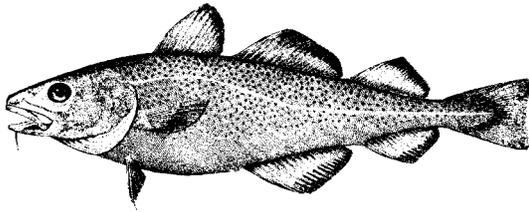




Quebec Region

Stock Status Report 2003/017



### The Northern Gulf of St. Lawrence (3Pn, 4RS) cod in 2002

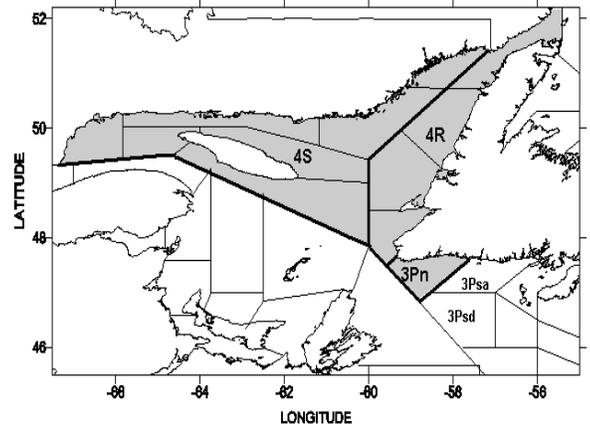


Figure 1: Cod stock management area in the Northern Gulf of St. Lawrence. For reference, fishery areas 3Psa and 3Psd are also indicated.

#### Background

The cod of the Northern Gulf of St. Lawrence (divisions 3Pn, 4RS) undertakes extensive annual migrations. In winter, it gathers off southwestern and southern Newfoundland at depths of more than 400 m (200 fathoms). In April and May, it moves towards the Port au Port Peninsula, on the West coast of Newfoundland (division 4R), where spawning starts. In 2002, a new zone was established in 4R to protect the spawning stock. It is a sector where any groundfish capture is prohibited between April 1<sup>st</sup> and June 15. During the summer, fish continues its migration and disperses towards the coastal zones, along the West coast of Newfoundland (division 4R) and towards the Middle and Lower North Shore of Quebec (division 4S). This migration towards the coasts is associated with warmer water and the presence of capelin, principal prey consumed by cod.

Based on the results of the many tagging experiments carried out, this stock is generally isolated from adjacent stocks (those of divisions 4TVn, 2J3KL and 3Ps). Stock can sometimes mix in the Northwest Gulf, (with stock of division 4TVn), in the Strait of Belle Isle, (with the 2J3KL stock), and especially in the area of the Burgeo Bank (with the 3Ps stock). A recent study evaluated that 75 % of cod present on the Burgeo Bank (3Psa and 3Psd) in winter would come from the Northern Gulf.

#### Landings (in thousands of tons)

Year	1977-1993	1994-1996	1997	1998	1999	2000	2001	2002 <sup>1</sup>
TAC	70.4	0	6	3	7.5	7	7	7
Landings	70.2	0.3	4.8	3.3	6.9	6.8	6.7 <sup>2</sup>	6.2 <sup>3</sup>

<sup>1</sup> Preliminary data

<sup>2</sup> Include 253 t for recreational fishery

<sup>3</sup> Include 34 t for recreational fishery

#### Summary

- In 2002-2003, the TAC was 7 000 t. As of December 31, 2002, 6 246 t had been landed.
- The abundance and spawning stock biomass remain low. The stock abundance increased between 1994 and 1999 but has declined since.
- The recruitment estimates at age 3 have been declining since 1998 and recruitment is predicted to reach a historic low in 2003.
- Energetic condition and growth have improved in recent years, and fish now mature at older ages.

- All three abundance indices based on research and sentinel trawl surveys increased from 1995 to 2000 but have declined since. The index from sentinel longlines increased from 1995 to 2001 but declined in 2002. This decline is most pronounced in southern 4R. The gillnet index appears to be stable.
- Cod are increasingly concentrated inshore in 4R and thus are more available to inshore fisheries. A portion of the stock may be becoming less available to research vessel and sentinel trawl surveys but is monitored by sentinel longlines.
- Natural mortality of adult cod remains high in this stock. Seal predation is a major factor contributing to this elevated mortality.
- Unaccounted fishing mortalities may have increased in recent years due to under-reporting in the recreational fishery and gillnet discards in the commercial fishery in 4R.
- Exploitation rate has been high since 1999.
- With no fishing, the stock is expected to increase marginally in 2003. With a 1 500 t fishery, stock abundance will likely not change. Catches of 7 000 t (the TAC since 2000) is estimated to result in a decline of about 12 % of the spawning stock biomass.
- Spawning stock biomass is estimated to be below the conservation limit reference points for this stock. There is a high likelihood that the productivity of stocks below the conservation limits has suffered serious harm.

### ***Biological characteristics of the resource***

The biological characteristics of the Northern Gulf cod varied over years, and certain changes occurred during the decline of the abundance of stock when the cold oceanographic conditions were unfavourable for the resource. Growth, condition, size and age at sexual maturity decreased in the middle of the 1980's and the beginning of the 1990's. These changes had a negative impact on egg production because a smaller fish, in bad condition at sexual maturity, is weaker and produces less eggs. On the other hand, the natural mortality rate may increase as a fish in bad condition has less chance to survive, particularly after the reproduction, when environmental conditions are unfavourable. However, an improvement of these biological parameters has been noted in recent years so that the assessment is more positive with regard to the biological characteristics of the stock.

The growth of cod increased during second half of the 1990's. Weight and size at age in the commercial fishery increased so that the actual values since 2000 are similar to those which were observed before the decline of the abundance, in early 1980's. Indeed, the mean weight of a 6-year-old cod in commercial fishery reached a minimum in 1992, then gradually increased since (Figure 2). The computed value of the mean weight for 2000 is the highest since 1984. Trends are similar for size and weight in the other year-classes. This increasing trend in size at age was also observed in the three trawl surveys carried out by the CCGS Alfred Needler, and the sentinel fisheries in July and October, as well as the sentinel fixed-

gear fisheries (longlines and gillnet). Compared to 2001, 2002 mean weight of a 6-year-old cod are high for the gillnets and the survey of the CCGS Alfred Needler. Generally, weights at

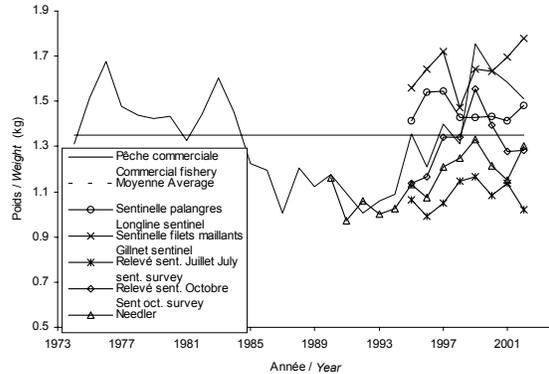


Figure 2. Mean weight of six-year-old cod caught in the commercial fishery, science surveys and fixed-gear sentinel fisheries. The dotted line is the commercial fishery average for the 1974-2002 period.

age from the surveys and the fishery have increased from 1990 to 1998 and varied afterwards without showing any trend.

The size at which cod reaches sexual maturity was re-examined in 2002. Contrary to the former years, the conversion of the ogive of maturity for length to mature proportions of individuals at age was carried out using the mean lengths at age of scientific surveys (DFO and sentinel fisheries surveys) rather than the matrix derived from commercial fishery. This approach eliminates overestimation of the mean length at age of the young year-classes (3 and 4 years), which can affect commercial samples. This problem is mainly related to the 42 cm limit for commercial size and to the selectivity of commercial gears. This new calculation will more accurately reflect the proportion of mature individuals in the stock.

For 2002, a new ogive was calculated following a survey carried out in early May. The review of inter-annual variations of length at 50 % of maturity seems to indicate an increase of this value (46.8 cm) for 2002 compared to the last computed value in 1998, which was lesser than 40 cm. This length at 50% of maturity for 2002 would be comparable to the values identified in the 1980's.

The feeding of cod in 3Pn, 4RS is influenced by many factors such as season, depth, abundance of prey and the size of cod. The feeding of small cod is mainly composed of invertebrates like amphipods and shrimp (Figure 3). The proportion of fish in stomachs increases with the size of cod. Capelin is the dominant species consumed by cod less than 63 cm. Gadoids (mainly cod) and flatfish become important species consumed for cod above 53 cm.

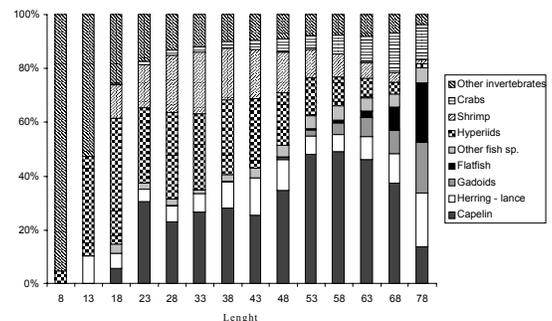


Figure 3. Cod feeding.

The condition of cod is a factor studied by a monitoring program whose aims is to determine the general health status of the Northern Gulf stock. Fish in good condition will have better chances of survival, particularly when environmental conditions are unfavourable. The condition of cod shows significant seasonal variations, with a maximum during the fall and a minimum during the

spring. The energy reserves accumulated at the end of the fall are critical for cod and must be sufficient to pass the winter. Between 1983 and 1989, the condition of cod (evaluated in January) was good (Figure 4). Then, a significant reduction in the condition in January was observed between 1989 and 1994. A sentinel survey carried out in January 2002 revealed that condition level was good and comparable with levels recorded in the middle of the 1980's. Since 1990, the condition of cod is also evaluated in August, during the surveys of the CCGS Alfred Needler. The four measured indices – the Fulton index, the hepatosomatic index, the liver

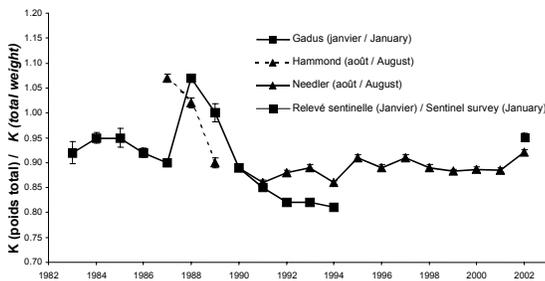


Figure 4. Fulton condition index (mean ± standard error) for winter (*Gadus Atlantica*, Sentinel 2002) and summer research surveys (NGCC Alfred Needler) from 1983 to 2002.

water content index and the muscle water content index – are considered good and indicate an increase for 2002.

### Description of fisheries

Cod landings in the Northern Gulf of St. Lawrence reached a maximum of more than 100 000 t in 1983 (Figure 5). Then, they regularly decreased until 1993. During the decline, boats using mobile gears captured their allocation, whereas those using fixed gears did not achieve it. Fishery was under moratorium from 1994 to 1996. A reduced fishery was

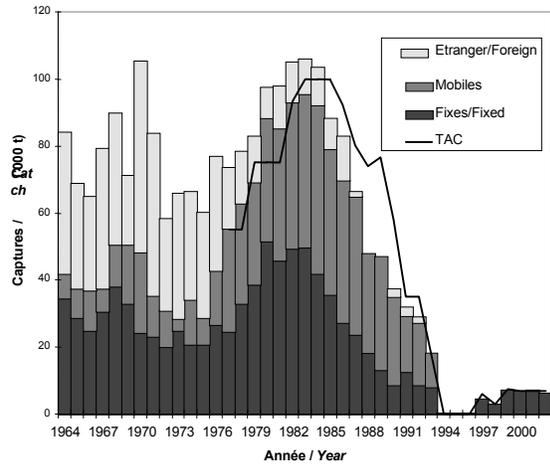


Figure 5. Landings and total allowable catches (TAC).

authorized in 1997 with a TAC of 6 000 t and landings added up to 4 792 t. The TAC was brought back to 3 000 t for 1998 and 3 313 t were landed. In 1999, the TAC was set to 7 500 t and 6 890 t were landed. In 2000, the TAC was reduced to 7 000 t, and it has been maintained since. The landings of the fishery season (May 15 to May 14 of the following year) for 2000, 2001 and 2002 totalized 6 556, 7 150 and 6 246 t respectively.

The profile of the commercial fishery has changed considerably since its reopening in 1997, as coastal directed fishing is restricted to fixed gears, such as longlines and gillnets. Fishing is carried out from small boats, and fishing effort is distributed over several monthly allocations. For example, a total of 2 000 hooks or 6 gillnets can be used by trip on the West coast of Newfoundland (4R and 3Pn), whereas a maximum of 25 gillnets for the West of Blanc Sablon and a maximum of 6 gillnets for the Blanc Sablon area can be used in the Lower North Shore of Quebec (4S).

Sentinel fisheries started in 1994 in order to develop a partnership between

industry and the department of Fisheries and Oceans. Sentinel fisheries are carried out within a well defined framework and provide abundance indices of the resource. Three types of fisheries are carried out each year: sentinel gillnet fishery on Lower North Shore (division 4S) and on the West coast of Newfoundland (division 4R), sentinel longline fishery and sentinel otter-trawl fishery on the entire territory (3Pn, 4RS). All catches made within the framework of sentinel fisheries are accounted with total landings of commercial fishery. Sentinel fisheries had an allocation of 400 t in 2002, and the catches added up to 234 t.

To increase our knowledge of the mixture between the Northern Gulf stock and that of the Southern coast of Newfoundland, three surveys financed by the FFAW and directed by DFO were done with commercial trawlers in the area of mixing (3Psa and 3Psd), as well as in 3Pn and 4R in January, March and May 2002. The chemical analyses of the trace elements in the otoliths of cods collected during these surveys are in progress. Moreover, these surveys also allowed us to establish a new maturity ogive.

A recreational fishery pilot program was set up in 2001. At the time of last year assessment, the official data concerning fishing were not available. We had estimated that the landings could be of the extent of 886 t. Now, official data for 2001 and 2002 are available (253 and 34 t respectively). Thus, these new data are included in the current assessment.

At the time of the July allocation of 2002, concerns were made concerning the poor quality of landed fish caught by gillnets in 4R: they reached 22% by weight for categories B, C, and rejects.

Moreover, it is likely that significant amounts of fish may have been discarded at sea.

### ***Industry perception***

For the fifth consecutive year the "Regroupment of the Lower North Shore Fishermen's Associations of Quebec" and the "Fish, Food and Allied Workers Union" of Newfoundland and Labrador have administered telephone surveys to fixed gear cod license holders in each NAFO zones. These organizations have been sponsors of the 4S and 3Pn, 4R Groundfish Sentinel Programs of the Northern Gulf of St. Lawrence (fixed gear sectors) respectively since the inception of the program in 1994. As in the past the surveys adopted a random sampling design. The current survey covered the 2002 fixed gear commercial fishing season with 50 fish harvesters being interviewed in 3Pn, 80 in 4R and 45 in 4S. The objective of the survey was to review various aspects of the fishery including fishermen demographics, biological information and trends in catch rates.

Results relating to fishermen demographics indicated that aspects of fishers experience in the fishery, average age and vessel length have remained very stable for all zones since the moratorium. For comparison of 2002 versus the 2001 season, respondents noted that cod size (overall length) and condition was the same or had increased. For 3Pn, more respondents noted a more positive result for both of these biological indicators compared to the other two zones. With respect to migration, the majority of the respondents in 4S and 4R noted that cod migration 'into' and 'out of' traditional areas occurred at the

same time in 2002. However, a much greater percentage of 3Pn respondents noted that the fish migrated out of the gulf earlier and in fact the majority of these respondents commented on the fact that there was an excellent abundance of fish in 3Pn in August and September.

With respect to fishing depth, fishers have maintained activity on the same grounds with very little reported variation. With respect to spawning activity, a greater number of 4S compared to 4R and 3Pn respondents noted spawning activity based on the qualitative criteria stated in the question. This has been a result observed in the survey since its inception.

With respect to catch rates, the trend has typically been a decreasing one from north to south with the most optimistic perception in 3Pn. In 2002, all respondents indicated an improvement in catch rates compared to 2001. This result was most dramatic for 3Pn, where the average number was the highest in the time series. It is also worth reiterating that these values are much higher compared to the pre-moratorium period (i.e. 1992-93). Based on a retrospective index analysis, fishers in 4R and 4S have maintained a stable view of catch rates over the past three years while those in 3Pn are providing an increasingly more positive view of stock abundance (Figure 6).

**Resource status**

**Abundance indices of catch rates from sentinel fixed-gear fisheries**

Sentinel fixed-gear fisheries provide two abundance indices. The first index is derived from longline fisheries, and the second is calculated from gillnet

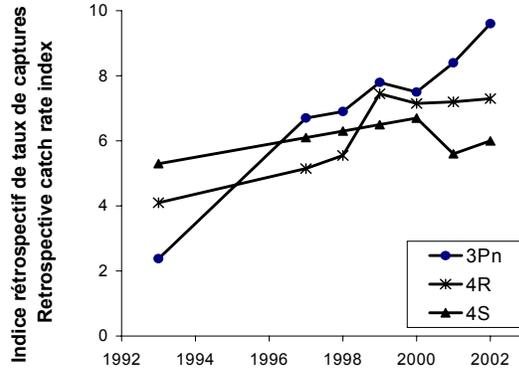


Figure 6. Retrospective catch rate index based on a questionnaire conducted by fishermen's associations.

fisheries. The catch and effort data was standardized with the use of a multiplicative model which allows to derive an index which reflects annual trends of abundance of cod since 1995.

The abundance index of sentinel gillnet fisheries in 4R and 4S shows very variable catch rates between years (Figure 7). The abundance index of sentinel longline fisheries in 3Pn, 4R and 4S shows an increase of the catch rates between 1995 and 2001, and a reduction for 2002. The good catch rates for sentinel longline fisheries since 1998 are due to the harvest of the 1993

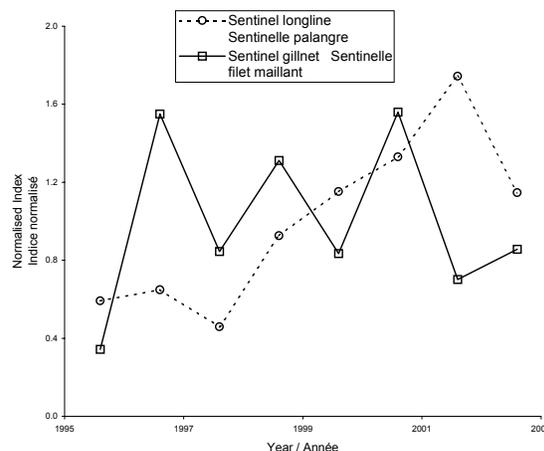


Figure 7. Normalised abundance indices derived from fixed gears.

year-class. In 2002, this year-class is 9-year-old and is less abundant, which may explain the decline of the abundance index for longline.

### Trawl surveys

The sentinel mobile-gear fisheries program began in 1994 in the Northern Gulf of St. Lawrence, but it is only from 1995 that surveys have covered division 4S. The surveys are performed twice a year (July and October) by nine trawlers using a stratified random sampling protocol similar to that used by DFO with the CCGS Alfred Needler. The gears used were adjusted and standardized in 1997 with the addition of restrictor cables which maintain a constant trawl opening during fishing operations. The two surveys of 2002 followed an optimal station allocation plan (Gagnon, 1991) in order to minimize the variability of estimates.

The 1995-2000 data series from sentinel fisheries surveys of July suggests a slight upward trend of the abundance of stock for this period. A reduction is noted for the two surveys since 2001 (Figure 8). The two surveys indicate that the major part of the biomass is found in the zone 4R.

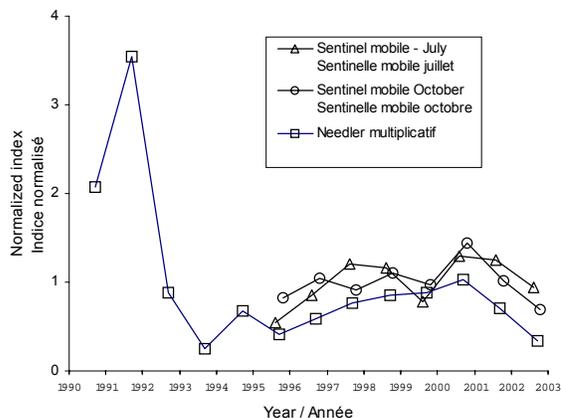


Figure 8. Normalised abundance indices derived from research surveys.

The summer survey carried out by the ship of the Ministry, the CCGS Alfred Needler, started in 1990 and was initially intended to assess shrimps populations and certain groundfish in the Gulf. Since 1991, adjustments have been carried out to increase coverage of the geographical territory frequented by cod; this was done by extending the surveys to the subdivision 3Pn and to depths ranging between 37 and 100 m (20 to 50 fathoms). The current assessment has corrected the situation by using a statistical model which allows to fill the missing annual data for these areas by using the trends observed in these zones during years of successful sampling.

The results from the DFO survey indicate that the abundance has increased from 1993 to 2000, but decreased in 2001 and in 2002. The index of 2002 is the second weaker of the 13-years series, the only lower value being that of 1993, right before the moratorium.

The estimates of minimum trawlable biomass of cod along the west coast of Newfoundland in shallow waters has increased for the July sentinel survey and for the DFO survey in August. This may reflect a displacement of cod to coastal waters. The proportion of minimum trawlable biomass in the 20-50 fathom stratum from the July sentinel survey follows closely the sentinel longline catch rates (Figure 9).

It is interesting to note that the three abundance indices based on mobile surveys reached a maximum in 2000, all declined in 2001 and continue to drop in 2002.

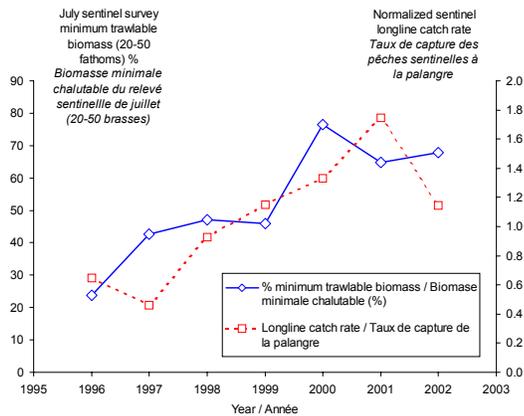


Figure 9. Comparison between the minimum trawlable biomass (%) in the 20 to 50 fathom depth strata from the July sentinel mobile survey and the sentinel longline catch rate normalised index.

**Estimate of total population**

The sequential population analyses (SPA) is an analytical model that allows to estimate population by year-class by taking into account natural mortality and fishing mortality as undergone by fish available to fishery. The analyses is based on the landings of 2000, 2001 and 2002 calendar years and were of 6 801, 6 950 and 6 439 t respectively. This analyses is also based on catches at the age estimated from commercial fishery and is calibrated with the indices of coastal sentinel fixed-gear fisheries, those of off-shore sentinel mobile-gear fisheries and those of the scientific survey made by the CCGS Alfred Needler.

To reflect the deterioration of environmental conditions, an increase in wasteful fishing practices and the intensification of predation by seals, it was decided during a zonal meeting held in the winter of 1999 to increase the coefficient of natural mortality (M) from 0.2 to 0.4 from 1986 for several cod

stocks. Although the condition of the fish improved recently, the predation by seals is believed to remain important so that the coefficient of natural mortality has been kept to 0.4 for the entire period of 1986-2002 in order to take account of the combined effect of these factors.

Maturity ogives, or the proportion of fish sexually mature by size or year-class, are used to establish estimates, based on the results of the sequential population analyses, of spawning stock or spawning biomass. Results of SPA indicate that the abundance of 3-year-old and over individuals dropped from 559 million in 1980 to 56 million in 1994, before increasing slowly to reach 85 million in 1999. Thereafter, total population decreased to reach 51 million of individuals in early 2003. The abundance of the spawning stock decreased from 223 million in 1982 to 11 million in 1994. It increased to 23 million of individuals at the beginning of 2003. The exploitation rate on 7 to 10 year-old cod from SPA is stable and around 20 % since 1999 (Figure 10).

Population numbers were converted to biomass using mean weights at age from the commercial fishery calculated

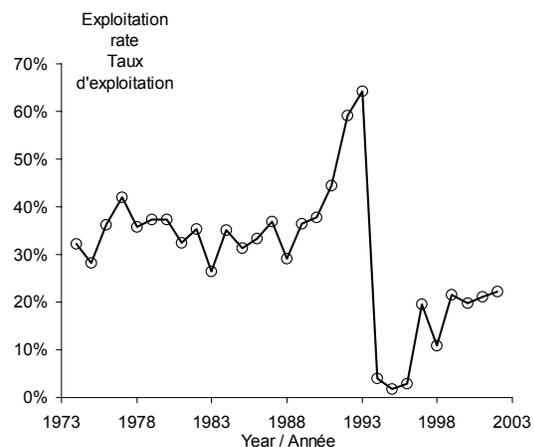


Figure 10. Exploitation rates for cod between age 7 and 10.

annually. The total biomass, for fish 3 years and older, passed from 604 000 t in 1983 to 36 000 t in 1994 (Figure 11). It increased to 62,000 t at the beginning of 2003. The spawning biomass decreased from 379 000 t in 1983 to 13 000 t in 1994, to increase thereafter to 39 000 t at the beginning of 2003.

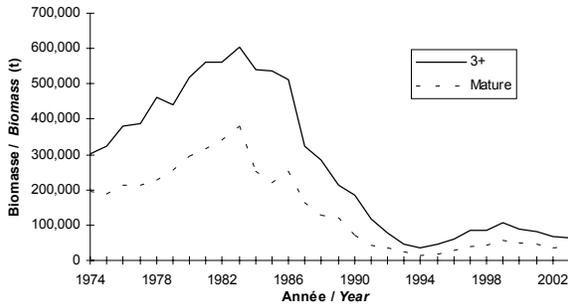


Figure 11. Estimated 3+ biomass and mature biomass.

Estimates for stock abundance and biomass for January 1<sup>st</sup>, 2003 were based on a mean recruitment (3-year-old fish) of mean weights at age and estimated maturity ogives for the last three years (2000 to 2002). Fishing mortality for the fully recruited individuals would have been of 22% (F=0.31) in 2002.

There have been no major signs of recruitment recovery since 12 years (Figure 12); commercial catches in the last four years have been sustained by the substantial 1993 year-class alone, which was produced prior to the application of the moratorium. Recruitment at age 3 has declined from 32 million individuals in 1998 to a historical minimum predicted at 10 million individuals in 2003.

**Sources of uncertainty**

The issue of the migration of Northern Gulf cod into fishing area 3Ps has been frequently discussed in the past. To

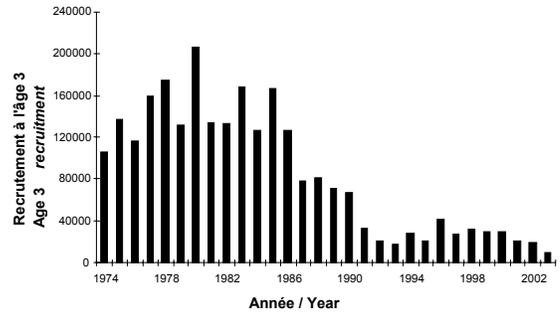


Figure 12. Estimated recruitment at age 3.

avoid the capture of these cod during the winter fishery in the western area 3Ps, a portion of the Burgeo Bank (3Psd) has been closed to cod fishery from November 15 to April 15 since 1999. This area is only part of the area in which cod from the Northern Gulf stock (3Pn, 4RS) mix with 3Ps cod. Several research projects were carried out in recent years in order to better describe the extent of mixing (tagging, seasonal evolution of maturities, microchemistry of otoliths). A specific workshop on this issue was held in October 2000 (Chouinard, 2000). The conclusion of this workshop was that a good portion of cod captured during winter in areas 3Psa and 3Psd were from the Northern Gulf stock. As recommended by the workshop, in this assessment we have added 75% of the catches made from November to April in 3Psa and 3Psd to the catches of 3Pn, 4RS, which assumes that these catches are from the Northern Gulf. The inclusion of these landings have little impact as the estimated stock size increases by only 5% according to the sequential population estimate, compared to analyses that do not include them.

Results from the groundfish survey aboard the CCGS Alfred Needler in 2002 were reviewed in detail because there were a larger than usual number

of unsuccessful tows in 2002, and most of them occurred in the earlier part of the survey. The larger amount of cod found in strata 20 to 100 fathoms is comparable to past surveys. Moreover, no tear ups occurred in the 20 to 50 fathom strata in 2002, where most of the cod were concentrated. Also, the pattern of residuals in the SPA suggests that the 2002 point from this survey were not highly influential on conclusions about stock status. Nonetheless, there remains uncertainty about the performance of the gear during that particular survey, which will be investigated further.

Adult mortality from natural causes is very high for this stock. Although causes of this elevated mortality are not fully known, estimates of cod consumed or otherwise killed by seals are high enough that such mortality contributed to the lack of recovery in this stock as well as for other stocks. The seal diet data indicate that the consumption is primarily of juvenile cod. However, stomach contents data underestimate the consumption of adult cod, because it has been observed that seals tend not eat the hard parts of large cod.

Unaccounted fishing mortalities may have increased in recent years for two reasons. First there may have been under-reporting in the recreational fishery. Second a new grading system put in place in 1999 in the gillnet fishery may have resulted in increased discarding.

In recent assessments, some tagging studies suggested exploitation rates were lower than indicated by other information sources. New analyses were able to largely reconcile results from the tagging with other indicators in this assessment. However, additional

work on the tagging database and analytical methods can reduce further the uncertainty associated with the tagging studies.

### ***Tagging and returns of tags***

Since 1995, sentinel fishermen tagged more than 57 000 cod in the Northern Gulf of St. Lawrence. Until now, only 2 600 tags have been returned, which gave a low rate of return of 5%.

In 2000, following a recommendation of the FRCC to conduct more research in order to clarify this situation, sentinel fisheries and DFO initiated some experimental tagging programs with high value rewards (100\$/returned tag) mixed with usual reward tags. These experiments with high value rewards have provided estimates of exploitation rate that are two to three times higher than those based on the rate of return for traditional tags.

Two analyses concerning tag returns were conducted during the 2003 assessment. One analysis estimated an exploitation level of 8 % while the other gave an estimate of 7 %. These estimates are similar to those obtained (9 %) for recent years through the use of the sequential population analysis for cod of equivalent size (50-60 cm or 5 to 8 year old).

### ***Outlook***

The landings for 2001 were revised downward, especially in the light of official statistics concerning the recreational fishery. Landings were reduced from 886 t to 253 t. The current assessment indicates that the mature biomass has decreased by 26% since 2000. At current productivity, the fishing pressure is unsustainable.

Overall, year-classes produced after 1993 are less abundant. With the low size of stock combined with the weak recruitment, total catches of more than 1 500 t in 2003 are projected to result in a further reduction of the spawning segment. Catches of 7 000 t (the TAC since 2000) are projected to produce a 12% decline of the mature biomass. A 5% target for growth in the mature biomass could not be achieved without a moratorium (Figure 13).

The mid-term outlook (5 years) suggests that declines in spawning stock biomass are highly likely. Rebuilding of spawning stock biomass is unlikely even without fishing. A strong recruitment event, which is highly unlikely under present conditions, and / or a large decrease in natural mortality would be required to change this outlook. The stock biomass is projected to decline by 36% if the current TAC of 7 000 t were maintained over 5 years.

Spawning stock biomass is estimated to be below the conservation limit reference points for this stock. There is a high likelihood that the productivity of

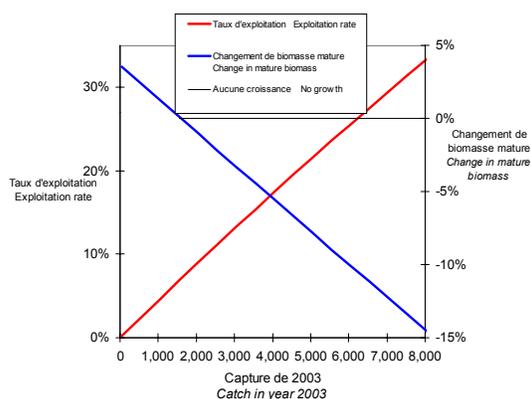
stocks below the conservation limits has suffered serious harm. Given our current knowledge of the productivity of this stock, the chances of obtaining good recruitment is severely reduced when spawning stock biomass is below about 200 000 t. The current situation is well below this level in 2003 even in the absence of fishing.

We currently have little knowledge of the stock productivity in the range of 100 000 t to 200 000 t. With more information of stock productivity in this range we will be able to revise the estimates of the biomass conservation limit. It is likely that the level will fall between 100 000 and 200 000 t.

### **Management considerations**

The examination of the quality of landings from gillnets in 4R indicates that a high proportion of fish are in such poor quality that they cannot be processed for human consumption. Even if this catch is accounted for in the TAC, it represents nevertheless an useless mortality.

The current assessment indicates that cod mature at moderately old ages, and only 50% are mature between the ages of 5 and 6 years. Gillnets and longlines have a selectivity which targets primarily individuals of eight-year-old and over, so most cod can spawn at least once before being vulnerable to these fisheries. The current assessment indicates that 646 000 individuals of this cohort were fished at eight years in 2002, on a total cohort number of 1,8 million individuals. This fishing pressure is not sustainable.



*Figure 13. Harvesting rate and projected variation in mature biomass relative to various catch levels for 2003.*

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