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Chairman—MANUEL ZEPEDA GARCIA, *President, Shrimp Association of the Americas, Mexico City, D.F.*

Studies of the Brown Shrimp, *Penaeus aztecus*, in Barataria Bay, Louisiana, 1962-1965

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Abstract

Initial studies on the brown shrimp were carried out in Barataria Bay in 1962 (St. Amant, Corkum, and Broom, 1962). Information gained by this work justified a continued and expanded effort. Accordingly, postlarval investigations were broadened to include more frequent sampling of the major passes, grid sampling of the bay, and 24-hour samplings of a major pass. Juvenile studies, including distribution, relative abundance, and growth, were intensified by sampling the bay system at weekly intervals throughout the study. These data were discussed in terms of hydrographic information obtained for this area. Correlations between these shrimp studies and landings data were offered. Some implications of the shrimp's habits in this nursery area during early juvenile stages were discussed in terms of these observations.

INTRODUCTION

SHRIMP RESEARCH in Louisiana was begun intensively in 1962 when, as a part of the coordinated shrimp research program of the Gulf States Marine Fisheries Commission, this state initiated quantitative studies of the shrimp cycle on an annual basis. A preliminary report of this work was made in 1962 (St. Amant et al., 1962). In this report is presented an analysis of data representing four complete brown shrimp cycles between 1962 and 1965. An effort is made herein to compare the four cycles as to timing and ultimate production. Environmental parameters are discussed and correlated with each cycle, and those factors which appear to have more influence are identified.

In order that this discussion involve the most reliable and complete data, only findings from the Greater Barataria Bay area, a semi-enclosed system, are considered here (Fig. 1). Intensive work has been carried out in this area for the four year period and should allow for a reliable comparison of the four cycles.

MATERIALS AND METHODS

Postlarval samples on a regular basis were first taken in the summer of 1961 (George, 1962). Inshore stations were made with a 6-foot beam net similar to

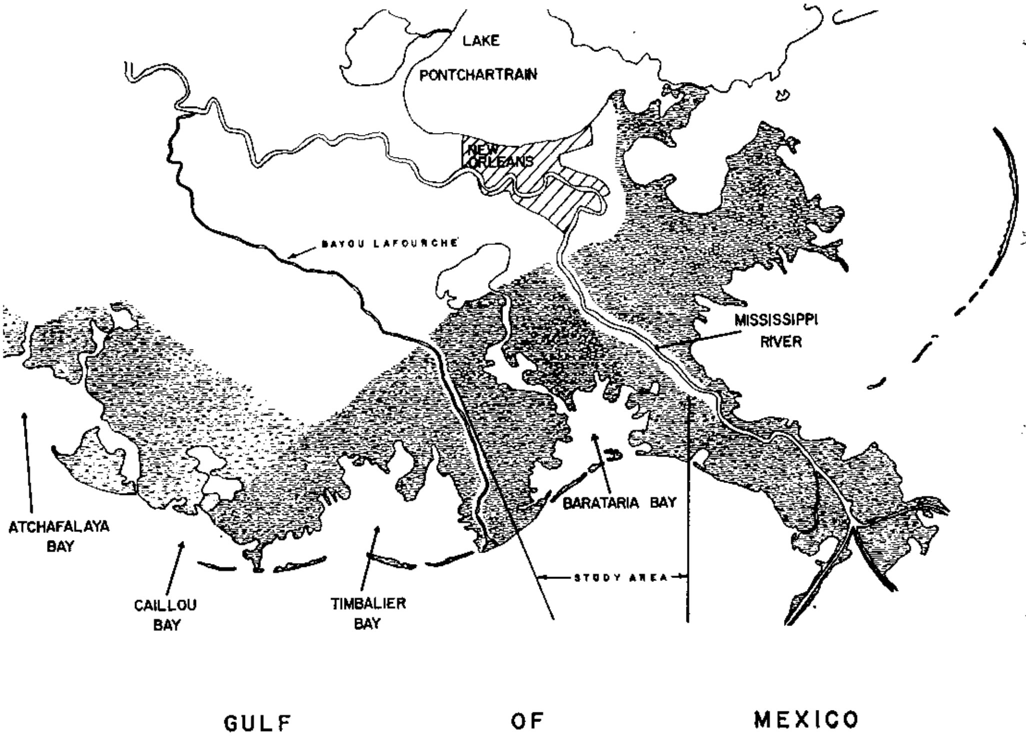

Fig. 1. VICINITY MAP SHOWING GREATER BARATARIA AREA

that reported by Renfro (1960). The beam net in this study has a No. 2 Clark-Bumpus tail connected to a 1-millimeter mesh throat by a 5-inch steel ring. Offshore samples were made with a 0.5-meter 175 micron-mesh net similar to the "Gulf V." Each net was towed from a boat for 10 minutes at each sample station. In the spring of 1962 offshore postlarval samples were discontinued and a more concerted effort was made inshore. The three major entrances into Barataria Bay were sampled weekly as well as nine stations throughout the bay system. This was carried out through September of 1963 when the bay stations were abandoned and the three passes were sampled every weekday that weather permitted. Top and bottom salinities and temperatures were recorded during the sample at each of the three passes.

In the summer of 1963, a 24-hour sampling effort was begun using the 6-foot beam net at a station established in one of the deeper channels in Caminada Pass. A boat was tied to the bridge pilings and the net was fished in the tidal current for 10 minutes at 2-hour intervals.

In the summer of 1964, a grid sampling of a portion of the Greater Barataria Bay system was conducted. For each sample the 6-foot beam net was towed for 10 minutes within a 1000 yard square. All fishable waters were included in the sample area, such as, major passes, large and small bays, bayous, and marsh ponds.

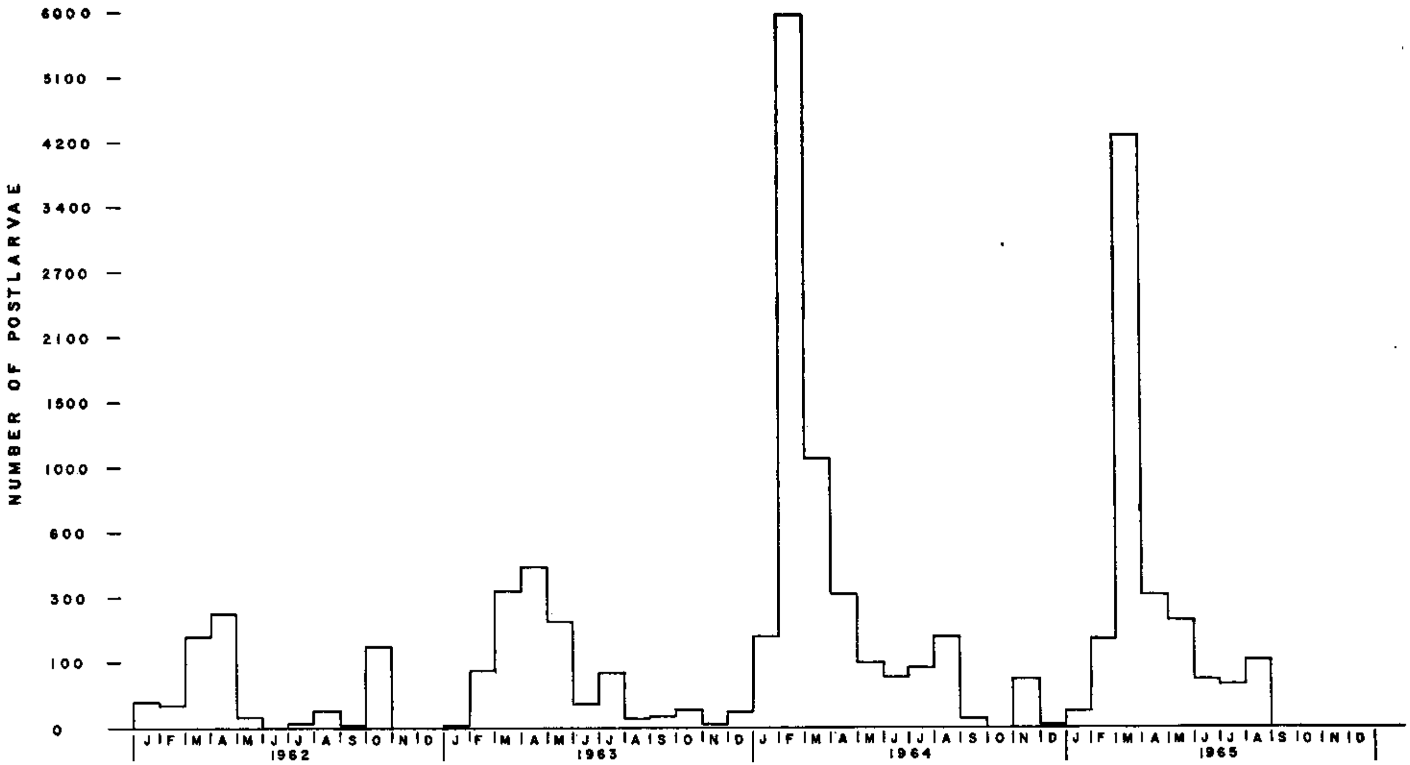

Fig.2.POSTLARVAL CATCH/120 MINUTES OF EFFORT: FOUR BAYOUS, BARATARIA, AND CAMINADA PASSES

Juvenile samples were made using a 6-foot, nylon, shrimp trawl with a ¼-inch mesh. These samples, of 10 minutes' duration, were made from both inboard and outboard boats. Juvenile, in this study, implies any shrimp caught in the 6-foot trawl and they ranged from 12 to 120 millimeters (mm) in length. Samples were made throughout the bay system, but were generally restricted to the shallow nursery areas with depths of 1 to 5 feet.

POSTLARVAL INVESTIGATIONS

Postlarval investigations were designed to determine the time of arrival, densities, and the peak movement of the postlarval population. Continuous data on salinity, water temperature, air temperature, wind direction and velocity, and tides, were taken at the level of the passes leading to the nursery areas. Correlations of these data with postlarval densities and movements were made in order to determine the factors which might control postlarval movements. Salinities and water temperatures were also taken at each station at the time of sampling.

Postlarval Recruitment, 1962-1965

The postlarval catch per 120 minutes of fishing effort for the three major passes for the four cycles between 1962-1965 is shown in Fig. 2. These data represent total catch and were not separated by species; however, that portion of the graph from January through May may be considered principally *P. aztecus* since *P. setiferus* is not present in numbers until June. As seen in Fig. 2, the postlarval population peaks occurred in April in 1962 and 1963, in February in 1964, and in March of 1965. These peak catches apparently represent the major influx of postlarvae into the bay system and should give an indication of the forthcoming shrimp crop.

It should be noted, however, that the total catch as well as the time of the peak occurrence varied considerably for the four year period. Obviously, the 1962 and 1963 catches were smaller than in 1964 and 1965. However, the greater catches in 1964 and 1965 may, in part, be a result of changes in sampling effort and technique which included an increase in effort after 1962 and a revision of the sampling time to fish the incoming tide after 1963. Though these two changes in sampling technique may have caused some increase in catch efficiency, nevertheless, it appears that the higher catches in 1964 and 1965 do represent a significant increase of postlarvae on the nursery grounds during these two years and should have resulted in a measurable increase in production. This, however, was not necessarily the case. An analysis of the data for 1962 and 1963 suggested an almost direct relationship between the postlarval catches and landings (Louisiana Wild Life and Fisheries Commission, 1964). When the data for 1964 and 1965 (Fig. 3) were considered, the same relationship did not exist. In this latter case, apparently heavy movements of postlarvae into the nursery area did not result in as high a production as might have been expected had the same correlation occurred in 1964 and 1965 as existed in 1962 and 1963. This suggests that the directness of relationship between postlarval catches and landings is governed by other factors which probably increase or decrease the mortality rate of postlarvae after they arrive on the nursery grounds. While it may take an analysis of many shrimp cycles in relation to environmental parameters to establish the exact causes of postlarval mortalities, it seems evident from these data that conditions in 1962 and 1963 were far more favorable to postlarval survival than in 1964 and 1965.

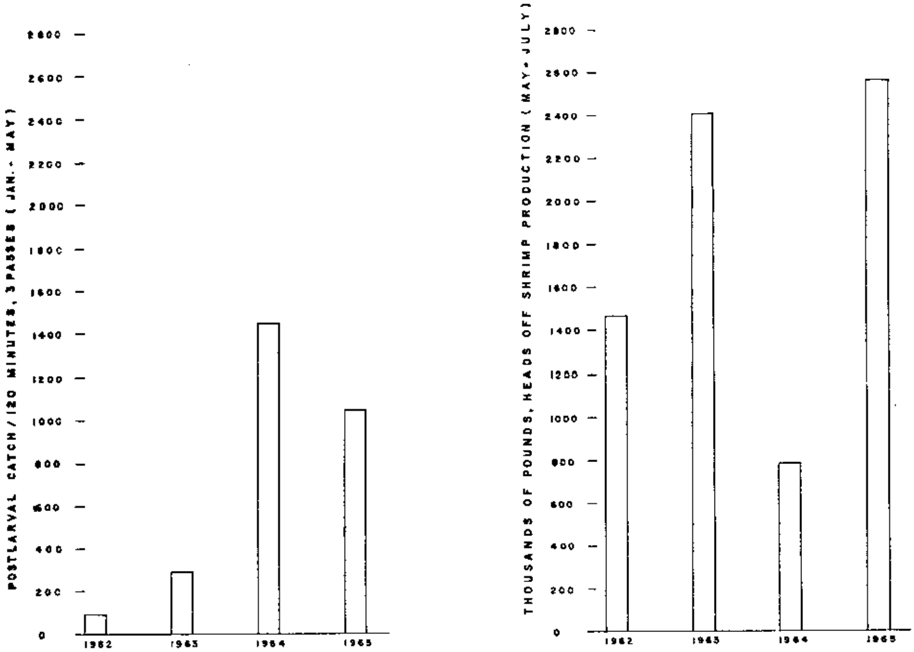

Fig. 3. COMPARISON OF POSTLARVAL DENSITY AND SHRIMP PRODUCTON: 1962-1965

Contrasting the cyclic timing and environmental factors which occurred in 1962 and 1963 with those from 1964 and 1965, some significant differences may be noted. In 1962 and 1963, peak postlarval movements occurred late after water temperatures exceeded 20C. Growth was rapid and conversion of the postlarval population to juvenile occurred in four weeks or less while subjected to water temperatures greater than 20C and salinities greater than 15 parts per thousand (ppt). In 1964 the postlarval peak occurred extremely early in February resulting in much longer exposure of postlarvae to temperatures below 20C, which delays growth; to large areas when salinities were below 8 ppt, which appears to be less suitable for survival; and, to a longer period of possible predation. In this instance great mortalities obviously occurred and the resulting production was even less than in preceding years when postlarval populations were low. One possible answer was the presence of a large number of small croakers during the early spring. In 1965 large numbers of postlarvae again occurred on the nursery grounds with the peak occurring in an intermediate position in March. Postlarval growth lagged until late April and presumably high losses did occur, since production, though good, was not as great as might have been expected from the large postlarval population.

Effects of Tides on Postlarval Movements

In early postlarval sampling efforts in 1962 and 1963 a wide variation in catch results was obtained. Some observations indicated a significant tidal effect on postlarval movements which, if true, would necessitate relating all

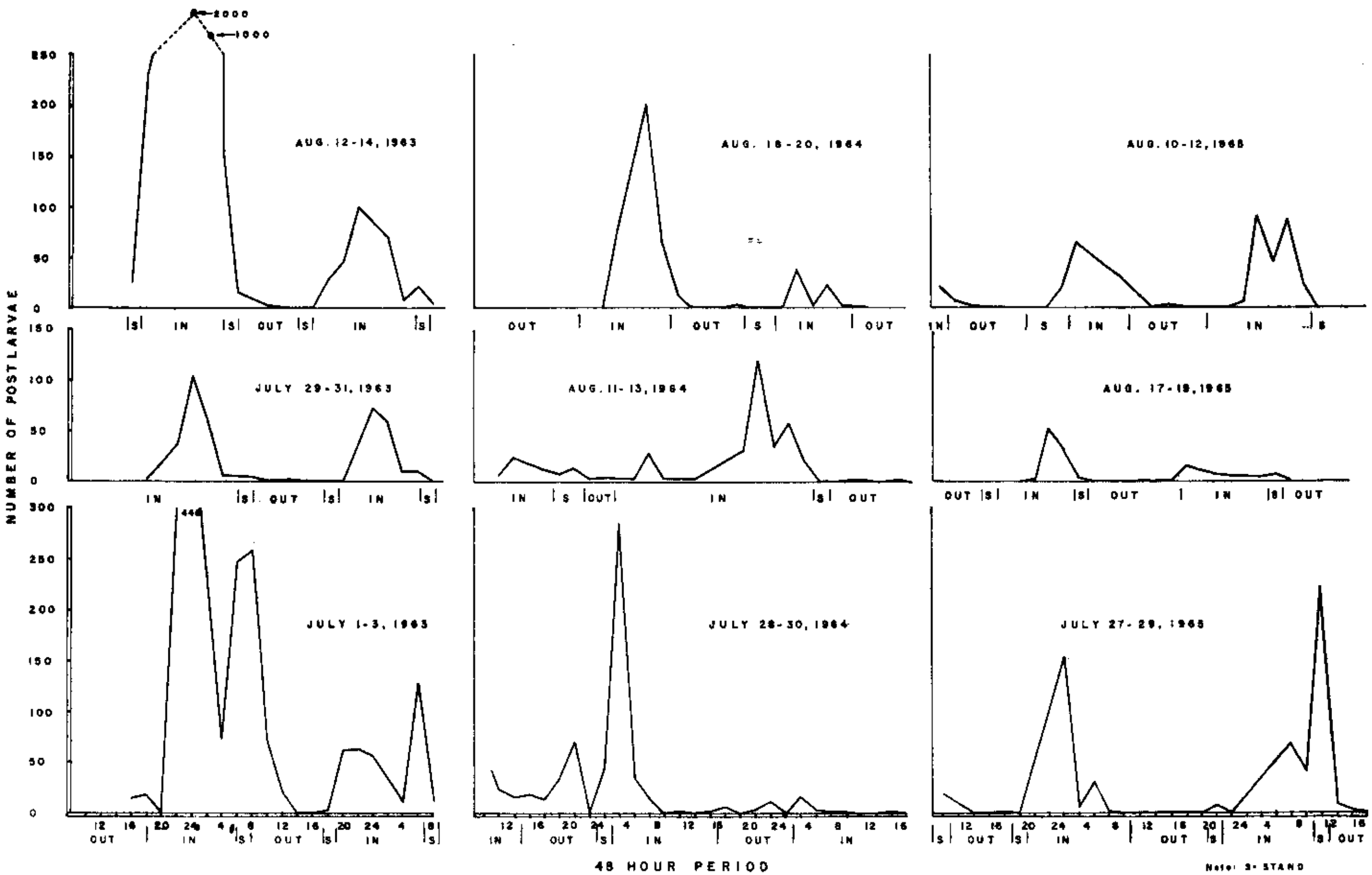

Fig. 4. COMPARISON OF TIDAL CYCLE AND POSTLARVAL CATCHES

postlarval sampling to the proper tidal phase. Therefore a study was begun in the summer of 1963 to determine tidal effects on postlarval recruitment. Samples were taken at 2-hour intervals during the 24-hour period. The total sampling effort was 144 hours in 1963, 173 hours in 1964, and 152 hours in 1965. All data from those experiments are presented in Fig. 4; an inspection of which shows that the preponderance of postlarval recruitment was on the incoming tide. No discernible difference was noted between nocturnal and diurnal sampling results during the period studied.

On the basis of a 2-hour sampling procedure, it appeared that a fairly sharp build-up of postlarvae was associated with each incoming tide. Apparently they move in some sort of sharp-sided wave as evidenced by an abrupt appearance of large numbers of postlarvae in the samples at some point on the incoming phase of the tidal cycle. Significant numbers of postlarvae then continue to occur in samples, in some instances, throughout the remainder of the incoming leg of the tidal cycle. This high catch rate may continue for as much as 12 hours if the onset of heavy movement occurs soon after the tide changes. In some cases a lag or delay in postlarval entry into the passes may occur resulting in heavy catches late in the incoming tidal phase. While the reasons for such lags are not clear, it is obvious that on some tidal exchanges a great many more postlarvae enter the nursery grounds than on others. In all cases it appears that outward movements of tidal flows reduce or prevent the movement of postlarvae into the nursery area. This being the case, it is suggested that all postlarval sampling procedures should be closely correlated with tidal exchanges.

Grid Sampling of Postlarvae

The period of bay sampling for postlarvae (1962-1963) previously men-

TABLE I

POSTLARVAL CATCH PER 10 MINUTE SAMPLE FOR NINE BAY STATIONS

Year	Month	Number of Stations	Postlarval Catch	Number of Postlarvae/10 Minute Sample
1962	March	33	116	3.5
	April	26	204	7.8
	May	43	1845	42.9
	June	36	2	0.06
	July	42	4	0.1
	August	36	1	0.03
	September	36	1	0.03
	October	33	0	0
	November	42	0	0
	December	23	0	0
1963	January	28	0	0
	February	29	7	0.2
	March	35	486	13.9
	April	24	435	18.1
	May	36	118	3.3
	June	36	46	1.3
	July	27	1	0.04
	August	24	20	0.8

tioned, Table 1, resulted in such variation in terms of catch that further work on this problem was suggested by statisticians studying the data. Accordingly, in the summer of 1964 a grid system for the Greater Barataria Bay area was established. The grid included 184 possible sample stations, consisting of 1000 square yards each. Each 10-minute sample covered approximately 1000 linear yards within the square. Weather permitting, 15 randomly selected stations were sampled 4 days each week for 1 month. These data are summarized in Table 2.

The grid study was designed to show the total surface population of the sample area. This population for each sample day is seen in Table 2 in the right hand column. These data confirmed that postlarval shrimp may be found in substantial numbers on occasion and at other times are entirely absent from bay surface waters. However, the excessive occurrence of such variability was considerably less using the random sampling of the grid system than when using fixed bay sampling stations. This reduction in variability resulted as the random sampling procedure satisfactorily sampled any postlarval movement regardless of its location in the bay, while fixed stations were successful only when postlarvae were in the vicinity of the station. This evidence substantiates the movement of postlarvae from the major passes, through the large bays, to the shallow nursery grounds in the marshes. Heretofore, this facet of the postlarval movement was assumed but not verified in this area.

TABLE 2

GRID STUDY — A RANDOM SAMPLING OF POSTLARVAE IN THE GREATER BARATARIA BAY AREA

Date	Number of Stations	Postlarval Catch	Number of PL/10 Minute Sample	Projected Total PL for 184 Stations
6-9-64	15	478	31.9	5864.1
10	15	290	19.3	3556.7
11	15	38	2.5	465.5
12	8	14	1.8	322.0
15	7	1	.1	25.8
16	15	8	.5	97.5
17	11	97	8.8	1622.9
18	15	57	3.8	699.2
19	8	0	0	
22	7	0	0	
23	15	0	0	
24	No Sample			
25	13	8	0.6	114.1
26	8	0	0	
30	15	15	1.0	184.0
7-1-64	15	13	.9	160.1

JUVENILE INVESTIGATIONS

In 1962 juvenile investigations were begun in the Greater Barataria Bay area. An intensive sampling program was carried out from March through mid-May (St. Amant et al., 1962). The knowledge gained from the 1962 data seemed to

TABLE 3
Weekly *Penaeus aztecus* Juvenile Data for 1962-1965

Years	Months	Weeks	Av. Water Temp. C.	Cumulative Av. Water Temp. C.	Av. Salinity ppt	Av. Length in mm	Incr. in Size in mm/day	Av. Catch/Sample	Total No. Shrimp Worked
1962	March	1	13.9	13.9	21.6				
		2	15.0	14.5	23.0				
		3	17.7	15.6	21.9				
		4	19.9	16.6	19.9	31		9	1225
	April	1	19.1	17.1	21.4	0		0	0
		2	22.6	18.0	19.0	—		*	—
		3	21.4	18.5	19.0	50.5	0.93	147	2491
		4	24.0	19.2	16.6	61	1.5	98	2341
		5	24.8	19.8	12.7	68	1.0	109	5433
	May	1	25.5	20.4	16.4	73.5	0.78	217	8871
		2	27.3	21.0	15.9	86	1.78	201	2608
		3	28.4	21.5	16.0	91	0.71	105	1263
		Total Av. Growth in mm/day					1.07		
1963	March	1	16.1	16.1	27.0				
		2	20.1	18.1	27.4				2
		3	19.8	18.7	26.2				2
		4	20.4	19.1	24.4	21.5		10	157
	April	1	22.7	19.8	19.9	26.5	0.72	26	1527
		2	21.8	20.1	23.9	36.5	1.43	87	21569
		3	23.2	20.6	23.2	43.0	0.93	145	2761
		4	26.1	21.3	19.9	60.0	2.46	106	3396
		5	23.8	21.5	20.1	72.5	1.78	150	3582
	May	1	24.2	21.7	25.9	77.0	0.64	192	7666
		2	25.7	22.0	28.2	78.0	0	244	3175
		3	26.5	22.4	23.4	77.0	0	113	1584
		Total Av. Growth in mm/day					0.99		
1964	March	1	16.7	16.7	27.7				
		2	18.5	17.6	23.9	15.0		2	8
		3	17.9	17.7	23.6	18.0	0.43	2	52
		4	17.6	17.7	22.2	22.5	0.57	2	106
	April	1	17.2	17.6	19.2	22.5	0	5	280
		2	19.9	18.0	17.0	31.0	1.28	23	298
		3	20.8	18.4	13.9	37.5	0.86	31	959
		4	24.2	19.1	14.9	43.5	0.86	24	806
		5	25.0	19.8	13.2	56.5	1.85	44	1710
	May	1	23.6	20.1	16.7	72.0	2.30	45	1658
		2	25.7	20.6	15.2	82.0	1.43	45	5386
		3	26.4	21.1	13.9	84.0	0.29	42	858
		Total Av. Growth in mm/day							
1965	March	1	14.1	14.1	17.5	31.0		5	136
		2	15.4	14.8	25.7	34.0	0.43	8	488
		3	17.5	15.7	25.9	32.5	0	8	81
		4	16.3	15.8	22.5	33.5	0	3	81
	April	1	20.8	16.8	22.0	33.0	0	8	459
		2	24.9	18.2	15.5	31.0	0	22	1301
		3	25.0	19.1	15.0	36.5	0.79	68	2030
		4	24.6	19.8	18.1	40.5	0.57	87	3046
		5	24.4	20.3	15.8	57.0	2.50	307	5840
	May	1	24.6	20.8	17.5	59.5	0.36	152	1751
		2	25.9	21.1	13.5	—	*	—	—
		3	25.2	21.4	13.4	73.5	1.00	353	2830
		Total Av. Growth in mm/day							

*No Sample

show several important characteristics of the shrimp population. Therefore, sampling effort was greatly increased in 1963 by making more samples in this area to improve the reliability of the previous year's work. Reasonably good confirmation was indicated and the effort in 1964 and 1965 was reduced accordingly. All of these data are summarized in Table 3. Included are time of initial catch, weekly average size, growth rate, number of shrimp caught each week, and catch per sample. Additionally, temperature and salinity data are given.

Landings from the Greater Barataria Bay area are given in Table 4. These data represent the commercial catch of brown shrimp from these inside waters during the 60-day spring season and should be considered conservative since there is a sizable sport fishery for shrimp in the area for which there are no catch statistics available. It should be noted that the production figures for the Barataria Bay area should reflect the results of the principal postlarval and juvenile data analysis offered herein.

TABLE 4

Monthly Total Brown Shrimp Landings in Pounds, Heads-Off
Barataria and Caminada Bays

	1962	1963	1964	1965
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	0	0	0	0
May	637,354	1,451,086	419,945	947,625
June	563,642	748,705	198,820	1,065,381
July	253,001	207,600	154,096	547,169
Total lbs.	1,453,997	2,407,391	772,861	2,560,175

First Occurrence

The first occurrence of juveniles in trawl samples has varied from year to year. In 1962 and 1963 they were first found in the fourth week in March. Then, in 1964 they first appeared in the second week in March, while in 1965 they apparently occurred during the first week of March. The latter case was not clear-cut because a mild, extensive winter was experienced and there was a considerable overwintering population. The first appearance of these very small juveniles, 12 to 40 mm in length, always occurred in a specific, shallow marsh area where salinities are high for this area ranging from 20 to 30 ppt. The bottom in this specific locality is characterized by having an abundance of material locally referred to as "coffee grounds." This material, a plant detritus closely associated with the bottom, is commonly found in shallow areas throughout the bay system. After this initial appearance, juveniles were generally found in other shallow marsh areas throughout the system.

Movement

The normal shrimp cycle is now well established and involves the movement of postlarvae into inland waters, thence deep into the shallow nursery areas where they metamorphose into rapidly growing juveniles. These juveniles, as they increase in size, begin a movement into the deeper, larger bays, through the lower bays and out the passes to offshore waters. Though the cycle is constant, the timing of this cycle from year to year may vary considerably as indicated by the early or late arrival of postlarvae, the first appearance of juveniles, and the relative sizes of shrimp as they move offshore. Our studies indicate that several factors may influence the timing of the shrimp cycle with respect to offshore movement; among these, crowding appears to be one of the most significant. For example, the average size of shrimp on inside fishing grounds in the third week of May in 1962 and 1964 was larger than those in 1963 and 1965. The latter were years of high population density, while those of 1962 and 1964 were appreciably lower. Such data indicate that crowding may be an important factor contributing to an earlier offshore movement of smaller shrimp, though at this time it is not known which crowding factor is causing the movement. Future studies should indicate whether competition is for food, space, cover or whether the movements are a result of some more obscure cause or combination of causes. Another factor which may influence movement is temperature. Weekly observations from pond studies indicated that growth was reduced when temperatures reached the 29 to 33 C range. This may indicate that brown shrimp move offshore seeking a more optimum temperature than would be found in the shallower bays as summer weather causes shallow water temperatures to soar.

Growth Rate

Studies of juvenile growth and densities in the Barataria Bay area indicate an important relationship between happenings at this stage of the cycle and eventual production (St. Amant et al., 1962). Because of this, intensive investigations were carried on from 1962-1965 of growth rates and densities and their relationship to hydrographic conditions. Reported here is a summary of the findings for the four year period. Growth rates are summarized as the average growth per day for each week during the months of March, April, and May for each year (Table 3). It is apparent from these data that growth varies from week to week and in corresponding weeks from year to year. The range of variation was from no growth to 2.5 mm per day during the 4-year period. It is significant, however, that though growth varies considerably the average growth rate from the initiation of growth through the third week in May is relatively constant. For example, in 1962, 1963, and 1964, growth averaged approximately 1.0 mm per day. In 1965 average growth was slower from the first appearance of juveniles to mid-May, but it should be noted that no significant growth occurred until mid-April. An average growth rate of 1.06 mm per day was attained after this date. An examination of Fig. 5 showing growth curves for the 4-year period indicates that there is a trend for late appearing or slow growing early juveniles to increase their rate of growth in the latter part of the cycle. This results in a relatively constant average growth rate from year to year.

In examining the environmental parameters in relation to growth, temperatures seem to be the most significant. There appeared to be a trend, though not completely evident in these data, for the growth of brown shrimp to be less than 1.0 mm per day when the water temperature was below 20C and less than 1.5 mm per day when the water temperature was below 25C. Little or no measurable growth was noted at cumulative average water temperatures below 16C.

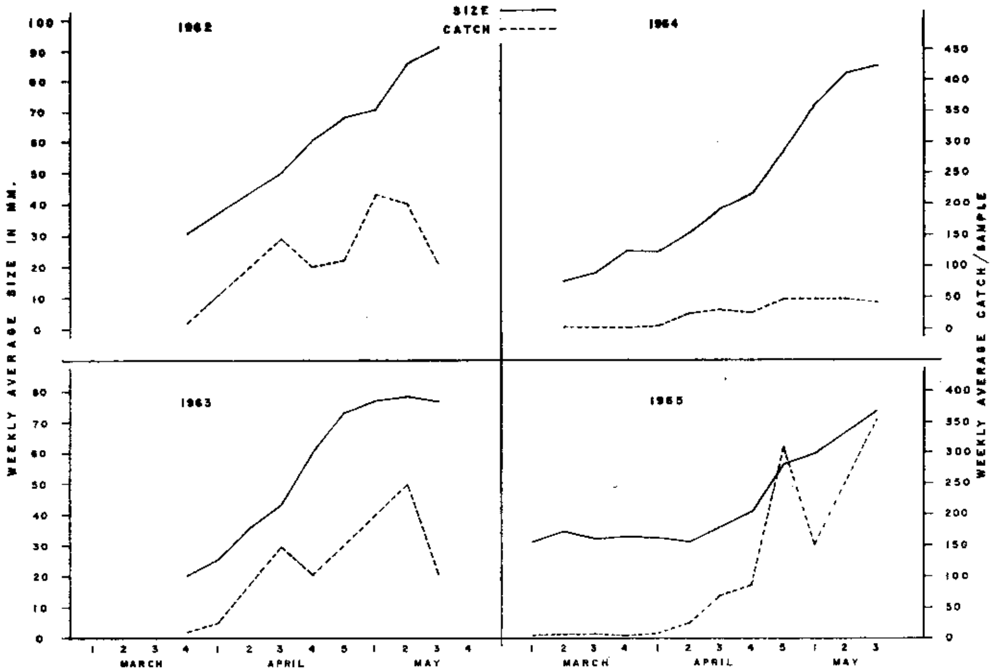

Fig. 5. COMPARISON OF BROWN SHRIMP SIZE AND CATCH

Density

An analysis of density data of juveniles appears to show the best correlation with future production. Catch per sample data in Table 3 and Fig. 5 compares well with total production (See Table 4 and Fig. 3). It seems evident that the density of juvenile brown shrimp on the nursery area was indicative of the final production for the years 1963, 1964, and 1965. In 1962, the catch per sample values were relatively high while landings were low, this is apparently the result of a known bias in sampling. The shrimp that year were concentrated on the western side of the Greater Barataria Bay system and almost no shrimp were on the eastern side. Samples were made much more frequently on the western side in an effort to increase the reliability of the growth rate. In the following years samples were made of near equal intensity in all areas.

The catch per sample of juveniles (Fig. 5) appeared to be a better indication of the forthcoming shrimp landings than the postlarval catch (See Fig. 3). As previously mentioned, the 1964 postlarval catch was very high but peaked earlier than usual. This indicated the possibility of a large, early shrimp population. Subsequently, a low catch per sample rate was obtained during juvenile sampling and the brown shrimp landings for Barataria Bay for 1964 proved to be low (Table 4). There is little doubt that a considerable mortality occurred between the time of first entrance into the bay system and the time of initial fast growth. The reason for this failure, at present, is not clear, but it should be noted that in 1964 postlarvae entered the bays extremely early and were subjected to low temperatures and salinities for a considerable period of time. This longer exposure to adverse environmental conditions and possible predation may in part account for the loss.

HYDROGRAPHIC CONSIDERATIONS

Since variations in the timing of the annual shrimp cycle and resultant production seem to be closely associated with several hydrographic factors, as much of these data has been collected, as possible, in an effort to correlate environmental parameters and shrimp production. Continuous recordings of salinity and temperature data were taken at the Marine Laboratory. These are summarized in Table 3 and represent average conditions in the southern half of Barataria Bay. Data for the north half of the Bay are based on weekly sampling efforts.

Water temperature variations in the bay area follow a cycle closely associated with air temperature as would be expected for such shallow inshore waters. Some slight difference may be noted between North and South Bay waters in that the latter are slightly higher in summer and colder in winter (Fig. 6). This is believed to be a result of the shallower waters in the upper bay. Though daily and weekly temperature variations are apparent in all measurements, the cycle in any given year between January and May is represented by a gradual rising trend (See Table 3 average and cumulative water temperatures). Most significant appears to be the variation in the timing of the temperature cycles from year to year. For example, in 1963 water temperatures exceeded 18C as early as the second week in March while in other years this cumulative average water temperature was not attained until the second week in April.

Typical salinity profiles of the Barataria Bay system are shown in Fig. 7. As would be expected under most conditions higher salinities prevail in the lower (South) bay near the Gulf and follow a decreasing gradient to the upper bay area. The slope of the gradient varies considerably and may become complex because South Bay salinities are strongly affected by Mississippi River flows while North Bay conditions are controlled by rainfall and local drainage. For example, South Bay salinities in 1963, 1964, and 1965, were relatively

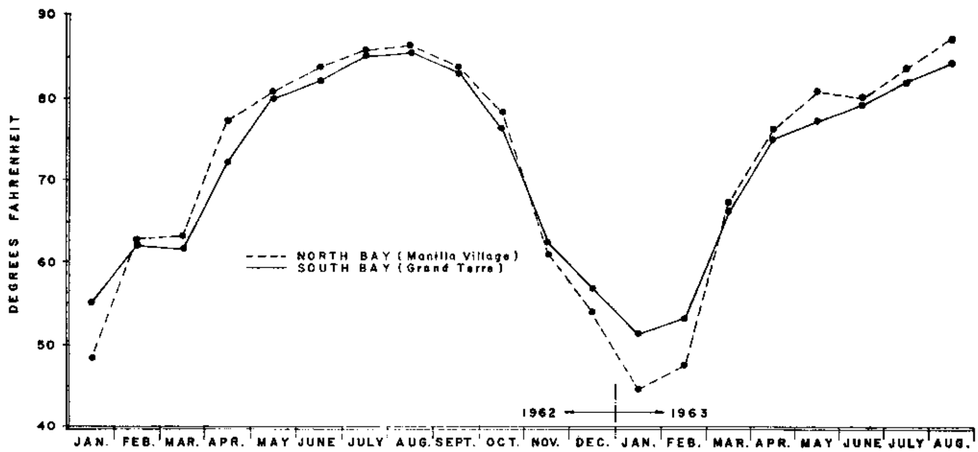

Fig. 6. COMPARISON OF BARATARIA BAY SURFACE WATER TEMPERATURES

high, but showed a lowering trend in April and May as river stages increased, while North Bay conditions showed different variations with high salinities in 1963, low in 1964, and average conditions in 1965 (See Table 5). It is now apparent that variations of rainfall and river stages from January through May subject postlarval and juvenile shrimp to significant changes in salinity from year to year. More significantly, these variations dictate whether substantial acreages of the nursery area will be suitable or unsuitable for the greater portion of the shrimp population.

TABLE 5

NORTH AND SOUTH BARATARIA BAY MONTHLY AVERAGE SALINITIES PPT

	1962	1963	1964	1965
		South Bay		
January	21.1	29.4	24.9	23.2
February	20.4	28.7	24.6	24.5
March	21.2	26.6	23.3	22.5
April	18.7	21.6	15.5	16.5
May	15.5	25.3	14.6	14.7
June	17.3	24.6	16.3	14.0
		North Bay		
January	3.4	17.1	8.6	12.1
February	9.4	11.1	7.2	9.8
March	12.3	18.4	4.5	11.2
April	10.5	21.8	5.7	13.2
May	12.9	19.8	7.9	14.8
June	13.1	17.3	10.7	15.7

DISCUSSION AND CONCLUSIONS

After four years of investigations of the brown shrimp cycle, it is becoming more and more apparent that environmental parameters, as they affect the timing of the shrimp cycle, to a large extent control final production. While we have no information to explain the success of offshore breeding or the relative abundance and time of arrival of the postlarvae at the passes, it is probable that this part of the shrimp cycle is also affected by environment. Once the postlarvae enter the passes, however, it becomes more apparent with each year's investigations that survival and efficient production from the available crop of postlarvae is associated with the environmental parameters they meet in the nursery area.

An examination of Fig. 3 indicates that the amount of postlarvae entering the Barataria Bay System varied considerably during the four year period. It is also evident that final production is not necessarily in direct proportion to postlarval density. It is now clear that efficient survival and growth of a relatively few postlarvae in 1963 produced as large a catch as a dense postlarval population in 1965. Even more significant is the failure of the extremely high postlarval population in 1964 to produce as well as 1963 or 1965 (Fig. 3 and Table 4).

Determining the exact nature of environmental control of the shrimp cycle and resultant production may require years of investigation; nevertheless, annual variations in temperature and salinity can be correlated to a degree with postlarval and juvenile survival, growth, and distribution on the nursery area. It now appears more optimum if post larvae arrive on the nursery area

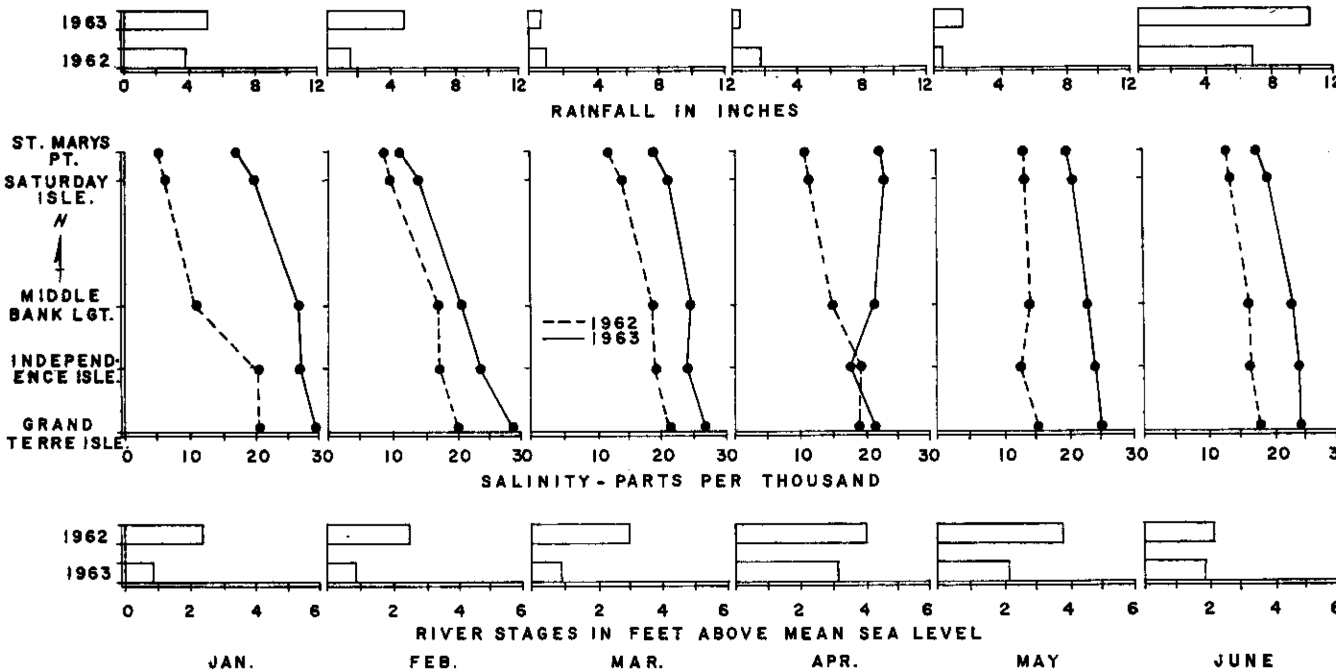

Fig.7. BARATARIA BAY SALINITY PROFILES

after late March when they are more likely to encounter waters warmer than 18C and preferably above 20C. Survival and growth also appears to be further enhanced if salinities are in excess of 10 ppt and preferably higher. Most efficient survival and growth of postlarvae occurred in 1963 when the population peak occurred in late April and when all postlarvae entering after the second week in March encountered waters above 18C, and salinities greater than 17 ppt over most of the nursery areas. By contrast the peak of an unusually dense postlarval population in 1964 occurred in late February and resulted in serious mortalities and poor production. In this case postlarvae were subject to temperatures below 18C for a period of seven weeks and were faced with large areas of nursery ground where salinities were less than 8 ppt (See Tables 3 and 5).

Whether the high mortality of postlarvae in 1964 was a result of long exposure to low temperature, or combined low temperature and low salinity, or excessive predation during a period of little growth is not known. Production in 1965 appears to confirm the analysis of conditions as presented for 1963 and 1964. In this case large numbers of postlarvae arrived on the nursery area and eventually produced slightly more poundage than in 1963 (Table 4). Nevertheless, it is clear that less efficient survival of postlarvae and juveniles occurred in 1965 than in 1963 and this low survival appears to be associated with early postlarval arrival (early March), long exposure to cold water, and intermediate salinity ranges.

In final analysis, it is apparent that shrimp cycles will vary in timing and efficiency from year to year and in certain instances from one nursery area to another in the same year. Such variation will necessitate that research programs be geared to routine annual investigations involving quantitative studies of the shrimp cycle and controlling environmental parameters if accurate predictions of production and information is to be furnished the industry.

Other important results and trends as indicated by the data presented above are as follows:

1. The appearance of postlarval population peaks may vary considerably occurring from late February to early May.
2. The appearance of postlarvae at the passes seems to have little relationship to water temperature on the nursery ground, but survival and growth of the postlarvae is apparently strongly affected by temperature and possibly salinity.
3. Heaviest postlarval movements are associated with incoming tides.
4. Best growth and survival occurred when late arriving postlarvae encountered water temperatures above 20C and salinities above 15 ppt.
5. Growth rates of juveniles vary from week to week, but average growth for the major growing period is approximately 1.0 mm per day.
6. Density and distribution of juveniles offers sounder information upon which to predict future production, while a direct relationship exists between postlarval density and future production. The efficiency of survival is apparently dependent on varying environmental parameters.

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