Capelin of the Estuary and Gulf of St. Lawrence

Background

Capelin (Mallotus villosus) is a relatively small, coldwater marine fish species with a circumpolar distribution. In eastern North America, the species occurs along the coast of Labrador and Newfoundland, on the Grand Banks, and in the Estuary and Gulf of St. Lawrence (Figure 1). Capelin were abundant in the Bay of Fundy during the 1960s and have been present on the eastern Scotian Shelf since the mid-1980s. Their presence in those regions is linked to below normal water temperatures. The colder water temperatures of recent years may have affected the species' growth rate, which would explain the reduction in individual fish size observed in the early 1990s. As a result of the smaller size of the capelin, the fishing season was cut short in 1994 and the fishery was closed almost completely in 1995. However, the situation has returned to normal over the past three years.

Capelin plays a key role in the food chain by transferring energy from primary and secondary producers to higher tropic levels. It is an important food resource for other fish species such as cod and salmon, as well as for certain birds and marine mammals whose migrations are linked to its presence. Preliminary estimates show that predators consume up to a million tonnes of capelin annually in the Gulf of St. Lawrence. In light of those estimates, it seems clear that the commercial fishery removes only a small portion of the total biomass.

The capelin fishery in the Estuary and Gulf of St. Lawrence developed rapidly with the emergence of a Japanese market for roe-bearing females in the late 1970s. Annual landings have risen to nearly 10 000 t from a level of less than 2 000 t back then. The bulk of catches are made with purse seines in a fishery conducted on the west coast of Newfoundland. In addition to being taken by recreational fishers on beaches during the spawning period, capelin is a by-catch of the shrimp fishery. Although its population structure has not been clearly defined, the species is managed based on two distinct management units, NAFO divisions 4ST and 4R (Figure 1). At present, no abundance survey is undertaken for the species, although relative indices are computed using data from two groundfish surveys, conducted in August and September in the northern and southern Gulf of St. Lawrence.

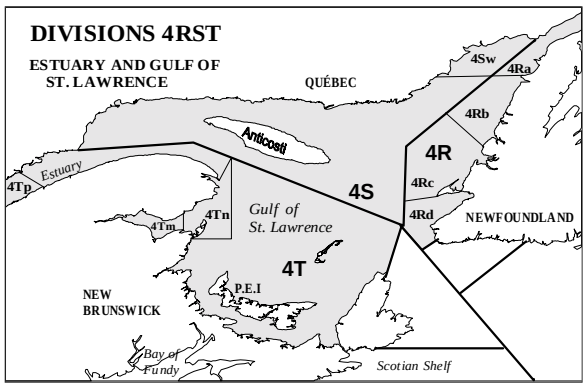


Figure 1. Map of North Atlantic Fishery Organization (NAFO) divisions and unit areas associated with the capelin fishery in the Estuary and Gulf of St. Lawrence.

Summary

- Capelin is undoubtedly one of the most important **forage species** of the Estuary and Gulf of St. Lawrence. Annual **consumption** of capelin by its main predators is estimated at several hundred thousand tonnes.
- 1998 capelin **landings** in NAFO divisions 4RST currently stand at 9,077 t, which represents an increase of just over 1,200 t from 1997.
- The **purse seine** fishery on the west coast of Newfoundland accounted for the bulk of capelin landings in 1998. The 6,000 t **quota** allocated to large and small seiners was even exceeded.
- In Chaleur Bay, nearly 800 t of fish was caught in June during an exploratory fishery using **pair trawl**.
- The temporal pattern of catches has returned to normal, given that the start of the 1998 fishing season was not delayed, as was commonly the case in the early 1990s.
- Furthermore, the gradual decline in the size of individual capelin, which triggered the premature halt to fishing in

1994 and the nearly complete closure in 1995, has not been observed since 1996.

- Capelin are still present in the southern Gulf of St. Lawrence, however the **range extension** noted in recent years appears to have stopped in 1998.
- The **mean weights** of catches per tow and **percentages of occurrence** computed from an abundance survey done with a bottom trawl in the northern Gulf have shown a downtrend since 1996. The mean weights calculated in 1998 are among the lowest recorded since 1990. However, these values are difficult to interpret owing to uncertainty over the use of this type of survey in assessing the abundance of a pelagic species like capelin.
- **Postspawning mortality** and **predation mortality** are very high among capelin. The present catch level has little bearing on fluctuations in the abundance of this species.
- In view of the sketchy knowledge of capelin biology, the absence of a separate abundance survey for the species and its prominent position in the marine ecosystem, any increase in the catch level must be implemented **gradually**.

Biology

Capelin spawn around three years of age and may live for five or six years. During the spawning period, males can be distinguished from females by their larger fins and the presence of two pairs of spawning **ridges** (four rows of elongated scales), one dorsally and the other ventrally. Spawning, which is preceded by a mass shoreward migration, occurs on beaches or in deeper water. During beach spawning, the capelin literally ***"roll"*** on sand or fine gravel, whereas the second type of breeding takes place in waters from 30 to 125 m deep (17-70 fathoms). On the west coast of Newfoundland, like elsewhere in the Gulf of St. Lawrence, spawning takes place at specific locations and may sometimes be sporadic due to annual fluctuations in water temperature. The beach spawning period lasts from four to six weeks, falling sometime between mid-April and July, but with increasingly later starting dates as one moves from west to east. At spawning sites, the males and females gather in separate schools. Mature males reach the beaches first and await the arrival of the females, which remain offshore longer. A large proportion of these capelin die after spawning, particularly the males, which are injured in repeated matings on the beach. Nonetheless, the survivors have the ability to spawn again over the coming years. Capelin eggs adhere to the gravel substrate, and the incubation period and the amount of time the larvae spend on the gravely bottom vary with the water temperature. The larvae soon become pelagic, remaining near the water surface until winter arrives.

Capelin do most of their **growing** during the first two years of life. From the age of two, the males are physically larger than the females (Figure 2a). Factors such as water temperature can have a major impact on the species' growth. Males and females have identical weight-length relationships (Figure 2b); however, since females are smaller, the range of lengths differs.

Capelin feed mainly on **plankton** (e.g. euphausiids, copepods, amphipods) but their feeding patterns vary with the seasons. For example, feeding stops almost completely during spawning, then gradually resumes.

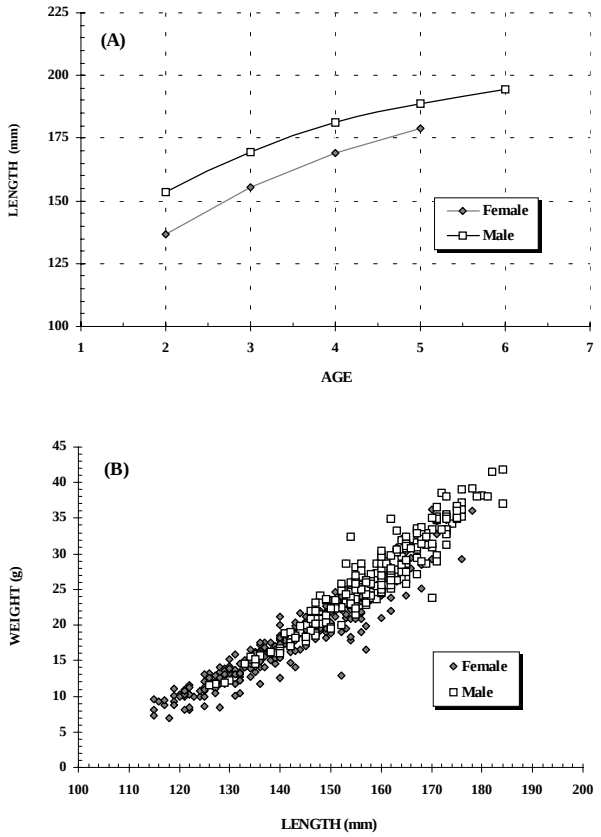


Figure 2. Length at age (A) and weight-length relationships (B) for the capelin of the Estuary and Gulf of St. Lawrence.

Description of the fishery

On an international scale, the largest catches of capelin are generally made in the **Barents Sea**. The main world markets for capelin are associated with this fishery, a situation that can be a hindrance for markets in Eastern Canada. Commercially, capelin has not been a much sought-after species. In Eastern Canada, the species has been used to produce farm fertilizer, food for human consumption, bait for cod fishing, and, more recently, fish meal. The emergence of a **Japanese** market for roe-bearing females has attracted the attention of Canadian fishers. Japanese demand is responsible for the sharp increase in landings, which totalled about 10,000 t in 1978 and 1979 and also between 1989 and 1993 (Figure 3).

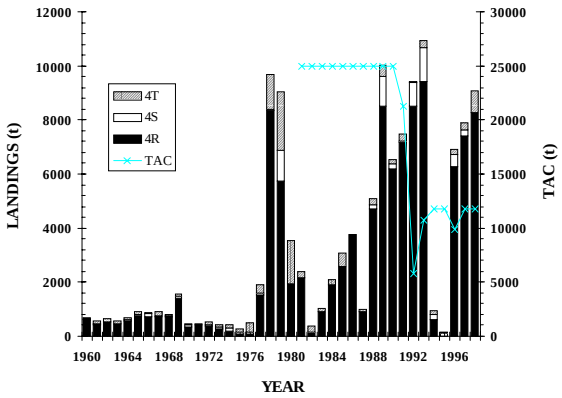


Figure 3. Capelin landings and TAC (t) in NAFO Divisions 4RST.

The fishing season is short and corresponds to the prespawning period, in the seine fishery, and to the spawning period, in the trap fishery. In both cases, the fishery chiefly targets mature females with the aim of meeting demand for roe capelin. The largest landings in the Gulf of St. Lawrence are nearly always made on the west coast of Newfoundland, that is, in Division 4R (Figures 1 and 3). In divisions 4R and 4S, the most intensive fishing generally takes place in June and July. By contrast, in Division 4T, the fishery sometimes begins as early as April, but the biggest landings are made in May and June. **Purse seines**, **traps** and **weirs** are used in most capelin catches in the Estuary and Gulf of St. Lawrence.

Main requirements of the 1998 management plan

In 1998, as in 1996 and 1997, landings were required to comprise at least 30% females (in number), which meant that fishers had to sample their catches at sea to determine the percentage of roe-bearing females. Discarding and unnecessary losses of capelin, along with the presence of large quantities of juvenile cod, were all factors that could trigger closure of the fishery. By-catches had to be returned to the water, and in order to prevent them a prohibition was placed on the use of monofilament in the construction

of the leaders used with traps. These trap net leaders also had to have mesh of the prescribed dimensions. If fishers attained the quotas for a given area, they were required to move to a new area. The industry was required to defray the costs associated with dockside monitoring and 5% at-sea observer coverage of fishing activities.

The total allowable catch or **TAC** for all of Eastern Canada was 47,545 t in 1998. The TAC was set at 10,000 t for Division 4R and 1,725 t for Divisions 4ST. This sharing of the TAC between the east and west coast of Newfoundland, and between the divisions within the Gulf of St. Lawrence, is not based on biological factors.

The fishery in 1998

In 1998, capelin landings in the Estuary (unit area 4Tp; Figure 1) and the Gulf of St. Lawrence (Division 4R and unit area 4Sw) totalled 9,077 t, up just over 1,200 t from the 1997 level (Figure 3). For the most part, the increase (800 t) derives from an exploratory fishery conducted with pair trawl in Chaleur Bay in June (unit areas 4Tm and 4Tn).

From the end of the 1980s through the early 1990s, the fishing season was generally **delayed** (Figure 4a). However, since 1996 an opposite trend has been observed, and in 1998 fishing activities occurred on approximately the same dates as in the late 1980s. Since the early 1990s, there has been a steady decrease in the mean size of female and male capelin (Figure 4b). This decline resulted in a shortened fishing season in 1994 and an almost complete closure in 1995. Since that closure, the mean size of individual fish increased between 1994 and 1996 and has held fairly steady ever since.

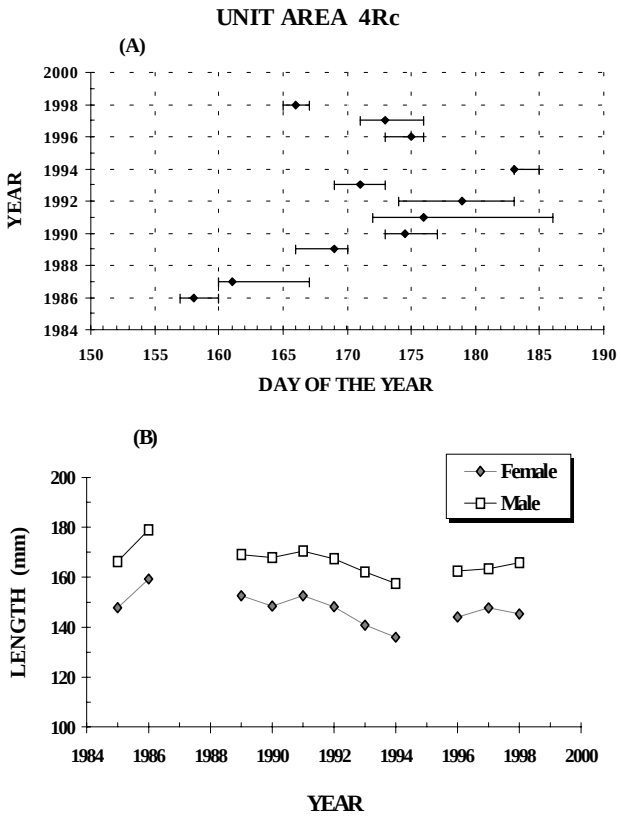


Figure 4. Temporal fishing pattern (A) (Symbol = median date of catches; bars = dates by which 25% and 75% of catches were made) and mean annual lengths of females and males caught with purse seines in unit area 4Rc (B).

This reduction in capelin size can also be seen from the annual **length frequencies** (Figure 5). In most cases, the length frequency distributions are unimodal owing to the overlapping lengths among the different age groups.

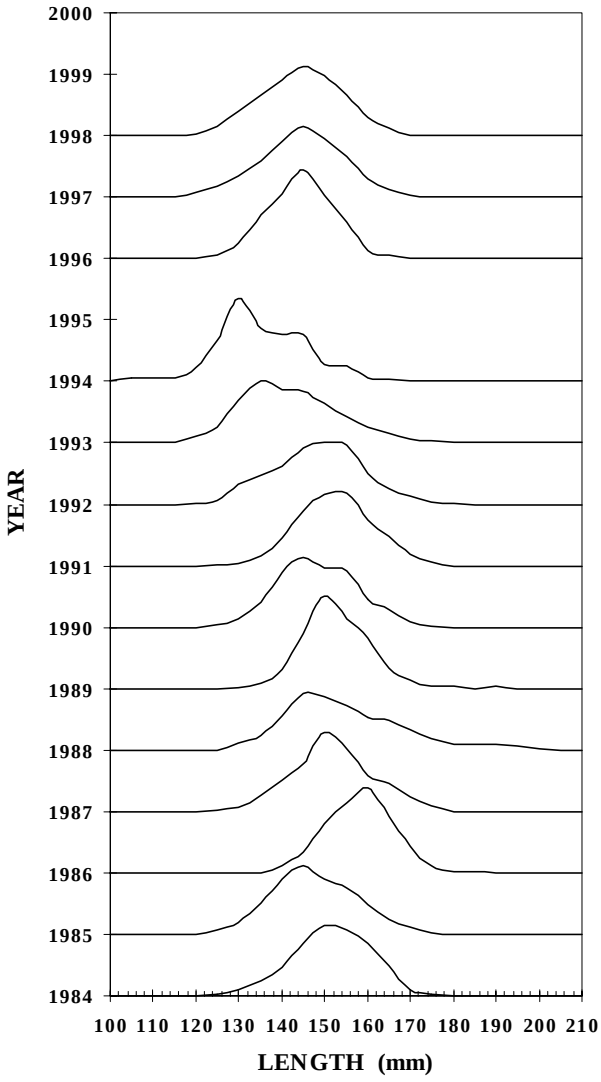


Figure 5. Size composition of females caught with purse seines in NAFO Division 4R (no samples were collected in 1995 because of the absence of fishing).

Comparison of the **mean number of capelin per kg** shows that the size of the capelin sampled in Divisions 4R and 4S in 1998 is greater than that in Division 4T (Figure 6). In Division 4R, the number is generally under the threshold level of 50 capelin per kg. Whereas in Division 4S there has been a steady decline in mean numbers of capelin per kg since 1993, in Division 4T the mean number has remained above the threshold value during this period.

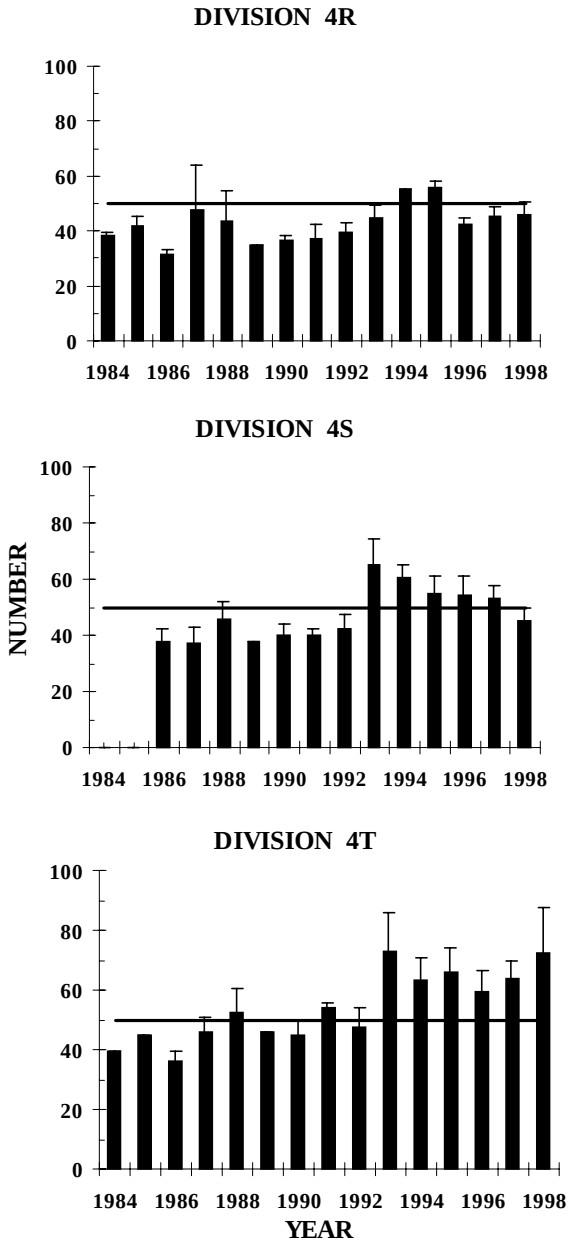


Figure 6. Mean numbers of capelin per kilogram (the bars represent the standard deviation) in NAFO Divisions 4RST (the horizontal line indicates the threshold of 50 capelin per kg used as a management measure until recently).

Capelin by-catches

During the period from 1990 to 1998, at-sea observers sampled up to 9,000 tows per year in the Estuary and Gulf of St. Lawrence. Owing to the imposition of **moratoria** on cod fishing in 1994 and on redfish fishing in 1996, shrimpers have largely been responsible for the capelin by-catches of the past few years. Annual by-catches of capelin by shrimp fishers are estimated at about 600 t. Between 1990 and 1996, 6% to 16% of all tows sampled contained capelin, with the corresponding value rising to 50% in 1997 and then falling to 16% in 1998. Mandatory use of the **Nordmore grate** by shrimpers, a requirement phased in as of 1993, has helped to reduce catches of capelin.

Abundance indices

Since 1990, a **bottom trawl** survey has been conducted to calculate shrimp and groundfish abundance in the northern Gulf of St. Lawrence. Because capelin catches are a regular occurrence during the survey, the relative abundance of this species is also derived from the data. Nonetheless, it is recognized that this type of survey is not entirely suitable for a pelagic species like capelin.

In 1998, as in previous years, the largest concentrations of capelin in the northern Gulf occurred around Anticosti Island, as well as in the northern part of the Esquiman Channel (Figure 7) on the west coast of Newfoundland.

In 1997, the dominant **length classes** were between 130 mm and 150 mm (Figure 8). A large part of these catches consisted of immature individuals. Although this mode was still present in length class distributions in 1998, they were characterized more by a mode at 100 mm. The latter mode may point to the presence of a strong year-class, which should be watched closely over the coming years.

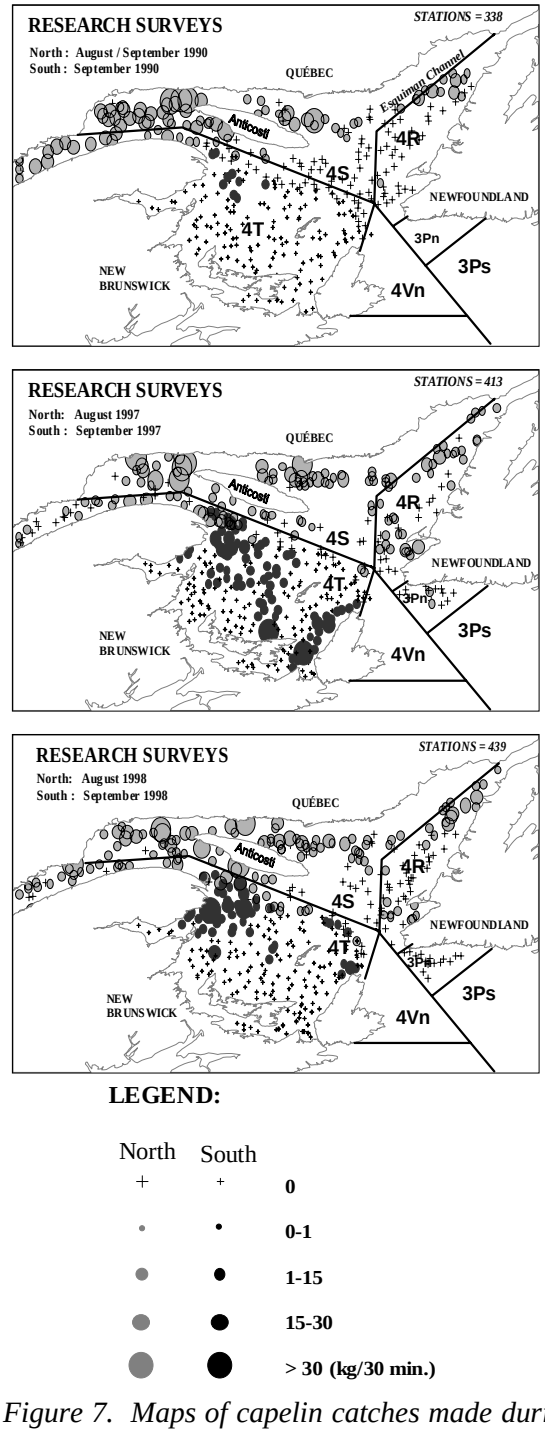


Figure 7. Maps of capelin catches made during shrimp and groundfish abundance surveys in the Gulf of St. Lawrence. These surveys use gear types with differing selectivity and the corresponding tows are distinguished by symbols of various colours.

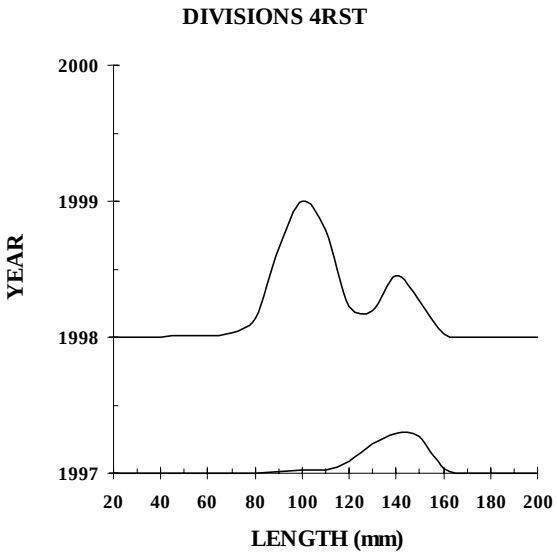
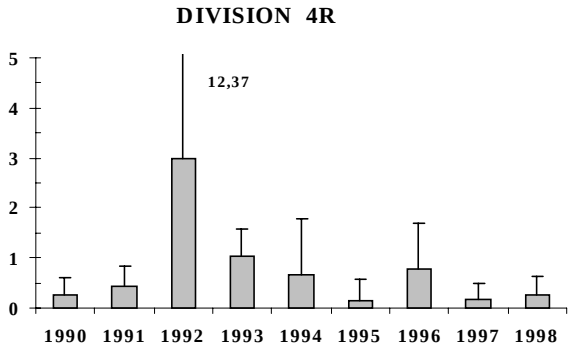


Figure 8. Capelin size distributions from the abundance surveys conducted aboard the Alfred Needler since 1997. The mean number of capelin per tow for each length class was used in deriving the curve.

Mean weights per tow

The **mean weights** of the capelin catch per tow vary widely from year to year. They followed a marked downtrend in Divisions 4RST between 1990 and 1995 (Figure 9). The highest value was recorded in 1996, and the estimate for 1997, albeit lower than the 1996 value, was close to the levels observed in the early 1990s. By contrast, the 1998 value is one of the lowest in the entire series. The mean weight of the capelin catch per tow was still higher in Division 4S than in divisions 4R and 4T (Figure 9).



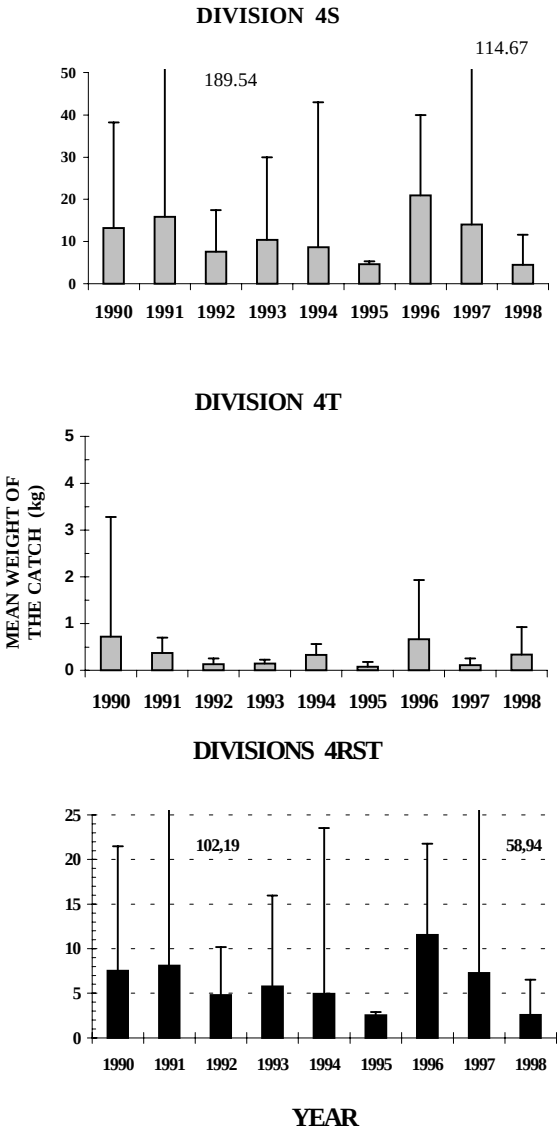


Figure 9. Mean weights (kg) of capelin catch per tow from the Alfred Needler surveys (the vertical lines represent the upper limits of the corresponding weights).

Occurrence index

In the northern Gulf, the extent of the geographic range of capelin is determined from the **occurrence index**, which corresponds to the percentage of tows in which capelin are present. The index is adjusted to account for the differing number of tows conducted per unit of sampled area. Between 1990 and 1997, the occurrence index showed an up-

trend, indicating that the species' geographic range had expanded in the northern Gulf (Figure 10). This index (adjusted and unadjusted) has declined steadily since 1996.

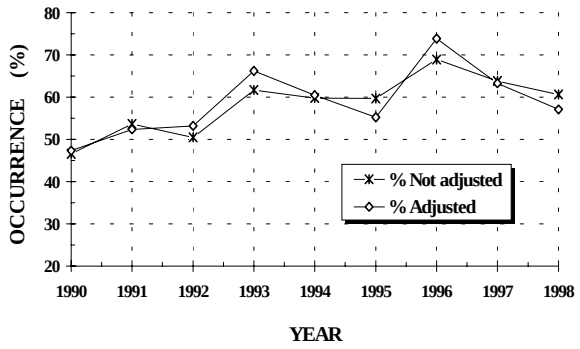


Figure 10. Capelin occurrence from the Alfred Needler surveys since 1990.

A groundfish abundance survey is also carried out every year in the southern Gulf of St. Lawrence under the supervision of the Department of Fisheries and Oceans, Maritimes Region. In 1998, 48 out of a total of 206 tows contained capelin. These tows were made off the Gaspé Peninsula and near the northern tip of Cape Breton Island. The capelin by-catches observed in earlier surveys provided clear-cut evidence of a considerable expansion in the species' geographic range in the Gulf region during between 1990 and 1997 (Figure 7). However, from an analysis of the locations of the 1998 tows in which capelin were caught, it appears that there has been a significant contraction in this geographic range. However, the numbers and mean weights per tow were higher in 1998 than in 1997, which means there is a larger concentration of capelin spread over a smaller area.

Assessment and prognoses

The recent **drop** in water **temperatures** in the Gulf of St. Lawrence appears to have significantly affected various aspects of the life cycle of certain commercial fish species. In the case of capelin, the temperature decrease appears to be the main factor behind the range extension observed for capelin between 1990 and 1997 throughout the Gulf and even on the eastern Scotian Shelf. Lower water temperatures also affect the growth rate of fish, possibly explaining the reduction in capelin size noted in the early 1990s which led to an early halt to fishing in 1994 and an almost complete closure in 1995.

Capelin is one of the most important forage species in the Estuary and Gulf of St. Lawrence. In the marine ecosystem, this species plays a role in transferring energy from the primary and secondary producers (on which it feeds) to species at higher tropic levels (predators of capelin). Indeed, many species of fish, mammals and seabirds depend on capelin for their survival. **Maximum Sustainable Yield** (MSY) analyses performed on catches at length indicate a very high mortality rate associated with the mass mortalities that occur after spawning, and especially with predation. Although **fishing mortality** cannot be estimated at present, these analyses have shown that this type of mortality is much lower than natural mortality. While fishing mortality probably does not have detectable effects within the population at the present catch level, it is impossible to predict what impact a major increase in catches would have on the population and the rest of the ecosystem, since fluctuations in capelin abundance are caused above all by natural factors. As this species is short-lived, its abundance can change suddenly owing to the small number of year-classes in the population.

Fishing effort is strongly correlated with the size of female capelin. The industry targets regions with favourable growing conditions above all, especially during years of strong growth. This explains the low demand for capelin in Divisions 4S and 4T. Since fishing mortality does not appear at present to

have a noticeable effect on the population compared with other types of mortality, there are no biological grounds for holding catches to the current level. However, given the lack of knowledge of this species' biology, its prominent position in the ecosystem and the absence of a specific abundance survey for capelin, any increase in the total allowable catch should be made gradually.

For more information:

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