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## Size of Brown Shrimp and Time of Emigration from the Galveston Bay System, Texas<sup>1</sup>

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### Abstract

A study was begun to determine the time period of emigration, the vertical distribution, and the size of juvenile and subadult brown shrimp leaving the Galveston Bay system, Texas, through the Bolivar Roads tidal pass to the Gulf of Mexico. The sampling gear consisted of a bottom and a surface trawl. Samples were taken both day and night on ebbing tides from May 18 to August 1, 1966.

Brown shrimp were caught throughout the sampling period. Two peaks occurred, the first in May and the second in June. Estimates of mean catch per unit of effort indicated that the shrimp were near the surface at night and near the bottom during the day.

The mean lengths of brown shrimp taken during the day and night with bottom and surface trawls on the same sampling date were similar. The size of the emigrating shrimp increased significantly as the season progressed.

### INTRODUCTION

MANY ANIMALS spend part of their lives in estuaries. Adult brown shrimp (*Penaeus aztecus*), which contribute to the Texas commercial fishery, spawn offshore in the Gulf of Mexico. Postlarvae (8 to 14 mm total length) move into the estuaries, grow for about 2 months and leave as juveniles and subadults (60 to 130 mm total length). It is important to develop accurate sampling procedures for estimating the size, relative abundance, and time of emigration of shrimp from estuaries to gain a clear understanding of the life histories.

Objectives of this study are to determine for juvenile and subadult brown shrimp: (1) the peaks of emigration; (2) the size at which they leave the Galveston Bay system; and (3) whether size or catch per unit of effort varies between surface and bottom, or between day and night. A further objective was to provide data essential for designing a more efficient sampling system for obtaining information on the preceding points.

Copeland (1965) used a tide trap set at mid-depth to sample animals moving with the tides in Aransas Pass Inlet, Texas. He collected brown shrimp during ebb tides from March 10 to December 31, 1963. Peaks of abundance usually occurred during full moon in May, June, July, and

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August. He stated (data are not shown) that the timing of peaks of emigration were similar during the summer of 1964. The emigration of pink shrimp (*P. duorarum*) resembled that of the brown shrimp except that they were caught only during April through September. He concluded that apparently the high tides and faster currents that accompany the time of full moon were enough to stimulate the movement of these shrimp from the bay nursery grounds.

Copeland (1965) stated that juvenile and subadult shrimp emigrated through the Aransas Pass Inlet at about the same size regardless of whether the time was May or June. On the basis of small numbers caught, he also stated that length frequencies were similar through September. Most of the brown shrimp emigrants were between 70 and 80 mm total length whereas most of the pink shrimp emigrants were between 70 and 90 mm.

Idyll (1963) and Idyll, Iversen, and Yokel (1964) used a channel net that blocked the entire 60-foot width of Buttonwood Canal in Everglades National Park near Flamingo, Florida, to catch juvenile pink shrimp moving on ebb tides from adjacent estuarine areas. Idyll, et al. (1964) stated that two of the more important sources of catch variation are speed of ebbing current and phase of the moon. In months when samples were taken in ebb currents during or near the new and full moon, the numbers of shrimp were consistently higher than during other moon phases. Also, numbers of shrimp taken decreased abruptly just after dawn and no shrimp were caught in full daylight.

Idyll (1963) observed that for pink shrimp (1) the mode and size range were identical for 5 months, December 1962 through April 1963; (2) distributions shifted markedly to the right beginning in early May and continuing through June; and (3) average size decreased because of the disappearance of large shrimp and the appearance in catches of a new group of smaller shrimp after June.

Beardsley and Iversen (1966) determined the vertical and horizontal distribution of juvenile pink shrimp as they moved out of the nursery grounds through Buttonwood Canal, Florida. The sampling gear consisted of 13 conical nets suspended in the canal on 5 iron frames. Sampling was at night during ebb tides on full moon, new moon, and quarter moon. On the average, the percentage of the shrimp caught at or near the surface was about 91% during full moon but only about 75% during new and quarter moon. Lateral distribution varied significantly in the surface layers.

## AREA AND SAMPLING PROCEDURE

The Galveston Bay system in southeast Texas exchanges water with the Gulf of Mexico through three passes (Fig. 1A and 1B). About 85% of this exchange is through Bolivar Roads (U.S. Army Corps of Engineers, personal communication). The Bolivar Roads tidal pass was, therefore, chosen for sampling brown shrimp as they moved from the Galveston Bay system to the Gulf of Mexico.

Samples of brown shrimp were taken at station 1 in the tidal pass and at station 2 just outside the jetties in the Gulf of Mexico (Fig. 1C). Water depths (mean low tide) at stations 1 and 2 were about 26 and 32 feet, respectively. I assumed that samples taken at station 1 represented shrimp

emigrating from the bay system. Reasons for this assumption are: (1) station 1, if the jetties are ignored, would be in the Gulf of Mexico; (2) shrimp taken at station 1, as compared to those taken in the Galveston Bay system on similar dates, averaged larger and showed less variation in length; and (3) station 1 does not resemble the habitats preferred by shrimp in the bay system. Samples were taken at station 2 to compare the size of shrimp in the Gulf of Mexico with the size of those from the tidal pass.

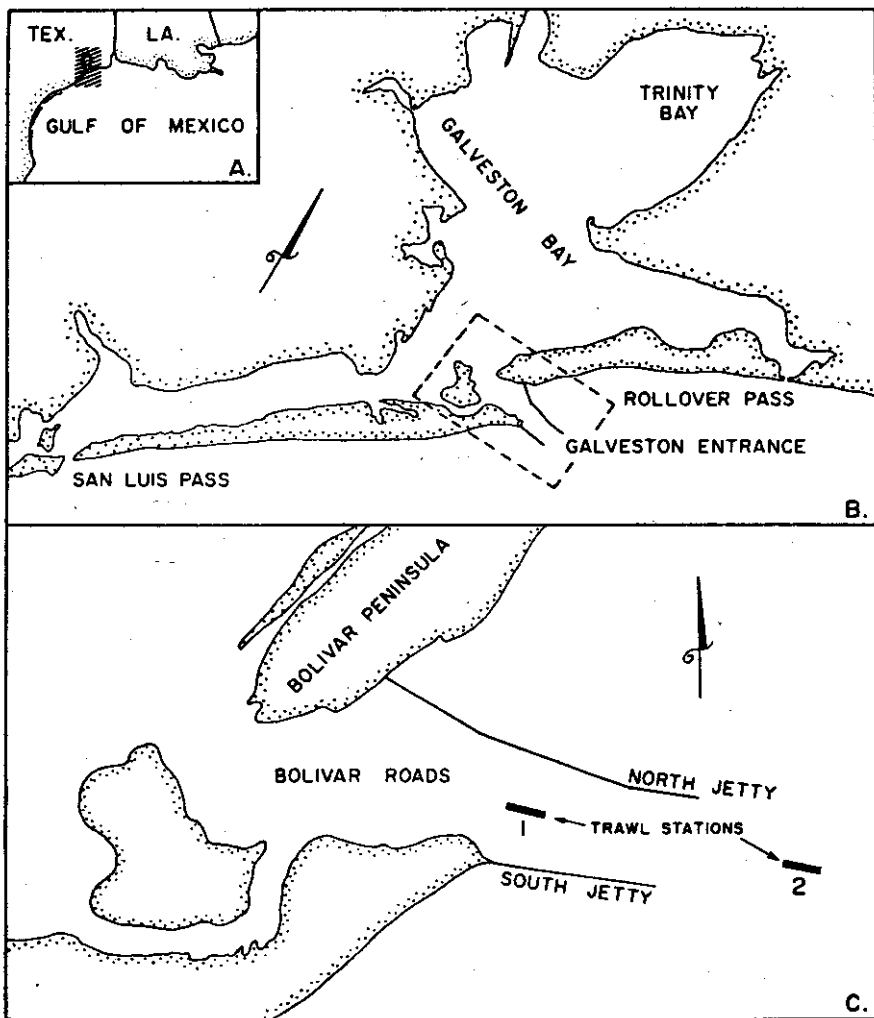


Fig. 1. The Galveston Bay system and Bolivar Roads tidal pass showing locations of station at which trawl samples were taken.

Samples used to estimate abundance and the size at emigration were taken, usually at 4-day intervals, from May 18 to August 1, 1966, with an otter trawl that had an opening of 2 x 10 feet. The cotton webbing had stretched mesh of 1.5 inches in the body and 1.1 inches in the cod end. Bottom and surface samples were taken by using regular and converted otter boards, respectively. Occasional mid-water tows were made with the bottom trawl by letting out only a short length of towing cable. A few samples were taken during flood tides. Shrimp caught in the mid-water tows or on flood tides were not used in the analyses of catch per unit of effort.

Most of the samples were taken by towing the trawl 8 minutes against the ebbing tides from the 40-foot vessel TOMMY BOX at an engine speed of 900 r.p.m. Samples were taken both day and night, usually within 2 hours of maximum ebb tide as predicted by the U.S. Coast and Geodetic Tide Tables (1966). I observed the direction of water flow past a buoy adjacent to station 1 to insure that the samples were collected during ebbing tides.

Total length (tip of rostrum to tip of telson) of all brown shrimp caught was measured to the nearest millimeter immediately after capture.

### **Abundance**

Summary statistics for the analyses of catch per unit of effort (Tables 1 and 2) indicate that the mean number of brown shrimp caught per minute (efficiency) at station 1 was greatest on the bottom during the day and greatest at the surface at night. Catch-per-minute data used to compute the weighted means shown in the last row of Table 2 were compared by analysis of variance (Steel and Torrie, 1960: 134). A significant difference was not found ( $F=1.66$ ;  $F_{.05}=2.49$  for 2 and 15 d.f.). I think, however, that the difference in the estimates of mean catch per minute shown in the bottom line of Table 2 are real, but the high variability and the small number of sampling dates available for comparison made it impossible to support the view statistically. If the differences are real, the relative efficiencies shown in the bottom line of Table 2 indicate that the shrimp were near the surface at night and near the bottom during the day.

All data shown in Table 1 were combined by date to estimate the relative abundance of brown shrimp as they emigrated through the tidal pass (Table 2 and Fig. 2). I assume that Fig. 2 accurately depicts the two major peaks of emigration during the sampling period, the first in mid-May and the second in mid-June. Brown shrimp were leaving the bay system when I started sampling (May 18). Thus, the magnitude of the first peak and the timing of emigration in May are unknown.

### **Size at Emigration**

The mean lengths of brown shrimp taken during the day and night with bottom and surface trawls on the same sampling date were similar (Table 3). Mean lengths of brown shrimp taken in the tidal pass and in the Gulf of Mexico on a given sampling date were similar also. On May 18, the mean length of 190 shrimp from station 1 was 58.0 mm and the length for 40 shrimp from station 2 was 62.0 mm. On May 30, 226 shrimp

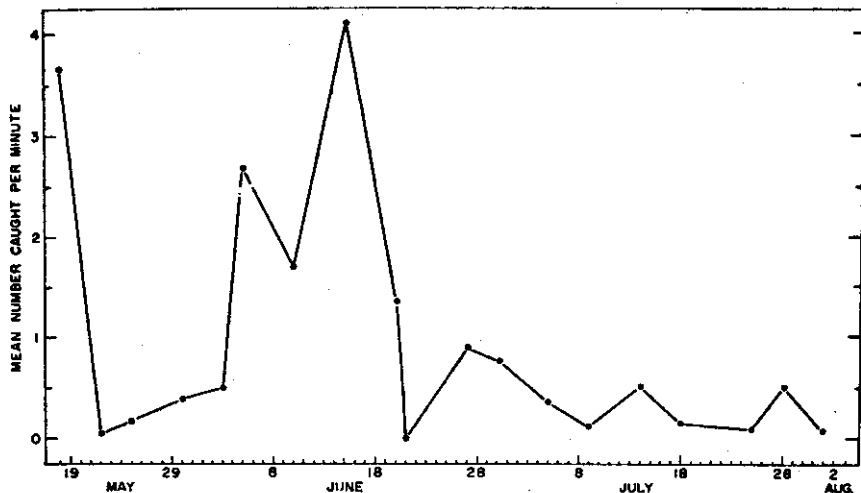


Fig. 2. Catch of brown shrimp per trawling minute as they emigrated through the Bolivar Roads tidal pass.

caught at station 1 on both ebb and flood tides had a mean length of 81.7 mm and 222 shrimp from station 2 had a mean length of 76.6 mm.

All shrimp caught at station 1 were combined by weekly intervals to represent the size of emigrating brown shrimp during the study (Fig. 3). In addition to the shrimp used in the catch-per-unit-of-effort analyses (Table 1), the graph in Fig. 3 includes 402 shrimp taken during flood tides and 129 taken with a mid-water trawl at station 2 (27 shrimp were discarded because they were too mutilated to measure).

Brown shrimp caught from May 14 to 21 had a mean length of 58.0 mm (Fig 3). Mean length was much greater (79.7 mm) the following week (May 22 to 28) and then the mean lengths tended to increase gradually for the remainder of the sampling period. The weekly length frequencies approximated normal distributions.

A linear relation between mean length and the time at emigration of brown shrimp is shown in Fig. 4. The null hypothesis that the regression coefficient ( $b = 3.61$ ) was equal to zero was tested to determine if the mean sizes were similar at different times. The hypothesis was rejected ( $t = 9.02$ ;  $t_{.01} = 3.17$  for 10 d.f.). I concluded that size at emigration increased significantly during the study.

### SUMMARY

Peaks in abundance of brown shrimp emigrating from the Galveston Bay system occurred in May and June 1966. The mean number of brown shrimp caught per minute was greatest on the bottom during the day and greatest at the surface at night. The mean lengths of brown shrimp taken during the day and night with bottom and surface trawls on the same sampling date were similar. The size of the emigrating shrimp increased significantly as the season progressed.

TABLE 1

NUMBER OF TOWS, TOWING TIME, AND NUMBER OF BROWN SHRIMP CAUGHT IN TRAWL SAMPLES  
TAKEN ON EBBING TIDES AT STATION 1 IN THE TIDAL PASS

Date (1966)	Surface						Bottom					
	Day			Night			Day			Night		
	Number of tows	Number trawling minutes	Number shrimp caught	Number of tows	Number trawling minutes	Number shrimp caught	Number of tows	Number trawling minutes	Number shrimp caught	Number of tows	Number trawling minutes	Number shrimp caught
May												
18				3	25	118	4	30	83			
22							3	20	1			
25							3	25	4			
30				4	32	13						
June												
3							5	40	20			
5												
10				2	11	29						
15				7	56	94						
20				10	80	327						
21	1	8	0	4	32	146						
27	4	32	0	3	24	0						
30	4	32	0	6	44	1						
July				12	80	134						
5												
9	2	12	0	8	64	23						
14	1	8	0	6	48	39						
18	3	24	1	8	64	14						
25	1	8	0	9	72	8						
28	1	8	0	4	36	33						
August												
1				5	40	5						
Totals	17	132	1	56	432	395	72	572	842	43	335	150

TABLE 2

THE MEAN NUMBER OF BROWN SHRIMP CAUGHT PER MINUTE IN TRAWL SAMPLES  
TAKEN ON EBBING TIDES AT STATION 1 IN THE TIDAL PASS

Date (1966)	Surface		Bottom		All data combined
	Day	Night	Day	Night	
May					
18			4.72	2.77	3.65
22				0.05	0.05
25				0.16	0.16
30			0.41		0.41
June					
3				0.50	0.50
5			2.64		2.64
10			1.68		1.68
15			4.09		4.09
20 <sup>1</sup>	0.00	4.56	0.88	0.22	1.34
21		0.00		0.00	0.00
27 <sup>1</sup>	0.00	0.02	4.37	0.06	0.92
30 <sup>1</sup>	0.00	1.67	0.49	0.19	0.82
July					
5		0.36			0.36
9	0.00			0.34	0.27
14 <sup>1</sup>	0.00	0.81	0.19	0.25	0.52
18 <sup>1</sup>	0.04	0.22	0.09	0.29	0.17
25	0.00		0.11		0.10
28 <sup>1</sup>	0.00	0.92	0.12	0.25	0.50
August					
1		0.12		0.02	0.07
Weighted mean —					
all samples	0.01	0.91	1.47	0.45	
Weighted mean —					
selected samples	0.01	1.21	0.85	0.22	

<sup>1</sup> Selected samples

TABLE 3

MEAN LENGTH (MILLIMETERS) OF BROWN SHRIMP CAUGHT AT STATION 1 ON EBB TIDES DURING THE DAY AND NIGHT  
AND AT THE SURFACE AND ON THE BOTTOM

Date (1966)	Day		Night		Difference	Surface		Bottom		Difference
	Number of shrimp	Mean length	Number of shrimp	Mean length		Number of shrimp	Mean length	Number of shrimp	Mean length	
May 18	109	58.5	81	57.5	+1.0					
July 20	92	89.1	150	80.5	+8.6	96	88.8	146	80.5	+ 8.3
27	105	90.8	2	84.5	+6.3					
30	47	90.0	137	92.3	-2.3	50	89.2	134	92.7	- 3.5
July 14	3	95.2	42	99.7	-4.5	7	92.4	39	100.5	- 8.1
18	3	99.3	21	99.6	-0.3	10	104.6	15	96.2	+ 8.4
28	3	103.6	33	108.4	-4.8	5	97.2	33	109.4	-12.2



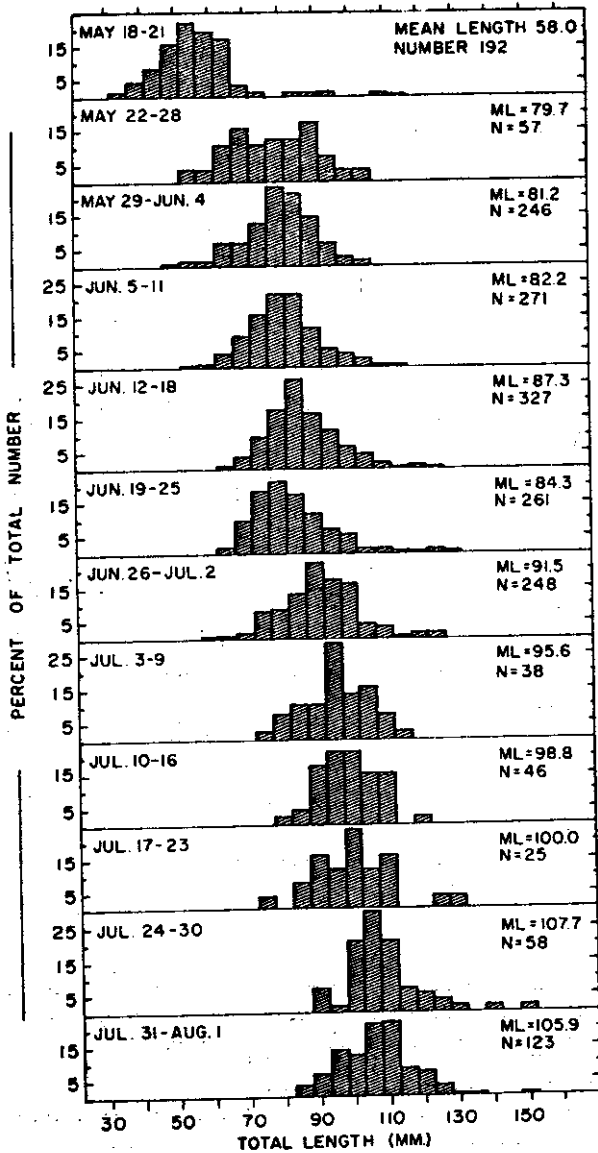


Fig. 3. Length-frequency distributions by week of brown shrimp caught in the Bolivar Roads tidal pass.

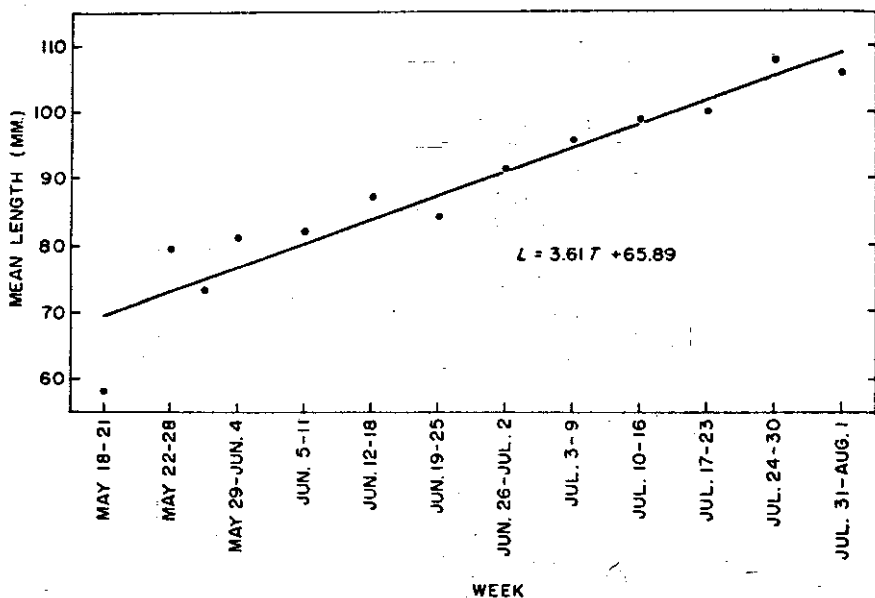


Fig. 4. Increase in mean length of brown shrimp caught in the Bolivar Roads tidal pass, May 18-August 1966.

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