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Assessment of the 2000 Snow crab (*Chionoecetes opilio*) fishery off eastern Nova Scotia (Areas 20 to 24).

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Abstract

Overall, fishery-related indices such as CPUEs have increased in all areas and sub-areas compared to 1999. There are however important considerations to be made before interpreting the 2000 fishery-related data and indices. The magnitude of certain increases in CPUEs or decrease in effort in 2000 should be considered 'inflated' by factors such as gear type, soak time, fishing season and pattern, seasonal movement, and may be even by the mobile gear fishery. Any attempts to compare this data with historical data, especially data before the mid-1990s, should only be done to illustrate how much these ENS fisheries have changed in recent years. Landings in ENS passed from the average 1,500 t in 1994-96 to 2,250 t in 1998, 3,600 t in 1999 and 9,765 t in 2000.

Estimates of the minimum trawlable biomass from the trawl survey realized before the snow crab fishery in 2000 were 2,926 t for the northern region (CFAs 20 to 22) and 28,939 t for the southern region (CFAs 23 and 24). Trawl survey data clearly indicates that recruitment to these fisheries has been consistently decreasing since 1997. There is also an indication that the biomass of adult males ≥95 mm have peaked in the 1997-1999 period. There should be no doubt, that from a global perspective, the adult snow crab segment of the population in both northern and southern ENS is on a decreasing trend. Indications of the decrease in adult male concentrations can also be drawn from the at-sea observer data. Both northern and southern ENS stock should be managed with the decreasing trend of commercial adult snow crab in perspective for the incoming years.

Résumé

De manière générale, les index reliés à la pêcherie, tel que les PUEs, ont augmentés dans toutes les zones et sous-zones lorsque ceux-ci sont comparé aux données de 1999. Il y a cependant d'importants points à considérer avant de pouvoir interprêter les données et index relié à la pêcherie de l'année 2000. L'amplitude de certaines augmentations des PUEs, ou de diminutions d'effort en 2000, devrait être considéré "gonflé" par des facteurs tel que les types d'engin de pêche, le temps d'immersion, la saison de pêche, le mouvement saisonnier, et peut-être même par les pêcheries utilisant des engins de pêche mobiles. La comparaison de ces données avec les données historiques, surtout les données datant d'avant la mi-1990, devrait être fait seulement pour démontrer à quel point ces pêcheries à l'est de la Nouvelle-Écosse (ENÉ) ont changées dernièrement. Les débarquements à l'ENÉ ont passé d'une moyenne de 1,500 t en 1994-96 à 2,250 t en 1998, à 3,600 t en 1999, et 9,765 t en 2000.

Les estimés de la biomasse minimum chalutable, et déterminés à partir du relevé au chalut réalisé avant le début des pêcheries, sont de 2,926 t pour la région du nord (ZPCs 20 à 22) et de 28,939 t pour la région du sud (ZPCs 23 et 24). Les données du relevé au chalut indiquent clairement que le recruitement à ces pêcheries est constamment en diminution depuis 1997. Il y a aussi des indications que la biomasse des males adultes ≥95 mm aurait atteint un sommet durant la période de 1997 à 1999. Il ne devrait n'y avoir aucun doute que, d'un point de vue globale, la tendance est à la baisse pour le segment adulte de la population de crabe des neiges du nord et du sud de l'ENÉ. Des indications de cette baisse dans la concentration des males adultes peut aussi être dérivées à partir des données des observateurs en-mer. Les stocks de crabes des neiges du nord et du sud de l'ENÉ devrait être gêré en ayant comme perspective que la tendance des crabes adultes commerciales sera à la baisse pour les quelques années à venir.

INTRODUCTION

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

From 1982 to 1993, the management of these fisheries was based strictly on effort controls (seasons, licenses and trap limits). The number of licenses remained stable except for CFA 24 where 7 new licenses were added between 1989 and 1991. Substantial changes to the management of these fisheries were introduced in each CFA from 1994 to 1999; IBQ was imposed in all CFAs; 100% dockside monitoring; a mandatory logbook for both dockside monitoring and the scientific data base; landings not more than 0-10% soft-shell crabs; at-sea monitoring by certified observers; a biodegradable panel on traps to prevent ghost fishing; and recently, the introduction of sub-areas in 1998 to ensure the distribution of the fishing effort. The number of permanent licenses in CFAs 20, 21 and 22 remained unchanged from 1994 to 1999. During this same period, no temporary allocations were allowed in CFAs 21 and 22, while 4 temporary permits were issued in CFA 20 in 1999. The number of permanent licenses increased by 2 in CFA 23 (from 22 to 24) and CFA 24 (from 21 to 23) in 1997, and has remained the same in 1998-99. The number of temporary permits in CFAs 23 and 24 has increased since 1996; from 5 in 1996 to 13 in 1999 in CFA 23 and from 6 to 22 permits in CFA 24.

The first large-scale annual trawl survey comprised 150 stations and was conducted in 1997 prior to the fishery. The data from this first annual survey were analyzed and biomass and/or abundance estimations were produced for the area surveyed. However, at the Regional Assessment Process (RAP) in January 1998, it was felt premature to present these results due to uncertainties concerning the direct application of the kriging method developed for the southern Gulf of St Lawrence (SGSL) to ENS. A new size-weight relationship and discriminant function were established for the ENS snow crab population in 1998, while the technique for biomass estimation by taking the bottom configuration factor into account was introduced in 1999 (Biron et al. 2000). For the first time, the 1999 ENS stock status was evaluated based on a trawl survey.

Estimates of the minimum trawlable biomass (refer to total biomass hereafter) for 2000 were 2,358 ± 2,285t for the northern region (CFAs 20 to 22) and 28,939 ± 13,515t for the southern region (CFAs 23 and 24). The size frequency distributions showed a substantial decrease in adolescent males from 1997 to 1999 in both northern and southern regions, while the adult male ≥95 mm of carapace width (CW) category remained stable. Trends in CPUE in all CFAs during the same period do not suggest any sign of stock decline. Seasonal movement of crab is believed to be an important factor influencing biomass estimate in ENS, especially in the northern region.

Current status – Increases in TAC for all CFAs were decided during the Management / Industry Consultative Process that preceded the snow crab fishing season of 2000 (Anonymous 2000); in northern ENS (CFAs 20 to 22), the TAC increased to 965 t (from 865,5 t in 1999), while in southern ENS (CFAs 23 and 24) it was increased to 8,799 t (from 2,700 t in 1999). In 2000, IBQs of regular licenses were increased in CFA 20 (from 11,340 to 13,608 kg); CFA 21 (from 9,072 to 11,340 kg); CFA 22 'northern' (from 13,154 to 13,834 kg); CFA 22 'outer' (remained at 15,422 kg); CFA 23 (from 37,500 to 72,601 kg); and CFA 24 (from 35,870 to 73,402 kg) (Table 1). Existing temporary fishermen allocations increased from 33.9 to 50 t in CFA 20, from 400 to 2,683 t in CFA 23, and from 575 to 2,686 t in CFA 24 (Table 1). There were no changes in the number of permanent licenses in all CFAs: 5 permanent licenses in CFA 20, 32 licenses in CFA 21, 37 in CFA 22, 24 in CFA 23 and 23 permanent licenses in CFA 24. The number of temporary permit holders increased compared to 1999; from 4 to 5 in CFA 20, from 13 to 53 in CFA 23, and from 22 to 56 in CFA 24. Some modifications were made on the shape of the outside sub-areas of southern ENS, and the number of traps allowed was increased from 30 to 45 in CFA 23. Other management items remained similar to what they were in 1999 for all the CFAs (Anonymous 2000).

MATERIALS AND METHODS

Landings, catch rate and effort

In 2000, data on landings and fishing effort were obtained from the mandatory logbooks completed by all fishermen for both dockside monitoring and the scientific database. Copies of the original completed logs and the compiled electronic database were obtained from the Statistics Division of the Maritimes Region of the Department of Fisheries and Oceans (DFO). Thereafter, total seasonal landings for each CFA were obtained from a revised preliminary report produced by the Statistics Division in late December 2000, and may slightly differ from results presented in the Stock Status Report in February 2001. All fishermen submitted their logs, but not all logs were usable; some have one or more missing or erroneous values such as the number of traps used or incomprehensive fishing positions. In 2000, TAC was divided into smaller allocations which were distributed on a sub-area(s) basis whenever applicable (Anonymous 2000). Landings, effort and calculated CPUE were determined for all CFAs and their respective sub-areas in 2000.

Management areas and sub-areas – Since the beginning of these fisheries in the 1970s, CFAs 20 to 24 and their respective sub-areas have been created for management purposes only, and not for biological reasons. Following the stock assessment of 1998, DFO considered that a reasonable increase in TAC could be allowed in CFAs 23 and 24. However, DFO Science noted that the heaviest effort was within the nearshore area and an increased quota without effort distribution could have increased exploitation above acceptable levels. Therefore since 1998, DFO Management in consultation with the Industry and DFO Science (Biron et al. 1998) 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 for northern ENS (CFAs 20, 21 and 22) as described in 1999 (Fig. 1)(Anonymous 2000, Biron et al. 2000). In CFA 20, permanent fishermen were allowed to fish anywhere, while temporary permit holders were confined to the outside fishing grounds only. In CFA 22, an industry-designed separation of the fleet (since 1996) into northern and outer areas was again incorporated into the management plan, and fishermen were supposed to fish in only one area (Anonymous 2000).

Some slight modifications were made by DFO Management on the outside sub-areas of southern ENS, however the A and B sub-areas, and the C sub-areas in CFA 24, have remained similar (Fig. 1)(Anonymous 2000, Biron et al. 2000). In CFA 23, the line separating the sub-areas C and D in 1999 was removed, and 2 new sub-areas C and D were redesigned, while in CFA 24, the old sub-areas 24E in 1999 has been reduced in 2000 to extend the limits of sub-areas 24D (Fig. 1).

Landings - Total landings by CFA are the sum of landings from the logs received for each CFA. The geographic distribution of landings was presented as a sum of total landings within each 10° latitude by 10° longitude grid (10 X 7 nautical mile grid). The fishing positions were taken from the logs.

CPUE and effort - The average seasonal CPUE for ENS (or by CFA, or by sub-areas) corresponds to the ratio of the sum of the landings (y) for ENS (or by CFA, or by sub-areas) to the sum of the number of trap hauled (tf) to catch these respective landings for ENS (or by CFA or sub-areas), as reported only in properly completed logs: $CPUE = \sum y / \sum tf$. The seasonal total effort (total number of trap hauls: F) was then estimated for ENS (or by CFA, or by sub-areas) from the sum of all landings (Y) (including landings from improperly completed logbooks) for ENS (or by CFA, or by sub-areas) divided by average seasonal CPUE for ENS (or by CFA, or by sub-areas): F = Y / CPUE. The geographic distribution of fishing effort was presented as a sum of the number of trap hauls within each 10° latitude by 10° longitude grid. The fishing positions were taken from the logs. The geographic distribution of the average CPUE was calculated within each of these grids.

Catch-effort maximum likelihood biomass estimations in CFAs 21 and 22 – By contrast to southern ENS, the fisheries in northern ENS are basically concentrated in 2 well defined fishing grounds: (1) the nearshore trough which is shared by all fishermen of CFAs 21 and 22 northern, as well some of the fishermen in CFA 20 (others fish along the CFAs 19/20 boundary); and (2) an area along the Laurentian Channel, also known as the Glace Bay Hole, that comprises the majority of the fishing activities of CFA 22 outer fishermen (Fig. 1). A catch-effort method was applied to the 2 fishing grounds in northern ENS, as an alternate method to verify trawl survey results obtained in 2000. The exclusion of CFA 20 from this analysis is based on the particular fishing distribution of the fishermen into 4 separated fishing grounds, and the much longer period of time taken to complete the season when compared to CFAs 21 and 22. Estimation of snow crab biomass from the daily CPUE in CFAs 21 and 22 were obtained according to the method Catch-effort maximum likelihood estimation of important population parameters described by Gould and Pollock (1997). Biomass estimations were calculated for CFAs 21, 22 northern, 21 and 22 northern (combined), and 22 outside.

Sea sampling

Sea sampling data were solely collected by certified observers. For each randomly-sampled 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, chela height (ChH), the carapace condition (on a scale of 1 to 5; Appendix I) and the hardness of the right claw (Foyle et al. 1989). Snow crab with claw hardness less than 68 in durometer readings were considered as soft-shell crab (Hébert et al. 1992).

Adult (terminal molt) and adolescent (non-terminal molt) individuals can be identified using chela morphometry by plotting logarithms (ln) of ChH against ln of CW (Conan and Comeau 1986). Data from adult and adolescent crabs fit into two distinct ellipses with parallel major axes (Conan and Comeau 1986).

The following discriminant function:

$$Y = 19.775707 \ln (ChH) - 25.324040 \ln (CW) + 56.649941$$

will assign individuals to the correct groups in 99% of cases (for adult males: $Y > 0$). By plotting ln ChH against ln CW, the ENS data from adult and adolescent crab fitted into two distinct ellipses with parallel major axes (Biron et al. 1999).

Northern ENS experimental trap survey

In an attempt to establish adult snow crab distribution and movement along the eastern slope of the Laurentian Channel in ENS, an experimental trap survey conducted by DFO between June 27 and July 6, 2000. Overall, 5 line transects spread over the length of the Channel were selected perpendicularly to the slope, between 200 and 400 m deep. For each corridor, ten heavy base high cone traps were to be distributed at a rate of 1 trap for every 20 m. For each trap, the total number of male crabs, the position and depth of the trap were recorded, and a sub-sample of 80 crabs were taken randomly for the following measurements: CW, ChH, the carapace condition and the hardness of the right claw. Some of the crab captured were tagged and released at the mouth of the trough in CFA 21 and in Glace Bay Hole in CFA 22.

Southern ENS fishermen (23D and 24 D) trap survey

Because the allocations distributed to temporary fishermen in the newly redesigned sub-area D of both CFAs 23 and 24 (Fig. 1) was for areas mostly not covered by the 1999 trawl survey, fishermen were asked to explore the ‘unknown’ areas during or after the normal course of there fishing activity. DFO management, in consultation with industry and DFO Science, partitioned these sub-area D’s and distributed each area to be covered by temporary fishermen. Fishermen fished these grounds as they would normally, and data on landings, fishing effort and locations were obtained from the logbooks. It is because most of the grounds explored were often devoid of crab or located in areas that would not have otherwise been fished that all logbook data for this trap survey were pulled out from the logbook analysis of the fishery above, and treated separately in this section. Two groups representing fishermen in sub-area 24D have also submitted detailed reports of their exploratory activities to DFO-Management, and copies were obtained by Science and compiled together with the logbook data.

Mobile gear fishery data

Historical and current 2000 data on landings, fishing effort and fishing locations of the groundfish and shrimp fisheries were obtained from compiled electronic database maintained by the Invertebrates and Marine Fish Divisions of DFO Maritimes Region.

Annual trawl survey

Trawl sampling – The number of stations sampled for the large-scale annual trawl survey increased from 274 to 322 between 1999 and 2000. However, of the 322 trawl stations surveyed between May 06 and July 04, 2000, 15 stations were part of experimental studies: 1) seasonality effect on the trawl survey in northern ENS (5 stations), and 2) impact of increasing the number of stations in 10° X 10° grid (10 stations). The five extra stations used in the seasonality effect experiment are not being used in the kriging calculations and resulting biomass estimation.

A Bigouden *Nephrops* trawl originally developed for the Norway lobster (*Nephrops norvegicus*) fishery in France was used (20 m opening with a 27.3 m foot rope on which is mounted a 3.2 m long, 8 mm galvanized chain (Conan et al. 1994). Each tow averaged 5 minutes at an average speed of 2 knots depending on the depth, current speed and sediment type. The horizontal opening of the trawl was measured every 7 seconds with a Net Mind™ net sensor. The distance of each tow was estimated from the position (Latitude / Longitude) measured every 7 seconds with a DGPS system from the beginning to the end of the tow. The swept surface was then calculated as the sum of the surface of each successive trapezoid. Starting point for each tow is decided by monitoring the depth sensor reading, as it compares to the boat's depth sounder reading, and both the headline primary and the headline secondary readings of the height sensor (i.e. height from headline to bottom, and height from headline to footrope). When both height sensor readings are equal, and the depth sensor compares to the boat's sounder, the tow is officially started. The vessel increase its speed to 2 knots, and remains at that speed for 5 minutes, after which the boat is put in neutral, the winches are started and the tow has ended.

In 1997, a systematic random design was used to determine the location of the original 150 stations with a single station within each 10° latitude by 10° longitude grid. The same design has been applied every year since 1997 to determine the location of every new trawl station added to the survey. Once selected, and with little exceptions, an attempt is made every year to repeat exactly the same trawl stations as the previous years, while adding the new ones randomly. However, the 15 extra locations for experimental purposes may not be repeated again in the same locations in 2001. The duration of each tow as well as depth was recorded. The following measurements were taken for all snow crab captured in each tow: CW, ChH and the carapace condition for males; CW, the width of the fifth abdominal segment and the color of the eggs and gonads for females.

Kriging - A geostatistical method (kriging) was used to estimate annual biomass and density contours of different biological categories of the snow crab biomass (Conan 1985; Conan et al. 1988). Kriging is described by Clark (1979) and its analytical basis was defined by Matheron (1970). It consists of two procedures: (1) analyzing and modeling the covariance between sampling units as a function of distance between their locations (i.e. variogram modeling), and (2) calculating optimal weights to be attributed to each sampling unit for calculating a predicted average characteristic of a given region to be assessed. Mapping of the entire surveyed area is the next step and, using point kriging and a fitted variogram; map of isodensity contours and isovariance contours is then generated for this area. We further use block kriging for estimating average density and variance over the whole area, and thereby estimating the total number of crab present in a given area. The model assumes that trawl efficiency is 100% for individuals larger than 50 mm CW. The abundance of snow crab estimated by kriging was converted into biomass according to the size-weight relationship and size-frequency histograms. To convert size to weight, size-weight relationships were calculated according to molt stage, the morphological maturity and sampling season. The size-weight relationship for adult hard-shell males in ENS is expressed by the function $W = 1.543 \times 10^{-4} CW^{3.206}$ (Biron et al. 1999).

Terminology – The trawl survey in ENS occurs 1-2 months before the fishery except in CFA 24 in 1998. By contrast, in the SGSL, the survey occurs immediately after the fishery, which means the terminology for ENS has a different meaning from that used in CFAs 12, 18 and 19. Crabs were categorized into five groups based on the carapace condition and hardness (Anonymous 1994)(Appendix 1). In this document, total biomass means all adult males ≥ 95 mm CW at the time of the survey (B_t); exploitable biomass means adult males ≥ 95 mm CW and of carapace condition 3, 4 and 5 at the time of the survey (B_e); recruitment to the fishery biomass means adult males ≥ 95 mm CW with carapace condition 1 and 2 at the time of the survey (B_{R-1}). In theory, these will not enter the fishery in the current season, but the following year (although some crab might be affected during the current fishery); and pre-recruits means adolescent males ≥ 56 mm CW at the time of the survey.

Total biomass estimation (see discussion) – It has been the norm since 1997 to determine independent variograms (and their resulting biomass estimates) for the recruitment to the fishery (B_{R-1}), for the exploitable biomass (B_e; also referred to as $B_{fishable}$ in previous ENS research documents), and also for the total biomass (B_t). In 2000 however, the RAP committee has recommended that estimation of total biomass for any given year be simply equal to the sum of the recruitment and exploitable biomass estimated that given year. Therefore, the following equation:

$$B_t = B_{R-1} + B_e$$

will now determine the total biomass estimate for any given year. The associated confidence interval will simply be the sum of the confidence intervals determined for B_{R-1} and B_e (both in t)(Cochran 1977).

Projected habitat area – The projected habitat area (PHA) was introduced in 1999 to compensate for the overestimation of adult male ≥95 mm (commercial size) snow crab resulting from the rough bottom particularity of ENS (Biron et al. 2000). The PHA is basically a mask that forces kriging calculations to assume that a certain surface of the surveyed area has zero snow crab density (Fig. 2). In the case of adult male ≥95 mm CW, kriging calculations are based on the assumption that all grounds with less than a 70 m depth limit have zero snow crab density, but only the surface regrouping all the grounds between 90 m and 300 m will be used as the projected area to be used for biomass estimation of the adult male snow crab ≥95 mm CW (Biron et al. 2000). Contrary to the erroneous statement in Biron et al. (2000), PHA is only used to evaluate the biomass of adult males ≥95 mm CW, and not for any other categories. The size distribution histograms used data from all stations sampled (i.e. without any mask). In 2000, the use of a PHA in northern ENS has been eliminated from the analysis process (see discussion).

Morphological maturity - The terminology "adolescent" (small claw) for non-terminal molt males and "adult" (large claw) to represent the terminal molt males (Sainte-Marie et al. 1995) was used. The distinction between the two groups is based on the bivariate discriminant function obtained using CW and ChH relationship.

Biological unit versus Management unit – From a scientific perspective, there are only two main biological concentrations of the resource in ENS, one in the north (CFAs 20-22) and the other in the south (CFAs 23-24) (Biron et al. 2000). 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 compromise the reliability of the biomass estimates. Therefore, trawl survey results are shown based on biological units only (northern and southern ENS). In an attempt to help DFO-Management and the Industry to better manage the resource, estimates of exploitable biomass are presented for 2001, as well as the proportion (in percentage) of the biomass estimated by CFA at the time of the survey in 2000.

Originally surveyed area versus Total surveyed area (Biron et al. 2000) – The number of trawl stations sampled has steadily increased from 150 to 322 between 1997 and 2000, and the surface to be covered by the survey is expected to increase again in 2001. Consequently, increasing the total surveyed area renders the comparison of 'total' trawl results very difficult between years. Therefore, trawl data is compared each year based on the originally surveyed area rather than the total surveyed area until the number of trawl stations sampled every year stabilizes. In southern ENS, the "originally surveyed area" refers to the surface used for kriging in 1997 (17,623 km^2), while in the case of northern ENS, it corresponds to the surface used in 1998 (4,250 km^2)(Fig 3).

Temperature – Since 1997, it has been common practice to attach a thermistor recorder (VEMCO Ltd) to the trawl for each tow. Although temperature data is sent to Hydrologic

Services, DFO-Halifax, for proper analysis, some results are briefly discussed in this document.

Seasonality effects experiment – Five trawl stations located within the Glace Bay Hole area were repeated on July 04, 2000. These extra tows were realized on the last day of the spring trawl survey in ENS, and as such were treated exactly as any other tows of the survey. These 5 extra stations are only used for comparison between the same 5 stations done earlier (May 11) as part of the annual survey, but are not used for kriging calculation and the resulting biomass estimation in northern ENS.

Increased sampling experiment – During the normal course of the trawl survey, ten 10°X10° grids with relatively high numbers of crabs captured in the Misaine Bank area were selected; a new trawl station was randomly selected for each of the grids and the sampled in the following 24-48 hrs. Sampling procedure for these extra 10 stations were the same as any other trawl stations. These 10 extra stations are used for comparison and the kriging calculations.

RESULTS

Fishery

The overall TAC for ENS in 2000 was 9,814 t compared to 3,600 t in 1999. Total reported landings in 2000 were 9,718 t (Table 2, Fig. 4). There was a 15% increase in the seasonal CPUE and a 2 folds increase in total fishing effort compared to 1999. The seasonal geographic distribution is presented for landings (Fig. 5), CPUE (Fig. 6) and fishing effort (Fig. 7), as well as the location of the logbook positions recorded by fishermen (Fig. 8).

CFA 20

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

Landings – The TAC increased to 118 t in 2000 compared to 91 t in 1999. Total landings in 2000 were 118 t (Table 3). This was 30 % higher than 1999, and also the highest recorded landing since 1978. Officially the landings occurred over 8 weeks, from July 22 to September 03, but in reality 90% of the landings occurred within the second and third weeks of the fishery (Table 4). In total, permanent and temporary fishermen landed 68 and 50 t respectively.

CPUE and effort - The average CPUE was 46.7 kg/th in 2000, an increase compared to 1999 (32.3 kg/th)(Table 4, Fig. 9). Meanwhile, total effort (2,543 trap hauls) decreased slightly compared to the 2,793 trap hauls in 1999 (Table 4, Fig. 10). The 2000 seasonal CPUE of permanent license holders of 56.6 kg/th is almost 50% higher than in 1999, while the total effort reported of 1,202 trap hauls in 2000 is 30% lower than those of 1999 (1,784 trap hauls). The temporary license holders have reported a seasonal CPUE of 35.8 kg/th in 2000, comparable to their 1999 CPUE of 33.7 kg/th, while the total effort of 1,383 trap hauls represented an increase of those of 1999 (1,004 traps hauls)(Table 4).

At-sea sampling by observers - The 2000 catch composition derived from the at-sea samples showed that 74% of the measured crabs were adult males ≥ 95 mm CW (Table 5a and Appendix 2), while this was 90% in 1999. Adolescent males accounted for 8% of the catches in 2000, compared to 5% in 1999. The averaged seasonal soft-shell crab percentages were 6% in 2000, the same as in 1999. The proportion of undersized adult males increased to 18.3 % in 2000, a three fold increase over 1999. The mean CW was 107.3 mm CW (Figs. 11) compared to 113.3 mm CW in 1999. Overall, 3 trips were covered by observers for a total of 11 traps sampled and 428 crabs measured, comparable to 1999 (3 trips, 9 trap, N=358).

CFA 21

Fishing distribution – The fishing occurred exclusively in the inshore area.

Landings - The TAC increased to 363 t in 2000 compared to 290.3 t in 1999. Total landings in CFA 21 were 364 t, 25% higher than those of 1999 (Table 6). Landings occurred within a three week period, from July 23 to August 06, 2000. Overall, 70% of the landings occurred in the 1st week of the fishery, and over 95% by the end of the 2nd week (Table 7).

CPUE and effort - The seasonal CPUE of 62.1 kg/th is the same as in 1999, and again the highest value ever recorded since 1978 (Table 7, Fig. 9). The effort (5,853 trap hauls) is about 25% higher compared to 1999 (Table 7, Fig. 10).

At-sea sampling by observers - The soft-shell crab percentage of 17% is higher than the percentage reported for 1999 (11%) (Table 5b). In 2000, 10 trips were covered by observers for a total of 28 traps sampled and 1,120 crabs measured, which is comparable to 1999 (10 trips, 36 trap, N=1,413)(Appendix 2). Adolescent males represented 16% of the catch composition in 2000, compared to 10% in 1999. The proportion of undersized adult males has increased to 14 % in 2000, a two fold increase over 1999. The mean CW of at-sea samples in 2000 was 106.7 mm (Fig. 11) compared to 110.6 mm in 1999.

CFA 22

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

Landings – The TAC increased to 534 t in 2000 (318t northern group and 216t southern group) compared to 518.5 t in 1999 (302.5t northern, 216t southern). The CFA 22 total landings in 2000 were 5% higher than those of 1999 (Table 8). In the northern portion, 23 fishermen landed 319t within 4 weeks, while 14 fishermen landed 216t in a period of 2 weeks in the outer area (Table 9). For both groups, 80% of the landings occurred in the week of July 24 -30.

CPUE and effort - The average seasonal CPUE of 78.7 kg/th is 40% higher than that of 1999 (Table 9, Fig. 9). In the northern area, the average CPUE was 68.6 kg/th in 2000, an increase compared to 54.1 kg/th in 1999 (Table 9). The average seasonal CPUE of 106.0 kg/th in the outer area in 2000 is over 40% higher than that reported for 1999 (65.7 kg/th). Total effort for CFA 22 in 2000 (6,803 trap hauls) is 30% lower than 1999 (8,841 trap hauls) (Table 9, Fig. 10). The breakdown shows that the seasonal effort for the northern area was 4,643 trap hauls in 2000, and 2,041 trap hauls for the outer area (Table 9).

At-sea sampling by observers – The soft-shell crab percentage of 14% is comparable to the percentage reported for 1999 (16%) (Table 5c). The observer coverage in 2000 was less extensive (12 trips covered by observers for a total of 58 traps sampled and 2,308 crabs measured) compared to 1999 (16 trips, 94 trap, N=3,680)(Appendix 2). Adolescent males represented 23% of the catch composition in 2000 compared to 12% in 1999 (Table 5c). The proportion of skip molters has also increased in 2000 (19%) compared to 1999 (8%). The mean CW of at-sea samples in 2000 was 102.5 mm (Fig. 11) compared to 106.2 mm in 1999. The proportion of undersized adult males has remained similar at 15 % in 2000 compared to 14% in 1999.

CFA 23

Fishing distribution – Fishing effort and distribution in 2000 was influenced by the sub-area boundaries which were introduced to control the fishing effort associated with the increase in the TAC in CFA 23 and by the “gentlemen’s sharing agreement” reached with the shrimp fishermen concerning the sharing of mutual fishing grounds. In this later case, some areas of CFA 23 were closed to the crab fishery for part of the year, and vice-versa. Permanent fishermen have mainly fished in sub-area 23A and 23B. Temporary fishermen have fished their respective sub-area (23B, 23C and 23D).

Landings **–** The TAC increased to 4,425 t in 2000 (i.e. 1,742t for the regular fleet and 2,683 t for the temporary fleet) compared to 1,300 t in 1999 (i.e. 900t for permanents and 400t for temporaries). Total landings in 2000 were 4,401 t (Table 10). Permanent license holders captured 1,743 t and temporary permit holders landed 2,658 t (Table 11). Landings occurred from June 1 to December 31, although 75% of the landings were caught in June and July alone.

CPUE and effort - The averaged seasonal CPUE of 85.0 kg/th is comparable to the average of 87.3 kg/th reported in 1999 (Table 10, Fig. 12). The total effort of 51,734 trap hauls is 3 times higher than 1999 (14,888 trap hauls)(Fig. 13). The 2000 seasonal CPUE of permanent license holders of 103.4 kg/th is 11% higher than 1999 (93.3 kg/th), while the total effort of 16,857 trap hauls is almost twice as high as 1999 (9,647 trap hauls)(Table 11). Meanwhile, temporary fishermen had a seasonal CPUE of 93.8 kg/th in sub-area 23B, 87.1 kg/th in 23C and 60.0 kg/th in 23D (Table 11).

At-sea sampling by observers - The 2000 seasonal percentage of soft-shell crab is 5% of total catches (Table 5d). In 2000, 4% of the hard-shell adult males were under the legal carapace size limit of 95mm CW (Table 5d) which is 4 times less than 1999 (16%). Adolescent male crabs accounted for 12% of the total catches in 2000, an increase compared to 8% in 1999. The mean CW of at-sea samples was 108.8 mm compared to 103.9 mm in 1999 (Fig. 11). In 2000, 46 trips were covered by observers for a total of 356 traps sampled and 13,475 crabs measured, which is more sampling compared to the 27 trips, 223 traps and 8,875 crabs measured in 1999 (Appendix 2).

CFA 24

Fishing distribution **–** Fishing effort and distribution in 2000 has been influenced by the sub-area boundaries introduced to control the fishing effort associated with the increase in the TAC in CFA 24 and by the “gentlemen’s sharing agreement” reached with the shrimp fishermen concerning the sharing of mutual fishing grounds. In this later case, some areas of CFA 24 were closed to the crab fishery for part of the year, and vice-versa. Permanent fishermen have mainly fished in sub-area 24A and 24B. Temporary fishermen have fished their respective sub-area (24B, 24C, 24D and 24E).

Landings **–** The TAC increased to 4,374 t in 2000 (i.e. 1,688t for the regular fleet and 2,686 t for the temporary fleet) compared to 1,400 t in 1999 (i.e. 825t for permanents and 575t for temporaries). Total landings in 2000 were 4,300 t (Table 12). A breakdown by status shows that permanent fishermen caught 1,689 t and temporary fishermen landed 2,608 t (Tables 13). Landings occurred from June 04 to late December. However, because of organizational delays, all temporary fishermen were not ready to fish during (at least) the first week of this fishery; therefore no fishery activities occurred in sub-area 24C until June 18, 2000, and until June 15, 2000 in 24D and 24E.

CPUE and effort – The seasonal CPUE of 84.7 kg/th is almost 40% higher than the average of 1999 (60.6 kg/th)(Table 12, Fig. 12). The total effort of 49,813 trap hauls is two fold higher than the total of 1999 (23,110 trap hauls)(Fig. 13). The 2000 seasonal CPUE of permanent fishermen of 87.5 kg/th is 35% higher compared to 1999 (64.4 kg/th), while the total effort of 19,315 trap hauls in 2000 is 50% higher than 1999 (12,816 trap hauls). Meanwhile, temporary fishermen had a seasonal CPUE of 96.8 kg/th and a total effort of 9,392 trap hauls for sub-area 24B; 85.5 kg/th and a total effort of 4,536 trap hauls in sub-area 24C; 80.1 kg/th and a total effort of 13,365 trap hauls in sub-area 24D; and 50.1 kg/th and a total effort of 3,212 trap hauls in sub-area 24E (Table 13).

At-sea sampling by observers - The seasonal percentage of soft-shell crab (< 5%) derived from the sea-sampling data is 50% lower than 1999 (Table 5e). The 2000 data showed that 6% of the hard-shell adult males were under the legal carapace size limit of 95mm CW (Table 5e), representing a decrease of about 50% in undersize adult males compared to 1999. Adolescent males accounted for 19% of the total catches in 2000; a 40% increase compared to 1999. The mean CW of at-sea samples in 2000 was 111.7 mm (Fig. 11) compared to 104.8 mm in 1999. In 2000, 41 trips were covered by observers for a total of 376 traps sampled and 14,694 crabs measured, which is more sampling compared to the 37 trips, 245 traps and 9,439 crabs measured in 1999 (Appendix 2).

Biomass estimates in CFAs 21 and 22 based on the catch-effort information

The fisheries in CFAs 21 and 22 both opened on Saturday July 22, 2000, but only fishermen in CFA 22 northern had landings reported for the first 2 days of the season. Furthermore, there is a gentlemen's agreement in CFA 21 that bans fishing on Sundays. The daily distribution of the landings for each group in CFA 21 and 22 shows that overall very little landings occurred during the first 2 days of this fishery (Table 14). Therefore, biomass estimations using the catch-effort maximum likelihood estimation method were also obtained for CFA 22 northern and the combination of CFAs 21 and 22 northern without considering the first 2 days of the fishery in CFA 22 northern. The catch-effort analysis estimates that the snow crab biomass at the beginning of the fishery was 686 t in CFA 21; 858 t in CFA 22 northern (668 t without first 2 days); 1,469 t if CFAs 21 and 22 northern are combined (1,331 t without first 2 days); and 309 t in CFA 22 outside (Table 15, Fig. 14).

Mobile gear fisheries

Effort from the plaice fishery in 2000 was 830 hrs of trawling time in 4VN (40 hrs by otter trawl, 780 hrs by Danish seine) and 1,442 hrs in 4VS (174 hrs otter trawl, 1268 hrs Danish seine). Cod fishery accounted for 44 hrs of effort in 4VN, 4VS and 4W. Total seasonal effort in the shrimp fishery has remained somewhat constant between 1997 and 2000, but a shift in the effort from the outside to the nearshore is occurring since 1998 (Table 16, Fig. 15). Monthly effort shows that in 1997-98, most of the fishing occurred from May to July, but this has shifted to April to June in 1999-2000 (Table 16).

Northern ENS experimental trap survey

Bad weather and mechanical problems allowed for only 1 1/2 day out of the 10 days planned for this experiment (June 27 to July 6, 2000). Only 1 line transect of the 5 planned was sampled. Seven traps were set on June 30 between 190 and 350 m and fished on July 4^{th} (Fig. 16). Estimated CPUE increased from 47 kg/th at 190 m to 84.1 kg/th at 205 m, then decreased and remained between 45 to 60 kg/th at depths of 235 to 300 m, to sharply decrease to 7.5 kg/th at 345 m (Table 17). Temperatures increased from a fluctuating and averaging 5°C at 200 m to 5.5 °C at 300 m, and decreased to a constant 5°C at 345 m. A total of 200 adult crabs were tagged and released at the mouth of the trough in CFA 21 (Fig. 16). As part of this experiment, but during a different period in August 2000, another 1000 crabs were tagged and 800 were released in Glace Bay Hole, while the remaining 200 were released again at the mouth of the trough (Fig. 16).

Southern ENS fishermen (23D and 24 D) trap survey

This exploratory trap fishery clearly shows the absence of snow crab south of Sable Island, and on Western Emerald Banks (Fig. 17).

Annual trawl survey

In 2000, 322 trawl stations were surveyed between May 06 and July 04 (Fig. 18).
The total area covered for biomass estimation by kriging was approximately 32,100 km^2 in 2000, a total of 4,600 km^2 more surface was covered than in 1999 (27,500 km^2). 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 9,647 males and 4,039 females collected and measured in 2000 compared to 7,810 and 6,787 in 1999, respectively.

Northern ENS

In northern ENS, the number of trawl stations increased to 64 (excluding 5 extra stations) compared to 60 in 1999. Four new stations were added along the outside limit of the Glace Bay Hole area, therefore now extending the surveyed area to the slope of the Laurentian Channel. All trawl stations were surveyed before the fishing season, from May 06 to May 20, 2000. The estimated total area covered for biomass estimation by kriging in northern

ENS was 4,820 km^2 in 2000. Total biomass based on the total surface covered and with the projected habitat area was estimated at 2,358t ± 97% in 2000 (Table 18). However, total biomass based only on the total surface covered (without the PHA) was estimated at 2,926t ± 72% in 2000 (Table 18).

In the case of the estimations done without the PHA, the exploitable biomass (B_e) was estimated at 2,619 t (± 61%) in 2000. The recruitment to the fishery (R-1) was estimated at 307 t (±164%) in 2000 compared to 1,101 (±106%) in 1999. Overall, the density (in number) of juvenile and adolescent, as well as adults, has decreased in 2000 compared to 1999 (Fig. 19). Proportional distribution (in % by CFA) of the biomass of adult males ≥ 95 mm CW at the time of the trawl survey in 2000 is shown for in Table 19.

Southern ENS

In southern ENS, 253 trawl stations (including 10 extra stations) were surveyed in 2000 compared to 214 in 1999. Ten old trawl stations (of the not to be repeated extra 30 in 1999; Biron et al. 2000) situated on Banquereau Bank were abandoned in 2000, but 5 new stations were added in the eastern limit of the Missaine Bank area, 10 others added in the already covered western Missaine Banks area, and 34 stations added to the western most portion of the survey which now covers most of Emerald Bassin (Fig. 18). The estimated total area used for biomass estimation by kriging in southern ENS was 27,312 km^2 in 2000. The total biomass based on the total surface covered each year was estimated at 28,939t ± 47% in 2000, while the total biomass estimate based on the originally surveyed area (OSA) was 28,726t ± 40% (Table 20). The exploitable biomass based on OSA was estimated at 22,325t ± 37% in 2000. The recruitment to the fishery (R-1) was estimated at 6,401t (±48%) in 2000 compared to 8,118 (±58%) in 1999. Overall, the density (in number) of juvenile and adolescent, as well as adults, has decreased in 2000 compared to 1999 in the originally surveyed area (Fig. 20). The size frequency histograms for the total area surveyed any given year (all stations) are almost identical to the histograms of the originally surveyed area for that given year (Fig. 21). Proportional distribution (in % by CFA) of the biomass of adult males ≥ 95 mm CW at the time of the trawl survey in 2000 is shown in Table 19.

Snow crab distribution

The adult male ≥ 95 mm CW density distribution map shows less patches of high density concentration than in 1998 and 1999, but with a more diffused density distribution throughout the surveyed area (Fig. 22). Patches of highest density concentration were mainly found in the troughs between Misaine and Banquereau Banks, and between Banquereau and Sable Is. Banks.

The highest density of adult male snow crab ≥ 95 mm CW with carapace condition 1 and 2 were found around the Misaine Bank area, especially in the trough between Misaine and Banquereau Bank (Fig. 23). The other patches of high density of adult male ≥ 95 mm CW found nearshore, west of Misaine Bank, and in the trough between Banquereau and Sable Is. Banks are mainly composed of snow crab of carapace condition 3, 4 and 5 (Fig. 23).

The highest density concentration of small male crabs (< 56 mm) was found near shore and in the Misaine Bank area (Fig. 24). Adolescent males between 56 and 76 mm CW were mainly concentrated on the north side of Sable Island Bank, with smaller density concentrations nearshore (Fig. 24). Adolescent males between 76 and 94 mm CW were mainly concentrated in sub-areas 23A, 23B and 24A, with another major concentration on the north side of Sable Is. Bank (Fig. 24).

The density distribution of immature female shows a patchy distribution that is mainly located along the shore region of CFAs 21 and 22 northern, and in sub-areas 23A, 24A, 24C and 24E (Fig. 25). Three major density concentrations of adult females were observed in CFAs 21 and 22 northern, on the north side of Sable Is. Bank and nearshore in sub-area 24E, with 2 other important concentrations in the Misaine Bank area and nearshore in sub-area 24A (Fig. 25).

<u>Temperature distribution from the trawl surveys</u>

In 2000, temperature data collected during the trawl survey shows that the coldest bottom temperatures were encountered in CFA 22 northern (-0.5 to 0.75°C), while most of the remaining grounds surveyed in northern ENS was between 1 to 3°C (Fig. 26). In southern ENS, cold water temperatures (-0.5 to 3.5) were also recorded during the trawl in most areas of CFA 23, in sub-area 24A, and along the shore in sub-areas 24C and D. The warmest temperatures were recorded in the southwestern portion of CFA 24 (Emerald Basin, Sable Is. Bank and Middle Bank) in 2000.

<u>Seasonality effects and the trawl survey</u>

Simple comparison of the number of crab captured at each of the same 5 trawl stations sampled in May and July shows a marked difference between the two sampling periods. There was 2 1/2 times less adult males and 8 times more females caught in May than in July (Table 21).

DISCUSSION

Overall, the CPUEs have increased in all areas and sub-areas compared to 1999 (or at the very least remained similar as in CFA 21). There are however important considerations to be made before interpreting the 2000 fishery-related data and indices. Any attempts to compare this data with historical data, especially data before the mid-1990s, should only be done to illustrate how much the ENS fisheries have changed in recent years.

CPUEs (effort, landings and other fishery-related indices)

Although preliminary analyses showed an increase in average soak time in some CFAs, it was judged unnecessary to adjust catch rates for soak times. The reality is that soak time is one of the factors that should be adjusted to render CPUEs of the 2000 fishing season comparable to those of recent history (mid-90s to date), let alone any historical data previous to that. Other than soak time, there is the change of gear, the new fishing season and the fishing pattern that should be accounted for, as well as seasonality and other fisheries impact (the last 2 factors will be discussed later).

<u>Factors influencing fishery-related indices in 2000</u>

Change of gear- In southern ENS, the increase in the TAC resulted in an increase in temporary permits and a sharp increase in newer types of gear. In CFA 23, the increase in the allowed number of traps to 45 from 30 resulted in some cases with fishermen having a mix of old/new traps. Unfortunately, information from the logbooks does not provide an accurate and complete picture of the types of gear used in ENS. Some logs report only the most common traps used by a given fisherman, while others are unclear (e.g. 6-7' cones). It is believed that CPUEs of high cone traps are usually higher than any other type of trap, under the same conditions, but two preliminary experiments attempting to verify this belief were inconclusive for ENS. Discussions with some fishermen also indicated that it was only after 48 hr soak time that differences between low and high cone traps can be appreciated. Indications of this may be drawn from CFA 22 outside where the average CPUE for 24 hr soaking time was 89.3 kg/th (N=39), while it was 153.6 kg/th at 48 hr soak times (N=18). There was a change of gear by some fishermen of this fleet, and a portion of these opted for the newer types of gear.

Fishing season **–** Fishing season in 2000 was not an issue for northern ENS since it was basically the same period as in 1999. It was however an issue in southern ENS, which started 7-8 weeks earlier and finished 12 to 14 weeks later than in 1999. The length of the fishing season does not reflect how long it took to catch the TAC, but was rather the reflection of personal preferences from fishermen and the manner some of the IBQs were fished. Some vessels had fished more than one IBQ, but had to do it one at a time and with a short break in between quotas being fished (by license conditions). In other cases, license owners were not ready to fish until late in the season. Most of the landings occurred in June and July in southern ENS.

Fishing patterns – In general, fishermen setting their gear nearshore (i.e. CFAs 20, 21, 22 northern, and sub-areas 23A, 24A, 24C and 24E) make day trips to attend their gear (on a regular daily basis whenever possible) until the completion of their respective IBQ. Fishermen fishing further away (sub-areas 23C, 23D, 24D and parts of 23B and 24B) generally make longer trips where they attend their gear, at first, after a 2-3 day soak time, and then remain on these fishing grounds to fish on a 12-24 hrs basis for 1 to 2 days before returning to shore. In both cases, fishing pattern can be altered by demands from processors to reduce daily landings or weekly trips (Biron et al. 1999, 2000), by increasing the number of allowed traps (e.g. increased from 30 traps to 45 in CFA 23), by the density of crab on the fishing grounds and / or holding capacity of the vessel used, or simply by personal preferences from any given fishermen.

Soak time – Changes in averaged soak time observed in ENS from year to year towards longer intervals between fishing may result in a false increase of CPUE value (underestimation of fishing effort). The similar phenomenon was observed in the CFA 12 fishery since 1994 (Hébert et al. 2001). However, to adjust CPUEs to soak time without considering any of the other factors such as new gear type, possible catchability difference of the traps over a 7 month fishery period, different fishing patterns between 'near to' and 'far from' shore, will only result in another set of numbers still not really comparable with earlier years, while inducing a false impression of "improving" the comparison of these data bases.

Implication to the fishery – If fishery-related indices such as CPUEs and total effort are compared to 1999, there should be no doubt that snow crab fisheries in ENS have done better (or similar in CFA 21). However, the magnitude of certain increases in CPUEs or decrease in effort should be considered 'inflated' by the above enumerated factors. For exemple, one permanent license changed hands in CFA 20 in 2000, and the new license holder is using the newer high cone traps. Omitting this 1 fishermen from the logbook analysis resulted in an averaged seasonal CPUE for the permanent fleet in that area to drop to 49 kg/th from 57 kg/th, if all 5 fishermen are considered.

Putting aside any comparison with previous years, CPUEs and fishing effort in ENS were fairly well distributed amongst all the available fishing grounds in 2000, and that regardless of the fishermen status or any specific fishing area (Fig. 27). This should be taken as evidence that management measures taken to distribute the increased fishing effort (e.g. management lines) seems to have worked well in 2000. Differences amongst fishing areas seems to be a fair reflection of the differences in gear type, concentration of fishing effort in given areas, and / or density of crabs on the exploited grounds.

At-sea sampling (by certified observers)

In CFAs 20, 21 and 22, the fishing season, location of the fishing grounds, and the coverage by the Observer Program (in number of trips and traps sampled) is comparable to 1999. In CFAs 23 and 24 however, the fishing season started 7 to 8 weeks earlier and finished 12 to 14 weeks later than 1999. In both CFAs 23 and 24, some permanent fishermen were kept outside of their ‘usual’ fishing grounds in 2000 because some areas were closed and reserved for the shrimp fishery until July 1st, while the increase in effort in 2000 generally translated in more fishing grounds being exploited than in 1999. The number of traps sampled and crab measured has increased by 50% compared to 1999, and all sampling coming from the second half of this fishery (Sept. 15 to Dec. 31) was covering only the C, D and E sub-areas because fishermen in the A and B sub-areas had basically finished their season. The relatively lower increase in the number of trips compared to the number of traps is the result of the fishing pattern in southern ENS. For the nearshore fleet, 1 trip represented approximately 24 hrs at sea with 4 to 8 traps sampled, while 1 trip in the far from shore fishing grounds often meant 48 to 72 hrs at sea with 15 to 30 traps sampled. Therefore, comparison by sub-areas in 2000, or with sub-areas data of 1999 was judged ill-advised and are therefore not presented in this stock assessment.

From a global perspective, there is one common characteristic to all CFAs observer data in 2000: the ratio of adolescent to adult crab has changed in favor of the adolescents, with the proportion of adolescent crab having increased 1 to 2 fold compared to 1999. By itself, it does not mean much, adolescent numbers could be increasing, adults could be decreasing, or a little bit of both. Put in the context of the trawl survey that shows recruitment (juvenile and adolescent) in ENS has been decreasing by up to 40-50% every years since 1997, the increase in the proportion of adolescents caught in the catches could be the results of the decreased abundance of adult males in 2000 compared to 1999. The decrease in soft-shell crab observed in CFAs 23 and 24 might only reflect the earlier start of these fisheries.

Review of the available literature on the effects of mobile fishing gears

During the snow crab RAP of Jan. 2000, concerns were expressed by the Scientific Committee and most of the ENS fishermen’s associations concerning the direct and indirect effects mobile gear had on the snow crab population. In fact, the gear used in the shrimp fishery was the one that seemed to attract the most attention because since 1998 this fishery shares most the same fishing grounds as the snow crab fishery. However, we should keep in mind that other fisheries, no matter how greatly reduced they have recently become, are also sharing the same fishing grounds like the Glace Bay Hole area in CFA 22 or the area near St. Paul Is. in CFA 20. Very little work has been done in areas of interests (depths and species wise), and none has been found concerning the type of gear used in the shrimp fishery in

ENS. Nevertheless, the current knowledge gives enough information to draw general conclusions that are ‘shared’ to different degrees by all type of mobile gears, as well as an indication of its impact on the snow crab population and their habitat. The degree of environmental perturbation from bottom trawling activities is related to the weight of the gear on the seabed, the towing speed, the nature of the bottom sediments, and the strength of the tides and currents (Jones 1992). In the specific case of the shrimp fishery, keep in mind that preliminary investigations have not shown any direct evidence of damage or mortality in snow crab (i.e. complete or parts of bodies in the bycatch and on the footgear) caused by the type of gear used in ENS during this fishery (Peter Koeller, pers comm.).

Effects of mobile gear on benthic habitat and communities – Recent reviews on the effects of mobile gear on benthic habitat and communities (Dorsey and Pederson 1998, Jennings and Kaiser 1998) have presented some conclusions that seem to be generally accepted by the scientific community (Gordon, unpublished information). There is, however, continuing scientific debate over the extent and significance of the effects that have been observed (Gordon, unpublished information). The overview produced by Gordon (unpublished information) probably resumes best the current state of knowledge that we have concerning the general impact of mobile gear on benthic habitat and communities:

- Effects of mobile gear can be seen on benthic habitat and communities but are quite variable and depend upon the type of gear (i.e. beam trawl, otter trawl, scallop rake, clam dredge, etc.), the intensity of use, the type of habitat (i.e. mud, sand, gravel, etc.) and the kind of benthic organisms present (i.e. attached, burrowing, tubedwelling, migratory, etc.). In some instances, effects are negligible while in others they can be substantial.
- Benthic habitat and communities are subjected to natural physical stress through agents such as storm waves, tidal currents, ice scour, sediment transport and bioturbation.
- Natural variability in benthic communities (both spatial and temporal) compounds the detection of mobile gear effects, especially if proper reference sites are not available.
- Effects are greatest on benthic habitat and communities infrequently subjected to natural stress.
- Frequently fished bottoms show less impact from mobile gear than undisturbed bottoms.
- Mobile gear can alter physical and biological habitat structures and thereby reduce habitat complexity.
- There is evidence that repeated physical disturbance by fishing gear can led to significant changes in the physical structure of benthic habitat and composition of benthic communities.
- Changes in habitat structure may affect the survival of juvenile commercial fish.
- Except on rough bottoms, mobile gear will suspend sediment into the water column and may also affect chemical exchanges between sediments and the water column.
- Organisms most affected are larger, longer-lived forms that live on or close to the seabed surface (e.g. echinoderms, molluscs, corals, etc.).

- Certain opportunistic species can increase in abundance.
- Damaged and exposed benthic organisms, as well as discarded bycatch, attract scavenging species into recently disturbed areas.
- The observed biological effects are due to several interacting factors including direct removal by the gear, damage, predation, migration and suspension.
- Analysis of fishing effort data indicates that bottom disturbance from mobile gear is very patchy in its geographic distribution.
- Almost 100 years of trawling in the North Sea has led to a decline in bivalves but an increase in scavengers such as crustaceans, gastropods and sea stars.

Effects of mobile gear on snow crab population – The effects described above are general conclusions drawn from the studies on the effects of mobile gear on various type of habitats. In that respect, one of the most important ecological impacts of fishing gear on the sea floor is reduction in habitat complexity and in biodiversity (Collie 1998; Engel and Kvitek 1998). However, snow crab is a scavenger by nature, and one other impact mobile gear has on the habitat is that it helps establishing the domination of scavenging species. Collie (1998) compared gravel bottoms of fished areas with those of unfished areas and reported that undisturbed areas in Georges Bank had a higher number of fragile species (shrimp, brittle stars, anemones, sponges and juvenile fish, colonial epifauna, and tube worms), while hard shell molluscs and scavengers (sea stars and hermit crabs) dominated disturbed (fished) areas. In a study on the response of benthic scavengers to fishing disturbance, Ramsay et al. (1998) observed an increase in the density of scavenger crab in some of the fished areas after fishing had taken place, while no change in density occurred in adjacent control (unfished) areas. But he also cautioned that the responses of scavengers to towed fishing gears varied considerably between different sites (in time of appearance and magnitude of response), and are not always manifested as a large increase in their abundance. It is clear that the magnitude of response varies between species and between habitat types (Ramsay et al. 1998). These scavengers were attracted and fed on damaged bivalves, echinoderms, crustaceans, whelks and polychaetes (Ramsay et al. 1998).

Since 1990, the Department of Fisheries and Oceans has been conducting an experimental program on the impacts of mobile gear on benthic ecosystems in Atlantic Canada (Messieh et al. 1991, Gordon et al. 1998). The main accomplishment to date has been a three years experiment (1993-1995) on the effects of otter trawling on a sandy bottom ecosystem of the Grand Banks of Newfoundland (Rowell et al. 1997, Gordon et al. 1998, Schwinghamer et al. 1998, Prena et al. 1999). Each year, three 13 km corridors (120-146 m depth) were trawled 12 times with an Engel 145 otter trawl (equipped with rock-hopper footgear) which created a disturbance zone on the order of 120 to 250 m wide (Gordon et al. 1998). In its description of the biological impacts of this experimental otter trawling, Gordon et al. (1998) mentions that the biomass of epibenthic organisms caught decreased significantly with repeated trawling, and an influx of scavenging snow crabs was observed during the later trawl sets

(10-12 h after trawling began). The fish catch and the catch of the three dominant species in the trawl bycatch (snow crab being one of them) declined steadily over three years. A significant difference was observed in the total biomass of invertebrates sampled by an epibenthic sled between trawled and adjacent untrawled corridors, with the total biomass being on average 25% lower in trawled corridors (Gordon et al. 1998). However, unlike the trawl catch, the sled catch did not decrease significantly from 1993 to 1995. The total biomass of benthic animals such as snow crab, sand dollars, soft corals and brittle stars was significantly lower in trawled corridors. And sand dollars, sea urchins and brittle stars also showed significant levels of physical damage.

Implications of mobile gear on snow crab fishery – Mobile gear might be a mixed blessing for the snow crab fishery. There is the indirect negative and yet to be quantified impact on the benthic habitat and communities, and the direct negative impact such as mortality, damaged shell, etc… Direct impact varies considerably between gear types. In ENS in 2000, the principal fishery using mobile gear was by far the shrimp fishery, where preliminary investigations have found very little evidence (body parts) of mortality or damage on the snow crabs. The true impact of the shrimp fishery mobile gear remains to be properly studied before any attempts at quantifying its effects are realized. But there might also be a (short term?) positive impact to the mobile gear fleets sharing of some fishing grounds with the snow crab fishery. Areas recently fished by a fleet using mobile gear has the potential to attract an influx of snow crab, and therefore increase the density of crab over what would have been present otherwise if the grounds had remained undisturbed. It becomes easy then to speculate that fishermen fishing on these grounds might have higher CPUE from resulting higher concentration of crabs than others fishing nearby but on undisturbed grounds. In other words, the hypothesis here is that for certain areas, and if the scale is large enough, disturbed grounds might act as center of attraction concentrating crabs that would otherwise have been less dense and more disperse.

Indications of this were suggested by trawl fishermen and snow crab fishermen who fished in and around Glace Bay Hole in recent years. It seems that when trawling activity begins in Glace Bay Hole there is no crab to be found, but towards the end (about 2 weeks before the crab fishery starts) the bycatch of crab becomes too much and trawling activities stop. However, Glace Bay Hole is a particular area, and it is premature to conclude that the fluctuation of the abundance of snow crab is caused by trawl activity, as seasonal movement might also be at play here.

The relationship between the shrimp fishery and the snow crab fishery, if any, is not clear. Before 1998 in CFAs 23 and 24, there was no effort by the shrimp fishery nearshore (excluding the trap fishery), nor too much activity by the snow crab fleet where the shrimp was concentrated further offshore. Since 1998, the averaged seasonal effort by the shrimp fishery has remained similar, but the effort has been concentrating (shifting) nearshore (Bad

Neighbor Shoal), while increased effort in the snow crab fishery has now spread to the outside edge of the Scotian Shelf.

Ecosystem Considerations

In winter, heat losses to the atmosphere and the outflow of frigid water from the Gulf of St. Lawrence reduce the temperatures of the surface waters on the Scotian Shelf to near the freezing point (Davis and Browne 1997). In some years sea-ice covers a large portion of the northeastern Shelf in winter. Subsurface temperatures tend to increase with depth at this time of year. In summer, seasonal heating near surface produces a warm upper layer. In some areas this results in a three-layer system, with this warm surface layer overlaying a cold intermediate layer and a warmer deep layer that originates in the offshore Slope Waters. This deep warm layer is not prevalent over much of the deep regions of the northeastern Scotian Shelf, however, because the topography prevents its penetration into the northeastern region (Ken Drinkwater, pers. comm.). Satellite images demonstrate that persistent southwesterly summer winds produce a band of cold, upwelled water near the coast that subsequently form eddies through instability of the upwelling front.

Studies of the seasonal variations show cold bottom temperatures (<4°C) year-round in the deeper area northeast of French, Middle and Banquereau Banks (CFAs 20 to 23, with 24A and 24B), as well as a narrow band along the shore (24C and E) that ends in southwestern Nova Scotia (4X fishery)(Drinkwater et al. 2001). At the time of the trawl survey, the coldest bottom temperatures (-0.5° to +2°C) were found near shore off southern Cape Breton and gradually increased to 5°-6°C to the east in Laurentian Channel and to 6°-7°C on the shallow water of Banquereau, Sable Island and Middle Banks to the south and west. The warmest temperatures in 2000 were in the southwestern portion of CFA 24 (Emerald Basin, Western Bank and Middle Bank). This spatial pattern is typical of what is seen in most years.

Bottom temperature conditions in the northeastern Scotian Shelf during 2000 were generally warmer than the long-term average conditions, defined using the years 1961-1990 (Drinkwater et al. 2001). They also warmed relative to 1999 and contrast to the colder-than-average temperatures from the mid-1980s to the late-1990s. The snow crab habitat index, defined by the area of the bottom with temperatures of -1° to 3°C, declined and was at its lowest value since 1984 (Drinkwater et al. 2001). Given that colder-than-average bottom temperatures are considered to be better for snow crab in these Areas, the low snow crab habitat index, the warmer-than-average bottom temperatures and the warming trend all indicate that bottom environmental conditions are becoming less favourable for the crab compared to conditions observed during the 1990s.

Annual trawl survey and Biomass estimations

Total biomass estimations

Since 1997, separate variogram and biomass estimates were established for each of the three adult categories: the recruitment to the fishery (adult ≥95 mm of carapace condition 1 and 2), the exploitable biomass (adult ≥95 mm of carapace condition 3, 4 and 5), and total adult snow crab population (adult ≥95 mm, all carapace condition included). However in February 2001, at the Snow Crab RAP meeting in Moncton, New Brunswick, the Scientific Committee recommended that 'total biomass' category be simply equal to the sum of the other two categories (recruitment and exploitable), rather than it to be separate set of kriging analysis. From a biological point of view, the recruitment and the exploitable adults categories are two distinct biological categories of crab which might have different distribution pattern (i.e. pinpointed, patchy, diffused, etc…), density concentration (i.e. low, high) and/or trend pattern (i.e. increasing, decreasing, peaking, bottoming). In some years, these differences result in variograms that are quite different between the two groups. Total adult biomass however is not a distinct biologically based category but the sum of the other adult categories. Producing a separate variogram and resulting set of estimation numbers for this category during years with marked difference will mostly reflect the stronger adult biological category of that given year.

In order to comply with this recommendation, total adult biomass for 1997, 1998 and 1999 presented in the present document have been corrected and are different from total biomass presented previous stock assessment.

Projected habitat area

Introduced in 1999 to compensate for the overestimation of adult males snow crab ≥ 95 mm CW, which was created by the particularly rough bottom encountered in CFAs 23 and 24, the projected habitat criteria were naturally applied to the smaller CFAs 20, 21 and 22 fisheries as well because they are part of ENS. Although the PHA seems to reflect the distribution of commercial snow crab at the time of the survey in southern ENS, it is a source of underestimation for northern ENS and the Misaine Bank area in CFA 23. Although depth is used to calculate the PHA, it is more of a coincidental parameter that seems to best describe the commercial size snow crab habitat (but not a limiting factor). The nature of the distribution of snow crab points to the fact that boundaries of distribution are determined mainly by the temperature factor, while the formation of large populations in a particular area is determined by a set of factors such as the direction of the currents that transport the larvae, the type of bottom substrates, sufficient space and a supply of food for foraging adults (Slizkin 1982).

In northern ENS, the problem is that the PHA was developed and based mainly on the commercial fishermen's knowledge from fisheries that, until 2000, began in July for all CFAs, while the trawl survey in this region is usually done in May. It is believed that because of the cold bottom water temperatures cover most of the grounds during the trawl survey in May, the application of the PHA to the kriging calculation results in lower estimation values of the commercial crab biomass for northern ENS. Furthermore, once all is considered, the bottom topography of northern ENS resembles more that of western Cape Breton (CFAs 18 and 19). In 2000 for example, the total biomass was estimated at 2,358 t when using the PHA, and 2,926 t when all trawl stations are considered in the analysis (i.e. without the PHA). In this case, the increase in biomass is not the result of an increase in surface considered for the analysis, but because crab were found in stations that would otherwise be excluded from the analysis by the PHA. The real extent of this underestimation is unknown, but the results from the catch-effort analysis in CFAs 21 and 22 northern in 2000 gave biomass estimation comparable, although lower, than the biomass estimation from the trawl survey for the same area. Even in CFA 22 outer, where some assumptions required by the catch-effort method were not met, results between the two methods were similar. In this case, the quickness of the fishery (9 consecutive fishing days) might have somewhat compensated for the missing requirements such as no immigration/emigration. It is also true that the overall surface covered by the trawl survey is larger than the two distinct fishing grounds covered by the catch-effort analyses. However, rather than to second guess if we should revert to the original PHA used in western Cape Breton or to simply modify the depth strata used in the current one to exclude less grounds, a detail investigation of the distribution of crab in northern ENS should be realized in 2001 to properly answer this question.

In southern ENS, the problem with the projected habitat in the Misaine Bank area is of a different nature. Contrary to Banquereau, Sable Is., French or any other major banks in ENS, Misaine Bank is not a well defined bank but rather is riddled with deep troughs separated by narrow bands of 'banks'. High concentrations of adult males >95 mm have been found in some of the trawl stations in the Misaine Bank area, but are being canceled by the more grossly defined mask of the PHA. Here again, the extend of the underestimation for that area of southern ENS is not known.

Surveyed area versus snow crab distribution

In the northern Pacific Ocean, snow crab is encountered everywhere where the water temperature at the bottom fluctuates from –1.8 to +7.0°C, and optimal temperatures for juveniles are below zero even in summer (Slizkin 1982). In SGSL and on the Scotian Shelf, previous studies have determined that snow crab are found where the range of –1 to 4°C prevails throughout the year (McLeese 1968, Squires, 1990). However, adult snow crab have been reported in warmer (6-7°C) bottom temperatures on the southwestern Scotian Shelf (4X fishery) during the summer of 1999 (Biron et al. 2000b), as well as along the slope of the Laurentian Channel (5-6°C) in 2000.

Northern ENS – The partial trap survey realized in June in northern ENS indicates that snow crab might be present on the slope area of the Laurentian Channel, at depth of 200 to 400 m at the time of the survey in May. The 4 new stations added along the outside limit of the Glace Bay Hole area improved the coverage by the trawl survey by extending the surveyed area to the edge of the slope of the Laurentian Channel in CFA 22. However, except for the St. Paul Is. area in CFA 20, the slope area of the Laurentian Channel in northern ENS remains largely uncovered by the trawl survey. Therefore, it implies that the area currently being covered by the trawl survey does not cover all the possible snow crab habitat available at that time of the year. The number of stations in the northern ENS trawl survey should be increased or reorganized to cover the slope area of the Laurentian Channel (200 to 400 m deep) in 2001.

Southern ENS – The trap survey that was realized in late summer/fall in sub-areas 23D and 24D has demonstrated the clear absence of adult snow crab on the southern side of Sable Island Bank and on Western Bank. In the same manner, temperature distribution and snow crab density distribution from the survey suggests the absence of snow crab in the offshore portion of sub-areas 24C and 24E (new stations added in 2000), while there is clear evidence of a high density concentration of snow crab in the colder uncovered grounds along the nearshore in sub-areas 24E. The number of trawl survey stations in southern ENS should be increased or reorganized to cover the nearshore area in sub-area 24E.

<u>Snow crab movement and distribution in ENS</u>

Seasonal movement – Recent investigations suggest that coastal populations of snow crab in the Gulf of St. Lawrence move extensively during winter and are not restricted to their deep summer habitat (Lovrich et al. 1995). Snow crab have been found in shallow water (2.5 to 30 m) between March and May (Taylor et al. 1985, Sainte-Marie et al. 1988, Comeau et al. 1991, Sainte-Marie and Hazel 1992, Lovrich et al. 1995). It is believed that movement to shallow water is linked to molting and reproduction. Snow crab occupation of the shallow grounds from October to May might be temperature dependent because it would be energetically costly for snow crab to reside in the shallow areas during summer (Maynard 1991, Lovrich et al. 1995). Snow crabs are believed to synchronize their inshore migrations with temperature in order to experience a stable thermal environment conducive to sustained locomotory activity (Lovrich et al. 1995).

The impact of snow crab movement on the results of the trawl survey in ENS, seasonal or other, is believed to be of a greater magnitude and importance than in the SGSL, especially in the Glace Bay Hole area and along the slope of the Laurentian Channel. In 2000, as in 1997-

99, a few snow crab fishermen have reported catching snow crab in shallow water (6 to 15 m) while attending their lobster or rock crab gear in early spring, an indication of shoaling behavior in ENS. Indirect evidence of movement in southern ENS was also underlined with the preliminary identification of two species of barnacles on the carapace of adult male crabs: *Balanus crenatus* and *Balanus balanus* (Gilles Miron, pers. Comm.). These two species are commonly found in ENS at depths of up to 90 and 160 m deep, respectively. Considering that the bulk of the snow crab fishery in ENS is realized at depths of 140 to 250 m, this could indicate movement towards or from shallower water at one point in adulthood. However, further scientific research is required before any final conclusion can be drawn from this.

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

Changes in 2000 fishing season versus the trawl survey – An earlier start to the snow crab fishery seasons in southern ENS in 2000 meant that 1/3 of the trawl stations in CFA 23 and most of the stations in CFA 24 were sampled during the beginning of these respective fisheries (Fig. 28). In CFA 23, however, all the stations covered after the official beginning of the fishery were done within 24 to 72 hr of the first appearance of fishing activities in each respective sub-areas, and in some cases were protected by the 'reserved to the shrimp fishery areas' that were off limits to the snow crab fishery until July 1st (e.g. 4 of the 7 station nearshore), or again, located in areas with very little fishing activities to begin with, like the stations on Banquereau Bank. In CFA 24, only the inshore of 24A was covered before the fishery began, but the lateness in announcing the early start in this CFA resulted in a slow and delayed (by up to 2 weeks in 24C) start in sub-areas B, C, D and E. The real impact of conducting the trawl survey at the beginning of fishing activity in 2000 is unknown, but the possibility that commercial size crab could have been removed by fishing activity in an area where a trawl station was to be done exists, which could mean another source of uncertainty toward the biomass estimations in 2000. However, considering how early the stations were realized into the start of the fishery, combined with the relatively small effort distribution at first and the substantial differences in fishing activity locations as compared with the locations of some of the last stations sampled, the impact of an early season on the trawl survey biomass estimates is considered minimal for the time being.

At the other extreme, the fact that there was still fishing activity going on in December, although very little in terms of proportion of landings, meant that the latest part of the fishery logbooks (December) were not included in the fishery analysis. The electronic version of the logbook data is readily available, but these latest entries are uncorrected and do not include all fishing positions on the logs, and the remaining fishermen were mostly in sub-areas 23 D where a exploratory trap survey had to be done.

Relationship between the shrimp fishery and the trawl survey timing **–** The relationship, if any, is not known, but it should be noted that since 1997, in ENS, the trawl survey has always occurred after the bulk of effort from the shrimp fisheries had been completed and before the snow crab fisheries (except CFA 24 in 1998). Considering that the crab concentration may be created by the mobile gear disturbance, and the possible seasonal movement occurs over time, it is quite probable that changing the timing of the trawl survey will result in a different 'picture' of the snow crab distribution in ENS. It should be made clear that Science does not oppose any modification to the timing of the trawl survey in ENS to accommodate a developing fishery, if it is what is required by the industry, but the realization of the trawl survey during the beginning of the fishery is unacceptable. It should however also be made clear that changing the timing of the trawl survey may have serious consequences on the work realized since 1997, even compromising the historical trend data collected to date.

Predicted biomass estimates for 2001

The 2000 survey indicated that there was 2,926 t of total biomass in northern ENS (CFAs 20, 21 and 22) and 28,939 t of total biomass in southern ENS (Areas 23(A-D) and 24(A-E)). The fishery in CFAs 20-22 harvested 1,017 t, while the fishery in CFA 23 and 24 harvested 8,701 t. Thus assuming that all major fishing grounds were covered by the trawl survey in 2000, and that no other losses will occur in the meantime, the biomass available for the 2001 fishery will be 1,909 t in northern ENS and 20238 t in southern ENS.

Although references to sources of underestimation (i.e. mask, seasonal movement, early fishery) have been made for ENS, it should not be interpreted as an overall gross underestimation of the biomass in 2000. In northern ENS, the catch-effort biomass estimations suggested a comparable lower biomass concentration in CFAs 21 and 22 northern than the trawl survey, an indication that the survey is not that far from the truth. Only in CFA 22 outside, which might benefit from a seasonal movement of crab from the slope area not covered by the survey, can underestimation be of concern. This year, the effort of Science was directed mainly towards the adaptation of the trawl survey to specific areas of ENS (the fine tuning stage) which has resulted mostly in the identification of possible sources of underestimation for the trawl survey. All the overestimation sources underlined in previous research document such as natural mortality, snow crab fishery induce mortality (other than landings), or other fisheries or industrial (i.e. natural gas, seismic exploration) induce mortality are not taken into account for the 2001 biomass estimation. In CFA 24, a 30% loss in biomass was noted in the originally surveyed surface in 1999 compared to 1998, and the change was put on mortality and movement (Biron et al. 1999). Mortality sources are basically being ignored from the assessment and management of these fisheries, but it exists and may be an important source of overestimation in a snow crab population on a decreasing trend.

The overall little difference in biomass estimates of male adult >95 mm crab between the originally surveyed area and total surveyed area in southern ENS can be explained by the fact that the area surveyed has increased by 4,600 km^2 in 2000, and most of these stations were added largely in area without snow crab. This had for consequence to decrease the average density/ km^2 of snow crab found in southern ENS, while increasing the overall surface covered by the trawl survey. Furthermore, adding stations in peripheral locations of the area covered by the trawl survey in 1999 such as sub-area 23D, 24 D, 24 C and 24E might have eliminated or reduced the impact of edge effect factor (replacing unknown surface by trawl info).

Conclusion / Recommendations

'Traffic light' style analysis – The traffic light analysis has been adopted by the Northwest Atlantic Fisheries Organization (NAFO) as a precautionary approach to assessment and management of stock, and it is becoming the norm to see some form of 'traffic light analysis' as a conclusion of a stock assessment. Some chosen parameters that are indicatives of the stock status are compared with the previous year, and a green, yellow or red 'light' is determined for the current year. The challenge here it is to find valid parameters that are indicatives of the current health of the stock from a fishery that, until 2000, have seen new management measures (e.g. IBQs, sub-areas), have been on a 'no new effort ban' in the originally surveyed areas for three years (1997-99) by Science request to accumulate data on the snow crab distribution and biomass, have seen the surface covered by the trawl station increase every year since it started in 1997 (from 20,000 km^2 in 1997 to 32,100 km^2 in 2000), and have seen the TAC and the total effort more than doubled in the last year in southern ENS. In other word, year 2000 stands out by itself. Nevertheless, an attempt at traffic light analysis is presented in Appendix 3 for discussion purpose. Historical fishery data tables of CFAs 20, 21 and 22 in northern and CFAs 23 and 24 in southern ENS have been have been combined for this exercise (Appendix 4).

Management considerations and recommendations –

- Trawl survey data clearly indicates that recruitment to these fisheries has been consistently decreasing since 1997. There is also an indication that adult males >95 mm have peaked in the 1997-1999 period, at least from a density concentration and distribution point of view. There should be no doubt, that from a global perspective, the adult snow crab segment of the population in both northern and southern ENS is on a decreasing trend. Indications of the decrease in adult male concentrations can also be drawn from the Observer at-sea data. Both northern and southern ENS stock should be managed with the decreasing trend of commercial adult snow crab in perspective for the incoming years.

- Fishery-related indices such as the increasing trend in the CPUEs since the mid-90's to 1999 is consistent with the trawl survey findings for that period. The increase in CPUEs observed in 2000 compared to 1999 is the reflection of a low exploitation rate (landings relative to the estimated biomass) until 1999 coupled with favorable habitat conditions that permitted a certain accumulation of crabs. Fishery-related indices are however influenced by other factors such as gear type, soak time, or even by the timing of a mobile gear fishery. The magnitude of certain increases in CPUEs or decrease in effort in 2000 should be considered 'inflated' by the factors enumerated above, and not taken as an sign that the snow crab population is still increasing overall.

- Until proper scientific studies prove the contrary, environmental considerations such as the warming/cooling of the water temperature on the Scotian Shelf should be left out of the ENS snow crab management equation altogether for the time being. Present knowledge indicates that unless a dramatic natural event occurs, the currently known snow crab habitat in ENS should be managed as a fairly stable environment and not as something that will change quickly.

- The trawl survey now covers most of the snow crab trawlable habitat in ENS for the time of the survey in late spring, and any new findings of crab outside of the surveyed area, as well as nearshore, on the banks or in the Laurentian Channel at different times of the year should not be considered as 'new' or 'unaccounted for' by the spring survey, nor as an indication that crabs are crawling all over the place. There are strong indications of seasonal movement of snow crab, exploiting different grounds at different times of the year in ENS. And until proven otherwise, these crabs are the same as the ones found during the spring survey.

- Although no separate proportional indices or direct biomass could be individually calculated for sub-areas 23C, 23D and 24D in 2000, their landings in 2000 is part of the total estimated biomass for southern ENS. The fishing locations reported in the logbooks were covered by the trawl survey in 2000.

Research recommendations **–**

- Trawl survey stations in northern ENS should be increased in number or reorganized to cover the slope area of the Laurentian Channel (200 to 400 m deep), as well as to cover the nearshore area in sub-area 24E.

- A seasonal trap survey or a partial seasonal trawl survey should be realized in 2001-2002 to study changes in the distribution and movement of snow crab over 1 year.

- A detailed and rigorous study of the type of gear used by all fishermen of ENS should be done in 2001.

- Tagging study to be continued in 2001.

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Table 1. Summary of the Management Plan measures for 2000. [1]

Area	Season	Regular licenses	Traps allowed	Quota per regular licenses (kg)		Temporary permits	Traps allowed	Total quota temporary permits (kg)
				per license	total			
20	July 22- Sept. 15	5	30	13,608	68,000	5	30	50,000
21	July 22- Sept. 15	32	25	11,340	363,000	none	none	none
22	Northern group:[2]							
	July 22- Sept. 15	23	30	13,834	318,000	none	none	none
	Southern group:[2]							
	July 22- Sept. 15	14	30	15,422	216,000	none	none	none
23	June 1st – Dec. 31	24	45	72,601	1,742,000	53	45	2,683,000
24	June 9th - Dec. 31	23	40	73,402	1,688,000	56	40	2,686,000

[1] Information from Integrated fishery management plan (Anonymous, 1999a)
[2] Both groups have agreed not to fish on Sundays.

Table 2. Landings of Snow Crab (*Chionoecetes opilio)* for eastern Nova Scotia (Crab Fishing Areas 20 to 24), 1978 - 2000.

Year	Active licenses/permits	TAC (t)	Landing Statistics (t)	Total mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	42	-	801	28.4	28.2
1979	98	-	1,634	28.7	56.9
1980	99	-	819	19.8	41.4
1981	55	-	156	21.8	7.2
1982	67	-	554	16.7	33.2
1983	97	-	259	9.6	27.0
1984	51	-	124	8.6	14.4
1985	29	-	89	8.7	10.2
1986	29	-	120	10.2	11.8
1987	61	-	361	12.6	28.7
1988	88	-	596	14.6	40.8
1989	100	-	616	18.7	32.9
1990	102	-	1,152	25.4	45.4
1991	101	-	1,533	30.9	49.6
1992	104	-	1,797	32.5	55.3
1993	113	-	2,016	28.1	71.7
1994	117	-	1,551	21.2	73.2
1995	134	-	1,554	22.0	70.6
1996	124	1,701	1,491	29.6	50.3
1997	133	1,703	1,691	37.3	44.9
1998	141	2,331	2,238	58.0	38.6
1999	160	3,600	3,599	66.5	54.1
2000	235	9,814	9,718	76.4	127.2
Average (all)		-	1,498	27.2	44.1
Average (96-00)		3,830	3,745	53.6	63.0

Table 3. Landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 20, 1978 - 2000.

Year	Active boats	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
average (all)		-	30.9	18.6	3.2
average (96-00)		68.8	68.2	29.9	2.4

Table 4. Weekly landings catch rate and effort statistics for Snow Crab in Crab Fishing Area 20, 2000.

a) Weekly landings statistics

week	landings (kg)		
	all	permanent	temporary
July 16	1,682	1,134	548
July 23	66,222	41,739	23,387
July 30	41,336	25,004	16,332
Aug. 06	4,581	155	4,426
Aug. 13	841	-	841
Aug. 20	3,223	-	3,223
Aug. 27	658	-	658
Sept 03	155	-	155
total[2]	118,698	68,032	49,570

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)		
	all	permanent	temporary
July 16	39.1	39.1	-
July 23	47.9	61.5	34.0
July 30	45.6	50.8	37.6
Aug. 06	38.9	-	38.9
Aug. 13	60.1	-	60.1
Aug. 20	-	-	-
Aug. 27	-	-	-
Sept 03	-	-	-
total[2]	46.7	56.6	35.8

c) Weekly effort statistics

week	Effort (total number of traps hauls)		
	all	Permanent	temporary
July 16	43	29	14
July 23	1,382	679	688
July 30	906	492	434
Aug. 06	118	-	114
Aug. 13	14	-	14
Aug. 20	-	-	-
Aug. 27	-	-	-
Sept 03	-	-	-
total[2]	2,543	1,202	1,383

[2] Total seasonal landings.

Table 5. Seasonal catch composition, in percentage, from at-sea samples for eastern Nova Scotia in 2000.

a) Catch composition in Area 20 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
3	11	< 95 mm	1.4	17.6	0.5	0.7	1.9	18.3	20.1
		> 95 mm	4.4	71.2	1.6	2.6	6.1	73.8	79.9
		total	5.9	88.8	2.1	3.3	8.0	92.0	100.0

b) Catch composition in Area 21 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
10	28	< 95 mm	2.2	13.8	0.8	0.1	3.0	13.9	16.8
		> 95 mm	7.4	59.5	5.3	11.0	12.7	70.5	83.2
		total	9.6	73.3	6.1	11.1	15.7	84.3	100.0

c) Catch composition in Area 22 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
12	58	< 95 mm	8.4	14.6	1.5	0.4	9.9	14.9	24.8
		> 95 mm	10.6	52.4	2.9	9.3	13.5	61.7	75.2
		total	19.0	67.0	4.4	9.6	23.4	76.6	100.0

d) Catch composition in Area 23 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
46	356	< 95 mm	2.9	8.8	1.0	0.3	9.1	3.9	13.0
		> 95 mm	6.7	76.4	1.0	3.0	7.7	79.4	87.0
		total	9.6	85.2	2.0	3.3	11.6	88.4	100

e) Catch composition in Area 24 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
41	376	< 95 mm	2.3	6.4	0.5	0.0	2.7	6.5	9.2
		> 95 mm	14.9	71.9	1.3	2.6	16.3	74.5	90.8
		total	17.2	78.4	1.8	2.6	19.0	81.0	100.0

Table 6. Landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 21, 1978-2000.

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
average (all)		-	140.7	17.1	10.2
average (96-00)		232.2	230.6	44.5	6.5

Table 7. Weekly landings, catch rate and effort statistics for Snow Crab, Crab Fishing Area 21, 2000.

week	landings (kg)	CPUE (kg/trap haul)	Effort (total number of trap hauls)
July 23	261,834	70.0	3,743
July 30	92,211	49.6	1,860
Aug. 06	9,642	37.4	258
total[1]	363,687	62.1	5,853

[1] Total seasonal landings and seasonal CPUE were used to obtain these results.

Table 8. Landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 22, 1978 - 2000.

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
average (all)		-	229.2	21.5	10.8
average (96-00)		430	396.2	42.0	12.1

Table 9. Weekly landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 22, 2000.

a) Weekly landings statistics

week	Landings (kg)		
	all	northern	outer area
July 16	16,000	16,000	-
July 24	418,522	235,977	182,545
July 31	99,463	65,613	33,850
Aug. 06	1,150	1,150	-
total[1]	535,135	318,740	216,395

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)		
	all	northern	Outer area
July 16	58.2	58.2	-
July 24	84.6	72.3	114.5
July 31	62.5	59.9	70.5
Aug. 06	-	-	-
total[1]	78.7	68.6	106.0

c) Weekly effort statistics

week	Effort (total number of traps hauls)		
	all	northern	outer area
July 16	275	275	-
July 24	4,947	3,264	1,594
July 31	1,590	1,095	480
Aug. 06	-	-	-
total[1]	6,803	4,643	2,041

[1] Total seasonal landings.

Table 10. Landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 23, 1978 - 2000.

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
average (all)		-	586.8	42.4	10.9
average (96-00)		1551.6	1,534.0	74.5	19.2

Table 11. Weekly landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 23, 2000.

week	Landings (kg)					CPUE (kg/trap haul)					Effort (total number of traps hauls)				
	all	permanent	temporary			all	permanent	temporary			all	permanent	temporary		
			b	c	d			b	c	d			b	c	d
May 28	18,626	18,626	-	-	-	78.9	78.9	-	-	-	236	236	-	-	-
June 04	205,607	196,496	2,706	6,405	-	109.1	111.8	60.1	78.1	-	1,885	1,758	45	82	-
June 11	420,266	283,207	21,389	108,249	7,421	90.6	107.1	59.7	83.4	22.5	4,641	2,645	358	1,299	330
June 18	576,889	322,851	70,876	146,169	36,993	96.5	113.1	93.1	86.1	56.3	5,977	2,854	761	1,697	657
June 25	507,660	259,107	82,965	100,881	64,707	90.3	104.1	95.6	78.1	67.9	5,620	2,490	867	1,292	953
July 02	426,190	160,674	97,135	65,841	102,540	94.1	106.1	111.3	81.6	76.5	4,531	1,515	873	807	1,341
July 09	385,340	131,151	69,142	76,407	108,640	101.3	106.8	101.3	99.9	96.7	3,803	1,228	683	765	1,123
July 16	322,045	68,791	102,147	56,750	94,357	97.6	101.9	98.4	102.1	91.5	3,301	675	1,038	556	1,031
July 23	346,070	85,895	130,803	48,577	80,795	83.4	84.9	93.3	89.2	67.6	4,150	1012	1,401	545	1,195
July 30	231,272	42,849	79,374	43,284	66,591	77.9	86.0	98.8	92.7	55.0	2,967	498	803	467	1,211
Aug. 06	236,834	41,795	54,198	51,742	79,024	75.8	80.3	92.4	113.5	53.6	3,123	521	686	456	1,473
Aug. 13	155,632	37,605	31,963	20,141	70,584	64.6	87.3	80.7	83.8	46.1	2,410	431	396	240	1,532
Aug. 20	98,834	19,406	14,940	7,244	54,775	58.3	100.3	79.0	90.5	46.5	1,696	194	189	80	1,178
Aug. 27	88,863	21,592	20,810	-	44,008	69.3	81.2	88.9	-	59.7	1,283	266	234	-	737
Sept. 03	49,548	7,535	9,359	1,444	31,210	55.5	114.2	81.4	26.3	47.5	893	66	115	55	657
Sept. 10	135,938	27,627	14,609	20,217	71,772	58.2	96.9	112.1	49.3	46.9	2,338	285	130	410	1,531
Sept. 17	31,715	3,376	3,551	5,574	19,214	54.2	82.3	57.3	126.7	40.1	585	41	62	44	479
Sept. 24	32,703	4,972	2,979	8,022	18,333	67.8	110.5	75.6	125.3	45.5	482	45	39	64	403
Oct. 01	42,301	6,789	-	5,276	30,236	65.2	113.2	-	122.7	54.4	649	60	-	43	556
Oct. 08	11,309	-	-	5,048	11,309	50.3	-	-	112.2	50.3	225	-	-	45	225
Oct. 15	41,996	2,946	2,501	16,341	20,208	62.0	105.3	138.9	62.4	54.8	677	28	18	262	369
Oct. 22	28,897	-	-	14,757	14,140	78.7	-	-	100.4	64.3	367	-	-	147	220
Oct. 29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov. 05	-	-	-	-	2,800	-	-	-	-	62.2	-	-	-	-	45
Nov. 12	4,800	-	-	-	2,000	53.3	-	-	-	44.4	90	-	-	-	45
Nov. 19	?	-	-	-	?	?	-	-	-	?	?	-	-	-	?
total[2]	4,399,335	1,743,290	820,696	808,369	1,025,402	85.0	103.4	93.8	87.1	60.0	51,734	16,857	8,745	9,281	17,094

Table 12. Landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 24, 1978 - 2000.

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
average (all)		-	558.8	30.1	12.9
average (96-00)		1,547.2	1,514.0	62.0	21.6

Table 13. Weekly landings, catch rate and effort statistics for Snow Crab in Crab Fishing Area 24, 2000.

Week	Landings (kg)						CPUE (kg/trap haul)						Effort (total number of traps hauls)					
	all	permanent	temporary				all	permanent	Temporary				All	Permanent	Temporary			
			b	c	d	e			b	c	d	e			b	c	d	e
June 04	29,294	29,294	-	-	-	-	85.4	85.4	-	-	-	-	343	343	-	-	-	-
June 11	363,243	306,481	43,180	-	13,177	405	88.1	94.2	78.2	-	55.1	**5.1**	4,125	3,252	552	-	239	80
June 18	497,496	343,066	68,905	32,247	47,753	1,565	86.5	93.8	87.1	74.8	68.5	**9.8**	5,751	3,699	791	431	697	160
June 25	382,874	226,783	36,963	48,887	55,905	14,336	78.4	89.8	73.4	67.1	72.5	39.8	4,885	2,526	503	729	771	360
July 02	386,278	183,501	61,811	41,281	83,668	16,017	81.7	89.0	93.7	81.3	69.8	53.9	4,726	2,063	660	508	1198	297
July 09	379,530	163,706	90,146	51,249	66,711	7,718	83.7	84.1	106.2	70.6	77.2	50.8	4,534	1,946	849	726	864	152
July 16	352,573	109,910	96,495	64,064	74,640	7,464	86.1	79.4	104.5	90.4	81.2	46.7	4,095	1,384	923	709	919	160
July 23	324,427	82,754	82,369	52,757	96,026	10,521	80.2	76.0	93.4	83.7	78.2	47.1	4,045	1,089	882	630	1,228	223
July 30	242,180	52,282	65,298	29,955	87,138	7,507	85.6	78.6	82.1	105.8	88.6	75.1	2,828	662	795	284	983	100
Aug. 06	184,078	41,592	44,273	22,464	72,294	3,455	87.9	68.5	92.4	141.3	91.7	57.6	2,093	607	479	159	788	60
Aug. 13	187,226	39,789	65,837	7,291	72,173	-	92.2	75.8	114.9	104.2	82.8	-	2,031	525	573	70	872	-
Aug. 20	180,557	29,413	64,886	21,877	64,381	-	94.4	84.5	122.2	120.9	76.5	-	5,011	348	531	181	842	-
Aug. 27	190,916	43,044	77,972	8,317	61,583	-	93.2	88.9	116.7	138.6	73.8	-	2,048	484	668	60	834	-
Sept. 03	98,238	20,238	32,338	7,215	33,361	5,086	84.8	97.8	96.5	136.1	75.3	42.4	1,158	207	335	53	443	120
Sept. 10	114,208	7,688	22,280	-	74,638	9,602	85.4	69.3	112.5	-	91.0	48.0	1,338	111	198	-	820	200
Sept. 17	65,220	5,828	7,541	-	31,764	20,087	82.4	67.0	100.5	-	108.4	59.3	792	87	75	-	293	339
Sept. 24	48,806	-	3,413	-	30,292	15,101	70.7	-	85.3	-	70.1	69.0	691	-	40	-	432	219
Oct. 01	48,343	-	4,374	-	31,194	12,775	76.4	-	118.2	-	92.7	55.4	633	-	37	-	336	231
Oct. 08	27,504	-	1,741	-	10,328	15,435	63.1	-	48.4	-	73.8	59.4	436	-	36	-	140	260
Oct. 15	51,930	-	16,268	-	27,841	7,821	105.7	-	109.1	-	130.3	65.2	491	-	149	-	214	120
Oct. 22	54,605	-	18,890	-	29,746	5,969	75.5	-	57.3	-	91.3	51.0	723	-	330	-	326	117
Oct. 29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov. 05	860	-	860	-	-	-	22.1	-	22.1	-	-	-	39	-	39	-	-	-
Nov. 12	8,967	-	3441	-	5,526	-	76.0	-	88.2	-	69.9	-	118	-	39	-	79	-
Nov. 19	?	-	-	-	?	-	?	-	-	-	?	-	?	-	-	-	?	-
total[2]	4,219,353	1,689,329	909,281	387,604	1,070,139	160,864	84.7	87.5	96.8	85.5	80.1	50.1	49,813	19,315	9,392	4,536	13,365	3,212

Table 14. Daily distribution of the landings in Crab Fishing Areas 21 and 22, 2000.

Landings / considered Areas (kg)						
Date	Area 21	Area 22n	Area 22n *	Area 22o	Areas 22n et 21	Areas 22n et 21 *
July 22	-	17,814	-	-	17,814	-
July 23	-	3,430	-	-	3,430	-
July 24	61,637	53,139	53,139	51,181	114,776	114,776
July 25	56,049	47,849	47,849	34,544	103,898	103,898
July 26	51,500	49,080	49,080	37,901	100,580	100,580
July 27	47,136	42,367	42,367	27,646	89,503	89,503
July 28	35,114	35,128	35,128	11,599	70,242	70,242
July 29	1,261	-	-	-	1,261	1,261
July 31	1,928	3,617	3,617	-	5,545	5,545
Aug. 01	31,494	14,096	14,096	7,575	45,590	45,590
Aug. 02	27,157	24,442	24,442	9,191	51,599	51,599
Aug. 03	14,683	10,305	10,305	4,965	24,988	24,988
Aug. 04	7,766	5,429	5,429	2,230	13,195	13,195
Aug. 05	3,216	3,092	3,092	-	6,308	6,308
Total	338,941	309,788	288,544	186,832	648,729	627,485

* 2 first days removed

Table 15. Biomass estimates in Crab Fishing Areas 21 and 22 based on catch-effort information.

				Percentiles	
Areas considered	Capturability	Biomass at the beginning of the fishery (t)	Standard deviation	5%	95%
21	0.00012739	686	4265.33	679,277.8	693,011.4
22o	0.00052783	309	1691.61	305,947.6	311,411.9
22n	0.000099251	858	9827.79	842,209.7	873,974.3
22n*	0.000135319	668	5798.12	657,491.1	676,451.9
22n and 21 combined	0.000059049	1,469	8329.78	1,456,399	1,483,532
22n and 21 *	0.000067183	1,331	6739.35	1,320,097	1,342,891

* 2 first days removed
- 22o: outer area or Glace Bay hole
- 22n: Northern area or north Smoky

Table 16. Monthly distribution of effort (total hours fished) of the shrimp fishery in eastern Nova Scotia, from 1997 to 2000.

Year	Effort/Month (hours)												Total effort
	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
1997	-	-	-	1,240	3,219	3,905	3,320	1,454	761	633	80	819	15,431
1998	-	152	343	1,290	3,041	3,780	2,262	724	488	443	478	280	13,281
1999	97	161	675	2,039	4,241	3,362	1,035	494	554	393	812	1,008	14,871
2000	50	287	749	2,225	3,567	3,279	994	854	752	584	-	-	13,341

Table 17. Catch per unit of effort, average weight, depth and temperature results from the experimental trip survey in north-eastern Nova Scotia.

Trap number	# crab	Weight (kg)*	CPUE	Depth (m)	Temperature (^{0}C)
1	78	0.600978	46.9	190	-
2	133	0.632066	84.1	205	5.0
3	109	0.561037	61.2	235	5.3
4	71	0.629525	44.7	275	5.3
5	69	0.759225	52.4	300	5.5
6	19	0.655523	12.5	320	5.0
7	9	0.832595	7.5	345	5.0

*Average weight for average crab size caught in the trap

Table 18. Biomass estimates (t) of male Snow Crab ≥ 95 mm of carapace width in northeastern Nova Scotia.

Estimate for the Total Surveyed Area for that given year.

Year	R-1		B (exploitable)		B (Total)	
	(t)	c int	(t)	c int	(t)	c int
1998	1,434	28%	1,215	215%	2,649	113.8%
1999	1,101	106%	1,200	133%	2,301	120.1%
2000[1]	210[1]	239%[1]	2,148[1]	83%[1]	2,358[1]	96.9%[1]
2000[2]	307[2]	164%[2]	2,619[2]	61%[2]	2,926[2]	56.3%[2]

R-1: CW ≥ 95 mm adult of carapace condition 1 and 2 at the time of the survey.

B (exploitable): CW ≥ 95 mm adult of carapace condition 3, 4 and 5 at the time of the survey.

B (total): CW ≥ 95 mm adult at the time of the survey (R-1 + B (exploitable)).

1) Estimated using the projected habitat area as in 1998 and 1999.
2) Calculated without the projected habitat area.

Table 19. Exploitable biomass (t) for 2001 fishery and proportion by fishing grounds.

Areas	Exploitable biomass (t)	(%)
20	-	7.7
21	-	33.9
22	-	58.4
Total	1,909	100.0
23	-	63.3
24	-	36.7
Total	20,238	100.0

Table 20. Biomass estimates (t) of male Snow Crab ≥ 95 mm of carapace width in south-eastern Nova Scotia.

Estimates for the Original Surveyed Area since 1997.

Year	R-1		B (exploitable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int[x]
1997*	10,335	49.6%	12,657	51.5%	22,992	50.7%
1998*	1,362	535.9%	23,510	47.7%	24,872	74.4%
1999	8,118	57.8%	17,056	34.9%	25,174	42.3%
2000	6,401	48.0%	22,325	37.0%	28,726	39.5%

*In 1997 and 1998, the originally surveyed area had 26 stations less compared to 1999.

[x] c int. in (t) of R-1 and B (exploitable) were added, and then expressed in %.

Estimate for the Total Surveyed Area for that given year.

Year	R-1		B (exploitable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int[x]
1997	10,335	49.6%	12,657	51.5%	22,992	50.7%
1998	1,415	291.3%	24,880	48.3%	26,295	61.4%
1999	8,624	64.6%	23,533	33.4%	32,157	41.8%
2000	5,957	26%	22,982	52.0%	28,939	46.7%

[x] c int. in (t) of R-1 and B (exploitable) were simply added, and then expressed in %.

R-1: CW ≥ 95 mm adult of carapace condition 1 and 2 at the time of the survey.
B (exploitable): CW ≥ 95 mm adult of carapace condition 3, 4 and 5 at the time of the survey.
B (total): CW ≥ 95 mm adult at the time of the survey (R-1 + B (exploitable)).

Table 21. Number of crab caught in May and July for the 5 same stations in Crab Fishing Area 22 outside in 2000

Trawl Stations #	May		July	
	male	female	male	female
14	18	9	32	0
21	6	1	29	2
22	34	16	101	0
25	26	14	37	3
24	11	8	37	1
total	95	48	236	6

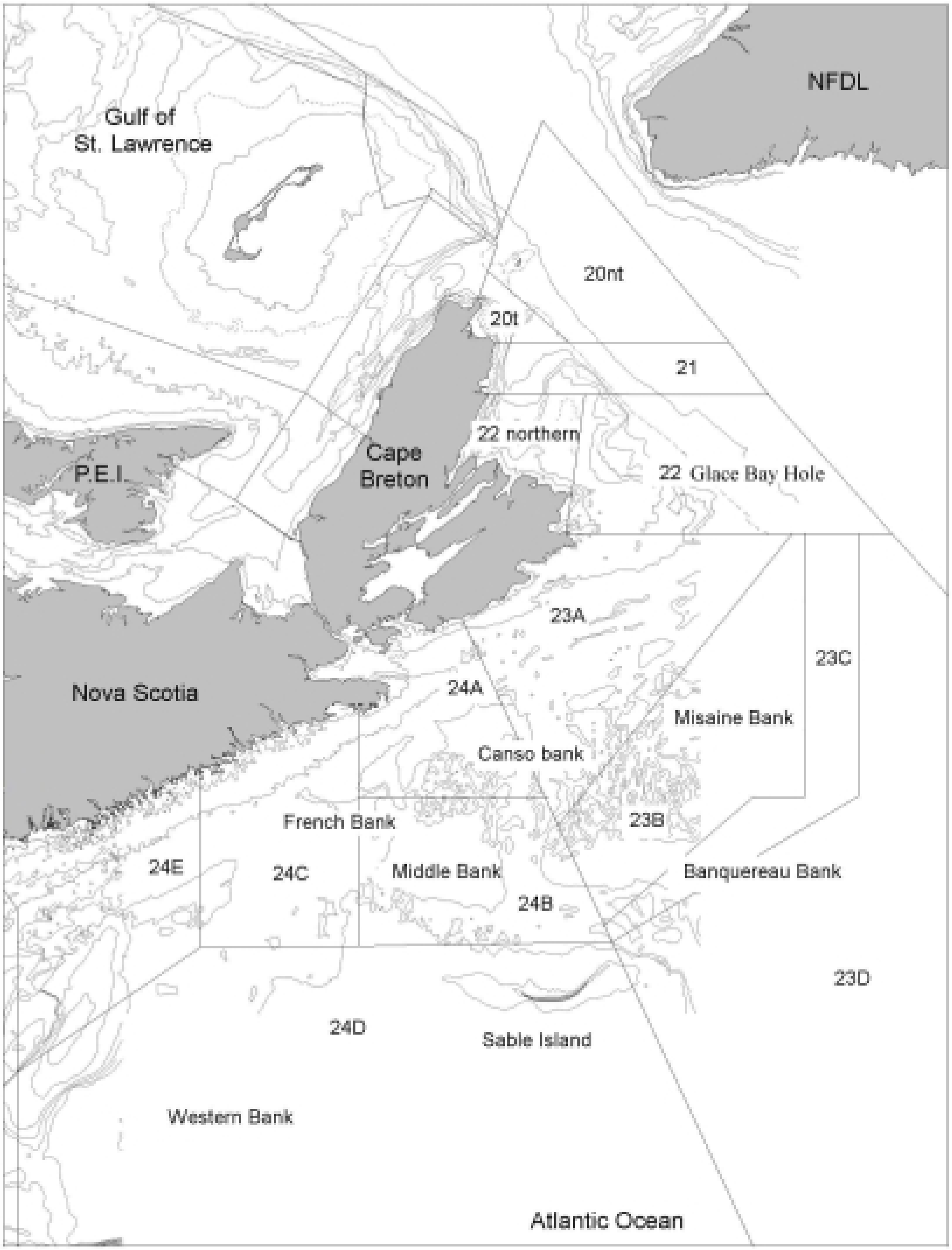


Figure 1. Snow Crab management sub-areas off eastern Nova Scotia.

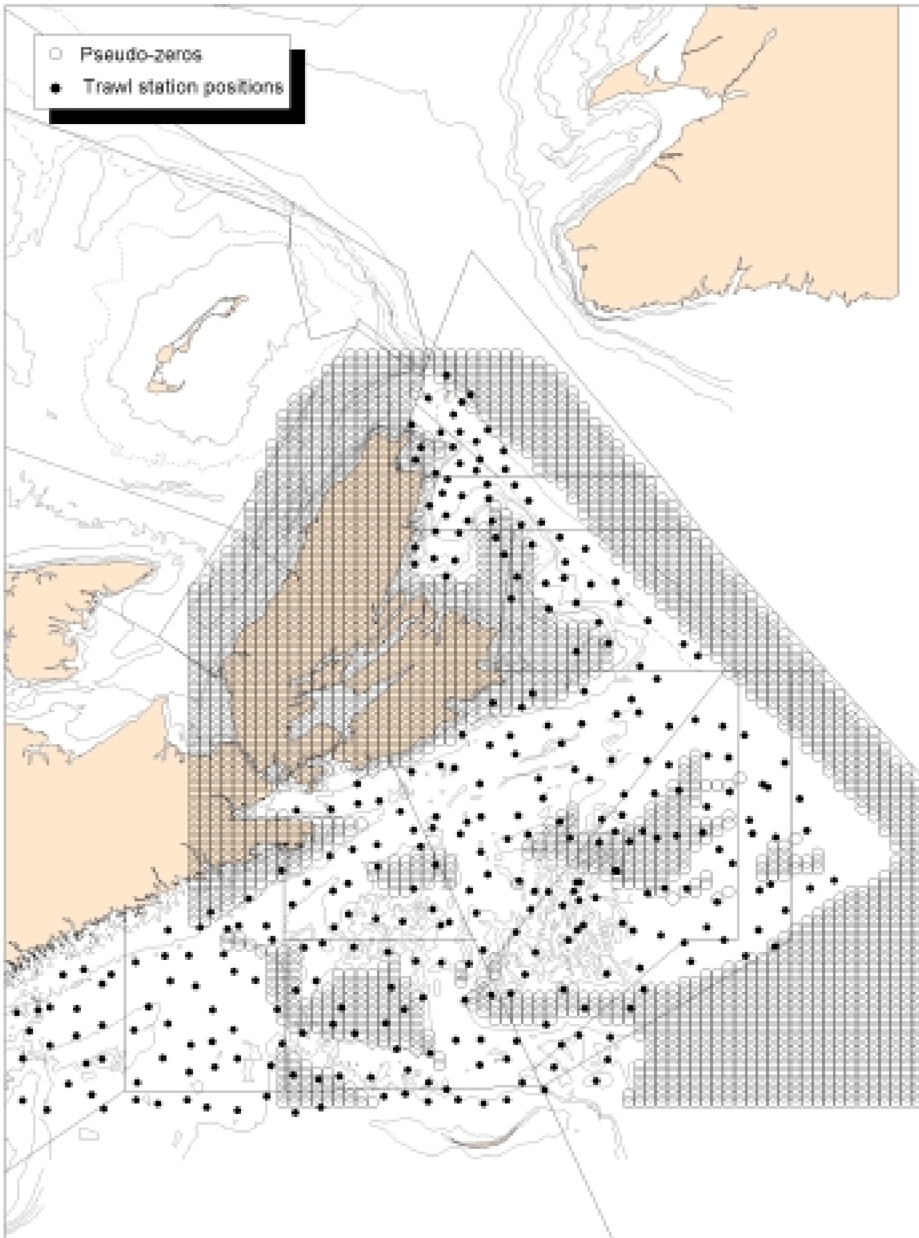


Figure 2. Mask with the pseudo-zeros used for kriging and the trawl station positions.

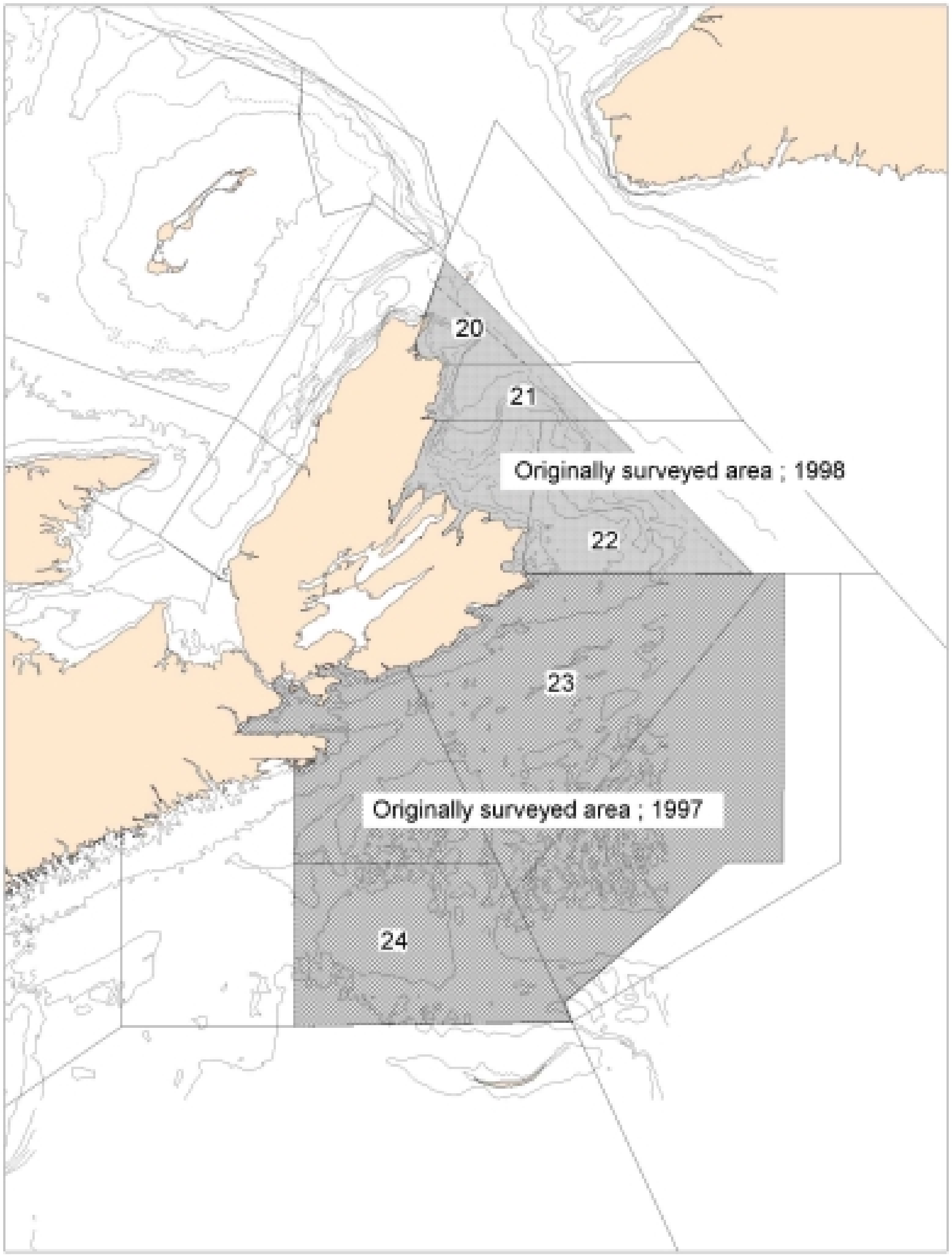


Figure 3. Originally surveyed areas of Crab Fishing Areas 20 to 24.

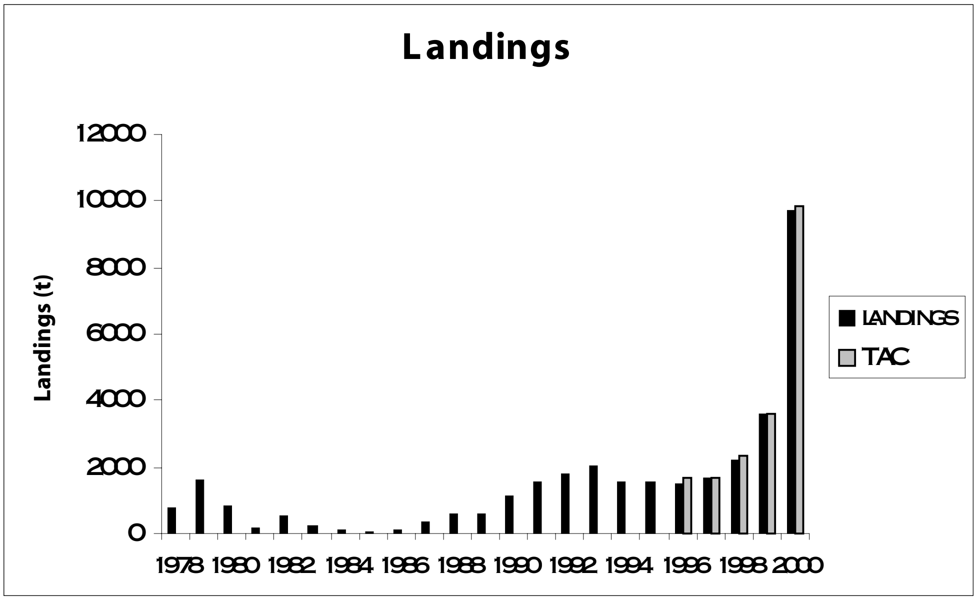


Figure 4. Snow Crab landings (t) in eastern Nova Scotia from 1978 to 2000.

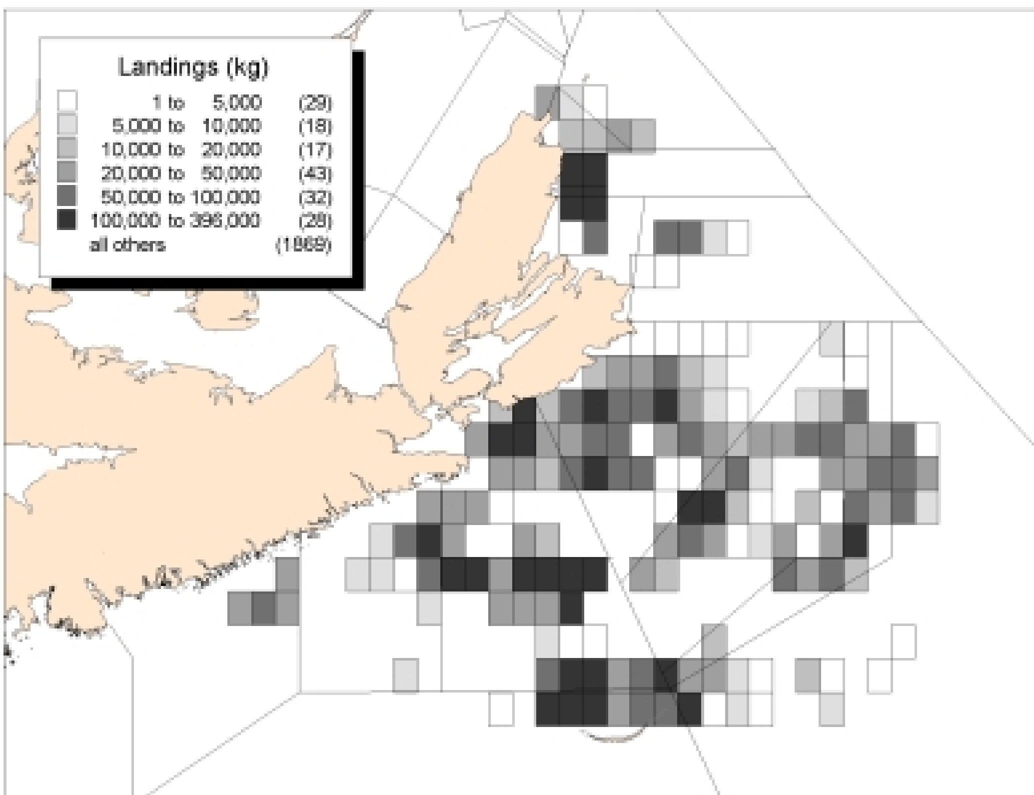


Figure 5. Seasonal distribution of Snow Crab landings (kg) in eastern Nova Scotia in 2000.

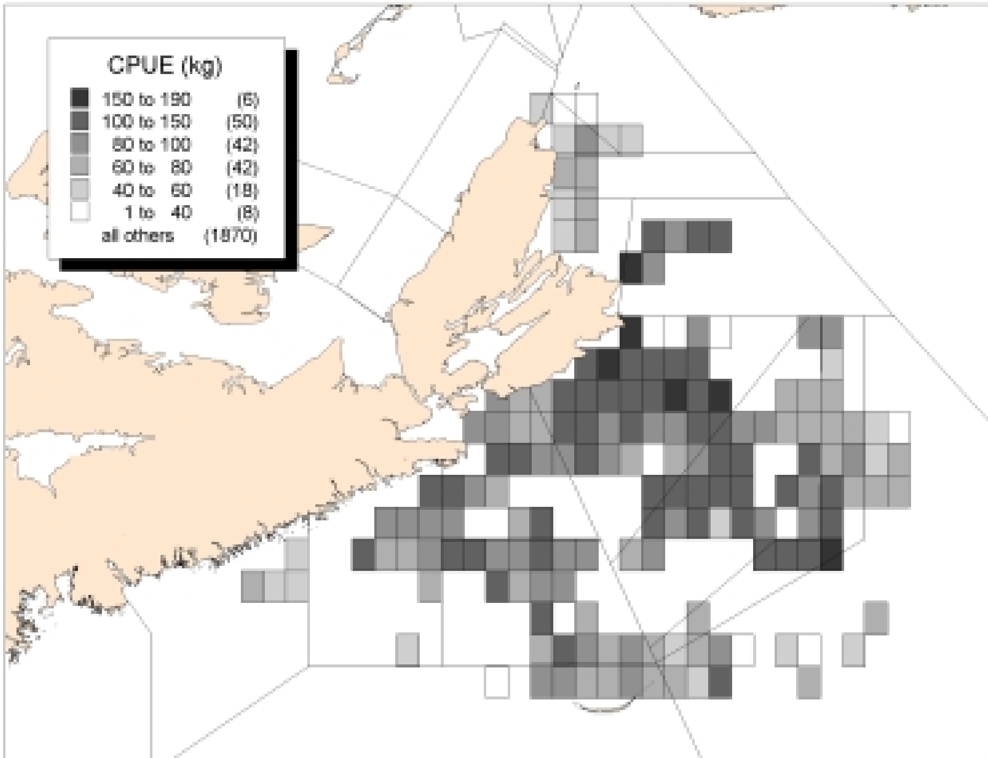


Figure 6. Seasonal distribution of the catch per unit of effort (kg/trap haul) in eastern Nova Scotia in 2000.

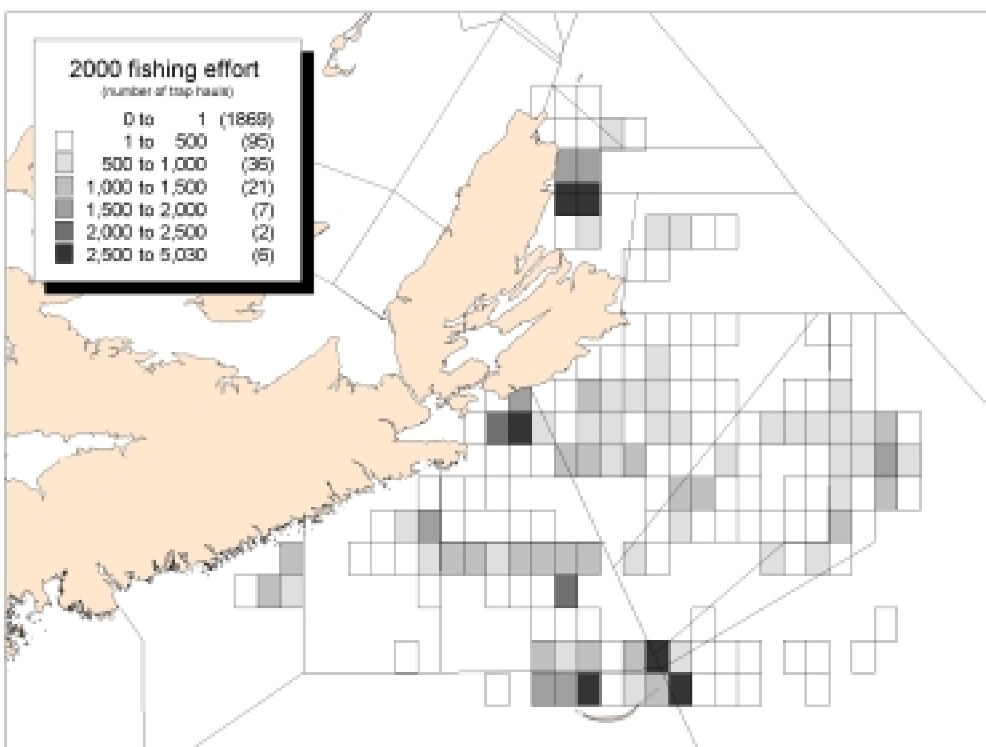


Figure 7. Seasonal distribution of the effort (# of trap hauls) in eastern Nova Scotia in 2000.

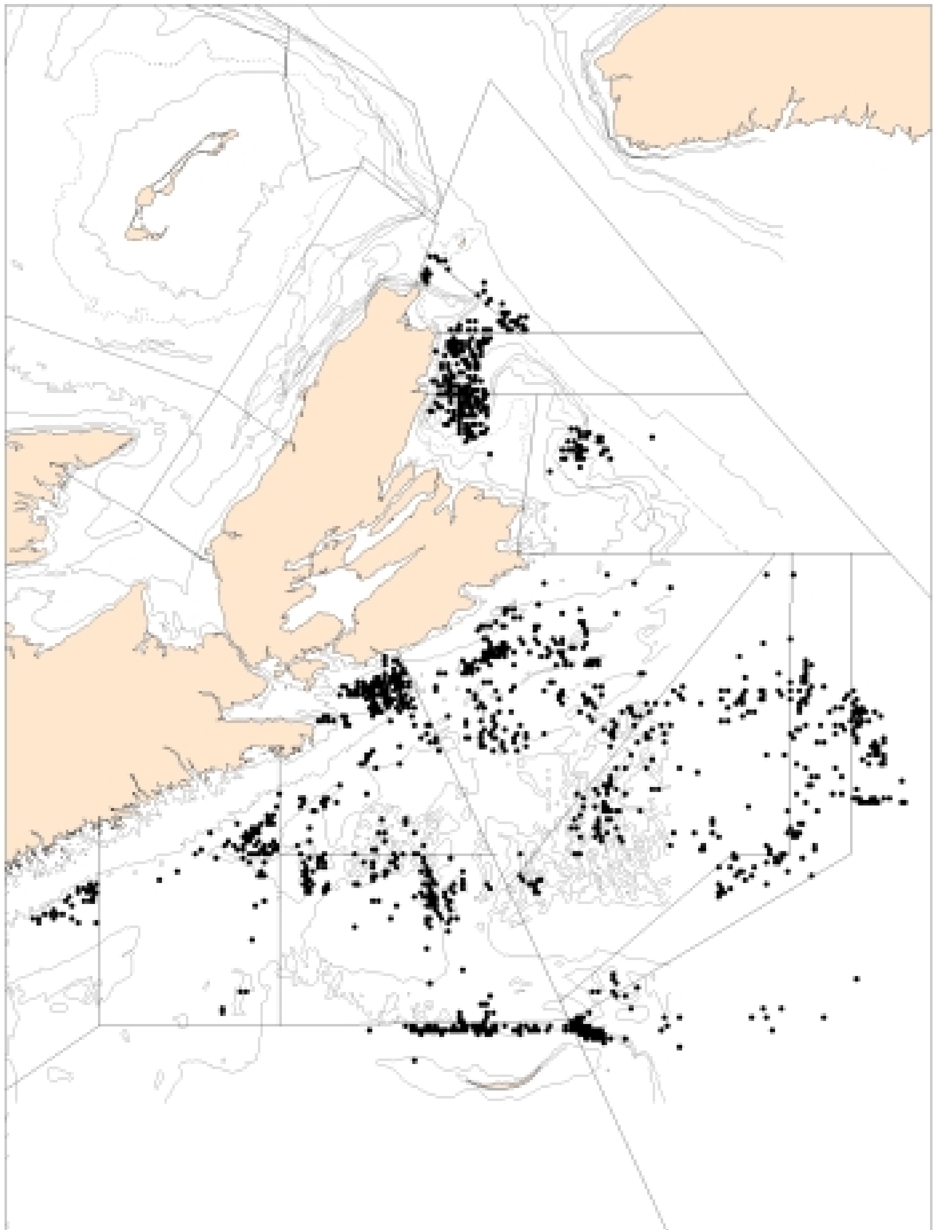


Figure 8. Reported logbook positions in eastern Nova Scotia in 2000.

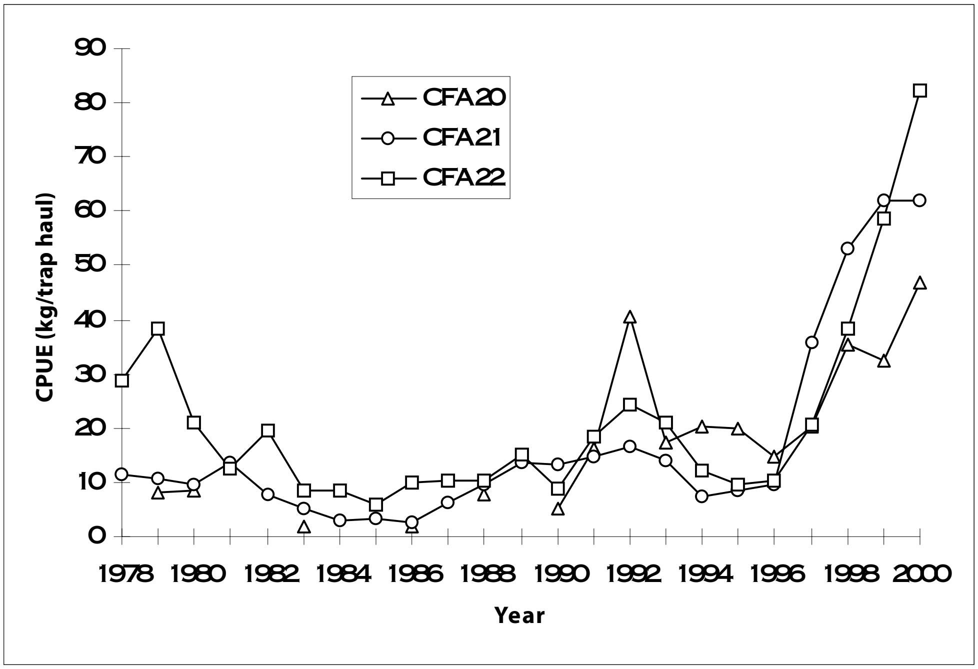


Figure 9. Catch per unit of effort for Crab fishing Areas (CFA) 20, 21 and 22 from 1978 to 2000.

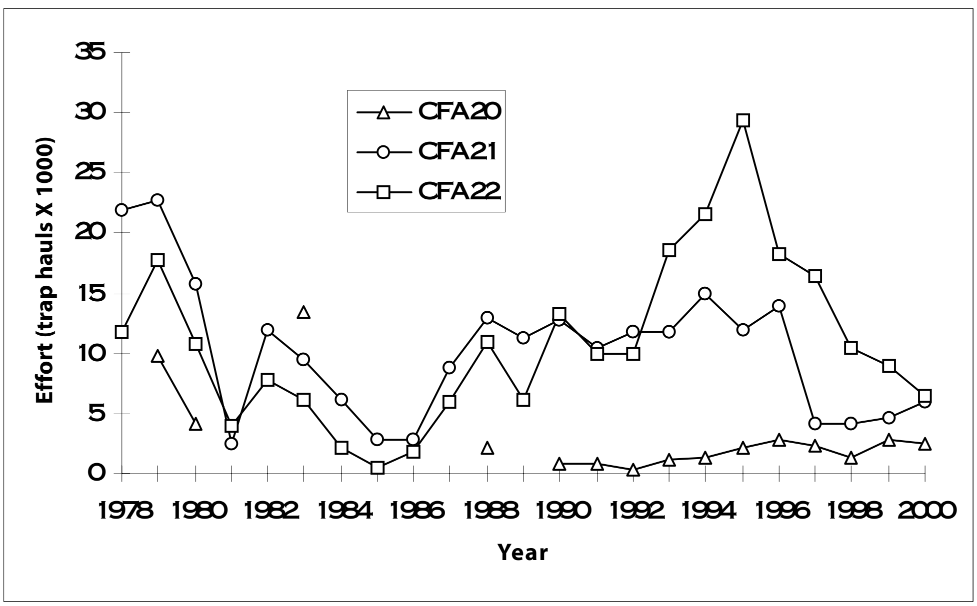


Figure 10. Fishing effort for Crab Fishing Areas (CFA) 20, 21 and 22 from 1978 to 2000.

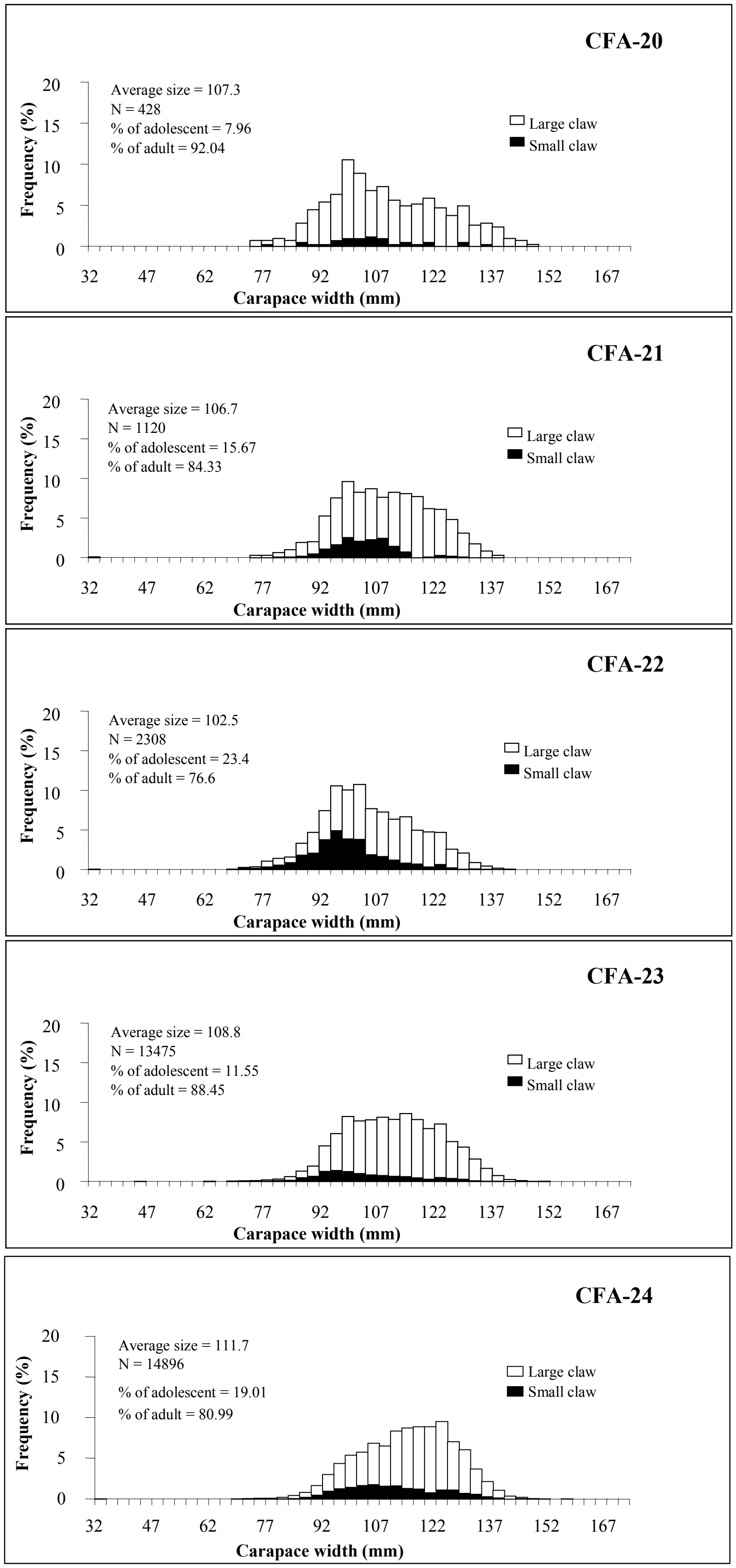


Figure 11. Size frequency distribution from the sea sampling in 2000 carried out in eastern Nova Scotia for Snow Crab.

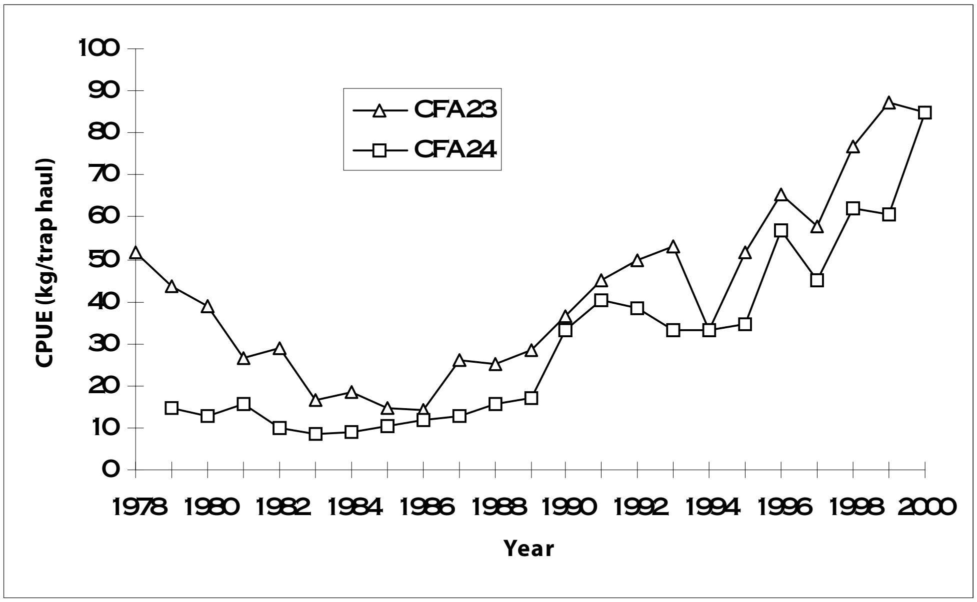


Figure 12. Catch per unit of effort for Crab Fishing Areas (CFA) 23 and 24 from 1978 to 2000.

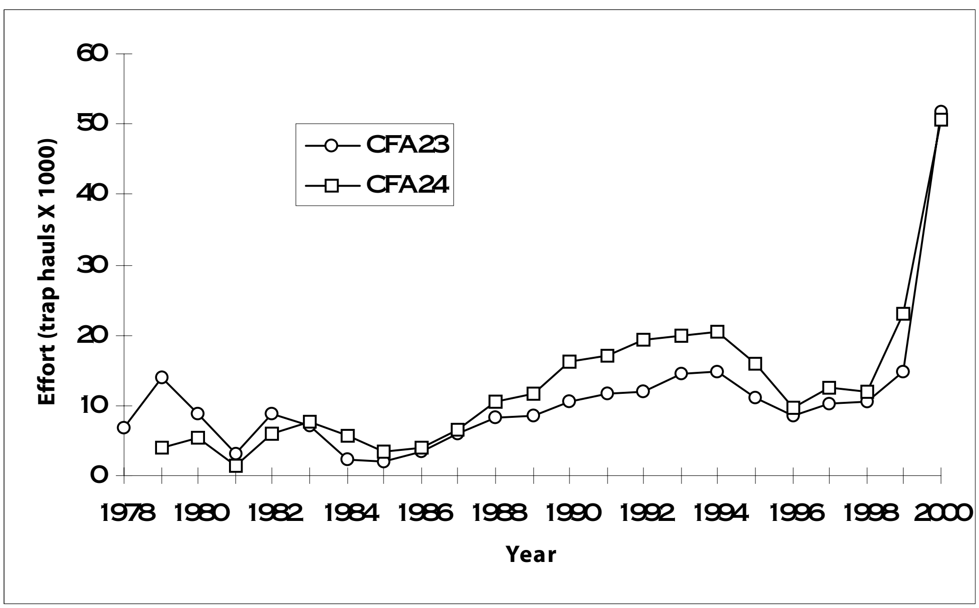


Figure 13. Fishing effort for Crab Fishing Areas (CFA) 23 and 24 from 1978 to 2000.

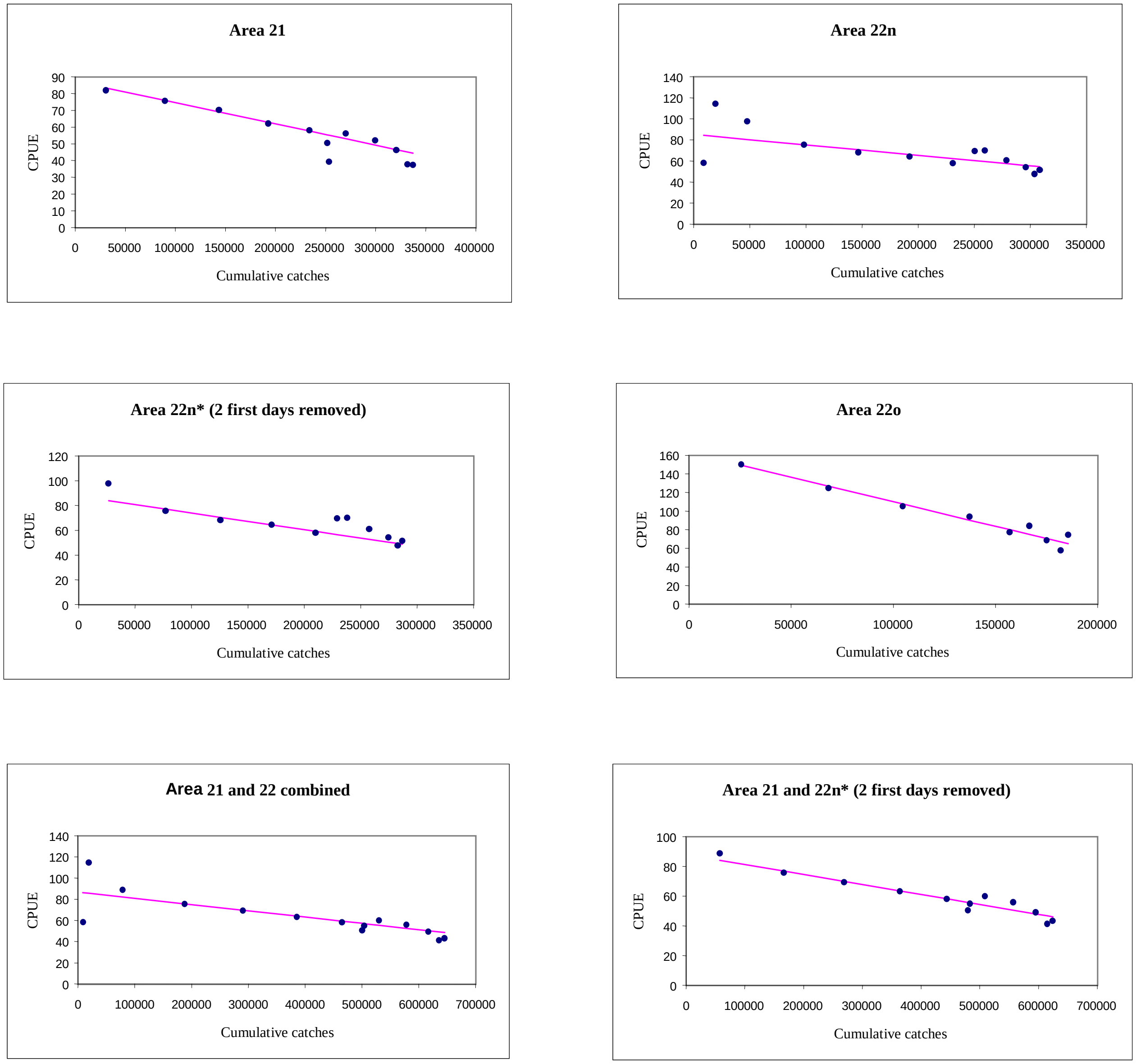
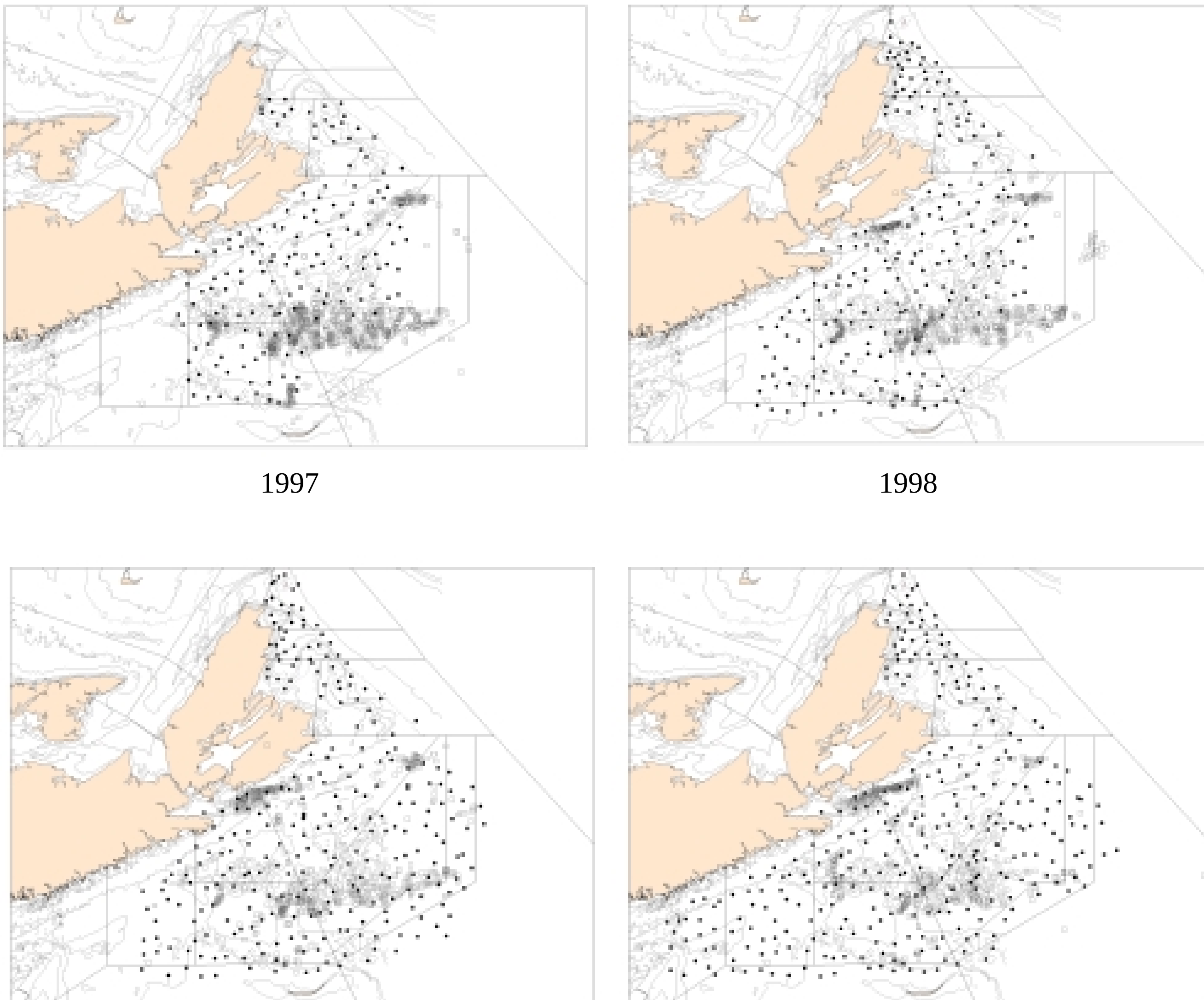


Figure 14. Resulting regressions from the catch-effort analysis.
***Area 22o: outer area or Glace Bay hole
*Area 22n: Northern area or north Smoky



1997 1998

1999 2000

Figure 15. Annual Snow Crab trawl survey positions (black circles) and shrimp fishery positions (empty squares) for 1997 to 2000.

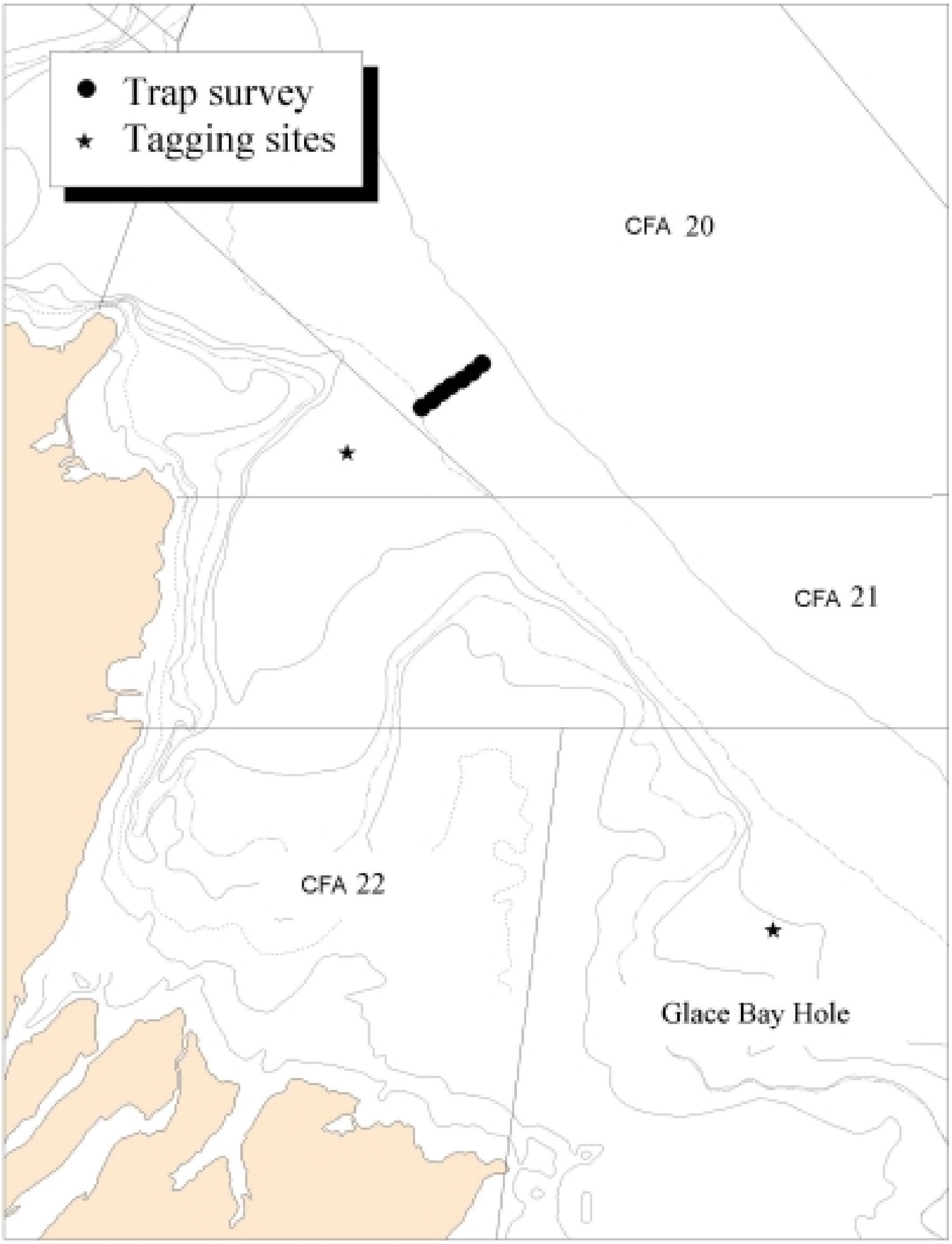


Figure 16. Trap survey in Crab Fishing Area 20 and the tagging sites for 2000.

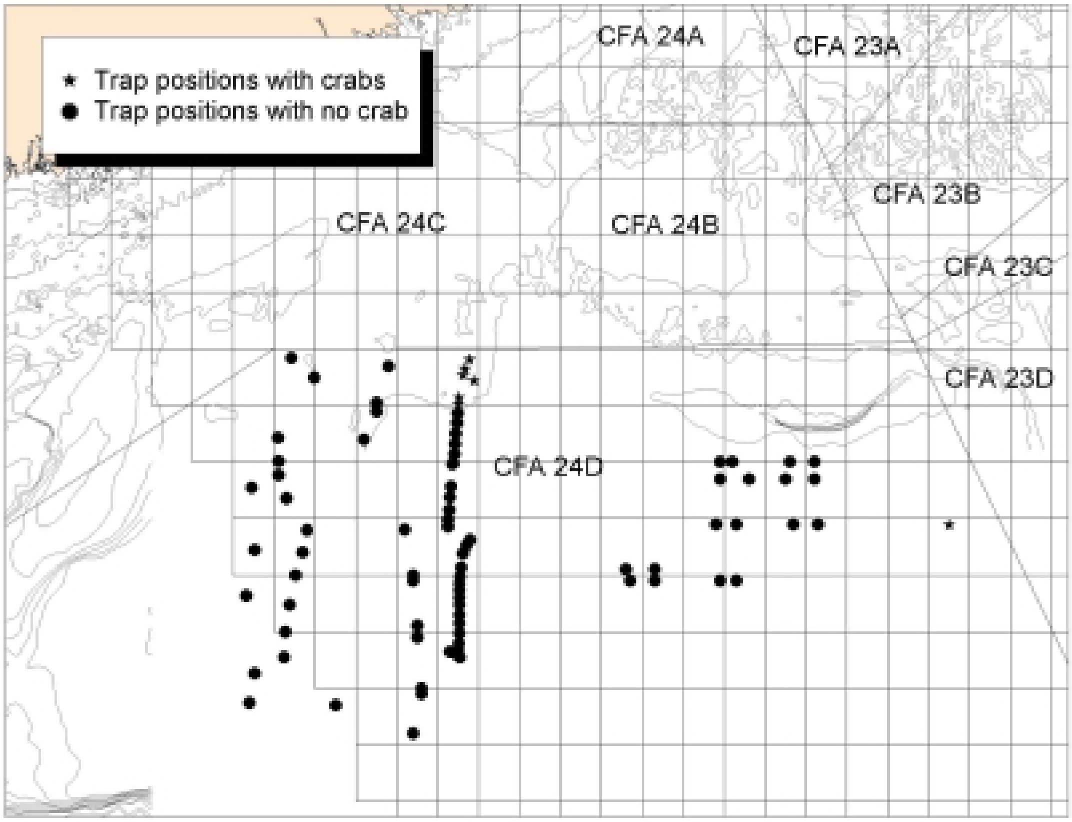


Figure 17. Snow Crab trap survey done by fishermen's in area 24D.

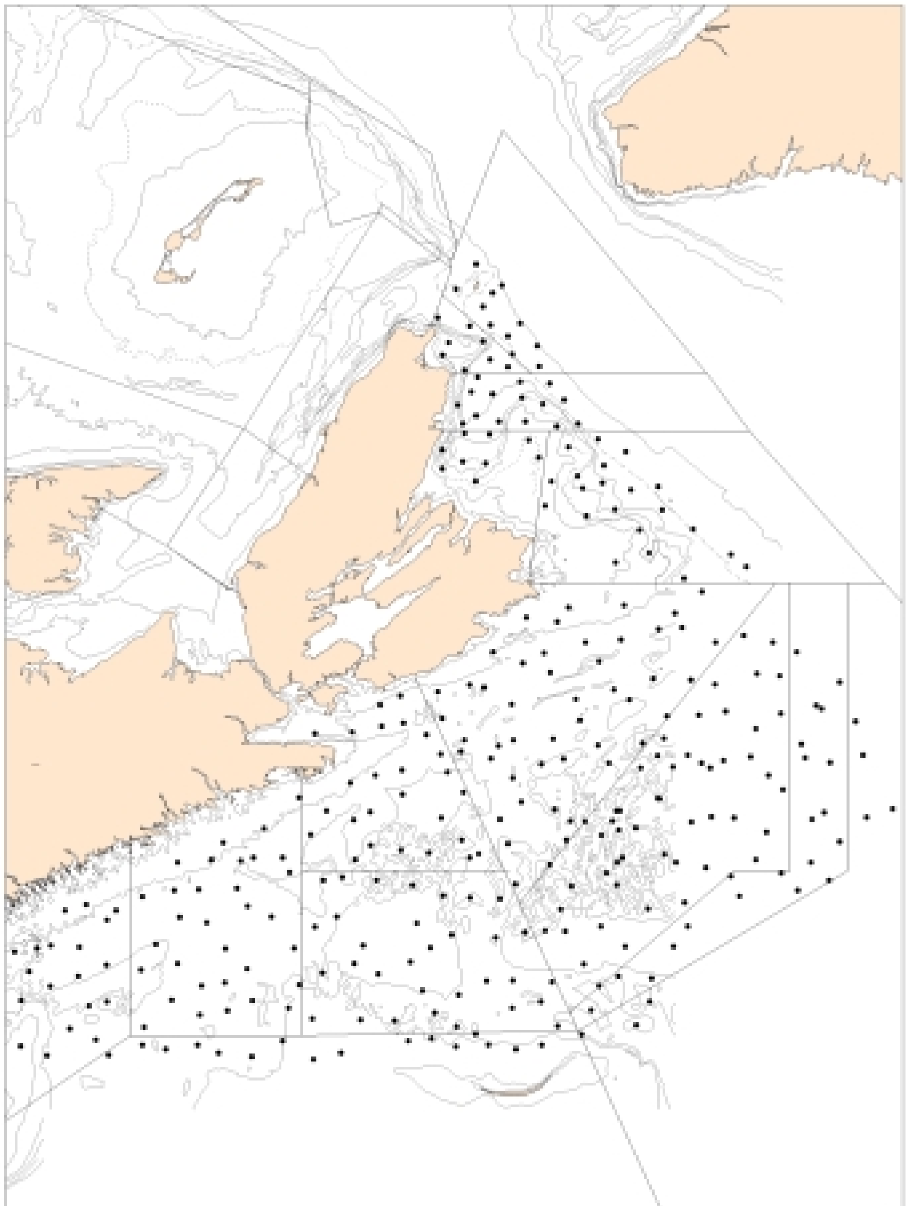


Figure 18. Location of Snow Crab trawl survey stations (N=317) in 2000.

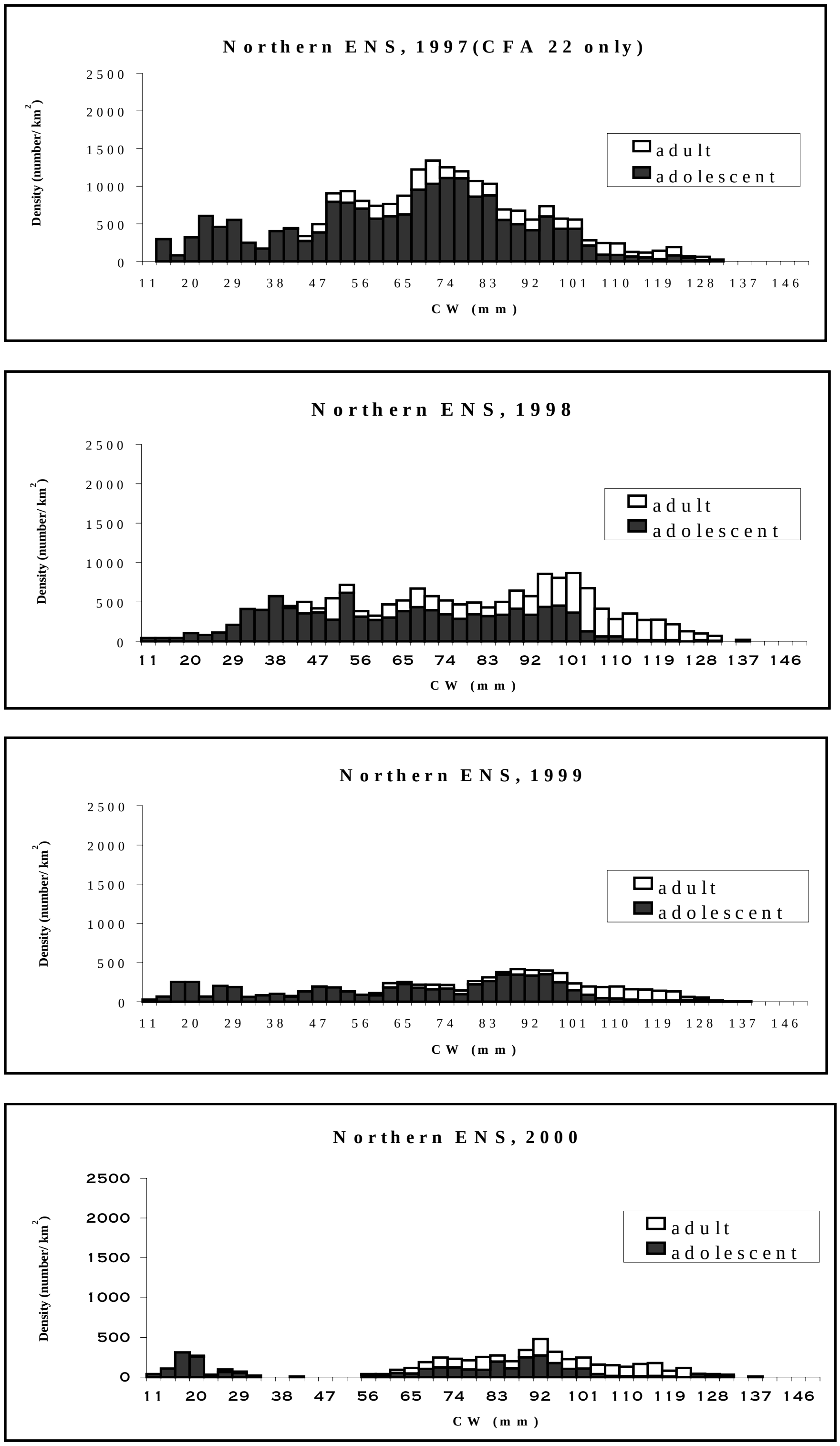


Figure 19. Survey size frequency of male Snow Crab in north-eastern Nova Scotia from 1997 to 2000.

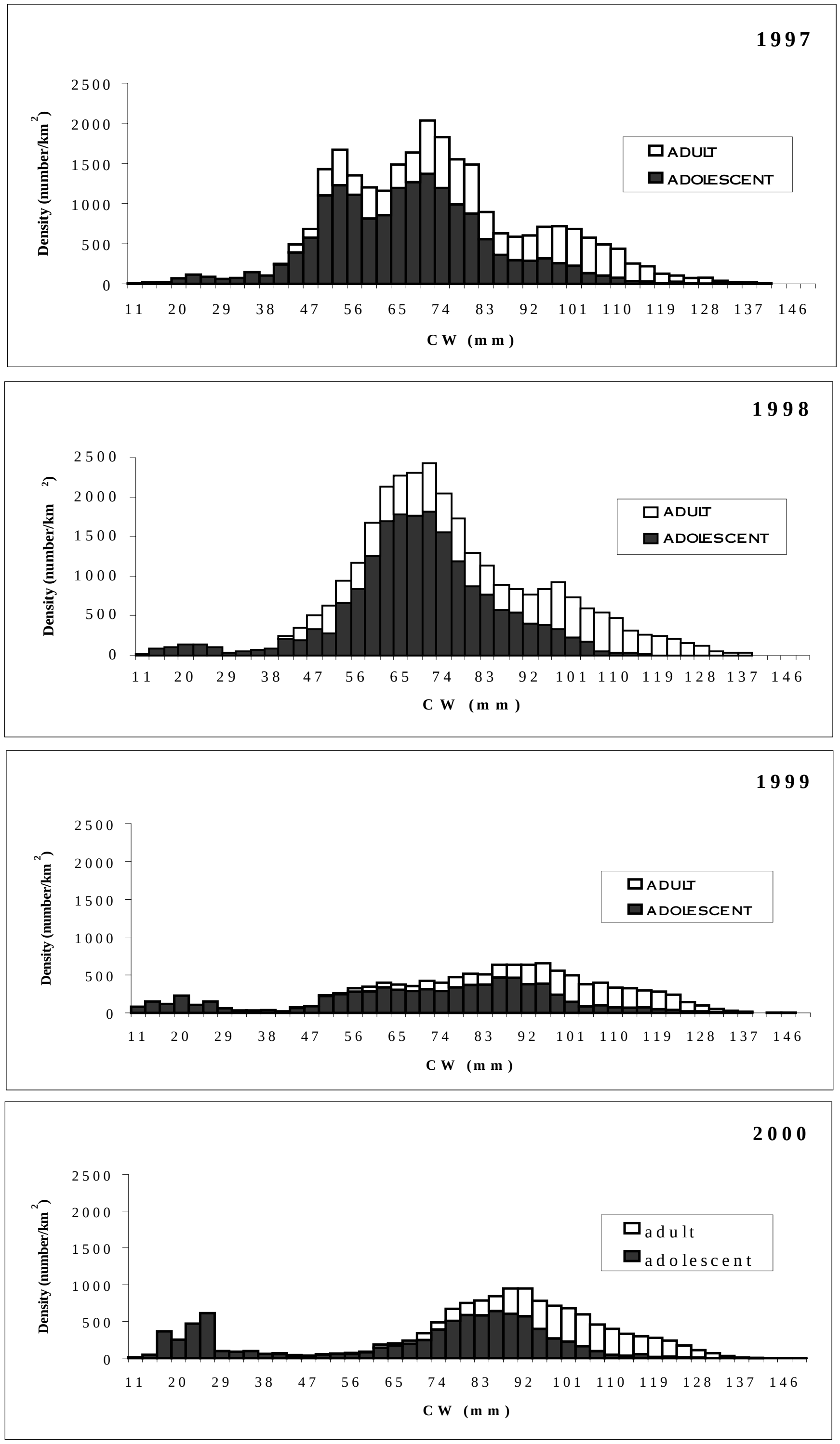


Figure 20. Survey size frequency of male Snow Crab in south-eastern Nova Scotia from 1997 to 2000 for the same surface surveyed (original surveyed area).

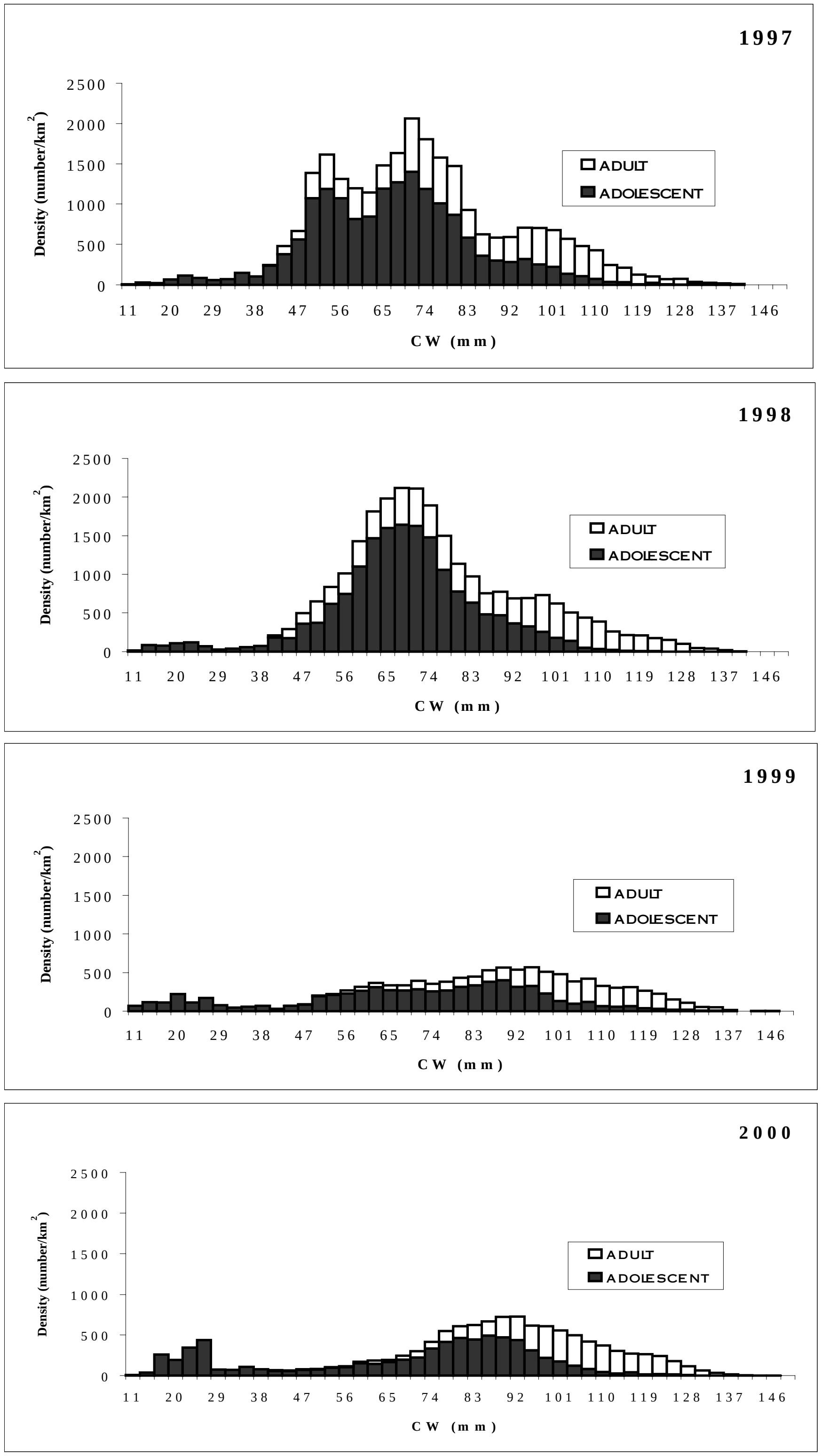


Figure 21. Survey size frequency of male Snow Crab in south-eastern Nova Scotia from 1997 to 2000 for the total surface surveyed every year.

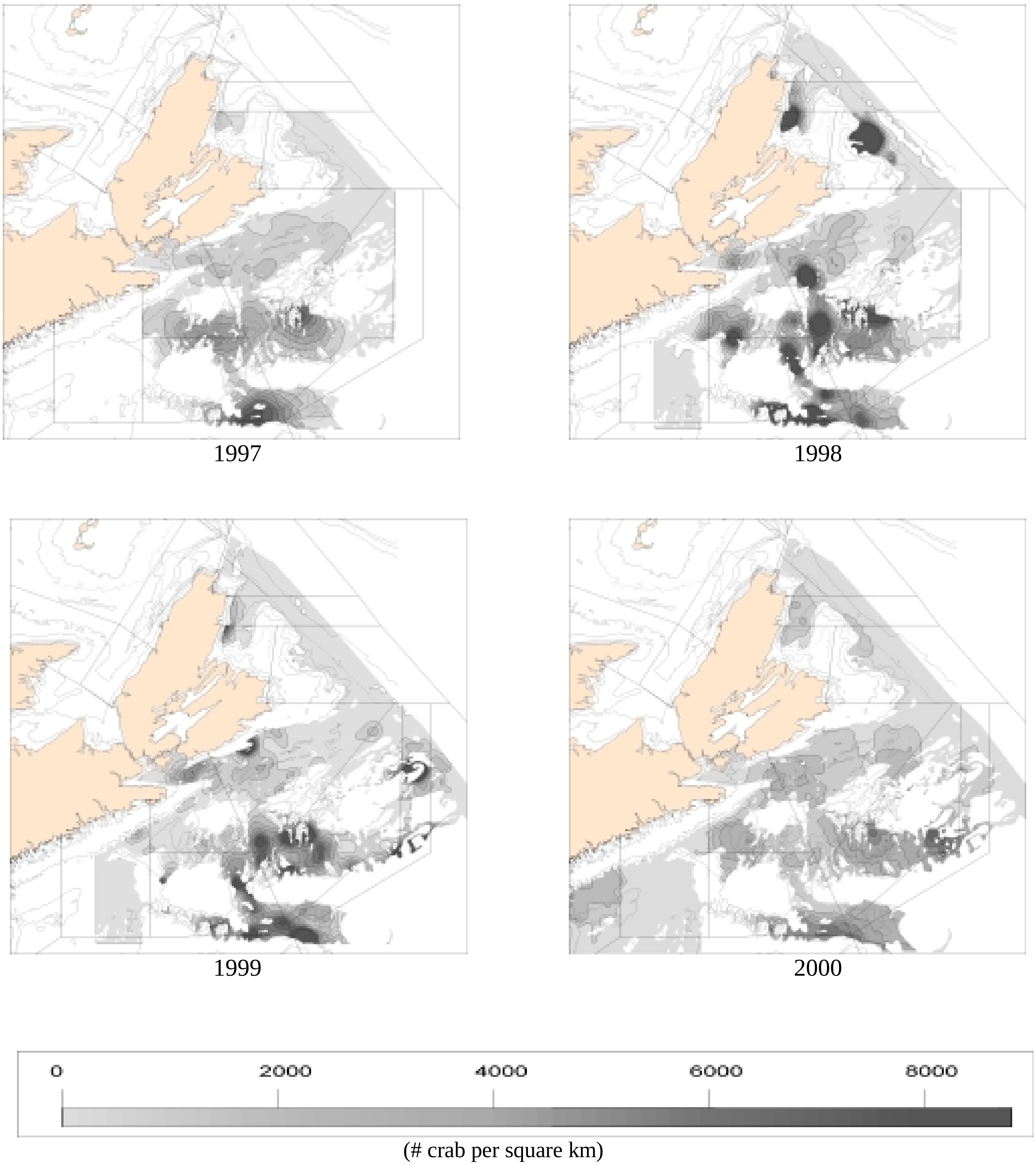
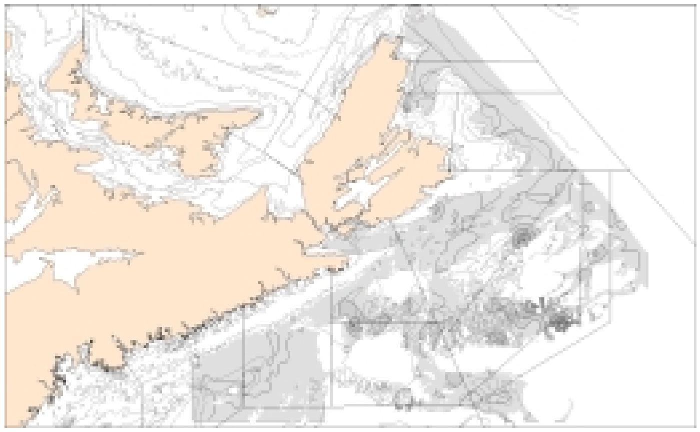
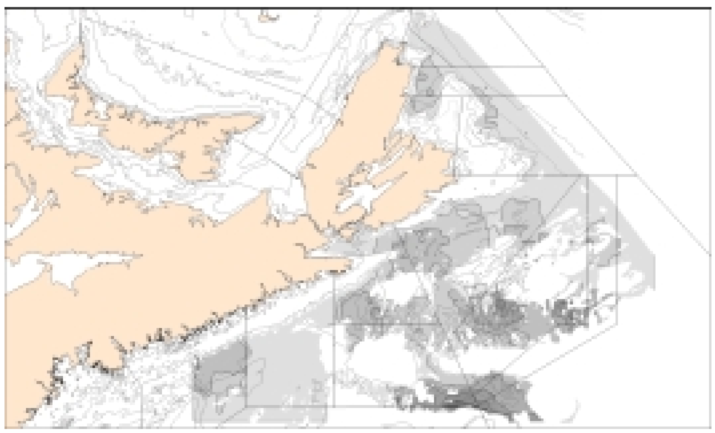


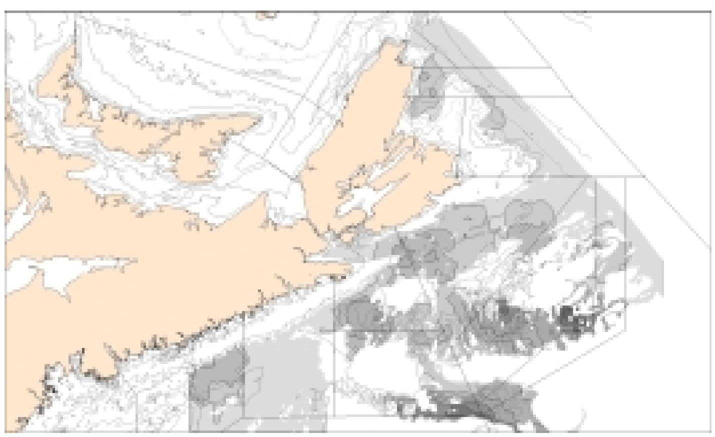
Figure 22. Snow Crab density distribution found in eastern Nova Scotia from 1997 to 2000.



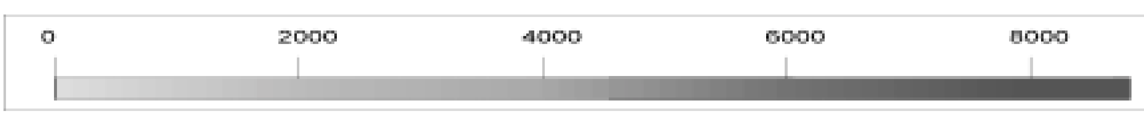
Shell condition 1 and 2



Shell condition 3, 4 and 5

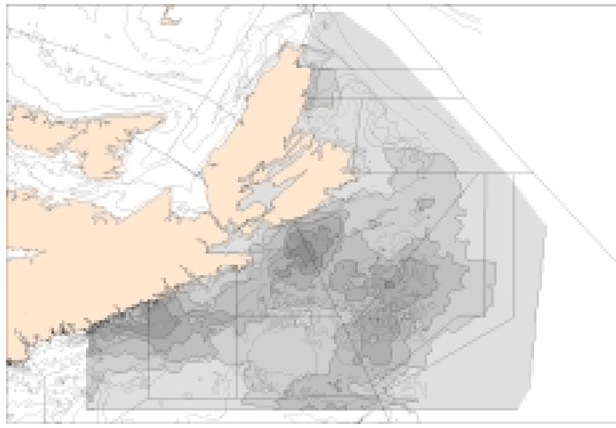


Shell condition 1, 2, 3, 4 and 5

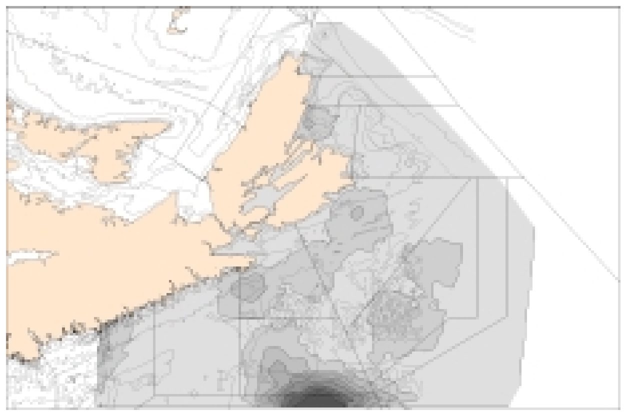


(# crab per square km)

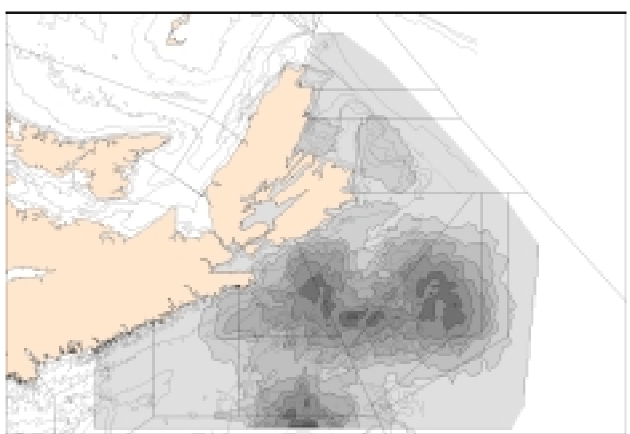
Figure 23. Adult male Snow Crab density distribution for different shell condition.



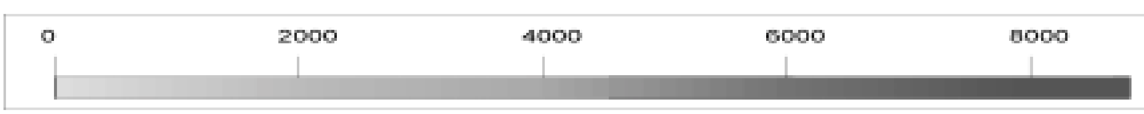
0-56mm



56-76 mm

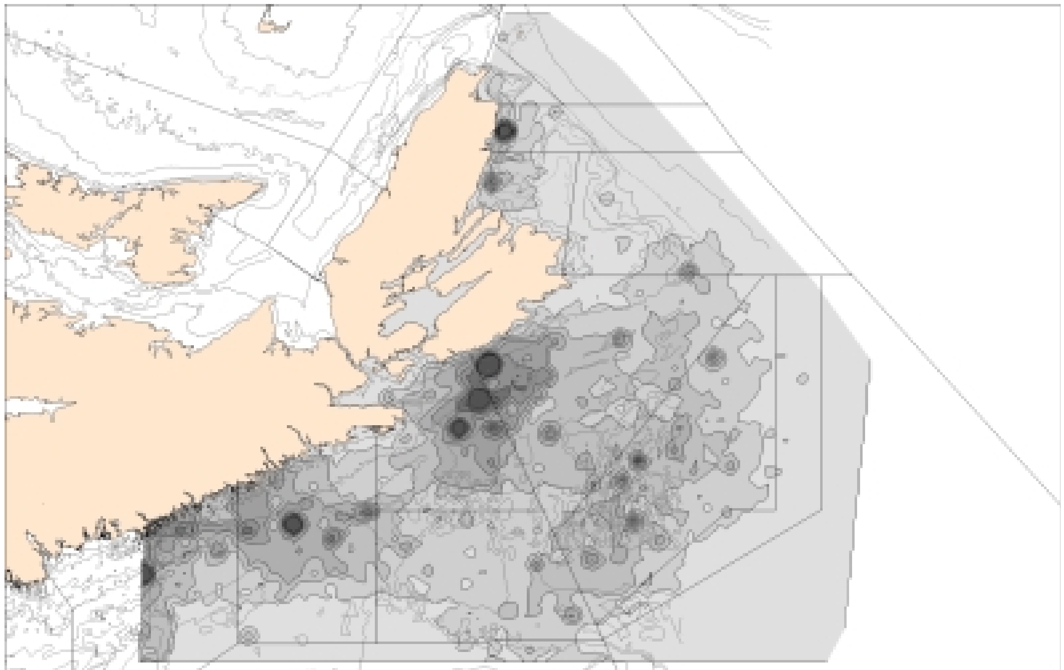


76-95 mm

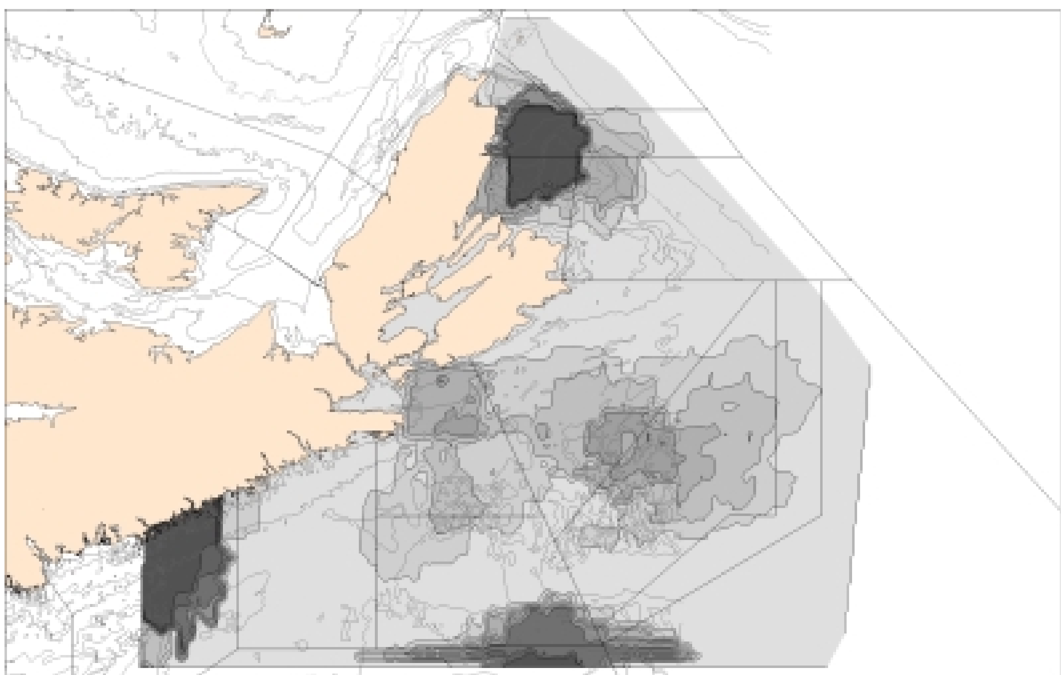


(# crab per square km)

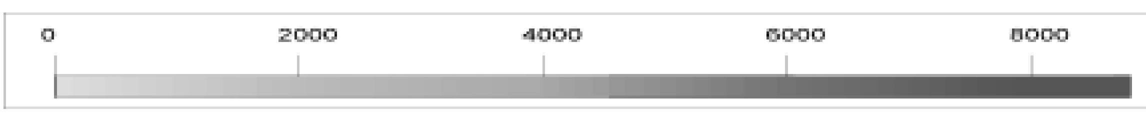
Figure 24. Adolescent male Snow Crab density distribution for different size ranges in 2000.



Immature female



Mature female



(# crab per square km)

Figure 25. Immature and mature female Snow Crab density distribution in 2000.

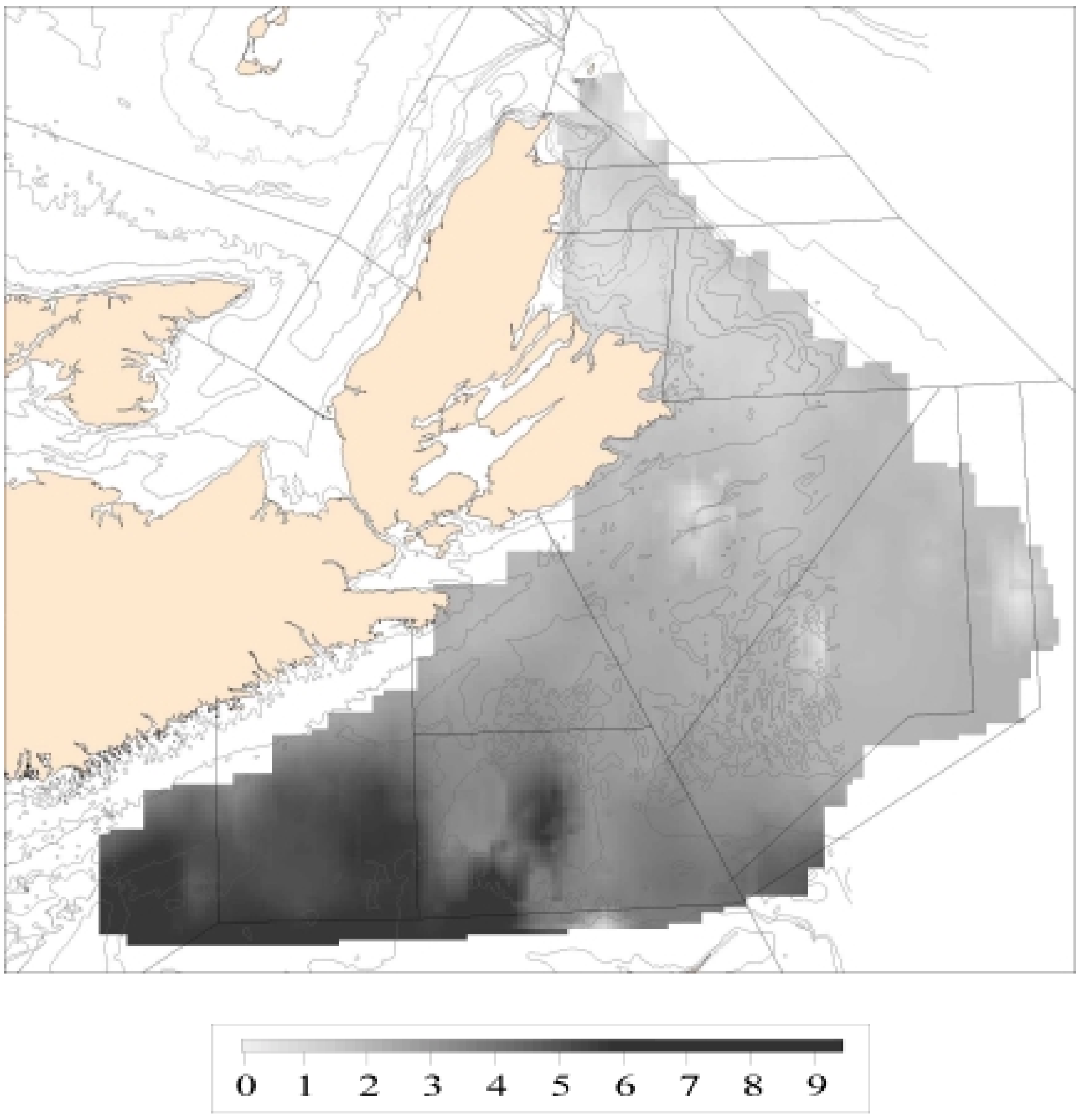
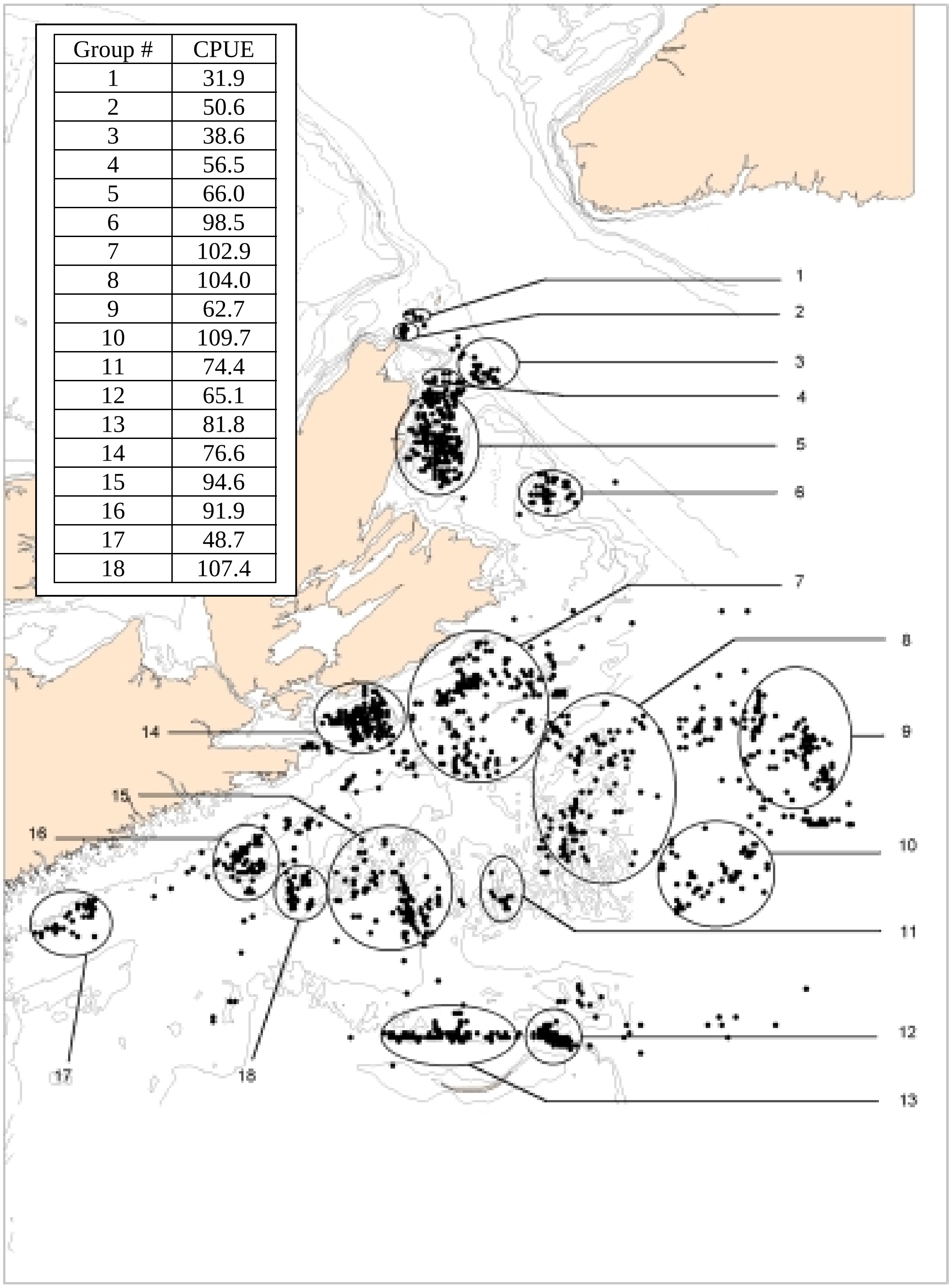


Figure 26. Temperature data from the Snow Crab trawl survey in 2000.



Group #	CPUE
1	31.9
2	50.6
3	38.6
4	56.5
5	66.0
6	98.5
7	102.9
8	104.0
9	62.7
10	109.7
11	74.4
12	65.1
13	81.8
14	76.6
15	94.6
16	91.9
17	48.7
18	107.4

Figure 27. Catch per unit of effort for different groups without taking in consideration the areas.

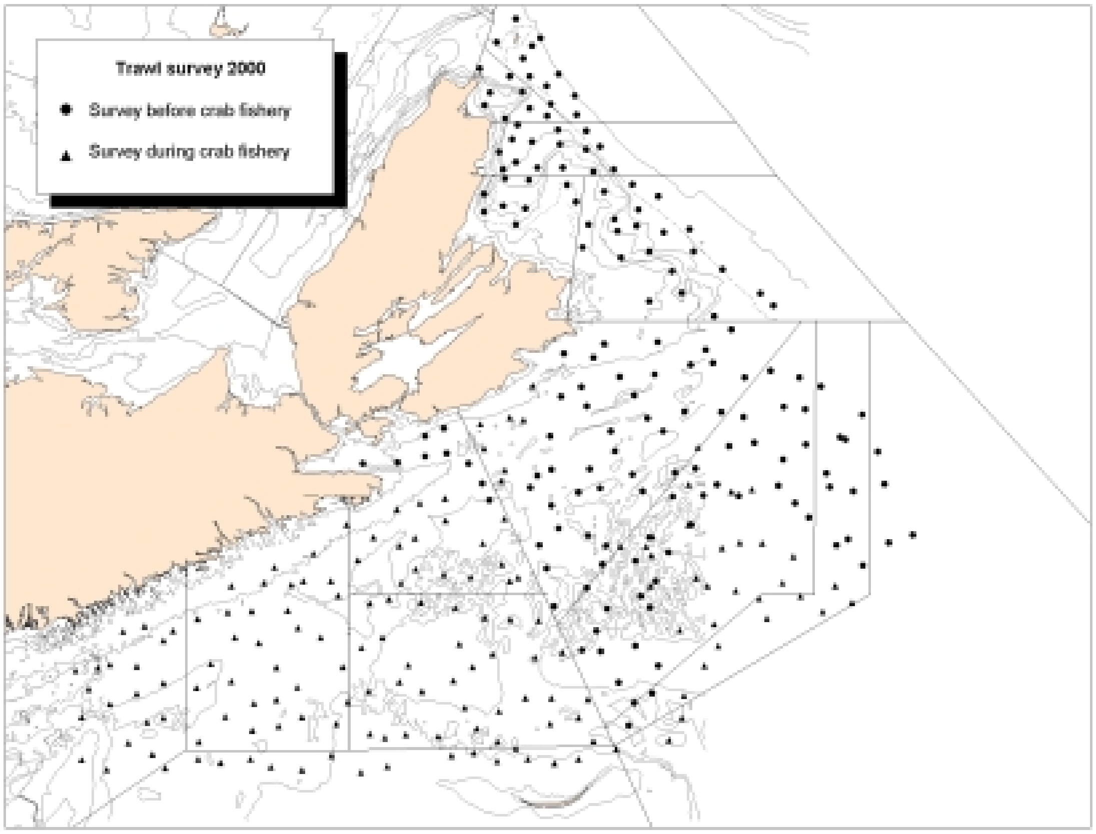


Figure 28. Trawl survey positions before and during the Snow Crab fisheries in 2000.

Appendix 1

Classification of carapace stages developped for the SGSL stock based on carapace condition, durometer reading and corresponding approximate age after terminal molt (modified from CAFSAC 1991; Anonymous 1994).

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

Appendix 2

Seasonal catch composition, in number, from at-sea samples for eastern Nova Scotia (Areas 20 – 24) in 2000.

a) Catch composition in Area 20 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
3	11	< 95 mm	6	75	2	3	8	78	86
		> 95 mm	19	304	7	11	26	315	341
		total	25	379	9	14	34	393	428

b) Catch composition in Area 21 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
10	28	< 95 mm	24	152	9	1	33	153	186
		> 95 mm	82	657	58	121	140	778	918
		total	106	809	67	122	173	931	1119

c) Catch composition in Area 22 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
12	58	< 95 mm	167	289	29	7	196	296	492
		> 95 mm	209	1038	58	184	267	1222	1489
		total	376	1327	87	191	463	1518	2300

d) Catch composition in Area 23 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
46	356	< 95 mm	382	1175	136	42	518	1217	1735
		> 95 mm	897	10225	131	396	1028	10621	11649
		total	1279	11400	267	438	1546	11838	13384

e) Catch composition in Area 24 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		adolescent	adult	adolescent	adult	adolescent	adult	
41	376	< 95 mm	334	949	69	7	403	956	1359
		> 95 mm	2193	10564	198	380	2391	10944	13335
		total	2527	11513	267	387	2794	11900	14694

Appendix 3

Retrospective Traffic Light Analysis (1997-1999) and current assessment (2000).

Northern ENS	1997	1998	1999	2000
Fishery Data				
CPUE (kg)				
Effort (# trap haul)				
Size (carapace width)				
Survey Data				
Biomass/abundance index				
Recruitment (juveniles)				
Recruitment (R-1)				
Other Data				
Temperature				
Industry perspective				
Score				

Southern ENS	1997	1998	1999	2000
Fishery Data				
CPUE (kg)				
Effort (# trap haul)				
Size (carapace width)				
Survey Data				
Biomass/abundance index				
Recruitment (juveniles)				
Recruitment (R-1)				
Other Data				
Temperature				
Industry perspective				
Score				

Appendix 4

Landings, catch rate and effort statistics for snow crab northern ENS (CFAs 20-22) and southern ENS (CFAs 23 and 24), 1997-2000.

a) Northern ENS

Year	Active Licenses/permits	Logbooks received	Landings statistics	Mean CPUE (kg/trap haul)	Total Effort (1000`s of trap hauls)
1997	74	74	534	23.3	22.9
1998	74	74	657	41.5	15.8
1999	78	78	899	54.8	16.4
2000	79	79	1,017	68.2	14.9
Average(97-00)			777	47.0	17.5

b) Southern ENS

Year	Active Licenses/permits	Logbooks received	Landings statistics	Mean CPUE (kg/trap haul)	Total Effort (1000`s of trap hauls)
1997	59	59	1,157	50.9	22.7
1998	67	67	1,558	68.9	22.6
1999	-	-	2,700	71.1	38.0
2000	158	157	8,701	85.0	102.4
Average(97-00)			3,529	69.0	46.4