



ASSESSMENT OF THE ESTUARY AND GULF OF ST. LAWRENCE (DIVISIONS 4RST) CAPELIN STOCK

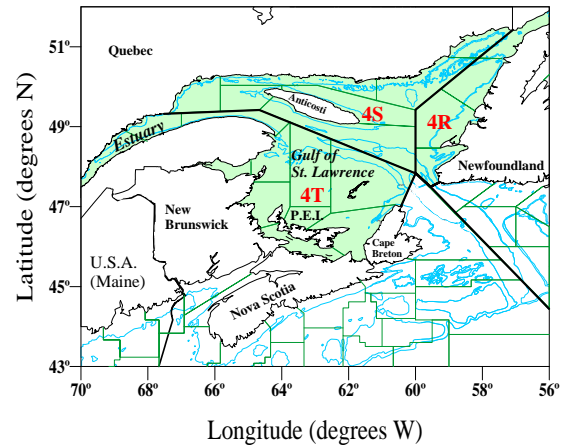


Figure 1. Map of NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence). Divisions 4RST are identified by the coloured area.

Context

In Canadian waters, capelin has traditionally been used as fertilizer, bait or for its oil. Towards the end of the 1970s, the emergence of a Japanese market for roe-bearing females sparked a rapid growth of the fishery. For the Estuary and Gulf of St. Lawrence, catches then increased from an average of 700 t per year to nearly 10,000 t. Most catches in the Estuary and Gulf of St. Lawrence are made on the west coast of Newfoundland by a fleet of small and large purse seiners and by trap fishermen. These two types of fisheries are an essential economic component of this region. Capelin are also caught using traps on Quebec's Lower North Shore and weirs in the St. Lawrence Estuary. In addition to recreational catches made on beaches during the spawning season, capelin are also a by-catch of the shrimp (*Pandalus borealis*) fishery and the bottom trawl scientific surveys conducted annually in the southern and northern Gulf of St. Lawrence.

Even though capelin population structures in the Estuary and Gulf of St. Lawrence are not clearly defined, the species is managed according to two distinct management units, the NAFO Divisions 4R and 4ST (Figure 1). A Total Allowable Catch (TAC) of 11,200 t is applied to Division 4R compared with 1,800 t for all of Divisions 4ST. There is no abundance survey specifically directed on capelin. Consequently, it is impossible to calculate biomass, fishing mortality, a minimum biomass limit or a TAC. A meeting of the Regional Advisory Process was held 19 March, 2008 in Moncton, N.B. to assess the status of the capelin resource in Divisions 4RST in support of the management of the 2008 fishery.

SUMMARY

- Capelin landings in NAFO Divisions 4RST decreased from 11,883 t (peak for the time series) in 2006 to 7,416 t in 2007 (preliminary). Most (72%) of these landings were made with purse seine and trap in the northern part of 4Ra on the west coast of Newfoundland.

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- The landings reduction observed in 2007 is explained by the marked decrease of catches in 4Rb and 4Rc. In 2007, landings in these two unit areas were 6 t and 691 t compared to annual averages (1990-2006) of 977 t and 2,729 t.
 - Capelin is regularly taken as a by-catch in the shrimp fishery. Based on observer data, an estimated 121 t of capelin were caught in 2007, mostly in the Seven Islands shrimp fishery management area.
 - The fishery in 4Rc in the 1990s occurred later than in the 1980s. A certain consistency has been observed since then except for 2006.
 - On the west coast of Newfoundland, the size (length) of capelin caught by purse seiners decreased from the early 1990s to 2001 and has increased since then. Lengths measured in 2007 were similar to the annual average of the 1984-2006 period.
 - Since 1990, the presence of capelin in the annual bottom trawl surveys has become more wide spread in the southern Gulf of St. Lawrence (Division 4T). However, for the west coast of Newfoundland (Division 4R), the presence of capelin in these surveys has decreased in recent years as the dispersion index values in 2006 and 2007 were among the lowest of the series.
 - Since 2005, TACs have been set at 11,200 t for 4R and 1,800 t for 4ST. Predation mortality indicates that the commercial fishery harvests a small proportion of the total biomass. However, any TAC increase should be made cautiously due to capelin's prominent role as a forage species in the marine ecosystem.
 - The failure to locate fish on the traditional fishing grounds in 4Rb and 4Rc in 2007 suggests that no increase of the TAC should be made in Division 4R. Fishing effort should preferably be dispersed along the coast.

INTRODUCTION

Species Biology

Capelin (*Mallotus villosus*) is a small marine fish species largely distributed in the oceans of the northern hemisphere. In the northeast Atlantic, capelin occur in waters near Russia (Barents Sea), Norway, Iceland, and Greenland. In the northwest Atlantic, it is found along the coasts of Labrador and Newfoundland, on the Grand Banks and in the Estuary and Gulf of St. Lawrence. Further south, capelin are also found in the eastern portion of the Scotian Shelf and occasionally, in the Bay of Fundy. In the Pacific, the species occurs along the coasts of Alaska and British Columbia, and in Asia, along the coasts of Japan, Korea, and Russia.

Capelin are part of the Osmeridae family and are olive in colour and have an elongated body. During the spawning period, there is a pronounced sexual dimorphism, males can be distinguished from females by their larger fins and by the occurrence of two pairs of spawning carina (elongated scales), one dorsal and the other ventral. Spawning is preceded by intense migration towards the coast and occurs inter-tidally on beaches and in deeper waters. In the first case, capelin literally "roll" on the sandy or fine gravel beaches. Spawning essentially occurs at water temperatures of 6-10°C and is more predominant at night. The eggs, which are reddish in colour and approximately 1 mm in diameter, attach to the substrate. The incubation period

varies according to ambient temperature, lasting for approximately 15 days at 10°C. Upon hatching, larvae quickly adopt a planktonic existence and remain near the surface until the arrival of winter. The most significant growth period occurs during the first year. Males are longer than females, with maximum lengths rarely above 210 mm. Capelin can spawn at age 2 years, and nearly 100% of males die following reproduction.

Capelin represent a very significant link in the food chain as they allow the transfer of energy from primary and secondary producers to higher trophic levels. In the mid 1980s, the annual capelin consumption by its main predators was approximately one million tons. In the early 2000s, despite a sharp drop in cod (*Gadus morhua*) and redfish (*Sebaste spp.*) abundance, nearly 400,000 t of capelin were still consumed by predators (C. Savenkoff, pers. comm.), making this small fish the principal forage species prey of the northern Gulf of St. Lawrence marine ecosystem over the last 20 years.

Fishery

Description of fishing activities

Purse seines, traps and weirs are the main commercial capelin fishing gears used in the Estuary and Gulf of St. Lawrence. Fishing seasons are generally short and correspond to the pre-spawning period for purse seines and to the spawning period for traps and weirs fisheries. In the case of purse seines and traps, the fishery mostly targets mature females for the Japanese roe market. The emergence of this market is responsible for the sharp increase in landings, up from an average of 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978, 1979, 1989, 1992, 1998, and 2006 (Figure 2).

Most capelin catches for the Estuary and Gulf of St. Lawrence occur on the west coast of Newfoundland, i.e. in NAFO (Northwest Atlantic Fisheries Organization) Division 4R (Figure 1). In Divisions 4R and 4S, the most intensive fishing usually occurs in June and July. In Division 4T (Estuary), the fishing season can begin as early as April, but most catches occur in May and June.

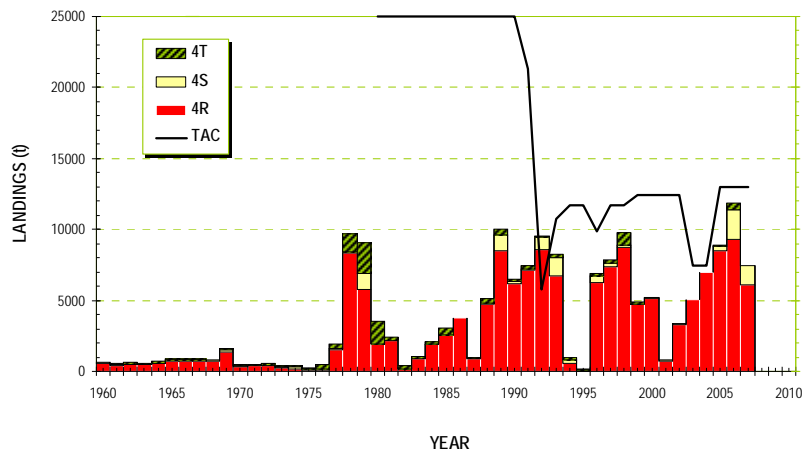


Figure 2. Capelin landings and TAC (t) for NAFO Divisions 4RST between 1960 and 2007. Since 2005, the TAC has been divided as follows: 11,200 t for 4R and 1,800 t for 4S.

The 2007 season

In 2007, capelin landings (preliminary) in Divisions 4RST totalled 7,416 t, compared to the 11,883 t (peak for the time series) recorded in 2006 (Table 1). These landings occurred mostly in Division 4R (6,092 t) and corresponded to 54% of the 11,200 t TAC for this Division. The two main fishing gears were purse seines (4,665 t) and traps (2,088 t). On the west coast of Newfoundland, most landings (5,321 t) occurred in 4Ra (Table 2). In 2007, a marked decrease in landings occurred in 4Rb (6 t) and 4Rc (691 t), compared to annual averages (1990-2006) of 977 t and 2,729 t respectively (Table 2). This reduction was accompanied by a displacement of the purse seine fishery from these two unit areas to the northern portion of 4Ra (Figure 3). This displacement was also observed in 2006, but in a lesser degree.

In division 4S, landings in 2007 were 1,324 t compared to 2,039 t in 2006 (Table 1). Most of the landings occurred in the eastern part of this division.

Table 1. Estuary and Gulf of St. Lawrence capelin landings (t) by NAFO Division and by fishing gear from 1990 to 2007.

DIVISION- GEAR	YEAR																	AVERAGE / (1990-2006)	
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006		2007*
4R	6,205	7,166	8,605	6,739	592	15	6,265	7,399	8,764	4,735	5,129	741	3,295	5,032	6,975	8,522	9,326	6,092	5,618
TAC 4R	20,000	18,000	4,025	9,025	10,000	10,000	8,400	10,000	10,000	10,700	10,700	10,700	10,700	6,420	6,420	11,200	11,200	11,200	
4S	164	59	856	1,263	208	90	461	252	141	10	69	66	77	0	0	305	2,039	1,324	357
4T	153	247	56	236	166	47	172	238	893	166	18	5	20	0	0	34	518	0	175
Total	317	306	912	1,499	374	137	633	490	1,035	176	87	71	97	0	0	339	2,557	1,324	531
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	1,035	1,035	1,800	1,800	1,800	
"Tuck ring" seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	298	982	663	75
Purse seine	4,215	7,014	7,517	6,827	649	0	5,479	6,511	7,232	4,791	5,129	741	3,295	4,654	4,639	5,485	7,335	4,665	4,795
Other seine**	458	149	12	0	13	15	0	0	0	0	0	0	0	0	0	0	0	0	38
Trap	1,720	181	1,921	1,283	210	103	1,306	1,203	2,509	11	1	0	7	379	2,148	3,078	3,567	2,088	1,154
Weir	129	127	56	128	94	34	113	175	57	0	0	0	0	0	0	0	0	0	54
Trawl	0	1	0	0	0	0	0	0	0	110	0	0	2	0	188	0	0	0	18
Other	0	0	11	0	0	0	0	0	0	0	87	0	87	0	0	0	0	0	11
TOTAL	6,522	7,472	9,517	8,238	966	152	6,898	7,889	9,799	4,911	5,217	811	3,392	5,032	6,975	8,861	11,883	7,416	6,149

* Preliminary; ** Beach seine included

Table 2. West coast of Newfoundland (4R) capelin landings (t) by NAFO unit area from 1990 to 2007.

UNIT AREA	YEAR																	AVERAGE / (1990-2006)	
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006		2007*
4Ra	1 959	154	1 554	73	10	15	605	734	1 827	29	0	0	115	513	3 965	4 946	5 917	5 321	1 319
4Rb	479	82	1 506	469	265	0	1 841	2 480	3 814	1 675	356	0	856	1 070	765	942	9	6	977
4Rc	925	4 907	4 675	4 264	245	0	3 364	4 171	2 541	3 031	4 773	605	2 323	3 450	2 185	2 289	2 644	691	2 729
4Rd	104	2 023	117	1 933	72	0	430	14	581	0	0	136	0	0	61	346	756	73	387
NK**	2 739	0	754	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	207
TOTAL	6 205	7 166	8 605	6 739	592	15	6 265	7 399	8 764	4 735	5 129	741	3 295	5 032	6 975	8 522	9 326	6 092	5 618

* Preliminary; ** Not known

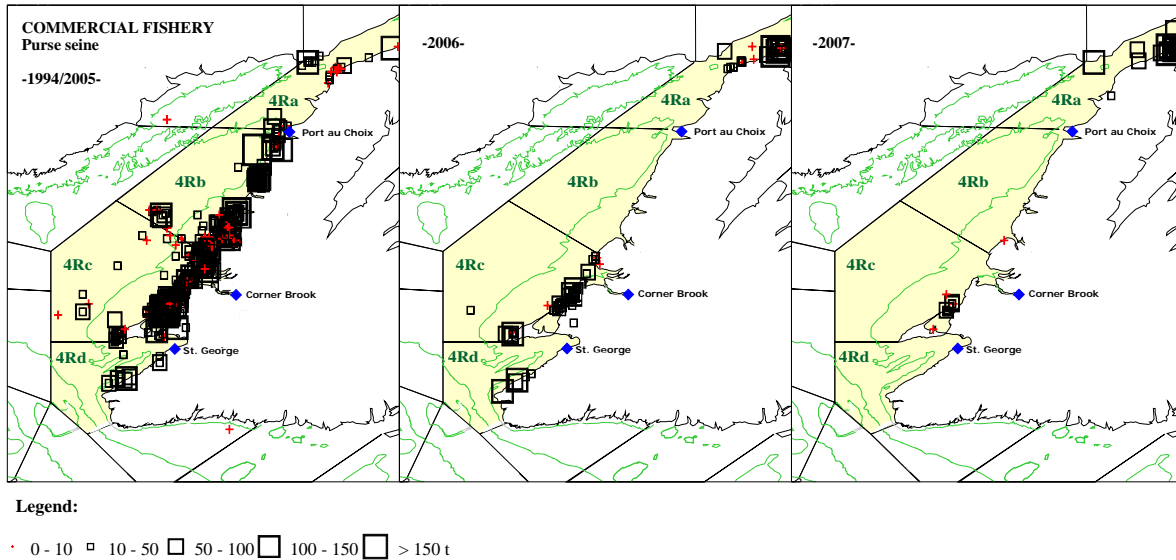


Figure 3. Location of capelin catches (t) by the commercial purse seine fishery in Division 4R from 1994 to 2007.

Capelin are a regular by-catch in the shrimp fishery. In the spring, and in areas such as the Esquiman Channel, the number of capelin caught by shrimpers can be significant. Some fishermen avoid some sectors during certain periods to avoid catching too many capelin. According to observers' data, capelin by-catches by shrimpers decreased from 887 t in 1993 to a low of 113 t in 1996 (Figure 4). In 2007, approximately 121 t of capelin were caught by shrimpers. Most of these catches were made in the Seven Islands shrimp fishery management area (Figure 5).

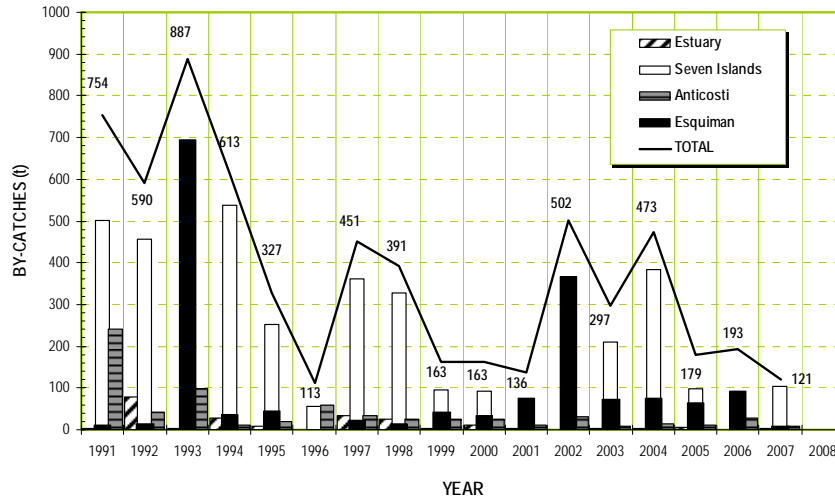


Figure 4. Annual capelin by-catch estimates (t) from the commercial shrimp fishery since 1991 (source of data: Biorex and Seawatch observers). Shrimp fishery management areas are indicated.

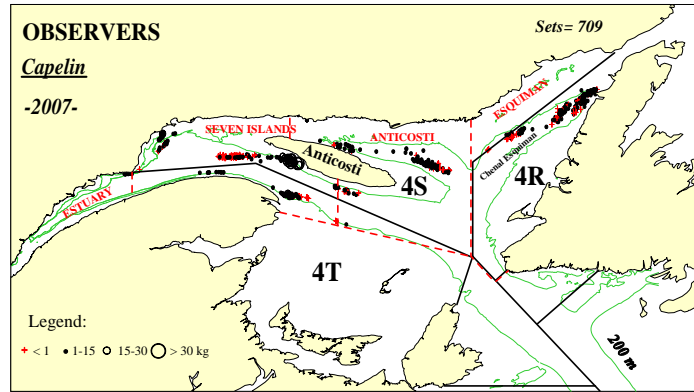


Figure 5. Location of capelin catches (kg) made by commercial shrimpers in 2007 (source of data: Biorex and Seawatch observers). Shrimp fishery management areas are indicated.

The fishery in 4Rc in the 1990s occurred later than in the 1980s (Figure 6). A certain consistency has been observed since then except for 2006.

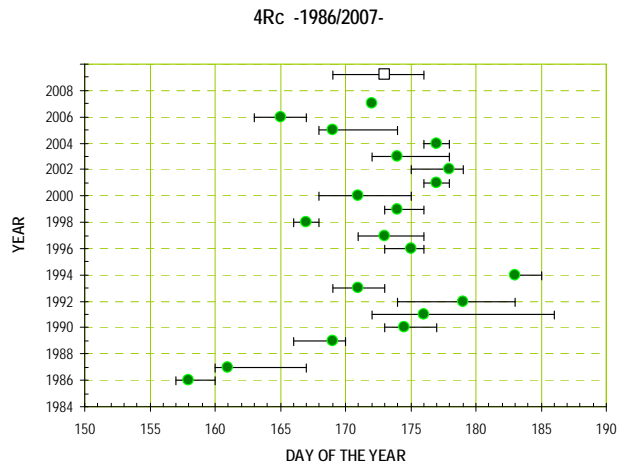


Figure 6. Temporal pattern of the capelin purse seine fishery catches in 4Rc on the west coast of Newfoundland (circles = median landing dates; lines = dates by which 25% and 75% of the landings were made; square = median landing date for all years combined).

ANALYSIS

Description of catches

Mean lengths (both sexes) decreased along the west coast of Newfoundland during the early 1990s (Figure 7). As the fishing effort is dependent upon fish size, the fishery was cut short in 1994, and almost completely closed in 1995. Capelin size stabilized between 1996 and 1998, before decreasing again in 1999. Lengths have increased since 1999 and in 2007 were similar to the annual averages of the 1984-2006 period. In 2007, the mean length was 149 mm for females and 165 mm for males compared to 145 mm and 162 mm respectively in 2006. Fluctuations in capelin size are also observed in the annual length frequencies (Figure 8). In most years, the length frequencies consist of a main mode as a result of overlapping lengths among various age groups.

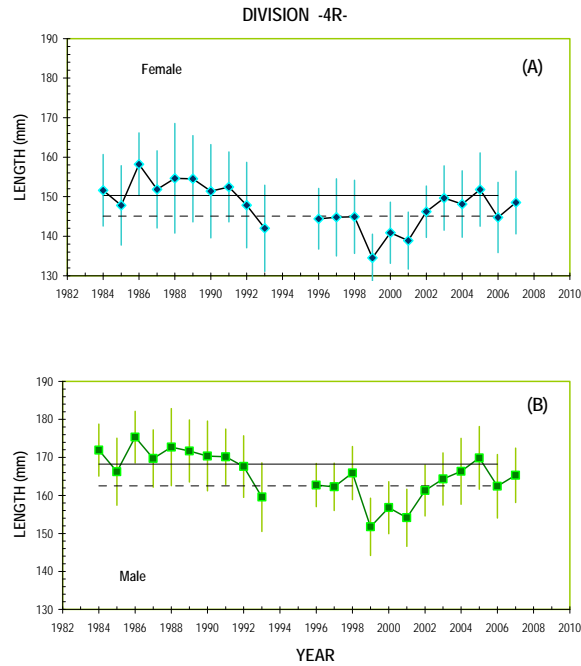


Figure 7. Mean length (mm) of female (A) and male (B) capelin caught with purse seines in NAFO Division 4R since 1984. The horizontal lines indicate the upper and lower limits of the confidence interval (95%) of the mean of years 1984 to 2006, and the vertical lines represent the standard deviations.

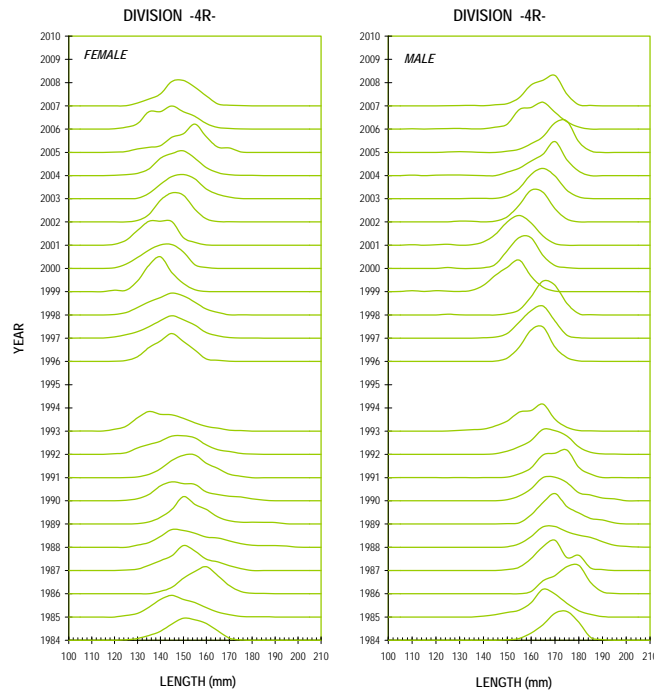


Figure 8. Length (mm) composition (%) of females and males caught with purse seines in NAFO Division 4R between 1984 and 2007.

Resource status

Catch distribution and dispersion index

Capelin are a regular catch in research bottom trawl surveys conducted in the Estuary, the southern and northern Gulf of St. Lawrence. A dispersion index is calculated by indicator kriging based on the presence or absence of capelin in these surveys. It must be noted that this is not an abundance index. The dispersion index indicates an upward trend since 1990 in the presence of capelin in the Estuary and Gulf of St. Lawrence, in particular in Division 4T (Figures 9 and 10). However, the opposite trend has been observed for the west coast of Newfoundland in recent years with values in 2006 and 2007 being among the lowest of the series. These low values are also translated in lower occurrence probabilities (Figure 11).

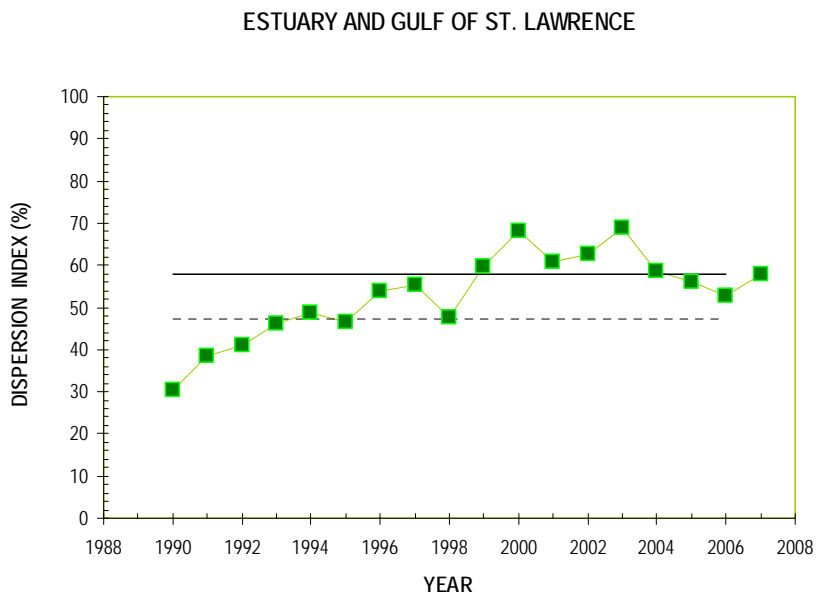


Figure 9. Capelin dispersion index (%) for the Estuary and Gulf of St. Lawrence (Divisions 4RST covered by the northern and southern Gulf surveys). The horizontal lines indicate upper and lower limits of the confidence interval (95%) of the mean of years 1990 to 2006.

The annual dispersion index in Division 4R is related, with a one year lag, to an index measuring the purse seine fishery performance (Figure 12).

Abundance and analytical assessment

There is no directed capelin abundance survey in the Estuary and Gulf of St. Lawrence. Consequently, it is impossible to calculate, using an analytical assessment (Sequential Population Analysis or SPA), biomass, fishing mortality, a minimum biomass limit or Total Allowable Catches (TAC). TACs currently in effect (11,200 t for Division 4R and 1,800 t for Divisions 4ST) are not science-based.

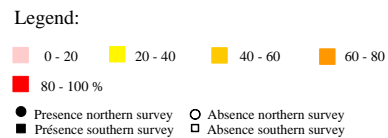
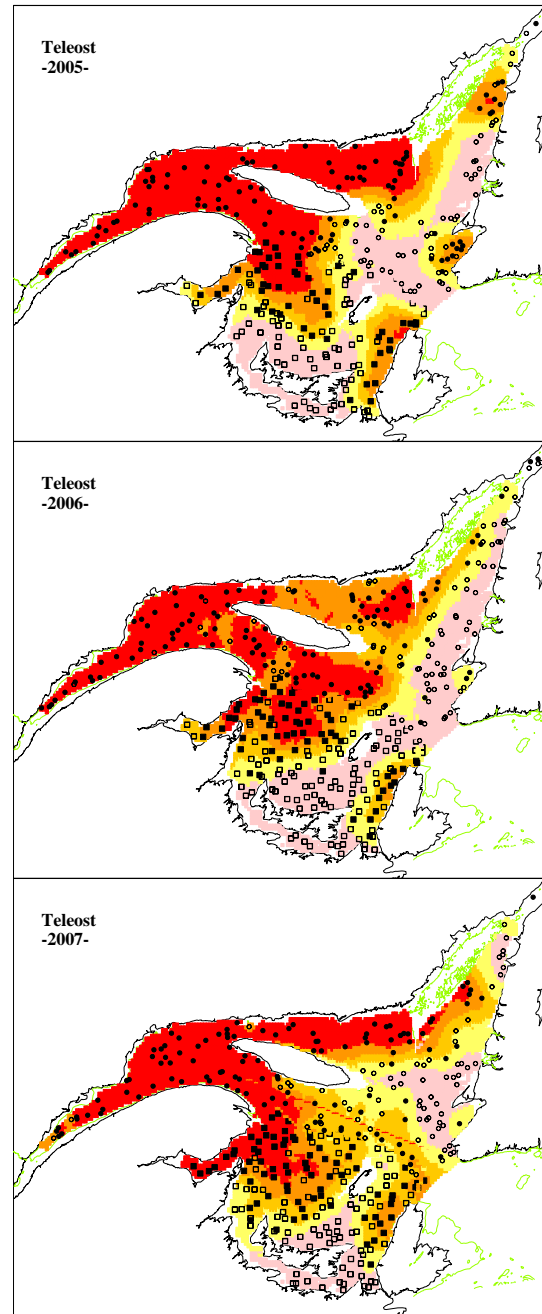
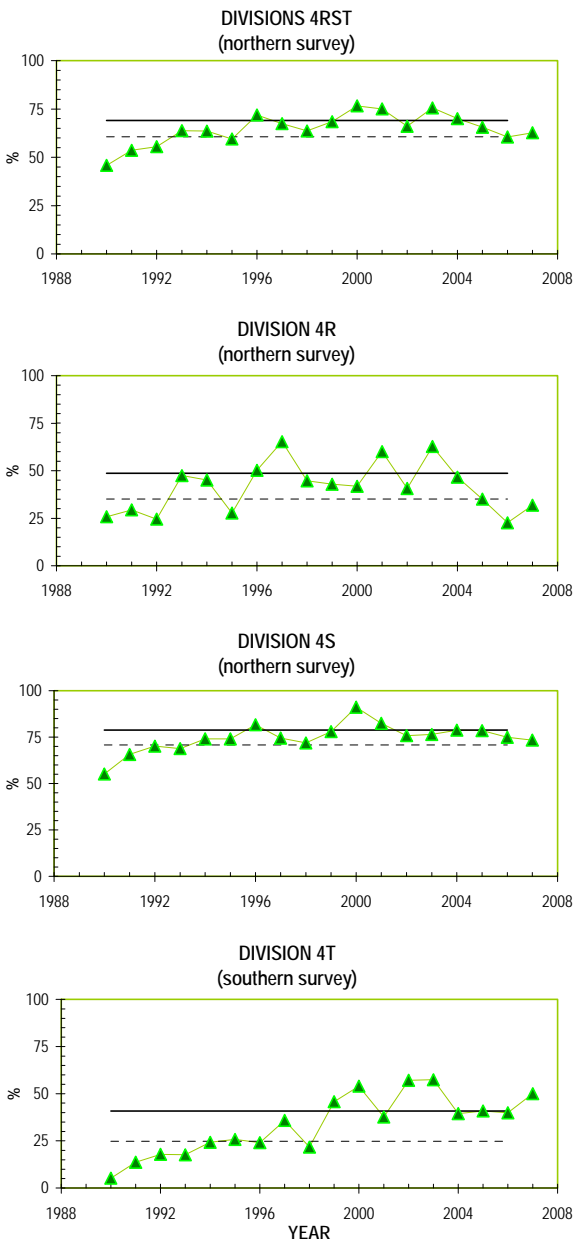


Figure 10. Capelin dispersion index (%) in NAFO Divisions 4RST during research bottom trawl surveys. The horizontal lines indicate upper and lower limits of the confidence interval (95%) of the 1990-2006 average.

Figure 11. Capelin occurrence probability (%) surface maps for the Estuary and Gulf of St. Lawrence in 2005, 2006 and 2007 from research bottom trawl surveys. Station location, capelin occurrence and the 100 m isobath are indicated.

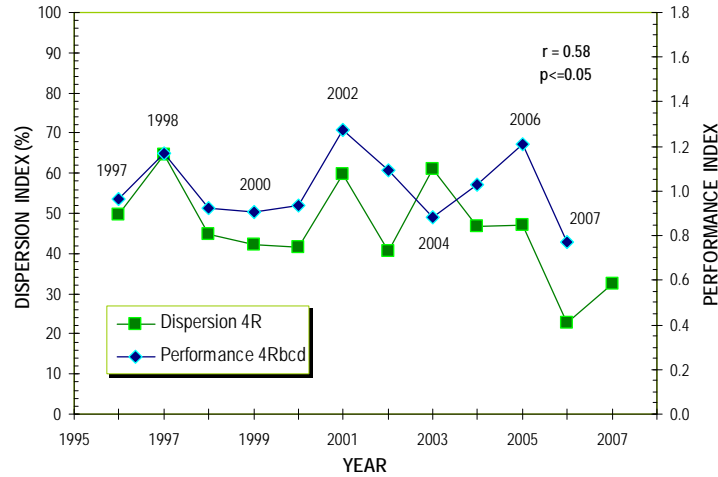


Figure 12. Annual variations of the dispersion index (%) in Division 4R and of an index (standardized) measuring purse seine fishery performance offset by one year.

Sources of uncertainty

The main source of uncertainty is the absence of information regarding capelin abundance in the Estuary and Gulf of St. Lawrence. There is also a lack of information on the number, the location, and size of spawning grounds, and stock structure. Furthermore, there is very little information concerning the role of certain environmental variables on annual migration patterns.

CONCLUSION AND ADVICE

Models of the northern Gulf of St. Lawrence marine ecosystem (Divisions 4RS) indicate that the main cause of capelin mortality is predation (Figure 13A), mostly by large cod and redfish during the mid-1980s, by cetaceans, harp seals (*Phoca groenlandica*) and Greenland halibut (*Reinhardtius hippoglossoides*) during the mid-1990s and the early 2000s, and by redfish and capelin during the mid-2000s (Figure 13B) (C. Savenkoff, pers. comm.). Fishing mortality does not appear to have a noticeable effect on the population(s) at current landing levels, although it is currently impossible to evaluate it.

It is also currently impossible to estimate the impact of a significant increase in landings on the capelin population(s) and the rest of the ecosystem because variations in capelin abundance are first and foremost the result of natural factors. As capelin has a short lifespan, its abundance can be subject to large changes as a population consists of only a few age groups. To satisfy market demand, fishing effort is strongly correlated to the size of female capelin. The industry has a greater interest in regions where environmental conditions are more favourable to capelin growth.

Although the commercial fishery may harvest a very small proportion of the total biomass, any TAC increase should be made cautiously due to capelin's prominent role as a forage species in the marine ecosystem. The failure to locate fish on the traditional fishing grounds in 4Rb and 4Rc in 2007 suggests that no increase of the TAC should be made in Division 4R. Fishing effort should also be dispersed all along the coast and not concentrated in localized areas.

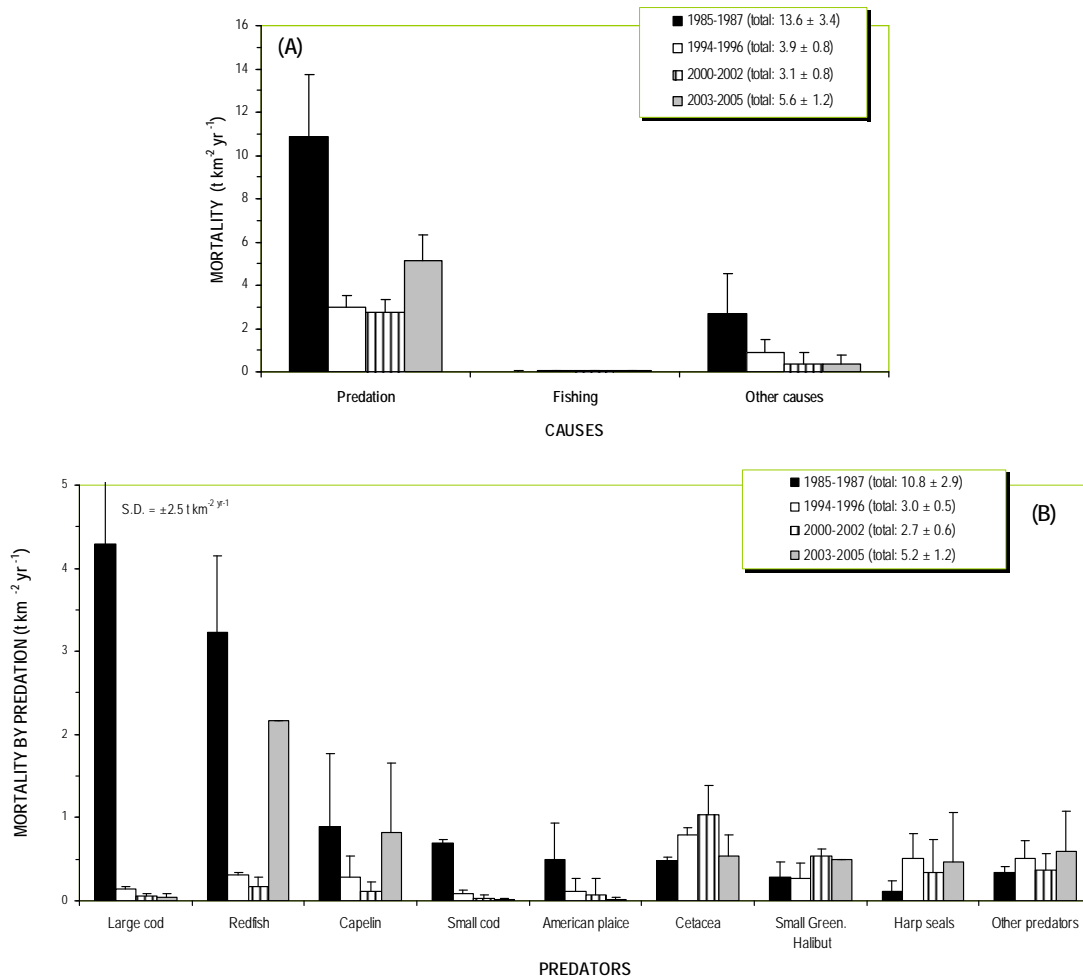


Figure 13. Main causes of capelin mortality ($t\ km^{-2}\ yr^{-1}$) (A) and predation mortality details (B) according to different models of the northern Gulf of St. Lawrence marine ecosystem (Divisions 4RS) from the mid-1980s to the mid-2000s.

SOURCES OF INFORMATION

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