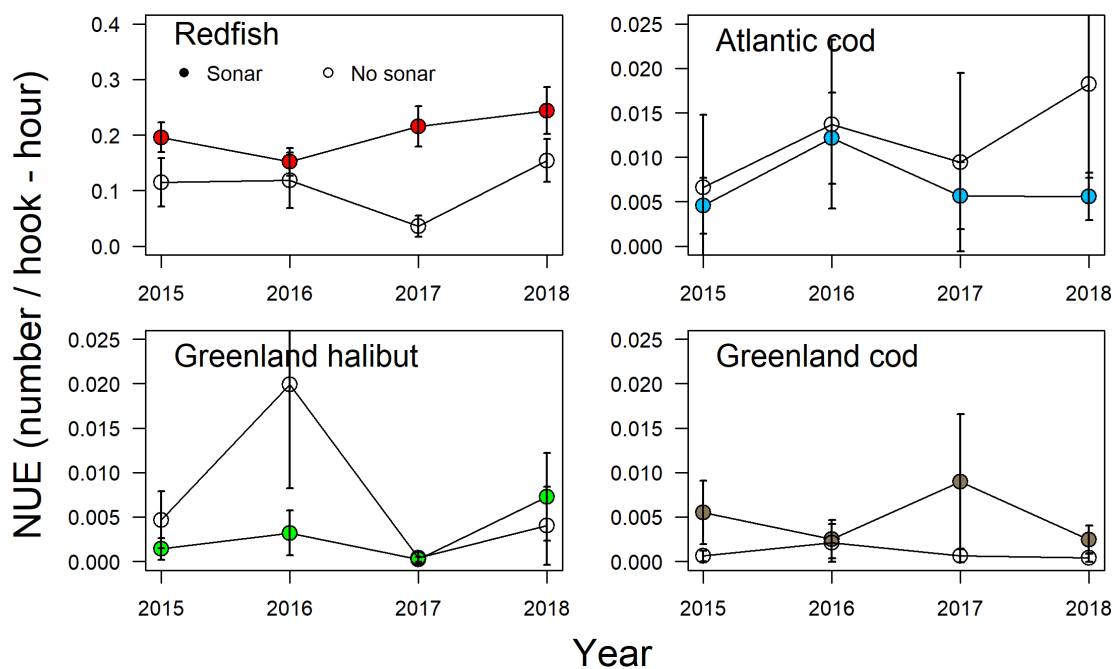


Figure 18. Number per unit of effort by species for fishers completing the logbook who use sonar (solid symbols) or do not use sonar (empty symbols).

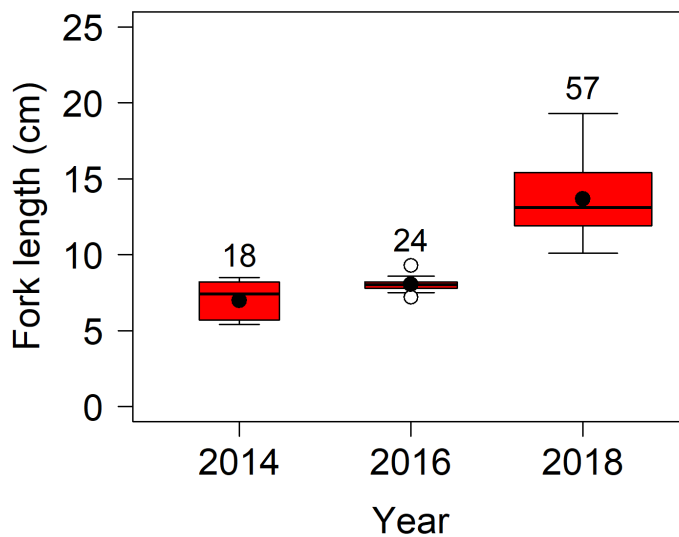
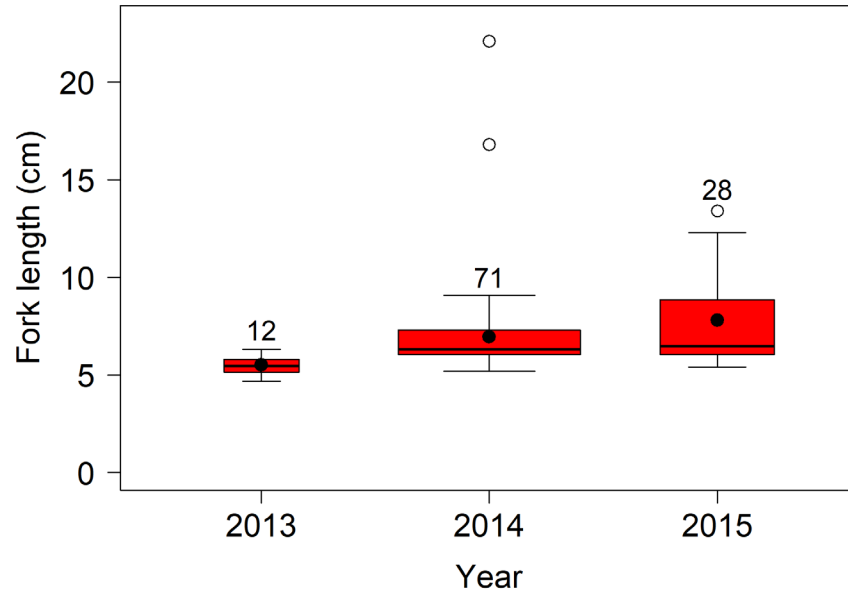


Figure 19. Size frequency distribution (fork length in cm) for redfish sampled during the winter recreational smelt fishery in the Saguenay Fjord. Graphic representation in box-and-whisker plots: the line inside the box represents the median and the solid circle is the average. The box ranges from the 25th to the 75th percentile, the whiskers range from the 5th to the 95th percentile and the empty circles represent outliers. The width of the boxes is proportional to the annual number of fish. The value above each box indicates the number of fish.



*Figure 20. Size frequency distribution (fork length in cm) of redfish sampled in the Saguenay Fjord for genetic testing (see Appendices 7 and 8 for genetic data). Graphic representation in box-and-whisker plots: the line inside the box represents the median and the solid circle is the average. The box ranges from the 25th to the 75th percentile, the whiskers range from the 5th to the 95th percentile and the empty circles represent outliers. The width of the boxes is proportional to the annual number of fish. The value above each box indicates the number of fish for the year.*

## APPENDICES

*Appendix 1. Total number of cabins set up by site during the winter recreational fishery in the Saguenay Fjord, smelt and groundfish areas combined (data provided by Guy Girard, Promotion Saguenay, pers. comm.).*

### La Baie

Fishing site	Annual number of cabins																				
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Anse-à-Benjamin	347	425	437	496	533	630	654	653	637	430	645	705	754	747	677	667	570	531	462	540	479
Grande-Baie	366	500	440	462	529	585	557	525	402	330	425	477	648	551	533	650	562	547	475	476	428
Les Battures	104	124	115	112	92	157	176	175	172	134	138	150	0	102	140	0	0	0	0	0	0
Hors sites	nd	nd	nd	nd	nd	20	58	40	35	6	nd	nd	10	10	30	40	60	95	50	50	80
<b>Subtotal</b>	<b>817</b>	<b>1049</b>	<b>992</b>	<b>1070</b>	<b>1154</b>	<b>1392</b>	<b>1445</b>	<b>1393</b>	<b>1246</b>	<b>900</b>	<b>1208</b>	<b>1332</b>	<b>1412</b>	<b>1410</b>	<b>1380</b>	<b>1357</b>	<b>1192</b>	<b>1173</b>	<b>987</b>	<b>1066</b>	<b>987</b>


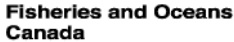
### Marine Park

Fishing site	Annual number of cabins																				
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Saint-Félix-d'Otis	12	0	17	36	28	35	20	25	12	4	5	5	5	5	5	25	21	23	25	25	
Rivière-Éternité	51	61	73	61	67	57	66	55	35	30	33	29	40	38	41	35	26	22	25	23	27
L'Anse-St-Jean	57	60	75	65	67	65	65	55	25	43	43	56	65	58	71	78	102	116	105	126	148
Ste-Rose-du-Nord	76	91	53	71	66	60	77	75	70	72	60	55	50	50	50	59	70	67	0	91	87
<b>Subtotal</b>	<b>196</b>	<b>212</b>	<b>218</b>	<b>233</b>	<b>228</b>	<b>217</b>	<b>228</b>	<b>210</b>	<b>142</b>	<b>149</b>	<b>141</b>	<b>145</b>	<b>160</b>	<b>151</b>	<b>167</b>	<b>177</b>	<b>223</b>	<b>226</b>	<b>153</b>	<b>265</b>	<b>287</b>

### Saint-Fulgence

Fishing site	Annual number of cabins																				
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Site	0	67	100	60	32	40	75	88	46	54	100	130	0	0	140	140	119	0	55	0	101
Offsite	nd	nd	nd	nd	nd	15	nd	10	10	10	10	10	10	15	15	15	20	28	17	20	25
<b>Subtotal</b>	<b>0</b>	<b>67</b>	<b>100</b>	<b>60</b>	<b>32</b>	<b>55</b>	<b>75</b>	<b>98</b>	<b>56</b>	<b>64</b>	<b>110</b>	<b>140</b>	<b>10</b>	<b>15</b>	<b>155</b>	<b>155</b>	<b>139</b>	<b>28</b>	<b>72</b>	<b>20</b>	<b>25</b>
<b>Total</b>	<b>1013</b>	<b>1328</b>	<b>1310</b>	<b>1363</b>	<b>1414</b>	<b>1664</b>	<b>1748</b>	<b>1701</b>	<b>1444</b>	<b>1113</b>	<b>1459</b>	<b>1617</b>	<b>1582</b>	<b>1576</b>	<b>1702</b>	<b>1689</b>	<b>1554</b>	<b>1427</b>	<b>1212</b>	<b>1351</b>	<b>1400</b>

Appendix 2. Form for recording data collected by samplers during the winter recreational groundfish fishery in the Saguenay Fjord for Component 1 – catch per unit of effort.

 <b>Pêches et Océans Canada</b>		 <b>Fisheries and Oceans Canada</b>										
<b>2018 - PÊCHE RÉCRÉATIVE HIVERNALE - FJORD DU SAGUENAY</b> Poisson de fond <b>PRISE PAR UNITÉ D'EFFORT 2018</b>												
<b>IDENTIFICATION</b>												
Nom de l'échantillonneur : _____					Date : _____ / _____ /2018		Jour de semaine		<input type="checkbox"/>			
_____					Heure début: _____		Jour de fin de semaine		<input type="checkbox"/>			
<b>LE SITE</b>												
Nom du site de pêche : _____												
Nombre total de pêcheurs secteur poisson de fond <input style="width: 100px; height: 20px;" type="text"/>												
Pêcheur no	Secteur - Engin	Nombre			Sonar (Oui/Non)	Profondeur de pêche (m)	Nombre capturé				Autres	
		Lignes	Hameçons par ligne	Heures de pêche			Morue franche	Ogac	Sébaste	Turbot	Espèce	Nombre
1	Fond-ligne											
	Fond-Brimbale											
	Fond-Rouleau											
2	Fond-ligne											
	Fond-Brimbale											
	Fond-Rouleau											
3	Fond-ligne											
	Fond-Brimbale											
	Fond-Rouleau											
4	Fond-ligne											
	Fond-Brimbale											
	Fond-Rouleau											
5	Fond-ligne											
	Fond-Brimbale											
	Fond-Rouleau											

Appendix 3. Annual estimate of the average number of active fishermen per village, weekday (week) and weekend (WE) from component 1 of the monitoring program..

Site	Anse-à-Benjamin		Anse-Saint-Jean		Grande Baie		Les Battures		Rivière Éternité		Sainte-Rose-du-Nord		Saint-Félix-d'Otis		Saint-Fulgence	
	Year	Week	WE	Week	WE	Week	WE	Week	WE	Week	WE	Week	WE	Week	WE	Week
1996	59	152	34	99	79	275	6	10	13	29	27	115	3	7	1	2
1997	71	206	38	71	53	228	5	9	21	47	35	119	4	8	10	PE
1998	78	NS	39	97	98	375	12	33	12	12	74	178	18	17	3	3
1999	83	105	55	110	123	405	16	54	18	26	40	163	4	6	0	0
2000	116	250	37	97	121	380	35	35	6	21	38	183	12	37	9	13
2001	133	NS	17	47	137	453	11	18	5	12	32	84	18	40	PE	8
2002	85	120	19	38	124	445	7	9	2	6	10	35	6	28	1	2
2003	113	186	29	66	145	423	4	5	4	8	8	81	5	8	NS	NS
2004	82	384	22	50	153	404	1	6	2	11	21	92	5	10	12	13
2005	300	417	12	53	160	476	3	4	3	10	10	45	10	13	0	0
2006	24	NS	19	39	144	331	7	8	4	9	14	40	4	5	NS	4
2007	116	170	14	35	165	254	NS	NS	5	25	9	26	NS	NS	10	7
2008	130	225	14	17	123	390	6	10	6	20	14	40	NS	NS	68	100
2009	160	332	15	41	190	407	6	14	10	30	12	30	NS	NS	11	13
2010	165	267	18	36	257	503	5	7	14	20	13	13	NS	NS	C	C
2011	167	369	32	60	162	489	6	11	14	15	11	40	NS	NS	1	4
2012	128	239	21	38	169	461	7	13	4	18	10	31	NS	NS	12	20
2013	149	353	22	52	220	499	C	C	5	13	9	28	NS	NS	24	30
2014	173	262	46	97	202	447	C	C	4	9	8	26	NS	NS	12	22
2015	205	374	48	62	187	441	C	C	6	6	18	34	NS	NS	C	C
2016	137	221	47	95	188	336	C	C	4	14	C	C	NS	NS	NS	NS
2017	163	307	71	127	155	351	C	C	4	6	20	43	NS	NS	C	C
2018	131	257	70	151	141	295	C	C	4	11	28	55	NS	NS	NS	NS

NS = Site open but not sampled, C= Site closed



Appendix 5. Logbook for the winter recreational groundfish fishery in the Saguenay Fjord.

**PÊCHE RÉCRÉATIVE HIVERNALE  
FJORD DU SAGUENAY  
Journal de bord - Poisson de fond**



Année : \_\_\_\_\_

**PÊCHE RÉCRÉATIVE HIVERNALE  
FJORD DU SAGUENAY  
Journal de bord - Poisson de fond**

Ce journal de bord appartient à :

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Si retrouvé,  
 Prière de retourner ce journal de bord à son propriétaire.

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 Pêches et Océans Canada  
 Institut Maurice-Lamontagne  
 Tél. : 418-775-0871

Date : 201\_\_ / \_\_\_\_ / \_\_\_\_ (aaaa/mm/jj)  
 Heure début pêche : \_\_\_\_\_ matin  après-midi   
 Heure fin pêche : \_\_\_\_\_ matin  après-midi   
 Nombre d'heures en pêche active : \_\_\_\_\_  
 Site de pêche : \_\_\_\_\_  
 Pêche dans le village  Pêche hors village   
 Latitude : \_\_\_\_\_ Longitude : \_\_\_\_\_  
 Marée : montante  descendante  Autre \_\_\_\_\_  
 Utilisation d'un sonar / échosondeur : oui  non   
 Profondeur maximale au site de pêche (m) : \_\_\_\_\_  
 Profondeur de pêche (m) : \_\_\_\_\_  
 Engin: Canne à pêche  Type: \_\_\_\_\_ (courte, conventionnelle, etc.)  
 Type d'appât : \_\_\_\_\_

EFFORT	
Nombre de lignes	Nombre d'hameçons par ligne

Espèce(s) recherchée(s):  
 Sébaste  Morue  Ogac  Turbot  Toutes  Autre \_\_\_\_\_

Nombre de poissons capturés					
Sébaste	Morue franche	Ogac	Turbot	Autre Espèce	Autre Nombre

Très important : Notez les résultats de votre journée de pêche même si vous n'avez rien capturé, inscrire 0 dans le tableau Nombre de poissons capturés.  
 Remarques : \_\_\_\_\_



Appendix 6. General information on the 2015–2018 logbook initiative.

Number of logbooks and fishing activities recorded in logbooks

	2015	2016	2017	2018
Logbooks - total	19	18	23	24
Logbooks - retained	17	14	12	18
Total number of activities	393	336	383	450
Number of activities retained	333	229	250	302

Annual number of activities by fishing site

Site	2015	2016	2017	2018
Saint-Fulgence	24	-	-	8
Anse à Philippe & Anse à Benjamin	152	131	164	138
Grande-Baie	90	43	79	53
Anse aux Billots	-	-	-	22
Sainte-Rose-du-Nord	12	8	-	6
Anse aux érables	-	-	6	1
Baie Éternité	-	18	-	8
L'Anse-Saint-Jean	55	23	-	59
Anse à Pelletier	-	-	1	7
Unknown	-	6	-	-
<b>Total</b>	<b>333</b>	<b>229</b>	<b>250</b>	<b>302</b>

Proportion of participants who use or do not use sonar

	2015	2016	2017	2018
Without sonar	24	20	23	22
With sonar	76	80	77	78

Proportion of activities carried out on weekdays and weekends

	2015	2016	2017	2018
Weekends	36	34	28	34
Weekdays	64	66	72	66

Proportion of activities carried out in a village or outside a village

	2015	2016	2017	2018
In a village	85	90	89	73
Outside a village	15	10	11	20
Unknown				7

Appendix 7. Small redfish stranded at Saint-Fulgence in the Saguenay. Photos taken on December 28, 2014, by index fisher Yvon Roy.



Appendix 8. Results of the genetic testing using 13 microsatellites on redfish caught in winter in the Saguenay Fjord. The identifier (ID) refers to the same fish in Appendices 7 and 8. The columns represent the genotypes observed at each of the 13 loci; each locus is defined by 2 alleles. A "0" indicates missing data.

ID	SEB25_1	SEB25_2	SEB31_1	SEB31_2	SEB33_1	SEB33_2	SEB9_1	SEB9_2	SAL4_1	SAL4_2	SEB30_1	SEB30_2	SEB37_1	SEB37_2	SEB46_1	SEB46_2	SEB45_1	SEB45_2	SAL3_1	SAL3_2	SPI6_1	SPI6_2	SPI10II_1	SPI10II_2	SPI4II_1	SPI4II_2
1	195	221	150	156	233	265	102	108	87	87	199	205	0	0	120	128	122	130	0	0	119	151	269	277	295	323
2	195	207	172	184	241	241	98	106	95	95	229	231	229	243	112	120	128	140	108	118	119	131	269	289	275	291
3	195	215	178	178	243	247	104	106	87	87	231	233	241	247	128	136	112	132	113	118	135	135	269	281	271	291
4	193	195	150	170	259	265	102	112	87	95	221	235	229	249	112	122	116	122	113	118	119	143	269	273	275	295
5	197	221	174	182	251	251	94	106	87	91	227	233	241	257	112	112	122	124	123	123	131	143	277	281	279	291
6	193	207	150	150	255	291	104	106	87	87	231	233	229	275	112	134	126	126	118	123	123	123	265	269	271	279
7	217	229	168	180	269	287	98	104	87	91	231	235	229	247	136	136	140	142	113	113	119	131	269	277	251	267
8	193	213	150	172	251	257	96	106	87	87	211	235	247	261	112	112	126	132	118	123	123	131	261	281	267	279
9	193	193	150	172	237	249	98	102	87	87	199	229	229	241	112	136	122	128	103	113	135	159	293	293	279	295
10	207	225	150	150	269	275	94	106	87	87	231	231	243	249	138	146	122	124	123	123	131	143	261	273	283	287
11	193	195	172	180	249	259	106	106	87	87	231	233	247	247	120	128	118	126	113	123	119	143	269	273	275	275
12	197	221	172	186	263	263	102	104	87	95	229	231	253	279	126	128	114	116	113	123	123	127	269	329	331	335
13	193	195	150	170	233	265	102	104	87	91	199	221	255	275	120	136	128	134	113	123	123	135	261	277	271	279
14	193	207	150	182	253	297	106	112	87	95	205	231	229	259	136	136	122	126	113	123	123	123	269	269	275	295
15	193	217	150	150	237	269	106	106	87	95	165	231	229	247	112	112	126	126	113	123	115	143	269	281	279	283
16	195	213	172	176	251	281	106	106	87	87	221	235	249	249	112	112	126	130	123	123	123	135	261	281	275	279
17	195	223	154	154	255	257	106	106	87	87	195	229	241	259	122	142	122	130	108	113	119	131	0	0	275	275
18	217	221	172	180	265	269	106	106	87	87	213	235	229	241	112	112	122	134	113	123	131	139	261	269	251	267
19	195	195	156	170	267	289	104	108	91	95	219	235	241	261	112	134	128	128	113	113	123	143	0	0	275	287
20	193	221	150	180	239	249	98	104	87	87	231	233	247	247	112	140	126	136	113	123	131	135	0	0	275	279
21	195	211	150	150	233	287	108	110	87	87	233	235	241	241	112	136	126	140	113	123	135	135	269	273	275	279
22	193	209	156	172	241	287	102	110	87	95	231	235	229	243	112	136	126	128	113	123	131	167	269	273	251	267
23	193	231	150	172	261	261	100	106	87	95	221	221	247	251	120	134	126	134	123	123	123	143	269	269	271	275
24	207	207	150	154	239	257	106	112	87	87	227	233	249	267	112	136	118	150	118	123	131	135	269	269	275	283
25	191	203	150	168	265	271	102	102	87	91	199	237	229	229	112	128	130	140	113	118	135	159	0	0	271	275
26	193	195	150	154	267	271	100	106	91	95	235	235	249	267	126	136	122	128	113	113	131	139	0	0	0	0
27	195	207	174	174	257	269	102	112	87	91	233	235	229	229	120	120	122	128	113	123	123	159	269	269	279	295
28	191	193	0	0	225	239	102	112	87	91	227	229	229	247	112	112	128	140	123	123	123	131	0	0	275	279
29	193	207	150	168	247	249	102	106	87	87	221	225	229	247	112	134	122	126	103	113	135	135	269	281	271	319

ID	SEB25_1	SEB25_2	SEB31_1	SEB31_2	SEB33_1	SEB33_2	SEB9_1	SEB9_2	SAL4_1	SAL4_2	SEB30_1	SEB30_2	SEB37_1	SEB37_2	SEB46_1	SEB46_2	SEB45_1	SEB45_2	SAL3_1	SAL3_2	SPI6_1	SPI6_2	SPI10II_1	SPI10II_2	SPI4II_1	SPI4II_2
30	193	219	150	154	265	275	98	104	87	99	145	221	259	259	132	132	122	130	118	123	123	143	269	269	279	283
31	195	221	174	180	265	271	106	106	87	91	199	231	257	309	124	134	118	130	123	123	123	143	0	0	267	275
32	193	197	150	150	225	281	106	106	87	91	229	233	251	271	134	138	126	132	113	113	123	135	269	277	251	279
33	213	221	150	156	265	273	106	112	87	87	197	231	265	265	112	112	118	128	113	123	131	131	0	0	283	295
34	213	221	150	174	233	269	106	106	91	95	231	235	231	243	120	136	122	128	113	113	123	155	0	0	271	275
35	195	195	150	180	257	281	106	110	87	87	213	229	0	0	112	120	116	126	108	113	107	123	269	269	275	275
36	207	219	150	150	257	263	94	96	83	87	199	239	241	275	122	144	128	130	113	113	111	119	269	281	267	267
37	221	229	150	154	261	267	106	112	87	95	205	231	229	253	112	124	112	140	108	123	123	139	269	273	271	279
38	221	221	176	180	241	283	102	106	87	87	201	207	229	229	112	120	128	134	113	113	131	135	269	301	267	279
39	193	221	150	150	239	261	106	112	87	91	231	235	229	263	112	132	122	144	113	123	139	171	273	293	275	287
40	193	197	156	160	0	0	106	112	87	87	203	205	241	257	112	128	126	128	123	123	123	135	281	293	271	275
41	193	195	150	180	263	275	102	106	87	87	231	239	241	279	136	136	126	130	103	113	123	131	269	297	275	279
42	197	213	150	166	251	273	106	112	87	95	235	241	229	247	112	128	126	128	113	123	131	151	0	0	0	0
43	191	207	150	172	271	277	106	106	87	91	171	235	231	249	112	120	126	126	123	123	119	131	261	269	267	291
44	197	229	150	166	261	271	94	106	87	87	207	231	241	275	120	128	118	128	113	123	123	131	265	293	251	295
45	207	221	150	198	237	253	106	106	87	91	169	239	243	267	112	156	126	126	123	123	127	131	0	0	267	275
46	191	203	156	172	249	257	102	106	87	95	221	235	229	247	112	112	122	132	103	128	123	139	269	269	271	279
47	193	223	150	172	243	273	96	106	87	91	231	231	229	273	120	134	116	126	118	123	131	139	281	293	275	279
48	197	213	150	182	275	283	102	112	87	87	219	239	229	267	112	112	128	134	123	123	123	135	277	281	271	275
49	219	227	150	150	243	271	106	106	87	87	191	213	229	267	136	138	114	146	108	123	135	155	269	273	267	295
50	193	195	156	182	257	265	102	112	87	91	0	0	0	0	112	112	118	128	113	123	143	159	261	269	271	279
51	193	207	150	172	243	261	106	106	87	95	235	239	243	283	112	144	128	140	113	118	119	119	269	289	267	279
52	193	221	150	180	241	243	100	106	87	87	229	235	245	283	112	112	126	128	123	123	131	135	261	293	295	323
53	193	195	150	166	241	243	102	106	95	99	233	233	247	257	112	128	126	148	113	123	123	123	269	269	275	287
54	193	211	170	174	225	271	102	106	87	91	219	235	241	251	112	120	126	128	113	123	135	143	0	0	267	295
55	195	219	150	172	263	267	102	106	87	91	231	231	229	247	112	112	126	132	113	113	135	143	269	269	279	299
56	195	197	150	150	243	251	106	106	87	95	231	233	231	233	112	136	126	128	123	123	123	123	0	0	0	0
57	221	221	150	172	241	265	94	102	87	91	207	237	229	245	120	132	122	130	113	123	131	135	261	293	271	271
58	191	193	174	184	263	277	106	110	87	87	197	227	241	251	126	126	126	130	123	123	131	155	269	281	295	315
59	195	201	150	168	249	251	106	112	87	99	231	233	229	251	120	126	128	130	113	123	123	143	265	281	275	319
60	219	227	150	178	263	265	102	104	87	87	231	233	229	229	112	128	116	132	123	123	135	167	265	273	267	275
61	195	197	150	180	263	265	106	106	87	95	199	229	247	249	120	130	126	126	123	123	115	131	269	269	267	287
62	193	211	166	174	259	269	106	106	87	87	219	225	247	249	120	132	126	128	118	123	131	135	277	281	271	275

ID	SEB25_1	SEB25_2	SEB31_1	SEB31_2	SEB33_1	SEB33_2	SEB9_1	SEB9_2	SAL4_1	SAL4_2	SEB30_1	SEB30_2	SEB37_1	SEB37_2	SEB46_1	SEB46_2	SEB45_1	SEB45_2	SAL3_1	SAL3_2	SPI6_1	SPI6_2	SPI10II_1	SPI10II_2	SPI4II_1	SPI4II_2
63	191	219	172	178	237	251	102	106	87	87	231	231	241	241	120	120	126	130	108	123	123	131	269	281	275	279
64	193	221	150	166	243	251	106	106	87	91	213	235	229	229	120	138	130	132	113	123	143	155	269	269	287	287
65	193	195	150	150	225	255	102	106	87	91	227	285	229	269	112	136	132	134	103	103	123	135	261	281	275	275
66	191	193	150	150	241	257	104	106	0	0	0	0	0	0	0	0	122	122	123	123	127	143	269	285	275	279
67	207	213	150	150	261	275	102	106	87	95	0	0	0	0	0	0	114	122	123	123	143	143	269	285	287	287
68	195	221	150	150	267	269	102	106	87	87	219	233	249	289	120	128	126	128	123	123	139	143	293	293	279	283
69	193	195	150	182	247	265	96	106	95	95	231	231	251	309	112	130	116	134	113	118	135	135	269	301	271	279
70	193	223	150	182	233	275	106	106	87	87	229	231	241	257	112	112	122	128	113	113	131	139	269	273	275	275
71	195	203	164	180	243	273	104	106	91	95	205	235	241	241	112	128	126	128	108	113	127	131	285	333	279	291
72	197	211	150	174	225	253	104	112	87	87	199	231	249	253	130	134	122	128	113	123	139	143	277	337	267	299
73	205	221	172	174	251	299	88	106	87	95	235	235	233	247	112	120	114	128	103	123	131	143	269	269	275	279
74	193	193	156	160	263	271	102	112	87	87	193	213	239	313	112	112	122	128	98	123	139	139	273	277	275	287
75	191	215	154	180	285	287	102	106	87	91	231	233	247	247	112	120	126	126	113	123	119	135	269	273	275	279
76	191	197	150	172	239	245	106	106	87	91	229	231	249	259	112	134	118	126	103	123	135	139	265	277	267	271
77	197	221	172	176	267	279	106	108	87	87	231	231	241	243	114	132	128	132	103	113	119	123	269	269	287	291
78	193	197	172	174	273	275	100	104	87	87	221	235	253	259	112	136	122	130	103	113	123	131	269	277	271	275
79	221	229	150	168	263	265	96	106	87	91	211	285	251	267	112	130	126	128	113	113	135	135	269	345	291	295
80	205	219	150	180	225	255	94	106	87	87	185	191	253	335	112	128	118	118	103	113	123	151	269	285	279	279
81	195	221	150	178	253	259	102	106	87	91	205	211	241	245	120	132	128	130	113	118	123	167	261	269	275	283
82	193	211	150	174	263	267	106	106	87	87	205	213	247	265	114	122	128	132	103	123	119	143	269	269	271	279
83	191	211	150	176	251	269	106	106	87	91	231	235	243	251	134	136	122	130	123	123	123	127	261	269	279	283
84	191	217	150	150	241	275	102	106	87	87	235	235	241	247	112	112	128	140	113	123	123	139	273	273	271	275
85	191	221	156	178	245	275	96	106	87	87	231	237	241	331	130	134	122	128	108	118	123	131	269	269	279	287
86	195	227	154	172	257	275	98	102	87	87	231	231	229	247	112	128	126	128	113	118	0	0	269	285	267	275
87	195	213	174	174	271	271	106	106	87	87	231	233	229	265	112	120	126	126	113	118	127	131	269	333	279	279
88	195	207	150	150	267	279	106	106	87	91	231	231	243	249	112	128	126	128	113	113	167	175	269	273	275	299
89	193	205	150	150	273	283	98	106	87	87	205	231	247	247	112	120	122	126	118	123	135	143	269	273	283	287
90	193	195	150	174	261	265	106	112	87	91	231	231	245	267	112	128	122	130	103	103	127	143	261	281	287	319
91	193	193	172	180	239	269	106	112	87	95	231	233	229	335	120	136	126	126	123	123	123	123	265	269	279	279
92	193	197	174	180	247	275	96	102	87	91	199	233	229	273	112	162	128	128	113	123	139	143	269	273	279	291
93	195	217	150	172	241	287	102	106	87	87	233	233	257	309	112	126	128	136	113	123	119	123	269	281	279	279
94	193	193	170	180	225	257	106	106	87	91	203	233	247	247	112	136	116	118	103	113	135	155	261	269	287	295
95	207	221	172	174	227	271	102	106	87	91	185	185	271	273	112	120	124	140	113	113	143	155	269	269	271	275

ID	SEB25_1	SEB25_2	SEB31_1	SEB31_2	SEB33_1	SEB33_2	SEB9_1	SEB9_2	SAL4_1	SAL4_2	SEB30_1	SEB30_2	SEB37_1	SEB37_2	SEB46_1	SEB46_2	SEB45_1	SEB45_2	SAL3_1	SAL3_2	SPI6_1	SPI6_2	SP10II_1	SP10II_2	SP14II_1	SP14II_2
96	209	221	150	172	0	0	106	112	87	87	221	231	225	241	112	138	126	134	113	113	119	159	273	273	267	287
97	213	215	150	182	253	255	102	110	87	87	225	231	241	243	120	136	116	126	123	123	131	135	281	325	271	271
98	195	219	166	182	247	249	106	106	87	87	221	233	271	279	112	130	118	128	123	123	131	143	265	269	271	279
99	193	195	180	184	259	265	106	106	87	87	231	233	229	229	112	128	118	122	113	123	127	135	269	281	267	275
100	193	195	150	150	0	0	106	106	87	87	231	235	229	229	128	162	126	128	113	123	119	139	265	293	267	275
101	219	221	150	168	239	255	102	104	87	87	235	235	241	243	126	170	122	128	123	123	143	151	261	269	279	291
102	193	195	150	150	257	265	102	112	87	91	201	231	229	253	126	134	112	128	103	123	135	143	261	289	275	275
103	199	229	150	180	269	299	106	106	87	87	193	233	245	271	120	126	126	128	108	113	119	131	281	289	267	279
104	193	207	174	180	249	275	106	106	87	95	229	233	229	253	112	112	128	128	118	123	119	135	269	273	267	327
105	211	221	150	166	263	269	104	106	87	87	229	231	237	265	126	136	128	128	123	123	123	127	269	293	267	275
106	209	221	172	172	225	257	102	106	91	95	231	235	229	245	112	120	112	116	113	123	143	167	281	285	279	295
107	191	195	150	166	247	269	102	102	87	95	235	237	229	331	132	132	122	136	113	123	119	119	269	293	279	287
108	193	193	164	172	249	265	102	106	87	91	231	233	229	233	112	128	116	126	103	123	119	131	269	269	267	275
109	195	221	150	150	243	287	106	106	87	95	221	231	229	229	112	112	128	146	113	113	143	143	261	269	251	267
110	193	197	174	180	247	269	102	106	87	87	221	229	245	247	120	130	130	134	113	123	123	143	269	269	275	299
111	197	221	170	180	263	287	106	112	91	95	235	245	255	269	112	162	114	122	113	113	123	143	269	269	275	335

Appendix 9. Information on redfish subject to genetic testing. The identifier (ID) refers to the same fish as in Appendix 7. The redfish samples were collected in the winter recreational fishery (source = WRF) or during a stranding event (source = S). The catch year, fork length (mm), and the number of soft rays in the anal fin (AFC) are indicated. The number of loci (Nb loci) used to determine the probability (Prob) of belonging to the species *Sebastes mentella* or *S. fasciatus* and the lower (IC90\_low) and upper (IC90\_up) limits of the 90% confidence intervals are shown in the table.

ID	Year	source	Length (mm)	AFR	Nb loci	<i>Sebastes mentella</i>			<i>Sebastes fasciatus</i>			Species
						Prob	IC90_inf	IC90_sup	Prob	IC90_inf	IC90_sup	
1	2013	WRF	51	NA	11	0.947	0.693	1	0.053	0	0.307	<i>S. mentella</i>
2	2013	WRF	53	NA	13	0.985	0.889	1	0.015	0	0.111	<i>S. mentella</i>
3	2013	WRF	47	NA	13	0.997	0.988	1	0.003	0	0.012	<i>S. mentella</i>
4	2013	WRF	57	NA	13	0.997	0.984	1	0.003	0	0.016	<i>S. mentella</i>
5	2013	WRF	59	NA	13	0.997	0.988	1	0.003	0	0.012	<i>S. mentella</i>
6	2013	WRF	51	NA	13	0.996	0.979	1	0.004	0	0.021	<i>S. mentella</i>
7	2013	WRF	57	NA	13	0.989	0.927	1	0.011	0	0.073	<i>S. mentella</i>
8	2013	WRF	55	NA	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
9	2013	WRF	52	NA	13	0.988	0.919	1	0.012	0	0.081	<i>S. mentella</i>
10	2013	WRF	54	NA	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
11	2013	WRF	62	NA	13	0.997	0.987	1	0.003	0	0.013	<i>S. mentella</i>
12	2013	WRF	63	NA	13	0.954	0.726	1	0.046	0	0.274	<i>S. mentella</i>
13	2014	WRF	55	NA	13	0.988	0.918	1	0.012	0	0.082	<i>S. mentella</i>
14	2014	WRF	76	NA	13	0.996	0.984	1	0.004	0	0.016	<i>S. mentella</i>
15	2014	WRF	85	8	13	0.987	0.901	1	0.013	0	0.099	<i>S. mentella</i>
16	2014	WRF	82	8	13	0.994	0.960	1	0.006	0	0.040	<i>S. mentella</i>
17	2014	WRF	83	8	12	0.915	0.599	1	0.085	0	0.401	<i>S. mentella</i>
18	2014	WRF	81	8	13	0.998	0.991	1	0.002	0	0.009	<i>S. mentella</i>
19	2014	WRF	74	NA	12	0.978	0.841	1	0.022	0	0.159	<i>S. mentella</i>
20	2014	WRF	64	NA	12	0.989	0.922	1	0.011	0	0.078	<i>S. mentella</i>
21	2014	WRF	52	NA	13	0.997	0.988	1	0.003	0	0.012	<i>S. mentella</i>
22	2014	WRF	77	NA	13	0.981	0.858	1	0.019	0	0.142	<i>S. mentella</i>
23	2014	WRF	73	NA	13	0.994	0.970	1	0.006	0	0.030	<i>S. mentella</i>
24	2014	WRF	71	NA	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>

ID	Year	source	Length (mm)	AFR	Nb loci	<i>Sebastes mentella</i>			<i>Sebastes fasciatus</i>			Species
						Prob	IC90_inf	IC90_sup	Prob	IC90_inf	IC90_sup	
25	2014	WRF	62	NA	12	0.992	0.954	1	0.008	0	0.046	<i>S. mentella</i>
26	2014	WRF	60	8	11	0.981	0.855	1	0.019	0	0.145	<i>S. mentella</i>
27	2014	WRF	58	NA	13	0.996	0.983	1	0.004	0	0.017	<i>S. mentella</i>
28	2014	WRF	58	NA	11	0.997	0.987	1	0.003	0	0.013	<i>S. mentella</i>
29	2014	WRF	60	NA	13	0.994	0.967	1	0.006	0	0.033	<i>S. mentella</i>
30	2014	WRF	84	NA	13	0.800	0.473	1	0.200	0	0.527	<i>S. mentella</i>
31	2014	WRF	84	NA	12	0.992	0.950	1	0.008	0	0.050	<i>S. mentella</i>
32	2014	WRF	57	NA	13	0.968	0.786	1	0.032	0	0.214	<i>S. mentella</i>
33	2014	WRF	57	8	12	0.984	0.880	1	0.016	0	0.120	<i>S. mentella</i>
34	2014	WRF	56	NA	12	0.987	0.910	1	0.013	0	0.090	<i>S. mentella</i>
35	2014	WRF	65	9	12	0.978	0.851	1	0.022	0	0.149	<i>S. mentella</i>
36	2014	WRF	168	8	13	0.786	0.495	1	0.214	0	0.505	<i>S. mentella</i>
37	2014	WRF	221	8	13	0.982	0.862	1	0.018	0	0.138	<i>S. mentella</i>
38	2014	WRF	75	8	13	0.877	0.570	1	0.123	0	0.430	<i>S. mentella</i>
39	2014	WRF	84	8	13	0.994	0.965	1	0.006	0	0.035	<i>S. mentella</i>
40	2014	WRF	91	8	12	0.937	0.693	1	0.063	0	0.307	<i>S. mentella</i>
41	2014	WRF	81	8	13	0.991	0.941	1	0.009	0	0.059	<i>S. mentella</i>
42	2014	WRF	73	8	11	0.996	0.982	1	0.004	0	0.018	<i>S. mentella</i>
43	2014	WRF	74	NA	13	0.995	0.971	1	0.005	0	0.029	<i>S. mentella</i>
44	2015	WRF	123	8	13	0.994	0.966	1	0.006	0	0.034	<i>S. mentella</i>
45	2015	WRF	90	8	12	0.995	0.972	1	0.005	0	0.028	<i>S. mentella</i>
46	2015	WRF	120	8	13	0.988	0.917	1	0.012	0	0.083	<i>S. mentella</i>
47	2015	WRF	134	8	13	0.991	0.945	1	0.009	0	0.055	<i>S. mentella</i>
48	2015	WRF	85	8	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
49	2015	WRF	87	8	13	0.994	0.958	1	0.006	0	0.042	<i>S. mentella</i>
50	2015	WRF	114	8	11	0.986	0.899	1	0.014	0	0.101	<i>S. mentella</i>
51	2015	WRF	84	8	13	0.995	0.974	1	0.005	0	0.026	<i>S. mentella</i>
52	2015	WRF	85	8	13	0.996	0.976	1	0.004	0	0.024	<i>S. mentella</i>
53	2015	WRF	116	7	13	0.990	0.932	1	0.010	0	0.068	<i>S. mentella</i>



ID	Year	source	Length (mm)	AFR	Nb loci	<i>Sebastes mentella</i>			<i>Sebastes fasciatus</i>			Species
						Prob	IC90_inf	IC90_sup	Prob	IC90_inf	IC90_sup	
54	2015	WRF	92	8	12	0.987	0.903	1	0.013	0	0.097	<i>S. mentella</i>
55	2015	WRF	81	8	13	0.995	0.978	1	0.005	0	0.022	<i>S. mentella</i>
56	2015	WRF	61	8	11	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
57	2015	WRF	65	NA	13	0.967	0.753	1	0.033	0	0.247	<i>S. mentella</i>
58	2015	WRF	54	NA	13	0.987	0.906	1	0.013	0	0.094	<i>S. mentella</i>
59	2015	WRF	63	NA	13	0.948	0.692	1	0.052	0	0.308	<i>S. mentella</i>
60	2015	WRF	59	NA	13	0.997	0.988	1	0.003	0	0.012	<i>S. mentella</i>
61	2015	WRF	64	7	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
62	2015	WRF	60	7	13	0.996	0.984	1	0.004	0	0.016	<i>S. mentella</i>
63	2015	WRF	64	8	13	0.993	0.964	1	0.007	0	0.036	<i>S. mentella</i>
64	2015	WRF	61	NA	13	0.995	0.977	1	0.005	0	0.023	<i>S. mentella</i>
65	2015	WRF	62	NA	13	0.994	0.971	1	0.006	0	0.029	<i>S. mentella</i>
66	2015	WRF	68	7	9	0.996	0.978	1	0.004	0	0.022	<i>S. mentella</i>
67	2015	WRF	58	NA	10	0.996	0.983	1	0.004	0	0.017	<i>S. mentella</i>
68	2015	WRF	60	NA	13	0.996	0.984	1	0.004	0	0.016	<i>S. mentella</i>
69	2015	WRF	58	NA	13	0.995	0.971	1	0.005	0	0.029	<i>S. mentella</i>
70	2015	WRF	61	NA	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
71	2015	WRF	59	NA	13	0.987	0.910	1	0.013	0	0.090	<i>S. mentella</i>
72	2014	S	69	8	13	0.996	0.980	1	0.004	0	0.020	<i>S. mentella</i>
73	2014	S	65	8	13	0.997	0.987	1	0.003	0	0.013	<i>S. mentella</i>
74	2014	S	62	8	13	0.983	0.877	1	0.017	0	0.123	<i>S. mentella</i>
75	2014	S	64	8	13	0.970	0.781	1	0.030	0	0.219	<i>S. mentella</i>
76	2014	S	68	8	13	0.997	0.985	1	0.003	0	0.015	<i>S. mentella</i>
77	2014	S	61	8	13	0.989	0.930	1	0.011	0	0.070	<i>S. mentella</i>
78	2014	S	62	8	13	0.995	0.975	1	0.005	0	0.025	<i>S. mentella</i>
79	2014	S	64	8	13	0.985	0.903	1	0.015	0	0.097	<i>S. mentella</i>
80	2014	S	61	8	13	0.988	0.917	1	0.012	0	0.083	<i>S. mentella</i>
81	2014	S	60	8	13	0.984	0.885	1	0.016	0	0.115	<i>S. mentella</i>
82	2014	S	60	7	13	0.995	0.977	1	0.005	0	0.023	<i>S. mentella</i>

ID	Year	source	Length (mm)	AFR	Nb loci	<i>Sebastes mentella</i>			<i>Sebastes fasciatus</i>			Species
						Prob	IC90_inf	IC90_sup	Prob	IC90_inf	IC90_sup	
83	2014	S	69	8	13	0.994	0.967	1	0.006	0	0.033	<i>S. mentella</i>
84	2014	S	64	7	13	0.997	0.984	1	0.003	0	0.016	<i>S. mentella</i>
85	2014	S	56	8	13	0.993	0.951	1	0.007	0	0.049	<i>S. mentella</i>
86	2014	S	63	8	12	0.982	0.867	1	0.018	0	0.133	<i>S. mentella</i>
87	2014	S	62	8	13	0.980	0.851	1	0.020	0	0.149	<i>S. mentella</i>
88	2014	S	61	8	13	0.997	0.985	1	0.003	0	0.015	<i>S. mentella</i>
89	2014	S	63	8	13	0.991	0.942	1	0.009	0	0.058	<i>S. mentella</i>
90	2014	S	68	7	13	0.991	0.940	1	0.009	0	0.060	<i>S. mentella</i>
91	2014	S	61	8	13	0.993	0.962	1	0.007	0	0.038	<i>S. mentella</i>
92	2014	S	65	8	13	0.996	0.981	1	0.004	0	0.019	<i>S. mentella</i>
93	2014	S	64	8	13	0.994	0.968	1	0.006	0	0.032	<i>S. mentella</i>
94	2014	S	61	8	13	0.993	0.955	1	0.007	0	0.045	<i>S. mentella</i>
95	2014	S	63	8	13	0.994	0.964	1	0.006	0	0.036	<i>S. mentella</i>
96	2014	S	65	8	12	0.990	0.935	1	0.010	0	0.065	<i>S. mentella</i>
97	2014	S	59	8	13	0.988	0.919	1	0.012	0	0.081	<i>S. mentella</i>
98	2014	S	62	8	13	0.998	0.990	1	0.002	0	0.010	<i>S. mentella</i>
99	2014	S	73	8	13	0.998	0.990	1	0.002	0	0.010	<i>S. mentella</i>
100	2014	S	58	8	12	0.997	0.987	1	0.003	0	0.013	<i>S. mentella</i>
101	2014	S	61	8	13	0.996	0.981	1	0.004	0	0.019	<i>S. mentella</i>
102	2014	S	60	8	13	0.980	0.858	1	0.020	0	0.142	<i>S. mentella</i>
103	2014	S	64	8	13	0.969	0.772	1	0.031	0	0.228	<i>S. mentella</i>
104	2014	S	63	8	13	0.997	0.986	1	0.003	0	0.014	<i>S. mentella</i>
105	2014	S	61	8	13	0.995	0.978	1	0.005	0	0.022	<i>S. mentella</i>
106	2014	S	62	8	13	0.985	0.890	1	0.015	0	0.110	<i>S. mentella</i>
107	2014	S	57	8	13	0.994	0.971	1	0.006	0	0.029	<i>S. mentella</i>
108	2014	S	57	8	13	0.997	0.985	1	0.003	0	0.015	<i>S. mentella</i>
109	2014	S	62	8	13	0.998	0.991	1	0.002	0	0.009	<i>S. mentella</i>
110	2014	S	60	8	13	0.996	0.976	1	0.004	0	0.024	<i>S. mentella</i>
111	2014	S	63	8	13	0.989	0.920	1	0.011	0	0.080	<i>S. mentella</i>