

Subdivision 3Ps cod

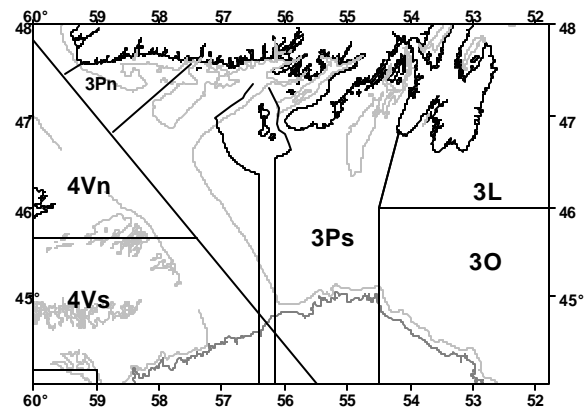
Background

In the Northwest Atlantic, cod are distributed from Greenland to Cape Hatteras and are managed as 12 stocks. The 'St. Pierre Bank' 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 to be 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 in more northerly areas. At least 50% of the females have been found to be mature by age 5 (53cm) in recent years, compared to age 6 (58cm) in the 1980s.

Catches from this stock have supported an inshore fixed gear fishery for centuries and have been of vital importance to the area. Fish are caught offshore by mobile and fixed gear and inshore by fixed gear. The stock was heavily exploited by Spain and other non-Canadian fleets 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 subsequently increased to 20,000 t for 1998 and 30,000 t for 1999.



Summary

- The status of the 3Ps cod stock remains extremely difficult to assess because of variability in the research vessel survey index, incomplete reporting of all mortality caused by fishing, low fishing levels during the moratorium, and the mixing of fish between adjacent stocks.
- Spawner biomass on January 1, 1999 was estimated at 147,000 t, similar to that estimated in the March 1999 assessment of this stock before the April 1999 research vessel survey data were available. This level is the highest estimated since 1962.
- The biomass of fish aged 3 and older is estimated to be 198,000 t, 50,000 t lower than the estimate in the March 1999 assessment. This is primarily because strengths of the 1993 to 1999 year classes have been revised down since the March 1999 assessment due to lower numbers of young fish in the April 1999 survey.
- Estimates of abundance of the population aged three years and older show a general decreasing trend over the period 1959 to 1999.

- Estimates of recruitment (nos. at age 3) show a general downward trend over the period 1959 to 1999 with all year-classes arising after 1989 being particularly low.
- Increased spawning stock biomass in recent years is due to good growth, early maturation and good survival over the moratorium period by the 1989 and 1990 year-classes.
- This increase in spawner biomass is not being sustained by more recent recruitment and the present assessment predicts that spawner biomass will decline in 1999 assuming the 30,000 t TAC is caught.
- While the current spawner biomass is high and a wide range of catch options for the year 2000 may be compatible with a short-term precautionary approach, consistently poor recruitment in recent years is resulting in declining spawner biomass.
- There is a greater than 50% risk that spawner biomass will decline further in the year 2000 at catch levels of 25,000 t or higher.
- Preliminary analysis indicate that shifting fishing mortality to younger ages in future fisheries through changes in mesh size alone could result in a larger decline in spawner biomass in the medium term.
- The risk of exceeding $F_{0.1}$ in the year 2000 with a TAC of 30,000 t is 0.22 and at 50,000 t is 0.91.
- Short-term risk analyses and medium term projections suggest that preserving spawner biomass can only be achieved by reducing the TAC.

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 have 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 the 3Ps cod fishery in 1999, reported landings up to the end of September were 12,100 t, mostly from the inshore fixed gear sector. This included a French catch of about 1,300 t of which approximately 800 t was caught by otter trawlers and the remainder by fixed gear, particularly gillnets.

Landings (000s t)

| Year | 59-76 | 77-92 | 1993 | 1999 | 1995 | 1996 ¹ | 1997 ¹ | 1998 ¹ | 1999 ² |
|--------|-------|-------|------|------|------|-------------------|-------------------|-------------------|-------------------|
| | Avg. | Avg. | | 4 | | | | | |
| TAC | - | - | 20 | 0 | 0 | 0 | 10 | 20 | 30 ² |
| Can. | 30 | 29 | 15 | 1 | 1 | 1 | 7 | 16.5 | 10.8 ² |
| Others | 29 | 12 | + | - | - | - | 2 | 3.1 | 1.3 ² |
| Totals | 59 | 41 | 15 | 1 | 1 | 1 | 9 | 19.6 | 12.1 ² |

¹ Provisional.

² Approximate landings to end of Sept. 1999.

+ Catch less than 500 t.

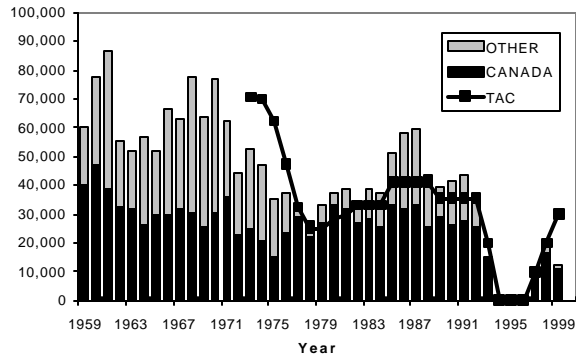


Figure 1. Reported landings (t) by country.

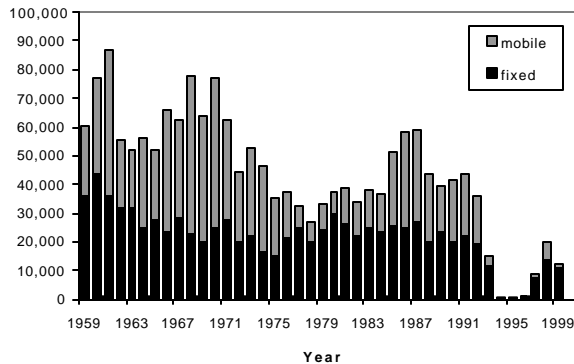


Figure 2. Reported landings (t) by gear sector.

The **age composition** of the fixed gear catch from the first half of 1999 comprised a range of ages from 3 to 15 with most of the catch comprised of 6-10 yr olds and age 7 (1992 year class) predominating. Otter trawl catches in the offshore commercial fishery, though small, also consisted of 6-10 yr olds but with ages 9 and 10 predominating.

Species biology

Stock structure and **migration patterns** of 3Ps cod are not fully understood. Migration of offshore components of the stock to inshore areas during spring and summer, as well as the possible existence of inshore components that remain outside the survey areas throughout the

year, also complicate the assessment of stock status.

Estimation of stock size is complicated by a seasonal movement of cod into 3Ps from adjacent management units, notably the northern Gulf of St. Lawrence (3Pn4RS) during winter. The main area of mixing appears to be the Burgeo Bank-Hermitage Channel area of western 3Ps. The proportion of 3Pn4RS cod present in the Burgeo-Hermitage Channel area during the winter can be substantial and both the extent and timing of mixing are variable.

Tagging studies initiated in 1997 in Placentia Bay were expanded in 1998 and 1999 to include Fortune Bay and two offshore areas (Burgeo/Hermitage and Halibut Channel). In these three years over 22,000 fish have been tagged. Returns indicated that offshore stock components contributed to inshore fixed gear catches on the south coast during the summer in both 1998 and 1999. Some cod tagged in the Burgeo area in April 1998 moved into 3Pn-4RS and others migrated north and eastward along the inshore of 3Ps. However, tagging in the Burgeo/Hermitage area in April 1999 gave recaptures only within 3Ps during the 1999 fishery, suggesting that only 3Ps cod were present.

Recaptures also indicated a spring-summer movement of cod from the inner reaches of Placentia Bay toward the mouth of the bay. Several of these cod were recaptured in 3L during the 1998 index fishery and the 1999 commercial fishery. The pattern of recaptures suggests a movement of some 3Ps cod across the stock management boundary into 3L during late spring, with a return migration during late fall. Historical and recent tagging of cod offshore in southern 3Ps also revealed some

movement of cod between this area and the southern Grand Banks (3NO).

Proportion mature at age in female cod sampled during research trawl surveys has increased among younger cod, particularly since the late 1980s (Fig. 3). For example, the proportion of 6 yr old females that are mature has increased from about 30% in the 1970s and early 1980s to over 80% in recent years.

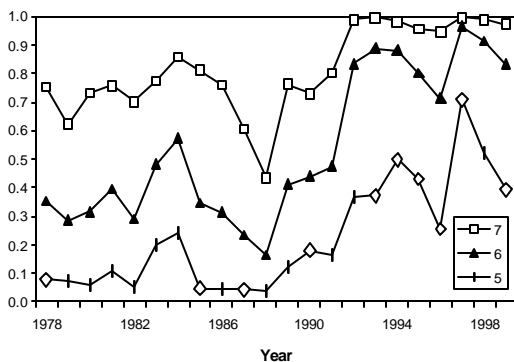


Figure 3. Proportion mature at age (females).

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

Spawning is spatially widespread in 3Ps, occurring throughout the inshore as well as offshore 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 seen during the 1999 spring research vessel survey were similar to those seen in recent years. However, samples taken during tagging studies suggested that spawning appeared to occur earlier in Placentia Bay in 1999 compared to 1998.

Growth, calculated from length-at-age in research trawl survey samples has varied over

time. For the period 1972-1999, peak lengths-at-age occurred in the mid-1970s for young ages and progressively later for older ages (Fig. 4). From the mid-1980s to the late 1990s, length at age varied with no trend (younger ages) or declined (older ages). There appears to have been some improvement in growth in the most recent years.

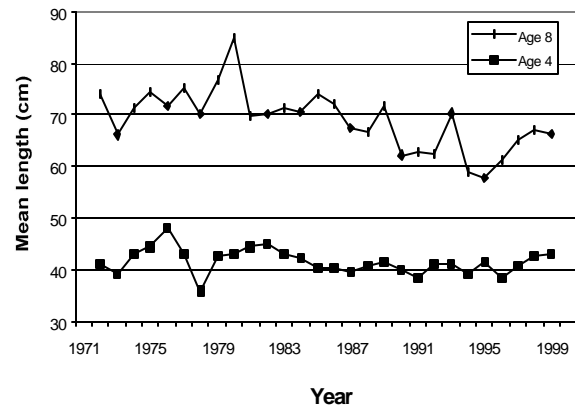


Figure 4. Mean lengths (cm) at age.

The **condition** of cod is typically determined by measuring temporal changes in weight of the body muscle (gutted weight) or of the liver. Condition varies seasonally and tends to decline during winter and early spring.

Cod collected during the April 1999 research vessel survey were generally in better condition than those sampled at the same time of year during 1993-95; comparison of post-1992 condition with condition during 1985-1992 is difficult because survey timing has changed. Nonetheless, condition of cod in the 1995-1999 surveys appeared to be normal.

Industry perspective

There was no attempt to gather and synthesize perspectives on the 1999 fishing season from

participants in the various gear sectors and geographic areas because less than half the quota had been taken at the time of the meeting. Fishermen who attended the meeting noted that fish seemed to be less available in the inshore to the west of the Burin Peninsula than they had been in the previous two years, but that they were locally abundant on St. Pierre Bank.

Resource Status

Sources of information

Stock status was estimated from **commercial landings** in conjunction with **abundance indices** from Canadian (1983-1999) and French (1980-1991) research vessel trawl surveys and sentinel surveys (1995-present). Information from tag returns in 1999 could not be used to determine resource status because the fishery was still in progress. As in 1997 and 1998, a **science logbook** for vessels <35 ft. was used in 1999 to provide detailed information on catch and effort for the inshore fixed gear fishery.

Information from research vessel surveys

The 1999 spring research vessel bottom **trawl survey** was again carried out on this stock with the Campelen 1800 shrimp trawl. Data collected with the previous gear in 1983-1995 were converted to Campelen equivalents. The survey **biomass index** shows a declining trend from the mid-1980s to the early 1990s but is variable, particularly during the past 5 years (Fig. 5). The 1995 estimate is influenced by a single enormous catch contributing 87% of the biomass index. The 1997 biomass index was the lowest observed in the time series, which

goes back to 1983, being less than half of the 1996 index. In contrast, the 1998 biomass index was much higher at 100,100 t. The biomass index in 1999 was 48,857 t, i.e. approximately half the 1998 survey estimate.

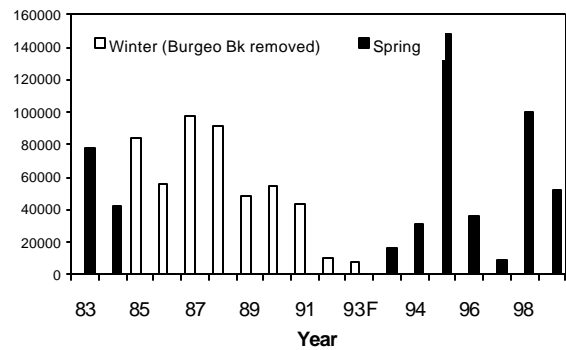


Figure 5. 3Ps survey biomass index (t).

The **age composition** of the survey catch in 1999 comprised a range of ages from 1 to 13 with ages 2-6 predominating, but with no particularly strong year classes present. Survey catches over the past three years have consistently shown few survivors from year classes prior to 1989.

Sentinel survey

A fixed gear sentinel survey has been conducted at several sites along the south coast of Newfoundland from St. Brides to Burgeo. The survey began in late February of 1995 and continued in 1999 but there was insufficient sentinel activity in the first half of 1999 to extend the analyses to include the current year.

Gillnet catch rates, mostly from sites in Placentia Bay, were low in 1998 relative to previous years but show no clear trend during 1995-1997; they also show strong seasonality and are consistently highest during fall in the eastern side

of Placentia Bay. Line-trawl catch rates, mostly from sites west of the Burin Peninsula, have declined since 1995 and exhibit strong seasonality within each year.

Science log-books

Inshore catch rate data from science log-books for vessels <35 ft for the period 1997 to mid-1999 suggest a seasonal cycle in gillnet catch rates within each year with an overall declining trend between years in 3Psa and 3Psb, but no trend in 3Psc. Line-trawl catch rates also show some seasonality, with a declining trend between years in 3Psa and 3Psc and no trend in 3Psb.

Other considerations

Temperature and salinity

Time series of **temperature anomalies** at depths less than 75m show cold periods in the mid-1970s and since the mid-1980s. The most recent cold period, which started around 1984, continued into the mid-1990s with temperatures as much as 1°C below average, and as much as 2°C below the warmer temperatures of the late 1970s and early 1980s in the surface layers. Temperatures in deeper water off the banks show no significant changes. Since 1991, temperatures have moderated somewhat in some areas and deep-water bottom temperatures are above normal, but large areas continued to have anomalously cold temperatures up to 1996, particularly on the eastern portion of St. Pierre Bank. In 1997, conditions were variable across the stock area, but in 1998 temperatures returned to more normal values. The warming trend seen in 1998 has continued, with complete disappearance of

subzero °C water and an increase in the extent of relatively warm (>1°C) water on St. Pierre Bank in 1999. Salinities also show considerable changes during the past two years, with a 40% increase in the areal extent of relatively high (>32.5 parts per thousand) salinity water on the banks.

Cold water in the 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 the most recent year when waters are warmer suggest some reappearance of cod in these shallow strata.

Population Analysis

Sequential population analysis was applied to the total reported commercial catch, Canadian research vessel survey index (1983-1999), and the sentinel survey gill net index (1995-1998). To account for variable stock mixing in the Burgeo Bank/Hermitage Channel area strata in this region were removed from the index derived from surveys conducted in February-March.

The sequential population analysis model used in the current assessment is an improvement on previous models in that it allows more flexibility in estimating the selectivity for the commercial fishery from the data and in describing the uncertainty associated with the surveys.

Population biomass declined from high values during the late 1950s to the mid-1970s, then increased to a peak in 1985 (Fig. 6). The stock declined from the mid-1980s to the early 1990s, but increased rapidly following the moratorium in August 1993. The current

population biomass is estimated to be 198,500 t. **Spawner biomass** shows a similar trend over time and is currently (1999) estimated to be 146,500 t, but in the past two years it has not increased.

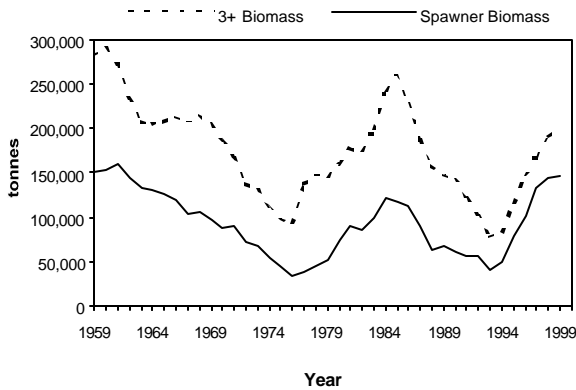


Figure 6. Spawner biomass and 3+ biomass.

Recruitment estimated from sequential population analysis has been variable in 3Ps, but shows a long-term decline (Fig. 7). Recruitment during the mid- to late-1990s does not appear to be strong, but is estimated with considerable uncertainty. Estimates of recruitment for the most recent years are strongly influenced by the numbers of young fish caught in the last research vessel survey. Estimates of recent recruitment have declined in the current assessment because substantially fewer 3-6 year old fish were observed in the April 1999 research vessel survey compared to the April 1998 survey.

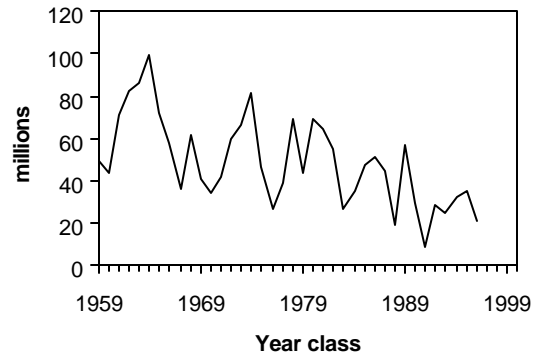


Figure 7. Recruitment (numbers at age 3).

Annual **exploitation rates**, expressed as % removals by numbers by the fishery, varied over time. Exploitation increased from the late 1950's to a peak of over 40% in 1975 and declined to a low of approximately 14% in 1984 then increased rapidly to between 30 and 50% just prior to the moratorium in 1993 (Fig. 8). With the reopening of the fishery in 1997, exploitation rates remained low in 1997 and 1998 relative to the pre-moratorium period.

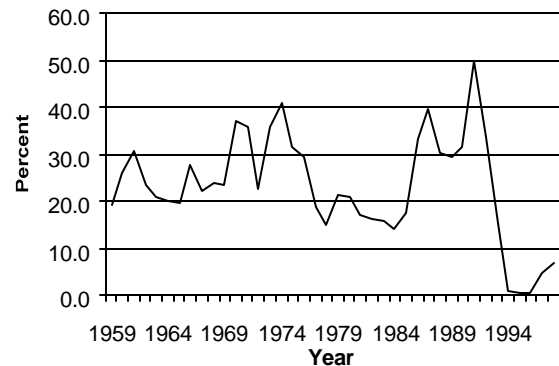


Figure 8. Exploitation rate

Risk analyses

A risk analysis based on the preferred model was used to propagate the uncertainty in the estimated population size to 1 January 2001. The uncertainties reflect only the discrepancies between the survey and the sequential population analysis. In keeping with a

precautionary approach, a number of **reference points** were developed for the evaluation of risk for a range of TAC options for year 2000. As in the March 1999 assessment of this stock, the risk of the spawning stock not growing and the risk of exceeding $F_{0.1}$ were considered for a range of TAC options.

The risk of exceeding $F_{0.1}$ in the year 2000 with a TAC of 30,000 t is 0.22 and at 50,000 t is 0.91 (Fig. 9). The risk of spawning stock biomass declining for a 30,000 t TAC in year 2000 is 0.68 and at a 50,000 t TAC the risk is 0.95 (Fig. 10).

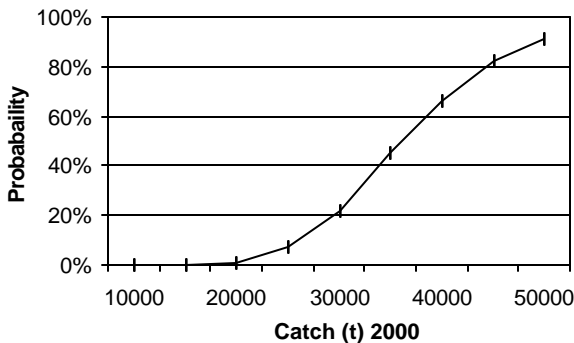


Figure 9. Risk of exceeding $F_{0.1}$.

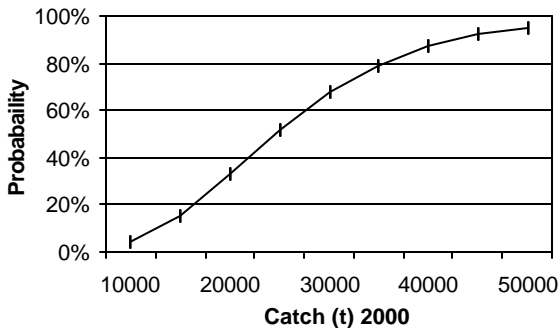


Figure 10. Risk of spawning stock biomass declining.

Two examples of limit reference points that provide biological definitions of over-fishing were considered. The first limit reference point defines an upper limit on fishing mortality (1.96) corresponding to the highest level of fishing mortality that can, on average, be expected to be sustainable at the lowest observed spawner biomass. The second limit defines a lower limit on the spawner biomass (70,635 t) corresponding to half the expected maximum recruitment. For all TAC options evaluated for the year 2000 the risk of falling on the wrong side of the two limit reference points considered was less than 0.1.

A medium-term (3 year) projection of the effect of fishing at $F_{0.1}$ suggested that total biomass and spawning stock biomass would decline.

Sources of uncertainty

The status of the 3Ps cod stock remains extremely difficult to assess because of variability in the research vessel survey index, incomplete reporting of all mortality caused by fishing, low fishing levels during the moratorium, and the mixing of fish between adjacent stocks.

Uncertainty in the interpretation of the survey index is aggravated by past changes in the timing of the survey. In the present assessment, strata in the western portion of the survey area (Burgeo Bank) are removed from the February-March survey index to reduce the problem of northern Gulf cod mixing into 3Ps. When this is done there is no compelling reason not to treat the survey as a single series from 1983 to 1999 for calibrating the sequential population analysis.

Present estimates of the size and trajectory of the stock are sensitive to the way in which the selectivity at age for the commercial fishery is treated in the analysis. In this assessment the selectivity pattern is partly estimated by the available data.

It should be noted that alternative treatments of the survey data and different ways of modeling commercial fishery selectivity, while considered inferior to the approach adopted, can result in declining trends and lower estimates of spawner stock biomass. The selected model is more consistent with independent information on stock size from tagging and industry surveys.

Strong year effects in the research vessel survey index, particularly among the younger ages during the most recent years, introduce considerable uncertainty in the estimates of current total population size and recruitment in the projection of spawner biomass to the beginning of year 2001.

Evaluation of the risk associated with alternative TAC's in the year 2000 are based on the assumption that the catch in 1999 will be 30,000 t and that it will be taken as allocated in the management plan. If this assumption does not hold then the current projections may not be valid.

The assessment does not appear to have significant retrospective effects, in that the perception regarding stock size for previous years does not change in a systematic way as progressively fewer years are used in the analysis.

In addition to uncertainties related to model formulation and input data, 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 and there is increasing evidence that a portion of the 3Ps cod stock migrates seasonally into 3L. 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.

There is concern regarding the continuing low age at maturity among 3Ps cod. This has been observed in adjacent cod stocks that have undergone population declines. The effects of low age-at-maturity on stock dynamics are not well known. A spawner biomass comprising younger fish may be less effective in producing recruits than an equivalent spawner biomass comprised of older fish.

Outlook

Spawner biomass on January 1, 1999 was estimated at 147,000 t, similar to that estimated in the March 1999 assessment of this stock before the April 1999 research vessel survey data were available. However, the biomass of fish aged 3 and older was estimated at 198,000, approximately 50,000 t lower than the estimate from the March 1999 assessment. The strengths of the 1993 to 1999 year classes have been revised down from those estimates provided in the March 1999 assessment of the stock.

Estimates of abundance of the population aged three years and older show a general decreasing trend over the period 1959 to 1999. Estimates of year-class strength show a general downward trend over the period 1959 to 1999 with all year-classes arising after 1989 being particularly low.

The increased spawning stock biomass in recent years is due to good growth, early maturation and good survival over the moratorium period by the 1989 and 1990 year-classes. This increase in spawner biomass is not being sustained by more recent recruitment and the present assessment predicts that spawner biomass will decline in 1999 assuming the 30,000 t TAC is taken. There is a greater than 50% risk that spawner biomass will decline further in the year 2000 at catch levels of 25,000 t or higher.

Thus, while the current spawner biomass is high and a wide range of catch options for the year 2000 may be compatible with a short-term precautionary approach, consistently poor recruitment in recent years is resulting in declining spawner biomass which will likely continue if the catch in the year 2000 exceeds 25,000 t. Estimates of incoming recruitment to the spawning stock are uncertain but suggest that all year classes after 1989 are small.

Short-term risk analysis and medium term projections suggest that preserving spawning stock biomass can only be achieved by reducing the TAC.

Management Considerations

In considering a TAC for the year 2000, it should be taken into account that risk is calculated for the calendar year, whereas TAC's for this stock are set for the period 1 April to 31 March.

The effect of the proposed implementation of limiting gill net mesh size to the range 5.5 to 6.5" needs to be thoroughly evaluated. Although this measure may afford some

protection to the largest spawning fish, the extent to which it will increase fishing mortality on younger ages and new spawners also needs to be evaluated. Preliminary analysis indicated that shifting fishing mortality to younger ages could result in a larger decline in spawner biomass in the medium term.

Observations by fishermen indicate that implementation of trip limits in a competitive fishery leads to discarding and misreporting of effort in log-books.

For More Information:

Contact: John Bratney
Dept. of Fisheries and Oceans
P.O. Box 5667
St. John's, NF A1C 5X1

Tel: 709-772-2055

Fax: 709-772-4188

email

Email: Bratneyj@dfo-mpo.gc.ca

References

Bratney, J., N. G. Cadigan, G. R. Lilly, E. F. Murphy, P. A. Shelton, and D. E. Stansbury 1999. An assessment of the cod stock in NAFO Subdivision 3Ps. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/36.

Bratney, J., N. G. Cadigan, G. R. Lilly, E. F. Murphy, P. A. Shelton, and D. E. Stansbury 1999. An assessment of the cod stock in NAFO Subdivision 3Ps in October 1999. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/--.

Cadigan, N. 1998. Semi-parametric inferences about fish stock size using virtual population analysis (VPA) and quasi-likelihood theory. Canadian Stock Assessment Secretariat Res. Doc. 98/25.

Colbourne, E. 1999. Oceanographic conditions in NAFO Subdivisions 3Pn and 3Ps during 1999 with comparisons to the long-term (1961-1990) average. Canadian Stock Assessment Secretariat Res. Doc. 99/--.

Correct citation for this publication

DFO, 1999. Subdivision 3Ps cod. DFO Stock Status Report A2-02 (1999).

This report is available from:

Science, Oceans and Environment Branch
Department of Fisheries and Oceans
Newfoundland Region
P.O. Box 5667
St. John's, NF A1C 5X1
E-Mail: tillmanj@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN: 1480-4913

La version française est disponible à l'adresse ci-dessus.

