

Shrimp of the Estuary and Gulf of St. Lawrence in 2002

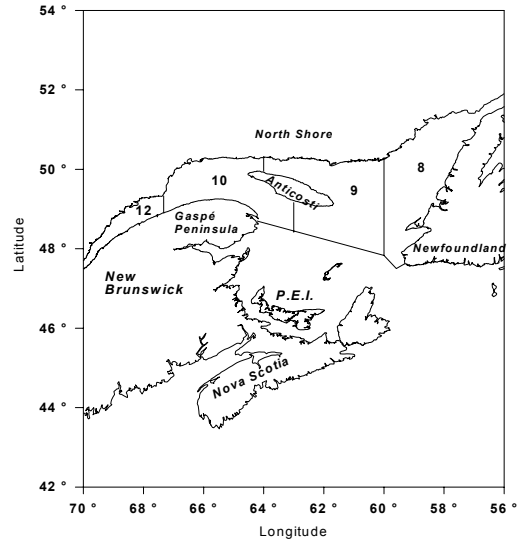


Figure 1. Shrimp management units in the Gulf of St. Lawrence : area 12 – Estuary, area 10 - Sept-Îles, area 9 – Anticosti, area 8 – Esquiman.

Background

Shrimp are fished commercially from spring to fall in four management areas. The resource is assessed each year to determine whether changes that have occurred in the stock status necessitate adjustments to the conservation approach and management plan.

A number of peculiarities of shrimp biology influence the fishery, fishery management and resource conservation.

Shrimp change sex in the course of their life cycle, achieving male sexual maturity at about two and a half, then becoming female at about four or five years of age. The females, which carry their eggs beneath the abdomen, are thus among the largest specimens in commercial catches; the males are smaller because they are younger. Mating takes place in the fall and the females carry their eggs for eight months, from September until April. The larvae are pelagic when they hatch in spring but settle on the bottom in late summer. Shrimp migrations are associated with breeding (the berried females migrate to shallower water in winter) and feeding (at night, they leave the ocean floor to feed on small planktonic organisms). Generally speaking, shrimp are found throughout the Estuary and in the northern Gulf at depths of 150 to 350 m.

Summary

Shrimp landings increased to 28,000 tons in 2002 relative to 2000 and 2001. The TACs that remained unchanged in 2002 after an increase in 2001 were reached in the four fishing areas.

In 2002, the commercial fishery catch per unit of effort and the research survey biomass index were higher than the 1990-1999 mean in the Sept-Îles and Anticosti areas while they decreased to reach the mean in the Estuary area. The fishery CPUE in the Esquiman area was still high in 2002 while the survey biomass index decreased to reach a value that is below the 1990-1999 mean. In the Estuary, Sept-Îles and Anticosti areas, the size of females responsible for the egg production increased between 1995 and 1998 above the 1990-1999 mean. It has decreased since then to reach a value below the mean in 2001 and 2002. The situation is

particularly of concern in the Esquiman area, where the size of spawning females showed a smaller increase between 1995 and 1998; the size has decreased since 1998 and has been below the mean since 1999.

The exploitation rate index in 2002 is similar to the 1990-1999 mean in the Estuary and Sept-Îles areas whereas it is lower than the mean in the Anticosti area. The index has increased since 1997 in the Esquiman area and now exceeds the mean.

The fishery in 2003 will harvest the reproductive females of the 1998 year class, the recruiting females of the 1999 year class and the spawning males of the 2000 year class. The cohort strength indices show that the 1998 year class is weak and that the 1999 year class is abundant. It is too early to determine with certainty the strength of the 2000 year class. The available biomass and the catch rates should remain stable in 2003, especially since the shrimp from the 1999 year class (most of which should lay eggs in fall 2003) seem smaller than average.

It is not possible to explain the fluctuations in the size of the spawning females. However, the impact of the female size reduction is negative for both the egg production and fishing success. In this context, it is recommended that 2003 yields be set at a level that would result in exploitation rates similar to the mean rate of the years 1990-1999. This should limit the harvest of females and preserve the reproductive capacity of the stocks.

In the Estuary, Sept-Îles and Anticosti areas, it is recommended that the 2003 TACs be kept equal to those of 2002 and 2001 since we do not expect an increase in biomass or in the size of shrimp available to the fishery. Keeping

2003 TACs similar to those of 2002 should result in exploitation rates similar to those observed since 1998.

In the Esquiman area, it is recommended that the 2003 TAC be decreased to 5,970 tons in order to decrease the exploitation rate, which has increased since 1997. Assuming that the abundance in 2003 is near the 1990-1999 mean and that the commercial catch composition is similar to that of 2002, a catch of 5,970 tons should result in an exploitation rate equivalent to the 1990-1999 mean.

An effect of the exploitation on the decrease in abundance and size of spawning females cannot be dismissed in the Esquiman area. The number of shrimp harvested by the fishery per landed ton is 30 % higher in Esquiman than in Sept-Îles. The total number of shrimp harvested by the fishery is equivalent to that of Sept-Îles for a TAC that is 25 % lower and a stock that is much smaller in abundance and area occupied. More severe actions will have to be taken as early as 2004 if the abundance and size of females do not increase or if the exploitation rate does not decrease.

Description of Fishery

The northern shrimp fishery began in the Gulf of St. Lawrence in 1965. Most of the fishing is done by three fleets (Quebec, New Brunswick and Newfoundland) in four management areas: Sept Îles (Area 10), Anticosti (Area 9), Esquiman (Area 8) and Estuary (Area 12) (Figure 1).

Shrimp fishing is controlled by a number of management measures, including TACs (total allowable catches) in the four management areas (Table 1). In 2002 there were 112 permanent shrimp licences, and the license holders have individual quotas. In addition, since 1997, temporary allocations have been granted to shrimpers without permanent licences. Other management tools include a minimum mesh size (40 mm) and, since 1993, the compulsory use of the Nordmore grate, which reduces groundfish by-catches significantly. The shrimp fishery runs from April 1 to December 31.

Landings of northern shrimp in the Estuary and Gulf of St. Lawrence have risen gradually since the fishery began.

(Table 1). Preliminary statistics indicate that landings increased in 2002 to reach the highest value that has been recorded since the beginning of the fishery.

Conservation Approach

TAC-based management limits fishing so as to protect the reproductive potential of the population. Limiting the catch ensures that a certain proportion of shrimp will not be harvested and will thus remain available for spawning. The TAC is empirically based on past catches. Minimum biomass or maximum fishing that could endanger the stock are not known, nor is the optimum fishing level that would allow precise targets to

Table 1. Landings and total allowable catch (TAC) in tons by management unit and by year. Data for 2002 are preliminary

Year	Estuaire		Sept-Iles		Anticosti		Esquiman		Gulf
	Landing	TAC	Landing	TAC	Landing	TAC	Landing	TAC	
1982	152	500	3774	3800	2464	4400	2111	4200	8501
1983	158	500	3647	3800	2925	5000	2242	6000	8972
1984	248	500	4383	4800	1336	5000	1578	6000	7545
1985	164	500	4399	4600	2786	3400	1421	6000	8770
1986	262	500	4216	4600	3340	3500	1592	3500	9410
1987	523	500	5411	5600	3422	3500	2685	3500	12041
1988	551	500	6047	5600	2844	3500	4335	3500	13777
1989	629	500	6254	5700	4253	4200	4614	4500	15750
1990	507	500	6839	6400	4723	4200	3303	4700	15372
1991	505	500	6411	6400	4590	5000	4773	4700	16279
1992	489	500	4957	6400	4162	5000	3149	4700	12757
1993	496	500	5485	6400	4791	5000	4683	4700	15455
1994	502	500	6165	6400	4854	5000	4689	4700	16210
1995	486	500	6386	6400	4962	5000	4800	4700	16634
1996	505	500	7014	7040	5469	5500	5123	5170	18111
1997	549	550	7737	7744	6058	6050	5957	5687	20301
1998	634	633	8981	8966	6932	7004	6554	6584	23101
1999	634	633	9058	8966	6884	7004	6603	6584	23179
2000	725	709	9907	10042	7760	7844	7184	7374	25576
2001	812	786	10687	11137	5294	8698	7581	8176	24374
2002	762	786	10975	11136	8360	8700	7992	8178	28089

Landings rose from approximately 1,000 tons to 7,500 tons between the early and late 1970s, reached nearly 15,000 tons by the late 1980s, and were over 23,000 tons by the late 1990s

be set.

Resource Assessment

Stock status was determined by examining a number of indicators from

the commercial fishery and research surveys. These indicators are based on fishing success, stock abundance and resource productivity. Shrimp abundance dropped between 1992 and 1994, then increased between 1994 and 1997, and remained stable at a very high level until 1999. To assess stock status in 2002 we used the mean values for 1990-1999 as a baseline.

Indicators were assessed and given one of three ratings:

Positive: The value of the indicator differs from the mean, with a positive result for resource status (for example, biomass above mean or mortality below mean).

Neutral: The value of the indicator is similar to the mean.

Negative: The value of the indicator differs from the mean, with a negative result for resource status.

The limits of the neutral category are defined by confidence intervals around the mean for the years 1990-1999. The indicators are different from the mean when their annual value is above or below the upper or lower limits of the confidence interval. Assessment results for the indicators are given for each stock and each year since 1990 (Table 2).

Data Used

Commercial fishery statistics (shrimper catch and effort) are used to calculate nominal fishing effort, i.e., total number of hours fished. They are then used to calculate catches per unit of effort (CPUEs) and numbers per unit of effort (NPUEs), i.e., the mean number of shrimp caught per hour fished. The effort data are standardized to take into account changes in fishery capacity and

seasonal fishing patterns. The mean length of shrimp harvested by the fishery is also calculated every year and is used to calculate the number of shrimp per landed kilogram or ton. The mean size of primiparous females caught in the spring (April and May) provides an indication of the size of females that changed sex and that will lay eggs the following fall. The mean size of females caught in the fall (September to December) as well as the mean size of multiparous females caught the following spring provides an indication of the size of the reproductive females.

Research surveys have been conducted in the Estuary and Gulf of St. Lawrence in August or September each year since 1990. The surveys use a stratified random design and are conducted from the department vessel *C.C.G.S. Alfred Needler*, equipped with a shrimp trawl. The data series has been adjusted to take into account the fact that shrimp catchability varies between day and night. Biomass indices are then calculated using a geostatistical method. Shrimp abundance (in number) is estimated using survey stations conducted in the daytime only. The mean lengths of females at the time of the survey provide an indication of the size of the reproductive females that will carry eggs for all winter. The abundance of the three-year-old males (CL = 19 mm) provides an indication of the strength of the cohort and the recruitment to the female component the year after.

An exploitation rate index is obtained by dividing commercial catches (in number) by the abundance index derived from the research surveys. This method cannot be used to estimate the absolute exploitation rate or to relate it to target

exploitation rates, but the exploitation rate index does make it possible to track relative changes in the exploitation rate over the years.

Resource Status

Most of the indicators of the resource status were negative through the first half of the 1990s (Table 2). Thereafter, the recruitment to the fishery of several year-classes with higher-than-average

resource status indicators were positive during the second half of the 1990s. Changes in the status of the resource have been perceptible since 2001, as the number of negative indicators increased. Some of the negative indicators are associated with the size of shrimp available to the fishery in the four areas. However, whereas the biomass of shrimp has been maintained at a high level in the Sept-Îles and Anticosti areas, it has decreased in the Estuary

Table 2. Indicators used to assess the status of the resource by management unit and by year. The symbols are determined by the difference between the annual value of the indicator and the 1990-1999 mean (⊕ : positive impact for the resource; = : similar to the mean; ⊖ : negative impact for the resource; nd : no data).

ESTUARY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishing effort	=	=	⊖	=	=	=	⊕	⊕	⊕	⊕	⊕	=	=
Catch per unit of effort	⊖	⊖	⊖	⊖	=	=	=	=	⊕	⊕	⊕	⊕	=
Number per unit of effort for males	nd	nd	nd	nd	nd	=	⊖	=	=	⊕	⊕	⊕	⊕
Number per unit of effort for females	nd	nd	nd	nd	nd	⊖	=	=	⊕	⊕	⊕	=	⊖
Number of shrimp per landed kg	nd	nd	nd	nd	nd	=	⊕	⊖	=	=	=	⊖	⊖
Survey biomass	=	=	=	=	=	⊖	=	⊕	⊖	⊕	⊕	=	=
Number of adult males from the survey	⊕	⊖	=	⊕	=	⊖	=	=	⊖	⊕	=	⊖	⊖
Number of females from the survey	=	=	=	⊖	=	⊖	⊕	⊕	⊖	⊕	⊕	=	=
Size of recruiting females	=	nd	⊖	nd	=	=	⊕	=	⊕	⊕	=	=	=
Size of spawning females	⊖	=	⊕	⊕	=	⊖	⊖	=	⊕	=	⊖	⊖	⊖
Recruitment at age 3	=	=	=	⊕	⊕	⊖	=	=	⊖	⊖	⊕	⊖	⊕
Total exploitation rate	nd	nd	nd	nd	nd	⊖	⊕	⊕	⊖	⊕	⊕	⊖	=

SEPT-ÎLES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishing effort	=	=	⊖	⊖	⊖	⊕	⊕	⊕	⊕	=	=	⊖	=
Catch per unit of effort	=	=	⊖	⊖	⊖	=	=	⊕	⊕	⊕	⊕	⊕	⊕
Number per unit of effort for males	=	⊖	⊖	⊖	⊖	⊕	⊕	⊕	⊕	=	⊕	=	⊕
Number per unit of effort for females	=	=	⊖	⊖	⊖	=	=	⊕	⊕	⊕	⊕	⊕	⊕
Number of shrimp per landed kg	⊕	=	⊖	⊖	⊖	=	=	⊕	⊕	⊕	=	=	⊖
Survey biomass	⊖	=	⊖	⊖	=	=	=	⊕	⊕	⊕	⊕	=	⊕
Number of adult males from the survey	⊕	⊖	⊖	=	=	=	=	⊕	⊖	⊕	⊕	=	⊕
Number of females from the survey	=	=	⊖	⊖	=	=	=	⊕	⊕	⊕	⊕	⊕	⊕
Size of recruiting females	⊖	=	⊕	=	⊖	⊖	=	=	⊕	⊕	=	⊖	⊖
Size of spawning females	=	=	⊕	=	=	⊖	⊖	=	⊕	⊕	⊖	⊖	⊖
Recruitment at age 3	⊕	⊖	⊖	=	⊕	⊕	=	⊕	=	⊖	⊕	⊖	⊕
Total exploitation rate	⊕	=	⊖	=	=	=	=	⊕	=	⊕	⊕	=	=

abundance led to an increase in productivity, to the point that most of the

and Esquiman areas, resulting in a supplementary increase in the number

Table 2 continued. Indicators used to assess the status of the resource by management unit and by year. The symbols are determined by the difference between the annual value of the indicator and the 1990-1999 mean (+ : positive impact for the resource; = : similar to the mean; - : negative impact for the resource; nd : no data).

ANTICOSTI	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishing effort	+	+	=	-	=	+	=	=	=	-	=	+	=
Catch per unit of effort	=	=	-	-	=	=	=	+	+	=	+	+	+
Number per unit of effort for males	=	=	-	-	=	+	=	=	=	+	+	+	+
Number per unit of effort for females	=	-	-	-	-	=	=	+	+	=	+	+	+
Number of shrimp per landed kg	-	=	+	-	-	-	+	+	+	=	=	-	-
Survey biomass	=	=	-	-	-	=	+	+	=	=	+	=	+
Number of adult males from the survey	=	=	-	-	-	=	+	+	=	=	=	=	+
Number of females from the survey	=	-	-	-	-	=	+	+	=	=	+	=	+
Size of recruiting females	nd	-	nd	+	-	-	=	=	=	=	=	-	=
Size of spawning females	-	-	=	+	=	-	=	+	=	+	=	=	-
Recruitment at age 3	=	=	-	-	=	+	+	=	=	-	+	-	+
Total exploitation rate	=	=	=	-	-	+	+	+	=	=	=	=	+

ESQUIMAN	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishing effort	+	-	=	-	=	-	+	+	=	=	=	=	-
Catch per unit of effort	-	=	-	-	=	=	+	+	+	+	+	+	+
Number per unit of effort for males	-	-	-	=	=	=	+	+	+	=	+	+	+
Number per unit of effort for females	-	-	-	-	=	=	=	+	+	+	+	+	+
Number of shrimp per landed kg	+	+	+	-	=	-	-	=	+	=	=	-	-
Survey biomass	=	=	-	-	-	=	=	+	+	+	=	=	-
Number of adult males from the survey	=	-	-	-	-	=	=	+	+	+	=	=	=
Number of females from the survey	=	=	-	-	-	=	=	+	=	+	+	=	=
Size of recruiting females	=	=	=	+	+	-	=	=	=	-	-	-	-
Size of spawning females	+	=	+	+	+	-	-	-	=	-	-	-	-
Recruitment at age 3	=	-	-	-	=	=	=	+	+	=	+	-	=
Total exploitation rate	+	=	=	-	-	=	=	+	+	+	=	=	-

of negative indicators for these two areas.

Since 1999, the recruitment to the fishery has alternated between strong (1997 and 1999) and weak (1996 and 1998) cohorts. The entry into the fishery of the abundant 1997 and 1999 year classes in 2000 and 2002 helped to keep the commercial fishermen catch rates high (Figure 2). The TACs were increased in 2000 and again in 2001, and fishermen had to expend a greater effort to catch their allocations. However, the size of females decreased, and this decrease combined with the high abundance of the males of

the 1997 and 1999 year classes over the fishing grounds resulted in an increase in the number of shrimp harvested per kilogram (Figure 3). Since 1998, the number of shrimp per kilogram has increased by 34 % in the Estuary area and by 21 to 23 % in the Sept-Îles, Anticosti and Esquiman areas. The total number of shrimp harvested by the fishery has increased continuously in all stocks but at a quicker rate than the landings. From 1998 to 2002, the landings in volume have increased by 20 to 22 % in the four areas while the catches in number have increased by 61 % in the Estuary area and by 46 to 50 % in the three other areas.

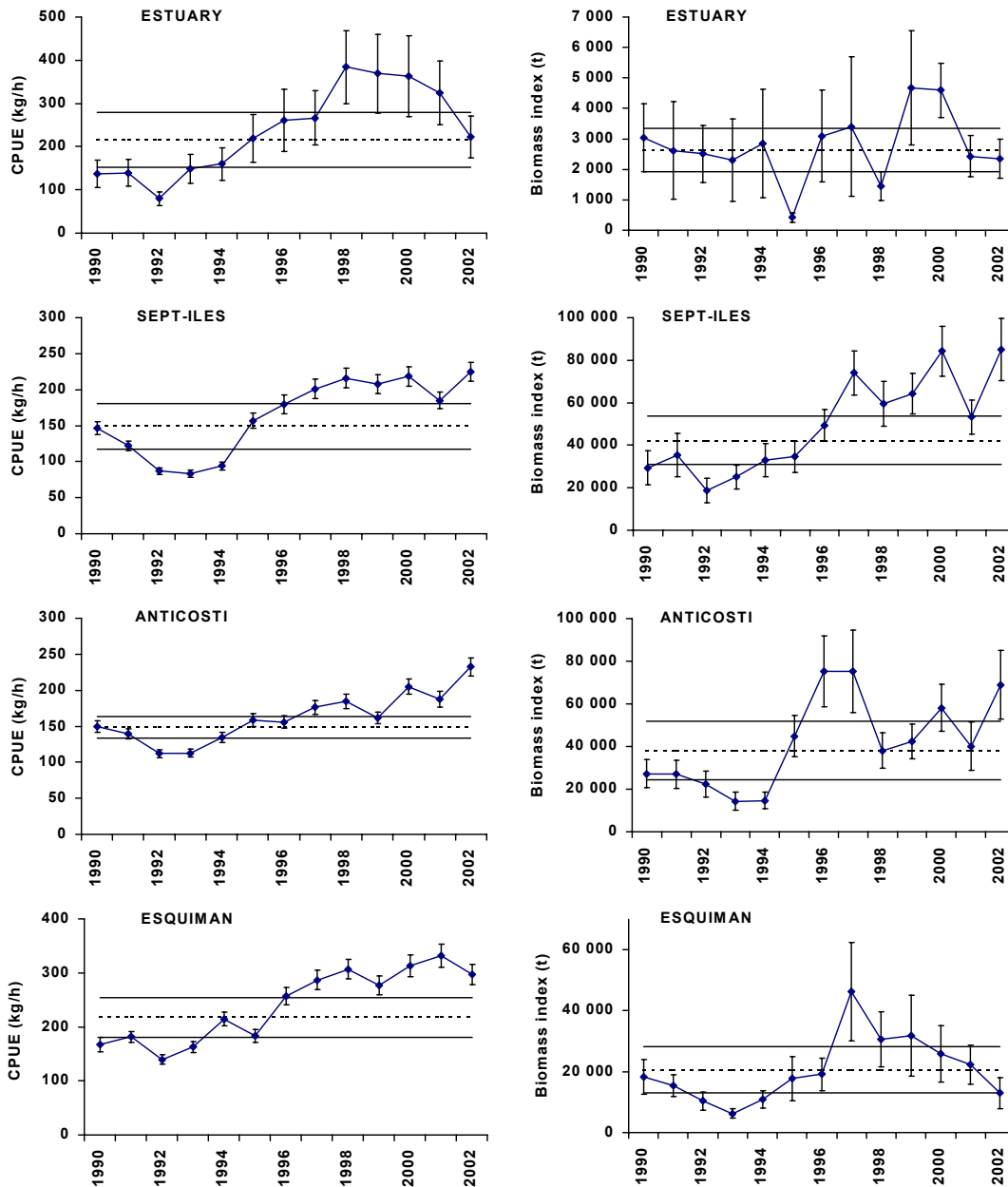


Figure 2. Standardized catch per unit of effort from the commercial fishery (left panel) and biomass index from research surveys (right panel) by management unit and by year. The broken line represents the mean of the years 1990-1999 and the continuous lines represent the upper and lower limits of the confidence interval (95%) of the mean.

In the Sept-Îles and Anticosti areas in 2000, 2001 and 2002, the research survey biomass index fluctuated at a level higher than the mean of the 1990s (Figure 2). The index decreased in 2001 in the Estuary area and has decreased

since 1999 in the Esquiman area to reach in 2002 a value that is below the lower limit of the confidence interval of the mean. The male and female abundance indices follow the same

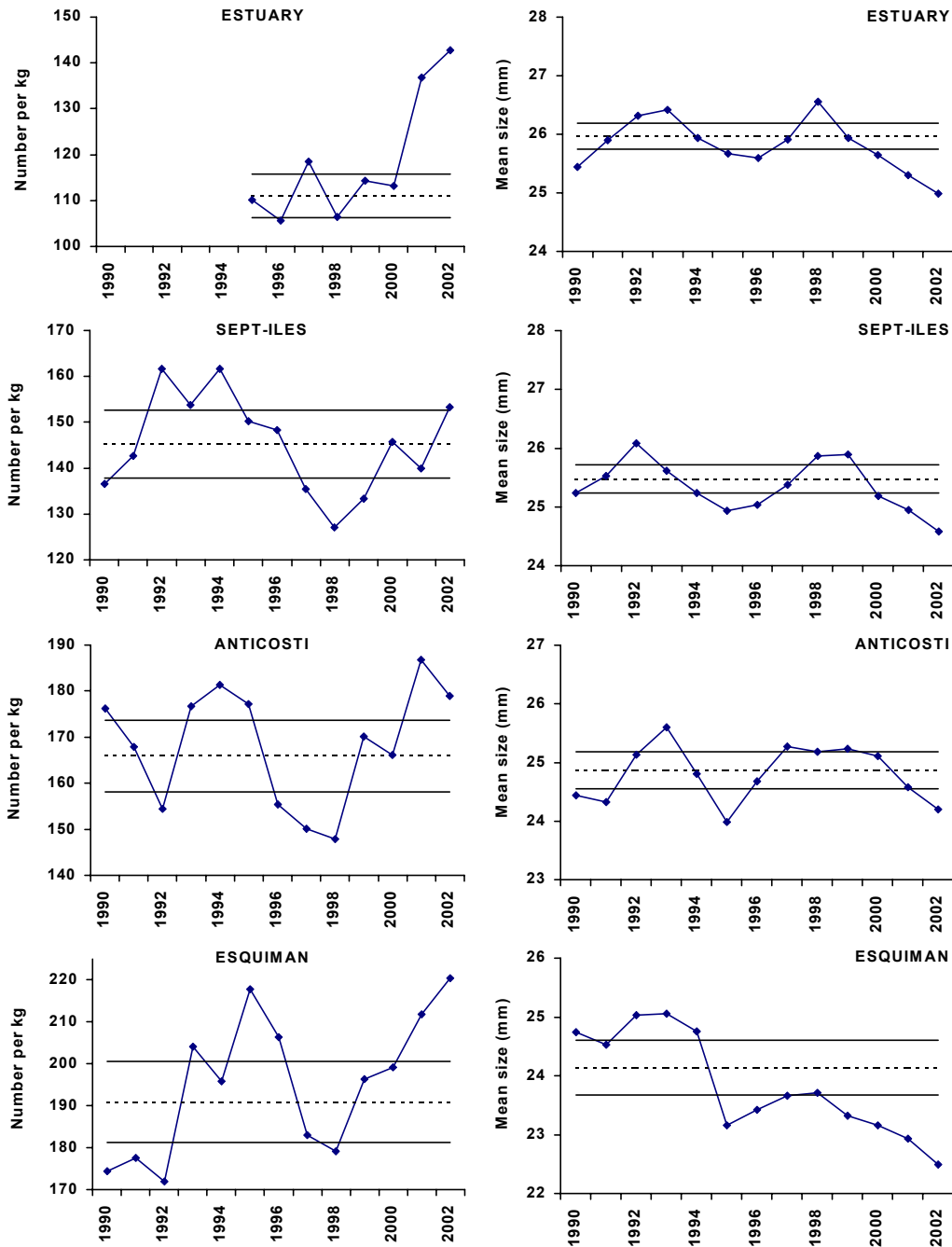


Figure 3. Number of shrimp harvested by the fishery per landed kilogram (left panel) and mean size of females responsible for the egg production (right panel) by management unit and by year. The broken line represents the mean of the years 1990-1999 and the continuous lines represent the upper and lower limits of the confidence interval (95%) of the mean.

trend as the biomass index in Sept-Îles and Anticosti and remain at a level that

is higher or similar to the mean of the 1990s. However, the male abundance

index has decreased since 1999 in the Estuary and Esquiman areas preceding the decrease of the female abundance index by one or two years.

Consequently, the exploitation rate index has been maintained at a level similar or slightly lower than the mean for the 1990s in the Sept-Îles and Anticosti areas (Figure 4). It increased in 2001 and remained high in 2002 in the Estuary area while it has increased

since 1997 in the Esquiman area to reach a value that is much higher than the mean.

The declining trend in the abundance of the Estuary stock is confirmed by the trend in the commercial fishery indices. A decrease in the annual catch per unit of effort as well as in the female number per unit of effort was observed in 2002 in the Estuary area. In the Esquiman area, the survey indicates a decrease in

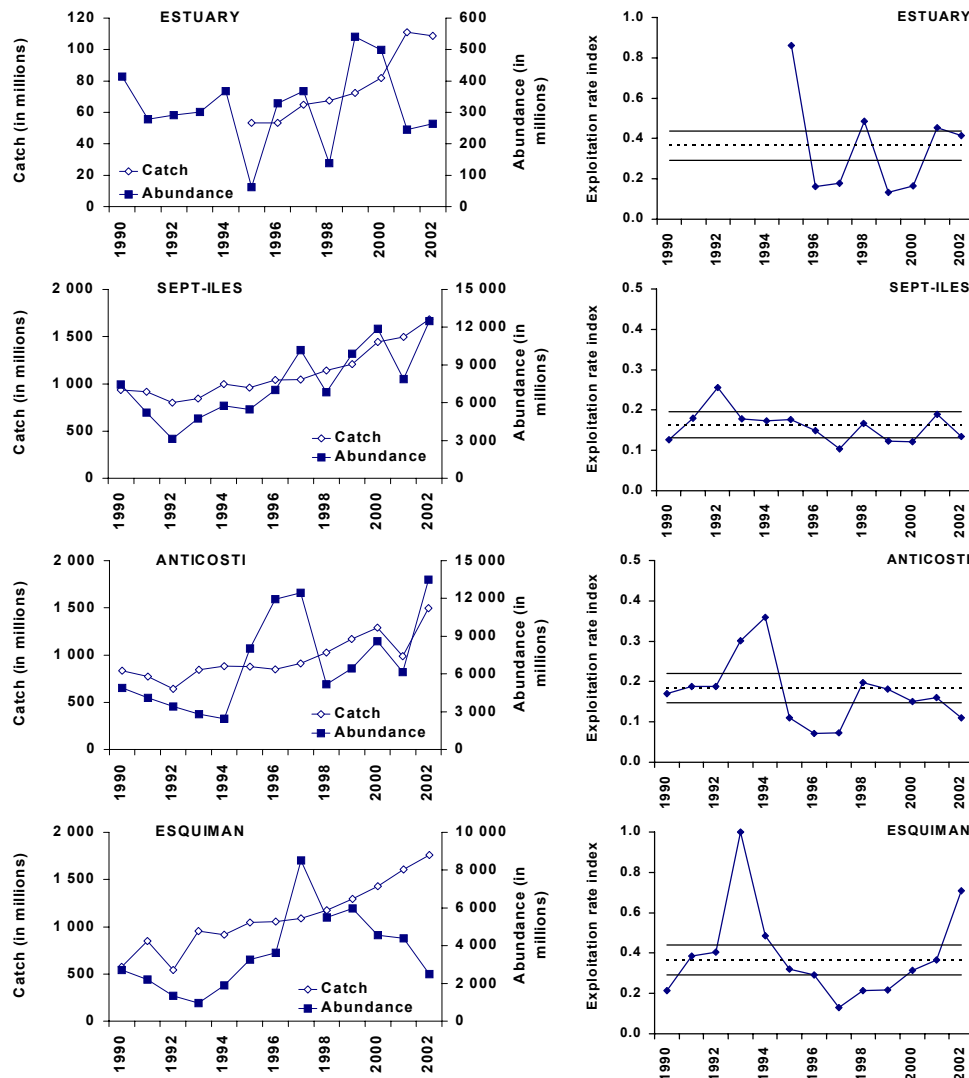


Figure 4. Commercial catch and survey abundance in numbers (left panel) and exploitation rate index (commercial catch divided by the survey abundance) (right panel) by management unit and by year. The broken line represents the mean of the years 1990-1999 and the continuous lines represent the upper and lower limits of the 20% interval around the mean.

the size of the stock over the last years while the annual commercial catch rate remains high. Although the 2002 survey estimate is uncertain given the limited sampling of the area, it confirms the declining trend observed in recent years. It is possible that the commercial annual CPUE has been maintained high in spite of a stock abundance decrease because the fishermen concentrate their activities in locations where the shrimp densities as measured by the survey are the highest.

In the Estuary, Sept-Îles and Anticosti areas, the size of females responsible for the egg production increased between 1995 and 1998 above the 1990-1999 (Figure 3) mean. It has decreased since then to reach a value below the mean in 2001 and 2002. The situation is particularly of concern in the Esquiman area, where the size of spawning females showed a smaller increase between 1995 and 1998; the size has decreased since 1998 and has been below the mean since 1999. Currently, it is not possible to explain the fluctuations in the size of the spawning females. However, the impact of the female size reduction is negative for both the egg production and fishing success. The size of females in the Estuary, Sept-Îles and Anticosti areas decreased between 4 to 6% from 1992 to 2002, resulting in a 9 to 13 % decrease in the individual fecundity; the female size in the Esquiman area has decreased by 10 % since 1992, which means a decrease in the individual fecundity of about 25 %.

Outlook

In 2003, the fishery will harvest the reproductive females of the 1998 year class, the recruiting females of the 1999

year class and the spawning males of the 2000 year class. The cohort strength indices show that the 1998 year class is weak and that the 1999 year class is abundant. It is too early to determine with certainty the strength of the 2000 year class. Therefore, the available biomass and the catch rates should remain stable in 2003, especially since the shrimp from the 1999 year class (most of which should lay eggs in fall 2003) seem smaller than average.

In this context, it is recommended that 2003 yields be set at a level that would result in exploitation rates similar to the mean rate of the years 1990-1999. This should limit the harvest of females and thus preserve the stocks' reproductive capacity.

In the Estuary, Sept-Îles and Anticosti areas, it is recommended that the 2003 TACs be kept equal to those of 2002 and 2001 since we do not expect an increase in either the biomass or the size of shrimp available to the fishery. Having 2003 TACs similar to those of 2002 should result in exploitation rates similar to those observed since 1998. In the Esquiman area, it is recommended that the 2003 TAC be decreased to 5,970 tons in order to decrease the exploitation rate, which has increased since 1997. Assuming that the abundance in 2003 is near the 1990-1999 mean and that the fishing pattern, in terms of shrimp sizes and catch composition, is similar to that of 2002, a catch of 5,970 tons should result in an exploitation rate equivalent to the 1990-1999 mean.

The four shrimp stocks were sensitive to the same trends between the early and late 1990s. Nonetheless, local differences have been observed, suggesting that the stock resilience to

exploitation could vary from area to area. The situation is a concern in the Esquiman area, where an effect of the exploitation on the decrease in abundance and size of spawning females cannot be dismissed. The number of shrimp harvested by the fishery per landed ton is 30 % higher in Esquiman than in Sept-Îles. The total number of shrimp harvested by the fishery is equivalent in Esquiman to that of Sept-Îles for a TAC that is 25 % lower and for a stock that is much smaller in abundance and area occupied. More severe actions will have to be taken as early as 2004 if the abundance and size of females do not increase or if the exploitation rate does not decrease.

Variation in female size follows an east-west gradient, with the smallest observed in the Esquiman Channel and the largest in the Estuary. For the same abundance of spawning females, the egg production of the stock will thus theoretically be lower in the east. On the other hand, preliminary results of a research project on egg production indicate that fecundity may vary between management units and between years. This biological characteristic may have a significant impact on the stock's capacity to withstand changes caused by fishing. The processes of shrimp recruitment and mechanisms responsible for shrimp production are still not fully known. However, a research program at the Maurice Lamontagne Institute is investigating shrimp production. This program is funded jointly by the group B shrimp fishermen associations and the Department of Fisheries and Oceans.

Uncertainties

Operational difficulties encountered during the research survey in 2002 in Esquiman Channel and in the sector north of Anticosti Island in 2001 limited the sampling of these management units. In 2001, the biomass index for a part of the Anticosti area was estimated using data from preceding years because the number of stations was not sufficient to produce an estimate with the current method. However, in 2002, the number of stations visited in the Esquiman area was sufficient to produce a biomass index that was statistically valid.

It is generally agreed that the survey accurately follows trends in the shrimp populations and that the fishermen's catch per unit of effort adequately reflects commercial activities. However, it does happen that the two indices diverge for a same year (for instance, in 1993 and 1994 in the Sept-Îles area and in 1998 in the Anticosti area) because the fishermen catch rates represent the fishing success over the fishing grounds, which do not necessarily correspond to the whole shrimp distribution area that is sampled by the research survey. In the Esquiman area from 1999 to 2002, the commercial fishermen were able to maintain their catch rates in spite of a decrease in the abundance and size of targeted shrimp because they directed their operations to the most productive locations in the north of the area.

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