FRIDAY—NOVEMBER 15, 1963

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The Biology and Fishery of the Sea Bob Shrimp of Santos Bay, Brazil[1]

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Abstract

The total Atlantic landings of sea bob, *Xiphopeneus kroyeri,* reach over eight thousand metric tons annually, however, few specific studies have been made on its biology and fishery. In late 1960 we began work on the sea bob population fished by the small vessel fleet of Santos, in southern Brazil, where it is the most important shrimp in terms of weight landed. We found spawning and recruitment practically continuous the year round, and a rapid growth rate, balanced by a high total mortality rate. There is some evidence that the productivity of the local grounds is currently being exploited to its maximum, but there appears to be no immediate danger to the fishery or to the stock. Some consideration is given to the implications of our findings on the fisheries for sea bob in other areas.

INTRODUCTION

AMONG THE PENAEID SHRIMP of commercial interest in the Western Atlantic, little attention has been paid to the sea bob, *Xiphopeneus kroyeri* (Heller), perhaps because of the small percentage that it contributes to the total landings in areas where the shrimp fishery is of considerable economic importance. Its value in underdeveloped areas and contribution to the protein supply of the population in these areas can be considerable, however, as may be seen from the estimated total Atlantic landings annually in recent years:

[1]Contribution No. 22 of the Sao Paulo State Research Group on Marine Fisheries (Grupo de Pesquisas Sôbre a Pesca Maritima).

Area				*Annual landings*
U.S.A.—Gulf of Mexico				1,800 metric tons, heads on
Mexico				10
Panama				10
Trinidad				70
Venezuela				10
British Guiana				10
Surinam				450
French Guiana				10
Brazil				
Between	4°N.	and	3°S.	3,400
Between	3°S.	and	23°S.	20
Between	23°S.	and	34°S.	2,810
				6,230
			Total	8,600

These statistics were compiled from different sources and are variable in their reliability; some are only educated guesses. The error is usually, if not always, on the side of underestimation, and the true total could be as much as 50% higher. No data were available from British Honduras, Honduras, Nicaragua, Costa Rica, or Colombia, although it is probable that some quantity of sea bob is taken in these countries. We have not considered the Antilles; although the sea bob exists and is fished there, no statistics are available to us.

It may be noted that the Brazilian landings are about three quarters of the total, with marked concentrations in the extreme north and extreme south of Brazil. In southern Brazil, among the commercial shrimps of the São Paulo coast, the sea bob plays an important part in the fisheries economy of the state. Of all crustaceans landed at the Santos Fish Pier, where the great majority of the state's fishery products are handled, it is the one landed in largest quantity. Also, the "seven-whiskered shrimp," "camarão sete barbas," as it is known locally, is sold at only a fraction of the price of other shrimps.

Three commercial varieties of shrimp are landed regularly in Santos, as shown below:

SANTOS LANDINGS — METRIC TONS, HEADS ON

Year	Sea bob	Pink shrimp	White shrimp
1959	498	433	70
1960	906	527	98
1961	717	657	164
1962	922	600	49
1963 (est.)	1,100	690	38

All of the sea bob and almost all of the white shrimp ("camarão legítimo," *Penaeus schmitti)* come from the São Paulo coast proper, while the major part of the pink shrimp ("camarão rosa," *P. aztecus* and *P. brasiliensis)* are captured along the coast of nearby states, notably to the south of São Paulo. During the southern summer and autumn, pink shrimp of about 120 mm total length appear mixed with the sea bob catch. This is probably due to the young of

these species coming out of the brackish waters where they have passed their early growth stages, and traversing the sea bob's shallow habitat on their way to offshore grounds.

The market values of the various shrimps are quite different, as may be seen in the approximate average prices (heads on) paid in 1962 to the fishermen:

Sea bob	Pink shrimp	White shrimp	
85	500	250	—cruzeiros per kilogram
5	32	16	—U.S. cents per pound

The sea bob frequents shallow coastal waters, although it does not usually occur in brackish waters as do many other Penaeids which require estuarine conditions for the completion of their life cycles. From our observations, it is limited to areas with mud or muddy sand bottoms. Data furnished by the Oceanographic Institute of the University of São Paulo show that close to the Santos fishing area the water temperatures vary from about 18C (66F) to 26C (79F) throughout the water column during the year, while salinities are always 33 ppt or higher.

THE SANTOS FISHERY

Fishing for sea bob is confined to a relatively small area, usually well within 20 miles of the mouth of Santos Bay, in less than 25 meters depth, even though the shrimp are available in considerable abundance in other areas along the São Paulo coast. The boats tend to stay in the traditional area because, in addition to incurring higher expenses on longer trips, they run the risk of losing the catch (the sea bob does not keep well, even on ice).

There are currently about 60 units fishing sea bob at one time or another. They are small motor vessels, less than 12 meters in length, mainly otter trawlers, "baleeiras." There are also a dozen or so small pair trawlers, "parelinhas". The catch per day's fishing of the baleeiras in the shrimp fishery is higher than that of the pair trawlers; for finfish the reverse is true. Larger vessels, which fish farther away for fin fish and the other shrimps, generally discard sea bob except for a small amount eaten on board. Occasionally a larger boat will land some sea bob caught on the last day or so of its trip.

The crews vary from three men in the otter trawlers to as many as ten in the pair trawlers. Nets are of cotton, and the handling is completely manual in the otter trawlers, while the pair trawlers generally have a hand winch. The nets of the otter trawlers are smaller than those of the pair trawlers, with stretched mesh size of about 35 mm. The catch is mixed, sea bob plus some small amounts of white and pink shrimp, fishes of commercial value (sharks, catfish, drums, etc.), plus fish of varied species and small size which are either discarded or sold as trash, "mistura".

Fishing is carried out "de sol a sol," that is, the boats go out around sunrise and return just before sunset on the same day. Usually three or four hauls of the net are made in a day's fishing, each lasting two or three hours; the pair trawlers tend to make fewer and longer hauls. After each drag the fishermen examine the catch for the proportion of live shrimp, thus judging whether the catch was made largely near the beginning or the end of the long haul, and modify the next accordingly. Fishing habits seem well adapted to the behavior

of the shrimp, for during research cruises we noted that after nightfall catches were very small, improving soon after dawn.

The fishery is not the same all year round. The best results are obtained from about December through June, in the southern summer through late autumn, with much lower catches during winter and spring. This is very probably related to the November-January (summer) spawning concentration mentioned below.

STATISTICS AND SAMPLING PROGRAM

Since mid-1958, data have been collected when possible from each boat landing in Santos, including those landing sea bob. Each skipper is asked where he fished, the amount of each species caught, the amount discarded at sea, and the amount landed, plus the number of days fished or the number and duration of the sets of the fishing gear. Coverage of the fleet in recent years is estimated to be 80-90% complete.

At the end of 1960, we began a biological sampling program on the sea bob. One sample a week was planned, but in practice during the first year about one sample every two weeks was collected. An estimated kilogram of shrimp was taken from the catch of one boat, and from this a sub-sample of about 100 individuals was examined. In the beginning the specimens for the sub-sample were taken one at a time until the desired number was obtained, but it soon proved that a combination of bias and mechanical factors led to selection of larger individuals; the system was then changed to taking a sub-sample by volume of an estimated 100 individuals. The following data were collected from each individual in the sub-sample: (1) sex; (2) total length in millimeters, from the end of the rostrum to the end of the telson, with the shrimp lightly extended on a ruler; (3) carapace length in millimeters, from the base of the eye notch to the posterior mid-dorsal edge of the carapace; (4) total weight to the nearest tenth of a gram.

When analysis showed that total length, carapace length and weight are closely correlated, the system was altered to measurement of carapace length only. At the end of the first year, due to the pressure of other work, the frequency of sampling was reduced to once a month; altogether in this program through July, 1963, about 5,400 shrimp have been examined. It is planned to carry out this sampling indefinitely to keep track of the effects of the fishery on the stock.

Beginning in late 1961, data were also collected on the stage of maturity of the females using a somewhat arbitrary scale as follows: stage I—immature, ovaries translucent, and fine; stage II—maturing, ovaries greenish, but still fine; stage III—mature, ovaries greenish, and swollen.

RESULTS

Body proportions

The correlation between total and carapace length was calculated using all of the 1961 samples. No significant difference was found between males and females, and the results were combined to yield the expression:

$$Y = 0.230\,X - 1.61$$

where X is the total length and Y is the carapace length, both in millimeters ($r = 0.972$, 2568 d.f., $\sigma = 0.85$).

The length-weight relationship was calculated from the same samples through a logarithmic transformation. Here also there was no significant difference between the males and the females, and the expression is:

$W = L^{3.34}/10^5$ or $\text{Log } W = -4.996 + 3.34 \text{ Log } L$

where W is the total weight in grams and L is the total length in millimeters.

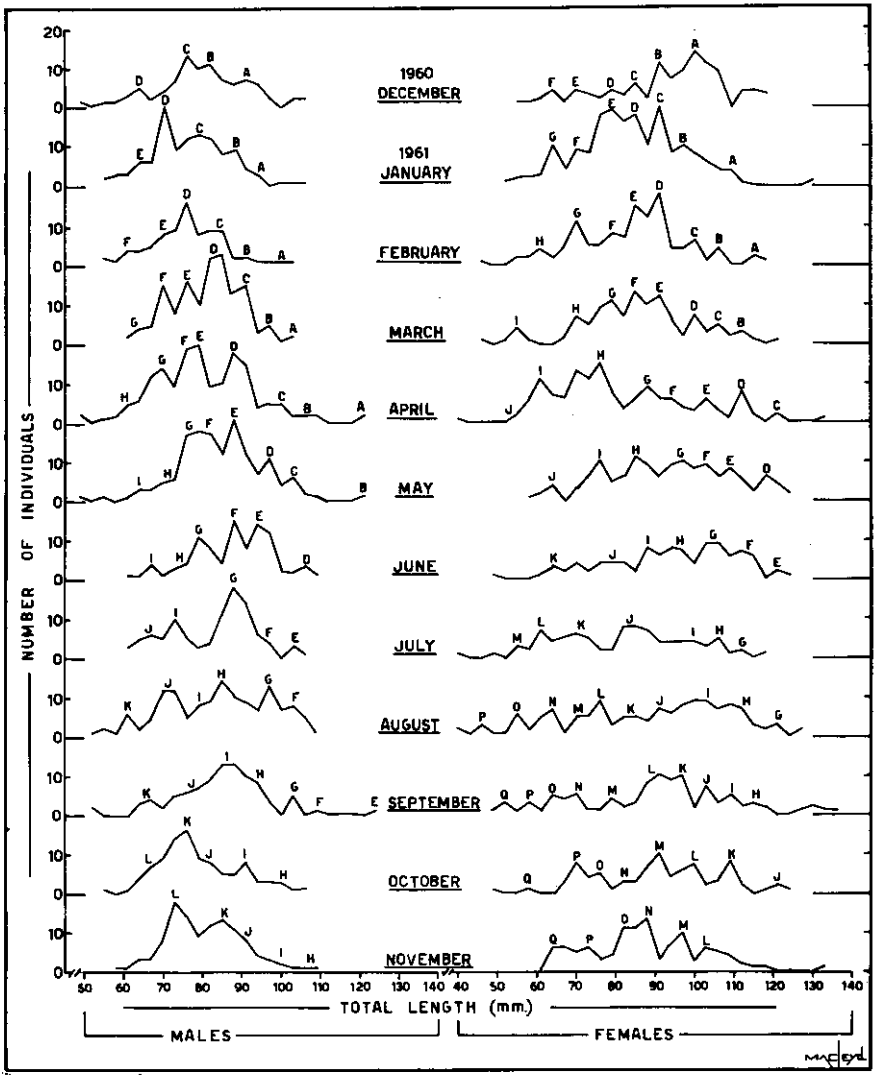

FIG. 1. Distribution of frequencies of total lengths, in three-millimeter groups by month, for males and females separately, of the samples of sea bob shrimp landed in Santos. Modes are lettered to demonstrate presumed progression from one month to the next.

Sex ratio

Except initially when the selection of larger individuals biased the samples, there have been approximately equal numbers of males and females, 2,783 (51%) and 2,693 (49%) respectively, from the beginning of the program through July, 1963, with little or no monthly or seasonal variation.

Reproduction

Borges Vieira (1947) noted that, in Santos, mature females ready to spawn were landed in large quantities from the early part of November until the end of January, with some mature females in the population all year round. Our observations of maturity support this idea. We noted another peak of spawning in March and April of some years. The females begin to mature between 90 and 100 mm total length, and the number of eggs is at least in the tens of thousands per individual.

Growth

When the total lengths taken in the samples are grouped by month in three-millimeter increments, some fairly well-defined modes of length frequency may be observed. These modes appear to progress in a regular manner from one month to the next (Fig. 1). Assuming that these represent different age-classes, we estimated the mean lengths for the groupings indicated in Fig. 1, separately for the two sexes, as follows:

Groups	I	II	III	IV	V	VI	VII	VIII	IX
Mean, males	64	71	77	82	89	95	102	108	122
Mean, females	58	67	78	87	96	102	109	116	121

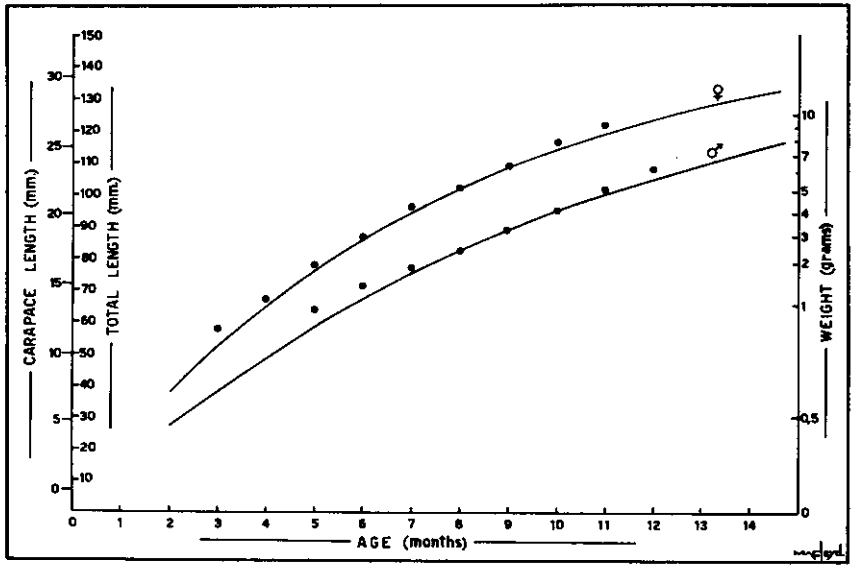

FIG. 2. Growth curves for males and females of the sea bob shrimp landed in Santos, with the corresponding total length, carapace length, and weight.

Calculating separate growth curves through the Walford transformation, we arrived at the equations:

$$\text{Males} \quad L = 155\ [1 - e^{-0.131\ (t\ +\ 0.107)}]$$

$$\text{Females} \quad L = 155\ [1 - e^{-0.093\ (t\ +\ 0.075)}]$$

where L is the total length in millimeters, t the age in months, and e a mathematical constant. These growth rates are shown in Fig. 2, along with the corresponding total length, carapace length, and weight. It may be noted that the females grow faster than the males, but that the theoretical possible length (L_∞), 155 mm, is the same for both sexes. The maximum observed sizes to date are 124 mm for males and 143 mm for females.

Recruitment and mortality

The shrimps first enter the fishery between 40 and 50 mm total length, for the females in the second month of life and the males in the third. Recruitment is complete between 70 and 80 mm, at about the completion of the fourth month for females and the sixth for males.

While small individuals enter the fishery more or less continuously the year round, there are two concentrations, one occurring around the first of the year and the other at the beginning of the second semester. It appears probable that the first of these is related to the concentration of spawning in the last quarter of the year and the second to the March-April spawning peak (see Figs. 1 and 2).

Total mortality after full recruitment is heavy. Calculation of the rate of descent of the length (or age) frequencies after recruitment is complete reveals a rate of about 55% per month, and as may be seen in Fig. 1, very few males over 110 mm or females over 120 mm are taken. Thus the total life of an individual shrimp in the fishery after reaching the size of full recruitment is unlikely to exceed about seven months.

Relation between the stock and the fishery

In the years for which we have data, the landings and fishing effort are as follows:

Year	Landings (tons)	Fishing effort (days fished)	Catch per day (kilograms)
1959	498	3,376	147
1960	906	4,958	183
1961	717	5,140	139
1962	922	7,003	132
1963 (est.)	1,100	10,000	110

From 1944 through 1953, according to some isolated figures given by Borges Vieira (1947) and W. E. Ripley (unpublished ms.), the annual landings never exceeded 280 tons.

It is evident that the fishing effort and the landings have been increasing, although not in the same proportion, with the result that the tendency has been for the catch per day to decrease. From 1959 to the present, the fishing effort has nearly tripled, while the landings have approximately doubled, and the catch per day is down about 25%. These data suggest that the area presently fished is capable of yielding only about one thousand tons annually, and that this yield can be attained with considerably less than the current effort level.

CONCLUSIONS

The main conclusions on the biology and fishery of the Santos sea bob are:

1. While the males and the females have similar body proportions and occur in equal proportions in the population, the growth rates are quite different, a female of a given size being about two months younger than a male of the same size;

2. Reproduction takes place all year round, with two concentrations, one in the southern summer and the other in the southern autumn;

3. The life of the sea bob is short, slightly more than one year;

4. Males are recruited to the fishery in the third month of life, females in the second, and recruitment is complete around the end of the fourth month for males and the sixth for females;

5. Mortality is heavy, about 55% per month for both males and females after reaching the size of full recruitment;

6. Both fishing effort and landings have increased in recent years, but catch per effort has decreased, suggesting that the productivity of the local grounds is limited and that the total effort could be reduced without substantially reducing the total catch.

DISCUSSION

With less than three years of study and less than five years of landings and effort data, all conclusions must be somewhat preliminary. In addition, for now at least, they must be considered also as applying only to the sea bob in the area immediately around Santos. With the distribution of the sea bob extending over about sixty degrees of latitude in the Atlantic, it is possible or even probable that the parameters described here could be considerably different in other areas.

However, the idea expressed above that the Santos fleet is currently taking nearly the maximum possible from the present fishing grounds is of interest from the management point of view. It indicates that if effort continues to increase, the catch per day will decrease until it is no longer profitable to fish. Should this happen, the results could be several—a "shake-out" of the less efficient operators, or an extension of the fishing area. It is difficult to predict exactly what will happen, for a slight modification in technique, such as cooking the catch aboard, or the opening of another port, could revolutionize the fishery and make areas presently unfishable available to the fleet. Because of these considerations, it would appear premature at this time to regulate the effort by means such as licensing.

It appears possible that the yield in weight in the Santos area could be increased by increasing the size at first capture. Under present conditions the shrimp are first fished at a weight of about one gram; a delay of only two months would mean a doubling of the weight of the individual. Whether this would mean a net increase in the yield depends of course on natural mortality, for the loss in numbers during these two months, if it were 50% or more, would cancel out any benefit. We must admit at this point that we do not know enough about the mortality rates to predict what would happen. Even if it could be shown that mortality is low enough to compensate, we are not sure whether control of mesh size, for instance, would have the desired effect.

A minimum size limit on landings would not, for after the long hauls most of the shrimp arrive on deck dead or dying.

It can be safely said, however, that the stock appears to be in no danger, immediate or long-term, if the fishery continues with its present tendencies. Doubtless some of the recruitment comes from outside of the fishing area, where there exist virgin or nearly virgin populations. Should anything happen to depress the abundance drastically, recovery would only be a matter of months, due to continuous spawning, high fecundity and extremely rapid growth to fishable size.

By extrapolation, it would appear that the sea bob of the São Paulo coast, and probably of the whole western Atlantic, is at the present very much under-exploited, and that the best general management policy might well be to facilitate the fishery and increase the effort, principally in areas where there is not presently much fishing, to produce much higher yields.

Forty miles of the São Paulo coast is producing about 10% of the total Atlantic catch of the sea bob, a shrimp whose distribution extends along well over four thousand miles of the coasts of North, Central, and South America. This suggests that similar intensive fisheries could be developed in other areas, with the advantage that the sea bob can be fished profitably, as shown by the Santos fleet, by small boats which are not elaborately equipped.

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Hypersaline Bays as an Environment of Young Fish

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Abstract

Investigations on the hydrological properties of the bays of Curacao have shown that the water is hypersaline during most of the year. Although the water is rather turbid, its fertility is very low compared with continental bays. Nevertheless, the bays are crowded with young fish, especially juveniles of *Mugil, Atherina, Elops,* and *Harengula.* Environmental factors that may attract these juvenile fish are discussed. It is not unlikely that, just as in elvers, it is some organic compound that attracts the fish.

CURAÇAO IS AN ISLAND of 450 square km, only 75 km from the Venezuelan coast, surrounded by clear oceanic water without any trace of continental influence. The island has many shallow lagoons and inland bays, all with exits to the Caribbean Sea. The tidal differences are minute, about one foot, so the daily exchange of water between the bays and the sea is small. The bays and lagoons are mostly hypersaline as evaporation is high (4-7 mm a day) and