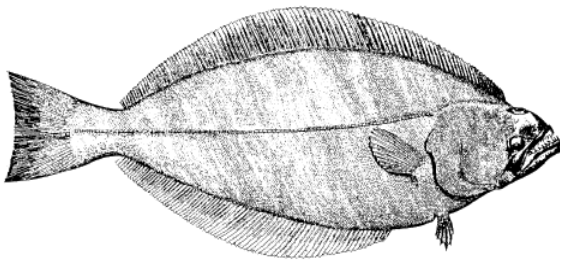


Gulf of St. Lawrence (4RST) Greenland Halibut in 2003

Background

Greenland halibut (also known as black halibut, or turbot) in the Gulf of St. Lawrence are considered to be a stock isolated from the main Northwest Atlantic population found to the east and north of Newfoundland's Grand Banks. Parasite research conducted in the early 1990s showed that the Gulf population was distinct; all Greenland halibut in the Gulf, the Laurentian Channel and adjacent areas could be clearly distinguished from those of Labrador and the northern Grand Banks, suggesting 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 of 130–500 m (70–280 fathoms). 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 more sharply than that of the latter. This difference helps explain why females grow to be larger than males and make up the majority of commercial landings.

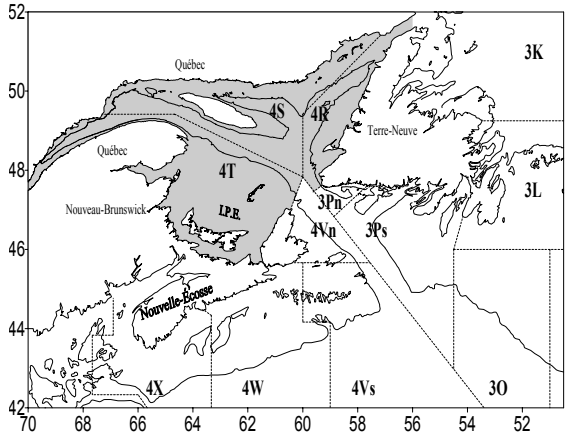


Figure 1. Map of the Gulf of St. Lawrence and adjacent areas, showing NAFO 4RST divisions

Summary

- Preliminary landings in 2003 were more than double those in 2002, increasing from 1,730 t to 3,525 t. For the last ten years, Quebec and Newfoundland fishers have used gillnets almost exclusively. In 2003, Newfoundland fishers exceeded their allocation by 53% and Quebec fishers, by 6%. This is the first time since 1998 that Quebec fishers caught their quota.
- Catch per unit of effort (CPUE) by gillnetters increased in all unit areas in 2003. Standardized CPUE by traditional gillnet fishers using 6-inch mesh have been increasing since 2001. Females have made up a greater proportion of landings since 1999, due to the decreased abundance of males over 42 cm in 1998–2002. The 1997 year-class, which was recruited to the Esquiman Channel fishery in 2002, probably made up a large proportion of the catch in all parts of the Gulf in 2003.
- Comparative fishing experiments conducted in Quebec in 2002 and 2003 using various mesh sizes showed that the proportion of females in landings increased slightly with mesh size, while CPUE decreased. In addition, the

percentage of mature females increased from 38% to 71% between 2002 and 2003 with 5.5-inch mesh and from 58% to 77% with 6-inch mesh. These changes can be attributed to the decrease in size at maturity for females between 2002 and 2003 (from 46 cm to 44.5 cm).

- Biomass indices obtained from trawl surveys (DFO and sentinel fishery surveys) decreased in 2001 and 2002 but increased in 2003. The higher biomass values in 2003 can be attributed to the recruitment of several large year-classes, including the 1997 year-class, which was first recruited to the fishery in 2002 and 2003. The 1999 year-class also seems to be fairly large and growth rates appear to be better than in the previous year-class. Abundance indices for juveniles of the 2001 and 2002 year-classes were also high.
- The 2004 fishery will probably be supported by the abundant 1997 year-class and, to a lesser extent, the 1998 year-class. The strong 1999 year-class could begin to be recruited to the fishery owing to its higher growth rates.
- Stock size indicators show an increase in abundance in 2003. Forecasts for 2004 are positive due to the presence of several good year-classes and high numbers of pre-recruits. CPUE data indicate that the fishable stock biomass increased by 55% between 2001 and 2002 and by 57% in 2003, while the July sentinel fishery survey showed increases of 10% and 31% for the same period. DFO research surveys indicate a 11% decrease between 2001 and 2002 and a 208% increase in 2003. However, the increase in fishable biomass calculated in the latter survey may be an overestimate since there is reason to believe that it was affected by changes in catchability between 2002 and 2003.

The fishery

Landings (thousands of tons)

Year	77-98 av.	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004[1]
TAC	-	4.5[2]	4.5[3]	4.5[3]	3.5[3]	3.5[3]
Fixed gear	3.1	3.4	2.0	1.2	1.6	3.4
Mobile gear	1.1	0.2	0.1	0.1	0.1	0.1
Total	4.2	3.6	2.1	1.3	1.7	3.5

[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*

Conservation measures

Total allowable catches (TAC) have been set for Greenland halibut since 1982, to manage the fishery (Figure 2). In 1999, the TAC was set at 4,500 t and the fishing season ran from January 1, 1999 to May 14, 2000. In 2000-2001 and 2001-2002, the TAC remained unchanged but the season ran from May 15 of the current year to May 14 of the following year. In 2002-2003 and 2003-2004, the TAC was cut to 3,500 t.

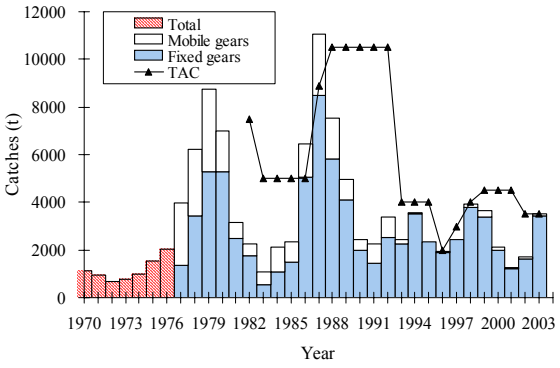


Figure 2. Annual Greenland halibut landings and total allowable catch (TAC). Data for 2003 are preliminary.

Following Fisheries Resource Conservation Council (FRCC) recommendations to reduce fishing effort and the number of immature fish caught, major conservation measures were implemented in 1995:

- 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 minimum legal size (42 cm in 1996 and 44 cm since 1997) along with enforcement of a small-fish tolerance protocol for commercial landings;
- Establishment of a dockside monitoring program for commercial landings;
- Voluntary reduction in the number of nets used by Quebec fishers (from 120 to 80 nets) between 1996 and 2000.

Landings

Until the mid-1970s, Greenland halibut landings in 4RST consisted mainly of by-catches of other fisheries (Figure 2). Subsequently, a directed gillnet fishery developed and landings fluctuated substantially, exceeding 8,000 t on two occasions (1979 and 1987), due in part to additional landings using mobile gear. Beginning in 1989, landings stabilized between 2,000 t and 4,000 t. Since 1993, virtually no landings have been made using mobile gear because of the moratorium on directed cod fishing with this type of gear and because shrimpers are required to use Nordmore grates. The fishery is now made up of gillnetters with home ports in Quebec and the west coast of Newfoundland. An individual quota pilot project was launched in 1999 for traditional Quebec fishers to extend their fishing season. The pilot project became permanent in 2002.

Landings decreased by 67% between 1999 and 2001. This significant drop reflects the disappointing results obtained for the fishery in 2000 and 2001, particularly for Quebec fishers. The 2002 data show a 25% increase in landings over the previous year, while preliminary data for 2003 landings show that they have more than doubled since 2002. Newfoundland fishers exceeded their allocation by 53% in 2003 and Quebec fishers exceeded theirs by 6%. This is the first time since 1998 that Quebec fishers caught their allocation.

Composition of landings

The mean size of the fish making up commercial landings was roughly 43 cm in 1995, increasing to 48 cm in 1996, after an increase in mesh size from 140 mm (5.5 inches) to 152 mm (6 inches) (Figure 3). The mean size decreased between 1998 and 2002 (from 48 cm to 45 cm); as a result, the number of Greenland halibut per tonne landed increased by 30% during the same period.

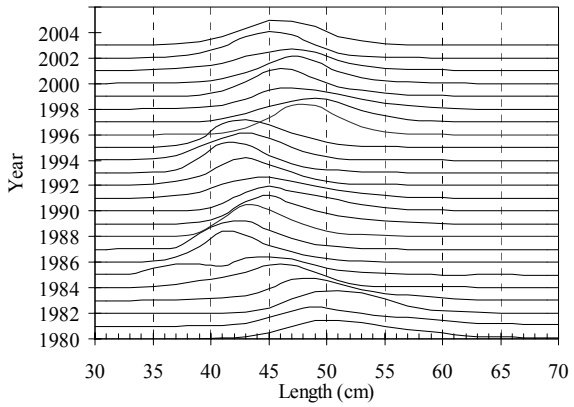


Figure 3. Size structure of Greenland halibut caught with gillnets, 1980–2003.

During the first half of the 1990s, the proportion of females in gillnet catches averaged 58%. Beginning in 1996, this figure rose to an average of 79%, as a result of the bigger mesh size. The percentage of females in landings has been increasing since 1998, reaching 86% in 2002 and 84% in 2003.

Fishery yields

Since 1999, the duration of gillnet sets has usually been three days or more, while between 1996 and 1998, nearly 50% of sets consisted of only a day or two. Between 2000 and 2002, however, the number of

sets of four days or more decreased. Decreased yields per set were observed between 1998 and 2001, which, along with the introduction of individual quotas (IQ) in Quebec, explains why the fishing season was extended during this period. In 2002 and 2003, however, yields increased for all set durations. Catch rates per subdivision (or unit area) improved in all areas in 2003.

Resource assessment

Resource status was determined by studying indicators from both the commercial fishery and scientific surveys. These indicators were examined for different periods so the status of the resource could be assessed over various time horizons. First, the values of a few indicators were compared with the 1990–2000 averages to assess long-term trends. Then, the values for all the indicators were compared with the 1996–2000 averages to assess recent stock trends. Lastly, the 2002 and 2003 values for all indicators were compared to gauge the direction and scale of changes between these two years.

For medium- and long-term trends, the indicators were rated according to three categories:

Positive: the indicator's value differs from the average in a way that positively affects resource status (e.g. above-average biomass).

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 neutral category is delineated by the confidence intervals for the 1990–2000 or 1996–2000 averages. Indicators differ from the average when their annual value is above or below the upper and lower confidence interval limits.

Data used

Research surveys

Since 1990, annual DFO research surveys have been carried out in the St. Lawrence estuary and northern Gulf of St. Lawrence. Surveys are conducted, using a stratified random sampling design, from the Department's research vessel, the *CCGS Alfred Needler*, which is equipped with a shrimp trawl.

Since 1995, cod sentinel fishery surveys have been conducted in July in the northern Gulf, using several vessels with otter trawls. These surveys do not cover the St. Lawrence estuary, where about 20% of the Greenland halibut biomass is found.

Indices for minimum trawlable biomass, abundance of juveniles (fish under 30 cm and 1 to 2 years old), and abundance of fish above the minimum legal size of 44 cm were calculated for the two surveys (DFO and sentinel).

Data on the sexual maturity of males and females have been gathered since 1996 during DFO August cruises, i.e. several months before spawning. Sexual maturity is assessed according to morphological criteria for all fish measured during these cruises. The length at which 50% of fish are mature (L_{50}) is determined for both males and females and is used as a stock status indicator.

The modal length at age 3 is determined from length frequencies obtained from the DFO survey and is used as a growth indicator. Condition indices (weight/length cubed) were also calculated from the DFO survey data. Lastly, an annual distribution index was calculated from DFO survey data, using biomass estimates per stratum. The index corresponds to the minimal area that contains 95% of the biomass.

Commercial fishery

The primary indicator of fishing success in the commercial fishery is the difference between fixed-gear quotas and related

landings. The catch rate indicator was determined by standardizing (by sector, soak time and month) catch rates by traditional gillnet fishers using 6-inch mesh nets between 1996 and 2003. Lastly, the mean fish size for landings made with gillnets was calculated and used as the third indicator.

Resource status

Recruitment and growth (Table 1)

Since the late 1980s, two good years for juvenile production (fish under 30 cm long and one or two years old) have been observed. A first group of average abundance was observed in DFO survey catches in the early 1990s (1989, 1990 and 1991 year-classes) (Figure 4). The next three year-classes (1992, 1993 and 1994) were low in abundance. Recruitment increased during the last half of the 1990s, a period that was also characterized by alternating year-classes of high and average abundance. The 1997, 1999 and 2001 year-classes were of above-average abundance, while those of 1996, 1998 and 2000 were lower in abundance.

Several hypotheses can be advanced to explain the causes of these fluctuations in year-class strength. For example, a link has been observed between the abundance of spawners and the abundance of the recruits produced by these spawners. An additional association has been observed in the western Gulf between primary production in spring and recruitment strength. Therefore, parental stock size and environmental conditions at the time larvae are released into the environment appear to be crucial to recruitment success in the Gulf of St. Lawrence Greenland halibut stock.

Growth rates during the first three years of life varied from cohort to cohort (Figure 5). Values for length at age 3 in the 1989, 1990 and 1991 year-classes were below average. The 1992 to 1995 year-classes, which were less abundant, had higher growth rates. Subsequently, growth rates decreased and the modal length at age 3 in the 1997, 1998 and 1999 year-classes was below average. Growth rates in the 1999 and 2000 year-classes were better than in previous year-classes.

Year-class strength and growth rates affect the abundance of halibut available to the fishery four or five years after they are detected in survey catches, depending on growth rate.

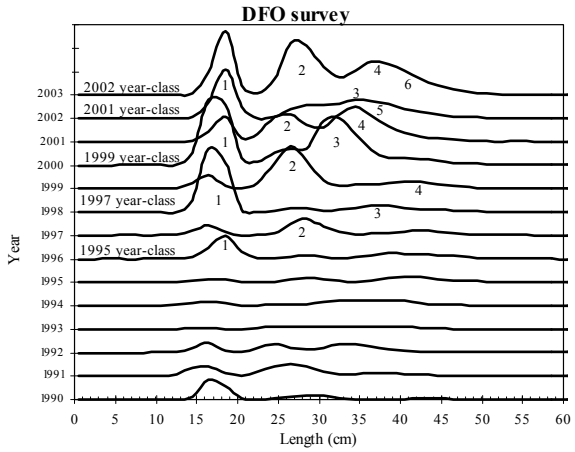


Figure 4. Size structure of Greenland halibut caught during DFO research surveys. The five largest recent year-classes (1995, 1997, 1999, 2001 and 2002) are shown, as is the age of the fish each year.

Table 1. Abundance of juveniles and growth index for three-year-old halibut.

Indicators	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Abundance of juveniles	=	=	=	−	−	−	=	=	+	+	+	+	=	+
Growth index	+	+	−	−	−	+	+	+	+	=	−	−	−	=

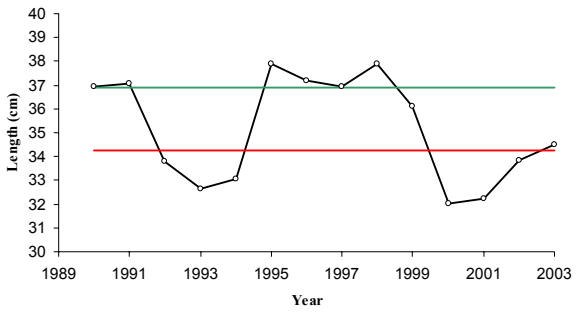


Figure 5. Mean length at three years of age for Greenland halibut, from DFO research surveys. Solid lines show the upper and lower limits for the 95% confidence interval for 1990–2000 means.

Long-term trends (Table 2)

Most stock status indicators from 1990 to 1994 were negative. The abundance of halibut over 44 cm long was at an all-time low (for the entire 1990-2003 period). Total stock biomass ranged from low to average (Figure 6), and the stock's distribution was limited to the estuary and the head of the Gulf of St. Lawrence channels. Stock condition was below average or average during the period.

From 1995 to 1998, indicators were neutral or positive, reflecting an increase in biomass and abundance of halibut available to the fishery, thanks to the contribution of the abundant 1989, 1990 and 1991 year-classes. Stock condition was quite good. The stock's geographic range expanded, mainly south of Anticosti Island along the Laurentian Channel.

The number of negative indicators rose between 1999 and 2001, reflecting lower values for fish condition indices. However, indicators for biomass and abundance remained high from 1999 to 2002 due to the contributions of the 1995 and 1996 year-classes. The stock's geographic range remained extensive, with high concentrations in the estuary and western Gulf.

Stock status indicators were all positive in 2003. The strong 1997 year-class was partly responsible for the increased abundance of halibut available to the fishery in 2003. The strong 1999 and 2001 year-classes also helped maintain total stock biomass and the area occupied by the stock at very high levels. Fish condition was also significantly better.

Recent trends (Table 3)

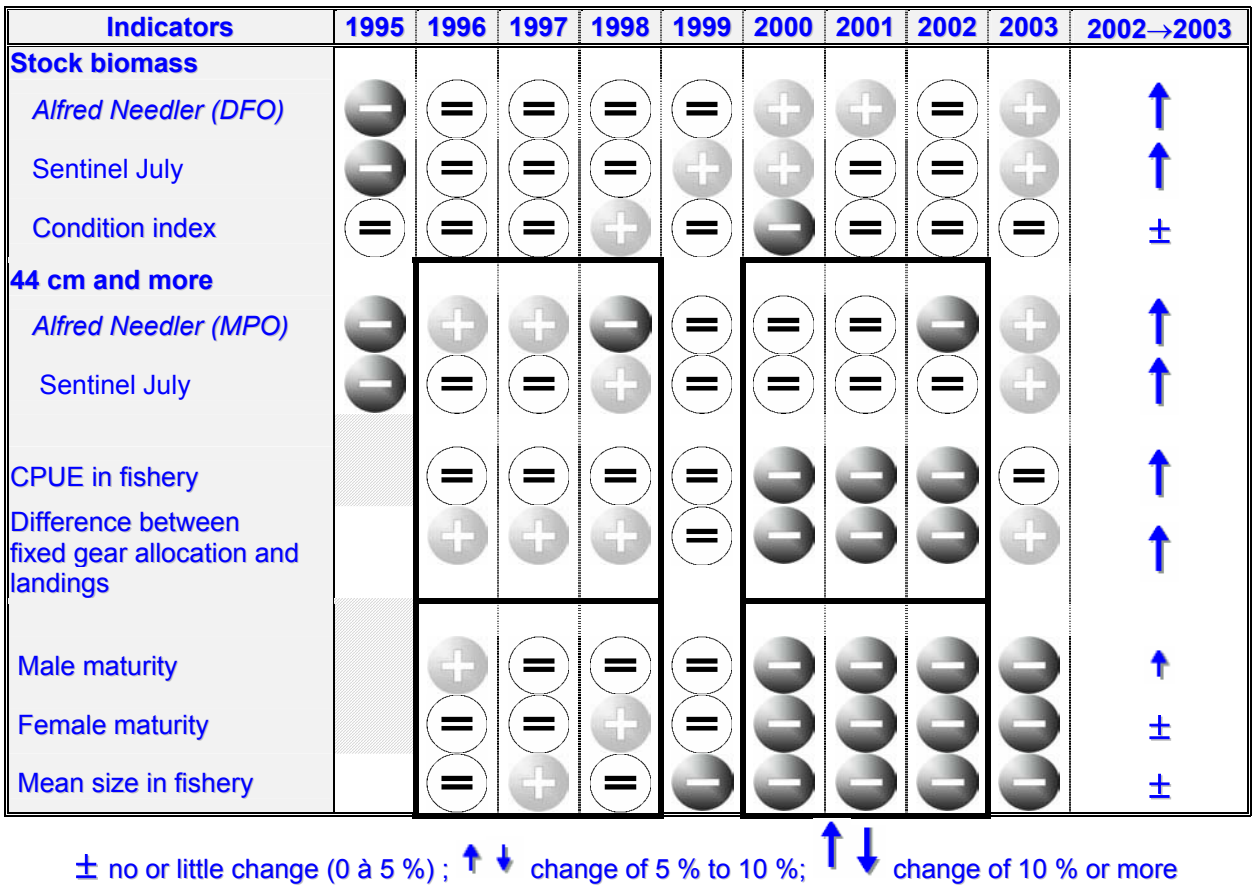
The set of indicators on which data have been gathered since 1996 allows recent stock trends and the effects of the recruitment of strong cohorts to the fishery to be assessed.

The 1989, 1990 and 1991 cohorts, of average abundance, began to be recruited to the fishery in 1995. The abundance of halibut available to the fishery increased in 1996 as these cohorts grew. These year-classes also had a positive effect on fishing success in 1996, 1997 and 1998 by keeping CPUEs at high levels, allowing fishers to easily catch their quotas. Fish condition was good and values for length at sexual

Table 2. Long-term stock indicator trends

Indicators	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Stock biomass	−	=	=	−	=	=	=	=	+	+	+	+	+	+
Stock distribution	−	−	−	=	=	+	=	+	=	+	+	=	=	+
Condition index	=	−	=	+	=	=	=	+	+	−	−	−	+	+
Abundance ≥ 44 cm	−	−	−	−	−	=	+	+	=	+	+	+	=	+

Table 3. Recent stock indicator trends



maturity were fairly high. Mean fish size remained high for commercial landings.

The year 1999 was a transitional one for many stock indicators. The 1989, 1990 and 1991 cohorts made a decreasing contribution to the fishery, while those year-classes that should have been recruited to the exploitable stock between 1997 and 1999 were not at all abundant. The 1999 fishery was dependent on recruits from the 1995 year-class, which was of average abundance. The contribution of females from the 1995 year-class to the 1999 fishery led to a decrease in mean fish size. The abundance of halibut available to the fishery was moderate and CPUE values decreased. Fishers were beginning to have difficulty catching their quotas.

From 2000 to 2002, the contribution from the 1995 and 1996 year-classes was not enough to counter the declining trend for indicators that began in 1999. The abundance of these year-classes was low to moderate; hence, the abundance of halibut available to the fishery remained at average levels. CPUEs dropped to below-average values and fishers were not able to catch all their quota. Size at sexual maturity and mean fish size were the lowest recorded. The 1997 year-class should have been recruited to the fishery at the end of this period. However, lower growth rates and smaller size at sexual maturity delayed the entry of this year-class into the fishery. The females of this year-class began to be recruited in the eastern Gulf in 2002 but their contribution was insufficient to significantly improve fishing success throughout the stock's range.

In 2003, females in the 1997 year-class were large enough to be recruited to the fishery in all sectors, resulting in an increase

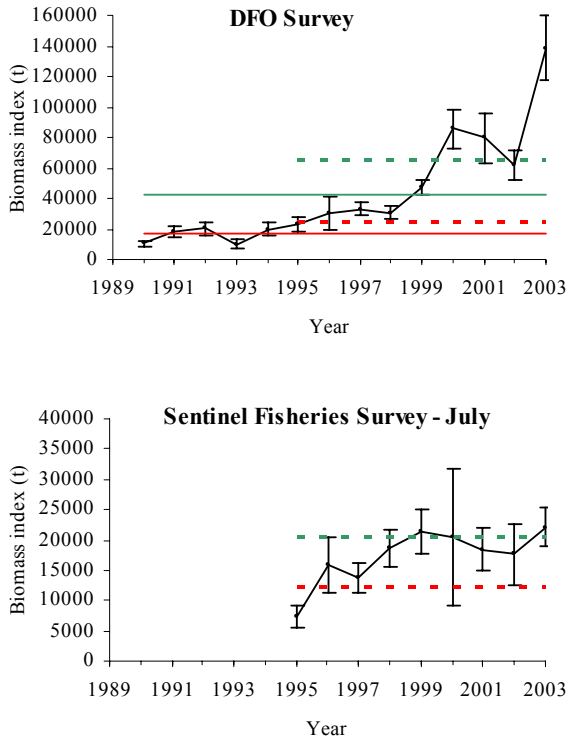


Figure 6. Minimum trawlable biomass indices for Greenland halibut in Divisions 4RST estimated from DFO and July sentinel fishery survey data. The lines represent the upper and lower limits for confidence intervals for 1990–2000 (solid lines) and 1996–2000 (dotted lines) mean.

in the number of halibut available to the fishery and in higher CPUEs. Fishers easily caught enough to meet their quota. Stock biomass was very high in 2003 due to the additional contribution from the abundant 1999 and 2001 year-classes, which had not yet reached recruitment size, however. Fish condition has been around average since 2001 but size at sexual maturity and mean fish size were still low in 2003.

Size at sexual maturity for males was still well below the minimum legal size. Since the growth rate in halibut decreases after sexual maturity, males probably take longer to reach minimum legal size than females of the same year-class. These sex-based differences in size at sexual maturity and growth rates biased the sex ratio in commercial landings in favour of females.

Data on sexual maturity show that the size at which 50% of halibut are mature (L_{50}) declined between 1998 and 2001 (Figure 7), decreasing from 39 cm to 33.5 cm for males and from 50 cm to 46 cm for females. After dipping in 2001, size at maturity for males has been increasing during the past two years while, for females, this value continued to decrease in 2003 to 44.5 cm, the lowest value recorded since 1996. The weaker growth for the 1997 year-class has probably had an effect on the values for size at maturity since 2001, since males normally reach maturity at four years and females at six. Size at maturity for females could increase by 2004, as was observed for males in 2002.

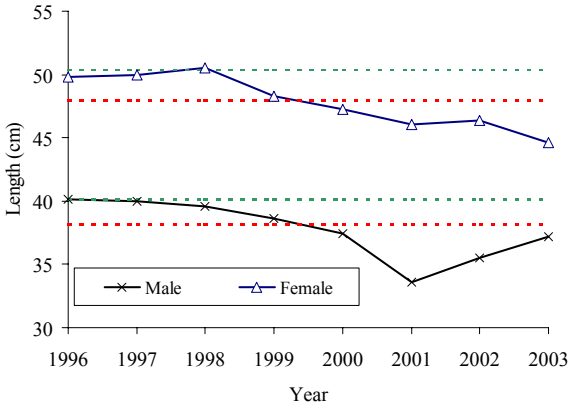


Figure 7. L_{50} values from fish caught in DFO research surveys between 1996 and 2003. The dotted lines represent the upper and lower limits for confidence intervals for the 1996–2000 mean.

Outlook

Stock size indicators show an increase in the size of the population in recent years. CPUE values indicate that the fishable stock biomass increased by 55% between 2001 and 2002 and by 57% in 2003, while the July sentinel fishery surveys showed increases of 10% and 31% for the same period (Figure 8). DFO research surveys indicate a 11% decrease between 2001 and

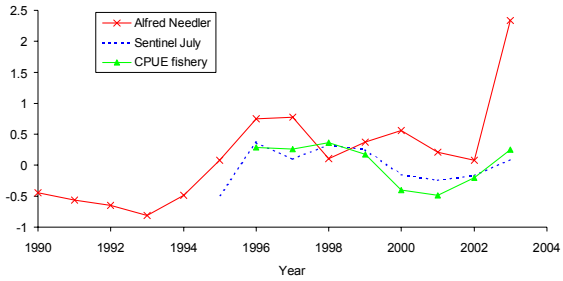


Figure 8. Standardized indices for fishable stock biomass (44 cm and over) for Greenland halibut and CPUE values for the fishery

2002, but a 208% increase in 2003. However, the increase in fishable biomass derived from the 2003 survey may be overestimated since researchers suspect that it has been affected by changes in catchability between 2002 and 2003.

Forecasts for 2004 are positive given the presence of several good year-classes responsible for increased stock abundance in recent years. The 2004 fishery will likely be supported by the abundant 1997 year-class and, to a lesser degree, the 1998 year-class. The strong 1999 year-class could begin to be recruited to the fishery due to its high growth rates. These year-classes will probably have a positive affect on fishing success in coming years.

Comparative fishing using different mesh sizes

Comparative fishing experiments were conducted by a number of fishers in the St. Lawrence estuary and northern Gaspésie in 2002 and 2003 using different mesh sizes. The objective of the initiative, which was carried out according to a scientific protocol, was to describe fish size, sex ratio, sexual maturity and yields by mesh size (5.5 and 6 inches in 2002 and 5, 5.5, 6 and 6.5 inches in 2003). The results showed that the proportion of females in landings increased slightly with mesh size (from 5 to 6 inches), while CPUE values decreased. In addition, from 2002 to 2003, the percentage of mature females increased from 38% to 71% with 5.5-inch mesh and from 58% to 77% with 6-inch mesh. These changes can probably be explained by the decrease in size at maturity for females from 46 cm in 2002 to 44.5 cm in 2003. CPUE values for 5.5- and 6-inch mesh were higher in 2003 than in 2002.

Uncertainty

Environmental factors may have had an impact on the availability of Greenland halibut of all sizes to trawls, probably resulting in increased catchability in 2003. A review of environmental conditions in the Gulf in 2003 shows that the mean thickness of the cold intermediate layer (CIL) increased by 35 metres and its volume by 40% compared with 2002. Minimum temperature in the CIL decreased by 0.6°C and salinity increased by roughly 0.4. These are significant changes that could have reduced the extent of vertical movements by Greenland halibut or its prey species, increasing the availability of these fish to bottom trawls in August 2003.

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ISSN 1480-4913 (Printed)

La version française est disponible à l'adresse ci-dessus.

Correct citation for this publication

DFO, 2004. Gulf of St. Lawrence (4RST) Greenland Halibut in 2003. DFO Can. Sci. Advis. Sec. Stock Status Rep. 2004/014.