

The Northern Gulf of St. Lawrence (3Pn, 4RS) cod in 2004

Background

Every year, Northern Gulf of St. Lawrence cod (NAFO Divisions 3Pn and 4RS) undertake extensive migrations. In winter, they gather off southwestern and southern Newfoundland at depths of more than 400 m (200 fathoms). In April and May, they move 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 1st and June 15. During the summer, fish continue their migration and disperse towards the coastal zones, along the West coast of Newfoundland (Division 4R) and towards Quebec's Middle and Lower North Shore (Division 4S). This migration towards the coasts is associated with warmer water and the presence of capelin, cod's main prey.

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

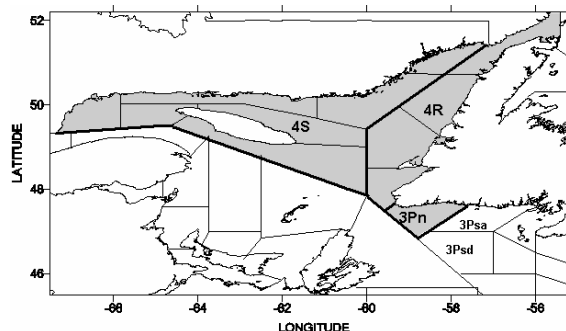


Figure 1. Cod stock management area in the Northern Gulf of St. Lawrence. For reference, fishing areas 3Psa and 3Psd are also indicated.

Cod landings (in thousands of tonnes) in Divisions 3Pn and 4RS

Year	1977-1993	1994-1996	1997	1998	1999	2000	2001	2002	2003	2004
TAC	70.4	0	6	3	7.5	7	7	7	0	3.5
Landings	70.2	0.3	4.8	3.3	7.1	6.8	7.1 ²	6.3 ³	0.4 ¹	3.1 ¹

¹ Preliminary data

² Includes 253 t from recreational fishery

³ Includes 34 t from recreational fishery

Summary

- In 2003, cod fishery was under moratorium. The 2004 TAC was established at 3,500 t, as recommended by the FRCC. Landings in January 2005 totalled 3,112 t.
- The abundance and spawning stock biomass remain low. The spawning stock biomass (SSB) increased from 9,000 t to 37,000 t between 1994 and 1999. The SSB estimate for 2005 is 39,000 t.
- The only available abundance indices for 2004 are from the July sentinel fishery trawl surveys as well as the catch rates for the longline and gillnet sentinel fishery. The data from the 2004 survey conducted by the CCGS Teleost could not be used for analytical

assessment because intercalibration with the ship used previously, the CCGS Alfred Needler, could not be carried out.

- All the indices expressed by weight increased substantially over the last two years.
- The two trawl indices (CCGS Alfred Needler and sentinel) increased from 1995 to 2000. The Needler index decreased in 2001 and 2002, then increased 3-fold in 2003. The index derived from the sentinel fishery trawl survey also increased in 2001, but decreased in 2002 and has since remained stable. The index for the longline sentinel fisheries has shown a general increase since 1995. The index for the gillnet sentinel fisheries has remained mostly stable from 1995 to 2002, but has substantially increased over the last two years.
- The recruitment estimates at age 3 in 2005 (the 2002 age class) is the lowest in the series. The only recent information regarding the young fish comes from the July sentinel fishery trawl survey. According to this limited information, 2004 estimates of individuals between 2 and 4 years old are also among the lowest in the series.
- Condition and growth have improved over recent years, and fish now mature at older ages.
- The natural mortality value (M) used for analytical model calculations was reduced from 0.4 to 0.3 from 1997 to 2000, and to 0.2 since 2001. This was done to reflect many positive observations and analysis (of M) regarding growth, proportions of older individuals and mortality.
- Spawning stock biomass is estimated to be below the biological reference points for conservation of this stock. The recruitment to productivity component is of concern as well.
- Without the fishery, the biomass of the spawning stock is expected to increase by 15% at the end of 2005. With a 6,000 t fishery, it is expected to remain stable.

- In order to promote the increase of the stock's biomass, it is recommended that landing levels remain low.

Biological characteristics of the resource

The biological characteristics of the Northern Gulf cod have varied over the years. Certain changes occurred during the decline of stock abundance, when cold oceanographic conditions were unfavorable. 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 unfavorable. 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 abundance decline of the early 1980s. In fact, the mean weight of a 6-year-old cod in the commercial fishery reached a minimum in 1992 and has gradually increased since (Figure 2). The calculated value of the mean weight for 2000 is the highest since 1984. Trends are similar for size and weight in the other year-classes. The results from the CCGS *Alfred Needler* trawl surveys made between 1991 and 1999 also show an increasing trend in weight-at-age. Generally, average weights-at-age from surveys and fisheries increased from 1990 to 1998, and then varied without showing a trend.

The condition of cod is a factor that is studied through a program monitoring the general health status of the Northern Gulf

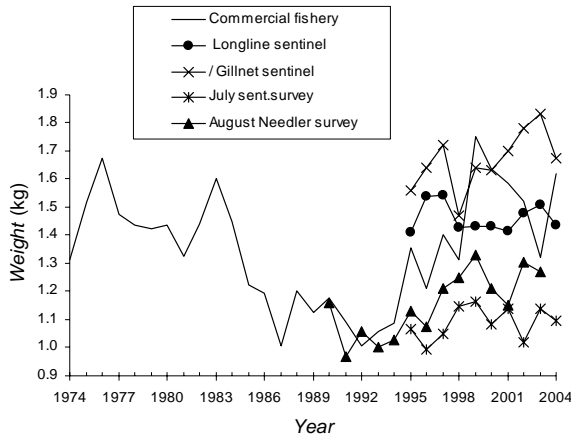


Figure 2. Mean weight of a six year-old cod caught in commercial fishery, research surveys, and fixed gear sentinel fisheries.

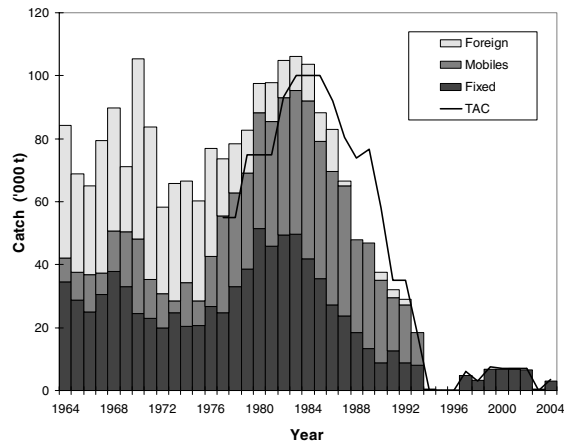


Figure 3. Landings and total allowable catches (TAC).

stock. Fish in good condition have better chances of survival. Cod condition shows significant seasonal variations, with a maximum in the fall and a minimum in spring. Accumulated energy reserves at the end of fall are critical for cod and must be sufficient to survive the winter and the spring spawning period. The condition of cod has been monitored through the fixed gear sentinel program since 1995. For the last five years, a period in which there has been more extensive monitoring, 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 t in 1983 (Figure 3). 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 t, and landings totalled 4,792 t. The TAC was reduced to 3,000 t for 1998 and 3,296 t were landed. In 1999, the TAC was set at 7,500 t and 7,136 t were landed. In 2000, the TAC was at 7,000 t, where it remained for 2001 and 2002, and landings for the

fishing season (May 15 to May 14 of the following year) for 2000, 2001 and 2002 totalled 6,834 t, 7,150 t and 6,338 t respectively. In 2003, the cod fishery faced a second moratorium, so there was no commercial fishery. The 2004 TAC was set at 3,500 t, as recommended by the FRCC. Reported landings in January 2005 were 3,112 t.

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.

Industry's perception

The second moratorium in 2003 prevented the *Regroupement des associations de pêcheurs de la Basse Côte-Nord (RAPBCN)* from Quebec and the Fish, Food and Allied Workers (FFAW) of Newfoundland and

Labrador to conduct telephone surveys among fixed gear cod license holders. Several meetings between DFO staff and fishermen (sentinel and fishermen involved in other groundfish fisheries) were held in 2004 to exchange views on stock status and other biological characteristics.

Generally, the industry considers that high catch rates by sentinel fisheries and high bycatch rates by other fisheries observed over a large portion of the area in 2003 and 2004 are indications of cod abundance and that therefore, the 2003 moratorium was unwarranted.

A new survey was conducted at the end of the 2004 fishing season among fishermen having landed at least 1,000 lbs of cod. According to the surveys conducted over the entire fishing area 3Pn, 4RS, fishing success rate was measured at 8.96 on a scale of 1 to 10. This is the highest value of the series that began in 1993.

Resource status

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.

Globally the indices of abundance do not show as important increase since 2002 than when expressed in weight. This is due to the few recruits and higher proportion of older fish observed. The abundance index of gillnet sentinel fisheries in 4R and 4S revealed changing catch rates between 1995 and 2002 (Figure 4), but they more than doubled from 2002 to 2003, and increased again in 2004. This increase was observed in almost all fishing areas. The abundance index of longline sentinel

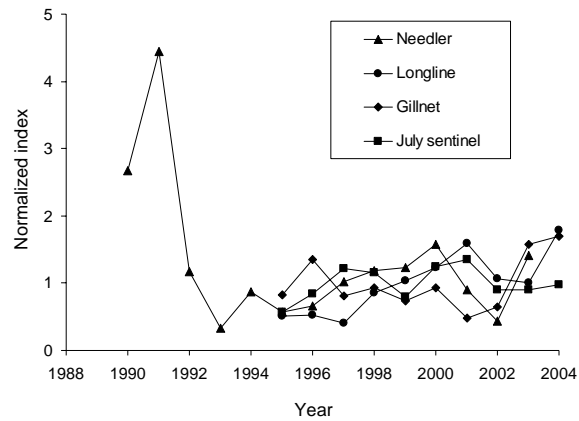


Figure 4. Standardized abundance indices.

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. The good CPUEs for both sentinel fisheries since 1998 are due to the harvest of the 1993 year-class. This year-class was 11 years old in 2004 and was significantly less abundant but nevertheless contributed to a proportional increase of older individuals within the captured population.

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 covering Division 4S. The October survey (1995-2002) was discontinued in 2003 due to the rationalization of the sentinel fisheries program. It is no longer used in the calibration of sequential population analysis.

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 in 2002 and remained stable in 2003, before increasing in 2004 (Figure 4). All three surveys indicate that most of the biomass is found in 4R.

Although the July sentinel fishery survey shows the largest minimal trawlable biomass values in 2004, a more comprehensive examination indicates that the increase is mostly due to the presence of many older individuals. The estimates of individuals between 2 and 4 years of age in 2004 are among the lowest in the series.

Ten additional trawl tows were carried out in July 2003 in three new shallow strata (10 to 20 fathoms). Many difficulties were encountered during these tows; unfavorable trawling grounds and the presence of fixed gears. Many tows did not reach the targeted 30-minute duration. Standardized catches ranged between 0 kg/30 min tow to 2,107 kg/30 min tow. Given the inconsistency of these 10 tows, confidence intervals of the estimated value of minimal trawlable biomass are very high.

These coastal strata were sampled again in 2004. The minimal trawlable biomass of strata between 10 and 20 fathoms contributed to 16% of the estimates in 2004 and 32% in 2003, for the entire depths. The age structure of sampled individuals in these strata is similar to those found deeper than 20 fathoms. Considering that these strata were only sampled twice, 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.

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. Unfortunately, technical problems prevented intercalibration in 2004. An intercalibration survey is planned for 2005.

The only available abundance indices for 2004 for calibrating sequential population analysis are from the July sentinel fishery trawl surveys as well as the longline and gillnet sentinel fishery CPUEs.

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 adjusted 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 wasteful fishing practices and of the increase predation by seals, 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 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 Z value.

SPA was also used to obtain estimates of M in blocks of years varying between 4 and 9 years for the 1990-2004 period. These analysis as well as the assessment of the Z

value of the surveys and a higher survival rate of recent cohorts suggests that M value would have gradually decreased since 1997. For more details, see Grégoire and Fréchet, (2004). 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 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 38 million individuals in early 2005. Spawning stock decreased from 223 million in 1982 to 8 million in 1994. It increased to 21 million at the beginning of 2005. 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 5). The exploitation rate associated with catches totaling 3,112 t in 2004 is 7%.

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 t in 1983 to 26,000 t in 1994. It increased to 54,000 t at the

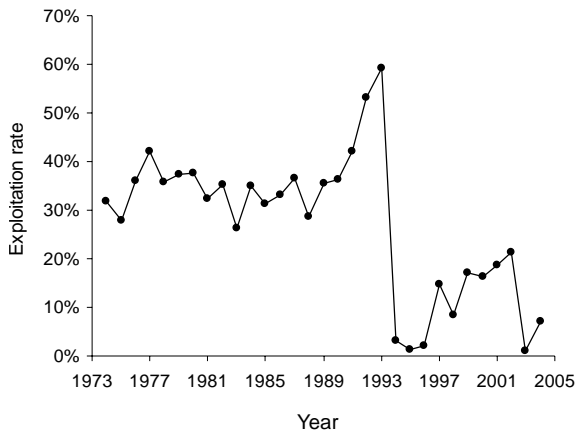


Figure 5. Exploitation rate of 7-10 year-old cod.

beginning of 2005 (Figure 6). Reproductive biomass declined from 378,000 t in 1983 to 9,000 t in 1994, to reach 39,000 t at the beginning of 2005.

Stock abundance and biomass estimates on January 1st, 2005, were based on 3+ year-old individuals, mean weights at age and maturity ogives (2002 to 2004). Fishing mortality for fully-recruited individuals was 7% (F=0.08) in 2004.

There have been no major signs of recruitment recovery in the past 15 years (Figure 7). 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 14 million individuals in 1998 to an all-time low of 4 million individuals in 2005. Abundance estimates of 2 year-old

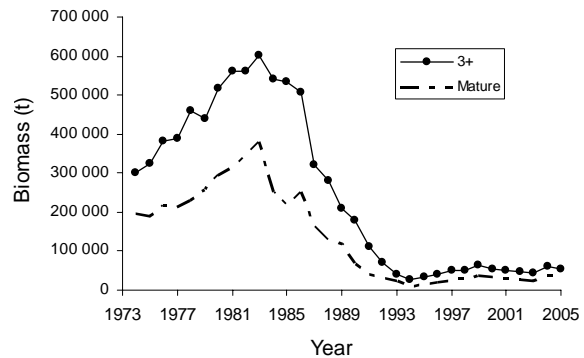


Figure 6. Estimated biomass of 3+ year-old individuals and biomass of mature individuals.

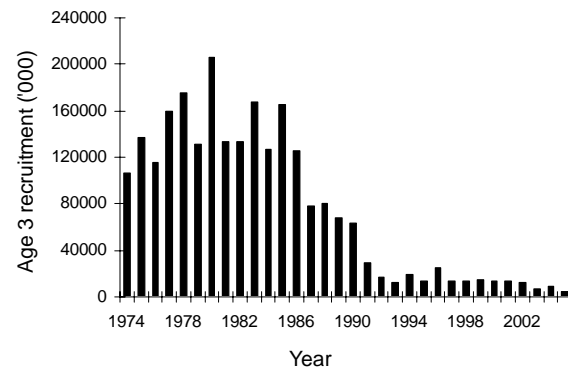


Figure 7. Estimated number of 3 year-old recruits.

fish, from the *Needler* survey in 2003, is the highest since 1990, but was not confirmed by the 2003 sentinel fishery survey for 2 year-olds or the 2004 survey for 3 year-olds. This age group was not as significant in the July 2003 sentinel fishery survey. The 3 year-old recruitment estimates in 2004 (2001 year class) was similar to year classes of the mid-1990s.

Sources of uncertainty

The issue of migration of Northern Gulf cod into 3Ps has been discussed frequently in the past. Since 1999, in order to avoid catching Northern Gulf cod during the winter fishery in the western part of 3Ps, a portion of the Burgeo Bank (3Psd) was closed to cod fishery from November 15 to April 15. This area would only be part of the area in which cod from the 3Pn, 4RS mix with 3Ps cod. Several research projects have been carried out in recent years in order to better describe the extent of the mixing (tagging, seasonal evolution of maturity, otolith microchemistry). A specific workshop on this issue was held in October 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.

The reduction of the natural mortality estimate is a key component of this assessment. Although abundance of this stock does not show a significant increase since the last assessment (as predicted in the risk analysis) this change means a higher productivity of the stock. The parameters invoked for these changes are described in section "Total population estimates". The exact value for natural mortality remains an uncertainty which will be examined in future years.

Another important source of uncertainty concerns the recruitment estimates for the cohorts from 1999 to 2001 based on the July 2004 sentinel survey. The trawl used in the sentinel survey uses a 40 mm liner whereas a 19 mm liner is used in the *Needler* survey. The latter provides more precision on these year class strengths. The

absence of the *Needler* survey in 2004 reduces significantly the quality and quantity of information of these year classes.

Tagging and return of tags

Since 1995, sentinel fishermen have tagged more than 62,000 cod in the Northern Gulf of St. Lawrence. So far, 3,112 tags have been returned, for a return rate of 5%. Experiments conducted with a high reward (\$100 per returned tag) have provided estimates of exploitation rate that are two to three times higher than those based on the rate of return of traditional tags (\$10 per returned tag). A project based on automated monitoring is presently in progress.

Outlook

The probability of a decline in mature biomass increases with the catch levels in 2005 (Figure 8). Overall, year-classes produced after 1993 are less abundant. Current low stock size combined with weak recruitment will result in a further reduction of spawning stock biomass with catches above 6,000 t in 2005. A 15% mature biomass growth target would require moratorium (Figure 9).

The mid-term outlook suggests that declines in spawning stock biomass are very likely. A strong recruitment event, which is highly unlikely under present conditions, and a

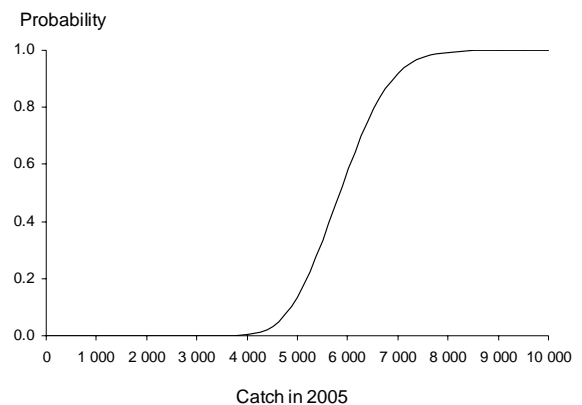


Figure 8. Decline probability of mature biomass according to different catch levels in 2005.

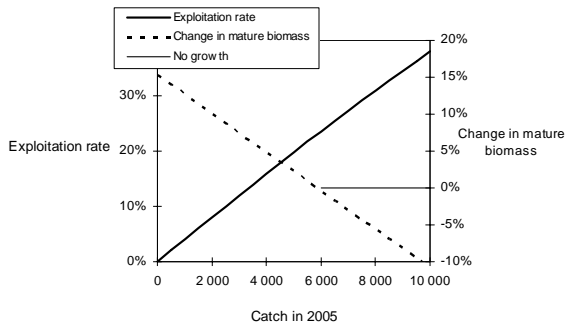


Figure 9. Harvesting rate and projected variation of mature biomass according to different catch levels in 2005.

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 to 110 thousand tons. The 2005 spawning stock biomass is well below this level.

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