



Capelin in the Estuary and the Gulf of St. Lawrence (4RST) in 2002

Background

Capelin (*Mallotus villosus*) is a small, marine fish species with a circumpolar distribution. In eastern North America, capelin occur along the coasts of Labrador and Newfoundland, on the Grand Banks and in the Estuary and Gulf of St. Lawrence. Capelin were abundant in the Bay of Fundy in the 1960s and have occurred on the eastern Scotian Shelf since the mid-1980s. Their presence in those regions is linked to below-normal water temperatures between depths of 30 m and 100 m (cold intermediate layer). The colder water temperatures in the Gulf of St. Lawrence may have affected the species' distribution, growth rate and gonad maturation, which has in turn affected spawning periods and fishing season dates. As a result of the reduction in individual fish size observed in the early 1990s, the fishing season was cut short in 1994 and the fishery was closed almost completely in 1995. However, growth in size has been noted in recent years.

Capelin plays a key role in the food chain by transferring energy from primary and secondary producers to higher trophic levels. It is an important food resource for other fish species such as cod and redfish, as well as for certain seabirds and marine mammals whose annual migrations are linked to those of capelin. Mid-1980s estimates show that predators consume

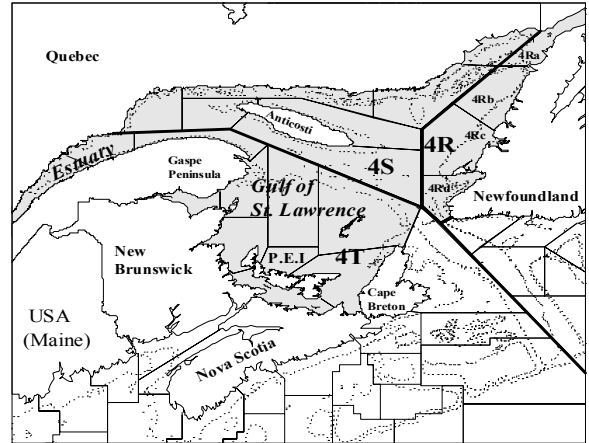


Figure 1. Map of NAFO Divisions 4RST and Unit Areas associated with the capelin fishery on Newfoundland's west coast.

several hundred thousand 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 700 t at that time. The bulk of catches are made by purse seiners on the west coast of Newfoundland. In addition to recreational fishery landings made during beach spawning, capelin is a by-catch of shrimp harvesting. Although the structure of the species' population is relatively unknown, capelin are managed via two separate management units, i.e. **NAFO** (Northwest Atlantic Fisheries Organization) Divisions 4ST and 4R (Figure 1), whose **TACs** (Total Allowable Catch) in 2002 were 1,725 t and 10,700 t, respectively. No abundance survey is currently conducted specifically for the species. However, an index of dispersion is derived from by-catches made in two groundfish surveys conducted in August and September in the northern and southern Gulf of St. Lawrence.

Summary

- First and foremost, capelin is one of the most important **forage** species in the Estuary and Gulf of St. Lawrence. Estimates show that its main predators consume hundreds of thousands of tonnes of capelin per year.
- Preliminary capelin **landings** made in NAFO divisions 4RST in 2002 total 3,302 t, an increase of a little more than 2,500 t from 2001 levels. However, these catches represent only 58 % of mean annual landings made between 1990 and 2001 and are well below the **TAC**.
- Since the late 1980s, the capelin fishing season has started at increasingly **later** dates. Accordingly, the industry mentions that it is no longer possible to forecast the spawning period and that the beach spawning period is very short.
- Capelin **size** has increased since 1999. As a result of the species' gradual reduction in size, the fishery was cut short in 1994 and completely closed in 1995. However, it is the loss of **traditional markets**, and not smaller capelin size, that has led to low landing levels since 1999.
- The species' geographical range is now assessed using two **dispersion indices**, which have been rising since 1990. Capelin is also increasingly found in the southern Gulf of St. Lawrence.
- **Post-spawning** and **predation** mortality are naturally higher among capelin. Current landing levels have little impact on the fluctuations in the abundance of the species. However, the impact that recent changes have had on the species' distribution, migration, spawning, production and abundance remains unknown.

- Although the commercial fishery accounts for only a small part of the total biomass, we recommend that current **TAC** levels be **maintained**, in light of the lack of knowledge on the species' biology, the lack of a separate abundance survey for capelin and the species' prominent role in the marine ecosystem.

Biology

Capelin spawn at around three years of age and 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 (elongated scales), one dorsally and the other ventrally. Spawning, which is preceded by a mass shoreward migration, occurs on beaches or in deeper waters. During beach spawning, the capelin "roll" on the sand

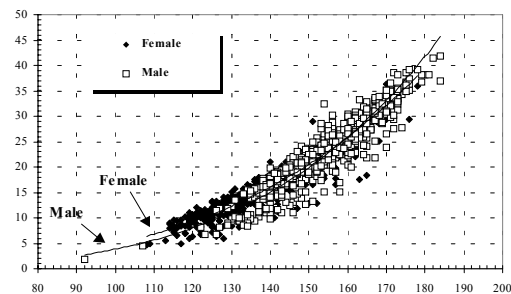
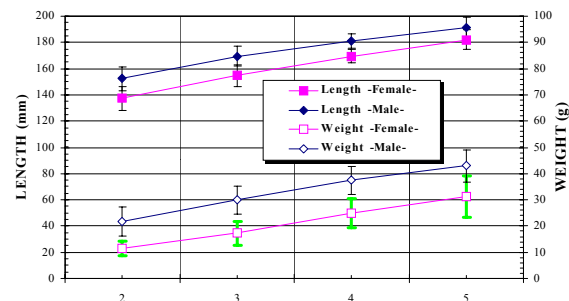


Figure 2. Mean length (mm) and weight (g) at age (A) (the vertical bars represent standard deviation) and weight-length relationships (B) for capelin in NAFO Division 4R.

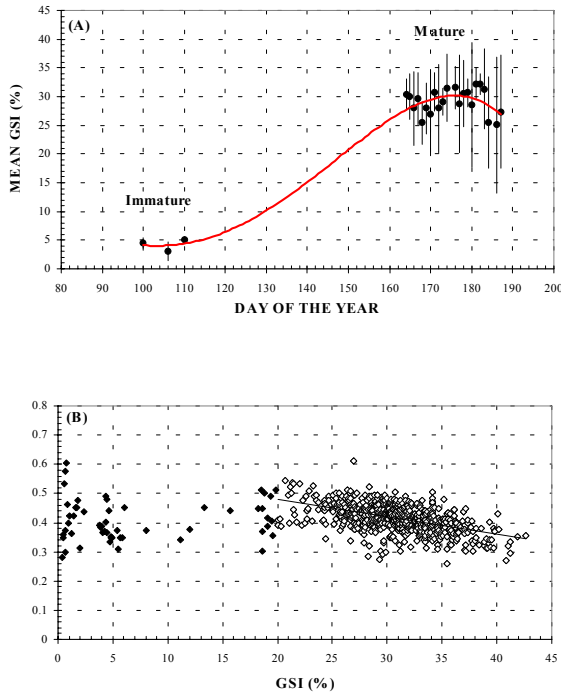


Figure 3. Relation between the mean gonadosomatic index (the vertical bars represent standard deviation) and the day of the year (A) and condition (Fulton index) (B) for capelin (females only) in NAFO Division 4R. The condition indicates a downward trend (noted by the line and open symbols) for GSI values greater than 20 %.

or fine gravel, whereas the second type of spawning takes place in deeper waters. On the west coast of Newfoundland, like elsewhere in the Gulf of St. Lawrence, spawning may sometimes occur in specific areas or be sporadic due to annual fluctuations in water temperature. The beach spawning period lasts from four to six weeks, beginning in the St. Lawrence Estuary in mid-April, then moving eastward to Quebec's Lower North Shore and Newfoundland's west coast in July. Males and females gather in separate schools at spawning grounds. Males migrate to the beaches first and await the arrival of the females, which

complete their maturity offshore. A large proportion of these capelin die after spawning, particularly the males, which injure themselves in repeated matings on the beach; the survivors have the ability to spawn again over the years. Capelin eggs adhere to the gravel substrate. The incubation period and the amount of time the larvae spend on the gravelly bottom depend on water temperature and turbulence in the surrounding environment. The larvae soon become pelagic, remaining near the water surface until the arrival of winter.

Capelin do most of their growing during their first few years of life. By the age of two, males are both longer and heavier than females (Figure 2A). Males and females have similar weight-length relationships (Figure 2B), but females that are smaller than 140 mm weigh slightly more than males of the same length. This can be explained by females' larger gonads. At maturity, gonad weight can account for up to 30 % of somatic weight (Figure 3A). The gonadosomatic index (GSI), used to measure gonad weight as compared to total body weight of the corresponding fish, was under 5 % for immature

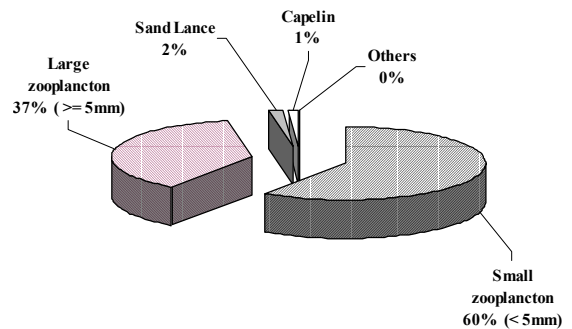


Figure 4. Diet (%) of capelin in the northern Gulf of St. Lawrence in the mid-1980s (C. Savenkoff and M. Castonguay, pers. comm.).

females. For GSI values of more than 20 %, there is an opposite relationship between this parameter and the condition (Fulton index) of females (Figure 3B).

Very little up-to-date information is available on capelin's diet. Mid-1980s estimates show that capelin feed mainly on zooplankton (Figure 4) and that their feeding patterns vary with the seasons. Therefore, feeding stops completely during spawning, then gradually resumes.

Description of the fishery

Internationally, the largest capelin annual landings are usually made off Iceland and east of Greenland, regularly topping more than 1 million tonnes. Very large capelin landings also occur in the Barents Sea. However, the precarious state of this stock required the fishery to be completely closed between 1987 and 1990 and between 1994 and 1998. The main international capelin markets are tied to these European fisheries, which are in direct competition with Eastern Canadian fisheries.

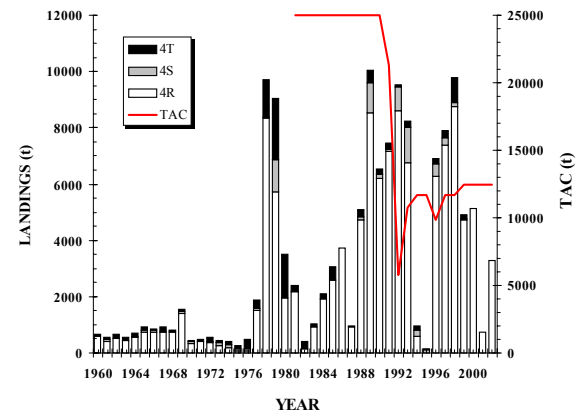


Figure 5. Capelin landings and TAC (t) for NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence) between 1960 and 2002.

Traditionally, capelin has not been a popular species with Canadian fishers. It has been used to produce farm fertilizer, food for human consumption, bait for cod and, more recently, fishmeal. The emergence of a Japanese market for roe-bearing females is responsible for the sharp increase in landings, up from 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978, 1979, 1989, 1992 and 1998 (Figure 5).

The capelin fishing season is short and corresponds to the pre-spawning period

Table 1. Estuary and Gulf of St. Lawrence: Capelin landings (t) by NAFO Division and by gear from 1990 to 2002.

DIVISION AND GEAR	YEAR													AVERAGE (1990-2001)
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002*	
4R	6 205	7 166	8 605	6 739	592	15	6 265	7 399	8 764	4 735	5 129	741	3 295	5 196
TAC 4R	18 000	4 025	9 025	10 000	10 000	8 400	10 000	10 000	10 700	10 700	10 700	10 700	10 700	
4S	164	59	856	1 263	208	90	461	252	141	0	0	0	7	292
4T	153	247	56	236	166	47	172	238	893	166	0	0	0	198
TAC 4ST	5 000	3 300	1 725	1 725	1 725	1 725	1 450	1 725	1 725	1 725	1 725	1 725	1 725	
Beach senne	458	149	12	0	13	15	0	0	0	0	0	0	0	54
Purse senne	4 215	7 014	7 517	6 827	649	0	5 479	6 511	7 232	4 901	5 128	741	3 295	4 684
Trap	1 720	181	1 921	1 283	210	103	1 306	1 203	2 509	11	1	0	7	871
Weir	129	127	56	128	94	34	113	175	57	0	0	0	0	76
Trawl	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	11	0	0	0	0	0	0	0	0	0	0	1
TOTAL	6 522	7 472	9 517	8 238	966	152	6 898	7 889	9 799	4 911	5 129	741	3 302	5 686

* Preliminary

Table 2. West coast of Newfoundland: Capelin landings (t) by NAFO Unit Area from 1990 to 2002.

UNIT AREA	YEAR													AVERAGE (1990-2001)
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002*	
4Ra	1 959	154	1 554	73	10	15	605	734	1 827	29	0	0	107	580
4Rb	479	82	1 506	469	265	0	1 841	2 480	3 814	1 675	356	0	731	1 081
4Rc	925	4 907	4 675	4 264	245	0	3 364	4 171	2 541	3 031	4 773	605	2 457	2 792
4Rd	104	2 023	117	1 933	72	0	430	14	581	0	0	136	0	451
NK**	2 739	0	754	0	0	0	25	0	0	0	0	0	0	293
TOTAL	6 205	7 166	8 605	6 739	592	15	6 265	7 399	8 764	4 735	5 129	741	3 295	5 196

* Preliminary; ** Not known

in the seine fishery and to the spawning period in the trap fishery. In both cases, the fishery chiefly targets mature females to meet roe-market demand. The largest landings in the Gulf of St. Lawrence are nearly always made on the west coast of Newfoundland, i.e. in **NAFO** (Northwest Atlantic Fisheries Organization) Division 4R (Figure 5). In Divisions 4R and 4S, the most intensive fishing generally occurs in June and July. In Division 4T, however, the fishing season sometimes begins as early as April, but the largest landings occur in May and June. Purse seines, traps and weirs are used in most capelin landings in the Estuary and Gulf of St. Lawrence.

The fishery in 2002

In 2002, capelin landings in Divisions 4RS totalled 3,302 t, an increase of 2,561 t from 2001 levels (Table 1). However, these catches represent only 58 % of mean annual landings made between 1990 and 2001 and are well below the TAC. Most landings in 2002 were made by the purse seine fishery in Division 4R, more specifically in Unit Area 4Rc (Table 2). No landings have been recorded in Division 4T since 2000 (Table 1).

The late 1980s and early 1990s were characterized by late fishing seasons

(Figure 6A). The opposite was true between 1996 and 1998, but increasingly later fishing seasons followed. The gradual reduction in mean female and male size has been noted since the mid-1980s (Figure 6B). As a result, the fishery was cut short in 1994

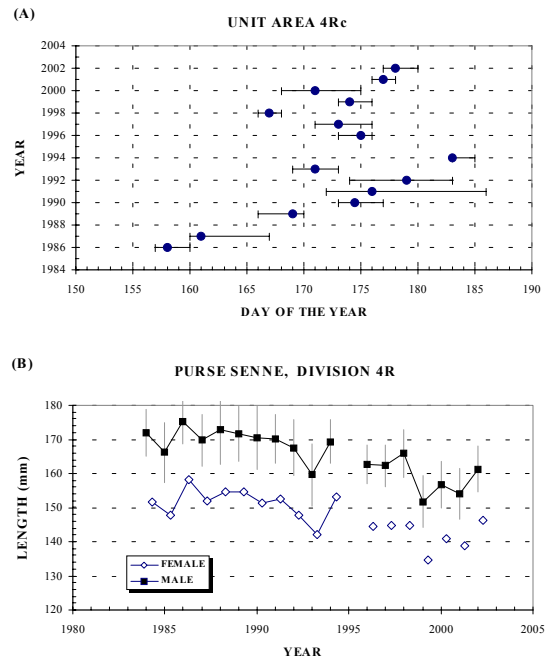


Figure 6. Temporal pattern of the capelin purse seine fishery in Unit Area 4Rc (A) (symbol= median landing dates; lines = dates by which 25 % and 75 % of the landings had been made) and mean length (B) of capelin caught with purse seines in NAFO Division 4R (the vertical bars represent standard deviation).

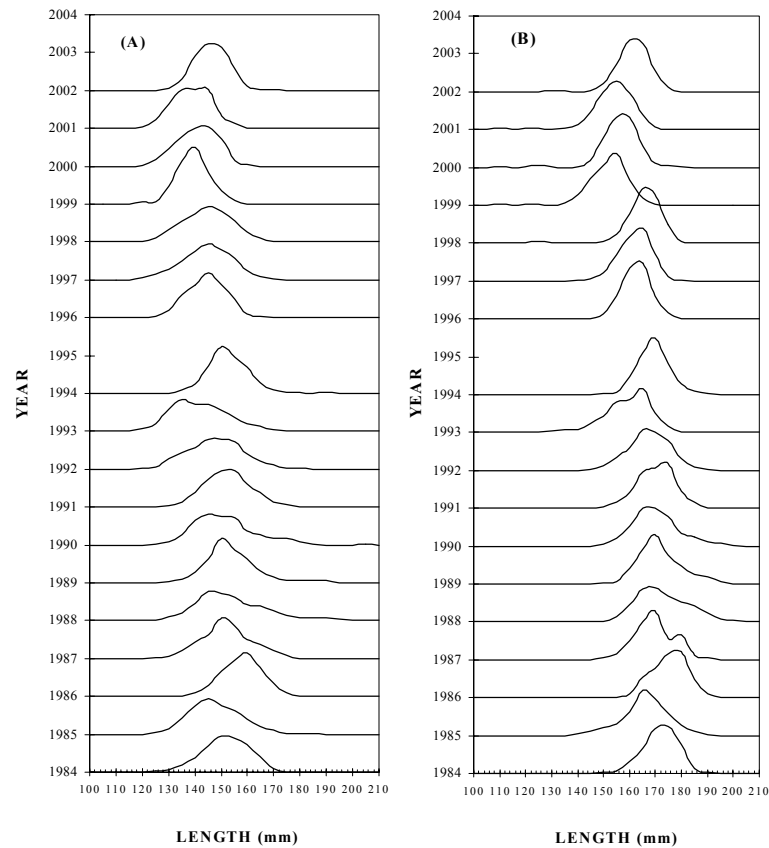


Figure 7. Size composition (%) of females (A) and males (B) caught with purse seines in NAFO Division 4R between 1984 and 2002 (except 1995).

and almost completely closed in 1995. Capelin size stabilized between 1996 and 1998, was smaller in 1999, but has been increasing ever since. Nevertheless, 2002 figures are still below those recorded in the 1980s.

Capelin size fluctuations were also noted in the assessment of annual length frequencies (Figures 7A and 7B), which, in most cases, consist of a single modal value as a result of lengths overlapping among the various age groups.

The number of capelin per kilogram shows that individuals sampled in Divisions 4R and 4S were bigger than those sampled in Division 4T (Figure 8). Mean figures for Division 4R have been

decreasing since 1999 and were below the 50 capelin/kg threshold in 2002. The threshold has been used for years as a management measure to reduce catches of small capelin.

State of the resource

Bottom trawl surveys are conducted annually to assess the abundance of shrimp and groundfish in the northern Gulf of St. Lawrence. Regular capelin by-catch data provided by the survey had been used, until recently, to calculate an abundance index expressed as mean weight of the catch per tow. A second groundfish abundance survey is also conducted in the southern Gulf of St. Lawrence under the supervision of Fisheries and Oceans

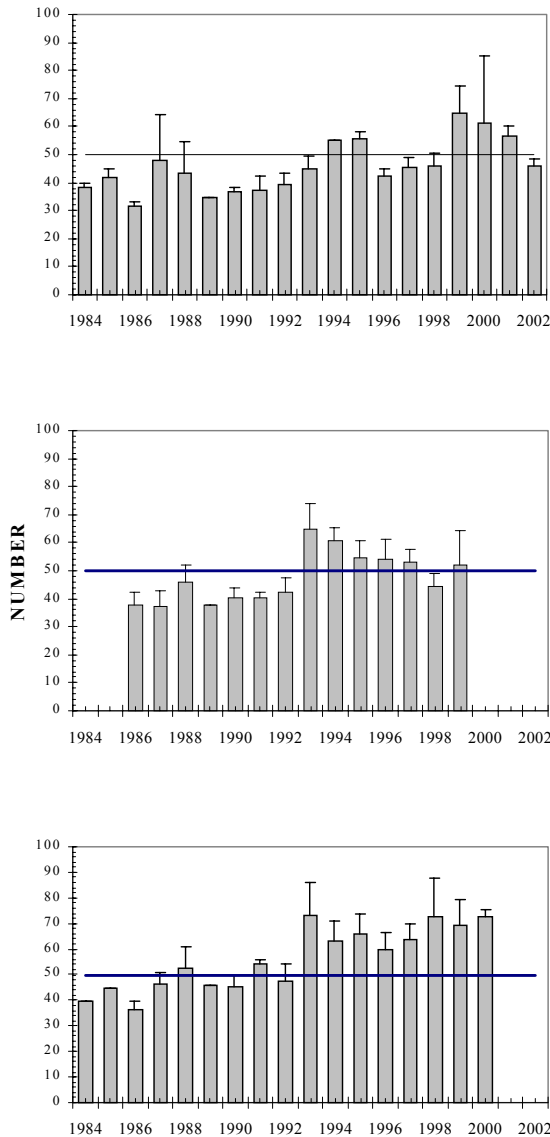


Figure 8. Mean number of capelin per kilogram (the vertical bars above the rectangles represent the standard deviation) in NAFO Divisions 4RST (the horizontal line indicates the threshold of 50 capelin per kg used as a management measure).

Canada, Gulf Region. Capelin by-catches that have been made in these two surveys since 1990 clearly show the significant expansion of the species' geographical range in the Gulf of St.

Lawrence. However, as these surveys are not exactly intended for landings of pelagic fish such as capelin (the mean weights per tow have great confidence intervals), it was agreed to use these catches only to assess the species' distribution and dispersal.

Distribution

Over the last three years, the greatest concentrations of capelin have been found around Anticosti Island, in the Northern Esquiman Channel off Newfoundland's west coast (Division 4R) and in the area located between the Gaspé Peninsula and the west coast of Cape Breton (Figure 9), where Capelin has occurred only since the mid-1990s.

Dispersion indices

Two dispersion indices are now calculated (by kriging) using presence and absence data of capelin gathered during bottom trawl surveys. The first of these indices concerns the total area (km²) associated to a minimal probability of finding capelin of 50 % and more. The index rose markedly between 1990 and 2002 (Figure 10A). The upward trend is greater in areas including the entire Gulf of St. Lawrence (and the Estuary). Maps are also provided to indicate areas with different probabilities. Two of these maps (Figure 11) clearly show the expansion of areas that has occurred between 1990 and 2002 where capelin is very likely to be found.

The second index consists of the mean probability of capelin occurrence per unit area (25 km²). This index also increased during the same period (Figure 10B). Mean probability is higher in the northern Gulf of St. Lawrence (including the Estuary). All of these indices, with the exception of the mean probability for

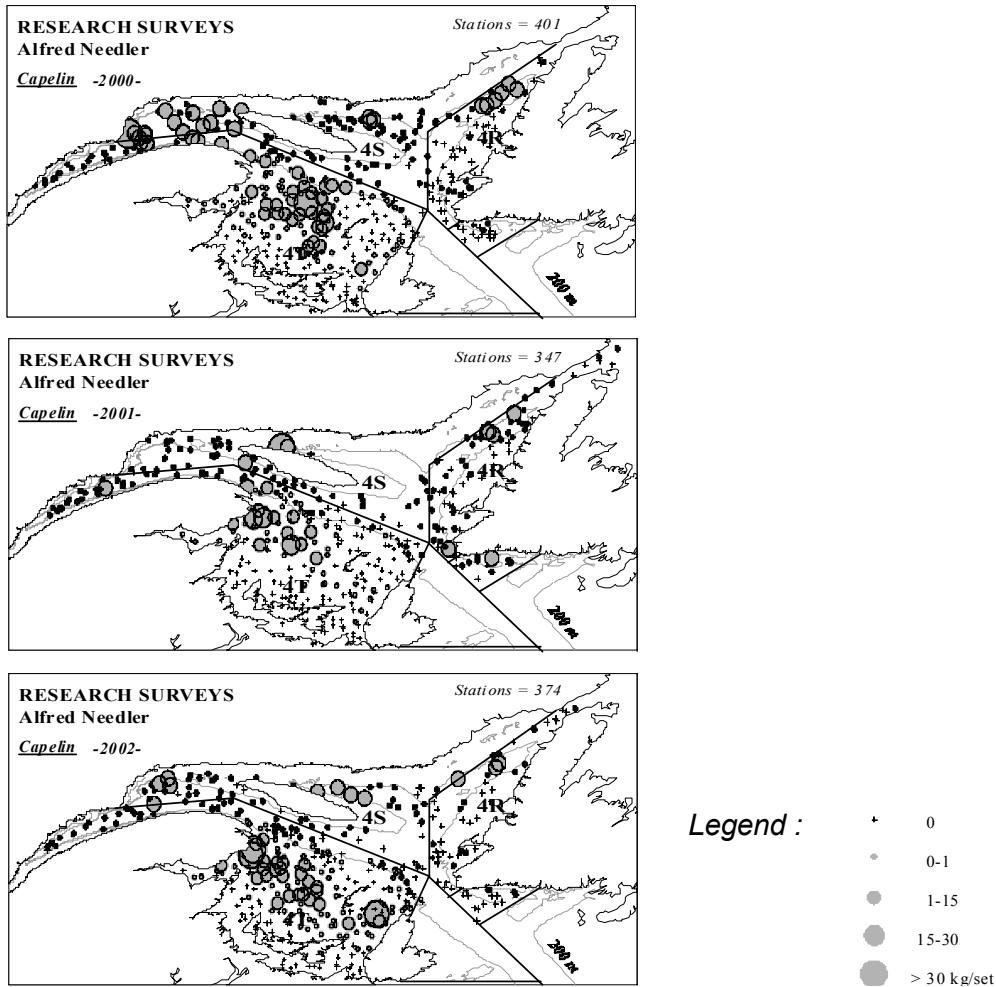


Figure 9. Maps of capelin by-catch (kg/set) during groundfish abundance surveys in the southern and northern Gulf of St. Lawrence. These surveys used gear with different selectivity (data on 4T: courtesy of Gloria Poirier, DFO, Moncton, NB).

the Estuary and the entire Gulf of St. Lawrence, have been down since 2001, despite increases over the long term.

Industry viewpoint

The comments that follow are from various sectors of the capelin fishery on Newfoundland’s west coast. They specifically address the following issues: (1) It is no longer possible to forecast the spawning period, which is short; (2) capelin no longer migrate shoreward, but remain in deeper waters off the coast. Very large schools are sometimes

observed; (3) spawning is occurring at an increasingly later date. Capelin was even caught in the late fall of 2002 and early winter of 2003. Individuals caught in the fall had mature gonads; (4) capelin abundance and size has increased in 2002, compared with mid-1990s levels; (5) low landings recorded since 1999 are the result of the loss of traditional markets to the Norwegians and Icelanders, and not small capelin size or reduced abundance; (6) early in the season, capelin is a huge problem for shrimpers in the Esquiman Channel;

(7) the species' current abundance does not justify the fishery's closure; (8) before developing this fishery further, studies should be conducted on the distribution and spawning changes noted in recent years.

As for the St. Lawrence Estuary, many comments were made on capelin's occurrence off the coast and the lack of beach spawning in the last few years. The same comments were made with respect to Chaleur Bay, where abundance is increasing and spawning in deeper waters is more and more common.

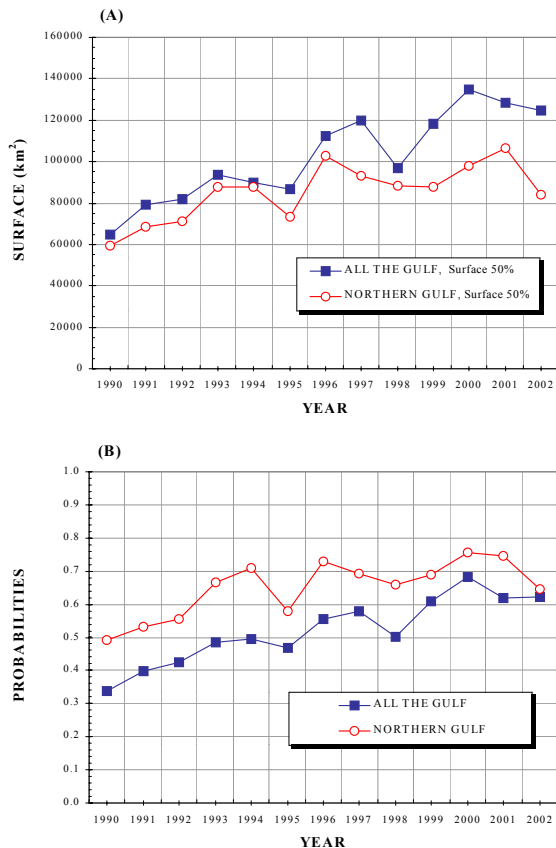
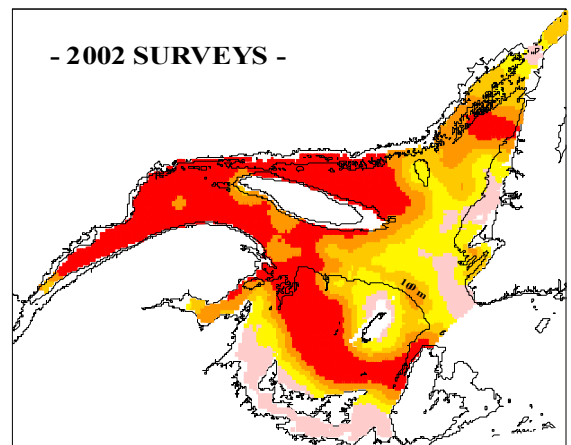
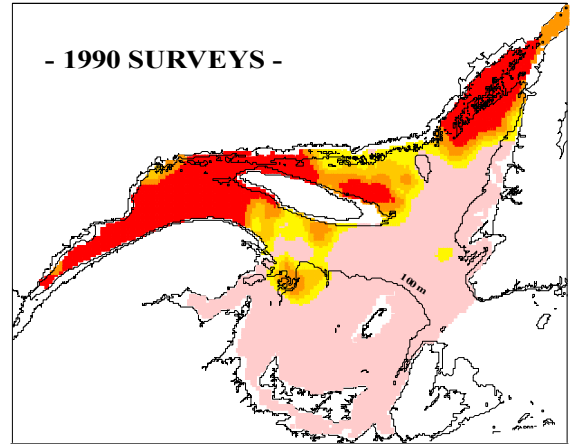


Figure 10. Annual (A) areas (km²) with capelin occurrence probability levels of 50 % and mean capelin occurrence probability (B) per 25 km² in the northern (including the Estuary) and southern Gulf of St. Lawrence between 1990 and 2002.



Legend :

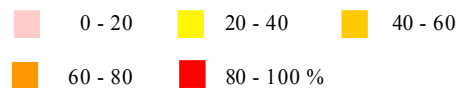


Figure 11. Perimeters of capelin occurrence probability areas (%) for surveys conducted in the Estuary and Gulf of St. Lawrence in 1990 and 2002 (the 100 m isobath is also indicated).

Assessment and outlook

Predation

Capelin is one of the most important forage species of the Estuary and Gulf of St. Lawrence. The species plays a role in transferring energy in the marine ecosystem from primary and secondary producers (on which it feeds) to species at higher trophic levels (its predators). Indeed, many fish, marine mammal and seabird species are dependent on capelin for their survival. In the mid-1980s, Atlantic cod was capelin's main predator (Figure 12). Capelin also

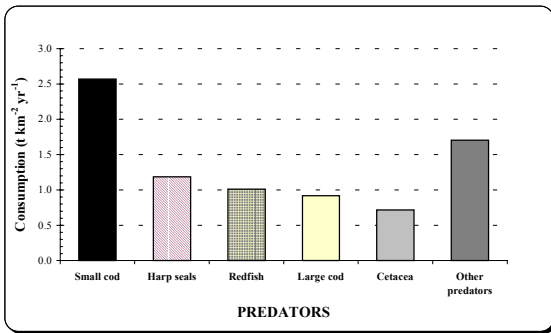


Figure 12. Capelin consumption (t km⁻² yr⁻¹) by main predators in the northern Gulf of St. Lawrence in the mid-1980s (C. Savenkoff and M. Castonguay, pers. comm.).

sustained marine mammals, redfish and large cod. According to data gathered since 1993, large cod has been feeding less on capelin and invertebrates and more on other species of fish (Figure 13). The occurrence of capelin in the stomach contents of cod depends on where samples were taken and the type or selectivity of fishing gear used. For example, in cod measuring between 20 cm and 50 cm, capelin is found more often in the stomachs of cod caught off the coast by the mobile-gear sentinel

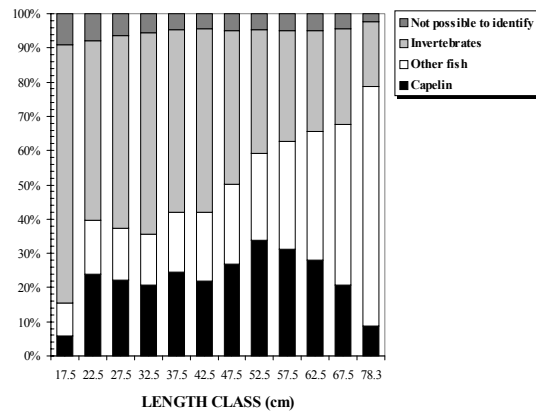


Figure 13. Mean percentage of stomach content (weight) by length-class among cod sampled since 1993 in research surveys conducted by DFO and the fixed- and mobile-gear sentinel fisheries (D. Chabot, pers. comm.).

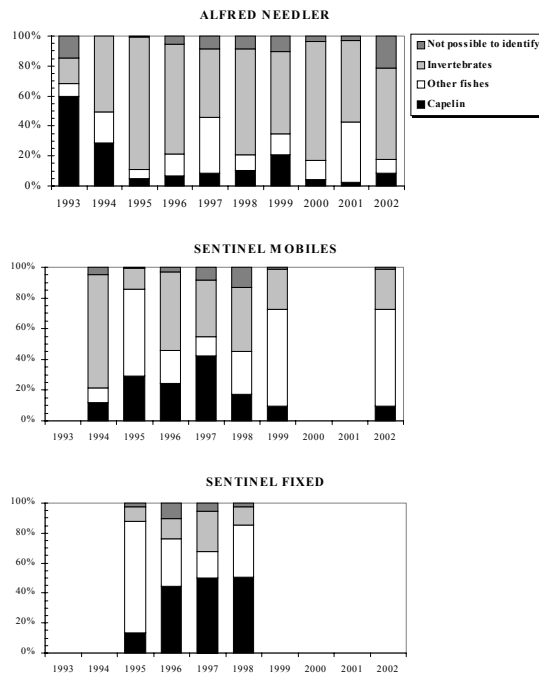


Figure 14. Annual mean percentage of stomach content (weight) among cod measuring between 20 cm and 50 cm, sampled since 1993 in research surveys conducted by DFO and the fixed- and mobile-gear sentinel fisheries (D. Chabot, pers. comm.).

fishery than by scientific bottom trawl surveys conducted by the *CCGS Alfred Needler* (Figure 14). However, capelin is most often found in the stomachs of cod sampled near the coast by the fixed-gear sentinel fishery.

Environment

Recent water temperature fluctuations in the Gulf of St. Lawrence appear to have had a big impact on various aspects of the lifecycle of certain commercial fish. In the capelin's case, the area of the Magdalen Shallows that is covered by water below 1°C seems to be linked to the expansion of the species' range in this part of the Gulf of St. Lawrence (Figure 15). Cooler waters off Newfoundland's west coast could explain the decrease in size observed in the early 1990s. It is not currently known what impact these water temperature fluctuations have had on capelin's natural mortality, production and recruitment. In addition, little data is available on traditional and new capelin spawning grounds that could be associated with recent changes in the species' distribution.

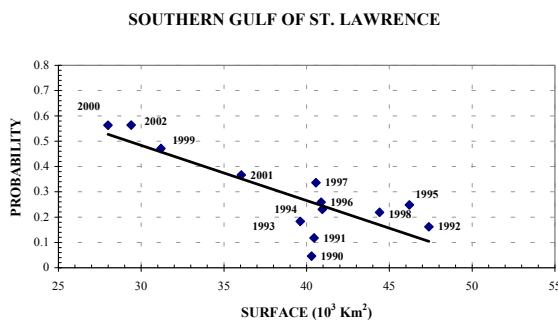


Figure 15. Relation between the Magdalen Shallows area (10^3 km^2) covered by waters below 1°C (K. Drinkwater, pers. comm.) and mean capelin occurrence probabilities by unit area.

Fishing mortality

Fishing mortality does not appear to have a noticeable effect on the population with respect to current landing levels even if it is not currently possible to evaluate it. However, it is impossible to evaluate the impact that the significant increase in landings has had on the capelin population and the rest of the ecosystem, as changes in the species' occurrence are first and foremost the result of natural factors. As capelin has a short lifespan, its abundance is subject to sharp changes, because the population consists of only a few age groups. Fishing effort is strongly correlated to the size of female capelin in order to satisfy market demand. The industry has a greater interest in regions where environmental conditions are more favourable to capelin growth. This explains the weak capelin demand in Divisions 4S and 4T.

Even if the fishery does not appear to have an impact on capelin abundance, current TAC levels should be maintained for now in Divisions 4R and 4ST because of our lack of knowledge of capelin biology, the potential impact of environmental change on stock production, the species' prominent role in the marine ecosystem, and the lack of a separate abundance survey for capelin.

References

- Beaulieu, J.-L. 2001. Description de la pêche au capelan (*Mallotus villosus*) dans l'estuaire et le golfe du Saint-Laurent (divisions 4RST) pour 1999 et 2000. DFO CSAS Res. Doc., 2001/048. 56p.
- Drinkwater, K.F., R. Pettipas, and L. Petrie. 2002. Physical environmental conditions in the southern Gulf of St. Lawrence during 2001. DFO CSAS Res. Doc., 2002/047, 40p.
- Grégoire, F., Savenkoff, C., Chabot, D., C. Lévesque, et C. Hudon. 2003. Pêche, biologie et abondance du capelan (*Mallotus villosus*) des divisions 4RST de l'OPANO en 2002. DFO CSAS Res. Doc., 2003/xx (not yet published).
- Grégoire, F., C. Lévesque, G. Poirier, et C. LeBlanc. 1999. Prises et débarquements de capelan (*Mallotus villosus*) dans le golfe du Saint-Laurent en 1998. DFO CSAS Res. Doc., 1999/09. 84p.

For more information:

François Grégoire
Maurice Lamontagne Institute
850 Route de la Mer
Mont-Joli, Québec
G5H 3Z4
Tel.: 418 775-0589
Fax: 418 775-0740
E-mail: GregoireF@dfo-mpo.gc.ca

This report is available from the:

Regional Science Advisory Bureau,
Department of Fisheries and Oceans,
Maurice Lamontagne Institute,
P.O. Box. 1000, Mont-Joli,
Quebec, Canada
G5H 3Z4

Email: Bras@dfo-mpo.gc.ca

ISSN 1480-4913
© Her Majesty the Queen in Right of Canada, 2003

*La version française est disponible à
l'adresse ci-dessus.*

**Correct citation for this
publication:**

DFO, 2003. Capelin of the Estuary and the Gulf of St. Lawrence (4RST) in 2002. DFO – Science, Stock Status Report 2003/009