



## ASSESSMENT OF THE GREENLAND HALIBUT STOCK IN THE GULF OF ST. LAWRENCE (4RST) IN 2006

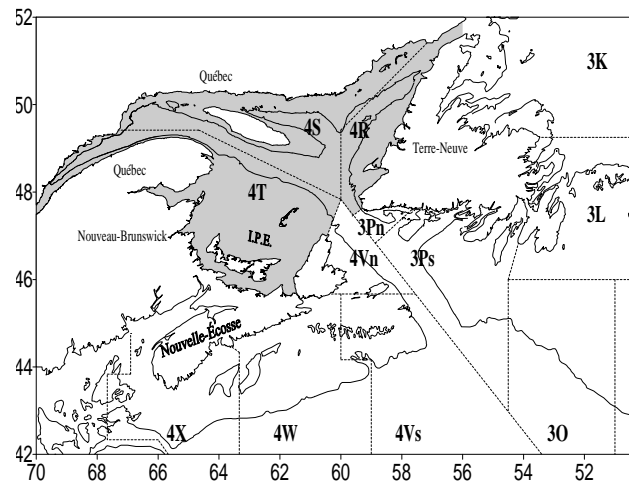
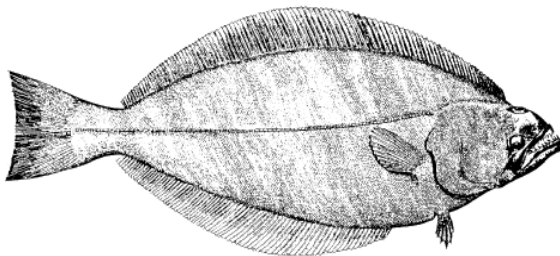


Figure 1. Map of the Gulf of St. Lawrence and neighbouring areas showing NAFO divisions 4RST.

### 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, the Department of Fisheries and Oceans (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.

Since 1995, due to the cod fishery moratorium, no directed fishery using mobile gear was permitted. 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, fish condition index, catches per unit of effort (CPUEs) from traditional gillnetters using 6 in. mesh nets, and the average size of fish caught. Standardized indices of exploitable stock biomass (44 cm and above) from fishery CPUEs and surveys are used as indicators for determining the size of the exploitable stock.

## SUMMARY

- Preliminary landings as of December 2006 totalled 3,654 t and the fishing season was delayed in 4T.
- Standardized catch rates by traditional gillnetters using 6-inch mesh nets increased from 2001 to 2003, and then dropped slightly until 2006.
- The proportion of females in catches was 84% in 2006 and has been more or less the same since 2002. The average size increased to 47.5 cm in 2006.
- The biomass index (kg/tow) from DFO surveys between 2000 and 2006 remained high.
- Biomass estimates from the July sentinel fishery survey showed an increase between 2002 and 2006.
- The size at which 50% of fish reach maturity increased slightly to 35 cm for males and to 47 cm for females in 2006. At the minimum size of 44 cm, 72% of females and 2% of males were immature.
- Research surveys indicated that the 2004 year-class was strong. However, the 2003 and 2005 classes were weak.
- Based on the analysis conducted in 2005 and 2006, the proportion of individuals in the fishery smaller than 44 cm raises concerns in the estuary where percentages can reach up to 54% in the western portion.
- The biomass available to the 2007 fishery will be comparable to that of recent years. The status quo is recommended for the catch levels in the 2007 fishing season.

## 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 2000, size at maturity for males and females has been below the 1995-2000 average. This change has resulted in an increase of the proportion of immature fish caught.

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**

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 <sup>1</sup>
TAC	-	4,5 <sup>2</sup>	4,5 <sup>3</sup>	4,5 <sup>3</sup>	3,5 <sup>3</sup>	3,5 <sup>3</sup>	4,5 <sup>3</sup>	4,5 <sup>3</sup>	4,5 <sup>3</sup>
Fixed gear	3,1	3,4	2,0	1,2	1,6	3,5	3,8	3,8	3,5
Mobile gear	1,1	0,2	0,1	0,1	0,1	0,1	0,1	0,2	0,1
Total	4,2	3,6	2,1	1,3	1,7	3,6	3,9	4,0	3,6

<sup>1</sup> Preliminary data

<sup>2</sup> TAC from January 1, 1999 to May 14, 2000

<sup>3</sup> TAC from May 15 of the current year to May 14 of the following year

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.

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 244 active boats in the Greenland halibut fishery in the estuary and Gulf in 2006.

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, catches made by mobile gear have been very low (4% in 2005) because of the stopping of directed cod fishing with this type of gear, and because shrimpers are required to use Nordmore grates. Catches stabilized between 2,000 and 4,000 tons 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 3,654 tons in 2006. Newfoundland fishermen exceeded their 2006 allocation by 13%. Since 1998, this is the fourth consecutive year that fixed gear fishermen of both provinces catch their allocation.

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 from 2004 to 2006.

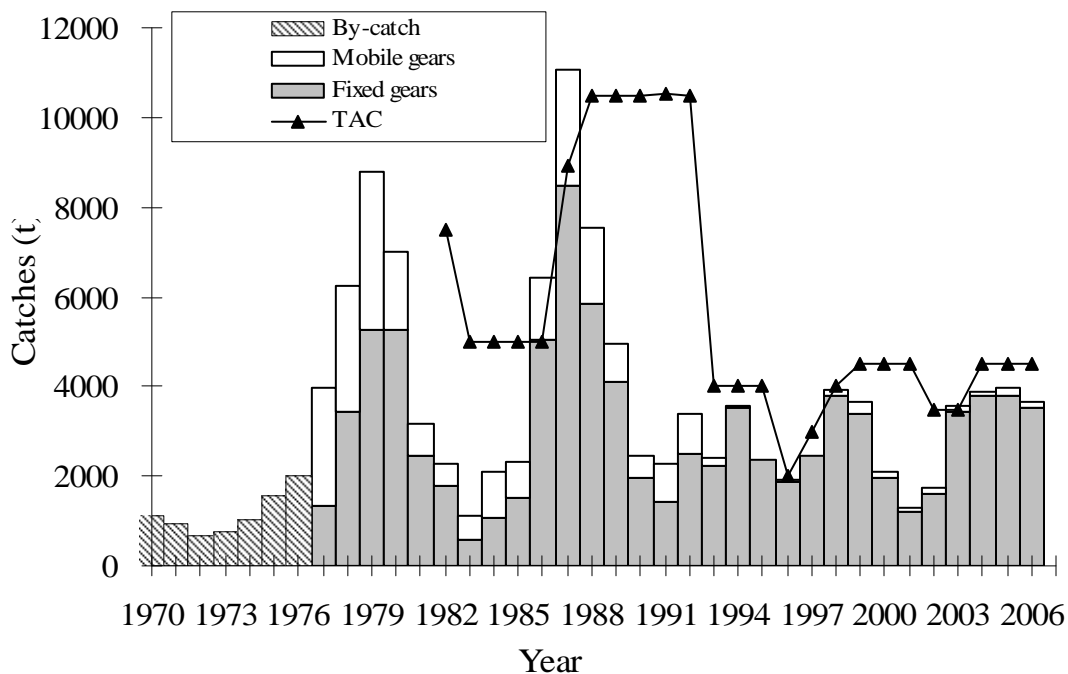


Figure 2. Annual Greenland halibut landings and total allowable catch (TAC) since 1970. Data for 2006 are preliminary.

## 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 biomass, fishery success and the stock's general condition. In order to assess the significance of the changes, the value of the 2006 indicators was compared with the 1996–2000 averages.

Indicators were rated according to one of the three following categories:

- Positive (+): the indicator's value differs from the average in a way that positively affects resource status;
- Neutral (=): the indicator's value is similar to the average;
- Negative (-): the indicator's value differs from the average in a way that adversely affects resource status.

The limits of the neutral category are delineated by the confidence intervals (95%) for the 1996–2000 average. Indicators differ from the average when their annual value is outside of the confidence interval.

### Surveys

A research survey is conducted annually in the Estuary and Gulf of St. Lawrence in August on board a Department 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 year-olds can be found.

Indices for minimum trawlable biomass, exploitable stock biomass, juvenile fish abundance (fish less than 30 cm and 1 to 2-years old), pre-recruit (40-43 cm) abundance, and the abundance of fish above the minimum legal size (over 44 cm) are calculated for these two surveys (DFO and sentinel).

Table 2. Stock indicator trends.

Indicators	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2005→2006
<b>Stock Biomass</b>													
Alfred Needler (DFO)	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↑
Sentinel July	⊖	⊕	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↑
<b>Juveniles (&lt;30 cm)</b>													
Alfred Needler (DFO)	⊖	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↑
Sentinel July	⊖	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↑
<b>Prerecruits (40-43 cm)</b>													
Alfred Needler (DFO)	⊕	⊕	⊕	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	±
Sentinel July	⊖	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↓
<b>44 cm and more</b>													
Alfred Needler (DFO)	⊕	⊕	⊕	⊖	⊕	⊕	⊕	⊖	⊕	⊕	⊕	⊕	↑
Sentinel July	⊖	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	↑
<b>Stock condition</b>													
Distribution index	⊕	⊖	⊕	⊕	⊕	⊕	⊖	⊖	⊕	na	na	na	na
Condition index	⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊕	⊕	⊕	⊕	⊕	±
Growth index	⊕	⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊕	na	na	na	na
Males maturity		⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊖	⊖	⊖	⊖	±
Females maturity		⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊖	⊖	⊖	⊖	±
<b>Fishery</b>													
Difference between fixed gear allocation and landings	⊕	⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊕	⊕	⊕	⊕	±
CPUE		⊕	⊕	⊕	⊕	⊖	⊖	⊖	⊕	⊕	⊕	⊕	↓
Mean size	⊖	⊕	⊕	⊕	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊕	±

± no or little change (0 à 5 %) ; ↑ ↓ change of 5 % à 10 %; ↑ ↓ change of 10 % or more; na indicator not available

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.

## **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 catch rate indicator was determined by standardizing (according to sector, soak time and month) the catch rates. 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.

## **Resource Status in 2006**

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 and 7). Greenland halibut stock distribution was then limited to the Estuary and the head of the Gulf channels. Recruitment of average abundance year classes (1989, 1990 1991 and 1995) then led to a productivity increase, and biomass and productivity indicators have been rather positive since 1999 (Table 2). However, fishery indicators and those describing stock condition have been mostly negative since 2000. Since the end of the 1990s, an alternation between productions of juveniles of high (1997, 1999, 2001 and 2004) and average or low abundance (1998, 2000, 2003 and 2005) has been observed (Figure 3). Biomass indices showed an upward trend in the early 2000s, which can be explained by the arrival of strong year classes from 1997 and 1999. There was no significant change in 2006. The biomass index remained the same as in 2005 and can be explained by the ever present 1999 year class and by the arrival of the 2001 average abundant year class. 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 was observed mostly south of Anticosti, along the Laurentian Channel and in the Anticosti Channel during good recruitment years.

### **Stock Status Indicators from Surveys:**

Biomass indices obtained from the DFO survey and the July sentinel fishery survey show an upward trend between 1995 and 2006 (Figure 4). However, results from the DFO survey indicate that the biomass index has remained at a relatively stable level from 2004 to 2006. The most significant biomass proportion of Greenland halibut in the Gulf of St. Lawrence is located in the west and has represented on average 77% of the total biomass since 1995. This proportion was 70% in 2006. The biomass proportion in the Estuary compared with total biomass increased from 7% to 13% between 2004 and 2006, which is closer to the average since 2000.

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.

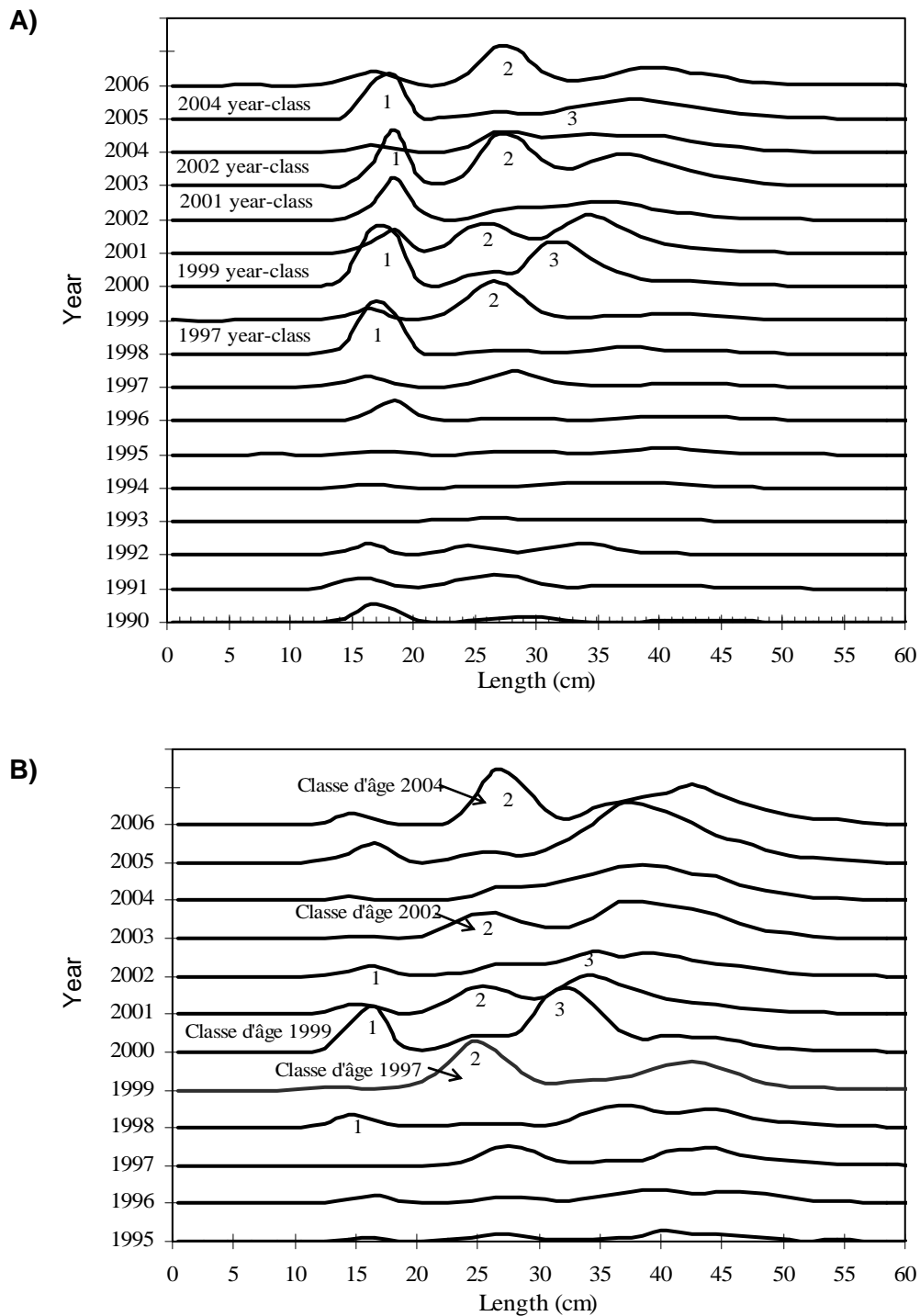


Figure 3. Size structure of Greenland halibut caught during DFO research surveys (A) (1990-2006) and (B) July sentinel survey (1995-2006). The last most significant year-classes (1997, 1999, 2001, 2002 and 2004) are shown as well as the age of the 3- year-old fish.



Even though the biomass estimates from the 2006 sentinel fishery survey dropped compared to 2005, the overall trend shows an increase between 2002 and 2006. On the whole, strong concentrations have been recorded in all areas. A 21% drop was noted in the western Gulf from 2005 to 2006.

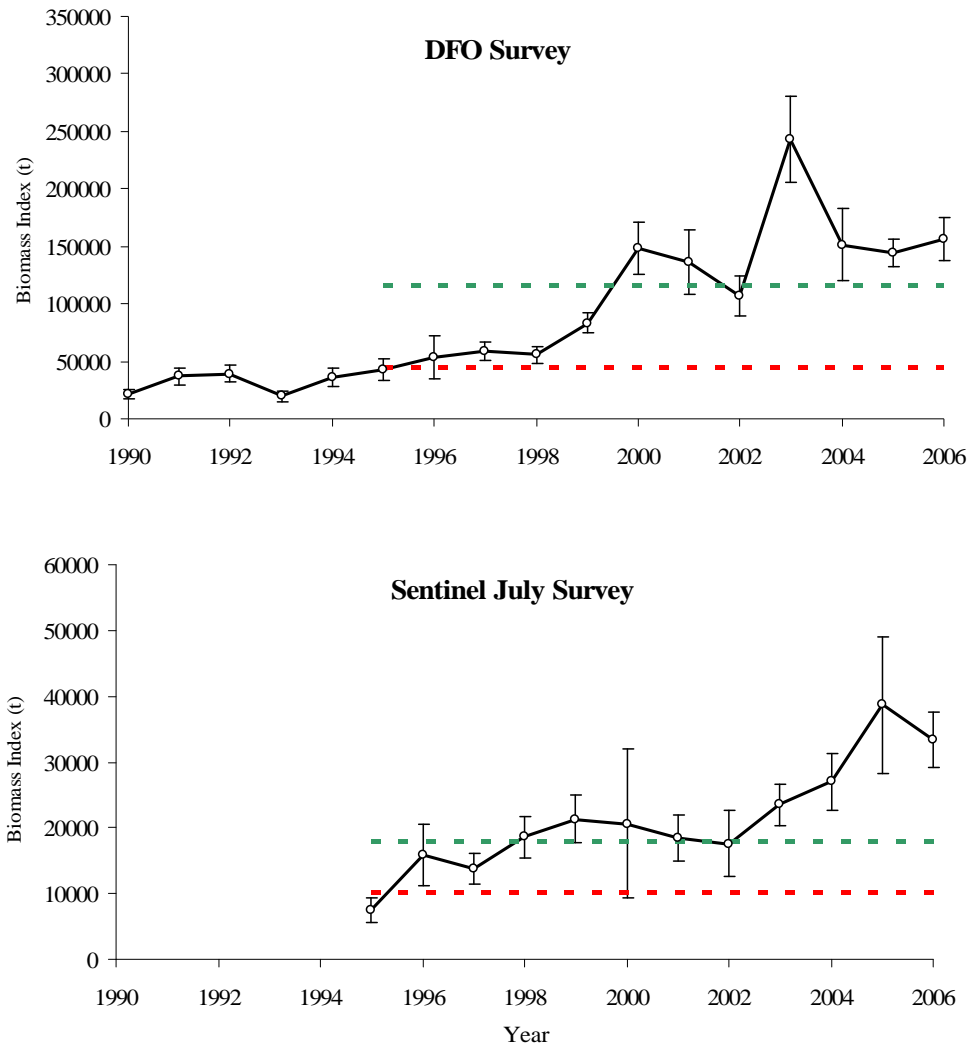


Figure 4. Minimum trawlable biomass indices for Greenland halibut in Divisions 4RST estimated from the DFO and the July sentinel survey data. The dotted lines represent the confidence intervals for the 1996-2000 average.

For the two surveys, abundance indices expressed in numbers of pre-recruits (40-43 cm) and recruits to the fishery (over 44 cm) have values that are higher in 2006 than the 1996-2000 series average.

The 2006 Fulton condition index was at its lowest level since 2002. The condition index, which is used as a fish health status indicator, was below the 1996-2000 average between 1999 and 2001. It then began improving between 2001 and 2003, and dropped again between 2004 and 2006. The 2006 value was near the lower limits of the 1996-2000 average confidence interval. There does not appear to have been any change in growth rate between 2004 and 2006, which could have explained this drop.

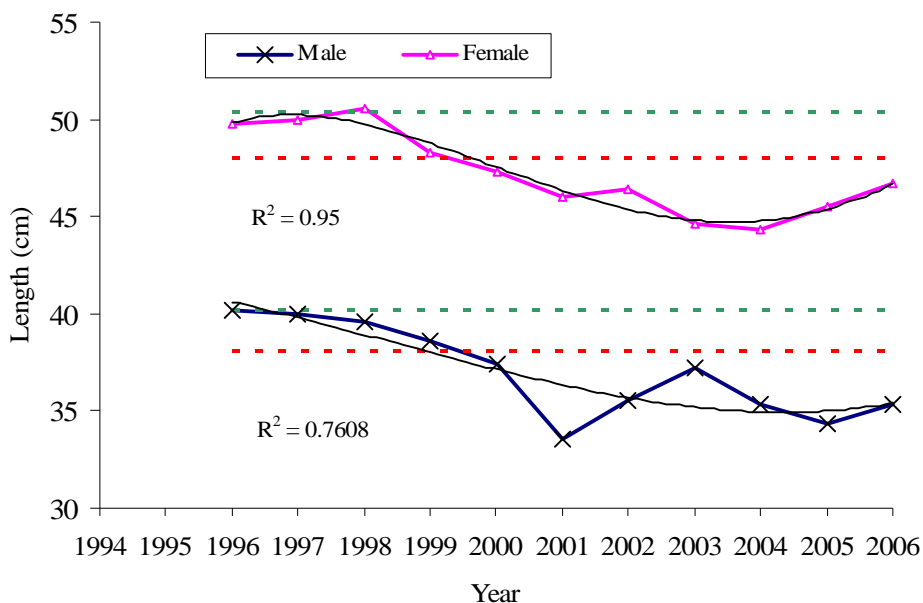


Figure 5. Length at 50% maturity for fish caught in the DFO research survey between 1996 and 2006. The dotted lines represent the confidence intervals for the 1996-2000 average.

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 47 cm for females (figure 5). The 2006 value increased slightly but remains below the 1996-2000 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, 72% of females and 2% of males are immature (Figure 6).

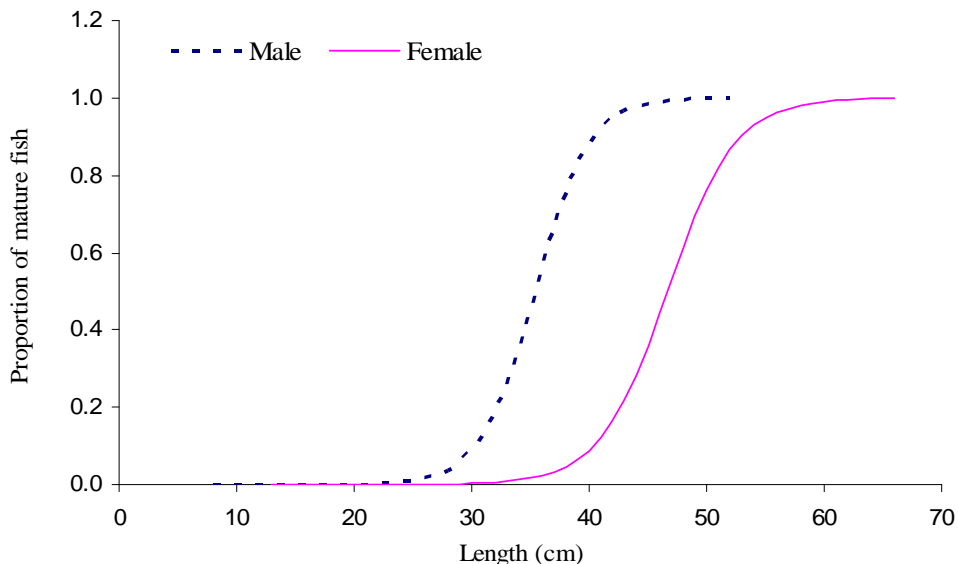


Figure 6. Maturity ogive for Greenland halibut caught in the 2006 DFO research survey.

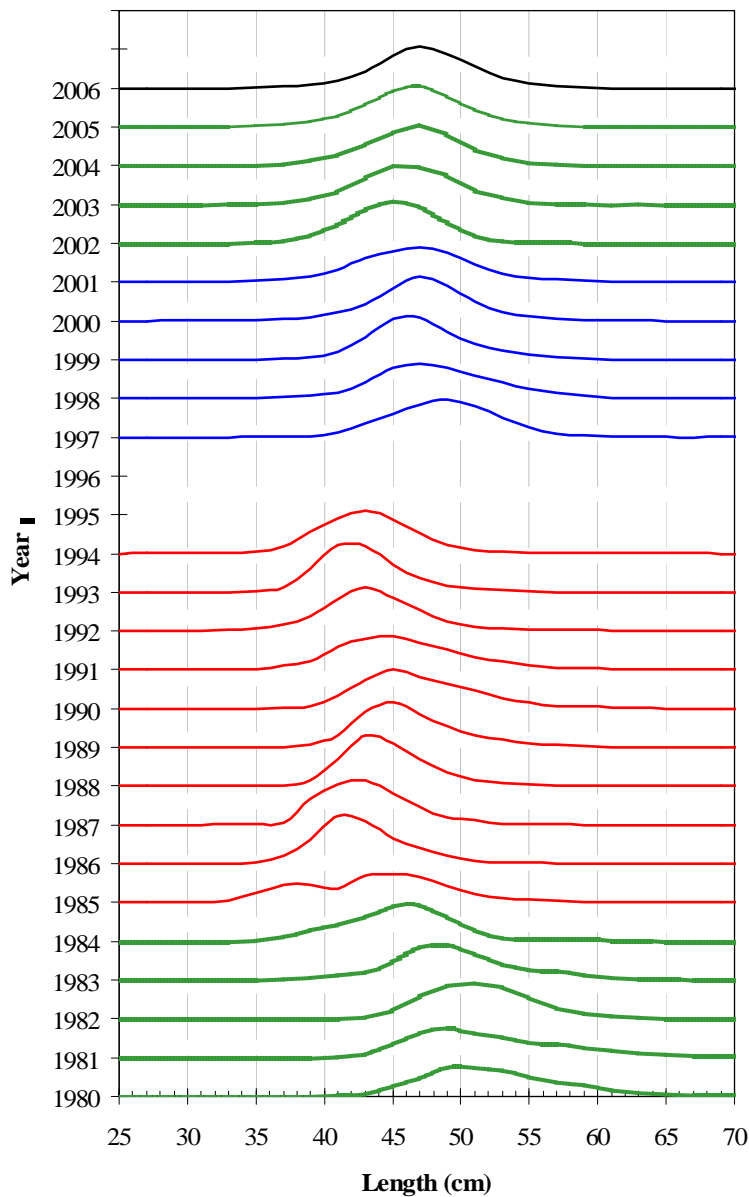


Figure 7. Size structure of Greenland halibut caught with gillnets, 1980-2006.

#### Stock Status Indicators from the Fishery:

The three fishery indicators show some stability from 2004 to 2005 (Table 2). 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. They 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 positive and stable in 2004 and 2005, indicating that these fishermen reached their allocation. CPUEs decreased by 13% in 2004, 4% in 2005 and 11% in 2006, but remain at the 1996-2000 series' average. It should be noted that in 2006, CPUEs were highest in areas north of Anticosti Island and reached their maximum in June for the entire Gulf.

The average size of the fish caught in the commercial fishery, which was roughly 43 cm in 1995, shifted to 48 cm in 1996, after an increase in mesh size from 140 mm (5.5 inches) to 152 mm (6 inches) (Figure 7). The average size of fish caught, which had been generally decreasing between 1998 and 2002 (from 48 cm to 45 cm), increased in 2004, reaching 48 cm in 2006. However, it still remains below the 1996-2000 series' average. Even though there is an upward trend in the average size in commercial catches over recent years, 17% of the fish landed are less than the legal 44 cm. This percentage differs according to the division. It is around 7% in 4R, 11% in 4S, and 33% in 4T, which represents a significant proportion of individuals that haven't reached sexual maturity.

The average size increased and the number of Greenland halibut harvested per ton landed decreased in 2006.

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 2006, 84% of commercial catches were females.

## **Outlook**

The recruitment of the two very abundant year-classes of 1997 and 1999 is the reason for the increases in abundance indices recorded in recent years. The fishery in 2007 will be mostly supported by the 2001 and 2002 year-classes, which do not appear to be as strong as the 1997 and 1999 year-classes but represent two consecutive year-classes of average abundance. For this reason, and because of the abundance of pre-recruits which remains above the 1996-2000 average, the biomass available to the fishery is expected to drop in 2007, but will remain at a similar level as in recent years. It is likely that the next year-classes, with lower abundance than 1997 and 1999, combined with the arrival of the weak year-class of 2003 in the 2008 fishery, will have a downward impact on the success of the fishery in upcoming years.

## **Sources of Uncertainty**

Indicators of the exploitable stock size differed from 2004 to 2006, even though they had been increasing since 2001 (Figure 8). The biomass of 44+ cm fish is still increasing according to the DFO and sentinel surveys, while the commercial fishery standardized CPUEs has shown a small decrease since 2004.

The extent of the simultaneous increase of abundance indices of all size classes (juveniles, pre-recruits, 44+ cm) of Greenland halibut and of several other species in the 2003 research survey indicate that external factors such as environmental factors could have an upward effect on catchability. In addition, variance associated with the 2003 biomass estimates was higher than in other years. The 2003 sentinel fishery survey also showed an increase in the abundance index for all size classes. However, the extent of the increase and variance is far less significant. These reasons lead to believe that the increase of the 2003 DFO survey indices was overestimated.

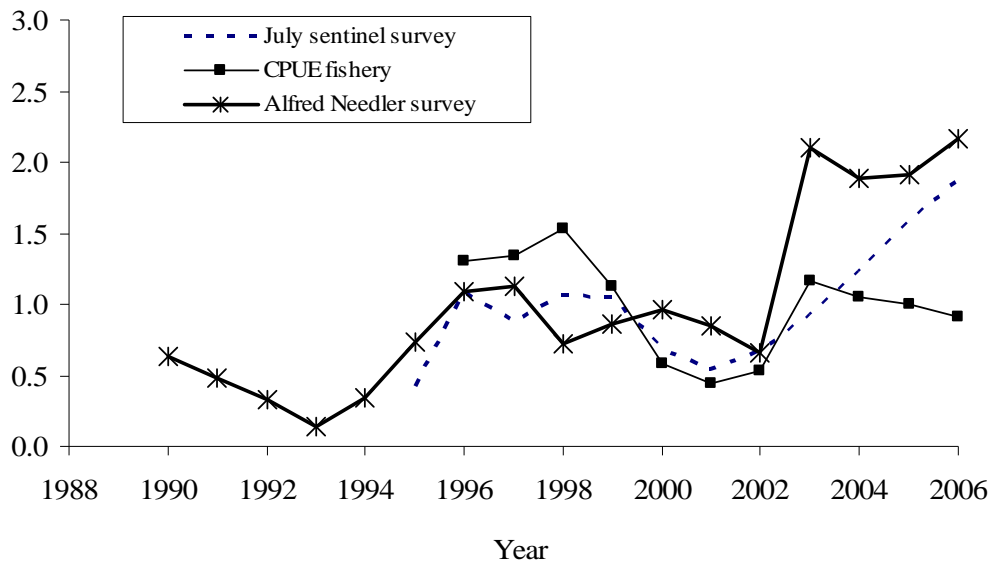


Figure 8. Standardized indices for fishable stock biomass (44+ cm) for Greenland halibut and fishery CPUEs.

The abundance index from the 2005 sentinel fishery survey has showed the highest value since 1995. This sharp increase as well as the high variability observed in 2005 would have been cut by half had it not been for the unusual presence of a large number of Greenland halibut in a localized tow south of Anticosti. Without this tow, the 2006 index would have been comparable to 2005.

## CONCLUSIONS AND ADVICE

Fishery results were generally good in 2006, and forecasts indicate that they will remain at a level comparable to recent years for 2007, 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 2007, catches equal to the 2006 TAC should create an increase in fishing pressure because the Greenland halibut biomass available to the fishery should decrease. However, because the biomass should remain at an above average level, it does not appear necessary to decrease the landings. Consequently, the status quo is recommended for the 2007 TAC.

## OTHER CONSIDERATIONS

A shift in fishing effort from west of the Estuary to the east was observed in the 2006 fishery as Greenland halibut landings were very low in the western part of the Estuary. A detailed analysis conducted from the 2005 and 2006 commercial data revealed that the percentage of individuals of less than 44 cm in the landings varied between 24% and 54% in the western part of the Estuary (4Tq and 4Tp respectively) (Figure 9). The shift of the fishery further to the east in 2006 is no doubt a consequence of the high percentage of individuals under 44 cm. This high proportion of immature individuals in commercial catches raises concerns.

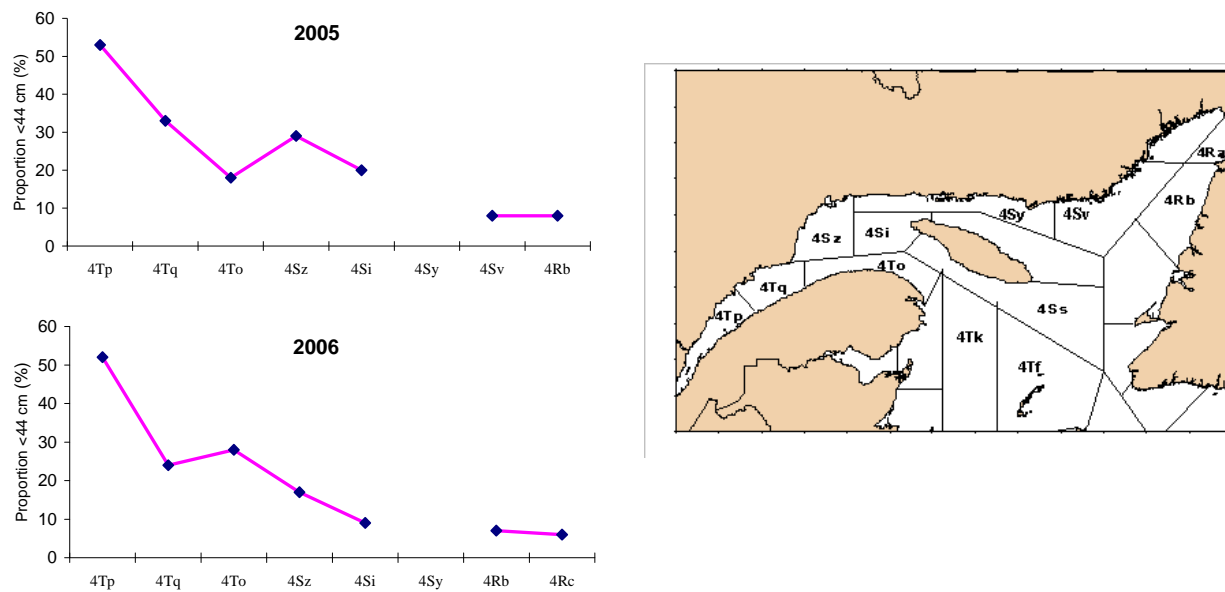


Figure 9. Distribution of individuals of less than 44 cm in 2005 and 2006

Even though size at sexual maturity slightly increased in 2006 for Greenland halibut males and females, the 2006 value was still below the 1996-2000 average. This indicator raises concerns in terms of conservation of the spawning stock.

Greenland halibut by-catches from the shrimp fishery from 1999 to 2006 were examined using the observers at sea database. At least one Greenland halibut was present 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 2006 is in the order of 100 tons and are mostly comprised of 1 and 2 year-old individuals.

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