

Cod in the Northern Gulf of St. Lawrence

Background

Cod in the northern Gulf of St. Lawrence (Divisions 3Pn, 4RS) undertake distant annual migrations. In winter, the fish gather southwest of Newfoundland at depths of over 400 m (200 fathoms). During April and May, they move towards the Port au Port Peninsula on the west coast of Newfoundland (Division 4R), where spawning begins. In summer, the cod disperse toward inshore areas, along the west coast of Newfoundland (Division 4R) and the Middle and Lower North Shore of Quebec (Division 4S). This inshore migration is influenced by warmer waters and the presence of capelin, a primary prey species for cod.

Based on the results of numerous tagging experiments, this stock is fairly isolated from other neighbouring stocks (those in 4TVn, 2J, 3KL and 3Ps). Mixing may occasionally occur in the northwestern Gulf (with the 4T,Vn stock), the Strait of Belle Isle (with the 2J, 3KL stock) and on Burgeo Bank (with the 3Ps stock). Recent studies have quantified the magnitude of the mixing around Burgeo Bank during the 1990s.

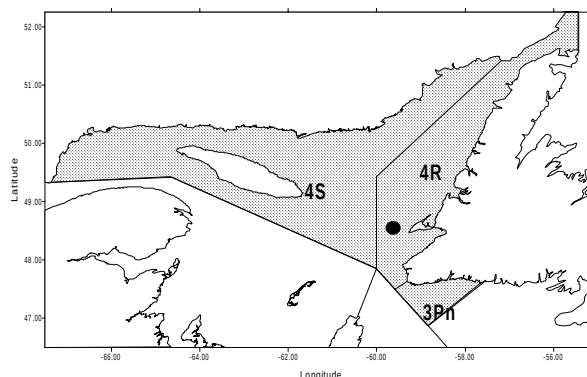


Figure 1. Range of the cod stock in the northern Gulf of St. Lawrence. The circle indicates a spawning ground identified in 1994 and 1995.

Landings (thousands of tonnes)

Year	1992	1993	1994	1995 ¹	1996 ¹	1997 ¹
TAC	35	18	0	0	0	6
Landings	28	18	0.4	0.3	0.7	4.4

¹ Preliminary data

Summary

- The abundance of the cod stock of the northern Gulf of St. Lawrence declined sharply in the late 1980s and early 1990s. The spawning biomass was only 26,000 t at the start of 1998, which is only 10% of the average spawning biomass for the period 1974 to 1986.
- The directed fishery in 1997 produced landings of 4,400 t, with a fishing mortality of 0.26. A complete ban on fishing in 1998 should allow the adult segment of this stock to grow by 20%, whereas a fishery with a TAC of 6,000 t would prevent any growth.
- The size of the 1993 year-class has been estimated at 30 million individuals, which is the largest number recorded since 1991, but well below average recruitment of 95 million individuals.

- The growth rates and condition of cod have improved in recent years.
- The catch rates in the sentinel fisheries using fixed gear fell in 1997; the fishers attribute this decrease to the re-opening of the fishery.
- Mortality caused by factors other than recorded landings was high in the late 1980s and played a role in the stock's collapse. It is very likely that, during the 1990s, this mortality remained at least twice as higher as previously estimated.
- This analytical assessment is the first to be conducted since 1994 and includes abundance indices from DFO research surveys and from the sentinel fisheries, which weren't available back then. The abundance index derived from the winter survey (*Gadus*, 1978 to 1994) has not been used.

Description of the fishery

The stock was under moratorium from 1994 to 1996. In 1997, a limited fishery was authorized, with a TAC of 6,000 t. Landings totalled 4,400 t. The directed fishery was restricted to longlines, with fishing effort not exceeding 2,000 hooks per trip. No fishing by foreign vessels was allowed, and the small catches made by trawlers occurred within the context of scientific projects. In Division 4S, a total of 218 t of cod was taken, mainly as part of an experimental fishery using gillnets.

Limited commercial fishing was authorized in 3Ps also. Recent studies have shown that

during the winter of 1996, the majority of cod on Burgeo Bank (western part of Division 3Ps) came from the northern Gulf of St. Lawrence. The analysis of samples collected in 1997 has not yet been completed, and no estimate can as yet be provided of the pro-

portion of northern Gulf cod that were in Division 3Ps, or of the size of Gulf cod

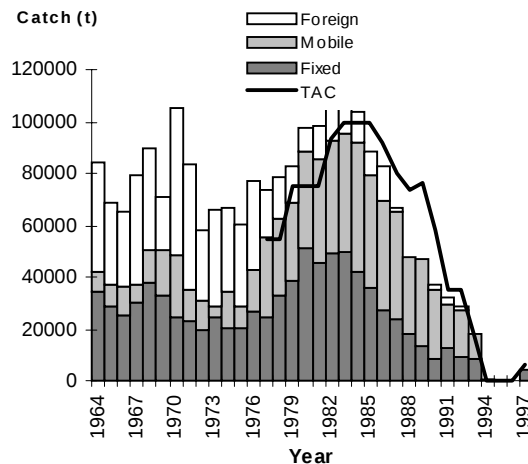


Figure 2. Landings and Total Allowable Catches (TAC).

catches made there. The magnitude of the mixing that occurs between the two stocks will be examined in detail before the next assessment.

Biological characteristics

The 1991 year-class (fish six years old) dominated commercial catches, accounting for 25% of the total number of cod caught. The mean weight at age rose in 1996 and 1997. The average size of the individuals taken by the sentinel fisheries using longlines rose each year during the moratorium. The average size of fish caught with longlines in 1997 was 55 cm, which is very similar to the value recorded in the late 1970s and early 1980s.

The condition of individual cod reflects their state of health. Since 1995, the condition of the fish has remained good during the summer and fall. However, their condition in winter is the only measure that indicates their potential for growth, reproductive success and survival after spawning. The winter

condition of cod has declined, reaching a record low level in 1991 and 1992, but has improved after that. In summer, cod caught by fixed gear near the east coast are in better condition than those caught in deeper waters by mobile gear. This finding may relate to different feeding patterns in the two environments. Inshore cod feed abundantly on prey with a higher energy content (fish), whereas the cod caught offshore eat less food and their diet is less rich (invertebrates).

Two new indices of reproductive potential are presented. The first indicates that major changes have occurred in the age at which sexual maturity is reached. Cod now reach

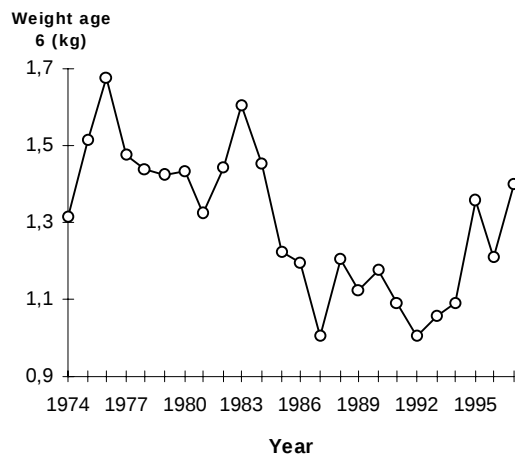


Figure 3. Mean weight of a six-year-old cod caught in the commercial fishery.

sexual maturity at age six on average, compared with age eight in the early 1980s. This may relate to the precarious state of the resource. The second is the index of fecundity at length. These two relationships have been used to describe reproductive potential, expressed in terms of egg production by all spawners.

Based on the data from DFO trawl surveys and the sentinel fisheries, **total mortality** during the moratorium may have reached

40% (instantaneous rate of 0.6). Since no fishing was conducted during the period, that estimate represents natural mortality (M). This high value is incompatible with the value of 16% (instantaneous rate of $M=0.2$) used in our analyses in the past. Several factors may explain the increase in natural mortality. They include unfavourable environmental conditions, an increase in unreported catches (discards, misreporting, etc) and higher predation. The available data do not allow us to precisely quantify seal predation on the two cod stocks in the Gulf of St. Lawrence. In view of this, we doubled the

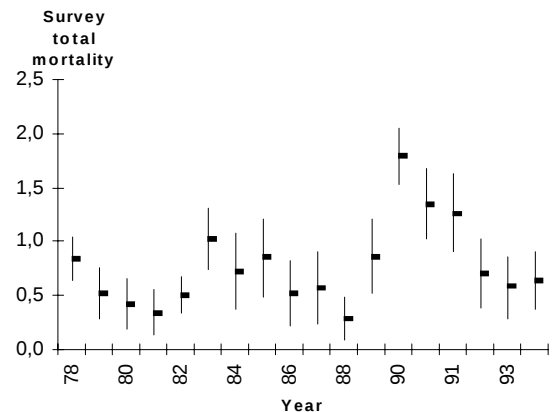


Figure 4. Estimate of total mortality based on research surveys (mortality values represent the mean of four consecutive years, e.g. 94 = 94 to 97).

value used for natural mortality in our analyses (from 0.2 to 0.4) as of 1986, in order to take account of all the factors mentioned earlier.

Abundance indices

Bottom trawl surveys

The **sentinel fishery program using mobile gear** began in the northern Gulf in 1994, but it was not until 1995 that the entire stock area was covered. These surveys are conducted twice a year (July and October) using

nine trawlers. They carry out stratified random sampling like that done by DFO staff aboard the *Needler*. The gear employed by the nine trawlers was standardized in 1997 by introducing the use of a restrictor cable, which keeps the size of the trawl opening constant throughout fishing operations. This device has reduced between-vessel variability from 25% to 6%, thereby enhancing the accuracy of abundance estimates. The July abundance index doubled between 1995 and 1997, but remains low in absolute terms. The October index rose between 1995 and 1996, but declined in 1997. The 1993 year-class has dominated catches during the last five surveys, from age two in 1995 to age four in 1997. The major part of the biomass is located in Division 4R. The distribution of cod does not vary significantly between July and October.

The *Alfred Needler* (DFO) survey was initiated in 1990 to assess the shrimp and redfish populations in the Gulf. In subsequent years, it was adjusted to enhance coverage of the geographic range of the northern Gulf cod by surveying fishing area 3Pn and waters less than 50 fathoms deep. The number of cod peaked in 1991, fell sharply after that and remained at a low level from 1993 to 1996. The population size rose slightly in 1997. As in the sentinel fisheries, the 1993 year-class dominated the catches from the 1996 and 1997 surveys. This result attests to the complementarity of the sentinel operations and the research surveys conducted aboard the *Needler*.

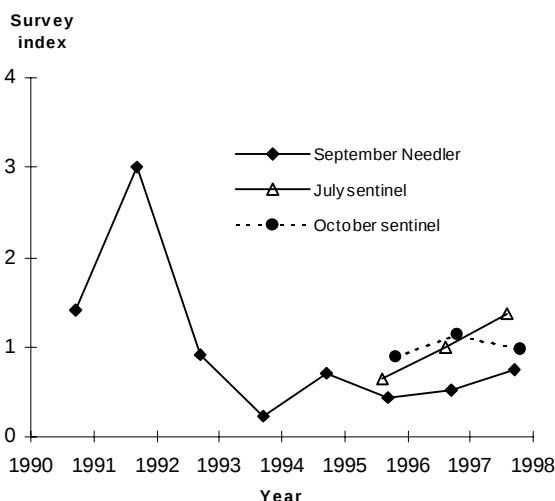


Figure 5. Abundance index from research surveys.

Catch rates dropped in 1997 for all fixed gear sentinel fishing activities in the area. The fishers were expecting this, because the many vessels participating in the commercial fishery were applying a great deal of effort in a small region. Hence, it is possible that a local decline in abundance affected the index. This situation limits the usefulness of the fixed gear sentinel fisheries as an abundance index for the present assessment, and the matter will be re-evaluated before the next assessment. Nonetheless, catch rates have remained high for the fishing sites farthest south of 4R and in 3Pn.

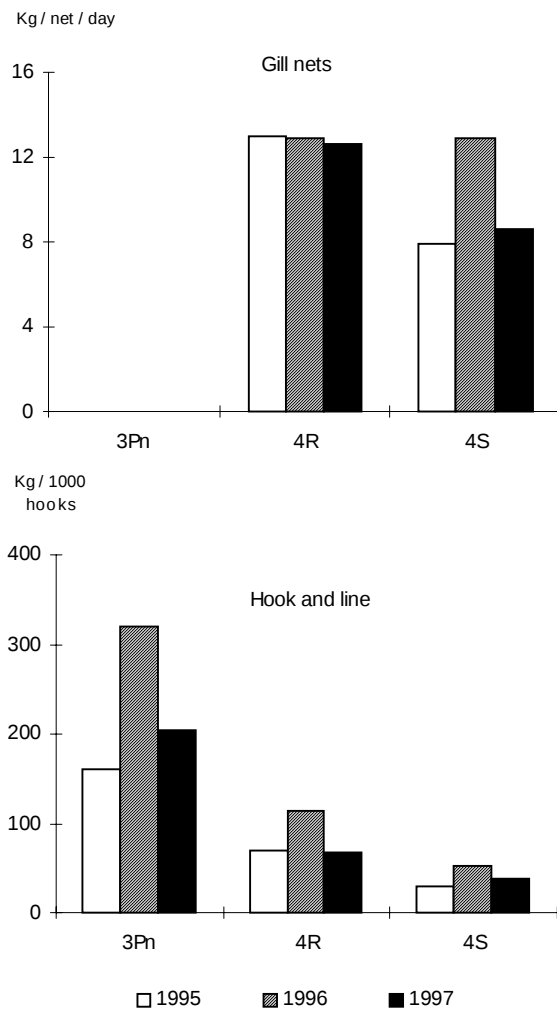


Figure 6. Catch rates of the sentinel fisheries using fixed gear.

State of the resource

This is the first analytical assessment that we have been able to do since 1994. Previous assessments were based solely on the index derived from a January survey conducted aboard the research vessel *Gadus Atlantica* (1978 to 1994). This index can no longer be used owing to the major incursions of northern Gulf cod into fishing area 3Ps, which may have caused an underestimation of stock abundance during the 1990s, given that 3Ps

was not sampled. In fact, this situation has been confirmed by recent research indicating that 83% of the cod in area 3Ps in January 1996 came from the Gulf (3Pn, 4RS). As a result of the change in cod distribution and the resulting mixing of stocks, the winter survey is no longer being used to derive an abundance index. The present assessment is based on sequential population analysis using the ADAPT model. Catch at age since 1994 is based on the by-catches of other fishers (flatfish, redfish, etc) and the sentinel fisheries; the corresponding value for 1997 includes the directed cod fisheries. The abundance indices used consist of the DFO trawl surveys, conducted aboard the *Alfred Neebler* from 1990 to 1997, and the sentinel fishery surveys (July and October, 1995-1997).

The **abundance** of fish three years old and over has fallen by 90% since 1985, and has remained at a record low level since 1995. The spawning **biomass** was 26,000 t in 1998, which corresponds to only 10% of the average spawning biomass between 1974 and 1986. There has been a slight increase in

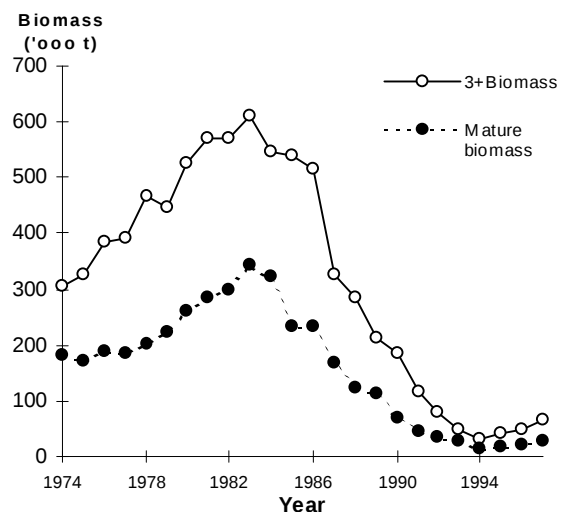


Figure 7. Total biomass (fish aged three and over) and spawning biomass estimated by sequential population analysis.

biomass since 1994, mainly due to growth of individual fish.

Egg production by the stock fell by 95% between 1983 and 1994. The factors responsible include the stock's decline, the decrease in cod growth and condition, and earlier sexual maturity. Egg production was so low in 1994 that average recruitment at age three was unlikely to occur. It is not surprising therefore that the 1993 year-class, which contains 30 million three-year-old individuals and is the largest year-class since the 1987 year-class, is significantly smaller than the long-term average size of 95 million.

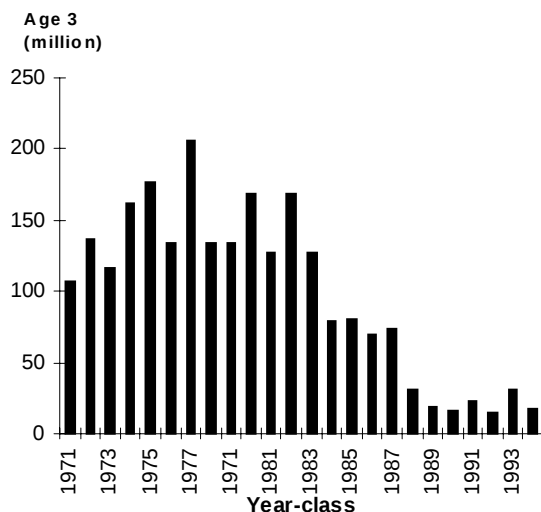


Figure 8. Estimate of recruitment at age three.

The 4,400 t of cod caught by the directed fishery in 1997 reflects an exploitation rate of 23% (fishing mortality rate of 0.26). This value does not necessarily indicate that the $F_{0.1}$ reference level used in the past has been exceeded. The fact that natural mortality has doubled in recent years adds a factor of **uncertainty** and invalidates the use of that reference level ($F_{0.1} = 0.2$) as computed in the past. Furthermore, given the uncertainty about whether the recently observed high



Figure 9. Estimate of fishing mortality.

level of natural mortality will persist, it is not necessary to calculate a new $F_{0.1}$. The $F_{0.1}$ level that includes natural mortality $M = 0.4$ should be higher, but it would be risky to harvest this stock more intensively when productivity and abundance are so low.

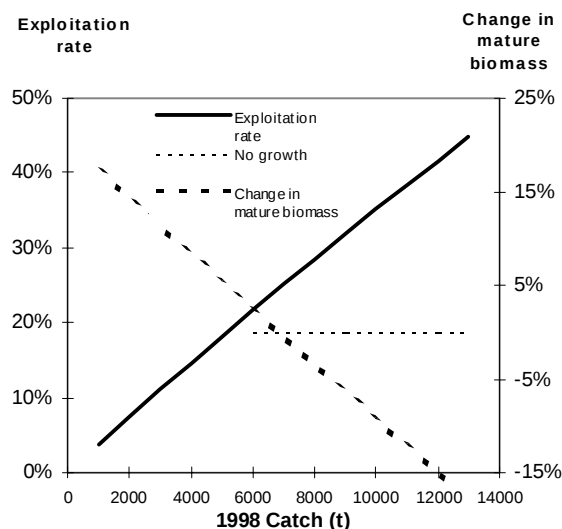


Figure 10. Projected exploitation rate and changes in spawning biomass relative to various catch levels in 1998.

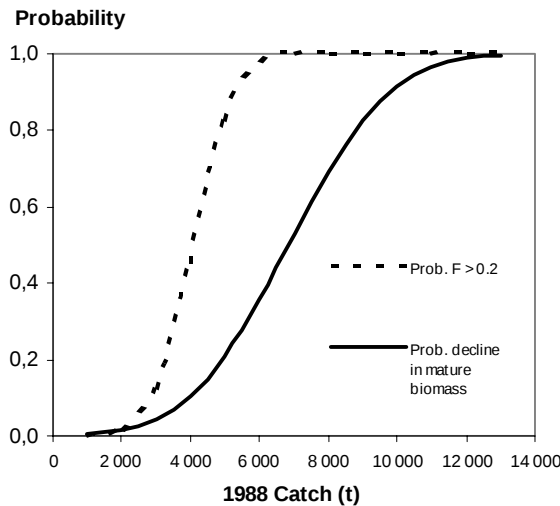


Figure 11. Probability of a decline in biomass (solid line) and of fishing mortality exceeding 0.2 in relation to various catch rates.

Another major source of uncertainty relates to the incursions of northern Gulf cod into 3Ps. It is impossible to separate the catches made in this region in the past and accurately assign them to the two stocks; however, it is likely that all winter fisheries in the western part of 3Ps may have occasionally included a major volume of cod from the northern Gulf. The fishing mortality imposed on this stock may thus have been higher than the current estimate.

Outlook

Risk analyses have been done to evaluate the effect of various catch levels in 1998 on the spawning biomass. The results indicate that the productivity of the stock should increase marginally in the short term due to faster individual growth. The 1993 year-class should contribute 33% of the total spawning biomass. A ban on fishing in 1998 would allow the adult segment of the stock to grow by 20%, whereas a fishery with a TAC of 6,000 t would prevent any population growth. A

catch in the order of 4,000 t would cause fishing mortality of 0.2.

For more information.

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Published by

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Quebec, Canada
G5H 3Z4

Email: Stocksrl@dfo-mpo.gc.ca

ISSN 1480-4913

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