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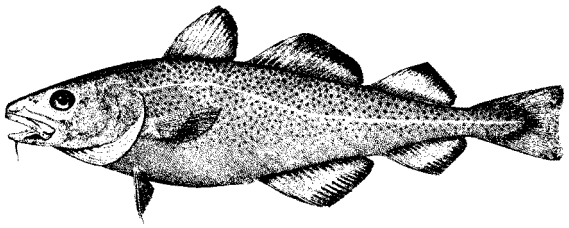
Newfoundland and Labrador, and Quebec Regions **Stock Status Report 2004/041**



Allowable Harm Assessment for Laurentian North Cod

Background

Laurentian North cod encompasses stocks inhabiting two management areas (3Pn, 4RS and 3Ps). This unit is designated as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is listed on Schedule 3 of the Species at Risk Act (SARA). If this population is subsequently listed in Schedule 1 of SARA then a series of potential prohibitions associated with SARA are scheduled to come into force. If listed, SARA may provide legal protection to this population. SARA provides that the Minister of Fisheries and Oceans may issue a permit to allow for incidental harm in the period prior to establishment of a recovery plan, provided that a number of conditions are met.

Under section 73(2), authorizations may only be issued if:

- *a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons;*
- *b) the activity benefits the species or is required to enhance its chance of survival in the wild; or*
- *c) affecting the species is incidental to the carrying out of the activity.*

Section 73(3) establishes that authorizations may be issued only if the competent minister is of the opinion that:

- *a) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;*
- *b) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals; and*
- *c) the activity will not jeopardize the survival or recovery of the species.*

The analysis provided herein will support the Minister of Fisheries and Oceans in determining the basis under which permits might be issued for the Laurentian North cod population.

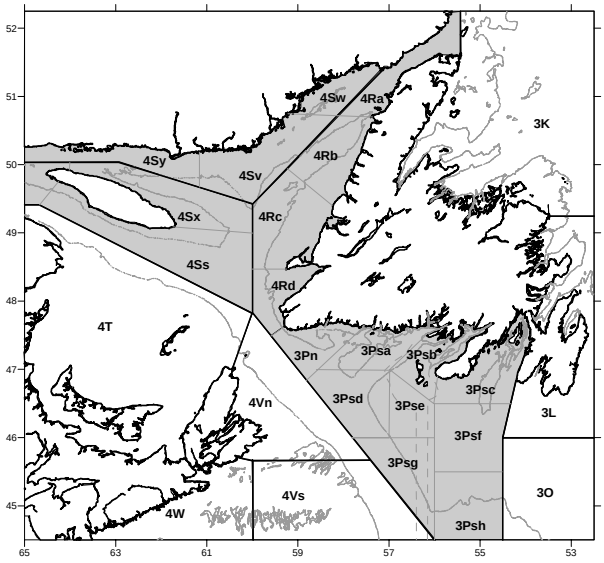


Fig. 1. Location of the 3Pn, 4RS (northern Gulf of St. Lawrence) and 3Ps (southern Newfoundland) stock management areas, which together comprise the Laurentian North designated unit.

Summary

- According to COSEWIC (2003), between 1974 and 2001, the abundance of the Laurentian North designated unit declined by 81%. This unit, which is designated as "threatened", comprises two cod stocks, the 3Ps stock (southern Newfoundland) and the 3Pn, 4RS stock (northern Gulf of St. Lawrence).

- There is a directed fishery in 2004 on both stocks (with TAC's of 15,000 t for 3Ps and 3,500 t for 3Pn, 4RS). They are also taken as by-catch in other fisheries, and these removals are included in the TACs. These fisheries are the main source of human-induced mortality.

- Population biomass of 3Ps cod estimated from SPA has increased significantly over the past decade and

is slightly more than half the peak observed in the mid-1980s.

- Spawning stock biomass (SSB) of 3Ps cod is close to the highest estimated since 1977 and is substantially above the recommended limit reference point (B_{lim}) for the stock.

- SSB of 3Pn, 4RS cod increased during the January 1994 - May 1997 moratorium and has not changed significantly from 1997 to 2004. However the current level of the SSB is substantially below the values of the mid 1980s and is also well below the recommended conservation limit reference point (B_{lim}) for the stock.

- There is scope for human-induced mortality on both stocks without jeopardizing survival of this unit.

- The 3Ps stock is considered to be recovered, and should be managed under conventional fisheries management practices.

- Continuation of fishing practices of 2004 in the northern Gulf will not jeopardize recovery over a period of 1-2 years.

- With the information available there does not seem to be scope for substantial increase in human induced mortality on 3Pn, 4RS cod, if commencement of recovery of the stock is a priority.

Issue

According to COSEWIC (2003), between 1974 and 2001, the abundance of cod (*Gadus morhua*) in the Laurentian North designated unit declined by 81%. This unit, which is designated as "threatened", comprises two cod stocks, one inhabiting 3Ps (southern Newfoundland) and the other 3Pn, 4RS (northern Gulf of St. Lawrence). Over a three-generation period, the 3Ps stock was estimated by COSEWIC to have declined by 46-47%, whereas the 3Pn, 4RS stock was estimated to have declined by 93%.

Specific threats cited by COSEWIC were fishing, and also marine mammal predation in the case of 3Pn, 4RS cod. Fishing induced and natural changes to the ecosystem were also listed. Alteration to bottom habitat was listed as a possible but unevaluated threat.

In respect to SARA Sect. 73, a scientific evaluation was carried out to identify potential sources of harm and to determine a level of incidental harm, if any, that would not jeopardize survival or recovery of cod in the Laurentian North designated unit over a period of 1-2 years.

Assessment of issue

History of the fishery

3Ps stock: Catches from the 3Ps stock have supported an inshore fixed gear fishery for centuries. 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. Following extension of jurisdiction in 1977, access to 3Ps cod by countries other than France and Canada was stopped. French catches increased in the offshore of 3Ps throughout the 1980s and the stock declined rapidly in the late 1980's and early 1990's. A moratorium on fishing initiated in August 1993 ended in May 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. The TAC for the past four management years (1 April - 31 March) ending in 2005 has been set at 15,000 t.

Currently, the stock is exploited only by Canada and France (the islands of St. Pierre and Miquelon, SPM). Under the terms of a bilateral agreement signed in 1995, for the post-moratorium period France is allocated

15.6% of the TAC most of which is fished by Canadian trawlers and landed for processing in Miquelon. SPM also has a small fleet of inshore vessels primarily fishing gillnets; in recent years these vessels have landed approximately 25-40% of the French allocation (i.e. <750 t). There is an exclusive economic zone surrounding St. Pierre and Miquelon that includes a narrow corridor extending southwards through Subdiv. 3Ps where fishing by Canadian vessels is not permitted (Fig. 1).

3Pn, 4RS stock: Before the extension of jurisdiction in 1977, the fishery was prosecuted by Canadian, Spanish, Portuguese and French fleets. Since 1977 only France (metropolitan), Saint Pierre and Miquelon (SPM) and Canada have been involved. Since 1995, SPM has had access to 2.6% of the annual TAC's set for this stock; however, given the low TAC's on this stock since 1997, SPM has not prosecuted any fishery recently.

Cod landings in the northern Gulf of St. Lawrence reached a maximum of more than 100,000 t in 1983. Then, they gradually decreased until 1993. During the decline, boats using mobile gears captured their allocation, whereas those using fixed gears did not.

The fishery was under moratorium from January 1994 to May 1997. TAC's from 1997 to 2002 ranged from 3,000 t to 7,500 t. A second moratorium was announced for 2003. A directed cod fishery was reopened in 2004 at 3,500 t. Only gillnets, handlines and longlines have been used in this fishery since 1997.

Species Status

3Ps stock: Recent assessments of 3Ps cod have been based on Sequential Population Analysis (SPA) using age-disaggregated data from commercial landings and various indices. The latest assessment of 3Ps cod was conducted in October 2004 (DFO, 2004; Brattey et al. 2004) using catch and survey indices from 1977 onwards. Several SPA formulations were used to explore the uncertainty in the 2004 assessment. There was considerable uncertainty about the absolute size of the population; however, the trends in stock size from the various SPA formulations were the same, and two formulations (labelled Run 1 and Run 2) were used to show these trends and illustrate the uncertainty in estimates of absolute population size. The instantaneous rate of natural mortality in all assessments of 3Ps cod has been assumed to be 0.2 per year.

Trends in stock size (3+ biomass and spawning stock biomass) from the two SPA formulations are shown in Figs. 2 and 3.

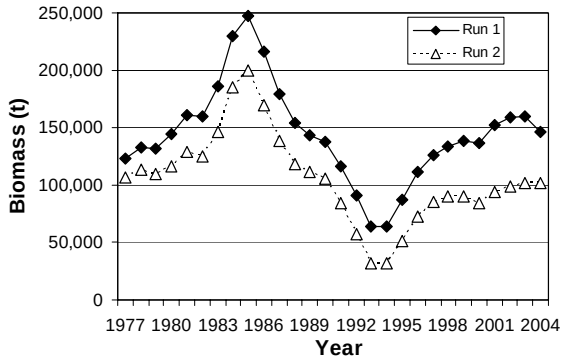


Fig. 2. Trends in (3+) population biomass of 3Ps cod.

Following extension of jurisdiction in 1977, 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. 2). Current population biomass of 3Ps cod estimated from SPA has increased significantly over the past decade and is slightly more than half the peak observed in the mid-1980s.

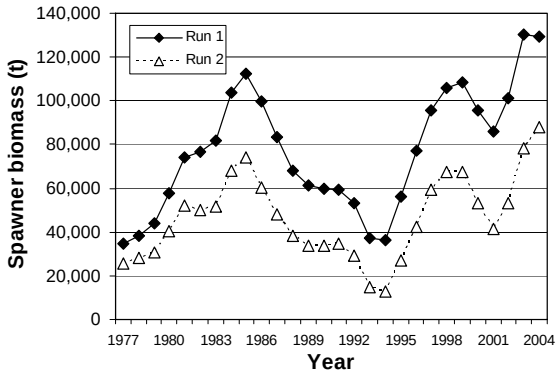


Fig. 3. Trends in spawning stock biomass of 3Ps cod.

Spawning stock biomass peaked in the mid-1980's and was followed by a progressive decline (Fig. 3). After 1993, spawning stock biomass increased to near the high observed in the mid-1980's, but declined during 1999-2001. This short decline was followed by a substantial increase in recent years (2001-2003).

The age composition of the spawning stock biomass has changed markedly in the recent period. Coincident with a recent decline in age at maturity, two strong year classes have appeared in the population and attained sexual maturity; consequently, overall spawning stock biomass has increased dramatically during 2001-2003. Spawning stock biomass (SSB) is close to the highest estimated since 1977.

In the 2004 assessment of 3Ps cod, (DFO, 2004) various candidate limit 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.

COSEWIC used three measures to determine species status: (1) trends in the numbers of mature cod in 3Ps from 1959-2001, and (2) trends in the abundance of 5+ cod from 1959-2001 along with (3) the DFO research vessel survey abundance index (mean numbers per tow) from 1983-2001. These values came from the 2001 assessment (Brattey et al. 2001) that incorporated landings data going back to 1959. However, in the most recent assessment, the catch-at-age prior to 1977 was not considered reliable, and the population reconstruction only covered the period 1977-2004.

3Pn, 4RS stock: Recent assessments of 3Pn, 4RS cod have been based on Sequential Population Analysis (SPA) using age-disaggregated data from commercial landings and 5 abundance indices. The latest assessment of 3Pn, 4RS cod was conducted in March 2004 (DFO, 2004) using catch and survey indices from 1974 onwards. The SPA was calibrated with the indices of coastal sentinel fixed gear fisheries using gillnets and longlines, and sentinel mobile gear surveys from July and October and those of the scientific survey made by the *Needler* in August.

To reflect the deterioration of environmental conditions, an increase in wasteful fishing practices and the intensification of predation by seals, it was considered appropriate to increase M from 0.2 to 0.4 from 1986 onward for this cod stock. Although fish condition has improved recently, predation by seals is believed to remain important. Hence M was kept at 0.4 for the entire period 1986-2003 to take account of the combined effect of these factors.

Trends in stock size (3+ biomass and spawning stock biomass) are shown in Fig 4. The total biomass, for fish 3 years and older, declined from 604,000 t in 1983 to 32,000 t in 1994 and increased to 69,000 t at the beginning of 2004 (Fig. 4).

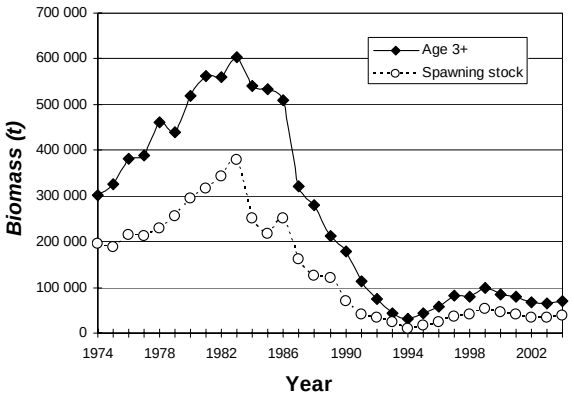


Fig. 4. Trends in (3+) population biomass and spawning stock biomass of 3Pn, 4RS cod

The spawning biomass decreased from 379,000 t in 1983 to 11,000 t in 1994, and increased thereafter to 38,000 t at the beginning of 2004. Confidence intervals at 95% for the 38,000 t SSB estimate are 23,000 t and 53,000 t.

The productivity of the northern Gulf cod was considered in establishing biomass reference points. These points were based on the concept that biomass could be partitioned into three zones which were labelled as "healthy", "cautious" and "critical". The boundary for the critical region (B_{lim}) gave two estimates, the first based on the level of spawning stock biomass (SSB) above which the stock was deemed healthy and estimated that boundary at about 85,000 t (DFO, 2004). The other method was to estimate at which SSB there was a probability that the stock would have negative growth, even in the absence of fishing. This gave an estimate of 110,000 t. The 2004 SSB is well below both of these.

COSEWIC used two measures to determine species status: (1) trends in the numbers of mature cod in 3Pn, 4RS from 1975-2002 which declined by 93%, and (2) trends in cod abundance from the DFO research vessel survey 1990-2002, which declined by 64%. These values came from the 2003 assessment of the 2002 fishery (Fréchet *et al.* 2003).

Target and time-frame for recovery

3Ps stock: The 3Ps stock is considered to be recovered and therefore there are no specific targets or time-frames for recovery.

The 3Ps stock has undergone recovery since the moratorium (1993-1997) and is presently in a healthy state in terms of population size, although there are concerns about some biological characteristics of the stock, such as poor recruitment and low age at maturity (DFO, 2004).

There is evidence in the historical catch statistics (1959-1976) that the 3Ps stock was at an even higher level than the peak estimated for the mid-1980's against which present status has been compared. However, there are no reliable data for this period for the stock in the northern Gulf of St. Lawrence so in the context of the designated unit defined by COSEWIC no reliable comparison back to this time period can be made for the entire Laurentian North unit.

3Pn, 4RS stock: The SSB had reached a historical low at the beginning of the first moratorium in 1994. The SSB increased during the three-year moratorium (1994-1996). Since the reopening of the cod directed fishery in 1997 and until 2004, the stock has not shown any significant increase in SSB. The catch appears to crop off the annual surplus production of the stock. Catches observed since the reopening in 1997 did not allow for stock rebuilding. However, the fishing industry considers that the stock is on a rebuilding trajectory.

Scope for Human-induced Harm (or mortality)

3Ps stock: In the 2004 assessment of 3Ps cod, 3-year deterministic projections to 1 April 2007 were carried out for the two SPA formulations. In the first year, the assumed catch was 15,000 t which is the TAC for the 1 April 2004 – 31 March 2005 management year currently in progress. The spawning stock biomass (SSB) is estimated to

decrease by approximately 7,000 t and 5,000 t for the two respective SPA formulations, by the end of the current management year (31 March 2005).

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 spawning stock biomass will decline by 1 April 2007. At a catch option of 5,000 t both formulations indicated a small increase (1.6-3.7%) in spawning stock biomass by 1 April 2007. However, under all catch options considered, the projected spawner biomass on 1 April 2007 was considerably greater than the recommended biological limit reference point (B_{lim}) for this stock.

The history of the 3Ps stock also provides information on the maximum human-induced mortality that can be sustained and not jeopardize recovery. Following extension of jurisdiction in 1977, the stock rebuilt rapidly until 1985, even in the presence of a substantial commercial fishery with annual landings (during 1977-1985) ranging from 27,000 to 39,000 t. During this 8 yr period, population biomass doubled (see Fig. 2) and spawning stock biomass tripled (see Fig. 3). Estimated fishing mortalities (mean F over ages 5-10) at the time were in the range 0.3-0.5.

The second recovery of the 3Ps stock took place during and following the moratorium period (1993-2003). The directed fishery was initially closed at that time and removals were limited to annual by-catch and sentinel fishery landings (after 1996) of 600-900 t; subsequently the commercial fisheries reopened with TAC's ranging from 10,000 – 30,000 t during 1997-2004. During 1993-2003 population biomass doubled (Fig. 2) and spawning stock biomass tripled (Fig. 3). Between 1997 and 2003 estimated fishing mortalities (mean F over ages 5-10) ranged from 0.2 – 0.4.

These indicate there is scope for human-induced mortality on the 3Ps stock without jeopardizing survival.

Conclusions from the 2004 assessment of the 3Ps stock concerning lower productivity in recent years are of potential significance in the context of allowable harm. Should the stock be reduced to a level of concern, the maximum human-induced mortality the stock can sustain and still rebuild may now be lower than in the past.

3Pn, 4RS stock: As part of the most recent assessment of this cod stock, risk analyses were conducted to assess the impact that various TAC levels for 2004 would have on the SSB. Catches in excess of 2,200 t in 2004 would result in a decline of SSB. However, the 2004 TAC was subsequently set at 3,500 t as recommended by the FRCC (2004) after public hearings and descriptions of uncertainties in the assessment.

Major Sources of Mortality

3Ps stock: The most significant potential source of mortality/harm within 3Ps is the directed fishery from the domestic and French (SPM) fleets. The vast majority of the total catch comes from the directed fishery. Total reported landings in the past four years, including recreational, sentinel, French and by-catch fisheries, have been stable at about 15,000 t.

Annual reported by-catch of 3Ps cod in fisheries directed at other species during 1997-2003 has been <1,000 t, except in 1997 (approx 1,600 t). By-catch is taken in fisheries for Atlantic halibut, redfish, witch flounder, white hake, skate, Greenland halibut and monkfish (angler).

3Pn, 4RS stock: The most significant potential source of human-induced mortality/harm within 3Pn, 4RS since 1997 is the directed fishery from the small inshore fixed gear domestic fleets.

By-catch of cod in other directed fisheries are accounted for in the TAC. They currently represent 3% of the 2004 TAC of 3,500 t, the most important being the Atlantic halibut and

also other flatfish fisheries (blackback, greysole, American plaice). Scientific and sentinel research activities account for 11% of the 2004 TAC.

Mixing occurs between cod from the northern Gulf of St. Lawrence (3Pn, 4RS) and the south coast of Newfoundland (3Ps). Northern Gulf cod migrate southward in late fall and leave the Gulf and migrate into 3Pn sometimes crossing the stock management boundary into western 3Ps, particularly during the winter months (approximately November to April). Catches of northern Gulf cod within the 3Ps stock area constitute a source of mortality/harm to the Laurentian North population. The percentage of northern Gulf cod in aggregations found in 3Psa and 3Psd in January and March surveys of 2002 varied from 27 to 64%, according to trace elements of otoliths. Cod sampled in late April 2001 and analysed using the same method were 40-51% of northern Gulf origin. Analyses of winter (November-April) landings indicate that the magnitude of potential harm to the northern Gulf stock due to mixing has diminished in recent years. Management measures and restrictions designed to limit winter-spring catches from this area have been implemented. These measures should be continued and their effectiveness monitored carefully.

Other Potential Sources of Mortality and Aggregate Harm

3Ps stock: Other potential sources of harm (such as habitat alteration, oil exploration and production, pollution, shipping, cables and lines, military activities, ecotourism, fisheries on food supplies; scientific research, aquaculture; introductions & transfers) were not specifically quantified in this assessment but are considered to have relatively low impacts on the ability of 3Ps cod to survive and recover, relative to the impact of the fishery.

COSEWIC (2003) concluded that marine mammal predation does not appear to pose a threat to recovery of 3Ps cod, based on McLaren *et al*. (2001).

Unaccounted fishing mortality also occurs, primarily from the commercial fishery through: dumping/discarding (mostly by gillnets which are the dominant gear in the post-moratorium fishery); high-grading (discarding of small fish due to lower price or nil value, primarily from the line-trawl fishery); ghost fishing by lost/discarded gillnets. Illegal fishing and unreported landings also occur, although the latter is likely reduced by observer coverage and dockside monitoring. The amount of mortality from these sources is not readily quantifiable, but is likely to be proportional to the total landings.

3Pn, 4RS stock: COSEWIC (2003) concluded that marine mammal predation appears to pose a threat to recovery of northern Gulf cod, based on a statement from McLaren et al. (2001) "*The conclusion that seals are important predators on cod in this area appears to be inescapable*".

Seismic activities to identify potential oil and gas reserves in the northern Gulf are planned along the inshore coast of western Newfoundland, to the east of the Madgalen Islands and around Anticosti Island. Although there is no substantiated evidence of directly induced mortality, cod and its prey, sandeel in the vicinity of the airgun arrays disperse (Engås *et. al.* 1996, Hassel 2003).

Discarding in the gillnet fishery due to poor fish quality may be significant in the northern Gulf as well as ghost fishing (Fréchet, 2003). An earlier study (RPPNG, 1991) found ghost gillnets along the Gaspé coast to have an average density of 85 nets per km^2, some nets had been lost for over 20 years. Two major gear recovery programs are underway in 2004, one along the Lower North Shore of Quebec and another on Newfoundland's northern Peninsula.

As noted above for 3Ps, there is also a potential for unreported mortality on the 3Pn, 4RS cod stock due to illegal activities.

Despite the fact that there has not been any cod directed trawling activity in the area since 1993, some long term habitat degradation may have occurred. There is also a significant and growing otter trawl shrimp fishery that still catches cod less than 20 cm at ages 1 and 2 despite the compulsory use of the Nordmore grate.

Sources of Uncertainty

3Ps stock: In the 2004 assessment of 3Ps cod it was concluded that there is considerable uncertainty about the current productivity of this stock (DFO, 2004). The spawner biomass is currently producing far fewer recruits than it did at the extension of jurisdiction in 1977. Recent changes in the composition of the spawner biomass may have lowered the reproductive potential of the stock. Consequently, should the stock again be reduced to a level of concern, the rate at which it can rebuild may be lower than in the past.

The 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.

3Pn, 4RS stock: There is uncertainty about the timing and extent of migration of northern Gulf cod into the 3Ps stock area. The amount of mixing can vary from year to year and it remains difficult to quantify on an annual basis the degree of harm on northern Gulf cod that migrate seasonally into 3Ps. Methods involving tagging and telemetry, maturation analyses, and microchemistry of otoliths are presently being employed to improve our understanding of the mixing issue.

Initial estimates of the Needler trawl survey data indicated a five-fold increase in the biomass index of cod between 2002 and 2003 (Bourdages *et al*. 2003). After review however, an alternative method for estimating biomass in missed strata was considered more appropriate. The revised increase for 2003 was in the range of only 3 times instead of 5-fold. Regardless, because of the high numbers of missing strata, the survey results for 2003 are associated with considerable uncertainty.

Sensitivity analyses were also undertaken to examine the use of various indices and their effect on the estimation of SSB. It was found to range from 30,000 t to 44,000 t depending on the formulation applied.

Adult mortality from natural causes is very high for this stock. Although causes of this elevated mortality are not fully understood, estimates of cod consumed or otherwise killed by seals are high enough that such mortality would contribute to the lack of recovery in this stock. The seal diet data indicate that the consumption is primarily of juvenile cod. However, stomach content data may underestimate the consumption of adult cod, because the heads of large cod may not be consumed.

Many sources of uncertainties were also mentioned by the FRCC (2004).

Conclusions

3Ps stock: The 3Ps stock is considered to be recovered and should be managed under conventional fisheries management practices.

Spawning biomass and the numbers of spawners are estimated to be at levels close to all-time highs for the period 1977-2004. Furthermore, the stock is presently well above a biological limit reference point recommended for 3Ps cod at the 2004 stock assessment (DFO, 2004).

The stock has shown two recoveries in the recent (since 1997) past, one while a substantial commercial fishery remained in

place and the other when by-catch of cod in other fisheries was permitted. During this later recovery, there were further increases after the fishery reopened. These findings indicate considerable scope for "incidental harm" with respect to cod in 3Ps.

The fisheries in 3Ps during winter may also result in some mortality on cod from the neighboring 3Pn, 4RS stock which is part of the Laurentian North unit. The potential magnitude of this harm has been reduced considerably in recent years by management measures such as seasonal closures of portions of western 3Ps. These measures should be continued and monitored carefully.

3Pn, 4RS stock: This cod stock has not recovered and is well below the recommended biological limit reference point (B_{lim}) for this stock. However, current removals will not jeopardize recovery over a period of 1-2 years.

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