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Research Document 2003/012 | **Document de recherche 2003/012**

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Assessment of the 2002 Snow crab (*Chionoecetes opilio*) fishery off eastern Nova Scotia (Areas 20 to 24).

Évaluation du crabe des neiges (*Chionoecetes opilio*) pour la saison de pêche 2002 au large de l'est de la Nouvelle-Écosse (zones 20 à 24).

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ISSN 1499-3848 (Printed)

Canada

Abstract

Overall, fishery-related indices (CPUE and at-sea observer data) showed generally positive signs in 2002. Reported landings were 10,186 t against a TAC of 10,315 t for the 2002 fishing season.

The 2002 annual survey was conducted in the late summer / early fall in consideration of seasonal movement that had been affecting the spring surveys in the past. This was the first time that a complete survey was conducted after the fishery in ENS (a partial fall survey was conducted in N-ENS in 2001). The fishable biomass index for 2003 was 2,800 t in N-ENS and 24,350 t in S-ENS. Size frequencies and the abundance index from the trawl survey indicate a continued decrease in recruitment. The fishable biomass index in the originally surveyed areas has been declining, which is expected to accelerate in all areas if recruitment does not improve. The mature female abundance has been decreasing since 1997-1998, which may impact the reproductive potential. Bottom temperatures were near their long-term mean in 2002. Due to uncertainties associated with the negative signs of recruitment, fishable biomass and reproductive potential, it is strongly recommended not to increase harvesting levels in 2003.

Résumé

De manière générale, les index reliés à la pêcherie, tels que les PUE et les données des observateurs en mer, démontraient des signes positifs en 2002. Les débarquements déclarés de la saison de pêche de 2002 se sont chiffrés à 10 186 t, par rapport à un TAC de 10 315 t.

On a effectué le relevé annuel de 2002 à la fin de l'été et au début de l'automne pour tenir compte des migrations saisonnières qui avaient influencé les relevés printaniers par le passé. C'était la première fois qu'un relevé complet était effectué après la pêche dans l'est de la Nouvelle-Écosse (un relevé partiel a été fait au nord-est de la N.-É en 2001). L'indice de la biomasse exploitable en 2003 était de 2 800 t pour le nord-est de la N.-É. et de 24 350 t pour le sud-est de la N.-É. Il ressort des fréquences de tailles et de l'indice d'abondance du relevé au chalut que le recrutement continue de diminuer. L'indice de la biomasse exploitable dans les zones ayant initialement fait l'objet du relevé est en baisse et cette baisse devrait s'accélérer dans toutes les zones si le recrutement ne s'améliore pas. L'abondance des femelles à maturité diminue depuis 1997-1998, ce qui peut se répercuter sur le potentiel de reproduction. Les températures du fond étaient proches de leur moyenne à long terme en 2002. En raison des incertitudes associées à des signes négatifs concernant le recrutement, la biomasse exploitable et le potentiel de reproduction, il est fortement recommandé de ne pas accroître les niveaux d'exploitation en 2003.

INTRODUCTION

History – Harvesting of snow crab (*Chionoecetes opilio*) off the coast of eastern Nova Scotia (ENS) began in the late 1970s (Tremblay et al., 1994). Landings peaked at 1,634 t in 1979, but these fisheries were believed to be near commercial extinction by 1985 (89 t). From 1982 to 1993, the management of these fisheries was based strictly on effort controls (seasons, licences and trap limits) with average annual landings of 768 t. Substantial changes to management measures were introduced from 1994 to 1999 such as individual boat quota (IBQ), 100% dockside monitoring, mandatory logbook, at-sea monitoring by certified observers and the introduction of sub-areas to ensure the distribution of fishing effort (Fig. 1). Landings remained stable around 1,500 t between 1994 and 1997, then rose quickly to 3,600 t by 1999.

For the first time in 1999, the ENS stock was assessed based on a trawl survey that began in 1997. Estimated biomass and density maps from 1997 to 1999 revealed that the geographical distribution of the resource was greater than the area being exploited at the time, especially in the southern portion of ENS. The total allowable catch (TAC) increased from 900 t in 1999 to 1,015 t in 2000 in north-eastern Nova Scotia (N-ENS), and from 2,700 t to 8,800 t in south-eastern Nova Scotia (S-ENS).

The size frequency distributions from trawl survey showed a substantial decrease in adolescent males from 1997 to 2001 in both northern and southern regions, while adult males $\geq$95 mm of carapace width (CW) had remained stable. There were no changes in the number of permanent licences in all crab fishing areas (CFAs) during the same period, but temporary licence holders were introduced in CFAs 20, 23 and 24.

Current status – In 2002, the TAC in N-ENS was increased by 50% in CFAs 20, 21 and 22 inside and 10% in CFA 22 outside (Table 1) compared to 2001. There were five permanent licences and six temporary licences in CFA 20, 32 permanents in CFA 21, and 37 permanents in CFA 22. Two fishermen in CFA 22 changed fishing grounds in 2002 bringing the number to 22 permanents in the northern area (20 in 2001) and 15 in the outside area (17 in 2001).

In S-ENS, the TAC in 2002 remained similar to 2001 at 8,822 t, with 4,776 t in CFA 23 and 4,046 t in CFA 24. In 2002, individual boat quotas (IBQ) of permanent licences also remained the same as in 2001, but the number of licences increased from 24 permanent licences in 2001 to 37 in CFA 23 and from 23 licences to 34 in CFA 24 (Table 1). The existing temporary fishermen allocations in 2002 decreased from 2,985 t to 2,038 t in CFA 23, and from 2,406 t to 1,564 t in CFA 24, compared to 2001. The number of temporary licence holders decreased from 59 to 38 in CFA 23, and from 57 to 40 in CFA 24.

Other management fishery measures in 2002 remained similar to what they were in 2001 for all the CFAs (Table 1).

MATERIALS AND METHODS

Landings, catch rate and effort

Commercial catch rates – Raw data on catches and fishing effort were obtained from the mandatory logbooks that are also used for dockside monitoring. Copies of the original completed logs and the compiled electronic database were obtained from the Maritimes Region Statistics Division of the Department of Fisheries and Oceans Canada (DFO). Thereafter, total seasonal landings for each CFA were obtained from a revised preliminary report produced by the Statistics Division in late December 2002. The average CPUE of the fleet at year (i) corresponds to the ratio of the total catch from the fishermen's logbooks (y) and the corresponding number of trap hauled (th) reported only in properly completed logs: $CPUE_i = \sum y_i / \sum th_i$. In 2002, properly completed logbook represented 90.3% of the total landings in ENS. Total effort (i.e. total number of traps hauls: TH) was estimated from total seasonal landings in the revised preliminary report produced by the Statistics Division (Y_i) divided by average CPUE: $TH_i = Y_i / CPUE_i$.

Management areas and sub-areas – Following the stock assessment of 1998, DFO considered that a reasonable increase of 50% could be allowed in 1999 in CFA 23 and CFA 24 (Biron et al., 2000). However, the DFO Science group noted that the heaviest effort was within the near shore fishing grounds and an increased quota without effort distribution could increase exploitation above acceptable levels (Biron et al., 1998). Therefore, DFO Management in consultation with the Industry and DFO Science has drawn (and/or modified) sub-areas in most CFAs of ENS to ensure the distribution of the fishing effort. There was no change in CFAs and sub-areas limits in 2002 compared to 2001 (Fig. 1). Landings, CPUE and fishing effort were also presented on the basis of these management areas and sub-areas.

At-sea observer sampling

At-sea sampling was carried out onboard commercial vessels to provide an assessment of the percentage of soft shell crabs in the catches and the size structures of crabs caught. Measurements were performed solely by certified observers. Two types of sampling were conducted on the commercial fishing vessels: sea sampling and port sampling. For the sea sampling, the total number of male crabs, the position and depth of the trap were recorded for each randomly sampled trap, and a sub-sample of 20 to 40 crabs was taken randomly for the following measurements: carapace width (CW) and chela height (CH) using modified vernier callipers (Watson and Wells, 1970), carapace hardness of the right claw using a hardness gauge (Foyle et al., 1989), and carapace condition (CC) (Appendix 1; Moriyasu et al., 1998). It should be noted that because this is a summer fishery, a minimum of 20 crabs are sampled on warm sunny days to reduce handling-induced mortality, while on cool overcast days a maximum of 40 crabs can be sampled. For the port sampling, a sub-sample of 20 crabs was sampled at random after a fisherman had sorted the catch, and the same measurements as above were taken.

Catch composition (% of different crab categories) was estimated based on carapace hardness (hard or soft), size (legal and sub-legal) and morphometric

maturity. New-soft (CC-1) and clean crab (CC-2) with durometer readings <68 was considered as a postmolt soft shell crab (Moriyasu et al., 1998). The terminology of male maturity phase follows Sainte-Marie et al. (1995). Adult (terminal molt) and adolescent (non-terminal molt) males were identified based on the following discriminant function assigning individuals to the correct groups in 99% of cases (for adult males: $Y > 0$), calculated for ENS male snow crab (Biron et al., 1999):

$$Y = 19.775707 \ln (CH) – 25.324040 \ln (CW) + 56.649941$$

Exploratory trap survey along the edge of the Scotian Shelf

Fishing began in this offshore area in 1999. After a limited, voluntary trap survey by industry in 2000, CFAs 23 and 24 Advisory Committees recommended that a more complete two-year industry survey be conducted and the results be reviewed when the management plan terminated at the end of 2002. The objectives of this project were to determine the distribution, density (mean number of crab / trap) and movement pattern (by tagging) of snow crab. A formal two-year trap survey with four experimental licences was initiated under the Emerging Fisheries Policy in 2001. All applicants were required to submit business proposals that outlined research, management and conservation approaches and harvest levels for the fishery. Twenty-one proposals were received, four were selected (Canso Trawlermen's Co-operative Ltd. (CTCL), Eskasoni First Nation, Native Council of Nova Scotia, and Herb Nash (Groundfish Dependent fishers)). Annual allocations of 50 t were provided to each licence holder.

The 2001 and 2002 survey occurred within the slope of Banquereau and Sable Island Banks at depths ranging between 60 m and 300 m. No effort was permitted within the Sable Gully candidate protected area. From the Gully area, the survey extended northward to latitude 45°00' in CFA 23 and eastward to longitude 61°00' in CFA 24. The survey areas were divided into 16 km (10 mile) sections, within which two transects were set with 1 trap placed at depths of 100 m, 200 m, 300 m and 400 m in 2001 and at depths of 75 m, 100 m, 200 m and 300 m in 2002. This was done a minimum of two times between May and November, with at least one month apart between each fishing. Selected fishermen were requested to follow the same management measures as for the commercial fisheries (i.e. mandatory logbook, hail requirements, 100% dockside monitoring, 25% at-sea observer coverage, etc.). For each trap, the total number of male crabs, the position and depth of the trap were recorded, and a sub-sample of 40 crabs was taken randomly for the following measurements: CW, CH, CC and hardness of the right claw. Additional reporting requirements included a description of by-catch species (e.g. lobster, Jonah crab, others). Temperature probes (VEMCO Ltd.) were attached to twelve traps of one participant. Tagging projects were conducted in October and November 2001 and 2002 (method described below).

Tagging

Tagging of adult male crab started in 1993 in the southern Gulf of St. Lawrence (sGSL) and in 1996 in ENS. Only vigorous adult males of CC-2, 3 and 4 captured with commercial snow crab traps were tagged using a modified spaghetti tag mounted with a numbered plastic disc and a metal sleeve. The tag was placed between the second and third legs, and secured by squeezing the metal sleeve. This particular placement of the tag still allows the male crab to open his abdomen, which is required during mating. Tagging was done onboard industry and/or research vessels. Crabs were measured for CW, CH and CC, tagged and released at the surface of the water in pre-determined positions. Tagging results for both sGSL and ENS are presented for comparison.

Annual trawl survey

Trawl sampling – A post-season trawl survey was conducted in 2002 using a chartered 20 m stern-trawler. Pre-season trawl surveys were conducted in previous years (1997-2001). A Bigouden *Nephrops* trawl was used (20 m head line, 27.3 m foot rope mounted with a 3.2 m long, 8 mm galvanised chain, and mesh size of 80 mm in the wings, 60 mm in the belly and 40 mm in the cod-end; Conan et al., 1994). A systematic random sampling design was used to determine the location of trawl stations. One location was randomly chosen within each 10 minute latitude / longitude grid. In some areas of N-ENS i.e. CFA 21 and CFA 22 inside, two stations were selected per grid in an attempt to improve our understanding of the stock distribution in that region. Once selected, the original stations from the first survey were used every year. Whenever new stations are required because of the expansion of the surveyed area, they are added randomly. In 1997 there were 150 stations within CFAs 22, 23 and 24. By 2000, the survey had extended to encompass areas of the Cabot Strait, Sydney Bight and most the Scotian Shelf east of the NAFO boundary line between 4W and 4X, with a total of 307 stations. The duration of each tow varied between 5 to 8 minutes at an average speed of two knots. The length of a tow was determined in 1987 (Moriyasu et al., 1998). The *Nephrops* trawl was constructed with a foot rope that digs into the bottom sediment, and tows longer than 5-8 minutes resulted in a full load of mud, reduced catchability, and significant net damage. Net behavior was monitored by NetMind® sensors. A Minilog® temperature / depth sensor was added in 2001 to complement other electronic sensors. The onboard starting point for each tow was based on the locking of the winch drums after a predetermined amount of warp is released. The tow ends as soon as the winches are started to bring the trawl back onboard. However, the actual length of the tow for the analysis was determined after the survey, using data as monitored by the depth Net Mind® sensor. In cases of abnormal net behavior or damage, a new tow was done. Information for each tow on duration, position at start, mid and end, horizontal opening of the trawl using NetMind®, and water depth was recorded. To cover the entire snow crab habitat in ENS, 45 sea-days were required. Water depths ranged from 50 m to 450 m. All male crabs were measured for CW, CH, carapace hardness and CC. Size-frequency histograms were adjusted to the surface area swept by the trawl. All female crabs were measured for CW and the width of the fifth abdominal segment. The presence and the color of the eggs was also recorded.

Before 2002, the annual survey began at the end of April or early May, and was completed in late June or early July, before the fishing season. In 2002, the annual survey was moved from the spring to the fall, and started in CFA 23 in mid-August, moved to CFA 24 in early September, CFA 4X by late September and CFAs 20, 21 and 22 by mid-October. In CFAs 20-22, the 59 trawl stations were also visited in May and July. These extra stations were used to estimate the commercial-sized adult male biomass in the spring and summer for comparison with the biomass estimated from the spring 2001 and fall 2002 surveys.

Mapping and abundance estimation by Kriging – Kriging (Matheron, 1970; Clark, 1979) was used to estimate biomass and map density of different crab categories (Conan, 1985; Conan et al., 1988; Conan et al., 1994). Kriging consisted of two procedures: (1) analyzing and modelling the covariance between sampling units as a function of distance using a variogram; and (2) then interpolating the densities of crab in unsampled areas by using the covariance function to assign weights to neighbouring samples. Separate variograms and density estimates were calculated for each sampling unit. Numbers of crab were converted to biomass using a CW-weight relationship, $W = 1.543 \times 10^{-4} CW^{3.206}$ (Biron et al., 1999). A projected habitat area (PHA), introduced in 1999, was used to account for the irregular bathymetry and subsequent bottom temperature profiles that may render a portion of the area non-habitable for commercial-sized adult males (Biron et al., 2000). The PHA was incorporated into our assessment process by means of “masks”, which impose restrictions or boundaries on the interpolation process. The “masks” included a series of zero values that were positioned onto areas of highly probable zero densities. Different “masks” were used for commercial and non-commercial snow crab categories. Starting in 2001, the surface used for kriging was fixed according to criteria developed in 1999 (Biron et al., 2000). The kriging surface was 5,000 km^2 in northern ENS and 28,900 km^2 in southern ENS.

Biological unit versus Management unit – From a scientific perspective, there were two main concentrations of the resource in ENS, one in the north (CFAs 20-22; N-ENS), and the other in the south (CFAs 23-24; S-ENS). Further, CFAs in ENS do not reflect biological distribution of the resource, and to use these CFAs as a reference point to present the trawl survey results compromises the reliability of the biomass estimates. Therefore, trawl survey results are shown for N-ENS and S-ENS only.

Temperature – It has been common practice to attach a temperature probe (VEMCO Ltd.) to the trawl for each tow. Each year, temperature data are sent to Hydrologic Services, DFO-Halifax for recording / analysis. However, for comparison purposes and to better illustrate differences, bottom temperature data collected during the spring, summer and fall trawl surveys were projected into geographic distribution maps. These do not account for difference and variation in sampling time (hour/day), date, tide, current and topography.

RESULTS

Fishery

The overall TAC for ENS in 2002 was 10,315 t (10,515 t if slope trap surveys were included) compared to 9,848 t in 2001. Total reported landings in 2002 were 10,186 t (Fig. 2). Logbook positions recorded by fishermen are presented in Fig. 3.

North-eastern Nova Scotia

In CFAs 20, 21 and 22, fishing activities at the beginning of the 2002 season were disrupted by wharf blockades (in protestation) that resulted in irregular fishing pattern for all fishermen compared to previous years, as well as longer soak time (up to nine days). Fishing activities in CFA 20 were also affected by the daily landing limits imposed by buyers on some fishermen.

Fishing distribution and landings – In 2002, as in previous years, CFAs 20, 21 and 22 inside fishermen exploited the grounds located within the near shore trough that is commonly shared by all three CFAs (Fig. 3). Little fishing effort was reported around St. Paul Island or along the snow crab boundary of CFAs 19/20. In CFA 22 outside, fishing activities were limited to the Glace Bay Hole fishing grounds with little exploration along the Laurentian Channel slope. Except for the 10% increase in CFA 22 outside area, TAC increased by 50% in all other management areas of N-ENS. In CFA 20, TAC increased from 118 t in 2001 to 177 t in 2002, with 102 t allocated to permanent fishermen and 75 t to temporary licence holders (Table 2). Fishermen landed 119 t from the inside grounds and 57 t from the outside grounds (Table 3). Temporary fishermen landed 18 t from the inside grounds, but only after permanent fishermen had captured their allocation. In CFA 21, the TAC increased from 363 t in 2001 to 545 t in 2002 (Table 4). Although the total landings of 547 t occurred over a five week period, 92% of the catch was landed during the first two weeks (Table 5). In CFA 22, the TAC increased from 318 t in 2001 to 477 t in 2002 in the inside area and from 267 t to 294 t in the outside area. Fishermen from the inside area landed 478 t within three weeks, while the ones from the outside area took a little longer to land 295 t (Tables 6 and 7).

CPUE and effort – In 2002, the average CPUE of 100.9 kg/th in N-ENS represented a 7% increase compared to 2001 (Table 8). By management areas, average CPUEs in 2002 increased by 27% in CFA 20 inside ground and 32% in CFA 22 inside, but remained similar in CFA 21, or decreased by 18% in CFA 20 outside area and 7% in CFA 22 outside area (Table 3, 5 and 7; Fig. 4). The total effort in N-ENS increased by 40% to 14,791 trap hauls in 2002 compared to 2001 (Table 8). Increases in fishing effort were reported for all CFAs and their sub-areas in 2002 compared to 2001 (Fig. 5).

At-sea sampling by observers – In 2002, there was up to 4% soft shell crab observed in the catch at-sea (Table 9). A decrease in the ratio of undersized adults was observed in CFA 20 (from 15.2% in 2001 to 7.7% in 2002). A decrease in hard shell adolescent was reported in CFA 21 (from the exceptional high of 54.3% in 2001 to 6.7% in 2002). A three fold increase in adolescents in CFA 22 (from 3.1% in

2001 to 10.9% in 2002) was also observed. In 2002, the mean CW of male crab was 110.0 mm CW (105.1 mm in 2001) in CFA 20, 106.2 mm (104.7 mm) in CFA 21, and 106.6 mm (104.7 mm) in CFA 22 (Figs 6 and 7). There was no obvious difference between the catch composition and distribution of the two sub-areas of CFA 22. The majority of the catch was of CC-3 (81%) and CC-3 with moss present on the carapace (14%) in N-ENS (Fig. 8). There was over 50% more coverage by certified observers in 2002 in CFAs 20 and 21 in terms of number of trips and traps observed, as well as number of crabs measured, compared to 2001. In CFA 22, the coverage was about 50% less than in 2001. The seasonal CPUE estimated from the sampled traps in 2002 was 60.4 kg/th in CFA 20, 121.9 kg/th in CFA 21 and 192.5 kg/th in CFA 22. The average mesh-size in 2002 was 70.9 mm in CFA 20, 69.3 in CFA 21 and 70.8 mm in CFA 22. The locations of all traps sampled in 2002 by the at-sea observer program in N-ENS are shown in Fig. 9.

South-eastern Nova Scotia

Fishing effort and pattern in 2002 were affected by the shorter fishing season compared to 2001. In 2002, there was a transfer of 'temporary' into 'permanent' allocations for First Nations, therefore creating 13 new permanent licences in CFA 23 and 11 in CFA 24 in 2002. In CFA 23, fishermen from all sub-areas required a vessel monitoring system (VMS) if they wanted to start fishing June 1st, resulting in a slow start, while only temporary fishermen from CFA 23D required them beginning in July. As opposed to 2001, only permanent fishermen had access to CFA 24B in 2002.

Fishing distribution and landings – In 2002, fishing effort and distribution in S-ENS was influenced by sub-area boundaries and an imposed sharing agreement with shrimp fishermen concerning the use of mutual fishing grounds. Accordingly, some areas in S-ENS were closed to the crab fishery for part of the year. In 2002, permanent fishermen in CFAs 23 and 24 have exclusively fished in sub-areas A and B, while temporary fishermen have fished in sub-areas B, C and D in CFA 23 and C, D and E in CFA 24.

The overall TAC in S-ENS was 8,822 t in 2002. The TAC of 4,776 t in CFA 23 and 4,046 t in CFA 24 were similar to those of 2001 (4,789 and 4,061 t, respectively). Overall, 8,767 t of snow crab were landed in S-ENS in 2002. In CFA 23, permanent licence holders captured 2,648 t and temporary licence holders landed 2,024 t (excluding the landings from the trap survey) for a total landing of 4,672 t (Tables 10 and 11). In CFA 24, permanent licence holders captured 2,450 t, while temporary ones landed 1,569 t (excluding the landings from the trap survey) for total landings of 4,019 t in 2002 (Tables 12 and 13).

CPUE and effort – In 2002, the average CPUE increased by 24% to 110.1 kg/th in S-ENS compared to 2001 (Table 14). This represented a 44% increase in CFA 23 and 6% in CFA 24 (Fig. 10). In CFA 23, marked increases in CPUE were observed for the permanent licence holders fishing in sub-areas A and B (44%) and temporary licence holders fishing in B (38%) and D (49%), but a 25% decreases in sub-area C. In CFA 23D, the CPUE was 80.4 kg/th in the gully area and 71.2 kg/th in the Artimon area (Table 15). In CFA 24, increases in CPUE were observed for the permanent

licence holders fishing in sub-areas A and B (13%) and temporary licence holders fishing in sub-area D (6%), while decreases were observed in C (-3%) and E (-17%) (Table 13). By comparison to 2001, CPUEs derived from the limited commercial fishery that occurred on the slope of the Scotian Shelf during the trap survey in 2002 increased by 61% in CFA 23 and decreased by 25% in CFA 24 (Tables 15 and 16). The total effort in S-ENS decreased by 23% to 69,100 trap hauls in 2002 compared to 2001, representing a 33% decrease in CFA 23 and 10% in CFA 24 (Fig. 11).

At-sea sampling by observers – In 2002, there was <5% soft shell crab observed in the catch at-sea in both CFAs 23 and 24 (Tables 17 and 18). There was a decrease in undersized adults in sub-area 23C (from 18.5% in 2001 to 3.2% in 2002) and an increase in the proportion of hard shell adolescent in sub-area 24C (from 4.4% in 2001 to 25.8% in 2002) and 24E (from 10% to 20%). The mean CW of at-sea samples in 2002 was 108.4 mm in CFA 23 and 106.8 mm in CFA 24 compared to 109.6 and 108.7 mm in 2001, respectively (Fig. 12). The majority of the catch was of CC-3 (65%) and CC-3 with moss present on the carapace (19%) in S-ENS (Fig. 8). In 2002, the 'seasonal' CPUE estimated from the sampled traps was 127.3 kg/th in CFA 23 and 105.1 kg/th in CFA 24. The average mesh-size observed was 69.6 mm in CFA 23 and 71.2 mm in CFA 24. The locations of all traps sampled in S-ENS by the at-sea observer program in 2002 are shown in Fig. 9.

Exploratory trap survey along the edge of the Scotian Shelf

Fishing locations of the trap surveys in 2001 and 2002 along the slope of the Scotian Shelf are shown in Fig. 13. Snow crab was found mainly at the shallowest depths (Figs 14 and 15). Mean number of crab by depth range was the highest at 75 m and 100 m, and decreased rapidly with depth (Fig. 16). In CFA 23, the mean number of crabs per trap was higher in the spring / summer than in the fall for both years (Fig. 16). It was the opposite in CFA 24 with the fall survey having higher mean counts than in the spring / summer of 2001 and 2002 (Fig. 16). It is worth noting that colder minimum and maximum water temperatures have been observed in the spring in CFA 23, while they were colder in the fall in CFA 24 (Fig. 17). Differences in by-catch existed between CFAs with most Northern Stone crab (n=262) caught on the slope of CFA 23 and the majority of Jonah crab (n=195) caught in CFA 24 (Fig. 18). All 47 reported lobsters in 2002 were captured on the slope of CFA 24, west of Sable Island, during both spring and fall surveys.

Overall, there were 12,675 males captured during the trap surveys in 2001 and 17,887 in 2002. However, there was more commercial crab landed in 2001 (500 t) from the slope areas than in 2002 (200 t). More male crab were sampled in 2001 (n=5,751) than 2002 (n=3,549). The average CW from the trap survey was 114.1 mm in 2001 and 112.7 mm in 2002. In CFA 23, the proportion of adolescents in the catch increased from 4% in summer 2001 to 10% in fall 2001 and 33% in spring 2002, and decreased to 8% in fall 2002 (Fig. 19). The same observations were reported in CFA 24 where the proportion of adolescents in the catch increased from 29% in summer 2001, to 33% in fall 2001 and 48% in spring 2002, and decreased to 24% in fall 2002 (Fig. 20). The actual number of adolescent sampled were the same in both years (n=1,020 in 2001, n=1,068 in 2002).

Average CW from the commercial fisheries along the slope areas were 118.9 mm in 2001 and 120.6 mm in 2002 in CFA 23, and 114.1 mm and 110.9 mm in CFA 24, respectively (Fig. 21). The proportion of adolescent crab in the catch increased from 19% in 2001 to 47% in 2002 in CFA 23 and from 26% to 48% in CFA 24, respectively.

Tagging

Southern Gulf of St. Lawrence - The recaptures data of snow crab tagged in sGSL show little movement in relation to time with a random overall orientation (Fig. 22). The tagging experiment done in CFA 19 in 1993 has a total recapture rate of 9% (49 tags out of 558 tagged crabs). The majority (74%) of the recaptures between 1994 and 1997 occurred within CFA 19, while the others were reported in surrounding CFAs (12, 12F, 18 and 21) adjacent to the CFA 19 boundary lines (Fig. 22). A 18% return rate over the years (43 out of 250 crabs) was recorded in Chaleur Bay (1999), with 44% of crabs recaptured within 10 km of the release site. All but one crab were recaptured in Chaleur Bay. No particular orientation was observed from the CFA 12 / Magdalen Island / P.E.I. (1999) experiment (Fig. 22). It had a 27% return rate over the years (77 out of 287 crabs), with 28% of crabs recaptured within 10 km of the release site. The average distance travelled each year was 20 km from the release point. Of the 24% recaptured crab (94 out of 394) from the Dumping Ground (1997), 43% were caught within 10 km of the release sites. Crab travelled south along Eastern Bradelle Valley and Western Bradelle Valley, with the average distance travelled each year increasing from 8 km in 1997 to over 50 km in 1999/2000 (Fig. 22). The 2000 CFA 19 experiment had an 26% return rate between 2000 and 2002 (192 out of 744 crabs), with 68% of crabs recaptured within 10 km of the release site. Most crabs recaptured within CFA 19 travelled southward (Fig. 22).

Eastern Nova Scotia – Longer distances were observed in ENS compared to the sGSL (Fig. 23). The 2000 CFA 20 tagging experiment had a 26% return rate over the years, with only 25% of crabs recaptured within 10 km of the release site (Fig. 23). However, this tagging experiment was done prior to the fishery and all recaptures occurred within 10 km in 2000. No recapture occurred within the tagging area in 2001 and 2002, but rather in CFAs 18, 19 and 22. The 2000 CFA 22 experiment had a low return rate of 5% (25 out of 655 crabs) and 95% of the recaptures occurred outside Glace Bay Hole (Fig. 23). Recaptures were reported westward toward and around the Cape Breton coast as far as CFA 18. The 2001 Chedabucto Bay experiment was done prior to the fishery and had a 16% return rate (109 out of 698 crabs) with no recapture within < 10 km of the release sites. The average distance travelled each year increased from 17 km in 2001 to 121 km in 2002 (Fig. 23). Similar results were found for the 2001 Bad Neighbour Shoal tagging experiment. The return rate of this pre-fishery tagging experiment was 16% (50 out of 309 crabs) with only 7% recaptured within 10 km in 2001. The average distance travelled for the following two years increase from 46 km in 2001 to 111 km in 2002. Recaptures from Bad Neighbour Shoal (2001) showed a no specific direction of movement with most tagged crab caught in CFA 23A, while the others were spread in all direction as far as CFAs 21, 22, 23B and 24E (Fig. 23). Because recapture rate depends on the fishing intensity in ENS, some experiments situated

outside heavily-exploited fishing grounds such as Sable Island (2001) and Area 24 Slope Survey (2001) showed low return rates (5%) so far.

Slopes of the Scotian Shelf - In 2001, 298 crabs were tagged on the slope of CFA 23 and 200 in CFA 24, while 248 crabs were tagged in CFA 23 in 2002 (Fig. 23). Four crabs were recaptured along the slope of CFA 23, all from the releasing sites in CFA 23, and had travelled an average of 24 km (14 - 46 km). Eight crabs in CFA 24 have been recaptured and have travelled an average distance of 15 km (4 - 59 km). One crab was reported in CFA 24 sub-area D, on the northern side of Sable Island.

Annual trawl survey

Between 1997-2001, the annual snow crab trawl survey was conducted in the spring / summer each year. In 2002, the annual survey for ENS was carried out between August 13 and September 24 for S-ENS (241 tows) and October 10 to 16 for N-ENS (59 tows), and encompassed areas of the Cabot Strait, Sydney Bight and Scotian Shelf (Fig. 24). In addition to the fall survey in N-ENS, the 59 stations were also surveyed in May and July in 2002. The different variograms used in the kriging calculations indicate that there is a covariance effect between the values sampled ranging from 10 to 90 km. There were 7,296 males and 2,852 females collected and measured in 2002 compared to 9,647 and 4,039 in 2001, respectively.

Breakdown of tows by date/area:

13/05/02 – 29/05/02 59 tows (N-ENS)
13/07/02 – 18/07/02 59 tows (N-ENS)
13/08/02 – 24/09/02 241 tows (S-ENS)
10/10/02 – 16/10/02 59 tows (N-ENS)

North-eastern Nova Scotia

The density of adolescents and adults decreased in the spring of 2002 compared to the spring of 2001 (Fig. 25). However, the density of adolescents remained similar throughout the seasonal surveys in 2002, while adults increased from spring to summer (Fig. 26). In spring 2002, the highest concentration of commercial crab was distributed within the trough in CFA 21, with high concentrations also present in the trough in CFAs 20 and 22, and on Smokey Bank (Fig. 27). A similar distribution was observed in the summer and fall, except that the highest concentration was now observed in CFA 22 inside. Adolescent males ≥76 mm CW were distributed in the near shore trough and in Glace Bay Hole in the spring, but were only observed in the near shore trough in the summer and fall (Fig. 28). The abundance of commercial size adult males has decreased from 1998-99, but has remained constant since 2000 (Fig. 29). The 2002 adolescent abundance was similar to the 2001 one with lower recruitment in comparison to earlier years (Fig. 29). In 2002, as in 2001, adult female abundance and distribution was generally low and almost exclusively comprised of multiparous females (Fig. 30).

The average CW estimated from the trawl survey in N-ENS was 111.7 mm, and has remained similar to 2001 (Fig. 31). The mean weight of commercial-sized crab caught during the 2002 survey was 606 g, an increase compared to the long-term

trend since 1998 (Fig. 32). Total biomass estimation for commercial-sized adult male in spring 2002 was 2,370 ± 986 t, and was comprised of 38 ± 53 t of soft shell and 2,332 ± 933 t of hard shell crab (Table 19). In summer 2002, total biomass for commercial-sized adult males was 4,285 ± 2,216 t, and was divided into 387 ± 735 t of soft shell and 3,898 ± 1,481 t of hard shell crab (Table 19). In fall 2002, the estimation for commercial-sized adult male was 2,820 ± 1,163 t, and was comprised of 199 ± 193 t of soft shell and 2,621 ± 970 t of hard shell crab (Table 19).

Southern ENS

The density of adolescents has increased in the fall 2002 compared to the spring of 2001 (Fig. 33). Total biomass (i.e. total surveyed area) of commercial-sized adult males was estimated at 24,454 ± 5,409 t in 2002, and was comprised of 4,141 ± 1,184 t of soft shell and 20,313 ± 4,225 t of hard shell crab (Table 20). The average CW from the trawl survey in S-ENS was 111.0 mm, which was comparable to those observed since 1999 (Fig. 31). The mean weight of commercial-sized crab caught during the 2002 survey was 592 g, which is similar to the 2001 value (Fig. 32). Commercial-sized crabs were more predominant in and around sub-area 23B, although smaller concentrations were found in all sub-areas (Fig. 34). Although less densely concentrated, adolescent male ≥76 mm CW in 2002 had a similar distribution to 2001 (Fig. 35). In the original surveyed area (23A,B and 24A,B), the abundance of commercial size adult males has been slowly decreasing since its high abundance period of 1998-2000 (Fig. 36). The adolescent abundance in the original surveyed area was similar to 2001 with lower recruitment in comparison to earlier years (Fig. 36). In 2002, as in 2001, adult female abundance was generally low and mostly distributed along the inside of Sable Island Bank and sub-areas 24E and 24C, with smaller concentrations north of Banquereau and around Misaine Banks (Fig. 30).

Temperature distribution from the trawl surveys

Regardless of the season, the coldest bottom temperatures observed (0-2°C) during the spring, summer and fall trawl surveys in N-ENS were in the near shore areas, and on Smoky and St Ann's Banks (Fig. 37). Bottom temperatures in Glace Bay Hole fishing grounds remained mostly within 1-3°C range, while fishing grounds in the inside trough varied between 0-3°C in CFA 22 inside to 3-5°C in CFA 20. Both mud and hard bottom of Sydney Bight encompassed a good temperature range for snow crab, while the Laurentian Channel had the warmest bottom temperature recorded (5-7°C). In S-ENS, colder water temperatures were recorded east of French and Middle Banks, and along the shore in sub-areas 24C and 24E (Fig. 38). The warmest temperatures were recorded in Emerald Basin, and on Middle and Sable Island Banks.

DISCUSSION

The fisheries and fishery related data

Logbook - CPUEs were at a historical high in 2002, higher than record CPUEs observed in 2001 on most fishing grounds. The catch rate for 2002 was not adjusted as mentioned in Biron et al. (2002) for the 2001 data. An increase in average soak time was observed in 2002. In N-ENS, this increase was directly caused by blockades at the beginning of the season that stopped fishermen from fishing their gear and landing crabs. CPUE was also affected by the new fishing season and VMS requirements in S-ENS, as well as the closure of previously-exploited grounds to the shrimp fishery (e.g. CFA 23C). Furthermore, misreporting of fishing effort in the logbooks was suspected in 2002. It should be pointed out that this misreporting was not necessarily intentional, and included such things as double-hauling and reporting the maximum number of traps allowed to fish rather than the actual number of traps fished, which was often less than the maximum allowed. Double-hauling artificially increased the CPUE in some areas while the reporting of the maximum number of traps allowed lowered the CPUE in other areas (e.g. reporting 30 traps when only 15 were fished). Fishermen should be reminded of the importance of logbook data as a source of information concerning their fishery. The accuracy of fishery-related data depends on the co-operation of the fishermen. It is meaningless if inaccurate. It must be made clear that the 'number of traps' column in the logbooks refers to the number of traps hauled. Double-hauling is not illegal, but should be clearly identified or accounted for in the number of traps reported. Traps that were not fished or catches that were not kept should not be counted as trap hauls, or again should be clearly identified. The catch-effort maximum likelihood method to estimate the biomass was not done in N-ENS. Contrary to what was stipulated in previous Research Documents (Biron et al., 2001; 2002), the basic assumptions (e.g. no migration) were not met, and combined with misrepresentation of effort, this method was judged inappropriate for N-ENS.

Overall, CPUE and fishing effort in ENS were well distributed among all the available fishing grounds in 2002 regardless of the fishermen's status or any specific fishing area (Fig. 39). In N-ENS, the area around St Paul Island (#1) and the one along the boundary line with CFA 19 (#2) saw little activity in 2002 (as in 2001). The reported CPUE increased on in all but four of the fishing grounds compared to 2001. Decreases were seen in CFA 20 outside (#3), Glace Bay Hole (#6) and the fishing grounds west of Middle Bank (#18) areas, while CFA 24E remained similar to 2001 (Fig. 39). The highest increase was observed in the N-ENS trough and in CFAs 23 and 24 sub-areas A and B.

At-sea Observers – Except for a few sub-areas, CPUEs estimated from at-sea observers showed a similar trend compared to the logbook CPUEs. However, at-sea observer CPUEs were not always representative of the fishery in some areas because of small sample size and timing (e.g. CFA 22 with only three trips per sub-areas, and most covered after soak time of 9 days). Furthermore, CPUEs were calculated from estimated counts of crab caught.

Catch compositions in 2002 were similar to 2001. Overall, CPUEs estimated from at-sea observer data validated logbook CPUEs. No 'warning signs' indicating immediate or potential problems for the fishery were observed in 2002. The proportion in the catch of soft shell crab (<5%), adolescent (5 to 20%), undersize crab (5 to 15%) and skip-molter (<5%) remained low. The majority of crabs in the catch (70-90%) were male adults of CC-3 (66%) and CC-3 with moss present on the carapace (18%).

Scotian Shelf slope surveys

The exploratory trap surveys in 2001 and 2002 have shown the presence of male adult and adolescent snow crab along the slope of the Scotian Shelf at depths from 50 to 400 m, but mostly from 60 to 200 m. Larger average CW and a higher proportion of older crab may have indicated a certain degree of 'accumulation' of the stock (Biron et al., 2000). The increase in the proportion of adolescents caught during the trap survey and the commercial fisheries in 2001 and 2002 may indicate a decrease in the number of available adult males rather than an increase in recruitment (i.e. similar number of adolescent between years). The available snow crab biomass for the slopes of CFAs 23 and 24 remained unknown.

Snow crab movement

There are limitations to the interpretation of tag-recapture data. For example, the fishery selects for commercial males so that smaller, tagged adults may be missed in the fishing process. It is known that recapture rates are highly correlated with fishing effort (Brêthes and Coulombe, 1989), and tag loss rates can not be calculated (Watson and Wells, 1970). Tag losses include tags dropping off, moulting crab (if adolescent tagged by mistake), mortality from tagging manipulation, natural mortality and non-reporting of tags. Releasing crabs at the surface may result in dispersion before reaching the bottom (Brêthes and Coulombe, 1989). In addition, co-ordinates are not verified with each fisherman, therefore we should not rely heavily on one single recapture.

In the sGSL, tagging results support findings from previous research that snow crab have a 'non-motile nature' in the Gulf (average annual distance travelled <15 km) (Watson, 1970; Watson and Wells, 1972; Brêthes and Coulombe, 1989) and in deeper fiords of Newfoundland such as Bonavista Bay (Taylor, 1992) and Bonne Bay (Maynard and Webber, 1987) with no clear movement pattern. The non-motile nature of snow crab was also observed in CFAs 21 and 22 inside where the majority (70-85%) of tagged crabs were recaptured within the inshore trough where they had been released (J.Tremblay, unpublished data). However, greater movement has been observed over the more dynamic habitat (i.e. bottom temperature range, bottom types, topography, currents, tides, etc.) found in most of ENS. Average distance travelled by male crab within 12 months was in the range of 15 to 160 km. These results were similar to those being observed in Alaska where average distance ranged from 10 to 170 km within one year (McBride, 1982).

Preliminary data from CFA 24 indicate that crabs dispersed throughout ENS, with most recaptures in CFA 23. Based on tagging, fishery results and trawl survey, one

must assume that crab in CFA 23 also travel towards CFA 24. More tagging is required to determine movement patterns, especially in the Misaine Bank Area of CFA 23. Immigration may be beneficial to supplement the crab fisheries of N-ENS, but no one can yet assess its contribution (if any), nor the emigration rate outside N-ENS. Crabs in some areas such as Glace Bay Hole seemed to be more active in terms of seasonal movement.

Recaptures reported to date from the slope tagging experiment indicate crabs travelled along the slope an average of 24 km (14 - 46 km) in CFA 23 and 15 km (4 - 59 km) in CFA 24. One crab out of eight recaptures from the slope of CFA 24 was reported in sub-area 24D, on the northern side of Sable Island. The stability of snow crab habitat is unknown, but it is limited to small areas with colder bottom temperatures, especially in CFA 24 which was at the limit of tolerance for this species.

Annual trawl survey

The annual trawl survey in 2002 was conducted in late summer in S-ENS and early fall in N-ENS to avoid seasonal crab movement that had been affecting the spring surveys (Biron et al., 2002). Previous research had demonstrated seasonal movement towards shallower and colder water in winter and early spring for breeding (Hooper, 1986; Brêthes and Coulombe, 1989; Comeau et al., 1998) and molting (Sainte-Marie and Hazel, 1992; Lovrich et al., 1995; Comeau et al., 1998). In ENS, near shore often means hard untrawlable bottom (Biron et al., 2000). The surface currently covered by the survey in the near shore area does not have trawl stations shallower than 60 m, and only ten stations are found between 60 to 75 m. There is no doubt that crabs were distributed outside the surveyed area (see below), but the extent of the area with cold water was less in the fall than in the spring. Therefore, it is believed that movement from warming shallow and hard bottom towards colder and deeper mud bottom during the summer/fall resulted in a better accounting of the crabs.

As in previous years, the distribution of snow crab in 2002 was similar to the distribution of cold water temperatures observed during the trawl survey, with the highest concentration of commercial crab found in the 1-3°C range. The seasonal surveys in N-ENS confirmed the presence of colder bottom temperatures in the near shore area in the spring compared to summer or fall. However, favourable water temperatures were located near shore during the three surveys, implying that some crab might still be distributed outside the trawl survey area in the fall. Lobster fishermen usually did not report snow crab by-catch in their traps after mid-May, suggesting that crabs were moving into deeper water as the water warms up near shore. Observations from tagging studies and other research activities in 2002 seem to indicate that these crabs were mostly undersize adults and/or older carapace stages (CC-4 and 5). Nevertheless, temperatures in some areas may be favourable for younger crab as well. Interestingly, the estimated abundance and composition of pre-recruits in N-ENS remained similar throughout the three seasonal surveys in 2002. In S-ENS, the estimated pre-recruit abundance in fall 2002 was comparable to the one in spring 2001.

There were other advantages to moving the annual trawl survey from spring to fall, which follow the fisheries. It cut from 14 to 7 months the delay period between the trawl survey sampling and the beginning of the fisheries to which the stock assessment is intended for. It eliminated the need of estimating fishery mortality on soft shell, white and other categories of crab, as well as illegal landings (if any), to be deducted from the forcasted biomass.

There were also disadvantages to conducting the survey in the fall. The fall survey can not be directly compared to the spring survey. For example, the greater abundance in pre-recruits (>56 mm) observed in S-ENS in 2002 does not necessarily mean an increase compared to 2001, but may simply reflect a better accounting of younger crab in the fall. By comparing the 2002 spring N-ENS trawl survey with the spring of 2001, the trends in pre-recruits were clearly still decreasing in ENS. These three surveys in N-ENS also showed more adult male crabs were found in the summer (before the fishery) and fall (after the fishery) than in the spring. Although in the summer some of the increases in adults were explained by the presence of a high concentration near the CFAs 22/23 boundary line, it does not account for all of the differences.

Biomass and abundance estimates

Changing the timing of the survey, eliminating sources of overestimation (Biron et al., 2000) and underestimation (Biron et al., 2002) has resulted in a better accounting of snow crab, and hence, in relative abundance indices (i.e. total biomass). However, although these improvements have produced better relative abundance indices, it did not account for differences in capturability amongst the different categories of snow crab to the trawl, nor for natural mortality. These relative indices should not be taken as absolute numbers.

Despite the alarming results of a series of trawl surveys showing a continuous decline in future recruitment, the stock apparently has maintained approximately the same level since 1998. However, we consider this stable commercial biomass index was due to a series of readjustments that resulted in an artificial increase of the abundance and biomass estimates. We consider that the stock decline is continuous.

In terms of accuracy of the estimates, we are confident that an active seasonal migration between offshore and inshore, and bank and gully, make an accurate abundance and biomass estimation very difficult. Hébert et al. (2003) demonstrated that a strong seasonal migration occurred between the Cape Breton corridor and the Cape Breton Trough (Area 19). During the spring period, crabs are dispersed over the corridor area, whereas during the summer period (just before fishing season) the crabs concentrated in the deeper trough area (Area 19). This type of seasonal migration may be occurring on the Scotian Shelf and the timing of the survey and the fishing season is the critical factor for an accurate abundance and biomass estimates. In addition, for the Scotian Shelf stock assessment, there is no account for trawl catchability (we are currently assuming 100% catchability) and crab mortality. Wade et al. (2003) suggested that there may be 25-35% mortality in newly molted adult crabs in the sGSL. If the trawl catchability is lower than 100%, the

current biomass estimates will be underestimated, but no account of crab mortality (except for carapace category-5) results in an overestimation. It is unknown how these factors influence our estimates and it is important to continue the survey and its analyses in a consistent manner so that year-to-year comparison can be made to follow a long-term stock trend.

Recently, reference points to assess invertebrate fisheries were discussed at a workshop (Biological Reference Point Workshop, December 3-5, 2003, Halifax, N.S.), and the importance of monitoring reproductive performance for snow crab was pointed out. Orensanz et al. (1998) stated that crab stocks offer a unique opportunity to monitor and detect signs of recruitment over-fishing and depletion directly, based on expedient and objective analysis of female clutch size variation in time and space. Wade et al. (2003) suggested that the population could be extremely sensitive to over-fishing, resulting in a long-term chained negative cryptic impact. The overexploitation regimes during the 1980s seem to have impacted the sex-ratio during the most crucial mating period in the late 1980s, resulting in a significant reduction (approximately by 40%) of subsequent female parental stock ten years later (late 1990s). This, in turn, may produce a reduced number of eggs. During a decade or more, there was no apparent negative reaction of commercially exploitable male crabs, whereas the cryptic albeit most critical portion of the stock, i.e. female spawning stock, has been silently showing a critical alert. The impact of the reduction of fecundity for the parental population on the subsequent recruitment in the late 1990s is not yet known. For the Scotian Shelf stock assessment, we found that the abundance of adult females decreased significantly through the last 2-3 years and currently their abundance has reached the lowest level ever since the trawl survey began. If the Scotian Shelf is a self-reproducing system, this reduction of the female spawning stock will result in a serious stock decline in the future.

Uncertainties

The current biomass estimates provided should not be considered as absolute because the natural mortality (e.g. predation, diseases, etc.) of commercially-exploitable crab between the time of survey and the fishing season has not been taken into account. The estimation of "biomass" was based on the assumption that the catchability of commercial-sized male crab in front of the trawl net foot rope was 100%. Until these uncertainties are assessed, the estimates are considered as relative.

The current post-season trawl survey makes comparison with the previous pre-season estimates more uncertain. In addition, the effect of change from three survey vessels in 2001 to one vessel in 2002 could not be assessed. The extensive trawl survey in 2002 covered all the major fishing grounds, but not necessarily all of the snow crab habitat.

Movement of crabs amongst CFAs is assumed to be active but was not explicitly considered in this assessment. Some areas such as Glace Bay Hole seemed to be more dynamic in their movement pattern. However, the accuracy of the trawl survey method becomes limited when dealing with small areas.

The geographic distribution of females, juveniles, adolescents and undersized adult males is different from that of commercial-sized adults. Further studies are required to improve our knowledge on the distribution of all size-classes of male and female snow crab. The categorisation of older crab (CC-5) based on the carapace condition index developed for the sGSL may not be directly applicable in ENS.

For the Scotian Shelf stock assessment, no monitoring of reproductive output has been done and the reaction of the snow crab population against the current exploitation level is unknown. We, at least, found that the abundance of adult females decreased significantly through the last 2-3 years and currently their abundance has reached the lowest level ever since the trawl survey has begun. If the Scotian Shelf is self-reproducing system, this decline of female spawning stock may result in a serious stock decline in the future.

Although some of these uncertainties may have lead to an underestimation of the snow crab population in 2002, the fact that data on carapace condition (e.g. at-sea observer, trawl survey) showed no accumulation of older crab proved that the stock was not being grossly underestimated.

CONCLUSION AND RECOMMENDATIONS

It is believed that eliminating sources of underestimation and changing the timing of the survey has resulted in better accounting of snow crab (i.e. the survey is less biased because it should be missing fewer crabs outside the trawl survey area), and hence, creating an index more representative of the snow crab abundance in ENS. However, there is no system in place to protect these fisheries if problems such as a high proportion of adolescent or soft shell and white crab arise in the catch.

Management recommendations

Fishery-related data showed generally positive signs in 2002. The trawl survey estimate gave a similar biomass for 2003 compared to that in 2002 with the new relative index. However, size frequencies from the trawl survey indicated low recruitment in 2002 and the biomass of fishable crab is expected to decline in the future. Due to uncertainties associated with the stock assessment and negative signs of recruitment, fishable biomass and reproductive potential of the Scotian Shelf snow crab population, it is strongly recommended not to increase harvesting levels in 2003.

Scotian Shelf slope surveys - The available snow crab biomass for the slopes of CFAs 23 and 24 remains unknown, and there is no scientifically justifiable data to determine a TAC for these areas. High incidences of adolescents in the catch were observed during the trap survey and commercial fisheries of 2002**.**

N-ENS –The near shore trough and immediate surrounding areas in CFAs 21 and 22 inside seem to constitute a stable habitat for snow crab. CFA 20 is relying on a small portion of the same trough for its current fishery. A change in fishing effort in any of these areas should have a direct impact on the others. The Glace Bay hole fishing ground in the outside area of CFA 22 seems to have a more dynamic snow

crab population and/or habitat. Seasonal movement and fishery timing seem to be of greater importance in this fishery.

Fishing season in S-ENS - Since 2000, landings after September 15 are due to personal choices, delays in getting started, vessels fishing multiple licences (i.e. possession of more than 2 licences), or again following mechanical or health problems, and not because of lack of commercial crab. The length of the fishing season in S-ENS is not reasonable from a biological point of view because it is running too late and increases the likelihood of problems with white crab and mortality (Biron et al., 2002). It may be especially important to protect soft and white crab, or any adolescent during low recruitment periods. In S-ENS, one way to reduce the manipulation of these crabs would be to shorten the fishing season to 10-15 weeks. And if the trawl survey is to remain after the fishery, which it should, then the fishing season should end before August 31st.

Soft and White crab protection – Protocols to control the capture of soft or white crab, comparable to those applied in the sGSL are required in order to minimise the mortality of these crabs and to protect future recruitment to the fishery. This is especially important if the current fishing effort is to be maintained. Furthermore, it should be clear that DFO-Science does not have the proper tools or guidelines to react if the capture of soft or white crab was to become problematic in ENS in the future. From experience, the more sophisticated the protocol, the more time, at-sea sampling and/or enforcement will be required to make it work.

Outlook for 2003 – Estimates of fishable biomass index for the 2003 fishery are 2,800 t for N-ENS (2,820 t –13 t of category-5) and 24,350 t for S-ENS (24,454 t –92 t of category-5). Based on the survey size frequency information, the decline is greater in pre-recruit sizes, which suggests the decline in adult crab will accelerate in future years. Future surveys will provide information on the strength of these incoming year classes, but the prognosis for the coming years is not promising.

<u>Research recommendations</u>

-Tagging of adult males in the Misaine Bank area must be a priority in 2003. Movement in ENS will not be understood without including these colder and densely populated grounds. It is speculated based on landings and trawl survey results, that crab move from Misaine towards the inside grounds of CFAs 23 and 24.

-The small increase in primiparous females observed in sub-areas 24E/C may provide an opportunity to start tagging a large number of females in ENS. Information on the movement of this important segment of the snow crab population is scarce and may be useful in understanding the distribution pattern for this species. Sources for the recapture of females are unknown.

-A extensive study concerning the distribution of snow crab outside the surveyed area (i.e. near shore, banks) should be conducted in 2003, preferably at the same time as the trawl survey. It is paramount to determine the size and age composition of the crab residing outside the surveyed area.

-A partial trawl survey should be conducted on the slope of the Scotian Shelf to determine the relative abundance of snow crab in these areas.

Acknowledgement

We thank Dr. Bernard Sainte-Marie (DFO Laurentian Region, Montjoli, QC) for his valuable information on the North Shore, Quebec, snow crab stocks. We thank Dr. Ken Drinkwater (DFO Maritimes Region, Halifax, N.S.) for the information we needed for the completion of this document. We also thank Dr. David Orr (DFO NFLD, St. John's, Nfld) and Mr. Michel Comeau (DFO Gulf Region, Moncton, N.B.), and Drs John Tremblay and Peter Koeller (DFO Maritimes Region, Halifax, N.S.) for the critical review of this report.

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Table 1. Summary of the Management Plan measures for the 2002 snow crab fisheries in eastern Nova Scotia.

Area	Season	Permanent licenses	Traps allowed	Total quota permanent licenses (kg)	Temporary licenses	Traps allowed	Total quota temporary licenses (kg)
20	July 20- Sept. 15	5	30	102,000	6	30	75,000
21	July 20- Sept. 15	32	25	545,000	-	-	-
22	*Inside group:*[1] July 20- Sept. 15	**22**	30	477,000	-	-	-
	Outside group:[1] July 20- Sept. 15	15	30	294,000	-	-	-
23	*All sub-areas:* *Sub-area 23D* May 27 – Oct. 31 *All other sub-areas* June 1st – Oct. 31	37	45	2,738,150	38	45	2,038,000
	Exploratory slope: May 27 – Nov. 30	-	-	-	2	45	100,000
24	*All sub-areas:* *Sub-area 24D* June 1st – Oct. 31 *All other sub-areas* July 1st – Oct. 31	34	40	2,482,300	40	40	1,564,000
	Exploratory slope: May 27 – Nov. 30	-	-	-	2	40	100,000

[1] Both groups have agreed not to fish on Sundays.

Table 2. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 20, 1978 - 2002.

Year	Active licenses	TAC (t)	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	-	61	-	-
1979	8	-	80	8.2	9.8
1980	8	-	34	8.3	4.1
1981	6	-	2	-	-
1982	-	-	2	-	-
1983	12	-	23	1.7	13.5
1984	2	-	10	-	-
1985	1	-	1	-	-
1986	2	-	0	1.9	-
1987	3	-	1	-	-
1988	4	-	17	7.9	2.2
1989	5	-	8	-	-
1990	4	-	5	5.3	0.9
1991	4	-	14	16.3	0.9
1992	3	-	18	40.6	0.4
1993	4	-	20	17.3	1.2
1994	5	-	29	20.2	1.4
1995	5	-	44	19.8	2.2
1996	5	45	43	14.7	2.9
1997	5	45	45	20.2	2.3
1998	5	45	45	35.5	1.3
1999	9	91	90	32.3	2.8
2000	10	118	118	46.7	2.5
2001	11	118	117	64.8	1.8
2002	11	177	175	69.2	2.6
average (all)		-	40.1	22.8	3.1
average (98-02)		109.8	109.0	49.7	2.2

Table 3. Weekly landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 20, in 2002.

a) Weekly landings statistics

Week	landings (kg)		
	all	inside	outside
July 21+	42,127	37,215	4,912
July 28	56,949	45,567	11,382
Aug. 04	28,029	14,081	13,948
Aug. 11	22,851	2,661	20,190
Aug. 18	26,637	19,633	7,004
Total*	174,624*	119,157	57,436

* Total seasonal landings from statistic; DFO.

+ Landings from July 20 are included.

b) Weekly catch rate statistics

Week	CPUE (kg/trap haul)		
	all	inside	outside
July 21	90.3	142.0	24.8
July 28	77.9	105.0	38.3
Aug. 04	60.8	110.0	41.9
Aug. 11	44.3	34.3	41.1
Aug. 18	71.1	119.6	34.2
Total	69.2	117.7	37.7

c) Weekly effort statistics

Week	Effort (total number of trap hauls)		
	all	inside	outside
July 21	466	262	198
July 28	731	434	297
Aug. 04	461	128	333
Aug. 11	515	78	491
Aug. 18	375	164	205
Total	2,553	1,012	1,524

Table 4. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 21, 1978-2002.

Year	Active licenses	TAC (t)	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	16	-	247	11.3	21.9
1979	27	-	243	10.7	22.7
1980	31	-	153	9.7	15.8
1981	22	-	34	13.6	2.5
1982	20	-	94	7.9	11.9
1983	27	-	48	5.1	9.4
1984	19	-	18	2.9	6.2
1985	10	-	10	3.5	2.9
1986	12	-	7	2.5	2.8
1987	21	-	56	6.4	8.8
1988	24	-	125	9.6	13.0
1989	30	-	154	13.7	11.2
1990	31	-	167	13.1	12.7
1991	29	-	157	14.9	10.5
1992	31	-	196	16.7	11.7
1993	30	-	168	14.2	11.8
1994	31	-	107	7.2	14.9
1995	32	-	100	8.3	12.0
1996	32	145	136	9.7	13.9
1997	32	145	146	35.7	4.1
1998	32	218	216	53.0	4.1
1999	32	290	291	62.1	4.7
2000	32	363	364	62.1	5.9
2001	32	363	363	93.4	3.9
2002	32	545	547	95.6	5.7
average (all)		-	165.9	23.3	9.8
average (98-02)		355.8	356.2	73.2	4.9

Table 5. Weekly landings, catch rate (CPUE) and effort statistics for snow crab, Crab Fishing Area 21, 2002.

Week	Landings (kg)	CPUE (kg/trap haul)	Effort (total number of trap hauls)
July 21	251,713	110.7	2,274
July 28	244,746	68.0	2,780
Aug. 04	37,139	77.8	477
Aug. 11	5,019	66.9	75
Aug. 18	3,356	67.1	50
Aug. 25	268	67.0	4
Total*	542,241*	95.6	5,670

* Total seasonal landings from statistic; DFO.

Table 6. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 22, 1978 - 2002.

Year	Active licenses	TAC (t)	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	15	-	341	28.9	11.8
1979	35	-	684	38.4	17.8
1980	26	-	227	21.0	10.8
1981	11	-	50	12.5	4.0
1982	21	-	153	19.6	7.8
1983	26	-	52	8.5	6.1
1984	7	-	18	8.6	2.1
1985	8	-	3	6.0	0.5
1986	5	-	18	10.0	1.8
1987	16	-	63	10.5	6.0
1988	29	-	114	10.4	11.0
1989	26	-	93	15.0	6.2
1990	26	-	119	9.0	13.2
1991	24	-	183	18.5	9.9
1992	27	-	240	24.2	9.9
1993	40	-	390	21.0	18.6
1994	38	-	259	12.0	21.6
1995	37	-	284	9.7	29.3
1996	37	350	189	10.3	18.3
1997	37	350	343	20.8	16.5
1998	37	397	396	38.2	10.4
1999	37	519	518	58.5	8.9
2000	37	534	535	82.3	6.5
2001	37	585	586	105.1	5.6
2002	37	771	773	119.5	6.5
average (all)		-	265.2	28.7	10.4
average (98-02)		561.2	561.6	80.7	7.6

Table 7. Weekly landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 22, in 2002.

a) Weekly landings statistics

Week	Landings (kg)		
	all	inside area	outside area
July 21+	228,956	155,123	77,171
July 28	426,650	233,993	189,319
Aug. 04	114,294	87,154	27,140
Aug. 11	1,474	-	1,474
Total*	773,595*	478,448*	295,147*

* Total seasonal landings from statistic; DFO.
\+ Landings from July 20 are included.

b) Weekly catch rate statistics

Week	CPUE (kg/trap haul)		
	all	inside area	outside area
July 21	148.5	140.0	176.2
July 28	114.7	109.8	121.3
Aug. 04	96.4	97.1	94.3
Aug. 11	98.3	-	98.3
Total	119.5	115.7	126.5

c) Weekly effort statistics

Week	Effort (total number of trap hauls)		
	all	inside area	outside area
July 21	1,542	1,108	438
July 28	3,719	2,131	1,561
Aug. 04	1,186	897	288
Aug. 11	15	-	15
Total	6,452	4,115	2,334

Table 8. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in north-eastern Nova Scotia (Crab Fishing Areas 20, 21 and 22), 1997-2002.

Year	Active licenses/permits	TAC (t)	Landing Statistics (t)	Total mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1997	74	540	534	23.3	22.9
1998	74	660	657	41.6	15.8
1999	78	900	899	54.8	16.4
2000	79	1,015	1,017	68.3	14.9
2001	80	1,065	1,066	94.1	11.3
2002	80	1,493	1,492	100.9	14.8
Average (98-02)		1,027	1,026	71.9	14.6

Table 9. Seasonal catch composition, in percentage, from at-sea samples for north-eastern Nova Scotia (Crab Fishing Areas 20, 21 and 22) in 2002.

a) Catch composition in CFA 20 (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
9	30	< 95 mm		7.7		0.0		7.7	8.5
		> 95 mm	0.7	87.2	0.1	0.1	0.8	87.3	91.5
		total	4.2	95.0	0.0	0.1	4.2	95.1	100.0
			4.8		0.1		4.9		

b) Catch composition in CFA 21 (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
16	32	< 95 mm		13.4		0.1		13.5	15.4
		> 95 mm	1.9	79.5	0.1	0.1	1.9	79.6	84.6
		total	4.9	92.9	0.1	0.2	5.0	93.1	100.0
			6.7		0.2		6.9		

c) Catch composition in CFA 22 (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
6	18	< 95 mm		13.4		0.3		13.6	17.0
		> 95 mm	3.1	73.7	0.3	2.4	3.4	76.1	83.0
		total	5.9	87.0	0.9	2.7	6.9	89.7	100.0
			9.0		1.2		10.3		

d) Catch composition in CFA 22 inside (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
4	9	< 95 mm		13.3		0.0		13.3	15.6
		> 95 mm	2.3	74.2	0.0	2.8	2.3	76.0	84.4
		total	6.6	87.5	0.8	2.8	7.4	90.3	100.0
			8.9		0.8		9.7		

e) Catch composition in CFA 22 outside (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
2	9	< 95 mm		12.9		0.6		13.5	18.1
		> 95 mm	4.0	72.4	0.6	3.2	4.6	75.6	81.9
		total	5.2	85.3	1.1	3.8	6.3	89.1	100.0
			9.2		1.7		10.9		

Table 10. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 23, 1978 - 2002.

Year	Active licenses/permits	TAC (t)	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	-	347	51.5	6.7
1979	-	-	608	43.4	14.0
1980	-	-	343	39.0	8.8
1981	-	-	82	26.5	3.1
1982	-	-	253	28.8	8.8
1983	-	-	119	16.5	7.2
1984	-	-	41	18.6	2.2
1985	5	-	28	14.7	1.9
1986	6	-	49	14.4	3.4
1987	14	-	157	26.2	6.0
1988	21	-	207	24.9	8.3
1989	25	-	243	28.3	8.6
1990	27	-	386	36.4	10.6
1991	23	-	528	44.8	11.8
1992	22	-	595	49.6	12.0
1993	26	-	770	53.1	14.5
1994	22	-	497	33.4	14.9
1995	31	-	576	51.8	11.1
1996	27	592	564	65.6	8.6
1997	30	593	592	57.8	10.2
1998	34	848	813	77.0	10.6
1999	-	1,300	1,300	87.3	14.9
2000	79	4,425	4,401	85.0	51.8
2001	85	4,789	4,805	82.6	59.0
2002	75	4,776	4,672	118.6	39.8
average (all)		-	919	47.0	14.0
average (98-02)		3,228	3,198	90.1	35.2

Table 11. Weekly landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 23, in 2002.

week	Landings (kg)					CPUE (kg/trap haul)					Effort (total number of trap hauls)				
	all	a	b	c	d	all	a	b	c	d	all	a	b	c	d
June 02	203,881	118,291	12,950	-	81,293	116.1	141.8	117.7	-	92.7	1,756	834	110	-	877
June 09	386,832	260,050	8,475	11,426	98,228	113.5	139.9	116.1	71.4	76.6	3,407	1,858	73	160	1,283
June 16	394,297	295,738	15,001	21,792	66,678	119.9	145.4	111.1	109.5	68.1	3,289	2,034	135	199	980
June 23	261,764	162,497	20,158	17,914	56,283	133.5	167.6	149.3	100.6	88.8	1,961	970	135	178	634
June 30	536,559	336,975	57,064	50,399	92,212	123.8	147.9	148.2	119.7	73.2	4,332	2,279	385	421	1,258
July 07	454,420	327,624	45,774	20,096	60,926	122.1	140.7	165.0	85.7	67.2	3,721	2,328	277	234	906
July 14	413,246	253,529	77,182	10,601	71,934	106.4	130.9	137.8	117.8	57.2	3,884	1,937	560	90	1,257
July 21	437,639	238,933	124,651	5,407	68,648	126.5	147.1	148.4	120.2	76.2	3,458	1,624	840	45	901
July 28	361,874	193,172	91,774	11,789	65,139	114.4	139.7	118.9	131.0	72.4	3,164	1,383	772	90	900
Aug. 04	198,865	97,198	70,628	-	31,039	118.4	145.1	121.2	-	73.6	1,679	670	583	-	422
Aug. 11	318,939	105,898	127,934	5,585	79,522	109.3	145.7	123.6	69.8	72.3	2,919	727	1,035	80	1,100
Aug. 18	233,736	112,026	68,107	6,911	46,692	122.4	138.1	136.2	83.3	87.2	1,910	811	500	83	535
Aug. 25	131,794	36,429	60,152	8,894	26,319	126.2	162.3	130.2	128.9	91.7	1,045	224	462	69	287
Sept. 01	72,126	15,231	39,250	7,969	9,676	132.1	145.1	150.1	139.8	82.7	546	105	261	57	117
Sept. 08	58,990	12,308	14,574	5,161	26,947	114.1	115.0	205.3	125.9	90.4	517	107	71	41	298
Sept. 15	103,399	10,767	36,891	8,138	47,603	105.2	174.4	135.2	111.5	82.5	982	62	273	73	577
Sept. 22	143,378	43,228	59,186	21,616	19,348	126.9	152.5	131.7	120.1	92.8	1,130	283	450	180	209
Sept. 29	7,621	-	7,621	-	-	159.5	-	159.5	-	-	48	-	48	-	-
Total	4,672,252*	2,619,894	937,372	213,698	948,396	118.6	143.6	134.8	107.7	75.7	39,776	18,243	6,955	1,985	12,535

* Total landings from statistic, DFO.

Table 12. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 24, 1978 - 2002.

Year	Active licenses/permits	TAC (t)	Landing statistics	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	-	-	-	-
1979	4	-	61	14.8	4.1
1980	10	-	70	12.8	5.5
1981	5	-	21	15.8	1.3
1982	7	-	62	10.1	6.1
1983	13	-	64	8.4	7.6
1984	13	-	52	9.2	5.6
1985	6	-	35	10.2	3.4
1986	7	-	49	11.9	4.1
1987	11	-	84	12.9	6.5
1988	13	-	163	15.7	10.4
1989	18	-	201	17.2	11.7
1990	19	-	543	33.3	16.3
1991	21	-	682	40.1	17.0
1992	22	-	743	38.5	19.3
1993	21	-	662	33.3	19.9
1994	21	-	682	33.4	20.4
1995	31	-	550	34.4	16.0
1996	27	569	560	57.1	9.8
1997	29	570	565	45.2	12.5
1998	33	823	745	62.0	12.0
1999	-	1,400	1,400	60.6	23.1
2000	79	4,374	4,300	84.9	50.6
2001	82	4,061	4,043	96.2	44.1
2002	74	4,046	4,019	101.6	39.8
average (all)		-	848	35.8	15.3
average (98-02)		2,941	2,901	81.1	33.9

Table 13. Weekly landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 24, in 2002.

Week	Landings (kg)						CPUE (kg/trap haul)						Effort (total number of trap hauls)					
	all	a	b	c	d	e	all	a	b	c	d	e	all	a	b	c	d	e
June 02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
June 09	42,136	-	-	-	34,766	-	120.7	-	-	-	129.2	-	349	-	-	-	269	-
June 16	50,429	-	-	-	32,495	-	104.2	-	-	-	99.4	-	487	-	-	-	327	-
June 23	37,746	-	-	-	40,240	-	132.4	-	-	-	132.4	-	285	-	-	-	304	-
June 30	518,213	212,744	110,906	19,919	84,789	81,744	111.5	128.5	140.7	87.0	106.5	74.1	4,649	1,656	788	229	796	1,104
July 07	716,612	214,781	217,306	48,979	130,560	104,986	104.8	132.5	144.2	86.4	96.0	59.0	6,837	1,621	1,507	567	1,360	1,778
July 14	576,535	213,390	169,531	31,351	131,169	66,192	99.2	134.1	133.6	78.8	79.6	51.7	5,812	1,592	1,269	398	1,648	1,279
July 21	451,110	188,433	70,888	4,669	93,073	58,949	94.2	128.6	133.6	122.1	70.8	52.6	4,789	1,465	531	38	1,314	1,120
July 28	437,018	204,005	71,944	11,598	104,216	45,255	92.1	118.2	132.7	96.7	77.0	48.1	4,744	1,726	542	120	1,354	941
Aug. 04	218,603	124,284	56,117	3,654	27,382	7,166	110.6	147.0	140.3	121.8	66.3	28.2	1,977	845	400	30	413	254
Aug. 11	371,444	160,611	91,847	14,846	91,995	12,145	102.9	127.0	123.1	123.7	81.6	38.3	3,608	1,264	746	120	1,127	317
Aug. 18	239,067	92,446	49,124	40,026	39,048	18,423	97.7	122.7	129.3	103.3	83.3	44.6	2,446	753	380	388	469	413
Aug. 25	135,608	44,103	24,217	20,192	35,977	11,119	87.3	111.9	159.3	80.2	92.5	41.5	1,553	394	152	252	389	268
Sept. 01	73,444	22,645	15,690	1,288	27,964	5,857	103.5	134.8	?	?	118.2	45.1	710	168	?	?	237	130
Sept. 08	34,852	18,802	-	-	11,982	4,068	107.2	159.3	-	-	94.3	50.9	325	118	-	-	127	80
Sept. 15	76,948	35,069	12,311	-	24,512	5,056	114.3	133.7	183.7	-	110.2	49.1	673	262	67	-	222	103
Sept. 22	65,487	15,309	9,447	-	37,281	3,450	117.3	81.0	157.5	-	129.5	60.5	558	189	60	-	288	57
Sept. 29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oct. 06	1,587	-	-	-	-	1,587	40.2	-	-	-	-	40.2	39	-	-	-	-	39
Total	4,019,127*	1,546,622	899,328	196,522	947,449	425,997	101.6	128.7	136.9	91.4	88.7	54.2	39,848	12,015	9,447	2,151	10,681	7,866

* Total landings from statistic, DFO.

Table 14. Total allowable catch (TAC), active licenses, landings, catch rate (CPUE) and effort statistics for snow crab in south-eastern Nova Scotia (Crab Fishing Areas 23 and 24), 1997-2002.

Year	Active licenses/permits	TAC (t)	Landing Statistics (t)	Total mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1997	59	1,163	1,157	50.9	22.7
1998	67	1,671	1,558	68.9	22.6
1999	-	2,700	2,700	71.1	38.0
2000	158	8,799	8,701	85.0	102.4
2001	163	8,823	8,912	88.5	102.9
2002	149	8,822	8,767	110.1	79.6
Average (98-02)		6,163	6,168	84.7	69.1

Table 15. Weekly landings, catch rate (CPUE) and effort statistics for snow crab in Crab Fishing Area 23, sub-area D, in 2002.

CFA 23 sub-area 23D												
week	Landings (kg)				CPUE (kg/trap haul)				Effort (total number of trap hauls)			
	all	artimon	gully	slope	all	artimon	gully	slope	all	artimon	gully	slope
June 02	81,293	42,223	39,060	-	92.7	93.9	91.5	-	877	450	427	-
June 09	98,228	55,157	43,071	-	76.6	70.2	89.1	-	1,283	786	483	-
June 16	66,678	35,203	31,475	-	98.1	66.8	69.9	-	980	527	450	-
June 23	56,283	21,021	35,262	-	88.8	86.3	90.5	-	634	244	390	-
June 30	92,121	38,745	53,376	-	73.2	53.7	107.1	-	1,258	721	498	-
July 07	85,046	23,033	37,893	24,120	76.5	52.4	81.8	111.7	1,111	440	463	216
July 14	79,302	40,202	31,732	7,368	61.0	80.0	70.7	163.7	1,301	804	449	45
July 21	76,577	24,022	44,626	7,929	73.8	77.5	75.4	58.7	1,038	310	592	135
July 28	71,343	25,682	39,457	6,204	69.3	71.5	73.1	48.5	1,030	359	540	128
Aug. 04	33,970	10,287	20,752	2,931	67.5	87.9	68.0	36.2	503	117	305	81
Aug. 11	90,603	29,753	49,769	11,081	74.4	65.0	77.8	92.3	1,218	457	640	120
Aug. 18	72,704	8,788	37,904	26,012	106.4	97.6	84.7	161.6	683	90	447	161
Aug. 25	26,319	10,595	15,724	-	91.7	89.0	93.6	-	287	119	168	-
Sept. 01	9,676	7,972	1,704	-	82.7	108.9	41.6	-	117	76	41	-
Sept. 08	26,947	21,534	5,413	-	90.4	103.5	60.1	-	298	208	90	-
Sept. 15	47,603	32,101	15,502	-	82.5	90.8	70.8	-	577	354	219	-
Sept. 22	19,348	14,316	5,032	-	92.8	129.7	55.9	-	209	110	90	-
Total	1,034,041	440,644	507,752	85,645	77.1	71.2	80.4	96.7	13,406	6,189	6,317	886

Table 16. Weekly landings, catch rate (CPUE) and effort statistics for Snow Crab in Crab Fishing Area 24, sub-area D, in 2002.

CFA 24 sub-area 24D										
week	Landings (kg)				CPUE (kg/trap haul)				Effort (total number of trap hauls)	
	all	sable	slope		all	sable	slope		all	sable	slope
June 02	-	-	-		-	-	-		-	-	-
June 09	19,550	34,766	229		135.8	129.2	9.5		144	269	24
June 16	31,359	32,495	22,255		117.4	99.4	111.3		267	327	200
June 23	44,216	40,240	8,545		128.4	132.4	106.8		344	304	80
June 30	94,822	84,789	15,431		119.1	106.5	192.9		796	796	80
July 07	95,436	130,560	5,303		85.8	96.0	27.3		1,113	1,360	194
July 14	136,366	131,169	3,232		88.3	79.6	42.5		1,544	1,648	76
July 21	80,243	93,073	5,019		62.1	70.8	46.0		1,292	1,314	109
July 28	98,924	104,216	3,955		74.5	77.0	33.0		1,328	1,354	120
Aug. 04	31,534	27,382	3,430		73.0	66.3	45.1		432	413	76
Aug. 11	80,766	91,995	3,841		76.8	81.6	98.5		1,052	1,127	39
Aug. 18	28,473	39,048	3,152		70.5	83.3	80.8		404	469	39
Aug. 25	29,421	35,977	5,184		75.8	92.5	132.9		388	389	39
Sept. 01	28,794	27,964	6,026		124.9	118.2	154.5		231	237	39
Sept. 08	14,308	11,982	6,800		89.4	94.3	87.2		160	127	78
Sept. 15	28,361	24,512	-		116.2	110.2	-		244	222	-
Sept. 22	31,984	37,281	242		119.7	129.5	6.2		267	288	39
Total	1,040,718	947,449	93,637		87.4	88.7	76.0		11,912	10,681	1,232

Table 17. Seasonal catch composition, in percentage, from at-sea samples for Crab Fishing Area 23 in 2002.

a) Catch composition in CFA 23, all sub-areas (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
81	537	< 95 mm		6.2		0.2		6.4	9.6
		> 95 mm	2.6	75.0	0.6	2.1	3.2	77.2	90.4
		total	11.7	81.2	1.5	2.3	13.2	83.6	100.0
			14.3		2.2		16.4		

b) Catch composition in CFA 23, sub-area A (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
42	214	< 95 mm		8.7		0.2		8.9	13.0
		> 95 mm	3.4	74.0	0.7	1.2	4.1	75.2	87.0
		total	10.5	82.7	1.3	1.4	11.8	84.1	100.0
			13.9		2.1		15.9		

c) Catch composition in CFA 23, sub-area B (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
15	86	< 95 mm		6.5		0.5		7.0	13.5
		> 95 mm	4.6	60.7	1.9	7.2	6.5	67.9	86.5
		total	14.4	67.2	4.1	7.8	18.6	74.9	100.0
			19.1		6.0		25.1		

d) Catch composition in CFA 23, sub-area C (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
3	42	< 95 mm		2.3		0.1		2.5	3.2
		> 95 mm	0.8	87.6	0.0	0.9	0.8	88.5	96.8
		total	8.0	89.9	0.4	1.0	8.3	90.9	100.0
			8.7		0.4		9.1		

e) Catch composition in CFA 23, sub-area D (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
18	169	< 95 mm		4.0		0.0		4.1	5.3
		> 95 mm	1.2	82.2	0.1	1.3	1.3	83.5	94.7
		total	10.6	86.2	0.6	1.3	11.2	87.5	100.0
			11.7		0.7		12.5		

Table 18. Seasonal catch composition, in percentage, from at-sea samples for Crab Fishing Area 24 in 2002.

a) Catch composition in CFA 24, all sub-areas (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
69	532	< 95 mm		10.2		0.1		10.3	15.7
		> 95 mm	4.9	65.7	0.5	2.3	5.4	67.9	84.3
		total	15.2	75.9	1.2	2.4	16.4	78.3	100.0
			20.1		1.6		21.7		

b) Catch composition in CFA 24, sub-area A (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
23	138	< 95 mm		11.6		0.1		11.7	16.2
		> 95 mm	4.1	67.1	0.4	4.6	4.5	71.7	83.8
		total	10.7	78.6	1.5	4.7	12.1	83.4	100.0
			14.8		1.8		16.6		

c) Catch composition in CFA 24, sub-area B (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
13	102	< 95 mm		4.6		0.2		4.6	8.2
		> 95 mm	3.4	74.8	0.1	0.0	3.6	75.0	91.8
		total	16.5	79.4	0.3	0.2	16.8	79.6	100.0
			19.9		0.4		20.4		

d) Catch composition in CFA 24, sub-area C (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
5	25	< 95 mm		8.9		0.1		9.0	20.5
		> 95 mm	11.5	65.1	0.0	0.1	11.5	65.2	79.5
		total	14.3	74.0	0.0	0.2	14.3	74.2	100.0
			25.8		0.0		25.8		

e) Catch composition in CFA 24, sub-area D (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
14	156	< 95 mm		6.4		0.2		6.5	10.9
		> 95 mm	3.6	63.8	0.8	2.7	4.4	66.5	89.1
		total	20.4	70.2	2.1	2.9	22.5	73.1	100.0
			24.0		2.9		26.9		

f) Catch composition in CFA 24, sub-area E (%).

Coverage		Size	Hard shel1 crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescen t	adult	adolescen t	adult	adolescen t	adult	
14	111	< 95 mm		19.6		0.2		19.8	27.9
		> 95 mm	7.5	58.0	0.5	1.1	8.1	59.1	72.1
		total	12.5	77.6	0.5	1.3	13.0	78.9	100.0
			20.0		1.1		21.1		

Table 19. Biomass estimates (t) of adult male snow crab ≥95mm CW in north-eastern Nova Scotia in 2002.

	Spring	Summer	Fall
Soft-shelled	38 ± 53	387 ± 735	199 ± 193
Hard-shelled	2,332 ± 933	3,898 ± 1,481	2,621 ± 970
Total	2,370 ± 986	4,285 ± 2,216	2,820 ± 1,163

Table 20. Biomass estimates (t) of adult male snow crab ≥95 mm CW in south-eastern Nova Scotia in 2002.

	Soft-shelled	Hard-shelled	Total
2000	8,422 ± 3,744	25,954 ± 7,450	34,376 ± 11,194
2001	8,541 ± 3,500	24,597 ± 2,964	33,139 ± 6,464
2002	4,141 ± 1,184	20,313 ± 4,225	24,454 ± 5,409

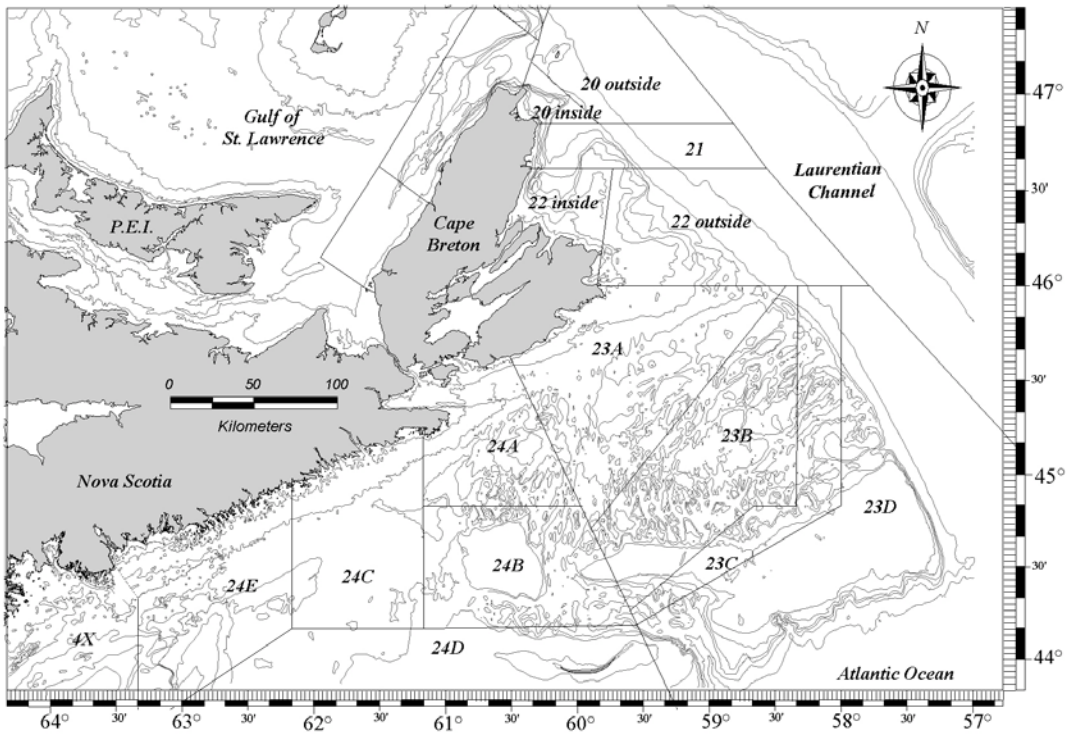


Figure 1a. Snow crab management sub-areas off eastern Nova Scotia.

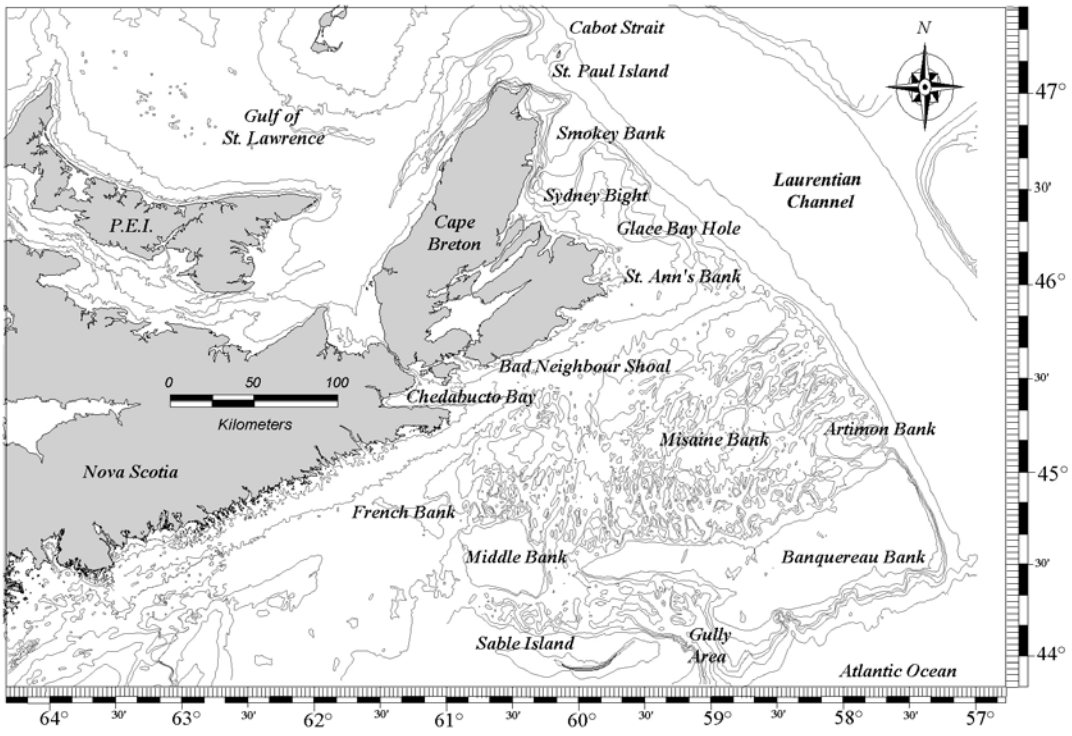


Figure 1b. Areas referred to in this document.

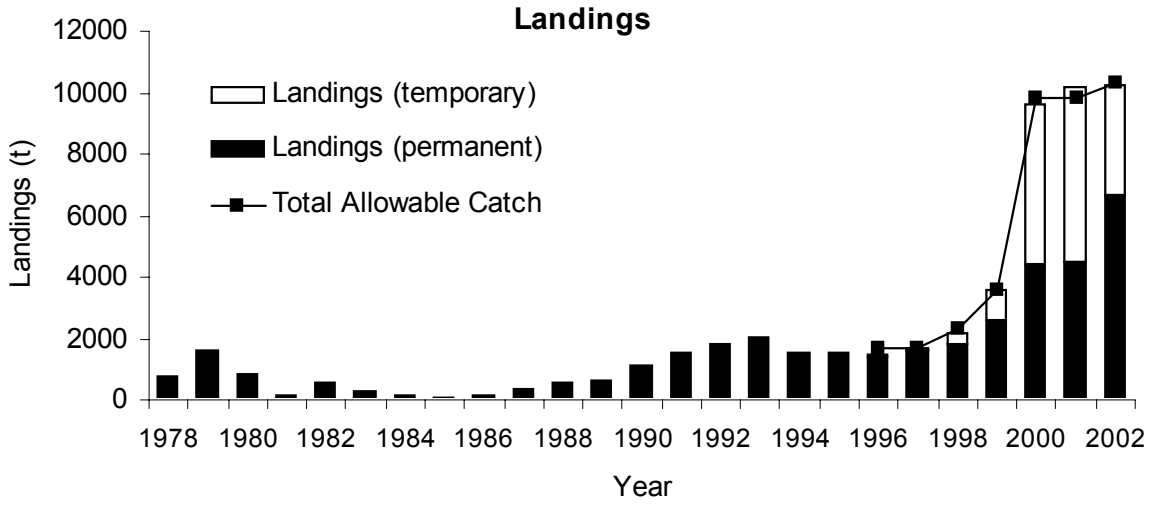


Figure 2. Snow crab landings (t) in eastern Nova Scotia from 1978 to 2002.

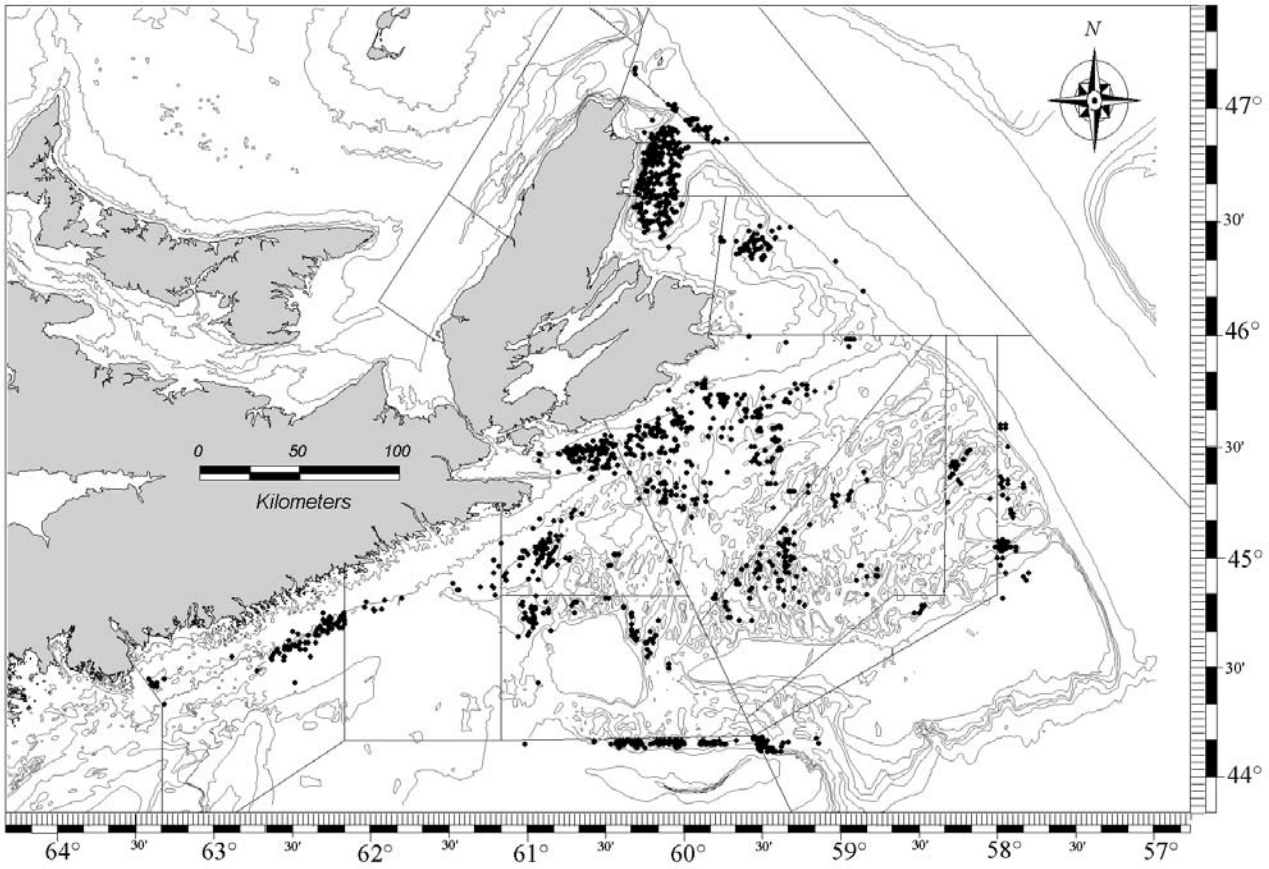


Figure 3. Reported logbook positions in eastern Nova Scotia in 2002.

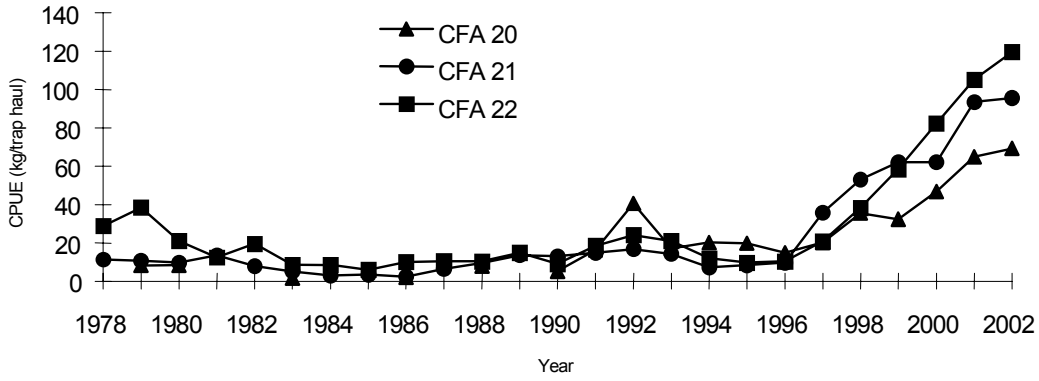


Figure 4. Catch per unit effort (CPUE) for Crab Fishing Areas (CFAs) 20, 21 and 22 from 1978 to 2002.

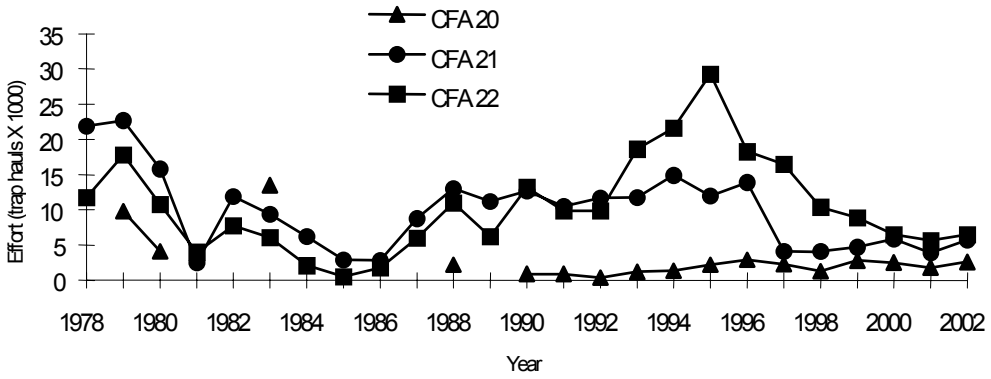


Figure 5. Fishing effort for Crab Fishing Areas (CFAs) 20, 21 and 22 from 1978 to 2002.

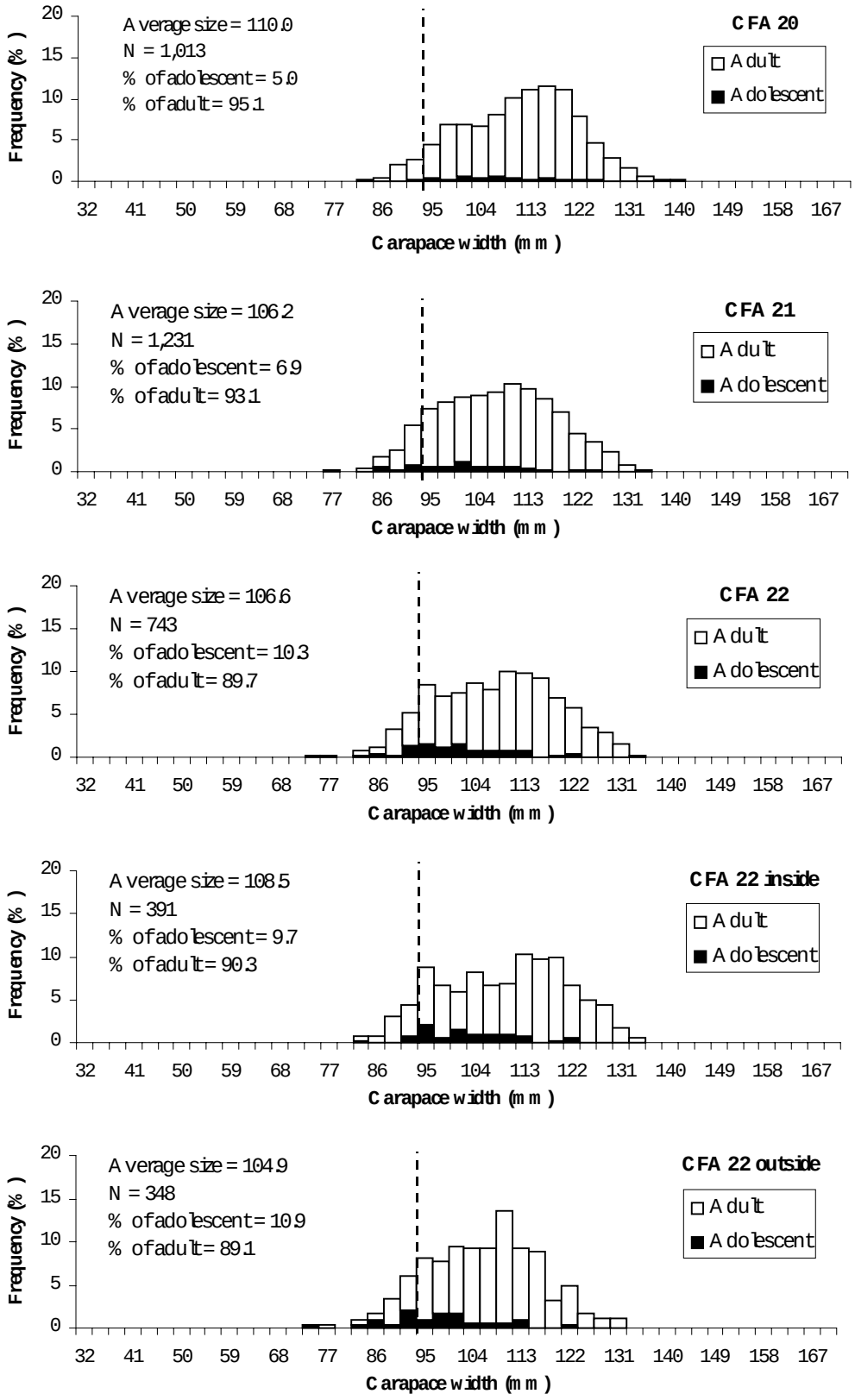


Figure 6. Size frequency distribution from sea sampling in north-eastern Nova Scotia (Crab Fishing Areas 20 to 22) in 2002.

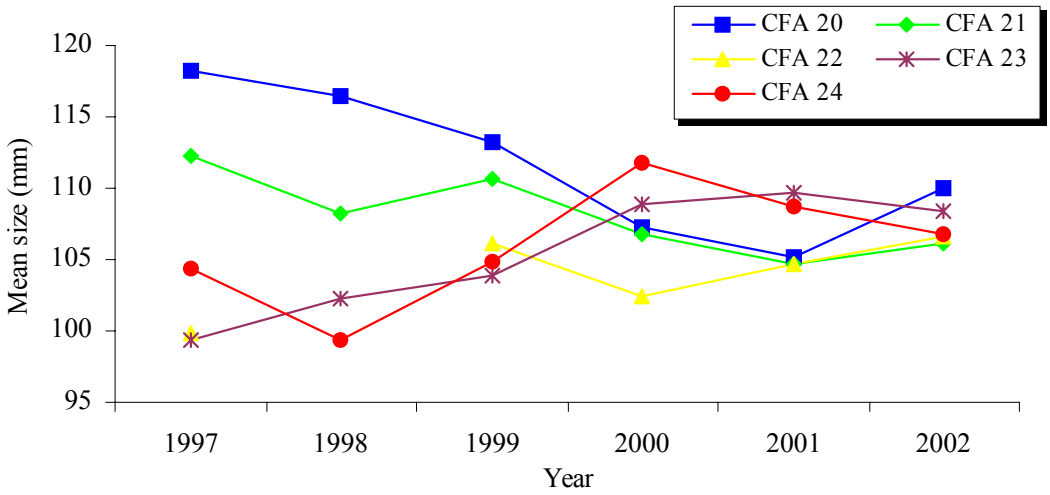


Figure 7. Mean size of commercial size snow crabs from at-sea sampling for eastern Nova Scotia (Crab Fishing Areas 20 to 24).

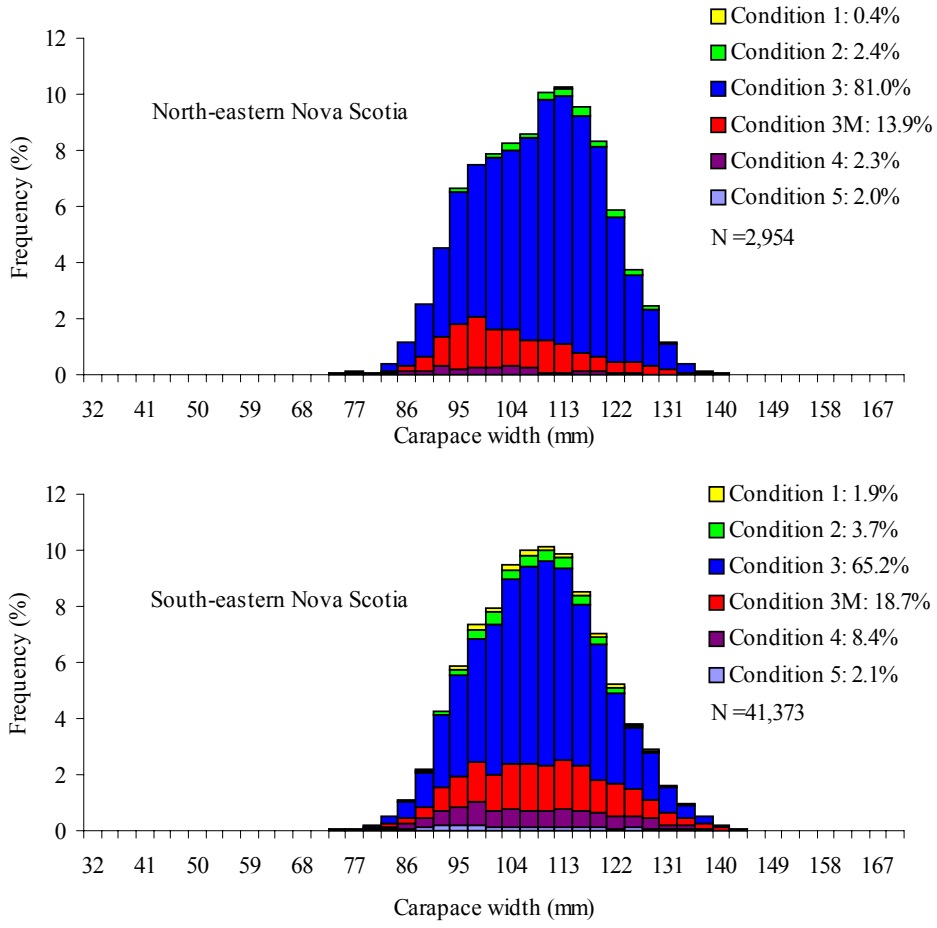


Figure 8. The 2002 catch composition from sea sampling, in north-eastern Nova Scotia and south-eastern Nova Scotia.

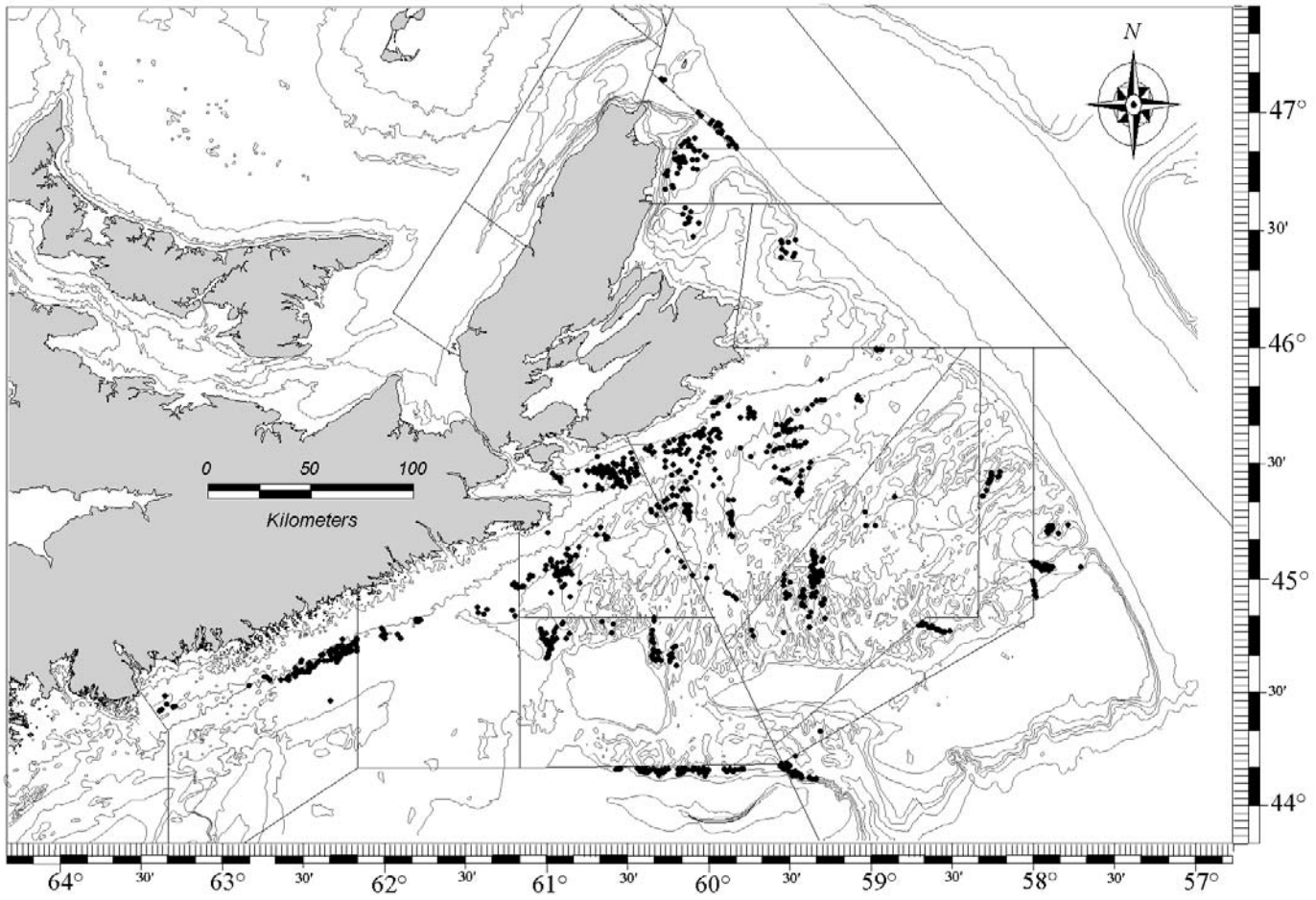


Figure 9. Reported observer positions in eastern Nova Scotia in 2002.

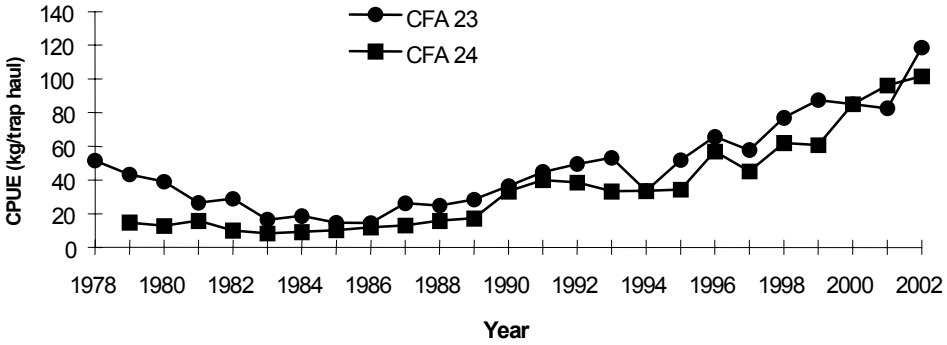


Figure 10. Catch per unit of effort (CPUE) for Crab Fishing Areas (CFAs) 23 and 24 from 1978 to 2002.

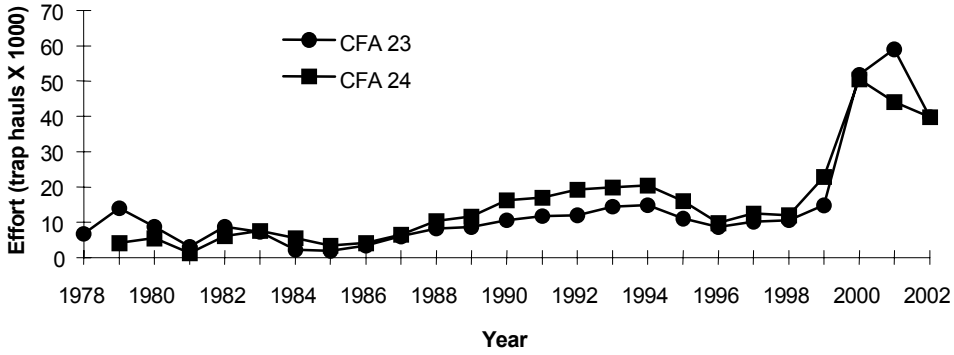
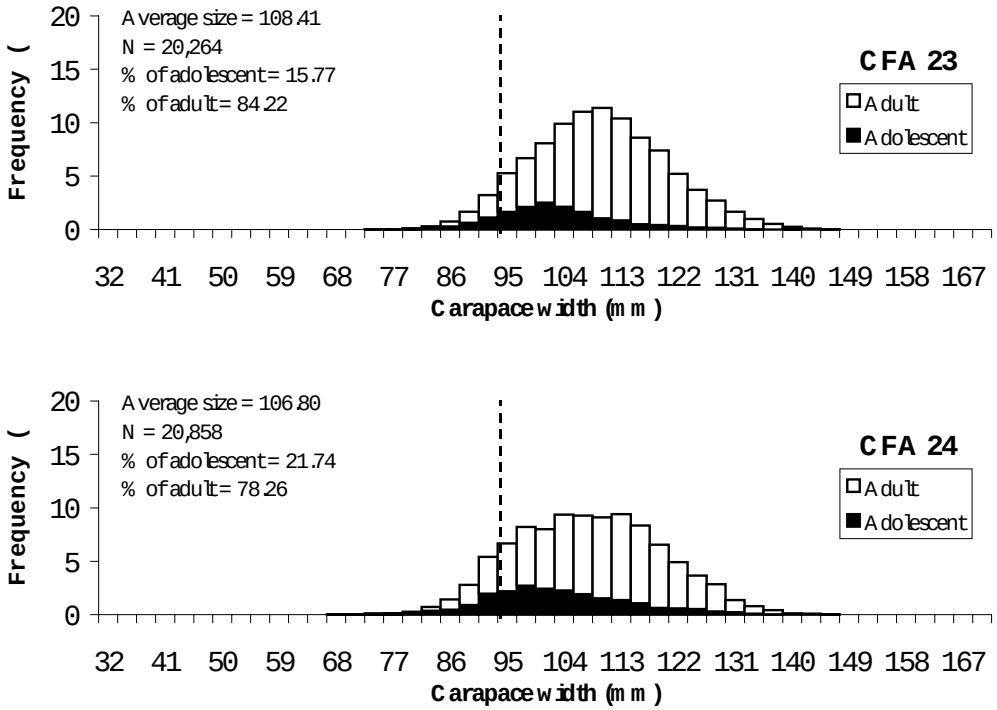


Figure 11. Fishing effort for Crab Fishing Areas (CFAs) 23 and 24 from 1978 to 2002.



Firgure 12. Size frequency distribution from sea sampling in south-eastern Nova Scotia (Crab Fishing Areas 23 and 24) in 2002.

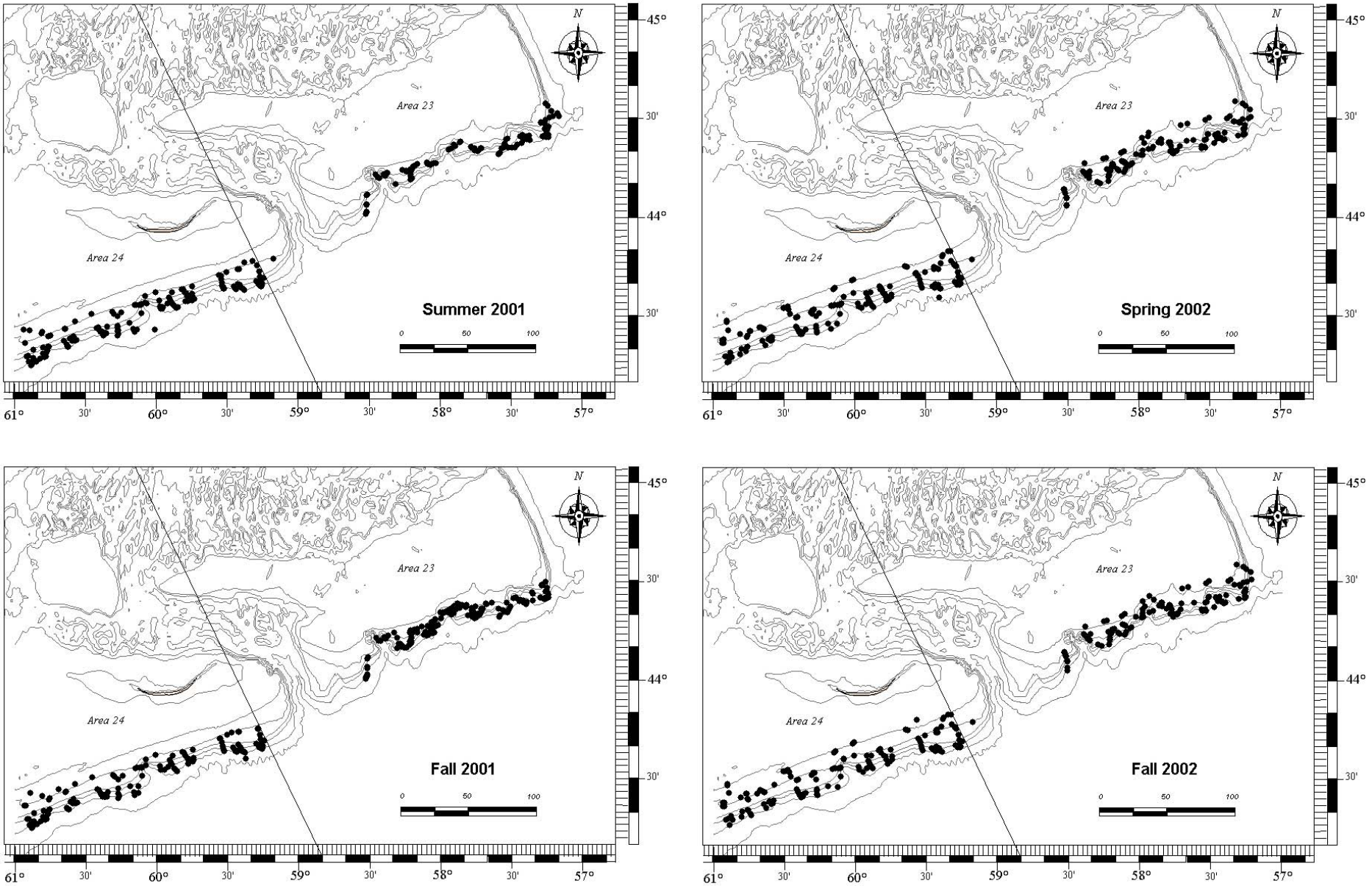


Figure 13. Reported trap positions of snow crab slope survey in 2001-2002.

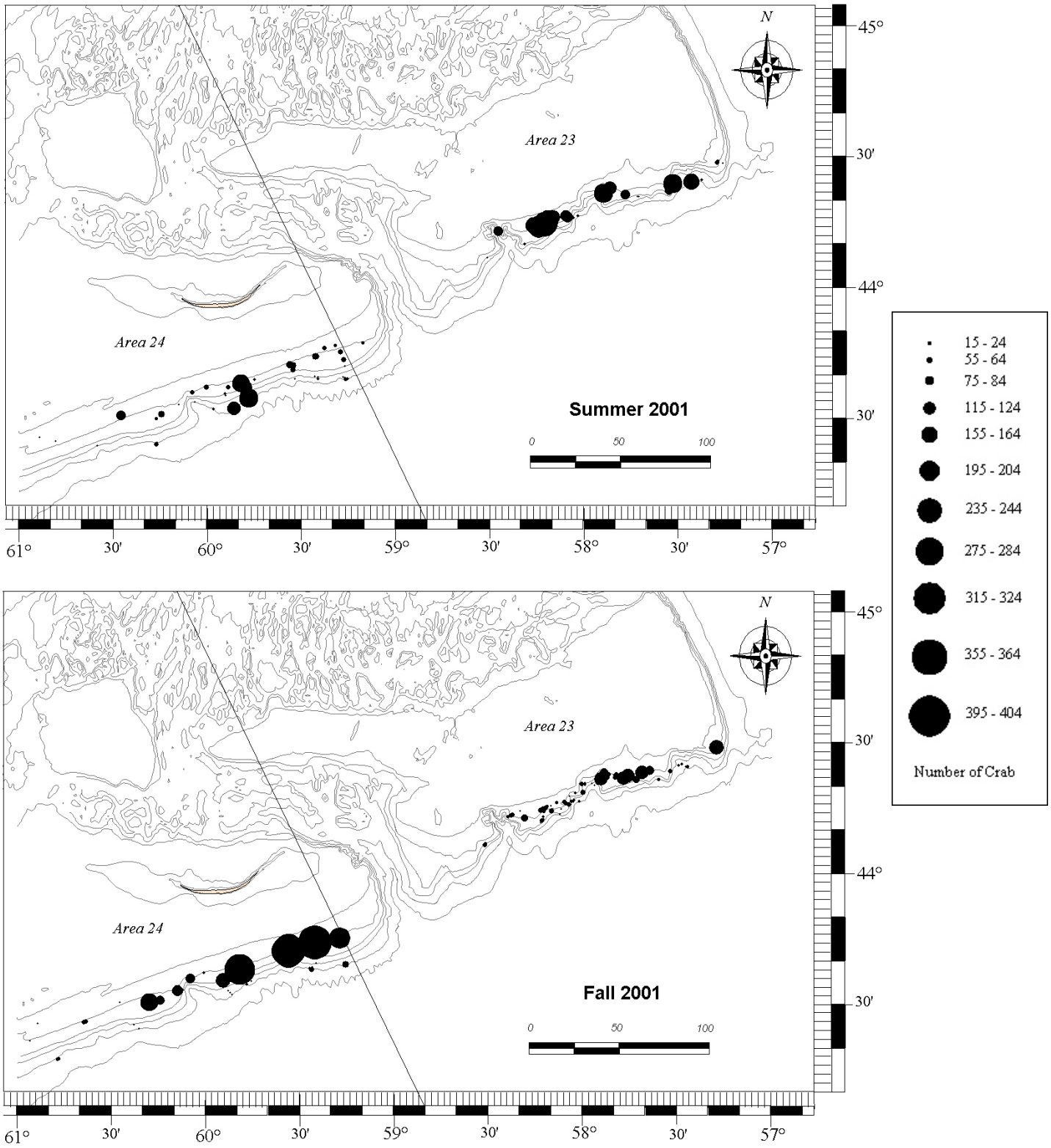


Figure 14. Snow crab counts per trap observed during the snow crab slope survey in 2001.

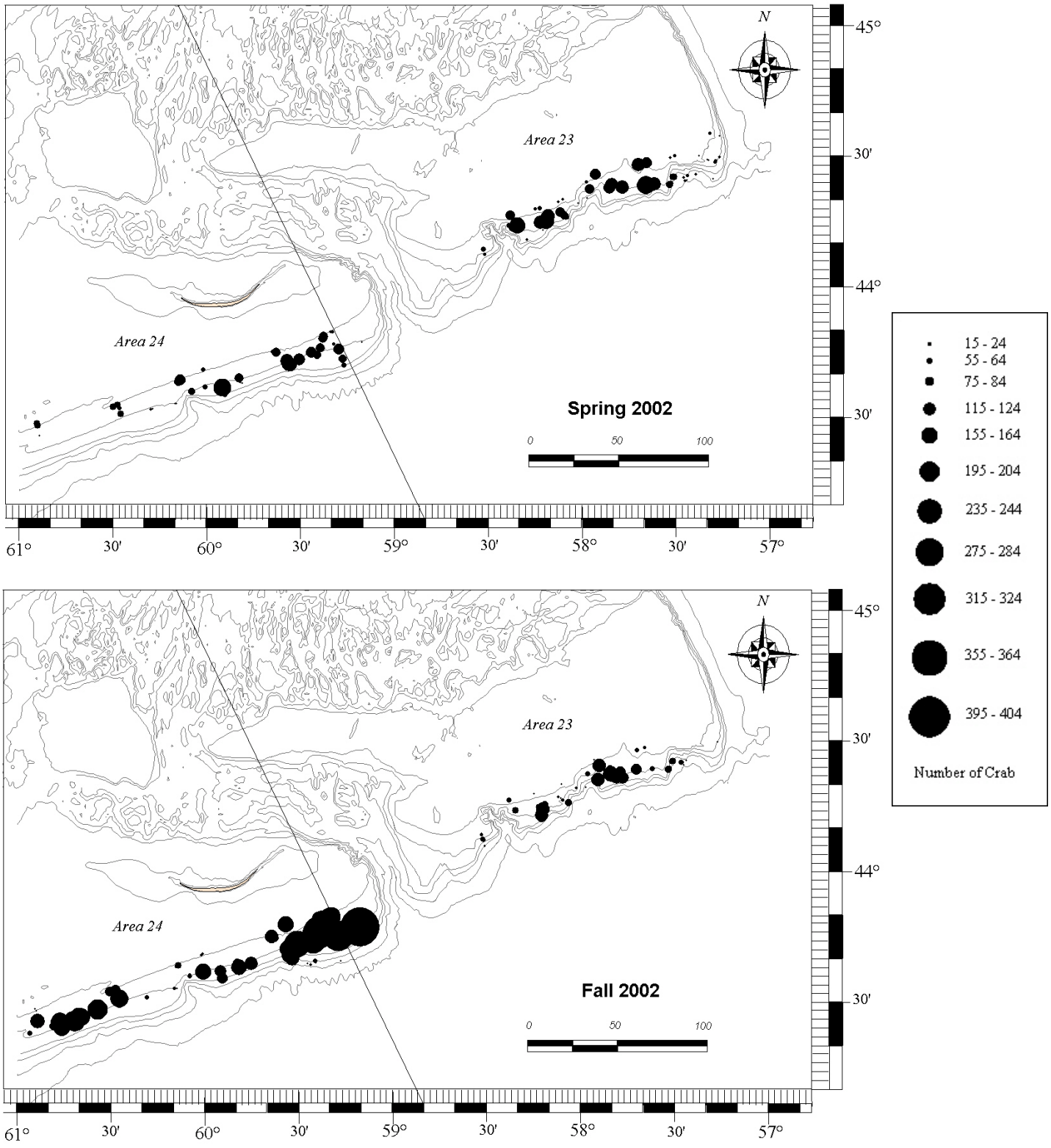


Figure 15. Snow crab counts per trap observed during the snow crab slope survey in 2002.

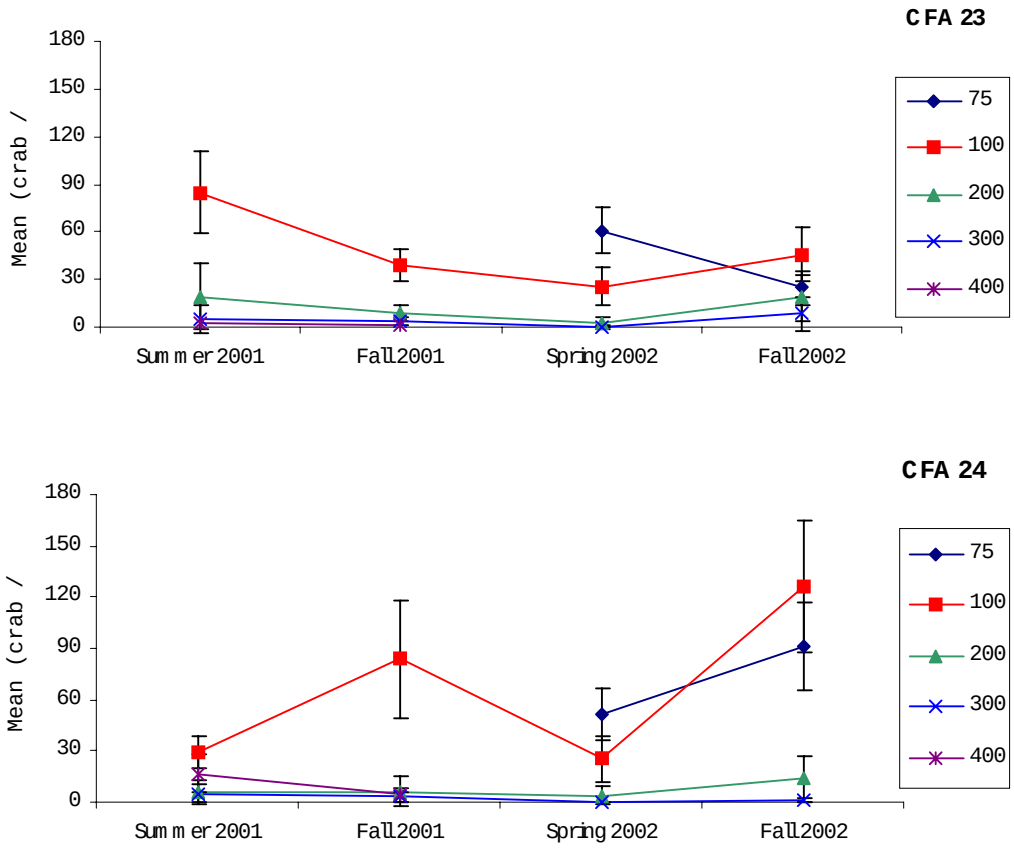


Figure 16. Seasonal mean number of crabs per trap by depth (m) for the snow crab slope survey in Crab Fishing Areas (CFAs) 23 and 24 in 2001-2002.

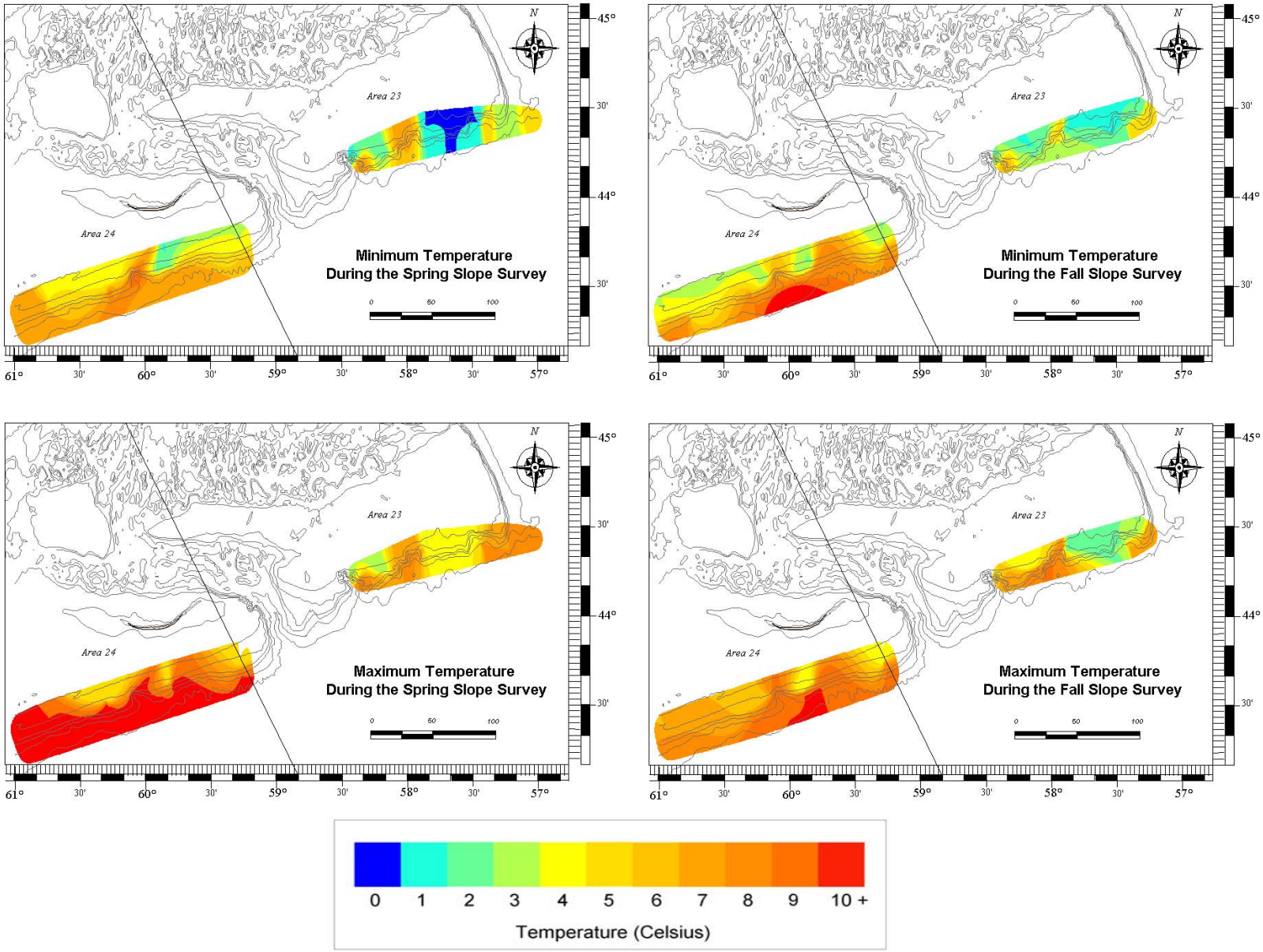


Figure 17. Temperature data observed during the snow crab slope survey in 2002.

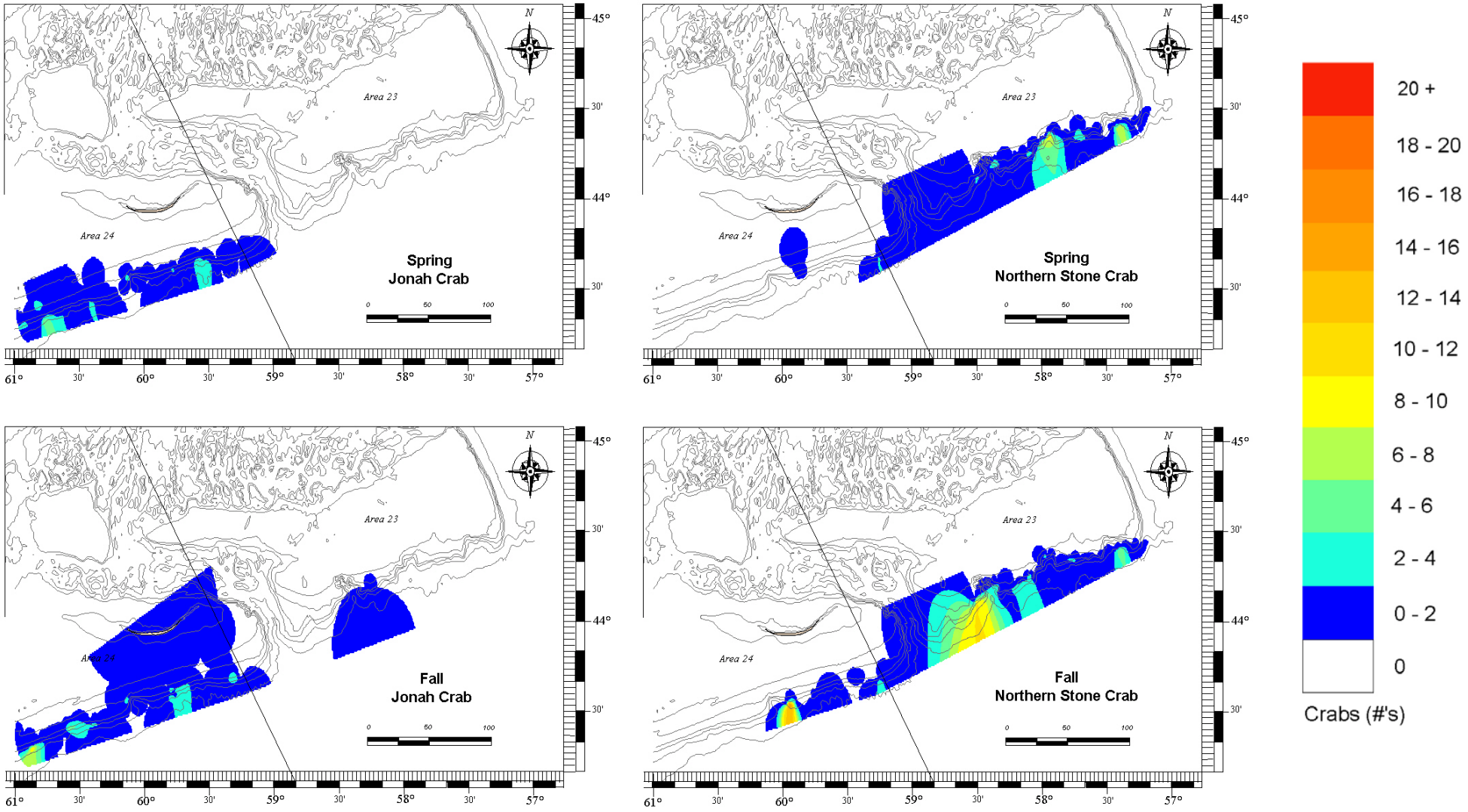


Figure 18. Jonah and northern stone crab counts observed during the snow crab slope survey in 2002.

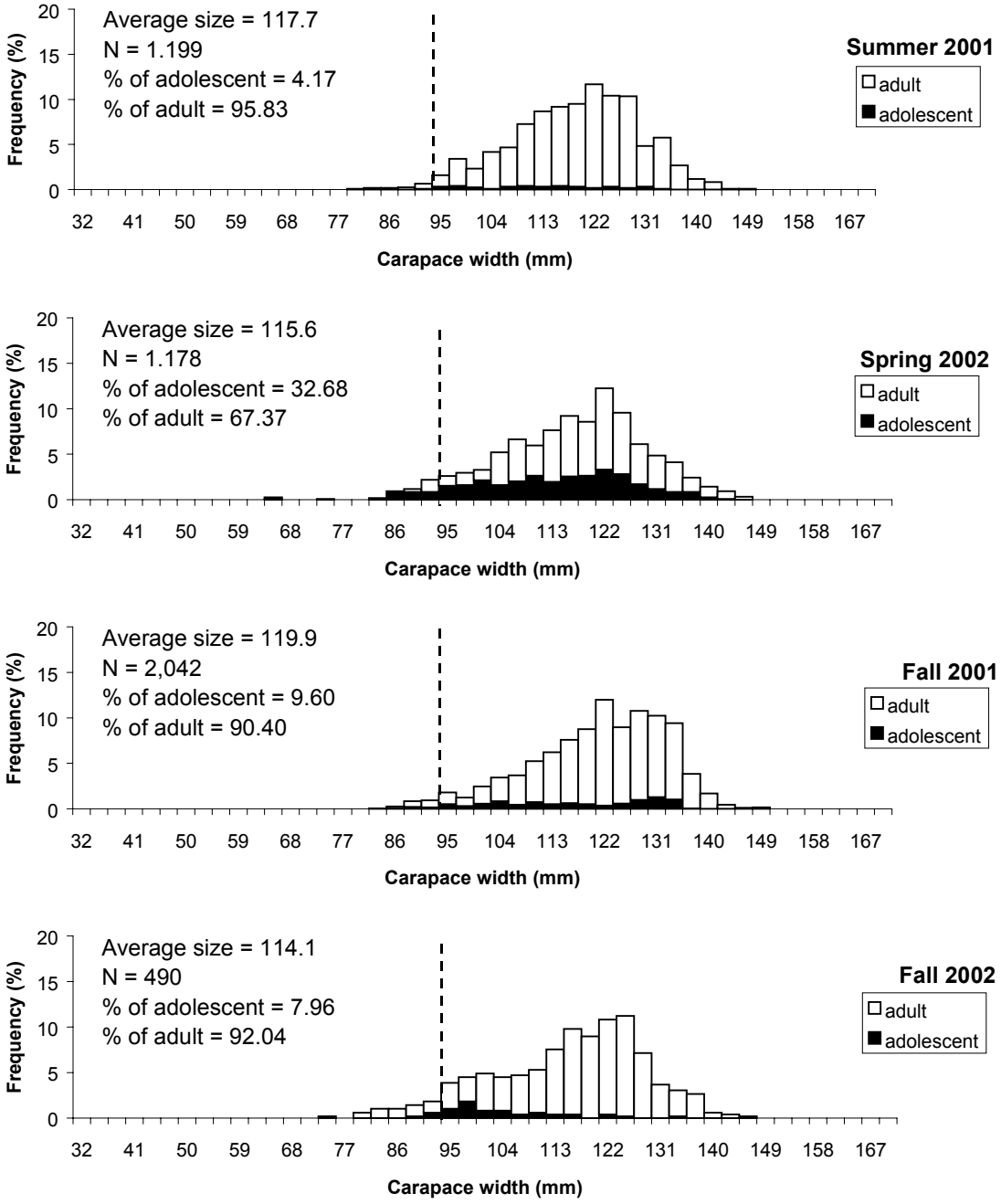


Figure 19. Size frequency distribution from the exploratory trap survey on the slope of Crab Fishing Area 23.

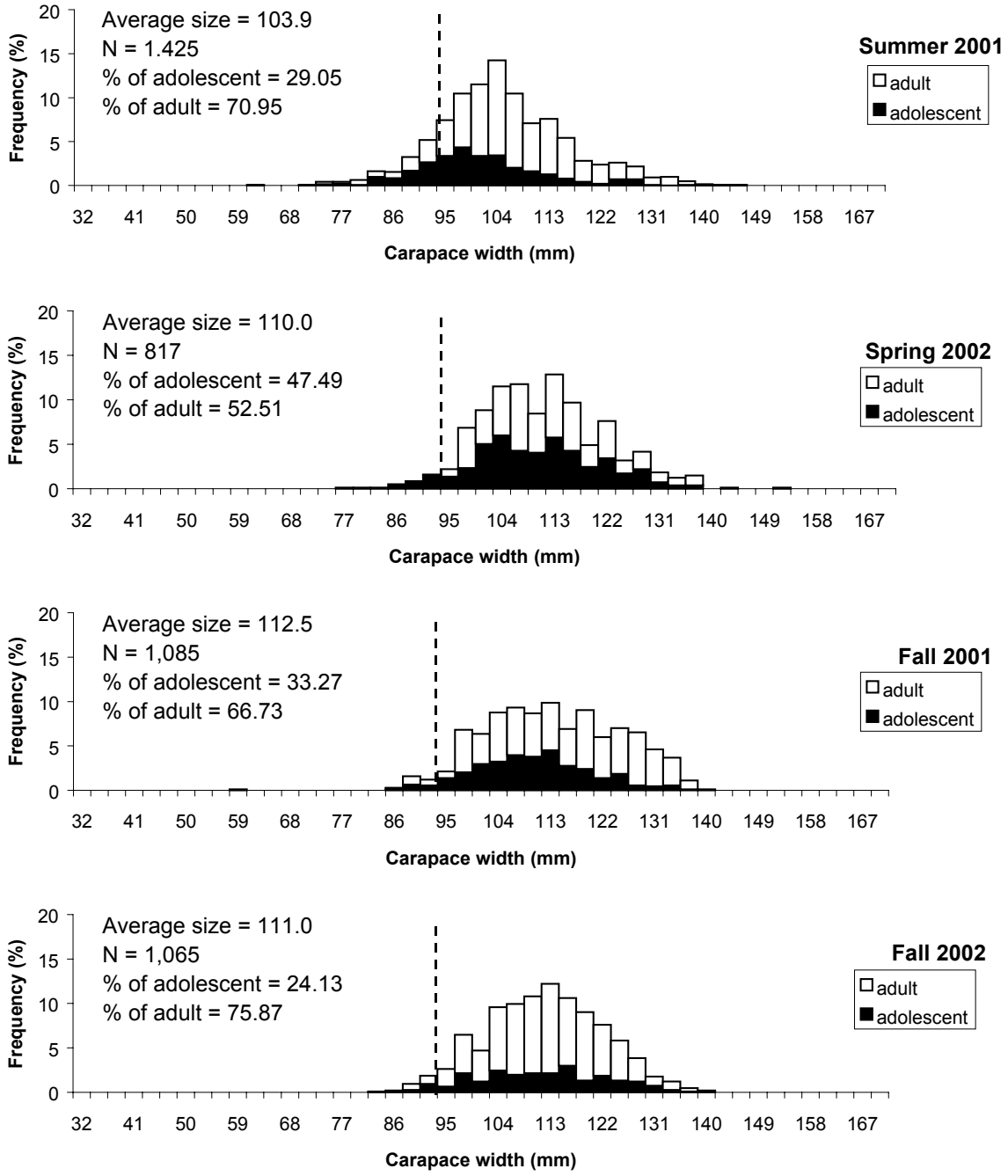


Figure 20. Size frequency distribution from the exploratory trap survey on the slope of Crab Fishing Area 24.

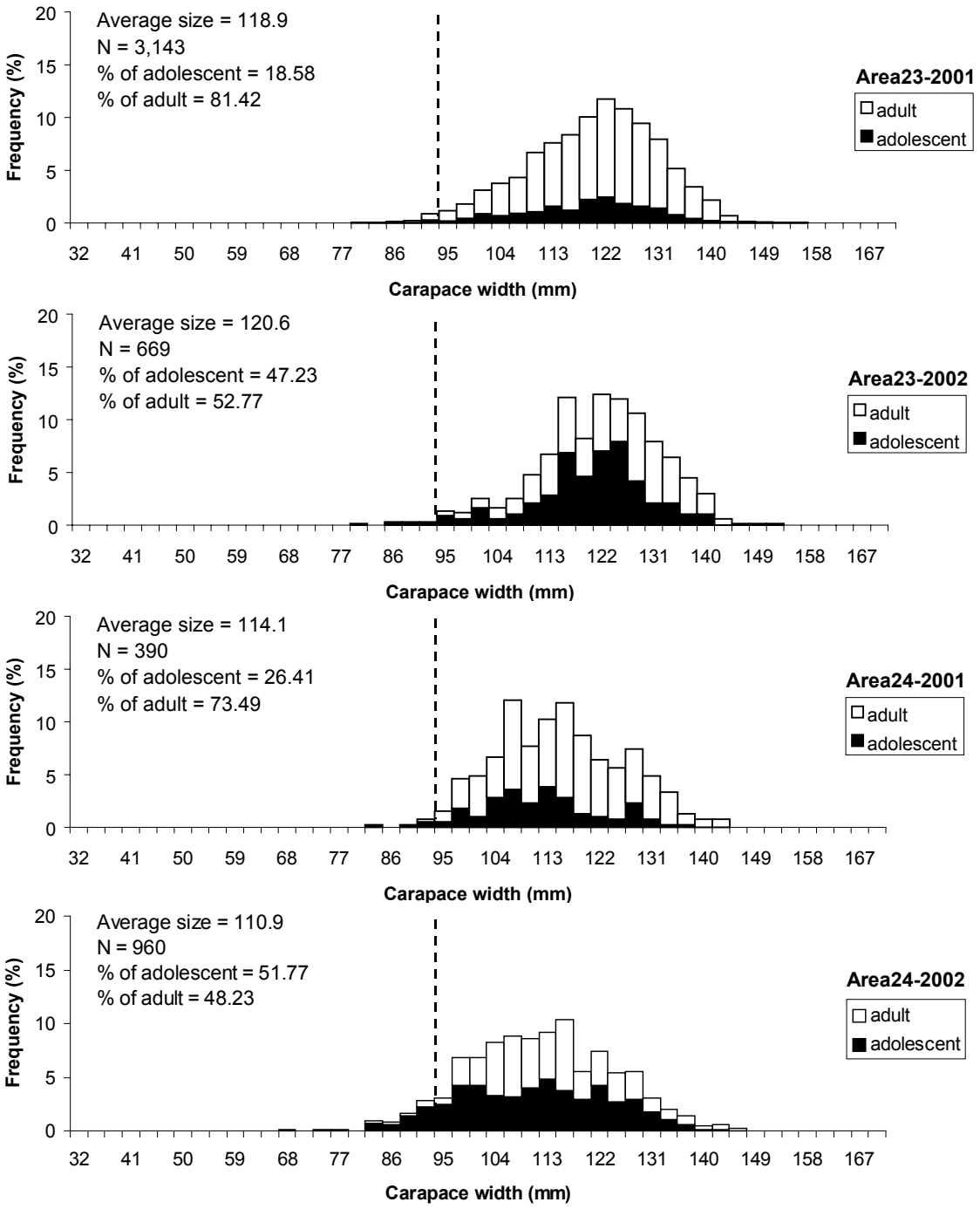


Figure 21. Size frequency distribution from commercial fisheries on the slope of Crab Fishing Area's 23 and 24.

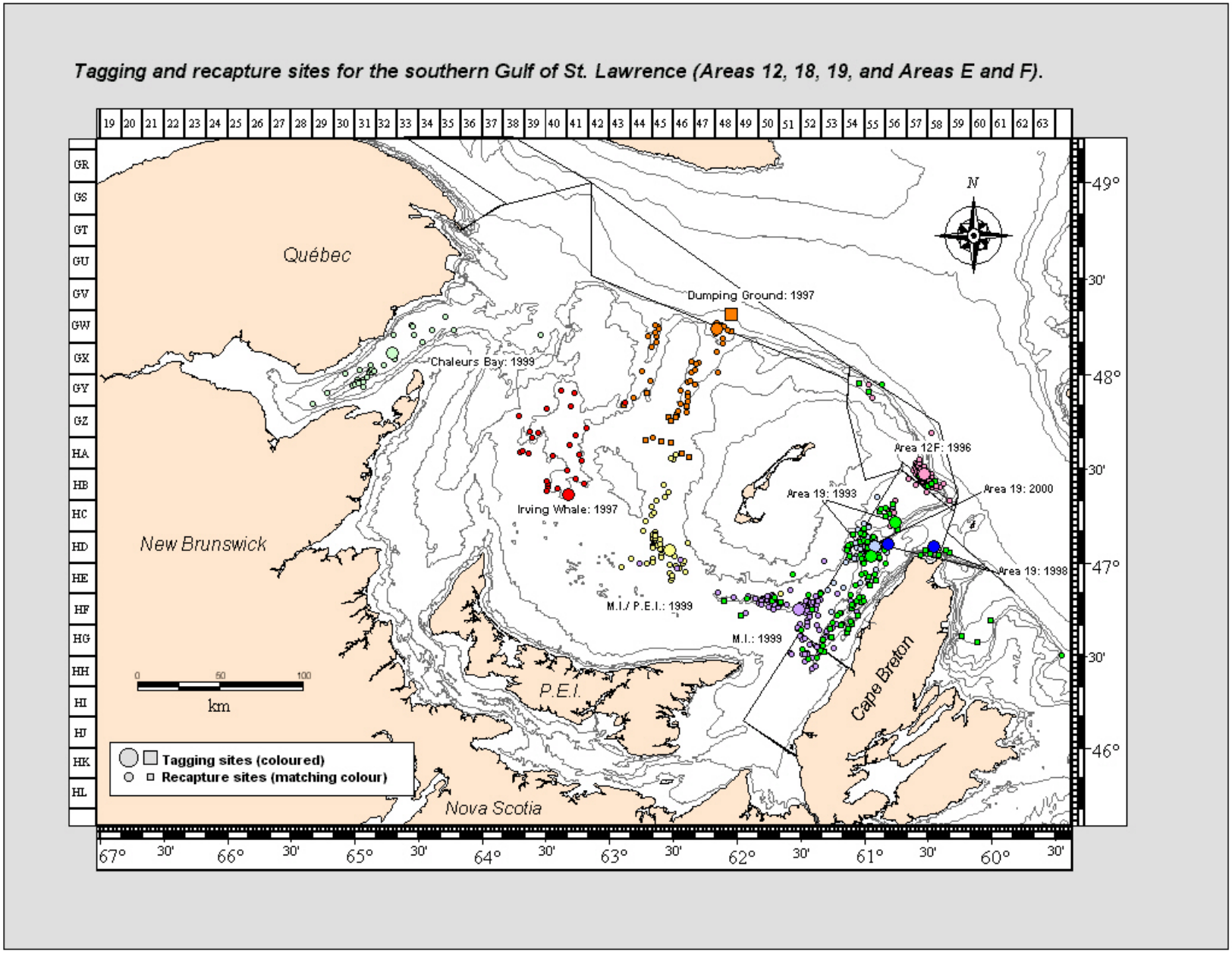


Figure 22. Tagging and recapture sites for the southern Gulf of St. Lawrence (Crab Fishing Areas 12, 18, 19 and Area E and F).

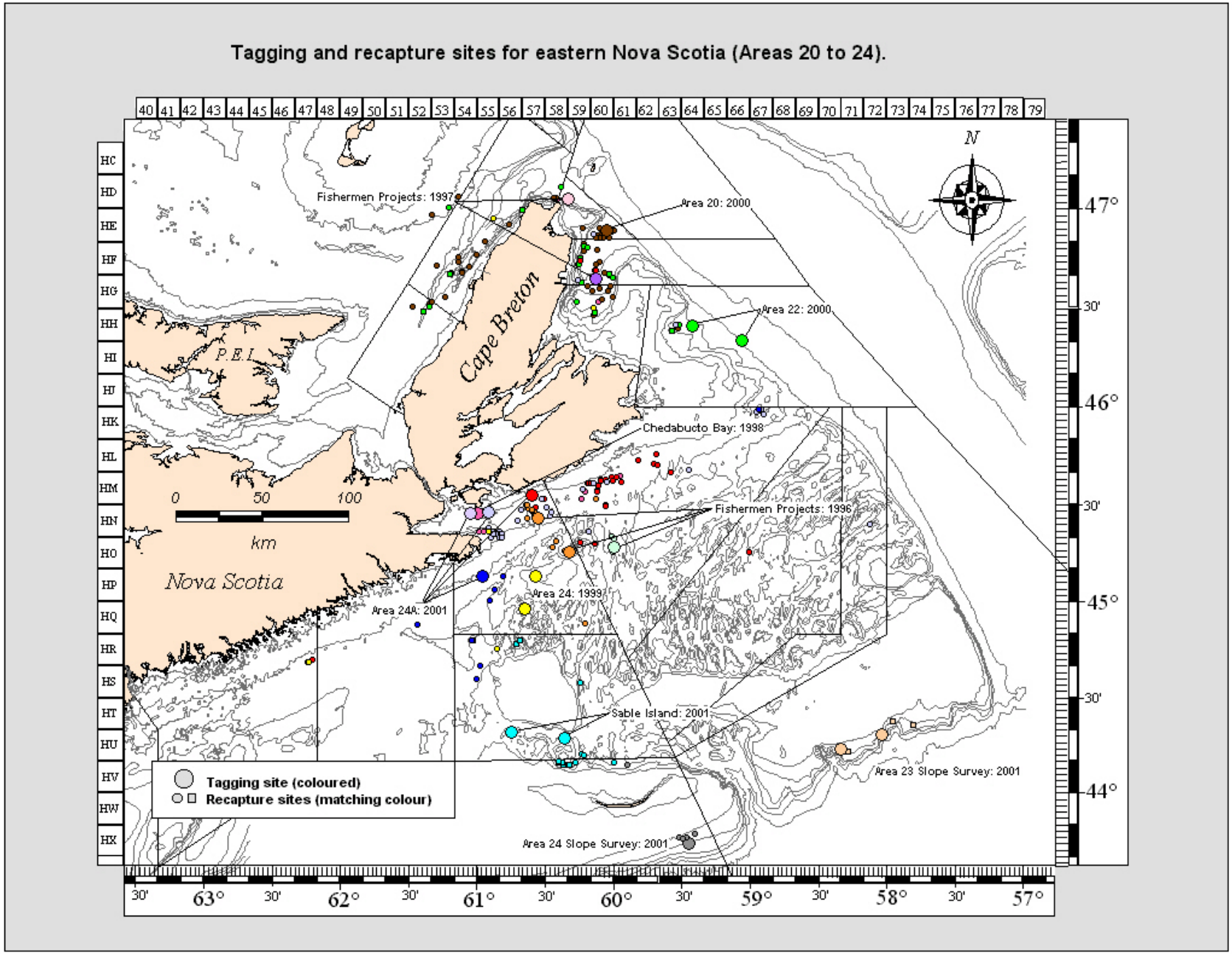


Figure 23. Tagging and recapture sites for eastern Nova Scotia (Crab Fishing Areas 20 to 24).

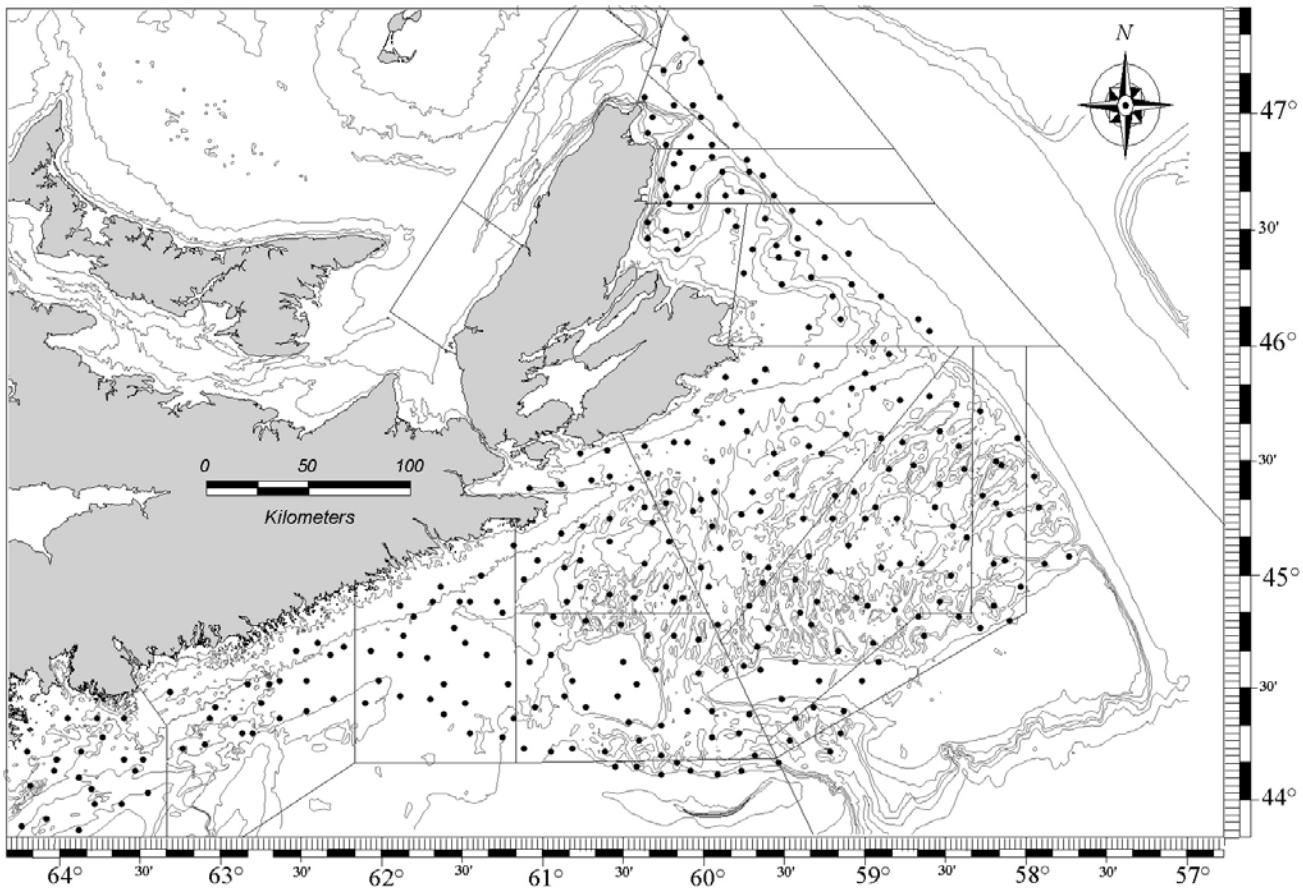


Figure 24. Location of snow crab trawl survey stations (n=321) in 2002.

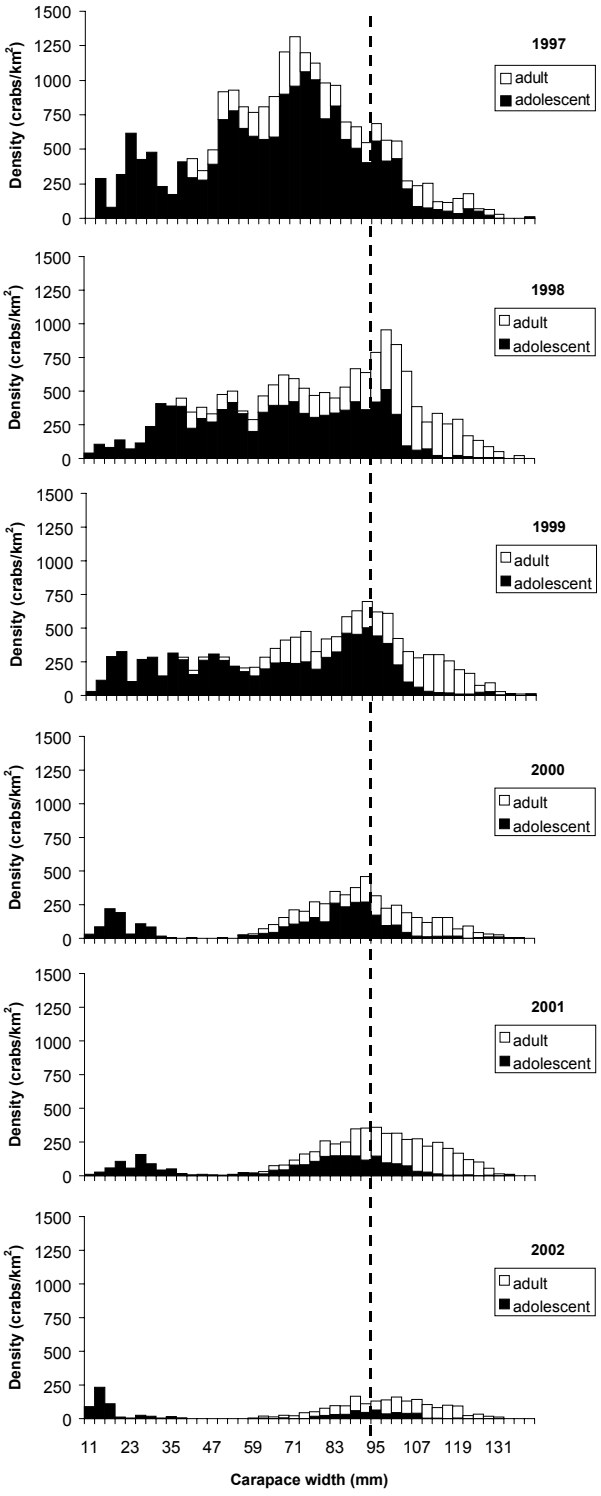


Figure 25. Survey size frequency of male snow crab in north-eastern Nova Scotia from 1997 to 2002.

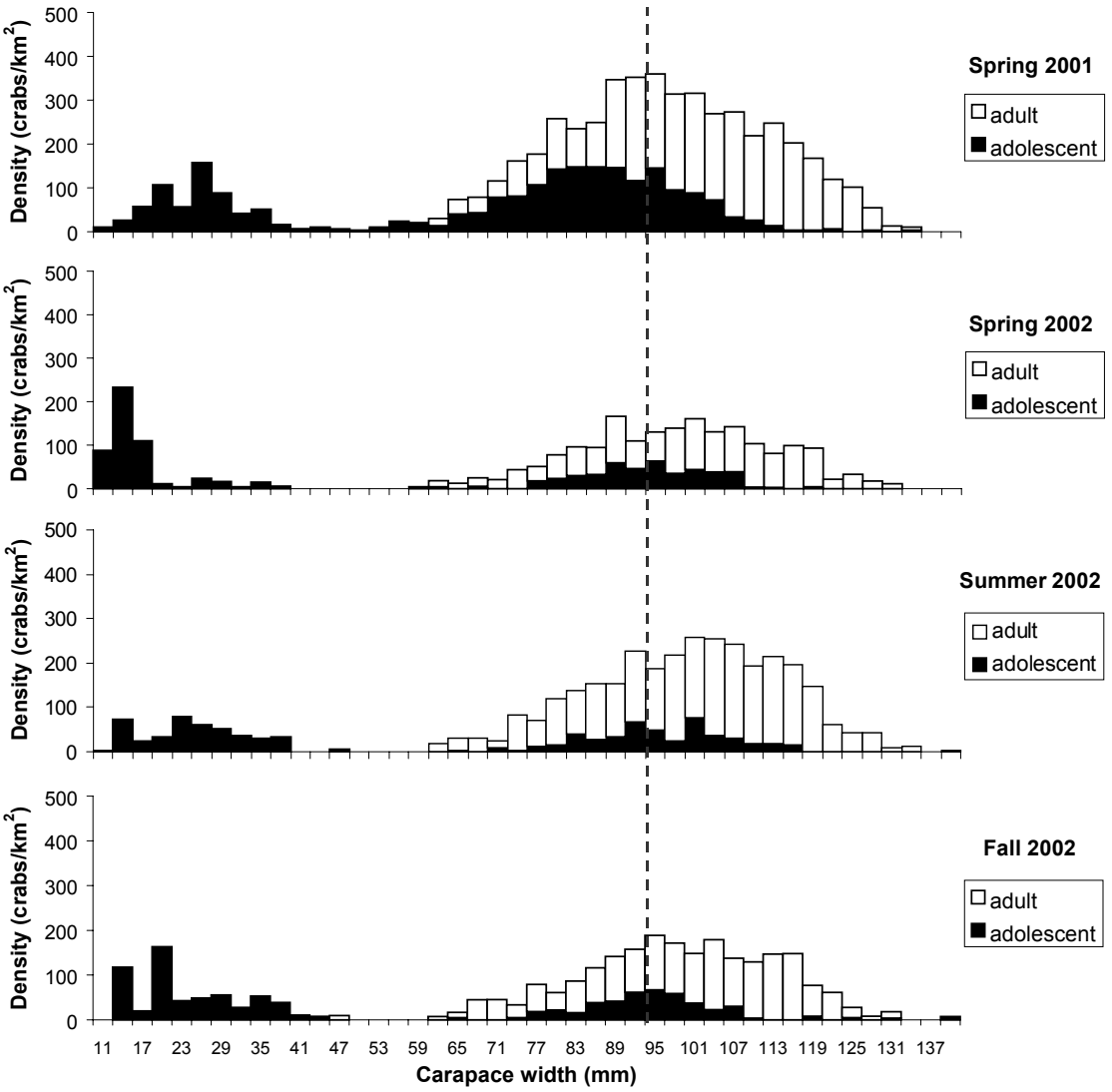


Figure 26. Survey size frequency of male snow crab in north-eastern Nova Scotia.

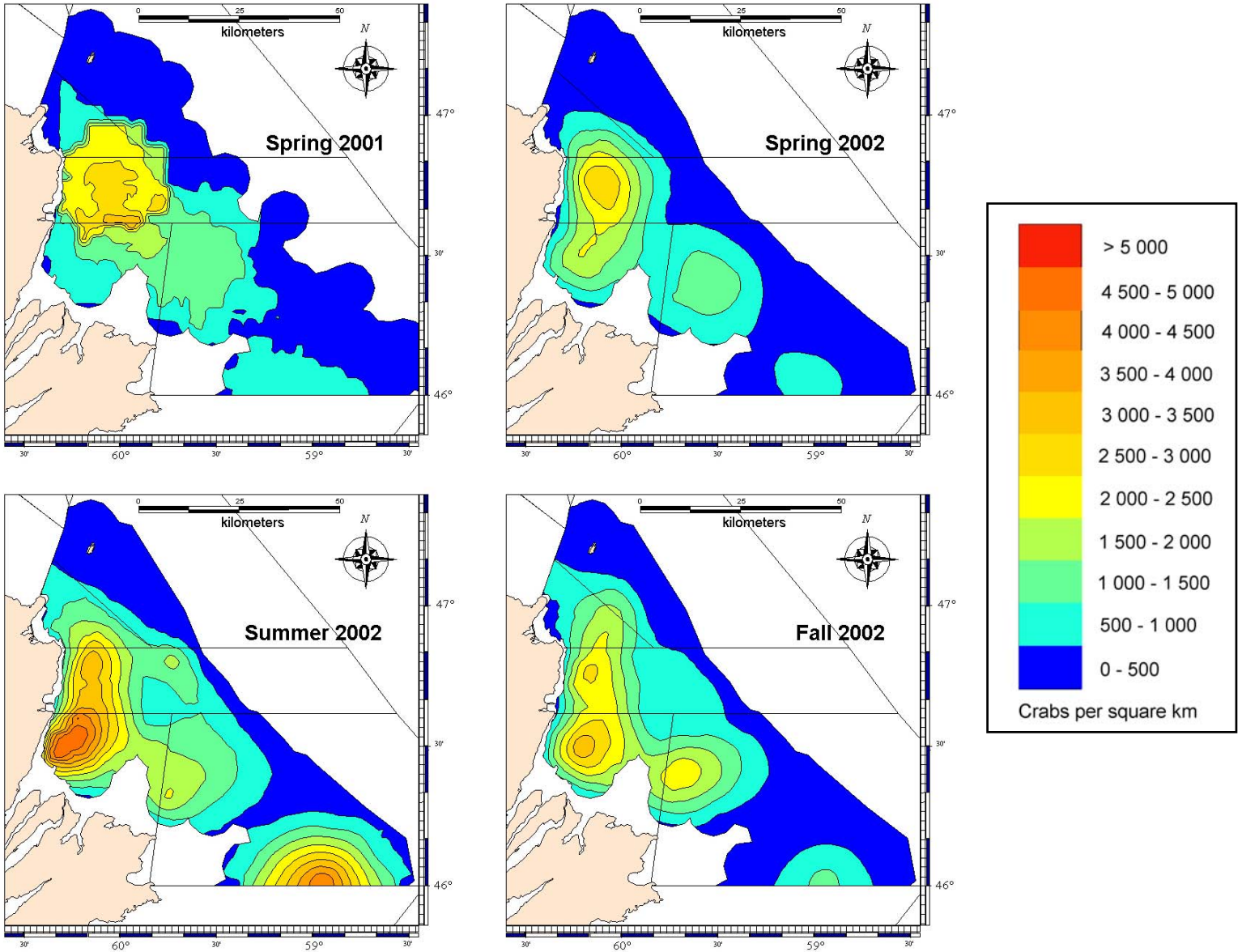


Figure 27. Snow crab density distribution of adult crabs of commercial size for north-eastern Nova Scotia in 2001 and 2002.

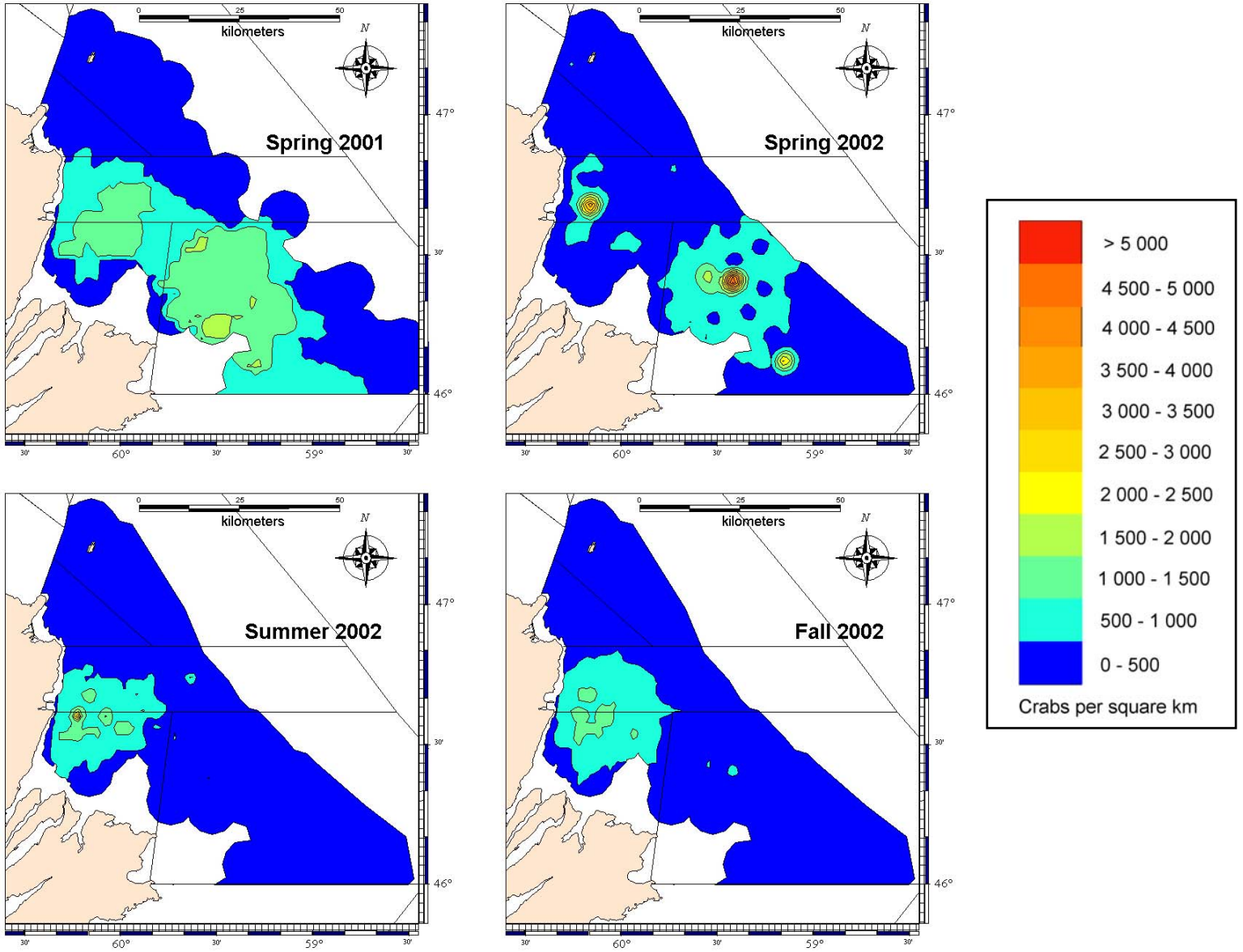


Figure 28. Snow crab density distribution of adolescent male ≥76mm carapace width for north-eastern Nova Scotia in 2001 and 2002.

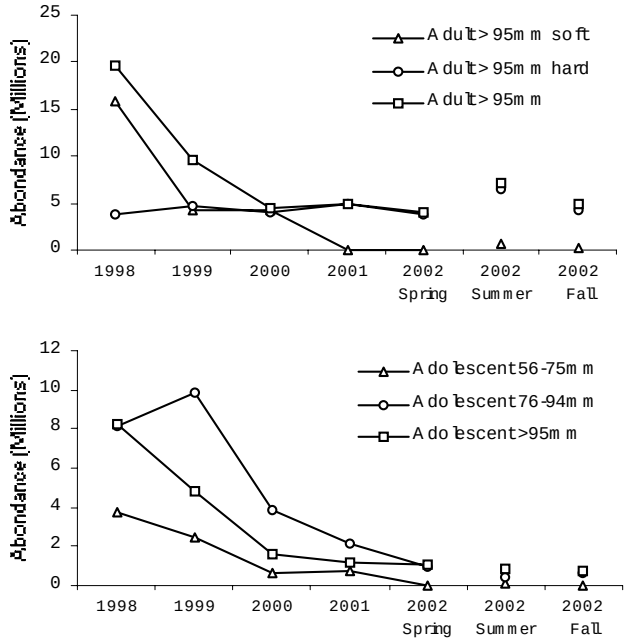


Figure 29. Relative abundance of commercial-sized adult and pre-recruits males observed during the trawl surveys in north-eastern Nova Scotia.

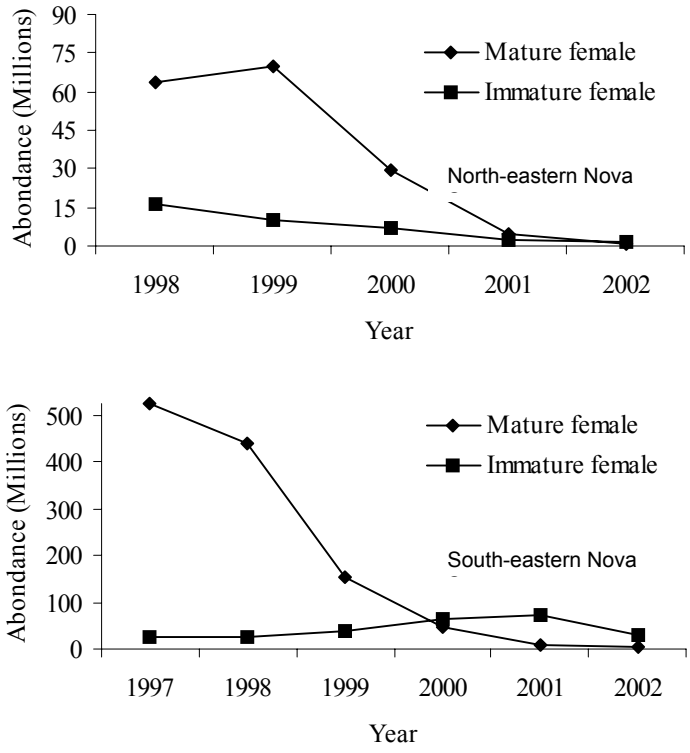


Figure 30. Relative abundance of adult and immature females observed during the trawl surveys in eastern Nova Scotia.

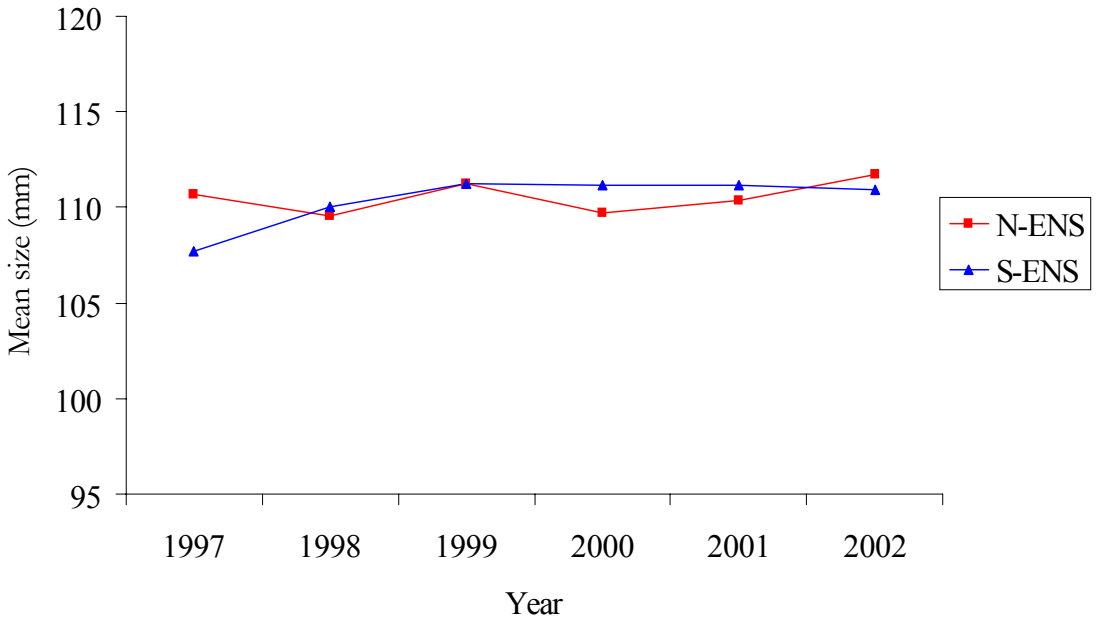


Figure 31. Mean size of commercial size snow crabs from the trawl surveys for north- and south-eastern Nova Scotia (Crab Fishing Areas 20 to 24).

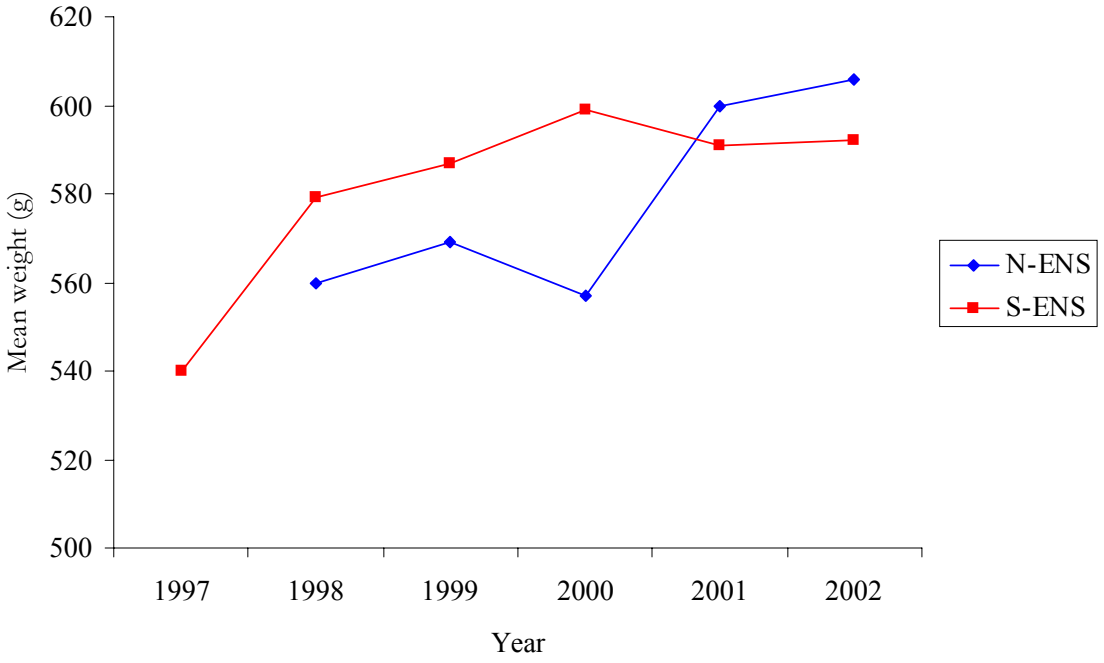


Figure 32. Mean weight of commercial size snow crabs from the trawl surveys for north- and south-eastern Nova Scotia (Crab Fishing Areas 20 to 24).

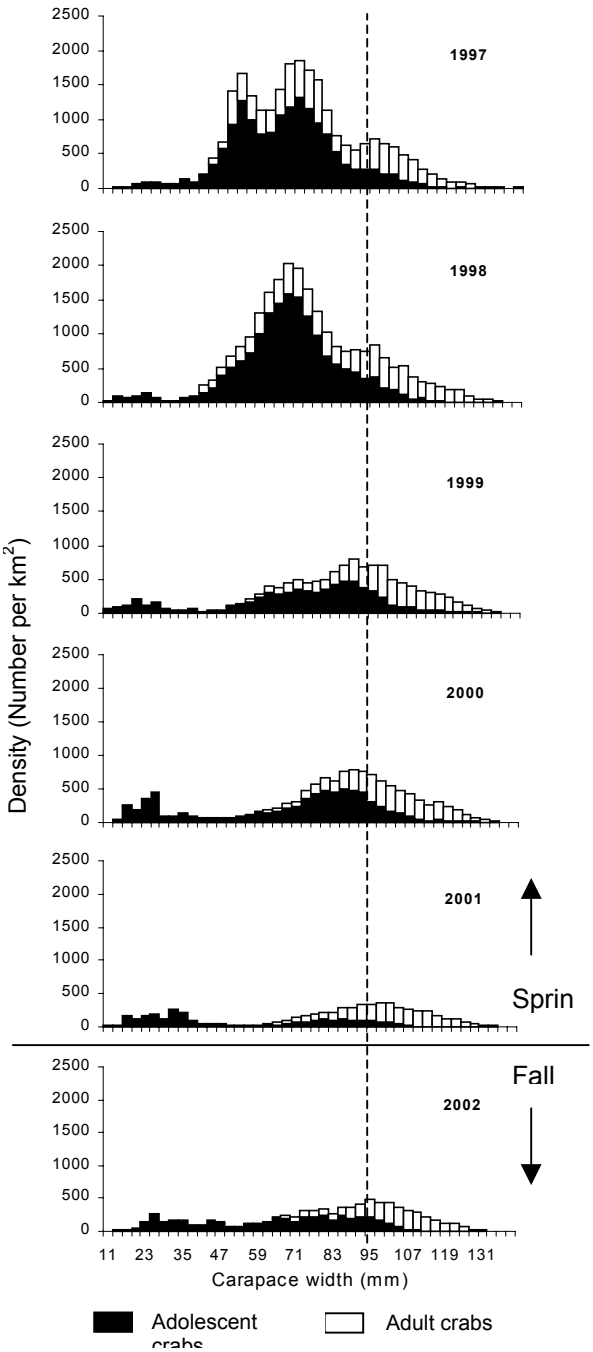


Figure 33. Survey size frequency of male snow crab in south-eastern Nova Scotia from 1997 to 2002.

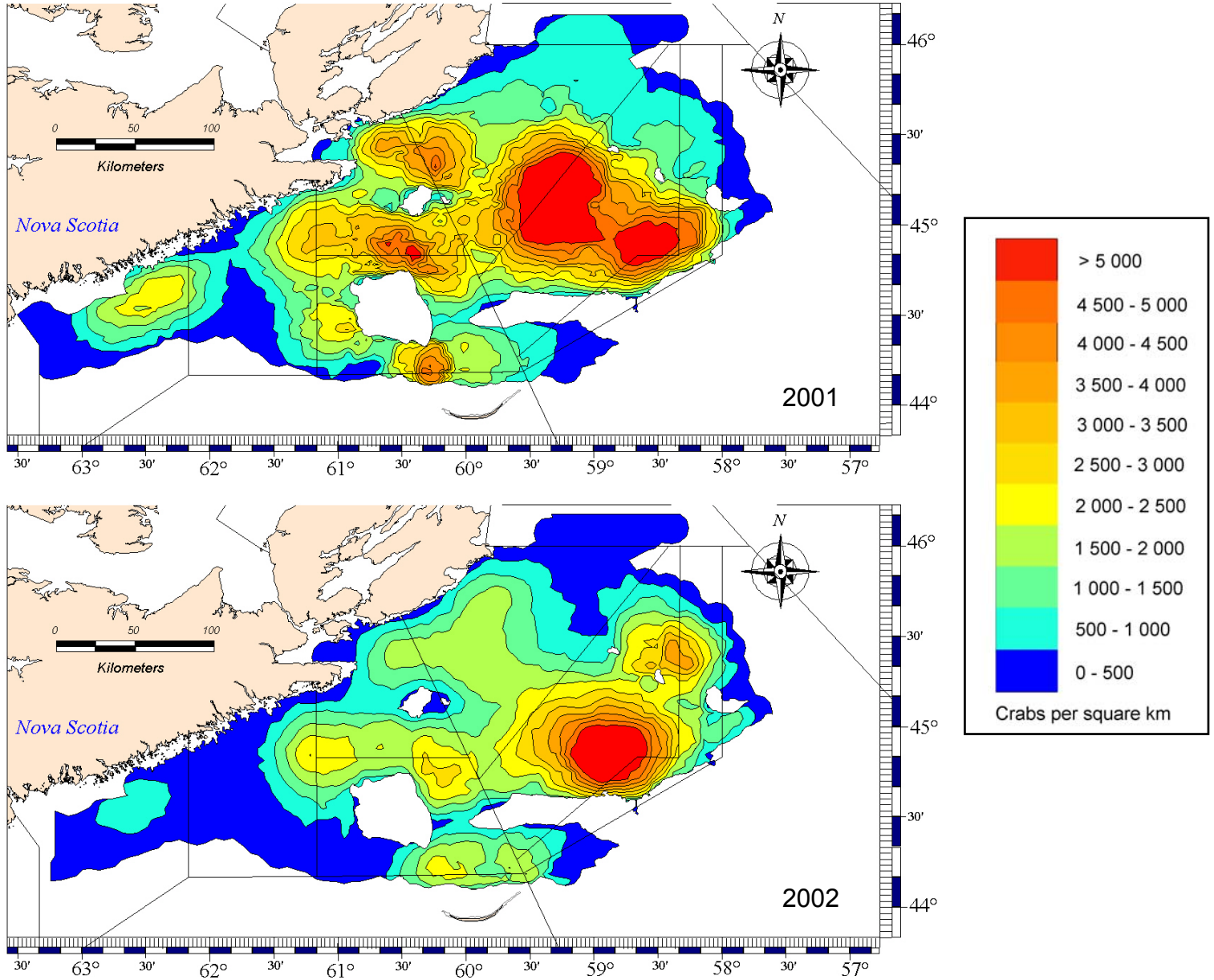


Figure 34. Snow crab density distribution of adult crabs of commercial size for south-eastern Nova Scotia in 2001 and 2002.

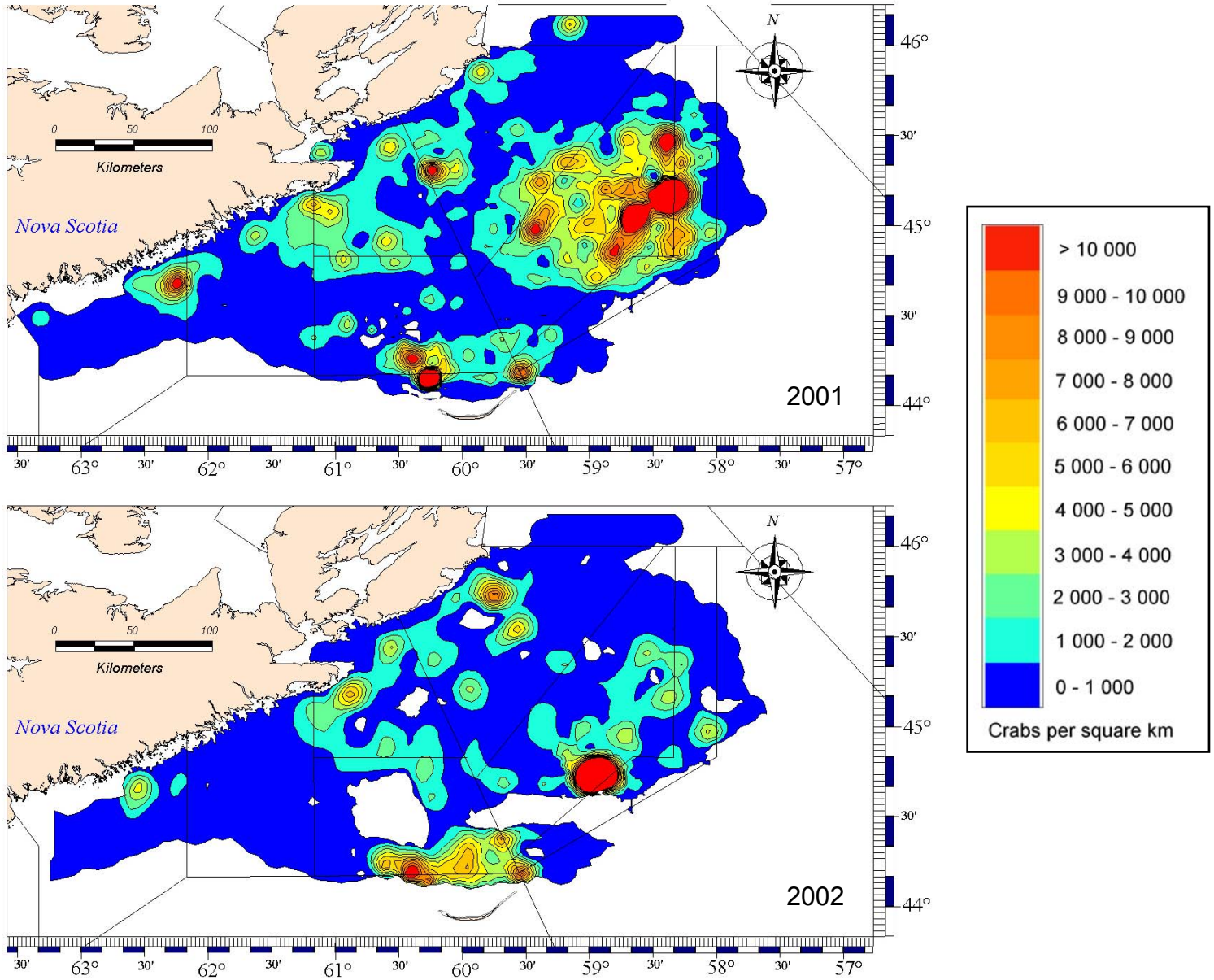


Figure 35. Snow crab density distribution of adolescent male ≥76mm carapace width for south-eastern Nova Scotia in 2001 and 2002.

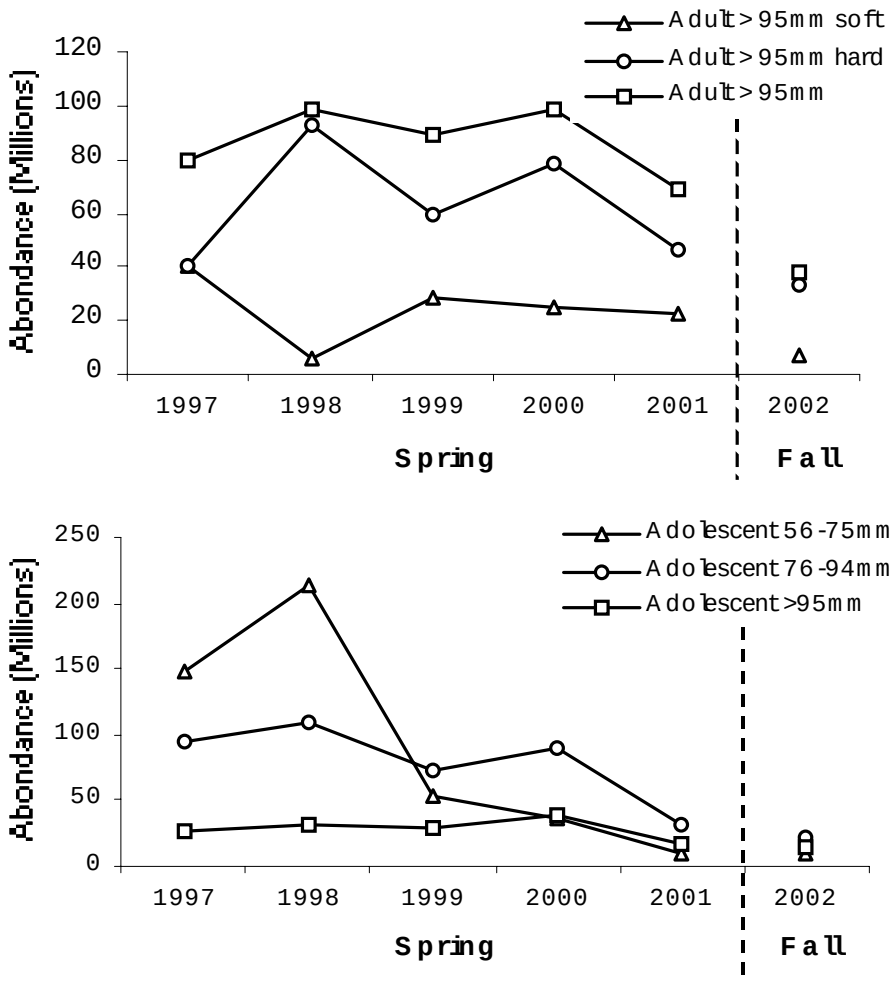


Figure 36. Relative abundance of commercial-sized adult and pre-recruits males observed in south-eastern Nova Scotia.

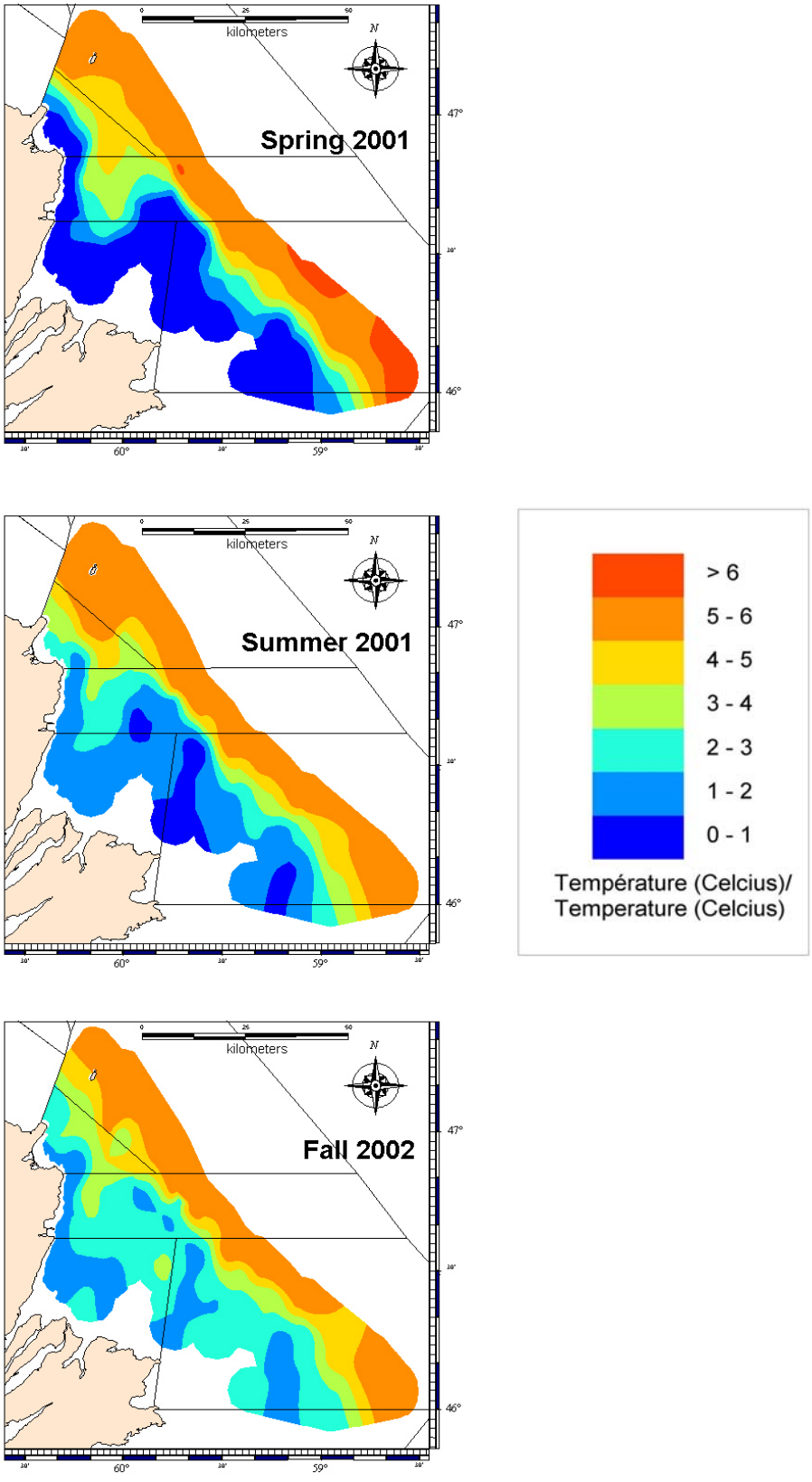


Figure 37. Seasonal temperature observed during the trawl surveys in north-eastern Nova Scotia.

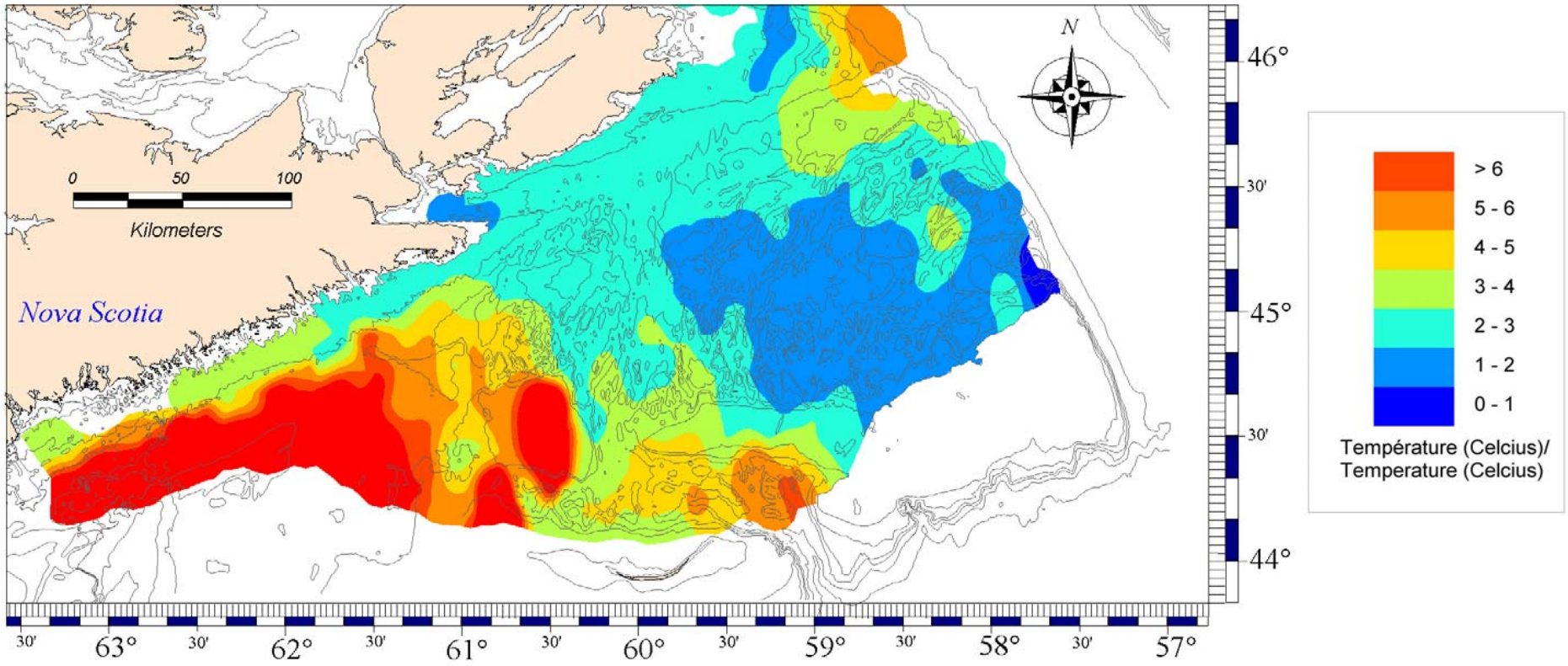
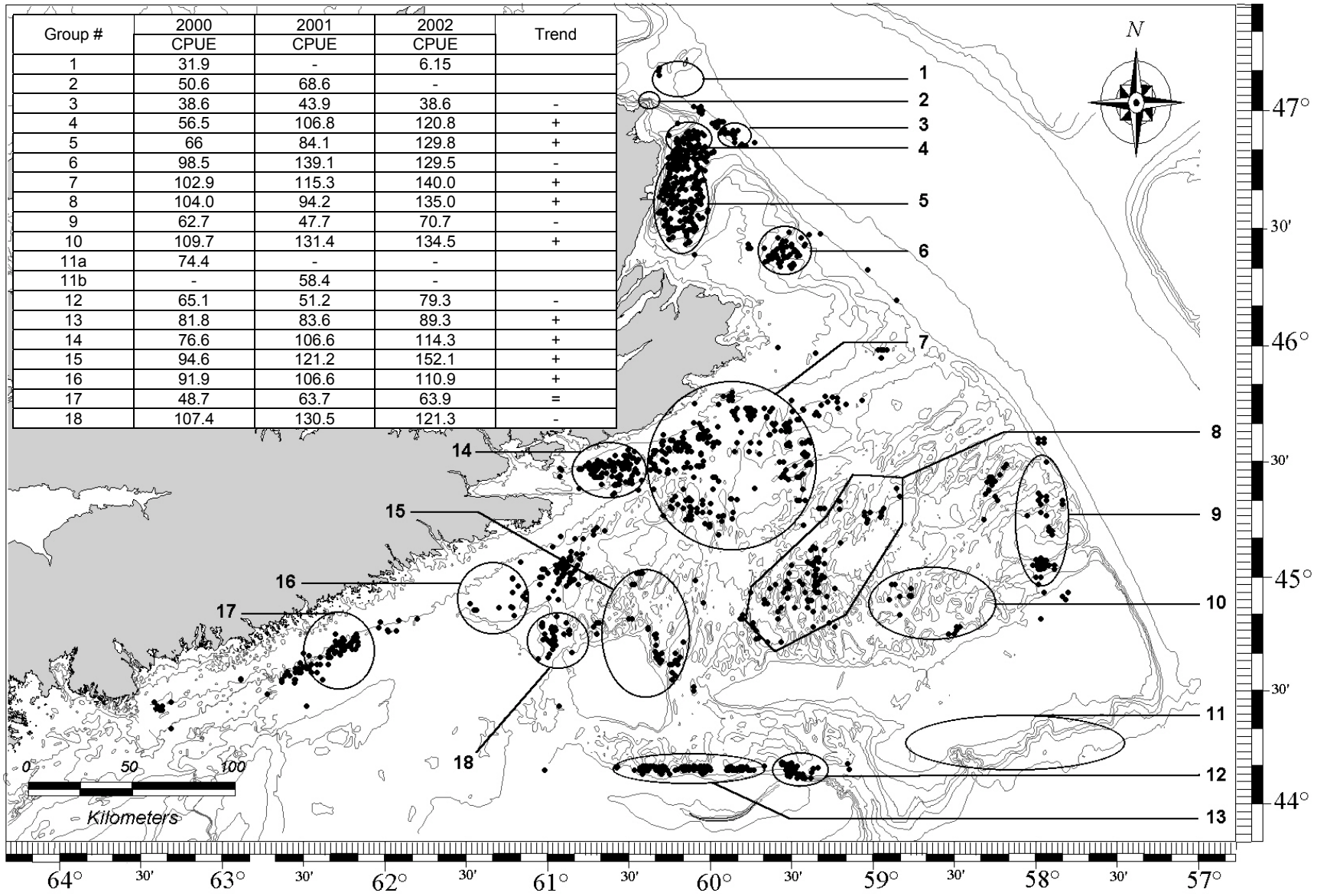


Figure 38. Snow crab trawl survey temperature observed for the year 2002 for south-eastern Nova Scotia.



Group #	2000 CPUE	2001 CPUE	2002 CPUE	Trend
1	31.9	-	6.15	
2	50.6	68.6	-	
3	38.6	43.9	38.6	-
4	56.5	106.8	120.8	+
5	66	84.1	129.8	+
6	98.5	139.1	129.5	-
7	102.9	115.3	140.0	+
8	104.0	94.2	135.0	+
9	62.7	47.7	70.7	-
10	109.7	131.4	134.5	+
11a	74.4	-	-	
11b	-	58.4	-	
12	65.1	51.2	79.3	-
13	81.8	83.6	89.3	+
14	76.6	106.6	114.3	+
15	94.6	121.2	152.1	+
16	91.9	106.6	110.9	+
17	48.7	63.7	63.9	=
18	107.4	130.5	121.3	-

Figure 39. Catch per unit effort (CPUE) for different actual fishing ground without taking into consideration the management Crab Fishing Areas.

Appendix 1

Classification of carapace stages developed for the Southern Gulf of St. Lawrence stock based on carapace condition, durometer reading and corresponding approximate age after terminal molt.

Category	Stage	Durometer reading	Carapace condition	Approximate age after terminal molt
New soft	1	< 68	brightly colored, iridescent, soft, no epibionts, chelae easily bent.	0-5 months
Clean	2	variable	brightly colored, some iridescence, may have epibionts, chelae not easily bent	5 months- 1 year
Inter-mediate	3	> 68	dull brown dorsally and yellow-brown ventrally, no irridescence, shell abrasion evident, epibionts.	8 months -3 years
Old	4	> 68	carapace very dirty but hard, decay may be present at leg joints, epibionts removable at processing plant.	2 - 5 years
Very old	5	variable	carapace very dirty and may be soft (durometer reading < 68), progression of decay may be evident, epibionts not removable at processing plant.	4-6 years