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Science Advisory Report 2006/022

ASSESSMENT OF THE ESTUARY AND GULF OF ST. LAWRENCE (DIVISIONS 4RST) CAPELIN STOCK IN 2005

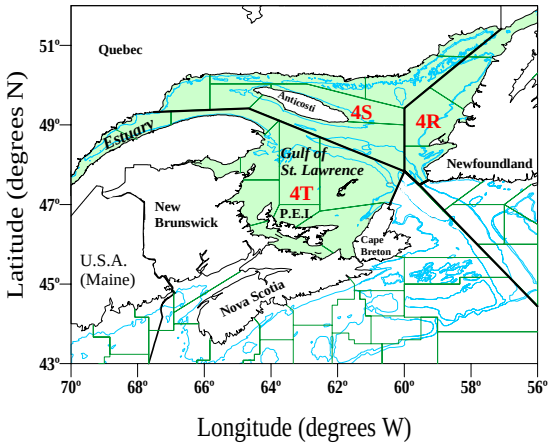

Figure 1. Map of NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence). Divisions 4RST are identified by the coloured area.

Context

During their annual migrations, capelin are subject to a very intense commercial fishery in certain areas. In Canadian waters, capelin has traditionally been used as fertilizer, bait or for its oil. But 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 increased from an average of 700 t per year to nearly 10,000 t. Most landings in the Gulf are made on the west coast of Newfoundland by a fleet of small and large purse senners and by trap fishermen. These two 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 trawls scientific surveys of the CCGS Alfred Needler and Teleost.

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 preventive 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 reproductive biomass, fishing mortality, a minimum biomass limit or even a TAC. Although the fishery probably has little impact on capelin abundance, any TAC increase should be made progressively and cautiously, and be followed by heightened scientific vigilance.

SUMMARY

- Capelin landings in NAFO Divisions 4RST increased from 6,975 t in 2004 to 8,585 t in 2005. Most of these landings were made by a fleet of small and large purse senners in unit areas 4Ra, 4Rb and 4Rc on the west coast of Newfoundland.

- Capelin is regularly caught by shrimpers. In the spring, and in certain areas, capelin catches are relatively significant. In 2005, data collected by observers allowed to determine that around 178 t of capelin were caught by shrimpers.

- During the 1990s, spawning, and therefore the fishery, was delayed compared with the 1980s. A certain stability has been observed since. In 2005, the situation was similar to the late 1980s.

- On the west coast of Newfoundland, the size of capelin caught by small and large purse senners has clearly diminished from the mid 1980s to the late 1990s. The opposite occurred since 1999, and in 2005, lengths were similar to those recorded in the late 1980s.

- For the Gulf as a whole, the dispersion index has shown a clear upward trend since 1990. For the west coast of Newfoundland however, such a trend has not been observed.

- TACs currently in effect are of a preventive nature only (i.e. 11,200 t for 4R and 1,800 t for 4ST). However, although it is well known that the commercial fishery only harvests a very small proportion of the total biomass, any TAC increase should be made progressively and cautiously due to capelin's prominent role in the marine ecosystem, and to the lack of knowledge regarding the species' ecology and biology. Any TAC increase should also be followed by heightened scientific vigilance.

INTRODUCTION

Species Biology

Capelin (*Mallotus villosus*) is a small marine fish species largely distributed in the oceans of the northern hemisphere. In the north of the Atlantic, capelin occur around Russia (Barents Sea), north of Norway, in Iceland, and in Greenland. In the Pacific, the species resides along the coasts of Alaska and British Columbia, and in Asia, along the coasts of Japan, Korea, and Russia. It is also 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. In the early part of the century, capelin were also caught in the Halifax region, in the Bay of Fundy and even in the Gulf of Maine.

Capelin are part of the Osmeridae family and are olive colour, elongated body, and during the spawning period have a pronounced sexual dimorphism. Males can therefore 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 on beaches or in deeper waters. In the first case, capelin literally "roll" on the sandy or fine gravel beaches. Spawning essentially occurs when water temperature is around 6-10°C and is also more active at night. Eggs are reddish and attach themselves to the substrate and are around 1 mm in diameter. The incubation period varies according to ambient temperature. It lasts around 15 days in temperatures of 10 °C. Upon hatching, larvae quickly adopt a planktonic existence and remain near the surface until the arrival of winter. Capelin can spawn at the age of two, and nearly 100% of males die following reproduction activities. The most significant growth period occurs during the first years. Males are longer than females. Furthermore, maximum recorded lengths are rarely above 210 mm.

Capelin are the ideal forage species. They represent a very significant link in the food chain because 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 around 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 are still being consumed by its various predators, making this small fish the principal prey of the northern Gulf of St. Lawrence marine ecosystem over the last 20 years.

Fishery

Description of fishing activities

Purse senne, trap and weir are the main fishing gears used for catching capelin commercially in the Estuary and Gulf of St. Lawrence. Fishing seasons are short and correspond to the pre-spawning period for purse senne and to the spawning period for trap and weir fisheries. In the case of purse senne and trap, 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 700 t/year between 1960 and 1976 to approximately 10,000 t in 1978, 1979, 1989, 1992, 1998 and 2005 (Figure 2).

The most significant landings for the entire Estuary and Gulf of St. Lawrence are made on the west coast of Newfoundland, i.e. in NAFO (Northwest Atlantic Fisheries Organization) Division 4R (Figure 1). In Divisions 4R and 4S (Quebec's North Shore), the most intensive fishing usually occurs in June and July. In Division 4T (Estuary), the fishing season sometimes begins as early as April, but the most significant landings occur in May and June.

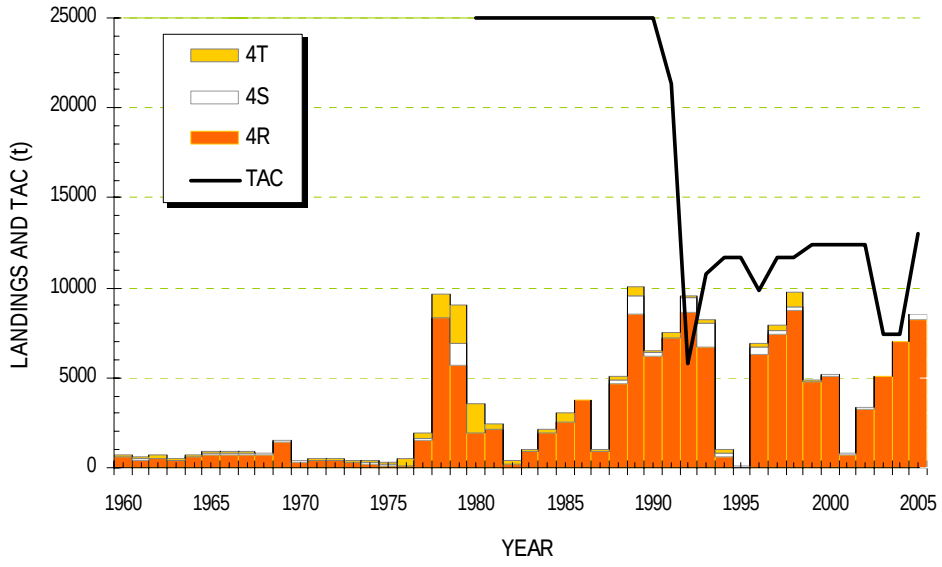

Figure 2. Capelin landings and TAC (t) for NAFO Divisions 4RST (Estuary and Gulf of St. Lawrence) between 1960 and 2005 (in 2005, TAC was divided in the following way: 11,200 t for Division 4R and 1,800 t for Divisions 4ST).

The 2005 season

In 2005, capelin landings (preliminary) in NAFO Divisions 4RST totalled 8,585 t, an increase of 1,609 t compared to 2004 (Table 1). These landings almost all occurred in Division 4R (8,279 t) and correspond to 74% of the 11,200 t TAC for this Division. Of the 8,585 t landed in 2005, 5,485 t were made by the purse senne fishery, 2,845 t by the trap fishery, and 255 t by trawl. The most significant landings of the 2005 season occurred in unit areas 4Ra and 4Rc, with 4,709 t and 2,302 t respectively (Table 2). Between 1990 and 2004, mean annual landings associated with the purse senne fishery were 4,579 t (Table 1). This fishery occurs near the coast, mainly between St. Paul's Inlet and Stephenville (Figure 3).

Table 1. Estuary and Gulf of St. Lawrence: Capelin landings (t) by NAFO Division and by fishing gear from 1990 to 2005.

DIVISION-GEAR	YEAR																AVERAGE
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*	(1990-2004)
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	8 279	5 177
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	
4S	164	59	856	1 263	208	90	461	252	141	10	69	66	77	0	0	305	248
4T	153	247	56	236	166	47	172	238	893	166	18	5	20	0	0	0	161
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*	
Beach senne	458	149	12	0	13	15	0	0	0	0	0	0	0	0	0	0	40
Purse senne	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	4 579
Trap	1 720	181	1 921	1 283	210	103	1 306	1 203	2 509	11	1	0	7	379	2 148	2 845	865
Weir	129	127	56	128	94	34	113	175	57	0	0	0	0	0	0	0	57
Trawl	0	1	0	0	0	0	0	0	0	110	0	0	2	0	188	255	20
Other	0	0	11	0	0	0	0	0	0	0	87	0	87	0	0	0	12
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	8 585	5 586

* Preliminary

Table 2. West coast of Newfoundland (4R): Capelin landings (t) by NAFO unit area from 1990 to 2005.

UNIT AREA	YEAR																AVERAGE
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005*	(1990-2004)
4Ra	1 959	154	1 554	73	10	15	605	734	1 827	29	0	0	115	513	3 965	4 709	770
4Rb	479	82	1 506	469	265	0	1 841	2 480	3 814	1 675	356	0	856	1 070	765	929	1 044
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	2 302	2 764
4Rd	104	2 023	117	1 933	72	0	430	14	581	0	0	136	0	0	61	340	365
NK**	2 739	0	754	0	0	0	25	0	0	0	0	0	0	0	0	0	220
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	8 279	5 177

* Preliminary; ** Not known

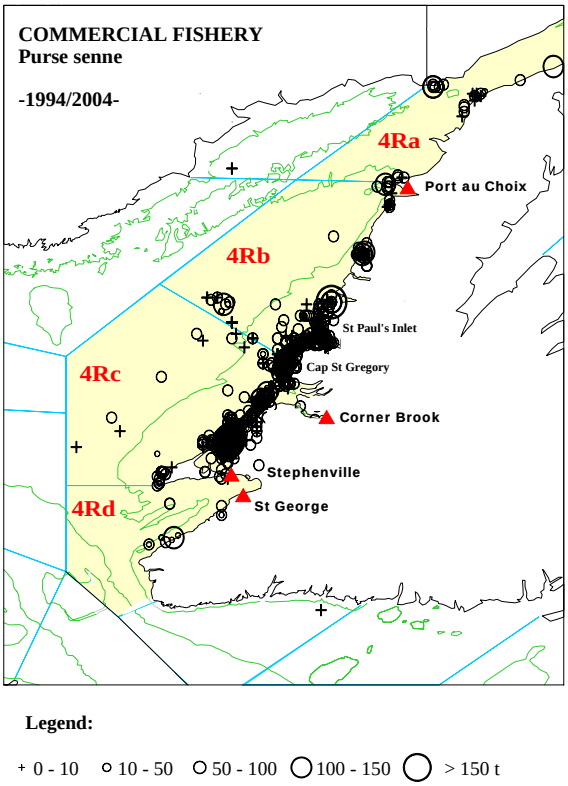

Figure 3. Location of capelin catches (t) made by purse senne commercial fishermen between 1994 and 2004.

Capelin are also a regular by-catch for shrimp fishermen. In the spring, in areas such as the Esquiman Channel, the number of capelin caught by shrimpers can be significant. Some fishermen even avoid some sectors during certain periods in order to not catch too many capelin. According to observers' data, capelin by-catches by shrimpers dropped from 887 t in 1993 to a minimum of 96 t in 2001 (Figure 4). These catches came mostly from the Seven Islands area (Figure 5). In 2005, approximately 178 t of capelin were caught by shrimpers. Most of these catches were made south of Anticosti Island and at the head of the Esquiman Channel (Figure 5).

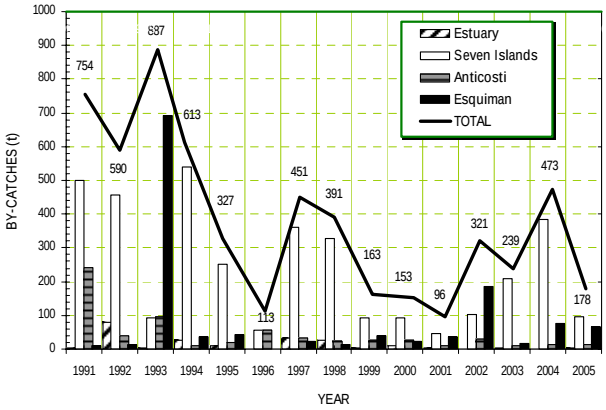

Figure 4. Annual capelin by-catch estimates (t) made by commercial shrimpers since 1991 (source of data: Biorex and Seawatch observers).

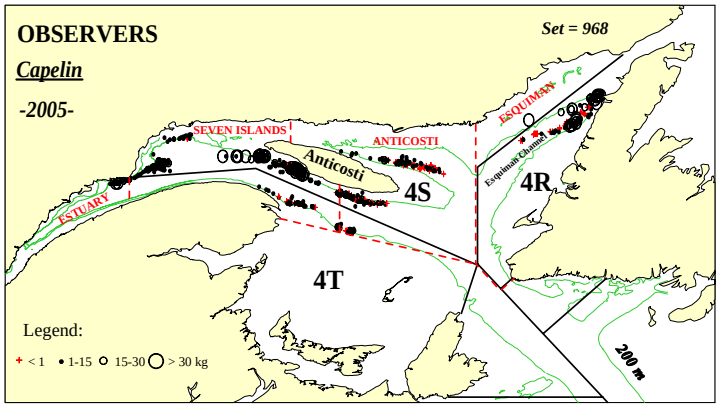

Figure 5. Location of capelin catches (t) made by commercial shrimpers in 2005 (source of data: Biorex and Seawatch observers). Shrimp fishery management areas are indicated.

Between the late 1980 and the mid-1990s, capelin fishing and spawning seasons occurred at increasingly later dates (Figures 6). A relative stability has been observed since. The situation in 2005 is similar to that of the late 1980s.

ANALYSIS

Description of catches

A constant reduction in female and male mean size has been observed on the west coast of Newfoundland since the late 1980s (Figure 7). As a result, 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. However, an upward trend has been observed since 1999. In 2005, average lengths for females and males were 152 mm and 170 mm respectively. These lengths are similar to those recorded during the late 1980s. These fluctuations in capelin size are also observed in the annual length frequencies (Figure 8). In most cases, the length frequencies consist of a main mode as a result of length overlapping among the various age groups.

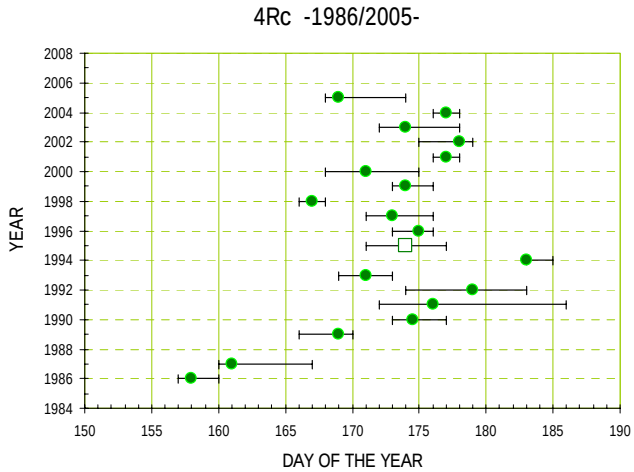

Figure 6. Temporal pattern of the capelin purse senne fishery in unit area 4Rc on the west coast of Newfoundland (circles = median landing dates; lines = dates by which 25% and 75% of the landings were made; square = median landing date for all years combined).

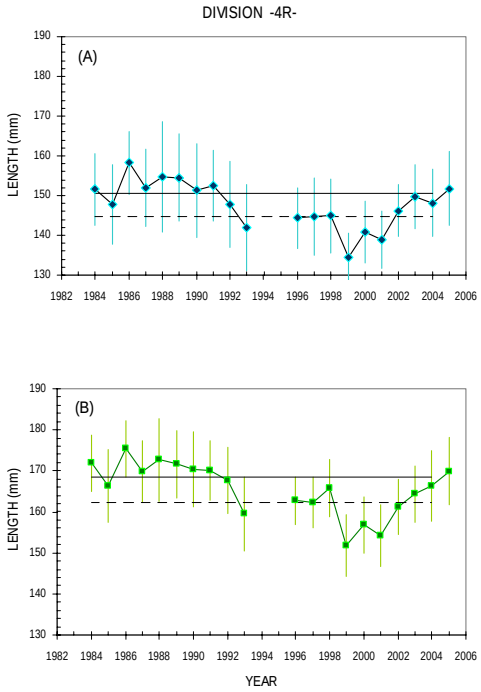

Figure 7. Mean length (mm) of female (A) and male (B) capelin caught with purse sennes in NAFO Division 4R since 1984. The horizontal lines indicate the upper and lower limits of the confidence interval (95%) of the mean of years 1984 to 2004, and the vertical lines represent the standard deviations.

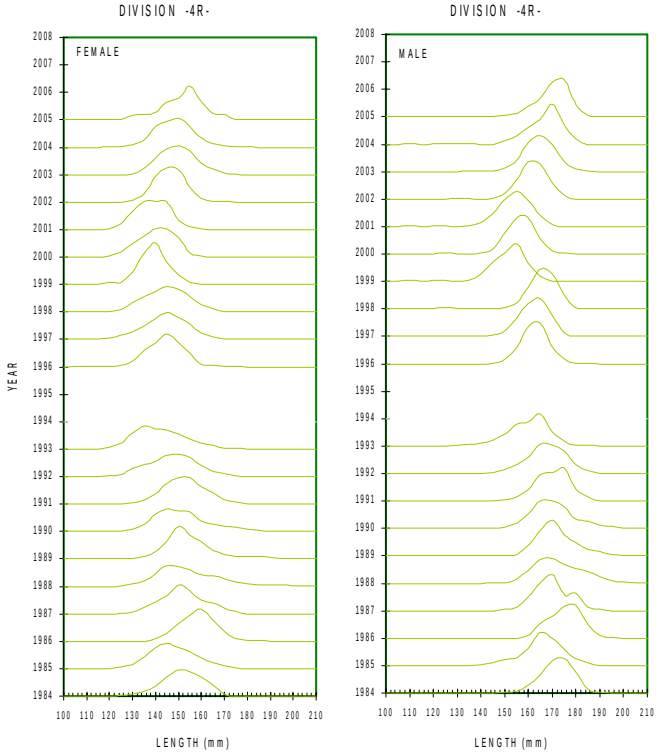

Figure 8. Size (mm) composition (%) of females and males caught with purse sennes in NAFO Division 4R between 1984 and 2005.

Resource status

Catch distribution and dispersion indices

Capelin are a regular catch in bottom trawl surveys of the CCGS *Alfred Needler* and *Teleost* in the southern and northern Gulf of St. Lawrence. A dispersion index is calculated by indicator kriging based on the capelin presence and absence data gathered during these surveys. This index, representing the average capelin occurrence probability in the Estuary and Gulf of St. Lawrence, shows a clear upward trend since 1990 (Figure 9). However, a drop in dispersion has been measured since 2004 on the west coast of Newfoundland (Division 4R) (Figure 10). This drop can be seen clearly by the reduction of the very high capelin occurrence probabilities (Figure 11).

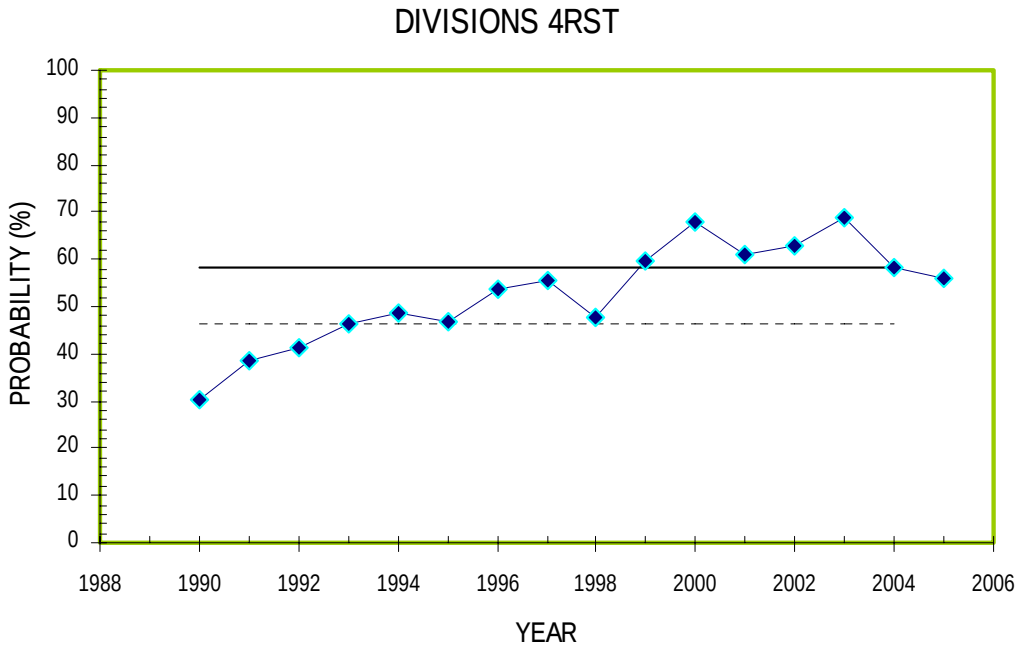

Figure 9. Mean capelin occurrence probabilities in the Estuary and Gulf of St. Lawrence (Divisions 4RST). The horizontal lines indicate upper and lower limits of the confidence interval (95%) of the mean of years 1990 to 2004.

Annual dispersion index variations in Division 4R are joined, a year later, by similar variations of an index measuring the purse senne fishery performance (Figure 12). As the dispersion index decreased in 2005, we could see a reduction in the purse senner performance in 2006.

Abundance and analytical assessment

There is no abundance survey specifically directed on capelin in the Estuary and Gulf of St. Lawrence. Consequently, it is impossible to calculate, using an analytical assessment (Sequential Population Analysis or SPA), spawning biomass, fishing mortality, a minimum b iomass limit or even a Total Allowable Catches (TAC). TACs currently in effect are of a preventive nature only (11,200 t for Division 4R and 1,800 t for Divisions 4ST).

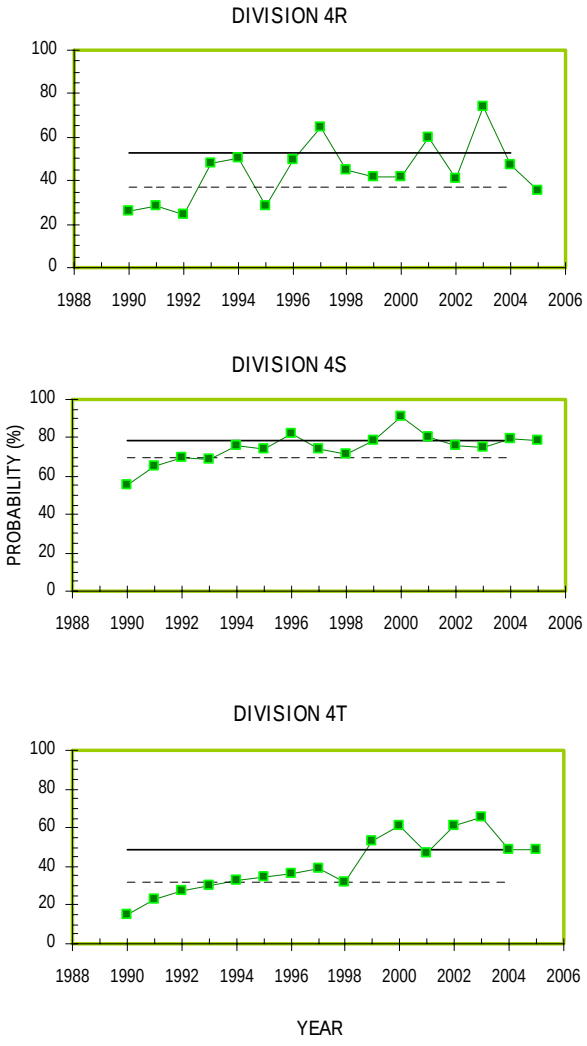

Figure 10. Mean probabilities of finding capelin in NAFO Divisions 4RST. The horizontal lines indicate upper and lower limits of the confidence interval (95%) of the 1990-2004 average.

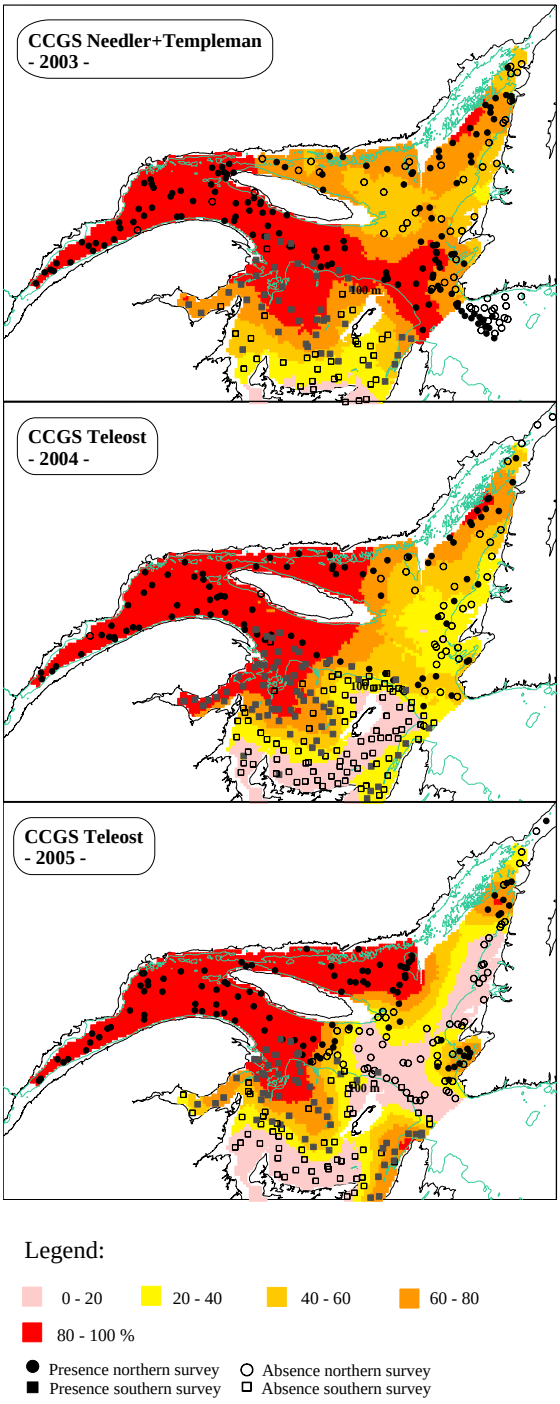

Figure 11. Capelin occurrence probability surface (%) in the Estuary and Gulf of St. Lawrence in 2003, 2004 and 2005. Station location, capelin occurrence and the 100 m isobath are indicated.

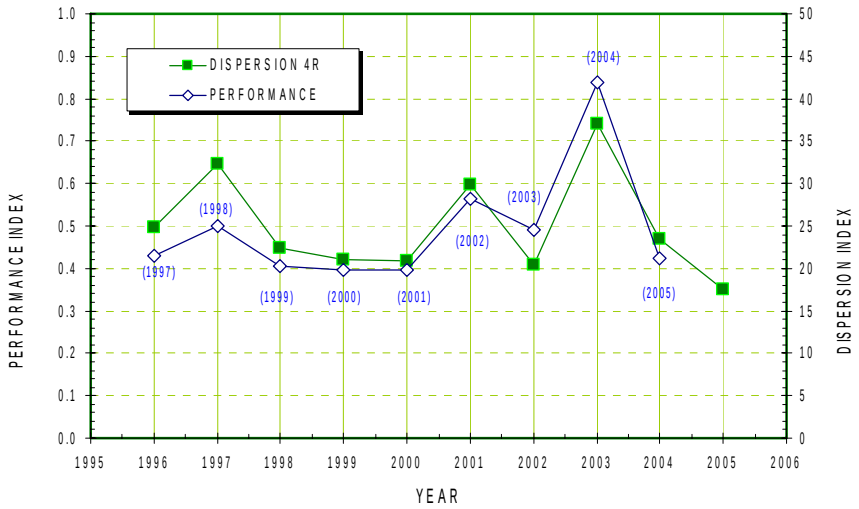

Figure 12. Annual variations of the dispersion index in Division 4R and of an index (standardized) measuring purse senne fishery performance dephased by a year.

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 the size of spawning grounds. Furthermore, there is very little information concerning the role of certain environmental variables on annual migration patterns.

CONCLUSION AND ADVICE

Fishing mortality does not appear to have a noticeable effect on the population at the current landing levels, even though it is currently impossible to evaluate it. Furthermore, according to the results from different models of the northern Gulf of St. Lawrence marine ecosystem (Divisions 4RS), the main cause of capelin mortality would be predation (Figure 13A), mostly by large cod and redfish during the mid-1980s, and by cetaceans, harp seals (*Phoca groenlandica*) and Greenland halibut (*Reinhardtius hippoglossoides*) during the mid-1990s and the early 2000s (Figure 13B).

It is currently impossible to estimate the impact that a significant increase in landings would have on the capelin population 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 is subject to sharp changes because the 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 it is common knowledge that the commercial fishery only harvests a very small proportion of the total biomass, we recommend that any TAC increase be made progressively and cautiously due to capelin's prominent role in the marine ecosystem, and because of the lack of knowledge regarding its biology and ecology. Any TAC increase should also be followed by heightened scientific vigilance.

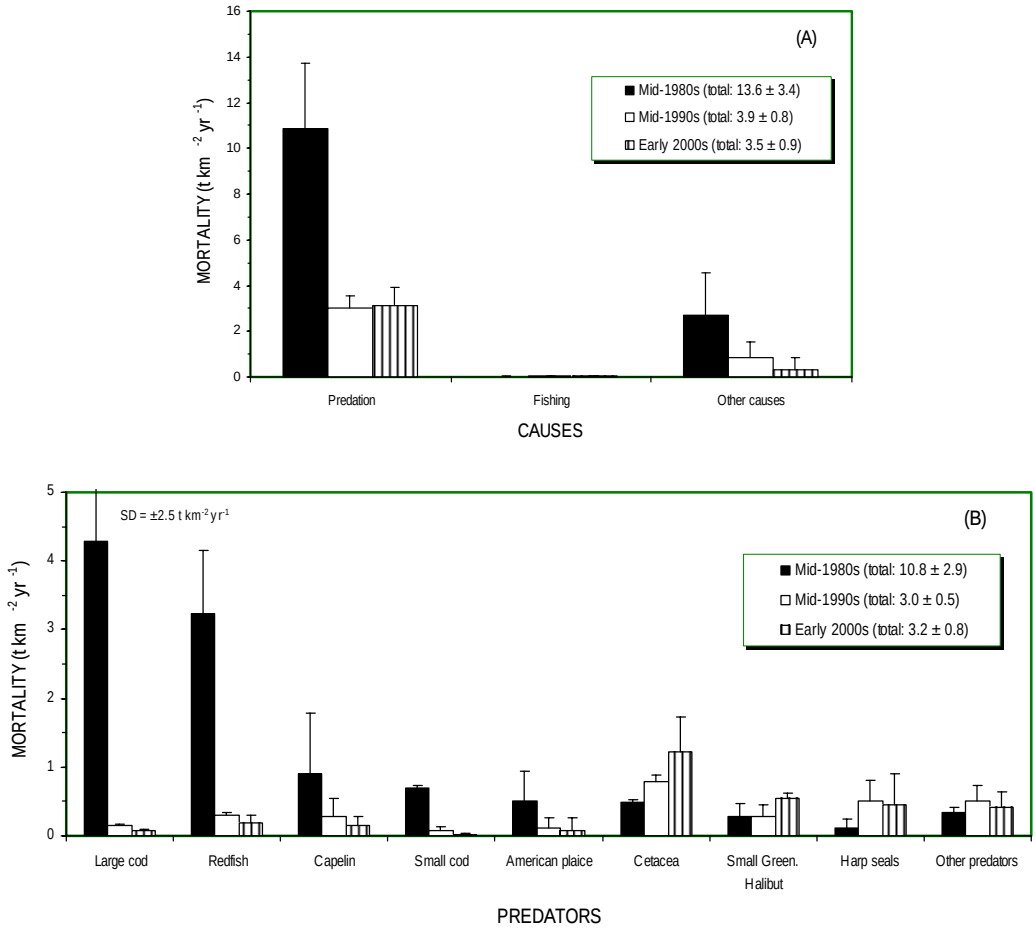

Figure 13. Main causes of capelin mortality (t km^{-2} yr^{-1}) (A) and predation mortality details (B) according to different models of the northern Gulf of St. Lawrence marine ecosystem (Divisions 4RS) from the mid-1980s to the early 2000s.

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