STUDIES OF ANNUAL ABUNDANCE OF POSTLARVAL PENAEID SHRIMP IN THE ESTUARINE WATERS OF MISSISSIPPI, AS RELATED TO SUBSEQUENT COMMERCIAL CATCHES[1]

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THE PROBLEM

During the past fifteen years the landings of commercial shrimp at Mississippi ports have varied by a factor of three and even from one year to the next the catch has varied by a factor of 2.5. These facts are shown in table 1. The dollar values of the landings have varied somewhat less, about 2.1 at the most, as shown in the same table, because as fewer shrimp are caught the price goes up and vice versa. Thus the law of supply and demand causes shrimp prices to vary less than total landings.

The above figures refer to Mississippi landings from all waters of the Gulf Coast, chiefly Louisiana, with lesser amounts from Mississippi, Alabama and a very little from Florida and Texas.

The commercial shrimp catch figures for Mississippi Sound have only been available since 1956. The annual catches are shown in table 2. This includes all three species of commercial shrimp. The area includes a small part of Mississippi Sound that lies in Alabama, and the figures do not include the outside waters of Mississippi. Therefore, the figures do not represent the total annual catches from State waters. Table 2 shows that Mississippi production has varied by a factor greater than three since 1956.

Not all shrimp taken in Mississippi Sound are landed in the State. Insofar as some shrimp caught within the State are carried out of it and some caught outside of the State are brought into it, it is most probable that the Mississippi Sound production plus the shrimp taken in the Gulf off Mississippi make up about half of the State landings. Between 1956 and 1964 the annual catch in the Sound varied from an amount equivalent to 27 to 46 per cent of the State landings, the average being 36 per cent per year.

The initial catches when the shrimp season opens are made mostly in the Sound and it is a matter of considerable economic importance to the local industry to know what the abundance of the commercial population will be from year to year. Additionally, many shrimp taken in the open Gulf off the Mississippi coast come from the Sound originally.

Several workers and several lines of evidence have shown that the

[1] Supported by United States Bureau of Commercial Fisheries contracts 14-17-0002-43, 14-17-0002-81-A and 14-17-0002-101 with the Gulf Coast Research Laboratory, which extended from 1 November 1962 to 31 October 1964.

Table 1. Mississippi Landings of Commercial Shrimp. Heads on Weight

	Thousand pounds	Thousand dollars
1950	9,460	2,071
1951	7,475	1,470
1952	6,800	1,611
1953	8,517	2,301
1954	8,261	1,534
1955	13,617	2,504
1956	10,912	2,753
1957	9,569	2,617
1958	6,476	2,377
1959	11,319	2,345
1960	11,031	2,899
1961	4,408	1,281
1962	6,104	2,220
1963	9,375	2,484
1964	4,034	1,805

Table 2. Mississippi Sound (areas 011.1 and 012.1) total catch, heads on weight in thousand pounds (Conversion from Gulf Coast Shrimp Data, U. S. Bureau of Commercial Fisheries).

1956	2991
1957	3194
1958	2504
1959	5167
1960	4234
1961	1584
1962	2147
1963	2225
1964	2295

shrimp life cycle is very short, probably about 15 to 16 months, for the very small fraction reaching the largest adult size. Additionally, a great deal of commercial fishing is carried out upon sub-adult populations within the bays and shallow Gulf. In fact most shrimp that are caught have never spawned. These shrimp grow up within one warm season and they are derived from larvae which make their way to inside waters from the offshore spawning areas. Thus, it has been surmised for a long time that prediction of at least the relative abundance of the future shrimp could be deduced from studies of the numbers of young or juvenile shrimp in the bays right after they have completed their larval immigration.

The first work on this problem was carried out by Baxter (1962) at the Galveston Laboratory of the Bureau of Commercial Fisheries. He sampled one area at the entrance of Bolivar Pass, leading into Galveston Bay, with a beam trawl.

Work at the Gulf Coast Research Laboratory in Mississippi Sound was carried out under contract with the Bureau of Commercial Fisheries, and was initiated on 1 November 1962. The contract was terminated on 31 October 1964, although the work has been carried out on a reduced scale since that time. The present report covers the period of the contract.

The Gear Used

A small beam trawl of such size that it could be dragged by one man was used in this program. In part this gear was used because it would give data comparable to what had been collected before by Baxter and in part because it was quite suitable for sampling small organisms in shallow waters. This gear was figured and described by Renfro (1963). It was also described by Baxter (1963) in the following words:

"Samples are collected semiweekly using a hand-drawn beam trawl fitted with a plankton net at the cod end (Renfro, In press). The net is 5 feet wide (along both cork and lead lines) by 2 1/3 feet long. The wings are made of nylon material having 50 holes per square centimeter. The body tapers to a canvas cylinder about 5 inches in diameter and 8 inches long. A 12-in, #1-mesh plankton net with a removable bucket is fitted over the collar. The plankton net is secured by a snap and ring arrangement.

"Around both collar and plankton net is fitted a 2 1/4-foot section of light canvas which acts as chafing gear. A 7-foot piece of 3/16-inch stainless steel cable, onto which are threaded additional lead weights, serves as the net's lead line. The ends of the cable are attached by means of swivels to the ends of a 6-foot length of 11/16-inch stainless steel pipe which constitutes the beam. To the cork line are threaded five 2 3/4-inch sponge floats. The cork line ends are tied directly to the beam, 8 inches from either end. A 15-foot length of nylon parachute cord serves as the bridle line. The effective opening of the net unit is approximately 5.8 square feet."

The net used in Mississippi differed from the one described by Baxter by two minor modifications. (1) The canvas section around the plankton net and collar was made longer than the Galveston net to prevent wear on the bag of the plankton net. (2) A short line was attached to a bight of the bridle to allow walking outside of the path of the net instead of in front of it. A strap loop was attached to the end of the line for easier handling.

Sampling Procedure

The following description of the method of sampling is given by Baxter:

"The sample is taken in the following manner. A 6-foot stake (½-inch galvanized tubing) with 150 feet of nylon parachute cord attached, is driven into the ground at the shoreline. The cord is payed out and stretched taut parallel to the water line. Using the cord as a constant radius, the operator pulls the net assembly along the bottom in a half circle. This method is duplicated each time so that standard tows are obtained. The depth of tow varies from 0 to 4 feet depending on tidal conditions and roughness of the water. The effective length of each tow is about 470 feet, the volume of water sampled is 2,477 cubic feet, and the bottom area traversed is 1,958 square feet."

In collecting the Mississippi samples the operators did not walk in in front of the net because it was thought this would unduly disturb the bottom. Thus, the man pulling the net walked outside of the smaller semi-circle the net traversed around the stake. At one station, number 31, the water was too deep for wading and the net was pulled for a fixed distance along the shore. For various reasons this station was not visited regularly.

After the tow was made the net was washed to remove as much mud and sand as possible. The net contents often included large amounts of vegetable debris. The washing usually reduced the total sample to an amount which could be placed in a gallon jar. A solution of 40% formaldehyde was added to this jar.

The water temperature, to the nearest tenth of a degree C., was taken by the simple process of holding the thermometer in the water. A water sample at the bottom was taken in a citrate bottle and returned to the laboratory where hydrometers were used to determine salinities. Tidal conditions, wind direction and estimated velocity, state of the sea and sky and general observations of turbidity of the water were recorded.

Stations

The location of all stations is given in table 3. These locations are shown on plate 1, which is a map of the Mississippi Sound area. A short description of each station area may be given as follows:

STATION 1 — Davis Bay

Located along East Beach of Ocean Springs, this station has a fairly firm sand bottom along its marsh-lined beach changing to a soft mud bottom in deeper water. A drainage ditch empties into the bay at the eastern edge of the station area.

STATION 4 — East End of Deer Island

Located along the western end and southern side of Little Deer Island (Fawn Island), the bottom of this station varies from firm sand to soft mud with a sand-mud combination being the usual case. Along the western edge of the station area is a small marsh bed. Extensive grass beds (***Ruppia maritima***) and an abundance of hermit crabs in the station area are seasonal occurrences.

STATION 8 — West End of Horn Island, North Shore

This station has a sand beach as the southern border and a clean, firm sand bottom. Shifting sand, causing increased depth, required shifting of this station location back and forth over an area within about a mile of the end of the island.

STATION 11 — Belle Fontaine Beach, East at Jetty

The sand bottom of this station is usually covered with a ½-6 inch layer of soft mud. The water in the area is generally quite muddy with a large amount of debris which makes a dark swash mark on the clean white sand beach. Dredging operations at this station changed the bottom so that the station location was moved east approximately one mile in August 1963.

STATION 13 — Horn Island, Horseshoe

The firm sand bottom of this station is spattered with occasional small grass patches. The sand beach border and the depth of water vary frequently.

STATION 14 — Round Island

This station has a sand beach with a clean, hard sand bottom.

STATION 15 — Pascagoula River, Island off Spanish Point

This station has a sand beach with its bottom varying from soft mud to firm sand. Spoil in the station area from the dredging of the Pascagoula Channel caused the abandonment of this station in October 1963.

STATION 18 — Henderson Point, East at Jetty

Sand beach with firm, clean sand bottom.

STATION 19 — Bayou Caddy, East of Entrance

Bordered by a sand beach and sea wall, this station has a fairly firm mud-sand bottom with shells along the sea wall. Usually there is much trash washed into the station area.

STATION 20 — Cedar Point, Bay of St. Louis

The haul here is made around a large marsh bed. The bottom varies from firm mud-sand to soft mud with occasional grass patches.

STATION 21 — Shell Beach, Bay St. Louis (Oblate Fathers Property)

The beach at this station is composed primarily of shells. The bottom is relatively soft mixture of red clay, sand, pebbles, and shells.

STATION 22 — East End of Horn Island

Sand beach with firm, clean sand bottom.

STATION 23 — Gaston Point, Gulfport Beach

Sand beach with firm sand bottom. Occasionally mud-sand bottom.

STATION 24 — North Point, Cat Island

Sand beach and firm sand bottom with approximately half of sampling area covered with grass beds.

STATION 25 — West End of Ship Island

Sand beach with firm, clean sand bottom.

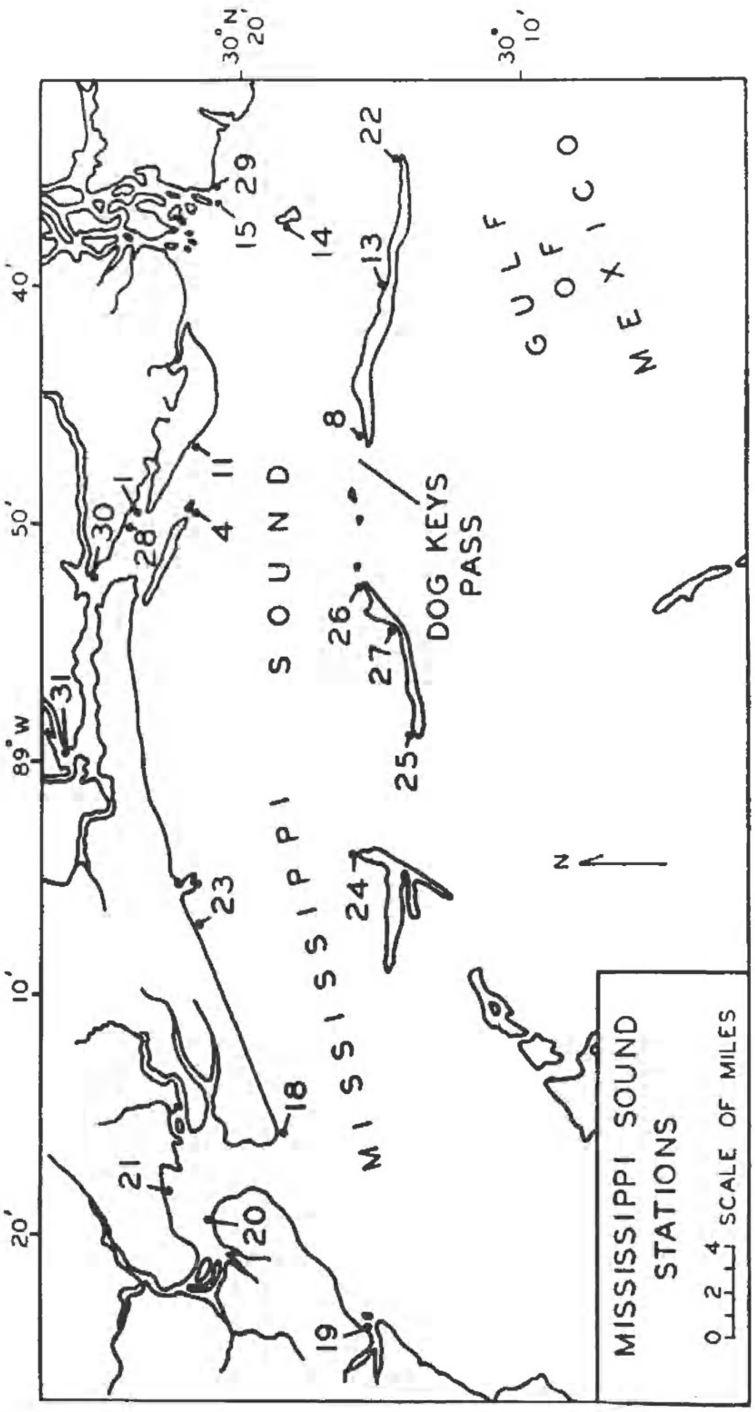

Figure 1. — Stations used for sampling penaeid postlarvae in Mississippi Sound and adjacent waters.

Table 3. Location of Stations Shrimp Postlarval Studies

Sta. No.	Latitude	Longitude	
1	30° 23' 36" N	88° 48' 31" W	Davis Bay
4	30° 21' 25" N	88° 48' 34" W	Deer Island, East End
8	30° 14' 42" N	88° 46' 11" W	Deer Island, West End
11	30° 20' 31" N	88° 45' 47" W	Belle Fontaine Beach, East at Jetty
13	30° 14' 03" N	88° 39' 13" W	Horn Island, Horseshoe
14	30° 17' 58" N	88° 35' 28" W	Round Island
15	30° 20' 12" N	88° 34' 07" W	Pascagoula River, Island off Spanish Point
18	30° 18' 10" N	89° 17' 25" W	Henderson Point, East at Jetty
19	30° 15' 35" N	89° 25' 27" W	Bayou Caddy, East of Entrance
20	30° 20' 35" N	89° 20' 48" W	Bay of St. Louis, Cedar Point
21	30° 22' 30" N	89° 19' 28" W	Bay of St. Louis, Shell Beach
22	30° 13' 21" N	88° 33' 32" W	Horn Island, East End
23	30° 21' 22" N	89° 06' 48" W	Gaston Point, Gulfport Beach
24	30° 15' 06" N	89° 03' 36" W	Cat Island, North Point
25	30° 12' 40" N	88° 58' 54" W	Ship Island, West End
26	30° 14' 42" N	88° 52' 25" W	Ship Island, East End
27	30° 14' 06" N	88° 53' 36" W	Ship Island, East Point of Lagoon Entrance
28	30° 23' 54" N	88° 48' 36" W	Ocean Springs East Beach, West End at Bridge
29	30° 20' 36" N	88° 33' 45" W	Pascagoula East River, East Point at Mouth
30	30° 25' 21" N	88° 50' 54" W	Biloxi Bay North Shore, East Point of Fort Bayou Entrance
31	30° 26' 12" N	88° 59' 42" W	Tchouticabouffa River, East Shore at Confluence with Biloxi River

Table 4. Number of Monthly Visits to Each Station

	1962		1963												1964									
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mr.	Apr.	Ma.	Jun.	Jul.	Au.	Sep.	Oct.
Station 1	1	4	4	3	4	4	5	4	5	4	4	5	4	2	4	4	4	5	4	4	5	3	4	4
Station 4	3	4	5	4	4	4	5	4	4	4	4	5	4	3	5	4	4	5	4	4	4	4	4	2
Station 8	1		4	4	4	4	4	3	5	4	3	5	4	4	2	2	4	4	4	4	5	4	3	
Station 11		1	4	3	4	4	5	4	5	4	4	5	4	3	2	4	4	5	4	4	5	4	4	4
Station 13			4	4	4	4	5	3	5	4	4	5	4	4	4	4	4	4	4	4	5	4	4	1
Station 14			3	4	3	3	5	3	5	4	3	5	4	3				1						
Station 15			2	2	3	4	5	2	5	3	3													
Station 18			1	4	4	4	5	4	5	4	4	5	4	3	1	3	4	5	4	4	5	4	5	4
Station 19			1	4	4	4	5	4	5	4	3	4	4	3	2	3	4	5	4	4	5	4	4	3
Station 20				4	4	4	5	4	5	4	3	5	5	3	3	3	4	5	4	4	5	4	5	4
Station 21				1	4	4	5	4	5	4	4	5	4	3										
Station 22				3	4	3	4	3	5	2	3	3	4	4	1			3	4	4	5	4	3	1
Station 23				1	4	4	5	4	5	4	4	5	4	3	3	4	4	5	4	4	5	4	5	4
Station 24					4	3	4	3	4	2	2	5	4	2				2	3	3	3	2	2	
Station 25					4	3	5	3	4	1	2	4	4	2				2	3	4	4	2	2	
Station 26					4	3	5	3	4	3	4	5	4	2				2	3	4	4	4	3	
Station 27						2	5	3	5	2	4	5	4	2		1		2	3	4	4	3	3	
Station 28							5	4	5	4	4	5	4	2										
Station 29												2	4			1	4	5	4	4	5	4	5	4
Station 30												1				4	4	4	4	2	4	4	3	2
Station 31															1	4	4	4		1	4	2		

STATION 26 — East End of Ship Island

Sand beach with clean sand bottom.

STATION 27 — Ship Island Lagoon

Sand beach and firm sand bottom with grass beds covering the sampling area at times. Grass beds were occasionally covered by shifting sand.

STATION 28 — Ocean Springs East Beach, Biloxi Bay

Sand beach with fairly firm sand-mud in close to shore and a soft mud bottom in deeper water.

STATION 29 — Entrance to Pascagoula Small Craft Harbor, southern side

Sand and shell beach with sand and shell mixture forming a crust over the soft mud bottom. One medium size grass patch was present in sampling area. This was established when station 15, across the Pascagoula river, was abandoned.

STATION 30 — Fort Bayou Entrance, Eastern Side

The bottom type is a mixture of sand, clay, and mud with occasional grass patches. The sampling area encompasses a large intertidal marsh bed.

STATION 31 — Lopez Point, Tchouticabouffa River

Grass-lined shore with a bottom of sand and mud. There is usually much detritus in the sampling area.

The original plans for visiting stations called upon the workers to begin on Wednesday of each week and complete a standard haul at each of the stations listed in table 3 as soon as weather and physical conditions permitted. Stations not sampled in 3 days were omitted until the following week. By and large this program was carried out. Table 4 gives the numbers of times each station was visited each month during the period of the project.

Laboratory Procedures

As stated above 40% formalin was added to the samples in the field, but the total solution was actually much less after the net was washed into the jar and water content of the plant debris was taken into consideration. Usually within three days after collection, penaeid larvae in the samples were removed and placed in buffered 5% formalin. Occasionally, when work fell behind for one reason or another, some of the field samples were not examined until two weeks had passed.

All penaeid postlarvae and juveniles were removed from each sample. The samples were examined in large shallow pans over and over until no further penaeids were found. The small shrimp were separated into species, were counted and stored in small cotton-stoppered vials placed inside of larger containers. The specimens for each station were kept separately by months and by sample numbers. The remainder of the samples have been kept, for these contain fish larvae and many other organisms. In some instances certain of the fishes have been removed and used for other studies.

Identification of the small shrimp caused some problems in the beginning because the published keys are not fully satisfactory and must be used with caution. The workers found, however, that by following the postlarvae up to easily recognized stages that they could differentiate the commercial post larvae quickly and with surety. On occasion other shrimp workers conferred with the staff on identification and checks of identification accuracy were made by different workers going through the same samples and separating the species. Correspondence was quite high and the workers quickly became adept and confident at their identifications. Needless to say the specimen material is being kept and is subject to further check at any time.

Figures two, three, four, and five show specific and seasonal differences in the three species of postlarvae included in this study. The figures were drawn by Mr. Douglas Farrell from preserved specimens collected and identified by project workers. All postlarvae were in about the same stage of development and the scale is the same for all four illustrations. Difference in the size of brown shrimp postlarvae in the spring and summer is evident in figures two and three. During the early part of the year there was no difficulty in distinguishing the brown shrimp postlarvae, because of their greater size. However, during the summer the postlarval brown shrimp did not vary a great deal in size from the other two species. Wide intraspecific variation of characteristics was observed. Identification was most difficult when postlarvae of all three species were on the nursery grounds at the same time.

THE ENVIRONMENT

Intertidal Bottom and Tides

In Mississippi Sound and adjacent waters many environmental factors vary from area to area and from time to time. Along the barrier islands, intertidal areas are almost entirely in sand. Fairly steep berms, bare of vegetation, form along the mean high tide level. Passes between the islands are wide and relatively shallow. Deeper passes are found at the west end of each of the islands.

Extensive grass beds appear along the Sound side. The bottom is always bare near the ends of the islands. Large masses of sand are sometimes shifted, changing the contour of the shoreline and bottom.

On the mainland and inshore islands, intertidal areas are more varied. Over one-third of the Mississippi Sound coastline in Mississippi has been "improved". Wide sand beaches have been built in front of sea walls by pumping material in from the shallow waters off shore. Clay and silt soon leach out, leaving a clean sand surface. Constant maintenance prevents the growth of plants which, initially at least, start to cover recently filled areas. The near shore bottom along these beaches varies from sand to sandy mud. The natural sand beach at Belle Fontaine is several miles long. The bottom along this beach is usually softer than that along the artificial beaches.

Around the bays, distributaries and bayous there is usually a marsh grass border of variable width. The bottom is usually soft mud which, in many places, will not support a man walking any distance off shore. During the two years of this study we have observed increased deposit of sand in several areas. When some stations were established the individual pulling the net usually sank at least knee deep at the outer edge of the haul, making it very difficult to complete the sample. At several stations the bottom became gradually firmer and by the end of the sampling period little diffi-

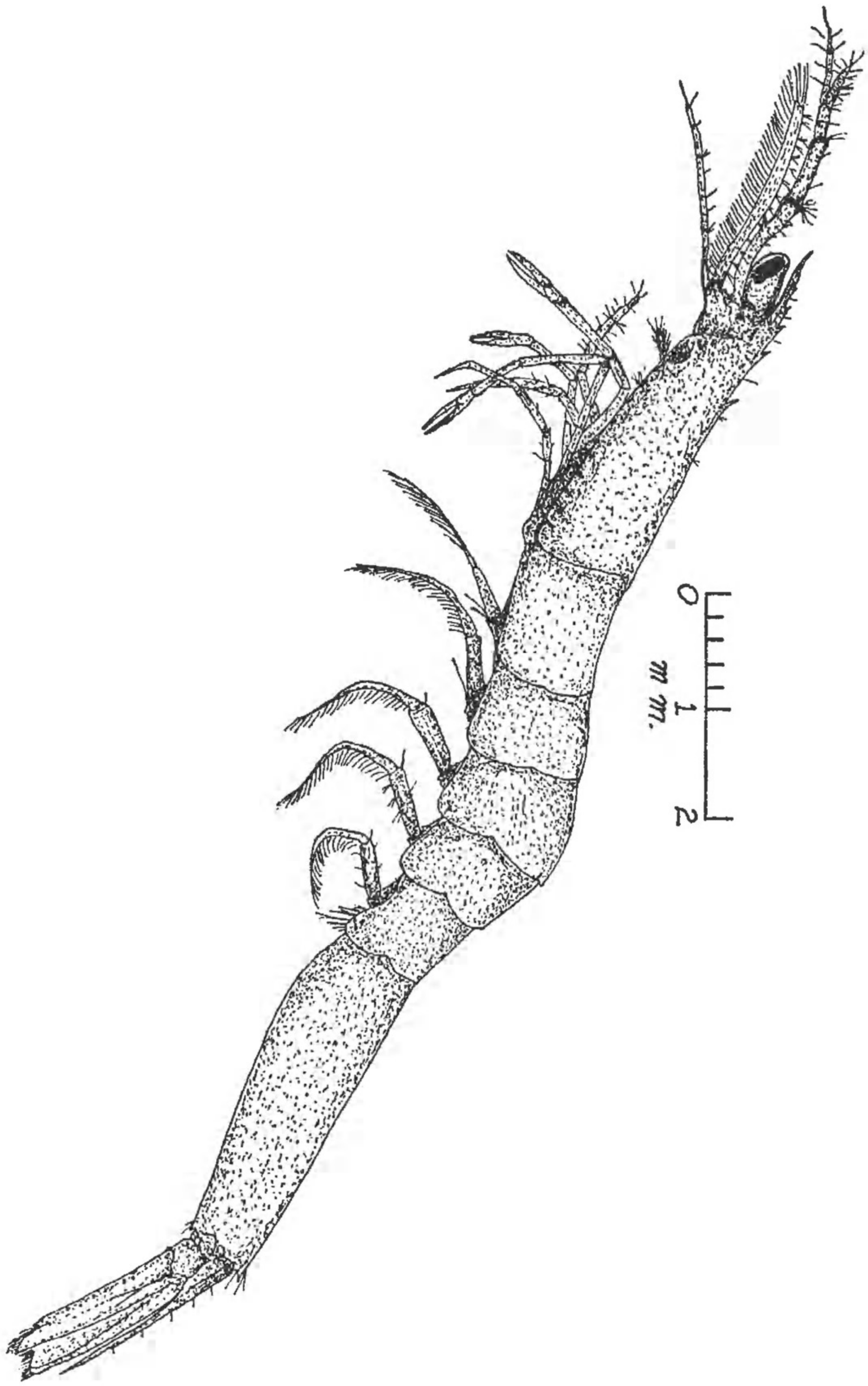

Figure 2. — Brown shrimp postlarva collected 2 March 1964.

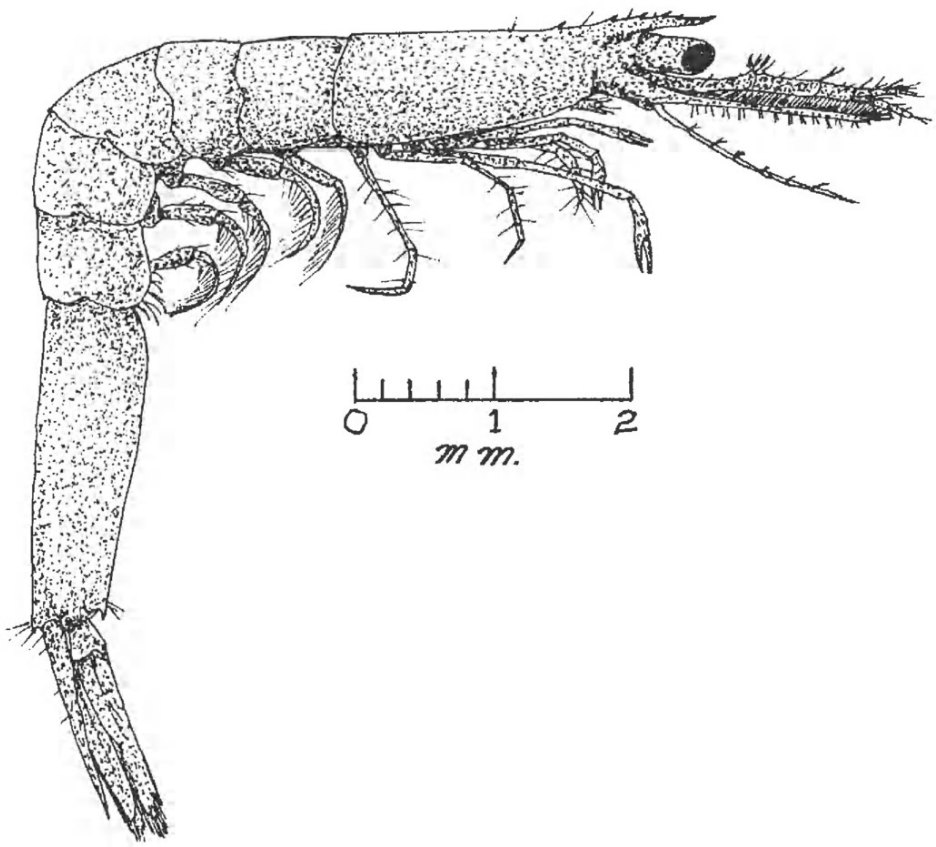

Figure 3. — Brown shrimp postlarva collected 12 August 1964.

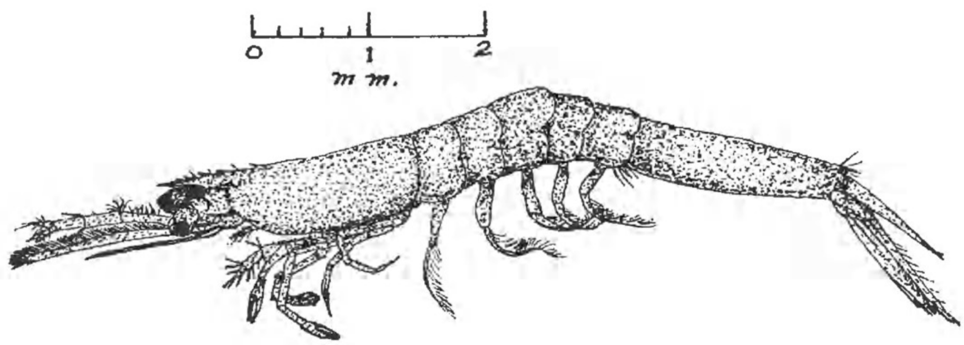

Figure 4. — White shrimp postlarva collected 29 July 1964.

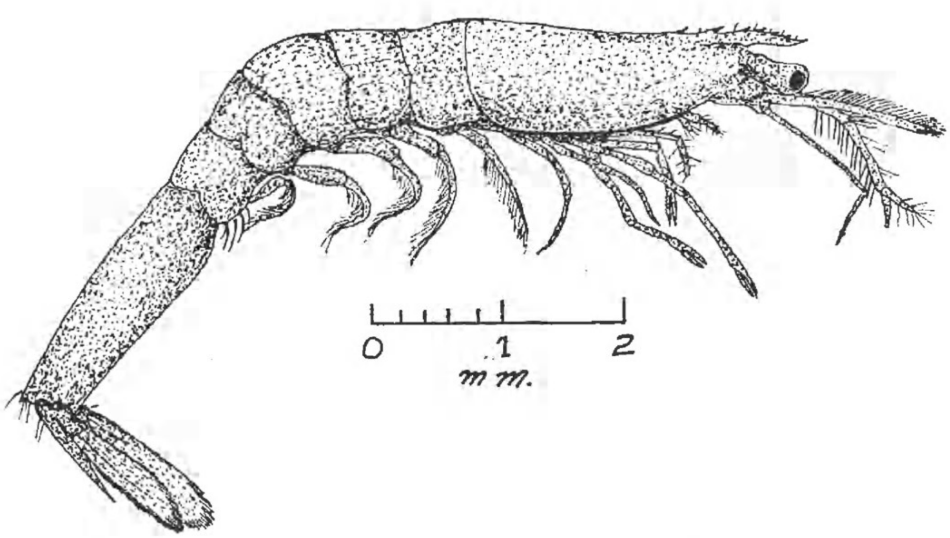

Figure 5. — Pink shrimp postlarva collected 29 July 1964.

culty was encountered at established stations because of soft bottom. This phenomenon was observed in other areas as well as at established stations and evidently was not caused by repeatedly walking over the same path.

The diurnal tides in the Mississippi Sound have a predicted range of a little over 1.5 feet and a mean tide level of .8 - .9 feet. However, the cyclic predictions are subject to drastic modification by wind. Large areas of shallow flats are sometimes uncovered when winds are from the north. Prolonged periods of easterly and southeasterly winds sometimes keep the marshes flooded for long periods. These periods vary from year to year and may, as suggested by Collier and Hedgpeth (1950), influence the success of a given year class of shrimp or other estuarine organisms.

Salinity

The major rivers bringing fresh water into Mississippi Sound are the Pascagoula and the Pearl. Streams with smaller drainage areas enter Biloxi Bay and the Bay of St. Louis. Numerous tidal bayous drain the coastal area. Annual rainfall in the area is usually heavy, averaging about 65 inches. Seasonal and annual variations are sometimes large. Consequently the salinity in the estuary is subject to sudden and drastic changes for short periods with longer term differences that may be considerable.

Table 5 shows monthly average salinity at 16 stations. Barrier island stations have been separated in the table so that the higher salinities along the islands is evident. Both mainland and barrier island stations have been arranged in geographic order from east to west.

In general, salinity was unusually high from the beginning of the project in November, 1962 until January, 1964. Seasonal differences, however, were evident during this period. Beginning in January 1964 salinity decreased throughout the area and remained below levels observed during the same month of the year before. In the two periods of postlarval immigration it is evident (Figure 6 and table 5) that salinity was quite different. The figure illustrates annual differences, differences between barrier island and mainland stations, and fluctuations within months.

Water Temperature

Water temperature in the shallow waters of Mississippi Sound and adjacent waters is subject to large seasonal variations. The lowest temperature we recorded occurred at station 1 in January, 1964, when the thermometer showed 3.4° C. The highest temperature, 36.5° C., occurred at station 21 in June, 1963. Temperatures between 34 and 35° C. were noted at several stations between May and September. Since all temperatures were taken in shallow water near shore, the highs probably represent extremes which occurred in the afternoon on clear, still days. Lows occurred during cold spells when no postlarvae were present and sampling was at a minimum.

Averages (Table 6) changed a little less from month to month and were usually a little lower at barrier island stations. However, minimum and maximum weekly averages usually came from mainland stations. Monthly averages for two years were very similar (Figure 7). They were a little lower in the spring months of 1964. Differences for some weeks in March and April were considerable.

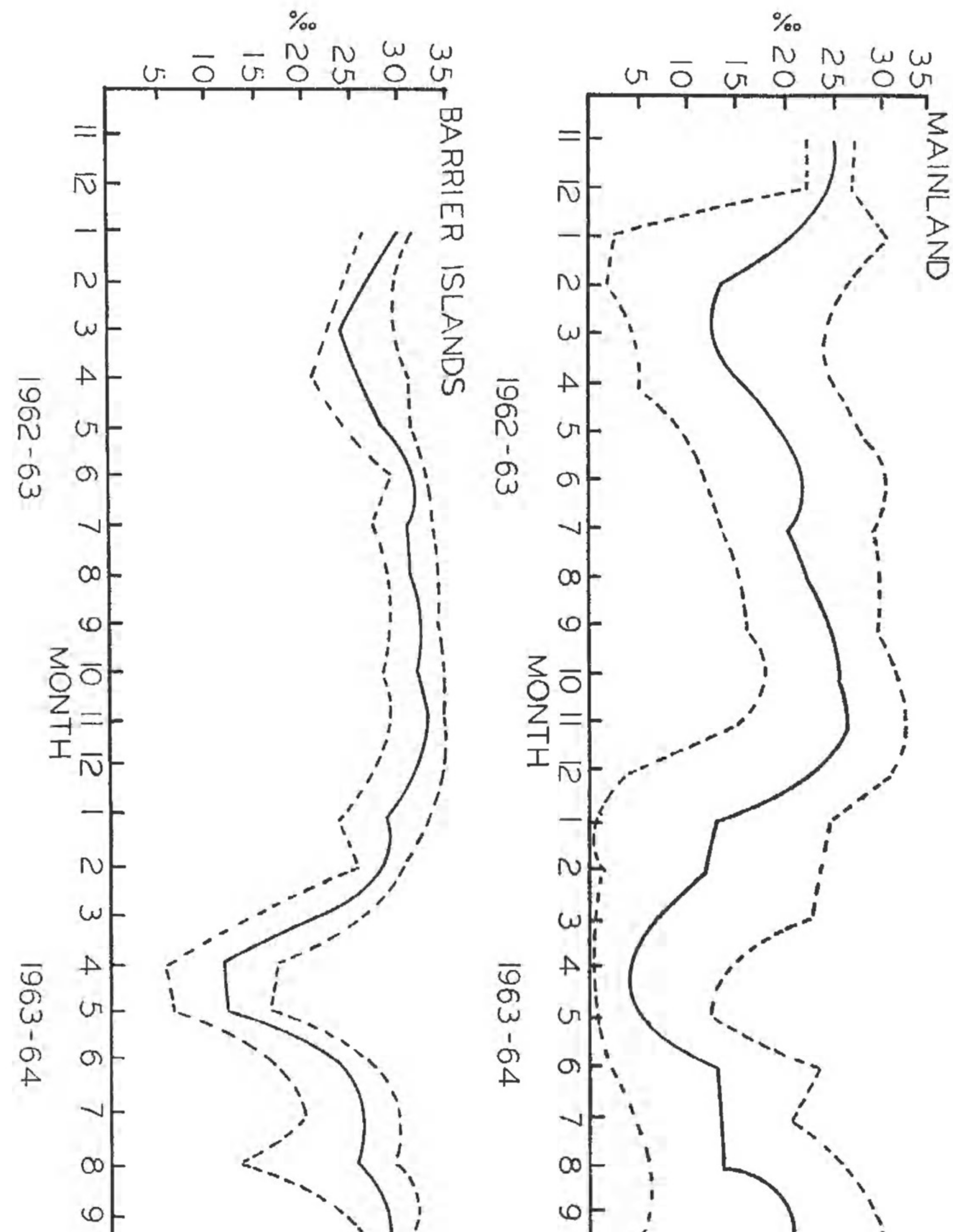

Figure 6. — Average salinity at barrier island and mainland stations with minimum and maximum observations for each month.

Table 5. Monthly average salinity, o/oo, at selected stations. Numbers have been arranged in east-west geographic order.

		Mainland Stations									Barrier Island Stations						
		15	29	11	4	1	23	18	20	19	22	13	8	26	27	25	24
Nov.	1962				26.8	22.7							31.9				
	1963		30.4	28.9	30.1	29.4	28.6	24.1	18.7	21.1	33.1	32.7	32.9	33.5	33.6	33.1	30.3
Dec.	1962			27.1	26.1	24.2											
	1963			27.2	29.8	27.0	26.5	17.8	12.4	15.7	31.2	31.2	31.4	33.5	33.4	33.9	29.0
Jan.	1963	21.1		19.1	22.2	21.8		21.0		16.3		29.6	29.9				
	1964			15.9	19.0	13.7	17.0	13.1	3.3	8.7	31.2	27.1	28.8				
Feb.	1963	4.5		16.3	18.9	13.5	22.0	16.1	7.5	12.8	27.7	26.3	27.5				
	1964		11.2	13.9	21.8	12.2	19.5	12.6	5.9	7.5		28.1	29.0		26.5		
Mar.	1963	11.4		18.3	12.2	11.1	19.8	15.1	7.3	11.6	21.3	25.5	26.4	25.8		24.3	22.7
	1964		11.8	7.0	12.2	9.0	14.1	6.1	2.8	5.0		20.8	22.4				
Apr.	1963	15.2		18.0	20.9	18.6	18.8	13.8	10.2	13.2	26.2	26.1	27.1	26.9	26.2	25.5	23.7
	1964		3.3	6.3	6.7	5.0	6.2	2.6	1.3	2.4	11.3	10.8	10.8	15.5	14.3	11.4	9.1
May	1963	20.8		22.5	24.0	20.1	21.0	17.4	12.3	16.8	27.9	27.1	28.8	28.5	28.9	28.2	26.5
	1964		7.4	6.1	9.3	5.3	5.9	2.4	1.2	2.3	13.3	12.6	14.3	11.0	10.7	9.0	8.3
June	1963	24.0		24.1	25.7	22.6	24.2	22.2	16.9	21.3	30.8	31.2	32.2	31.4	31.6	31.1	30.2
	1964		17.0	20.3	18.5	15.1	14.1	10.8	4.3	8.7	23.6	23.2	23.2	22.8	23.1	23.6	19.0
July	1963	20.5		23.3	22.7	18.4	22.3	22.1	16.1	20.6	31.0	30.5	32.1	30.7	31.2	31.1	29.0
	1964		14.6	14.3	19.0	12.7	16.9	13.4	6.5	11.9	27.1	26.1	26.9	25.8	25.4	25.3	21.3
Aug.	1963	21.4		23.9	26.9	22.0	25.6	21.3	16.3	21.5	31.4	30.8	32.9	32.9	33.0	34.0	30.8
	1964		17.8	17.3	20.7	12.0	19.3	14.0	7.3	13.2	25.5	24.4	26.1	26.2	25.2	26.3	18.0
Sept.	1963	26.1		26.7	27.7	25.4	29.0	25.2	17.4	22.0	32.3	31.4	31.7	32.4	32.4	33.1	31.8
	1964		27.3	24.0	26.4	20.4	24.4	19.6	10.3	15.4	29.1	28.1	28.3	28.3	28.0	26.6	25.5
Oct.	1963		30.7	28.2	29.3	26.4	28.5	23.2	20.4	20.5	32.8	31.6	32.2	32.2	31.9	30.8	29.5
	1964		25.5	24.3	26.9	22.9	25.7	18.1	9.0	15.0	28.5	26.9					

Table 6. Monthly average temperature, °C., at selected stations. Numbers have been arranged in east-west geographic order.

		Mainland Stations									Barrier Island Stations						
		15	29	11	4	1	23	18	20	19	22	13	8	26	27	25	24
Nov.	1962				16.6	18.7							18.5				
	1963		18.0	18.2	19.8	22.1	18.3	18.3	18.7	18.3	18.9	18.2	17.6	19.2	19.3	18.0	18.5
Dec.	1962			14.5	13.5	12.8											
	1963			10.1	13.9	13.7	11.6	13.1	15.0	12.8	10.7	11.2	12.5	14.9	14.8	16.4	17.3
Jan.	1963	16.3		14.7	12.2	12.4		11.4		11.6		11.5	10.8				
	1964			13.9	11.6	9.5	13.8	13.6	12.6	11.9	9.1	9.2	9.8				
Feb.	1963	14.5		17.6	14.0	13.9	14.9	10.8	11.8	10.9	10.8	11.2	10.6				
	1964		12.3	15.3	14.5	15.2	15.8	15.9	12.9	13.8		12.2	13.1		13.8		
Mar.	1963	21.6		21.3	22.0	21.7	18.7	19.4	19.6	18.9	17.1	17.0	16.2	17.0		18.2	18.1
	1964		17.4	18.0	18.4	20.0	18.6	18.4	17.9	18.2		16.3	17.3				
April	1963	25.6		24.4	24.9	24.4	25.6	24.2	24.7	23.7	23.3	22.8	23.3	23.7	24.1	23.1	23.9
	1964		22.9	22.0	22.5	23.9	25.0	24.3	22.7	23.2	24.0	21.9	22.8	23.7	24.6	22.9	26.8
May	1963	30.4		28.2	30.2	27.5	27.1	26.3	27.0	27.3	28.4	26.3	27.3	26.5	28.6	25.7	26.4
	1964		26.7	26.8	28.0	29.6	28.5	28.5	27.7	28.0	27.5	26.5	26.8	27.0	26.0	26.5	27.9
June	1963	29.2		25.9	27.4	29.8	29.5	29.3	29.5	29.6	30.4	29.7		30.7	30.8	30.1	31.6
	1964		31.6	31.5	29.4	30.7	30.2	30.0	29.8	29.3	30.0	29.6	30.4	30.2	32.1	30.3	32.8
July	1963			28.5		29.5	30.3	29.9	31.0	31.0							
	1964		29.9	29.8	29.0	30.6	28.5	28.2	29.0	27.9	29.2	29.3	29.7	30.2	31.0	30.3	33.4
Aug.	1963			27.5		29.7	31.3	31.8	31.2	31.0							
	1964		31.5	31.6	29.9	31.3	30.6	30.4	30.0	30.3	30.1	29.5	29.7	30.5	31.1	30.7	30.8
Sept.	1963	31.7		26.6		27.7	28.5	29.0	28.4	27.9	31.9	29.5	31.0	29.4	29.5	30.3	28.5
	1964		28.6	28.6	28.7	30.6	29.8	29.8	29.2	30.4	29.3	28.4	30.0	30.3	31.1	30.4	31.7
Oct.	1963		22.7	21.8	23.6	24.7	25.5	23.1	23.0	23.6	24.9	24.0	23.3	24.7	23.0	23.0	23.3
	1964		23.4	22.4	22.7	22.2	24.0	23.0	22.7	20.4	23.3	19.9					

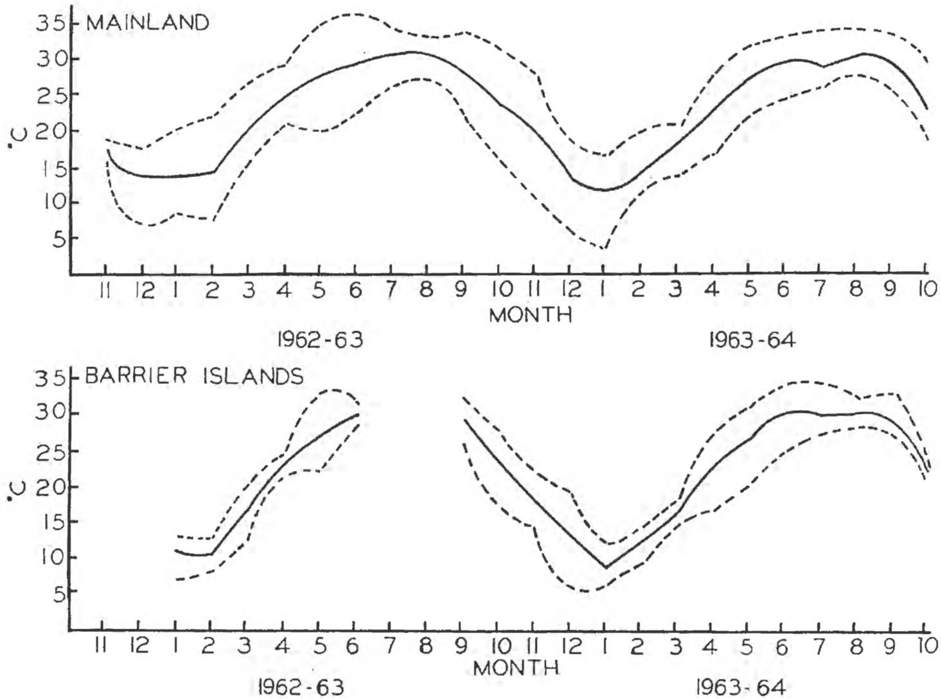

Figure 7.—Average temperature at barrier island and mainland stations with minimum and maximum observations for each month.

Turbidity

Water along the barrier islands is often clear. Inshore stations were usually muddy and especially so when southerly winds had waves moving across shallow area with mud bottoms. High winds or heavy rains cause the turbidity to increase throughout the Sound. Light penetration was reduced occasionally by dark brown organic coloring dissolved in the water coming out of marsh areas.

Organic Debris

As has already been indicated, large quantities of debris were taken in the net on many occasions. Dead grass collected at the swash line and for several feet from the beach occasionally required that the net be lifted before it could be hauled out. At other times large quantities of finely shredded and broken grasses were adrift and on the bottom.

Colonial bryozoans, particularly *Zoobotryon pellucidum* and *Bugula* spp. sometimes drifted into the sampling area in large quantities. At times the net came in almost completely filled with *Zoobotryon.*

In the fall, winter, and spring when the water was cool, algae of various kinds grew at some stations, and the abundance occasionally was great enough to cause trouble in the sample. This was particularly true when additional material had drifted into the sampling area.

Small bunches of sargassum were sometimes encountered. During this two year period there was not an extensive influx of drifting Sargassum like that encountered by Baxter (1962) in the spring and summer of 1962. Larger quantities of *Sargassum* have been observed in Mississippi Sound on several occasions during the past ten years. One of these occurred at the same time Baxter's (*op. cit.*) sampling in Galveston Bay was disrupted in 1962. Attached species growing on the rocks around Ship Island broke loose in rough weather and drifted into the sampling area at some stations.

Fecal pellets collected along the shore in large quantities on some stations.

Associated Animals

Little is known about the interrelationships of the many species of animals occupying the nursery area with penaeid postlarvae and collected in our samples. Time did not permit study of this material but some observations seem pertinent to this problem. The extent to which the abundance of predator and forage organisms affects the success of any brood of penaeid postlarvae is unknown.

Large numbers of other crustaceans were taken in samples with penaeid postlarvae. Palaemonids and mysids occurred in most samples with commercial penaeid postlarvae, often in large numbers. Swarms of the little sergestid, *Acetes,* occurred periodically literally filling the bag of the net. In March, 1963, a large copepod, *Anomalocera ornata,* appeared in tremendous swarms along the Mississippi Sound shore of Horn and Ship Islands. It remained active about a week, filling the net in every sample taken in the area. Afterwards it was seen in windrows on the beaches at the swash line. This was the only time the species was observed in our samples.

Horseshoe crabs, both adults and earlier stages, were collected in several samples. Blue crabs in various stages of development were often abundant. Hermit crabs were sometimes so abundant that they had to be removed from the sample before preservation. Other invertebrates noticed in casual observations included polychaetes, haustoriids, leeches, flat worms, parasitic isopods and many others. An octopus was caught in one haul at Station 25.

Coelenterates and ctenophores were so abundant at times that they quickly filled the net. Few postlarvae were caught in samples including large quantities of ctenophores. Whether this resulted from failure of the net to fish properly after fouling with the "jelly" or from absence of young shrimp in the area is not known.

Amphioxus appeared in some samples. The larvae and juveniles of many fishes and the small adults of several species were often collected in considerable abundance. Young sciaenids, engraulids, and clupeids were especially noticeable. A few large fish, including stingrays, flounders and sheepshead, were caught but larger specimens usually escaped the net.

THE CATCH OF COMMERCIAL PENAEIDS

A total of 1305 samples was completed. They contained 71,529 postlarvae belonging to the three major commercial species. Table 7 shows the number of samples completed at mainland and barrier island stations. Total numbers and average catches are shown for brown (*Penaeus aztecus*), pink (*P. duorarum*), and white (*P. fluviatilis*) shrimp. Although a small percentage of the annual commercial catch in Mississippi Sound is always pink shrimp, their postlarvae have not been previously reported in the area. *Trachypeneus* postlarvae and young *Xiphopeneus* were also included in the catch. Since they were caught in only a few samples and are not recorded as a part of the area commercial catch they will not be considered here.

Some juveniles of all three major species were taken in the beam net. However, both the size of the net and the sampling area probably limited the catch of juveniles. They were seen escaping over and around the net on some hauls. It should be noted, nevertheless, that brown shrimp juveniles appeared in our catch later in the spring of 1964 than they did in 1963.

DISTRIBUTION

Areal

Monthly average catches of brown shrimp per haul for 16 stations is shown in table 8. Station 29 was established in October 1963 when station 15, across the Pascagoula river, was abandoned because of extensive dredging operations in the Pascagoula ship channel. Sampling at the new station was continued but the catches did not seem to be comparable to that at the old station (15). Few shrimp were caught at station 14 on Round Island and it was finally abandoned. Stations 28, 30, and 31 (Figure 1) were established in the second year of sampling and are not included in this table. Station numbers between 1 and 31 which are not shown in figure 1 were used for stations in various locations. Efforts to sample at these stations were abandoned after a few samples were completed. In most cases, the bottom was too soft to walk on. Tables 9 and 10 give similar data for white and pink shrimp respectively. The 16 remaining stations have been arranged in east to west order along the mainland and the barrier islands.

In general, postlarvae were more abundant at mainland stations, with the greatest concentration found at Biloxi Bay stations. Variations in east-west distribution was not evident but the largest hauls were made near river mouths.

At barrier island stations more shrimp were taken at stations which included grass beds. These stations, 13, 27, and 24, were located away from the strong currents associated with the ends of Horn and Ship islands. Evidently most of the postlarvae moved through the wide passes without stopping along the island beaches.

Weekly data sheets show irregular variations in the catch at different stations but monthly averages are consistently higher at stations 1, 4, and 11 on the mainland and at stations 13 and 24 on the Islands. Over half of the total catch of postlarvae was taken at these stations.

Temporal

Examination of table 8 shows that the first brown shrimp postlarvae were caught in February in both 1963 and 1964. Weekly data sheets show brown shrimp juveniles about three weeks earlier in 1964 than in 1963. Earlier distribution over the whole area is evident (table 8) in average station catches for 1964.

Immigration continued through the summer and a few brown shrimp postlarvae were found at mainland stations through October. Some specimens are shown in November 1962. The total catch at all stations shows only 17 specimens recorded for November 1963.

No postlarvae were caught at barrier island stations in February 1963

Table 7. Total catch of brown, pink, and white shrimp postlarvae at mainland and barrier island stations with species totals and average catch per haul.

	No. Hauls	No. Brown	No. Pink	No. White	Totals	Average Catch Brown	Pink	White
1962-63								
Mainland	427	16,332	1,396	8,443	26,171	38.2	3.3	19.8
Barrier Is.	224	2,412	1,960	1,646	6,018	10.8	8.7	7.3
Totals	651	18,744	3,356	10,089	32,189	28.8	5.2	15.5
1963-64								
Mainland	439	20,481	998	8,171	29,650	46.7	2.3	18.6
Barrier Is.	215	5,610	404	3,686	9,700	26.1	1.9	17.1
Totals	654	26,091	1,402	11,857	39,350	39.9	2.1	18.1

Table 8 Average haul of brown shrimp postlarvae at certain stations by months and years. Stations have been arranged in east-west geographic order.

Mon./	MAINLAND STATIONS									BARRIER ISLAND STATIONS					
Year	15	28	11	4	1	23	18	20	19	22	13	8	26	27	25	24
Nov.																
1962				62	2							0				
1963		2	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Dec.																
1962			0	2	0											
1963			0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan.																
1963	0		0	2	0		0		0		0	0				
1964			0	0	0	0	0	0	0	0	0	0				
Feb.																
1963	0		0	0	0	6	0	0	0	0	0	0				
1964		1	5	29	13	2	3	0	4		4	1		0		
Mar.																
1963	33		78	99	67	1	6	4	25	1	14	2	0		1	3
1964		74	84	153	379	24	110	3	63		14	11				
Apr.																
1963	241		84	262	54	14	4	18	88	0	6	1	0	1	0	15
1964		31	139	270	249	33	58	1	146	0	12	7	3	6	4	57
May																
1963	162		42	353	59	21	49	35	26	6	32	1	5	7	0	26
1964		86	50	125	24	26	6	0	32	2	31	12	5	8	2	122
June																
1963	86		100	387	27	41	24	15	20	4	134	47	1	24	14	100
1964		40	15	170	33	17	4	2	10	4	266	119	5	29	2	69
July																
1963	106		163	268	40	22	13	9	10	4	32	2	1	38	2	58
1964		21	43	227	15	7	5	3	7	6	171	35	2	1	3	166
Aug.																
1963	56		36	122	11	10	1	25	20	2	11	12	2	10	2	28
1964		26	78	420	74	30	1	7	5	9	160	28	3	1	2	78
Sept.																
1963	14		22	36	1	1	8	0	15	10	3	4	4	6	0	10
1964		38	27	266	5	4	5	4	32	0	24	20	0	2	6	24
Oct.																
1963		1	3	5	3	1	0	1	2	0	0	0	0	0	0	0
1964		10	3	119	3	3	1	1	3	0	1					
Totals																
62-63	96	1	54	134	25	14	12	12	22	3	20	6	2	13	2	29
63-64		36	42	152	72	13	18	2	30	3	63	24	2	6	2	66

Table 9. Average haul of white shrimp postlarvae at certain stations by months and years. Stations have been arranged in east-west geographic order. Figures have been rounded off to the nearest whole number.

Mon./	MAINLAND STATIONS									BARRIER ISLAND STATIONS						
Year	15	29	11	4	1	23	18	20	19	22	13	8	26	27	25	24
Nov.																
1962				0	0							0				
1963		0	0	6	1	1	1	0	0	0	0	1	0	0	0	1
Dec.																
1962			0	0	0											
1963			0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan.																
1963	0		0	0	0		0		0		0	0				
1964			0	0	0	0	0	0	0	0	0	0				
Feb.																
1963	0		0	0	0	0	0	0	0	0	0	0				
1964		0	0	0	0	0	0	0	0	0	0		0			
Mar.																
1963	0		0	0	0	0	0	0	0	0	0	0	0		0	0
1964		0	0	0	0	0	0	0	0		0	0				
Apr.																
1963	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0
1964		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May																
1963	2		2	3	1	10	10	6	4	1	2	0	0	2	0	1
1964		5	8	22	2	0	1	0	0	38	52	9	0	7	0	8
June																
1963	60		14	26	11	30	2	3	15	1	74	6	7	18	23	15
1964		76	116	84	28	22	15	10	13	2	132	19	4	4	5	16
July																
1963	84		285	114	56	154	40	14	23	2	50	2	6	31	0	3
1964		28	47	89	13	4	8	2	13	0	94	9	2	2	8	17
Aug.																
1963	244		49	90	27	49	32	33	47	2	31	44	7	21	0	18
1964		43	72	313	83	49	9	6	15	19	304	34	8	13	2	66
Sept.																
1963	142		30	62	8	18	10	2	20	11	10	30	12	10	2	4
1964		22	12	285	6	5	2	4	33	9	28	38	1	1	6	8
Oct.																
1963		2	1	12	5	2	1	2	9	0	7	2	0	0	0	3
1964		8	4	164	8	6	6	1	5	1	0					
Totals																
62-63	59	2	42	25	11	34	11	7	12	2	16	7	4	12	3	5
63-64		20	23	75	10	7	9	2	7	8	55	10	2	4	3	13

Table 10. Average haul of pink shrimp postlarvae at certain stations by months and years. Stations have been arranged in east-west geographic order. Figures have been rounded off to the nearest whole number.

Mon./	MAINLAND STATIONS									BARRIER ISLAND STATIONS						
Year	15	29	11	4	1	23	18	20	19	22	13	8	26	27	25	24
Nov.																
1962				0	0							0				
1963		0	1	15	2	2	1	1	3	0	5	0	0	0	0	12
Dec.																
1962			0	0	0											
1963			0	4	0	0	0	0	0	0	0	0	0	0	0	4
Jan.																
1963	0		0	0	0		0		0		0	0				
1964			0	0	0	0	0	0	0	0	0	0				
Feb.																
1963	0		0	0	0	0	0	0	0	0	0	0				
1964		0	0	0	0	0	0	0	0		0	0		0		
Mar.																
1963	0		0	0	1	0	0	0	0	0	0	0	0		0	0
1964		0	0	0	0	0	0	0	0		0	0				
Apr.																
1963	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May																
1963	0		0	1	0	0	0	5	0	0	1	0	0	1	0	1
1964		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
June																
1963	2		8	6	1	1	1	0	0	0	3	4	1	6	0	12
1964		0	0	1	0	0	0	0	0	0	4	2	0	1	1	0
July																
1963	9		1	21	0	1	2	2	1	4	8	2	5	12	4	19
1964		0	6	4	4	0	0	0	0	1	31	1	2	0	0	0
Aug.																
1963	1		2	9	8	6	2	8	0	0	156	8	8	6	10	78
1964		0	0	46	4	0	0	0	0	0	17	1	0	0	0	2
Sept.																
1963	21		5	14	5	7	17	4	49	38	65	34	0	7	4	12
1964		0	0	41	1	1	1	1	4	0	3	12	0	0	0	0
Oct.																
1963		4	4	15	4	9	1	4	4	0	11	6	0	2	3	27
1964		13	1	80	6	7	1	1	5	0	0					
Totals																
62-63	4	4	2	6	2	3	2	3	4	4	24	4	2	5	2	16
63-64		1	1	13	1	1	0	0	1	0	6	1	0	0	0	3

but a few were found at stations 8 and 13 in 1964. They had practically disappeared from offshore island stations by the end of September in both years.

White shrimp were first found in our samples (table 9) in May of both years. The first white shrimp was taken on May 8, in 1963 at an island station but only one specimen was found in the sample. In 1964 white shrimp were first found on May 20 when 200 specimens were collected at eight stations. However, 144 of these were collected at stations 13 and 22 on Horn Island. Immigration continued through the summer until the end of October. A few specimens were collected in November 1963.

Pink shrimp postlarvae (table 10) were found in some samples from May through December. Only a few were recorded before July in either year. Apparently our sampling included only one complete pink shrimp cycle. The fishery in this area takes pink shrimp in the spring and summer (Gulf Coast Shrimp Data 1963 and 1964). It is unlikely that pink shrimp postlarvae taken in our samples could contribute to the commercial catch until they had survived one winter.

Salinity

Brown shrimp postlarvae were caught at salinities ranging from less than 2 o/oo to 34 o/oo. In the 1962-63 period the highest average catch was found in the 20-21.9 o/oo interval when the catch at stations 1, 4, 11 and 13 were arranged in salinity intervals of 2 o/oo. In the second year the highest average occurred in the 18-19.9 o/oo interval. However, in the second year the next highest average occurred in the 4-5.9 o/oo interval while the first year next to highest average was found in the interval 22-23.9 o/oo. Multi-modal curves of abundance skewed in opposite directions in the first and second year. The two highest peaks for white shrimp occurred in the 28-29.9 and the 16-17.9 o/oo intervals in the first year. In the second year they were in the 18-19.9 and 24-25.9 intervals, respectively.

However, in the second year, when salinity generally was lower, a greater percentage of both brown and white shrimp postlarvae were caught at barrier island stations.

Pink shrimp were caught at higher salinities. The two highest averages occurred in 32-33.9 and 18-19.9 o/oo intervals. The curve of distribution was skewed strongly toward the higher salinity.

Temperature

No penaeid postlarvae were taken at stations 1, 4, 11, and 13 when the water temperatures were 12° C. In general, numbers increased until the temperatures exceeded 30-32° C. Average catches were lower at temperatures above this level.

POSTLARVAL INDEX OF ABUNDANCE

Selection of Stations

The feasibility of a continuing program of sampling postlarval commercial shrimps as a means of predicting the ensuing commercial availability depends largely on the reliability and the cost of the program.

Table 11. The catch of brown shrimp postlarvae at stations 1, 4, 11 and 13.

Month	Year	Average Catch by Weeks 1	2	3	4	5	Total Hauls	Month Averages
Nov.	1962		76	32	48		4	47
	1963	0	0	0	0		16	0
Dec.	1962	5	0	0	0		9	1
	1963	0	0	0	0		12	0
Jan.	1963	2	0	0	0	0	17	1
	1964	0	0	0	0	0	15	0
Feb.	1963	0	0	0	0		14	0
	1964	4	5	26	16		16	13
March	1963	16	59	69	114		16	64
	1964	27	186	107	310		16	158
April	1963	57	196	27	126		16	101
	1964	589	279	52	42	13	19	176
May	1963	84	246	41	136	104	20	122
	1964	41	63	106	19		16	57
June	1963	230	139	34	219		15	164
	1964	52	277	108	46		16	121
July	1963	96	155	47	157	137	19	116
	1964	68	5	168	150	92	19	108
Aug.	1963	98	37	27	18		16	45
	1964	105	176	164	359		15	190
Sept.	1963	7	46	4	5		16	15
	1964	43	9	178	162	18	16	80
Oct.	1963	1	7	1	0	4	20	3
	1964	46	2	4	22		11	24

Table 12. The catch of white shrimp postlarvae at stations 1, 4, 11 and 13.

Month	Year	Average Catch by Weeks 1	2	3	4	5	Total Hauls	Month Averages
Nov.	1962		0	0	0		4	0
	1963	1	6	0	0		16	2
Dec.	1962	0	0	0	0		9	0
	1963	0	0	0	0		12	0
Jan.	1963	0	0	0	0	0	17	0
	1964	0	0	0	0	0	15	0
Feb.	1963	0	0	0	0		14	0
	1964	0	0	0	0		16	0
Mar.	1963	0	0	0	0		16	0
	1964	0	0	0	0		16	0
April	1963	0	0	0	0		16	0
	1964	0	0	0	0	0	19	0
May	1963	0	0	1	4	6	20	2
	1964	0	0	32	5		16	21
June	1963	35	25	15	36		15	29
	1964	164	150	37	9		16	90
July	1963	45	311	15	133	132	19	127
	1964	12	26	56	109	80	19	59
Aug.	1963	40	52	53	32		16	49
	1964	109	131	364	196		15	200
Sept.	1963	36	62	8	6		16	28
	1964	48	6	177	128	49	16	83
Oct.	1963	2	10	1	2	18	20	7
	1964	68	8	6	25		11	34

Table 13. The catch of pink shrimp postlarvae at stations 1, 4, 11 and 13.

Month	Year	Average Catch by Weeks 1	2	3	4	5	Total Hauls	Month Averages
Nov.	1962		0	0	0		4	0
	1963	19	2	0	2		16	6
Dec.	1962	0	0	0	0		9	0
	1963	3	1	0	0		12	1
Jan.	1963	0	0	0	0	0	17	0
	1964	0	0	0	0	0	15	0
Feb.	1963	0	0	0	0		14	0
	1964	0	0	0	0		16	0
March	1963	0	0	1	0		16	0
	1964	0	0	0	0		16	0
April	1963	0	0	0	0		16	0
	1964	0	0	0	0	0	19	0
May	1963	0	0	0	1	2	20	1
	1964	0	0	0	1		16	0
June	1963	8	1	5	5		15	4
	1964	4	1	0	0		16	1
July	1963	2	2	15	0	13	19	7
	1964	0	0	8	38	9	19	12
Aug.	1963	6	59	38	72		16	44
	1964	12	4	23	35		15	18
Sept.	1963	58	7	15	9		16	22
	1964	3	0	25	21	8	16	11
Oct.	1963	1	11	5	6	18	20	8
	1964	29	6	6	16		11	17

Several things indicate that one station sampling would not be satisfactory in Mississippi Sound and adjacent waters. Wide variations, both areal and temporal, in the abundance of postlarvae at stations established in this program have been observed. Differences in distribution of postlarvae from one year to the next have been noted as well as the variety of environmental conditions involved.

In order to be useful in a long term program, stations selected for development of abundance indices must be as accessible as possible, must encompass as many variants of the environment as practicable, must be few in number, and must produce representative numbers of postlarvae.

Four stations used in this project apparently satisfy these conditions. Station 1 is located near the laboratory. A soft mud bottom is bordered by a typical marsh. Station 4 is located on a shallow, moderately firm flat with considerable seasonal grass growing on the bottom. Station 11 is bordered by a clean sand beach facing the open sound. Station 13 on Horn Island is much more accessible than station 24 on Cat Island, the other island station that might be considered. Average hauls at these stations have been consistently higher than those made at other island stations. Sampling at all four stations can be completed by a two-man crew in about four hours. These stations have been used to develop the index of postlarval abundance for Mississippi Sound and adjacent waters. The combined catch at stations 1, 4, 11, and 13 is shown in detail in tables 11, 12, and 13.

For Brown Shrimp

Brown shrimp postlarval immigration begins as early as February at these stations (table 11). The commercial catch takes relatively few brown shrimp (figure 9) after September. It is unlikely that postlarvae caught after July would contribute much to the year's commercial catch. Therefore the index for brown shrimp is taken as the average haul for the period of February through July. The index for 1963 is 97.5 and for 1964 it is 107.5. Dividing the second year index by the first we get 110.3%. Consequently the postlarval index would predict that the commercial crop of brown shrimp for 1964 would be 110.3% of the 1963 catch.

For White Shrimp

White shrimp postlarval immigration started in May of both years (table 12). Movement of postlarvae into the nursery area continued until the end of October with a few postlarvae entering the estuary later. The commercial fishery for the new crop of white shrimp begins in August (figure 10). Commercial fishermen continue to take white shrimp throughout the year. Therefore the entire white shrimp postlarval crop may be available to the fishery within the year. Average numbers of white shrimp postlarvae taken in hauls from May through the remainder of the year are used as the index of postlarval abundance for white shrimp. The index for 1963 is 40.04 and 81.81 in 1964. The second year index is 204.3% of the first. Hence the prediction would be for a catch in 1964 that doubles the 1963 catch.

For Pink Shrimp

As previously indicated our sampling probably did not cover two complete cycles of pink shrimp recruitment. Pink shrimp usually make up

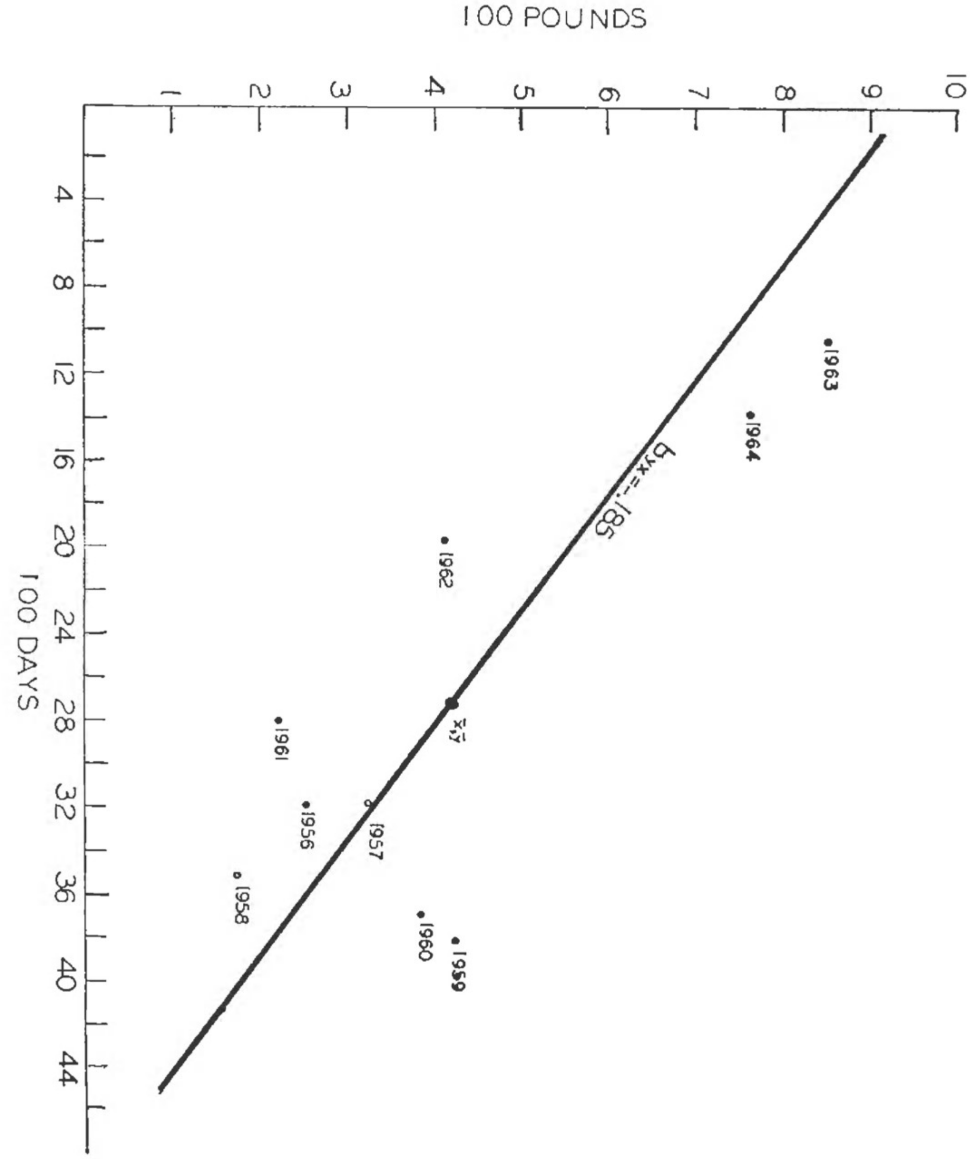

Figure 8. — Relationship of brown shrimp catch per 24 hours fishing to total days fishing in area 011.1, 1956 through 1963.

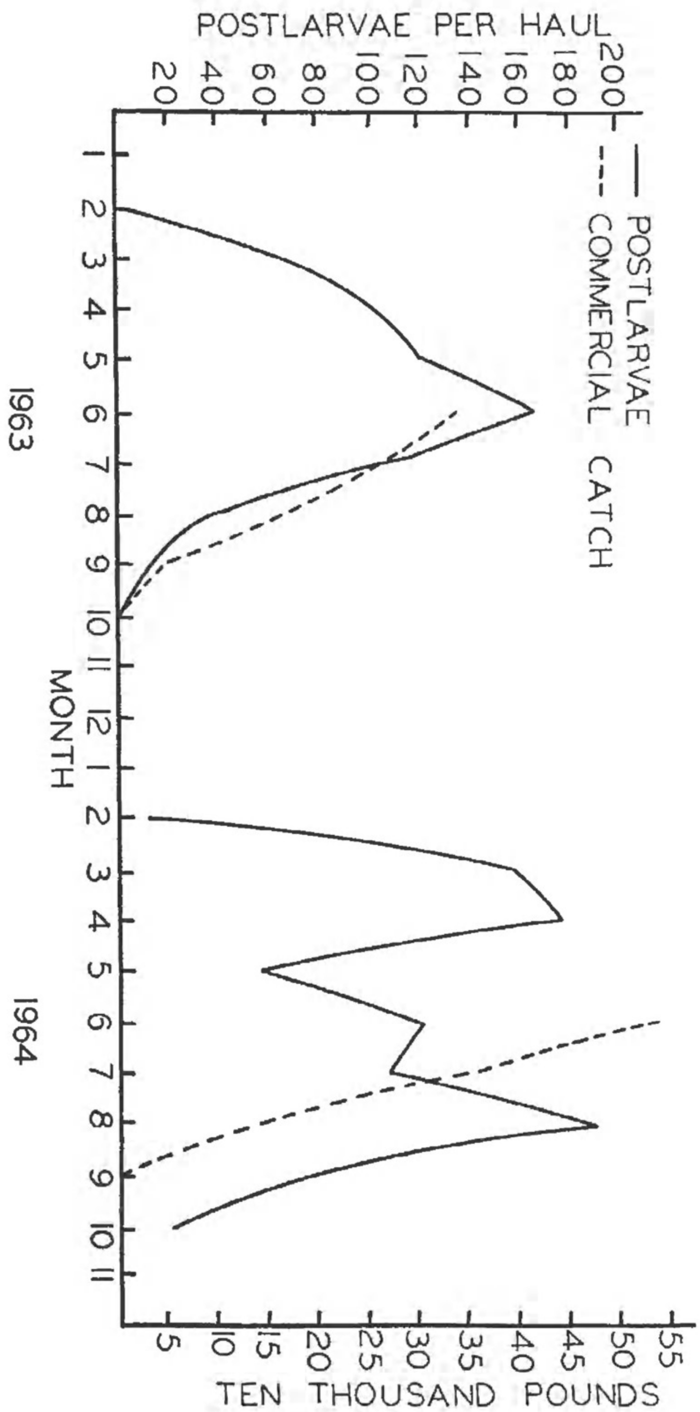

Figure 9. — Monthly average catch of brown shrimp per haul and monthly commercial catch in area 011.1, 1963 and 1964.

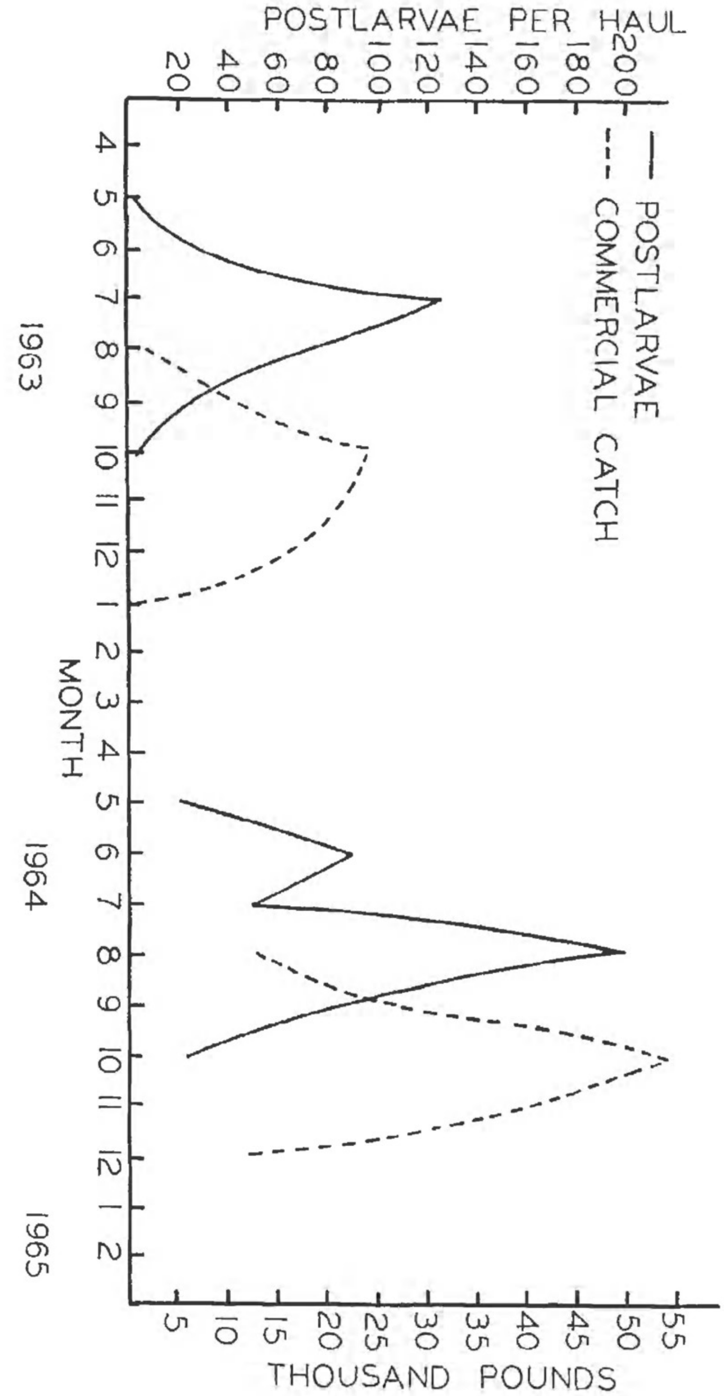

Figure 10. — Monthly average catch of white shrimp per haul and monthly commercial catch in area 011.1, 1963 and 1964.

less than three per cent of the total catch in this area. It is doubtful that our data could be used to produce an index for pink shrimp.

COMMERCIAL FISHERIES INDEX OF ABUNDANCE

Selection of Areas

Since 1956 Gulf Coast Shrimp data, published by the Bureau of Commercial Fisheries, has reported the shrimp catch by species, size, area of capture and depth of water with the number of trips and amount of fishing effort in 24 hour days. Area 011.1 is most closely associated with the area sampled by our stations. It is located in Mississippi Sound, extending from the east end of the Sound to the Gulfport ship channel.

Area 0110 includes offshore Mississippi waters. It extends offshore from the Gulf side of the barrier islands between Mobile Bay and the Chandeleur Islands (see FWS Shrimp Fishing Grid Zones for details). It is known (Lindner and Anderson, 1956) that white shrimp from Mississippi waters enter this area. Abundance indices for both of these areas should be considered.

Derivation of Indices of Abundance

In a heavily fished, restricted area like 011.1 the fishing intensity might affect the catch per unit of effort. The relationship between fishing effort and the catch per 24 hour day of fishing since 1956 is shown in figure 8.

Correlation ($r = -.8018$) between fishing effort and catch per 24 hour days fishing is significant (when $p = .01$, with seven degrees of freedom $r = .7977$). Ninety-five per cent confidence limits of b_{YX} are -.308 to -.062. Since $B = 0$ is not included, the regression of catch per unit of effort is significant.

In 1964 the number of 24 hour days of fishing for brown shrimp in area 011.1 increased from the 1963 effort, 1,082.2 days, to 1,515.7 days. This is 140 per cent of the 1963 effort. Similarly, the effort involved in catching white shrimp in 1964 is 144 per cent of the corresponding 1963 effort. Although the area catch of brown shrimp for 1964 was 84.7 per cent of the 1963 catch per 24 hour day, the total catch was 118.7 per cent. Hence, the total catch in area 011.1 is a better indicator of abundance than the catch per unit of effort. This would, of course, not be true if the intensity did not affect the catch per day. The index for abundance in area 011.1 is determined by the total catch of each species.

In area 0110 the situation is different. There is no evident historical relationship between fishing intensity and catch per day. Fishing intensity does fluctuate and the catch per 24 hour day would evidently be the best indicator of abundance.

For Brown Shrimp

In area 011.1 the catch of brown shrimp in 1964 (1,064,685 pounds) was 118.7 per cent of the 1963 catch (897,039 pounds). The 1964 catch of brown shrimp per 24 hour day in area 0110 was 497.6 pounds. In 1963 this amounted to 459.1 pounds. The 1964 catch was 108.4 per cent of the 1963 catch.

For White Shrimp

Similar calculations for white shrimp (see table 15) show that the 1964 catch in 011.1 was 204.3 per cent of the 1963 catch. In area 0110 the second year production per day was 207.6 per cent of the catch per 24 hour day in the first year.

COMPARISON OF POSTLARVAL INDEX AND COMMERCIAL CATCH

Brown Shrimp

Table 14 shows the relationship between the brown shrimp postlarval index and the ensuing commercial catch in the selected areas. The 1964 commercial catch in area 011.1 was 75, 251 pounds (8.4 per cent) greater than the postlarval index predicted. Figure 9 shows the relationship between the monthly commercial catch and the average catch of postlarvae.

Table 14. Index of postlarval abundance of brown shrimp compared to the commercial catch in adjacent waters.

	1963	1964	1964/1963 per cent
Pl. Index	97.5	107.5	110.3
Catch in Area 011.1	897,039	1,064,685	118.7
Catch per 24 hours Area 0110	459.1	497.6	108.4

Table 15. Index of postlarval abundance of white shrimp compared to the commercial catch in adjacent waters.

	1963	1964	1964/1963 per cent
Pl. index	40.04	81.81	204.3
Catch in Area 011.1	75,570	149,035	197.2
Catch per 24 hours Area 0110	86.6	183.9	207.6

In area 0110, the catch per 24 hour day was 8.3 pounds (1.9 per cent) less than the prediction.

White Shrimp

Table 15 shows the relationship between the white shrimp postlarval index and the ensuing commercial catch in area 011.1 and 0110. In Mississippi Sound, the 1964 catch was 5,534 pounds (7.1 per cent) less than the amount predicted by the postlarval index. In offshore area, the 1964 catch per days fishing was 2.9 (3.3 per cent) pounds greater than that predicted by the postlarval index. Figure 10 shows the relationship between the monthly commercial catch of white shrimp and the monthly average catch of postlarvae in area 011.1.

DISCUSSION

The postlarvae of all three major species can be expected on the nursery grounds at the same time in late summer and fall. Little difficulty with identification was encountered in the spring and early summer. Brown shrimp postlarvae during this period were noticeably larger than whites at the same stage of development. Brown shrimp postlarvae, however, were smaller during the warmer months. Differentiating characters overlapped in many cases. This was particularly true of sizes from about 14mm. total length until the rostral groove was evident on grooved species. Experienced workers recognized subtle differences which they were not always able to clearly describe. Although there were almost certainly some errors in identifications, averages seem to be correct.

Despite the accuracy of prediction made by the indices developed in this short project, reliability has not been established. The indices need further refining. Although most of the shrimp caught in the statistical areas used in this study during a calendar year come from one year class, a fiscal year including the spring months of the year following inshore movement of the postlarvae may reflect the contribution of a year class more accurately.

Evidence of slower development from postlarvae into rapidly growing juveniles in the spring of 1964 and the chance that adverse factors or combinations of factors may affect survival indicate the advisability of monitoring the abundance of juveniles as a check on the success of postlarvae used for an index of abundance.

The occurrence of rather consistently larger numbers of postlarvae at stations 1, 4, 11, and 13, may be partially explained by the movement of Gulf waters through the passes between Horn and Ship Islands (Figure 1). Priddy (1955) adapted data from Phleger (1954) to show that marine *Foraminifera* "mingle with Sound facies and even estuarine facies". All four stations are located near the inner limit of the Gulf facies. However, little is known about the movement of water masses in the Sound and better understanding of these movements would help clarify the picture.

SUMMARY

1. An extensive sampling project in Mississippi Sound and adjacent waters was carried out during the two years between November 1962 and the end of October 1964.

2. Postlarval pink shrimp were reported from this area for the first time.

3. The salinity regime in the years was very different.

4. From a total of 31 stations established, four were selected as being suitable for use in long term studies of postlarval abundance.

5. Indices of abundance developed from the catch of postlarvae at the selected stations predicted the 1964 catch of both white and brown shrimp within ten per cent.

6. Determination of the relative abundance of postlarval penaeid shrimp by season and area in Mississippi Sound and adjacent waters seems to be feasible, but reliability of the indices has not been fully established. Refinement of the indices and several more years experience will be required to refine the predictions.

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