

A Survey of Shrimp Populations in the Inshore Gulf of Mexico off Texas

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Abstract

In 1965 shrimp and associated bottom organisms were sampled for type, abundance, size groups, and seasonal availability with a 23-25-foot flat otter trawl in the Gulf of Mexico off Port Aransas, Port Mansfield, Port Isabel, and briefly off Galveston, Texas. In regular weekly samples, commercial shrimp of four species, non-commercial shrimp of seven species, two species of squid, and various associated animals were caught in 100 trawl samples. Brown shrimp, Penaeus aztecus, were the most abundant of the commercial species, followed by white shrimp, Penaeus setiferus, and pink shrimp, Penaeus duorarum. Trachypeneus similis and Squilla empusa were the most abundant non-commercial species.

This survey indicates the seasonality of Gulf shrimp populations and the cyclic growth and migration patterns in inshore waters. Periods of abundance are noted for all shrimp. Growth cycle information is given for brown, white, and pink shrimp. Any variation of catch between areas sampled is noted, and data on non-commercial species are included for a more comprehensive understanding of the ecology of the inshore Gulf of Mexico.

Introduction

The commercial shrimp fishery in the shallow Gulf of Mexico produces a high percentage of North America's most valuable fishery resource. On the Texas coast this Gulf fishery, with the bay shrimp harvest, supports the only continually thriving commercial fishery. The importance of intelligent management of Texas shrimp populations is obvious.

The object of this study was to obtain information on bottom living populations of commercially important shrimp of the family Penaeidae in selected areas of the inshore Gulf of Mexico. The size, age, composition, and trawl availability of these populations were determined. Seasonal changes in these characteristics were noted. Information on hydrographic and ecological factors which may influence commercial shrimp populations is included.

Early work in coastal waters of the Atlantic and of the Gulf of Mexico was concerned with life history and fishery investigations on the white shrimp, Penaeus setiferus. Until almost 1950, this shrimp was considered the only one of commercial value. Some results of this background work are presented by Weymouth, Lindner, and Anderson (1933), Johnson and Lindner (1934), Pearson (1939), Anderson, King, and Lindner (1949), Burkenroad (1951), and Lindner and Anderson (1956).

Broad meteorological changes in the late forties affected the hydrography of nursery areas (Hildebrand and Gunter, 1953). The advent of offshore

trawlers and better equipment and the finally realized market acceptance increased the importance of the brown shrimp, Penaeus aztecus. Discovery of unexploited grounds in the southern Gulf brought the pink shrimp, Penaeus duorarum, into the Texas market. Today brown shrimp comprise the bulk of landed commercial shrimp (Texas Landings, 1965).

Hildebrand (1954) published the authoritative work on the brown shrimp grounds in the Western Gulf of Mexico. Hildebrand (1955) presented the study of the pink shrimp grounds in the southwestern Gulf, from which area most pinks are taken which enter the Texas Gulf shrimp market. Lindner and Anderson (1954) covered briefly some biology of all three commercial shrimp in the Gulf of Mexico.

Exploratory shrimp fishing in search of concentrations of shrimp, fishable bottom, and most effective gear was undertaken by the federal government in 1950-51 (Springer and Bullis, Jr., 1952).

Important work on the trends and characteristics of Gulf shrimp populations was presented by Kutkuhn for 1956 through 1959, (Kutkuhn, 1962). The federal government compiled a survey of the United States shrimp industry from various sources to include all phases of the fishery. (U. S. Fish and Wildlife Service, 1958). Fishery research reports of the Galveston Biological Laboratory generally contain, at each publication, information on shrimp biology and fishery status gathered through statistics, field work, or laboratory projects.

The bait shrimp industry in Gulf waters was covered by Inglis and Chin (1959).

Gulf shrimp research conducted by biologists of the Texas Parks and Wildlife Department from 1960 through 1963 was presented by Compton (1959-1960 and 1960-1961) and Compton and Bradley (1961-1962 and 1963). Report on work accomplished during the calendar year 1964 is awaiting reproduction.

From January 1 through December 31, 1965, I examined trawl catches obtained in three areas of the inshore Gulf of Mexico to assay the commercial shrimp populations for age, seasonal abundance and distribution, and relation to the other inhabitants of their areas. Fifty-four samples were taken in depths of 3 to 16 fathoms during the year off Port Aransas, Texas, and thirty-eight samples in the same depth zone off Port Mansfield and Port Isabel, Texas. Eight samples were obtained in 3 to 8 fathoms in January off Galveston and Freeport, Texas.

Description of Area

The north area sampled was southeast of Freeport and Galveston; the main middle sampling zone was east-southeast of Port Aransas; and the southern area was east of Port Mansfield and Port Isabel. A federal publication presents general information on the Gulf of Mexico (Price, Lynch, Leipper, Marmer, Shoemaker, and Williams, 1954). Hildebrand (1954) published maps of the western Texas Gulf grounds with major fishing areas delineated for white shrimp and brown shrimp.

Hydrography of the water masses in the main middle sampling area of this project was covered by Jones, Copeland, and Hoese (1965).

Methods

A standard flat otter trawl of 2-inch stretch mesh nylon measuring 23-25 feet along the headline was used in sampling. The net was spread by 26-by-60-inch doors. The foot rope was leaded, and a tickler chain was used. The net was in all respects comparable to gear used by the commercial shrimp fleet in Texas bays and the shallow Gulf. This net was pulled for 15 minutes, timed from completion of shooting the trawl. The samples were taken from the 38-foot Texas Parks and Wildlife Department shrimper "Goby", a vessel similar to those used by commercial shrimpers along the Texas coast. Estimated speed of trawling was two knots.

All samples were made between 7 a.m. and 1 p.m. Hydrographic data were obtained at the time of sampling.

Prior to the 13th of April, water samples were taken at the bottom and at the surface using a standard Kemmerer Water Bottle, and temperature was measured in degrees centigrade. A sample of the water was retained and salinity was later determined with an American Optical Company Goldberg T/C Hand Refractometer and recorded from an appropriate table in the American Optical Company Tables of Properties of Aqueous Solutions Related to Index of Refraction. After April 13, the water sample was taken with a Van Dorn insulated sampler at two fathom intervals, the temperature was read from a Centigrade thermometer mounted within the sampling case, and the salinity was determined as before. Visibility in meters from the surface was determined using a 0.25 meter diameter Secchi disc. The sigma t factor for water density was determined by temperature and salinity from the U. S. Navy H. O. Publication No. 615, Tables for Sea Water Density.

In samples of one hundred or fewer shrimp, all were measured in millimeters, and the sizes recorded on length-frequency sheets by sex. When the catch of shrimp was large, a portion of the catch was counted and measured and the total determined by calculation. This procedure was used for both commercial and non-commercial species. Ripe ovaries and testes were noted when present.

Organisms other than crustaceans were listed. Two species of squid were measured in the catches and noted by length from beak area to extremity of body sac.

Results

Brown shrimp taken in the samples during the study period ranged from 53 mm to 178 mm in length. The few shrimp caught in April were 133 mm to 148 mm long, and in May, 88 mm to 163 mm. In June, the size range extended from 53 mm to 153 mm. In July and August, shrimp of 63 mm to 168 mm were caught, and in September the range was 103 mm to 178 mm. In October, the few shrimp taken were scattered in size from 73 mm to 168 mm. In November, two size groups were present, 103-123 mm and 153-173 mm. In December, brown shrimp was in the 163-183 mm range.

Fewer brown shrimp were caught in the inshore Gulf off Port Mansfield and Port Isabel, but these had a wider range. In May, shrimp were from 28 mm to

68 mm long. In June, browns were 88 mm to 133 mm. In September, large shrimp of 153-173 mm were caught. In November and December, shrimp were in an extended size range of 53 mm to 178 mm.

White shrimp caught from January through March off Port Aransas were 78 mm to 128 mm long. Throughout September, whites ranged from 143 mm to a peak size of 203 mm. In October, November, and December, the range was 73 mm to 198 mm.

Only a few white shrimp of scattered sizes were taken in March and May off the southern coast. In June, 158-203 mm shrimp were caught. No whites were caught in July and August. In September, white shrimp measured 138-183 mm in length. Shrimp in November and December ranged in size from 108 mm to 198 mm.

Pink shrimp were caught off Port Aransas in abundance only in February. In that month 175 pinks 118 mm to 178 mm long were caught in one trawl sample. The mode was from 138-168 mm. A few pinks in a size range of 63-113 mm were taken during the rest of the year.

In the Port Mansfield/Port Isabel area, pink shrimp were more common. In February, shrimp measured 43-63 mm and 88-113 mm in length. In May, the few caught were in the 63-78 mm and 128-133 groupings. In June, pinks were 123-188 mm long, and in September the bulk of the catch was 148-168 mm long. In November, pinks were scattered through a wide size range of 68 mm to 178 mm. December produced the most shrimp in sizes of 78 through 168 mm.

No browns were taken off Galveston/Freeport in January. Whites were abundant in a size range of 83-143 mm and in a mode of 93-138 mm. The few pinks caught were from 63-128 mm long.

Female brown shrimp were slightly more abundant than males in the larger size ranges in June and July off Port Aransas. The sexes were about equal in the samples for other months. The yearly sex percentage breakdown of brown shrimp off Port Aransas was as follows:

MONTH	MALE		FEMALE		TOTAL
April	0		3	100%	3
May	11	58%	8	42%	19
June	1,458	46%	1,684	54%	3,142
July	442	44%	561	56%	1,003
August	73	41%	103	59%	176
September	158	39%	249	61%	407
October	11	52%	10	48%	21
November	167	66%	86	34%	253
December	8	26%	23	74%	31
TOTAL	2,328	46%	2,727	54%	5,055

Female white shrimp were slightly more abundant in the larger size ranges, especially in June and October when large females dominated the catch. Throughout the rest of the year when whites were abundant at all, male and female were about equal in the samples. The following is the white shrimp sex breakdown for the Gulf off Port Aransas:

MONTH	MALE		FEMALE		TOTAL
January	284	55%	228	45%	512
March	27	87%	4	13%	31
April	4	57%	3	43%	7
May	6	46%	7	54%	13
June	18	12%	129	88%	147
July	475	39%	752	61%	1,227
August	7	30%	16	70%	23
September	0		1	100%	1
October	28	22%	99	78%	127
November	190	45%	228	55%	418
December	127	39%	197	61%	324
TOTAL	1,166	41%	1,664	59%	2,830

The following is the sex percentage for pink shrimp the one month of abundance.

MONTH	MALE		FEMALE		TOTAL
February	75	43%	100	57%	175

In samples off Port Mansfield and Port Isabel, female brown shrimp were more abundant than males, as shown below:

MONTH	MALE		FEMALE		TOTAL
May	1	11%	8	89%	9
June	80	29%	192	71%	272
August	7	33%	14	67%	21
September	19	18%	50	72%	69
November	369	44%	462	56%	831
December	270	44%	346	56%	616
TOTAL	746	41%	1,072	59%	1,818

Male and female white shrimp were equal in number throughout the year off the southern coast except in June and December when females were more abundant.

MONTH	MALE		FEMALE		TOTAL
March	2	22%	7	78%	9
May	2	50%	2	50%	4
June	98	35%	181	65%	279

MONTH	MALE		FEMALE		TOTAL
September	84	50%	83	50%	167
November	328	55%	266	45%	594
December	96	33%	191	67%	287
TOTAL	610	46%	730	54%	1,340

In the pink shrimp population off Port Mansfield and Port Isabel, females generally dominated.

MONTH	MALE		FEMALE		TOTAL
February	12	48%	13	52%	25
May	6	50%	6	50%	12
June	71	39%	112	61%	183
August	1	100%	0		1
September	12	24%	39	76%	51
November	27	45%	33	55%	60
December	90	44%	114	56%	204
TOTAL	219	41%	317	59%	536

Figures 1 and 2 are graphs of brown and white shrimp caught off Port Aransas plotted for monthly abundance by the average number caught per trawl for each month. Abundance is plotted below the percentage length-frequency of the population for each month. Brown shrimp were taken in greatest numbers in June at a small size mode range of 53 mm to 103 mm. White shrimp were most abundant in samples in January in a size range of 73 mm to 133 mm, and were again abundant in July samples in size ranges of 153 mm to 203 mm.

Figures 3 and 4 are graphs of brown and white shrimp from the Gulf off Port Mansfield and Port Isabel plotted for abundance and population length-frequency. Both browns and whites were at peak abundance in November samples. Browns were in a size range of 53-163 mm; whites in a range of 108-193 mm.

Figure 5 is a graph for pink shrimp caught off Port Mansfield and Port Isabel plotted for abundance and population length-frequency. Pinks were most abundant in December samples in sizes ranging from 73 mm to 168 mm.

Depth distribution of three important species of commercial shrimp off Port Aransas was characteristic of all areas sampled. In April, May, and June, brown shrimp were most abundant in 6 to 10 fathoms. From June through December, they were most frequently caught in 11 to 16 fathoms.

From April through November, most white shrimp were taken in 6 to 10 fathoms. In January, March, and again in December, most were caught in 3 to 5 fathoms.

Pink shrimp were caught in 3 to 5 fathoms in February and March, and in 6 to 10 fathoms through the rest of the year.

No ripe brown or pink shrimp were caught. Male white shrimp were apparently ripe from April through August. All female whites were ripe in May, one-half were ripe in June, and one-fourth in July and August.

The semi-commercial shrimp, Xiphopeneus kroyeri, or seabob was not abundant in the samples. Two females, 83 mm and 98 mm, were caught off Port Aransas in 5 fathoms in January. One 58 mm male was caught in the Port Mansfield/Port Isabel area in 4 fathoms in July. Forty-six, 58 mm to 113 mm long, were caught in January off Galveston/Freeport. Thirty per cent were male; seventy per cent were female.

Seven species of decopod and stomatopod shrimp with no present commercial value were caught. The jackass shrimp, Trachypeneus similis, was the most abundant of these. Figure 6 is a graph of the yearly abundance of this species and of a related shrimp, Trachypeneus constrictus. Both shrimp were abundant in samples taken off Galveston/Freeport in January. T. similis was abundant off Port Aransas in March, May, June, and December; and off Port Mansfield/Port Isabel in November. The size of both species was from 33 mm to 88 mm. No male over 60 mm was caught. The sex ratio was 7 per cent male to 93 per cent female, probably due to net selectivity.

Figure 7 is a yearly abundance graph for the 2 species of rock shrimp, Sicyonia dorsalis and Sicyonia brevirostris. S. dorsalis was abundant in January off Galveston; in March, April, and May off Port Aransas; and in September in the Port Mansfield/Port Isabel area. These shrimp ranged in size from 18 mm to 88 mm. Sex percentage was 32 per cent male to 68 per cent female.

S. brevirostris was taken only in the southern sampling area and was abundant in July, September, and November, at a size range of 63-113 mm. Males and females were caught in equal number.

Figure 8 is a yearly abundance graph of the squillid shrimp, Squilla empusa, in all areas, and for the related squillids, S. neglecta and S. lijdingi, off Port Aransas. The common mantis shrimp, S. empusa, ranged in length from 33 mm to 143 mm, and was abundant off Galveston in January, off Port Aransas in February, and in the Port Mansfield/Port Isabel area in June and December. There were 37 per cent males to 63 per cent females.

Squilla neglecta was abundant off Port Aransas in February. The rarer S. lijdingi was caught only in May and October in this area.

The common white squid, Lollinguncula brevis, was most abundant in the winter months off both Port Aransas and the southern zone. Specimens ranged in size from 40 mm to 160 mm.

The larger red squid, Loligo pealei, was most abundant off Port Aransas in December and in the Port Mansfield/Port Isabel area in November. Off Port Aransas no specimen exceeded 150 mm in length, but squid as large as 243 mm were taken in the southern zone. Smallest specimens were about 50 mm long.

No squid were caught off Galveston/Freeport in January. In both of the southern sampling areas, masses of squid eggs were common and abundant in the samples in May, June and July.

Table 1 is the list of squid and other invertebrates caught during this study. The various coelentrates were most abundant, and ripe individuals were taken in October, November, and December.

Table 2 is the list of squid and invertebrates taken in the Port Mansfield/Port Isabel area throughout the year and off Galveston in January. Moon jelly fish, Aurelia aurita, were abundant off Galveston and were ripe in January.

Table 3 contains data on temperature, salinity, density, and visibility obtained during the year in the inshore Gulf off Port Aransas. Table 4 is the same for the area off Port Mansfield and Port Isabel, and Table 5 is for the Gulf off Galveston and Freeport.

Discussion

The Gulf of Mexico portion of the brown shrimp life cycle involves adult spawning activity in the offshore Gulf (45 fathoms), larval and post-larval emigration inshore to the bays, and migration of juvenile and adult shrimp back to the deeper Gulf. Gross adult morphology is attained at or near inlets leading from the Gulf into the bays. Young shrimp move into and spread through the shallow bays growing rapidly for a period of several months, leave the bays when 80-100 mm long, and return to the Gulf spawning grounds.

The brown shrimp community in the shallow Gulf (3-16 fathoms) consists of young migrants. These schools, which move outward through the inshore Gulf in waves during certain months, are age groups with definite size modes traceable to previous bay juveniles.

The first brown shrimp were caught in April at sizes of 128 mm to 153 mm. In May, a wave of juvenile shrimp from the bay contained two distinct size groups, one of 83 to 108 mm, one of 128 to 143 mm. The smaller size group was composed of the first outbound migrants from the bays at the end of April. This group had grown in the nursery areas through March and April. In June, large schools of shrimp in a modal size of 53-153 mm moved out through the inshore Gulf. This series of waves of shrimp was the real bulk of browns moving offshore. In May, shrimp were not abundant.

The growing monthly stock of shrimp taken off Port Aransas is graphed in Figure 1. The progression of size peaks through the months may show the continual growth of different age groups. The first migrants in May, at a peak of 88 mm, were picked up again in July at 133 mm and possibly in September at 163 mm. The abundant catch in June at a peak of 73 mm reoccurred in August at 123 mm, September at 138 mm, and October at 163 mm.

Successive smaller waves of small shrimp moved out through the rest of the summer and fall. Shrimp at a peak of 68 mm were caught in August and reappeared in October at 113 mm and in December at 168 mm. A wave of shrimp appearing first in October at 83 mm was evident in November at 108 mm.

Apparently four successive main waves of juvenile shrimp moved outward in the Gulf from May through December. Only in June were shrimp abundant enough to suggest a dominant population migration. Brown shrimp moved offshore beyond the sampling area at sizes generally above 178 mm. Shrimp left the area continually from September through December as shown by the similarity of size peaks between 160 and 170 mm.

Brown shrimp of 128-153 mm in April and of 128-143 mm in May were too large to have been spawned in 1965. No previous research on brown shrimp stocks defines the exact origin of this size group. Most evidence indicates a protracted spawning period for brown shrimp and continuous influx of larvae to the passes (Kutkuhn 1962). Apparently, only in spring are the factors of favorable bay environmental conditions such that the yearly immense crop of young migrating shrimp results. At other times, adverse conditions may limit the survival; however, the large Gulf shrimp found in April and May are probably survivors of the previous year.

Size distribution of brown shrimp off Port Mansfield/Port Isabel was comparable to that off Port Aransas (Figure 3). Three possible waves were found. The first appearance in May at a main peak size of 63 mm was followed by successive catches at 128 mm in August and 168 mm in September. Shrimp which were 73 mm long in August were apparently 113-158 mm in November, and 143-158 mm in December. There was a slight indication that shrimp 58 mm long in November were 98 mm in December.

The size of the shrimp in May, and especially in June at a 118 mm peak, suggests an earlier appearance of smaller shrimp in April. Unfortunately, due to lack of data from the southern area, this cannot be confirmed.

Brown shrimp were abundant in catches off Port Mansfield only in November and December (no data from October).

Figure 2 shows the growth peaks for white shrimp caught off Port Aransas. The white shrimp life cycle differs from that of the brown in the times at which spawning occurs and larvae enter the passes, and the depths in the Gulf that limit habitat. White shrimp spawn from spring to early fall with peaks in late spring and early fall. The young grow up in bay nursery areas and migrate back into the Gulf in the fall. The adult Gulf habitat is in depths of 3 to 16 fathoms, and most spawning activity is in depths of 5-10 fathoms.

Small white shrimp from the bays first were caught in the Gulf in October 1964 at a 98 mm peak, continuing into November at a peak of 123 mm. In December 1964, shrimp at peaks of 88 and 108 mm were found in Gulf waters. These shrimp are from the spawn and juveniles of the late summer and fall of 1964. In January 1965, the peak size was 113 mm and in April it was 153 mm. By May this peak was 163 mm, in June it was 168 and 178 mm, in August and September it was 198-203 mm. A lesser peak of 88 mm shrimp in January 1965 might further be traced to a later catch of 113 and 123 mm shrimp in March. Shrimp of 183 and 163 mm found in October and November 1965 were probably from the 113-123 mm shrimp found in March.

White shrimp migrate from the bay at larger sizes than browns. The smallest white shrimp taken were 73 mm compared with brown shrimp as small as 28 mm caught off Port Mansfield/Port Isabel. The large 203 mm whites are only the largest members of the stock and do not represent shrimp moving offshore for further growth.

The size of white shrimp plotted in Figure 4 from the Gulf off Port Mansfield and Port Isabel was comparable to those caught off Port Aransas. Abundance was generally greatest in November, December, and January.

Pink shrimp are graphed in Figure 5. From the data, it appears that pinks entered the Gulf, presumably from the bays, at small sizes on widely separated dates. Shrimp which were of 63 mm in February apparently were 123 mm in May and 158 mm in June. Pinks of 63 mm caught in May might be forerunners of 153 mm specimens caught in September, and possibly those at 173 mm caught in November. Smaller shrimp of 128 mm in November and 143 mm in December indicate some previous wave of smaller shrimp were not detected. In November and December shrimp of 83 mm peaks indicate that smaller shrimp had been present in October. Pinks were only taken in any abundance in December in the southern zone and in February off Port Aransas.

The sex composition of the three commercial shrimp from all the sampling areas was very close to 60 per cent female and to 40 per cent male. No variation was noted when the number of specimens caught was sufficient to obtain a reasonable percentage figure.

Contrary to the uneven year-round spawning activity of brown shrimp, whites apparently spawned only from May through August. No ripe individuals were caught during the rest of the year. The limits of this season are supported by the rather concentrated dates of entry of post-juvenile whites into the Gulf, Figures 2 and 4. Browns spawn beyond the limits of the depths sampled in this project. None were found ripe. No pinks were taken ripe, although in previous years some have been caught with developed and ripe ovaries.

The hydrography of the areas studied, covered in Tables 3, 4, and 5, was comparable to that obtained in previous years, and no special ecological changes due to hydrographic differences were found.

Of all the associated organisms caught with commercial shrimp in the samples, only the seabob, Xiphopenus kroyeri, is used to any extent. Few were caught during this project. Trachypeneus similis, Sicyonia dorsalis, and Squilla empusa are common and occasionally abundant in the inshore Gulf. Their small size limits their commercial value.

Most of the organisms caught with and apparently thriving with schools of commercial shrimp are competitors rather than prey or predators. This competition may be keenest during planktonic stages. T. similis were all ripe and spawning in March and April. If larval brown shrimp are moving through the inshore Gulf during this time, some competition exists. S. empusa spawns in January, February, and March, and S. dorsalis in June and July. The latter might compete with planktonic stages of white shrimp. In May and June, masses of squid eggs are caught in the trawl samples. Hatching squid could also compete. One

strictly planktonic shrimp, Acetes sp., is present in the summer and is even abundant in trawl catches, although it is at maximum size at 25 mm.

Present sampling methods induce definite bias as far as frequency is concerned. The coverage of shrimp stocks in the inshore Gulf is also limited by inadequate equipment. The length-frequency data are not subject to variables, but the abundance data are. Future improvements in both vessel and gear should resolve these discrepancies.

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Table 1

Seasonal Abundance of Common Invertebrates off Port Aransas

ORGANISM	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
<i>Lolliguncula brevis</i>	17		3	80	7	96	159	46	48	48	363	249
Number per trawl:	8.5		1.5	26.7	2.3	12	15.9	5.8	8	16	72.6	83
Size in mm:	40		60-100	40-130	140	40-130	60-100	50-125	100	50-125	50-100	75-100
<i>Loligo pealei</i>				1		44	101	88	64	34	2	109
Number per trawl:				.33		5.5	10.1	11	10.7	5.7	.4	36.3
Size in mm:				80		70-120	75-150	100-150	100-150	50-100	75	100-150
<i>Octopus sp.</i>								1				
<i>Dactylometra quinquecirrha</i>											50 ripe	
<i>Aurelia aurita</i>	2		6							500ripe	310 ripe	
<i>Stomolophus meleagris</i>			1									
<i>Renilla mulleri</i>				33	10	86	6				25	6
<i>Calliactis tricolor</i>		7		6	3							
<i>Astropecten antillensis</i>											6	
<i>Astropecten cingulatus</i>	2				80		6		2	4		80
<i>Luidia alternata</i>						1			2			1
<i>Luidia clathrata</i>										1		
<i>Mellita quinquiesperforata</i>					21				6	19		
<i>Sertularia sp.</i>								Very abundant in July.				

Table 2

Seasonal Abundance of Common Invertebrates off Port Mansfield/Port Isabel from February through December and off Galveston/Freeport in January

ORGANISM	Jan	Feb	Mar	May	June	July	Aug	Sept	Nov	Dec
<i>Lolliguncula brevis</i>		17	112	27	6		8		20	133
Number per trawl:		5.7	16	6.8	2		1.3		6.7	44.3
Size in mm:		90-100	25-100	40-100	80-100		125-150		40-160	60-100
<i>Loligo pealei</i>					26		50		76	22
Number per trawl:					8.7		6.3		25.3	7.3
Size in mm:					100-200		100-200		50-250	100-130
<i>Aplesya</i>						7				
<i>Aurelia aurita</i>	198 ripe	2								
<i>Renilla mulleri</i>	80	200	14			2				
<i>Calliactis tricolor</i>	47	2	4							
<i>Astropecten antillensis</i>					25					
<i>Astropecten cingulatus</i>					3		3			39
<i>Luidia alternata</i>							3		3	5
<i>Luidia clathrata</i>					24		24	35	20	81
<i>Mellita quinquiesperforata</i>								20		

Table 3

Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
January					
5	5	16.3	34.62	25.405	.30
		16.9	34.43	25.120	
5	9	15.0	35.07	26.044	.48
		15.7	34.92	25.772	
February					
1	4	12.4	34.43	26.089	1.09
		12.6	35.02	26.507	
March					
4	4	13.7	32.8	24.571	.36
		14.1	31.7	23.642	
4	7	14.1	33.9	25.336	.69
		13.6	33.35	25.016	
April					
13	5	24.3	26.36	17.069	4.25
		23.8	27.43	18.016	
13	10	24.1	31.41	20.924	4.8
		23.4	33.68	22.842	
22	8	24.0	25.10	16.208	6.04
		23.75	26.75	18.271	
		23.25	25.65	16.809	
		23.25	27.30	18.073	
		22.0	28.95	19.661	
May					
21	6	26.5	23.87	14.348	3.62
		25.0	23.87	15.0	
		25.5	24.43	15.271	
		26.0	24.43	15.123	

Table 3--continued
 Temperatures and Salinity for 1965 in the Inshore Gulf off Port Aransas by
 Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
21	12	26.5	24.0	14.651	3.40
		26.5	27.30	17.119	
		26.0	29.50	18.921	
		25.5	30.05	19.486	
		25.0	30.05	19.636	
		25.5	27.30	17.422	
		25.0	27.30	17.571	
21	16	25.5	21.25	12.893	3.98
		25.5	24.0	14.950	
		26.0	25.10	15.625	
		26.0	26.75	16.860	
		25.5	27.30	17.422	
		25.0	29.50	19.223	
		25.0	30.05	19.636	
		25.5	27.30	17.422	
		25.0	27.30	17.571	
June					
14	4	28.75	27.30	16.408	4.94
		28.75	25.65	15.177	
		28.75	27.30	16.408	
14	8	29.0	27.85	16.737	5.37
		29.0	28.40	17.147	
		29.0	27.85	16.737	
		28.0	27.85	17.061	
		28.0	27.85	17.061	
14	12	28.75	27.30	16.408	6.27
		28.75	27.85	16.818	
		28.75	28.40	17.229	
		27.75	30.05	18.786	
		27.25	30.05	18.786	
		26.5	31.70	20.417	
		26.5	32.25	20.831	
19	4	31.0	27.30	15.996	3.42
		31.0	27.30	15.996	
		30.0	27.85	16.405	
19	8	30.0	27.85	16.405	2.60
		30.0	27.85	16.405	
		29.0	28.95	17.557	
		29.0	28.95	17.557	
		29.0	28.95	17.557	

Table 3 continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
June					
30	4	29.0	28.40	17.147	3.84
		29.0	28.40	17.147	
		29.0	28.40	17.147	
30	8	30.0	28.95	17.225	8.53
		29.0	28.95	17.557	
		29.0	30.60	18.790	
		27.0	30.60	19.435	
		27.0	30.60	19.435	
30	12	29.0	27.76	16.103	13.27
		29.0	29.42	17.909	
		29.0	29.42	17.909	
		29.0	29.42	17.909	
		29.0	31.09	19.156	
		29.0	33.31	20.819	
		28.0	33.31	21.148	
30	16	29.0	28.95	17.557	14.60
		29.0	28.95	17.557	
		29.0	29.5	17.969	
		27.75	29.5	18.374	
		27.75	29.5	18.374	
		25.5	30.6	19.499	
		25.5	30.6	19.499	
		24.0	31.7	21.172	
		24.0	32.98	22.137	
July					
14	4	28.25	27.30	16.570	1.83
		28.25	25.65	15.339	
		28.25	27.85	16.981	
14	8	28.5	27.30	16.489	2.64
		28.5	27.85	16.899	
		28.25	28.40	17.391	
		28.25	30.53	18.983	
		28.0	30.53	19.064	
20	6	29.5	27.30	16.162	4.78
		29.75	27.85	16.448	
		29.0	30.53	18.738	
		29.0	30.53	18.738	

Table 3--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by
Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
July					
20	8	29.75	29.42	17.659	4.60
		29.75	29.42	17.659	
		29.5	30.53	18.572	
		29.0	32.75	20.398	
		28.5	32.75	20.564	
21	6	29.5	29.42	17.742	3.62
		29.5	29.98	18.160	
		29.0	30.53	18.738	
		29.0	30.53	18.738	
21	10	29.0	30.53	18.738	5.38
		29.0	30.53	18.738	
		28.5	30.53	18.902	
		28.25	31.09	19.402	
		28.5	32.20	20.152	
		28.5	32.75	20.564	
July					
22	8	28.0	28.87	17.823	6.24
		27.5	30.53	19.226	
		27.5	33.31	21.306	
		27.0	33.31	21.469	
		26.5	30.53	19.540	
22	12	28.5	31.64	19.773	8.54
		28.5	30.53	18.902	
		28.0	30.53	19.064	
		27.5	33.31	21.309	
		27.0	33.31	21.469	
		26.0	34.98	23.039	
		26.0	34.98	23.039	
22	16	27.0	33.31	21.469	11.84
		27.0	33.31	21.469	
		27.0	34.98	22.724	
		27.0	34.98	22.724	
		27.0	30.53	19.384	
		27.0	30.53	19.384	
		26.25	33.31	21.706	
		26.25	34.42	22.540	
		24.4	34.42	23.076	

Table 3--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by
Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
July					
29	12	28.5	27.76	16.832	3.17
		28.5	27.76	16.832	
		28.5	31.09	19.421	
		29.0	32.20	19.987	
		29.0	34.42	21.650	
		28.5	34.42	21.816	
		28.5	34.98	22.237	
August					
2	9	28.0	34.42	21.980	1.46
		28.5	34.42	21.816	
		28.5	34.98	22.237	
		28.0	34.42	21.980	
		27.0	36.09	23.560	
		27.0	35.53	23.138	
2	14	28.0	34.42	21.980	6.23
		28.5	34.42	21.816	
		28.0	35.53	22.815	
		27.0	35.53	23.138	
		27.0	36.09	23.560	
		24.5	35.53	23.914	
		24.5	36.64	24.753	
		24.5	36.64	24.753	
9	4	29.75	32.2	19.736	2.34
		29.75	32.2	19.736	
		29.0	32.2	19.987	
9	9	29.25	32.2	19.904	6.04
		29.25	32.2	19.904	
		29.25	31.64	19.485	
		28.0	33.31	21.148	
		28.0	33.31	21.148	
9	12	29.0	33.31	20.919	6.48
		29.0	33.31	20.819	
		29.0	32.75	20.399	
		28.5	33.31	20.984	
		28.25	32.75	20.646	
		26.0	34.98	23.039	
		26.0	36.09	23.236	

Table 3--continued
 Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by
 Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
August					
10	14	29.0	32.75	20.399	13.16
		29.0	33.31	20.819	
		28.75	31.09	19.239	
		28.75	34.42	21.741	
		28.75	32.20	20.070	
		28.75	33.87	20.322	
		28.75	33.31	20.902	
		28.5	36.09	23.071	
11	10	29.0	33.87	21.237	4.10
		28.5	33.87	21.403	
		28.5	33.31	20.984	
		28.5	32.75	20.564	
		27.0	31.09	19.803	
		26.0	36.09	23.876	
		26.0	35.53	23.455	
		25	14	29.0	
29.0	34.42			21.650	
28.0	33.31			21.148	
28.5	33.87			21.404	
28.0	35.53			22.815	
27.0	37.20			24.396	
27.0	36.09			23.560	
27.0	36.09			23.560	
September					
1	4	29.0	33.87	21.237	3.4
		29.0	33.87	21.237	
		29.0	34.98	22.070	
1	8	31.0	33.31	20.481	4.37
		30.5	33.31	20.481	
		30.5	34.98	21.732	
		30.5	34.98	21.732	
		30.0	36.09	22.564	
1	12	30.5	33.87	20.944	4.23
		30.5	33.87	20.944	
		29.0	34.98	22.070	
		29.0	34.98	22.070	
		28.5	34.98	22.237	
		28.0	33.31	21.148	
		28.0	33.87	21.568	

Table 3--continued
 Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by
 Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
September					
7	4	29.5	31.09	18.990	4.36
		29.0	31.09	19.156	
		29.0	32.20	19.987	
7	9	29.0	33.87	21.237	4.53
		28.5	33.87	20.404	
		28.5	34.98	22.177	
		27.0	36.09	23.560	
		27.0	34.98	22.724	
7	14	28.0	34.98	22.401	3.64
		27.0	33.87	21.890	
		27.5	34.42	22.142	
		27.5	34.98	22.563	
		27.0	37.75	24.811	
		26.5	37.75	24.971	
		26.0	37.75	25.130	
		26.0	37.75	25.130	
October					
13	4	27.5	30.53	19.226	2.04
		27.0	30.53	19.384	
		26.5	31.09	19.960	
13	9	26.5	32.75	21.207	8.78
		26.5	33.31	21.628	
		27.0	33.31	21.469	
		27.5	34.42	22.142	
		27.0	34.42	22.303	
		27.0	34.42	22.303	
13	14	25.0	31.09	20.418	9.68
		25.0	31.09	20.418	
		25.0	31.64	20.831	
		25.0	33.31	22.089	
		25.0	33.31	22.098	
		25.0	33.31	22.098	
		26.0	33.31	21.783	
		26.5	34.42	22.461	

Table 3--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Aransas by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
November					
16	8	24.0	34.98	22.975	4.38
		24.0	34.42	23.647	
		22.0	34.98	23.798	
		22.0	36.09	25.740	
		22.0	36.09	25.064	
16	14	23.25	35.53	23.950	5.63
		23.0	35.53	24.356	
		22.75	36.64	25.185	
		22.75	36.64	25.268	
		22.5	36.09	24.923	
		22.0	36.64	25.481	
		21.0	36.64	25.759	
17	2	22.0	34.98	22.461	1.42
		22.0	34.98	24.223	
17	4	24.0	34.42	23.798	2.67
		24.0	34.42	23.798	
		24.0	34.42	23.798	
17	6	21.75	34.98	23.587	8.41
		21.75	35.53	24.769	
		22.0	36.09	25.399	
		23.0	36.09	24.779	
December					
15	4	19.0	33.87	24.178	3.17
		20.0	33.87	23.921	
		20.0	34.98	24.765	
15	8	19.5	33.87	24.051	7.84
		19.5	34.42	24.469	
		20.0	34.98	24.765	
		20.0	34.98	24.765	
		21.0	35.53	24.917	
15	14	18.0	33.87	24.426	7.43
		18.5	33.87	24.304	
		19.0	33.87	24.178	
		20.0	34.98	24.765	
		21.0	35.53	24.917	
		21.0	34.98	24.498	
		20.0	34.42	24.339	
		18.0	34.42	24.847	

Table 4

Temperature and Salinity for 1965 in the Inshore Gulf off Port Mansfield and Port Isabel by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
February					
16	4	15.9	35.62	26.265	.38
		15.9	35.56	26.219	
17	4	13.6	35.41	25.606	.25
		14.8	35.32	26.280	
17	6	13.7	35.61	25.739	.25
		14.3	35.43	26.473	
March					
14	8	17.3	33.7	24.467	1.19
		17.1	35.16	25.632	
15	14	18.9	33.21	23.701	9.75
		18.2	34.37	24.760	
15	18	17.6	32.6	23.707	13.54
		18.0	34.25	24.718	
16	4	16.75	32.8	23.908	3.47
		17.5	33.35	24.141	
16	8	17.0	33.4	24.308	6.35
		17.1	33.63	24.461	
17	6	16.1	33.9	24.898	1.83
		16.9	33.35	24.293	
17	8	18.1	33.42	24.059	6.43
		16.9	33.07	24.079	
May					
7	6	23.5	32.8	22.147	1.37
		24.5	35.0	23.513	
		24.5	35.0	23.513	
		23.0	35.0	23.945	

Table 4--continued
 Temperature and Salinity for 1965 in the Inshore Gulf off Port Mansfield and
 Port Isabel by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
May					
8	6	25.5	33.90	22.381	.49
		25.75	34.45	22.718	
		24.5	34.45	23.099	
		24.5	34.45	23.099	
10	2	24.5	33.8	22.600	.82
		24.5	33.8	22.600	
10	6	24.5	32.8	21.853	.74
		24.5	32.8	21.853	
		24.5	33.9	22.683	
		24.5	33.9	22.683	
June					
9	10	26.0	32.8	21.399	4.36
		26.0	35.53	23.455	
		26.5	32.8	21.244	
		26.5	32.8	21.244	
		27.0	31.7	20.260	
10	8	26.0	32.8	21.399	3.80
		26.0	34.45	22.641	
		26.0	31.7	20.573	
		26.0	32.8	21.399	
		26.0	32.25	20.986	
10	14	26.0	34.98	23.039	10.31
		26.0	35.53	23.455	
		26.0	33.31	21.783	
		26.5	32.75	21.207	
		27.0	34.98	22.724	
		27.0	35.53	23.138	
		24.0	35.53	24.063	
		24.0	35.53	24.063	
July					
3	4	29.0	33.86	21.230	1.84
		29.0	33.31	20.819	
		29.0	33.31	20.819	
3	8	28.5	34.98	22.237	11.48
		28.25	34.42	21.891	
		28.25	32.75	20.646	
		28.25	32.75	20.646	
		28.0	32.20	20.315	

Table 4--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Mansfield and Port Isabel by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
July					
3	12	28.25	35.53	22.733	15.94
		28.25	35.53	22.733	
		28.25	34.98	22.319	
		28.25	33.87	21.486	
		28.25	33.31	21.066	
		28.25	34.98	22.319	
		28.25	34.98	22.319	
4	4	29.0	29.98	18.327	.84
		29.0	31.09	19.156	
		29.0	31.09	19.156	
4	8	29.0	30.53	18.739	3.28
		29.0	31.09	19.156	
		28.0	31.09	19.483	
		28.0	32.75	20.727	
		27.5	32.75	20.889	
4	12	29.0	31.09	19.156	4.16
		29.0	30.53	18.738	
		28.0	31.09	19.483	
		28.0	33.31	21.148	
		27.5	34.98	22.563	
		27.0	35.53	23.138	
		26.75	34.98	22.804	
August					
21	8	28.5	33.31	20.984	8.43
		28.5	34.98	22.237	
		28.5	37.75	24.320	
		27.0	37.75	24.811	
		27.0	38.86	25.648	
21	12	28.0	33.87	21.173	9.64
		28.0	33.87	21.173	
		27.5	33.31	21.309	
		27.5	36.09	23.399	
		27.0	37.75	24.811	
		27.0	33.31	21.469	
		27.0	33.31	21.469	

Table 4--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Mansfield and Port Isabel by Depth and Date and Visibility from Surface in Meters

DATE	DEPTHS IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
August					
22	4	29.0	32.75	20.398	2.40
		29.0	32.75	20.398	
		28.5	33.31	20.984	
22	8	29.0	33.87	21.247	3.93
		29.0	34.42	21.650	
		28.75	33.31	20.902	
		28.5	36.09	23.071	
		28.5	36.09	23.071	
22	14	28.5	33.31	20.984	8.52
		28.5	33.31	20.984	
		28.0	33.31	21.148	
		28.0	36.09	23.236	
		28.0	36.09	23.236	
		28.0	33.31	21.148	
		27.5	32.20	20.476	
		27.5	30.53	19.226	
23	4	30.5	34.98	21.732	3.51
		30.0	34.98	21.732	
		30.0	34.98	21.732	
24	4	27.5	34.98	22.563	2.97
		27.5	36.09	23.399	
		27.0	36.09	23.560	
September					
15	4	30.5	36.09	22.564	1.36
		30.0	37.20	23.397	
		29.5	37.20	23.568	
15	8	30.0	34.98	21.732	3.64
		29.5	34.98	21.901	
		28.0	34.42	21.980	
		27.0	34.42	22.303	
		27.5	36.64	23.813	
15	16	30.5	34.98	21.732	17.84
		29.5	34.98	21.901	
		28.0	34.98	22.401	
		26.0	34.42	22.618	
		26.0	36.64	24.290	
		27.0	36.64	23.974	
		26.0	36.09	23.876	
		26.0	36.09	23.876	

Table 4--continued

Temperature and Salinity for 1965 in the Inshore Gulf off Port Mansfield and Port Isabel by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
November					
19	4	25.0	35.53	23.763	1.37
		24.5	36.09	24.337	
		24.5	36.09	24.337	
19	16	26.5	34.42	22.461	16.49
		27.0	34.42	22.303	
		27.0	34.98	22.724	
		26.75	35.53	23.219	
		24.0	35.53	24.063	
		23.5	36.09	24.634	
		23.0	36.09	24.779	
		23.0	36.64	25.196	
		22.0	36.64	25.481	
20	8	26.0	34.98	23.039	6.42
		25.75	34.98	23.117	
		25.0	34.98	23.347	
		24.0	35.53	24.063	
		24.0	35.53	24.063	
December					
11	4	19.0	35.53	25.446	2.34
		20.5	36.09	25.477	
		20.5	36.09	25.477	
11	10	19.5	34.98	24.896	8.72
		20.0	35.53	25.185	
		20.0	36.09	25.611	
		22.0	36.09	25.064	
		22.0	36.64	25.481	
12	14	19.5	34.98	24.896	15.21
		19.5	35.53	25.316	
		19.0	36.64	26.292	
		19.0	36.64	26.292	
		20.0	35.53	25.185	
		22.0	35.53	24.640	
		22.0	35.53	24.640	
		22.0	36.64	25.481	

Table 5

Temperature and Salinity for January 1965 in the Inshore Gulf off Freeport and Galveston by Depth and Date and Visibility from Surface in Meters

DATE	DEPTH IN FATHOMS	DEGREES C.	SALINITY ppt	DENSITY (sigma t)	VISIBILITY IN METERS
January					
22	4	14.9	32.31	23.945	.56
		15.3	34.06	25.201	
22	6	15.6	33.64	24.812	1.02
		15.6	33.97	25.065	
22	8	14.9	33.62	24.950	.76
		15.3	34.17	25.286	
23	4	15.3	34.48	25.525	1.04
		16.0	34.51	25.391	
23	6	16.9	34.41	25.105	1.02
		16.9	33.9	25.714	
23	8	15.7	33.62	24.912	1.04
		16.0	34.03	25.022	
24	4	16.1	33.09	24.278	.38
		16.1	33.1	24.286	
24	8	17.3	34.61	25.232	.58
		16.0	34.54	25.414	

Figure 1

Brown Shrimp Abundance and Percentage Length-Frequency by Month off Port Aransas

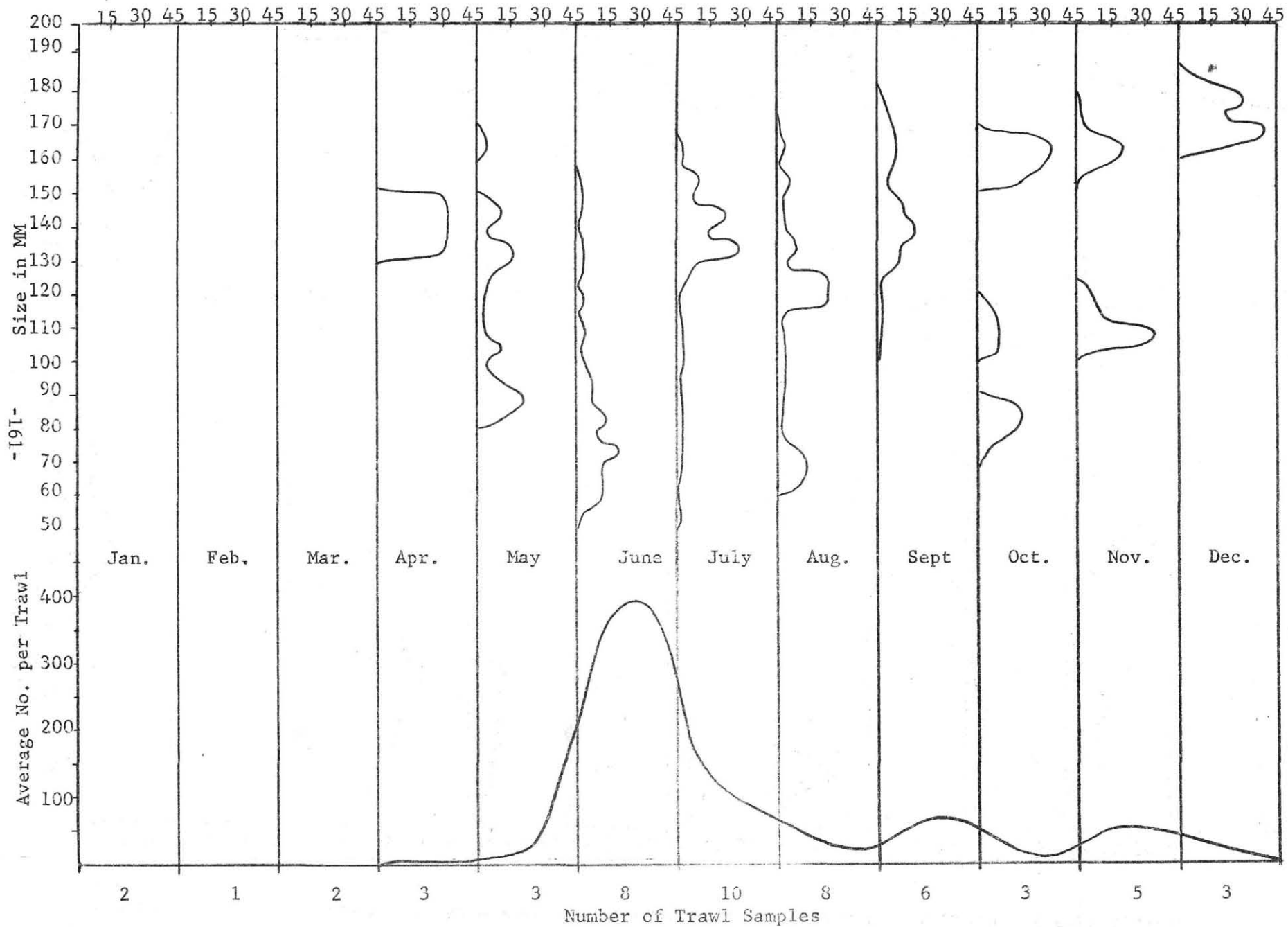


Figure 2

White Shrimp Abundance and Percentage Length-Frequency by Month off Port Aransas

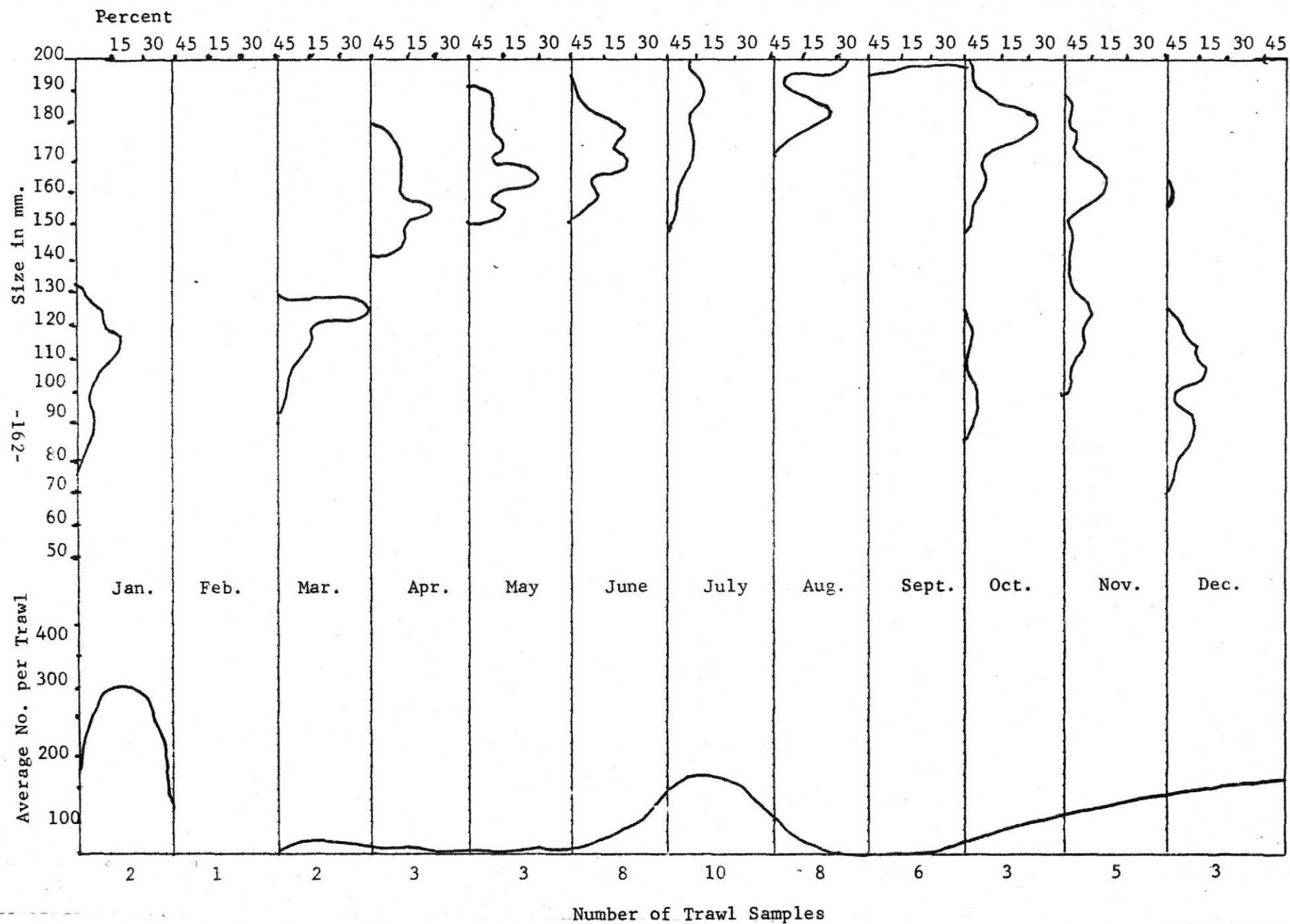


Figure 5

BROWN SHRIMP ABUNDANCE AND PERCENTAGE LENGTH-FREQUENCY BY MONTH OFF PORT ISABEL-
 Port Mansfield

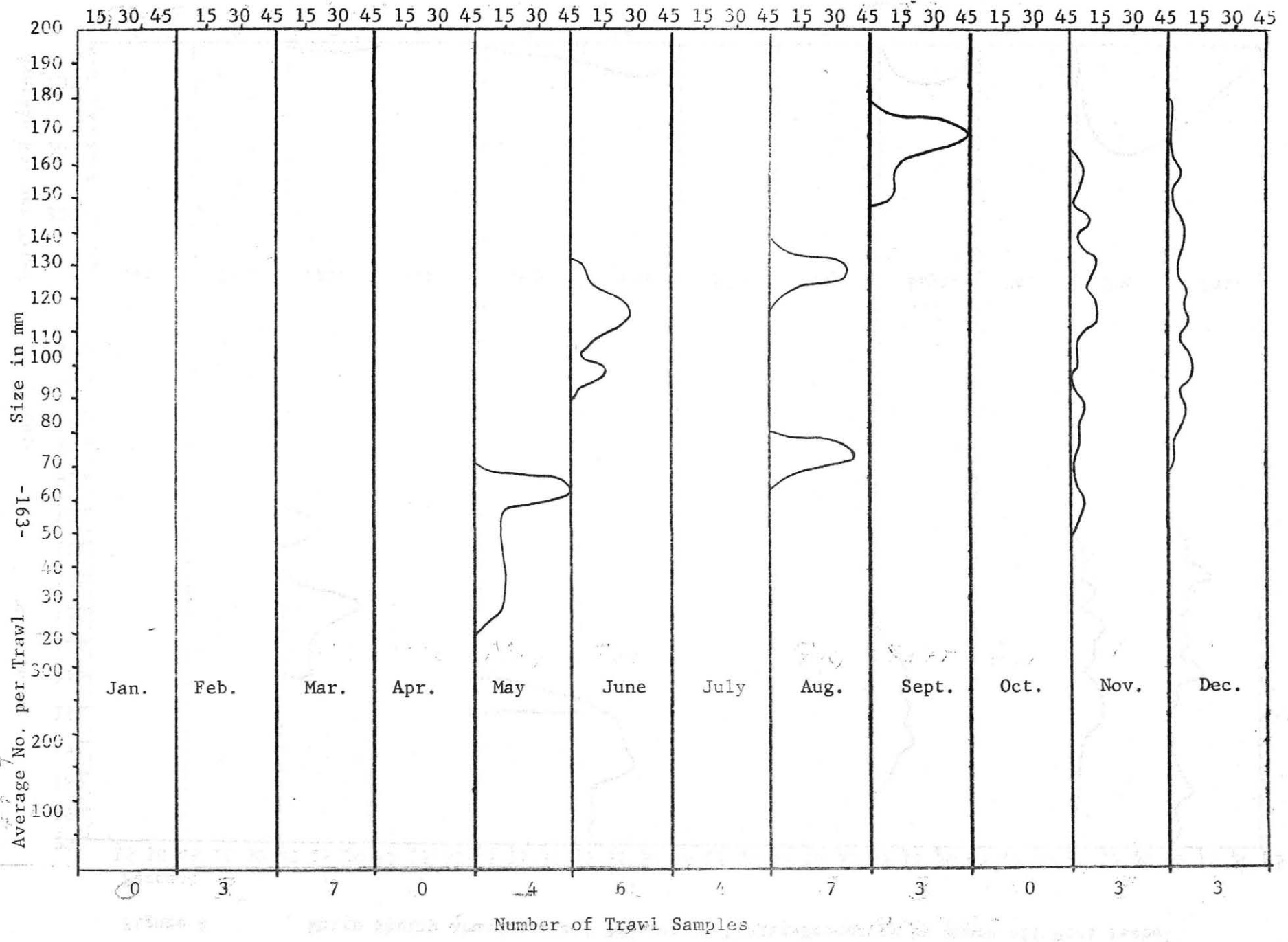


Figure 4

White Shrimp Abundance and Percentage Length-Frequency by Month off Port Isabel

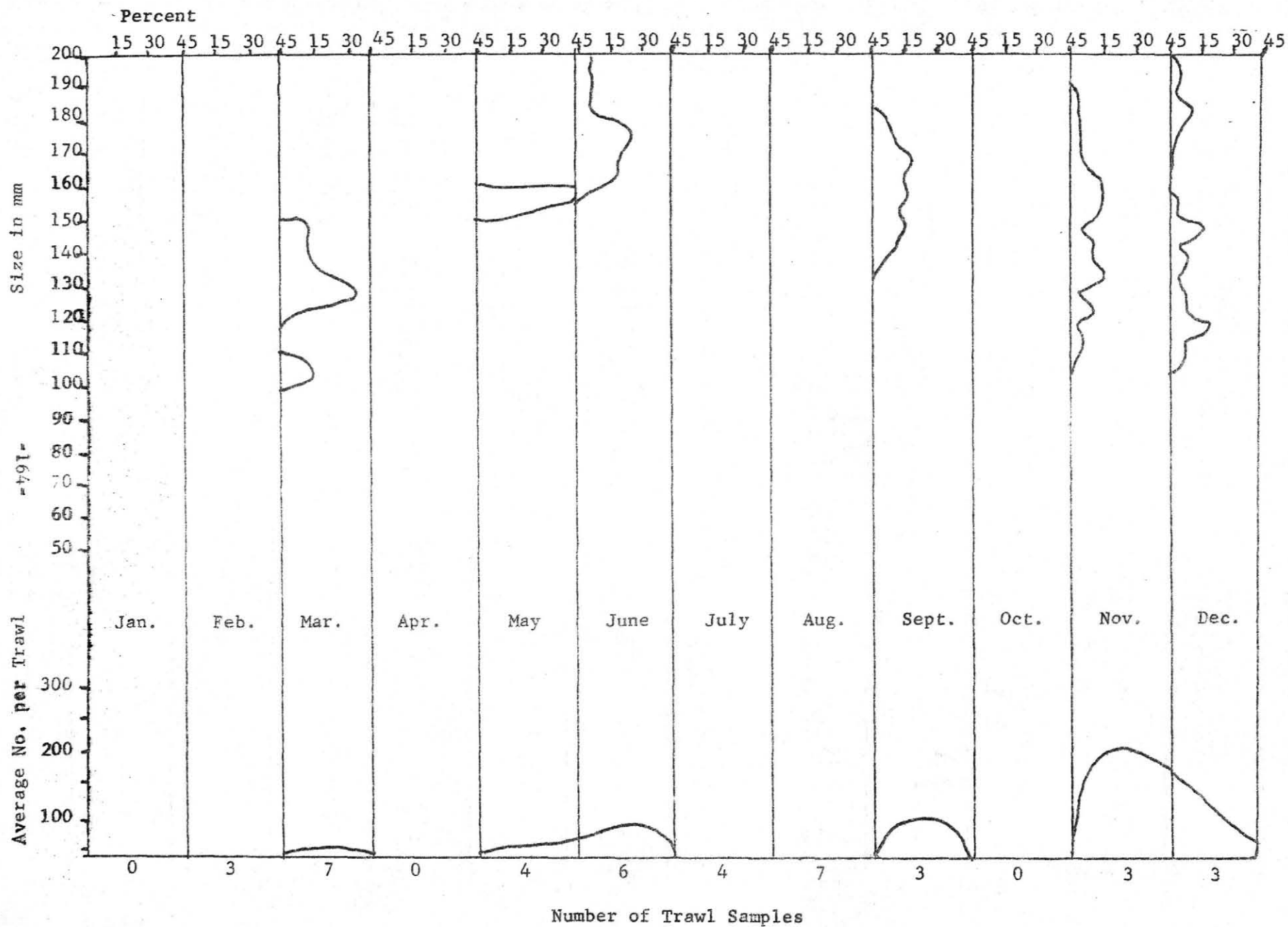


Figure 5

Pink Shrimp Abundance and Percentage Length-Frequency by Month off Port Isabel-
Port Mansfield

Percent

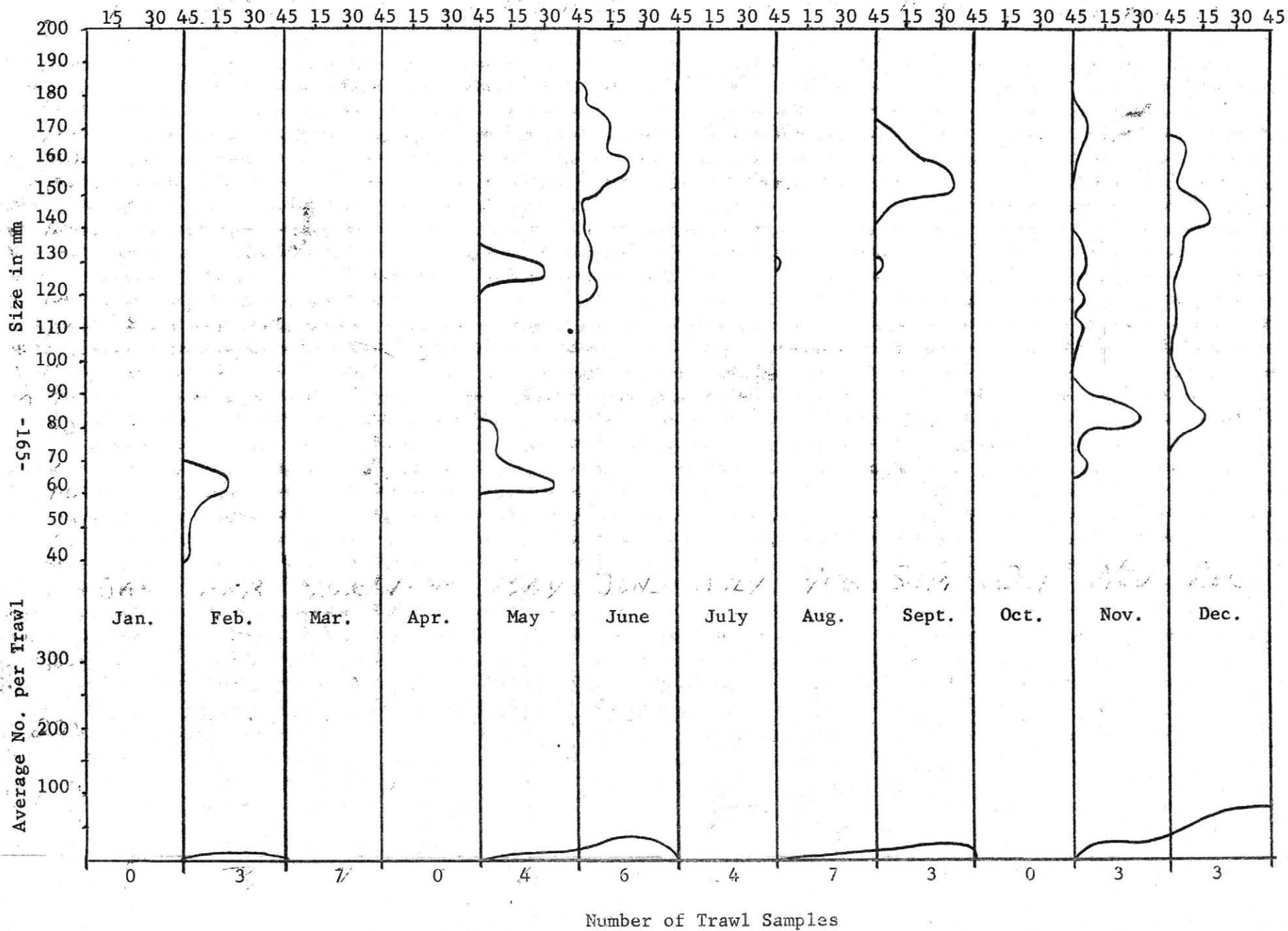
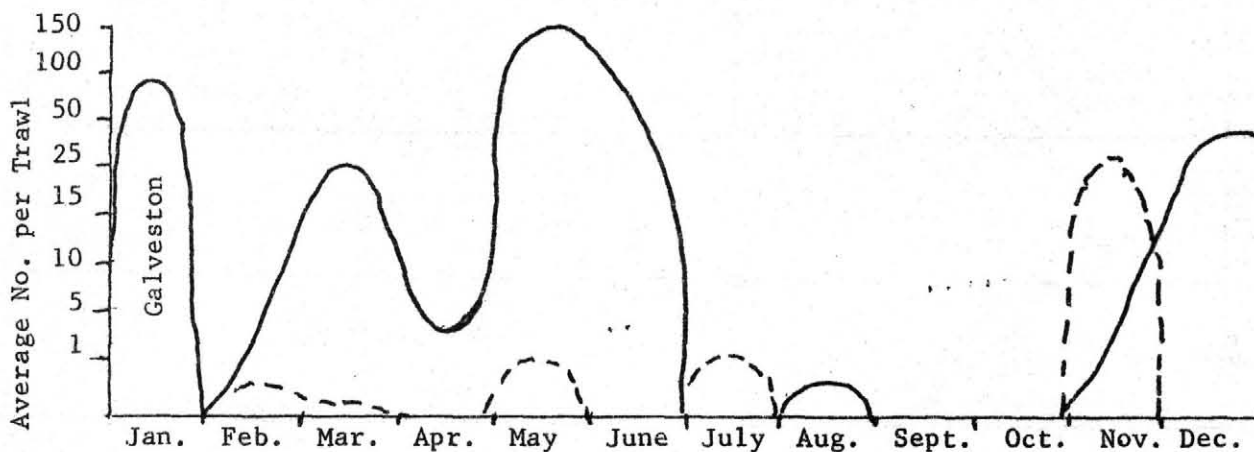


Figure 6 Abundance of *T. similis* off:

Port Aransas: _____

Port Isabel/Port Mansfield -----

Galveston: Denoted



Abundance of *T. constrictus* off:

Port Aransas: _____

Port Isabel/Port Mansfield -----

Galveston: Denoted

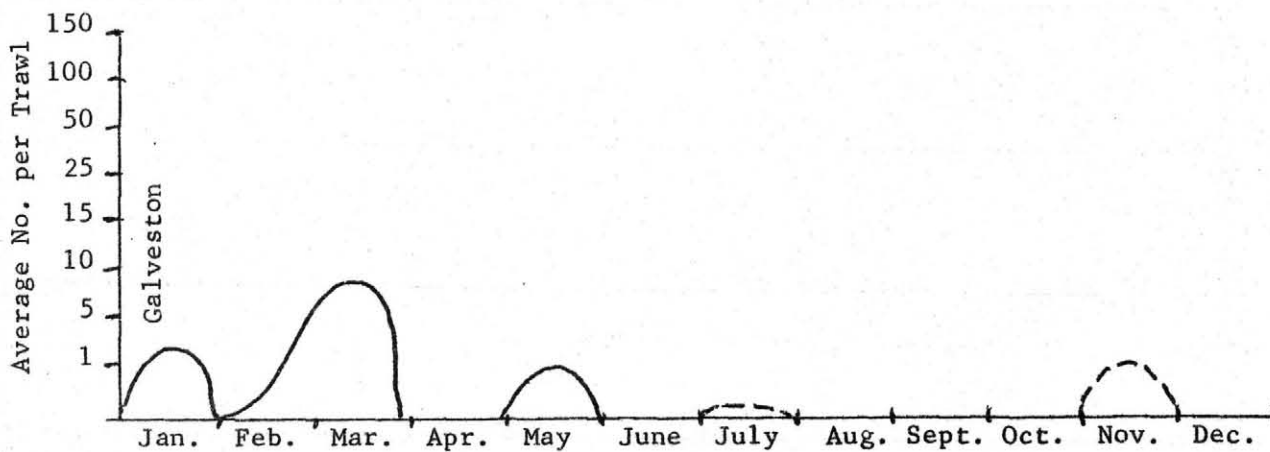
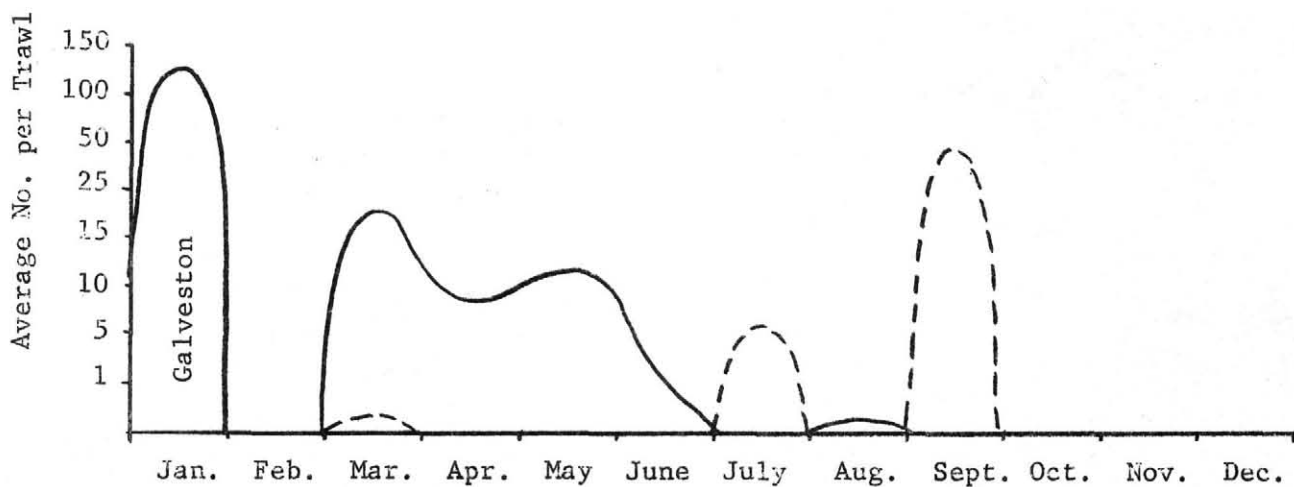


Figure 7

Abundance of *S. dorsalis* off:

Port Aransas: _____
 Port Isabel/Port Mansfield: - - - - -
 Galveston: Denoted



Abundance of *S. brevirostris* off Port Isabel/Port Mansfield

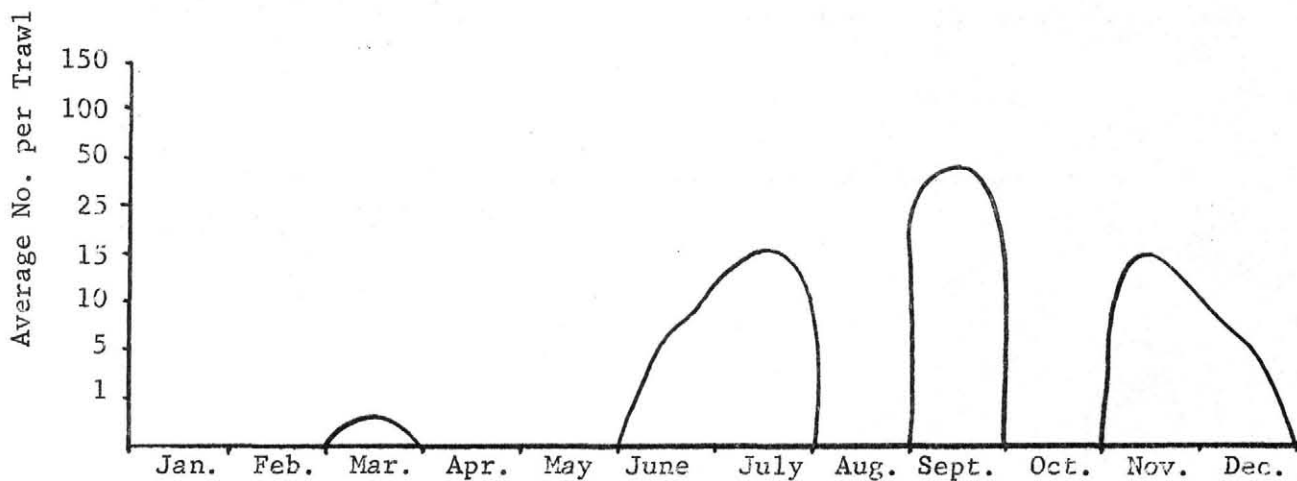
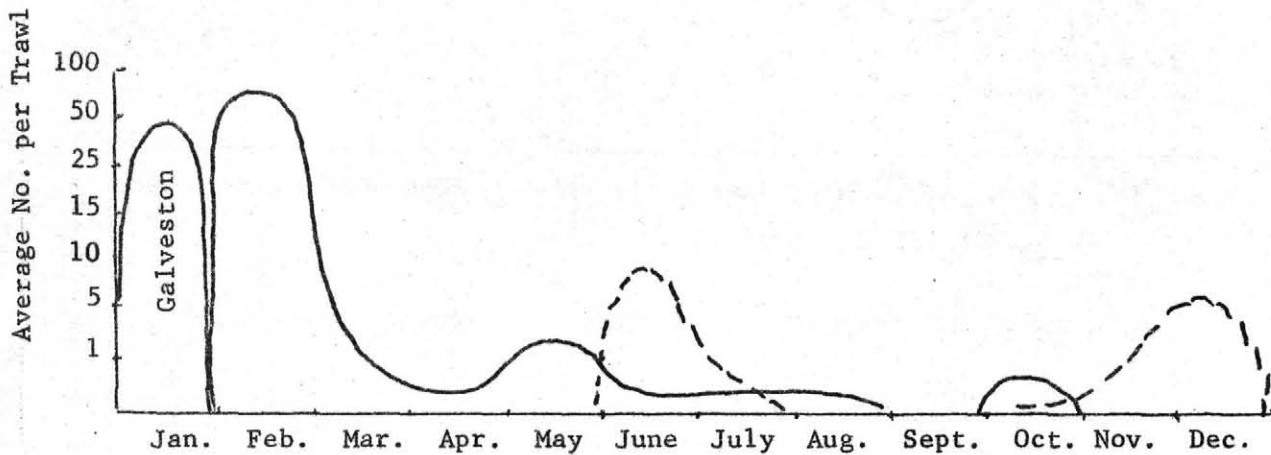


Figure 8 Abundance of *S. empusa* Off:

Port Aransas: _____

Port Isabel/Port Mansfield: - - - - -

Galveston: Denoted



Abundance off Port Aransas of:

S. Neglecta: _____

S. ligdingi: - - - - -

