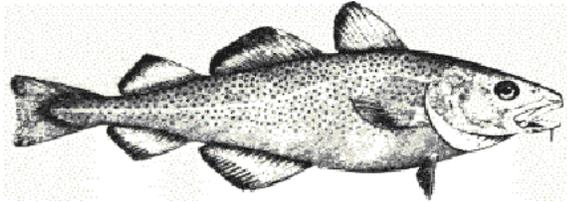




## Newfoundland and Labrador Region

## Stock Status Report 2004/039



### Subdivision 3Ps cod

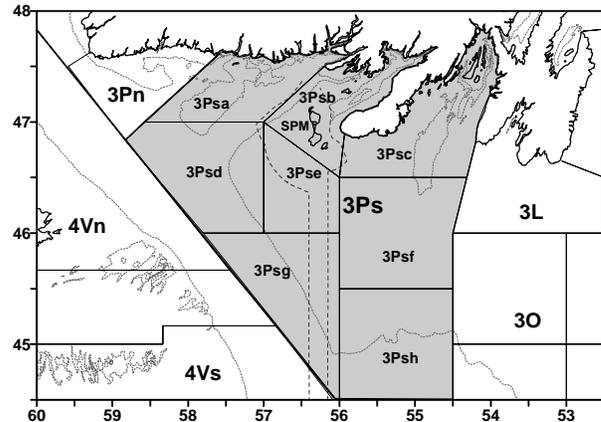
#### Background

In the Northwest Atlantic, cod are distributed from Greenland to Cape Hatteras and are managed as 12 stocks. The 3Ps stock off southern Newfoundland extends from Cape St. Mary's to just west of Burgeo Bank, and over St. Pierre Bank and most of Green Bank.

The distribution of 3Ps cod does not conform well to management boundaries and the stock is considered a complex mixture of sub-components. These may include fish that move seasonally between adjacent areas as well as fish that migrate seasonally between inshore and offshore. The extent to which the different components contribute to the fisheries is not fully understood.

Cod from this stock generally grow faster than those from areas further northward. At least 50% of the females are mature by age 5 (~53cm) in recent cohorts, compared to age 6 (~58cm) among cohorts present in the 1970s-early 1980s.

Catches from this stock have supported an inshore fixed gear fishery for centuries and are of vital importance to the area. Fish are caught offshore by mobile and fixed gear and inshore by fixed gear. Spanish and other non-Canadian fleets heavily exploited the stock in the 1960s and early 1970s. French catches increased in the offshore throughout the 1980s. A moratorium on fishing initiated in August 1993 ended in 1997 with a quota set at 10,000 t. The TAC was increased to 20,000 t for 1998 and to 30,000 t for 1999. Beginning in 2000, the management year was changed to begin on 1 April. An interim quota of 6,000 t was set for Jan.-Mar. 2000. The TAC for 1 April 2000 to 31 March 2001 was set at 20,000 t, but this was reduced to 15,000 t for the next four management years to 31 March 2005.



#### Summary

- Stock status was evaluated from commercial landings (1959 until 31 March 2004) and log-book data (1997-2003) in conjunction with abundance indices from Canadian (1972-2004) research vessel trawl surveys, industry trawl surveys (1997-2003), and sentinel fixed gear surveys (1995-2003). Exploitation rates were estimated from sequential population analyses (SPA) and tagging experiments.
- Two strong year classes (1997-1998) are well represented in the 2003 catch and these are likely to dominate the fishery in the coming years. However, these are followed by weak recruitment (1999-2001 year classes), and current catch levels are unlikely to be sustainable in the long-term unless recruitment improves.

- Spawner biomass estimates for 1 January 2004 from two sequential population analysis formulations used to illustrate the uncertainty in stock size ranged from 88,000 t to 130,000 t. Spawner biomass estimates from both formulations are the highest in their respective time series (i.e. since 1977).
- The age structure of the recent spawner biomass is unusual and comprises a much higher proportion of fish that are maturing at younger ages than in the past. Younger spawners are less effective at producing recruitment; consequently, although the spawner biomass is high, the current reproductive potential of the stock is lower than in the past.
- There are no explicit management objectives for this stock. Consequently, only catch options considered to be informative for fisheries management were evaluated in the current assessment. The TAC in the four management years ending 31 March 2005 was 15,000 t and the catch options considered in this report were 5, 10, 15, and 20,000 t.
- Both SPA formulations used to illustrate stock trends indicated that spawner biomass will decline in the next management year (2005/06) for all catch options from 5,000 to 20,000 t. However, the estimated spawning biomass at 1 April 2006 will be considerably greater than the recommended biological limit reference point ( $B_{lim}$ ).
- At fixed annual catch options ranging from 10,000 to 20,000 t for the 2005/06 and 2006/07 management years, both SPA formulations indicated that spawner biomass will decline further by 1 April 2007. At a catch option of 5,000 t both of these SPA formulations indicated a small increase in spawner biomass by 1 April 2007.

### ***The Fishery***

The stock was heavily exploited in the 1960s and early 1970s by non-Canadian fleets, mainly from Spain, with catches peaking at 84,000 t in 1961 (Fig. 1).

After the extension of jurisdiction in 1977, catches averaged around 30,000 t until the mid-1980s when fishing effort by France increased and total landings reached about 59,000 t in 1987. Catches then declined gradually to 36,000 t in 1992.

A moratorium was imposed in August 1993 after only 15,000 t had been landed. Although offshore landings fluctuated, the inshore fixed gear fishery reported landings around 20,000 t each year up until the moratorium (Fig. 2).

The fishery reopened in May 1997 with a TAC of 10,000 t. This was subsequently increased to 20,000 t for 1998 and to 30,000 t for 1999. In 2000 the management year was changed to begin on 1 April. An interim quota of 6,000 t was set for the first three months of 2000. For 1 April 2000 to 31 March 2001 the TAC was set at 20,000 t, and for the next four management years ending 31 March 2005 the TAC was set at 15,000 t.

**Landings (000s t)**

Year <sup>1</sup>	97	98	99	00 <sup>2</sup> (J-M)	00- 01	01- 02 <sup>3</sup>	02- 03 <sup>3</sup>	03- 04 <sup>3</sup>	04- 05 <sup>3</sup>
TAC	10.0	20.0	30.0	6.0 <sup>2</sup>	20.0	15.0	15.0	15.0	15.0
Can.	7.4	16.6	20.4	3.5	20.3	13.2	12.5	12.6	7.0
French	1.6	3.1	3.2	4.7 <sup>4</sup>	4.7	2.3	2.3	2.4	0.9
<b>Totals</b>	<b>9</b>	<b>19.7</b>	<b>23.6</b>	<b>8.2</b>	<b>25.0</b>	<b>15.5</b>	<b>14.8</b>	<b>15.0</b>	<b>7.9<sup>5</sup></b>

<sup>1</sup> During the moratorium (1994-1996) catches were limited to by-catch and sentinel fishery and were <1,000 t and are not shown.

<sup>2</sup> During 2000 the management year was changed to begin on 1 April (rather than 1 January) and an interim TAC of 6,000 t was allocated for the first three months (Jan.-Mar.) of 2000.

<sup>3</sup> Provisional.

<sup>4</sup> France (St. Pierre and Miquelon) is allocated 15.6% of the TAC but carried forward a portion the 1999 allocation to the first three months (Jan-Mar) of 2000.

<sup>5</sup> Approximate landings to end of September 2004.

In 2003/04, total reported landings were 14,980 t, mostly (76.5%) from the fixed gear sector. The total includes a recreational fishery catch of 152 t, and a French catch of 2,376 t, approximately 1,642 t of which was caught by otter trawlers and the remainder (734 t) by fixed gear, particularly gillnets.

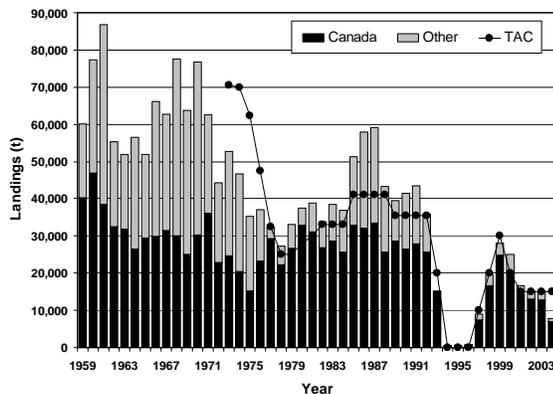


Fig. 1. Reported calendar year landings (t) by country. Note that TAC's are by management year (1 April-31 March) since 2000.

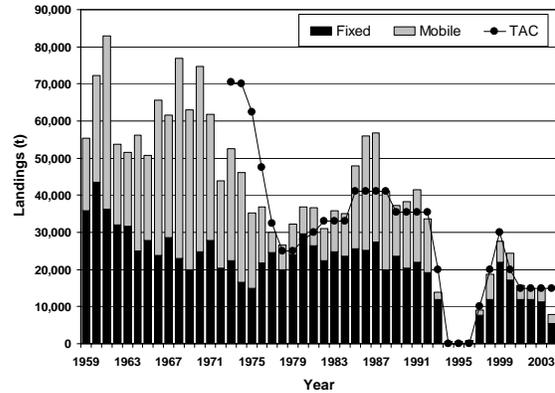


Fig. 2. Reported annual calendar year landings (t) by gear sector. Note that TAC's are by management year (1 April-31 March) since 2000.

During 2003, cod landings comprised a range of ages (mostly 5-7 year olds). The 1997 year class accounted for 32% of the total catch numbers in the 2003 fishery compared to 24% at age 5 in 2002. This year class was strongly represented in catches of all gear types.

The catch in the first three months of 2004 was taken mostly by offshore mobile gear and was dominated by 6-7 year olds, with 15 year olds (1989 year class) also well represented.

**Species Biology**

**Stock structure and migration patterns** of 3Ps cod are complex and poorly understood. Migration of offshore components of the stock to inshore areas during spring and summer, as well as the existence of inshore components that remain outside the research vessel trawl survey areas throughout the year, complicate the assessment of stock status.

**Tagging studies** initiated in spring 1997 in Placentia Bay were expanded in subsequent years (1998-2003) to include

inner and outer Fortune Bay and two offshore areas (Burgeo/Hermitage Channel and Halibut Channel). In these seven years over 63,700 fish were tagged and 11,800 reported as recaptured. Cod tagged inshore were mostly recaptured inshore, even 5-6 years after release. Returns also indicated that some cod tagged offshore were recaptured in the inshore fixed gear fishery on the south coast during the summer and fall. Tagging indicated some **movement** of cod between 3Ps and neighbouring stock areas (3Pn4RS, 3KL, and 3NO). No tagging was conducted in the inshore of 3Ps during 2004.

**Maturation** in female cod sampled during research trawl surveys was estimated by cohort for the current assessment. The proportion of female cod maturing at younger ages has increased (Fig. 3).

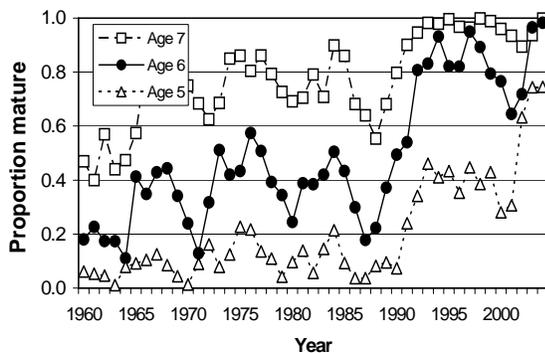


Fig. 3. Estimated proportion mature at ages 5-7 (females).

For example, the proportion of 5 year old females that are mature is now the highest in the time series and has increased from about 10-20% in the 1970s and early 1980s to 40% in the mid-1990's and to over 60% in the early 2000s. The reasons for the change toward earlier age at maturity are not fully understood, but changing age at maturity has a considerable influence in the

calculation of spawner biomass. Males generally mature about one year younger than females but show a similar trend over time.

**Spawning** is spatially widespread in 3Ps, occurring close to shore as well as on Burgeo Bank, St. Pierre Bank, and in Halibut Channel. Timing of spawning is variable and extremely protracted, with spawning fish present from March until August in Placentia Bay. The proportions of fish at various stages of maturation during the 2004 spring research vessel survey were similar to those observed in recent years.

**Growth**, calculated from length-at-age in research trawl survey samples, has varied over time. A peak occurred in the mid-1970s for young ages (3-4) and progressively later to 1980 for older ages. From the mid-1980s to the present, length-at-age tended to increase at young ages (2-3) and to vary with no clear trend at older ages. Year-to-year variability at older ages has been considerable (as much as 20 cm at age 10) during the past decade or so. In general, current values of length at age are not unusual in comparison to past values.

The **condition** of cod is typically expressed as  $W/L^3$ , where  $W$  is the gutted weight or liver weight, and  $L$  is the length. Comparison of post-1992 condition with that observed during 1985-1992 is difficult because survey timing has changed. Condition varies seasonally and tends to decline during winter and early spring. In general, condition of cod in the 1993-2004 surveys shows no clear trend and does not appear to be unusual.

## Resource Status

### Sources of information

Stock status at the end of March 2004 was updated using age-disaggregated data from **commercial landings** to the end of the 2003/04 fishery, and **abundance indices** from Canadian (1972-2004) research vessel trawl surveys, industry trawl surveys (GEAC, 1997-2003), and sentinel surveys (1995-2003). Age-aggregated catch rate data from logbooks for the under 35' sector (1997-2003) were also examined. Annual exploitation rates were estimated from tagging experiments conducted in different regions of 3Ps during 1997-2003.

### Research vessel surveys

Canadian research vessel bottom **trawl surveys** were conducted from 1972-1982 by the research vessel A. T. Cameron using a Yankee 41.5 otter trawl. Surveys from 1983 to 1995 were conducted by the Wilfred Templeman, or the sister vessel the Alfred Needler, using the Engel 145 Hi-Lift otter trawl. Since 1996, the surveys have been conducted by the Wilfred Templeman and the Teleost using the Campelen 1800 shrimp trawl. Data collected with the gear used between 1983-1995 were converted to Campelen-equivalent units based on comparative fishing experiments.

The survey **biomass index** is variable but declined from the mid-1980s to the lowest values observed during the early 1990s. Values for the post-moratorium period have been higher than those of the early 1990's, but not as high as those of the 1980's (Fig. 4). The biomass index in

2004 was 80,500 t, slightly higher than the 2003 survey estimate.

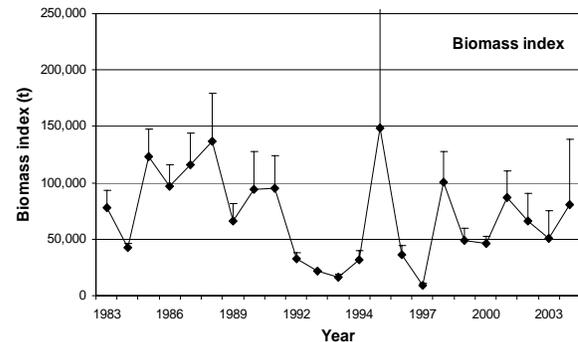


Fig. 4. Research vessel survey biomass index (t) (+1 SD). There were two surveys in 1993 (February and April).

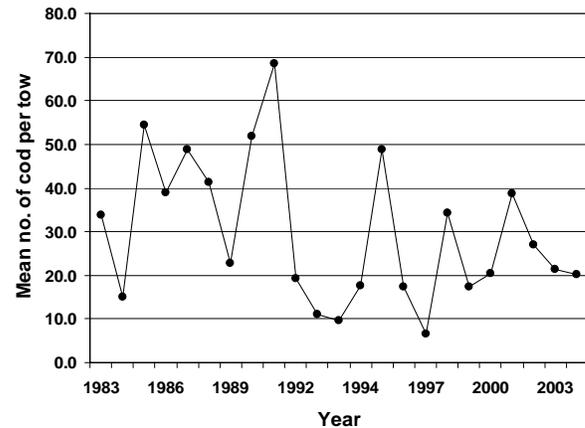


Fig. 5. Research vessel survey abundance index (mean numbers per tow) for 3Ps. There were two surveys in 1993 (February and April).

The survey abundance index is variable, but shows a declining trend from the mid-1980s to the early 1990s. There has been a slight upward trend since the early 1990s, but this has reversed in the past three years. The high 1995 estimate was strongly influenced by a single large catch. The 1997 survey was low and did not encounter aggregations of fish that were observed in surveys and commercial catches in subsequent years.

**Spatial distribution:** During the April 2004 survey, the distribution of cod was

similar to that during the 2001-2003 surveys (Fig. 6). Cod in these recent surveys remain less widely distributed across the top of St. Pierre Bank compared to 1999 and 2000. The largest catches in 2004 were localized in the southern Halibut Channel, Fortune Bay, and in the Burgeo Bank-Hermitage Channel area.

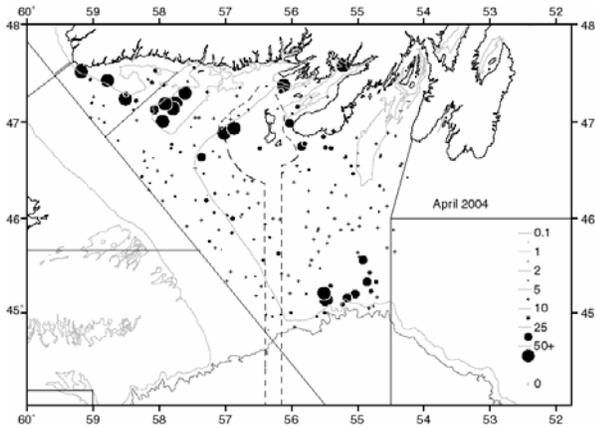


Fig. 6. Spatial distribution of 2004 research vessel trawl survey catches. The scale is numbers of cod per tow.

**Age composition:** The age range of survey catches over the post-moratorium period has expanded, with the 1989 year class relatively well represented in the most recent survey at age 15. The 1997 and 1998 year classes have been strongly represented in the survey index for several years. The 2000 and 2001 year classes appear particularly weak in the most recent surveys. The 1999 year class is also below average.

**Industry (GEAC, Groundfish Enterprise Allocation Council) trawl survey**

During fall 2003 a seventh consecutive industry survey was conducted with a standardized un-lined commercial trawl. Survey coverage has varied slightly and

results for 1997 were from a smaller surveyed area. In all years this survey has shown aggregations of cod in the southern Halibut Channel and on or adjacent to St. Pierre Bank.

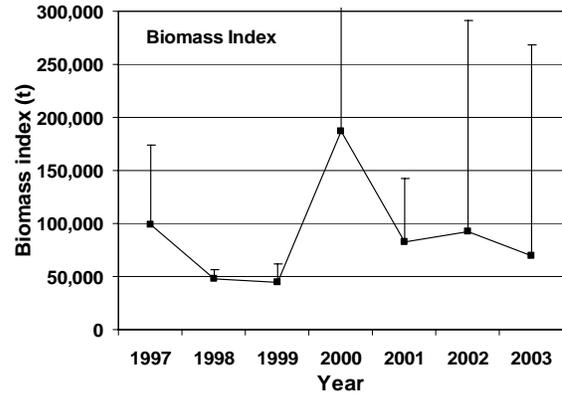


Fig. 7. Biomass index (t) (+1 SD) from the industry (GEAC) trawl surveys.

The biomass index from the GEAC surveys is variable with no clear trend over time (Fig. 7).

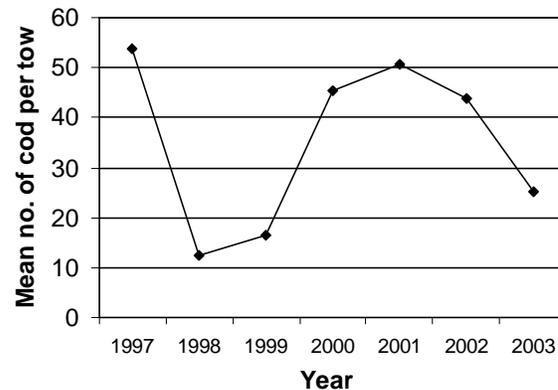


Fig. 8. Abundance index (mean numbers per tow) from the industry (GEAC) trawl surveys.

The abundance index (numbers per tow) from the GEAC surveys has also been variable with no clear trend from 1997 to 2003 (Fig. 8).

In the 2003 survey, the 1997 and 1998 year-classes were well represented. These results are in general agreement with those from spring research vessel

trawl surveys and previous GEAC surveys in 2001 and 2002.

**Sentinel survey**

Fixed gear **sentinel surveys** have been conducted at 16 sites along the south coast of Newfoundland (13 sites in 2003) from St. Brides to Burgeo from late February of 1995 and are continuing in 2004. However, the 2004 survey is not yet complete and the analysis could not be extended to include the current year.

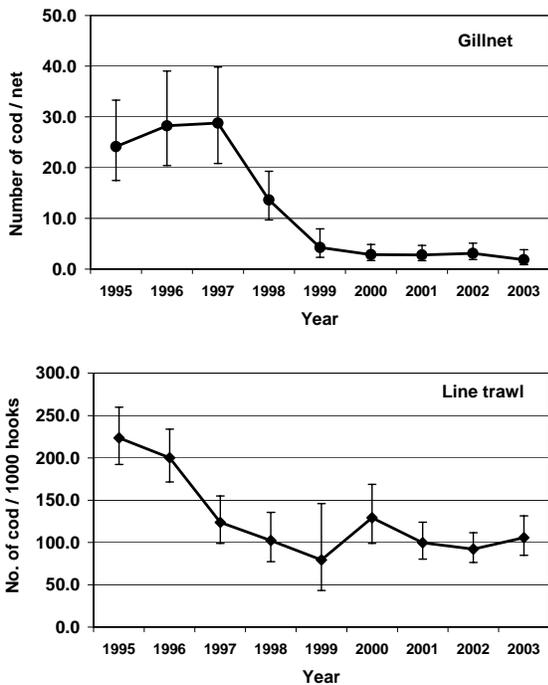


Fig. 9. Standardized sentinel catch rate indices for gillnets (upper panel) and line-trawls (lower panel). Error bars are 95% confidence intervals for the estimates.

Gillnet catch rates come mostly from sites in Placentia Bay whereas line-trawl catch rates come mostly from sites west of the Burin Peninsula.

The sentinel survey data were standardized to remove site and seasonal

effects to produce annual indices of total catch rate and catch rate-at-age.

The standardized total annual **catch rate index** for gillnets shows no clear trend from 1995-1997, but was progressively lower in 1998 and 1999, and remained low from 2000 to 2003 (Fig. 9, upper panel). The index for line-trawls shows a decline from 1996 to 1997, but has subsequently been relatively stable (Fig. 9, lower panel).

The standardized age-disaggregated indices for gillnets and line-trawls show similar trends with the relatively strong 1989 and 1990 year-classes being replaced by subsequent weaker year-classes resulting in an overall decline in catch rates. The incoming 1997 and 1998 year-classes appear to be slightly stronger in the line-trawl index in 2001, 2002 and 2003, but are poorly represented in the gillnet index in those years. Catch rates for older fish (age classes prior to 1997) have continued to decline in the index for gillnets but not in the index for linetrawl.

**Log-books**

Standardized annual catch rates from science logbooks (<35' sector) for vessels fishing gillnets show a declining trend during 1998-2000, but have subsequently shown a slight increasing trend. A declining trend during 1997-1999 was observed for line-trawls, followed by stable catch rates to 2002 and an increase in 2003. The commercial index is based on weight of fish caught whereas the sentinel index is based on numbers.

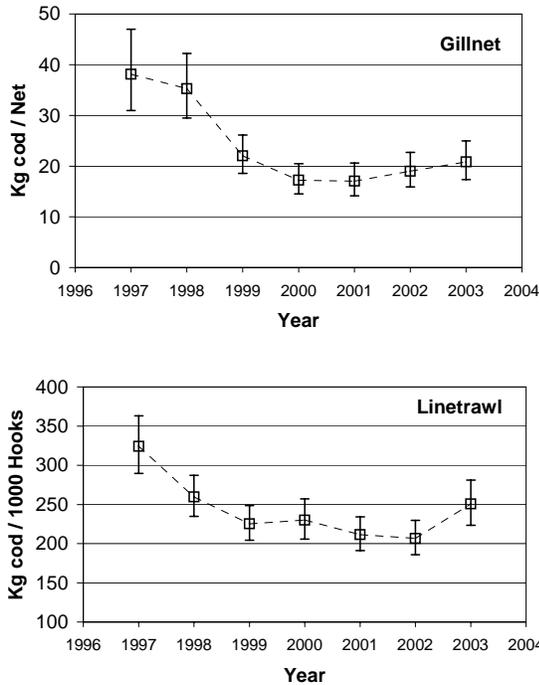


Fig. 10. Standardized catch rates for gillnets and line-trawls from science logbooks for vessels <35'. Error bars are 95% confidence intervals of the means.

**Tagging**

Information from recaptures of cod tagged in various regions of 3Ps since 1997 was used to estimate average **annual exploitation (harvest) rates** for cod tagged in specific unit areas. During 2001 and 2002, the mean exploitation rate was relatively high for cod tagged in Placentia Bay (26% and 21%) compared to those tagged in Fortune Bay (11%, both years), Burgeo Bank/Hermitage Channel (7% and 5%) or Halibut Channel (2% and 1%), respectively.

During 2003, mean annual exploitation estimates remained high for cod tagged in Placentia Bay (22.4%), but remained low (2-10%) for cod tagged elsewhere in 3Ps.

As in the previous assessment, mean exploitation was much lower among cod tagged offshore (3Psh) throughout 1998-2003 in spite of substantial offshore landings. These low offshore exploitation rates are consistent with a large offshore biomass in relation to the magnitude of recent offshore catches. However, the offshore estimates of exploitation are considered uncertain because of localized offshore tagging coverage and localized distribution of fishing activity in the offshore. There is also greater uncertainty in the reporting rates of tags from the offshore, and in the survival of fish caught for tagging offshore in deep (>200 m) water.

Tagging coverage of the offshore was expanded in 2003 to address some of these concerns, and to investigate whether winter catches in the offshore portion of 3Ps include northern Gulf cod. A total of 1,000 cod were tagged and released in 3Psg/h during the December 2003 GEAC survey. Results to date are preliminary, but both the numbers of tagged cod returned and distribution of recaptures (all within 3Ps) are similar to those of cod tagged in the offshore of 3Ps during April.

**Industry perspective**

In the offshore fishing areas, there was a continuing trend toward smaller proportions of very large cod in the 2003/04 catch. These larger fish tend to be caught in the winter months from January to March. The change in spawning closure from the end of March to the end of February in 2001 may have contributed to the trend toward smaller fish in catches. No significant changes in catch rates or distribution were noted.

## Other considerations

### Temperature

Temperatures during the spring of 2004 warmed considerably over 2003 values to 1°C above normal in the surface layers and by almost 0.5°C in the near-bottom depths over St. Pierre Bank. The areal extent of <0°C bottom water during 2003 increased to the highest in about 13 years but decreased during 2004 to <10%, the lowest since 1988.

Cold water in the late 1980s and early 1990s was associated with a disappearance of cod from the shallow strata on top of St. Pierre Bank and a shift to deeper water at the time of year when the research trawl survey was conducted. Survey results from 1998-2000, when waters were warmer, indicate some reappearance of cod in these shallow strata; however, in 2001-2003 the numbers of cod in these shallow strata and regions to the east were lower and this pattern has persisted into 2004 in spite of the warmer temperatures.

### Sequential Population Analyses

Several sequential population analysis (SPA) model formulations were applied in the current assessment to explore the uncertainty regarding the appropriate model. These included some of the formulations used in the 2001-2003 assessments, updated with one more year of data. In addition to the total reported commercial catch, results from DFO RV surveys, GEAC surveys and sentinel surveys were used in the analysis.

Trends in population size, spawner biomass, recruitment, and exploitation were similar among different model formulations. Results from two of the SPA formulations are given to show these trends and to illustrate uncertainty related to different fishery selectivity patterns. In one of these formulations (Run 1), older ages were assumed to be not fully selected by the fishery; in the other (Run 2) it was assumed that older ages were fully selected by the fishery.

Results from the two SPA formulations indicate that there is considerable uncertainty about the absolute size of the cod population. The spawner stock biomass estimates for 1 January 2004 from these two SPA formulations ranged from 88,000 to 130,000 t.

Population numbers increased from the late 1970s to a peak in 1985 (Fig. 11). Numbers declined from the mid-1980s to the early 1990s, and remained low during the moratorium. Population numbers increased during the late 1990's (1998-2000), but have subsequently declined.

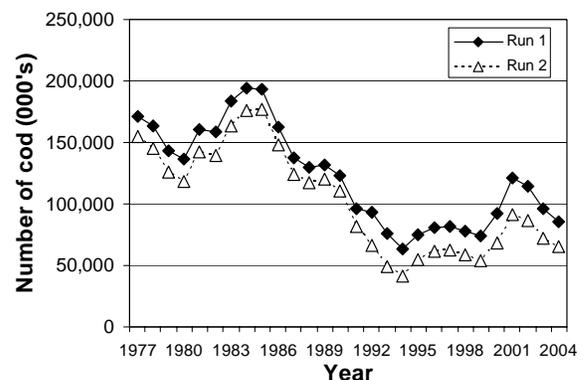


Fig. 11. Trends in population (3+) numbers.

Population biomass increased during the late 1970's to a peak in 1985 then declined steadily through the late 1980's and early 1990's (Fig. 12). Population biomass increased during the moratorium, but

leveled off or declined slightly during 1998-2000 before increasing again during 2000-2003. Population biomass in 2004 is similar to or slightly less than 2003 values.

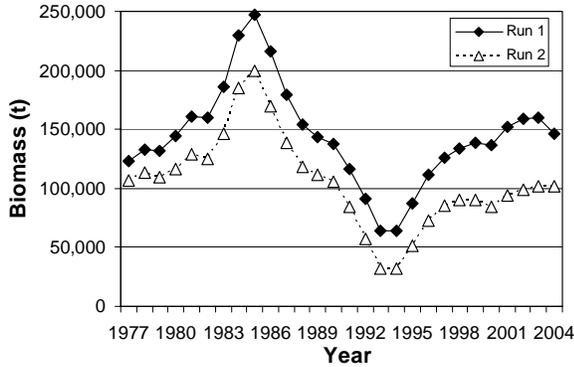


Fig. 12. Trends in 3+ population biomass.

Spawner biomass showed a similar trend to that of population biomass from 1977 to 1999; thereafter the trends differ markedly, with spawner biomass declining during 1999 to 2001, followed by a substantial increase in recent years, particularly during 2001 to 2003 (Fig. 13).

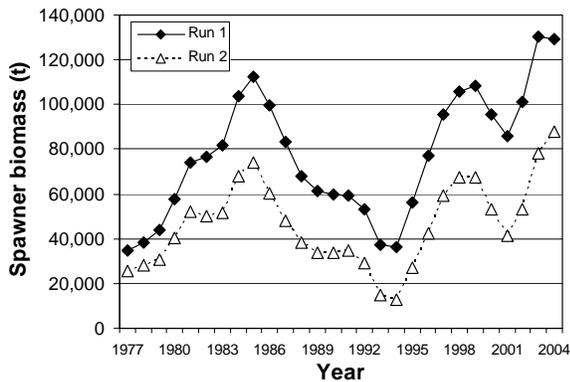


Fig. 13. Trends in spawner biomass.

The age composition of the spawner biomass has changed considerably in the recent period (Fig. 14). With the decline in age at maturity of two strong year classes, spawner biomass has increased dramatically during 2002-2004. The spawner biomass in 2002-2004 comprises an unusually high proportion of 5 and 6 yr olds.

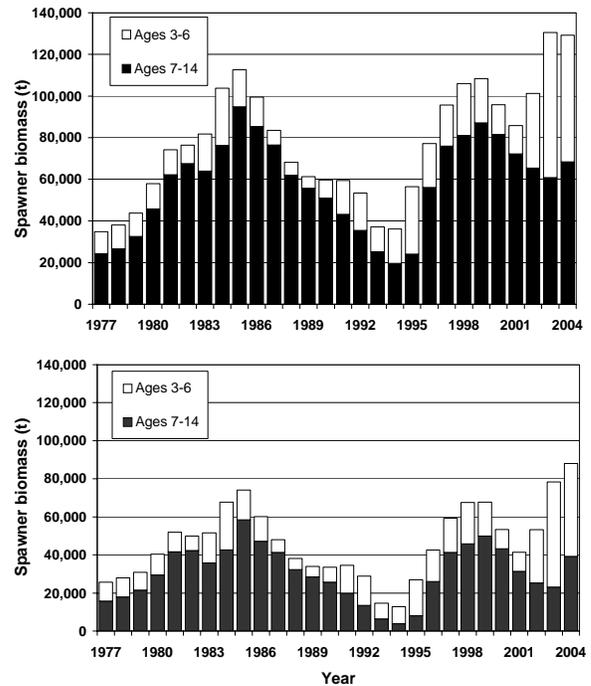


Fig. 14. Trends in the age composition of the spawner biomass. Upper panel - Run 1, lower panel - Run 2.

Estimates from the two SPAs show that recruitment has been variable in 3Ps, with a long-term decline between year classes in the mid-1970s and the mid-1990s (Fig. 15). SPA estimates indicate a succession of relatively weak age classes during the early to mid-1990's. The year classes produced in 1997 and 1998 are estimated to be relatively strong, but these are followed by three weak year classes (1999, 2000, and 2001).

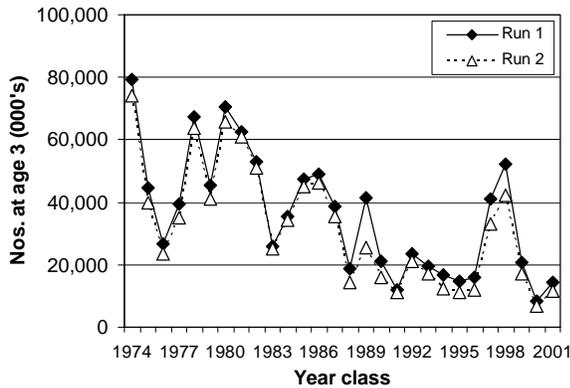


Fig. 15. Trends in recruitment (numbers at age 3).

Estimates from the two SPA formulations also show that the annual **exploitation rate**, expressed as percentage of 3+ numbers removed by the fishery, varied over time (Fig. 16). Exploitation during the late 1970s to 1985 was typically between 10 and 17%, but increased to between 20 and 35% just prior to the moratorium in 1993. With the reopening of the fishery in 1997, exploitation rates were low relative to the pre-moratorium period and increased to a peak in 1999, but thereafter have declined again to about 6-8%.

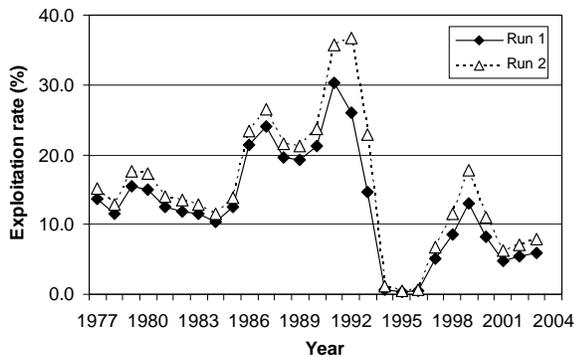


Fig. 16. Exploitation rate (percent 3+ numbers removed by the fishery).

### Spawner biomass limit reference points

The precautionary approach framework under development for management of domestic fisheries requires a spawning stock biomass limit reference point ( $B_{lim}$ ) to be developed for each stock. The risk that the stock may fall below this limit should be assessed with respect to catch options. In the current assessment, various candidate reference points were reviewed.  $B_{rec}$  (where rec=recovery) is the lowest spawner biomass from which a secure recovery has occurred.  $B_{rec}$  is recommended as being suitable for 3Ps cod as this stock has undergone two recovery cycles since 1977. Current spawning stock biomass was compared in relative terms with  $B_{rec}$ , defined as the spawning stock biomass at the beginning of 1994 (i.e. 36,000 t and 13,000 t for the two respective SPA formulations). The current biomass is 3.6 times larger and 6.9 times larger than  $B_{rec}$  for the two respective SPA formulations (see Fig. 13)

### Projections

In the current assessment, 3-year deterministic projections to 1 April 2007 were computed for the two SPA formulations. In the first year the catch was assumed to be 15,000 t which is the TAC for the 1 April 2004 – 31 March 2005 management year. At this catch level, the spawner biomass is estimated to decrease by approximately 7,000 t and 5,000 t for the respective SPA formulations. These declines are consistent with the projections from the 2003 assessment.

The projections for the management years 2005/06 and 2006/07 were for fixed annual catch options ranging from 5,000 to 20,000 t. At catch options ranging from

10,000 to 20,000 t both formulations indicated that spawner biomass will decline by 1 April 2007 (Table 1). At a catch option of 5,000 t both formulations indicated a small increase (1.6-3.7%) in spawner biomass by 1 April 2007.

Under all catch options considered for the two SPA formulations, the projected spawner biomass on 1 April 2007 was considerably greater than  $B_{lim}$ .

% change in SSB from 120,000 t (Apr.1/2004)					
	Year	5,000t	10,000t	15,000t	20,000t
Run 1	2006	-1.4%	-5.4%	-9.3%	-13.3%
	2007	1.6%	-6.2%	-14.1%	-21.9%
% change in SSB from 81,000 t (Apr.1/2004)					
	Year	5,000t	10,000t	15,000t	20,000t
Run 2	2006	-0.9%	-6.8%	-12.6%	-18.4%
	2007	3.7%	-7.8%	-19.4%	-30.9%

Table 1. Projected changes in spawner biomass (SSB) at various fixed catch options to 1 April 2006 and 1 April 2007.

### Sources of uncertainty

Information on fish older than age 14 is not included in the analytical assessment of this stock, because the available data are not considered reliable. Nevertheless, the proportion of the population greater than age 14 is likely to have been small since the moratorium.

There is considerable uncertainty regarding the origins of fish found in 3Ps at various times of year. Tagging experiments suggest that the amount of mixing with adjacent stocks can vary from year to year. The assessment is sensitive to mortality on 3Ps cod occurring when fish are outside 3Ps and to the incursions of non-3Ps fish into the stock area at the time of the survey and the fishery.

In the previous assessment, splitting the research vessel survey index of 3Ps was intended to reduce the possible influence of northern Gulf cod on the index. However, new information shows synchrony in recent year class strengths between eastern and western 3Ps and general asynchrony with the northern Gulf stock. In the current assessment the research vessel survey was treated as a single index. Nevertheless, there will be years when mixing will occur and influence survey catch rates.

As described in previous assessments, there is considerable uncertainty regarding the appropriate SPA formulation for this stock. Consequently, different SPA formulations were again evaluated in this assessment to explore this uncertainty.

To estimate population numbers using SPA, some assumptions are usually made about how commercial fishery selectivity changes with cod size and hence age. Different assumptions can produce estimates that differ substantially, although overall trends are similar for this stock.

The sentinel gillnet index is based on data primarily from Placentia Bay and shows trends that are inconsistent among sites. While the reasons for the inconsistencies are unclear, during 1997-2003 this index may have been influenced by competitive effects associated with high effort from the reopened commercial fishery.

The 3 year deterministic projections do not take any uncertainties into account. The trends in the projections depend heavily on the accuracy of estimates of recent year classes, and their subsequent survival and recruitment to the fishery in 2005-2007. These projections are also sensitive to

recent and substantial changes in estimates of the proportion of females that mature at young ages and become part of the spawning population.

The estimates of exploitation for fish tagged offshore are considered more uncertain because of localized offshore tagging coverage and localized distribution of fishing activity in the offshore. There is also greater uncertainty in the reporting rates of tags from the offshore and possibly in the survival of fish caught for tagging offshore in deep water.

There is considerable uncertainty about the current productivity of this stock. The spawner biomass is currently producing far fewer recruits than it did at the start of this period (i.e. 1977). This may be cause for concern in the application of limit reference points such as  $B_{rec}$ . Recent changes in the composition of the spawner biomass may have lowered the reproductive potential of the stock; consequently, the ability of the stock to rebuild from  $B_{rec}$  may be lower than in the past, should it be reduced to that level.

### **Outlook**

Two strong year classes (1997-1998) are well represented in the 2003 catch and these are likely to dominate the fishery in the coming years. However, these are followed by weak recruitment (1999-2001 year classes), and current catch levels are unlikely to be sustainable in the long-term unless recruitment improves.

Spawner biomass estimates for 1 January 2004 from the two SPA formulations ranged from 88,000 t to 130,000 t. Spawner biomass estimates from both SPA formulations are the

highest in their respective time series (i.e. since 1977).

The age structure of the recent spawner biomass is unusual and comprises a much higher proportion of fish that are maturing at younger ages than in the past. Younger spawners are less effective at producing recruitment; consequently, although the spawner biomass is high the current reproductive potential of the stock is lower than in the past.

### **Management Considerations**

There are no explicit management objectives for this stock. Consequently, only catch options considered to be informative for fisheries management were evaluated in the current assessment. The TAC in the four management years ending 31 March 2005 was 15,000 t and the catch options considered were 5, 10, 15, and 20,000 t.

Both SPA formulations used to illustrate stock trends indicated that spawner biomass will decline in the next management year (2005/06) for all catch options from 5,000 to 20,000 t. However, the estimated spawning biomass at 1 April 2006 will be considerably greater than the recommended biological limit reference point ( $B_{lim}$ ).

At fixed annual catch options ranging from 10,000 to 20,000 t for the 2005/06 and 2006/07 management years, both SPA formulations indicated that spawner biomass will decline further by 1 April 2007 (see Table 1). At a catch option of 5,000 t both SPA formulations indicated a small increase in spawner biomass by 1 April 2007.

The incentive for under-reporting of catches remains with the implementation of trip limits, and IQ's. There are also concerns about discarding of small fish in the hook and line fishery. Increased monitoring of catches and landings would result in better estimates of deaths caused by fishing.

Because of uncertainties in stock structure, excessive exploitation on sub-components of the stock should be avoided. Measures should be implemented to further reduce the relatively high exploitation rate in Placentia Bay (3Psc) that is evident from analyses of the tagging data, sentinel catch rate indices, and commercial catch rate indices for vessels <35'.

Recent management measures (seasonal closures and switch to individual quotas, rather than a competitive fishery in western 3Ps) reduced the reported winter catches from the mixing area (3Psa/d combined) to only 260 t during 2002/03. However, the winter catch from this area increased to over 500 t in 2003/04. Catches from this area in winter should be minimized to reduce the potential impact on the 3Pn4RS cod stock.

A complex series of area/time closures on directed cod fishing in 3Ps has been introduced to address concerns about stock mixing and disruption of spawning activity. The consequences of area/time closures should be carefully considered as these may result in higher exploitation rates on the components of the stock that remain open to fishing.

### **For More Information:**

Contact: John Bratney  
Fisheries and Oceans Canada  
PO Box 5667  
St. John's, NL A1C 5X1

Tel: 709-772-2001  
Fax: 709-772-4501  
Email: Bratneyj@dfo-mpo.gc.ca

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Newfoundland and Labrador Region  
Science Branch  
Fisheries and Oceans Canada  
PO Box 5667  
St. John's NL  
A1C 5X1

Telephone: (709) 772-2027/8892  
Fax: (709) 772-6100  
E-mail: [osborned@dfo-mpo.gc.ca](mailto:osborned@dfo-mpo.gc.ca)  
Internet address: [www.dfo-mpo.gc.ca/csas](http://www.dfo-mpo.gc.ca/csas)

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