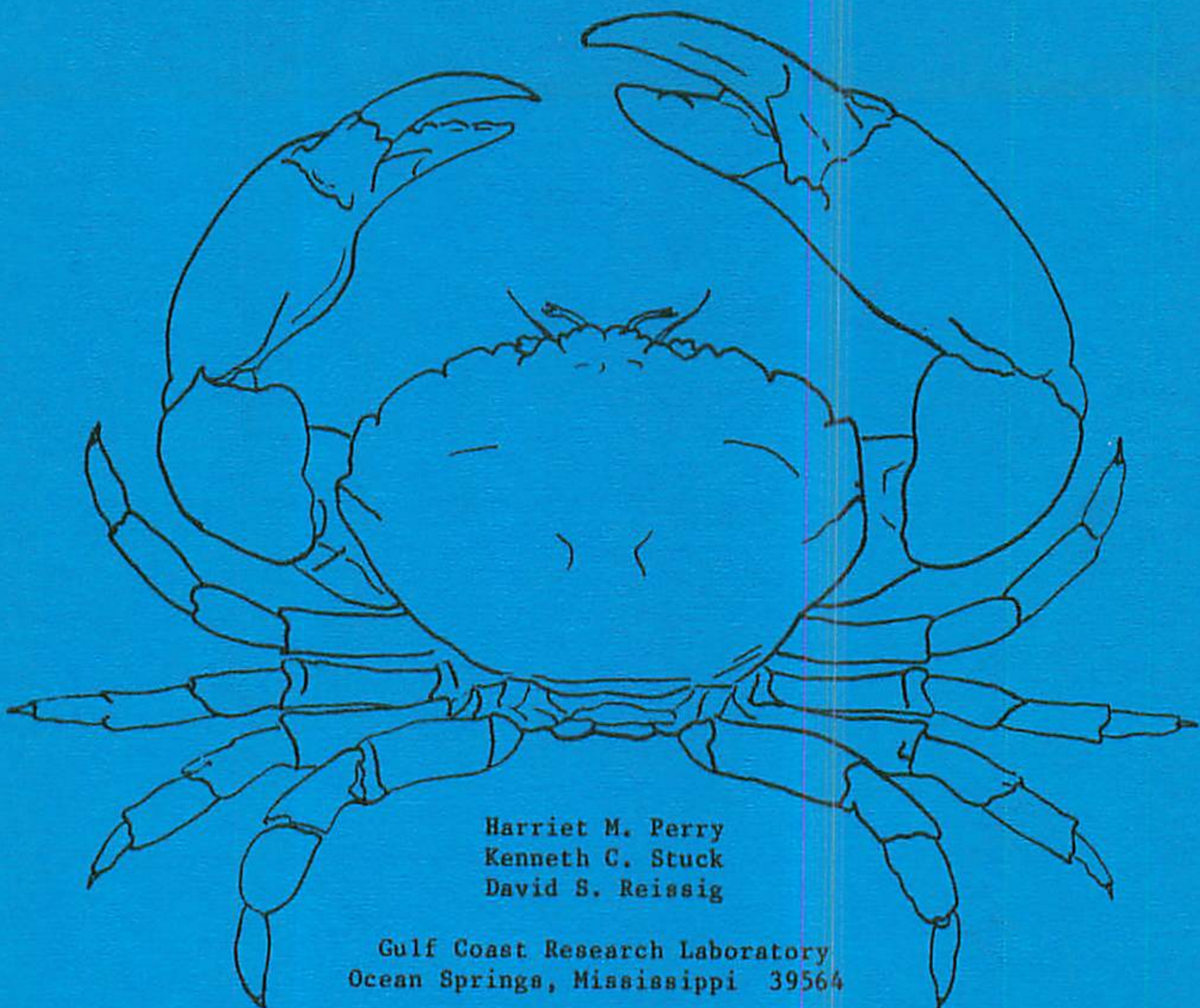
# *MENIPPE MERCENARIA*: THE POTENTIAL FOR DEVELOPMENT OF A FISHERY



1983 Annual Report



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# *Menippe mercenaria*: The Potential for Development of a Fishery

Annual Report to Sea Grant for Calendar Year 1983

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# INTRODUCTION

The stone crab, *Menippe mercenaria*, ranges from the Yucatan Peninsula of Mexico through the Gulf of Mexico and into the Atlantic Ocean, north to Cape Lookout, North Carolina (Williams 1965). Stone crabs occur subtidally on rocks, jetties, oyster reefs, and submerged grass beds. The United States fishery for this species is largely confined to south Florida where abundance is greatest due to favorable habitat conditions. The stone crab fishery constitutes the third largest crustacean fishery in Florida. The chelipeds or claws, which approximate one half of the body weight, are the saleable portion of the crab. In the Florida fishery, the claws are removed in the field and the rest of the animal released back into the water. Florida statutes define legal-sized claws as those with a propodus length of 70.0 mm. Both claws are allowed to be harvested if of legal size. Stone crabs enter the fishery at approximately three years of age (Sullivan 1979).

Subsequent to the initiation of this research project, it was learned that inshore populations of *Menippe* in the north central Gulf of Mexico were not referable to *M. mercenaria* but appeared to be a new species (personal communication, Austin Williams, U.S. National Museum). Electrophoretic studies conducted on crabs from Mississippi suggested that the estuarine population of *Menippe* was probably not a new species, but an incipient species with hybridization at the zone of overlap (Apalachee Bay) with *M. mercenaria* (personal communication, Theresa Bert, Yale University). In either case, much of the life history data available for *M. mercenaria* is not directly applicable to populations of stone crabs in the western Gulf.

Published data on the seasonal and areal distribution of stone crabs in Mississippi Sound are lacking. Juveniles are reported to be numerous in the "shell hash" near the barrier islands (Richard Heard, personal communication) and over the oyster reefs (Vincent J. Smith, personal communication). Examination of crabs from oyster dredge samples taken from the Merrill Coquille reef indicated that juvenile stone crabs made up a large portion of the crabs captured. Crabs of the families Porcellanidae, Xanthidae, and Majidae were identified from samples, with Menippe comprising from 18.9 to 38.6% of the catch. Adult stone crabs have been reported from the rock rubble in the vicinity of Cat Island and Pass Marianne Lights, and from the rock pile off Ship Island (Bill Demoran, personal communication).

Stone crabs have always entered the commercial blue crab catch in Mississippi but never in any numbers (Luke Dubaz, formerly of Dubaz Brothers Seafood, personal communication). The catch of stone crabs taken incidentally to the catch of blue crabs has increased dramatically in the last three years. This increase may be attributed to one or, more probably, a combination of factors. Recent favorable environmental conditions may have allowed for successful larval recruitment and increased juvenile survival and growth. Salinity may be an important variable in determining survival of both larvae and juveniles. Hydrographic data collected during the course of an assessment and monitoring project (Public Law 88-309, Project 2-296-R, Gulf Coast Research Laboratory) indicate that average yearly salinities in Mississippi Sound have increased over the last four years. More importantly, the increase in available habitat for the species brought about by the establishment of new oyster reefs and the expansion and revitalization of existing reefs is thought to be a major factor in the observed increase of juveniles and harvestable adults. State oyster reef acreage, through shell planting, increased from 3,920 acres in 1977, to 7,820 acres in 1981 (Bill Demoran, personal communication). In addition, 2,064 acres of bottom have been leased to private individuals (Tommy VanDevender, Bureau of Marine Resources, personal communication). The Bureau estimates that 10% of the acreage has been planted in shell bringing the total oyster reef acreage in Mississippi to 8,080 acres.

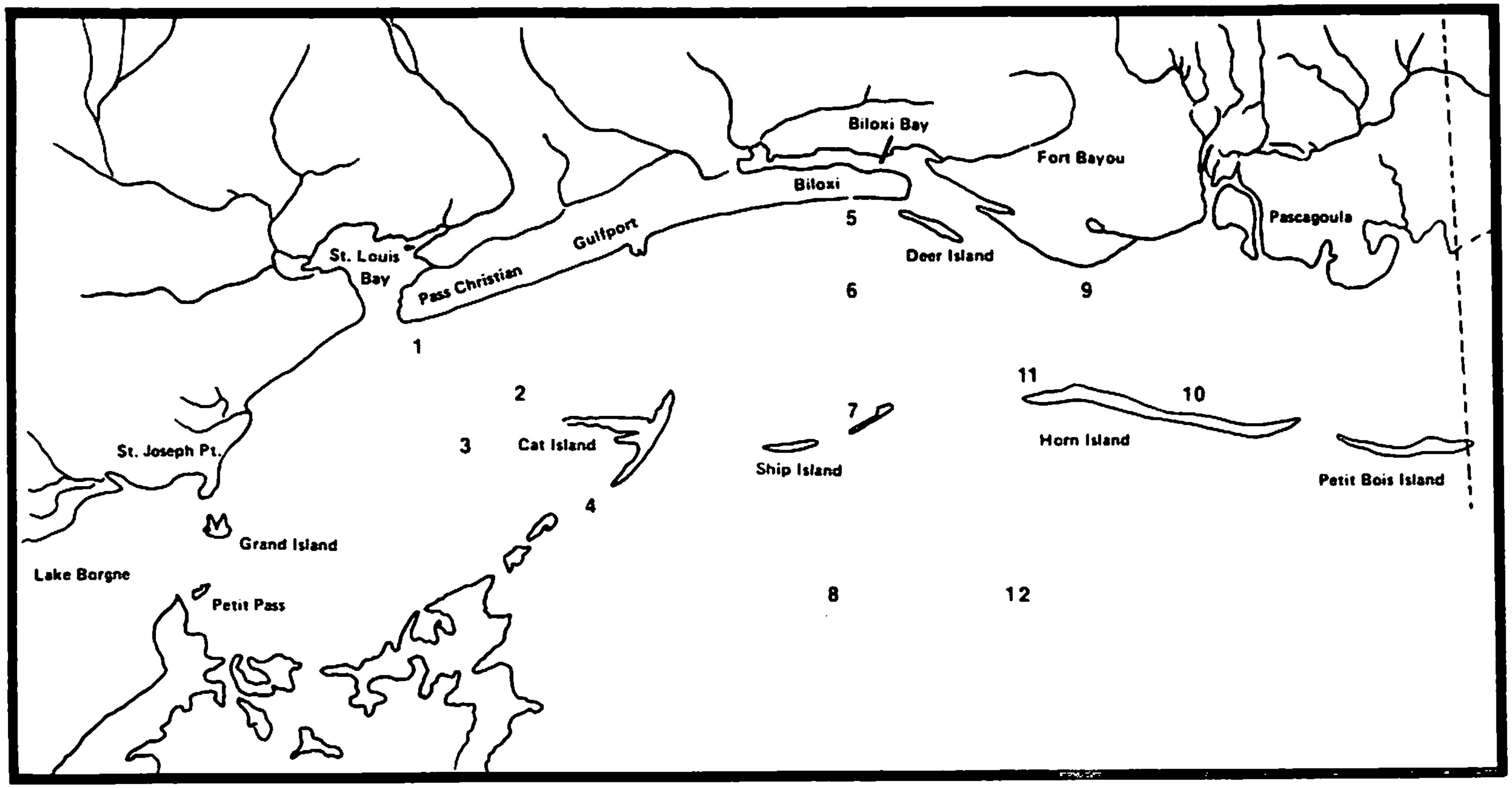
Local fishermen expressed an interest in fishing for stone crabs. A review of the harvesting methods in use in the Florida fishery indicated that crab pots designed to catch the blue crab, Callinectes sapidus, were deployed by some fishermen in that state to take stone crabs, thus, an investment in new gear would be unnecessary. While fishing costs (fuel, bait, pots, vessel maintenance) have continued to increase over the last few years, the ex-vessel value of hard blue crabs has not kept pace. In fact, the ex-vessel value of hard crabs in Mississippi in 1977 and 1980 was the same ($0.25/pound) (NOAA, Current Fishery Statistics, Monthly Landings, Mississippi). In contrast, the ex-vessel value of landings in the stone crab fishery has increased over 20 times with stone crab claws worth $1.82/pound in 1977-78 (Costello et al. 1979). Demand for the product and favorable prices are expected to continue. The establishment of a stone crab fishery would provide a source of additional income for local blue crab fishermen and would supply a "speciality item" to seafood restaurants. Marketing and consumer acceptance are not expected to be a problem. Stone crabs claws brought in from Florida were available at a seafood market in Ocean Springs for several years, and Mississippi fishermen currently harvesting the claws have found outlets for them in Biloxi and Pascagoula (Vincent J. Smith, personal communication).

Mississippi crab fishermen interested in the potential development of a fishery for stone crabs fear that the indiscriminate harvesting practices now going on may irreparably damage the existing population. They have requested specific data on the fishery in hopes of an orderly progressive development of exploitation of this species.

## MATERIALS AND METHODS

All samples were taken from Mississippi Sound and surrounding waters (Figure 1). Quantitative zooplankton samples were collected twice monthly using a ½-meter plankton net fitted with #303-micron mesh netting. Eighty-four samples were collected at specified stations from April through October. Samples were preserved in the field in 5% formalin and returned to the laboratory for analysis. Stone crab zoeae and megalopae were counted, staged, and the samples archived.

Juveniles were sampled using several gear types. A standard oyster dredge lined with 1 mm nylon netting was used to collect samples over oyster reefs. Artificial habitats (Figure 2) consisting of 1 inch plastic netting and containing 0.5 $ft^3$ of oyster shell were deployed in surface and bottom waters at selected stations. Over sand and grass bottoms a scallop dredge fitted with #750-micron mesh netting was employed. Quantitative estimates of juvenile stone crab densities were calculated and expressed as crabs/$ft^3$ of shell examined. Samples were collected twice monthly except in January when severe weather allowed only one trip. Juvenile habitat samples were occassionally destroyed due to tampering or severe weather. Overall, 506 oyster dredge and habitat samples, containing over 262 $ft^3$ of shell, were collected. Samples were returned to the laboratory where stone crab megalopae and juveniles were removed. Morphometric measurements,




## STATION LOCATIONS AND SAMPLING GEAR

| STATION | | GEAR | STATION | | GEAR |
|---|---|---|---|---|---|
| 1 | Square Handkerchief Reef | Dredge,[1] habitat | 7 | Camille Cut, Ship Island | Dredge,[2] habitat |
| 2 | Pass Marianne Light | Dredge,[1] habitat, plankton | 8 | Offshore, Ship Island | Habitat, plankton |
| 3 | Telegraph Reef | Dredge,[1] habitat | 9 | Belle Fontaine Reef | Dredge,[1] habitat |
| 4 | Cat Island Channel | Habitat, plankton | 10 | Horseshoe, Horn Island | Dredge[2] |
| 5 | White House Reef | Dredge,[1] habitat | 11 | Dog Keys Pass | Dredge,[2] habitat, plankton |
| 6 | Intracoastal Waterway | Plankton | 12 | Farewell Bouy | Habitat, plankton |

[1]Oyster dredge
[2]Scallop dredge

Figure 1. Location of stations.

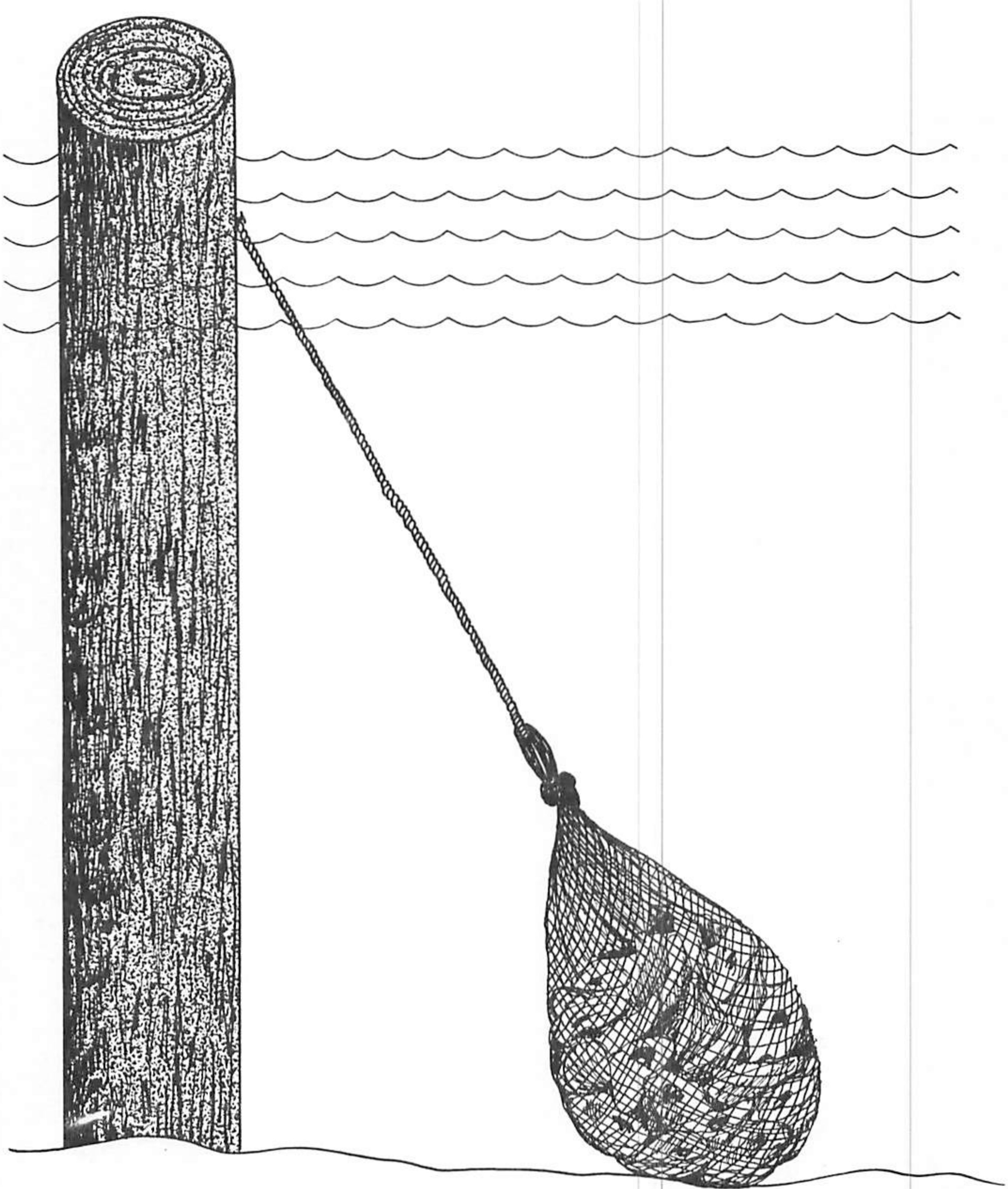


Figure 2. Artificial habitat of plastic netting filled with oyster shell (modified from Supan 1983).

including carapace width, length, handedness, propodus length and sex (larger individuals) were recorded on all juveniles.

A systematic interview program was conducted with local blue crab fishermen to gain information on those stone crabs currently entering the fishery. Bi-monthly visits to local crab processing plants and trips with local fishermen were made with the following data collected: number caught, location, date, carapace width, propodus length, sex and handedness.

All data were coded for electronic data processing.

## RESULTS

### Hydrology

Temperature fluctuations within the sampling area followed general seasonal patterns characteristic of Mississippi coastal waters. Mean surface water temperatures (combined station data) varied from 11.5°C in January to 30.0°C in August. Bottom water averages ranged from a low of 11.7°C in January to 30.2°C in July. Individual readings as low as 9.5°C in January and 35.0°C in July were recorded.

Salinity patterns were atypical due to extremely heavy rainfall during the late winter/early spring that necessitated the opening of the Bonnet Carre Spillway on 20 May (U.S. Army Corps of Engineers, New Orleans District). Salinities were severly depressed in the western Sound, rising in the early summer following the closing of the Spillway on 23 June.

Mean bottom salinities fell from 14.9°/₀₀ in January to 8.2°/₀₀ in February with salinities in the western Sound at Stations 0, 1, 2 and 3 near 0.0°/₀₀. Salinities rose again in March averaging 19.3°/₀₀ for bottom waters but began to fall again in April. From April through June bottom salinities in the western Sound were below 2.0°/₀₀ with surface salinities near 0.0°/₀₀. Salinities in the central and eastern Sound were also depressed during this period. Following closure of the Spillway, salinities rapidly increased, reaching mean values of 19.3°/₀₀ on the bottom and 14.7°/₀₀ on the surface. Salinities remained relatively high throughout the remainder of the sampling period.

## Larval Sampling

### Zoeae

Twenty-two of the 84 samples collected contained stone crab larvae. Zoeae were present in samples from late May through September with greatest numbers occurring in August (Figure 3). They were collected in temperatures ranging from 22.0 to 32.0°C, however, 90% of the total catch occurred in temperatures between 27.0 and 31.0°C. Zoeae were taken from salinities as low as 9.0°/₀₀, but the majority of the catch was taken in salinities ranging from 17.0 to 30.0°/₀₀. Zoeal stages I through V were noted in samples. Second stage zoeae made up the majority of the zoeal catch. Percent composition for developmental stages was as follows:

| Zoeal Stage | Percent Composition |
|---|---|
| I | 19.5 |
| II | 41.9 |
| III | 28.5 |
| IV | 5.6 |
| V | 3.5 |

Stations 4, 8 and 12 collectively were most productive for stone crab zoeae, accounting for over 85% of the total catch (Figure 4). These three stations were located just south of the barrier islands and generally maintained the highest salinities of all stations sampled

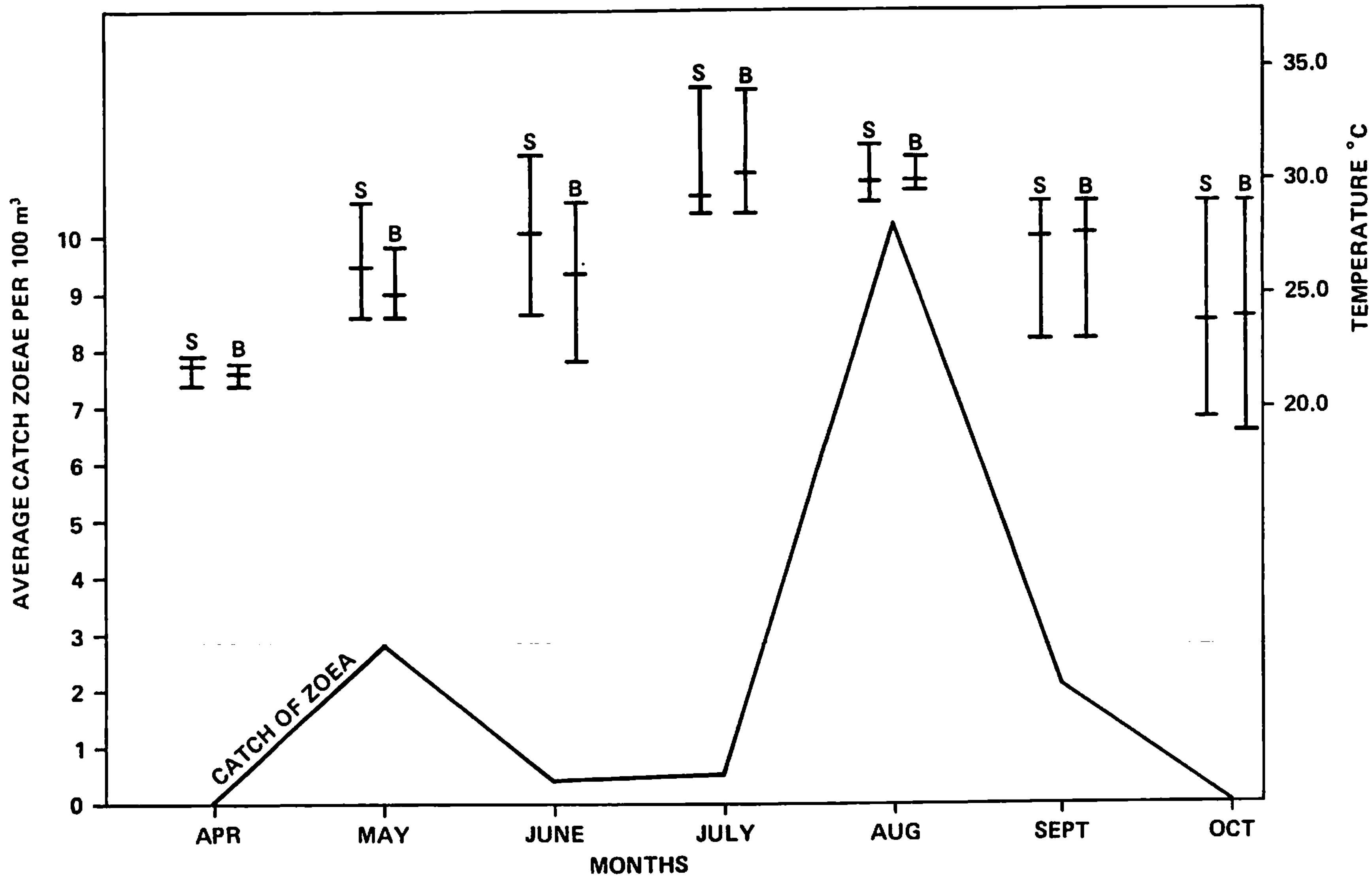



Figure 3. Seasonal abundance of stone crab zoeae. Temperature ranges and means for samples collected during each month for surface (S) and bottom (B) waters are indicated on the upper half of the graph.

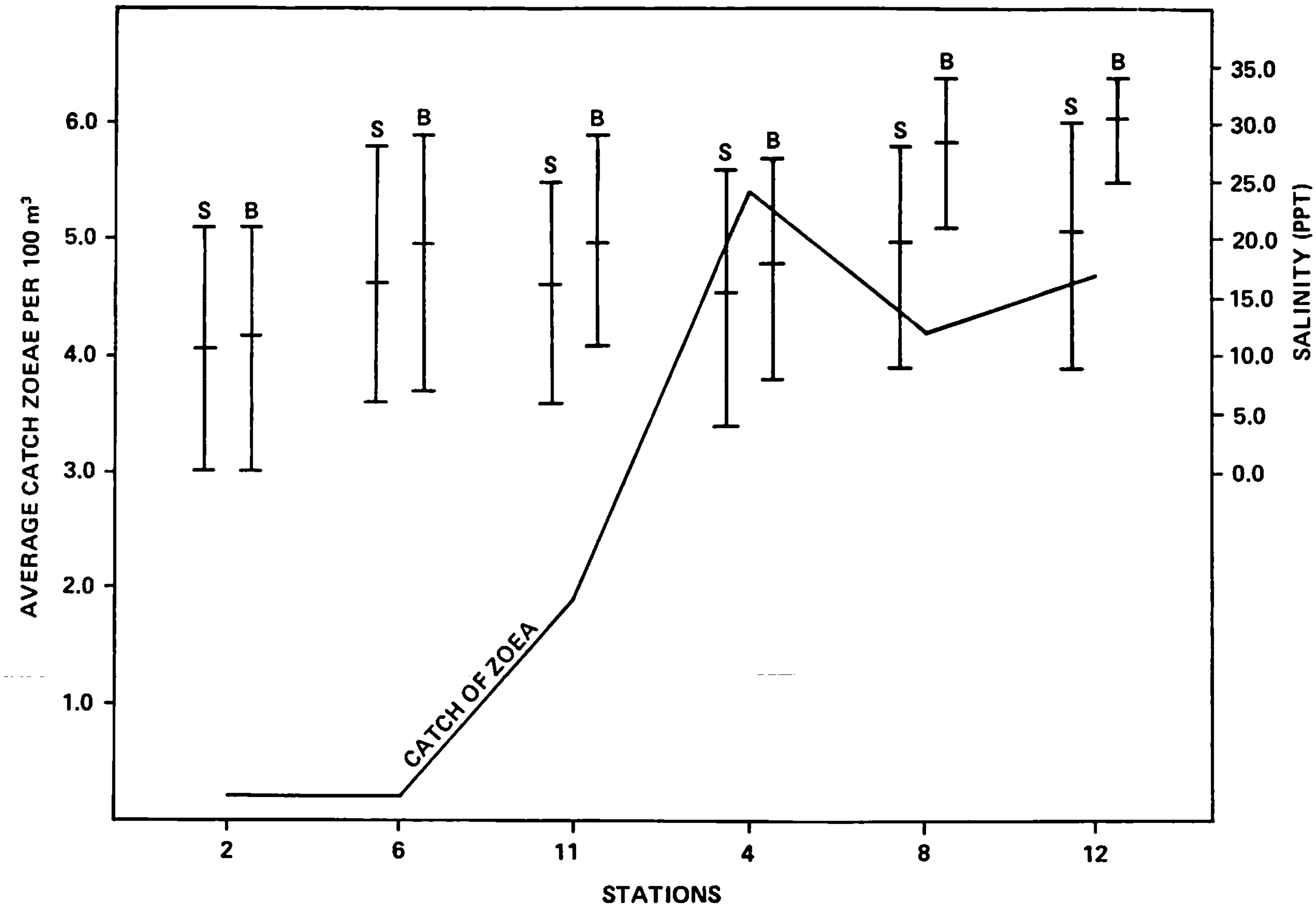



Figure 4. Catch of stone crab zoeae by station. Salinity ranges and means for each station for surface (S) and bottom (B) waters are indicated on the upper half of the graph.

(Table 1). Bottom water salinities at Stations 8 and 12 never fell below 21.0°/$_{oo}$ and surface waters were normally above 15.0°/$_{oo}$. Due to heavy spring flooding in the western sound, salinities at Station 4 were unusually low; often below 10.0°/$_{oo}$. However, by late summer and fall, salinities above 20.0°/$_{oo}$ were maintained. As a result, stone crab zoeae were not commonly collected at Station 4 until August whereas, they were present in samples taken from Stations 8 and 12 as early as May.

Megalopae

Stone crab megalopae were present in shell bag habitats from June through October with peak abundance occurring from July through September (Figure 5). They were present in temperatures ranging from 18.0 to 34.0°C with the majority (85%) collected in temperatures above 26.0°C. Megalopae were taken in salinities as low as 9.0°/$_{oo}$, however, most (87%) were taken in salinities ranging from 15.0 to 30.0°/$_{oo}$.

Megalopae showed wide distribution in coastal waters. They occurred in greatest numbers at Station 11 in lower Mississippi Sound, but were common at Stations 4, 8 and 12 south of the Intracoastal Waterway and Stations 5 and 9 off the mainland beaches (Figure 6).

The vast majority of stone crab megalopae were taken in shell bag habitats. Only two individuals were identified from plankton samples.

Discussion

The abundance of stone crab zoeae in plankton samples corresponded with records of ovigerous females. Collection of early stage zoeae in May occurred approximately 3 weeks after the initial appearance of

Table 1. Salinity range, mean and average catch per sample (zoeae/100m$^3$) for each station.

| | Stations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity: | 2 | | 4 | | 6 | | 8 | | 11 | | 12 | |
| Depth: | S | B | S | B | S | B | S | B | S | B | S | B |
| High: | 21.0 | 21.0 | 26.0 | 27.0 | 28.0 | 29.0 | 28.0 | 34.0 | 25.0 | 29.0 | 30.0 | 34.0 |
| Mean: | 10.8 | 11.8 | 15.8 | 18.0 | 16.2 | 19.6 | 19.2 | 28.3 | 16.3 | 19.9 | 20.8 | 30.1 |
| Low: | 0.0 | 0.0 | 4.0 | 8.0 | 6.0 | 7.0 | 9.0 | 21.0 | 6.0 | 11.0 | 9.0 | 25.0 |
| Average Catch/Sample | | 0.2 | | 5.4 | | 0.2 | | 4.2 | | 1.9 | | 4.7 |

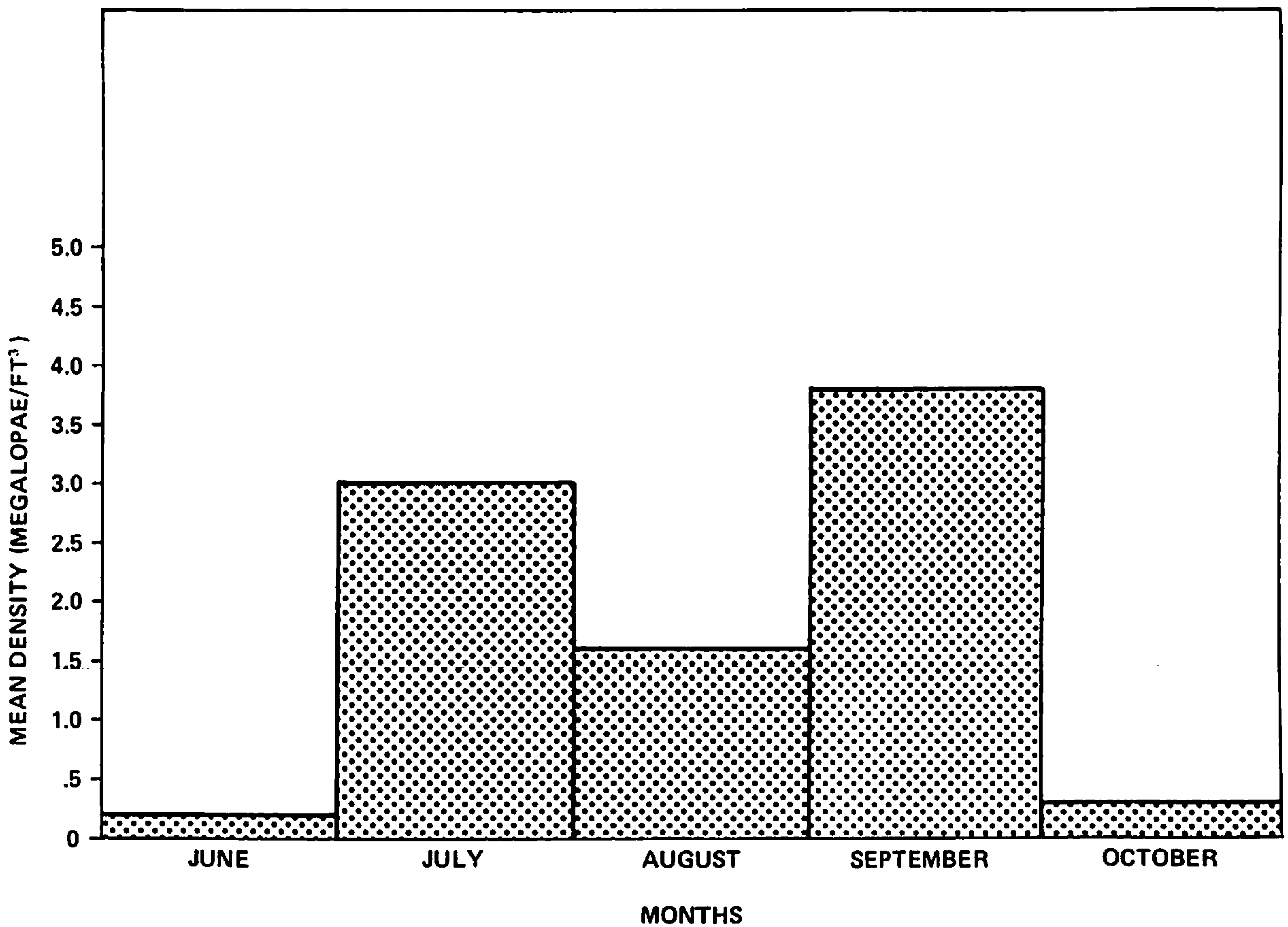



Figure 5. Mean densities of stone crab megalopae by month.

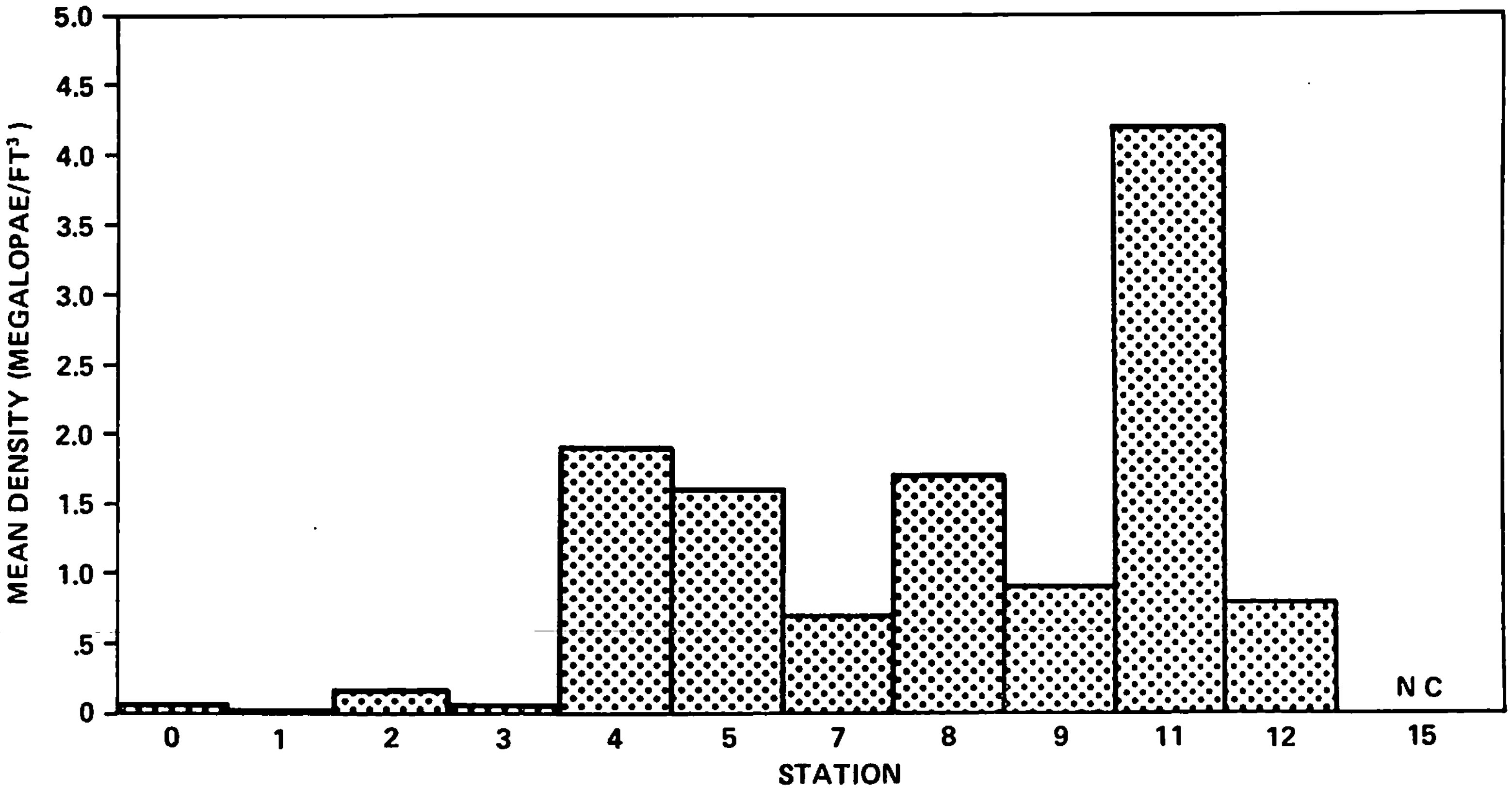



Figure 6. Mean densities of stone crab megalopae by station.

ovigerous crabs in late April. Maximum numbers of ovigerous females were noted in July while maximum numbers of larvae were collected in August. Ovigerous crabs and larvae were not collected after September.

Spawning of M. mercenaria in south Florida waters may occur year-round (Bert et al. 1978) although the frequency is decreased from November through March (Cheung 1969). Noe (1967) and Bender (1971) noted temperature and photoperiod as the primary regulators of spawning frequency for M. mercenaria; accelerated ovarian development was reported by Cheung (1969) at 29.0°C.

Temperature and salinity tolerances of M. mercenaria zoeae and megalopae are known for laboratory-reared larvae. Optimal growth and survival of zoeae to megalopae and first crab stages in culture systems occurred at a temperature of 30°C and in salinities from 30.0 to 35.0°/oo (Mootz and Epifanio 1974). Our data indicated that for the western Gulf form of Menippe, larval salinity tolerances were substantially lower as zoeae were abundant in salinities as low as 17.0°/oo in temperatures above 27.0°C and megalopae occurred routinely in salinities as low as 15.0°/oo.

The collection of ovigerous females, zoeal stages I-V and megalopae in our samples suggest that larval development may be completed within Mississippi Sound and adjacent offshore waters. In contrast, blue crab larval development is completed offshore as only zoeae I, II and megalopae are found in local waters; later zoeal stages develop in the open Gulf (Andryszak 1979, Perry and Stuck 1982). These data indicate that factors affecting spawning, larval recruitment and abundance of juvenile stone crabs are more localized in their effects as compared to blue crabs.

Juvenile Sampling

Juvenile stone crabs were present in 273 of the 506 oyster and habitat samples taken. Only 4 juveniles were collected in scallop dredge samples and therefore are not included in the following analysis. Juveniles were collected all year, however, the majority (74%) were collected during the 4-month period from July through October. Greatest densities were observed during August; 21.5 crabs/$ft^3$ shell volume and September, 16.5 crabs/$ft^3$ (Figure 7). Seventy-one percent of the juveniles collected during this summer-fall period were below 5.0 mm carapace width. Samples collected from January through June and in November and December contributed only 26% of the total catch. Juveniles collected during these months were generally larger in size than the summer-fall group with 76% of these crabs above 8.0 mm carapace width. The density of juvenile stone crabs was relatively high in January (11.5 crabs/$ft^3$) but steadily declined through May when the lowest density (1.0 crabs/$ft^3$) was recorded. Following the summer-fall peaks in abundance, densities were again low (2.0 crabs/$ft^3$) in November and December.

Juvenile stone crabs were collected at all stations except 15. Mean densities were highest at Stations 9 (16.0 crabs/$ft^3$) and 11 (14.5 crabs/$ft^3$) located in eastern Mississippi Sound (Figure 8). Mean densities were low (less than 3.0/$ft^3$) for western Sound stations 1, 2 and 3. Initial density estimates for these stations taken in January, however, were relatively high (above 10.0 crabs/$ft^3$), but steadily declined in the following months reaching lowest values (0.0/$ft^3$) in June and July.

Juvenile stone crabs were collected in water temperatures ranging from 5.8 to 33.0°C, with 74% of the total catch occurring in temperatures

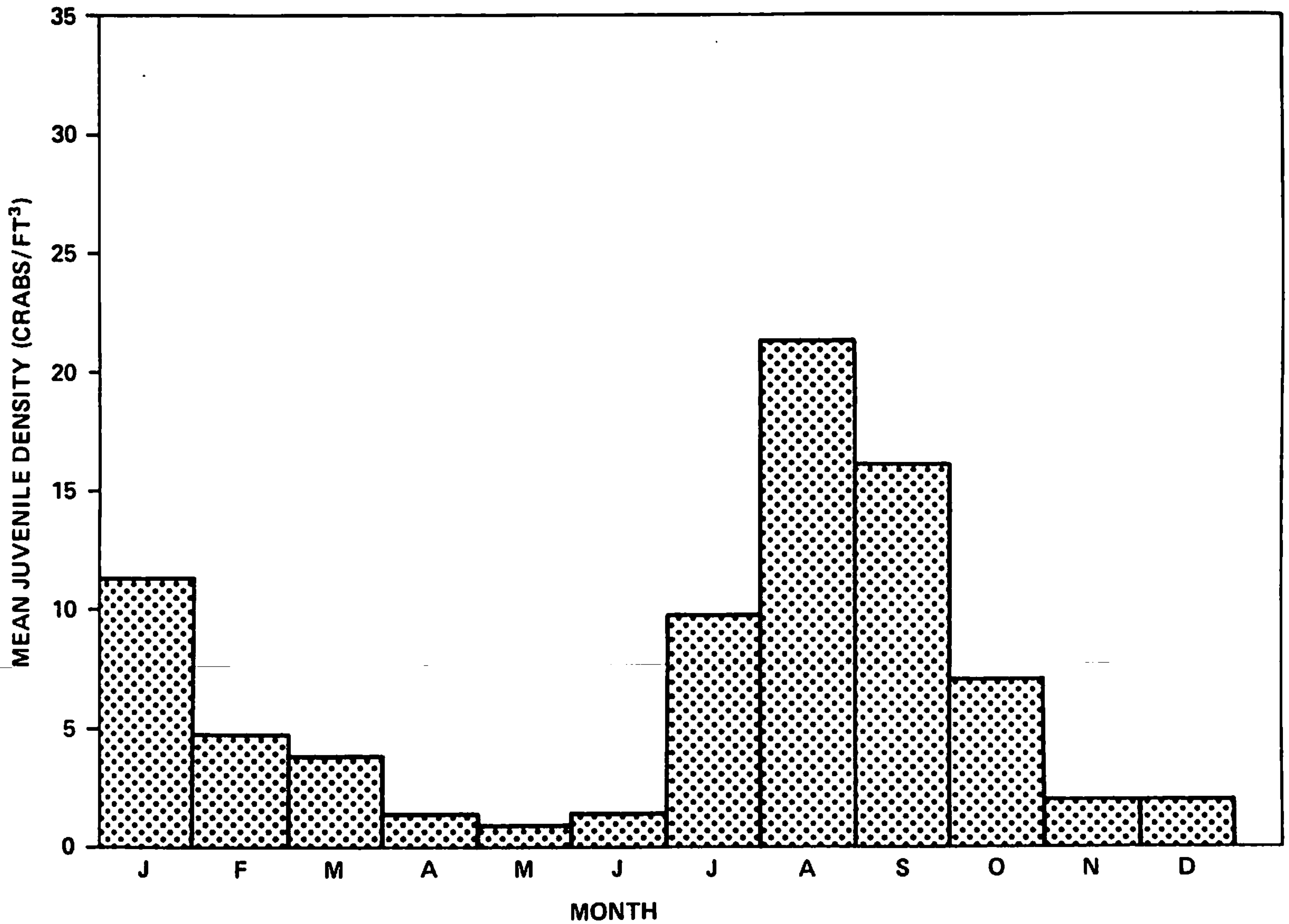



Figure 7. Mean densities of stone crab juveniles by month.

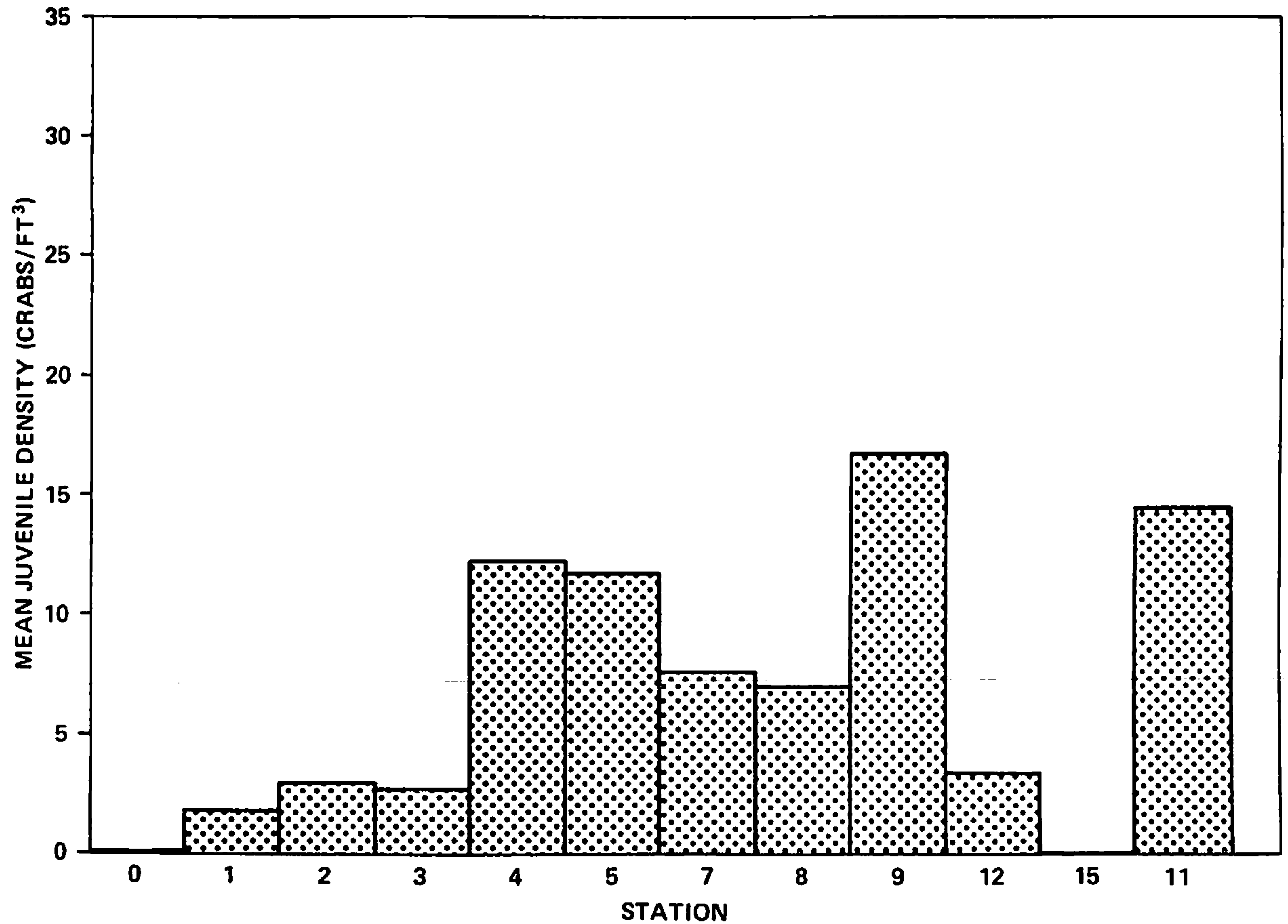



Figure 8. Mean densities of stone crab juveniles by station.

above 25°C. Analysis of variance (ANOVA) indicated a significant (0.05 probability) relationship between temperature and juvenile densities, however, using Duncan's Multiple Range Test, a direct relationship between high temperatures and mean catch of juveniles was not apparent (Figure 9). This is due in large part to the occurrence of juveniles in a few (8) high salinity, low temperature samples. The effect of salinity on juvenile densities is more apparent. Most (82%) juvenile crabs were collected from waters in the salinity range of 15.0 to 28.5°/oo and were present in offshore waters of 33.0°/oo salinity. In February, juveniles were collected over oyster reefs in the western Sound under freshwater conditions, however catches decreased markedly as salinities began to drop in April. Analysis of variance indicated that salinity had a significant influence (0.01 probability) on the abundance of juveniles (Figure 10). Intermediate salinities in the range of 20.0-29.9°/oo appeared most favorable for high juvenile densities. Both low salinities (below 14.9°/oo) and high salinities (above 30.0°/oo) were far less productive.

## Discussion

Juveniles were collected from a variety of habitats including mud, sand, oyster reefs and "shell hash" bottoms. Greatest densities of juveniles were consistently obtained from inshore oyster bed samples and on mud bottoms along channels in the lower Sound. Overall juvenile densities were far greater in central and eastern Sound samples compared to samples taken in the western Sound. This may, in part, be due to severe spring floods which lowered the salinity of western Sound waters to near fresh conditions for several months. From April through June,

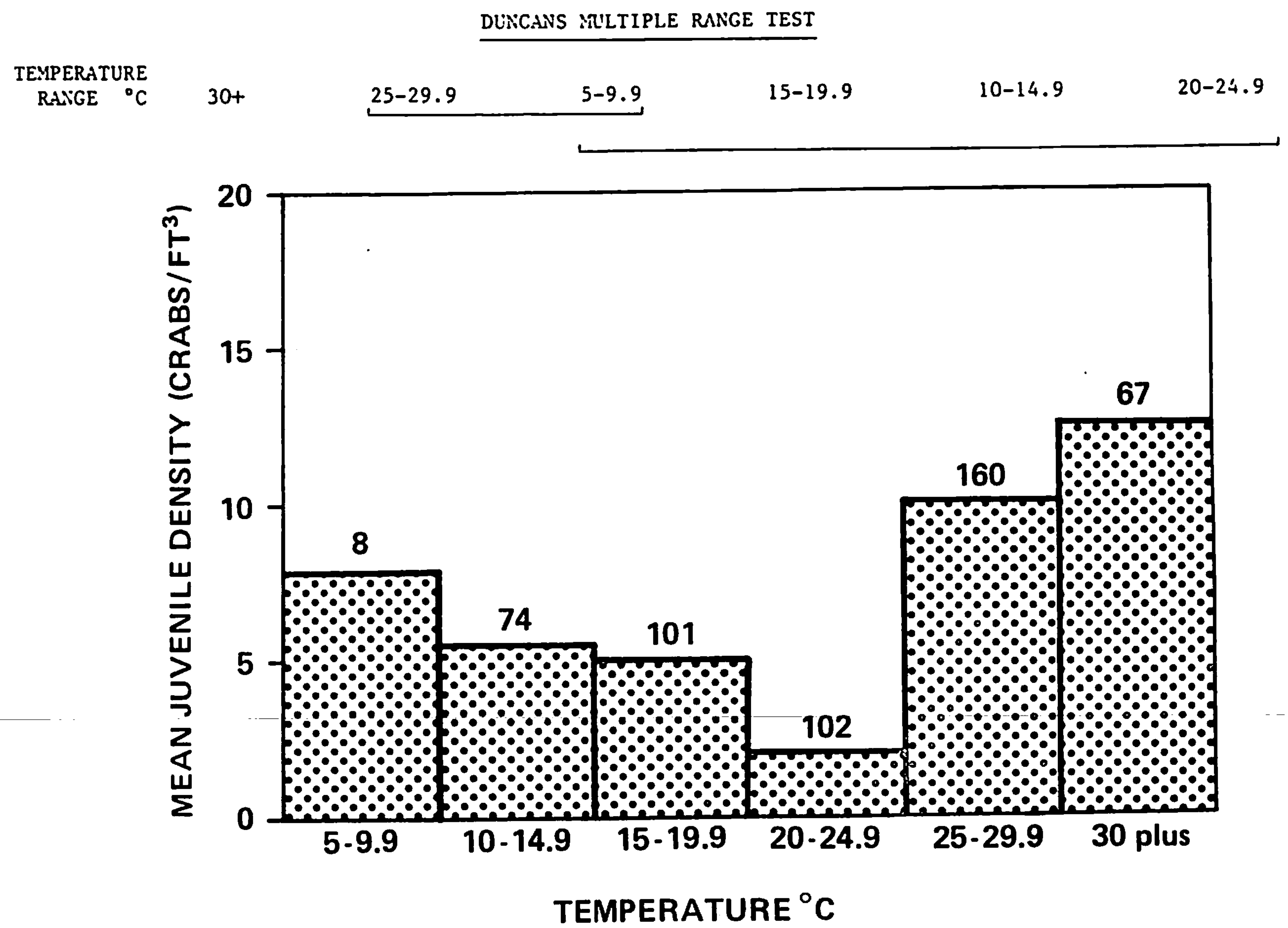



Figure 9. Distribution of juvenile stone crabs by temperature. Similarities in juvenile densities by temperature range are indicated by Duncans' Multiple Range Test.

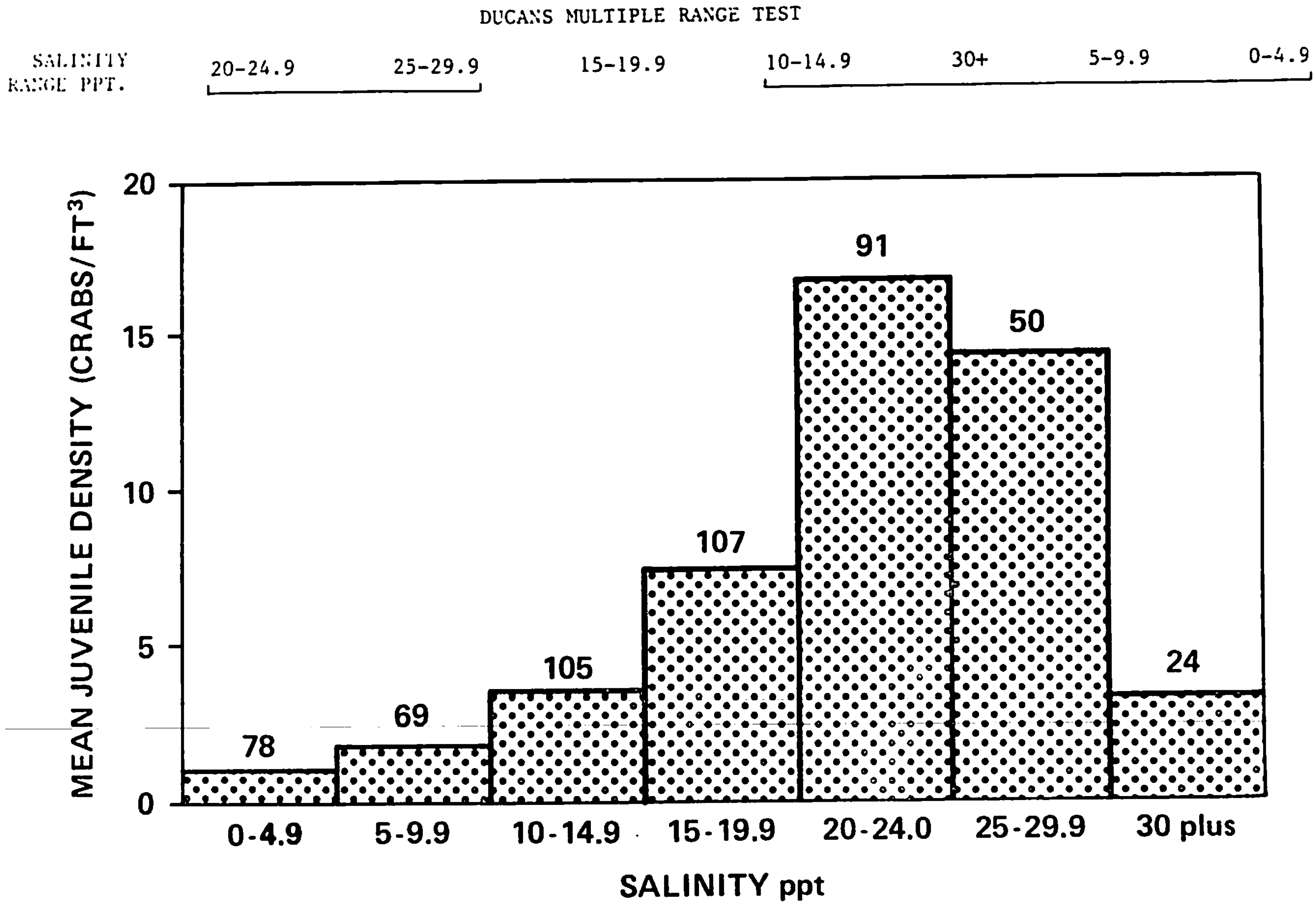



Figure 10. Distribution of juvenile stone crabs by salinity. Similarities in juvenile densities by salinity range are indicated by Duncans' Multiple Range Test.

juvenile crabs were not collected in western Mississippi Sound and did not reappear until late July when salinities approached 15.0°/₀₀ and above.

Comparison of data concerning ecological requirements for juvenile stone crabs is complicated by current taxonomic confusion. The studies of McRae (1950), Wass (1955) and Bender (1971) were conducted in the vicinity of Cedar Key, Florida, a region recently characterized as an area of hybridization between *M. mercenaria* and the western Gulf form of *Menippe* (Bert, unpublished manuscript).

In Cedar Key, Florida, juveniles below 3.0 cm were found to be abundant on shell bottoms, sponges and grass flats, while crabs above 3.0 cm were found on oyster bars in the summer (Bender 1971). Wass (1955) found small crabs (below 1.3 cm) primarily along muddy channel bottoms in northwest Florida.

While the type of bottom habitat preferred by juveniles in the present study appears to be similar to that in other areas, tolerance to low salinities and temperatures was greater in northern gulf populations. Data collected in the present study indicated a preferred salinity range of 20.0 to 29.9°/₀₀, however, juveniles were also collected in large numbers in salinities of 15.0 to 19.9°/₀₀. Our data also indicated that juveniles tolerated very low salinities (below 5.0 ppt) for periods as long as 3 to 4 weeks. These results are in sharp contrast to previous studies indicating that salinities above 24.0°/₀₀ are required for juvenile survival (McRae 1950, Manning 1961, Bender 1971). Bender (1971) also reported that optimal growth of juveniles occurred in the salinity range of 27.0 to 30.0°/₀₀. Salinities in this range were never recorded over oyster reefs and only rarely occurred in lower Mississippi Sound.

Although salinity appeared to be the single most important environmental factor controlling juvenile survival, greatest catches of juveniles occurred during periods of high temperatures. Water temperatures above 25.0°C corresponded with the initiation of juvenile recruitment beginning in July and continuing through September. During this period juvenile densities as high as 122.0 crabs/$ft^3$ of shell were recorded from individual samples. The summer juvenile population was dominated by crabs below 4.0 mm carapace width; crabs recently metamorphosed from the megalopal stage. During 7 to 8 months of the year however, juvenile stone crabs in Mississippi Sound were exposed to water temperatures below 22.0°C and for a period of several weeks were exposed to winter temperatures below 10.0°C. During this time, mortality of juveniles due to extremely low temperatures was not evident. Bender (1971) found small crabs to be most abundant after the spring spawn in the temperature range of 22.0 to 31.0°C. He reported growth rates and survival were significantly greater at 30.0°C than 20.0°C. Juveniles were not collected in temperatures below 12.0°C.

In M. mercenaria size and age at sexual maturity are not clearly known, however juvenile stone crabs are believed to reach sexual maturity after the first year of growth (Lindberg and Marshall 1984). Lower temperatures and salinities both act to slow juvenile growth rates and prolong development time to the adult. The effect that the lower salinities and temperatures of Mississippi coastal waters has on the growth rates of juvenile stone crabs in local water is at present unknown.

## Commercial Fisheries Studies

Data were collected on 533 stone crabs. All crabs measured were taken from blue crab traps with the majority of measurements made aboard commercial fishing vessels. Seasonal and areal distribution and abundance data necessarily reflect fishing effort and patterns. During the winter and spring, severe weather, low blue crab availability and an abundant oyster harvest all combined to lower effort in the commercial fishery for blue crabs. During the late summer-early fall, effort again decreased in the fishery due to a "glut" of crabs that exceeded processing capabilities and placed crab fishermen on harvest limits. While useful spawning and morphometric data were collected, it is doubtful that abundance data are indicative of population size.

### Seasonal and Areal Distribution and Abundance

Total catch, catch by sex, number of ovigerous females and catch by area were tabulated monthly and are presented in Table 2. Over one-half of all crabs collected were taken in July and August. Catches of females exceeded catches of males in eight of the twelve months. Female stone crabs comprised 69.2% of the total catch. Of the 369 female crabs collected, 44.7% were taken in July. Ovigerous females were noted in samples from April through September, with peak numbers recorded in July. The smallest spawning female measured 73.0 mm carapace width. A few ovigerous females were missing either a major or a minor claw. Berried females from April through July were taken from waters north of the Intracoastal Waterway. In August, egg crabs were taken from near-shore waters in the vicinity of Bayou Cassotte and off Belle Fontaine Beach.

Table 2. Catch of adult stone crabs by month, sex and area.

| Month | Total Catch | Male | Female | | Area** 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 8 | 6 | 2 | | 8 | | | | | | | | |
| Feb | 0 | 0 | 0 | | | | | | | | | | |
| Mar | 56 | 14 | 42 | | | | | | | | | 14 | 42 |
| Apr | 29 | 9 | 20 | $\binom{1^*}{90}$ | | | 4 | | | | | 8 | 17 |
| May | 23 | 11 | 12 | $\binom{3}{90-95}$ | | | 1 | 11 | | 6 | 5 | | |
| Jun | 61 | 28 | 33 | $\binom{11}{80-106}$ | 4 | 25 | | 11 | 21 | | | | |
| Jul | 204 | 39 | 165 | $\binom{38}{73-110}$ | | 55 | 84 | 11 | | | 8 | | 46 |
| Aug | 109 | 42 | 67 | $\binom{19}{85-110}$ | 19 | | 31 | 3 | 16 | | 6 | | 34 |
| Sep | 36 | 12 | 24 | $\binom{1}{98}$ | 21 | | 2 | 9 | 4 | | | | |
| Oct | 1 | 1 | 0 | | | | | | | 1 | | | |
| Nov | 6 | 2 | 4 | | | | | | | 6 | | | |
| Dec | 0 | 0 | 0 | | | | | | | | | | |
| Total | 533 | 164 | 369 | | 52 | 80 | 122 | 45 | 41 | 13 | 19 | 22 | 139 |

*$\binom{\text{number ovigerous}}{\text{range, carapace width}}$

** 1 - Bayou Cassotte
2 - Petit Bois Island
3 - Horn Island
4 - Belle Fountaine Buoy
5 - Belle Fountaine Beach/St. Andrews
6 - Deer Island
7 - Ship Island
8 - Gulfport Ship Channel West
9 - Cat Island/Pass Marianne

Stone crabs were collected from nine general areas: eastern Mississippi Sound - Bayou Cassotte, Petit Bois Island; central Mississippi Sound - Horn Island, Belle Fontaine Buoy, Belle Fontaine Beach/St. Andrews, Deer Island, Ship Island; western Mississippi Sound - Gulfport Ship Channel west, Cat Island/Pass Marianne. Over 63.0% of the catch was taken in the vicinity of the barrier islands of Cat, Horn and Petit Bois.

## Size

Cumulative width-frequency distribution and length-frequency distributions for claw types are found in Table 3. Over 71.0% of the crabs entering the fishery were between 80.0 and 104.9 mm in carapace width. Considering all claw types, 69.1% were below 70.0 mm propodus length, the legal size limit for harvest of *M. mercenaria* in Florida. Fifty percent of the crushers or major claws and 12.3% of the pinchers or minor claws were harvestable using Florida standards. Mean carapace widths for stone crabs entering the fishery ranged from 99.25 mm in January to 80.83 in November. With the exception of September, females averaged slightly larger than males (Table 4).

## Morphometric Analyses

Because only the claws are harvested, commercial fisheries data do not include carapace width; the standard measurement used in brachyuran size frequency distribution and other size-related biological parameters. The relationship between claw size and carapace width thus becomes necessary to interpret data from the commercial harvest.

Relationships between carapace width and major and minor claws were determined for male and female stone crabs (Table 5, Figures 11 through 14). Crabs with intermediate claws were not used in the analyses. Of

Table 3.

Frequency distribution for stone crab data - cumulative 1983.

| INTERVALS | CARAPACE WIDTH | | PROPODUS LENGTH | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | RC | | RP | | LC | | LP | |
| | F | FP | F | FP | F | FP | F | FP | F | FP |
| 0.0 4.9 | | | | | | | | | | |
| 5.0 9.9 | | | | | | | | | | |
| 10.0 14.9 | | | | | | | | | | |
| 15.0 - 19.9 | | | | | | | | | | |
| 20.0 – 24.9 | | | | | | | | | | |
| 25.0 – 29.9 | | | | | | | | | | |
| 30.0 – 34.9 | | | | | | | | | 3 | 0.77 |
| 35.9 – 39.9 | | | 1 | 0.26 | 3 | 2.41 | | | 5 | 1.28 |
| 40.0- 44.9 | | | | | 11 | 8.87 | | | 17 | 4.38 |
| 45.0 – 49.9 | | | 4 | 1.06 | 16 | 12.90 | 5 | 4.23 | 43 | 11.08 |
| 50.0 54.9 | 1 | 0.18 | 21 | 5.57 | 23 | 18.54 | 6 | 5.08 | 66 | 17.01 |
| 55.0- 59.9 | 1 | 0.18 | 36 | 9.54 | 23 | 18.54 | 14 | 11.86 | 82 | 21.13 |
| 60.0 64.9 | 4 | 0.75 | 53 | 14.05 | 24 | 19.35 | 17 | 14.40 | 65 | 16.75 |
| 65.0 69.9 | 13 | 2.43 | 71 | 18.83 | 14 | 11.29 | 19 | 16.10 | 54 | 13.91 |
| 70.0 74.9 | 29 | 5.44 | 57 | 15.11 | 4 | 3.22 | 18 | 15.25 | 25 | 6.44 |
| 75.0 – 79.9 | 48 | 9.00 | 39 | 10.34 | 2 | 1.61 | 22 | 18.64 | 19 | 4.89 |
| 80.0 – 84.9 | 69 | 12.94 | 40 | 10.61 | 2 | 1.61 | 6 | 5.08 | 6 | 1.54 |
| 85.0 – 89.9 | 89 | 16.69 | 31 | 8.22 | 1 | 0.80 | 6 | 5.08 | 1 | 0.25 |
| 90.0 94.9 | 87 | 16.32 | 9 | 2.38 | | | 1 | 0.84 | 2 | 0.51 |
| 95.0 – 99.9 | 71 | 13.32 | 7 | 1.85 | | | 2 | 1.69 | | |
| 100.0 – 104.9 | 65 | 12.19 | 4 | 1.06 | 1 | 0.80 | | | | |
| 105.0- 109.9 | 31 | 5.81 | 3 | 0.79 | | | 1 | 0.84 | | |
| 110.0 – 114.9 | 16 | 3.00 | | | | | | | | |
| 115.0 – 119.9 | 7 | 1.31 | 1 | 0.26 | | | | | | |
| 120.0 – 124.9 | 2 | 0.37 | | | | | 1 | 0.84 | | |
| ALL INTERVALS | 533 | 100.00 | 377 | 100.00 | 124 | 100.00 | 118 | 100.00 | 388 | 100.00 |

Table 4. Mean carapace widths by month; females, males, combined.

| Month 1983 | Females Carapace Width (mm) | | Males Carapace Width (mm) | | Combined Carapace Width (mm) | |
|---|---|---|---|---|---|---|
| | N | Mean | N | Mean | N | Mean |
| 1 | 2 | 102.50 | 6 | 98.16 | 8 | 99.25 |
| 2 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 3 | 42 | 94.19 | 14 | 93.85 | 56 | 94.10 |
| 4 | 20 | 97.35 | 9 | 92.33 | 29 | 95.79 |
| 5 | 12 | 88.50 | 11 | 87.72 | 23 | 88.13 |
| 6 | 33 | 89.45 | 28 | 82.85 | 61 | 86.42 |
| 7 | 165 | 88.66 | 39 | 87.17 | 204 | 88.37 |
| 8 | 67 | 91.59 | 42 | 88.66 | 109 | 90.46 |
| 9 | 24 | 89.66 | 12 | 92.66 | 36 | 90.66 |
| 10 | 0 | 0.00 | 1 | 93.00 | 1 | 93.00 |
| 11 | 4 | 76.50 | 2 | 89.50 | 6 | 80.83 |
| 12 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| | 369 | 90.36 | 164 | 88.57 | 533 | 89.81 |

Table 5. Morphometric relationships, Menippe sp.

| Test | Sex | Number | Equation | R Value | $R^2$ | F Value* |
|---|---|---|---|---|---|---|
| CW vs RC | M | 115 | y = -22.431 + 1.127x | 0.915 | .837 | 579.875 |
| | F | 262 | y = -4.359 + 0.802x | 0.939 | .882 | 1936.907 |
| CW vs LC | M | 38 | y = -22.783 + 1.100x | 0.925 | .856 | 211.885 |
| | F | 80 | y = -0.908 + 0.752x | 0.919 | .844 | 425.920 |
| CW vs RP | M | 41 | y = -12.210 + 0.822x | 0.845 | .714 | 97.400 |
| | F | 83 | y = 4.196 + 0.561x | 0.745 | .555 | 100.337 |
| CW vs LP | M | 115 | y = -12.916 + 0.855 | 0.891 | .794 | 436.200 |
| | F | 273 | y = -3.155 + 0.658 | 0.855 | .731 | 738.737 |

*P<0.005
CW = carapace width, RC = right crusher, LC = left crusher, RP = right pincher
LP = left pincher

Table 6. Regression equations for Florida and Mississippi stone crabs (Florida data from Sullivan 1979).

| | | |
|---|---|---|
| FL | RC = -27.559 + 1.232 CW | ♂ |
| MS | RC = -22.431 + 1.127 CW | ♂ |
| FL | RC = -11.403 + 0.940 CW | ♀ |
| MS | RC = -4.359 + 0.802 CW | ♀ |
| FL | LC = -28.685 + 1.245 CW | ♂ |
| MS | LC = -22.783 + 1.100 CW | ♂ |
| FL | LC = -11.22 + 0.928 CW | ♀ |
| MS | LC = -0.908 + 0.752 CW | ♀ |
| FL | RP = -19.040 + 0.987 CW | ♂ |
| MS | RP = -12.210 + 0.822 CW | ♂ |
| FL | RP = -6.221 + 0.752 CW | ♀ |
| MS | RP = 4.196 + 0.561 CW | ♀ |
| FL | LP = -18.555 + 0.971 CW | ♂ |
| MS | LP = -12.916 + 0.855 CW | ♂ |
| FL | LP = -5.693 + 0.745 CW | ♀ |
| MS | LP = -3.155 + 0.658 CW | ♀ |

RC - right crusher, LC - left crusher, RP - right pincher, LP - left pincher

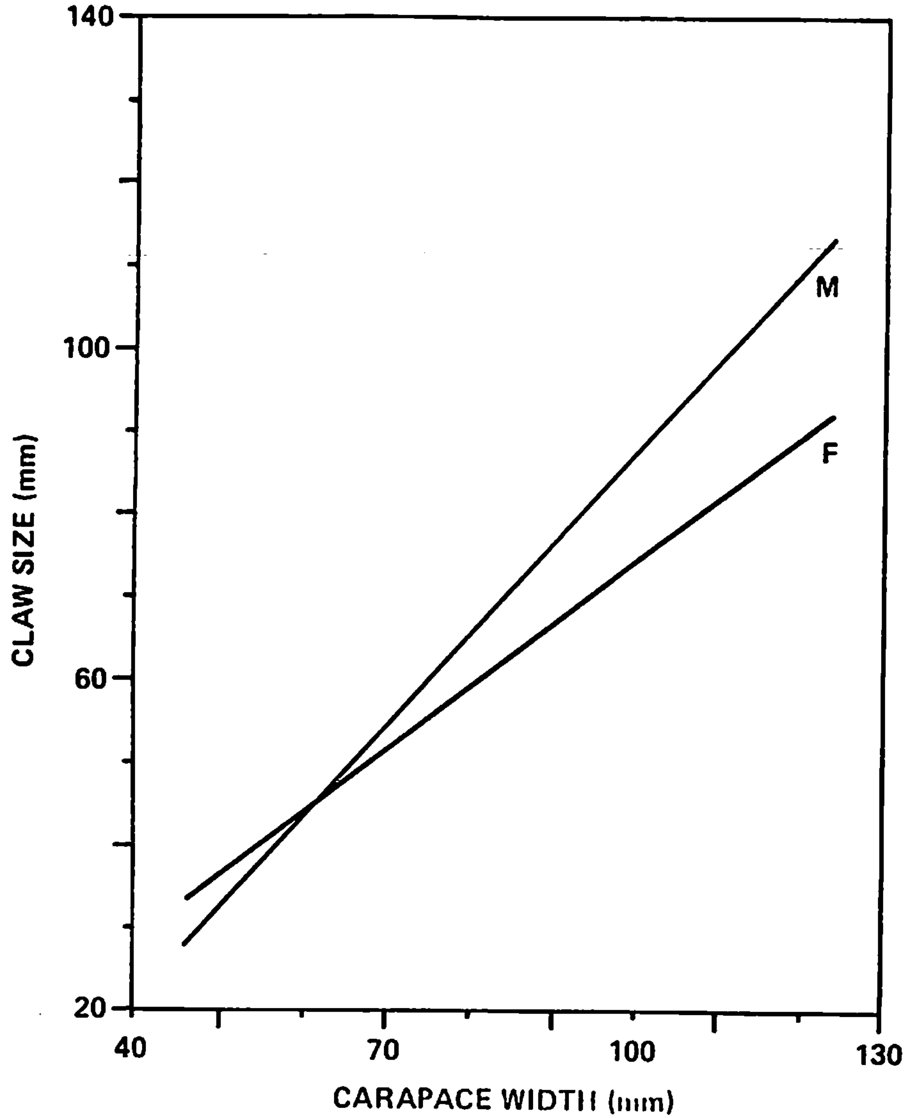



Figure 11. Derived relationship between carapace width and left crusher, male and female.

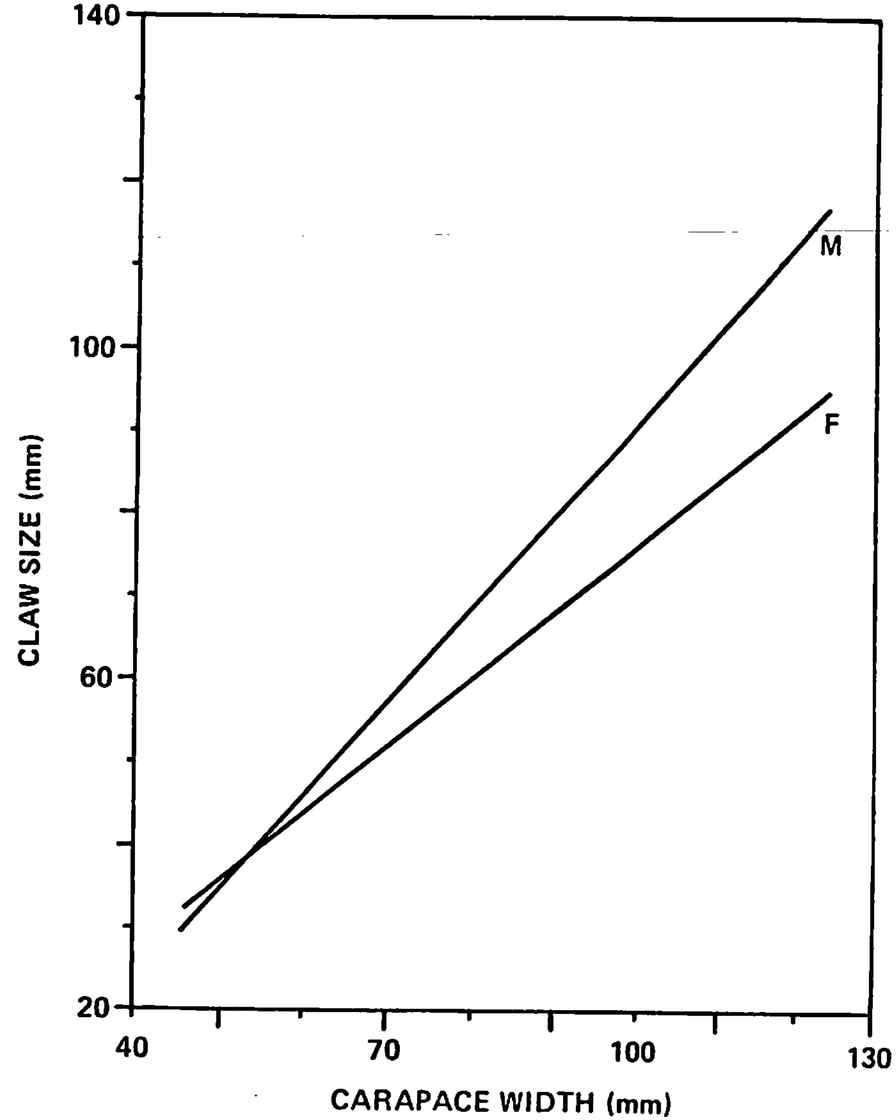



Figure 12. Derived relationship between carapace width and right crusher, male and female.

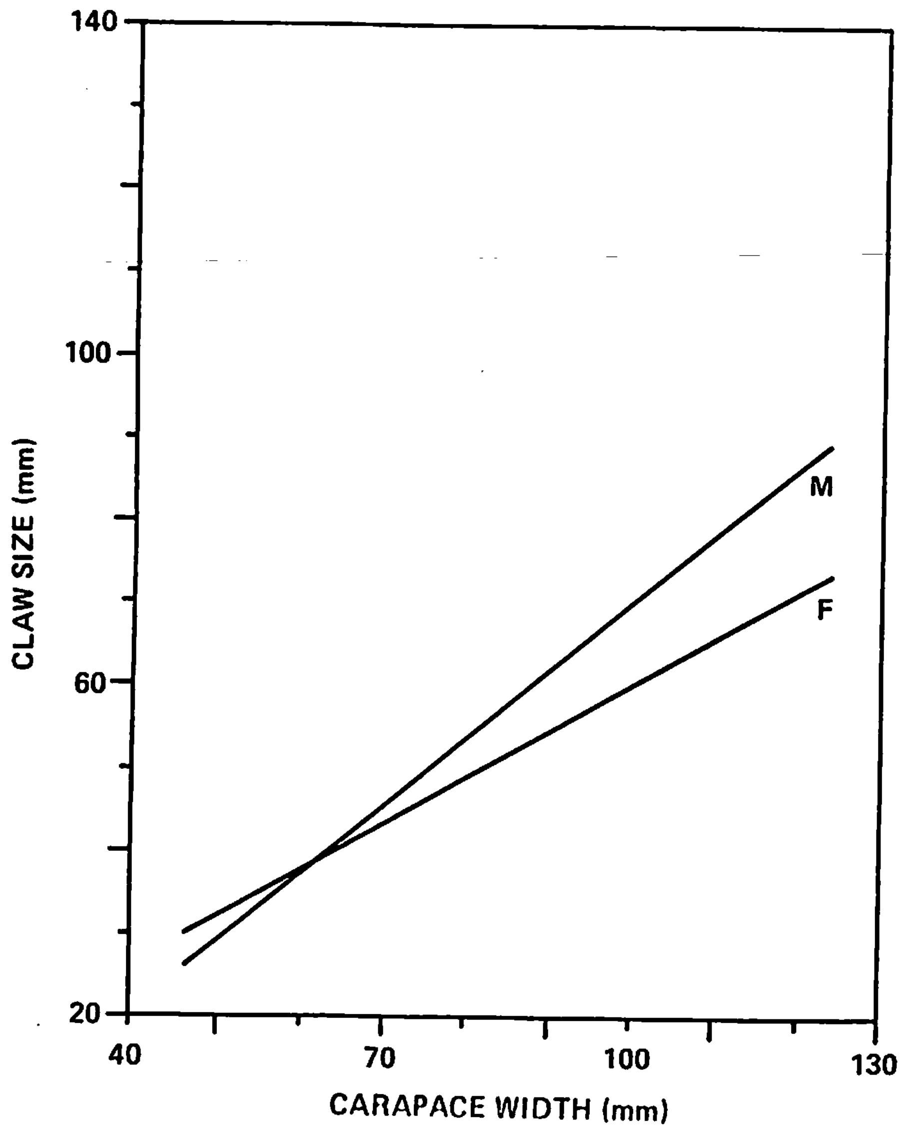



Figure 13. Derived relationship between carapace width and right pincher, male and female.

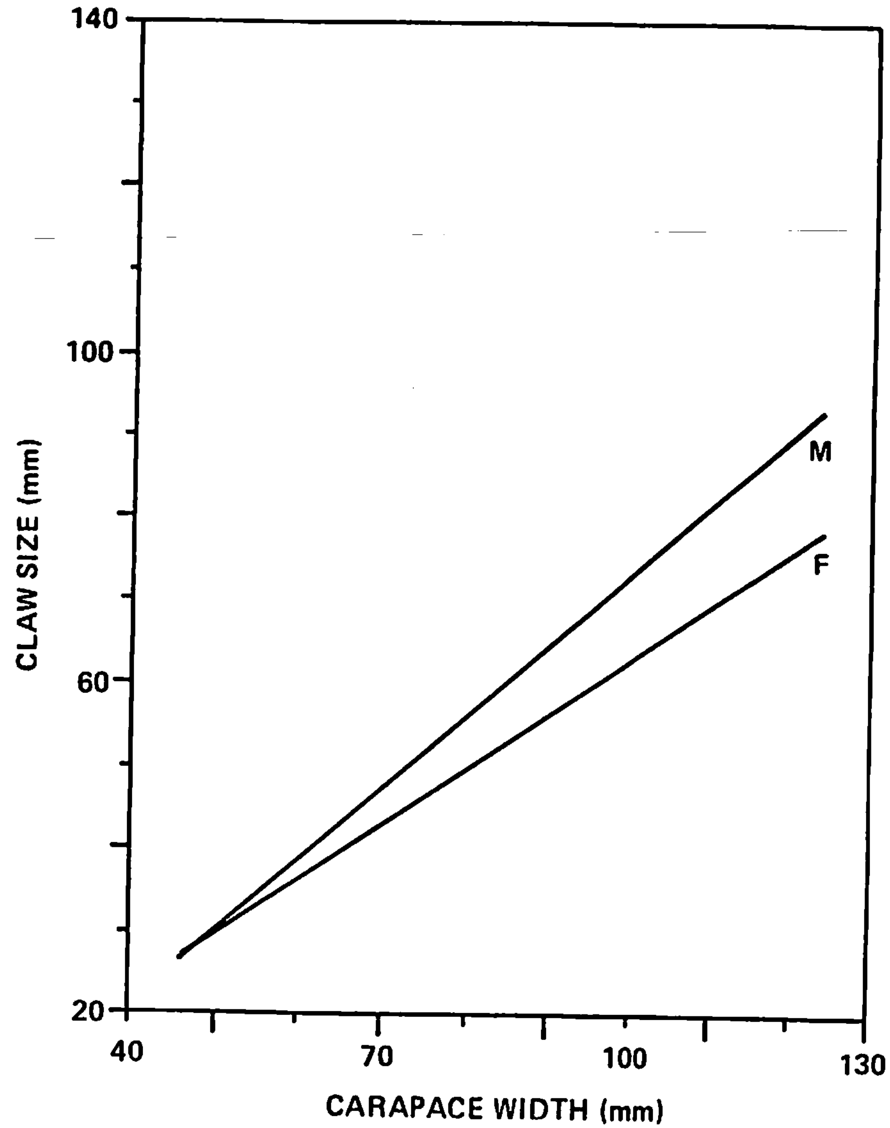



Figure 14. Derived relationship between carapace width and left pincher, male and female.

the 533 crabs measured, 479 had both claws. In all comparisons, there was a significant relationship between carapace width and propodus length. Male claws were always larger than female claws for carapace widths exceeding 62.0 mm. Right major claws and left minor claws for both males and females were slightly larger than left major claws and right minor claws, respectively. Using the Florida harvestable size limit of 70.0 mm propodus length for comparative purposes, male claws of all types reached harvestable size at smaller carapace widths than did female claws.

Regression equations for carapace width and propodus length for Florida and Mississippi stone crabs are presented in Table 6. Using these equations and taking selected carapace widths, propodus lengths were calculated to plot the relationship between carapace width and propodus length for Florida and Mississippi crabs (Figures 15 through 20). Although the equations appear similar, they were not tested statistically for significant differences. In all comparisons, the slope of the line was greater for males than for females for both the Florida and Mississippi animals. Mississippi crabs showed a greater initial carapace width/propodus length size relationship, however Florida claws grew faster relative to carapace width.

## Handedness

Both claws were intact on 479 of the 533 crabs examined. Twenty-six crabs were missing right claws, 22 were missing left claws and both claws were missing on three animals. Three right and two left claws were classified as intermediate. Using those individuals with both claws intact and those crabs for which claw types were surmised based on a single intact claw, 75.1% of the adult stone crabs were right handed

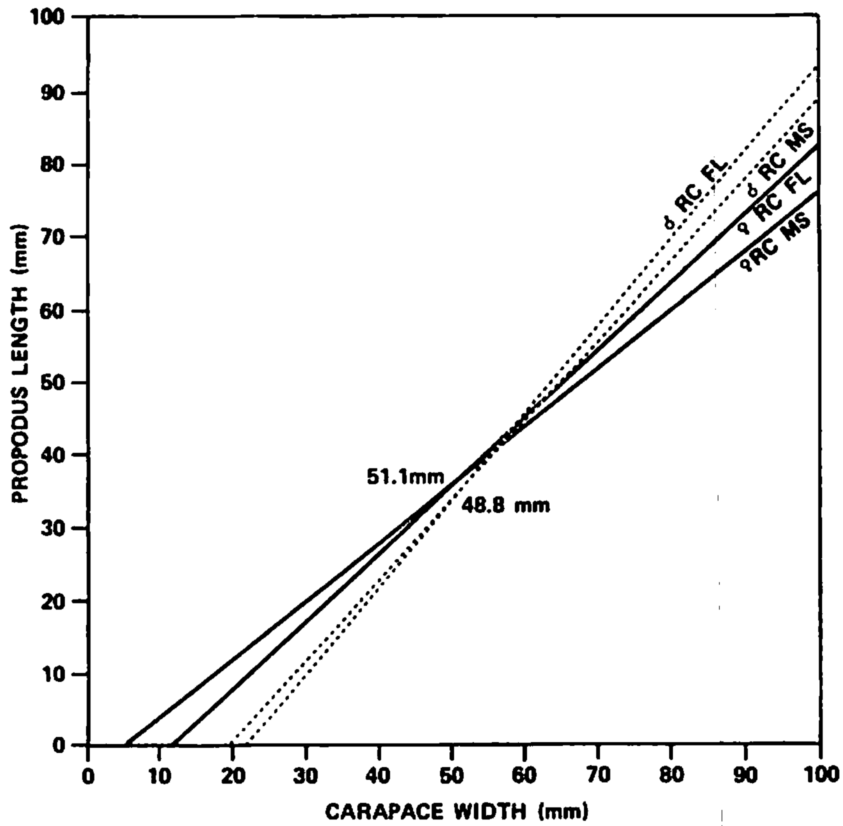



Figure 15. Relationships between carapace width and propodus length (right crusher claws) for Florida and Mississippi stone crabs, male and female.

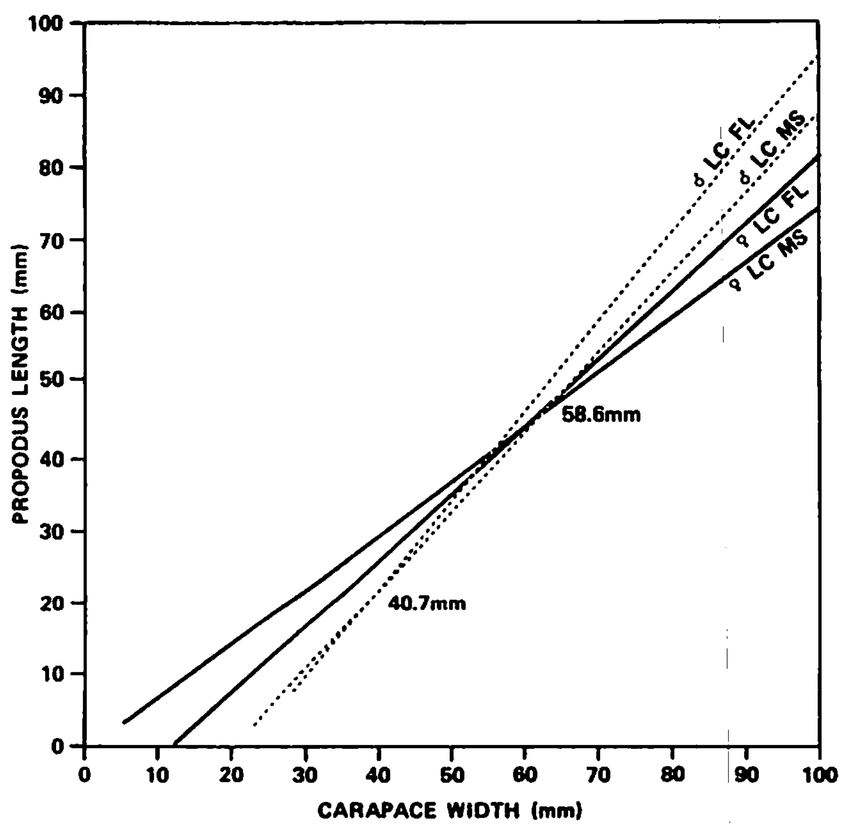



Figure 16. Relationships between carapace width and propodus length (left crusher claws) for Florida and Mississippi stone crabs, male and female.

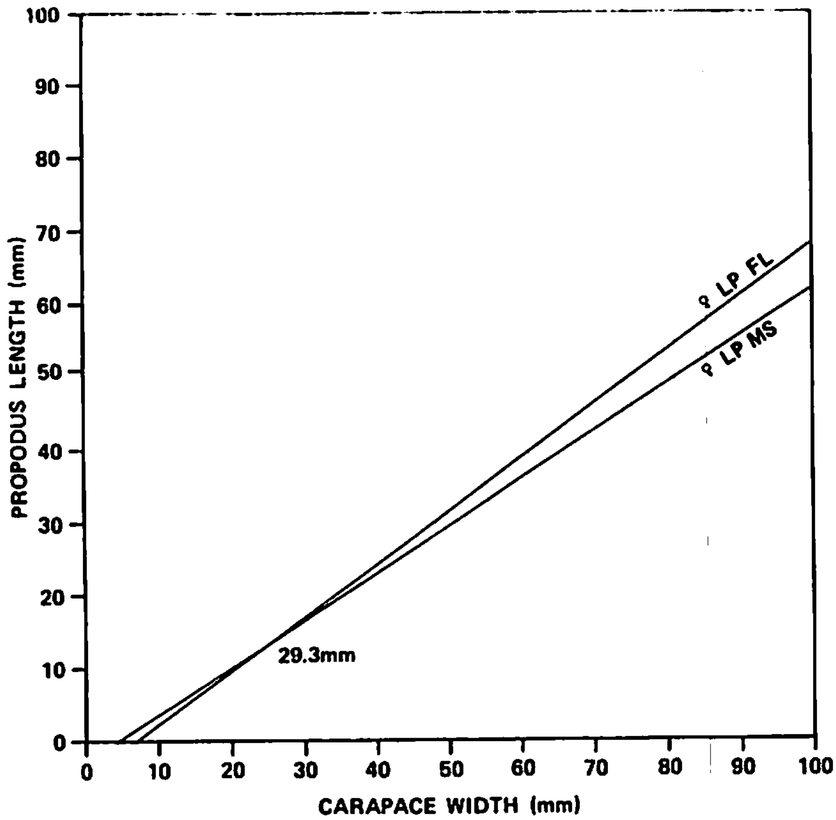



Figure 17. Relationship between carapace width and propodus length (left pincher claw) for Florida and Mississippi stone crabs, female.

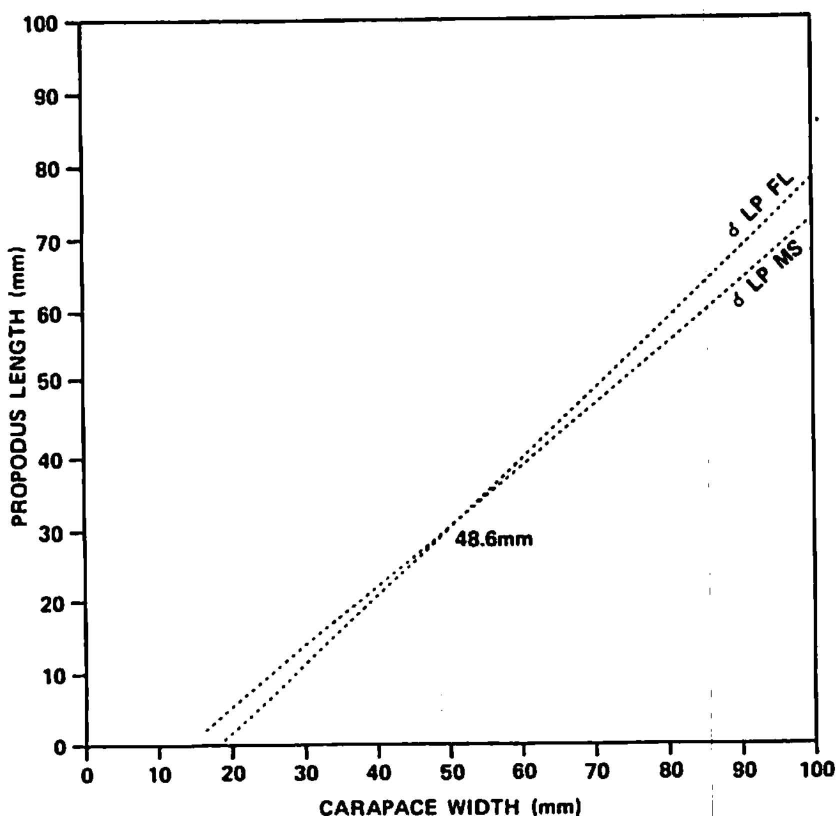



Figure 18. Relationship between carapace width and propodus length (left pincher claw) for Florida and Mississippi stone crabs, male.

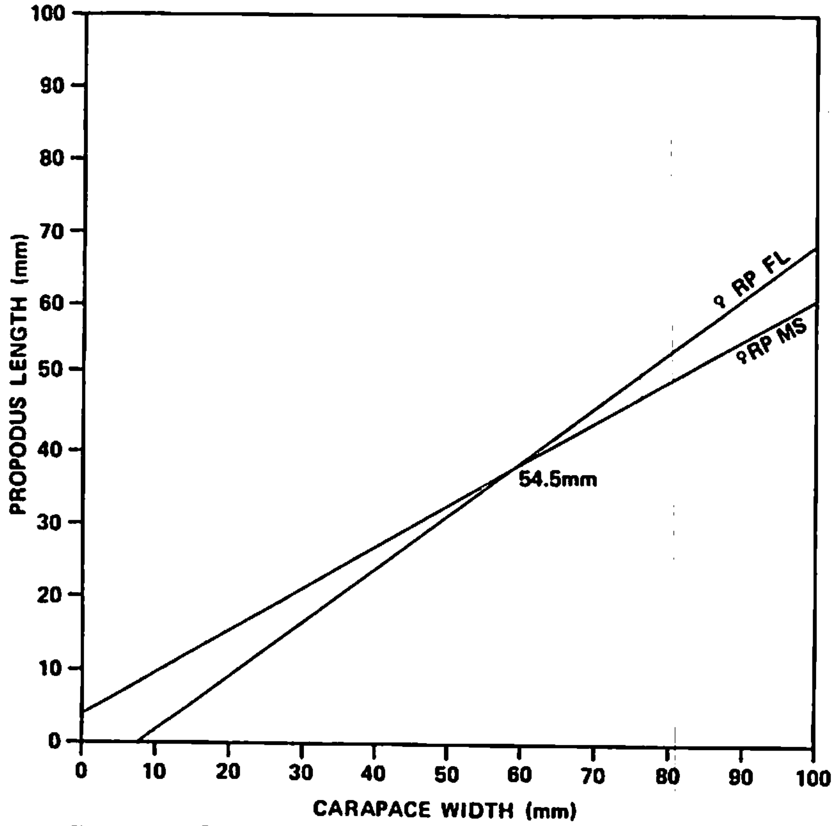



Figure 19. Relationship between carapace width and propodus length (right pincher claw) for Florida and Mississippi stone crabs, female.

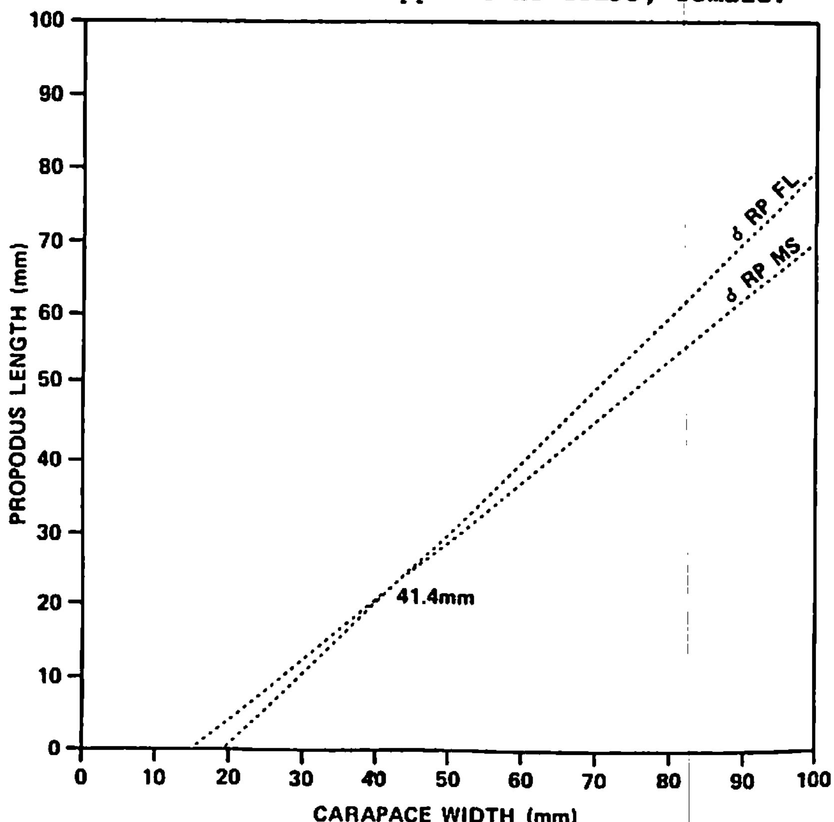



Figure 20. Relationship between carapace width and propodus length (right pincher claw) for Florida and Mississippi stone crabs, male.

(major claw on the right side). This 75:25 right:left handed ratio for adult stone crabs in Mississippi approximates the 80:20 ratio observed in Florida for M. mercenaria (Simonson and Steele 1981).

Handedness data for early crab stages indicated all crabs began right handed; stone crabs below 2.6 mm carapace width had right major claws. Later juvenile stages (20.0-23.9 mm carapace width) more closely approached the ratio observed in the commercial fishery with a 74:26 ratio.

## Summary

1. Stone crab zoeae were collected from late May through September in salinities ranging from 9.0 to 30.0°/₀₀. Megalopae first appeared in June and were collected through October. Megalopae occurred in salinities above 15.0°/₀₀.

2. Juvenile stone crabs were collected throughout the year. They occurred in greatest abundance in late summer over nearshore oyster reefs in the eastern Sound and over mud bottoms along channels in lower Mississippi Sound. Highest juvenile densities were found in salinities between 20.0 and 29.9°/₀₀.

3. Salinity appeared to be a highly important environmental factor controlling the occurrence, distribution and survival of larval and juvenile stone crabs in Mississippi.

4. The collection of larval, juvenile and ovigerous stone crabs within the study area indicated that local crabs can complete their entire life cycle in lower Mississippi Sound and adjacent offshore waters.

5. Maximum numbers of adult stone crabs appeared in the commercial blue crab catch in July and August. Female stone crabs comprised 69.2% of the catch of Menippe.

6. Ovigerous females occurred in commercial catches from April through September with peak numbers in July. Berried females from April through July occurred in traps placed south of the Intracoastal Waterway. Movement of berried females to nearshore waters was noted in August.

7. The majority (71.0%) of the stone crabs entering the blue crab fishery were between 80.0 and 104.9 mm carapace width. Females averaged slightly larger than did males with mean carapace widths of 90.36 mm and 88.57 mm, respectively. Mean carapace width for all crabs was 89.81 mm.

8. Using 70.0 mm propodus length, the legal harvestable claw size for Florida stone crabs, 69.1% of the stone crabs captured in Mississippi waters fell below legal size. Fifty percent of the major claws and 12.3% of the minor claws were harvestable using Florida standards.

9. There was a significant relationship between carapace width and propodus length. Males claws were always larger than female claws as carapace widths exceeded 62.0 mm. Male claws reached harvestable size at smaller carapace widths than did female claws.

10. Mississippi crabs exhibited a handedness ratio of 75:25 (right:left). Handedness data for early crab stages indicated that all crabs began right handed.

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