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RED CRAB (*GERYON QUINQUEDENS*) TRAP SURVEY ALONG THE EDGE OF THE SCOTIAN SHELF, SEPTEMBER 1980

by

James F. McElman and Robert W. Elner

Invertebrates and Marine Plants Division
Department of Fisheries and Oceans
Biological Station
St. Andrews, New Brunswick
EOG 2XO

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ABSTRACT

McElman, James, F., and Robert W. Elner. 1982. Red crab (Geryon quinquedens) trap survey along the edge of the Scotian Shelf, September 1980. Can. J. Fish. Aquat. Sci. 1084: iii + 12 p.

In September 1980 a trap survey for the red crab (Geryon quinquedens) was conducted along the edge of the Scotian Shelf, from Browns Bank to Emerald Bank. Trap strings were set at depths from 183-732 m. A total of 3643 red crabs were caught, 2466 (68%) males and 1177 (32%) females, in 573 trap hauls. Males had a mean carapace width of 123 mm and females 102 mm. Extruded eggs were found on 209 (18%) female red crabs. Soft shells were found on 73 males and 5 females (2.6% of total crabs examined).

The distribution of red crabs was patchy and no measured parameter could account for their distribution or abundance. Mean catches per string were as high as 50 crabs/trap, representing an estimated density of 21,546 crabs/km^2 based on an estimate of effective fishing area (EFA) of 2300 m^2/trap. Assuming this EFA, total trapable red crabs for the 2186 km^2 study area would be 4,969,890, with a biomass of 2,290,028 kg. Culling crabs with a carapace width 100 mm reduces the biomass estimate to 2,090,338 kg (91% unculled biomass). The biomass for crabs with a carapace width 115 mm would be 1,604,852 kg (70% unculled biomass).

Key words: abundance, biomass, Crustacea, decapod, density, distribution, effective fishing area, sex ratio, size frequency

RÉSUMÉ

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Un relevé du crabe rouge (Geryon quinquedens) a été effectué à l'aide de casiers en septembre 1980 le long de la marge du plateau Scotian, depuis le banc Browns jusqu'au banc Émeraude. Des lignes de casiers furent placées à des profondeurs de 183 à 732 m. Au total, 3643 crabes ont été capturés, dont 2466 (68%) des mâles et 1177 (32%) des femelles, lors de 573 mises à l'eau de casiers. La largeur moyenne de carapace des mâles était de 123 mm, celle des femelles 102 mm. On a trouvé des oeufs expulsés chez 209 femelles (18%). Des carapaces molles ont été observées chez 73 mâles et 5 femelles (2.6% de tous les crabes examinés).

La distribution des crabes rouges est inégale, et celle-ci ainsi que leur abondance ne peuvent s'expliquer par aucun des paramètres mesurés. Les prises moyennes des lignes peuvent aller jusqu'à 50 crabes par casier. Ceci représente une densité de 21,546 crabes/km^2, fondée sur une aire de pêche effective estimée à 2300 m^2/casier. À supposer que ce soit là l'aire réelle, le total des crabes pêchables dans la superficie de 2186 km^2 étudiée serait de 4,969,890, soit une biomasse de 2,290,028 kg. En mettant de côté les crabes de largeur de carapace de 100 mm ou moins, la biomasse estimée est réduite à 2,090,338 kg (91% de la biomasse non triée). La biomasse des crabes de plus de 115 mm serait de 1,604,852 kg (70% de la biomasse non triée).

INTRODUCTION

The deep-sea red crab, Geryon quinquedens, is widely distributed in the Atlantic, Pacific, and Indian Oceans at depths from 40-2156 m. In the western Atlantic, red crabs are found from Nova Scotia to Argentina and are most common at depths from 265-915 m (Haefner and Musick 1974; Wigley et al. 1975; Haefner 1978). They have been found in association with mud, sand or hard bottoms (Caddy et al. 1974) where temperatures are 5-8°C (Wigley et al. 1975). Little is known of their life history and habits. Males attain a maximum carapace width (CW) of 178 mm, and a maximum weight of 1.35 kg (Caddy et al. 1974; Holmsen and McAllister 1974). Females attain a maximum CW of 114 mm, and a maximum weight of 0.57 kg (Caddy et al. 1974; Holmsen and McAllister 1974). Sexual maturity occurs in females at a CW of 80-91 mm (Haefner 1978). No discrete molting period has been discerned and a slow growth rate is indicated by tag returns. Red crabs that were tagged (i.e. with tags normally shed at molting) off Massachusetts, USA, in 1974 (Ganz and Herrmann, unpubl. data)[1], have been found in commercial catches as recently as August 1981 (P. Gerrior, pers. comm.).

Previous attempts to assess the magnitude and commercial potential of the Scotian Shelf (and Georges Bank) red crab resource were carried out by Stone and Bailey (1980), the Nova Scotia Dept. of Fisheries (Perry[2], Sharp[3], Cadegan[4], all unpubl. data), and McKenzie (1966). Attempts to establish a commercial fishery off eastern North America have been examined by Gerrior (1981) and indicate the need for appropriate technology and economic conditions for the successful establishment of such a fishery. The quality of red crab meat is high, but fishing costs would be relatively high also. Costs for an offshore decapod fishery, compared to those of an inshore decapod fishery, would be greater because vessels must be larger, travel further, trap deeper, and have additional equipment for catch preservation.

At present, a small and apparently successful commercial red crab fishery (two vessels fishing off Massachusetts and Rhode Island) provides enough red crab to allow the Bay Trading Company, Inc. of Danvers, Mass., to produce a variety of red crab products. The success of this operation may be attributed to a number of factors, such as: 1) a cooperative working relationship between the owner of the fishing vessels and the producer of the commercial product, i.e. all crabs landed are processed rapidly at a plant that handles only red crab; 2) labor cost reduction aboard the fishing vessels through mechanization of trap handling and crab butchering; 3) a processing plant designed specifically for the mechanical extraction of red crab meat; and 4) the production of a variety of red crab products of consistent quality (including high quality red crab products as well as bulk institutional products that lack species specific identity but utilize fully the lower grade or secondary products of processing).

The purpose of this investigation was to examine the distribution and abundance of the red crab resource on the edge of the Scotian Shelf, especially in the area most accessible to the existing offshore lobster fishing fleet. This information is essential to an economic analysis which should precede any attempt to establish a commercial red crab fishery. The establishment of a successful red crab fishery in Canada will depend on the efficient exploitation of this resource.

MATERIALS AND METHODS

The survey was conducted from the 30.5 m chartered vessel, M/V FLYING DUCHESS, out of Port Mouton, Nova Scotia. Traps were set between September 7 and 15, 1980, at 25 sites along 240 km of continental slope, from the east side of the Fundian Channel south of Browns Bank to south of the eastern extremity of Emerald Bank (Fig. 1). The exact location of each site is given in Table 1.

The strategy of the survey was to examine approximately equidistant transects, with traps placed at random within each of three depth zones delineated by 183-365 m (100-199 fm), 366-548 m (200-299 fm), and 549-732 m (300-400 fm). One string went deeper than expected to a mean depth of 736 m. Deviation from the sampling strategy was the result of attempts to minimize gear loss by not setting traps where the bottom gradient was too steep or uneven. Although this exclusion of trap sets due to bottom type contributed a bias to the sampling procedure, the compromise was considered necessary for the completion of the survey.

Traps were set between mid-afternoon and early evening, and hauled the following day between sunrise and mid-day. Soak times (Table 1) averaged 16¼ h, ranging from 10¾ to 22¼ h. The highest catch per trap has been noted to occur after a 14 to 20 h soak (Ganz and Herrmann, unpubl. data)[1]. Only four strings of traps (out of a total of 25) did not have soak times within these limits.

Since the characteristics of the trap type used may affect the size of crab and magnitude and sex composition of the catch, a number of the more commonly used decapod traps were examined. Five kinds of traps were used: 1) large rectangular steel-framed snow crab traps measuring 0.53 m x 1.19 m x 1.17 m with two rectangular side openings of 0.12 m x 0.39 m and a mesh of 25 mm; 2) large steel-framed Japanese-type conical traps measuring 0.70 m high, 1.60 m base diameter, with a single circular top entrance of 0.45 m diameter and a mesh of 130 mm; 3) small steel-framed Japanese-type conical traps measuring 0.64 m high, 1.20 m base diameter, 0.72 m top diameter with a mesh of 112 mm and a single top entrance of 0.45 m diameter; 4) wooden half-round inshore lobster traps from southwest Nova Scotia (Port Maitland) measuring 1.21 m long, 0.70 m wide, 0.38 m high with lath spacing of

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[1]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.

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

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

[4]Cadegan, E. 1971. Development of red crab fishery 1970 and 1971. Unpubl. Rep., N.S. Dept. Fish., 15 p.

32-38 mm and with two side and one end entrance of 0.14 m diameter; and 5) wooden offshore lobster traps measuring 1.02 m long, 0.81 m bottom width, 0.66 m top width, 0.40 m high with lath spacing of 22-48 mm, and two opposite side entrances of 0.17 m diameter. All trap types are as used in commercial decapod fisheries.

The groundline for each trap string was 1493 m long with traps spaced 62 m apart in the sequences shown in Fig. 2. Short strings of 13 traps, also spaced 62 m apart, were used at depths greater than 630 m and where a steep bottom gradient and/or strong tidal currents made the manipulation of a 25-trap string impractical. Whenever possible, strings were set parallel to the bottom contour to avoid large depth differences between traps on the same string. In the deeper areas where the bottom gradient was steep, trap strings were set tangentially across the contour or, in some instances, were hung perpendicular to the contour over the slope. This latter method was used for setting traps in precarious shelf-edge positions. Mooring lines, two to three times longer than the depth, were attached to both ends of each string, except for the short strings where only one mooring line was used. At the surface end of each mooring line there was a buoy and a high flyer with a radar reflector.

Traps were baited with frozen mackerel in a nylon mesh bait bag. The Nova Scotia Department of Fisheries (Perry, unpubl. data)[2] found mackerel to be the best bait for trapping red crabs. Large rectangular steel-framed and large conical traps were baited with six mackerel (about 0.45 kg each) while the smaller traps were baited with three fish each. Old bait was removed and new bait added as each trap was emptied after hauling.

Positions at both ends of each string were recorded as Loran C coordinates and subsequently converted to latitude and longitude. Depths were recorded continuously during setting and hauling. Bottom temperatures were recorded with a bathythermograph.

Data recorded for each crab species included numbers per trap, sex, carapace width, shell hardness and the presence or absence of eggs. Carapace width (maximum distance between the tips of the antero-lateral spines) was measured to the nearest millimeter with vernier calipers. Shell hardness was evaluated only in the extremes of hard and soft by manual compression of the propodus. Individual wet weights of frozen crabs were taken with a top-loading balance.

Estimates of density, trapable numbers, and trapable biomass were based solely on the catches of offshore lobster traps, since they were the most common trap type used, normally comprising 60% of each string. The mean number of red crabs caught per offshore lobster trap was calculated for each sample site (trap string). The mean catch per offshore trap was considered as a representative catch of the whole "sampling area." Sampling areas were delineated by the depth zone contour limits to the north and south, and half the distance to adjacent sample sites within the same depth zone.

In four cases, catch data from proximal strings were combined and analyzed as a single site (sites 3 and 4, 13 and 14, 17 and 18, and 24 and 25). In each case, one of the two strings was a short one (Fig. 2, Table 1) which was set within 3.7 km of the other.

Catch per trap was converted into density based on an estimate for the effective fishing area (EFA) per trap. An EFA of 2300 m^2/trap was used by Stone and Bailey (1980) for red crab in about the same study area. Their estimate was based on the assumption each trap fished a circular area with a radius of half the distance between adjacent traps. On the same basis, the EFA estimate in this investigation would be approximately 3000 m^2/trap.

During experimental trapping for snow crab, Chionoecetes opilio, Miller (1975) estimated EFA's of 2500-5300 m^2/trap (mean of 4100 m^2/trap) for Japanese-style conical traps baited with an unspecified quantity of frozen herring. These EFA estimates were based on the calibration of commercial traps with bottom photography. In the present investigation, EFA values between 2000 and 4100 m^2/trap were used to produce estimates of total trapable numbers. However, assuming each trap is positioned at the center of a circular fishing area, the estimates of EFA in excess of 3000 m^2/trap would have radii greater than the 31 m (half the distance between traps) used in this study, and would therefore experience overlap in the areas of attraction with actual densities being higher than those estimated here.

An estimate for the number of trapable crabs for each sampling area was derived as follows:

$$\text{No. trapable crabs} = \frac{1\ km^2}{EFA(km^2/trap)} \times \frac{\text{mean no. crabs}}{\text{offshore trap}} \times \text{sampling area}(km^2)$$

These values were then summed for all sampling areas within a depth zone. The trapable numbers for the three depth zones were then summed for a total trapable number estimate for the entire 2186 km^2 study area.

Sex ratios and size frequencies were determined from the total catch for each depth zone. A mean crab weight for each sex within each depth zone was used to convert trapable numbers into trapable biomass. The mean crab weight for each sex within each depth zone was determined as follows:

$$\text{Mean crab weight (kg)} = \sum_{i=1}^{n} Y_i P_i$$

where Y_i is each individual crab weight with a CW at the midpoint of a 5-mm increment group, as determined from a power curve equation describing the relationship between CW and total wet weight, and P_i is the percent contribution of the whole 5-mm increment group to the trapable number estimate for each sex in each depth zone (n is the number of 5-mm increment groups existing within the frequency distribution for each sex in each depth zone).

Biomass estimates for commercial sized crabs (i.e. culling crabs ≤100 mm as suggested by Stone and Bailey (1980) and ≤115 mm as practiced by the commercial red crab fishery in the northeastern United States) were derived by the same methods as described above.

RESULTS

A total of 3643 red crabs were caught at 25 sites (Fig. 1). Of these, 3015 were examined for 1) carapace width, 2) sex, 3) shell hardness, and 4) the presence or absence of eggs. The remaining 628 crabs (321 males, 307 females), all from site 5, were examined only for sex.

The geographic distribution of red crabs was patchy with respect to comparative abundance. Ninety-six percent of all crabs were obtained at 9 of the 25 sample sites. The greatest proportion of crabs was caught southwest of Emerald Bank at sites 5, 6, and 7, where 2152 crabs, or 59% of the total catch, were obtained. One site southeast of Emerald Bank (site 2), two sites south of Baccaro Bank (sites 16 and 17), and three sites south of Browns Bank (sites 23, 24 and 25) accounted for another 1344 red crab captures, or 37% of the total catch.

Red crabs were caught at 8 of 13 sites at which bottom temperatures were recorded (Table 1). The 8 sites had temperatures of 5.5-8.7°C with a mean of 6.9°C. Five of the 13 sites at which temperatures were recorded produced no red crabs and had higher temperatures of 8.3-10.0°C with a mean of 8.9°C.

Males comprised two thirds of the total catch, outnumbering females by 2466 to 1177. Sex ratios at individual sites were highly variable (Table 1), though males were more abundant than females at all locations except sites 5 and 6, where male:female sex ratios were 0.97:1 and 0.80:1, respectively. The proportion of females decreased with increasing depth (Table 2).

Of the 209 female red crabs with extruded eggs, 89% (186) were caught at depths of 183-365 m, 9.6% (20) at 366-548 m and 1.4% (3) at 549-732 m. Although there were fewer females with increasing depth, the percentage of berried females to the total number of females caught within the depth zone remained fairly constant at 23.6, 29.9, and 21.4, respectively.

A total of 73 males and 5 females had soft shells. Of these, 51% (36 males, 4 females) were caught in the 183-365 m depth zone, 19% (14 males, 1 female) in the 366-548 m depth zone, 27% (21 males) in the 549-732 m depth zone, and 3% (2 males) over 732 m.

In terms of CW, males (range 60-163 mm, $\bar{X} \pm$ SE = 123 $\pm$ 0.3 mm, n = 2145) were larger than females (range 70-131 mm, $\bar{X} \pm$ SE = 102 $\pm$ 0.3 mm, n = 870), considering the catches of all trap types combined (Table 3). Males and females combined (n = 3015) had a mean CW of 117 mm. For each sex, the largest mean CW occurred at depths of 366-548 m, the second largest at 183-365 m, and the smallest at 549-732 m (Table 3). The few crabs (23) that were caught deeper than 732 m were smaller again than those from all lesser depths. The mean CW ($\pm$ SE) for all berried females was 103 $\pm$ 0.6 mm (n = 209). Carapace width frequency distributions are given in 5 mm increments, according to sex (Fig. 3, 4) and also to sex and depth (Fig. 5, 6 and 7; Table 4).

Of the five trap types used, the large steel-framed conicals had the poorest catch/trap (Table 5), but caught the largest individuals (mean CW) of each sex. The remaining four trap types had similar catch rates, ranging from 4.2-4.6 crabs/trap for males, 1.4-2.6 crabs/trap for females, and 6.0-6.8 crabs/trap for both sexes combined. The small steel-framed conical traps captured the second largest crabs (mean CW) of each sex, followed by the wooden offshore traps. The small wooden inshore traps and large rectangular steel-framed traps caught the smallest crabs (mean CW).

The CW (X in mm) crab wet weight (Y in g) relationship (using the least squares method) for males was fitted to the power curve (Fig. 8): $Y = 0.0001189\ X^{3.18}$ ($r^2 = 0.92$, n = 24).

The mean catches of only the offshore lobster traps (Table 6) were used for all estimates of density (Table 7), trapable numbers (Tables 8 and 9), trapable biomass (Tables 8 and 9), and biomass after culling (Table 9). Trapable numbers and trapable biomass were subdivided by sex and depth zone and determined for effective fishing areas of 2300 m^2/trap, 3000 m^2/trap and 4100 m^2/trap (Table 8). The effect of culling on the trapable biomass of male and female red crabs at all depth zones is demonstrated in Table 10. The trapable biomass of males, which are generally larger than females, appears less affected by culling.

For the 2186 km^2 study area, the total trapable numbers were as high as 4,969,890 with a biomass of 2,290,028 kg, based on an EFA estimate of 2300 m^2. The biomass after culling would be 2,090,338 kg after removing red crabs $\leq$100 mm CW and 1,604,852 kg after removing red crabs $\leq$115 mm CW. Trapable numbers may be as low as 2,789,422 with a biomass of 1,285,248 kg, based on an EFA estimate of 4100 m^2. The biomass after culling would be 1,173,174 kg after removing crabs $\leq$100 mm CW or 900,707 kg after removing crabs $\leq$115 mm CW.

Other decapods caught during the survey included 615 Jonah crabs (Cancer borealis), 38 stone crabs (Lithodes maia), and 1 snow crab Chionoecetes opilio).

DISCUSSION

The occurrence of patches of red crabs at high concentrations appears usual for this species in this area (Stone and Bailey 1980). High catches in the area southwest of Emerald Bank (sites 5 and 6, Fig. 1) were also obtained by McKenzie (1966) and Stone and Bailey (1980), although Stone and Bailey suspected that an extended trap soak time (31.4 h, about twice as long as at the rest of their sites) may have been responsible for the high catch in this area. More likely, escapement and/or reduced entry, both considered components of trap saturation (Miller 1979), reduced their catch which was approximately equal (51.5 crabs/trap) to that found in this study (49.6 crabs/trap) at a soak time of only 15¼ h. Site 21 (42°13'N, 65°17'W), which produced no red crabs in 25 traps soaked for 16 h, was very close to Stone and Bailey's (1980) transect 7 (42°14'N, 65°19'W) that produced only 12 red crabs after three 12-trap strings were set between 180 and 720 m depth. Only 2 red crabs were caught in 36 traps set between 180 and 720 m at transect 5 (Stone and Bailey 1980) which was close to sites 11, 12, 13, and 14 which collectively produced only 45 crabs in 88 traps.

In this study, the shallowest depth at which high concentrations of red crabs were encountered was at site 6 in 296 m. Off the northeastern United States, Wigley et al. (1975) found the minimum depth of high crab abundance to be 274 m, while Pecci (unpublished data)[5] indicated a minimum depth of

[5]Pecci, K. J. unpublished MS. Comparative trap catches of American lobster, Jonah crab, and red crab at Veatch Canyon. U.S. Dept. Comm., NOAA, NMFS, Northeast Fish. Center, Woods Hole, MA, 15 p.

294 m in the Veatch Canyon area. However, since similar as well as greater depths also produced poor catches (Table 1), other factors need to be considered as determinants of abundance.

The highest catches occurred in the 183-365 m depth zone, in contrast to those found by Stone and Bailey (1980) in the same area where the 366-548 m depth zone was the most productive at the same time of year. The cause of this discrepancy is likely the biased sampling (this study) that occurred in the area of highest abundance. Sites 5, 6, and 7 were all at depths less than 366 m. All other sites where red crab were abundant (sites 2, 16, 17, 23, 24, and 25) were at depths greater than 365 m. Greater depths were deliberately avoided in the area of high abundance due to the apparently steep and irregular bottom gradient.

The overall sex composition found in this study (68% male, 32% female) was the same as that found in Veatch Canyon (Pecci, unpubl. data)[5]. However, Stone and Bailey (1980) found 99% males in the same general area and at the same time of year as this study. The high percentage of females (32%), compared to the 1% observed by Stone and Bailey (1980), is almost entirely due to catches of females in the area of high abundance (sites 5, 6, and 7) where 93% of all females were caught.

The mean CW's found (males 123 mm, females 102 mm) were close to those observed in Veatch Canyon (Pecci, unpubl. data)[5] where males were 122.0 mm and females 105.3 mm. The tendency for mean CW to increase with decreasing depths has been proposed as supportive evidence (Stone and Bailey 1980) of an hypothesis for upslope migration (Wigley et al. 1975). In this study, mean carapace widths of both sexes decreased (Table 5) from the 366-548 m depth zone to the 183-365 m depth zone. The changes of mean CW with depth may also, or alternatively, be reflecting a relationship between environmental quality and growth (molt) rate. Tag return studies (Ganz and Herrmann, unpubl. data)[1] have indicated little movement by red crabs off the northeastern United States.

Since 21 of 25 strings of traps (Trap sequence I, Fig. 2) had large steel-framed rectangular snow crab traps on either end (with none in the middle), it was not possible to assess comparative catch rates of end versus middle trap position for each trap type. Stone and Bailey (1980), however, found no difference with small steel-framed conical traps (using twice as much bait as this study) with a distance between traps of only 54 m, compared to 62 m in this study. Without greater catches at end positions, it is unlikely that overlap existed in the effective fishing areas of traps spaced 54, or even 62 m apart, and therefore density, total trapable number, and biomass estimates are possibly best based on EFA's of 2300 m^2/trap or less. Cayré and Bouchereau (1977) demonstrated that conical traps placed 40 m apart (EFA = 1257 m^2/trap) had overlapping areas of attraction since end traps caught significantly more crabs than middle ones. Actual effective fishing area would be expected to vary with: 1) bait quality and quantity, 2) bottom substrate topography, 3) physical and chemical characteristics of the water (for example current velocity and direction), and 4) the physiological condition of the crabs.

The trapable number estimates are probably low within the two deepest depth zones immediately adjacent to the area of high abundance (sites 5, 6, and 7). The comparatively poor catches of sites 2, 3 and 4, 9, and 10 (10.9, 1.2, 0.4, and 0.4 crabs/trap, respectively) have been used to estimate abundance, where the substantially higher values of 49.6, 30.4, and 7.5, found at adjacent sites but in the 183-365 m depth zone, may be more appropriate. Estimates of trapable numbers and biomass at an EFA of 2300 m^2/trap may also be somewhat lower than that which truly exists. The EFA is probably smaller so the trapable numbers would increase if the actual EFA were known.

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Table 1. Summary of sample site data from the red crab survey, September 1980.

Site no.	Date sampled day/mo/yr	Location Lat (N)	Location Long (W)	Average depth (m)	Site bottom temp. (°C)	No. of traps	Soak time (h)	Number of red crabs Male	Number of red crabs Female	Number of red crabs Total
1	9-10/9/80	42°55'10"	62°20'59"	258	8.7	25	14½	–	1	1
2	9-10/9/80	42 53 17	62 20 07	432	6.1	25	15	180	56	236
3	9-10/9/80	42 51 59	62 20 19	630	–	24	14	9	–	9
4	9-10/9/80	42 50 46	62 21 39	690	–	13	16½	47	4	51
5	8-9/9/80	42 49 49	62 45 06	309	–	25	15¼	573	589	1162
6	8-9/9/80	42 48 21	62 56 38	296	8.7	25	13½	322	403	725
7	8-9/9/80	42 48 01	63 07 45	322	–	25	14	163	102	265
8	7-8/9/80	42 48 03	63 41 58	234	9.8	23	22¼	–	–	–
9	7-8/9/80	42 46 30	63 38 52	448	–	24	16¾	6	1	7
10	7-8/9/80	42 45 33	63 38 03	615	–	25	16¾	13	1	14
11	11-12/9/80	42 45 38	64 05 21	223	8.7	25	17½	–	–	–
12	11-12/9/80	42 43 12	64 03 17	476	5.8	25	17½	4	–	4
13	11-12/9/80	42 41 20	64 01 11	695	–	25	17¾	18	–	18
14	11-12/9/80	42 39 51	64 04 11	736	–	13	10¾	22	1	23
15	12-13/9/80	42 30 48	64 34 47	322	8.7	25	16½	1	–	1
16	12-13/9/80	42 30 28	64 32 25	465	6.0	25	17½	320	2	322
17	12-13/9/80	42 31 00	64 30 05	608	–	25	18½	342	8	350
18	12-13/9/80	42 30 56	64 27 38	688	–	13	12¾	11	–	11
19	13-14/9/80	42 20 03	64 59 38	390	5.9	25	14½	7	2	9
20	13-14/9/80	42 16 00	65 10 38	304	8.3	25	15¼	–	–	–
21	13-14/9/80	42 13 03	65 17 27	375	7.3	25	16	–	–	–
22	14-15/9/80	42 09 11	65 25 54	227	10.0	25	20	–	–	–
23	14-15/9/80	42 07 28	65 26 08	472	5.5	25	19¼	196	6	202
24	14-15/9/80	42 06 32	65 26 34	576	–	25	18½	139	–	139
25	14-15/9/80	42 07 32	65 23 33	608	–	13	15	94	1	95

Table 2. Sex composition of red crabs by depth zones for all trap types combined.

	Percent trapable number (percent trapable biomass) 183-365 m	366-548 m	549-732 m	183-732 m
Male	48.5 (63.8)	91.4 (94.8)	98.0 (99.3)	67.0 (78.8)
Female	51.5 (36.2)	8.6 (5.2)	2.0 (0.7)	33.0 (21.2)
Combined	60.1 (54.3)	22.6 (26.9)	17.3 (18.8)	100.0 (100.0)

Table 3. Mean carapace widths and wet weights (calculated from CW:wet weight regression, Fig. 8) of red crabs by depth zone as determined from the catches of all trap types combined. ($\bar{X}$ = mean, SE = standard error, n = number of crabs).

Depth zone (m)	Carapace width $\bar{X} \pm$ SE (mm)		Mean wet weight (kg)	
	Males	Females	Males	Females
183-365	124.1 $\pm$ 0.5 (n = 738)	102.1 $\pm$ 0.3 (n = 788)	0.5471	0.2920
366-548	125.6 $\pm$ 0.5 (n = 713)	105.8 $\pm$ 1.3 (n = 67)	0.5711	0.3297
549-732	120.1 $\pm$ 0.6 (n = 672)	87.1 $\pm$ 2.9 (n = 14)	0.5069	0.1782

Table 4. Percent composition (within sex group and depth zone) of red crabs by 5-mm CW increments, for all trap types (M = male, F = female).

Carapace width (mm)	Percent of crabs by depth							
	183-365 m		366-548 m		549-732 m		183-732 m	
	F	M	F	M	F	M	F	M
56-60						0.15		0.05
61-65								
66-70					7.14	0.15	0.12	0.05
71-75				0.14	14.28	0.74	0.23	0.28
76-80	0.13		1.49		7.14	1.34	0.34	0.42
81-85	2.16		2.98		7.14	1.64	2.30	0.52
86-90	6.47	0.54	4.48	0.42	21.43	1.93	6.56	0.94
91-95	13.58	1.49	7.46	1.68	21.43	2.83	13.23	1.98
96-100	20.43	2.71	7.46	3.08	14.28	3.12	19.33	2.97
101-105	23.10	4.47	25.37	2.24	7.14	7.14	23.02	4.19
106-110	17.77	5.15	20.90	5.05		6.99	17.72	5.70
111-115	9.77	7.86	11.94	8.70		8.18	9.78	8.24
116-120	4.82	12.20	11.94	9.82		10.86	5.29	10.98
121-125	1.65	13.96	1.49	14.16		14.73	1.61	14.27
126-130	0.13	18.43	2.98	16.83		13.24	0.34	16.25
131-135		18.16	1.49	16.27		13.84	0.12	16.16
136-140		8.54		9.54		7.14		8.43
141-145		4.88		7.29		4.17		5.46
146-150		1.49		3.65		1.78		2.31
151-155		0.14		0.98		0.89		0.66
156-160				0.14		0.15		0.09
161-165						0.15		0.05

Table 5. Summary of catch and crab size data according to trap type.

Trap type	Total number traps fished	Total number crabs caught			Catch/trap			Mean CW + SE (mm)	
		Male	Female	Combined	Male	Female	Combined	Male	Female
Rectangular steel	45	188	117	305	4.2	2.6	6.8	121.8 ± 1.4	99.8 ± 0.9
Conical steel large	63	250	65	315	4.0	1.0	5.0	127.4 ± 0.7	107.2 ± 0.9
Conical steel small	50	230	69	299	4.6	1.4	6.0	125.2 ± 0.9	105.1 ± 1.0
Inshore lobster	71	295	162	457	4.2	2.3	6.4	119.6 ± 1.1	100.4 ± 0.6
Offshore lobster	344	1503	764	2266	4.4	2.2	6.6	123.2 ± 0.4	102.2 ± 0.4

Table 6. Red crab catches in offshore lobster traps, Sept. 1980.

Depth zone (m)	Site no.	No. of traps	No. of red crabs	Mean no. of red crab per trap	Sampling area (km^2)
183-365	1	15	1	0.1	75.2
	5	15	744	49.6	100.6
	6	16	486	30.4	32.8
	7	15	112	7.5	115.9
	8	14	0	0.0	119.0
	11	15	0	0.0	177.2
	15	15	1	0.1	155.3
	20	15	0	0.0	87.5
	22	15	0	0.0	28.4
Subtotal		135	1344	$\bar{X}$ = 10.0	971.9
366-548	2	15	164	10.9	129.0
	9	15	6	0.4	148.7
	12	15	2	0.1	124.7
	16	15	188	12.5	76.5
	19	15	9	0.6	65.6
	21	15	0	0.0	37.2
	23	15	121	8.1	13.1
Subtotal		105	490	$\bar{X}$ = 4.7	594.8
549-732	3+4	24	30	1.2	109.4
	10	15	6	0.4	196.8
	13+14	24	26	1.1	122.5
	17+18	21	232	11.0	113.7
	24+25	22	109	5.0	76.5
Subtotal		106	403	$\bar{X}$ = 3.8	618.9
Total		346	2237	$\bar{X}$ = 6.5	2185.6

Table 7. Red crab densities relative to EFA estimates based on catches of offshore lobster traps only.

Depth zone (m)	Site no.	Crabs/km^2 according to various EFA (m^2) estimates													
		2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3500	4000	4100
183-365	1	50	48	45	44	42	40	38	37	36	34	33	29	25	24
	5	24,800	23,619	22,543	21,546	20,668	19,840	19,076	18,372	17,712	17,102	16,532	14,171	12,400	12,097
	6	15,200	14,476	13,817	13,206	12,668	12,160	11,692	11,260	10,856	10,482	10,099	8,685	7,600	7,415
	7	3,750	3,572	3,409	3,258	3,125	3,000	2,884	2,778	2,678	2,586	2,500	2,143	1,875	1,829
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	50	48	45	44	42	40	38	37	36	34	33	29	25	24
	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0
366-548	2	5,450	5,191	4,954	4,739	4,542	4,360	4,192	4,037	3,892	3,758	3,633	3,114	2,725	2,658
	9	200	190	182	174	167	160	154	148	143	138	133	114	100	98
	12	50	48	45	44	42	40	38	37	36	34	33	29	25	24
	16	6,250	5,952	5,681	5,435	5,209	5,000	4,808	4,630	4,464	4,310	4,166	3,571	3,125	3,049
	19	300	286	273	261	250	240	231	222	214	207	200	171	150	146
	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	23	4,050	3,857	3,681	3,522	3,375	3,240	3,115	3,000	2,892	2,793	2,700	2,314	2,025	1,976
549-732	3+4	600	571	545	521	500	480	462	444	428	414	400	343	300	293
	10	200	190	182	174	167	160	154	148	143	138	133	114	100	98
	13+14	550	524	500	478	458	440	423	407	393	379	367	314	275	268
	17+18	5,500	5,238	5,000	4,783	4,584	4,400	4,231	4,074	3,928	3,793	3,666	3,143	2,750	2,683
	24+25	2,500	2,381	2,272	2,174	2,084	2,000	1,923	1,852	1,786	1,724	1,666	1,428	1,250	1,219

Table 8. Trapable numbers and biomass estimates of red crabs by sex and depth zone for several EFA's derived from the catches of offshore lobster traps only.

EFA (m^2)	Depth zone (m)	Trapable numbers			Trapable biomass (kg)		
		Males	Females	Combined	Males	Females	Combined
2300	183-365	1,449,340	1,538,990	2,988,330	792,970	449,493	1,242,463
	366-548	1,025,163	96,459	1,121,622	585,493	31,808	617,301
	549-732	842,739	17,199	859,938	427,198	3,066	430,264
	183-732	3,317,242	1,652,648	4,969,890	1,805,661	484,367	2,290,028
3000	183-365	1,112,019	1,180,804	2,292,823	608,413	344,877	953,291
	366-548	785,891	73,946	859,837	448,840	24,384	473,224
	549-732	646,065	13,185	659,250	327,501	2,350	329,851
	183-732	2,543,975	1,267,935	3,811,910	1,384,754	371,611	1,756,366
4100	183-365	813,734	864,069	1,677,803	445,214	252,369	697,583
	366-548	575,102	54,112	639,214	328,453	17,844	346,297
	549-732	472,757	9,648	482,405	239,648	1,720	241,368
	183-732	1,861,593	927,829	2,789,422	1,013,315	271,933	1,285,248

Table 9. Biomass of red crab after culling at various EFA estimates.

EFA (m^2)	Total trapable numbers estimate	Biomass of total trapable number (kg)	Culled biomass (males + females) (kg)	
			CW >100 mm	CW > 115 mm
2000	5,718,450	2,634,818	2,405,062	1,846,481
2100	5,446,966	2,509,795	2,290,941	1,758,864
2200	5,198,047	2,395,038	2,186,190	1,678,442
2300	4,969,890	2,290,028	2,090,338	1,604,852
2400	4,765,761	2,195,859	2,004,380	1,538,858
2500	4,574,760	2,107,854	2,924,050	1,477,184
2600	4,398,618	2,026,694	1,849,966	1,420,307
2700	4,240,805	1,953,770	1,783,401	1,369,202
2800	4,084,072	1,881,763	1,717,673	1,318,740
2900	3,943,409	1,816,951	1,658,513	1,273,319
3000	3,811,910	1,756,366	1,603,211	1,230,861
3500	3,267,520	1,505,533	1,374,250	1,055,077
4000	2,859,225	1,312,509	1,198,058	919,806
4100	2,789,422	1,285,248	1,173,174	900,702

Table 10. Percent of trapable red crab biomass left after culling.

Sex	Depth zone (m)							
	183-365		366-548		549-732		183-732	
	>100 mm	>115 mm	>100 mm	>115 mm	>100 mm	>115 mm	>100 mm	>115 mm
Male	98.0	86.8	97.9	87.7	95.6	81.2	97.4	85.8
Female	67.6	10.6	85.3	27.0	11.7	0.0	68.4	11.6
Combined	87.0	59.2	97.2	84.6	95.0	80.6	91.3	70.1

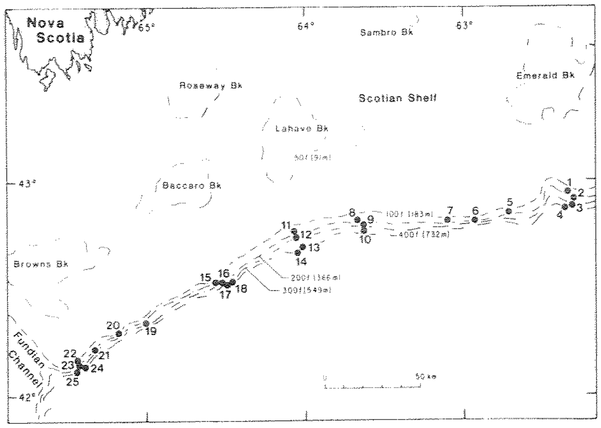

Fig. 1. Location of sample sites for the red crab survey, September 1980.

Trap sequence	I	II	III
	A	A	A
1	R	R	I
2	O	O	O
3	O	O	O
4	C(L)	C(S)	C(S)
5	O	O	O
6	O	O	O
7	C(S)	C(S)	I
8	O	O	O
9	O	O	O
10	I	I	C(S)
11	O	O	O
12	O	O	I
13	C(L)	O	S
14	O		
15	O		
16	C(S)		
17	O		
18	O		
19	I		
20	O		
21	O		
22	C(L)		
23	O		
24	I		
25	R		
	A		

Fig. 2. Trap sequences used in the red crab survey, September 1980. Trap sequence I was used at sites 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 19, 20, 21, 22, 23, 24; sequence II at sites 4 and 14; and sequence III at sites 18 and 25. A = anchor; C(L) = conical trap (large); C(S) = conical trap (small); I = inshore lobster trap; O = offshore lobster trap; R = rectangular steel trap.

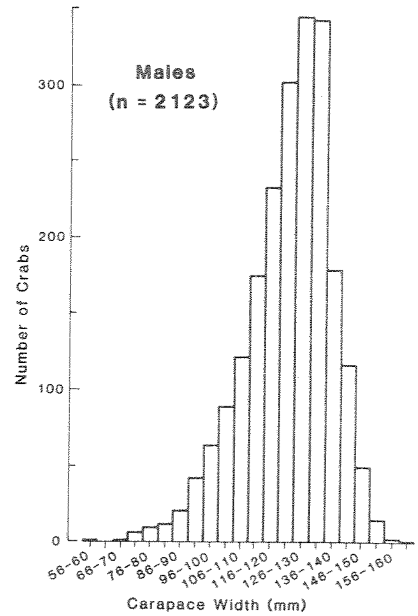

Fig. 3. Size frequencies of male red crabs trapped along the edge of the Scotian Shelf, September 1980, all trap types and depth zones combined.

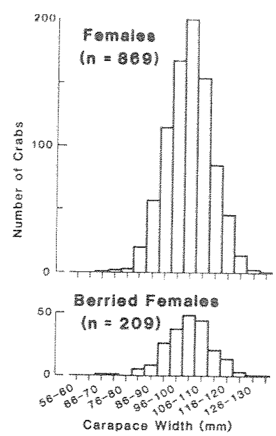

Fig. 4. Size frequencies of female red crabs trapped along the edge of the Scotian Shelf, September 1980, all trap types and depth zones combined.

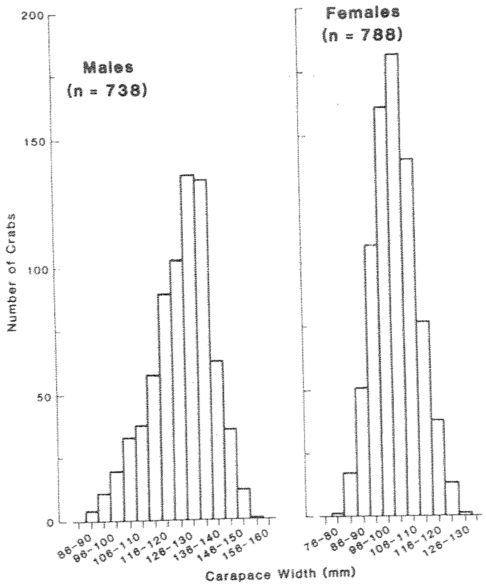

Fig. 5. Size frequencies of red crabs trapped in the 183-365 m depth zone along the edge of the Scotian Shelf, September 1980, all trap types.

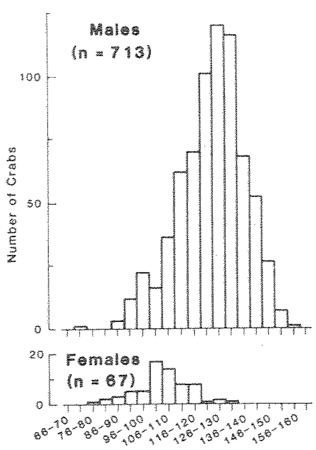

Fig. 6. Size frequencies of red crabs trapped in the 366-548 m depth zone along the edge of the Scotian Shelf, September 1980, all trap types.

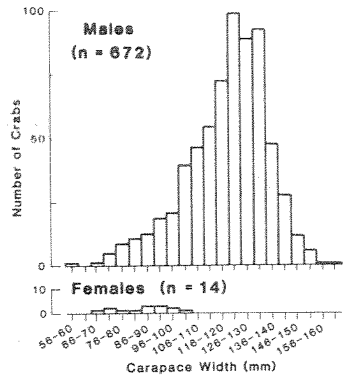

Fig. 7. Size frequencies of red crabs trapped in the 549-732 m depth zone along the edge of the Scotian Shelf, September 1980, all trap types.

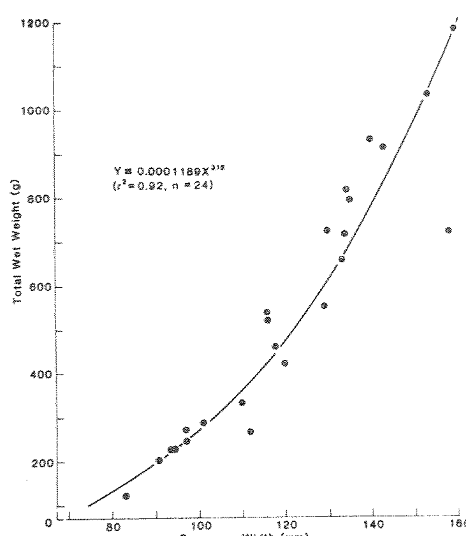

Fig. 8. Relationship between size and total wet weight for male red crabs trapped along the edge of the Scotian Shelf, September 1980.