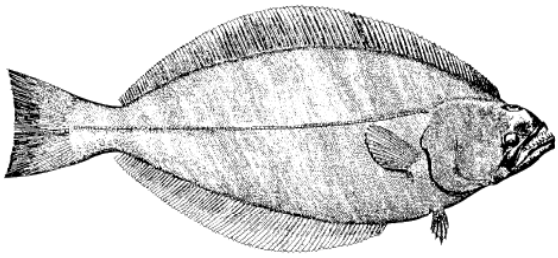

Gulf of St. Lawrence (4RST) Greenland Halibut in 2001

Background

The Greenland halibut (also known as turbot) population of the Gulf of St. Lawrence is considered an isolated stock, the main population being found in the north-west Atlantic, east and north of the Newfoundland Grand Banks. In the early 1990s, parasite studies showed that the Gulf population was distinct. All Greenland halibut from the Gulf, the Laurentian Channel and adjoining areas could be clearly distinguished from those of Labrador and the northern Grand Banks, suggesting that these turbot complete their life cycle within the Gulf.

Greenland halibut is generally found in the channels of the Gulf of St. Lawrence at depths of 130 to 500 m (70–280 fathoms). Spawning takes place mainly in winter, from January to March. Males reach sexual maturity at smaller sizes than do females, so that their growth rate drops more sharply than the females. This difference helps explain why females grow larger and make up the majority of commercial catches.

In the early 1990s, the fishery was characterized by low yields and a preponderance of small, immature fish in catches. Pursuant to FRCC recommendations in 1994, conservation measures (reduced fishing effort, bigger mesh size, a small fish tolerance protocol for commercial catches) were implemented to improve protection of breeding potential.

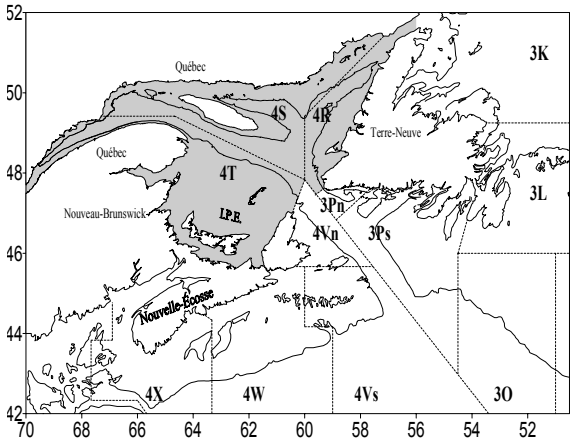

Figure 1. Map of the Gulf of St. Lawrence and adjacent areas showing NAFO 4RST divisions

Summary

- In spite of a slight drop in the minimum trawlable biomass indices from 2000 to 2001, the indices determined by recent years' surveys have been higher than in the early and mid nineties. These high indices are chiefly due to the production of three large year-classes (1995, 1997 and 1999). The increase in biomass in the later nineties was accompanied by a wider dispersal of Greenland halibut in the Gulf of St. Lawrence.
- Abundance of fish of larger than minimum catch size (44 cm plus) declined from 2000 to 2001, but is still within the average for the years 1996 to 2000. Since 1998, males of 44 cm and up have been less abundant, which may explain the greater proportion of females in commercial catches over the same period.
- The individual growth rate in the large 1997 year-class is lower than for previous ones in the western Gulf, which means that this year-class will not be available to the fishery in 2002 because it will not have reached minimum catch size. In the Esquiman Channel,

however, fish of this year-class may start recruiting to the fishery in 2002, since their growth rate appears to be normal. The modal length of these fish in the Esquiman Channel in 2001 was about 40 cm, compared to 35 cm elsewhere.

- Between 1996 and 2001, there was a decline in size of sexual maturity. For males, the length at which 50% of specimens were mature fell from 40 to 33.5 cm, while for females it fell from 50 to 46 cm.
- Catch rates for gillnet fishermen fell again in 2001 and are now very low compared with the 1996-1998 period. Preliminary landings for 2001-2002 were down 43% from the previous year for the same TAC.
- Though the survey abundance indices remain high, gillnet catch rates are low, for reasons that still have to be elucidated.

The Fishery

Landings (thousands of tonnes)

Year	77-96 av.	1997	1998	1999-2000	2000-2001	2001-2002[1]
TAC	-	3.0	4.0	4.5[2]	4.5[3]	4.5[3]
Fixed gear	3.1	2.4	3.8	3.4	2.0	1.2
Mobile gear	1.2	0	0.1	0.2	0.1	0
Total	4.3	2.4	3.9	3.6	2.1	1.2

[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*

Until the mid 1970s, turbot landings in 4RST consisted primarily of bycatches of other fisheries. Later, a fishery using gillnets and bottom trawls developed, and the increased fishing effort led to the 1979 peak in landings (Figure 2). Soon after, landings plummeted and remained weak

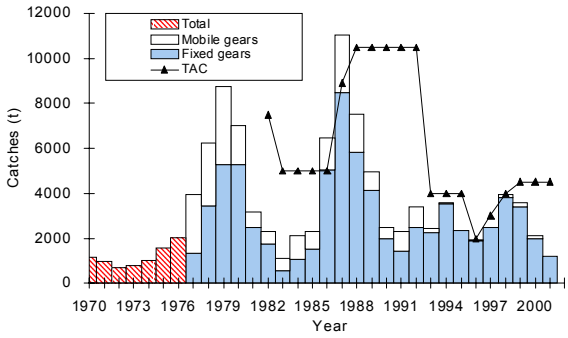

Figure 2. Annual Greenland halibut landings and total allowable catch (TAC) since 1970. Figures for 2001-2002 are preliminary

between 1981 and 1985. The second period of high landings was between 1986 and 1988 and stemmed from several factors: resource abundance, growing interest on the part of fishers, greater fishing efficiency thanks to the technological developments of the early 1980s, and the increase in the price offered. In 1989, catches began a steep downturn, falling as low as 2,306 t in 1991, and remained between 2,000 and 4,000 t until 1999. Landings shrank by 42% from 1999 to 2000, and preliminary 2001 figures point to a further decline of 43% from the previous year. This serious decline reflects the disappointing results of the 2001 season, especially for Quebec fishers. However, a significant portion of the Quebec quota (over 2,300 t) is still available to the fishery for the spring of 2002.

Since 1993, virtually no catches have been made using mobile gear because of the moratorium on cod fishing with this gear type and because use of the Nordmore grate has been made mandatory for shrimpers. This fishery is now dominated by gillnetters whose home ports are in Quebec and on the west coast of Newfoundland. An individual quota pilot project was introduced in 1999 for traditional fishers in Quebec to allow them to extend their fishing season. The project was continued in 2000 and 2001.

Conservation Measures

The total allowable catch (TAC) was set at 4,000 t from 1993 to 1995. In 1996, it was cut to 2,000 t, but was raised to 3,000 t in 1997 and to 4,000 t in 1998. The 1999 TAC was increased to 4,500 t, and the season ran from January 1, 1999 until May 14, 2000. In 2000 and 2001, TAC remained unchanged (4,500 t), but the season ran from May 15 of one year to May 14 of the next. Pursuant to FRCC recommendations to reduce fishing effort and cut the quantity of immature fish taken, far-reaching conservation measures were introduced starting in 1995:

- increase in mesh size from 140 mm (5½ inches) to 152 mm (6 inches);
- adoption of a fishing net configuration that is more selective;
- introduction of a minimum size limit (42 cm in 1996 and 44 cm since 1997), along with application of a small fish tolerance protocol for commercial catches;
- establishment of a dockside monitoring program;
- voluntary reduction in the number of nets used by Quebec fishers (from 120 to 80 nets) between 1996 and 2000.

Composition of commercial catches

The average size of gillnet-caught fish fell between 1980 and 1985 (Figure 3). From 1985 on, the strong year-classes of 1979 and 1980 started to be fished, leading to a gradual increase in average catch length because of their growth rate. Starting in 1990, when these cohorts had been fully exploited, the fishery targeted new, less robust year-classes. The result was that average catch size declined again, reaching about 43 cm in 1995. Mean catch size grew from 43 to 48 cm from 1995 to 1996 following introduction of a larger mesh size, from 140 to 152 mm (5½ to 6 inches), in the latter year. Average size then decreased to 46 cm by 2001. Catches in the years 1995 to 1998 consisted chiefly of fish from the 1989 to 1991 year-classes. Starting in 1999, the 1995 year-class began recruitment, and in 2000 and 2001 the females of this year-class probably accounted for the majority of catches.

In the first half of the nineties, the proportion of females in gillnet catches averaged 58%. Starting in 1996, this proportion rose to 77% because of the larger mesh size. In 2000 and 2001, the percentage of females in commercial catches was 82%.

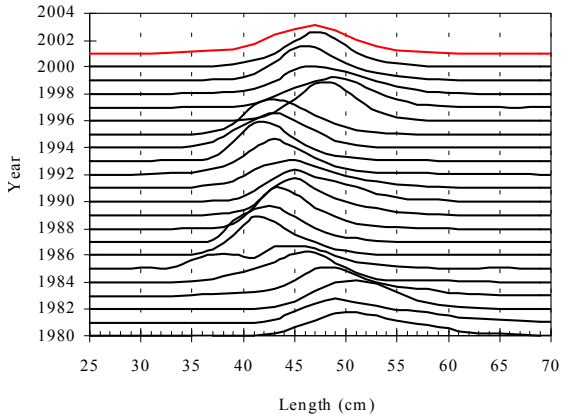

Figure 3. Size structure of gillnet Greenland halibut catches from 1980 to 2001

Commercial Fishery Yields

Yields or catch rates for gillnet fishers have been estimated since 1996 on the basis of the logbooks of vessels over 35 feet overall (Newfoundland) and over 45 feet (Quebec) and index fisher logs. Logbooks were also used to estimate immersion period.

Most gillnets have been cast for three days or longer since 1999, whereas from 1996 to 1998 nearly 50% of immersions lasted only one or two days. Yields have been calculated for each immersion period (one to four days and five days and more). There has been a decline in yields since 1998 for each immersion period, which, together with

the introduction of individual quotas in Quebec, explains why the fishing season has been extended in recent years. From 1996 to 1998, the Quebec fishery was essentially limited to a period of five to seven weeks, but in 1999 and 2000 the season ran from the spring until November. In 2001, the Quebec season ran from early April to November 1. Although Newfoundland fishers still operate in a competitive fishery, their season too has been extended, from three months in 1998 to five to seven months in 1999-2001.

Resource Evaluation

The state of the resource is determined by examining indicators from both the commercial fishery and research surveys. These indicators are examined for different time frames so that the state of the resource can be determined for various time horizons. First, the values of a few indicators were compared with the averages for the years 1990 to 2000 to look for any long-term trends. Then, all indicators were compared with the averages for the period from 1996 to 2000 to assess more recent stock trends, and finally the values of all indicators for 2000 and 2001 were compared to gauge the direction and scale of any changes between the two years.

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

Positive: the value of the indicator has shifted positively for the state of the resource (eg: biomass exceeding the average).

Neutral: the value of the indicator has hardly changed, if at all.

Negative: the value of the indicator has shifted negatively for the state of the resource.

The neutral category is delineated by the confidence intervals of the 1990-2000 or 1996-2000 averages. Indicators vary from the average when their value for the year falls above the upper or below the lower confidence interval limit. The results of indicator ratings are shown in two tables (long and medium-term and short-term; Tables 1 and 2).

Data used

Research surveys

A research survey has been conducted in the St. Lawrence estuary and the northern Gulf each year since 1990. The survey follows a random stratified pattern and is conducted from the Department's research vessel, the *CCGS Alfred Needler*, using a shrimp trawl.

Operational difficulties encountered in the sector to the north of Anticosti Island during the 2001 survey limited coverage in that area. To make the 2001 indices comparable with those of other years (ie: to make the area for which they are calculated the same), the values of the missing sector in 2001 and of strata that had not been sampled in other years were estimated using a multiplicative model.

Cod sentinel fishery surveys have been conducted in divisions 4RST3Pn since 1995, using several boats with otter trawls. Seven of these were summer surveys (July-August 1995 and July in 1996-2001) and seven were taken in the fall (November 1995 and October in 1996-2001), but these surveys do not cover the St. Lawrence estuary, where about 20% of the turbot biomass is located.

For the three surveys (DFO and sentinel), the minimum trawlable biomass, abundance of juveniles (fish under 30 cm) and of pre-recruits (fish between 40 and 43 cm) and abundance of fish above minimum catch size (44 cm plus) have been calculated.

Condition of the stock

Data on the sexual maturity of males and females has been gathered since 1996 during the DFO missions in August, several months before spawning, which takes place between January and March. Sexual maturity is evaluated according to morphological criteria for all fish measured on these missions. The size at which 50% of the fish are mature (L_{50}) has been determined for both males and females and is used as a stock status indicator.

The average length of three-year-old fish was determined from length frequencies in DFO surveys and is used as a growth indicator. The condition indicator (weight/length cubed) was also computed from DFO surveys. Lastly, an annual distribution indicator was calculated from biomass estimates per stratum in DFO surveys; this indicator corresponds to the area occupied by 75% of the biomass.

Commercial Fishery

The primary indicator of fishing success is the difference between the fixed-gear allocation and the landings associated with that allocation. The catch rate indicator is derived by standardizing (by sector, immersion period and month) the catch rates for traditional gillnet fishers for the period 1996 to 2001 (when mesh of size 152 mm, or 6 inches, was in use). Lastly, the average size of fish caught in gillnets was calculated.

State of the Resource

Long-term Trends (Table 1)

Most stock status indicators were negative from 1990 to 1994. Total stock biomass was low, (Figure 4) and pre-recruit abundance was below average. Abundance of males and females of commercial size was sliding, while growth of three-year-olds and turbot condition were similar or inferior to 1990-2000 averages. Turbot distribution

Table 1. Indicators used to assess long-term stock status (1990 to 2001). (See text for meaning of symbols).

Indicators	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
***Alfred Needler* (DFO)**												
Stock Biomass	−	=	=	−	=	=	=	=	+	+	+	+
Juveniles (< 30 cm)	=	=	=	−	−	−	=	=	+	+	+	+
Prerecruits (40-43 cm)	−	−	−	−	=	+	=	=	=	+	+	+
44 cm and more	−	−	−	−	−	=	+	+	=	+	+	+
Stock condition												
Distribution index	−	−	−	=	=	=	=	+	+	+	+	+
Growth index	=	=	=	−	−	=	+	=	+	=	−	−
Condition index	=	−	=	+	=	=	=	+	+	−	−	−
Fishery												
Difference between Fixed gear allocation and landings	−	−	−	=	+	+	+	+	+	=	−	−
Mean size	=	=	−	−	−	−	+	+	+	=	=	=

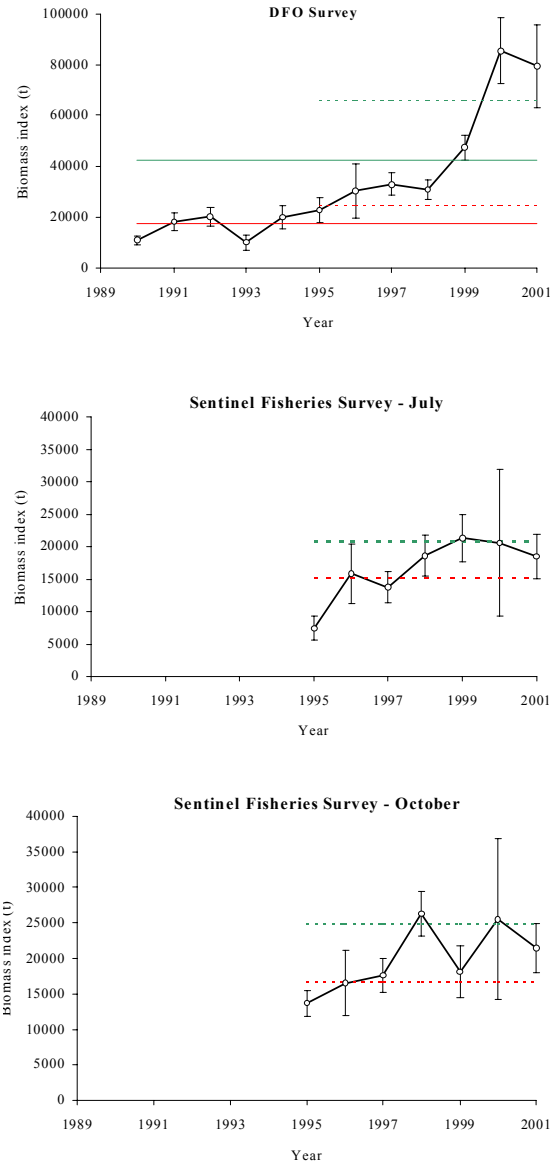

Figure 4. Minimum trawlable Greenland halibut biomass indices for divisions 4RST estimated from DFO and sentinel fishery surveys. The lines represent the upper and lower confidence intervals for the averages for 1990-2000 (solid lines) and 1996-2000 (broken lines).

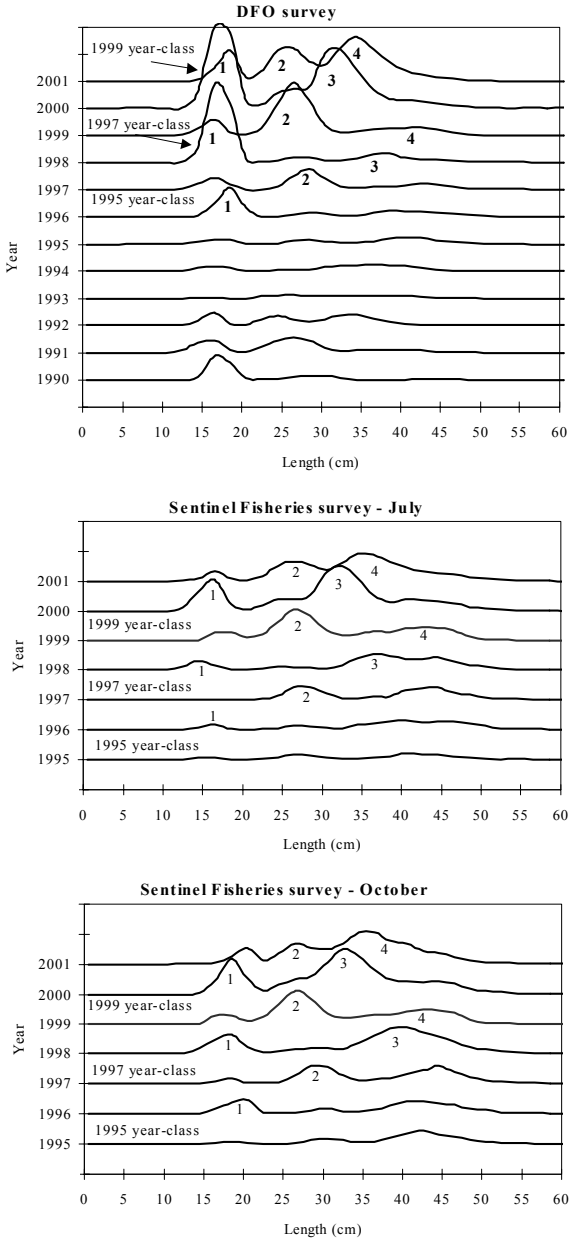

Figure 5. Size structure of Greenland halibut taken in DFO and sentinel fishery surveys. The three largest year-classes (1995, 1997, 1999) are indicated, as is the age of these fish in each year.

was limited to the head of the channels of the Gulf of St. Lawrence. Average catch size was in decline, and commercial catches were below 4,000 t, even though the TAC was 10,500 t.

The size structure of catches in DFO surveys shows that juveniles between 15 and 20 cm in length were abundant between 1990 and 1992. These juveniles belonged to the 1989, 1990 and 1991 year-classes (Figure 5) and helped improve the stock starting in the mid

nineties. The minimum fishable biomass index from the DFO survey showed an upward trend starting in 1994 attributable to the growing input of these year-classes. From 1995 to 1998, most indicators were positive, reflected in an increase in size, improved condition of the stock and greater fishing success. Average catch size increased from 1994 to 1998, as did growth of three-year-olds. The distribution of the stock was also observed to expand, mainly south of Anticosti Island along the Laurentian Channel.

Indicators from Needler surveys have remained above average over recent years. The size structure of catches in DFO surveys shows a surge in the abundance of juveniles between 1996 and 2001, essentially due to the production of the strong year-classes of 1995, 1997 and 1999 (Figure 5). These year-classes helped boost survey indices, even though the 1997 and 1999 classes had not yet attained the minimum catch size of 44 cm. Among fish larger than 44 cm, the abundance index shows males to have been in decline since 1997, while females have held steady at high levels since 1999. (Figure 6) Values for condition and growth were below average in 2000 and 2001, and average catch size has also fallen. While TAC was filled in 1998, landings slipped in 1999, and the spread between commercial catches and TAC widened from 1999 to 2001.

Medium-term Trends (Table 2)

Minimum fishable biomass indices from sentinel fishery surveys confirm the findings of DFO surveys, namely an upward trend from 1995 to 2000 (Figure 4) and a slight drop in 2001. This increase is attributable to the production of the stronger year-classes (1995, 1997 and 1999). These year-classes show up in the length frequency distributions from the July and October sentinel fishery surveys and in DFO surveys

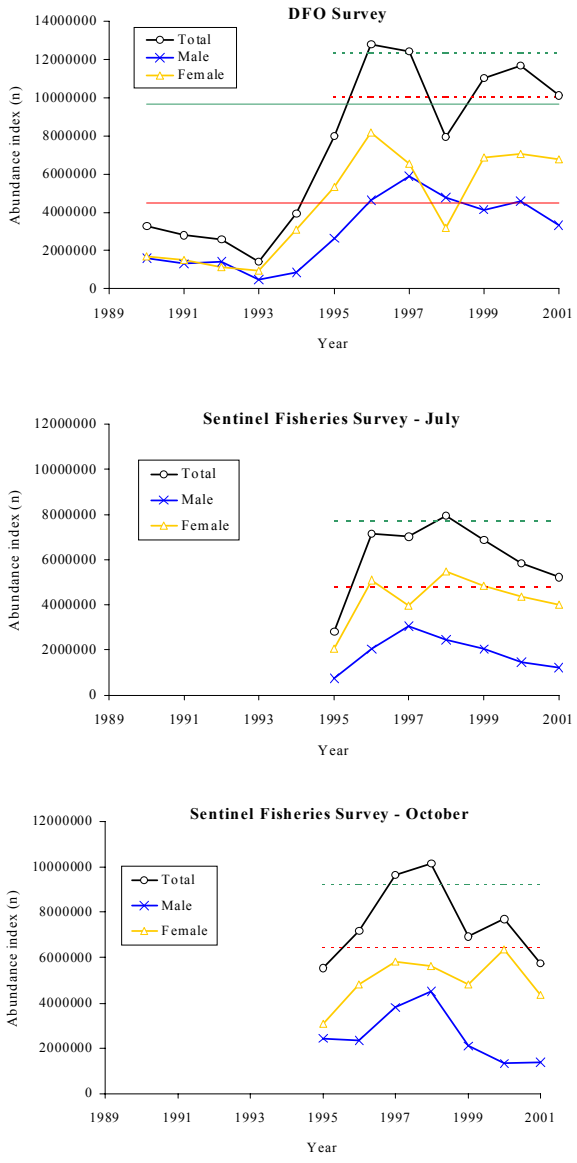

Figure 6. Abundance indices for Greenland halibut 44 cm long and more taken in DFO and sentinel fishery surveys. The lines represent the upper and lower limits of confidence intervals for the averages for 1990-2000 (solid lines) and 1996-2000 (broken lines).

(Figure 5). Abundance indices for juveniles and pre-recruits (40–43 cm) have held steady at high levels since 1999. In contrast, the abundance of fish 44 cm long and more (minimum catch size since 1997) shows a

Table 2 Indicators used to assess short-term (2000-2001) and medium-term (1995-2001) stock status. (See text for meaning of round symbols.)

Indicators	1995	1996	1997	1998	1999	2000	2001	2000→2001
Stock biomass								
Alfred Needler (DFO)	−	=	=	=	=	+	+	↓
Sentinel July	−	=	−	=	+	=	=	↓
Sentinel October	−	−	=	+	=	=	=	↓
Juveniles (< 30 cm)								
Alfred Needler (DFO)	−	−	=	=	=	+	=	↓
Sentinel July	−	−	=	=	+	+	=	↓
Sentinel October	−	=	−	=	+	+	=	↓
Prerecruits (40-43 cm)								
Alfred Needler (DFO)	=	=	=	−	=	=	=	↑
Sentinel July	−	−	=	=	+	=	=	↑
Sentinel October	=	=	=	+	=	=	=	↑
44 cm and more								
Alfred Needler (DFO)	=	+	+	−	=	=	=	↓
Sentinel July	−	=	=	+	=	=	=	↓
Sentinel October	−	=	=	=	=	=	−	↓
Stock condition								
Distribution index	=	−	=	=	+	=	=	↑
Condition index	=	=	=	+	=	−	=	±
Growth index	=	=	=	=	=	−	−	±
Males maturity		+	=	=	=	−	−	↓
Females maturity		=	=	+	=	−	−	±
Fishery								
Difference between Fixed gear allocation and Landings	+	+	+	+	=	−	−	↑
CPUE		=	=	=	=	−	−	↓
Mean size	−	=	+	=	−	−	−	±

± no or little change (0 à 5 %) ; ↑ ↓ change of 5 % to 10 %; ↑↑ ↓↓ change of 10 % or more

downturn in the harvestable stock since 1996 in DFO surveys and since 1998 in sentinel fisheries (Figure 6). This decline is more marked among males than females. According to DFO surveys, the shrinkage in 2001 was more marked in the western reaches of the Gulf, while the Esquiman Channel showed a measure of stablity from 1998 to 2000 and an upturn in 2001.

Stock condition indicators show a deterioration, particularly in 2000 and 2001. Size and condition data for the 1996-1998 period were very good for both growth and condition, but since 1999 indices have been down, especially in the western Gulf. Fish of the 1997 year-class were found to have a lower growth rate, and their modal length was only 35 cm in the summer of 2001. However, a breakdown by area revealed that growth in the Esquiman Channel, in the eastern Gulf, was adhering to a more normal pattern, and modal length there was about 40 cm in 2001.

Data on turbot diet since 1993 show differences in diet and the size of stomach contents by fish size and area. Very small fish (under 20 cm) eat mainly invertebrates, their main prey species being a small planktonic crustacean (*Themisto libellula*). Fish between 20 and 35 cm in length feed on invertebrates and fish in almost equal proportions, their chief prey being capelin, *Themisto libellula* and northern shrimp. Larger turbot eat mainly fish, including capelin, fourbeard rockling and herring. Stomachs were also found to be less replete as fish size increased. Stomachs were generally less full for fish in the western Gulf than in the Esquiman Channel. The lowest stomach content values were seen over the last three years in the western Gulf, and this difference may be one of the causes of the drop in growth rates observed in the western reaches of the Gulf in 2000 and 2001.

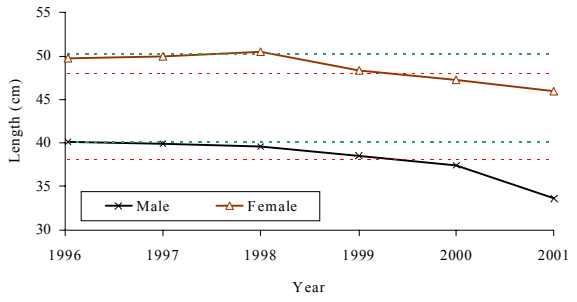

Figure 7. Length at which 50% of fish caught in DFO surveys were mature, 1996 to 2001. The dashed lines represent the upper and lower limits of confidence intervals for the averages of 1996 to 2000.

Data on maturity show that the size at which 50% of fish are mature (L_{50}) fell between 1996 and 2001 (Figure 7), from 40 to 33.5 cm for males and from 50 to 46 cm for females. Size at maturity for males is well below minimum catch size. Given the slowdown in growth rate after sexual maturity, it is likely that it will take the males of a year-class many more years than the females to reach minimum catch size. This difference in size at sexual maturity and in growth rate has accentuated the imbalance in the ratio of the sexes in commercial catches arising from the ligher proportion of females in recent years.

Standardized commercial catch rates were high between 1996 and 1998 (Figure 8), but they have dropped by 63% since 1999. It should be noted that until now, these yields were used as an indicator of fishing success, not of harvestable stock abundance. The average size of fish taken has been below average since 1999, and at the same time the difference between fixed-gear allocations and the associated landings has widened, especially for Quebec fishers, reflecting the troubles of the fishery during this period. Some fishers have switched their operations to other resources because of the low yields, which may have further depressed landings.

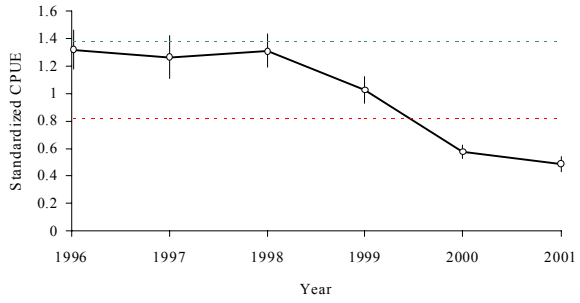

Figure 8. Standardized catch rates for gillnet fishers, 1996 to 2001. The dashed lines represent the upper and lower limits of the confidence intervals for the average of 1996 to 2000.

Industry Point of View

The 2001 season was difficult for all fishers pursuing this species. Newfoundland fishers noted low yields and more small fish in catches. Some felt that the low prices offered had affected the Newfoundland fishery. In Quebec, low yields prompted some fishers to cut back on their operations. Temporary snow crab allocations for some of them have partially offset the drop in revenues. A number of Quebec fishers have been asking to use some nets with a 5½-inch mesh because they want to boost their yields, pointing out that with this mesh size the proportion of males taken should be higher than in the last few years.

Sources of uncertainty

Data on commercial catch rates show a sharp decline in the Greenland halibut available to the fishery over the past three years. Over the same period, abundance indices from surveys have remained high, notwithstanding a downward trend over the last three or four years. The reasons for the lack of fishing success do not seem to arise only from resource abundance, as estimated from surveys, but also from other factors impinging on turbot availability for gillnet fishing. Possible factors are biological (growth, condition, diet, distribution and movement) or the result of interaction with other species, in particular snow crab, which is currently very abundant. For the present, the information available does not permit precise identification of the causes. Uncertainty thus still reigns as to the scale of the contribution of the 1995 year-class to the fishery and the recovery of fishing yields pending the entry of new strong year-classes to the harvestable stock.

The decline in growth seen in juveniles also raises doubts about the entry of one of the last strong year-classes (1997) to the fishery in the next few years. Although there was another low growth period in the past (early nineties), the various factors affecting growth are still poorly understood.

Outlook

In 2002, the fishery will focus primarily on the 1995 and 1996 year-classes, since the production of the year-classes from 1992 to 1994 has been weak. Research survey abundance indices for juveniles and pre-recruits indicate that the 1997 and 1999 year-classes are abundant, but that the 1997 year-class will not be available to the fishery in 2002 because it will not have been fully recruited to the minimum catch size, especially in the western Gulf. Moreover, the great abundance of the 1997 and 1999 year-classes means that there may be many undersize fish (less than 44 cm) in catches in the next few years. Survey results indicate that the abundance of males over 44 cm in length has fallen since 1997 and was the same in 2001 as in 1995. Female abundance was also down in 2001, below 1997 or 1998 levels, so that no substantial increase in the size of the stock available to gillnet fishing is expected in 2002. In addition, the very low yields seen in the 2000 and 2001 seasons and the lower juvenile growth rates make it difficult to predict whether the fishery will be successful in the next few

years or the year when the 1997 year-class will become available to the fishery.

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