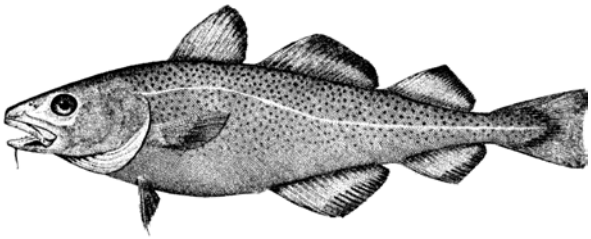

Northern Gulf of St Lawrence Cod (3Pn, 4RS) in 2001

Biology and Background

Each year, northern Gulf of St Lawrence cod (Divisions 3Pn, 4RS) undertakes long-distance migrations. During winter, the stock gathers southwest of Newfoundland at depths exceeding 400 m (200 fathoms). In April and May, the fish move toward the Port au Port Peninsula on the west coast of Newfoundland (Division 4R), where spawning begins. During 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, the primary prey of cod.

Based on the results of numerous tagging experiments, this stock is generally isolated from neighbouring stocks (those in divisions 4TVn, 2J, 3KL and 3Ps). Mixing may sometimes occur in the northwestern Gulf area (with the 4TVn stock), the Strait of Belle Isle (with the 2J, 3KL stock) and on Burgeo Bank (with the 3Ps stock). A recent study estimated that a large proportion (up to 75% of catches from November to April) of the northern Gulf cod stock may be present on Burgeo Bank (3Psa and 3Psd)

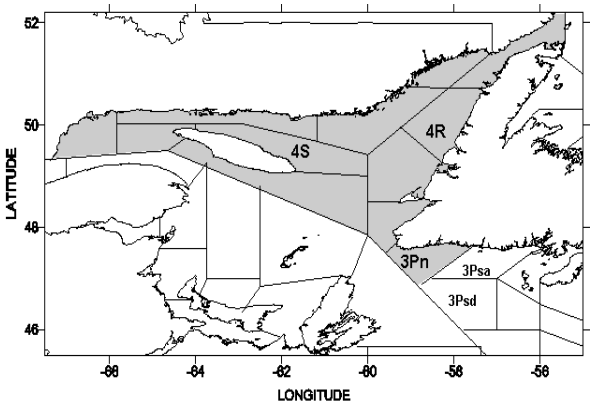

Figure 1: Management units of cod stock in the northern Gulf of St Lawrence. For reference, fishing areas 3Psa and 3Psd are also shown.

Landings (in thousands of tonnes)

Year	*1977-1993*	*1994-1996*	*1997*	*1998*	*1999*	*2000*	*2001*[1]
TAC	*70.4*	*0*	*6*	*3*	*7.5*	*7*	*7*
Landings	*70.2*	*0.3*	*4.8*	*3.3*	*6.9*	*6.8*	*7.5*[2]

[1] *Preliminary data*
[2] *Includes 886 t from the pilot recreational fishery.*

Summary

- Stock abundance remains low, and the slow rebuilding of 20% observed since 1995 has stopped.
- All 5 abundance indices were down in 2001. The sequential population analysis (SPA) shows a reduction of spawning stock between 2001 and 2002, due to excessive fishing mortality.
- Total Allowable Catches (TAC) will now have to include all sources of fishing mortality. There must be better monitoring of dockside landings, particularly in 3Psa+d from November 1 to April 30. The recreational fishery must be prohibited because it cannot be appropriately controlled and accounted for.

- In 2002, catches must be limited to the lowest level possible. Any catch over 4,000 t would seriously compromise all growth of spawning stock. A catch of 7,000 t (the TAC for 2001) could cause a decline of at least 5% in the spawning biomass.

Biological characteristics of the resource

The biological characteristics of northern Gulf cod have varied over the years; certain changes occurred when stock abundance declined with cold oceanographic conditions that were unfavourable to the resource. Growth, condition and size and age at sexual maturity decreased through the eighties and early nineties. These changes may have had a negative impact on egg production, since a small fish in poor condition and with smaller size at maturity produce fewer eggs. In addition, natural mortality may have increased, since fish in poor condition have less chance of surviving, particularly after spawning when conditions are unfavourable. However, improvements in these biological parameters have been noted in recent years, and the biological characteristics of this stock are positive.

Cod growth increased in the second half of the nineties. Weight and size at age in the commercial fishery increased to the point that the values observed in 2000 are similar to prevailing values before the decline in abundance in the early 1980s. The mean weight of a 6-year-old cod reached a record low in 1992 and then gradually rose (Figure 2). The weight value in 2000 was the highest observed since 1984. Size and weight trends were the same for the other age groups, whether in the commercial fishery, the three trawl surveys (*CCGS ALFRED NEEDLER* and the sentinel surveys in July and October) or the fixed-gear sentinel fisheries (longline and gillnet). However, mean weight of a 6-year-old cod seems to be down

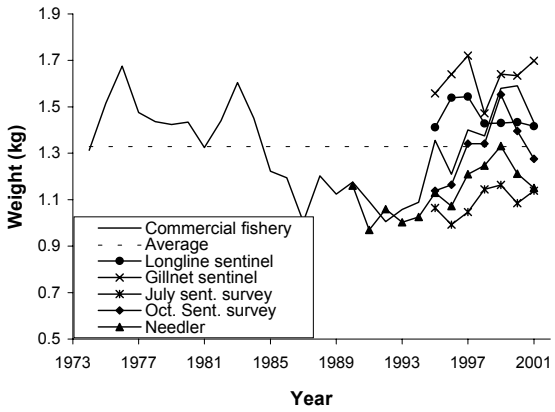

Figure 2. Mean weight of six-year-old cod caught in the commercial fishery, science surveys and fixed-gear sentinel fisheries. The dotted line is the commercial fishery average for the 1974-2001 period.

for the most recent period for most indicators.

The size of cod at sexual maturity declined between 1985 and 1995. In 1985, 50% of females were mature at 50 cm compared with 50% of females mature at 37 cm in 1995. These changes in size at maturity and mean size at age are reflected in changes in the age of maturity for females. Whereas 50% of females were mature between 5 and 6 years old in 1985, this percentage was reached between 3 and 4 years old in 1995. The most recent data collected in spring 1998 indicate that the size at which 50% of females are mature had increased slightly, to around 40 cm. Despite this increase, age and size structure at maturity is still different from what it was in the 1980s. However, no sampling to monitor changes in size at maturity has occurred since 1998. Maturity at age for 2001 has decreased on account of a decline in mean weights at age.

The fishery

Cod landings in the northern Gulf of St Lawrence peaked at over 100,000 t in 1983 (Figure 3), then subsequently declined

steadily until 1993. During the decline, the mobile-gear boats reached their allocation, while the fixed-gear sector could not. The fishery was under moratorium from 1994 to 1996. In 1997, a limited fishery was authorized, with a TAC of 6,000 t. Landings totalled 4,792 t. The TAC was brought back to 3,000 t for 1998, and 3,296 t were landed. In 1999 the TAC was set at 7,500 t, and 6,891 t were landed. For 2000, the TAC was reduced to 7,000 t, and 6,800 t were landed. Finally, the TAC for 2001 was maintained at 7,000 t, and the preliminary landings available for the assessment were 7,526 t.

The profile of the commercial fishery has changed considerably since the moratorium. Since the fishery reopened in 1997, directed fishing has been restricted to fixed gear (longlines and gillnets) and conducted from small craft. The fishing effort has been distributed over several months through the use of monthly catch allocations. A total of 2,000 hooks or 6 gillnets could be used per trip on the west coast of Newfoundland (4R and 3Pn), whereas a maximum of 25 gillnets west of Blanc Sablon and a maximum of 6 gillnets for the Blanc Sablon region could be used on the Lower North Shore of Quebec (4S).

One component of the commercial fishery is carried out within the sentinel fisheries introduced in 1995 to develop a partnership between fishermen and the Department of Fisheries and Oceans. The sentinel fisheries are conducted according to a strict protocol that allows resource abundance indices to be established. Three types of fisheries are conducted every year since 1994: the gillnet sentinel fishery on the Lower North Shore (Division 4S) and the west coast of Newfoundland (Division 4R), and the longline sentinel fishery and otter trawl sentinel fishery (research surveys) for the entire stock area (3Pn, 4RS). All catches made in the sentinel fisheries are accounted

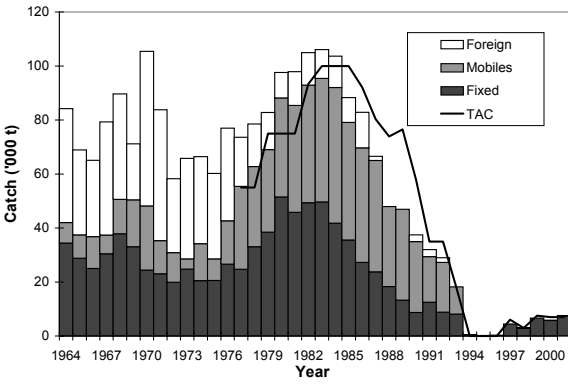

Figure 3. Landings and total allowable catches (TAC)

with the landings of the commercial fishery. The sentinel fisheries had an allocation of 400 t in 2001, of which 263 t were landed.

A new pilot recreational fishery was introduced in 2001. This pilot program allowed cod fishing in the 2J, 3KL, 3Ps and 3Pn, and 4RS stocks (for 4S, only the portion east of longitude 61^{o} 31' 42'' West was authorised). Licences were sold at post offices. For $10, any person over age 16 could buy a licence to fish 30 cod. This new fishery saw participation by nearly 15,000 people, compared with the thousand or so commercial fishermen for 4R 3Pn and 300 for 4S.

The recreational fishermen had to fill out logbooks in order to account for the catches in 2001. These logbooks were sent to DFO. However, these data were not available at the time of the assessment. In order to account for this fishery, an approximation was calculated from the number of licences sold, i.e. 14,768 for the 3Pn, 4RS stock times 30 cod times at an average weight of 2 kg per cod. This results in a conservative estimate of 886 t of cod. This is considered conservative because there have been a number of allegations by fishermen and media of catches in excess of the 30 fish permitted per person. Some individuals even discovered that the tags could be re-used by

boiling them. DFO will conduct a program review before extending this exercise to other cod stocks and marine species in eastern Canada. We feel that the recreational fishery has to be prohibited because it cannot be appropriately controlled and accounted for.

The industry

For the fourth consecutive year, the Quebec Lower North Shore Fishermen' Associations (*Regroupement des associations des pêcheurs de la Basse Côte-Nord du Québec*) and the Fish, Food and Allied Workers of Newfoundland, which are responsible for the 4S and 4R, 3Pn sentinel fisheries respectively, conducted a telephone survey of persons licensed to fish 3Pn, 4RS cod using fixed gear. The questionnaires covered the 2001 fixed-gear fishing season and involved 50 fishermen in 3Pn, 76 in 4R and 53 in 4S. The object of the questionnaire was to examine various aspects of the fishery, including demography, biological information and catch rates.

Comparing the 2000 fishing season with 2001, the fishermen said the size and condition of the fish were the same or better for areas 3Pn and 4R, but the same or worse for 4S. The majority of the 3Pn, 4RS fishermen reported in the 2001 questionnaire that the dates of migration to and departure from their region were the same or later than for 2000.

Fishermen rated their commercial catch rates on a scale from 0 to 10 since 1993, the year previous to the moratorium. There is thus no data available for the period of the moratorium (1994 to 1996) (Figure 4). Data from 3Pn are exclusively with longline whereas data from 4R are a mixture of gillnets and longlines, finally the 4S data are dominated by gillnets. According to this analysis, the 4R fishermen indicate stable catch rates over the last three years, a situation that has greatly improved since the moratorium. The area 4S fishermen indicate the same trend, with a decrease between 2000 and 2001. Fishermen in 3Pn note a decrease between 1999 and 2000 followed by an increase for 2001, which was the highest for the last four years. These values are higher than the 1997 and 1998 period and, as for fishing area 4R, are considerably improved compared with the pre-moratorium period.

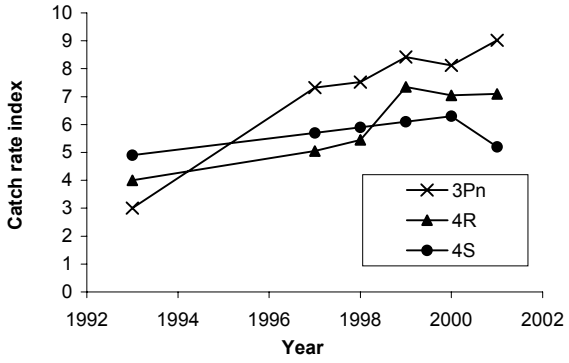

Figure 4: Index of catch rates based on a telephone survey conducted by some fishermen's associations.

General comments on the fishery in the most northern sector of 4R and 4S mentioned a lack of prey (capelin) in the area and the fact that fishing was better with handlines than gillnets. In addition, fishermen in 4S noted that the water was colder and dirtier (slub) at the spring of 2001.

Resource status

Abundance indices of catch rates from sentinel fixed-gear fisheries

In the past, catch and effort data for the fixed-gear sentinel fisheries were standardized using a multiplicative model. This allows to take into account any change of fishing activities between years. However, in order to adequately represent the normal distribution of the sampled

population, it is important that the trends in catch rates be similar between regions. If this condition is not met, certain regions may show increased catch rates or declining catch rates, which could falsify the overall estimate for the region. In 2001, however, there was an increase in longline catch rates in northern 4R, whereas in the southern 4R and in 3Pn, important regions for the longline fishery, catch rates in 2001 have remained at the same level since 1998 (Figure 5). The catch rates for the northern part of 4R would have an exaggerated influence in the multiplicative model. This has led us to dismiss the use of the model to derive a catch rate that is representative of the overall abundance of the stock. Given that there is little spatio-temporal variation in deployment of the sentinel fisheries, catch rates have been calculated as total catch divided by total effort.

Catch rates for sentinel fisheries using gillnets in 4R and 4S show that, inter-annual changes notwithstanding, there has been a general downward trend since 1995. The value for 2001 is the lowest in a 7-year series. This decline was also observed in the directed gillnet fishery in 2001.

Catch rates for sentinel fisheries using longlines show an increase starting in 1995 (except for 1997) to 1998, followed by a stable period from 1998 to 2001. The good catch rates for longline sentinel fisheries since 1998 are due to harvesting of the 1993 year-class.

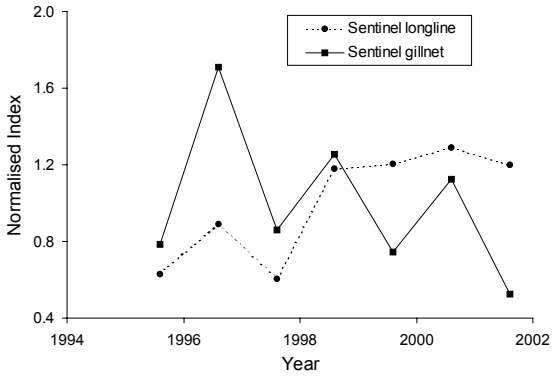

Figure 5. Normalised abundance indices derived from fixed gear.

Trawl surveys

The mobile-gear sentinel fishery program began in 1994 in the northern Gulf of St Lawrence, but the surveys have covered the entire stock from the coast to the offshore area only since 1995. Nine trawlers conduct the surveys twice a year (in July and October), using a stratified random sampling protocol similar to that applied by DFO aboard the *CCGS ALFRED NEEDLER*. The gear types were standardized in 1997 by adding restrictor cables to maintain a constant trawl opening during fishing operations.

The 1995-2000 data series from the July sentinel fisheries surveys suggests a slight upward trend in stock abundance during this period, although a minor decline was noted in 2001 (Figure 6). The abundance indices from the October survey indicate a very slight increase since 1995, to a peak in 2000, followed by a decline in 2001. According to both surveys, most of the biomass is located in Division 4R. Cod distribution does not vary significantly between July and October.

The summer survey on the DFO vessel the *CCGS ALFRED NEEDLER* (DFO), initiated in 1990, was originally intended to assess stocks of shrimp and certain groundfish in the Gulf. Some adjustments were made in later years to increase coverage of the geographic region frequented by cod; this was done by extending the surveys to Subdivision 3Pn and to waters between 37 and 100 m (20 to 50 fathoms). Since the spatial coverage has varied over time, only regions that have been consistently sampled were considered in previous assessments. For example, 3Pn, the Strait of Belle Isle and the 1990 survey were excluded from the analyses in the past. The current assessment has corrected this situation by using a

mathematical model which allows to fill in the missing regions through the use of trends observed in those areas over a few adjacent years. The fact that these areas are now filled in results in an increase in the absolute value of the index but does not affect trends (Figure 6).

The results from the DFO survey shows that the abundance has increased from 1993 to 2000 but has declined in 2001. The abundance index for the 1997 year-class derived from the 1999 and 2000 *CCGS ALFRED NEEDLER* surveys represented the highest value in the 10-year data series. In 1999, two-year-old cod were very abundant; in 2000, the largest age-class was three years. However this year-class is not abundant for the 2001 *CCGS ALFRED NEEDLER* but it is well represented in the trawl sentinel surveys from 1999 to 2001. It is not strong for the gillnet sentinel fisheries and not big enough to be well caught by gillnets.

It is important to note that for the 1995-2001 period, all five abundance indices available for this stock posted highs in 2000, and they all declined in 2001.

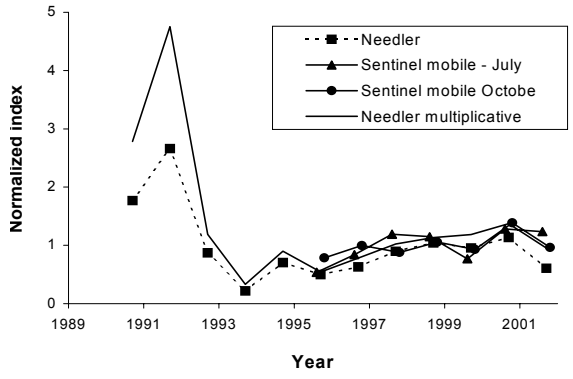

Figure 6. Normalised abundance indices derived from research surveys.

Estimation of stock size

Sequential population analysis (SPA) is an analytical model that allows to estimate stock abundance by year-class while taking account of natural mortality and fishing mortality. The analysis is based on catches at age estimated from the commercial fishery and is calibrated with the indices derived from the fixed-gear sentinel fisheries in inshore waters, the mobile-gear sentinel fisheries in offshore waters, and the *CCGS ALFRED NEEDLER* survey.

To take into account the degradation of environmental conditions, an increase in wasteful fishing practices and intensified predation by seals, it was decided during a zonal meeting in winter 1998 that the natural mortality (M) coefficient should be increased from 0.2 to 0.4 as of 1986 for SPA's for several cod stocks. Although the condition of the fish has improved recently, predation by seals continued to increase until at least 1996, and so the natural mortality coefficient has been kept at 0.4 for the entire period of 1986 to 2001 in order to take account of the combined effect of these factors.

The maturity ogives**,** or proportion of fish that are sexually mature by year-class or size, are used to estimate spawning stock or spawning biomass abundance from the results of the sequential population analysis. Previously, the maturity at age data obtained from winter surveys between 1983 and 1994 were used. The 1983 ogive was applied for years prior to 1983, and the 1994 ogive was applied for 1995 and subsequent years. Two years ago, the maturity ogives at age were replaced by maturity ogives at length in order to take changes in growth into account. Recent data from surveys done in 1994, 1995 and 1998 on spawning aggregations have been used for years subsequent to 1993. It should be noted that only the estimated maturity ogive for

females is used to estimate the proportion of male and female spawning stock.

The results of the SPA indicate that the abundance of fish aged three years and over dropped from 537 million in 1983 to 54 million in 1994, and then rose to 64 million in 2002. Abundance only increased by 1% between 2000 and 2001. Abundance of spawning stock declined from 311 million in 1982 to 23 million in 1994. It increased to 43 million in 2002, with a 10% decline between 2000 and 2001.

Population numbers are converted to biomass using mean weights at age from the commercial fishery calculated annually. Total biomass (fish three years of age and over) dropped from 610,000 tonnes in 1983 to 34,000 tonnes in 1994 (Figure 7). It climbed to 66,000 tonnes at the beginning of 2002, with a 15% decline between 2000 and 2001. The spawning biomass fell from 468,000 tonnes in 1983 to 19,000 tonnes in 1994, subsequently rising to 54,000 tonnes in early 2002. There was a 13% decrease in mature biomass between 2000 and 2001.

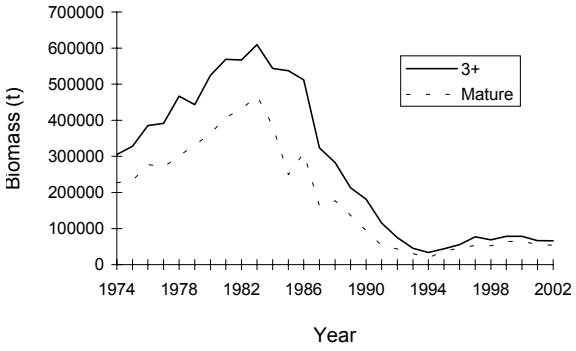

Figure 7: Estimated 3+ biomass and mature biomass.

Estimates of stock abundance and biomass for January 1, 2002 were based on estimated average recruitment at three years old for the last four years (1998 to 2001), mean weights at age and estimated maturity ogives for the last three years (1999 to 2001). From these data, total abundance should increase only 1% and spawner abundance should decrease 8%. There should be no increase in total biomass, and spawning biomass should decrease by 4%.

Fishing mortality for fully recruited cod was 33% (F=0.51) in 2001. This value is much higher than the target $F_{0.1}$ level previously estimated at 15% (F=0.2). However, given the changes in cod growth, maturity and fixed gear selectivity, this reference level has probably changed. In light of the low abundance of the stock, it would be imprudent to calculate a new $F_{0.1}$ type target.

There have been no major signs of recruitment recovery in 10 years (Figure 8); commercial catches in the last three years have been sustained by the substantial 1993 year-class alone, which was produced prior to the moratorium.

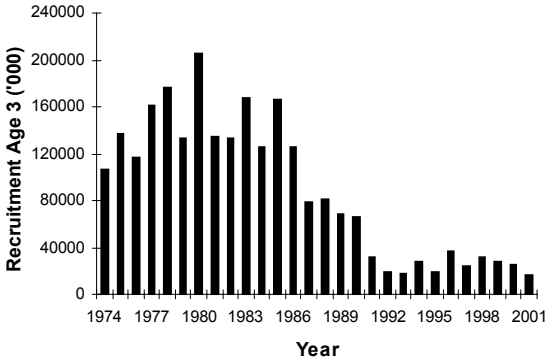

Figure 8. Estimated recruitment at age 3.

Sources of uncertainty

The recreational fishery of 2001 was often called into question by the fishing industry and the media. There was frequent mention of uncontrolled fishing and excessive use of the 30 tags provided with each licence. The estimate of 886 t used in this assessment represents the best estimate of removals in 2001.

The issue of the influx of northern Gulf cod into fishing area 3Ps has been frequently discussed in the past. To avoid the capture

of northern Gulf cod during the winter fishery in western 3Ps, the area around Burgeo Bank (3Psd) has been closed to directed winter cod fishing since 1999. This sector represents a fraction of the area of mixing between the northern Gulf stock (3Pn, 4RS) and the Burgeo Bank stock. Many research projects have been conducted in recent years to better describe the extent of this mixing (tagging, otolith microchemistry). A specific workshop on this subject was held in October 2000 (Chouinard G.A., 2000); it concluded that a significant proportion of the cod caught in winter in areas 3Psa and 3Psd were incursions of northern Gulf stock. As the workshop recommended, we tried to examine the impact that allocating 75% of the catches made from November to April in 3Psa and 3Psd to the catches of 3Pn, 4RS has on the results of the sequential population analysis.

This exercise has been deemed too risky in view of the high variability of the landing statistics for fishing areas 3Psa and 3Psd. For example, the preliminary values used in last year's analysis showed that one ton had been fished from January to March 2001. The updated data for the periods of January to April and November to December 2001 indicated that 1,212 t had been fished. Such an uncertainty requires that fishing statistics be clarified before we analyse the impact of mixing on the 3Pn, 4RS stock.

Since 1995, sentinel fishermen have tagged more than 45,000 cod. However, the fishery has only recaptured 1,746 tagged cod and that suggests a very low exploitation rate, well below the rate of 33% estimated in this assessment. This has led the FRCC to recommend that more research be carried out so that the situation can be clarified.

In order to address this, we have initiated a high-value tagging program. In 2000 and 2001, 488 tags with a recapture value of $100 were affixed to cod in the Codroy (southern 4R) and Burnt Island (3Pn) region. To date, 44 tags have been returned. The average rate of return for traditional tags since 1995 is 3.8% with little inter-annual variation, whereas for the high-value tags it is 9.0%, ie, 2.4 times more effective. It is possible that offering a larger reward will have the effect of significantly increasing return rates. Efforts will be made to improve this situation. This means that we can still analyse tagging data to find out about migrations, mixing and growth, but not to estimate exploitation rates.

Outlook

In last year's assessment, it was mentioned that landings in the neighbourhood of 7,000 t would give only a small probability (less than 5%) of observing an increase in the mature biomass of this stock. The present assessment indicates that at least 7,526 t have been landed. It could easily be more, given the uncertainties surrounding the catch levels for the recreational fishery and the issue of mixing with 3Ps. This assessment shows that the mature biomass has not increased and that all five abundance indices as well as weights at age decreased between 2000 and 2001. The result is a more

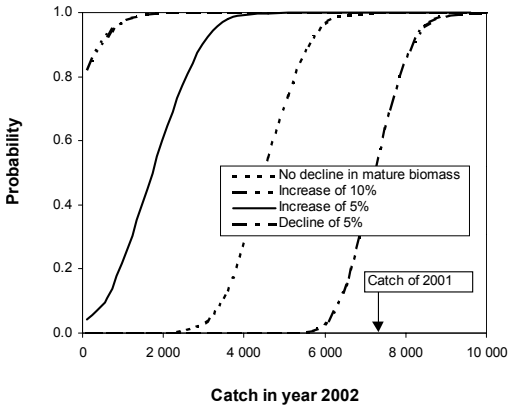

Figure 9. Probability of a decline and an increase in the mature biomass relative to various catch levels for 2002.

pessimistic view of the resource than last year. Both assessments are therefore consistent, the fishing effort is too high for the available biomass and such an intense fishery applied in 2001 will cause a decline in stock biomass.

Since the strong 1993 year-class, subsequent year-classes have all been inferior and in decline. The small size of the stock is such that a harvest of around 4,000 t would result in 14% exploitation rate of the fishable biomass, and no probability of seeing any growth of the mature segment of this stock (Figure 9). A harvest of 7,000 t (the TAC for 2001) would produce a decline of around 5% in the mature biomass. A target of 10% growth in the mature biomass would basically necessitate reinstituting the moratorium (Figure 10).

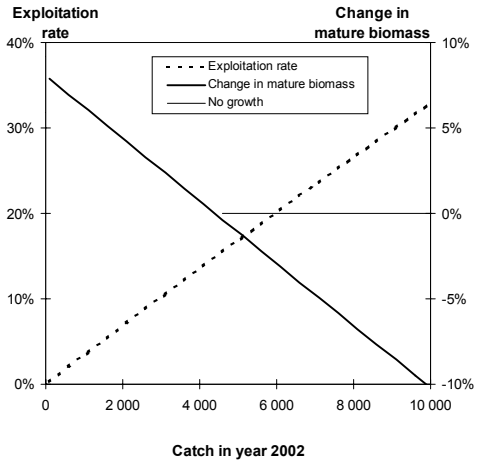

Figure 10. Harvesting rate and projected variation in mature biomass relative to various catch levels for 2002.

Management considerations

Based on this assessment, three-year-old cod is immature and not yet recruited, and almost all individuals reach full maturity at four years of age. Gillnets and longlines have a selectivity that mainly targets fish six years old and over, so cod can spawn at four and five years before becoming vulnerable to these fisheries. However, the FRCC has recommended that the fishery not be concentrated on the 1993 year-class. The 1993 year class was the most important in both gillnet and longline fisheries in 1999, 2000 and 2001. The present assessment indicates that over 1 million individuals in this cohort were fished at eight years in 2001, out of a total population of 3 million. This sort of fishing pressure cannot be sustained for the 2002 season.

Catches in the recreational fishery were not included in the TAC of 7 000 t that was in place in 2001. If these landings were taken into account, the estimated figure for 2001 rises from 6,640 t to 7,526 t. This represents an additional 12% pressure on this stock. The projections in the Outlook section of this report and the FRCC recommendations for the 2002 TAC must include all sources of fishing mortality. If the recreational fishery is to be continued in 2002, it will have to be accounted within the TAC.

Other considerations

A precautionary approach must be implemented for this stock in the years ahead; it will require that targets and limits be set with respect to mature biomass and fishing mortality. In that context, figure 11

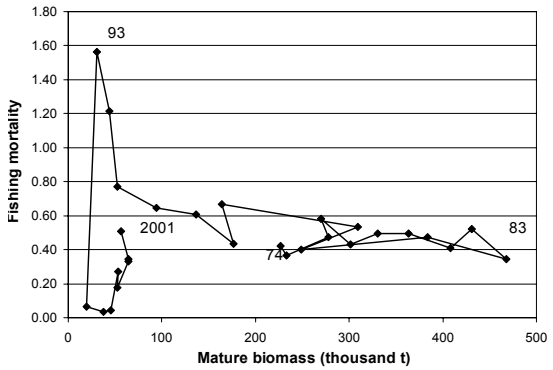

Figure 11. Precautionary approach for the cod stock.

illustrates the path that this stock has followed since 1974. Note that the mature biomass doubled between 1974 and 1982 in spite of exploitation rates that were twice the target of $F_{0.1}$=0.2. Afterward, the biomass declined and fishing effort increased steadily to a peak in 1993, just before the moratorium. Since then, fishing mortality has increased with the reopening of the fishery, without substantial growth in the spawning biomass. The lack of objectives for the rebuilding of this stock is resulting in an excessive increase in fishing mortality that cannot be sustained by the available mature biomass.

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