Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

C S A S | *S C C S*

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2002/014 | **Document de recherche 2002/014**

Not to be cited without permission of the authors * | Ne pas citer sans autorisation des auteurs *

Assessment of the western Cape Breton snow crab fisheries (Areas 18 and 19) within the southeastern Gulf of St. Lawrence unit in 2001.

Évaluation des pêcherie de l'ouest du Cap-Breton (zones 18 et 19) dans l'unité sud-est du golfe du Saint-Laurent en 2001.

M. Hébert, E. Wade, and/et M. Moriyasu
Science Branch / Direction des Sciences
Gulf Region / Région du Golfe
Department of Fisheries and Oceans / Ministère des Pêches et des Océans
Gulf Fisheries Centre / Centre des Pêches du Golfe
P.O. Box 5030 / C.P. 5030
Moncton, NB E1C 9B6

ISSN 1480-4883

Canada

Abstract

The assessment of the western Cape Breton snow crab fisheries, Areas 18 and 19, was done based on information collected from fishermen's logbooks, at-sea and port samplings, and post-season trawl survey.

In **Area 18**, a quota of 476 t was allowed despite of a very low biomass index, which resulted in the lean total landings slightly exceeding 50% of the quota. All available stock indices indicated a negative condition of immediately exploitable stock. The mean CPUE for the 2001 season was at the lowest level since 1985 (15.3 kg/trap haul). The mean size of commercially caught crab has been decreasing since 1995. However, the 2001 trawl survey results showed that the biomass/abundance indices of adult legal-sized males projected for 2002 and future recruitment slightly increased despite of very large confidence intervals. We attribute this increasing trend in biomass to the relative high abundance of large instars within the Area since 1999. The larger-sized adolescent groups started to appear in the catch in the 2001 season as soft/white crabs. The relative abundance of pre-recruits (R-2, R-3) was at the highest level since 1993. Therefore, there is a good potential for the growth in abundance of commercially exploitable crab in the near future (2-4 years), although this depends largely on the extent of fishing effort put in the adjacent fishing Areas (Areas 12 and 19) and also the seasonal movement of crab in and out of the area. This high abundance of pre-recruits may result in a high incidence of soft-shell/white crabs. For 2002, it is strongly recommended to follow the soft-shelled crabs protocol in order to protect the future recruitment to the fishery.

In **Area 19**, a quota of 3,912 t, the highest quota ever allocated in the history of this fishery, was caught. The fishery performance reacted positively resulting in a 28 % increase in CPUE (88.5 kg/trap haul) compared to the 2000 season. However, this level was lower than that observed in 1999 (the highest CPUE for the Area). The percentage of soft-shelled crab was below the mean over the last 5-yrs, but showed a slight increase since 1999. The mean size of commercially caught crab has been decreasing since 1996. The commercial biomass index projected for 2002 (5,214 t) decreased by 20% (although with a wider confidence limits) from the 2001 season. This may be due to a net decrease of recruitment to the fishery (2,927 t, representing 56% of the commercial biomass index) compared to the 2001 season (i.e., 4,614 t, representing 68% of the commercial biomass index). The relative abundance of pre-recruits (R-2, R-3) was at its highest level ever recorded since the beginning of the survey (1990). This high abundance of pre-recruit may result in a high incidence of soft-shell/white crabs during next couple of years. For 2002, it is, therefore, strongly recommended to follow the soft-shelled crab protocol in order to protect the future recruitment to the fishery.

Geographic distribution of females, adolescents, and adult males in the southern Gulf of St. Lawrence showed that the snow crab population is continuously distributed in all fishing areas. There was a tendency of movement of larger instars towards southeastern Gulf. In the southern Gulf of St. Lawrence, the abundance of multiparous females has been decreasing from 1990 and reached the lowest level in 1995 and peaked again in 1997-98. Currently, the primiparous females abundance is decreasing. In the southeastern unit, the same fluctuation pattern of primiparous and multiparous females is observed. The difference between the two sub-units is that the abundance of preprimiparous females is still high in the southeastern unit. However, there is no sign of immediate decline in the **population's reproductive potential in both sub-units**. An increasing population of primature (preprimiparous) and new mature (primipares) females suggested a necessity to protect (i.e. lower exploitation) the most reproductive group of adult males (carapace categories 3 and 4) to ensure a high stock reproductive potential.

Résumé

L'évaluation des pêcheries de l'ouest du Cap-Breton (zones 18 et 19) a été faite en se basant sur les informations provenant des carnets de bord des pêcheurs, des échantillonnage en mer et au port, et des relevés au chalut effectués après la saison de pêche.

Dans la **zone 18**, un quota de 476 t a été alloué malgré un indice de biomasse commerciale peu élevé, résultant à des débarquements excédent légèrement 50 % du quota global. Tous les indicateurs disponibles de stock indiquaient une condition négative de la partie exploitable de stock. La PUE moyenne pour la saison de pêche de 2001 a été au niveau le plus bas depuis 1985 (15,3 kg/casier levé). La taille moyenne des crabes de taille commerciale diminue depuis 1995. Cependant, les résultats du relevé au chalut de 2001 indiquent que les indices de la biomasse/abondance des mâles adultes de taille commerciale projetée pour 2002 ainsi que le futur recrutement ont légèrement augmenté malgré des intervalles de confiance très larges. Nous attribuons cette augmentation d'abondance à une augmentation du nombre de prérecrues de grande taille à l'intérieure de la zone depuis 1999. Ces adolescents de grande taille ont commencé à apparaître dans les captures durant la saison de 2001 comme crabe mou/blanc. L'abondance relative du futur recrutement (R-2, R-3) a été au niveau le plus haut depuis 1993. Par conséquent, il y a un bon potentiel d'une augmentation de l'abondance des crabes commercialement exploitable dans un avenir proche (2-4 ans), malgré que ceci va dépendre largement de l'effort de pêche effectué dans les zones adjacentes (zones 12 et 19) et aussi du déplacement saisonnier des crabes vers l'intérieur et vers l'extérieur de la zone. L'abondance élevé des prérecrues résultera à une incidence élevée des crabes à carapace molle. Pour 2002, il est fortement recommandé de suivre le protocole des crabes à carapace molle dans le but de protéger le futur recrutement à la pêcherie.

Dans la **zone 19**, un quota de 3,912 t, le quota le plus élevé jamais alloué dans l'histoire de cette pêcherie, a été capturé. La performance de pêche a réagi positivement résultant à une augmentation de 28 % de la PUE (88,5 kg/casier levé) comparativement à la saison de 2000. Cependant, ce niveau de la PUE a été plus basse que celui observé en 1999 (la PUE la plus élevée pour cette zone). Le pourcentage des crabes à carapace molle était inférieur à la moyenne des cinq dernières années, mais montre une légère et continuelle augmentation depuis 1999. La taille moyenne des crabes de taille commerciale diminue depuis 1996. L'indice de la biomasse projetée pour 2002 (5 214 t) a diminué de 20 % (malgré des intervalles de confiance plus larges) comparativement à la saison de 2001. Ceci est probablement due à une diminution importante de la biomasse du recrutement à la pêcherie (2 927 t, représentant 56 % de l'indice de la biomasse commerciale) comparativement à la saison de 2001 (4 614 t, représentant 68 % de l'indice de la biomasse commerciale). L'abondance relative des prérecrues (R-2 et R-3) a été à leur plus haut niveau jamais observé depuis le début des relevés au chalut en 1990. L'abondance élevé des prérecrues résultera à une incidence élevée des crabes à carapace molle dans les captures dans les deux prochaines années. Pour 2002, il est donc recommandé de suivre le protocole des crabes à carapace molle dans le but de protéger le futur recrutement à la pêcherie.

La distribution géographique des femelles matures et des mâles adolescents et adultes dans le sud du golfe du Saint-Laurent montre que la population du crabe des neiges est répandue dans toutes les zones de pêche. Il semble y avoir un déplacement des crabes adolescents de grande taille vers la partie sud-est du golfe du Saint-Laurent. Dans le sud du golfe du Saint-Laurent, l'abondance des femelles multipares a diminué à partir de 1990 pour atteindre le plus bas niveau en 1995 et a augmenté pour atteindre un sommet en 1997-98. Présentement, l'abondance des femelles primipares est en diminution. Dans l'unité sud-est, le même patron de fluctuation des femelles primipares et multipares est observé. La différence entre les deux sous-unités est que l'abondance des femelles préprimipares est demeuré élevé dans l'unité sud-est. Cependant, il n'y a aucun signe immédiat d'un déclin dans le potentiel reproducteur de la population dans les deux sous-unités. Une augmentation des femelles préprimipares et primipares suggère à une nécessité de protéger (en diminuant l'exploitation) les mâles adultes les plus reproducteurs (conditions de carapace 3 et 4) pour assurer des conditions favorables à la reproduction du stock.

Introduction

Harvesting of snow crab in Area 18 (Fig. 1) began in 1979 by 14 inshore vessels with exploratory licenses, using a maximum of 30 traps per license. These licenses were converted into permanent ones the following year and 9 additional licenses were issued to explore grounds further offshore. Mid-shore vessels fished these same fishing grounds until 1982. In 1984, Area 18 was exclusively set aside for inshore fishermen. An overall quota initially established at 835 t in 1981 was reduced to 626 t in 1986 and increased to 674 t from 1988 to 1990. In the spring of 1991, a 200 t quota was allocated to promote a spring fishery in this area. A 674 t quota was then set for the fall 1991 and spring of 1992. This quota was raised to 749 t for 1992-93 and has remained the same until 1995. Since 1992, there have been 30 participants in this fishery. In 1995, 30 temporary (one year) license holders using a total of 26 inshore vessels fished 109 t of the total quota (709 t). The spring fishery was not been actively pursued by participants (the 1995 spring landing was 10 t) and was then abolished to simplify the management of the fishery. In 1996, the total quota was set at 340 t and was fished by the 30 traditional license holders. The fishery was prematurely closed (landings of 306 t) because of the high incidence of soft-shelled crabs and low CPUE in the last fishing weeks. No temporary licenses were issued due to the predicted declining stock condition. In 1997, the total quota was set at 580 t, but the fishery was prematurely closed for a second consecutive year and landings reached 406 t (70 % of the total quota). In 1998, landings were 289 t, which correspond to 70 % of the total quota set at 411 t. The fishery was closed three times during the fishing season because of the high percentage of soft-shelled crabs in the catches and the low commercial quality of landed crabs. In 1999, the quota of 408 t was caught for the first time since 1995. For the 2000 fishery, a quota of 408 t was allowed at the beginning of the season and an additional 68 t was added during the season. The quota was almost reached (landings of 472 t). In 2001, the quota was set at 478 t but landings reached only 53 % of the total quota.

In 1978, Area 19 (Fig. 1) was established for the exclusive use of inshore fishermen using vessels less than 13.7 m (45 feet) in length. Landings, controlled by quota, ranged from 900 to 1,390 t between 1979 and 1991. The quotas, set at 1,686 t from 1992 to 1994, were reached. In 1995, 37 temporary (one year) license holders using 25 inshore vessels fished 134 t of the total quota (1,577 t). In 1996, the 111 permanent license holders fished a quota of 1,343 t. In the same year, a 5-year partnership was signed between the Department of Fisheries and Oceans (DFO) and Area 19 snow crab fishermen's association (Anonymous, 1996). In 1997, the total quota was set at 1,386 t and was increased to 1,991 t in 1998 (the 1998 landings reached 1,988 t). In 1999, the quota was set at 1,986 t, which represented an exploitation rate of 63 % of the exploitable biomass. For the 2000 season, a quota of 3,370 t was set. This quota was shared between traditional and temporary fishermen according to the co-management agreement (2,702 t to the traditional and 668 t to the temporary). The fishing season was

closed before the temporary fishermen had time to finish their quotas because of high incidence of white crab (hard-shelled crab with low meat yield) in landings and also to permit DFO Science Branch to conduct the trawl survey. In 2001, the quota in Area 19 increased to 3,910 t shared between traditional (3,617 t) and temporary (293 t) fishemen according to the co-management agreement.

Prior to 1990, the biomass of snow crab for the western Cape Breton fisheries (Areas 18 and 19) has been estimated indirectly from catch and effort data using Leslie analysis (Leslie and Davis 1939; Ricker 1975). In 1990, a trawl survey with a geostatistical data analysis (kriging) was introduced (Conan et Maynard 1987) to enhance the precision of snow crab abundance estimation and establish sound stock management strategies. New management measures were introduced in 1991. One of the strategies used was to determine the total allowable catch (TAC) or quota based on the biomass of adult male crabs ≥95 mm CW. A second management strategy was to avoid soft-shelled crabs in the catches because they are in poor commercial quality, unable to participate in mating and represent recruits for the following fishing seasons. Soft-shelled crabs are discarded at sea by fishermen. They are fragile and should be carefully handled to avoid mortality before being returned to the sea. Monitoring of soft-shelled crabs in the catches during the fishery can be achieved by using a durometer gauge (Foyle et al. 1989). Since 1997, a protocol for the daily monitoring of the soft-shelled crabs was put in place for the western Cape Breton fisheries. These fisheries could be partially or completely closed when the average of soft-shelled crabs (in number) exceeds 20 % over two consecutive periods of two days. In Area 18, an individual boat quota was established from 1991 to 1997 based on the trawl survey results. In 1998 and 1999, the quota was established using only the information on the fishery performances (catch per unit of effort (CPUE) and percentage of soft-shelled crabs). In Area 19, an individual boat quota was established since 1991 in collaboration with the industry based on the trawl survey results.

Methods

Fishery monitoring

Raw data on catches and fishing effort were obtained from the fishermen's logbooks and the sales slips of processing plants. The data were compiled by the Informatics and Statistics Branch of Gulf Regions of the Department of Fisheries and Oceans and re-verified by Science Branch. Not all logbooks were usable. The mean catch per unit of effort (CPUE) of the fleet at year (i) corresponds to the ratio of total catches from sales slips (where available) or the fishermen's logbooks (y_i) and the corresponding number of trap hauls (th_i) reported in the logbooks: $CPUE_i = \sum y_i / \sum th_i$. The total effort (total number of trap hauls: (TH_i) was then

estimated by total landings (Y_i) from the quota report divided by average $CPUE_i$: $TH_i = Y_i/CPUE_i$. The geographical distribution of fishing effort was presented as the sum of the total number of trap hauls within each grid of 5 minutes latitude by 5 minutes longitude. The fishing positions were taken from logbooks. In Area 19, the fishing performance between the traditional and temporary fishermen is different (DeGrâce et al. 2001) and in order to better compare the annual CPUE, from 1998 to 2001, data from temporary fishermen were excluded.

Since 1990, DFO has carried out an intensive sampling program (observer program) onboard commercial vessels (Fig. 2) to provide a weekly assessment of the percentage of soft-shelled crabs in the catches. For each trap sampled, the position, depth and total number of male crab were recorded. A sub-sample of 40 crabs were chosen randomly and the following measurements were taken: carapace width (CW), chela height (ChH), carapace condition (CC: Hébert et al. 1997) and the hardness of carapace (CH) measured at the base of the right propodus with a durometer (Foyle et al. 1989).

The catch composition (% of different categories of crab) was estimated based on the carapace hardness (hard or soft), size (legal and sub-legal), and morphometric maturity. The terminology described by Sainte-Marie et al. (1995) is used in this paper; ‘’adolescent’’ formerly called morphometrically immature and ‘’adult’’ formerly called morphometrically mature (Conan and Comeau 1986). Individuals with carapace conditions 1 and 2 and claw hardness less than 68 on the durometer were considered as soft-shelled crabs (Hébert et al. 1992). The annual and weekly mean percentages of soft-shelled crabs were calculated based on the size distributions obtained at-sea and at-port samplings, then weighted by the landing for each sampled vessel (Hébert et al. 1992).

Trawl survey

A trawl survey has been conducted since 1990 in the southeastern Gulf of St. Lawrence except for 1997 and 1998 (no survey has been conducted in Area 18) to evaluate the commercial biomass and population dynamics. From 1990 to 1992, the trawl survey in Areas 18 and 19 were conducted before the fishing season but since 1993, the trawl surveys were conducted after the fishing season. From 1990 to 1998, the “Emy-Serge”, (65 feet side-trawl wooden boat with 375 HP), was used to conduct the trawl survey. Since 1999, the “Den C. Martin”, (65 feet stern-trawl steel boat with 402 HP), has been utilized to conduct the survey. The “Emy-Serge” was sold, which unable us to perform a comparative study between the two boats. Without a comparative study between the two survey vessels, the biomass estimations from both time series could not be compared. It was also decided at the last RAP meeting (Anonymous 2001) that the 2000 biomass estimate from the 1999 trawl survey is not considered to be reliable due to the malfunction of the Netmind sensors and the difficulty to calculate the swept area by the trawl. This problem was resolved for the 2000 trawl survey by calibrating the distance sensors

and adding a Netmind depth sensor and a Minilog depth-temperature probe to the trawl to better monitor the touchdown of the trawl net.

A systematic random sampling design was used to determine the location of trawl stations (Fig. 3). One to two locations were randomly chosen among nine sub-grids (station in the middle of the grid) within each grid of 10 minutes latitude by 10 minutes longitude. The center of each sub-grid chosen was used as the position of each trawl station. The starting and ending positions and time of each tow, depth and bottom water temperature were recorded. Once the locations of each tow were determined, they remained fix every year. Since 1999, trawl survey has been conducted on board the ''Den C. Martin'', a 65 feet steel hulled stern-trawler with a 402 HP. A Bigouden *Nephrops* trawl net originally developed for Norway lobster (*Nephrops norvegicus*) fisheries in France was used (20 m opening with a 27.3 m foot rope on which is mounted a 3.2 m long, 8 mm galvanized chain; Conan et al. 1994). All stations were trawled during daylight time. For each tow, the predetermined amount of warp was let out (3 times the distance of the depth) and winch drums were locked. The start time of a standard tow was determined when the trawl touched the bottom monitored by the Netmind depth sensor (signal received at every 7 seconds) and the Minilog temperature-depth probe (signal received at every 3 seconds) attached to the trawl. The duration of each tow varied between 4 to 6 minutes at an average speed of approximately 2 knots depending on the depth, current speed and sediment type. The catch of each tow was photographed after the catch had been released to the deck and downloaded on computer. The horizontal opening of the trawl was measured every 4 seconds with the Netmind distance sensors. The swept distance by the trawl was estimated from the position (latitude/longitude) measured every second with a DGPS system. The swept surface for each tow was then calculated using an instantaneous surface algorithm (Surette, unpublished). The carapace width (CW), chela height (ChH for male only), width of the 5^{th} abdominal segment (AW, for female only), carapace hardness (CH) measured with a durometer, and carapace condition (CC) were recorded on every individual crab caught during the survey. The color of the eggs of mature females and the color of the gonads of immature females were noted.

A kriging (MPGEOS) program (Wade et al. in prep.) for snow crab stock assessment in the southern Gulf of St. Lawrence was used to estimate annual abundance and density contours for both males and females based on their size and maturity status. Using point kriging and a fitted variogram, we generated maps of density and variance contour. We further used block kriging for estimating an average density and variance to estimate the total number of crab present in a given area. The abundance of snow crab estimated by kriging was converted into biomass (called biomass index hereafter) using a size-weight relationship. To convert size to weight, size-weight relationships were calculated according to molt stage, maturity status, and sampling season. The size-weight relationship for adult hard-shelled males is expressed by the following function: $W = (2.665 \times 10^{-4})$ CW

$^{3.098}$ (Hébert et al. 1992). Mortality between the survey and the fishing season (8-9 month period) was considered as null except for category-5 crabs (very old carapace). Biomass index was projected for (1) total biomass (B) for the following fishing season without considering the mortality for category-5 crabs, (2) annual recruitment to the fishery (R), and (3) biomass of category-5 crabs (OB). The abundance indices of future recruitment to the fishery (R-3 and R-2) were also estimated. The R-3 group represents the adolescent crabs with a CW between 69 and 83 mm caught at the time of the survey, which a portion could be available for harvesting in 3 years. The R-2 group represents the adolescent crabs with a CW larger than 83 mm caught at the time of the survey, which a portion could be available for harvesting in 2 years. In addition, the abundance index of pre-primiparous, primiparous and multiparous females was estimated. The term pre-primiparous defines females with a narrow abdomen and orange gonads that would molt to maturity the following year as primiparous females (first brood). The term multiparous defines females, which are in their second brood or older. To assess the reproductive potential of the stock, a functional sex ratio was established by comparing the abundance of commercial-sized adult males versus the abundance of pre-primiparous and total mature females (primiparous and multiparous). It is important that the abundance and biomass indices of the different categories of crabs should not be considered as the absolute values since the natural mortality, the emigration or immigration of crabs after the survey and the catchability of the trawl are not considered in the biomass estimation. Consequently, the exploitation rate should not be applied based on the commercial biomass index values.

The hypothesis of crab movement from the northwestern towards the southeastern area of the southern Gulf of St. Lawrence was discussed at the 2001 RAP session to elucidate the differential stock fluctuation pattern between southwestern unit (Areas 12 & 12E) and southeastern unit (Areas 18, 19 & 12F). Although subsequent analyses on geographic distribution of different instars revealed that snow crab population distributed without interruption between the two units (Moriyasu, unpublished information), it was thought that this approach is still valid especially when assessing global trend in the southeastern unit because of possible active seasonal movement of crab within this unit. The boundary between the two units was set at 62° 10 ‘ (Fig. 1) based on the historical distribution of fishing effort and fishable biomass distribution. Sex ratio and abundance index of pre-primiparous, primiparous, multiparous females and commercial-sized males were analyzed within this unit rather than assessing in each fishing Area.

Bias in the commercial biomass estimates

Since we first estimated the commercial biomass index in 1989, we have not considered any natural mortality in our projection. We have also assumed that the catchability of the trawl is 100 % for commercial-sized crabs. As such, the biomass projection should be considered as a relative abundance, although

managers and clients have been using the mid-values of our estimates as absolute abundances. Some concern was expressed during a recent Zonal Assessment Process meeting held in Newfoundland in January 2002 about this issue. Although complementary information concerning possible losses has been presenting at the Regional Assessment Process (RAP) meetings since 1999, it was felt that discrepancies between the expected and observed values from the simple forward projection model be explicitly considered as the natural mortality in the assessment process. The forward projection model simply states that discrepancies between the estimated abundance of commercial crabs (adult males ≥ 95 mm CW with carapace conditions 1, 2, 3, 4 and 5) from the trawl survey at year (y) and the sum of the landings at year (y + 1) and the remaining abundance at year (y + 1) should be considered as the natural mortality. The remaining abundance component of this model is the adult males ≥ 95 mm CW with carapace conditions 3, 4 and 5 caught at the time of the trawl survey. The bias between these two values was evaluated from the survey data series from 1997 to 2001.

Results and Discussion

Area 18

Fishery information: In 2001, the fishery in Area 18 started on April 30 and was temporally stopped on June 02 for five weeks and started again on July 1 until August 18. The same amount of quota (476 t) as the 2000 season was allocated in 2001, but landings only reached 53% of the quota (Table 1, Fig. 4). The fishing effort in 2001 was estimated at 16,446 trap hauls, an increase compared to 2000 (14,696 trap hauls) (Table 1). As usual, the majority of fishing effort and landings was located in one grid at the northern boundary of the Area (Figs. 5 & 6). The average CPUE in 2001 was significantly decreased from that in 2000 (32.1 kg/th) and was at the lowest recorded level (15.3 kg/th) since 1986 (Table 1, Figs. 7 & 8).

Sea sampling provided a good coverage of the main fishing grounds in the western Cape Breton (Areas 18 and 19) fisheries in 2001 (Fig. 2). In Area 18, a total of 56 traps were sampled (4.0 % coverage) and 2,179 males were measured during the 2001 fishing season. The sampling coverage, number of trap sampled, and number of crabs measured were lower than the 2000 season (5.4 % coverage, 92 traps, and 3,628 crabs, respectively). The annual mean percentage of soft-shelled crabs increased to 8.6 % in the 2001 fishing season compared to 8.4 % and 3.2 % in 2000 and 1999, respectively (Table 1, Fig. 9). The weekly percentage of soft-shelled crabs varied between 0 and 14.2 % (Fig. 10). A higher percentage of white crab appeared in the fishing ground near the northern boundary, but no closure of the fishery occurred in 2001 (Fig. 11). The catch composition (Table 2) changed significantly in 2001 compared to 2000. The percentage of legal-sized crabs decreased (72.9 % in 2000 to 50.5 % in 2001), whereas a significant increase in

percentage of “pigmy” crab (adult males of sub-legal sized) was observed in 2001 (19.5 % to 42.1%). The percentage of soft-shelled and skip molters were at a comparable level between 2000 and 2001. The commercial catch composition by carapace category (Table 3) showed that the percentage of commercial-sized adult of category 1+2 (soft/white) and category 4 have been increasing since 1999 and 1997, respectively, whereas category 3 adult crab of legal size has been continuously decreasing since 1998. The size frequency distributions (Fig. 12) of crab caught at sea during the season from 1997-2001 showed a continuous shift of distribution towards the smaller sizes and a lack of larger size adolescent crabs. The mean size has been continuously decreasing since 1995 from 118.6 mm CW to 108.3 mm CW in 2001 (Fig. 13).

Trawl survey: The biomass index (B) at the time of survey (without considering the natural mortality) was estimated at 1,063 t (±115%), which represented an increase of 109% compared to the 2000 projection (Table 4, Fig. 14). This biomass was concentrated in the northern part of Area 18 (Fig. 15). The index of recruitment to the fishery (R) was estimated at 817 t (± 123%) constituting 77% of the total biomass index. The abundance of R-3 and R-2 (Fig. 16) peaked at 6.1 millions in 2000 and at 3.9 millions in 2001, respectively. A high abundance of R-3 was observed in 1991 (4.4 millions) and in 1995 (7.3 millions), and there were a high abundance of R-2 in 1991 (3.8 millions) and in 1995 (5.0 millions). However, the high abundance of pre-recruits (R-2 and R-3) observed in 1995 did not result in a subsequent high abundance of fishable biomass index. The projected geographic distribution of white crab (Fig. 17) revealed that the distribution pattern has changed from that seen in 2000. Two highly concentrated zones found in Areas 18 and 19 were more diffused over the southeastern Gulf. This may result in a higher possibility of encountering white crab during the 2002 season in Area 18. The biomass index of category 5 (very old crab) was estimated at 76 t (±191%).

Size distributions of crabs caught in the trawl survey (Fig. 19) showed continuous growth of younger instars found in 1999 towards larger size categories. The comparison of histograms since 1990 suggested that a high abundance of pre-recruit observed has occurred three times in the past (1990, 1995 and 2001). Although the current size distributions suggests a potential for a significant increase in fishable biomass in the near future within this fishing area, the abundance of pre-recruits may not necessarily contribute to the future biomass as it is uncertain whether this potential recruitment to the fishery will stay within the area after molting to adult phase.

Area 19

The 2001 fishing season started July 9 and closed September 14. The landings have increased since 1996 and reached the highest level ever record for this Area. The landings for the 2001 fishing season were 3,910 t compared to 3,225 t in 2000 (Table 5, Fig. 20). The traditional and temporary fishermen caught their quota (total

of 3,910 t) by the eleventh fishing week. Temporary fishermen only started fishing in week 5. The 2001 landings mainly came from the southern part of Area 19, although there was a slight shift of fishing effort towards the northern part of the Area compared to 2000 (Fig. 6). The average CPUE in 2001 (88.5 kg/th) increased by 27.6 % compared to the 2000 level (64.1 kg/th, Table 5). The CPUEs were homogeneously high all over the fishing ground except for the southwestern and northeastern corners of the Area (Fig. 8). The weekly CPUE (Fig. 21) started at 120 kg/th and gradually decreased to 60 kg/th during the 10th week. The weekly CPUE pattern was identical to the 2000 season with higher weekly CPUE values. The fishing effort (46,251 trap hauls) decreased by 16% compared to 2000 (55,977 trap hauls, Table 1). The fishing effort was spread all over of Area 19 except for the northern (hard bottom) zone (Fig. 5).

Sea sampling provided a good coverage of the main fishing grounds in the western Cape Breton (Areas 18 and 19) fisheries in 2001 (Fig. 2). In Area 19, a total of 233 traps was sampled (4.4 % coverage) in 128 trips with 9,299 males measured. The coverage by observers was less than what was reached during the 2000 season (370 traps in 166 trips with 4.3 % coverage, and 14,762 males measured). This was mainly due to the decreased number of trips in 2001 (2,920 trips) compared to 2000 (3,897 trips). The weekly percentage of soft-shelled crabs (Fig. 21) increased from 4.1 % in the first week to 10.2 % in the fourth week and decreased gradually to 0 % at the tenth week. The weekly percentage of soft-shelled crabs increased to 5.1 % at the last fishing week (week 11). The seasonal average percentage of soft-shelled crabs increased to 6.5 % in 2001 compared to 5.6% in 2000 (Table 5, Fig. 22).

The seasonal catch composition from the observer data (Table 6) was identical between the last two seasons except for an increase in the percentages of soft-shelled and pigmy crabs and a decline in skip molters. In 2001, the percentage of commercial-sized adult males (Table 7) of categories 1 and 2 (8.3 %) decreased significantly compared to the 2000 season (16.6 %). This is contrary to what we observed in soft-shelled crab percentage, however, the soft-shelled crab percentage includes all male crabs caught by trap, whereas the carapace composition was estimated based on the commercial-sized males. This suggested an increased proportion of under-sized soft-shelled crab, the future recruitment (R-3 and R-2), in the commercial catch. The percentage of commercial-sized crab (category 4) has been continuously increasing since 1997 and reached 60.1% in 2001. Category 5 crab has decreased from 0.8% in 2000 to 0.3% in 2001. The mean CW of the catch has decreased from 120.5 mm CW in 1995 to 114.9 mm CW in 1998 and then slightly decreased to 114.3 mm CW in 2001 (Fig. 23). However, the size distribution of crabs caught at sea showed a bi-modal distribution pattern in 2000 and 2001 compared to a uni-modal distribution pattern in 1997-1999 (Fig. 24). Decomposition of the histograms into carapace conditions (Fig. 25) showed that the larger mode group was comprised of more new crabs

(carapace conditions 1 and 2) than the smaller mode group (mainly carapace conditions 3, 4 and 5).

The **biomass index** (B) at the time of the survey (without considering the natural mortality) was estimated at 5,214 t (± 32 %), which was a decrease of 16% from the 2000 projection (6,210 t ± 18 %) (Table 8, Fig. 26). The three main patches of concentration were observed in the southern, middle and northwestern parts of the Area (Fig. 15). The index of recruitment to the fishery (R) was estimated at 2,927 t (± 47%), which was a significant decrease from the previous year (4,328 t ± 22%). This index was 56% of the total projected biomass index. The abundance indices of future recruitment to the fishery, both R-3 and R-2, were at their highest level observed since 1991 reaching 21.8 and 14.1 millions, respectively (Fig. 27). As the biomass index of recruitment decreases, the catch composition in the 2002 season will shift towards older crabs. In addition, with the arrival of an increased abundance of soft-shelled crab (R-2 and R-3), a high incidence of soft-shelled crab is anticipated. The biomass index of very old crab was estimated at 206 t (± 96%), which showed a continuous increase since 1999. The main concentration of old-shelled crab was found in one of the main fishing grounds (southern part of the Area: Fig. 18) where high fishing effort has traditionally been observed.

Size frequency distributions of crab caught in the trawl survey (Fig. 28) have been available since 1990. In this area, the size distribution pattern seemed to be different compared to that of Area 12. There has been uninterrupted appearance of small instars (absence of trough). Between 1990 and 1993, the progression of modes was not apparent. There was also no evidence of a lack of medium sized adolescents during these years. Since 1993, a continuous appearance of many instars and their progression (growth) has been observed. In 1996, six distinct modes (21.5 mm CW, 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 properly investigated due to the *Nephrops* trawl net selectivity. The continuous appearance of small instars in this Area may be explained by: (1) the larvae hatched from females in the southwestern Gulf may be transported towards western Cape Breton (unpublished data, Dr. J. Chassé, DFO/BIO) or (2) the movement of smaller-sized instars from the southwestern to the southeastern area of the southern Gulf of St. Lawrence. The hypothesis of larval transportation towards western Cape Breton from the southwestern Gulf may compensate for years of low recruitment in the southeastern unit, which may result in a continuous supply of larval settlement in this area.

Estimation of the bias of commercial crab abundance

A discrepancy was observed between the observed and expected abundances of the commercial crabs since 1997 from the simple forward projection model (Fig.

29). A mean negative bias of 22.3% was observed and considered as a loss due to various factors such as the natural mortality and emigration. In this model, the catchability was considered to be 100% for commercial-sized crabs. By taking into account this loss, the true estimate of the available commercial biomass for the 2002 fishing season would be 826 t for Area 18 and 4,051 t for Area 19. However, until the catchability of the trawl and mortality parameters are correctly assessed, the survey estimates should be considered as a relative index of abundance.

Abundance index of adult males ≥ 95 mm CW within the Southeastern unit

The abundance index of adult males ≥ 95 mm CW (Fig. 30) increased from 12.7 to 23.9 millions of crabs from 1991 to 1992. From 1992 to 1995, the abundance index of adult males ≥ 95 mm CW decreased from 23.9 to 9.7 millions (Fig. 30). Since 1995, the abundance index of adult males ≥ 95 mm CW has continuously increased to reach 19.8 millions in 2001 (Fig. 30).

Abundance index of females and sex-ratio within Southeastern unit

The abundance index of the pre-primiparous females decreased from 1.9 to 1.2 millions from 1991 to 1992 and has been continuously increasing since then to reach 14.7 millions in 1994 (Figs. 31 and 32). The abundance index of pre-primiparous females decreased to 10.1 millions in 1995 (Figs. 31 and 32). From 1995 to 2000, the abundance index of pre-primiparous females increased from 10.7 to 19.3 millions (Figs. 31 and 32). The abundance index of pre-primiparous females decreased in 2001 to 4.9 millions (Figs. 31 and 32). The main concentrations in 2001 of pre-primiparous females were located in the southeastern part of the sub-unit (Fig. 32).

The abundance index of the primiparous females has gradually decreased from 16.6 to 1.0 millions between 1991 and 1993 and increased to 10.9 millions in 1994 (Figs. 31 and 33). From 1995 to 2000, the abundance index of primiparous females increased from 6.1 to 23.3 millions but the abundance index decreased to 5.9 millions in 2001 (Figs. 31 and 33). The main concentrations of primiparous females in 2001 were located in the southern part of the sub-unit (Fig. 33).

The abundance index of multiparous females decreased from 127.8 to 47.0 millions from 1991 to 1994 (Figs. 31 and 34). The abundance index of multiparous females increased in 1995 to 75.9 millions (Figs. 31 and 34). Since 1999, the abundance index of multiparous females has fluctuated between 47.5 and 52.7 millions (Figs. 31 and 34). The main concentrations of the multiparous females in 2001 were located mostly in Area 19 (Fig. 34).

The sex ratio, within the sub-unit, between the adult males ≥ 95 mm CW and the pre-primiparous females (Fig. 35A) shifted to the male dominate phase from 6.4:1 in 1991 to 19.3:1 in 1992. From 1993 to 2000, the sex ratio remained stable

varying between 0.9 and 1.3 for 1 pre-primiparous female. The sex ratio increased in 2001 to reach 4:1.

The sex ratio, within the sub-unit, between the adult males ≥ 95 mm CW and the total mature females (Fig. 35B) varied from 0.2:1 in 1991 to 0.7:1 in 2001.

The current abundance of pre-primiparous females in the southeastern unit is relatively high. Therefore, there is no sign of decline in **population reproductive potential in the near future**. However, an increasing population of pre-primiparous and new mature females suggested a necessity of the protection (i.e. lower exploitation) of the most reproductive group of adult males (carapace categories 3 and 4) to ensure maximal stock reproduction.

Prognosis

Seasonal movement between areas may occur from the time of the trawl survey and the beginning of the subsequent fishing season. As the concentration of biomass straddles the boundaries of Areas 12, 18 and 19, seasonal movements of crabs among these areas will affect the biomass level in any given area.

Area 18 (Fig. 9)

Negative elements:

- In Area 18, a quota of 476 t was allowed despite a very low biomass index, which resulted in the total landings only slightly exceeding 50% of the quota.
- The mean CPUE for the 2001 season was at the lowest level since 1986, i.e. 15.3 kg/trap haul.
- The mean size of commercially caught crab has been decreasing since 1995.

Alarming elements:

- The relative abundance of future recruits was at their highest since 1993, which will result in a high incidence of soft-shell/white crabs during the 2002 fishing season.

Positive elements:

- The biomass/abundance indices of adult legal-sized males projected for 2002 and future recruitment slightly increased despite of very large confidence intervals.
- There is a good potential of increasing abundance of commercially exploitable crab in the near future (2-4 years), although this depends largely on the extent of fishing effort in the adjacent fishing Areas (Areas 12 and 19) and also on the seasonal movement of crab in and out of the area.

Recommendations:

- For 2002, it is strongly recommended that the fishery be partially or totally closed as soon as the catches of soft-shelled crabs exceed 20 % in order to protect the future recruitment to the fishery.
- It is difficult to suggest a sound long-term fishing strategy for Area 18, because the main fishing activities occur in a limited portion of the Area (about 2-3 10'x10' grids at most) and of probable active seasonal movement between Areas 18, 19 and 12. However, there is no reason to change the harvest strategy of previous years for the 2002 fishery.

Area 19 (Fig. 9)

Negative elements:

- The projected biomass index for 2002 (5,214 t) decreased by 19% from the 2001 season (6,210 t).
- A net decrease of recruitment to the fishery index (2,927 t, representing 56% of the biomass index) compared to the 2001 season (4,614 t).
- The mean size of commercially caught crab has been decreasing since 1996.

Alarming elements:

- The percentage of soft-shelled crab was below the 5-yr mean, but showed a slight albeit continuous increase since 1999.
- Increasing abundance of pre-primiparous female and decreasing abundance of most fertile males (adult males in categories 3 & 4) are simultaneously occurring in this Area. As such, extensive exploitation of the stock may not be beneficial to the long-term reproduction of the stock.

Positive elements:

- In Area 19, a quota of 3,910 t, the highest quota ever allocated in the history of the Area 19, was reached without any sign of problem.
- The fishery performance reacted positively resulting in 28 % increase in CPUE (88.5 kg/trap haul) compared to that in the 2000 season.
- The relative abundance of pre- and future recruits (R-2, R-3) was at their highest level ever recorded since the beginning of the survey (1990), which will result in a high incidence of soft-shell/white crabs during next couple of years.

Recommendations:

- For 2002, it is strongly recommended to follow the soft crab protocol in order to protect the future recruitment to the fishery.
- For the 2002 fishery, there is no reason to change the harvest strategy from previous years.

2. Environmental factors:

Environmental factors, such as water temperature, can affect the molting and reproductive dynamic as well as the movement of crab. Bottom temperatures in the southern Gulf of St. Lawrence and in the northern Scotian Shelf have been generally less than 3 °C, which are ideal conditions for snow crab (Drinkwater et al. 1997). Water temperature data collected by Swain (1993) revealed that the bottom temperatures in deeper waters of Area E are higher (1 to 5 °C) than traditional crab grounds (-1 to 0 °C) in Area 12 (50 to 100 m). This range of temperature is at the upper physiological tolerance threshold for snow crab based on aquarium observations (M. Moriyasu, pers. obs.). Drinkwater et al. (2001) reported that the index of snow crab habitat (between –1 and 3 °C) remained high since late 1980s to 2000, for the southern Gulf of St. Lawrence. Bottoms temperatures within the snow crab areas of the southern Gulf were generally colder than average in 2001 (Drinkwater et al. 2002). This was largely due to a significant increase in area covered by temperatures of 0-1 °C (Drinkwater et al. 2002). Lower temperatures in 2001 are possibly due to cold water adevected into the Gulf Of St. Lawrence from Labrador Shelf through the Strait of Belle Isle (Drinkwater et al. 2002). The present temperature conditions are considered favorable for snow crab.

3. Research Recommendations

- Net selectivity and catchability have to be assessed in order to improve abundance estimations;
- Double trawl survey (regular fall and pre-fishery spring surveys) has to be conducted to verify the seasonal migration and to quantify the possible incoming migration;
- Continue to monitor the key events of population biology (fecundity, spermathecal load, molting season, seasonal movement). The monitoring project has been initiated in 2001 although the results have not been available at this time.

Acknowledgements

The authors wish to thank Pr. G. Miron (Université de Moncton, N.B.) and Mr. R. Dufour (DFO, Mont-Joli, Qué.) for the critical review of this report and P. DeGrâce, D. Giard, C. Sabean, and R. Ruest (DFO, Moncton, N.B.) for their assistance in preparing this report. We also wish to tank Dr. J. Chassé (DFO, Halifax, N.S.) for his valuable information on snow crab larval dispersal in the southern Gulf of St. Lawrence.

References

Anonymous, 1996. Fisheries Management Plan. Area 19 snow crab 1996 to 2001. DFO. Integrated Fisheries Management Plan.

Anonymous, 2001. Southern Gulf snow crab. DFO Science Stock Status Rep. 2001/C3-01.

Conan , G.Y. and M. Comeau. 1986. Functional maturity of male snow crab, (*Chionoecetes opilio*). Can. J. Fish. Aquat. Sci. 43 : 1710-1719.

Conan, G. Y. and D. R. Maynard. 1987. Estimates of snow crab (*Chionoecetes opilio*), abundance by underwater television – a method for population studies on benthic fisheries resources. J. Appl. Ichtyol. 3: 158-165.

Conan, G.Y., M. Comeau, C. Gosset, G. Robichaud and C. Garaïcoechea. 1994. The Bigouden *Nephrops* trawl, and the devismes trawl, two otter trawls efficiency catching benthic stages of snow crab (*Chionoecetes opilio*), and the American lobster (*Homarus americanus*). Can. Tech. Rep. Fish. Aquat. Sci. 1992.

DeGrâce, P., M. Hébert, E. Wade, T. Surette and/et M. Moriyasu. 2001. Assessment of the 2000 snow crab (Chionoecetes opilio) fisheries off western Cape Breton (Areas 18 and 19). DFO. Can. Sci. Adv. Sec. Res. Doc. 2001/016.

Drinkwater, K.F., R. G. Pettipas, L. Petrie, and D.P. Swain. 1997. Temperature conditions in the Gulf of St. Lawrence and on the Scotian Shelf during 1996 relevant to snow crab. DFO. Atlan. Fish. Res. Doc. 97/02.

Drinkwater, K.F., R. G. Pettipas, and L. Petrie. 2001. Temperature conditions on the Scotian Shelf and in the Gulf of St. Lawrence during 2000 relevant to snow crab. DFO. Can. Sci. Adv. Sec. Res. Doc. 2001/052.

Drinkwater, K.F., R. G. Pettipas, and W.M. Petrie. 2002. Temperature conditions on the Scotian Shelf and in the southern Gulf of St. Lawrence during 2001 relevant to snow crab. DFO. Can. Sci. Adv. Sec. Res. Doc. 2002/043.

Foyle, T.P., G.V. Hurley, and D.M. Taylor. 1989. Field testing shell hardness gauges for the snow crab fishery. Can. Ind. Rep. Fish. Aquat. Sci. 193.

Hébert, M., C. Gallant, Y. Chiasson, P. Mallet, P. DeGrâce, et M. Moriyasu. 1992. Le suivi du pourcentage de crabes mous dans les prises commerciales de crabe des neiges (*Chionoecetes opilio*) dans le sud-ouest du golfe du Saint-Laurent (zone 12) en 1990 et 1991. Rapp. Tech. Can. Sci. Halieut. Aquat. 1886.

Hébert, M., E. Wade, P. DeGrâce, M. Biron, A. Hébert et M. Moriyasu. 1997. Évaluation de 1996 du stock de crabe des neiges (*Chionoecetes opilio*) dans le sud du golfe du Saint-Laurent (zones 12, 18, 19, 25/26, E et F). Sécrétariat canadien pour l'évaluation des stocks. Doc. Rech. 97/86.

Leslie, P.H. and D.H.S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. J. Anim. Ecol. 8: 94-113.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada, 191.

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

Swain, D. P. 1993. Age and density-dependent bathymetric pattern of Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci., 50(6): 1255-1264.

Table 1. Catches, fishing efforts, catch per unit of effort (CPUE) and average percentage of soft-shelled crab in Area.

Year	Catch (t)	Effort (ths)	CPUE (kg/th)	Soft crab %
1986	618	14372	43.0	-
1987	626	9766	64.1	-
1988	669	10790	62.0	-
1989	669	11463	58.1	-
1990	662	15691	42.2	24,8 (f)
1991	187(s)/ 668(f)	6091(s)/ 9346(f)	30.7(s)/ 72.2(f)	18.0(s)/ 5.7(f)
1992	741	14820	50.0	1.4 (s)/5.6 (f)
1993	748	13271	55.5	10.4
1994	734	12363	59.4	7.2
1995	693	20662	33.5	8.2
1996	306	14421	21.2	20.5
1997	406	22431	18.1	13.0
1998	289	16092	18.0	17.1
1999	407	11788	34.5	3.2
2000	472	14696	32.1	8.4
2001	251	16446	15.3	8.6

s: spring season; f: fall season

Table 2. Catch composition (%) by size and carapace hardness in Area 18 based on at-sea observer data.

2001

	Soft-shelled			Hard-shelled			Total		
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	1.3	3.6	4.9	2.7	46.9	49.6	4.0	50.5	54.5
Sub-legal size	0.5	0.4	0.9	2.5	42.1	44.6	3.0	42.5	45.5
Total	1.8	3.9	5.7	5.3	89.0	94.3	7.1	92.9	100.0

S: adolescent, L: adult, Tot: total

2000

	Soft-shelled			Hard-shelled		Total			
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	1.4	4.4	5.8	3.9	68.5	72.3	5.5	72.9	78.1
Sub-legal size	0.4	0.7	1.1	1.4	19.5	20.8	1.7	20.1	21.9
Total	1.7	5.1	6.8	5.3	87.9	93.2	7.0	93.0	100.0

S: adolescent, L: adult, Tot: total

Table 3. The overall composition of carapace conditions for adult males ≥ 95 mm CW in Area 18 based on at-sea observer data.

Carapace conditions/ Conditions de carapace	1994	1995	1996	1997	1998	1999	2000	2001
1	4.9	10.8	7.6	1.2	6.6	0.7	2.2	2.7
2	0.8	0.1	2.2	17.9	12.2	6.0	5.8	7.3
3	45.5	24.9	54.2	53.1	54.2	33.3	22.4	18.2
4	47.3	61.6	30.0	21.8	23.8	58.5	60.1	69.5
5	1.5	2.6	6.0	5.8	3.2	1.5	9.5	2.3
Total	100	100	100	100	100	100	100	100

Table 4. Biomass indices (t) for different stages of male snow crab (B, R and OB) with 95 % confidence limits in Areas 18.

Year	Area 18		
	B	R	OB
1991	**-**	-	-
1992	**1278** ±1171	-	-
1993	**1256** ±1043	**753** ±439	**59** ±122
1994	**1195** ±1060	**426** ±294	**45** ±34
1995	**582** ±229	**318** ±179	**110** ±57
1996	**970** ±523	**703** ±375	**57** ±83
1997	**N/D**	**N/D**	**N/D**
1998	**N/D**	**N/D**	**ND**
1999	**593** ±428	**260** ± 237	**2** ± 2
2000	**508** ± 563	**286** ± 566	**50** ± 29
2001	**1,063** ± 1,227	**817** ± 1,009	**76** ± 145

B: CW ≥ 95 mm with a hard carapace (projected); R: Annual recruitment to the fishery (projected); OB: CW ≥ 95 mm with a very old carapace (direct).

Table 5. Catches, fishing efforts, catch per unit of effort (CPUE) and average percentage of soft-shelled crab in Area 19.

Year	Catch (t)	Effort (# of trap haul)	CPUE (kg/trap haul)	Soft-shelled %
1987	1151	37987	30.3	-
1988	1337	22794	58.7	-
1989	1334	29978	44.5	-
1990	1333	28422	46.9	19.4
1991	1337	16733	79.9	5.1
1992	1678	17140	97.9	6.6
1993	1678	18204	92.2	1.9
1994	1672	24495	68.3	5.5
1995	1575	24854	63.4	3.5
1996	1342	24583	54.6	10.8
1997	1386	21930	63.2	11.1
1998	1988	31232	63.1	11.2
1999	1979	19088	103.7	4.1
2000	3225	55977	64.1	5.6
2001	3910	46251	88.5	6.5

s: spring season; f: fall season

Table 6. Catch composition (%) by size and carapace hardness in Area 19 based on at-sea observer data.

2001

	Soft-shelled crabs			Hard-shelled crabs			Total		
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	0.7	4.7	5.4	3.2	70.7	73.9	3.9	75.4	79.3
Sub-legal size	0.3	0.1	0.4	1.7	18.6	20.3	2.0	18.7	20.7
Total	1.0	4.8	5.8	4.9	89.3	94.2	5.9	94.1	100.0

S: adolescent, L: adult, Tot: total

2000

	Soft-shelled crabs			Hard-shelled crabs			Total		
	S	L	Tot	S	L	Tot	S	L	Tot
Legal size	0.6	4.0	4.5	3.6	75.6	79.2	4.1	79.6	83.8
Sub-legal size	0.1	0.1	0.2	1.9	14.2	16.1	2.0	14.2	16.2
Total	0.7	4.0	4.7	5.5	89.8	95.3	6.2	93.8	100.0

S: adolescent, L: adult, Tot: total

Table 7. The overall composition of carapace conditions for adult males ≥ 95 mm CW in Area 19 based on at-sea observer data.

Carapace conditions	1994	1995	1996	1997	1998	1999	2000	2001
1	4.9	3.4	6.1	2.8	0.6	0.3	2.0	1.8
2	0.4	0.9	7.7	15.5	13.7	4.2	14.6	6.5
3	27.2	52.3	42.4	52.4	44.1	45.2	26.9	31.3
4	57.6	42.8	38.4	26.7	40.7	49.8	55.8	60.1
5	9.9	0.6	5.4	2.6	0.9	0.5	0.8	0.3
Total	100	100	100	100	100	100	100	100

Table 8. Biomass indices (t) for different stages of male snow crab (B, R and OB) with 95 % confidence limits in Area 19.

Year	Area 19		
	B	R	0B
1991	**5459** ±1942	**1279** ± 374	-
1992	**5226** ± 2205	**1762** ± 885	-
1993	**2300** ± 621	**672** ± 184	**114** ± 117
1994	**2598** ± 1045	**836** ± 227	**110** ± 74
1995	**1825** ± 376	**280** ± 131	**223** ± 71
1996	**2190** ± 600	**965** ± 435	**292** ± 95
1997	**3160** ± 749	**1953** ± 469	**0** ± 0
1998	**3152** ± 1091	**1901** ± 1092	**38** ± 125
1999*	**5351** ± 1584	**1830** ± 966	**1** ± 1
2000*	**6210** ± 1118	**4328** ± 952	**126** ± 49
2001	**5214** ± 1689	**2927** ± 1373	**206** ± 197

B: CW ≥ 95 mm with a hard carapace (projected); R: Annual recruitment to the fishery (projected); OB: CW ≥ 95 mm with a very old carapace (direct).

***** Biomass estimates from the “Den C. Martin“ without adjustment of net efficiency change.

Table 9. Retrospective Traffic Light Analysis (1997-2001) for Areas 18 and 19.

Area 18	1997	1998	1999	2000	2001
Fishery data					
CPUE (kg/th)	↓	↓	↑	↑	↓
Effort (# trap hauls)	↑	↓	↓	↑	↑
Soft/White crab (%)	↑	↑	↓	↑	↑
Mean size	↓	↓	↓	↓	↓
Survey data					
Biomass index	-	-	↓	↓	↑
Prerecruits (R-3, R-2)	-	-	↓	↑	↑
Recruitment (R-1)	-	-	↓	↓	↑
Biomass of old crabs	-	-	↓	↑	↑
Abundance of mature females	-	-	-	↓	↓

Area 19	1997	1998	1999	2000	2001
Fishery data					
CPUE (kg/trap hauls)	↑	↑	↑	↓	↑
Effort (# trap hauls)	↑	↑	↓	↑	↑
Soft/White crab (%)	↑	↑	↓	↑	↑
Mean size	↓	↓	↓	↓	↑
Survey data					
Biomass index	↑	↑	↑	↑	↓
Prerecruits (R-3, R-2)	↓	↑	↑	↑	↑
Recruitment (R-1)	↑	↑	↓	↑	↓
Biomass of old crabs	↓	↑	↓	↑	↑
Abundance of mature females	-	-	-	↓	↓

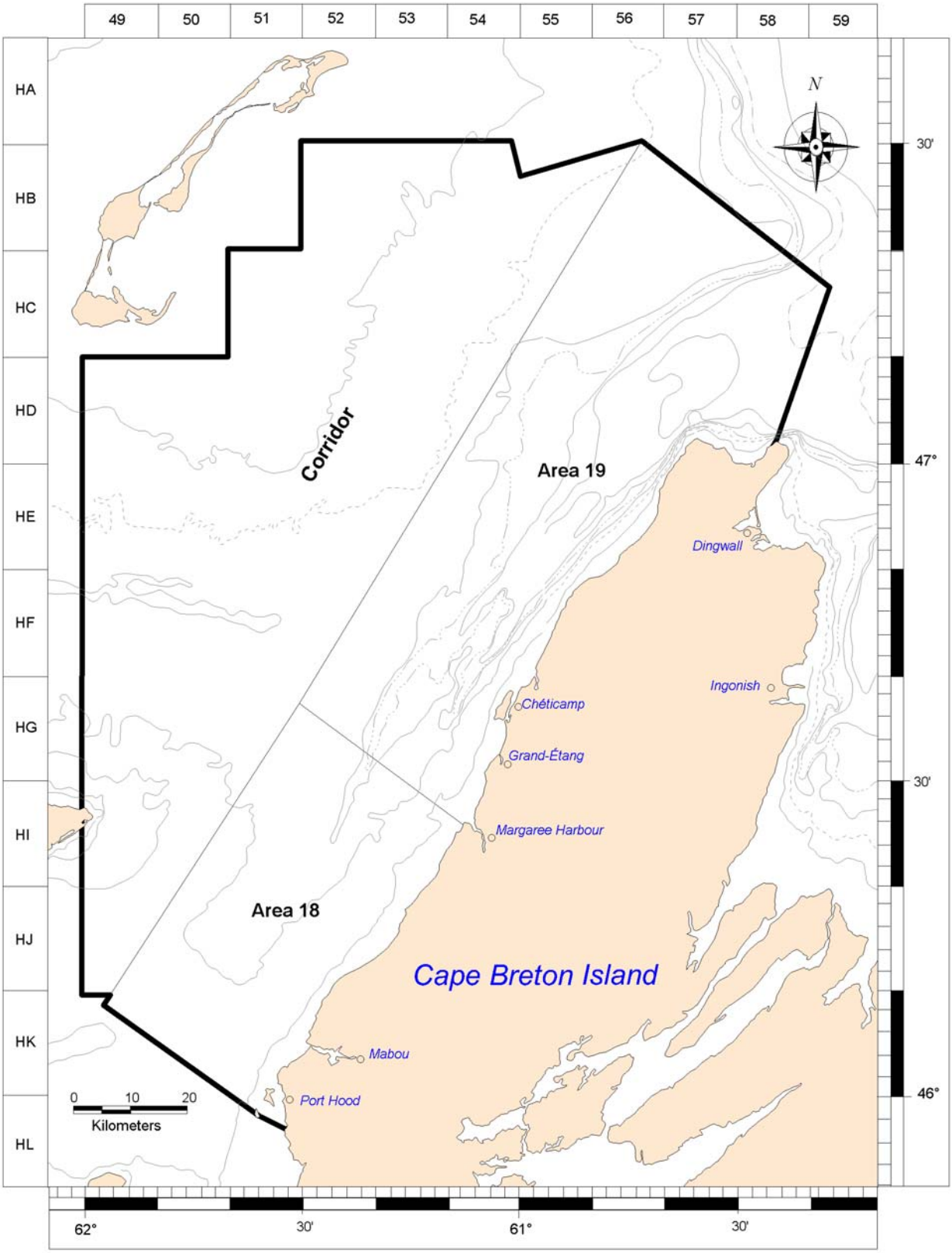


Figure 1. Western Cape Breton snow crab management Areas 18 and 19 and the corridor zone of Area 12 (southeastern unit is shown by bolded line).

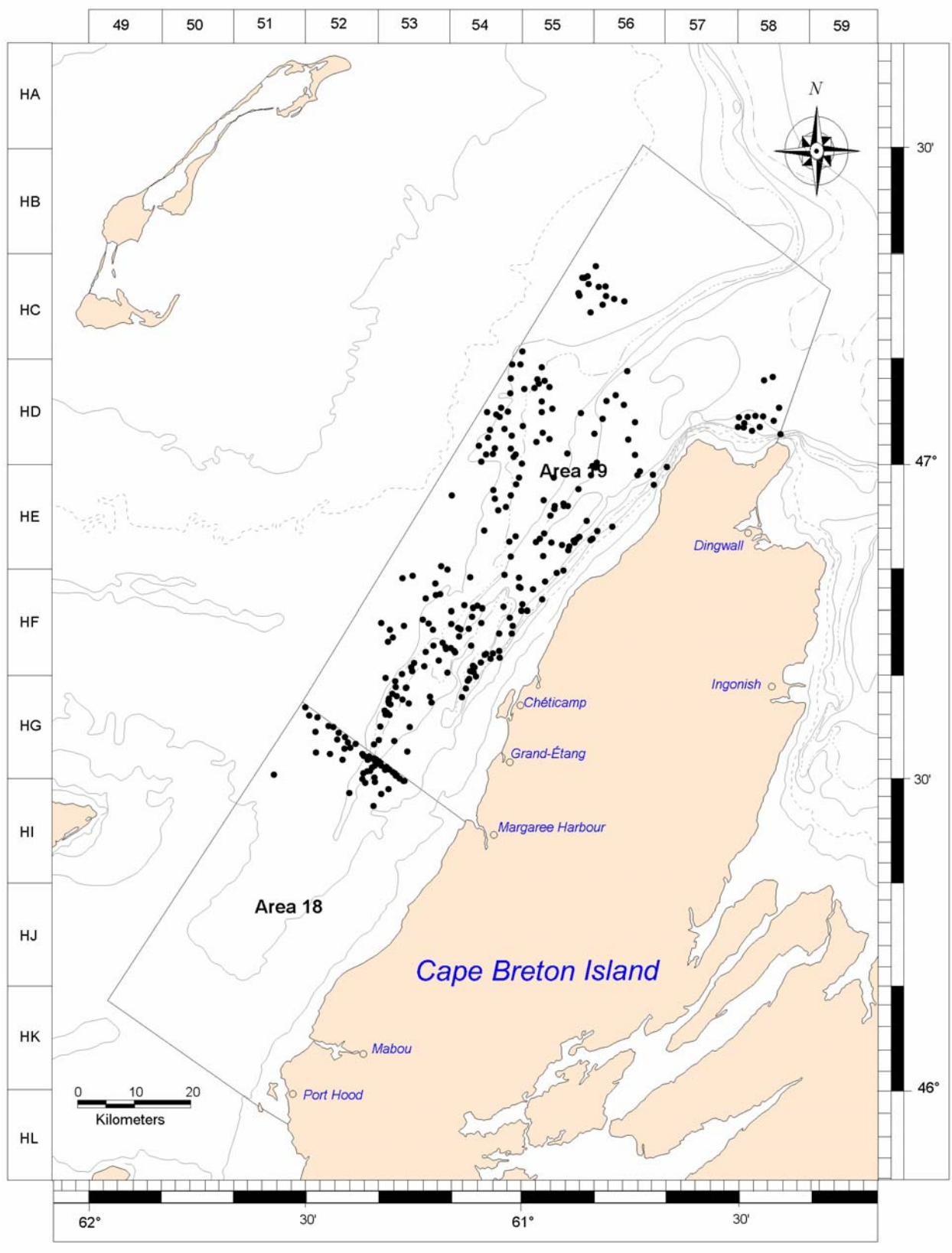


Figure 2. Locations of traps sampled aboard commercial vessels by at-sea observers in Areas 18 and 19 during the 2001 fishing season.

2000

2001

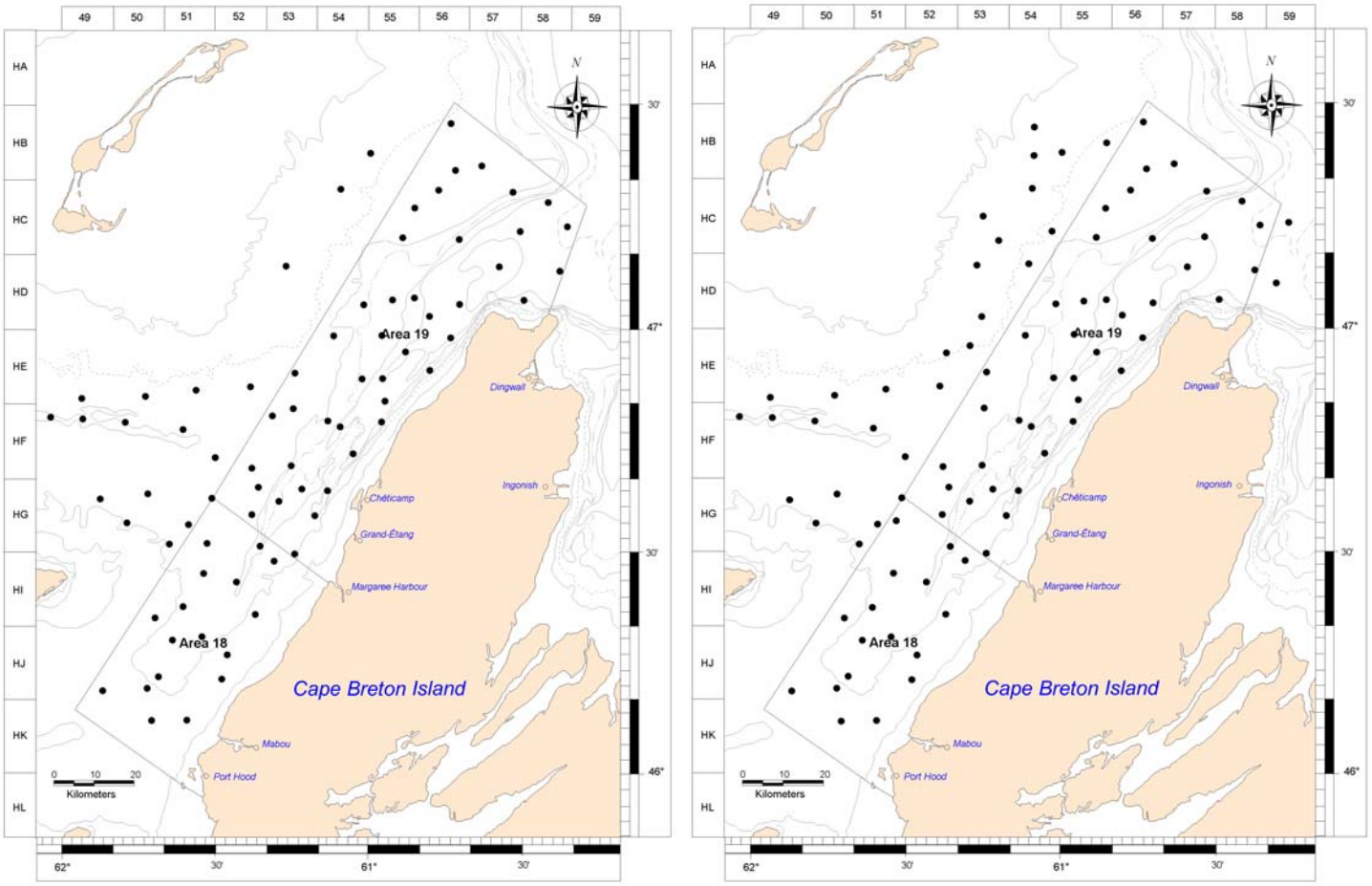


Figure 3. Locations of the 2000 and 2001 trawl survey stations in western Cape Breton (Areas 18 and 19 and adjacent zone).

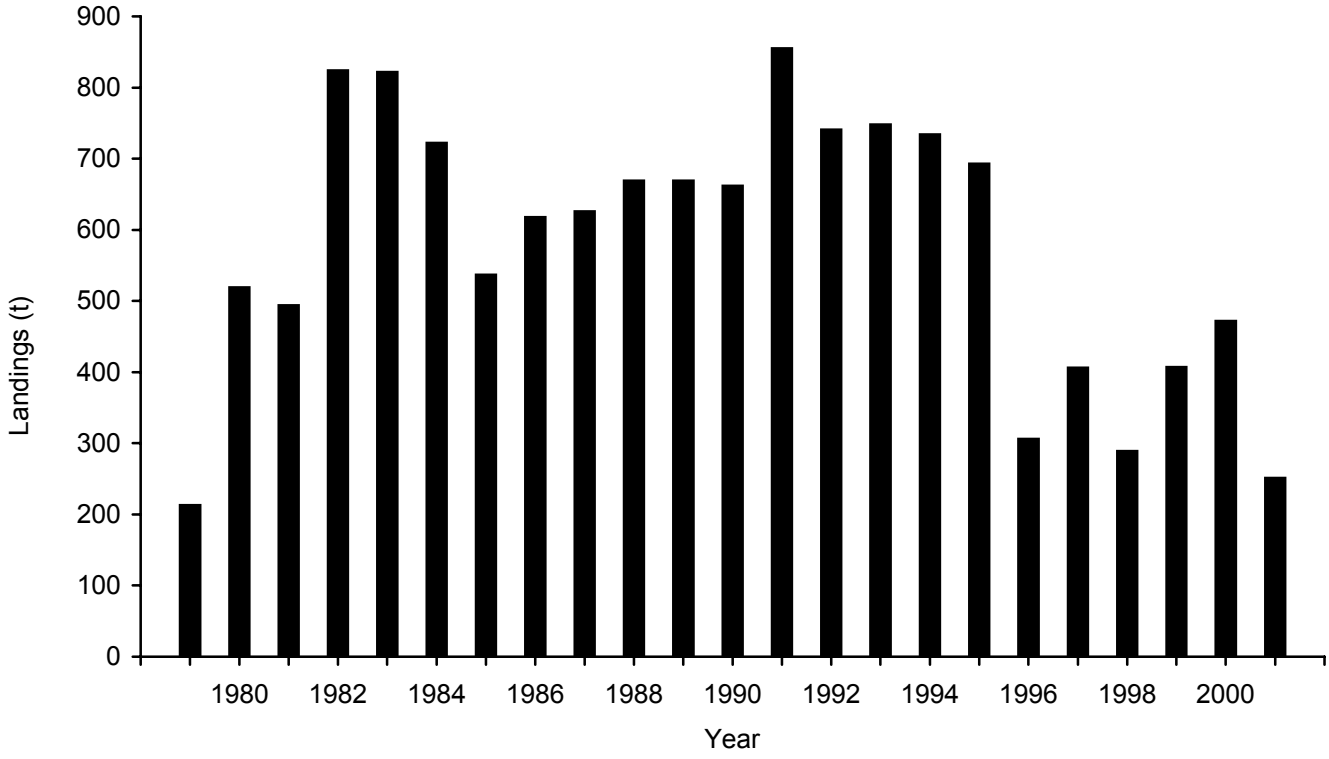


Figure 4. Annual landings in Area 18 between 1979 and 2001.

2000 2001

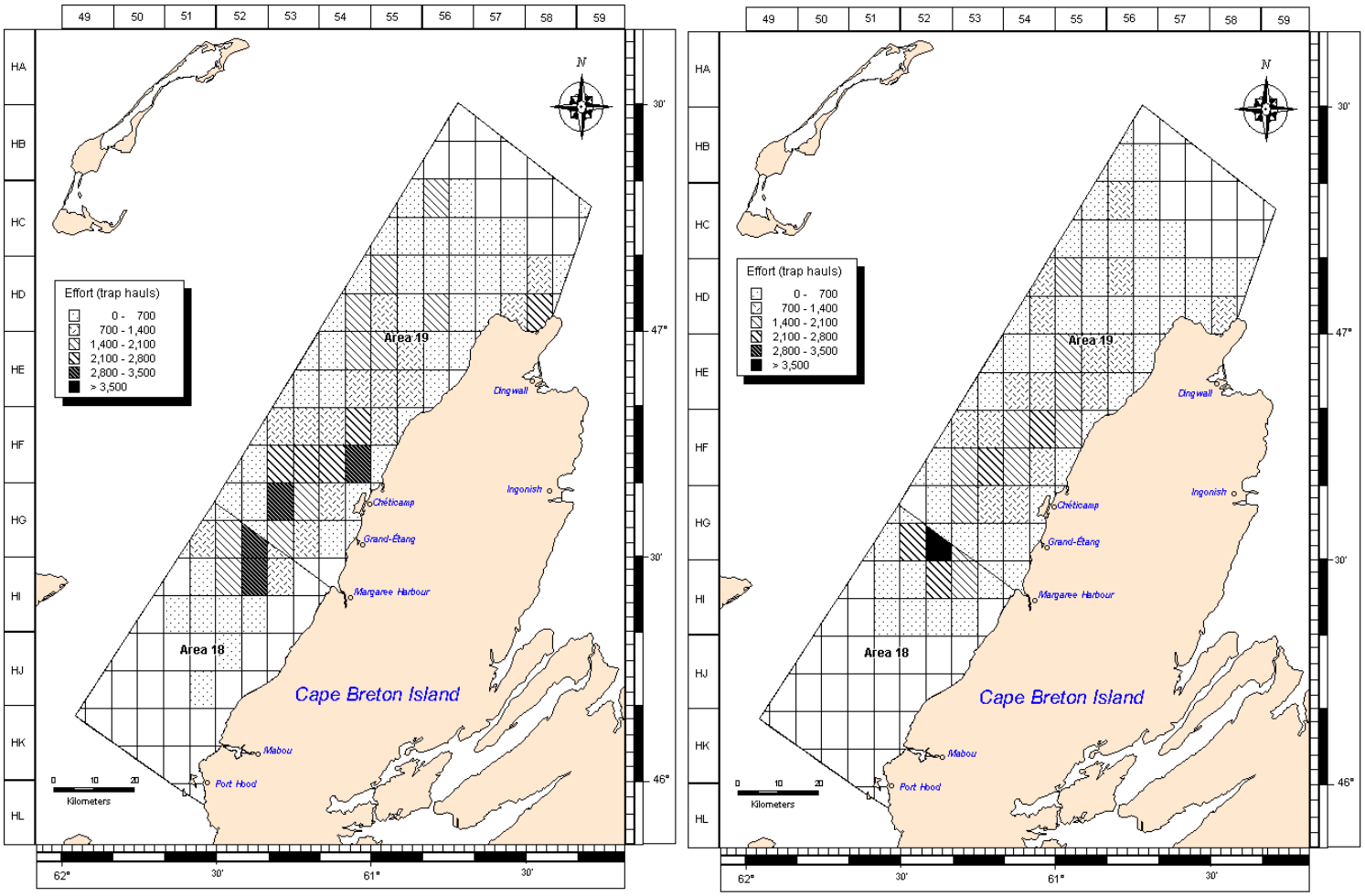


Figure 5. Geographic distribution of fishing effort in Areas 18 and 19 in 2000 and 2001.

2000 2001

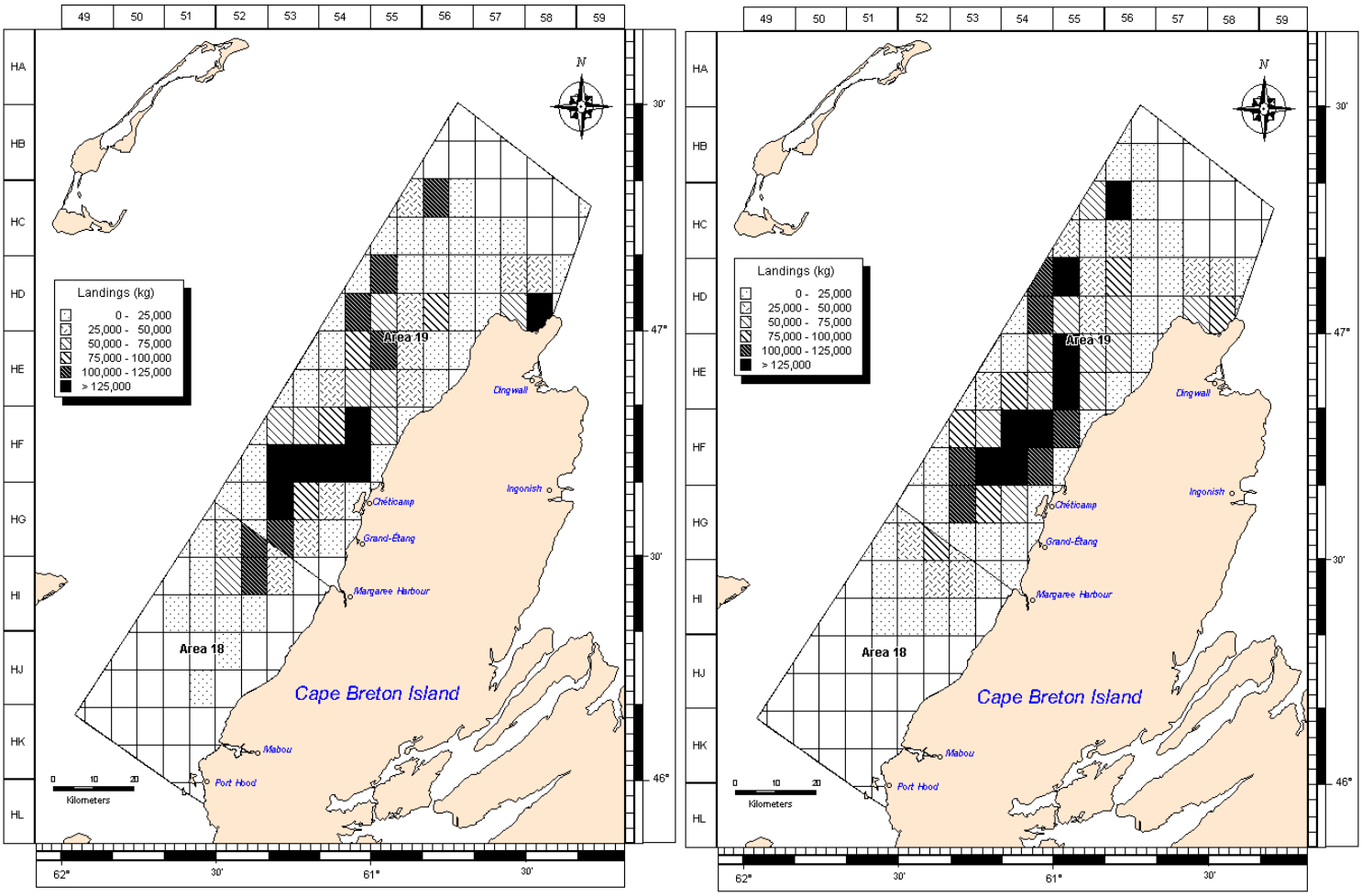


Figure 6. Geographic distribution of landings in Areas 18 and 19 in 2000 and 2001.

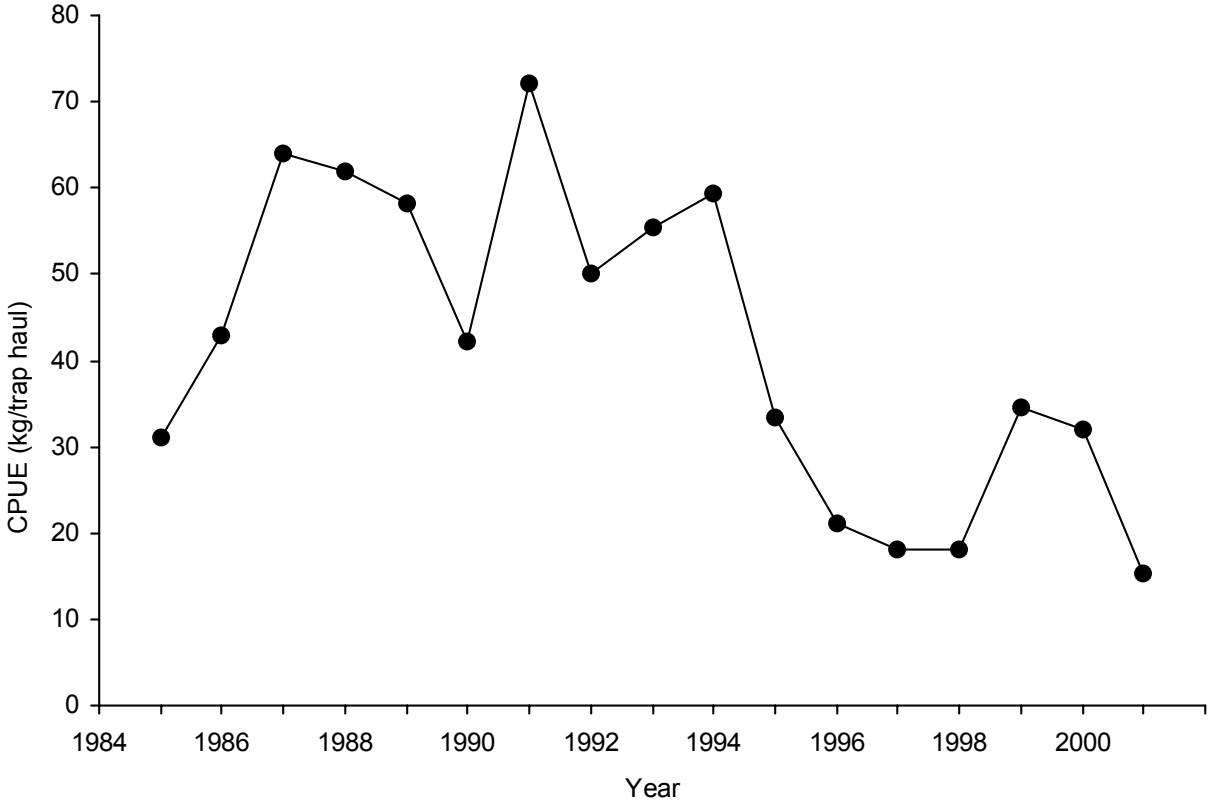


Figure 7. Annual catch per unit of effort (CPUE) in Area 18 estimated from logbook between 1985 and 2001.

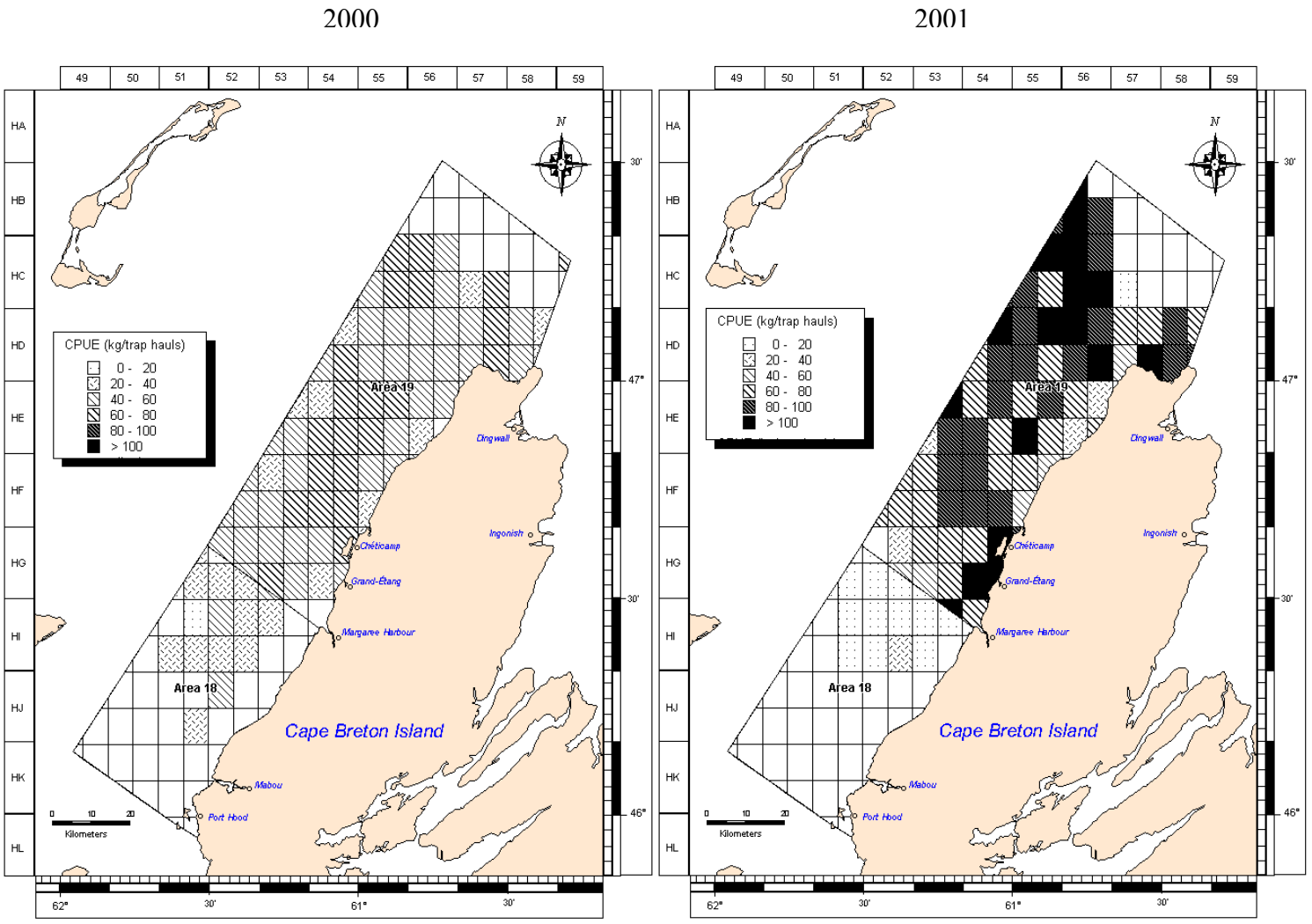


Figure 8. Geographic distribution of mean CPUE (kg/th) in Areas 18 and 19 in 2000 and 2001.

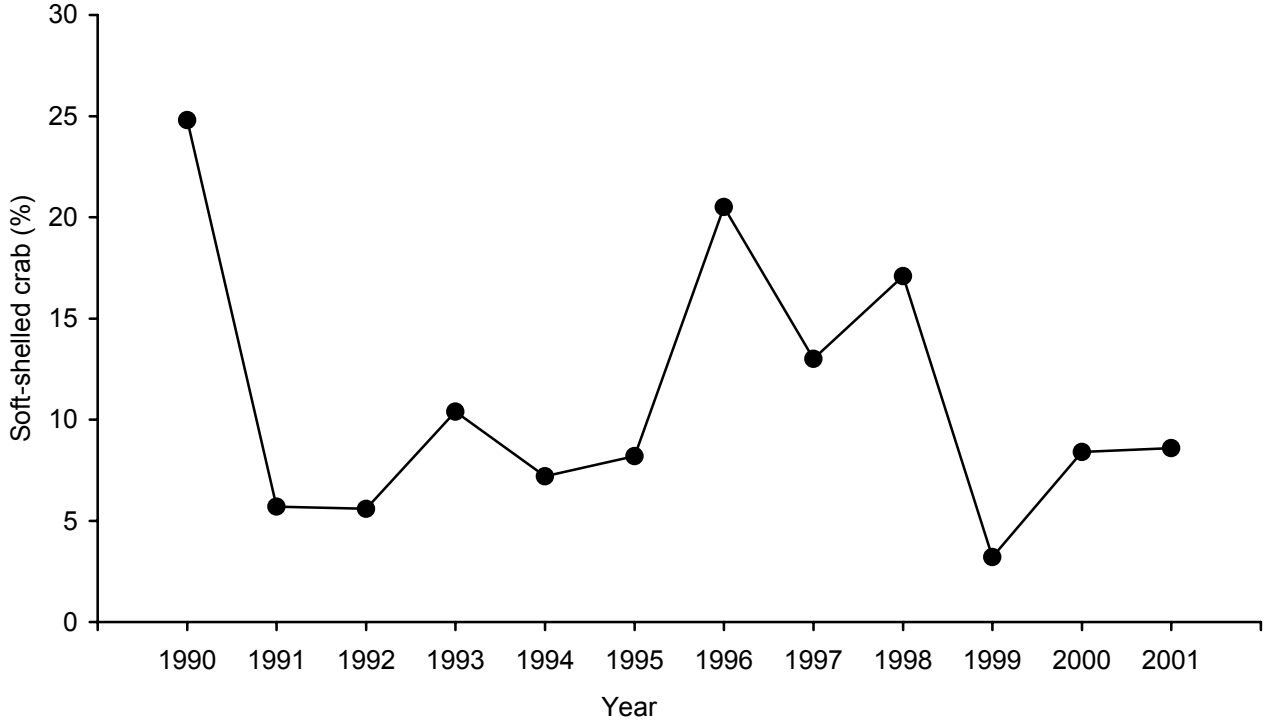


Figure 9. Annual soft-shelled crab percentage in Area 18 between 1990 and 2001.

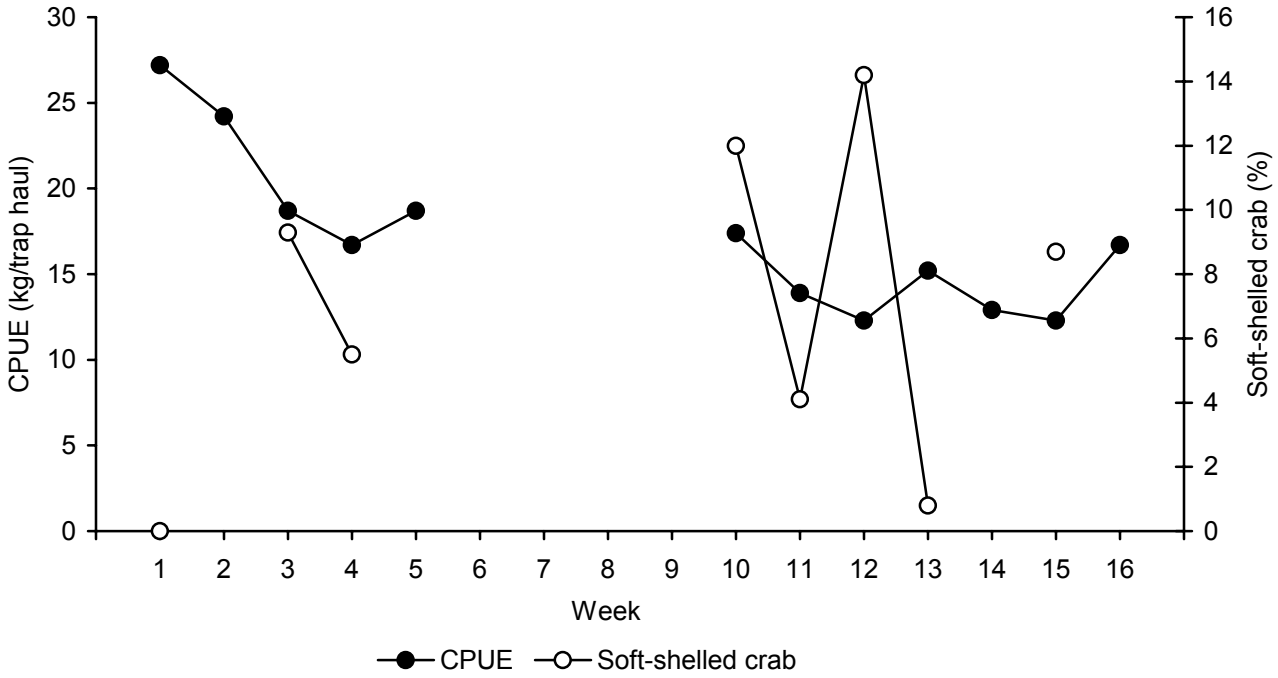
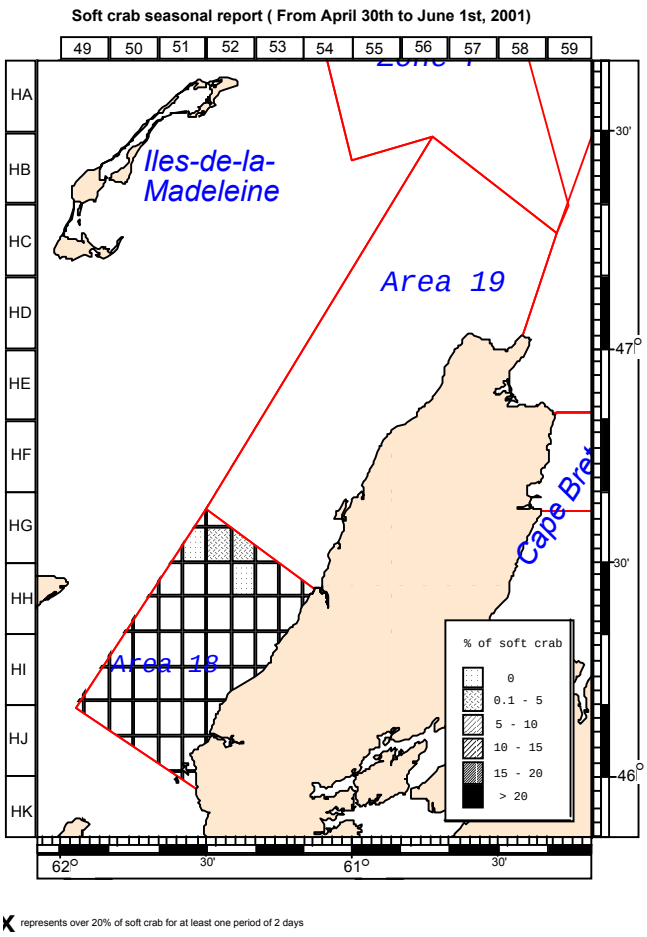


Figure 10. Weekly catch per unit of effort (CPUE) estimated from logbooks and percentage of soft-shelled crabs in Area 18 during the 2001 fishing season.

First season



Second season

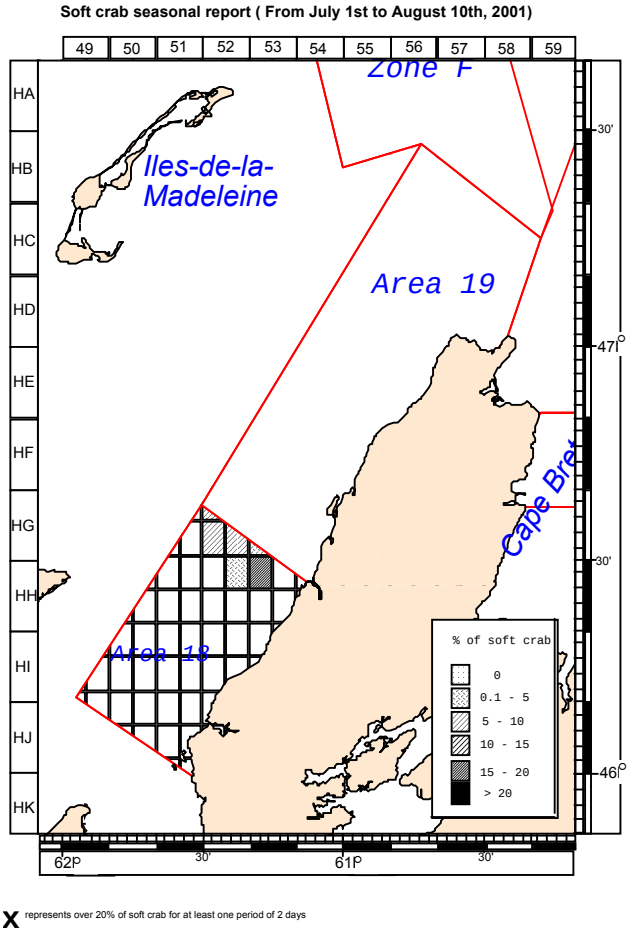


Figure 11. Distribution of soft-shelled crab in Area 18 during the 2001 fishing season (April 30-June 1, July 1- August 10).

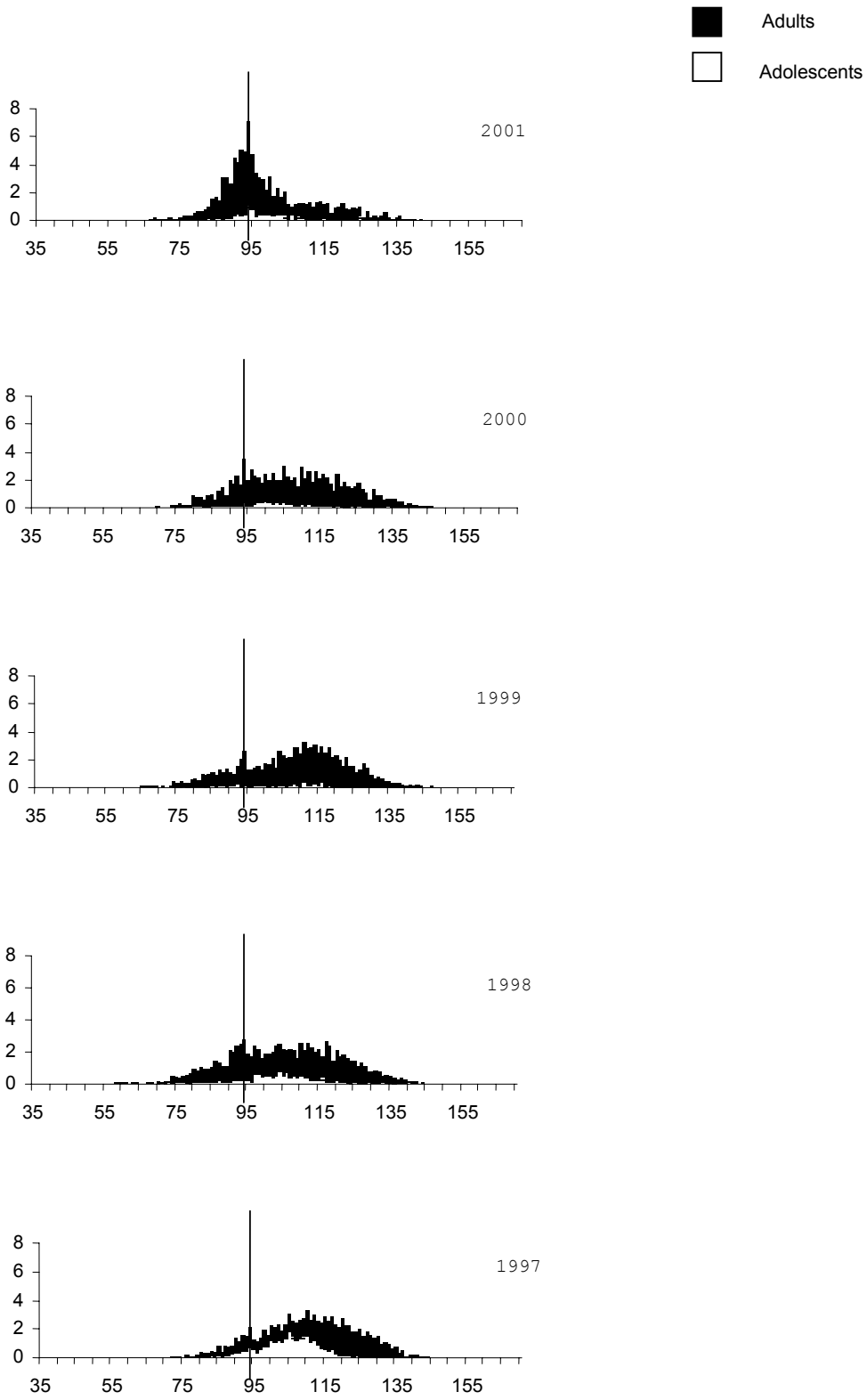


Figure 12. Size frequency distributions of male crabs measured during at-sea sampling in Area 18 between 1997 and 2001.

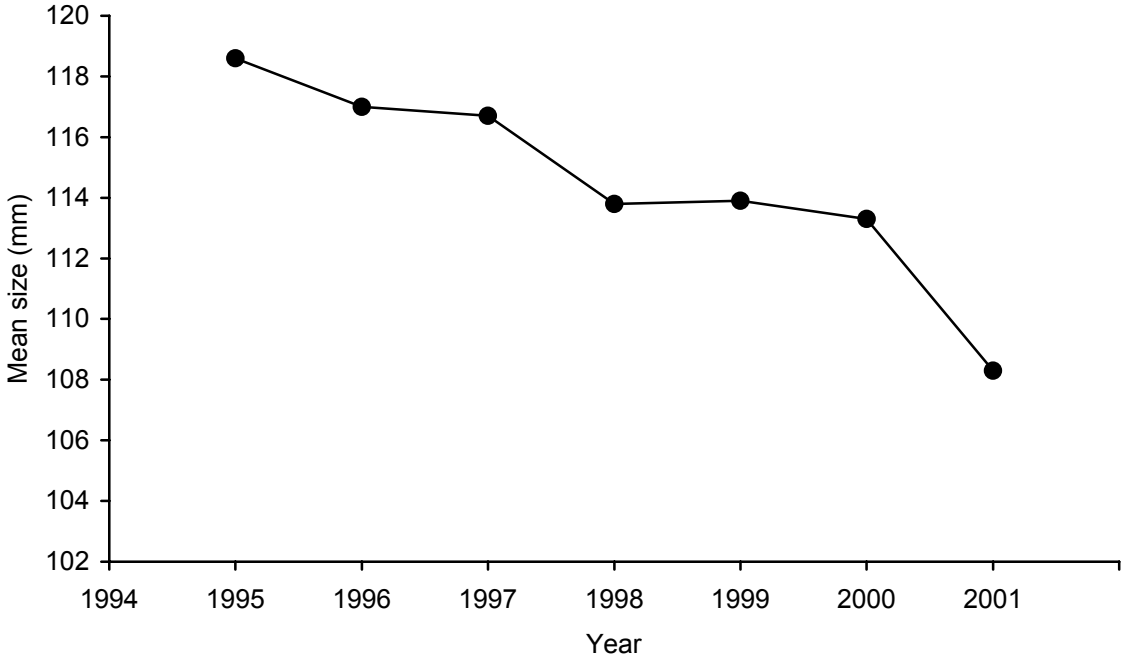


Figure 13. Annual mean size of the commercial catch in Area 18 between 1995 and 2001.

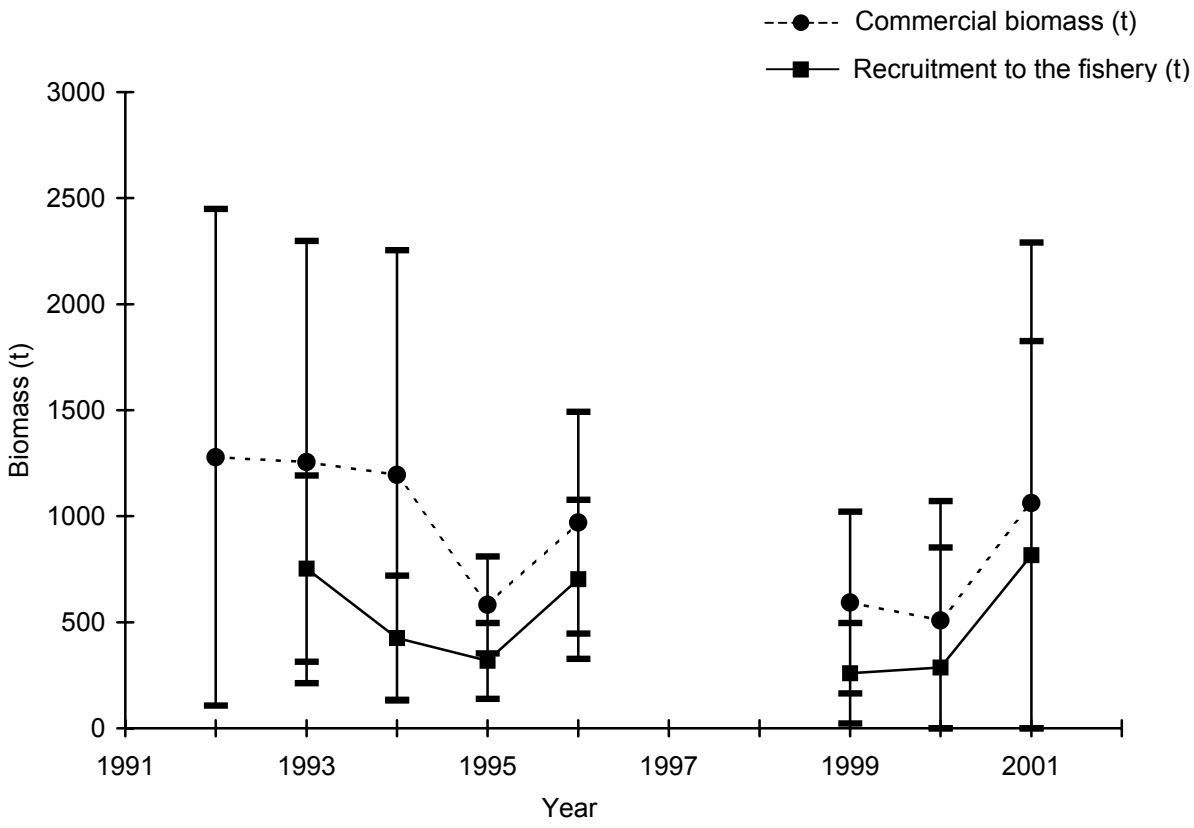


Figure 14. Annual commercial biomass (t) and recruitment to the fishery (t) indices in Area 18 estimated from the trawl survey between 1992 and 2001 (1997-1998 surveys were not conducted).

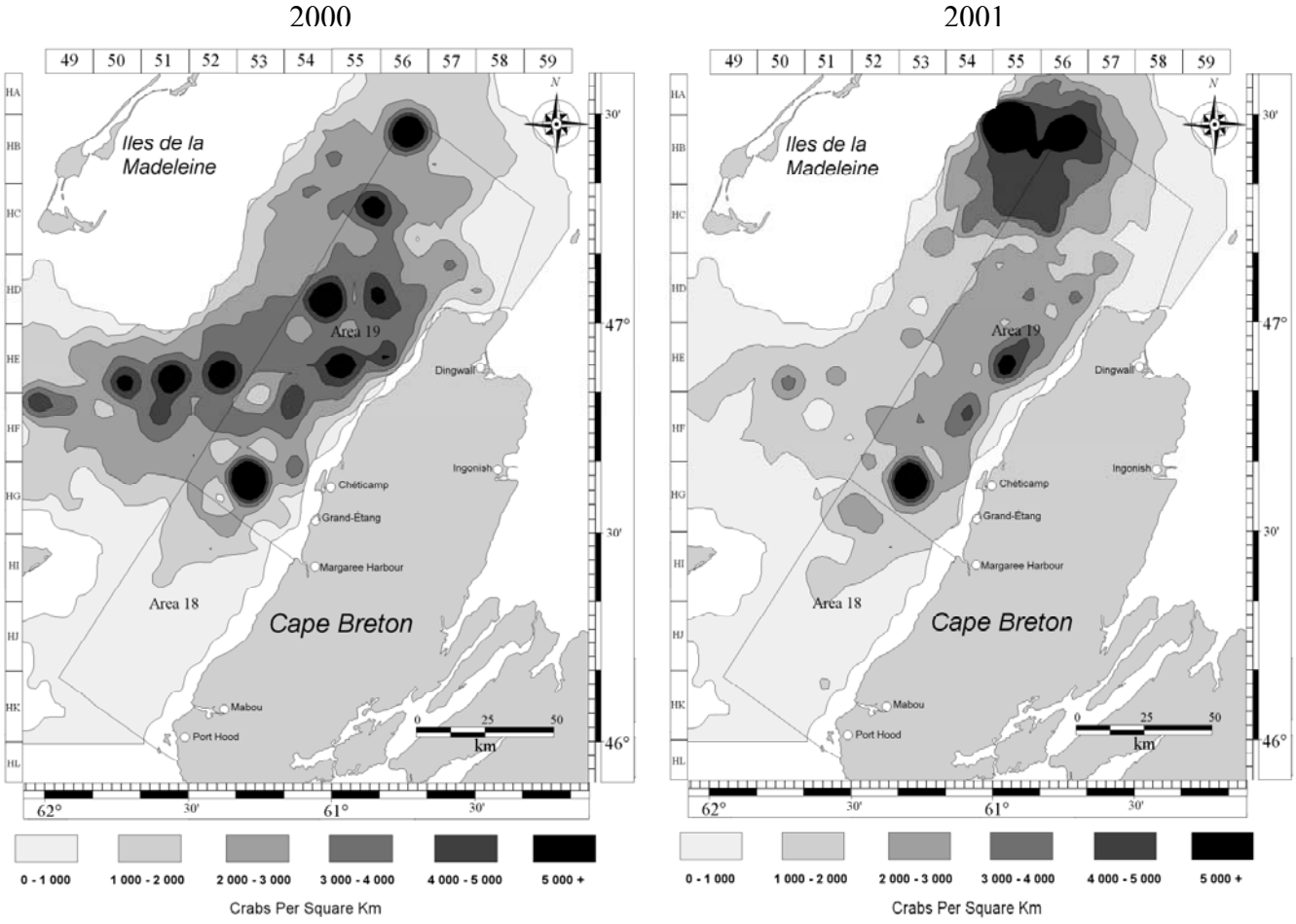


Figure 15. Density contours of adult snow crab of commercial size in Areas 18 and 19 observed in the 2000 and 2001 trawl surveys.

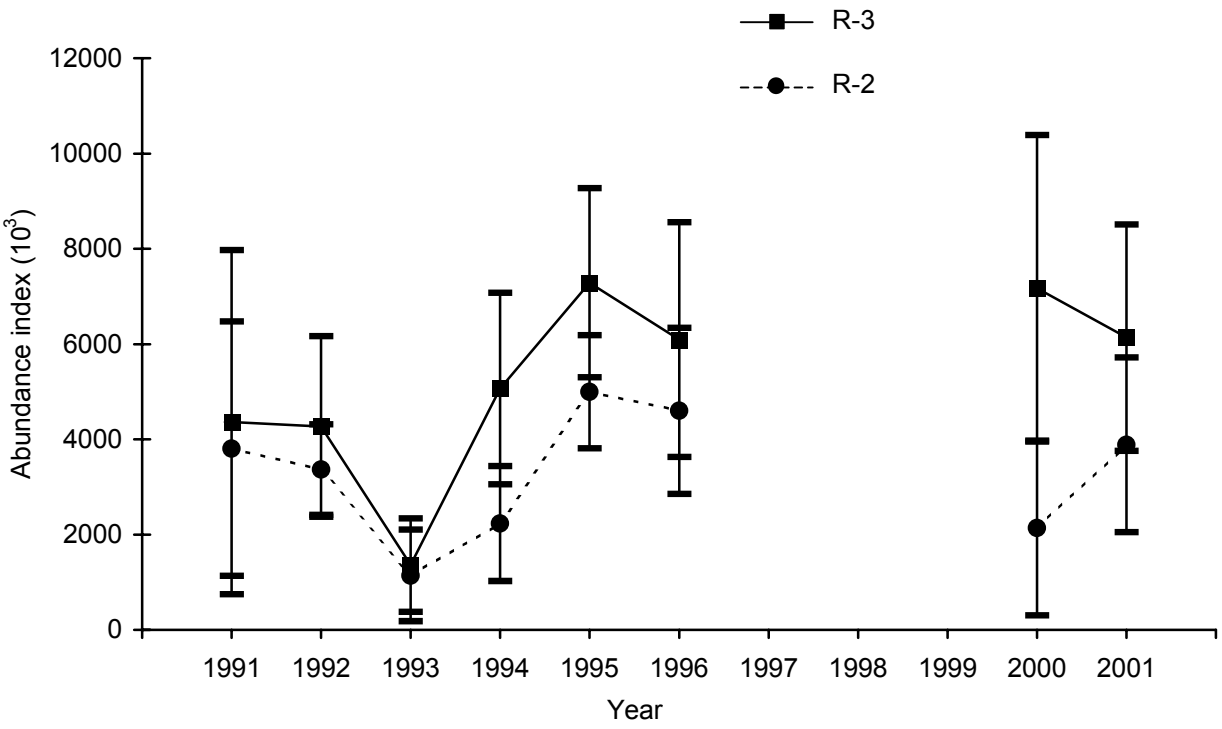


Figure 16. Abundance index of prerecruits R-3 and R-2 in Area 18 between 1991 and 2001 (1997-1998 surveys were not conducted).

* No abundance index in 1999 due to the malfunction of the Netmind system.

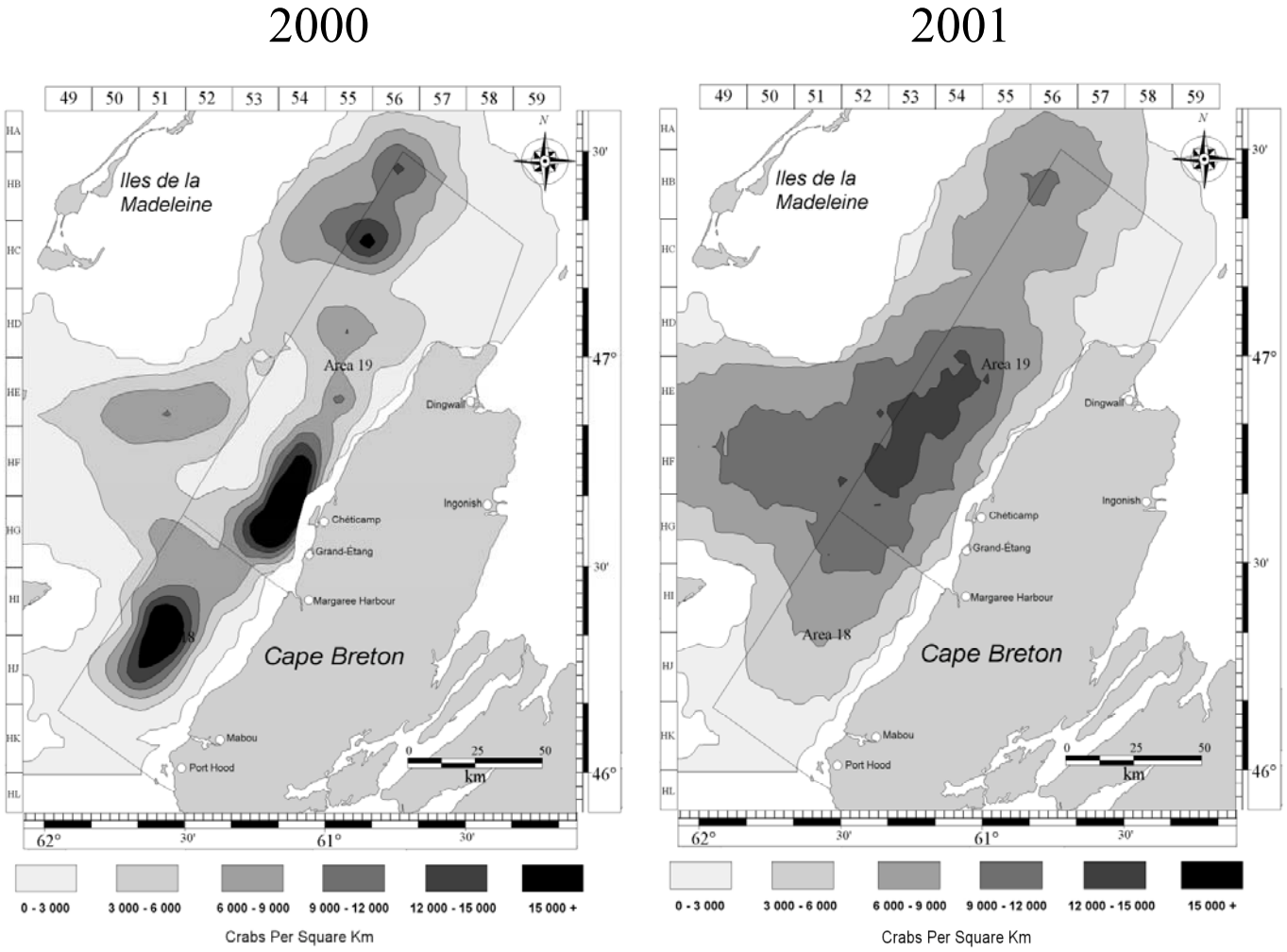


Figure 17. Density contours of adolescent snow crab with a carapace width greater or equal to 56 mm observed in the 2000 and 2001 trawl surveys in the southeastern unit of the southern Gulf of St. Lawrence.

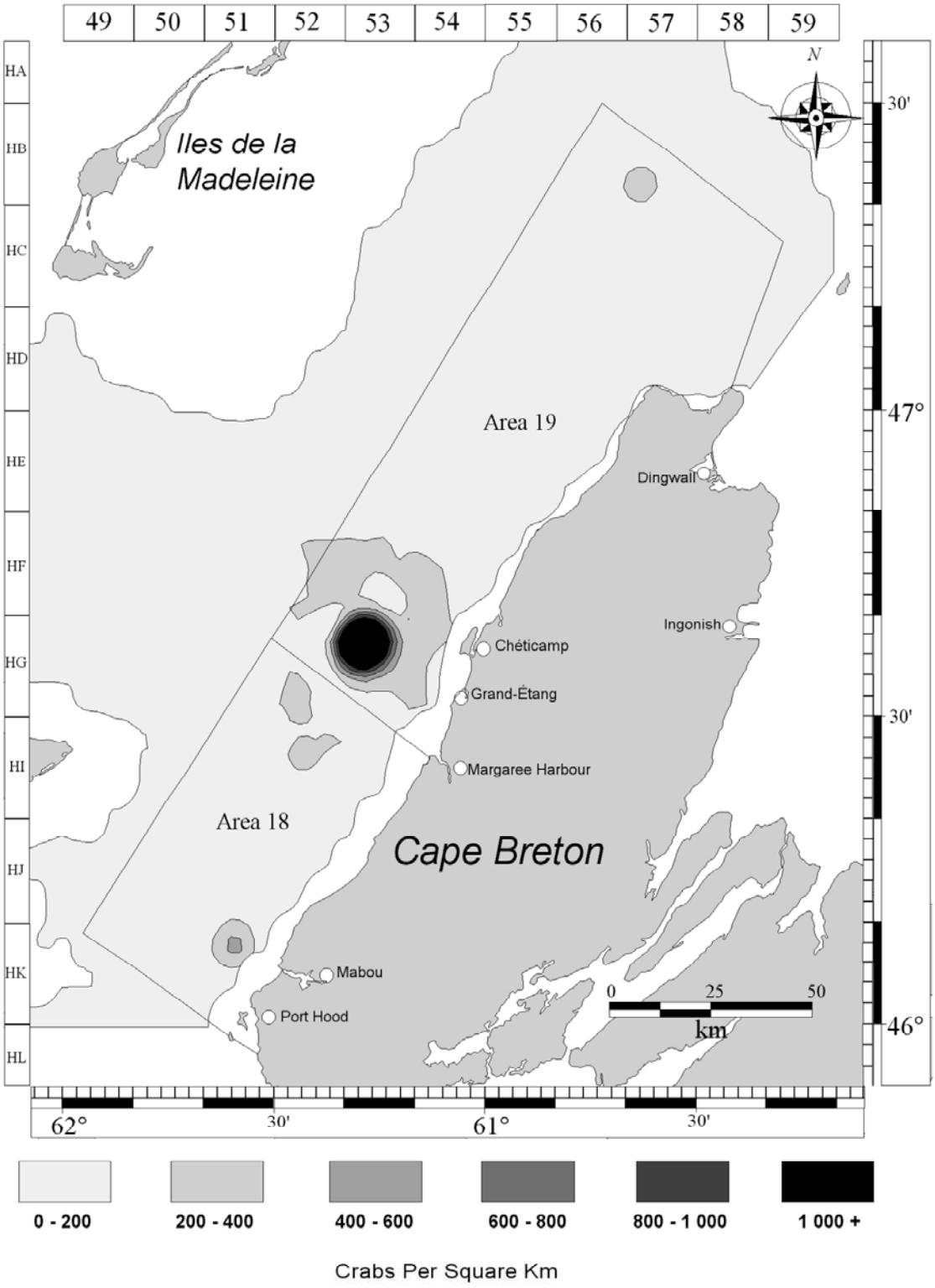


Figure 18. Density contours of very old crab biomass (category 5) in the southeastern unit of the southern Gulf of St. Lawrence.

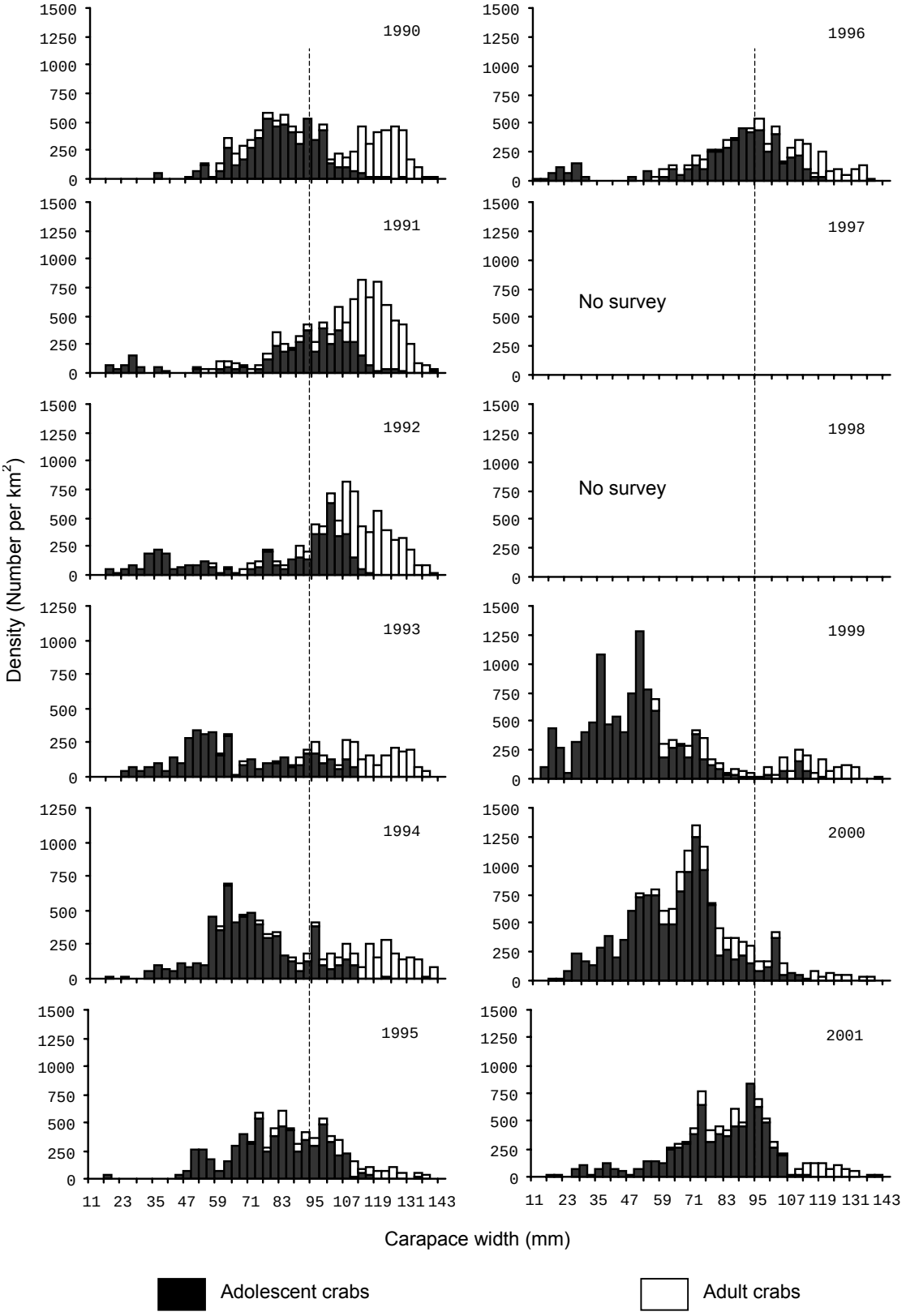


Figure 19. Size frequency distributions of male snow crabs in Area 18 between 1990 and 2001 (1990-1992 surveys were conducted before the fishing season).

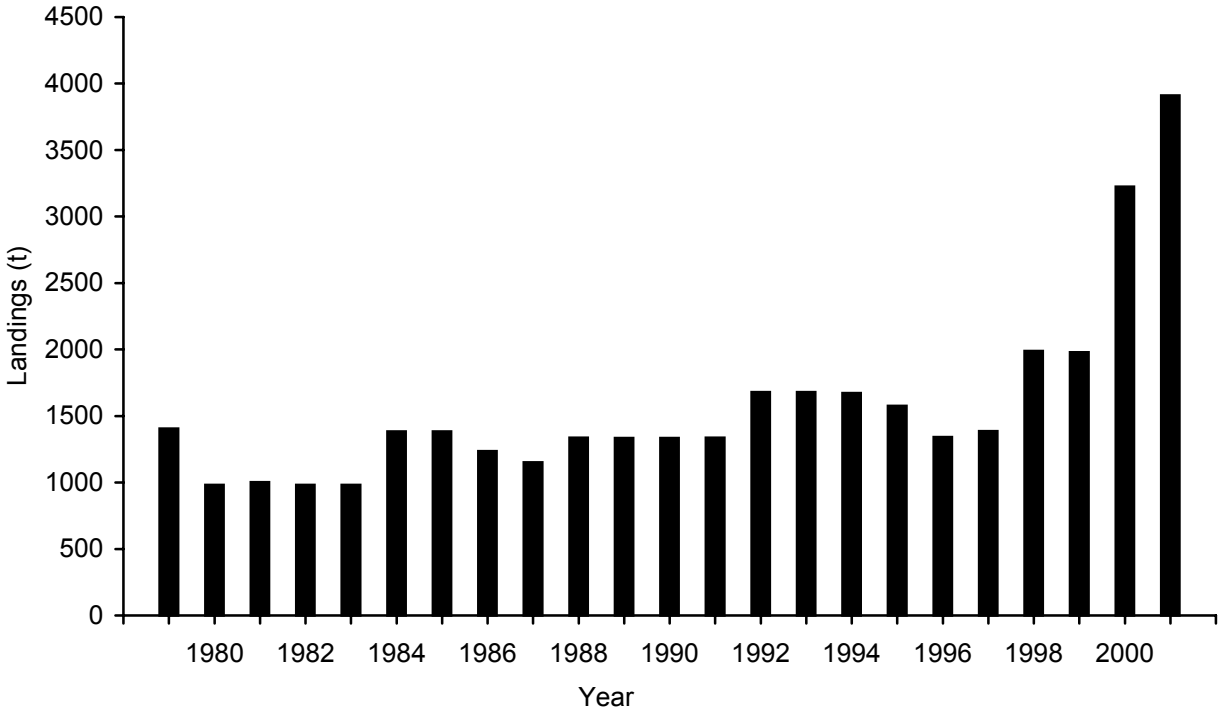


Figure 20. Annual landings in Area 19 between 1979 and 2001.

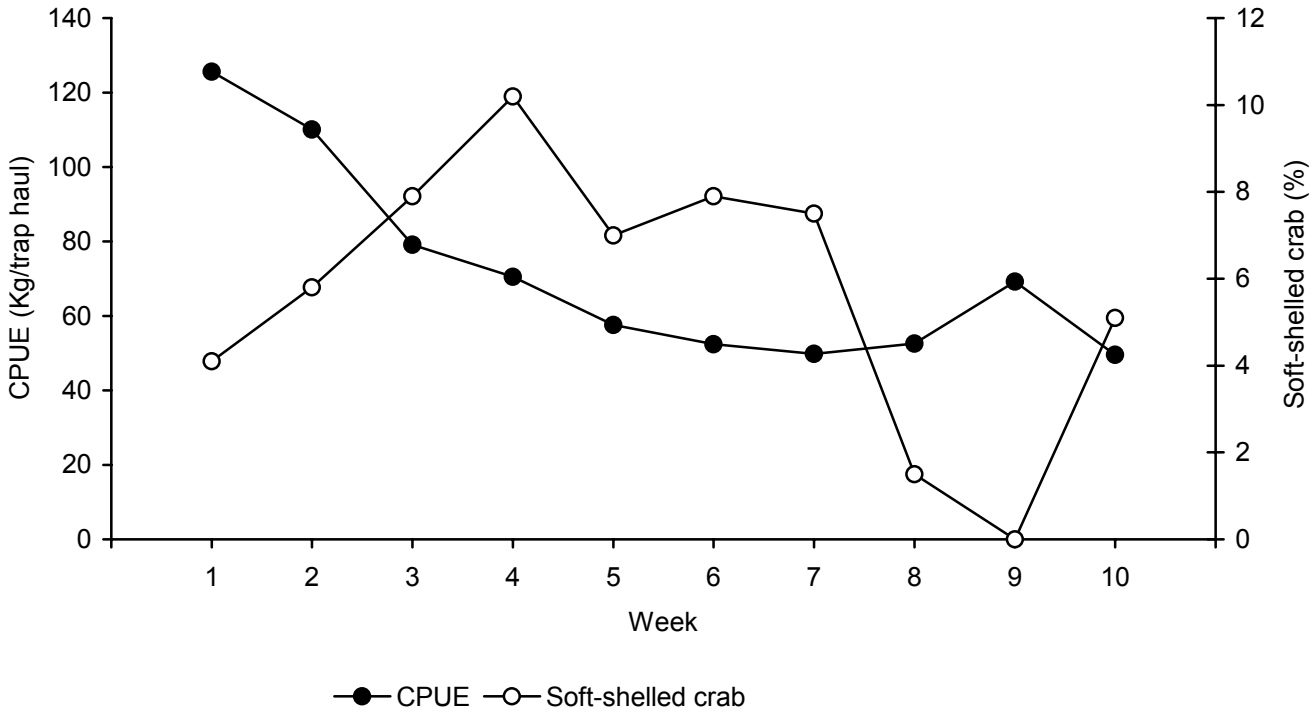


Figure 21. Weekly catch per unit of effort (CPUE) and percentage of soft-shelled crab in Area 19 during the 2001 fishing season.

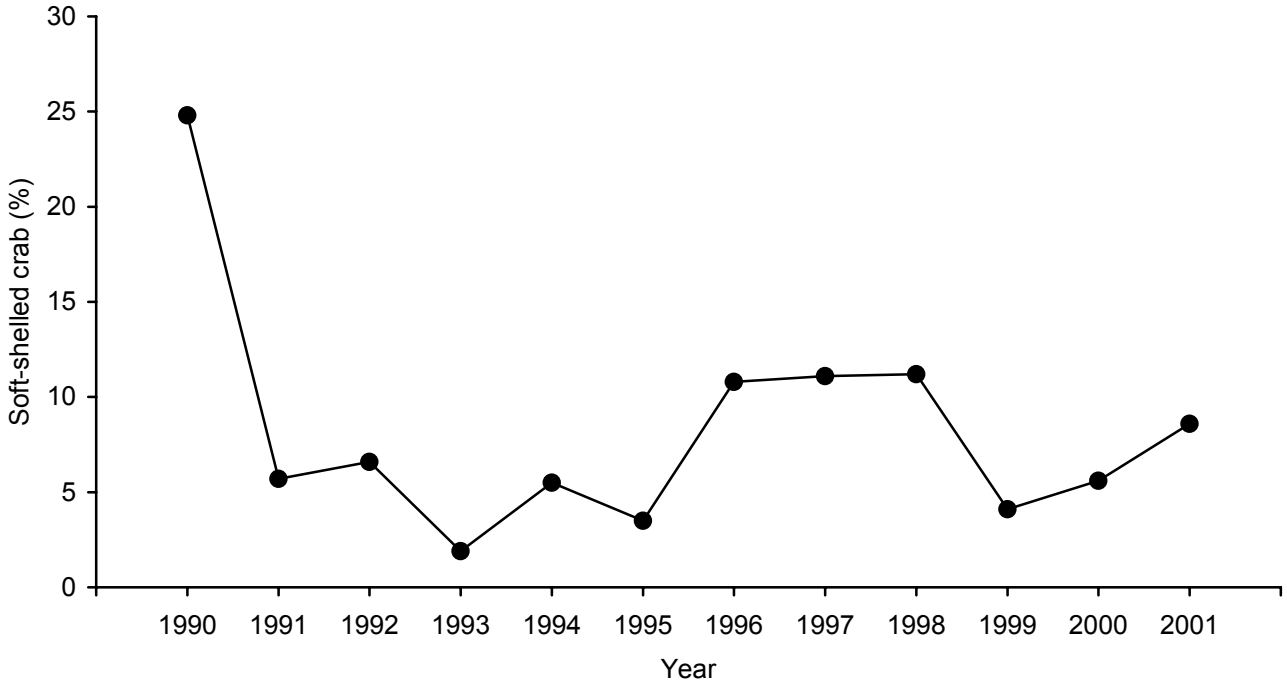


Figure 22. Annual percentage of soft-shelled crab in Area 19 between 1990 and 2001.

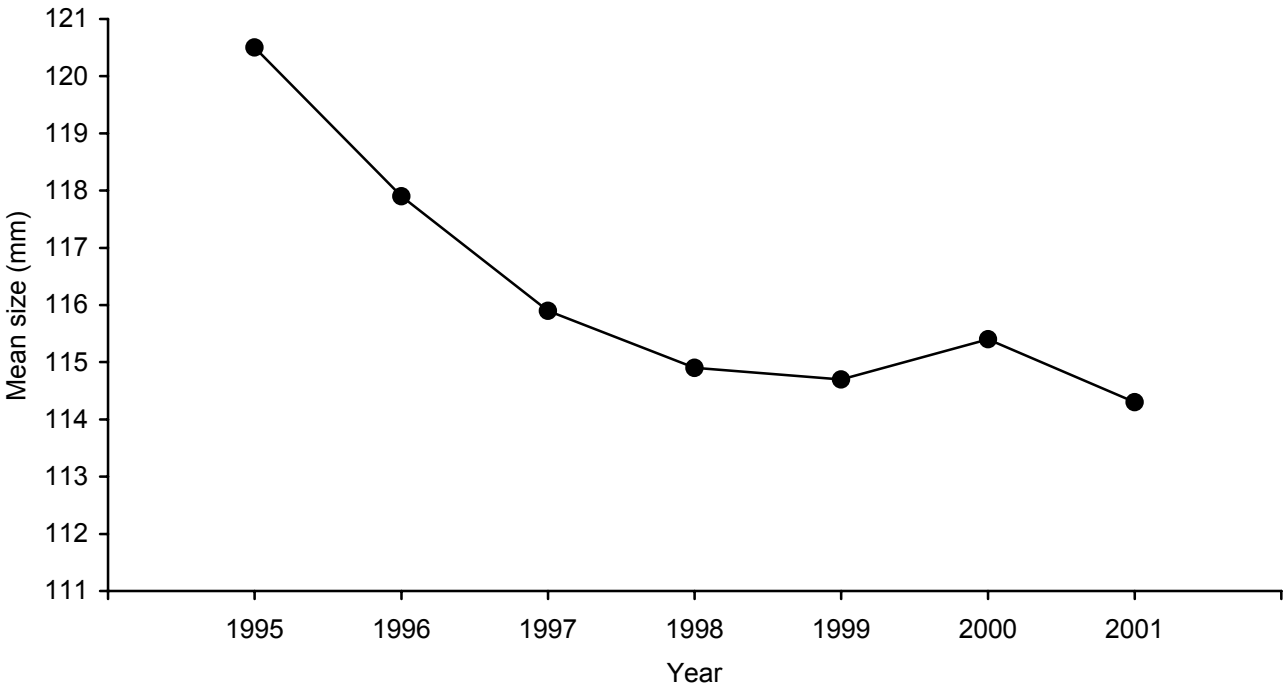


Figure 23. Annual mean size of the commercial catch in Area 19 between 1995 and 2001.

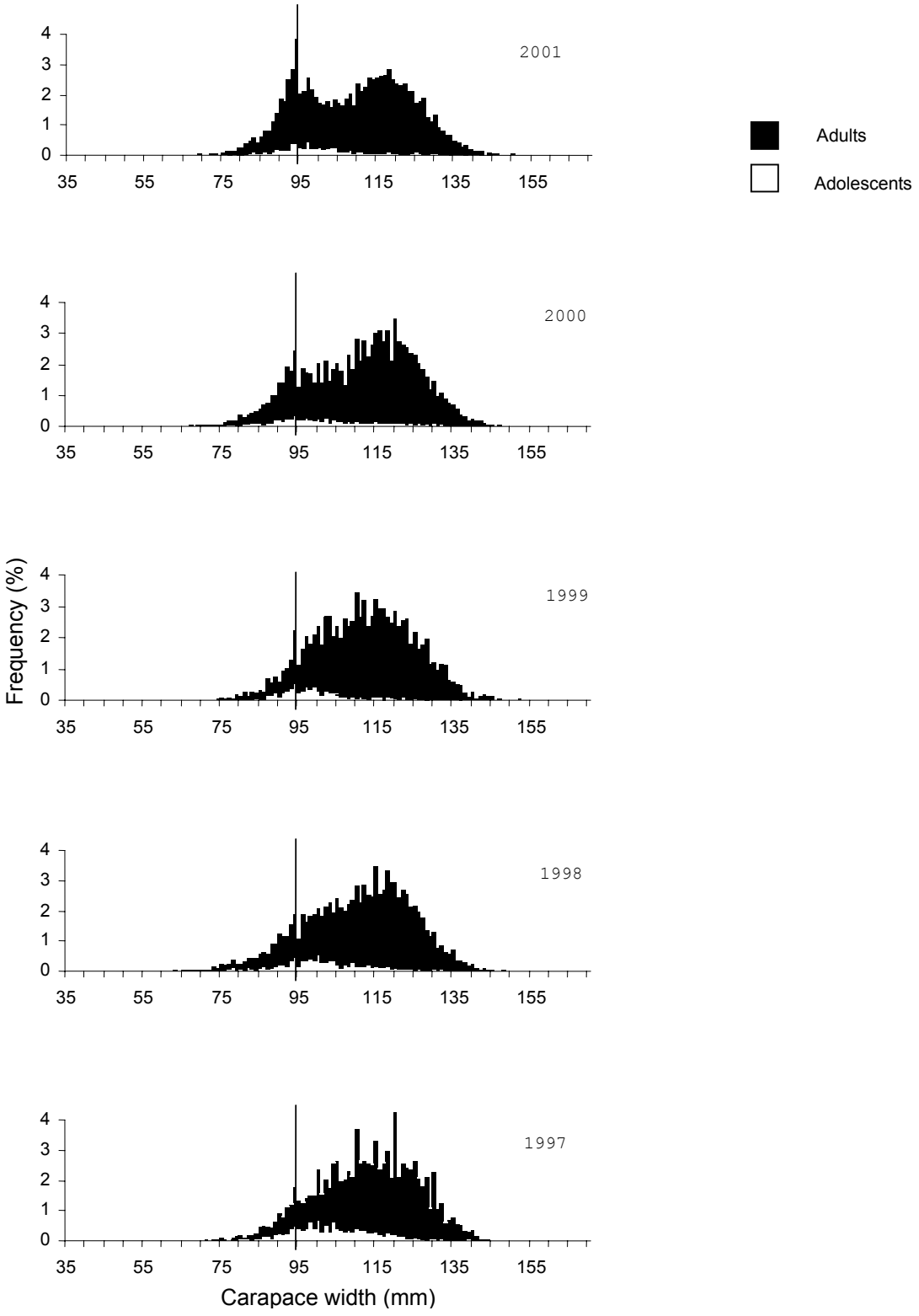


Figure 24. Size frequency distributions of male crabs measured during at-sea sampling in Area 19 between 1997 and 2001.

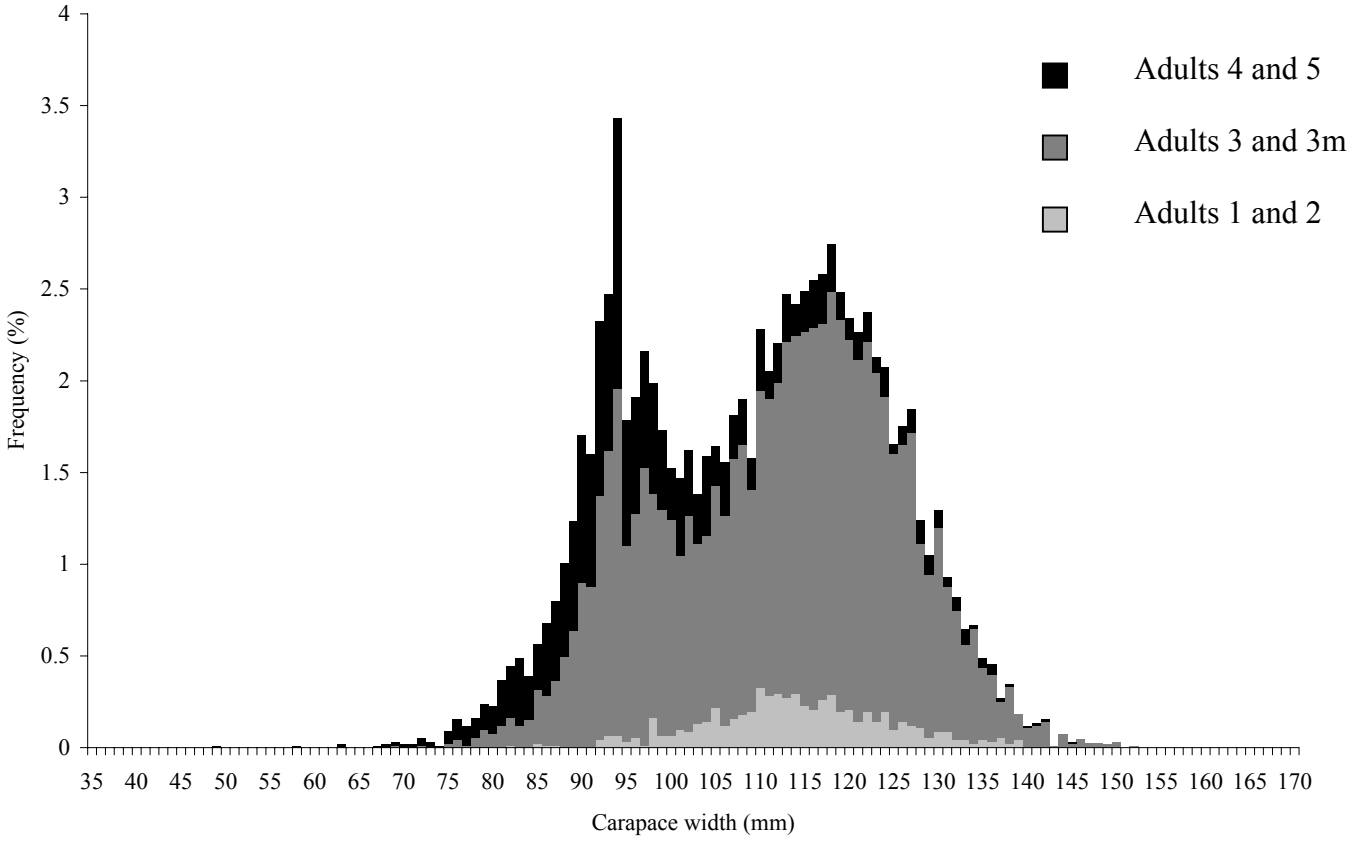


Figure 25. Size frequency distributions of adult male crab by carapace condition in Area 19 during the 2001 fishing season.

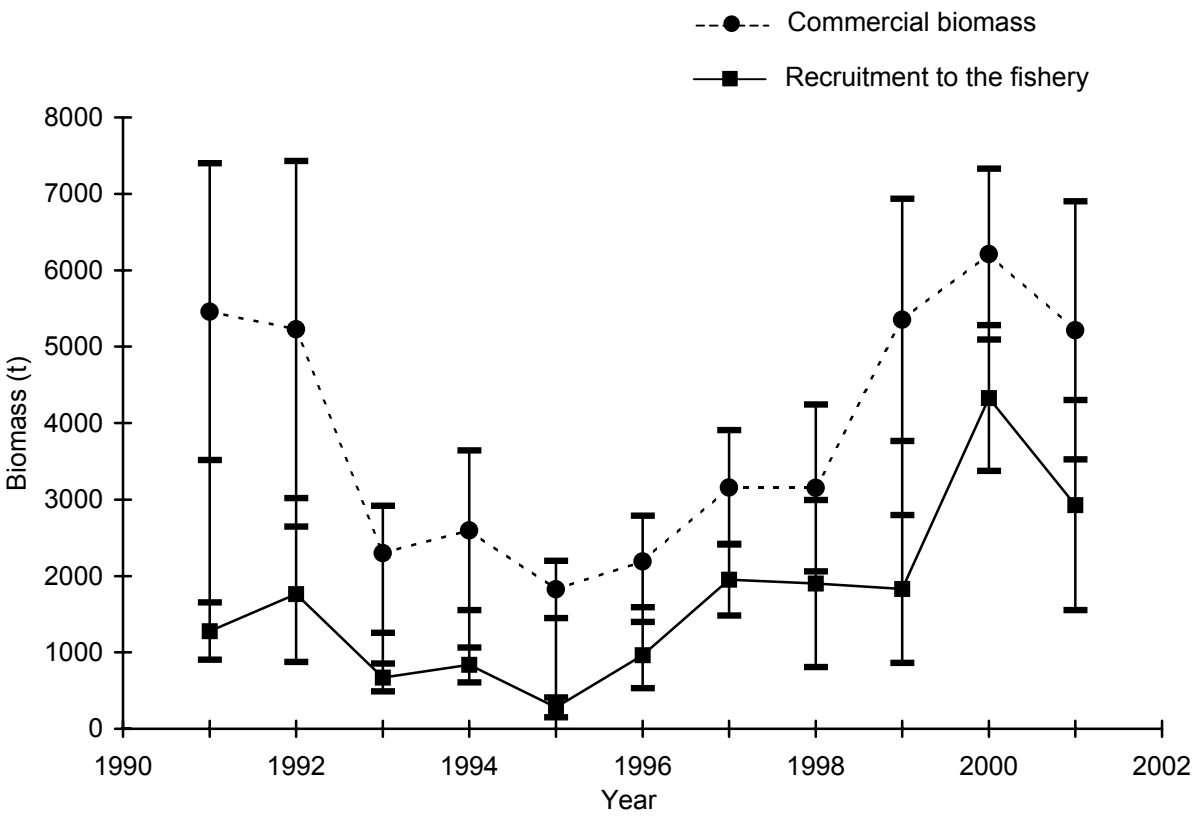
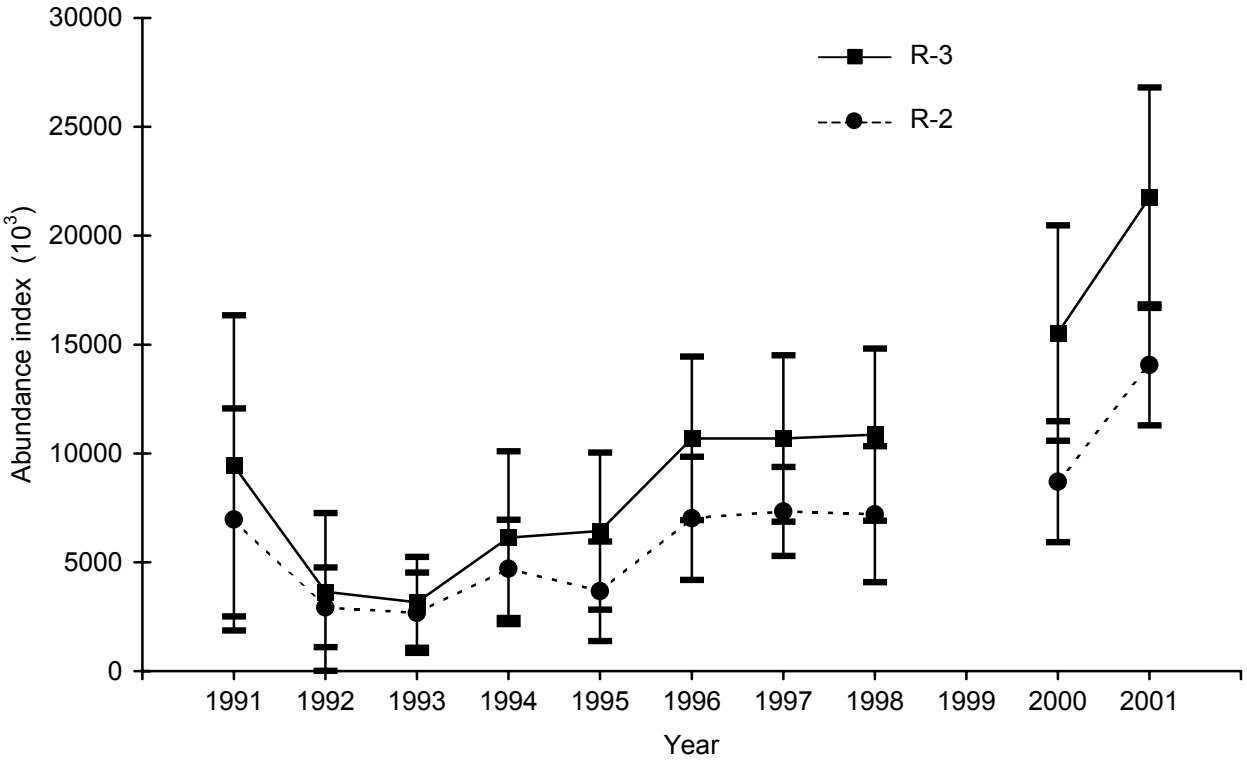


Figure 26. Annual commercial biomass (t) and recruitment to the fishery (t) indices in Area 19 between 1991 and 2001 (1991-1992 trawl surveys were conducted before the fishing season).



* No abundance index in 1999 due to malfunction of the Netmind system.

Figure 27. Abundance index of prerecruits R-3 and R-2 in Area 19 between 1991 and 2001.

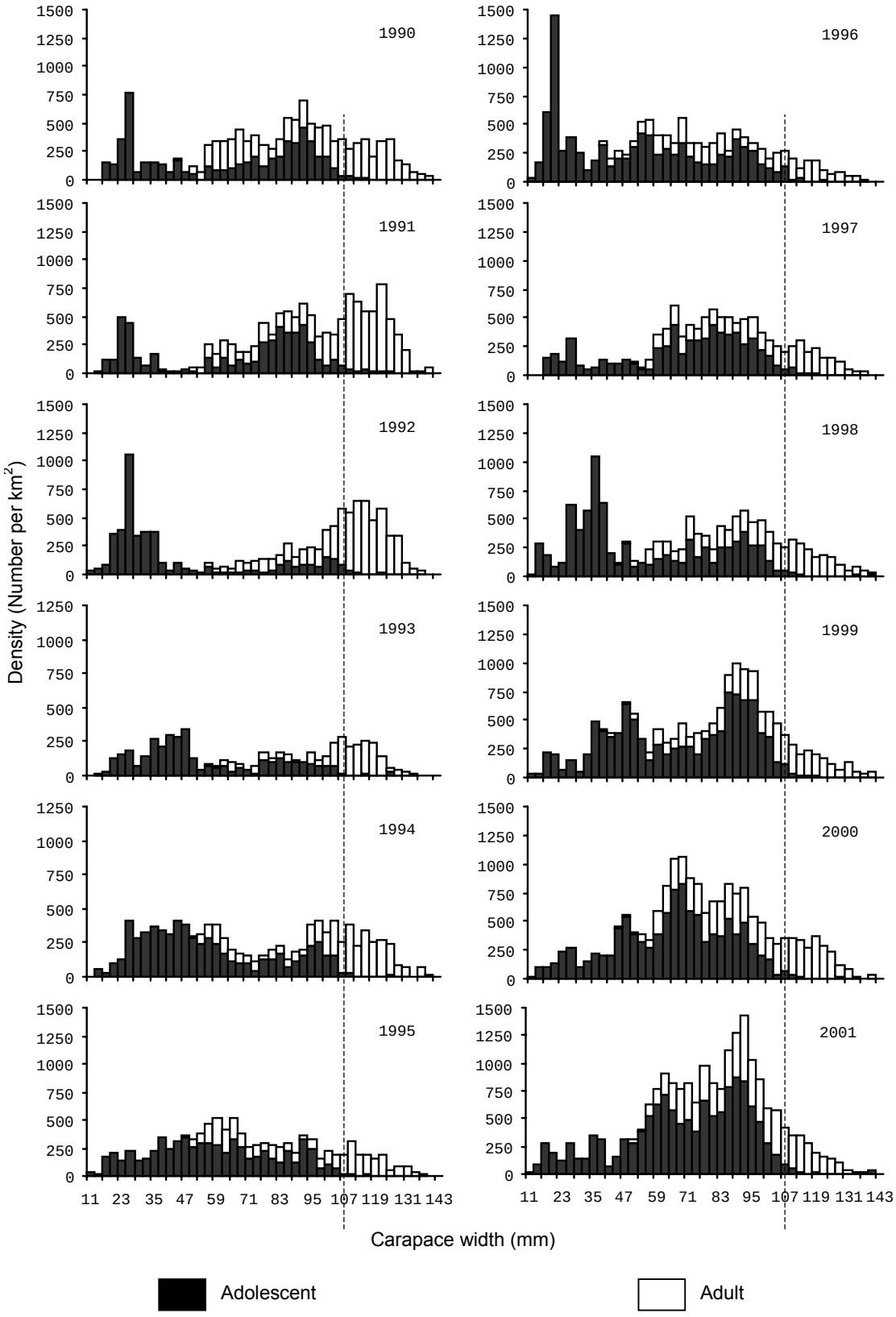


Figure 28. Size frequency distributions for male snow crabs in Area 19 between 1990 and 2001 (1990-1992 trawl surveys were conducted before the fishing season).

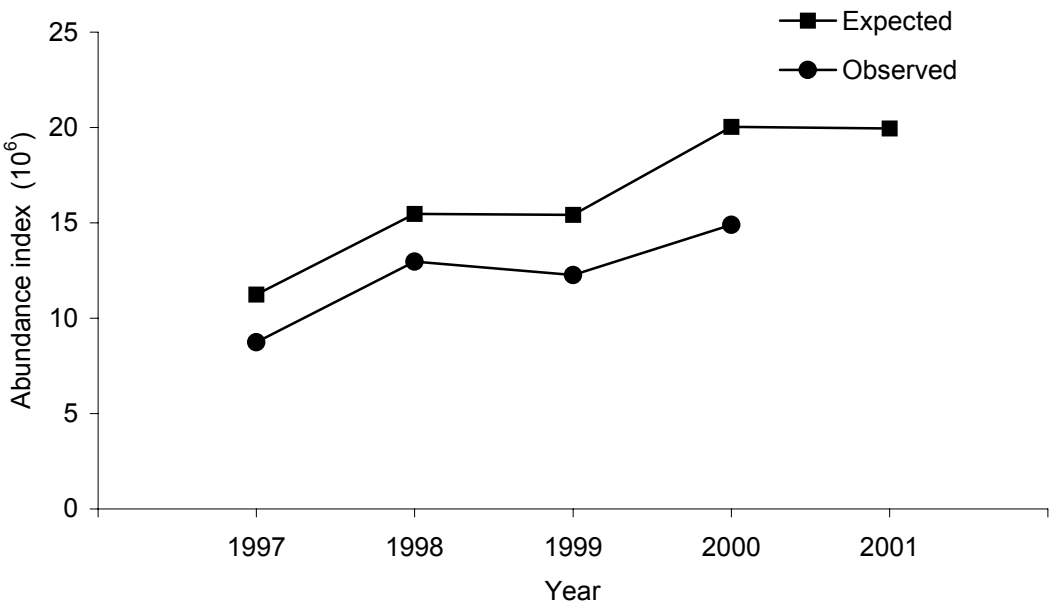


Figure 29. Difference between the observed and expected values of the commercial abundance in the southeastern unit of the southern Gulf of St. Lawrence between 1997 and 2001.

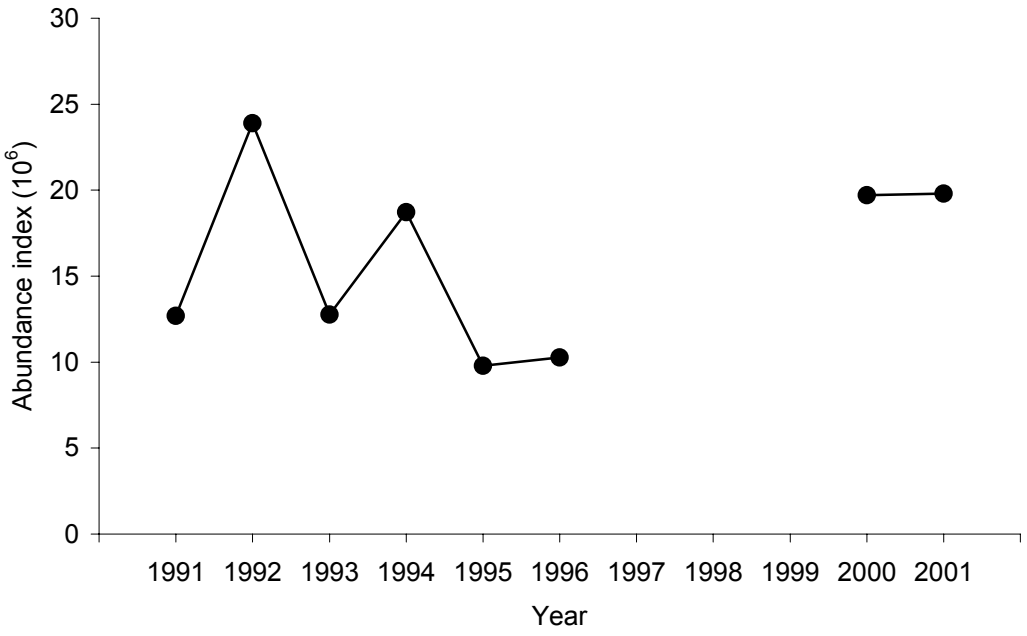


Figure 30. Abundance of adult males ≥ 95 mm CW within the southeastern unit of the southern Gulf of St. Lawrence between 1991 and 2001 (no survey was done in 1997-1998 in Area 18).

* No abundance index in 1999 due to the malfunction of the Netmind system.

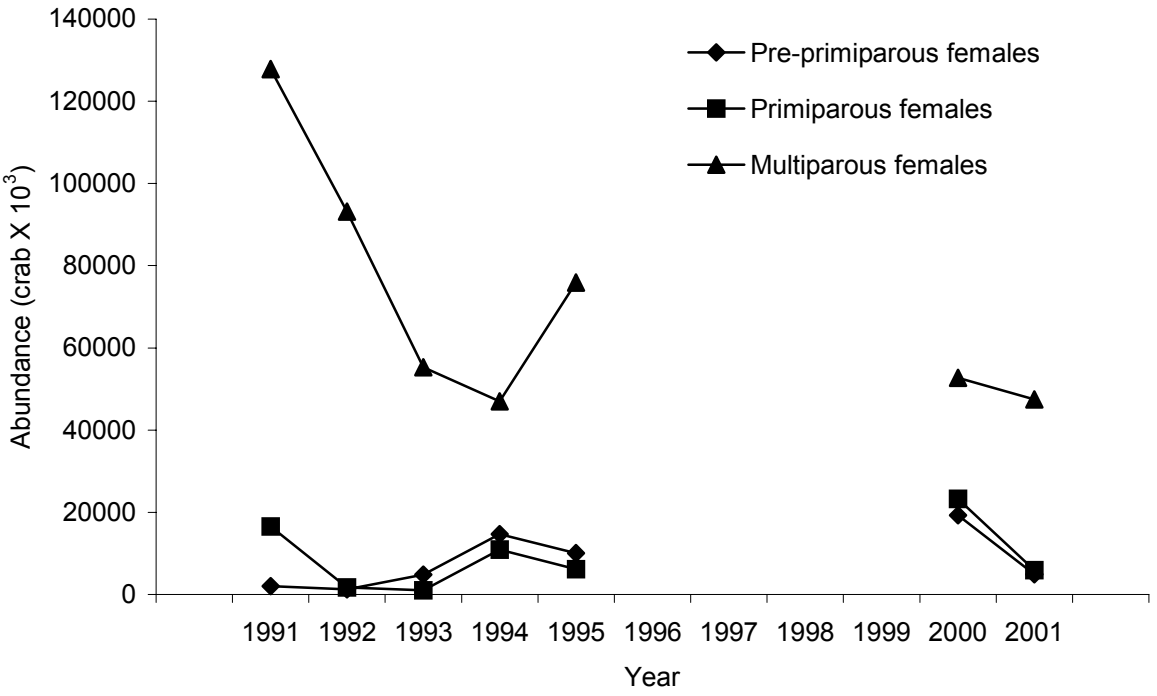


Figure 31. Abundance index of pre-primiparous, primiparous and multiparous females in the southeastern unit of the southern Gulf of St. Lawrence between 1991 and 2001 (no survey in Area 18 between 1997-1998).

* No abundance index in 1999 due to the malfunction of the Netmind system.

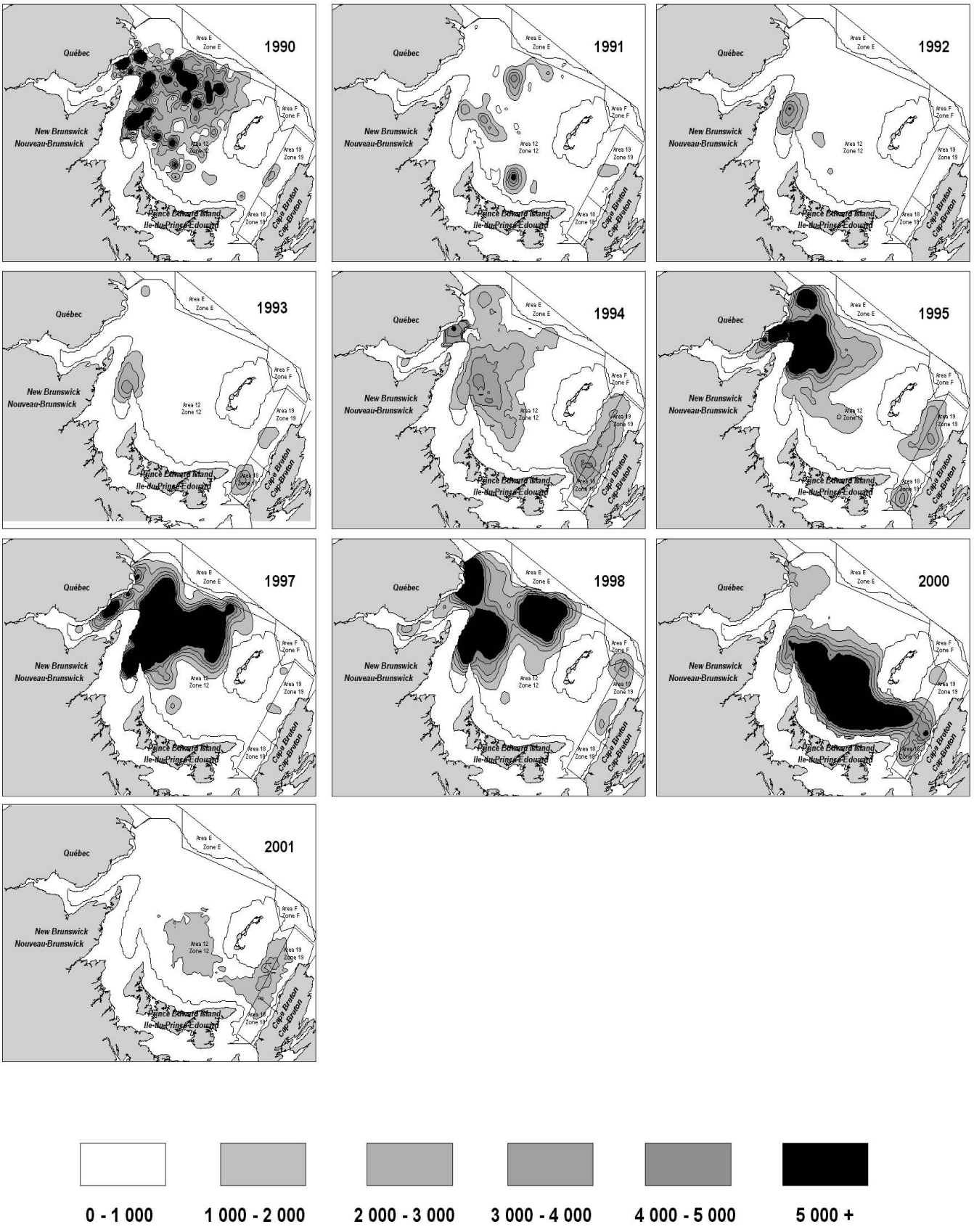


Figure 32. Density contours for pre-primiparous females based on the trawl survey between 1990 and 2001 in the southern Gulf of St. Lawrence.

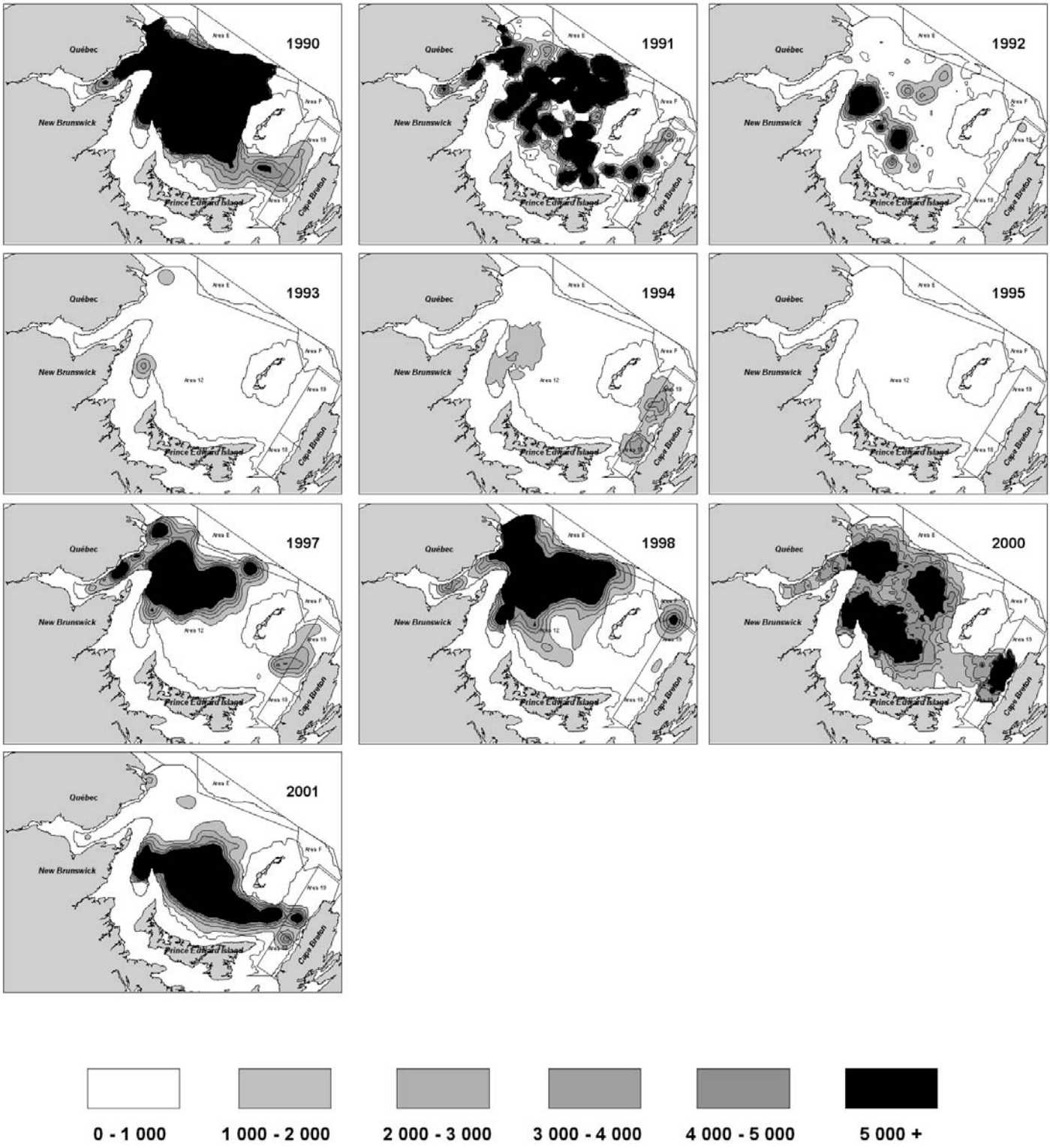


Figure 33. Density contours for primiparous females based on the trawl survey between 1990 and 2001 in the southern Gulf of St. Lawrence.

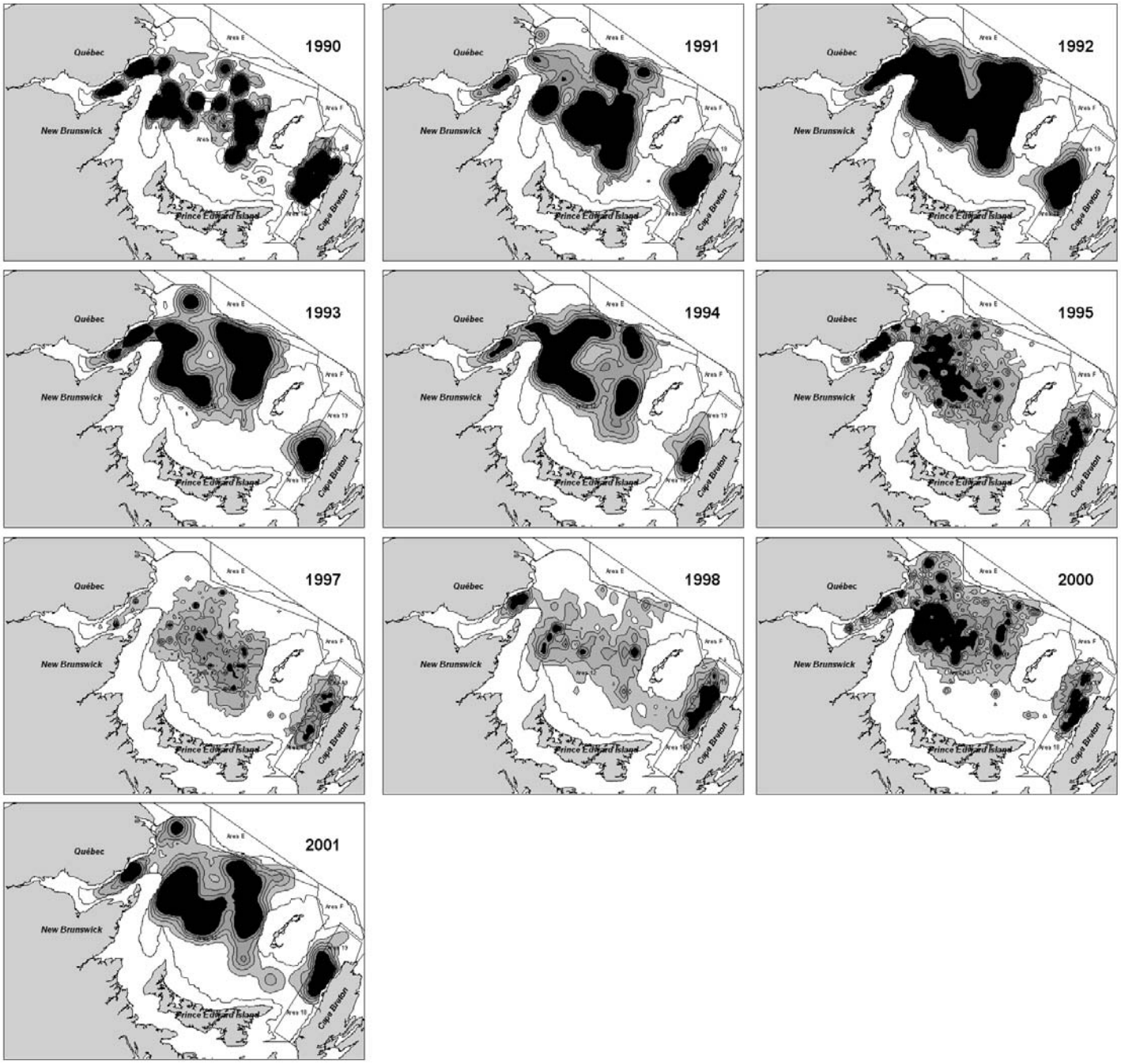


Figure 34. Density contours for multiparous females based on the trawl survey between 1990 and 2001 in the southern Gulf of St. Lawrence.

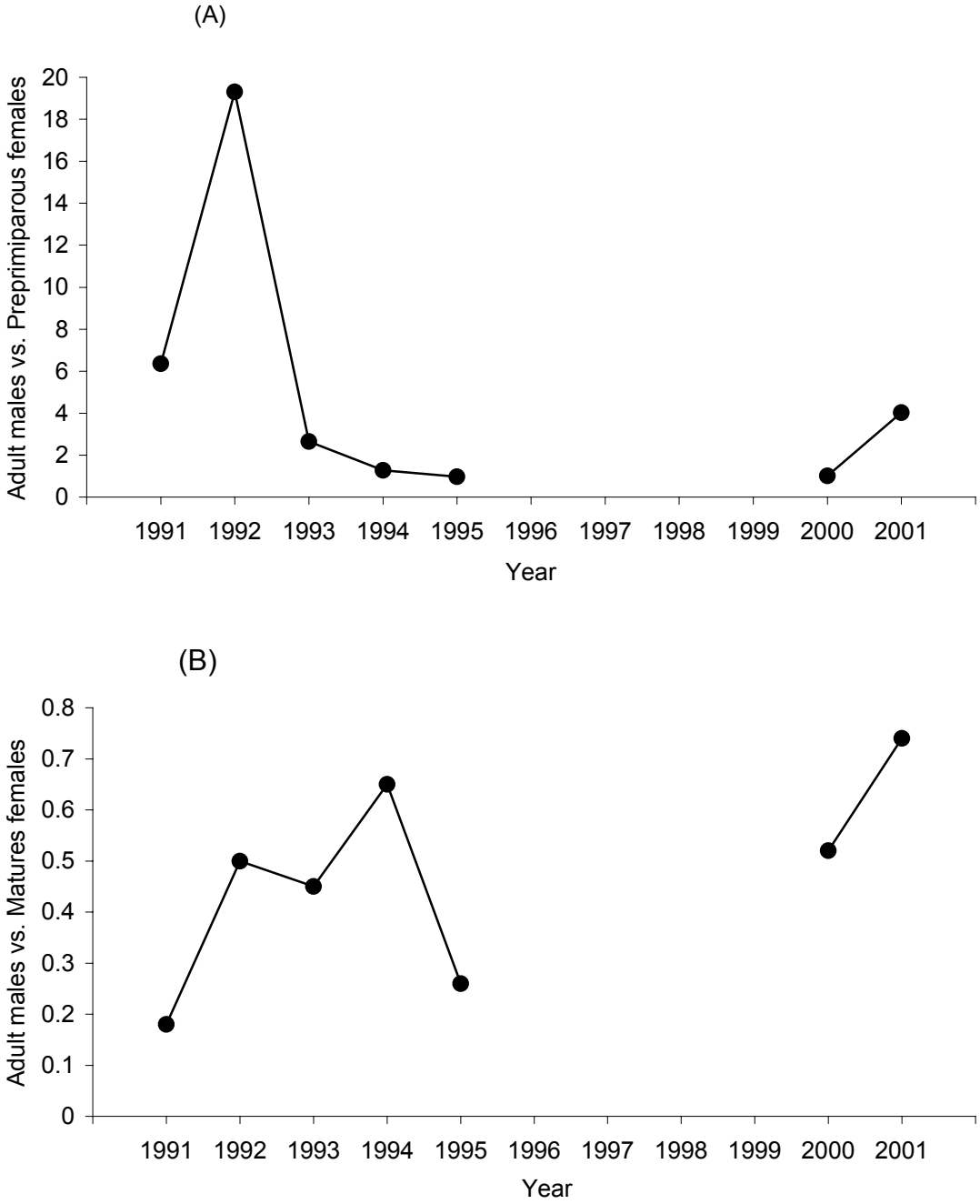


Figure 35. Sex ratio (A: adult males ≥ 95 mm CW vs. pre-primiparous females and B : adult males ≥ 95 mm CW vs. total mature females) in the southeastern unit of the southern Gulf of St. Lawrence between 1991 and 2001.