GENERAL OVERVIEW OF ATLANTIC COAST SNOW CRAB AND REPORT ON THE STATUS OF SNOW CRAB IN THE SOUTHERN GULF OF ST. LAWRENCE (FISHING AREAS 12, 18, 19, 25 AND 26)

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Original

February 1994

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INTRODUCTION

This report contains a general overview of snow crab on the Atlantic coast and an assessment of snow crab populations in the southern Gulf of St. Lawrence (areas 12, 18, 19, 25 and 26). Scientists working on invertebrates and marine plants along the Atlantic coast and scientists stationed at the Headquarters of the Department of Fisheries and Oceans have reviewed the data and analyses that were used to estimate the present status of stocks, future prospects for recruitment and population size, and the impact of fishing practices. The data used to prepare this assessment, together with technical details of the analyses used, will be published in the department's research document series dealing with the Atlantic fisheries.

GENERAL OVERVIEW OF THE ATLANTIC COAST SNOW CRAB FISHERY

LANDING TRENDS

Figures 1 and 2

The southern Gulf of St. Lawrence

Harvesting of snow crab in the southern Gulf of St. Lawrence (areas 12, 18, 19, 25 and 26) began toward the mid-1960s. Landings increased rapidly, reaching a peak of over 33,000 tonnes in 1982. Thereafter, the figures were around 27,000 tonnes until 1986, and then declined to 9,500 tonnes in 1990. Landings subsequently increased to reach 17,550 tonnes in 1993. Since 1990 the fishery has been managed by total allowable catch (TAC) in all areas.

The Atlantic coast of Cape Breton Island

On the Atlantic coast of Cape Breton Island (areas 20 to 24), landings increased by a factor of 2.7 between 1989 and 1992 (a total of 1,800 tonnes were landed in 1992). This increase in landings was due partly to rising catch rates and partly to an expansion of the fishing area. Preliminary data from 1993 indicate a further increase in landings in areas 20-23, while landings decreased in the southernmost area (Area 24), giving total quantities landed for the sector as a whole that were similar to those observed in 1992 (1,819 tonnes in 1993).

The St. Lawrence estuary and the northern part of the Gulf

The origins of the snow crab fishery in the St. Lawrence estuary and the northern Gulf of St. Lawrence (areas 13, 14, 15, 16 and 17) date back to the mid-1960s, but it was not until the latter years of the 1970s that these crab began to be landed in commercial quantities, with total landings increasing from 645 tonnes in 1978 to over 5,800 tonnes by 1985. However, this increase was followed by a decline, and only 2,600 tonnes were landed in 1989. The main cause of this downward trend was smaller catches along the Lower North Shore. Catches improved again in 1990, when nearly 4,500 tonnes of snow crabs were landed, and landings remained fairly stable until 1992. There was a further increase in 1993, owing to larger catches along the Lower North Shore. The snow crab fishery is managed by TAC throughout the entire sector, apart from Area 15, where only fishing effort is regulated.

The eastern coast of Newfoundland

Landings here increased steadily from 1970 to 1981 when they reached nearly 14,000 tonnes. They then decreased to less than 7,000 tonnes by 1987. The causes of this decline were overharvesting aggravated by a simultaneous decline in recruitment, probably as a result of unfavourable environmental conditions. Landings increased again to a total of over 22,000 tonnes in 1993; this upturn is thought to have been due to an increase in abundance of the resource as well as an expansion of the area harvested. The fishery is managed by TAC throughout the entire sector.

THE SITUATION IN 1993 AND THE OUTLOOK FOR THE FUTURE Figure 3

The use of small-mesh bottom trawls to sample snow crab populations has yielded data on the abundance of very small crabs, and these in turn afford indications on medium- and long-term recruitment to harvestable stocks. Sampling operations of this type have been carried out for several years now in the southern and northern sectors of the Gulf of St. Lawrence and along the Middle North Shore. In addition, recent surveys conducted in the St. Lawrence estuary and a different location in the Middle North Shore have given additional information on the large-scale events that occur among the snow crab population of the Gulf of St. Lawrence as a whole.

The findings indicate that snow crab populations in the estuary and the northern Gulf of St. Lawrence are characterized by substantial deficits, i.e. very small numbers of crabs with shells between 40 and 85 mm in width in 1993. These low abundance levels are presumably the result of very low rates of recruitment to these populations from three consecutive year-classes in 1985, 1986 and 1987. Projections based on a growth model developed in the northern Gulf of St. Lawrence indicate that a sharp decline in numbers of crabs of commercial size is to be anticipated beginning in 1994. These crabs will be available for harvesting one year later, when their shells have hardened, and consequently this decline will be reflected in the fishery in 1995 and the two subsequent years.

However, findings reported from sampling operations conducted with a very-small-mesh trawl in the northern Gulf of St. Lawrence indicate that subsequent year-classes (1989 to 1992) are larger, and consequently higher abundance levels should be observed by the end of the decade.

The findings obtained from surveys conducted in the southern Gulf of St. Lawrence also indicate a deficit situation among crabs with a carapace width (CW) under 76 mm in 1993. The trawl that was used to take the samples in the southern part of the Gulf was of larger mesh than its northern counterpart, and consequently the number of year-classes characterized by very low abundance levels cannot be accurately estimated in the case of the southern snow crab population. The quantities of crab with a carapace width of less than 30 mm in the samples taken in the southern Gulf of St. Lawrence are probably not typical of their actual abundance, owing to the selectivity of the trawl. However, we may reasonably anticipate that in the southern part of the Gulf as well, recruitment to crab populations of commercial size will be characterized by a substantial decline beginning in 1995, and this situation will be reflected in the fishery as of 1996.

Concurrently with these observations, sampling operations carried out at sea aboard commercial snow crab fishing boats along the Atlantic coast of Cape Breton Island indicate that recruitment to the fishery will be reduced in the next few years. A combined index based on catch rates and prerecruitment crab occurrence rates has been declining since 1991, and this suggests that catch rates for crabs of commercial size will be down in 1995 or 1996. Similar data from the eastern coast of Newfoundland indicate that the occurrence of prerecruits in commercial catches has declined from over 40% in recent years to under 10% in 1993. The

decline that has been observed in this index also suggests that recruitment to harvestable populations --and hence catch rates--may well be down in 1994 or 1995.

However, when projections concerning recruitment to harvestable stocks are extended over a period of more than one year, their accuracy is affected by two factors. The first of these is related to the phenomenon known as terminal moult, which is the moult that marks an individual's passage to maturity. After going through its terminal moult, the individual stops growing. In male snow crab, the terminal size range extends between 40 and 155 mm (CW). At present we have no means of determining what fraction of prerecruits will go through their terminal moult before they have reached the minimum legal size of 95 mm (CW), but unquestionably a substantial proportion (it is estimated at 30% or 40% at the very least) of males recruited to the population will never grow to commercial size. The second factor has to do with a problem of irregularity in frequency of moulting. As a rule, crabs with a carapace width greater than 20 mm moult once a year, between March and July. In some years, however, a substantial fraction of male crabs (as many as 60% of the total male population on occasion) go two years between moults instead of one, with the result that these individuals take a year longer to reach the minimum legal size and hence to recruit the harvestable population.

Historical data tell us that this variable pattern of recruitment to the harvestable population has occurred in the Gulf of St. Lawrence in the past. The 1977 to 1979 year-classes were exceptionally small, and this fact probably accounts for the decline in landings that marked the second half of the 1980s. As yet it is difficult to explain the causes of these variations in recruitment among the snow crab population; the operative factors may be intrinsic to the species. However, in view of the geographic scale of the events involved and their virtually simultaneous occurrence, large scale phenomena such as environmental conditions may well be playing a role.

THE IMPACT OF LOW RECRUITMENT LEVELS

The magnitude of the impact of weak year-classes on the quantity and quality of landings is difficult to estimate precisely. The biomass of snow crab of commercial size, the great majority of which are post-terminal moulters, is currently large, and this should serve to offset the effect of low recruitment rates to some extent, at least in the year when the first of these small year-classes joins the harvestable stock. Tagging experiments conducted on individuals in the fiord of the Saguenay and along the eastern coast of Newfoundland concluded that snow crab may live from 4 to 6 years after terminal moult. The radioisotope technique for determining shell age was used to estimate the ages of a number of post-terminal moult individuals, and the findings indicated that the crabs in question could live for another four to five years after terminal moult.

However, the external characteristics of a post-terminal moult snow crab's shell change as the crab grows older. Observations made in the fiord of the Saguenay have afforded a means of correlating external shell characteristics with the length of time that has elapsed since the crab's terminal moult.

External characteristics of shell after terminal moult	Approximate age of shell after terminal moult
Clean, soft	0-5 months
Clean, hard	5 months - 1 year
Intermediate condition	8 months - 3 years
Dirty or mossy, hard, brushable	2 - 5 years
Dirty or mossy, soft, non-brushable	4 - 6 years

It is not yet clear to what extent these findings from observations made in the fiord of the Saguenay are applicable to the Gulf of St. Lawrence as a whole, as changes in the external characteristics of a post-terminal moult crab may depend on local conditions. However, these findings do provide some indication of the changes in appearance that the shell undergoes with the passage of time after the terminal moult event.

Male crabs stop growing after their terminal moult: their biomass will not increase thereafter, regardless of how long they are left on the fishing ground. In addition, they are subject to natural mortality, so that their numbers gradually diminish over time. They also become progressively less catchable; the older they are, the more they tend to avoid entering crab traps, and this means that they are less available for harvesting. Furthermore, the changes in the appearance of their shells may make them less commercially valuable, depending on market demand.

The value of a reserve stock of post-terminal moult crabs acting as a "buffer" to provide a measure of stability in commercial catch rates one fishing season after another must thus depend both on biological factors (such as natural mortality rate and catchability) and on economic factors (such as commercial value, which may depend on the appearance of the shell). Crab harvesters must thus weigh up the gains and losses associated with various harvesting scenarios.

THE IMPACT OF CHANGES ASSOCIATED WITH DISCARDING PRACTICES

Information obtained from a variety of sources indicates that changes have recently been observed in the way snow crab fishers sort the catches which they bring on board their boats and ultimately sell; there are some who select specific categories of crabs and discard others, which they regard as potentially of lower commercial value. Discarding can be defined as throwing male crabs of legal size (CW 95 mm and over) back into the water because in the fisher's judgement they are likely to be of lower commercial value. The reasons for this practice may vary, depending on market demand: a crab's shell may be too "dirty" or "mossy" (i.e. characterized by an accumulation of organisms), one or more of its legs may be missing, or its size may be such that the processing industry will regard it as undesirable, even though its shell is clean and hard. Putting soft-shell crabs and crabs with small claws back into the water as a means of protecting future recruitment to the fishery, on the other hand, is a practice that is routinely followed by crab fishers, and one that is altogether legitimate and desirable.

The main negative impact of discarding crabs consists in a potential increase in fishing mortality among that fraction of the crab population which is fished. Before crabs can be thrown back into the water, they must necessarily be handled on the deck of a fishing boat. The conditions prevalent at the time and the handling to which the crabs are subjected will determine what percentage of them will survive after they have been thrown back into the water on the fishing grounds. One study which was conducted in the St. Lawrence estuary in 1991, for example, demonstrated that factors affecting survival rates among soft-shell crabs that had been returned to the water included loss of legs as a result of handling, vitality, in relation to length of exposure to air, and crab size. If heavy mortality occurs among crabs that are thrown back into the water, actual total mortality among the population will be greater than its estimated value based on commercial landings. Consequently, it is of the utmost importance that handling aboard the fishing boat be as gentle as possible to increase the chances that crabs which are put back into the water will survive.

Provided the crabs are handled carefully, so that the discarding mortality rate is negligible, the practice of actively selecting certain categories of crabs and discarding some specimens should not increase the exploitation rate applied to the snow crab population as a whole. The explotation rate is calculated for all crabs

that are over the minimum legal size. The overall exploitation rate should not change as long as the total number of individuals removed from the population remains the same, e.g. if one crab is kept for each one that is put back into the water. However, as the TAC is calculated in terms of weight, the practice of selecting and keeping crabs which are larger in size (and therefore heavier) may result in a smaller total number of crabs harvested.

As a consequence of the practice of selecting crabs on the basis of size, shell appearance, or number of legs (with a view to enhancing the commercial value of the total catch), some crabs that are over the minimum legal size are being thrown back into the water. Most of these are crabs that have gone through their terminal moult, so that they are no longer growing and will never develop into the large-sized crabs that the fishers are after. Furthermore, the appearance of their shells will change with time. It is difficult to determine whether the practice of discarding post-terminal moult crabs of commercial size is likely to have much of an impact on the reproductive potential of the snow crab population as a whole. For one thing, the minimum legal size limit serves to protect the females, as they are smaller than the males. Observation of female crabs has shown that as a rule, all their eggs are fertilized, and this suggests that the numbers of mature males remaining in the population as a result of present management methods are adequate to ensure reproduction. However, in a small population large females were observed with eggs that were not fertilized, and it is thought that these problems may be associated with the fact that large males were fewer in number and hence less readily available for mating with the females in question. As yet the reproductive competence of each of the various categories of male crabs has not been demonstrated. At present, for example, we cannot estimate whether the characteristics of larvae (survival rates, numbers, size or condition) are correlated in any way with such characteristics of their male parent as size and age after terminal moult.

OTHER INFORMATION

Small numbers of snow crab affected by what is known as the bitter crab syndrome (BCS) have been observed along the northeastern coast of Newfoundland since 1988. The cause of BCS is a parasitic dinoflagellate (*Hematodinum sp*), which is harmless to human beings. A crab in the final stages of infection with this parasite displays a "cooked" appearance, and its meat is characterized by a peculiar texture and a bitter taste. A suitable monitoring program should serve to detect any change in the incidence of this parasitic infestation among snow crab populations in the waters off Newfoundland. Only a very few cases of infestation with *Hematodinum* have been reported from the Gulf of St. Lawrence.

STATUS OF THE SNOW CRAB POPULATION IN THE SOUTHERN GULF OF ST. LAWRENCE

DESCRIPTION OF THE FISHERY

Figure 2
Table 1

Harvesting of snow crab in the southern Gulf of St. Lawrence (areas 12, 18, 19, 25 and 26) began in the mid-1960s.

Area 12, the mid-shore fishery , represents the largest snow crab fishery. It is worked by 130 fishers from New Brunswick, Quebec and Nova Scotia. Each licence holder may use 150 traps. This fishery grew rapidly at first, and the total catch peaked at 31,500 tonnes in 1982. In subsequent years, catches were around the 25,000-tonne mark until 1986, but then declined severely to reach 7,000 tonnes in 1990. The TAC was set at 7,000 t in 1990. Catches have recovered; the 1993 total was 14,336 tonnes (the quota was 14,500 tonnes).

The snow crab fishing grounds along the western coast of Cape Breton Island were initially fished by a group of fishers based in Chéticamp. Subsequently, fishers from Quebec and New Brunswick also fished the area from time to time. When the commercial value of snow crab went up in the late 1970s, the fishery was gradually extended until it covered all the fishing grounds along the island's western coast. In 1978, Area 19 was established as an inshore area open only to inshore fishers using boats less than 13.7 m (45 feet) in length. Landings, which are subject to a quota, ranged between 900 tonnes and 1,390 tonnes from 1979 to 1991. In 1993, 74 fishers using a total of 20 traps each were engaged in this fishery. The quotas, which were set at 1,686 tonnes both in 1992 and in 1993, were fully used.

Area 18 was fished for the first time in 1979 by 14 inshore boats with exploration permits and a maximum limit of 30 traps per permit. In the following year, these permits were converted into fishing licences, and 9 additional permits were issued with a view to the exploration of areas further offshore. Mid-shore crab fishing boats worked these same fishing grounds until 1982. In 1984, Area 18 was reserved exclusively for inshore fishers. The overall quota, which had initially been set at 835 tonnes in 1981, was cut back to 626 tonnes in 1986 and then increased to a level of 674 tonnes in 1988, where it remained through the 1990 fishing season. In the spring of 1991 a quota of 200 tonnes was set with a view to encouraging a spring fishery in the area, and later in that year a quota of 674 tonnes was set for the autumn of 1991 and the spring of 1992. The quota was raised to 749 tonnes for 1992-1993, and has been left unchanged at that level for 1993-1994. Since 1992-1993, the number of fishers working this area has totalled 30.

The Prince Edward Island fishery, which comprises areas 25 and 26, began on an exploratory basis in 1985. By the next year, the number of permits issued had increased to 30. Since 1989, this fishery has been conducted only in the spring. In 1990 the two areas in question were reserved exclusively for Prince Edward Island fishers. Each of the 30 operators may use 30 traps. The largest total catch recorded to date has been 1,239 tonnes (in 1986). Since 1990 this fishery has been subject to a quota, which was originally 500 tonnes but was increased to 800 tonnes in 1993. Quotas have consistently been fully used.

Previously, CAFSAC assessed the status of snow crab populations on the basis of the five management units. In 1991, however, it was concluded that the concentrations of snow crab in the various areas were actually interrelated, and in fact constituted a single biological unit. Accordingly, the snow crab of the southern Gulf of St. Lawrence have been assessed as a single stock since 1992. An overall assessment is produced for the whole of the southern Gulf, based on fisheries data and data from sampling operations carried out by means of a bottom trawl. However, relevant details pertaining to the individual areas are also included; these are based on the geographic distribution of snow crab as observed by means of trawl sampling surveys and analysis of fishing operations. This approach should yield a general overview of changes occurring in the southern Gulf of St. Lawrence as a whole, thereby affording a means of interpreting fluctuations in the abundance of crab in the several management units.

ASSESSMENT

Fishing effort and catches per unit effort

Figure 4

For all areas, data from fishers' logbooks have been used to describe the general distribution of fishing effort per section measuring 10 minutes of latitude by 10 minutes of longitude. The distribution of fishing effort during the 1993 season is continuous in all areas; there is a noticeable concentration of fishing activity straddling the boundary between areas 12, 18, 19 and 25-26. As noted above, this indicates that the management units do not necessarily coincide with biological units.

Logbooks could also be used to obtain data on catch rates. However, in view of the various alterations that have been made in the size and shape of the traps used in Area 12, catch per unit effort values cannot, for

the time being, be used as indicators of abundance. Furthermore, fishing activities are heavily influenced by socioeconomic factors (including the number of weeks of work required to be eligible for unemployment insurance, discarding practices, the catch limit imposed by the industry on any given trip, and the optimization of fishers' earnings relative to the boat-related expenditures involved in filling their quotas) and by the fact that fishers are provided with density contour information obtained during the autumn survey before the opening of the subsequent fishing season.

Research survey **Figures 5, 6 and 7**

In 1988, a survey involving the use of a bottom trawl for sampling operations was conducted for the first time in areas 12, 25 and 26; since 1990, the entire southern Gulf of St. Lawrence has been covered. The trawl used is a Nephrops trawl with a 20-metre opening. Sampling operations in areas 12, 25 and 26 have always been carried out after the fishing season is over; areas 18 and 19 were sampled after the end of the fishing season in 1992 and 1993. Data on catches have been standardized for a sampled surface area of 0.8 km^2. A geostatistical method known as "kriging" has been used to estimate biomass and produce charts showing density contours for various categories of crabs.

Distribution values for numbers of male crabs by size class (cephalothorax width), as estimated at the time of the survey, indicate that crabs with a carapace width greater than 95 mm were more abundant in 1993 than they had been in previous years. It is noteworthy that very abundant year-classes in the 38 mm to 60 mm CW range were present in 1988. The growth of these year-classes in successive years can be followed by observing the upward shift of the modes toward larger size categories. These year-classes began to reach the minimum legal size in 1991-1992. They account for the overall increase in the biomass of crabs with a carapace width greater than 95 mm which was observed in 1992-1993.

At the same time, crabs with under 76 mm CW were much scarcer in the samples taken in the course of the 1993 survey than they had been in 1988. It thus appears that the abundant year-classes which are observed to be moving up steadily year by year are being followed by other year-classes which are much less abundant. As yet it is difficult to determine the number of year-classes involved here or to comment on the strength of year-classes with under a 38 mm CW, as the trawl used for sampling purposes catches only a small, variable proportion of individuals with under a 38 mm CW. It is highly probable that the first year-class characterized by low abundance, i.e. the class with under a 56 mm CW in 1993, will reach the minimum legal size in 1995 after having moulted twice. In 1995, the individuals in question will have just moulted and will still be soft-shelled; they will not be hard and fully available for harvesting until 1996. Because of their small numbers, catch rates in that year may be expected to be substantially lower than the levels observed in 1992 or 1993.

Distribution values found for numbers of female crabs provide indications of the weakness of these year-classes. Female snow crabs are not as large as males; they go through their terminal moult and become fully mature (and stop growing) when their carapace width is in the 55 mm to 80 mm range. Multiparous females that were present in 1993 originated from the same strong year-classes as those which were identified in the case of the males. They were still relatively abundant in the samples taken in the course of the 1993 survey. In contrast, primiparous and immature females were younger than the multiparous females and belonged to the weaker year-classes observed in the case of the males. Very small numbers of immature females were observed in the samples taken in the course of the 1991, 1992 and 1993 surveys; the numbers of primiparous females found in samples taken in 1992 and 1993 were also very small.

Isodensity charts produced by means of the kriging operations which were performed on the survey data clearly show the geographic distribution of male crabs belonging to two different size classes as of the time of the autumn survey. Abundance values for crab with a greater than 56 mm CW at the time of the survey (which will have a greater than 70 mm CW the following spring) declined between 1990 and 1993. Changes in their geographic distribution also occurred; in 1993 they were found almost exclusively in Area 12, northwest of the

Magdalen Islands, and in Gaspé Bay. The isodensity charts for crab of legal size with large claws clearly show that abundance increased between 1988 and 1993. Furthermore, the geographic distribution of these crab evidently changes over time. In 1993, crabs with a carapace width greater than 95 mm, like their counterparts with a carapace width greater than 56 mm, were hardly to be found anywhere outside of Area 12, northwest of the Magdalen Islands. In 1993, 51.1% of all crabs in the samples taken with the trawl were soft-shell males, 34.2% of which also had small claws. In all, 59.1% of all crabs found in the samples had small claws.

RESOURCE STATUS

The harvestable biomass of crab with a greater than 95 mm CW has increased since 1988. These crab originate from the strong year-classes produced early in the 1980s. They will cease to contribute to the fishery in the course of the next two years, after the group consisting of crabs with a greater than 76 mm CW, which were still abundant in 1993, reaches commercial size in 1994.

The year-classes produced in the second half of the 1980s are much weaker than the ones which are currently contributing to the fishery. In 1991, 1992, and 1993 the members of these year-classes had grown large enough to be vulnerable to the trawl that was used to take samples; numbers of immature and primiparous females and males with under a 76 mm CW were very small in 1992 and 1993. The males belonging to these weak year-classes should reach commercial size in 1995, and may be expected to be fully available for harvesting in 1996. Accordingly, we may expect a sharp decline in the numbers of crab with a carapace width greater than 95 mm that are recruited to the fishery in 1995, and hence lower yields in 1996.

PROJECTED BIOMASS VALUES

The results of the survey conducted in the autumn, after the fishing season is over, are used to prepare projections on the groups of crab that will be present at the beginning of the following fishing season, in spring, after they have moulted. This approach yields a picture of the situation at the beginning of each successive fishing season. To prepare these projections, it is necessary to apply a growth model to the various groups of crab, as estimated at the time of the sampling survey, in order to simulate the moult which they will undergo the following spring. These projections are prepared only for male crab, as it is only the males that are harvested commercially. The model takes into account the fact that male crab go through a terminal moult, after which they cease to grow. At that point in their lives they acquire large claws.

The availability of any given crab to commercial harvesting depends on two characteristics:

> *Size*. Only males with greater than a 95 mm CW are harvested. Males with small claws whose carapace width lies within a range extending between 76 mm and 94 mm will reach legal size (95 mm to 115 mm CW) after moulting once. Males which have gone through their terminal moult while their carapace width was under 95 mm will never be available for harvesting, as they are too small.
>
> *Shell condition*. Only crab with hard shells are harvested. A snow crab's shell does not become fully hardened until one year after the crab has moulted. Males with small claws continue to moult until they go through their terminal moult and acquire large claws. Post-terminal moult males will thus not be available for harvesting until one year has passed after they have moulted for the last time.

These projections are prepared for various groups of crab. The model is applied to the numbers of crab as estimated at the time of the survey, in the autumn. The model projects crab numbers as they will be in the following spring, in accordance with the growth model, which takes into account the gains in size or weight resulting from a moult. The steps involved in the calculation are described below and illustrated in the following figure:

P: "dwarf crab".
At time of survey: crab with large claws that are under the legal size (i.e. with under a 95 mm CW), which will not moult again and thus will never be recruited to the fishery.
In the spring (projection): same definition.

R-3: "recruits - 3 years"
At time of survey: crab with a carapace width in the range extending between 56 mm and 76 mm, having small claws and soft shells.
In the spring (projection): these crab will have moulted but will not have gone through their terminal moult. Their size (CW) will fall within a range extending between 76 mm and 95 mm; they will have small claws and soft shells. A percentage of these crab will go through their terminal moult and become "dwarf" crabs.
In the summer, during the fishing season: these crab are not available for harvesting, as they are too small.

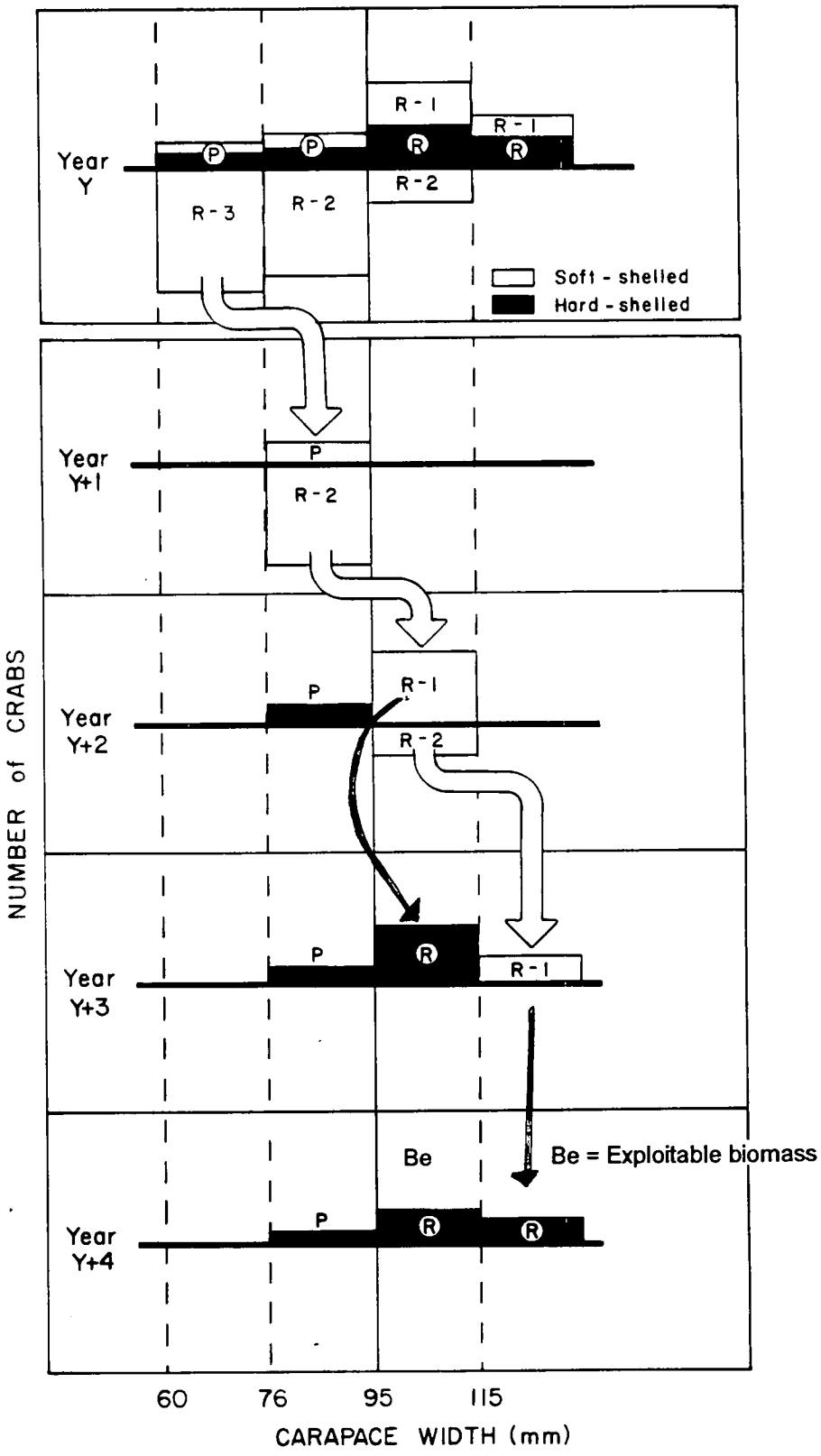
R-2: "recruits - 2 years"
At time of survey: crab within a size range extending between 76 mm and 95 mm, with small claws and soft shells.

In the spring (projection): these crab will have gone through their terminal moult and reached the minimum legal size. They will have acquired large claws, but their shells will be soft. A percentage of these crab will go through a moult that is not the terminal moult, and consequently they will have further growth potential. Crab in this category are still known as R-2s.
In the summer, during the fishing season: these crab are not available for harvesting, as they have soft shells.

R-1: "recruits - 1 year"
At time of survey: crab of legal size with soft shells and large claws. These crab have just gone through their terminal moult.
In the spring (projection): these crabs' shells will have hardened, but their size will remain unchanged. These crab will be added to the accumulated biomass of crab over 95 mm in size, with hard shells and large claws.
In the summer, during the fishing season: these crab constitute the harvestable biomass and will be fully available for harvesting.

R: "recruits"
At time of survey: crab of legal size, with large claws and hard shells, which have not been harvested during the fishing season just ended because the harvesting rate is not 100%. As of the time of the survey, it is difficult to distinguish these crab from those which have not been harvested during previous fishing seasons (unless shell appearance is noted and classified) and whose biomass is accumulating.

In the spring (projection): these crab will be part of the accumulated biomass consisting of crab over 95 mm in size, with hard shells and large claws.


Year Y
R-1
R-1
R-2
R-3
R-2
Soft - shelled
Hard - shelled
Year Y+1
R-2
Year Y+2
R-1
R-2
Year Y+3
R-1
Be
Be = Exploitable biomass
Year Y+4
NUMBER of CRABS
60
76
95
115
CARAPACE WIDTH (mm)

However, the model used contains various sources of inaccuracy. In the first place, it does not take natural mortality into account. Projected numbers are thus the same from one year to the next, without diminishing over time. In the second place, the model assumes that all individuals moult once a year, every year, until the terminal moult occurs. In reality, some individuals may not moult in a particular year; they are then said to have "skipped a moult". As yet the proportion of nonmoulting individuals in any given year-class is unknown. In the third place, the model assumes that trawl efficiency is 100% for individuals with a carapace width greater than approximately 30 mm.

The purpose is to calculate the crab biomass that will be available for harvesting at the beginning of each season. That is, the crab in question will possess large claws, they will be over 95 mm CW, and they will have hard shells. An effort is also made to calculate the numbers of crab over 70 mm CW, with small claws, that will be present on the fishing grounds at the beginning of the season, in order to give the fishers some idea of the quantities of soft-shell crab that they are likely to find in their catches during the coming season.

Projections relating to the biomass and abundance of these two categories of crab are shown in the table below.

	SOFT-SHELL CRAB WITH CW GREATER THAN 70 MM NUMBER (X 10^4)					HARD-SHELL CRAB WITH CW GREATER THAN 95 MM BIOMASS (t)				
	Southern Gulf	Area 12	Areas 25-26	Area 19	Area 18	Southern Gulf	Area 12	Areas 25-26	Area 19	Area 18
1989		11904					8676 (3635)	472 (570)		
1990		28700					21748 (11614)	1298 (1274)		
1991		36802	2098				23444 (12402)	1325 (950)		
1992		22578	1754	1724			29443 (14714)	2665 (1661)	5459 (1942)	
1993	21828	19910	944	612	361	46483 (19338)	37771 (14175)	2208 (1787)	5226 (2205)	1278 (1171)
1994	15572 (372)	14831 (2892)	150 (259)	486 (285)	106 (285)	68221 (10616)	62914 (8305)	623 (455)	3428 (1440)	1256 (1043)

The figures in parentheses indicate the value that must be subtracted from or added to the estimate in order to obtain the lower and upper limits of the 95% confidence interval.

For the southern Gulf of St. Lawrence as a whole, the biomass of crab with large claws, hard shells and a 95 mm CW or more is estimated at 68,221 tonnes for the spring of 1994; this figure represents an increase over the corresponding value for the spring of 1993 (46,483 tonnes). It is not feasible to calculate the biomass of these crab for the southern Gulf as a whole for the years before 1993, as not all the areas were covered in the sampling surveys. However, the biomass projections for Area 12 since sampling began

in 1988 indicate that harvestable biomass has been increasing since at least the spring of 1989. In the case of soft-shell crab with a 70 mm CW or more, the estimated abundance (in terms of numbers) for 1994 is lower than the corresponding value for 1993 in the southern Gulf, declining from 218,280,000 individuals in 1993 to 155,720,000 in 1994. In Area 12, the abundance of crab in this category has been declining since 1991.

It is anticipated that for the southern Gulf of St. Lawrence as a whole, commercially harvestable snow crab biomass at the beginning of the 1994 fishing season will be 47% higher than the corresponding value that was estimated for 1993. This increase in biomass should result in good catch rates during the 1994 season. The relatively large numbers of crab in the over 76 mm CW size class which were estimated for 1993 should produce good recruitment to the 1995 fishery. However, a longer-term projection indicates that recruitment to the fishery is likely to decline substantially in 1996.

GEOGRAPHIC DISTRIBUTION

While total snow crab biomass has increased in the southern Gulf of St. Lawrence in recent years, the changes that have been observed in the geographic distribution of these crab will affect different management areas in different ways. At present, the crab are concentrated in an area northwest of the Magdalen Islands, in Area 12 and there are very few of them in the areas located along the coast of Prince Edward Island. It is not yet clear what the implications of this change in distribution are likely to be for fishing success in each of the areas in question. In the inshore Area 19, much smaller quantities of crab are expected to be available for harvesting in 1994 than were estimated to be available in 1992 and 1993 and abundance appears to have reverted to previous levels.

OUTLOOK FOR THE FUTURE AND HARVESTING SCENARIOS

Three levels of harvesting for 1994 are shown in the table below (similar values were presented by CAFSAC in 1992). The scenarios developed for the 1994 fishing season take into consideration both the biological characteristics of snow crab and present management practices. The present minimum size limit of a 95 mm CW ensures that all females taken will be returned to the water and thus serves to protect them. In the short term, given the numbers of males with large claws that are left on the fishing grounds, it seems to be safe to conclude that the eggs of all mature females will be fertilized. There are no grounds for assuming that the presence of larger numbers of males would enhance recruitment.

CRITERIA	1994 HARVEST	1994 EXPLOITATION RATE	BIOMASS OF CRABS WITH GREATER THAN 95 MM CW REMAINING AFTER THE 1994 FISHING SEASON
To maintain the 1994 harvestl at a value similar to the 1993	17,735 t	31.1%	50,486 t
To maintain the 1994 exploitation rate similar to 1993	25,788 t	37.8%	42,433 t
To maintain the biomass remaining after the 1994 season similar to 1993	39,288 t	57.6%	28,933 t

It is still difficult to quantify the prospective impact of the weak year-classes. The biomass of commercial-sized crab is currently high, and this may serve to buffer the effects of lower recruitment to some extent, at least in 1996. However, a post-terminal moult snow crab's life expectancy rarely exceeds five years, the shells of old crab soon become degraded in appearance, and the crab become dirty within an average time of less than three years. After their terminal moult, their numbers are reduced by natural mortality and their catchability also declined during the 3-4 years following terminal moult. To sum up, post-terminal moult male snow crab that are not caught during the first two years after they have become available for harvesting will subsequently become dirty, less readily catchable, and less numerous.

In view of the prospective decline in recruitment to the fishery, two possible approaches for the next few years are worth considering. Given the present state of our knowledge, the consequences of these approaches cannot be quantified, but they can be described in general terms.

Maximize catches over the short term. This approach would allow taking advantage, in the short term, of the abundant crab stocks which are currently available and which will decline in terms of both quantity and quality in the future. With this approach, good landings would be anticipated in 1994-1995; these would be followed by smaller landings containing progressively larger proportions of dirty crab in 1996-1997.

Spread out catches. If catches were deliberately held down in 1994-1995, it should be feasible to maintain a population of commercial-sized males with a variety of appearance and survival potential characteristics to serve as a buffer stock for the coming period of low recruitment to the fishery. Landings would be smaller in 1994-1995 than would be the case with the other approach, but they might well be larger in 1996-1997. However, it is important to bear in mind that the older the crab, the less attractive its shell in terms of appearance.

Table 1. Landings and TACs of snow crab in the southern Gulf of St. Lawrence, by fishing area.

	12		18		19		25+26		Total
	Catch (t)	TAC (t)	Catch (t)	TAC (t)	Catch (t)	TAC (t)	Catch (t)	TAC (t)	Catch (t)
1968	3,939								3,939
1969	2,580								2,580
1970	5,634								5,634
1971	5,374								5,374
1972	5,392								5,392
1973	6,969								6,969
1974	6,704								6,704
1975	4,632								4,632
1976	7,568								7,568
1977	9,537								9,537
1978	10,462				1,941				12,403
1979	15,794		213		1,390	1,406			17,397
1980	14,854		519		1,158	1,225			16,531
1981	21,877		494	835	913	1,004			23,284
1982	31,585		824	835	953	1,004			33,362
1983	24,342		822	835	906	1,004			26,070
1984	26,062	26,000	722	835	1,315	1,385			28,099
1985	25,158	26,000	537	835	1,234	1,385	802		27,602
1986	24,267	26,000	618	626	1,235	1,338	1,239		27,359
1987	11,782	26,000	626	626	1,151	1,150	457		14,016
1988	12,355		669	674	1,337	1,338	666		15,027
1989	7,882		666	674	1,334	1,338	747		10,629
1990	6,950	7,000	662	674[1]	1,333	1,338	546	500	9,491
1991	10,019	10,000	722	874[2]	1,337	1,338	615	600	12,693
1992	11,235	11,200	715	749[3]	1,678	1,686	783	800	14,411
1993	14,336	14,500	736	749[3]	1 678	1 686	800	800	17,550

[1]The spring fishing season in 1990 was interrupted by a conflict between groundfish and snow crab fishers, and later by the high occurrence of soft-shelled crab in the commercial traps. The remainder of the spring quota was therefore taken during the autumn fishery.

[2]In 1991, a quota of 200 tonnes was allocated for the spring season; a quota of 674 tonnes was allocated for the autumn 1991 and spring of 1992. Therefore, the table above indicates 874 tonnes for Area 18 for 1991 which includes the spring and autumn seasons of 1991 and the spring season in 1992.

[3]Similarly the 1992 TAC corresponds to the autumn 1992 and spring 1993 seasons and the season for 1993 corresponds to the autumn of 1993 and the spring of 1994.

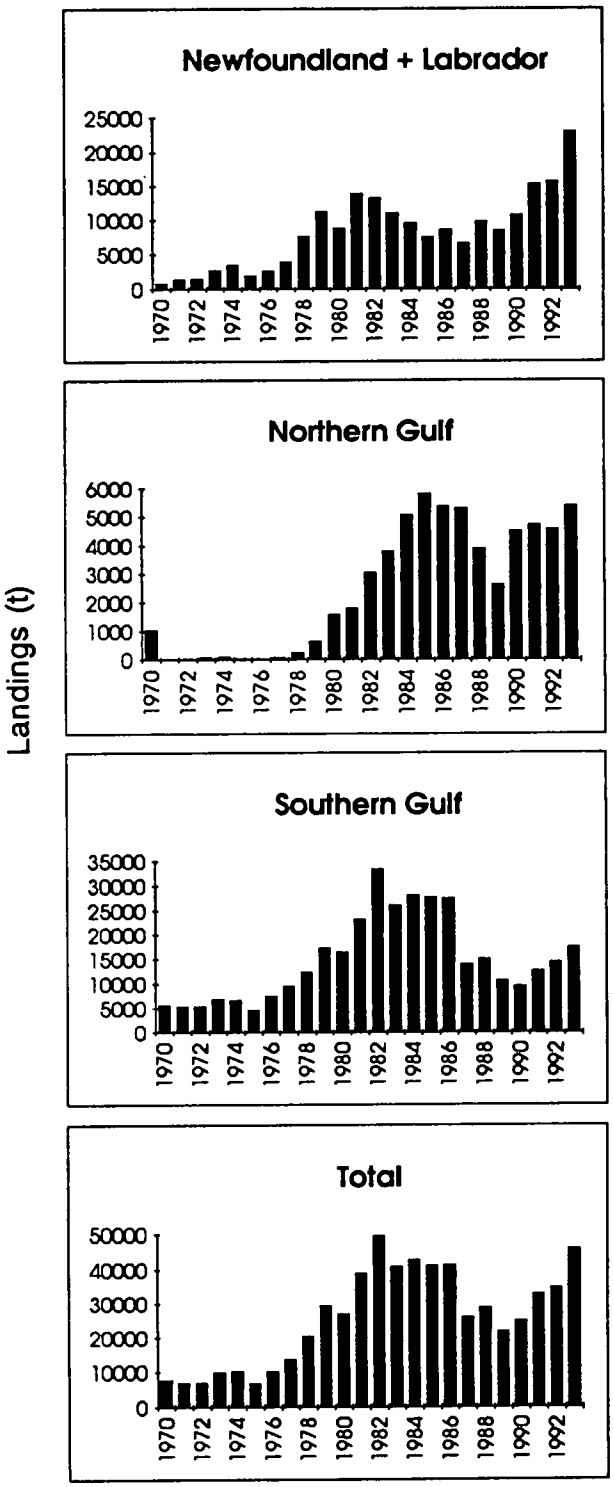


Figure 1. Snow crab landings on the Atlantic coast.

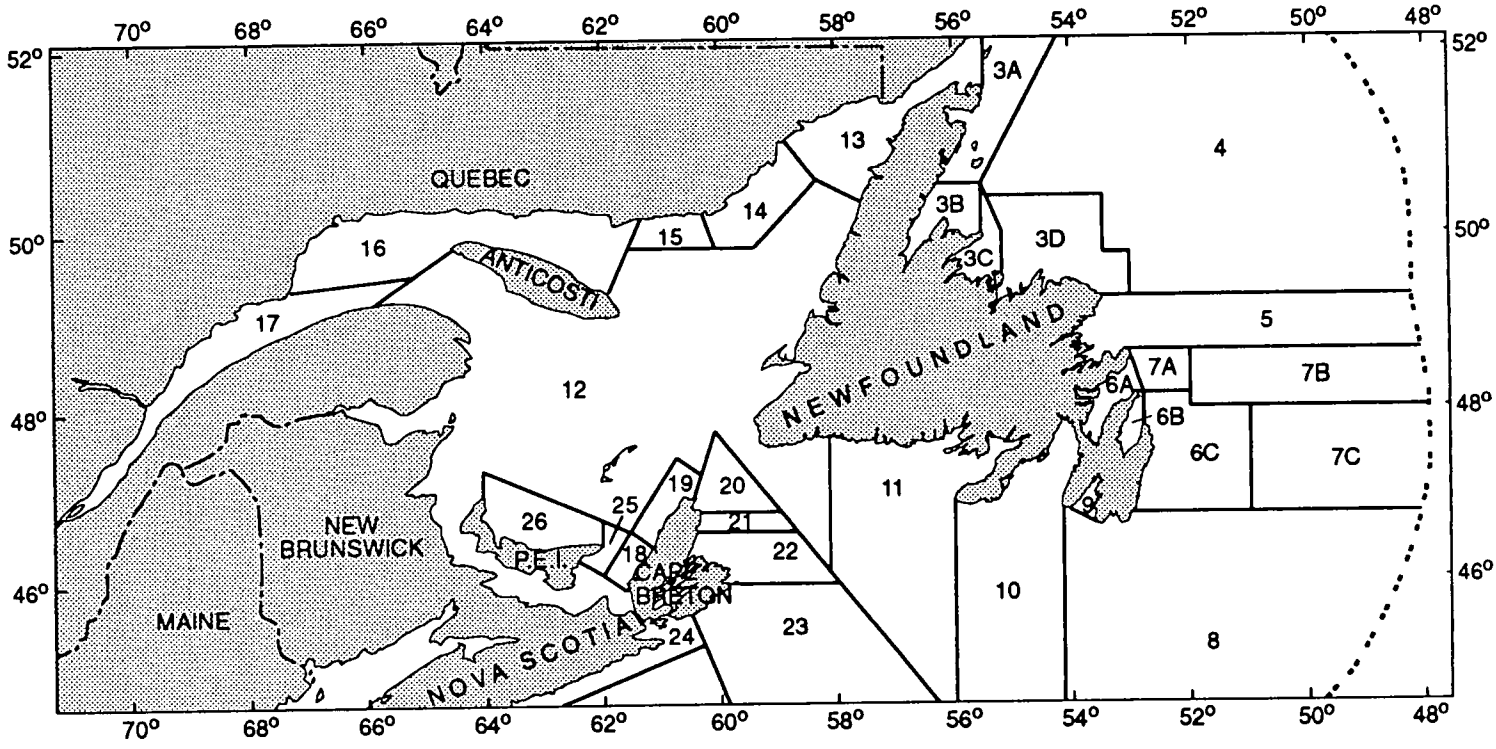


Figure 2. Snow crab fishing areas along the Atlantic coast

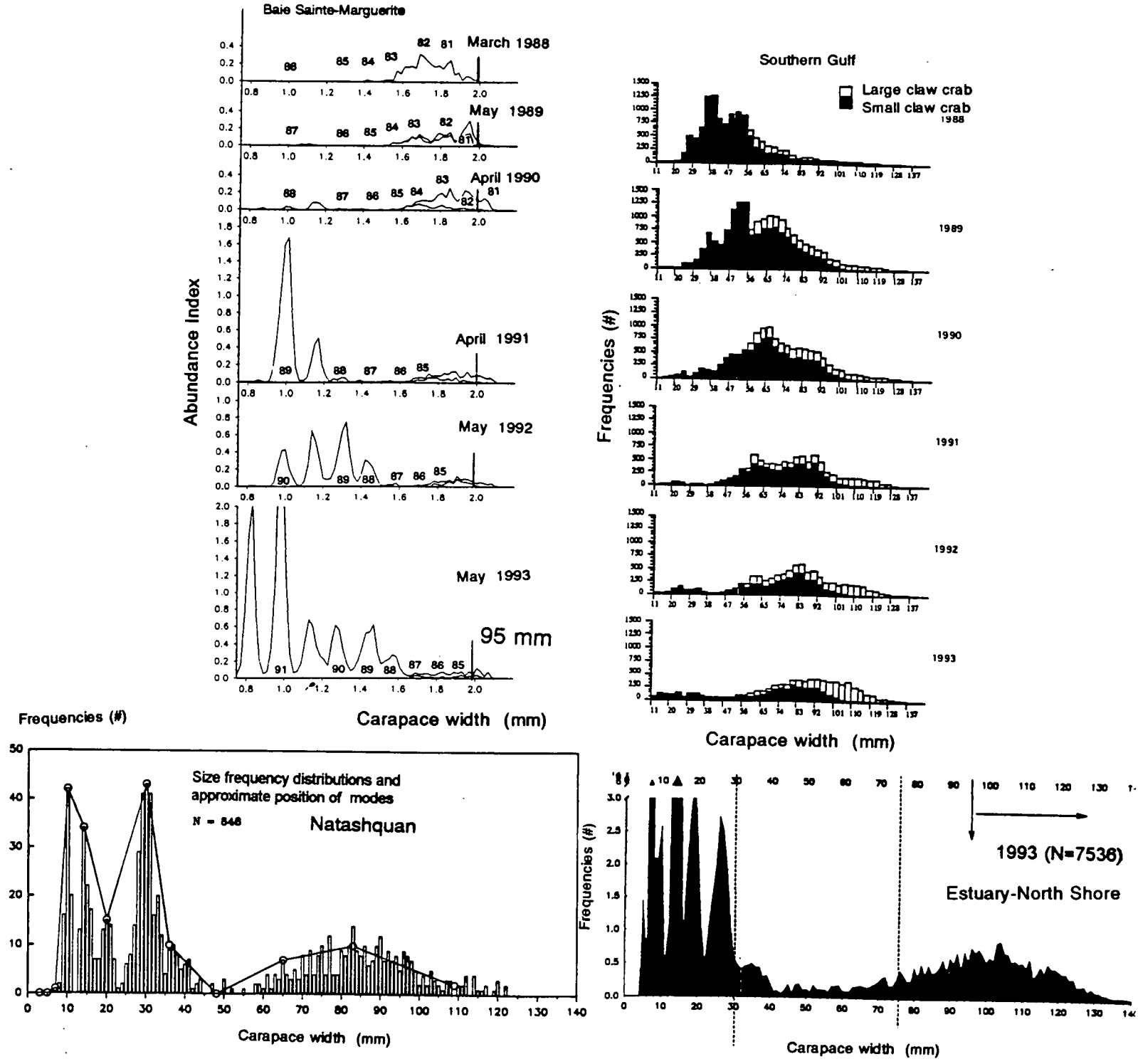


Figure 3. Size frequency distributions of crab taken with a bottom trawl during surveys carried out in the southern Gulf of St. Lawrence, the northern Gulf of St. Lawrence, and the St. Lawrence estuary .

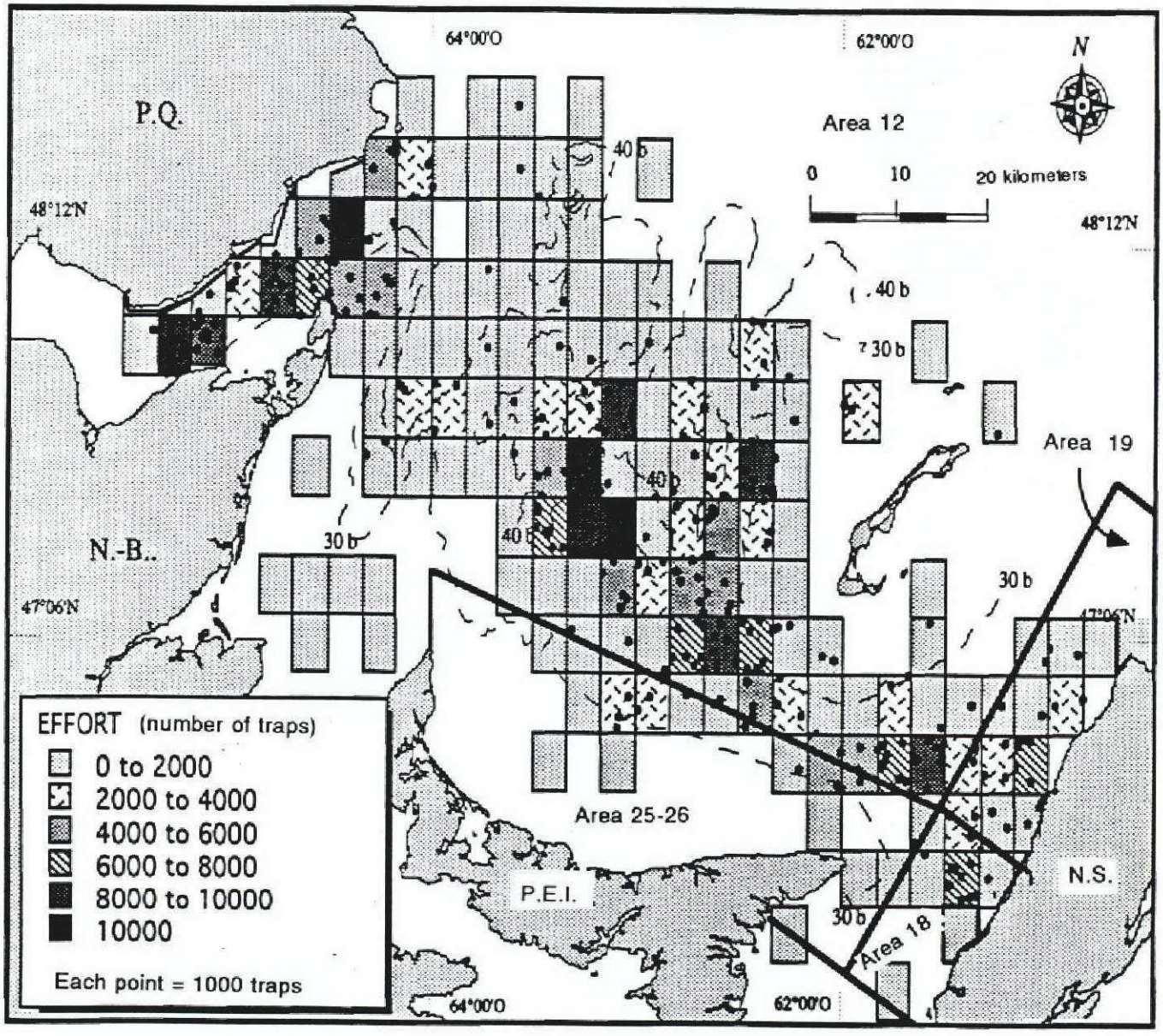


Figure 4. Distribution of fishing effort in the southern Gulf of St. Lawrence, 1993

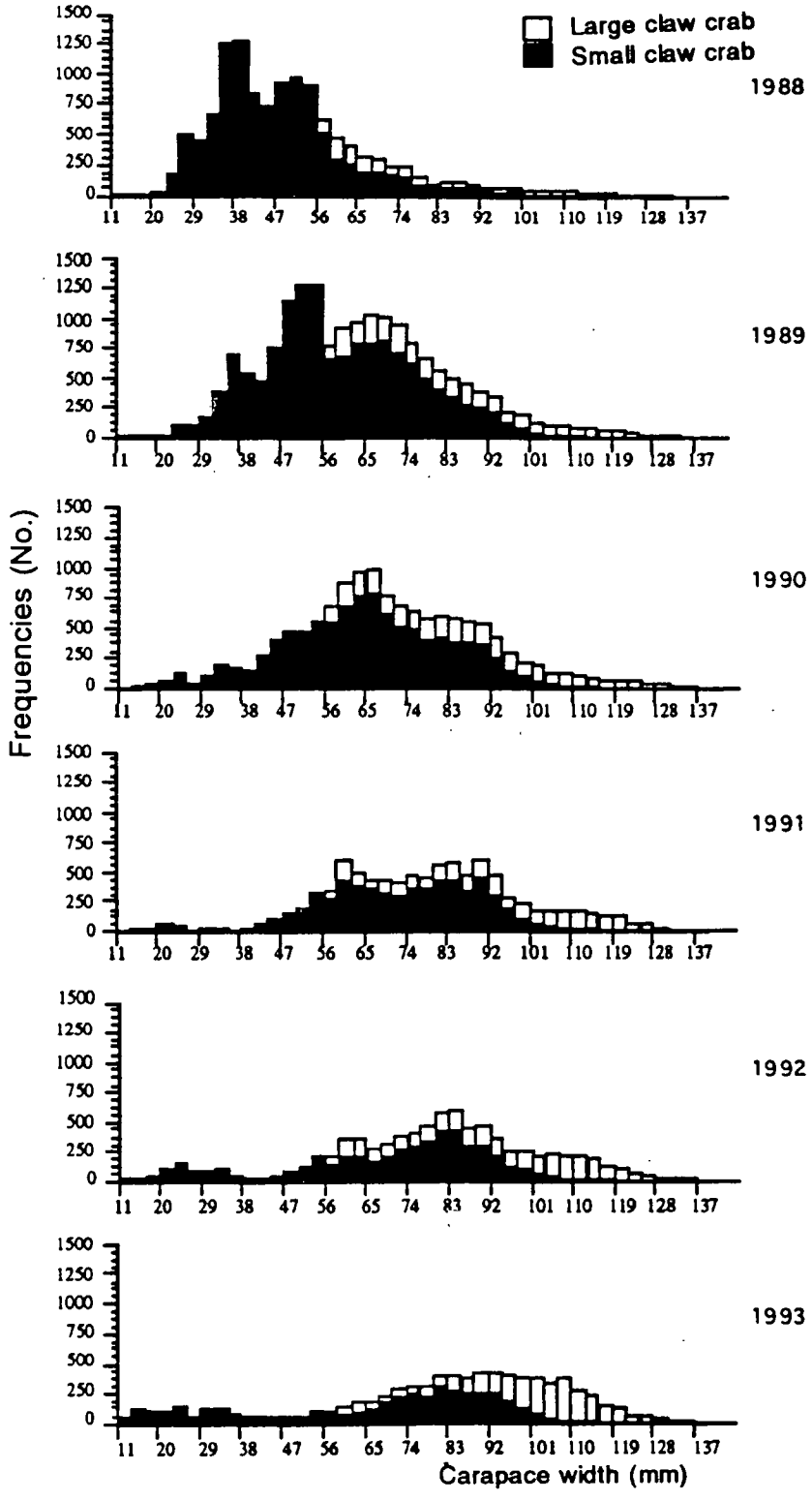


Figure 5a. Size frequency distribution for male crabs taken during the research surveys in the southern Gulf of St. Lawrence, 1988 to 1993

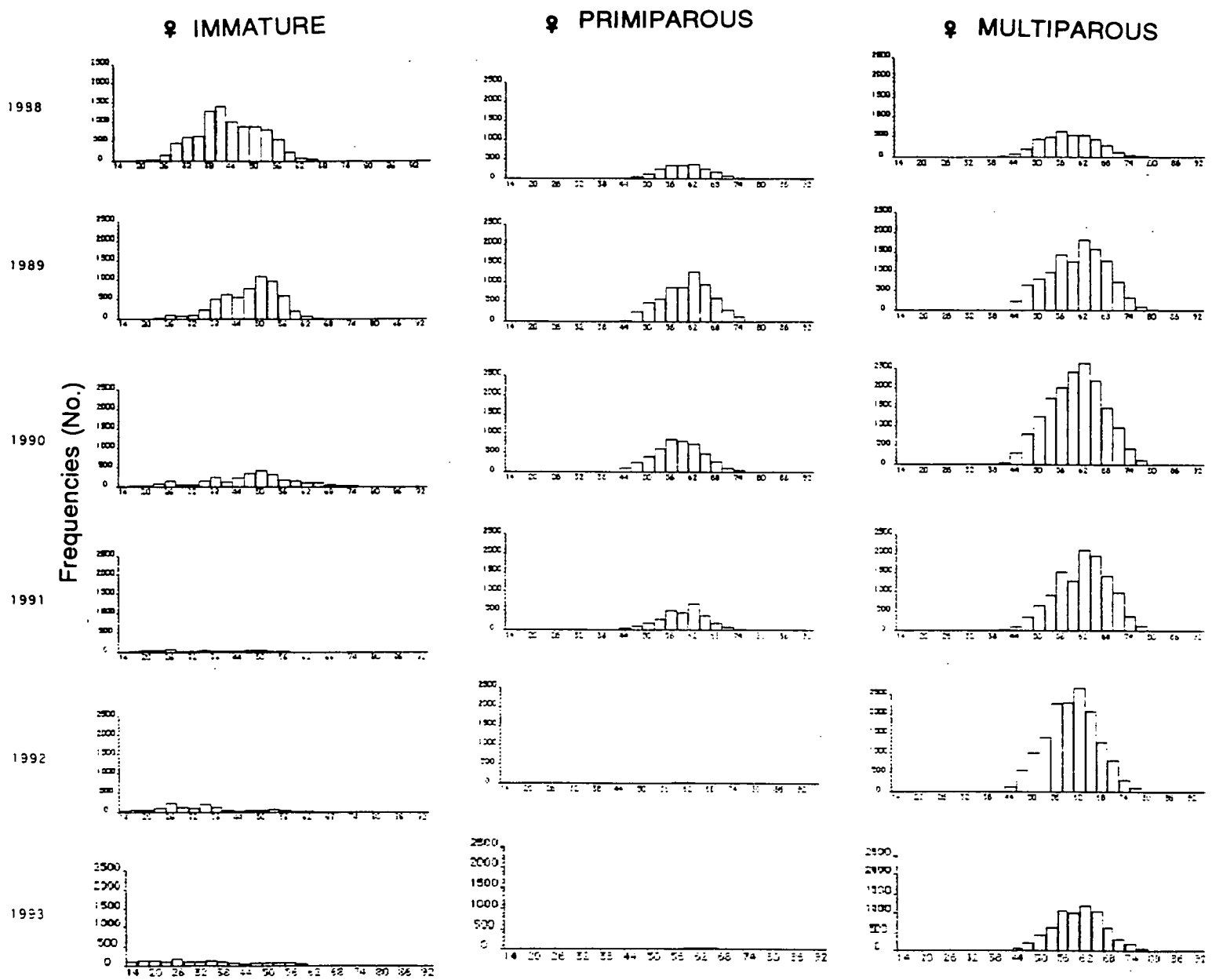


Figure 5b. Size frequency distribution for female crabs taken during research surveys in the southern Gulf of St. Lawrence, 1988 to 1993

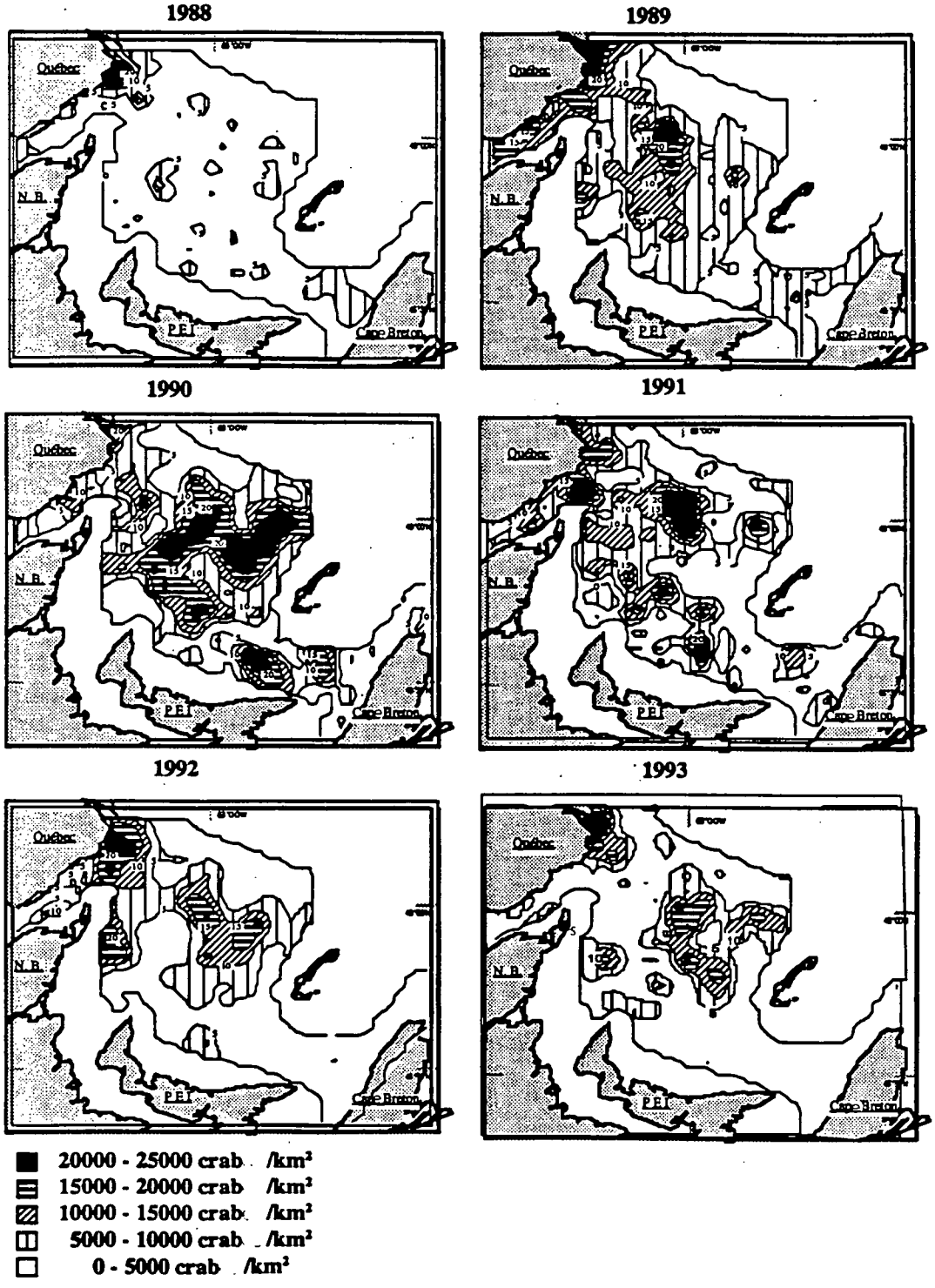


Figure 6. Density contours for crabs with small claws and a carapace width equal to or greater than 56 mm, as calculated by application of the kriging method to survey data from the period 1988 to 1993.

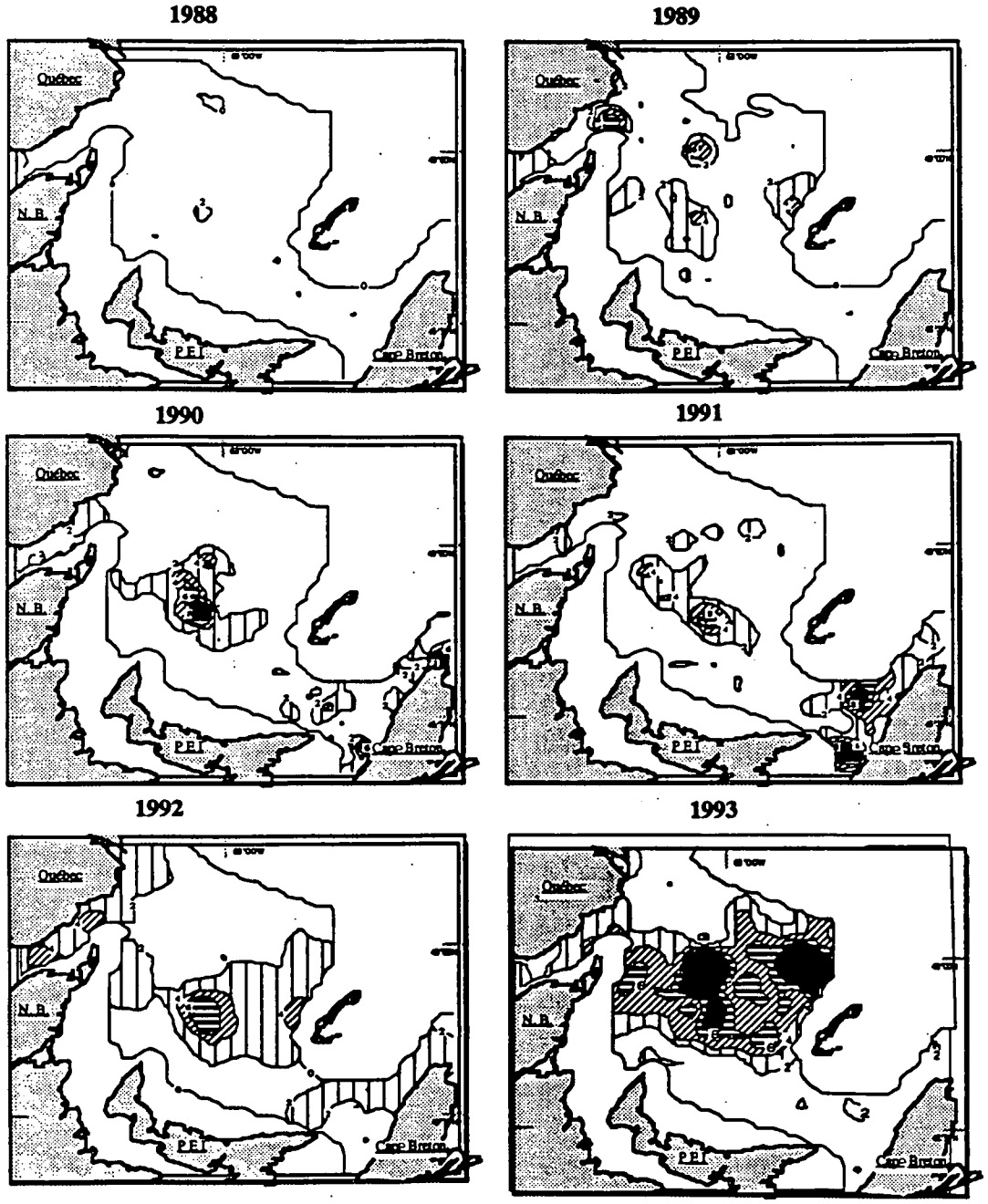


Figure 7. Density contours for crabs with large claws and a carpace width equal to or greater than 95 mm, as calculated by application of the kriging method to survey data from the period 1988 to 1993.