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Harold C. Loesch
Louisiana State University

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SHRIMP POPULATION DENSITIES WITHIN MOBILE BAY*

HAROLD C. LOESCH*
Department of Marine Sciences, Louisiana State University, Baton Rouge, Louisiana 70803

ABSTRACT Brown shrimp and white shrimp populations available to the shrimp trawl in Mobile Bay were estimated on a monthly basis by two methods: one using existing commercial statistics and the other using experimental trawling. These methods produced similar estimates for brown shrimp whose peak standing crop in Mobile Bay occurred in June–July and was estimated at 200,000–300,000 pounds. Commercial landings peaked in July at about 342,000 pounds and were higher than the standing crop, indicating an extremely fast growth rate.

White shrimp data were variable, with commercial statistics indicating a crop in Mobile Bay of about 100,000 pounds from September to November and with experimental trawl data indicating a peak of 267,000 pounds in August. Average monthly harvests approached 100,000 pounds from August to October.

Abundance of pink shrimp was erratic and commercial shrimp statistics indicate variation from 475 pounds landed in 1956 to 34,000 pounds landed in 1957.

INTRODUCTION

The shrimp fishery is the most valuable fishery in the Gulf of Mexico. Its value and poundage have increased with the introduction of the gas engine, the otter trawl, and modern refrigeration; with the discovery of new fishery grounds; and most recently with the increase in fishing pressure. Despite the latest increase in fishing pressure, the total yield remained stable in the Gulf states until 1971. Variations since that time seem to have been related to rainfall and river flow (Gunter and McGraw 1973).

Gunter (1956) said that because of extremely fast growth rates of shrimp in warm months, no reasonable amount of fishing would reduce the total weight of the population during these months.

Loesch (1962) stated, "According to pioneer shrimpers, shrimping was much better in years gone by. Their observations may be faulty in that they may remember the exceptional catches but not their frequency. If there is a reduction in the number of shrimp in the bay now compared to twenty years ago a number of factors could be involved. Increased fishing pressure is not the only man-made difference in the bays. Agriculture, industry, and navigational improvements have wrought great changes, so former abundance is not a sure index to present potentialities."

Penaeus setiferus (Linnaeus) and *Penaeus aztecus* Ives are two species of commercial shrimp found more or less abundantly in all five Gulf states; *Penaeus duorarum* Burkenroad also is common in Florida and Texas and appears sporadically in the intervening states.

Loesch's dissertation (1962) was an attempt to add to the general knowledge of the shrimp during the time they live in brackish water. Loesch (1965) gave seasons they appeared in the bays and size distribution within different water depths, salinities, and areas. This paper attempts to estimate monthly populations of brown shrimp and white shrimp by using two different methods. One method uses commercial fisheries data, by determining both the ratio of area swept by commercial trawl to total area in Mobile Bay and the ratio of shrimp caught to total estimated population in Mobile Bay. The other method uses similar techniques but substitutes experimental trawl data for commercial trawl data.

MATERIALS AND METHODS

The fishing mortality generated by a single operation, which may be considered as taking part of the whole stock, is equal to the fraction of the population caught. If the stock is evenly distributed and the gear effectively catches all the shrimp within a certain area (a), and if the total area inhabited by the stock equals A, then the fishing mortality is equal to a/A. The mortality generated by the whole fishery is then a^1/A, where a^1 is the sum of the areas covered by all the vessels of the whole fleet. The area covered would be the distance between the doors of the trawl times the total distance dragged.

There are two important sources of errors, acting in opposite directions. First, not all the shrimp in the area covered by the gear will be caught, resulting in an underestimation of available crop or population occupying area A. Second, the density of shrimp in the fished area will be greater than the average density, resulting in an overestimation of the available crop in area A. While the method is not suitable for an exact account of the population or available crop in area A, it may be useful in giving an indication of its magnitude. By estimating the population and knowing the commercial catch one can arrive at the fishing mortality.

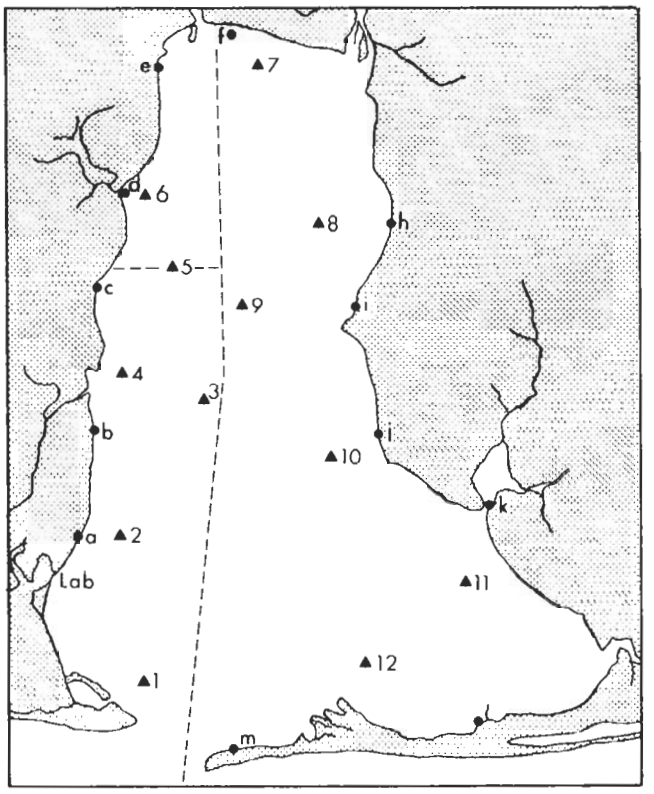
Using a^1 as the sum of the area covered by all vessels in Mobile Bay during a given month, and A as the area of Mobile Bay (297 square nautical miles), then a^1/A is the number of times an area equal to A is swept. Using W_c as the

*Part of Ph.D. Dissertation, Loesch (1962)

average pounds of shrimp caught commercially during each month with the fleet covering a^1, then the computed crop in pounds available to trawls at a given time during a given month would be $W_c/a^1/A$. A trawling speed of 3 knots and an average net spread of 60 feet were assumed in making these computations.

Another estimate may be obtained from experimental trawl data. A 23-foot trawl was dragged at 3 knots for 30 minutes at each of 12 bay stations (Figure 1). This covered about 0.068 square nautical miles, or about 1/4370th of Mobile Bay. Using w_c as equal to the pounds of shrimp caught with this gear, then the product ($4370 \times w_c$) would be equal to the computed crop in pounds available to trawls during any given month. Thus, two estimates of available crop were made.

The average poundage of each species of shrimp caught commercially during each month and the average number of days fished during each month were computed from U.S. Fish and Wildlife Service statistics (1956–1960). During July, August, and September of these years a^1/A was greater than 1. This means that an area greater than the total area of Mobile Bay was swept by commercial gear during each of these months. Therefore, $W_c/a^1/A$, or the estimated shrimp available at a given time during the month, is less than the total shrimp caught during the month by the commercial fishery. For a more accurate picture, daily records would have been better, but such data were not available. However, an average for daily W_c figures would be about one-thirtieth of the monthly figures, and a daily average of area swept would be about one-thirtieth of a^1. Therefore, figures obtained on the estimated standing crop would be very similar to those obtained from monthly figures.



Bay Stations		Inshore and nearshore stations	
1	Beacon No. 4	a	Alabama Port
2	Alabama Port	b	Austins
3	Beacon No. 18	c	Bellefontaine
4	Fowl River	d	Dog River
5	Deer River	e	Brookley Field
6	Dog River	f	South of Causeway
7	Devil's Channel	g	North of Causeway
8	Daphne	h	Daphne
9	Dredge	i	Fairhope
10	Mullet Point	j	Mullet Point
11	Bon Secour	k	Weeks Bay
12	Little Point Clear	l	Pleasure Point
		m	Fort Morgan

Figure 1. Location of stations in Mobile Bay.

RESULTS AND DISCUSSION

Brown Shrimp

Data from experimental trawling for brown shrimp *P. aztecus* indicate that the amount of shrimp caught during July and August was greater than the estimated standing crop available to trawlers at any given time during these months (Table 1). During September the amount caught was about equal to the estimated standing crop available. The experimental data closely parallel data obtained from the commercial fishery, especially during the brown shrimp season which lasts to October. From October on, more white shrimp were caught.

Loesch (1962) shows that the length-frequency, means, and modes advanced only slightly from June to August and there often was a decrease in the modal length. Large numbers of small brown shrimp were available around the edges of the bay to replace those caught by trawl. With fast growth and an ample recruitment stock, it is possible for the monthly poundage of shrimp caught to exceed the pounds available at a given time.

A drag bar used during the sampling program covered a strip 2.5 feet (0.76 m) wide (Figure 2). The 10 nearshore stations constituted a sampling of 25 feet total shoreline since hauls were made perpendicular to shore. The shoreline of the bay is about 425,000 feet, so the gear sampled about 1/17,000th of the shoreline area. If the areas sampled are representative, millions of very small young brown shrimp were always available around the periphery of the bay from April to September (billions during the peak season) to replace those removed by man and other predators.

The apparent two periods of recruitment in brown shrimp populations may not reflect spawning peaks but rather a combination of growth and survival peaks. Subrahmanyam's (1971) studies in Mississippi indicate that the commercial penaeids spawn during most of the year and that influx of larvae into the bays is related to factors other than spawning peaks. Peaks in recruitment may occur at times when competition is least—early in the season before the area becomes densely populated and again when the first "crop" that is able to survive moves out into the Gulf.

There was little change in mean size of young brown

TABLE 1.

Various trawl data of brown shrimp catch relationships in Mobile Bay, Alabama.

Month	g	a^1/A	W_c	$W_c/a^1/A$	$4370 \cdot w_c$	W_c/g
January	0	insuf	0	insuf	17,000	0
February	0.2	0.005	53	insuf	26,000	insuf
March	32.0	0.078	1,699	21,782	8,000	53
April	17.0	0.041	2,101	51,244	21,000	124
May	69.0	0.167	12,390	74,192	28,000	180
June	397.0	0.962	171,270	178,035	297,000	431
July	708.0	1.716	342,135	199,379	205,000	483
August	685.0	1.660	175,293	105,598	114,000	256
September	444.0	1.076	38,245	35,544	41,000	86
October	316.0	0.766	6,900	9,007	48,000	22
November	246.0	0.596	5,605	9,404	16,000	23
December	51.0	0.124	677	5,459	12,000	13

g = average number of 24-hour fishing days in Mobile Bay (1956–60)
a^1 = sum of areas swept by trawl of entire fleet in Mobile Bay (1956–60)
A = total area of Mobile Bay
a^1/A = number of times area equal to a^1 is swept by trawls in Mobile Bay (1956–60)
W_c = average pounds of shrimp caught commercially in Mobile Bay (1956–60)
$W_c/a^1/A$ = computed crop of shrimp in pounds available to trawls at a given time during a given month as estimated from swept areas (1956–60)
w_c = pounds of shrimp caught with 23-ft trawl dragged for 30 minutes at 12 bay stations (July 1953–Sept. 1955)
$4370 \cdot w_c$ = computed crop of shrimp in pounds available to trawls at a given time during a given month as estimated from experimental trawling (July 1953–Sept. 1955)
W_c/g = average pounds of shrimp tails caught per day commercial trawling (1956–60)

shrimp taken near shore. When the mean length remains constant, there apparently is continuous recruitment of young shrimp and migration of slightly larger shrimp off shore. The mean size varied from about 20 mm in April or March, when the young shrimp first appeared in the bay, to about 40 mm the first month after appearance. A possible reason for this increase is the absence of an accumulated population of larger shrimp to migrate off shore this first month. Thereafter, with the population buildup completed, the larger individuals left the shore area and the mean varied between 30 and 50 mm.

Only in June, July, and August were above-average numbers of brown shrimp taken by trawl (Table 2). There was a general decrease in May, a great increase in June, followed by a gradual decrease until September and an increase in October. This is essentially the same pattern reported by Gunter (1950) in Texas.

The following is a list of the stations (see Figure 1) in order of decreasing average numbers of brown shrimp taken per 30-minute trawl: Deer River (station 5), Beacon No. 4 (station 1), Fowl River (station 4), Alabama Port (station 2), Dredge (station 9), and Dog River (station 6). Of these six top producers all except the dredge station are located on the western side of Mobile Bay. The remaining stations, continuing in order of decreasing abundance, are as follows: Mullet Point (station 10), Little Point Clear (station 12), Bon Secour (station 11), Beacon No. 18 (station 3), Daphne (station 8), and Devil's Channel (station 7). Detailed figures are given in Table 2.

Deer River (station 5) had the largest number of shrimp primarily because of the larger winter catches there. The 32-foot water is somewhat warmer than that of the surrounding shallower area during the winter. The channel is oriented in an east-west direction, so shrimp attempting to leave the bay in a north-south direction would cross the channel. Although the water at Beacon No. 18 (station 3) is 35 feet deep, this channel runs north and south, so shrimp are able to continue their north to south movement within the deeper water of the channel and for this reason do not accumulate in the main ship channel in winter as much as they do in the Deer River channel.

White Shrimp

Using the same procedures outlined in the discussion on brown shrimp, tabulations of estimated standing crop using experimental trawl data and commercial catch data are given for white shrimp *P. setiferus* in Table 3.

The experimental data reveal that some larger shrimp came into the lower bay during the early part of the year, but they left and by June almost no white shrimp were in the bay (Loesch 1962). Commercial statistics corroborate this. In July, according to experimental data, there was a rapid buildup. Commercial data do not indicate a population until August. Young white shrimp prefer fresher water, and during July most of the shrimp were in upper Mobile Bay, which is closed to commercial shrimping during this season. Also during July the commercial fleet is concentrating on the larger brown shrimp because the new population of white shrimp is very small. In August the experimental data again indicated a much larger population of white shrimp than was indicated by the commercial data (Table 3).

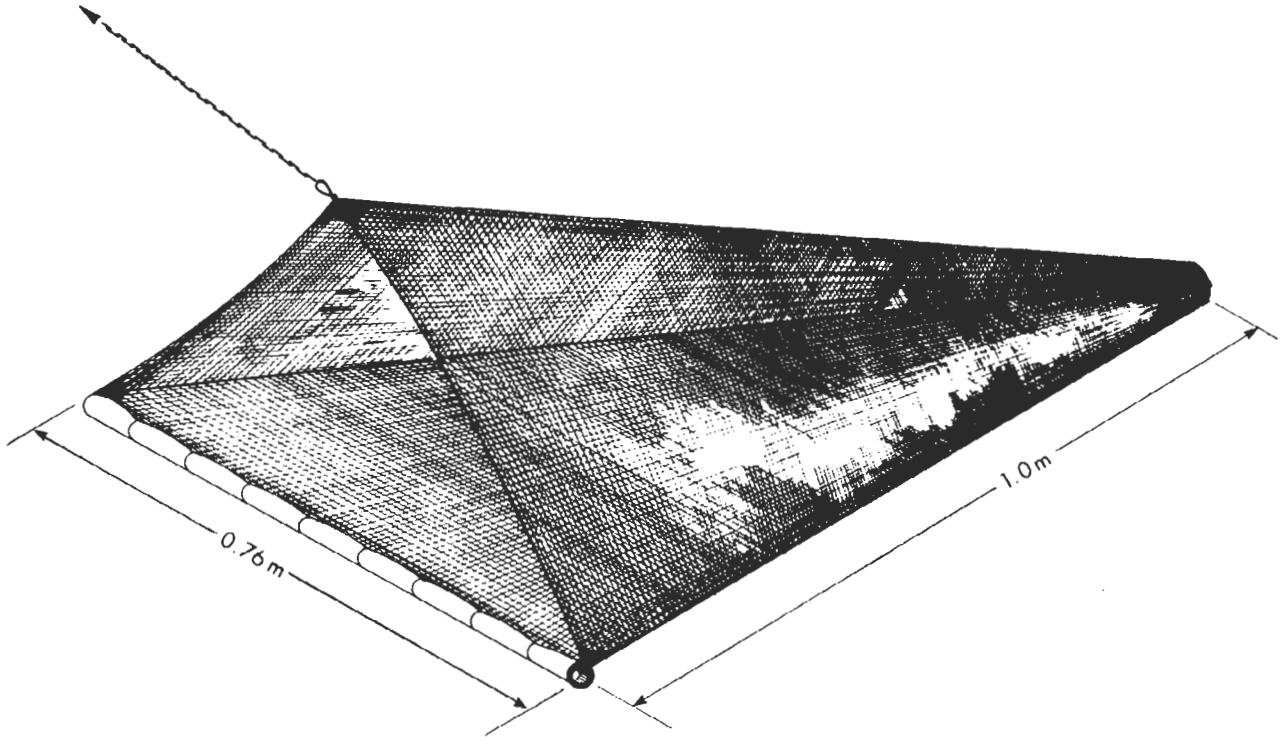


Figure 2. Drag bar for nearshore sampling.

TABLE 2.

Average number of shrimp taken each month at each bay station (July 1953–September 1955).

No.	Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
							P. aztecus							
7	Devil's Channel	0	0	0	0	0	22.0	2.7	1.5	5.5	20.0	0.5	1.5	4.0
6	Dog River	0.5	0	0	0.5	3.5	412.0	106.0	23.0	8.3	14.0	0	4.5	47.0
8	Daphne	0	0	0	0	18.0	132.0	69.0	0	1.3	2.5	1.0	0	19.0
5	Deer River	179.0	305.0	34.0	13.0	32.0	611.0	168.0	50.0	11.0	202.0	60.0	44.0	140.0
9	Dredge	3.5	0	0	0	4.0	249.0	206.0	22.0	1.5	32.0	10.0	0.5	73.0
4	Fowl River	0	1.0	0	0.5	24.0	802.0	134.0	74.0	6.0	2.5	3.5	14.0	89.0
10	Mullet Point	0	0.5	0	0.5	42.0	144.0	162.0	49.0	11.0	12.0	1.5	0	41.0
3	Beacon No. 18	3.5	4.0	0	0.5	54.0	33.0	210.0	48.0	7.5	4.0	3.0	5.5	38.0
11	Bon Secour	1.0	0	1.5	3.5	14.0	98.0	203.0	60.0	44.0	10.0	3.0	2.0	41.0
2	Alabama Port	6.5	1.0	9.5	1.0	3.0	128.0	232.0	162.0	202.0	9.0	6.0	24.0	79.0
12	Little Point Clear	1.0	1.0	0.5	5.0	6.0	26.0	160.0	85.0	47.0	35.0	8.0	3.0	40.0
1	Beacon No. 4	5.0	6.0	10.0	88.0	3.0	52.0	344.0	207.0	58.0	162.0	45.0	9.5	103.0
	AVERAGE	16.7	27.7	4.6	9.4	16.8	229.6	169.0	77.5	30.3	42.0	11.8	9.0	59.0
							P. setiferus							
7	Devil's Channel	0	0	0	0	0	0	0	886.0	2.0	84.0	0	0	130.0
6	Dog River	0	0	28.0	5.0	9.0	8.5	437.0	788.0	95.0	42.0	2.0	1.0	205.0
8	Daphne	0	0.5	0	0	1.5	0	1.7	14.0	4.0	6.0	4.5	0	3.0
5	Deer River	112.0	54.0	14.0	0	8.5	0	107.0	122.0	56.0	206.0	580.0	40.0	124.0
9	Dredge	2.5	0	0	0	0	0	177.0	312.0	74.0	422.0	240.0	0	125.0
4	Fowl River	0.5	1.0	29.0	18.0	5.0	0.5	226.0	62.0	9.0	4.0	18.0	10.0	41.0
10	Mullet Point	0	10.0	8.5	1.0	4.5	0	1.0	4.0	4.0	70.0	14.0	0.5	14.0
3	Beacon No. 18	6.5	89.0	3.0	2.5	3.0	1.0	91.0	28.0	5.0	2.5	2.0	34.0	25.0
11	Bon Secour	1.5	10.0	8.0	9.5	3.0	0	19.0	49.0	5.5	40.0	23.0	5.0	17.0
2	Alabama Port	39.0	48.0	54.0	12.0	1.0	1.0	2.0	134.0	90.0	31.0	24.0	14.0	47.0
12	Little Point Clear	0.5	15.0	12.0	1.5	4.0	1.0	0.7	494.0	28.0	26.0	32.0	22.0	84.0
1	Beacon No. 4	7.5	5.0	0.5	0	1.0	1.0	0	31.0	0	6.5	10.0	11.0	8.0
	AVERAGE	14.2	20.3	13.1	4.2	3.3	0.3	105.2	247.1	31.2	78.0	78.9	11.4	67.2
	TOTAL DRAGS	24.0	23.0	24.0	24.0	24.0	23.0	36.0	48.0	27.0	24.0	24.0	24.0	325.0

TABLE 3.

Various trawl data of white shrimp catch relationships in Mobile Bay, Alabama.

Month	g	a^1/A	W_c	$W_c/a^1/A$	$4370 \cdot w_c$	W_c/g
January	0	–	–	–	22,000	–
February	0.2	0.005	0	insuf	26,000	0
March	32.0	0.078	770	5,872	22,000	24
April	17.0	0.041	63	1,536	13,000	4
May	69.0	0.167	260	1,557	9,000	4
June	397.0	0.962	318	330	1,000	1
July	708.0	1.716	669	390	100,000	1
August	685.0	1.660	97,256	59,793	267,000	111
September	444.0	1.076	99,599	92,564	66,000	208
October	316.0	0.766	82,783	108,072	105,000	262
November	246.0	0.596	58,749	98,572	113,000	238
December	51.0	0.124	12,588	101,516	18,000	247

g = average number of 24-hour fishing days in Mobile Bay (1956–60)
a^1 = sum of areas swept by trawl of entire fleet in Mobile Bay (1956–60)
A = total area of Mobile Bay
a^1/A = number of times area equal to a^1 is swept by trawls in Mobile Bay (1956–60)
W_c = average pounds of shrimp caught commercially in Mobile Bay (1956–60)
$W_c/a^1/A$ = computed crop of shrimp in pounds available to trawls at a given time during a given month as estimated from swept areas (1956–60)
w_c = pounds of shrimp caught with 23 ft-trawl dragged for 30 minutes at 12 bay stations (July 1953–Sept. 1955)
$4370 \cdot w_c$ = computed crop of shrimp in pounds available to trawls at a given time during a given month as estimated from experimental trawling (July 1953–Sept. 1955)
W_c/g = average pounds of shrimp tails caught per day commercial trawling (1956–60)

Part of the difference can be attributed to the fact that these data were also obtained from fresher northern Mobile Bay which was closed to commercial shrimping, and perhaps another part may be attributed to the schooling habits of white shrimp which the experimental methods by chance sampled in concentrations during this month. During December commercial catches indicated a much larger population of white shrimp than actually existed in Mobile Bay because the shrimp were concentrated and commercial boats worked in those areas. Good individual catches are made in cold weather and fishing effort is expended only during times when catches might be good.

Because very young white shrimp stay at the extreme shoreward edge of the water, it is impossible to project the nearshore data as was done for the brown shrimp. Considering the number available as indicated by minnow seine catches, it is obvious that white shrimp were available in approximately the same order of magnitude as were brown shrimp, but for a much shorter period of time, including only late July, August, and September.

If statistics reported the effort directed towards each species, a better estimate could be made of the availability of each species. However, except for the few months where major discrepancies have been noted, standing crop estimates obtained by experimental and by commercial data are of the same order of magnitude. These figures are more accurate for a particular species at the times when that species is being commercially pursued.

The number of white shrimp increased sharply in July and August, decreased in September and increased in October and November, then decreased to practically none in June (Table 2). Gunter (1950) reported a similar seasonal change in Texas. The most productive stations for white shrimp were: Dog River (station 6), Devil's Channel (station 7), Dredge (station 9), and Deer River (station 5). These four most productive stations are all located in the upper end of Mobile Bay. The following stations continue in order of decreasing abundance of white shrimp: Little Point Clear (station 12), Alabama Port (station 2), Fowl River (station 4), Beacon No. 18 (station 3), Bon Secour (station 11), Mullet Point (station 10), Beacon No. 4 (station 1), and Daphne (station 8).

Almost all of the white shrimp caught in the experimental period were taken during the last six months of the year, while the majority of brown shrimp were taken from May through September (Loesch 1962, Table 8). Almost 7000 white shrimp and less than 2000 brown shrimp were taken in hauls in water less than 2 feet deep. Only 326 white shrimp and over 4300 brown shrimp were taken in drags in water from 2 to 10 feet deep.

Pink Shrimp

During the entire survey, only 262 pink shrimp *P. duorarum* were caught in Mobile Bay. These were all taken from October to May. All pink shrimp caught in October and November were taken in the lower end of the bay.

In the 1953–54 winter season, 62 pink shrimp were caught in the sampling trawls; in the 1954–55 season 200 pink shrimp were taken. In 1956, according to U. S. Fish and Wildlife Service statistics, Mobile Bay produced 475 pounds of pink shrimp, all in May. In March 1957 examination of

several commercial catches of shrimp from Mobile Bay showed pink shrimp comprising about one-third of the catch. More than 34,000 pounds of pink shrimp were caught in Mobile Bay in 1957. The following year 2086 pounds of pink shrimp were reported caught in Mobile Bay. Apparently the presence of pink shrimp in large numbers in Mobile Bay is sporadic. Springer and Bullis (1954) report that pink shrimp appeared abundantly in Mississippi coastal waters in 1950 but that they were practically nonexistent in catches the previous year and the following three years.

CONCLUSION

Shrimp are subjected to intense fishing pressure in Mobile Bay. During June, July, August, and September the commercial catch of brown shrimp each month may exceed the amount available to the trawl at a given time during that month, as estimated from both experimental data and commercial statistics. About half the available white shrimp are taken each month from August to December. Large numbers of small shrimp are available to replace those caught. It is apparent that shrimp populations have very high recuperative properties due to the fast growth rate and are able to withstand high fishing pressure.

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