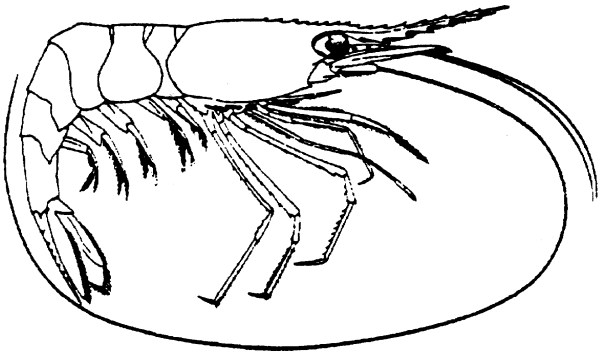

Shrimp of the Estuary and Gulf of St. Lawrence

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 2000 were the highest ever recorded and TACs were reached in all areas.

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 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.

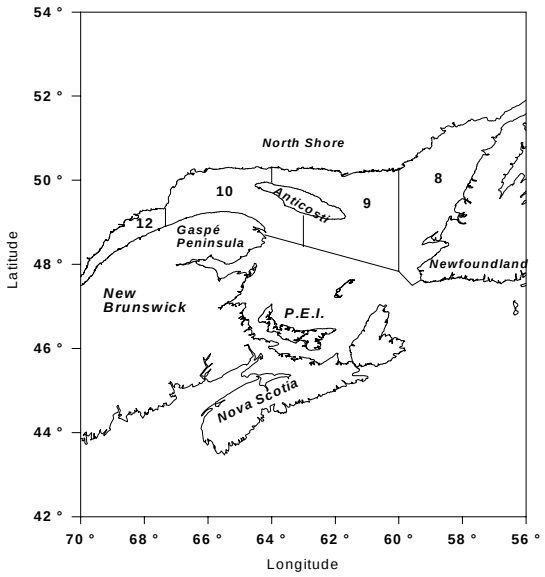

Figure 1. Shrimp fishery management units in the Estuary and Gulf of St. Lawrence (Area 10 - Sept Îles, Area 9 - Anticosti, Area 8 – Esquiman, Area 12 - Estuary).

Summary

- In general, the commercial fishery indices and research surveys show that the abundance of shrimp stocks remained at a high level in 2000. Female abundance was found to be high and recruitment in 2001 (1997 year-class) will be particularly strong. By contrast, the 1998 year-class appears to be weak.
- In the Sept-Îles and Anticosti areas, the biomass index in 2000 was well above the average level, whereas in the Esquiman area it was close to average. The exploitation rate index was lower than average in the Sept-Îles area and close to average in the Anticosti and Esquiman areas.

- The growth of the 1997 year-class appears to be lower than average, a situation which could affect the size of the females available to the fishery and available for reproduction in 2001. The abundance of the main predators of shrimp (cod, redfish) is still low, but Greenland halibut (turbot), another major predator, has increased in abundance.
- In 2001, landings similar to those recorded in 2000 should generate exploitation rates within the range of values observed since 1995. Although the resource could likely withstand higher exploitation rates in some areas, it is not feasible to set a target rate at present.

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 2000, there were 117 permanent shrimp licences and license holders have individual quotas. In addition, since 1997, temporary allocations have been granted to fishers without

Table 1. Landings (Ldg) and total allowable catches (TAC) in tons by management unit since 1982. Data for 2000 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*	7031	*7040*	5469	*5500*	5123	*5170*	18128	*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*	9028	*8966*	6891	*7004*	6647	*6584*	23200	*23187*
2000	725	*709*	9996	*10042*	7777	*7844*	6924	*7374*	25422	*25969*

permanent shrimp 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 gradually increased since the fishery began. Landings rose from approximately 1 000 t to 7 500 t between the early and late 1970s, reaching over 15 000 t by the late 1980s (Table 1). In 1992, landings dropped 22 % from 1991 levels, but since then have steadily increased, totalling more than 25 000 t in 2000. The TACs have been taken in all shrimp fishing areas since 1995.

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 recent increases in abundance indices, the TAC was raised by 10 % in 1996 in three of the four areas (Sept Îles, Anticosti and Esquiman), then by 10 % in 1997 and by 15.8 % in 1998 in all four management areas. The short-term outlook for the availability of shrimp to the fishery was excellent in 1995, 1996 and 1997. The TAC was left unchanged in 1999, then raised again by 12 % in 2000. This last increase was based on a high biomass and a relatively low, stable exploitation rate in all areas. So far, no negative effects of harvesting northern shrimp have been seen in the 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 refer to factors that can affect fishing success, stock abundance or resource productivity. Shrimp abundance was high in 1990 and 1991, dropped between 1992 and 1994, then increased between 1994 and 1997, remaining stable at a very high level from that point on. To assess stock status in 2000, we used the mean values for 1990–99 as a reference.

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 or fixed intervals around the mean. Results of the assessment of the indicators are given for each stock and each year since 1990 (Table 2).

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. This year, the data series has been corrected to take into account the fact that shrimp catchability varies between day and night. Values differ slightly from those presented in the past but general tendencies stay unchanged. Density and biomass indices are then calculated using a geostatistical method. Geostatistics allows the incorporation of information from all neighbouring stations, not just those in the same stratum, even though they may be hundreds of kilometres apart. The geostatistical method could not be applied to estimate abundance figures, however, which were estimated from the stratified mean.

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) 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.

Some indicators are used to assess the components of production of a stock. Recruitment is estimated by male abundance in the commercial catch and research surveys. Growth is estimated from the size at which 50 % of shrimp are female. Year-classes with weaker growth change sex at a smaller size.

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 intensity of predation 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. 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

The first half of the 1990s 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. Indices from surveys then decreased (Figure 2) as the year-classes grew and reached the size at which they changed sex. Shrimp concentrations were limited to the deep parts of the Equiman Channel, Jacques Cartier Strait and the Sept Îles Basin. Growth of the last year-classes in the series also decreased, so that total stock production was low. The component of the shrimp stock recruited to the fishery was below average in abundance (Figure 3).

Table 2. Indicators used to assess resource status, by management unit and by year (+ : different from the 1990-1999 mean with a positive result for resource status; = : similar to the mean; - : different from the mean with a negative result for resource status).

ESTUARY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESEARCH SURVEYS											
Male density	+	=	=	=	=	-	=	=	-	=	=
Female density	=	=	=	=	=	-	=	=	=	+	+
Total biomass	=	=	=	=	=	-	=	=	=	+	+
COMMERCIAL FISHERY											
Nominal effort	-	=	-	=	=	+	+	=	+	+	=
Male NPUE						=	-	=	=	+	=
Female NPUE						-	=	=	+	=	=
CPUE	-	-	-	-	-	=	+	+	+	+	+
COMPONENTS OF STOCK PRODUCTION											
Recruitment						=	=	=	=	=	=
Growth	=	-	+	=	-	-	=	=	+	=	-
Predation	-	-	=	+	+	+	+	+	+	+	=
Exploitation						-	+	+	-	+	+

SEPT ÎLES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESEARCH SURVEYS											
Male density	-	=	-	-	=	=	+	+	=	+	+
Female density	-	-	-	-	-	-	+	+	+	+	+
Total biomass	-	=	-	-	-	=	+	+	+	+	+
COMMERCIAL FISHERY											
Nominal effort	=	=	-	-	-	+	+	+	+	=	=
Male NPUE	=	-	-	-	=	+	+	+	=	=	+
Female NPUE	=	=	-	-	-	=	=	+	+	+	+
CPUE	=	-	-	-	-	=	+	+	+	+	+
COMPONENTS OF STOCK PRODUCTION											
Recruitment	=	=	-	-	=	=	+	+	=	=	+
Growth	=	=	+	-	-	=	=	+	+	+	-
Predation	-	-	=	+	+	+	+	+	+	+	=
Exploitation	=	=	-	-	+	=	=	=	+	=	+

Table 2, continued. Indicators used to assess resource status, by management unit and by year (+ : different from the 1990-1999 mean with a positive result for resource status; = : similar to the mean; - : different from the mean with a negative result for resource status).

ANTICOSTI	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESEARCH SURVEYS											
Male density	=	=	-	-	-	=	+	+	=	=	=
Female density	-	-	-	-	-	=	+	+	=	=	+
Total biomass	-	-	-	-	-	=	+	+	=	=	+
COMMERCIAL FISHERY											
Nominal effort	+	=	=	-	=	+	=	=	=	-	=
Male NPUE	=	=	-	-	+	+	=	=	=	+	+
Female NPUE	+	=	-	-	-	-	+	+	+	=	+
CPUE	=	-	-	-	-	+	=	+	+	+	+
COMPONENTS OF STOCK PRODUCTION											
Recruitment	=	=	-	-	=	=	=	=	=	=	=
Growth	=	=	+	-	-	-	=	=	+	=	-
Predation	-	-	=	+	+	+	+	+	+	+	=
Exploitation	=	-	=	-	-	+	+	+	=	+	+

ESQUIMAN	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESEARCH SURVEYS											
Male density	-	-	-	-	-	=	=	+	+	+	=
Female density	=	-	-	-	-	=	=	+	+	=	=
Total biomass	=	-	-	-	-	=	=	+	+	+	=
COMMERCIAL FISHERY											
Nominal effort	+	=	=	-	=	-	+	=	=	=	+
Male NPUE	-	-	-	=	=	=	+	=	=	+	+
Female NPUE	-	-	-	-	=	=	=	+	+	+	+
CPUE	-	-	-	-	=	-	+	+	+	+	+
COMPONENTS OF STOCK PRODUCTION											
Recruitment	-	-	-	=	=	=	=	=	=	+	=
Growth	=	+	+	+	-	-	=	=	=	-	-
Predation	-	-	=	+	+	+	+	+	+	+	=
Exploitation	+	+	=	-	-	=	=	+	=	+	=

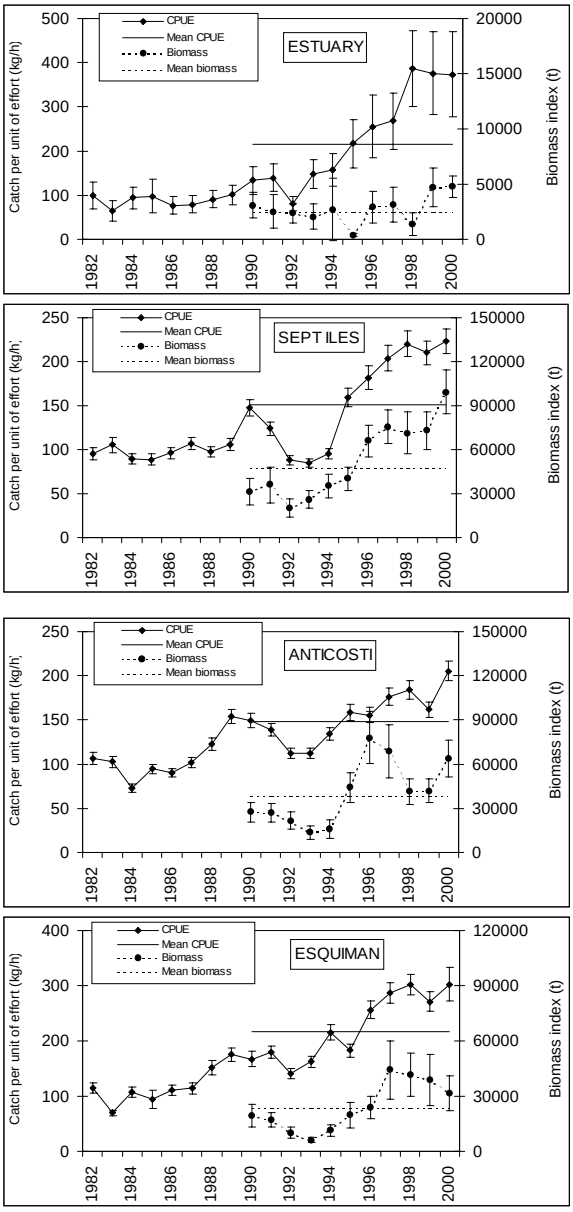

Figure 2. Standardised catch per unit of effort and biomass index by management unit and by year.

The commercial catch rates, which had gone up in the late 1980s, declined between 1990 and 1992–94 (Figure 2) although 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. Exploitation rates consequently went up, reaching their highest levels of the 1990s (Figure 4).

Recruitment to the fishery of several year-classes with higher than average abundance led to an increase in survey indices starting in the mid-1990s (Figure 2). 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. The growth of the shrimp increased and mortality through predation apparently declined, given the very low abundance of their main predators. The commercial catch rates increased (Figure 2) and the component of the shrimp stock recruited to the fishery was above average in abundance (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 increased by 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.

The 2000 fishing season followed a pattern similar to that of recent years. The entry into the fishery of the 1997 year-class kept commercial catch rates high, but contributed to a decline in the mean size of shrimp taken. The female component of commercial catches was still above average. The fishing pattern has not changed and fishing effort has not increased significantly. TACs, which were raised 12 % in 2000, were all reached and exploitation rate indices were similar to or below the 1990–1999 mean.

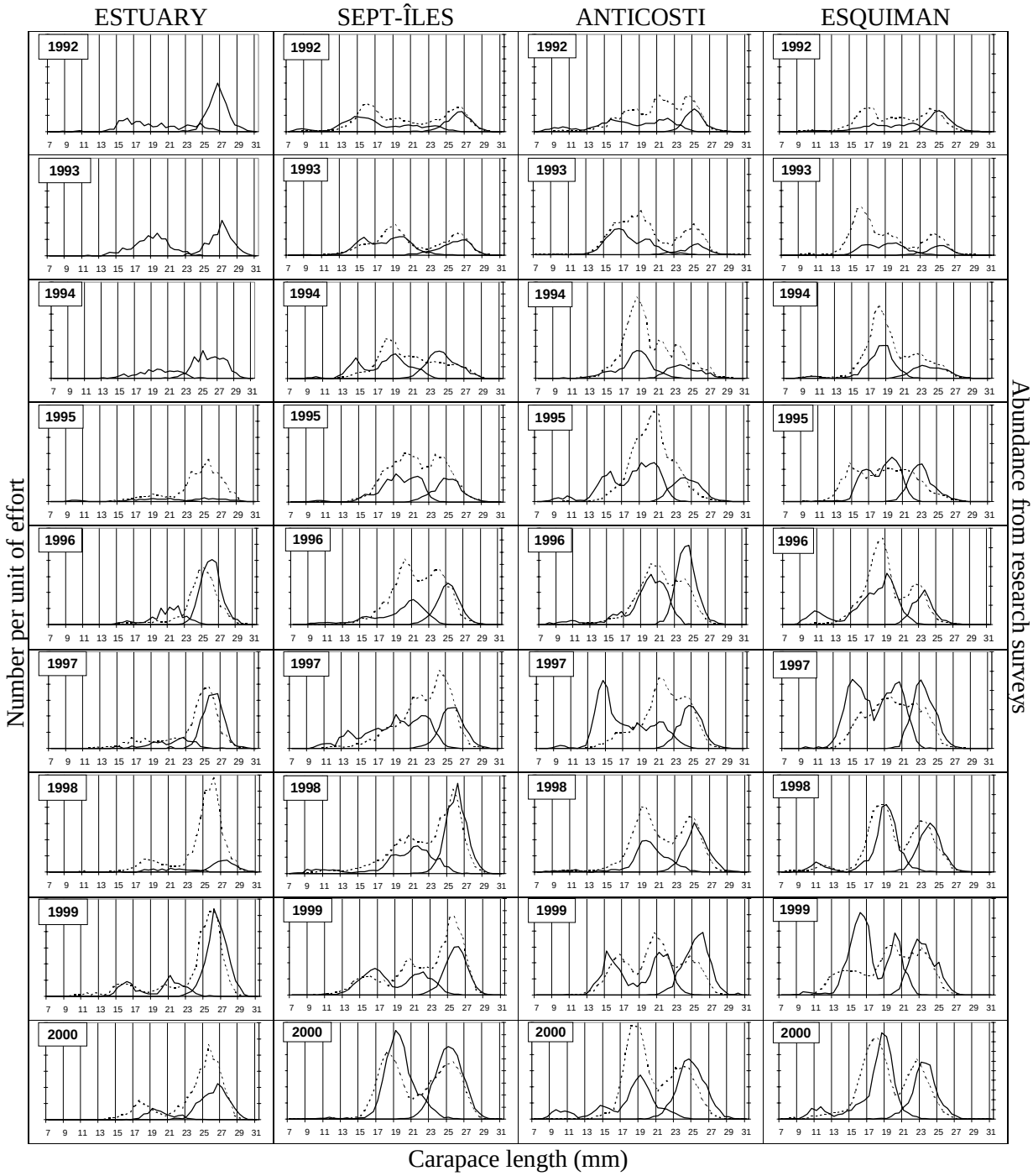

Figure 3. Number per unit of effort from the commercial fishery (dash line) and abundance from the research surveys (continuous line) by carapace length class by management unit from 1992 to 2000.

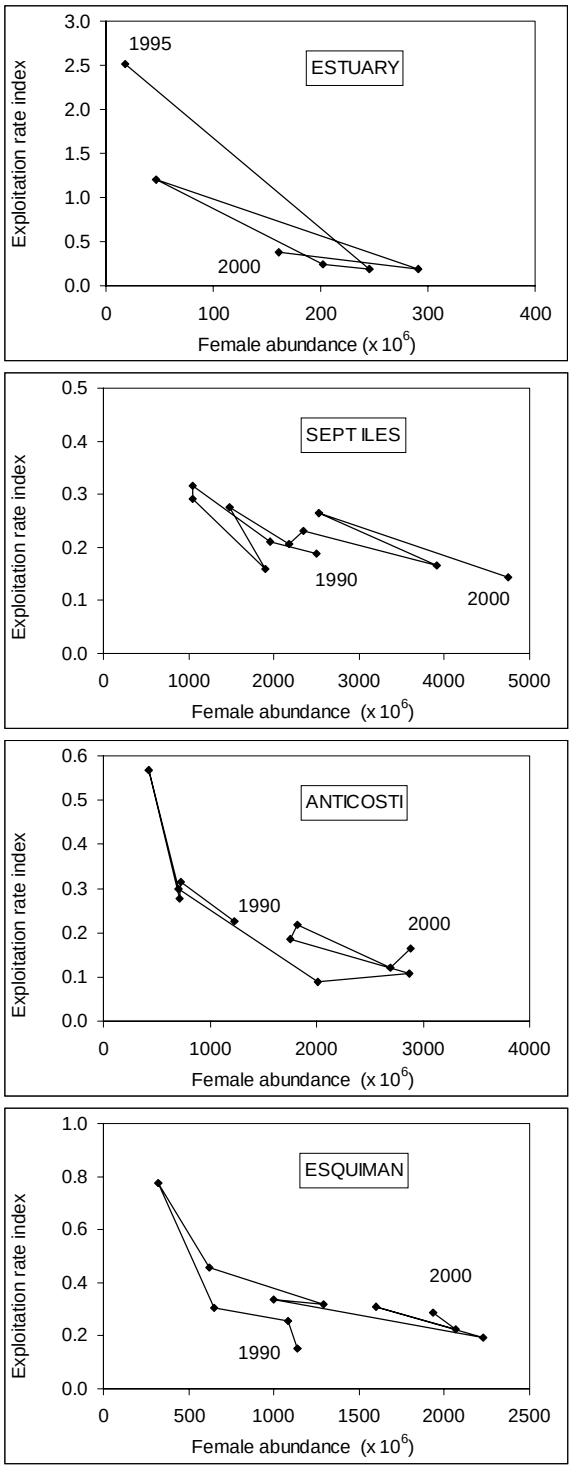

Figure 4. Exploitation rate index against female abundance by management unit and by year.

Female density indices in 2000 were similar to or above those estimated for 1999 and above the mean for 1990 to 1999. Indices for males in 2000 were similar to those of 1999 and characterized by the strong representation of the 1997 year-class and the very weak representation of the 1998 year-class. The distribution area remains wide, with high densities seen in all parts of the Gulf. The growth of the 1997 year-class declined, however, with the individuals smaller at three years of age than those of the two preceding year-classes. The high abundance of the 1997 year-class and low representation of the 1998 year-class have also been seen in 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 1999 year-class seems to be just as abundant as that of 1997 at the same age.

Outlook

In the next few years, the fishery will harvest the 1997, 1998 and 1999 year-classes. The recruitment indices show that the 1997 and 1999 year-classes appear to be abundant, while that of 1998 seems to be weak. The situation is similar to that in the late 1990s, when alternating strong and weak year-classes were recruited to the fishery. Therefore, there is no concern in the short term about shrimp stock abundance.

The production of the 1997, 1998 and 1999 year-classes may vary over the next few years, depending on their growth and survival. Growth of the 1997 year-class is weaker than average and this may have a negative impact on the size of females available to the fishery and for spawning in 2001. Egg production per female may decrease, as fecundity depends on size; smaller females produce fewer eggs. The abundance of Greenland halibut, one of shrimp's main predators, also seems to have

increased, which may lead to an increase in mortality through predation.

In 2001, landings similar to those of 2000 should generate exploitation rates within the values observed since 1995, when stock production was high. It is also probable that the resource could support a higher exploitation rate in some areas, but it is not possible at present to determine what that target rate would be.

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. 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 could induce 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. This biological characteristic may have a significant impact on the stock's capacity to withstand changes caused by fishing or predation.

The process 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 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 financed by group B shrimp fishermen 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

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P.O. Box. 1000, Mont-Joli,
Quebec, Canada
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Email: Stocksrl@dfo-mpo.gc.ca

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