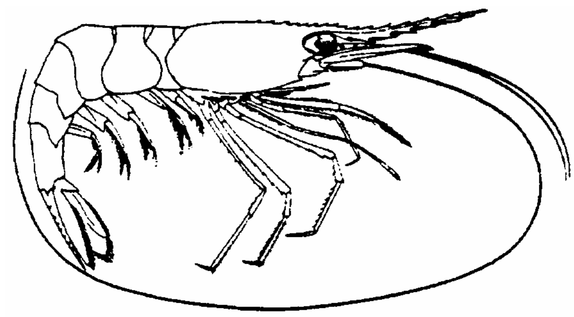
# ASSESSMENT OF SHRIMP STOCKS IN THE ESTUARY AND GULF OF ST. LAWRENCE IN 2005



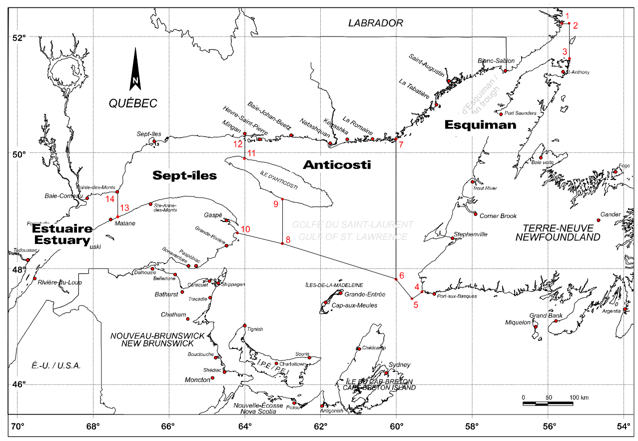



*Figure 1. Shrimp fishing areas in the Estuary and Gulf of St. Lawrence.*

## Context

*The northern shrimp fishery began in the Gulf of St. Lawrence in 1965. Three fleets of trawlers (Quebec, New Brunswick and Newfoundland) do most of the fishing in four areas: Estuary, Sept-Îles, Anticosti and Esquiman (Figure 1).*

*A number of management measures, including total allowable catches (TAC) in the four areas, controls shrimp fishing. TAC-based management limits fishing 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.*

*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.*

## SUMMARY

- The landings went from 36,000 t in 2004 to 31,000 t in 2005. This decrease is due to a reduction in fishing effort related to a deterioration of the market conditions.

- The catch per unit of effort (CPUE) was higher in 2005 than the 1990-1999 mean in the four areas while the fishing effort was similar or lower than the mean. The CPUE was higher in 2005 than in 2003 in Esquiman and Anticosti and was similar in the two other areas.

- The biomass index of the 2005 research survey conducted on the CCGS *A. Needler* was higher than the mean in the four areas. It was similar to the 2003 index in Anticosti and lower in the three other areas.

- In 2005, the abundance index of prerecruits was in general higher than the mean but in diminution relatively to 2003. The catch rate of female recruits was higher than in 2003 at a level above the mean. The mean size of females has been stable since 2003 at a level below the mean.

- The exploitation rate index in 2005 was lower than the mean in all areas. It was higher that the 2003 index.

- The spawning stock abundance and fishery catch rate in the four areas should be higher than the mean in 2006. However, the spawning stock abundance should be lower than the 2003 value in all areas except for Esquiman while the catch rate should be similar or lower. The size of females in 2006 should stay below the mean.

- In 2006, catches equal to the 2005 TAC should generate an increase in the exploitation rate near the historic mean. Consequently, the status quo is recommended in all areas for the 2006 TACs.

# INTRODUCTION

## Species Biology

A number of peculiarities of shrimp biology influences 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 northern Gulf of St. Lawrence at depths of 150 to 350 m.

## Description of the fishery

In 2005, there were 112 permanent shrimp licences in the Estuary and the Gulf. 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 (Figure 2). Landings rose from approximately 1,000 tons to 7,500 tons between the early and late 1970s. They reached nearly 15,000 tons by the late 1980s, and were over 23,000 tons by the late 1990s. The TACs were increased in 2000, 2001 and 2004. They did not change in 2005 except in Esquiman where the TAC was increased by 10%. Preliminary statistics indicate that the Gulf landings reached 31,000 tons in 2005. The TACs were not reached in Sept-Îles and Anticosti because the deterioration of market conditions has considerably slowed down the fishing activities at the end of the season.

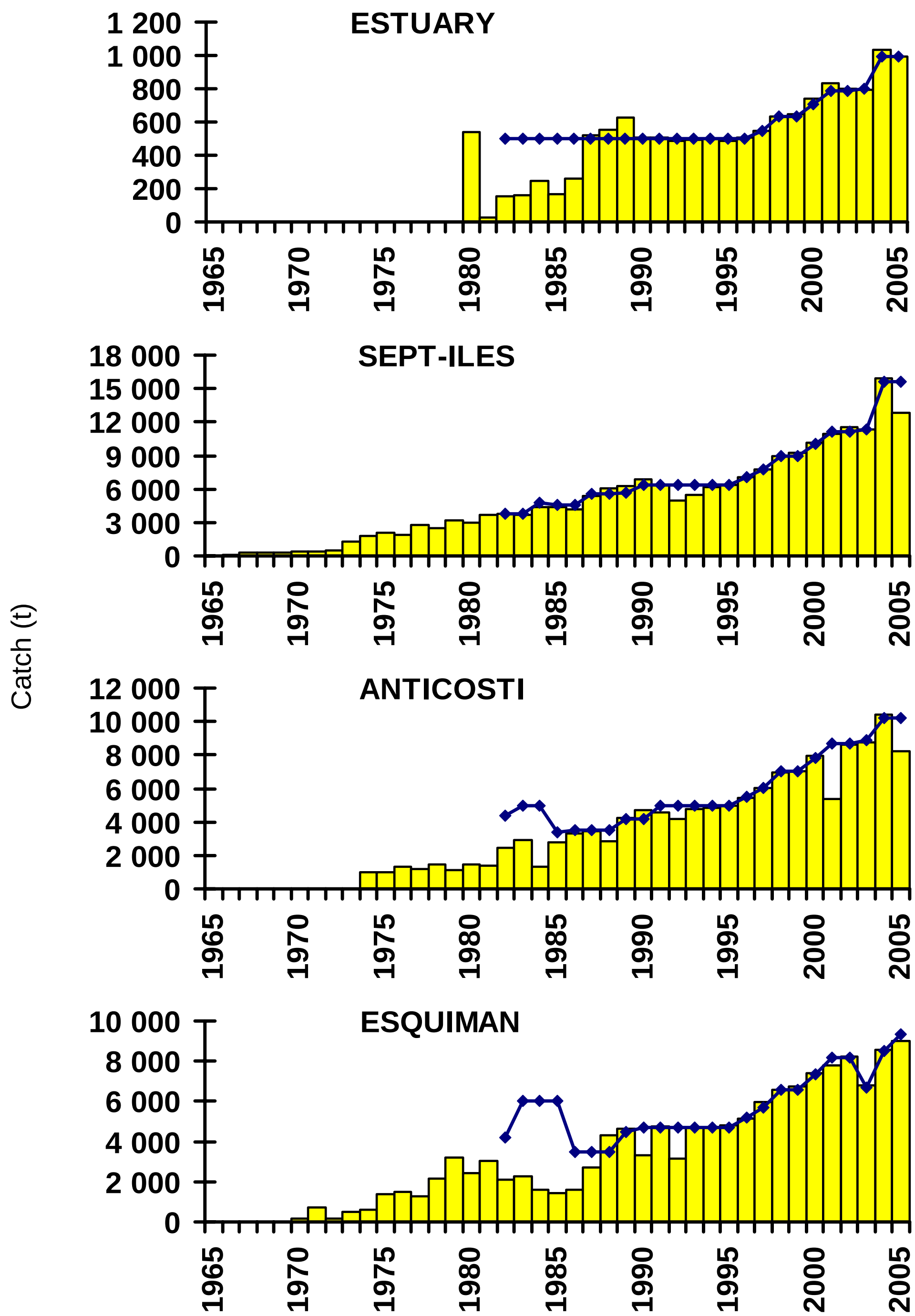



*Figure 2. Catch and total of admissible catch (TAC) by fishing area and by year. 2005 data are preliminary.*

# RESOURCE ASSESSMENT

The stock status was determined by examining a number of indicators from the commercial fishery and research survey. These indicators refer to fishing success, stock abundance and resource productivity. To assess the stock status in 2005, 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 sampling 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 outside the limits of the confidence interval.

The 2005 indicator values were also compared to those of 2003 to give an indication of recent trends. The two annual values are similar when the difference is less than 10%.

Commercial fishery statistics (shrimper catch and effort) are used to estimate 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 model used for the standardization explains more than 60% of the variability in the data. The commercial catch samples allow the estimation of the number of shrimp harvested by the fishery by sexual maturity stage as well as the estimation of their mean size.

A research survey has been conducted in the Estuary and Gulf of St. Lawrence in August each year from the department vessel *C.C.G.S. Alfred Needler* equipped with a shrimp trawl. The survey was conducted from 1990 to 2003 and then again in 2005. The catch data have 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 catch samples of the stations visited in the daytime allow the estimation of the abundance of shrimp by sexual maturity stage as well as the estimation their mean size.

An exploitation rate index is obtained by dividing the 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 in 2005

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. During the most recent years, the majority of the indicators of the abundance and biomass of shrimp available to the fishery were neutral or positive (Table 1). However, most of the indicators of size of females available to the reproduction and to the fishery were negative.

*Tableau 1. Indicators used to assess the status of the resource in the four fishing areas for the last three years. The indicators are assessed relatively to the 1990-1999 mean (P : positive impact, green; = : neutral impact, yellow; N : negative impact, red; nd : indicator not available). The direction of changes between 2003 and 2005 is also indicated.*

| | ESTUARY | | | | SEPT-ILES | | | | ANTICOSTI | | | | ESQUIMAN | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | Change 2003-2005 | 2003 | 2004 | 2005 | Change 2003-2005 | 2003 | 2004 | 2005 | Change 2003-2005 | 2003 | 2004 | 2005 | Change 2003-2005 |
| **FISHERY INDICATORS** | | | | | | | | | | | | | | | | |
| Fishing effort | P | = | = | ↑ | P | = | P | ≈ | P | = | P | ↓ | P | P | P | ≈ |
| Catch per unit of effort | P | P | P | ≈ | P | P | P | ≈ | P | P | P | ↑ | P | P | P | ↑ |
| Spawning female catch rate | P | = | = | ↓ | P | P | P | ↓ | P | P | P | ↑ | = | P | P | ↑ |
| Recruit female catch rate | P | = | P | ↑ | P | P | P | ↑ | P | P | P | ↑ | P | P | P | ↑ |
| Spawning female size | N | N | N | ≈ | N | N | N | ≈ | N | N | N | ≈ | N | N | N | ≈ |
| Recruit female size | N | N | N | ≈ | N | N | = | ≈ | N | N | N | ≈ | N | N | N | ≈ |
| **SURVEY INDICATORS** | | | | | | | | | | | | | | | | |
| Minimum trawlable biomass | P | nd | P | ↓ | P | nd | P | ↓ | P | nd | P | ≈ | P | nd | P | ↓ |
| Abundance of males | P | nd | = | ↓ | P | nd | P | ↓ | P | nd | P | ≈ | P | nd | P | ↓ |
| Abundance of females | P | nd | P | ↓ | P | nd | P | ↓ | P | nd | P | ↓ | P | nd | P | ↓ |
| Female size | = | nd | N | ≈ | N | nd | N | ≈ | N | nd | N | ≈ | N | nd | N | ≈ |
| Abundance of prerecruits | P | nd | = | ↓ | P | nd | P | ↓ | P | nd | P | ↑ | P | nd | P | ↓ |
| **EXPLOITATION RATE INDICATOR** | | | | | | | | | | | | | | | | |
| Fishery / Survey (in numbers) | P | nd | = | ↑ | P | nd | = | ↑ | P | nd | P | ≈ | P | nd | P | ↑ |

There was no noticeable change in the distribution of fishing effort in 2005. The sectors that sustain fishing in the four areas have not changed for the last years. They are: the north shore of the Estuary, the western part of Sept-Îles, the two slopes of the Laurentian Channel south of Anticosti Island, the Anticosti Channel and the head of the Esquiman Channel. The effort increased in the Estuary, was similar in Sept-Îles and decreased in Anticosti and Esquiman in 2005 relatively to 2003. It was similar to the 1990-1999 mean in the Estuary while it was below the mean in the three other areas.

The commercial fishery catch rates are considered as good indicators of the abundance of shrimp available to the fishery (Figure 3). The annual catch per unit of effort (CPUE) in 2005 was similar to that of 2003 in the Estuary and Sept-Îles while it increased in Anticosti and Esquiman. This year, we added two indicators that refer to the abundance of females. The catch rate for multiparous females that carry eggs in April and May is a good indicator of the abundance of the spawning stock, which is responsible for the production of the year-class of the same year. The catch rate decreased relatively to 2003 in the Estuary and Sept-Îles while it increased in Anticosti and Esquiman. The catch rate for primiparous females in June, July and August gives an indication of the abundance of recruit females that just completed sex change during the few preceding months. These females will participate to the reproduction for the first time during the fall of the same year. The catch rate of the recruit females increased in 2005 relatively to 2003 in all areas. In general, the 2005 catch rates were higher than the 1990-1999 mean.

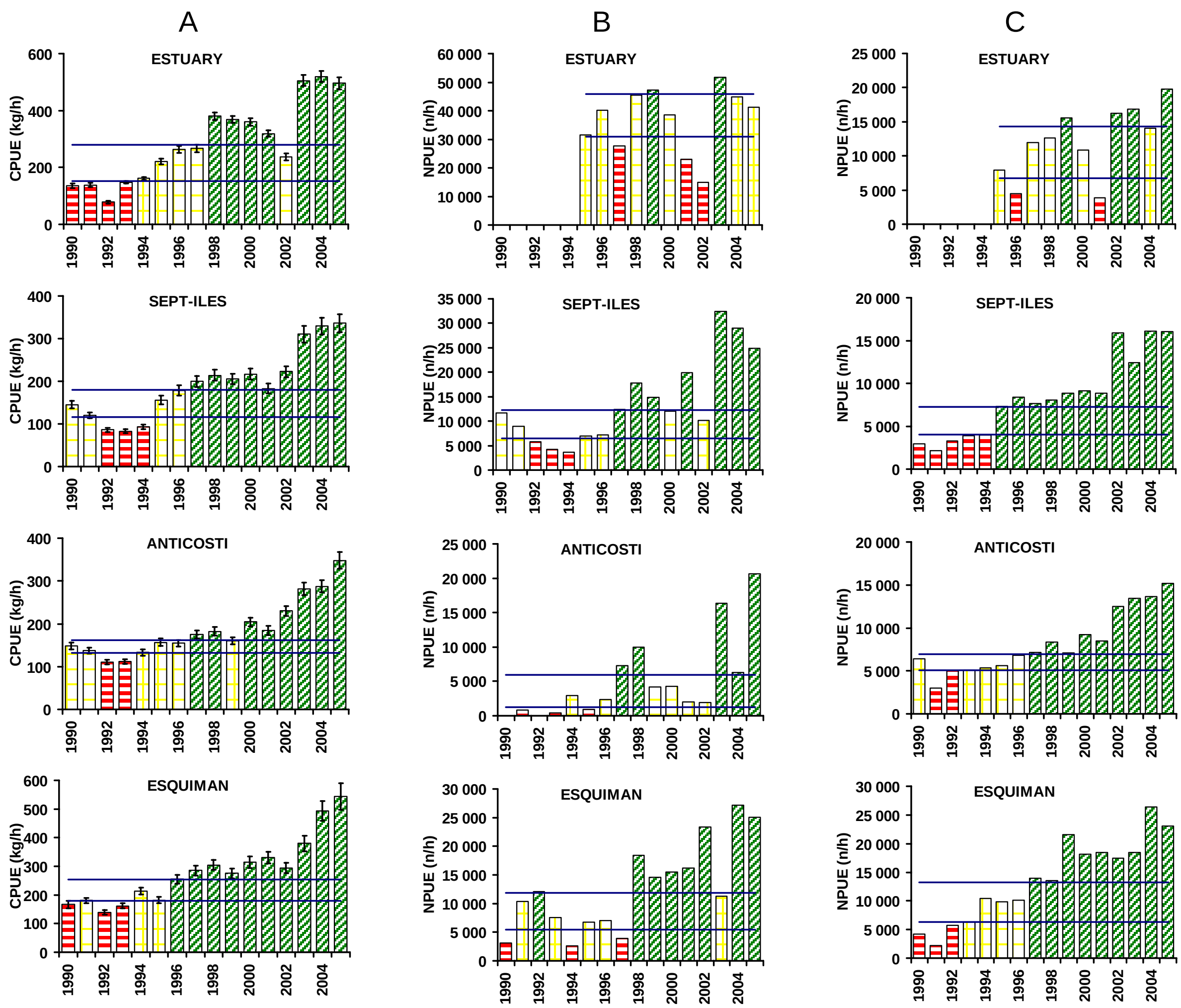



*Figure 3. Commercial fishery catch rates by fishing area from 1990 to 2005. A) Annual standardized catch per unit of effort. B) Number per unit of effort for multiparous females at spring. C) Number per unit of effort for primiparous females in summer. The continuous lines represent the limits of the confidence interval of the 1990-1999 mean.*

The mean size of females that are harvested by the fishery is an indicator of the size of females that participate to the reproduction. The individual fecundity is proportional to the female size and the stock egg production is a function of the spawning female abundance and the individual fecundity. The variations in the female sizes follow an east-west gradient, the smallest being observed in the Esquiman Channel and the largest, in the Estuary. For a same abundance of spawning females, the stock egg production would be theoretically lower in the east. This biological characteristic could have a significant impact on the capacity of the stock to withstand changes induced by the fishery.

The mean sizes of multiparous and primiparous females in 2005 were similar to those of 2003 (Figure 4). They were lower than the 1990-1999 mean and are among the lowest values of the series. However, the decreasing trend that has been observed since 1998-2000 has stopped.

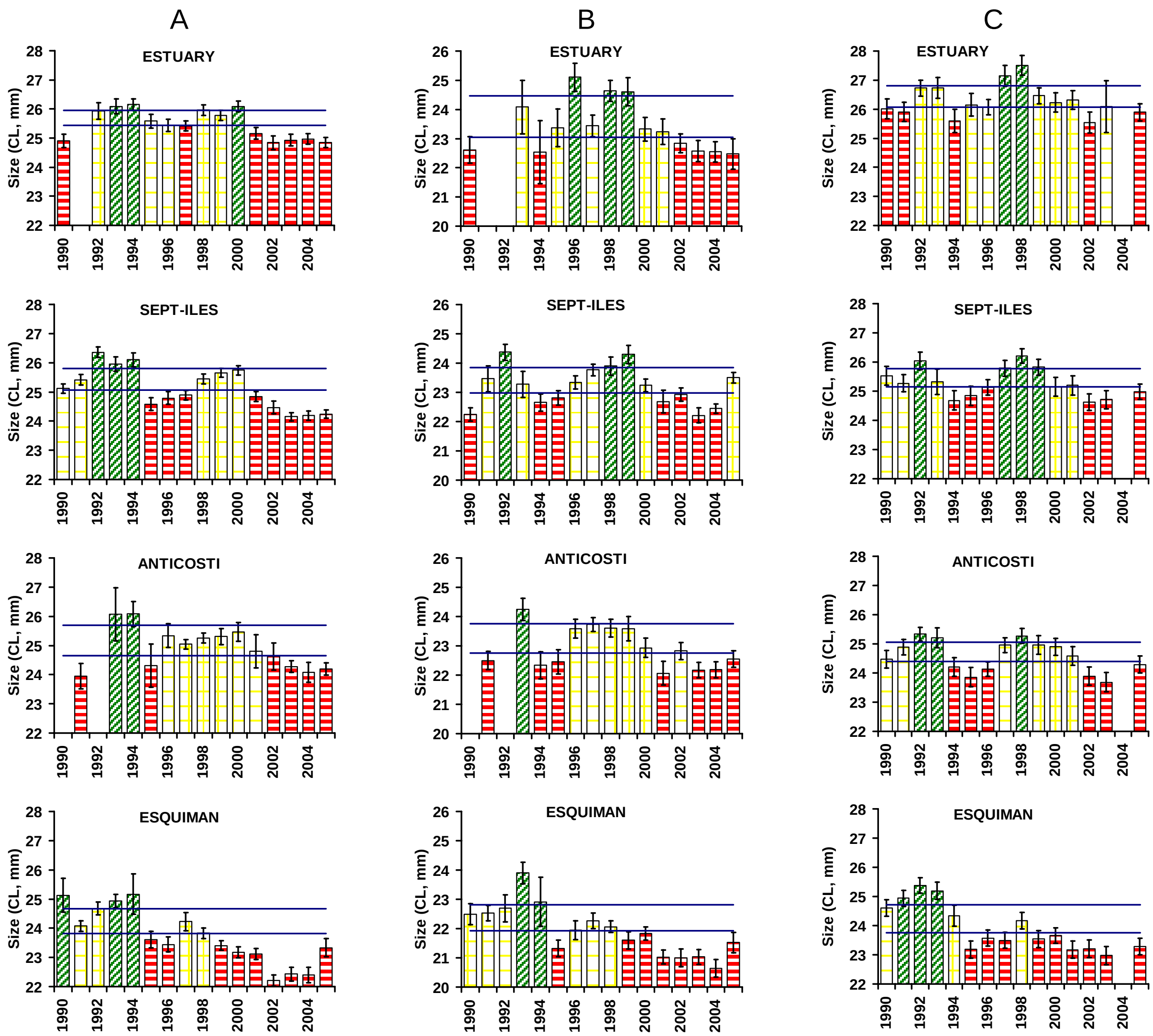



*Figure 4. Mean size of females by area from 1990 to 2005. A) Multiparous females from the fishery at spring. B) Primiparous females from the fishery at spring. C) All females from the survey. The continuous lines represent the limits of the confidence interval of the 1990-1999 mean.*

The results from the 2005 research survey indicate that good concentrations of shrimp were found in all areas. The distribution pattern does not show any significant change relatively to the recent years. The minimum trawlable biomass as well as the male abundance index decreased in 2005 relatively to 2003 in all areas except in Anticosti (Figure 5). The female abundance index decreased everywhere. The biomass of a fishing area is a function of the density of shrimp over the bottom and the total surface of the area. In general, the higher shrimp density is found in Sept-Îles, followed by Anticosti, Esquiman and the Estuary. However, the largest area is Anticosti and the smallest is the Estuary while Sept-Îles and Esquiman Esquiman have similar surface.

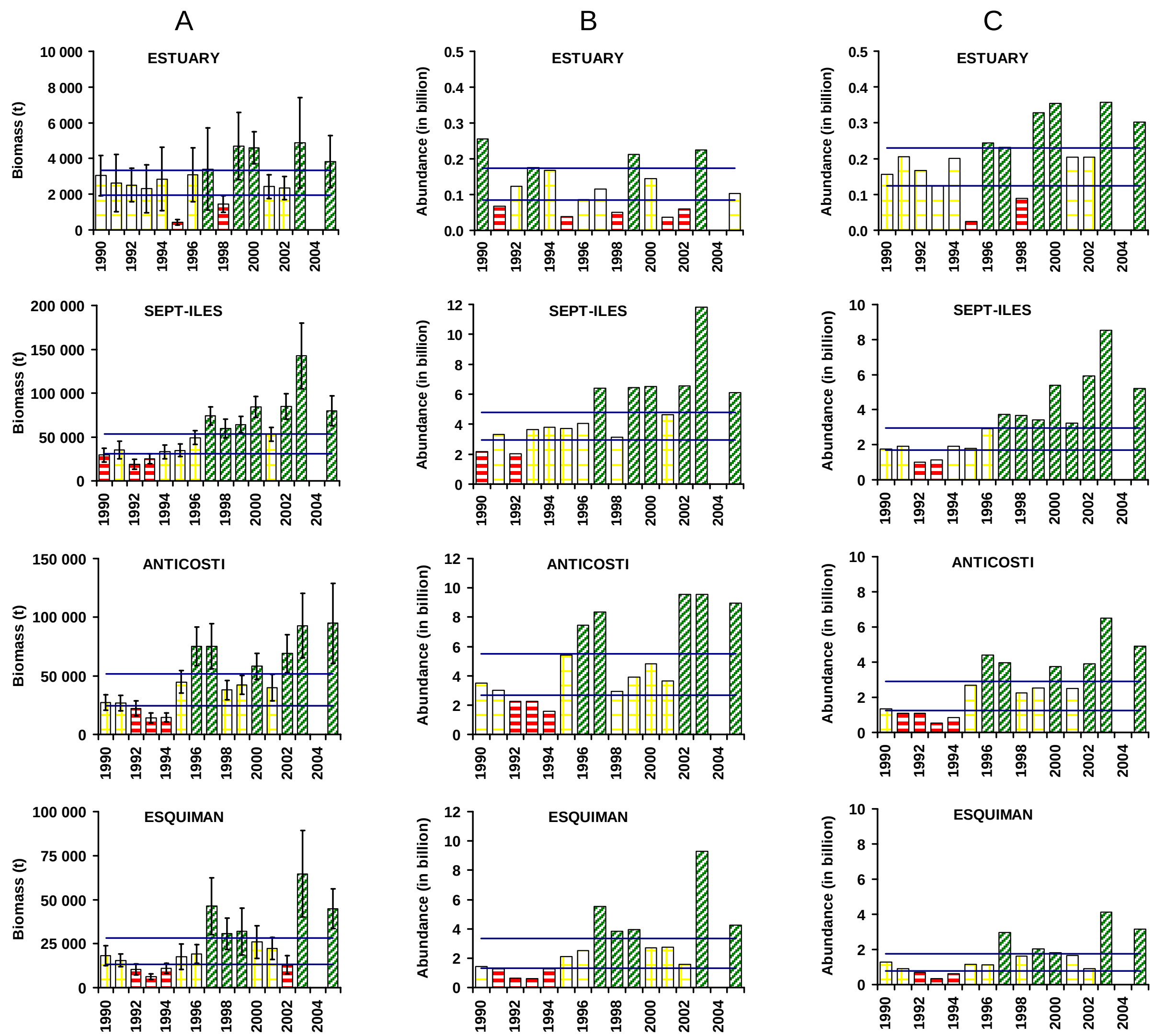



*Figure 5. Research survey indices by area from 1990 to 2005. A) Minimum trawlable biomass. B) Abundance of males. C) Abundance of females. The continuous lines represent the limits of the confidence interval of the 1990-1999 mean.*

The variations in female size from the survey catches show a trend that is similar to the one observed in the fishery data (Figure 4). The 2005 mean size was among the lowest of the series and was below the 1990-1999 mean in all areas. The east-west gradient in the female sizes is also well apparent.

The abundance of males greater than 18 mm (CL) in the Estuary, Sept-Îles and Anticosti and greater than 17 mm in Esquiman from the survey catches gives an indication of the quantity of shrimp that should change sex during the winter and be available to the fishery the following year as primiparous females. The prerecruit abundance was similar or higher than the historic mean in the four areas in 2005. The abundance was however lower than in 2003 in all areas except in Anticosti.

The exploitation rate index (commercial catch / survey abundance) decreased from 2001 to 2003 in all areas except in Esquiman where it increased from 1997 to 2002 (Figure 6). The 2003 index was lower than the 1990-1999 mean reflecting the increase in the survey biomass. The index increased in 2005 to reach values that are similar to the historic mean in the Estuary and Sept-Îles. The 2005 index was still below the mean in Anticosti and Esquiman.

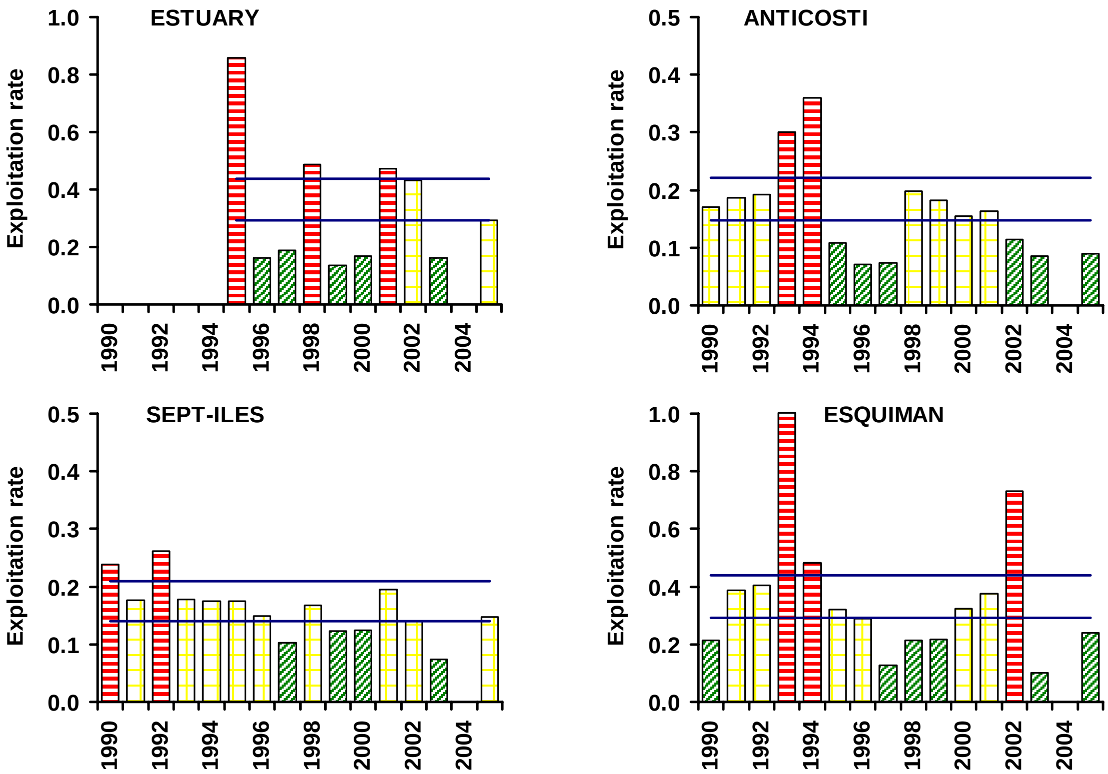



*Figure 6. Exploitation rate index by area from 1990 to 2005. The continuous lines represent the limits of a 20% interval around the 1990-1999 mean.*

## Outlook

The abundance of females estimated by the survey is a good indicator of the abundance of the spawning stock i.e. the amount of females that will carry eggs the following spring. Indeed, the fishery in the fall and the following spring focuses on the same group of females for which there was neither somatic growth nor recruitment. On the other hand, the total biomass of shrimp estimated by the survey is a good indicator of the catch rate of the fishery of the following year. Finally, the mean size of multiparous females caught by the fishery in fall (September to December) is a good indicator of the size of females that will constitute the spawning stock and that will be available to the fishery the following spring. These relationships were used to predict the spawning stock abundance, the annual catch rate and the size of spawning females in 2006.

The results of the linear regressions indicate that the spawning stock ($R^2$ = 0.9 for Sept-Îles, $R^2$ = 0.3 for Anticosti and $R^2$ = 0.7 for Esquiman, non significant for the Estuary) and the fishery catch rate ($R^2$ = 0.7 for Sept-Îles, $R^2$ = 0.5 for Anticosti and $R^2$ = 0.5 for Esquiman, non significant for the Estuary) in 2006 will be lower than in 2005. On the other hand, the size of females should be similar or increasing in 2006 ($R^2$ = 0.8 for the Estuary, $R^2$ = 0.8 for Sept-Îles, $R^2$ = 0.5 for Anticosti and $R^2$ = 0.8 for Esquiman).

The trends in the evolution of stocks have been similar between the areas since 2000 (Figure 7). The recruitment of the two very abundant 1997 and 1999 year-classes is at the origin of the increases in the abundance indices that have been observed since 2001. Females of the 1997 and 1999 year-lasses contributed to the fishing success in 2003, 2004 and 2005. It seems that the size at sex change for these two year-classes was rather small so that the mean size of females was very small between 2002 and 2004. The abundance of the 2000 and 2001 year-classes does not seem as high as the abundance of the 1997 and 1999 year-classes at the same age. Their contribution to the 2006 fishery should be of average.

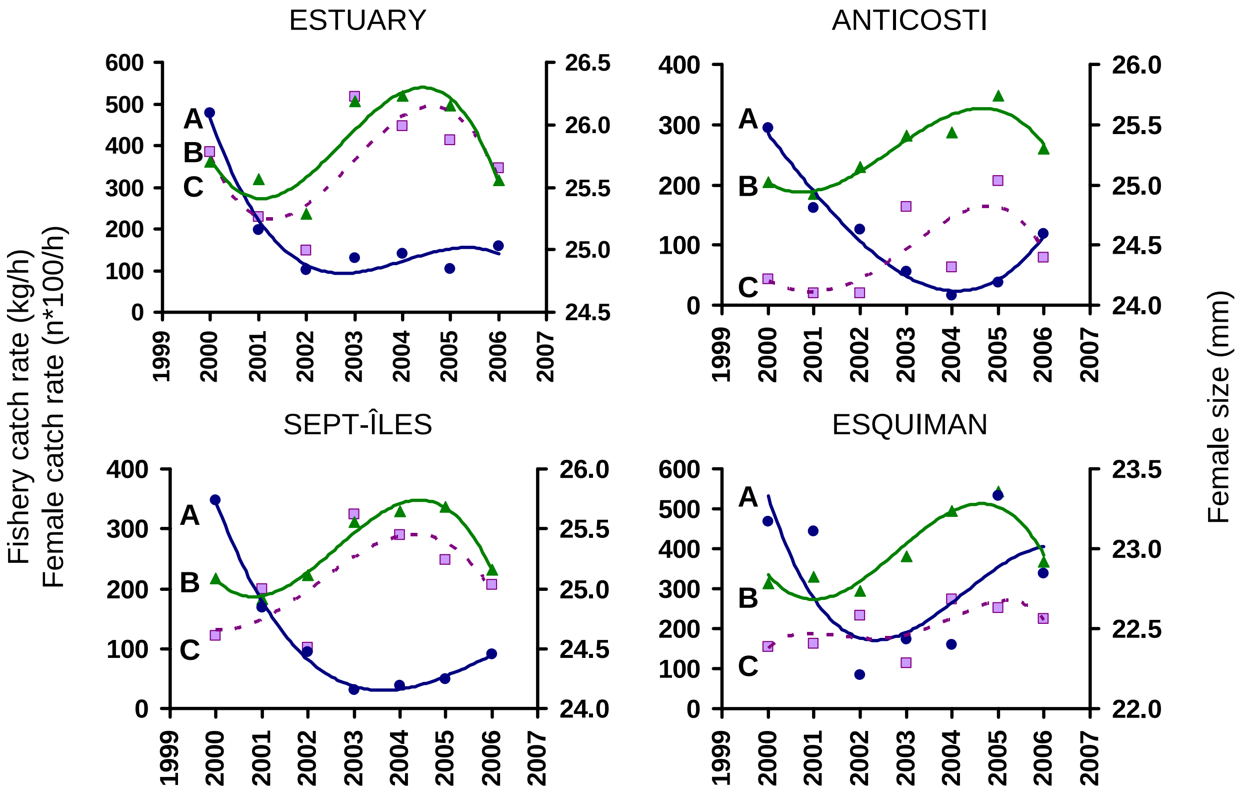



*Figure 7. Stock evolution trends from 2000 to 2006. A) Spawning female mean size at spring. B) Commercial fishery catch rate. C) Spawning female catch rate at spring. The 2006 values are predicted by the linear regressions described in the text.*

It is thus expected that the biomass and abundance of shrimp available to the fishery decrease in 2006. However, the predicted values for 2006 are still higher than the 1990-1999 mean for the biomass and abundance of shrimp and lower than the historic mean for the female size. The predicted biomass and abundance in 2006 are lower than the 2003 values in all areas except in Esquiman. The mean size should be similar or slightly higher than in 2003.

## Sources of uncertainties

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. Moreover, the variance associated with the 2003 biomass estimates is higher than in the past. 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.

## CONCLUSIONS AND ADVICE

The results of fishing were very good in 2005 but the outlooks indicate a decrease for 2006. The TACs were increased everywhere in 2004 and again in Esquiman in 2005 in order to take advantage of the 1997 and 1999 year-classes. The 2005 TACs generated an increase in the exploitation rates everywhere relatively to 2003. In 2006, catches equal to the 2005 TACs should generate an increase in the exploitation rates since the biomasses of shrimp available to the fishery should decrease. However, because the biomasses should stay at a level that is higher than the 1990-1999 mean, it is likely that the exploitation rates stay near the historic mean. Consequently, it does not seem necessary to decrease the TACs and the status quo is recommended in all areas for the 2006 TACs.

## OTHER CONSIDERATIONS

By-catches of small fish in the shrimp fishery between 1999 and 2005 were examined from the at-sea observer database. Species that were most frequently observed were Greenland halibut, capelin and redfish, which were present in 89%, 80% and 73% of the observed tows. Cod was present in 22% of the observed activities. Fish by-catches were in majority in the range of 1 kg per observed tow. The presence of observers on board does not seem to have changed the general fishing pattern since the shrimper catch rates with and without observers do not show any changes. In general, by-catch of a given species is variable between areas and years. By-catch is greatly influenced by the recruitment of the species and by the shrimper fishing effort. No increasing trend was observed between 1999 and 2005. In 2005, by-catches in the Estuary and Gulf of St. Lawrence shrimp fishery represented catches of about 75 tons for turbot, 25 tons for redfish and 5 tons for cod. Capelin by-catch was more important and represented about 200 tons.

## SOURCES OF INFORMATION

Savard, L. et H. Bouchard. 2004. État des stocks de crevette (*Pandalus borealis*) de l'estuaire et du golfe du Saint-Laurent en 2003. Sec. can. de consult. sci. du MPO, Doc. de rech. 2004/091.

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