



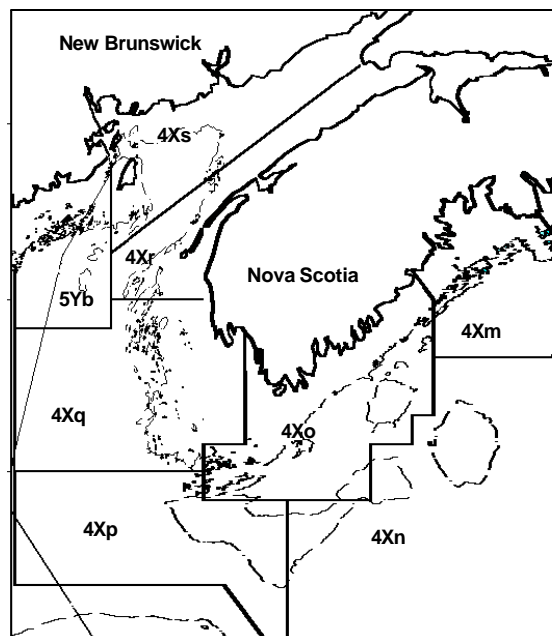
Haddock on the Southern Scotian Shelf and Bay of Fundy (Div. 4X/5Y)

Background

Haddock are found on both sides of the North Atlantic. In the west Atlantic, they occur from southwest Greenland to Cape Hatteras. A major stock exists in the southern Scotian Shelf and Bay of Fundy area. This bottom-dwelling species is a member of the cod family and feeds mainly on small invertebrates. It is most common at depths ranging from 25-75 fathoms (46-137 m) and in bottom temperatures above 2°C. Although seasonal migrations are evident within the stock area, there is relatively little exchange between adjacent haddock stocks.

Young haddock in this stock are relatively fast growing, reaching 17 inches (43 cm) and 1.7 pounds (0.8 kg) by age 3 on average. Growth slows thereafter and haddock reach only about 26 inches (66 cm) in length by age 10. Haddock in the Bay of Fundy grow more rapidly than those on the southern Scotian Shelf. Approximately 50% of female haddock are mature by age 3; however the number of eggs produced by a female of this age is low and increases dramatically with age. Browns Bank is the major spawning area for the stock and peak spawning may occur from April to June.

Reported annual landings have been as high as 38,000t and the long-term average is about 18,000t. Landings have been below 11,000t since 1988. Historically this fishery has been dominated by mobile gear except during 1990-93 when the proportion of landings taken by fixed gear was greater. Quotas for this stock were introduced in 1970 and a spawning season/area closure has been in place since that time.



Summary

- Reported landings of 4X haddock increased from a low of 4,406t in 1994 to 7,843t in 1998. Landings in the first half of 1999 were 2,313t.
- Exploitation rate for ages 5-7 decreased from approximately 50% in the early 1980s but dropped below the $F_{0.1}$ target in 1994-97. Exploitation in 1999 will be about the target if the TAC is not exceeded.
- The projected yield at $F_{0.1}$ in the fishing year 2000/01 would be about 8,200t.
- If fished at $F_{0.1}$, the spawning stock biomass is projected to increase to 39,000t in 2001.

Summary of Attributes of Stock Status

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 tabular form facilitates comparison and should be an aid for decision makers.

Attribute	Recent trend	Current Status
Biomass SPA 4+ 1970-99	Increasing since 1994	Above average
Abundance RV number/tow 1970-99	Increasing	Above average
Recruitment SPA age 1 1970-99	Increasing	Above average in 4 of last 5 years
Exploitation SPA ages 5-7 1970-99	Stable	Near $F_{0.1}$
Total mortality RV ages 5-7 1970-99	Stable	Near average
Mean Length RV age 5 1970-99	Decreasing	Lowest observed
Condition RV 1970-99	Increasing	Below average
Resource concentration	Stable	Evenly dispersed
Geographical Range	Increasing	Widest observed

The Fishery

Landings (thousands of tonnes)

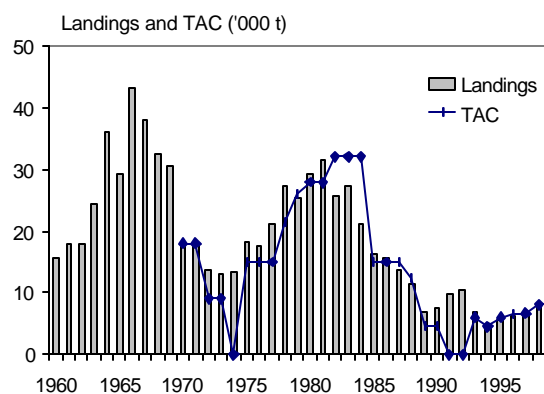
Year	1993	1994	1995	1996	1997	1998	1999
TAC	6.0	4.5	6.0	6.5	6.7	8.1	8.1
TOTAL	7.0	4.4	5.7	6.2	6.5	7.8	

Reported **landings** of 4X haddock in 1998 were 7,843t relative to a quota of 8,100t. Mobile gear landings were 5,234t while fixed gear landings were 2,608t. The 1999

TAC of 8,100t was prorated to a 15-month fishing year ending March 31, 2000 (9,800t). Landings in the first half of 1999 were 2,313t.

Since 1993, more than half of mobile gear landings were from the Bay of Fundy. In 1998, this dropped to 43% because there was a shift in the mobile gear effort directed for haddock in the spring. A concentration of haddock was located in deep water outside the Browns Bank closed area, where haddock have not traditionally been found. As a result of increased quota and favourable markets, a substantial amount of haddock was landed. This concentration of market-sized haddock also contained small haddock and a small-fish closure was implemented in this area in March. Mobile gear landings in the first half of 1999 are much lower than in recent years.

The introduction of sharing arrangements in the fixed gear sector, as a result of Community Management, led to a slow start in the fishery in 1998. The delay in the start of the 1999 fixed gear fishery was greater and landings in the first half of the year were the lowest in at least fifteen years.



Reports from industry indicate that haddock abundance was good throughout most of the stock area in 1998. Catches of small fish were prevalent, particularly in eastern 4X. Industry reports indicated they

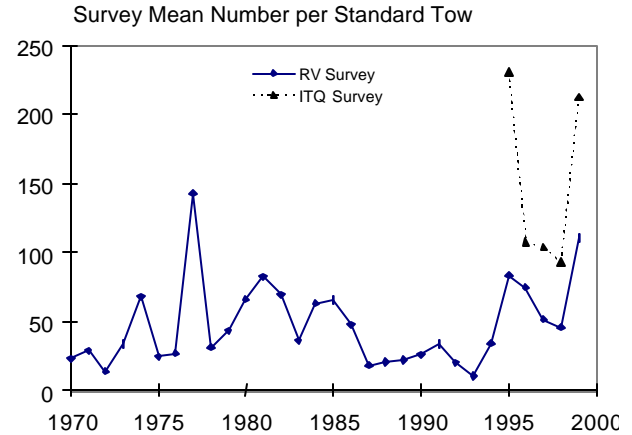
felt that discarding of small haddock was reduced in 1998, and was further reduced in 1999 due to improved prices for small fish. It was thought that misreporting was also reduced, with the introduction of community quotas. The absence of dogfish through most of 1998 permitted fixed gear fishermen to fish closer to shore. Dogfish were again prevalent in most areas in 1999. Haddock availability was low in many inshore areas while cod and hake were more available. It was felt that these changes in distribution were a result of warmer water temperatures. These changes contributed to the delay of the fixed gear fishery.

A comparison of the **size composition of commercial landings** of 4X haddock showed that the mean length of mobile gear landings increased from 1990 to 1995 but has subsequently declined. Mean length of fixed gear landings decreased from 1990. Currently the mean lengths of landings from the two gear sectors are the same.

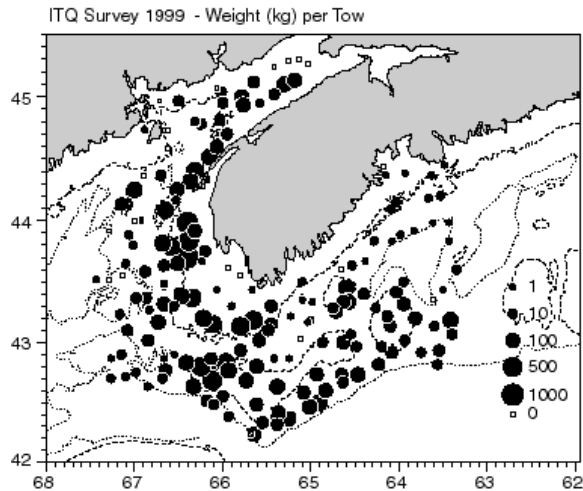
Mean weights-at-age in the commercial landings have been decreasing since the early to mid 1990s and are the lowest observed since the early 1970s.

Resource Status

Abundance in **the summer DFO research vessel survey** in 1999 increased to the second highest value in the series, due largely to record catches of age 0 haddock and near record catches of age 1 haddock. Catches of these ages were widespread in the survey area. Catches of all ages were above average on the Scotian Shelf but only slightly above average in the Bay of Fundy.

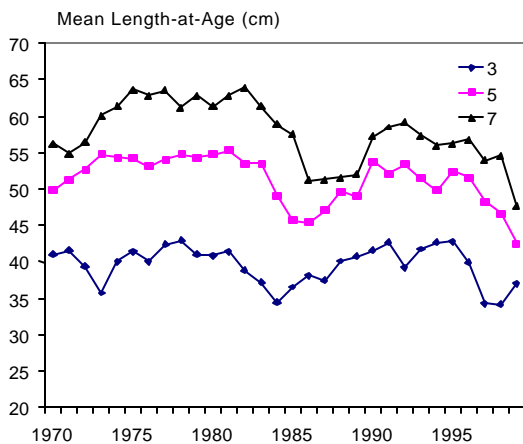


A **joint industry/DFO Science resource survey** of 4X was conducted in summer 1995-99 by the ITQ fleet. Survey coverage has increased to 187 standardized fishing sets and now covers most of the 4X area. In addition to providing extensive coverage of the traditional research vessel survey strata, this survey provides coverage inshore of the traditional strata in an area where a substantial portion of the mobile gear fishery occurs. Haddock were widespread throughout the survey area. Catches in the inshore area were higher than in the adjacent survey strata at lengths less than 40cm, but slightly lower at larger lengths. Abundance in the inshore area increased over the last three years, but remained stable in the Bay of Fundy. As in the research vessel survey, abundance on the Scotian Shelf was high in 1999. It was noted that the 1995 survey point might be biased high relative to subsequent years because of fewer tows that year.



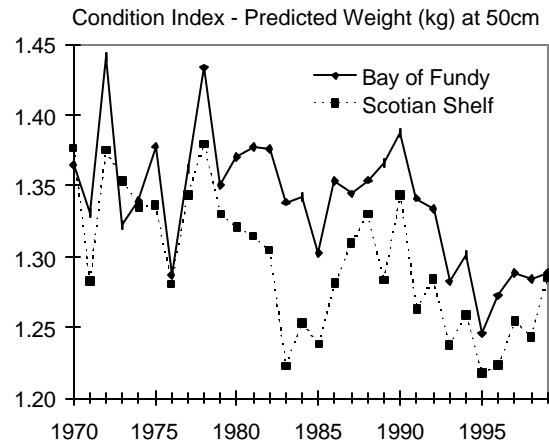
Total mortality estimated for ages 5-7 from summer research vessel surveys were relatively stable in recent years and implied fishing mortality of about $F_{0.1}$.

Mean lengths-at-age in the research vessel survey have been decreasing since the mid 1990s, particularly at older ages. Mean weights-at-age show similar trends. Many ages are below the long-term mean length and weight and some are at the smallest size observed in the research vessel survey series.



Condition is the relative weight of the fish for their length (i.e. their plumpness). An index of condition, developed from the summer research vessel surveys, was variable but indicated that condition

decreased since the late 1980s, reached a minimum in 1995 and has increased since. The attributes, condition and fish size are believed to be related to spawning potential for cod. This could also be true for haddock.

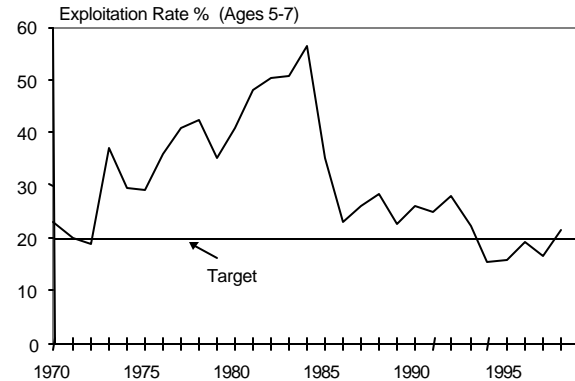
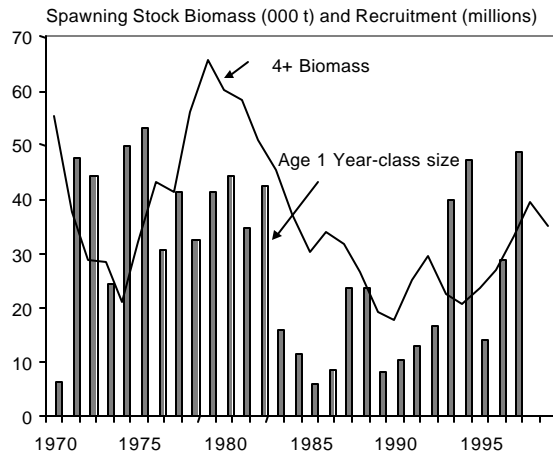


A measure of **resource concentration** is the proportion of the historical stock area encompassing 75% of the annually estimated survey biomass. The resource is presently evenly distributed over the survey area.

A measure of how widely a stock is distributed within its historical **geographic range** is the proportion of annual survey sets where the species occurs (non-zero sets). This indicates the resource is presently widely distributed.

A **Sequential Population Analysis (SPA)** was conducted using both the research vessel and the ITQ surveys for fitting the model.

Except for the 1987 and 1988 year-classes, **recruitment** from 1983-92 was below average. Both the 1993 and 1994 year-classes are estimated to be strong. The 1995 year-class is weak but the 1996 year-class is above average. The model suggests the 1997 year-class is also strong.



Spawning stock biomass (age 4+) decreased since 1979 and reached a low of 18,000t in 1990. The strong 1993 and 1994 year-classes resulted in spawning stock biomass increasing to 40,000t in 1998 but this will decrease to 35,000t in 1999 due primarily to recruitment of the below average 1995 year-class.

There appears to be no relationship between spawning stock biomass and recruitment over the biomass range observed.

The **exploitation rate** on ages 5-7 has been higher than the $F_{0.1}$ target (20%, $F_{0.1}=0.25$) since the early 1970s. Exploitation decreased from approximately 50% in the early 1980s to close to the target level and dropped below the target in 1994-97, but the partial recruitment of these ages appears to have declined in recent years. The exploitation rate on the whole population may have been somewhat higher.

Sources of Uncertainty

Past assessments of this resource have exhibited a retrospective pattern where there is a tendency to under-estimate exploitation and over-estimate population abundance in the most recent year, particularly when strong year-classes occur. This analysis estimates the 1997 year-class to be very strong, but the research vessel and ITQ surveys indicate it to be average or above average. Age 2 population numbers are not well estimated in the most recent year in this assessment and were adjusted downward from 41 to 24 million, based on the tendency to overestimate strong year-classes.

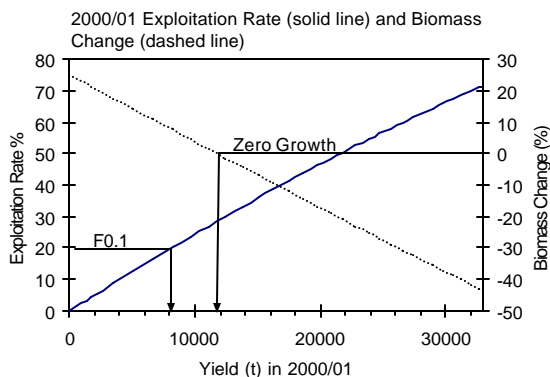
In previous assessments, the 1993 and 1994 year-classes were also adjusted downward. It was judged that these adjustments are no longer required, because of better estimations at these older ages. The analysis is sensitive to these adjustments. If in fact these adjustments were required, they would result in a 10,000t decrease in the estimate of 1999 spawning stock biomass.

Projected yield is calculated using commercial weights-at-age. Weights-at-age in this resource have been declining since the mid 1990s. If this trend continues, then yield will be over-estimated. A shift in the proportion of landings from the Bay of

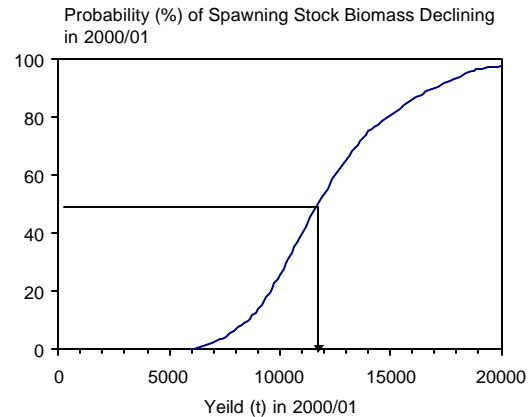
Fundy to the Scotian Shelf where growth is slower would also result in yield being overestimated.

Outlook

This analysis indicates that landings of 8,100t in 1999 will result in an exploitation rate at about the target. The **projected yield** was calculated using recent commercial weights-at-age and partial recruitment. For the 2000/01 fishing year, yield at the target exploitation rate (20%, $F_{0.1}=0.25$) would be 8,200t. Spawning stock biomass would increase to 39,000t in 2001.



It is possible to estimate the uncertainties from the model regarding stock size and then use these in a **risk analysis**. The risk plot incorporates the discrepancy between the accepted model and the data. Other uncertainties not considered in this risk analysis include errors in the model and model formulations, changes in fishing practices, and environmental effects on survivorship. This analysis indicates that at a yield of 8,200t, which corresponds to a 50% risk of exceeding $F_{0.1}$, spawning stock biomass has an 18% probability of decreasing for the 2001/02 fishing year. The probability of spawning stock biomass decreasing for the 2001/02 fishing year increases to 50% at a yield of 10,900t.



This assessment indicates the resource is rebuilding, due to a number of strong year-classes and recent exploitation levels at or slightly below the target level. Spawning stock biomass is near average levels but will decrease until further strong recruitment occurs. There are indications of good recruitment in 1999 as evidenced by the widespread occurrence of age 0 and 1 year old haddock in the surveys. All age classes are widely distributed, a condition usually associated with high abundance in this resource. Fish condition and mean fish size are currently low but increasing.

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Reference

Hurley, P.C.F., G.A.P. Black, P.A. Comeau and R.K. Mohn. 1999. Assessment of 4X haddock in 1998 and the first half of 1999. DFO Canadian Stock Assessment Secretariat Res. Doc. 99/147.

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