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Abundance of Postlarval Shrimp — One Index of Future Shrimping Success[1]

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Abstract

The feasibility of forecasting offshore abundance of commercial-size shrimp from preseason counts of postlarvae as they enter passes to inshore nursery grounds is discussed. Indices derived from the results of 3 years' postlarvae sampling inside Galveston Entrance are correlated with corresponding measures of juvenile abundance on the nursery grounds and, in turn, with appropriate measures of adult abundance on offshore fishing grounds. Indices of juvenile and adult abundance are provided by commercial fishery statistics. The method employed to sample postlarvae is described.

INTRODUCTION

THE BROWN SHRIMP, *Penaeus aztecus*, spawns in the offshore waters of the Gulf of Mexico in all seasons, with the greatest activity taking place between late January and early April. The resulting larvae quickly transform to postlarvae which probably arrive at the barrier islands and passes, such as Galveston Entrance, from four to five weeks after spawning and hatching take place. Some six to eight weeks later the young shrimp reach a size which makes them ideal for sport fishing bait and soon thereafter return to open Gulf waters where they are henceforth exploited by the commercial fleet.

A continuing survey of the movements of postlarval shrimp into the Galveston Bay system was begun in November of 1959. It was felt that if a reliable measure of postlarval abundance could be so obtained, it might serve as an index with which offshore shrimp production during the last half of the same year could be predicted. This survey has since provided semiweekly counts of all penaeid postlarvae entering Galveston Bay, although discussion here will be limited to those of the brown shrimp.

Description of Postlarval Survey

SAMPLING GEAR: Samples are collected semiweekly using a hand-drawn beam trawl fitted with a plankton net at the cod end (Renfro, In press). The net is 5 feet wide (along both cork and lead lines) by 2 1/3 feet long. The wings are made of nylon material having 50 holes per square centimeter. The body

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tapers to a canvas cylinder about 5 inches in diameter and 8 inches long. A 12-inch, #1-mesh plankton net with a removable bucket is fitted over the collar. The plankton net is secured by a snap and ring arrangement.

Around both collar and plankton net is fitted a 2¼-foot section of light canvas which acts as chafing gear. A 7-foot piece of 3/16-inch stainless steel cable, onto which are threaded additional lead weights, serves as the net's lead line. The ends of the cable are attached by means of swivels to the ends of a 6-foot length of 11/16-inch stainless steel pipe which constitutes the beam. To the cork line are threaded five 2¾-inch sponge floats. The cork line ends are tied directly to the beam, 8 inches from either end. A 15-foot length of nylon parachute cord serves as the bridle line. The effective opening of the net unit is approximately 5.8 square feet.

SAMPLING PROCEDURE: The sample is taken in the following manner. A 6-foot stake (½-inch galvanized tubing) with 150 feet of nylon parachute cord attached, is driven into the ground at the shoreline. The cord is payed out and stretched taut parallel to the water line. Using the cord as a constant radius, the operator pulls the net assembly along the bottom in a half circle. This method is duplicated each time so that standard tows are obtained. The depth of tow varies from 0 to 4 feet depending on tidal conditions and roughness of the water. The effective length of each tow is about 470 feet, the volume of water sampled is 2,477 cubic feet, and the bottom area traversed is 1,958 square feet. These are average measurements and vary according to the contour of the shoreline. The postlarvae sample is immediately preserved in a 5%, buffered solution of formalin in sea water. Together with the sample of postlarvae, a water sample for salinity determination is obtained and the following observations are made: air and water temperatures, current direction and velocity, tide conditions, turbidity, condition of sea and sky, force and direction of wind, and the presence and abundance of fish in the immediate vicinity.

At the laboratory penaeid postlarvae are removed from each sample, then identified and counted. Identification to species is made using the descriptive characteristics noted by Pearson (1939) and Williams (1959).

It is believed that the important "spring run" of postlarvae consists almost entirely of brown shrimp and that chances of taking pink shrimp, *Penaeus duorarum*, postlarvae in Galveston Entrance between February and May are very slight. Of 27,700 juvenile shrimp examined from Galveston Bay bait shrimp samples between January, 1960 and October, 1962, only 13 were identified as pink shrimp. This species was never found in bait samples secured later than mid-May. Two specimens obtained on May 19, 1961 had an average weight of 8.4 grams whereas the mean weight for 84 juvenile brown shrimp in the same bait sample was 2.9 grams. It is assumed, on the basis of preliminary knowledge of the brown shrimp's growth pattern, that the latter specimens had entered Galveston Bay as postlarvae in March and April. In contrast, it is quite unlikely that the much larger pink shrimp had passed through the same stage in the same period.

To supply anglers in the Galveston area during winter months, bait dealers often transport shrimp from other areas in aerated tank trucks (Chin, 1960). Most of those brought from the Matagorda Bay area are pink shrimp, some of which could have escaped the live bait boxes and survived to be taken the following spring. It is also reasonable to assume that fishermen having live

shrimp left after a fishing trip released them in the area, only to have them recaught when trawling for bait shrimp intensified in May.

SAMPLING SITES AND FREQUENCY: The first sampling station was established in the Bolivar Roads area near the south jetty on the east-end sand flats of Galveston Island (SF, Fig. 1). Semiweekly samples were taken at this site from November, 1959 to May, 1961, and again from mid-August to September 8, 1961. During the period September 9 to 12, 1961, flood waters from Hurricane Carla cut a channel approximately 200 feet wide and 14 feet deep through the sand flats adjacent to the jetty, making the station site inaccessible. Following the hurricane, a new monitoring station (BSF) was selected on Bolivar Peninsula in a cove off State Highway 87 opposite the abandoned lighthouse. This location was used from September 25 to November 21, 1961. When this section of beach was fenced off, a third station site was selected midway between the north jetty and the Fort Travis ruins on Bolivar Peninsula (NJSF-1).

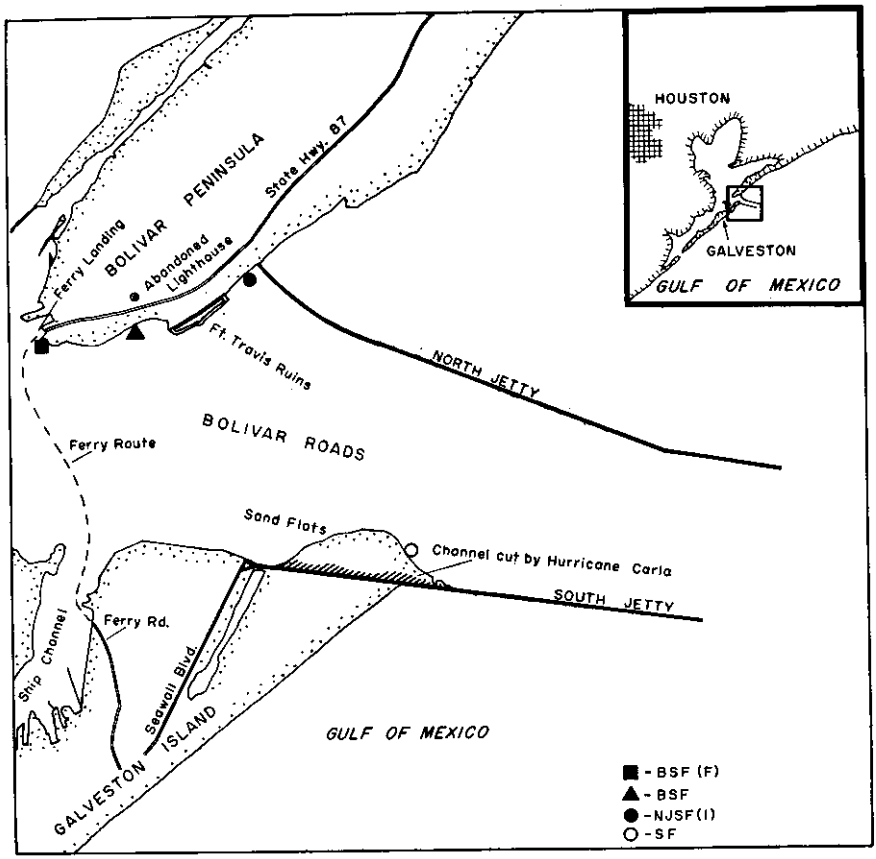

FIG. 1. Galveston Entrance showing location of stations at which postlarval shrimp were sampled.

TABLE 1

RESULTS OF SAMPLING FOR BROWN SHRIMP POSTLARVAE IN GALVESTON ENTRANCE, 1960-62.

Item	Year	MONTH Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Number of samples	1960	7	8	8	9	9	9	8	9	9	9	8	9
	1961	9	7	8	7	2	—	—	6	4	10	9	8
	1962	9	8	11	9	9	9	9	9	8	9	9	—
Total number of postlarvae	1960	19	13	4919	4989	34	379	509	838	10	4	6	7
	1961	0	6	183	246	940	—	—	97	694	268	76	43
	1962	241	1847	3495	2514	290	62	50	310	515	Counts not completed		
Range	1960	0-12	0-3	0-4710	0-3680	0-9	0-167	0-241	0-306	0-4	0-2	0-3	0-6
	1961	—	0-4	0-97	0-209	0-889	—	—	0-54	4-620	0-144	0-45	0-20
	1962	0-224	1-1220	0-1083	3-1682	0-250	0-32	0-14	0-153	0-351	—	—	—
Number per sample	1960	3	2	615	554	4	42	64	93	1	1	1	1
	1961	0	1	23	35	470	—	—	16	174	27	8	5
	1962	27	231	318	279	32	7	6	34	64	—	—	—

Twice-weekly sampling has since been carried on at this site with the exception that in early June, after vast quantities of "seaweed" (*Sargassum natans* and *S. fluitans*) built up in the area, an alternate station (BSF-F) was established at the ferry landing. Although the cove in which this station site is located affords room for only half the normal towing space required, it was protected to some extent from the southeasterly winds which piled seaweed onto the beach at the regular station site. Between June 4 and July 12, 1962, nine tows were made at this location. The presence of seaweed began to hamper sampling operations as early as April 23 and continued to impede them through May, June, and July. As of this writing (November, 1962), samples are still congested with decomposing weed which continues to litter the bottom in the sampling area.

Over the 3-year period, all tows were made during daylight hours, alternating from morning to afternoon so as to sample during both flooding and ebbing tides. Fig. 2 shows the movement of brown shrimp postlarvae through Galveston Entrance for the 3-year study period. From 7 to 9 tows were ordinarily made each month. Wide variation in the numbers of postlarvae occurring in each sample indicated that, while immigration may have been continuous during seasons of peak abundance, its intensity fluctuated broadly (Table 1).

Indices of Abundance

COMMERCIAL FISHING OPERATIONS: The number of commercial bait trawlers operating in the Galveston Bay area fluctuates annually between 85 and 125, the number of dealers between 100 and 145. Bait shrimp are caught with small shrimp trawls ranging from 10 feet to a maximum width of 25 feet along the cork line. Mesh sizes vary from 1½- to 1¾-inch stretched measure. These nets are towed principally by small trawlers ranging up to 35 feet in length, but a few dealers are supplied from catches made with outboard-powered skiffs. Although bait shrimp may be legally taken from the bay throughout the year, most production occurs from May to October.

COLLECTION OF STATISTICS: Approximately 50 bait dealers are interviewed each week by means of a continuing sample survey. Production and effort statistics are obtained along with information on area(s) fished, number of fishing trips, and time spent trawling. Since January, 1959, monthly estimates of total production and effort have been made utilizing these data. Samples of live or fresh-frozen shrimp, which provide material for determining growth as well as catch size and species composition are obtained weekly from each section of the Galveston Bay system.

DERIVATION OF INDICES: The monthly index of brown shrimp postlarval abundance was obtained by dividing the total number of postlarvae collected during a given month by the number of tows made in the same period. The resulting number of postlarvae per tow, or postlarval index, is plotted serially in Fig. 3.

In order to obtain a juvenile index, total monthly brown shrimp bait production (pounds) was divided by total effort expended (hours). The resulting catch per unit of effort (pounds per hour's fishing) was used as a monthly index to juvenile brown shrimp abundance on the nursery grounds.

An index of adult brown shrimp abundance, expressed in terms of the average catch of commercial-size brown shrimp per 24 hours' trawling off the upper Texas coast (Fig. 3) was obtained by dividing the monthly catch of

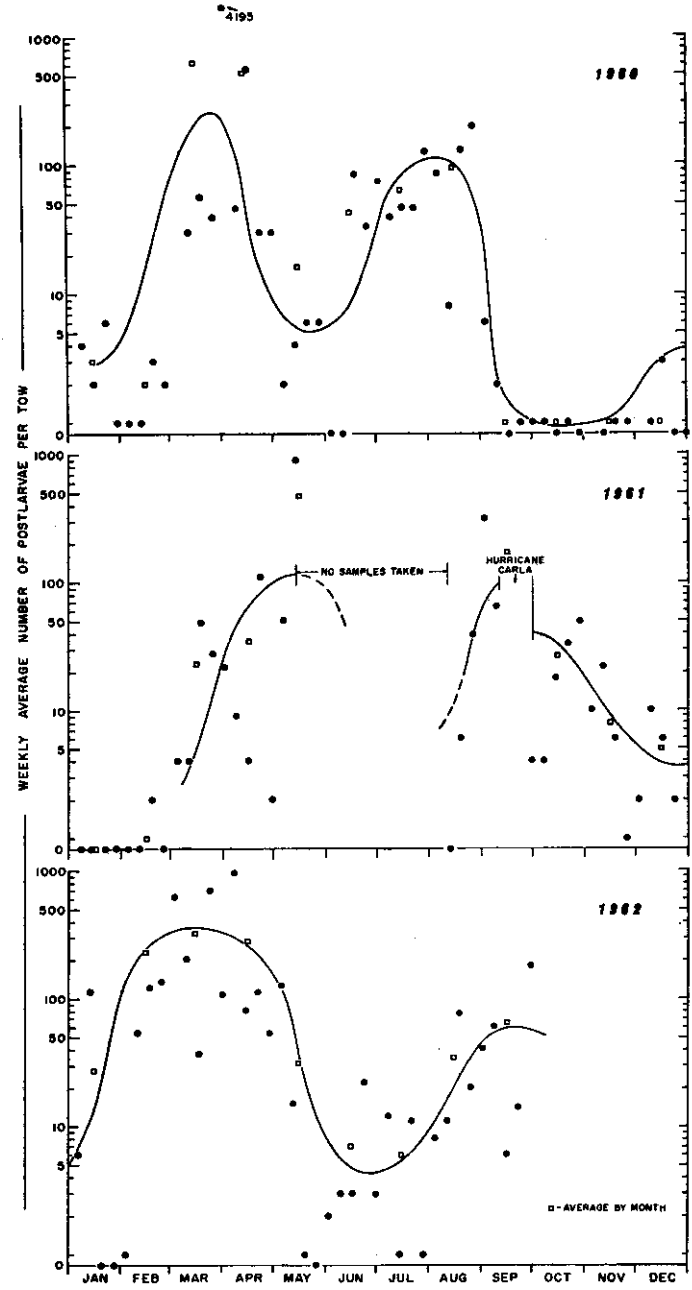

FIG. 2. Relative density of brown shrimp postlarvae occurring in Galveston Entrance, 1960-62.

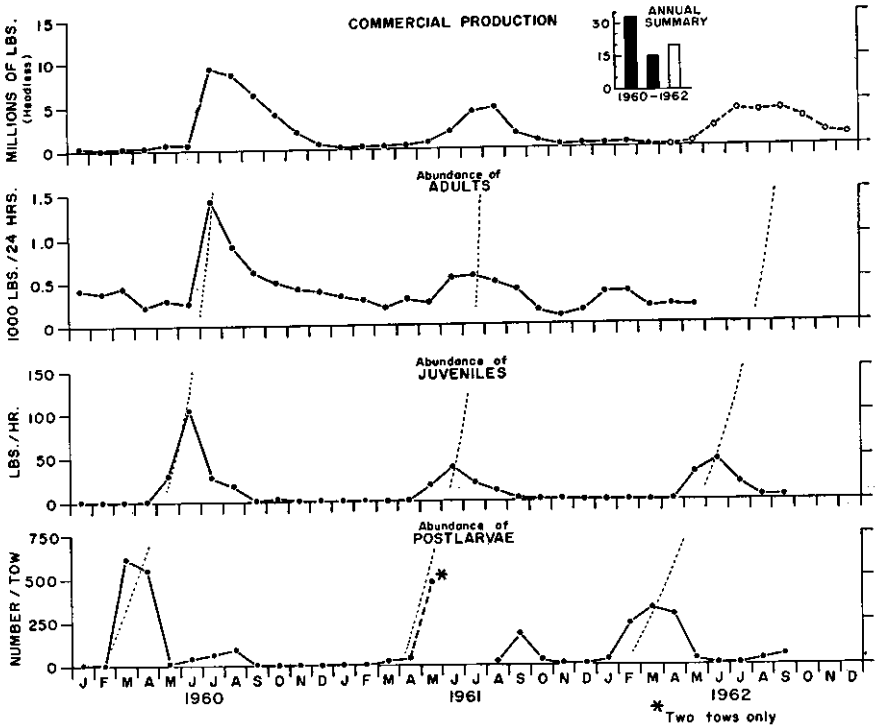

FIG. 3. Correlation of abundance indices for brown shrimp postlarvae, juveniles, and adults with subsequent offshore production, Galveston and upper Texas coast, 1960-62. (Unshaded portion of production graph indicate preliminary estimates for 1962.)

brown shrimp by the corresponding number of days fishing time expended. Production and effort statistics used to derive this index were obtained from tables entitled *Gulf Coast Shrimp Catch by Area, Depth, Variety and Size* published monthly by the Bureau of Commercial Fisheries.

Consolidation of these indices for comparative purposes is attempted in Table 2. Here, the postlarval index for each of the three years involved was obtained by dividing the total number of brown shrimp postlarvae taken during months of greatest postlarval movement (February, March, April and May), by the total number of samples taken in the same period.

The juvenile index was obtained by combining catch values for the three months of peak brown shrimp bait production on the nursery grounds (May, June, and July), and dividing this figure by the combined effort expended by bait fishermen during the same period.

The adult index (Table 2) was developed by considering only commercially acceptable brown shrimp of a size that could conceivably have been young-of-the-year, *i.e.*, February-May postlarvae and May-July juveniles. Thus the catch of small shrimp (41 headless-count and smaller) taken from statistical

TABLE 2

COMBINED INDICES OF BROWN SHRIMP ABUNDANCE AT EACH OF THREE LIFE HISTORY STAGES IN THE GALVESTON AREA AND OFF THE UPPER TEXAS COAST, 1960-62

YEAR	POSTLARVAE February-May (number/std. tow)	JUVENILES May-July (pounds/hour)	ADULTS June-September (pounds/24 hours)*
1960	297	54	260
1961	134	25	116
1962	215	32	Not yet available

*Includes small shrimp only (41 headless-count and smaller).

subarea 18 off Galveston (Kutkuhn, 1962) during June, July, August, and September, divided by the corresponding number of days fished, yielded the required index.

DISCUSSION OF RESULTS, 1960-62

Primary peaks of brown shrimp postlarvae occurred annually between mid-February and mid-May, secondary peaks between late July and mid-September (Figs. 2 and 3). Maximum movement of postlarvae in 1960 occurred during March and April. In 1961, fewer postlarvae were taken and the greatest movement occurred in May. In 1962, postlarvae began to appear in large quantities in February, and continued to enter the nursery area in comparable numbers during March and April.

In 1960, a high postlarval index in March and April was succeeded in May and June by a high juvenile index and record high bait shrimp production (Fig. 3). Both indices forecast a great abundance of shrimp offshore in late summer. As it turned out, 1960 proved to be a record year for brown shrimp production in western Gulf waters.

In 1961, the postlarval index dropped considerably compared with that of 1960. A corresponding drop in bait shrimp production was also observed. Commercial brown shrimp production in 1961 amounted to only about one-half that of 1960. Parenthetically, it should be noted that only two postlarvae samples were taken in May of 1961 (May 1st and 8th), each containing an average of 470 individuals. Unfortunately, sampling was discontinued at this time and not resumed until mid-August, leaving the question unanswered as to whether counts from these two samples truly indicated the magnitude of postlarval immigration during May. In any event, the postlarval maximum in May, as suggested by the two samples, was not reflected in corresponding plots of juvenile abundance (Fig. 3).

In 1962, the postlarval index exceeded that of 1961, but fell somewhat short of the 1960 index (Fig. 3). The juvenile index also showed an increase over that for 1961. Although offshore production figures are not yet available for 1962, the supply as reflected by landings and amounts of discards should measurably exceed that of 1961. Production, however, will probably not approach the record-high level of 1960.

Offshore abundance of adult shrimp was not accurately mirrored by preliminary production figures for the months of June, July, and August of

1962. Abnormally large numbers of small brown shrimp, according to reports of fishermen, were discarded at sea off the Texas and Louisiana coasts during this period. Over a 10-day period in August, 1962, observations aboard a commercial trawler operating off Aransas Pass, Texas, revealed that approximately 26 percent by weight (30 percent by number) of its shrimp catch was being discarded because it failed to meet the minimum legal size. Texas law forbids the commercial fleet to land shrimp of 50 headless-count size or smaller. If we assume that shrimp at this life history stage grow in length about 15 mm per month, the discard rate a month earlier (July) would have been about 50 percent by weight (60-70 percent by number).

SUMMARY

To determine their possible use in predicting catch potential for the commercially important brown shrimp, indices derived from the results of 3 years' postlarvae sampling inside Galveston Entrance are correlated with corresponding measures of juvenile abundance on the nursery grounds and, in turn, with appropriate measures of adult abundance on offshore fishing grounds. Although further work is necessary in order to establish its reliability, it is apparent that the postlarval index forecasts quite well the relative magnitude of subsequent juvenile abundance in estuarine areas, as well as the ultimate quantity of commercial-size shrimp available offshore.

LITERATURE CITED

CHIN, EDWARD
1960. The bait shrimp fishery of Galveston Bay, Texas. Trans. Am. Fish. Soc., *89* (2): 135-141.

KUTKUHN, JOSEPH H.
1962. Recent trends in white shrimp stocks of the northern Gulf. Proc. Gulf and Carib. Fish. Inst., 14th Annual Session (1961), p. 3-16.

PEARSON, JOHN C.
1939. The early life histories of some American Penaeidae, chiefly the commercial shrimp, *Penaeus setiferus* (Linn.). Bull. U.S. Bur. Fish. *49* (30): 1-73.

RENFRO, WILLIAM C.
1962. Small beam net for sampling postlarval shrimp. *In:* Galveston Biological Laboratory—Fishery research for the year ending June 30, 1962. U.S. Fish and Wildlife Service. Circular (In press).

WILLIAMS, AUSTIN B.
1959. Spotted and brown shrimp postlarvae *(Penaeus)* in North Carolina. Bull. Mar. Sci. Gulf and Caribbean. *9* (3): 281-290.

A Biological Study and Some Economic Aspects of Squid in Tampa Bay, Florida

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Abstract

Distribution of the squid *Lolliguncula brevis* by time and area is described for Tampa Bay and its adjacent waters. Tolerances of *L. brevis* to salinity and temperature are discussed. Particular emphasis is placed upon size at which sexual maturity occurs. A discussion of the economics of the squid fishery is given.