



ASSESSMENT OF COD STOCK IN THE NORTHERN GULF OF ST. LAWRENCE (3Pn, 4RS) IN 2005

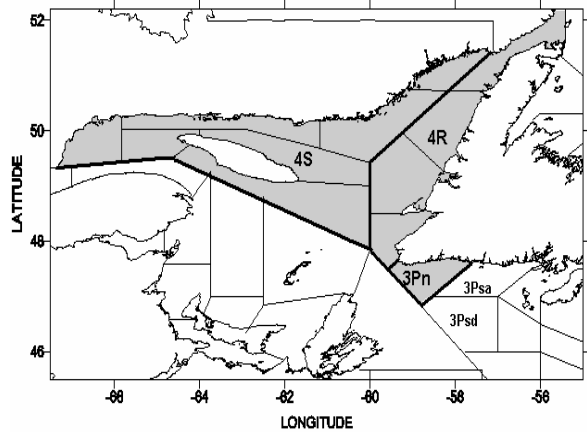
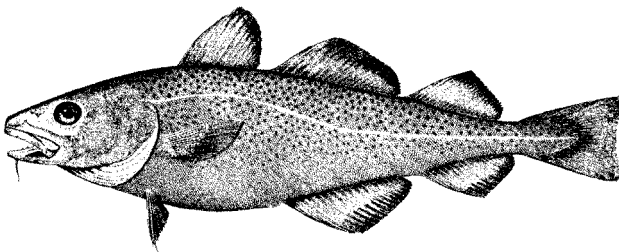


Figure 1: Cod stock management area in the Northern Gulf of St. Lawrence. For reference, fishing areas 3Psa and 3Psd are also indicated.

Context

The assessment of cod stock in the Northern Gulf (3Pn, 4RS) is conducted annually based on four abundance indices, three from sentinel fisheries and the other from the Department's research mission. Resource status is measured by analysing risks in the context of the precautionary approach. Resource management is mainly done by imposing annual TACs (total allowable catches) and a series of other follow-up measures (spawning period, presence of observers, minimal size, bycatches, etc.). A new process for TACs was set up with the industry's participation based on mutually agreed rules.

Cod landings (in thousands of tons) in divisions 3Pn, 4RS

Year	1977-1993	1994-1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TAC	70,4	0	6	3	7,5	7	7	7	0	3,5	5
Landings	70,2	0,3	4,8	3,3	7,1	6,8	7,1 ²	6,3 ³	0,4	3,3 ¹	4,3 ¹

¹ Preliminary data

² Includes 253 tons from recreational fishing

³ Includes 34 tons from recreational fishing

SUMMARY

- The 2005 TAC was established at 5,000 tons. Preliminary catches in January totalled 4,334 tons.
- The four 2005 abundance indices dropped slightly or remained stable. Fixed gear catch rates are nevertheless among the series' highest (1995-2005).
- Yields as well as the geographical range observed by the commercial and sentinel fisheries suggest to fishermen that abundance and biomass are much more significant than what was estimated by the recent assessment.
- According to an analytical model, spawning stock abundance and biomass are still low. The spawning stock biomass reached a high of 378,000 tons in 1983 and dropped to 9,000 tons in 1994. During the first moratorium, this stock's biomass increased to 29,000 tons in 1998. Since the reopening of the fishery in 1997, spawning stock biomass has fluctuated between 25,000 tons and 38,000 tons, without any evident sign of recovery.
- Estimated abundance dropped by 6% between 2005 and 2006. However, spawning stock biomass increased by 12% between 2005 and 2006 to reach 42,000 tons.
- Tagging experiments conducted in 2004 and 2005 helped evaluate annual exploitation rates (harvested proportion). Most of the estimates were above 12%, which is slightly higher than independent results from the sequential population analysis.
- Results of a study using counting fences indicate that 61% of cod over 55 cm in length tagged with transmitters migrated from 3Pn, 4R to the western portion of 3Ps in winter. However, there are few catches in winter in 3Ps other than those from the Halibut Channel.
- Spawning stock biomass estimates are below the conservation limit for this stock. Recruitment contribution towards stock productivity is also concerning.
- According to the risk analysis, it is expected that without the fishery, the spawning stock biomass should increase by 7% at the end of 2006. With a 5,000 tons fishery, this biomass is expected to drop by 5%. A 3,000 tons fishery in 2006 would produce no increase in spawning stock biomass.
- In order to promote the increase of the stock's biomass, it is recommended that captures remain at a very low level.

INTRODUCTION

The biological characteristics of Northern Gulf cod have varied over the years. Certain changes occurred during the decline of stock abundance, when cold oceanographic conditions were unfavourable. Growth, condition, size and age at sexual maturity decreased in the mid-1980s and in the early 1990s. These changes had a negative impact on egg production because smaller fish, in poor condition at sexual maturity, are weaker and produce fewer eggs. On the other hand, the natural mortality rate may have increased, as fish in poor condition have lower

chances to survive, particularly after reproduction, when environmental conditions are unfavourable. However, an improvement of these biological parameters has been noted in recent years, so much so that the situation is more positive with regards to the biological characteristics of the stock.

Cod growth increased during the second half of the 1990s. Weight and size at the commercial fishery age increased, and the observed values since 2000 are similar to those noted before the decline in abundance of the early 1980s. Fish in good condition have a better chance of surviving. There are significant seasonal variations in terms of cod condition, with a high in fall and a low in spring. Energy reserves accumulated in late fall are critical for cod and must be sufficient for it to survive the winter and get through the spawning period in spring. Over the last six years, a period in which follow-up has been more intense, cod condition is considered to be stable and good.

Description of the fishery

Cod landings in the Northern Gulf of St. Lawrence totalled more than 100,000 tons in 1983 (Figure 2). They then regularly decreased until 1993. During the decline, boats using mobile gear caught their allocation, whereas those using fixed gear did not. The fishery was under moratorium from 1994 to 1996. A reduced fishery was authorized in 1997, with a TAC of 6,000 tons, and landings totalled 4,792 tons. The TAC was reduced to 3,000 tons for 1998 and 3,296 tons were landed. In 1999, the TAC was set at 7,500 tons and 7,136 tons were landed. In 2000, the TAC was at 7,000 tons, where it remained for 2001 and 2002, and landings for the fishing seasons for 2000, 2001 and 2002 (May 15 to May 14 of the following year) totalled 6,834 tons, 7,150 tons and 6,338 tons respectively. In 2003, the cod fishery faced a second moratorium, so there was no commercial fishery. The 2004 TAC was set at 3,500 tons and the 2005 TAC at 5,000 tons. Reported landings in January 2006 were 4,334 tons.

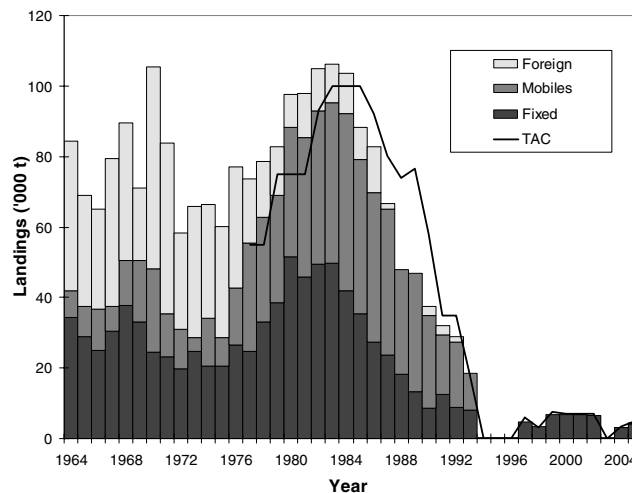


Figure 2. Landings and total allowable catches (TACs).

Sentinel fisheries were introduced in 1994 in order to develop a partnership between the industry and the Department of Fisheries and Oceans (DFO). Sentinel fisheries are carried out within a well-defined framework and provide, among other things, abundance indices of the resource. Three types of fisheries are carried out each year: the gillnet sentinel fishery on the Lower North Shore (Division 4S) and on the west coast of Newfoundland (Division 4R), the

longline sentinel fishery and the trawl sentinel fishery on the entire territory (3Pn, 4RS). All catches made by sentinel fisheries are included in the TAC.

RESOURCE ASSESSMENT

Sources and trends

Abundance indices based on catch rates from fixed gear sentinel fisheries

Fixed gear sentinel fisheries provide two abundance indices. The first index comes from longline fishery, and the second from gillnet fishery. The catch and effort (CPUE) data was standardized using a multiplicative model, which establishes an index that reflects annual trends regarding cod abundance since 1995.

The abundance index of gillnet sentinel fisheries in 4R and 4S revealed changing catch rates between 1995 and 2002 (Figure 3), but they more than doubled from 2002 to 2003, and remained high in 2004 and 2005. The abundance index of longline sentinel fisheries in 3Pn, 4RS showed a CPUE increase between 1995 and 2001, followed by a drop in 2002. CPUEs remained stable in 2003. Longline CPUEs also increased significantly to reach a historical high in 2004, followed by a drop in 2005. The good CPUEs for both sentinel fisheries since 1998 are due to the harvest of the 1993 year-class.

Abundance indices based on trawl survey catch rates

The mobile gear sentinel fisheries program began in 1994 in the Northern Gulf of St. Lawrence, but only since 1995 have surveys covered Division 4S. Nine trawlers using a stratified random sampling protocol similar to that used by the DFO's scientific survey made by the CCGS *Needler* perform the July surveys. The gears used were adjusted and standardized in 1997 with the adding of restrictor cables, which maintain a constant trawl opening during fishing operations. The series of July sentinel fishery surveys show a gradual increase in stock abundance from 1995 to 2001. This abundance index then decreased from 2001 to 2002 and has remained stable since 2002 (Figure 3). All surveys indicate that most of the biomass is found in 4R.

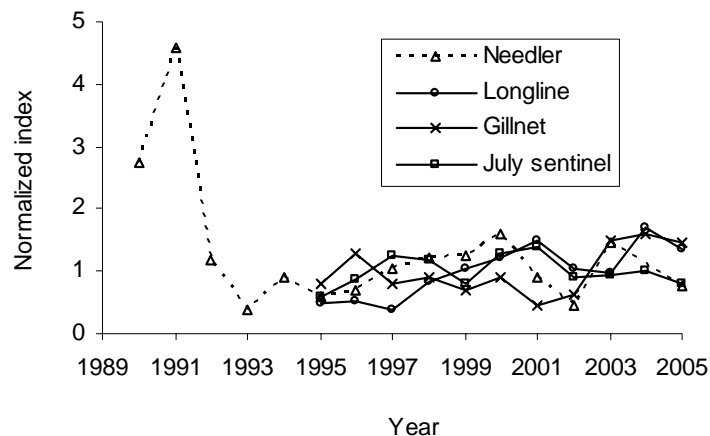


Figure 3. Normalized abundance indices.

Since July 2003, ten additional trawl tows have been carried out in three new shallow strata (10 to 20 fathoms). Many difficulties were encountered during these tows; unfavourable trawling locations and the presence of fixed gears. Many tows did not reach the targeted 30-minute duration. Given the inconsistency of these 10 tows, confidence intervals of the estimated value of minimal trawlable biomass are very high. Considering that these strata were only sampled three times, it is still too early to include them as an index for adjusting sequential population analysis.

The results from the CCGS *Needler* survey indicate that cod abundance increased from 1993 to 2000, but decreased in 2001 and 2002. The 2002 index is the second weakest of the 13-year series, the only lower value being that of 1993, right before the first moratorium. Abundance estimates dropped from 2003 to 2005 (there was no *Needler* survey in 2004, but there was a survey from the NGCC *Teleost*).

The Department's survey will now be conducted using the research vessel CCGS *Teleost* in replacement of the CCGS *Needler*. Because the CCGS *Teleost* uses a trawl with different selectivity, intercalibration is necessary to link both time series. Such intercalibrations were conducted in August 2005.

Exploitation indices from tagging results analysis

We analysed tagging-recapture data from 1,297 cod tagged with simple, double or high value tags in 4Rd and 3Pn in 2004 and 2005. A total of 183 cod were recaptured. The recapture pattern suggests the occurrence of at least two stock components, one migrating to the north along the west coast of Newfoundland in summer, and another distributed across 4Rd, 3Pn and 3Psa in summer. Annual exploitation rates calculated from various tagging experiments were variable (1 to 63%), but generally higher than 12%, which is slightly higher than the exploitation rates calculated by the sequential population analysis. Exploitation rate calculations from tagging represent an independent source of information which supports stock assessment calculated according to sequential population analysis.

Resource Status in 2005

Total population estimates

Sequential population analysis (SPA) is an analytical model that provides population estimates per year class by taking into account natural mortality (M) and fishing mortality (F), for fish available to the fishery. This analysis is also based on approximate age of catches according to commercial fishery. It is calibrated using indices from fixed gear sentinel fishery in coastal waters, from mobile gear sentinel fishery in offshore waters, and from the scientific survey conducted by the *Needler*.

To reflect the deterioration of environmental conditions, of an escalation in poor fishing practices and of the increase of seal predation, it was decided to increase M from 0.2 to 0.4 beginning in 1986 for several cod stocks. Environmental conditions have improved recently, which has led to renewed growth and an improvement in fish condition. Furthermore, wasteful fishing practices stated in the past are not as prevalent because of strict monitoring of the fishery (new log books, presence of observers, dockside monitoring, quality control, etc.). Nevertheless, seal predation remains significant.

Total mortality rates (Z) of fully-recruited Northern Gulf cod (ages 4-12 years old) during the 1990-2003 period were assessed using catch rates from the CCGS *Needler* and sentinel surveys of July. The two surveys show a gradual decrease of the total mortality value (Grégoire and Fréchet, 2005). The natural mortality value was thus reduced from 0.4 to 0.3 for the 1997-2000 period and from 0.3 to 0.2 since 2001.

The proportion of sexually mature fish (spawning stock) according to size or year-class is used to establish spawning stock biomass (SSB) or size. SPA results indicate that the abundance of 3+ year-old individuals dropped from 559 million in 1980 to 40 million in 1994, before slowly increasing to 47 million in 1999. Thereafter, total population decreased to 34 million individuals in early 2006. Spawning stock decreased from 223 million in 1982 to 8 million in 1994. It increased to 22 million at the beginning of 2006. The exploitation rate of 7-10 year-old individuals calculated by SPA was stable (around 20%) from 1999 to 2002; this value was very low in 2003 due to the moratorium (Figure 4). The exploitation rate associated with catches totalling 4,334 tons in 2005 is 12%.

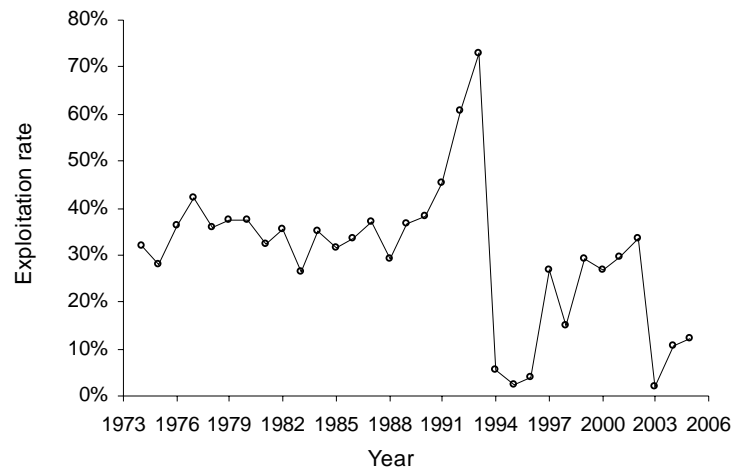


Figure 4. Exploitation rate of 7-10 year-old cod.

Population numbers were converted to biomass using average weights-at-age calculated annually from commercial fishery. Total biomass for 3+ year-old fish declined from 603,000 tons in 1983 to 26,000 tons in 1994. It increased to 51,000 tons at the beginning of 2006 (Figure 5). Reproductive biomass declined from 378,000 tons in 1983 to 9,000 tons in 1994, to reach 42,000 tons at the beginning of 2006.

Stock abundance and biomass estimates on January 1st, 2006, were based on 3+ year-old individuals, mean weights at age and maturity ogives (2003 to 2005).

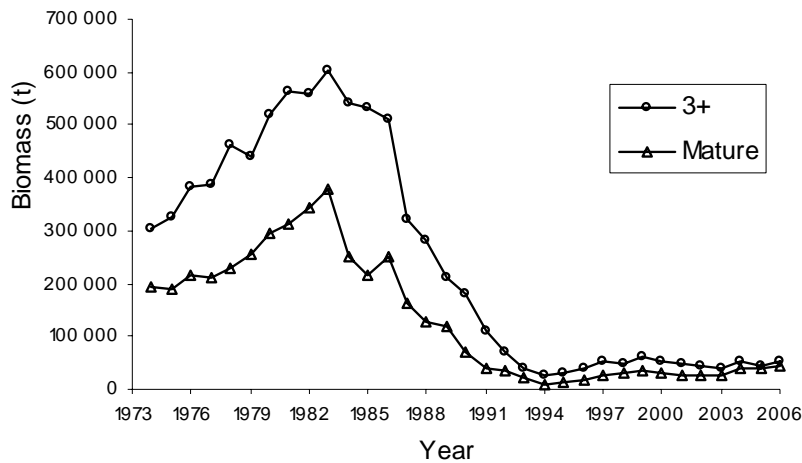


Figure 5. Estimated biomass of 3+ year-old individuals and biomass of mature individuals.

There have been no major signs of recruitment recovery in the past 16 years (Figure 6). Commercial catches from 1999 to 2001 were sustained mostly by the 1993 year-class, which came about prior to the moratorium. Recruitment at age 3 has declined from 13 million individuals in 1998 to an all-time low of 6 million individuals in 2005. The 3 year-old recruitment estimates in 2006 (2003 year class) was similar to year classes observed since 2003.

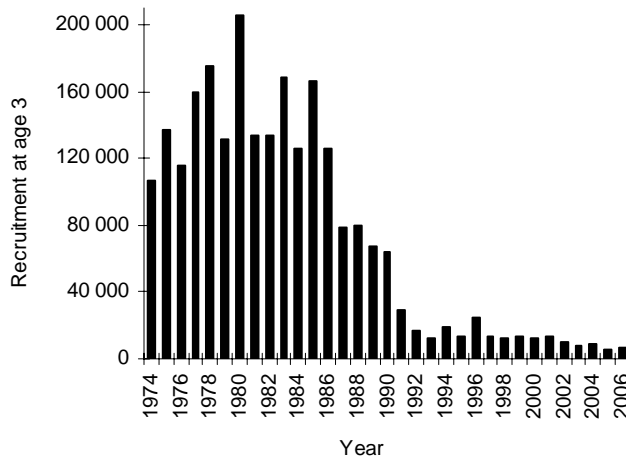


Figure 6. Estimated number of 3 year-old recruits.

Numbers at age, the proportion of mature females at age and egg production at age were used to calculate the total production of eggs for the stock, the probability of survival between hatching and recruitment at age 3 and the potential population increase. Based on natural mortality values used in the sequential population analysis, the potential population increase would have dropped significantly between the mid 80s and 90s. The average reproductive characteristics of recent years would favour average increase rates between 10% and 20% per year. However, average total mortality conditions maintained since the end of the first moratorium in 1997 would not re-establish the population, while maintaining the total mortality conditions followed since 2004 would create potential increase rates around 4% per year in average recruitment conditions.

Biological data

The direct influence of the condition factor on cod fertility has helped develop a multiple regression model describing the relation between size, condition and potential fertility of northern Gulf cod. This model has helped estimate the changes in fertility for this cod stock since 1994. Egg production at size and age has dropped significantly between the mid 80s and mid 90s. A gradual increase has been observed since this period, and the current levels are comparable to those in the early 80s.

Sources of uncertainty

For many years, accidental catches by shrimpers in the Gulf are an issue of concern for several stakeholders in the fishery industry and DFO. This has led, since 1994, to the use of the Nordmore grate by all shrimpers in the Gulf. This grate is installed on the trawl and prevents from catching large fish.

The Gulf shrimp fleet is subject to a 5% coverage of its fishing effort (h) by the observer program. This coverage totals a yearly average of nearly 5,550 observation hours. The collected data from the ocean observation program has helped locate the cod catch areas (Figure 7). The area with the most cod catches is located south-west of Anticosti Island. The size of the cod caught indicates that they are mainly 1 and 2 year-old juveniles. These small cod are captured in 22% of the tows covered by the observers and these captures are of the order of 1 kg per tow. Total annual quantities of cod captured by shrimpers can be projected by multiplying the catch rates recorded by the ocean observation program with the total shrimper effort. Between 1999 and 2005, the annual captures of small cod by Gulf shrimpers totalled on average 9.4 tons, with a maximum of 17 tons in 1999 and a minimum of 4 tons in 2005. A study published in 1992 by Hurtubise *et al.* indicated that cod captures by shrimpers in 1991, prior to the introduction of the Nordmore grate, was 3,793 tons. These numbers before (3,793 tons) and after (9.4 tons) the introduction of the grate show its great efficiency. The average number of cod captured by shrimpers for the 1999-2005 period is 81,000 for 1 or 2 year-old fish. It's not easy to determine whether this number is significant or not, but it represents 11% of the 2 year-old cod population in 2005 according to the estimates provided by the SPA.

In addition to the dumping at sea of smaller cod, another potential problem with unaccounted fish mortalities in the shrimp fishery could be the post-selection mortality of fish excluded by the grate. In fact, there is no information regarding the fate of fish that escape and the mortality that could result from stress, fatigue and grate related injuries.

The issue of migration of the northern Gulf cod in 3Ps has been frequently discussed in the past. Since 1999, to prevent northern Gulf cod from being captured during the winter fishery in the western part of 3Ps, a portion of the Burgeo Bank (3Psd) has been closed to the cod fishery from November 15th to April 15th. This section would correspond to a fraction of the mixing area between the 3Pn, 4RS stock and the 3Ps stock. Several research projects have been carried out over recent years in order to better describe the extent of the mixing (tagging, seasonal evolution of maturity, otolith trace elements) (Bérubé and Fréchet 2001; Méthot *et al.* 2005). A workshop on this issue took place in October 2000. The conclusion was that a significant portion of captured cod in winter in areas 3Psa and 3Psd came from the northern Gulf stock.

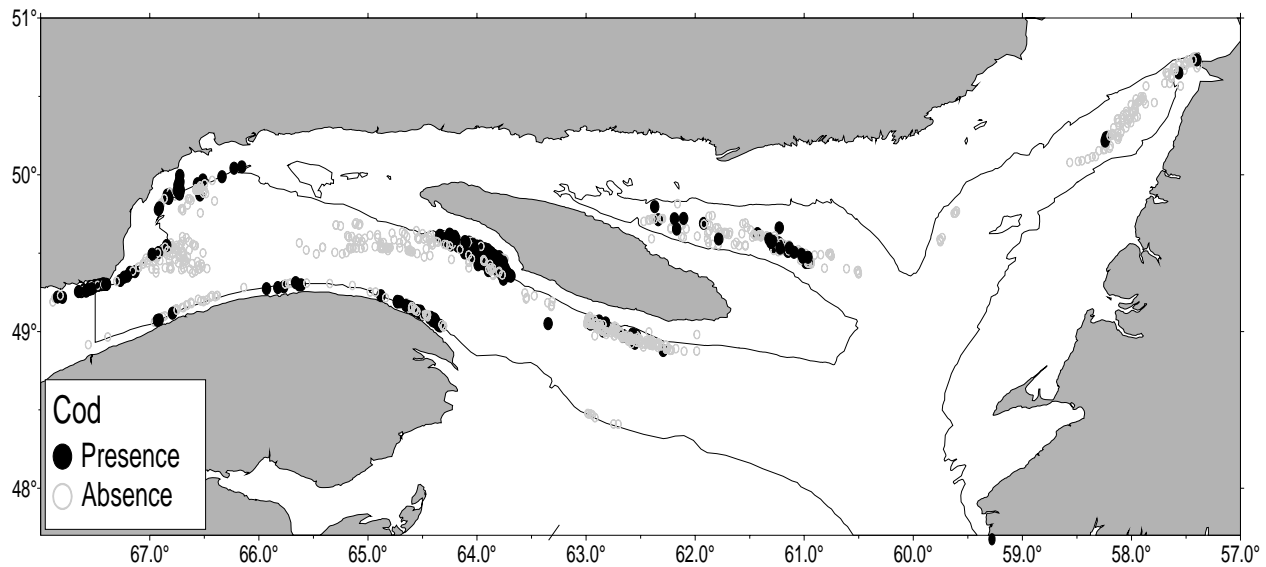


Figure 7. Spatial distribution of accidental cod catches in the shrimp fishery.

One of the mixing projects consisted in estimating the proportion of northern Gulf cod stock wintering in area 3Ps by using telemetry methods (the Counting Fence project). Transmitters were inserted in the abdominal cavity of 262 cod from the northern Gulf and sent an individually coded signal every minute over the course of 15 months. These signals were collected by four counting fences and the main one was deployed on the border between 3Pn and 3Ps (49 receivers) and 3 secondary lines in 4R and 3Pn (9 receivers), on the eastern flank of the Burgeo Bank (11 receivers) and on the western flank of the St. Pierre Bank (11 receivers). Based on detection efficiency tests, we concluded that 61% of cod >55 cm crossed into 3Ps in the fall of 2004. Cod crossed over to 3Ps mainly in December and returned to 3Pn generally in April. This study also highlights the fact that a variable proportion of the northern Gulf stock is present in 3Ps in April at the moment when the abundance survey in 3Ps is conducted, which may bias the abundance estimates of cod in 3Ps. This study also shows that current management measures in 3Ps appear to sufficiently protect the northern Gulf stock when it is present in this area in winter.

ADDITIONAL POINT OF VIEW FROM THE STAKEHOLDERS

For the ninth year in the past decade (no survey in 2004 due to moratorium in 2003) the *Re-groupment 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 within each of the three (3) respective 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 2005 fixed gear commercial fishing season with 51 fish harvesters being interviewed in 3Pn, 83 in 4R and 41 in 4S. The objective of the survey was to review various aspects of the fishery including population demographics, biological information and trends in catch rates.

Results relating to population demographics indicated that aspects of fishers experience in the fishery and average age has increased somewhat in recent years while average vessel length has remained stable for all zones since the moratorium. For comparison of 2005 versus the 2004 season, respondents noted that cod size (overall length) and condition was the same or had increased and was in recent years extremely positive, particularly with respect to condition. With respect to migration, the majority of the respondents indicated minimal change in migration timing, however, in recent years a greater percentage of 3Pn respondents noted the excellent abundance (high commercial CPUE) of fish in 3Pn in July which is not a 'traditional' observation for this area. With respect to fishing depth, fishers have maintained activity on the same grounds with very little reported variation. This has been a result observed in the survey since its inception.

With respect to catch rates, the recent trend has been an increasing one for all zones, with the most optimistic perception in 2005 (Figure 1). The most optimistic view remains in 3Pn, followed by 4R and 4S. It is also worth reiterating that these values are much higher compared to the pre-moratorium period (i.e. 1992-93). In summary, the positive trend in catch rates both in terms of level and the extensive geographic area observed indicate to harvesters that the abundance of this stock is much higher than what the current assessment indicates.

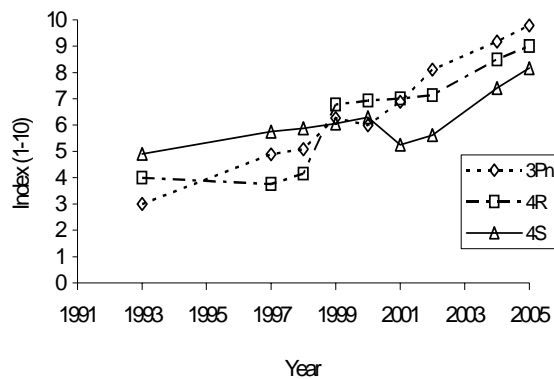


Figure 8. Performance index of a survey conducted with fixed gear fishermen.

CONCLUSIONS AND ADVICE

Based on current productivity, the pressure exercised by the fishery between 2000 and 2005 is too high (except for 2003 which was under moratorium).

Overall, year-classes produced after 1993 are less abundant. Current low stock size combined with weak recruitment ensures that catches over 3,000 tons in 2006 would lead to a drop in spawning stock biomass (Figure 9). An increase in mature biomass of 7% would require a moratorium (Figure 10).

The mid-term outlook suggests that declines in spawning stock biomass are very likely. A strong recruitment event, which is highly unlikely under current conditions and a significant decrease in mortality would be required to change this outlook.

Spawning stock biomass is estimated to be below the conservation limit reference points for this stock. When a stock is in such a situation, it is highly likely that its productivity has already been seriously reduced. The conservation limit for this stock is between 85 and 110 thousand tons of reproductive biomass. The 2006 spawning stock biomass is well below this level.

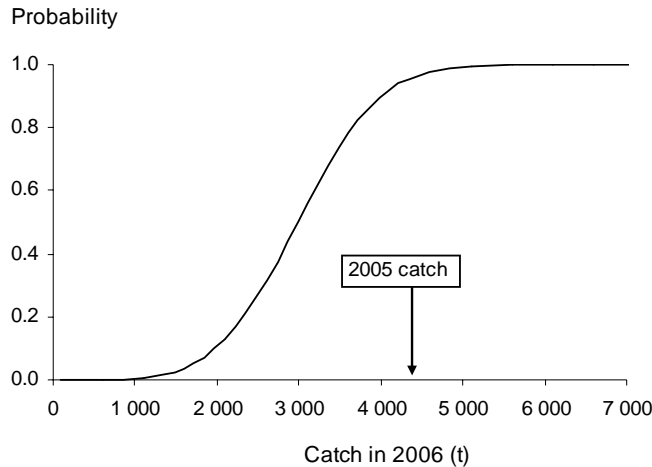


Figure 9. Mature biomass decline probability according to different catch levels in 2006.

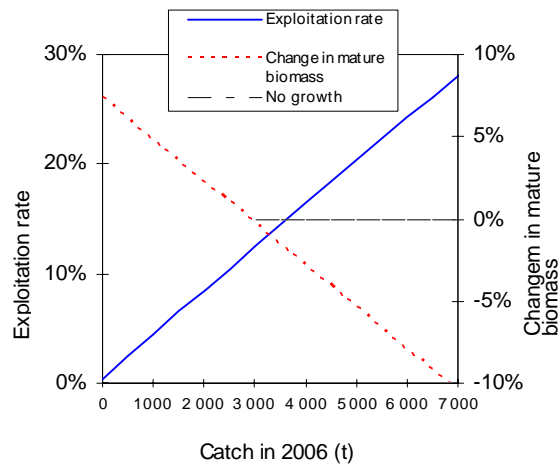


Figure 10. Harvesting rate and projected variation of mature biomass according to different catch levels in 2006.

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