The Fishery for Snow Crab off the Atlantic Coast of Cape Breton Island: The 1983 Assessment

by

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Abstract

Biological assessments are presented for the 1983 Cape Breton Island (Atlantic coast, areas 2-6) snow crab fishery, based on data derived from fishermen's logbooks, tagging studies, and commercial catch sampling.

Overall, for the 1983 season, a continued rise in market demand for crab failed to maintain fishing effort (trap hauls) at 1982 levels. The reduced effort coupled with low catch rates, relative to historical levels, resulted in total recorded landings (306.8 MT) from the 97 active fishermen, falling to 50% of the 1982 value (615.4 MT). Leslie analysis of 1983 logbooks, in addition to Leslie analysis of tagging data (Area 5), indicate that exploitable stock abundances have been further depressed in all areas since 1982. No soft-shell crab were found during commercial catch sampling in areas 4 and 5, indicating that no in-season growth and recruitment occurred. Similarly, comparisons between end of 1982 season commercial biomass estimates with estimates for the start of 1983 season indicate no major inter-season pulses of growth and recruitment for any area. Exploitation rates have attained record highs whereas mean catch rates have declined to record lows in all areas. Area 6 was the only area where increases in effort and expansion of the fishing ground offset reduced catch rates and resulted in landings above 1982 values.

Given high exploitation rates and the continued absence of major production in areas 2-6, it appears inevitable that exploitable stock abundances and catch rates will continue to decline. The future of the snow crab fishery off the Atlantic coast of Cape Breton Island will depend on market demand and production patterns. With the present low catch rates, a decrease in price paid to fishermen could make fishing uneconomical; on the other hand, prices notwithstanding, a continued lack of production will lead to the practical extinction of the fishery.

Résumé

L'article qui suit donne les résultats des évaluations biologiques de la pêcherie de crabe des neiges de l'île du Cap-Breton (côte Atlantique, zones 2 à 6) fondées sur les journaux de bord des pêcheurs, des études d'étiquetage du crabe ainsi que de l'échantillonnage des prises commerciales.

Dans l'ensemble, l'augmentation de la demande du crabe sur le marché en 1983 n'a pas réussi à maintenir l'effort de pêche (nombre de casiers) au niveaux de 1982. Cette réduction de l'effort de pêche, jointe à la baisse du taux des prises, a donné lieu à des débarquements enregistrés de 306,8 tonnes métriques (97 pêcheurs actifs), ce qui représente une baisse de 50 % par rapport à 1982 (615,4 tonnes métriques). L'analyse de Leslie, sur les données des journaux de bord, et des données d'étiquetage (zone 5), indique que les stocks exploitables ont encore diminué dans toutes les zones depuis 1982. On n'a trouvé aucun crabe à carapace molle parmi les échantillons prélevés dans les zones 4 et 5, ce qui signifie une absence de recrutement et de croissance durant la saison de pêche. Les comparaisons effectuées entre les estimés de biomasse de la fin de la saison 1982 et ceux du début de la saison 1983 ne révèlent aucune poussée importante de croissance et de recrutement entre les deux saisons, et ce quelle que soit la zone de pêche étudiée. Les taux d'exploitation ont atteint des sommets, mais les taux de capture moyens n'ont jamais été aussi bas dans toutes les zones. La zone 6 est la seule qui ait enregistré une hausse de l'effort de pêche, et l'expansion de la pêcherie a compensé à la diminution des taux de capture, ce qui a donné lieu à des débarquements supérieurs à ceux de 1982.

Vu les taux d'exploitation élevés et la diminution de la production dans les zones 2 à 6, les stocks exploitables ne pourront que diminuer tout comme les taux de capture. L'avenir de la pêcherie de crabe des neiges de la côte est de l'île du Cap-Breton dépendra de la demande du marché et de la production. D'une part, si le taux des prises n'augmente pas et que le montant versé au pêcheur diminue, la pêche ne sera plus rentable. D'autre part, et peu importe les prix, une diminution continue de la production va causé une extinction quasi totale de cette pêcherie.

Introduction

The directed fishery for snow crab around Cape Breton Island was started in 1966 by inshore boats trapping off the northwest coast. Between 1977 and 1979, landings rose markedly in phase with effort and the expansion of the fishery to approximately 180 inshore vessels operating around most of the Island (Table 1). Between 1976 and 1978, six inshore areas were defined around Cape Breton Island (Fig. 1) for exclusive exploitation by inshore boats under 45 ft (13.7 m) in length. One hundred and fifty snow crab licenses were issued to inshore boats to fish these areas in 1981. Additionally, 28 licenses were allotted for inshore boats to fish area 7 off the SW coast; area 7 is also open to the New Brunswick and Quebec offshore crab fleets.

By 1982 it became apparent that the snow crab fisheries on the Atlantic coast of Cape Breton Island (areas 2-6, Scotia-Fundy Region) are based on a resource which has a low productivity and that the accumulated virgin biomass had been drastically reduced by fishing. In contrast, on the Gulf of St. Lawrence coast of the Island (areas 1 and 7, Gulf Region) larger production levels have conferred relative stability to the commercial biomass and landings (Elner 1982). As the productivity of the Atlantic coast resource appeared too low and erratic to allow for a strategy of biomass stabilization, management dropped catch controls for the fishery in 1982; thus allowing existing fishermen to take advantage of whatever productivity occurs from time to time on an opportunistic basis. The fact that there is a minimum legal size regulation (95 mm carapace width, CW) confining exploitation to mature males that have had 1-3 yr to mate, is believed to protect the reproductive potential of the resource (Elner and Robichaud 1983a).

Based on fishermen's logbooks, tagging studies and commercial catch sampling, this paper assesses the status of the snow crab fishery in areas 2, 3, 4, 5, and 6.

Methods

Since 1978, Cape Breton Island snow crab fishermen have been required to maintain logbooks. To improve trap location information in logbooks, fishermen were given new large-scale grid charts in 1983 and requested to indicate the grid number(s) corresponding to their fishing area(s).

Biomass estimates for each area were made, where possible, by Leslie analysis, plotting cumulative catch (x-axis) at weekly intervals against mean CPUE (kg.trap haul^{-1}), from logbook data (Ricker 1975). The slope of the linear regression gives an estimate of the catchability (q) of the gear. The intercept of the regression line on the x-axis gives an estimate of the total biomass (B_o) above legal minimum CW available for the fishing season. Assuming that natural mortality is not significant during the relatively short fishing season (i.e. a type I fishery, Ricker (1975)), the rate of exploitation (U) is given by:

$$U = \frac{Y}{B_o} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where Y is the total catch.

If q is assumed to be constant throughout the fishing season, it is possible to calculate the biomass (B_t) present at a given time, knowing the CPUE value at that time ($CPUE_t$), from:

$$\frac{CPUE_t}{q} = B_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Equation (2) makes it possible to estimate biomass increases from growth and recruitment, through molting, during the fishing season. Significant molting periods are detectable by in-season rises in mean CPUE and simultaneous increases in the observed frequency of soft-shelled crabs in commercial catch samples.

Ricker (1975) gives a detailed account of possible sources of discrepancy in Leslie analyses.

Tag returns from mark-recapture studies were analyzed by Leslie and Peterson techniques to provide biomass and exploitation rate estimates.

In area 5, between June 14 and 16, a total of 1284 male snow crabs were caught, marked with t-bar tags and released prior to the fishing season; area of release bounded by:

Latitude (N)	Longitude (W)
45°45'00"	59°56'30"
45°43'00"	59°50'50"
45°39'00"	59°55'00"

The t-bar tags (molting-cone type) were injected through the right end of the posterior suture-line and designed to be retained through ecdysis. Fishermen were relied upon to return all tags recovered. A $2.00 reward was given the finder for each tag returned with details of how, where, and when the capture was made. An additional reward of $2.00 was offered for tagged crabs that were made available for measurement.

Port and at-sea sampling of commercial landings was carried out throughout the fishing season in area 5, and to a more limited extent in area 4, to assess catch size-frequency distribution and shell hardness. Manpower shortages precluded sampling in areas 2, 3, and 6.

Results

The 1983 fishing season was from July 22 to September 15. The average CPUE for each grid square and the distribution of fishing effort from logbook data in 1983 is shown in Fig. 2.

A summary of snow crab landings, effort statistics, and assessment estimates for each area since 1978 is given in Tables 1 and 2.

Areas 2, 3, and 4 (northeast Cape Breton)

Since 1980, snow crab areas 2 and 3, plus the nearshore portion of area 4 (being adjacent, relatively small management areas with a paucity of landings and commercial catch statistics) have been treated as a single stock for the purpose of annual assessments.

Only scanty fisheries information was forthcoming from area 2[2]. Two logbooks detailing landings of 248 kg were received from the 13 licensed fishermen, although sales slips indicate that 12 fishermen caught 7130 kg (Tables 1, 3).

Logbooks, recording landings of 40,172 kg, were received from all 27 of the active fishermen in area 3. For the purpose of the following Leslie analysis, logbooks from 12 fishermen from area 4 who fished in, or adjacent to, area 3 have been included with the area 3 logbooks. CPUE, plotted against cumulative catch, demonstrates a steady decline throughout the fishing season, indicating that no significant biomass pulse occurred during this period (Table 4, Fig. 3). A linear regression through all data points gives an estimate for total available biomass (B_o) of 76.5 MT (95% confidence limits: 69.5 and 87.2 MT). By subtraction of the 1983 catch for area 3 and part of area 4, 55.2 MT (from logbook data), we calculate that 21.3 MT (95% confidence limits: 14.3 and 32.0 MT) of commercial crab were left on the grounds when the fishery closed. Given that natural mortality was not significant during the fishing season, this fishery is experiencing an exploitation rate of 72% (95% confidence limits: 63% and 80%). Elner and Robichaud (1983b) observed a similar pattern and level of catch rates for this area in 1982 and estimated that the total available biomass for the similar area was 153.0 MT (95% confidence limits: 140.1 and 170.7 MT); the exploitation rate was calculated at 65% (95% confidence limits: 72% and 59%). The estimated end of season biomass in 1982 of 52.8 MT is 23.7 MT below the biomass at the start of the 1983 season; suggesting that limited growth and recruitment occurred between the two seasons.)

Eighteen fishermen from area 4 returned logbooks detailing catches of 31,612 kg; although 24 of 38 licensed fishermen actually set traps and landed 44,199 kg according to statistics from sales slips. A Leslie analysis for area 4 is impractical because the landings of 12 fishermen were included in the area 3 analysis. Table 5 summarizes available logbook data from fishermen setting traps offshore and away from the area 3 boundary in area 4 and demonstrates a marked decline in CPUE (17.0 to 2.5 kg·trap haul^{-1}) through the fishing season. Comparative CPUE's for 1982 ranged from 48.4 to 12.9 kg·trap haul^{-1}.

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[2]An unknown proportion of area 2 catches are probably made in area 1.

Port and at-sea sampling

Due to the relatively low landings in areas 2, 3, and 4, sampling manpower was largely diverted to the more important area 5 fishery. A single port sample for area 4 in August is shown in Fig. 4.

The "offshore" snow crab fishery in area 4 was closed due to soft-shell problems in 1982 (Elner and Robichaud 1983b); however, no such problem was detected in 1983.

Area 5 (southeast Cape Breton)

Port and at-sea sampling

Size-frequency histograms from port sampling during July, August, and September and at-sea sampling during July and August are shown in Fig. 5. Mean carapace widths from both port and at-sea sampling appeared to increase through the fishing season. (A post-season, at-sea sample of 59 male snow crabs was taken on December 16, 1983 by a commercial vessel under charter (Fig. 5). Traps were set at 120-160 m between 45°41'00N:59°53'00"W; 45°40'00"N:59°53'00"W; 45°40'30"N:59°59'00"W; 45°38'00"N:59°56'00"W). Comparison of commercial catch size-frequency distributions since 1978 demonstrate no pronounced trends (Fig. 6).

The absence of soft-shell crabs and the low incidence of intermediate-shell crabs (Fig. 7), as determined from port and at-sea sampling, suggests that molting and growth were not prevalent within the 1983 fishing season. In-season growth and recruitment has not been apparent over the period 1978-82 (Elner 1982; Elner and Robichaud 1983b).

Logbooks

Logbooks were received from all of the 21 area 5 fishermen who set traps in 1983. Total landings derived from logbooks were 148,827 kg, as compared to 151,296 kg from sales slips' statistics (Table 2). CPUE declined only slowly throughout the 1983 fishing season (Table 6, Fig. 8). The CPUE pattern and mean CPUE value (20.50 kg·trap haul^{-1}) are below those observed in 1981 (28.9 kg·trap haul^{-1}) and 1982 (33.73 kg·trap haul^{-1}) and are considerably below those of 1978-1980 (Fig. 10). Landings in 1983 (148.8 MT) are lower than those of 1982 (298.5 MT) and there is also a decrease in effort between the two years (8848 vs 7261 total trap hauls for the 1982 and 1983 season, respectively). The decreases in landings and effort have occurred despite record prices paid to fishermen for snow crab (1981: $0.25/lb ($0.55/kg); 1982: $0.65/lb ($1.43/kg); 1983: $0.90/lb ($1.98/ kg). Leslie analysis of the 1983 logbook data was impractical due to the relatively flat shape of the mean CPUE vs cumulative catch curve (Fig. 8). Comparison of CPUE through the 1983 fishing season for individual vessels (Fig. 9) reveals an apparently chaotic array of CPUE patterns. Such high inter- and intra-vessel variability in fishing success probably reflects the searching behavior of fishermen faced with a dispersed, low density resource interspersed with occasional higher density "pockets" of crab.

Tagging

Six hundred and twenty-four (48.6%) of the 1284 tagged crabs released in 1983 were recovered during the 1983 fishing season. The size frequency of the crabs tagged and returned is shown in Fig. 11. An additional 154 tagged crabs released in 1982 were also recovered in 1983 (Fig. 12).

Assuming a 20% mortality from the tagging process in 1982 (4 crabs out of 20 untagged control crabs and 4 tagged crabs out of 20 tagged crabs died in a trap set over a 24-h soak time) and no in-season additions to the commercial population, the 1983 tag return data has been analyzed:

A Leslie analysis of tag return data (Table 7, 8, Fig. 13) gives an exploitation rate of 85% (95% confidence limits: 101% and 59%). A Petersen estimate of biomass (B_1) can be obtained for the initial week of the fishery from:

$$B_1 = \frac{C_{1-q} \times M_1}{R_{1-q}} = \frac{148{,}827 \text{ kg} \times 738}{624} = 176.0 \text{ MT}$$

where C_{1-q} = catch in weeks 1-8 of the fishing season;

M_1 = apparent number of crabs tagged, from Leslie analysis of tagging data;

R_{1-q} = number of tags returned during weeks 1-8 of the fishing season.

A straight Petersen estimate of biomass, utilizing the actual number of crab tagged (1284) less 20% tagging mortality (257):

$$B_1 = \frac{148{,}827 \text{ kg} \times 1027}{624} = 244.9 \text{ MT}$$

gives a biomass value in reasonable agreement with the Leslie-Petersen estimate. Biomass (B_o) on the area 5 fishing grounds during the 1982 season was estimated by Leslie analysis of logbooks at 670.1 MT (95% confidence limits: 514.5 and 1056.4 MT) and at 356.9 MT and 505.8 MT by Leslie-Petersen analysis of tag returns, respectively.

Using the most liberal estimate of area 5 biomass (244.9 MT) in 1983 and the 1983 catch of 148.8 MT, the estimated exploitation rate was 60.8%. Similarly, by subtraction of the catch from the biomass, an estimated 96.1 MT would remain on the fishing grounds at the end of the 1983 season. In comparison, 371.6 MT (95% confidence limits: 216.0 MT and 757.9 MT) was estimated to remain on the grounds at the end of the 1982 season after an exploitation rate of 44.5% (95% confidence limits: 58.0% and 28.3%).

A total of seven crabs out of the 578 measured appeared to have grown (Fig. 14). However, it should be noted that a further four crabs measured appeared to have decreased in carapace width due probably to sampling error. In addition, five crabs from the 1566 crabs tagged in 1982 and returned in 1983 (Fig. 12) molted; only one decrease in carapace width was dectected.

Area 6 (south Cape Breton)

In 1983, five additional fishermen from the Canso area were allowed to fish on previously unexploited grounds in area 6.

Port and at-sea sampling

No port samples were obtained from area 6 during the 1983 fishing season.

Logbooks

The total landings from logbooks of 12 area 6 fishermen who fished during 1983 amounted to 64,461 kg, as opposed to the 64,084 kg recorded through the Area Managers' statistics system. Area 6 was unique in that it was the only area where increases in effort offset reduced catch rates and resulted in landings above 1982 values (Table 2).

CPUE declined slowly through the 1983 fishing season (Table 9; Fig. 15); a similar CPUE pattern has been observed each year since 1979. CPUE values dropped under 10 kg·trap haul^{-1} for the second time since the fishery opened, and the overall mean CPUE value for the season (8.47 kg·trap haul^{-1}) was 13% below the 1982 value of 9.77 kg·trap haul^{-1}. In a Leslie analysis of 1982 logbook data, a linear regression through all data points gives an estimate of total available biomass (B_0) of 102.7 MT (95% confidence limits: 88.7 and 126.3 MT). Given this value for B_0, the 1983 catch of 64.5 MT and assuming no in-season growth and recruitment, an exploitation rate of 63% (95% confidence limits: 73% and 51%) is indicated. Similarly, by subtraction of the total catch from B_0, 38.2 MT (95% confidence limits: 24.2 and 61.8 MT) of commercial crab is estimated to remain on the fishing grounds at the end of the 1983 season. [119.9 MT (95% confidence limits: 61.9 and 283.7 MT) was estimated to remain on the grounds at the end of the 1982 season]. Direct comparisons between area 6 commercial biomass values in 1983 and previous years are confounded due to the expansion of the fishing grounds by the Canso entrants; nevertheless, it is evident that landings outweigh production and the exploitable biomass is rapidly diminishing.

Note: Leslie Analysis

The Leslie estimates of biomass for areas 3 and 6 should be viewed with caution as it is probable that, when a stock is reduced beyond a critical level, fishing patterns and the dispersed, low density of the resource lead to a depressed but generally uniform mean CPUE throughout the fishing season. Such a trend in CPUE can produce an excessive value for B_0 when data are analyzed by the Leslie technique (Mohn and Elner, unpublished computer model).

Discussion

In 1982, CAFSAC determined, given the low catch rates prevailing in areas 2-6, the resultant scanty data produced for assessment purposes, and limitations in the assessment techniques themselves, that provision of advice to management on annual TAC levels was not feasible. Certainly, the assessments for the 1983 season do not appear cause for change in CAFSAC's decision and thus, there appears no rationale for re-introducing catch controls for the 1984 season.

Overall, the 1983 stock status for areas 2-6 appears to be a further degeneration of the depressed state noted in 1981 and 1982. No major pulses of growth and recruitment were detected in the system during the fishing season. The increase in price paid for snow crab failed to generate an increase in effort. In turn, the overall decrease in effort and reductions in CPUE have resulted in a decrease in total landings.

Although (given the sparsely distributed stocks and incomplete statistics) our assessments are at the boundaries of feasibility, it appears unlikely that even the present CPUE can be retained in the face of high exploitation rates and the continued absence of major growth and recruitment. The viability of the 1983 fishery was considerably enhanced by the strong world market demand for crab.[3] The future of the snow crab fishery on the Atlantic coast of Cape Breton Island will depend on the world market situation and recruitment patterns. With the present low CPUE levels, a decrease in the price paid to fishermen could lead to the cost of fishing rising above income and an abandonment of the fishery. On the other hand, notwithstanding prices, a continued lack of growth and recruitment must lead to the practical extinction of the fishery.

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[3]Due largely to collapse of the Alaskan king and tanner crab fisheries.

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Table 1. Snow crab statistics for the Atlantic coast of Cape Breton Island, 1978-83.

Area	Year	No. of boats Licensed	No. of active boats	No. of logbooks received	Statistics landed area managers (kg)	Statistics landed logbooks (kg)	Actual effort in traps hauled (from 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
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
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
5	1978	15	15	15	-	250,076	6,165
	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	3,135
	1982	25	19	18	300,145	298,469	9,931
	1983	22	21	21	151,296	148,827	8,146
6	1979	8	4	4	24,868	27,351	1,880
	1980	11	10	9	58,586	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
TOTAL	1978	89	42	42	-	646,270	25,296
	1979	119	98	83	1,621,507	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

Table 2. Comparison of assessment data for Cape Breton Island snow crab (Areas 2-6), 1978-83.

Area	Year	No. of active boats	No. of logbooks received	Landed statistics: area managers (kg)	Landed statistics: logbooks (kg)	Effort (standardized trap hauls)	Mean CPUE	Available biomass for season (MT)	Exploitation rate (%)	Standardized trap type
2, 3 & 4	1978	27	23	-	192,228	17,258	11.14	-	-	(1.2x0.9x0.8 m, wood)
(inshore)	1979	70	40	917,136	262,250	25,660	10.22	324.9	81	"
	1980	65	42	367,846	181,033	17,499	10.35	225.2	80	"
	1981	39	4	97,386	7,361	580	12.69	-	-	(1.5x1.5x0.5 m, steel)
	1982	41	28	252,209	100,161	13,971	7.17	153.0	65	(1.2x0.9x0.8 m, wood)
	1983	63	41	91,387	55,242	11,780	4.69	76.5	72	"
4	1978	*	4	-	203,966	4,916	41.49	-	-	(1.5x1.5x0.5 m, steel)
(offshore)	1979	*	16	*	507,569	10,546	48.13	790.0	64	"
	1980	*	4	*	39,800	827	48.13	-	-	"
	1981	*	-	*	-	-	-	-	-	"
	1982	*	10	*	91,377	2,875	31.78	-	-	"
	1983	*	6	*	16,790	1,454	11.55	-	-	"
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	7,341	44.24	543.0	60	"
	1981	11	10	90,463	81,819	2,835	28.86	-	-	"
	1982	19	18	300,145	298,469	8,848	33.73	356.9**	84	"
	1983	21	21	151,296	148,827	7,261	20.50	176.0**	85	
6	1979	4	4	24,868	27,351	1,880	14.55	69.44	39	"
	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	"
TOTAL	1978	42	42	-	646,270	26,705	24.20	440.0	57	All trap types combined
	1979	98	83	1,621,507	1,479,901	52,833	28.01	2369.34	62	"
	1980	99	76	822,287	614,755	30,913	19.89	945.2	61	"
	1981	55	19	203,745	109,530	4,731	23.15	35.8	57	"
	1982	67	63	615,426	553,140	32,156	17.20	684.9	67	"
	1983	97	80	306,767	285,320	28,109	10.15	355.2	76	"

*Included in area 2, 3 & 4.
**From tagging estimate, all other estimates from Leslie analysis of tagging data.

Table 3. Catch and effort statistics from logbook data for the snow crab fishery in area 2, 1983.

Week period	Conical and wooden traps	Catch (kg)	CPUE (kg/trap haul)
29/7-4/8	120	239	2.00
5/8-11/8	30	9	0.30
Total	150	248	1.65

Table 4. Catch and effort statistics from logbook data for the snow crab fishery in area 3 and part of 4, 1983.

Week period	Trap hauls: Steel traps (1.5x1.5x0.5 m)	Trap hauls: Conical and wooden traps (1.2x0.9x0.8 m)	Trap hauls: All traps converted into wooden traps	Catch (kg)	Cumulative catch (kg)	CPUE kg/trap haul (wooden traps)	Estimated biomass (MT)
22/7-28/7	224	2,036	2,400	17,065	8,532.5	7.11	66.7
29/7-4/8	497	2,846	3,513	19,322	26,726.0	5.50	51.6
5/8-11/8	397	2,252	2,919	10,915	41,844.5	3.74	35.1
12/8-18/8	74	1,810	1,961	5,471	50,037.5	2.79	26.2
19/8-25/8	83	669	771	1,998	53,772.0	2.59	24.3
26/8-1/9	--	50	50	82	54,812.0	1.64	15.4
2/9-8/9	--	60	60	183	54,944.5	3.05	28.6
9/9-15/9	--	106	106	206	55,139.0	1.94	18.2
Total	1,275	9,829	11,780	55,242	55,242	-	-

Table 5. Catch and effort statistics from logbook data for the snow crab fishery in area 4, 1983 (not including data from area 4 boats which fished adjacent to or in area 3).

Week period	Steel traps (1.5x1.5x0.5 m)	Catch (kg)	CPUE (kg/trap haul)
22/7-28/7	270	4,589	17.00
29/7-4/8	430	5,464	12.71
5/8-11/8	415	3,910	9.42
12/8-18/8	233	2,152	9.24
19/8-25/8	82	615	7.50
26/8-1/9	24	60	2.50
Total	1,454	16,790	-

Table 6. Catch and effort statistics from logbook data for the snow crab fishery in area 5, 1983.

Week period	Steel traps (1.5x1.5x0.5 m)	Conical traps	All traps converted into steel traps	Catch (kg)	Cumulative catch (kg)	CPUE (kg/trap haul)
22/7-28/7	928	173	996	23,619	11,809.5	23.71
29/7-4/8	1,228	178	1,312	28,039	37,638.5	21.37
5/8-11/8	1,260	210	1,362	27,770	65,543.0	20.39
12/8-18/8	899	204	985	17,277	88,066.5	17.54
19/8-25/8	778	171	844	16,258	104,834.0	19.26
26/8-1/9	722	227	794	16,086	121,006.0	20.25
2/9-8/9	543	147	587	12,568	135,333.0	21.40
9/9-15/9	329	149	381	7,210	145,222.0	18.91
Total	6,687	1,459	7,261	148,827	148,827	-

Table 7. Tag returns from the snow crab fishery in area 5, 1983.

Week period	No. of tag returns	Cumulative recaptures	Effort (trap hauls)	No. recapture/effort
22/7-28/7	198	99	996	0.199
29/7-4/8	111	253.5	1,312	0.085
5/8-11/8	123	370.5	1,362	0.090
12/8-18/8	58	461	985	0.059
19/8-25/8	71	525.5	844	0.084
26/8-1/9	24	573	794	0.030
2/9-8/9	21	595.5	587	0.036
9/9-15/9	18	615	381	0.047
Total	624	624	7,261	-

Table 8. Survival and mortality estimates for tagging study in area 5, 1983.

Estimates	Total no. of tagged crab returns
Initial number marked: (M)	1284
Mortality (No.) from marking: (X) (rate observed experimentally during tagging)	257 (.20)
Actual number marked: (M-X)	1027
Apparent number marked (M') (limits of confidence at P=.05)	738 (616-1053)
Number recaptured: (R)	624
Rate of fishing: (R/M-X)	61%
Estimated rate of fishing: (R/M') (from Leslie regression)	85% (101%-59%)
Estimated number remaining: (M'-R)	114
Survival rate (S' = M'-R/M-X)	0.11
Instantaneous rate of total mortality (X' = -lnS')	2.20
Disappearance (No.) from other causes (X' = M-X-R-(M'-R))	289
Rate of disappearance from other causes (X'/M-X)	0.28

Table 9. Catch and effort statistics from logbook data for the snow crab fishery in area 6, 1983.

Week period	Conical traps	Steel traps (1.5x1.5x0.5 m)	All traps converted into steel traps (1.5x1.5x0.5 m)	Catch (kg)	Cumulative catch (kg)	CPUE (kg/trap haul)	Estimated biomass (MT)
29/7-4/8	10	391	396	4,716	2,358.0	11.90	92.5
5/8-11/8	90	1,149	1,183	15,582	12,507.0	13.17	102.4
12/8-18/8	142	1,326	1,410	14,017	27,306.5	9.94	77.3
19/8-25/8	79	989	1,065	8,563	38,596.5	8.04	62.5
26/8-1/9	58	782	872	5,308	45,532.0	6.09	47.3
2/9-8/9	66	932	988	6,489	51,430.5	6.57	51.1
9/9-15/9	60	576	624	3,774	56,562.0	6.05	47.0
16/9-22/9	28	581	603	3,412	60,155.0	5.66	44.0
23/9-29/9	14	460	473	2,600	63,161.0	5.50	42.8
Total	547	7,186	7,614	64,461	64,461	-	-

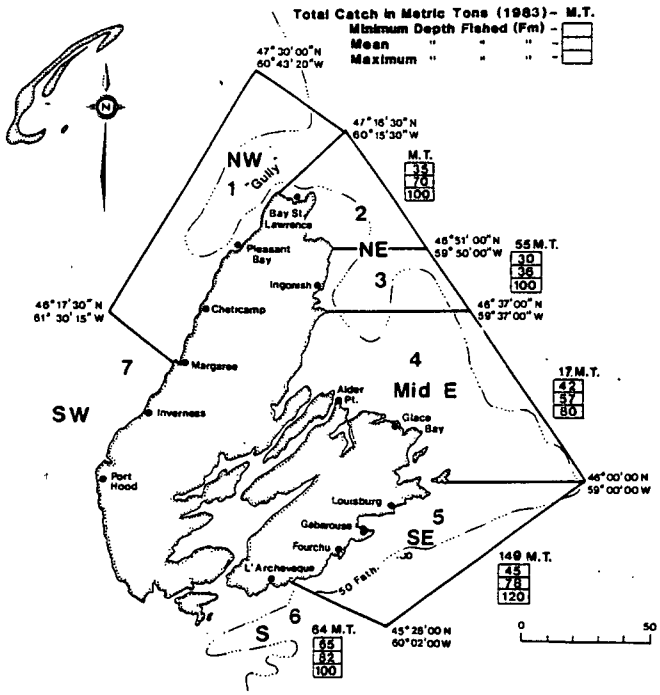


Fig. 1. 1983 Cape Breton Island snow crab fishing areas and landings.

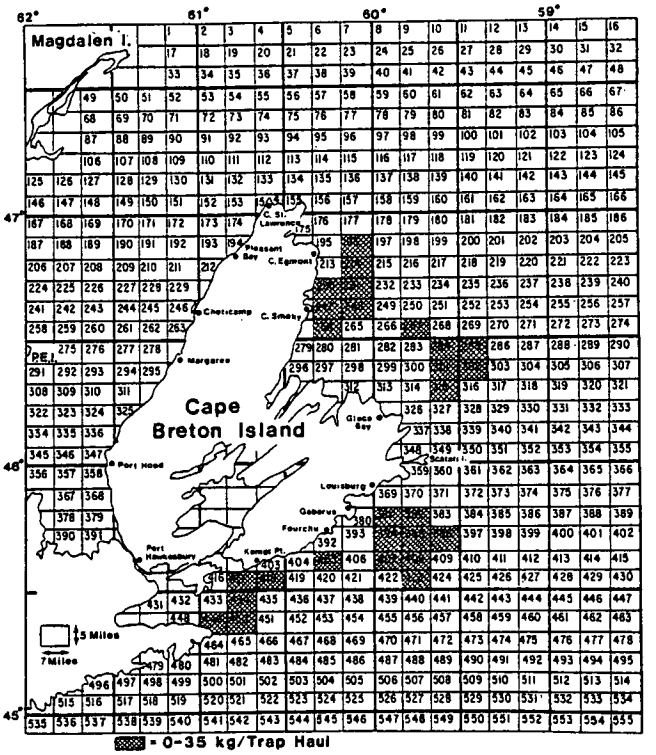


Fig. 2. Distribution of snow crab fishing effort off the Atlantic coast of Cape Breton Island during the 1983 season, as derived from logbook grid map data.

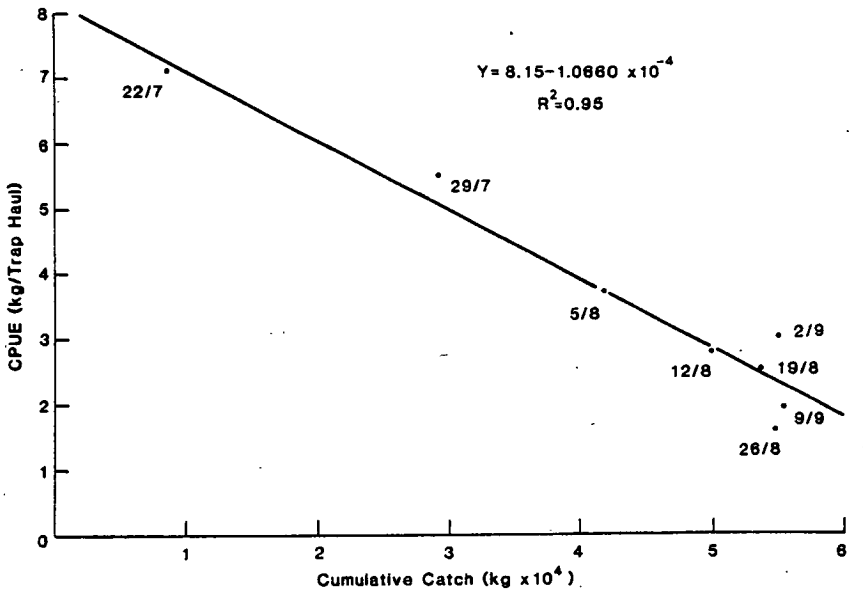


Fig. 3. Leslie graph of cumulative weekly landings against CPUE, from logbook data, for modified area 3 in 1983.

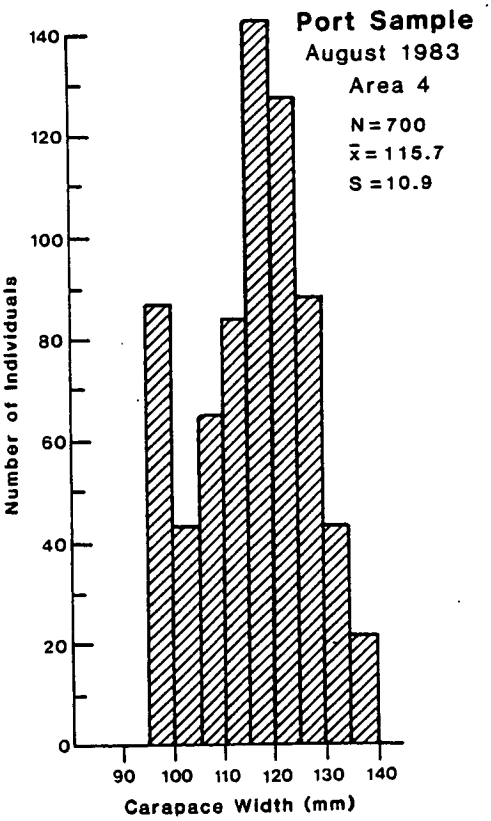


Fig. 4. Size-frequency histogram for male snow crabs sampled from commercial boats in area 4 during the 1983 fishing season.

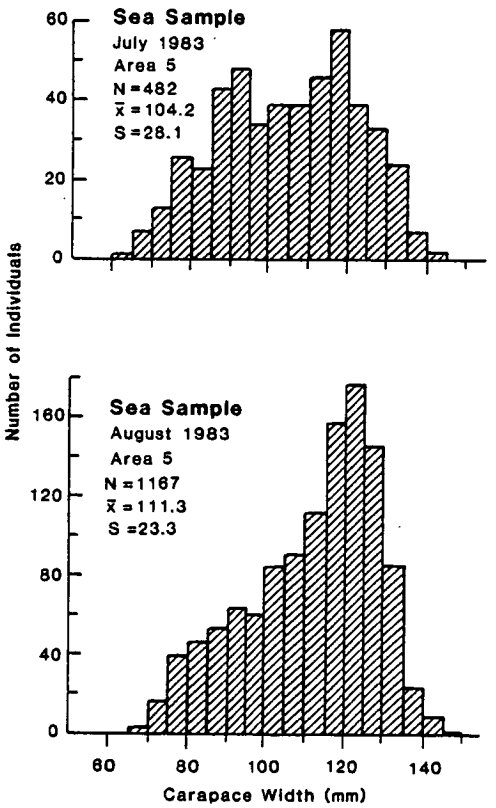


Fig. 5. Size-frequency histograms for male snow crabs sampled in area 5 during 1983.

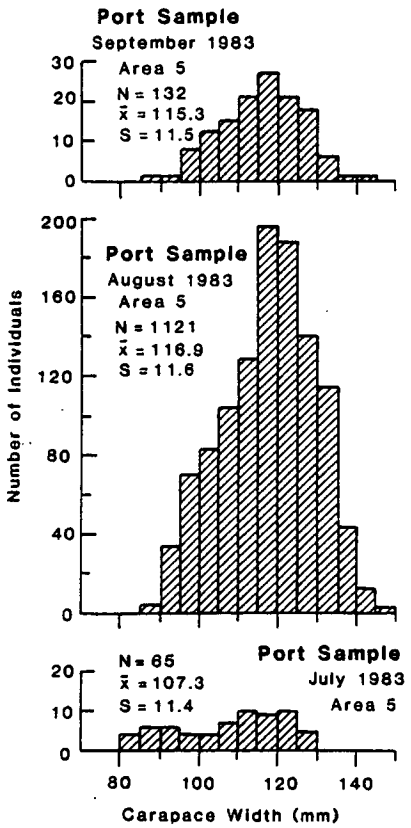
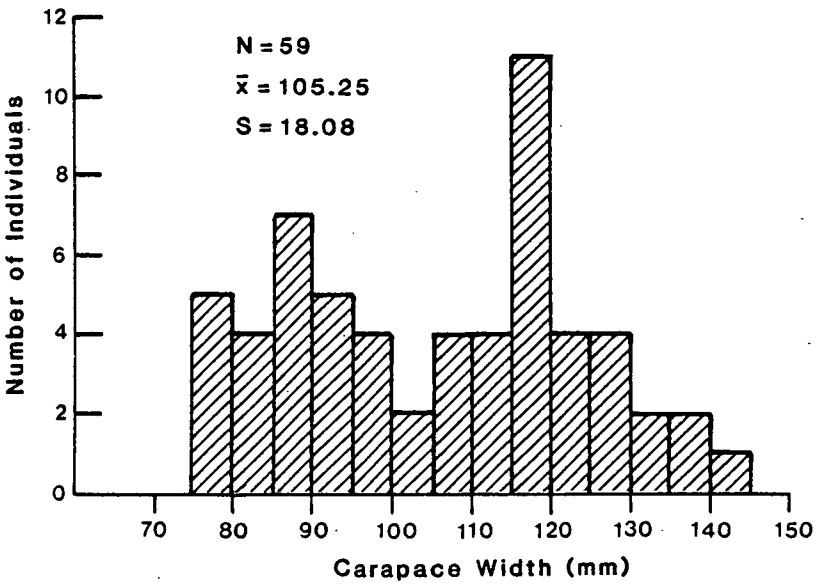


Figure 5. Continued.



AREA 5 SEA SAMPLE DECEMBER 1983

Figure 5. Continued.

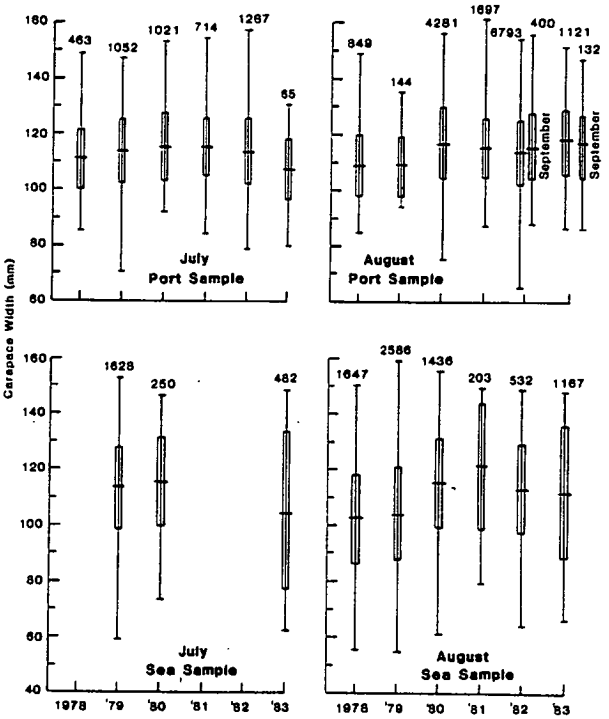


Fig. 6. Historical monthly mean carapace widths for male snow crabs from port and at-sea sampling of commercial catches in area 5, SE Cape Breton Island.

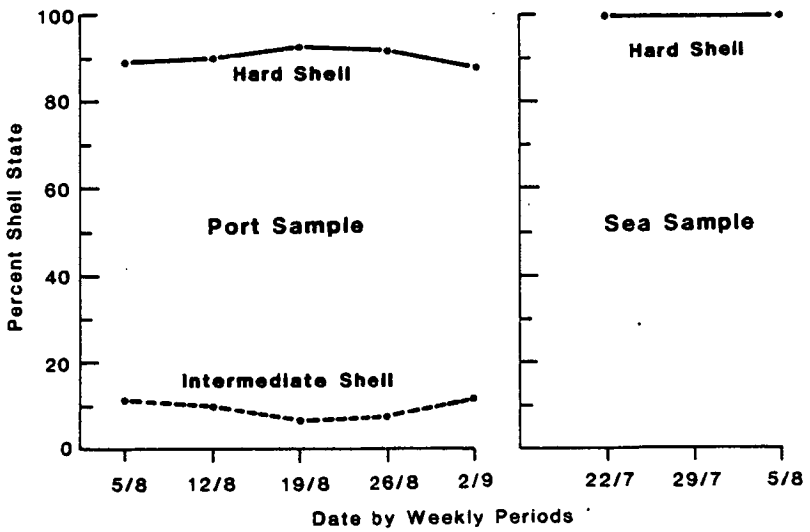


Fig. 7. Percentage frequency of occurrence of shell states for male snow crabs throughout the 1983 fishing season in area 5, SE Cape Breton Island.

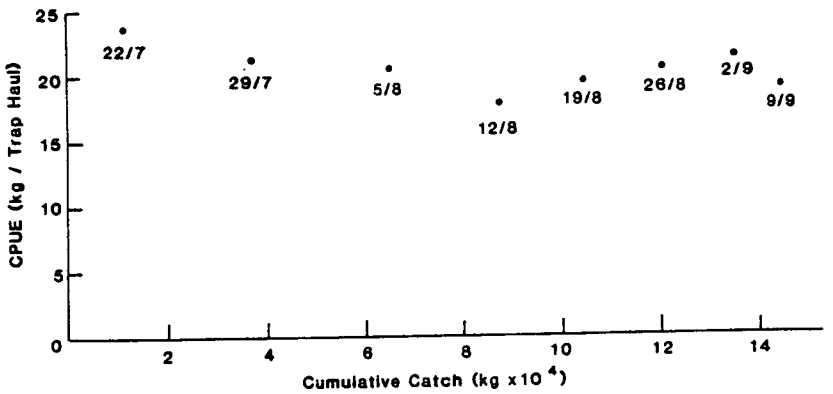


Fig. 8. Graph of cumulative weekly landings against CPUE, from logbook data, for area 5 in 1983.

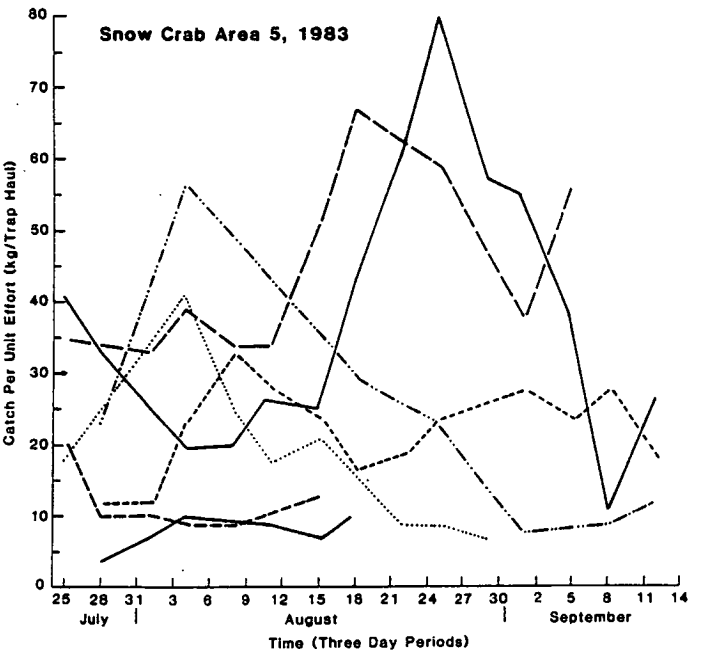


Fig. 9. CPUE, from logbook data, at 3-d intervals through the 1983 season, for randomly selected, area 5 snow crab vessels.

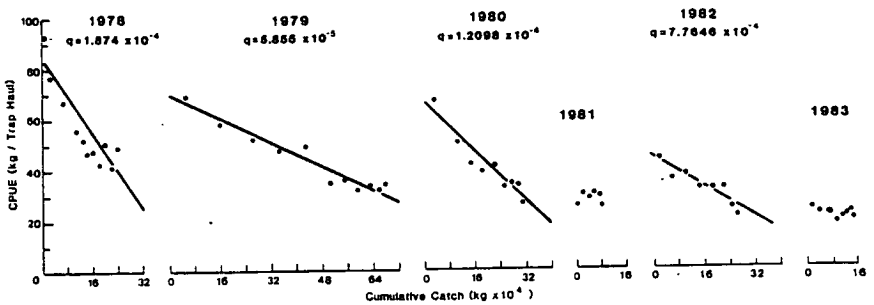


Fig. 10. Historical trends of CPUE against cumulative catch in area 5 from logbook data.

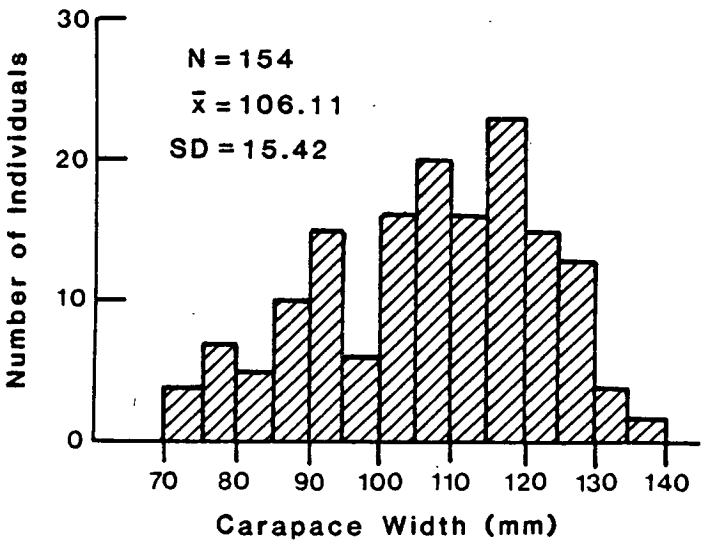


Fig. 11. Size frequency of male snow crabs tagged in June 1983 and recaptured during the 1983 fishing season in area 5.

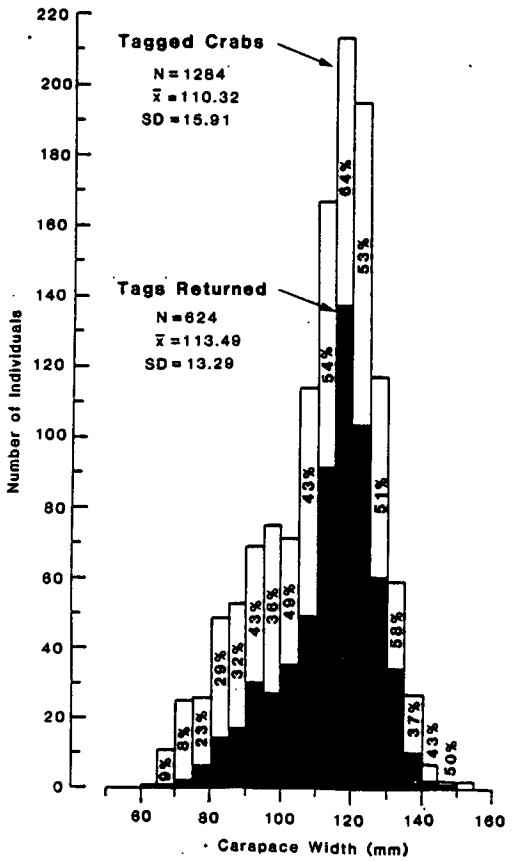


Fig. 12. Size frequency of male snow crabs tagged in June 1982 and recaptured during the 1983 fishing season in area 5.

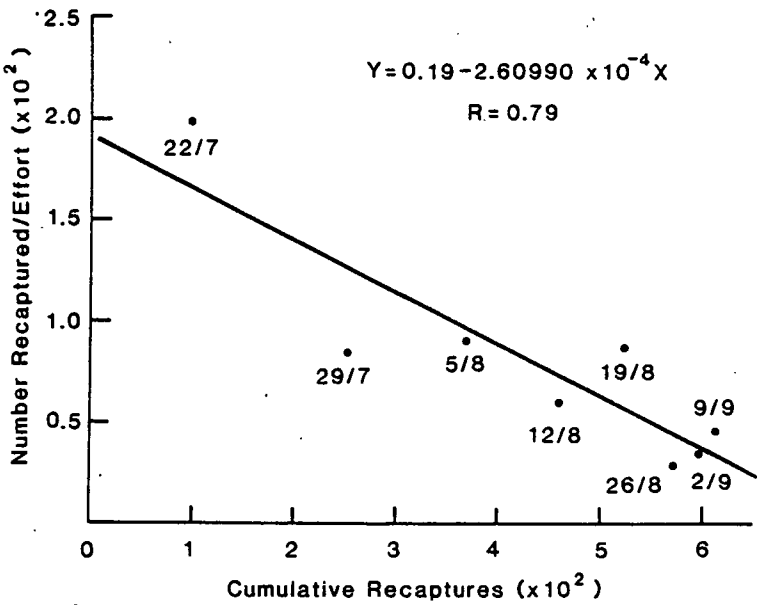


Fig. 13. Leslie graph of weekly tag returns against tag returns per unit of effort in area 5 in 1983.

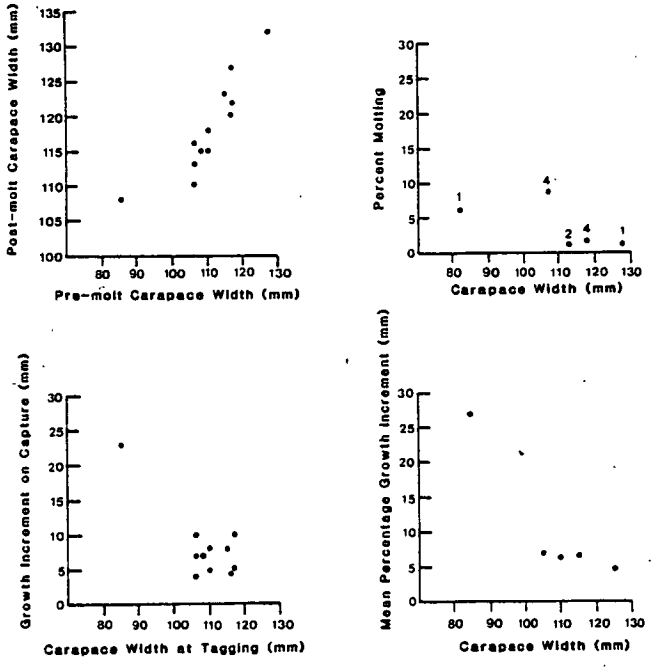


Fig. 14. Display of snow crab growth information from crabs tagged in area 5 and returned in 1983.

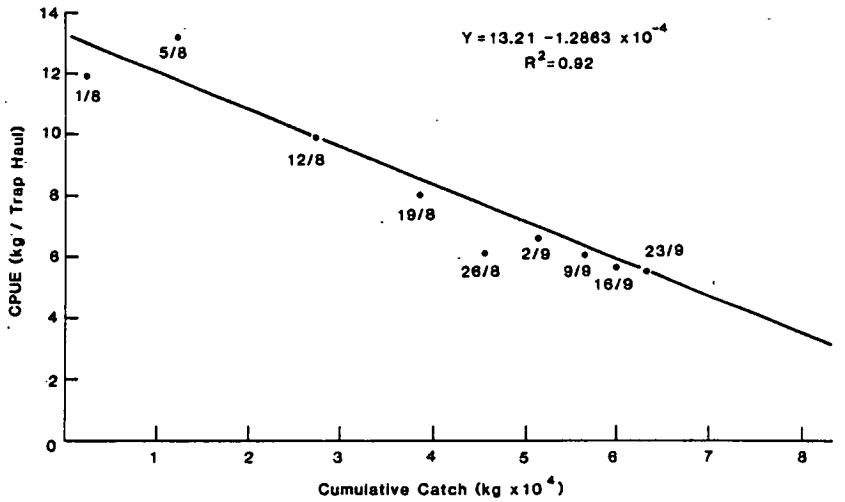


Fig. 15. Leslie graph of cumulative weekly landings against CPUE, from logbook data, for area 6 in 1983.