Exploration for Golden Crab, *Geryon fenneri*, in the South Atlantic Bight: Distribution, Population, Structure, and Gear Assessment

Final Report, Year I

Elizabeth L. Wenner
Marine Resources Research Institute

and

Glenn Ulrich
Office of Fisheries Management

South Carolina Wildlife and Marine Resources Department
Post Office Box 12559
Charleston, South Carolina 29412

SUMMARY

Exploratory trapping for golden crab, Geryon fenneri, was conducted from 5 August 1985 to 21 February 1986 off South Carolina and Georgia. A buoyed system with strings of six traps (three side-entry Fathoms Plus and three top-entry Florida traps) was fished in six depth strata: 274-366m (150-200 fm), 367-457m (210-250 fm), 458-549m (251-300 fm), 550-640m (301-350 fm), 641-732m (351-400 fm), and 733-823m (401-450 fm). A total of 70 trap sets consisting of 416 trap hauls collected 3152 G. fenneri (2661.9 kg) and 864 jonah crab, C. borealis, (227.5 kg) at sampled depths between 296-810m.

Catches of golden crab were highly variable between strata. Catch per trap increased from 1.6 crabs (1.67 kg) in the shallowest stratum sampled to a maximum abundance of 22.3 crabs/trap (18.04 kg/trap) in the 458-549m depth zone. Catches abruptly declined in the deeper strata sampled. Catch per trap of golden crab from this survey compares favorably with catch rates reported in the Gulf of Mexico. Distribution within strata was apparently related to bottom type since catches were highest on bottom sediments of silt-clay and foraminiferan tests, while few crabs were collected from coral rubble bottom.

The Florida trap outfished the Fathoms Plus trap in terms of number of golden crab per trap (1.7:1) and weight per trap (1.6:1) for all completed sets. Catches of jonah crab were lowest for the Florida trap. These two traps also differed in the size and weight of species caught, with larger and heavier golden crab occurring in the Fathoms Plus trap. Differences observed between traps are probably related to trap design or behavioral interactions of golden and jonah crabs. Since decreased abundance of C. borealis occurs with increasing depth and catch rates are apparently lower in top entry traps, abundance of these crabs relative to golden crab could be avoided in commercial trapping if desired.

Male golden crab were more numerous and larger than females. In strata 1-3, males were more than 20 times as numerous as females. Females outnumbered males (2.9:1) in the deepest stratum only, suggesting their increased abundance at greater depths. The small number of females collected precluded any definitive statements regarding ovarian cycles or spawning patterns; however, tentative interpretations on ovarian development, vulval condition and presence of seminal products suggest that females may become sexually mature at 97mm CW.

Golden crab were trappable as small as 85m CW but the greatest proportion of trapped individuals was >100mm CW. Over 90% of all individuals collected exceeded 114mm CW which is the minimum size of red crab accepted for commercial utilization.

Approximately 1000 lbs. live weight of golden crab were distributed to two of the major blue crab processors in South Carolina. One processor who steamed and picked the crabs in the traditional blue crab fashion has reported meat yields between 10% and 11%. The second processor shipped its share to two major live-crab buyers in Baltimore. Response there was favorable and a standing order has been placed for the product.

INTRODUCTION

Crabs of the genus Geryon (Brachyura: Geryonidae) are deepwater inhabitants of the Atlantic, Indian and Pacific Oceans (Rathbun 1937, Monod 1956, Christiansen 1969, Manning and Holthuis 1981). Species reported off the United States in the western Atlantic and Gulf of Mexico include the red crab, G. quinquedens (Smith 1879), and the golden crab, G. fenneri (Manning and Holthuis 1984).

Both G. quinquedens and G. fenneri have been the target of limited and sporadic commercial fishing efforts off the east coast of the United States (Gerrior 1981), in the Gulf of Mexico (Otwell et al. 1984; National Marine Fisheries Service 1986) and off Bermuda (Luckhurst 1985). The red crab fishery, initiated by exploratory fishing and development efforts in Rhode Island (summarized by Gerrior 1981), has prompted much biological, fisheries and production research (reviewed in Otwell et al. 1984; National Marine Fisheries Service 1986). Information on golden crab, however, is more limited. Otwell et al. (1984) demonstrated exploratory trapping and processing techniques for golden crab from the Gulf of Mexico. At the time the species was described by Manning and Holthuis (1984), its geographic and bathymetric distribution included the continental slope off eastern Florida, the Florida Straits and the Gulf of Mexico. An exploratory fishing effort in 1984 collected the first known specimens of golden crab off South Carolina (C.A. Wenner, South Carolina Wildlife and Marine Resources Dept., pers. comm.), and it is now known that golden crab occur in waters off Bermuda (Luckhurst 1985).

The initiation of a small commercial crabbing enterprise during 1984 in South Carolina yielded promising quantities of golden crab and jonah crab, Cancer borealis. A desire to know more about fishery potential and trap design, as well as bathymetric distribution and biology of the golden crab in the South Atlantic Bight was responsible for initiation of a cooperatively funded research effort in March 1985 by the Gulf and South Atlantic Fisheries Development Foundation, the South Carolina Wildlife and Marine Resources Department (SCWMRD), the South Carolina Sea Grant Consortium and the Marquette Foundation. The primary goals of this two-year project are to determine the extent of the resource of G. fenneri in the South Atlantic Bight, work with the private sector to establish appropriate fishing techniques, and provide information which will guide the private sector in entry and capitalization of the potential fishery for G. fenneri and other decapod species which co-occur on the continental slope. The research, of which first-year results are presented herein, included specific objectives to:

- define the bathymetric distribution of Geryon fenneri in the South Atlantic Bight;
- determine the density, size and sex composition of G. fenneri in the South Atlantic Bight;
- evaluate traps, soak time and gear performance in an effort to optimize fishing technique;
- cooperate with commercial processors and seafood marketing experts on handling, processing and marketing G. fenneri;
- determine aspects of adult life history, such as substrate preference, reproductive biology and growth rate; and to assess other crustacean resources that co-occur with G. fenneri.

METHODS

Cruises were made during the period from 5 August 1985 to 21 February 1986 (Appendix I) on board the SCWMRD research vessels Oregon, a 32m steel-hulled converted tuna purse-seiner and the Lady Lisa, a 22.1m wooden hulled double-rigged St. Augustine shrimp trawler. One cruise from 20 June to 24 June 1985 was made on the National Marine Fisheries Service vessel R/V *Chapman*, a 39m steel-hulled stern trawler. All vessels were equipped with both Loran C receivers and plotter, color fathometers, and radar. On board gear modifications required for the SCWMRD vessels included a large capacity (30 gal/min) hydraulic system which was installed on the R/V *Lady Lisa*, along with a 15 inch heavy duty (Kolstrand) pot hauler mounted on a removable davit. The hauler-davit assembly was transferred to the R/V *Oregon* when this vessel was used for sampling. No hydraulic modifications were necessary on the R/V *Oregon*. The R/V *Chapman* was equipped with a 20 inch heavy duty pot hauler of the type used in the king-crab fishery. Two commercially available trap designs were utilized for sampling crabs during this project: the Fathoms Plus trap and Florida trap. Commercial gear was used in order to eliminate the time required to design and construct suitable traps and to allow comparisons with a commercial *Geryon* trapping operation that used these types of traps.

The Fathoms-Plus traps are elliptical, nesting shellfish traps constructed of injection molded plastic. The trap has two side funnels that can be enlarged by removing more of the plastic funnel's inner lip. The original, oval funnel opening is 10cm x 20cm (3.9 in x 7.9 in) and some of the traps were cut out to a maximum opening size of 14cm x 22cm (5.5 x 8.7 inches). The bait wells supplied with these traps are hinged, side-opening cylinders measuring 31cm (12.2 in) long by 11cm (4.3 in) diameter.

The Florida trap is an injection molded, high-impact plastic version of a Florida spiny lobster trap. The top of the trap is constructed of wood lath to provide a bio-degradeable escape panel in the event that the trap is lost. The trap is 82cm (32.3 in) long, 61cm (24 in) wide and 45cm (17.7 in) high. The top entrance funnel has adjustable panels and is 20cm x 25cm (7.8 in x 9.8 in) in the most open position, as fished throughout the study. Two strips of poured concrete in each end of the trap provided ballast, making the total weight of the trap about 22.7 kg (50 lbs). Small cup-type bait receptacles were provided with these traps but due to their small volume we substituted Fathoms-Plus bait wells, which were suspended on bungee-cord near the top of the trap.

Traps were baited with 1.2 - 1.6 kg of frozen herring or menhaden. Three Florida and three Fathoms-Plus traps were alternately attached to 365.6m (1200 ft) of groundline (Figure 1). The groundline was constructed of 5/16 in diameter Iceline, a dacron, polyethylene line that has a very high tensile strength relative to its diameter and was developed specifically for fishing traps. A loop was spliced into each end of the groundline for attachment of anchor gangions and buoy lines. Beckets of 3/16 in braided nylon were spliced into the groundline at 60.9m (200 ft) intervals and the 1.8m (6 ft) trap gangions were attached to the beckets using heavy duty longline clips.

A small weight consisting of approximately 9.0 kg (20 lb) of heavy anchor chain was attached to the terminal end of the groundline. A large home-made, yachts man-type, anchor of 22.7-27.3 kg (50-60 lb) was attached to the buoyline end of the gear with a 1/4 in polypropylene gangion and heavy-duty longline clip. A lighter line was used on the anchor gangions so that it would break instead of the ground line or buoyline if the anchor hung on a bottom obstruction.

Buoy lines were 365.6m (1200 ft) sections of 5/16 in Iceline and were of two configurations designated as primary and secondary buoy lines. Both types had loops spliced in each end and sections could be joined together using a double sheet bend to achieve at least a 3:1 ratio of line to water depth. The primary buoyline had four beckets of Iceline with a Brummel hook spliced into one end of the buoyline at 3m (10 ft) intervals, starting at 18.3m (60 ft) from

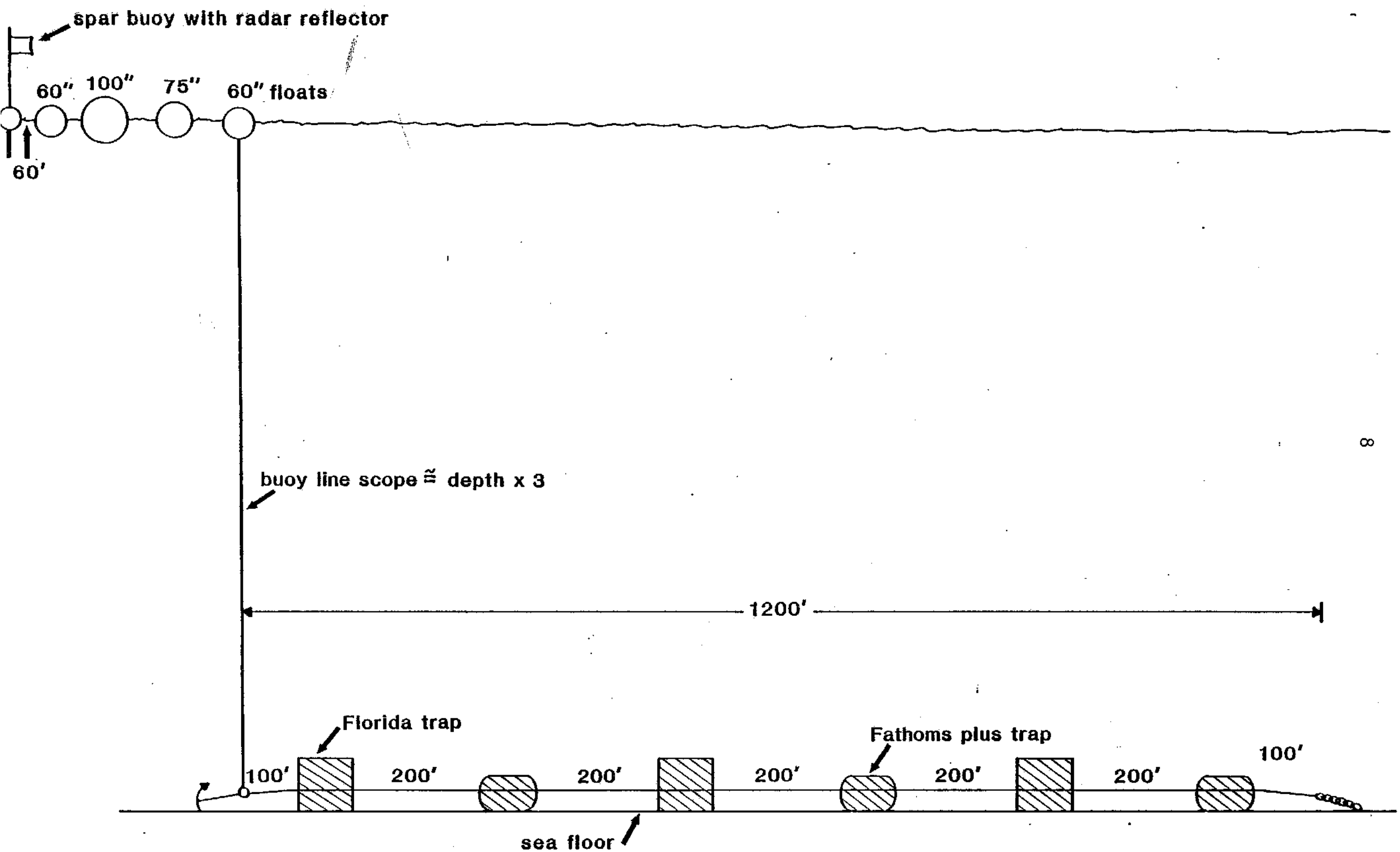


Figure 1. Schematic of a set of traps used in exploratory assessment of *Geryon fenneri*.

the end of the line. Inflatable net buoys were attached to the beckets with Brummel hooks and a spar buoy with radar reflector was attached to the terminal end of the primary buoyline. Approximately 1000 lb of buoyancy was achieved by using two 60 in circumference, one 75 in and one 100 in inflatable net buoys.

All connections of traps, anchors, buoylines and buoys for a complete trap string were made prior to setting. Ground-line between traps was coiled in plastic fish baskets and buoyline was coiled in plastic 55 gallon drums. Prior to setting gear, a 15 minute drift was made and the LORAN C plotter was used to determine surface current speed and direction. The trap string was deployed from a stern launching ramp and was set with the vessel under power, heading down current. Sets were made down current to prevent the main anchor from dragging back through the trap string.

Six depth strata were sampled: 274-366m (150-200 fm), 367-457m (201-250 fm), 458-549m (251-300 fm), 550-640m (301-350 fm), 641-732m (351-400 fm), and 733-823m (401-450 fm) between $29^{\circ}53.1'$ - $32^{\circ}20.0'$ N and $78^{\circ}01.5'$ - $79^{\circ}24.8'$ W. Generally, three sets which consisted of an arrangement of gear, as shown in Figure 1, were made approximately 0.9-1.8 km (0.5-1.0 nmi) apart within the same depth stratum over a 24-hour period. Sampling locations were selected by making fathometer transects of the potential fishing area to determine depth and bottom type. Initially, each stratum was to have received equal effort; however, cruise schedule limitations and poor weather conditions necessitated alteration of the sampling program. The realized effort in terms of number of sets within each stratum is summarized in Table 1. Traps were fished in units of six (three of each type) per set. The first trap type on the line was randomly selected, with trap type alternating thereafter. The exception to this arrangement occurred in the deepest stratum (733-823m) where only the Fathoms Plus trap was used. Fishing duration was standardized at 20

Table 1. Fishing duration in hours of trap sets within six strata sampled during Year I.

		Fishing duration (hrs)			
Stratum	No.Sets	$\bar{x}$	(s)	min.	max.
1	8	17.5	3.75	12.4	21.2
2	32	18.8	2.36	14.0	23.2
3	16	20.5	2.07	16.2	23.7
4	6	22.9	1.15	21.5	24.7
5	4	17.2	0.73	16.4	18.1
6	4	20.2	5.69	11.7	23.3

hours for most sets; however, poor weather conditions and logistical considerations necessitated reduced fishing duration for some sets. Average fishing duration within strata, however, exceeded 17 hours (Table 1).

When hauling gear, the vessel maneuvered and used power as necessary to maintain as much vertical pull on the traps as possible, which minimized dragging the string over the bottom. A 55-gal plastic drum was placed directly under the head of the pot hauler. The line coiled itself with handling limited to pushing the coils down periodically to conserve space. As traps were brought aboard their catch was emptied into numbered baskets so data could be recorded for each trap.

Galvanized wire mesh minnow traps and experimental prawn traps were designed and deployed in an attempt to collect pandalid shrimp Heterocarpus sp. The prawn traps were cylindrical with a diameter of 60cm and a depth of 30cm. The top, bottom and side were metal with three equispaced funnels (~12cm x 6cm) located along the side. The minnow traps were baited with herring or canned cat food and fastened to the outside of the Fathoms Plus crab traps on several sets. Prawn traps were baited with herring and placed on the end of several trap sets. The prawn traps were unsuccessful in collecting shrimp and appeared to be havens for hagfish, Myxine glutinosa. Minnow traps caught small quantities of Heterocarpus ensifer at depths between 458-549m.

Bottom temperature was determined at most sites by reversing thermometers. Bottom sediments were sampled by a rocket grab for each group of three sets made in an area. Sediments retrieved were frozen on board and examined under a microscope for gross characterization in the laboratory. Sampling depth was recorded as the depth recorded at deployment of the anchor.

The catch of decapod crustaceans in each trap was identified and counted while other species were identified. Golden crab and jonah crab were individually sexed and measured to the nearest millimeter for carapace width (CW, distance between the tips of the fifth lateral spines) and carapace length (CL, distance from the diastema between the rostral teeth to the posterior edge of the carapace, along the midline). Individual weights of crabs were recorded to the nearest gram for all sets except 68-82 (Appendix I) when total weight per trap was recorded for golden crab. The number of missing chelae and pereopods was recorded for each crab, as was molt condition and presence of chitinolytic bacteria and lepadid barnacles Trilasmis sp. on the exoskeleton. Molt condition of G. fenneri was modified from criteria established by Beyers and Wilke (1980) for G. quinquedens (probably = G. maritae Manning and Holthius 1981) and consisted of five categories: 1) Hard - carapace at maximum strength, little fouling by barnacles or chitinolytic bacteria, 2) Hard old - carapace strong but heavily fouled by barnacles and abraded or blackened by chitinolytic bacteria, 3) Soft old - resorptive line along postero lateral sides of the carapace is weak and gives; carapace heavily fouled as with hard-old condition, 4) Soft new - carapace soft or jellylike with no fouling, and 5) Hard new - carapace cracks under pressure and is without fouling. Molt condition of C. borealis followed stages defined by Carpenter (1978).

Female G. fenneri and C. borealis were examined for evidence of egg extrusion and mating. Presence of eggs or egg remnants on pleopods and the size, shape and physical condition of vulvae, as described by Haefner (1977) and Carpenter (1978), were noted.

Females of both species were sacrified to determine gonadal condition and color. Ovaries from 73 of the 167 G. fenneri captured were initially classified by relative size and color following the scheme described by Haefner (1977) for G. quinquedens. Ovaries of C. borealis were examined and assigned to one of five stages of development described by Carpenter (1978). Seminal receptacles of sacrified females were examined for presence of sperm or spermatophores and relative size. A representative series of ovaries and seminal receptacles were prepared for histological examination. All tissue was placed in 10% seawater formalin. After a fixation period of at least 48 hours, tissues were processed in a Model 2A Autotechnicon, vacuum infiltrated and supported in paraffin. Sections were cut at 6-9 μm using an AO 820 microtome. Sections were stained with Gill's hematoxylin and counterstained with eosin-Y. Oocytes from G. fenneri were measured using an ocular micrometer and descriptions of developmental stages were made from resultant slides.

Several male G. fenneri were sacrified to obtain samples of the testes and vas deferens for scanning electon microscopy. Excised tissues were fixed in 2.5% glutaraldehyde prepared in a sodium cacodylate buffer and seawater solution. After 24 hours tissues were rinsed in cacodylate buffer and dehydrated in ethanol. Tissues were then placed in a lens paper envelope and critical-point dried. The dried specimens were mounted on SEM stubs, placed in a vacuum evaporator and coated with gold-palladium. Images were examined and photographed at 20 kv on a Joel JSM-35C scanning electron microscope.

A total of 248 G. fenneri were tagged with numbered dart tags (Floy Tag Co.) and released on cruises from 3 February to 19 February 1986. Since only one individual has been recaptured, these results will not be further discussed. Limited tagging efforts will continue during the second year of the study.

Catch per trap from damaged traps or sets which moved substantially from sites of deployment were not included in analyses of distribution and abundance. These data were used, however, for assessing biological aspects of the population. Catch per trap was converted into density based on an estimate of the effective fishing area (EFA) per trap. This estimate was

$2922.5 m^2$/trap and was based on the assumption that each trap fished a circular area with radius of half the distance between adjacent traps (McElman and Elner 1982).

An estimate of the population size of crabs within each stratum was derived according to Stone and Bailey (1980) and McElman and Elner (1982) as follows:

$$\text{Population size} = \frac{\text{catch (crabs/trap)}}{\text{area fished } (0.00292 km^2/\text{trap})} \times \text{sampling area } (km^2)$$

Stations, trapstrings and associated depths were plotted on a LORAN C grid. Clusters of stations within the same depth stratum were delineated by LORAN grid lines and the area of the resultant parallelogram calculated. The total sampled area in each stratum was then calculated by summing area estimates for these subareas.

RESULTS

Gear Assessment

Two types of gear have been used to fish for *G. fenneri* off South Carolina and Georgia: a commercial scale, cable longline system with 100-125 traps per string and the buoyed system used during the present study. Trap types (Florida trap and Fathoms Plus) were the same for each system.

The fishing vessel *Heavy Duty II* used the cable longline system during attempts to develop a commercial fishery for golden crab in early 1985. The 3/16 inch, galvanized cable was spooled on a heavy duty, direct drive, longline reel. One hundred to 125 traps were attached to the cable with longline snaps (#148SS) every 30 fathoms as the vessel was underway heading in the direction of the prevailing surface current. After dropping the last trap, sufficient cable to approximately equal twice the depth was deployed and five inflatable net buoys and a "high flyer" buoy were clipped to the cable. The cable was then cut from that remaining on the spool. When the gear was retrieved the terminal buoy was picked up and the cable was crimp spliced to that on the spool and hauling began. The vessel was maneuvered to keep the pull on the gear vertical and the heading over the set location. This system worked well, allowing large numbers of traps to be set with a single set of buoys. The weight of the cable and large number of traps accounted for this gear's primary advantage - that of staying at the position where it was set.

The buoyed system with strings of six traps was not as stationary as the cable long line system. Traps would often move considerable distances when strong currents were encountered. In one instance, the distance moved was as much as ten miles. During our initial fishing operations, a 2:1 ratio of buoy line to water depth was sufficient. When stronger currents were encountered, we found that a 3:1 scope was more appropriate and produced less drag on the buoys. Using such large amounts of line created storage problems, however. The Iceline used for buoy and groundline was stored in barrels and took up more space on deck than the same amount of cable spooled on a reel. The buoying system must be adequate for the most severe conditions expected. Velocity of the surface current changed over short time spans, varying from <0.5 knots to >4.0 knots over the 20 hour soak period. The combined buoyancy of the inflatable net floats of about 1000 pounds and the increased buoy line scope eliminated problems of the buoys being pulled underwater by the current drag. Strong currents caused problems primarily by dragging the trap strings accross the bottom, thereby reducing their catching efficiency and requiring that time which could otherwise be used more productively be spent searching for traps.

Gear loss has not been a problem using the buoyed trap system. Trap sets moved by currents were relocated. Several traps were lost in the 550-640m stratum from abrasion of the groundline on hard bottom. In other strata, soft substrates preferred by the crabs are free of obstructions and line abrasion is minimal. Gear conflicts which result in entanglement or vandalism may occur with swordfish longliners at certain times of the year (mainly summer and fall). Longline gear set near the depth of maximum crab abundance tangled in our buoyline and resulted in the longliner cutting the buoyline to free his gear. If there is a high degree of confidence in the bottom position of the gear, such lost strings may be retrieved by dragging a grappeling device through the area.

The major advantage of the buoyed system for purposes of this project was its low cost compared to capital outlay necessary to purchase and install a suitable longline reel. Cable gear was also not well adapted for making a number of replicate sets because of the necessity of making numerous cuts and splices in the cable.

The two trap designs differed with regard to catch rates (Figure 2), durability, ease of handling, and conservation of deck space. The Florida traps were durable, but they took up much deck space and were heavy and difficult to handle. The Fathoms Plus traps were lightweight, easily handled and took up considerably less deck space because of their nesting design. They were not as durable as the Florida traps, however. Both traps are comparable in cost with the Florida trap costing $38 and the Fathoms Plus trap $32 (1986 prices).

Distribution and Relative Abundance

A total of 70 trap sets consisting of 416 trap hauls collected 3152 *G. fenneri* (2661.9 kg) and 864 *C. borealis* (227.5 kg) at sampled depths between 296–810m (Appendix I). One *G. quinquedens* was collected in a trap set at 808m. Other organisms collected in traps are listed in Appendix II. Fishing effort was not evenly distributed among the six depth strata sampled (Table

1). Maximum effort was expended at depths between 367-549m. Nevertheless, catches of golden crab and jonah crab showed a strong relation to depth.

Although *G. fenneri* were collected at the minimum and maximum depths sampled, catches were highly variable between strata (Figure 2). Catch per trap increased from 1.6 crabs (1.67 kg) in the shallowest stratum sampled to a maximum abundance of 22.3 crabs/trap (18.04 kg/trap) in the 458-549m depth zone. Catches abruptly declined in the deeper strata sampled. The absence of golden crab in traps fished between 550-640m may be related to unsuitable sediments at sites sampled in this stratum since grab samples contained coral rubble. At locations in shoaler strata where crabs were abundant (Figure 3) sediments consisted of a mixture of soft silt-clay, molluscan and foraminiferan shell fragments.

Golden crab were collected in 23 of the 26 sets at which bottom water temperatures were measured (Appendix 1). Temperatures at sites where crabs were collected ranged from 7.14°C to 9.15°C.

Minimum population estimates indicated that 694,172 golden crab weighing 596,898 kg may occur in the 208 km^2 area sampled in stratum 2 between 367-457m (Table 2). Density and biomass of *G. fenneri* was highest, however, in areas sampled between 458-549m (stratum 3). A total population size of 1.1 x 10^6 golden crab (938,932 kg) was estimated for the entire 586.15 km^2 area sampled.

The Florida trap outfished the Fathoms Plus trap in terms of number of golden crab per trap (1.7:1) and weight per trap (1.6:1) for all completed sets (Table 3). Statistical results by strata using two-sample T-test or an approximate T-test when variances were heterogeneous (Sokal and Rohlf 1983), indicated significantly more crabs were collected with the Florida trap than with the Fathoms Plus trap from 367-457m (stratum 2) and from 458-549m (stratum

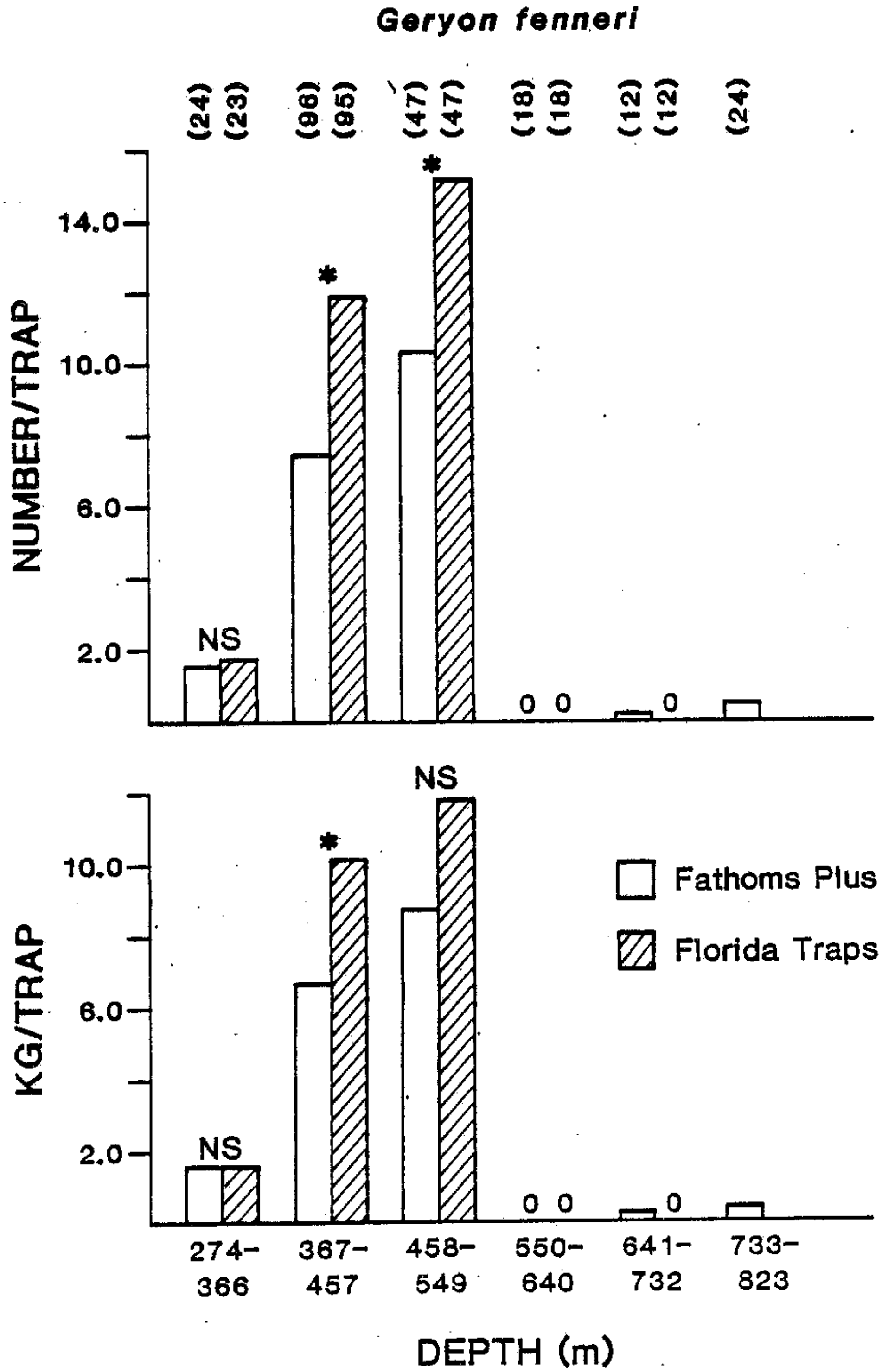


Figure 2. Catch per trap of Geryon fenneri for six depth strata sampled. Effort (number of traps) is shown in parentheses. Statistical significance, as determined by two sample t-test, is indicated by * ($P<0.05$). NS indicates no significant difference in catch rates between the two trap types.

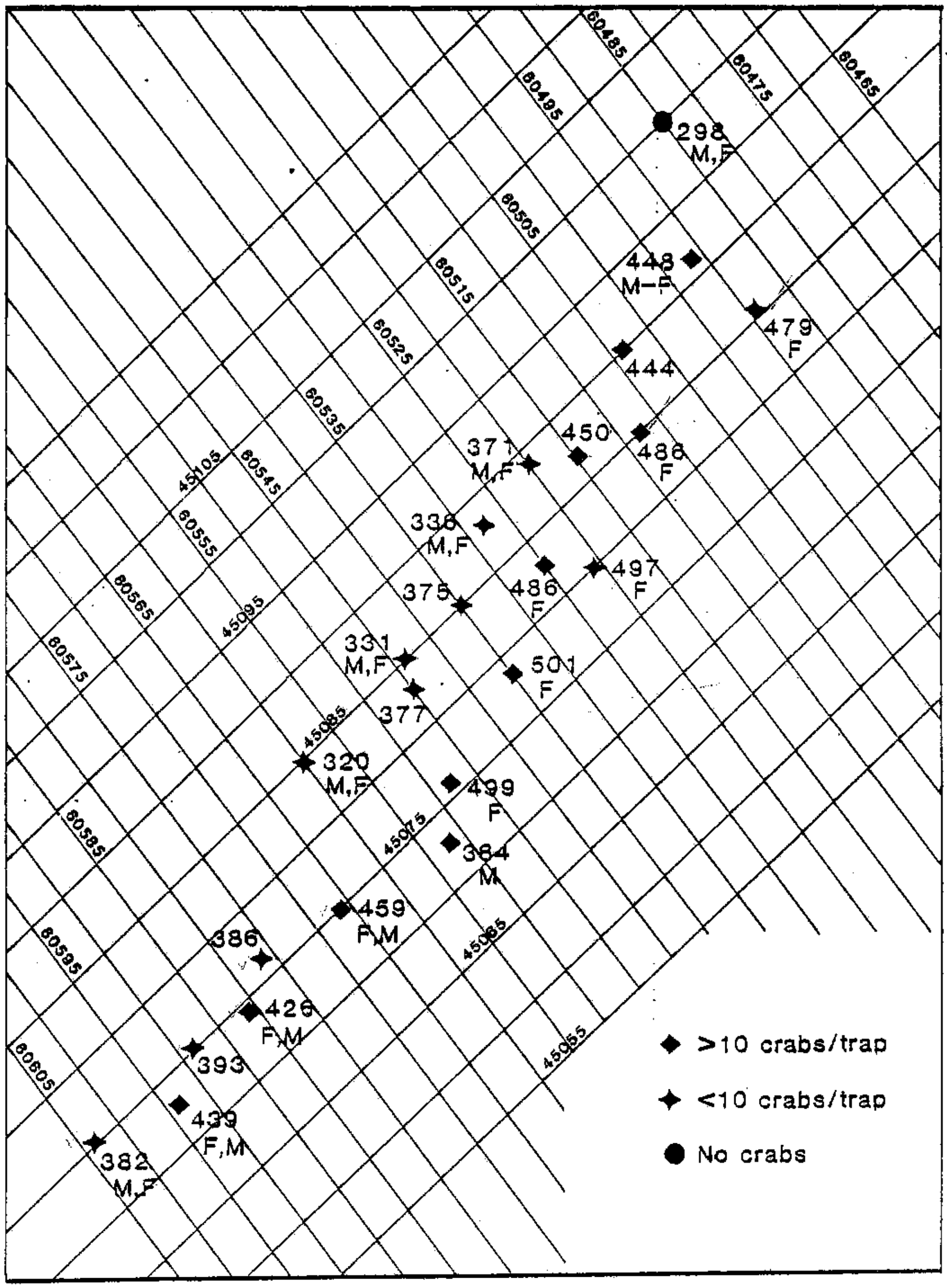


Figure 3. Station locations within strata encompassing 274-549m. Depth (m) and sediment type (M = mud; F = foraminiferan ooze; M, F = predominantly mud; F, M = predominantly foraminiferan ooze; S = shell hash; M-S = mud and sand mixture) at each station noted where available.

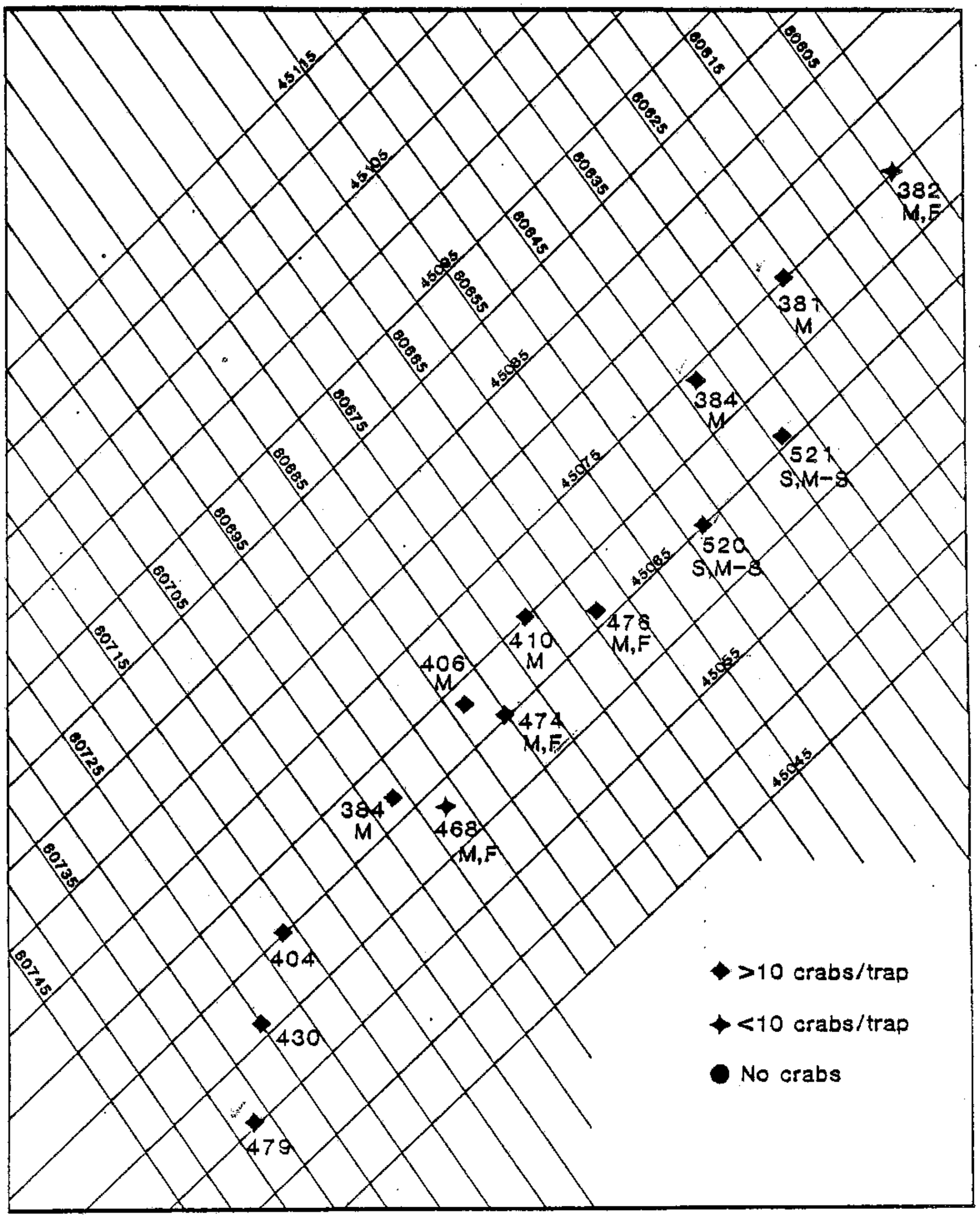


Figure 3. Continued:

Table 2. Estimates of density, population size and biomass of golden crab and jonah crab within each stratum sampled.

Stratum	Calculated Area Sampled (km^2)		Population Density (No./km^2)	Pop. Estimate	Biomass Density wt/km^2	Pop.Biomass (kg)
			Geryon fenneri			
1	76.33	13.02 %	561	42,821	570.067	43,513
2	208.46	35.56	3330	694,172	2863.370	596,898
3	81.27	13.87	4383	356,206	3546.082	288,190
4	80.19	13.68	0	---	0	---
5	75.17	12.82	14	1,052	11.534	867
6	64.73	11.04	156	10,098	146.208	9464
	586.15					
			Cancer borealis			
1	76.33		2133	162,812	555.987	42,438
2	208.46		851	177,399	227.334	47,390
3	81.27		349	28,363	88.463	7,189
4	80.19		0	---	0	---
5	75.17		0	---	0	---
6	64.73		0	---	0	---

Table 3. Results of t-test comparisons of mean number and weight (kg) per trap for two trap types fished in each depth stratum. Standard deviation noted in parentheses; * indicates significance at 0.05 level.

Geryon fenneri

STRATUM	NUMBER/TRAP FM+	NUMBER/TRAP FLA	T_s	WEIGHT/TRAP FM+	WEIGHT/TRAP FLA	T_s
1	1.6(1.92)	1.8(2.21)	0.14	1.66(1.912)	1.80(2.157)	0.14
2	7.5(5.96)	11.9(9.95)	2.16*	6.67(5.097)	10.02(7.651)	2.06*
3	10.4(5.08)	15.2(7.08)	2.22*	8.82(4.164)	11.84(4.752)	1.91
4	0	0	--	0	0	--
5	0.1	0	--	0.07	0	--
6	0.5(0.28)	--	--	0.43(0.321)	--	--
TOTAL	7.0(5.98)	11.4(9.38)	8.51*	6.16(5.052)	9.37(7.078)	6.18*

Cancer borealis

STRATUM	NUMBER/TRAP FM+	NUMBER/TRAP FLA	T_s	WEIGHT/TRAP FM+	WEIGHT/TRAP FLA	T_s
1	8.6(3.91)	3.6(2.54)	3.02*	2.19(1.197)	0.99(0.811)	2.36*
2	3.6(3.59)	1.4(1.71)	3.17*	0.95(0.983)	0.37(0.485)	2.99*
3	1.1(3.31)	0.9(1.27)	0.27	0.29(0.860)	0.23(0.334)	2.28*
TOTAL	3.6(4.19)	1.6(1.92)	3.25*	0.94(1.133)	0.42(0.554)	3.09*

3)(Figure 2, Table 3). Weight per trap was significantly different for the 367–457 m stratum only.

Segregation of catch data into northern and southern sections of the survey area (using the 60600 LORAN line as an arbitrary division) revealed no statistically significant differences for either stratum 2 (t_s= 1.79, P>0.05) or stratum 3 (t_s = 1.09, P>0.2)(Figure 4). Mean catch per trap was very similar between these depth strata within both northern and southern areas, suggesting that peak abundance of golden crab for these two strata was homogeneous within the study area.

Jonah crab, Cancer borealis, were collected in traps set at depths from 296m to 501m (Figure 5). Catches were greatest [6.2 crabs/trap (1.61 kg/trap] in the shallowest stratum where C. borealis was present in every set (n=8). Abundance declined with depth so that fewest crabs (1.0 crabs/trap) were collected in the 489–549m depth zone. Population estimates indicated 368,574 crabs (97,017 kg) may exist in the 366.06 km^2 area sampled within the 274–549m depth zones (Table 2).

Statistical comparisons of catch data between the two trap types revealed significantly greater catches of C. borealis occurred in the Fathoms Plus trap for strata 1 and 2 (Figure 5, Table 3). Mean weight per trap was significantly greater in this trap for all depth strata where jonah crabs were captured.

Size and Sex Composition

G. fenneri – Male golden crab were significantly more numerous than females, outnumbering them by 3051 to 167 (P<0.001). No ovigerous females were collected during the study. The dominance of male golden crab was statistically significant (P<0.001) for strata 1-3 (Table 4). In these depth strata, males were more than 20 times as numerous as females. In depths of 550–732m, a male G. fenneri was the only crab collected. In the deepest

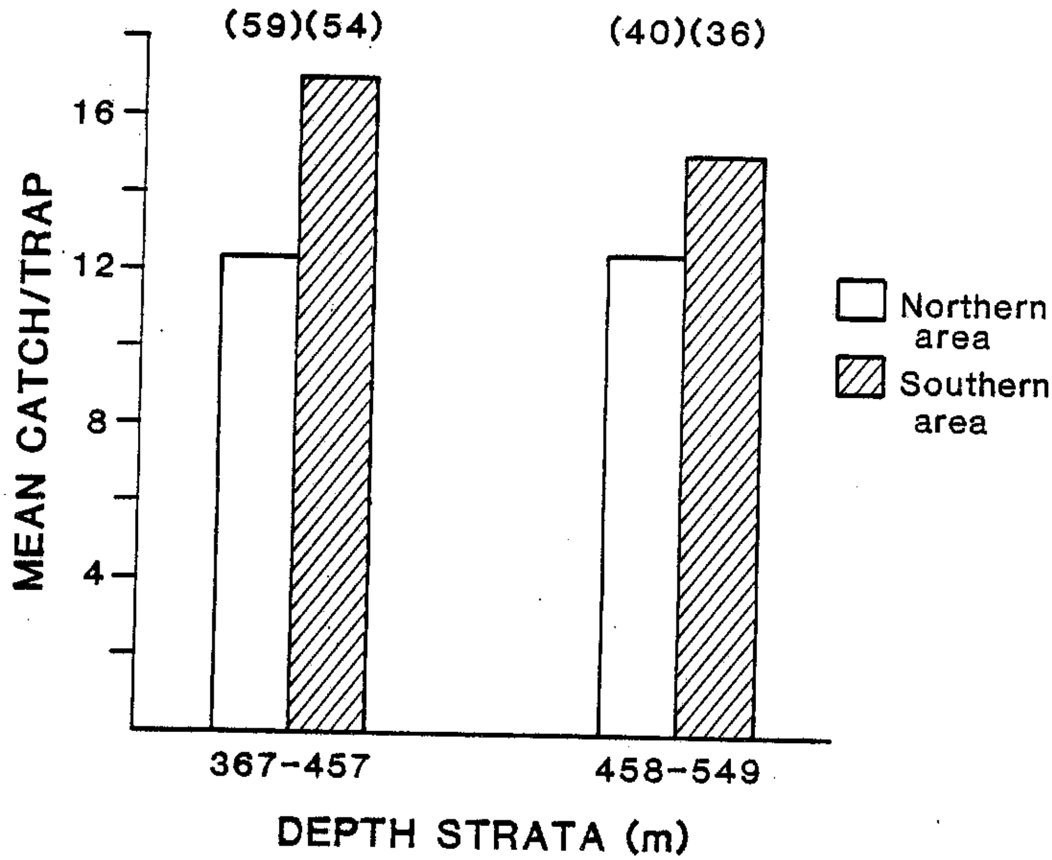


Figure 4. Mean number of G. fenneri per trap for two depth strata in the northern and southern portions of the study area. Effort (number of traps) is shown in parentheses.

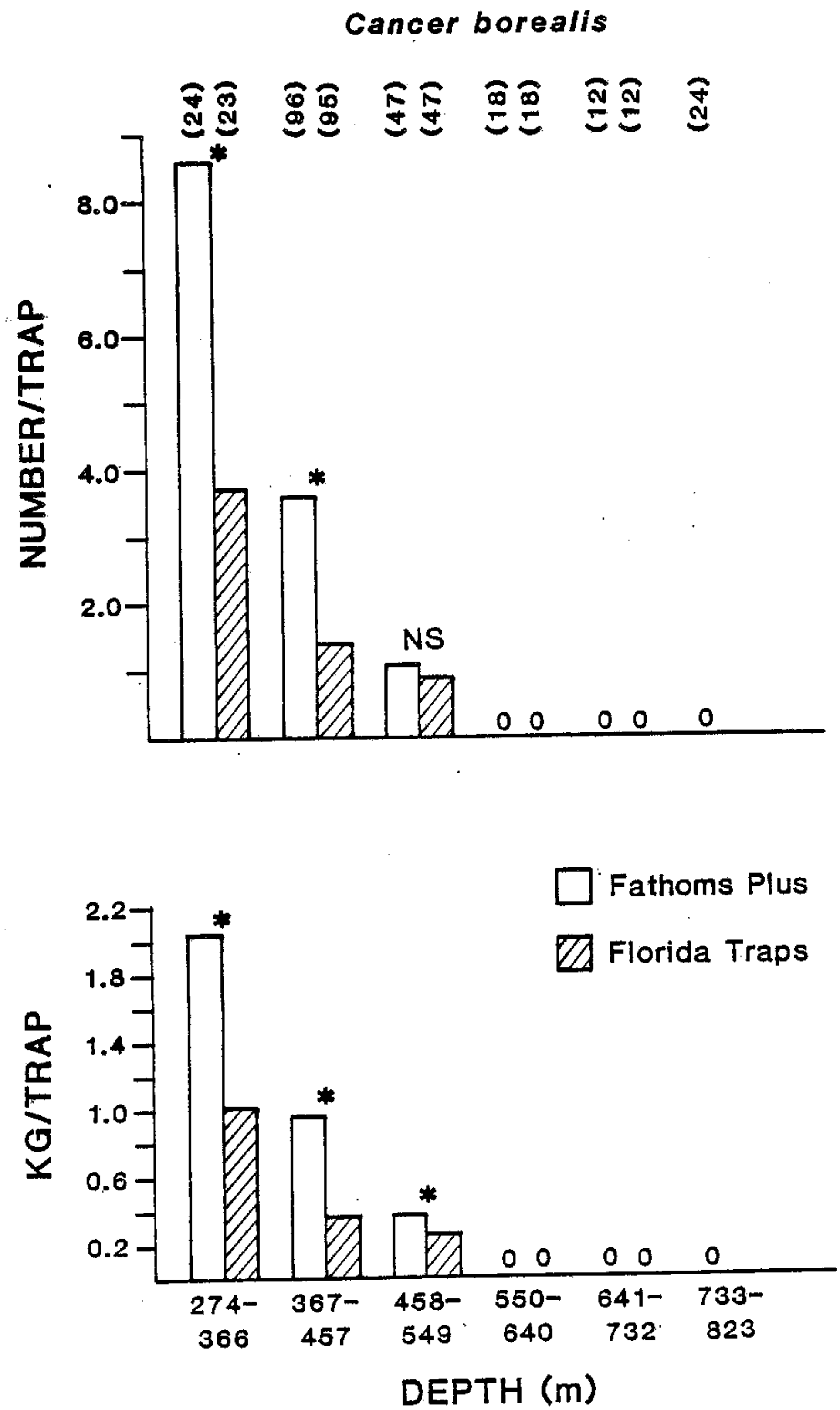


Figure 5. Catch per trap of Cancer borealis for six depth strata sampled. Effort (number of traps) is shown in parentheses. Statistical significance, as determined by two-sample t-test, is indicated by * (P<0.05). NS indicates no significant difference in catch rates between the two trap types.

Table 4. Frequency of male and female *G. fenneri* and *C. borealis* within each depth stratum. Asterisks denote significant deviation from 1:1 by Chi-square analysis.

	STRATA (m)					
	274-366	367-457	458-549	550-640	641-732	733-823
G. fenneri						
Male	84*	1790*	1165*	0	1	11
Female	3	91	41	0	0	32*
C. borealis						
Male	301*	477*	96	-	-	--
Female	12	11	0	-	-	--

stratum sampled (641-732m), females significantly outnumbered males 2.9:1 ($P<0.01$). Although the Florida trap caught significantly more crabs than the Fathoms Plus trap overall, no significant difference was noted in the number of female crabs between these two trap types ($X^2 = 0.148$, $P>0.5$).

The 3217 golden crab which were measured ranged from 85mm to 193mm in carapace width and weighed from 100 g to 2109 g. Male crabs were significantly larger than females in carapace width ($t_s = 18.75$, $P<0.001$) and heavier in weight ($t_s = 14.91$, $P<0.001$). Carapace width frequency distribution for *G. fenneri* gave modes at 155mm for males and 100mm for females (Figure 6). The largest crab collected measured 193 mm and weighed 2091 g. Average weight of male golden crab collected during the study was 927 g ($s = 373.448$, $n = 1640$) while average weight of females was 443 g ($s = 289.385$, $n = 86$).

Linear least-squares and functional regression equations (Ricker 1973; Sokal and Rohlf 1983) were calculated to explain the relationship between carapace length (L) and width (W). For males (n = 3042), these relationships were :

Linear: $CL = -9.54 + 0.892\ CW$, $r^2 = 0.95$

Functional: $CL = -11.96 + 0.909\ CW$

For the 141 females measured, these relationships were:

Linear: $CL = 4.01 + 0.769\ CW$, $r^2 = 0.92$

Functional: $CL = 0.664 + 0.801\ CW$

The relationship between the logarithmically ($\log_{10}$) transformed variables of carapace width (CW) and wet body weight (Wt) was calculated for male and female *G. fenneri* that were not missing appendages. For males (n = 1453) this relationship was:

Linear: $\log_{10}Wt = -4.739 + 3.54\ \log_{10}CW$, $r^2 = 0.94$

Functional: $\log_{10}Wt = -4.995 + 3.66\ \log_{10}CW$

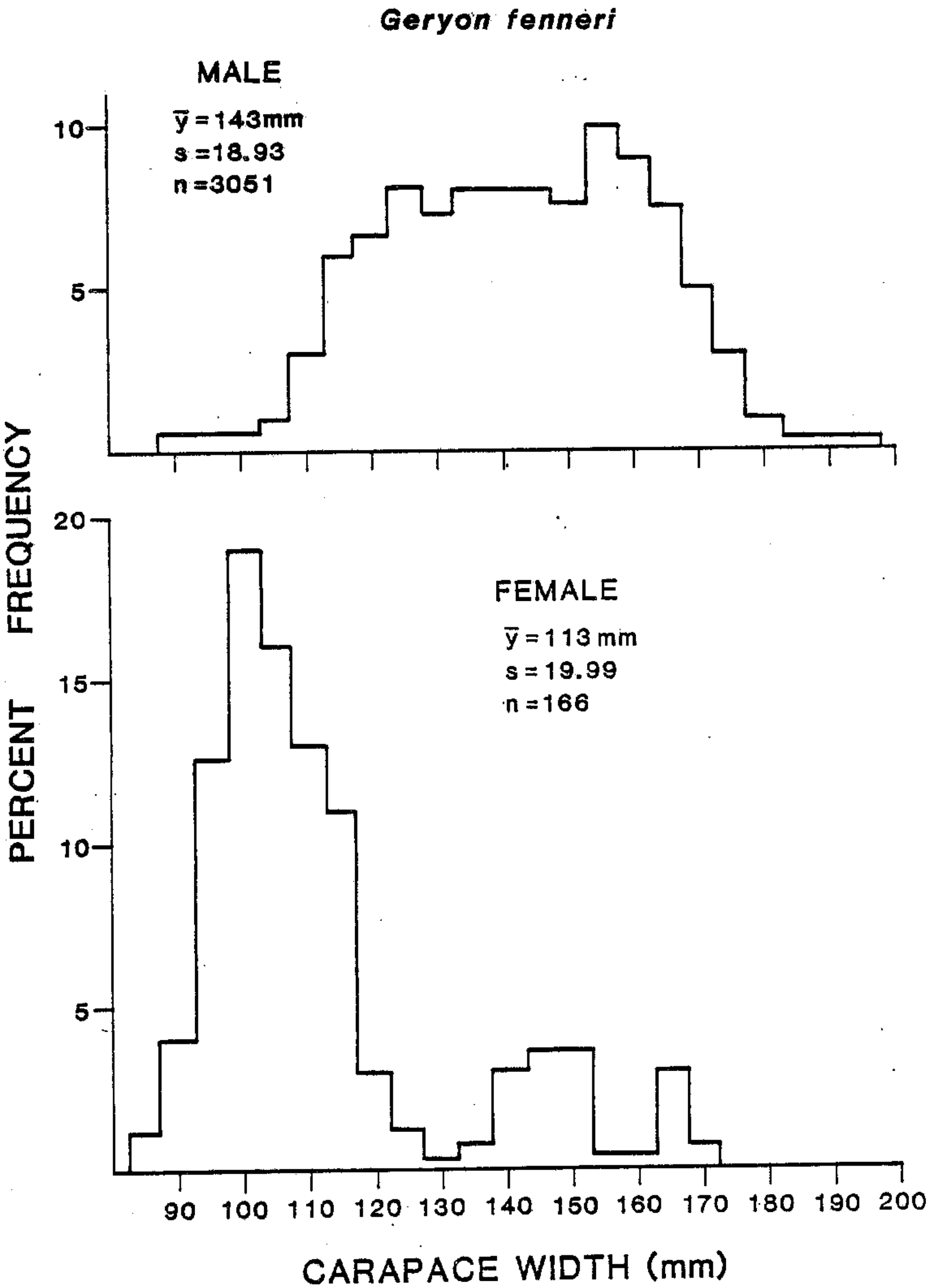


Figure 6. Width-frequency distributions of male and female G. fenneri caught with experimental traps.

The relationship for 74 females measured was:

Linear: $\log_{10}Wt = -3.967 + 3.14 \log_{10}CW$, $r^2 = 0.91$

Functional: $\log_{10}Wt = -4.273 + 3.29 \log_{10}CW$

Of the 3183 crabs examined for missing appendages 2.4% were missing one or both chelae. Pereopods were missing from 307 individuals (9.6%)

Examination of carapace width and weight statistics for each depth stratum suggested that mean size of male G. fenneri was greatest for the shallowest (274-366m) and deepest (733-823m) strata sampled (Table 5). For females, however, mean carapace width and weight was greatest in the 733-823m depth zone. At depths of peak abundance, mean carapace width (t'_s - 4.70, $P<0.001$) and mean body weight ($t'_s = 2.70$, $P<0.01$) of male crabs was significantly greater in the 367-457m than in the 458-549m depth strata. No significant differences, however, were noted in mean carapace width ($t_s = 0.85$, $P>0.05$) and mean body weight ($t_s = 1.48$, $P>0.05$) of females from these same strata.

Of the two traps used, the Fathoms Plus trap caught larger and heavier golden crab than did the Florida trap. Mean carapace width ($\bar{x} = 143.$ mm, s = 19.69, n = 1303) of crabs in the Fathoms Plus trap was significantly larger than that of crabs in the Florida trap ($\bar{x} = 139$, s = 20.21, n = 1914)[t_s = 5.478, $P<0.001$]. A statistically significant difference was also noted for mean weight (Fathoms Plus: $\bar{y} = 928$, s = 366.77 n = 775; Florida: $\bar{y} = 881$, s = 377.69, n = 951)[$t_s = 2.598$, $P<0.001$].

C. borealis - A total of 874 male jonah crab and 23 females were collected during the study. Sex ratios deviated significantly from 1:1 in strata 1-3 where C. borealis were collected (Table 4).

Male jonah crab which averaged 128mm CW (s = 8.99, n = 874) were significantly larger than females ($\bar{y} = 105$, s = 7.39, n = 23)[$t_s = 14.33$, $P<0.001$] and weighed more (Male: $\bar{y} = 268$ s = 69.36, n = 839; Female: $\bar{y} = 151$g,

Table 5. Size and weight statistics of male and female G. *fenneri* from six sampled depth strata.

	STRATUM (m)	CARAPACE WIDTH (mm)					WEIGHT (G)		
		Mean	Min.	Max.	s	n	Mean	s	n
Male	274-366	156	117	186	14.4	84	1064	339.15	84
	367-457	144	100	190	18.1	1790	937	354.03	983
	458-549	140	88	193	19.9	1165	884	373.47	561
	550-640	---	---	---	----	----	---	-----	---
	641-732	139	---	---	----	1	809	-----	1
	733-823	161	135	181	11.7	11	1112	225.22	11
Female	274-366	105	92	113	11.2	3	189	80.88	3
	367-457	105	85	145	8.6	91	265	103.13	35
	458-549	104	85	137	9.7	41	228	70.06	16
	550-640	---	--	---	----	----	----	------	---
	641-732	---	--	---	----	----	----	------	---
	733-823	149	117	170	13.6	31	768	201.09	32

s = 34.21, n = 23) [t'_s = 15.44, P<0.001]. No crabs of either sex smaller than 85mm CW were collected; however, maximum size of male C. borealis was 155mm (Figure 7).

A carapace width and length relationship was established for male C. borealis (n = 874) by the following equations:

Linear: CL = 5.48 + 0.573 CW, r^2 = 0.80

Functional: CL = -3.17 + 0.641 CW

The relationship between the logarithmically ($\log_{10}$) transformed variables of carapace width and body weight for 471 male crabs with no missing appendages was:

Linear: $\log_{10}$Wt = -4.24 + 3.17 $\log_{10}$CW, r^2 = 0.72

Functional: $\log_{10}$Wt = -5.42 + 3.73 $\log_{10}$CW

These relationships were not calculated for female C. borealis because of small sample size.

Of the 895 C. borealis examined for missing appendages, 14% were missing one or both chelae. Pereopods were missing from 320 individuals (35.8%), all of which were males.

No marked differences were noted in mean carapace width between strata 1-3 for male or female C. borealis (Table 6). Weight, however, was greatest in the 367-457m depth stratum for both sexes.

Jonah crab collected in the Florida trap ($\bar{y}$ = 128mm, s = 8.6, n = 276) were significantly larger in mean carapace width than those in the Fathoms Plus trap ($\bar{y}$ = 127mm, s = 10.0, n = 621) [t'_s = 1.99, P<0.05]. Mean body weight was also significantly greater in the Florida trap ($\bar{y}$ = 273 g, s = 66.28, n = 266) than in the Fathoms Plus trap ($\bar{y}$ = 261g, s = 72.98, n = 596) [t'_s = 2.37, P<0.05].

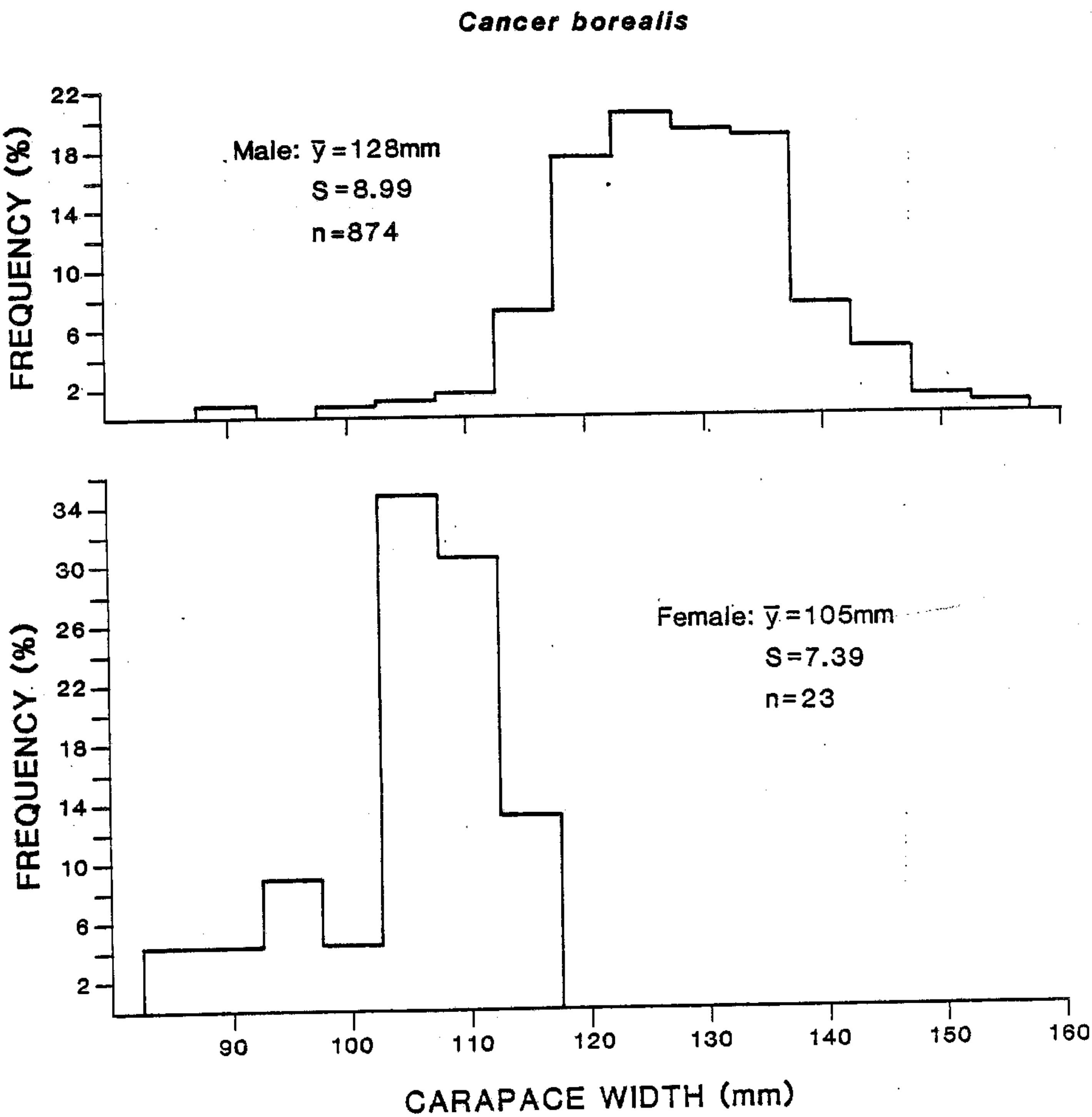


Figure 7. Width-frequency distributions of male and female C. borealis caught with experimental traps.

Table 6. Size and weight statistics of male and female C. borealis for depth strata.

	STRATUM (m)	CARAPACE WIDTH (mm) Mean	Min.	Max.	s	n	WEIGHT (G) Mean	s	n
Male	274–366	130	111	152	9.8	301	268	81.54	301
	367–457	127	92	155	8.6	477	271	61.12	447
	458–549	127	98	145	7.3	96	250	61.23	91
Female	274–366	107	95	111	4.9	12	146	30.04	12
	367–457	104	87	115	9.5	11	158	38.77	11

REPRODUCTIVE BIOLOGY

G. fenneri - Of the 73 crabs examined, 39 sectioned sufficiently well to provide histological preparations from which four developmental stages could be described: 1) early, 2) intermediate, 3) advanced and 4) mature.

In the early stage of development, the slightly lobate ovary is very small, transparent to white in color, and bounded by fibrous connective tissue. Oocyte diameter ranged from 58 to 92 μm with a mean of 75 μm (Figure 8A). Nuclei and nucleoli are apparent in the oocytes, as are follicle or accessory cells which surround each cell. In the larger oocytes, cytoplasmic vitellin globules indicative of vitellogenesis are present.

The ovary at the intermediate stage is yellow in color, occupies more space in the body cavity, and has more pronounced lobation than the early stage ovary. The diameter of oocytes ranged from 112-175 μm with a mean diameter of 145 μm. The number of oocytes undergoing vitellogenesis increased markedly in this stage (Figure 7B).

As the ovary matures to the advanced stage, the ovarian lobes become well developed and the color becomes light orange to orange-red in color. The anterior portion of the ovary obscures that portion of the hepatopancreas from dorsal view. Oocytes are 175-300 μm in diameter ($\bar{y}$ = 240 μm) and enlarge as vitellogenesis continues (Figure 7C).

The mature ovary, brown to purple in color, is the dominant visible organ and obscures the hepatopancreas in dorsal view. Oocytes are tightly packed with yolk globules averaging 300 to 400 μm in diameter as vitellogenesis nears completion.

Size at sexual maturity was difficult to assess because of the small number of female crabs collected. Considerable overlap existed in the size of female G. fenneri in each stage of development. The carapace width of females having early ovarian development ranged from 85-116mm ($\bar{y}$ = 104mm, n = 27).

Intermediate ovaries were present in females measuring 105-169mm CW ($\bar{y}$ = 127 mm, n = 13) while advanced ovaries occurred at sizes from 110-136mm CW ($\bar{y}$ = 123, n = 2). The 29 females with mature ovaries ranged from 97-169mm CW ($\bar{y}$ = 141).

Five vulval forms were identified among the 142 females examined for vulvae conditions as defined by Haefner (1977). Most of the females had immature vulvae (types a and b) suggesting that these crabs had not recently mated. Ovarian condition in a subsample of these females indicated all had early development (Table 7). Only one female (111mm CW) with immature vulvae had sperm present in the seminal receptacles, indicating copulation had occurred. Vulvae type c was noted on two females, one having ovaries in early development with no sperm present in the seminal receptacles while the other crab had mature ovaries and sperm present. Vulvae type e and f were found on the largest females collected, all of which had at least intermediate stage ovaries. Eight of the fourteen females with these vulval types whose seminal receptacles were examined had been inseminated.

Three male _G. fenneri_ examined exhibited typical brachyuran reproductive morphology. The testes which are dorsal to the hepatopancreas are tubular and highly lobate. The testicular lobes, adjacent to the central seminiferous duct, contain spermatocytes, spermatids, and spermatozoa, suggesting asynchronous development (Fig. 8D). After maturation, ripened spermatozoa move into the seminiferous duct. Examination of the testes and vas deferens by scanning electron microscopy revealed germ cells at various stages of development. Maturing sperm cells (Figure 9A), surrounded by supportive tissue, were observed within a single lobe of the testis. These spermatids appear to be composed of a central nucleus framed in cytoplasm. The cytoplasm may reshape to form multiple projections or spikes indicative of maturing

Table 7. Incidence of vulval type in relation to carapace width and gonadal condition of female *Geryon fenneri*.

Type	n	Carapace Width (mm)	n	Gonad Condition
a	112	85 - 119	22	early
b	4	98 - 116	4	early
c	2	97 - 109	1	early
			1	mature
d	0	----	0	---
e	19	105 - 156	8	intermediate
			1	advanced
			9	mature
f	5	124 - 169	2	intermediate
			3	mature

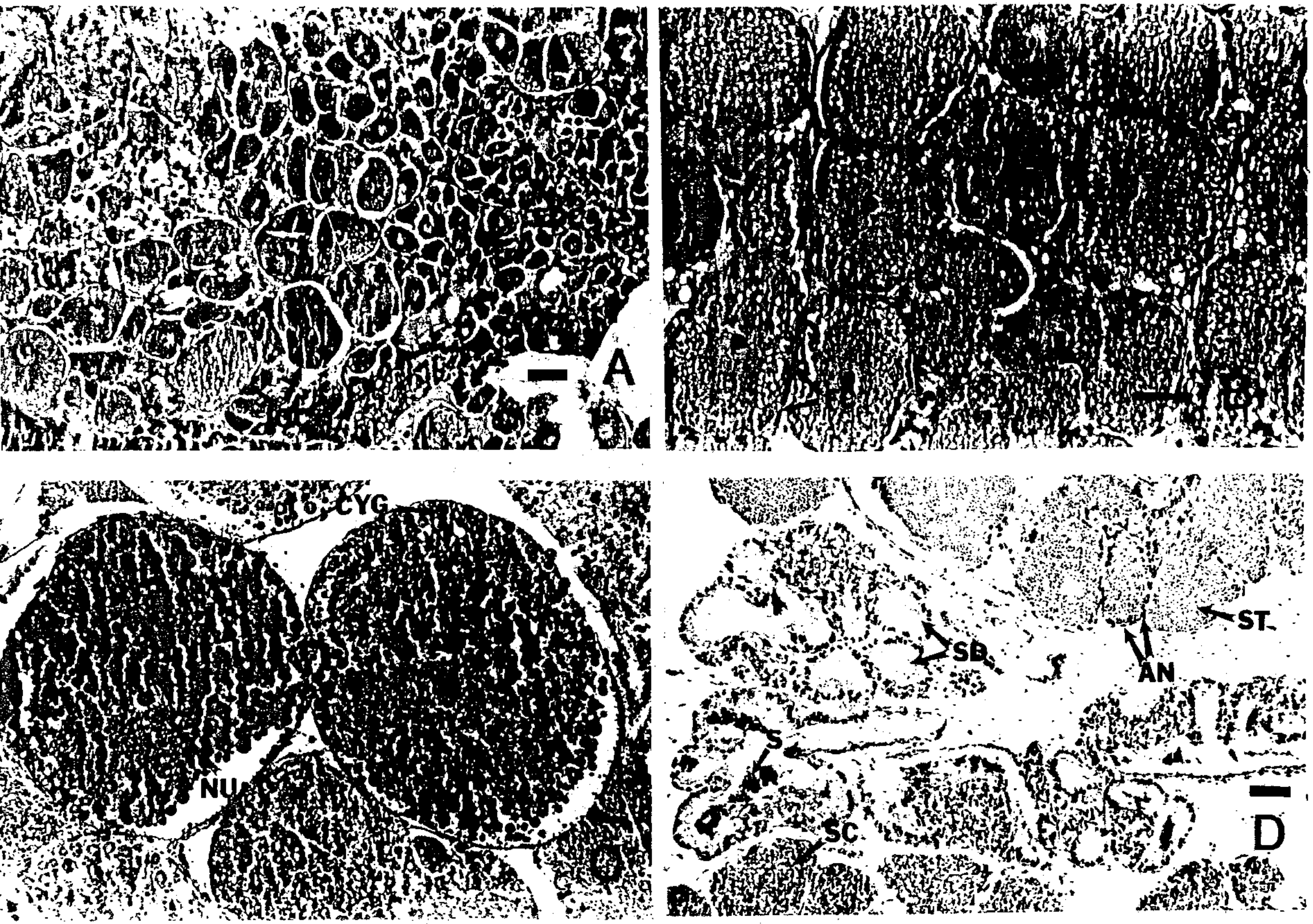
Figure 8. Ovarian and testicular tissue of Geryon fenneri.

A. Ovarian tissue showing early (EDC) to intermediate oocyte (IOC) development. Oocytes range in size from 30–100 μm. Scale bar 60 μm.

B. Oocytes at the intermediate stage of development. Nucleus (N), nucleolus (NU), cytoplasmic yolk globules (CYG), follicle cells (FC). Oocytes size extremes are 100–125 μm. Scale bar 60 μm.

C. Oocytes in the advanced stage of development. Nucleus (N), cytoplasmic yolk granules (CYG). Oocytes 200–300 μm in size. Scale bar 15 μm.

D. A portion of a mature testis showing the seminiferous duct (SD) and testicular lobes containing spermatocytes (SC), spermatids (ST) and sperm (S). Acessory cell nuclei (AN). Scale bar 10 μm.


A
B
CYG
NU
SB
AN
ST
S
SC
D

spermatids (Figure 9A). In addition to spermatids, the testes contain mature sperm which possess well-defined cytoplasmic spikes (Figure 9B). A sagittal section through the vas deferens revealed a complex of supportive tissue in which the stellate spermatzoa are embedded (Figure 9C,D).

C. borealis - Of the 23 females C. borealis collected, 20 individuals ranging from 91mm to 115mm carapace width were vivisected for gross and histological examination of the ovaries. Seminal receptacles from 14 females were also examined histologically for presence of sperm. These methods indicated that ovarian condition was either moderate ($\bar{y}$ = 105mm CW, n = 4), advanced ($\bar{y}$ = 107mmCW, n = 9), or mature ($\bar{y}$ = 107mmCW, n = 7). Sperm was present in all seminal receptacles examined.

Molt Condition and Fouling

The majority of male and female G. fenneri and C. borealis were in the inter-molt stage (Table 8). Less than 1% of the male golden crab collected showed evidence of having recently molted. Incidence of imminent or recently molted female G. fenneri was higher than that observed for males, with four individuals classified as premolt (soft-old) and two in the newly molted (soft-new) condition.

Most (95%) of the 3183 G. fenneri for which molt condition was noted had blackened abraded areas on the exoskeleton, indicative of damage by chitinolytic bacteria. Exoskeleton damage was most prevalent on individuals in the intermolt (75%) and premolt (19%) condition. Incidence of chitinolytic bacteria was also high (89%) among the 895 C. borealis examined for this condition. Jonah crab in the premolt condition (hard and peeler stages) were most affected with 85% occurrence.

Figure 9. Scanning electron micrograph of testis and vas deferens from male *Geryon fenneri*.

A. *Geryon fenneri* testis. Maturing germ cells (spermatids, ST) surrounded by sustentacular tissue. Developing sperm (D-S), cytoplasmic spike (sp), x 4000. Scale bar 3 μm.

B. *Geryon fenneri* testis. A developing sperm (D-S) possessing partial to fully formed cytoplasmic spikes (sp); x 4000. Scale bar 3 μm.

C. *Geryon fenneri* vas deferens. Mature multiple stellate sperm (s) showing cytoplasmic spike (sp); x 4800. Scale bar 2 μm.

D. *Geryon fenneri* vas deferens. Pockets (p) within the vas deferens previously occupied by the mature stellate sperm; x 2000. Scale bar 10 μm.

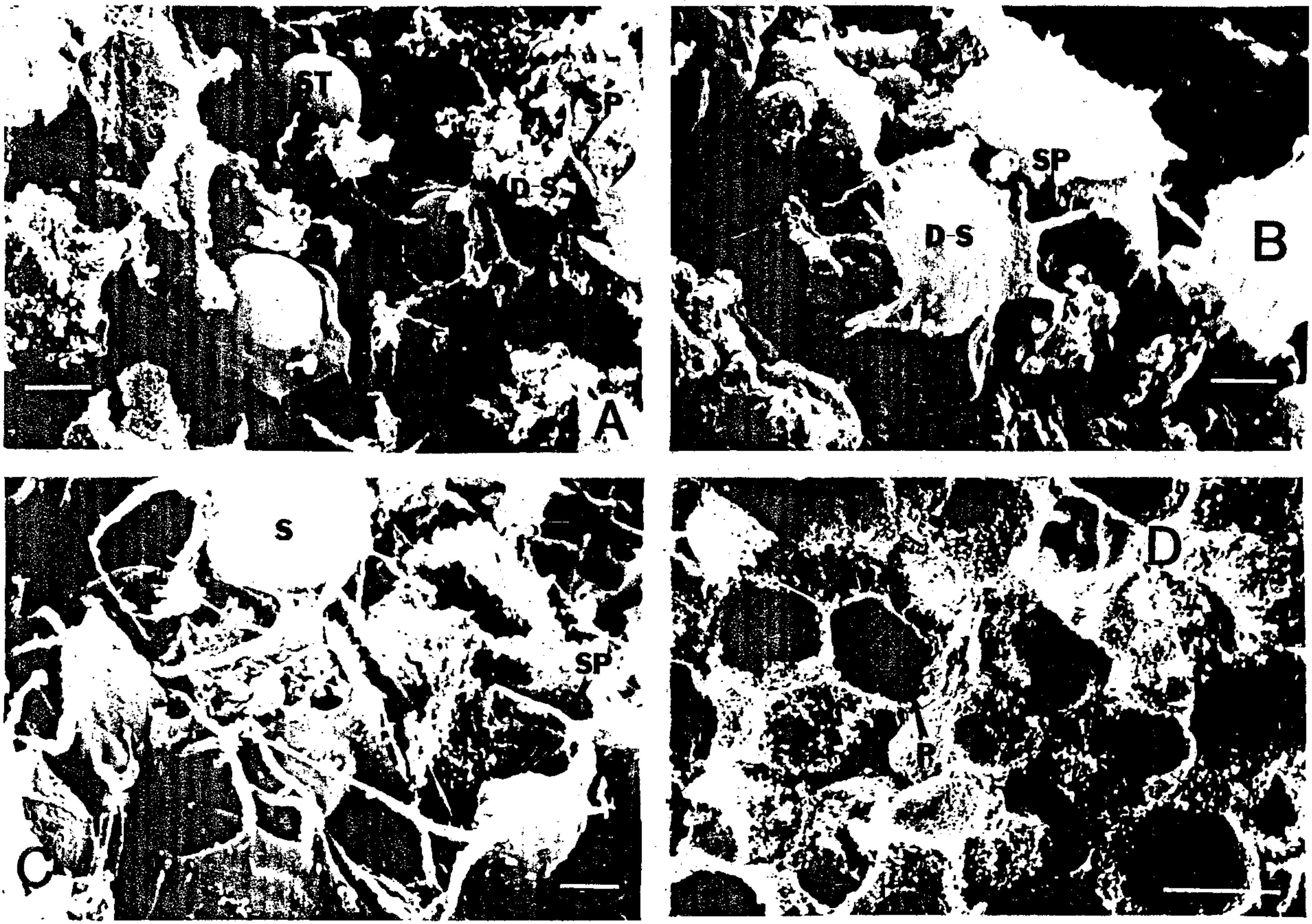

ST
SP
D-S
A
SP
D-S
B
S
SP
C
D
P

Table 8. Exoskeleton condition of male and female *G. fenneri* and *C. borealis*.

G. fenneri	Intermolt	Pre-Molt		Post-Molt	
	Hard	Hard-Old	Soft-Old	Soft-New	Hard-New
Male	2413	586	23	6	13
Female	131	5	4	2	0
%	79.9	18.6	0.8	0.3	0.4

C. borealis	Hard	Peeler	Soft	Papershell
Male	620	208	34	10
Female	21	0	2	0
%	72	23	4	1

Processing and Marketing

Approximately 1,000 lbs. live weight of golden crab were distributed to two of the major blue crab processors in South Carolina, so that the private sector would gain experience with the handling and processing characteristics, as well as marketing aspects of this crab. Although complete evaluations from the project participants are not currently available, they have supplied the following results. One processor who steamed and picked the crabs in the traditional blue crab fashion has reported meat yields between 10% and 11%. Five market forms were selected including special white or flake meat, jumbo lump, leg meat, cocktail claws and claw meats (the carpus). Twenty-two pounds of this product was retained by the Seafood Marketing Services Section of SCWMRD for evaluation by appropriate user-groups. Of this total, 12 lbs. went to Johnson and Wales Culinary College in Charleston for recipe development and comparison with other types of crab meat. The remaining ten lbs. was provided to the Greater Charleston Chef's Association. They in turn provided the product for consumer comparison to Marianne's, a Charleston restaurant specializing in French cuisine. The first processor placed the balance of the inventory with several of its better accounts in the Myrtle Beach area for similar evaluations.

The second processor took a somewhat different approach with the product it received. Rather than processing the crabs, its share was shipped to two major live-crab buyers in Baltimore. These buyers in turn marketed live golden crab at the retail level or served them steamed in restaurants as an entree or "take out" order. Apparently, the response in Baltimore has been favorable as a standing order for 750 lbs. per week has been placed with this processor.

DISCUSSION

Golden Crab

Results of our first year study suggest that G. fenneri have a wide bathymetric occurrence in the South Atlantic Bight. Depth extremes for the species probably extend beyond those encompassed by our sampling design, however. Records of Geryon sp. and G. affinis (which were probably G. fenneri) from the Gulf of Mexico indicate a depth distribution of 365 to 1455m (Pequegnat 1970), while Luckhurst (1985) reported golden crab at depths from 786-1462m off Bermuda.

Although a broad bathymetric range for the species is likely, maximum abundance appears to be concentrated between 367-549m in our study area. This depth coincides with that reported by Stone and Bailey (1980) for maximum trap catches of red crab along the Scotian Shelf and approximates the limits (320-503m) determined by Wigley et al. (1975) by trawl and photographic methods to be most productive for that species off the northeastern U.S. Information on sediment composition taken coincidentally with fishing activities suggests that abundance of both G. fenneri and G. quinquedens may be influenced by sediment type at these optimum depths. Our results indicate catches were favorable on substrates containing a mixture of silt-clay and foraminiferan shell. Rock and coral rubble bottom such as was encountered in the 550-640m stratum proved to be unproductive for golden crab. Other studies have described an association of G. quinquedens with soft substrates. Wigley et al. (1975) noted that bottom sediments throughout the area surveyed for red crab from offshore Maryland to Corsair Canyon consisted of a soft, olive-green, silt-clay mixture. If golden crab preferentially occur on soft substrates, then their zone of maximum abundance may be further limited within the South Atlantic Bight. Surveys by Bullis and Rathjen (1959) indicate that green mud occurred consistently at 150-250 fathoms between St. Augustine and Cape Canaveral, Florida (30°N and 28°N). These same depths from Savannah, GA to St. Augustine were generally characterized by Bullis and Rathjen (1959) as extremely irregular bottom with some smooth limestone or "slab" rock present. Our study indicates, however, that the bottom due east between Savannah and St. Catherines Island at 150-300 fathoms consists of mud and biogenic ooze. Further north from Cape Fear to Savannah, Bullis and Rathjen (1959) reported that the bottom between 150 and 250 fathoms was composed of mud and sand. Low and Ulrich (1983) found bottom topography to be highly valuable in this area with rocky outcrops, sand and mud ooze present. Additional information on sediment type during our Year II fishing efforts will be necessary before any validation of sediment preference by golden crab can be made.

Catch per trap of golden crab from this survey compares favorably with catch rates reported by Otwell et al. (1984) in the Gulf of Mexico. Although their study was not intended to assess the resource, they reported mean catch per trap values of 7.4 - 8.4 for the nested design fished between 210 and 340 fms. Information on catch rates of red crab from trap surveys and the fishery is perhaps more relevant to our study. Ganz and Herrmann (1975) reported an overall unculled mean catch per pot of 40-93 crabs off southern New England. Their study used four types of double parlor offshore lobster pots. An average catch of 26.8 crabs per trap (conical-top entry) was reported in 360-540m depths on the Scotian Shelf by Stone and Bailey (1980). The only available information on weight per trap was provided by Gerrior (1981) who found seasonal catch rates that ranged from a low of 8.4 kg in March to a high of 11.1 kg per pot in June. Although comparison of catch per unit of effort between these studies is questionable because trap type and fishing duration, as well as physical features of the sampling areas differ, catch per trap of golden crab in depths of maximum abundance off South Carolina and Georgia appears promising.

Estimates of the resource potential of golden crab within our study area represent minimum values since actual effective fishing area per trap is influenced by a number of factors such as fishing duration (Rothschild et al. 1970), stage of molt cycle (Watson 1971), trap design (Watson and Simpson 1969) and fullness of trap (Miller 1975). In addition, the distance between traps *in situ* may be highly variable, and it is questionable whether the effective fishing area is symmetrical. McElman and Elner (1982) indicated that trap influence may be greater than the assumed radii of half the distance between traps, in which case fishing area would overlap and trap competition would exist . Furthermore, our estimate of EFA represents only a fraction of the actual area of influence of a trap since bait presumably attracts a portion of crabs from a large area rather than all of the crabs in a small area (Miller 1975). EFA may change with strength of current and age or amount of bait present. Since bait is presumably reduced over time, EFA may be reduced as soak time increases. With these limitations in mind, the density of golden crab reported from the two depth strata between 367-549m is much lower than the highest density estimate (~22400/km^2 for a 37.34 km^2 area in 360-540m) suggested for *G. quinquedens* on the Scotian shelf by Stone and Bailey (1980). Using an EFA of 2300m^2, they reported the population estimate of red crab was 2.3 x 10^6 in a 2767 km^2 area. In another trap survey of red crab on the Scotian shelf McElman and Elner (1982) assumed an EFA of 3000 m^2 and reported the trapable number of crabs to be 3.8 x 10^6 with a trapable biomass of 1.7 x 10^6 kg between 183-732m in a 2186 km^2 area. Considering the smaller sampling area (586 km^2) encompassed by our study, the total estimated population size of golden crab (1.1 x 10^6 crabs and 938,932 kg) is comparable. Density estimates from all of these studies remain substantially below those reported by Wigley et al. (1975) for red crab off southern New England. Using photographic techniques to estimate density, they calculated that red crab densities could be as high as 258-282/ha in the 320-640m depth range. They estimated 182 million crabs inhabit the entire study area from Maryland to Corsair Canyon off Georges Bank at depths from 229-1646m. Submersible activities planned during the second year of our study should provide much needed information on *in situ* densities of golden crab which can be used to determine effective fishing area of traps and population size. This information will enable us to make more meaningful comparisons of golden crab population size off the southeastern U.S. with historical estimates of the red crab resource potential off New England.

Comparison of catches (no./trap) between the Fathoms Plus trap and the Florida trap clearly indicated superiority of the latter for golden crab. Catches of jonah crab, however, were reduced for that design. These two traps also differed in the size and weight of species caught, with larger and heavier golden crab occurring in the Fathoms Plus trap. The Florida trap, however, captured jonah crab that were larger and weighed more than those in the Fathoms Plus trap. Differences observed between traps may be related to trap design which affects success of entry and maximum catch (Miller 1980) or behavioral interactions which affect probability of capture (Richards et al. 1983). Although no studies have been done to evaluate behavior of *G. quinquedens* or *G. fenneri* to traps, responses of the spider crab, *Hyas araneus* , and the rock crab, *Cancer irroratus* to top and side entry traps were reported by Miller (1980). He found success of entry by *C. irroratus* was greater, escapement was reduced and fewer agonistic encounters occurred in top entry traps. In a complementary study, however, *Cancer productus* had highest success in entering a side entry trap whose entrances were parallel to the current. Although our traps were deployed parallel to current, their location on the bottom relative to the current is unknown. We are assuming that golden crab were successful in locating the entrance and were retained longer in the top entry Florida trap than in the Fathoms Plus trap. It is possible, however, that golden crab were equally or more successful in locating the side entrances of the Fathoms Plus trap but that escapement, especially of smaller golden crab was higher. This would explain the capture of fewer but larger individuals by the Fathoms Plus trap. Observations of increased size and reduced catch rates for C. borealis in the Florida trap may reflect behavioral and ecological relationship of this species and G. fenneri. C. borealis may have had difficulty scaling the vertical sides of the Florida trap which would explain the difference in catch rates of the two traps. In addition, reduced entry and increased escapement of C. borealis may occur in response to increasing numbers of golden crab in the Florida trap. Such density-dependent effects in catchability have been suggested for American lobster, Homarus americanus and two Cancer species, C. borealis and C. irroratus (Richards et al. 1983).

The overwhelming dominance of males in this study contrasts with results reported in other geographic areas for golden crab. Luckhurst (1985) noted that sex ratio in his sample (n=244) of G. fenneri from Bermuda waters was approximately 1:1. Otwell et al. (1984) noted that males tended to be more abundant at greater depths (>540m) in the Gulf of Mexico; however, they cautioned that trap design may influence the percentage of male crabs caught. Commercial crabbers noted a decline in catch rates and number of male G. fenneri with increasing depth on the slope in the eastern Gulf of Mexico (NMFS, 1986). Our results, which are limited due to the small number of females collected, also suggest increased abundance of females at greater depths. This is apparently not an artifact of sampling with only the Fathoms Plus trap in the deepest stratum since more females were collected in the Florida trap than with the Fathoms Plus trap when only strata 1-3 were considered. Segregation of the sexes by depth has been observed in several studies of G. quinquedens. Wigley et al. (1975) found female red crab were substantially more numerous than males, but this dominance was limited to intermediate depths (320-503m). Ganz and Herrman (1975) similarly noted dominance by male red crab at depths >685m off Rhode Island. This same pattern was noted for red crab in the vicinity of Norfolk Canyon where females were more abundant than males from depths <600m (Haefner and Musick 1974); Haefner 1978). In Canadian waters, however, female red crab were reported by Stone and Bailey (1980) to be considerably less abundant than males. Although they attributed this discrepancy to trap bias, another study in the same general area found females were present but highly contagious in distribution. Additional effort in the deeper strata during the second year of our study should reveal whether a depth-related pattern in sex ratios exists for golden crab. Whether seasonal migrations related to mating or spawning occur as hypothesized by Wigley et al. (1975) for G. quinquedens remains to be substantiated. What is evident from our results is that male G. fenneri are dominant in depth strata where catch per unit of effort is highest.

Size related distribution of G. fenneri with depth similar to that reported for red crab, may occur in the South Atlantic Bight. Study results suggested that largest crabs were located in the shallowest (274-366m) and deepest (733-823m) strata. A clear trend of size-related up-slope migration such as Wigley et al. (1975) reported for G. quinquedens is not apparent, however, because of trap bias for capture of larger crabs of both sexes. Otwell et al. (1984) also noted no pattern in size of golden crab by depth for either sex.

Tagging studies of red crab off southern New England provided no evidence for migration patterns and indicated instead that tagged crabs seldom moved more than 20 km from their site of release (Lux et al. 1982).

The size composition of golden crab from our study suggests that crabs become trappable as small as 85mm CW but that the greatest proportion of trapped individuals is >100mm CW. Over 90% of all individuals collected exceeded 114mm CW which is the minimum size of red crab accepted for commercial utilization (Wigley et al. 1975). A much smaller proportion (52%) of golden crab >114 mm was indicated in size frequency distributions of trap-caught golden crab near Bermuda (Luckhurst 1985). Although Otwell et al. (1984) did not present size and weight frequency data for golden crab in the Gulf of Mexico, they found mean size of male crabs ranged from 155-163mm with mean weight extremes of 1.07-1.15 kg, while females were smaller with mean CW ranging from 119-135mm and mean weight extremes of 0.45-0.50 kg. These data and those from our study suggest that the average size of golden crab from the South Atlantic Bight and Gulf of Mexico is larger than average size of red crab reported along the eastern U.S. and Canada. Wigley et al. (1975) reported average width of male *G. quinquedens* was 99 mm with an average weight of 413 g. Average width of all females from their study was 90mm with a mean weight of 244 g. Comparisons of size composition between the two studies must be qualified, however, by a caveat that differences in sampling methods probably influenced sample statistics. The apparent larger size of golden crab may be better substantiated by maximum width and weight measurements, which for our study were 193mm and 2109g, respectively. These values were markedly larger than those reported for red crab in the vicinity of Norfolk Canyon (Haefner 1978), off northeastern U.S. (Wigley et al. 1975) or the Scotian Shelf (Stone and Bailey 1980; McElman and Elner 1982).

Since no growth data are available for G. fenneri, it is uncertain whether growth rates are comparable to those reported for G. quinquedens. Van Heukelem et al (1981) showed from laboratory experiments that growth of red crab occurs slowly with age at entry to the red crab fishery (114mmCW) estimated at 5.3 yr for 15C or 6.0 yr at 9-12C. They further estimated that it would take 7.0 years at 15C for male red crab to reach the maximum size of 150mm, while females would require 6.5 years to reach their maximum carapace width of 140mm. Based on tagging results, Lux et al (1982) found molt frequency of red crab to be low and suggested a slow growth rate for the species. As a result they concluded that sustained exploitation of the harvested segment of the male population which are old male crabs could exert a considerable mortality on market-size crabs. The likelihood of slow growth rates for G. fenneri suggests that a parallel conclusion may be hypothesized as well.

The small number of females collected during the first year precludes any definitive statements regarding ovarian cycles or spawning patterns. Ovarian developmental stages are similar to those reported by Haefner (1977) for G. quinquedens. We also found his use of vulvae condition as an external indicator of copulation to be fairly reliable, but examination of the seminal receptacles for sperm or spermatophores provided the only true indication of mating. Tentative interpretations on ovarian development, vulval condition and presence of seminal products suggest that females may become sexually mature at 97mm CW. Haefner (1977) suggested that female G. quinquedens become sexually mature within the intermolt size of 80-91mm carapace width.

A lack of ovigerous females in our first-year sampling effort could be indicative of a restricted spawning season similar to that reported for red crab (Haefner 1977; Wigley et al. 1975). Their absence from our samples, however, may merely be related to the small number of female golden crab collected. Observations on molting and mating of a female (110mm CW) which had been held in a refrigerated aquarium since February and completed ecdysis in late May confirmed that female golden crab molt just before mating occurs. This behavior, as well as the observed pre-molt embrace, is common in brachyurans (Hartnoll 1969), although it has not been reported previously for either G. quinquedens or G. fenneri. Additional exploration of the golden crab resource in the second year of our study should provide more females from which we hope to acquire a better understanding of reproductive biology.

Handling golden crab on board presented storage problems similar to those discussed by Otwell et al. (1984) and Holmsen and McAllister (1974). Once crabs were brought on board and were sorted by trap into baskets, processing of individuals for biological information was completed and the catch was culled for small individuals and those recently molted. Stage of ecdysis was an important factor affecting meat condition and yield. Crabs which have recently molted generally have a very poor meat yield and are not marketable. Since most golden crab in the intermolt stage had blackened abraded areas or lepadid barnacles on the exoskeleton, their presence was useful in distinguishing pre-molt from post-molt crabs which were brighter in color and had few abrasions. After culling the catch, crabs were placed between layers of ice in large storage bins on deck. Generally, we found survival of golden crab was good. Survival of crabs during a four or five day fishing trip was probably enhanced by conducting cruises during fall and winter. Minimization of handling will be necessary during other times of the year when temperature on deck is prohibitive for survival.

Jonah Crab

Bathymetric distribution and abundance of C. borealis is consistent with results reported by Haefner (1977) and Carpenter (1978) for the Middle Atlantic

Bight. Haefner (1977) found jonah crab were most abundant between 150-400m from late winter to early summer, while Carpenter (1978) found low abundance at depths <150m and maximum catches between 250 and 350m.

Unequal sex ratios for C. borealis have been attributed to apparent migrational movement of females (Krouse 1980). Haefner (1977) had insufficient data to indicate depth preference by sex but found that very large male crabs occurred in deeper water. Carpenter (1978) first suggested an inshore migration of large females based on their dominance at depths less than 150m. Inshore migration was also suggested for populations near Boothbay Harbor, Maine in which an inshore movement occurs during summer and fall, apparently as a result of behavior associated with molting and mating.

The lack of small C. borealis in our collections is probably related to trap bias. Minimum size of C. borealis captured (85mm) coincides with the same minimum size observed for trapped G. fenneri. Size distribution of jonah crab may also vary with depth, in which small crabs (<41mm) were most abundant at depths <150m (Haefner 1977; Carpenter 1978).

Although jonah crab constitute a small commercial fishery in New England waters, most are discarded as by-catch of the pot fisheries for American lobster and black sea bass (Briggs and Mushacke 1982). Palatability of the claw meat is good but the claws are difficult to crack and meat yield is low compared to that of golden crab. Since decreased abundance of C. borealis occurs with increasing depth and catch rates are apparently lower in top entry traps, abundance of these crabs relative to golden crab could be avoided in commercial trapping if desired.

ACKNOWLEDGEMENTS

This project could not have been completed without the assistance of numerous individuals and organizations.

We are most grateful to R. Beatty, D. Oakley and J. Wise of SCWMRD who helped extensively with all aspects of the project. Initial phases of this project benefited from our discussions with commercial fishermen H. Holley and J. Busse; C.A. Wenner (SCWMRD); W. Rathjen (Florida Institute of Technology); R. Manning (U.S. National Museum of Natural History); and S. Otwell (University of Florida). We also appreciate the hospitality and information on the Bermuda fishery provided by J.P. Ingham (Pathfinder Fisheries) and B. Luckhurst (Bureau of Agriculture and Fisheries). Personnel from the S.C. Wildlife and Marine Resources Department who assisted on cruises included: R. Low, M. Maddox, J. Moran, D. Stubbs, C. Wenner, C. Zemp and the crews of the R/V Oregon and R/V Lady Lisa. J. Keener (S.C. Sea Grant Consortium) also participated regularly in cruises, and together with W. Lacy (S.C.W.M.R.D.), arranged contacts with local crab processing companies. Technical assistance was provided by W. Roumillat for photographic preparations; B. Ashcraft (Medical University of South Carolina) for SEM preparations; K. Swanson who drafted the figures; and M. Lentz who typed the manuscript.

Financial support for this project was provided by the Gulf and South Atlantic Fisheries Development Foundation, the Marquette Foundation, the S.C. Wildlife and Marine Resources Department, and the S.C. Sea Grant Consortium. We are grateful to D. Cupka for his assistance as project manager.

LITERATURE CITED

Beyers, C.J. de B. and G.G. Wilke. 1980. Quantitative stock survey and some biological and morphometric characteristics of the deep-sea red crab Geryon quinquedens off southwest Africa. Fish. Bull. S. Afr. 13: 9-19.

Briggs, P.T. and F.M. Mushacke. 1982. Characteristics of the jonah crab and rock crab in New York waters. N.Y. Fish and Game J. 29(2): 109-126.

Bullis, H.R., Jr. and W.F. Rathjen. 1959. Shrimp explorations off southeastern coast of the United States (1956-1958). Comm. Fish. Rev. 21(6): 1-20.

Carpenter, R.K. 1978. Aspects of growth, reproduction, distribution and abundance of the jonah crab, (Cancer borealis) Stimpson in Norfolk Canyon and the adjacent slope. Univ. Virginia, Charlottesville, Va. M.A. Thesis, 69 p.

Christiansen, M.E. 1969. Crustacea Decapoda Brachyura. Mar. Invert. Scandinavia (Oslo) 2: 1-143.

Ganz, A.R. and J.F. Herrmann. 1975. Investigations into the southern New England red crab fishery. Rhode Island Dept. Natural Resources, Project Rep. New England Fish. Develop. Prog., Natinal Mar. Fish. Serv. 78 pp.

Gerrior, P. 1981. The distribution and effects of fishing on the deep sea red crab, Geryon quinquedens Smith, off southern New England. Southeastern Mass. Univ. North Dartmouth, MA. M.S. Thesis. 130 p.

Haefner, P.A., Jr. and J.A. Musick. 1974. Observations on distribution and abundance of red crabs in Norfolk Canyon and adjacent continental slope. Mar. Fish. Rev. 36(1): 31-34.

Haefner, P.A., Jr., 1977. Aspects of the biology of the jonah crab, Cancer borealis Stimpson, 1859 in the mid-Atlantic Bight. J. Nat. Hist. 11: 303-320.

Haefner, P.A., Jr. 1977. Reproductive biology of the female deep-sea red crab, Geryon quinquedens, from the Chesapeake Bight. Fish. Bull. 75(1): 91-102.

Haefner, P.A., Jr. 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: 49-62.

Hartnoll, R.G. 1969. Mating in the Brachyura. Crustaceana 16: 161-181.

Holmsen, A.A. and H. McAllister. 1974. Technological and economic aspects of red crab harvesting and processing. Univ. Rhode Island Mar. Tech. Rep. No. 28. 35pp.

Krouse, J.S. 1980. Distribution and catch composition of jonah crab, Cancer borealis, and rock crab, Cancer irroratus, near Boothbay Harbor, Maine. Fish. Bull. 77(3): 685-693.

Low, R.A. and G.F. Ulrich. 1983. Deep-water demarsal finfish resources and fisheries off South Carolina. S.C. Mar. Resource Cent. Tech. Rep. No. 57. 24 pp.

Luckhurst, B. 1985. Discovery of deep-water crabs (Geryon spp.) at Bermuda - a new potential fishery resource. Proc. 37th Anov. Gult Carib. Fish. Instit. (in press)

Lux, F.E., A.R. Ganz, and W.F. Rathjen. 1982. Marking studies on the red crab Geryon quinquedens Smith off southern New England. J. Shellfish Res. 2(1): 71-80.

Manning, R.B. and L.B. Holthuis. 1981. West African Brachyuran Crabs (Crustacea: Decapoda). Smith. Contrib. Zool. 306: 379 pp.

Manning, R.B. and L.B. Holthuis. 1984. Geryon fenneri, a new deep-water crab from Florida (Crustacea: Decapoda: Geryonidae). Proc. Biol. Soc. Wash. 97(3): 666-673.

McElman, J.F. and R.W. Elner. 1982. Red crab (Geryon quinquedens) trap survey along the edge of the Scotian shelf, September 1980. Can. Tech. Rep. Fish. Aquat. Sci. 1084: 12 p.

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

Miller, R.J. 1980. Design criteria for crab traps. J. Cons. Int. Explor. Mer. 39: 140-147.

Monrod, Th. 1956. Hippidea et Brachyura ouest-africains. Mem. de l'Instit. Franscais d'Afrique Noire 45: 1-674.

National Marine Fisheries Service. 1986. Species Profile: Deep sea red crab Geryon quinquedens, Smith and Golden crab, Geryon fenneri, Manning and Holthius, 1984 from the Southeastern U.S. south of Cape Hatteras, N.C. Latent Resource Report, Pascagoula Laboratory. 17 pp.

Otwell, W.S., J. Bellairs, and D. Sweat. 1984. Initial development of a deep-sea crab fishery in the Gulf of Mexico. Florida Sea Grant College Report No. 61: 1-29.

Pequegnat, W.E. 1970. Deep-water brachyuran crabs. In: W.E. Pequagnat and F.A. Chace, Jr. (eds.). Contributions on the biology of the Gulf of Mexico. Texas A & M Univ. Oceanogr. Stud. 1: 171-204.

Rathbun, M.J. 1937. The Oxystomatous and Allied Crabs of America. Bull. 166, U.S. Nat. Mus. 278 pp.

Richards, R.A., J.S. Cobb, and M.J. Fogarty. 1983. Effects of behavioral interactions on the catchability of American lobster, Homarus americanus, and two species of Cancer crab. Fish. Bull. 81(1): 51-60.

Ricker, W.E. 1973. Linear regression in fishery research. J. Fish. Res. Board Can. 30: 409-434.

Rothschild, B.J., G. Powell, J. Joseph, N.J. Abramson, J.A. Buss and P. Eldridge. 1970. A survey of the population dynamics of king crab in Alaska with particular reference ot the Kodiak area. Alaska Inp. Leaf. 147, Alaska Dep. Fish Game, Juneau, 149 pp.

Smith, S.I. 1879. The stalk-eyed crustaceans of the Atlantic coast of North America north of Cape Cod. Trans. Conn. Acad. Arts and Sci. 5: 35-37.

Sokal, R.R. and F.J. Rohlf. 1983. Biometry. Second Edition, W.H. Freeman and Co., San Francisco. 850 pp.

Stone, H. and R.F.J. Bailey. 1980. A survey of the red crab resource on the continental slope, N.E. Georges Bank and western Scotian shelf. Can. Tech. Rep. Fish. Aquat. Sci. 977: 9 p.

Van Heukelem, W., M.C. Christman, C.E. Epifanio, S.D. Sulkin. 1981. Growth of Geryon quinquedens (Brachyura: Geryonidae) juveniles in the laboratory. Fish. Bull. 81(4): 903-905.

Watson, J. and S.L. Simpson. 1969. The queen crab industry in the Atlantic Provinces. Ind. Dev. Branch, Dep. Environ., Ottawa, Proj. Rep. 28: 67 pp.

Watson, J. 1971. Ecdysis of the snow crab, Chionoecetes opilio. Can. J. Zool. 49: 1025-1027.

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): 1-27.

Appendix I. Depth, location, soak time, fishing effort and catch per trap for each set.

Set No.	Date	Position ° 'N / ° 'W	Depth (m)	Str	Temp	Soak Time (hrs.)	No. Traps FM+	No. Traps FLA	Geryon Number FM+	Geryon Number FLA	Geryon Weight FM+	Geryon Weight FLA	Cancer Number FM+	Cancer Number FLA	Cancer Weight FM+	Cancer Weight FLA
	1985															
1	21/06	29°55.4'/78°01.5'	806	6		11.7	6		1	—	1.080	—	—	—	—	—
2	21/06	29°53.1'/78°04.1'	808	6	8.6	22.6	6	—	3	—	2.828	—	—	—	—	—
3	21/06	29°53.1'/78°03.0'	808	6	8.6	23.3	6	—	2	—	1.162	—	—	—	—	—
4	21/06	29°53.2'/78°01.8'	810	6	8.6	23.2	6	—	5	—	5.185	—	—	—	—	—
9	05/08	31°56.8'/79°06.6'	463	3	8.2	19.9	3	3	—	9	—	8.954	—	3	—	0.847
10	05/08	31°57.5'/79°07.3'	373	2	8.2	20.1	3	3	6	20	6.128	28.672	17	6	4.606	1.739
12	06/08	31°57.1'/79°08.4'	296	1	8.2	20.7	3	3	1	—	1.302	—	38	18	11.077	5.346
13	06/08	31°55.4'/79°09.3'	298	1	8.2	19.6	3	3	—	—	—	—	43	25	12.486	7.656
15	06/08	32°01.7'/78°59.6'	428	2	8.2	19.9	3	3	20	8	18.261	5.129	—	2	—	0.496
16	06/08	32°01.5'/78°58.8'	377	2	8.2	19.2	3	3	7	15	5.322	14.220	2	2	0.556	0.636
17	06/08	32°02.5'/79°00.3'	410	2	8.2	19.6	3	3	12	24	11.773	19.464	13	1	3.396	0.195
20	07/08	31°57.1'/79°06.1'	466	3	8.2	19.7	3	3	24	23	29.734	26.261	40	13	10.408	3.780
21	07/08	31°58.7'/79°05.1'	450	2	8.2	20.0	3	3	20	13	23.272	15.415	48	7	13.240	1.798
22	07/08	31°59.6'/79°03.5'	437	2	8.2	20.6	3	3	13	9	14.359	8.007	7	10	1.735	2.048
23	24/09	32°20.0'/78°35.0'	366	1	7.8	12.4	3	3	1	2	1.482	2.627	8	3	2.275	0.877
24	24/09	32°21.5'/78°33.6'	362	1	7.8	13.6	3	3	2	1	2.126	1.320	16	5	4.886	1.169
25	24/09	32°19.0'/78°37.0'	362	1	7.8	13.2	3	3	—	—	—	—	24	10	6.652	2.872
26	24/09	32°13.1'/78°33.0'	422	2	8.0	19.6	3	3	7	6	6.385	6.041	18	6	4.267	1.502
27	24/09	32°12.2'/78°31.5'	428	2	8.0	20.1	3	3	3	1	2.921	0.397	25	8	6.895	2.079
28	24/09	32°11.1'/78°31.4'	422	2	8.0	20.2	3	3	6	5	3.212	2.532	16	14	4.294	4.029
29	24/09	32°12.8'/78°35.0'	432	2	8.0	16.0	3	3	2	2	2.205	2.501	22	15	6.538	4.471
30	24/09	32°12.0'/78°34.0'	432	2	8.0	15.2	3	3	—	5	—	4.157	20	21	5.373	5.739
31	24/09	32°10.0'/78°33.2'	439	2	8.0	14.2	3	3	4	2	2.796	1.164	22	8	5.963	2.652
32	15/10	31°16.6'/78°26.1'	594	4		21.5	3	3	0	0	—	—	0	0	—	—
33	15/10	31°17.4'/78°24.5'	593	4		22.6	3	3	0	0	—	—	0	0	—	—
34	15/10	31°18.4'/78°22.8'	622	4		23.2	3	3	0	0	—	—	0	0	—	—
35	15/10	31°14.5'/78°28.4'	600	4		24.7	3	3	0	0	—	—	0	0	—	—
36	15/10	31°15.4'/78°26.7'	602	4		23.6	3	3	0	0	—	—	0	0	—	—
37	15/10	31°16.0'/78°24.4'	607	4	9.96	22.1	3	3	0	0	—	—	0	0	—	—
38	16/10	31°08.3'/78°33.6'	689	5		18.1	3	3	0	0	—	—	0	0	—	—
41	16/10	31°07.4'/78°32.1'	706	5		16.4	3	3	0	0	—	—	0	0	—	—
42	16/10	31°08.2'/78°30.8'	697	5		17.0	3	3	1	0	0.809	—	0	0	—	—
43	16/10	31°09.0'/78°29.5'	689	5		17.4	3	3	0	0	—	—	0	0	—	—
	1986															
46	07/01	32°02.0'/79°00.4'	424	2	9.15	14.0	3	3	6	9	5.797	8.650	—	1	—	0.255
47	21/01	31°51.0'/79°12.0'	377	2		20.1	3	3	23	25	24.219	23.825	7	4	1.586	1.177
48	21/01	31°51.5'/79°10.0'	375	2		19.8	3	2	5	19	4.883	19.286	22	1	5.793	0.239
49	21/01	31°51.2'/79°10.5'	371	2		20.2	3	3	22	20	26.228	20.074	12	9	2.735	2.442
50	21/01	31°52.0'/79°10.5'	450	2		22.4	3	3	63	61	57.574	50.090	4	—	1.211	—
51	21/01	31°53.5'/79°10.5'	444	2		22.8	3	3	37	61	33.183	49.621	6	—	1.580	—
52	21/01	31°54.5'/79°09.0'	448	2		23.2	3	3	48	66	44.916	60.280	1	—	0.267	—

Appendix I. Continued:

Set No.	Date	Position °'N °'W	Depth (m)	Str	Temp	Soak Time (hrs.)	No. Traps FM+	No. Traps FLA	Geryon Number FM+	Geryon Number FLA	Geryon Weight FM+	Geryon Weight FLA	Cancer Number FM+	Cancer Number FLA	Cancer Weight FM+	Cancer Weight FLA
53	22/01	31°46.0'/79°16.0'	382	2		18.9	3	3	14	35	13.505	34.005	15	5	3.902	1.220
54	22/01	31°46.5'/79°15.0'	393	2		19.2	3	3	11	27	8.397	27.356	15	1	3.639	0.240
55	22/01	31°47.5'/79°14.0'	386	2		19.8	3	3	11	12	11.889	12.546	16	1	3.847	0.162
56	03/02	31°51.0'/79°10.7'	486	3	7.14	17.8	3	3	30	33	26.150	29.541	3	4	0.644	0.866
57	03/02	31°52.4'/79°09.6'	486	3	7.14	18.2	3	3	37	47	32.997	47.466	6	4	1.656	0.995
58	03/02	31°53.5'/79°08.5'	479	3		18.7	2	3	15	30	12.902	27.759	—	10	—	1.975
59	04/02	31°45.5'/79°15.3'	439	2		20.2	3	3	56	66	45.199	54.228	0	0	—	—
60	04/02	31°46.6'/79°14.3'	426	2		20.7	3	3	43	47	39.502	35.050	7	1	1.846	0.315
61	04/02	31°47.4'/79°13.3'	459	3		21.4	3	3	26	57	21.656	39.839	2	0	0.409	—
62	04/02	31°48.8'/79°12.0'	499	3		20.6	3	3	50	71	40.347	55.418	0	1	—	0.266
63	04/02	31°49.0'/79°11.2'	501	3		21.1	3	2	38	31	32.544	21.881	0	3	—	0.783
64	04/02	31°51.0'/79°10.1'	497	3		21.6	3	3	24	30	21.430	23.083	1	1	0.193	0.210
65	05/02	31°48.9'/79°13.7'	320	1		21.2	3	3	14	15	14.329	12.574	24	14	4.486	3.320
66	05/02	31°50.1'/79°12.6'	331	1		20.2	3	3	11	11	9.400	12.075	34	8	7.300	1.829
67	05/02	31°51.5'/79°11.5'	336	1		19.2	3	2	10	9	11.295	9.773	20	3	3.611	0.527
68	19/02	31°41.6'/79°20.0'	384	2		15.4	3	3	23	64	17.770	53.250	7	5	1.575	1.685
69	19/02	31°42.6'/79°19.0'	384	2		16.0	3	3	40	69	33.300	57.100	1	0	0.242	—
70	19/02	31°43.7'/79°19.9'	381	2		17.8	3	3	26	59	27.770	48.900	19	2	5.284	0.600
71	19/02	31°37.9'/79°22.3'	468	3		22.7	3	3	24	24	18.500	18.700	0	0	—	—
72	19/02	31°38.8'/79°21.4'	476	3		23.4	3	3	28	36	24.500	29.300	1	1	0.270	0.300
73	19/02	31°40.0'/79°20.4'	474	3		23.7	3	3	60	52	49.100	35.500	1	2	0.200	0.500
74	19/02	31°40.9'/79°19.0'	521	3		20.8	3	3	39	53	31.500	39.000	0	0	—	—
75	19/02	31°41.9'/79°17.9'	520	3		21.4	3	3	16	81	14.600	61.100	0	0	—	—
76	19/02	31°43.0'/79°16.7'	518	3		21.8	3	3	23	52	15.000	36.600	0	0	—	—
77	20/02	31°38.1'/79°22.9'	384	2		19.4	3	3	22	39	19.700	34.300	0	0	—	—
78	20/02	31°39.1'/79°22.0'	406	2		17.4	3	3	40	89	26.100	66.500	2	0	0.558	—
79	20/02	31°39.9'/79°21.2'	410	2		16.6	3	3	41	72	36.000	55.200	0	0	—	—
80	20/02	31°34.4'/79°24.8'	479	3		16.2	3	3	56	85	46.000	56.800	0	0	—	—
81	20/02	31°35.3'/79°24.8'	430	2		16.5	3	3	38	87	26.900	65.000	0	0	—	—
82	20/02	31°36.4'/79°24.4'	404	2		17.4	3	3	52	101	40.500	75.400	0	1	—	0.250
						TOTAL	197	195	1251	1890	1097.669	1553.931	605	259	157.481	70.087

Appendix II. Species other than golden crab and jonah crab which were collected in traps.

Fathoms Plus Trap	Florida Trap	Minnow Trap	Praun Trap
Rochinia crassa	*Rochinia crassa*	*Heterocarpus ensifer*	*Myxine glutinosa*
Bathynomus gigantea	*Bathynectes longispina*	*Parapagurus* sp.	*Synaphobranchus kaupi*
Bathynectes longispina	*Scyliorhiuus retifer*	*Acanthephyra* sp.	
Scyliorhinus retifer		*Myxine glutinosa*	
Squalus blainvillei		*Bathynectes longispina*	
Conger sp.			
Geryon quinquedens			