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Diel and Seasonal Occurrence of Pink Shrimp, Penaeus duorarum Burkenroad, in Two Divergent Habitats of Tampa Bay, Florida

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ABSTRACT

Pink shrimp, Penaeus duorarum, were sampled for 17 months in two divergent habitats in Tamp Bay, Fla. Information was obtained on size and sex of the shrimp, water temperature, salinity, light transmission, and activity in relation to moon phase. Catches were larger during darkness and rose as temperature decreased from about 30° C. to 14° C. Larger shrimp were caught in darkness than in daylight throughout the period. Larger shrimp were also caught at the station having lowest salinity and incidence of transmitted light. In dark phases of the moon greater numbers of shrimp were caught than during light phases. The size of shrimp reached a peak in April and May after an average increase in length of about 1 mm. carapace length per month. Female shrimp were larger than males in all samples except two.

INTRODUCTION

The pink shrimp, Penaeus duorarum, is one of three principal penaeids caught in the Gulf of Mexico and along the southeastern coast of the United States. It supports a sizable bait-shrimp fishery in Tampa Bay, Fla., and is occasionally harvested offshore near the Bay (Saloman, 1965). This report results from ecological investigations in Tampa Bay and concerns some of the habits of pink shrimp and their abundance in relation to biological and hydrological factors. The importance of understanding inshore behavior and development of young shrimp lies in the fact that estuaries serve as nurseries for shrimp which as adults support offshore commercial fisheries. The significance of the estuary in the life cycle of certain penaeid shrimp is widely recognized.

Diel sampling was undertaken at two Tampa Bay stations representing different types of habitat. The Egmont Key station (fig. 1) is in relatively clear water, has a depth of 4 to 6 m., and swift tidal currents (1.5 knots; U.S. Coast & Geodetic Survey, 1951). Mean salinity was 33.2 p.p.t., and the range was 29.3 to 35.2 p.p.t. Attached vegetation (Thalassia testudinum and Syringodium filiforme) was abundant in each sampling period, but the plants became partially defoliated during the winter. Bottom sediments were a fairly uniform

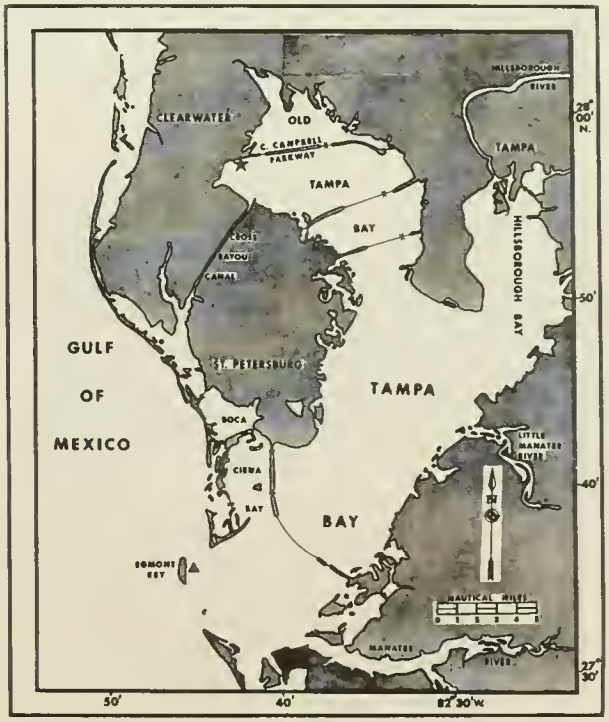

Figure 1.--Sampling stations in Tampa Bay, Fla.--Egmont Key (triangle) and Old Tampa Bay (star).

sand-shell mixture. The most common macroinvertebrates in the area were pink shrimp, arrow shrimp (Tozeuma carolinense), and the portunid crab (Portunus gibbesi).

The station in Old Tampa Bay is off the southwestern edge of Courtney Campbell Parkway in fairly turbid water of 2 to 3 m. depth, and minor tidal currents (0.5 knot; U.S. Coast & Geodetic Survey, 1951). Mean salinity was 22.7 p.p.t., and the range was 19.6 to 25.4 p.p.t. The bottom lacked attached vegetation, but several species of red and green algae (Gracilaria spp. and Ulva lactuca Linnaeus) were noted occasionally. Bottom sediments were a silty-sand mixture. The most abundant macroinvertebrates in the area were pink shrimp, blue crab (Callinectes sapidus), and squid (Lolliguncula brevis)--Dragovich and Kelly (1964).

Results of systematic sampling to determine the diel habits of pink shrimp have not been reported previously, although Eldred, Ingle, Woodburn, Hutton, and Jones (1961) made limited observations in Tampa Bay.

PROCEDURE AND EQUIPMENT

The two stations were occupied eight times each for 24-hour periods in alternate months from August 1962 through December 1963. Shrimp were taken at 3-hour intervals with a 4.9 m. (16-ft.), nylon, semiballoon shrimp trawl of 3.8 cm. (1-1/2 inch) stretch mesh webbing in the body and bag, and an inner liner of 1.2 cm. (1/2-inch) stretch mesh in the cod end. Tows were made for 10 minutes at 3 to 4 knots from the R. V. Kingfish.

Hydrological measurements were made prior to the collection of shrimp samples. Salinity samples were taken with modified Van Dorn sampling bottles (Van Dorn, 1957) and analyzed according to the methods described by Saloman, Finucane, and Kelly (1964). Water temperature was taken with a Whitney[1] underwater thermistor. A Kahl submarine photometer equipped with deck and sea cells was used to measure light intensity in microamps for later conversion to percentage light transmission. Water samples and measurements were taken at surface, middepth, and bottom.

Shrimp were preserved in 10 percent buffered formalin immediately after collection. Later, the carapace length was measured with vernier calipers and the sex determined.

DIEL FLUCTUATIONS OF CATCH AND SIZE OF PINK SHRIMP IN RELATION TO LIGHT

At Egmont Key, 779 pink shrimp were caught (table 1) along with specimens of Trachypeneus sp. and Sicyonia sp. In the same period and with identical effort and procedures, 454 pink shrimp were caught in Old Tampa Bay (table 2).

Table 1.--Pink shrimp caught during diel sampling at Egmont Key, Fla.

Date	Time of sampling									
	0900	1200	1500	1800	2100	2400	0300	0600	0900	Total
1962					Number					
Aug. 30-31..	1	--	--	--	40	13	2	--	--	56
Oct. 29-30..	--	--	--	--	13	5	22	--	--	40
Dec. 20-21..	2	2	--	2	121	31	23	6	4	191
1963										
Mar. 25-26..	--	--	--	--	5	12	9	6	1	33
May 23-24...	--	--	--	--	9	4	4	--	--	17
July. 8-9...	--	--	--	--	36	22	17	5	--	80
Oct. 3-4....	--	--	--	--	3	4	--	--	1	8
Dec. 12-13..	1	2	--	2	20	154	110	64	1	354
Total.....	4	4	--	4	247	245	187	81	7	779

Table 2.--Pink shrimp caught during diel sampling in Old Tampa Bay, Fla.

Date	Time of sampling									
	0900	1200	1500	1800	2100	2400	0300	0600	0900	Total
1962					Number					
Sept. 27-28.	11	2	--	1	11	1	7	11	5	49
Nov. 29-30..	11	4	6	1	28	26	20	16	4	116
1963										
Feb. 27-28..	1	1	--	--	6	5	9	2	1	25
Apr. 25-26..	--	4	2	3	10	--	44	--	--	63
Jun. 19-20..	--	--	--	--	1	--	--	--	--	1
Aug. 27-28..	--	2	3	4	26	25	34	4	2	100
Oct. 24-25..	7	4	11	20	6	17	5	3	--	73
Dec. 18-19..	--	1	1	2	7	10	4	1	1	27
Total.....	30	18	23	31	95	84	123	37	13	454

Catches of shrimp at both stations were inversely related to the amount of light transmitted to the bottom (fig. 2). The nocturnal catch (2100, 2400, and 0300 hours) at Egmont Key accounted for 87 percent of the total catch at this station; catches in "marginal" light (1800 and 0600 hours) and daylight (0900, 1200, and 1500 hours) accounted for 11 percent and 2 percent. In Old Tampa Bay the nocturnal catch was 67 percent and the catches by daylight and marginal light were 18 percent and 15 percent. Pink shrimp are generally considered nocturnal (Eldred, et al., 1961; Fuss and Ogren, 1966; and others), but a few daytime captures have been recorded in muddy water, during ground swells, or under cloudy skies (Eldred, et al., 1961; Hildebrand, 1955; and Fuss, 1964). Altough the water is shallower in Old Tampa Bay than at Egmont Key, the periods of light intensity are less sharply defined in Old Tampa Bay because of the higher turbidity (table 3).

Although pink shrimp are far more active at night than during the day, Aaron and Wisby (1964) reported that in laboratory experiments more than half of the shrimp in the

[1] References to trade names in this publication do not imply endorsement of commercial products.

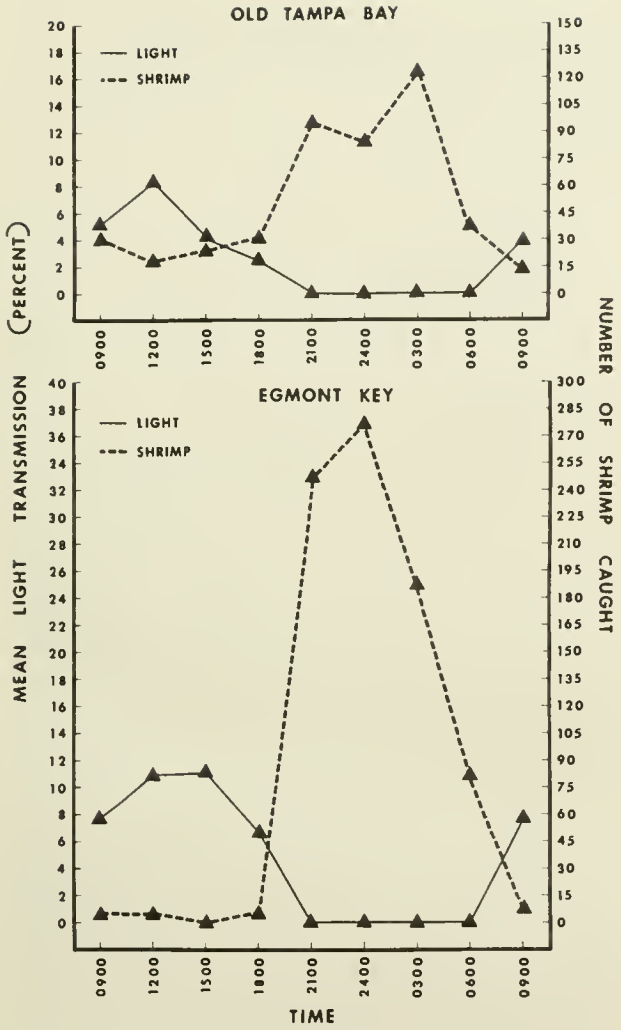

Figure 2.--Catch of pink shrimp and mean percentage of light transmitted to the bottom, Egmont Key and Old Tampa Bay stations.

size range 55 to 105 mm. (total length) showed positive phototaxis at 0.3 foot-candle (3.229 lumens per $m.^2$). Shrimp showing a phototactic drive (movement through an alternating current toward a light source) ranged from 27 percent to 68 percent in different

Table 3.--Light transmission at different times and depths at Egmont Key and Old Tampa Bay, Fla.

Station and item	0900	1200	1500	1800	0900	Summary of mean values
Egmont Key			Percent			
Surface mean[1]....	46.6	59.5	60.8	47.5	54.7	53.8
Middepth mean....	17.6	26.4	28.4	16.3	18.9	21.5
Bottom mean.....	7.7	10.9	11.1	6.7	7.7	8.8
Old Tampa Bay						
Surface mean[1]....	37.5	44.3	36.8	38.2	47.1	40.8
Middepth mean....	13.8	19.5	15.3	8.5	12.3	13.9
Bottom mean.....	5.1	8.3	4.2	2.5	3.9	4.8

[1] About 45 cm. below surface.

lots; those measuring 90 mm. showed the least phototactic drive. A difference in reaction to light in relation to size was also shown by Fuss and Ogren (1966), who observed that large pink shrimp were more sensitive to light than small ones, and by Eldred et al. (1961), who found that larger pink shrimp were caught at night than by day. In the present study the size range was wide throughout the 24-hour periods and varied most in darkness. Slightly larger specimens were caught in darkness than in daylight at Egmont Key (table 4), but not in Old Tampa Bay (table 5).

Females were larger than males in all samples of pink shrimp except two from Egmont Key (tables 4 and 5). Similar sex differences in the size of pink shrimp were also noted by Eldred et al. (1961), Broad (1950), Williams (1955a), and Saloman (1965).

Larger pink shrimp were taken at lower salinities (Old Tampa Bay station, table 5) than at higher salinities (Egmont Key, table 4), but the significance of this difference is questionable. The size differences could be attributed also to the amount of light reaching the bottom. Light penetration was considerably greater at Egmont Key than in Old Tampa Bay. If light controls activity of larger animals more than salinity as reported by Fuss and Ogren (1966), an explanation is provided for the capture of larger shrimp in the lower salinity of Old Tampa Bay. Lindner and Anderson (1956) took larger shrimp in lower

Table 4.--Number, size (carapace length, millimeters), and sex of pink shrimp caught at Egmont Key, Fla., at different hours

Sex and item	Time									
	0900	1200	1500	1800	2100	2400	0300	0600	0900	Total
Females										
Number.....	1	2	--	--	112	122	85	34	4	360
Mean length..	15.3	16.1	--	--	17.0	18.1	17.0	16.8	16.6	17.3
Range.....	15.3	14.9-17.3	--	--	8.0-31.7	11.4-39.0	9.6-29.6	10.6-30.0	10.8-24.3	8.0-39.0
Males										
Number.....	3	2	--	4	135	123	102	47	3	419
Mean length..	14.5	13.2	--	16.0	16.5	16.9	17.4	15.4	19.2	16.7
Range.....	11.1-18.2	10.2-16.0	--	13.3-19.2	7.1-27.7	7.1-28.9	10.2-25.4	9.5-21.2	15.7-21.6	7.1-28.9

Table 5.--Number, size (carapace length, millimeters), and sex of pink shrimp caught in Old Tampa Bay, Fla., at difference hours

Sex and item	Time									
	9000	1200	1500	1800	2100	2400	0300	0600	9000	Total
Females										
Number.....	16	13	16	22	50	53	66	17	8	261
Mean length..	13.7	19.5	19.4	19.7	20.0	18.6	20.6	17.9	20.1	19.3
Range.....	8.7-26.8	10.7-33.7	11.0-29.4	10.2-31.3	5.5-30-4	9.1-34.3	8.7-31.8	11.2-27.0	14.9-26.3	5.5.-34.3
Males										
Number.....	14	5	7	9	45	31	57	20	5	193
Mean length..	11.7	16.2	16.9	17.7	16.6	16.2	19.3	16.0	13.8	16.9
Range.....	7.3-20.1	9.0-24.1	13.2-19.9	10.1-30.1	8.6-24.3	8.6-26.3	9.3-27.2	11.8-19.7	8.0-21.5	7.3-30.1

salinities on a few occasions and concluded that size was related more closely to locality than salinity. This finding is not in agreement with other reports on size in relation to location and salinity of an estuary. Gunter, Christmas, and Killebrew (1964), Williams (1955a, b), Tabb, et al. (1962), and Saloman (1965) concluded that an increase in shrimp size usually accompanies an increase in salinity. Obviously the relative influence of various factors on the size of shrimp captured will not be easy to determine.

The 16 sampling series were conducted during periods of moon phases as follows: new moon, 11 series; first quarter, 2; full moon, 2; and last quarter, 1 series. Although cloud cover at night was not recorded and results are not conclusive, greater numbers of pink shrimp were caught during the dark phases (new moon, first quarter, and last quarter) of the lunar cycle than during the light phase (full moon)--table 6.

Various authors have mentioned that availability of pink shrimp varies with moon phases--that more are caught during the dark or new moon phase (Iversen and Idyll, 1959; Fuss, 1964; Idyll, Iversen, and Yokel, 1965). Perhaps the greatest effect of the moon on shrimp behavior is through the intensity of light (Wheeler, 1937; Fuss and Ogren, 1966). In that event a correlation between catch and moon phase would be expected since light intensity in the first and last quarters is only one-ninth of the moon's total intensity.

Table 6.--Pink shrimp caught at Egmont Key and in Old Tampa Bay, Fla., (data combined) during various moon phases

Moon phase	Diel samples	Total shrimp	Mean sample
	Number	Number	Number
New.....	11	781	71
First quarter..	2	173	86
Full.....	2	88	44
Last quarter...	1	191	191

SEASONAL CHANGES IN ABUNDANCE AND SIZE OF PINK SHRIMP

The mean size (CL) of pink shrimp caught in Tampa Bay showed an average increase of 1.2 mm. per month from August 1962 through May 1963 (fig. 3). Small shrimp started to appear again in June and July. The mean size at Egmont Key steadily increased from July to mid-December 1963. In Old Tampa Bay mean sizes increased from a low of 5.5 mm. CL in June to 19.5 mm. CL in August 1963 and then decreased slightly.

Growth rates at Egmont Key were similar in both years; shrimp gained about 0.7 mm. per month from August through December 1962, and 0.4 mm. per month from July through December 1963. The size increase was greatest from December 1962 through May 1963 when the rate was about 1.5 mm. per month. Mean sizes of pink shrimp at Egmont Key caught during October through December of both 1962 and 1963 were almost identical (fig. 3).

Mean size of pink shrimp reached a peak at both stations in April or May but decreased sharply by June or July (fig. 3). The absence of large pink shrimp in Tampa Bay in June, after a gradual increase ending in April and May, appears to have resulted from the movement of shrimp to offshore waters. Eldred, et al. (1961) found that larger shrimp (85-140 mm. total length) migrated out of Tampa Bay from April through July. Commercial shrimp boats seen offshore by Eldred, et al. (1961) in 1958, by Saloman (1965) in March and April 1963, 1964, and 1965, and by the author again in 1966 also give evidence of a migration from Tampa Bay in the spring.

Catches of pink shrimp increased as temperature decreased to 14° C., but declined at temperatures below this level (fig. 4). Eldred, et al. (1961) and Williams (1955a) suggested that pink shrimp remain in the sediment during cold periods, and Williams also mentioned

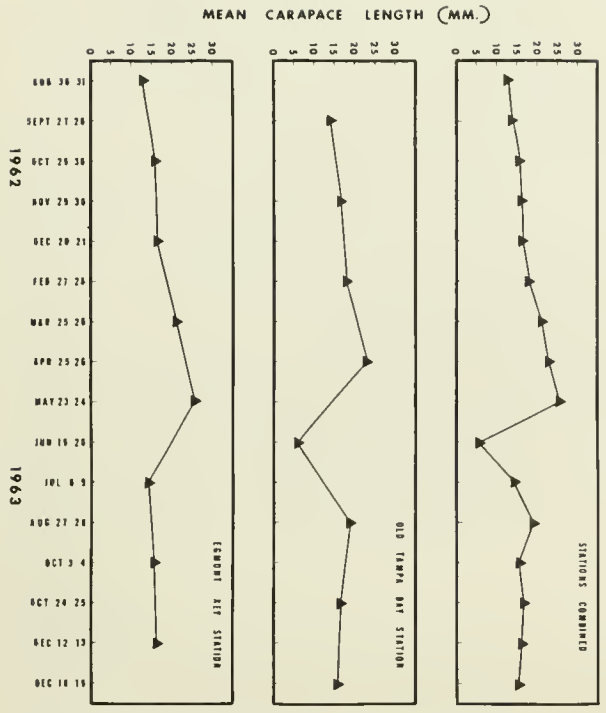

Figure 3.--Mean size of pink shrimp caught on different dates in Old Tampa Bay and at Egmont Key, Fla.

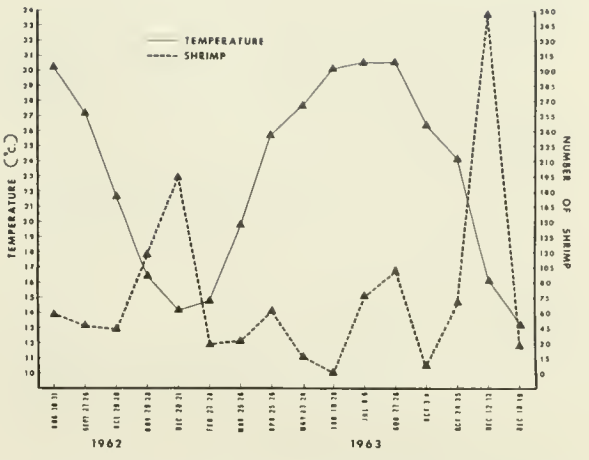

Figure 4.--Number of pink shrimp caught in Old Tampa Bay and at Egmont Key (data combined) in relation to temperature.

that they become more active and numerous in a given area when water temperature had risen to 15° C. Fuss and Ogren (1966) found that they tend to remain burrowed at temperatures below 14° C. and to show an activity ratio of 50 percent or less regardless of light levels or moon phase. Tabb, et al. (1962) suggested that they might move into deeper water.

Catches also varied between stations by month (tables 1 and 2). In general, catches were lowest in the spring and early summer, and peaks generally came in the fall and early winter.

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