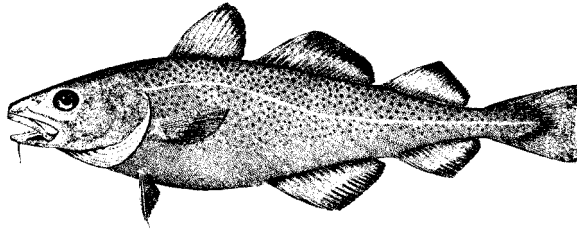


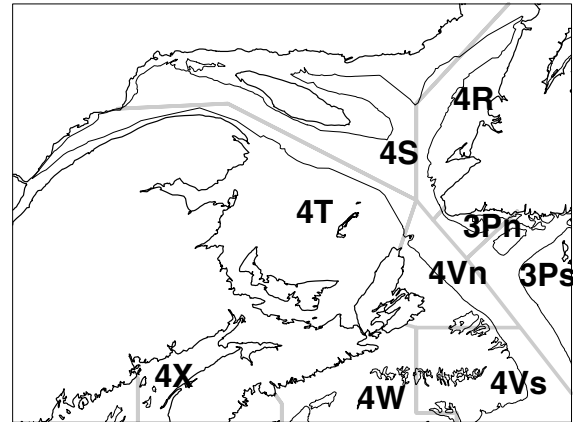


Gulf Region

Canadian Science Advisory Secretariat  
Science Advisory Report 2005/007



Cod in the Southern Gulf of St. Lawrence



Background

Southern Gulf of St. Lawrence cod are relatively long lived, and may reach ages of 20 or more when mortality is low. They begin to reach commercial size at age 4, and are fully available to the commercial fishery by age 8. They mature sexually at a size slightly below the commercial size of 41 cm (ages 4-5).

Southern Gulf cod are highly migratory. Spawning occurs in the Shediac Valley and around the Magdalen Islands from late April to early July. During the summer, the cod are widely distributed while they feed heavily on krill, shrimp, and small fish, primarily herring, Am. plaice, and capelin. The fall migration begins in late October and cod become concentrated off western Cape Breton in November as they move into 4Vn. The stock overwinters in 4Vn and northern 4Vs, along the edge of the Laurentian Channel. The return migration usually begins in mid-April, although this can be delayed by the late breakup of the winter ice. The management unit for this stock includes all of 4T and catches in 4Vn during November-April. In some years, catches in 4Vs in January-April are attributed to this stock

Southern Gulf cod have been exploited commercially since at least the 16<sup>th</sup> century. Landings varied between 20,000 - 40,000 t annually between 1917-1940, and then began to increase to a peak of over 100,000 t in 1958. The fishery was primarily prosecuted with hook and line until the late 1940s, when a ban on otter trawling was lifted. Landings remained relatively high in the 1960s and early 1970s, in the range of 60,000 t. TACs were first imposed in 1974, and these became restrictive as the stock declined in the mid-1970s. The stock recovered somewhat and landings returned to the 60,000 t range during the 1980s. During the 1980s, the fixed gear fishery declined drastically, and the fishery was mainly prosecuted by mobile gear until it was closed in September 1993, due to low abundance. A 3,000 t index fishery was allowed in 1998. A TAC of 6,000 t was in 1999 to 2002. Larger mesh sizes are in use in the mobile gear fishery since the re-opening. The directed fishery was closed again in 2003 due to a lack of recovery but re-opened at a TAC of 3,000 t in 2004. The management year for the fishery now runs from May 15 of the current year to May 14 of the following year.

Summary

- In 2004-2005, the TAC was 3,000 t. As of December 31, 2004, 2,281 t had been landed.
- Current abundance indices indicate that stock status has not changed markedly over recent years.
- Abundance is low and spawning stock biomass is near the lowest observed level. The current estimate of spawning stock biomass is about 66,000 t in 2005
- Spawning stock biomass is estimated to be below the conservation limit reference point for this stock (80,000 t). There is a high likelihood that the productivity of a stock below the conservation limit has suffered serious harm.
- Year-classes in the 1990s are estimated to be below average. Some recent year-classes (1998-2000) are estimated to be amongst the lowest on record.
- The 2002 year-class is estimated to be above average but this estimate is uncertain due to a change in the research vessel used for the survey.
- Natural mortality remains high (near 0.4). Fishing mortality in 2004 was 0.04.
- With catches of 3,000 t in 2005, the point estimate of spawning stock biomass would be expected to increase by about 6%.
- Rebuilding of spawning stock biomass will require continued good recruitment and low catches.

## The Fishery

A TAC of 3,000 t was in place for 2004-2005. This included an allowance of 200 t for sentinel and scientific surveys. Cod were caught in cod-directed fisheries and as by-catch in fisheries directed at other species, mainly flatfish. Directed fisheries for cod were closed until June 24, 2004. By-catch of cod in other fisheries was restricted to between 5 and 30% depending on the target species. The recreational fishery was prohibited.

### Landings (thousands of tonnes)

	1981- 1990	1991- 1995	1996- 2000	2001	2002	2003	2004
Year	Avg.	Avg.	Avg.				
Landings	61	20	4	6	5	0	2
TAC	58	21	2 <sup>1</sup>	6	6	0	3 <sup>2</sup>

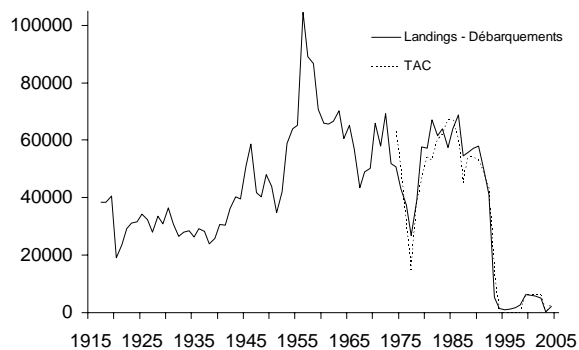
1. Including the allowance of 3000 t for an index fishery in 1998.

2. Preliminary data

(Note: starting in 1999, TAC for May 15 to May 14 of the following year.)

The total reported **landings** were 2,281 t in 2004. Catches in the cod-directed and by-catch fisheries amounted to 2,137 t. Catch reporting in the commercial fishery is considered reliable. The TAC was not reached because little effort was directed for the 4Vn allocation and due to management measures, such as area closures in 4T, to promote conservation

### Landings and TAC (t)

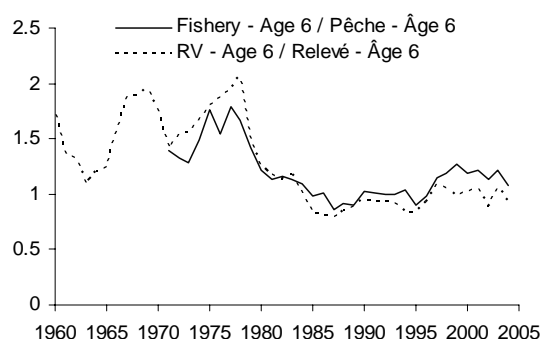


Sentinel surveys that are used to obtain additional indices of abundance of the stock caught 144 t. As in recent years, the fishery

in 2004 was concentrated close to shore in the Miscou Bank – Shediac Valley area, north shore of PEI, western shore of Cape Breton and the edge of the Laurentian Channel near 4Vn.

Ages seven to nine were the dominant age-groups in the 2004 landings. Overall, in 2004, the **average weights at age** of cod in the catch and the annual research vessel survey remained low relative to the period before 1980. Weights at age in the fishery were also slightly lower than in 2003.

### Average weight (kg)



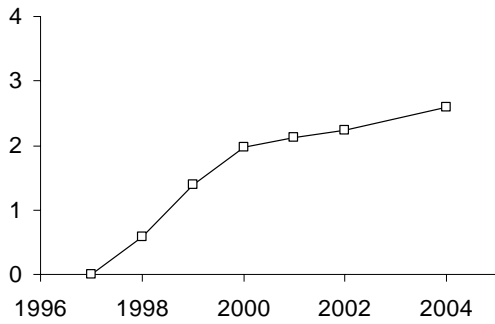
## Resource Status

The information used in this assessment included the annual research vessel survey (1971-2002, 2004), the landings data from 1917-2004, the commercial catch at age from 1971-2004, sentinel survey data from 1995-2004, the otter trawl catch rate data from 1982-1993, and the views of industry expressed in the annual telephone survey from 1997-2002 and 2004.

## Abundance Indices

The **views of fishers** on the state of the resource were obtained through a telephone survey of active cod fishers in 2004. Of 142 fishers interviewed, 50 % felt that the status of the stock was higher or much higher when compared to 2002, while 11% considered the 2004 cod abundance to be lower or much lower than in 2002.

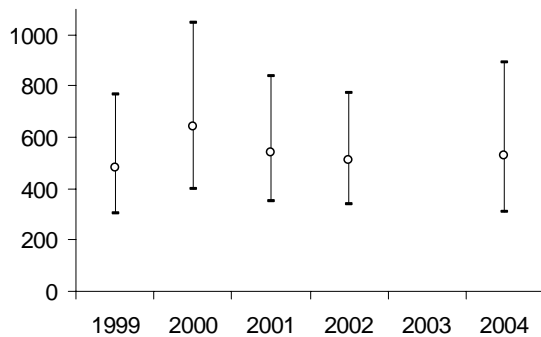
Fisher opinion index of cod abundance



The remainder (39%) thought that abundance of cod was about the same. The opinion of fishers about stock abundance continues to be optimistic.

Cod **catch rates** for 13 groundfish seiners involved in the commercial fishery since 1999 have been relatively constant.

Seiner catch rates (kg/hour)

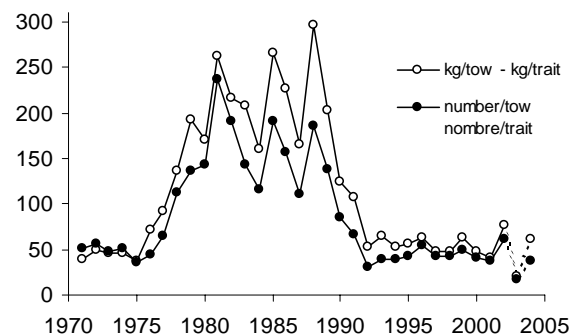


The **annual research vessel (RV) survey** has been conducted in September since 1971. The survey index indicates that the abundance of cod was low in the early to mid-1970s then increased to the early 1980s. Abundance was high until the late 1980s but declined rapidly to low levels by 1992. With the closure of the fishery in 1993, the decline was arrested but the abundance index has remained low.

There have been difficulties with the annual research surveys in 2003 and 2004. In 2003, the survey vessel, the *CCGS Alfred Needler* was disabled shortly before the survey and was replaced by the *CCGS Wilfred Templeman*. The start of the survey was about two weeks later than usual and some areas were either un-sampled or

under-sampled. Because of these problems, even after adjusting for missed areas, the survey results in 2003 are not considered to provide an adequate indicator of stock status. In 2004, another survey ship, *CCGS Teleost*, conducted the survey and *CCGS Alfred Needler* conducted a partial survey (52 sets). While the standard survey trawl was used in 2004, the relative fishing efficiency of the *CCGS Teleost* relative to the *CCGS Alfred Needler* used previously is unknown. Although there are uncertainties related to potential vessel differences in 2004, the timing and coverage of the survey were comparable to previous surveys and the survey is used as an indication of stock abundance. Once conversion factors obtained from planned comparative fishing experiments in 2005 between *CCGS Alfred Needler* and *CCGS Teleost* are available, the estimates for 2004 will be revised.

September research survey indices

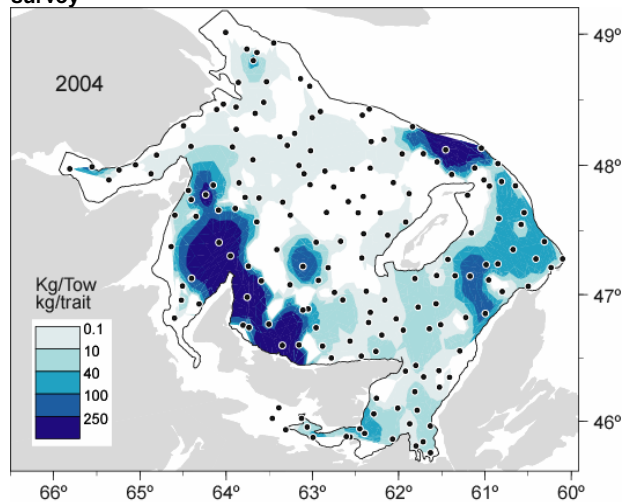


The preliminary 2004 estimate suggests that stock abundance has remained low. Survey mean weight per tow also indicates that stock biomass has remained low since 1993.

In 2004, the abundance of cod aged two years of age was significantly higher than that observed in the surveys conducted in recent years prior to 2003. While there are uncertainties given the change in research vessel, information from the partial survey conducted by *CCGS Alfred Needler* in 2004 also suggested that abundance of age 2 was higher than that observed since the mid-1990s.

During the 2004 survey, cod tended to be distributed close to shore and in shallower waters, a distribution characteristic of periods of low abundance. Highest concentrations were found in the Shediac Valley, the north coast of PEI, north of the Magdalen Islands and in the area between the Magdalen Islands and Cape Breton.

Distribution of cod (kg) in the 2004 September research survey

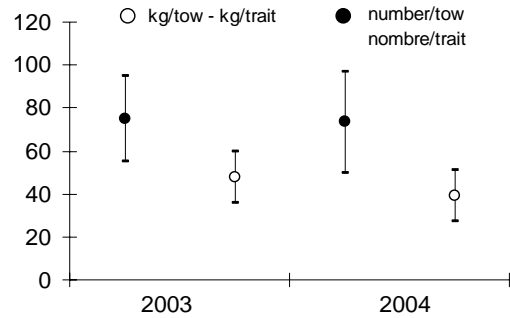


The **sentinel survey** program was continued in 2004. Twenty-two fixed and mobile gears vessels fished in various areas of the southern Gulf to monitor cod abundance.

A synoptic **sentinel trawl survey**, started in 2003, was conducted from August 2 to 19, 2004 by four trawlers. This survey followed methods similar to the research survey conducted in September and the vessels used a standard trawl (300 Star Balloon) fitted with a 40 mm liner in the codend and lengthening piece. A total of 237 valid fishing sets were done.

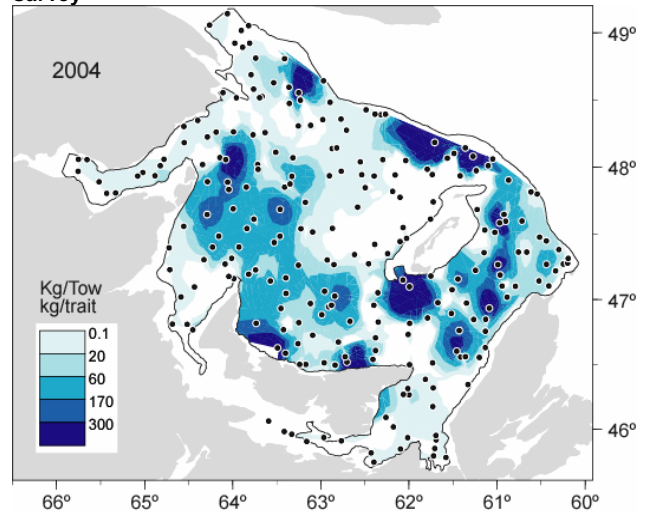
Analyses to examine relative fishing efficiency of the four trawlers at catching cod showed that one vessel was more efficient than the others and a conversion factor was used to obtain survey estimates. Estimates of abundance were similar to those of 2003 but biomass was slightly lower.

August sentinel trawl survey indices



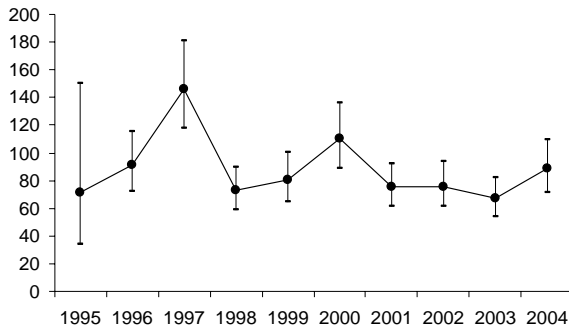
The geographic distribution was mostly similar to that observed in the September research survey with areas of highest concentration in the Shediac Valley, the north coast of PEI and in the area between the Magdalen Islands and Cape Breton. However, concentrations were also found near the Gaspé Peninsula.

Distribution of cod (kg) in the 2004 August sentinel trawl survey



The **sentinel longline** survey was continued in 2004 and resulted in a catch of 134 t. 18 vessels fished at 40 reference sites. Standardized catch rates were slightly higher than in 2003 but not significantly different. Overall, catch rates have been relatively stable since the late 1990s and suggest that there has not been a major change in population biomass. As in recent years, sentinel catch rates for fixed gears near PEI tended to be higher than in other areas.

## Longline sentinel catch rate index



In summary, current abundance indices indicate that stock status has not changed markedly over recent years.

**Natural Mortality**

Previous work had indicated an increase in the **natural mortality** rate ( $M$ ) of this cod stock. This would include unaccounted mortalities due to factors such as poor environmental conditions, predation, unreported catches and changes in life history characteristics.

Total mortality estimates from survey data have not declined despite population abundance indices and catches remaining relatively constant in recent years. This suggests that natural mortality has also remained relatively constant recently. Estimates of natural mortality from population analyses also suggested that  $M$  has not declined appreciably since the late eighties. Consequently, the assumptions for  $M$  were the same used in previous assessments.  $M$  for all age groups was set at 0.2 from 1971 to 1985 and 0.4 from 1986 to 2004.

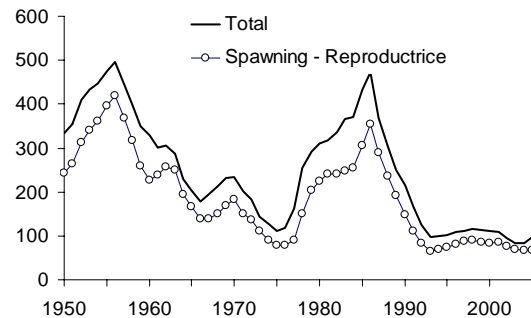
The contribution of each of the various potential causes to the recent high estimates of  $M$  is undetermined. Estimates of the predation of cod by grey and harp seals in 2000 for this stock range from 19,000 to 39,000 t (all ages) depending on diet assumptions. The higher estimates were produced using diet compositions from outside the stock area.

Grey seals are estimated to consume more cod than harp seals in the southern Gulf. Although diet samples suggest that most cod consumed by seals appear to be less than 35 cm in length, diet analyses cannot account for cod that may be killed but not consumed totally (heads are not eaten). Changes in natural mortality estimates for cod are consistent with trends in grey seal abundance in the southern Gulf of St. Lawrence.

**Population Estimates**

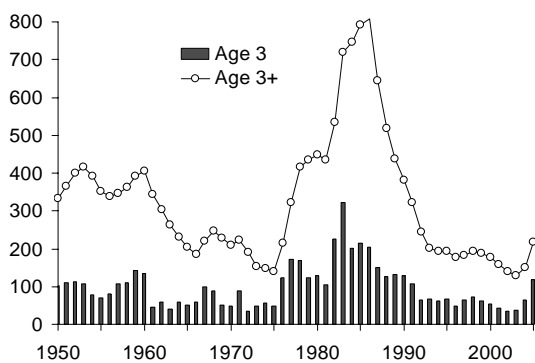
**Spawning stock biomass** was high in the 1950s, but declined throughout the 1960s and reached a minimum in the mid-1970s. There was a sharp increase in spawning biomass with the recruitment of strong year-classes (1974-75 1979-80), but then declined rapidly, reaching a low in 1993.

Spawning stock biomass has been low since the early 1990s. Spawning stock biomass has declined since 2001. The estimate of spawning stock biomass at the beginning of 2005 is 66,000 t.

**Biomass ('000 t)**

The trend in total **abundance** is largely similar to that of spawning biomass. However, spawning biomass was lower in the 1980s than the 1950s due to lower weights at age. Abundance remains low but because the abundance of incoming year-classes is estimated to be higher, abundance increased in 2004 and 2005. These year-classes are expected to contribute to the spawning biomass over the next few years.

Abundance (millions)



**Recruitment** of year-classes produced in the late 1980s and throughout the 1990s are significantly below the long-term average of about 100 million fish.

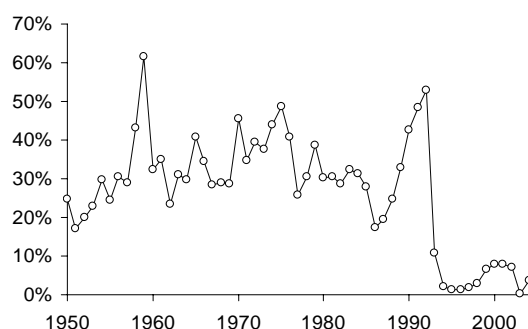
The 1993-1994 year-classes were previously estimated to be amongst the lowest for this stock since the early 1970s. The 1998-2000 year-classes are estimated to be amongst the lowest on record. However, the 2001 year-class appears more abundant than previous ones and the 2002 year-class is estimated to be above average. This is the first estimate of these year-classes and uncertainty of the estimate of the 2002 year-class is large.

Analyses have indicated that the high production of recruits in the mid to late 1970s may have resulted from the low abundance of pelagic fish species (herring and mackerel). Herring and mackerel feed on small prey including the early life stages of cod (eggs and larvae). Pelagic fish biomass (particularly mackerel) is expected to be very high over the next few years.

The **exploitation rate** increased from the early 1950s to the mid-1970s, with the exception of a high value in 1959. There was a slight decrease in 1977 and 1978 with the extension of fisheries jurisdiction. The exploitation rate increased again and averaged near 30% up to 1988. The exploitation rate then increased sharply and reached near 60% in 1992. Fishing effort was reduced markedly in 1993 with the closure of the directed fishery. Exploitation rates during the period of the moratorium have ranged between one and three

percent. In 2004, the exploitation rate was estimated at about 4% ( $F=0.04$ ).

Exploitation rate (7+)



## Sources of Uncertainty

The estimate of natural mortality in recent years remains a source of **uncertainty** in the assessment. The predation by seals is considered to be a significant component of natural mortality and analyses suggest that changes in natural mortality are consistent with grey seal abundance trends. Recent analyses indicate that seal predation is higher than previously estimated; however, there is considerable uncertainty about seal diets in the southern Gulf. Diet analyses rely on the presence of hard parts from prey species in seal stomachs. Conclusions about diet composition would be affected if seals tend not to eat the heads of larger cod.

The lack of useable survey data for 2003 and the change in research vessel used for the September survey in 2004 introduce some uncertainty of this index of abundance. Thus, the estimate of the 2002 year-class (age 3 in 2005) is uncertain, as it is the first estimate of this year-class and is based on the September research survey. However, this year-class will not contribute significantly to the fishery or the spawning biomass until 2007.

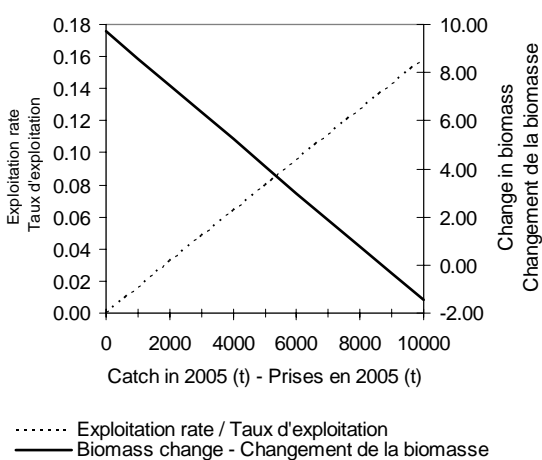
Because of the low fishing mortalities, estimates of population abundance are particularly dependent upon indices of abundance.

### Outlook

The productivity of the stock has been low for more than a decade because of poor growth and high natural mortality. Although the situation has improved marginally in terms of growth, the estimates of the 1998, 1999 and 2000 year-classes are amongst the lowest on record. However, because the estimate of the 2002 year-class is above average, the outlook for the stock is slightly more optimistic than in previous assessment.

**Catch projections** at various levels of catch in 2005 are provided. The estimates referred to below were made using the best available point estimates of stock size. The estimate of the 2002 year-class was also used. Although there is a high level of uncertainty associated with this estimate, only a small fraction of this age group contributes to spawning stock biomass. For any catch in 2005, the associated exploitation rate is determined by reading up to the dotted line, then across to the left side. The percent change in spawning stock biomass can be determined by reading up to the solid line then across to the right side.

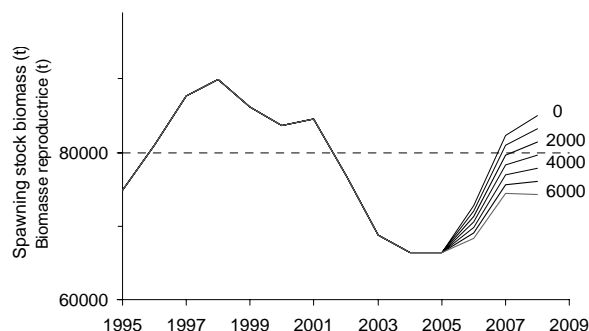
#### Catch projections in 2005



Because of the higher estimate of the 2002 year-class, the spawning biomass is estimated to increase by about 10% if there is no catch in 2005. Maintaining the TAC at 3,000 t in 2005 would result in about a 6% increase in spawning biomass.

A projection over three years was also conducted assuming constant catch of 0 to 6,000 t (steps of 1,000 t). It is noted that predictions over this longer period can be expected to be more uncertain as there are currently no estimates for some year-classes that would contribute to the spawning biomass at the end of the period. As well, it is assumed that a number of factors such as growth and natural mortality will not change.

#### 3-year projections for various catch levels



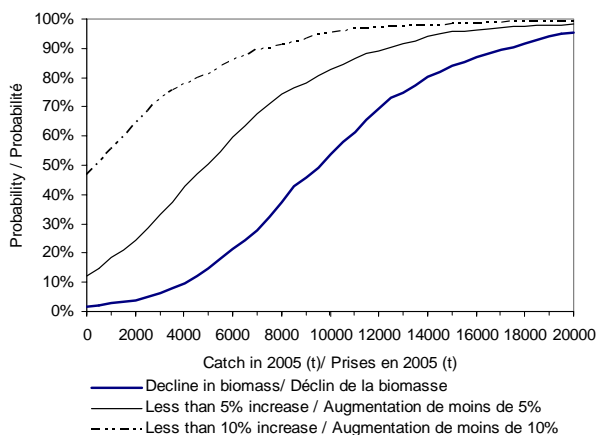
The results indicate that spawning stock biomass can be expected to increase over the next two years because incoming year-classes (2001-2002) are estimated to be more abundant than the preceding ones. With a constant catch of 3,000 t from 2005 to 2007, spawning stock biomass would increase by about 20% to about 80,000 t.

It is also possible to estimate the uncertainties regarding stock size and then use these in **risk analysis**. The risk analyses considered were: a) the probability that the 2006 spawning biomass would be less than the 2005 biomass, b) the probability that the spawning biomass would not increase by at least 5% from 2005 to 2006 and c) the probability that the spawning biomass would not increase by at least 10%. These risk analyses include uncertainties of the population estimates but not those associated with natural mortality, weight at age and partial recruitment. It should be noted that risk was calculated for the calendar year, whereas TACs for this stock are set for the period 15 May to 14 May.



There is only a 2% probability that spawning biomass will decline during 2005 with no catch. If the TAC in 2005 was the same as in 2004 (3,000 t), there is a 67% probability of having a 5% increase in spawning stock biomass but a low chance (27%) of having a 10% increase.

#### Risk analyses



At the low spawning biomass observed recently for this stock, the spawning stock biomass may be sufficiently depressed that the chance of obtaining good recruitment is greatly reduced. This could pose a risk of serious harm to the stock. Analyses for this stock indicated that the chance of obtaining good recruitment is reduced when spawning stock biomass is below about 80,000 t. The risk of being below this conservation limit reference point at the end of 2005 is 80%, even in the absence of fishing. There is a high likelihood that the productivity of a stock below the conservation limit has suffered serious harm.

The short-term outlook (3 years) suggests that a 20% increase in spawning stock biomass can be expected at catches of 3,000 t from 2005 to 2007. This trend is entirely dependent on the estimate of the 2002 year-class. If this year-class were only slightly above the average of recent years, there would be no increase in spawning stock biomass at those catch levels. The strength of recent year-classes and the level of natural mortality can affect this conclusion but a significant change in

these parameters would be required to change this outlook.

Rebuilding of spawning stock biomass will require continued good recruitment and low catches.

#### For more Information

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