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A SURVEY OF THE RED CRAB RESOURCE ON THE CONTINENTAL SLOPE, N.E. GEORGES BANK AND WESTERN SCOTIAN SHELF

by

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ABSTRACT

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In 1978, a survey was conducted to assess the red crab (*Geryon quinquedens*) resource on the continental slope, between Sable Island Bank and Corsair Canyon. The number of crabs per trap, sex, carapace width and shell hardness were recorded.

A total of 1335 red crabs were caught, 75.4% of which were trapped in the 360-540 m depth range. Transect 3 yielded the highest catch with 758 crabs in 48 traps. Estimates of population size, standing stock and biomass were obtained for the total survey area as well as for transects 2, 3 and 4 which covered the area of greatest abundance. This area, between southwest of Emerald Bank and south of La Have Bank, yielded an average catch of 26.8 crabs/trap in the 360-540 m depth range. The minimum population estimate for the total area surveyed (2767 km^2) is approximately 2,300,000 crabs, with a standing stock of approximately 2,000,000 crabs (for a culling size of 101 mm carapace width) and biomass of 1,136,000 kg. For transects 2, 3 and 4 (825 km^2), the population is estimated at approximately 2,000,000 crabs, with a standing stock of approximately 1,800,000 crabs and biomass of 1,000,000 kg.

Key words: Assessment, biomass, decapod, Crustacea, *Geryon quinquedens*, *Cancer borealis*

RÉSUMÉ

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Une étude a été réalisée en 1978 afin d'évaluer la ressource de crabe rouge (*Geryon quinquedens*) le long du talus continental. Le nombre de crabes par casier, leur sexe, largeur et condition de carapace furent notés à chaque station d'échantillonnage.

La majorité (75.4%) des captures, estimées à 1335 crabes rouges, proviennent de la strate de 360 à 540 m. Les meilleures captures furent obtenues sur la radiale 3 avec un total de 758 crabes dans 48 casiers. Des estimations de population et de biomasse ont été calculées pour toute la région prospectée ainsi que pour une région plus restreinte, couverte par les radiales 2, 3 et 4, où l'abondance était la plus forte. Dans cette région, située entre le sud-ouest du Band Emerald et le sud du Banc La Have, le rendement moyen a été de 26.8 crabes/casier dans la strate de 360-540 m. L'estimation de population minimum pour l'ensemble de la région (2767 km^2) est de 2,300,000 crabes dont 2,000,000 sont de taille supérieure à 101 mm et ont une biomasse de 1,136,000 kg. Pour la région couverte par les radiales 2, 3 et 4 (825 km^2), la population capturable est estimée à 2,000,000 crabes, dont 1,800,000 ont plus de 101 mm en largeur de carapace avec une biomasse de 1,000,000 kg.

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. The Americans have begun harvesting and processing this resource, and four vessels, operating out of Massachusetts and Virginia, have landed an annual catch of about 3550 metric tons. A similar fishery may develop in Canada, owing to the high demand and increasing prices for crab meat, but information on red crab distribution and abundance is needed.

The commercial potential of this species has induced various investigations by both Canadian and American scientists on general biology, distribution and technological aspects of fishing and processing. Between 1969 and 1971 the Nova Scotia Department of Fisheries 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 occurred in waters 360-540 m deep and that males were on average larger than females. Various American surveys have obtained similar results. A 1975 survey by the Rhode Island Department of Natural Resources (unpublished) found that male crabs had a greater mean carapace width and body weight than females. The latter were more abundant in catches from shallow depths (270-360 m) while males were more numerous 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 trawls, yielded information on densities, biomass and distribution. Haefner (1978), in a 3-yr demersal trawl survey, looked at some seasonal aspects of the 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 scarce. In a 1975 tag-recapture study by the Rhode Island Department of Natural Resources (unpublished) one individual that did not molt for a whole year was observed.

Some other aspects of the red crab biology are discussed 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 collect information on distribution, abundance, sex ratio and size frequency of red crabs in Canadian waters along the Scotian Shelf. Such information, necessary for proper management of this potential resource, is not readily available.

MATERIALS AND METHODS

A 27.6-m (92-ft) offshore lobster boat, the M.V. *Judy and Linda IV*, was chartered for a total of 20 fishing days between September 11 and October 11, 1978. The survey consisted of sampling of nine 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, 360-540, 540-720 and 729-900 m.

Table 1. Location, sampling dates and soak time of traps in each transect.

Transect no.	Position	Date sampled	Average soak time (h)
1	49°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

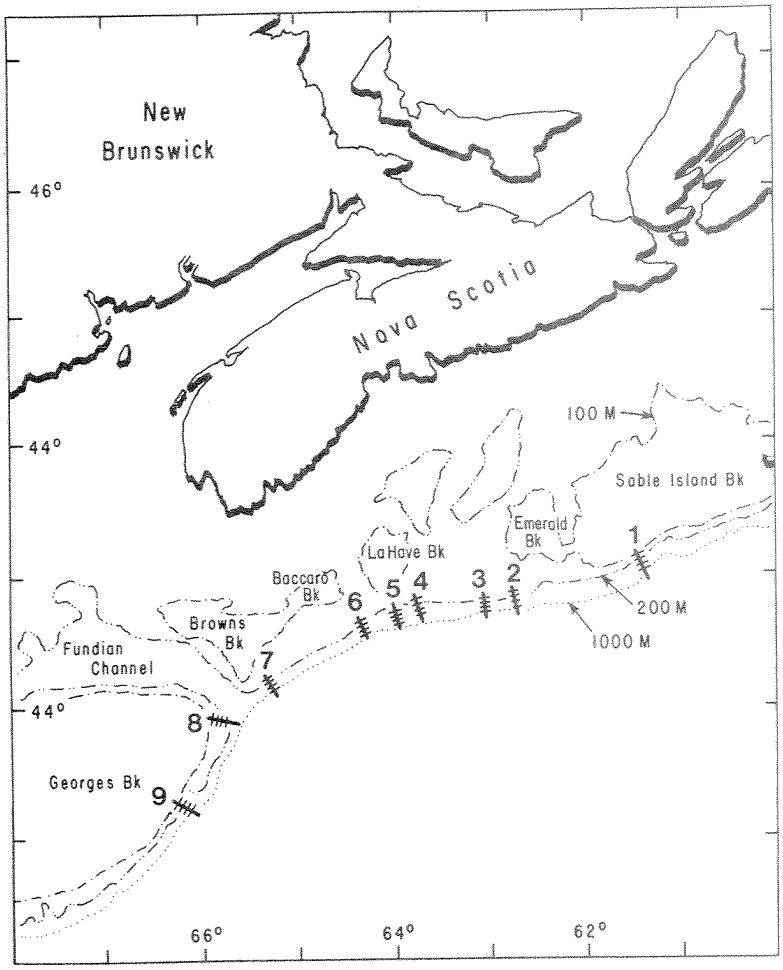

Fig. 1. Location of transects within the survey area.

A string of 12 conical top-entry traps was 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 the 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 maximum carapace width was measured by placing vernier calipers just above and touching the fifth anterolateral spine on each side. Measurements were taken on all specimens caught except for 44% (n=274) of the total catch in transect 3, depth of 360-540 m.

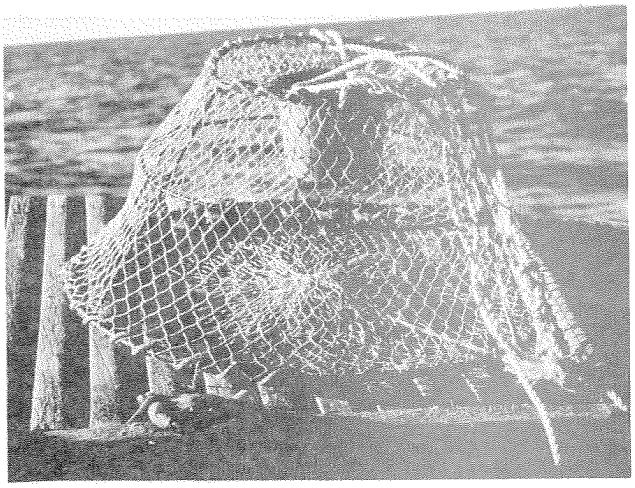

Fig. 2. Conical top-entry trap, as used in the survey.

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 in. (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.

Other species caught in our traps were recorded. Numbers and length frequencies of jonah crabs (*Cancer borealis*) were also recorded.

A procedure used by Miller (1975) to calculate densities of snow crab (*Chionoecetes opilio*) was adapted to estimate the population size of the red crab. The distance between traps of 54 m limited the radius of the area fished to 27 m, for a total circular area of 2300 m^2. The density of crabs for each of the 36 subareas (four depth ranges in nine transects) was calculated as follows:

$$\text{Density (crabs/m}^2\text{)} = \frac{\text{catch (crabs/trap)}}{\text{area fished (2300 m}^2\text{/trap)}}$$

The total surface area of each subarea was measured between isobath limits and mid-points. Population numbers were estimated by multiplying density by total surface in each subarea.

RESULTS

CATCHES OF RED CRABS

A total of 1335 red crabs were caught during this survey. The highest catch rate, in transect 3, yielded 758 crabs in 48 traps, with a culled weight of 394.5 kg (Table 2). Low numbers of commercial-sized crabs were caught in transects 1, 5, 7 and 8. Most crabs (75.4%, n=1007) were trapped at a depth of 360-540 m. Catches at 180-360 m yielded only 50 crabs (3.7%) in all transects combined. Of all male crabs caught, only 67 or 5% of the total were classified as soft-shelled.

Red crabs caught in this survey ranged from 54-156 mm in carapace width and males were generally larger than females. No significant differences were found between average carapace width of males within equivalent depth strata over all transects. However, a decrease in size is noticed when comparing overall average carapace widths in each of the four depth strata (Fig. 3). Differences were tested with a t-test, and were significant at $P < .01$ for all comparisons except between depth ranges of 360-540 m and 540-720 m.

Carapace width frequencies of male red crabs captured indicate that a major proportion are over the commercial size of 101 mm (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 female red crabs, one berried, were caught, the mean carapace width being 99.0 mm (±4.2 mm SE).

ESTIMATES OF POPULATION SIZE, DENSITY AND BIOMASS

Catchable male crab numbers and density, numbers of commercial-size crabs (or standing crop) and density, and available biomass and biomass density were calculated by depth strata as well as for the total area (Tables 3 and 4). The same estimates were also calculated for transects 2, 3 and 4 (Table 5). These transects cover the area having the highest abundance of crabs.

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 maximum carapace width was 143.0 mm (±1.6 mm SE) (Fig. 4). The highest catch of jonah crabs occurred in transect 3.

DISCUSSION

The area along the Scotian Shelf with the highest density of red crabs appears to be between southwest Emerald Bank and south of La Have 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.

Larger catches in transect 3 might have been caused by a longer soak time (Table 1) and better quality bait. Surveys by the Rhode Island Department of Natural Resources (unpublished), although working with two other types of traps, have established that saturation was reached after a 14-20 h soak time only. In a 1970 study by the Nova Scotia Department of Fisheries (unpublished) traps hauled after 44-h soaks contained catches similar to those reported in a 1969 study by the same Department, after only 12-14 h. Thus, it is possible that longer soak time was not an important factor for the higher 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 wk at sea, the mackerel had spoiled, which may have reduced the catch rates for transects 1, 2, 4, 5 and 6. An unpublished study by the Nova Scotia Department of Fisheries in 1969 found that traps baited with frozen mackerel yielded twice as many crabs per trap as those baited with salted herring in the same area on the same day. But once the mackerel had spoiled it attracted even fewer crabs than the salted herring. Frozen mackerel was used in transect 3, which might have been partly responsible for the higher catch. However, good quality mackerel was used in transects 7, 8 and 9, and resulted in low catches, while bait used in transects 2 and 4 was not fresh and yet produced good catches.

In previous surveys along the Scotian Shelf the highest catch rates were obtained within the same area as that 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 highest catch was made southwest of La Have Bank, at a location relatively close to transect 3. In his survey, 87% of the crabs were caught in the 360-540 m depth zone, and no catches were recorded south of Browns Bank along the Fundian Channel. An unpublished 1969 survey by the Nova Scotia Department of Fisheries from the southeast tip of Sable Island Bank, west to the eastern end of Browns Bank along the 180 m line caught a mean of 66 crabs/trap, with a maximum of 165 crabs/trap at 42°47'N, 63°02'W. Maximum catch rates during these two earlier surveys occurred in the vicinity of our transect 3, confirming our findings of high crab numbers in this area.

Table 2. Catch composition of red crabs by depth, for each transect.

Transect numbers	Depth range (m)[a]	Male red crabs		Female red crabs		Number of crabs per trap	Total catch males and females	Total catch per transect	Catch weight of commercial-sized crabs (>101 mm) kg
		hard	soft	barren	berried				
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)[b]	(20)[b]	0	0	(51.50)[b]	(618)	(758)[b]	(394.5)[b]
	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	

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

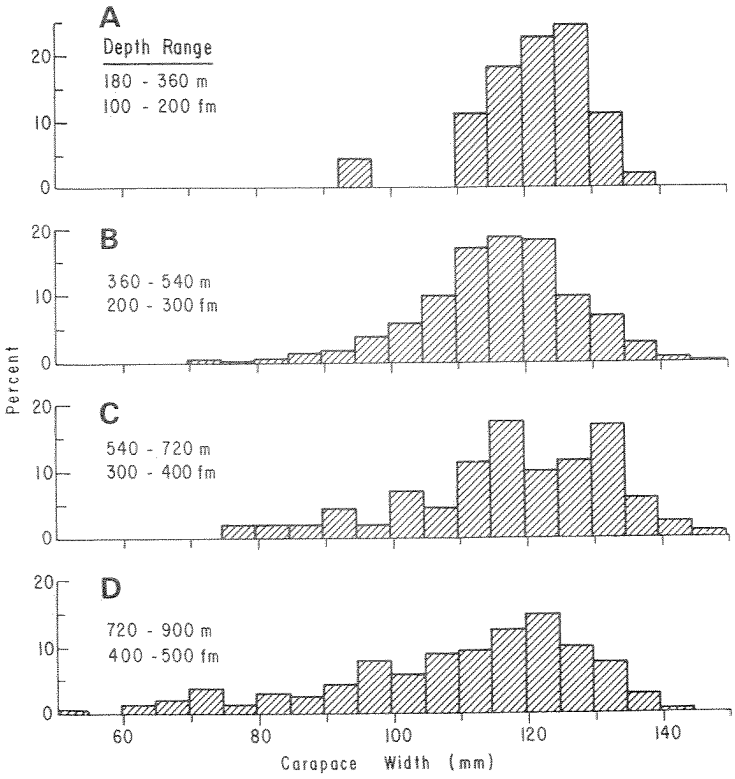

Fig. 3. Size frequencies of male red crabs, by depth strata, trapped along the Scotian Shelf, September 11-October 11, 1978.

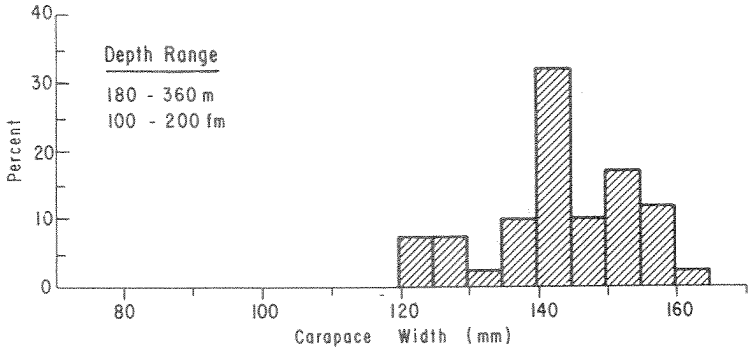

Fig. 4. Size frequencies of jonah crabs trapped in transects 1, 8 and 9 along the Scotian Shelf, September 11-October 11, 1978.

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

Transect	Depth range (m)[a]	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	1,100	175,413
5	A	81.57	0	0
	B	61.91	35	2,167
	C	66.83	35	2,339
	D	84.51	870	73,254
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

[a] 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 in traps, by transect.

Transect number	Depth (m)[a]	Jonah crabs	Bycatch
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	

[a]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 - Polychaete, *Hyalinoecia tubicola*;
S - Sipuncula, *Phascolopsis gouldi*;
Z - Sea pen, *Balticina fiamarchia*;
L - Stone crab, *Lithodes maia*;
X - Snow crab, *Chionoecetes opilio*;
F - Starfish, Odontasteridae

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

A 1970 survey by the Nova Scotia Department of Fisheries (unpublished) investigated a small area along the shelf extending from 63°41' to 62°50'W and corresponding to transects 2, 3 and 4. Average catches of 50 crabs/trap at 450 m were recorded, similar to what we obtained in transect 3. The Nova Scotia Department of Fisheries used larger traps than us during its surveys.

The distribution of crabs on the Canadian continental slope is much more restricted by depth than on the American continental slope. This can be illustrated by comparing an index of abundance in each depth stratum for both areas. Calculations for the index of abundance from the American waters are based on trawl catches/unit of effort from Wigley et al. (1975). Our average catch/trap was used for the Canadian waters' index. For comparison, the index for each depth range is given as a fraction of the highest abundance. Females are not included since they probably have a different pattern of distribution (LeLoeuff et al. 1979).

	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 differences in distribution patterns could be attributed to environmental factors confining the majority of red crabs along the Scotian Shelf to the 360- to 540-m depth range. In shallower waters, 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 recorded variations in sex ratio 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 compared to traps in the Canadian surveys. A 1970 survey by the Nova Scotia Department of Fisheries (unpublished), using rectangular 1.8 x 1.8 x 0.75 m traps in Canadian waters, found that 99% of the catch were males. In an earlier survey, using a bottom trawl, McKenzie (1966) reported a higher percentage of females (12%), but still lower than in the American studies.

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 with some of them remaining in deep water. Our data support this hypothesis by showing a significant increase in mean size with decreasing depth.

The effective area of attraction for our traps has been assumed to be a 27-m radius circle. If this is underestimated, then there was overlapping of attraction between traps on the same string. One would expect a higher catch in traps placed at the end of the strings as 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 area. It could be that the area of attraction was considerably larger than our assumption, in which case crabs are likely to be attracted at random to any trap on a string, resulting in equal catches in each trap. But, most likely, each trap was effectively fishing a 27-m radius circle or less.

Cayré and Bouchereau (1977) fished for red crabs off the coast of the Congo with traps similar to ours. They demonstrated that at a distance of 40 m between traps, giving a radius of only 20 m for each trap, the attractions were overlapping and end traps were catching significantly more crabs than the middle ones. With the use of bottom photography and catch data, an effective area of red crab attraction for a big lobster pot was calculated to correspond to a 27-m radius circle (LeLoeuff et al. 1978). It was calculated as 36 m for the larger king crab pot. Our conical trap presumably has a fishing power closer to the lobster pot than to the king crab pot.

Wigley et al. (1975), using photographic techniques in American waters, calculated that red crab densities could be as high as 12800-38200/km^2 in the 320- to 640-m depth range. Our highest density estimate (approximately 22400/km^2 in transect 3, 360-540 m) falls within that range. But most of our stations had apparently much lower densities. Other higher density estimates were obtained by Haefner (1978) and Grassle et al. (1975) for the American waters.

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