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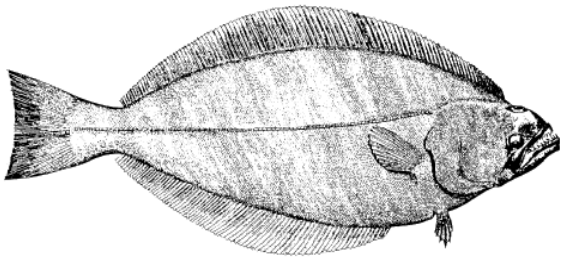
ASSESSMENT OF THE GREENLAND HALIBUT STOCK IN THE GULF OF ST. LAWRENCE (4RST) IN 2008



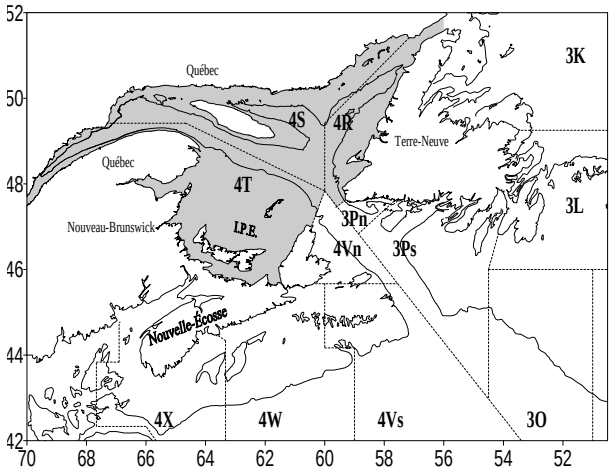


Figure 1. Map of the Gulf of St. Lawrence and neighbouring areas showing NAFO divisions 4RST.

Context

Until the mid 1970s, Greenland halibut (also called turbot) from the Gulf of St. Lawrence (4RST) were not subjected to any directed fishery. At the end of the 1970s, a Greenland halibut fishery developed using gillnets and bottom trawls.

Since 1982, the Greenland halibut fishery has been managed by controlling total allowable catches (TAC). This TAC management helps limit exploitation in order to protect the population's reproductive potential. Over the years, Fisheries and Oceans Canada (DFO) has implemented other conservation measures that have helped reduce the number of immature fish caught. However, minimum biomass or maximum exploitation rates that could jeopardize the resource are unknown. Also unknown is the optimal exploitation rate which could help set precise targets.

The Atlantic cod mobile gear fishery has been closed since 1993 and, subsequently, any mobile gear directed fishery for Greenland halibut has been prohibited. This fishery is now dominated by boats equipped with gillnets, whose homeports are located in Quebec or on the west coast of Newfoundland.

Greenland halibut population assessment is done annually in order to highlight changes in the status of the resource that would justify adjustments to the conservation measures and management plan.

The main information used to evaluate this resource is biomass indices from DFO research surveys and sentinel fishery surveys conducted each year in July, evolution and strength of cohorts that will be recruited to the fishery, size at sexual maturity for each sex and the fish condition index. Catches per unit of effort (CPUEs) from traditional gillnetters using 6 in. mesh nets, the mean size of fish caught as well as standardized indices of exploitable stock biomass (44 cm and above) from fishery CPUEs and surveys are also used as indicators of stock status and fishery success.

SUMMARY

- Preliminary landings as of December 2008 totalled 3,438 t.
- Standardized catch rates of traditional gillnetters using 6 in. mesh nets have remained stable over the last five years.
- The proportion of females in catches was 83% in 2008 and has remained more or less the same since 2000. The mean size of fish caught dropped to 47.3 cm between 2007 and 2008, and the proportion of individuals smaller than 44 cm increased from 15% in 2007 to 19% in 2008.
- The biomass index (kg/tow) from the DFO surveys dropped in 2008 but remains average for the last ten years (1998-2007). The biomass estimate from the July sentinel fishery index also dropped in 2008 despite remaining above the 1998-2007 average and comparable to the values recorded since 2005.
- The size at which 50% of fish are mature has remained at a rather low level since 2001. At 44 cm, 63% of females and 4% of males are immature.
- The 2009 fishery will mostly be supported by the 2002 year-class for a third consecutive year, as well as by the weak 2003 year-class. The arrival of the strong 2004 cohort will partly contribute to the fishery since only a portion of these individuals will have reached minimum legal size.
- The 2010 fishery will also be supported by the 2004 year-class. The 2005 cohort, which will enter the fishery in 2010, is of low abundance.
- Data from the DFO and sentinel fishery survey suggest that recruitment to the fishery should be similar in 2009 due to the arrival of the 2004 year-class, even though it is made up of fish under the minimum legal size. In 2009, the increased occurrence of fish around the minimum legal size will result in an increase of the number of fish caught in order to reach the catch level. However, the principal indicators will have to be closely monitored over the three years following the arrival of the 2004 year-class in order to verify whether there is any strong cohort. Thus the status quo is recommended for catch levels for the 2009-2010 and 2010-2011 fishing seasons.

INTRODUCTION

Species Biology and Background Information

The Greenland halibut population of the Gulf of St. Lawrence is considered to be a stock isolated from the main Northwest Atlantic population found east and north of Newfoundland's Grand Bank. Parasite studies conducted in the early 1990s showed that the Gulf population was distinct, which led to the conclusion that Greenland halibut complete their entire life cycle within the Gulf.

Greenland halibut are generally found in the channels of the Gulf of St. Lawrence at depths ranging between 130 and 500 m (70-280 fathoms). Juveniles dominate the estuary and north of

Anticosti. Spawning takes place primarily in winter, from January to March. Males reach sexual maturity at a smaller size than females, so their growth rate drops earlier than that of females. This difference helps explain why females grow to be larger than males and make up the majority of commercial catches.

Since 2001, size at maturity for females and in most of the cases for males has been below the series average (1996-2007).

Juvenile abundance varies a lot from one year to the next, and they are recruited to the fishery around the age of 5. The strength of these year-classes, their growth, as well as environmental conditions influence stock abundance fluctuations and have an impact on the fishery's success.

Description of the Fishery and Conservation Measures

In 2008, Greenland halibut landings for the current year in NAFO Divisions 4RST totalled 3,438 tons (Table 1). Prior to 1999, the Greenland halibut fishery was essentially competitive based. An individual quota pilot project was introduced in 1999 for traditional fishermen in Quebec in order to extend their fishing season. This pilot project became permanent in 2002. Beginning in 1999, the fishing season was modified in order to correspond with the year of the management plan, i.e. from the current year until May 14 of the following year.

Table 1. Landings (thousands of tons)

Year	77-98 avg.	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009[1]
TAC	-	4,5[2]	4,5[3]	4,5[3]	3,5[3]	3,5[3]	4,5[3]	4,5[3]	4,5[3]	4,5[3]	4,5[3]
Fixed gear	3,1	3,4	2,0	1,2	1,6	3,5	3.8	3.8	3,8	3,6	3.3
Mobile gear	1,1	0,2	0,1	0,1	0,1	0,1	0,1	0,2	0,1	0,1	0,1
Total	4,2	3,6	2,1	1,3	1,7	3,6	3,9	4,0	3,9	3,7	3.4[1]

[1] *Preliminary data*
[2] *TAC from January 1, 1999 to May 14, 2000*
[3] *TAC from May 15 of the current year to May 14 of the following year*

In addition to managing the fishery by total allowable catches (TAC), other conservation measures have been implemented since 1995 following recommendations from the Fisheries Resource Conservation Council (FRCC), which are aimed at reducing the fishing effort and the number of immature fish caught:

- increase in mesh size from 140 mm (5.5 inches) to 152 mm (6 inches);
- adoption of a more selective fishing net configuration;
- implementation of a small-fish tolerance protocol for commercial catches with a minimum legal size increasing from 42 cm in 1996 to 44 cm since 1997;

- establishment of a dockside monitoring program for commercial catches;
- voluntary reduction in the number of nets used by Quebec fishermen (from 120 to 80 nets) between 1996 and 2000.

There were approximately 209 active boats in the Greenland halibut fishery in the estuary and Gulf in 2008.

Until the mid-1970s, Greenland halibut landings in 4RST consisted mainly of by-catches from other fisheries (Figure 2). Subsequently, a directed gillnet fishery developed, and landings fluctuated substantially. Total catches, including mobile gear, peaked on two occasions, in 1979 and 1987, followed by severe drops. Since 1993, recorded catches from mobile gear have dropped considerably (varying between 1% and 7% of the total catches) because directed fishing activities on Atlantic cod by mobile gear have been prohibited and because of the mandatory use of the Nordmore grate by shrimpers.

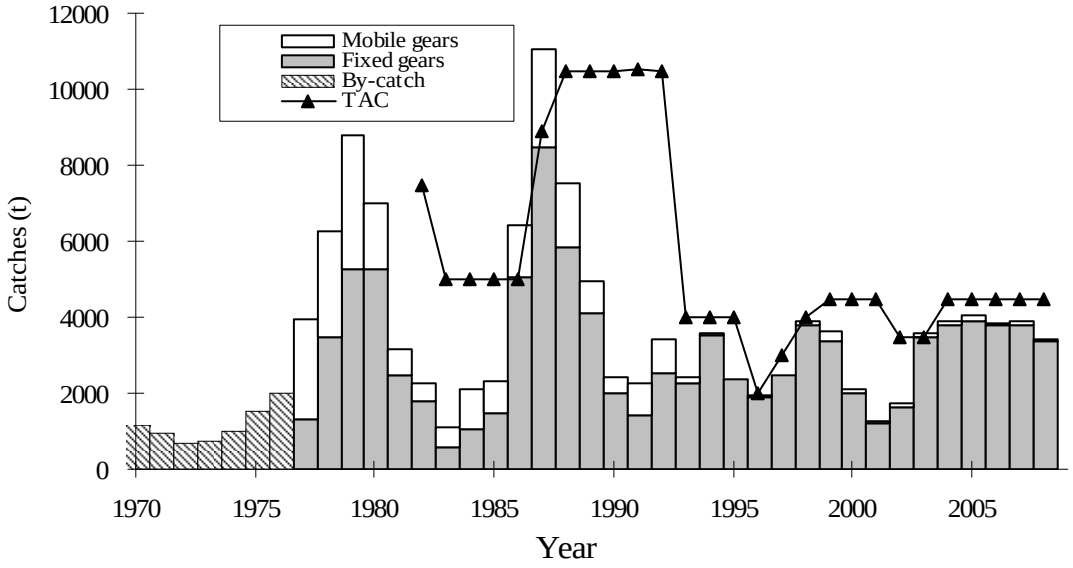


Figure 2. Annual Greenland halibut landings and total allowable catch (TAC) since 1970. Data for 2008 are preliminary.

Catches remained between 2,000 t and 4,000 t from 1989 to 1998. Landings decreased by 67% between 1999 and 2001, dropping from 3,600 tons to less than 1,300 tons, and increasing to 3,900 tons between 2001 and 2004. Preliminary landings reached 3,438 tons in 2008. Since 1998, this is the fifth consecutive year that fixed gear fishermen of both provinces catch their allocation. Newfoundland fishermen did not exceed their allocation in 2008.

Between 1999 and 2001, TAC was set at 4,500 tons, and then dropped by 22%, totalling 3,500 tons in 2002 and 2003. TAC has been increased to 4,500 tons since 2004.

RESOURCE ASSESSMENT

The status of the resource is determined by examining indicators from the DFO research survey, the July sentinel survey, and from the commercial fishery. These indicators concern stock's abundance and general condition as well as the fishery success. In order to assess the significance of the changes, the value of the 2008 indicators was compared with the 1998–2007 averages. The average related to the complete series (1990-2007) is also presented for the DFO research survey indicators. Indicators differ from the average when their annual value is outside of the confidence interval (95%).

The significance of recruitment to the population (one-year-old fish) is characterized based on the abundance index (in millions of fish) recorded from the research survey and is divided into four large categories (Figure 3): Low: 0-50; Average: 50-100; Good: 100-150; High: above 150. Furthermore, the 1992, 1993 and 1994 year-classes represent the lowest abundance level (less than 20) and the 1997 and 1999 year-classes represent the highest level of the series (more than 200).

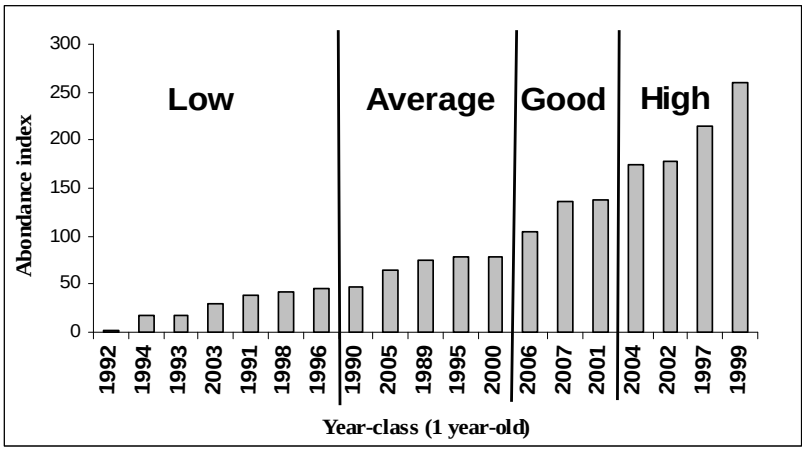


Figure 3. Recruitment to the population abundance index (year-class - 1 year-old) of Greenland halibut calculated from the research survey from 1990 to 2007. The significance of recruitment is presented in four categories (low, average, good and high)

Surveys

A research survey is conducted annually in the Estuary and Gulf of St. Lawrence in August on board a DFO vessel. Between 1990 and 2003, the survey was conducted on board the CCGS *Alfred Needler*. It was then replaced by the CCGS *Teleost*. Following some comparative fishing experiments between the two vessels, catches by the CCGS *Alfred Needler* between 1990 and 2003 were corrected to match the catches made by the CCGS *Teleost.*

The cod sentinel fishery survey, conducted in July in the northern Gulf since 1995, is also used for determining the status of the resource. This survey is conducted by nine otter trawlers according to a stratified sampling plan. It does not cover the St. Lawrence Estuary, where an average of 15% (14% over the last ten years and 18% for the series) of the Greenland halibut biomass is located and where a large concentration of 1 and 2 years-olds can be found.

For these two surveys (DFO and sentinel), indices for overall biomass and exploitable stock biomass, recruitment to the population abundance (fish of less than 30 cm and 1-2 years-old), abundance of pre-recruits (fish of 40-43 cm entering the fishery the following year), and the abundance of fish above the minimum legal size (44+ cm) serve as stock status indicators. Furthermore, abundance indices per region are also calculated; the western Gulf (including the Estuary and southern Anticosti), northern Anticosti and Esquiman Channel (Figure 4).

Data on the sexual maturity of males and females have been gathered since 1996 during DFO August missions, i.e. several months before spawning. Sexual maturity is assessed according to morphological criteria for all fish measured during these missions. A maturity ogive is then calculated, allowing estimating the length at which 50% of fish are mature (L50) for both males and females. The Fulton condition index (fish weight / cubed length) was calculated for fish of 40+ cm. This index provides information on the physical condition of the fish.

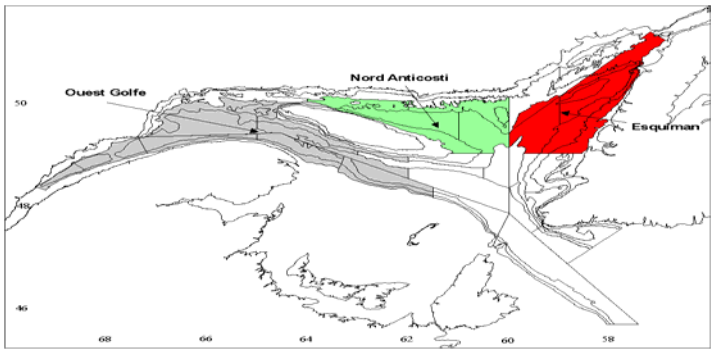


Figure 4. Reference areas for calculating biomass per region.

Commercial Fishery

Commercial fishery statistics and logbooks from traditional gillnetters (6-inch mesh) from Quebec and Newfoundland have been used to estimate catches per unit of effort (CPUEs) since 1996. The CPUE is defined as the weight in kg of Greenland halibut caught in a net during a one-day immersion period. The catch rate indicator comes from standardizing the gross values based on NAFO subarea 4Si for a three-day immersion period in July.

The two other indicators of fishing success are the gap between fixed gear allocation and the landings related to this fleet and the estimate of the mean size of fish caught by gillnets from the commercial catch samples.

Resource Status in 2008

In the early 1990s, most abundance indicators were below the 1990-2007 average. Total biomass and the abundance of fish available to the fishery (44+ cm) were the lowest of the 1990-2008 series (Figures 5). Greenland halibut stock distribution was then limited to the Estuary and the head of the Gulf channels. The recruitment of average abundance year-classes (1989 and 1995) resulted in a productivity increase to a point that biomass and abundance indicators improved towards the end of the 1990s.

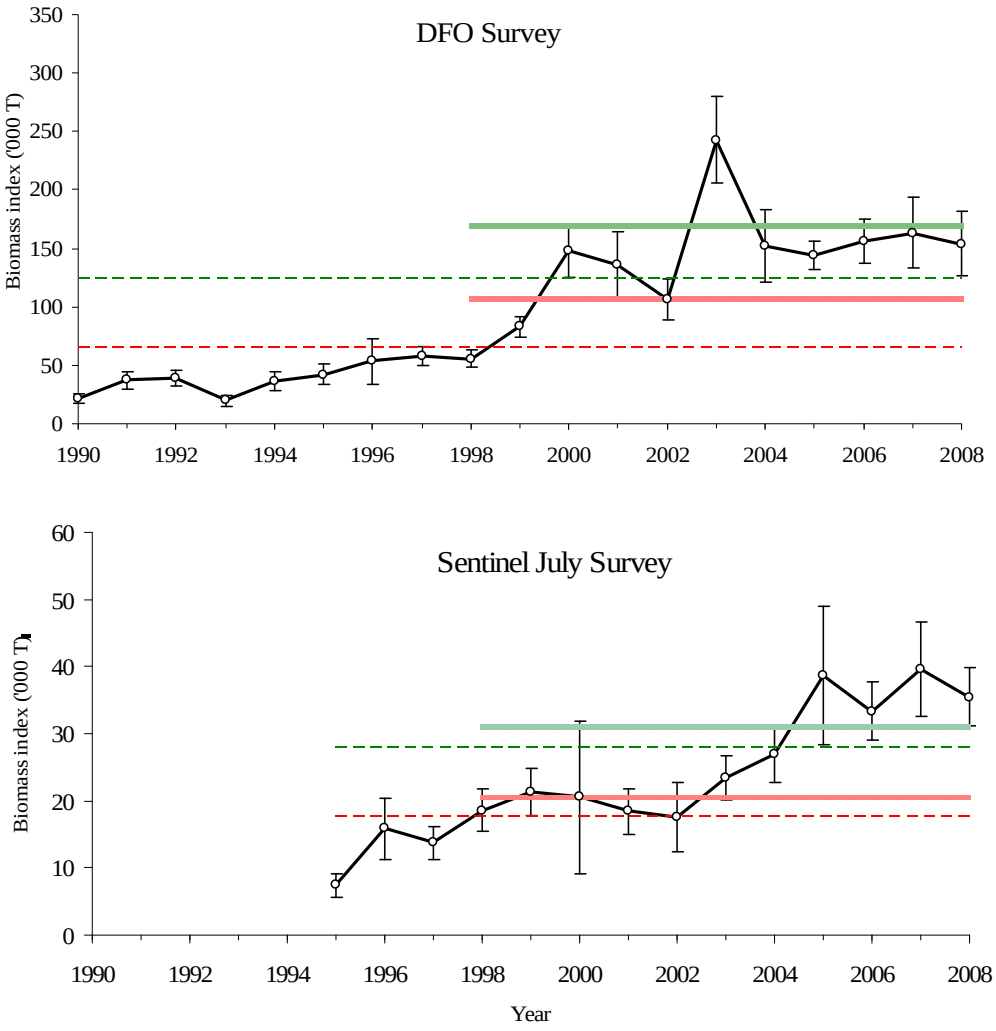


Figure 5. Minimum trawlable biomass indices for Greenland halibut in Divisions 4RST estimated from the DFO and the July sentinel survey data. The lines represent the confidence intervals for the 1998-2007 average (solid lines) and for the entire series (dotted lines).

Since then (1998), there has been better recruitment overall and this has resulted in considerable increases in terms of biomass indices. However, since 2000, the biomass index from the research survey has stabilized around the 1998-2007 average. This stability has been observed since 2005 for the sentinel fisheries survey.

From 1998 to 2004, strong year-classes (1997, 1999, 2002 and 2004) were recruited four times and were always followed by a low or average recruitment (1998, 2000, 2003 and 2005) (Figure 6). The abundance of the cohorts produced between 2006 and 2008 were of an average to good level. However, the last three years represented the longest period where there has been no high recruitment production.

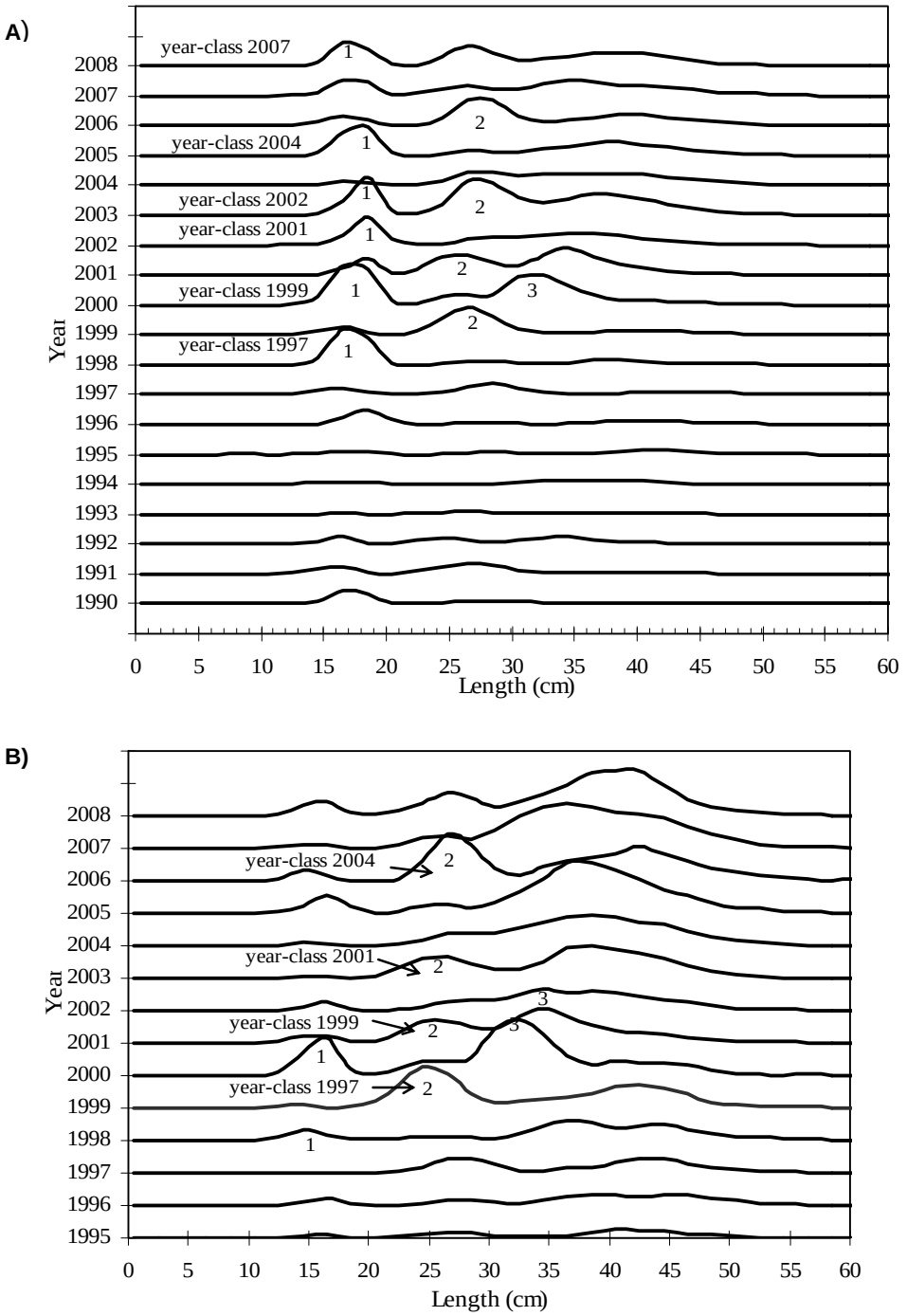


Figure 6. Size structure of Greenland halibut caught during DFO research surveys (A) (1990-2008) and (B) July sentinel survey (1995-2008). The last most significant year-classes (1997, 1999, 2001, 2002 and 2004) are shown as well as the age of the 3- year-old fish.

There was no change in the performance by the Gulf's commercial fishermen in 2008. However, there was a noticeable difference in the length of the fishing season in Newfoundland's competitive fishery. It went from 10 days in 2007 to 64 in 2008. Because of Atlantic halibut by-catch issues, the fishery closed for five days in June and then this group of fishermen were

forced to fish at greater depths. This restriction led to the withdrawal of several small halibut fishing vessels in Division 4R.

In the early 2000s, low performance, the drop in mean size and the gap increase between fixed gear allocations and related landings reflect the difficulties experienced in the Gulf fishery during this period. In 2003, performance improved considerably and has remained relatively stable since.

However, fish condition and size at first maturity has revealed that the situation has deteriorated starting in 1999 and has remained at a lower level than before this period.

Most of the time, the western Gulf represents more than half the total biomass. Correspondingly to the biomass increase, an expansion of the distribution range for juveniles (1 and 2 years old) was observed mostly south of Anticosti, along the Laurentian Channel and in the Anticosti Channel during good recruitment years.

Stock Status Indicators from Surveys:

The historical series of biomass indicators from the DFO and sentinel fishery survey for July show an overall upward trend beginning in the mid-1990s leading to a certain stability for a number of years (Figure 5). Results from the DFO survey indicate that the biomass index has been within the average limits of the last ten years (1998-2007) since 2000. The sentinel fishery indices have been rather stable and above the 1998-2007 average since 2005. The 2008 value has dropped compared to 2007 for both surveys, but was similar to the values from recent years because of the degree of the estimate's confidence interval.

For the DFO survey, the biomass proportion recorded in the western Gulf in 2008 was similar to the 1995-2008 average and accounted for 72% of the total biomass. This percentage averaged 60% for the sentinel survey series and can be explained in part because the Estuary was not covered and represents about 15% of the total biomass (12% in 2008).

In 2008, the DFO survey showed an increase (6%) in the western part of the Gulf and the sentinel fisheries survey showed a drop (9%) compared to 2007. Both surveys showed a decrease in the Esquiman Channel and in northern Anticosti between 2007 and 2008. Overall, since the mid-1990s, both surveys show an upward trend in the western Gulf, whereas the biomass index dropped by half in the Esquiman Channel and northern Anticosti in recent years.

The summer distribution (August) of individuals in the research surveys for the 1993-2003 period reveals that the distribution range of larger size fish extends eastwards, along the Laurentian Channel, south of Anticosti, whereas it is usually different for juveniles. Surveys over the last ten years show a high concentration of juvenile fish (< 32 cm, 1 and 2 year-olds) mostly in the Estuary (particularly at the head of the Estuary) and drops considerably in the east, except for the northern part of Anticosti. In high recruitment years, juvenile distribution seems to extend towards the Laurentian Channel and their concentration generally increases in the Sept-Iles basin and north of Anticosti.

Analyses conducted from the 2008 survey presenting the density per stratum according to size and sex revealed that, in the Laurentian Channel (southern part of Anticosti) and in the Esquiman Channel, males of 30+ cm were more abundant than females (about twice as much) and that their maximum size is larger than in the western part of the Gulf. In addition, large size

females and males (> 50 cm) are not abundant and are mostly found in the Laurentian Channel and the Esquiman Channel.

For both surveys, the abundance indices (in numbers) of pre-recruits (40-43 cm), sexes confounded, increased in 2008 compared to 2007 and remained above the 1998-2007 average. This increase can be explained in part by the male component from the 2002 year-class still present (these males will only be slightly recruited to the fishery if at all because of their small maximum size) and also by the occurrence of the very abundant 2004 year-class. The fish recruited to the fishery (44+ cm), the abundance indices dropped in 2008 and had values similar to the 1998-2007 average. This drop is likely the result of the weak 2003 year-class combined with successive exploitation of the same year-classes (2001-2002) in the same size range.

The 2008 Fulton condition index was the lowest since 1995 (except for 1999) and was under the minimum limit of the 1998-2007 confidence interval average. The condition index, which is used as a fish health status indicator, was below the 1997-2006 average between 1999 and 2001. It then began improving between 2001 and 2003, and has been dropping since. There does not appear to have been any change in growth rate between 2004 and 2008, which could explain this drop.

Information regarding sexual maturity shows that the size at which 50% of fish are mature (L50) has dropped since 1996, from 40 cm to 35 cm for males and from 50 to 45 cm for females (Figure 7). The 2008 value has remained low for males and females and was below the 1998-2007 average.

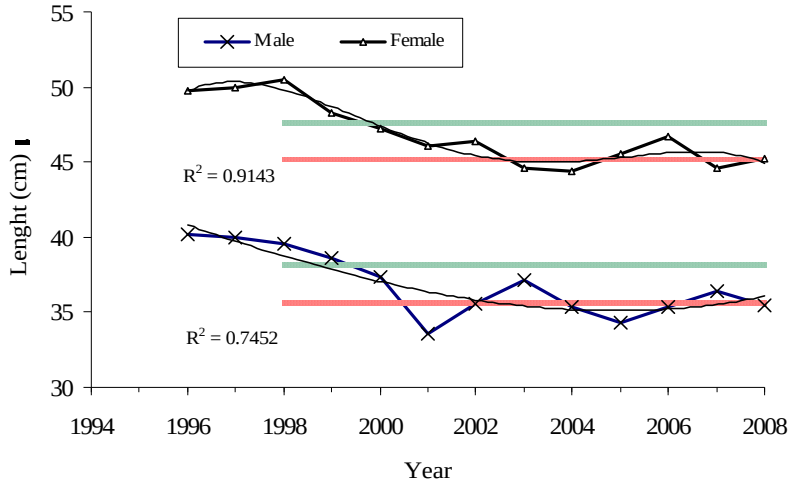


Figure 7. Length at 50% maturity for fish caught in the DFO research survey between 1996 and 2008. The sold lines represent the confidence intervals for the 1998-2007 average.

The size at maturity for males is considerably lower than the minimum size of 44 cm established for the small fish protocol. Because growth rate drops after reaching sexual maturity, there exists a size dimorphism between males and females that increases the proportion of females in commercial catches. Maturity ogives that estimate the proportion of mature individuals at length indicate that at 44 cm, 63% of females and 4% of males are immature (Figure 8). This proportion changed from 56% to 63% for females between 2007 and 2008. This change is a result of a size difference at maturity. The average of the last three years was 64% for females and 4% for males.

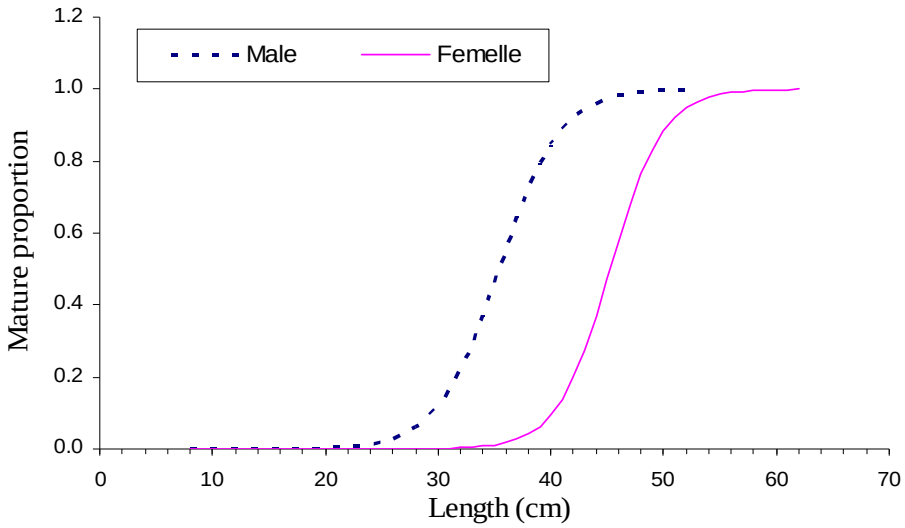


Figure 8. Maturity ogive for Greenland halibut caught in the 2008 DFO research survey.

Stock Status Indicators from the Fishery:

The first fishing success indicator comes from the CPUE estimate and does not show any changes in 2008.

The second fishery indicator, which was the mean size of fish caught in gillnets, decreased from 48 cm in 2007 to 47 cm in 2008, and was closer to the 1998-2007 average. A 2 cm drop was recorded in 4R and 1 cm in 4S. There was no change in 4T. The depletion of large size fish and the beginning of the new year-class (2003) exploitation probably led to a drop in medium size fish.

The mean size of fish was around 43 cm in 1995, and rose to 48 cm in 1996 following the mesh size increase from 140 mm (5.5 in.) to 152mm (6.0 in) (Figure 9).

Overall, the proportion of fish landed that were smaller than the legal size of 44cm increased from 15% in 2007 to 19% in 2008. This proportion increased in 4S (16% to 20%) and doubled in 4R (6% to 12%), whereas it fell slightly for a second consecutive year in 4T (from 33% in 2006 to 23% in 2008). The change in 4T is likely due in part to a shift in fishing effort in the Estuary from west to east, which had been observed in 2006 but was even more evident in 2007 and 2008. Based on a study on sized-based catch distribution, there have been more small fish caught in the west of the Estuary (4Tq and 4Tp), which represent a significant proportion of individuals that have not reached sexual maturity.

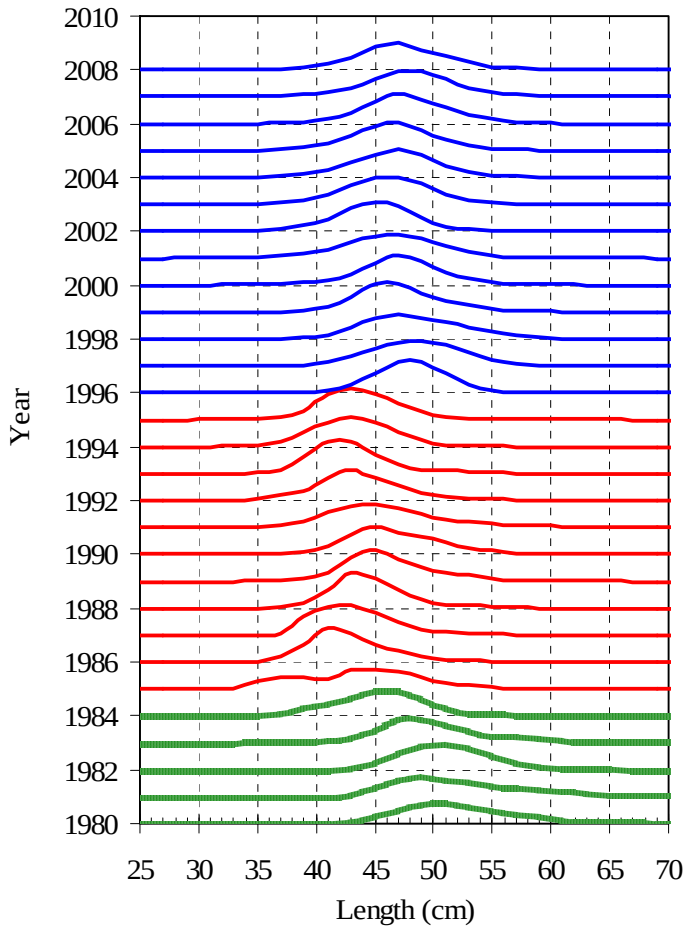


Figure 9. Size structure of Greenland halibut caught with gillnets, 1980-2008. (1980 to 1984: mesh size of 5.5 and 6.0 in. and more; 1985 to 1995: mesh size of 5.5 in.; 1996 and later: mesh size of 6.0 in.)

The average size of fish caught decreased in 2008 and the number of Greenland halibut harvested per ton landed increased by 5%.

In 2008, 83% of the commercial catches were females. The proportion of females in the gillnet catches has increased significantly since 1996 due to the mesh size increase. Since 1998, there has been an increase of the percentage of females in the catches, but this percentage has been relatively stable since 2000.

Outlook

Recruitment of the two very abundant year-classes of 1997 and 1999 resulted in the abundance index increases observed in the early 2000s. Prior to the arrival of these year-classes, indices were at a low level. In recent years, the fishery has targeted new and less abundant year-classes (2001 and 2002) than the 1997 and 1999 year-classes but that represent nonetheless two considerably abundant year-classes (Figure 3).

In 2008, according to the research survey, the portion of biomass available to the fishery dropped compared to the previous five years, which was the result of the arrival of the weak

2003 year-class combined with the successive exploitation of the same cohorts (2001 and 2002). Consequently, larger size fish will likely be even less abundant in 2009 and the fishery will target the strong 2004 year-class which will partly contribute to the fishery because only some of the individuals will have reached the minimum legal size and will not have reached size at maturity.

In addition, since the 2004 cohort is preceded and followed by year-classes of weak and average abundance (2003 and 2005 respectively), it is likely that the mean catch size will drop in 2009.

In 2010, the fishery will also be supported by the 2004 year-class and, to a lesser extent, by the 2005 cohort of average abundance.

Because of the abundance of pre-recruits (40-43 cm, including the strong 2004 year-class) which is above the 1998-2007 average, the biomass available to the fishery in 2009 is expected to remain at a similar level as in recent years.

The precautionary approach for Greenland halibut is being developed. A peer review was conducted in January 2009 to assess the methods for establishing reference levels (LRP: limit reference point and USR: upper stock reference). The method used is based on the temporal series of biomass indices from the surveys. Despite agreeing on the LRP, more work will be needed to better define the USR and finalize the precautionary approach. The decision rules will then have to be developed in collaboration with Industry and fisheries management. The development of the precautionary approach for this stock, including the decision rules, should be completed within 2-3 years.

Sources of Uncertainty

The indicators for the size of exploitable stock and fishing success differ between 2007 and 2008. The biomass of 44+ cm fish from the surveys dropped whereas the CPUE from the commercial fishery remained stable (Figure 10).

The condition index continued to drop between 2003 and 2008 and is unexplained and worrisome.

The size value at sexual maturity in 2008 remained at a low level and is below the 1996-2007 average for females. This indicator raises some concern in terms of conservation of the spawning stock.

The abundance index from the sentinel fisheries survey has shown considerable inconsistency between 2005 and 2007 due to large catches made in one and three tows respectively, on a total of more than 200.

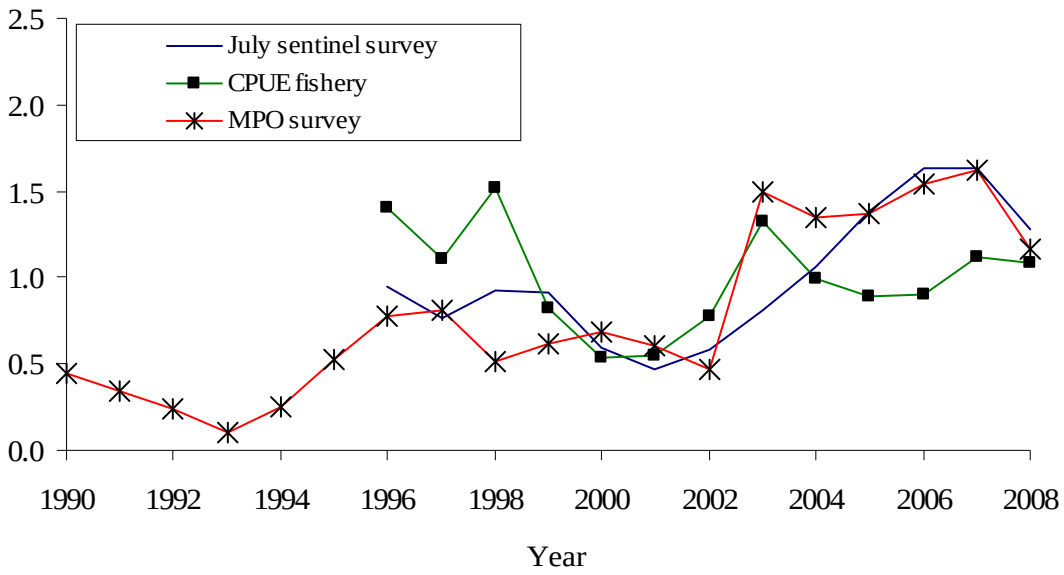


Figure 10. Standardized indices for fishable stock biomass (44+ cm) for Greenland halibut and fishery CPUEs.

CONCLUSIONS AND ADVICE

Fishery results were generally good in 2008, and forecasts indicate that they will remain at a level comparable to recent years for 2009. The biomass index for the Gulf should remain at a level nearing the average from the last ten years. Thus, it does not seem necessary to reduce the landings.

However, the exploitable biomass estimates from the two surveys as well as the biomass indices from Esquiman and northern Anticosti show a decrease. It is therefore important to be cautious and monitor the main indicators and not increase the exploitation rate in order for the spawning biomass to remain at a suitable level. Consequently, the status quo is recommended in terms of catch levels for the 2009-2010 and 2010-2011 seasons.

OTHER CONSIDERATIONS

Between 2006 and 2008, the percentage of fish measuring less than the legal size of 44 cm increased from 11% to 20% in 4S, where almost half the catches were made. This increase in 4S raises some concern.

Greenland halibut by-catches from the shrimp fishery from 1999 to 2008 were examined using the observers at sea database. At least one Greenland halibut was present on average in 89% of the activities observed. Fish by-catches are mostly of the order of 1 kg or less per tow observed. The presence of an observer does not appear to disrupt the general fishing pattern, as the catch rates with or without an observer do not vary.

Greenland halibut catches (in numbers and in weight) are variable according to areas and years and appear to be largely influenced by fishing effort by shrimpers. Consequently, the areas of Sept-Îles and Anticosti have the highest by-catch rates of Greenland halibut. In 2008, they more

than doubled in Sept-Îles. The average annual Greenland halibut by-catches (in weight) from the shrimp fishery in the Estuary and Gulf from 1999 to 2008 are in the order of 100 tons. Generally, they are mostly made up of 1 year-old individuals, and in a lesser extent 2 year-old individuals. In 2008, shrimp fishery by-catches of Greenland halibut in the Estuary and Gulf totalled around 128 tons, which represents a 35% increase from 2007.

SOURCES OF INFORMATION

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