CONTRIBUTIONS TO THE BIOLOGY OF THE ROYAL RED SHRIMP, *Hymenopenaeus robustus* SMITH[1]

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ABSTRACT

The royal red shrimp, *Hymenopenaeus robustus*, has been located in commercial concentrations in three areas off the coast of the United States in depths from about 250 to 550 m: one area, known as the St. Augustine Grounds, is off the east coast of Florida; another is off the Dry Tortugas; and the third is off the Mississippi River Delta.

Information on the biology of the species on the St. Augustine Grounds was collected intermittently from 1957 to 1967.

The reproductive systems of males and females are described and illustrated. The ovaries of ripe females are dark red or maroon, and the exceedingly large spermatophores are bright yellow. We observed no indication of sex reversal.

Burrowing and swimming habits as observed from the research submarine *Aluminaut* are summarized.

The early life history of *H. robustus* is unknown. Neither larval nor postlarval stages were encountered in the plankton collections of the M/V *Theodore N. Gill*. Juveniles under 50 mm total length were not caught.

Size of shrimp was not correlated with depth but appeared to be correlated with latitude. Usually shrimp were larger north of lat 29°39′ N than between lat 29°00′ and 29°39′ N.

Males mature at about 125 mm and females at about 155 mm total length. In each sex, maturity is reflected by a change in the regression of carapace length on total length.

Spawning probably occurs throughout the year, but the peak is between January and May.

Year classes are evident in the length distributions. Recruitment on the fishing grounds begins when the shrimp are approaching 1 year of age and are less than 100 mm total length. They reach maturity at about 3 years, and minimum life span appears to be no less than 5 years. Recruitment is probably not complete until at least 2 years. Most of the shrimp on the fishing grounds are mature.

The royal red shrimp, *Hymenopenaeus robustus* Smith, a large deepwater penaeid (Figure 1), has a wide distribution from the east coast of the United States to well down the east coast of South America, principally in depths of 256 to 549 m (140-300 fm).

Surveys by the Bureau of Commercial Fisheries (now the National Marine Fisheries Service) have indicated three major concentrations of these shrimp off the coast of the United States that have commercial possibilities: (1) off St. Augustine on the east coast of Florida (Figure 2), (2) off the Dry Tortugas in the Florida

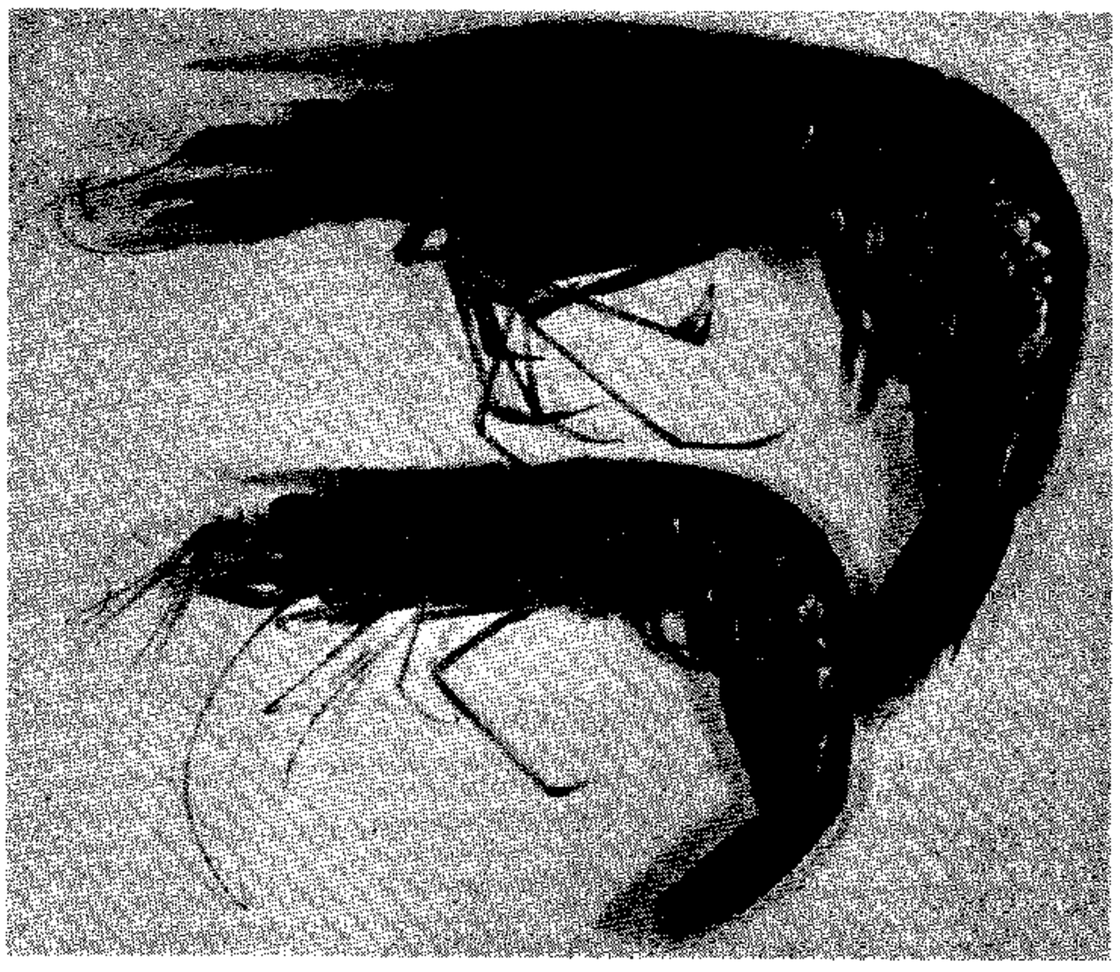

FIGURE 1.—Adult female and male royal red shrimp, showing great difference in size of sexes. Female (upper) 210 mm and male (lower) 160 mm total length.

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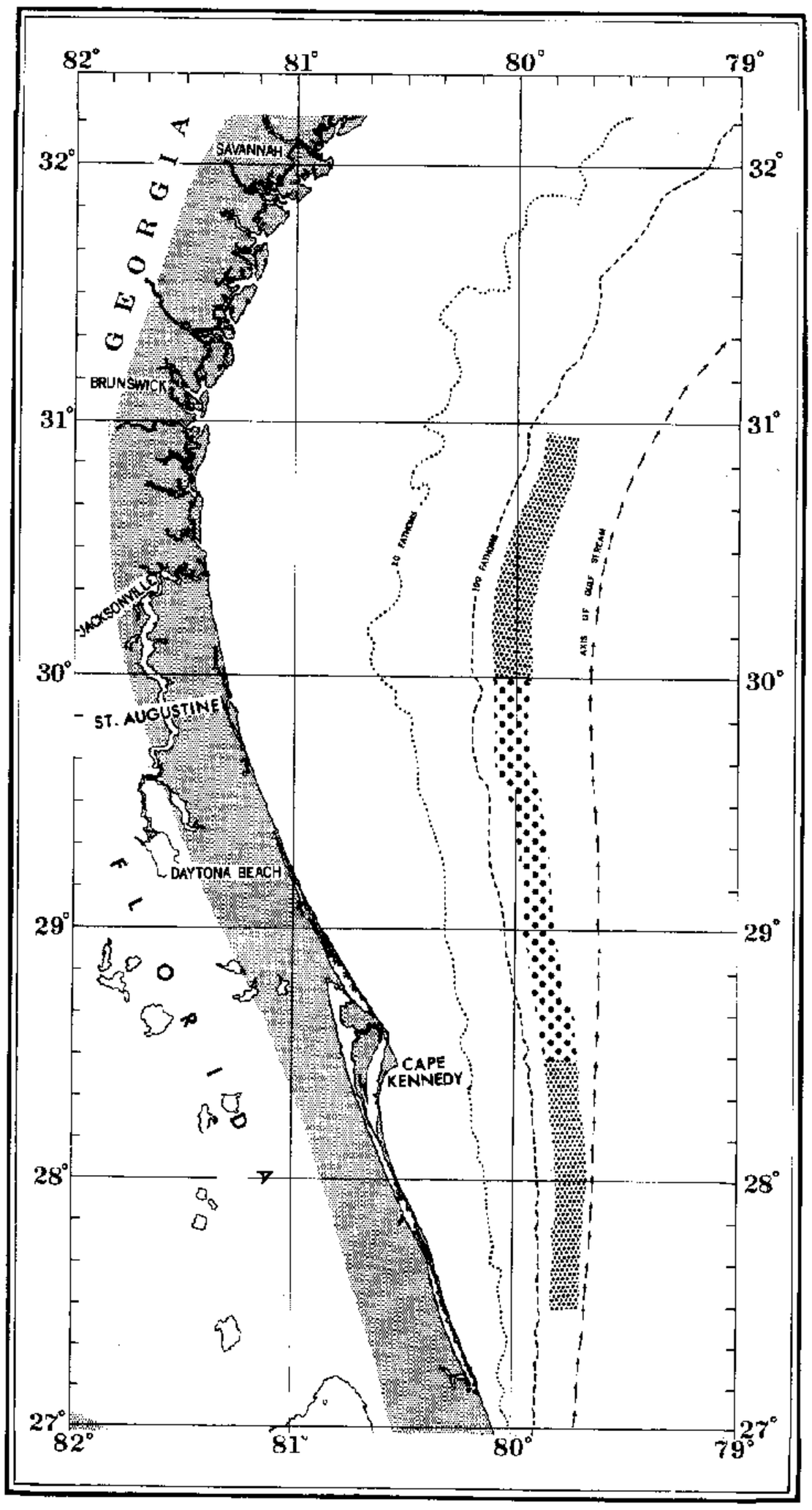

FIGURE 2.—Royal red shrimp grounds off east coast of Florida. Large dots, lat 28°30′ to 30°00′ N, represent most productive portion.

Straits, and (3) off the Mississippi River Delta. Accounts of these surveys were given by Springer and Bullis (1952, 1954), Bullis (1956), Bullis and Rathjen (1959), Bullis and Thompson (1959), Cummins and Rivers (1962), and Bullis and Cummins (1963). Anderson and Bullis (1970) gave an account of direct observations made on the St. Augustine grounds during a dive with the research submarine *Aluminaut* on September 21, 1967; Klima (1969) gave the length-weight relation; and Roe (1969) summarized the distribution on the three major grounds off the southeastern United States.

Biologists at the former BCF Biological Laboratory, Brunswick, Ga., studied the biology of royal red shrimp at the grounds off St. Augustine, Fla., by accompanying vessels of the BCF Exploratory Fishing and Gear Research Base, Pascagoula, Miss., and of the Exploratory Fishing Station, Brunswick, Ga. The work continued from 1957 to 1967, as opportunities arose, on the exploratory fishing vessels *Combat, Silver Bay,* and *Oregon.*

This paper presents the results of these 11 years of intermittent data-gathering.

THE ST. AUGUSTINE GROUNDS

The part of these grounds generally fished extends from about lat 28°30′ N to 30°00′ N in 256 to 475 m (140-260 fm) but the most productive part is between lat 29°00′ N and lat 30°00′ N, and it is from this area that most of the data were obtained.

The BCF surveys of the St. Augustine Grounds indicate that they average about 15.4 km (8.3 nautical miles) in width and have a steep angle of descent. The bottom between 183 and 256 m (100 and 140 fm) is largely untrawlable owing to dense stands of deep-sea alyconarians (sea fans) and limestone formations. Between 256 and 475 m (140 and 260 fm) the bottom is largely sand or silty-sand sediments (referred to as "green mud" by fishermen), is relatively free of obstructions, and provides excellent trawling conditions. Deeper than 475 m (260 fm), extensive patches of deep-sea coral, *Lophelia prolifera,* make the bottom hazardous to trawling with standard shrimp gear.

Anderson and Bullis (1970) made the following observations from the *Aluminaut* in 457 to 274 m (250-150 fm), and between lat 29°10′ and 29°20′ N: "The bottom was remarkedly free from obstructions and consisted of a grayish, loosely constituted sediment that readily clouded the water at the least disturbance. It was

formed into a myriad of shallow depressions and mounds, pitted with holes. Claws protruding from many of these holes indicated the richness of the crustacean bottom fauna. Some fishes were also observed in holes, but these were not nearly so numerous. From the bottom port it was possible to see directly into some of the holes, and we observed animals that would have been invisible at an angle."

These fishing grounds are directly under the Gulf Stream.

DATA AND METHODS

The data were obtained from operations of several vessels either owned or leased by the BCF—M/V *Combat*, a 30-m converted minesweeper; M/V *Silver Bay*, a 29-m New England-type trawler; and the R/V *Oregon*, a 30-m trawler. Bullis (1956) and Bullis and Rathjen (1959) have given details of vessels, gear, and operating procedures.

The data consist of length measurements and observations on ovarian development taken from random samples (100 specimens, if this number or more were caught; the total catch if fewer were caught) at irregular intervals from 1957 to 1967 (Table 1). They also consist of one set

TABLE 1.—Cruise dates, number of stations, and number of *H. robustus* in samples.

Vessel	Cruise dates	Stations sampled	Shrimp measured	
			Males	Females
		Number	*Number*	*Number*
Combat	Apr 26-28, 1957	7	495	624
Combat	May 29-31, 1957	3	187	373
Combat	July 17-30, 1957	9	350	456
Combat	Aug. 13-20, 1957	18	798	874
Silver Bay	Nov. 20-25, 1957	14	441	755
Silver Bay	June 11-22, 1958	28	1,136	1,811
Silver Bay	Jan. 18-28, 1960	13	408	356
Silver Bay	Apr. 30-May 3, 1960	10	379	463
Silver Bay	Apr. 28-May 1, 1961	12	489	601
Silver Bay	Jan. 16-Feb. 22, 1962	24	881	1,386
Silver Bay	Aug. 22-28, 1962	10	393	525
Silver Bay	Sept. 25-28, 1962	8	373	376
Silver Bay	Feb. 5-7, 1964	6	290	309
Oregon	Nov. 11-18, 1964	21	863	1,233
Oregon	July 20-22, 1967	6	251	299
Total		189	7,734	10,441

of total length-carapace length measurements from nonrandom samples taken during July 1957. Date, location, depth (with two exceptions), and duration of haul are known for each trawling station from which the samples were taken. Data on bottom temperatures are not available. The location of each trawling station was obtained by sonar fixes and the depth, in fathoms, from sonic depth recordings. The depths have been converted to the nearest meter.

Throughout almost every cruise during which length measurements were taken, the operation simulated commercial fishing; consequently the shrimp measured were caught by several types of trawls in a wide range of sizes. Mesh sizes, however, probably did not vary much. The most commonly used trawl was constructed of "commercial" nylon webbing with 2-inch (50.8-mm) stretched mesh in the body and 1½-inch (38.1-mm) stretched mesh in the cod end. These sizes of mesh are generally used by commercial shrimp fishermen. As shown by Berry and Hervey (1965), the greatest inside dimensions usually are somewhat less than 50.8 mm and 38.1 mm, respectively. Measurements we made on the greatest inside mesh dimensions of the shrimp trawls used by the exploratory vessels for capturing *H. robustus* indicate a range between 43 and 48 mm (mean 45.7 mm or 1.8 inches) for the "commercial" 50.8-mm mesh and between 30 and 34 mm (mean 31.7 mm of 1¼ inches) for the "commercial" 38.1-mm mesh.

Mesh selectivity studies have not been made on *H. robustus*, but we doubt that the variability in types and sizes of trawls appreciably affected the lengths of shrimp caught. We assume that mesh selectivity would be about the same as that shown by Berry and Hervey (1965) for *Penaeus aztecus* for 2-hr tows. Most of our tows lasted 2 to 4 hr, with 3-hr tows predominating. The 50% escapement length for 31.7-mm mesh would thus be about 70 mm total length and specimens of *H. robustus* less than 50 mm total length, if present, would have been represented in the catches. We can expect, however, that specimens less than about 100 mm total length probably were not represented in their true perspective in the random samples.

Total length measurements (tip of rostrum to end of telson—all length measurements are

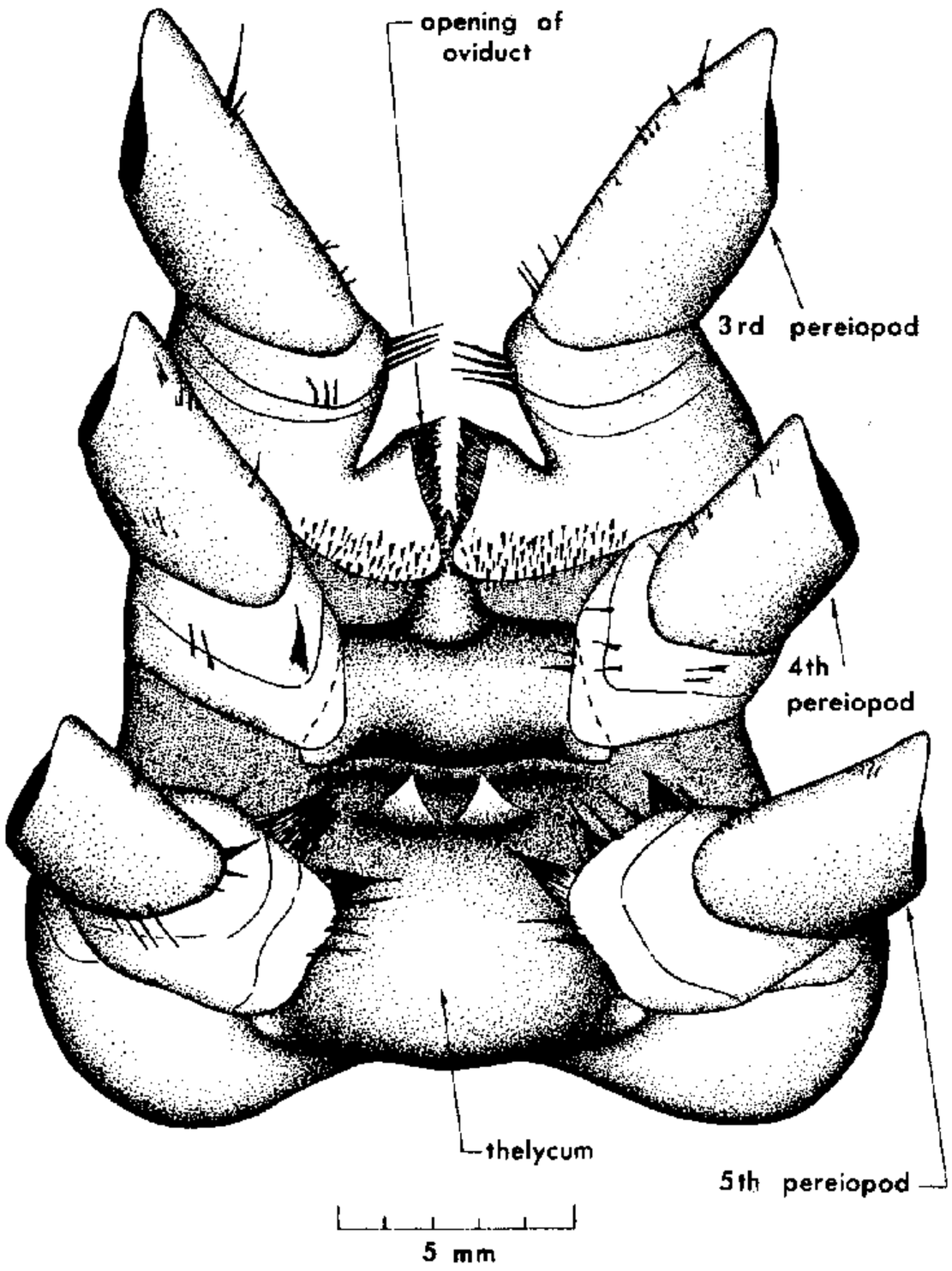

FIGURE 4.—Ventral view of thorax of adult female.

a forward projecting cone-shaped protuberance which lies between the fourth pereiopods; the paired triangular protuberances about midway between the fourth and fifth pereiopods; and the dome-shaped area between the fifth pereiopods.

Burkenroad (1936) described in detail the petasma of *H. robustus* but did not illustrate it. Figure 5 shows the petasma of *H. robustus*, spread open to show its structure.

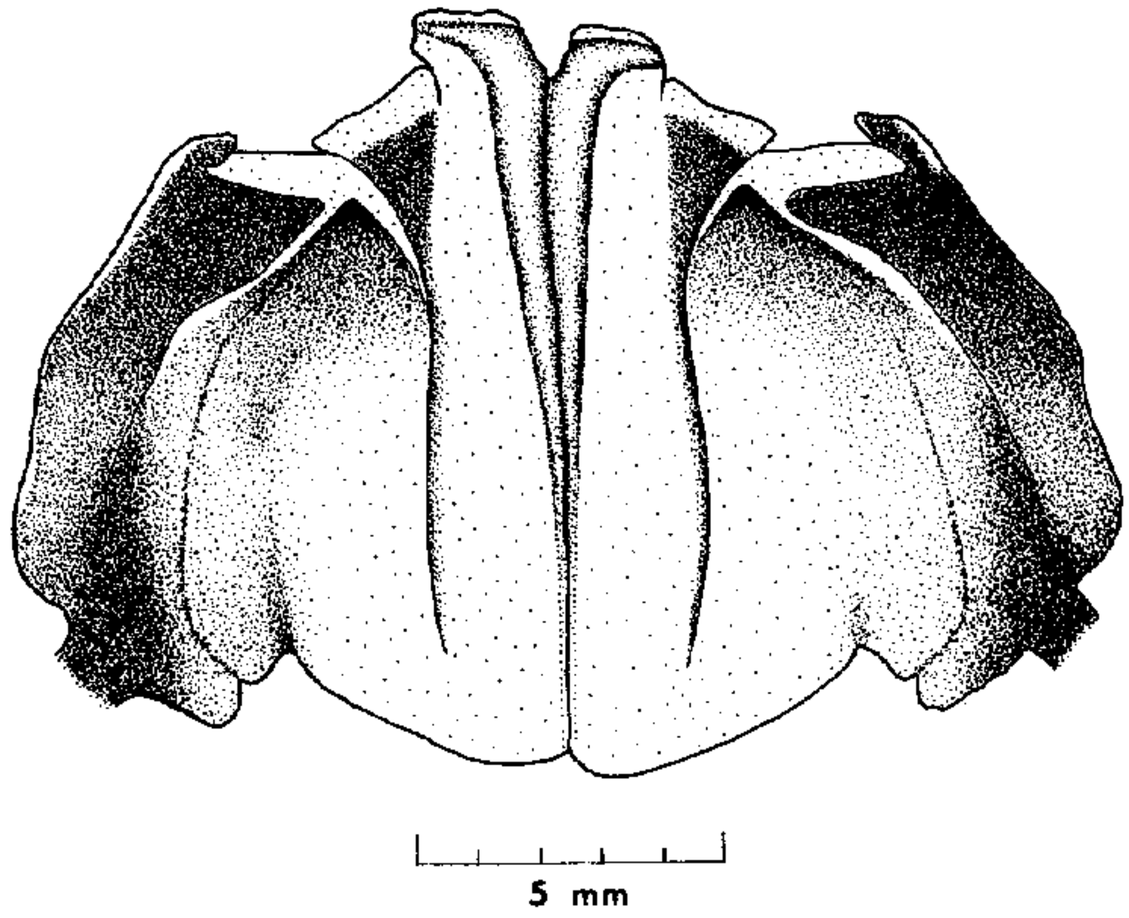

FIGURE 5.—Petasma of male spread open to show arrangement of rods and folds.

Figure 6 shows a spermatophore in attached position; Figure 7 shows a detached spermatophore. The winglike protuberances extend between the pereiopods, and the knobby and bristly sections of the coxae help hold the spermatophore in place. A gluelike substance that accompanies the spermatophore when attached by the male also helps hold it secure. The spermatophores of royal red shrimp are much more securely attached than those of the white shrimp and are not easily dislodged.

HABITS

Anderson and Bullis (1970) contributed most of our limited knowledge of the habits of this deep-sea shrimp. Their observations from the submarine *Aluminaut* were as follows: "Bottom photographs had previously indicated that royal-red shrimp stayed on the sea-floor surface, but we saw numerous shallow furrows (1 to 3 ft long) in the bottom in which royal-red shrimp were partly buried. They apparently do not burrow as deeply or completely as do brown and pink shrimp. We believe the shrimp plow into the bottom in search of food rather than protection, and that this feeding activity produces the grooves or furrows.

"When disturbed, the royal-red shrimp rise gently from the furrows and swim in normal

Spermatophore

Compared with the spermatophores of the white shrimp (*Penaeus setiferus*), the brown shrimp (*P. aztecus*), and the pink shrimp (*P. duorarum*)—all penaeid shrimp similar in size to *H. robustus*—the spermatophore of the royal red shrimp is exceptionally large. In fresh material the spermatophore is bright yellow.

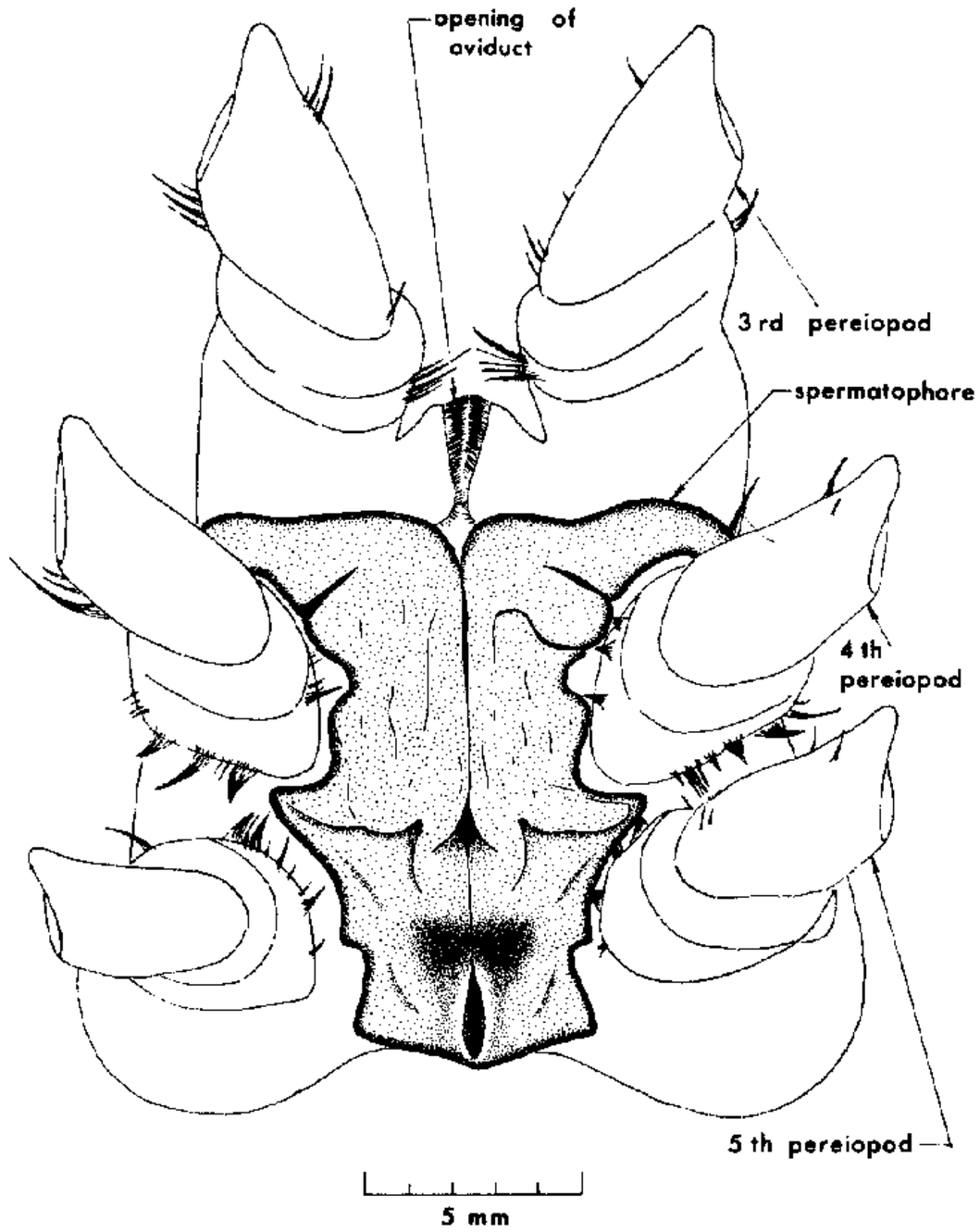

FIGURE 6.—Ventral view of thorax of adult female with spermatophore (shaded) attached.

upright position. If frightened, they flip back in typical penaeid fashion by quick flexing of the abdomen and then swim forward rapidly, but usually they are turned on their sides so that they bounce off the bottom every few feet. At the end of the run they stand on the bottom rather than burrow in. The shrimp walk either forward or sideways. Color varied from grayish pink to red—similar to colors observed on trawl-caught specimens."

LARVAL, POSTLARVAL, AND JUVENILE STAGES

The larvae of *Hymenopenaeus robustus* are unknown. Several attempts were made by Anderson to hatch eggs from ripe females bearing spermatophores. The eggs failed to develop, however—perhaps because of the drastic changes in temperature and pressure when the animals were quickly brought from the cold

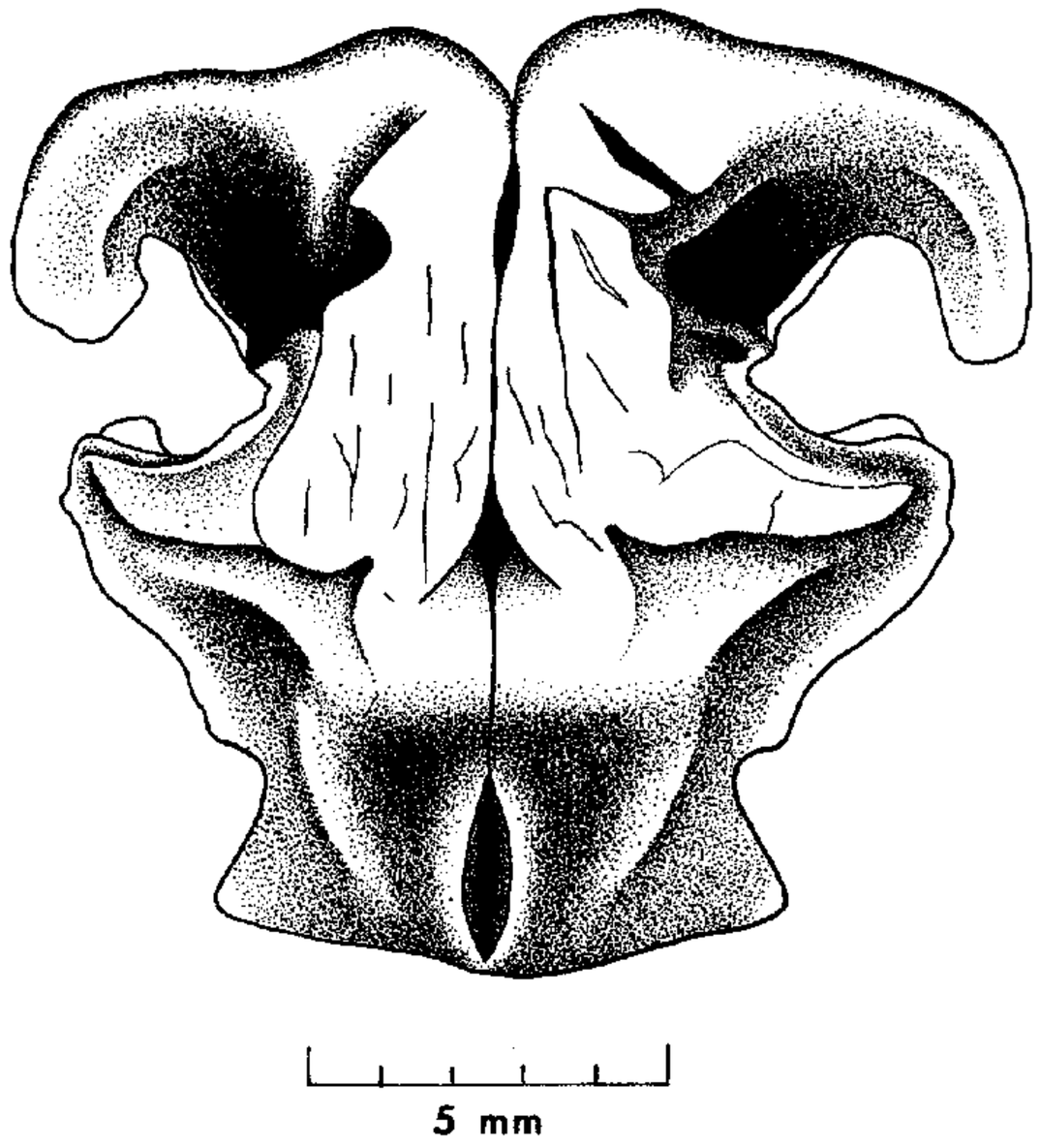

FIGURE 7.—Ventral view of detached spermatophore.

waters of about 385 m (200 fm) to the warm surface waters of the Gulf Stream.

In attempts to find larval and postlarval royal red shrimp, we examined numerous plankton samples from the M/V *Theodore N. Gill* cruises, covering all seasons, in an area from about the 183-m (100 fm) contour to well beyond the axis of the Gulf Stream and over the entire length of the St. Augustine Grounds. Only a few larval or postlarval penaeids were found and only one of these, a *Solenocera*-like mysis stage, was considered as possibly being *Hymenopenaeus* (Harry L. Cook, then a fishery biologist at the BCF Biological Laboratory, Galveston, Tex., kindly made the identifications).

Burkenroad (1936) has provided the only record of postlarval *H. robustus*. He described nine specimens (all dead when examined), which he believed to be juveniles (postlarvae), that were collected in the northern Gulf of Mexico off the mouth of the Mississippi River. Eight (12.0-21.5 mm total length) were taken at R/V *Atlantis* station 2377 on March 24, 1935, and one (no length given) was taken at *Atlantis* station 2381 on March 26, 1935.

LATITUDE AND DEPTH DISTRIBUTIONS

A preliminary examination of our data suggested that royal red shrimp tended to be larger in the northern part of the collection area than in the central part, and that size was inversely related to depth. Correlations were significant between median lengths of females and latitude ($r = +0.46$; $t = +6.65$; $Y = 23.39 + 0.09X$) and between median lengths of females and depth ($r = -0.46$; $t = -6.65$; $Y = 53.78 - 0.11X$). The data used for these correlations were from the 164 stations at which 20 or more females were measured; the lengths are in ½-cm units. We did not repeat the calculations for the males because when the smaller size groups of females were caught in a tow, invariably the smaller size groups of males also were caught.

For the latitude correlation we grouped the median lengths by 10′ intervals of latitude. A graph of the data showed that female shrimp tended to be smaller between lat 29°00′ and 29°39′ N than between lat 29°40′ and 30°13′ N. We had samples from only five stations south of lat 29°00′ N, of which four were between lat 28°00′ and 28°39′ N. Although the data suggested that large shrimp also tended to inhabit the southern part of the grounds, we are unwilling to draw conclusions for the area south of lat 29°00′ N from this small sample.

The size and latitude relation confirmed reports of the fishermen that usually, but not always, they encountered larger shrimp on the northern portion of the grounds than on the central portion. The fishermen rarely fish the southern part of the grounds, and we received conflicting reports on the size of shrimp caught in this area.

For the depth relation we grouped the data by 25-fm (46-m) depth intervals (151-175; 176-200, etc.). The highly significant negative relation between size and depth (large shrimp in shallow water and smaller shrimp in deeper water) did not agree with some of our data (Table 2) nor with reports from the fishermen and exploratory fishing personnel; hence we suspected that this relation and perhaps that with latitude were fortuitously caused by the fishing pattern at the times our samples were

TABLE 2.—Median length of *H. robustus* and depth of hauls for eight stations in the same latitude—*Silver Bay* cruise September 25-28, 1962.

Lat N	Depth of hauls		Median length	
			Males	Females
	m	*fm*	*mm*	*mm*
29°54′	324-329	177-180	138	178
29°54′	329-338	180-185	138	178
29°54′	348	190	138	178
29°54′	357-362	195-198	138	178
29°53′	366	200	138	183
29°53′	375	205	138	178
29°53′	384	210	138	173
29°53′	411-421	225-230	138	178

taken. We therefore re-examined the data and selected only those cruises during which more than one depth class was fished in the same latitude zone and those cruises during which the same depth class was fished in the two latitude zones. The depth classes used were 150 to 175 fm (274-320 m), 176 to 200 fm (322-366 m), 201 to 225 fm (368-411 m), and 226+ fm (413+ m). The latitude zones chosen were lat 29°00′ to 29°39′ N and 29°40′ to 30°13′ N. We had no stations south of lat 29°00′N that met the requirements.

After the selection was made, we had 12 cruises with 93 stations and 2 depth classes that could be compared by latitude zone for the same depth class; and 18 cruises with 95 stations and 4 depth classes that could be compared by depth class for the same latitude zone. Only those stations were selected from which 20 or more females were measured. The results are shown in Figures 8 and 9 and in Appendix Tables 1 and 2.

In Figure 8 we have plotted the mean median lengths (in ½-cm units) as scatter diagrams against depth class with latitude zone lat 29°00′ to 29°39′ N as the abscissa and latitude zone lat 29°40′ to 30°13′ N as the ordinate. If no relation existed between the length of the shrimp and the latitude, the dots and crosses would be scattered along and on either side of the 45° lines. All 12 marks fall above the 45° lines, however, showing that shrimp tended to be larger north of lat 29°39′ N than in the area between lat 29°00′ and 29°39′ N.

In Figure 9 we have plotted the mean median lengths as scatter diagrams separately for each

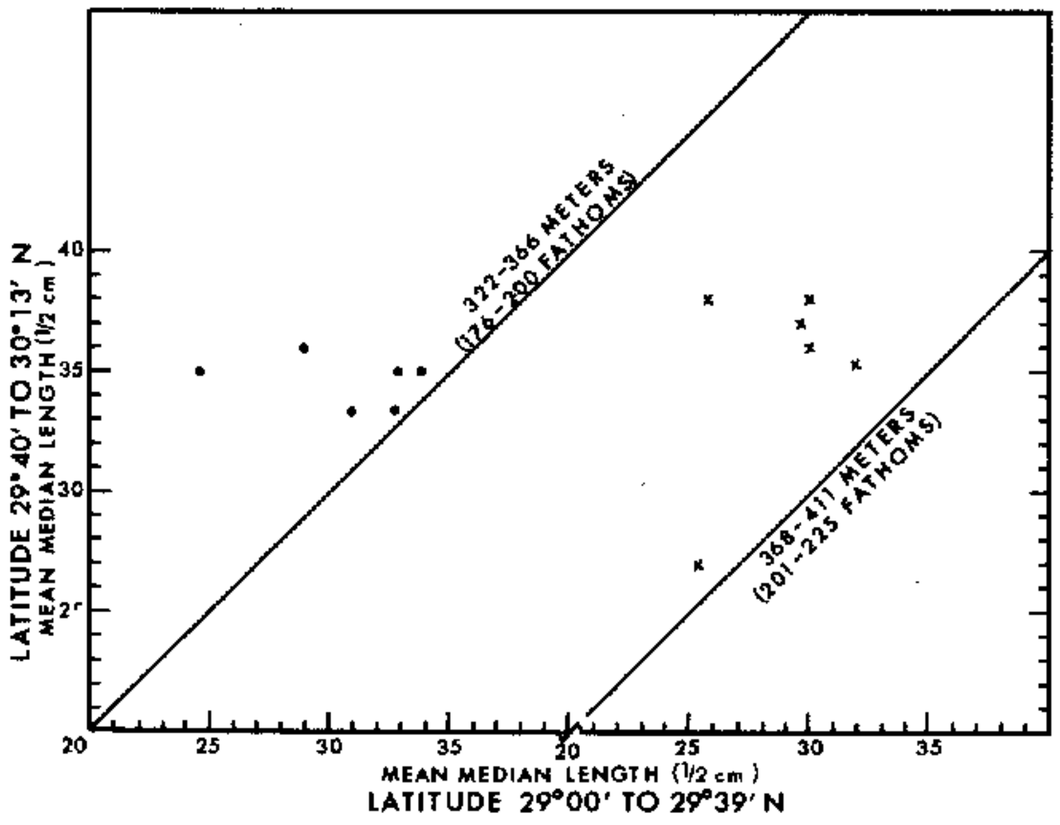

FIGURE 8.—Mean median length of females by latitude and depth (see text for explanation).

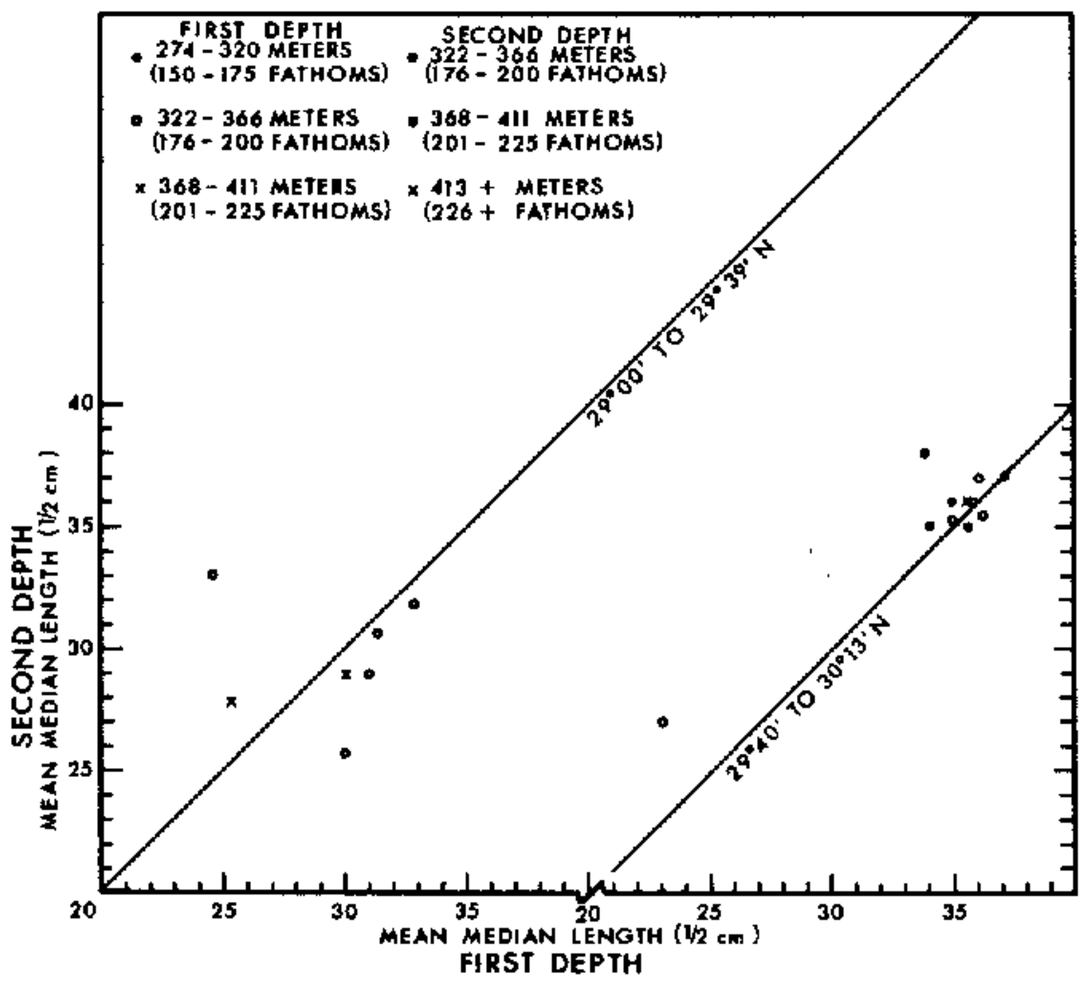

FIGURE 9.—Mean median length of females by depth and latitude (see text for explanation).

latitude zone, with the first or shallowest depth class as the abscissa and the next succeeding depth class as the ordinate. The marks for each latitude zone appear to fall in a random fashion about the 45° lines; consequently there was no apparent relation between the length of the shrimp and the depth from which they were caught. This figure also indicates that the average size of shrimp is usually, but not always, larger in that part of the St. Augustine Grounds north of lat 29°39′ N than between lat 29°00′ and 29°39′ N.

We are not certain why shrimp tend to be smaller in the central than in the northern portion of the St. Augustine Grounds unless most of the recruitment is in the central area. If shrimp also are larger in the southern portion of the grounds (as our meager data from that area suggest), the obvious conclusion is that most of the recruitment occurs in the central portion of the grounds; otherwise, it may be that recruitment is from the south.

SIZE AT MATURITY

The terminal ampoules were small and poorly developed in most males less than about 125 mm long but were large and prominent in specimens greater than this length. This observation suggests that sexual maturity in the males is reached at about 125 mm total length.

Development of the ovaries began in most females at about 136 mm total length, but maturity was not attained until they were about 155 mm long. In the random samples, all of the 1,327 females that had attached spermatophores were ripe. Of this number only 55 or about 4% were less than 151 mm long. The smallest ripe shrimp with attached spermatophores (three individuals) were in the 136- to 140-mm size class.

Lindner and Anderson (1956) demonstrated that female *Penaeus setiferus* underwent certain morphometric changes on attaining maturity. It is evident from Figures 10 and 11 and Appendix Table 3 that the regressions of carapace length on total length for both male and female royal red shrimp also show changes in slope at about the lengths at which each sex reaches maturity. Male royal red shrimp (Figure 10) demonstrate a change in slope at the midpoint of the 126- to 130-mm class interval, which agrees with field observations on the size at which the males reach maturity.

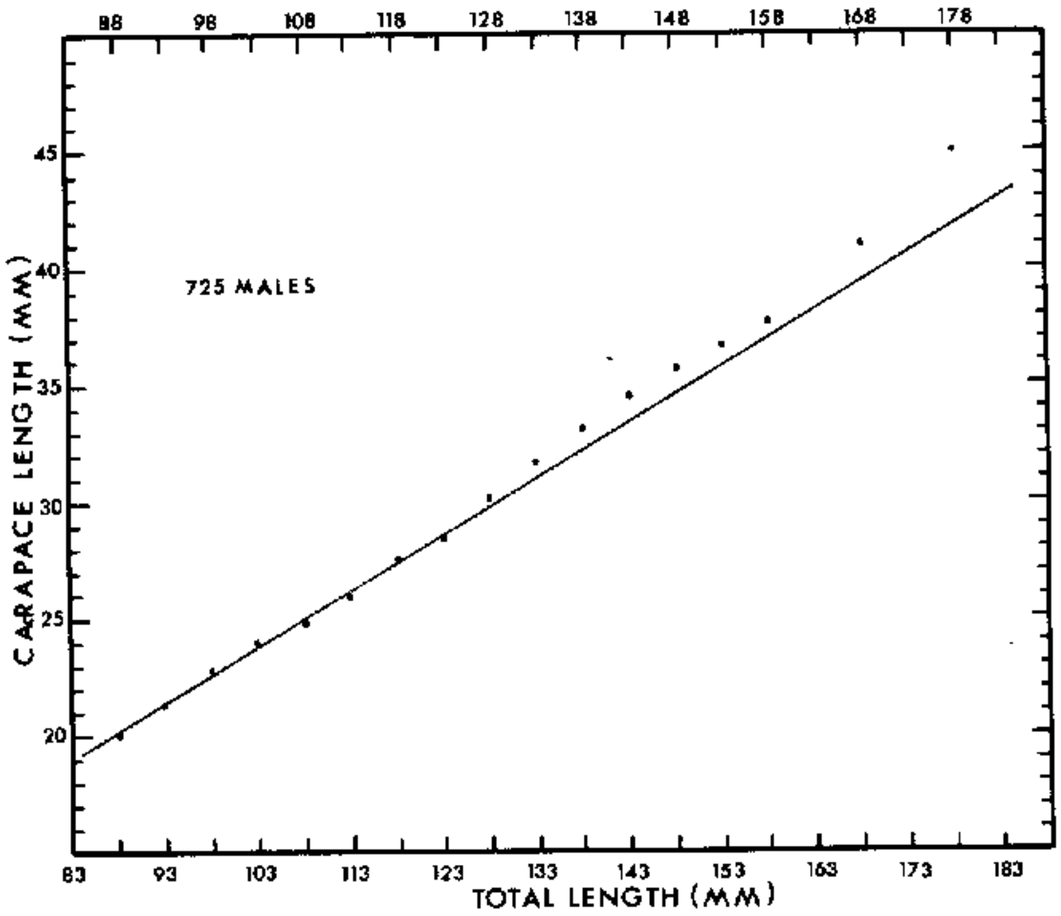

FIGURE 10.—Regression of carapace length on total length for males.

For female *H. robustus* (Figure 11) the break occurs at the midpoint of the 151- to 155-mm class interval and the new slope is not reached until the midpoint of the 161- to 165-mm class interval. Here again this morphometric change is associated with maturity.

These regressions were made from data gathered in July 1957. Possibly the lengths at which the slopes change would be different at other times of the year.

SPAWNING

It was possible to separate several stages of ovarian development in the field without microscopic examination, because maturation is accompanied by changes in size of the ovaries and by very distinct color changes. In the field, however, we were unable to distinguish with certainty the spent females. These were included in the "undeveloped" and "developing" categories. We usually recorded ovary development in the following stages:

1. UN = undeveloped. In this stage the tiny ovaries are almost threadlike and transparent.
2. D = developing. The ovaries have increased markedly in size and are opaque but have not developed a distinctive color.
3. P = pink. The ovaries continue to increase in size and first take on a light yellow color which rapidly becomes light pink.
4. R = ripe. Now swollen to full size, the ovaries are a dark red or maroon color. At this stage the male attaches the spermatophore to the female.

The length distribution of shrimp with pink ovaries differed little from the length distribution of those with ripe ovaries. Because we have no conception of the time required for the pink stage to develop to the ripe stage, and because the sizes were similar, we grouped these two ovarian stages and called them ripe. We also grouped females with undeveloped and developing ovaries, mainly to avoid discarding the data collected during the first two cruises in 1957, when these two stages were not differentiated.

We have presented this material in Figure 12 by seasonal periods. The periods chosen were November; January and February; April, May, and June; and July, August, and September.

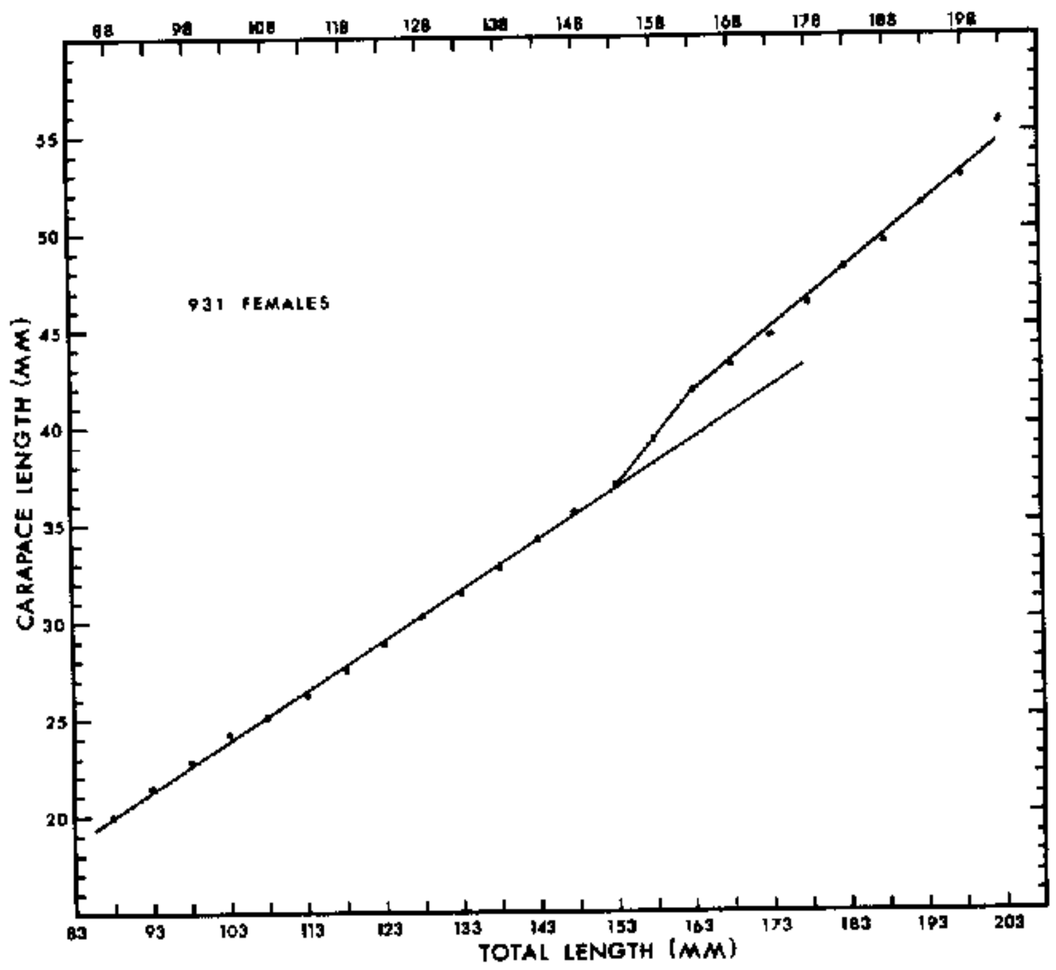

FIGURE 11.—Regression of carapace length on total length for females.

Because many more shrimp were measured during some cruises than during others in the same season, we weighted the data in Figure 12 and Appendix Table 4 to give each cruise equal weight, irrespective of the number of shrimp in the samples. Figure 12 demonstrates that the peak of spawning is during the winter and spring. Spawning probably is not extensive before December and is essentially completed by June, although some spawning continues throughout the year. Figure 12 also indicates that few females less than 150 mm long have ripe ovaries.

The occurrence of small specimens reported by Burkenroad (1936) in March corresponds with our estimate of the peak spawning season.

AGE CLASSES

In compiling total length distributions for males and females, we have again given equal weights to data from each cruise irrespective

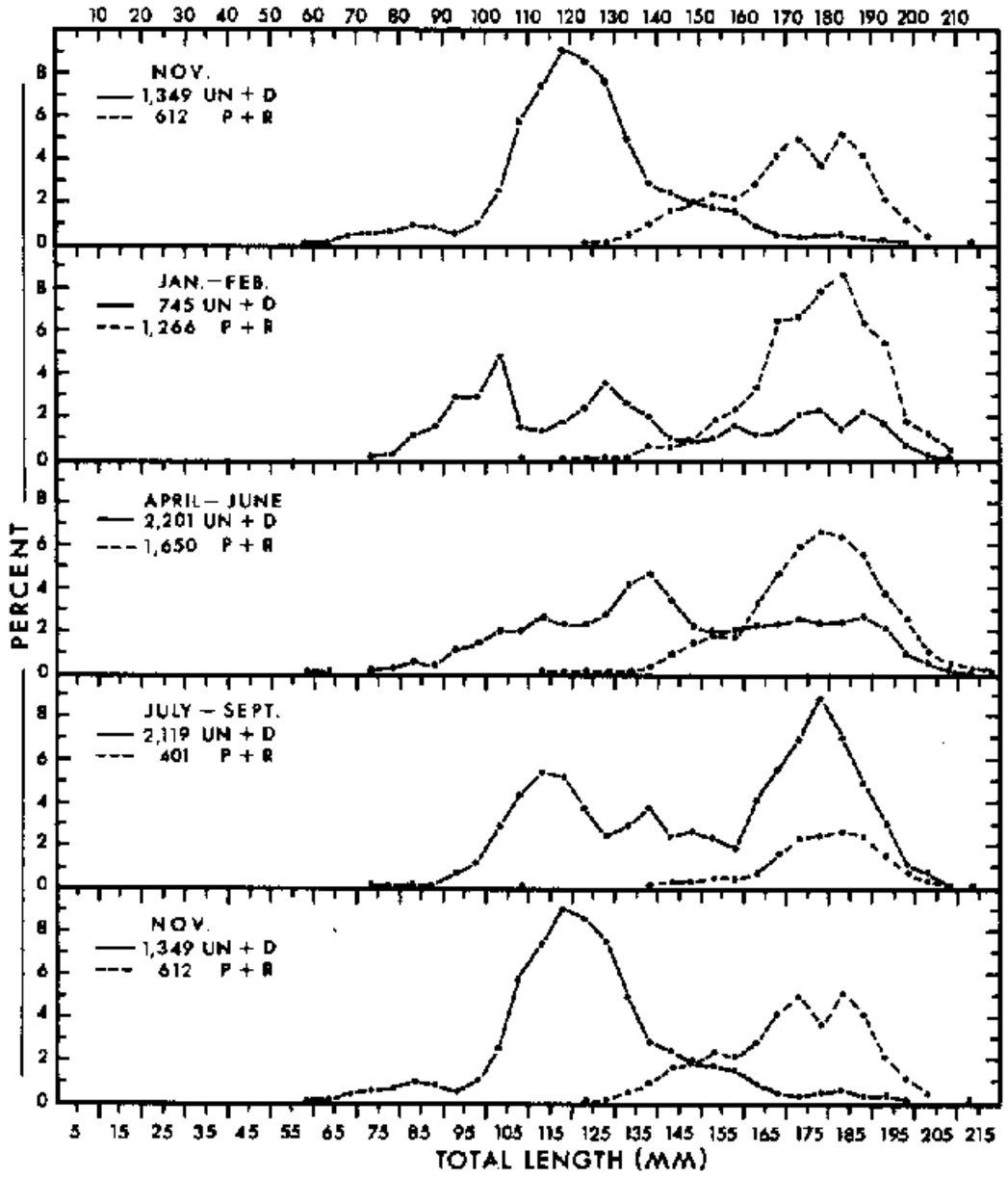

FIGURE 12.—Seasonal length distributions of female *H. robustus* by ovarian stages. (UN = undeveloped; D = developing; P = pink; R = ripe.)

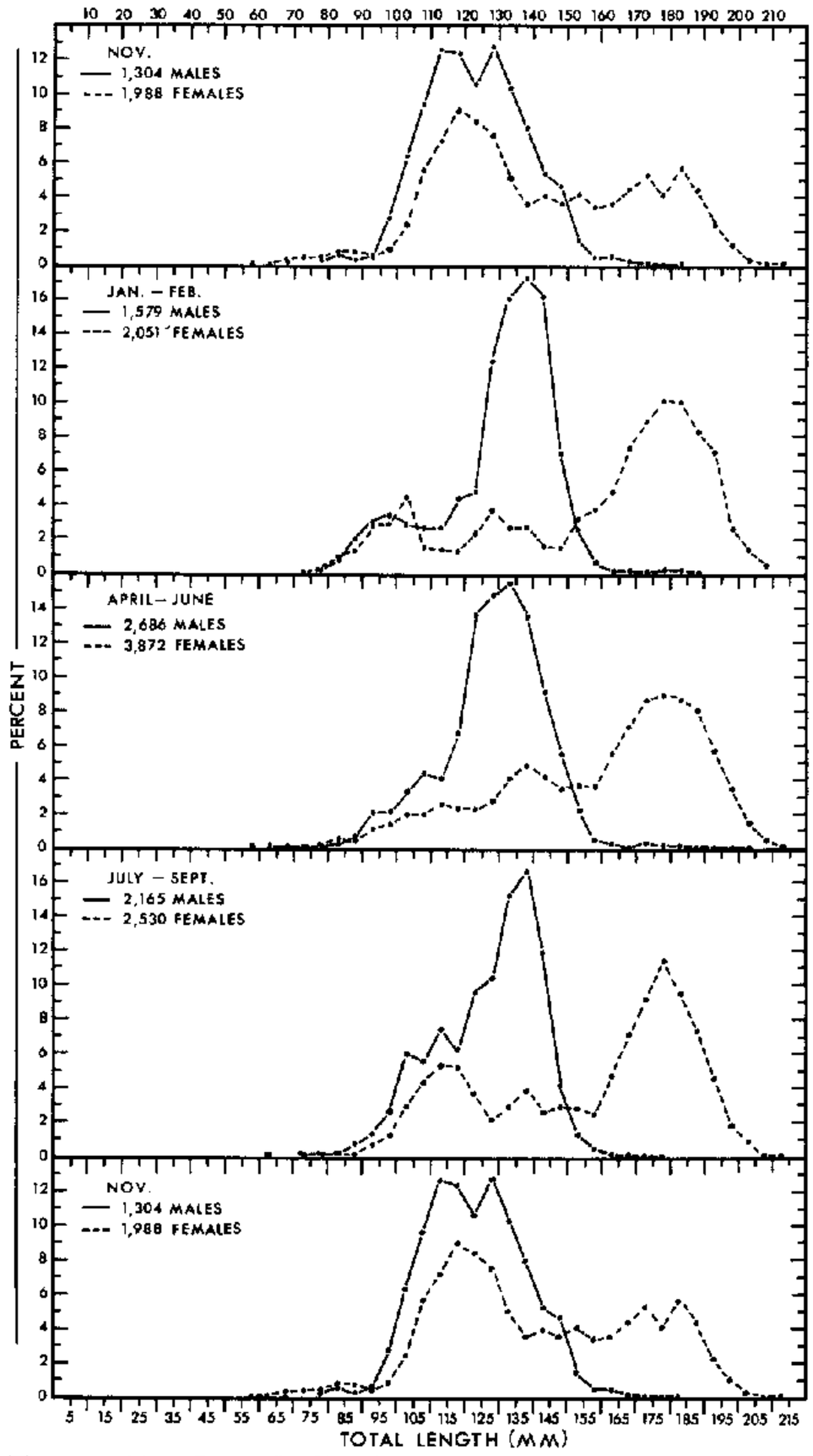

FIGURE 13.—Length distributions of *H. robustus* by sex and season.

of the number of shrimp measured, and we present the data for the same seasonal periods used to show the spawning season (Figure 13 and Appendix Table 5). The relative heights of the modes can be misleading because the data are scattered sparsely through 11 years and the appearance of a dominant year class in one sample (as occurred in November 1964) can have a disproportionate effect when applied to the material as a whole.

The graphs for the females are more readily interpreted than those for the males. In No-

vember the females show a mode at about 80 mm total length that can be followed readily throughout the year to a second mode at about 120 mm. The mode at 120 mm can also be traced throughout the year to the bimodal group with modes at 143 and 153 mm. The bimodality of this latter group we believe to be fortuitous, but it can be followed to a hump between 153 and 158 mm in the January-February distributions. Thereafter the modes become lost in the large group of mature females. We believe that the two additional modes in our November distributions (173 and 183 mm) also are fortuitous and result from the sampling procedures.

A group of small male shrimp also appears in November, forming a mode at about the same length as that for the females, which can be traced throughout the year to the second mode at about 115 mm. This second mode can be traced as a hump to the left of the main mode from January through September to the third mode at 128 mm, beyond which it is lost.

We made various attempts to fit Von Bertalanfy growth curves to the data without satisfactory results other than it was apparent the first two modes could be attributed to 1- and 2-year-old shrimp. Evidently morphometric changes associated with maturity preclude the use of total length as a means of determining age of *H. robustus* after they reach maturity.

We believe the first three groups of males and females we have cited are 3 distinct age classes. If the peak of spawning is in March, both sexes would be about 100 mm total length at 1 year of age. From our data it is impossible to distinguish more than the first 3 age classes. The older age classes, which probably represent 2 or more additional years, would give a minimum life span of 5 years. Probably, however, at least some of the largest shrimp are older than this.

SIZE AND AGE AT RECRUITMENT

When we consider all of our length measurements as a unit, either unweighted, weighted to give each cruise equal weight, or weighted to give each year equal weight, we obtain almost identical distributions. In Figure 14 we show

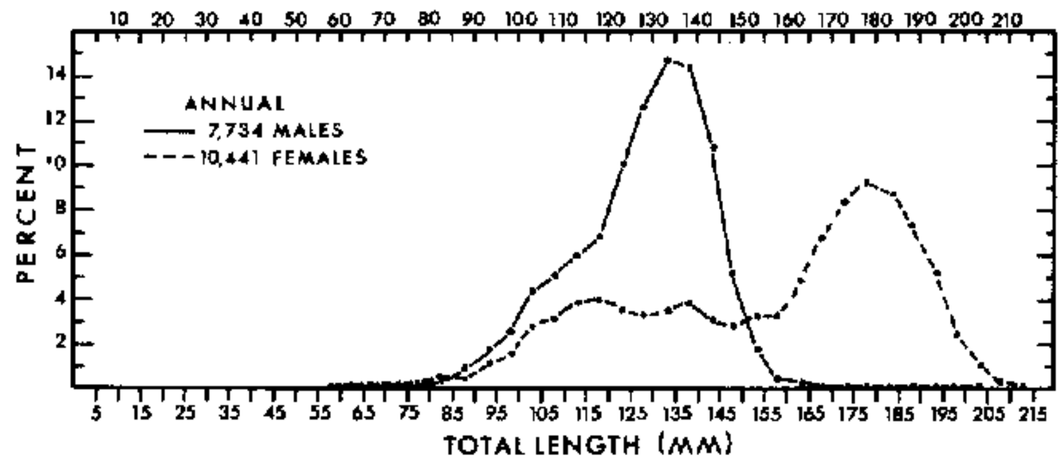

FIGURE 14.—Length distributions of *H. robustus* by sex for all samples combined.

these length distributions weighted to give equal weight to collections during each cruise. It is readily evident from these curves that only the groups presumed to represent the second, third, and fourth and older age groups are present in substantial numbers and that the population is composed largely of mature shrimp.

Although the data are not adequate, they suggest that recruitment starts at about 1 year of age, but the shrimp are not fully recruited until about 2 years of age, and recruitment may not be complete until the shrimp are mature—about 3 years old. In the combined length distributions (Figure 14), 55% of the females were longer than 160 mm and 61% of the males were longer than 125 mm (the lengths at which we believe each sex is fully mature). Only 6% of the males and 4% of the females were less than 100 mm long. The smallest shrimp we sampled was in the 56- to 60-mm length class. As we mentioned earlier, we do not believe that gear selectivity causes the scarcity of shrimp under 100 mm long and the lack of them under 56 mm long. Royal red shrimp do not appear on the fishing grounds at sizes smaller than about 55 mm. The observations of Anderson and Bullis (1970) who had clear visibility of the bottom from a distance of less than 1 m, substantiated the lack of small shrimp on the St. Augustine Grounds. Furthermore, 37 *H. modestus*, 43 to 93 mm long (mode, 63 mm) were taken on April 20, 1957, in 225 fm with a 40-ft flat shrimp trawl fitted with commercial 2-inch stretched mesh in the body and 1½-inch mesh in the cod end. In addition, H. R. Bullis, BCF Pascagoula, Miss. (personal communication), concerning trawling on the *H. robustus* grounds

off the Mississippi River Delta, stated, "Of special interest was the discovery of high densities of small red (*Hymenopenaeus debilis*) shrimp in 208 fathoms. These shrimp averaged less than 35 mm total length." These two species of *Hymenopenaeus* are similar in shape to *H. robustus;* consequently, we believe that small *H. robustus* would have been taken in our gear if they had been present on the fishing grounds. We have no idea where they might be.

The sex ratios for all the data combined show 42.6% males and 57.4% females. Some, but probably not all, of this difference is undoubtedly the result of mesh selectivity. We observed no indication of sex reversal in the species.

Appendix Table 6 shows the length distributions in numbers of shrimp by sex for each cruise.

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APPENDIX TABLES

APPENDIX TABLE 1.—Mean median lengths of female *H. robustus* by depth, latitude, and cruise.

Item	322 to 366 m (176-200 fm)											
	Lat 29°00′ to 29°39′ N						Lat 29°40′ to 30°13′ N					
Cruise dates	Aug. 13-20 1957	Nov. 20-25 1957	June 11-22 1958	Jan. 18-28 1960	Apr. 28-May 1 1961	Jan. 16-Feb. 22 1962	Aug. 13-20 1957	Nov. 20-25 1957	June 11-22 1958	Jan. 18-28 1960	Apr. 28-May 1 1961	Jan. 16-Feb. 22 1962
Number of stations	8	5	3	1	2	2	1	4	22	1	2	1
Mean median length (½ cm)	32.8	30.9	32.7	24.5	29.0	33.8	35.0	33.4	33.6	35.0	36.0	35.0

Item	368 to 411 m (201-225 fm)											
	Lat 29°00′ to 29°39′ N						Lat 29°40′ to 30°13′ N					
Cruise dates	Apr. 26-28 1957	July 17-30 1957	Aug. 13-20 1957	Aug. 22-28 1962	Feb. 5-7 1964	Nov. 11-18 1964	Apr. 26-28 1957	July 17-30 1957	Aug. 13-20 1957	Aug. 22-28 1962	Feb. 5-7 1964	Nov. 11-18 1964
Number of stations	2	2	4	2	4	15	1	1	2	2	1	5
Mean median length (½ cm)	25.8	30.0	31.9	30.0	29.6	25.4	38.0	38.0	35.3	36.0	37.0	27.0

APPENDIX TABLE 2.—Mean median lengths of female *H. robustus* by latitude, depth, and cruise.

Item	Lat 29°40′ to 30°13′ N							
	First depth 274-320 m (150-175 fm)				Second depth 322-366 m (176-200 fm)			
Cruise dates	May 29-31 1957	Jan. 18-28 1960	Apr. 28-May 1 1961	Jan. 16-Feb. 22 1962	May 29-31 1957	Jan. 18-28 1960	Apr. 28-May 1 1961	Jan. 16-Feb. 22 1962
Number of stations	1	1	6	6	1	1	2	1
Mean median length (½ cm)	37.0	34.0	34.9	35.6	37.0	35.0	36.0	35.0

	First depth 322-366 m (176-200 fm)						Second depth 368-411 m (201-225 fm)					
Cruise dates	July 17-30 1957	Aug. 13-20 1957	Aug. 22-28 1962	Sept. 25-28 1962	Feb. 5-7 1964	Nov. 11-18 1964	July 17-30 1957	Aug. 13-20 1957	Aug. 22-28 1962	Sept. 25-28 1962	Feb. 5-7 1964	Nov. 11-18 1964
Number of stations	5	1	3	5	1	1	1	2	2	2	1	5
Mean median length (½ cm)	33.8	35.0	35.7	36.2	36.0	23.0	38.0	35.3	36.0	35.5	37.0	27.0

	First depth 368-411 m (201-225 fm)	Second depth 413 plus m (226 plus fm)
Cruise dates	Sept. 25-28 1962	Sept. 25-28 1962
Number of stations	2	1
Mean median length (½ cm)	35.5	36.0

Item	Lat 29°00′ to 29°39′ N									
	First depth 322-366 m (176-200 fm)					Second depth 368-411 m (201-225 fm)				
Cruise dates	April 26-28 1957	Aug. 13-20 1957	Nov. 20-25 1957	Jan. 18-28 1960	Apr. 30-May 3 1960	April 26-28 1957	Aug. 13-20 1957	Nov. 20-25 1957	Jan. 18-28 1960	Apr. 30-May 3 1960
Number of stations	2	8	5	1	6	2	4	2	1	4
Mean median length (½ cm)	30.0	32.8	30.9	24.5	31.3	25.8	31.9	29.0	33.0	30.6

	First depth 368-411 m (201-225 fm)		Second depth 413 plus m (226 plus fm)	
Cruise dates	July 17-30 1957	July 20-22 1967	July 17-30 1957	July 20-22 1967
Number of stations	2	4	1	2
Mean median length (½ cm)	30.0	25.3	29.0	27.8

APPENDIX TABLE 3.—Regression of carapace length on total length for *H. robustus*.

Total length	Males	Females	Mean carapace length	
			Males	Females
mm	*Number*	*Number*	*mm*	*mm*
83	--	1	--	20.0
88	6	1	20.2	20.0
93	8	4	21.3	21.5
98	12	5	22.8	22.8
103	22	10	24.0	24.2
108	23	12	24.9	25.1
113	45	18	25.9	26.2
118	63	23	27.5	27.6
123	94	20	28.8	28.9
128	86	17	30.1	30.3
133	104	34	31.7	31.4
138	115	46	33.1	32.8
143	94	53	34.5	34.1
148	34	60	35.6	35.4
153	14	36	36.8	37.0
158	3	36	37.7	39.3
163	--	56	--	41.7
168	1	86	41.0	43.1
173	--	102	--	44.6
178	1	82	45.0	46.3
183	--	77	--	48.1
188	--	81	--	49.4
193	--	49	--	51.3
198	--	16	--	52.9
203	--	6	--	55.5
Total	725	931		

APPENDIX TABLE 4.—Length distributions of ovarian stages by season and cruise.
[UN = undeveloped; D = developing; P = pink; R = ripe]

Total length	Fall				Winter					
	Nov. 20-25, 1957		Nov. 11-18, 1964		Jan. 18-28, 1960		Jan. 16-Feb. 22, 1962		Feb. 5-7, 1964	
	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	0.2	--	--	--	--	--	--	--
63	--	--	0.2	--	--	--	--	--	--	--
68	--	--	0.7	--	--	--	--	--	--	--
73	--	--	0.9	--	--	--	0.1	--	0.3	--
78	0.1	--	1.1	--	0.3	--	0.1	--	0.3	--
83	0.5	--	1.2	--	2.4	--	0.1	--	0.7	--
88	0.5	--	1.1	--	3.4	--	0.3	--	0.7	--
93	--	--	1.0	--	6.7	--	0.3	--	1.6	--
98	0.7	--	1.2	--	5.3	--	0.2	--	3.3	--
103	2.3	--	2.7	--	8.0	--	0.6	--	5.8	--
108	5.2	--	6.1	--	2.4	0.3	0.7	--	1.3	--
113	5.6	--	9.0	--	1.5	--	0.3	--	2.0	--
118	5.2	--	12.7	--	1.2	--	1.3	0.1	2.6	--
123	3.2	--	13.7	0.2	1.8	--	1.8	0.1	3.6	--
128	2.7	0.1	12.2	0.1	3.2	--	1.0	0.1	6.1	--
133	2.4	0.6	7.3	0.1	2.4	--	1.0	0.1	4.3	--
138	1.5	1.6	4.0	0.1	2.8	0.9	0.5	0.1	2.6	0.7
143	2.1	2.8	2.7	0.4	0.3	0.6	0.3	0.1	2.3	1.0
148	1.0	2.7	2.7	0.9	0.9	1.8	0.7	0.3	1.0	0.3
153	0.8	3.2	2.5	1.4	1.5	3.0	0.5	0.9	1.0	1.6
158	1.5	3.1	1.4	1.0	2.4	3.3	1.4	1.4	1.0	2.3
163	0.4	4.5	1.2	1.1	1.5	4.2	1.9	4.2	0.3	2.0
168	--	7.4	0.7	0.7	0.6	7.5	2.7	8.5	0.7	3.0
173	--	8.5	0.6	1.2	1.2	3.9	4.4	12.4	0.7	3.6
178	0.4	6.5	0.3	0.8	1.5	5.8	3.7	12.9	1.6	4.6
183	0.5	9.6	0.5	0.5	0.9	4.1	1.8	12.9	1.6	8.5
188	0.1	7.7	0.4	0.3	2.1	3.6	1.4	8.4	3.0	6.9
193	0.3	2.6	0.2	1.6	1.2	2.7	1.0	5.2	3.0	8.2
198	--	1.6	0.2	0.6	0.6	0.3	0.4	2.1	1.0	3.0
203	--	0.5	--	0.2	0.6	0.9	0.1	1.0	--	1.6
208	--	--	--	--	0.3	0.3	0.1	0.5	--	0.3
213	--	--	--	0.1	--	--	--	--	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	37.0	63.0	88.7	11.3	56.8	43.2	28.7	71.3	52.4	47.6
Number of females	278	476	1,071	136	193	146	392	975	160	145

APPENDIX TABLE 4.—Length distributions of ovarian stages by season and cruise—*Continued.*
[UN = undeveloped; D = developing; P = pink; R = ripe]

Total length	Spring									
	Apr. 26-28, 1957		May 29-31, 1957		June 11-22, 1958		Apr. 30-May 3, 1960		Apr. 28-May 1, 1961	
	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	0.3	--	--	--	--	--	--	--
63	0.2	--	--	--	--	--	--	--	--	--
68	--	--	--	--	--	--	--	--	--	--
73	0.2	--	--	--	--	--	--	--	0.2	--
78	0.3	--	0.5	--	--	--	--	--	0.2	--
83	1.6	--	0.3	--	--	--	0.2	--	0.3	--
88	1.3	--	--	--	--	--	--	--	0.5	--
93	1.8	--	--	--	0.1	--	0.9	--	2.5	--
98	3.8	--	0.3	--	0.2	--	0.4	--	2.4	--
103	4.2	--	0.3	--	0.4	--	2.0	--	3.2	--
108	2.6	--	0.5	--	0.2	--	4.2	--	2.5	--
113	3.0	--	1.1	--	0.9	--	5.3	--	2.5	0.2
118	2.4	--	0.8	--	1.3	--	5.5	0.2	1.5	--
123	3.2	0.2	1.1	--	2.2	--	4.6	--	0.5	--
128	5.9	0.2	1.6	--	2.9	--	2.4	--	0.8	--
133	7.8	0.3	3.2	--	4.6	--	4.0	--	0.5	--
138	6.4	0.5	2.9	--	5.7	0.1	5.7	0.7	2.0	0.2
143	4.2	1.2	3.2	0.8	4.6	0.9	3.1	1.3	1.7	0.4
148	2.2	0.8	1.1	1.6	3.4	1.6	2.9	1.6	1.2	1.2
153	0.6	0.5	1.1	1.1	4.0	2.5	2.4	2.0	1.5	2.7
158	1.1	0.8	0.3	0.5	3.8	2.8	3.1	2.0	1.5	2.6
163	2.2	1.2	1.3	3.5	3.1	3.8	3.3	4.0	1.0	3.5
168	2.2	1.6	1.1	7.2	3.2	3.0	3.5	4.0	1.5	7.2
173	2.2	3.0	1.3	7.5	3.3	3.9	3.5	5.0	2.4	10.4
178	1.9	2.5	1.3	8.8	3.6	4.4	4.4	4.7	1.0	12.5
183	3.4	2.4	1.6	12.7	3.7	5.5	2.2	2.4	1.0	8.5
188	3.7	4.0	1.9	11.3	4.1	4.1	2.2	1.6	1.2	6.7
193	4.2	2.3	1.3	6.7	2.8	3.4	1.5	0.9	0.7	5.1
198	2.6	1.0	--	6.2	1.7	2.6	0.2	1.1	--	2.2
203	0.8	0.5	0.5	2.4	0.4	0.7	0.4	0.2	0.2	1.2
208	0.6	0.2	--	0.8	0.2	0.1	0.2	0.2	--	0.5
213	0.2	--	--	--	--	0.1	--	--	--	0.2
218	--	--	--	--	--	0.1	--	--	--	--
Total	76.8	23.2	28.9	71.1	60.4	39.6	68.1	31.9	34.5	65.5
Number of females	480	144	108	265	1,098	713	310	144	205	384

APPENDIX TABLE 4.—Length distributions of ovarian stages by season and cruise—*Continued.*
[UN = undeveloped; D = developing; P = pink; R = ripe]

Total length	Summer									
	July 17-30, 1957		Aug. 13-20, 1957		Aug. 22-28, 1962		Sept. 25-28, 1962		July 20-22, 1967	
	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R	UN + D	P + R
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	--	--	--	--	--	--	--
63	--	--	--	--	--	--	--	--	--	--
68	--	--	--	--	--	--	--	--	--	--
73	--	--	--	--	--	--	--	--	0.3	--
78	--	--	0.3	--	--	--	0.3	--	--	--
83	0.2	--	0.2	--	0.2	--	0.3	--	--	--
88	0.2	--	0.5	--	--	--	--	--	--	--
93	0.9	--	0.9	--	0.8	--	--	--	0.7	--
98	1.3	--	1.9	--	0.6	--	0.8	--	1.3	--
103	2.2	--	3.3	--	0.6	--	0.8	--	7.4	--
108	2.6	--	3.9	0.1	3.3	--	1.6	--	10.1	--
113	4.0	--	3.8	--	4.8	--	0.8	--	13.4	--
118	4.9	--	3.3	--	3.5	--	0.8	--	13.7	--
123	2.9	--	2.8	--	3.3	--	1.3	--	8.1	--
128	1.5	--	1.3	--	3.5	--	1.1	--	3.7	--
133	4.4	--	3.2	--	2.9	--	0.5	--	3.7	--
138	5.4	0.2	4.4	0.2	1.7	--	1.6	--	5.4	0.3
143	4.8	0.4	4.0	0.2	1.3	--	0.8	--	1.0	0.3
148	3.9	0.4	4.3	0.8	1.7	--	0.8	--	2.4	--
153	2.9	0.8	2.3	0.4	1.0	0.2	2.1	--	3.4	0.7
158	1.1	0.2	3.2	0.5	1.7	0.2	1.3	--	2.4	1.3
163	3.1	0.4	6.2	0.8	6.5	0.4	3.6	1.1	1.3	0.3
168	3.1	2.0	6.0	1.8	9.1	1.0	6.4	1.3	2.7	2.0
173	4.2	4.6	7.2	2.1	10.7	1.5	9.9	1.9	2.7	1.3
178	3.5	3.8	6.5	1.2	14.7	1.9	18.3	1.9	1.0	3.4
183	3.3	5.1	5.5	2.3	10.7	1.0	14.8	2.4	1.0	1.7
188	3.3	7.5	4.3	2.4	6.3	--	9.9	0.8	0.7	1.3
193	2.6	5.0	2.8	1.1	2.5	0.4	6.4	1.3	0.7	--
198	0.9	1.3	1.1	0.9	0.8	--	2.9	0.8	--	0.3
203	0.2	0.9	1.1	0.5	1.0	--	1.1	--	--	--
208	--	--	0.3	0.1	0.2	--	--	--	--	--
213	--	--	--	--	--	--	0.3	--	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	67.4	32.6	84.6	15.4	93.4	6.6	88.5	11.5	87.1	12.9
Number of females	305	149	738	136	487	34	330	43	259	39

APPENDIX TABLE 5.—Length distributions by sex for season and cruise.

Total length	Fall				Winter					
	Nov. 20-25, 1957		Nov. 11-18, 1964		Jan. 18-28, 1960		Jan. 16-Feb. 22, 1962		Feb. 5-7, 1964	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	0.2	--	--	--	--	--	--
63	--	--	--	0.2	--	--	--	--	--	--
68	0.2	--	0.1	0.7	--	--	--	--	--	--
73	--	--	--	0.9	--	--	--	0.1	--	0.3
78	0.5	--	0.2	1.1	0.7	0.3	--	0.1	--	0.3
83	0.9	0.5	0.4	1.1	1.7	2.3	--	0.1	0.7	0.7
88	0.2	0.5	0.4	1.1	3.7	3.4	0.1	0.1	2.1	0.7
93	0.9	--	0.2	1.0	3.7	6.7	0.1	0.3	5.2	1.6
98	3.9	0.7	1.7	1.1	3.4	5.1	0.6	0.3	6.2	3.2
103	7.7	2.3	4.9	2.6	2.0	7.6	0.8	0.2	5.9	5.8
108	10.0	5.2	9.3	6.0	2.0	2.5	1.6	0.6	4.5	1.3
113	10.3	5.6	14.6	8.8	1.7	1.4	1.8	0.7	4.5	1.9
118	8.2	5.2	16.5	12.8	3.4	1.1	3.2	0.3	6.6	2.6
123	9.1	3.2	12.1	13.4	7.6	2.0	3.6	1.8	3.1	3.6
128	14.0	2.8	11.3	12.4	20.4	3.1	9.0	1.8	7.9	6.1
133	12.0	2.9	8.6	7.3	18.6	2.5	20.4	1.3	9.3	4.2
138	9.8	3.1	6.2	4.1	15.4	3.9	26.4	0.9	10.0	3.2
143	6.4	4.9	4.2	3.0	9.6	0.8	21.3	0.4	17.6	3.6
148	5.2	3.7	4.2	3.4	2.7	2.5	7.4	0.8	11.0	1.3
153	0.5	4.1	2.6	4.1	2.0	5.1	1.8	1.6	4.1	2.9
158	--	4.5	0.9	2.4	0.5	5.3	0.8	2.8	0.7	3.2
163	--	4.9	1.0	2.4	--	5.6	0.6	6.6	--	2.3
168	--	7.4	0.4	1.4	0.5	8.7	0.1	10.0	--	3.6
173	0.2	8.6	--	2.0	0.2	5.6	0.1	17.0	--	4.2
178	--	6.9	0.1	1.4	0.2	7.6	0.1	16.3	0.3	6.5
183	--	10.1	0.1	1.2	--	4.8	0.1	15.4	0.3	10.0
188	--	8.0	--	0.8	--	5.3	0.1	9.7	--	9.7
193	--	2.8	--	1.8	--	3.7	--	6.3	--	11.4
198	--	1.6	--	0.9	--	1.1	--	2.7	--	3.9
203	--	0.5	--	0.2	--	1.4	--	1.2	--	1.6
208	--	--	--	0.1	--	0.6	--	0.6	--	0.3
213	--	--	--	0.1	--	--	--	--	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of shrimp	441	755	863	1,233	408	356	881	1,386	290	309

APPENDIX TABLE 5.—Length distributions by sex for season and cruise.—*Continued.*

Total length	Spring									
	Apr. 26-28, 1957		May 29-31, 1957		June 11-22, 1958		Apr. 30-May 3, 1960		Apr. 28-May 1, 1961	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	0.3	--	--	--	--	--	--
63	--	0.2	0.5	--	--	0.1	--	--	--	--
68	0.2	--	--	--	--	--	--	--	--	--
73	0.4	0.2	--	--	--	--	--	--	--	0.2
78	0.8	0.3	--	0.5	--	--	--	--	--	0.2
83	1.0	1.6	--	0.3	--	--	--	0.2	0.6	0.3
88	1.8	1.3	0.5	--	0.3	--	--	--	0.8	0.5
93	5.7	1.8	2.1	--	0.3	0.1	0.3	0.9	2.0	2.5
98	5.1	3.8	0.5	0.3	0.4	0.2	0.5	0.4	3.9	2.3
103	5.5	4.2	2.7	0.3	0.7	0.4	2.4	1.9	5.1	3.2
108	5.1	2.6	7.0	0.5	2.5	0.2	4.2	4.1	3.1	2.5
113	6.5	3.0	4.3	1.1	4.2	0.9	4.0	5.4	1.4	2.7
118	8.5	2.4	8.0	0.8	7.6	1.3	7.7	5.6	1.8	1.5
123	12.2	3.4	17.2	1.1	19.1	2.2	16.0	4.5	3.3	0.5
128	7.3	6.1	13.4	1.6	17.6	2.9	19.2	2.6	16.4	0.8
133	8.3	8.2	10.8	3.2	18.3	4.7	18.1	3.9	21.9	0.5
138	9.3	6.9	13.9	3.0	11.2	5.9	13.5	6.3	19.4	2.2
143	10.2	5.5	6.4	4.0	9.1	5.4	7.9	4.3	11.9	2.0
148	8.5	3.0	7.5	2.7	5.5	5.0	1.6	4.3	4.3	2.5
153	2.4	1.1	2.7	2.1	1.7	6.5	1.6	4.5	2.5	4.3
158	0.8	1.9	--	0.8	0.2	6.6	0.8	5.0	0.8	4.0
163	0.2	3.4	--	4.8	0.4	6.9	1.1	7.6	--	5.0
168	--	3.8	--	8.3	--	6.1	0.3	7.7	--	9.0
173	0.2	5.3	0.5	8.8	0.3	7.2	0.5	8.9	0.2	12.7
178	--	4.5	0.5	10.2	0.4	8.1	--	8.9	0.2	13.0
183	--	5.8	0.5	14.2	0.1	9.1	0.3	4.5	0.2	9.7
188	--	7.6	--	13.1	0.1	8.2	--	3.7	--	8.0
193	--	6.3	--	8.0	--	6.2	--	2.4	0.2	5.7
198	--	3.5	0.5	6.2	--	4.3	--	1.3	--	2.2
203	--	1.3	0.5	3.0	--	1.2	--	0.7	--	1.3
208	--	0.8	--	0.8	--	0.2	--	0.4	--	0.5
213	--	0.2	--	--	--	0.1	--	--	--	0.2
218	--	--	--	--	--	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of shrimp	495	624	187	373	1,136	1,811	379	463	489	601

total length unless otherwise indicated) were made in ½-cm units on a measuring board so adjusted that when the ½-cm units were converted to millimeters the midpoints fell on 3 and 8 (e.g., a length of 25 ½-cm units represents lengths between 121 and 125 mm with midpoint at 123 mm; similarly, the midpoint in millimeters for 26 ½-cm units is 128 mm). Carapace lengths (orbital angle to mid-dorsal end of carapace) were measured with calipers to the nearest millimeter. Both total length and carapace length measurements were made of freshly caught specimens.

The ovarian stages, determined by visual inspection at the time each female was measured, were based on size and color of the ovaries. We also noted whether spermatophores were attached to females.

SYSTEMATICS

In the shrimp family Penaeidae the royal red shrimp, *Hymenopenaeus robustus* Smith, belongs in the subfamily Solenocerinae, which is distinguished from the three other subfamilies by having a postorbital spine (Figure 3).

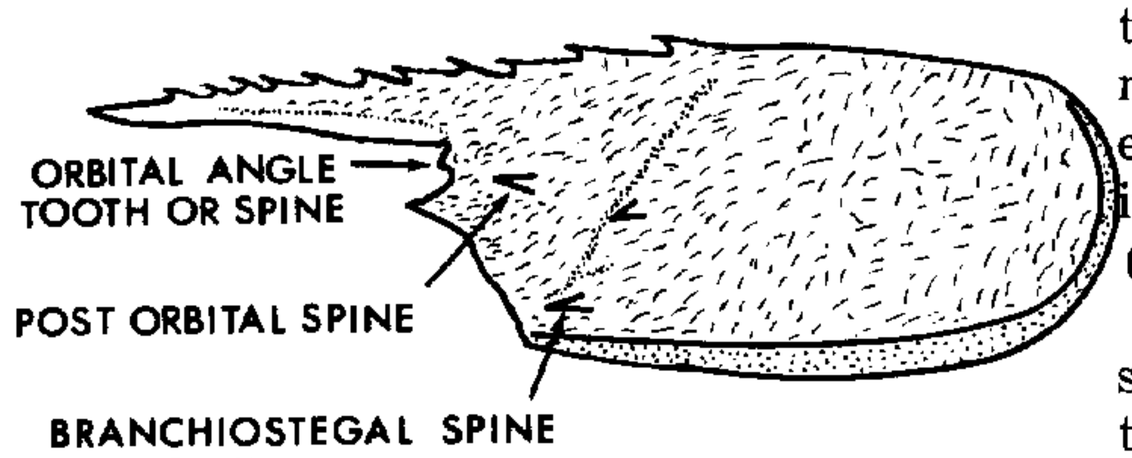

FIGURE 3.—Outline of carapace of *H. robustus* showing position of spines.

Three genera (*Haliporus* Bate, *Hymenopenaeus* Smith, and *Solenocera* Lucas) make up the subfamily Solenocerinae. *Solenocera* is distinct from the other two genera in having the antennular flagella flattened or hollowed out—channellike in structure—rather than cylindrical and filiform. *Hymenopenaeus* has a single pair of lateral telson spines and lacks podobranchs behind segment VIII, whereas *Haliporus* has several pairs of lateral telson spines and podobranchs posterior to segment VIII.

Within the genus *Hymenopenaeus*, three species (*H. robustus, H. modestus* Smith, and *H. lucasii* Bate) are separated from all other species by the following combination of characters: branchiostegal spine present, pterygostomian spine absent, and no postrostral teeth separated from the rostral group (Figure 3).

H. robustus is distinct from *H. modestus* and *H. lucasii* in having a tooth or spine in the orbital angle (Figure 3).

BIOLOGY OF THE SHRIMP

REPRODUCTIVE SYSTEMS

Internal

The internal reproductive organs of royal red shrimp are so similar to those described by Angelescu and Boschi (1959) for *Hymenopenaeus muelleri* and by King (1948) and Young (1959) for the white shrimp, *Penaeus setiferus*, that only gross anatomy is given here.

The ovaries are paired. In the cephalothoracic region they are partly fused; each ovary has an anterior pointed lobe and 6 to 8 finger-like lateral projections which lie over the hepatopancreas. A lobe from each ovary extends nearly the full length of the abdomen dorsolateral to the intestine. The oviducts lead to genital pores at the bases of the third pereiopods (Figure 4).

The testes are also paired and occupy a position in the cephalothoracic region similar to that of the ovaries. Each testis has several lateral lobes, and a looped vas deferens which connects to the terminal ampoule on the coxa of the fifth pereiopod. The testes do not extend into the abdomen.

External

Details of the structure of the thelycum in the female (considered to be modifications to the sternal plates of somites XII, XIII, and XIV) are shown in Figure 4. Note the bristly, cuplike paired openings of the oviducts at the bases of the third pereiopods; the rectangular plate with

APPENDIX TABLE 5.—Length distributions by sex for season and cruise.—*Continued.*

Total length	Summer									
	July 17-30, 1957		Aug. 13-20, 1957		Aug. 22-28, 1962		Sept. 25-28, 1962		July 20-22, 1967	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	%	%	%	%	%	%	%	%	%	%
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	--	--	--	--	--	--	--
63	--	--	--	--	--	0.2	--	--	--	--
68	--	--	--	--	--	--	--	--	--	--
73	--	--	--	--	0.3	--	--	--	--	0.3
78	--	--	0.4	0.3	--	--	--	0.3	--	--
83	--	0.2	0.4	0.2	--	0.2	--	0.3	0.4	--
88	1.7	0.2	1.1	0.5	0.5	--	0.3	--	--	--
93	2.3	0.9	1.3	0.9	1.5	0.8	0.5	--	0.8	0.7
98	3.4	1.3	2.3	1.9	3.3	0.6	0.8	0.8	3.2	1.3
103	5.7	2.2	4.5	3.3	6.9	0.6	1.9	0.8	11.2	7.4
108	5.1	2.6	5.9	4.0	8.1	3.2	0.8	1.6	9.2	10.0
113	8.3	4.0	4.1	3.8	7.9	4.8	3.0	0.8	13.8	13.4
118	7.1	4.8	7.4	3.3	3.8	3.4	2.7	0.8	10.0	13.6
123	9.4	2.9	14.9	2.8	8.1	3.2	3.2	1.3	12.3	8.0
128	11.4	1.5	13.0	1.3	12.0	2.9	5.4	1.3	10.0	3.7
133	12.6	4.4	15.4	3.2	19.8	2.9	16.4	0.5	11.5	3.7
138	13.8	5.5	15.4	4.6	18.6	1.7	28.3	1.9	6.8	5.7
143	13.4	5.0	8.9	4.2	4.3	1.3	25.5	0.8	7.2	1.3
148	2.6	4.4	4.4	5.2	4.1	1.7	8.8	0.8	0.8	2.7
153	1.7	3.7	0.6	2.8	0.5	1.1	1.3	2.1	1.6	4.0
158	0.9	1.5	--	3.8	--	1.9	0.5	1.3	0.8	3.7
163	--	3.5	--	7.0	0.3	6.8	--	4.5	0.4	1.7
168	0.3	5.0	--	7.8	--	10.1	0.3	7.7	--	4.7
173	--	8.8	--	9.1	--	12.0	0.3	11.7	--	4.0
178	0.3	7.2	--	7.6	--	17.6	--	19.9	--	4.4
183	--	8.4	--	7.8	--	11.8	--	17.1	--	2.7
188	--	10.8	--	6.7	--	6.3	--	10.9	--	2.0
193	--	7.9	--	4.0	--	2.7	--	7.7	--	0.7
198	--	2.2	--	1.9	--	1.0	--	3.7	--	0.3
203	--	1.1	--	1.5	--	1.0	--	1.1	--	--
208	--	--	--	0.5	--	0.2	--	--	--	--
213	--	--	--	--	--	--	--	0.3	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of shrimp	350	456	798	874	393	525	373	376	251	299

APPENDIX TABLE 6.—Length distributions by cruise and sex.

Total length	Apr. 26-28, 1957		May 29-31, 1957		July 17-30, 1957		Aug. 13-20, 1957		Nov. 20-25, 1957	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	1	--	--	--	--	--	--
63	--	1	1	--	--	--	--	--	--	--
68	1	--	--	--	--	--	--	--	1	--
73	2	1	--	--	--	--	--	--	--	--
78	4	2	--	2	--	--	3	3	2	--
83	5	10	--	1	--	1	3	2	4	4
88	9	8	1	--	6	1	9	4	1	4
93	28	11	4	--	8	4	10	8	4	--
98	25	24	1	1	12	6	18	17	17	5
103	27	26	5	1	20	10	36	29	34	17
108	25	16	13	2	18	12	47	35	44	39
113	32	19	8	4	29	18	33	33	46	42
118	42	15	15	3	25	22	59	29	36	39
123	61	21	32	4	33	13	119	24	40	24
128	36	38	25	6	40	7	104	11	62	21
133	41	51	20	12	44	20	123	28	53	22
138	46	43	26	11	48	25	123	40	43	23
143	51	34	12	15	47	23	71	37	28	37
148	42	19	14	10	9	20	35	45	23	28
153	12	7	5	8	6	17	5	24	2	31
158	4	12	--	3	3	7	--	33	--	34
163	1	21	--	18	--	16	--	61	--	37
168	--	24	--	31	1	23	--	68	--	56
173	1	33	1	33	--	40	--	80	1	65
178	--	28	1	38	1	33	--	67	--	52
183	--	36	1	53	--	38	--	68	--	77
188	--	48	--	49	--	49	--	59	--	61
193	--	40	--	30	--	36	--	35	--	21
198	--	22	1	23	--	10	--	17	--	12
203	--	8	1	11	--	5	--	13	--	4
208	--	5	--	3	--	--	--	4	--	--
213	--	1	--	--	--	--	--	--	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	495	624	187	373	350	456	798	874	441	755
Number of stations	7		3		9		18		14	

APPENDIX TABLE 6.—Length distributions by cruise and sex.—*Continued.*

Total length	Aug. 22-28, 1962		Sept. 25-28, 1962		Feb. 5-7, 1964		Nov. 11-18, 1964		July 20-22, 1967	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	--	--	--	--	2	--	--
63	--	1	--	--	--	--	--	2	--	--
68	--	--	--	-	--	--	1	8	--	--
73	1	--	--	--	--	1	--	11	--	1
78	--	--	--	1	--	1	2	13	--	--
83	--	1	--	1	2	2	3	14	1	--
88	2	--	1	--	6	2	3	13	--	--
93	6	4	2	--	15	5	2	12	2	2
98	13	3	3	3	18	10	15	14	8	4
103	27	3	7	3	17	18	42	32	28	22
108	32	17	3	6	13	4	80	74	23	30
113	31	25	11	3	13	6	127	110	35	40
118	15	18	10	3	19	8	143	159	25	41
123	32	17	12	5	9	11	105	167	31	24
128	47	15	20	5	23	19	97	154	25	11
133	78	15	61	2	27	13	74	90	29	11
138	73	9	100	7	29	10	53	50	17	17
143	17	7	95	3	51	11	36	37	18	4
148	16	9	33	3	32	4	36	42	2	8
153	2	6	5	8	12	9	22	50	4	12
158	--	10	2	5	2	10	8	29	2	11
163	1	36	--	17	--	7	9	29	1	5
168	--	53	1	29	--	11	3	17	--	14
173	--	63	1	44	--	13	--	25	--	12
178	--	93	--	75	1	20	1	17	--	13
183	--	62	--	64	1	31	1	15	--	8
188	--	33	--	41	--	30	--	10	--	6
193	--	14	--	29	--	35	--	22	--	2
198	--	5	--	14	--	12	--	11	--	1
203	--	5	--	4	--	5	--	2	--	--
208	--	1	--	--	--	1	--	1	--	--
213	--	--	--	1	--	--	--	1	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	393	525	373	376	290	309	863	1,233	251	299
Number of stations	10		8		6		21		6	

APPENDIX TABLE 6.—Length distributions by cruise and sex.—*Continued.*

Total length	June 11-22, 1958		Jan. 18-28, 1960		Apr. 30-May 3, 1960		Apr. 28-May 1, 1961		Jan. 16-Feb. 22, 1962	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
mm	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
53	--	--	--	--	--	--	--	--	--	--
58	--	--	--	--	--	--	--	--	--	--
63	--	1	--	--	--	--	--	--	--	--
68	--	--	--	--	--	--	--	--	--	--
73	--	--	--	--	--	--	--	1	--	1
78	--	--	3	1	--	--	--	1	--	1
83	--	--	7	8	--	1	3	2	--	2
88	3	--	15	12	--	--	4	3	1	2
93	3	2	15	24	1	4	10	15	1	4
98	4	3	14	18	2	2	19	14	5	4
103	8	7	8	27	9	9	25	19	7	3
108	28	3	8	9	16	19	15	15	14	8
113	48	17	7	5	15	25	7	16	16	10
118	86	23	14	4	29	26	9	9	28	4
123	218	40	31	7	61	21	16	3	32	25
128	201	53	83	11	73	12	80	5	79	25
133	209	85	76	9	69	18	107	3	180	18
138	128	107	63	14	51	29	95	13	232	13
143	104	98	39	3	30	20	58	12	188	5
148	62	91	11	9	6	20	21	15	65	11
153	19	117	8	18	6	21	12	26	16	22
158	2	119	2	19	3	23	4	24	7	39
163	4	125	--	20	4	35	--	30	5	91
168	--	111	2	31	1	36	--	54	1	138
173	3	130	1	20	2	41	1	77	1	236
178	4	146	1	27	--	41	1	79	1	225
183	1	166	--	17	1	21	1	58	1	213
188	1	149	--	19	--	17	--	48	1	135
193	--	113	--	13	--	11	1	34	--	88
198	--	78	--	4	--	6	--	13	--	38
203	--	22	--	5	--	3	--	8	--	17
208	--	4	--	2	--	2	--	3	--	8
213	--	1	--	--	--	--	--	1	--	--
218	--	--	--	--	--	--	--	--	--	--
Total	1,136	1,811	408	356	379	463	489	601	881	1,386
Number of stations	28		13		10		12		24	