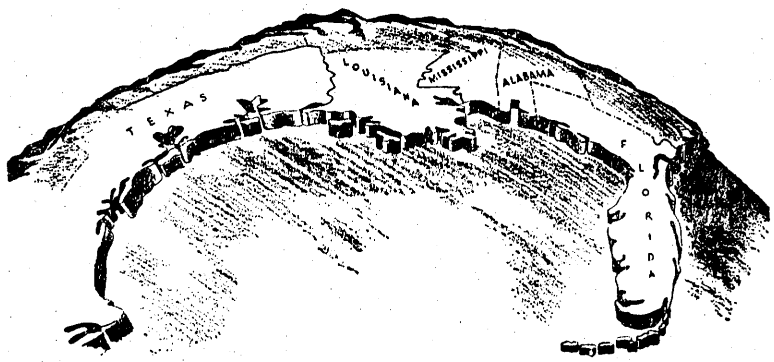
Gulf States Marine Fisheries Commission



INFORMATIONAL SERIES No. 3

THE SHRIMP FISHERY OF THE GULF OF MEXICO

(Rio Grande River to Key West, Florida)

BIOLOGICAL NOTES AND RECOMMENDATIONS

by

SHRIMP BIOLOGICAL RESEARCH COMMITTEE

October 1966

This revision of Informational Series No. 2 has been published by the Gulf States Marine Fisheries Commission as information to the governors, legislators and marine fisheries administrators of the several compacted Gulf States, and for such consideration as may be deemed appropriate in the development of laws and regulations pertaining to the shrimp fishery of their respective states.

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INTRODUCTION

Since the publication in 1959 of Informational Bulletin No. 2 on the Shrimp Fishery of the Gulf of Mexico, a sizeable amount of research has been carried out by the U. S. Fish and Wildlife Service, the various States bordering the Gulf of Mexico, and by universities operating under federal or state contract. In general, the knowledge gained confirms the summary of information offered in bulletins Nos. 1 and 2, but the considerable amount of additional and excellent data now on hand makes it desirable that the most recent thinking and conclusions on shrimp biology and management be made available to the industry and the administrators charged with the management of this important fishery.

The new information on shrimp biology offers no startling panacea to shrimp production but does offer an important contribution to the knowledge of shrimp biology and the management of the shrimp industry. Some of the more important information now on hand includes:

1. More detailed information on the life cycle, habits, growth rates, and movement of all three commercially important species, i.e., the white shrimp, *Penaeus setiferus*, the brown shrimp, *P. aztecus*, and the pink shrimp, *P. duorarum*. In particular, information about the latter two species is now equivalent to that on the white shrimp.

2. Much of the data is of a quantitative nature which affords a system of correlating early stages in the annual shrimp cycle with later production figures. This had led to some successful predictions of shrimp abundance in advance of the harvesting seasons and has afforded administrators better information upon which to regulate the industry.

3. Annual variations in the timing of the shrimp cycle and the localized effects of weather and water conditions on shrimp growth, movements, and densities are better understood.

4. Standardized methods of collecting data in all research efforts along the northern Gulf delimit the difference in time and appearance of shrimp populations in different areas and suggest possible differences in the timing of the cycles from one embayment to another. This information when more complete should afford much more efficient management of the resources.

5. Studies on shrimp movements and population dynamics now in progress already offer some usable information with respect to the relation between shrimp size at which to begin harvesting, the ultimate poundage of the catch, and the point of maximum value of the harvest.

BIOLOGICAL SUMMARY

The following summary of biological data has been assembled by the Shrimp Research Committee of the Gulf States Marine Fisheries Commission. This summary is not intended to be an extensive technical discussion of shrimp biology, but rather a statement of biological information immediately usable by fishery administrators and industry for understanding and managing shrimp production.

Important biological factors determined for the three principal commercial species are summarized in Tables I, II, and III. Careful examination of them indicates that in general the life cycles of the three species are much the same. All mature at approximately the same size and spawn offshore. The postlarvae migrate to inshore nursery areas where they rapidly grow to subadulthood. The adolescent shrimp then return to offshore waters where they become adults and spawn, thus, completing their life cycle. Of most significance in this summary is to note that the basic shrimp life cycle is an annual, but not necessarily a calendar year, affair. The populations are maintained usually by successful spawning and rapid growth rates. This means that shrimp production in a given biological year is a reflection of the success of spawning, growth, and survival within that year.

A limited number of spawners are capable of producing a maximum population if environmental conditions are optimum. On the other hand, large brood stocks may not result in good production if environmental conditions are adverse in the spawning and nursery areas.

Considering the management of individual species, one should note the differences which occur between species (Tables I, II, and III.) These differences involve variations in the location of the spawning areas and the timing of the ingress of the postlarvae into, and the egress of subadults from, the nursery areas. In areas where two or more species make up major portions of the fishery, variations in timing can be of considerable significance since the two cycles may overlap at a time when one species is too small to be utilized by the industry.

QUANTITATIVE STUDIES, ENVIRONMENTAL PARAMETERS, AND PREDICTIONS

The above biological data merely reinforces previous knowledge of the white shrimp life history and furnishes additional evidence that the brown and pink species have similar life cycles but with significant differences in the timing or occurrence of spawning and movements into and out of the bays and other components of the cycles. The timing and the success of production of a species varies from year to year, presumably as a result of changing environmental conditions. It is becoming evident that annual quantitative and juvenile postlarval surveys combined with a physical survey of the environment offers promise for predicting much about the harvest in advance of the season.

Studies of Postlarval Densities and Movement

Annual quantitative studies of postlarval populations moving onto the nursery areas are now standardized so that the information may be used to aid in the prediction of forthcoming harvests. Basically, the size of the postlarval population entering the nursery areas reflects the success or failure of offshore spawning, and environmental conditions in the nursery areas determine the survival and growth rates of the preharvest crop. It appears that in some instances the arrival time of the peak of the postlarval population can be used to indicate the probable success of survival and growth of the population to commercial size. Other factors which concern principally the brown shrimp are: 1) Peak populations of postlarvae may occur in late fall after spawning occurs and these winter-over in a state of reduced activity as inshore water temperatures decline. 2) Late winter and early spring movements of postlarvae onto nursery grounds appear to be associated with rising water temperatures and incoming tides. (Note: White and pink postlarval movements are also associated with incoming tides.) 3) Rapid growth of postlarvae into juveniles does not occur until water temperatures reach about 20°C. (68°F.).

Oceanography and Crop Prediction

Environmental conditions in the nursery areas can affect the abundance of brown shrimp but the principal cause or causes of these annual fluctuations in abundance lies in the Gulf of Mexico. If these causes can be determined it should be possible to advance crop prediction by weeks or months. A combined physical and biological oceanographic study of the waters of the Gulf of Mexico should provide the answers.

Temperature and the Shrimp Cycle

Increasing evidence from all research efforts indicates that water temperature is an important factor affecting shrimp cycles. Temperature appears to influence the time of spawning but more significantly is associated with the growth rate of all species of shrimp throughout their life cycle. Water temperatures below 20°C. (68°F.) greatly inhibit the rate of growth to a point where it becomes practically nil at 16°. Conversely, growth rates are extremely rapid above 20°C. and that of juveniles may exceed 1.5 mm. per day at 25°C.

From the standpoint of practical management of the resource and of predicting the outcome of annual production, water temperature information coupled with quantitative data on postlarval and juvenile populations are invaluable. In the northern Gulf during late fall and winter it is particularly evident with the white shrimp that the growth of juveniles slows down or stops, and these

TABLE I. Spawning time, location—size of spawners

Species	Minimum size of females spawning	Location	Time
White Shrimp	140 mm. or 5½" (35 tails/lb.)	Offshore 5 to 20 fathoms—around 7 fathoms in summer months	Spring to early fall—peaks in late spring and early fall.
Brown Shrimp	140 mm. or 5½" (30 tails/lb.)	Offshore to at least 60 fathoms. Usually between 15-40 fathoms. In shallower water in warmer months	Spawning may be year round—major speak Sept. to Nov.—minor April to May.
Pink Shrimp	95 mm. or 3 3/4" (88 tails/lb.) in Florida 135-140 mm. or 5¼" (30 tails/lb.) in Northwestern Gulf.	Tortugas grounds 15 to 25 fathoms. Tampa offshore 5 to 21 fathoms.	Year round spawning on Tortugas—peak in spring, summer and fall—when bottom water temperature is near or above 75°F.

TABLE II. Time of ingress to and egress from nursery area—offshore migrations and sizes

Species	Ingress of postlarvae into nursery grounds	Egress from bays to offshore area	Movements of offshore populations
White	Enter nursery area from mid-April to mid-November. Two peaks—one from mid-May to July and one in Sept. and Oct.	Leave embayment at larger size than Brown. Size ranges from 120 to 140 mm. 4¾ to 5½". Peak movement occurs from Sept. to Dec. as waters cool.	Movement toward deeper water—accelerates as temperatures drop.
Brown	Enter nursery area Feb. to Dec.—major peak in March and April and minor peak in late summer and fall.	Egress occurs at approximately 100 mm. or 4". The major movements occur from May to August.	Migrate rapidly to 10 fathoms and may move parallel to shore with prevailing westerly currents—gradually move to deeper water 25 to 50 fathoms.
Pink	Enter South Florida nursery areas all months of year, with peak of abundance in spring, early summer and winter. Enter Tampa Bay during most months with major peak in July.	In southern Florida movement from Everglades nursery area occurs at an average size of 65 mm. or 2½" during all months of year—peaks occur from Sept. to Nov. and Jan. to April. In Tampa Bay movement from March or April through July at about 95 mm. or 4".	Movements toward deeper water. Like other two species average size generally increases with depth.

TABLE III. Shrimp growth rates determined by various research efforts

Species	Alabama	Florida	Louisiana	Mississippi	Texas
White	-----------	1.0 to 1.2 mm. per day-or 1⅕ - 1 2/5" per month total length on nursery ground.	Generally at a faster rate than Browns.	Postlarvae and juveniles—1.5 mm. per day or 2-2¼" per month. Adults slower growing.	Postlarvae and juveniles—1.5 mm. per day approx. 2" per month larger shrimp rate—0.5 mm. per day.
		1.3 mm. per day or 1½" per month.[1]	1.3 mm. per day or 1½" per month.[1]	1.3 mm. per day or 1½" per month.[1]	1.3 to 1.9 mm. per day or 1½-2¼" per month.[1]
					2.3 mm. per day or 2¾" per month.[2]
Brown	-----------	1.3 to 1.5 mm. per day or 1½ - 1¾" per month total length on nursery ground.	Postlarvae and juveniles 1.1 to 1.3 mm. per day or approx. 1¼-2" per month. Maximum rate 2.5 mm. per day or 3" per month.	Postlarvae and juveniles — 1.5 mm. per day or 2-2¼" per month. Adults slower.	Postlarvae and juveniles—1.0-1.5 mm. per day or 1 1/8-1¾" per month.
			1.2 to 1.3 mm. per day or 1 2/5-1½" per month.[1]	1.2 to 1.3 mm. per day or 1⅖-1½" per month.[1]	1.2 to 1.3 mm. per day or 1 2/5-1½" per month.[1]
Pink	-----------	Postlarvae or juveniles 0.3 to 0.5 mm. per day—approx. ½" per month. Adults 0.2 to 4.0 mm. per month, carapace length.	Not. studied	Not. studied	Not. studied
		0.8 to 1.1 mm. per day or 1-1⅓" per month.[1]			

[1] B.C.F data calculated from Von Bertalanffy growth curves determined from mark-recapture experiments for shrimp growing from 30 to 100 mm. in total length. Rate shown is the average daily increase for the entire 70 mm. of growth.

[2] B.C.F. data from pond experiment.

small creatures are forced to winter-over as a nonmarketable population mixed with some older shrimp of marketable size. Investigations are needed to determine if it is more profitable to protect such populations until growth resumes the following spring or if losses will be so great from natural attrition and predation that the population should be harvested though undersized.

Salinities in Relation to the Shrimp Cycle

The effects of salinity on shrimp are not nearly so clear as that of temperature. Under some conditions all species of shrimp are tolerant of extreme salinity ranges from greater than normal sea water to virtually fresh water. Investigation of brown shrimp on the nursery areas indicates that low salinities coupled with low temperatures may result in postlarval and juvenile mortalities. These field observations have been confirmed by laboratory experiments.

Juvenile Growth and Density

Quantitative studies on growth, density, and distribution of juveniles on the nursery area are necessary to make a satisfactory prediction of the forthcoming shrimp crop. Once growth rate is established it may be projected to determine the average size of the shrimp in the population on any given date. This serves to determine when the season should be opened. Juvenile density obtained by periodic sampling at predetermined stations gives significant evidence of the density and distribution of the population and can be used as an index to total production.

Size of Migrating Shrimp a Function of Density

Some evidence is now on hand from several investigators which indicates that the size of the adolescent shrimp as it migrates offshore may be associated with the population density on the nursery grounds. It appears that the greater the number of shrimp on the nursery grounds the smaller the average size of the shrimp migrating offshore. The reason for this is not yet known, but it may be the result of crowding or competition for food. Nevertheless, from a management standpoint the industry should be constantly aware that in high production years one may be faced with smaller sized shrimp on nursery grounds and near-shore waters.

Shrimp Farming and Seeding

The white, pink and brown shrimp and the seabob have now been reared to the juvenile stage from eggs hatched in the laboratory. Some preliminary experiments suggest that shrimp farming, at least to bait size, might be feasible. Eventually it may also be possible through seeding to maximize and stabilize the annual shrimp crops and to bring some low producing areas into greater productivity.

Size at Beginning of Harvest

Probably one of the most perplexing questions facing the administrator is:

What size should shrimp reach before fishing begins in order to obtain maximum yield from a brood or crop of shrimp?

Because of the way shrimp distribute themselves on the fishing grounds and because the industry pays more for large than for small shrimp, there are three types of maximum yields from which to choose: maximum yield in weight, maximum yield in value, and maximum yield in profit. The size at which harvesting should begin will vary somewhat depending upon the type of maximum chosen. In general, however, the yield curves so far developed are flat-topped which means that a rather wide range in size at first harvest is permissible.

For example, latest information suggests that for the Tortugas pink fishery about the same yield in weight would be obtained if fishing began when shrimp reached 80 tail count per pound as would be obtained if fishing were delayed until the shrimp reached 40 count. When maximum yield in value is considered, the sizes would drop to between 65 and 30 tail count.* A profit curve has not yet been developed, but in all probability it would give sizes ranging intermediate between those for weight and value.

A logical question to ask is why are such wide ranges in size given? The answer is simply that so far it has been impossible to pinpoint some of the factors needed in order to develop the curves. Before a yield curve can be constructed, certain information must be available. This information includes the following:

1. The maximum age shrimp reach;
2. Their average size at maximum age;
3. Their growth rate;
4. Their natural death rate; and
5. The rate at which they are being fished.

With shrimp, the last three are not constant.

Most progress so far has been made with the dynamics of the Tortugas pink shrimp populations. Work is in progress that soon should provide usable information on the dynamics of the brown and white shrimp populations in the northern Gulf.

RECOMMENDATIONS

1. Because it is evident in the northern Gulf that the time at which commercial-size shrimp appear on the fishing grounds varies from year to year and because, in most instances, the State conser-

*Tail counts of 80, 40, 65, and 30 are equivalent to heads-on counts, respectively, of 49, 25, 40, and 18.

vation agencies are now following the progress of shrimp development on the nursery grounds and are able to predict when the shrimp will reach marketable size, it appears that the State conservation agencies should be encouraged to continue these endeavors and that these agencies should be empowered to determine the fishing seasons.

2. More intensified studies are needed in these areas:

   a. What predictable changes take place in the waters bathing the spawning and fishing grounds?

   b. What characteristics of the Gulf water masses are significant to spawning, survival, migrations and growth? Evaluation of the water masses must include predators, food and the physical factors of temperature, salinity, oxygen and turbidity.

   c. Is it feasible to farm shrimp and would seeding be a means for stabilizing and increasing production?

   d. What size shrimp should reach before fishing begins in order to obtain maximum economic yield?

   e. Is it more profitable to protect small white shrimp during late fall and winter than it is to harvest them though undersized?

   f. What is the relation between size of migrating shrimp and population density in nursery areas?