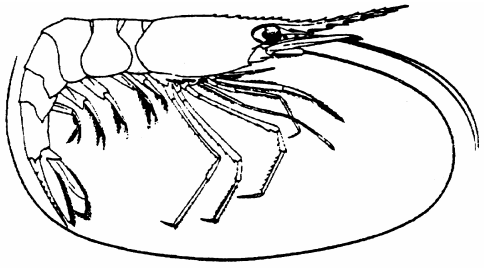
ASSESSMENT OF SHRIMP STATUS IN THE ESTUARY AND GULF OF ST. LAWRENCE IN 2006



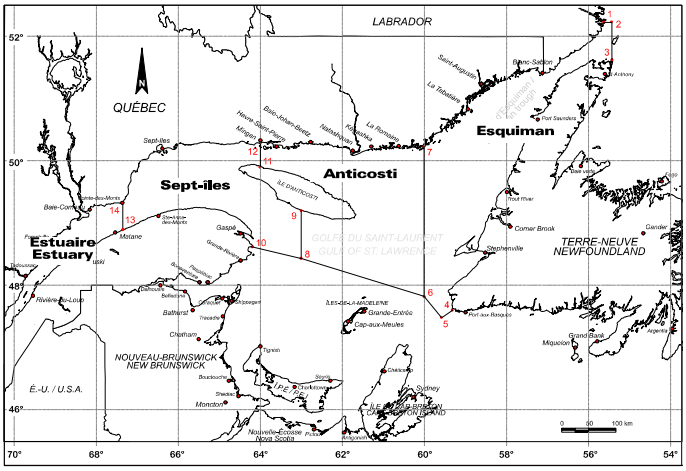


Figure 1. Shrimp fishing areas in the Estuary and Gulf of St. Lawrence.

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 levels 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

- Landings in the Estuary and Gulf of St. Lawrence totalled 34,100 t in 2006, which represents an increase of 10% compared with 2005. Landings reached more than 96% of the TAC of all areas, except for Anticosti where they represented only 84% of the TAC.

- The fishing effort increased compared with 2005 in Sept-Iles and Esquiman while remaining similar in the Estuary and Anticosti. The 2006 value is near the 1990-2005 mean, except for Anticosti where it is lower.

- The 2006 catch per unit of effort for the four areas was similar to that of 2005 and stayed at a value that is much higher than the mean. The biomass index of the research survey has decreased in all areas since 2003 except in Esquiman. The 2006 index is near the mean, except in Esquiman where it is higher. The spawning female abundance index in the spring of 2006 was higher than the mean in all four areas. The size of spawning females has remained lower than the mean since 2002.

- The exploitation rate index has been rising since 2003 in the Estuary, Sept-Iles and Anticosti areas and reached similar or above mean values in 2006. The index value in Esquiman was below the mean and stable.

- The index of recruitment to the spawning stock (primiparous female catch rate) decreased in all areas in 2006 to values that are closer to the mean. The index of recruitment to the female component (abundance of large males) decreased in Esquiman and Anticosti while it was stable in the Estuary and Sept-Iles. It is still higher than the mean in Esquiman while it is close to the mean in Sept-Iles and Anticosti and below the mean in the Estuary. The size of females that will carry eggs at spring in 2007 should stay close or below the mean.

- The stock abundances return to the mean level of the years 1990-2005 following the decreasing contribution of the 1997 and 1999 year classes. The year classes that follow seem to be of average to weak abundance while that of 2004 seems to be more abundant, especially in Esquiman. It should recruit to the female component in 2009. Since then, the stock abundances should decrease or stay stable at the best.

- In 2007, catches equal to the 2006 TAC should generate an increase in the exploitation rate at a value that should be close or slightly higher than the mean. Consequently, the status quo is recommended in all areas for the 2007 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 the spring, but settle on the bottom in late summer. Shrimp migrations are associated with breeding (the egg-bearing 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 m to 350 m.

Description of the Fishery

The number of permanent shrimp licences in the Estuary and the Gulf in 2006 was 112. Licence holders come from 5 provinces and 6 First Nations. In addition, since 1997, temporary allocations have been granted to fishers who do not have permanent licences. The other fishery management measures include the imposition of a minimum mesh size (40 mm) and, since 1993, the compulsory use of the Nordmore grate, which significantly reduces groundfish by-catches. Shrimpers must also keep a log book, have their catches weighted by a dockside monitoring program and agree to have an observer on board upon DFO request (5% coverage). The fishery opening date is set at the first of April and the closing date, at the 31st of December. The fishery has been managed by TAC since 1982, and permanent fishermen have had individual transferable quotas since the mid-1990s.

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, and to 15,000 tons by the late 1980s. Landings remained mostly stable between 1990 and 1995 (Figure 2). The TACs increased gradually beginning in 1996, and landings totalled over 23,000 tons by the late 1990s. TACs rose again in 2000, 2001 and 2004, and landings followed, totalling over 36,000 tons in 2004. The TAC had however been lowered in the Esquiman area in 2003 in order to reduce the exploitation rate. The TACs did not change in 2005, except in Esquiman where the TAC was increased by 10%. They remained stable in 2006. Preliminary statistics indicate that the Gulf landings reached around 34,000 tons in 2006. The TAC was not reached in the Sept-Iles and Anticosti areas in 2005, and again in Anticosti in 2006 because the deterioration of market conditions has considerably slowed down the fishing activities during the season.

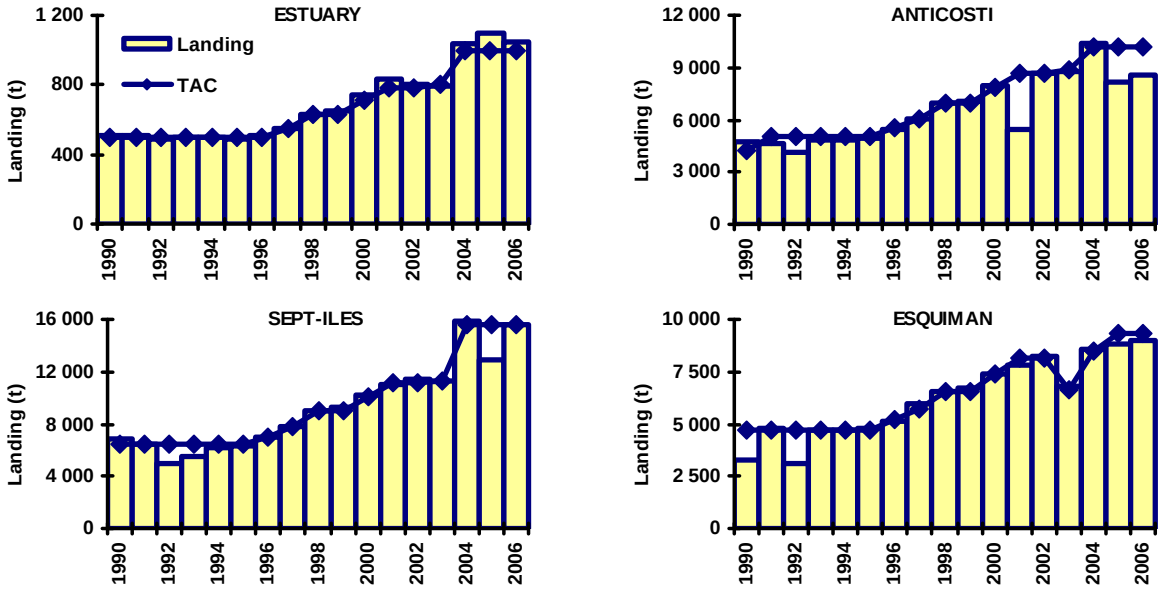


Figure 2. Landing and total of admissible catch (TAC) by fishing area and by year. The 2006 landing data are preliminary.

RESOURCE ASSESSMENT

The stock status is 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 2006, we compared each indicator to the mean value for 1990-2005 period. The 1995-2005 period was used for the indicators associated to the commercial sampling in the Estuary area.

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 fishing capacity and seasonal fishing patterns. The model used for the standardization explains more than 65% of the variability in the data. The commercial catch samples allow the estimation of the number of shrimp harvested by sexual maturity stage as well as the estimation of their mean size.

A research survey is conducted every year in the Estuary and Gulf of St. Lawrence in August from a Departmental vessel. The survey was conducted from 1990 to 2003 and then again in 2005 from the *C.C.G.S. Alfred Needler* equipped with a *URI 81'/114'* shrimp trawl. However, it was decided that the fishing gear and platform would be replaced in order to continue the annual survey beyond 2005. The *C.C.G.S. Teleost* equipped with a *Campelen* shrimp trawl was then used. Because the vessels and gear are quite different, comparative fishing missions were conducted in 2004 and 2005 in order to estimate the catchability differences between the two vessel/trawl tandems. The effect of the tow depth, time of day and size of individual covariables on shrimp catchability differences was tested. The effect of the depth and time of day covariable was not significant in the case of northern shrimp. A statistical model was adjusted to describe the catchability differences based on the size of individuals caught. The *Needler* survey catches were adjusted to match those that would have been made by the *Teleost* for the 2000 to 2005 period. Data corrections for the 1990 to 1999 period will be done at a later date. Overall, the corrections to be made are higher in the case of small individuals.

Biomass indices are then calculated using a geostatistical method. Catches from stations that were visited at night used to be corrected to account for the catchability difference of male shrimp during the day and at night. This correction is no longer made and the biomass and abundance estimates are now produced using the data from all stations whether they were visited at night or during the day. In addition, depth strata of less than 50 fathoms were also included in the study area. These changes allow the inclusion in the new series of all the stations visited during the northern Gulf survey except for the Strait of Belle Isle areas and subdivision 3Pn, just outside Cabot Strait. The changes were made for the 2000-2006 period, and the series will be completed until 1990 at a later date. Finally, survey catch samples provide abundance estimates of shrimp by sexual maturity stage.

The new series of indices adjusted to match those that would have been obtained by the *Teleost* for the 2000-2006 period was compared to the *Needler* series covering the years 1990 to 2003 and 2005. The latter was used for assessing the shrimp stock until last year in order to evaluate the status of the resource. Results show that the differences between the two series are marginal for overlapping years (Figure 3). Recent trends are the same for both series. The *Needler* series from 1990 to 1999 will still be used in the current assessment in order to maintain a historic perspective when observing the indicators from recent years.

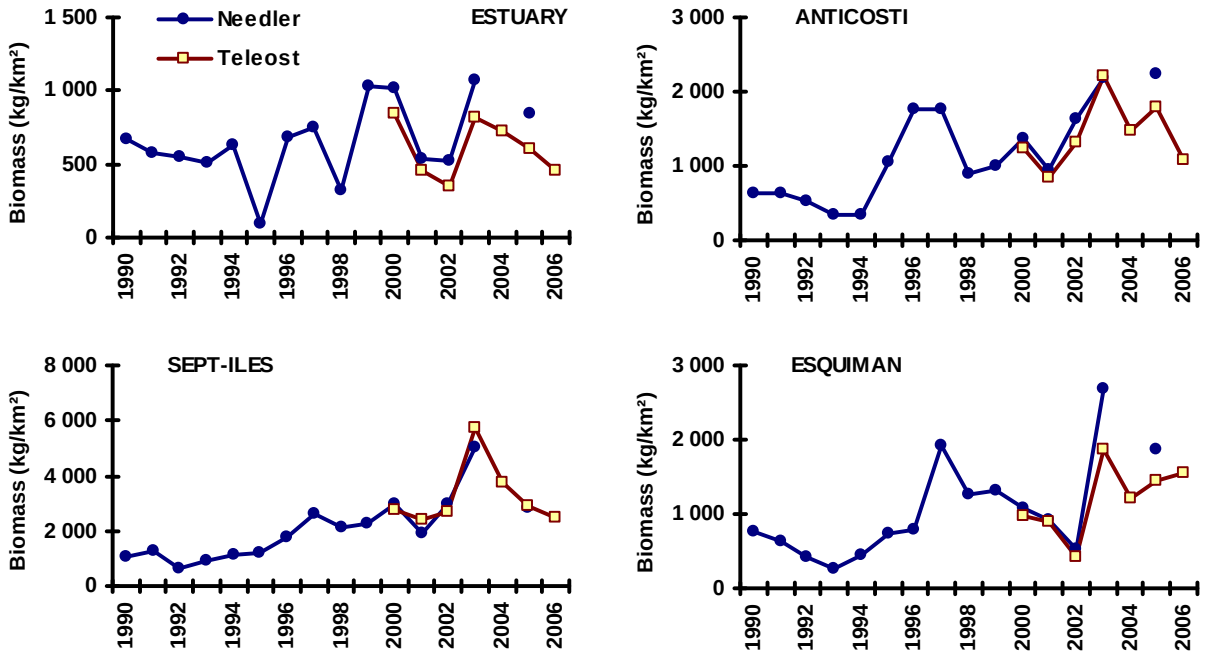


Figure 3. Biomass estimated by krigging for the two data series : 1) Needler series obtained by using the CCGS Alfred Needler uncorrected data from 1990 to 2003 and in 2005, 2) Teleost series obtained by using the adjusted data from the CCGS Alfred Neelder from 2000 to 2003 and in 2005 in combination with the data from the CCGS Teleost from 2004 to 2006.

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 method does make it possible to track relative changes in the exploitation rate over the years.

Resource Status in 2006

There was no noticeable change in the distribution of fishing effort in 2006. The sectors that sustain fishing in the four areas have not changed in recent years. They are the north shore of the Estuary, near the border of the Sept-Iles area, the western part of the Sept-Iles area, the two slopes of the Laurentian Channel south of Anticosti Island, the Anticosti Channel and the head of the Esquiman Channel.

The total fishing effort increased in 2006 compared to 2005 in the Sept-Iles and Esquiman areas, while it decreased in the Estuary and remained similar in Anticosti. Overall, the values in recent years are under or near the mean from the 1990-2005 period. The 2006 value is near the mean in all areas except Anticosti where it is lower.

The commercial fishery catch rates are considered as good indicators of the abundance of shrimp available to the fishery (Figure 4). The annual standardized catch per unit of effort (CPUE) in 2006 was not significantly different from that of 2005 and was higher than the mean from the 1990-2005 period in all four areas.

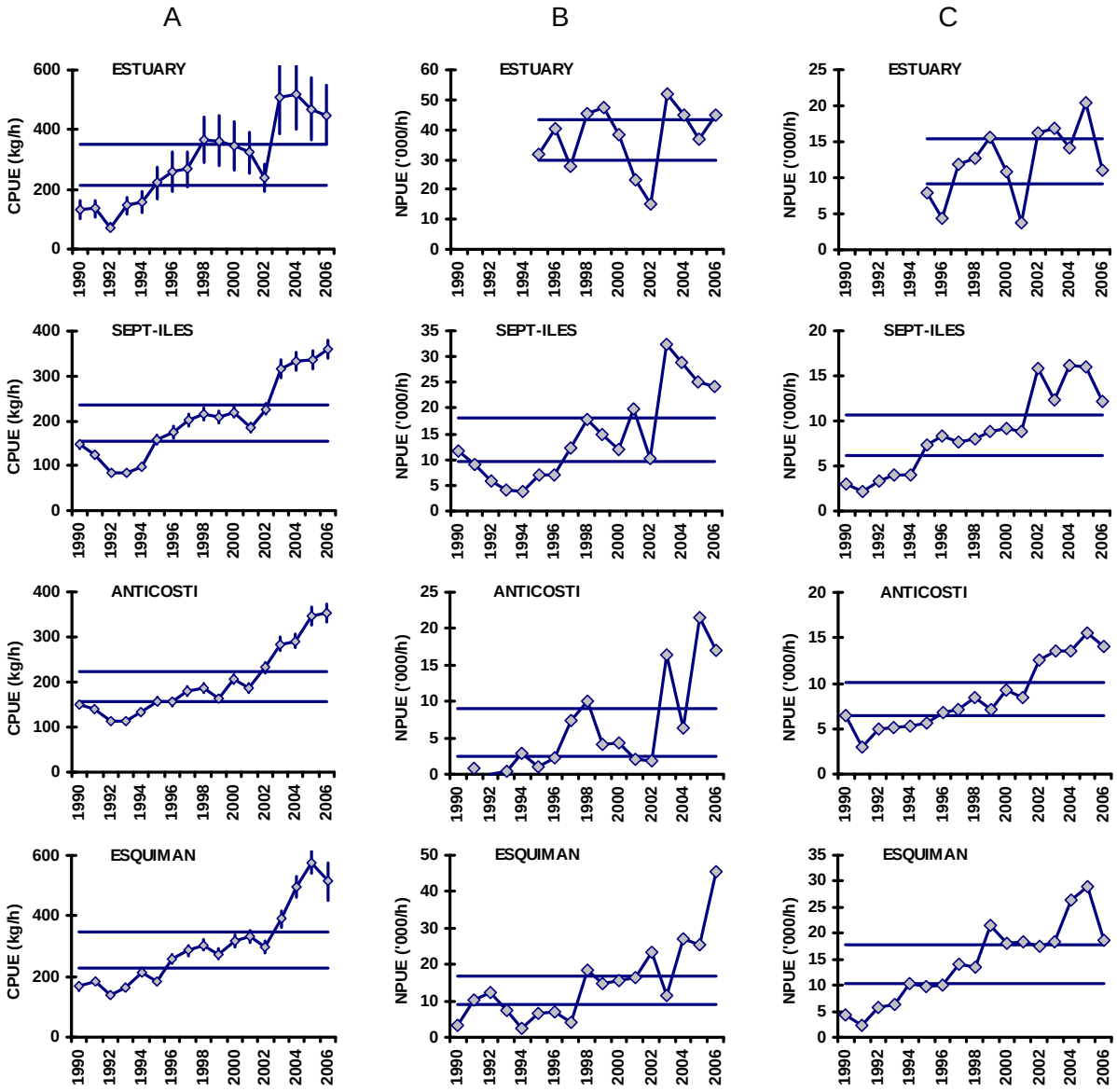


Figure 4. Commercial fishery catch rate by fishing area from 1990 to 2006. A) Annual standardized catch per unit of effort. B) Number per unit of effort for multiparous females in spring. C) Number per unit of effort for primiparous females in summer. The continuous lines represent the limits of the confidence interval of the 1990-2005 mean.

The catch rate for the multiparous females that carry eggs in April and May is an 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 for multiparous females in the spring of 2006 is above the mean in all areas (Figure 4). The catch rate for primiparous females in June, July and August provides an indication of the abundance of recruit females that just completed sex change during the few preceding months. These females will participate in the reproduction for the first time during the fall of the same year. The catch rate of recruit females decreased in 2006 in all areas and is approaching the mean from the 1990-2005 period.

The biomass index and the total abundance index from the research survey have been decreasing since 2003 in all areas except for Esquiman (Figure 5). The 2006 value is near the mean from the 1990-2005 period, except in the Estuary where it is below and in Esquiman where it is above the mean. Abundance fluctuations are more evident in males than in females. The abundance of males greater than 20 mm (CL) in the Estuary, Sept-Iles and Anticosti, and greater than 19 mm (CL) 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 in 2006 dropped compared with 2005 in Anticosti and Esquiman, while it was similar in the Estuary and Sept-Îles.

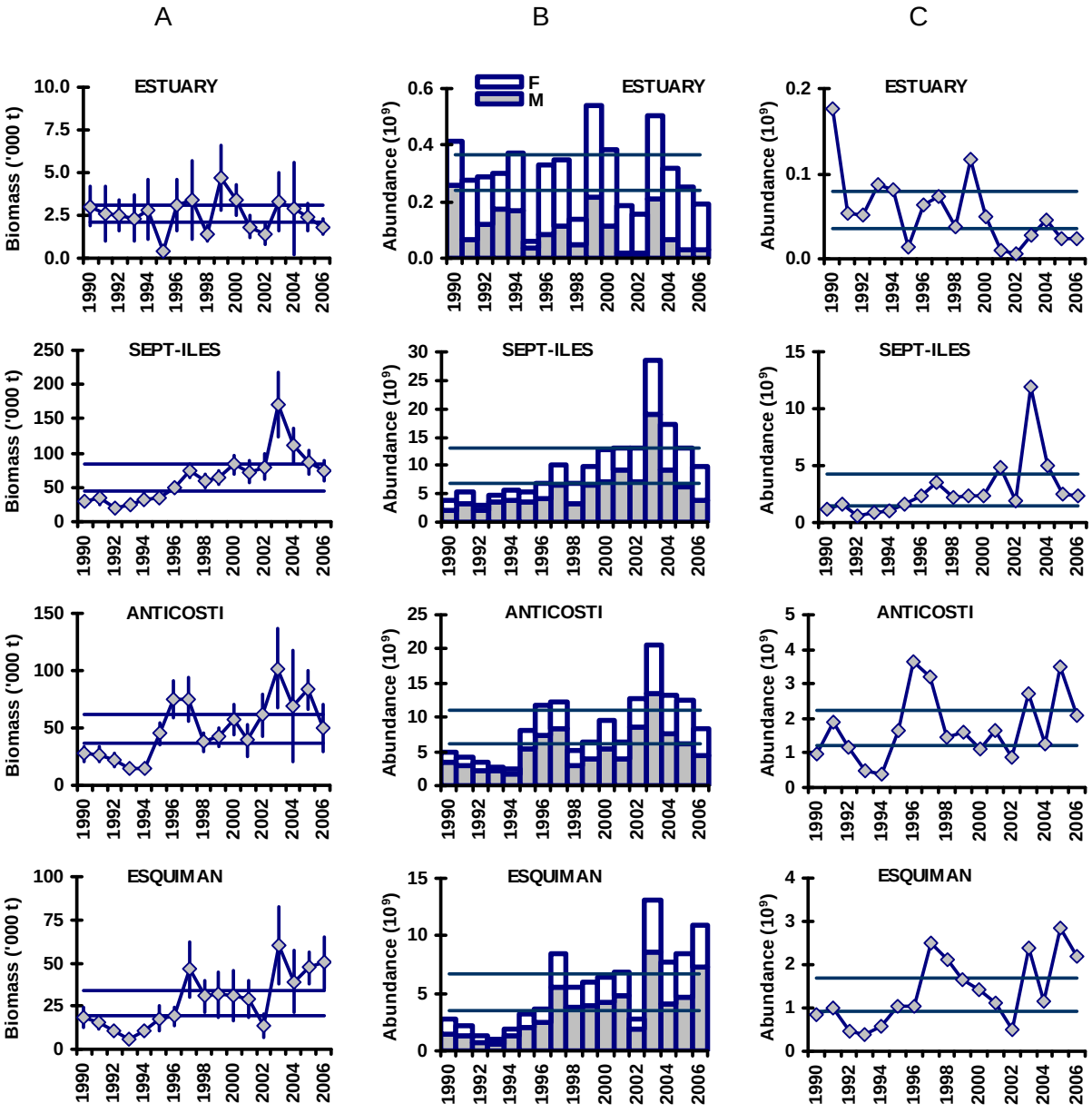


Figure 5. Research survey indices by fishing area from 1990 to 2006. A) Total biomass. B) Abundance of males and females. C) Abundance of males larger than 20 mm (CL). The continuous lines represent the limits of the confidence interval of the 1990-2005 mean.

The variations in 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. The mean sizes of females caught in the commercial fishery increased slightly in 2006 as compared to 2005 (Figure 6). They are nevertheless below the mean from the 1990-2005 period in most of the cases and are among the lowest values in the series. The variations in female sizes caught in the survey show the same trends as in the fishery. Mean sizes have increased slightly since 2004 to approach the mean of the 1990-2005 period in all areas.

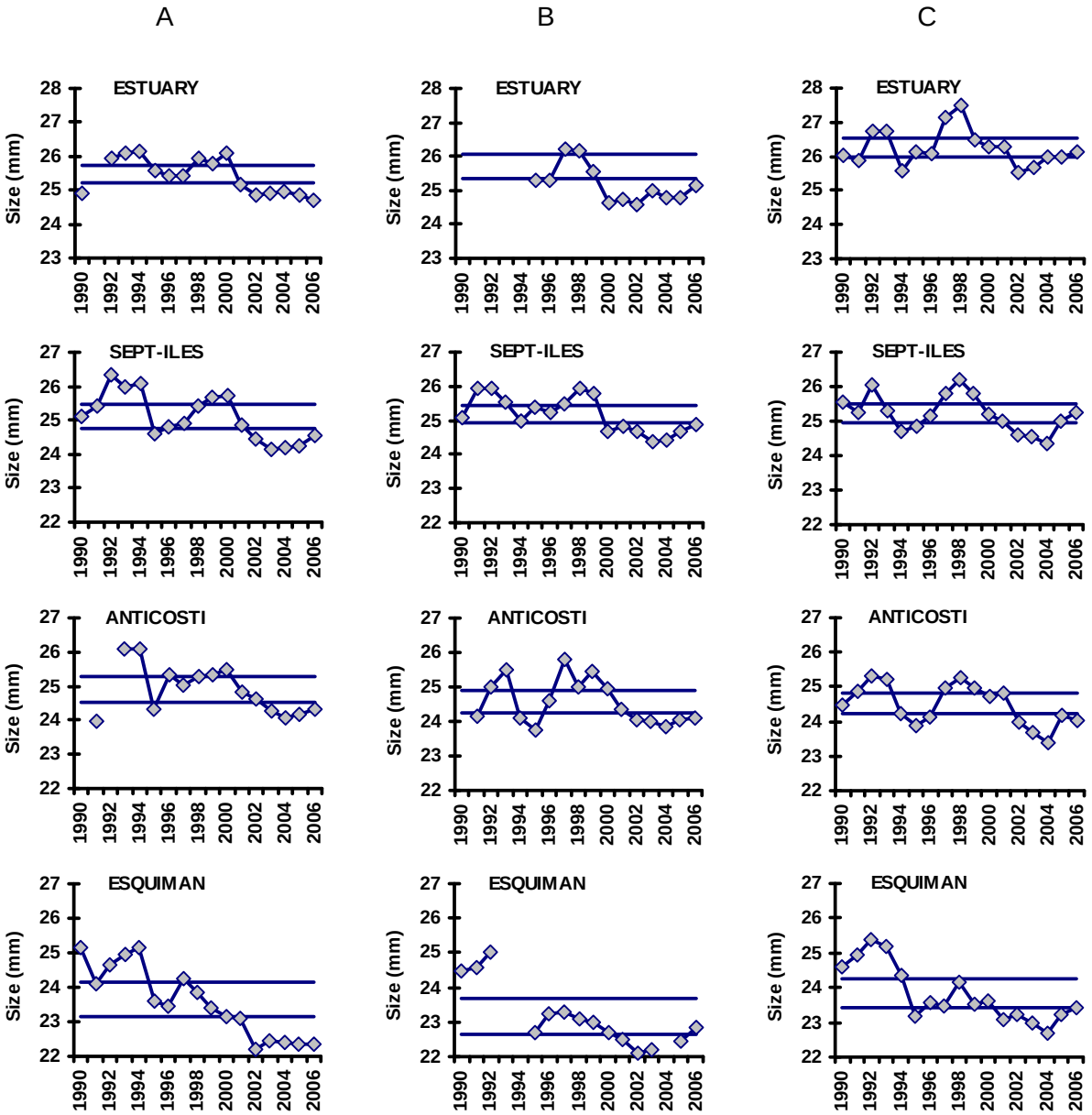


Figure 6. Mean size of females by fishing area from 1990 to 2006. A) Multiparous females from the spring fishery. B) Females from the fall fishery. C) All females from the survey. The continuous lines represent the limits of the confidence interval of the 1990-2005 mean.

The exploitation rate index (commercial catch / survey abundance) increased in 2006 in all areas except in Esquiman where it was slightly lower to 2005 (Figure 7). The index is similar or above the mean from the 1990-2005 period everywhere except in Esquiman where it remained below the mean.

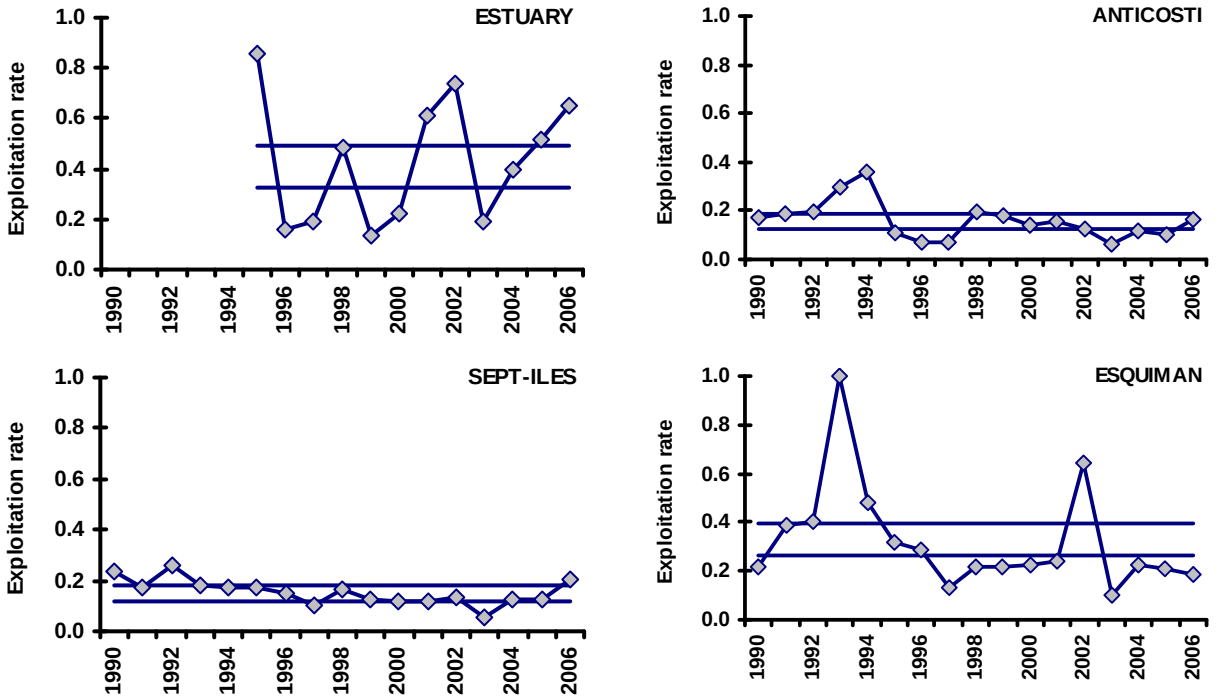


Figure 7. Exploitation rate index by fishing area from 1990 to 2006. The continuous lines represent the limits of a 20% interval around the 1990-2005 mean.

Outlook

Recent years have been characterized by the recruitment to the fishery of two very abundant (1997 and 1999) cohorts. The female component whose catch rates were under the mean in 2001 and 2002 began increasing in 2003 when individuals from the 1997 year-class changed sex (Figure 8). The 1999 year-class was very noticeable in the 2001 commercial catches as early as two years of age. This highly above average year-class was characterized by positive anomalies throughout its passage in the commercial catches of the four areas until 2006, as it still sustained the fishery.

The research survey biomass decreased in 2004 because the post-1999 year-classes were less abundant. In the west and middle of the Gulf (Estuary, Sept-Îles and Anticosti), the biomass continued to decrease until 2006. The male component decrease in the research survey was more evident than the female one, which indicates that the abundance of year-classes 2000, 2001, 2002 and 2003 was generally lower than in 1999. In the eastern part of the Gulf (Esquiman), the male component increased until 2006 due to the exceptional contribution from the 2004 year-class.

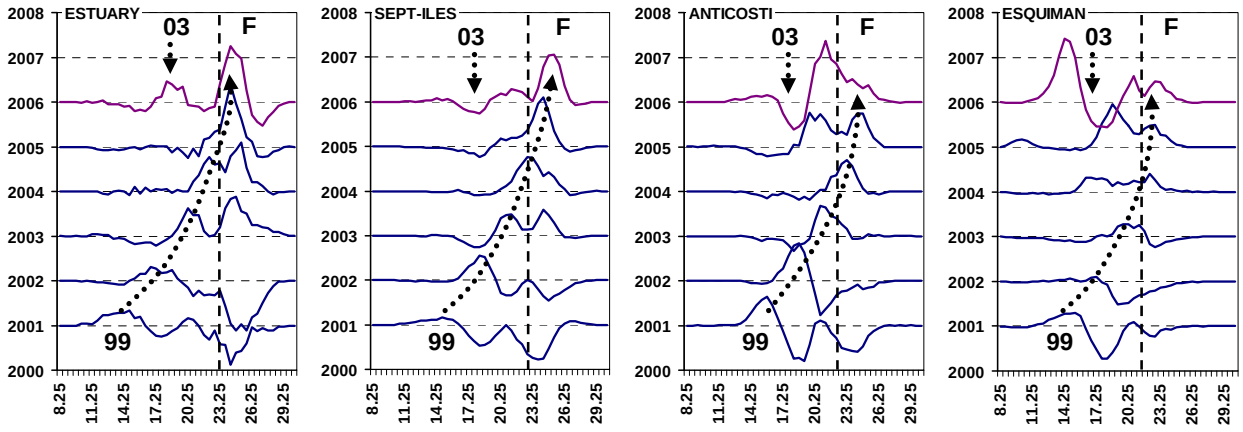


Figure 8. Commercial fishery catch rate deviation from the 2000-2005 mean per size class. The dotted lines represent the 2000-2005 mean while the continuous lines represent the deviation from the mean of the size class.

In the four fishery areas, females were able to maintain a relatively high biomass from 2004 to 2006 due to the contribution of the strong 1999 year-class, and because only the two first cohorts (2000 and 2001) from the weaker year-class series changed sex in 2005 and 2006. Catch rates also remained quite high in 2005 and 2006 because the 1999 year-class was still contributing to the fishery and operators were able to target females by fishing on the most productive bottoms.

Catch rates and female biomass should decrease in 2007 and 2008 because the 1999 year-class will no longer contribute to the fishery, while the 2002 and 2003 year-classes, which should be changing sexe over the next two years, are among the least abundant in the series (Figure 8). The 2003 year-class is characterized by negative anomalies in the Sept-Iles, Anticosti and Esquiman areas, and recruitment to the female component is expected to be weak in 2008. With regards to the Estuary area, a decrease is expected as early as 2007 because the 2002 year-class shows a negative anomaly. Predicted values for 2007 are nonetheless still above the mean from the 1990-2005 period in terms of catch rates for spawning females in spring and below the mean in terms of female size.

However, male biomass should stabilize due to the contribution of the 2004 year-class whose abundance is among the highest since 1999. This is especially evident to the east, particularly in the Esquiman area where the 2004 year-class shows an exceptional abundance in both the survey and fishery catches. This year-class should recruit to the female component in 2009 and have a positive impact on spawning stock abundance in the spring of 2010.

Sources of Uncertainty

As with many groundfish species, the indices of all components of the shrimp stocks (juveniles, males and females) increased simultaneously in the 2003 survey. It is possible that external factors affected the catchability of the shrimp and of several other species. 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. The marked drop in survey indices between 2003 and 2004 may have therefore been overestimated.

CONCLUSIONS AND ADVICE

Fishery results were very good in 2006, but the outlooks indicate a decrease for 2007. In 2007, catches equal to the 2006 TACs should generate an increase in the exploitation rates because the biomass of shrimp available to the fishery should decrease. However, because the biomasses should stay at a level that is higher than the 1990-2005 mean, it is likely that the exploitation rates will also remain near or slightly above the mean and therefore it does not appear necessary to decrease the TACs. Consequently, the status quo is recommended in all areas for the 2007 TACs.

OTHER CONSIDERATIONS

By-catches of small fish in the shrimp fishery between 1999 and 2006 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 or less 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 strength of the recruitment of the species and by the shrimper fishing effort. No upward trend was observed between 1999 and 2006. In 2006, by-catches in the Estuary and Gulf of St. Lawrence shrimp fishery represented catches of about 82 tons for turbot (1.0 million individuals), 59 tons for redfish (2.3 million individuals), and 6 tons for cod (0.18 million i. By-catches decreased in 2006 compared to 2005 for turbot but increased for redfish and cod.

SOURCES OF INFORMATION

Bourdages H., L. Savard, D. Archambault and S. Valois. 2007. Results from the August 2004 and 2005 comparative fishing experiments in the northern Gulf of St. Lawrence between the *CCGS Alfred Needler* and the *CCGS Teleost*. Canadian Technical Report of Fisheries and Aquatic Sciences. In press.

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