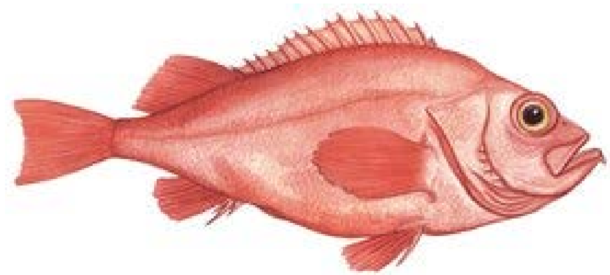
Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Quebec and Newfoundland and Labrador Regions
Canadian Science Advisory Secretariat
Science Advisory Report 2018/032

ASSESSMENT OF REDFISH STOCKS (*SEBASTES MENTELLA* AND *S. FASCIATUS*) IN UNITS 1 AND 2 IN 2017



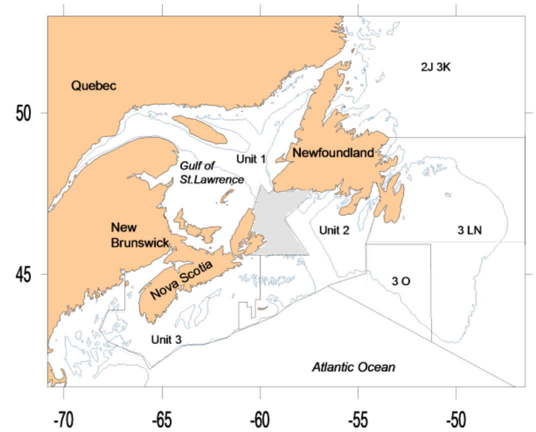


Figure 1. Units 1 and 2 Redfish stock management areas. The (grey) area, where Northwest Atlantic Fisheries Organization (NAFO) Subdivisions 3Pn and 4Vn are located, indicates the seasonal common area (January to May, Unit 1 and June to December, Unit 2).

Context:

The Redfish index fishery in Unit 1 and commercial fishery in Unit 2 harvest two Redfish species, Deepwater Redfish (Sebastes mentella) and Acadian Redfish (Sebastes fasciatus). Units 1 and 2 contain a single biological population of each species and they are assessed separately. Combined landings of both species and both units have dropped from over 100,000 t in the 1970s to less than 10,000 t since 2004. Management measures have been applied to promote species recovery. Since 1995, the Redfish fishery has been under a moratorium in Unit 1 and a 2,000 t/year index fishery has been authorized since 1999. There has been no moratorium on the commercial fishery in Unit 2 and the TAC has been 8,500 t/year since 2006. In 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated S. mentella as endangered and S. fasciatus as threatened.

In 2011, 2012 and 2013, three strong cohorts recruited to the stock. Genetic analyses have indicated that they were dominated by S. mentella and show the signature of the population of the Gulf of St. Lawrence. Since then, juvenile Redfish biomass has increased in both DFO (Unit 1) and GEAC (Unit 2) research surveys. If the anticipated growth of these cohorts continues, in 2018 close to 50% of the individuals of the 2011 cohort should be larger than 22 cm, the minimum commercial size.

This Science Advisory Report is from the March 14-15, 2018 meeting on the Assessment of Redfish Stock (Sebastes mentella and S. fasciatus) in Units 1 and 2. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

SUMMARY

- During the management year 2017-2018 (preliminary data as of February 26th 2018), Redfish landings reached 192 t in Unit 1 under an index fishery of 2,000 t. In Unit 2, 2,077 t of Redfish were landed on a total allowable catch (TAC) of 8,500 t. Landings were below the average annual reported landings from 2010 to 2016 of 499 t and 3,592 t in Units 1 and 2, respectively.
- Based on the main stakeholder input, management measures, market conditions, small Redfish size and moratorium impact limited fishing effort in the past few years in Unit 1. In Unit 2, market conditions represented the main factor limiting fishing effort.
- Bycatch landings in the directed Redfish fishery using mobile bottom gears represent 9% of Redfish landings in Unit 1 and 4% in Unit 2 from 2010 to 2017. The most common bycatch species in Unit 1 were Greenland Halibut, White Hake, and Atlantic Cod, whereas Atlantic Cod and Witch Flounder were the most common in Unit 2.
- Juvenile Redfish abundance from the 2011 to 2013 cohorts has increased dramatically in both DFO (Unit 1) and GEAC (Unit 2) research surveys. These cohorts are the most abundant ever observed in the research surveys. These individuals are largely dominated by *S. mentella* and show the genetic signature of the Units 1 and 2 adult population.
- In the summer 2017, the 2011 to 2013 Redfish cohorts' modal size was 20 cm. If the anticipated growth of these cohorts continues, close to 50% of the individuals (59% biomass) of the 2011 cohort should be larger than 22 cm in 2018, the minimum commercial size. By 2020, 51% of the cohort (62% biomass) should be larger than 25 cm.
- According to research survey in Unit 1 in 2017, total minimum trawlable biomass was estimated to be 2,166,000 t for *S. mentella*, the highest value observed since 1984. Total biomass of *S. fasciatus* estimated to be 346,000 t is of the same order of magnitude as the highest value observed since 1984.
- In Unit 1, total minimum trawlable biomass of Redfish greater than 22 cm in length began to increase in 2017. It was estimated to be 349,000 t and 89,000 t for *S. mentella* and *S. fasciatus*, respectively. However, biomass of Redfish greater than 25 cm in length has not yet started to increase in the survey. By 2019, biomass of Redfish greater than 25 cm is expected to increase substantially.
- In Unit 2, total minimum trawlable biomass of Redfish greater than 22 cm in length has been stable since 2005. In 2016, it was estimated to be 86,000 t for *S. mentella* and 167,000 t for *S. fasciatus*. Biomass of Redfish greater than 25 cm in length remained stable and should increase substantially by 2019.
- Based on August bottom trawl research survey in Unit 1, both Redfish species are distributed according to depth. In addition, as they grow, larger Redfish appear to concentrate in Laurentian channel deeper areas. Currently, the strong recruitment of new cohorts means that the biomass of individuals smaller than 22 cm dominates at all depths.
- Redfish summer diet in Unit 1 varies according to fish size. Redfish less than 20 cm consume mostly zooplankton, and primarily shrimps (Northern Shrimp and Pink Glass Shrimp) when they are over 20 cm. When Redfish reach a size of 25 cm, they start consuming fish.

- The massive increase in Redfish has important repercussions for the ecosystem. Increasing predation among other things is contributing to the Northern Shrimp decline in the Estuary and Gulf of St. Lawrence.
- Prospects for Redfish stocks in Units 1 and 2 are extremely positive. The strong recruitment and biomass increase may allow higher catches of *S. mentella* in Unit 1 by 2018, while it is preferable to remain cautious for *S. fasciatus*.

BACKGROUND

Species biology

Redfish inhabit cold waters along the slopes of banks and deep channels at depths ranging from 100 to 700 m. *Sebastes mentella* is typically found in deeper waters than *S. fasciatus*. In the Gulf of St. Lawrence and Laurentian Channel, *S. mentella* is found primarily in the main channels at depths ranging from 200 to 400 m. In contrast, *S. fasciatus* is present mainly at depths of less than 300 m, along the slopes of channels and on the banks, except in the Laurentian Fan where it inhabits deeper waters. Redfish generally live near the bottom. However, various studies have shown that these species reside near the bottom during the day, leaving the sea floor at night to follow their prey as they migrate. Juvenile Redfish feed mainly on various species of crustaceans, including several species of shrimp. The adult Redfish diet is more diversified and includes fish.

Redfish are a slow growing and long lived species. *S. fasciatus* grows more slowly than *S. mentella*, although this difference in growth rates only becomes obvious after 10 years of age. In both species, females grow faster than males after about 10 years of age. On average, it takes Redfish seven to eight years to reach the 22 cm minimum legal size. Males reach sexual maturity one to two years earlier than females. Male *S. mentella* mature at 9 years (L50: 22.8 cm) and female at 10 years (L50: 25.4 cm), whereas male *S. fasciatus* mature at 7 years (L50: 19.6 cm) and female at 9 years (L50: 24.1 cm).

Unlike many cold-water marine fish species, Redfish are ovoviviparous. Mating occurs in the fall, most likely between September and December, and the females carry developing embryos until they are extruded in spring at the larval stage when they are able to swim. Larval extrusion occurs from April to July, depending on the area and species. Mating and larval extrusion do not necessarily occur in the same locations. In the Gulf of St. Lawrence, *S. mentella* releases its larvae approximately three to four weeks earlier than *S. fasciatus*. The larvae develop in surface waters and juveniles gradually migrate to greater depths as they grow.

Redfish species identification criteria

Sebastes mentella and *S. fasciatus* in Units 1 and 2 have traditionally been assessed as "*Sebastes sp.*" because they are difficult to identify. As part of the multidisciplinary research program on Redfish (1995-1998), various meristic, morphometric and genetic tools were used in order to distinguish the two species to document their specific life history and identify distribution and recruitment patterns specific to each species. Species were clearly distinguished with microsatellite genetic markers. A minimum of 4 loci were required to assign individuals to a species. However, analysis of microsatellite markers remains costly and logistically challenging, which restricts their use for monitoring the species composition of catches on a large scale.

Three characteristics were traditionally used to distinguish *S. mentella* and *S. fasciatus* in the Northwest Atlantic: the number of soft rays on the anal fin (anal fin ray count or AFC), extrinsic gas bladder muscle passage patterns (EGM), and the genotype at the malate dehydrogenase locus (MDH-A*). In the absence of information about microsatellites, the MDH-A* genotype has historically been considered as the genetic criterion. These three criteria (MDH-A*, AFC, EGM) were used to describe the geographic range of these two species in the North Atlantic.

Since 2009, Redfish stocks in Units 1 and 2 have been assessed by species. Species identification based on anal fin ray counts and depth data are integrated to determine the proportion of each species caught during the surveys. Anal fin ray count patterns vary between the two species and this criterion can easily be identified at sea. For this reason, it was selected as a practical, economical alternative to genetic analysis for estimating the specific composition of catches.

Genetic structure of stocks in Units 1 and 2

An analysis of genetic variation (13 microsatellite loci) suggests that Units 1 and 2 contain a single population of *S. mentella*. This population is itself distinct from other populations of *S. mentella* distributed in the Northwest Atlantic Ocean. For *S. fasciatus*, the results suggest the presence of five populations in the Northwest Atlantic, three of which overlap Units 1 and 2. A first *S. fasciatus* population is found in the area covered by Units 1 and 2, excluding the southern edge of Unit 2. A second *S. fasciatus* population includes the southern edge of Unit 2 (including the mouth of the Laurentian Channel (fan)), and extends along the continental shelf break from the Grand Banks (3LNO) to Nova Scotia (4W), which we will refer to as the “Atlantic population of the continental shelf break.” A third, geographically small *S. fasciatus* population has been highlighted in the east inlet of the Bonne Bay fjord, on the west coast of Newfoundland.

Recruitment events

In the Northwest Atlantic, Redfish is characterized by significant variability in recruitment. Genetic analysis results indicated that around 1980, Units 1 and 2 produced the last strong year-class of *S. mentella* that greatly contributed to the fishery afterwards. Until 2011, all other strong year-classes found in Units 1 and/or 2 (1974, 1985, 1988 and 2003) were identified as *S. fasciatus* with the genetic signature of the Atlantic population of the continental shelf break (adults). Consequently, these *S. fasciatus* year-classes, which seemed strong in their early stages, particularly in Unit 1, decreased significantly within a few years without contributing significantly to adult populations and the fishery. Ocean currents and aged-based spatial and temporal abundance trends suggest that this *S. fasciatus* population uses the Gulf of St. Lawrence as a nursery area only. The larvae/juveniles apparently drifted to the Gulf of St. Lawrence, and 5 to 6 years later the older juveniles returned to the Atlantic population of the continental shelf break.

The most recent DFO research surveys indicated that there were three abundant Redfish year-classes in Unit 1, the 2011, 2012 and 2013 cohorts. Genetic analyses performed on the 2011 and 2012 cohort indicated that 91% of these fish belonged to the *S. mentella* species within the adult population of Units 1 and 2. This information suggested that these Redfish will remain in the area and should promote the recovery of *S. mentella* in Units 1 and 2. Juvenile Redfish abundance from the 2011 to 2013 cohorts has increased dramatically in both DFO (Unit 1) and GEAC (Unit 2) research surveys. These cohorts are the most abundant ever observed in the research surveys. Juveniles of the 2011 and 2012 *S. fasciatus* year-classes show genetic evidence of introgression (ancestral hybridization) with *S. mentella*, which is characteristic of adult Redfish in Units 1 and 2, also indicating a local origin.

Ecosystem

Fisheries and Oceans Canada annually assesses the physical oceanographic conditions prevailing in the Gulf of St. Lawrence with the Atlantic Zone Monitoring Program (AZMP). Conditions encountered in the northern Gulf from 2011 to 2017 were generally warmer than historical averages, particularly for surface and deep-water temperatures. Deep-water temperatures in the Gulf have been increasing in recent years. Overall, temperatures at 250 m and 300 m depth have reached a series high since 1915. The surface of the seabed covered by temperatures greater than 6° C has finally decreased in the Anticosti Channel and the Esquiman Channel, but has increased significantly in the central Gulf and made its first appearance in the northwestern Gulf (Galbraith et al. 2017).

The Gulf of St. Lawrence ecosystem is composed of a diverse fish community whose abundance varies over time and space. For example, the various herring stocks are declining (DFO 2016a, DFO 2017a) and the mackerel stock is at a record low level (DFO 2017b). The indicators of Greenland Halibut (4RST) stock decreased in 2017 (DFO 2018a), while Atlantic Halibut (4RST) is at its highest historical and stable level since 2013 (DFO 2018b). The Atlantic Cod stock in the southern Gulf of St. Lawrence (4T) is very low but stable (DFO 2016b), whereas the northern Gulf (3Pn, 4RS) stock is also low, but slightly increasing (DFO 2017c). The Northern Shrimp stock in the Estuary and Gulf of St. Lawrence has been declining since 2010 but has been in the healthy zone for several years (DFO 2018c).

FISHERY

In the late 1950s, a directed fishery for Redfish was developed in the Gulf of St. Lawrence and the Laurentian Channel outside the Gulf. Prior to 1993, the Redfish fishery was managed as three divisions established by NAFO (Northwest Atlantic Fisheries Organization): Divisions 4RST, Division 3P and Divisions 4VWX. In 1993, these management units were redefined to provide a stronger biological basis and take various factors into account, including the winter migration to the Cabot Strait area of the Gulf Redfish stocks. The resulting management units were divided as follows: Unit 1 included Divisions 4RST and Subdivisions 3Pn4Vn from January to May; Unit 2 included Subdivisions 3Ps4Vs, Subdivisions 4Wfgj, and Subdivisions 3Pn4Vn from June to December; and Unit 3 included Divisions 4WdehklX (Figure 1).

The first total allowable catches (TAC) of Redfish stocks were set according to the 1993 management structure were 60,000 t in Unit 1 and 28,000 t in Unit 2. They are now 2,000 t/year (since 1999) for the index fishery in Unit 1 and 8,500 t/year for the commercial fishery in Unit 2 (since 2006). Bottom trawls are currently the primary gear type used in the Redfish fishery while midwaters trawls were primarily used in the 1980s and 1990s.

Redfish conservation measures for the fishery include: implementation of a protocol for protecting small fish (< 22 cm), 100% dockside monitoring, mandatory hail reports upon departure and arrival, imposition of a level of coverage by observers (25% or 10% with the Vessel Monitoring System (VMS) in Unit 1, 10% for fixed gear and 5% to 20% for mobile gear in Unit 2) and, implementation of a bycatch protocol (5% to 15% in Unit 1 and 10% for fleets > 65 feet using mobile gear in Unit 2). Closure periods were also introduced, 1) to protect Redfish mating (fall) and larval extrusion periods (spring), 2) to minimize catches of Unit 1 Redfish migrating in Subdivisions 3Pn4Vn at the end of fall and winter, and 3) to protect spawning Atlantic Cod (Divisions 4RS). In addition, since the index fishery was introduced in 1998, fishing is allowed only between longitudes 59° and 65° at depths > 100 fathoms and to avoid Greenland Halibut bycatch, an area has been closed in Division 4T since August 2009.

Unit 1 landings

The Redfish fishery in the Gulf of St. Lawrence has been characterized by two periods of high landings: the first in the 1970s, and the second in the early 1990s (Figure 2). From 1965 to 1976, annual landings averaged 79,000 t. Landings peaked at 136,000 t in 1973. From 1987 to 1992, average annual landings were 59,000 t. In 1995, a moratorium was imposed on the Redfish fishery due to low stock abundance and poor recruitment. An index fishery began in 1998 with a 1,000 t TAC. From 1999 to date, the TAC has been maintained at 2,000 t/year. Between 1999 and 2005, average annual landings from the index fishery and bycatch reached 1,054 t in Unit 1. From 2006 to 2017, average annual landings were 461 t (preliminary data for 2016 and 2017).

Unit 2 landings

Between 1960 and 1969, average annual landings were 27,000 t; from 1970 to 1976, they averaged 40,000 t, with peak removals (58,000 t) occurring in 1972 (Figure 2). This increase in removals was primarily due to the increased catches recorded by foreign fleets. Following the introduction of the 200 nautical mile limit in 1977, landings decreased to an average of 18,000 t from 1977 to 1994 (with an annual TAC of 27,000 t in 1993-1994). Landings continued to decrease between 1995 and 2003 to an average of 10,500 t, identical to the TAC in place during this period. From 2004 to 2008, average landings in Unit 2 were 5,250 t, with an average annual 8,333 t TAC. From 2010 to 2017, average annual landings were 2,737 t (preliminary data for 2017) with an 8,500 t TAC.

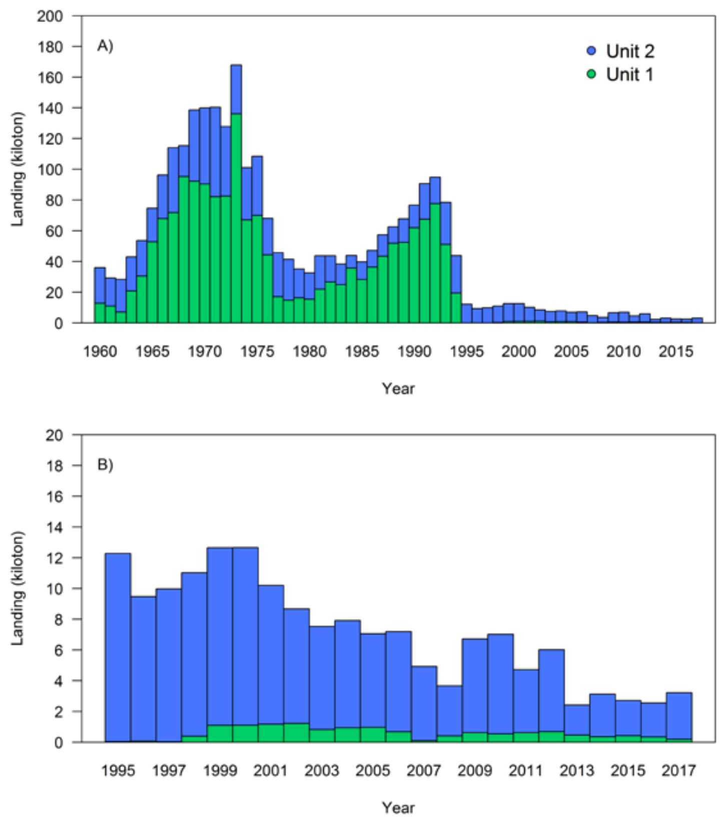


Figure 2. Annual landings in thousands of tonnes of Redfish in Units 1 in green and 2 in blue since 1960 (A) and for the most recent years (B).

Fishery performance index

In Unit 1, spatial distribution of fishing effort varied during the time-series. From 1986 to 1994, fishing effort was comparable across division (4R = 28%, 4S = 35% and 4T = 34%). In 1998, following the moratorium, an index fishery to collect data on trawl catches per unit effort (CPUE) was introduced. From 1998 to 2009, 54% and 40% of the fishing effort occurred in 4T and 4R, respectively. Between 2010 and 2017, fishing effort was mainly concentrated in 4T (70%) (Figure 3).

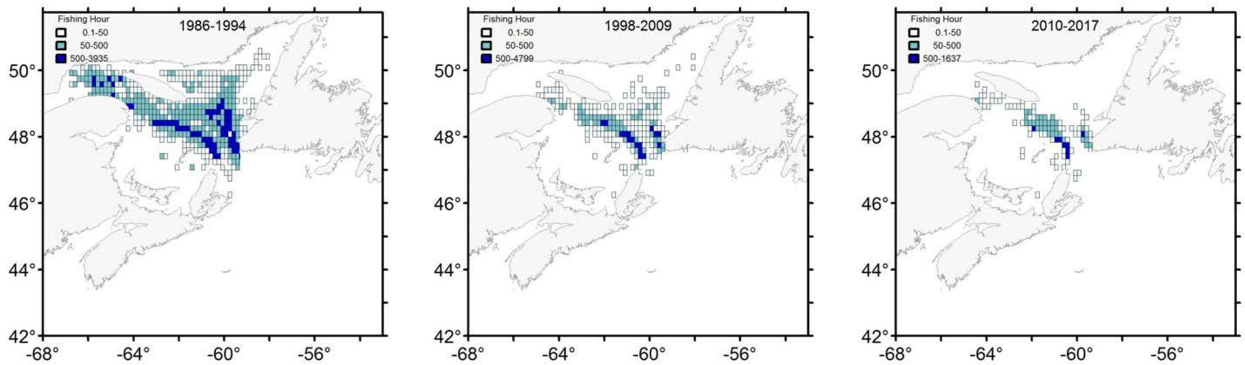


Figure 3. Spatial distribution of fishing effort (hour) of Redfish directed fishery in Unit 1 across years.

CPUE is considered as an index of fishery performance rather than an indicator of stock abundance. The fishery performance index, comparing CPUE from the commercial fishery in Unit 1 prior to the moratorium (1981-1994) to those of the index fishery (1999-2017), is presented in Figure 4A. This index dropped sharply between 1993 and 1994, and stabilized at a low level from 1999 to 2003. Since 2004, the index has been stable and comparable to the series average. The performance index in Unit 2 (Figure 4B), showed an increasing trend from 2003-2011 followed by a drastic decline in 2012. The performance index then increased slightly in 2013 and has since been stable.

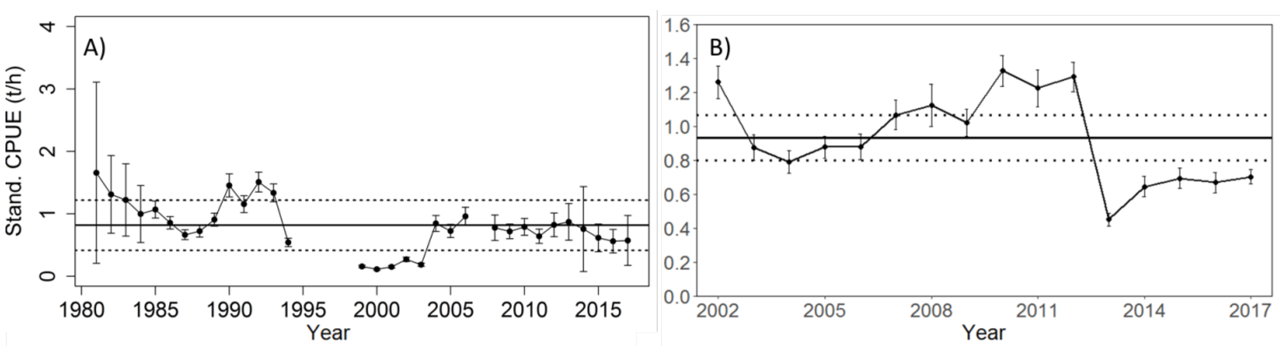


Figure 4. Standardized bottom trawl catch per unit effort (average CPUE ±95% confidence interval) in Unit 1 commercial fishery between May and October (1981–1994) and index fishery (1998–2017) (A); and in Unit 2 commercial fishery from 2002-2017 (B). The solid line represents the average and the dashed lines represent a ± ½ standard deviation.

Commercial catch at length in Unit 1

From 1981 to 1988, the commercial catch at length in Unit 1 indicated that catches primarily consisted of fish born in the early 1970s. From 1988 to 2008, catches predominantly consisted of fish born in the early 1980s (Figure 5). From 1999 to 2016, most fish caught were larger than

30 cm. Since 1999, commercial catch at length has been more difficult to establish because landings have dropped significantly (especially since 2006). As a result, fewer fish were measured by observers and through DFO sampling programs. However, it appears that the 1980 year-class began to be recruited to the fishery in 1987 and remained in catches to date. The new Redfish cohorts (2011-2013) started to recruit to the commercial fishery in 2015 but they do not yet represent a large proportion of catches.

Commercial catch at length in Unit 2

From 1995 to 2004, commercial catch at length in Unit 2 indicated that most catches consisted of the strong 1980 year-class (Figure 5). Starting in 2005, size frequency distributions were broader and more difficult to track through time, potentially indicating the presence of numerous cohorts in the fishery. During this period, especially from 2006 to 2012, more than 50% of annual landings came from the southern edge of Unit 2 (Laurentian Fan area). *S. fasciatus* were observed in this area and their genetic signature was that of the Atlantic population of the continental shelf break, which could account for the presence of fish smaller than 30 cm. Also, the 2003 *S. fasciatus* cohort apparently left Unit 1 and returned to their area of origin (Atlantic coast along the continental shelf break) contributing to the fishery in Unit 2 starting in 2010. Recently, there has been an increasing presence of the 2011-2013 cohorts (18-20 cm) appearing in commercial catches.

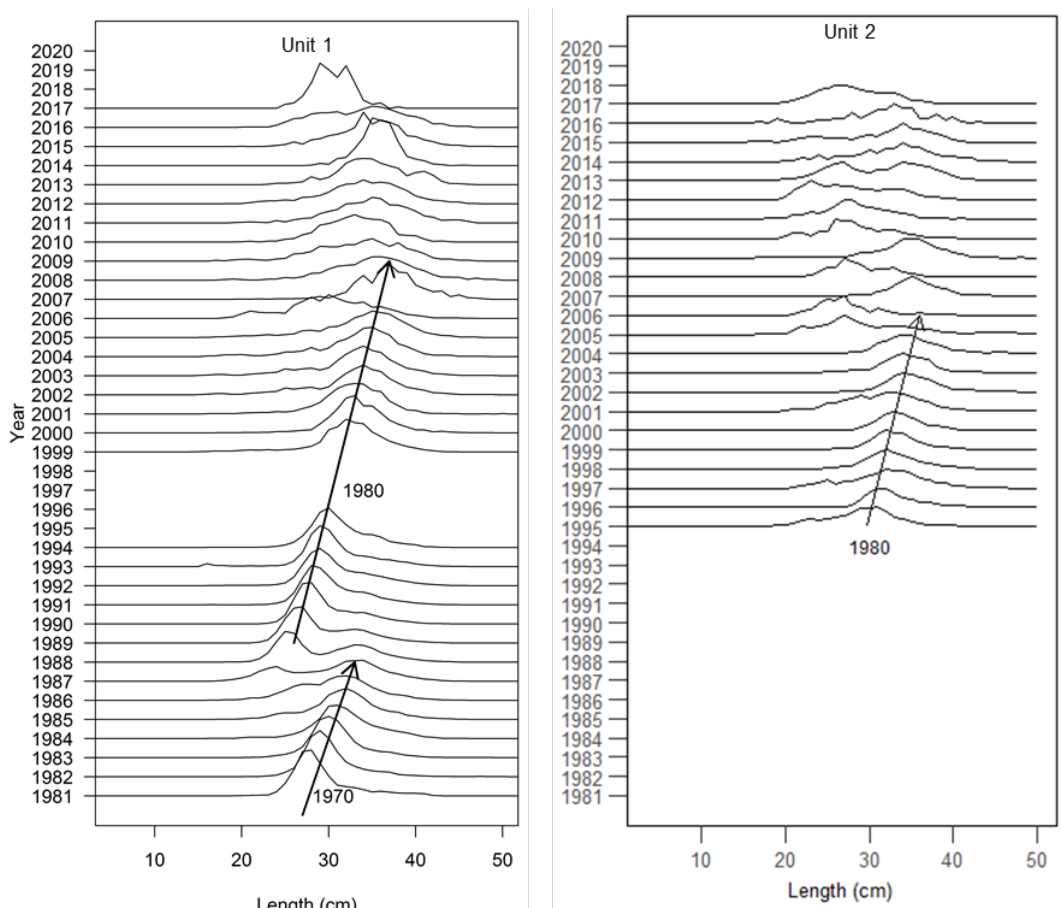


Figure 5. Commercial catch at length in percentage in Unit 1 (1981 to 2017) and Unit 2 (1995 to 2017). Arrows indicate cohorts recruiting to the fishery.

Bycatch

Redfish catches reported in directed fisheries for most commercial fisheries conducted in Units 1 and 2 from 2000 to 2017 were examined. This analysis revealed that more than 90% of the reported Redfish catches came from the directed Redfish fishery (91% Unit 1 and 96% Unit 2). Fisheries targeting Greenland Halibut and Atlantic Cod were responsible for 3% and 2% of Redfish landings in Unit 1, respectively.

From 2000 to 2017, bycatch landings in the directed Redfish fishery using mobile bottom gears represent 9% of Redfish landings in Unit 1 and 4% in Unit 2 from 2010 to 2017 (Figure 6A and 7A). The most common bycatch in Unit 1 were Greenland Halibut, White Hake, and Atlantic Cod, whereas Atlantic Cod (Figure 6B) and Witch Flounder were the most common species caught as bycatch in Unit 2 (Figure 7B). Due to privacy constraints, Redfish landings from Unit 2 are only shown as a proportion of the total landings (Figure 7). Spatio-temporal distribution and depth preference of these species as well as improving gear selectivity can help reduce the occurrence of bycatch in Redfish fisheries.

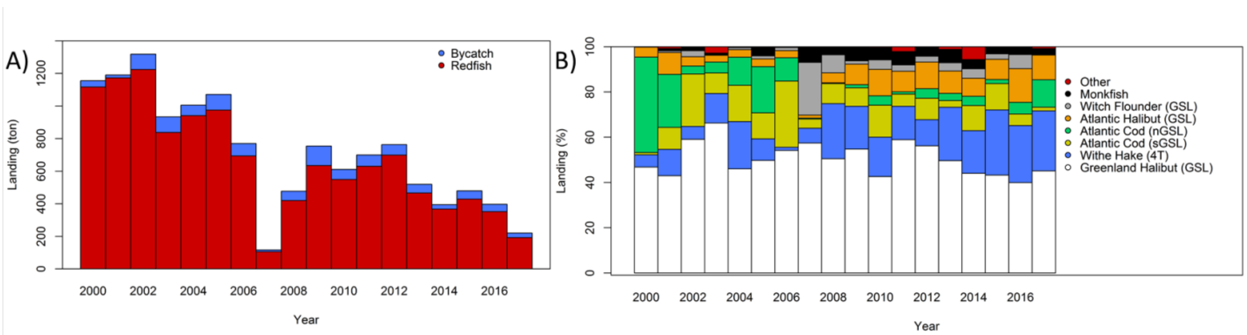


Figure 6. Declared landings in tonnes of Redfish and bycatch species (A), as well as bycatch species percentage (B), in the directed Redfish fishery in Unit 1 from 2000 and 2017.

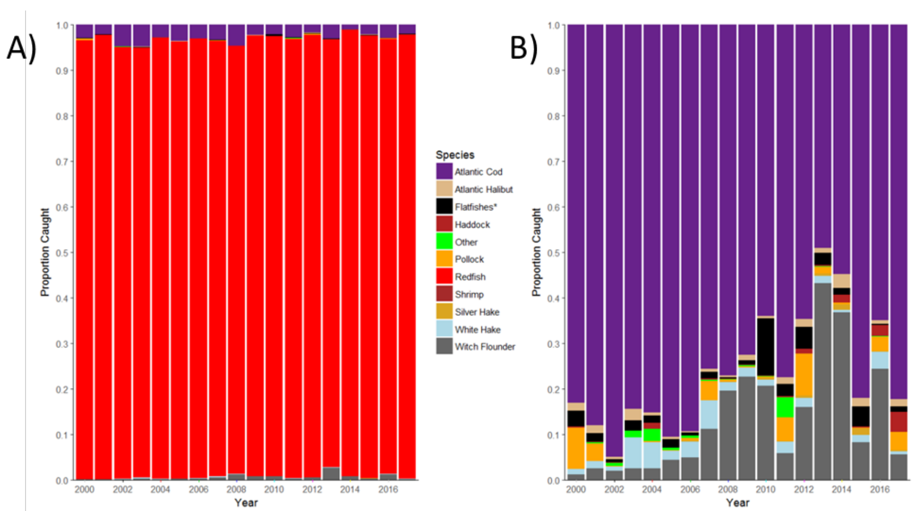


Figure 7. Bycatch caught as a proportion in the commercial Redfish fishery in Unit 2 (A) and proportion of bycatch separated by species (B) are presented from 2000 to 2017.

Industry's perspective

Based on the main stakeholder input, management measures, market conditions, small Redfish size and moratorium impacts limited fishing effort in the past years in Unit 1. In Unit 2, market conditions represented the main factor limiting fishing effort.

ASSESSMENT

Research surveys

Abundance and biomass indices derived from bottom trawl surveys are available for Unit 1, August DFO research survey (1984-2017), and for Unit 2, August/September *Groundfish Enterprise Allocation Council* (GEAC) industry survey (2000-2016). Each survey analysis focused on each species, *S. mentella* and *S. fasciatus*. A combined series (2000-2016) was created for each species in Units 1 and 2 using DFO scientific survey data (Unit 1) and GEAC data (Unit 2) converted into CCGS Teleost/Campelen equivalents. During the 2014 survey in Unit 2, Redfish species could not be differentiated due to a problem with the application of the method of the anal fin ray count data.

Redfish biomass indices and length composition in Unit 1 (1984-2017)

According to the DFO research survey in Unit 1, *S. mentella* and *S. fasciatus* abundance and biomass declined sharply from the late 1980s to 1994 (Figure 8). Subsequently, the indices of small and large Redfish remained low and stable. The new cohorts (2011-2013) mainly dominated by the 2011 year-class started being caught by the research trawl in 2013, and biomass of juvenile Redfish (0-22 cm) increased substantially since then. These juveniles were largely dominated by *S. mentella*, with the genetic signature of the adult population of the northern Gulf of St Lawrence. In 2017, total minimum trawlable biomass was estimated to be 2,166,000 t for *S. mentella*, the highest value observed since 1984. Total biomass of *S. fasciatus* estimated to be 346,000 t, is of the same order of magnitude as the highest value observed since 1984. The biomass of juvenile *S. mentella* and *S. fasciatus* was 60 and 10 times higher, respectively, than their mean biomass for 1995-2015. Minimum trawlable biomass of Redfish greater than 22 cm in length began to increase in 2017. It was estimated to be 349,000 t and 89,000 t for *S. mentella* and *S. fasciatus*, respectively. However, biomass of Redfish greater than 25 cm in length has not yet started to increase in the survey. By 2019, biomass of Redfish greater than 25 cm is expected to increase substantially. In summer 2017, the 2011 to 2013 Redfish cohorts' modal size was 20 cm (Figure 9). If the anticipated growth of these cohorts continues, close to 50% of the individuals (59% biomass) of the 2011 cohort should be larger than 22 cm in 2018, the minimum commercial size. By 2020, 51% of the cohort (62% biomass) should be larger than 25 cm.

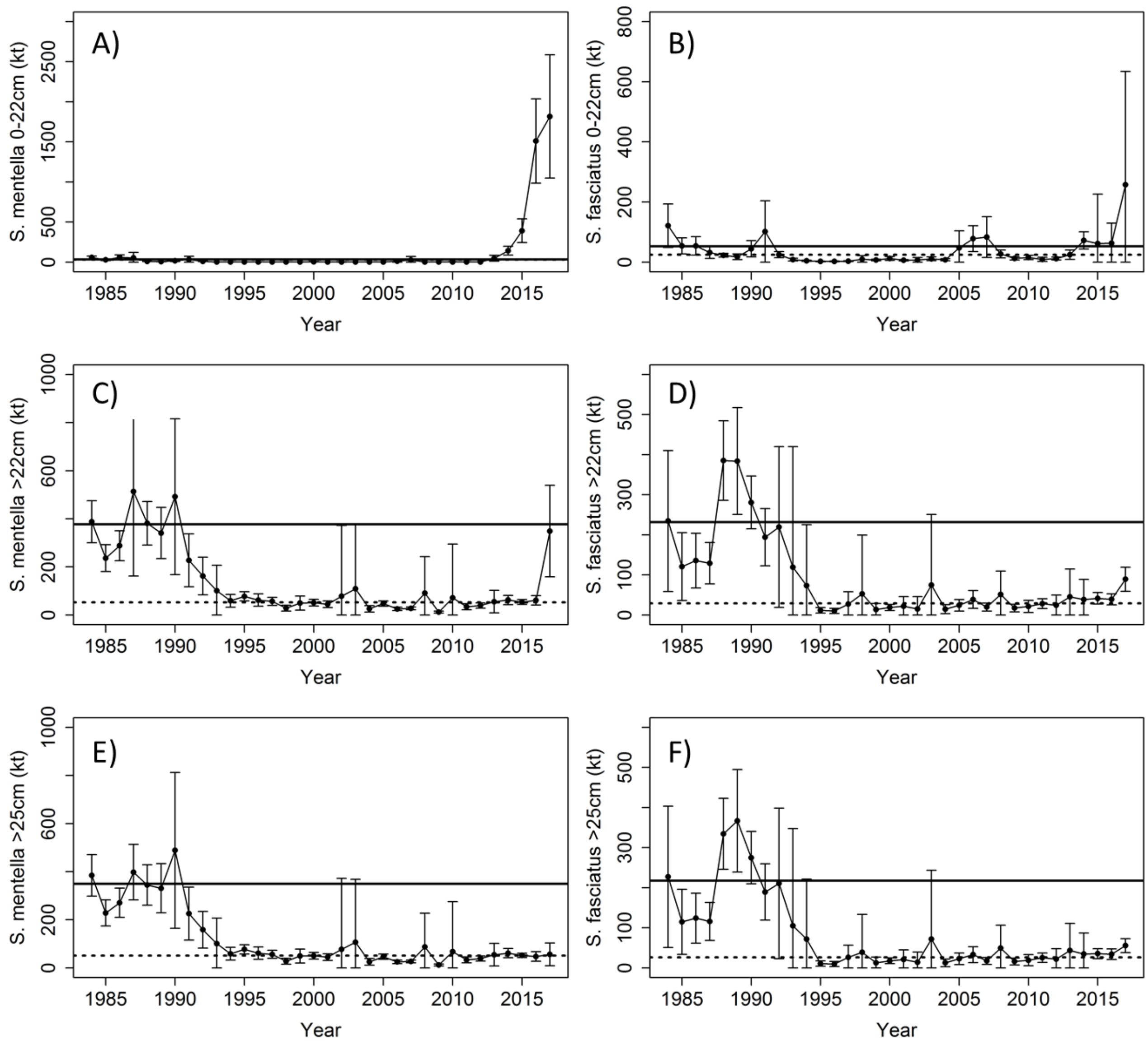


Figure 8. Minimum trawlable biomass in thousands of tonnes (kt) of S. mentella and S. fasciatus, 0-22 cm (A-B), >22 cm (C-D), and > 25 cm (E-F) in Unit 1 DFO survey from 1984 to 2017. The solid and dotted lines represent the mean for the 1984-1990 and 1995-2015 periods, respectively.

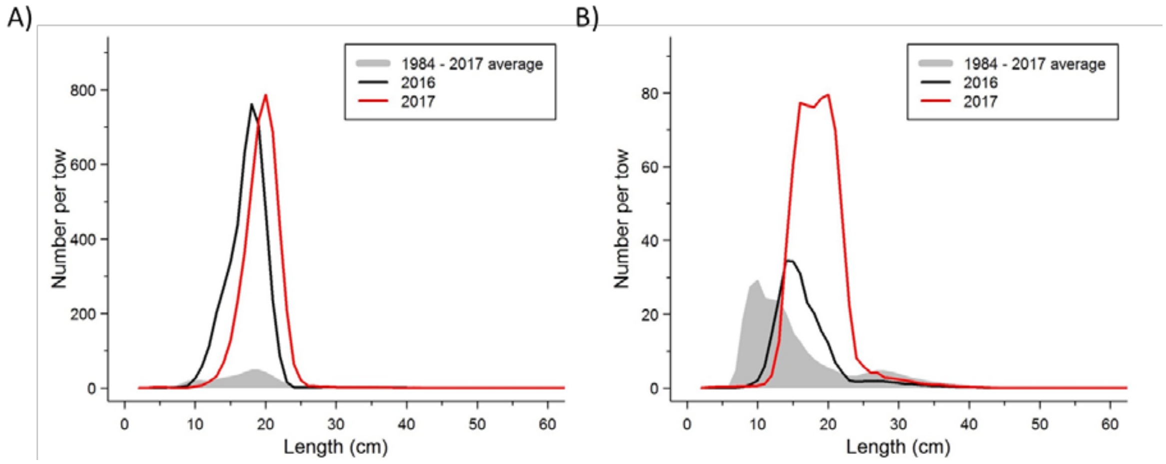


Figure 9. Length composition of S. mentella (A) and S. fasciatus (B) in Unit 1 DFO survey from 1984-2017.

Redfish biomass indices and length composition in Unit 2 (2000-2016)

Information was not available by species for 2014. Hence, industry survey data are presented for both species combined, *Sebastes sp.*, from 2000 to 2016 (Figure 10) and by species, from 2000 to 2011 and 2016 (Figure 12). The abundance and biomass indices of *Sebastes sp*. in Unit 2 show an increasing trend in 2016 (Figure 10). Modal size of Redfish in Unit 2 was ~19 cm in 2016, about 4 cm larger than the 2014 survey, with numbers per tow of 18-20 cm fish being much higher than in previous years. The shift in the modal size illustrates the movement of the 2011-2013 cohorts through the system. The distribution of lengths in the 2016 Unit 2 GEAC survey is similar to the long-term average, although the magnitude of most length classes is greater (Figure 11). In 2016, minimum trawlable biomass of juvenile Redfish cohorts from 2011 to 2013, largely dominated by *S. mentella*, increased in the Unit 2 GEAC survey (Figure 12). Minimum trawlable biomass of small *S. fasciatus* (0-22 cm) was at a time-series high, with the next highest values (2007), being attributed to the strong 2003 year-class. Minimum trawlable biomass of Redfish greater than 22 cm in length was stable since 2005. In 2016, it was estimated to be 86,000 t for *S. mentella* and 167,000 t for *S. fasciatus*.

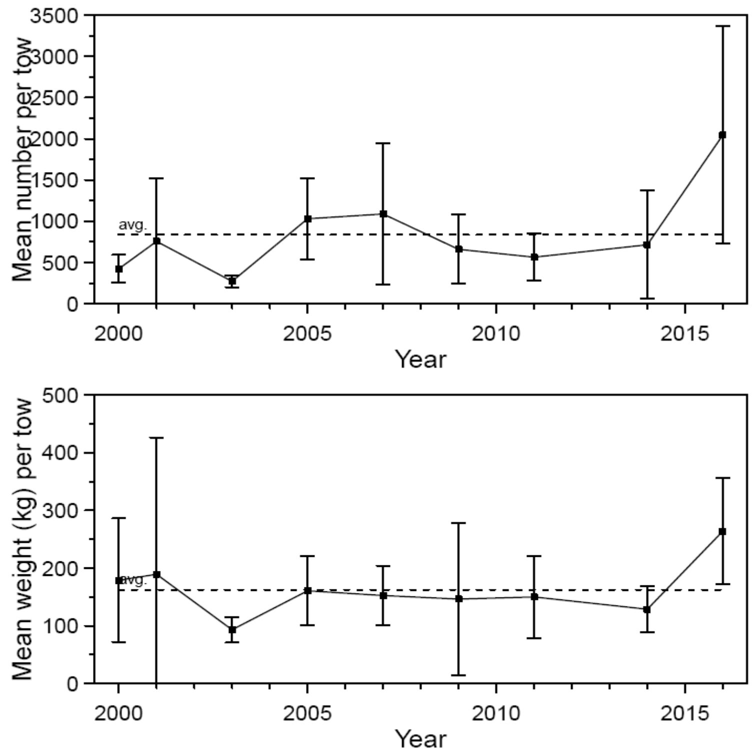


Figure 10. Mean number per tow and mean weight per tow (kg) of Sebastes sp. in the Unit 2 GEAC survey. The dotted horizontal line represents the mean for the 2000–2016 period.

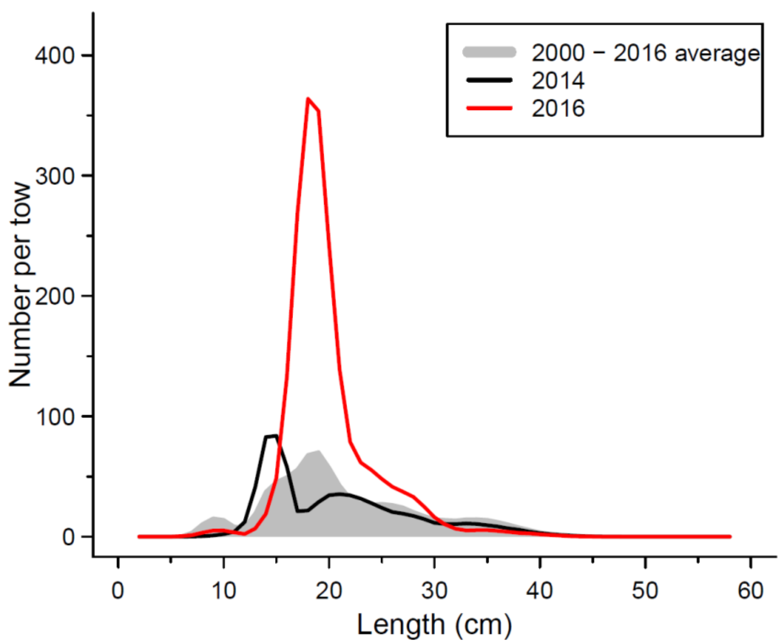


Figure 11. Size frequencies of Redfish (S. fasciatus and S. mentella combined) in the Unit 2 GEAC survey.

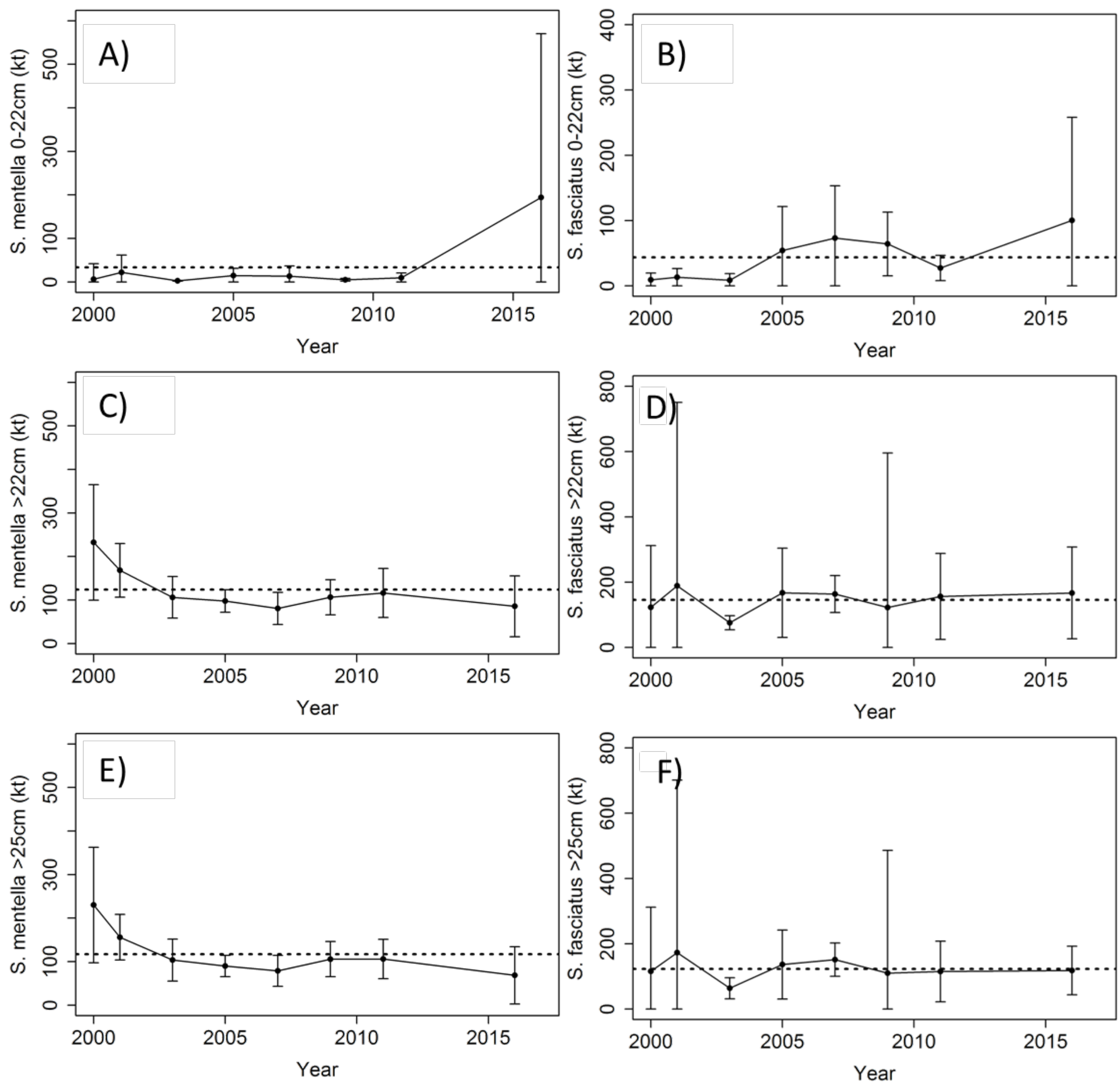


Figure 12. Minimum trawlable biomass in thousands of tonnes (kt) of S. mentella and S. fasciatus, 0-22 cm (A-B), >22 cm (C-D), and > 25 cm (E-F) in Unit 2 GEAC survey from 2000 to 2017. The dotted lines represents the mean for the 2000-2017 period.

Combined biomass indices of *Sebastes* sp. (*S. mentella* and *S. fasciatus)* in Units 1 and 2

The combined *Sebastes sp*. indices show that the total biomass was stable until 2011 (Figure 13). Between 2000 and 2011, total Redfish biomass was greater in Unit 2 than in Unit 1. In 2014, biomass was similar in both units. In 2016, biomass in Unit 1 was three times the biomass in Unit 2. The increase in biomass in Unit 1 was attributable to the high abundance of Redfish smaller than 22 cm (Figure 13).

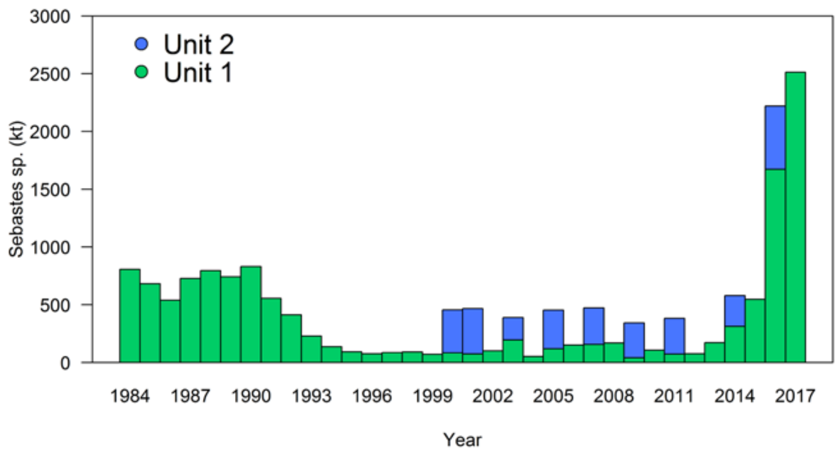


Figure 13. Minimum trawlable biomass of Sebastes sp. (S. mentella and S. fasciatus) in Units 1 and 2 based on DFO and GEAC indices.

The biomass of *S. mentella* 0-22 cm remained low and stable in both Units until 2013. In 2014, the new cohorts started being captured by the research gear and increased in Unit 1 biomass indices (Figure 14). There was no comparison available for 2014 because the data in Unit 2 were not available by species. In 2016, the massive increase in juveniles was apparent in Unit 1, but less in Unit 2. In both Units, the biomass of *S. mentella* larger than 22 cm was high in the 1980s, decreased in the early 1990s, and remained low and stable until 2016. The biomass of *S. mentella* larger than 22 cm was higher in Unit 2 than in Unit 1 from 2000 to 2011, but similar in both Units in 2016.

The biomass of *S. fasciatus* 0-22 cm was more variable than *S. mentella*. Some cohorts (1985, 1988, and 2003) were identified as having the genetic signature of the Atlantic population of the continental shelf break. These year-classes seemed strong in their early stages, particularly in Unit 1, but decreased considerably within a few years without contributing substantially to the adult population of Unit 1 and 2. The biomass of *S. fasciatus* larger than 22 cm was higher in Unit 2 than in Unit 1 from 2000 to 2016. In 2016, the total biomass of *S. mentella* was 5 times larger than that of *S. fasciatus* (Figure 14).

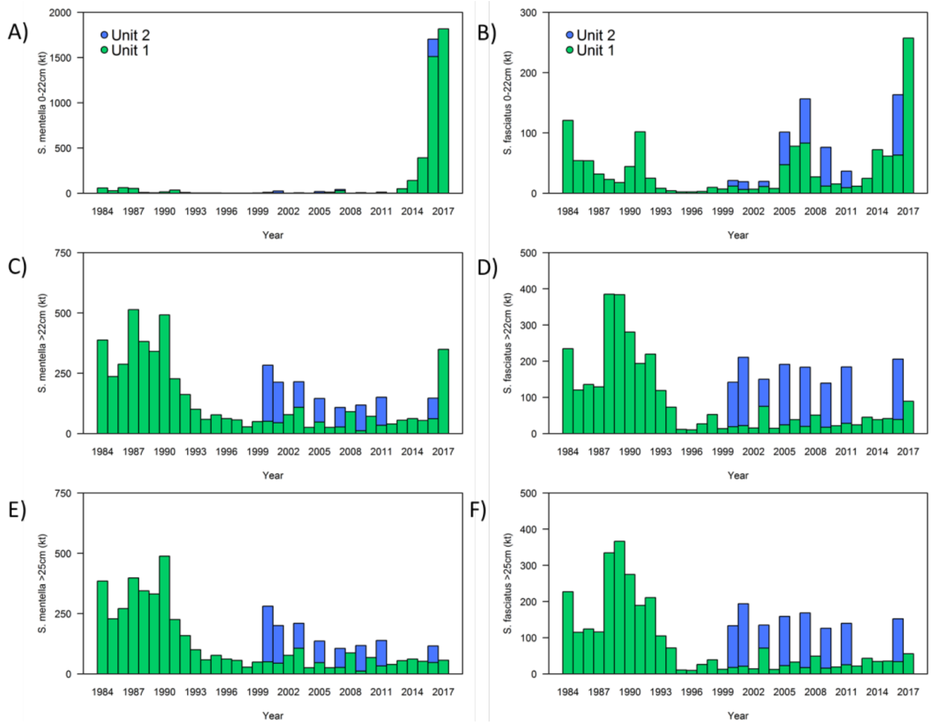


Figure 14. Minimum trawlable biomass in thousands of tonnes (kt) of S. mentella and S. fasciatus, 0-22 cm (A-B), >22 cm (C-D), and > 25 cm (E-F) in Units 1 and 2 based on DFO and GEAC indices.

Sebastes mentella **and** ***S. fasciatus*** **spatial distribution in Units 1 and 2**

The spatial distribution maps of Redfish biomass (kg/tow) show a continuous distribution of Redfish between Units 1 and 2 along the Laurentian Channel to the head of the Esquiman, Anticosti and Laurentian Channels in the Gulf of St. Lawrence (Figures 15-18). These maps indicate that *S. fasciatus* occupies shallower waters than *S. mentella*, with the exception of the Laurentian Fan area where *S. fasciatus* inhabits deeper waters.

The spatial distribution of Redfish catch rates in the DFO survey indicated that between 1984 and 1995 the Laurentian, Esquiman and Anticosti Channels were densely populated by both species (Figures 15-18). Subsequently, there was a substantial decrease in the density of mature individuals in both Redfish species, in particular west of Anticosti Island and north of Esquiman (Figures 16 and 18). Immature *S. mentella* have shown an increase in density from 2011-2017, particularly in the Esquiman, Anticosti and Laurentian Channels, and the Southwestern edge of Cabot Strait. Immature *S. fasciatus* have also shown a recent increase in density (2011-2017), albeit less so than in *S. mentella*. Overall, densities of immature and mature *S. fasciatus* are lower than in *S. mentella*, although their distribution is broadly similar.

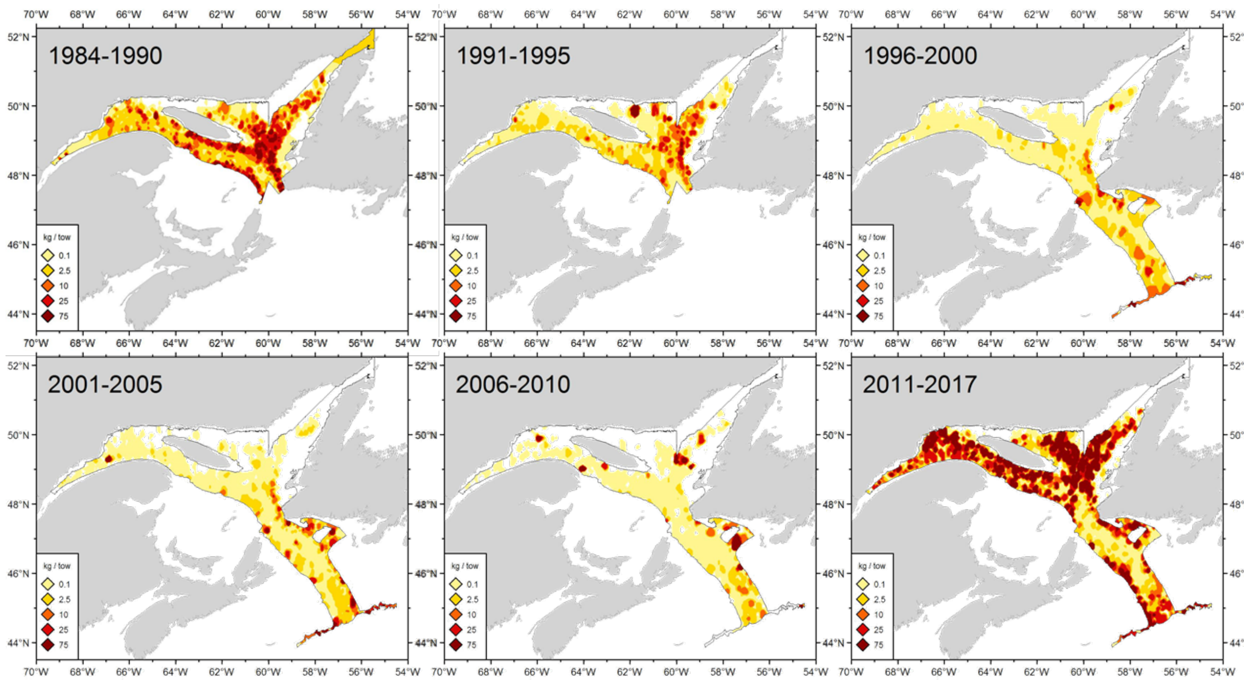


Figure 15. Catch rates distribution of immature S. mentella (kg/15-minute tow) in the Unit 1 and 2 surveys.

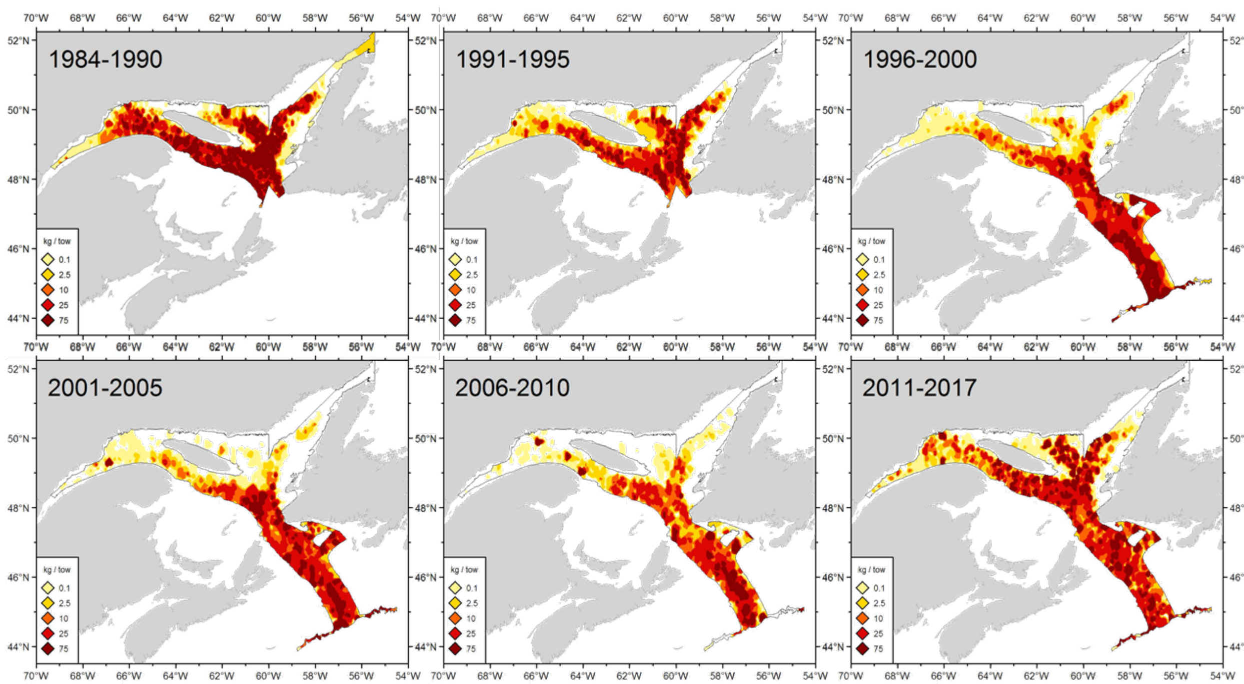


Figure 16. Catch rates distribution of mature S. mentella (kg/15-minute tow) in the Unit 1 and 2 surveys.

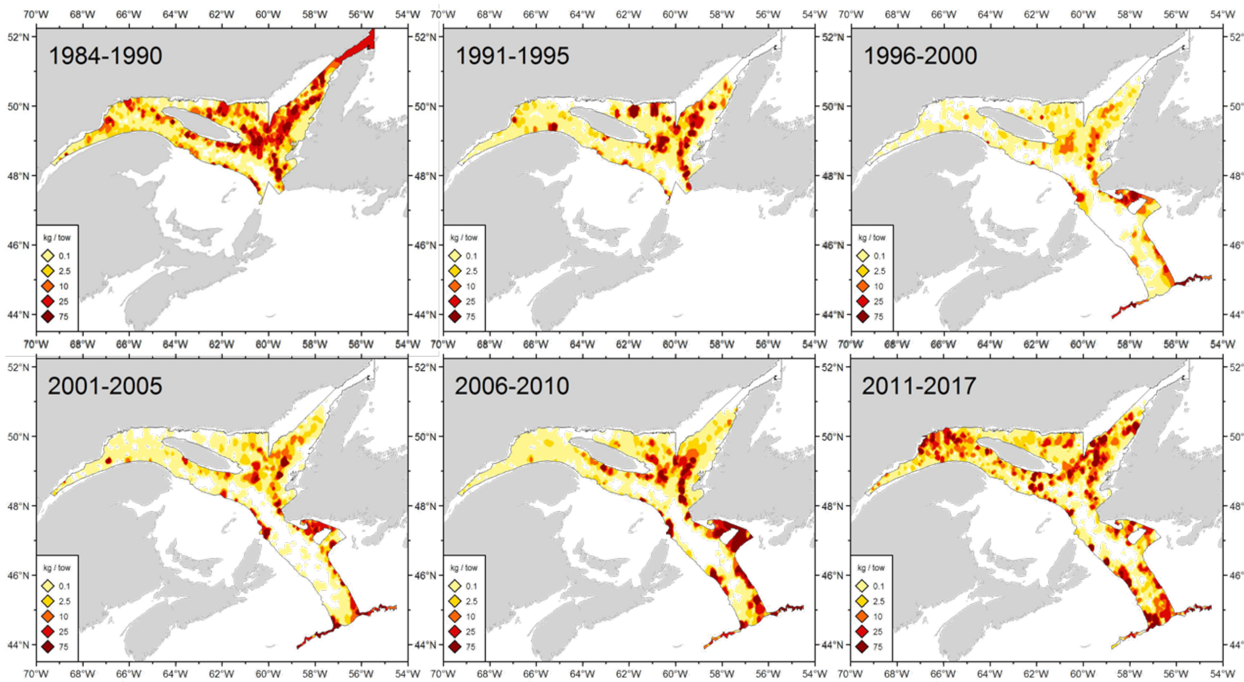


Figure 17. Catch rates distribution of immature S. fasciatus (kg/15-minute tow) in the Unit 1 and 2 surveys.

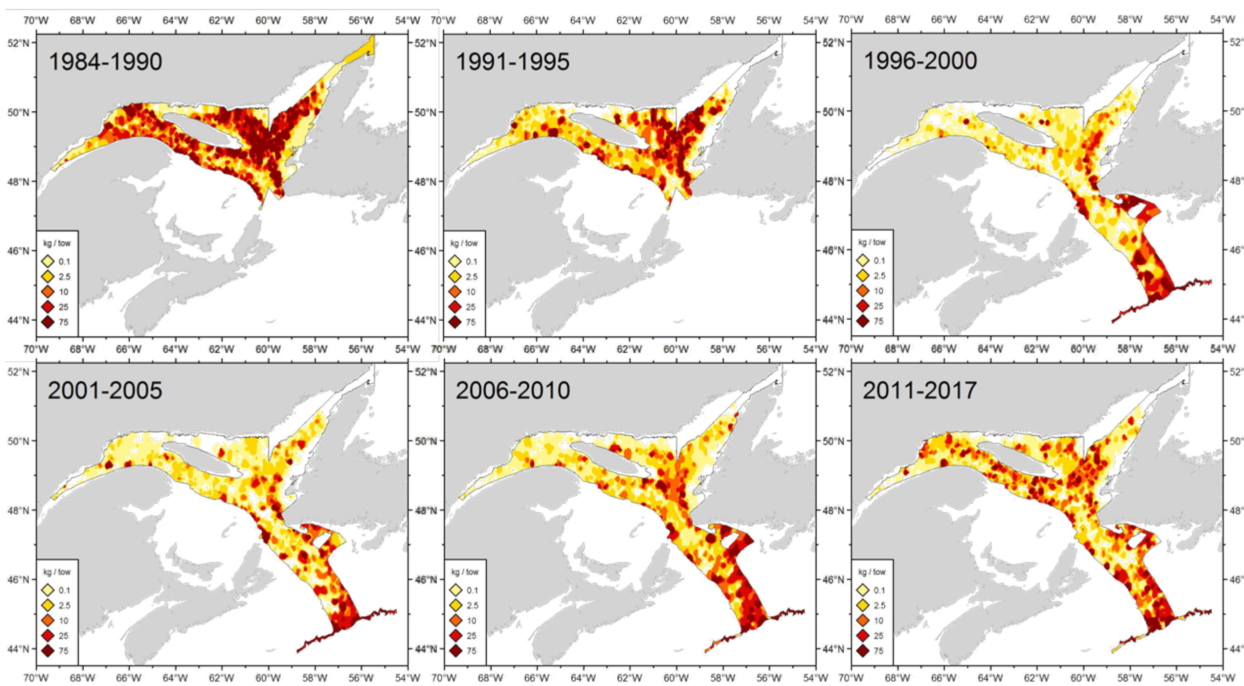


Figure 18. Catch rates distribution of mature S. fasciatus (kg/15-minute tow) in the Unit 1 and 2 surveys.

Redfish diet

From 2015 to 2017, during the DFO August survey in Unit 1, 2,172 Redfish stomachs from 5 to 50 cm were collected and the percentages of prey by mass were quantified. Redfish summer diet in Unit 1 varies according to fish size. Redfish less than 20 cm consume mostly zooplankton and shrimp (Northern Shrimp and Pink Glass Shrimp) when they grow over 20 cm. When Redfish reach a size of 25 cm, they start consuming fish, including Redfish (Figure 19). The massive increase in Redfish has important repercussions for the ecosystem. Increasing predation is contributing to the Northern Shrimp decline in the Estuary and Gulf of St. Lawrence.

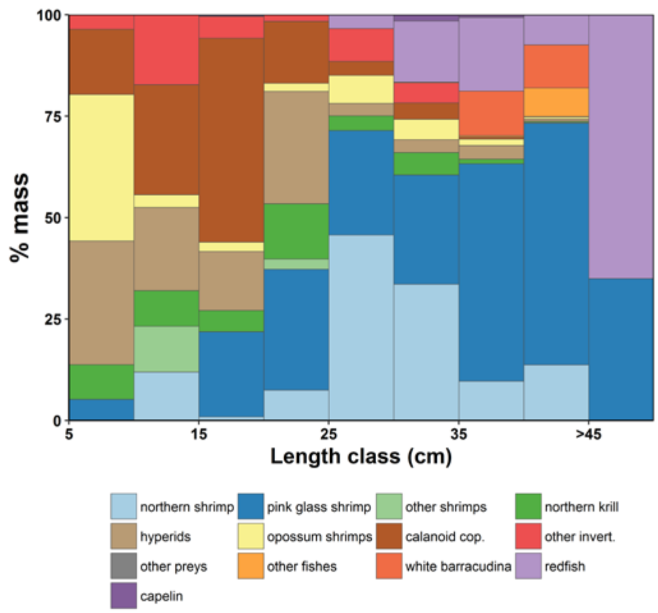


Figure 19. Description of Redfish summer diet in Unit 1 according to individual size, the mass percentages of prey are indicated.

Redfish depth distribution

Based on the August research survey in Unit 1, both Redfish species are distributed according to depth (Figure 20). Although the depth distribution of the two species overlaps, *S. mentella* is found deeper (200-400 m) than *S. fasciatus* (150-300 m).

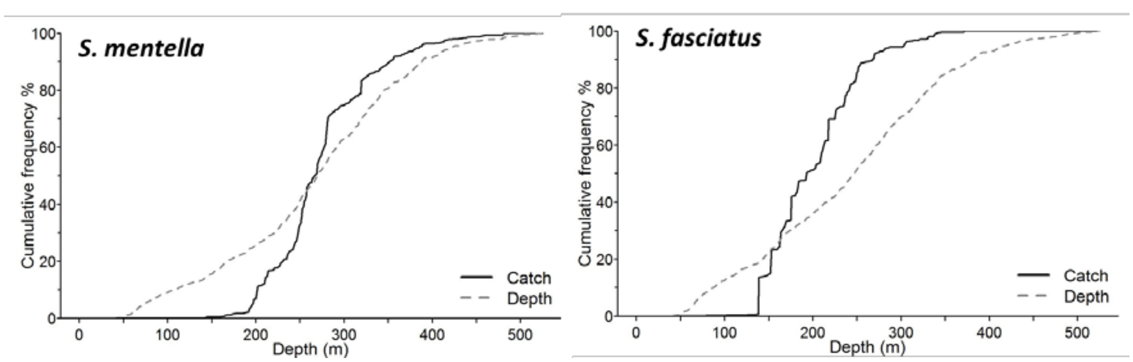


Figure 20. Depth distribution of S. mentella and S. fasciatus in Unit 1 DFO survey from 1990-2017. The solid and dotted lines represent the cumulative frequency of catches and survey stations, respectively, according to depth.

In addition, as they grow, larger Redfish appear to concentrate in the deeper areas of the Laurentian Channel (Figure 21). Redfish biomass was calculated for 3 size classes (0-22 cm, 22-25 cm and > 25 cm) as a function of depth from 1984 to 2017. Areas identified as "Deep" included strata greater than 274 meters and located between 59°W and 65°W (where the index fishery is permitted), while the "Shallow" areas include the rest of the study area. From 1984 to 1994, 83% of the biomass corresponded to individuals larger than 25 cm distributed evenly between deep and shallow areas. Between 1995 and 2012, Redfish biomass decreased substantially and the stock was then composed of large Redfish concentrated in deep areas. Since 2013, the arrival of new cohorts has increased the biomass of Redfish smaller than 22 cm, mainly in shallow areas. In 2017, the strong recruitment of new cohorts means that the biomass of individuals smaller than 22 cm dominates at all depths (Figure 21).

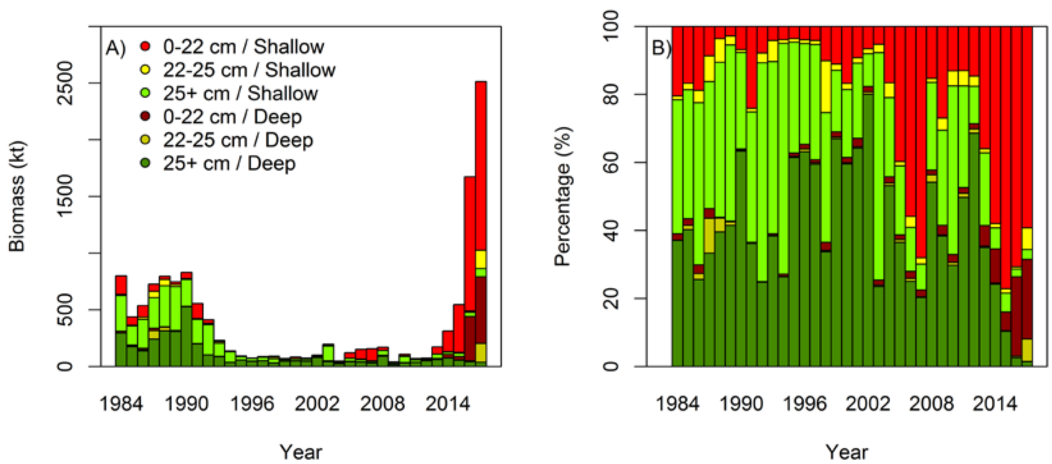


Figure 21. Redfish size classes distribution between "Deep" and "Shallow" areas in biomass (A) and percentage (B) in Unit 1 DFO survey from 1984-2017.

Sources of uncertainty

The absence of species identification in the commercial fishery is a major gap in the assessment of these stocks. A systematic sampling campaign should be conducted to clearly identify the species caught in each Unit. Genetic analyses indicate that a percentage of commercial fishery catches in the Laurentian Fan, i.e. the southern edge of Unit 2, may be composed of *Sebastes fasciatus*, belonging to the Atlantic population of the continental shelf break. This factor should be taken into consideration in assessing the stock and managing this fishery.

CONCLUSION

Prospects for Redfish stocks in Units 1 and 2 are extremely positive due to the large cohorts from 2011, 2012 and 2013. Large numbers of these fish will start recruiting to the fishery from 2018 to 2020. The strong recruitment and biomass increase may allow higher catches of *S. mentella* in Unit 1 by 2018, while it is preferable to remain cautious for *S. fasciatus*.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 14-15, 2018 Assessment of Redfish stocks (*Sebastes mentella* and *Sebastes fasciatus*) in Units 1 and 2. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2016a. Assessment of the West Coast of Newfoundland (Division 4R) herring stocks in 2015. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/024.

DFO. 2016b. Assessment of Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence (NAFO Div. 4T-4Vn (Nov. – April)) to 2014. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/061.

DFO. 2017a. Assessment of the Quebec North Shore (Division 4S) herring stocks in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/027.

DFO. 2017b. Assessment of the Atlantic Mackerel Stock for the Northwest Atlantic (Subareas 3 and 4) in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/034.

DFO. 2017c. Assessment of the Northern Gulf of St. Lawrence (3Pn, 4RS) Cod Stock in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/042.

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

DFO. 2018b. Stock Assessment of Atlantic Halibut of the Gulf of St. Lawrence (4RST) in 2016. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/052.

DFO. 2018c. Assessment of Northern Shrimp stocks in the Estuary and Gulf of St. Lawrence in 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/015.

Galbraith, P.S., Chassé, J., Caverhill, C., Nicot, P., Gilbert, D., Pettigrew, B., Lefaivre, D., Brickman, D., Devine, L., and Lafleur, C. 2017. Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2016. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/044. v + 91 p.

THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canad
Maurice Lamontagne Institute
850 route de la Mer
P.O. Box 1000
Mont-Joli (Quebec)
Canada G5H 3Z4

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

ISSN 1919-5087
© Her Majesty the Queen in Right of Canada, 2018

Correct Citation for this Publication:

DFO. 2018. Assessment of Redfish Stocks (*Sebastes mentella* and *S. fasciatus*) in Units 1 and 2 in 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/032.

Aussi disponible en français :

MPO. 2018. Évaluation des stocks de sébaste (Sebastes mentella et S. fasciatus) des unités 1 et 2 en 2017. Secr. can. de consult. sci. du MPO, Avis Sci. 2018/032.