Canadian Atlantic Fisheries
Scientific Advisory
Committee

CAFSAC Res. Doc. 1978/38
Invertebrates & Marine Plants
Committee
November 30, 1978

Preliminary assessment of the red crab resource off the Scotian Shelf

by

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Introduction

Previous exploratory surveys of the deep-sea red crab, Geryon quinquedens Smith, by Canada and the United States have revealed stocks sufficient to support a viable fishery. Recently, the Americans began harvesting and processing this resource. Four vessels, operating out of Massachusetts and Virginia land an annual catch of about 7.8 million pounds. A similar fishery may develop in Canada, owing to the high demand and increasing prices for crab meat. Information on red crab distribution and abundance is therefore needed.

The commercial potential of this crab has stimulated various investigations by both Canadian and American scientists on general biology, distribution and technological aspects of fishing and processing. Perry (1969), Sharp (1970) and Cadegan (1971) representing the Nova Scotia Department of Fisheries have surveyed the continental slope between Browns Bank and Sable Island Bank for commercial concentrations of red crabs, while experimenting with trap design, bait preference, holding facilities and processing techniques. McKenzie (1966) observed from a series of tows along the Scotian Shelf that the largest catches occurrred in waters 360-540-m deep and that males were larger than females. This coincides with results obtained from various American surveys. Ganz and Herrmann (1975) found that male crabs had a greater carapace width and body weight than females. These were more abundant in catches from shallow depths (270-360 m) while males outnumbered them in deep water (630-900 m). Their tag-recapture experiments

indicated some movement of individuals but no particular trend was noticed. A quantitative survey conducted by Wigley et al. (1975), using sea bottom photographs and bottom trawl, gives information on densities, biomass and distribution. Haefner (1978) in a 3-yr demersal trawl survey looked at some seasonal aspects of biology, distribution and abundance of the red crab. Although he and Wigley et al. (1975) gave some information on potential yield from the fishery, knowledge on this subject and others, such as growth rates, size at maturity, age at which commercial size is reached and migratory habits, is relatively scarce. In their tag-recapture study, Ganz and Herrmann (1975) observed one individual that did not moult for a whole year. Moulting frequency, actual size increments per moult and the behavioural aspects of moulting are unknown.

Some other aspects of the red crab biology are covered by Perkins (1973), who describes the larval stages of the deep sea red crab, and Haefner (1977), who deals with the reproductive biology of the female.

This project was designed to obtain information on distribution, abundance, sex ratio and size frequency of red crabs in Canadian waters along the Scotian Shelf. At present, such information is scarce, but necessary for proper management of this new resource.

Materials and Methods

A 27.6-m (92-ft) offshore lobster boat, the M.V. Judy and Linda IV, was chartered out of Shelbourne, Nova Scotia, for a total of 20 fishing days between September 11 and October 11, 1978. The survey consisted of sampling on 9 randomly selected transects (Table 1), lying perpendicular to the contour of the continental slope between Sable Island Bank (42°59'N, 61°59'W) and Corsair Canyon on Georges Bank (41°21'N, 66°00'W) (Fig. 1). Each transect was divided into four depth zones: 180-360 m, 360-540 m,

540-720 m and 720-900 m.

A string of 12 conical top-entry traps were set within each of the four depth strata. The traps consisted of a welded steel frame, height 0.6 m, bottom diameter 1.2 m, top diameter 0.6 m (Fig. 2), covered with nylon netting with a mesh size of 6.6 cm. Crab entry was through a plastic cylinder 28 cm long x 20 cm in diameter, fastened at the top of the trap.

Traps were set in the mid-depth of each stratum and baited with 2-3 kg of frozen mackerel in nylon mesh bait bags. Individual traps were attached to the trawl line at 54-m intervals. A 45-kg anchor was fastened at each end of the string to minimize movement on the bottom. The end lines leading to the surface were attached to two large orange balloons connected with a radar reflecting buoy. Traps were generally set in the afternoon and hauled the following morning after a soak period of 13-17 h (Table 1), except at transect 3 where they were left longer because of bad weather.

The number of crabs per trap, the sex and carapace width, barren and berried females, and shell hardness in males were recorded. The carapace width (CW) was measured by placing vernier calipers just above and touching the fifth anterolateral spine on each side (giving the widest size of the carapace). All crabs trapped were measured except for four-ninths of the total catch (N = 618) in transect 3, depth of 360-540 m.

The culled weight, or weight of all commercial-sized crabs trapped in each transect was measured with a beam balance. The minimum carapace width of 4 inches (101 mm) was originally and arbitrarily set by commercial plants during earlier experimental processing of red crabs. A mean individual weight of 0.57 kg, used for biomass conversions, was obtained from a sample of 75 individual crabs.

All other species trapped were recorded. Length frequency measurements, when time permitted, and the number of Jonah crabs (Cancer borealis) caught within each depth strata were also recorded.

A procedure used by Miller (1975) to calculate densities of snow crab (Chionoecetes opilio) was adapted to obtain an estimate of population size from our data. Miller estimated the effective fishing area to 4,100 m^2, which means a radius of 36 m for a circular area of attraction. We expected our traps (same as Miller's) and bait (mackerel instead of herring) to attract red crabs to a similar distance. But the distance between traps (54 m) limited the radius of the fishing area to 27 m, for a total area of 2,300 m^2.

The density of crabs for each 36 subareas (four depth ranges in nine transects) was calculated as follows:

$$\text{Crab density}(\text{crabs}/m^2) = \frac{\text{catch (crabs/trap)}}{\text{effective fishing area (2,300 } m^2/\text{trap)}}$$

Total surface of each subarea was measured between isobath limits and mid-points to next transects (or ends of total area). Population numbers were estimated by multiplying density and total surface.

Results

Catches of red crabs

An estimated total 1,335 red crabs were caught during this survey. The highest catch rate, in transect 3, yielded an estimated 758 crabs in 48 traps, with a culled weight of 394.5 kg (Table 2). Extremely low catches of commercial-sized crabs were found in transects 1, 5, 7 and 8.

Most crabs (75.4%) were trapped at 360-540 m deep. Catches at 180-360 m yielded only 50 crabs (3.7%) in all transects combined.

Of all male crabs caught, 67 or 5% of the total were classified as soft-shelled.

Red crabs caught in this survey ranged from 54 mm to 156 mm in carapace width (CW) with males generally larger than females. No significant differences were found between average CW of males in each transect within a same depth stratum. A trend in size to decrease with depth was noticed, however, when overall average CW were calculated for each of the 4 depth strata (Fig. 3). Differences were tested with t-statistic, and were significant at $P = .01$ for all comparisons except between depths 360-540 m and 540-720 m.

The histograms of CW frequencies of male red crabs indicate that a major proportion of the measured males fall within the commercial size range (Fig. 3). The proportion of commercial crabs increases with decreasing depths, from 77% at 720-900 m to 82%, 89% and 98% in the shallower depths.

Only 14 females red crabs (1%), one berried, were caught, the mean carapace width being 99.0 mm (± 4.2 mm S.E.).

Estimates of population size, density and biomass

Catchable male crab numbers and density, commercial-size crab (or standing crop) numbers and density, and available biomass and biomass density were calculated by depth strata and for the total area (Tables 3-4). The same estimates were also calculated for transects 2, 3 and 4 (Table 5). These transects represent the only area that seems to warrant commercial interest.

Jonah crabs

A total of 195 jonah crabs were trapped in this survey, 95.9% of which were caught at 180-360 m (Table 6). The mean CW was 143.0 mm (± 1.6 mm S.E.) (Fig. 4). The highest catch of jonah crabs coccurred in transect 3.

Discussion

The most densely populated area for red crabs along the Scotian Shelf appears to be between southwest Emerald Bank and south of LaHave Bank. This area was sampled by transects 2, 3 and 4, and yielded an average catch of 26.8 crabs per trap in the 360-540 m depth range.

Concluding to greater abundance because of bigger catch in transect 3 might be questioned for two reasons: longer soak time and better quality bait. Ganz and Herrmann (1975) established for two other types of traps that saturation was reached after a 14-20 h soak time only. Sharp (1970) used a soak time of 44 h and obtained catches similar to those reported by Perry (1969) after only 12-14 h. It is thus possible that longer soak time was not an important factor for the high catch in transect 3.

The overall catch rate in the survey might have been higher if bait of better quality had been used. Unfortunately, after 2 weeks at sea, the mackerel has spoiled and may have reduced the catch rates for transects 1, 2, 4, 5 and 6. During a series of experiments, Perry (1969) found that traps baited in the same area on the same day yielded twice the catch per trap with frozen mackerel as opposed to salt herring. But, once the mackerel had spoiled, it attracted even fewer crabs than the salt herring. Fresh frozen mackerel was used in transect 3 and might have been partly responsible for the high catch. However, good quality mackerel was used in transects 7, 8 and 9, with poor catches; while bait used in transects 2 and 4 was not fresh and yet gave relatively good catches.

Previous surveys along the Scotian Shelf have indicated the highest catch rates within the same area sampled by our transects 2, 3 and 4. McKenzie (1966) caught only 81 crabs in an area extending from south of Browns Bank to south of Emerald Bank on the continental slope. His biggest catch was southwest of LaHave Bank, at a location relatively close to transect 3. In his survey, 87% of the crabs were caught at the 360-540 m depth, with no catches reported south of Browns along the Fundian Channel. Perry (1969) surveyed the southeast tip of Sable Island Bank, west to the eastern end of Browns Bank along the 180-m line. Although he did not specify the depth range, he caught 66 crabs/trap, with a maximum of 165 crabs/trap at 63°02'W, 42°47'N. Maximum catch rates for both these two earlier surveys were found in the vicinity of our transect 3 which confirms our findings of high crab numbers in this area. Sharp (1970) investigated a small area along the shelf extending from 63°41' to 62°50'N, and recorded average catches of 50 crabs/trap at 450 m. The range and location of Sharp's survey is identical to those of our transects 2, 3 and 4, and his catch rates are similar to those obtained in transect 3. Perry and Sharp both used larger traps during their investigations.

Distribution of crabs on the Scotian continental slope is much more restricted by depth than on the American continental slope. This can be illustrated by comparing index of abundance in each depth strata for both areas. Calculations for index of abundance from the American waters are based on trawl catches/unit of effort taken from data of Wigley et al. (1975). Our average catch/trap was used for the Canadian waters index. For the purpose of comparison, data for each depth is given as a fraction of the highest index. Females are not included since they probably possess a

different pattern of distribution.

	Abundance	
Depth (m)	Wigley et al. (1975)	This survey
180-360	0.22	0.05
360-540	0.78	1.00
540-720	1.00	0.11
720-900	0.41	0.24

The difference in distribution patterns could be attributed to environmental factors confining the majority of red crabs along the Scotian Shelf to a narrow band in the 360-540 m depth range. In shallower depths, the presence of many jonah crabs in the traps may indicate interspecific competition.

Investigations conducted in continental slope waters off the United States have revealed females to be substantially more numerous than what we found in Canadian waters. Wigley et al. (1975) found more females than males in their survey, and their ratio (F:M) varied according to depth and geographic location. Haefner (1978) noted seasonal variations, as well as variations with depth, in the sex ratio. The difference in female catches could be a result of sampling techniques since bottom trawls were used in the American surveys as compared to traps, which may be selective for males. However, Sharp (1970), using rectangular 1.8 x 1.8 x 0.75 m traps in Canadian waters, found that 99% of the catch was male. In an earlier survey, using a bottom trawl, McKenzie (1966) reported than 12% of the catch was female, a higher percentage, but still lower than in the American waters.

In accordance with the up-slope migration theory of Wigley et al. (1975), it is possible that as red crabs become older and larger, they disperse up the continental slope into shallower water although some of them remain in deep water. Our data support this hypothesis by showing a significant increase in mean size (CW) with decreasing depth, caused by the absence of small crabs in the shallower depths.

The effective area of attraction for our traps, because of poor bait quality or some unknown behavioural aspects of the red crab, might have been less than the 27-m radius circle. If there was overlapping of attraction between traps on a same string, one would expect a higher catch in traps at the end of the strings since one of their sides was not competing with another trap. The average catch/trap for 68 end traps was 3.3 crabs, while the 366 middle traps averaged 3.2 crabs/trap. Consequently, we consider that in both positions, traps were fishing the same. Each trap was then fishing 2,300 m^2 or less, in which latter case we are getting a minimum estimate for the red crab population in our survey area.

There are two sources of information dealing specifically with red crab densities in American waters. We used them to indicate a possible population size for the area we surveyed, if crab densities were actually similar to those in the United States.

The first estimate, using density values from Wigley et al. (1975), gives a total population size of approximately 36,000,000 crabs, with the highest proportion in the 360-540 m depth range. Data from Haefner (1978) give a lower population size of approximately 9,000,000 crabs. The highest abundance is again in the 360-540 m depth range.

Summary

1. The highest catch rate of red crabs (Geryon quinquedens) occurred within the 360-540 m depth range for all transects.
2. Highest catch rates occurred in an area extending 70-80 km (825.5 km^2) along the Scotian continental slope between southwest Emerald Bank and southeast Baccaro Bank.
3. Approximately 99% of the catch was male, 87% of which were above 101 mm (4 inches) carapace width (CW), below which, crabs are assumed to be too small for commercial interest. Overall mean CW for males is 116.4 mm. Females are smaller in size than males, averaging 99.0-mm CW.
4. The proportion of smaller crabs (<101-mm CW) increases with depth.
5. A minimum population estimate of catchable red crabs within the survey area of 2,767 km^2 is 2,297,200 crabs. The standing stock estimate for a culling size of 101 mm is 1,996,514 crabs with a biomass of 1,136,016 kg.
6. The population estimate for the area sampled in transects 2,3 and 4 (825.5 km^2) is 2,006,583 crabs, with a standing stock estimate of 1,754,622 and biomass of 1,000,135 kg.

References

Cadegan, E. 1971. Development of red crab fishery, 1970 and 1971. N. S. Dep. Fish., 15 p.

Ganz, A. R., and J. F. Herrmann. 1975. Investigations into the southern New England red crab fishery. Rhode Island Dept. Nat. Res., Div. of Fish and Wildlife, Marine Fish Section, 78 p.

Gray, G. W., Jr. 1969. Investigation of the basic life history of the red crab (Geryon quinquedens). R.I. Division of Conservation, Completion Rep. P.L. 88-309, Project 3-46R, 36 p.

Haefner, P. A., Jr. 1977. Reproductive biology of the female deep-sea red crab, Geryon quinquedens, from Chesapeake Bight. Fish. Bull. 75: 91-102.

1978. Seasonal aspects of the biology, distribution and relative abundance of the deep-sea red crab, Geryon quinquedens Smith, in the vicinity of the Norfolk Canyon, western North Atlantic. Proc. Nat. Shellfish. Assoc. 68: 49-61.

Holmsen, A. A., and H. McAllister. 1974. Technological and economic aspects of red crab harvesting and processing. Resource Economics, Univ. of R.I., Mar. Tech. Rep. 28, 35 p.

McKenzie, R. A. 1966. Canadian Atlantic offshore lobster and red crab investigations, 1966. Fish. Res. Board Can. MS Rep. Ser. 895, 34 p.

McRae, E. D., Jr. 1961. Red crab explorations off the northeastern coast of the United States. Commer. Fish. Rev. 23(5): 5-10.

Miller, R. J. 1975. Density of the commercial spider crab, Chionoecetes opilio, and calibrations of effective area fished per trap using bottom photography. J. Fish. Res. Board Can. 32: 761-768.

Perkins, H. C. 1973. The larval stages of the deep-sea red crab, Geryon quinquedens Smith, reared under laboratory conditions (Decapoda,

Brachyrhyncha). Fish. Bull. (NOAA, U.S.) 71: 69-82.

Perry, L. A. 1969. Nova Scotia deep sea crab explorations 1968. MS Rep., N.S. Dept. Fish., 38 p.

Sharp, G. 1970. Trial commercial exploitation of red crab resources. Unpubl. Rep., N.S. Dept. Fish., 14 p.

Wigley, R. L., R. B. Theroux, and H. E. Murray. 1975. Deep-sea red crab, Geryon quinquedens, survey off northeastern United States. Mar. Fish. Rev. 37(8): 1-21 (MFR Paper 1154).

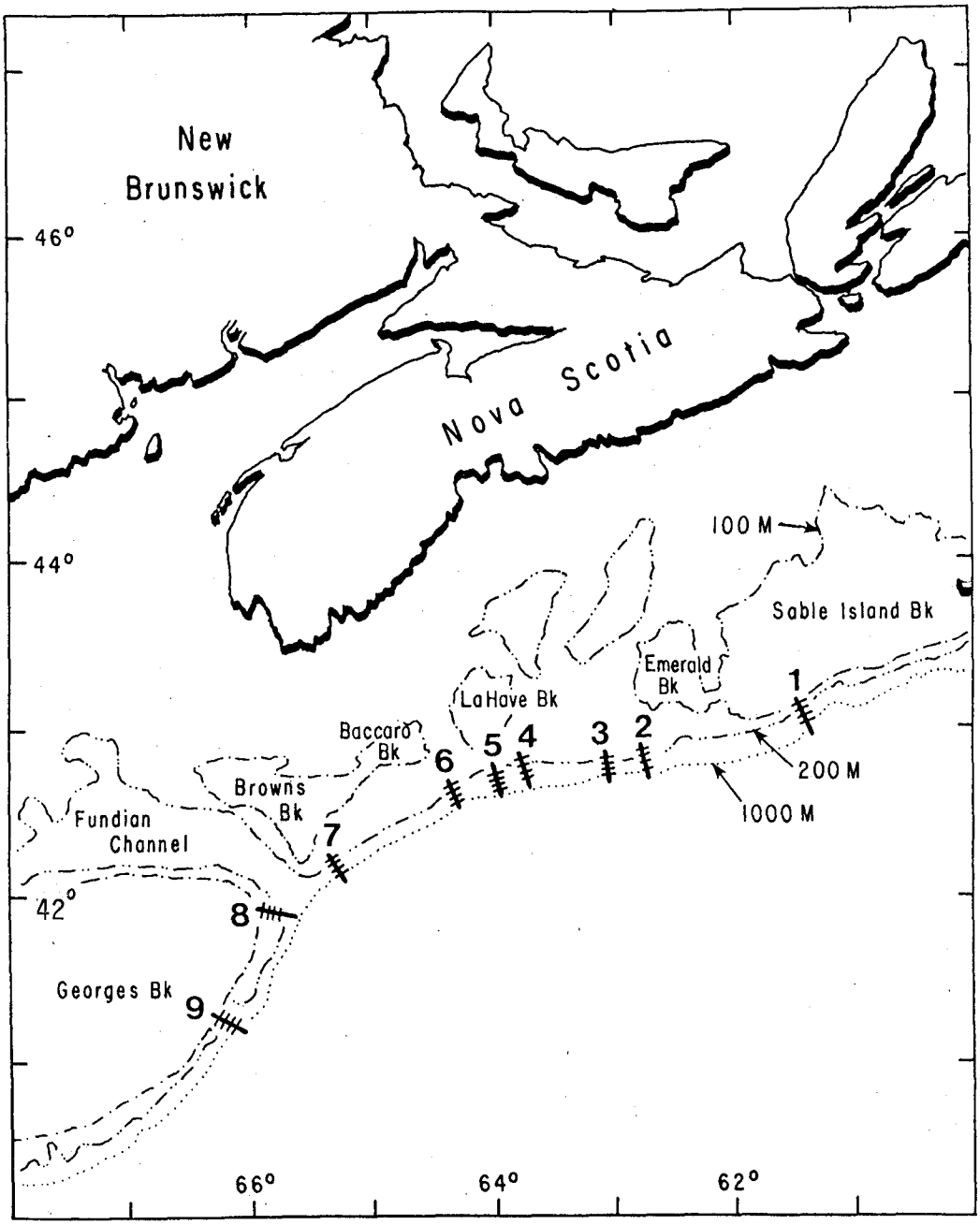

Fig. 1. Approximate locations of transects within the survey area.

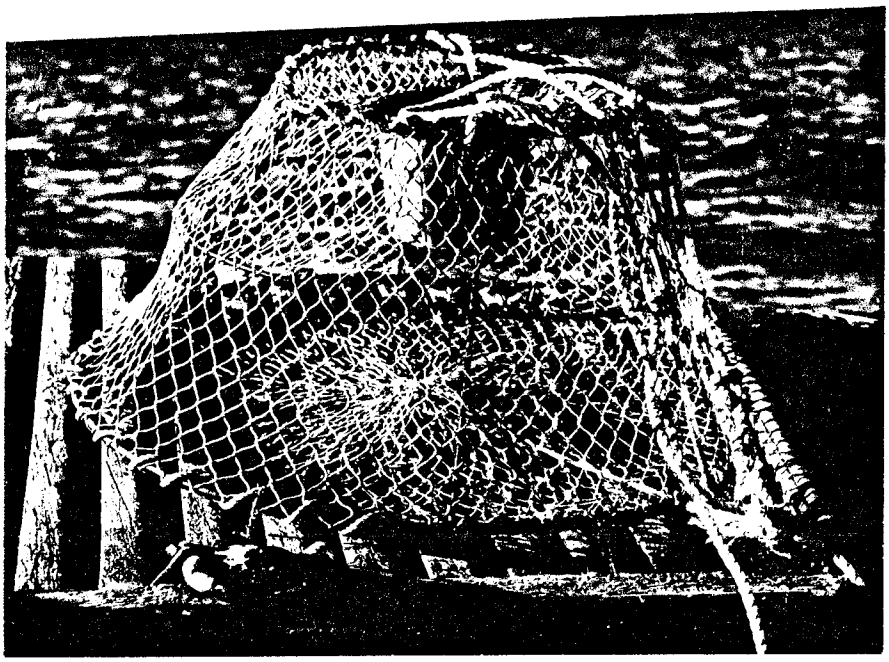

Fig. 2. Conical trap.

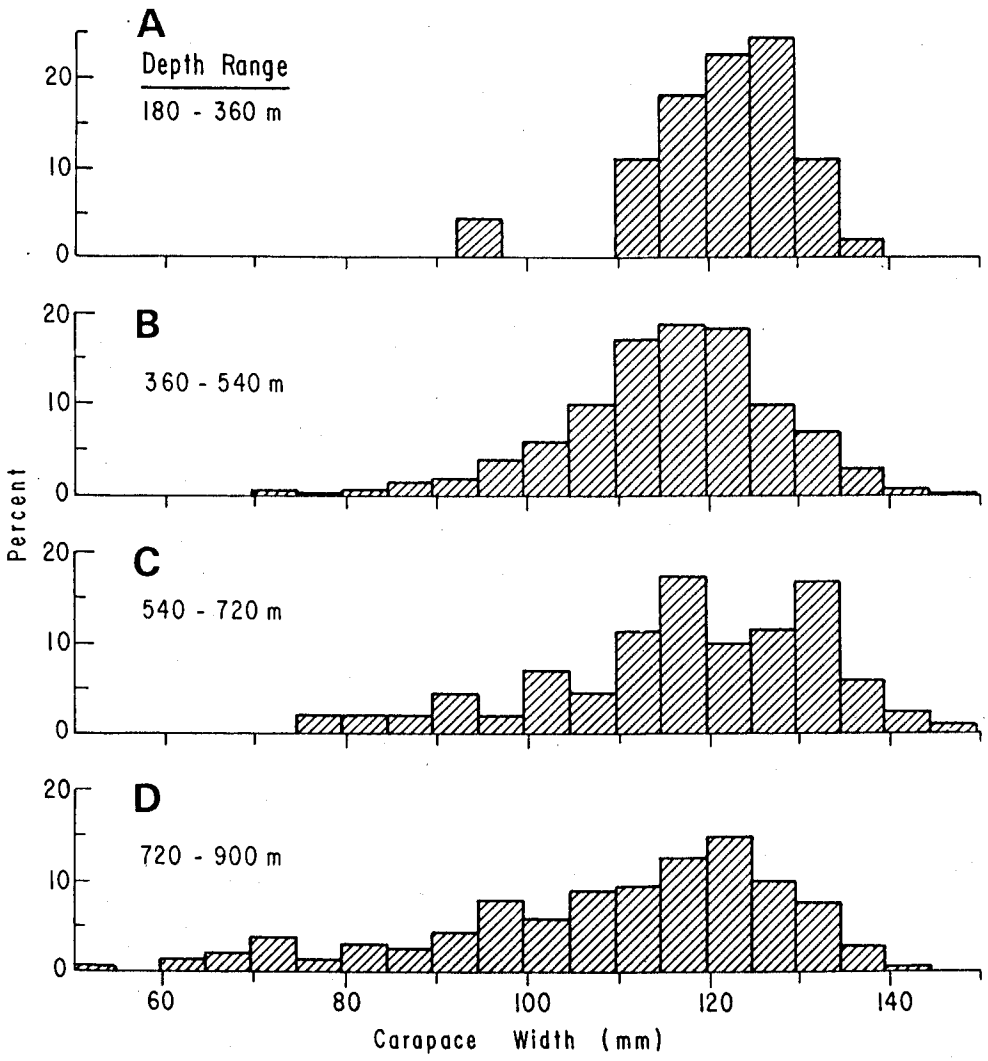

Fig. 3. Size frequencies of male red crabs caught along the Scotian Shelf from September 11 to October 11, 1978.

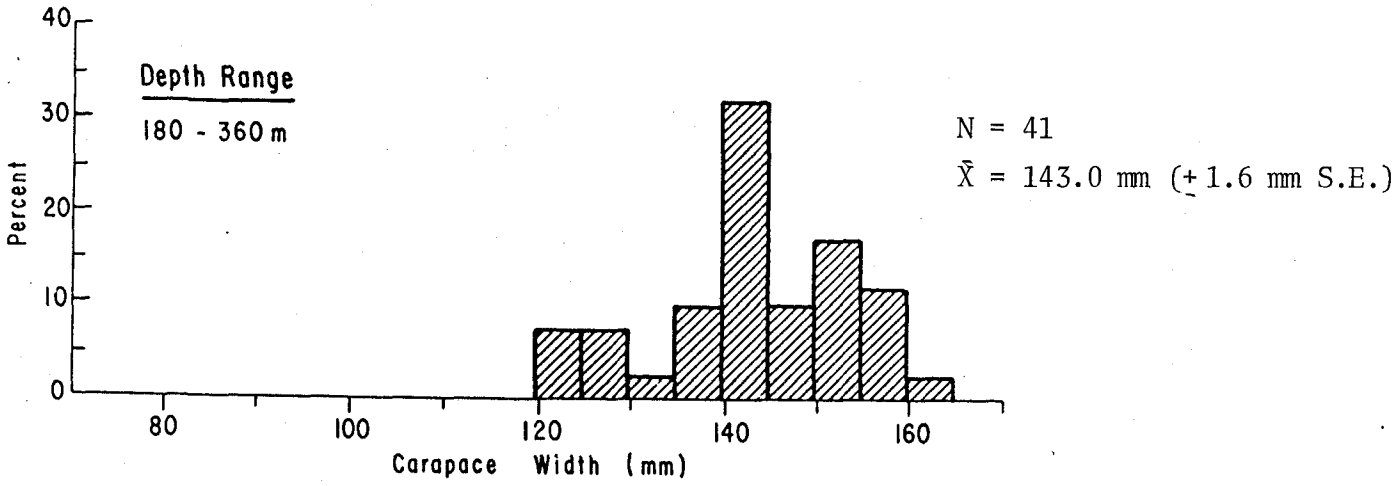

Fig. 4. Size frequencies of Jonah crabs caught in transects 1, 8 and 9 along the Scotian Shelf from September 11 to October 11, 1978.

Table 1: Information on the red crab survey.

Transect No.	Position	Date Sampled	Average soak time (hrs.)
1	42° 59'N 61° 59'W	Sept. 21-22 1978	16.8
2	42° 52'N 62° 38'W	Sept. 22-23 1978	14.2
3	42° 59'N 63° 05'W	Oct. 4-6 1978	31.4
4	42° 51'N 63° 37'W	Sept. 23-24 1978	13.0
5	42° 47'N 64° 00'W	Sept. 24-25 1978	14.7
6	42° 39'N 64° 23'W	Sept. 25-26 1978	15.9
7	42° 14'N 65° 19'W	Sept. 16-17 1978	14.8
8	41° 55'N 65° 47'W	Sept. 15-16 1978	15.4
9	41° 25'N 66° 00'W	Sept. 14-15 1978	16.4

Table 2: Information on the catches of red crabs.

Transect numbers	Depth range (m)	Male red crabs hard	Male red crabs soft	Female red crabs barren	Female red crabs berried	Number of crabs per trap	Total catch males & females	Total catch per transect	Catch weight of commercial sized crabs (>101 mm) kg
1	A	0	0	0	0	0	0		
	B	3	0	0	0	.33	3	12	5.9
	C	8	1	0	0	.75	9		
	D	-	-	-	-	-	-		
2	A	0	0	0	0	0	0		
	B	75	2	0	0	6.42	77	106	74.5
	C	10	0	0	0	.83	10		
	D	19	0	0	0	1.58	19		
3	A	34	7	5	0	4.17	46		
	B	(598)	(20)	0	0	(51.50)	(618)	(758)	(394.5)
	C	48	2	0	0	4.17	50		
	D	37	4	3	0	2.42	44		
4	A	0	0	0	0	0	0		
	B	248	24	0	0	22.42	272	335	266.8
	C	5	0	0	0	.42	5		
	D	52	5	1	0	4.83	58		
5	A	0	0	0	0	0	0		
	B	1	0	0	0	.08	1	27	9.1
	C	1	0	0	0	.08	1		
	D	22	0	2	1	2.00	25		
6	A	0	0	0	0	0	0		
	B	22	0	0	0	1.83	22	32	21.8
	C	4	0	0	0	.33	4		
	D	6	0	0	0	.42	6		
7	A	3	0	1	0	.42	4		
	B	4	0	0	0	.33	4	12	5.9
	C	4	0	0	0	.33	4		
	D	-	-	-	-	-	-		
8	A	0	0	0	0	0	0		
	B	0	0	0	0	0	0	3	1.4
	C	3	0	0	0	.25	3		
	D	0	0	0	0	0	0		
9	A	0	0	0	0	0	0		
	B	4	2	1	0	.42	7	50	28.2
	C	26	0	0	0	2.50	26		
	D	17	0	0	0	1.42	17		
Total		1254	67	13	1		1335	1335	

NOTE: Numbers in parenthesis were estimated from subsamples.
Depth ranges: A=180-360 m, B=360-540 m, C=540-720 m, D=720-900 m.

Table 3: Density and population estimates of male red crabs for all depth ranges within the transects.

Transect	Depth range (m)	A Calculated area (km^2)	B Calculated density (no./km^2)	Population estimate (A x B)
1	A	141.51	0	0
	B	104.17	143	14,896
	C	124.81	326	40,688
	D	156.25	0	0
2	A	109.08	0	0
	B	67.81	2,791	189,258
	C	64.86	361	23,415
	D	86.48	687	59,412
3	A	70.76	1,813	128,288
	B	37.34	22,391	836.080
	C	36.36	1,813	65,921
	D	45.21	1,052	47,561
4	A	111.05	0	0
	B	48.15	9,748	469,366
	C	64.86	183	11,869
	D	83.53	2,100	175,413
5	A	81.57	0	0
	B	61.91	35	2,167
	C	66.83	35	2,339
	D	84.51	870	73,524
6	A	119.89	0	0
	B	59.95	796	47,720
	C	60.93	143	8,713
	D	79.60	183	14,567
7	A	97.29	183	17,804
	B	69.77	143	9,977
	C	66.83	143	9,557
	D	76.65	0	0
8	A	145.44	0	0
	B	65.84	0	0
	C	61.91	109	6,748
	D	58.96	0	0
9	A	84.51	0	0
	B	33.41	189	6,114
	C	24.57	1,087	26,708
	D	14.74	617	9,095
Total		2767		2,297,200

Depth ranges: A=180-360 m, B=360-540 m, C=540-720 m, D=720-900 m.

Table 4: Population and biomass estimates of male red crabs in the total area.

Depth range (m)	Population estimate (no.)	Population density (no./km^2)	Standing crop (no. >101 mm CW)	Standing crop density (no./km^2)	Biomass (kg)	Biomass density (kg/km^2)
180-360	146,052	152	143,130	149	81,441	85
360-540	1,575,578	2,873	1,402,264	2,557	797,888	1,455
540-720	195,958	342	162,645	284	92,545	162
720-900	379,572	553	288,475	421	164,142	239
Total	2,297,200	830	1,996,514	721	1,136,016	411

Table 5: Population and biomass estimates of male red crabs in transects 2, 3 and 4.

Depth range (m)	Population estimate (no.)	Population density (no./km^2)	Standing crop (no. >101 mm CW)	Standing crop density (no./km^2)	Biomass (kg)	Biomass density (kg/km^2)
180-360	128,288	441	125,722	432	71,662	246
360-540	1,494,704	9,750	1,330,287	8,687	758,264	4,946
540-720	101,205	609	84,000	506	47,880	288
720-900	282,386	1,312	214,613	977	122,329	568
Total	2,006,583	2,431	1,754,622	2,126	1,000,135	1,212

Table 6: Occurrence of Jonah crabs and other species.

Transect number	Depth (m)	Jonah crabs	By catch
1	A	8	
	B	1	1C
	C	0	
2	A	16	
3	A	128	2C
4	A	0	3L, 1X, F
6	A	2	F
	C	0	F
	D	0	4B, 2H
7	A	4	E
8	A	4	E
9	A	29	2C, 2P, 2S, Z
	B	5	7C
	C	2	2B
Total		195	

Depth ranges: A=180-360 m, B=360-540 m, C=540-720 m, D=720-900 m.

Bycatch:
B - Black dogfish, Centroscyllium fabricii;
C - Cusk, Brosme brosme;
H - White hake, Urophycis tenuis;
E - Snubnose eel, Simenchelys parasiticus;
P - Polychaeta, Hyalinoecia tubicola;
S - Sipuncula, Phascolopsis gouldi;
Z - Sea pen, Balticina Fiamarchia;
L - Stone crab, Lithodes maia;
X - Snow crab, Chinoecetes opilio;
F - Starfish, Odontasteridae

Note: goose necked barnacles, Poecilasma inoequilaterale were found livng commensally on Geryon.

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DATE: 17 November 1982

SUBJECT / OBJET: CHANGES TO COMPUTING SERVICES' TELEPHONE NUMBERS

Please note the following changes in Computing Services' telephone numbers published in Computing Services Newsletter #44:

V.N. Beck, change from 8814 to 2187

delete #8883 (User Room)

delete #7939 (Mini Computer Room)

David M. Porteous

attach.