NOTE ON THE SAMPLING OF SARDINE (*SARDINELLA ALLECIA*) AT CANANÉIA, STATE OF SÃO PAULO, BRAZIL

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CONTENTS

I — INTRODUCTION

At Cananéia, situated about Lat. 25° South in the south of State of São Paulo, Brazil, catches of small Sardines are sometimes made. Dr. Sadowsky, Head of the Marine Station of Cananéia, a laboratory belonging to the Instituto Oceanográfico of the University of São Paulo, has recorded the total weight of Sardine landed in Cananéia during each year from 1949 to 1957. In addition, he has collected and measured samples of Sardine every 15 days or so from October 1956 to October 1957. The fish were measured from the tip of the nose to the extremity of the caudal fin in intervals of one millimetre and the measurements were later grouped to the half centimetre below. This routine length sampling was suggested by Dr. Finn Devold when on a Technical Assistance Mission of the Food and Agriculture Organization of the United Nations to Brazil, in 1956.

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In this paper, the total weight of Sardine landed in Rio de Janeiro is used. These data were drawn from tables prepared by W. E. Ripley (1956) and also from information kindly supplied by Dr. Fridtjoff, a Food and Agriculture Organization Technical Expert working on marketing problems in Rio de Janeiro. The data were collected in Rio de Janeiro, some 280 miles to the north east of Cananéia, but the fishing grounds normally used by the Rio de Janeiro fleet lie somewhat to the south of the port and are therefore slightly nearer than 280 miles to Cananéia. These fishing grounds are shown in a paper by Richardson *et al.* (1959).

II — LENGTH DISTRIBUTION OF THE SARDINE LANDED IN CANANÉIA

In Table I, the length distribution of each sample measured in Cananéia is shown together with the date on which the sample was taken and the numbers of fish measured on that day. Some of the length frequencies have a normal, or at least approximate to, a normal distribution. Others are more complex and are gimodal or multimodal in form. For this reason, each distribution was plotted and the principal modes were estimated by fitting normal curves within the frequency distributions. These modal lengths are used in preference to the mean lengths of the samples. In Table I, the modes are shown and these are plotted in Fig. 1 against the day on which the sample was taken. No correction has been applied to compensate for the grouping of the data into half centimetre intervals.

Curves have been drawn in on Fig. 1 in such a way as to include the majority of the points between the upper and lower curves and it is assumed that the true curve lies somewhere between these two limits. From October to January, the curve rises steeply and then flattens out until about May. In May to June the majority of the points lie below the curve and we have therefore terminated the first curve in April. There are insufficient points remaining to draw a similar curve from May to October and we are unable to say whether the final point on the diagram in October, is part of the first curve or belongs to the second group of points. In order to test whether the group of points found in May-June were in actual fact significantly different from those forming the earlier curve (curve A) a "t" test was applied using all the points in February to April on curve A and comparing them with the points from May to July (curve B). The difference between the two sets of points is highly significant to the 1% level and we therefore feel justified in assuming that there are two "populations" A and B, indicated.

TABLE I — Length distribution of sardine measured at Cananéia (0.5 cm below, measured to extremity of caudal fin)

Length (cm)	1956						1957														
	October		November		December		January			February		March	April		May		June		July		October
	Days		Days		Days		Days			Days		Day	Days		Days		Days		Days		Days
	14	30	14	28	6	21	4	17	30	15	27	14	8	24	10	24	8	21	5	20	23
7.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.0	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.5	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.0	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.5	10	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.0	4	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.5	-	27	-	-	2	-	21	-	-	-	-	-	-	-	-	5	-	-	-	-	-
11.0	1	71	3	9	23	-	27	-	-	-	-	1	-	-	-	10	3	-	-	1	-
11.5	1	59	18	14	32	-	33	-	-	-	-	8	-	-	8	16	28	2	-	2	-
12.0	-	37	64	40	73	12	30	9	9	2	-	40	-	4	18	45	33	39	10	22	-
12.5	-	2	52	63	36	49	29	31	11	4	2	51	4	22	46	13	23	34	28	29	-
13.0	-	-	48	53	27	70	15	70	18	9	22	33	27	39	71	6	5	21	37	28	-
13.5	-	-	9	13	4	54	14	48	24	11	35	22	43	40	29	2	2	-	16	12	-
14.0	-	-	5	6	2	14	20	36	44	36	71	17	55	40	16	1	1	4	7	2	-
14.5	-	-	1	-	1	-	4	4	35	47	45	10	30	30	2	1	1	-	2	2	12
15.0	-	-	-	1	-	2	1	2	43	58	21	12	23	24	6	-	1	-	-	2	11
15.5	-	-	-	-	-	-	-	-	12	17	1	5	10	3	1	-	1	-	-	-	38
16.0	-	-	-	-	-	-	-	-	3	14	1	1	5	-	1	-	1	-	-	-	17
16.5	-	-	-	-	-	-	-	-	-	1	-	-	3	-	-	-	1	-	-	-	12
17.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
17.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
18.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19.0	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	99	198	200	199	200	201	200	200	199	199	198	200	200	202	200	99	100	100	100	100	100
MODES	8.75	11.3 12.0?	12.3 12.7?	12.7	12.1?	12.8?	10.5 11.5 12.5 14.0	13.3 14.0	14.3 14.9	13.9 14.8	14.2 14.8	12.6 14.8	13.7 14.8	-	12.8 14.0 15.0	12.0	11.7	12.3	12.8	12.7	14.8 16.7 16.7

Insufficient points are available to draw a curve for population B, but population A shows a rapid increase in length from October to January and we presume that as the fish of 14 cm no longer appear in the catches after May, these fish must migrate from the lagoon to the open sea about this time.

Shore seine hauls were made in Santos about latitude 23.5° south and some 100 miles north east of Cananéia from January to April 1960 at least twice a month, but sardines did not appear in the catches until April 26th, 1960. On April 26th, the sardines gave the length distribution shown in Table II, with a modal length of 8.8 cm. A second sample measured on May 20th, gave a main mode at 9.2 cm. If it is assumed that the curve of popula-

tion B would be similar in form to that of population A, the curve would pass very close to the modal length obtained at Santos, would pass through the paints found in Cananéia in May-June and would approximate to the value found in October 1957, as indicated in Fig. 1.

TABLE II — Length distribution of sardine caught near Santos

Length (cm)	1960 — April, 26	Percentage	1960 — May, 20
7.0	1	0.3	—
7.5	2	0.6	2
8.0	16	5.4	17
8.5	40	13.5	12
9.0	155	52.5	32
9.5	62	21.0	23
10.0	12	4.0	7
10.5	6	2.0	1
11.0	—	—	—
11.5	1	0.3	—
Total	295	—	94
Modes	8.8 10.1	—	9.2

III — CATCHES OF SARDINE IN CANANÉIA AND RIO DE JANEIRO

The weight of Sardine landed in Cananéia and Rio de Janeiro is shown in kilogrammes for the years 1950 to 1957 below:

1950	1951	1952	1953	1954	1955	1956	1957			
0.322	6.03	2.83	9.53	9.41	3.39	4.51	4.62	' 0.000	Kilogrammes	Cananéia
—	2.37	5.33	4.00	5.94	8.02	4.68	5.99	'000.000	„ „	Rio de Janeiro - Large fish
—	2.63	0.90	2.28	0.32	0.33	1.11	0.33	'000.000	„ „	Rio de Janeiro - Small fish

In Rio de Janeiro the landings of fish are classified according to size as either large or small fish.

In the following analysis we have made the assumption that the total quantity of fish landed in both ports is indicative of the quantity of available fish on the grounds and this presumes that there has been no significant change in effort during the period. This assumption may or may not be correct. We have no data available to check it. In each port, the annual landings show large fluctuations but the fluctuations in one port are not reflected in the landings made at the other port during the same year. In other words, there does not exist a correlation between the landings of small fish made at Cananéia with the small fish made in the same year at Rio de Janeiro, or between the Cananéia landings of small fish and the landings of large fish made at Rio de Janeiro.

There is a relation between the weight of Sardine landed in Cananéia and the weight of the larger fish landed in Rio de Janeiro one year later. This is shown graphically in Fig. 2. The correlation coefficient was calculated and was found to be high, giving a value of rxy-0.83 which is within the 5% level for the degrees of freedom used.

In the previous section it was shown that the fish at Cananéia were all below 14 cm in length and in the correlation we have made, we have related these fish to those fish which appear in Rio de Janeiro one year later, and are included in the category of large fish. Previously, Richardson *et al.* (1959), it has been shown that the Rio de Janeiro fish are composed of a number of year groups and it appears that the relation is probably one between the Cananéia fish and the two year old fish in Rio de Janeiro, as these fish are the most represented age group.

There is also an inverse correlation between the weight of small fish landed at Cananéia and the weight of small fish landed in Rio de Janeiro one year later. This is probably an indirect correlation caused by the landings of small fish in Rio de Janeiro being dependent on the availability of the larger fish. In other words, when the larger fish are abundant, these are fished in preference to the smaller fish. The landings of smaller fish in Rio de Janeiro would therefore be dependent on the quantity of larger fish available, the cause of which would be the size of the available two year old group. The landings do not therefore represent abundance of the small fish.

The regression which has been drawn into Fig. 2 cuts the Y axis at 2.82 million kilogrammes which represents that part of the available stock not affected by the Cananéia sampling. This will be discussed later.

IV — DISCUSSION

The length distributions of the fish sampled in Cananéia show, at least for the year for which data is available, that there are two populations within the lagoon. The population which contributed most to the total weight of fish landed during the year is that which we have called population A and which appears in October and leaves the lagoon at a length of about 14 cm in May or a little earlier. A second population, B is represented by fish which reach a length of about 12 cm in June, but this population is numerically poorly represented in comparison with the previous one. It is probable that the same population as B is found to the north of Cananéia as the Santos sample suggested and therefore that the two populations are separated geographically, A being to the south and B to the north. If the curve of the two populations is assumed to be similar, it follows that the two populations of sardines off the Brazilian coast are separated by their time of spawning. There may be other populations but within the data available only two are indicated and by extrapolation of the curves, the spawning times would be separated by some 5 to 6 months.

We found no significant correlation between the landings of small sardine in Cananéia and the larger sardine landed in Rio de Janeiro during the same year. We can therefore assume that the factors which influence the size of the available stock in Cananéia do not influence directly or inversely the abundance of fish in Rio de Janeiro during the same year. Such factors would be meteorological and hydrographical conditions which would affect the stock as a whole irrespective of age composition.

The significant correlation between the small fish at Cananéia and the larger fish at Rio de Janeiro one year later suggests that the Cananéia fish, when larger, and when about one year older, play an important part in the stock of fish fished by the Rio de Janeiro fleet and therefore the landings in Cananéia can be used as a forecasting index of the size of the available stock in Rio de Janeiro. Clearly, the Cananéia fish can only form one age group during the following year in the Rio de Janeiro landings, this is probably the two year olds, but the Rio de Janeiro catches include fish of various age groups. However, for the one year for which age samples from Rio de Janeiro are available, the two year old fish showed the highest percentage of any age group (Richardson *et al.*, 1959). The correlation cannot be perfect and there exists a residual stock available which will be composed of the older age groups and possibly other populations. This

stock will not be related directly to the abundance of fish at Cananéia the previous year.

This residual population may be indicated by the level at which the regression cuts the Y axis. From the data available we cannot estimate how much of this is due to the other age groups and how much is due to one or more other populations of Sardine such as that population which we called population B.

V — SUMMARY

This paper includes an analysis of the length distribution of Sardine landed from the Lagoon of Cananéia in the south of the State of São Paulo, Brazil, in which it is shown that young Sardines appear in the catches during October, grow quickly until about January, and then more slowly until they reach the length of 14 cm in April. They then disappear from the Lagoon.

A correlation is made between the landings of larger Sardine in Rio de Janeiro and the small Sardine landed in Cananéia the previous year. It is suggested that the abundance of Sardine landed in Cananéia may be used as an index of abundance in the following year at Rio de Janeiro.

VI — RESUMO

Êste trabalho inclui uma análise da distribuição de comprimentos das sardinhas pescadas na Lagoa de Cananéia, ao sul do Estado de São Paulo, Brasil. Demonstra-se que as sardinhas jovens aparecem nas pescas realizadas durante o mês de outubro, crescem ràpidamente mais ou menos até janeiro e daí para diante, mais vagarosamente, até atingirem o comprimento de 14 cm em abril, quando então desaparecem da Lagoa.

Faz-se a correlação entre os desembarques de sardinhas maiores no Rio de Janeiro e das sardinhas pequenas desembarcadas em Cananéia no ano anterior. Sugere-se que a abundância de sardinhas desembarcadas em Cananéia, num ano, pode ser usada como índice de abundância de sardinhas no ano seguinte no Rio de Janeiro.

VII — BIBLIOGRAPHY

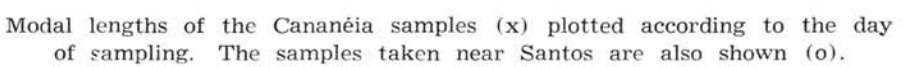
RICHARDSON, I. D. *et al.*

1959. Report on sardine investigations in Brazil. FAO, Rome, v+7p., tabs. figs.

RIPLEY, W. E.

1956. Relatório ao Govêrno do Brasil sôbre Biologia da Pesca. Rep. FAO/TAP (494), 23 p. figs.

FIGURE 1



Modal lengths of the Cananéia samples (x) plotted according to the day of sampling. The samples taken near Santos are also shown (o).

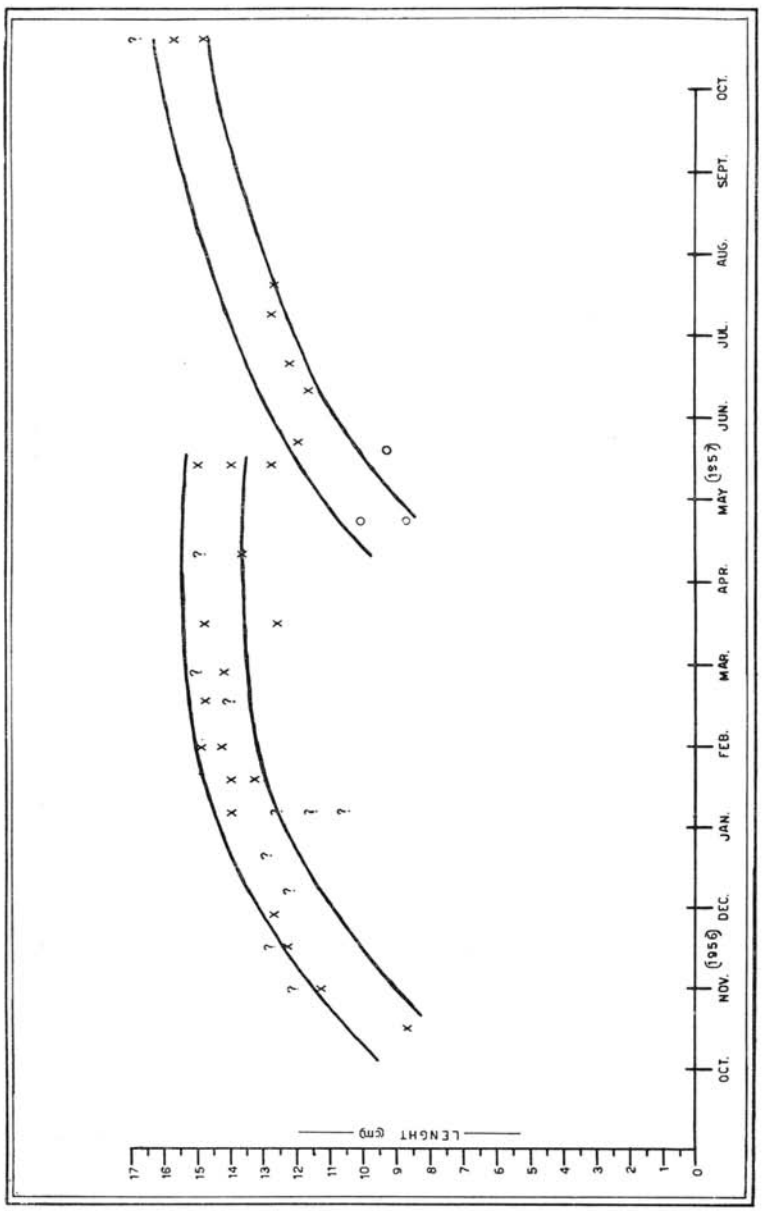
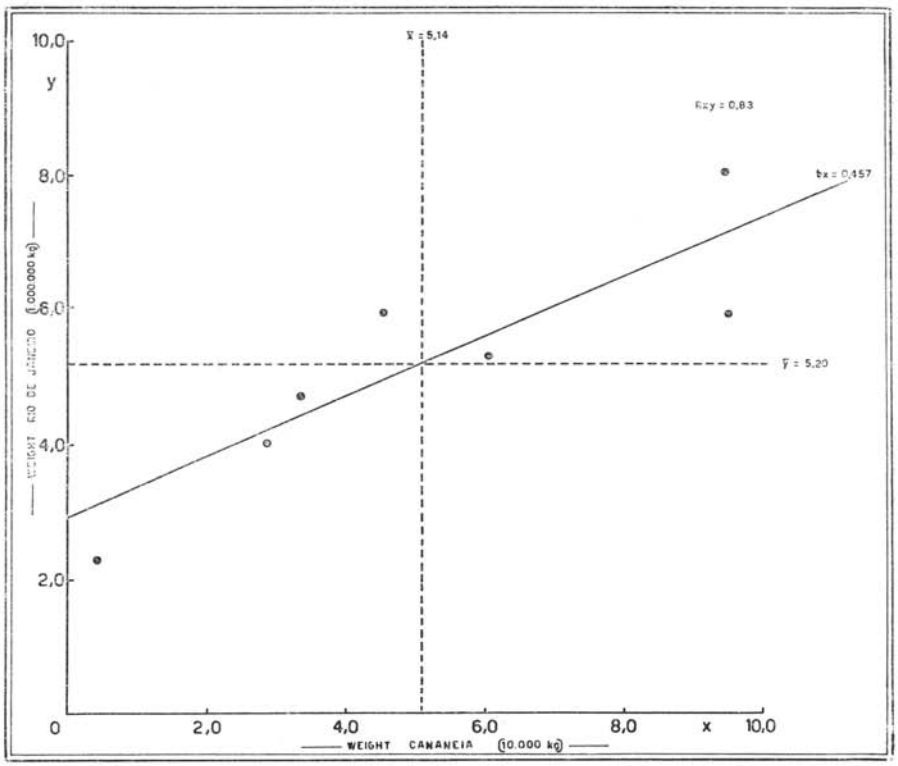

LENGHT (mm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
OCT.
NOV. (1956)
DEC.
JAN.
FEB.
MAR.
APR.
MAY (1957)
JUN.
JUL.
AUG.
SEPT.
OCT.

FIGURE 2

Landings of sardine in Cananéia plotted against landings of large sardine in Rio de Janeiro the following year.


10,0
y
8,0
6,0
4,0
2,0
0
2,0
4,0
6,0
8,0
x
10,0
X̄ = 5,14
Ȳ = 5,20
Rxy = 0,83
bx = 0,457
— WEIGHT CANANEIA (10.000 kg) —
— WEIGHT EQ. DISTR. (10.000 kg) —