



## Eastern Scotian Shelf Haddock

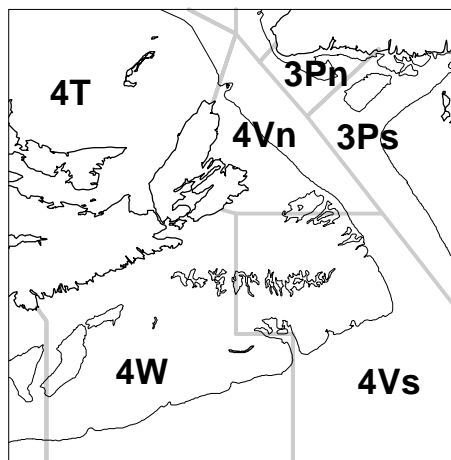
### Background

The haddock resource on the eastern Scotian Shelf and southern Gulf of St. Lawrence is considered a single management unit distinct from the adjacent stock in 4X. The majority of 4TVW haddock occur on the offshore banks of the Scotian Shelf ranging from Emerald Bank in the west to Banquereau Bank in the east.

Haddock prefer hard sand or gravel bottoms at depths ranging from less than 50 m to about 350 m, and temperatures ranging from 4 - 8° C. During summer haddock are distributed on the tops of banks while in winter months they move to deeper waters to avoid cold temperatures. Spawning occurs in spring and the principal spawning areas are the complex of banks in 4W including Emerald, Western and Sable Island banks. In the past, these spawning aggregations were the target of intense fisheries until the imposition of a closed area, which encompasses Emerald and part of Western banks in 1987.

A large female haddock (about 60 cm or 24 inches) can produce several hundred thousand eggs which are liberated near the bottom and rise to the surface during an average incubation period of two weeks. During the first year of life, young haddock actively feed on plankton in the surface waters and gradually descend to the bottom as juveniles in mid-summer. Thereafter, they remain on bottom, feeding and growing at a rate of about 5-10 cm (2-4 inches) in length per year. When sexual maturity is reached after 3-5 years, growth rates diminish. Haddock are relatively long-lived (>10 years) and age is determined from the pattern of rings in their otoliths (earbones). The 4TVW haddock otoliths have been particularly difficult to interpret in the past. However, completion of a recent age validation study has resolved this problem.

Since 1987, the haddock fishery has been regulated through a combination of by-catch restrictions and trip limits. The year-round nursery ground closure established in 1987 (initially exempt to fixed gear) remains in effect. In 1993 the area was closed to all groundfish fishing.



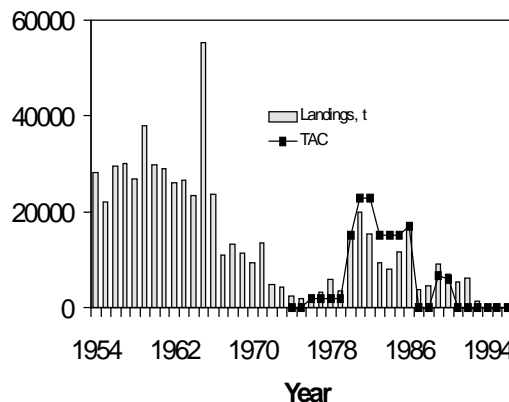
## The Fishery

### Landings, t

Year	1970-	1980-	1992	1993	1994	1995	1996
	79	89					
	Avg.	Avg.					
TAC*	1,333	12,970	..**	..**	..**	..**	..**
Total	5,023	11,362	6,231	1,351	103	135	133

\* = no TAC from 1970-73

\*\* = by-catch only



Annual **landings** averaged about 26,000t from 1960 to 1969, 5,000t from 1970 to 1979, and 11,400t from 1980 to 1989. Since 1987, the fishery has been regulated through a combination of by-catch restrictions and trip limits with a virtual closure since 1994.

Strict by-catch restrictions were in place for those fisheries (such as flatfish) operating in the area in 1996 resulting in total landings of 133t. The year-round nursery ground closure (mainly Emerald and Western banks) imposed in 1987 remains in effect to present. Throughout 1987 to 1992, fixed gear vessels had been allowed to fish inside the closed area resulting in a five-fold increase in landings in 4W to just over 5,200t. In 1993, following the exclusion of all gears from the closed area, landings in 4W fell to just over 800t. Given the severely restricted nature of the fishery in the recent past, it is difficult to compare the distribution of landings by gear type with those of previous years.

### Ageing

A significant bias in the ageing of haddock occurred in the 1980s resulting in the under-ageing of fish at ages four and older. Verified and consistent ageing criteria have now been established and re-ageing of historical otoliths has been in progress since October 1996. The original goal was to age commercial and survey otoliths of haddock using the new ageing criteria back to 1985. This goal was reached for the surveys but not for the commercial samples due to time constraints. Ageing of the commercial samples from 1985 to 1989 has not been completed and the age composition of the landings in those years was derived from annual survey age-length keys. In addition, there are patterns in the resulting data which suggests that further re-ageing of historical otoliths may be necessary (before 1985). Until re-ageing has been fully completed the historical representation of this resource will remain uncertain.

### *Resource Status*

The evaluation of stock status was derived from reported landings, shore and at-sea

based samples taken from commercial landings for size and age composition, research vessel surveys conducted in March and July, and a fixed-gear Sentinel Survey conducted in the fall.

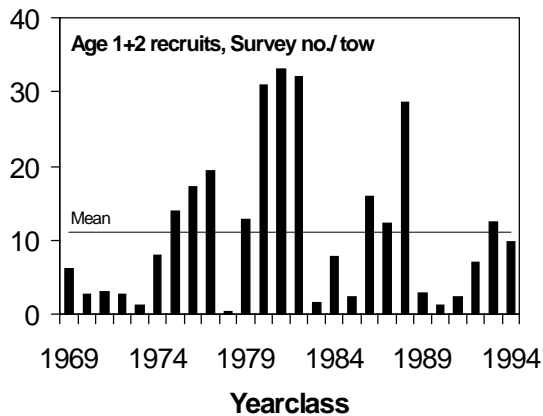
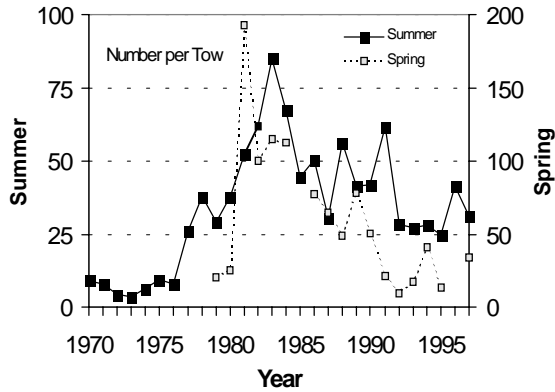
Samples of the **commercial catch** have been difficult to obtain in the past few years because landings were limited to by-catch throughout the year. The numbers at age in the 1996 catch are skewed toward younger ages. This resulted from by-catches in the small mesh gear fishery and although they are very low (40t) have a greater influence on the age structure of the 1996 catch because of the reduction in domestic fleet landings.

There are two **research survey** series available for this stock: a July series starting in 1970 and a March series starting in 1979 (except 1985 and 1996). Both series show a substantial decline in abundance since the late 1980s. The abundance levels have been below the long-term average since 1990 for the spring series and since 1991 for the summer with the exception of 1996.

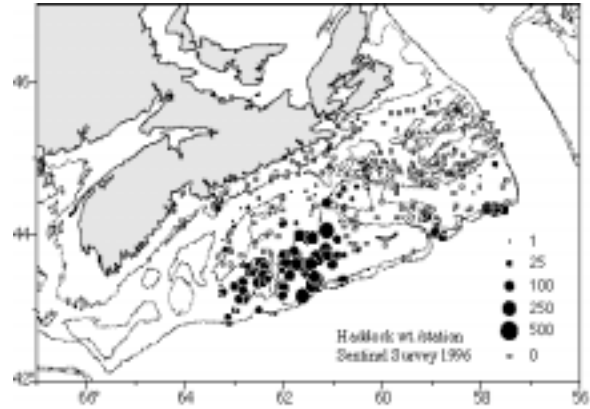
Recent **recruitment**, based on the combined abundance of ages 1 and 2 for each year-class from the July survey, is near average and slightly below average from the 1993 and 1994 year-classes respectively. Recruitment has been well below average for the 1989 to 1992 year-classes which, in part, explains the current low level of older haddock.

**Total mortality** estimates derived from the July survey show high, year-to-year variability. This makes it difficult to draw any firm conclusions about trends in the data. However, total mortality estimates have been relatively stable since 1992 with an average of about 0.4. Total mortality (Z) should approximate natural mortality in a closed

fishery. If this estimate is correct, then the assumed level of natural mortality of 0.2 for this stock may be too low. Further research is required to determine the validity of the current estimate.

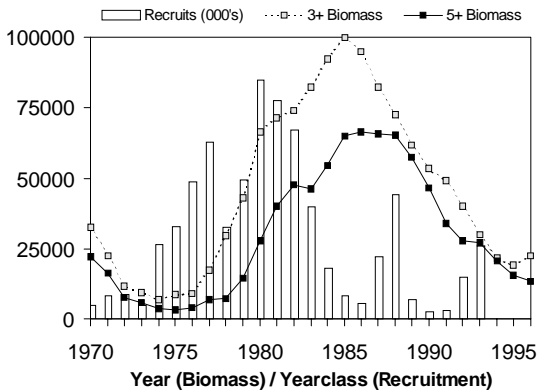


The second annual 4VW **Sentinel Survey** conducted in the fall of 1996 landed a total 7.5t of haddock from a total of 252 standardized longline sets of 1500 hooks (#12 circle). Sets were distributed throughout 4Vs and 4W from inshore waters (inside 50 m) to the edge of the continental shelf.

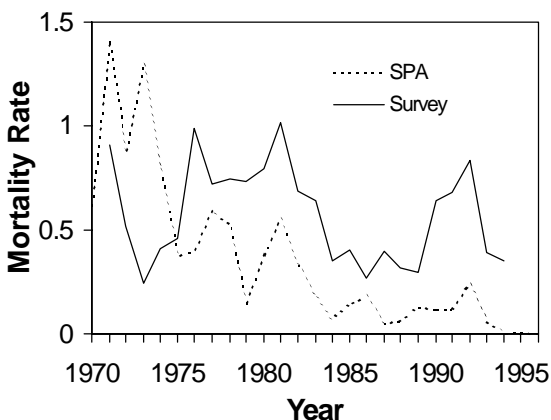


The **catch rate** in 1996 (26 kg per set) was nearly identical to the one in 1995 (22 kg per set) and the distributions were similar as well. Haddock catches were concentrated on Emerald, Western and Sable Island banks with some smaller catches coming from the Gully and edges of Banquereau. Almost no haddock were caught inshore and over most of 4Vs. The most common size haddock caught during the survey was about 43 cm (17 inches) with only about 10% of the total fish caught being larger than 48 cm (19 inches). The Sentinel Survey does not provide an index of prerecruit abundance because of the selectivity of the longline gear.

The standard age-based **population analysis** (SPA) was used to estimate the current status of the stock. The abundance estimates indicate the population is near to historic low levels. The biomass in 1996 of 3 year old haddock and older (3+) is about 23,000t and the 5+ biomass is about 13,000t; the 3+ and 5+ biomass reflects the range of current spawning stock biomass. The estimate of recruitment for the 1993 year-class is below the long-term average of 28 million fish. The 1989 to 1992 year-classes have also been below average. The persistent low levels of recruitment seen in this stock has contributed to the current low spawning stock biomass.



High **exploitation** levels seen in the early to mid-1970s reflect the fact that the fishery was unregulated and in 1974 catch quotas were first imposed on this fishery. The SPA model indicated that exploitation rates have been low since the mid-1980s. Exploitation levels increased slightly up to 1992 reflecting the expansion of the fixed gear fishery inside the 4W closed area. With the removal of all fishing activity from the closed area in 1993 and a closure of the fishery in 1994, exploitation has fallen to the lowest observed since 1970. Also, trends in total mortality from the summer survey alone and fishing mortality derived from the SPA are generally consistent, although the increase in the early 1990s from the survey estimate is more pronounced.



There are a number of **uncertainties** with this assessment. The population analysis

(SPA) presented here using the new ageing criteria resulted in a better fit to the data than previous such analyses of this resource and the severe retrospective pattern that has plagued past evaluations of this resource was not considered as strong. However, the historical representation of the resource generated by the current analysis deviates substantially from previous analyses. For example, while trends in historical exploitation are similar, their magnitude is substantially different with exploitation levels resulting from the previous analyses being much higher during the 1980s and early 1990s. During this same time period, the population numbers are also different, with the current analysis generating estimates of historical population numbers that are much higher than those seen in past analyses.

The causes of these difference are not fully known. However, it is known that the input data to the present analysis have changed for the period 1985 to present and it has a greatly expanded age range relative to the previous ageing criteria used to generate the catch at age. Further re-ageing of historical material is also required.

For these reasons, the historical view of the haddock resource generated by the current population analysis should be considered an interim step until further work is completed.

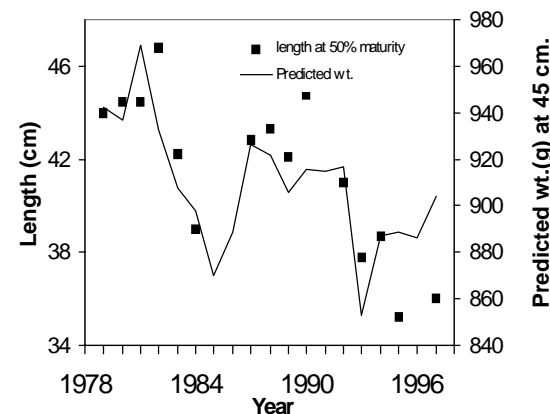
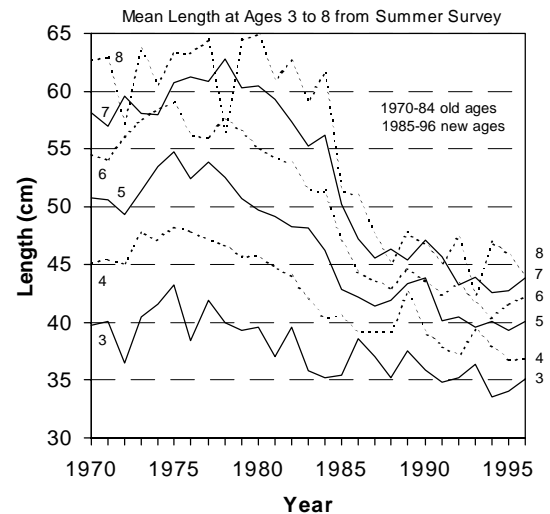
### *Population Considerations*

Substantial long-term declines in **size at age** are evident in haddock age 3 and older. Among the several age groups examined, size at age is at a minimum in the 1990s for ages 4 to 11 years old. At present, very few fish in the stock are larger than 45 cm (18 inches). This suggests the potential for fish to grow large in this haddock stock is currently quite low. Furthermore, reduced size at age does not appear to be an isolated

occurrence in the 4TVW haddock stock and evidence of size reductions has been seen in 4TVn cod, 4VsW cod, and to a lesser extent the eastern component of 4X haddock. The recent resumption of routine ageing for this stock has made this analysis possible. Not only has it provided new insight into growth changes occurring in this stock, it sheds light on an important industry concern that large haddock were disappearing from the stock area and possibly moving into 4X. It now appears that haddock remain within the stock area and grow older but not larger. Recent declines in size at age coupled with a high rate of natural mortality implied by the recent summer surveys could translate into substantial reduction in production and potential yield of the stock.

**Condition**, the relative weight of the fish at a given length, is used as an index of the health of the fish in a stock and the index is derived from the July survey. The condition index of adult haddock has shown a 10 to 15% decline since 1970. Although variable between years, there is a downward trend in the condition index. The cause of low condition in this stock is uncertain. Unlike the adults, juvenile haddock do not show trends in condition.

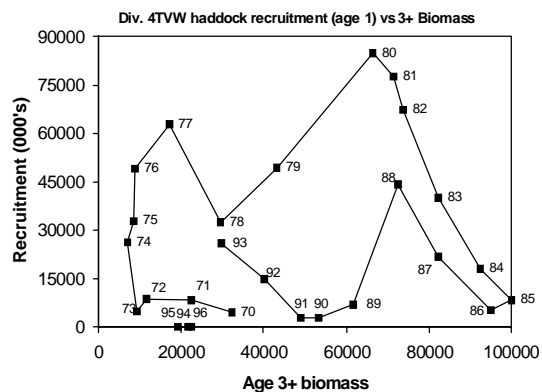
Bottom water **temperatures** on the eastern Scotian Shelf remained cold in 1996, continuing a trend that has persisted since the mid-1980s. The only notable exception lay in the vicinity of Emerald Basin where warm slope water continued to keep near-bottom temperatures higher than average. For 1997, bottom temperatures recorded during the July RV survey in Div. 4VW were similar to those in 1996.



Estimates of the proportion of mature female haddock at length derived from the spring surveys has shown that the **length at 50% maturity** has declined by about 20% since 1990. Prior to 1990, lengths at 50% maturity were generally greater than 42 cm (16 inches) which corresponded to haddock 5 to 6 years old. The recent estimates indicated mature lengths are less than 36 cm (14 inches) and this corresponds to a haddock 3 years old. Maturing at such a small size and lower age could be contributing to the reduced growth potential of haddock. Further, a recent study in progress on the **fecundity** (egg production) of female haddock in 4TVW is showing lower numbers of eggs per female at comparable lengths,

compared to data collected in the early 1980s from the adjacent 4X haddock stock.

The relationship between parent stock and subsequent recruitment, based on the SPA results from 1970 to 1995, reveals several important features. During the 1970s when spawning stock biomass was very low, gradual rebuilding of the stock occurred because of the production of above-average year-classes. Both recruitment and spawning stock biomass levels increased up to the early 1980s. The pattern began to change in the mid-1980s when below average year-classes were associated with high spawning stock biomass levels. Low recruitment has contributed to reduced spawning stock biomass levels, but as yet there has been no evidence of rebuilding as had been seen during the mid- to late 1970s.



## Outlook

The **short-term prospects** for this stock are not encouraging. The adult population biomass is presently low and recruitment has been below average since the mid-1980s with the exception of the 1988 year-class. Some improvement in recruitment has been seen in the most recent years in the summer survey series to levels only slightly below average (1993 and 1994 year-classes). These year-classes could contribute to stock rebuilding. However, the current growth,

condition and reproductive potential of the stock appears to be quite low and the population may not respond as expected to a regime of little or no commercial exploitation. It is expected that the stock will decline given recent low recruitment levels and the disappearance of the last large year-class produced in 1988. A reversal of recent changes in the ecosystem of the eastern Scotian Shelf that have occurred, such as the significant cooling of the bottom waters, increases in capelin and shrimp stocks, and the collapse of cod in the area, may be necessary for improvement in the status of the 4TVW haddock stock.

## For more Information

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## References

Frank, K.T., R.K. Mohn, and J.E. Simon. 1997. Assessment of 4TVW haddock in 1996. DFO Canadian Stock Assessment Secretariat Res. Doc. 97/107.

This report is available from the:

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