Studies on Growth Dynamics of the Brown Shrimp, *Penaeus aztecus*, in Louisiana Waters

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INTRODUCTION

SHRIMP RESEARCH IN LOUISIANA and the Northern Gulf was sporadic from the early part of the century until the mid 1950's. Some of the classic early work is reflected in the studies of Viosca (1920), Weymouth, Lindner and Anderson (1933), Burkenroad (1934, 1939, 1949), Anderson, King and Lindner (1949), Gunter (1950, and Gunter and Hildebrand 1954). Intense large scale studies evidently were not accomplished in these early efforts simply because the shrimp industry, seemingly faced with an inexhaustible supply of shrimp, did not demand such studies nor instigate the financing of such investigations. With

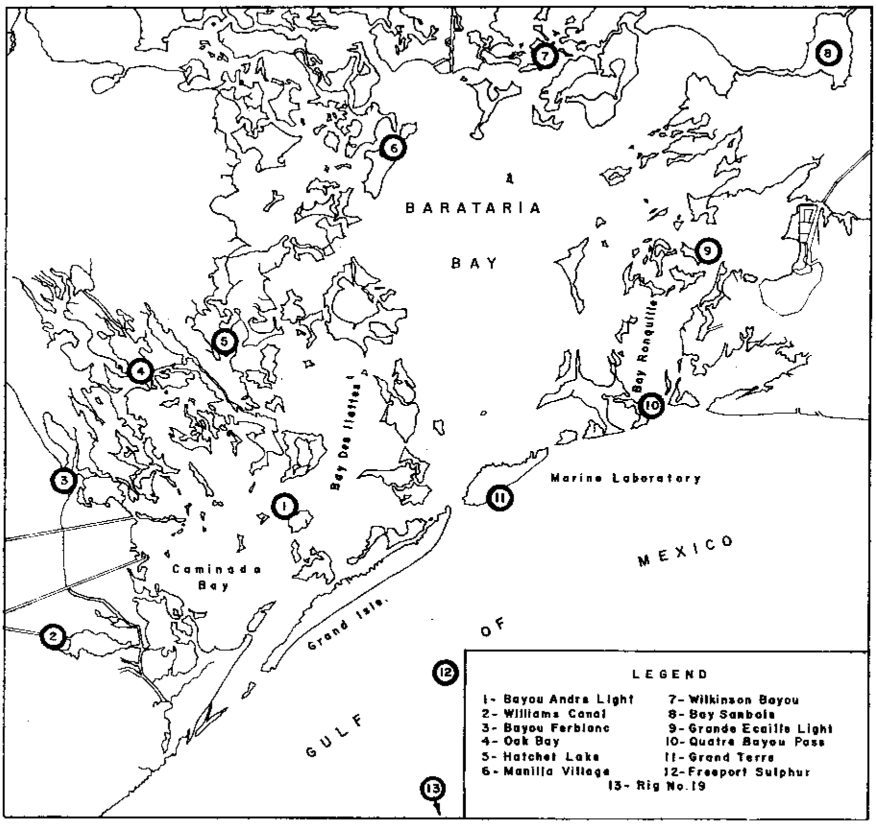

FIG. 1. Location of permanent postlarvel and juvenile sampling stations.

a sudden drop in production in 1957, however, and a second failure of the shrimp crop in 1961, a demand was created for shrimp investigations and funds became available. During the past four years investigations of the three principal species of shrimp of economic importance in the Gulf area have been greatly intensified. Most of this work was carried on by the U. S. Fish and Wildlife Service, a few states, and by universities operating under contractual arrangement with the Federal or State Governments— U. S. Fish and Wildlife Service reports (1958, 1959, 1960, 1961); Lindner and Anderson (1956); Iverson et al (1960); Eldred et al (1961); and Tabb et al (1962). During the last two years research efforts by most of the states bordering the Gulf have been greatly expanded and a major research effort is now being applied to determine the factors controlling shrimp production in the northern Gulf. The total effort using standardized procedures is coordinated by the shrimp research committee of the Gulf States Marine Fisheries Commission (Ingle et al 1962).

Louisiana is taking an active part in the coordinated research effort and the preliminary findings reported here are a part of the total study. All data discussed, were gathered according to standardized procedures being used in the northern Gulf and only slight modifications were made to adjust for local conditions. The aim of this particular study was an attempt to establish the normal pattern of movements, density, and growth rates of the brown shrimp in the nursery grounds of the Louisiana coast. Factors controlling these patterns and the possibility of predicting production from the data collected were also investigated.

This particular study was undertaken first because experience and early observations indicate that the brown shrimp production in Louisiana from inside (bay and nursery areas) and near offshore waters is derived from a well defined population, or portion of the total offshore population, which moves into the nursery area as postlarvae in early spring, grows rapidly, and moves offshore by mid and late summer. Much of the population is harvested in inside waters and it seemed reasonable to expect better results from dealing with a confined population over a short period of time.

SAMPLING GEAR AND METHODS

From the outset of the 1962 sampling program, an attempt was made to follow the standardization of equipment and procedure suggested by the Shrimp Research Committee of the Gulf States Marine Fisheries Commission. Because of the nature of the sample area, several modifications had to be made; but once established, they were adhered to.

During the early months of 1962, postlarval sampling was accomplished at a series of stations from Barataria Bay seaward (Fig. 1) using a 0.5 meter 175 micron-mesh net for a period of 20 minutes. This procedure was followed until postlarvae began to appear in quantities, at which time the offshore stations were abandoned to permit a more concentrated effort in the inside waters. The 0.5-meter net was found unsatisfactory for the shallower water and was replaced with a 6-foot beam net of the type used by a number of laboratories along the Gulf Coast (George, 1962). This net was then towed for 10 minutes at each of eleven stations (Fig. 1).

Concurrent with the postlarval sampling, weekly trawl samples were made at the same stations. These stations had been tested on a weekly basis since June, 1961, and were believed to provide a clear picture of the shrimp population in and around Barataria Bay. The 10 minute trawl at each station was run simultaneously with the plankton tow. The trawl used in early 1962 was a 10-foot otter net with a ½-inch mesh. When very small juveniles were first found, this net was replaced with a 6-foot net of ¼-inch mesh to ensure a good sampling of the smaller shrimp at a given station. The latter net was employed until the program ended at the opening of the commercial season. This change in equipment not only provided a more adequate sample, but also facilitated extensive testing in shallow marsh areas accessible only to small craft. Too, field crews were permitted greater mobility with this lighter equipment.

Postlarval Investigations

Postlarval investigations were designed to determine the time of arrival, densities, and the peak 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.

Thirteen stations were sampled in the Barataria Bay area (Fig. 1). Two of these were offshore seven and twenty miles respectively, the remaining eleven were located from the passes northward across the bay and nursery area. Sampling was started in January, 1962, and continued weekly throughout the year. In March and April when juvenile brown shrimp first made an appearance in the nursery area and postlarvae became more prevalent, samples were made at 352 stations extending from the Mississippi line to near the Atchafalaya River. This extensive lateral sampling along the coast was made in a 30 day period in order to determine the coastal distribution of postlarvae and juveniles.

Fig. 2 shows the results of the postlarval sampling. Samples from the 13 stations were combined and indicated in units of 120 minutes of sampling effort. The first half of the graph indicates principally offshore and pass samples taken with the ½-meter net as the larvae in the early part of the breeding cycle began their movement inshore to the nursery area. The latter half of the graph gives samples from the passes and the nursery areas showing the density of larvae actually arriving inshore.

First appearance of postlarvae in samples was on January 29, 1962; the biggest peak occurred on May 5. This unusual catch may not represent the true peak of the curve, which appears to have occurred in April (Fig. 2). Postlarval movements into the nursery ground continued in lessening amounts until the first week of June.

Some effort was made to determine if the arrival and density data could be used to predict production during the forthcoming season. When compared to data collected by George (1962), it was evident that 1962 postlarval densities in the area studied were considerably higher and portended a more normal if not exceptional production in 1962. However, lateral coastal sampling extending from the Mississippi line westward to the Atchafalaya River (Fig. 3) indicated that this situation did not exist east of the Mississippi River or in the area from East of Barataria Bay to the Delta. From Barataria Bay west to the Atchafalaya River, distribution and density of postlarvae and juveniles (see below) were uniform and well above 1961 conditions. West of the Atchafalaya system no samples were taken. Since postlarval densities and distribu-

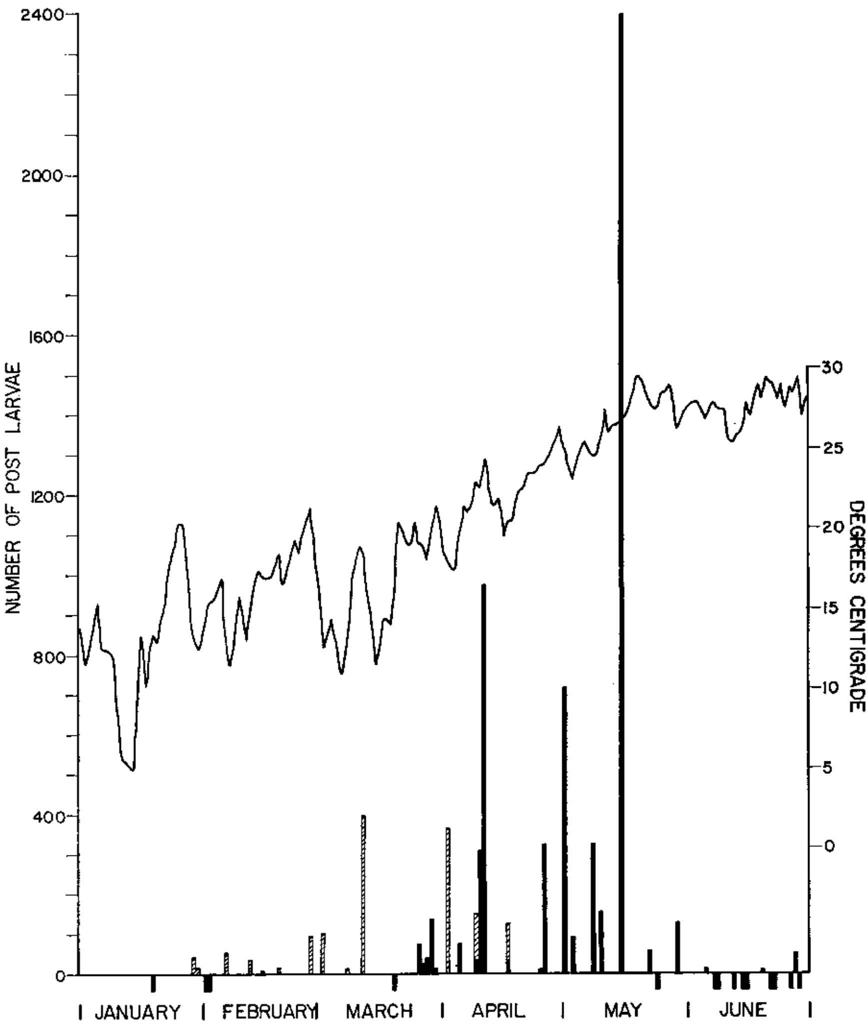

FIG. 2. Postlarval densities per 120 minutes of sampling effort compared to water temperatures, Spring, 1962.

tions were not uniform on a coastwide basis, total state production could not be anticipated and predictions were limited to pointing out expected good and poor producing areas of the coast. Actual production figures indicate a 31% increase over last year as of August, 1962. Since this increase represents the entire Louisiana coastal production and it is now known that some areas did fail as predicted, it would appear that production in the central sector of the coast where highest postlarval densities occurred increased considerably more than 31%.

In attempting to correlate hydrographic and weather data with postlarval movements and density, it became apparent that daily sampling at selected stations would be necessary before a true correlation could be determined. Nevertheless, studies by hydrographic and weather data when reinforced by field observations and postlarval movement and density data indicate several trends worthy of mention and point to the nature of future studies.

These may be outlined as follows:

1. Postlarval movements are definitely cyclic with sampling efforts being completely negative at times as opposed to good catches a few days later.
2. The appearance of increased or decreased numbers of postlarvae in the samples apparently follows the spring weather cycles of cold and warm fronts, i.e., during and shortly after cold fronts postlarvae disappear or lessen in the samples. Warm fronts accompanied by south and southeasterly onshore winds increase the density and stimulate the movement of postlarvae.
3. Correlation of the cyclic activity and density of postlarvae at a given sample period could not be made with a single factor or set of factors since the weather cycles cause distinct changes in all variables. For example, cold fronts, lower water levels and tides, decrease water temperatures, cause currents to be reduced or reversed to an offshore direction and reduce salinities; an opposite set of conditions is generally true during warm fronts.
4. As water temperatures increase and exceed 20 C in the late spring, the cycles are less pronounced but still distinct. Maximal postlarval densities apparently do not appear in Louisiana until water temperatures remain above 20 C (Fig. 2).
5. Postlarval densities and size appear to be governed to some extent by sal-

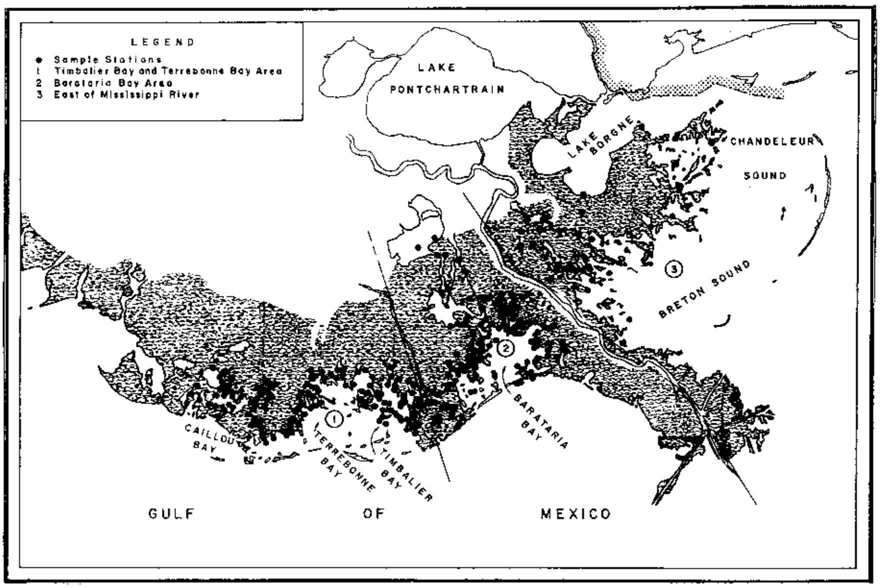

FIG. 3. Location of total sampling stations for postlarvae and juveniles to determine general distribution and density.

inity. More dense populations and larger size larvae were evident in the higher salinity ranges. This could be a function of pure chance and distance, since larvae must pass through the higher saline areas and travel as much as 20 miles to reach areas of low salinity. Postlarvae were found in greater abundance in salinities above 15 ppm.

6. The effect of cold water temperature or sudden drops in temperature is not altogether clear. Although the larvae may disappear completely from samples, we failed to note dead larvae in the sample after cold spells as reported by some investigators. Furthermore, limited laboratory experiments indicated that postlarvae survived well below 15 C but failed to grow. This leads us to believe that the postlarvae tend to accumulate in the nursery grounds, remaining at or near the same size, until the waters reach late spring or summer temperatures, at which time the entire population virtually explodes into rapid growth. Such reaction to low temperature would have a marked effect on the time at which the population will be of fishable size. It seems clear to us now, based on observations of the past three years, that late warming of the water in spring effectively delays the appearance of and growth of shrimp in the nursery area.

Distribution, Density, and Growth of Sub-Adults in the Nursery Area

In order to understand the relationship between postlarval conditions and

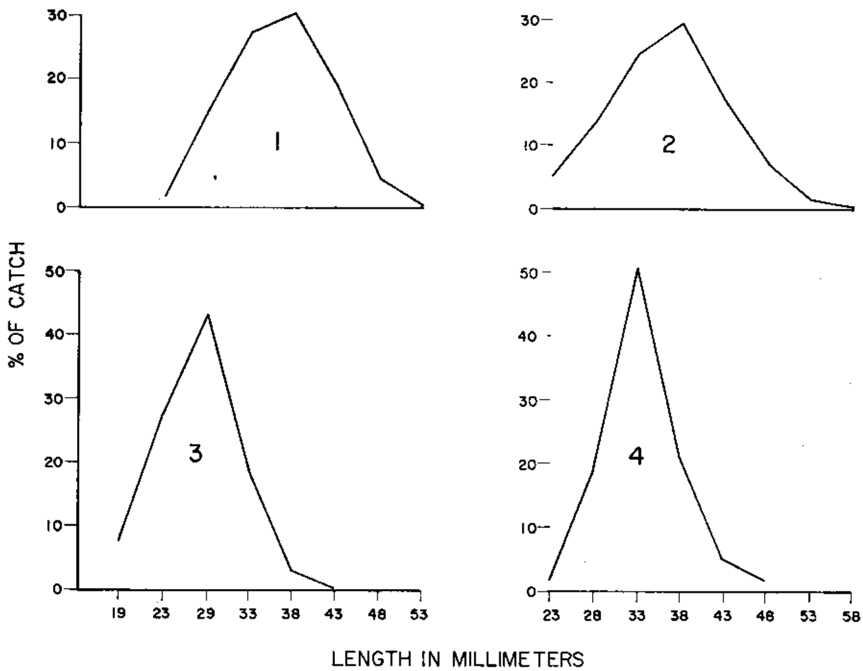

FIG. 4. Population curves of juveniles in four sectors of coast taken in same week. Similarity of curves indicates one population of same size and age over entire area.

final production, an extensive study of the juvenile shrimp was made in the nursery area. Samples from the beam plankton trawls and a standard 12 ft. trawl from all standard stations were examined throughout the winter and early spring in order to determine the first appearance of very small juveniles. These examinations were reinforced by random and widespread sampling throughout the Barataria Bay area. The first appearance of juveniles was noted on March 20, 1962. An immediate intensive study of the Barataria Bay region was initiated and 152 stations in five sectors were sampled during the week of March 26. Fig. 4 indicates the results. The population in the whole Bay area was in the same size range, from 21 to 50 mm, with the modes falling at approximately 35 mm. Several facts of importance may be attached to these data. First, the appearance of these juveniles of the same size was sudden and is associated with the warming of Bay waters to temperatures above 20 C. Second, since the population curves from all sectors tend to superimpose each other and the shrimp are of the same size, it appears that we are dealing with a single population which commenced growth the same time, and is the precursor of the brown shrimp catch for the forthcoming spring and summer. It was apparent that a careful study of this population as it progressed should afford a good evidence of growth rates and population densities.

In order to determine coastwide distribution and densities of juveniles a

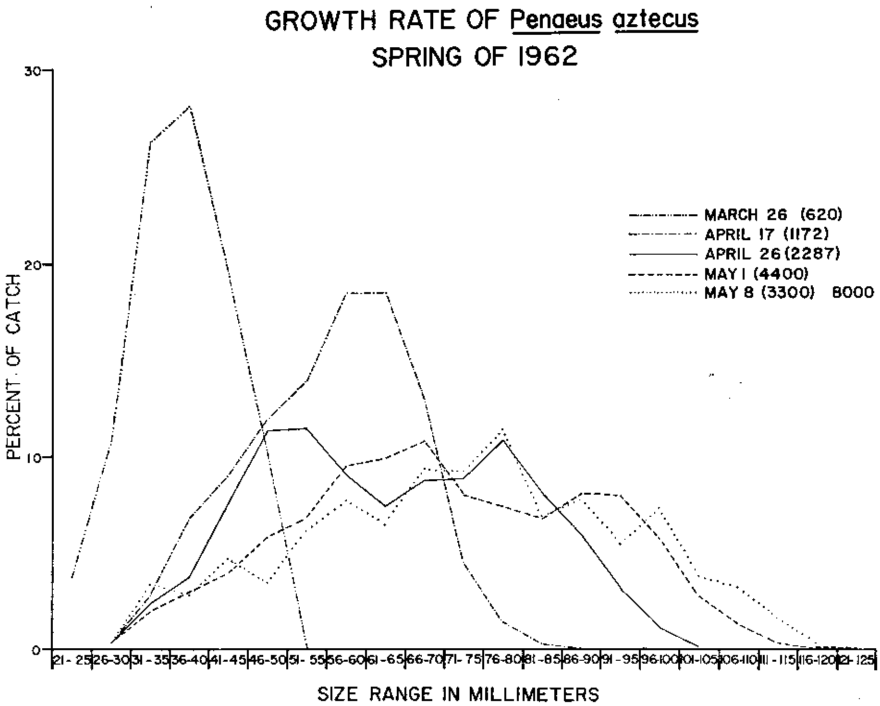

FIG. 5. Population curves showing percent of catch in each size group and growth rates in *P. aztecus*, March 26 - May 8, 1962.

total of 352 stations were sampled from the Mississippi line to the Atachafalaya River (Fig. 3). Over 50,000 shrimp were measured and weighed. This program was carried out over a very short period of time in order to avoid serious population changes or movements that would lessen the value of the data. The results of this study, along with postlarval sampling at the same stations, indicated that some areas of the coast, notably east of the river, were devoid of good populations while the central section of the coast had a generally even distribution of juveniles of the same general age class.

Intensive length, weight, and growth studies were made of the Barataria Bay segment of the population. Eleven stations were sampled weekly and length-weight data were gathered on some 20,000 juvenile shrimp between March 26 and May 15, 1962.

The results of these data are summarized in Figs. 5, 6, 7, and 8.

Figs. 5 and 6 show a series of curves of the brown shrimp population in Barataria Bay from March 26 and at intervals thereafter until May 8, 1962. In Fig. 5 the percent of the population in each size group is shown, while Fig. 6 indicates the total number of individuals in the samples in each size group. The curve for March 26 (Fig. 5) is a composite of all curves shown in Fig. 4 and represents the uniformity of the population at the start of the study. Succeeding curves became broader and broader across the base as growth proceeds rapidly. It also should be noted that all curves start at the 26-30 mm size range. This

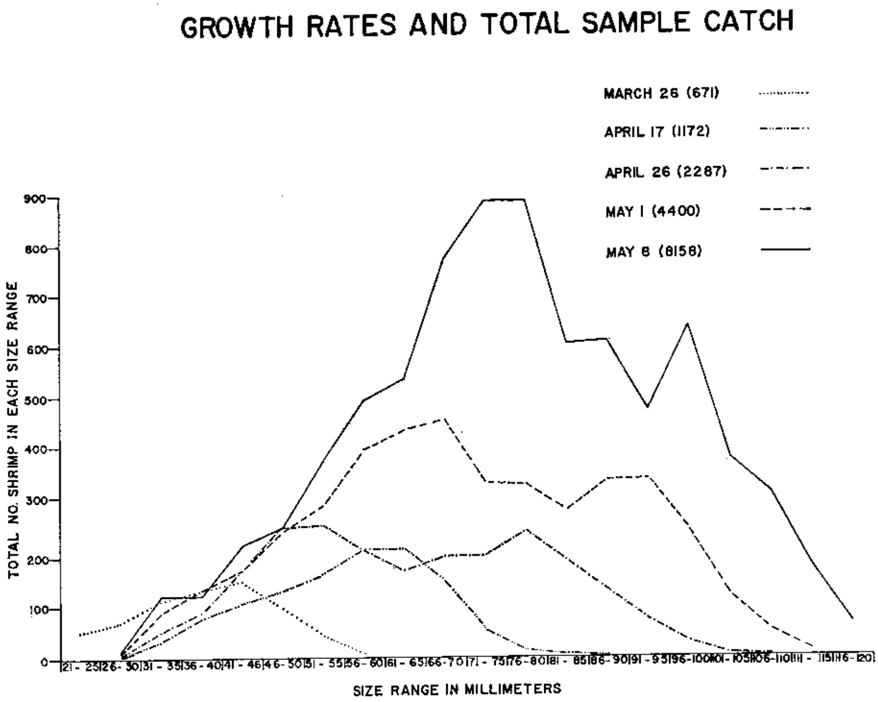

FIG. 6. Population curves showing total catch in each size group, March 26 through May 8, 1962.

latter fact indicates continuous recruitment of postlarvae throughout the study and is evidence of a population build-up. The curves in Figs. 5 and 6 indicate clearly the rapid rate of growth of brown shrimp in the nursery areas of Louisiana. The rate, from examining the changes in the position of the modes, or the largest size shrimp, in each curve indicates a growth of 72 mm in 6 weeks, or approximately 1.7 mm per day.

The last three curves of Fig. 5 show that after April 26 recruitment of postlarvae was great enough to counterbalance the effect of growth and mortality. The height of the curve does not continue to be depressed as the base broadens, and the curves remain approximately superimposed without shifts of modes to right or left. In Fig. 6 it is readily seen that the total density of the population is increasing, since the areas of the curves are a function of the standard sampling rate.

Fig. 7 shows weight-length comparisons as percent of the total population at three different periods. These curves were used to predict and to follow the size and weight composition of the total population on a percentage basis prior to and at the opening of the trawling season. Based on these data it became apparent as early as April 26 (top curve) that when projecting the curve at a growth rate of 1.5 mm per day only a small percent of the total population in size or weight would be of fishable size by May 1, the normal opening day of the season. On the basis of these data the season was postponed until May 15 to allow for a greater segment of the population to reach fishable size. The curve based on data taken May 8 indicated the prediction to be reliable when based on a growth rate of 1.5 mm per day; the actual growth rate proved to be 1.7 per day. The bottom curve shows the actual composition of the population at the opening of the season.

Fig. 8 is a curve showing the length in relationship to count per pound ratio of the brown shrimp in the Louisiana nursery grounds as indicated in numbers of individual per pound (heads on) when plotted against total length of the individual. The curve is based on measurements and weights of 8,000 individuals over a growing period of 9 weeks demonstrating a growth rate of 1.5 mm per day. It is apparent from the curve that with such rapid rates of growth as occur in Louisiana, varying the opening of the season by as little as one or two weeks can have a striking effect on the size and weight composition of the catch.

DISCUSSION AND CONCLUSION

The data presented here represent a preliminary search for some of the facts of the shrimp cycle in Louisiana waters. The analysis presented should be viewed as part of a single shrimp cycle as it responded to a given set of hydrographic and weather factors associated with the 1962 season. The size of our samples, the short period of the study, the total area surveyed, and the fact that the prediction made from the data was borne out by future production lead us to believe that the 1962 brown shrimp cycle in Louisiana has been analyzed with acceptable accuracy. On the other hand, the abnormality of the 1961 season in Louisiana, as well as the probability of varying conditions in future seasons, necessitates repetition of this type of study over several cycles before complete reliability can be attached to 1962 conditions as the expected norm.

The more important results and trends indicated by the study which will guide investigations in the future are:

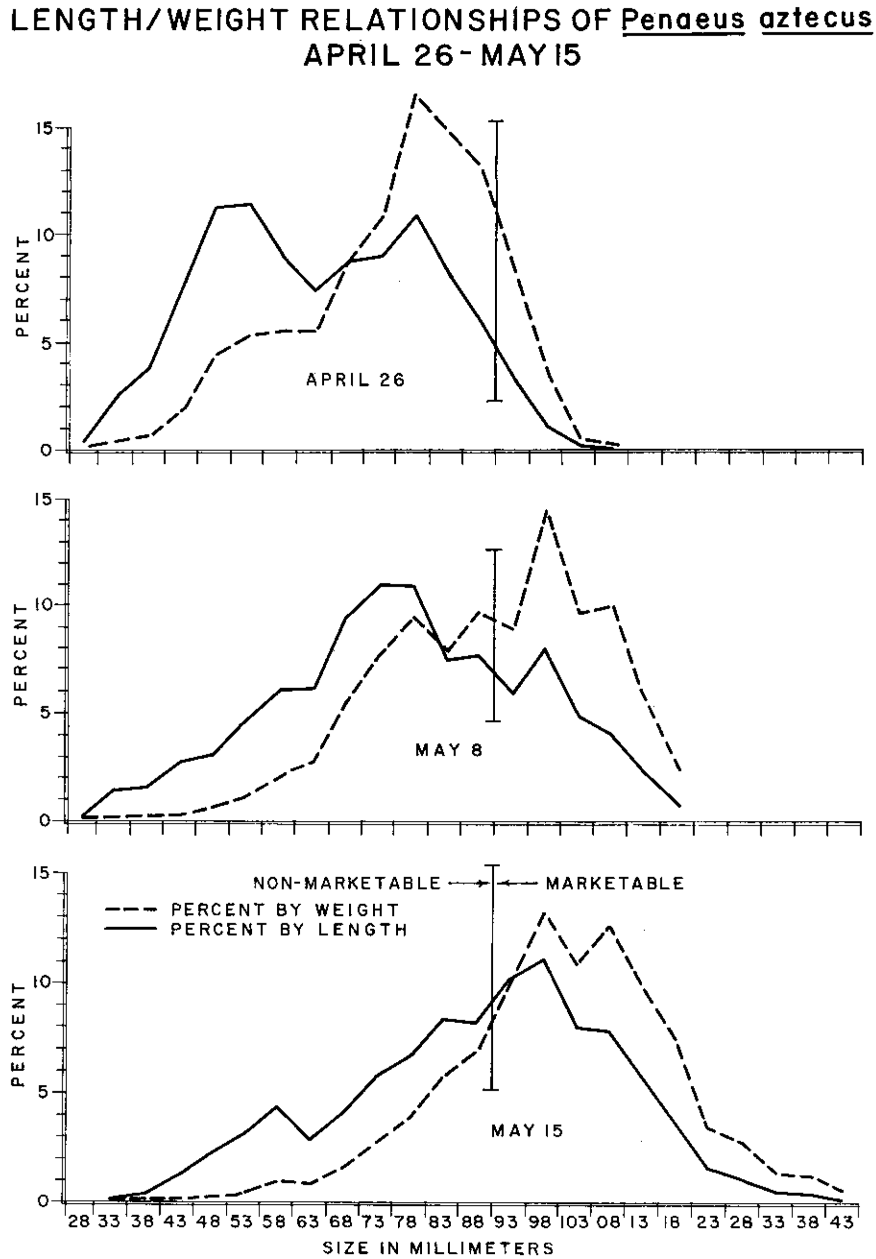

FIG. 7. Length-weight relationship of *P. aztecus* population in Barataria Bay at three intervals during spring growing season. Note rapid change from non-marketable to marketable size shrimp in population.

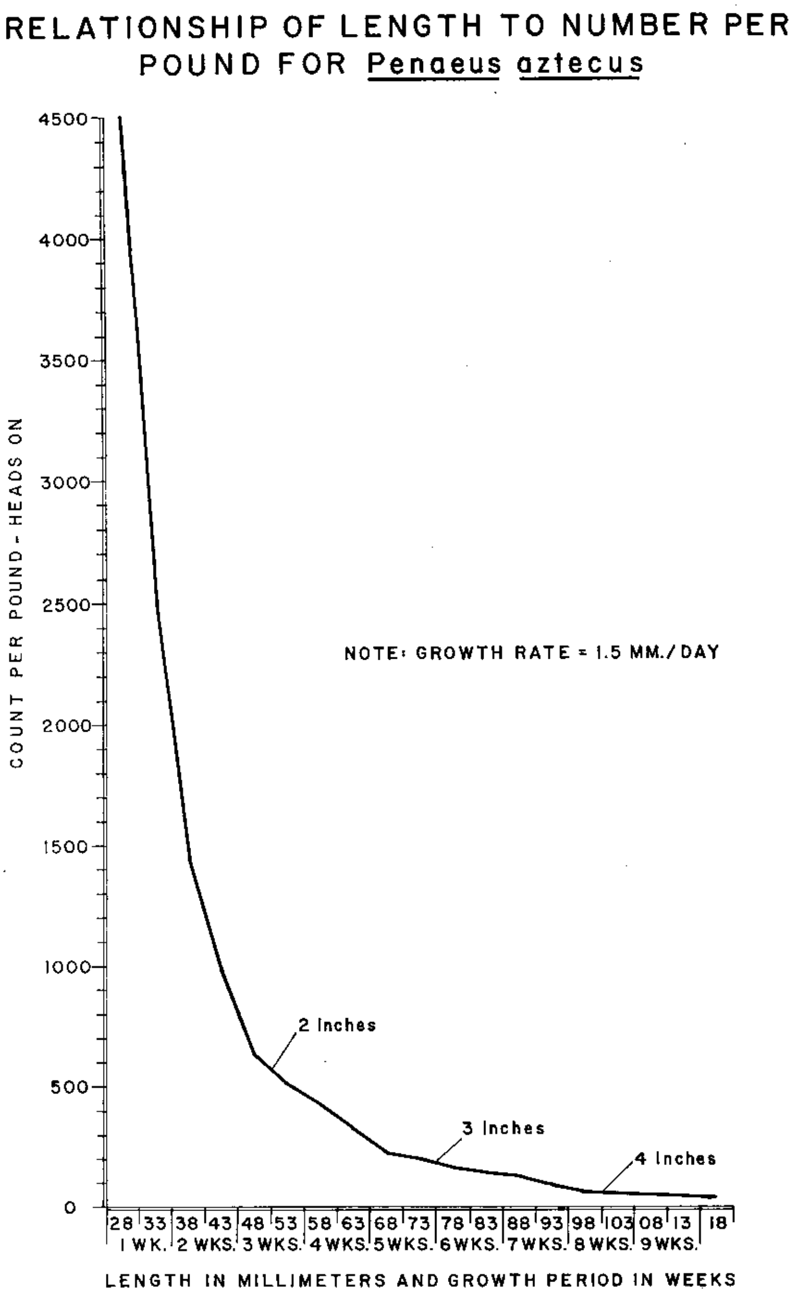

FIG. 8. Relationship of length to number per pound for *P. aztecus* over nine week growth period.

1. Postlarval movements and densities as they enter inside nursery areas are cyclic, the cycles being controlled by hydrographic and weather variables occurring in the spring.

2. The appearance of postlarvae in abundance is associated with water temperatures greater than 20 C.

3. Metamorphosis of postlarvae into rapidly growing juveniles occurs suddenly after water temperature exceeds 20 C and continues upward to summer levels.

4. Growth rates of juveniles in 1962 averaged 1.7 mm per day from their first appearance until they reached 125 mm in length, at which point growth studies were suspended.

5. The density and distribution of postlarvae and juveniles were used to predict future production to a limited degree.

6. Density and distribution of postlarvae and juveniles may vary considerably from one nursery area to another, particularly when these areas are separated by some natural barrier.

REFERENCES

ANDERSON, W. W., J. E. KING AND M. J. LINDNER

1949. Early stages in the life history of the common marine shrimp, *Penaeus setiferus* (Linnaeus). Biol. Bull. 96 (2): 168-172.

BURKENROAD, MARTIN D.

1934. The Penaeidae of Louisiana with a discussion of their world relationships. Bull. Am. Mus. Nat. Hist. 68 (article 2).

1939. Further observations on penaeidae of the northern Gulf of Mexico. Bull. Bingham Oc. Coll. 6 (article 6): 1-62.

1949. Occurrences and life histories of commercial shrimp, Sci. 110: 688-689.

ELDRED, BONNIE, ROBERT M. INGLE, KENNETH D. WOODBURN, ROBERT F. HUTTON AND HAZEL JONES.

1961. Biological observations on the commercial shrimp, *Penaeus duorarum* Burkenroad, in Florida waters. Fla. St. Bd. Consv. Prof. Pap. Ser. No. 3:1-139.

GEORGE, M. J.

1962. Preliminary observations of the recruitment of postlarvae and growth of juveniles of the brown shrimp *Penaeus aztecus* Ives in Barataria Bay. La. Wild Life and Fish. Comm., Ninth Bien. Rpt. 1960-61: 160-163.

GUNTER, GORDON

1950. Seasonal population changes and distributions as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. Univ. of Tex. Pubs. Inst. Mar. Sci., 1 (2): 1-51.

GUNTER, G. AND H. H. HILDEBRAND.

1954. The relation of total rainfall of the State and catch of marine shrimp *(Penaeus setiferus)* in Texas waters. Bull. Mar. Sci. Gulf and Carib., 4 (3): 95-103.

INGLE, ROBERT M., LYLE S. ST. AMANT, WILLIAM J. DEMORAN, JOSEPH H. KUTKUHN, TERRANCE R. LEARY AND JACK C. MALLORY.

1962. Present research on shrimp in the Gulf of Mexico, Gulf States Mar. Fish. Comm., 1-52.

IVERSON, EDWIN S., ANDREW E. JONES AND C. P. IDYLL.

1960. Size distribution of pink shrimp, *Penaeus duorarum,* and fleet concentrations on the Tortugas fishing grounds. Report on contract Nos. 14-17-008-7 and 14-17-008-23. Mar. Lab., Univ. of Miami to U. S. Fish and Wildlife Serv., Bur. Com. Fish., Sp. Sci. Rpt. — Fisheries No. 356.

LINDNER, MILTON J. AND WILLIAM W. ANDERSON.
1956. Growth, migrations, spawning, and size distribution of shrimp, *Penaeus setiferus*. Fish. Bull. 106, Bull. U. S. Fish & Wildl. Serv. 56:553-645.

TABB, DURBIN C., DAVID L. DUBROW AND ANDREW E. JONES.
1962. Studies on the biology of the pink shrimp, *Penaeus duorarum* Burkenroad, in Everglades National Park, Florida. Fla. St. Bd. Consv., Tech. Ser. No. 37: 1-30.

VIOSCA, PERCY.
1920. Louisiana — greatest in the production of shrimp — *Penaeus setiferus*. La. Dept. Consv., Fourth Bien. Rpt.:106-130.

WEYMOUTH, F. W., M. J. LINDNER AND W. W. ANDERSON.
1933. Preliminary report on the life history of the common shrimp *Penaeus setiferus* (Linnaeus). Bull. 14, U. S. Dept. Com., Bur. of Fisheries.

U. S. DEPT. OF INT., FISH AND WILDLIFE SERV.
Annual Reports, Gulf Fishery Investigations. 1958, R59, R60 and R61.

What Does Area Redevelopment Mean to Fisheries?

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Abstract

Public Law 87-27, enacted in May, 1961, is designed to relieve unemployment in certain economically distressed areas. In such coastal areas as are designated as ARA-eligible, the fishing industry may receive benefits in the form of low-cost long term loans, public facilities loans or grants, or technical assistance grants. Universities, research agencies, and state fisheries agencies may also participate as contractors for technical assistance projects. Only recently moving into high gear, the ARA program offers new prospects for much-needed development of the fisheries in eligible areas.

Electrofishing With Bottom Trawls at Sea

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Abstract

Experiments with an electrical field in the area in front of a standard trawl were recently concluded. 154 test tows, about half with electricity and half without electricity for comparison purposes, were made. The analysis of the