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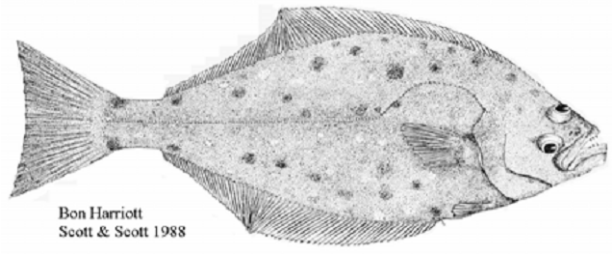
Canadian Science Advisory Secretariat
Quebec Region **Science Advisory Report 2015/023**

STOCK ASSESSMENT OF ATLANTIC HALIBUT OF THE GULF OF ST. LAWRENCE (NAFO DIVISIONS 4RST) FOR 2013 AND 2014



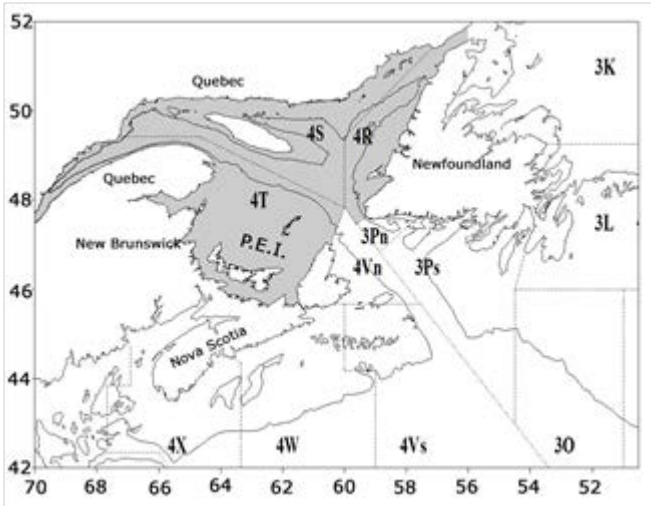


Figure 1. Map of the Gulf of St. Lawrence and neighbouring regions.

Context

The Atlantic halibut 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 almost exclusively carried out by the Canadian fleet from the four Atlantic Provinces as well as Quebec. From over 600 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 800 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 Atlantic Halibut and its commercial exploitation for 2013 and 2014. A science peer review meeting was conducted February 17, 2015 in Mont-Joli, QC. Participants at the science review were from DFO Science, DFO Fisheries Management, the fishing industry, provincial governments, university researchers and Aboriginal organizations.

SUMMARY

- Atlantic Halibut landings have been increasing since the early 2000s. For management years 2013-2014 and 2014-2015, preliminary landings were 802 t and 834 t (TAC of 864 t), the highest since 1952.
- Landings from the non-directed Atlantic Halibut fishery represented 18% and 15% of total landings for 2013-2014 and 2014-2015. The directed Greenland Halibut gillnet fishery contributed to more than half of those catches.
- In the past 10 years, the proportion of Atlantic Halibut under 85 cm decreased by half in catches sampled at sea. In the last two management years, this proportion was about 40% in the gillnet fishery and 24% in the longline fishery.
- There is no reliable indicator of spawning biomass for this stock. Consequently, current approaches do not provide data on spawning biomass levels or trends.
- Catches per unit effort for the directed Atlantic Halibut longline fishery show an estimated annual increase of 11% for the entire historical series (1997 to 2014). This trend corresponds to a 300% increase in the fishery's standardized yield since 2005.
- For catches sampled at sea, the proportion of fish over 130 cm (i.e. size at 50% maturity for females) increased from under 5% to about 20% over the past 10 years.
- 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.
- The size frequency distributions suggest that cohorts that will reach legal size in the next two years will be less abundant than in previous years.
- The fished component of the stock is rising and has reached high levels. However, the harvest levels for the fished component are unknown. Pre-recruit indicators suggest high recruitment to the fishery over five years, although more limited in the short term.

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.

The Gulf Atlantic Halibut stock (NAFO Divisions 4RST) can be found throughout the Estuary and 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. According to recent research, the size at sexual maturity (L_{50}) for the Atlantic Halibut Gulf stock is 130 cm for females and 92 cm for males. Based on observations made during scientific surveys, Gulf halibut spawns between January and May.

The diet of the Gulf Atlantic Halibut stock, as determined from stomach contents collected between May and November, is comparable to that described elsewhere in the Atlantic Ocean. In the Gulf, halibuts of less than 30 cm eat mainly invertebrates such as krill, Northern Shrimp and other shrimps, while larger halibuts have a diet consisting of invertebrates and fish. Thus, halibuts measuring 30–80 cm mostly feed on Snow Crab, Northern Shortfin Squid, and various species of small fish such as Capelin, Fourbeard Rockling, Witch Flounder, blennies, eelpouts and sculpins. Commercial-size halibut primarily feed on herring, cod, redfish and flatfish.

Results from the Atlantic Halibut tagging program conducted in the Gulf indicate that fish tagged in the commercial fishery are mainly recaptured in the same division where they were tagged or within the Gulf stock management unit. About 15% of individuals were recaptured outside the Gulf management unit.

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 2). Halibut landings, which were around 650 t in the early 1960s, hit a record low in 1982 at 91 t. Until 2004, the TACs established in 1988 were reached only four times. Since 2004, they have been reached every year. Landings exceeded 500 t in 2008 and reached their highest levels in the past 60 years in 2013 and 2014, more than 800 t. In recent years, the TAC was divided among 13 fleets (nine with fixed gear and four with mobile gear) in Quebec and the four Maritime provinces.

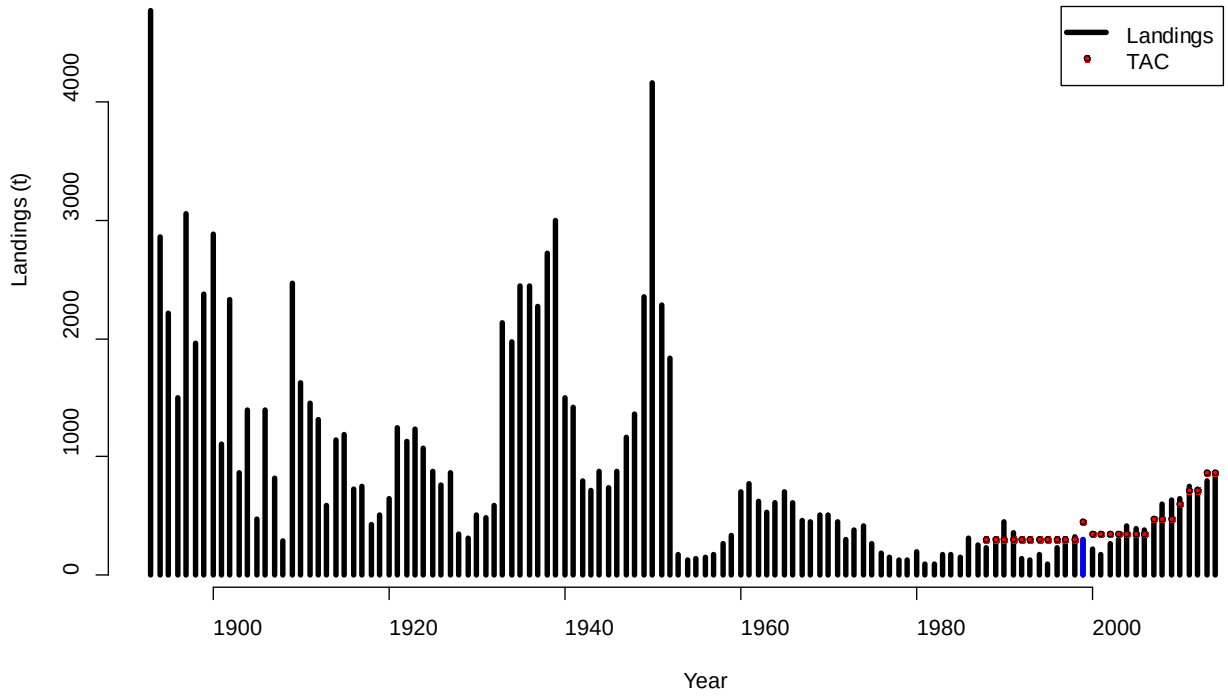


Figure 2. Atlantic Halibut annual landings (t) and TAC for NAFO Divisions 4RST. The 2013 and 2014 data are preliminary.

The longline fishing effort (Figure 3) shows a slight downward trend since the early 2000s, although significant annual variations are observed. The trend is the opposite for landings, which increased over the same period to recently reach values three to four times higher than those from 2000.

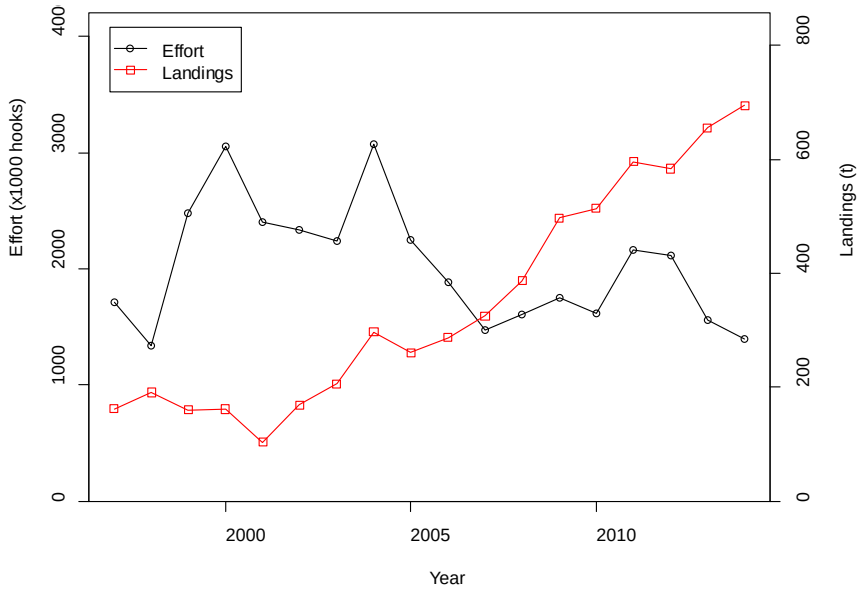


Figure 3. Estimated total effort (x 1000 hooks) for the Atlantic Halibut directed longline commercial fishery in relation to annual longline landings (t). The 2013 and 2014 data are preliminary.

Several management measures have been introduced to protect the resource, in addition to the TAC. 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 license 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.

There are other existing management measures, such as 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 was introduced in 2010 and became effective at the start of the 2011 fishing season. Consequently, any fleet exceeding its quota in the fishery in a given year sees its quota reduced the following year by its quota overage.

Since 2010, over 98% of Atlantic Halibut landings were made by the fixed gear fleet, primarily longliners (Table 1). Since 2006, the halibut landings corresponding to bycatch caught by gillnet fishing (Table 2) amounts between 10 and 18% of total landings. Among the landings associated to the gillnet over the last five years, more than 80% were from the Greenland Halibut directed fishery.

Table 1. Atlantic Halibut commercial landings (t) by gear.

Management year	*Fixed gear*					*Mobile gear*							*Other*				*Grand Total*	*TAC*
	Longline	*Gillnet*	*Hand-line*	*Total*	*% of Grand Total*	*Bottom trawl (fish)*	*Bottom trawl (shrimp)*	*Scottish seine*	*Danish seine*	*Mesopelagic trawl*	*Total*	*% of Grand Total*	*Other*	*Unknown*	*Total*	*% of Grand Total*		
1993[1]	77.3	17.5	4.5	99.3	85.6	4.2	11.7	0.0	0.4	0.1	16.3	14.1	0.3	0.0	0.3	0.3	115.9	300.0
1994[1]	87.8	18.7	1.4	107.9	63.7	4.1	4.6	0.0	0.5	0.5	9.6	5.7	0.4	51.6	52.0	30.7	169.5	300.0
1995[1]	34.0	24.2	2.1	60.3	56.7	3.2	0.8	0.2	0.6	0.0	4.8	4.5	7.8	33.4	41.2	38.8	106.3	300.0
1996[1]	154.4	14.3	25.8	194.5	82.4	10.4	1.0	2.5	0.4	0.0	14.3	6.1	4.6	22.5	27.1	11.5	235.9	300.0
1997[1]	230.7	32.8	0.5	264.1	88.7	7.2	2.5	8.3	5.7	0.0	23.6	7.9	0.3	9.6	9.9	3.3	297.6	300.0
1998[1]	273.0	20.9	0.1	294.0	91.6	10.0	0.6	1.7	0.4	0.0	12.7	4.0	0.5	13.7	14.2	4.4	320.9	300.0
1999[2]	259.5	32.6	1.2	293.2	94.3	12.9	1.5	2.5	0.7	0.0	17.6	5.7	0.0	0.0	0.0	0.0	310.9	450.0
2000[3]	264.4	24.6	0.2	289.1	95.1	12.4	1.4	0.5	0.2	0.2	14.7	4.8	0.3	0.0	0.3	0.1	304.1	350.0
2001[3]	264.3	25.8	0.4	290.5	95.4	8.8	1.7	2.4	0.9	0.0	13.8	4.5	0.1	0.0	0.1	0.0	304.3	350.0
2002[3]	263.5	16.9	0.9	281.3	95.9	6.0	2.0	1.8	0.8	0.0	10.6	3.6	0.0	1.5	1.5	0.5	293.4	350.0
2003[3]	271.5	23.9	0.0	295.4	96.1	8.0	1.8	1.9	0.2	0.0	11.9	3.9	0.0	0.0	0.0	0.0	307.4	350.0
2004[3]	391.7	21.1	0.6	413.4	97.5	3.3	3.1	1.2	2.8	0.0	10.4	2.5	0.1	0.0	0.1	0.0	423.9	350.0
2005[3]	364.1	28.8	1.1	394.0	96.1	5.0	1.7	4.0	5.2	0.0	15.9	3.9	0.1	0.0	0.1	0.0	410.1	350.0
2006[3]	327.7	42.8	0.2	370.6	96.3	6.7	1.8	2.3	2.4	0.0	13.3	3.5	0.1	0.9	1.0	0.3	384.9	350.0
2007[3]	359.6	59.0	1.8	420.4	95.7	3.7	4.6	9.4	1.2	0.0	18.9	4.3	0.1	0.0	0.1	0.0	439.5	475.0
2008[3]	474.3	107.3	0.0	581.7	97.9	2.1	3.8	4.4	2.1	0.0	12.3	2.1	0.1	0.0	0.1	0.0	594.0	475.0
2009[3]	511.2	78.3	5.4	594.9	97.6	7.5	3.2	3.3	0.6	0.0	14.7	2.4	0.0	0.0	0.0	0.0	609.6	475.0
2010[3]	572.2	83.2	0.8	656.2	98.3	5.5	3.5	2.2	0.1	0.0	11.3	1.7	0.2	0.0	0.2	0.0	667.7	600.0
2011[3]	665.2	83.6	0.6	749.4	98.7	5.0	3.5	1.6	0.1	0.0	10.1	1.3	0.0	0.0	0.0	0.0	759.6	720.0
2012[3]	626.4	103.8	0.9	731.1	98.4	6.7	4.1	0.9	0.1	0.0	11.9	1.6	0.0	0.0	0.0	0.0	743.0	720.0
2013[3,4]	696.1	110.5	0.1	806.7	98.7	4.1	4.2	1.9	0.2	0.0	10.4	1.3	0.0	0.1	0.1	0.0	817.2	864.3
2014[3,4]	621.7	75.7	0.0	697.4	99.2	3.2	1.7	0.7	0.0	0.0	5.5	0.8	0.0	0.0	0.0	0.0	702.9	864.3

[1]: fishing season from January 1 to December 31

[2]: fishing season from January 1 to May 14 of the following year

[3]: fishing season from May 15 to May 14 of the following year

4: preliminary data

Table 2. Atlantic Halibut commercial landings (t) from different directed fisheries in 4RST. The 2013 and 2014 data are preliminary.

Management year	Target species					
	Atlantic Halibut	Turbot	Cod	Other	Unknown	Total
Gear: longline						
2005	276.2	3.5	62.9	20.1	1.3	364.1
2006	286.7	2.0	34.1	4.2	0.6	327.7
2007	319.9	4.1	34.9	0.7	0.0	359.5
2008	397.8	0.1	75.9	0.7	0.0	474.4
2009	467.6	0.0	43.1	0.4	0.1	511.2
2010	537.5	0.0	33.5	0.5	0.1	571.6
2011	602.8	2.5	59.1	1.2	0.4	665.8
2012	587.3	6.4	32.7	0.0	0.0	626.4
2013	672.7	2.2	21.2	0.0	0.0	696.1
2014	585.7	0.0	35.9	0.0	0.0	621.7
Gear: gillnet						
2005	2.2	10.4	1.2	13.1	1.6	28.6
2006	0.7	24.7	0.1	10.7	6.6	42.7
2007	0.6	39.4	1.1	11.2	6.9	59.2
2008	0.5	88.7	1.0	5.9	11.4	107.5
2009	0.0	70.4	0.5	0.1	7.3	78.3
2010	0.0	75.8	0.8	0.0	6.8	83.3
2011	0.1	76.5	0.2	0.0	6.6	83.5
2012	1.2	98.5	0.4	0.0	3.7	103.8
2013	0.2	109.3	0.8	0.0	0.2	110.5
2014	11.0	61.6	2.8	0.0	0.4	75.8

The distribution of Atlantic Halibut catches in recent years (Figure 4) shows that they are made on the slope along the Anticosti, Esquiman and Laurentian channels, on the Sept-Iles and Miscou banks, and in shallow waters on the north side of Prince Edward Island and around the Magdalen Islands. It should be noted that it was possible to associate 70% of catches with a geographic location. Catches made by certain fleets may therefore not appear on the maps.

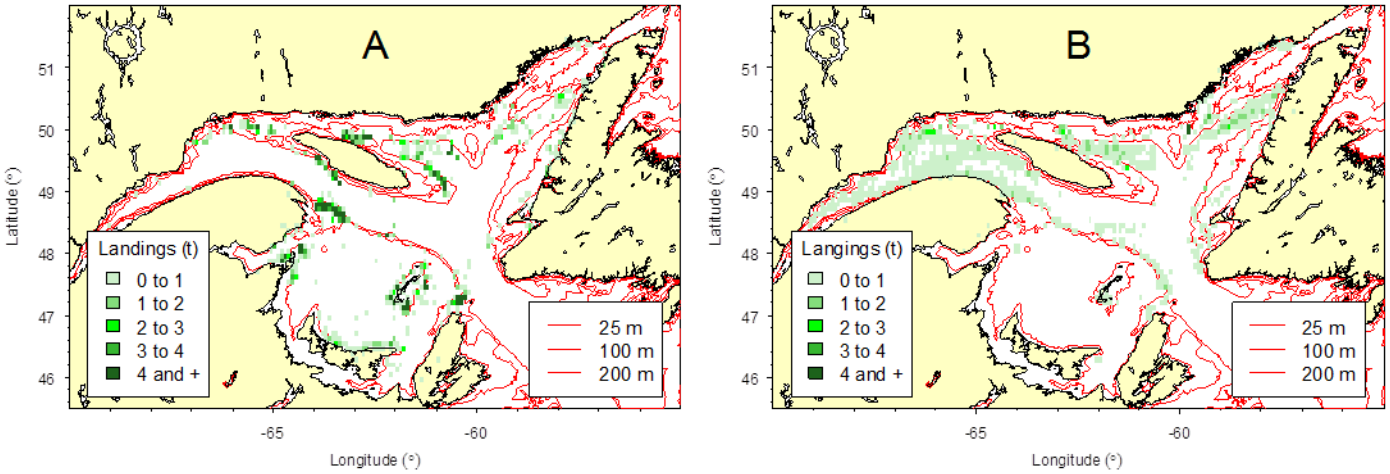


Figure 4. Distribution of Atlantic Halibut catches for the 2013 and 2014 seasons combined, according to whether the target species is Atlantic Halibut (a) or another species (b). The data are preliminary.

RESOURCE ASSESSMENT

The assessment of the Atlantic Halibut stock is mostly based on analysis of commercial fishery data and from independent research surveys. These data come from three different sources of information: purchase slip, fisherman's daily logbook 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 program.

Size structures

The size frequency distributions in Figures 5 and 6 show that fish caught during research surveys are small, which allows individuals not targeted by the commercial fishery to be monitored. Data from the two DFO surveys and from the sentinel program survey in the northern Gulf of St. Lawrence (nGSL) suggest the synchronized passage of cohorts of variable strength and a duration of about 11 years between the release of larvae and the recruitment to the fishery. This interpretation is consistent with other work done on Atlantic Halibut in Canadian waters. The cohorts from 1996 to 2002 have apparently contributed to the recent increase in commercial fishery catch rates. Less abundant cohorts (2003 to 2005) are then observed, and these started recruiting to the fishery in 2014. As a result, the prospects for recruitment to the fishery for 2015 and 2016 are lower than they were for recruitments observed before 2014. Cohort strength seems to recover as of 2006, suggesting a return to higher recruitments over three to five years. 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.

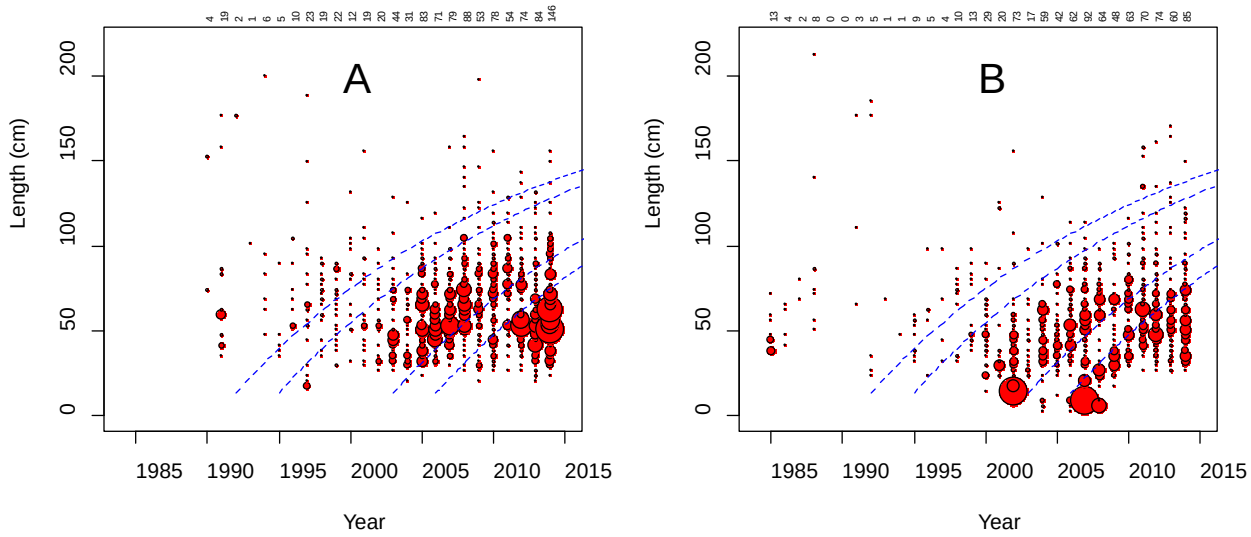


Figure 5. Size frequency distribution for the surveys conducted using a DFO vessel in nGSL (a) and sGSL (b). The diameter of each bubble is proportional to the number of individuals caught for the size class. The total number of individuals caught per year is indicated at the top of the graph. The dotted lines show the presumed trajectory of certain cohorts.

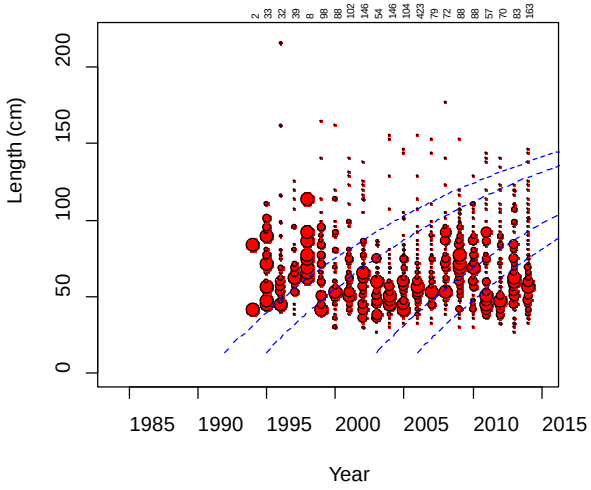


Figure 6. Size frequency distribution for the survey conducted by the mobile gear sentinel fishery program in nGSL. The diameter of the bubbles is proportional to the number of individuals caught for the size class and relative to the year concerned. The total number of individuals sampled per year is indicated at the top of the graph. The dotted lines show the presumed trajectory of certain cohorts.

The size frequency distributions of commercial catches sampled at sea show that longline catches (Figure 7a) have varied little over the years, the annual medians ranging between 85 cm and 100 cm, and that there are few large individuals in these catches. This observation is interpreted as a function of the fleet's ability to target certain sizes of higher-value halibut. Gillnet catch sizes (Figure 7b) are smaller than longline catches sizes, and the median values vary more widely over the years. The passage of weaker cohorts (2003 to 2005) can be seen, and it can be assumed that their recruitment to the fishery is impending, as noted in the fishery-independent data. Figure 7c shows the impact of management measures with regard to minimum legal landing size.

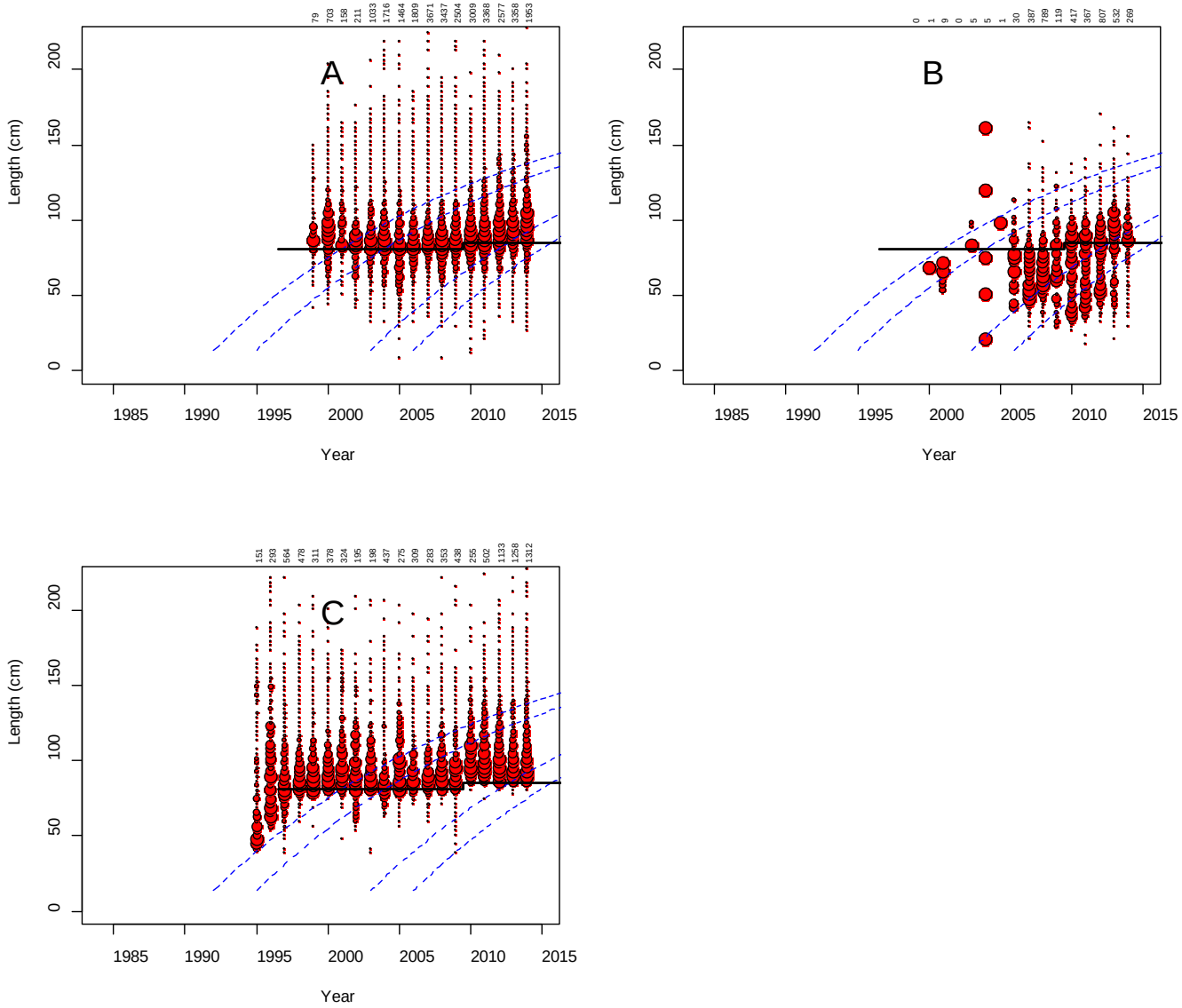


Figure 7. Size frequency distribution for commercial catches: (a) at-sea sampling, longline, (b) at-sea sampling, gillnet and (c) dockside sampling, all gear. The diameter of the bubbles is proportional to the number of individuals caught for the size class and relative to the year concerned. The total number of individuals sampled per year is indicated at the top of the graphs. The horizontal line indicates the minimum legal size and the dotted lines show the presumed trajectory of certain cohorts.

Figure 8 compares the size structures of catches sampled at sea by gear used. For the two main gear types used, a large proportion of catches cannot be landed because they are smaller than 85 cm. Figure 9a shows this proportion by year and indicates that it has dropped by half over an approximately 10-year period. The proportions are about twice as high for gillnet as for longline. Figure 9b indicates that there is a growing number of individuals over 130 cm in catches sampled at sea, rising from 5% to 20% between 2005 and 2014.

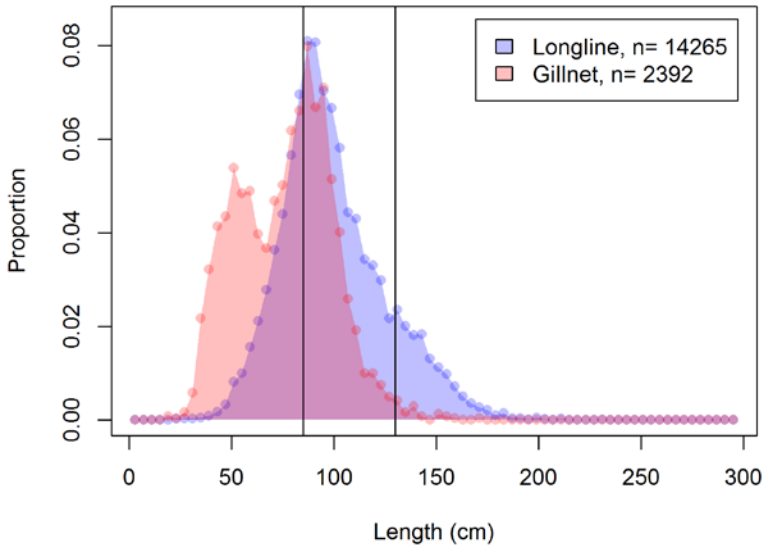


Figure 8. Comparison of catches sampled at sea from 2010 to 2014 by fishing gear.

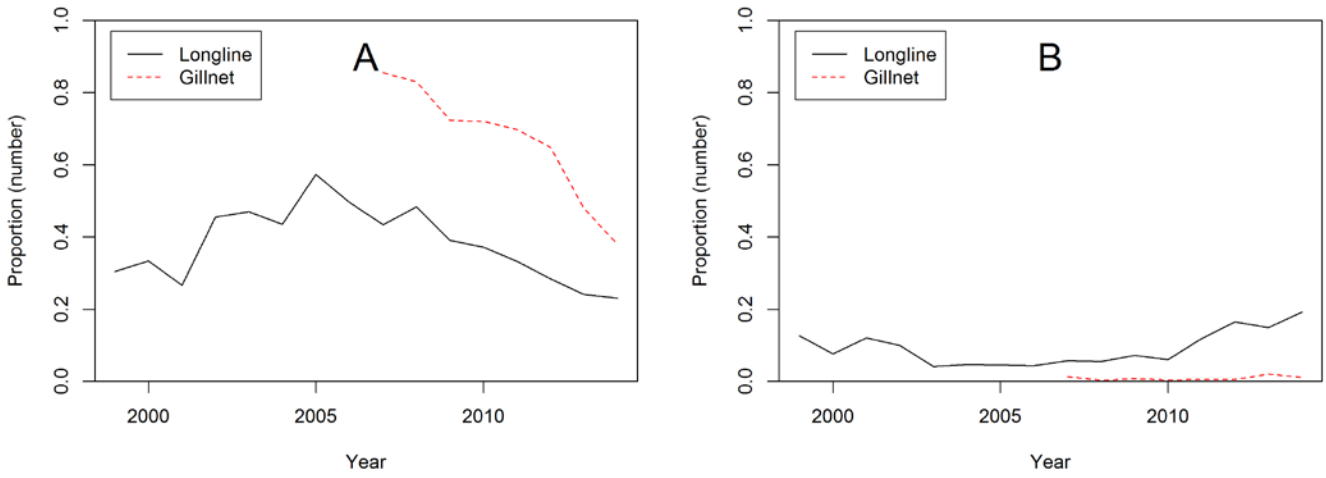


Figure 9. Proportion of individuals caught by year and gear, under 85 cm (a) and over 130 cm (b).

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 behaviour and the implementation of management measures regarding minimum legal size likely influenced the size of the fish constituting the harvested component of the stock.

Abundance indices and catch rates

The standardized catch rate for the commercial longline fishery, measured in weight, is used as an indicator of the fishery's success. This rate (Figure 10) was standardized using a generalized linear model to consider the effect of the following variables: soak time, fishing depth, month of the year, NAFO sub-area and vessel size. Catches per unit effort (CPUE), in kg/1000 hooks, increased at an average rate of 11% per year, reaching the highest levels observed in the series (1997–2014). If the analysis were limited to the past 10 years, then the value of the indicator was multiplied by four.

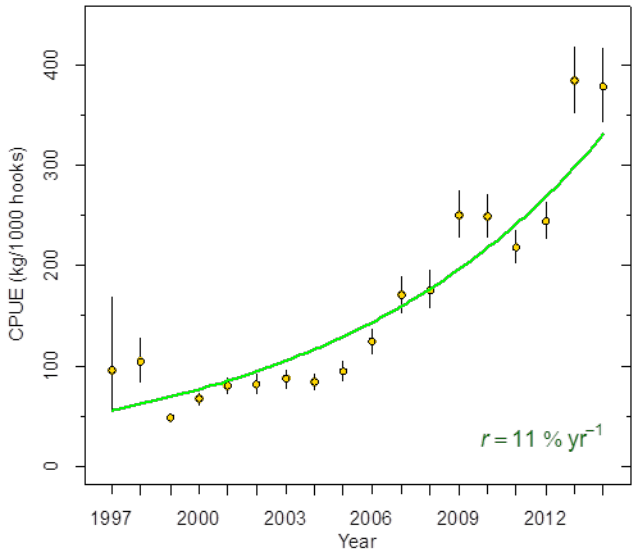


Figure 10. Fishing yield (in weight). The adjustment of an exponential curve is indicated in green and is characterized by an annual growth (r) of 11%.

Catch rates in numbers from fishery-independent surveys are presented in Figure 11. For all of these surveys, the average number of individuals per tow never exceeds one, and the confidence intervals are quite large. However, the consistency between the various surveys strongly suggests that the increase in indicators over the past 15 years is not the result of sampling-related processes, but a reflection of an increase in the abundance of the portion of the population that is catchable through these surveys.

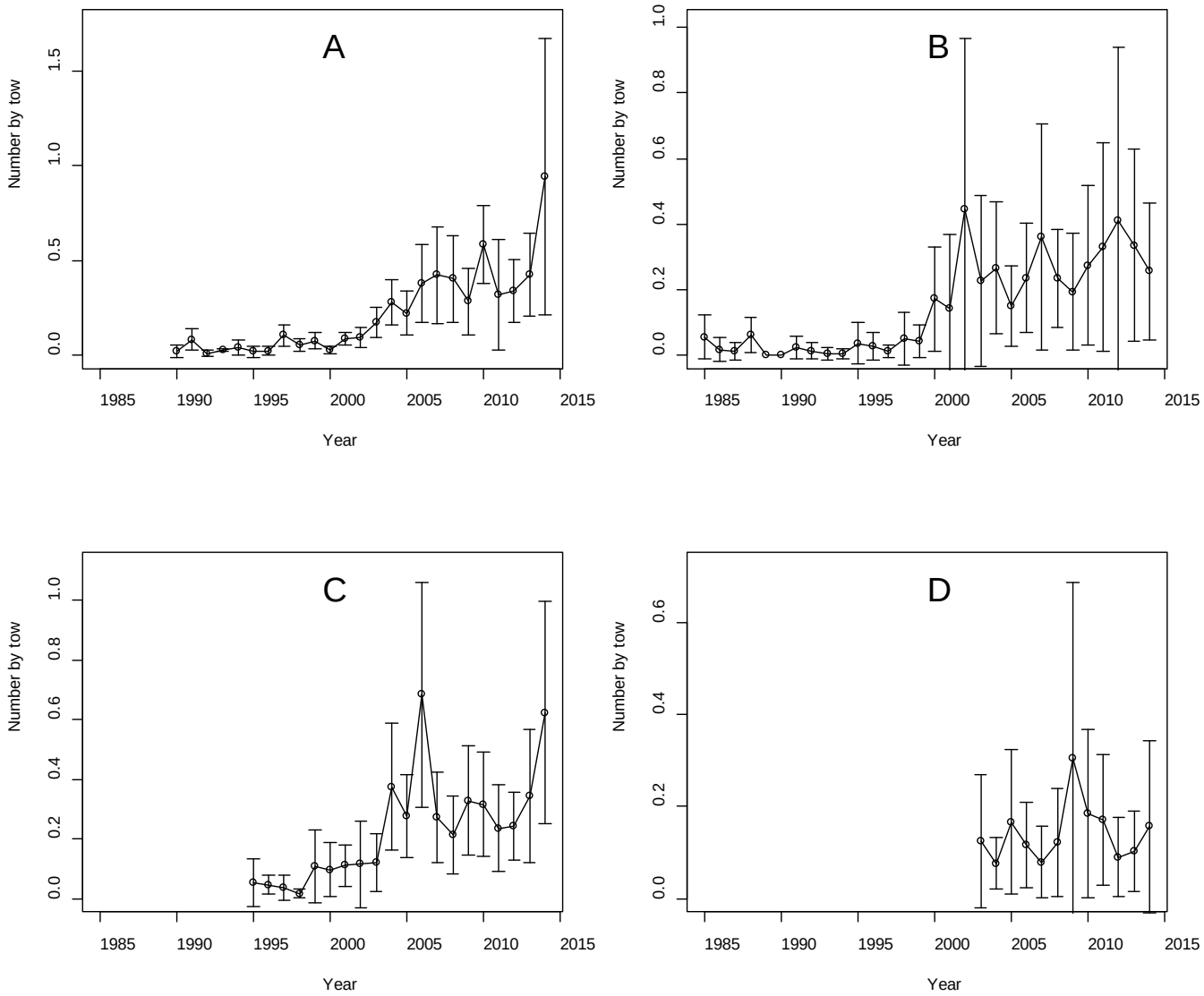


Figure 11. Yields (mean number per tow) obtained in the four fishery-independent surveys: the DFO research vessel survey in nGSL (a), the DFO research vessel survey in sGSL (b), the sentinel fishery program survey in nGSL (c) and the sentinel fishery program survey in sGSL (d). The 95% confidence intervals are are shown.

Figure 12 shows the distribution of catches made during mobile gear fishery-independent surveys. To account for differences in methodology between the four surveys (vessel and trawl type, tow length, tow speed, etc.), the catch probability was used as a unit of measurement. Catches are most likely on the slope, along the channels at depths around 200 metres, and around the 25-m isobath in the southern Gulf of St. Lawrence.

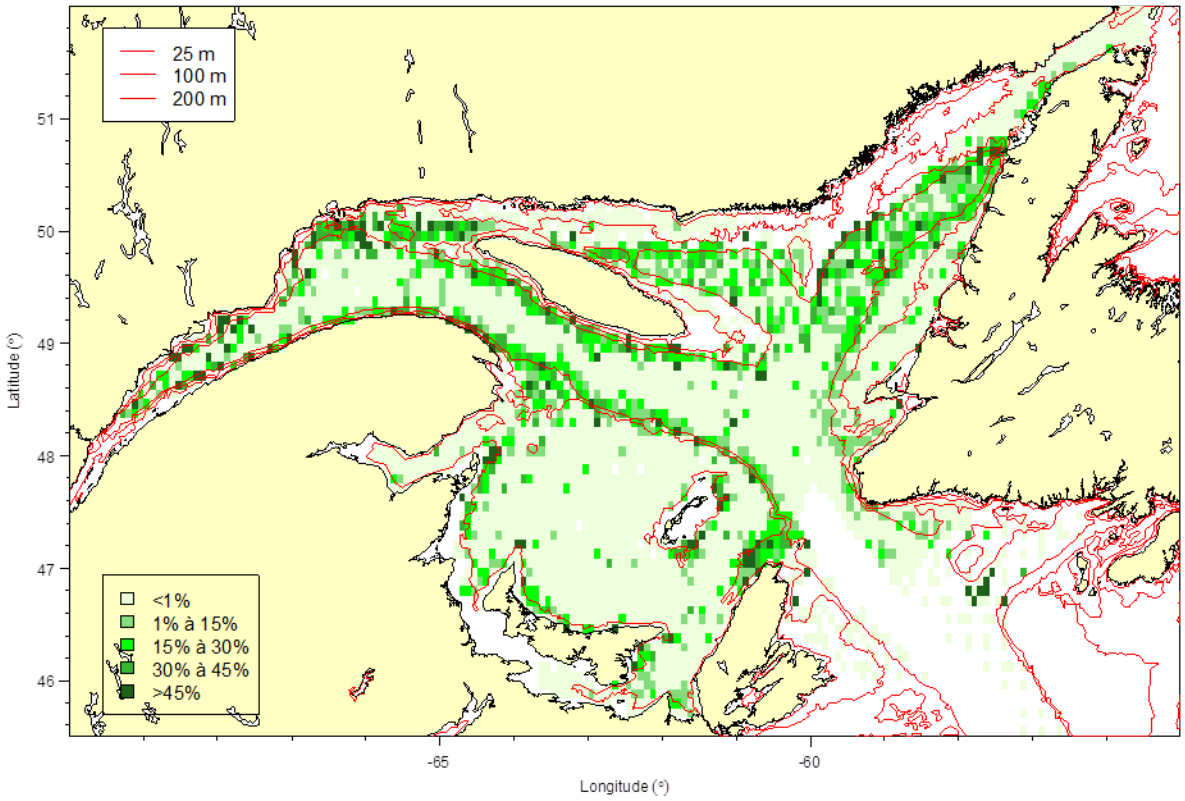


Figure 12. Probability of occurrence of Atlantic Halibut in catches made during mobile gear research surveys. All available years are considered, and they vary depending on survey.

Sources of Uncertainty

The main source of uncertainty in the stock status assessment of Atlantic Halibut of the Gulf of St. Lawrence is the absence of abundance indices 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. This uncertainty limits the ability to comment on the impact of catches 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 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 (1997–2014). This indicator has increased by 11% on average per year since 1997 and has quadrupled in the past 10 years. However, the exploitation rate for the harvested component still remains unknown.

The fishery-independent surveys show that the total abundance of sub-legal size individuals has either remained stable or increased since the beginning of the respective historical series. Cohort monitoring suggests that recruitment will be lower over the next two years than it was in previous years. In the longer term, the data seem to show a return of stronger cohorts. The proportion of pre-recruits caught in the commercial fishery, and possibly the incidental mortality in this component, has been declining in the past 10 years.

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.

SOURCES OF INFORMATION

This science advisory report is from the February 17, 2015 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.

DFO. 2013. Stock Assessment of Atlantic Halibut of the Gulf of St. Lawrence (NAFO Divisions 4RST) for 2011 and 2012. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/033.

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