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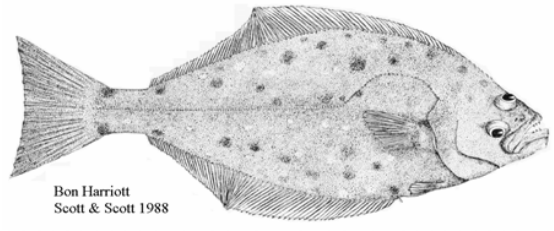
Canadian Science Advisory Secretariat
Quebec Region **Science Advisory Report 2017/052**

STOCK ASSESSMENT OF ATLANTIC HALIBUT OF THE GULF OF ST. LAWRENCE (4RST) FOR 2016



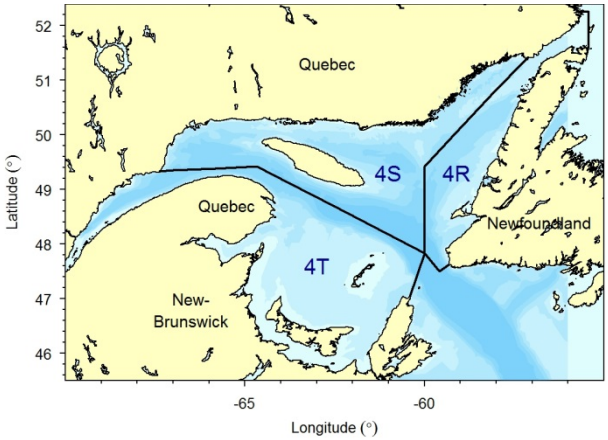


Figure 1. Atlantic halibut stock management area in the Gulf of St. Lawrence

Context:

The Atlantic halibut commercial fishery in the Gulf of St. Lawrence began at the end of the 19th century. During the first half of the 20th century, this resource was exploited by American and Canadian fleets. It was not unusual at the time to see annual landings of around 1,000 t. Since the second half of the 20th century, exploitation was carried out almost exclusively by the Canadian fleet from the four Atlantic Provinces as well as Quebec. From over 650 t during the 1960s, landings steadily decreased until the early 1980s, totalling 91 t in 1982. Landings increased again in the late 1990s and are now at over 1,000 t, the highest level recorded in the past 60 years.

The current Atlantic halibut stock management unit in the Gulf (Figure 1), NAFO Divisions 4RST, was defined in 1987. In 1988, Management introduced the first total allowable catch, followed in 1997 by a minimum legal size. The Atlantic halibut directed fishery is carried out by longliners on a competitive basis or by Individual Transferable Quota (ITQ).

Assessment of the resource is conducted every two years in order to highlight changes in the status of the resource that would justify adjustments to the conservation measures and management plan. The current assessment puts into perspective the available information on the biological characteristics of the Gulf halibut and its commercial exploitation for 2015 and 2016. A science peer review meeting was conducted on February 21, 2017, in Mont-Joli, Quebec. Participants at the science review were from DFO Science, DFO Fisheries Management, the halibut fishing industry, provincial governments, university researchers, and Aboriginal organizations. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule (DFO) as they become available.

SUMMARY

- Atlantic halibut landings have been increasing since the early 2000s and have reached the highest values since 1952. For management years 2015-2016 and 2016-2017, preliminary landings were respectively 1,024 t and 950 t for a TAC of 1,037 t. There is no reason to believe that the 2016-2017 TAC will not be reached.
- Over the past 10 years, the proportion of Atlantic halibut under 85 cm has decreased in catches at sea, and was about 40% in the last two years. Conversely, the proportion of halibut over 130 cm (i.e. the size at 50% maturity for females) increased from under 5% to about 20% over the past 10 years.
- Catches per unit effort for the directed Atlantic halibut longline fishery are at their highest historical levels and have been stable since 2013.
- Pre-recruit abundance indicators from fishery-independent survey data reached among the highest levels in the historical series, and recent trends are stable or rising. Also, the size frequency distributions suggest good recruitment to the fishery in the coming years.
- There is no reliable indicator to measure spawning biomass for this stock. Current approaches do not provide quantitative data on spawning biomass levels or trends.
- Recent tagging has identified a potential winter breeding area at depths greater than 350 m at the junction of the Esquiman and Laurentian channels near the Cabot Strait.
- The fished component of the stock has been stable for the last four years, at the highest historical level, and recruitment to the fishery is expected to increase in the coming years. However, harvest levels for the fished component are unknown.

INTRODUCTION

Species biology

Atlantic halibut, the largest flatfish in the northwest Atlantic, is a prized species on the market. However, knowledge pertaining to the biology and stock status of the Gulf of St. Lawrence halibut is limited.

Atlantic halibut can be found throughout the Estuary and Gulf of St. Lawrence. Figure 2 shows the distribution of catches made during mobile gear fishery independent surveys. The probability of capture is higher on the channel banks at depths near 200 metres, and around the 35-m isobath in the southern Gulf of St. Lawrence.

The mean annual male and female growth rate of Atlantic halibut in the Gulf was evaluated at 7.5–8.5 cm. However, females reach a larger maximum size than males. The size at which 50% of Atlantic halibut reach sexual maturity (L_{50}) is estimated at 130 cm for females and 92 cm for males. Potential breeding areas were identified through physical modelling of locations where tagged fish made rapid vertical migrations associated with spawning. These behaviours were observed between mid-January and mid-March at depths greater than 350 m at the junction of the Esquiman and Laurentian channels and near the Cabot Strait (Figure 3).

The diet of the Gulf Atlantic halibut stock, as determined from stomach contents, is similar to that described for Atlantic halibut elsewhere in the Atlantic Ocean. Atlantic halibut less than 30 cm feed mainly on crustaceans (krill, northern shrimp, and other shrimp). Halibut measuring 30–80 cm feed mostly on smaller fish (for example, capelin, fourbeard rockling, witch flounder, blennies, eelpouts, and sculpins) as well as snow crab and northern shortfin squid, while commercial size halibut primarily feed on herring, cod, redfish, and flatfish.

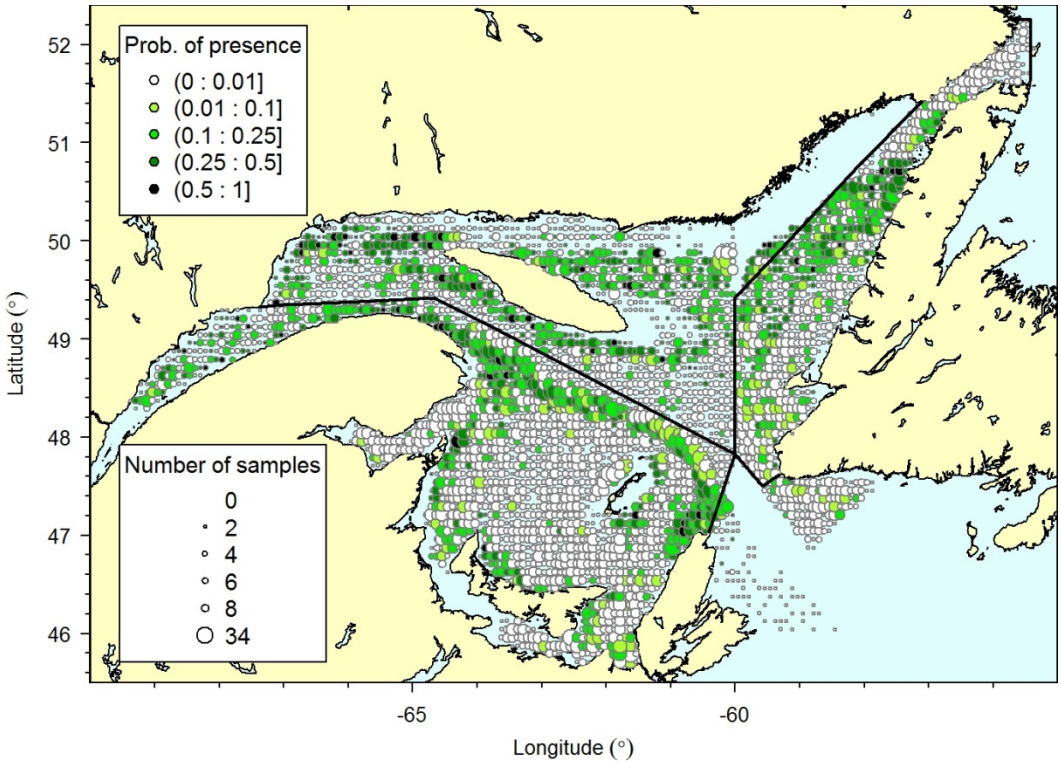


Figure 2. Probability of occurrence of Atlantic halibut in catches made during mobile gear research surveys, per 5-minute square. All available years for each survey are considered, and they vary depending on the survey.

Work is underway to identify the migration patterns of the Atlantic halibut. Results from the traditional tagging program (spaghetti tag) indicate that fish tagged in the commercial fishery were mainly recaptured in the same division where they were tagged. Movements between the Gulf stock management unit and adjacent management units have also been reported.

Description of the Fishery

There were average annual landings of 1500 t of Atlantic halibut harvested in the Gulf of St. Lawrence during the first half of the 20th century (Figure 4). Halibut landings, which were around 600 t in the early 1960s, hit a record low in 1982 at 91 t. TACs were established in 1988, and until 2004, were reached only four times. Since 2004, TACs have been reached every year. Landings reached their highest levels in the past 60 years in 2015 and 2016 at approximately 1,000 t. In recent years, the TAC was divided among 13 fleets in Quebec and the four Maritime provinces, nine with fixed gear and four with mobile gear.

Several management measures have been introduced over the years to protect the Atlantic halibut. In 1997, a minimum legal catch size of 81 cm, based on a yield and value per recruit model, was added to the commercial fishing licence conditions for Atlantic halibut. Since 2010, the minimum legal catch size is 85 cm for all the Gulf Atlantic halibut stock and any halibut below that size must be returned to the water.

Other management measures in place include: a dockside commercial catch monitoring program (100%), at-sea coverage by observers (percentage varies by fleet), mandatory logbooks (except for vessels < 10.67 m in Newfoundland), predetermined fishing periods, limits on the size and maximum number of hooks allowed per line, by-catch protocols and, for large longliners in Quebec, a vessel monitoring system (VMS). Finally, a quota conciliation program

has been in effect since the 2011 fishing season. Consequently, any fleet exceeding its quota in the fishery in a given year is subject to a quota reduction in the following year, equivalent to its quota overage.

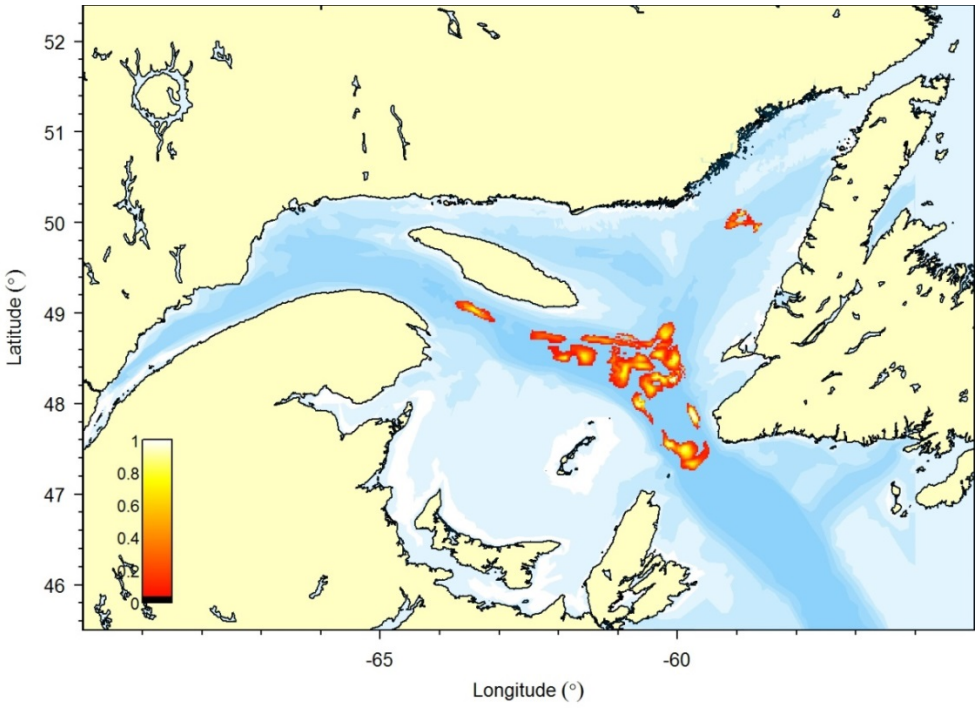


Figure 3. Distribution of the density of probabilities of presence of 22 halibut in which reproductive behaviour is presumed, between 2014 and 2016.

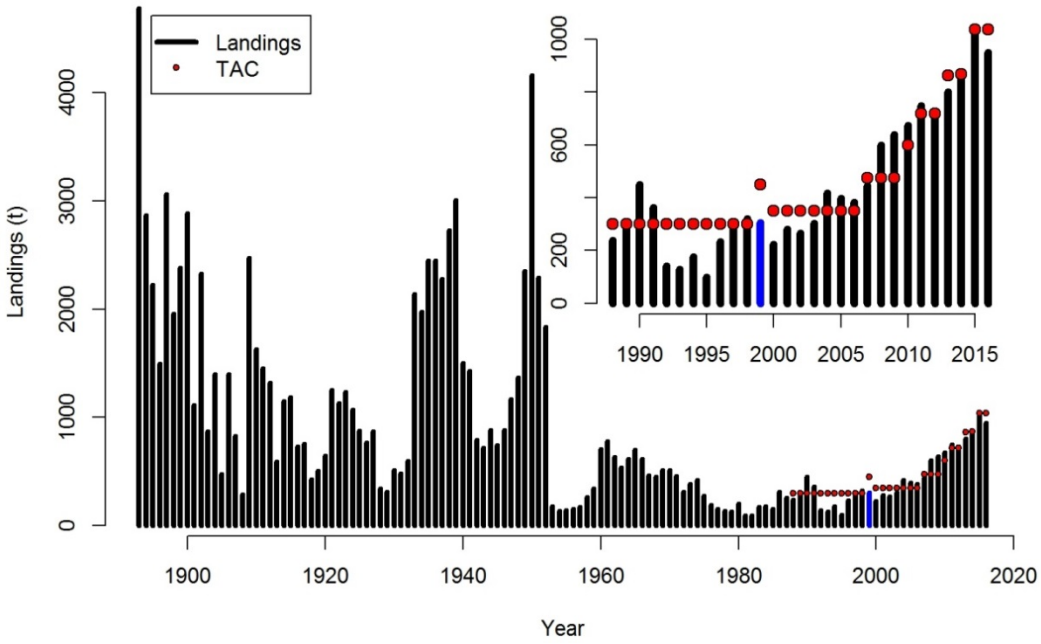


Figure 4. Atlantic halibut annual landings (t) and TAC for NAFO divisions 4RST. Data for 2015 and 2016 are preliminary.

The longline fishing effort decreased significantly between 2004 and 2007 and remained stable since then, although significant annual variations are observed (Figure 5). The recent trend in longline landings is up, after having been stable between 1997 and 2003.

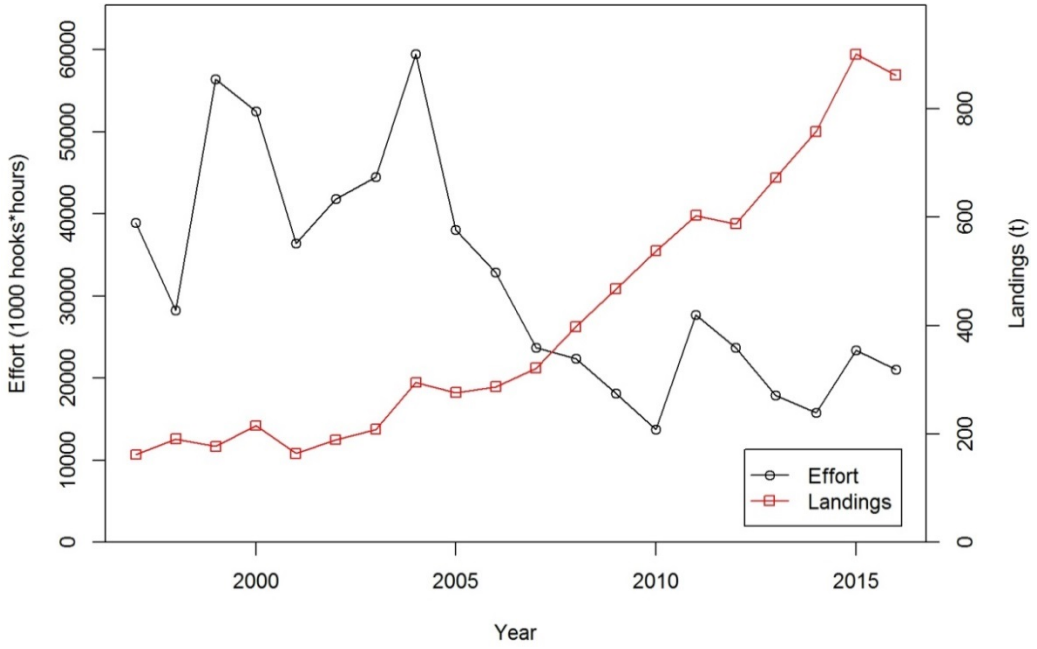


*Figure 5. Total effort (x 1000 hooks*hours) estimated for the Atlantic halibut directed longline commercial fishery in relation to annual longline landings (t) of this fishery. Data for 2015 and 2016 are preliminary.*

Since 2010, over 98% of Atlantic halibut landings were made by the fixed gear fleet, primarily longliners (Table 1). Greenland halibut and cod are the two principal species whose fisheries generate by-catch of Atlantic halibut, which has accounted for as much as 20% of commercial landings, since 2010 (Table 2).

Table 1. Average annual commercial landings (t) of Atlantic halibut by type of fishing gear

Management year	Longline	Gillnet	Other	Unknown	Total
1993-1999	159.5	23.0	21.2	18.7	222.4
2000-2009	349.5	42.9	14.8	0.2	407.3
2010-2014	671.0	89.6	10.9	0.0	771.4
2015[1]	922.8	42.5	10.9	0.3	976.5
2016 [1]	882.6	36.8	12.5	0.6	932.5

[1]: Preliminary data as of December 31, 2016.

Table 2. Average annual commercial landings (t) of Atlantic halibut from different directed fisheries in 4RST.

Management year	Atlantic Halibut	Greenland Halibut	Cod	Other	Unknown	Total
1993-1999	109.5	5.9	7.6	89.7	9.7	222.4
2000-2009	283.9	36.1	54.0	22.2	11.1	407.3
2010-2014	632.5	87.2	37.6	0.4	13.7	771.4
2015[1]	901.0	40.1	19.7	4.4	11.3	976.5
2016[1]	862.6	34.3	20.0	2.8	12.9	932.6

[1]: Preliminary data as of December 31, 2016.

The distribution of Atlantic halibut catches in 2015 and 2016 (Figure 6) shows that these catches were made about 200 m deep on the slope along the Anticosti, Esquiman and Laurentian channels, and about 35 m deep on the north side of Prince Edward Island, on the Miscou bank, and around the Magdalen Islands. It should be noted that only 70% of the catches could be associated with a geographic location. Catches made by certain fleets may therefore not appear on the maps.

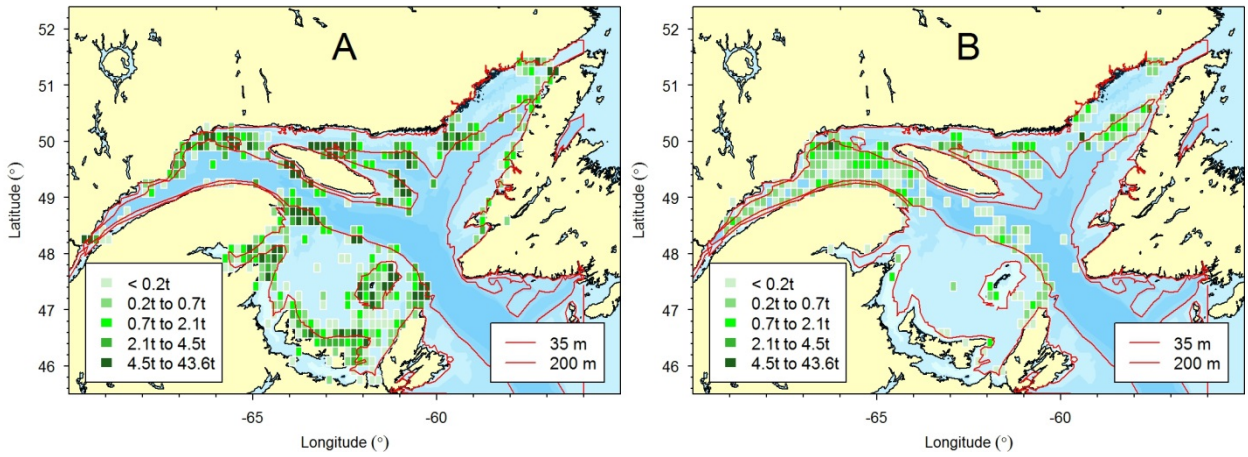


Figure 6. Distribution of Atlantic halibut catches per 10-minute square for the 2015 and 2016 seasons combined, according to whether the target species is Atlantic halibut (a) or another species (b). The data are preliminary.

RESOURCE ASSESSMENT

The assessment of the Atlantic halibut stock is mostly based on analysis of commercial fishery data and from independent research surveys. Fishery data come from three different sources of information: purchase slips, fishers' daily logbooks, and samples of commercial catches made at sea and dockside. Four research surveys with trawls are conducted annually in the Gulf between July and September. Two are conducted from a DFO vessel and two by the sentinel fishery program.

Size structures

The size of the fish caught during research surveys is generally less than 85 cm, which allows individuals not targeted by the commercial fishery to be monitored (Figures 7 and 8). Data from the two DFO surveys and from the sentinel fishery program survey in the northern Gulf of St. Lawrence (nGSL) consistently suggest the synchronized passage of cohorts of variable strength and a duration of about 10 years between the release of larvae and the recruitment of new individuals to the fishery. The cohorts from 1995 to 2002 appear strong, and have probably contributed to the increase in commercial fishery catch rates in the last decade. Less abundant cohorts from 2003 to 2005 were followed by more abundant cohorts since 2006. The 2006 cohort would have reached the minimum legal size of 85 cm in 2016. This and subsequent cohorts should allow the maintenance of good recruitment to the fishery in 2017 and 2018. The size structures from the sentinel fishery program survey in the southern Gulf of St. Lawrence (sGSL) were not considered in the analyses because these structures were just available between 2003 and 2006.

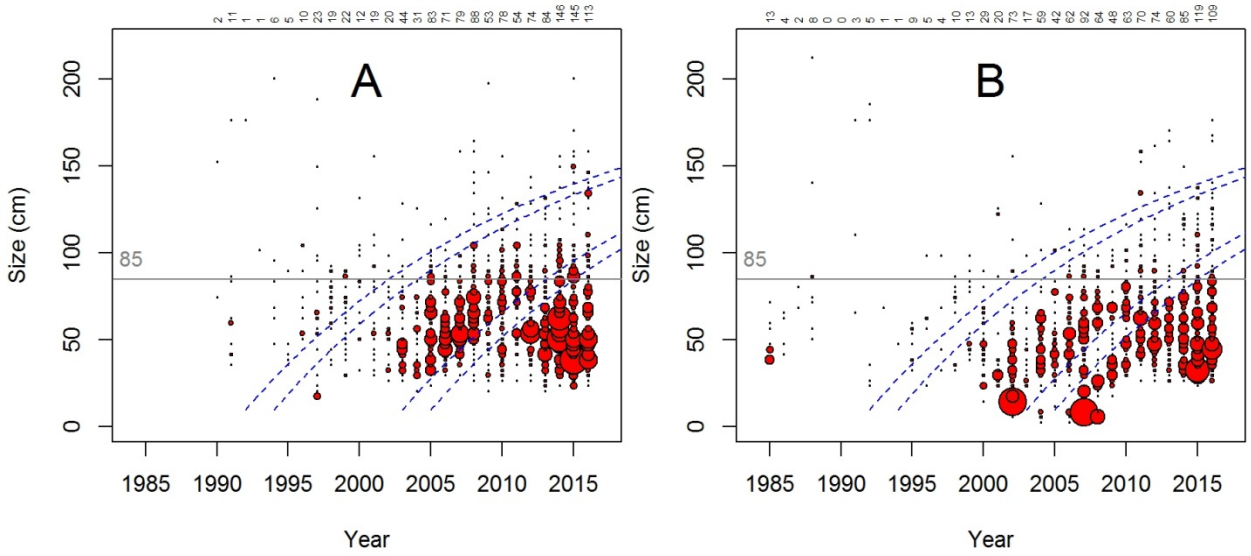


Figure 7. Size frequency distributions for the surveys conducted using a DFO vessel in nGSL (a) and sGSL (b). The diameter of each bubble is proportional to the number of individuals caught for the size class. The total number of individuals caught per year is indicated at the top of the graph. The dotted lines show the presumed trajectory of cohorts from 1992, 1994, 2003, and 2005.

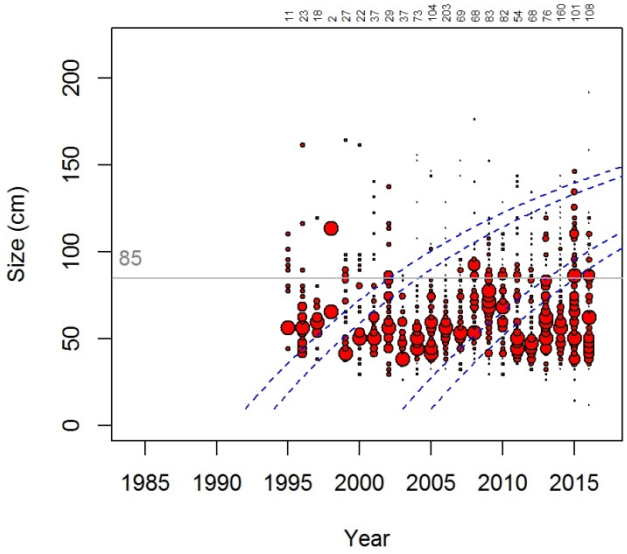


Figure 8. Size frequency distribution for the survey conducted by the mobile gear sentinel fishery program in nGSL. The diameter of each bubble is proportional to the number of individuals measured for the size class, standardized by dividing by the number of measured individuals in the most abundant size class of the year. The total number of individuals sampled per year is indicated at the top of the graph. The dotted lines show the presumed trajectory of cohorts from 1992, 1994, 2003, and 2005.

The size frequency distributions of the commercial catches sampled at sea show a small variation in annual modal sizes for longline fishing (Figure 9a), ranging from 80 to 90 cm. This observation is interpreted as the result of the fleet's ability to adapt fishing behaviours that favour the capture of certain size groups of higher-value halibut. Gillnet catch sizes are smaller than longline catch sizes, and modal values vary more widely over the years (Figure 9b). The passage of weaker cohorts (2003 to 2005) and the return of stronger cohorts from 2006 onward can be observed, as noted in the fishery-independent data. Figure 10 shows that once the catch

is landed at the wharf, the majority of fish are less than 110 cm and fish smaller than the minimum legal size in force, are virtually absent from the samples.

Catches sampled at sea for the two principal fishing gear used show structures of similar sizes for 2015 and 2016 (Figure 11). In both cases, a large proportion of catches cannot be landed because they are smaller than 85 cm. The proportion of Atlantic halibut under 85 cm decreased by half between 2007 and 2014 (Figure 12a). This proportion remained stable (gillnet) or increased (longline) in 2015 and 2016 to approximately 40%. This observation is consistent with the arrival of new cohorts near the minimum legal size, as observed in the fishery-independent survey data. A growing number of individuals over 130 cm in the catches sampled at sea has been noted (Figure 12b). This proportion is about 18% since 2012 for the longline fishery.

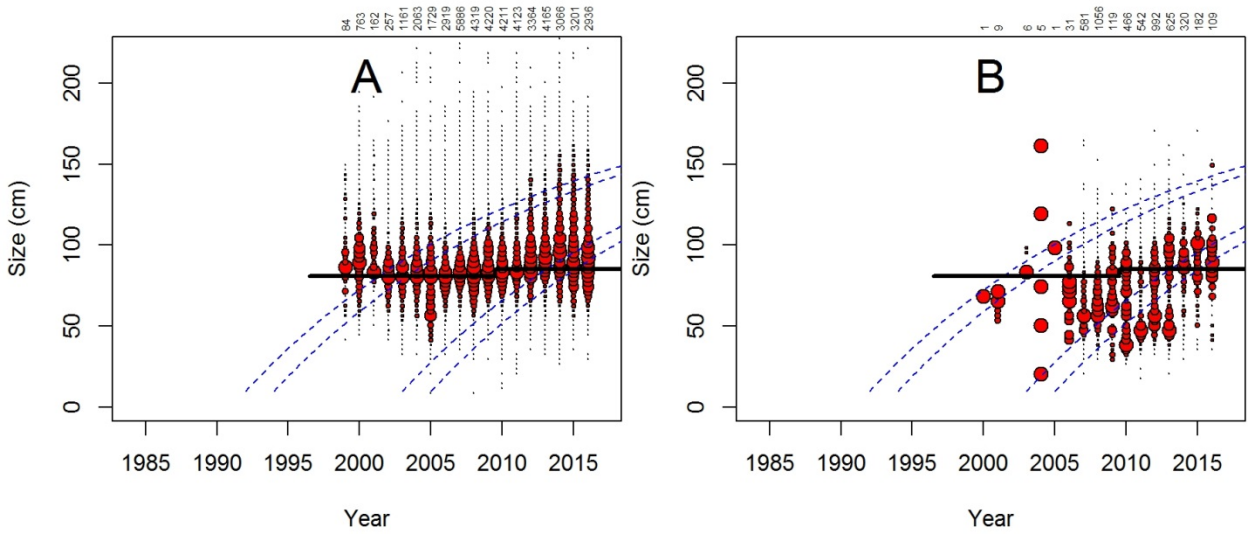


Figure 9. Size frequency distribution for commercial catches sampled during the at-sea observer program for: (a) the longline fishery, (b) the gillnet fishery. The diameter of each bubble is proportional to the number of individuals measured for the size class, standardized by dividing by the number of measured individuals in the most abundant size class of the year. The total number of individuals sampled per year is indicated at the top of the graph. The horizontal line indicates the minimum legal size and the dotted lines show the presumed trajectory of the 1992, 1994, 2003, and 2005 cohorts.

The size frequency distribution shows that neither the independent research survey data nor the commercial fishery data allow the abundance of the stock's reproductive component to be monitored. Data from independent research surveys provide the required information for monitoring individuals that will reach legal size in the coming years (pre-recruitment), whereas data from the fishery can be used to describe the annual evolution of the stock's harvested component. Over the years, changes in fishing behaviours and the implementation of a minimum legal size likely influenced the size of the fish constituting the harvested component of the stock.

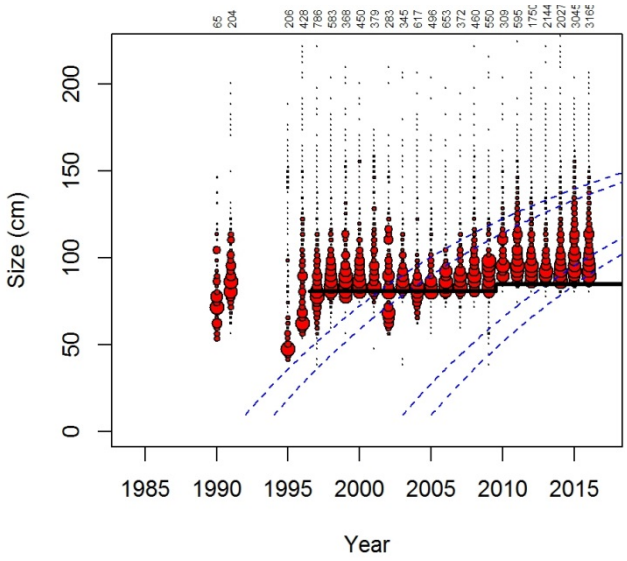


Figure 10. Size frequency distribution for commercial catches sampled dockside (all gears combined). The diameter of each bubble is proportional to the number of individuals measured for the size class, standardized by dividing by the number of measured individuals in the most abundant size class of the year. The total number of individuals sampled per year is indicated at the top of the graph. The horizontal line indicates the minimum legal size and the dotted lines show the presumed trajectory of the 1992, 1994, 2003, and 2005 cohorts.

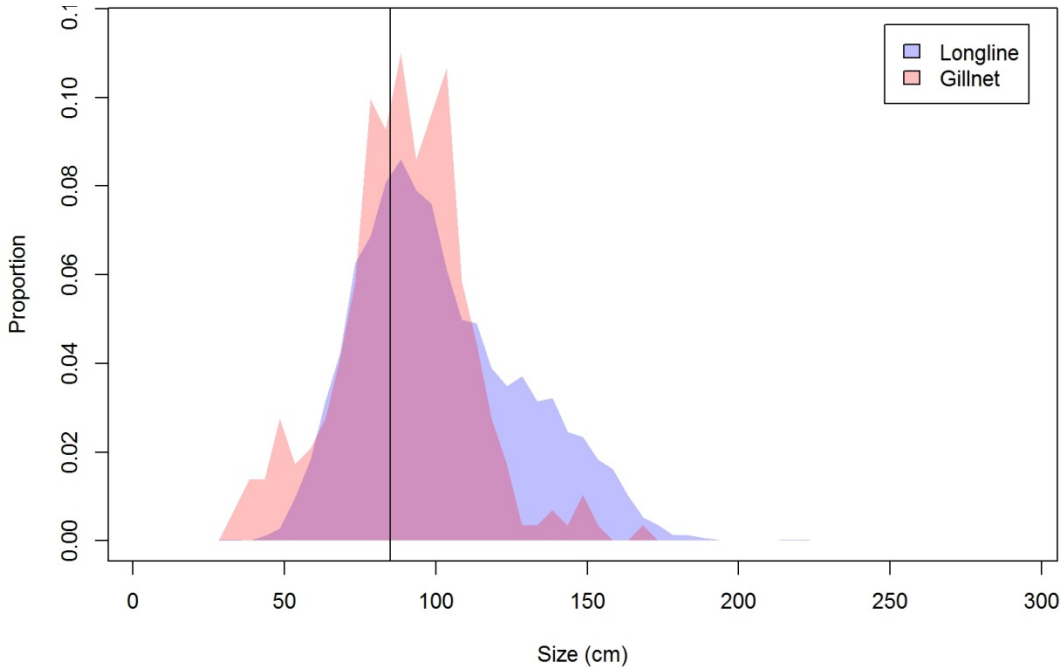


Figure 11. Comparison of size structures of catches sampled at sea in 2015 and 2016 by fishing gear. The vertical line represents the minimum legal size in effect (85 cm).

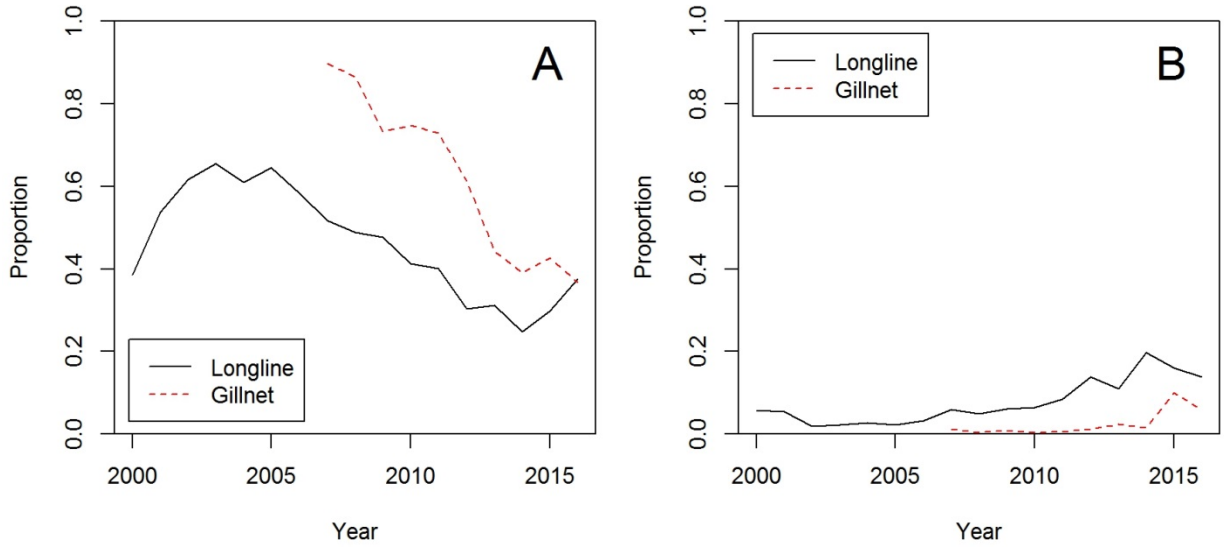


Figure 12. Proportion of individuals of less than 85 cm (a) and greater than 130 cm (b) caught by fishing gear, and by year.

Catch rates and abundance indices

The standardized catch rate for the commercial longline fishery, which is the catch measured in weight per 1,000 hooks, is used as an indicator of the fishery's success (Figure 13). This rate was standardized using a generalized linear model to consider the effect of the following variables: soak time, month of the year, NAFO sub-area, and vessel size. Catches per unit effort (CPUE), increased at an average rate of 12% per year, reaching the highest levels observed in the series (1997–2016) and are stable between 2013 and 2016.

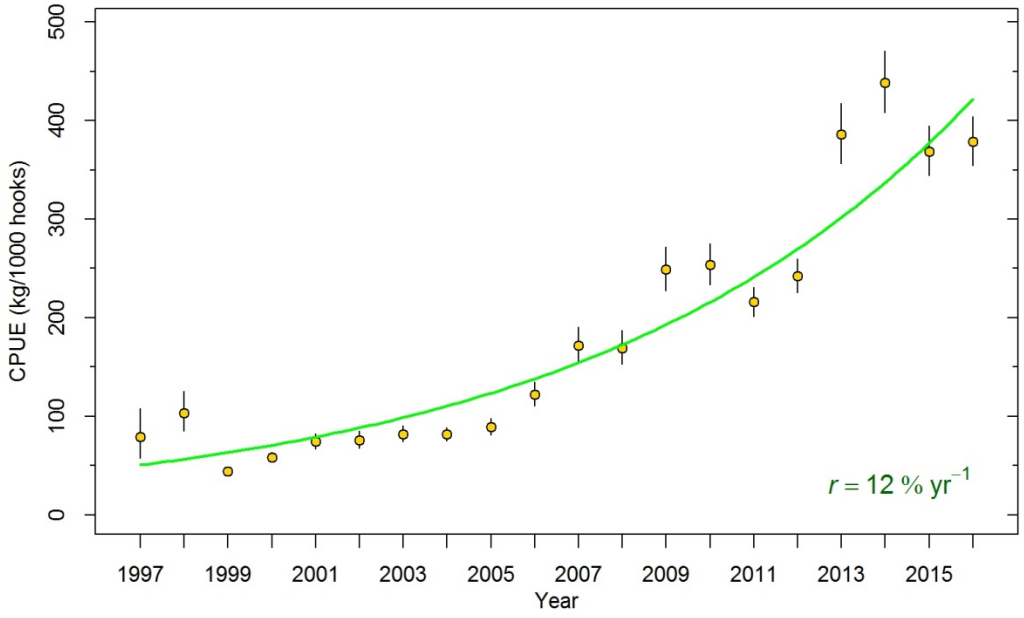


Figure 13. The fishery's standardized catch rate. The adjustment of an exponential curve is indicated in green and is characterized by annual growth (r) of 12%.

Catch rates from fishery-independent survey data reached among the highest levels in the historical series, and recent trends are stable or rising (Figure 14). For all these surveys, the average number of individuals per tow only occasionally exceeds one, and the magnitude of the confidence intervals generally does not allow the increase in these abundance indicators to be considered significant. However, the consistency between the various surveys strongly suggests that the increase in indicators over the past 15 years is not a result of sampling-related processes, but rather a reflection of an increase in the abundance of the portion of the population that is catchable through these surveys.

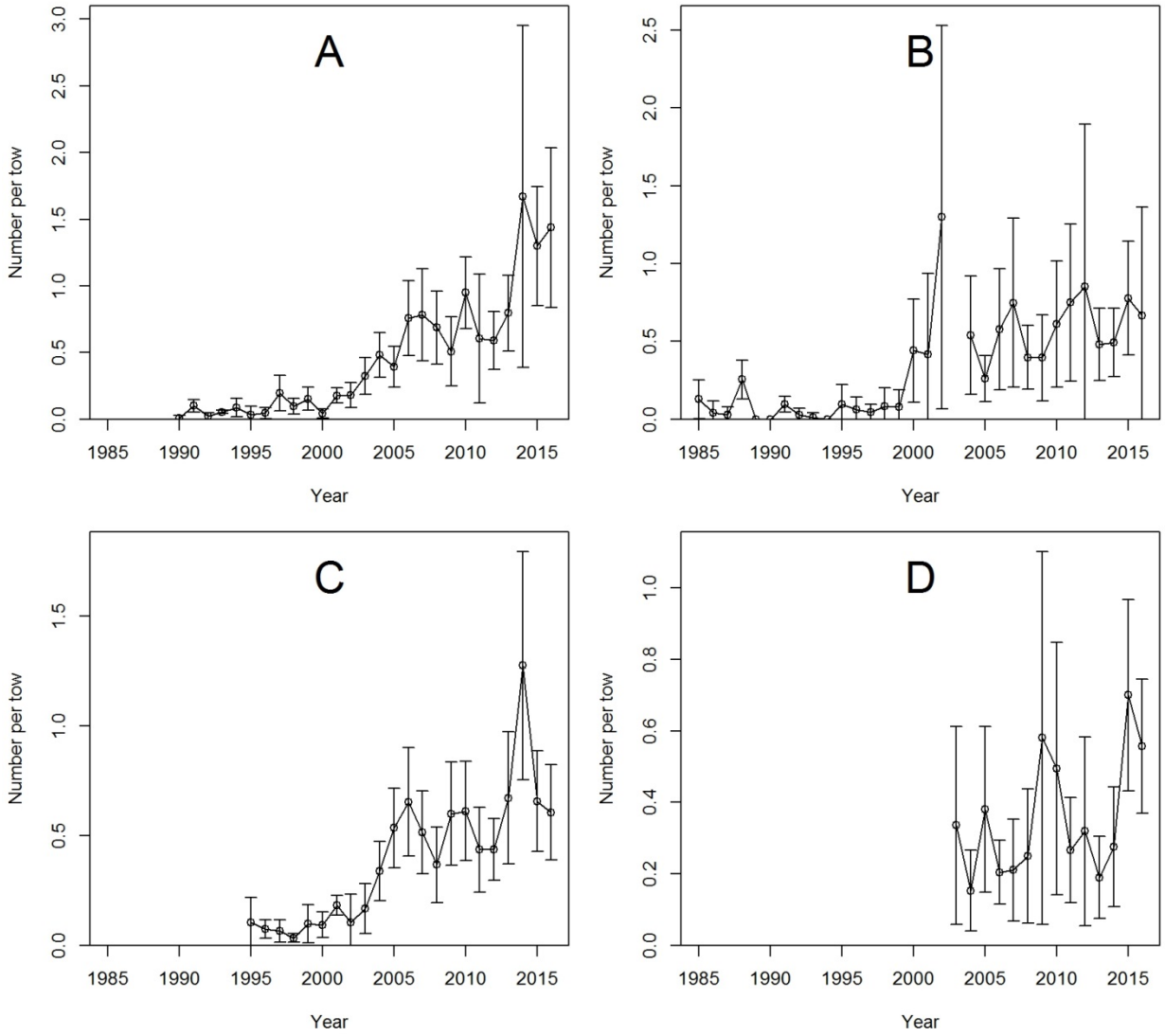


Figure 14. Yields (by mean number per tow) obtained in the four fishery-independent surveys: the DFO research vessel survey in the nGSL (a), and the sGSL (b), as well as the sentinel fishery program surveys in the nGSL (c) and the sGSL (d). The 95% confidence intervals are shown.

Sources of uncertainty

The main source of uncertainty regarding the stock status of the Atlantic halibut of the Gulf of St. Lawrence is the absence of an abundance index for adult females and, consequently, an estimate of the stock's reproductive potential. It was not possible to determine whether the increase in catches of individuals over 130 cm in the commercial fishery corresponds to an

increase in the abundance of this component of the stock, or to a change in fishing behaviour. These uncertainties limit the ability to comment on the impact of harvesting on the resource's sustainability.

The definition of both stocks in Atlantic Canada has not been reviewed in 25 years and could benefit from new genetic approaches that have since been developed. Migrations between the two stocks are observed, but their extent is poorly documented. In addition, catches are made in NAFO sub-area 3Pn without this area being allocated to either of the two stocks.

Logbook data available for the analyses are incomplete; data on fishing position and amount of gear used are regularly missing. Regional disparities in the availability of this information can lead to a bias in the interpretation of results and the representativeness of catches per unit effort that are calculated for the commercial fishery. In addition, the proportion of data available at the time of the assessment varies from one year to the next, with the fishing season and data entry not being completed.

The release of Atlantic halibut, caught using either longline or gillnet, remains a topic of concern. These discards are not recorded and the survival rate after release remains uncertain. The proportion of at-sea catches of sub-legal size halibut suggests, however, that the discarded quantity has declined in recent years. No information is available on discards of large halibut. Consequently, although not assessed, the actual fishing-related mortality rate is certainly higher than the rate associated with the landing statistics.

CONCLUSIONS AND ADVICE

The catch rate measured in weight, taken from the fishery data, indicates that the harvested component, mostly individuals between 85 cm and 110 cm, is at the highest level observed in the historical series (1997–2016). Although stable since 2013, this indicator has increased by an average of 12% per year since 1997. The exploitation rate for the harvested component, however, still remains unknown.

Fishery-independent surveys show that the total abundance of sub-legal size individuals is either stable or has increased since the beginning of the respective historical series. Cohort monitoring suggests that recruitment will be good over the coming years. The proportion of fish under the size of 85 cm caught in the commercial fishery, and possibly the mortality of this component, has decreased between 2007 and 2014, and is now around 40%.

Current approaches do not quantitatively or even qualitatively describe the levels and trends of the stock's female reproductive component and, consequently, the stock's reproductive potential. However, a growing number of individuals over 130 cm in the catches sampled at sea or dockside has been noted. It is impossible to determine whether this indicates an increase in the abundance of this component of the stock or a change in fishing behaviour.

OTHER CONSIDERATIONS

Discussions are ongoing regarding implementation of a longline survey and a tagging program for the entire Gulf of St. Lawrence. These initiatives could provide usable information for the next assessment, such as distribution of large fish, a size structure description valid for the entire population, and an initial estimate of fishing mortality. In the longer term, this work should lead to the development of a relative indicator of spawning biomass, the determination of biological reference points, and the adjustment of a population dynamics model to this stock.

IMPLEMENTATION SCHEDULE

The stock of 4RST Atlantic halibut is currently evaluated and managed according to a two-year cycle. In the intermediate year, no indicator will be reviewed.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 21, 2017 meeting on the Assessment of the Gulf of St. Lawrence (4RST) Atlantic Halibut. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule as they become available.

Bourdages, H., Brassard, C., Desgagnés, M., Galbraith, P., Gauthier, J., Légaré, B., Nozères, C., Parent, E. and Schwab P. 2016. Preliminary results from the groundfish and shrimp multidisciplinary survey in August 2015 in the Estuary and northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/004. v + 88 p.

Desgagnés, M. 2016. Assessment of Atlantic halibut (*Hippoglossus hippoglossus*) stock in the Gulf of St. Lawrence (4RST) for 2013 and 2014: data source and processing. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/098. v + 23 p.

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