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Current knowledge on the commercially important invertebrate stocks (Lobster, Snow crab, and Sea Scallop) in the proposed oil and gas exploitation sites in the southern Gulf of St. Lawrence, Sydney Bight and adjacent area

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Abstract

A summary of current knowledge on the life cycle, the fishery, and the biology of the American lobster (*Homarus americanus*), the sea scallop (*Placopecten magellanicus*), and the snow crab (*Chionoecetes opilio*) in the proposed oil and gas exploration site (Western Cape Breton and Sydney Bight) and adjacent areas is presented. For lobster, moulting and mating seasons generally occur between July and September. Larval hatching and settlement occur in July-August and August-November, respectively. For scallop, the fertilization of gametes occurs in late August and spat settlement in late September to October. For snow crab, moulting occurs between December and March and mating in February and May. Larval hatching and settlement occur in May and August-October, respectively.

Within the concerned oil and gas exploration and adjacent area, lobster is commercially exploited in Lobster Fishing Area (LFA) 26B at depths shallower than 40 m, scallop in SFA 24 at depths from 20 to 40 m, and snow crab in Crab Fishing Areas (CFAs) 12 and 18 to 22 at depths between 50 and 200 m. Tag-recapture studies showed that lobsters are relatively sedentary, especially in LFA 26B, whereas an active movement pattern was observed in snow crab. For lobster, the commercial catches in LFA 26B have been stable around 1000 t since 1993. Although LFA 26B is a small fishable surface, it is the most productive LFA among the southern Gulf of St. Lawrence lobster fisheries. Scallop Landings in Scallop Fishing Area (SFA) 24 have been fluctuating between 100 t and 200 t since 1974. For snow crab, the exploitable biomass has been continuously increasing in CFA 19 since 1996 and exceeded the 6,000 t level in 2000 (survey year). In eastern Nova Scotia, the catch rate has been increasing significantly in the northern CFAs (CFA 20, 21, and 22) since 1996. No lobster fishing activities occurred within the proposed oil and gas exploration survey sites, whereas snow crab was actively exploited in both southeastern Gulf of St. Lawrence and Sydney Bight. In addition, both sites include important reproductive areas for snow crab (concentration of ovigerous females, juvenile males, and possible settlement sites of larvae). For lobster and scallop, the main habitat of post-larval lobster is far from the proposed seismic survey sites. Only during the planktonic larval phase, may lobster and scallop be found within the survey sites. No scientific information is available regarding the impact of the seismic survey on those three species. However, more direct and immediate impact, if any, may be expected on snow crab than on lobster or scallop.

Résumé

Le résumé des connaîssances actuelles sur le cycle de vie, la pêcherie et la biologie du homard d'Amérique (*Homarus americanus*), de la pétoncle giante (*Placopecten magellanicus*),, et du crabe des neiges (*Chionoecetes opilio*) dans la zone proposée du releve sismique et ses environs (sud-est du golfe Saint-Laurent et Sydney Bight) a été présenté dans ce document. Chez le homard, la saison de mue et de l'accouplement ont lieu, en générale , entre les mois de juillet et septembre. L'éclosion et la deposition sur le fond des larves ont lieu en juillet-août et au mois d'août à novembre, respectivement. Chez le pétoncle, le fertilization des gametes a lieu à la fin août et la deposition des naissants sur le fond vers la fin septembre et au début octobre. Chez le crabe des neiges la mue a lieu entre décembre et mars, et l'accouplement au mois de février et mai. L'éclosion des larves et la déposition sur le fond ont lieu au mois de mai et d'août à octobre, respectivement.

À l'intérieur de la zone proposée du relevé sismique et ses environs, le homard est commercialement exploité dans la zone de pêche du homard (LFA) 26B dans une profondeur de moins que 40 m, le pétoncle est exploité dans la zone de pêche 24 aux profondeurs entre 20 et 40 m, et le crabe des neiges dans la zone de pêche 12, et 18 à 22 aux profonduer entre 50 et 200 m. Les études eu marquage-recapture ont démontré que le homard est relativement sédentaire, spécialement dans la zone de pêche 26B, tandis que chez le crabe des neiges des movements actif ont été observés. Pour le homard, les débarquements commerciaux dans la zone LFA26B sont stable autour de 1 000 t depuis 1993. Malgré sa surface pêchable réduite, la LFA 26B est la zone la plus productive parmi les zones de pêches au homard dans le sud du golfe Saint-Laurent. Chez le pétoncle, les débarquement totaux (muscle de la chair) fluctuent entre 100 et 200 t depuis 1974. Pour le crabe des neiges depuis 1996, la biomasse exploitable continue d'augmenter dans la zone 19 et a dépassée le niveau de 6000 t en 2000. Dans l'est de la Nouvelle-Ecosse, le taux de capture également continue d'augmenter depuis 1996 dans la partie du nord (CFAs 20, 21 ,22). Aucune activité de pêche commerciale du homard a lieu dans la zone du relevé sismique proposée, tandis que le crabe des neiges a été la cible actif des pêches commerciales dans les deux sites (sud-est du golfe Saint-Laurent et Sydney Bight). De plus, les deux sites d'exploration font partie d'un zone de reproduction importante pour le crabe des neiges (concentration de femelles ovigères et de mâles juvéniles, et la zone possiblement une zone de recrutement des larves). Pour le homard et le pétoncle, l'habitat principale des stades post-larvaires se trouve loin de la zone du relevé sismique proposée. Il est cependant probable que durant la phase larvaire planctonique des larves de pétoncle et de homard s'aient presenté sur le site proposée. Aucune information scientifique est disponible concernant l'impact du relevé sismique sur les trois espèces. Cependant l'impact le plus direct et immediat, s'il y a lieu, pourrait être possible chez le crabe des neiges comparé aux homard ou pétoncle.

Introduction

Seismic exploration is used by the offshore oil and gas industry to evaluate the underlying geological structure by transmitting sound beams through the water column and into the ocean bottom. There are many questions regarding the behavioural and physiological effects of seismic sounds on marine animals, e.g., the effect on the catch performance of commercially exploited species, the global effect on the ecosystem, the long-term effect on marine resources; yet no conclusive evidence of any effect has been demonstrated. Some studies showed that seismic surveys affect short-term groundfish catchability (Engås et al., 1996) and long-line catch rate (Løkkeborg, 1991) due to the change in the availability of resource. Other studies (all in grey literature) showed no effect on the invertebrates, e.i., no mortality and no evidence of reduced catch rate for brown shrimp by the airgun beam with 190 dB in water depth >1 m, no mortality on clam with an array of 16 airguns (250 dB). Our preliminary reference search showed a major gap in the literature on potential effects of seismic surveys on the behaviour and distributions of large invertebrates, particularly crustaceans. The commercial landings of snow crab (*Chionoecetes opilio*) and American lobster (*Homarus americanus*) account for more than 65% of the value of all species caught in Atlantic Canada for the last 5 years. Within the proposed oil & gas exploration site, i.e., western Cape Breton and Sydney Bight area, lobster is exploited in LFA 26B (Fig. 1), sea scallop (*Placopecten magellanicus*) in SFA 24 (Fig. 2), and snow crab is exploited in SCFA 12, 12F, 18-19 (Western Cape Breton), and 20-22 (Eastern Cape Breton) (Fig. 3). There are some other potentially exploitable invertebrate species or currently exploited species with a low level of landings in the southwestern Gulf of St. Lawrence, e.g. toad crab (*Hyas araneus* and *H. coarctatus*), northern stone crab (*Lithodes maja*), rock crab (*Cancer irroratus*) and whelk (*Buccinum undatum* and related species). However, the current level of knowledge on the biology and fisheries of those species is limited.

In this document, we present the current fishery status, resource distribution, and life cycle of the most important commercially exploited species (lobster, scallop, and snow crab) to identify the sensitive area within the proposed seismic survey site and the critical period of life cycle for each species.

Current knowledge

(1) American Lobster

(1-1) General description of the species and their life cycle (Fig. 4)

The American Lobster inhabits the length of the Atlantic coast from North Carolina to Labrador. In Canadian waters, lobsters may be fished in deep waters (e.g., near Georges Bank), but the most important concentrations are generally observed within 20 km from the shore. In the southern Gulf of St. Lawrence, lobsters are found in depths ranging from 1 to 40 meters. Although the species has a preference for hard substrate with shelters, it is often found on sandy and muddy bottoms.

The life history of the lobster can be divided into benthic and planktonic phases. The planktonic phase starts after the hatching of the eggs during the months of July and August. The larvae will go through the free-swimming period lasting from 3 to 10 weeks depending on environmental conditions. The planktonic phase ends when the larvae settle on the substrate. After 5 to 6 years of growth, female lobsters in the southern Gulf of St. Lawrence become sexually mature. The size at which 50% of the female lobsters in the southern Gulf of St. Lawrence are sexually mature ranges between 70 and 72 mm in carapace length. For males, sexual maturity is achieved at smaller sizes (younger ages) than females. Mating occurs between the months of July and September. Generally, female lobsters will follow a 2-year cycle of egg production, alternating moulting and spawning. In a typical cycle, female moult and mate during the same summer. The eggs are extruded one year after and attached to pleopods under the abdomen for nearly another year. This cycle may vary with the fluctuating environmental factors and especially, with the age of the female.

(1-2) **Movement** (Fig. 5)

The first lobster tagging study in the southern Gulf of St. Lawrence was conducted in the 1930's (Templeman 1935). Tagging studies have always been a major interest to fishermen. Over the last 20 years, more than 50,000 lobster were tagged and released in the southern Gulf. These studies demonstrated that the average movement of lobster was within 15 km from their release sites (Conan *et al.* 1982; Maynard and Chiasson 1986; Maynard *et al*. 1992; Comeau *et al.* 1998, 1999; Comeau and Savoie, 2002). These observations are similar to the ones obtained in the Magdelan Islands (Templeman 1935; Montreuil 1953, 1954; Bergeron 1967; Dubé 1984). A review of past tagging studies in the southern Gulf can be found in Comeau and Savoie (2002). Seasonal movements to shallow waters in the summer and back to deeper waters during the cold season were documented (Munro and Therriault 1983) and are well known movement patterns by fishers.

A total of 42,445 American lobsters (*Homarus americanus*) was tagged in thirty-one sites throughout the southwestern Gulf of St. Lawrence between 1980 and 1997 (Comeau and Savoie, 2002). Results from the recapture of 8,503 tagged lobsters showed small distances traveled between the release and the recapture position for animals ranging in size from 51 to 152 mm of carapace length. The average distance traveled ranged from 2 km in parts of the Baie des Chaleurs, and western Cape Breton to 19 km in central Northumberland Strait. Movements were generally along the shore with 93% of the dispersion in areas between the shore and the 20 m bathymetric contour. As a result, lobsters traveled longer distances in sites characterized by a gradually sloping bottom where the distance between the shore and the 20 m contour line was extensive in comparison with areas characterized by rapidly changing depths and relatively small amount of habitat shallower than 20 m. In the majority of sites (14 of 19), there was no significant difference between males and females in the average distance they traveled. In four of the five sites, females moved farther than males. In general, the average distance traveled by berried females was shorter than males or non-berried females. No relationship was observed between the distance traveled and the size of the animal.

There was no strong evidence of a relationship between the average distance traveled and the number of days at liberty. In general, lobsters in the southwestern Gulf of St. Lawrence traveled short distances with a dispersion restricted to the near-shore habitat especially in LFA 26B, where 9,744 lobsters were tagged and 2,724 were recaptured.

(1-3) Commercial Fisheries (Lanteigne et al., 1998)

The Canadian lobster fishery began in the mid 1800's. During a short period corresponding to the transition between the 19th and the 20th century (Fig. 6), high lobster catches were reported in the southern Gulf of St. Lawrence. With the expanding fishing effort, these years of good catches were rapidly followed by an overall decline in landings in the early part of the 1900's. Annual catches decreased from 15,000t annually in 1895 to approximately 8,000t level between 1915 and 1975. It is only in the mid 1970's that lobster landings in the southern Gulf of St. Lawrence regained in strength, reaching record high landings of 22,000t in 1990. The factors responsible for the extraordinary catch increase in the last 30 years is not well understood. It is thought that the overall fishing power substantially increased when economic and technological developments took an accelerated pace after the Second World War. However, this alone cannot explain the magnitude of the increase that was seen over the geographical range of the American lobster, from North Carolina to Labrador. Favorable environmental factors are believed to have favored the survival of lobster recruitment over its entire geographical range. Over the years, the lobster fishery has become, and is still, a major factor in the social and economic development of communities along the Atlantic coast, and especially to communities surrounding the Gulf of St. Lawrence.

The southern Gulf of St. Lawrence lobster fishery management regime is based on effort and size control in five management areas or Lobster Fishing Areas (LFA). LFA 26B is opened for spring (May-June) with the minimum carapace size limit at 70 mm CL (carapace length). The lobster fishing effort is also controlled by having the trap as the only fishing gear authorized, and by having a maximum gear dimension (125 cm in length, 90 cm in width et 50 cm in height). Furthermore, it is required to have an escape mechanism installed on each trap, allowing under-size lobsters to escape the fishing gear. The regulation on the escape mechanism dimension stipulates a minimum opening of 127 mm in width and 38.1 mm in height. In LFA 26B, fishermen are allowed to use up to 300 traps.

Major elements of the 1997 lobster fishery management regime for Lobster Fishing Area 26B

Lobster Fishing Area (LFA)	Minimum carapace size	Fishing season	Number of license holders *	Maximum number of traps/fisher
LFA 26B	70.0 mm	May – June	256	300

* 1997 census

Commercial lobster catches in the southern Gulf of St. Lawrence have shown a sharp increase since 1974 from 5,594 t landed to a record high of 22,063 t in 1990 (Figs. 6-7). This represents a four folds increase during a 16-year period. However, since 1990, landings in the southern Gulf have shown a steady declining trend. In 1997, 16,413 t of lobster were landed which represent a 25% reduction from the peak landing in 1990. The increase in catches has been observed in all LFAs, though there are some variations in the year of peak landing. Furthermore, the declining trend is not observed with the same amplitude in all LFAs. In 2000, 3,276 license holders in Lobster Fishing Areas 23, 24, 25, 26A and 26B (southern Gulf of St. Lawrence) caught 16,413 t of lobster for a landed value of more than $170 million.

Lobster landings (t) by Lobster Fishing Area (Figs. 6-7).

LFA	1980-89 Avg.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
23	2,463	4,508	4,186	4,257	4,486	4,111	4,069	3,784	3,467	3,453	3,752	3,740
24	3,090	4,591	5,109	4,605	4,732	4,830	5,083	4,604	4,757	4,959	5,079	5,183
25	4,764	5,320	4,770	4,578	4,100	4,572	4,360	4,239	3,784	3,844	3,946	3,541
26A	4,389	6,363	5,844	4,594	4,686	3,480	3,536	3,720	3,481	3,804	3,554	3,903
26B	977	1,281	1,543	1,411	1,455	1,110	1,152	1,126	1,079	1,098	1,068	1,117
Total	15,683	22,063	21,451	19,444	19,459	18,103	18,200	17,472	16,568	17,158	17,398	17,494

Lobster catch information for the southern Gulf of St. Lawrence can be dissected further into their different size categories. These categories have been industry standards for decades and are defined as canner size (from the minimum legal size to < 81 mm) and market size lobster (≥ 81 mm). The ratios of these size categories (percentage of canners in weight) provide valuable information on fluctuations of the different size groups over the years. In 1984, landings in all LFAs showed relatively similar percentages of canners by weight ranging from 63% to 85% in LFA 26A and 25, respectively. With a period of good recruitment into the fishery and increasing catches, percentages of canner size lobster also increased. This increase was most evident in LFA 24 where the percentage of canners reached 91% in 1990. The LFA 25 was the area that presented the most important reduction with a decrease from 85% canner in the catch of 1995 to 76% in 1997. The percentage of canners in the LFA 26B stayed relatively stable as in LFAs 23 and 26A during this period.

(1-4) Resource status

Productivity: By using lobster landings and the approximate surface (km^2) of potential fishing ground in each LFA, it is possible to obtain a crude estimate of the productivity for each management area. The total potential surface of fishing ground is comprised between the 1 and 20 fathom depth contours. To be comparable from year to year, this calculation assumes that no major changes in the fishing ground surface (reduction or increase) occurred during the time period considered.

Estimated fishing ground area (area between the 1 and 20 fathoms depth contour in km^2) by LFA .

Lobster Fishing Area (LFA)	23	24	25	26A	26B
Area in km^2	4,625	2,249	4,394	4,530	613

The productivity by LFA can be used as a crude biomass index. In recent years, two LFAs are emerging as the most productive fishing grounds; LFA 24 and 26B. Since

1990, productivity values for these LFAs have increased, ranging between 1.8 and 2.5t of lobster per km^2. During the same period, the other LFAs have shown a steady decline with values ranging between 0.7 and 1.0 t of lobster per km^2. For the entire period observed (1984 to 1997), LFA 26B have maintained the highest or second highest productivity value. This same LFA has also the smallest fishing ground area and went through the most important increase of the minimum legal carapace size from 63.5 mm to 70 mm (the 2nd largest in the southern Gulf).

<u>CPUE:</u>

For a LFA, the weekly catch per unit of effort (CPUE) was calculated as the average weekly CPUE of all the index fishermen in that LFA. For a particular fisher, the weekly CPUE is given by the total landings for that week divided by the total trap hauls. The number of index fishermen varied between 1 (1993) and 13 (1995) in LFA 26B. For LFA 26B, the CPUE pattern and values (Fig. 8) are quite similar to those observed in other LFAs (23, 24 and 26A). For all LFAs, the variation in weekly CPUE between index fishermen is fairly large.

<u>Exploitation rate:</u>

Ports were combined with respect to fishing habits; the habitat and the bottom type form 23 homogeneous fishing areas. The Leslie method (Ricker, 1975) was applied to the index-fishermen information. When the relationship between CPUE and cumulative catch did not show a negative linear trend (i.e. a minimum necessary condition for the validity of the Leslie analysis), the estimate was not done. The exploitation rate estimates for LFA 26B and years where the method seemed to hold are presented in the table below. Within the years and areas where the underlying assumptions of the Leslie analysis were met, exploitation rates varied between 75% and 86% for LFA 26B. These values confirms the high levels found in earlier studies (DFO, 1996).

Exploitation rate estimates and ranges (in parenthesis) using the Leslie method, for areas and years that meet the underlying assumptions.

		Estimates of exploitation rate (%)			
LFA	Area (combined ports)	1994	1995	1996	1997
26B	Chéticamp, Grand Étang La Pointe, Margaree	83 (77 – 89)	-	86 (80 - 92)	-
26B	Inverness, Little Judique Harbour, Murphy's Pond, Baxter's Cove, Mabou Harbour, Por t Hood	82 (77 – 86)	-	75 (58 - 88)	-

<u>Outlook:</u>

With minimum carapace size increases in all LFAs (with the exception of LFA 26B) as part of the 4 year management plan (1998-2001), catches in the southern Gulf were expected to be somewhat lower than in 1997. However, overall landings for the 1998 spring fisheries were as good if not better than in 1997. There are indications this period of high catches may not last very long. On a large geographical scale (southern

Gulf), the trend has been a steady decrease in catches since the extremely high landings of the early 1990's. The concerns about the high fishing mortality, high fishing effort, increasing fishing power, and low egg production still exist. Over the longer term, the management changes announced in 1998 should help increase the egg production of the lobster population and reduce the risk of recruitment declines if environmental conditions become unfavorable.

For LFA 26B, the general trend of lobster commercial catches fluctuations is similar to the overall trend for the southern Gulf. It is thought that the numerous management measures taken since the mid 1980's, and especially the implementation of the largest minimum legal size in the Gulf Region (70 mm) have been promoting factors for these good years of lobster production. Although landings have been slowly declining since the 1990's, catches are still above the average annual catch of 500 t that prevailed prior to 1980's. There is presently no assessment that may allow any catch or trend predictions in the lobster fishery. As for the other LFAs, the concerns about the high fishing mortality, high fishing effort, increasing fishing power, and low egg production still exist.

(2) Sea Scallop

(2-1) General description of the species and their life cycle

The seascallop , a bivalve mollusc found in the Atlantic coastal waters, has a range from Cape Hatteras to the Strait of Belle Isle. There are male and female scallops and the sex ratio is 1:1. Sexual differentiation occurs at an age of 1+ years and most scallops are sexually mature at a shell height of 70 mm; however, they do not contribute significantly to the population dynamics until they reach a length 80 mm (approximately 6-7 years old) (Fig. 9). In the Northumberland Strait, the male and female scallops release the eggs and sperm between the mid to the end of August. Fertilization occurs in the water column and the young scallop larvae, commonly referred to as spat, are free swimming for 4 to 5 weeks. At the end of their larval development, they swim near the bottom and attach themselves with their byssal threads to a suitable substrate, and begin their bottom dwelling life (Fig. 9). Scallops tend to aggregate. The areas where scallops are found in high densities are referred to as beds (Fig. 10). Scallop beds are usually found at depths of 20 to 40 meters; however, scallops can be found in water as shallow as 2 meters. Scallop beds often are located on rocky, gravel-sand, or sandy bottoms and occasionally scallops are found on muddy bottoms.

(2-2) Commercial Fisheries

For management purposes, the southern Gulf is divided into four areas: Scallop Fishing Area (SFA) 21, 22, 23 and 24 (Fig. 2). The area under review is the SFA 24. PEI and NS fishermen share the SFA 24. Presently, the scallop fishery in the SFA 24 is a fall fishery only, from October 29 to December 15 in 2001. The fishery takes place between 06:00 hours until 18:00 hours daily, and is closed on Sundays. The scallops are fished using a Digby type dredge. The dredge is dropped to the bottom and towed for 10 to 15 minutes. The dredge is emptied on the dumping board of the boat. The scallops are removed and shucked, and the rest of the material that was dredged up is returned the sea.

There are approximately 390 scallop license holders in SFA 24. Scallop landings in the SFA 24 have been recorded since the 1940's. The peak landings were recorded in 1970 at just over 400 t of meat. Recorded landings in SFA 24 have been below 200 t since 1972 and occasionally below 100 t of meat (Fig. 11).

(2-3) Scallop Enhancement

In 1998, the SFA 24 fishermen from PEI and NS have participated in a Scallop Spat Survey. Determining the location of potential commercial scallop spat sites is the first step towards scallop enhancement. Potential commercial scallop spat sites have been located from Merigomish Island to Cape George Point, St. Georges's Bay, and along the western coast of Cape Breton. (Fig. 12).

(3) Snow Crab

(3-1) General description of species and their Life Cycle (Fig. 13)

Snow crab is present in Northwest Atlantic Ocean from west Greenland to the Gulf of Maine, where only a few individuals have been reported (Squires, 1990). This species is common in the estuary and the Gulf of St. Lawrence, around the Cape Breton Island and the bays of Newfoundland. Snow crab lives most commonly on muddy or sand-mud bottoms (Powles, 1968; Elner, 1985) at temperatures ranging from –1 to 4.5°C (Powles, 1966). They are found at depths of 20 to 420 m. In the Gulf of St.Lawrence, they are usually found at depths of 70 to 140 m, while in Cape Breton the depth varies from 45 to 245 m. The fully grown male is almost twice as large as the female, reaching a maximum shell width of 165 mm and a weight of 1.35 kg. The average size crab in the commercial catch measures approximately 110 mm and weighs 0.5 kg. Females grow to a maximum of 95 mm shell width, with a weigh of 0.45 kg. They are not commercially exploited.

Male snow crab develop in three steps: Immature with non-functional reproductive organs; Adolescent, with functional reproductive organs, but with undifferentiated claws; and finally Adult, with functional reproductive organs and differentiated claws (Comeau and Conan, 1992; Saint-Marie et al., 1995). Immature males reach the adolescent level after the puberty moult. Spermatogenesis (production of sperm) begins and a slight increase of claw size is noted (Comeau and Conan, 1992). Finally the terminal moult (with large claw) occurs at the end of winter or in spring (Moriyasu et al., 1987; Sainte-Marie and Hazel, 1992). By the following spring, they rebuild their shell and mate with females that have reached the terminal moult. Female snow crab also develop in three steps: Immature with narrow abdomen and without apparent ovaries; Pubescent with narrow abdomen and with apparent ovaries; and finally Adult, with large abdomen for carrying eggs and fully functional ovaries. There are two types of mature females, those that have just moulted to maturity and have a soft shell (first spawners called primiparous), and those with a hard shell that have hatched their eggs (second or more spawners called multiparous). In the estuary and Gulf of St. Lawrence and in the Atlantic, females reach maturity in winter and early spring (Moriyasu et al., 1987; Alunno-Bruscia and Sainte-Marie, 1998).

Both males and females stop growing after the moult through which they reach maturity, called the terminal moult. The mating period of the female with a hard carapace begins between April and May. The male crabs fight with the other males to obtain the female. Once acquired, the male protects the female by seizing her with one claw and uses the other claw to ward off other males. Generally, the largest male has the greatest chance of obtaining a female. Females with a soft carapace release a chemical (called a pheromone) that attracts the males for mating. For this type of mating, the males do not fight much because the soft females could not survive the altercations. However, many females were found to be killed by male-male fighting prior or during the copulation period.

A female has two sacs inside of her body that can store sperm after mating. She can use this stored sperm to fertilize later batches of eggs if she does not meet a male during subsequent mating periods. The female produces eggs that are carried beneath the abdomen for approximately two years. Depending on her size, a female can produce between 12 000 and 130 000 eggs/clutch (Elner and Robichaud, 1983; Davidson et al., 1985). The eggs usually hatch in late spring or early summer (Moriyasu and Conan, 1988; Moriyasu and Lanteigne, 1998). The newly hatched crab larvae can spend 12 to 15 weeks floating freely in the water column before they settle to the bottom of the ocean (Lanteigne, 1985). After settlement, they moult immediately and finally become the shape of a small crab. It takes at least 8-9 years before the male snow crabs reach the commercial size of 95 mm.

(3-2) Seasonal movement (Figs. 14-15)

The data presented here are preliminary and the last data entered are from September 15, 2000. The number of recaptures for each release site was dependent on the number of specimens tagged. But it also depended on the location of the release site (within or outside usual fishing grounds), on the timing of the release (before, during or after the fishery), and on the exploitation rate of given area. The rate of tag loss or mortality associated with tagging was uncertain. This rate was in part dependent on the time of the year the tagging occurred (e.g. a cold or hot day), and on the experience of the person doing the tagging. A tag tied too loosely could be lost, but those attached too tightly may kill the crab. The tagging study also suggested that crab tend to move around between Areas 18-19-12F-20 and adjacent Area 12. Although there was a limitation in the interpretation of tag-recapture results: 1) tagging gave only point A (release) and B (recapture), but not real movement in between, 2) the recaptures were limited to fishing location of any given year, and 3) the tag return and mortality rates were unknown; it may have provided a general tendency of crab movement over years.

The tagging study was not conducted every year, which did not allow us to evaluate the tendency relative to the stock condition. However, tag-recapture results showed that crabs tagged in the peripheral areas during the period of decreasing biomass (southern part of the Magdalen channel in 1999 and the Dumping ground and Irving Whale regions in 1997), a general movement was found towards the main habitat, center of Bradelle Bank (Fig. 14). In Areas 18 and 19, tag-recapture experiments were conducted during two different phases of stock condition: decreasing biomass phase in 1993-1996 and increasing biomass phase in 1997-2000. During the decreasing biomass phase, crabs tended to stay within Area 19, whereas crabs tagged during the increasing biomass phase tended to move greater distance, even outside the Gulf towards eastern Cape Breton (Area 20-22), (Fig. 15). There were some crabs tagged in eastern Cape Breton that were recaptured in the western Cape Breton, showing a high movement of adult crabs in this area. It is clear that a frequent exchange of crab exists in southeastern part of Area 12 (former Area 25 and southern part of corridor between Cape Breton Island and Magdalen Islands), as well as between western and eastern Cape Breton Island (Areas 18-19 vs 20-22). M However more studies are necessary to better understand the dynamics of snow crab in the southwestern and southeastern regions of the southern Gulf, e.g. movement of crab towards Area 19 relative to the abundance of commercial size crab within and outside of the Area.

Summary of Snow Crab Tagging Projects between 1993 and 2001

year	Location/titre	# of crabs	# of returns
1993	Area 19	558	67
1994	Area 21-22	870	182
1996	Area 12 / F	745	291
1996	Areas 23, 24 / Fishermen' projects	(250)	21
1997	Area 12 / Dumping ground	400	86
1997	Area 12 / Irving Whale	329	30
1997	Areas 20, 21, 22 / Fishermen' projects	(250)	7
1998	Area 19	595	57
1998	Area 24 / Chedabucto Bay	247	6
1999	Areas 23, 24	500	1
1999	Area 18	360	23
1999	Area 12 / Prince Edward Island	287	45
1999	Area 12 / Magdelen Shallows	757	54
1999	Area 12 / Chaleur Bay	287	19
2000	Area 19	731	23
2000	Area 20	258	17
2001	Area 24	234	4
2001	Area 24	698	8
2001	Area 24	471	5
2001	Area 24	309	8
Total	*All areas*	*9156*	*954*

(3-3) Southern Gulf of St. Lawrence Fisheries

Commercial exploitation: (Hébert et al. 2001)

The snow crab fishery in the southern Gulf (Fig. 2) began in 1966. Currently, there are 3 fishing areas (12-18-19) and 2 exploratory zones (E-F). Area 12 is the largest fishery in the Gulf of St. Lawrence and is exploited by inshore and mid-shore fishermen from New Brunswick, Quebec, Prince Edward Island, and Nova Scotia. Fishermen usually use rectangular, pyramidal, or conic traps made of steel rods and covered with propylene netting. The fishery takes place in the spring in Areas 12, E, and F, and in late summer in Areas 18 and 19. Neither soft-shelled (<68 durometer units) nor white crabs (newly molted) are commercially exploited. The fishing grounds along the west coast of Cape Breton were initially fished by a group of fishermen based in Cheticamp. Subsequently, fishermen from Quebec and New Brunswick sporadically fished in the area. With the increase in the commercial value of snow crab in the late 1970s, the fishery gradually expanded to cover all fishing grounds along the west coast of Cape Breton.

Area 18 as a separate zone was fished for the first time in 1979 by 14 inshore vessels with exploratory licenses and a trap limit of 30 traps per license. In 1984, Area 18 was reserved exclusively for inshore fishermen. Since 1992-93, 30 fishermen have participated in this fishery. The overall quota, which had initially been set at 835 t in 1981, varied between 626 t and 749 t until 1995. Due to the declining trend in biomass, the quota level was reduced significantly since 1996 varying from 340 t to 580 t.

Area 18

Year	1995	1996	1997	1998	1999	2000
Quota	705	340	580	411	408	476
Landings	693	306	406	289	407	472
CPUE	33.5	21.2	18.1	18.0	34.5	32.1

In 1978, Area 19 was established as an inshore area reserved exclusively for inshore fishermen using vessels under 13.7 m (45 ft) in length. Landings, regulated by quotas, fluctuated between 900 t and 1,390 t from 1979 to 1991. During 1992-94, quotas were set at 1,686 t. In 1995, there were 74 permanent and 37 temporary license holders in the fishery with a global quota of 1,575 t. In 1996, the quota was 1,343 t for the 111 permanent license holders. In 1997 and 1998, the quotas were 1,386 t (landings of 1,386 t) and 1,991 t (landings of 1,988 t), respectively. The 1999 quota (1,986 t) was reached (landings of 1979 t). In 2000, the quota (3,370 t) was shared with temporary fishermen who had an allocation of 668 t. The 2000 landings were 3,225 t, which represent 96 % of the total quota (3,370 t).

Area 19

Year	1995	1996	1997	1998	1999	2000
Quota	1,575	1,343	1,386	1,991	1,986	3,370
Landings	1,575	1,343	1,386	1,988	1,979	3,225
CPUE*	63.4	54.6	63.2	71.6	103.8	73.0

* In 1998, mean CPUE was calculated using week 2 to 4. In 1999 and 2000, the mean CPUE were calculated using the first four weeks.

Area 12 fishery expanded rapidly in late 1970's, and reported landings peaked in 1982 at 31,500 t. Landings then fluctuated around 25,000 t until 1986, falling to 7,000 t in 1990. The biomass continuously grew until 1994-95 (quota of 20,000 t). After reaching a peak in biomass, the quota level was reduced (11,125 t to 16,100 t) during the subsequent downward trend until 1999. In the 2000 season, the quota increased slightly due to an increasing trend in biomass.

Area 12

Year	1995	1996	1997	1998	1999	2000
Quota	20,000	16,100	15,400	11,125	12,686	15,500
Landings	19,944	15,978	15,413	11,136	12,682	15,046
CPUE	47.8	50.1	50.8	45.8	43.9	34.5

In 1995, DFO issued exploratory permits to evaluate the availability of commercial size crabs in an adjacent area (deeper waters along the Laurentian Channel) to the Area 12 snow crab fishery: the Laurentian Channel (Area E) and the Magdalen Islands/Cape Breton (Area F) (Fig. 2). Four experimental permits were issued for Area E with a trap limit of 100 per boat and a total quota of 217 t. In Area F, 7 experimental permits were issued with a trap limits of 40 per boat and a total quota of 317 t. In 1996, the number of exploratory permits was doubled (8 in Area E and 14 in Area F) and the quotas were set at 238 t in Area F and at 163 t in Area E. In 1997, total quotas were set at 288 t with 2 additional experimental permits for a total of 16. In 2000, the quota for Area E was increased to 317 t.

Area 12F

Year	1995	1996	1997	1998	1999	2000
Quota	238	288	288	288	288	317
Landings	238	287	290	290	291	317
CPUE	42.4	44.9	48.1	57.2	56.7	27.4
Soft crab (%)	11.8	5.3	1.5	1.1	1.1	2.4

<u>Geographic distribution of landings, effort, and CPUE in 2000:</u>

A total of 3,765 traps was sampled at sea, corresponding to approximately 0.7 % of the total number of trap hauls in Areas 12, E, F, 18 and 19. A total of 146,223 male snow crabs was measured. Sea sampling provided a good coverage of the main fishing ground in Areas 12, E and F in 2000 (Fig. 16). The fishing pattern in the 2000 season followed the general pattern observed in the past several years. In Area 18, the main fishing ground was in the northern part of the Area. In Area 19, the landings were mainly from the southern part of the Area, whereas the CPUE level was similar in each grid throughout the Area. In Area 12F, fishing efforts and landings were mostly concentrated in the southeastern, (adjacent to Area 19), and northwestern (adjacent to Area 12) areas of the zone where the highest CPUE were also observed. In Area 12, the fishing effort during the 2000 fishing season was concentrated mostly in Bradelle Bank and Shediac Valley and, to a lesser extend, in the Baie des Chaleurs and the southeastern part of Magdalen Islands. The majority of landings were from Bradelle Bank, Shediac Valley, Baie des Chaleurs, Magdalen channel and in the southeastern part of Magdalen Islands. The highest CPUE were located in the northern and southern areas of the Magdalen

Islands. In general, southeastern part of Area 12 (corridor between Magdalen Islands and Cape Breton Island) has not been the target of a high exploitation by Area 12 fleet. However, a slight fishing effort increase has been observed recently in that Area, especially by the vessels from Magdalen Islands.

Commercial fishing activities within the proposed seismic survey block

The estimation of landings, effort, and CPUE within the proposed seismic survey block showed the importance of this block for commercial fishing activity, especially Area 18 as 75% of total landings and 73% of fishing effort were found within this block. For Areas 19 and 12, the landings and fishing effort within this block was very low (2% of both landings and effort for Area 19, and 6% for landings and 5% of effort for Area 12), (Figs. 17-19). During the last five years, the total landings within this block has fluctuated from 259 t (1998) to 634 t (1995) in the past 5 years.

Estimated landings, fishing effort and CPUE within the proposed seismic block in the southeastern Gulf of St. Lawrence.

CFA	12	18	19	Total/Average
Landings (t)	92.1	355.22	67.48	514.803
Effort (# of trap haul)	2216	10767	1203	14186
CPUE (kg/trap haul)	41.56	32.99	56.09	36.29

Size distribution:

Based on the availability of data and the general trend in the past couple of years in adjacent areas (Area 12F and 18), we concluded that the size frequency distribution for Area 19 can be considered representative of the southeastern Gulf of St. Lawrence. In this area, although instars VI and VII were present since 1990, the progression of modes was only observed after 1993. In 1996, six modes (21.5 mm CW (carapace width), 30.5 mm CW, 42.5 mm CW, 60.5 mm CW, 77.5 mm CW, and 93.5 mm CW) of adolescent males corresponding to instars VI, VII, VIII, X, XI, and XII were observed. Although the general tendency for the progression of modes was observed between 1996 and 1999, the density of each instar cannot be explained. This was the case in 1999 when a sudden increase of instars IX, X and XI was observed compared to the previous years. According to the 2000 trawl survey, instars IX and X are showing an increase while instar XI decreases compared to 1999 (Fig. 20).

Size distributions of crabs caught by trawl in Area 12 are available beginning in 1988 (Fig. 21). Adolescent males were observed in the 1988 trawl survey as three distinct modes (27.5, 39.5 and 51.5 mm CW), which correspond to instars VII, VIII and IX. Based on the estimated age of these instars at 3.3, 4.3 and 5.7 years old (Sainte-Marie et al. 1995), they should have recruited in the period 1982-1985. Therefore, based on the succession of modes from instar IX to X (65.0 mm CW) and XI (81.5 mm CW), we can assume that instars VII-IX observed in 1988 reached the commercial size between 1991 and 1993. The succession of modes was not clearly detectable after instar XI, which may be due to a higher occurrence of terminal moult and/or skip moult at instar X and older (Comeau et al. 1998). Instars VI (mode at 21.5 mm CW) and VII (mode at 27.5 mm CW) observed in the 1994 survey, may enter the fishery in a minimum of 5-6 years, e.g. 2000 and 2001. The scarcity of crab smaller than instar VII observed between

1990 and 1993 indicates the existence of a recruitment trough, which have reduced the recruitment to the fishery between 1995 and 1999. In 1997, a strong wave of instars VI and instar X was observed. The succession of these instars has been observed since then and resulted in a high abundance of instars X and XI in 1999 and 2000. An increase in the recruitment to the fishery (R) is now anticipated. However, the percentage of instar X (adolescent) reaching the terminal phase at sub-legal sizes and their survival rate may affect the increment rates of the potential recruitment to the fishery.

Commercial biomass and distribution

The total biomass (B) for the 2001 fishing season in Area 12(without considering the natural mortality of very old crab) was estimated at 26,468 ± 5,029 t. However, part of this biomass is very old crab (625 ± 300t) that will mate and die and not be available for the 2001 fishing season. The recruitment to the fishery (R) for the 2001 fishing season was estimated at 22,920 ± 4,355t, which represents a decrease compared to the 2000 estimate (30,956t). The decrease in exploitable biomass for the 2001 fishing season was unforeseen due to the fact that the recruitment to the fishery increased since 1998. he unforeseen decrease in exploitable biomass for the 2001 fishing season could be: 1) change in catch efficiency due to the change of the survey vessel in 1999, 2) the unreported landings, 3) fishing-induced mortality, 4) the natural mortality (disease and predation), and/or 5) southeastern-ward movement of adult crabs from Bradelle Bank area.

Geographic distribution of commercial sized adult males in 2000 (survey year) showed two major concentrations, one in the Bradelle Bank area and the other in the southeastern Gulf. In addition, there were three small patches found in the Baie des Chaleurs, between Orphan and American Banks and in eastern Bradelle Valley (Fig. 40). Within the southeastern Gulf of St.Lawrence, there were four major patches (northern, middle, southern and southwestern) of which the southern patch was found within the proposed seismic survey block (Fig. 40). In the past decade, the biomass in the southeastern unit varied from 6,000 t (1995) to 16,000 t (1992). In this same area, the biomass level (although the confidence limits of the estimate are very wide due to the very limited surface of the area) has been continuously increasing since 1995 and currently (2000) at 12,567 t. The biomass within the proposed seismic survey block has fluctuated from 324 t (1997) to 2,484 t (1992) and is currently at 789 t.

Hébert et al. (2001) mentioned that based on the comparison of biomass fluctuation between the eastern and western part of the southern Gulf of St. Lawrence the spatial and temporal distribution of commercial-sized crab showed that the patch concentrations of crab in the western and eastern units of southern Gulf extended and shrunk by the same manner through the last decade. The difference in landing pattern or CPUE trend in Area 12 and Area 19 (3-year lug between the two fisheries) appear to be due to the differential exploitation strategy adopted by each area and the standing stock level. However, there seems to be some difference in the proportion of recruitment to the population and exploitable biomass between the eastern and western units. Although the level of adolescent abundance of instars up to XI is much smaller in the eastern unit, the adult males larger than 95mm are proportionally higher compared to the western unit since 1995. Is this due to the density-dependent mortality of smaller crabs occurring in the western unit or due to the emigration of commercial sized males from western to eastern unit? Stud on the recruitment dynamic between the two units to be pursued although there is no evidence showing origin of the recruitment in both units. The commercial landings outside the inshore fishing Areas 18 and 19 (Cape Breton corridor) followed the same tendency in biomass fluctuation as inside Area 19, suggesting crab movement between the two areas.

Instar distribution including mature females and commercial-sized adult

The size frequency distributions were analyzed by a structured separation model, which indicated the existence of 10 instars (V-XIV) in male and 6 instars (V-X) in females in 2000 (Fig. 29). The mean size and size range for each instar determined here are presented below.

Results of mixture model analysis applied to the 2000 trawl survey data

	Male			Female		
Instar	Proportions	Mean CW (mm)	S.D. (mm)	Proportions	Mean CW (mm)	S.D. (mm)
I	0.0000	3.100	0.000	0.0000	6.1286	0.0001
II	0.0000	4.740	0.366	0.0000	7.2627	0.2487
III	0.0002	6.944	0.613	0.0000	8.9044	0.4537
IV	0.0004	9.907	0.901	0.0023	11.2809	0.7312
V	0.0040	13.888	1.265	0.0314	14.7211	1.1316
VI	0.0124	19.238	1.739	0.0841	19.7010	1.7280
VII	0.0283	26.429	2.365	0.1725	26.9099	2.6488
VIII	0.0597	36.093	3.200	0.6747	37.3453	4.1927
IX	0.3039	48.676	5.699	0.0307	52.4515	7.5243
X	0.2759	61.226	7.390	0.0043	74.3190	21.0005
XI	0.1603	73.743	8.753			
XII	0.1550	86.228	9.926			
XIII	0.0000	98.680	10.968			
XIV	0.0000	111.099	11.915			
XV	0.0000	123.486	12.788			

Based on this result, the geographic distribution of each instar in 2000 was produced (Figs. 30-47 for zoom version of the western Cape Breton area including the proposed seismic survey block).

For male crabs, in early instars (V-VII), involving mean sizes between 14 and 26 mm, there were local concentrations, mainly one in the northwestern Gulf and the other in the southeastern Gulf between CFA 18 and 19 (Figs. 30-32). For instar VIII, the surface of distribution was extended towards the Bradelle bank (Fig. 33). Instars IX and X were spread from the northwestern Gulf to southeastern Gulf and the distribution patches were fused together showing a single large distribution patch (Figs. 34-35). For instars XI-XIV, the frequency moulting to terminal phase increases and the patch starts to shrink gradually towards the two zones, Bradelle Bank and northern Area 19 (Fig. 36-39), which coincides very well with the distribution of commercial-sized adult males (Fig. 40).

For females, the distribution pattern is identical to that observed for males between instars V and IX (Figs. 40-45). However, females reach sexual maturity at much smaller sizes than males, and the majority of them moult to maturity after the Xth instar. The Xth instar concentrated from the northern Prince Edward Island to Area 18 (Fig. 46). This patch of Xth instar represents a group of larger size mature females after the following moult. Finally, the major concentration of mature females was found in two areas, Bradelle Bank and the southern Area 19 (Fig. 47).

Both male and female instars occupied the space in the proposed seismic survey block. Male instars VII-XI and female instars VII-V are especially abundant in this block.

(3-4) Eastern Cape Breton Fisheries Biron et al. (2001)

<u>Commercial exploitation:</u>

Harvesting of snow crab off the coast of eastern Nova Scotia (ENS), (Fig. 3) began in the late 1970's. Landings rose rapidly with an increase in effort, to a peak of 1,634 t in 1979, but landings and catch-per-unit-of-effort (CPUE) then collapsed within four fishing seasons. In 1985, this fishery was thought to be near commercial extinction. However, a pulse of pre-recruits entered the commercial catches of snow crab in all Crab Fishing Areas (CFAs) in 1986. Total landings rose rapidly from 1989 to 1993 when peak levels were reached at 2016 t. In 1994, total landings declined by 23% to 1,551 t and remained stable at that level in 1995 and 1996. The landings increased to 1,677 t in 1997, 2,238 t in 1998 and 3,599 t in 1999. In 1997, the increase in overall landings was mostly the result of an 80% increase in landings observed in CFA 22, coupled with the fact that CFA 21 met their Total Allowable Catch (TAC) that year. In 1998, the increase in overall landings was the result of a 50% increase in individual boat quota's (IBQ's) in CFA 21 and the introduction of new temporary allocations (outside the trawl surveyed area, for a total of 500 t) in CFAs 23 and 24. The increase in landings in 1999 resulted from increase in IBQs of regular licenses in all CFAs, the introduction of new temporary allocations in CFA 20 (outside the trawl survey area), and increases in temporary allocations in CFAs 23 and 24.

Increases in TAC for all CFAs were decided on during the Management / Industry Consultative Process that preceded the snow crab fishing season in 2000 (DFO, 2000). In northern ENS (CFAs 20 to 22), the TAC increased to 965 t (from 865.5 t in 1999), while in southern ENS (CFAs 23 and 24) it was increased to 8,799 t (from 2,700 t in 1999). In 2000, IBQs of regular licenses were increased in CFA 20 (from 11,340 to 13,608 kg); CFA 21 (from 9,072 to 11,340 kg); CFA 22 'northern' (from 13,154 to 13,834 kg); CFA 22 'outer' (remained at 15,422 kg); CFA 23 (from 37,500 to 72,601 kg); and CFA 24 (from 35,870 to 73,402 kg). Existing temporary fishermen allocations increased from 33.9 to 50 t in CFA 20, from 400 to 2,683 t in CFA 23, and from 575 to 2,686 t in CFA 24. There were no changes in the number of permanent licenses in all CFAs: 5 permanent licenses in CFA 20, 32 licenses in CFA 21, 37 in CFA 22, 24 in CFA 23, and 23 permanent licenses in CFA 24. The number of temporary permit holders increased compared to 1999; from 4 to 5 in CFA 20, from 13 to 53 in CFA 23, and from 22 to 56 in

CFA 24. Some modifications were made on the shape of the outside sub-areas of southern ENS, and the number of traps allowed was increased from 30 to 45 in CFA 23. Other management items remained similar to what they were in 1999 for all the CFAs (DFO, 2000).

Fishing effort, Landing and CPUE distribution (Fig. 22)

The overall TAC for ENS in 2000 was 9,814t compared to 3,600t in 1999. Total reported landings in 2000 were 9,718 t. There was a 15% increase in the seasonal CPUE and a 2-fold increase in total fishing effort compared to 1999. The seasonal geographic distribution is presented for landings, CPUE, and fishing effort, as well as the location of the logbook positions recorded by fishermen.

Landings (t) in Eastern Nova Scotia

CFA	90-94	95-96	1997	1998	1999	2000
20	17	55	45	45	97	118
21	159	178	146	216	291	364
22	238	346	343	396	519	535
23	555	768	592	813	1,296	4,401
24	662	762	565	745	1,390	4,300
Total	1,631	2,109	1,691	2,215	3,593	9,718

CFA20

Fishing distribution - Fishing locations based on logbooks received show that the fishing effort of permanent license holders was concentrated along the snow crab boundaries of CFAs 19/20 and 20/21. Temporary fishermen also concentrated some effort in an area along CFA boundary 19/20 and further southeast along the CFA 20 temporary line.

Landings – The TAC increased to 118 t in 2000 compared to 91 t in 1999. Total landings in 2000 were 118 t. This was 30 % higher than 1999, and also the highest recorded landing since 1978. Officially, the landings occurred over 8 weeks, from July 22 to September 03, but in reality 90% of the landings occurred within the second and third weeks of the fishery. In total, permanent and temporary fishermen landed 68 and 50 t respectively.

CPUE and effort - The average CPUE was 46.7kg/trap haul in 2000, an increase compared to 1999 (32.3kg/trap haul). Meanwhile, total effort (2,543 trap hauls) decreased slightly compared to the 2,793 trap hauls in 1999. The 2000 seasonal CPUE of permanent license holders of 56.6kg/trap haul is almost 50% higher than in 1999, while the total effort reported of 1,202 trap hauls in 2000 is 30% lower than those of 1999 (1,784 trap hauls). The temporary license holders reported a seasonal CPUE of 35.8kg/th in 2000, comparable to their 1999 CPUE of 33.7kg/th, while the total effort of 1,383 trap hauls represented an increase over those of 1999 (1,004 traps hauls).

At-sea sampling by observers - The 2000 catch composition derived from the at-sea samples showed that 74% of the crabs were adult males ≥ 95 mm CW , while this was 90% in 1999. Adolescent males accounted for 8% of the catches in 2000, compared to

5% in 1999. The average seasonal soft-shell crab percentages were 6% in 2000, the same as in 1999. The proportion of undersized adult males increased to 18.3 % in 2000, a three fold increase over 1999. The mean CW was 107.3 mm CW compared to 113.3 mm CW in 1999. Overall, 3 trips were covered by observers for a total of 11 traps sampled and 428 crabs measured, comparable to 1999 (3 trips, 9 trap, N=358).

<u>CFA 21</u>
Fishing distribution – The fishing occurred exclusively in the inshore area.

Landings - The TAC increased to 363 t in 2000 compared to 290.3 t in 1999. Total landings in CFA 21 were 364 t, 25% higher than those of 1999. Landings occurred within a three week period, from July 23 to August 06, 2000. Overall, 70% of the landings occurred in the 1st week of the fishery, and over 95% by the end of the 2nd week.

CPUE and effort - The seasonal CPUE of 62.1kg/th is the same as in 1999, and again the highest value ever recorded since 1978. The effort (5,853 trap hauls) is about 25% higher compared to 1999.

At-sea sampling by observers - The soft-shell crab percentage of 17% was higher than the percentage reported for 1999 (11%). In 2000, 10 trips were covered by observers for a total of 28 traps sampled and 1,120 crabs measured, which is comparable to 1999 (10 trips, 36 trap, N=1,413). Adolescent males represented 16% of the catch composition in 2000, compared to 10% in 1999. The proportion of undersized adult males has increased to 14 % in 2000, a two fold increase over 1999. The mean CW of at-sea samples in 2000 was 106.7 mm compared to 110.6 mm in 1999.

<u>CFA 22</u>
Fishing distribution – In the northern area of CFA 22, the fishing effort was concentrated near shore towards CFAs 21/22 boundary, while the outer area fishermen concentrated in and around Glace Bay Hole.

Landings – The TAC increased to 534 t in 2000 (318 t northern group and 216 t southern group) compared to 518.5 t in 1999 (302.5 t northern, 216 t southern). The CFA 22 total landings in 2000 were 5% higher than those of 1999. In the northern portion, 23 fishermen landed 319 t within 4 weeks, while 14 fishermen landed 216 t in a period of 2 weeks in the outer area. For both groups, 80% of the landings occurred in the week of July 24 -30.

CPUE and effort - The average seasonal CPUE of 78.7 kg/trap haul was 40% higher than that of 1999. In the northern area, the average CPUE was 68.6kg/th in 2000, compared to 54.1 kg/trap haul in 1999. The average seasonal CPUE of 106.0 kg/trap haul in the outer area in 2000 was over 40% higher than that reported for 1999 (65.7kg/trap haul). Total effort for CFA 22 in 2000 (6,803 trap hauls) was 30% lower than 1999 (8,841 trap hauls). The breakdown shows that the seasonal effort for the northern area was 4,643 trap hauls in 2000, and 2,041 trap hauls for the outer area.

At-sea sampling by observers – The soft-shell crab percentage of 14% was comparable to the percentage reported for 1999 (16%). The observer coverage in 2000 was less extensive (12 trips covered by observers for a total of 58 traps sampled and 2,308 crabs measured) compared to 1999 (16 trips, 94 trap, N=3,680). Adolescent males represented 23% of the catch composition in 2000 compared to 12% in 1999. The proportion of skip moulters has also increased in 2000 (19%) compared to 1999 (8%). The mean CW of at-sea samples in 2000 was 102.5 mm compared to 106.2 mm in 1999. The proportion of undersized adult males has remained similar at 15 % in 2000 compared to 14% in 1999.

<u>Commercial fishing activities in the proposed Oil and Gas exploration site:</u>

Within the proposed oil and gas exploration site (Fig. 24), commercial fishing activities, involving Area 21 and 22, were very high in the 2000 and 2001 seasons showing total landings of 684 t in 2000 and 655 t in 2001 with corresponding fishing effort of 9,650 and 6,400 trap hauls, respectively (Fig. 23). The combined total landings and fishing effort in Areas 21 and 22 in 1999 and 2000 were 810 t and 899 t, with 12,900 and 12,400 trap hauls, respectively. Therefore the proposed seismic survey block represents 73-84% of annual landings and 52-75% of fishing effort of Areas 21 and 22.

<u>Size distribution</u> (Fig. 25):

In this area, a wide size range of crab has been observed during the trawl survey (11 - 137 mm CW) showing several modes. However, a clear trend in transition of subsequent modes is lacking. In addition, the density of all size classes has been decreasing since 1997.

<u>Biomass, abundance and resource distribution:</u>

In northern ENS, the number of trawl stations increased to 64. All trawl stations were surveyed before the fishing season, from May 06 to May 20, 2000. The estimated total area covered for biomass estimation by kriging in northern ENS was 4,820km^2 in 2000. Total biomass in 2000 on the total surface covered and within the projected habitat area was estimated at 2,926 ± 2107 t and 2,358 ± 2288 t, respectively.

The adult male ≥ 95 mm CW density distribution map showed fewer patches of high density concentration than in 1998 and 1999, but with a more diffused density distribution throughout the surveyed area (Fig. 26). Patches of highest density concentration were mainly found in the troughs between Misaine and Banquereau Banks, and between Banquereau and Sable Island Banks. The highest density of adult male snow crab ≥ 95 mm CW with carapace condition 1 and 2 were found around the Misaine Bank area, especially in the trough between Misaine and Banquereau Bank. The other patches of high density of adult male ≥ 95 mm CW found nearshore, west of Misaine Bank, and in the trough between Banquereau and Sable Island Banks (Fig. 26) were mainly composed of snow crab of carapace condition 3, 4 and 5. The highest density concentration of small male crabs (< 56 mm) was found near shore and in the Misaine Bank area. Adolescent males between 56 and 76 mm CW were mainly concentrated on the north side of Sable Island Bank, with smaller density concentrations near shore. Adolescent males between 76 and 94 mm CW were mainly concentrated in sub-areas 23A, 23B and 24A, with another major concentration on the north side of Sable Island

Bank (Fig. 27). The density distribution of immature female showed a patchy distribution that is mainly located along the shore region of CFAs 21 and 22 northern, and in sub-areas 23A, 24A, 24C and 24E. Three major density concentrations of adult females were observed in CFAs 21 and 22 northern, on the north side of Sable Island Bank and near shore in sub-area 24E, with 2 other important concentrations in the Misaine Bank area and near shore in sub-area 24A (Fig. 28).

Seasonal movement:

Recent investigations suggest that coastal populations of snow crab in the Gulf of St. Lawrence move extensively during winter and are not restricted to their deep summer habitat (Lovrich et al. 1995). Snow crab have been found in shallow water (2.5 to 30 m) between March and May (Taylor et al. 1985, Comeau et al. 1991, Sainte-Marie and Hazel 1992, Lovrich et al. 1995). It is believed that movement to shallow water is linked to moulting and reproduction. Snow crab occupation of the shallow grounds from October to May might be temperature dependent because it would be energetically costly for snow crab to reside in the shallow areas during summer (Maynard 1991, Lovrich et al. 1995). Snow crabs are believed to synchronize their inshore migrations with temperature in order to experience a stable thermal environment conducive to sustained locomotory activity (Lovrich et al. 1995).

The impact of snow crab movement on the results of the trawl survey in ENS, seasonal or other, is believed to be of a greater magnitude and importance than in the southern Gulf of St. Lawrence, especially in the Glace Bay Hole area and along the slope of the Laurentian Channel. In 2000, as in 1997-99, a few snow crab fishermen reported catching snow crab in shallow water (6 to 15 m) while attending their lobster or rock crab gear in early spring, an indication of shoaling behaviour in ENS. Indirect evidence of movement in southern ENS was also underlined with the preliminary identification of two species of barnacles on the carapace of adult male crabs: *Balanus crenatus* and *Balanus balanus* (Gilles Miron, pers. Comm.). These two species are commonly found in ENS at depths of up to 90 and 160 m deep, respectively. Considering that the bulk of the snow crab fishery in ENS is realized at depths of 140 to 250 m, this could indicate movement towards or from shallower water at one point in adulthood. However, further scientific research is required before any conclusion can be drawn from this.

Snow crab distribution:

Snow crabs have a heterotopic cycle of development, and that is why the pelagic larvea, juveniles, adolescents, and adults are encountered in different environmental conditions (Slizkin 1982). Density distribution indicates that male crab <56 mm and immature females seem to be distributed mostly near shore and in the Misaine Bank area, the two coldest bottom temperature areas found during the survey. In the northern Pacific, evidence also indicates that optimal temperature requirements for juveniles is colder (preferably sub-zero bottom temperature ranges), than adult (Slizkin 1982). An investigation into the early-spring segregation by depth showed that adolescent and adult males < 70 mm mean CW, along with pubescent-primiparous females, were relatively more abundant at depths < 80 m, while larger adult males and multiparous females occurred on deeper grounds (Sainte-Marie and Hazel 1992).

Likely impacts of drilling and seismic survey

Current knowledge on the impact of seismic survey activities on invertebrate species is very limited and sometimes shows controversial results. Often these results are published in grey literature (project reports, contract reports, etc.). Some grey literature reports did not describe any negative effect of seismic survey on the larval stage of Dungeness crab and on the shrimp catch rate. Others showed serious effects on behaviour and catch rate of certain fish species. However, published results in reviewed scientific papers (that we examined: Dalen and Knutsen, 1987; Løkkerborg, 1991; Parson et al., 1992; Salski et al., 1992; Løkkerborg and Soldal, 1993; Engås et al., 1996) shows some effects of seismic surveys, although the degree of the effect varies on mortality and change in behaviour of various fish species. It is difficult to compare results obtained from different testing conditions and materials. In addition, no published information has been encountered (except for those in grey literature) on the effect of seismic survey on invertebrate species.

Boudreau et al. (1999) examined the potential impacts of petroleum exploration activities on Georges Bank ecosystem. They concluded that 1) Routine exploratory seismic activity might have a significant but temporary impact on adult fish behaviour and movement affecting fish catch rates and spawning behaviour; 2) Routine operational exploratory drilling activity is likely to have only localised impacts on the ecosystem components reviewed. The actual impacts will be dependent on the location, timing of the discharges. A small probability exists that these impacts will have population and ecosystem-level effects. And 3) Exploration drilling would lead to a temporary loss of access to some portion of the fishing grounds, although the area lost would be relatively small. Seismic activity would lead to temporary space conflicts with fishing activities that would depend on the timing, location, and the gear type involved. This conflict would be greatest during the summer months.

Snow crab is the species for which we have the most information on population biology and fishery related issues. The proposed exploration area is one of the most productive fishing grounds of CFA 18, showing greater than 75% of annual landings. In addition, since 1996 in the southwestern Gulf of St. Lawrence, the commercial biomass estimate has been increasing. Post-larval instars are existent and continuously growing to larger size within the concerned area. Preliminary larval flow simulation models suggested that southwestern Gulf of St. Lawrence may be a major larval settlement site even influencing the northeastern Cape Breton Island area. In addition, there seems to be an active seasonal migration of commercial-sized snow crab towards the southwestern Gulf of St. Lawrence after the DFO fall trawl survey and before the summer fishing season, and possibly to eastern Cape Breton (CFA 20-22). Furthermore, an immediate impact of seismic survey on the commercial fishery, especially for Area 18 and 19, may be the loss of a part of high productive fishing ground due to the exclusion surface for the oil/gas exploration. A global view of snow crab population dynamics in the southern Gulf of St. Lawrence and Eastern Nova Scotia suggests that there is a global flow of snow crab throughout their life span from northwestern to southeastern Gulf of St. Lawrence and towards eastern northeastern Cape Breton. The effect of the seismic survey in southeastern Gulf of St. Lawrence and Sydney Bight may not be negligible in terms of both short- and long-term stock fluctuation. If the seismic survey activity occurs, the possible effects have to be thoroughly assessed prior to the starting the survey. The possible consequences may include direct physical effects (causing instantaneous mortality, temporary or long-term disability), physiological effects (causing loss of physiological function such as mode of communication, reproduction and growth capability), and behavioural changes (causing avoidance of the site, changing migration pattern). Although our knowledge on the abundance, movement, and fisheries productivity showed the importance of the southwestern Gulf of St. Lawrence and northeastern Cape Breton Island area for the major commercial invertebrates, no tool is currently available for assessing any changes of these species during and after the seismic survey activities.

REFERENCES

Alunno-Bruscia, M. and Sainte-Marie, B. 1998. Abdomen allometry, ovary development, and growth of female *snow crab, Chionoecetes opilio* (Brahyura, Majidae), in the northwestern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 55: 459-477.

Anonymous, 1994. Gulf Region, Workshop Report on Lobster Conservation, Held January 4 and 5 1995. Regional Report, (bilingual).

Bergeron, T. 1967. Contribution à la biologie du homard (*Homarus americanus* M. Edw.) des Îles-de-la-Madeleine. Naturaliste Can. 94: 169-207.

Biron, M., Savoie, L., Campbell, R., Wade, E., Moriyasu, M., DeGrâce, P. and Gautreau, R., 2001. Assessment of the 2000 snow crab (Chionoecetes opilio) fishery off eastern Nova Scotia (Areas 20 to 24). Canadian Science Advisory Secretariat, Res. Doc. 2001/017.

Boudreau et al., 1999. The possible environmental impacts of petroleum exploration activities on the Georges Bank ecosystem. Can. Tech. Rep. Fish. Aquat. Sci., 2259.

Comeau, M., Conan, G.Y., Robichaud, G., and Jones, A. 1991. Life history patterns and population fluctuations of snow crab (*Chionoecetes opilio*) in the fjord of Bonne Bay on the west coast of Newfoundland, Canada – from 1983 to 1990. Can. Tech. Rep. Fish. Aquat. Sci. No. 1817.

Comeau, M. and Conan, G.Y. 1992. Morphometry and gonad maturity of male snow crab, *Chionoecetes opilio.* Can. J. Fish. Aquat. Sci. 49: 2460-24-68.

Comeau, M., W. Landsburg, M. Lanteigne, M. Mallet, P. Mallet, G. Robichaud and F. Savoie. 1998. Lobster (*Homarus americanus*) tagging project in Caraquet (1993) - tag return from 1994 to 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2216.

Comeau, M., Lanteigne, M., Robichaud, G and Savoie. F. 1998. Lobster (*Homarus americanus*) movement sheets of tagging projects conducted between 1980 and 1997. Can. Ind. Rep. Fish. Aquat. Sci. 249.

Comeau, M., M. Lanteigne, G Robichaud, and F. Savoie. 1999. Lobster (*Homarus americanus*) movement in the southern Gulf of St. Lawrence – Summary sheets of tagging projects conducted between 1980 and 1997. Can. Ind. Rep. Fish. Aquat. Sci. 249.

Comeau, M. and F. Savoie. 2002. Movement of the American lobster, (*Homarus americanus*), in the southwestern Gulf of St. Lawrence. Fish. Bull. 100:181-192.

Conan, G.Y., Robinson, D.G., and Maynard, D.R. 1982. Growth at moult of lobsters in two areas of Northumberland Strait, Canada. Int. Counc. Explor. Sea C.M. 1982/K: 35.

Dalen, J. and Knutsen, G.M., 1987. Scaring effects in fish and harmful effects on eggs, larvae and fry bu offshore seismic explorations. In: Progress in underwater acoustics. Merklinger, H.M. (ed.). Pleum Publ. Co.

Davidson, K., Roff, J.C. and Elner, R.W. 1985. Morphological, elctrophoretic, and fecundity characteristics of Atlantic snow crab, *Chionoecetes opilio,* and implications for fisheries management. Can. J. Fish. Aquat. Sci.42: 474-482.

DeGrâce, P., Hébert, M., Wade, E., Surette, T. and Moriyasu, M., 2001. Assessment of the 2000 snow crab (*Chionoecetes opilio*) fisheries off western Cape Breton (Areas 18 and 19). Canadian Science Advisory Secretariat, Res. Doc. 2001/016.

DeWolf, A.G., 1974. The lobster fishery of the Maritime Provinces: economic effects of regulations. Bull. Fish. Res. Board Can. 187: 59 p.

DFO, 1996. American Lobster (*Homarus americanus*), Southern Gulf of St. Lawrence. DFO Sci. Stock Status Report. 96/115E.

DFO, 2000. Eastern Nova Scotia Snow Crab. DFO Science Stock Status Report C3-02(2000).

Dubé, P. 1984. Analyse des déplacements du homard (*Homarus americanus*) sur les côtes des Îles-de-la-Madeleine, à partir des données de marquage et de recaptures, de 1978 à 1983. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 84/37.

Elner, R.W. 1985. Crabs of the Atlantic coast of Canada. DFO Underwater World Factsheet UW/43: 8 p.

Elner, R.W. and Robichaud, D.A. 1983. Observation on the efficacy of the minimum legal size for Atlantic snow crab, *Chionoecetes opilio.* Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 83/63: 17 p.

Engås, A., Løkkeborg, S.,Ona, E. and Soldal A.V., 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Can. J. Fish. Aquat. Sci. 53: 2238-2249.

Hébert, M., Robichaud-LeBlanc, K., DeGrâce, P., Biron, M. and Moriyasu, M.. Évaluation des zones exploiratoires au crabe des neiges (*Chionoecetes opilio*) dans le canal Laurentien (zone E) et la région des Iles-de-la-Madeleine/Cap-Breton (zone F) dans le golfe du Saint-Laurent en 1995 et 1996. Canadian Stock Assessment Secretariat, Res. Doc. 97/111.

Hébert, M., Wade, E., Surette, T. and Moriyasu, M., 2001. The 2000 assessment of snow crab, *Chionoecetes opilio*, stock in the southern Gulf of St. Lawrence (Areas 12, E and F). Canadian Science Advisory Secretariat, Res. Doc. 2001/015.

Lanteigne, M. 1985. Distribution spatio-temporelle des larves de crabe appartenant aux. genres *Chionoecetes* et Hyas, dans la Baie des Chaleurs, Canada. M.Sc. thesis, Universite' de Moncton, New Brunswick: 161 p.

Lanteigne, M., Comeau, M., Mallet, M. Robichaud, G., Savoie, F., 1998. The American Lobster, *Homarus americanus*, in the Southern Gulf of St. Lawrence (Lobster Fishing Areas 23, 24, 25, 26A and 26B). DFO, Can. Stock Assess. Sec. Res. Doc. 98/72.

Løkkeborg, S., 1991. Effects of a geophysical survey on catching success in longline fishing. ICES C.M. 1991/B:40

Løkkeborg, S. and Soldal, A.V., 1993. The influence of seismic exploration with airguns on cod (Gadus morhua) behaviour and catch rates. ICES mar. Sci. Symp., 196: 62-67.

Lovrich, G.A., Sainte-Marie, B., and Smith, B.D. 1995. Depth distribution and seasonal movements of *Chionoecetes opilio* (Brachyura: Majidae) in Baie Sainte-Marguerite, Gulf of St. Lawrence. Can. J. Zool. 73:1712-1726.

Maynard, D.R., and Chiasson, Y. 1986. Dispersion of tagged lobsters (*Homarus americanus*) in two areas of Northunberland Strait. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 86/72.

Maynard, D.R. 1991. Biophysical ecology of snow crab *Chionoecetes opilio*; relating respiration rates and walking speeds from the laboratory to field observations. M.Sc. thesis, Dalhousie University, Halifax, N.S.

Maynard, D.R., Savoie, F., Landsburg, W., Roach, G., and Wade, E. 1992. The Cape Breton experiment on legal minimum lobster size increase: an intermediate report. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 92/64.

Montreuil, P. 1953. Recherches sur le homard des Îles-de-la-Madeleine *In* Rapport Annuel de la Station de Biologie Marine 1953. Contr. Dépt. Pêch. Québec 43: pp. 75-86.

Montreuil, P. 1954. Lobster tagging. *In* Rapport Annuel de la Station de Biologie Marine 1953. Contr. Dépt. Pêch. Québec 44: pp. 75-86.

Moriyasu, M. and Conan, G.Y. 1988. Aquarium observation on mating behaviour of snow crab, *Chionoecetes opilio. Int.* Counc. Explor. Sea CM 1988/K:9. 14 p.

Moriyasu, M. Conan, G.Y., Mallet, P. and Chiasson, Y. 1987. Growth at moult, moulting season and mating of snow crab *(Chionoecetes opilio) in* relation to functional and morphometric maturity. Int. Counc. Explor. Sea CM 1987/K: 21. 14 p.

Moriyasu, M. and Lanteigne, C. 1998. Embryo development and reproductive cycle in the snow crab, *Chionoecetes opilio* (Brahyura: Majidae), in the southern Gulf of St. Lawrence, Canada. Can. J. Zool. 76: 2040-2048.

Munro, J., and Therriault, J.-C. 1983. Migrations saisonnières du homard (*Homarus americanus*) entre la côte et les lagunes des Îles-de-la-Madeleine. Can. J. Fish. Aquat. Sci.: 40: 905-918.

Person, W.H., Skalski, J.R. and Malme, C.I., 1992. Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp.). Can. J. Fish. Aquat. Sci. 49:1343-1356.

Powles, H. 1966. Observation on the biology of two species of Spider crabs, *Chionoecetes* opilio and *Hyas araneus* in the Gulf of St. Lawrence. Can. Fish. Mar. Serv. Manuscr. Rep. 84: 36 p.

Powles, H. 1968. Distribution and biology of the Spider crab *Chionoecetes opilio in* the Magdalen Shallows, Gulf of St. Lawrence. Fish. Res. Board Can. Man. Rep. Ser. 997: 106p.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Res. Board Can. 191: 382 p.

Salski, J.R., Pearson, W.H. and Malme, C.I., 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). Can. J. Fish. Aqaut. Sci. 49: 1357-1365.

Sainte-Marie, B. and Gilbert, D. 1998. Possible effects on changes in CIL temperature and thickness on population dynamics of snow crab, *Chionoecetes opilio*, in the Gulf of St. Lawrence. Secrétariat canadien pour l'évaluation des stocks 98/38. 18 p.

Sainte-Marie, B. and Hazel, F. 1992. Moulting and mating of snow crabs, *Chionoecetes opilio* (0. Fabricius), in shallow water of northwestern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 49 .- 1282-1293.

Sainte-Marie, B. Raymond, S. and Brêthes, J.-C. 1995. Growth and maturation of the benthic stages of male snow crab, *Chionoecetes opilo* (Brahyura: Majidae). Can. J. Fish. Aquat. Sci. 52 : 903-924.

Slizkin, A.G. 1982. Distribution of snow crab of the genus *Chionoecetes* and their habitat in the northern part of the Pacific Ocean. *In* Population dynamics and reproductive conditions of commercial invertebrates and algae in the far Eastern seas, Izvestiya TINRO, Vladisvostok, vol 106, p. 26-33. [Can. Transl. Fish. Aquat. Sci. 5664].

Squires, H.J. 1990. Decapod Crustacea of the Atlantic Coast of Canada. Can. Bull. Fish. Aquat. Sci. 221:532 p.

Taylor, D.M., Hooper, R.G., and Ennis, G.P. 1985. Biological aspects of the spring breeding migration of snow crabs, *Chionoecetes opilio*, in Bonne Bay, Newfoundland (Canada). Fish. Bull. 83: 707-711.

Templeman, W. 1935. Lobster tagging in the Gulf of St. Lawrence. J. Biol. Board Can. 1: 269-278.

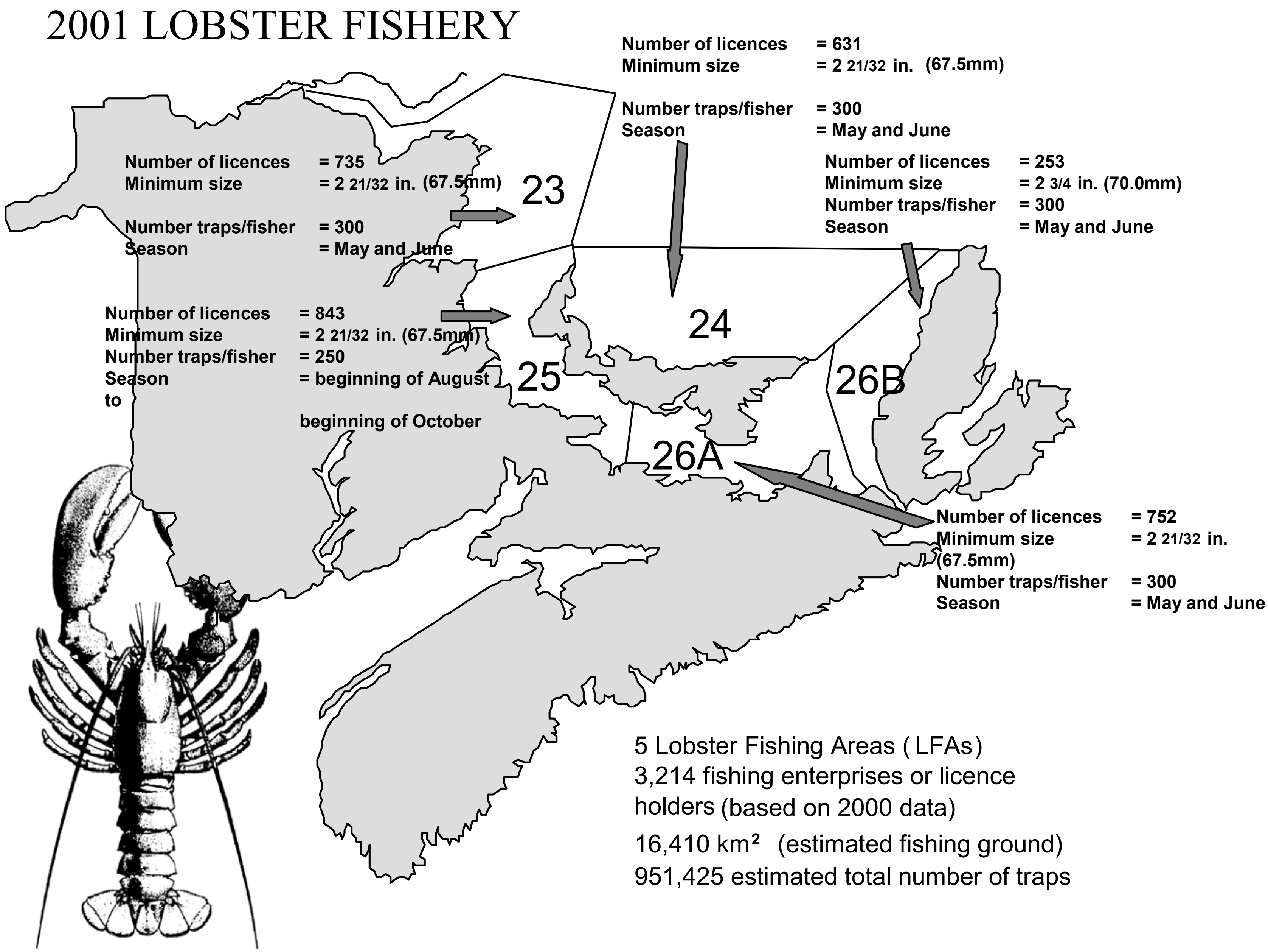


Figure 1. Lobster fishing areas (LFA) and management measures in the southern Gulf of St. Lawrence.

Figure 2. Scallop commercial fishing areas in the southern Gulf of St.Lawrence

Snow Crab Fishing Areas (CFAs)

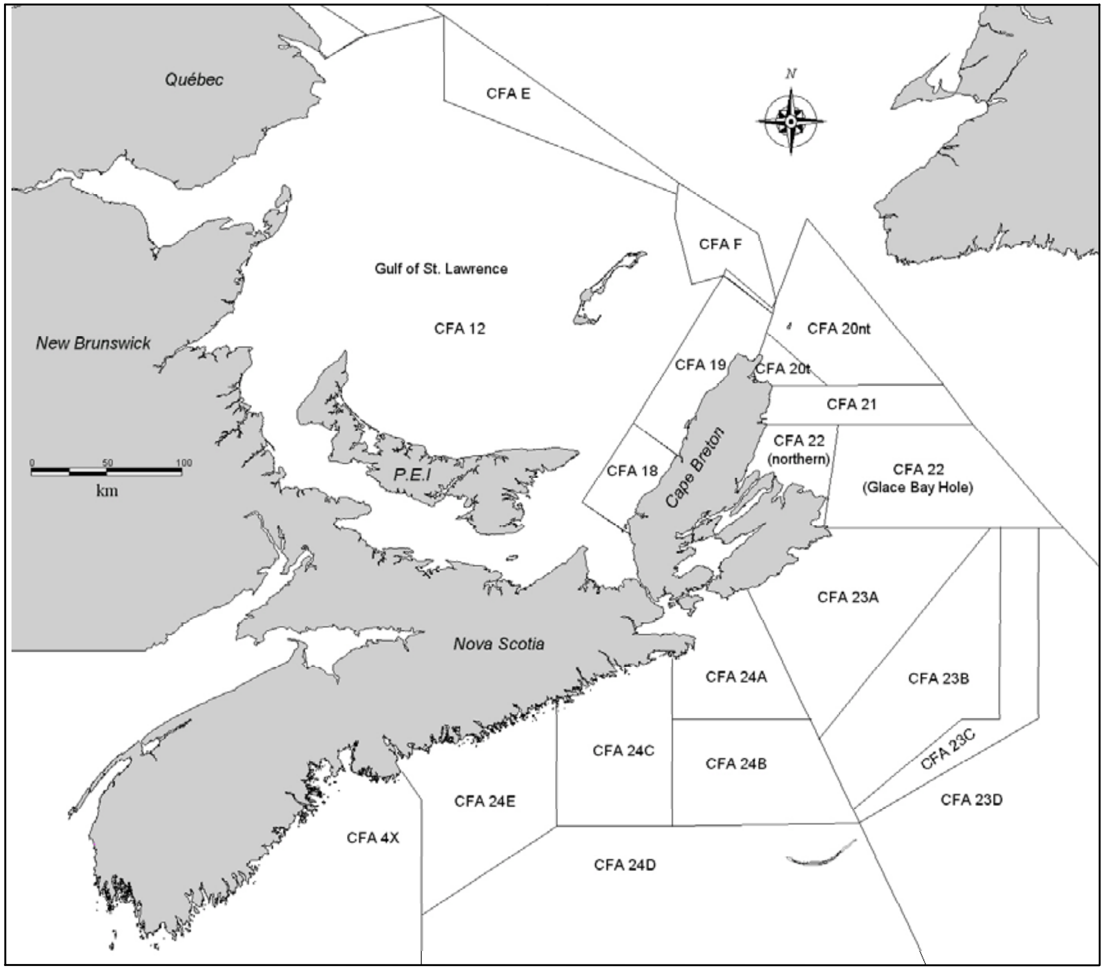


Figure 3. Snow Crab fishing areas (CFAs) in the southern Gulf of St. Lawrence and Eastern Nova Scotia.

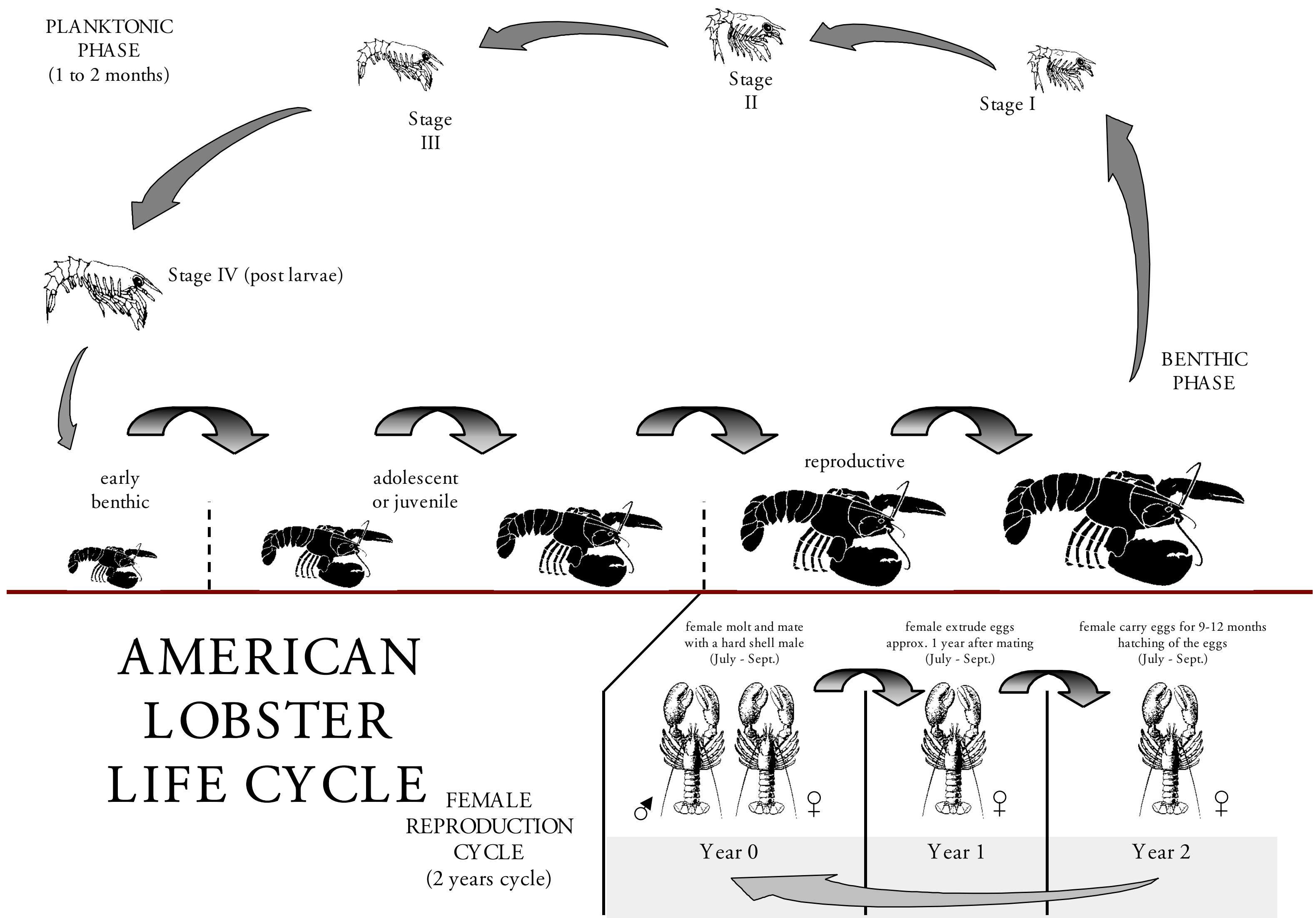


Figure 4. Life Cycle of the American Lobster (*Homarus americanus*).

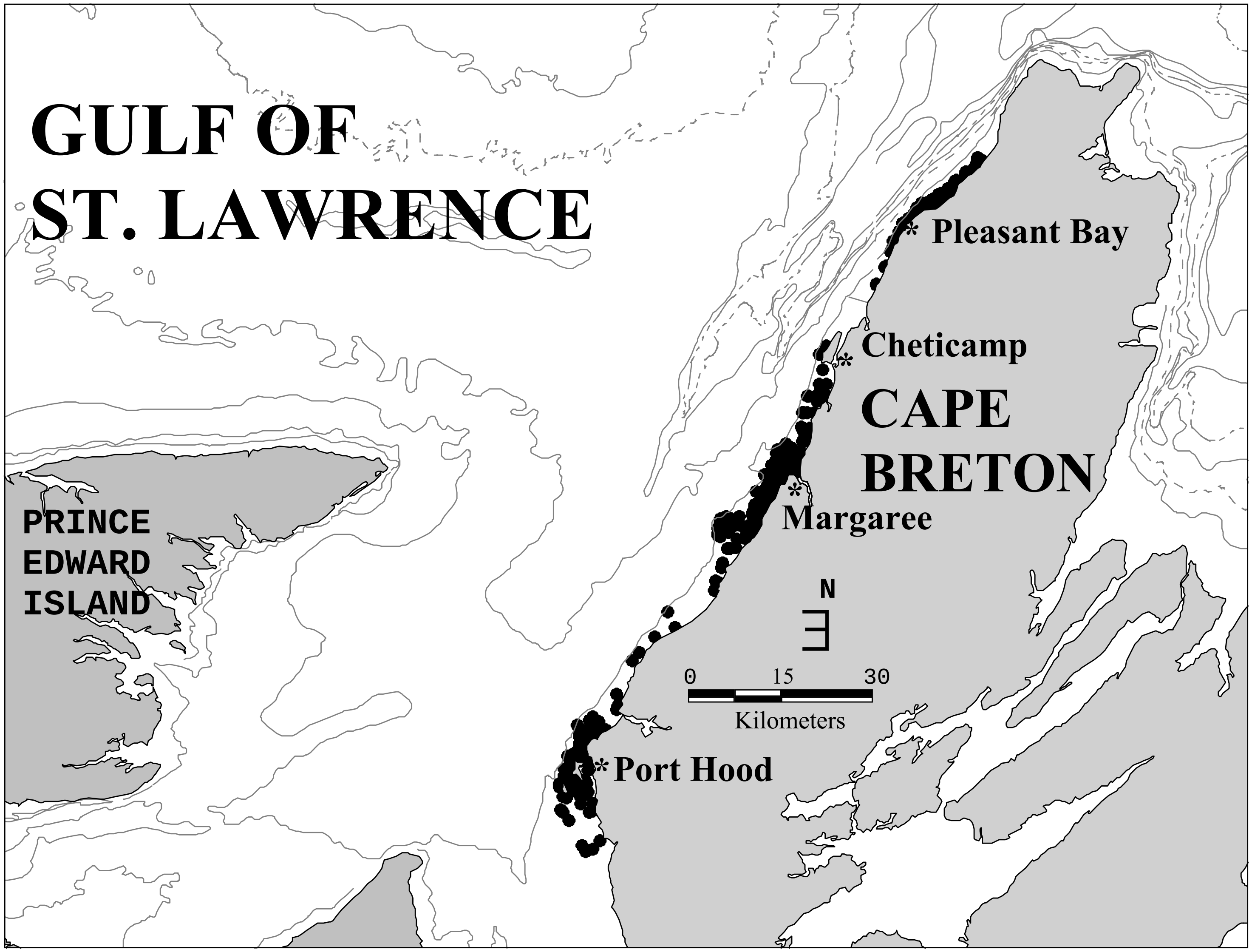


Figure 5. Distribution of recapture sites of tagged lobster off Port Hood, Margaree, Chéticamp, and Pleasant Bay, Nova Scotia.

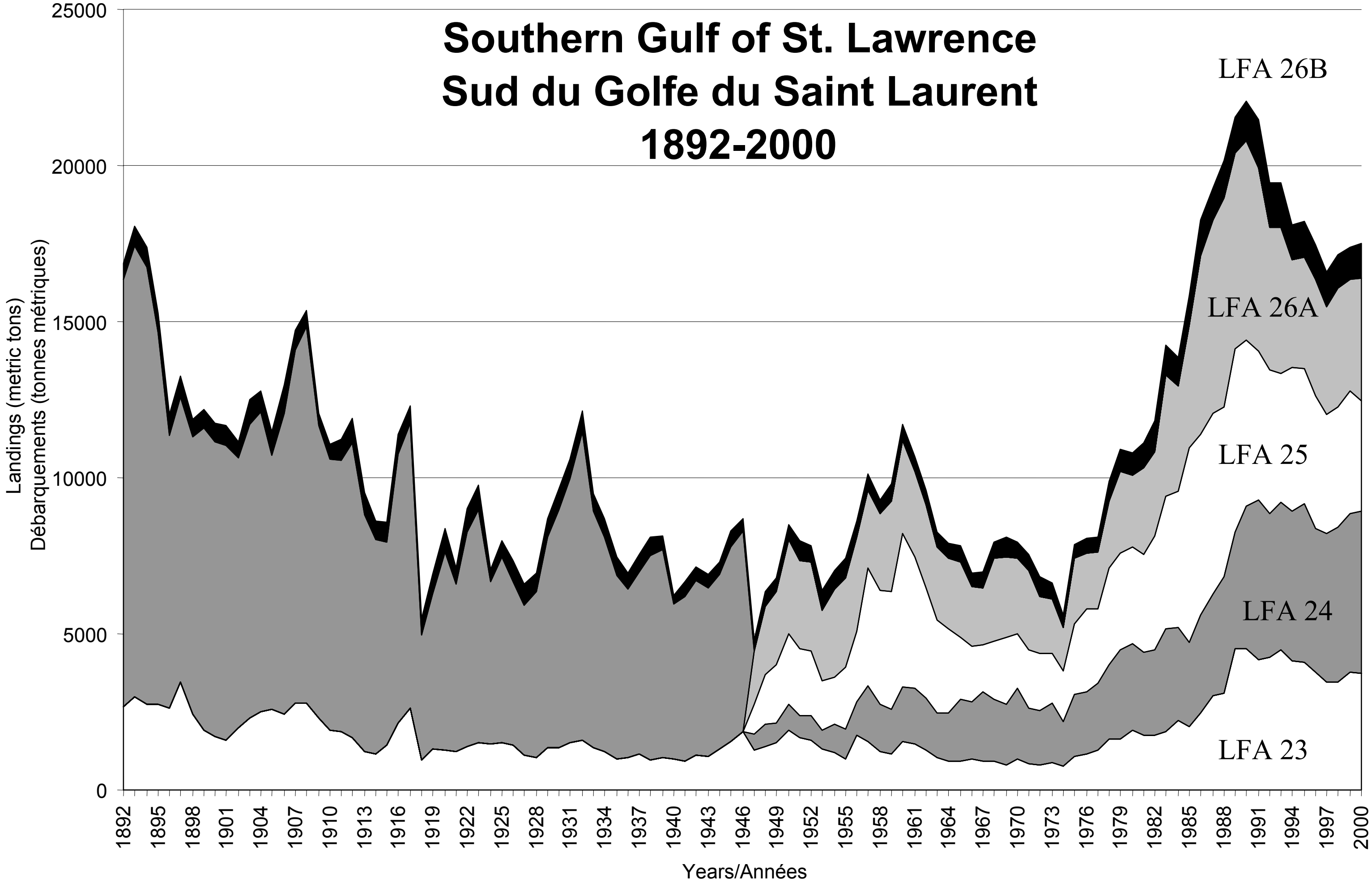


Figure 6. Historical landings by LFA (23-26B) of lobster in the southern Gulf of St. Lawrence (Gulf Region). (Modified from Lanteigne et al. 1998)

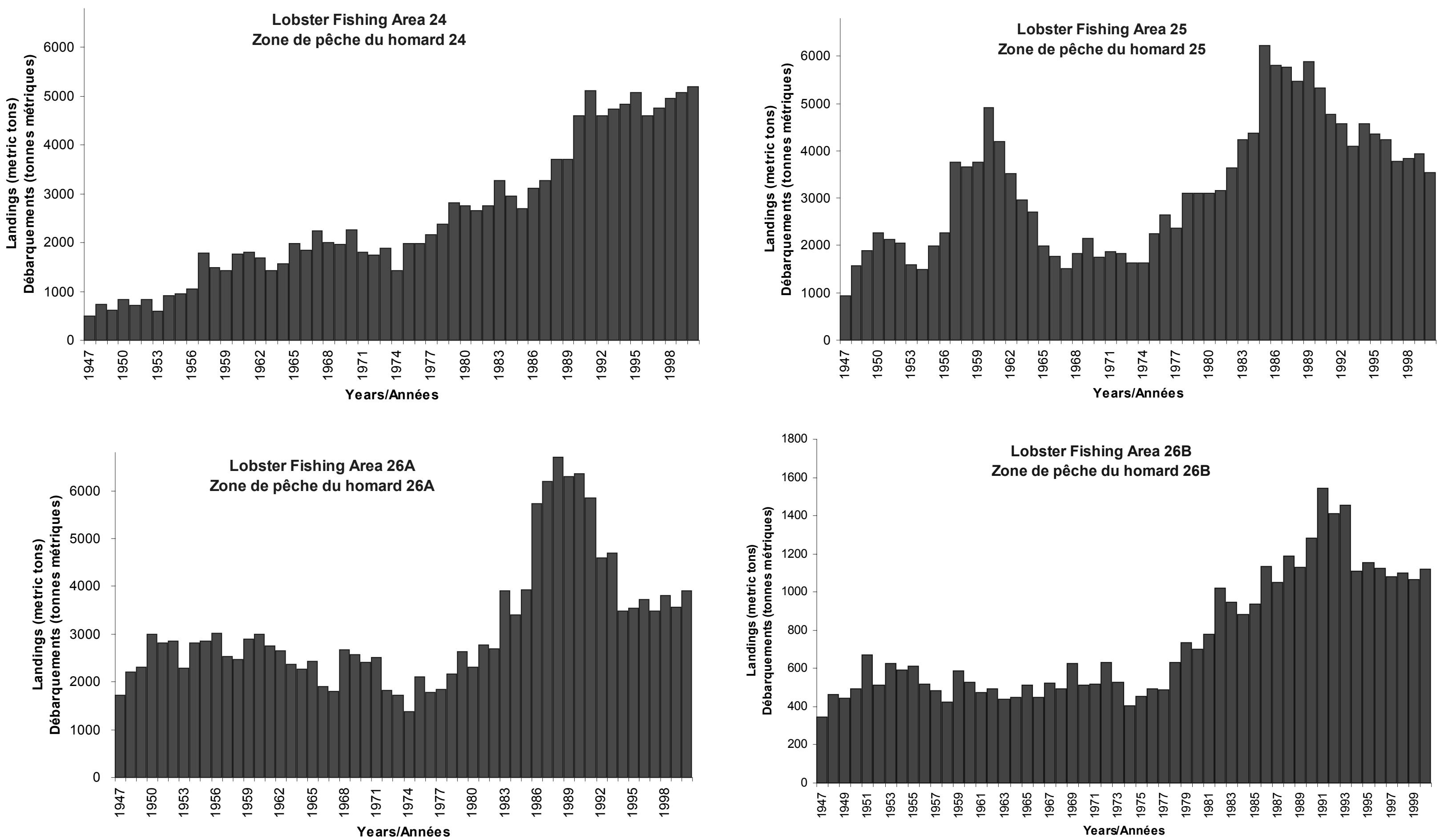
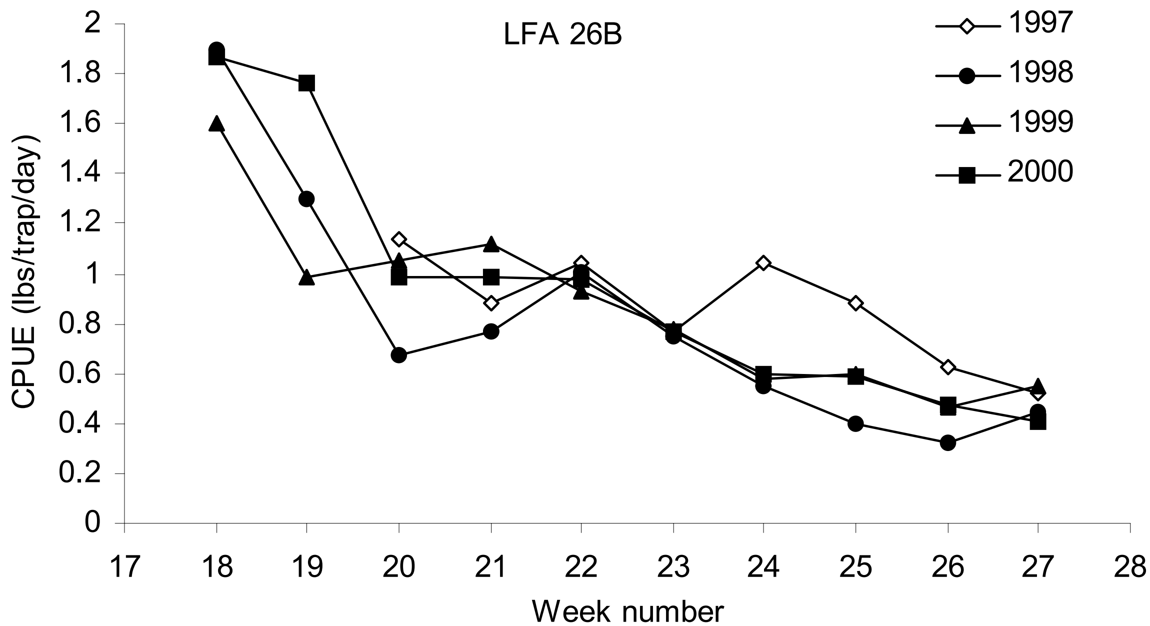


Figure 7. Historical landings by LFA (24 - 26B) in the southern Gulf of St. Lawrence (Gulf Region).



Number of licences **= 253**
Minimum size **= 2 3/4 in. (70.0mm)**
Number traps/fisherman **= 300**
Season **= May and June**

Weekly average catch (pounds) per trap per day

Week Number	1994	1995	1996	1997	1998	1999	2000
18	2.02		1.77		1.89	1.60	1.87
19	1.64	0.92	1.21		1.30	0.99	1.76
20	1.23	0.88	1.07	1.14	0.67	1.05	0.98
21	0.88	1.00	0.96	0.88	0.77	1.12	0.98
22	0.81	1.21	0.75	1.05	1.00	0.92	0.98
23	0.70	1.14	0.67	0.77	0.75	0.78	0.76
24	0.53	0.88	0.46	1.04	0.55	0.58	0.60
25	0.43	0.68	0.34	0.88	0.40	0.60	0.59
26	0.40	0.48	0.33	0.63	0.32	0.46	0.48
27	0.33	0.46		0.52	0.44	0.55	0.41
28		0.51					

Figure 8. Weekly CPUE trend calculated from index fishermen's logbooks in LFA 26B between 1994 and 2000.

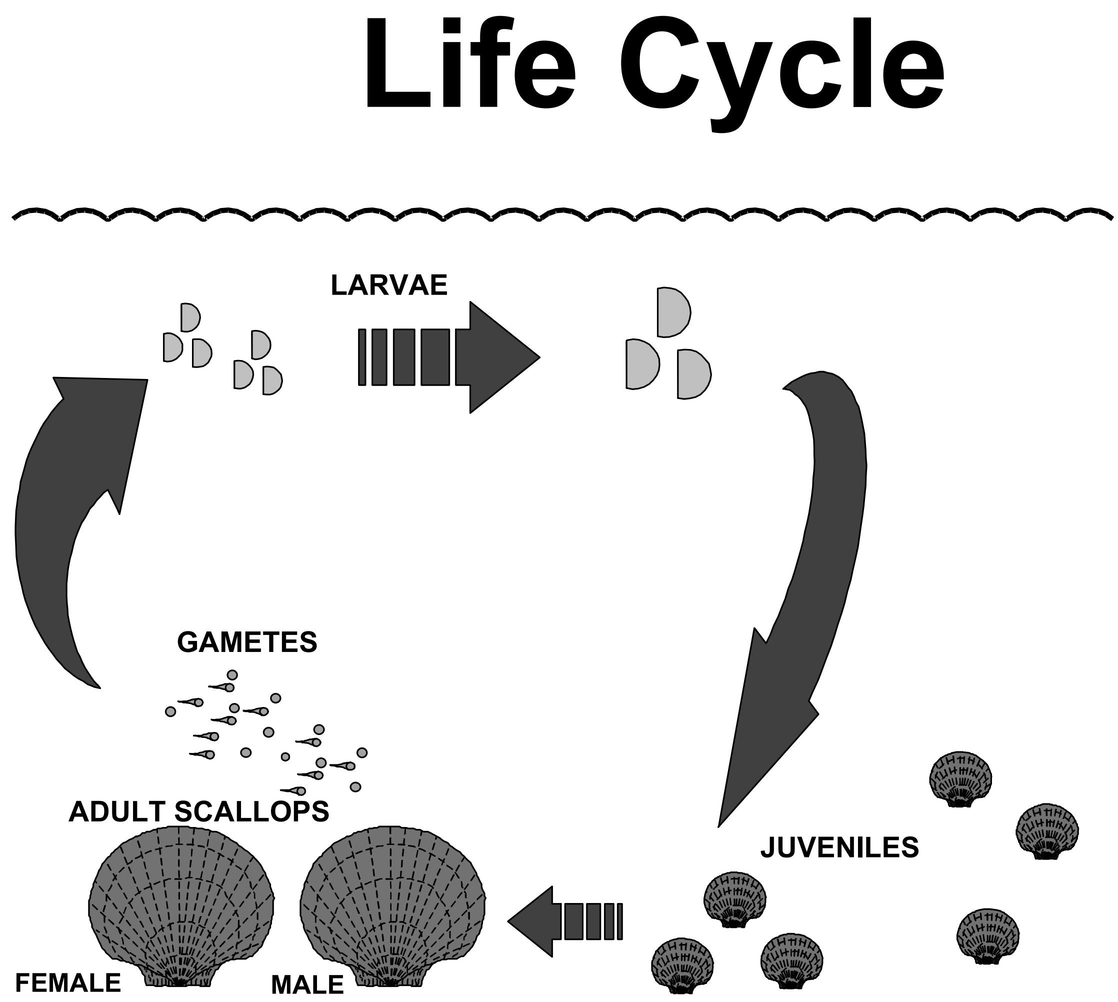


Figure 9. Life cycle of the Sea Scallop in the southern Gulf of St. Lawrence.

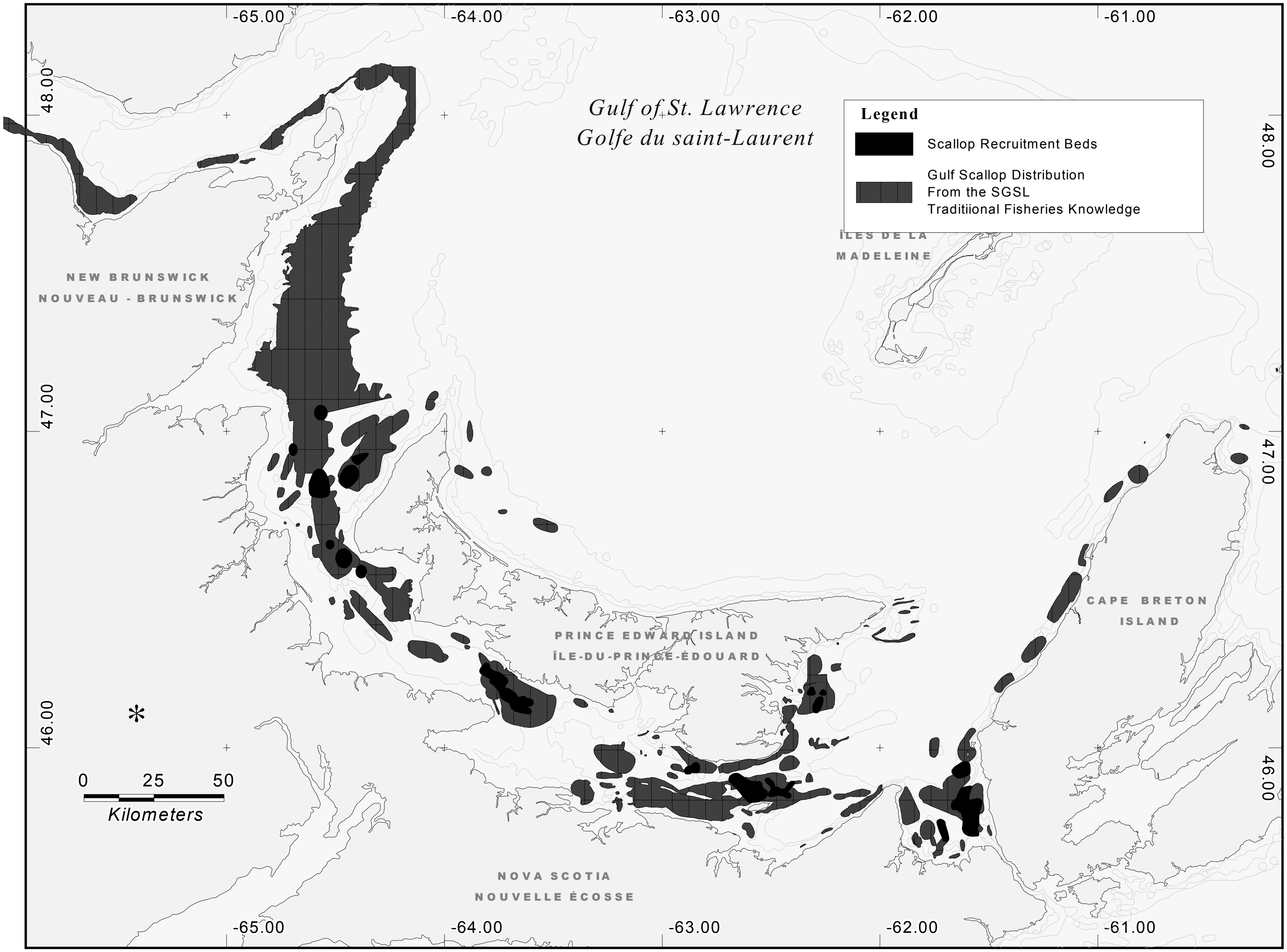


Figure 10. Geographic distribution of scallop beds in the southern Gulf of St. Lawrence.

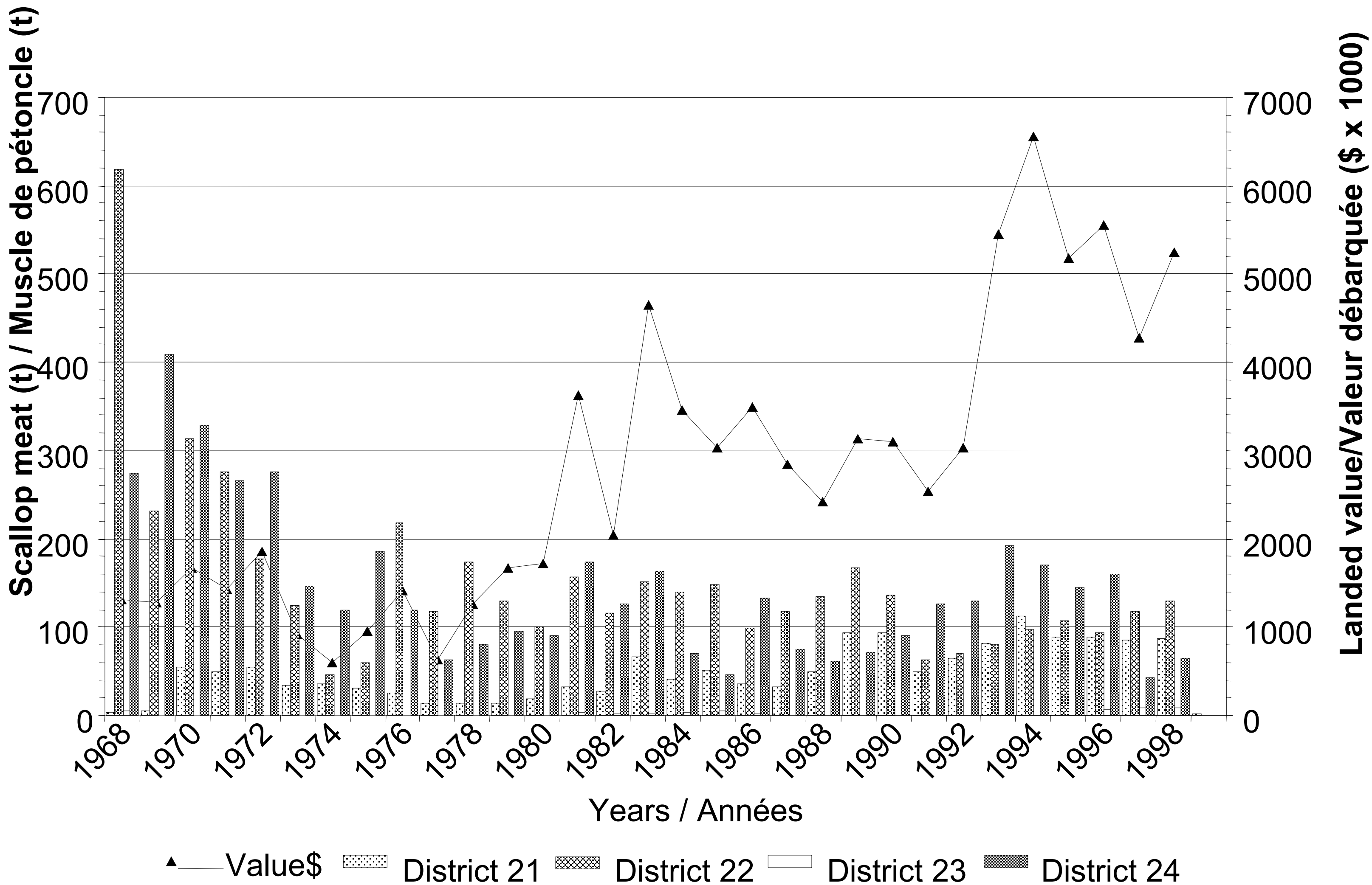


Figure 11. Historic landings and total landing values of the Sea Scallop in the southern Gulf of St. Lawrence.

Scallop Enhancement

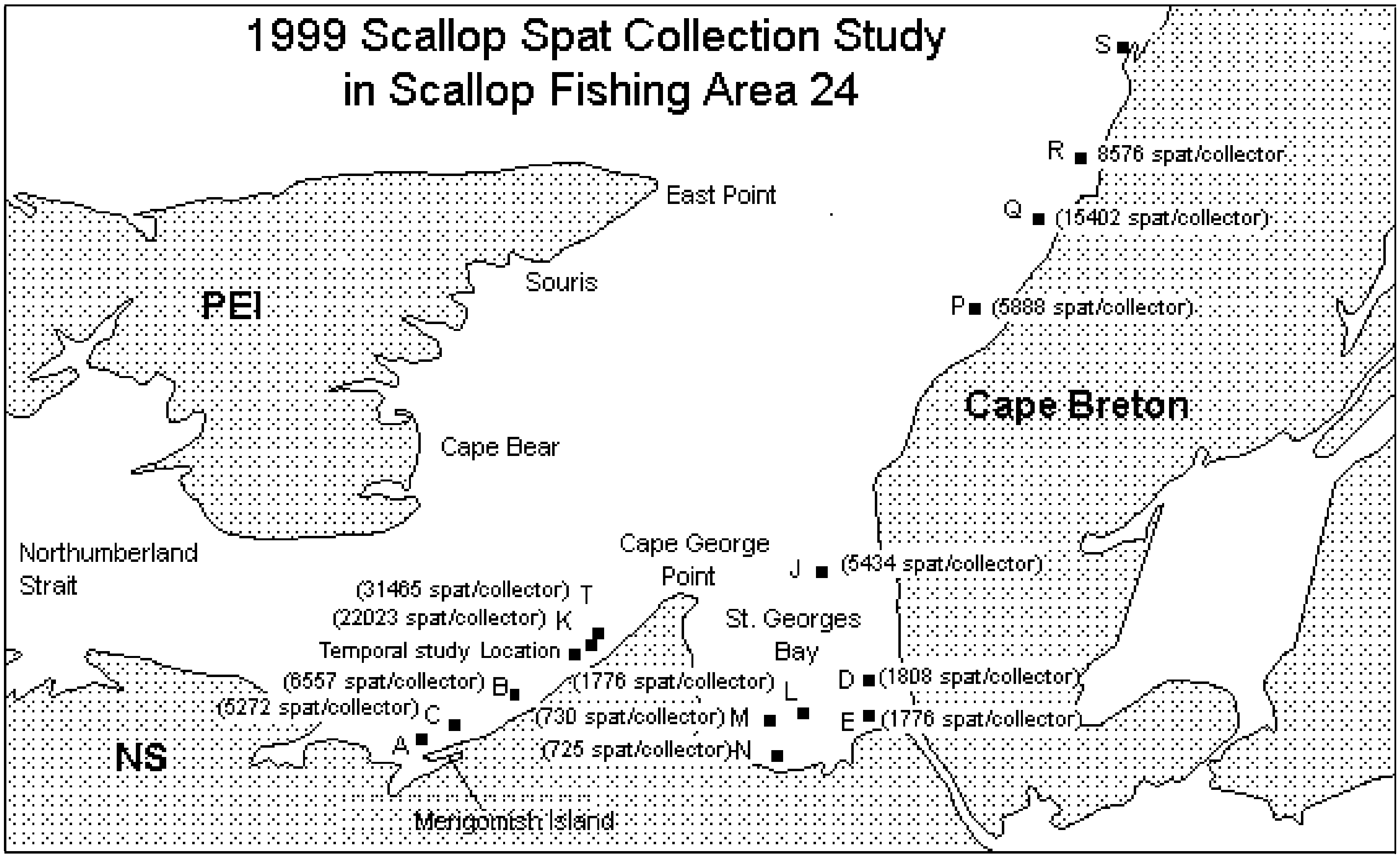


Figure 12. Results of scallop spat collection studies in the southern Gulf of St. Lawrence.

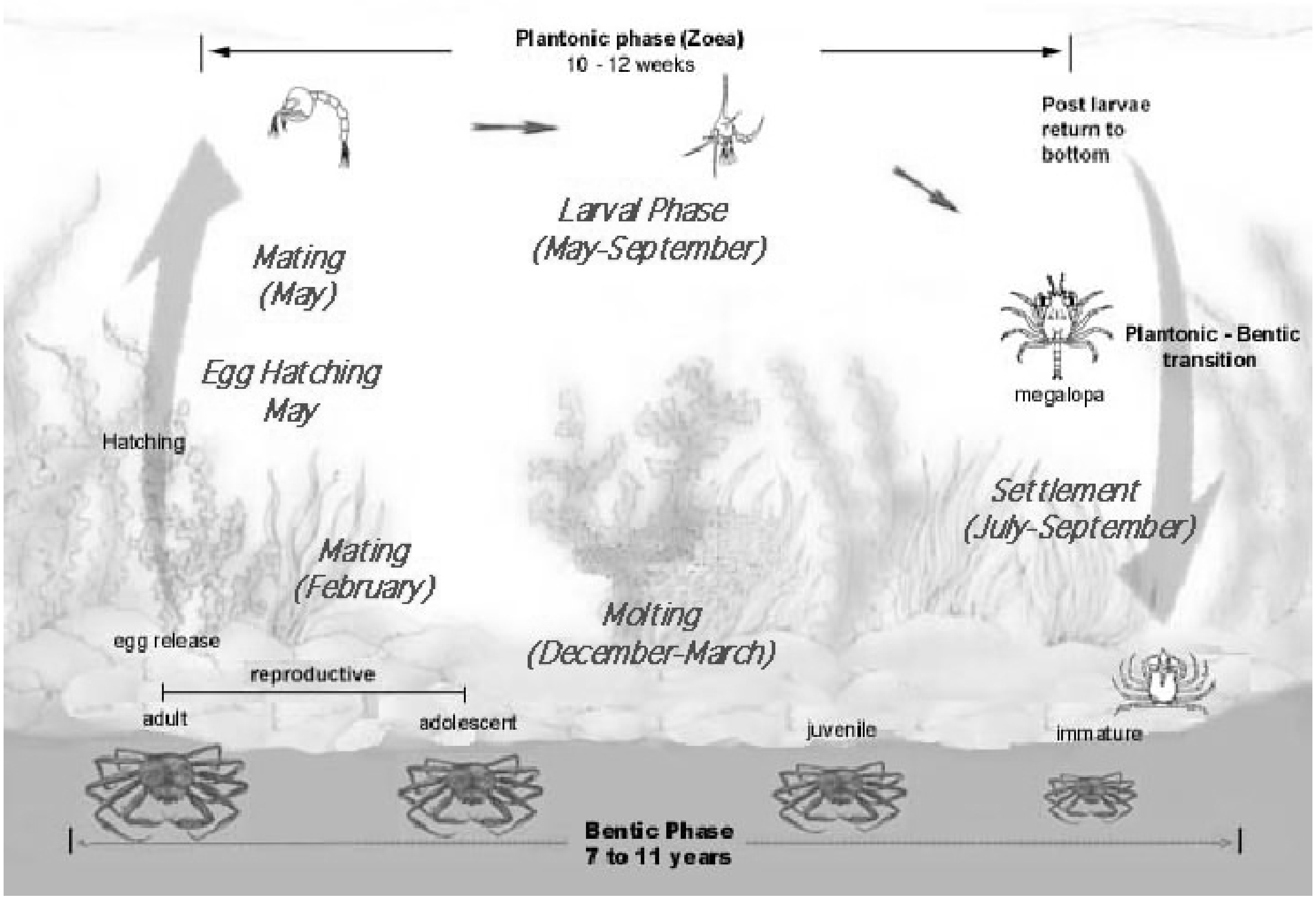


Figure 13. Snow Crab life cycle in the southern Gulf of St. Lawrence and Eastern Nova Scotia.

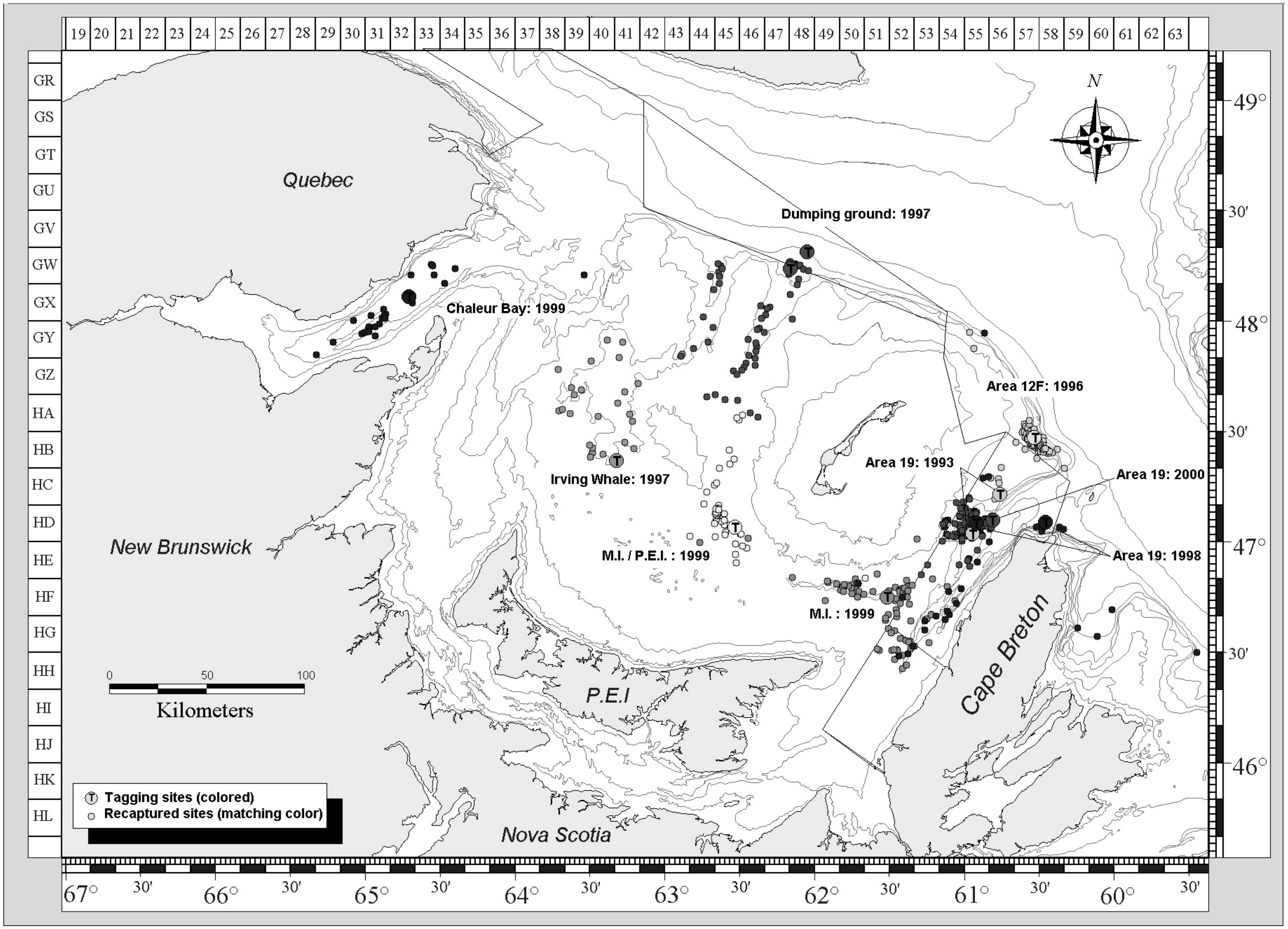


Figure 14. Snow crab tagging and recapture sites for the southern Gulf of St. Lawrence (Areas 12, 18, 19, and Areas E and F).

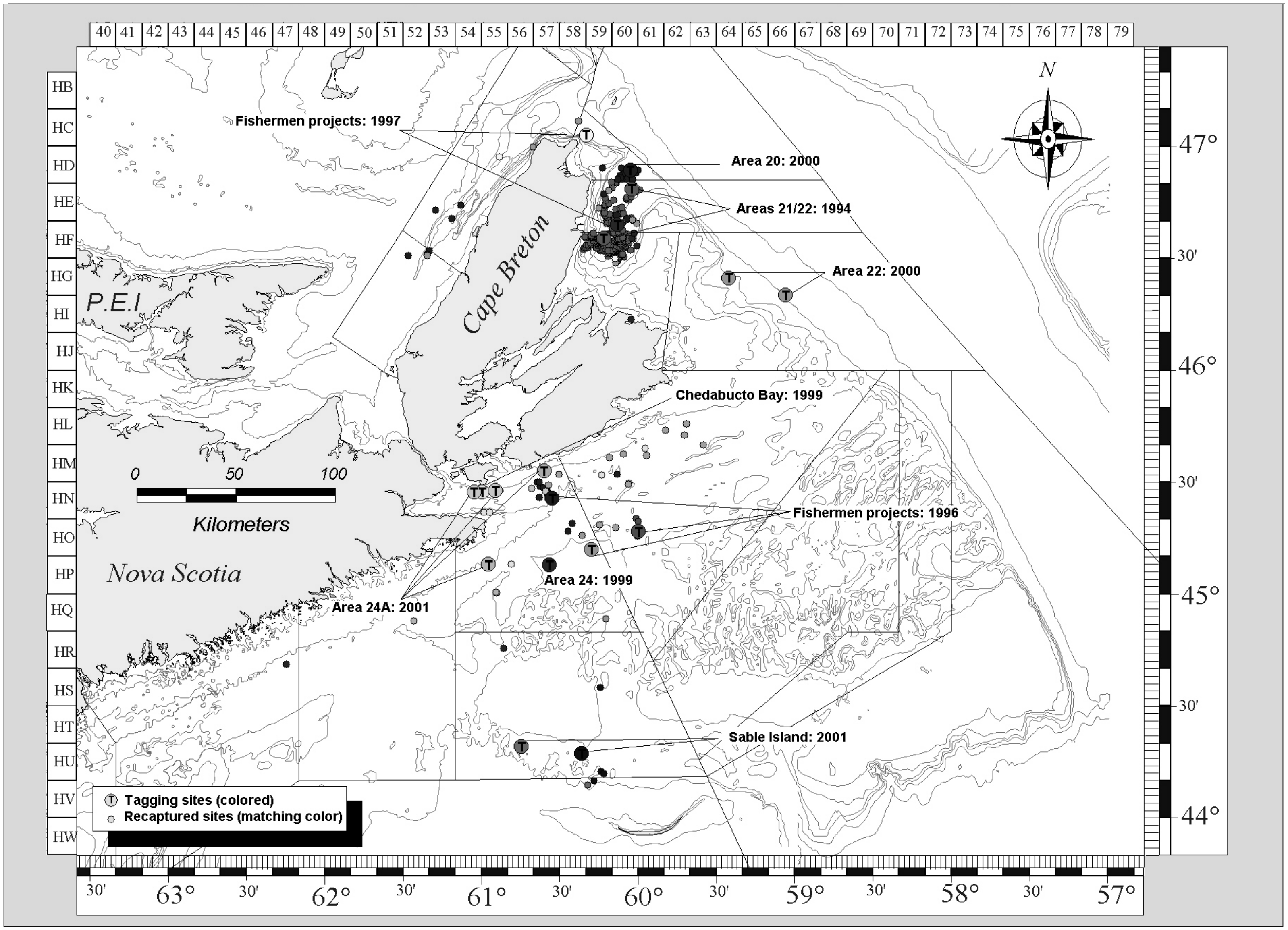


Figure 15. Snow crab tagging and recapture sites for eastern Nova Scotia (Areas 20 to 24).

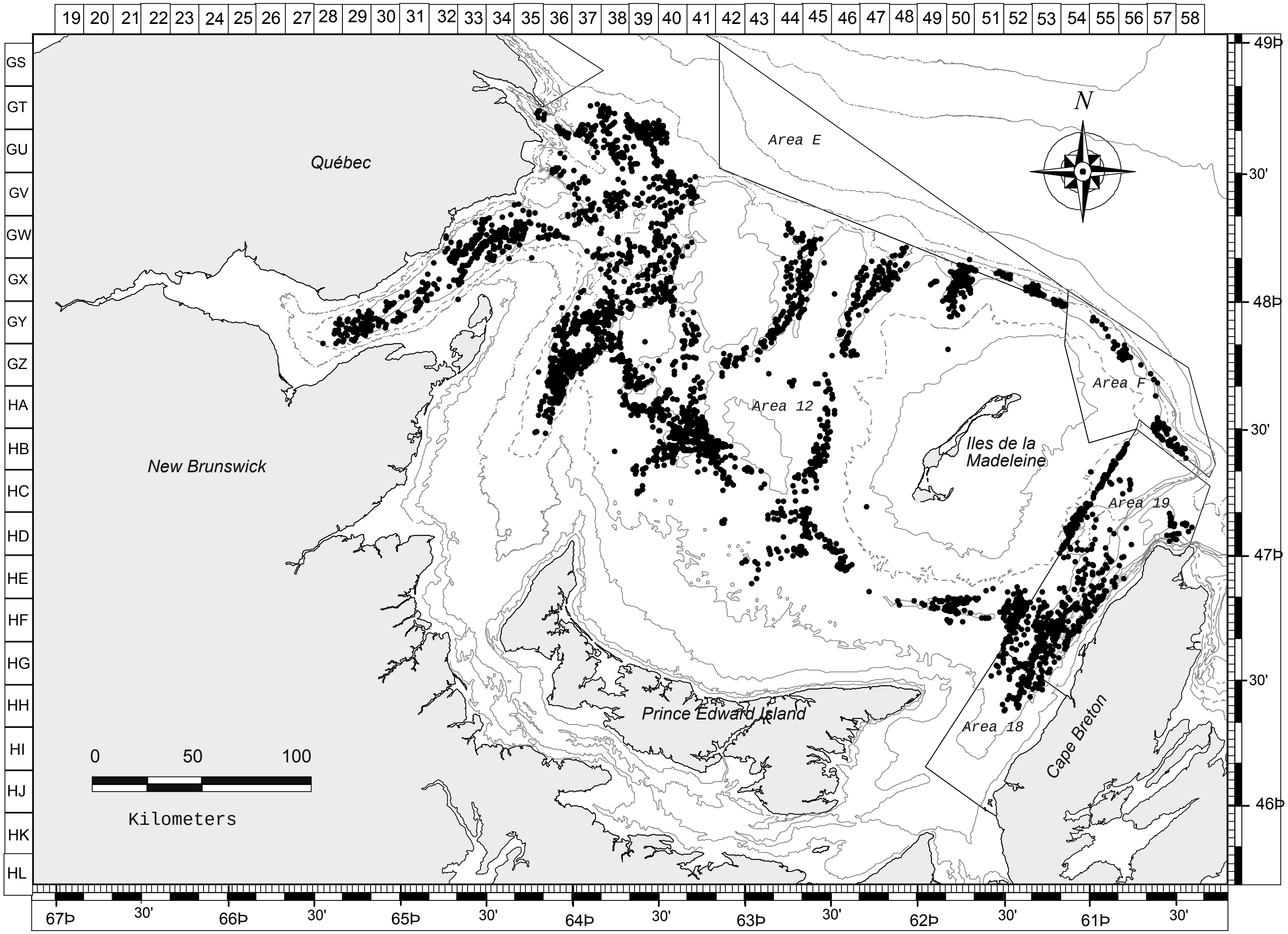


Figure 16. Southern Gulf of St. Lawrence snow crab, *Chionoecetes opilio*, management Areas and locations of traps sampled aboard commercial vessels during the 2000 fishing season.

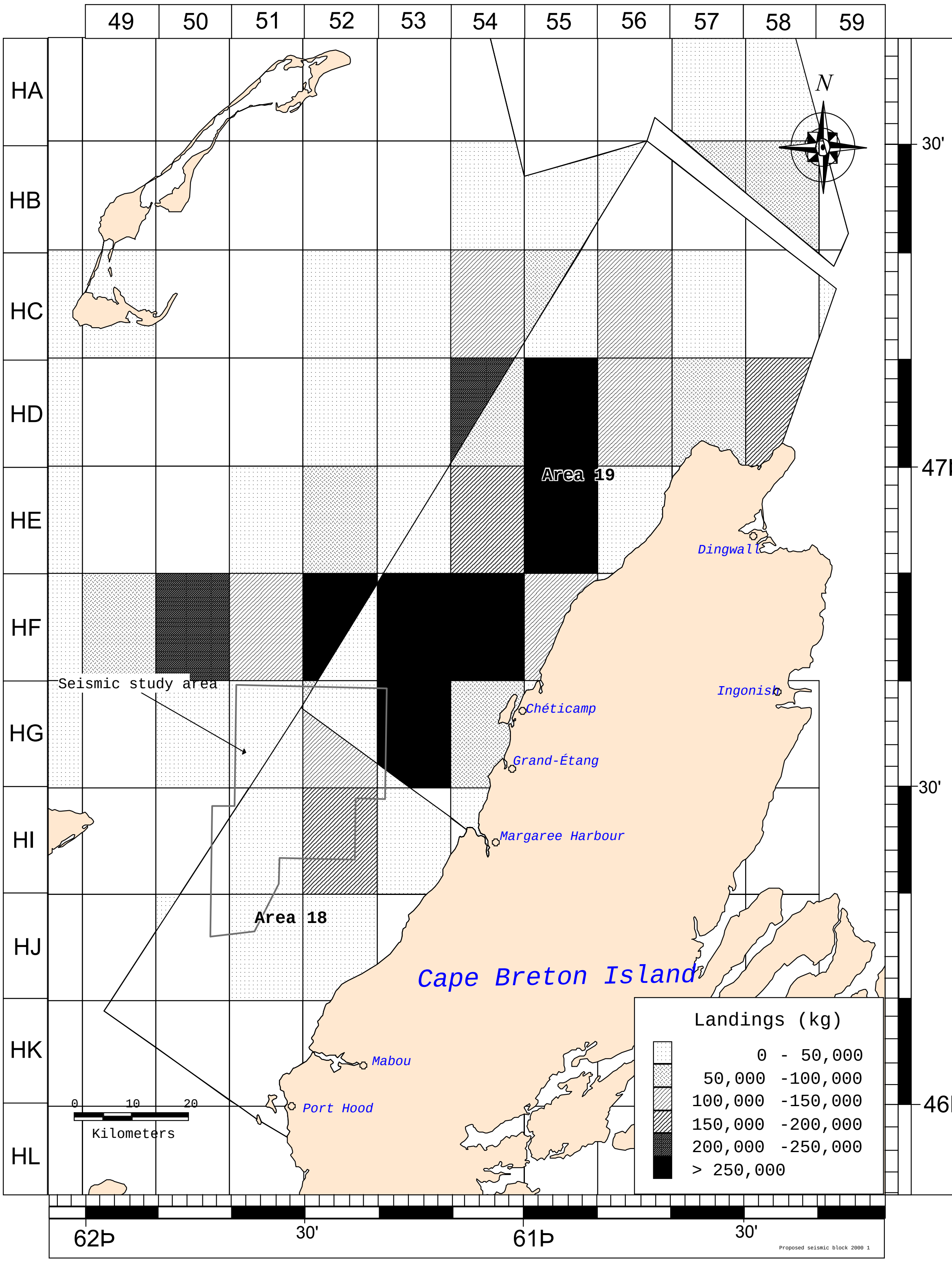


Figure 17. Geographic distribution of snow crab landings (kg) by 10 x 10 minute grids (Data were analyzed separately by fishing Area).

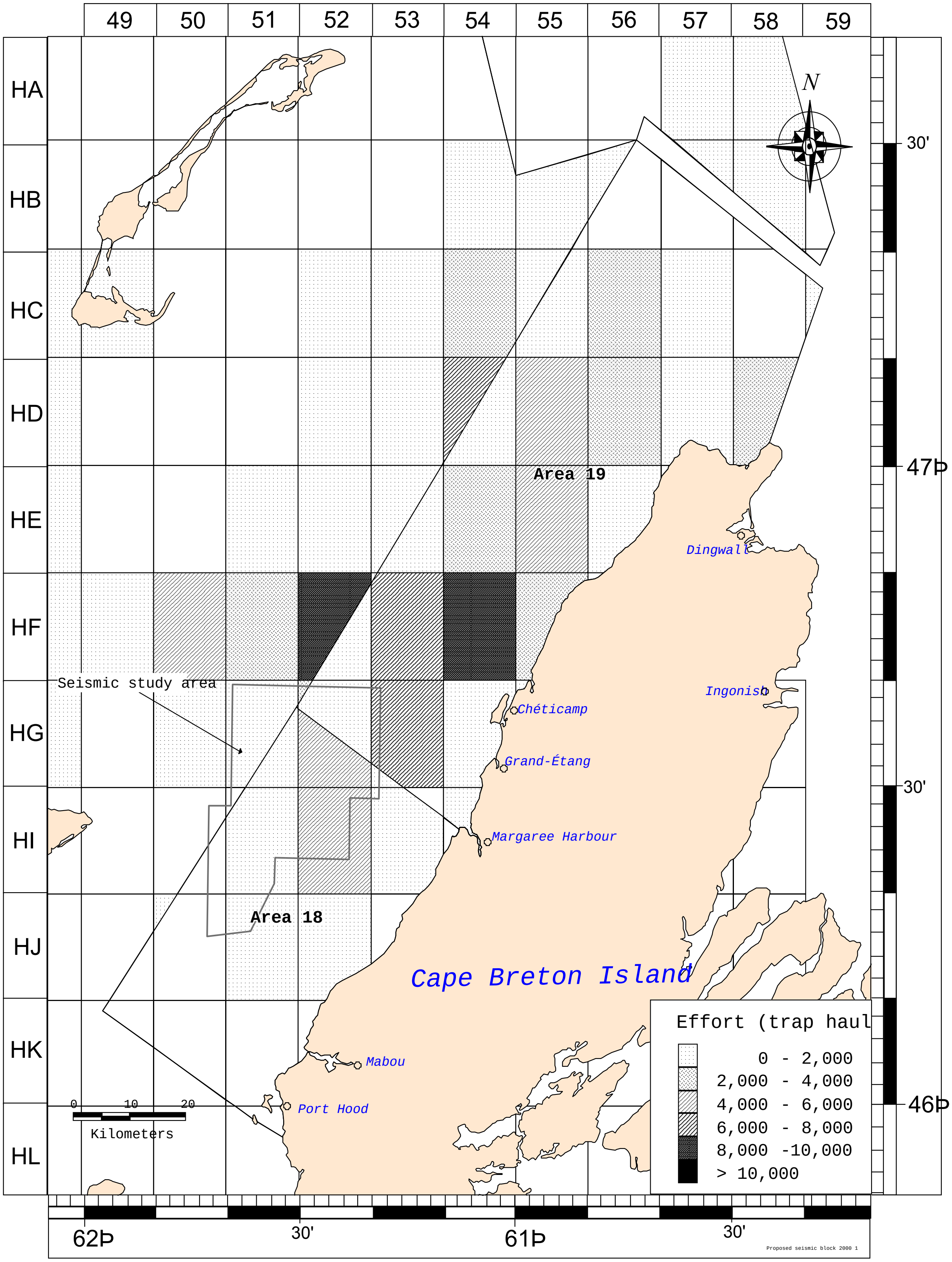


Figure 18. Geographic distribution of snow crab fishing effort (trap hauls) by 10 x 10 minute grids (Data were analyzed separately by fishing Area).

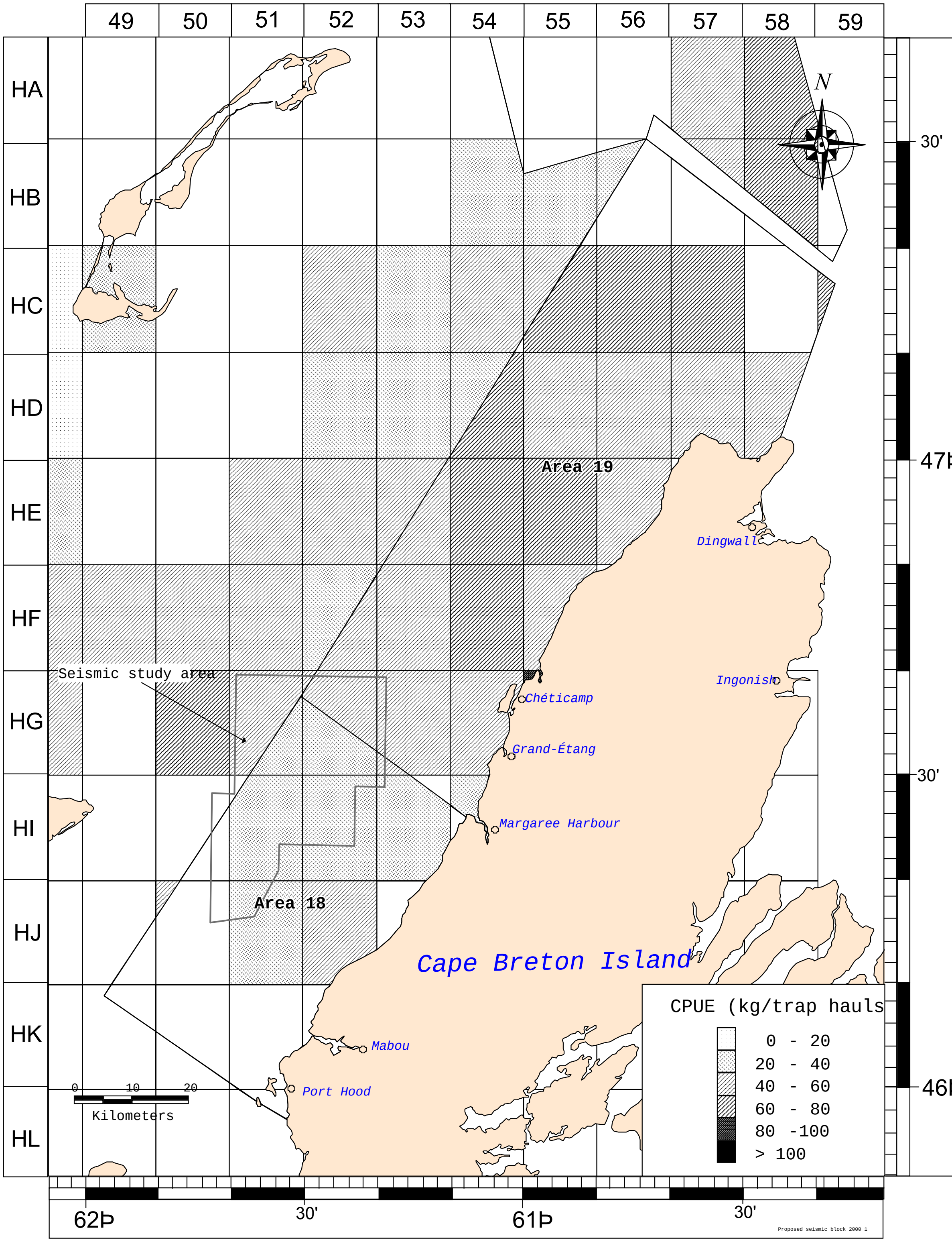
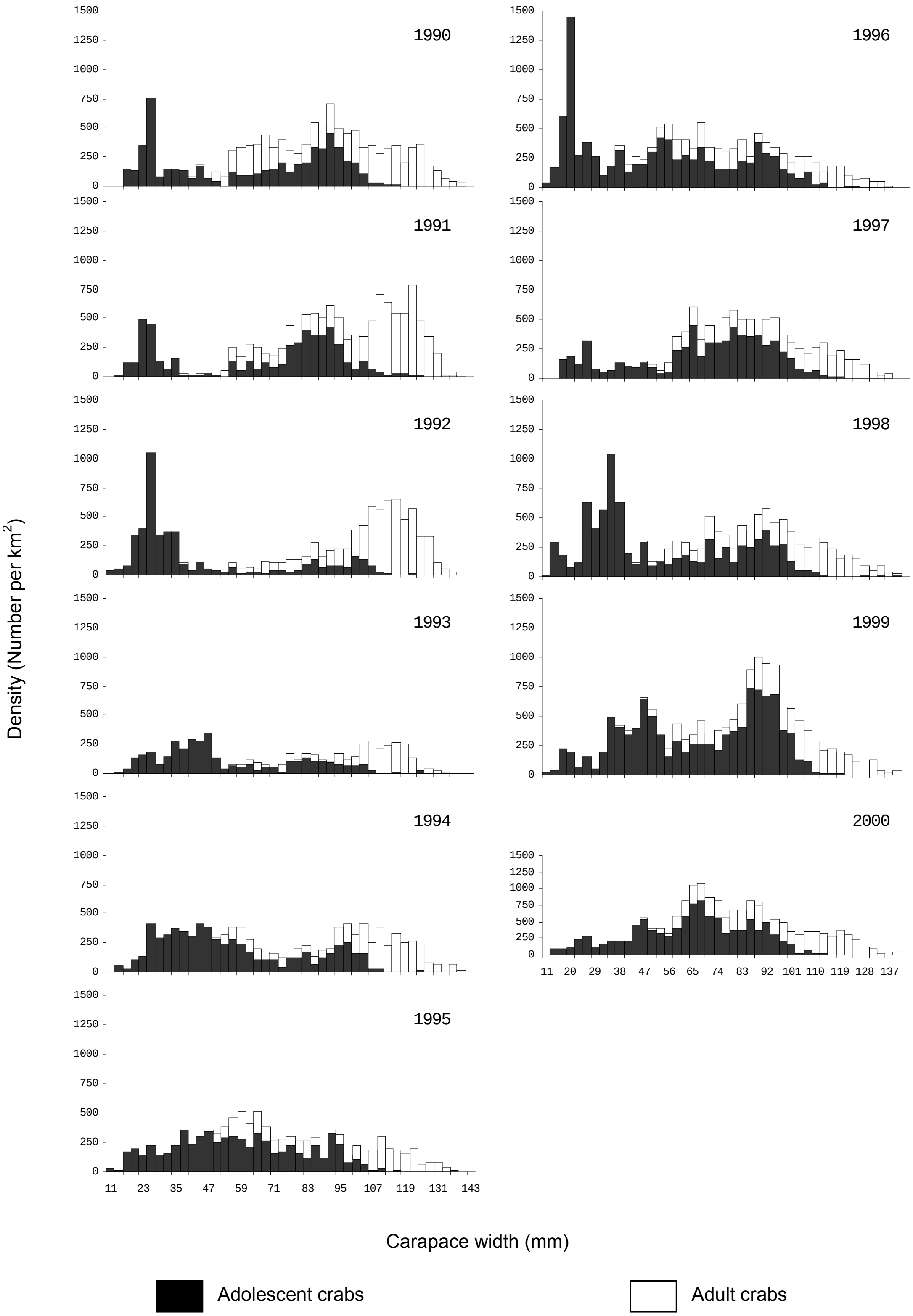


Figure 19. Geographic distribution of snow crab CPUE (kg/trap hauls) by 10 x 10 minute grids (Data were analyzed separately by fishing Area).



Fiugre 20. Size frequency distributions for male snow crabs, *Chionoecetes* opilio, taken during the research surveys in Area 19 following the fishing season from 1990 to 2000.

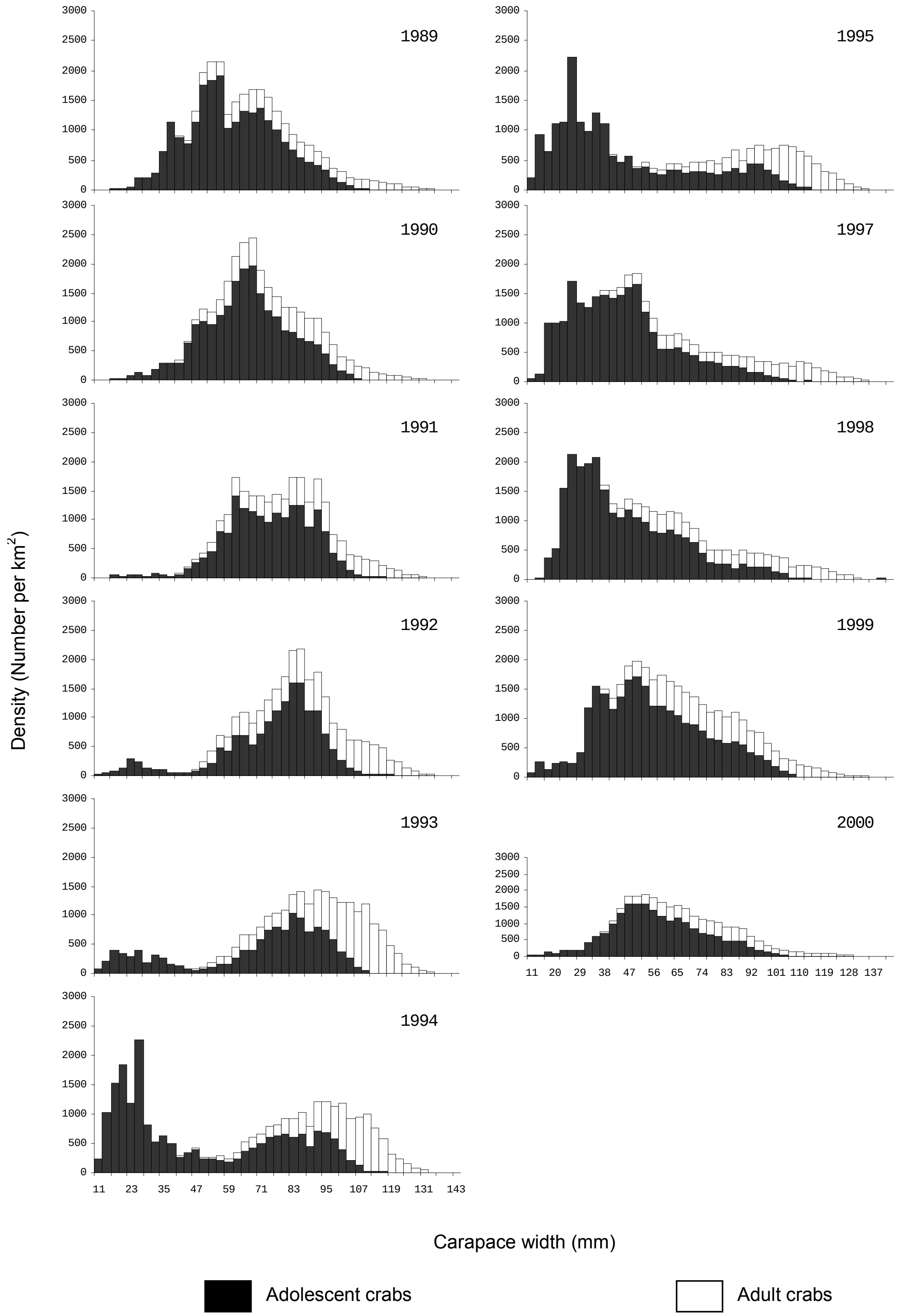


Figure 21. Size frequency distributions for male snow crabs, *Chionoecetes* opilio, collected during the research surveys in Area 12 following the fishing season from 1989 to 2000.

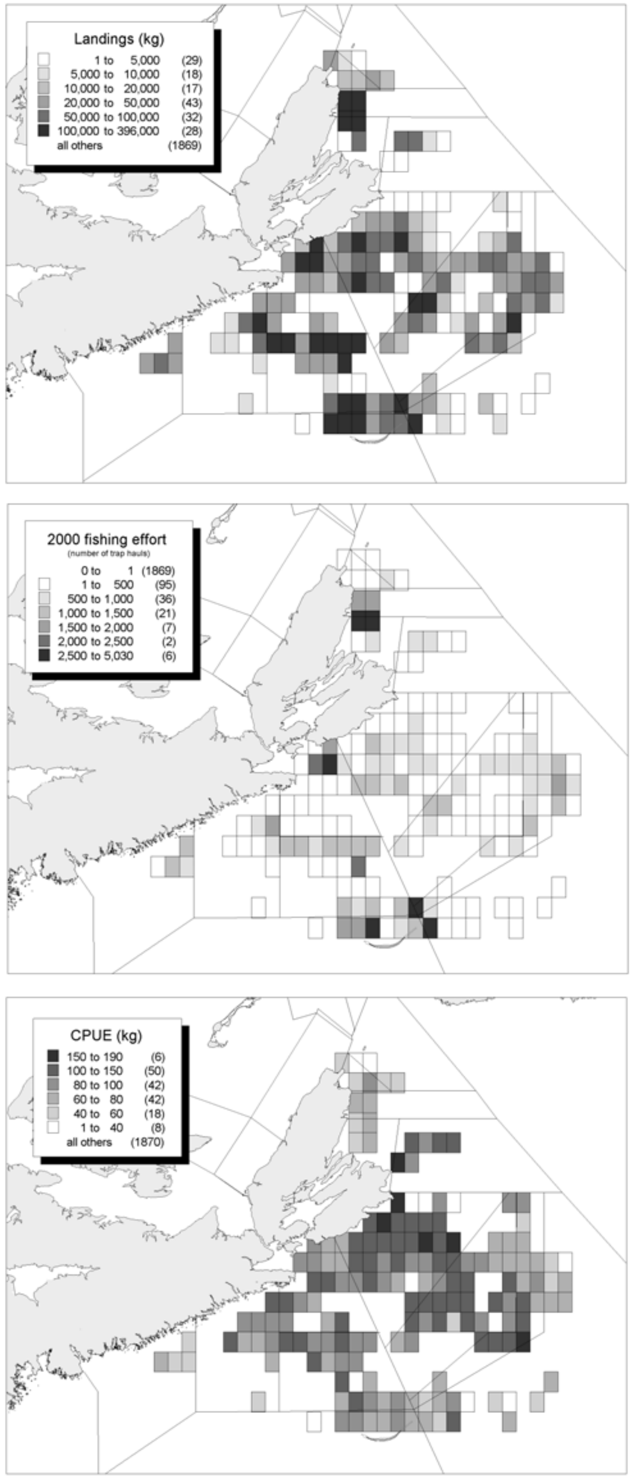


Figure 22. Seasonal distribution of the snow crab landings (kg), fishing effort (# of trap hauls) and the catch per unit effort (kg/trap haul) in eastern Nova Scotia in 2000.

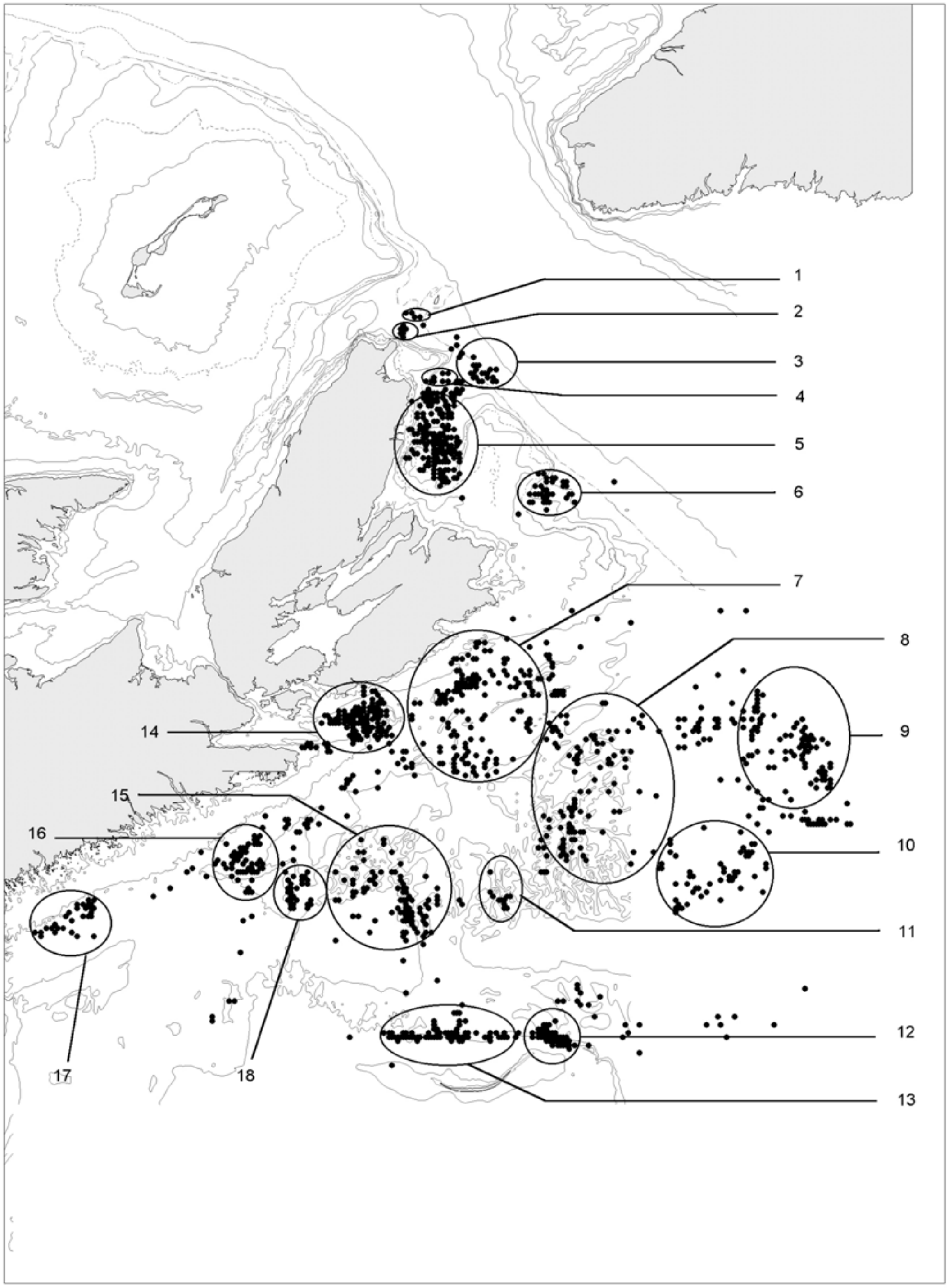


Figure 23. Catch per unit of effort for different groups without taking in consideration the areas.

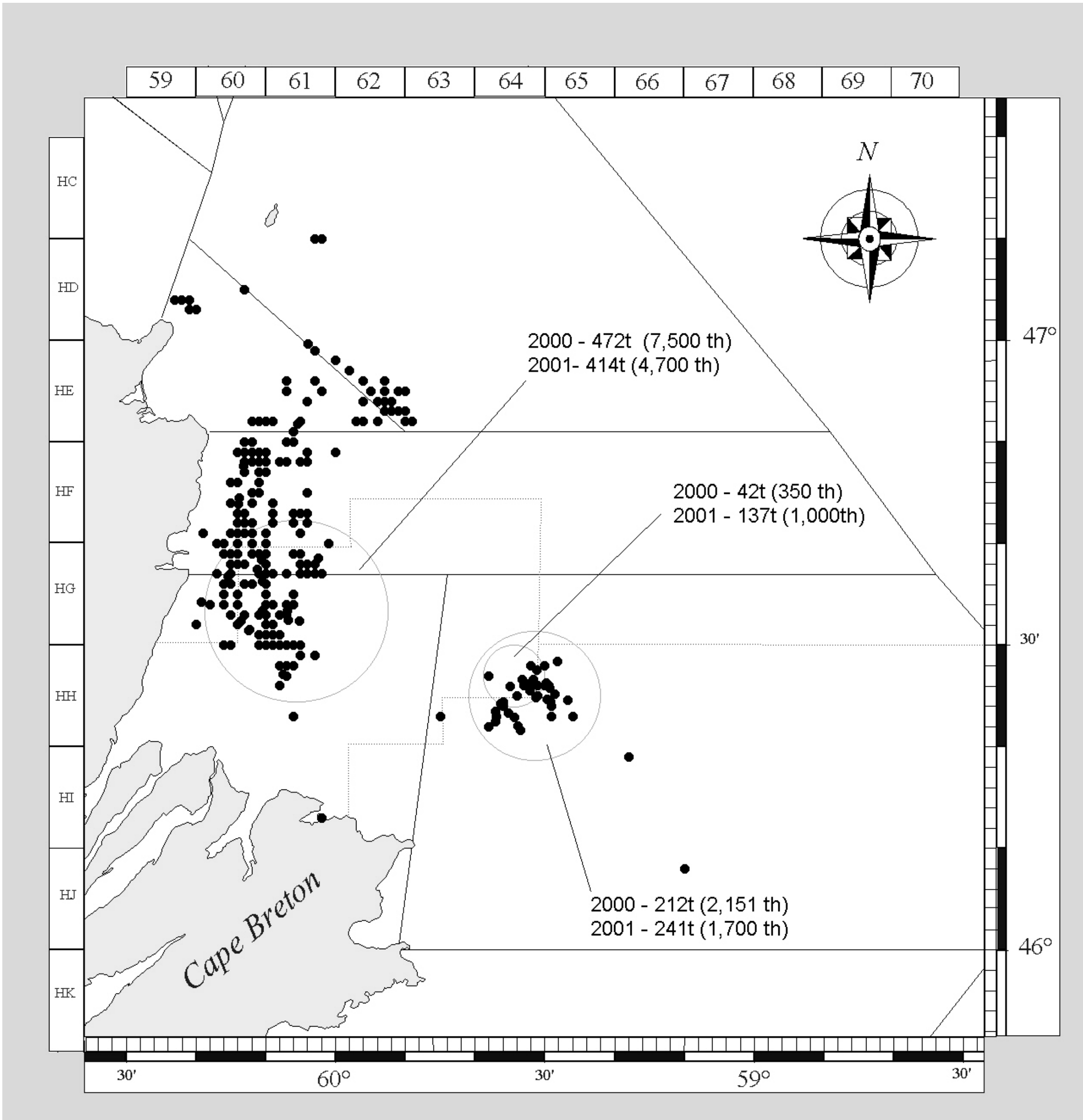


Figure 24. Commercial fishing activity within the proposed Oil & Gas exploration block.

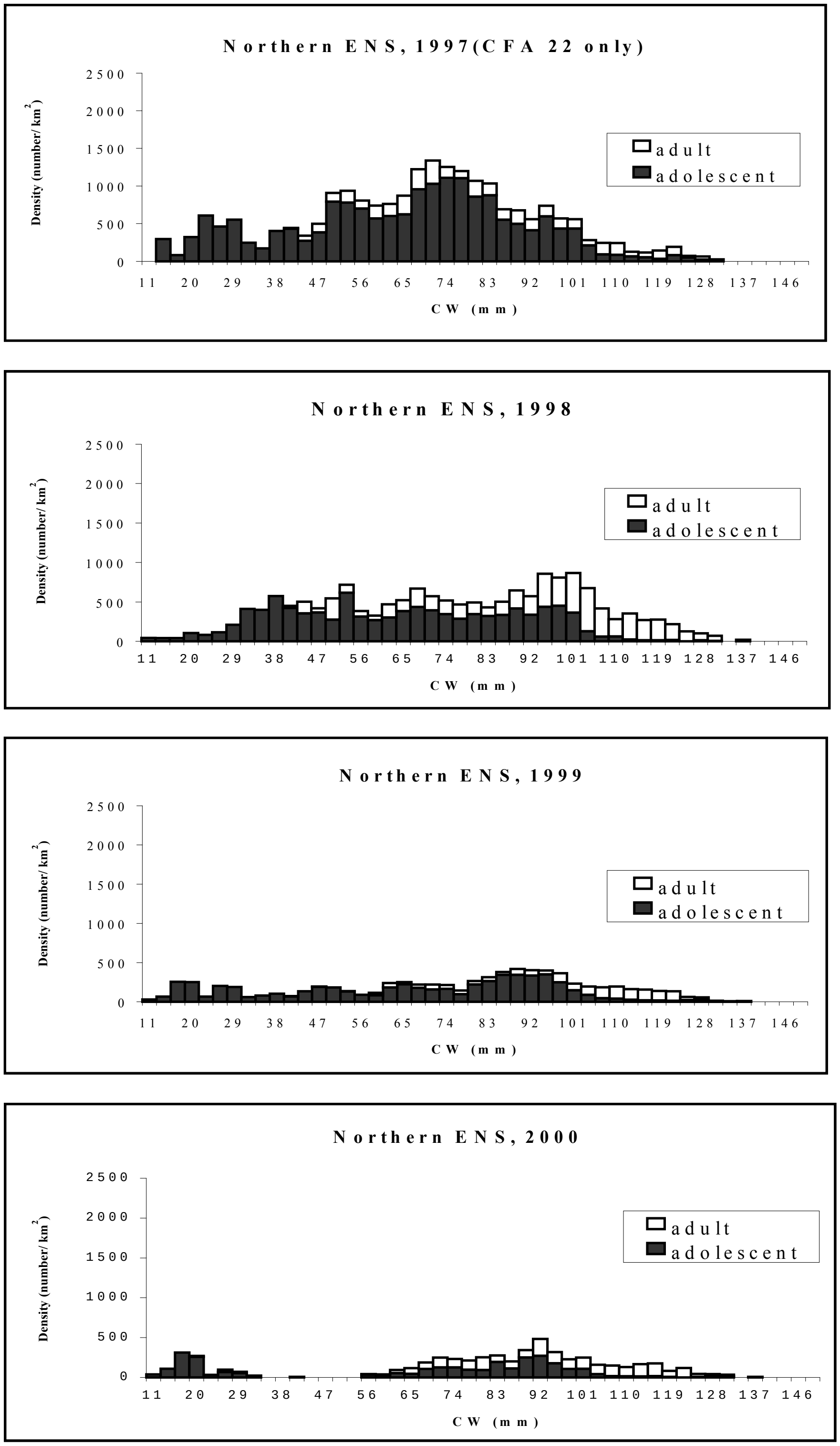


Figure 25. Survey size frequency of male snow crab in north-eastern Nova Scotia from 1997 to 2000.