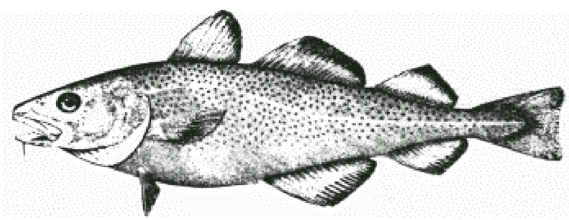
STOCK ASSESSMENT OF NORTHERN (2J3KL) COD IN 2008



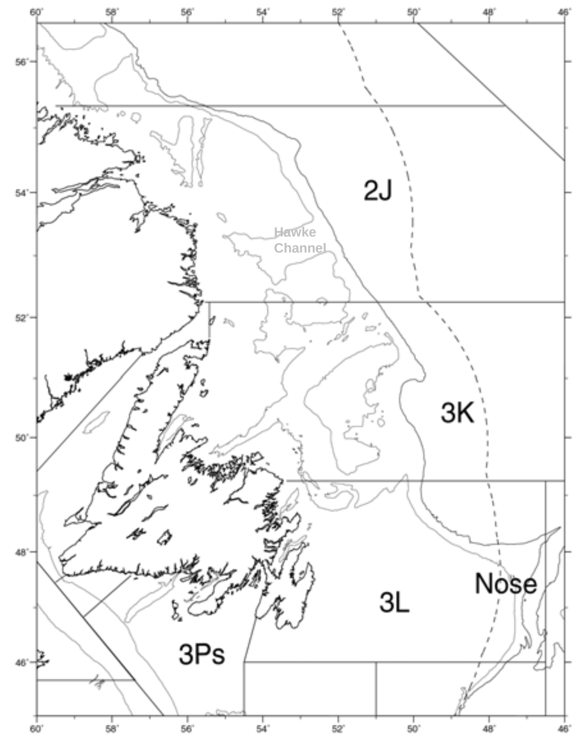


Figure 1: Stock area of northern (2J3KL) cod. The dashed line indicates Canada's 200 nautical mile Exclusive Economic Zone (EEZ).

Context :

The biomass (of ages 3 and older) of the northern cod (Gadus morhua) stock off southern Labrador and eastern Newfoundland (NAFO Divisions 2J3KL; Fig. 1) was about 3 million t in the early 1960s. Fishing intensity increased greatly in the 1960s as non-Canadian fleets exploited dense offshore over-wintering aggregations. The stock collapsed to about 0.5 million t by the late 1970s. After extension of jurisdiction in 1977, the stock recovered partially to just over 1 million t in the mid-1980s, but it declined again during the late 1980s and collapsed to an extremely low level by the early to mid-1990s. A moratorium on directed commercial fishing was declared in 1992.

Historically, many cod migrated from over-wintering areas offshore to feeding areas inshore, where they were exploited by the traditional inshore fixed-gear fishery. By the mid-1990s it was apparent that these offshore populations were barely detectable. At the same time, it was recognized that there were aggregations of cod in the inshore in Div. 3L and southern Div. 3K. These inshore populations appeared to be more productive during the 1990s than populations in the offshore. A small fishery directed at these inshore populations was introduced in 1998. Catch rates declined and the directed commercial fishery was closed in 2003. A food/recreational fishery, which had been open for several years, was also closed. Catches during 2003-2005 were limited mainly to bycatch during a winter flounder (blackback) fishery.

A directed stewardship fishery and recreational fisheries were re-opened in the inshore in 2006 and continued in 2007. There are no management goals against which current status and trends may be compared; there is no target for rebuilding, nor is there a target rebuilding rate. This stock is assessed *annually.*

The present assessment is the result of a request for science advice from the Fisheries and Aquaculture Management (FAM) Branch, Newfoundland and Labrador Region. The objectives were as follows:

- *Assess the current status of offshore populations, inshore populations and the stock as a whole. In particular, assess current spawning biomass, total (age 3+) biomass, exploitation rate, natural mortality and biological characteristics (including age composition, size at age, age at maturity, and distribution). Describe these variables in relation to historic observations.*
- *Highlight major sources of uncertainty in the assessment, and where appropriate, consider alternative analytical formulations of the assessment.*
- *To the extent possible with available information, provide information on the strengths of year-classes expected to enter the exploitable populations in the next 1-3 years.*
- *Assess the implications to stock growth of inshore fishery removals varying from zero to 2500 t in 2008 and annually in the medium term (2008-2010). Implications are to be assessed in terms of a risk analysis, specifically, the risk of the beginning of year SSB not meeting a growth rate of (0%, 5% and 10%) for inshore populations, offshore populations, and the stock as a whole where possible.*
- *Assess the implications of conducting an inshore fishery on a bay-by-bay basis.*

A meeting of the Regional Advisory Process was held during 26 March - 4 April 2008 to conduct the assessment as requested above. Participants included DFO Scientists, fisheries managers, and representatives from the provincial government, industry, Memorial University, and the Fish, Food and Allied Workers Union.

SUMMARY

- Reported total **landings** from the 2007 stewardship fishery were 2364 t. This included 2192 t taken as directed catch and 172 t as by-catch. In addition, 182 t were landed in the sentinel surveys. The offshore portion of the stock area remained closed to directed fishing.
- Two estimates of **landings** from recreational fisheries in 2007 were available. One suggested a recreational catch that was comparable to the stewardship fishery catch; the other suggested the recreational catch was much lower (371 t).
- Until recreational catch is determined, total catch is uncertain. Without a reliable estimate of **total catch**, a sequential population analysis could not be conducted.
- Total **mortality** in the offshore was extremely high during 1996-2003 and has been a major impediment to stock recovery. Total mortality has declined substantially since 2003.
- Based on autumn and spring surveys, the average biomass of cod in the **offshore** over the last 3 years is 4-5% of the average during the 1980's. However, survey biomass has been increasing since 2003.
- The recent increase in offshore biomass is mostly due to **improved survival** and the continued growth of the 2002 year-class, and the appearance offshore after 2005 of the 2000-2001 year-classes.
- **Recruitment** in the offshore has been weak since the 1989 year-class and has subsequently varied without trend.
- The **moratorium** on directed fishing in the offshore should be continued, and by-catch should be minimized.

- The **industry telephone survey** conducted during 2007 showed most harvesters in 2J3KL felt that cod were more abundant during 2007 than during 2006.
- For assessment purposes the inshore was divided into three areas: 1) a northern area (2J and northern 3K); 2) a central area (southern 3K and northern 3L) where most of the resident inshore fish are located; and 3) a southern area (southern 3L) that is largely dependent on migrant fish, from 3Ps and possibly other offshore areas.
- In the **inshore northern area**, sentinel catch rates were low in 1995-2004, increased in 2005, and are currently above the average of the time series. Stewardship fishery catch rates in 2006-07 were slightly higher than in earlier fisheries during 1998-2002.
- In the **inshore central area**, sentinel catch rates have generally increased since 2002 and are currently above the average of the time series. Stewardship fishery catch rates in 2006-07 were higher than in earlier fisheries during 1998-2002.
- In the **inshore southern area**, sentinel catch rates have remained stable since 2003, but are below the average of the time series. Stewardship fishery catch rates in 2006-07 were similar to those in earlier fisheries during 1998-2002.
- **Catch rates** in the inshore northern area and inshore southern area have been lower than those in the inshore central area since 2002, suggesting lower cod densities in these areas.
- In the inshore central area, a **pre-recruit index** suggests that the strength of the 2003-2006 year-classes will be much lower than those that have supported recent fisheries. Sentinel small-mesh gillnet catch rates also suggest the 2003-2004 year-classes are weak; the 2005 and 2006 year-classes are not yet sampled by this gear.
- During 2007, mean annual **exploitation rates** from tagging studies were consistently low among inshore central and southern areas, ranging from 6 – 7%.
- The inshore northern area is primarily dependent on seasonal immigration of fish, possibly from the offshore. Therefore it is recommended to **minimize removals** from this area.
- In the inshore central area the **exploitable biomass** has increased recently, as inferred from trends in catch rates. However, due to the weaker 2003-2006 year-classes, this increasing trend may not continue. The impacts on stock growth of fishing at specific catch levels could not be quantified.
- The inshore southern area is primarily dependent on **seasonal immigration** of fish, the magnitude of which cannot be predicted. Therefore, the effect of removals of various levels cannot be estimated.
- There is a risk that fishing inshore will impede **stock growth** offshore. The level of risk is difficult to quantify, but exploitation rates inshore are currently low and offshore biomass is increasing.
- If exploitation rates inshore increase then the risk of fishing inshore on **stock growth** offshore may increase.

INTRODUCTION

Species Biology

Cod off Labrador and eastern Newfoundland grow slowly compared with individuals in the eastern Atlantic and further south in the western Atlantic. Since the late 1980s females have been maturing at about age 5, which is younger than in previous years.

Historically much of the stock was highly migratory. They over-wintered near the edge of the continental shelf and migrated in spring/summer to shallow waters along the coast and onto the plateau of Grand Bank.

Both prey and predators change as the cod grow. Small cod tend to feed on small crustaceans; medium-sized cod feed on larger crustaceans and small fish; and large cod feed on medium-sized fish and crabs. Capelin in particular has historically been a very important part of the annual diet. Very small cod are eaten by squid, many species of groundfish, including larger cod, and some species of birds. Larger juveniles are eaten by larger groundfish, seals and other marine mammals. Large cod probably have few natural predators, but seals can prey upon them by belly-feeding.

Stock Structure

Various observations, both historic and recent, and much of the genetic information, are consistent with the hypothesis that there are populations in the inshore that are functionally distinct from those in the offshore. Inshore populations are small relative to the populations that historically migrated into the inshore from the offshore during spring/summer.

Tagging studies have revealed that since the late 1990s the inshore of 3KL is inhabited by at least two groups of cod: (1) a resident coastal group that inhabited an area from eastern Trinity Bay northward to western Notre Dame Bay (Fig. 2) and (2) a migrant group that over-wintered in inshore and offshore areas of 3Ps, moved into 3L during late spring and summer, and returned to 3Ps during the autumn. Tagging studies also indicated considerable movement of cod among Trinity, Bonavista and Notre Dame bays.

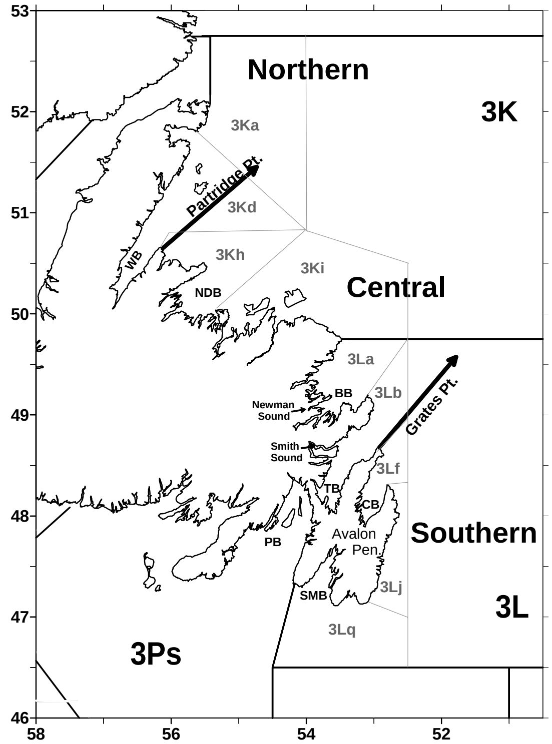


Figure 2: Eastern Newfoundland indicating the locations of the inshore northern, inshore central and inshore southern areas. Major bays are indicated: White Bay (WB), Notre Dame Bay (NDB), Bonavista Bay (BB), Trinity Bay (TB), Conception Bay (CB), and St. Mary's Bay (SMB); Placentia Bay (PB) is in Subdiv. 3Ps. Grey lines delimit boundaries of inshore statistical unit areas (i.e. 3Ka, 3Kd, etc.) referred to in the text.

Some aspects of current stock structure remain uncertain. Catch rates increased in sentinel surveys in 2J and northern 3K in 2005 (see below), but the origin of the fish that generated these higher catch rates is unknown. The extent of migration between the inshore and offshore of 2J3KL during recent years is not well understood, and is currently being investigated by a resumption of tagging. The offshore biomass of cod in 2J3KL remains low but has been increasing since 2003; the current contribution to the inshore biomass during summer is uncertain.

Fishery

Catches of northern cod increased during the 1960s to a peak of over 800,000 t in 1968, declined steadily to a low of 140,000 t in 1978, increased to about 240,000 t through much of the 1980s, and then declined rapidly in the early 1990s in advance of a moratorium on directed fishing in 1992 (Fig. 3).

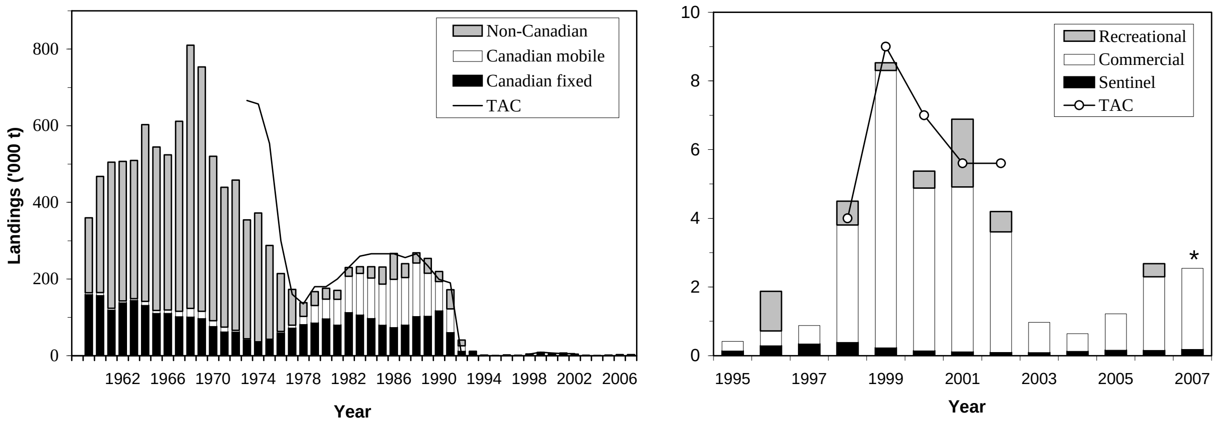


Figure 3: TACs and landings (thousands of tons) in 1959-2007. The right panel is expanded to show trends from 1995 onwards. Non-Canadian catch since 1995 is estimated at less than 80 t per year. The asterisk indicates the 2007 value excludes the recreational catch which has not been determined.

Catches during 1993-1997 came from by-catches, food/recreational fisheries, and DFO-industry sentinel surveys that started in 1995. In addition, catches from 1998-2002 also came from a limited index/commercial inshore fishery restricted to fixed gear and small vessels (<65 ft). The directed commercial and recreational fisheries were closed in April 2003; most of the landings in 2003 came from an unusual mortality event in Smith Sound (Colbourne et al. 2003). During 2004 and 2005, substantial by-catches (>600 t) of cod were taken in the inshore, mostly in 3KL, in the winter flounder (blackback) fishery.

A stewardship fishery and a recreational fishery for cod were re-opened during 2006 and continued in 2007. Commercial fishers were permitted an allowance of 3000 lb of cod per license holder in 2006 and 2500 lb in 2007. Reported total landings from the 2007 stewardship fishery were 2364 t. This included 2192 t taken as directed catch, and 172 t as by-catch mainly in the turbot gillnet test fishery. In addition, 182 t were landed in the sentinel surveys. The offshore portion of the stock area remained closed to directed fishing.

Two estimates of landings from recreational fisheries in 2007 were available. A telephone survey suggested a recreational catch that was comparable to the stewardship fishery catch; monitoring by fisheries officers suggested the recreational catch was much lower (371 t). The issues affecting the 2007 recreational catch estimation may also affect estimates for previous years. Until recreational catch is determined, total catch is uncertain.

Estimates of commercial catch are also uncertain. Commercial fishers often report that commercial landings are underestimated. If the level is substantial then there is more uncertainty in catch-based assessments and in the evaluation of the impact of future removals.

An estimate is not yet available for the 2007 catch by non-Canadian fleets outside the 200 nautical mile limit on the Nose of the Grand Bank (Div. 3L). The Scientific Council of the Northwest Atlantic Fisheries Organization (NAFO) estimated that annual catches during 2000-2006 were 80 t or less.

ASSESSMENT

This assessment is based on trends in indices and harvest rates inferred from tagging studies as described below. Total landings have not been determined and analytical models such as sequential population analysis (SPA) could not be used.

Due to differences in the dynamics of offshore and inshore populations since the mid-1990s, information is provided for the offshore and inshore separately.

The main sources of data for this assessment are as follows: For the offshore, indices of abundance, biomass and other biological characteristics are obtained from multi-species research vessel bottom-trawl (RV) surveys conducted by Fisheries and Oceans Canada (DFO) in the whole of Div. 2J3KL during the autumn and in Div. 3L during the spring. Information on recruitment and total mortality is obtained from catch rate at age in the autumn surveys. An offshore hydroacoustic-tagging survey was initiated in February-March 2007 and repeated in March 2008. This survey provides information on the winter distribution, movements and abundance of cod along the continental shelf edge of 2J3KL.

For the inshore, indices of abundance are provided by DFO-Industry fixed-gear sentinel surveys, which are conducted by two traditional gears, gillnets of 5½ inch mesh and line-trawls, and a non-traditional 3¼ inch mesh gillnet, which is intended to provide information on young fish. Logbooks from vessels less than 35 feet for the fisheries in 1998-2002 and 2006-2007 are examined. Tagging studies provide information on exploitation, distribution and migration. Tagging studies initiated in 1997 were continued in 2006 and 2007. Hydroacoustic surveys (Rose 2002) were conducted in Smith Sound for many years, particularly during winter and spring 1997-2004 and these were continued in 2006 and 2007. An annual telephone survey of fish harvesters' observations is conducted by the Fish, Food and Allied Workers (FFAW) Union. Information on the relative abundance of very young cod is provided by beach seine studies in Newman Sound, Bonavista Bay (Fig 2). Information on the size and age composition of the catch is obtained from lengths and otoliths collected from cod sampled at ports and at sea. A DFO-Industry bottom-trawl survey conducted during July-August 2006 using small (<65 ft) commercial vessels was continued in 2007. This inshore trawl survey provides information on the relative abundance, age composition and distribution of cod inhabiting the coastal and nearshore area of 2J3KL.

Oceanographic information is also considered.

Stock Trends – Offshore

Bottom-trawl surveys

In 2004, the autumn survey did not complete a portion of northeastern 3L that includes seven strata where cod have often been found at higher density in previous surveys. The survey estimate for 2004 is probably low.

The offshore biomass index from the autumn RV surveys have been very low for more than a decade (Fig. 4). The biomass index during 2005-2007 was 5% of the average during the 1980s. However, survey biomass has been increasing since 2003 and the value in 2007 was the highest since 1992. The increases are most noticeable in southern 3K and northern 3L.

The recent increase in offshore biomass is mostly due to improved survival and the continued growth of the 2002 year-class, and the appearance offshore after 2005 of the 2000-2001 year-classes, particularly in 3K. There is uncertainty about the origins of the 2000-2001 year-classes. There is no strong evidence, based on tagging and analyses of changes in the age-composition of inshore catches, that these represent inshore fish that have moved offshore.

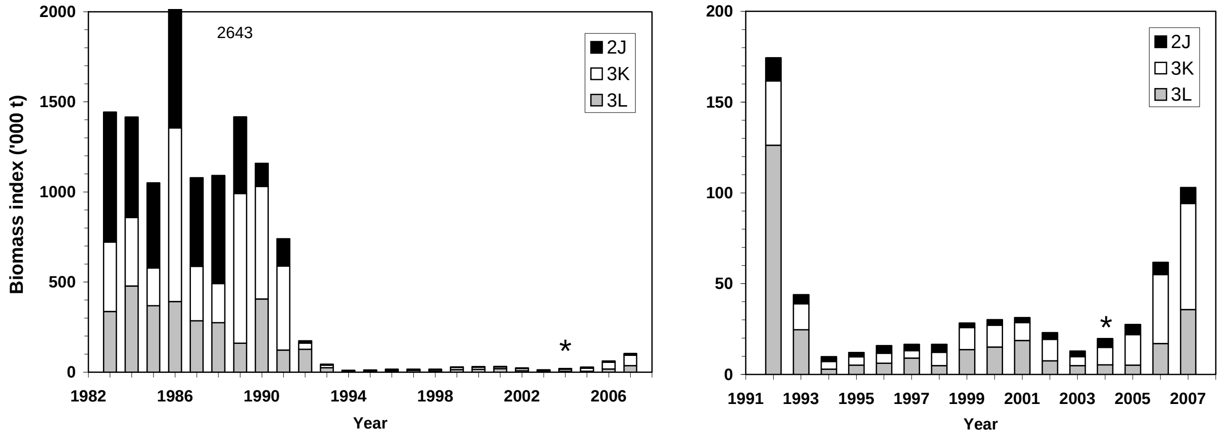


Figure 4: Offshore biomass index from autumn RV surveys in 2J3KL. The right panel is expanded to show trends from 1992 onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004.

The biomass index from the spring RV survey in 3L was, during 2005-2007, 4% of the average in the 1980s (Fig. 5). However, the biomass index from this survey has been increasing since 2003. The value in 2007 was the highest since 1991

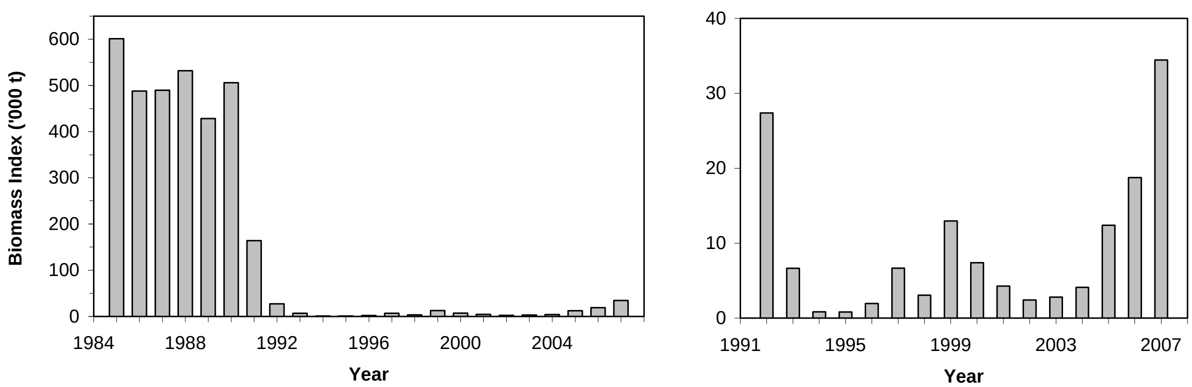


Figure 5: Offshore biomass index from spring RV surveys in 3L. The right panel is expanded to show trends from 1992 onwards.

Information on recruitment and mortality is derived from analyses of mean catch rate at age during the autumn RV surveys.

Recruitment in the offshore (Fig. 6) has been weak since the 1989 year-class and has subsequently varied without trend.

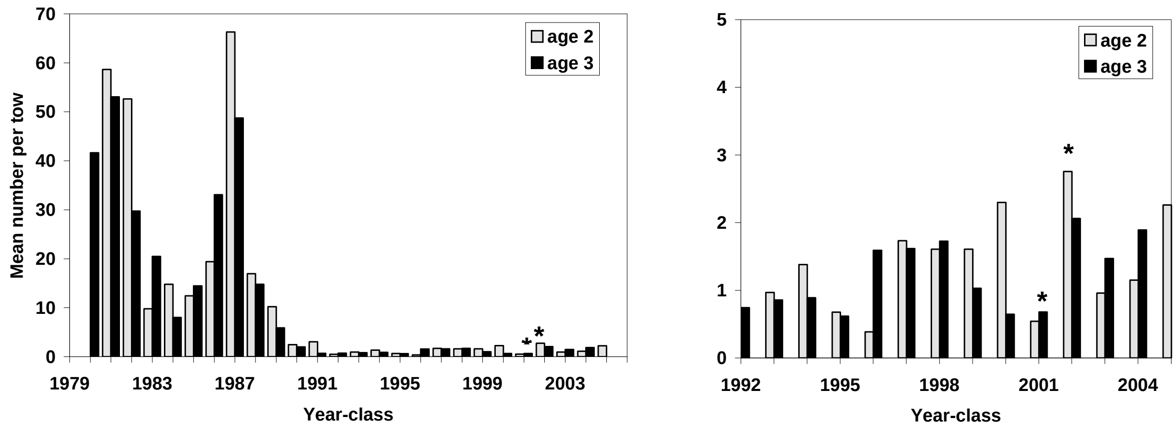


Figure 6: Abundance of the 1980-2005 year-classes in the offshore of 2J3KL from the autumn RV surveys. The right panel is expanded to show trends for the 1992 year-class onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004.

The total mortality rate remained at a high level throughout the mid-1990s, and increased further during 2001-2003 (Fig. 7); this high level of mortality has been a major impediment to stock recovery. Total mortality has declined substantially since 2003. The negative 2006 value may have resulted from year-effects in the surveys; the numbers at age 5, 6, and 7 in the 2006 survey were all higher than the age 4, 5, and 6 values in the 2005 survey. The lack of older fish (ages 8 and older) in the survey since the early 1990s is a consequence of the high rate of mortality. The relative contributions of fishing and natural mortality to the high total mortality are difficult to quantify.

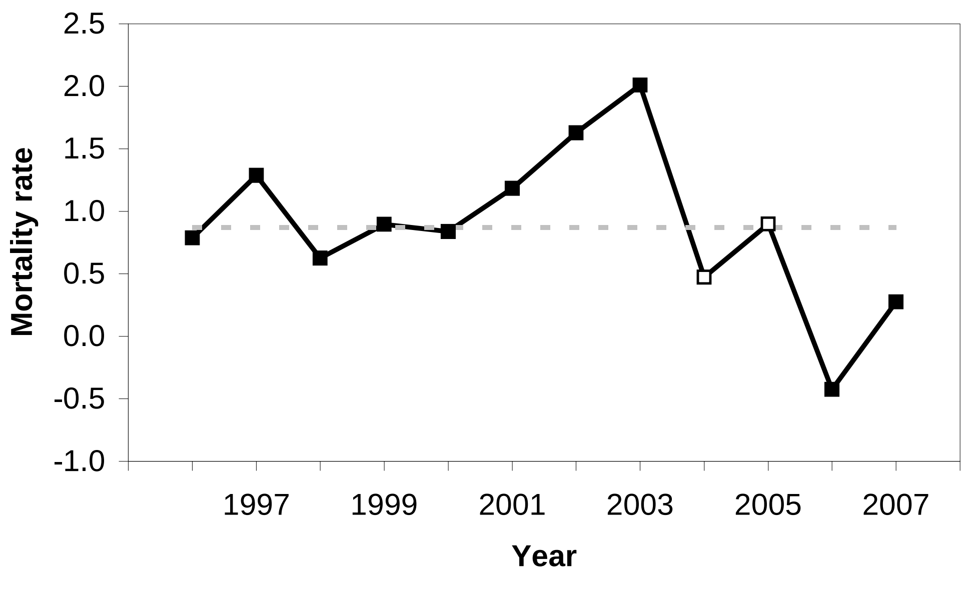


Figure 7: Total mortality rate (Z) of cod aged 4-6 calculated using data from the autumn RV surveys in the offshore of 2J3KL. For example, the value in 1996 is the mortality experienced by the 1991-1989 year-classes from ages 4-6 in 1995 to ages 5-7 in 1996. The dashed line is the average (Z=0.87, which corresponds to 58% mortality each year). Open symbols indicate estimates based on an incomplete survey in 2004.

Offshore winter acoustic / tagging surveys

An acoustic and tagging survey directed at cod was conducted on the outer edge of the continental shelf (depths from 200 m to 700 m) from southern Labrador southward to the nose of the Grand Bank during February-March 2007. The survey was repeated in 2008.

In the 2007 survey, two aggregations of cod were detected, both at low densities; one in the Hawke Channel (Div. 2J, Fig. 1) and the other in southern 3K near the slope edge (Divs. 3KL). Biomass in the surveyed portion of each division was estimated at 4100 t in 2J, 16,800 t in 3K, and 2574 t in 3L. Cod aged 3-5 were most abundant, although small numbers of ages 1-2 and ages 6-10 were also observed in trawl catches from these aggregations.

In 2007, cod captured offshore were tagged and released, including 164 with surgically implanted transmitters. Two were detected on receivers moored inshore in Bonavista Bay and Trinity Bay during the summer of 2007, indicating that they had migrated inshore. None of 1100 tagged cod released offshore were reported as recaptured in the inshore fishery. Cod released with tags and/or transmitters may have suffered high post-release mortality due to the extreme depth at capture (430 m).

In the 2008 survey, two aggregations were detected, one at low density in the Hawke Channel, and one at high density in southern 3K near the slope edge at depths from 300 m to 550 m. Biomass and age composition of catches from the 2008 survey have yet to be quantified.

During the 2008 survey, a further 2,200 cod were tagged and released, including 147 with implanted transmitters. They were captured at shallower depths (340 m) than in the 2007 survey.

By-catch of cod in the turbot fishery

Commercial-sized cod were taken as by-catch in the turbot gillnet test fishery, and the level of by-catch increased from about 2% in 2004-2006 to 18% in 2007, suggesting that the abundance of cod in the offshore increased. Cod were captured over a wide area of northern 3L during August-October when catch rates in adjacent inshore areas were high. This increase in cod by-catch is consistent with the increased cod biomass observed in the same area of 3L during the autumn RV survey in 2007.

Stock Trends – Inshore

For assessment purposes the inshore was divided into three areas: 1) a northern area (2J and northern 3K); 2) a central area (southern 3K and northern 3L) where most of the resident inshore fish are located; and 3) a southern area (southern 3L) that is largely dependent on migrant fish, from 3Ps and possibly other offshore areas. The dividing lines for these areas are Partridge Point at the western side of Notre Dame Bay and Grates Point at the eastern side of Trinity Bay (Fig. 2).

Fishery catch rates

Median commercial gillnet catch rates (Fig. 8) were calculated from catch and effort data for the < 35 ft. sector. Catch rates during 2007 were higher than those observed in 2006 in all three areas. Catch rates in 2006-07 were higher than in earlier fisheries during 1998-2002 in the northern and inshore central areas, but about average in the southern area. Catch rates in the northern and southern areas have been lower than those in the central area after 1998, suggesting lower cod densities in these areas. It is not clear if commercial catch rates are indicative of trends in stock size.

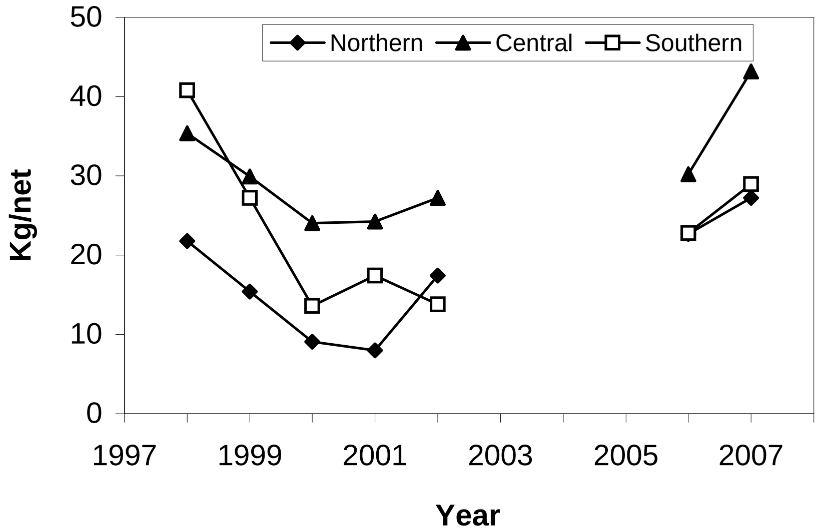


Figure 8: Median gillnet catch rates from fixed gear logbooks. There was no directed fishery from 2003-2005.

Sentinel surveys

In the northern area, catch rates with gillnets (5½ inch mesh) were very low in 1995-2004, increased in 2005, and are currently above the average of the time series (Fig. 9). In the central area, catch rates have generally increased since 2002 and are currently above average. In the southern area, catch rates have remained stable since 2003, but are currently below average.

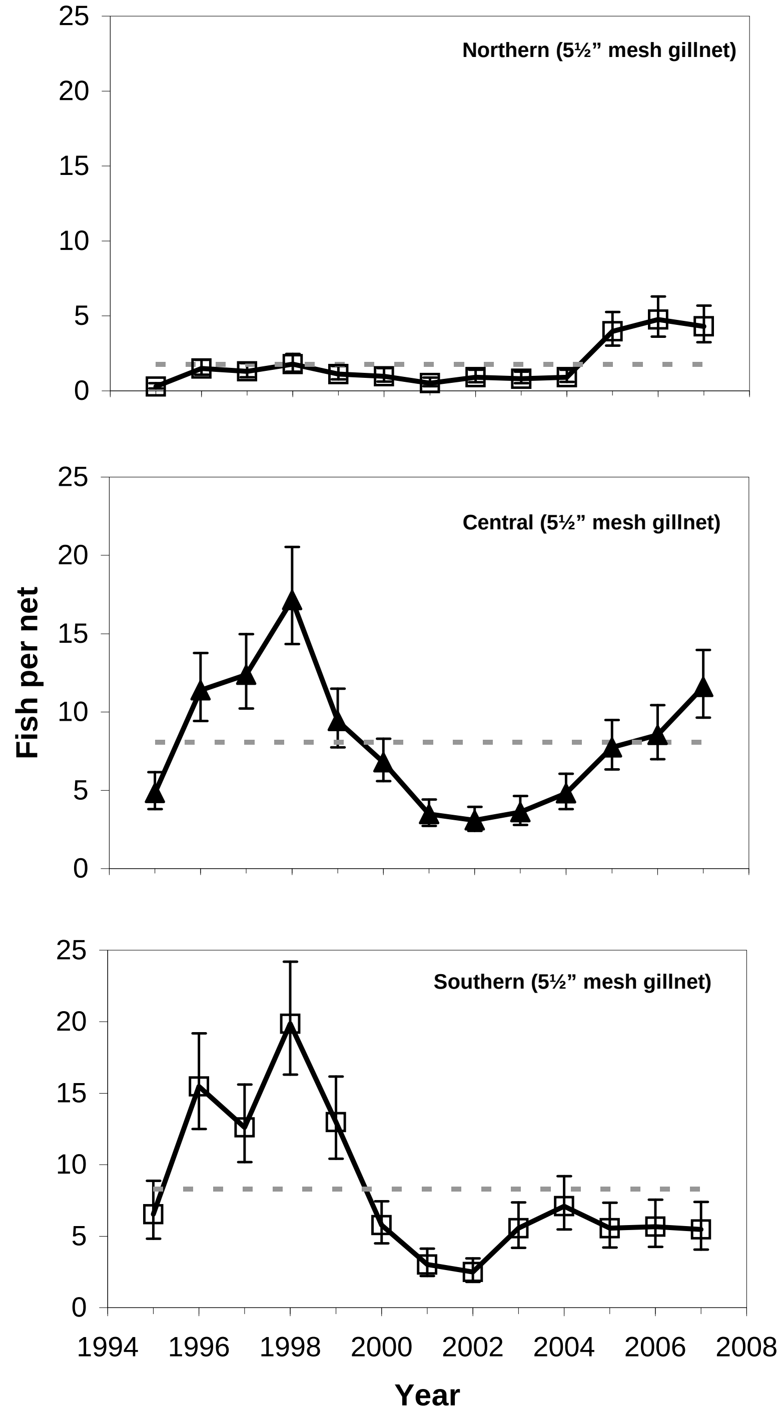


Figure 9: Standardized catch rates with 95% confidence limits from sentinel surveys using gillnets (5½ inch mesh) for each of the three inshore areas. Series means are plotted as dashed lines.

In the central area, catch-rate indices from line-trawls increased during 2007 to above the average of the time-series (Fig. 10). Catch rates in the southern area have been slightly below average in recent years. There are insufficient line-trawl data in the northern area to produce a standardized time series.

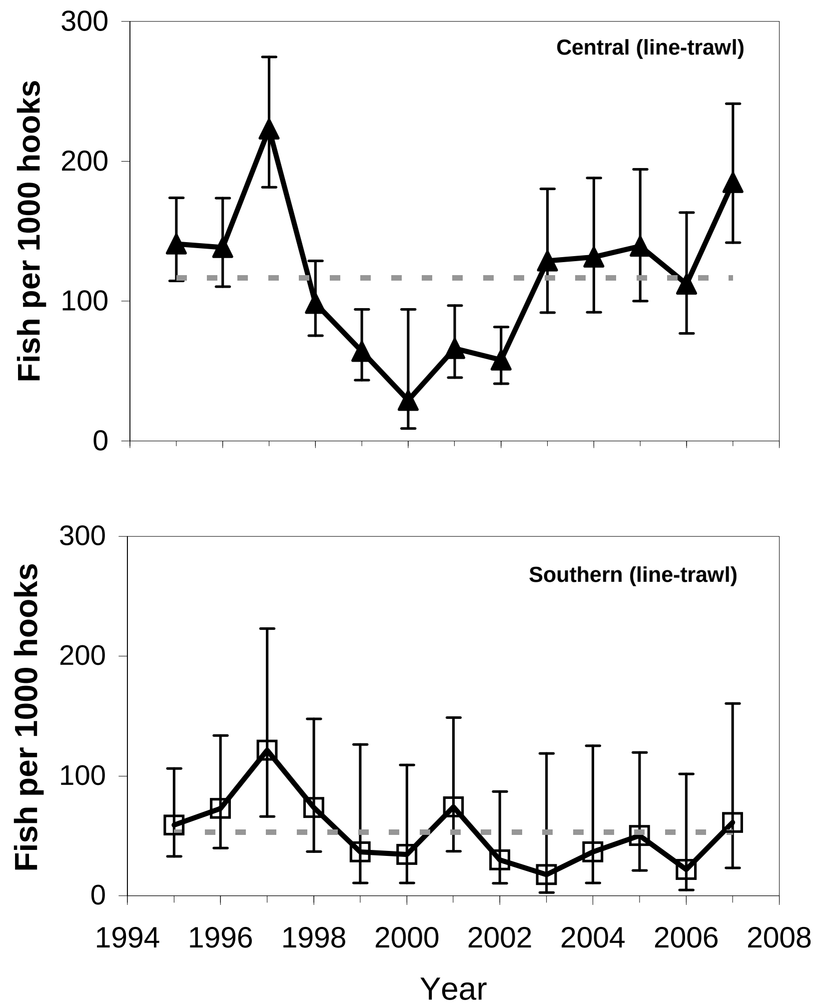


Figure 10: Standardized catch rates with 95% confidence limits from sentinel surveys using line-trawls for the inshore central and inshore southern areas. Series means are plotted as dashed lines.

Catch rates from the small mesh (3¼ inch mesh) gillnets tended to be lower in the northern area than in other areas but increased and are above the average in the past three years. In the central area catch rates are about average, whereas those in the southern area are below average. Trends in the age-aggregated catch rates from small mesh gillnet are difficult to interpret; they do not reflect changes in abundance of small fish alone but include larger fish which tended to be caught in higher numbers in earlier years.

Sentinel survey – recruitment

Catch-rate indices from the small mesh (3¼ inch mesh) gillnets are intended to provide an index of recruitment. Catch rates at age require standardization and this could only be completed for the inshore central area. Therefore, information is provided on year-class strength for ages 3-5 for the central area only (Fig. 11). These catch rates suggest the 2003-2004 year-classes are weak; the 2005 and 2006 year-classes are not yet sampled by this gear.

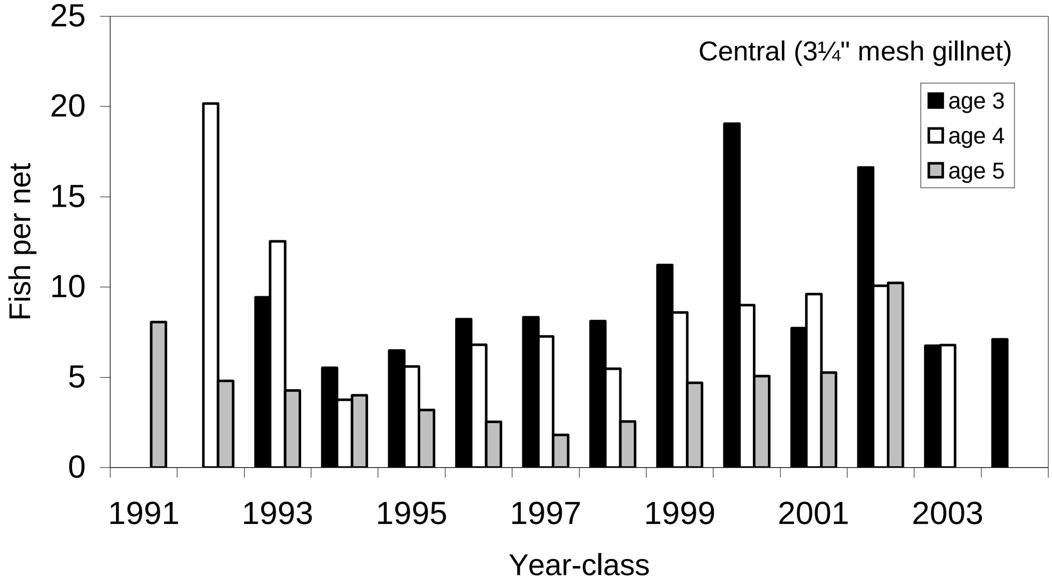


Figure 11: Standardized catch rates from sentinel surveys for ages 3-5 using small mesh (3¼ inch mesh) gillnets for the inshore central area.

Beach seine surveys

Information on the strength of recent year-classes is available from a beach seine survey in Newman Sound, Bonavista Bay (northern 3L). This survey catches cod mainly of ages 0 and 1, with age 0 being much more strongly represented. These pre-recruit ages are not adequately represented in other indices. The information on age 1 from this study has been consistent with the sentinel gillnet indices for the same year-classes at older ages. Recent year-classes (2003-2006) are all weak at age 1 and the 2005 year-class is the lowest in the time-series (Fig. 12). Relatively high numbers of age 0 cod were caught at Newman Sound and several other sites during 2007 surveys. However, survival to age 1 can be highly variable; therefore, the strength of the 2007 year-class is currently uncertain.

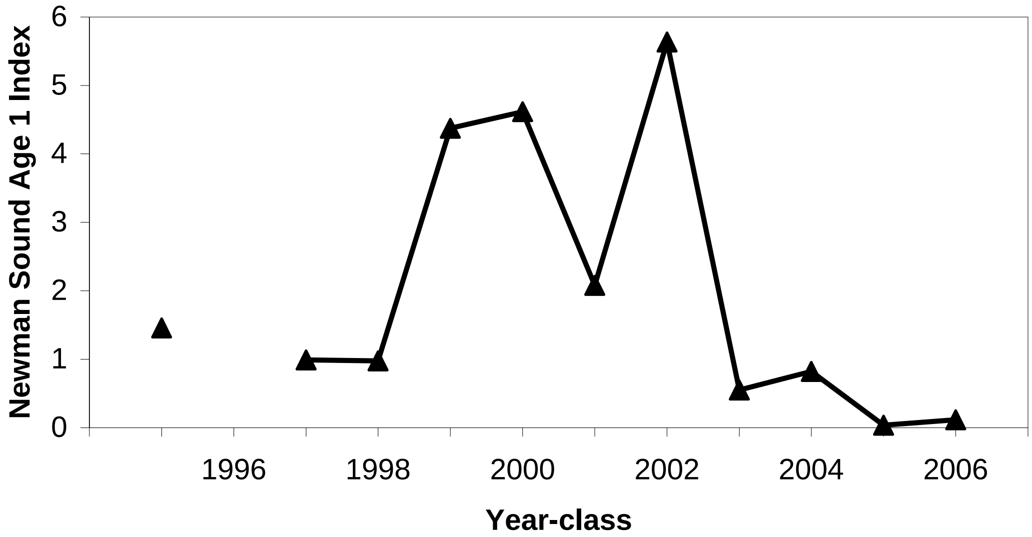


Figure 12: Trends in the numbers of age 1 cod from beach seine surveys in Newman Sound.

Stock mixing in the inshore southern area

The 1997 year-class is well represented in sentinel catches in the southern area during 2001-2007, but not in the northern or central areas. This year-class has been strongly represented in survey and commercial catches in NAFO Subdiv. 3Ps. However, the 1998 year-class was also strong in 3Ps but not in the southern area. The 2002 year-class is well represented in the southern and central area, and offshore in 2J3KL, but not in 3Ps. These findings support results from tagging studies which have shown that inshore southern 3L is dependant on migrant fish, some of which come from 3Ps.

Hydroacoustic surveys

Winter hydroacoustic studies were conducted in Smith Sound in western Trinity Bay (Fig. 2) starting in 1999 (Rose, 2003). Biomass indices increased to a peak of about 26,000 t in 2001 and then declined to 18,000 t in 2004. The surveys were suspended in 2005 but resumed in 2006. Biomass indices were stable in 2006 at 16,500-18,500 t, but declined in 2007 to 14,000 t, the lowest in the time series. The 2006 biomass indices may be underestimated as survey coverage was reduced in that year. The estimate for 2007 was revised upward substantially from the previous assessment (DFO, 2007).

Inshore trawl survey

This survey was initiated in July-August 2006 and continued in August 2007. The surveyed area included the coastal zone from 15 to 200 m depth. The time series is too short to interpret trends in catch rates, but catches have generally been higher in the shallowest strata (< 50 m depth) and lowest in the northern area in both 2006 and 2007. Ages of cod caught ranged from 1-10 years, but ages 2 and 3 were most strongly represented, comprising about 70% of the numbers caught in each year.

Inshore tagging and telemetry

Information from recaptures of cod tagged in various inshore regions of 3KL during 1997-2007 was used to estimate average annual exploitation (harvest) rates. During 1998-2002, exploitation rates for the inshore central area ranged from 10-17% and were highest in 1999, particularly in area 3Ki (37%), when reported landings peaked at 6,500 t. Exploitation rates were lower (2-9%) during 2003-2005 when the directed fishery was closed and annual landings were reduced to <1,000 t.

During 2006, exploitation rate estimates increased to 10% for the inshore central area where the reported landings were 1750 t; the exploitation rate was much higher in southern 3K (20%) than in Bonavista Bay and Trinity Bay combined (7%). During 2007, exploitation rates were consistently low among central and southern areas, ranging from 6–7%. No tagging was conducted in the northern area.

The reporting rate of tags has declined slightly during 2006-2007 compared with previous years (1997-2005) indicating that fishers are becoming less inclined to return tags and recapture information. This adds uncertainty to the estimates of exploitation rates, and analyses of movement patterns and stock structure.

A telemetry study initiated in 2005 indicated a minimum annual survival rate of 79% for cod >60 cm released with transmitters in Smith Sound during winter/spring 2005/06. Most telemetred cod left Smith Sound in spring (March-June) but showed strong over-wintering site fidelity, with >70% returning to over-winter in Smith Sound during the following winter. Dispersal of these cod during summer was monitored by arrays of receivers moored throughout the inshore of southern 3K and 3L. Cod dispersed widely, particularly around northwestern Trinity Bay and Bonavista Bay during summer, but none were detected outside the inshore central area.

Sources of Uncertainty

The movement of offshore cod to the inshore during summer is uncertain. For example, the 2002 year-class is well represented in the inshore and offshore in 2J3KL, but it is not clear if this reflects substantial mixing and/or synchronous recruitment. Hence, the degree of exploitation of offshore cod by inshore fisheries is uncertain, but is likely to be higher in areas where resident inshore cod are less abundant.

Two estimates of landings from recreational fisheries in 2007 were available. One suggested a recreational catch that was comparable to the stewardship fishery catch; the other suggested the recreational catch was much lower (371 t). The main source of disagreement is in estimates of the amount of effort (number of boat trips per day). Until a reliable method of estimating recreational catch is determined, total catch for northern cod and adjacent coastal cod stocks remains uncertain. Estimates of recreational catch for previous years may also require revision.

Estimates of commercial catch are also uncertain. At stock assessment meetings commercial fishers often report that commercial landings are underestimated. If the level is substantial, then there is more uncertainty in catch-based assessments and in the evaluation of the impact of future removals.

Several of the recent autumn RV surveys have extended well beyond their normal time and into the winter because of vessel problems. In addition, the survey was not fully completed in some years. These changes may affect survey estimates of mortality rates, abundance, and biomass.

INDUSTRY PERSPECTIVE

Telephone survey of fish harvesters

A telephone survey was conducted by the Fish, Food and Allied Workers Union (FFAW) to assess the opinions of fish harvesters regarding the abundance of cod in inshore waters, the size and condition of the cod, and the abundance of prey. Most harvesters in 2J felt cod were less abundant in 2007 than the late 1980's. However, most 3K and 3L harvesters felt cod abundance was better during 2007 than the late 1980's. Harvesters in 2J3KL found cod more abundant in 2007 than in 2006. Most harvesters felt that cod were distributed throughout their area and felt that cod were in good condition in 2007. As this survey continues, added utility can be derived by monitoring harvester's perceptions from year to year.

2007 Fishery

Fish Harvesters feel that the lack of confidence in recent recreational cod fishery annual catch estimates is reason for concern. To improve those estimates and improve scientific assessments, Fish Harvesters feel that recreational landings should be subject to the same rules and regulations that apply to commercial landings.

During 2007, Fish Harvesters observed large concentrations of cod inshore where the Stewardship Fishery was prosecuted and in the offshore where the 3L Turbot test Fishery was prosecuted. Because those fisheries were occurring at the same time, Fish Harvesters have little doubt that there has been a significant increase in cod abundance in the inshore and in the offshore in recent years.

Biological Information

The information presented in this section comes mostly from the autumn offshore RV surveys.

Maturity

The proportion mature at age among young female cod is variable but increased during the early 1990s and remains high. For example, the proportion of age 6 cod that are mature averaged about 0.5 in the 1980's, but has increased to about 0.8 since the early 1990s. Males generally mature about one year younger than females and show a similar trend over time. The reasons for the change towards earlier age at maturity are not fully understood, but may partly be associated with high levels of mortality, low stock size, and have a genetic component.

There has been substantial annual variability in the estimates of the proportion mature at younger ages for recent cohorts. This may be partly the result of low sample sizes. The estimates of the proportion of females at young ages that contribute to the spawning stock are thus uncertain.

It is unknown whether fish in the inshore are maturing at the same rate as those in the offshore.

Weight at age

Weight at age has improved since the early to mid-1990s and current values are about average.

Condition

Condition of cod, as measured by both gutted body weight and liver weight relative to fish length, declined in the offshore during the early 1990s, especially in 2J. Since the mid-1990s, condition levels have been similar to those of the mid-1980s.

Respondents to the fish harvester telephone survey reported that the condition of cod in the inshore was good.

CONCLUSIONS AND ADVICE

Offshore

Based on autumn and spring surveys, the average biomass of cod in the offshore over the last 3 years is 4-5% of the average during the 1980’s. However, survey biomass has been increasing since 2003 and for both surveys the 2007 value is the highest since 1992.

Total mortality in the offshore was extremely high during 1996-2003 and has been a major impediment to stock recovery. Total mortality has declined substantially since 2003 and the prospects for recovery have improved.

Specific limit reference points have not been established; however, the stock is well below any reasonable limit reference point. Therefore, it is recommended that the moratorium on directed fishing in the offshore be continued, and that by-catch be minimized.

Inshore northern area

It is inferred from low catch rates in the sentinel surveys (1995-2004) and the commercial fishery (1998-2002) that cod densities have been very low. Catch rates in the sentinel surveys during 2005-2007 and the Stewardship fishery during 2006-2007 were slightly higher, but they remain lower than those in the inshore central area. The origins of fish in the northern area remain uncertain. They appear to be immigrants, possibly from the offshore; therefore, it is recommended that removals be minimized.

Inshore central area

Sentinel catch rates have generally increased since 2002 and are currently above the average for the time series. Stewardship fishery catch rates in 2006-2007 were higher than in earlier fisheries during 1998-2002. This implies that the exploitable biomass has increased recently. However, due to the weaker 2003-2006 year-classes, this trend may not continue. The impacts on stock growth of fishing at specific catch levels could not be quantified.

Inshore southern area

Sentinel catch rates have remained stable since 2003, but are below the average for the time series. Stewardship fishery catch rates in 2006-07 were similar to those in earlier fisheries during 1998-2002, but are lower than those in the inshore central area. Tagging data and age compositions of catches indicate that fisheries during 1998-2002 and 2006-2007 were partly dependent on fish that migrate seasonally between 3Ps and the inshore southern area. Since the magnitude of annual migration cannot be predicted, the effect of various levels of removals cannot be estimated.

Fisheries in this area will contribute additional mortality to fish that migrate between 3Ps and southern 3L. Some of these fish already experience high fishing mortality within Placentia Bay. If fisheries in the southern area increase, the consequences for the neighbouring 3Ps stock should be carefully considered.

Stock as a whole

There is no single measure of the biomass of the stock as a whole. The information from the RV survey in the offshore and the three inshore areas are not directly comparable. However, information from offshore and inshore areas suggests that the biomass of the overall stock is increasing. Historically, the bulk of the biomass was in the offshore, and based on autumn and spring surveys, the average biomass of cod in the offshore over the last 3 years is 4-5% of the average during the 1980’s.

There is a risk that fishing inshore will impede stock growth offshore. The level of risk is difficult to quantify, but exploitation rates inshore are currently low and offshore biomass is increasing. If exploitation rates inshore increase then the risk of fishing inshore on stock growth offshore may increase.

OTHER CONSIDERATIONS

Management Issues

Recreational fishery

A reliable method of estimating recreational catch is required, so total catch can be determined and used in stock assessments.

Consequences of an inshore fishery

Cod currently offshore in 2J3KL may undergo spring/summer feeding migrations to the inshore, similar to their historic pattern. At current offshore population levels, there is a risk that fishing inshore will impede stock growth offshore. The risk may have been higher in the late 1990's when offshore biomass was low and showed no signs of increasing.

The inshore fishery in 1998-2002, though small by historical standards, clearly had a significantly negative impact on the stock. Catch rates in the sentinel fishery and commercial fishery declined dramatically, and tagging indicated high fishing mortality in some areas, particularly in southern 3Ki where resident inshore cod may be less abundant. The increase in total mortality in the offshore at the same time was of further concern. The small inshore fishery may have also been an important source of mortality on offshore cod migrating to the inshore.

The closure of the fishery in 2003 and lower landings in 2004-2005 coincided with a decline in mortality and improved survival in the offshore. Sentinel catch rates in the inshore also began to increase in this period.

The Stewardship and recreational fisheries in 2006-2007 have not resulted in an increase in total mortality offshore, or a reduction in catch rates inshore, and tagging suggests inshore exploitation (harvest) rates were low in 2006-2007. However, if exploitation rates inshore increase in the future then this situation may change. Managers should be aware that a recent reduction in recruitment, as indicated by the beach-seine surveys and small-mesh sentinel catch rates, will likely result in increased exploitation rates in the next few years, even if total catches remain at 2006-2007 levels. In the event of lower recruitment, fishing mortality may also increase on offshore cod that migrate inshore.

The potential for cod currently in the inshore to repopulate the offshore of 2J3KL remains uncertain. Some genetic studies have demonstrated a population substructure between inshore and most offshore areas. Genetic substructure indicates a lower likelihood that inshore-spawning cod will contribute to offshore recovery. Nevertheless, it is well known that fish populations can expand into new environments, and that this is more likely to occur as population levels increase. Cod from inshore populations may expand into the offshore habitat; allowing the inshore populations to grow might increase the likelihood of this happening.

Implications of fishing bay-by-bay

The distribution of fish harvesters does not match the distribution of cod. In some years this has caused geographic variability in fishing mortality rates, as evidenced by tagging studies. Therefore, fishing bay-by-bay may result in local over-exploitation, particularly in areas where resident inshore cod are less abundant and effort is high. Managers should attempt to keep exploitation rates low and preserve and enhance population spatial structure and diversity within the stock.

Physical Environment

The marine environment off Labrador and eastern Newfoundland experienced considerable variability since the start of standardized measurements in the mid-1940s. A general warming phase reached its maximum by the mid-1960s. Beginning in the early 1970s there was a general downward trend in ocean temperatures, with particularly cold periods in the early 1970s, early to mid-1980s and early 1990s. Ocean temperatures have been above normal for the past decade, with 2006 at a record high, but temperatures in 2007 declined to nearer normal values.

Studies based on data up to the mid-1990s have demonstrated that growth of cod declines when temperature declines, but there has been no analysis of more recent data. Whether or not the cold water of the early 1990s influenced recruitment and natural mortality is contentious.

It is anticipated that cod in this area may be more productive when water temperatures are toward the warm end of the regional norm; cod in the offshore have not shown increased growth rates or recruitment, but there are indications that biomass is increasing mainly through improved survival.

Predators

No new information regarding the impact of seals on the dynamics of cod was presented to the meeting. Previous cod assessments (DFO 2003) have concluded, based on seal feeding behaviour and trends in the abundance of both seals and cod, that predation by seals is a factor contributing to the high total mortality of cod in the offshore and the high natural mortality of adult cod in the inshore.

A two-year programme of enhanced study of seals, initiated in 2003, has included new population surveys, new studies of distribution, and new studies of diet, both inshore and offshore. A pilot study on the efficacy of seal exclusion zones was conducted in Smith Sound (Bowen 2004). The information from these programmes is not yet available for review.

White hake (*Urophycis tenuis*) have been identified as an important predator of cod < 1yr old in the nearshore environment.

Prey

The trend in capelin biomass has been uncertain since the late 1980s. Biomass estimates from hydroacoustic surveys in an index area offshore have been much lower since the early 1990s compared with the 1980s. No offshore biomass estimates are available for 2005 and 2006 due to incomplete or missed surveys. Indices of capelin biomass from the inshore did not show such extensive declines in the early 1990's. However, these same inshore indices are no longer available. Concurrent with the decline in capelin abundance offshore, capelin underwent dramatic changes in their biological and behavioural characteristics. These included: decreased size of spawners, delayed timing of spawning, reduced beach spawning and perceived increase in off beach spawning. There have also been changes in horizontal and vertical distribution, decreases in condition and changes in prey composition. In the last two years it would appear that size of spawners are increasing, spawning times are getting earlier and beach spawning, especially in the northern areas has increased, but none of these attributes have yet approached levels observed in the late 1980s.

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