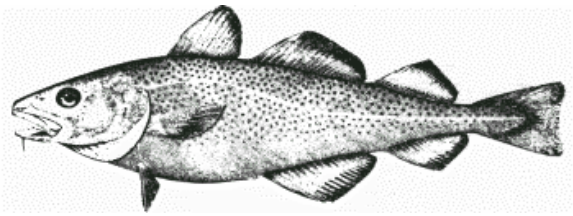
STOCK ASSESSMENT UPDATE OF NORTHERN (2J3KL) COD



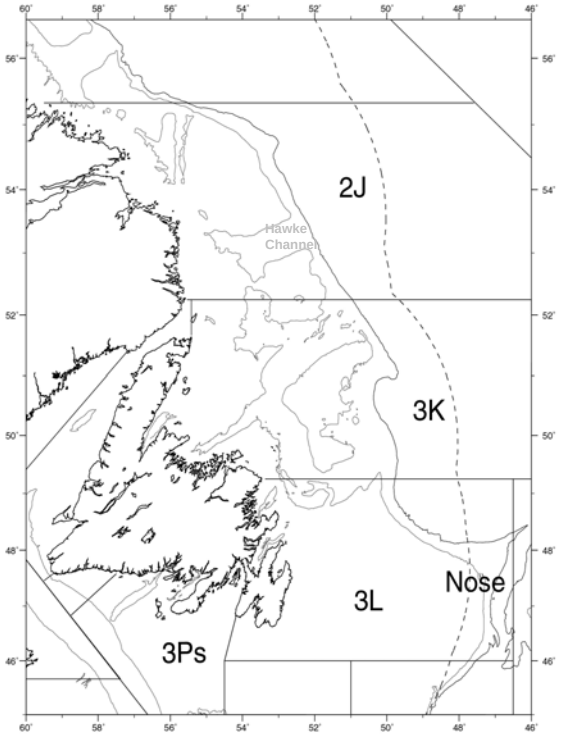


Figure 1: Stock area of Northern (2J3KL) cod. The dashed line indicates Canada's 200 nautical mile Exclusive Economic Zone (EEZ).

Context

At a framework meeting held in November 2010 a conservation limit reference point (LRP) was established for Northern cod (DFO, 2010). This reference point defines the boundary between the critical and cautious zones within the Precautionary Approach framework and defines the stock level below which serious harm is occurring. The most recent assessment (March 2011) concluded that the stock was 90% below the LRP and at current levels of productivity would not reach the LRP within the next 5 years (DFO, 2011). Given the poor prognosis for stock recovery and lack of major change in stock status during the recent period, a stock assessment update was conducted for 2012, rather than a full assessment. This update was prepared to provide the Minister with advice on the latest status of the stock which has been subjected to ongoing stewardship and recreational fisheries in the inshore since 2006. There are no explicit timelines or targets for rebuilding this stock although a rebuilding plan is currently under development.

This Science Special Response report from Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, summarizes the findings from a Regional Science Special Response Process (SSRP) conducted on 12 March 2012. The status of the Northern cod stock was

updated based on key information obtained during 2011. The meeting reviewed information from (1) the DFO autumn research vessel (RV) survey (indices of abundance, biomass, spawning stock biomass (SSB), and trends in mortality rates), (2) the inshore sentinel catch rate index, and (3) fishery exploitation rates based on tagging.

Analysis and Responses

Reported landings

A stewardship fishery for cod and a recreational fishery for groundfish were permitted in the inshore during 2011. Commercial fishers were permitted an allowance of 1.7 t (3,750 lb). Recreational fishers were permitted a maximum catch of 15 fish per boat per day. Reported landings in 2011 were 3,139 t (recent catch history is summarized in Appendix Table 1). The 2011 landings comprised 2,872 t in the stewardship fishery, 214 t in the sentinel surveys, and 43 t taken as by-catch. There are no direct estimates of landings from the recreational fishery; therefore total catch in 2011 is uncertain. However, analysis of tag returns suggests that removals from recreational fisheries during 2011 were approximately 50% of removals from the stewardship fishery.

Stock Trends – Offshore

Bottom-trawl surveys

The abundance and biomass indices from the autumn RV surveys have been extremely low since the start of the moratorium in 1992 (Figs. 2 and 3). The abundance index increased during 2005-09 and the biomass index increased during 2005-08; these increasing trends have not persisted. The average abundance and biomass indices during 2009-11 are 8% and 9%, respectively, of the average during the 1980s. Index values for the period 1991-2011 are summarized in Appendix Table 2.

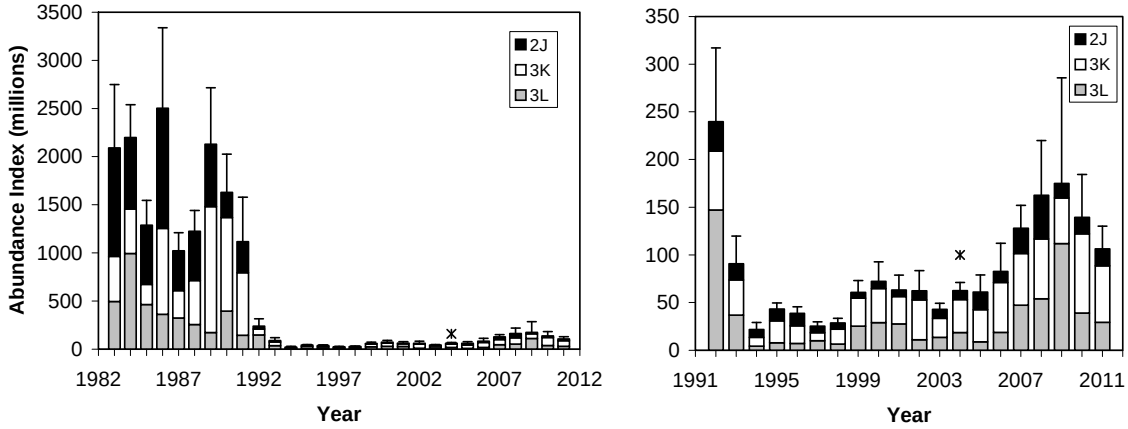


Figure 2: Offshore abundance index (+2 SE's) from autumn RV surveys in 2J3KL. The right panel is expanded to show trends from 1992 onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004.

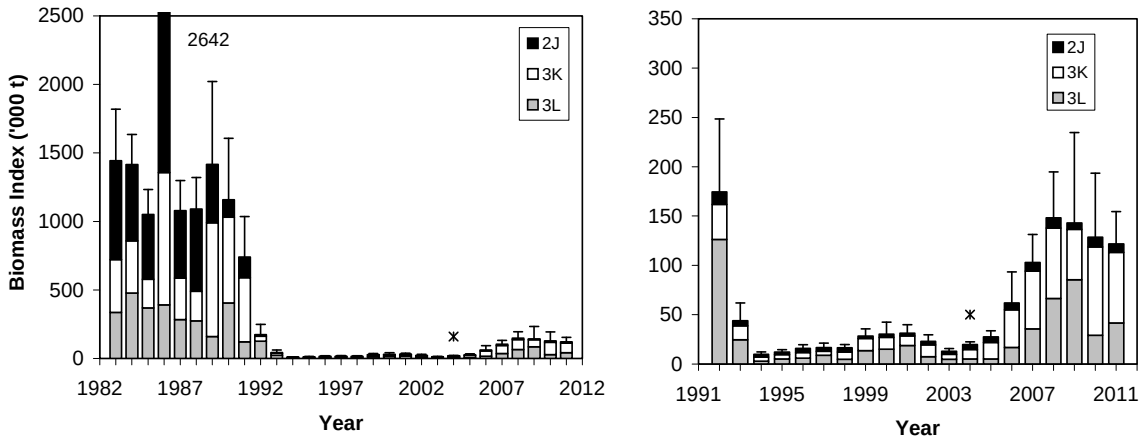


Figure 3: Offshore biomass index (+2 SE's) from autumn RV surveys in 2J3KL. The right panel is expanded to show trends from 1992 onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004.

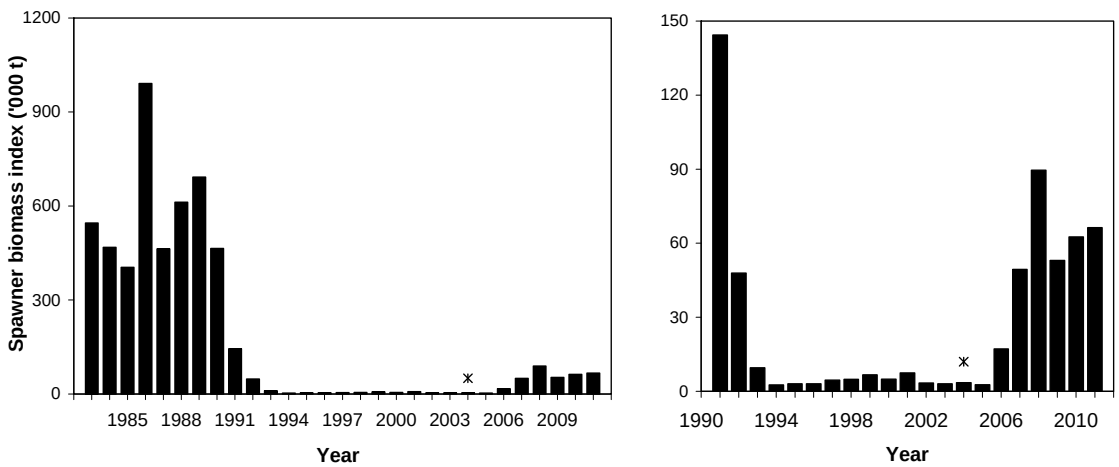


Figure 4: Offshore spawning stock biomass index from autumn RV surveys in 2J3KL. The right panel is expanded to show trends from 1991 onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004.

The SSB index from the autumn RV survey has been low for several years since the 1992 moratorium, but increased somewhat during 2005-08 (Fig. 4). The three most recent values of the SSB index show no major changes and during 2009-11 represent 10% of the average observed in the 1980s.

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

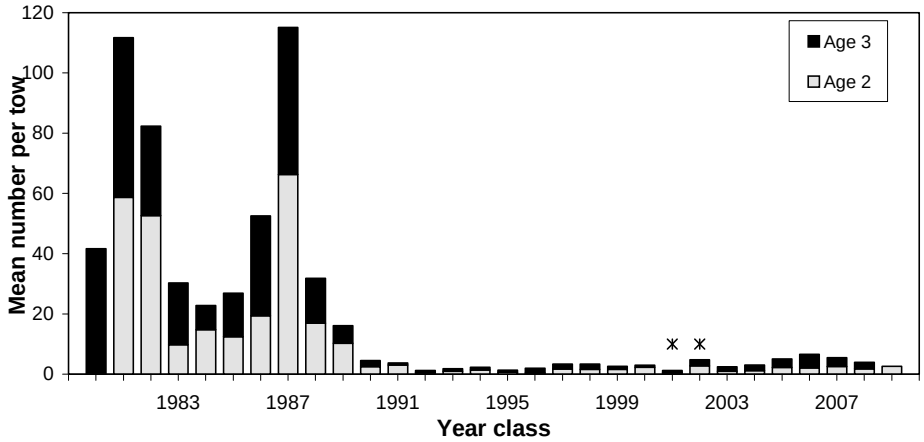


Figure 5: Abundance of the 1980-2009 year-classes at age 2 and age 3 in the offshore of 2J3KL from the autumn RV surveys. Asterisks indicate partial estimates for the 2002 year-class at age 2 and the 2001 year-class at age 3 due to incomplete survey coverage of 3L in 2004.

Year-class strength in the offshore in the 1990s and 2000s has been poor compared to the 1980s. The number of young fish (ages 2 and 3) in the autumn RV survey in the 1990s and 2000s has consistently been much lower than during the 1980s (Fig. 5).

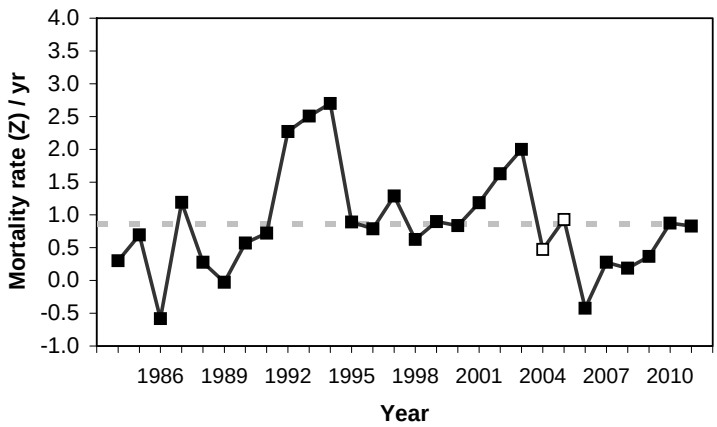


Figure 6: Total mortality rate (Z) of cod aged 4-6 calculated using data from the autumn RV surveys in the offshore of 2J3KL. For example, the value in 1996 is the mortality experienced by the 1991-1989 year-classes from ages 4-6 in 1995 to ages 5-7 in 1996. The dashed line is the time-series average (Z=0.87 which corresponds to 58% mortality per year). Open symbols indicate estimates based on an incomplete survey of 3L in 2004.

The total mortality rate (*Z*, ages 4-6) was low in the 1980s, but was at a high level (*Z*>0.6, i.e., >45% per yr) from the early 1990s to the mid-2000s, with peaks during the early 1990s and early 2000s (Fig. 6). This high level of mortality during much of the post-moratorium period has been a major impediment to stock recovery. Total mortality declined substantially during 2003-06, resulting in an expansion of the age composition, and this was an important factor in the increase in total biomass and SSB during 2005-08 (Figs. 3 and 4). However, Z has increased in the recent period and in 2009-11 averaged 0.69, which corresponds to 50% mortality per year. If this level of total mortality continues, prospects for further stock growth are poor.

Stock Trends – Inshore

For assessment and stock update 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. 7).

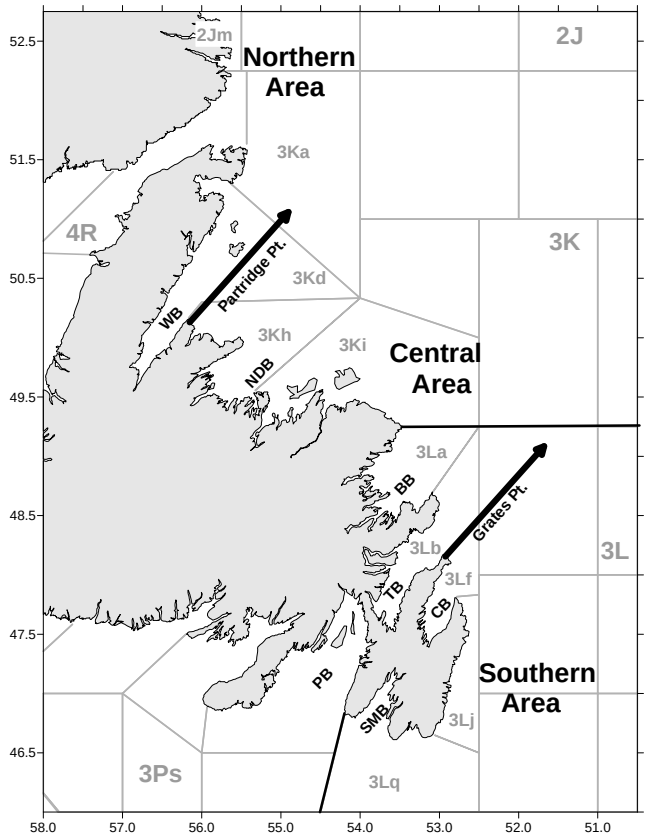


Figure 7: Eastern Newfoundland indicating the locations of the inshore northern, inshore central and inshore southern areas. Major bays are indicated: White Bay (WB), Notre Dame Bay (NDB), Bonavista Bay (BB), Trinity Bay (TB), Conception Bay (CB), and St. Mary's Bay (SMB); Placentia Bay (PB) is in Subdiv. 3Ps. Grey lines delimit boundaries of statistical unit areas (i.e., 3Ka, 3Kd, etc.).

Sentinel surveys

Age-aggregated catch rates

Sentinel catch rates in the northern area increased in 2011 and were above the 1995-2011 northern area average (Fig. 8, upper panel). Catches in this area depend on seasonal immigration of fish from offshore regions, including 2J where offshore biomass remains low. Sentinel catch rates are lower in the northern area than those in the central area.

Sentinel catch rates in the central area were unchanged in 2011 and are close to the 1995-2011 central area average (Fig. 8, middle panel). Catches in this area depend on resident inshore components and seasonal migrants from the offshore.

Sentinel catch rates in the southern area were unchanged in 2011 and remain well below the 1995-2011 southern area average (Fig. 8, lower panel). Catches in this area are partly dependent on seasonal immigration of fish from the offshore of 3KL, and from 3Ps where the stock is at a low level.

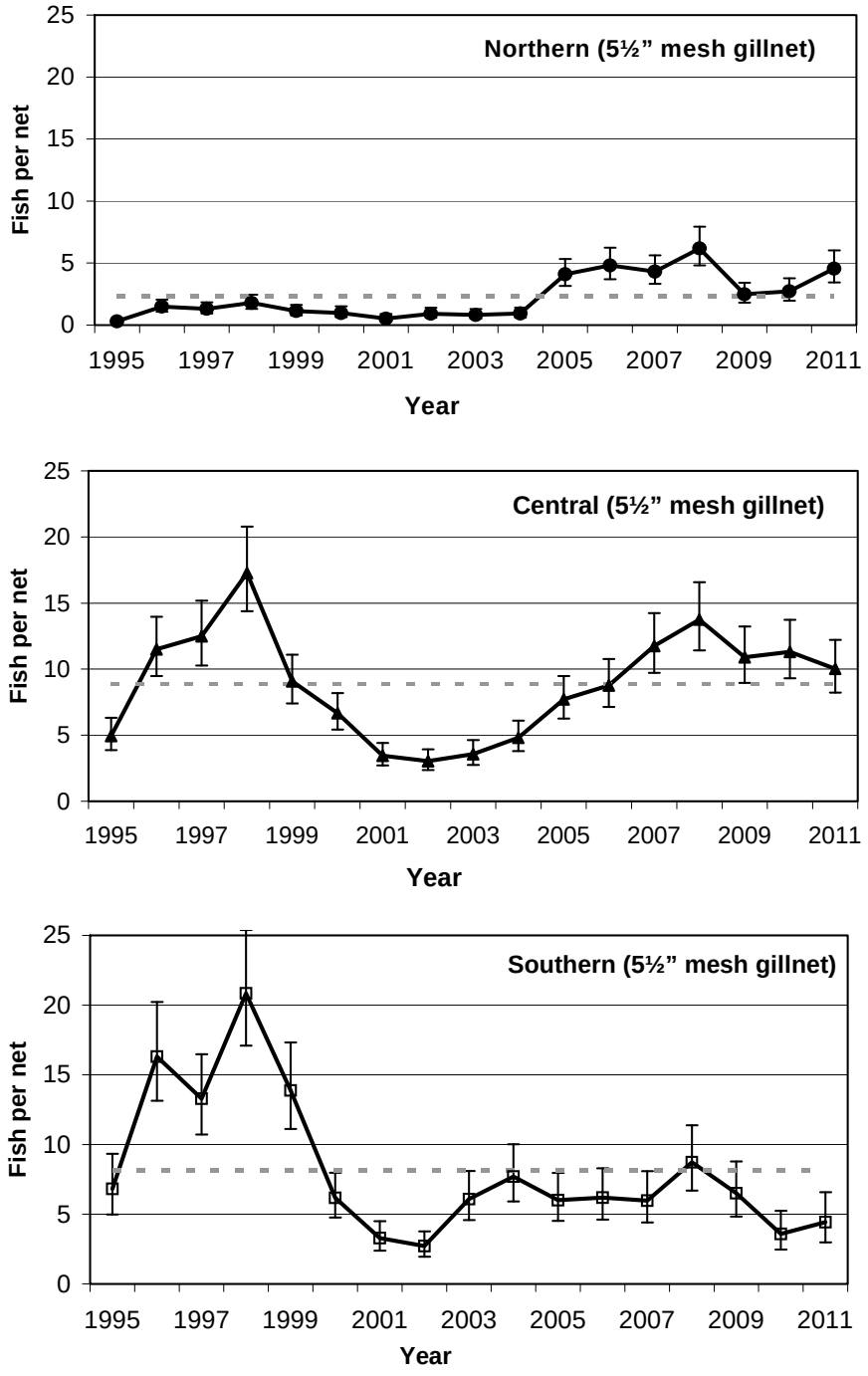


Figure 8: Standardized catch rates, with 95% confidence limits, from sentinel surveys using gillnets (5½ inch mesh) for each of the three inshore areas. Series means are plotted as dashed lines.

In the central area, catch-rate indices from line-trawls are slightly below the average of the time-series and are declining (Fig. 9). There are insufficient line-trawl data in the northern and southern areas to produce a standardized index time series.

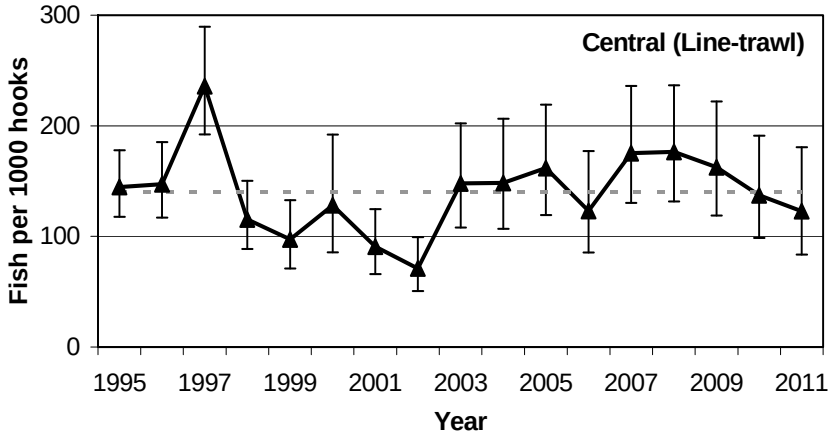


Figure 9: Standardized catch rates, with 95% confidence limits, from sentinel surveys using line-trawls for the inshore central area. Series mean is plotted as a dashed line.

Age-disaggregated catch rates and recruitment

Trends in the age composition (ages 3-10) of the overall catch rate are shown for 5½" mesh gillnets in the central area (Fig. 10). Three year-classes (1990, 2001 and 2002) have contributed strongly to sentinel catch rates. Most recently, the 2001 and 2002 year-classes remain relatively strong at ages 9 and 10. However, younger fish (ages 3-5) are poorly represented in recent catches, indicating that subsequent year-classes are weaker relative to the 2001 and 2002 year-classes. Similar patterns were observed for the age composition of catches from 5½" mesh gillnet in the northern and southern areas, and for other gears (line trawl and small-mesh gillnet) in the central area (not shown).

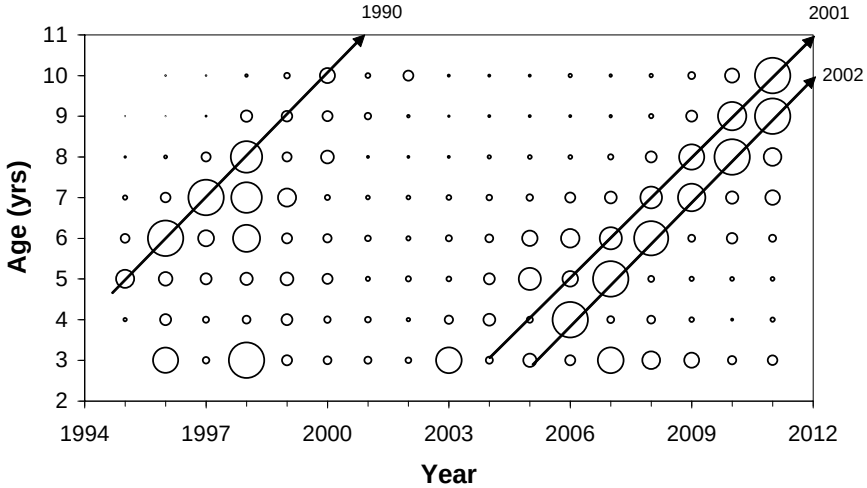


Figure 10: Age-disaggregated standardized catch rates (ages 3-10) from sentinel surveys using 5½" mesh gillnets for the inshore central area. Symbol sizes are scaled to the maximum within each age. Labeled diagonal lines indicate three year- classes (1990, 2001 and 2002) that have been strongly represented at successive ages in sentinel catches.

Inshore tagging

Information from recaptures of cod tagged in various inshore regions of 3KL during 1997-2011 was used to estimate average annual exploitation (harvest) rates. No cod were tagged in the offshore during 2009-11, but some tagging was conducted during July-October when migrant offshore cod would be inshore.

Exploitation rates were consistently low for cod tagged in central and southern areas, ranging between 2 and 10% during 2009-11. These estimates included different assumed values for the annual rate of natural mortality (0.2 and 0.4) and different size ranges of tagged cod (50-85 cm and > 60 cm) to account for the influence of size-selective fishing gears.

The reporting rate of tags from commercial fishers during 1997-2011 has ranged from 70% to 86% and shows no clear trend; the 2011 reporting rate was 73%. A constant but lower reporting rate of tags was estimated for recreational fishers during 2006-11 (51-53%). Lower reporting rates add uncertainty to the estimates of exploitation rates and the analyses of movement patterns and stock structure.

Conclusions

Catch

- Reported landings in 2011 were 3,139 t. This comprised 2,871 t in the stewardship fishery, 214 t in the sentinel surveys, and 43 t taken as by-catch, but excludes recreational fishery removals.

- There are no direct estimates of recreational landings for 2011. Therefore, total catch in 2011 is uncertain. However, analysis of tag returns suggests that removals of commercial size fish from recreational fisheries during 2011 were approximately 50% of the removals from the stewardship fishery.

Offshore

- Based on trends in the DFO autumn RV survey indices, the recent increases in total abundance, biomass, and spawning stock biomass (SSB) have not continued beyond 2009. The abundance and biomass indices during 2009-11 are 8% and 9%, respectively, of the average during the 1980s. The SSB index during 2009-11 is 10% of the average during the 1980s.

- Total mortality rates (ages 4 to 6) declined substantially during 2003-05 and remained low to 2007 (<20%). This was an important factor in the recent increase in total biomass and SSB. However, total mortality rates increased to approximately 50% per year in 2009-11. If this level of total mortality continues, prospects for further stock growth are poor.

- Recruitment remains much lower than was observed in the 1980s.

Inshore

- Sentinel catch rates in the northern area increased in 2011 and were above the 1995-2011 northern area average. Catches in this area depend on seasonal immigration of fish from offshore regions, including 2J where offshore biomass remains low. Sentinel catch rates are lower in the northern area than those in the central area.

- Sentinel catch rates in the central area were unchanged in 2011 and are close to the 1995-2011 central area average. Catches in this area depend on resident inshore components and seasonal migrants from the offshore.

- Sentinel catch rates in the southern area were unchanged in 2011 and remain well below the 1995-2011 southern area average. Catches in this area are partly dependent on seasonal immigration of fish from the offshore of 3KL, and from 3Ps where the stock is at a low level.

- During 2009-11, mean exploitation rates (percent harvested) from tagging studies were low and ranged between 2% and 10% among inshore central and southern areas.

Whole stock

- A conservation limit reference point (LRP) has been established for Northern cod based on modeling of DFO RV survey data. Estimated spawning stock biomass (SSB) has been well below the LRP since the early 1990s and in 2010 was 90% below the LRP.

- Modeling of SSB from DFO RV survey data was not conducted for this update. However, the SSB index value from the 2011 survey is only marginally above the 2010 value and the stock has shown no significant improvement, remaining well below the LRP.

- Tagging results indicate that current levels of removals have resulted in low exploitation rates; however, total mortality rates increased to approximately 50% per year in 2009-11. If this level of total mortality continues, prospects for further stock growth are poor.

- At current levels of recruitment and survival the stock will not reach the LRP in the short term.

- The application of the DFO fishery decision-making framework incorporating the precautionary approach would require catches in 2012 to be at the lowest possible level.

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Appendices

Table 1: Reported landings by management year in NAFO Divs. 2J3KL (nearest thousand metric tons). Detailed catch history is reported in Brattey et al. 2010.

Year	62-76 Avg.	77-91 Avg.	98	99	00/ 01	01/ 02	02/ 03	03-06 Avg.	06/07 & 07/08[1,2]	08/ 09[1]	09/ 10[1,2]	10/ 11[1,2]	11/ 12 [1,2]
TAC	N/A	N/A	4	9	7	6	6	0	-	-	-	-	-
Can. Fixed	88	90	5	9	5	7	4	1	3	4	3	3	3
Can. Mobile	9	84	-	-	-	-	-	-	-	-	-	-	-
Others	405	38	-	-	-	-	-	-	-	-	-	-	-
Totals	502	212	5	9	5	7	4	1	3	4	3	3	3

[1] There was no TAC in the last six years, but fishers were permitted an allowance per license holder of 3,000 lb in 2006/07, 2,500 lb in 2007/08, 3,250 lb in 2008/09, and 3,750 lb in 2009/10, 2010/11, 2011/12.
[2] Does not include estimates of Canadian recreational fisheries.

Table 2. Cod abundance (000's), biomass (t) and spawning stock biomass (SSB, t) estimates from DFO autumn RV surveys (1991 onwards). Values for years prior to 1991 are reported in Brattey et al. 2010.

	Abundance (000's)				Biomass (t)				SSB (t)
Year	**2J**	**3K**	**3L**	**Total**	**2J**	**3K**	**3L**	**Total**	**Total**
1991	323,637	649,349	144,684	1,117,670	150,136	467,502	121,759	739,397	144,399
1992	30,960	61,622	147,158	239,740	12,795	35,344	126,323	174,462	47,909
1993	16,989	36,907	36,813	90,709	5,129	14,227	24,596	43,952	9,561
1994	8,145	9,361	4,291	21,797	2,693	4,241	2,874	9,808	2,578
1995	12,305	23,200	7,735	43,240	2,312	4,578	5,115	12,005	3,050
1996	13,081	18,550	7,067	38,698	4,261	5,457	6,140	15,858	3,057
1997	6,936	8,428	9,859	25,223	3,609	3,978	8,991	16,578	4,502
1998	6,636	15,612	6,454	28,702	4,483	7,280	4,804	16,567	4,865
1999	6,074	29,308	25,281	60,663	2,527	12,230	13,611	28,368	6,643
2000	7,516	35,774	29,010	72,300	3,082	11,994	15,070	30,146	4,885
2001	7,033	28,535	27,724	63,292	2,646	9,890	18,706	31,242	7,378
2002	9,534	41,853	10,984	62,371	3,680	11,889	7,460	23,029	3,388
2003	9,315	19,908	13,638	42,861	3,065	4,912	4,849	12,826	3,065
2004	9,503	34,468	18,605	62,576	4,921	9,609	5,266	19,796	3,472
2005	18,519	33,834	8,780	61,133	5,719	16,696	5,118	27,533	2,625
2006	11,739	52,285	18,711	82,735	6,818	38,009	16,982	61,809	17,150
2007	26,656	54,122	47,249	128,027	8,755	58,427	35,722	102,904	49,354
2008	45,583	62,848	53,957	162,388	10,429	71,329	66,401	148,159	89,553
2009	15,250	47,949	111,782	174,981	6,473	51,106	85,410	142,989	52,996
2010	17,278	83,060	39,012	139,350	9,905	89,388	29,255	128,548	62,573
2011	17,937	59,233	29,282	106,452	8,542	71,541	41,615	121,698	66,312

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