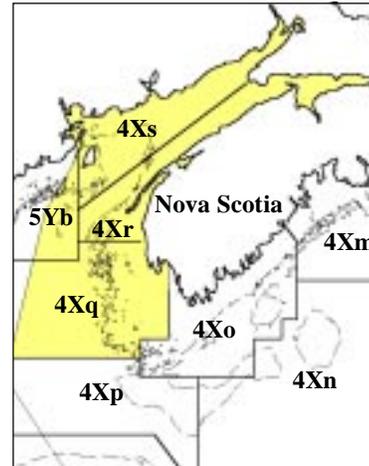




Southern Scotian Shelf and Bay of Fundy Cod



Background

Atlantic cod is a bottom dwelling fish occurring on both sides of the North Atlantic. In the Canadian Atlantic, cod range from northern Georges Bank to northern Labrador. There are several concentrations of cod within this range, including those on the southern Scotian Shelf and Bay of Fundy (NAFO Division 4X).

Juvenile cod in Division 4X feed on a wide variety of invertebrates and as they grow include fish in their diet. Seasonal movements associated with spawning occur and a number of spawning areas exist in Division 4X with the largest occurring during winter on Browns Bank. Growth rates vary among cod in Division 4X with more rapid growth noted in the Bay of Fundy. Cod in Division 4X reach on average 53 cm (21 inches) by age 3 years and increase to 72 cm (29 inches) by age 5 and 110 cm (43 inches) by age 10. Age at first reproduction generally occurs at 3 years and individuals tend to spawn several batches of eggs during a single spawning period.

Cod in Division 4X has supported a commercial fishery since the 1700s and until the 1960s was primarily an inshore fishery. Following extension of jurisdiction to 200 miles by coastal states in 1977, only Canada has made substantial landings of cod from this area. Minimum mesh size and hook size regulations have been enacted to reduce the catch of juvenile cod. Spawning area/seasonal closure of Browns Bank is in place from 1 February-15 June. Scientific advice is presented on the basis of a target capture rate of roughly 16% of the population and maintaining a large spawning stock biomass to enhance the probability of good recruitment.

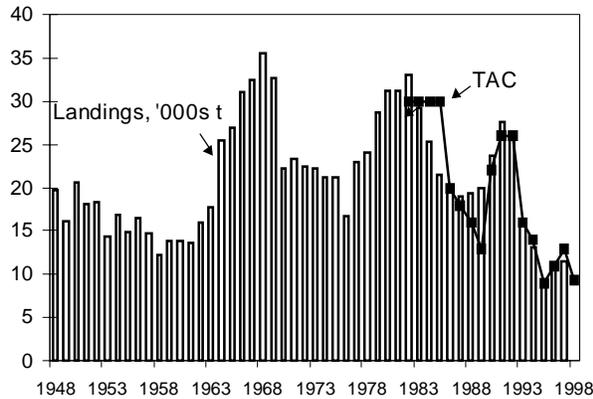
Summary

- Landings have declined throughout the 1990s, and will likely be the lowest on record in 1998.
- Biomass increase since 1993 is due primarily to the recruitment and growth of the 1992 year-class.
- Recruitment has been below average since 1992. The 1996 year-class, although below average, appears stronger than the three preceding it.
- There is considerable uncertainty in the estimates of recent stock abundance and exploitation levels.
- Exploitation rate has declined from the high of 60% in 1992, and is estimated to be between 22% and 29% in 1998.
- Spawning stock biomass has increased from a minimum in 1994 to between 20,000 and 36,000t. This may still be at a level which has been associated with consistently poor recruitment in the past.
- Yield projections for 1999 at $F_{0.1}$ are between 4,400t, and 7,500t.
- For the range of estimated stock sizes, spawning stock biomass is expected to increase by 7,000t in the year 2000 at $F_{0.1}$ yield levels.

The Fishery

Landings (thousands of tonnes)

Year	1992	1993	1994	1995	1996	1997	1998
TAC	26	16	13	9	11	13	9.3
Total	26	16	13	9	11	11.5	



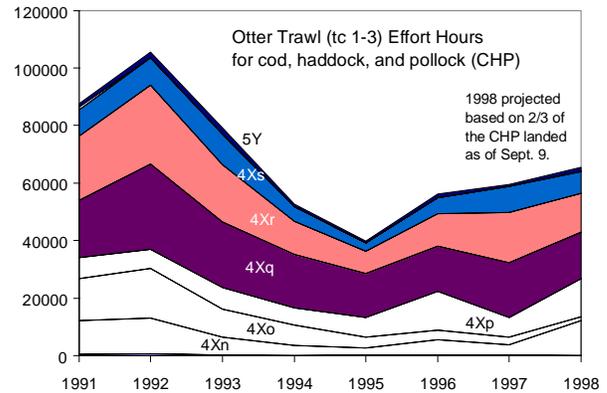
Landings increased through the 1960s from 14,000t to 36,000t as large offshore trawlers became active in the fishery. Recent decreases in landings are a reflection of the Total Allowable Catch (TAC), which declined from 26,000t in 1992 to 9,000t in 1995. The TAC increased to 13,000t for 1997, a harvest level which was projected to entail a 50% risk of a reduction in age 4+ biomass. 1,500t of the quota went uncaught, primarily due to shortfalls by a number of fixed gear groups.

The fishery takes place year round, peaking in June and July, and is prosecuted predominantly by tonnage class (TC) 1 and 2 hook and line vessels (45% of landings), and TC 2 and 3 otter trawlers (37% of landings), along with gillnetters and large otter trawl vessels. The distribution of landings in 4X has shifted west in recent years, with both the gillnet and otter trawl fleets concentrating more in 4Xqrs.

The 1998 quota is 9,300t, 6,400t of which was landed by Oct. 1. The fishery in 1998 has been poor in inshore areas. Handliners in particular

have been unable to catch their quotas, with Digby Neck and Eastern NS groups landing less than 25% of their quotas. Fishing has been better offshore, and groups comprised of vessels with the capacity to fish in these areas will likely catch most of their quotas.

Effort by all gear sectors has declined from a peak in 1991 or 92. Since 1995, effort appears to have increased for some, though not all, sectors of the fishery, but remains lower than the levels seen in the early 1990's.

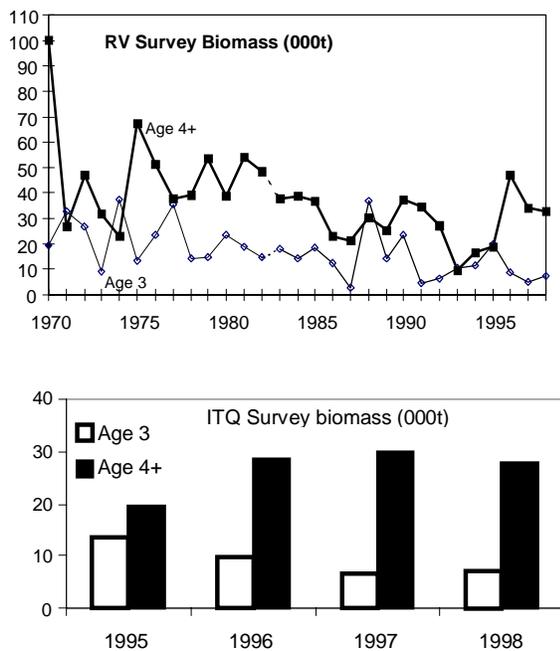


In 1997 and the first half of 1998, landings were distributed evenly among the 1992-94 year-classes. The 1992 year-class has contributed more than average for its age, but has not been dominant in the fishery, as had been forecast. Fish older than the 1992 year-class, 6+ in 1997 and 7+ in 1998, have contributed much less to landings than anticipated. Fish over age 5 have consistently comprised a lower proportion of the landings than projected in recent years, possibly indicating that the abundance of these ages is being over-estimated.

Resource Status

Stock status evaluation was based on an analytical assessment using commercial landing statistics, samples for size and age composition of the commercial catch, and trends in abundance from the July research survey and the ITQ vessel survey.

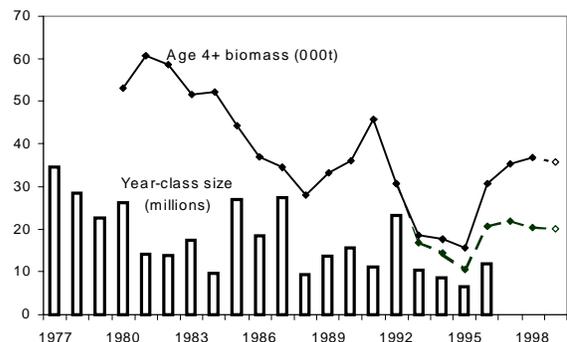
The 1997 **research vessel (RV) survey** biomass (adjusted for differences in survey vessel catchability before and after 1983) for ages 4 and older combined increased from 1993, and is about average in 1997 and 1998 due to high catches of the strong 1992 year-class. Survey biomass estimates for age 3 (the 1995 year-class) are among the lowest in the series. The 1996 year-class (age 2) appears below average from the RV survey, but better than the three preceding it. Lengths at age for cod have remained fairly consistent throughout this time series.



The **ITQ vessel survey** has been conducted in 4X since 1995. The 4X area was divided into roughly 200 blocks of 100nm², and locations picked in selected blocks to use as fixed sites for sampling each year. Currently 187 stations are sampled, 122 of which are common to all 4 years. For this analysis, the subset of 122 stations was utilized. This survey involves three vessels using balloon trawls with rockhopper gear. Although catches of large fish are similar to those from the RV survey, this survey catches much more fish less than 45 cm. Small fish are more fully recruited to this

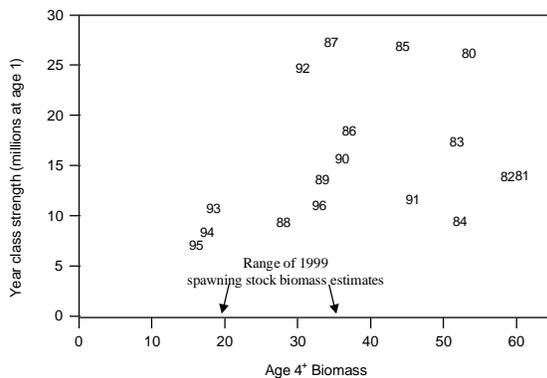
survey due to the rockhopper gear, which leaves little room below the footrope for them to escape. This survey will likely prove valuable as a recruitment index.

For the areas of overlap, the geographic pattern of cod catches in the ITQ survey was similar to those from the RV survey; the highest catches were in the Bay of Fundy, while catches of cod were generally poor in deep water of the Fundian Channel and Gulf of Maine, and over much of the area covered on the Scotian Shelf. Catches on the Scotian Shelf and in the inshore area (less than 50 fm along SW Nova Scotia; the area not covered by the RV survey) were poor in 1998, with very few commercial-sized fish. Only in 1995 were fish over 45 cm a significant part of the catch for this survey in the inshore area. The results of this survey suggest there has been little change in cod biomass from 1997.



Population abundance estimates indicate that the stock will decline slightly during 1998. The beginning of year population biomass for ages 4+ peaked in 1991, then dropped to the lowest levels in the time series in 1995. The increase since 1995 is primarily due to recruitment of the very strong 1992 cohort. Assuming that the 1998 TAC of 9,300t is caught, the beginning of 1999 age 4+ biomass is projected to drop to 36,000t, down 1,000t from 1998. This estimates the proportion of the population aged 4+ at a level higher than is seen in commercial landings, and may, therefore be an over-estimate of population biomass. An

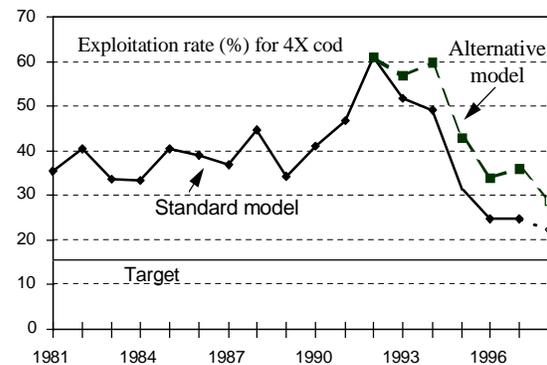
alternate model estimates biomass much lower (20,000t).



Spawning occurs in 4X both in fall (Oct. - Nov.), and spring (Feb. - May), and is quite widespread geographically. In fall, cod spawn along the coast from Halifax around into the Bay of Fundy. Until about 1984, cod concentrating off Halifax Harbour and St. Margarets Bay were the subject of a substantial seasonal gillnet fishery. In recent years, however, this has all but disappeared. In spring, cod spawn primarily on Browns Bank, but also near the mouth of, and in, the Bay of Fundy.

Recruitment has been below average since the 1992 year-class. The 1994 and 1995 year-classes are estimated as the lowest in the time series. Based on this year's surveys, the 1996 year-class is estimated as still below average, but better than the preceeding three. A range of 4+ biomass estimates are provided for 1999 which indicate that it may still not have climbed above 30,000t, where a more complete range of recruitment levels have been seen.

The **exploitation rate** throughout most of the recent past has consistently been well over twice the target of 16%, reaching a high of 60% in 1992. Exploitation rate has declined since then. A standard analysis estimates exploitation has leveled out near 24% since 1996, but the alternative model estimates it as remaining higher (29% in 1998).



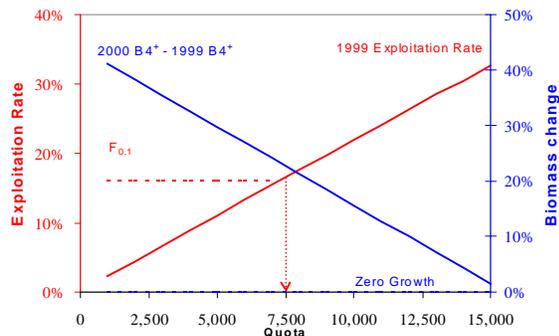
The assessment for this stock shows no strong retrospective pattern. There is some inter-annual variability in estimates of year-class size, however, there is generally little change with additional years of information.

Outlook

Using the standard assessment model for 4X, the expected catch of about 9,300t in 1998 results in an estimated exploitation rate of 22%, similar to 1997. The projected yield at the target exploitation rate for 1999 would be about 7500t. At this fishing level, the age 4+ biomass is projected to increase by 7,000t in 1999 to about 43,000t at the beginning of 2000. Ages 7+ are expected to contribute 50% of the landed weight. In the first half of 1998, these cohorts are accounting for roughly 35% of the landings. Given that the proportion of the stock biomass comprised by these cohorts will decrease next year, it seems unlikely that their contribution to the fishery will increase. This may indicate that the number of old fish is overestimated, and hence that population biomass is overestimated by roughly 20%.

The uncertainty in this assessment is due more to concerns about assumptions in the model than to precision of the estimate, so no risk plot can be derived for the assessment. Poor catches of cod in many areas of 4X this year, the lower than anticipated contribution of fish over age 5 to

the landings and the possibility of changes in the distribution of the resource which would make it more available to the RV survey, are cause for concern that this assessment may over-estimate abundance.



An alternative model which estimated higher catchability for the survey since 1992 estimates biomass considerably lower (4⁺: 20,000t for 1999), with an $F_{0.1}$ harvest level also lower (4,400t). This gives higher fishing mortality estimates in recent years, and estimates that the contribution of fish aged 7⁺ to the landings in 1999 will be 30% rather than 50%. Although this seems more in keeping with the observations from the fishery, it also resulted in estimates of exploitation in the fishery remaining at 60% from 1992-1994, despite the declines in fishing effort through this period. If, however, there has been a much lower proportion of the population in inshore areas in the summer since 1992, this estimate may be more appropriate.

As a result of improved recruitment for the 1996 year-class, biomass is expected to increase for the stock as this cohort enters the fishery. Age 4⁺ biomass is expected to increase by 7,000t in 2000. The alternative model estimated a similar increase in biomass if the harvest is held to the $F_{0.1}$ harvest of 4,400t derived from that model.

Further improvements in recruitment are required before any sustained growth in this fishery can be realized. With the concerns expressed about the uncertainty in current stock biomass, it is important to ensure that the recruiting 1996 year-class is not exploited heavily. These fish will generally be less than 19in. on the Scotian Shelf in 1998, but will range between 17 and 22in. in the Bay of Fundy. These fish are expected to contribute only slightly more in numbers to the fishery than the 1995, 1994, or 1992 year-classes. Substantial deviation from this may be cause for concern. Careful monitoring of the fishery in 1999 could help us distinguish between these alternatives.

To ensure a higher probability of average or better recruitment it is important to ensure that the spawning stock biomass is high. Given the poor recruitment of recent year-classes, this will require ensuring that fishing mortality is low.

For More Information

Contact:

Donald Clark
St. Andrews Biological Station
St. Andrews, New Brunswick
E0G 2X0

TEL: (506) 529-8854

FAX: (506) 529-5862

EMAIL: clarkd@mar.dfo-mpo.gc.ca

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Clark, D. S. 1998. Assessment of cod in Division 4X in 1998. Can. Stock Assess. Secr. Res. Doc. 98/135.

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Maritimes Regional Advisory Process
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2
Phone number: 902-426-7070
e-mail address: myrav@mar.dfo-mpo.gc.ca

Internet address: www.dfo-mpo.gc.ca/csas
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