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Science Sciences
Quebec Region

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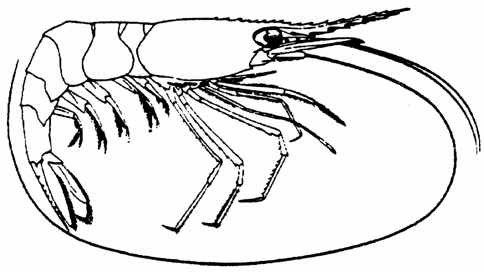
Science Advisory Report 2011/006

ASSESSMENT OF SHRIMP STOCKS IN THE ESTUARY AND GULF OF ST. LAWRENCE IN 2010



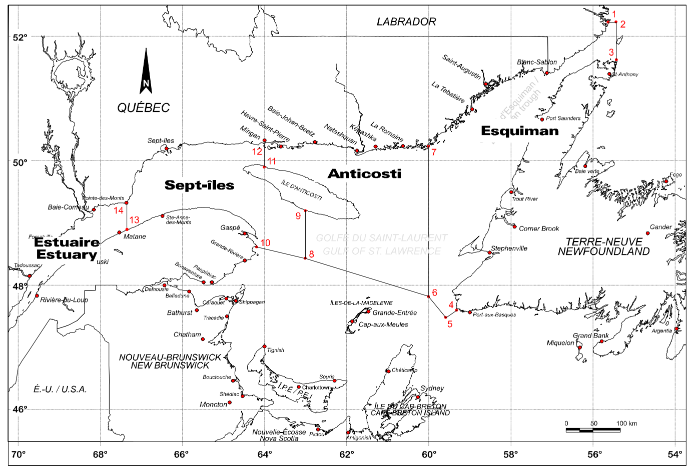


Figure 1. Shrimp fishing areas in the Estuary and Gulf of St. Lawrence.

Context

The northern shrimp (Pandalus borealis) fishery began in the Gulf of St. Lawrence in 1965. The exploitation is conducted by trawlers in four shrimp fishing areas (SFA): Estuary (SFA 12), Sept-Iles (SFA 10), Anticosti (SFA 9) and Esquiman (SFA 8) (Figure 1).

Shrimp fishing is regulated by a number of management measures, including the setting of total allowable catches (TAC) in the four areas. TAC-based management limits fishing to protect the reproductive potential of the population. The essential elements for the establishment of a precautionary approach were examined during a national DFO-Industry workshop held in 2008. Provisional reference points were adopted in order to initiate the development of a precautionary approach for the Gulf shrimp fishery.

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 totalled nearly 36,000 t in 2010 and were similar to those of 2009. The TACs were the same as those of 2009 in all areas except for Estuary where it was 10% lower. The fishing effort increased in 2010 in Sept-Iles and Anticosti. The commercial fishery catch rate decreased relatively to 2009 in all areas except Esquiman where it increased. The survey biomass index stayed similar to that of 2009 in all areas.

- The male and female abundance indices estimated from the fishery and survey data are combined to constitute the main indicator for the status of the stocks. This index gives an

indication of the amount of females that will be available to the fishery and to the reproduction the following year. The comparison of the female abundance index to the provisional reference points allows determining in which zone, healthy, precautionary or critical, the stock is situated.

- The stock status indicator for Estuary has slightly improved in 2010. However, according to the results of the survey since the coverage of the area was extended, it seems that the total abundance of the stock is much higher than what was estimated before and that the exploitation rate is much lower. Consequently, the status quo is recommended for the 2011 TAC for this area.

- In Sept-Iles, both indicators have decreased relatively to 2007. In 2010, the stock status indicator was above the mean (1990-2009) and the female abundance was in the healthy zone. However, the female size was lower than the mean and the 2010 catches have generated an increase in the exploitation rate above the mean.

- In Anticosti, the female abundance has decreased since 2007 but was in the healthy zone in 2010 while the stock status indicator was slightly above the mean. The female size was lower than the mean and the 2010 catches have generated an increase in the exploitation rate above the mean.

- The stock status indicator for Esquiman has been decreasing since 2006 and the 2010 value is slightly above the mean. The female abundance has decreased since 2006. The 2010 value is similar to that of 2009 and is situated in the healthy zone. The female size was similar to the mean and the 2010 catches have generated an exploitation rate similar to the mean.

- The abundance has been decreasing gradually for the last 4 to 5 years in the Sept-Iles, Anticosti and Esquiman stocks and although they are still in the healthy zone, it is recommended to decrease the TACs in order to prevent the exploitation rates from increasing and to maintain the stocks in the healthy zone. In 2011, the TACs should be reduced by 10% relative to the 2010 TACs in each of these fishing areas.

INTRODUCTION

Species Biology

The biology of shrimp has several particularities which in turn influence the exploitation strategy, fishery management and resource conservation.

Shrimp change sex over 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 by 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). In general, 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 active licences in the Estuary and the Gulf shrimp fishery in 2010 was about 150. The harvesters come from five provinces and seven First Nations. The 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 request by the Department (5% coverage). The fishery opens on April 1st and closes on December 31st. The fishery has been managed by TAC since 1982, and the traditional fishermen have had individual 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. They 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 and 2007. In 2008 and 2009, they were increased relative to 2007 by 2.0 and 2.3% respectively. In 2010, the TACs were similar to those of 2009 except in Estuary where the TAC was lower by 10%. Preliminary statistics indicate that the Gulf landings were close to 36,000 tons in 2010.

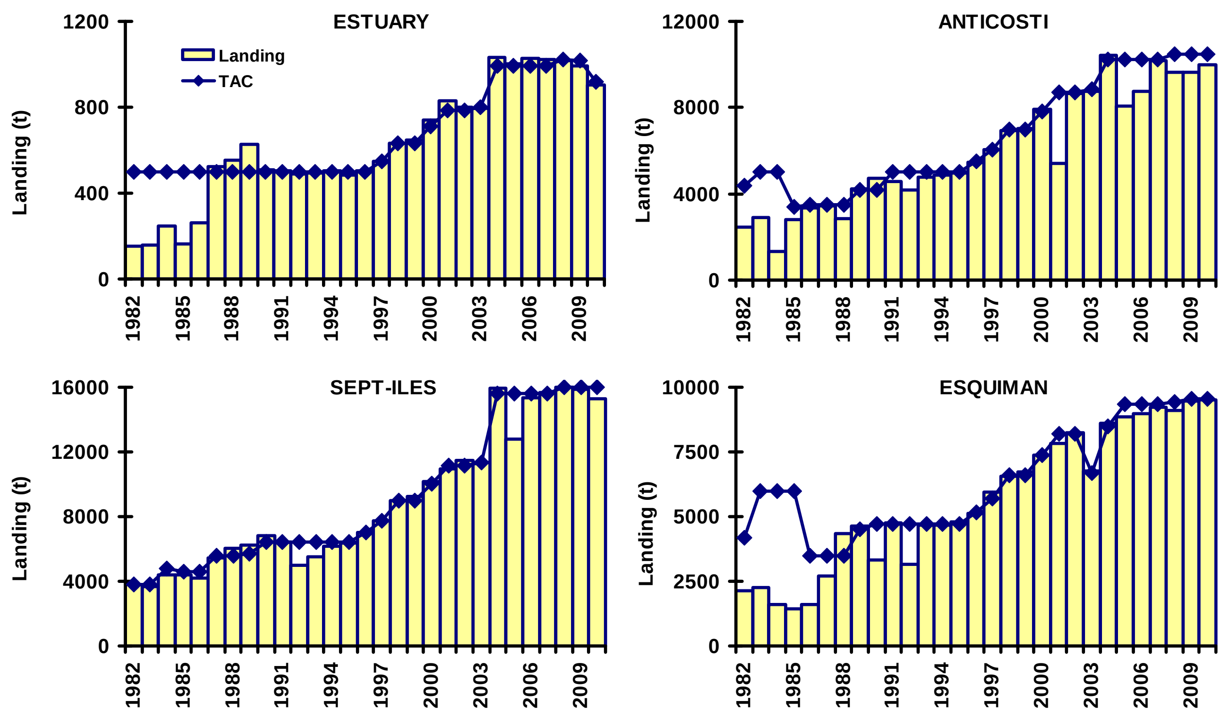


Figure 2. Landing and total of admissible catch (TAC) by fishing area and by year. The 2010 landing data are preliminary.

RESOURCE ASSESSMENT

The stock status is determined by examining a number of indicators from the commercial fishery and the research survey. The indicators are compared to the 1990-2009 mean in order to assess their trend over time.

The statistics from the commercial fishery (shrimper catch and effort) are used to estimate the fishing effort and to calculate catch rates in weight or in number. The data are standardized to take into account changes in fishing capacity and seasonal fishing patterns. The model used for the standardization explains 50% or more of the variability in the data. The commercial catch samples allow the estimation of the number of shrimp harvested by size classes and by sexual maturity stage.

A research survey is conducted every year in the Estuary and Gulf of St. Lawrence in August from a Departmental vessel. The *CCGS Alfred Needler* was used to do the survey from 1990 to 2003 and in 2005 while the *CCGS Teleost* has been used for the survey since 2004. Following a comparative fishing survey, the *CCGS Alfred Needler* catches were adjusted to match those that would have been made by the *CCGS Teleost.* Biomass indices are calculated using a geostatistical method. Survey catch samples provide abundance estimates of shrimp by size classes and by stage of sexual maturity.

In the Gulf, the grounds located at depths greater than 37 m (20 fathoms) are covered by the survey. In the Estuary, the survey covered the grounds at depths greater than 183 m (100 fathoms) from 1990 to 2007. In 2008, it was decided to add strata to cover depths from 37 to 183 m in oerder to obtain a better coverage of the northern shrimp spatial distribution. The area covered by the survey in the Estuary fishing area has therefore increased from 4,000 to 6,325 km². The impact of the allocation of supplementary stations in the shallow part of the Estuary is discussed in the Sources of uncertainty section.

Resource Status in 2010

The sectors that sustain fishing in the four areas have not changed in recent years and correspond to the spots where high concentrations of shrimp were observed during the survey (Figure 3).

A B

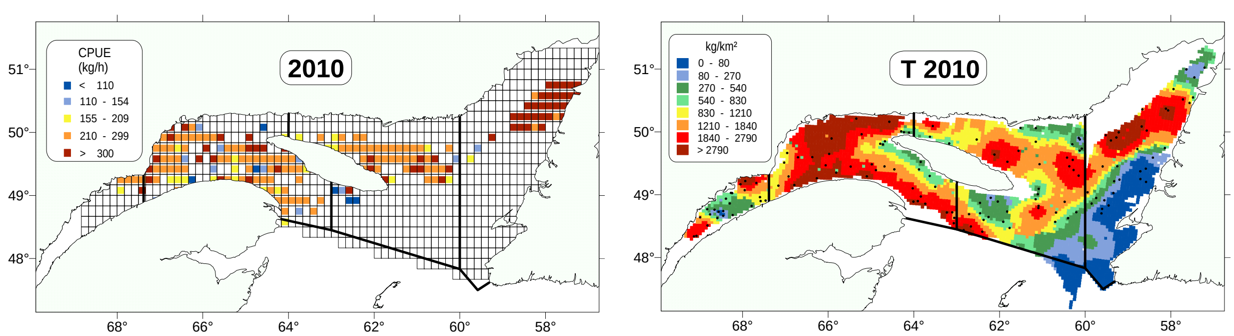


Figure 3. A) Spatial distribution of catch rates (CPUE) from the shrimp fishery in 2010. B) Spatial distribution of shrimp biomass estimated by kriging during the research survey in 2010.

There was no noticeable change in the distribution of fishing effort in 2010. In 2010, the total number of fishing hours increased by 14% in Sept-Iles and 30% in Anticosti but stayed the same as in 2009 in Estuary and Esquiman.

The catch rate from the commercial fishery and the biomass index from the research survey are considered as good indicators of the size of the stocks (Figure 4).

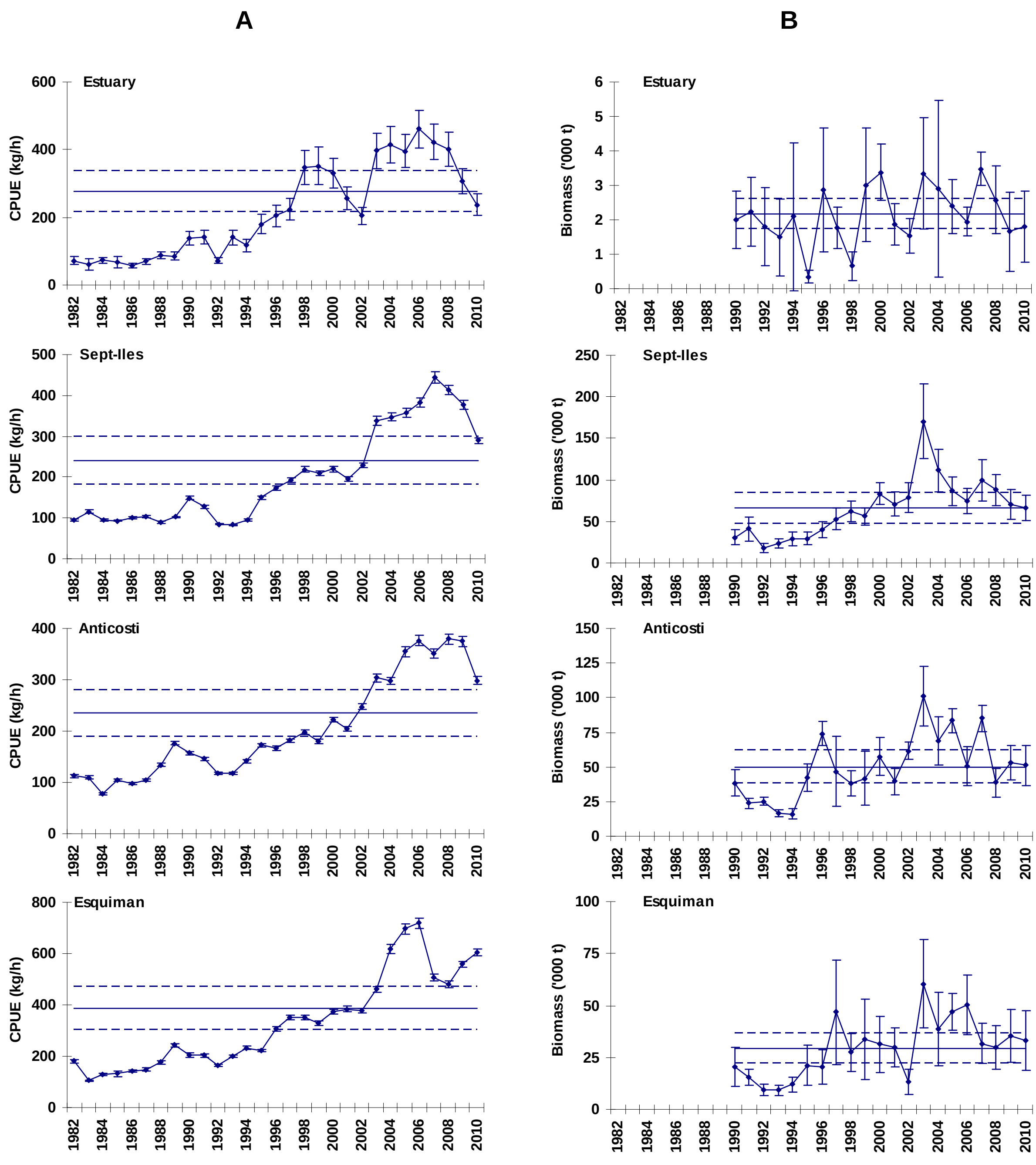


Figure 4. Indices for the size of the stock by fishing area and by year. A) Catch rate from the commercial fishery ± confidence interval (95%). B) Biomass index from the research survey ± confidence interval (95%). The full horizontal line represents the 1990-2009 mean ± 0.5 standard deviation.

In 2010, the annual standardized catch rate from the commercial fishery decreased relatively to 2009 in all areas except Esquiman where it increased (Figure 4A). The catch rates are higher than the mean in Anticosti and Esquiman. In 2010, the biomass index from the research survey was similar to that of 2009 in all areas (Figure 4B). The biomass indices are similar to the mean in all areas.

An index of the exploitation rate is obtained by dividing the commercial catches in number by the abundance estimated from the research survey. This method cannot be used to estimate the absolute exploitation rate nor 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. The exploitation rate index increased in 2010 in all areas except Estuary where it decreased (Figure 5). The index is above the mean in Sept-Iles and Anticosti while it is similar to the mean in Estuary and Esquiman. In general, the exploitation rate index shows an increasing trend in all areas since 2003 even though the landings have stayed relatively stable since 2005 or 2006.

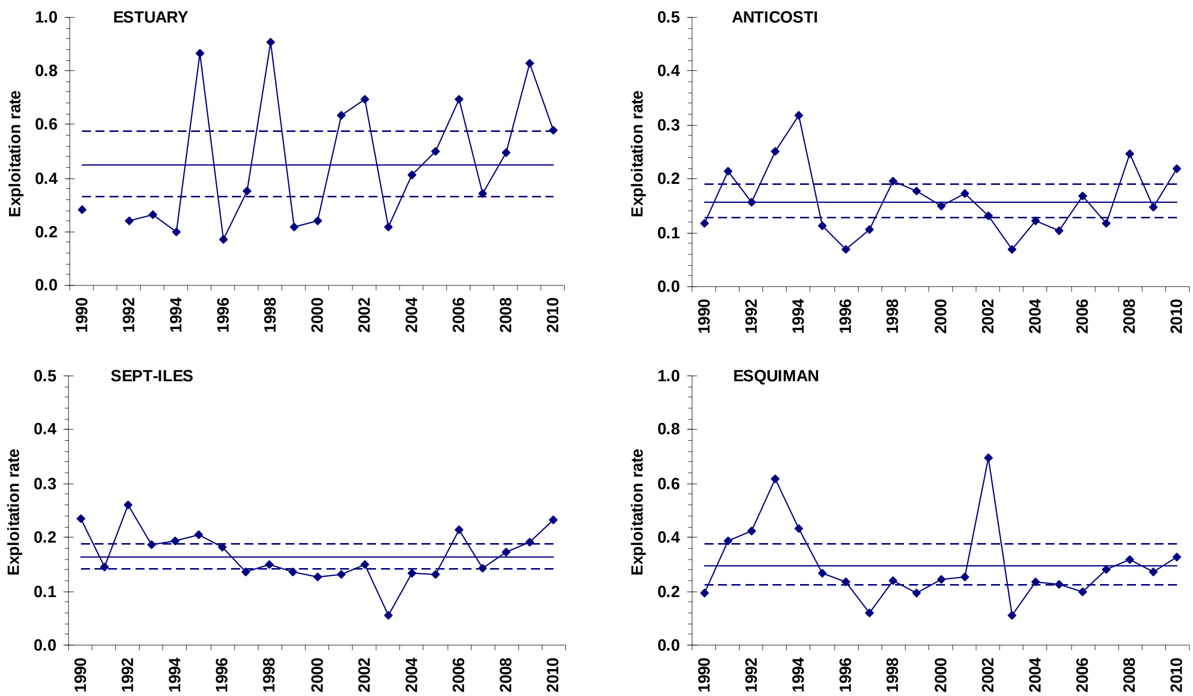


Figure 5. Indices of the exploitation rate by fishing area and by year. The full horizontal line represents the 1990-2009 mean ± 0.5 standard deviation.

The abundance of primiparous females which will recruit to the spawning stock a given year can be predicted from the abundance of males the preceding year. Similarly, the abundance of reproductive females which will hatch the larvae at spring can be predicted from the abundance of females the preceding year. The abundance indices for males and females are therefore good indicators of the quantity of females that will be available to the fishery and the reproduction the following year and constitute, when they are combined, the main indicator for the stock status.

The stock status combined indicator is calculated from the indices for males and for females, obtained from the fishery in summer (number per unit of effort for June, July and August) and from the research survey (abundance). Each index is first standardized relative to the 1990-1999 period (annual value of the index divided by the 1990-1999 geometric mean). An integrated index by sex is obtained by calculating the mean between the index from the fishery and the index from the survey. The stock status combined indicator represents the mean between of the integrated indices estimated for each sex.

In 2010, the stock status combined indicators were all below the value observed in 2007 in Estuary, Sept-Iles and Anticosti and in 2006, in Esquiman (Figure 6). The 2010 indicator was slightly above the mean in all areas except in Estuary where it was similar to the mean.

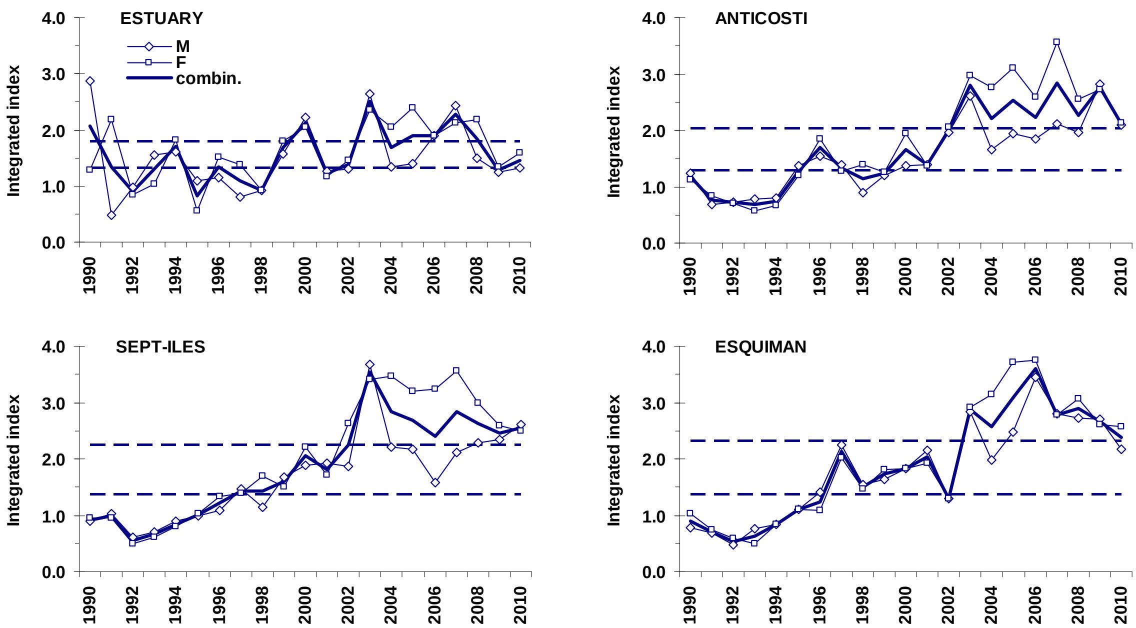


Figure 6. Integrated index for males (M) and females (F) and stock status combined indicator (combin.) by fishing area and by year. The dotted horizontal line represents the interval (± 0.5 standard deviation) around the 1990-2009 mean of the combined indicator.

A national workshop was held in November 2008 on the development of precautionary approach frameworks for Canadian shrimp fisheries. The establishment of limit reference points and upper stock reference points delineating the healthy, cautious and critical stock status zones was discussed at the meeting. Provisional reference points based on female abundance were proposed for the Gulf of St. Lawrence fishery. The reference points were determined from a smoothed standardized mean index of the female abundance. The lowest observed value was used as the limit reference point and the upper stock reference was based on a reference period corresponding to the index appearing to plateau before increasing again.

The mean index for female abundance in 2010 is compared to the provisional reference points to determine in which zone each of the four stocks is situated (Figure 7). In 2010, the index for the abundance of the spawning stock stayed in the healthy zone in Sept-Iles, Anticosti and Esquiman. The index for the Estuary area which decreased in the cautious zone in 2009, increased slightly in 2010 at a value equal to the upper reference point. In general, the female index has bee decreasing gradually in all fishing areas for the last 4 to 5 years.

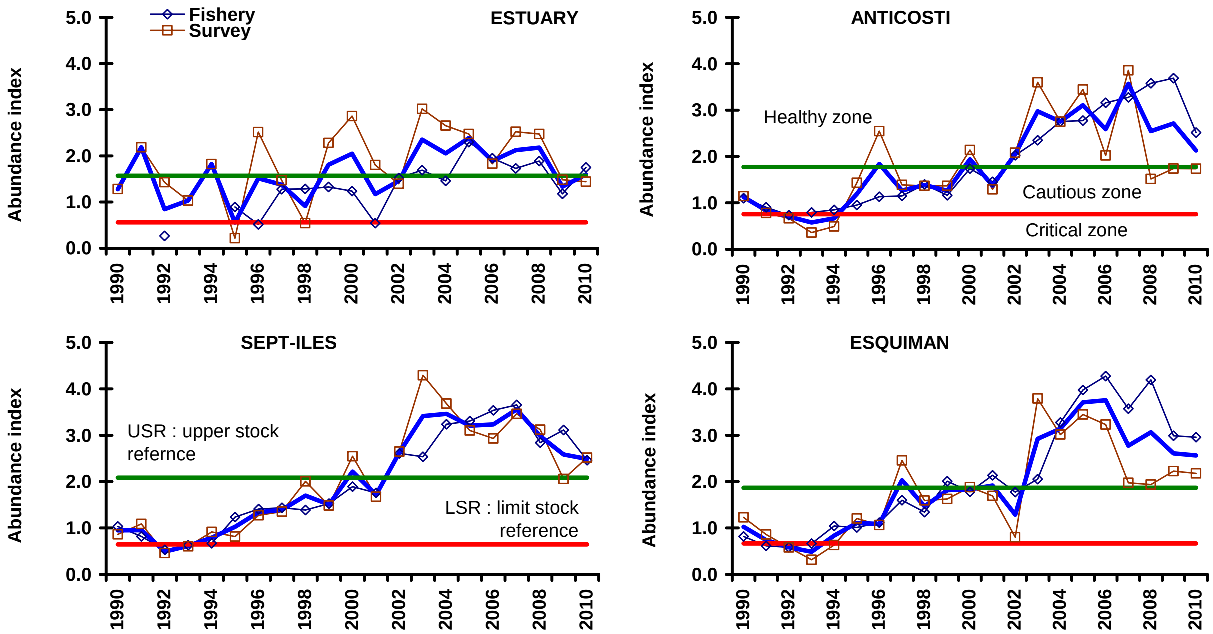


Figure 7. Abundance index for females obtained from the fishery and from the survey and mean integrated index by fishing area and by year. The horizontal lines correspond to the provisional reference points (USR and LSR, see Sept-Iles panel) that delineate the healthy, cautious and critical zones (see Anticosti panel).

The variations in female sizes follow an east-west gradient, the smallest being observed in Esquiman and the largest in Estuary (Figure 8). In 2010, the mean size of females was similar to the mean in Estuary and Esquiman. The size decreased below the mean in Sept-Iles and stayed lower than the mean in Anticosti.

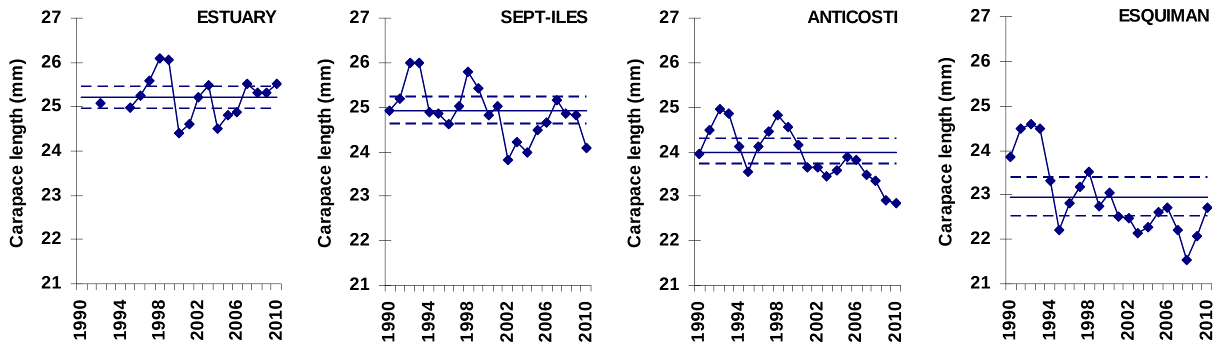


Figure 8. Mean size of females in summer by fishing area and by year. The full horizontal line represents the 1990-2009 mean ± 0.5 standard deviation.

Outlook

The fishery for the next years will be sustained by the 2007, 2008 and 2009 year classes. It is possible to obtain an estimate of their relative abundance by examining their contribution to the research survey catches (Figure 9). The year classes are identified by the year of their birth and their progression through the years can be followed with the arrows. The range of sizes at which males may change sex during the winter following the survey is also identified by a horizontal bracket. The abundances for the Estuary area correspond to those estimated for the area that was exptended in 2008 (see section Sources of uncertainty).

It is not likely that the abundance of shrimp available to the fishery increases in 2011. The 2009 and 2008 year classes seem average to low abundance in all areas. The 2007 year class seems more abundant than the mean particularly in Estuary and Anticosti. The individuals of this year class should contribute to the fishery as 4 years old males in 2011 and should change sex during the 2012 winter. However, it is possible that a fair proportion of males of this year class change sex as early as during the 2011 winter in Anticosti and Esquiman and thus contribute to the 2011 fishery as primiparous females. The individuals who reached in 2010 the sizes where the sex change usually occurs seem of average abundance.

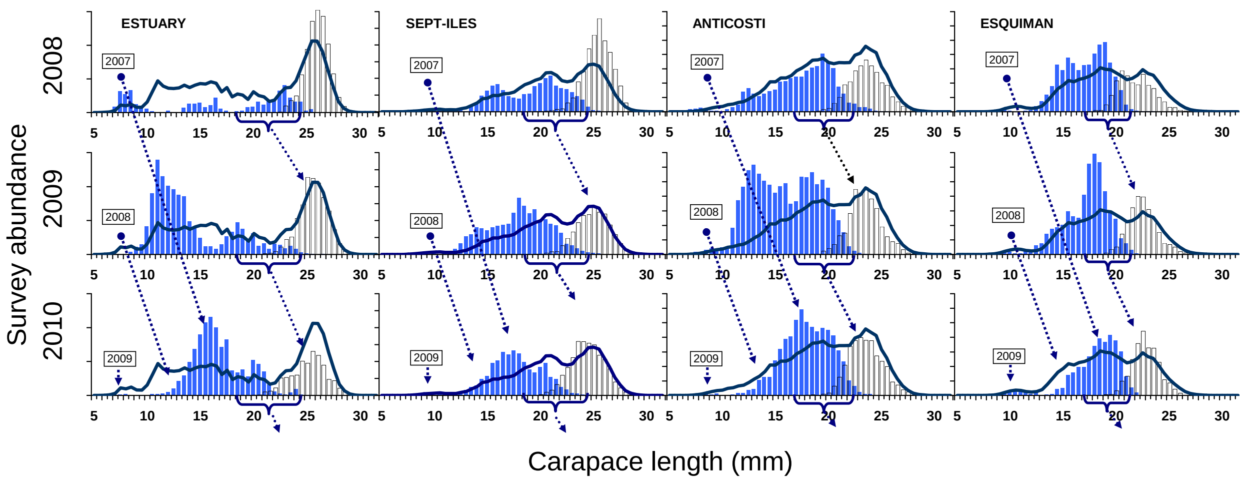


Figure 9. Abundance from the research survey (in number) by length class and by fishing area from 2008 to 2010. The histograms represent males (dark) and females (pale) and the solid line represents the mean of the years 1990-2009 (2008-2010 for the Estuary area).

Sources of Uncertainty

The allocation of supplementary stations in the Estuary shallow waters in 2008, 2009 and 2010 had a very important impact on the catches of males and females of the Estuary fishing area. Indeed, the abundance of males increased by 14 times and that of females, by 4 times with the addition of new strata. The biomass estimates corresponding to the extended area are 4 to 5 times higher than those corresponding to the area that was usually sampled (Figure 10). The exploitation rate index estimated from the extended area abundance is largely lower than the rate that was estimated previously (Figure 10).

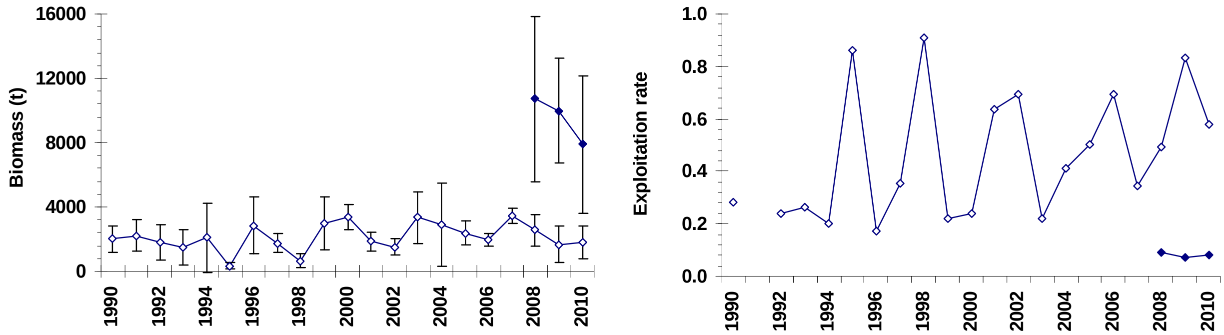


Figure 10. Biomass and exploitation rate index estimated from the research survey covering the usual area (open dots) and the extended area (dark dots).

The results obtained after three surveys realized on the extended area are consistent between years and indicate that the abundance of the Estuary area is largely higher than what was estimated before and that the exploitation rate index is much lower. However, the new series is still too short to be able to identify with certainty, trends in the abundance or the biomass of the stock.

CONCLUSIONS AND ADVICE

<u>Estuary</u>

According to the results of the survey realized since the coverage of the area was extended, it seems that the total abundance of the stock is much higher than what was estimated before and that the exploitation rate is much lower. Moreover, the stock status indices have slightly improved in 2010. Consequently, the status quo is recommended for the 2011 TAC for this area.

<u>Sept-Iles</u>

In 2010, the male and female combined indicator was above the mean (1990-2009) and the female abundance was in the healthy zone. However, the indices have decreased relative to 2007, the female size was lower than the mean and the 2010 catches have generated an increase in the exploitation rate above the mean. The abundance has been decreasing gradually since 2007 and although the stock is still in the healthy zone, it is recommended to decrease the TAC by 10% in order to stop the increase in the exploitation rate observed since 2007 and to help maintaining the stock in the healthy zone.

<u>Anticosti</u>

The male and female combined indicator has fluctuated for some years and was slightly above the mean in 2010 at a value that is however lower than that was observed in 2007. The female abundance has decreased since 2007 but was in the healthy zone in 2010. The female size was lower than the mean and the 2010 catches have generated an increase in the exploitation rate above the mean. The abundance has been decreasing gradually since 2007 and although the stock is still in the healthy zone, it is recommended to decrease the TAC by 10% in order to stop the increase in the exploitation rate and to help maintaining the stock in the healthy zone.

Esquiman

The male and female combined indicator has been decreasing since 2006 and the 2010 value is slightly above the mean. The female abundance has decreased since 2006. The 2010 value is similar to that of 2009 and is situated in the healthy zone. The female size was similar to the mean and the 2010 catches have generated an exploitation rate similar to the mean. However, the exploitation rate has been increasing since 2006. The stock abundance has been decreasing for the last four years and although the stock is still in the healthy zone, it is recommended to decrease the TAC by 10% in order to stop the increase in the exploitation rate and to help maintaining the stock in the healthy zone.

OTHER CONSIDERATIONS

By-catches of small fish in the shrimp fishery between 1999 and 2010 were examined from the at-sea observer database. Fish by-catches were predominantly in the range of 1 kg or less per species and per sampled tow. In 2010, by-catches of the shrimp fishery represented catches of about 77 tons (1.0 million individuals) for turbot, 22 tons (0.6 million individuals) for redfish, 6 tons (0.1 million individuals) for cod and 9 tons (6.0 million individuals) for capelin.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of January 26, 2011 on Assessment of Estuary and Gulf of St. Lawrence Shrimp Stocks. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Bourdages, H., Archambault, D., Bernier, B., Fréchet, A., Gauthier, J., Grégoire, F., Lambert, J. and Savard, L. 2010. Preliminary results from the groundfish and shrimp multidisciplinary survey in August 2010 in the northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/001. vi + 90 p.

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