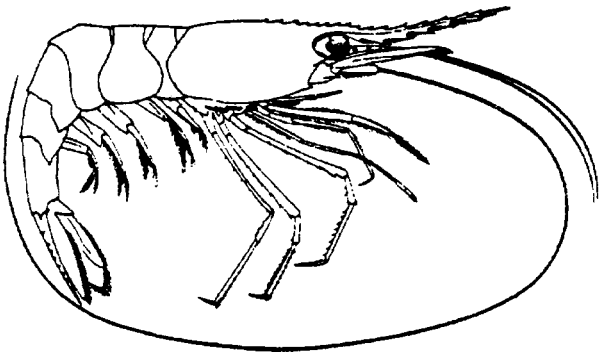

Shrimp of the Estuary and Gulf of St. Lawrence

Background

Shrimp are fished commercially from spring to fall in four management areas. The resource is assessed each year to determine whether changes that have occurred in the stock status necessitate adjustments to the conservation approach and management plan. Landings in 2001 were down 5% from 2000, representing only 84% of the total TAC for the four fishing areas.

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

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

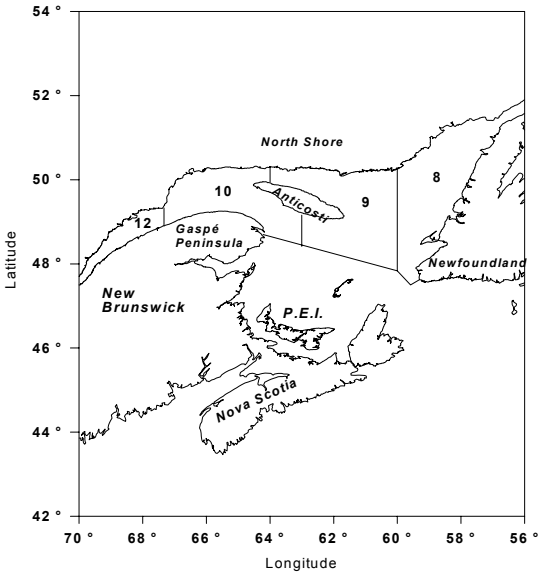

Figure 1. Shrimp fishery management units in the Estuary and Gulf of St. Lawrence (Area 12 - Estuary, Area 10 - Sept-Îles, Area 9 - Anticosti, Area 8 - Esquiman).

Summary

- In general, research survey indices show that the biomass was very high in 2000 and then decreased in 2001 to approach the average observed during the 1990-1999 period. However, the 2001 survey index for Anticosti area is uncertain. The abundance of females decreased in 2001 but is still similar to that observed in 1998 and 1999. It seems that not all individuals of the 1997 year class changed sex in spring 2001 and that a certain proportion remained males.
- Preliminary statistics in 2001 indicate that landings decreased by 5 % relatively to 2000; they represent only 84 % of the total TAC for the four fishing areas. Difficulties experienced by the industry in 2001 were such that the fishing pattern was atypical. Catch rates slightly decreased in 2001 but are still higher

than the 1990-1999 average. Exploitation rate indices increased but are similar to the 1990-1999 average.

- Given the slow growth of the 1997 year class, the small abundance of the 1998 year class and the strong presence of the 1999 year class, it is likely that the mean size of shrimp available to the fishery will remain low in 2002. Consequently, landings at the 2001 TAC level would generate an increase in the number of individuals harvested by the fishery.
- Given the possible increase of catches in number and the decrease of abundance observed on the 2001 survey, landings in 2002 at the 2001 TAC level would result in an increase of exploitation rates that cannot be quantified. In this context, it is recommended that TACs for 2002 not to be increased so that the exploitation rates do not greatly exceed those of the 1990-1999 period.

Description of Fishery

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

Shrimp fishing is controlled by a number of management measures, including TACs (total allowable catches) in the four management areas (Table 1). In 2001 there were 115 permanent shrimp licences, and the license holders have individual quotas.

Table 1. Landings (Ldg) and total allowable catch (TAC) in tons by management unit since 1982. Data for 2001 are preliminary.

Year	ESTUARY		SEPT ILES		ANTICOSTI		ESQUIMAN		GULF	
	Ldg	*TAC*	Ldg	*TAC*	Ldg	*TAC*	Ldg	*TAC*	Ldg	*TAC*
1982	152	*500*	3774	*3800*	2464	*4400*	2111	*4200*	8501	*12900*
1983	158	*500*	3647	*3800*	2925	*5000*	2242	*6000*	8972	*15300*
1984	248	*500*	4383	*4800*	1336	*5000*	1578	*6000*	7545	*16300*
1985	164	*500*	4399	*4600*	2786	*3400*	1421	*6000*	8770	*14500*
1986	262	*500*	4216	*4600*	3340	*3500*	1592	*3500*	9410	*12100*
1987	523	*500*	5411	*5600*	3422	*3500*	2685	*3500*	12041	*13100*
1988	551	*500*	6047	*5600*	2844	*3500*	4335	*3500*	13777	*13100*
1989	629	*500*	6254	*5700*	4253	*4200*	4614	*4500*	15750	*14900*
1990	507	*500*	6839	*6400*	4723	*4200*	3303	*4700*	15372	*15800*
1991	505	*500*	6411	*6400*	4590	*5000*	4773	*4700*	16279	*16600*
1992	489	*500*	4957	*6400*	4162	*5000*	3149	*4700*	12757	*16600*
1993	496	*500*	5485	*6400*	4791	*5000*	4683	*4700*	15455	*16600*
1994	502	*500*	6165	*6400*	4854	*5000*	4689	*4700*	16210	*16600*
1995	486	*500*	6386	*6400*	4962	*5000*	4800	*4700*	16634	*16600*
1996	505	*500*	7014	*7040*	5469	*5500*	5123	*5170*	18111	*18210*
1997	549	*550*	7737	*7744*	6058	*6050*	5957	*5687*	20301	*20031*
1998	634	*633*	8981	*8966*	6932	*7004*	6554	*6584*	23101	*23187*
1999	634	*633*	9058	*8966*	6884	*7004*	6603	*6584*	23179	*23187*
2000	725	*709*	9907	*10042*	7761	*7844*	7153	*7374*	25546	*25969*
2001	809	*786*	10717	*11136*	5300	*8700*	7449	*8178*	24275	*28800*

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 t to 7,500 t between the early and late 1970s, reached nearly 15,000 t by the late 1980s, and over 23,000 t by the late 1990s (Table 1). Preliminary statistics indicate that landings were down in 2001, representing 61% of the TAC in the Anticosti area, 91% in the Esquiman area, 96% in the Sept-Îles area and 103% in the Estuary area. The difficulties encountered by fishers and producers made for an atypical fishing pattern in 2001, since difficult market conditions caused a few fleets to stop fishing during the season. The fishing pattern in 2001 is therefore different, and characterized by a slack summer fishery and more intense operations in the fall.

Conservation Approach

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

In response to increases in abundance indices in the second half of the 1990s, TACs were raised by more than 70% between 1995 and 2001. The short-term outlook for the availability of shrimp to the fishery was excellent, and the TAC increases were justified by a high biomass and a relatively low, stable exploitation rate in all areas. So far, no negative effects of harvesting have been seen in the northern shrimp populations of the Estuary and Gulf.

Resource Assessment

Stock status was determined by examining a number of indicators from the commercial fishery and research surveys. These indicators are based on fishing success, stock abundance and resource productivity. Shrimp abundance dropped between 1992 and 1994, then increased between 1994 and 1997, remaining stable at a very high level until 1999. To assess stock status in 2000 and 2001, we used the mean values for 1990-1999 as a baseline.

Indicators were assessed and given one of three ratings:

- Positive: The value of the indicator differs from the mean, with a positive result for resource status (for example, biomass above mean or mortality below mean).
- Neutral: The value of the indicator is similar to the mean.
- Negative: The value of the indicator differs from the mean, with a negative result for resource status.

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

Table 2. Indicators used to assess resource status by management unit and by year (see the text for the meaning of the symbols).

ESTUARY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
RESEARCH SURVEYS												
Male biomass	+	=	=	=	=	–	=	=	–	+	=	–
Female biomass	=	=	=	=	=	–	+	+	–	+	+	=
Total biomass	=	=	=	=	=	–	=	=	–	+	+	=
COMMERCIAL FISHERY												
Nominal effort	–	=	–	=	=	+	+	=	=	+	=	=
NPUE < 22 mm	No available data					=	–	=	=	+	+	+
NPUE > 22 mm	No available data					–	=	=	+	+	+	=
CPUE	–	–	–	–	=	=	=	=	+	+	+	+
STOCK PRODUCTION												
Recruitment	=	=	=	+	+	=	=	=	=	–	+	–
Predators	–	–	=	=	=	+	+	=	=	=	=	=
Exploitation rate	No available data					–	+	+	–	+	+	–

SEPT ILES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
RESEARCH SURVEYS												
Male biomass	–	=	–	–	=	=	+	+	=	+	+	=
Female biomass	=	=	–	–	=	=	+	+	+	+	+	=
Total biomass	–	=	–	–	=	=	+	+	+	+	+	=
COMMERCIAL FISHERY												
Nominal effort	=	=	–	–	–	+	+	+	+	=	=	=
NPUE < 22 mm	=	–	–	–	=	+	+	=	=	=	+	+
NPUE > 22 mm	=	=	–	–	–	=	=	+	+	+	+	+
CPUE	=	=	–	–	–	=	=	+	+	+	+	+
STOCK PRODUCTION												
Recruitment	=	–	–	=	+	+	=	+	=	–	+	–
Predators	–	–	=	=	=	+	+	=	=	=	=	=
Exploitation rate	–	=	–	=	=	=	+	+	=	+	+	=

Table 2 continued. Indicators used to assess resource status by management unit and by year (see the text for the meaning of the symbols).

ANTICOSTI	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
RESEARCH SURVEYS												
Male biomass	=	=	–	–	–	=	+	+	=	=	=	=
Female biomass	=	–	–	–	–	=	+	+	=	=	+	=
Total biomass	=	=	–	–	–	=	+	+	=	=	+	=
COMMERCIAL FISHERY												
Nominal effort	+	=	=	–	=	+	=	=	=	–	=	+
NPUE < 22 mm	+	=	–	–	+	+	=	=	=	=	+	+
NPUE > 22 mm	=	=	=	–	–	–	=	+	+	=	+	=
CPUE	=	=	–	–	=	=	=	+	+	=	+	+
STOCK PRODUCTION												
Recruitment	=	=	–	–	=	+	+	=	+	–	+	–
Predators	–	–	=	=	=	+	+	=	=	=	=	=
Exploitation rate	=	=	=	–	–	+	+	+	=	=	+	=

ESQUIMAN	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
RESEARCH SURVEYS												
Male biomass	=	=	–	–	–	=	=	+	+	+	=	=
Female biomass	=	=	–	–	–	=	=	+	+	+	+	=
Total biomass	=	=	–	–	–	=	=	+	+	+	=	=
COMMERCIAL FISHERY												
Nominal effort	+	=	=	–	=	–	+	+	=	=	=	=
NPUE < 22 mm	–	–	–	=	=	=	+	+	=	+	+	+
NPUE > 22 mm	–	=	=	–	=	–	=	+	+	+	+	+
CPUE	–	=	–	–	=	=	+	+	+	+	+	+
STOCK PRODUCTION												
Recruitment	=	–	–	–	=	=	=	=	+	=	+	=
Predators	–	–	=	=	=	+	+	=	=	=	=	=
Exploitation rate	+	=	=	–	–	=	+	+	+	+	+	=

Data Used

Research surveys have been conducted in the Estuary and Gulf of St. Lawrence in August-September each year since 1990. The surveys use a stratified random design and are conducted from DFO's *C.S.S. Alfred Needler*, equipped with a shrimp trawl. The data series has been corrected to take into account the fact that shrimp catchability varies between day and night. Biomass indices are then calculated using a geostatistical method (Figure 2). Shrimp abundance (in number) is estimated using survey stations conducted in the daytime only. The mean lengths of females and of the last age-class of males at the time of the survey provide an indication of growth of the cohorts (Figure 3). Operational difficulties encountered during the 2001 survey in the sector north of Anticosti Island limited coverage of the Anticosti area. To make the 2001 index comparable to that of other years, the value

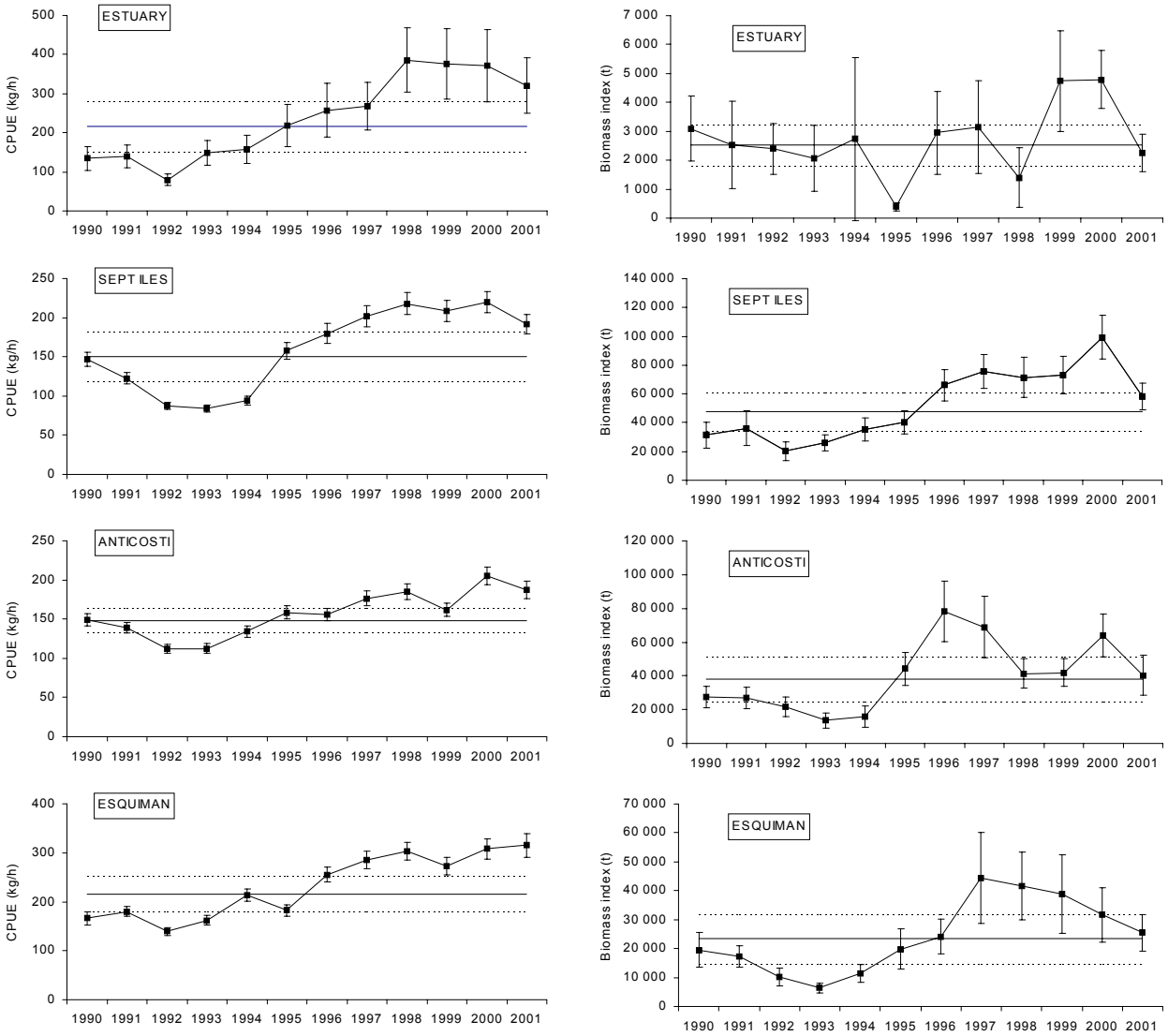

Figure 2. Standardized catch per unit of effort (left panel) and biomass index (right panel) by management unit and by year. The continuous line represents the mean for 1990-1999 and the dashed lines the upper and lower limits of the confidence interval.

of the missing 2001 sector was estimated using its mean contribution to the total biomass of the Gulf from 1996 to 2000.

Commercial fishery statistics (shrimper catch and effort) are used to calculate nominal fishing effort, i.e., total number of hours fished. They are then used to calculate catches per unit of effort (CPUEs) (Figure 2) and numbers per unit of effort (NPUEs), i.e., the mean number of shrimp caught per hour fished. The data are standardized to take into account changes in fishery capacity and seasonal fishing patterns. The mean length of shrimp harvested is also calculated every year (Figure 3).

Certain indicators are used to assess the productive components of a stock. Recruitment to the female component for the next year is estimated by the abundance of males of 19 mm CL in the research surveys. Abundance of the three main predators (cod, redfish, Greenland halibut) is used as an estimate of natural mortality of shrimp, assuming that predator abundance determines the predation pressure on the stocks. An exploitation rate index can be obtained by comparing commercial catches (in number) with the abundance index derived from the research surveys (Figure 4). 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

First half of the 1990s

Most indicators of resource status were negative through the first half of the 1990s because stock productivity was below the mean for that decade (Table 2). The first half of the nineties was characterized by the successive entry into the fishery of several year-classes of average or lower abundance. Those year-classes had been produced in the late 1980s at a time of high predator abundance. Survey indices then decreased (Figure 2) as these year-classes grew and reached the size at which they changed sex. Shrimp concentrations were limited to the deep parts of the Esquiman Channel, Jacques Cartier Strait and the Sept Îles Basin. The component of the shrimp stock recruited to the fishery was below average in abundance and the mean size of males and females decreased (Figure 3). The commercial catch rates, which had gone up in the late 1980s, declined between 1990 and 1992–94 (Figure 2) even though fishing effort increased. Despite the increased effort, TACs were not achieved in 1992 in the three main fishing areas and even in 1993 in the Sept Îles area. The mean size of shrimp harvested by the fishery was rather small (Figure 3), and exploitation rates consequently went up, reaching their highest levels of the 1990s (Figure 4).

Second half of the 1990s

Recruitment to the fishery of several year-classes with higher than average abundance led to an increase in productivity, to the point that most of the resource status indicators were positive (Table 2). Survey indices rose starting in the mid-1990s (Figure 2), and high shrimp concentrations were found not only in the channels, but also on the north and south slopes of the Laurentian Channel, where few shrimp had ever been seen before. Mean size of males and females increased (Figure 3), and mortality through predation apparently declined, given the very low abundance of their chief predators. The commercial catch rates increased (Figure 2) and the component of the shrimp stock recruited to the fishery was above average in abundance. Mean size of the shrimp harvested by the fishery increased (Figure 3), fishing effort decreased and shrimpers directed their effort to more productive sites at the head of the

Esquiman Channel and Jacques Cartier Strait and along the slopes of the Laurentian Channel. TACs were all met, even though they had jumped 40% between 1996 and 1998. Exploitation rate indices varied during the same period, but did not show an overall upward trend (Figure 4). Stock production was high at that time.

2000 and 2001

Productivity was high in 2000, and most resource status indicators continued positive (Table 2). The entry into the fishery of the 1997 year-class kept commercial catch rates high in 2000 (Figure 2). The female component of commercial catches and surveys was still above average, and biomass indices were very high (Figure 2). However the mean size of males was not as great (Figure 3). The fishing pattern did not change, fishing effort did not increase significantly, and the exploitation rate remained relatively low (Figure 4).

In 2001, the resource status indicators are for the most part similar to the mean for the 1990s (Table 2). Biomass indices in 2001 are below those estimated for 2000 and closer to the mean values observed from 1990 to 1999 (Figure 2). The male component in 2001 is characterized by representation of three year-classes of different strength. The 1997 year-class is still present, since many individuals appear not to have changed sex in spring 2001. The 1998 year-class is weakly represented, and the 1999 is very abundant in all areas. The mean size of males is up compared with 2000, but that of females is below the size observed in 1998 (Figure 3). The distribution area remains wide, with high densities seen in all fishing areas of the Gulf. However, operational difficulties during the survey in the sector north of Anticosti Island were such that the estimate for the Anticosti fishing area in 2001 is uncertain.

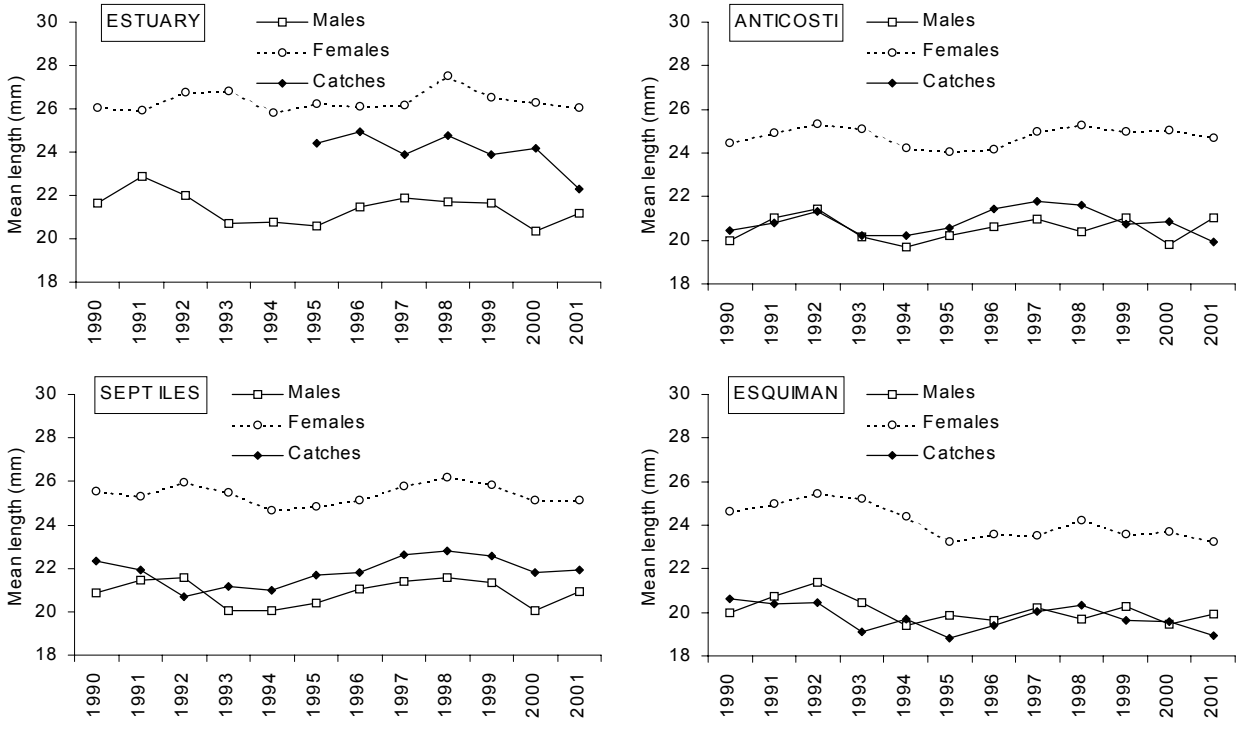

Figure 3. Mean length of cephalothorax of the last year class of males and females at the time of the surveys and of shrimp caught commercially, by management unit and by year.

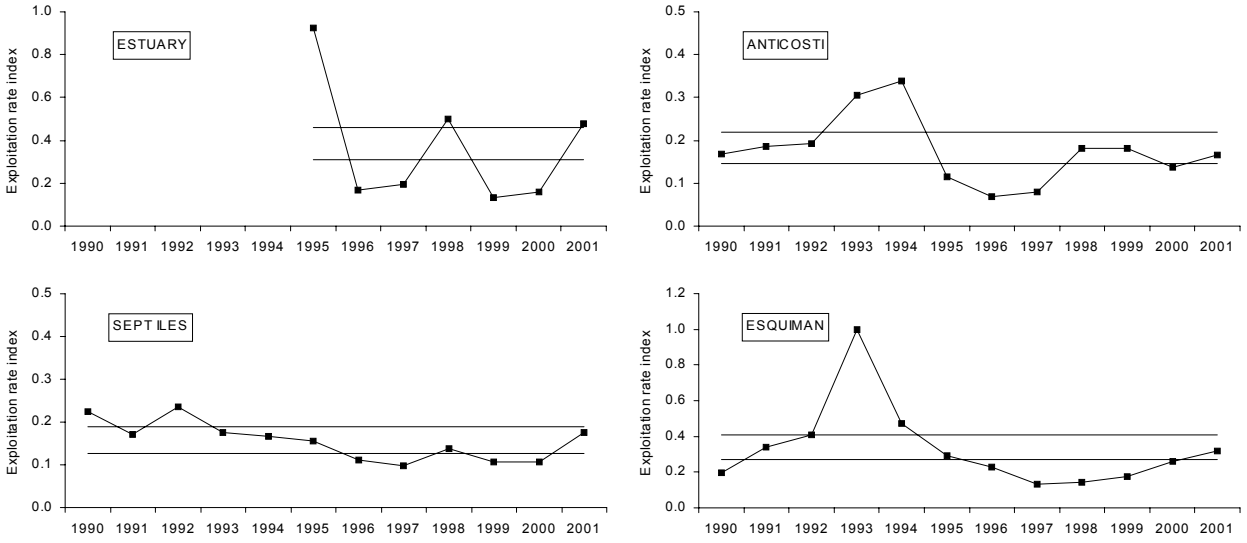

Figure 4. Exploitation rate index by management unit and by year. The continuous lines represent an interval of 20% on either side of the mean for 1990-1999.

The presence of males in the fishing grounds helped to keep catch rates high in 2001, although slightly lower than in 2000 in the Estuary, Sept-Îles and Anticosti areas (Figure 2). However, the mean size of shrimp harvested was lower in 2001 than in 2000 for the Estuary, Anticosti and Esquiman areas (Figure 3). Exploitation rates were up because catches in numbers were up, but abundances as estimated by the survey were down (Figure 4).

The weak representation of the 1998 year-class and the high abundance of the 1999 year-class have also been noted in the new recruitment survey catches in the Estuary and western Gulf. It should be pointed out that the preliminary results of the recruitment survey indicate that the 2000 year-class seems weak.

Outlook

The 2002 fishery will mainly harvest the 1997 and 1998 year-classes. The 1997 year-class, which seemed very abundant in commercial catches and survey catches in 1999 and 2000, has not produced a substantial increase in commercial yields and biomass estimates in 2001. Many individuals remained male in 2001 and should be available to the fishery as females in 2002. However those that changed sex in 2001 have produced females that are small. The 1998 year-class is weak in the survey and commercial catches, and we do not expect a substantial increase in the survey and fishery indices in 2002. Males from the 1999 year-class were strongly represented in fishery and survey catches in 2001. However, these will not change sex, and should not contribute to a significant increase in the size of shrimp harvested in 2002.

Given the poor growth of the 1997 year-class, the weak representation of the 1998 and the strong presence of the 1999, the mean size of shrimp available to the fishery will probably remain below average in 2002, to the point where landings comparable to the 2001 TAC could mean an increase in the number of individuals harvested. This increase in numbers within catches, combined with the decrease in abundance

observed in the 2001 survey, mean that landings comparable to the 2001 TAC would entail an increase in exploitation rates, which, however, cannot be quantified. In that context, it is recommended that TACs in 2002 not to be increased so that exploitation rates do not greatly exceed those for the 1990-1999 period.

The four shrimp stocks were sensitive to the same trends between the early and late 1990s. Nonetheless, local differences have been observed, suggesting that the stock's resilience to exploitation could vary from area to area. The situation is a concern in the Esquiman area, since the survey results for 2001 indicate a decrease in the biomass index for the fourth year in a row. This decrease is, however, less pronounced when one compares abundances in terms of number.

Variation in the size of females follows an east-west gradient, with the smallest ones observed in the Esquiman Channel and the largest in the Estuary. The difference between the maximum size seen in the Estuary area and the minimum size observed in the Esquiman area represents a difference of 20% in egg production per female. For the same spawning biomass, the egg production of the stock will thus theoretically be lower in the east. Preliminary results of a research project on egg production indicate that fecundity may vary in different management units and different years. This biological characteristic may thus have a significant impact on the stock's capacity to withstand changes caused by fishing or predation.

The processes of shrimp recruitment and mechanisms responsible for shrimp growth and production are still not fully known. We do not know how resilient stocks might be under heavy fishing pressure in changing biological and environmental conditions. However, a research program at the Maurice Lamontagne Institute is investigating shrimp growth, survival and production at various stages in the life cycle and in different environmental and fishing conditions. This program is funded jointly by the Group B shrimp fishers' associations and the Department of Fisheries and Oceans.

For more information:

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

Correct citation for this publication:

DFO, 2002. Shrimp of the Estuary and Gulf of St. Lawrence DFO Science Stock Status Report C4-06 (2002).

This report is available from the:

Regional Stock Assessment Office,
Department of Fisheries and Oceans,
Maurice Lamontagne Institute,
P.O. Box. 1000, Mont-Joli,
Quebec, Canada
G5H 3Z4

Email: Stocksrl@dfo-mpo.gc.ca

ISSN 1480-4913

La version française est disponible à l'adresse ci-dessus.

Pêches et Océans Canada
Sciences

Fisheries and Oceans Canada
Science