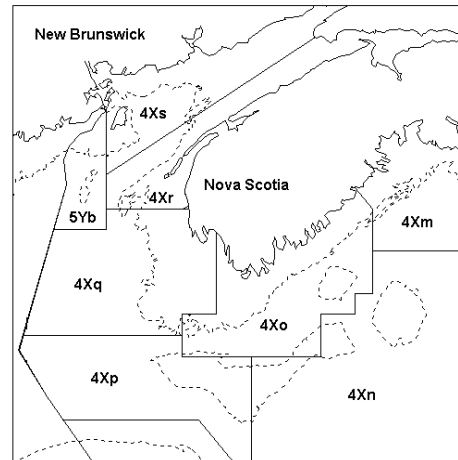


## Cod on the Southern Scotian Shelf and in the Bay of Fundy (Div. 4X/5Y)



### Background

Atlantic cod (*Gadus morhua*) 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 and Canadian portions of 5Y).

Juvenile cod 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 this management area with the largest occurring during winter on Browns Bank. Cod in this area 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. Growth rates, however, vary among cod in this area with more rapid growth noted in the Bay of Fundy. Age at first reproduction generally occurs at 3 years and individuals tend to spawn several batches of eggs during a single spawning period.

Cod has supported a commercial fishery in this area 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. Closure of Browns Bank is in place from 1 February-15 June.

### Summary

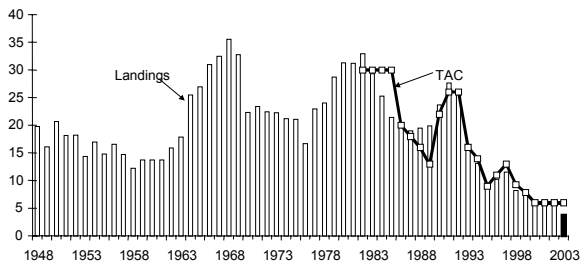
- Nominal landings and TAC declined through the 1990s and were 6000t annually from 2000-2003.
- Recruitment has improved in the Bay of Fundy starting with the 1998 year-class. On the Scotian Shelf, RV survey catch at age 2 has been low since 1995, while the ITQ survey indicates recruitment in 2000-2003 is roughly double the previous 4 years.
- There has been little change in biomass in the past 5 years.
- Available data are insufficient to determine if nominal landings accurately reflect mortality from fishing.
- Length at age and condition are about average.
- As stock structure is not well defined for cod within 4X, special attention is required to avoid over-exploitation of local or sub-populations.
- In 2002, half of cod landings came from trips where cod was not the main species. Potential impacts on cod should, therefore, be considered in managing other groundfish.
- With the improved recruitment observed, biomass should gradually increase if catch does not exceed 6000t.

## The Fishery

Landings (000s t)								
Year	1970-1979	1980-1989	1990-1998	1999	2000 <sup>2</sup>	2001	2002	2003
Avg.	Avg.	Avg.						
TAC	-	23.4	16.2	7.9	6	6	6	6
Total	22.5	24.9	16.2	7.4	5.9	5.9	5.9	

1. Fishing year, landings and TAC refer to the 15-month period from January 1, 1999 to March 31, 2000.
2. Commencing in 2000, fishing year, landings and TAC refers to the period April 1<sup>st</sup> of the current year to March 31<sup>st</sup> of the following year.

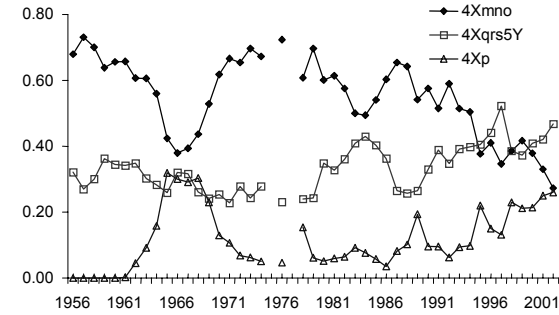
Landings and TAC (000t)



Nominal **landings** peak in 1968, 1982 and 1991. The first peak coincides with the period when trawlers >100ft became active in the fishery, but this fleet is virtually absent from this fishery after 1984. Recent landings reflect increasingly restrictive total allowable catch (TAC) which declined from 26,000t in 1992 to 6,000t in 2000. The quota has been 6,000t for the past 4 years as part of a rebuilding strategy. As of 26 September 2003, 2,800t of cod had been landed.

The distribution of the fishery has shifted in recent years, with the Bay of Fundy (4Xqrs5Y) and Georges and Crowell Basins (4Xp) increasing in importance. This is a general pattern in the groundfish fishery, and reflects shifts in distribution of abundance for a number of species.

Proportional Landings of 4X Cod by Area



The fishery takes place year round, peaking in June and July. Landings from the winter declined after 1992, with many fishing sectors treating cod as a bycatch as they pursued other species. Since 2000, the quota year has run from April 1<sup>st</sup>. With this change in fishing year, and the increase in haddock quotas relative to cod, the winter haddock fishery has increased, and winter landings of cod have also increased as the remaining quota is caught.

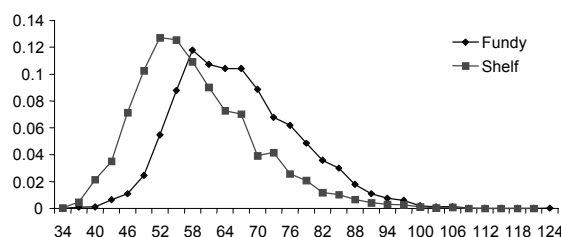
In 2002, the cod fishery was reported to have improved in most areas aside from coastal hook and line fisheries. Most groups reported no difficulty in catching their quota despite the fact that many were directing their effort primarily for other species. In 2003, fishing was again poor in most coastal areas. Many fixed gear fishers delayed their activity this year, reportedly due to prevalence of dogfish in early summer and colder water temperatures.

**Fishing effort** for groundfish (where the main species in the catch is cod, haddock, pollock, white hake, or cusk) has been fairly stable for 2000-2002 for otter trawl, longline and gillnet, at levels less than half what was recorded in the early 1990s. Handline effort, once a significant part of the fishery, continues to decline and has dropped over 80% since 1997.

In both 2001 and 2002, the 1998 year-class dominated the landings of 4X cod. The contributions from ages 7 and over were very low. In 2003, landings are dominated by the 1998 and 1999 year-classes, and the age range in the fishery shows some expansion, with the 1996 year-class at age 7.

The length frequency of the catch peaks somewhat lower on the Shelf, than in the Bay of Fundy, reflecting differences in growth between these areas. In both areas the peak is consistent with length at age 4, the 1998 year-class.

Proportion at Length (cm) in Commercial Landings of 4X Cod by Area in 2003



There were numerous reports of cod being **discarded or landed unreported** in 2000 and 2001 to avoid exceeding the quota. This was thought to have decreased in 2002. There have been no reports from industry of discarding in 2003, and some have maintained that it was never a serious problem.

Industry members expressed concern that the winter flounder trawl fishery in 4Xr cannot use separator trawls in an area in which cod bycatch is difficult to avoid. It has been alleged that discarding of cod in the flatfish fishery may be a problem. Increased monitoring of this fishery could resolve this issue.

Surveillance information indicates that vessels observed fishing without matching records from log books are exceptions and their presence can generally be explained (e.g. fishing for lobster).

Discrepancies in species composition between trips carrying an observer and unobserved trips may be indicative of potential discarding or misreporting of landings. The level of observer coverage in 4X is generally below 1%, too low for any meaningful comparisons; thus it cannot be determined whether nominal landings are an accurate reflection of mortality from fishing. Much higher coverage stratified to account for heterogeneity in the fishery would be required to make useful comparisons of observed and unobserved trips. Experience with the 5Z groundfish fishery, which is less heterogeneous, suggests that 10% observer coverage may not always be sufficient for detecting potential discarding.

Level of Observer Coverage in Cod/Haddock Directed Fisheries in 4X

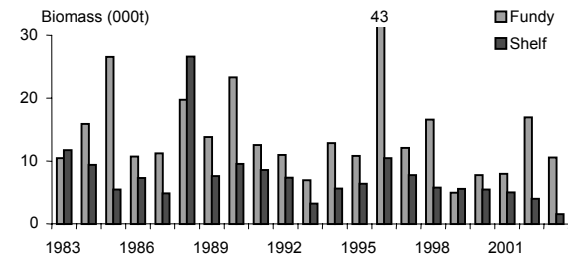
Year		Otter trawl		Longline	
		Tonnage	proportion	Tonnage	proportion
2001	observed	45.4		11.1	
	landed	1188	3.80%	1500	0.74%
2002	observed	0.3		6.3	
	landed	1777	0.01%	1867	0.30%
2003	observed	10.5		6.9	
	landed	1233	0.85%	842	0.82%

## Resource Status

Due to changes in fishing patterns and the impact of management measures, it has been argued that catch rates may have limited information value regarding cod abundance; hence, they are not reported here.

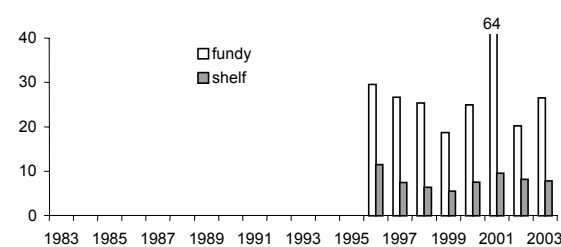
The **research vessel** (RV) survey index for the Bay of Fundy increased and was above the median in 2002 and 2003. The index has been below the median on the Scotian Shelf since 1998, with a declining trend since 1997.

RV Survey Biomass Estimates by Area



The ITQ survey index, which began in 1996, does not show any strong trends in the Bay of Fundy or on the Scotian Shelf.

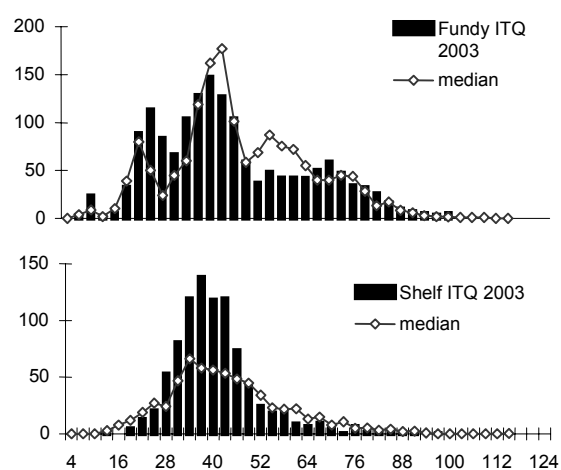
ITQ Survey Cod Catch by Region in 4X



There has been little change in 4X cod biomass estimates from either the RV or ITQ surveys in the last 5 years.

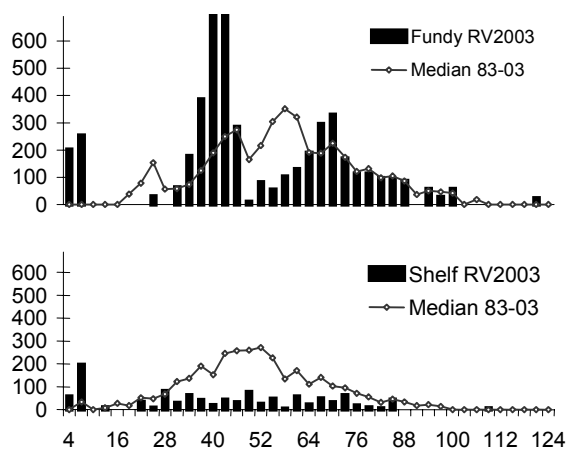
ITQ survey, length frequencies were similar to the median in the Bay of Fundy and on the Shelf, were well above median from 28-49 cm, although relatively few are caught above 52cm.

ITQ Survey Length Composition Compared to Series Medians



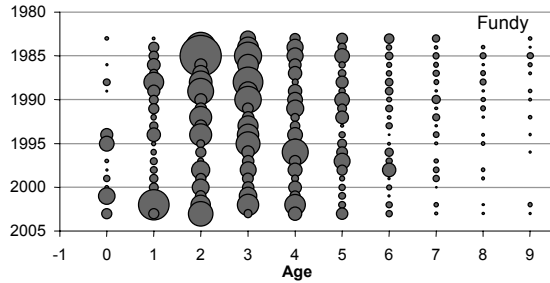
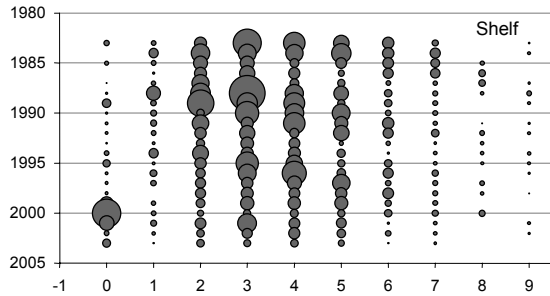
Size composition from the RV survey indicates that 2003 catches were at or above the median at most lengths in the Bay of Fundy, but very low for lengths >28cm on the Scotian Shelf. The absence of a mode for the Scotian Shelf size composition is not consistent with the size composition from the ITQ survey or the fishery, and is unlikely to be representative of the population.

RV Survey Length Composition by Region for 4X Cod

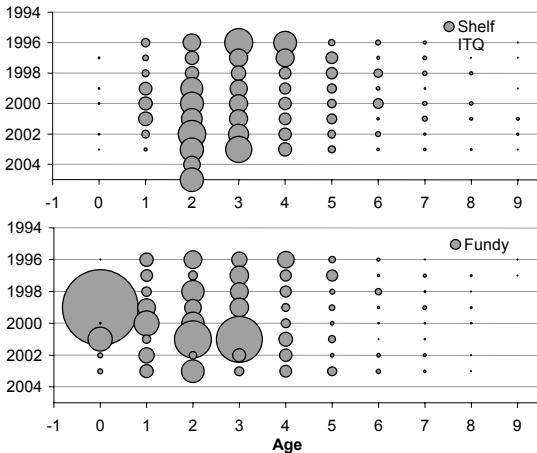


**Recruitment**, as indicated by both RV and ITQ survey catch at age 2, has improved in the Bay of Fundy starting with the 1998 year-class. On the Scotian Shelf, RV survey catch at age 2 has been uniformly low since 1995, while the ITQ survey indicates recruitment in 2000-2003 is roughly double the previous 4 years. RV catch of the 2001 year-class in the Bay of Fundy at age 2 in 2003 is above the median, as it was at ages 0 and 1, suggesting recruitment may be further improved over recent years.

4X Cod RV Survey Indices (size proportional to abundance)

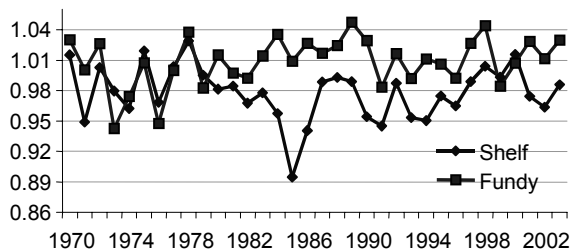


4X Cod ITQ Survey Indices by Area (size proportional to abundance)



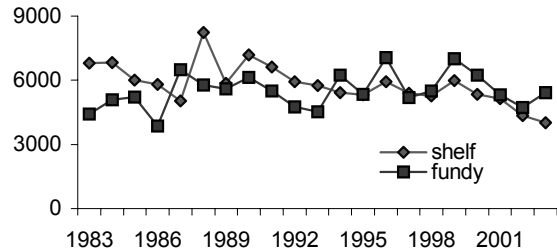
The **Length-at-age** and **Condition** (Fulton's K) are currently about average for cod in both the Scotian Shelf and Bay of Fundy.

Condition Factor (Fulton's K) for 4X Cod by Area

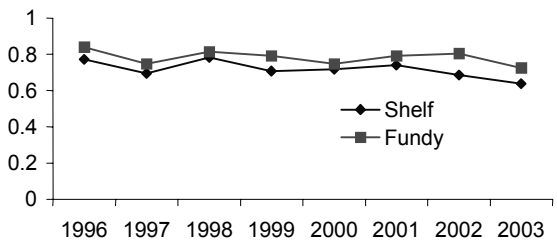


The stratified proportion of RV survey sets where cod are caught (**area occupied**) in the Bay of Fundy has been variable but remains about average, while on the Scotian Shelf it has declined annually since 1999. For the ITQ survey there has been little change for the Bay of Fundy, but a declining trend for the Scotian Shelf since 1998.

Area Occupied by 4X Cod from the RV Survey



Proportion of ITQ Survey Sets Where Cod were Caught



**Total mortality (Z)**, as calculated from the RV survey has such high interannual variability that no trend can be discerned and no conclusions drawn in relation to total mortality.

Dividing commercial landings by survey biomass is an estimate of **relative fishing mortality**. This has declined in recent years, reflecting the reduction in landing and generally stable overall (Bay of Fundy and Scotian Shelf) survey biomass index. Estimates of relative fishing mortality for the Bay of Fundy and Scotian Shelf separately requires appropriate partitioning of the catch, which is currently not available.

The strong retrospective observed in the **sequential population analysis (SPA)**

was thought to indicate a high level of unaccounted mortality. This could be caused by elevated natural mortality, but appeared to be highest on fishable ages, which would be consistent with a high level of discarding or unreported landings in past years. It may also be confounded by divergent trends in the Bay of Fundy and Scotian Shelf. Reliable interpretation of SPA results cannot be made without resolving these issues.

### **Management Considerations**

Data indicate that there are separate cod stock components in 4X that may be following divergent trends. As stock structure is not well defined for 4X cod special attention is required to avoid over exploitation of local or sub-populations. In 2002, half of cod landings came from trips where cod was not the main species; potential impacts on cod should, therefore, be considered in managing other groundfish.

Cod is caught in a mixed species fishery together with several other commercial species such as haddock, pollock, flatfish, redfish, white hake, cusk and monkfish. Consideration of the mixed nature of this fishery is required in any management decisions. In particular, cusk has been designated as threatened by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and the ability to target haddock while keeping cod catch low is a concern.

Analysis of fishery data suggests there are areas which can be fished by hook-and-line and mobile gear where high ratios of haddock to cod may be caught to minimize cod bycatch when directing for haddock. The otter trawl fishery has in recent years focused in 4Xpqrs, and in 4Xn in winter. The ratio of haddock to

cod in the winter can exceed 10:1 in several areas, and is generally above this in 4Xn. High ratios of haddock to cod are also experienced in 4Xp and 4Xs in summer months. Longliners fish primarily in 4Xmnop. Throughout the year in offshore areas (including Roseway and LaHave Banks, all of 4Xn and 4Xp south of Browns Bank), longliners can catch more haddock than cod.

2002 cod and haddock directed landings (tonnes) where haddock is predominant

Area	Gear	Month	cod	had	had/cod
4Xn	otter trawl	jan.-may	62	1059	17.1
4Xp	otter trawl	july-nov.	69	628	9.1
4Xs	otter trawl	june-dec.	294	1013	3.4
offshore	longline	may-oct.	791	1263	1.6
offshore	longline	jan.-apr.; nov.-dec.	261	454	1.7

offshore = 4Xn, 4Xp at depths >100m, and Roseway Bank and Basin in 4Xo

It is possible, therefore, that an increase in haddock quota could be considered without leading to increased cod catches, if the fishery operates in those areas where haddock is more abundant. If the current cod/haddock quota ratio of 6,000:10,000 is increased, enhanced monitoring of species composition through increased observer coverage should be considered.

### **Ecosystem Considerations**

Marine species are exposed to interacting biophysical influences, such as temperature, currents and primary productivity that affect their growth, survival and reproductive success. Our current understanding of these effects on our estimates of fish populations and potential yield is poor. Fish species should be considered as living components of ecosystems, subject to changes in their environment. Reviews of comprehensive suites of biophysical data should be undertaken, to gain greater understanding of the relationship

between fish and the environment in which they live.

There appears to have been a reduction in the productivity of demersal fish species on the Scotian Shelf. For many species, this has been most apparent in 4VW. This is evident in the reduced growth for some species, and can be inferred from the accumulations of large numbers of small individuals for many other species where direct measures of growth are not available. Many of these species are also showing the onset of sexual maturity at small sizes. In a single-species context this implies a significant loss in potential yield relative to historical catches. Many of these species, including some that are subject to little or no fishing mortality, are showing similar changes in productivity. This makes it likely that an environmental or ecological effect is responsible. What this may be is currently unknown.

All fisheries have the potential for discarding undersized specimens of targeted species or all size classes of non-target species, the mix of which is dependent on the gear used and the location of the fishery. The mix of species caught in 4X groundfish fisheries is currently not completely known because landings information do not include discards and observer information is available for only a limited proportion of the fleet. The wider ecosystem effects of these fisheries, in terms of total bycatch, can not be assessed at this time.

Fishing gears can have negative physical impacts on the seafloor, reducing epifauna and flora and damaging or modifying fish and invertebrate habitat. These potential impacts have not been assessed for groundfish fisheries.

## **Sources of Uncertainty**

The principal source of uncertainty in evaluation of stock status in 4X cod is the amount of removals in each year. Reports of current and historical discarding and under-reporting indicate that these vary from year to year due to stock condition and fishermen's perceived incentives and risks. Prior to the mid-1980s misreporting could also have included over-reporting of landings from other species or areas as 4X cod. This uncertainty can potentially be alleviated in future years with additional effort in monitoring and following delineation of stock components. Interannual variability in natural mortality must also be considered.

This **management unit** has been treated as a stock complex comprised of a number of spawning components. Difficulty in separating landings has precluded analyses of discreet components. The similarities in past abundance trends for components had alleviated concerns about treatment as a single management unit. A divergence in population trends among these components would be inconsistent with model assumptions. Efforts to delineate components based on tagging and biological data are underway.

## **Outlook**

The summer RV surveys have been the long-term, fishery-independent source of information on biomass, abundance and size-composition for many fish stocks including 4X cod. For a variety of reasons the assessments have become increasingly dependent on the survey data. Consistency has been maintained with standardized sampling protocols and calibration of the gears. In the past, changes in the survey vessel have been

made after calibration experiments have provided information on the expected effects of the change. Due to the recent fire on the Alfred Needler, there is the possibility that an unplanned and uncalibrated vessel change may occur. This will create great uncertainty in any comparisons of subsequent survey results to the historical series for at least the next five years. It will also make it difficult to determine how the stock may be responding to any particular management action.

Overall **biomass** has not increased since 1999, when the quota was reduced to 6,000t to promote recovery; therefore an increase in quota above 6000t is not supported. While biomass remains about average in the Bay of Fundy, one of the two surveys suggests a decline in cod abundance on the Scotian Shelf recently. This suggests that consideration may need to be given to the distribution of catch between the Bay of Fundy and the Scotian Shelf.

**Recruitment** has improved in the Bay of Fundy starting with the 1998 year-class. On the Scotian Shelf, RV survey catch at age 2 has been low since 1995, while the ITQ survey indicates recruitment in 2000-2003 is roughly double the previous 4 years.

**Area occupied** has declined on the Scotian Shelf, but remains about average in the Bay of Fundy. **Condition** and **length-at-age** show no trends.

A **prospective** gradual increase in biomass for 4X cod in the short-term can be anticipated due to improvements in recruitment following the 1997 year-class, if fishery catches are kept to 6000t.

## ***For More Information***

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## ***References***

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