Management Guidelines for Predicting Brown Shrimp, *Penaeus aztecus*, Production in Louisiana

T. B. FORD[1] and L. S. ST. AMANT
Louisiana Wild Life and Fisheries Commission
New Orleans, Louisiana

Abstract

Ten years of field studies on brown shrimp, *Penaeus aztecus*, in the Barataria Bay area of Louisiana, initiated in 1961, with an expansion into other coastal areas in 1966, provided a broad basis for recognizing environmental parameters affecting this species. Factors, such as temperature and salinity, are discussed in relation to their influence on the distribution of postlarval shrimp over the nursery grounds and extent of available, favorable habitat. Likewise, the diminishing effect of low salinity areas is considered in terms of increasing spring temperatures. Dimensions of distribution, relative abundance and growth of juvenile shrimp with respect to the three major coastal zones and the fixing of seasons for inside waters are discussed. Projections of prior years juvenile shrimp studies and landings data provide a useful basis for predicting the range of the new crop's harvest. These data and experiences provided the basis for statutory changes enabling more efficient utilization of the resource.

INTRODUCTION

Intensive field studies on brown shrimp *(Penaeus aztecus)* began in the Barataria Bay area of coastal Louisiana in 1961. This effort was expanded into other coastal areas in 1966. These investigations provided a broad basis for recognizing environmental parameters affecting this species. Previous reports (George, 1962; St. Amant et al., 1962; and, St. Amant et al., 1965) presented specific data concerned with postlarval sampling and recruitment into the Barataria Bay system, juvenile distribution, relative abundance and growth in terms of hydrographic data. A continuation of these studies complemented by the expansion into other coastal areas provided a basis of comparison of differences in predicting brown shrimp production for Louisiana. During this period, years of low, average and above average production were experienced. Hence, selected data are used to illustrate those environmental and other parameters which appear to be more meaningful for brown shrimp management guidelines.

Coastal Louisiana is considered here as having three primary zones -- East, Central and West (Fig. 1). Six study areas were established within these zones. Barataria Bay lies south of New Orleans and was the location of our initial quantitative efforts. Accordingly, these data serve as a reference base for those data from the other areas.

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[1]Currently on leave of absence at Louisiana State University, Baton Rouge, Louisiana

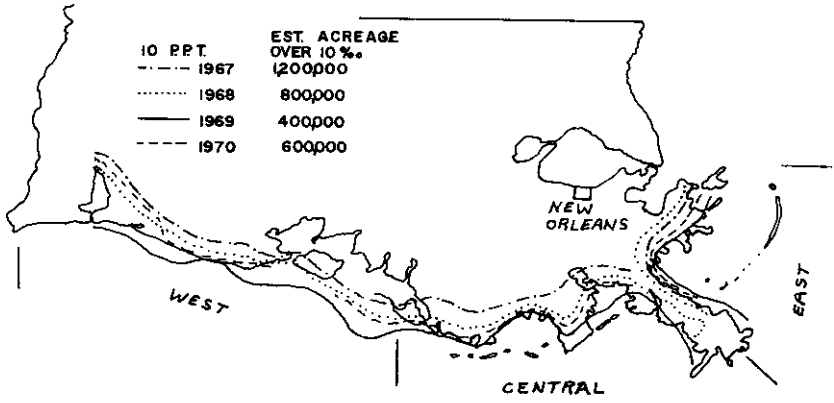

Fig. 1. Coastal Louisiana: March–April average salinity.

PRODUCTION

Brown shrimp production (Fig. 2) in Louisiana averaged approximately 18.4 million pounds (heads off) annually between 1958 and 1970, while preliminary data for 1970 showed it to be above average, on the order of 26 million pounds. It is evident that production during the 1960's for which our data are available was below average in 1962 and 1964, about average in 1963, 1965 and 1966, and above average from 1967 through 1970. By inspection, this figure would suggest that brown shrimp production here may be cyclic. White shrimp, *P. setiferus*, production is plotted to give a dimension to the two major species which comprise about 98% of our commercial shrimp catch. The average heads off total annual production for the two species since 1958 is approximately 41 million pounds. A comparison of production data for these two species suggests that there may be some compensating mechanism functioning between the two if environmental conditions are generally satisfactory–i.e., when brown shrimp

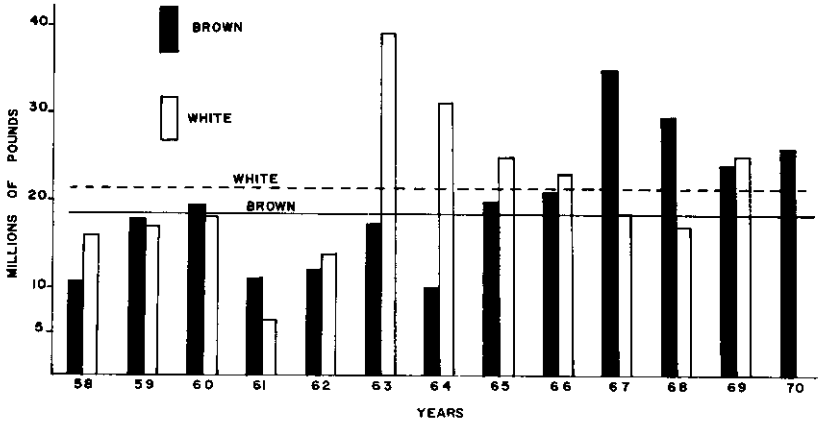

Fig. 2. Louisiana shrimp production – Heads off.

production is low, white shrimp production runs high. Likewise, when white shrimp production is low, brown shrimp production increases, appearing to compensate the annual total crop.

Focusing on brown shrimp production for the Barataria Bay area (Fig. 3) which includes Caminada and several other smaller bays, the 1970 season (May - July) is one of the best on record being approximately 4,980,000 pounds. The average production for the previous twleve years was 2,360,000 pounds annually. This local production generally agrees with the annual totals for the state in being below, average or above average. Such production in the Barataria Bay area for 1970 suggests that postlarval recruitment and survival were good and environmental conditions were excellent for brown shrimp.

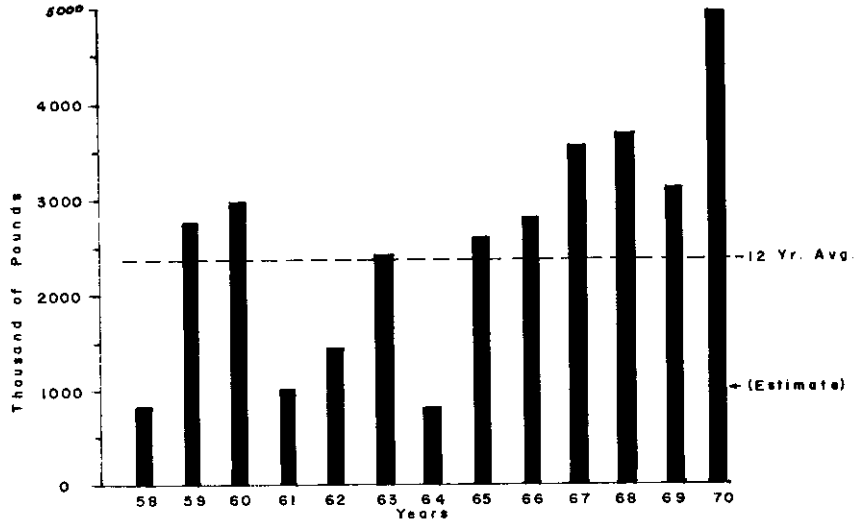

Fig. 3. Brown shrimp production (heads off) May–July: Barataria and Caminada Bays.

FACTORS

Postlarvae

Postlarval brown shrimp were recruited into the bay system in greater numbers between January and April with more peak movements occurring in February and March during these observations. Based upon these studies, the number of postlarval brown shrimp taken in the passes annually from January through May is given in Figure 4. A comparison of these numbers (Fig. 4) with production (Fig. 3) shows that a relatively low order of recruitment as evident for 1967, 1968 and 1970, resulted in above average production. To the contrary, large numbers of postlarvae taken in 1964 and 1966 failed to provide comparable production. Low-level recruitment and below average production was observed in 1962. Thus, factors other than total recruitment must contribute to production.

Peak postlarval movements into this estuary are shown in Figure 5. Time of arrival and condition of the environment appear to be important factors

associated with survival of postlarvae on the nursery grounds. For example, in 1964 large numbers were recruited in late February and early March; however, that year was well below average in production. An early arrival of moderate numbers was observed for 1969, and yet production was above average.

Salinity

The salinity regime of the Barataria Bay area is typically estuarine (Fig. 6) as suggested by these data. Northern or upper bay salinities during March through May vary from almost 0 to 25 parts per thousand (°/oo), being substantially influenced by rainfall within the watershed. Those of the southern or lower bay are expectedly higher, ranging from 14 to 28 °/oo. These salinities are influenced more by the offshore littoral waters. During periods of high river, fresh water from the western passes of the Mississippi River requires approximately 8 days to drift across the Gulf and enter the passes of Barataria Bay. This causes salinities of the lower bay to be greatly lowered. In the low production

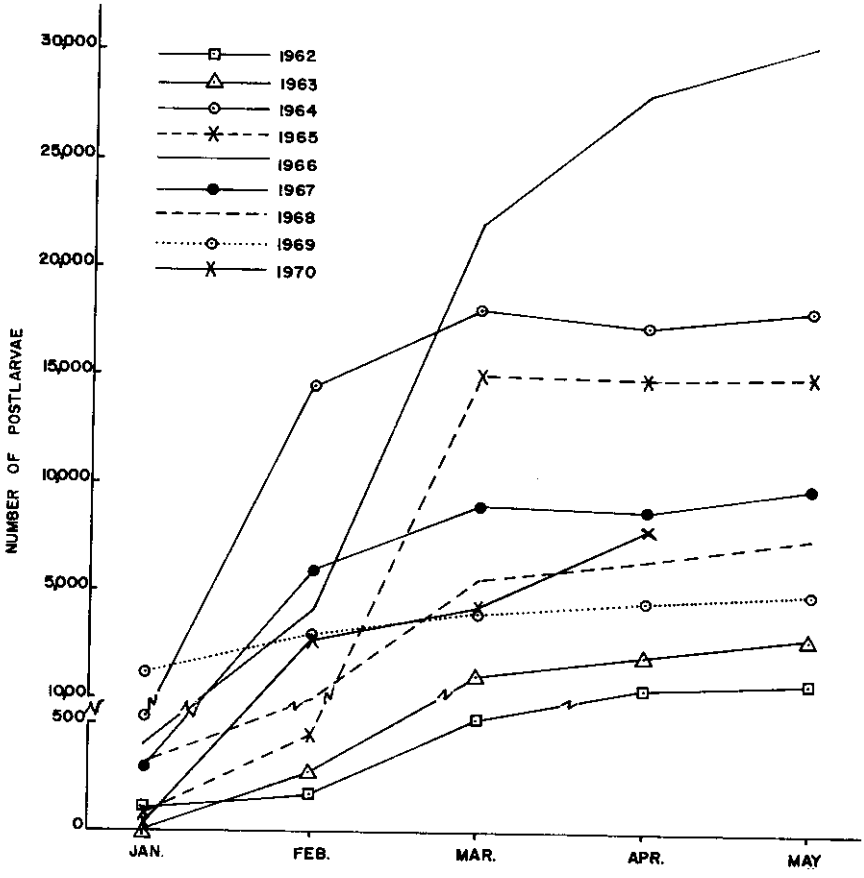

Fig. 4. Number of postlarval brown shrimp: Barataria Bay Passes.

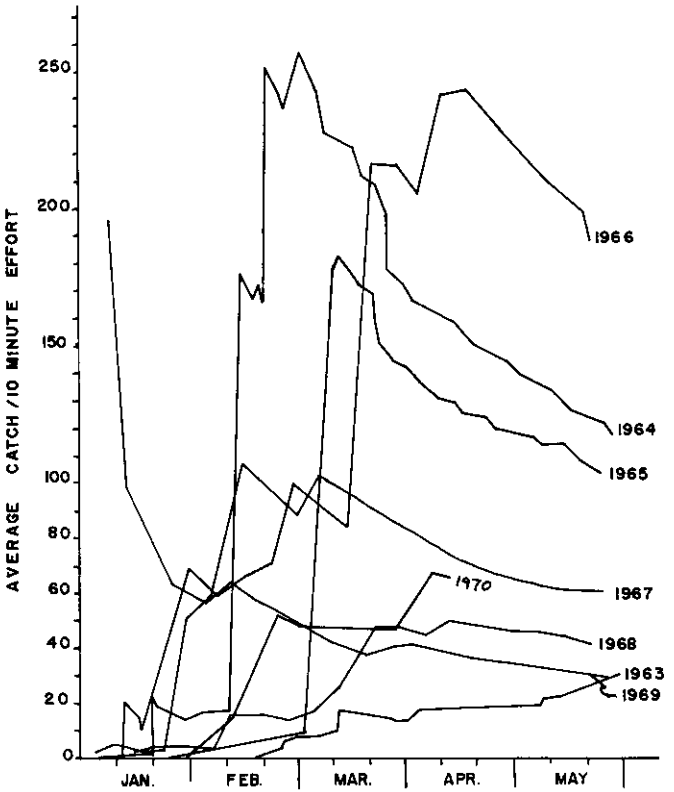

Fig. 5. Barataria Bay – Cumulative postlarval catch.

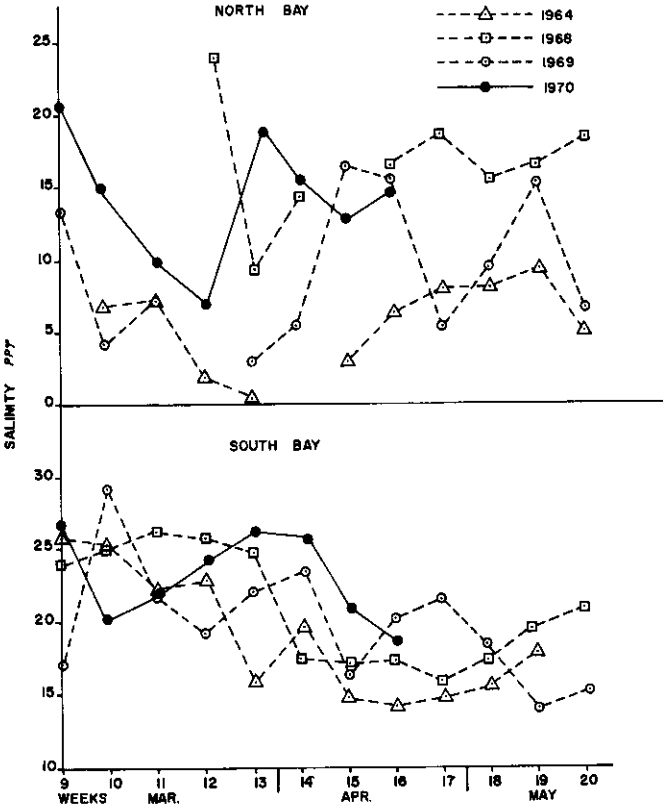

Fig. 6. Comparison of north and south bay salinities in Barataria Bay.

year of 1964 (Fig. 3), salinities were decreasing to their lower range in the south bay during March while becoming virtually fresh in the north bay. In retrospect, the implications were not clearly recognized at the time. A very limited higher salinity habitat remained available to the postlarvae following the peak of recruitment in late February and early March. A late peak of recruitment in 1968 with generally higher salinities ranging from 17 to 26 °/oo in south bay and 9 to 23 °/oo in north bay appears to correlate well with its production. This led to consideration about the extent of available nursery grounds having average salinities of 10 °/oo or higher during March and April since this appeared to be a critical period for survival of postlarvae. Superimposed on the map of coastal Louisiana (Fig. 1) are 10 °/oo average isohalines for March and April with the estimated available acreage of this habitat during the past 4 years. Since these are the only years for this type of projection, this specific isohaline may not be definitive. Nevertheless, during these 2 months it seems to be significant for juvenile shrimp are taken earlier and in greater numbers within this salinity zone of 10 °/oo and higher. Also, above average production fits well for these years.

Temperature

Observations made during the past several years indicate that increasing numbers of juvenile brown shrimp begin to appear when temperatures increase and hold at 15C. At sustaining temperatures of 20C, brown shrimp begin to disperse into areas having a salinity less than 10 °/oo. Since sampling data is treated on a weekly basis, temperature data is treated similarly (Fig. 7). It shows that temperatures reached 20C during the first 3 weeks of April each year over the past 13 years. Average or above average production occurred during the years of early warming (April 2 - 8) and the same was true for warming during the second week (April 9 - 15) except during 1962 when production was below average. Warming did not occur until the third week (April 16 - 22) during 4 of these years; production for 3 of these was well below average while that of 1966 was just above average. Hence, early warming without subsequent severe decreases due to late cold fronts appears to support higher shrimp production provided an extensive environment of favorable salinity was available and postlarval recruitment and survival was adequate.

Juvenile brown shrimp growth was compared with temperature (Fig. 8) for 4 years having above average production to illustrate the influence of temperature. It is evident that the earlier warming cumulative temperatures of 1967 in an area estimated to be 1.2 million acres (Fig. 1) having favorable salinities over 10 °/oo showed more rapid growth. Also, a year having a late peak postlarval recruitment as 1970 with steadily warming temperatures suggests that lower salinity has a diminishing effect. Half of the estimated area of salinities of 10 °/oo or over for 1967 (Fig. 1) was seemingly available in 1970; yet, production (Fig. 3) was approximately one-third greater, thereby reinforcing the previously suggested diminishing influence of salinity with increased warming above 20C.

Growth and Density

Growth curves for the years 1962 through 1970 are shown for the Barataria Bay area in Figure 9. Generalizing, relatively slow growth was observed until water temperatures warmed above 20C after which rapid growth occurred as temperatures approached 25C from late April into the latter part of May. The leveling off and negative growth observed for some years in late May is

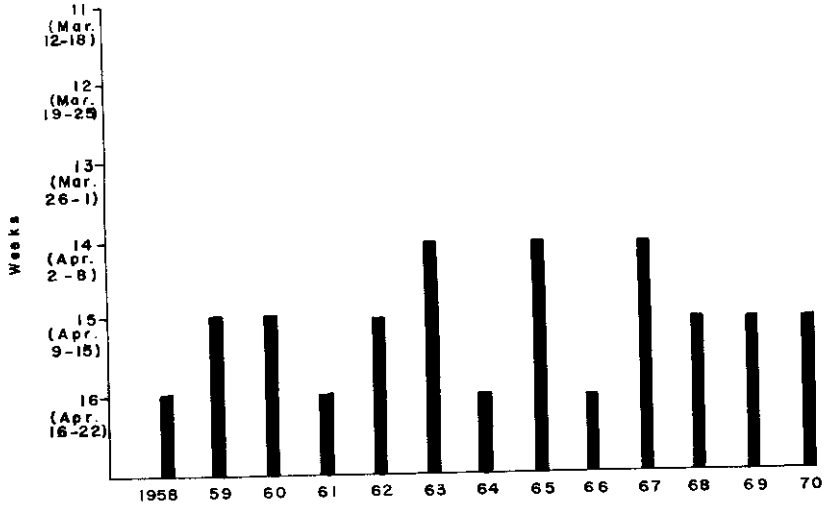

Fig. 7. Weeks water temperature warmed above 20C.

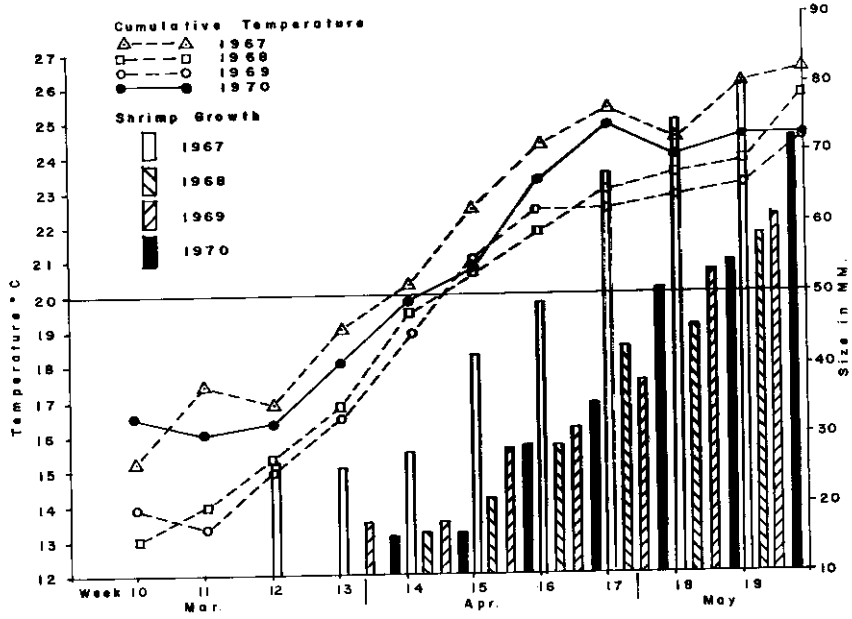

Fig. 8. Comparison of juvenile brown shrimp growth with temperature.

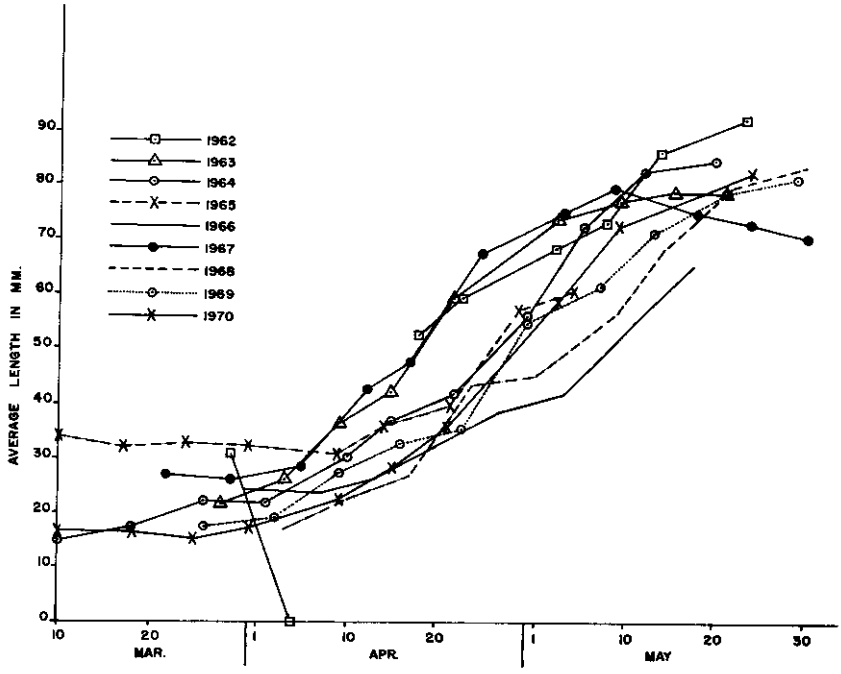

Fig. 9. Barataria Bay – Average length of juvenile brown shrimp.

attributed to two factors since sampling stations remained fixed: (1) Migration of the larger shrimp to the lower bay areas and offshore, and (2) An increase of smaller juveniles resulting from postlarval recruitment to the nursery grounds. Growth observed for 1962, 1963 and 1967, is associated with temperatures having warmed above 20C by the second week of April. Other curves lag by 1 to 3 weeks and this appears to be temperature-related in part.

Selected years of catch data are presented in Figure 10 to illustrate generally (1) the year to year variance, (2) the absence of a steady state within a year, and, (3) the build-up of numbers. Represented by these 5 years are less than average production for 1964, about average for 1966, and above average for 1968, 1969 and 1970. Our predictions for each annual brown shrimp crop are based upon data accumulated through mid-April and those data of prior years. At this time we feel that it is possible to predict the crop whereas, in 1964 juvenile brown shrimp catch data were of a low order of magnitude and remained so. However, postlarval catch data were excellent and it appeared as though the crop was just slow in developing. Based chiefly upon the postlarvae, an above average crop was predicted. In retrospect, it is obvious that the postlarvae experienced a high mortality which may be attributed to an early arrival having too long a period on the nursery grounds under adverse environmental conditions of low salinities and low temperatures. The effect of predation under such circumstances is not well understood.

Even so, it may be stated that an average density of postlarvae arriving in late March or early April in an estuary having salinities of 10 ‰ and greater with increasingly warming temperatures above 15C will provide for good survival of the postlarvae and an average to above average production of brown shrimp. To the contrary, early arrival of large numbers of postlarvae in an estuary having low salinities below 10 ‰ and low temperatures results in poor survival and a below average production. As postlarval numbers and conditions vary between those given above, production also varies within these limits.

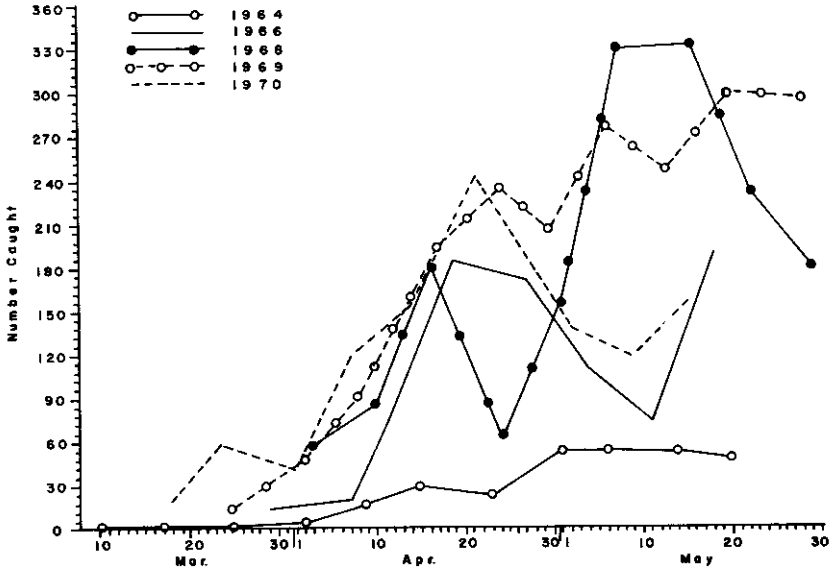

Fig. 10. Juvenile brown shrimp – Average catch per 10 minute sample.

The 1964 curve (Fig. 10) in contrast with the others more closely, but incompletely, approaches a steady state. The other curves more strongly suggest a pulsing effect which allows for a continuing periodic recruitment of postlarvae thereby providing for replacement stock on the nursery grounds for those migrating out as sub-adults.

Based upon catch data of previous years, improved sampling confidence and general distribution within the Barataria Bay area, the build-up of numbers by mid-April with respect to previously discussed parameters now provides a basis of dimension for this area. Also, it serves as a reference for other zones of coastal Louisiana.

Catch and growth data for 1969, which are characteristic of most years for coastal Louisiana, are shown in Figure 11. Area 1 essentially represents the East zone (Fig. 1), Areas 2 to 5 comprise the Central zone, and Area 6 the West zone. By inspection of the catch curves, it is evident that Areas 1 and 6 (East and West zones) lag some 2 to 4 weeks behind that of the Central zone. Interestingly, catches generally run much higher in mid-April for Areas 2 and 3 than those of Areas 4 and 5. Usually, catches of the latter two increase rapidly in late April

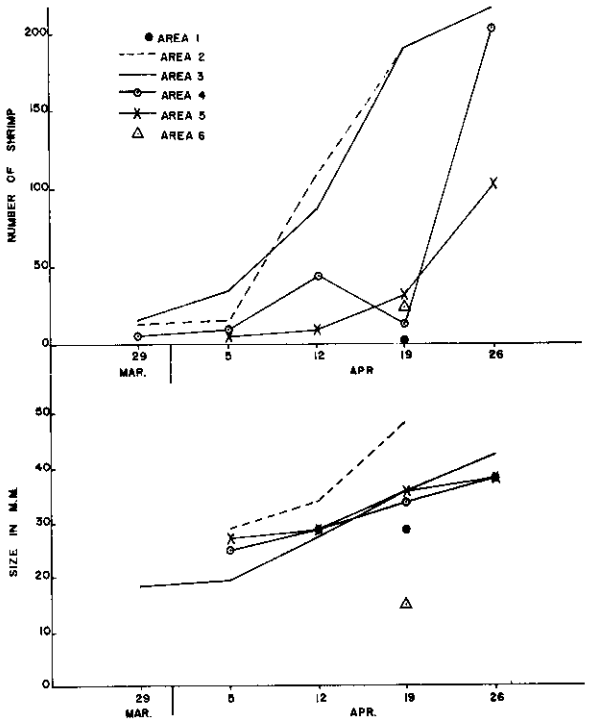

Fig. 11. Coastwide juvenile brown shrimp by size and number in 1969.

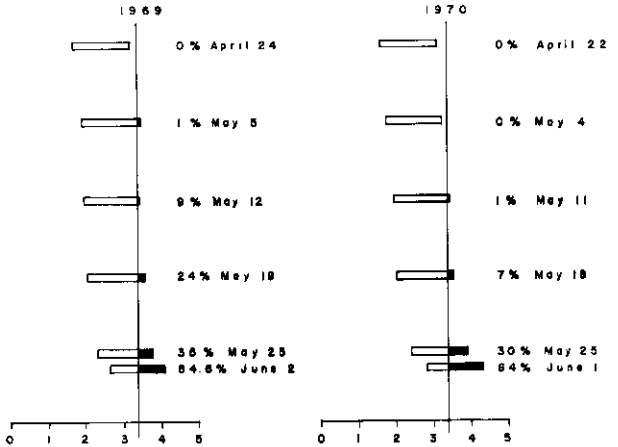

Fig. 12. Projected growth rate at 1.5 mm per day.

and early May, approximating those of Areas 2 and 3. Growth curves for each of these areas generally are similar to the catch curves with the exception of Area 2. Here, the shrimp usually average 10 to 15 mm larger than those of the other areas in the Central zone in late April.

Projected Growth Rate and Fixing of Seasons

Since brown shrimp can grow rapidly (up to 2.5 mm/day, although usually less) as water temperatures warm to 25C or more in late April and most observed sustained field growth rates fit during this period, we use 1.5 mm/day as a projected growth rate. The purpose is to develop recommendations for consideration by the Louisiana Wild Life and Fisheries Commission in fixing the opening and closing dates of the brown shrimp season for inside waters. These are waters lying inside of the barrier islands and beaches. Representatives of the shrimp industry advised us that a 100-count heads-on shrimp is a useful size (about 86 mm) for processing. Based upon observed growth characteristics of the current year for the Barataria Bay area, projected growth rates are calculated to indicate when more than 50% of the first major group of shrimp will achieve this size. Projections for 1969 and 1970 are given in Figure 12. The calculated growth lag between comparable periods of 1969 and 1970 illustrates the crop's capability in maturing by early June. From Figure 9, it becomes obvious that in recent years the crop becomes usefully available sometime betwen May 10 and June 1. Generally, these projections fit the Central sector from which the majority of Louisiana's sub-adult brown shrimp are produced.

Data of the types given herein are presented to representatives of the shrimp industry including the fishermen in mid-April. The following week on the fourth Tuesday in April, these same data with our recommendations are presented to the Commission for its consideration. At times, some fishermen urge modification of our recommendations. The Commission has the responsibility of fixing the opening and closing dates of the season within a statutory framework. Since 1962, our management recommendations for brown shrimp were accepted; infrequently, nominal modifications were made.

MANAGEMENT PROBLEMS AND STATUTORY CHANGES

Undersized white shrimp (68-count heads-on is legal size) frequently overwinter in near offshore waters. In the spring as temperatures begin to rise, these shrimp move into estuarine waters to complete this part of their life cycle. Good numbers of these large shrimp occur during some years. When this happens, some fishermen quite naturally want to catch them. Keeping in mind that the late spring shrimp season was designed for catching brown shrimp and statutorially had a 15 day variance for opening between May 1 and 15, to extend for 60 continuous days and to close by July 15, it was virtually impossible to permit fishing for an estimated 0.5 million pounds of white shrimp without jeopardizing the loss of several million pounds of brown shrimp. This would be attributed to a loss of fishing time in the latter part of the season and possibly some loss due to catching brown shrimp too small to use when they would ordinarily be experiencing a rapid growth phase. A part of the shrimp fleet in all probability would catch most of the available white shrimp in less than a week. Then that part of the fleet would be confronted with waiting 2 to 3 weeks until 50% or more of the brown shrimp reached a useful size.

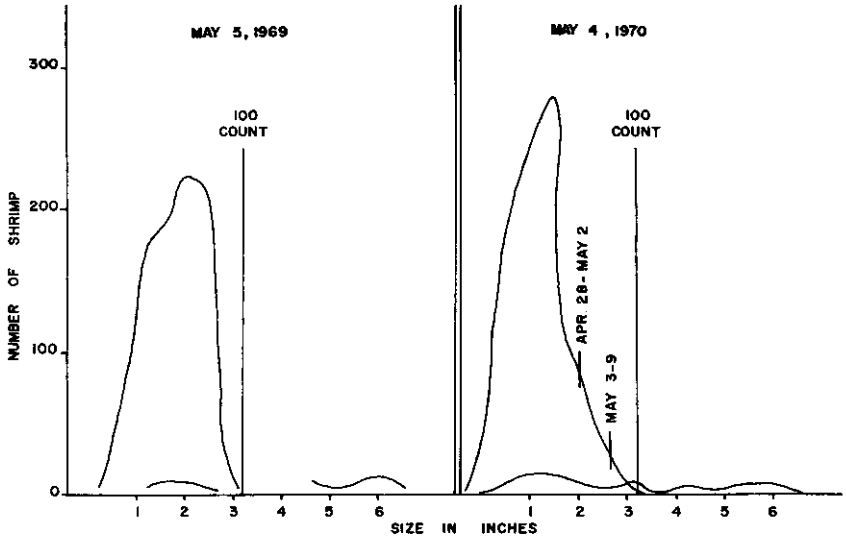

Fig. 13. Barataria Bay shrimp population.

Data presented in Figure 13 for the Barataria Bay area in early May of 1969 and 1970 is probably representative of this problem and typical for the several areas where it arises periodically in Louisiana. The large peaked curve represents the brown shrimp while the small flat curve represents the white shrimp. On May 5, 1969, some 17% of the available crop were white shrimp ranging in size from about 119 to 165 mm, this group being discreetly separated from the smaller brown shrimp. Accordingly, it appeared as though it would be feasible from the management viewpoint to harvest them. However, it could not be accomplished without the losses or risks stated above. To the contrary, the curves for May 4, 1970, show some 10% of the crop being white shrimp with less than 6% being larger than 100-count in size and these not being discreetly separated as in 1969. During the interim period in 1969 and at the urging of representatives of the industry, the Louisiana Legislature amended the law to provide a more lenient framework to the Commission for managing the spring shrimp crop. Generally, most shrimp fishermen and others in the industry have come to understand and accept these data and our interpretations; a comparatively small minority rejects them with little, if any, apparent basis. Because of this general acceptance throughout coastal Louisiana, the above mentioned statutory change was accomplished without the usual severe difficulties associate with much fish and wildlife legislation. The application of this statutory change in Breton Sound permitted the continued harvest of brown shrimp without jeopardizing the developing crop of white shrimp in more inshore waters.

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