exposure is most important when determining a sublethal concentration of endrin to fish.

Endrin residues in the tissues of living fish do not appear to be detrimental during periods of starvation when fat is being mobilized. Further study is needed to evaluate more fully the effects of physiological stress on insecticide-exposed fish.

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STUDIES OF COMMERCIAL SHRIMP POSTLARVAE IN MISSISSIPPI SOUND AND ADJACENT WATERS

INTRODUCTION

As a result of the discovery of new fishing grounds in the Gulf of Mexico, expansion of the shrimp fishery has been rapid since 1950. In 1952 the United States shrimp catch of 227.2 million pounds was valued at 55.1 million dollars, exceeding the dollar value of any other fishery (Anderson and Power, 1952). In the period 1950 through 1963 the catch from the Gulf of Mexico averaged 83 per cent of the total catch.

In the Gulf, brown shrimp *(Penaeus aztecus)*, white shrimp (*Penaeus fluviatilis*) and pink shrimp (*Penaeus duorarum*) contribute nearly all of the commercial catch. Before 1950 the catch was dominated by white shrimp. Since 1956 the Gulf shrimp catch has been reported by depth and area of capture, species, size, number of trips and days fished (Gulf Coast Shrimp Data) by the U. S. Bureau of Commercial Fisheries. These data show that about half of the Gulf catch since 1956 has been brown shrimp with the remainder about equally divided, on the average, between pink and white. The catch of white shrimp remains below the volume taken in the mid-thirties. Total catch was greatly reduced in 1957 and again in 1961.

Biological research on Gulf of Mexico shrimp stocks began just before the outbreak of World War I. Kutkuhn (1962) pointed out that the efforts of pioneer biologists, working with limited funds, established a firm life history base for the current expanded effort to bring

our study of shrimp stocks in line with investigations of other major fisheries resources. Increased appropriations implemented the 1959 recommendations of the Gulf States Fisheries Commission. Investigations advanced in several study areas, including the movement and density of postlarvae.

Commercial penaeids in the Gulf spawn in the open sea. The eggs produce planktonic nauplii. As metamorphosis proceeds through numerous ecdyses to early postlarval stages the young shrimp move toward estuarine areas where they drop out of the plankton. In reduced salinities at temperatures above 20° C (Saint Amant *et al.*, 1963) "Metamorphosis of postlarvae into rapidly growing juveniles occurs suddenly." Within a few months, as they approach maturity, young adults move back to the more constant environment of the open sea to complete the life cycle.

STUDIES OF POSTLARVAL ABUNDANCE IN MISSISSIPPI

The study of relative abundance of postlarvae entering the estuary was begun in 1959. After three years of collecting at one location near the entrance of Galveston Bay, Baxter (1963) reported good correlation between the postlarval index of abundance and the ensuing commercial catch. Since that time, similar studies have been undertaken in other Texas areas and in Louisiana and Mississippi.

In November 1962, under contract with the U. S. Fish and Wildlife Service, the Gulf Coast Research Laboratory started a study of the feasibility of determining the relative abundance of postlarval penaeid shrimp by season and area in Mississippi Sound and adjacent waters.

Mississippi Sound is a shallow estuarine area bounded by Mobile Bay on the east, Lake Borgne on the west, and a series of barrier islands on the Gulf side. Fresh water enters the Sound through distributaries of the Pascagoula and Pearl rivers. Smaller streams bring fresh water through Biloxi Bay and the Bay of St. Louis. Extensive marsh areas and the shallow near shore waters of the Sound serve as nursery areas for penaeid shrimp and many other marine animals.

Most of the bottom is soft mud but fairly extensive grassbeds are found in some areas, particularly along the barrier islands. Seasonal changes in salinity and temperature are large and sometimes rapid. The diurnal tide has a normal range of about 1.5 feet but wide variations, depending on wind direction, do occur. Shallow areas are often uncovered in the winter and marshes are flooded for periods which may vary from year to year.

A total of 31 stations (Fig. 1) was set up as collecting grounds to sample a variety of environmental conditions. These were reduced to a series of eighteen locations where standard sampling methods could be employed (Christmas, 1964) weekly for a two year period.

A six foot beam net (see Renfro, 1962 for details) was pulled by hand in a semi-circle with a radius of 150 feet, duplicating the method used in Galveston Bay (Baxter, 1963). Depth of water ranged from the shore line to 4.5 feet. High tides or shifting sand at some island stations occasionally prevented completion of some stations. Water temperature near shore was recorded to the nearest 0.1° C. Water samples were returned to the laboratory where hydrometers were used to determine salinities. Observations of tide stage, weather, and turbidity were recorded.

Biological samples were fixed in formaldehyde after removal of as much debris as possible. In the laboratory, penaeid shrimp were removed and stored in five percent sea water formaldehyde buffered with borax. Glycerine was added to prevent excessive hardening of small specimens. The remaining sample, including considerable residual debris, was stored for further study.

Identification of postlarvae proved to be difficult and positive identification of some stages remains uncertain. This is particularly true in the summer when postlarval brown shrimp and white shrimp at the same stage of development are about the same size. However, with some experience, different workers produce almost identical results in identification. In two years 1,301 samples were completed.

They included over 71,000 penaeid postlarvae belonging to the three commercial species. Over half of these were taken at stations 1, 4, 11, and 13. Since postlarvae were consistently more abundant at these stations they have been selected as being most useful for determining relative abundance. Juveniles, over about 25 mm. total length, were taken in very limited numbers in these samples.

Average salinity was much lower (Fig. 2) in 1964 than in 1963. Temperatures averaged (Fig. 3) a little lower in the spring months of 1964 than they were in 1963.

Brown shrimp postlarvae first appeared in late February (Fig. 4) in both years. Numbers increased steadily until June, 1963 with little evidence of two waves of recruitment. In 1964 a high peak was reached in March and April with a second wave of recruitment reaching a maximum in August.

The season in Mississippi waters is opened for commercial shrimping in June. The date is determined by the projected growth of young brown shrimp. Very few brown shrimp were caught in the sound (Gulf Coast Shrimp Data-1963 and-1964) after September. Consequently it seems likely that postlarval abundance from February through July would indicate the extent of commercial stocks.

POSTLARVAL ABUNDANCE AND THE COMMERCIAL CATCH

U. S. Fish and Wildlife Service statistical area 011.1 covers Mississippi Sound from Mobile Bay to the Gulfport Ship Channel. Area 0110 includes Gulf waters off the Mississippi coast. The commercial catch from these areas has been selected for comparison with the postlarval index (average catch per haul) resulting from this study (manuscript). Comparisons are shown in Table 1.

Catch data for area 011.1 since 1956 shows a negative correlation between catch per 24 hours of trawling and the amount of effort expended (manuscript). Total catch of brown shrimp in this area for 1964 was predicted by the post-larval index within 10 percent.

In the offshore area (0110) there seems to be no relationship between catch per 24 hours trawling and amount of effort. As indicated in Table 1 the catch per 24 hours of trawling in 1964 was predicted within 10 percent.

Beginning in August, shrimp fishermen in the Sound catch mostly white shrimp during the remainder of the year. Postlarval recruitment in Mississippi Sound and adjacent waters started in May, reaching a peak in July of 1963. In 1964 two waves, in June and August, are evident (Fig. 5). The fishing in the Sound, extending two months beyond the end of white shrimp recruitment, may take shrimp from all of the postlarval recruitment.

Comparison of 1963 and 1964 indices are shown in Table 2. The commercial catch of white shrimp for 1964 was also predicted within 10 percent of the catch as shown in Gulf Coast Shrimp Data.

Although there are indications that the survival of postlarvae in the nursery grounds depends on many variable factors, the results of this study indicate that reasonable predictions of commercial availability can be made from a postlarval index determined from a limited amount of sampling.

This year sampling has been irregular but reports to interested people in the industry have satisfactorily indicated availability to the fishery. Refinement of the index and several more years' experience are needed to validate results.

Little has been done to determine the relationship between shrimp and associated organisms in the nursery area. Lack of funds has prevented study of the vast array of animals collected in this project. A few species from a wide range of taxa have been picked out. Gobies and pipefishes have been studied in detail. A graduate student is working on larval and juvenile fishes. Much remains to be done before we understand interrelationships in the all important nursery area.

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J. Y. CHRISTMAS

Gulf Coast Research Laboratory
Ocean Springs, Mississippi

Table 1. Index of postlarval abundance of brown shrimp compared to the commercial catch in adjacent waters.

	1963	1964	1964/1963 per cent
Pl. index	97.5	107.5	110.3
Catch in Area 011.1	897,039	1,064,685	118.7
Catch per 24 hours Area 0110	459.1	497.6	108.4

Table 2. Index of postlarval abundance of white shrimp compared to the commercial catch in adjacent waters.

	1963	1964	1963/1964 per cent
Pl. index	40.04	81.81	204.3
Catch in Area 011.1	75,570	149,035	197.2
Catch per 24 hours Area 0110	88.6	183.9	207.6

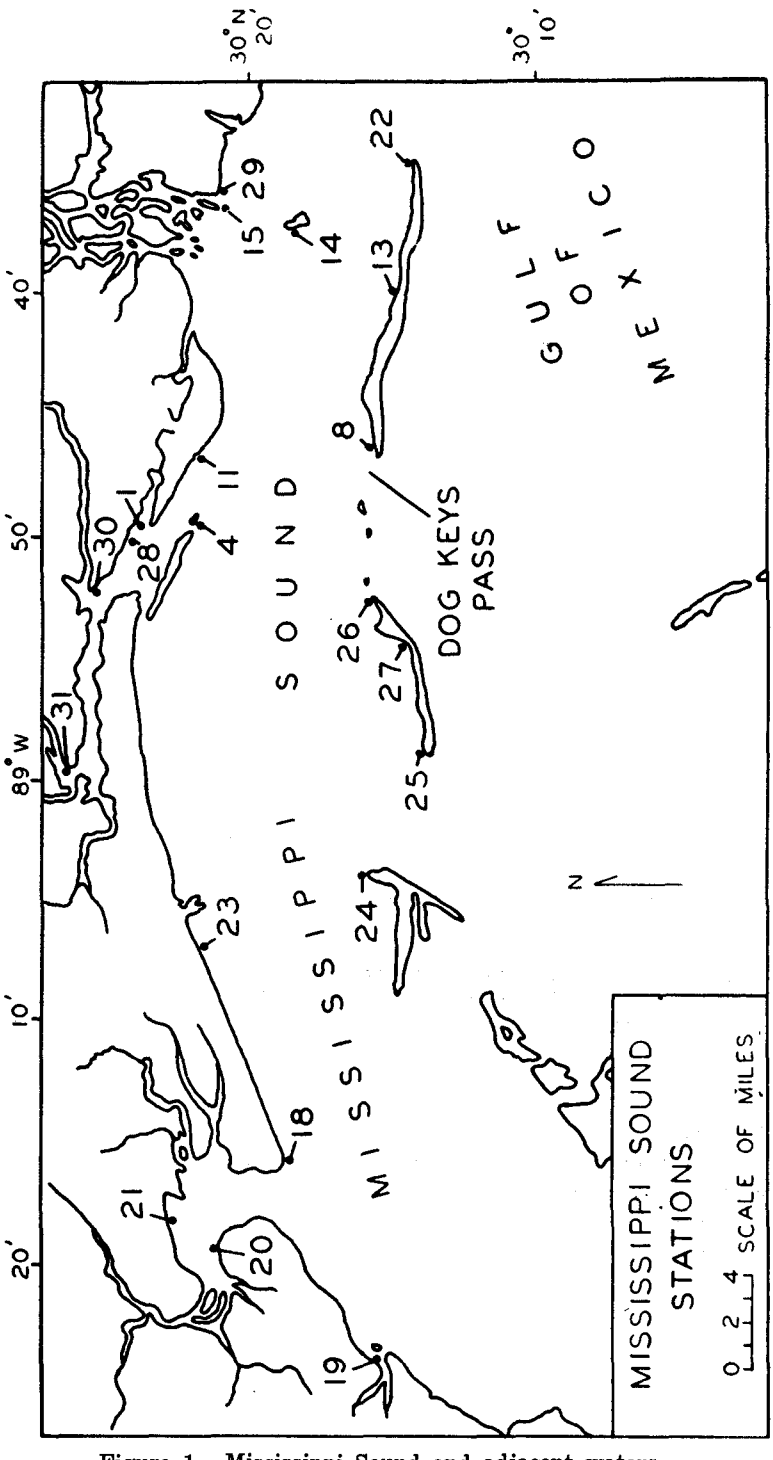

Figure 1. Mississippi Sound and adjacent waters with location of postlarval shrimp stations.

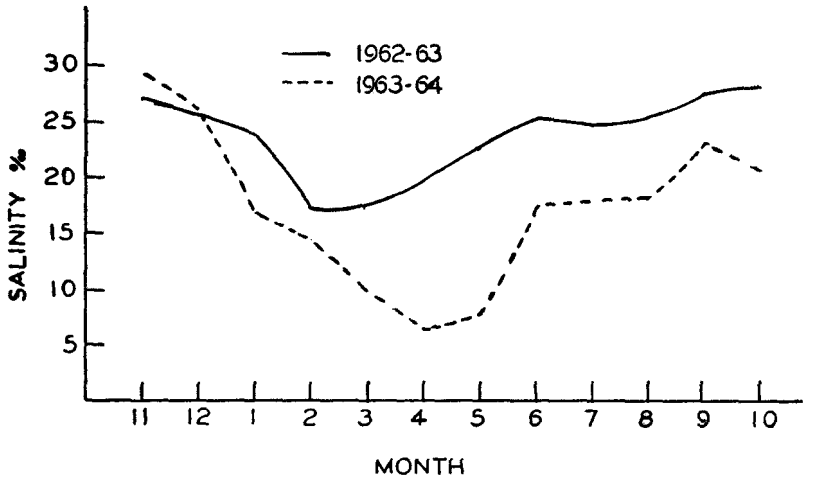

Figure 2. Average salinity at all stations.

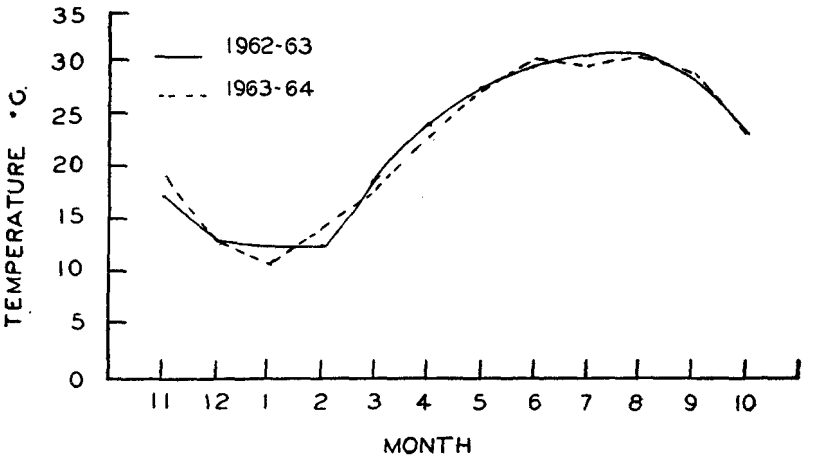

Figure 3. Average Temperature at All Stations.

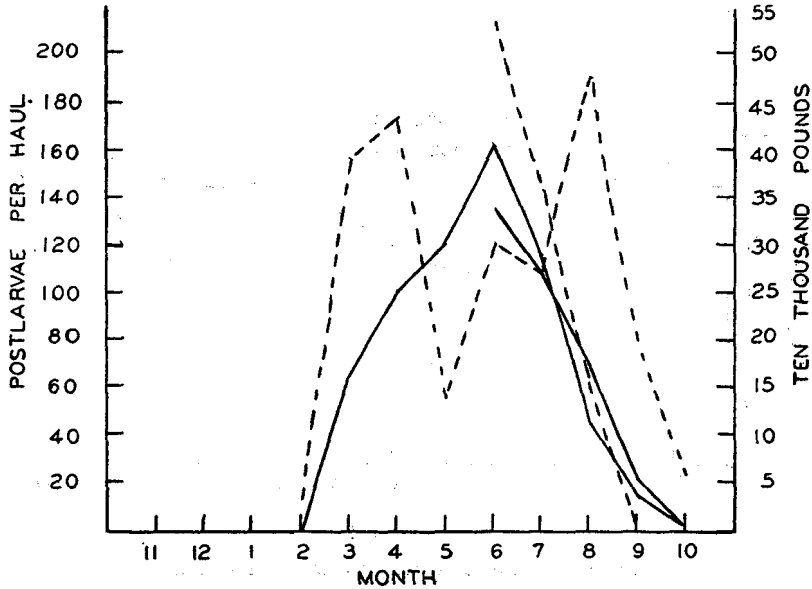

Figure. 4. Brown shrimp catch of postlarvae at stations 1, 4, 11, and 13 and commercial catch in area 011.1.

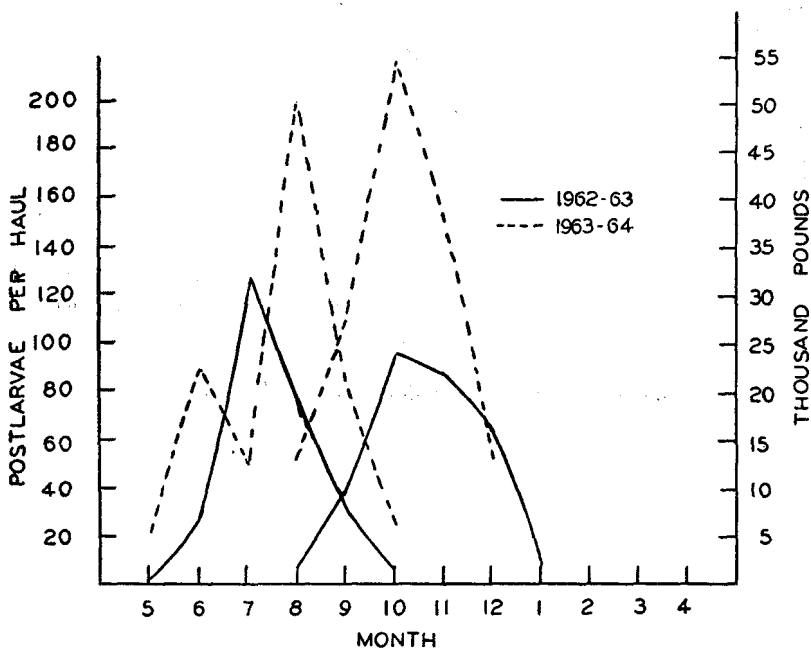

Figure 5. White shrimp catch of postlarvae at stations 1, 4, 11, and 13 and commercial catch in area 011.1.