

## Shrimp of the Estuary and Gulf of St. Lawrence in 2003

### Background

Shrimp are fished commercially from spring to fall in four fishing 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 between four and five years old. 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 of St. Lawrence at depths of 150 to 350 m.

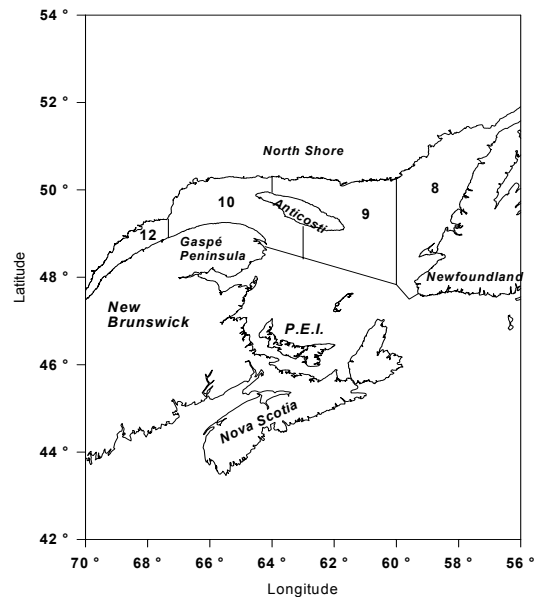


Figure 1. Shrimp fishing areas in the Gulf of St. Lawrence : area 12 – Estuary, area 10 - Sept-Îles, area 9 – Anticosti, area 8 – Esquiman.

### Summary

- Gulf shrimp landings decreased in 2003 relative to 2002, going from about 28,600 tons to 27,000 tons. The decrease in landings is due to the 20% decrease in TAC in the Esquiman area. The TACs remained unchanged in the Estuary, Sept-Îles and Anticosti areas.
- In 2003, the catch per unit of effort of the commercial fishery was higher than the 1990-1999 mean in the four areas. The fishing effort decreased and the 1997 and 1999 year classes dominated the commercial catches. The number of shrimp per kilogram (kg) decreased because of the higher proportion of females and the larger size of males in the catches. However, the number per kg was still higher than the 1990-1999 mean in the Estuary and Esquiman areas. The mean size of spawning females was still low in 2003.
- The research survey indices were very high in 2003, well above the 1990-1999

mean. The males of the 1999 year class and the females of the 1997 year class dominated the survey catches. The mean size of females was still below the 1990-1999 mean. Since the indices of all components of the stocks (juveniles, males and females) increased simultaneously in the 2003 survey, it is possible that external factors positively affected the indices.

- The exploitation rate index decreased noticeably in 2003 in all areas, reaching values lower than the 1990-1999 mean. This decrease is due to both the decrease in the number of shrimp harvested by the fishery and the increase in the survey abundance indices.
- In 2004, the fishery will be sustained by the females of the abundant 1997 year class and, to a lesser extent, by those of the 1998 year class. Moreover, the 1999 year class (very abundant in 2003) should recruit to the female component in 2004. The contribution of the 2000 and 2001 year classes is uncertain for 2004 as they do not seem to be as abundant as the 1997 and 1999 year classes were at the same age. The mean size of spawning females is not likely to increase significantly in 2004.
- Projections made for 2004 indicate that the abundance and biomass available to the fishery as well as the fishing success should be higher than what they have been since 2001. This positive change in the stock status justifies an adjustment of the TACs in order to take advantage of the high abundance of the 1997 and 1999 year classes, which will sustain the fishery in 2004 and 2005.
- The possible yield for 2004 is estimated for each fishing area. It corresponds to the 2003 yield adjusted by the increase observed between 2001 and 2003 in the fishery and survey indices. As the indices can be expressed in number

and weight, two values are possible to estimate the 2004 yield and therefore, the TAC. Thus, the 2004 TAC could be set between 830 and 975 tons for the Estuary area, between 14,255 and 15,305 tons for Sept-Îles, between 9,285 and 10,025 tons for Anticosti and between 7,925 and 8,335 tons for Esquiman.

- These TACs represent different increases for the fishing areas. However, they should generate exploitation rates similar to those observed in 2003 for each area. The use of an approach that takes into account the particularities of each stock/fishery complex allows the resilience of each stock to be considered, thus equilibrating the yield with respect to the abundance and the size of shrimp available to the fishery.

### ***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 of trawlers (Quebec, New Brunswick and Newfoundland) in four 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 total allowable catches (TAC) in the four areas. In 2002, there were 112 permanent shrimp licences. 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. 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. The TACs were increased for the last time in 2001 in the four fishing areas and the landings reached more than 28,600 tons in 2002 (Table 1). The TAC for the Esquiman area was reduced by 20% in 2003. Preliminary statistics indicate that the Gulf landings reached 27,000 tons in 2003 and that the TACs were reached in all areas.

### 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. However 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 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.

To assess stock status in 2003, we compared each indicator to the mean value for 1990-1999 period (the 1995-1999 period was used for the indicators associated to the commercial catch in the Estuary area). Indicators were assessed and given one of three ratings:

Positive (P) : 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 (N) : 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 (95%) around the mean. The indicators are different from the mean when their annual value is above or below the upper or lower limit of the confidence interval. An interval equals to 20% of the mean was used to determine the neutral category for the exploitation rate index.

Table 1. Landings and total allowable catch (TAC) in tons by fishing area and by year. The 2003 data are preliminary.

Year	Estuaire		Sept-Iles		Anticosti		Esquiman		Gulf
	Landing	TAC	Landing	TAC	Landing	TAC	Landing	TAC	
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	11136	5294	8700	7581	8178	24374
2002	784	786	11270	11136	8470	8700	8090	8178	28614
2003	780	786	11099	11136	8596	8700	6586	6541	27061

Table 2. Indicators used to evaluate resource status in the four fishing areas in 2003. The indicators are evaluated based on the 1990-1999 mean (P : positive impact; = : neutral impact; N : negative impact).

2003	ESTUAIRE	SEPT-ILES	ANTICOSTI	ESQUIMAN
<b>FISHERY INDICATORS</b>				
Effort	P	P	P	P
Catch per unit of effort	P	P	P	P
Male number per unit of effort	P	P	P	P
Female number per unit of effort	P	P	P	P
Number of shrimp per kg	N	P	=	N
Size of recruits (females)	N	N	N	N
<b>SURVEY INDICATORS</b>				
Minimum trawlable biomass	P	P	P	P
Number of males	P	P	P	P
Number of females	P	P	P	P
Size of females	=	N	N	N
Pre-recruit abundance	P	P	P	P
<b>EXPLOITATION RATE INDICATOR</b>				
Fishery / Survey (numbers)	P	P	P	P
<b>SUMMARY</b> (number of indicators by impact ratings)	<b>ESTUAIRE</b>	<b>SEPT-ILES</b>	<b>ANTICOSTI</b>	<b>ESQUIMAN</b>
	P = N	P = N	P = N	P = N

**Data Used**

Commercial fishery statistics (shrimper catch and effort) are used to estimate nominal fishing effort and to calculate catches per unit of effort (CPUEs) and numbers per unit of effort (NPUEs). The data are standardized to take into account changes in fishery capacity and seasonal fishing patterns. The commercial catch samples allow the identification of the year classes as well as the estimate of the number of shrimp harvested which is used to calculate the number of shrimp per kg. 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.

A research survey has been conducted in the Estuary and Gulf of St. Lawrence in August or September each year since 1990. The survey uses a stratified random design and is conducted from the department vessel *C.C.G.S. Alfred Needler*, equipped with a shrimp trawl. The survey catch data have been adjusted to take into account the fact that shrimp catchability varies between day and night. Minimum trawlable biomass indices are then calculated using a geostatistical method. Shrimp abundance (in number) is estimated using survey stations conducted in the daytime only. The survey catch samples allow the identification of shrimp year classes. The mean lengths of females provide an indication of the size of the reproductive females that will carry eggs for all winter. The abundance of the three-year-old male

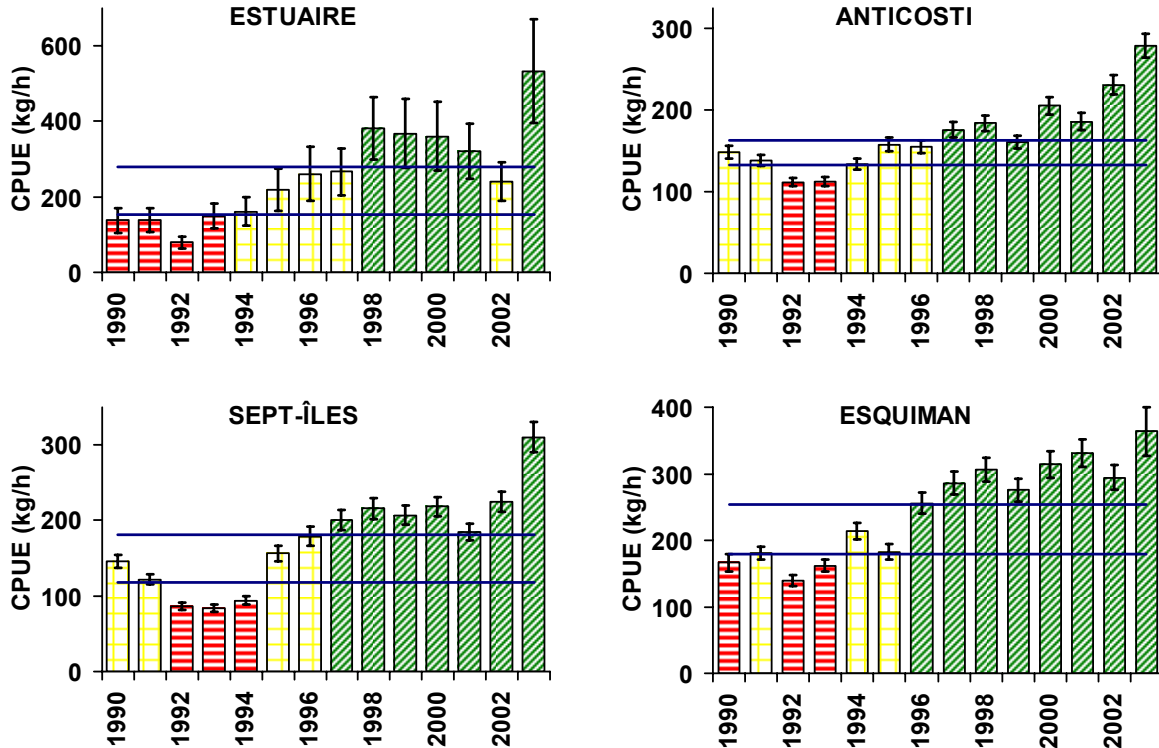


Figure 2. Standardized catch per unit of effort (CPUE) by fishing area and by year since 1990. The higher and lower limits of the confidence interval (95%) for the 1990-1999 mean are represented by solid lines.

pre-recruits (CL > 18 mm for the Estuary, Sept-Îles and Anticosti areas, CL > 17 mm for the Esquiman area) provides an indication of the recruitment to the female component in the short term (1 or 2 years).

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 resource status indicators were negative during the first half of the 1990s. But thereafter, several year-classes with higher than average abundance were

recruited, causing the productivity to increase, with the result that most of the resource status indicators were positive during the second half of the 1990s.

As of 2001, changes in the resource status have been noticeable and the proportion of negative indicators has increased. Most of negative indicators were linked to the size of shrimps available to the fishery. In 2003, all the indicators of abundance and of biomass of shrimps available to the fishery as well as the indicator of success of the fishery were positive (Table 2). However, the indicators of size of females available for reproduction and to the fishery remained negative.

In 2003, catches per unit of effort recorded for commercial fishery were higher than the 1990-1999 mean in the four areas (Figure 2). The fishing effort decreased below the mean, while numbers per unit of effort for

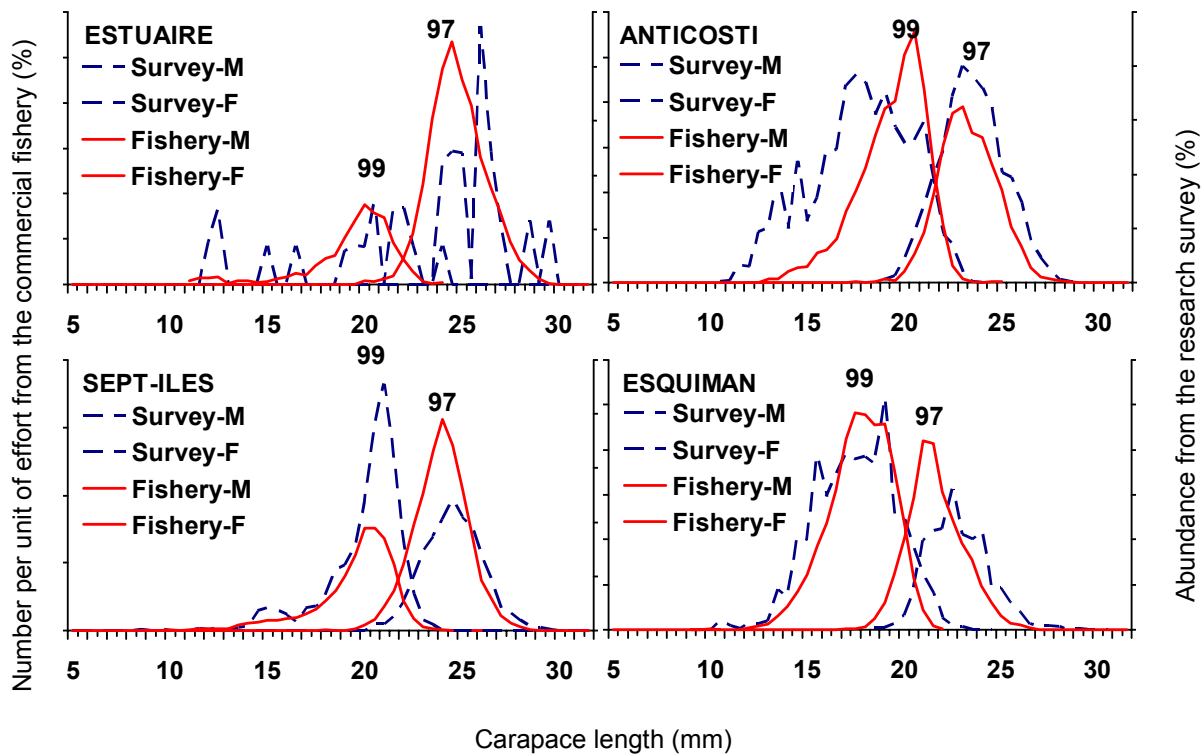


Figure 3. Distribution of the carapace length frequencies of males (M) and females (F) from commercial fishery and research survey samples, by fishing area, in 2003. Year-classes of 1999 and 1997 are identified.

males and females were higher than the mean. The 1997 and 1999 year-classes were predominant in commercial catches (Figure 3). The number of shrimps per kg fell due to the greater proportion of females and the greater size of males in commercial catches. However, the numbers per kg was still higher than the mean in the Estuary and Esquiman areas. The mean size of recruited females remained low in all the areas in 2003 (Figure 4).

In 2003, the minimum trawlable biomass index from research survey was above the 1990-1999 mean in the four areas (Figure 5). Male and female abundance was higher than the mean, whereas the 1997 and 1999 year-classes were predominant in survey catches (Figure 3). However, the mean size of females was always lower than the mean (Figure 6). The abundance of pre-recruits was higher than the mean in all the areas.

The index of exploitation rate significantly decreased in 2003 in all the areas to reach values below the 1990-1999 mean (Figure 7). This reduction is due to both the decrease in the number of shrimp harvested and the increase in the abundance index from survey.

The recruitment of the very abundant year-classes of 1997 and 1999 is responsible for the increases in the abundance indices that have been observed since 2001. Spawning females of the 1997 year-class as well as males of the 1999 year-class (that reached, in 2003, the size preceding sex change) contributed to the success of the fishery in 2003. The projections made for 2004 indicate that the abundance and biomass of shrimp available to the fishery as well as the success of the fishery should be higher than in 2001.

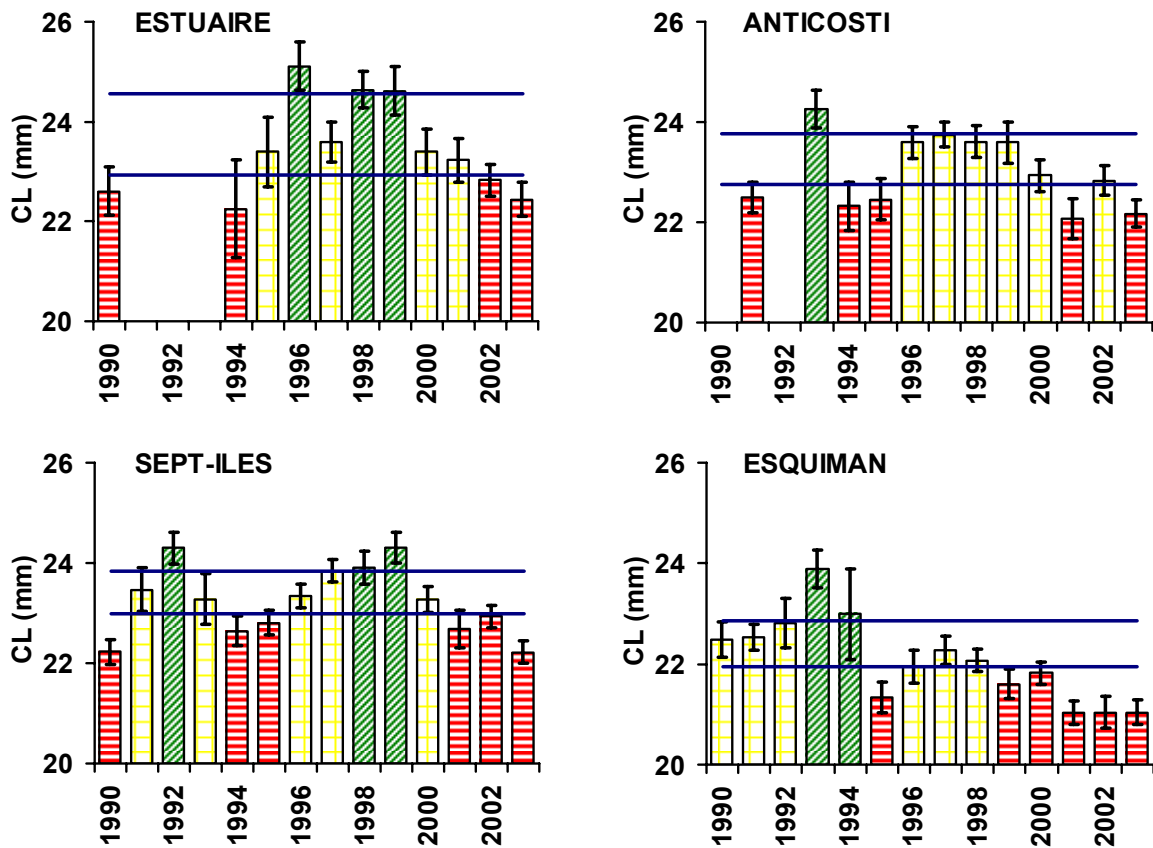


Figure 4. Mean carapace length (CL) of females recruits (primiparous in the spring) by fishing area and year since 1990. The higher and lower limits of the confidence interval (95%) of the 1990-1999 mean are represented by solid lines.

### Outlook

In the spring of 2004, the fishery will focus on egg-bearing females of the 1997 year-class. These females, that will be at their second production of larvae, played a role in the excellent catch rates observed in the spring of 2003. The good catch rates recorded later in the fall of the same year suggested that their abundance remained high, and that they should contribute to maintain high catch rates throughout the spring of 2004. However, it is probable that they could not maintain such a significant contribution to the fishery beyond 2004.

Shrimp from the 1999 year-class will be primiparous females (without eggs) in the spring and summer of 2004. They will lay eggs for the first time in the fall of 2004, and

should generate very good catch rates in the spring of 2005 as egg-bearing females. They should still support the fishery in 2006, year during which their second production of larvae will occur.

The catches of 2004 and 2005 will be supplemented by the contribution of the multiparous females of the 1998 year-class, whose abundance seems to be low. The catches of males in 2004 and 2005 will be made of the 2000 and 2001 year-classes. Their abundances do not seem as strong as those of the 1997 and 1999 year-classes at the same age. Their contribution to the female group in 2005 (for the 2000 year-class) is difficult to predict.

These positive changes in stock status justify an adjustment of TACs in order to benefit from the abundance of the 1997 and



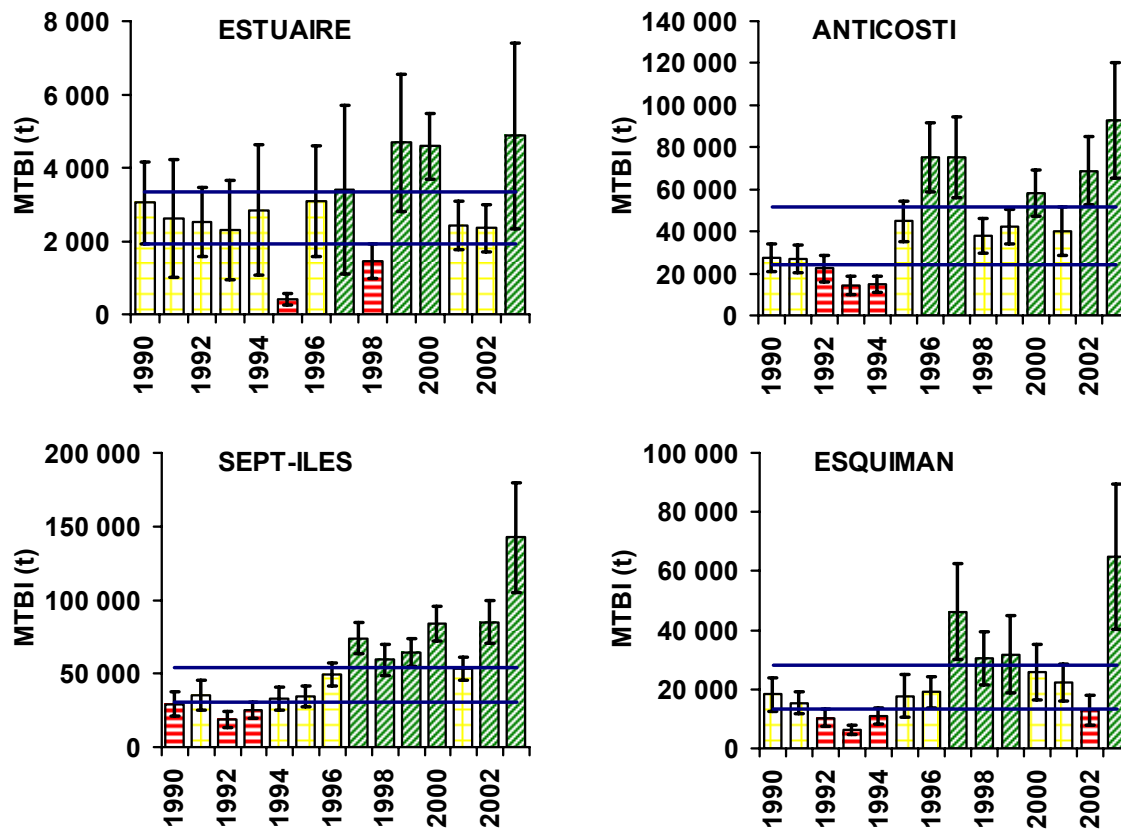


Figure 5. Minimum trawlable biomass index (MTBI) by fishing area and year since 1990. The higher and lower limits of the confidence interval (95%) of the 1990-1999 mean are represented by solid lines.

1999 year-classes, which will support the fishery in 2004 and 2005.

TAC adjustments must take account of the rate of increase in the abundance of each stock. The survey and fishery results indicate that the increase in the abundance between 2001 and 2003 was stronger in the area of Sept-Îles than in the other areas. In addition, the adjustments must consider that the size of the females targeted by the fishery has been decreasing since 1998, which caused an increase in the number of shrimp harvested per kg between 1998 and 2002 in all the areas. In addition, as females are generally smaller towards the east of the Gulf, the number of shrimps harvested per kg significantly increases towards the east. For example, in 2002 and 2003, the mean number of shrimp per kg was 132 for the Estuary area, 144 for Sept-Îles, 169 for Anticosti, and 213 for Esquiman. For the

same unit of TAC, the number of shrimp harvested is higher in 2002 than in 1998, and is 61% higher in the Esquiman area, compared to the Estuary.

The TAC reduction for the Esquiman area in 2003 aimed to significantly reduce the exploitation rate, whose index has been increasing since 1997. The situation was alarming at the end of the 2002 fishery season, whereas the number of shrimp harvested by the fishery in the Esquiman area was nearly the same as in the Sept-Îles area, for a 25% lower TAC and a stock of size much more smaller both in terms of abundance and of surface. The number of shrimp harvested by the fishery actually decreased in 2003 with the TAC reduction. This specific action made it possible to significantly reduce the exploitation rate index to a level where any additional action would not be necessary, particularly



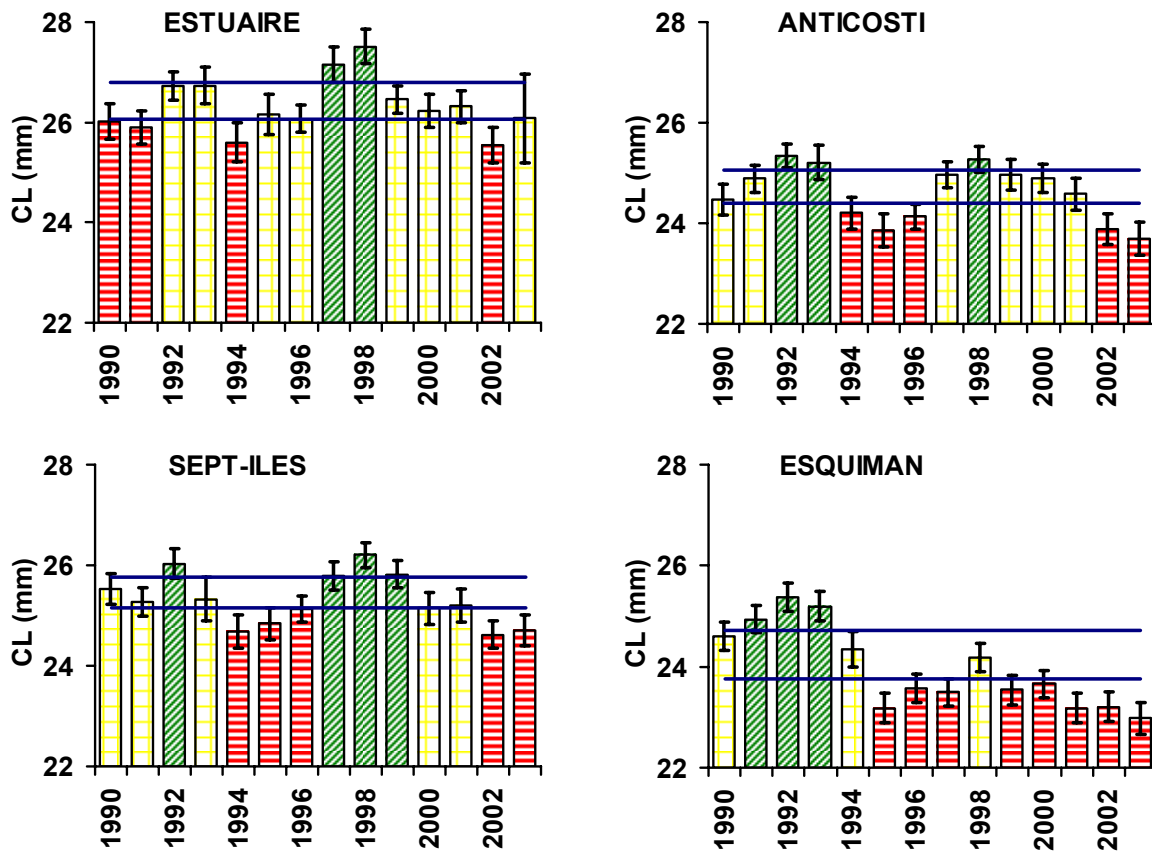


Figure 6. Mean carapace length (CL) of females from the survey, by fishing area and year, since 1990. The higher and lower limits of the confidence interval (95%) of the 1990-1999 mean are represented by solid lines.

because the abundance and biomass of shrimps available to the fishery should be high in 2004.

It is preferable that TAC adjustments for 2004 do not generate exploitation rates higher than those recorded in 2003. Indeed, it is possible that the general reduction in the size of females observed since the beginning of the fishery in the 1970s and 1980s be the consequence of an exploitation mainly focused on large size females. Although the total mortality decreased between the middle of the 1980s and 1990s, the contribution of fishing mortality would have increased by approximately 33%. The main predators of the 1980s (redfish and cod) were replaced by Greenland halibut in the 1990s. It is possible however that predation mortality

will increase throughout the 2000s as a consequence of the increase in Greenland halibut stock in the Gulf of St. Lawrence.

The fishery and survey indices are coherent and show an increase in the abundance of shrimp available to the fishery between 2001 and 2003. The regressions between the biomass or the abundance of shrimp of the size targeted by the fishery (> 22 or 21 mm) and the catch rates of the fishery (expressed as numbers or weights) for the same year are all positive (Figure 8). These relations were used to estimate the possible harvest levels for 2004 in each fishery area. The 2004 harvest corresponds to the 2003 harvest, which is adjusted by the factor corresponding to the mean increase estimated between 2001-2002 and between 2002-2003, based on the regressions

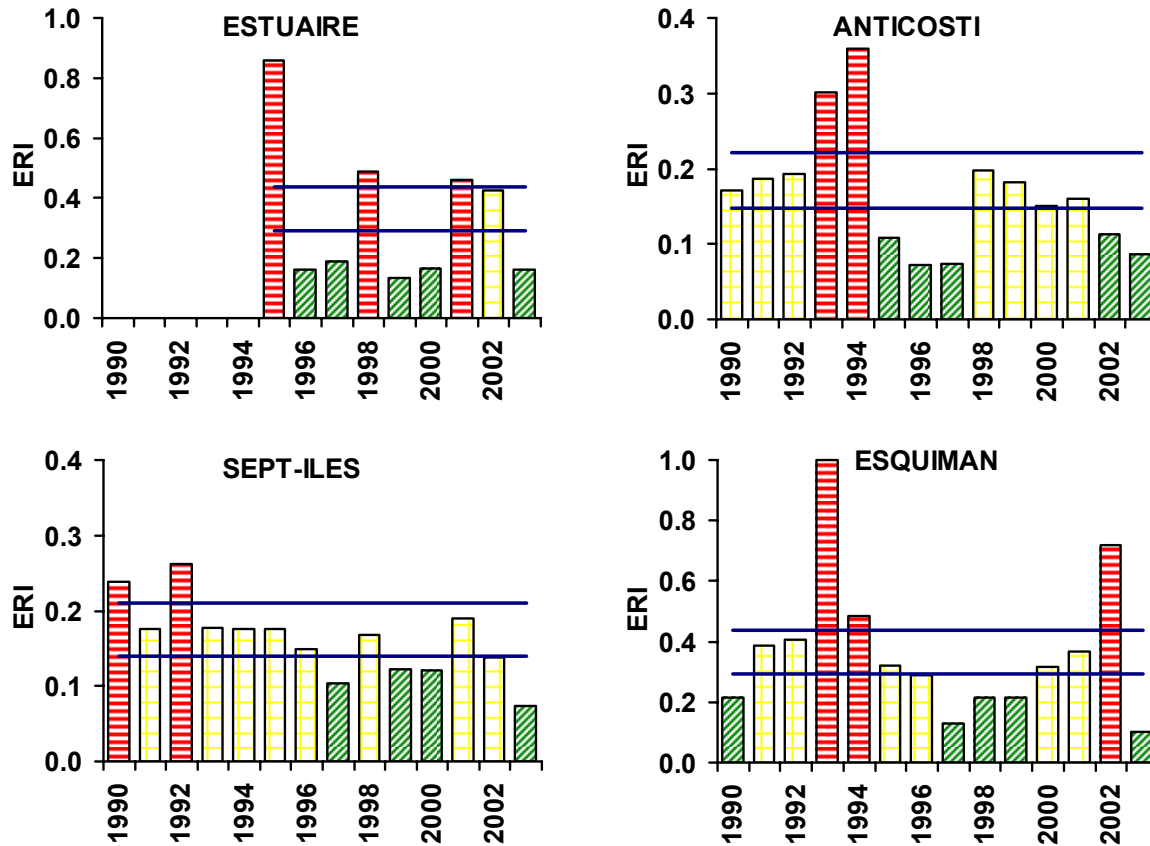


Figure 7. Exploitation rate index (ERI), by fishing area and year, since 1990. The higher and lower limits of the interval situated at 20% on either side of the 1990-1999 mean are represented by solid lines.

between the fishery and survey indices. The mean factors applied to increase the 2003 harvest values are:

	EST.	S.-Î.	ANT.	ESQ.
Weight	1.25	1.38	1.17	1.27
Number	1.16	1.37	1.15	1.25

As the indices are expressed as numbers or weights, two values are possible to estimate the 2004 harvest. The conversion into a weight value of the 2004 harvest, estimated from the relationships in numbers, was based on the mean number of shrimp per kg recorded in 2002 and 2003.

Thus, the 2004 TAC could range between 830 tons and 975 tons for the Estuary area,

between 14,255 tons and 15,305 tons for Sept-Îles, between 9,285 tons and 10,025 tons for Anticosti, and between 7,925 tons and 8,335 tons for Esquiman. These values can be regarded as minimum and maximum values that should not generate any change in the exploitation rate for 2004.

In the past, the increases in TAC were identical in percentage in the four areas. The size of shrimps available to the fishery and the biomass specific rates of increase for each area were not considered. The application of a single percentage to increase the TACs in all the areas had as a consequence that the Estuary and Esquiman areas were subjected to a relatively higher exploitation than central areas. This approach led to the alarming situation that prevailed in the Esquiman

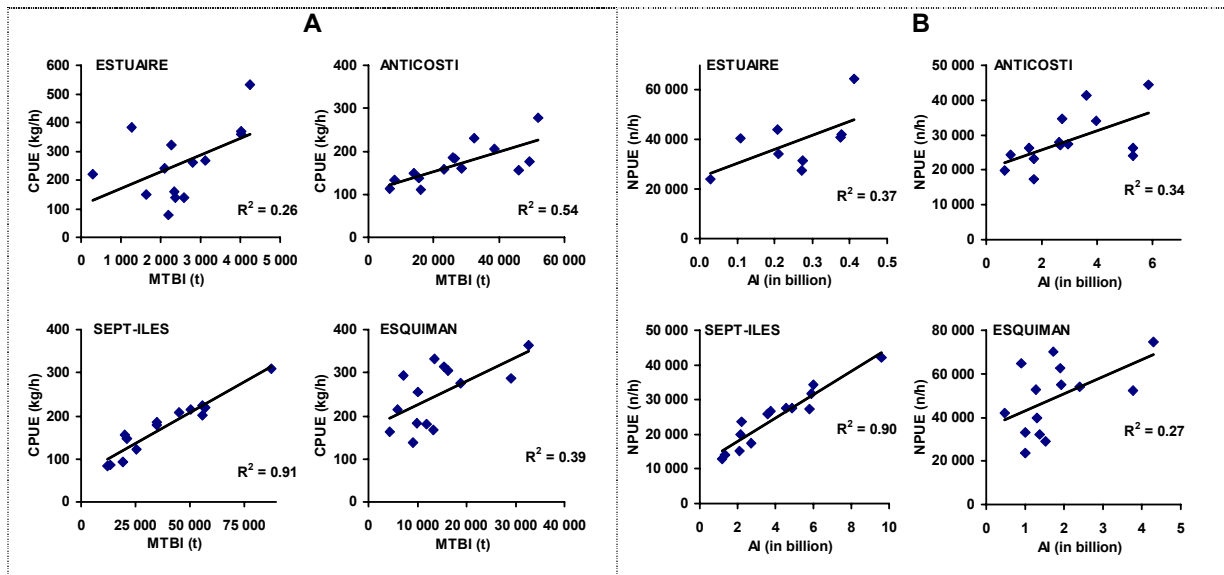


Figure 8. A: Relationship between the minimum trawlable biomass index (MTBI) of shrimp of the size targeted by the fishery and the standardized catch per unit of effort (CPUE) of the same year, by fishing area. B: Relationship between the abundance index (AI) of shrimp of the size targeted by the fishery and the standardized number per unit of effort (NPUE) of the same year, by fishing area.

area in 2002, and that required the implementation of a significant TAC reduction in 2003. The approach based on local differences breaks the synchronism that characterized the management of the stocks of the Gulf until 2002, but further balances the exploitation according to the abundance of the stocks and the size of shrimps available to the fishery. It was mentioned in the stock status report of 2003 that the four stocks had shown very similar trends between the beginning and the end of 1990s, but that the resilience of the stocks to exploitation could be different from an area to another.

### Sources of uncertainty

The variance associated with the 2003 biomass estimates is higher than in the past. Moreover, it is possible that environmental factors could have had an impact on the availability to the trawl of shrimp of all the sizes, which could explain the increase in their catchability observed in 2003. The review of the environmental

conditions that prevailed in the Gulf in 2003 indicates that the mean thickness of the cold intermediate layer (CIL) increased by 35 meters, and its volume by 40%, compared to 2002. The minimal temperature of the CIL decreased by 0.6°C, and its salinity increased approximately by 0.4. This significant change could have reduced the vertical migration range of shrimp and made them more accessible to bottom trawls.

The relationships between the survey and fishery indices used to estimate the 2004 harvest levels are all positive, but are not significant to the same degree. Thus, the relationship observed for the Sept-Îles area are strongly significant ( $r^2=0.9$ ,  $p=0.0001$ ), whereas those for the Anticosti and Esquiman areas are poorly significant ( $0.5 > r^2 > 0.3$ ,  $p=0.05$ ). And those for the Estuary area are not significant ( $p=0.08$ ). On the one hand, these results reflect the higher inter- and intra-annual variability observed in the survey for the Estuary, Anticosti and Esquiman areas. On the other hand, the regressions are affected by the

relationship between the fishery spatial coverage and the shrimp distribution also observed in the survey. In fact, the fishery in the Sept-Îles area covers the main part of the stock distribution, whereas the fishery in the Estuary and Esquiman areas only partially covers shrimp distribution.

### **For more information:**

Contact : Louise Savard  
Maurice Lamontagne Institute  
850, route de la Mer  
P.O. Box 1000  
Mont-Joli, Québec  
G5H 3Z4  
Tel.: (418) 775-0621  
Fax: (418) 775-0740  
Email: [savardl@dfo-mpo.gc.ca](mailto:savardl@dfo-mpo.gc.ca)

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Quebec Region  
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Quebec, Canada  
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Phone Number : 418-775-0766

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ISSN 1480-4913 (Printed)

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#### **Correct citation for this publication:**

DFO, 2004. Shrimp of the Estuary and Gulf of St. Lawrence in 2003. DFO Science, Stock Assess. Sec., Stock Status Report 2004/009.