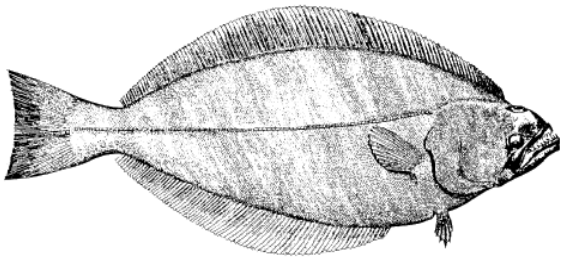
ASSESSMENT OF THE GREENLAND HALIBUT STOCK IN THE GULF OF ST. LAWRENCE (4RST) IN 2007



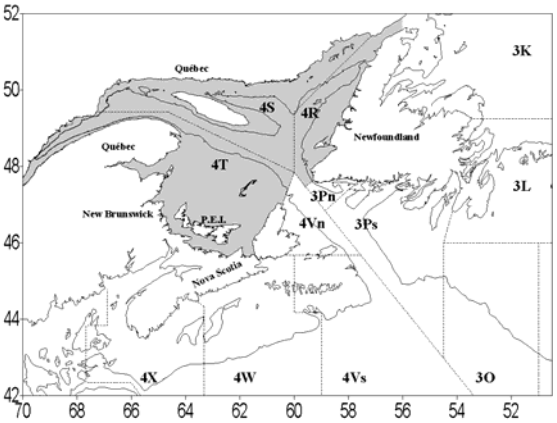


Figure 1. Map of the Gulf of St. Lawrence and neighbouring areas showing NAFO divisions 4RST.

Context

Until the mid 1970s, Greenland halibut (also called black turbot, or more commonly 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 for the fishery, size at sexual maturity for each sex and 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 used as indicators of stock status and fishery success.

SUMMARY

- Preliminary landings as of December 2007 totalled 3,692 t.

- Standardized catch rates and the mean CPUEs of traditional gillnetters using 6 in. mesh nets showed a significant increase between 2006 and 2007. This increase is a result of the rise in catch rates in Areas 4T and 4S. On the other hand however, a drop in fishing success occurred in Area 4R in 2007.

- The proportion of females in catches was 83% in 2007 and has remained more or less the same since 2000. The mean size increased to 48.0 cm in 2007.

- The trawlable biomass index (kg/tow) from the DFO surveys has remained close to the maximum limit from the 1997-2006 average since 2004. The biomass estimate from the July sentinel fishery index remained above the 1997-2006 average in 2007 and comparable to the 2005 and 2006 values.

- The size at which 50% of fish are mature has remained at a rather low level since 2001. At 44 cm, 56% of females and 5% of males are immature.

- Recruitment in recent years has fluctuated but remains above those observed prior to 1997.

- For the second and third consecutive year, the 2008 fishery will mostly be supported by the 2002 and 2001 year-classes, consecutively. The 2003 year-class had the lowest level since 2000.

- Data from the DFO and sentinel fishery survey suggest that recruitment to the fishery should be similar to that of recent years. The status quo is recommended for catch levels for the 2008 fishery.

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 1996-2006 average.

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 2007, Greenland halibut landings in NAFO Divisions 4RST totalled 3,692 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 moy.	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008[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]
Fixed gear	3,1	3,4	2,0	1,2	1,6	3,5	3.8	3.8	3,8	3,6
Mobile gear	1,1	0,2	0,1	0,1	0,1	0,1	0,1	0,2	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

[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 263 active boats in the Greenland halibut fishery in the estuary and Gulf in 2007.

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.

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 more than tripled between 2001 and 2004. Preliminary landings reached 3,692 tons in 2007. Since 1998, this is the fifth consecutive year that fixed gear fishermen of both provinces catch their allocation. Newfoundland fishermen exceeded their 2007 allocation by 8%.

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 was increased to 4,500 tons since 2004.

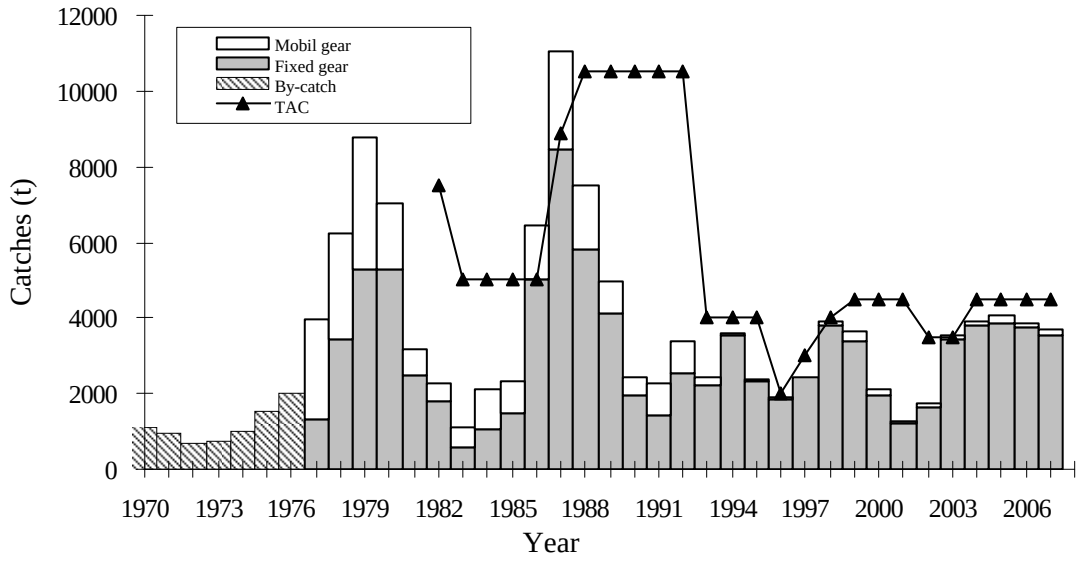


Figure 2. Annual Greenland halibut landings and total allowable catch (TAC) since 1970. Data for 2007 are preliminary.

RESOURCE ASSESSMENT

The status of the resource is determined by examining indicators from the DFO's 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 2007 indicators was compared with the 1997–2006 averages. The average related to the complete series (1990-2006) 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%).

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*, equipped with a URI 81'/114' shrimp trawl. However, it was decided that the vessel and fishing gear would be replaced to continue the survey beyond this period. The vessel CCGS *Teleost*, equipped with a Campelen shrimp trawl, would now be used. Because the vessels and trawls were considerably different, comparative fishing experiments were conducted in 2004 and 2005 in order to assess the catchability differences between the two vessel/gear tandems. The effects of depth, time of day and individual size covariables on the catchability of Greenland halibut were tested. The effects of depth and fishing period covariables were statistically insignificant. However, catchability differences obtained according to size were adjusted based on a statistical model. On the whole, catches by the CCGS *Teleost* were superior to those by the CCGS *Needler*. Catches by the CCGS *Alfred Needler* between 1990 and 2003 were therefore corrected to match the catches that would have been 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% of the Greenland halibut biomass is located and where a large concentration of 1 and 2 years-olds can be found.

Indices for minimum trawlable biomass and exploitable stock biomass are calculated for these two surveys (DFO and sentinel). Total abundance indices and by region (Figure 3) for juvenile fish (less than 30 cm and 1-2 years-old), pre-recruits (40-43 cm), and fish above the minimum fishery size (44+cm) also serve as stock status indicators. Also, indices are estimates for the western Gulf, north Anticostie and Esquiman chanel.

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.

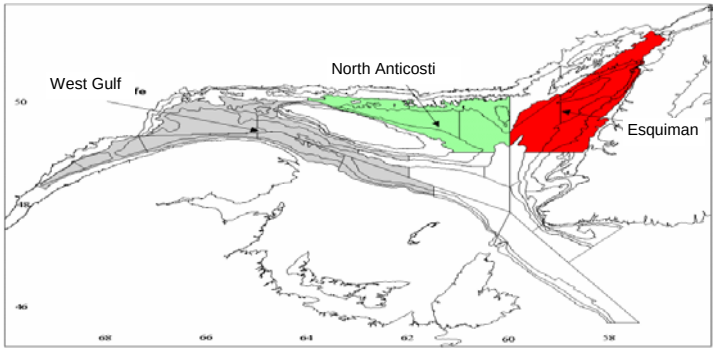


Figure 3. Reference areas for calculating biomass per region.

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. This procedure is consistent with analysis procedures used since 1996. The two other fishery success indicators are the difference between the fixed gear allocation and the landings associated to this fleet, and the estimate of the average size of fish caught with gillnets from commercial fishery samples.

Status in 2007

In the early 1990s, most abundance indicators were negative. Total biomass and the abundance of fish available for the fishery (44+ cm) were the lowest of the 1990-2006 series (Figures 4). 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, 1990, 1991 and 1995) resulted in a productivity increase to a point that biomass and abundance indicators improved towards the end of the 1990s.

Since then, the cycle between the production of high (1997, 1999, 2001 and 2004) and average or low juvenile abundance (1998, 2000, 2003, 2005 and 2006) (Figure 5) resulted in an increase in biomass indices. However, since 2004, the biomass index has stabilized at a level nearing the maximum limit of the 1997-2006 average, and is partly caused by the 1999 year-class which is still present and also by the consecutive arrival of the 2001 and 2002 year-classes which were of high and average abundance.

Performance by the local commercial fishermen was high at the end of the 1990s and then dropped sharply in the early 2000s. The drop in mean size and the gap increase between fixed gear allocations and related landings also reflect the difficulties experienced in the fishery during this period. In 2003, performance improved considerably and indicators from the fishery have maintained a rather positive trend 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 double the total biomass. Correspondingly to the increase of biomass, 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 leading to a certain stability in recent years (Figure 4). Results from the DFO survey indicate that the biomass index has been within the average limits of the last ten years (1997-2006) since 2000. The 2007 value from the sentinel fishery survey was similar to the values from the last two years because of the degree of the estimate's confidence interval. The sentinel fishery indices have been above the 1997-2006 average since 2005.

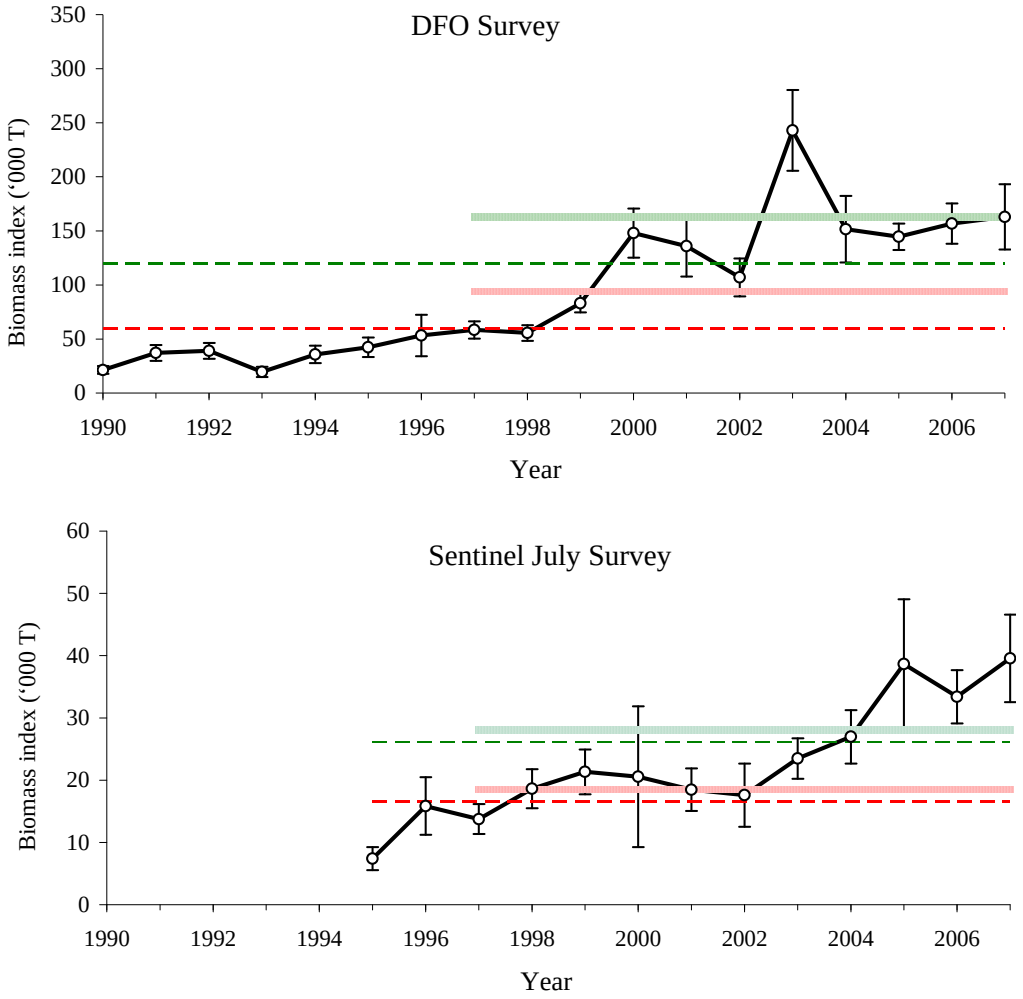


Figure 4. Minimum trawlable biomass indices for Greenland halibut in Divisions 4RST estimated from the DFO and the July sentinel survey data. The lines represent the confidence intervals for the 1997-2006 average (solid lines) and for the entire series (dotted lines).

In 2007, both surveys showed an increase in the western part of the Gulf (14% increase for the DFO survey and 59% increase for the sentinel survey) and a drop in the Esquiman Channel and north of Anticosti, compared to 2006. The most significant biomass in 2007 was found in the western Gulf (including south of Anticosti). For the DFO survey, the proportion recorded in the western Gulf in 2007 was equal to the 1995-2006 average and accounted for 72% of the total biomass. This percentage averaged 57% 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. In 2007, the sentinel survey indicated that 77% of the biomass was found in the western Gulf, which represents by far the highest value in the series. This increase was the result of three tows that were carried out south-west of Anticosti and yielded the highest catches of the series.

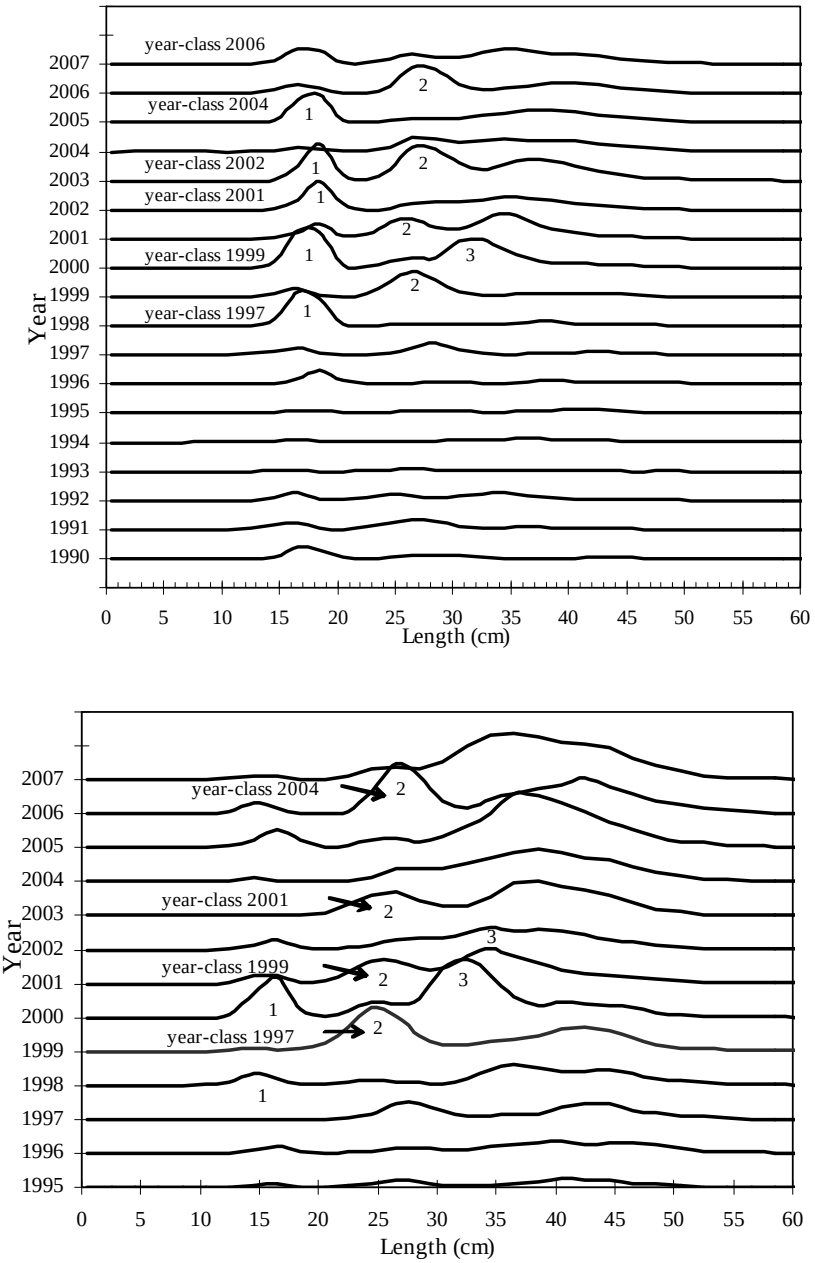


Figure 5. Size structure of Greenland halibut caught during DFO research surveys (A) (1990-2007) and (B) July sentinel survey (1995-2007). The last most significant year-classes (1997, 1999, 2001, 2002 and 2004) are shown as well as the age of the 3- year-old fish.

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 different for juveniles. Surveys in recent years also show a high concentration of juvenile fish (< 32 cm) in the Estuary and drops considerably in the east, except for the northern part of Anticosti.

For both surveys, the abundance indices in numbers of pre-recruits (40-43 cm) and fish recruited to the fishery (44+ cm), sexes confounded, had similar values in 2007 as in 2005 and 2006 and remain above the 1997-2006 average. However, the abundance index from the DFO

survey indicated a drop in female pre-recruits in 2007 with regard to the values covering the 2004-2006 period. The male pre-recruit index on the other hand has remained rather stable.

The 2007 Fulton condition index was the lowest since 2002 and was under the minimum limit of the 1997-2006 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 dropped again between 2004 and 2007. There does not appear to have been any change in growth rate between 2004 and 2007, which could have explained 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 36 cm for males and from 50 to 45 cm for females (Figure 6). The 2007 value dropped by 2 cm for females and was among the lowest in the series.

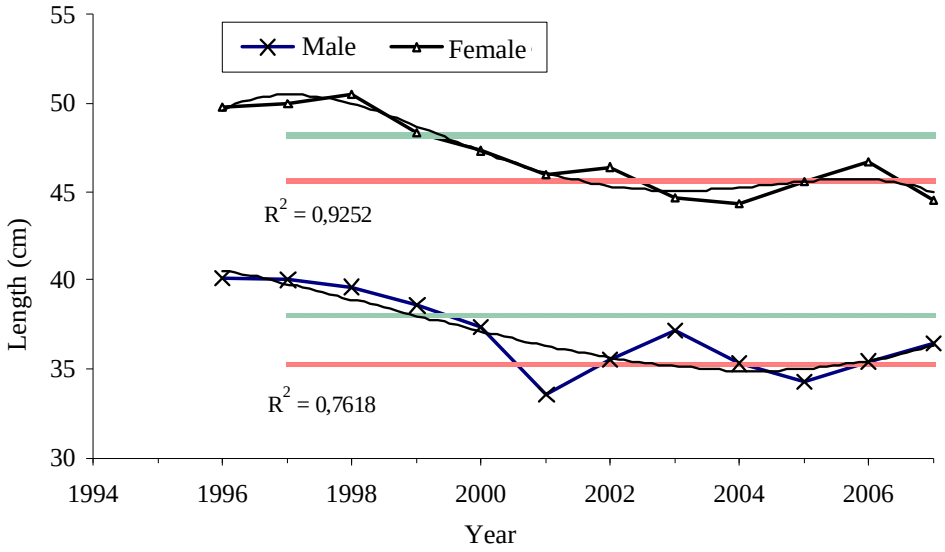


Figure 6. Length at 50% maturity for fish caught in the DFO research survey between 1996 and 2007. The sold lines represent the confidence intervals for the 1997-2006 average.

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, 56% of females and 5% of males are immature (Figure 7). This proportion dropped from 72% to 56% for females between 2006 and 2007. This considerable decrease is a result of a substantial drop in size at maturity.

Stock Status Indicators from the Fishery:

Two of the three fishery indicators (i.e. the difference between allocation and landings and the CPUEs) have shown the same trend since the late 1990s. The have shown an improved situation since 2003, yet they were negative between 2000 and 2002. Thus, the difference between the allocation of fixed-gear fishermen and landings was stable between 2003 and 2007, indicating that these fishermen reached their allocation. Although the CPUEs were higher than in the early 2000s, they have nevertheless dropped slightly between 2004 and 2006. In

2007, the recorded CPUEs showed a relative increase compared to 2006. The values observed over the last five years have been about the same for the 4RST Divisions combined. This increase was the result of an increase in 4Sz and 4T. However, there was a drop in 4R and in most 4S sub-divisions.

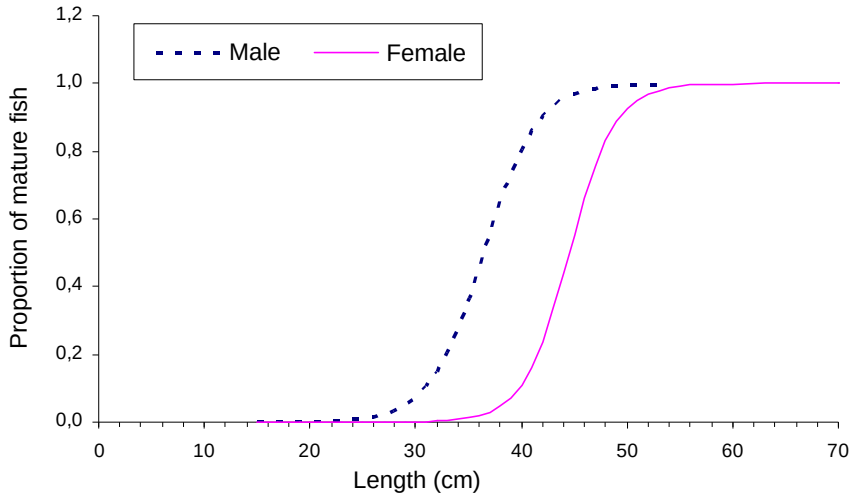


Figure 7. Maturity ogive for Greenland halibut caught in the 2007 DFO research survey.

The third indicator from the fishery, mean size of fish caught in gillnets, 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 8). The average size of fish caught, which had been generally decreasing between 1998 and 2002 (from 48 cm to 45 cm), increased progressively to 48 cm in 2007. This increase is likely attributable to the increase of the good year-classes of 1997, 1999, 2001 and 2002, which have entered the fishery since 2003.

The results recorded in 4RST in 2007 were mostly due to the mean size increase recorded in Divisions 4R and 4T. Although most of the catches were made in 4S, the mean size dropped slightly in 2007 compared to 2006 in this division.

Overall, 15% of the fish landed were smaller than the minimum legal size of 44 cm. The proportion of fish landed that were smaller than the legal size of 44cm consequently increased from 11% to 16% in 4S. This proportion was more or less the same in 4R and represented around 6%, whereas a drop from 33% to 26% was recorded in 4T. 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. In recent years, 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.

The average size increased and the number of Greenland halibut harvested per ton landed decreased slightly in 2007.

The proportion of females caught in gillnets has significantly increased since 1996 due to the increase of mesh size. Since 1998, there has been an increase in the percentage of females caught, but this percentage appears to have remained relatively stable since 2002. In 2007, 83% of commercial catches were females.

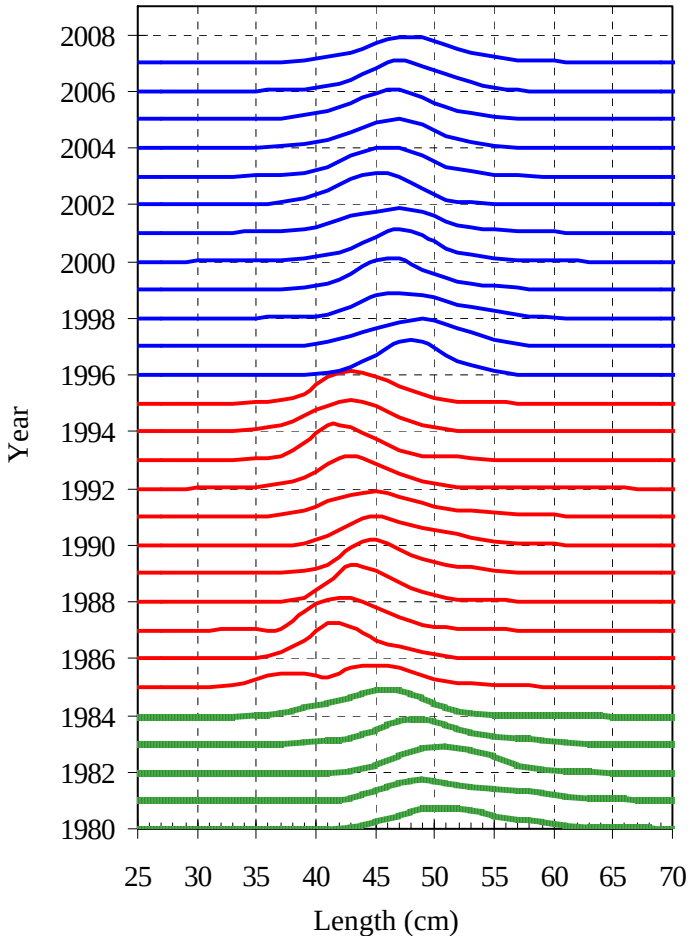


Figure 8. Size structure of Greenland halibut caught with gillnets, 1980-2007. (1980 to 1984: mesh size of 5.5 and 6.0 in. and more; 1985 to 1995: mesh size of 5.5 in.; 1996 and later: mesh size of 6.0 in.)

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 mainly been supported by the 2002 and 2001 year-classes.

In 2008, the fishery will also be supported by the 2002 and 2001 year-classes, for a second and third consecutive year. Although they do not seem to be as strong as the 1997 and 1999 year-classes, they represent two year-classes that are both sufficiently abundant and consecutive, which had not occurred over the last ten years because juvenile abundance had alternated between high and low levels. Because of this, and because of the abundance of pre-recruits (males and females 40-43 cm) which is still above 1997-2006 average, the biomass available to the fishery in 2008 is expected to remain at a similar level as in recent years. However, the abundance of pre-recruits differs based on sex. In 2007, female pre-recruits dropped slightly compared to recent years, which was probably the result of the weak year-class of 2003. Because catches are mostly made up of females, it is likely that this drop, combined with the consecutive exploitation of the same year-classes (2001 and 2002), will have a weak downward

impact on the biomass available to the fishery in 2008 compared to 2007. Normally, the 2004 year-class will be available to the fishery in 2009 and 2010.

Sources of Uncertainty

Between 2001 and 2003, fishing success (CPUE) showed the same upward trend as the two size indicators for exploitable stock (Figure 9). Although the biomass of 44+ cm fish from the DFO survey and the CPUE showed a slight drop between 2003 and 2005, the sentinel fishery index continued to increase up to 2006. In 2007, the fishery success index was more positive than in 2006 and the exploitable stock size indices remained relatively stable. The CPUE increase from the 2007 fishery was welcomed news but it does not reflect the overall status of the stock.

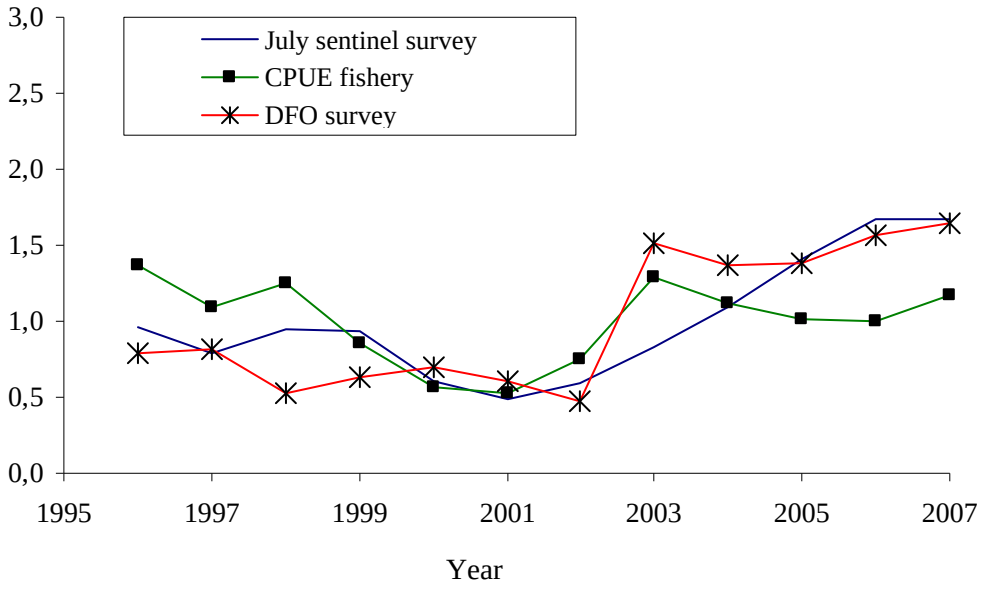


Figure 9. Standardized indices for fishable stock biomass (44+ cm) for Greenland halibut and fishery CPUEs.

The CPUE and the two indices show a drop in fishing success and minimum trawlable biomass in Esquiman. Both surveys show a drop in the biomass index north of Anticosti and an increase in the western Gulf.

The magnitude of the simultaneous increases of abundance indices for all size classes (juveniles, pre-recruits, 44+ cm) of Greenland halibut and for several other groundfish species from the 2003 research survey suggest that environmental factors may have affected Greenland halibut population availability and led to increased catchability of this species during that year.

The abundance index from the sentinel fisheries survey showed considerable variability in 2005 and 2007 due to substantial catches made in one and three tows respectively, over a total of more than 200.

CONCLUSIONS AND ADVICE

Fishery results were generally good in 2007, and forecasts indicate that they will remain at a level comparable to recent years for 2008, but probabilities are high that fishery success will drop over the next few years. The TAC was increased in 2004 to take advantage of the 1997 and 1999 year classes. In 2008, catches equal to the 2007 TAC should create an increase in fishing pressure because the Greenland halibut biomass available to the fishery should decrease, mainly in the case of females. Nevertheless, because biomass should remain at a high level compared to the average of the last ten years, it does not appear necessary to decrease the landings. Consequently, the status quo is recommended for the 2008 TAC.

OTHER CONSIDERATIONS

A shift in fishing effort in the Estuary from west to east was observed in the 2006 fishery, and it was even more evident in 2007. Detailed analysis conducted using commercial data from 2005 and 2006 indicating that the percentage of individuals in the catches measuring less than 44 cm was between 24% and 54% in the western Estuary (4Tq and 4Tp, respectively) was presented last year. This high percentage of individuals of less than 44 cm in the western Estuary is likely the cause for the shift in fishing effort towards the east. Consequently, this percentage dropped from 33% to 26% between 2006 and 2007 in 4T. The percentage of fish under the legal size of 44 cm increased from 11% to 16% in 4S, where over half the catches were made in 2007. Although the percentage of immature individuals in commercial catches dropped in 4T, this rate remains high and the increase in 4S is concerning.

The size value at sexual maturity in 2007 remained at a low level and is below the 1997-2006 average for females. This indicator raises concerns in terms of conservation of the spawning stock.

Greenland halibut by-catches from the shrimp fishery from 1999 to 2007 were examined using the observers at sea database. At least one Greenland halibut was present in 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. Generally, 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. The average annual Greenland halibut by-catches (in weight) from the shrimp fishery in the Estuary and Gulf from 1999 to 2007 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, except for years when the latter represent strong year-classes, the 1 and 2 year-old catches are then more or less the same. In 2007, shrimp fishery by-catches of Greenland halibut in the Estuary and Gulf totalled around 93 tons (about 1.5 million individuals).

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