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The 1989 Assessment for Snow Crab on the Atlantic Coast of Cape Breton Island

by

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ABSTRACT

The overall status of stocks in areas 2-6 in 1989 appears to show a slight improvement over 1988, continuing the reversal of the collapsed state noted in previous years. A wave of males first detected as pre-recruits in 1985 continued recruiting into the commercial stocks prior to the 1989 fishing season and at least maintained fishable biomass over 1988 levels in all areas. A weaker market demand for snow crab resulted in a slight decrease in estimated total fishing effort (trap hauls) but this was offset by a higher average catch rate and total landings were marginally higher than in 1988. Although 96 of a possible 111 vessels were active, only 34 logbooks were received covering 221.6 t of the total recorded catch (560.4 t). Nevertheless the available logbooks and pattern of CPUE permitted estimates of exploitation rate for all inshore areas by Leslie analyses. Crude estimates of total available commercial biomass were made by multiplying the landings from sales slips, by the reciprocal of the exploitation rate.

Fishing activity was minor in area 2 (5 vessels: 12.0 t). Landings of 146.6 t were recorded from sales slips for the 27 active vessels in area 3. The 26 active vessels in area 4 all fished inshore and recorded total landings of 93.9 t (by sales slips). Analyses of logbooks for vessels fishing in the combined area 2, 3, 4 (inshore) gave a mean CPUE of 13.0 kg/trap haul (compared to the mean of 9.9 kg/trap haul recorded in 1988). Total available biomass for the combined inshore area was estimated at 395 t and the exploitation rate at 64%.

Sales slips from area 5 indicated landings of 114.4 t, a drop from the 174.1 t reported in 1988. Logbooks from 4 of the 21 active vessels reported landings of 40.2 t. The mean CPUE of 19.7 kg/trap haul was below that for 1988 (25.7 kg/trap haul). Leslie analyses (unsatisfactory due to poor logbook returns and increasing catch rates during the latter part of the season) gave an exploitation rate of 22%.

Logbooks for area 6 showed catches of 77.2 t for 11 of the 12 vessels fishing inshore; landings of 136.9 t were recorded by sales slips. The mean CPUE for the inshore grounds was 16.9 kg/trap haul, an increase from 13.5 kg/trap haul in 1988 and a record for the area. Total available biomass and exploitation rate of the inshore ground were estimated at 249 t and 55% respectively.

One licensed vessel plus 4 vessels with exploratory permits prosecuted the newly-delineated offshore grounds in area 6. Logbooks from the 4 permit holders recorded landings of 19 t, as opposed to 22 t from sales slips. The licensed vessel landed 34.6 t, according to sales slips but failed to declare a logbook. The mean CPUE was 24.1 kg/trap haul as compared to 29.2 kg/trap haul in 1988. Mean catch rates were maintained above 20 kg/trap haul throughout the latter half of the season. At-sea sampling showed that most of the males captured were relatively old-shelled and had attained morphometric maturity. Evidently vessels in the offshore are exploiting virgin grounds, catch rates remain high and the fishery has yet to significantly impact on the resource.

The 1989 assessment for areas 2-6, does not appear to justify changes in the current management strategy. As with other snow crab stocks, it is not possible to forecast future

catches because growth is not well understood and recruitment is unpredictable. However, the exploitation rates in inshore areas 2-6 are close to the target level, catch rates remain high, relative to lows in the early 1980's, and the high proportion of morphometrically immature males in the stocks suggest that the current improved trend in growth and recruitment will continue for at least a further fishing season.

RESUME

En 1989, la situation globale des stocks des zones 2 à 6 semble s'être légèrement améliorée par rapport à 1988, poursuivant une remontée après l'effondrement constaté dans les années précédentes. Une vague de mâles repérés comme pré-recrues en 1985 a continué son recrutement dans les stocks commerciaux avant la saison de pêche de 1989 et a permis de maintenir à tout le moins la biomasse exploitable à son niveau de 1988 dans l'ensemble des zones. Un fléchissement de la demande de crabe des neiges a entraîné une légère diminution de l'effort de pêche total estimé (casiers mis à l'eau), mais celle-ci a été compensée par une hausse du taux de prise moyen; aussi, les débarquements globaux ont-ils été quelque peu supérieurs à ceux de 1988. Bien que 96 bateaux (sur une possiblilité de 111) aient activement pratiqué la pêche, on n'a reçu que 34 journaux de bord, portant sur 221,6 t des 560,4 t de prises totales déclarées. Les journaux remis et la tendance des PUE ont néanmoins permis d'établir une estimation du taux d'exploitation dans toute les zones côtière, fondée sur les analyses de Leslie. On a établi une estimation grossière de la biomasse commerciale totale disponible en multipliant les débarquements indiquées sur les récépissés de vente par l'inverse du taux d'exploitation.

L'activité de pêche a été minime dans la zone 2 (cinq bateaux : 12 t). Dans la zone 3, les débarquements indiqués sur les récépissés de vente de 27 bateaux actifs s'élevaient à 146,6 t. Dans la zone 4, les 26 bateaux qui ont activement pratiqué la pêche l'ont fait dans le secteur côtier et ont obtenu des débarquements totaux de 93,9 t (d'après les récépissés). L'analyse des journaux de bord des bateaux qui pêchaient dans ces zones - 2, 3 et 4 (secteur côtier) -a abouti à des PUE moyennes de 13 kg par casier (comparativement à une moyenne de 9,9 kg par casier en 1988). On a estimé la biomasse totale de l'ensemble du secteur côtier à 395 t et le taux d'exploitation à 64 %.

Les récépissés de vente de la zone 5 indiquaient des débarquements de 114,4 t, en baisse par rapport aux 174,1 t déclarées en 1988. Les journaux de bord de quatre des 21 bateaux actifs révélaient des débarquements de 40,2 t. Les PUE moyennes, soit 19,7 kg par casier, ont été inférieures à celles de 1988 (25,7 kg par casier). Les analyses de Leslie, insatisfaisantes en raison du nombre insuffisant de journaux de bord et de l'accroissement des taux de prise durant la dernière partie de la saison, ont abouti à un taux d'exploitation de 22 %.

Les journaux de bord de 11 des 12 bateaux qui pêchaient dans les eaux côtières de la zone 6 révélaient des prises de 77,2 t. D'après les récépissés de vente, les débarquements s'élevaient à 136,9 t. Les PUE moyennes dans le secteur côtier étaient de 16,9 kg par casier, ce qui représente une hausse par rapport au 13,5 kg par casier enregistrés en 1988 et un record pour la zone. On a estimé respectivement à 249 t et 55 % la biomasse disponible et le taux d'exploitation.

Un bateau visé par un permis de pêche normal et quatre autres habilités à pratiquer une pêche exploratoire ont exploité les nouveaux lieux de pêche hauturière de la zone 6. D'après les journaux de bord des quatre détenteurs de permis de pêche exploratoire, les débarquements se chiffraient à 19 t. Les récépissés révélaient des débarquements de 22 t. Le bateau visé par un permis normal de pêche du crabe a débarqué 34,6 t de prises, d'après ses récépissés de vente, mais n'a pas remis de journaux de bord. Les PUE moyennes étaient de 24,1 kg par casier, comparativement à 29,2 kg par casier en 1988. Les taux de prises moyennes se sont maintenues au dessus de 20 kg par casier dans toute la deuxième moitié de la saison. L'échantillonnage en mer a révélé que la plupart des mâles capturés avaient une caparace relativement vieille et avaient atteint la maturité morphologique. Comme les bateaux qui pratiquent la pêche hauturière exploitent de nouveaux lieux de pêche, les taux de prise demeurent élevés et la pêche n'a pas encore eu de répercussions notables sur la ressource.

Les prévisions pour 1989 dans les zones 2 à 6 ne semblent pas justifier de changement dans la stratégie actuelle de gestion. Comme pour les autres stocks de crabe des neiges, il n'est pas possible d'estimer les prises futures parce qu'on connaît mal la croissance du stock et que le recrutement est imprévisible. Cela dit, les taux d'exploitation des zones de pêche côtière (2-6) sont proches du niveau cible, les taux de prise demeurent élevés, comparativement à leur bas niveau du début des années 1980, et la forte porportion de mâles morphologiquement immatures présente dans le stock permet de penser que la croissance et le recrutement continueront se s'améliorer durant au moins une autre saison de pêche.

INTRODUCTION

A directed fishery for snow crab off Cape Breton Island was started in 1966 on the northwest coast. Between 1976 and 1978, seven management areas were defined around the Island (Fig. 1) for exclusive exploitation by inshore vessels under 45 ft. (13.7 m) length. Between 1977 and 1979, landings rose markedly in phase with effort and the expansion of the fishery to approximately 180 vessels operating in all seven areas (Elner 1982a). However, in 1982 it was postulated that the snow crabs on the Atlantic coast of Cape Breton Island (areas 2-6) were based on a resource with low, or sporadic, production because although the virgin biomass had been rapidly removed by fishing no significant recruitment had occurred (Davidson et al 1985). Management discontinued catch controls for areas 2-6 in 1982 to allow the existing fishermen to take advantage of whatever productivity occurs from time to time on an opportunistic basis. The regulatory measures remaining include strict licensing controls, a 30 trap/vessel limit, a relatively short fishing season (10 weeks, July to September). Since 1987 sustained recruitment into the commercial stocks has increased fishable biomass in all areas. A previously unexploited group of snow crab was fished for the first time in the offshore part of area 6 in 1988; four exploratory permits were issued for these offshore grounds in 1989.

The minimum legal size regulation of 95 mm carapace width was thought to confine exploitation to males mature for 1 to 3 yr and thus theoretically protect the reproductive potential of the resource (Elner and Robichaud 1983a; Elner and Gas 1984). However, up to approximately 50% of the commercial-sized males sampled in Areas 3, 5, and 6 during 1988 were morphometrically immature (Elner et al. 1989). Furthermore, both male and female snow crabs in eastern Canada are now considered to have a terminal molt to morphometric maturity (O'Halloran 1985: Conan and Comeau 1986). The size, and presumably age, at which this may occur is variable. Factors influencing when an individual crab undergoes its terminal molt are unknown; but for males, the size of terminal molt can be 50-150 mm CW. Analyses of morphometric data have shown that large numbers of males have attained a terminal molt below the legal minimum size. The implications of this new knowledge on snow crab management are still unclear (see Bailey and Elner 1989, for discussion of the issue).

The present paper assesses the status of the snow cab fishery in Areas 2, 3, 4, 5, and 6* for 1989. Such annual assessments form the biological basis for management of the various Canadian fisheries for snow crab. In addition, a supplementary study (Appendix IV) addresses the nature of the Areas, in terms of long-term recruitment dynamics.

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*Revised Management Areas: 20, 21, 22, 21, and 24, respectively.

MATERIALS AND METHODS

Biological monitoring data based on fishermen's logbooks, sales slip statistics, and commercial sampling) were examined for the Cape Breton Island (Atlantic coast, areas 2-6) snow crab fishery in 1989. Assessments for each stock were made by comparing the monitoring data against historical patterns.

Cape Breton Island snow crab fishermen have been required to maintain logbooks for each fishing season since 1978. The logbooks from the 1989 season provided catch, effort, and CPUE data for each area over time. In contrast to previous years, poor logbook returns prohibited full Leslie analyses. Nevertheless, the available logbooks and patterns of CPUE permitted estimates of exploitation rates in all inshore areas by the Leslie method. Crude estimates of total available commercial biomass were then made by multiplying the landings (from sales slips) by the reciprocal of the exploitation rate.

Sales slips provided supplementary landing statistics and also served to check logbook coverage (see also Appendix I). To improve trap location information given in logbooks, fishermen have been provided large-scale grid charts since 1983 and requested to indicate the grid number(s) corresponding to their fishing area(s). For detailed accounts of snow crab logbook format and Leslie analysis see Elner (1982b) and Mohn and Elner (1988). Port and at-sea sampling were carried out throughout the fishing season in Areas 2, 3, 4, 5, and 6, to monitor the size-frequency distribution and shell hardness profile of commercial catches (see Appendix II for sampling sheet). Snow crab size was determined by measurement of carapace width (CW) across the widest part of the carapace. Shell flexibility was assessed subjectively as "hard", "intermediate", or "soft" by applying thumb pressure across a chela. Shells were also subjectively classified as either "new" or "dark" according to colour.

Chela height (Fig. 2) was measured for male snow crabs to continue research into morphometrics and size at maturity. Conan and Comeau (1986) and O'Halloran (1985) detail the relationship between chela allometry and morphometric maturity. In summary, when logarithms of chela height are plotted against the logarithms of carapace width, morphometrically immature crabs form a swarm of data points distinct from morphometrically mature crabs. The major axes of the swarms are parallel, and area-specific cutting lines effectively separate the two swarms; data points for mature crabs appear above the cutting line and point for immature crabs fall underneath. Details of the discriminant function analyses and cutting line equations (produced by M. Comeau, DFO, Gulf Region) are given in Elner et al. (1988).

RESULTS

Areas 2, 3, and 4 (Northeastern Cape Breton - inshore).

Port and at-Sea Sampling

Size frequency histograms for port and at-sea sampling in Areas 3 and 4 (inshore) during July and August 1989 are shown in Figures 3 and 4. Comparisons against size-frequency profiles taken in 1988 in the same area (Elner et al. 1989) reveal a similar pattern of modes and there is close agreement in mean carapace widths. No newly molted, soft-shelled, male or female snow crab were detected in port and at-sea samples from Areas 3 and 4 in 1989. However, between 16.1 and 58.3% of the samples in a given Area were classed as 'medium' in the shell flexibility scale (Table 3). Such medium-shelled crabs could be comprised of either recently molted individuals and/or individuals that have been in terminal molt status for several years. To help resolve the dichotomy, males were also classified according to shell colour ('new' or 'dark'). Thus, it can be expected that dark shelled males with medium shell flexibility have been several years without molting and 'new' shelled males with medium shell flexibility have only recently molted. In terms of relative age since last molt the following classification (from shortest to longest time interval) is probably applicable:

- Medium flexibility/new shell
- Hard flexibility/new shell
- Hard flexibility/dark shell
- Medium flexibility/dark shell

Some buyers independently classified males as 'light' or 'dark', according to colour, and give a lower price for 'light' crab on account of purported lower meat yield at processing.

Maturity

Chela height versus CW data for males in the August at-sea sample for Area 3 (Figure 7) indicates that 18% of the catch, including many legal-sized crabs were morphometrically immature. Similarly, up to 45.5% of the landed crabs sampled in port in Area 3, and 4 in July and August 1989 were morphometrically immature (Fig. 8). While the morphometrically immature crabs will molt and further contribute to production in the 1990 season, the morphometrically mature individuals, including those below the legal minimum size cannot be expected to grow again (Table 4).

Females

All 9 mature females sampled in Area 3 during August 1989 were ovigerous (Fig. 11; Table 3).

Logbooks

Five fishermen were active in Area 2, 27 were active in Area 3, and 26 in Area 4. No logbooks were forthcoming from the Area 2 fishermen, 12 were received from Area 3 and 3 from Area 4 (Tables 1, 2). Most of the traps were set on inshore grounds, in or adjacent to, Area 3 (Fig. 1). Thus, for assessment purposes (as in previous years) fishermen are considered to have exploited a single stock (Areas 2, 3, and 4, inshore). The offshore of Area 4, which has been exploited in previous years (Elner and Robichaud, 1987) does not appear to have been fished in 1989. Landings, as recorded from sales slips and logbooks for the combined inshore area, were 252.6 t and 84.7 t, respectively; sales slips values are 20 t above the record landings of 1988 and the highest since 1980 (Table 2; Fig. 16).

Analysis of catch and effort data from logbooks for the combined Areas 2, 3 and 4 revealed a declining trend in mean weekly CPUE through the fishing seas (Table 5). The mean CPUE (13.0 kg trap haul) in 1989 is the highest recorded since the fishery started in 1978 and approximately triple the rate observed for the 1984-1986 annual assessments (Fig. 12). Leslie analysis, corrected for missing logbooks, (Fig. 15) indicates that the total available commercial biomass (B^0) for the fishing season was 394.7 t after an exploitation rate of 64% (95% cl:78% and 50%). The total available biomass estimated for 1989 is approximately 100 t higher than that assessed for 1988 and a record overall (Table 2).

Area 5 (Southeastern Cape Breton).

Port and at-sea sampling

Size-frequency histograms for port and at-sea sampling Area 5 during August 1989 are shown in Fig. 5. Port and at-sea samples in August 1989 had similar profiles and mean carapace widths to August 1988.

All male and female crabs sampled at-sea and in port during the 1989 fishing season were either in a hard or medium-shelled condition (Table 3). In season growth and recruitment has not been recorded in Area 5 since 1978 (Elner et al. 1988). As for Areas 2, 3, and 4, a large proportion (56.4%) of the males sampled had 'medium' shells; of these individuals 85.2% were classified as 'new' shelled, indicating they had molted relatively recently.

Maturity

Plots of chela height versus CW for male crab sampled at-sea and in port (Fig. 9) during the 1989 season indicate that up to 50.5% were morphometrically immature. Again, as in Areas 2, 3, and 4, there is a large 'sink' of males in terminal molt status below the legal minimum size. There appears to be a similar proportion of morphometrically immature males to 1988 (Table 4).

Females

If the 85 mature females sampled at-sea in August 1989 all but one was ovigerous (Table 3; Fig. 11). The high proportion of ovigerous females appears to be a further reversal of the declining trend noted in previous years (Elner and Robichard, 1986) and is probably a reflection of the same recruitment wave detected for the male crabs. Previously, a lack of recruitment had led to a "sensility" phenomenon with either barren females or multiparous females with reduced egg clutches becoming increasingly common as the population aged (Bailey and Elner 1989).

Logbooks

Logbooks were received from 4 of the 21 Area 5 fishermen who set traps in 1989. Total landings derived from logbooks were 40.2 t as compared to 114.4 t from sales slips statistics (Table 1). Landings in 1989, according to sales slips, were approximately 60 t below the value for 1988 (174.1 t) and the lowest since 1986 (44 t) (Fig. 13).

The overall mean CPUE value for the 1989 season (19.7 kg trap $haul^{-1}$) was markedly below the 1988 value (25.7 kg trap $haul^{-1}$) but still above mean values estimated for the 1984-86 "trough" (Table 2; Fig. 13). Mean weekly CPUE values demonstrated a declining trend that was barely amendable to analysis by the Leslie method (Table 5, Fig. 15). Based on Leslie analysis and correcting for missing logbooks, the B^0 for the season was 520.2 t. Logbook-derived catches would have resulted in an exploitation rate of 22% (95% CL: 51% and 19%). The B^0 estimated for 1989 is in excess of that for 1988 (284.6 t) but given the falling trend in CPUE and the crude methodology used in estimating B^0 for 1989 this index should be viewed with caution.

Area 6 (Southern Cape Breton)

Port and at-Sea Sampling (inshore)

Port and at-sea sampling was carried out in area 6 during August 1989 (Figure 6). The mean carapace width for the sea sample was similar to that for 1988. However, the mean CW for the port sample (112.6mm) was sharply below that for 1988 (120.4mm) due to a pulse of morphometrically immature males recruiting into be commercial size range.

As for the preceding Areas, all male and female snow crabs inspected in Area 6 during 1989 were either 'hard' or 'medium' shelled (Table 3). Most (93.2%) of the 'medium' shelled males classified as being 'new' and, thus, having molted relatively recently.

Maturity (inshore)

Plots of chela height versus CW for male crab sampled at-sea and in port of Area 6 during August 1989 are shown in Fig. 10. Again, as for Areas 2, 3, 4 and 5, the sea samples show a large 'sink' of terminal males below the minimal legal size. The August 1989 sea sample shows a relatively greater proportion of morphometrically mature males present as compared to the equivalent 1988 sample; however, the August 1989 port sample had relatively fewer mature males than in August 1988 (Table 4).

Females (inshore)

All but two of the 88 mature female snow crabs sampled at sea in August and September 1988 were ovigerous (Table 3; Figure 11).

Logbooks (inshore)

The total landings from the 11 logbooks received from the 12 Area 6 fishermen active in 1989 amounted to 77.2 t, as opposed to 136.9 t recorded through the sales slips statistics system (Table 1 and 2). Total landings were approximately the same as the 1988 values, which were above all historical levels (Fig. 14).

The overall mean CPUE value (inshore) estimated for the 1989 season (16.9 kg trap haul^{-1}) was the highest ever recorded, the previous peak year was 1981 (15.46 kg trap haul^{-1}). CPUE declined through the season, and the resultant pattern was amenable to analysis by the Leslie method (Table 5; Fig. 15). Logbook corrected B_0 for the 1989 season was estimated at 248.8 t after an exploitation rate of 55% (95% CL: 72% and 31%). The B_0 level for 1989 is the highest ever estimated for Area 6 and is likely a reflection of improved recruitment.

At-Sea Sampling (offshore)

A size-frequency histogram for at-sea sampling on the newly-established offshore grounds of Area 6 is shown in Figure 6. The mean CW (112.2mm CW) is above that for the inshore grounds (106.8mm) and reflects an accumulation of morphometrically mature (adult) males around a modal size of 120mm CW. Most males from the offshore had hard, dark shells (Table 3). By the males with medium shells, the majority were also dark indicating that they had not molted for a considerable time. The overall shell characteristics of males from Area 6 (offshore) area are distinct from all other areas (Table 3).

Maturity (Offshore)

Chela height versus CW data for crabs sampled at-sea in August 1989 indicate that 91.4% of the males were morphometrically mature (Fig. 10). This is in accord with the data on shell characteristics and indicates that these offshore grounds are based on an accumulated virgin resource that, currently, exhibits low growth.

Females (Offshore)

All 21 of the Females sampled at-sea in August 1989 were carrying eggs (Table 3, Fig. 11).

Logbooks (Offshore)

One licensed fishermen plus 4 fishermen with exploratory permits exploited the newly-delineated offshore grounds of Area 6 in 1989 (Fig. 17). Logbooks from the 4 permit holders recorded landings of 19 t, as opposed to 22 t from sales slips (Tables 1,2). The licensed fisherman landed 34.6 t, according to sales slips but failed to declare a logbook. The mean CPUE was 24.1 kg/trap haul as compared to 29.2 kg/trap haul the previous year. In 1989 catch-rates increased rapidly, dropped then were maintained above 20 kg/trap haul throughout the latter part of the season (Table 5, Fig. 17); the pattern, probably due in part to the fishermen learning to fish new grounds, was not amenable to Leslie analysis.

DISCUSSION

A notable change in the dynamics of the snow crab stocks around the Atlantic coast of Cape Breton Island occurred between the end of the 1985 fishing season and commencement of the 1986 season (Elner and Robichaud 1987; Elner et al. 1988; Elner et al. 1989). Essentially, a moderately large wave of snow crab recruited into the fisheries in Areas 2 to 6; the first significant production noted in the system since assessments began in 1978. The present assessment indicates that the wave continued to recruit into the system in 1989. Previously, the lack of production in the face of heavy fishing pressure had resulted in rapidly declining commercial biomass levels, excessive exploitation rates, and marginal catch rates (see also Appendix III). Consequently, annual effort and landings fell progressively between 1979 and 1985 (Elner and Robichaud, 1983b, 1984, 1985). It is probable that the upcoming recruitment wave was detected as by-catch to a Danish seiner operating in Area 5 in July 1985 (Elner and Robichaud 1986). Size-frequency histograms of the by-catch showed immature males and females at a modal size of approximately 58 mm CW. Given the large numbers of morphometrically immature, pre-recruit males sampled in 1986, 1987, 1988 and 1989, the improved production trend seems likely to continue into the 1990 season with concommittant increases in commercial biomass and catch rates. Nevertheless, considering the erratic nature of recruitment, there appears to be no biological basis for reintroducing catch controls (TAC's). Restricting effort to the present level should not only extend to the period over which the current recruitment pulse will support the fishery but will, also, help to restrain exploitation close to the target rate of 50-60% (Elner and Bailey 1986). The long-term prognosis for snow crab in Cape Breton remains uncertain; the fundamental biological basis to snow crab management is acknowledged to be weak; and biologists and managers continue to react to system changes as they occur rather than to plan for predicted commercial biomass levels (Bailey and Elner 1989).

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Table 1. Snow crab statistics for the Atlantic coast of Cape Breton Island, 1978-89.

Area	Year	No. of Possible boats	No. of active boats	No. of logbooks received	Landing Statistics Area Managers (kg)	Landing Statistics logbooks (kg)	Effort in traps hauled (logbook data) (all trap types combined)
2	1978	-	-	-	-	-	-
	1979	12	8	3	108,005	14,129	1,739
	1980	12	8	3	46,919	10,240	1,276
	1981	13	6	-	4,695	-	-
	1982	13	-	-	-	-	-
	1983	13	12	2	7,130	248	150
	1984	5	2	-	9,593	-	-
	1985	5	-	-	-	-	-
	1986	5	1	1	56	56	30
	1987	4	3	-	529	-	-
	1988	6	4	2	16,635	7,932	1,005
	1989	7	5	0	12,005	-	-
3	1978	36	16	16	-	91,118	7,863
	1979	36	27	27	185,101	164,110	18,124
	1980	36	31	25	139,686	73,988	13,835
	1981	36	22	1	31,215	816	60
	1982	35	20	18	86,814	75,295	9,388
	1983	35	27	27	40,058	40,172	8,217
	1984	37	19	13	14,649	12,839	4,346
	1985	40	10	10	13,537	12,732	3,220
	1986	40	12	8	5,632	5,805	2,306
	1987	32	21	14	59,756	56,826	8,137
	1988	31	24	19	125,110	105,559	9,920
	1989	29	27	12	146,638	74,063	4,944
4	1978	38	11	11	-	305,076	11,268
	1979	38	35	26	624,029	591,580	22,775
	1980	38	26	18	181,241	136,605	7,543
	1981	37	11	3	61,476	6,545	520
	1982	37	21	20	165,395	116,243	6,138
	1983	38	24	18	44,199	31,612	4,341
	1984	37	7	6	17,581	18,141	2,173
	1985	37	4	4	406	568	156
	1986	37	7	2	16,744	4,333	729
	1987	34	15	12	58,671	49,096	4,801
	1988	34	29	23	90,490	117,668	7,982
	1989	33	26	3	93,938	11,157	1,160
5	1978	15	15	15	-	250,076	4,531
	1979	25	24	23	679,504	682,731	15,382
	1980	26	24	21	395,855	324,786	9,261
	1981	25	11	10	90,463	81,819	2,835
	1982	25	19	18	300,145	298,469	9,931
	1983	22	21	21	151,296	148,827	8,146
	1984	24	10	6	45,215	41,295	2,220
	1985	24	5	5	29,171	20,833	1,465
	1986	24	7	6	43,972	40,155	2,837
	1987	21	14	11	157,408	119,321	4,547
	1988	21	19	16	174,112	162,946	6,321
	1989	24	21	4	114,434	40,179	2,040

Table 1. (cont.)

Area	Year	No. of Possible boats	No. of active boats	No. of logbooks received	Landing Statistics Area Managers (kg)	Landing Statistics logbooks (kg)	Effort in traps hauled (logbook data) (all trap types combined)
6	1979	8	4	4	24,868	27,351	1,880
	1980	11	10	9	58,596	69,136	5,246
	1981	11	5	5	15,896	20,350	1,316
	1982	11	7	7	63,072	63,133	6,462
	1983	14	13	12	64,084	64,461	7,733
	1984	14	13	12	53,889	50,239	5,229
	1985	14	6	5	40,844	32,219	3,157
	1986	14	5	5	37,770	49,027	4,119
	1987	13	11	9	83,931	77,782	6,021
	1988	14	13	13	134,216	162,550	10,115
	1989	13	12	11	136,855	77,202	4,187
Offshore Area 6							
	1988	1	1	1	41,160	42,819	1,466
	1989	1	1	0	34,553	-	-
Experimental Offshore Area 6							
	1989	4	4	4	22,029	19,015	789

Area	Year	No. of Possible boats	No. of active boats	No. of logbooks received	Landing Statistics Area Managers (kg)	Landing Statistics logbooks (kg)	Actual effort in traps hauled (logbook data) (all trap types combined)
Total	1978	89	42	42	-	646,270	25,296
	1979	119	98	83	1,621,508	1,479,901	59,900
	1980	123	99	76	822,287	614,755	37,161
	1981	122	55	19	203,745	109,530	5,031
	1982	121	67	63	615,426	553,140	31,919
	1983	122	97	80	306,767	285,320	28,587
	1984	117	51	37	140,927	122,514	13,968
	1985	120	25	24	83,958	66,352	7,998
	1986	120	32	22	104,174	99,376	10,021
	1987	104	64	48	360,295	303,025	23,506
	1988	106	89	73	540,563	556,655	35,343
	1989	111	96	34	560,452	221,615	13,120

Table 2. Comparsion of assessment data for Cape Breton Island snow crab (Areas 2-6) 1978-89.

Area	Year	No. of active boats	No. of logbooks received	Landing Statistics: Area Managers (kg)	Landing Statistics: logbooks† (kg)	Total Effort (estimated trap hauls)#	Mean CPUE	Available Biomass for Season (mt)	Exploitation rate (%)	Standardized trap type
2,3 & 4	1978	23	23	-	192,228	17,258	11.14	-	-	(1.2X.9X.8m,wood)
(inshore)	1979	70	40	917,136	262,250	89,739	10.22	324.9	81	"
	1980	65	42	367,846	181,033	35,541	10.35	225.2	80	"
	1981	39	4	97,386	7,361	7,674	12.69	-	-	(1.5X1.5X.5m,steel)
	1982	41	28	252,209	100,161	35,176	7.17	153.0	65	(1.2X.9X.8m,wood)
	1983	63	41	91,387	55,242	19,486	4.69	76.5	72	"
	1984	28	18	41,823	16,423	13,713	3.05	24.2	68	"
	1985	14	14	13,943	13,300	3,539	3.94	-	-	"
	1986	19	11	13,712	10,194	6,736	3.33	20.2	51	"
	1987	39	26	118,956	105,922	14,173	8.20	229.2	46	-
	1988	57	44	232,235	187,144	23,458	9.9	292.3	64	-
	1989	58	15	252,581	84,709	19,429	13.0	394.7Ω	64	-
4	1978	4	4	-	203,966	4,916	41.49	-	-	(1.5X1.5X.5m,steel)
(offshore)	1979	*	16	*	507,569	10,546	48.13	-	-	"
	1980	*	4	*	39,800	827	48.13	790.0	64	"
	1981	*	-	*	-	-	-	-	-	"
	1982	*	10	*	91,377	2,875	31.78	-	-	"
	1983	*	6	*	16,790	1,454	11.55	-	-	"
	1984	*	2	*	14,557	1,159	12.56	28.3	51	"
	1985	*	-	*	-	-	-	-	-	"
	1986	1	-	8,720	-	-	-		-	"
	1987	0	0	0	0	0	0	0	0	0
	1988	0	0	0	0	0	0	0	0	0
	1989	0	0	0	0	0	0	0	0	0
5	1978	15	15	-	250,076	4,531	55.19	440.0	57	""
	1979	24	23	679,504	682,731	14,747	46.30	1185.0	58	"
	1980	24	21	395,855	324,786	8,948	44.24	543.0	60	"
	1981	11	10	90,463	81,819	3,135	28.86	-	-	"
	1982	19	18	300,145	298,469	8,898	33.73	356.9**	84	"
	1983	21	21	151,296	148,827	7,380	20.50	176.0**	85	"
	1984	10	6	45,215	41,295	2,557	17.68	55.3	75	"
	1985	5	5	29,171	20,833	2,051***	14.22		-	"
	1986	7	6	43,972	40,155	3,108***	14.15	72.9	55	"
	1987	14	11	157,408	119,321	5,990	26.24	293.4	41	"
	1988	19	16	174,112	162,187	6,775	25.70	284.6	57	
	1989	21	4	114,434	40,179	5,809	19.7	520.2Ω	22	-
6	1979	4	4	24,868	27,351	1,880	14.55	69.4	39	(1.5X1.5X.5m,steel)
	1980	10	9	58,586	69,136	5,246	13.18	177.0	39	"
	1981	5	5	15,896	20,350	1,316	15.46	35.8	57	"
	1982	7	7	63,072	63,133	6,462	9.77	175.0	36	"
	1983	13	12	64,084	64,461	7,614	8.47	102.7	63	"
	1984	13	12	53,889	50,239	5,608	9.61	-	-	"
	1985	6	5	40,844	32,219	4,000	10.21	-	-	"
	1986	5	5	37,770	49,027	4,119	11.90	69.2	71	"
	1987	11	9	83,931	77,782	6,501	12.92	181.7	43	"
	1988	13	13	134,216	162,550	9,941	13.50	199.7	59	"
	1989	12	11	136,855	77,202	8,098	16.90	248.8Ω	55	"
Offshore 6	1988	1	1	41,160	42,819	1,466	29.2			
	1989	1	0	34,553	-	-	-	-	-	
Experimental 6	1989	4	4	22,029	19,015	789	24.1	-	-	

Table 2. (cont.)

Area	Year	No. of active boats	No. of logbooks received	Landing Statistics: Area Managers (kg)	Landing Statistics: logbooks† (kg)	Total Effort (estimated trap hauls)#	Mean CPUE	Available Biomass for Season (mt)	Exploitation rate (%)	Standardized trap type
Total	1978	42	42	-	646,270	26,705	24.20			All traps types combined
	1979	98	83	1,621,508	1,479,901	57,890	28.01			"
	1980	99	76	822,287	614,755	41,342	19.89			"
	1981	55	19	203,745	109,530	8,801	23.15			"
	1982	67	63	615,426	553,140	35,781	17.20			"
	1983	97	80	306,767	285,320	30,223	10.15			"
	1984	51	37	140,927	122,514	16,217	8.69			"
	1985	25	24	83,958	66,352	10,115	8.30			"
	1986	32	22	104,174	99,376	10,501	9.92			"
	1987	64	48	360,295	303,025	27,959	12.89			"
	1988	89	73	540,563	466,448	39,171	13.80			"
	1989	96	34	560,452	221,104	35,116	15.96			"

† utilizable

* landings included in Area 3

** from tagging, all other estimates from Leslie analysis of logbook data

*** Japanese conical traps combined with steel trap (1.5 X 1.5 X 0.5m)

estimated trap hauls are calculated from the area managers landings divided by the CPUE (derived from the logbooks) whenever they are less than the logbook landings.

Ω extrapolated estimate, from exploitation rate from Leslie and Area Managers landings.

Table 3. Compilation of shell hardness and egg presence data for male and female snow crabs sampled in-port and at-sea for Cape Breton (areas 2,3,4,5 and 6) for the 1989 fishing season.

Area	No. of Males	n(%) Hard Shell	n(%) Medium Shell	n(%) Dark Shell	n(%) New Shell
3	679	418(61.6)	261(38.4)	137(20.2)	542(79.8)
4	1234	514(41.7)	720(58.3)	416(33.7)	818(66.3)
5	779	339(43.5)	440(56.4)	344(44.2)	435(55.8)
(inshore)6	1322	719(54.4)	603(45.6)	486(36.8)	836(63.2)
(offshore)6	659	553(83.9)	106(16.1)	502(76.2)	157(23.8)
Total	4673	2543(54.4)	2130(45.6)	1885(40.3)	2788(59.7)

	Males with Hard Shells			Males with Medium Shells		
Area	No. of Males	n(%) Dark Shell	n(%) New Shell	No. of Males	n(%) Dark Shell	n(%) New Shell
3	418	121(29.0)	297(71.0)	261	16(6.1)	245(93.9)
4	514	385(74.9)	129(25.1)	720	31(4.3)	689(95.7)
5	339	279(82.3)	60(17.7)	440	65(14.8)	375(85.2)
(inshore)6	719	445(61.9)	274(38.1)	603	41(6.8)	562(93.2)
(offshore)6	553	439(79.4)	114(20.6)	106	63(59.4)	43(40.6)
Total	2543	1669(65.6)	874(34.4)	2130	216(10.1)	1914(89.9)

Area	No.of Females	n(%) Hard Shell	n(%) Medium Shell	n(%) With Egggs	n(%) Without Eggs
3	9	9(100.0)	0	9(100.0)	0
4	0	0	0	0	0
5	85	82(96.5)	3(3.5)	84(98.8)	1(1.2)
(inshore)6	88	75(85.2)	13(14.8)	86(97.7)	2(2.3)
(offshore)6	21	13(61.9)	8(38.1)	21(100.0)	0
Total	203	179(88.2)	24(11.8)	200(98.5)	3(1.5)

Table 4.
Compilation of Morphometric Maturity Data for Male Snow Crabs Sampled In-Port and At-Sea for Areas 2, 3, 4, 5 and 6 for 1987-1989.

		At-Sea			In-Port		
Area	Month	% Mature 1987	% Mature 1988	% Mature 1989	% Mature 1987	% Mature 1988	% Mature 1989
2	July	-	-	-	-	-	-
	August	100	73.9	-	98	89.1	-
	Sept	-	-	-	-	-	-
3	July	-	-	-	92	81.5	54.5
	August	93	72.6	82.0	98	72.0	-
	Sept	-	-	-	-	-	-
4	July	-	-	-	96	83.1	61.1
	August	91	-	-	89	84.0	91.5
	Sept	-	78.9	-	-	-	-
5	July	-	-	-	-	71.0	-
	August	74	58.8	49.5	83	66.9	69.9
	Sept	-	-	-	97	47.9	-
6 inshore	July	-	-	-	-	-	-
	August	66	52.9	62.4	54	75.0	62.9
	Sept	-	58.6	-	-	65.0	-
6 offshore	July			-			
	August			91.4			
	Sept			-			

Table 5. Catch and effort statistics from utilizible logbook data for the snow crab fishery in 1989.

Areas 2,3 & 4

Week Period	Trap Hauls	Catch (kg)	CPUE (kg/trap haul)	Cumulative Catch (Kg)
July 22-28	1719	30120	17.5	15060
July 29-Aug. 4	2124	28560	13.4	44400
Aug. 5-11	1289	12881	10.0	65120.5
Aug. 12-18	812	7012	8.6	75067
Aug. 19-25	160	929	5.8	79037.5
Aug. 26-Sept. 1	0	0	0	0
Sept. 2-8	0	0	0	0
Sept. 9-15+	0	0	0	0
Total	6104	79502*	13.0	

Area 5

Week Period	Trap Hauls	Catch (kg)	CPUE (kg/trap haul)	Cumulative Catch (Kg)
July 22-28	107	2653	24.8	1326.5
July 29-Aug. 4	466	10372	22.3	7839
Aug. 5-11	207	3585	17.3	14817.5
Aug. 12-18	321	5327	16.6	19273.5
Aug. 19-25	227	4140	18.2	24007
Aug. 26-Sept. 1	112	2053	18.3	27103.5
Sept. 2-8	236	4401	18.6	30330.5
Sept. 9-15+	364	7648	21.0	36355
Total	2040	40179*	19.7	

Area 6

Week Period	Trap Hauls	Catch (kg)	CPUE (kg/trap haul)	Cumulative Catch (Kg)
Aug. 2-7	476	10268	21.6	5134
Aug. 8-14	1148	21210	18.5	20873
Aug. 15-21	739	14865	20.1	38910.5
Aug. 22-28	529	8883	16.8	50784.5
Aug. 29-Sept. 4	382	3946	10.3	57199
Sept. 5-11	351	4672	13.3	61508
Sept. 12-18	338	4283	12.7	65985.5
Sept. 19-25	180	2263	12.6	69258.5
Sept. 26-30	44	273	6.2	70526.5
Total	4187	70663*	16.9	

* Actual logbook catches: Areas 2,3 & 4 = 85,220 kg; Area 5=40,179 kg; Area 6=77,202 kg

Area 6 (Experimental Offshore Licenses)

Week Period	Trap Hauls	Catch (kg)	CPUE (kg/trap haul)	Cumulative Catch (Kg)
Aug. 8-14	40	546	13.6	273
Aug. 15-21	58	1270	21.9	1181
Aug. 22-28	57	1932	33.9	2782
Aug. 29-Sept. 4	79	2736	34.6	5116
Sept. 5-11	72	1707	23.7	7337.5
Sept. 12-18	184	3658	19.9	10020
Sept. 19-25	143	3383	23.7	13540.5
Sept. 26-30+	156	3783	24.2	17123.5
Total	789	19015	24.1	

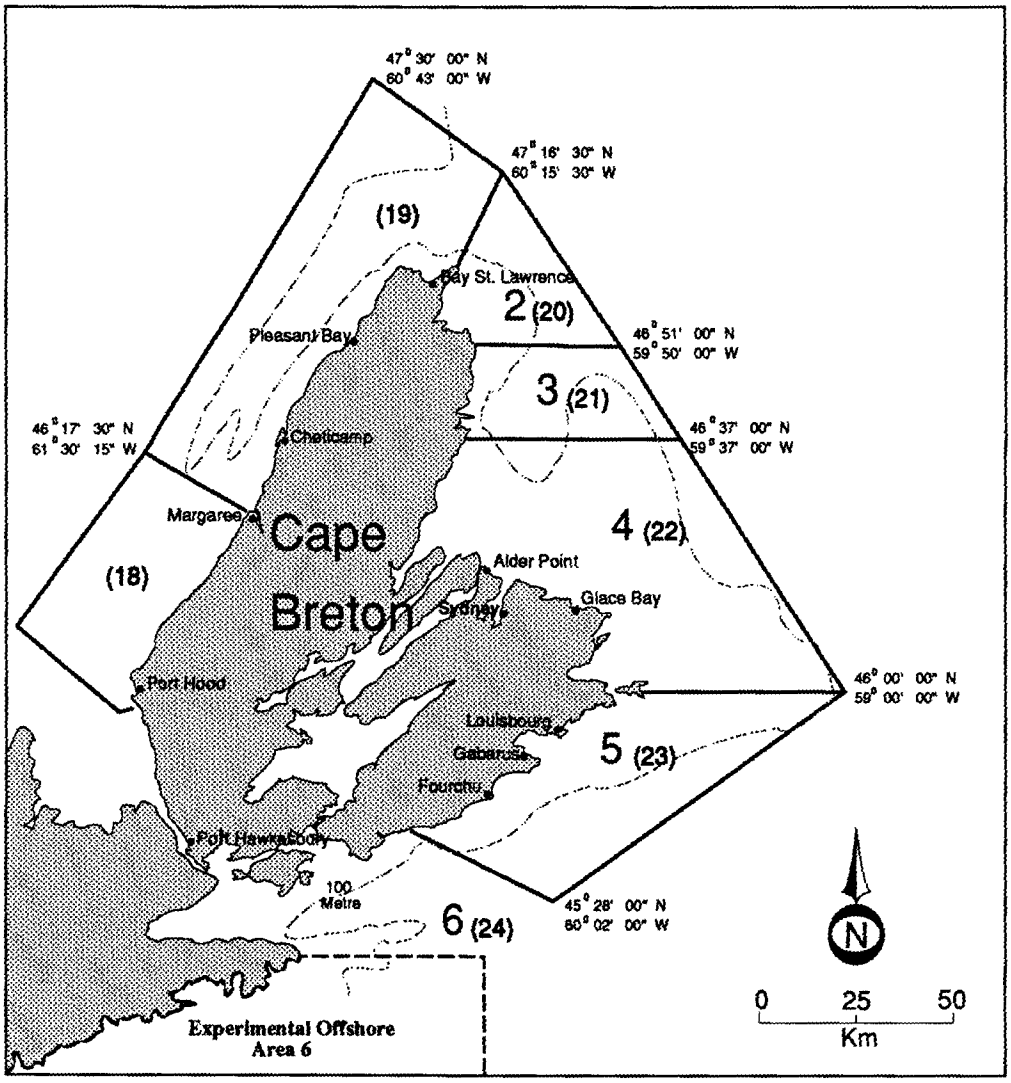


Fig. 1 Cape Breton Island snow crab fishing areas.

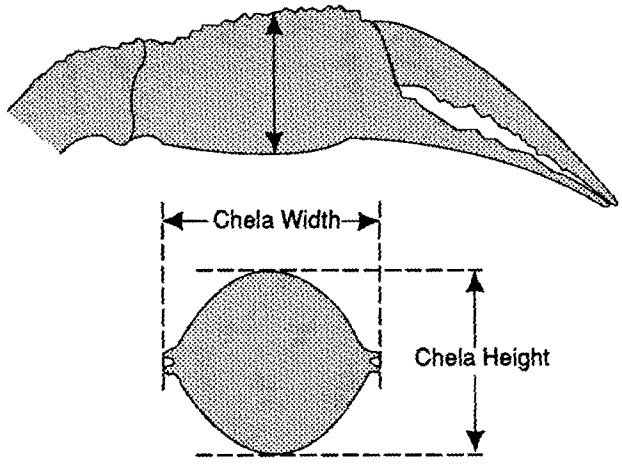


Fig. 2 Diagram of a male snow crab chela. Note: chela width and chela height dimensions.

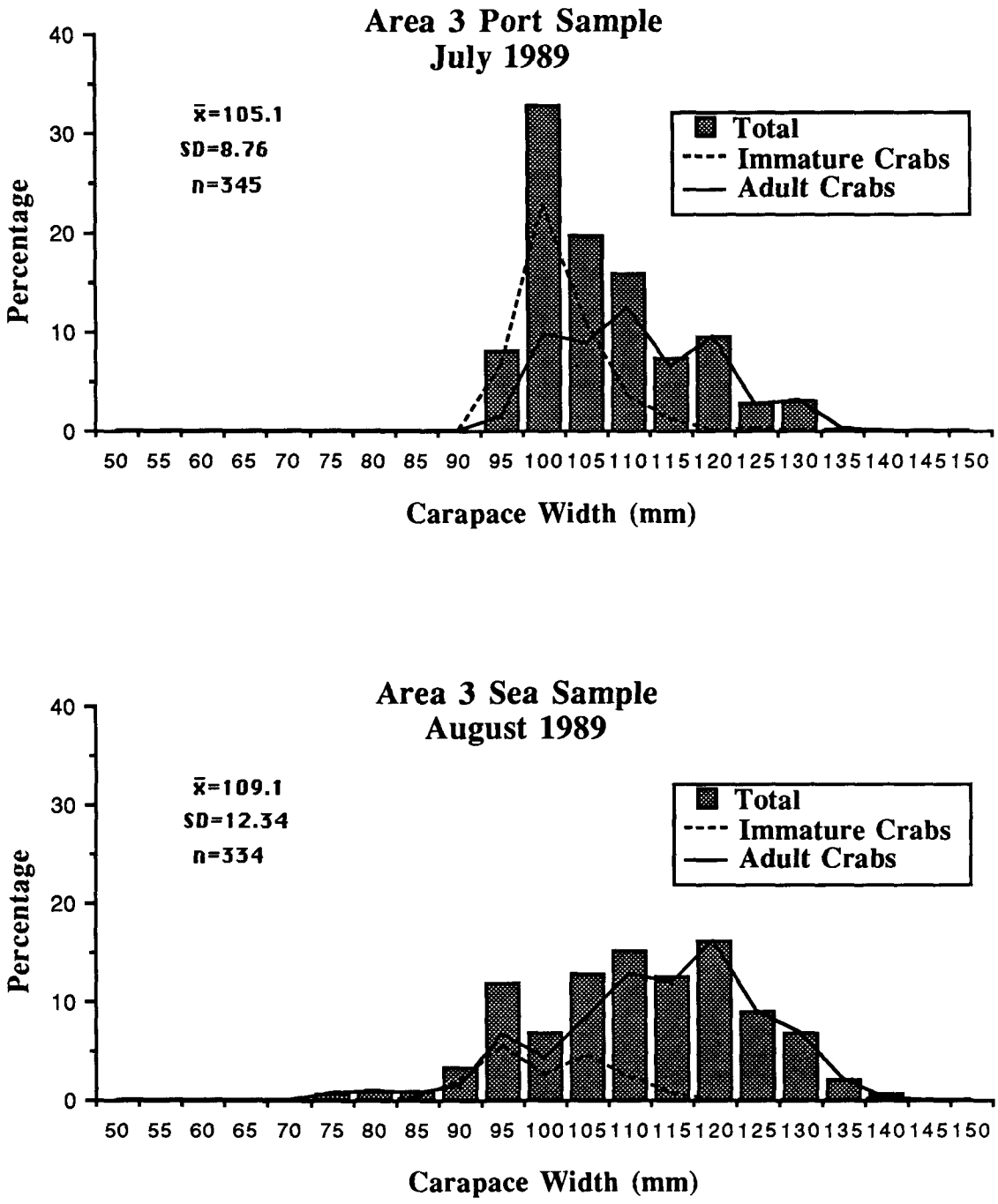


Fig. 3. Size frequency histograms for male snow crabs sampled in-port and at-sea from commercial vessels in Area 3 during the 1989 fishing season.

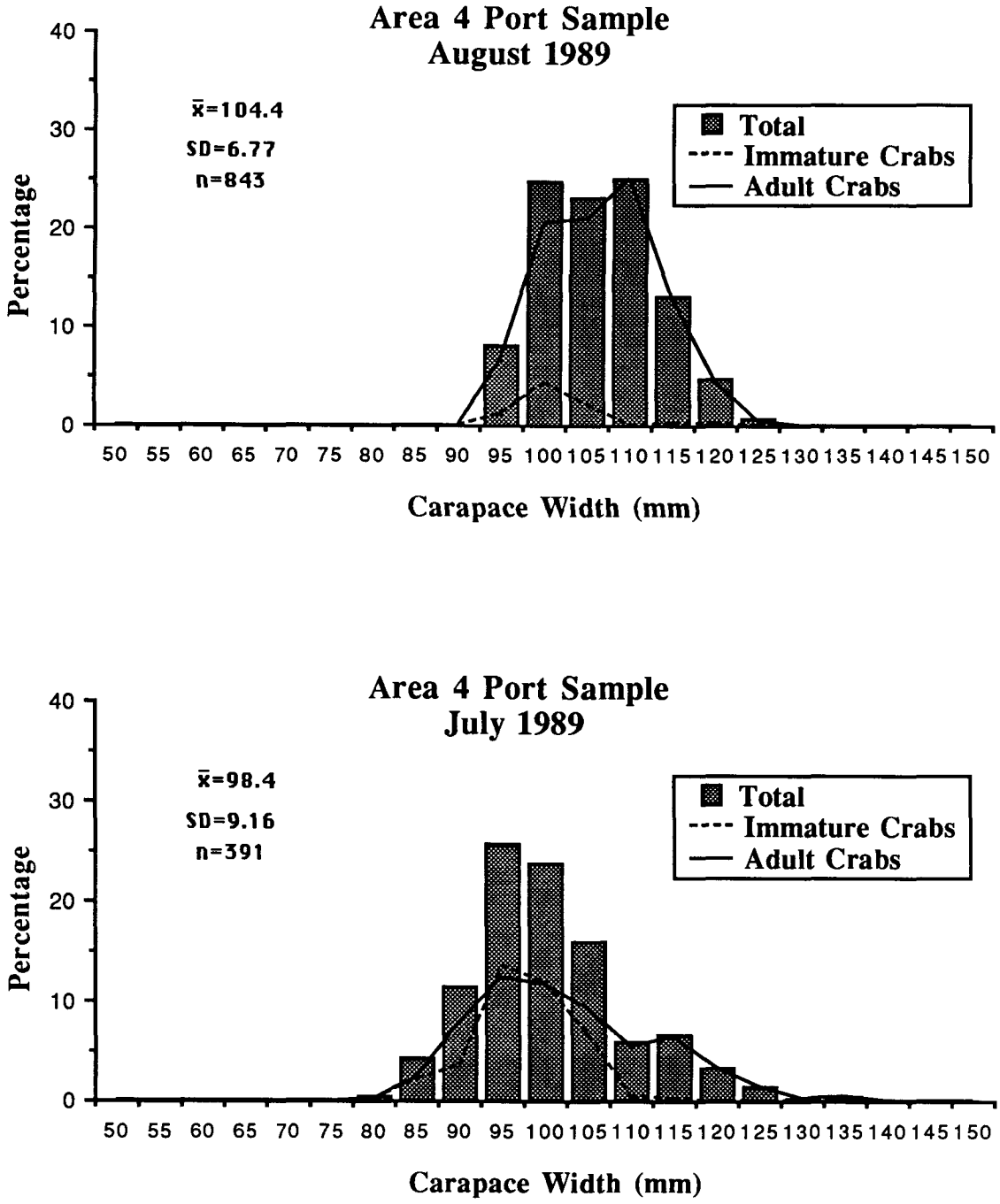
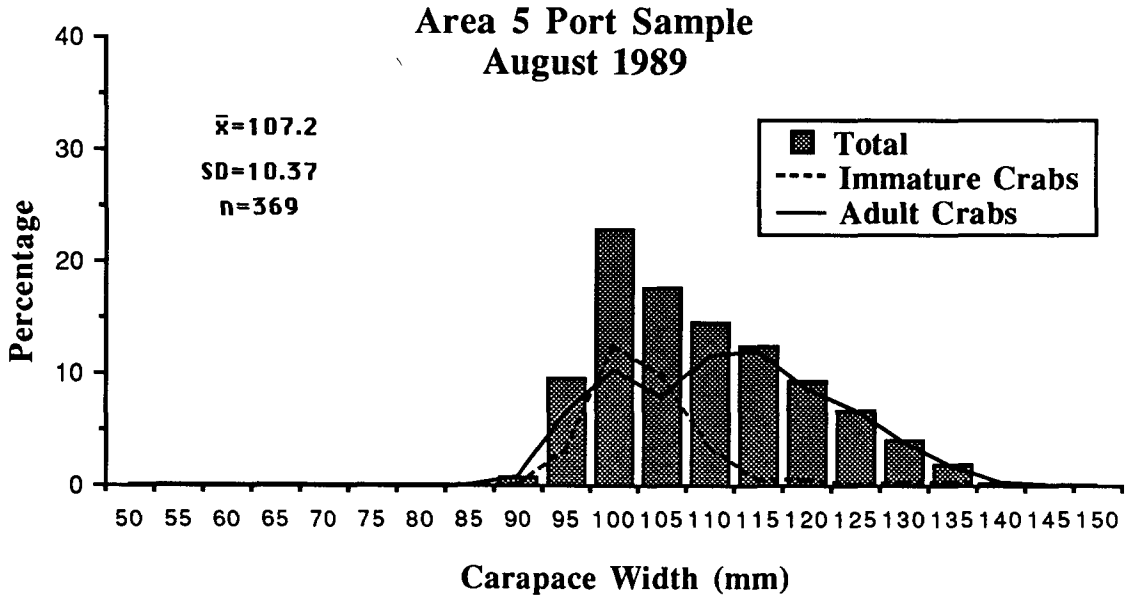


Fig. 4. Size frequency histograms for male snow crabs sampled in-port from commercial vessels in Area 4 during the 1989 fishing season.



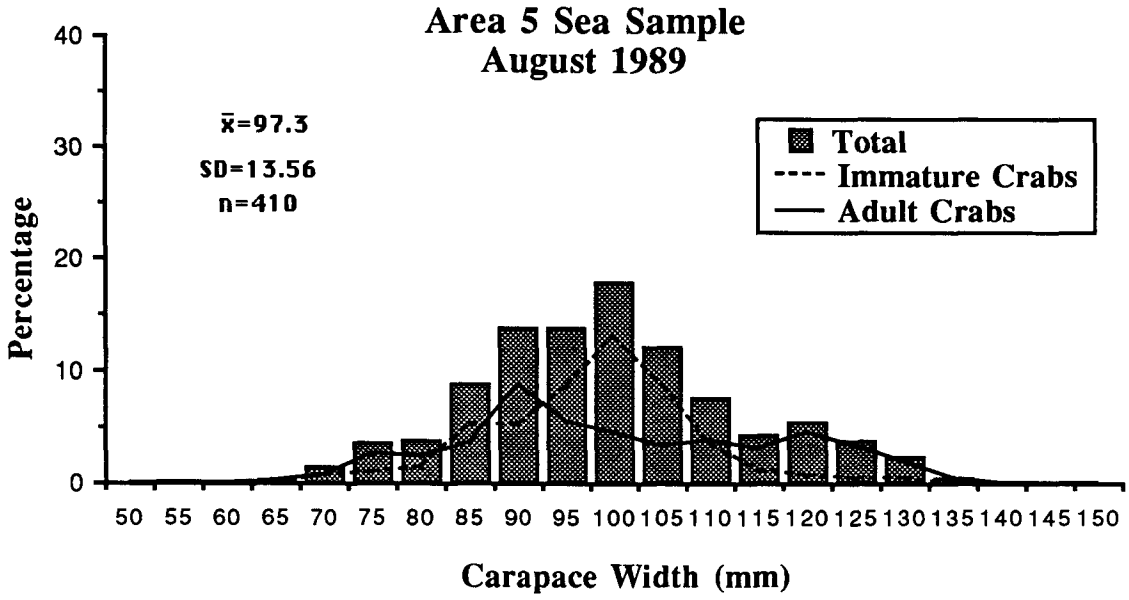


Fig. 5. Size frequency histograms for male snow crabs sampled in-port and at-sea from commercial vessels in Area 5 during the 1989 fishing season.

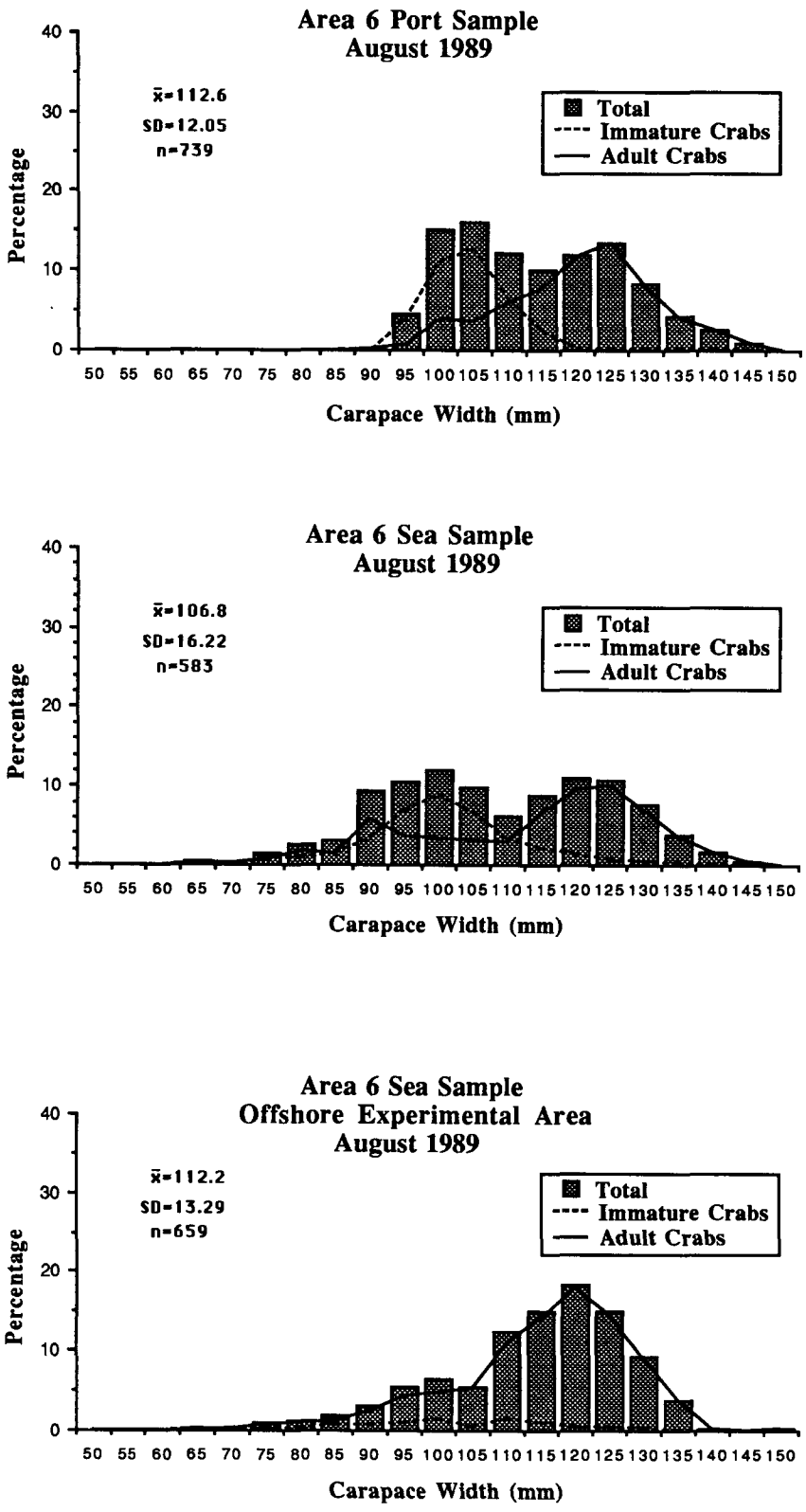


Fig. 6. Size frequency histograms for male snow crabs sampled in-port and at-sea from commercial vessels in Area 6 during the 1989 fishing season.

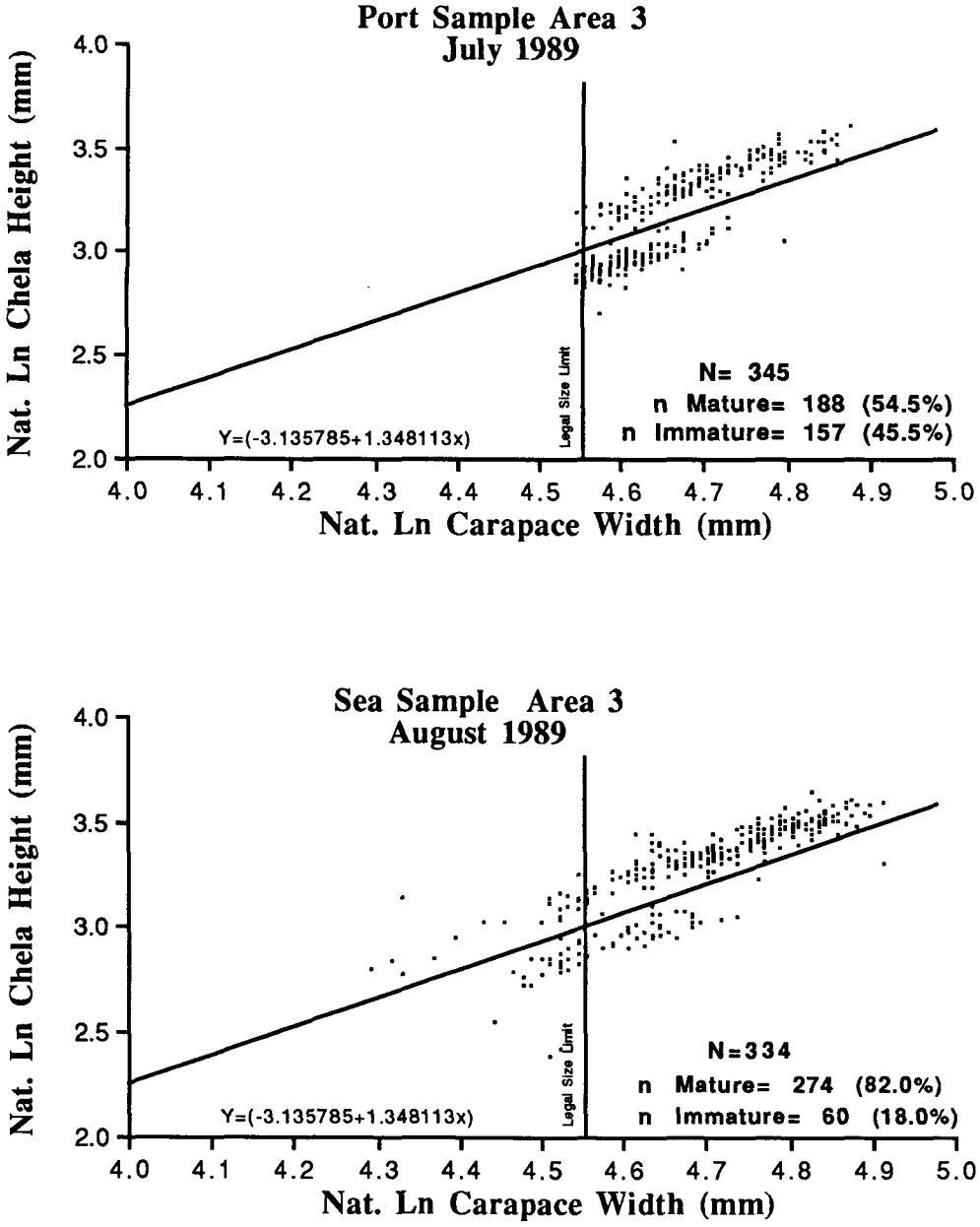


Fig. 7. Graphs showing the relationship between the natural logarithms of the chela height and the natural logarithms of the carapace width for male snow crab sampled in-port and at-sea from commercial vessels in Area 3 during the 1989 fishing season.

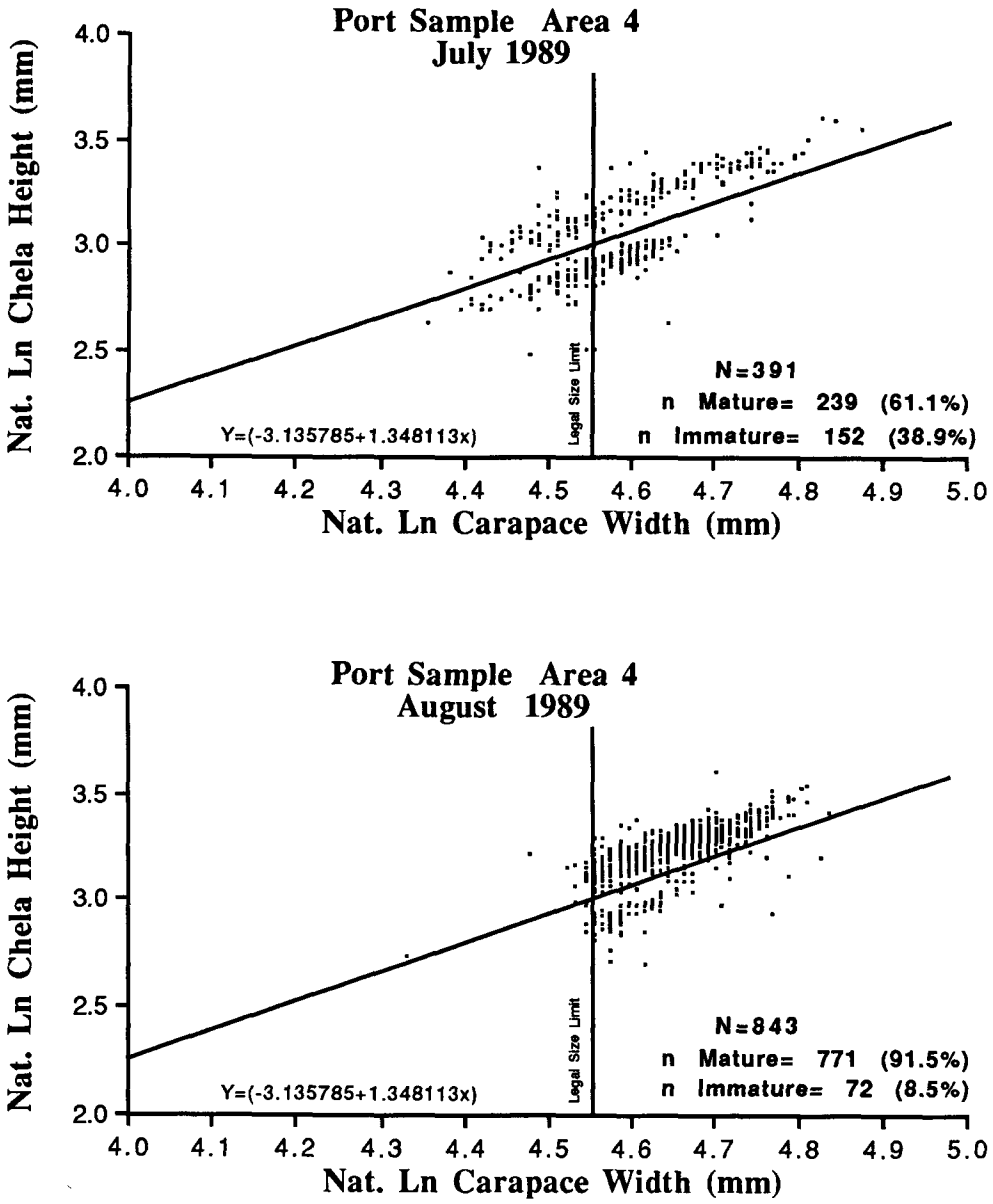


Fig. 8. Graphs showing the relationship between the natural logarithms of the chela height and the natural logarithms of the carapace width for male snow crab sampled in-port from commercial vessels in Area 4 during the 1989 fishing season.

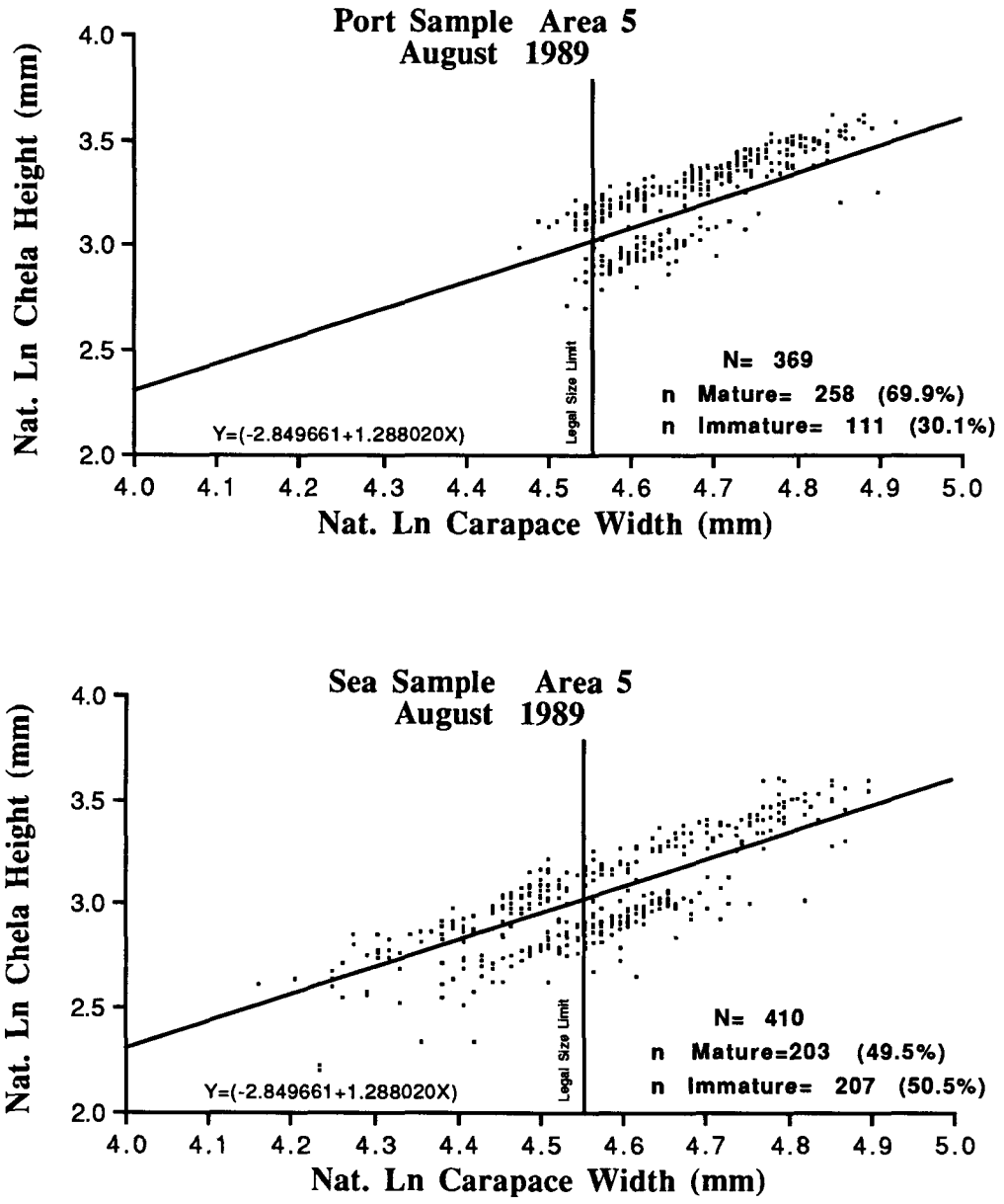


Fig. 9. Graphs showing the relationship between the natural logarithms of the chela height and the natural logarithms of the carapace width for male snow crab sampled in-port and at-sea from commercial vessels in Area 5 during the 1989 fishing season.

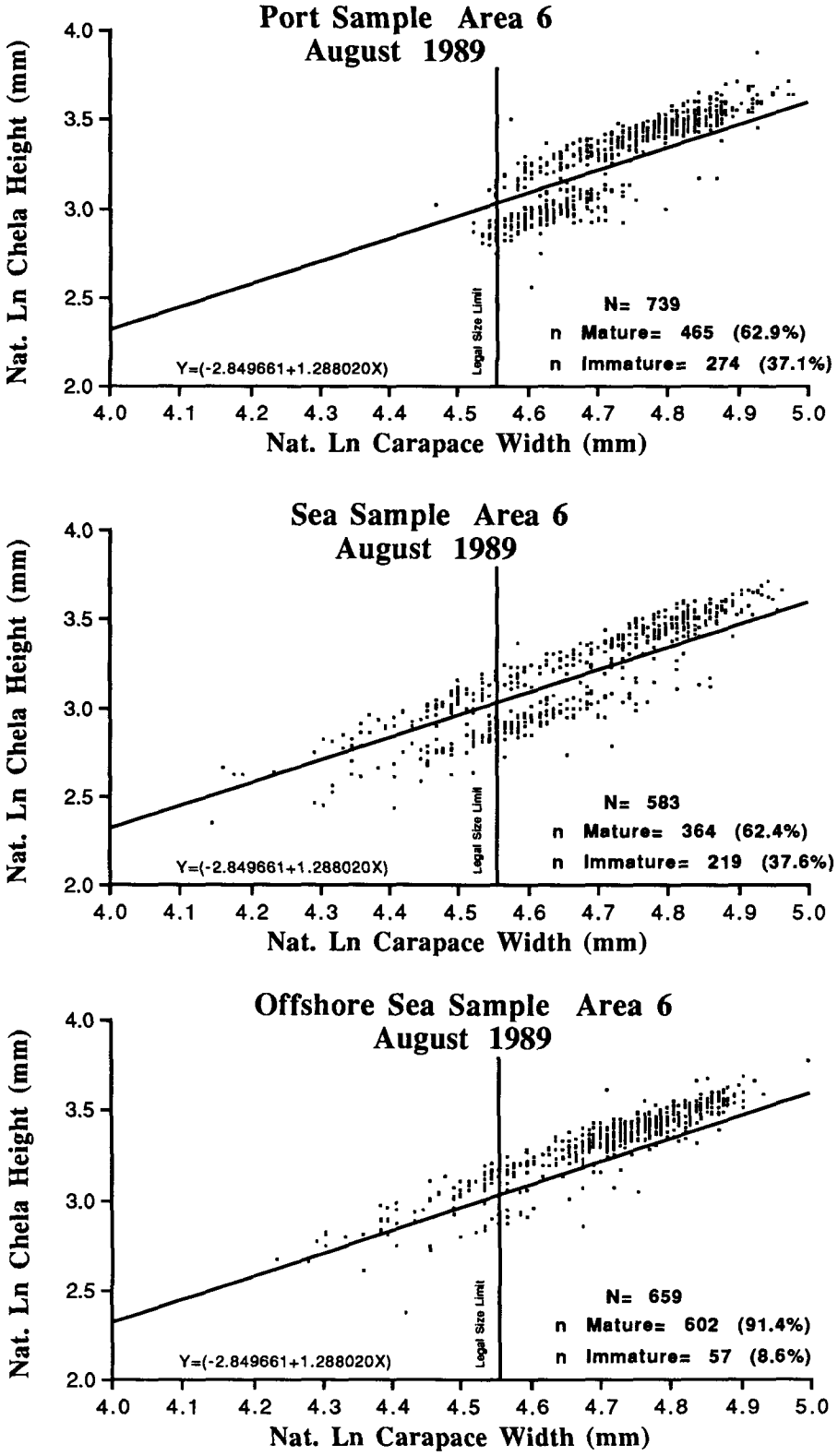


Fig. 10. Graphs showing the relationship between the natural logarithms of the chela height and the natural logarithms of the carapace width for male snow crab sampled in-port and at-sea from commercial vessels in Area 3 during the 1989 fishing season.

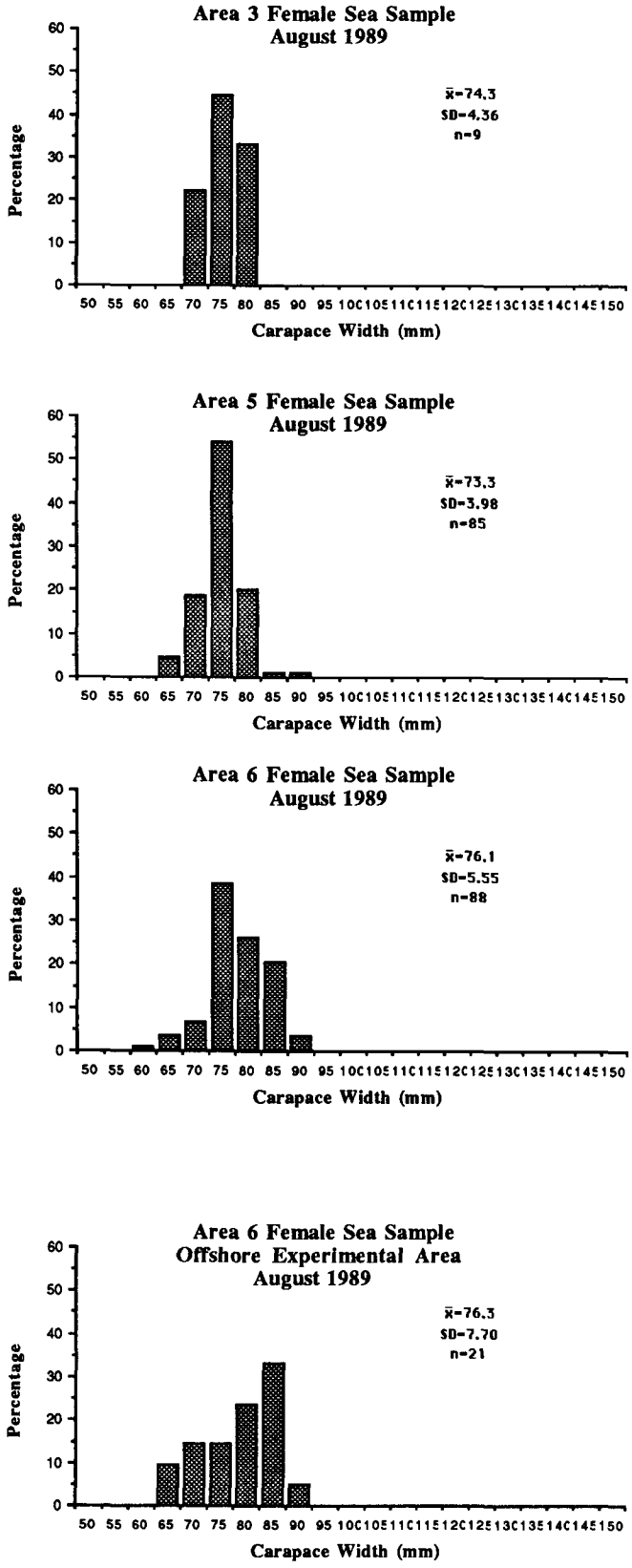
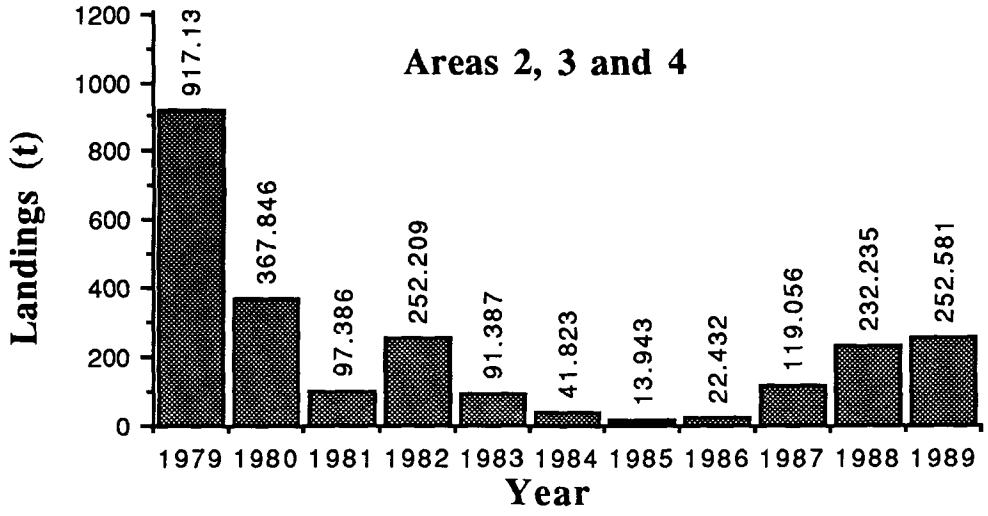


Fig. 11. Size frequency histograms of mature female snow crabs sampled at-sea from commercial vessels in Areas 3-6 during the 1989 fishing season.



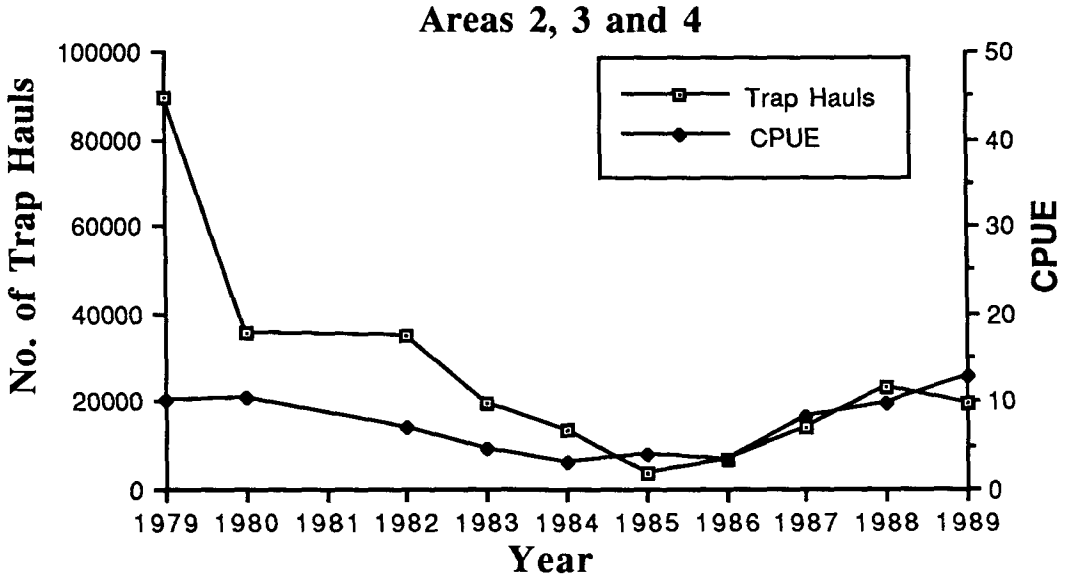


Fig. 12. Historical series (1979-1989) of data on landings, effort and CPUE (kg. per trap haul) for the snow crab fishery Areas 2, 3 and 4 (inshore).

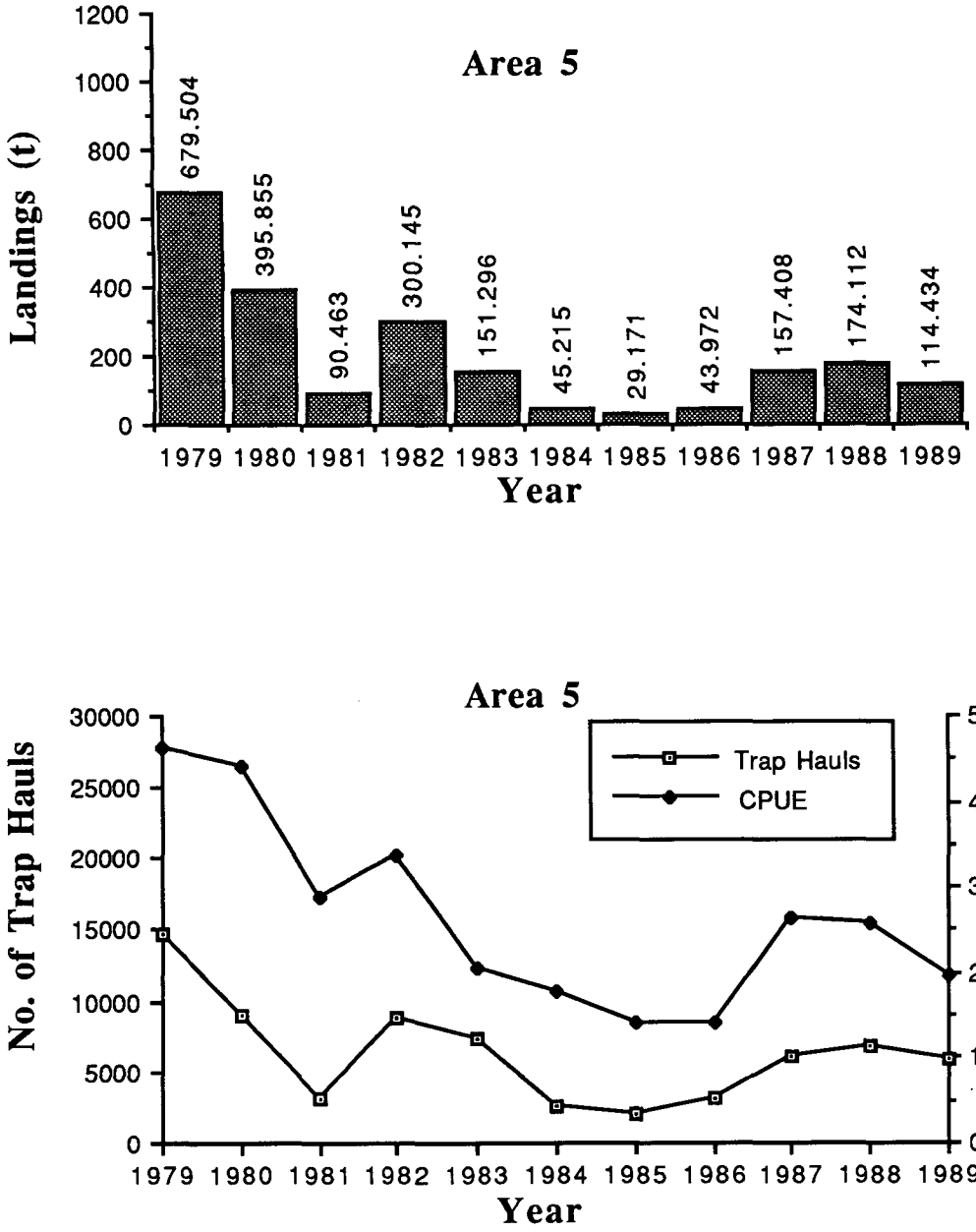
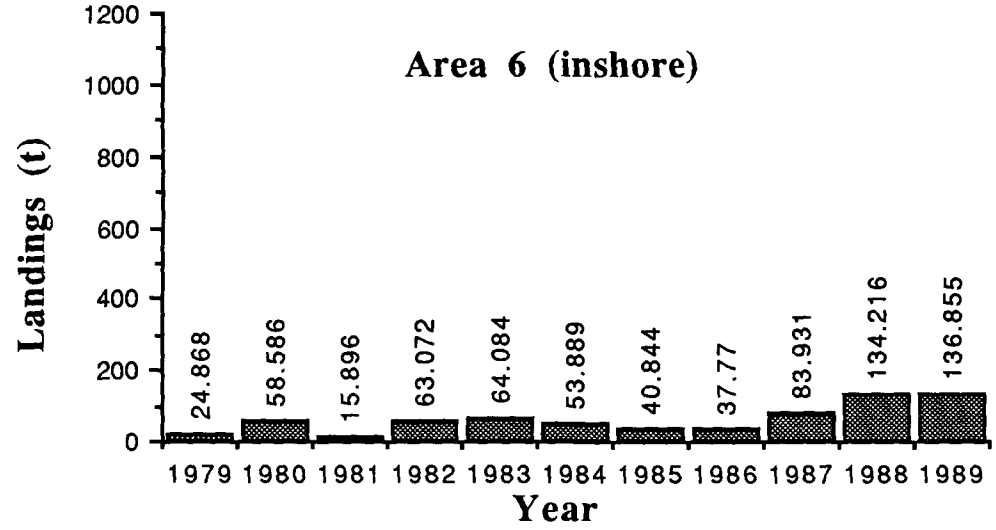


Fig. 13. Historical series (1979-1989) of data on landings, effort and CPUE (kg. per trap haul) for the snow crab fishery Area 5.



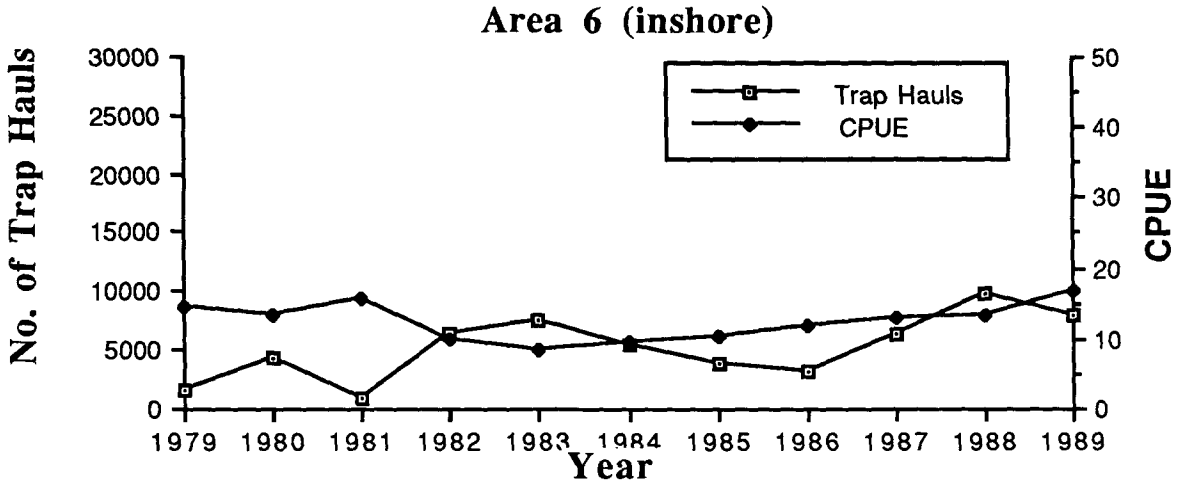


Fig. 14. Historical series (1979-1989) of data on landings, effort and CPU (kg. per trap haul) for the snow crab fishery Area 6.

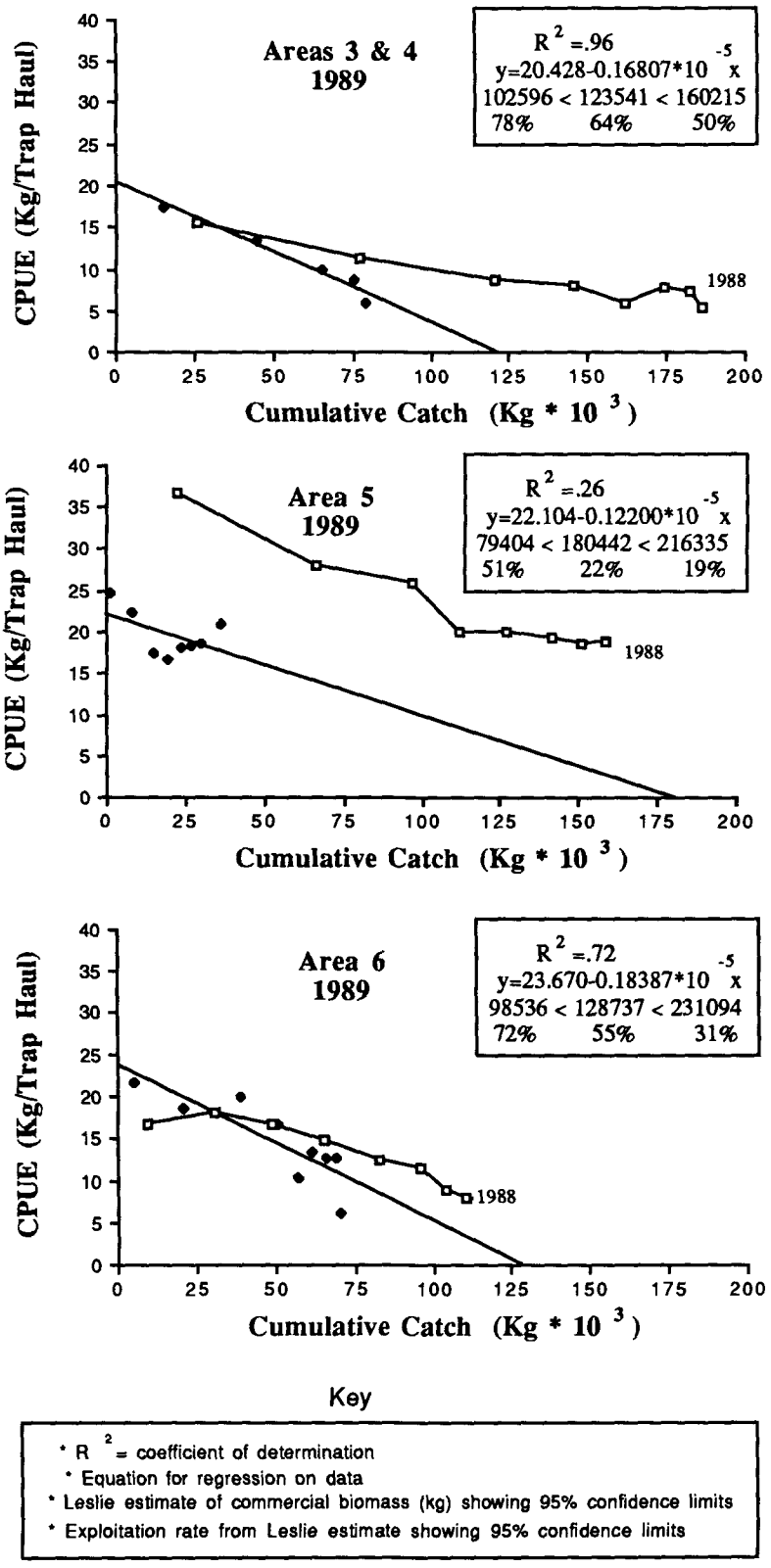


Fig. 15. Graphs of cumulative weekly landings against CPUE, from logbook data for a) Areas 3 and 4; b) Area 5; and c) Area 6 in 1989 and Leslie estimates of commercial biomass and exploitation rate.

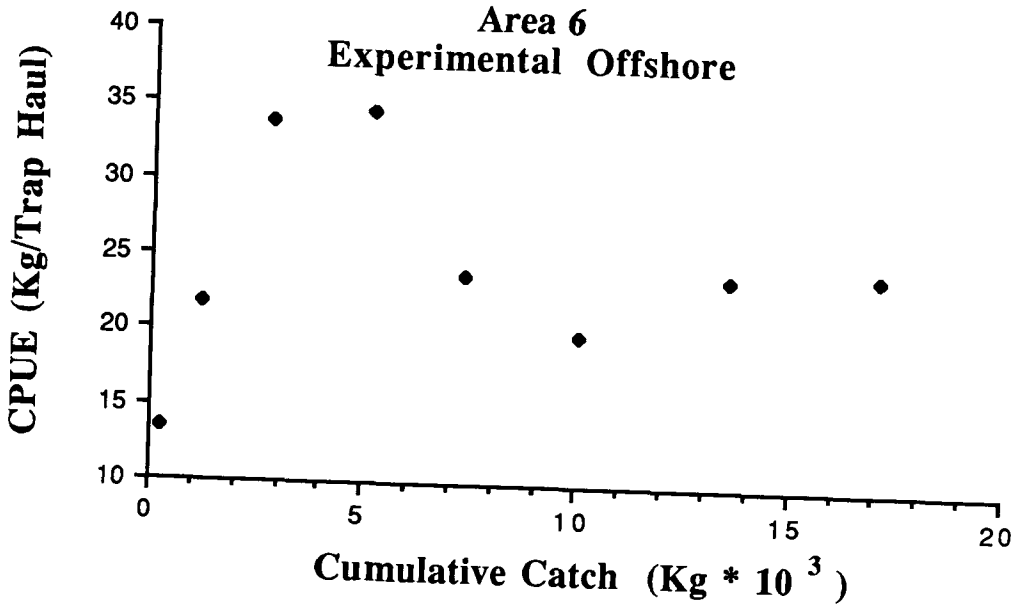


Fig. 16. Graph of cumulative weekly landings against CPUE, from logbook data for Experimental Offshore Area 6.

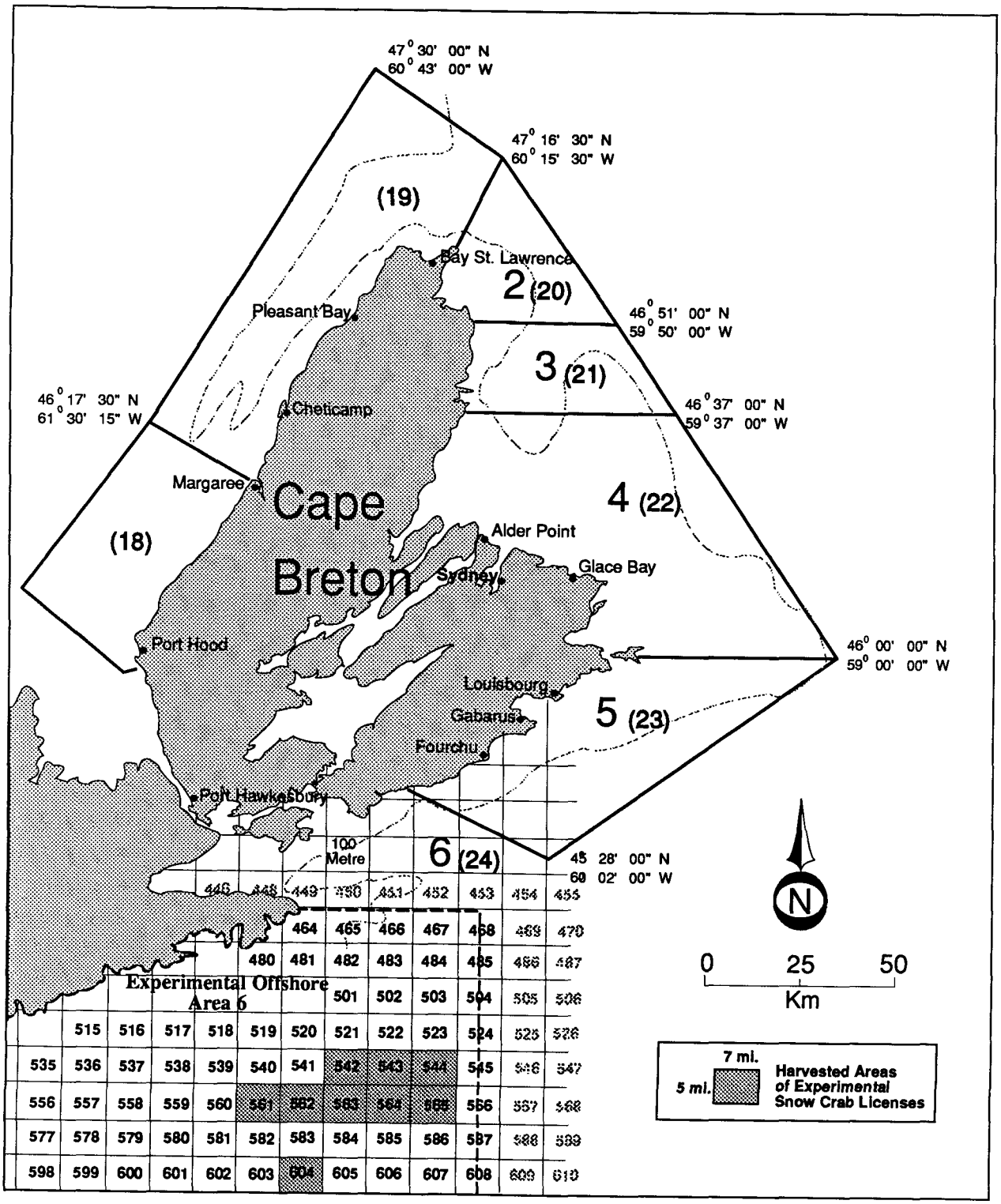
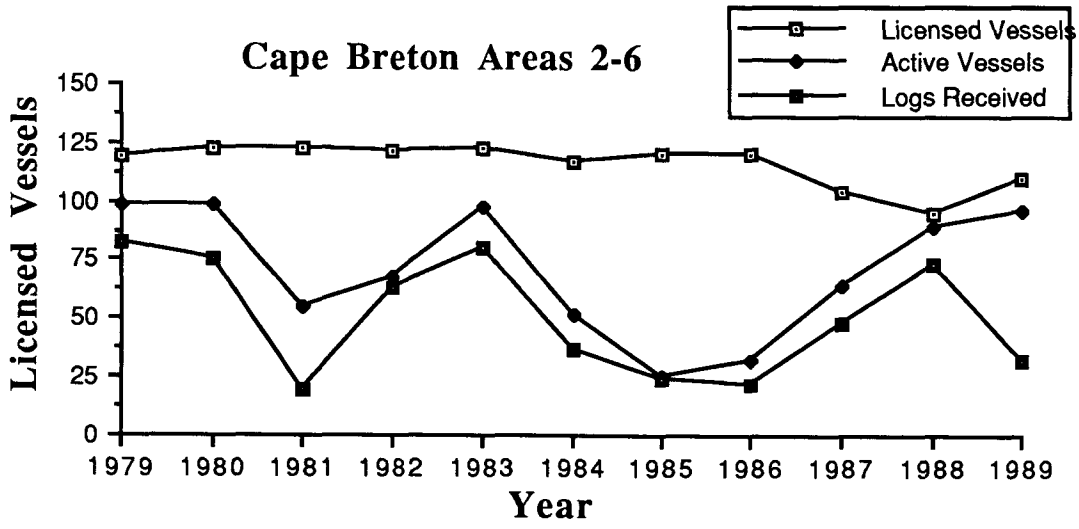


Fig. 17 Cape Breton Island snow crab fishing areas showing experimental snow crab harvesting area.



Appendix I. Statistical display of numbers of snow crab vessels licensed, active and logbooks received for Cape Breton Areas 2-6 for the period 1979 - 89.

PORT SAMPLE: ______
SEA SAMPLE : ______
__ INSHORE : ______
__ OFFSHORE: ______

DATE: ______________

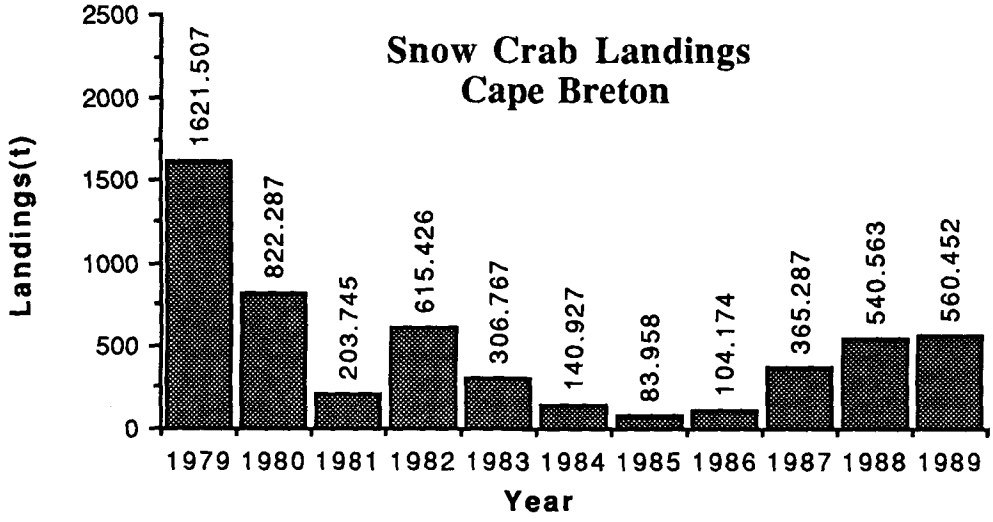
Snow Crab Sampling Sheet

NAME OF VESSEL : ____________________
NAME OF SKIPPER: ____________________
PORT LOCATION : ____________________

AREA FISHED: ____________________
LOCATION : ____________________
DEPTH : ____________________

Carap. width	Right claw	Chela height	Shell hardness	Shell condition	Sex	Egg color	Egg clutch size	Tag number
(mm)	(mm)	(mm)	H M S	New Old	M F		Missing Full	

Appendix II. Recording sheet as used for at-sea and in-port sampling of snow crab around Cape Breton Island (Areas 2-6) in 1989.



Appendix III. Historical series (1979-1989) of data on snow crab landings for Cape Breton Areas 2-6.

Appendix IV

Supplementary Study on Snow Crab Around the Atlantic Coast of Cape Breton Island (Areas 2-6)

a) Introduction

For the past 8 years snow crab fisheries around the Atlantic coast of Cape Breton Island (Areas 2-6) have been presumed to be based on spill-over recruitment from the Gulf of St. Lawrence (Elner 1982a). Thus, the 5 areas were designated relic stocks that did not comprise self-sustaining, populations(s), and could not be managed Davidson et al. 1985. Here catch rates, biomass and exploitation rates are examined over the period 1978 - 1985 for the 3 stock areas. The basis for a constant exploitation rate strategy is linked to the relationship between exploitation rate and fishing effort (over years); hitherto, no such relationships have been sought for Atlantic snow crab.

b) The Interpretation

The directed fishery for snow crab off the Atlantic coast of Cape Breton Island was started in 1978 for exploitation by inshore vessels under 45 ft length. Initially, landings rose rapidly with effort, however, within 4 fishing seasons landings and CPUE had crashed. Consequently, it was postulated that the snow crab fishery in areas 2-6 was based on a resource with low, or sporadic, production because after the virgin biomass had been reduced by fishing no significant recruitment had occurred. On this rationale, management discontinued catch controls to allow existing fishermen to take advantage of whatever productivity occurs from time to time on an opportunistic basis. The regulatory measures remaining include strict licensing control, a 30 trap/vessel limit and a relatively short fishing season. Since 1987 sustained recruitment into the commercial stocks has increased fishable biomass in all areas (see this assessment, and references therein).

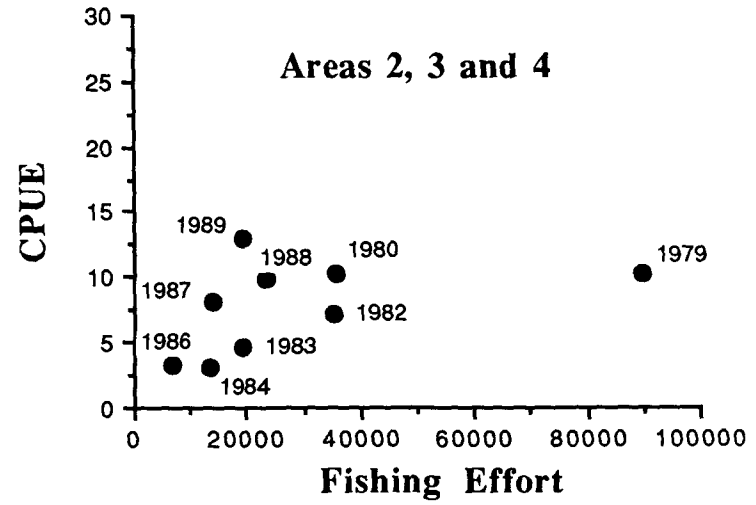
The relic stocks interpretation was based mainly on evidence accrued from annual stock assessments to CAFSAC documenting a collapse together with limited information on species distribution and larval dispersion patterns. It was argued that these Cape Breton areas, being at the southern edge of known commercial snow crab concentrations in the Atlantic, could represent marginal grounds in terms of habitat. Thus, the apparent recruitment failures in the annual assessments seemed indicative of a normal pattern of production. Also, it was postulated that there was little endemic recruitment within the Atlantic coast of Cape Breton stocks. While some larvae released from these grounds could become entrained in local gyres or swept

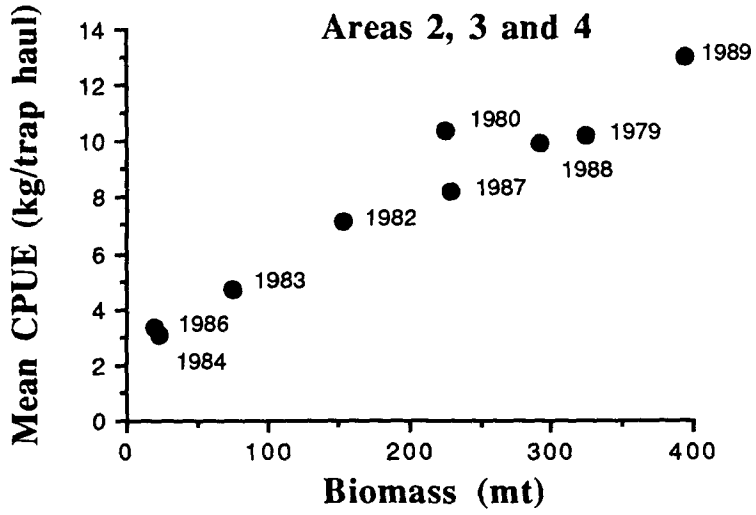
northeast towards Newfoundland, the predominant surface currents in the area seemed to disperse pelagic larvae south, either down the coast of Nova Scotia or out into the Atlantic. Larval distribution patterns plus the present of small numbers of snow crab in the Bay of Fundy supported the notion of a large southward loss of snow crab larvae from the Atlantic coast of Cape Breton. In summary, stocks in areas 2-6 were hypothesized to have been built up over time through trickles of larval recruitment (largely from the Gulf-coast of Cape Breton). Such a scenario accounted for the initially high catch rates and landings on the grounds, the lack of resilience of the stocks to exploitation, and the subsequent devastation of biomass after only a few fishing seasons.

The relic stock interpretation was based on observations and data of the time; an untested hypothesis that subsequent events have shown to be incorrect. There has been a sustained recruitment surge that was first noted in 1985/86, approximately 8-9 years after first harvesting and 4-5 years of "collapse". However, while the Atlantic coast of Cape Breton stocks may be more productive that was originally anticipated, it is still not possible to forecast future catches because growth is not well understood and recruitment is unpredictable. Until there is a better understanding of long-term production patterns, the current management strategy for areas 2-6 should probably remain unchanged. Currently, the stocks are harvested at close to the target exploitation rate, catch rates remain high and there is a high proportion of morphometrically immature males in the system.

c) Historical Series

Figures A, B and C show mean CPUE, commercial biomass, fishing effort (trap hauls) and exploitation rate relationships for each stock area since 1978. There appears to be a strong positive linear relationship between CPUE and biomass for areas 2/3/4 and area 5 but not for area 6. Relationships between the other parameters appear more circumspect; in particular, with the possible exception of areas 2/3/4, there is no obvious relationship between exploitation rate and fishing effort. As the rationale for a constant exploitation rate strategy is linked to the existence of such a relationship, these time series cast some doubt on the current management strategy.





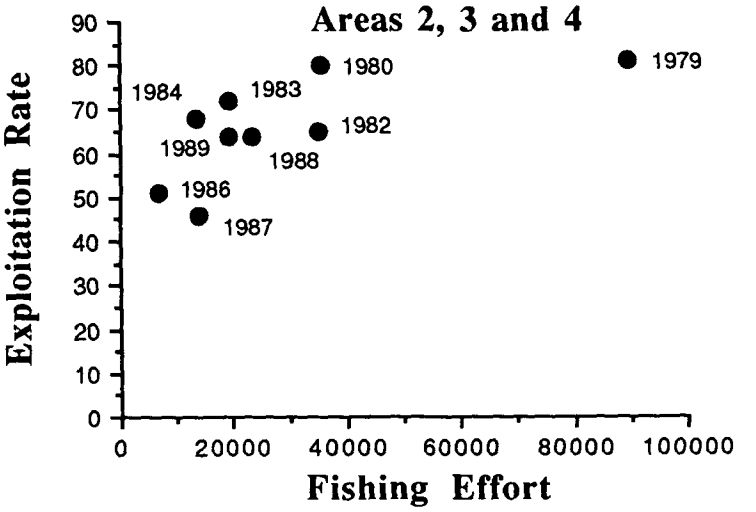


Fig. A. Graphs of CPUE and biomass, CPUE and fishing effort, exploitation rate and fishing effort from 1978 to 1989 for Areas 2, 3 and 4.

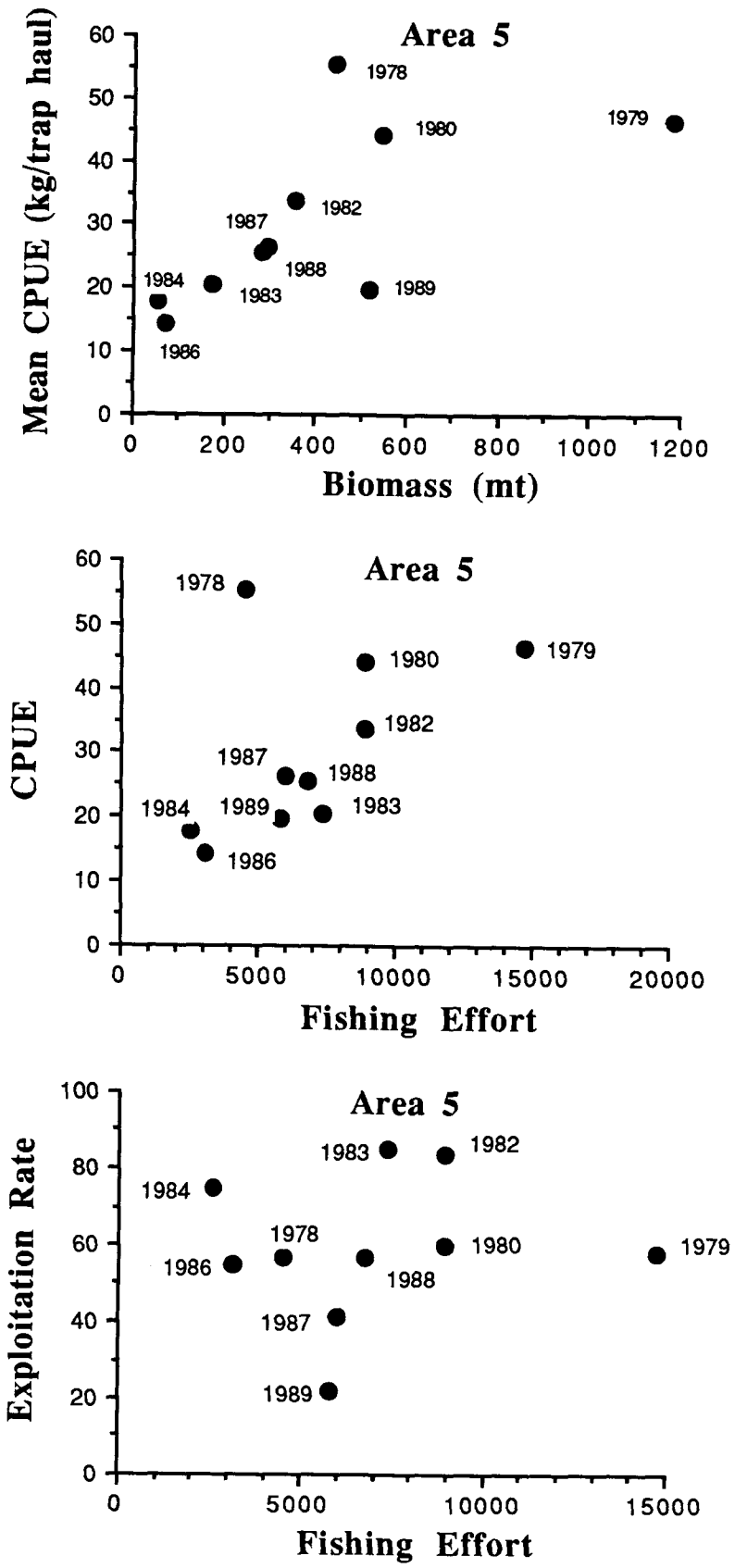


Fig. B. Graphs of CPUE and biomass, CPUE and fishing effort, exploitation rate and fishing effort from 1978 to 1989 for Area 5.

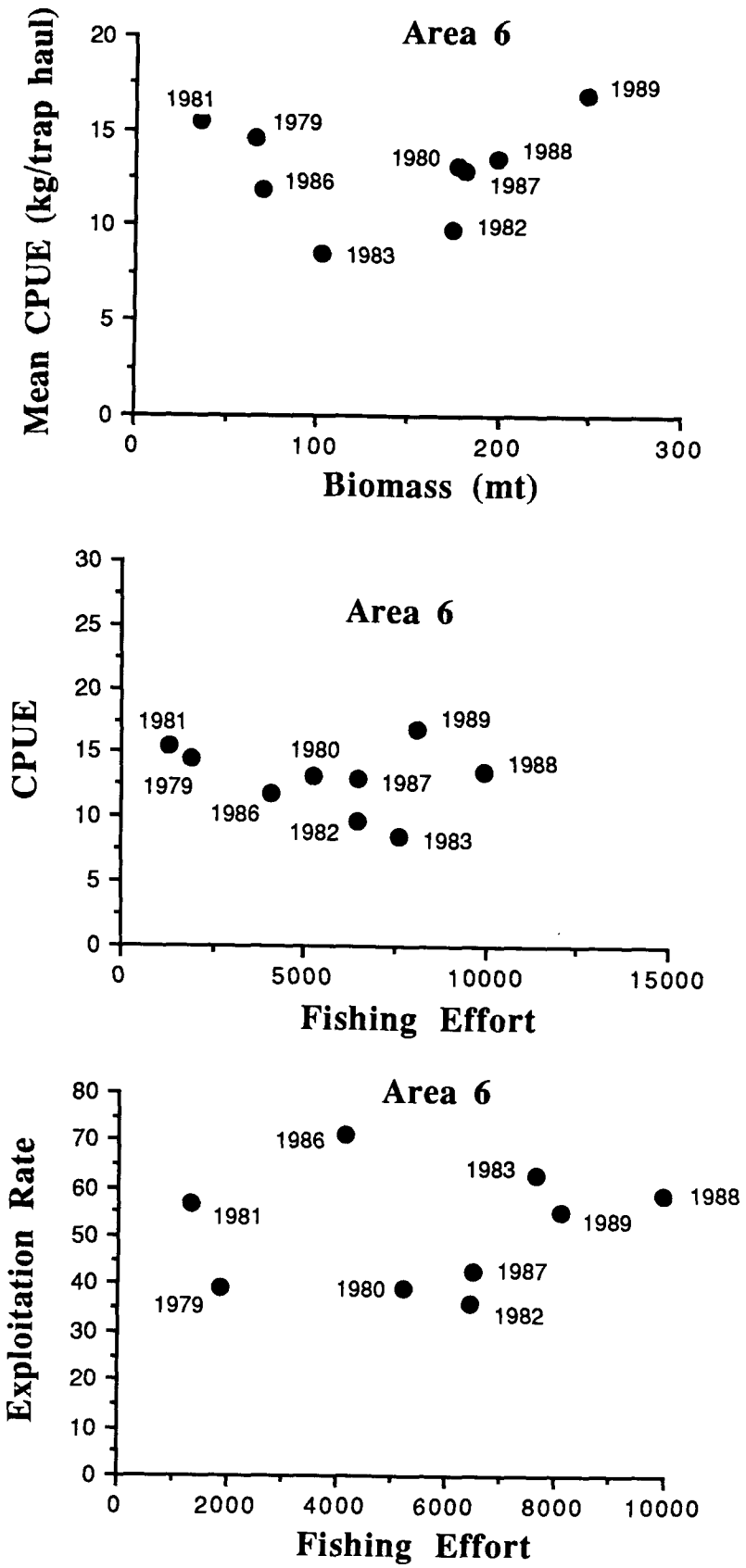


Fig. C. Graphs of CPUE and biomass, CPUE and fishing effort, exploitation rate and fishing effort from 1978 to 1989 for Area 6.