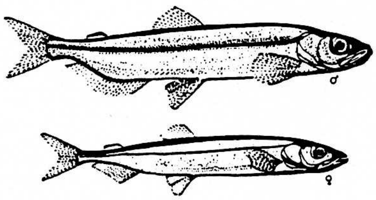


STOCK STATUS REPORT
CAPELIN IN SUBAREA 2 + DIV. 3KL

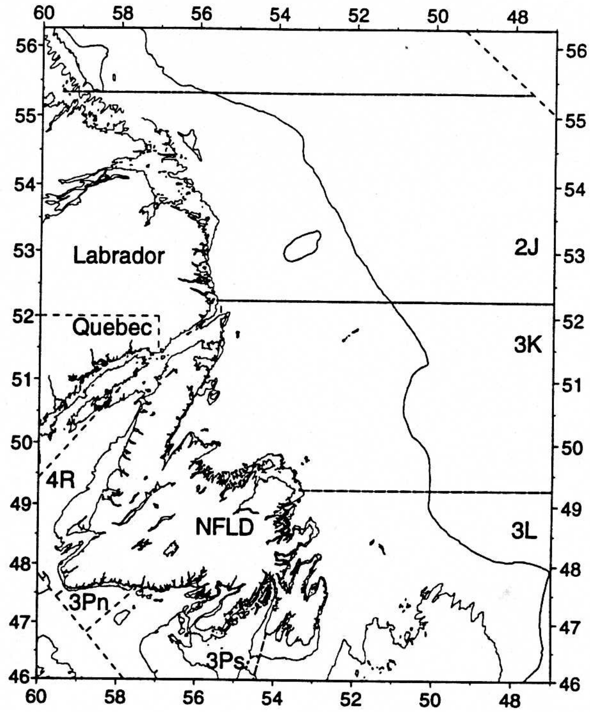
Background

Capelin (Mallotus villosus) is a small pelagic schooling species with major populations occurring in the Northwest Atlantic, in waters around Iceland, in the Barents Sea and in the northern Pacific. For several years, capelin in SA2 + Div. 3K and Div. 3L were treated as two stocks but, as a result of accumulated evidence, scientists recommended in 1992 that capelin in these areas be considered one stock complex.

Adult fish range in size from about 12 to 23 cm with males being larger than females. The spawning populations are composed of mainly three and four year old fish. The short life span and variable recruitment offer the potential for frequent and dramatic changes in mature biomass.

Juvenile capelin of the SA2 + Div. 3KL stock can be found both in major bays and in offshore waters although the northern Grand Bank and Northeast Newfoundland Shelf are thought to be major nursery areas. At maturity, schools of adults migrate inshore to spawn on Newfoundland beaches during June and July. After the eggs have hatched, the larvae exit the beach gravel and most are carried out of the bays rapidly by surface currents.

Capelin are eaten by many predators including seals, whales, cod, Greenland halibut, salmon and seabirds. They are considered to be a key element in the food chain. Because of this prominent position in the ecosystem a conservative approach to their management has been adopted. In the late 1970's, scientists recommended that no more than 10% of the projected mature biomass be removed annually in a commercial fishery.



The Fishery

Historically, a small domestic fishery (annual harvest estimated at about 25,000 t) for capelin on the Newfoundland spawning beaches existed to provide food, bait and fertilizer. A directed foreign offshore fishery began in the early 1970's and was closed in Div. 3L and in Div. 2J3K beginning in 1979 and 1992, respectively. During the late 1970's, an inshore fishery for roe capelin began. Throughout the 1980's, the inshore fishery usually started by mid-June in the south and finished about mid-July in the north.

Gear types in the inshore fishery are traps, purse seines and, to a lesser extent, beach seines. The primary market is for frozen roe-bearing female capelin in Japan. This market is limited and the demand for quality is high. Failure to meet quality standards results in discarding. Most discarding is believed to occur after the fish are landed and since the TAC is applied to the landings, these discards are accounted for in the application of the TAC.

In 1994 and 1995, the average size of female capelin in most areas was too small to meet the management plan size criterion of 50 count/kg (sea run). As a result, the fishery either did not open or opened for only a short time and catches were low. In 1996, the management plan did not include a size criterion. In much of the area in 1996, fish were of marketable size and most of the TAC was taken. A summary of catches and TAC's (tons x 10^{-3}) since 1991 is given below:

	1991	1992	1993	1994	1995	1996	1997
SA2 + Div. 3K							
Offshore							
TAC	57	0	0	0	0	-	-
Nominal catch	0.5	0	0	0	0	-	-
Inshore							
TAC	29	17	11.4	11.5	11.5	9.7	11.4
Nominal catch	20	18	13[a]	<.1[a]	<.1[a]	8.9[a]	5.5[a]
Div. 3L							
TAC	56	19.3	21	21	22	18.3	21.7
Nominal catch	22	3	23[a]	1[a]	1[a]	16.8	3.6[a]
SA2 + Div. 3KL							
Total nominal catch	42.5	21	36	1	1	25.7	9.1

[a] provisional

In 1997, the management plan again did not include a size criterion. However, fish were monitored by the industry with the aim of opening the fishery when fish met market requirements. Capelin were smaller in Div. 3L than Div. 3K and this is reflected in the catches.

Since 1991, the fishery has been delayed by up to four weeks because of the late arrival of capelin, which has been linked with below normal water temperatures.

Multispecies Considerations

No new consumption estimates were considered in this assessment, however, such estimates were available last year. Harp seals are estimated to have consumed about 800,000 tons of capelin in Div. 2J3KL in 1996. Puffins are estimated to consume about 12,000 tons during the breeding season alone. Consumption estimates for puffins outside the breeding season, for other seabirds and indeed for many other predators are not available for recent years. Previous estimates for cod consumption indicated that during the early 1980's, cod were consuming 1 to 3 million tons of capelin annually. During the same time period, a minimum of 100,000-200,000 tons of capelin was estimated to have been consumed by Greenland halibut. Although consumption estimates can vary depending on the assumptions underlying the calculations, they serve to illustrate sustenance provided to predators. Because the consumption estimates are calculated using predator abundance, they will vary with the marked changes in abundance of the various predators over time.

There is considerable evidence that seabird ecology has changed in recent years. Differential breeding success of two species of seabirds in the Witless Bay area during the 1990's appeared to be related to the vertical availability of capelin. Kittiwakes, which are shallow divers, experienced relatively low breeding success during the early 1990's. Breeding success improved during 1996 and 1997 and approached historical levels.

The timing of kittiwake breeding was later in the 1990's, and like the delay in capelin spawning, appeared to be related to environmental factors. Puffins are a deeper-diving species and in contrast to kittiwakes, they have experienced good breeding success during the 1990's.

On Funk Island, gannet chick diets have shown a food change over two decades (1977-97) with capelin occurring in higher proportions in the 1990's. This shift to capelin is believed to be a result of greater availability of capelin during the chick feeding period, consistent with the later capelin spawning during the 1990's, and lower availability of warm-water species such as mackerel and squid.

At the Gannet Islands, off the coast of Labrador, thick-billed and common murres were consuming lower proportions of capelin in 1996 and 1997 compared to historical feeding rates. This decline in the diets was consistent with other evidence that indicated that capelin have been lower in abundance in the same area. However, neither seabird species experienced decreased breeding success and growth rates were good.

Biology and Resource Status

During the 1990's, several biological changes, coincident with below normal water temperatures, have been documented. During offshore fall surveys in the 1980's, capelin were widely distributed from Div. 2J to Div. 3L, with a cline of larger to smaller capelin from north to south. In the 1990's, few capelin have been observed in Div. 2J and northern Div. 3K while most have been detected in southern Div. 3K and northern Div. 3L. The trends in size have been similar to the 1980's with larger capelin occurring in the northern part of the new distribution range and smaller capelin in the south. Also during the 1990's, capelin abundance measured by acoustic surveys was low.

During the late 1980's and through the 1990's, capelin bycatches increased one hundred fold in groundfish surveys on the eastern Scotian Shelf (Div. 4VW). Capelin occur sporadically in this area and as a result, it is not known whether the increase was a result of immigration or enhanced reproductive success. Capelin also appeared on the Flemish Cap (Div. 3M) during the 1990's as bycatch in groundfish surveys and the shrimp fishery. Capelin are rare here and this appearance was most likely due to migration. Increases in abundance in both areas, both historically and recently, have coincided with cold water.

The average size of capelin has declined during the 1990's. At the same time, the timing of inshore spawning has been delayed by up to four weeks. The later spawning has been correlated with colder water and smaller fish size.

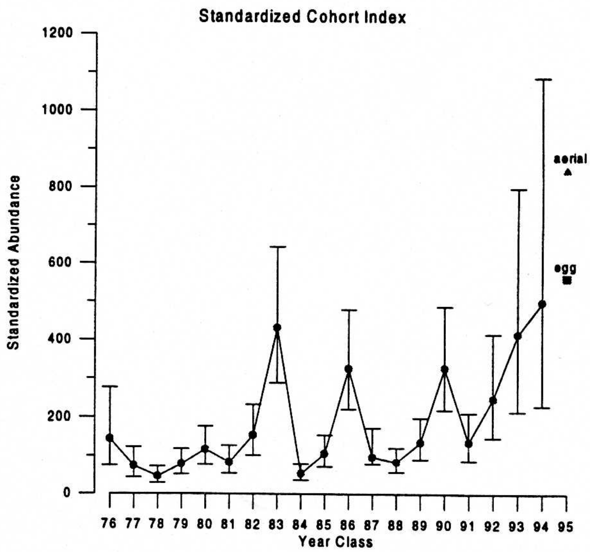
Other observations of unusual characteristics of capelin biology during the 1990's, not documented in the scientific literature, include: an increase in the relative proportion of spawning at night; changes in physical structure of the otoliths causing problems in age determinations; an increased incidence of females with ovaries full of unspawned eggs in the fall; a consistent and relatively high level of the proportions of spent females in the fall since 1992.

In the evaluation of resource status, seven partially overlapping series of indicators were combined in a mathematical model to provide relative estimates of yearclass strength. The indicators used in the model were:

1) aerial survey index 1982-97
2) purse seine catch rate index 1981-96
3) trap catch rate index 1981-93
4) groundfish 3L fall bycatch 1985-94
5) groundfish 2J3K fall bycatch 1985-94
6) Russian 2J3K fall commercial catch rate index 1972-91
7) egg deposition index 1990-97

The aerial survey and egg deposition index provided the only information on the 1995 yearclass and the 1997 mature biomass in this formulation of the mathematical model. The 1997 aerial survey index was lower than the 1996 estimate. It was the fourth highest in the series and higher than all but one (1987) of the estimates from the 1980's. Egg densities in Bellevue Beach were the second highest in the series (highest in 1993). Catch rate data from purse seines and traps for 1997 were not considered to be indicative of stock status because the fishery was very contracted both spatially and temporally. A change in the gear in the fall groundfish survey in Div. 2J3KL in 1995 has effectively produced a new series which is too short to use.

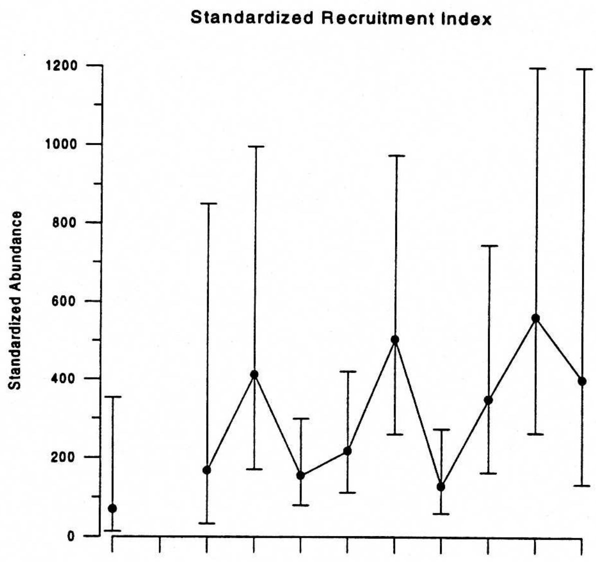
Results from the model indicate that the 1983, 1986 and 1990 yearclasses were strong. Yearclasses since 1992 also appear strong but the standard errors were so large that the relative abundance of these yearclasses is statistically indistinguishable from both large and less abundant yearclasses.



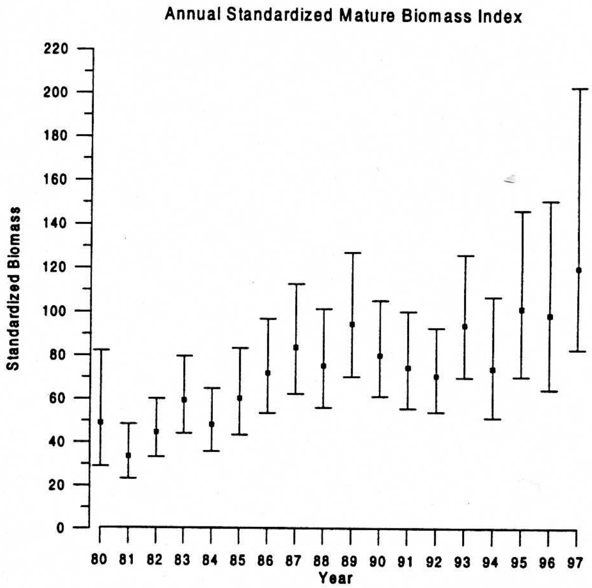
A second mathematical model using results from surveys for larvae and one-year-olds produced a recruitment index. The indicators used in the model were:

1) oceanic 0-group index 1991-97
2) sediment larval index 1990-97
3) emergent larval index 1990-96
4) Conception Bay sediment larval abundance 1987-93
5) oceanic age 1 index 1992-97

This recruitment index shows trends in yearclasses up to 1993 that are similar to trends in the cohort index. After 1993, the largest difference between these two indices occurs for the 1994 yearclass which in the recruitment index is relatively weak. The 1995, 1996, and 1997 yearclasses appear strong with the 1996 yearclass as strong as any in the series. Although the estimates of yearclass strength exhibit considerable variation, the statistical uncertainties are large.



A third mathematical model (using the same seven series of indicators as the cohort model and which includes an assumption that recruitment does not change) provided trends in mature biomass. The trends indicate that biomass was relatively high in the late 1980's and in the more recent years in the 1990's, consistent with the presence of strong yearclasses. However, standard errors are large and biomasses from the mid-1980's to the present are not statistically different.



The assessment of the capelin stock described above is more optimistic than the results from an opinion survey of capelin fixed gear fishermen. Most respondents considered capelin abundance to have decreased from 1996. This survey has been conducted for four years and in each year, fishers indicated that the abundance of capelin has been lower than when they first started fishing capelin.

Sources of Uncertainty

Many sources of uncertainty have been cited in previous stock status reports. These included the large-scale changes in distribution, the unreconciled divergence between low offshore acoustic estimates and inshore indices in the 1990's, difficulties in ageing capelin in the 1990's compared to earlier years and the large statistical uncertainties from the mathematical model. The mathematical models used assume that a number of things are constant over time; for example, maturity schedules, survival rates and for the biomass model, yearclass strengths. The effects of violations of these assumptions have not been examined.

There is particular concern about whether the individual indices are now providing reliable indicators of stock status. During the 1980's, catch rates and other indices showed similar annual patterns. However, catch rates may now be poor indicators of stock status. Fishing effort has declined in recent years, due in part to monitoring for quality and fishing only when the fish meet market requirements. This results in catch rates which probably cannot be compared to the 1980's and may not reflect stock status. Both the aerial survey and egg deposition studies which provide fishery-independent indices, have been reduced in geographical coverage and/or intensity. The aerial survey now covers only the transects in the inner parts of Trinity and Conception Bays. The only beach study area is Bellevue Beach compared to six study beaches (three in each of Div. 3L and 3K) in the original study. There are two major concerns with the 1997 aerial and beach surveys: 1) they are so limited in geographical coverage compared to the overall stock area that the results may not reflect status of the whole stock, and 2) there are indications from the opinion survey that abundance may be changing at different rates within the stock area, for example, within the bays versus near headlands. If this is the case, the limited geographical coverage by the aerial and beach survey may not detect these changes. While the offshore surveys for early life stages (primarily 0- and 1-group) are continuing, acoustic surveys for older juveniles and adults have been discontinued. Scientific investigations have been reduced to such an extent that it may not be possible to assess the status of capelin stocks.

There is also concern over the divergence between the assessment using the mathematical model and the opinions of fixed gear fishermen, particularly the contradiction in comparisons between the 1990's and earlier periods. A longer timeseries and further evaluation are necessary to determine whether the opinion survey can be used as a stock status indicator but this evaluation will be very difficult without other sources of data, which as noted, may be compromised by reduced coverage.

Outlook for 1998

The 1994 and 1995 yearclasses are expected to be major contributors to the 1998 spawning stock. The results from this and previous assessments on the relative strength of the 1994 yearclass are contradictory. The recruitment index indicates the 1994 yearclass is relatively weak while the cohort index indicates this yearclass is relatively strong. The 1995 yearclass is stronger than the 1994 yearclass from both the recruitment and cohort indices. The recruitment index, which incorporates several observations of the strength of this yearclass, indicates that it is about average strength (1987-97 yearclasses). If the conservative estimates of yearclass strength for the 1994 and 1995 yearclasses as derived from the recruitment index are considered, the 1998 mature biomass would be expected to be no better than average, when compared to biomasses of the 1990's.

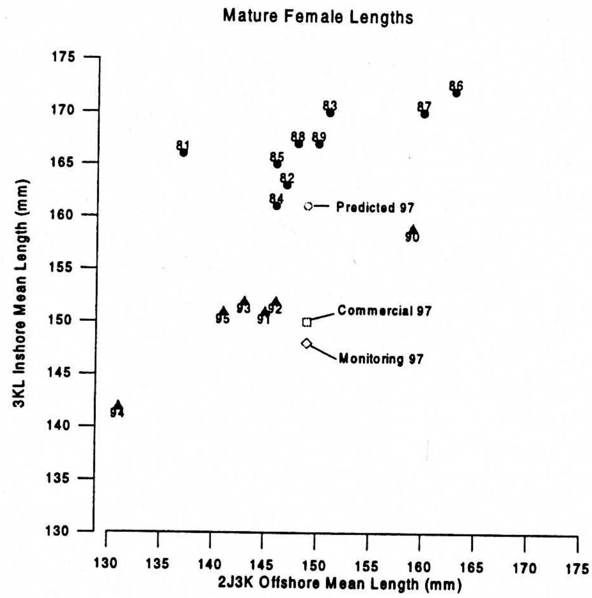
The TAC of 33,000 tons in 1977 was about 65% of the average inshore TAC (51,000 tons) during 1990-95 and about 79% of the average inshore TAC (42,000 tons) during 1982-89. Although there is a great deal of uncertainty in the indices, it would appear that the capelin stock has not exhibited any extreme changes in abundance during the 1990's. Given the above considerations, there is no biological basis to suggest alterations to this TAC.

There have been many problems and uncertainties in assessing the capelin stocks in recent years related in part perhaps to changing behaviour during unusual oceanographic conditions, as well as reduced directed scientific research. It is unlikely that future assessments will be improved at the current level of research activity.

Sizes of Females

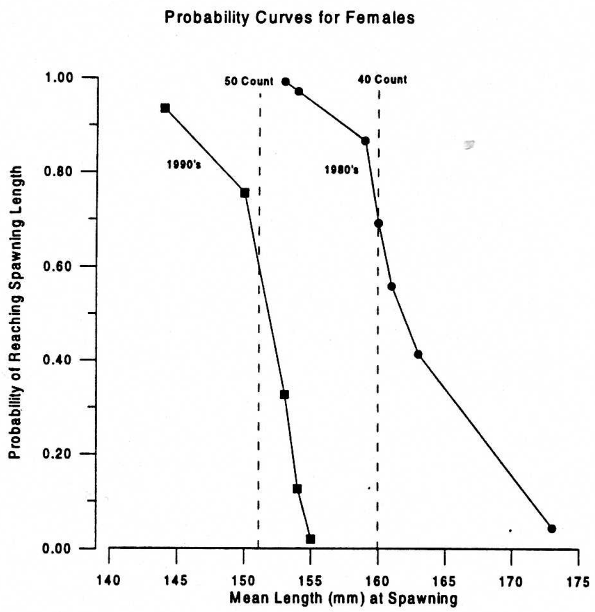
The average size of female capelin inshore in 1997 was smaller than predicted in last year's assessment. The exact reasons for this are not known but possibilities include inadequate sampling during the fall of 1996 and/or spawning season of 1997 and different ecological regimes during the 1980's and 1990's. The latter possibility can be seen in the figure where data points in the 1980's and 1990's are clustered separately.

This possibility is consistent with other changes in capelin biology including large-scale changes in offshore distribution and later spawning.



It is not possible to predict growth between the fall of 1997 and the spring of 1998. However, using growth increments derived from the above figure, probabilities of achieving a range of final lengths were calculated using a starting mean length of 144 mm in the fall of 1997 derived from bycatch from the fall groundfish survey in Div. 2J3KL. Probability curves were calculated separately for data from the 1980's and 1990's.

These curves can be used to provide guidance on approximate counts in the mature female population in 1998 (counts are approximate because the weight-length relationship varies during the maturation process), depending on whether growth is more typical of the 1980's or 1990's. If growth increments resemble those observed in the 1990's, there is about a 60% probability that the average count will be 50 or less. On the other hand, if growth is more typical of the 1980's, there is a 100% probability that counts will average 50 or less. This analysis is based on pooled data from the stock area and consequently, it is not possible to account for differences that may occur between geographical areas and between spawning runs.



For More Information

Research Document:

Anonymous. 1998. Capelin in SA2 + Div. 3KL. CSAS Res. Doc. 98/63.

Carscadden, J., B. S. Nakashima, and K. T. Frank. 1997. Effects of fish length and temperature on the timing of peak spawning in capelin (Mallotus villosus). Can. J. Fish. Aquat. Sci. 54: 781-787.

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