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PROJECT REPORT

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Project Name: A Study of the Bay Populations of Juvenile Shrimp, Penaeus aztecus and Penaeus setiferus

Period Covered: January 1, 1961 through December 31, 1961

A Study of the Bay Populations of Juvenile Shrimp, Penaeus aztecus and Penaeus setiferus

Abstract: This report is based on a total of 542 samples, 29,063 brown shrimp and 14,569 white shrimp.

Semi-monthly sampling of juvenile shrimp in Texas bays in 1961 confirmed that there are at least three waves of brown shrimp, P. aztecus, and white, P. setiferus, shrimp entering bay nursery habitats. The greatest abundance of juvenile browns occurred in May and June, whereas juvenile whites were present in fair numbers from July through December.

Growth rates during July and August were highest for both species, with that for browns computed up to 1.5 mm per day and that for whites up to 1.8 mm per day.

A sharp drop in abundance of both species in the bay this year was reflected later in almost direct proportion to the Gulf commercial catch.

Bay environmental conditions possibly affecting abundance of at least the brown shrimp include higher river runoff, lower bay salinities, and lower bay water temperatures at a time when most of the larval browns were entering nursery areas. It is more probable, however, that some adverse condition in the Gulf was the main cause of the poor shrimp production of 1961.

It was again found that in many shallow, tertiary bays and bayous shrimp do not reach the proper size for harvesting.

Objectives: To compare shrimp data gathered in 1961 with that gathered in 1960 to begin predictions of the abundance and composition of the shrimp populations which will serve as a basis for proper management of this valuable fishery in the coming years.

Procedure: Sampling and reporting procedure remained identical with that instigated in 1960.

In each bay area, biologists sampled at least one tertiary, one secondary, and one primary shrimp habitat every two weeks. Dates for sampling were limited to three calendar days on either side of the first of the month and three calendar days on either side of the fifteenth of the month.

Duration of the sample was standardized at 15 minutes. When excess grass or algae limited sampling to less than the prescribed period, the data was multiplied to correct for time.

Tertiary stations were sampled with a 6-foot pull seine having a square mesh size of one-fourth inch. Secondary and primary stations were sampled with a 10-foot flat trawl of 1-1/4 inch mesh with a bag liner of one-fourth inch mesh. A 20-foot flat trawl of 1-1/2 inch mesh was used to sample a main bay area being worked by the commercial fleet.

The same locations sampled in 1960 were utilized again in 1961. In those areas in which no shallow water samples were taken in 1960, tertiary habitats were chosen to complete the data for this year. As before, tertiary

stations were characterized by water about two feet deep, mud and grass bottoms and presence of the smallest shrimp; secondary stations by 4- or 5-foot depths with varying bottom characteristics; and primary stations by 6- to 12-foot depths and position within the main bay of a system. Maps of the stations, covered in the 1960 report, are not reprinted.

Information on the gear used, weight and abundance of shrimp caught, and environmental conditions was recorded at each sampling. Length-frequency sheets were used to record abundance by size range for the shrimp taken. Shrimp were measured in millimeters from the end of the rostrum to the point of the telson. In presenting the data, the number of shrimp in each five millimeter block was plotted on the center three or eight numeral of that block.

In each bay system the total yield of a type station was divided by the number of samples in that type for the sampling period to give an average semi-monthly sample. These were plotted graphically for each station type. Figure 1 is an example graph.

From these semi-monthly total length-frequency graphs populations modes were taken, the method being shown in Figure 1. Separate mode and abundance graphs for brown and white shrimp are covered in Figures 2 through 13.

Graphs on 1960-1961 comparison of modes, abundance, and environmental conditions (Figures 14 through 20) are covered in the findings.

Records kept on the few pink shrimp taken are not included in this report.

Findings:

Penaeus aztecus

Galveston Bay - There were indications of at least three waves of small shrimp, the first being the most abundant and important. Small browns first appeared in the April 1 samples, indicating an early March spawning in the Gulf. Recruitment of 18 mm shrimp continued through May 1. Although most of this first wave left the bay by June 15 at a size below 95 mm, scattered specimens remained through September 1. The average growth rate was about 0.6 mm per day.

A second wave of small shrimp appeared on August 1 and grew in the bay through October 15, leaving when less than 85 mm long. A poorly defined growth rate of 1 mm per day was indicated.

A third wave appeared on September 1 and remained through December, with an indicated growth rate of 0.7 mm per day.

Largest average size attained in the tertiary was 63 mm; in the secondary, 88 mm; and in the primary, 95 mm.

Matagorda Bay - There were indications of probably four waves of shrimp. First appearance of small shrimp was on April 1 at a mean size of 30 mm. This wave remained in the bay through June 15, with an indicated growth rate of about 0.5 mm per day. These shrimp left when less than 95 mm long. The second wave appeared June 1 at a mean of 28 mm and remained through August 1, with an indicated growth rate of 0.8 mm per day, leaving before reaching 90 mm. There appeared to be continual recruitment of small shrimp during the peak abundance period of April 1 through July 1.

The third wave appeared in the tertiary July 15 at a mean of 28 mm and remained until August 15 with a growth rate of 1.5 mm per day, leaving before reaching 85 mm. The start of a last wave was sampled on November 1 at a mean of 28 mm.

Disregarding a few scattered large shrimp taken on March 15, the largest average size attained in the tertiary was 58 mm; in the secondary, 73 mm; and in the primary, 78 mm.

San Antonio Bay - There were indications of possibly four waves of juvenile shrimp. The first appearance of small shrimp was on April 1 at a mean of 33 mm. Continual recruitment occurred from April through June 1, the peak of abundance being in May. This wave, or succeeding parts of it, remained in the bay through July 15 with an indicated growth rate of 1.3 mm per day and left before reaching 105 mm.

The second wave appeared August 15 at a mean of 35 mm. An indication of a third wave occurred October 15 at a mean of 43 mm. The last wave appeared at 40 mm on December 15.

Largest average size attained in the tertiary was 80 mm; in the secondary, 85 mm; and in the primary, 78 mm.

Aransas Bay - There were indications of four waves of shrimp. The first group appeared on April 1 at a mean of 18 mm and began leaving the bay May 15 when less than 90 mm. The indicated growth rate was 1.15 mm per day.

The second wave began May 15 with continual recruitment through June 15. Modes for September indicate that a third wave probably entered August 1. The last wave probably entered October 1 with continued minor recruitment through November 1.

Largest average size attained in the tertiary was 60 mm; in the secondary, 88 mm; and in the primary, 83 mm.

Corpus Christi Bay - There were three waves of shrimp. The first appeared on April 15 at a mean of 33 mm and remained through June 15 with a growth rate of about 1 mm per day, leaving when less than 100 mm. The second wave appeared June 15 and remained through August 15. Indications of a third wave which probably entered the bay September 15 showed up in the samples of October 1 at a mean of 38 mm. Most left the bay before reaching 110 mm.

Largest average size attained in the tertiary was 75 mm; in the secondary, 90 mm; and in the primary, 100 mm.

Overwintering of brown shrimp from Corpus Bay south is covered in the comparison findings.

Upper Laguna Madre - There were indications of three periods during which small shrimp entered these waters. Whether these represent "waves" is uncertain.

The first group which showed up on May 1 at a mean of 53 mm was probably a part of the first wave entering Corpus Bay on April 15 at a mean of 33 mm. This group remained in the Upper Laguna through June 15 with an indicated growth rate of 1 mm per day.

A second group appeared August 15 at 35 mm and remained through October 15 with a growth rate of about 0.9 mm per day. Shrimp of a mean of 33 mm appeared again on October 15.

To date the sampling in the Upper Laguna has not been broken down into tertiary, secondary, and primary areas. The largest average size taken was 108 mm, although most of the shrimp left below 105 mm.

Lower Laguna Madre - The Lower Laguna has not yet been definitely divided into tertiary, secondary, and primary areas. For graphing purposes sampling stations furthest from the pass at Port Isabel are considered secondary areas and generally produce smaller shrimp.

There were indications of five "waves" with more or less continual recruitment from February to October. The first showed up in the February 15 sample at a mean of 40 mm, but with shrimp as small as 23 mm in the mode. This would indicate a January spawn in the Gulf off Port Isabel.

The second and most abundant wave appeared April 1 at a mean of 38 mm with an indicated growth rate of about 0.4 mm per day.

The third group appeared June 15 at a mean of 45 mm with a growth rate of 0.8 mm per day. Shrimp of a fourth group were taken August 1 at a mean of 43 mm. The fifth wave appeared October 1 at a mean of 28 mm and displayed a growth rate of 0.7 mm per day.

Most of the shrimp in the area left before reaching 85 mm. The largest average size attained in the secondary was 60 mm and in the primary, 73 mm.

Penaeus setiferus

Galveston Bay - Overwintering whites were picked up January 1 at a mean of 78 mm and remained in the bay through May 1, leaving at a size below 148 mm.

There were at least two waves of juvenile shrimp. The first wave appeared June 15 at 30 mm and remained through August 1 with a growth rate of 1.3 mm per day.

The second wave entered August 1 at 18 mm and showed a growth rate of 1.8 mm per day. There was continual recruitment through October 15, apparently by shrimp of a gradually increasing size mode. Tertiary samples produced shrimp of a mean size as follows: 18 mm on August 1, 23 mm on September 1, 30 mm on October 1, 35 mm on October 15, 43 mm on November 15, and 53 mm on December 15.

The period of greatest abundance was in September.

Matagorda Bay - White shrimp were first taken January 15 at a mean size of 63 mm and were fairly abundant February 1 at a mean of 65 mm. These shrimp represented an overwintering population which remained in the bay from November 1960 until July 1, 1961, showing a growth rate of about 0.7 mm per day. Some specimens reached 188 mm before leaving.

There were indications of four 1961 waves. The first wave appeared March 15 at 25 mm. The second appeared June 1 at 23 mm and remained through September 1 with a growth rate of 1.2 mm per day. The third appeared July 1 at 23 mm. The fourth appeared October 15 at 33 mm. Most of these shrimp left before reaching 133 mm.

Abundance ran low but steady from February through March and again from July through September 1. Indications were that the abundance peak was in September and November.

San Antonio Bay - Shrimp overwintering in the bay were taken January 15 at a mean of 80 mm and remained through June 15 with a growth rate of 0.6 mm per day, leaving below 170 mm.

There was evidence of two waves of shrimp. The first appeared June 15 at a mean of 38 mm and showed a growth rate of 0.8 mm per day. The second appeared August 15 at a mean of 38 mm. Most shrimp in these waves left below 128 mm.

Aransas Bay - The overwintering population showed up February 15 at 65 mm and remained through June 15 with a growth rate of 0.8 mm per day, leaving below 163 mm.

There were possibly three waves of juveniles with only the first being well defined. The first appeared June 15 at a mean of 13 mm and remained through August with a growth rate of 1.2 mm per day. The second appeared September 1 at 43 mm, and the third on October 15 at 40 mm. Most of the shrimp from these waves left below 123 mm.

Corpus Christi Bay - Samples of January 1 produced two modal groups. The largest with a mean of 88 mm represents the overwintering population from November 1960. The other group had a mean size of 35 mm and presumably was from a late November or early December spawn. These shrimp remained through April 15, leaving below 148 mm.

Later in the year there were indications of four waves of young shrimp. The first wave showed up July 1 at a mean of 43 mm with a growth rate of 1.3 mm per day. The second appeared August 15 and remained through October 1 with a growth rate of 0.8 mm per day. The third group appeared October 15 at a mean of 45 mm, and the fourth on November 1 at a mean of 45 mm.

Upper Laguna Madre - Scattered specimens were taken in March, April and October. Too few were taken to graph.

Lower Laguna Madre - More or less continual recruitment occurred from June 15 through November. The smallest shrimp appeared in the samples of June 15 at a mean of 33 mm, October 1 at a mean of 25 mm, and November 15 at a mean of 28 mm. All left below 93 mm.
Too few were taken to graph effectively.

Data from the 20-foot trawl samples and that gathered at night are comparatively inconclusive. It will be more effective to reserve this information until more extensive sampling can be accomplished in 1962.

Bay Comparison

All bay systems were characterized by the presence of waves of juvenile browns entering nursery areas in spring and summer and by whites entering in summary and fall. In those areas from San Antonio Bay north the waves of brown shrimp were rather clearly defined, Aransas Bay was less so, and Corpus Christi Bay and the Lower Laguna Madre demonstrated obscure groupings and continual recruitment.

Figure 14 graphically represents brown shrimp in Galveston and Corpus Christi Bays. The modes are presented from 1960 through 1961 for clarity. The definite waves of shrimp in Galveston Bay can be compared with the ill-defined ones characteristic of Corpus Christi and other southern bays.

It can be noted that most brown shrimp leave Galveston Bay by the end of November. In Corpus Christi Bay browns of a sizable mode spread remain from October through the winter into at least April and begin leaving on the advent of juveniles from the Gulf.

An obvious reason for these differences lies in the higher temperature and higher salinity in the southern bay waters, as well as in the warmer inshore Gulf waters to the south. Figure 15 shows these differences, marked for salinity.

Brown shrimp were most abundant in Galveston Bay and in the Lower Laguna Madre.

White shrimp overwintered in all bays, showing a continued growth rate, and in many bays were large enough and numerous enough to supply a fair harvest of large shrimp in early spring. They were most abundant in the systems north of Aransas Bay.

1960-1961 Comparison

Growth rates for both species were comparable and it was found again that brown shrimp left the bays at a smaller size than white shrimp.

There was poor shrimp production in both the bay sampling and in the Gulf commercial catch in 1961. Total bay production of browns was about 16 percent of the previous year in May and 50 percent in June. Total Gulf

landings showed a decrease to 50 percent in July and August.

Total bay production of whites was 20 percent of the previous year in June and about 16 percent in July. Total Gulf landings showed a decrease to 50 percent in August and 20 percent in September.

Figures 16 through 18 show comparison of the two years for the bay and Gulf production of both species. The bay abundance graphs were plotted in the following manner. For the first of each month average samples from all bays were totaled and divided by the number of samples; the same was done for the fifteenth of each month. The first and fifteenth figures were then totaled, but not divided to average, and graphed.

The Gulf production graphs were plotted from the U.S. Market News Report using the section on Shrimp Landings by Species--Gulf States for the Texas area. Each plot is a total from nine ports and does not show catch per unit of effort.

Figure 19 covers Gulf production as catch per unit of effort and these graphs are more comparable to the bay graphs which are in averaged trawl samples, again unit of effort. Unfortunately, the information from which these graphs are taken is only available three to five months after the landings are recorded.

These graphs were plotted from the U.S. Fish and Wildlife Service reports on Gulf Coast Shrimp Catch by Area and Depth, Catch by Variety for the Texas coast, areas 18, 19, 20, and 21. For any month the reported catch in pounds of browns was totaled for the four areas, excluding bay reports such as area 18.5, divided by the total number of days fished and graphed as pounds per one day fishing effort. Only Area 18 was plotted for whites.

The top graph on Figure 19 shows a 1960-1961 comparison of the Texas landings for brown shrimp. In July 1961 the catch was down about 66 percent from the previous year.

The middle graph is a plot of landings from each area in 1961. Roughly, area 18 consists of the Gulf waters off Galveston Bay; area 19, the waters off Matagorda and San Antonio Bays; area 20, the waters off Aransas and Corpus Christi Bays; and area 21, the waters off the Lower Laguna Madre.

This graph points up the seasonal differences in abundance as reported from these areas. Although the abundance peak in July and August is reflected in all areas, an interesting variation is apparent between the first and last of the year. Areas 18 and 19 in the north were the leading producers in January and February, declining through June, whereas the southern areas 20 and 21 became increasingly important from October through December. This seems to reflect both the southward movement of Gulf browns throughout the year and the presence of an overwintering stock of browns in the southern bays.

The bottom graph on Figure 19 shows a 1960-1961 comparison of area 18 landings for white shrimp. The catch in March and April was perhaps one-half the previous year's. It could be expected that if information were available beyond July 1961, a decline would also be apparent. Area 18 was chosen instead of a total of all bays for graphing because this area leads in white shrimp production.

Three possible bay environmental factors responsible for the shrimp decline in 1961 are graphed in Figure 20. Space prohibits publication of hydrographic data from all bays and that from Galveston Bay was used. The 1960-1961 differences were comparable in other bays.

The top graph plots water temperature. A sharp drop in temperature occurred in April in the tertiary habitat. This drop was reflected also in the secondary and primary areas (not graphed). This drop to about 17°C occurred at the time when most post-larval browns were entering the bay. It should be stated that apparently temperatures above and below a rather arbitrary 20°-23°C gradient have some effect on small bay shrimp, possibly governing their entry and initiating their departure.

The middle graph plots salinity. The salinity from March through June, the season for entry and abundance of juvenile browns, was lower in 1961 than in 1960. The salinity in August and September, the season for abundance of juvenile whites, was higher in 1961 than in the previous year.

The bottom graph was plotted from available data on runoff in acre feet of six rivers in the coastal watershed, the Sabine, the Brazos, the Colorado, the Navidad, the San Antonio, and the Nueces. This was compiled from the Surface Water Runoff Reports of the Water Resources Division of the U. S. Department of the Interior. It shows the heavier runoff in 1961 with a drop in August; not, however, to the August level of 1960.

All of this bay environmental information relates to a decline of brown shrimp; however, only the salinity rise in August is in any way pertinent to the decline of whites. Although circumstances in the bays undoubtedly compounded the situation, they are by no means the full answer.

Some seasonal environment difference in the Gulf in 1961, presumably in the more unstable inshore waters, was the main cause of the shrimp decline. This is evidenced by two things. First, a 1961 decline in the commercial catch did not occur only in Texas waters; it occurred along the entire Gulf coast from Campeche to Florida. Second, without encroaching upon the biological findings of another agency, it can be said briefly that the U. S. Fish and Wildlife Service found a sharp drop in abundance of very small postlarval browns at the mouth of the pass into Galveston Bay in 1961 as compared with 1960. This was reported to the special committee on shrimp research in the Gulf at Galveston on December 13, 1961.

Thus, it is probable that during certain crucial periods larval shrimp were unable to make a safe entry to the bay nursery areas. This is obvious in the case of the browns; whether the same circumstances occurred later in the summer and affected entry of the whites is uncertain. Information and research are needed on the inshore Gulf waters, especially in the vicinity of passes, in the matter of currents, both Gulf and tidal, temperature and salinity to complement bay information.

Summary: There was evidence in most bays of at least three waves of both brown and white shrimp. These waves were definite in the north, less so in southern bay systems. Brown shrimp were most abundant in early summer, whites most abundant in late summer. Growth rate for young browns might be averaged at 0.9 mm per day; whites at 1.0 mm per day.

Some whites overwintered in all bays, reaching sizes up to 188 mm. Browns left usually before reaching 105 mm in length. Browns overwintered to some extent in the southern bay systems.

Juvenile browns were first taken in large numbers in the May 1 sample; juvenile whites appeared in June.

Closure of certain nursery areas to all trawling at all times probably would increase the overall harvest since shrimp do not reach a size for optimum harvest in most of the shallow tributary bays and marginal areas.

The present bay shrimp season opening of August 15, protects undercount browns as they are gone by this time; however, in some areas many undersized whites are present until September 1. There seems to be no conservation reason why the season, which closes at present on December 15, should not remain open through March 15, in some areas to allow harvest of large whites in the spring.

A 1961 drop in bay abundance of from 50 percent to 85 percent in both species was reflected later in the Gulf commercial catch. Seasonal environmental changes in both the bays and the inshore Gulf were probably responsible for this decline, Gulf factors being the most important.

Recommendations for Sampling

1. The program should continue one more year exactly as done in 1960-1961.

2. The 20-foot trawl should be used semi-monthly in an area of commercial harvest for a period of one hour.

3. Night sampling should be attempted at those periods when shrimp are plentiful in the day.

4. Postlarval shrimp sampling should be instigated adjacent to the Port Aransas Channel on the bay side.

5. Effort should be made to obtain accurate and continual information on current, salinity, and temperature in Port Aransas Channel and the immediate inshore Gulf.

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Coordinator

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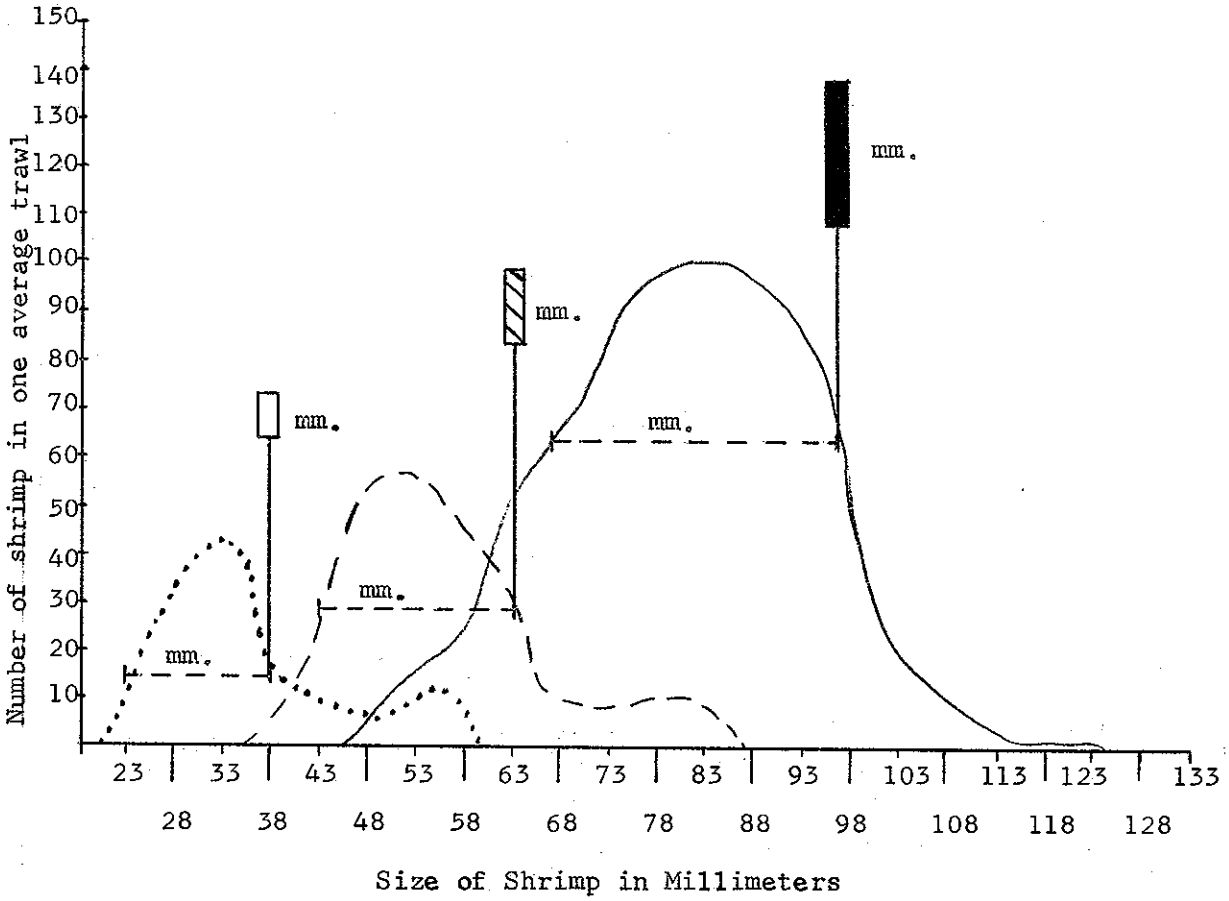
Figure 1

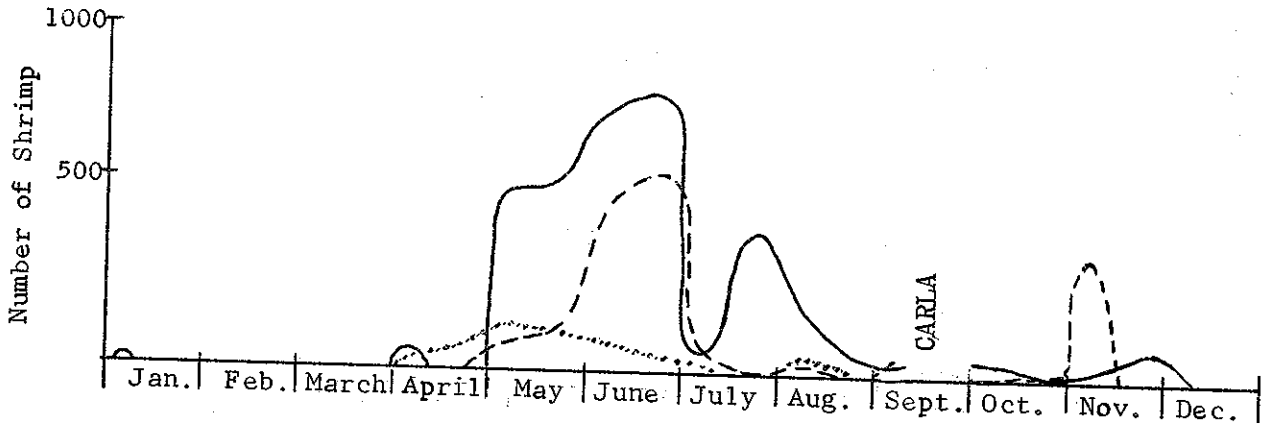
Sample Total Length Frequency Graph for Three Area Types
Brown Shrimp, By Bay, July 1, 1961



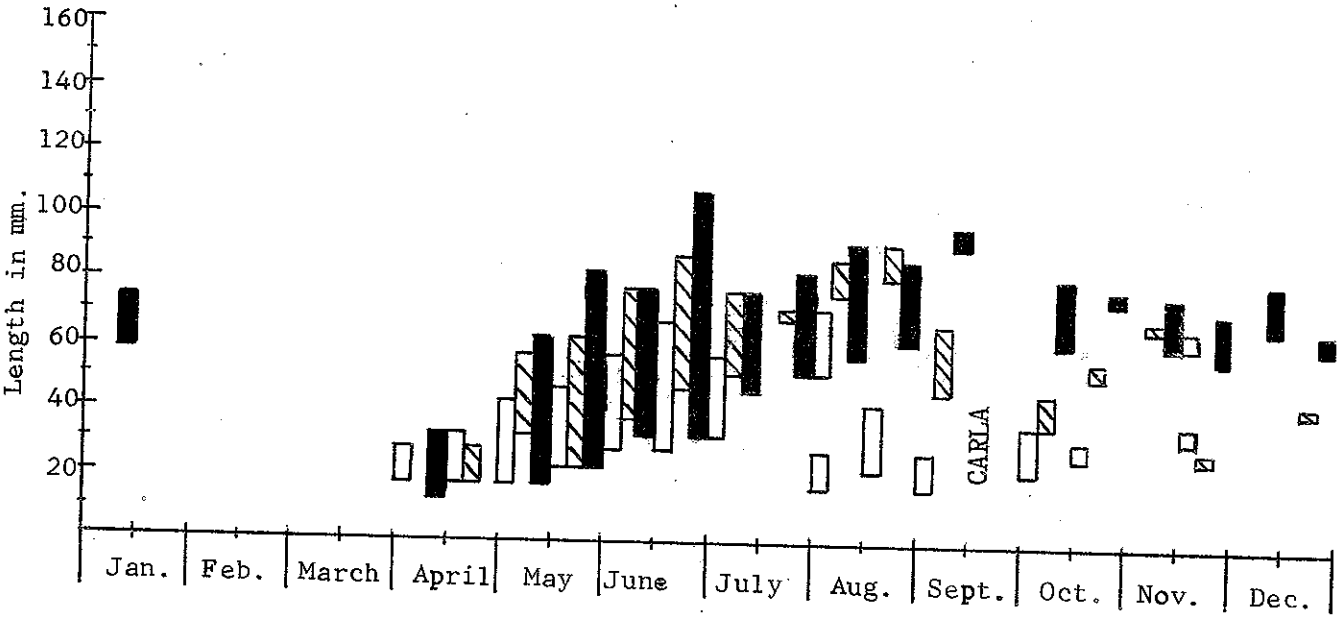
On the following mode and abundance graphs, the below legend is used for interpretation.

Mode Graphs	Abundance Graphs
Primary Bay Area	——— Primary Bay Area
Secondary Bay Area	– – – Secondary Bay Area
Tertiary Bay Area	····· Tertiary Bay Area

Figure 2
Galveston Bay - Brown Shrimp Population



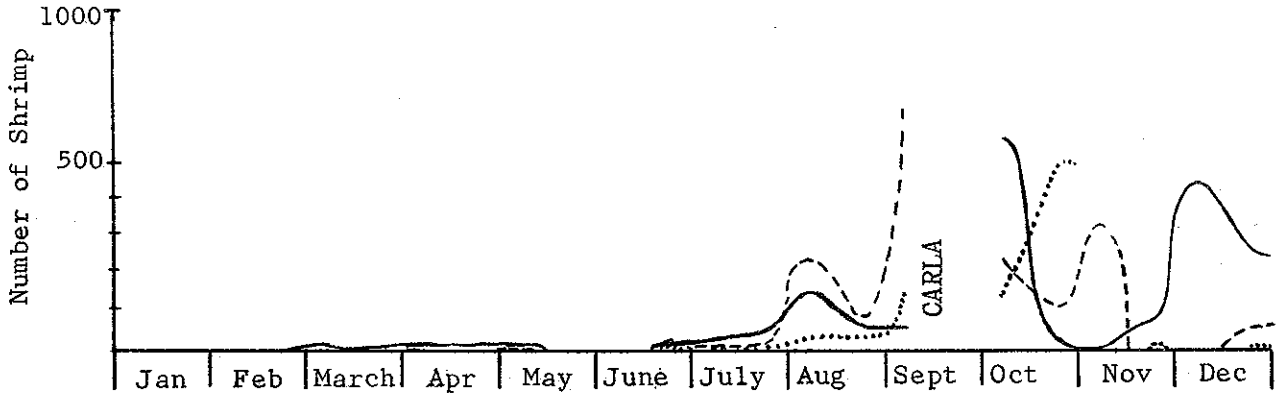
Average Number Per Sample by Month



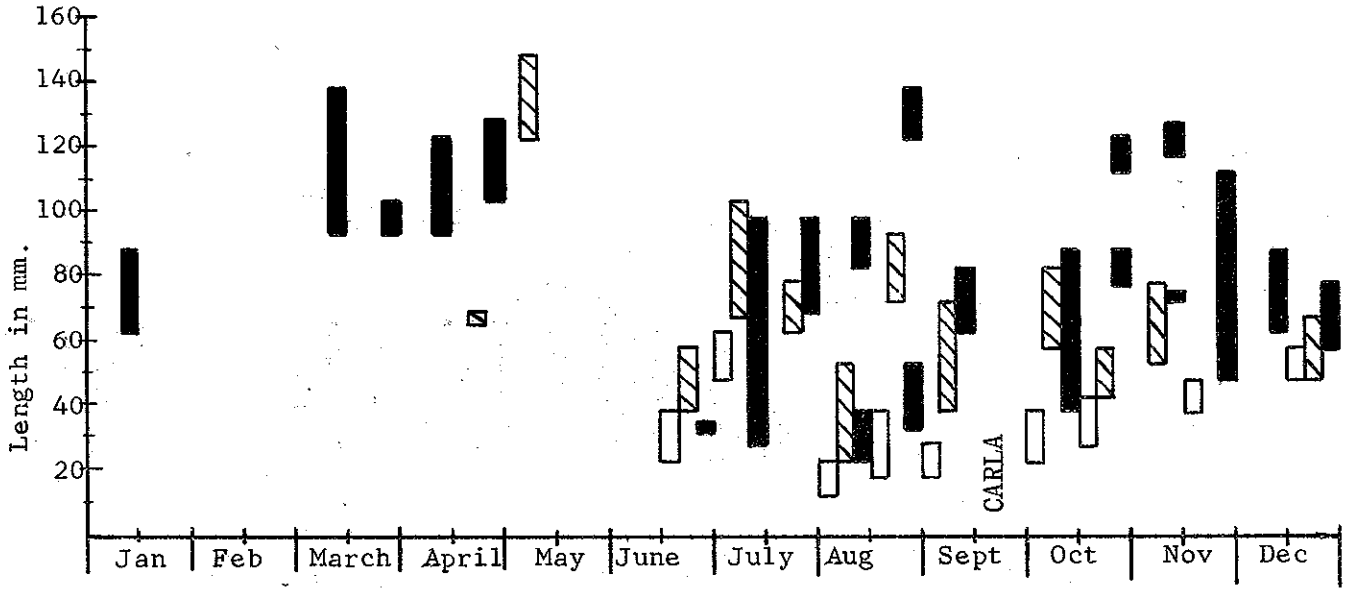
Population Mode by Month

83

Figure 3
Galveston Bay - White Shrimp Population

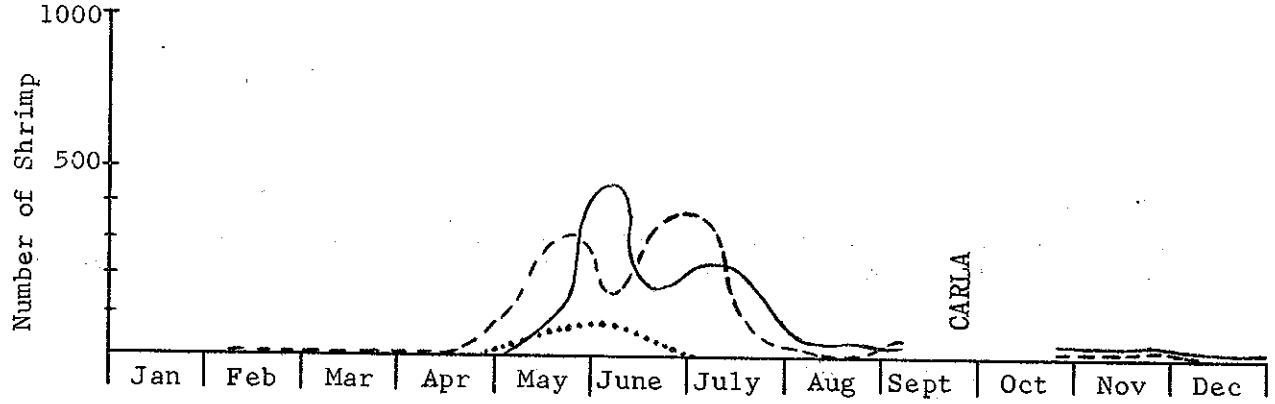


Average Number Per Sample by Month

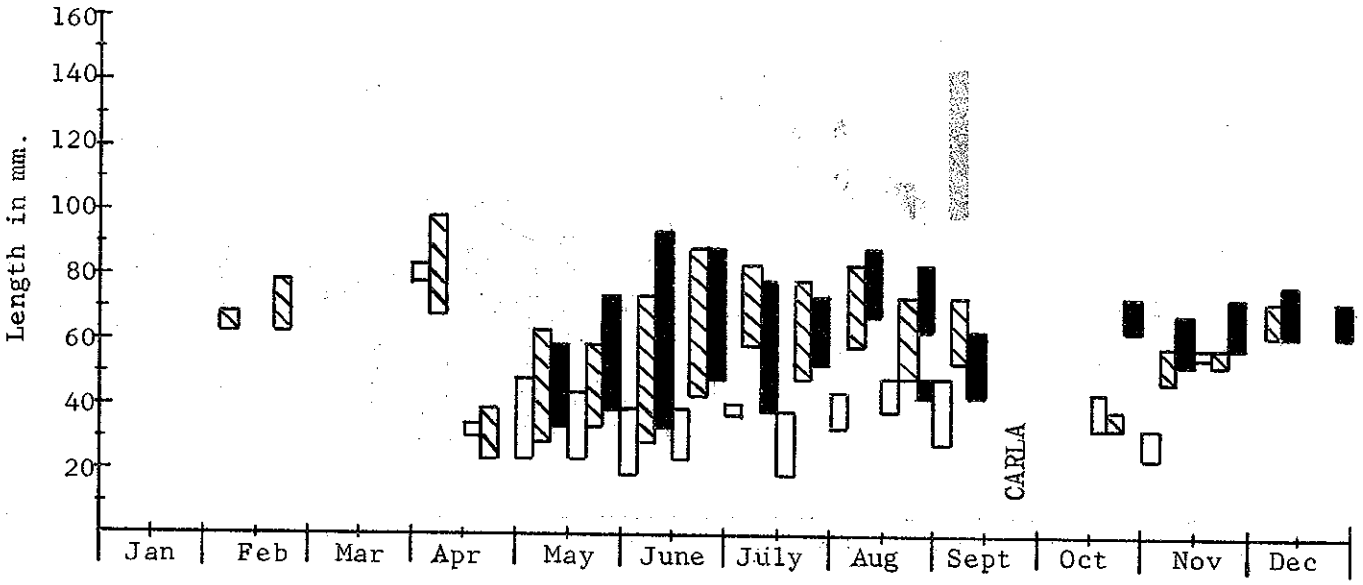


Population Mode by Month

Figure 4
Matagorda Bay - Brown Shrimp Population

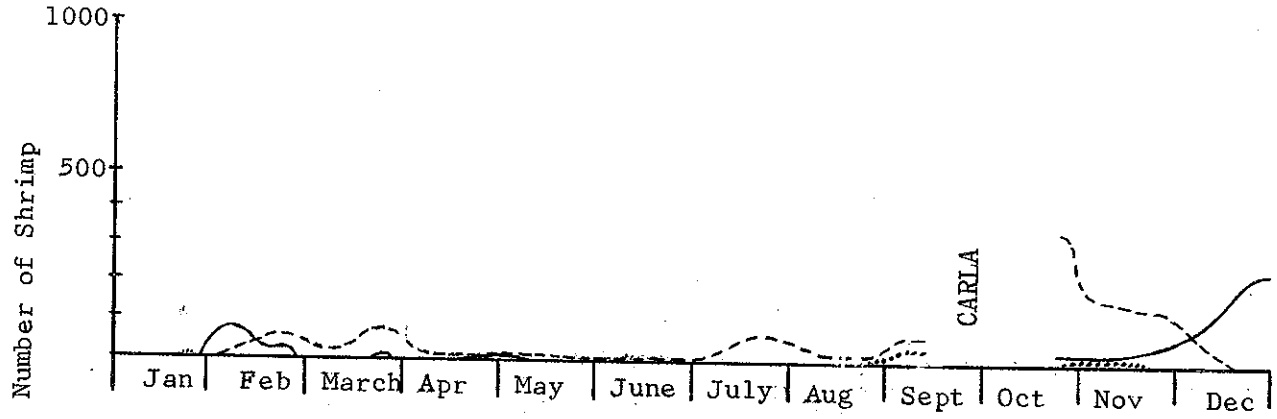


Average Number per Sample by Month

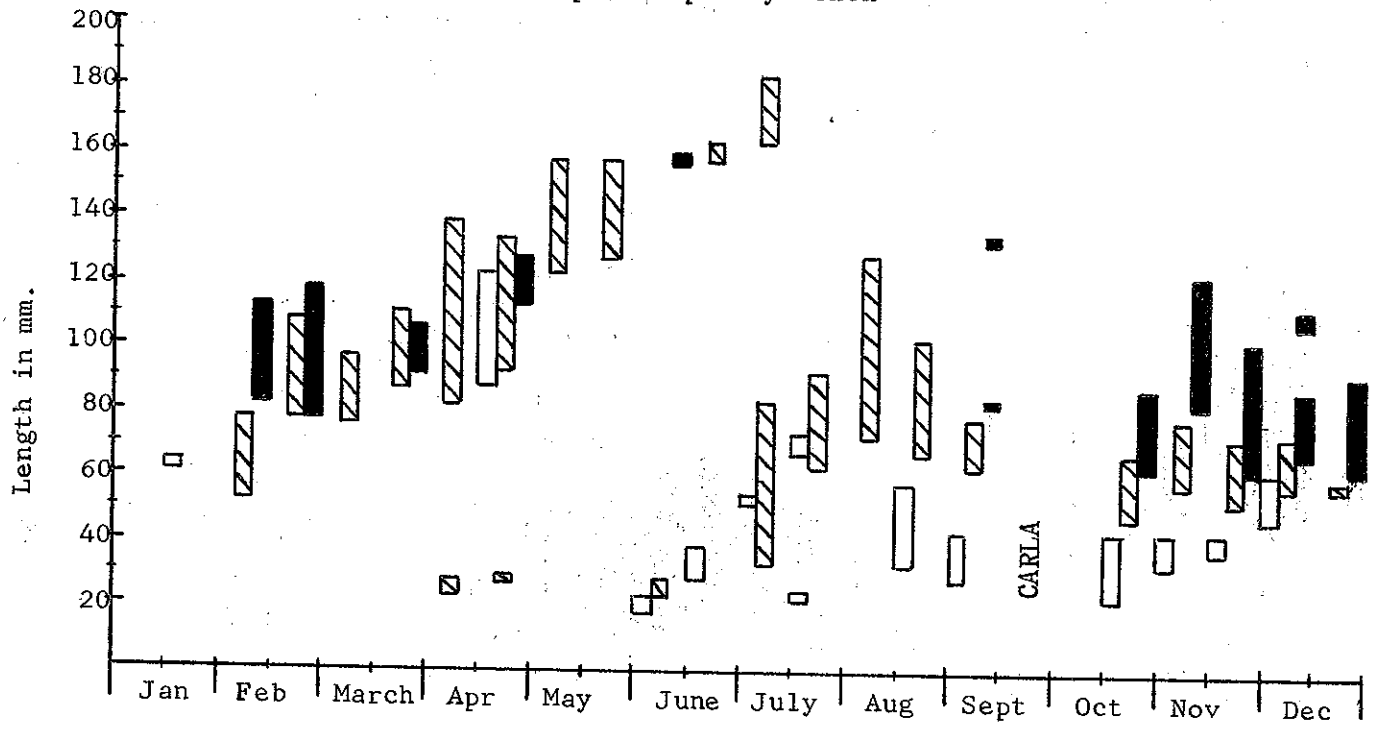


Population Mode by Month

Figure 5
Matagorda Bay - White Shrimp Population

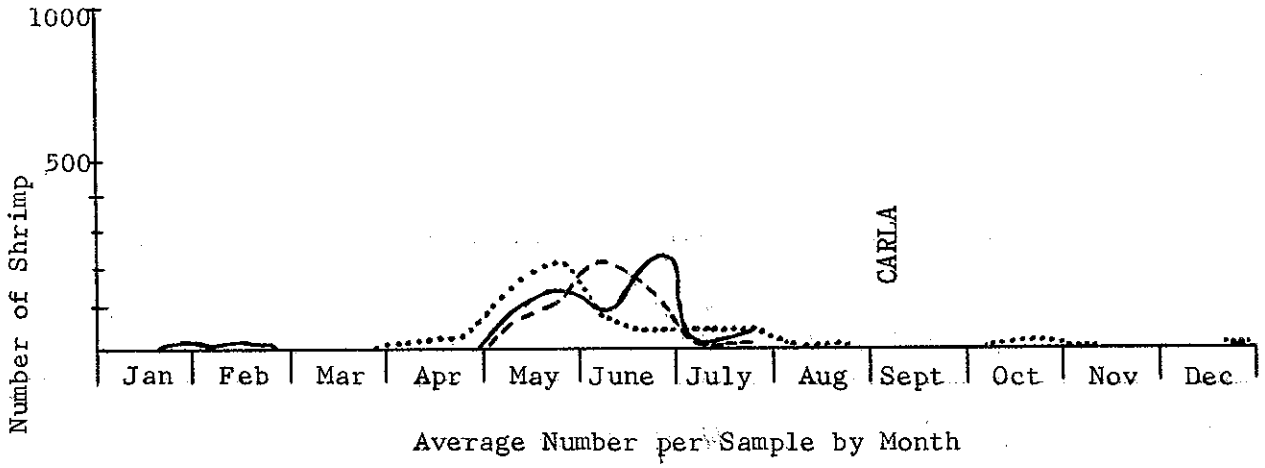


Average Number per Sample by Month

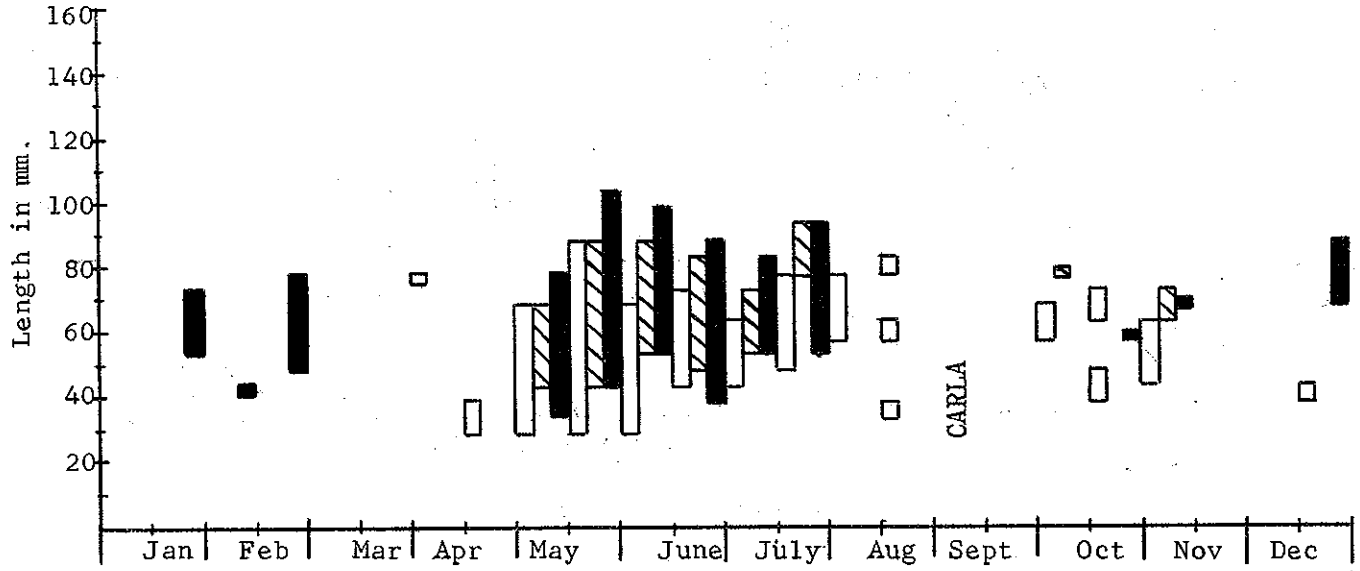


Population Mode by Month

Figure 6
San Antonio Bay - Brown Shrimp Population



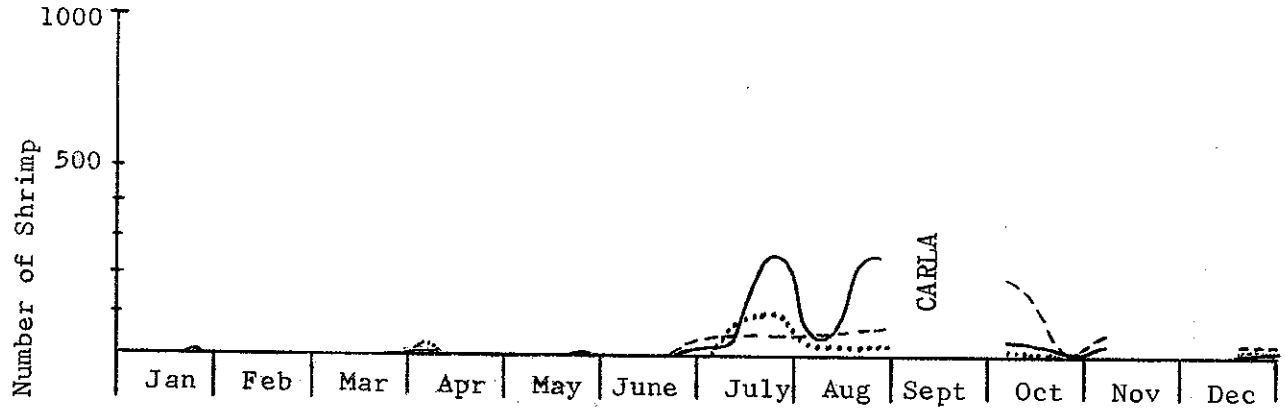
Average Number per Sample by Month



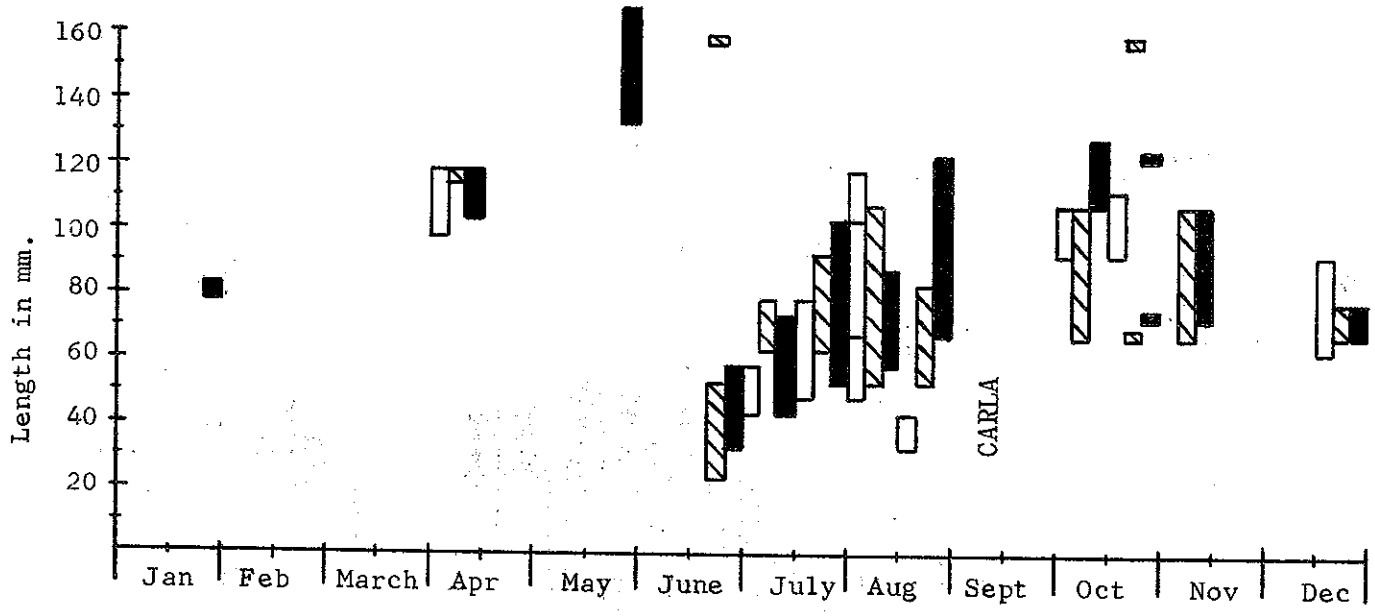
Population Mode by Month

87

Figure 7
San Antonio Bay - White Shrimp Population

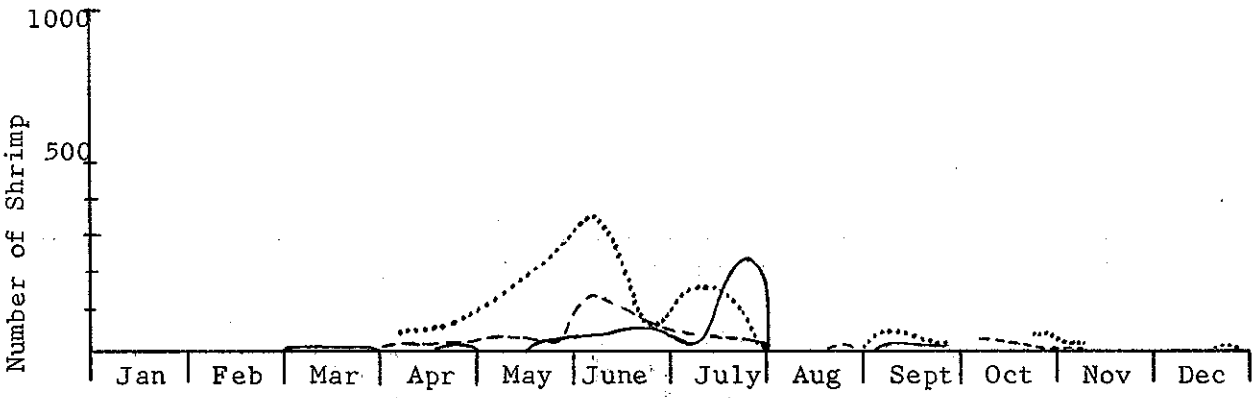


Average Number per Sample by Month

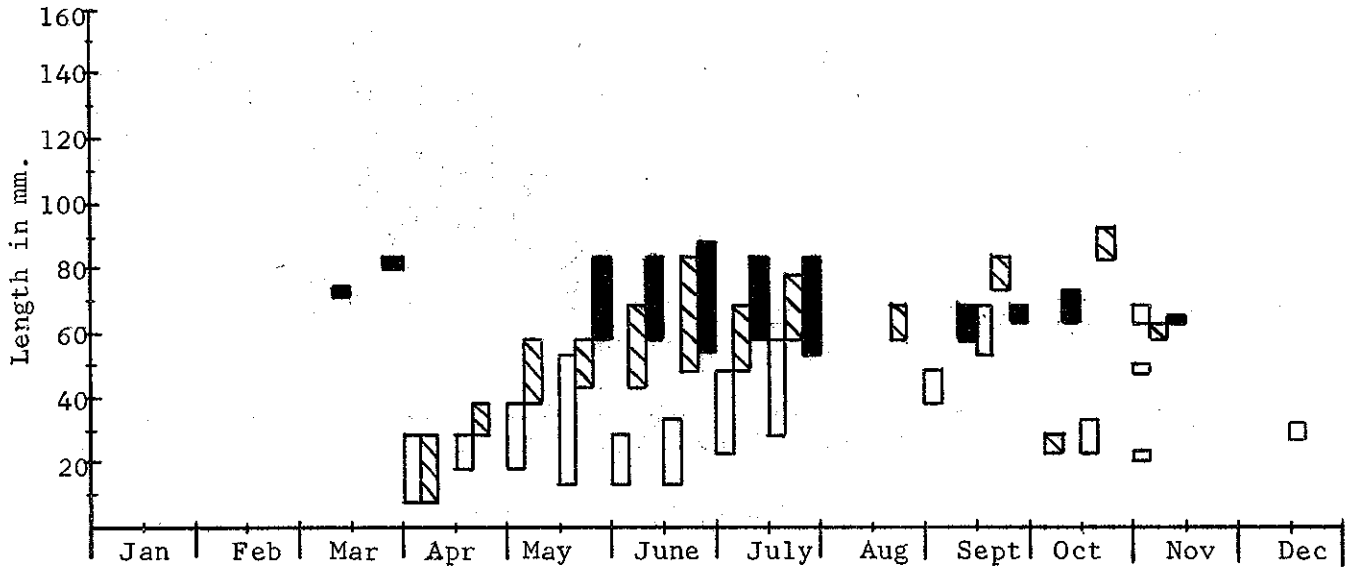


Population Mode by Month

Figure 8
Aransas Bay - Brown Shrimp Population



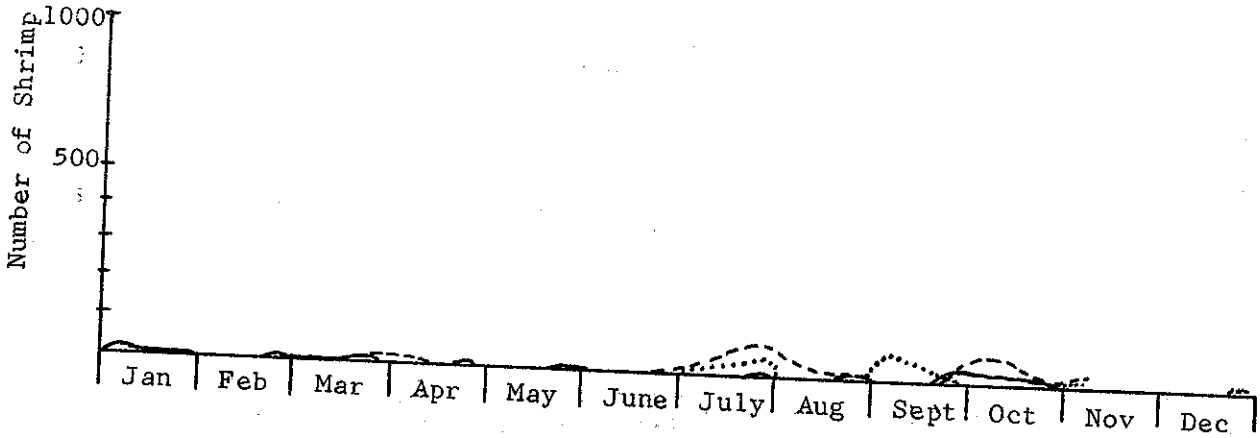
Average Number per Sample by Month



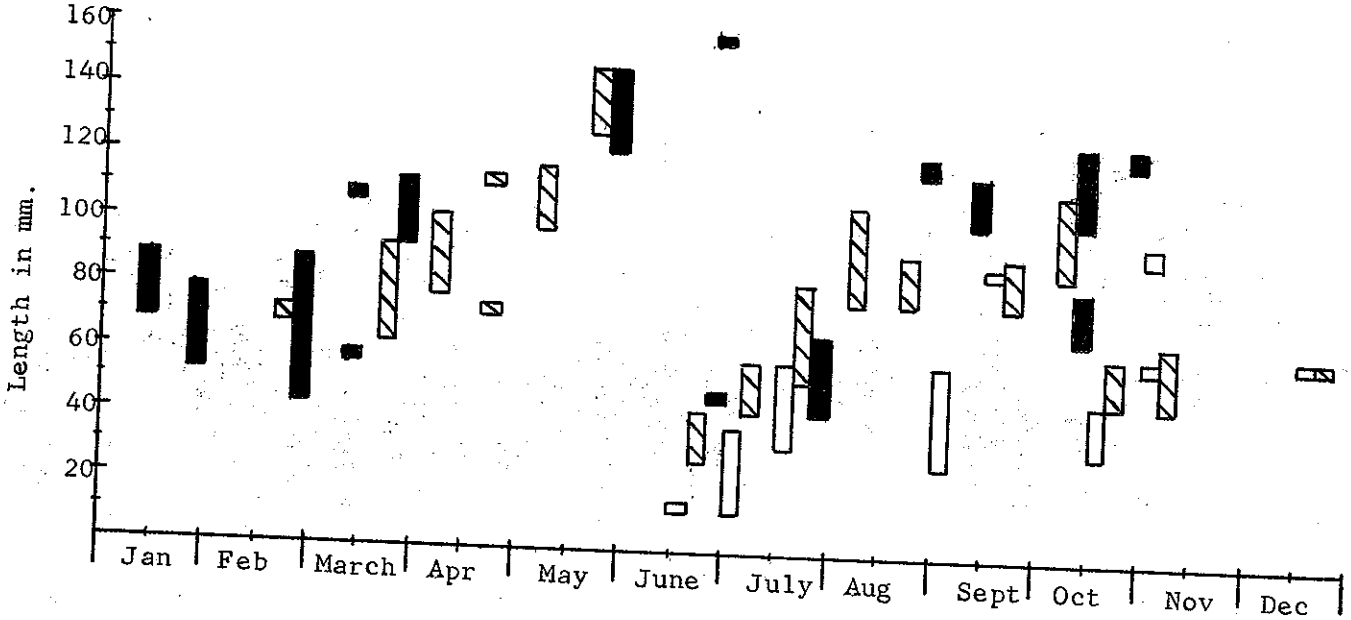
Population Mode by Month

89

Figure 9
Aransas Bay - White Shrimp Population

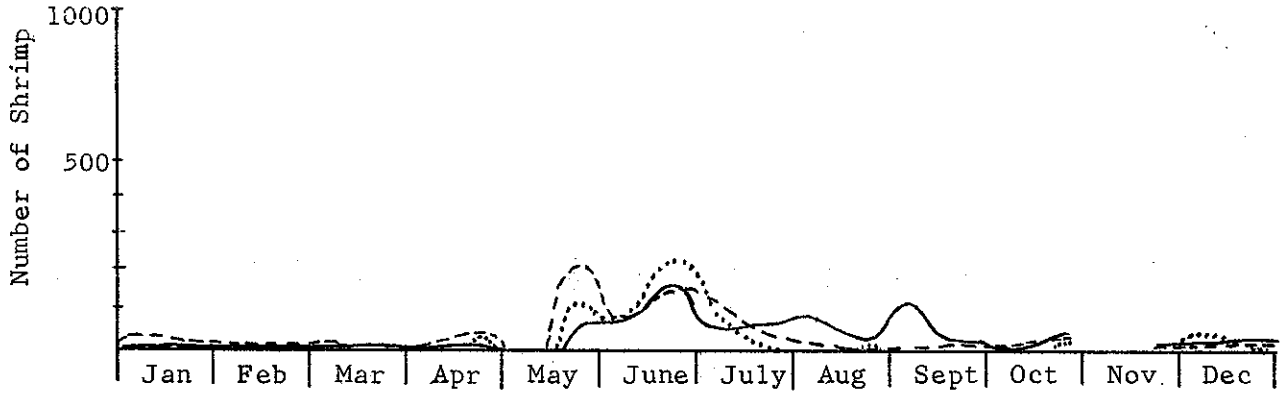


Average Number per Sample by Month

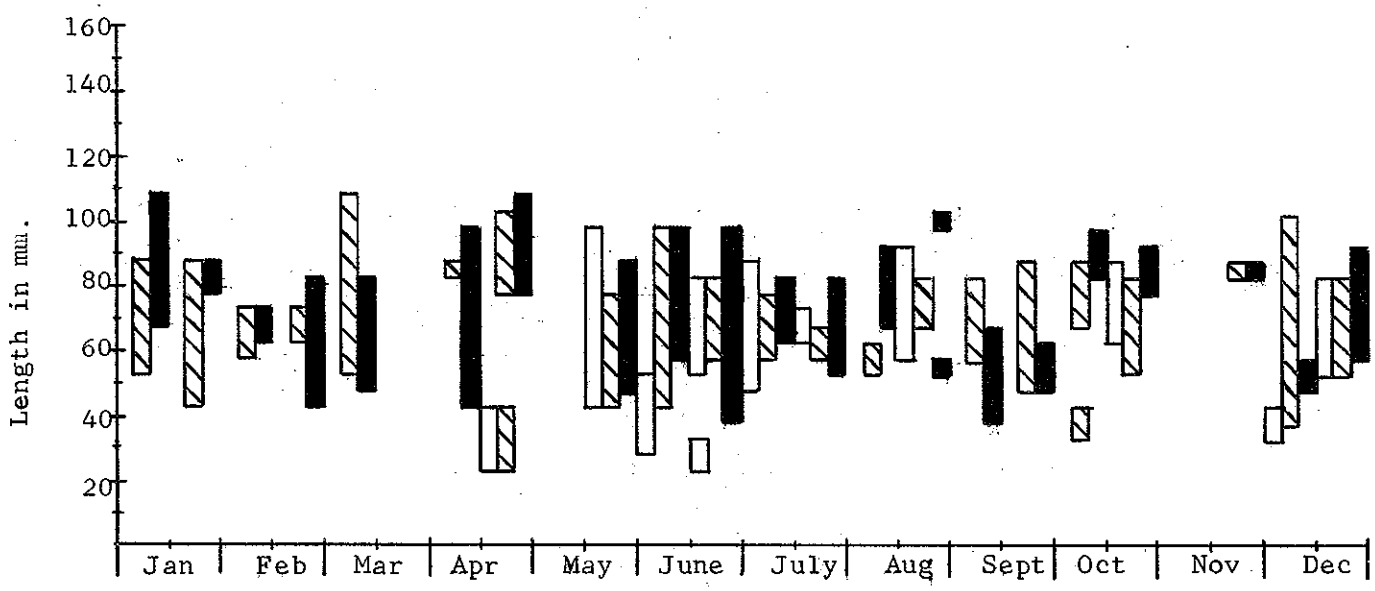


Population Mode by Month

Figure 10
Corpus Christi Bay - Brown Shrimp Population



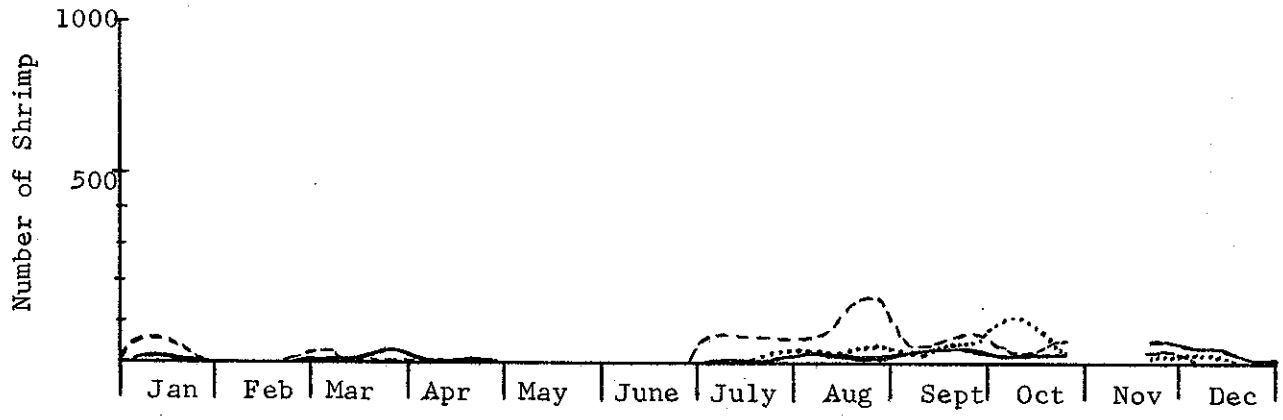
Average Number per Sample by Month



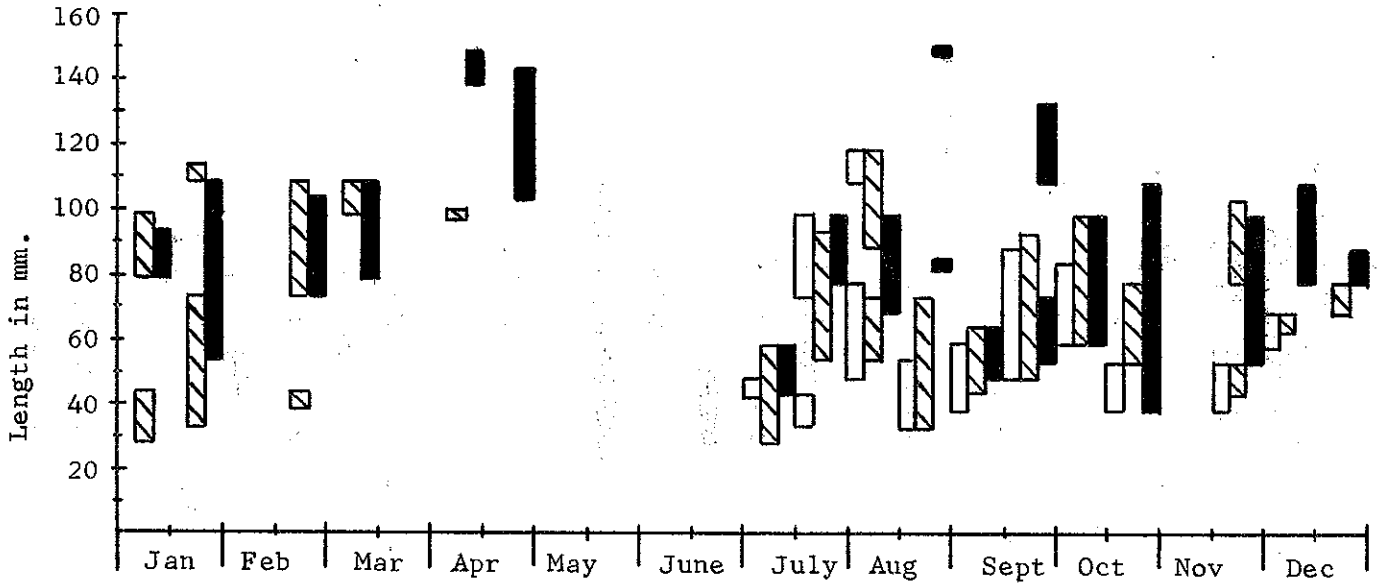
Population Mode by Month

91

Figure 11
Corpus Christi Bay - White Shrimp Population

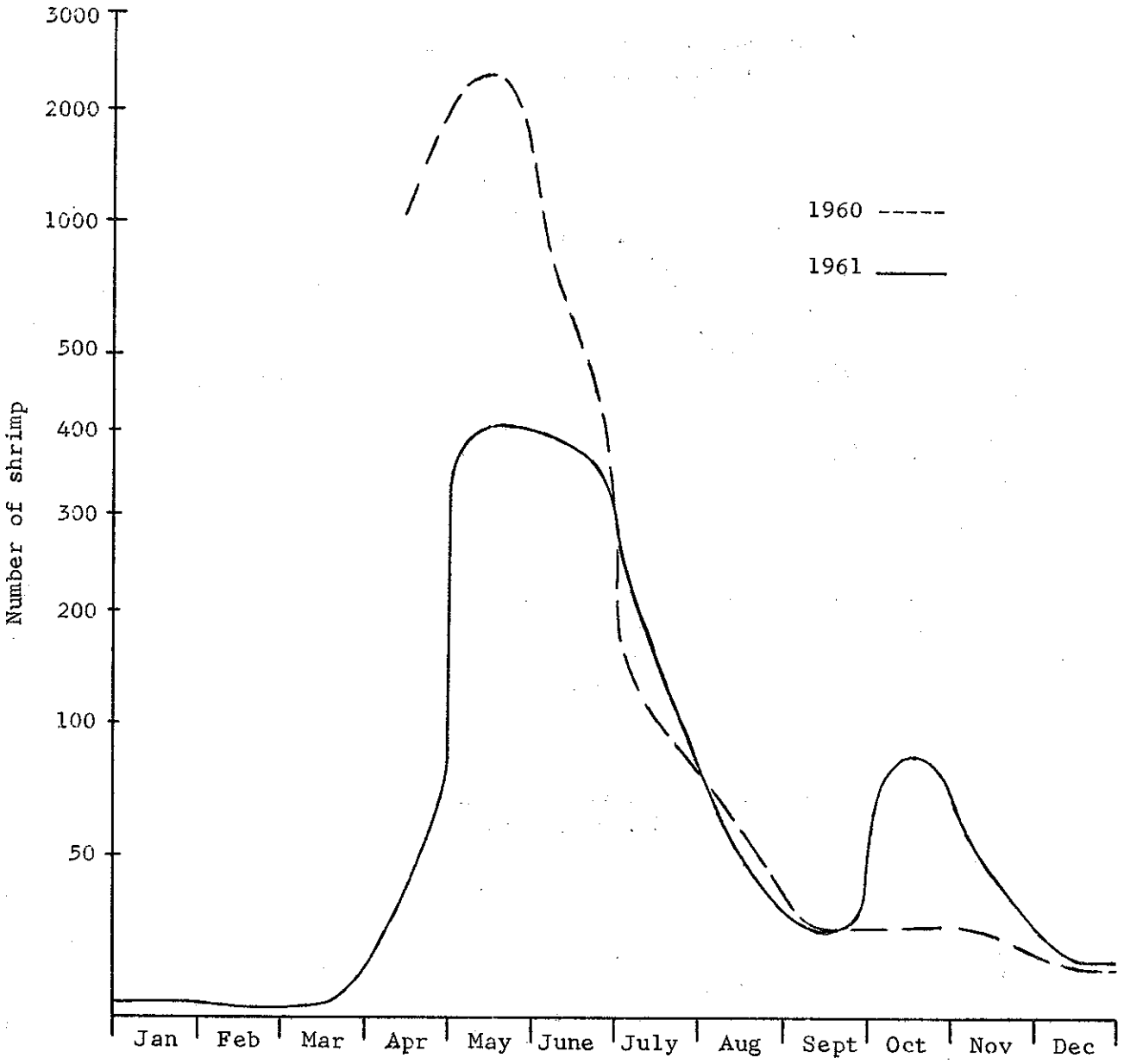


Average Number per Sample by Month



Population Mode by Month

Figure 16
Texas Bay Production
Brown Shrimp Abundance



Average Number per Sample by Month

Figure 17
Texas Gulf Production
Brown Shrimp Landings

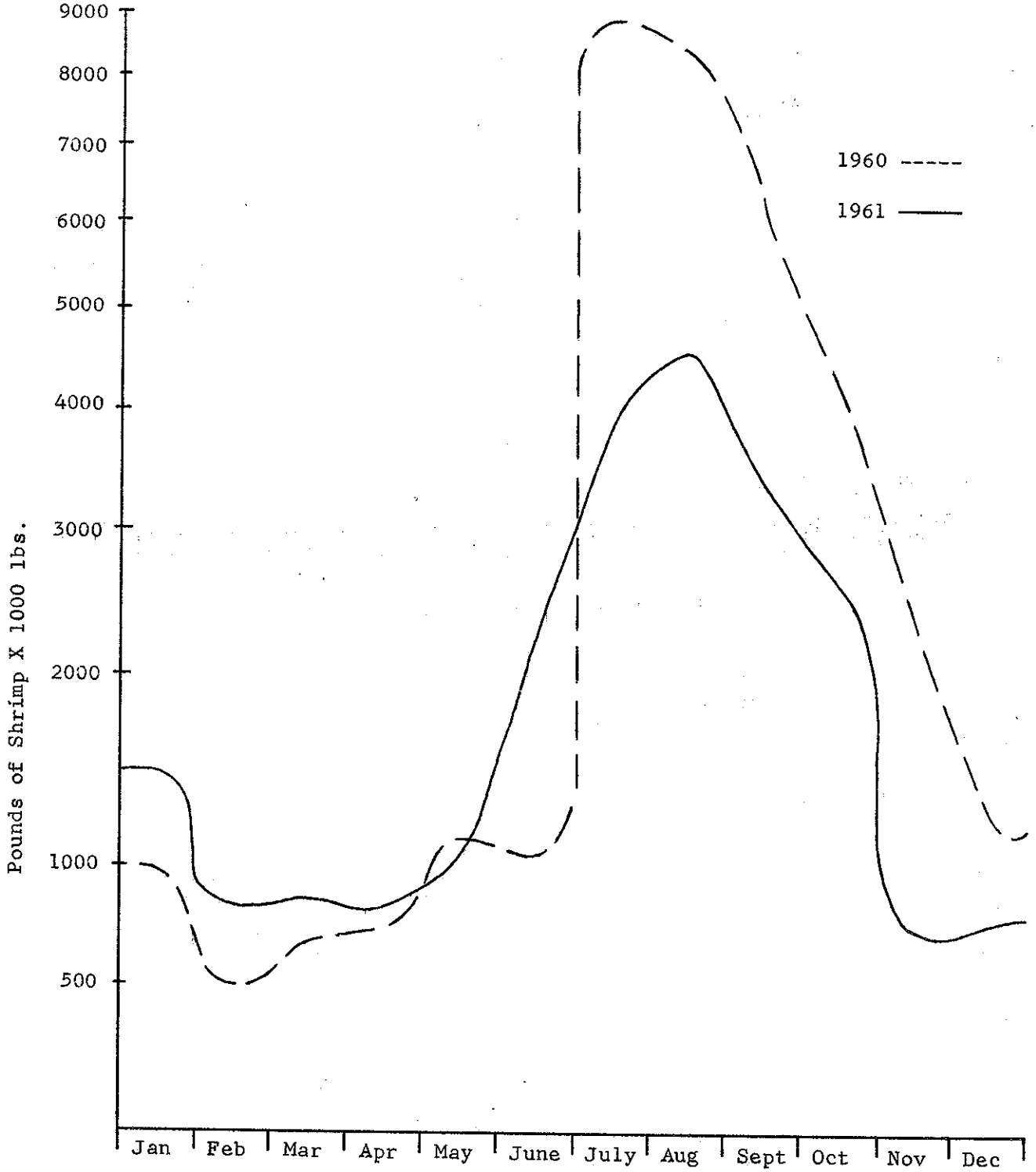
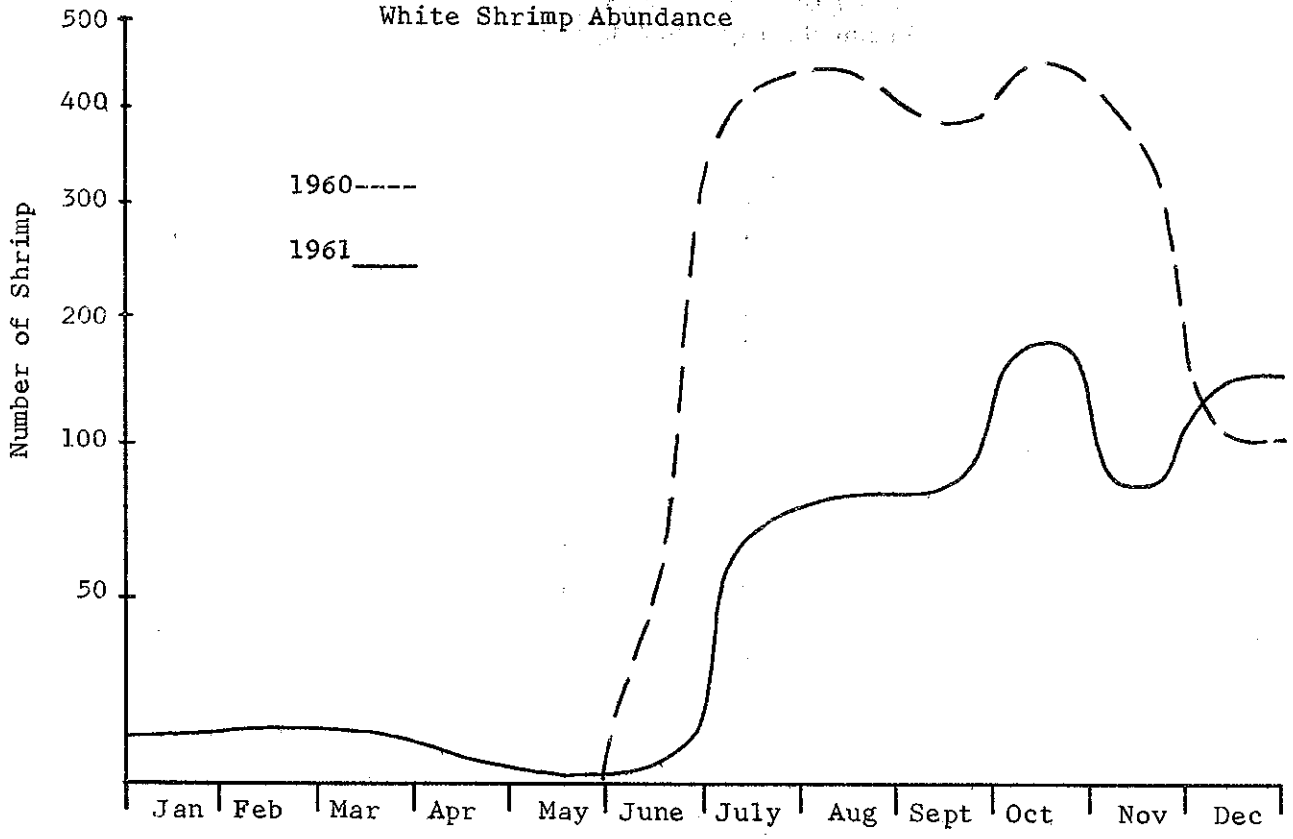
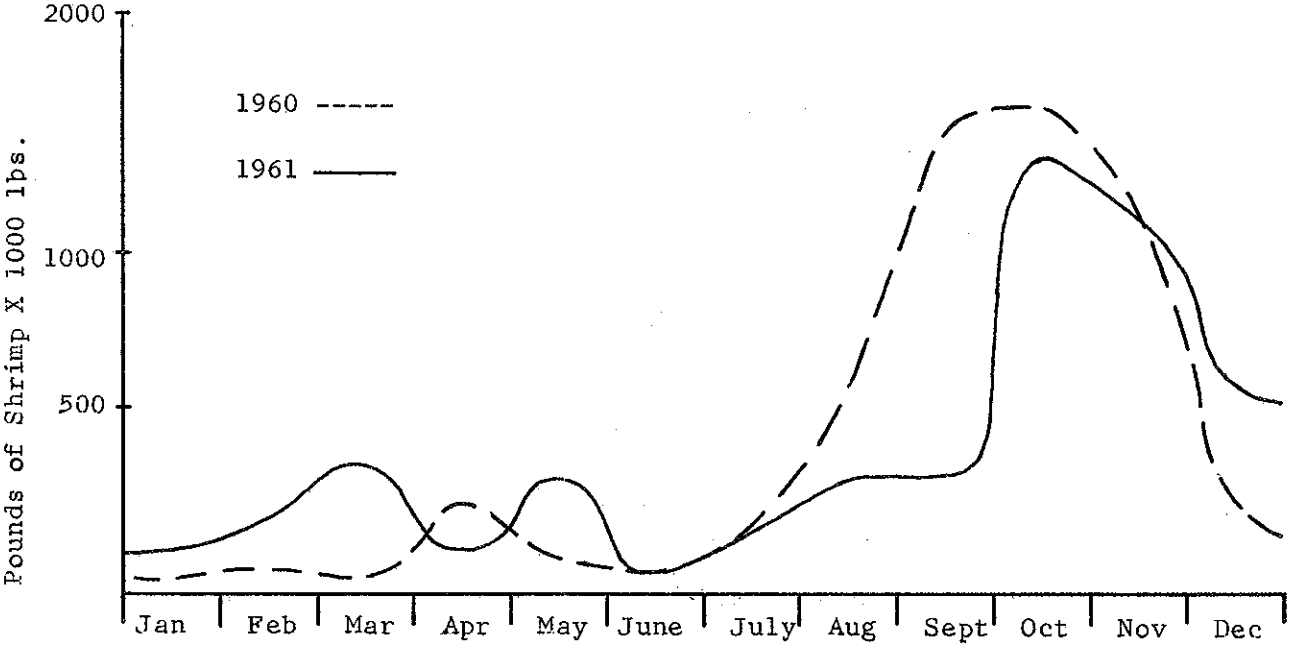


Figure 18
Texas Bay Production
White Shrimp Abundance



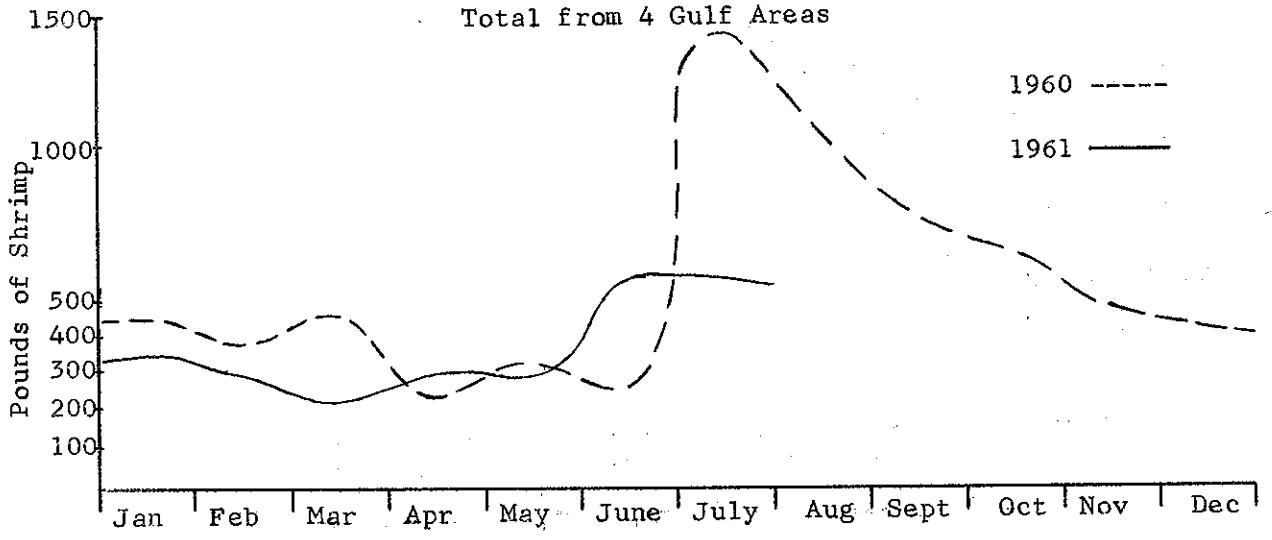
Average Number per Sample by Month

Texas Gulf Production
White Shrimp Landings



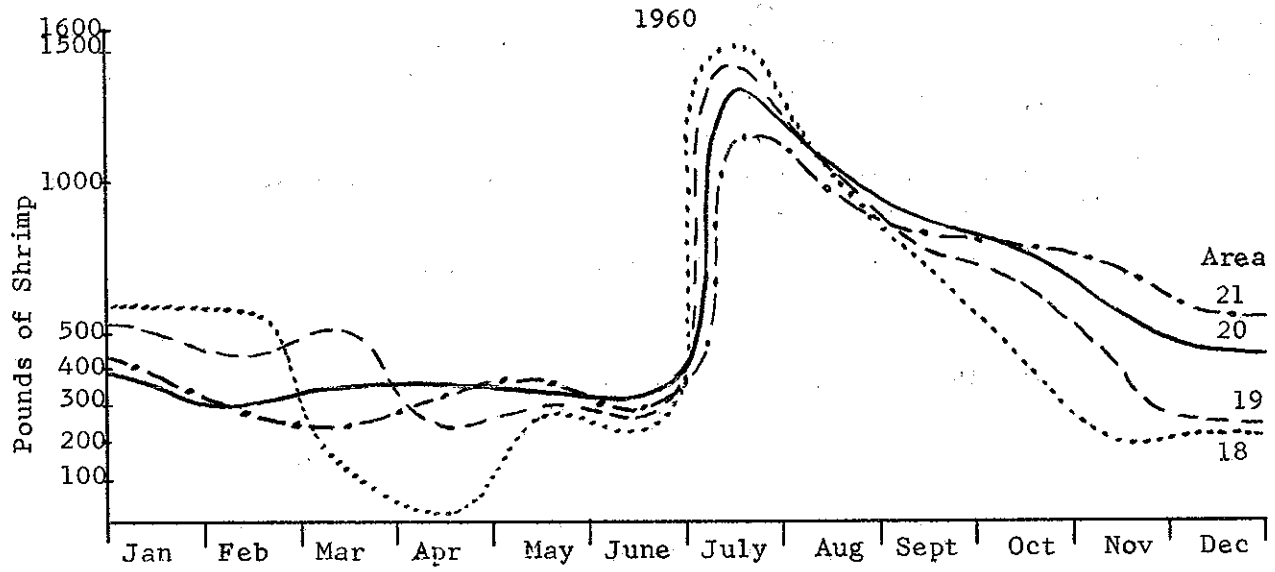
Poundage by Month

Figure 19
Texas Coast Brown Shrimp Landings
Total from 4 Gulf Areas

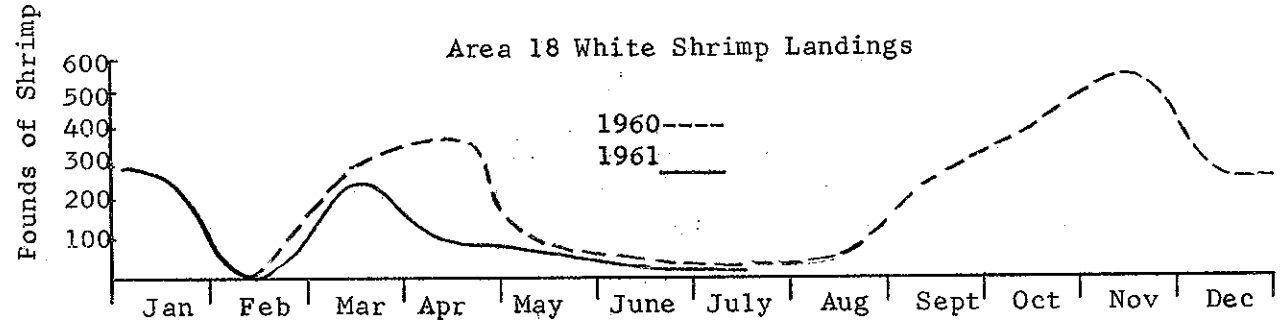


Pounds of Shrimp per Day Fishing Effort by Month

Texas Coast Brown Shrimp Landings by Area
1960



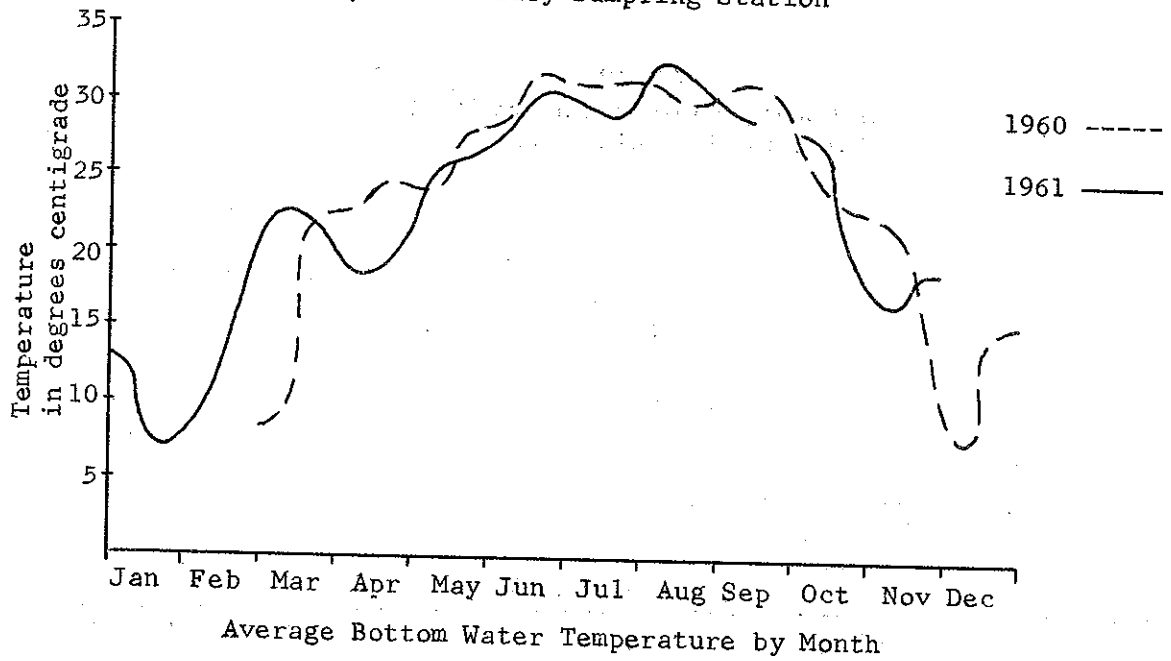
Pounds of Shrimp per Day Fishing Effort by Month



Pounds of Shrimp per Day Fishing Effort by Month

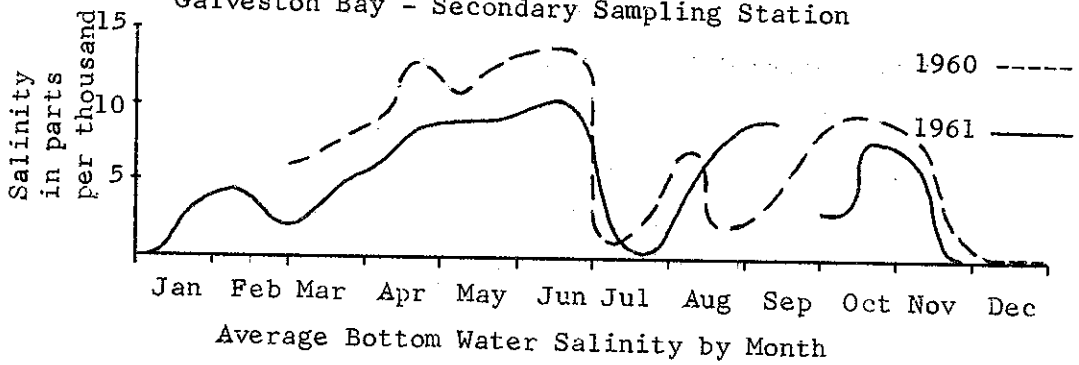
Figure 20

Galveston Bay - Secondary Sampling Station



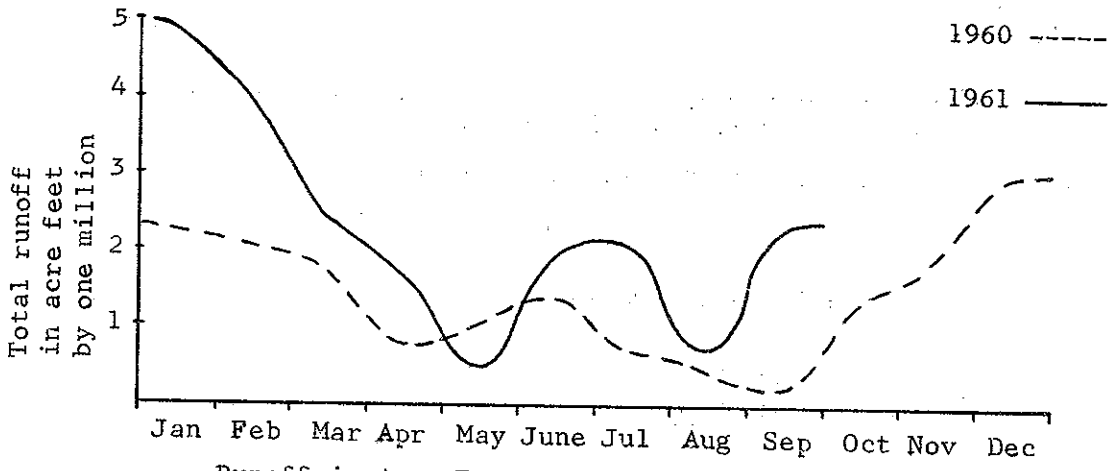
Average Bottom Water Temperature by Month

Galveston Bay - Secondary Sampling Station



Average Bottom Water Salinity by Month

Combined Runoff for Six Rivers



Runoff in Acre Feet by Month

101