



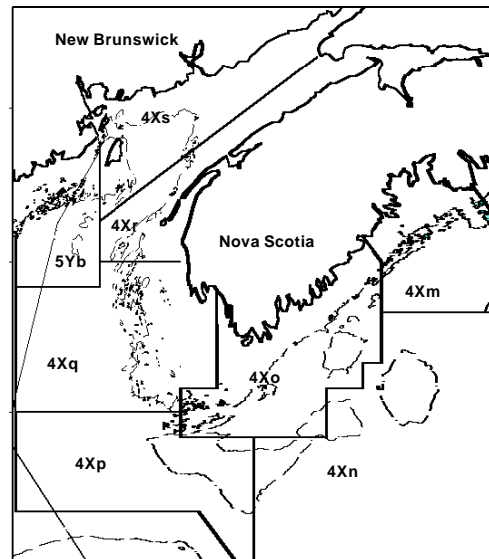
## Cod on the Southern Scotian Shelf and in the Bay of Fundy (Div. 4X/5Y)

### 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.



### Summary

- Landings and TAC have declined throughout the 1990s, and were the lowest on record in 1998.
- Recruitment has been below average since 1992.
- There is considerable uncertainty in the estimates of recent stock abundance and exploitation levels.
- Exploitation rate has declined from the high of 64% in 1992 to about 30% in 1998.
- Spawning stock biomass is low.
- $F_{0.1}$  yield for this stock for the fishing year beginning in April, 2000 is likely in the range of 4,000t to 6,000t.

### Summary of Stock Status Attributes

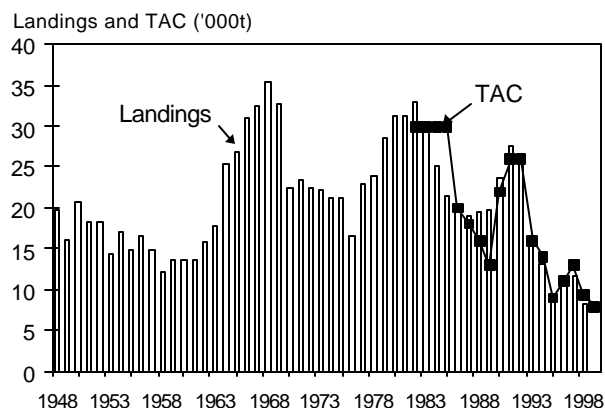
This year, the stock assessment includes a compilation of attributes of stock status. While the attributes are generally those traditionally included in an assessment, other more novel indicators are also included. Summarizing these attributes in a tabular format facilitates comparison and should be an aid for decision makers.

Attribute	Recent Trend	Current Status
Biomass SPA age 4+ (1980-1999)	Unchanged	Low
Biomass RV Kg/tow (1970-1999)	Decreasing	Lowest observed
Recruitment SPA age 1 (1980-1999)	Unchanged	Low
Recruitment RV age 2 (1983-1999)	Unchanged	Low
Exploitation SPA age 4-7 (1980-1999)	Decreasing	Lowest observed, but above $F_{0.1}$
Total Mortality RV ages 4+ (1983-1999)	Increasing	Above average
Condition	Unchanged	High
Resource Concentration	Unchanged	More concentrated than average
Geographic distribution	Unchanged	Average
Mean length Age 4 (1970-1999)	Unchanged	Average

### The Fishery

#### Landings (thousands of tonnes)

Year	1993	1994	1995	1996	1997	1998	1999
TAC	15	13	9	11	13	9.3	7.0
Total	16	13	9	11	11.5	8.2	



**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 in 1998 was 9,300t, 1,100t of which 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 1999 TAC (7,000t) was prorated to a 15-month fishing year ending March 31, 2000 (7,910t). Landings to Oct. 1 in 1999

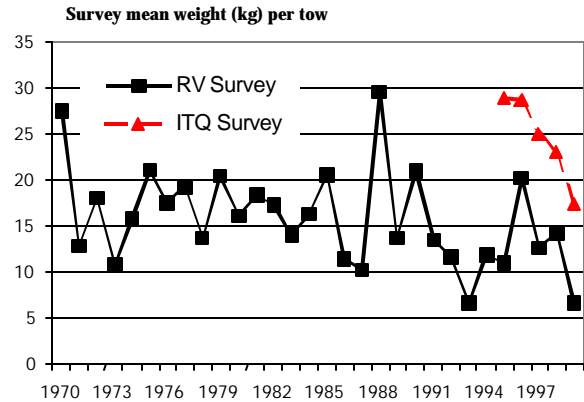
were 5,500t. The fishery in 1999 is reported to have been good in inshore areas for the first time in four years. Fishing success is reported to have been poor east of Browns Bank, but improved in most other areas.

**Effort** by all gear sectors has declined from a peak in 1991 or 1992. The number of vessels engaged in the fishery and the effort (days fished) has declined from 1996 to 1998, and appears to be dropping again in 1999. Catch rates for fixed gear dropped from 1996 to 1998, but are higher in 1999.

In 1998 and the first half of 1999, landings were distributed amongst ages 3-7. In 1999, the 1996 year-class is contributing more to the landings than expected. The 1992 year-class has contributed more than average for its age in both 1998 and 1999, but has not been dominant in the fishery as had been forecast. Fish older than the 1992 year-class, 7+ in 1998 and 8+ in 1999, 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.

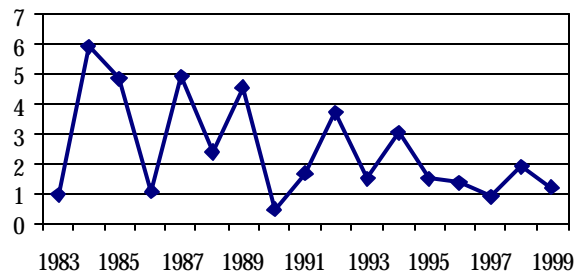
### *Resource Status*

The catch per tow (**biomass index**) for the **summer research vessel (RV) survey** dropped in 1999, and was among the lowest in the series. The 1992 year-class has had the highest index in the series at ages 4, 5 and 6 and the second highest at age 3. In 1999, this year-class, at age 7, is only slightly above average, and all other ages are below average.



**Recruitment** prospects based on the catch of the 1997 year-class at age 2 in the RV survey appear below average.

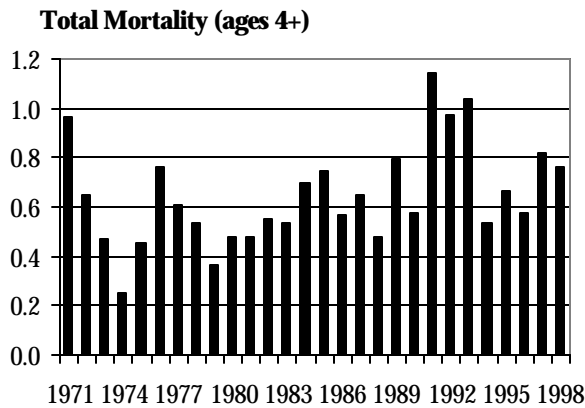
#### **Recruitment: RV number per tow at age 2**



Mean **lengths-at-age**, and **condition** (calculated weight at 60cm) differ between the Bay of Fundy and the Scotian Shelf, with the Bay of Fundy higher for both. Length at age has shown no long-term trends in either area, and is currently about average. No trends are apparent in condition and the weight at 60cm is currently among the highest in the series.

The proportion of the 4X survey stations encompassing 75% of the annually estimated survey biomass may be used as a measure of **resource concentration**. The resource concentration has been high for 4X cod in the 1990's, and is currently above average. The proportion of the annual survey sets in which cod are caught may be used as a measure of the extent of **geographic range**. The proportion of non-zero survey sets is currently about average for 4X cod.

**Total mortality** as calculated from the RV survey can be quite variable, due to interannual variability in survey catches, but should reflect trends in fishing mortality. Total mortality estimates (3 year running average) are quite high in recent years, suggesting that exploitation may still be above the long-term average.



A joint industry/DFO Science survey (the **ITQ survey**) has been conducted in 4X since 1995. Currently, 187 stations are sampled, 124 of which are common to all 5 years. For this analysis, the subset of 124 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.

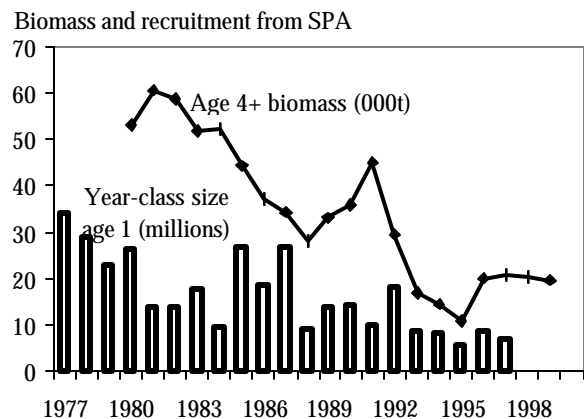
Catch **weight-per-tow** in 1999 was at its lowest for this survey. Catches were below average at most stations, except for ages 0 and 1, which were very high. Numbers per tow at age 1 in 1999 were more than ten times higher than in previous years.

A single formulation for the **sequential population analysis** (SPA) could not be identified that adequately described the dynamics of this stock in recent years; however, alternative formulations identified

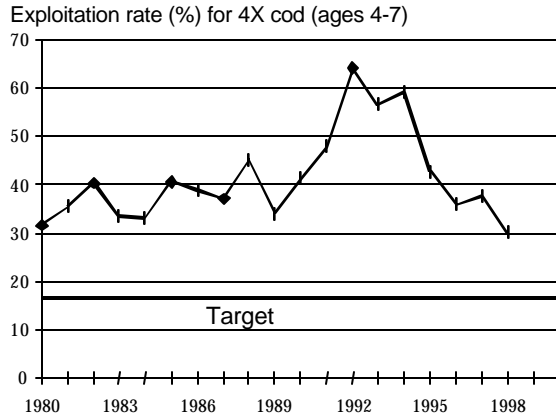
consistent overall trends in population numbers and fishing mortality. The results of an analytical assessment based on the RV and ITQ surveys and commercial landings data are presented here to illustrate the current status of this stock.

**Population biomass** estimates indicate that the stock will increase slightly during 1999. In recent years population biomass for ages 4+ peaked in 1991, then dropped to the lowest levels in the time series in 1995. The increase in 1996 was due to the recruitment of the moderate 1992 cohort. Assuming that 6,900t is caught in 1999, the beginning of 2000 age 4+ biomass is projected to remain at about 20,000t.

**Recruitment** as estimated by this SPA has been below average since the 1992 year-class. The 1993 to 1997 year-classes are five of the six lowest in the series.



The **exploitation rate** estimated for ages 4-7 from SPA, has consistently been well over twice the target of 16% throughout most of the recent past, reaching a high of 64% in 1992. Exploitation rate has declined since then, dropping to 30% in 1998, and is projected as 25% for 1999.



### Sources of Uncertainty

Two versions of a sequential population analysis were considered for this stock. These analyses differed in input data, and model formulation, but the trends in population numbers and fishing mortality derived from them were consistent. The first of these models was strongly influenced by the 1999 survey data. The inclusion of these data resulted in a substantial change in the estimated 1999 population numbers. The second model estimated higher population numbers at ages 7 to 10 than seemed plausible given the paucity of these age groups in either the commercial fishery or recent surveys. Given this uncertainty in population reconstruction it is not possible to give well-resolved estimates of the proportional change in stock biomass that would ensue for specific harvest levels. These analyses, however, do still provide a useful integration of landings data, and the results of two surveys, both of which indicate the population is declining.

The uncertainty in this assessment is due more to concerns about the adequacy of the model than the precision of the estimate. These uncertainties include potential errors in the model and model formulations, the influence of changes in fishing practices, and environmental effects on survivorship.

### Outlook

Yield at  $F_{0.1}$  for the fishing year beginning April 1, 2000 is poorly resolved, but would appear to lie in the range of 4,000t – 6,000t. A harvest in this range would allow only for modest growth in spawning stock biomass of about 2,000t – 4,000t. Due to the nature of the uncertainties in this assessment, risk plots are not considered appropriate.

A harvest in the fishing year beginning April 1, 2000 equal to the 1999 quota of 7,000t will likely allow for little or no growth in this stock. With the concern expressed about uncertainties in current stock biomass, the downward trend in survey catches, and the continued poor recruitment, it is important to ensure that exploitation is kept low if recruitment overfishing is to be avoided. Improvements in recruitment are required before any sustained growth in this stock can be realized.

### For More Information

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### References

- Clark, D. S. and S. D. Paul. 1999. Assessment of cod in Division 4X in 1999. Can. Stock Assess. Secr. Res. Doc. 99/159.

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