

Shrimp of the Estuary and the Gulf of St. Lawrence

Background

The shrimp fishery in the Gulf of St. Lawrence began in 1965. Shrimp are exploited from spring to fall in four management units by three provincial fleets. Stock assessments are carried out each year in order to determine whether significant changes have occurred in the status of the stock that would warrant adjustments in the conservation strategy and management plan. TACs were increased by 20.7% over the last two years, representing an increase of 3 431 tons since 1995. In 1997, shrimp landings were even higher than the record landings of 1996, and TACs were once more reached in all fishing areas.

The abundance of shrimp in the Gulf and Estuary has fluctuated since the end of the 1980s. The latest stock assessment, though, indicates that the status of the shrimp population was good at the end of the 1997 fishing season. Fluctuations in abundance may be explained by the strength of the year-classes supporting the fishery. Thus, high abundance indices in 1994, 1995, 1996 and 1997 are due to the increasing contribution of the year-classes produced at the beginning of the 1990s. The 19 to 21 mm size-class, composed mainly of shrimp hatched in 1994, is expected to reach the size that is fully retained in trawls in 1998. Together with the strong 1993 year-class, it should maintain catch rates at a high level in 1998.

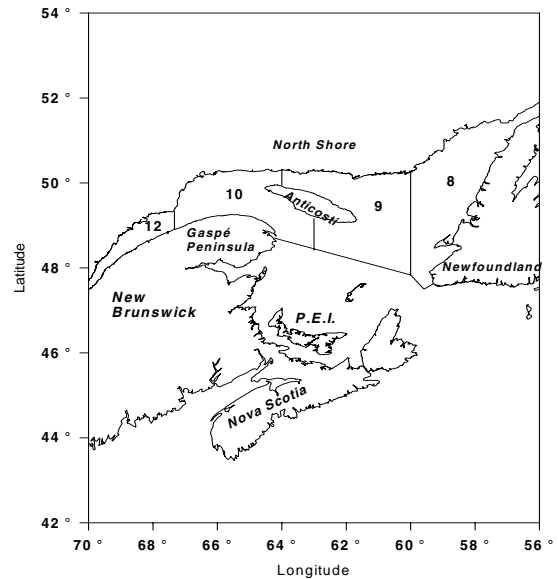


Figure 1 The management units for the shrimp fishery of the St. Lawrence Estuary and Gulf: Sept-Îles (Area 10), Anticosti (Area 9), Esquiman (Area 8) and Estuary (area 12).

Biological characteristics

Peculiarities in the biology of the northern shrimp (*Pandalus borealis*) have had a direct impact on the type of fishing that has developed in the Gulf since the 1960s. Fishers have learned to take these peculiarities into account in order to optimize their performance and minimize their operating costs. Shrimp are found throughout the northern Gulf at depths varying from 150 to more than 300 m (80 to 160 fathoms); concentrations are found where the water temperature remains between 4 and 6°C.

Life cycle

Commercial shrimp catches are made up of variable proportions of males and females. Females caught at the beginning and at the end of the fishing season bear eggs under

their abdomen. This is because shrimp reproduce in fall, and the females carry their eggs under their abdomen all winter, from September to May. The eggs hatch and the larvae are released in spring, from April to mid-May. The larvae are pelagic and settle on the bottom in late summer, three or four months later. Their form and behaviour are then adult. All shrimp hatch as males. They reach maturity around two and a half years old. At about four years old, they change sex becoming females, which live another two years producing eggs. Egg-bearing shrimp are therefore the largest in commercial catches; male shrimp are smaller than female shrimp because they are younger.

Migration and distribution

Shrimp follow migratory patterns that are well known to commercial fishers. Each year, they carry out migration related to their reproduction. In late fall and early winter, the egg-bearing females begin to migrate to shallower areas (150 to 180 meters) in their distribution range. In spring, they gather at sites suitable for releasing the larvae. Fishers take full advantage of this spring gathering of egg-bearing females to obtain high yields. Once the larvae have been released, the females molt and then disperse to deeper areas (220 to 275 meters).

Shrimp also migrate vertically. They leave the bottom at night to rise in the water column, probably to feed on plankton, then return to the bottom during the day. The scale of vertical migrations may vary depending on the stage of development of the shrimp and local conditions. For example, small male shrimp appear to leave the bottom earlier and rise higher in the water column than do female shrimp. Fishers usually fish only during the day, when shrimp are concentrated in the first few meters above the seabed. Yields are lower at night.

In general, shrimp are distributed differently throughout the area according to their age and size. Young male shrimp are found in shallower areas (175 to 225 meters), often at the heads of channels, while older shrimp, the females, are often found in deeper areas.

Description of the fishery

The development of the fishery has varied with the sector and the fishing fleet. The Quebec fleet harvests mainly the western Gulf, while the Newfoundland fleet concentrates its operations in the Esquiman channel. The New Brunswick fleet divides its operations between the eastern and western Gulf. To more accurately reflect the fishing pattern and the geographic distribution of shrimp, a reorganization of the management units was proposed in 1992. The five management units in place since the beginning of the 1980s were reduced to four in 1993: Sept-Îles (Area 10) which now includes the previous South Anticosti unit, Anticosti (Area 9) previously named North Anticosti, Esquiman (Area 8), and Estuary (Area 12) (Figure 1).

Management of the shrimp fishery of the northern Gulf consists of a range of measures, including control of catches by means of Total Allowable Catches (TACs) for the four management units. Quebec and New Brunswick license holders have had individual quotas since 1991, and those from the Lower North Shore and the west coast of Newfoundland only since 1996. The number of licenses in 1997 in the Gulf was 118. Other management measures include the setting of a minimum mesh size (40 mm) and, since 1993, the requirement to use the Nordmore grate to reduce the groundfish by-catch significantly.

Conservation approach

TAC management is a way of limiting exploitation of shrimp and protecting the reproductive potential of the population. Landings are limited so that a certain proportion of the shrimp are not fished and remain in the population for reproduction. The aim is to maintain a sufficient reproductive biomass to ensure recruitment. The TAC can be adjusted in accordance to the stock status. However, the analytical tools necessary for calculating increases and decreases in TAC in response to changes in stock status are unavailable for shrimp. Changes in TAC are thus made on an empirical or experimental basis.

The increase in the TACs of the Sept-Îles management unit in the 1980s was intended as a cautious attempt at experimental management. In gradually increasing the TACs, the intention was to raise the exploitation rate so as to assess the impact on the resource and ultimately to determine the optimal exploitation rate. The TACs of three management units (Sept-Îles, Anticosti, Esquiman) was then increased at the beginning of the 1990s in response to increases in abundance that came about during the second half of the 1980s (Figure 2, Annex 1). The TAC remained unchanged until 1995 even though the abundance of shrimp fluctuated between 1990 and 1995. In response to recent increases in abundance indices, TAC was increased by 10% in 1996 in three of the four units (Sept-Îles, Anticosti, Esquiman) and another 10% in 1997 in all four units. The short-term prospects regarding shrimp availability were excellent for 1996 and 1997. The TAC of the Estuary management unit has not been increased since 1982 because of uncertainty in the assessment of the stock in that fishing area. No negative effect has ever been detected of exploitation

on the populations of shrimp in the Estuary and Gulf.

Commercial Catches

Landings of northern shrimp in the St. Lawrence Estuary and Gulf of have grown steadily since the shrimp fishery began in the mid-1960s. They increased from approximately 1 000 t to 7 500 t during the 1970s and reaching over 15 000 t in the late 1980s (Figure 2, Annex 1). Landings decreased by 22% between 1991 and 1992, but increased progressively thereafter. Landings in 1997 were 10% higher than 1996 and therefore represent a new summit. Each fishing area has attained its TAC since 1994.

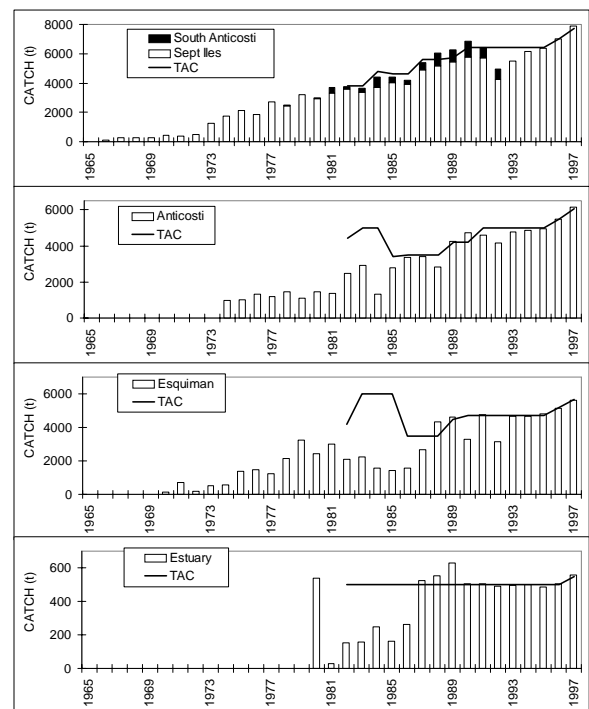


Figure 2 Landings and Total Allowable Catch (TAC) for northern shrimp in the management units of the St. Lawrence Estuary and Gulf since 1982.

Fishing effort

The geographic distribution of fishing effort of shrimpers has changed since 1990. In

1990, 1991 and 1992, the fishing effort was concentrated at the heads of the channels in the Anticosti and Esquiman Channel areas and off the northwest side of Anticosti Island in Sept-Îles area. In 1993, fishers began to exploit more southern locations while decreasing the effort in northern locations (at the heads of the channels). In 1994 and 1995, most of the effort was concentrated off the Gaspé Peninsula, off southeast coast of Anticosti Island, and in the Laurentian Channel in the Sept-Îles and Anticosti areas. The pattern was similar in 1997 except for a slight decrease in effort on the southern part of the Laurentian Channel and a slight increase north-west of Anticosti Island. (Figure 3). These changes in the geographic fishing pattern are probably due to two factors. Firstly, the constraints or borders which restrained the spread of the effort to more southern locations were eliminated in 1993 when the management units were reorganized. Secondly, shrimp

concentrations have increased in southern locations, in the Laurentian Channel in particular, where they have been less abundant before. It must be noted that the data used to determine the distribution of effort in the Esquiman unit is still incomplete for 1997.

Stock assessment

Catch rate

Commercial fishery statistics (shrimper catch and effort data) are used to calculate annual catch rates or catch per unit of effort (CPUE) i.e. the quantity of shrimp caught in one hour of fishing. The data are standardized to account for the evolution of fishing fleets (changes in fishing power brought about by changes in fishing boats and renewal of the fleets) and the seasonal fishing pattern; statistics from the three fleets have been included in the analyses

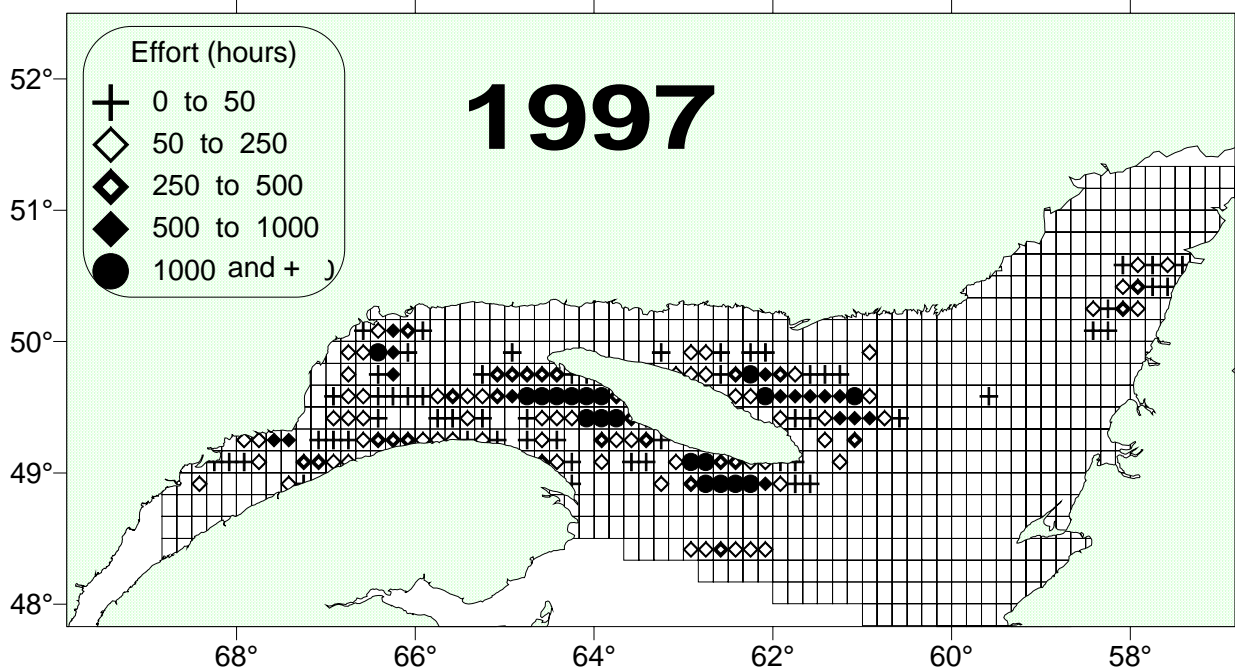


Figure 3. Geographic distribution of fishing effort in the shrimp fishery of the St. Lawrence Estuary and Gulf in 1997.

since 1982. The statistics from years prior to the reorganization of the management units in 1993 were reanalyzed to correspond with the present management units. The Newfoundland fleet fishing statistics for 1997, and to a lesser extent those of New

Brunswick, were only partial at the time the compilations were made.

CPUEs for Anticosti and Esquiman Channel areas increased from the middle of the 1980s to the beginning of 1990s (Figure 4). CPUE increased later in the Sept-Îles and Estuary areas; they were relatively stable up to 1989, then increased in 1990 and 1991. CPUE in all four areas decreased in 1992. The catch per unit of effort of Sept-Îles was relatively stable in 1992, 1993 and 1994 then increased from 1995 to 1997. CPUE in the Estuary increased from 1992 to 1996, then stabilized in 1997. Anticosti and Esquiman Channel CPUEs remained at a low level in 1992 and 1993, then rose in 1994. It increased again in 1995, remained stable in 1996 then rose again in 1997 in the Anticosti area. In the Esquiman Channel, CPUE decreased in 1995 and increased in 1996 and 1997. Here again, it must be noted that for the Esquiman Channel the values for 1997 are calculated from very partial data, less than 10% of the landings.

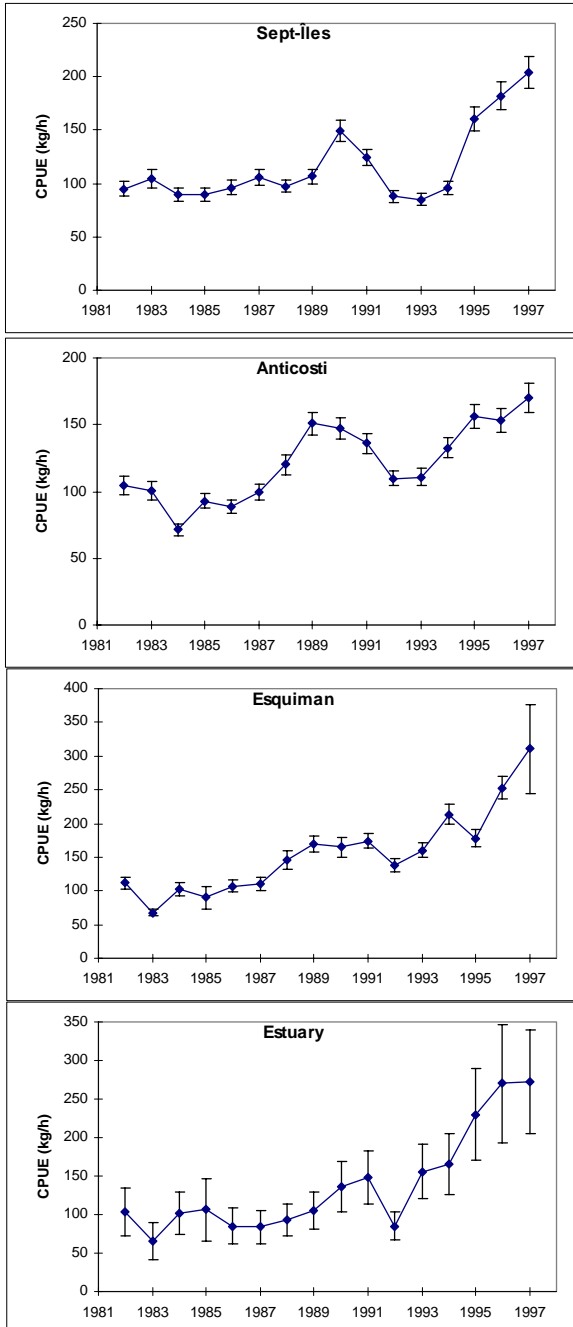


Figure 4. Standardized catch per unit effort (CPUE) for commercial shrimpers in the four management units of the St. Lawrence Estuary and Gulf since 1982.

Research surveys

Since 1990, research surveys have been conducted in the St. Lawrence Estuary and Gulf in August-September of each year. They are carried out on a DFO vessel, *the C.S.S. Alfred Needler*, using a shrimp trawl and following a stratified random sampling scheme. The survey index indicates relative abundance since the trawl does not capture all shrimp in the water column as it passes over the bottom. Total biomass cannot therefore be estimated from surveys. However, since the shrimp survey is carried out uniformly from one year to the next and it covers the whole area of distribution of the stock in the Gulf, the survey index can be considered fairly accurate indication of the variations in the abundance of shrimp in the Gulf.

The survey results clearly show changes in the geographic distribution of shrimp since

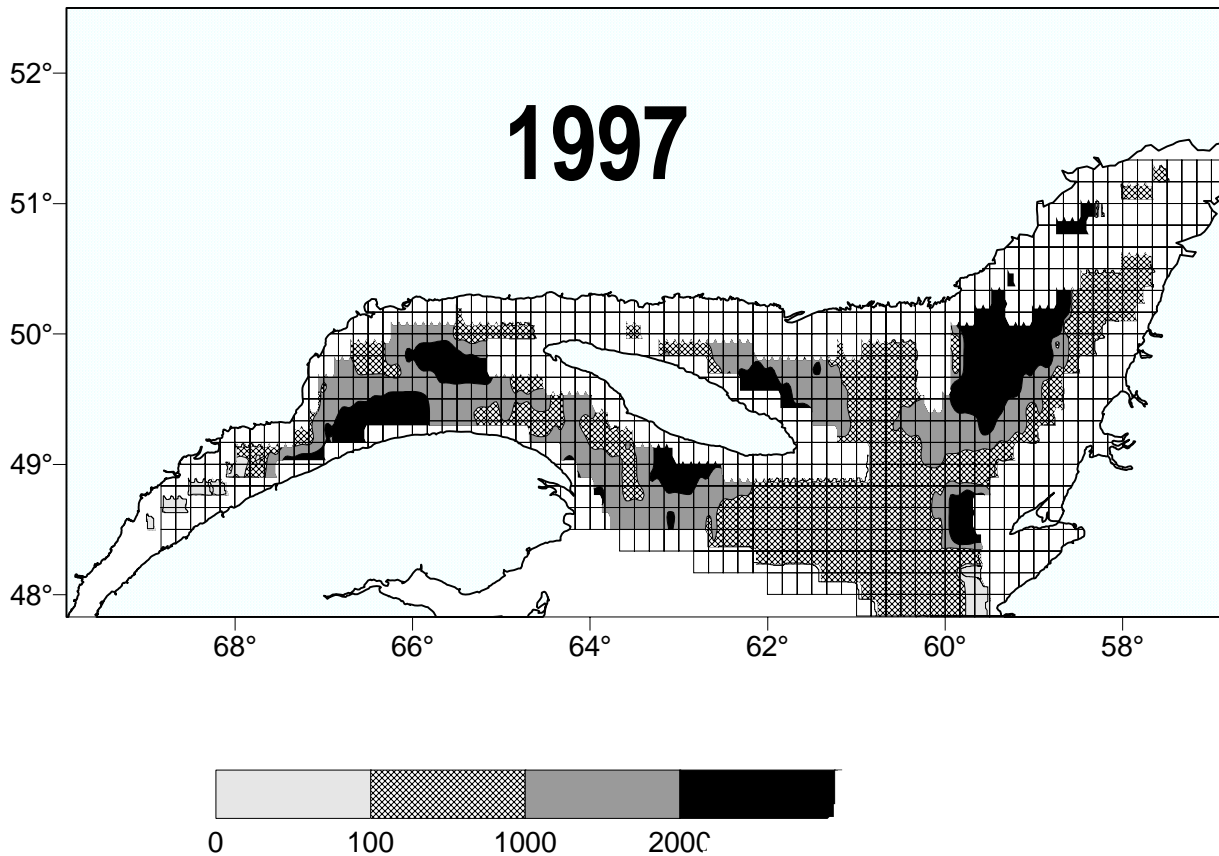


Figure 5. Geographic distribution of shrimp in the St. Lawrence Estuary and Gulf in 1997. The shades of gray represent the different shrimp densities in kg/km^2 .

1990. Shrimp aggregations are found in places where few shrimp were found in previous years. The distribution of shrimp in the Sept-Îles and Anticosti areas, where high densities are observed, has progressively spread southward. In 1990, shrimp were present mainly in the northern part of these management units, but since 1994 the center of the distribution has shifted toward the Laurentian Channel in the southern part of the units. In 1997, female shrimp were distributed throughout the Gulf, including the Laurentian Channel (Figure 5). On the other hand, the high concentrations the male shrimp have remained on the traditional sites in the north of the units.

In general, the survey abundance index decreased between 1990 and 1993, then

increased progressively. In the Sept-Îles area, the index reached its highest level ever in 1997 (Figure 6). On the other hand, the index for the Anticosti area dropped substantially from 1996 to 1997. In the Esquiman Channel, a progressive increase in 1994 and 1995 was followed by a slight decrease in 1996 and a sharp rise in 1997. The 1997 value is associated with a large confidence interval indicating great variability in the data. In the Estuary, the confidence intervals are too large to indicate a clear pattern in the abundance index.

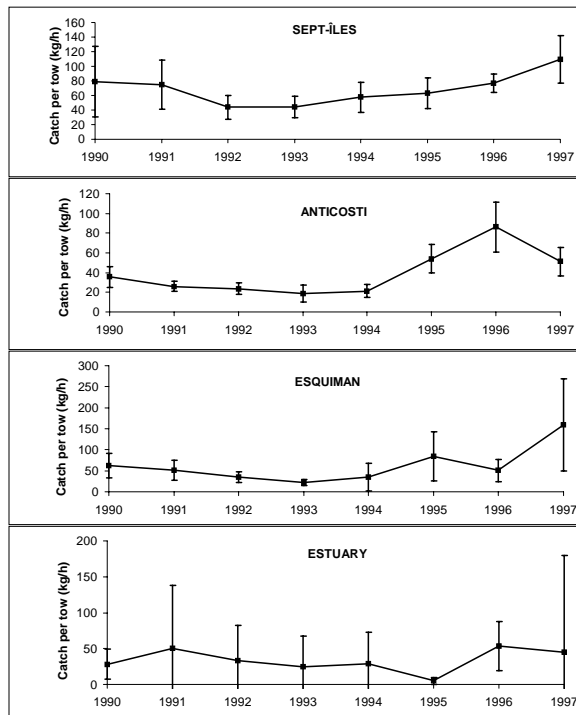


Figure 6. Shrimp abundance index, kg per tow standardized to one hour, from research sampling aboard the Alfred Needler in the St. Lawrence Estuary and Gulf since 1990. The vertical bars represent the confidence interval of the mean value, an indication of their precision.

Size structure

Length frequency distributions are calculated from commercial catch and survey samples. Commercial catch length frequency distributions have been obtained since 1982 and from research samples since 1990.

Cohorts can be identified by examining the length frequency distributions obtained from research surveys and commercial catches. A cohort is made up of individuals born the same year and four or five of them can be identified. The first year-class, with a modal size of approximately 11 mm, are about a year and a half old, meaning that the individuals in that year-class hatched into larvae in the spring of the preceding year.

The subsequent modes represent the preceding year-classes while the last mode represents an accumulation of female shrimp of one or more year-classes. It is therefore possible to follow the progress of the cohorts over several consecutive years and thus assess their relative abundance.

Using bottom trawls with 40-mm mesh, shrimp are first caught when they are two or three years old; they then measure approximately 14 mm in length (cephalothorax length) and are male. They are fully recruited to the fishery i.e. 100% vulnerable to capture by trawls at about 22 mm, when they are four and a half years old and are mostly female. The abundance in the catch of young cohorts in the first sizes to be selected by the trawls will depend not only on their abundance, but also on their growth. A faster growing cohort will appear earlier in the catches, sometimes giving the impression of being highly abundant. Moreover, because the shrimp, as they grow, are increasingly retained by trawls, the numbers of individuals in the cohorts rise in the catches from year to year while in the population, their abundance declines owing to natural mortality and fishing.

Fishers particularly target large shrimp, with the result that their catch rates depend on the abundance of shrimp having a cephalothorax length greater than 22 mm. Fluctuations in the abundance of shrimp having a cephalothorax length greater than 22 mm may be explained by the strength of the cohorts. A very strong cohort may support the fishery for a year or two when the shrimp reach the size at which they change sex. The successive arrival of several strong cohorts may thus maintain the biomass and catch rates at a high level for several years.

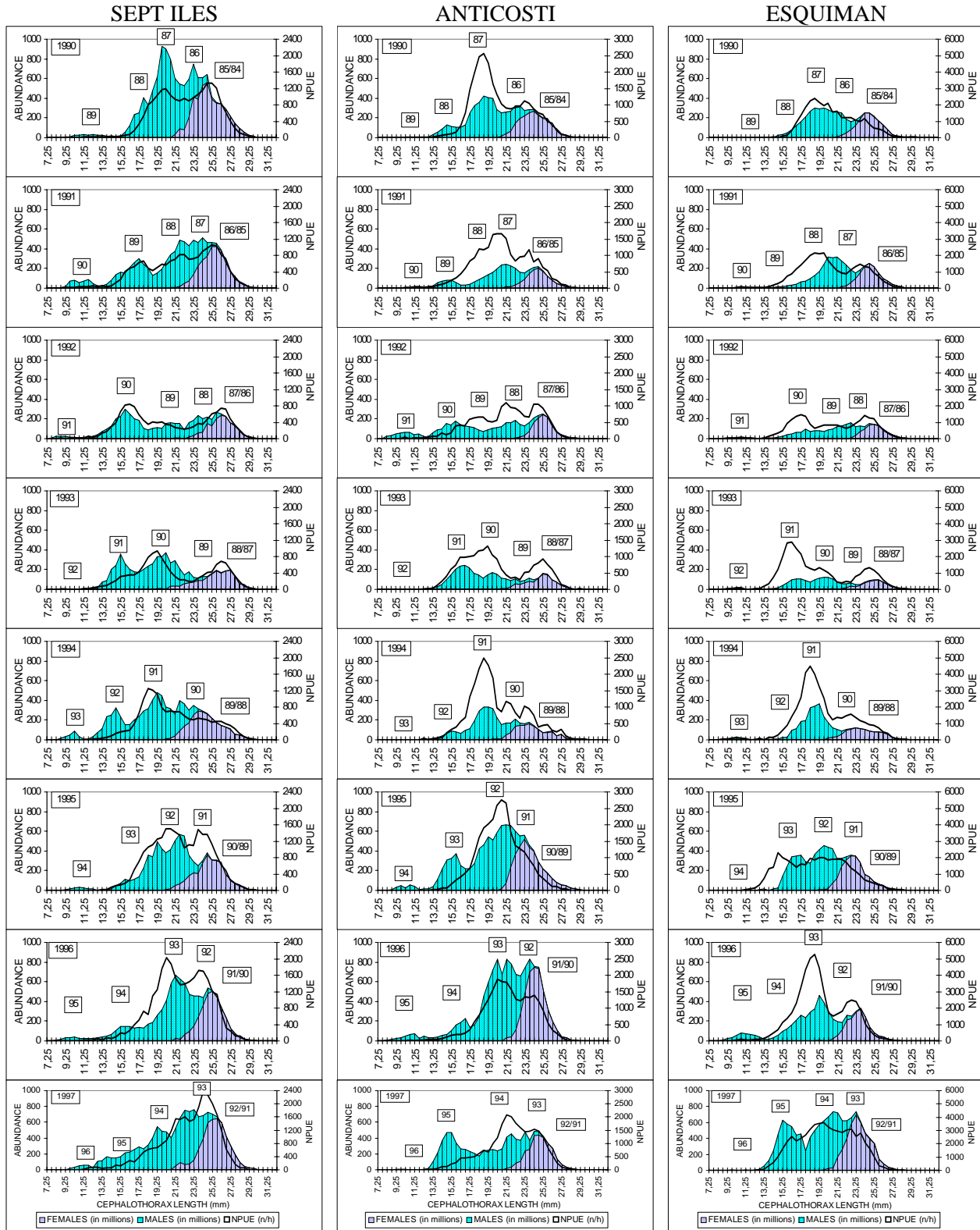


Figure 7. Size frequency distribution of shrimp in the four management units: shrimp abundance obtained from research surveys in the grayed area, and number per unit effort obtained from commercial catch samples is in the ungrayed areas.

The increase in the abundance indices in the late 1980s and early 1990s was due to the very high abundance of some cohorts produced in the mid-1980s (the 1984, 1985, 1986 and 1987 year-classes) that reached the size retained by fishing gear and that were targeted by the fishers during the same years (Figure 7). The decline in catch rates and survey indices observed in 1992 and 1993 was due to the fact that the cohorts produced in the late 1980s, which sustained the fishery in 1992 and 1993 (the 1988 and 1989 year-classes), were much less abundant. The 1990 year-class seems to have an abundance equal to or lower than the mean; its impact maintained the catch rates and survey indices without making them rise. Catch rates and survey indices rose in 1994 to 1997 thanks to the growing contribution of the 1991, 1992, 1993 and 1994 year-classes; these cohorts seem more abundant than the preceding ones. The 1992 and 1993 year-classes, especially the latter, contributed greatly to the 1997 fishery. The 1994 cohort, although slightly weaker than that of 1993, will combine with the others during the 1998 fishing season. Together, these cohorts should maintain yields at a high level in 1998.

Since 1990, the abundance of females has varied, depending mainly on the strength of the cohorts recruiting to the fishery. Male shrimp, smaller than 21 mm of cephalothorax length, decreased gradually in abundance between 1990 and 1993, as the 1988, 1989 and 1990 year-classes recruited to the fishery (Figure 8). Female shrimp, greater than 22 mm, decreased subsequently and reached their lowest level in 1993 and 1994. Male shrimp increased in abundance in 1993, 1994 and 1995 with the contribution of the 1991, 1992 and 1993 year-classes. The abundance of females then began to increase in 1994 and 1995. Shrimp smaller than 21 mm of cephalothorax length were as abundant in the catches of the 1997

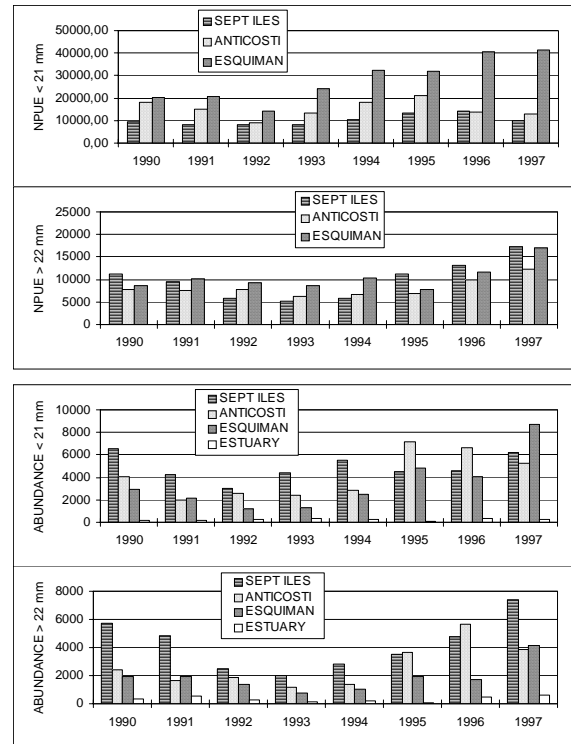


Figure 8. Numbers of shrimp smaller the 21 mm cephalothorax length (mostly males) and those larger than 22 mm (mostly females) in commercial catches (number per unit effort) and in research survey samples (abundance) in the four management units.

research survey as in those of 1995 and 1996. Shrimp larger than 22 mm were also abundant in 1997 survey catches as well as in commercial catches.

Exploitation rate

The exploitation rate represents the proportion of the shrimp population removed annually by commercial fishing. Since fishing gear is selective, the rate is usually calculated on only that part of population that is vulnerable to exploitation (exploitable biomass). In the Gulf, shrimp measuring 22 mm or more constitute the exploitable part of the population. The exploitation rate is thus an indication of the intensity of fishing pressure which is

directly related to fishing effort. An exploitation rate index has been developed in order to compare the intensity of exploitation in recent years with that of previous years.

An index of exploitation rate can be obtained by comparing the commercial catches to the survey index. Since the abundance index is a relative index, the result is not an estimate of absolute exploitation rate, nor can it be compared with target exploitation, which is not even known for shrimp. However, this index allows the monitoring of changes in exploitation rate.

The exploitation rate index (Figure 9) indicates that the exploitation rate doubled from 1990 to 1993, then systematically decreased until 1996, even though a constant augmentation in catches has been observed since 1994. The exploitation rate index for 1997 was at the same level as in 1996.

The exploitation rate index was calculated globally for the Gulf in order to eliminate variability associated with the biomass estimates of each management unit. A global calculation also allows us to take into consideration certain fundamental biological mechanisms, such as recruitment, that probably operate on the scale of the whole Gulf. This does not mean that the exploitation rate is identical in all the areas; it is possibly higher in the Sept-Îles area than in other areas, but the variability of the

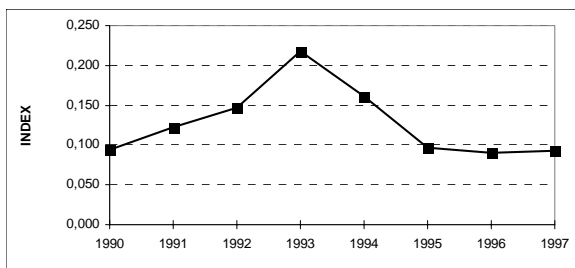


Figure 9. Exploitation rate index for shrimp in the St. Lawrence Estuary and Gulf as a whole since 1990.

data on a small geographical scale precludes any conclusion.

Status of the resource and future prospects

The indices confirm that shrimp abundance in the Gulf St. Lawrence was high in 1997. The catch rates of fishers were at their highest since 1982. Abundance indices from research surveys show the same pattern and are near the maximum values observed since 1990. The area of distribution of shrimp has considerably increased since 1990, and they are often abundant in large areas of Gulf where they were previously found in low densities. Generally speaking for the entire Gulf, the shrimp abundance increased between the first half of the 1980s and the end of the decade, remained high in the early 1990s, and then decreased in 1992. It remained stable in 1993 then increased gradually up until 1997.

Survey data (abundance indices and population structure) for shrimp in the Estuary and Gulf have been discussed with the fishers involved in the fishery. In general, indices from both the commercial fishery and research samples conform very well with the fishers' view of the abundance of the resource.

The recent high abundance indices are probably due to the growing contribution of the cohorts produced in 1991, 1992 and 1993. The 1994 year-class, which should recruit to the fishery in 1998, seems abundant enough to contribute significantly, along with the strong cohort of 1993, to maintaining the biomass. It is difficult to estimate with precision the abundance of the 1995 cohort since they are presently only partially vulnerable to the fishing gear used in surveys. However, there are no indication that this cohort is particularly weak.

It is difficult to explain the recent increase in abundance of shrimp. The most probable explanation is related to a reduction in predation. The biomass of redfish and cod is very low in the Gulf. These two species are important predators of shrimp. If this hypothesis is true, the present situation of high shrimp abundance must be considered as exceptional and temporary.

Recent commercial fishing seems not to have affected the population adversely. TACs have been reached in each area since 1994 even though allocations to Sept-Îles, Anticosti and Esquiman were significantly increased in 1996 and in all four areas in 1997. The population has increased appreciably and the catch rate index since 1995 has been at the same level as in 1990. It should be noted, however that the TAC was not reached in 1992, and the exploitation rate doubled between 1990 and 1993.

Leaving the 1998 TAC at the 1997 level of 20 031 t would present no risk to the conservation of the resource. The exploitation rate that would result from this TAC should be the same as that from 1995 to 1997. Abundance indices are high, and recruitment in the short term appears favorable. However, any eventual increase should be applied cautiously so that the exploitation rate index does not exceed the mean of the levels observed in the 1990s. The level, which varied from par to double over that period, was sustainable, but the impact of a higher rate over several years is unknown. With natural fluctuations in population abundance, strategies aimed at stabilizing TACs could result in large variations in exploitation rate such as those observed between 1990 and 1995. If the hypothesis relating recent abundance in shrimp to absence of predators is correct, it is likely that shrimp abundance will decrease rapidly as cod stocks are restored.

Annex 1 A Landings (t) of northern shrimp per management unit since 1965 (SI: Sept-Îles; ANT: Anticosti; ESQ: Esquiman; EST: Estuary).

CATCH					
Year	SI	ANT	ESQ	EST	Gulf
1965	11				11
1966	95				95
1967	278				278
1968	271				271
1969	273				273
1970	413		159		572
1971	393		691		1084
1972	481		184		665
1973	1273		520		1793
1974	1743	980	594		3317
1975	2135	1025	1368		4528
1976	1841	1310	1494		4645
1977	2746	1185	1249		5180
1978	2526	1460	2166		6152
1979	3207	1108	3226		7541
1980	2978	1454	2441	539	7412
1981	3680	1385	3014	27	8106
1982	3774	2464	2111	152	8501
1983	3647	2925	2242	158	8972
1984	4383	1336	1578	248	7545
1985	4399	2786	1421	164	8770
1986	4216	3340	1592	262	9410
1987	5411	3422	2685	523	12041
1988	6047	2844	4335	551	13777
1989	6254	4253	4614	629	15750
1990	6839	4723	3303	507	15372
1991	6411	4590	4773	505	16279
1992	4957	4162	3149	489	12757
1993	5485	4791	4683	496	15455
1994	6165	4854	4689	502	16210
1995	6386	4962	4800	486	16634
1996	7014	5469	5123	505	18111
1997	7719	6044	5483	547	19793

Annex 1 B. Total Allowable Catch (TAC, t) of northern shrimp per management unit since 1982 (SI: Sept-Îles; ANT: Anticosti; ESQ: Esquiman; EST: Estuary).

TAC Year	SI	ANT	ESQ	EST	Gulf
1982	3800	4400	4200	500	12900
1983	3800	5000	6000	500	15300
1984	4800	5000	6000	500	16300
1985	4600	3400	6000	500	14500
1986	4600	3500	3500	500	12100
1987	5600	3500	3500	500	13100
1988	5600	3500	3500	500	13100
1989	5700	4200	4500	500	14900
1990	6400	4200	4700	500	15800
1991	6400	5000	4700	500	16600
1992	6400	5000	4700	500	16600
1993	6400	5000	4700	500	16600
1994	6400	5000	4700	500	16600
1995	6400	5000	4700	500	16600
1996	7040	5500	5170	500	18210
1997	7744	6050	5687	550	20031

For more information:

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