MORPHOMETRY, GROWTH, AND AGE OF TUNAS

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FISH AND WILDLIFE SERVICE

Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating agencies and in processed form for economy and to avoid delay in publication.

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United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

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No. 22

MORPHOMETRY, GROWTH, AND AGE OF TUNAS

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Pacific Oceanic Fishery Investigations

CONTENTS

1/ From South Sea Fishery News [Nanyō Suisan Jōhō], Vol. 5, No. 3, pp. 5-13. June 25, 1941.

2/ From the Formosan Fisheries Magazine [Taiwan Suisan Zasshi], No. 241, pp. 8-10. 1935.

3/ From the Bulletin of the Japanese Society of Scientific Fisheries, [Nippon Suisangakkai Shi], Vol. 1, No. 1. May 1932.

4/ From the South Sea Fishery News, Vol. 3, No. 10., Vol. 4, No. 1, Vol. 4, No. 2, Vol. 4, No. 5, respectively.

Measurements of Yellowfin Tuna from the Equatorial Countercurrent Area

The writer has previously reported in this journal how he measured yellowfin tuna (taken on longlines) from Palau waters and determined their ages by consulting an age-length table. The majority of the tuna taken were in their seventh year; eighth-year and sixth-year fish were next most numerous.

Past fishery investigations have shown that fish in their fourth year, and some as young as the second year, are caught near the islands (the so-called "resident fish"), but the yellowfin which migrate continually in the currents of the open sea have rarely been found to be younger than the fourth year.

Although these facts were obtained from the results of a survey conducted in the waters off Palau, they coincided in general with those obtained in the later survey carried out in the waters south of the Marshall Islands.

Since it was thought that it would be possible to get a general knowledge of the morphometry of yellowfin tuna inhabiting the South Sea area by conducting a survey midway between the two archipelagoes, that is, in the waters south of Truk, Ponape, Kusaie and Jaluit islands, we waited for an opportunity to gather data in that area. When at a later date the survey ship Zuihō Maru carried out fishing ground surveys in that area, we measured the yellowfin taken there. The results of these measurements are compiled in this article.

As seen under the column heading of current direction, every one of the grounds surveyed at that time is shown to be in the area of easterly currents. We can definitely assume from this fact that the fishing grounds were within the Equatorial Countercurrent. The title of this article therefore, can be justified.

The data contained in the tables which follow can be summarized as follows:

Table 1	out of 2	7th-year fish	1
		6th-year fish	1
Table 2	out of 11	7th to 8th-year fish	3
		7th-year fish	4
		6th to 7th year fish	2
		6th-year fish	2
Table 3	out of 9	8th-year fish	2
		7th-year fish	5
		6th to 7th-year fish	1
		6th-year fish	1
	out of 12*	7th to 8th-year fish	1
		7th-year fish	7
		6th to 6th-year fish	5*

(TN. *Presumed to be out of 14 with 5th to 6th-year fish 6)

Table 5	out of 61	8th-year fish	1
		7th to 8th-year fish	4
		7th-year fish	38
		6th to 7th-year fish	2
		6th-year fish	8
		5th to 6th-year fish	5
		5th-year fish	3
Table 6	out of 22	7th to 8th-year fish	2
		7th-year fish	17
		6th-year fish	3
		6th to 7th-year fish	2

Table 8	out of 65*	7th to 8th-year fish	1
		7th-year fish	36
		6th to 7th-year fish	4
		6th-year fish	18
		5th to 6th-year fish	5
		5th-year fish	1

(TN. *Presumed to be out of 66 with 7th-year fish 37)

The majority of the yellowfin caught in this area were in their seventh year; next most numerous were 8th-year and 6th-year fish. The data clearly indicate that yellowfin under the 4th-year were not caught.

I took great pains in measuring these yellowfin in order to learn the age of the fish taken by tuna longlines in island waters. Although this was the objective, I felt my interest mount as I accumulated more and more measurements for I was able to obtain strong evidence of the permanent nature of the tuna fishing industry of the islands.

Briefly, the fact that the tuna longline, which is the principal gear used in tuna fishing, takes only the mature yellowfin and does not catch those below the 4th-year or those which are immature means that the fishery is conducted according to the natural law of spawning protection. (Although young and immature yellowfin are sometimes caught in the waters near the island, such instances are rare and insignificant.) For this reason, I believe that the stock of this tuna species is of a permanent nature.

(May 23)

TABLE 1

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
1	11-14	5°40'N 145°13'E	E/S	0.4	118	8.000	female	7th
2	"	"	"		107	6.500	"	6th

TN: 1 kan = 8.27 lbs.

TABLE 2

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
1	11-15	4°13'N 146°23'E	E/S	1.0	131	11.00	female	7th-8th
2	"	"	"	"	130	10.500	"	7th
3	"	"	"	"	114	8.000	"	6th
4	"	"	"	"	113	8.500	"	6th-7th
5	"	"	"	"	115	8.000	"	6th
6	"	"	"	"	128	11.500	male	7th
7	"	"	"	"	128	11.900	"	7th-8th
8	"	"	"	"	121	11.900	female	7th-8th
9	"	"	"	"	124	10.200	"	7th
10	"	"	"	"	127	10.600	male	7th

TABLE 3

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
1	11-20	5°28'N 151°29'E	SE/E	0.2	125	10.500	male	7th
2	"	"	"	"	125	10.500	"	7th
3	"	"	"	"	137	10.500	female	7th
4	"	"	"	"	133	12.000	male	8th
5	"	"	"	"	118	9.000	female	7th
6	"	"	"	"	123	10.500	male	7th
7	"	"	"	"	114	7.500	"	6th
8	"	"	"	"	135	13.400	"	8th
9	"	"	"	"	120	7.900	female	6th-7th

TABLE 4

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
		3°56'N						
1	11-21	152°50'E	E	--	124	10.700	male	7th
2	"	"	"		129	10.000	"	7th
3	"	"	"		105	5.100	female	5th-6th
4	"	"	"		105	5.200	"	5th-6th
5	"	"	"		135	11.100	male	7th-8th
6	"	"	"		123	9.100	"	7th
7	"	"	"		127	10.000	"	7th
8	"	"	"		119	8.200	"	7th
9	"	"	"		105	5.600	"	5th-6th
10	"	"	"		123	10.000	"	7th
11	"	"	"		127	10.000	"	7th
12	"	"	"		102	5.000	female	5th-6th
13	"	"	"		106	5.200	male	5th-6th
14	"	"	"		101	4.600	"	5th-6th

TABLE 5

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
		2°30'N						
1	11-22	154°20'E	ENE	--	112	7.000	female	6th
2	"	"	"		117	8.000	"	7th
3	"	"	"		111	6.800	male	6th
4	"	"	"		119	10.000	female	7th
5	"	"	"		96	4.500	male	5th
6	"	"	"		121	10.400	"	7th
7	"	"	"		102	9.100	"	6th-7th
8	"	"	"		127	8.900	female	7th
9	"	"	"		124	9.300	"	7th
10	"	"	"		108	5.500	male	5th-6th
11	"	"	"		123	8.500	female	7th
12	"	"	"		123	9.000	male	7th
13	"	"	"		112	7.600	female	6th
14	"	"	"		119	9.300	"	7th
15	"	"	"		128	10.000	male	7th
16	"	"	"		138	11.000	"	7th-8th
17	"	"	"		125	8.600	"	7th
18	"	"	"		127	10.100	"	7th
19	"	"	"		127	9.200	"	7th
20	"	"	"		119	8.500	female	7th
21	"	"	"		105	5.500	male	5th-6th
22	"	"	"		125	9.700	"	7th
23	"	"	"		105	5.300	"	5th-6th
24	"	"	"		114	7.600	"	6th
25	"	"	"		117	8.600	female	7th
26	"	"	"		128	11.000	male	7th
27	"	"	"		128	8.600	"	7th
28	"	"	"		122	7.900	female	6th-7th

TABLE 5 (Cont'd)

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
		2°30'N						
29	11-22	154°20'E	ENE	--	131	10.700	male	7th-8th
30	"	"	"		100	4.800	"	5th
31	"	"	"		123	8.200	female	7th
32	"	"	"		130	11.000	male	7th
33	"	"	"		128	10.000	"	7th
34	"	"	"		122	8.000	female	7th
35	"	"	"		105	6.000	male	6th
36	"	"	"		117	8.000	female	7th
37	"	"	"		102	5.500	male	5th-6th
38	"	"	"		120	8.500	female	7th
39	"	"	"		123	8.500	"	7th
40	"	"	"		122	10.500	male	7th
41	"	"	"		110	6.000	"	6th
42	"	"	"		122	10.500	"	7th
43	"	"	"		124	10.500	"	7th
44	"	"	"		110	6.500	female	6th
45	"	"	"		100	5.000	male	5th
46	"	"	"		107	6.000	"	6th
47	"	"	"		131	10.100	"	7th-8th
48	"	"	"		121	9.000	"	7th
49	"	"	"		131	11.000	"	7th-8th
50	"	"	"		130	10.500	"	7th
51	"	"	"		103	4.800	"	5th-6th
52	"	"	"		129	10.500	"	7th
53	"	"	"		125	9.000	female	7th
54	"	"	"		128	10.000	"	7th
55	"	"	"		130	9.300	"	7th
56	"	"	"		119	8.000	"	7th
57	"	"	"		140	13.000	"	8th
58	"	"	"		119	8.800	"	7th
59	"	"	"		121	9.000	male	7th
60	"	"	"		125	10.000	"	7th
61	"	"	"		130	11.000	"	7th

TABLE 6

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
		3°25'N						
1	11-29	159°27'E	SE	--	125	11.000	male	7th
2	"	"	"		125	10.000	female	7th
3	"	"	"		123	10.000	male	7th
4	"	"	"		128	9.000	"	7th
5	"	"	"		125	10.600	"	7th
6	"	"	"		122	8.300	female	7th
7	"	"	"		121	9.000	male	7th
8	"	"	"		123	9.800	"	7th

TABLE 6 (Cont'd)

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
9	11-29	3°25'N 159°27'E	SE	--	125	8.900	female	7th
10	"	"	"		120	9.200	"	7th
11	"	"	"		108	5.700	"	6th
12	"	"	"		135	11.100	male	7th-8th
13	"	"	"		135	11.000	"	7th-8th
14	"	"	"		125	9.100	female	7th
15	"	"	"		125	10.000	male	7th
16	"	"	"		122	9.400	"	7th
17	"	"	"		108	6.800	"	6th
18	"	"	"		110	5.900	"	6th
19	"	"	"		129	9.000	female	7th
20	"	"	"		120	9.200	"	7th
21	"	"	"		119	9.000	"	7th
22	"	"	"		128	10.500	male	7th

TABLE 7

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
1	12-3	5°20'N 164°59'E	Unknown		120	7.400	male	6th-7th
2	"	"	"		120	7.400	female	6th-7th

TABLE 8

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
1	12-6	3°45'N 165°40'E	E	--	130	10.100	male	7th
2	"	"	"		127	9.400	female	7th
3	"	"	"		129	10.500	male	7th
4	"	"	"		124	8.500	female	7th
5	"	"	"		112	7.500	"	6th
6	"	"	"		122	8.500	"	7th
7	"	"	"		125	8.500	"	7th
8	"	"	"		132	11.200	male	7th-8th
9	"	"	"		115	8.500	female	7th
10	"	"	"		105	5.500	"	5th-6th
11	"	"	"		106	5.800	male	6th
12	"	"	"		102	5.300	"	5th-6th
13	"	"	"		108	6.100	"	6th
14	"	"	"		110	6.200	female	6th
15	"	"	"		122	9.600	male	7th
16	"	"	"		123	9.600	female	7th
17	"	"	"		105	7.000	male	6th
18	"	"	"		109	5.800	female	6th
19	"	"	"		108	7.000	male	6th

TABLE 8 (Cont'd)

No.	Date of Catch	Fishing Ground Position	Current Direction	Current Speed	Length (Centimeter)	Weight (Kan)	Sex	Year of Age
		3°45'N						
20	12-6	165°40'E	E	--	124	10.200	--	7th
21	"	"	"		112	4.400	female	5th-6th
22	"	"	"		122	9.500	"	7th
23	"	"	"		117	8.400	--	7th
24	"	"	"		130	11.000	male	7th
25	"	"	"		126	8.400	female	7th
26	"	"	"		113	9.000	"	6th-7th
27	"	"	"		111	8.000	"	6th
28	"	"	"		107	4.900	"	5th-6th
29	"	"	"		127	9.300	male	7th
30	"	"	"		125	9.700	"	7th
31	"	"	"		109	5.800	female	6th
32	"	"	"		124	8.700	male	7th
33	"	"	"		127	9.300	female	7th
34	"	"	"		109	6.700	male	6th
35	"	"	"		105	6.300	"	6th
36	"	"	"		107	5.700	female	6th
37	"	"	"		120	9.400	male	7th
38	"	"	"		109	6.700	female	6th
39	"	"	"		109	6.000	"	6th
40	"	"	"		127	11.000	male	7th
41	"	"	"		104	6.500	female	6th
42	"	"	"		97	4.800	male	5th
43	"	"	"		120	10.000	"	7th
44	"	"	"		127	9.300	female	7th
45	"	"	"		118	9.000	male	7th
46	"	"	"		122	9.700	"	7th
47	"	"	"		127	10.600	"	7th
48	"	"	"		105	5.800	"	6th
49	"	"	"		125	9.500	female	7th
50	"	"	"		117	7.700	"	6th-7th
51	"	"	"		106	6.000	male	6th
52	"	"	"		121	9.500	female	7th
53	"	"	"		128	11.000	male	7th
54	"	"	"		109	6.900	female	6th
55	"	"	"		120	9.800	male	7th
56	"	"	"		106	5.500	female	5th-6th
57	"	"	"		127	10.400	male	7th
58	"	"	"		118	8.300	"	7th
59	"	"	"		127	9.700	female	7th
60	"	"	"		108	8.500	male	6th-7th
61	"	"	"		117	7.700	female	6th-7th
62	"	"	"		128	11.000	male	7th
63	"	"	"		127	10.000	"	7th
64	"	"	"		130	10.500	"	7th
65	"	"	"		130	11.000	"	7th
66	"	"	"		118	8.400	"	7th

The Correlation Between the Length and Weight of Yellowfin Tuna

Based on measurements taken aboard the Shōnan Maru during the course of experimental tuna fishing in 1934. January 1935.

I Introduction

This paper is an attempt to show the correlation between the lengths and weights of 44 yellowfin tuna taken during experimental tuna fishing in 1934.

II Method of Measuring Length and Weight

The fish were weighed in the condition in which they were when captured and their lengths were taken as the horizontal distance between the snout and the end of the base of the caudal (see the accompanying sketch). The units of measurement employed were kilograms and centimeters.

III Summary

As is clearly shown by Figure 1, the coordinates of each specimen were found by representing the weights (W) on the X axis and the lengths (L) on the Y axis. The line XY was found by the "method of great majority" [sic]. The line XY satisfies the equation $L = aW^b$. In other words, if a number of points are taken at random on this line, a line connecting the points whose coordinates are represented by Log 10 L Log 10 W of these points taken at random can be considered to be roughly a straight line, as shown in Figure 2. If we calculate the constants a and b of the equation $L = aW^b$ in Figure 2, they are as follows:

$$a = 40.12$$
$$b = 1/3$$

Accordingly we arrive at the equation

$$L = 40.12W\ 1/3$$

IV Conclusion

As shown in the preceding paragraph, the correlation between the lengths and weights of yellowfin tuna within the range of 5 to 60 kg taken within this area at this season can in general be shown by the formula given in Paragraph III.

[Figure 1 is a scatter diagram of the lengths and weights with a curve fitted to it. Figure 2 is a graph with a straight line connecting points whose coordinates are the logs of weights and lengths. There is also a sketch of a tuna showing what measurement was used for L.]

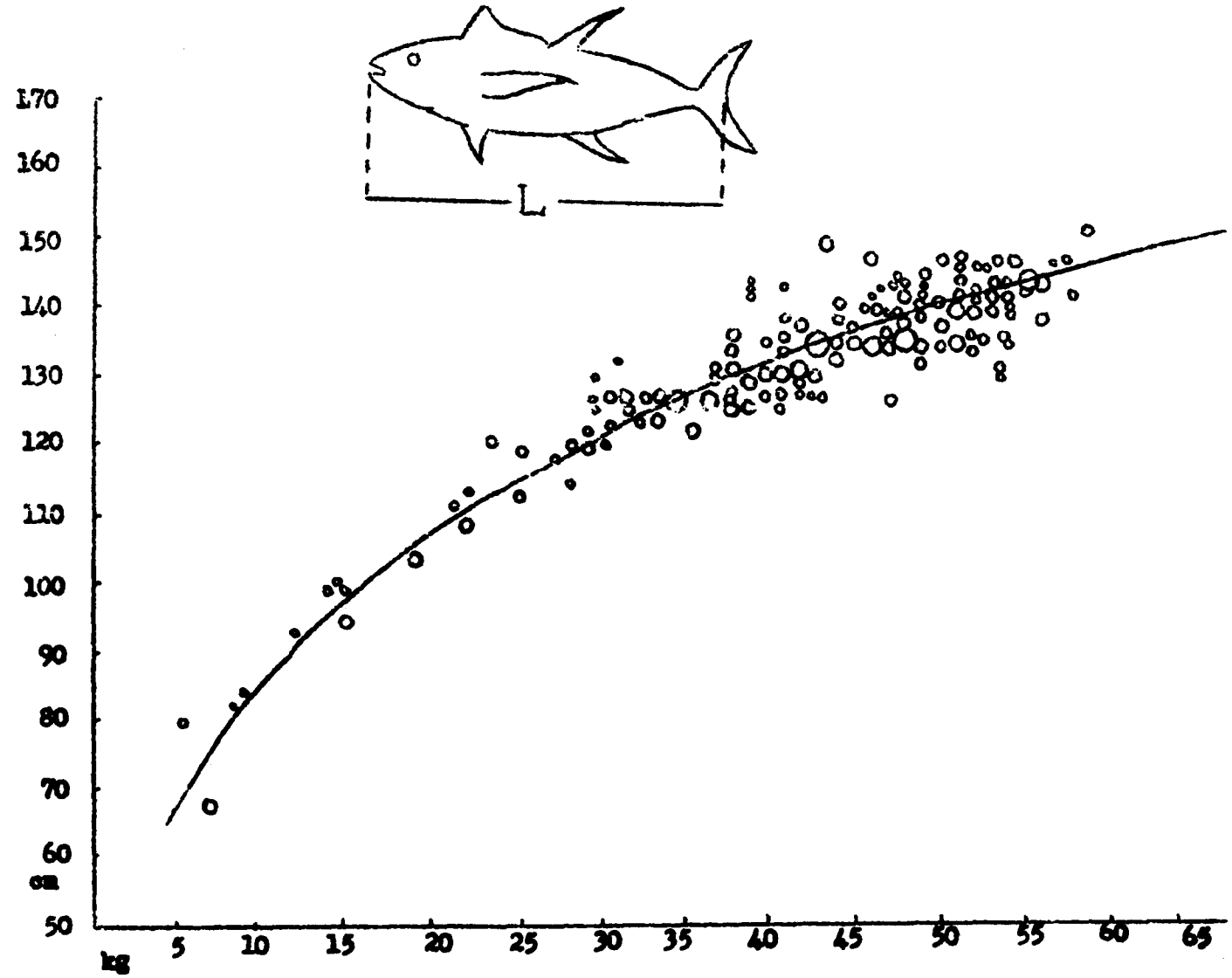
L
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Figure 1

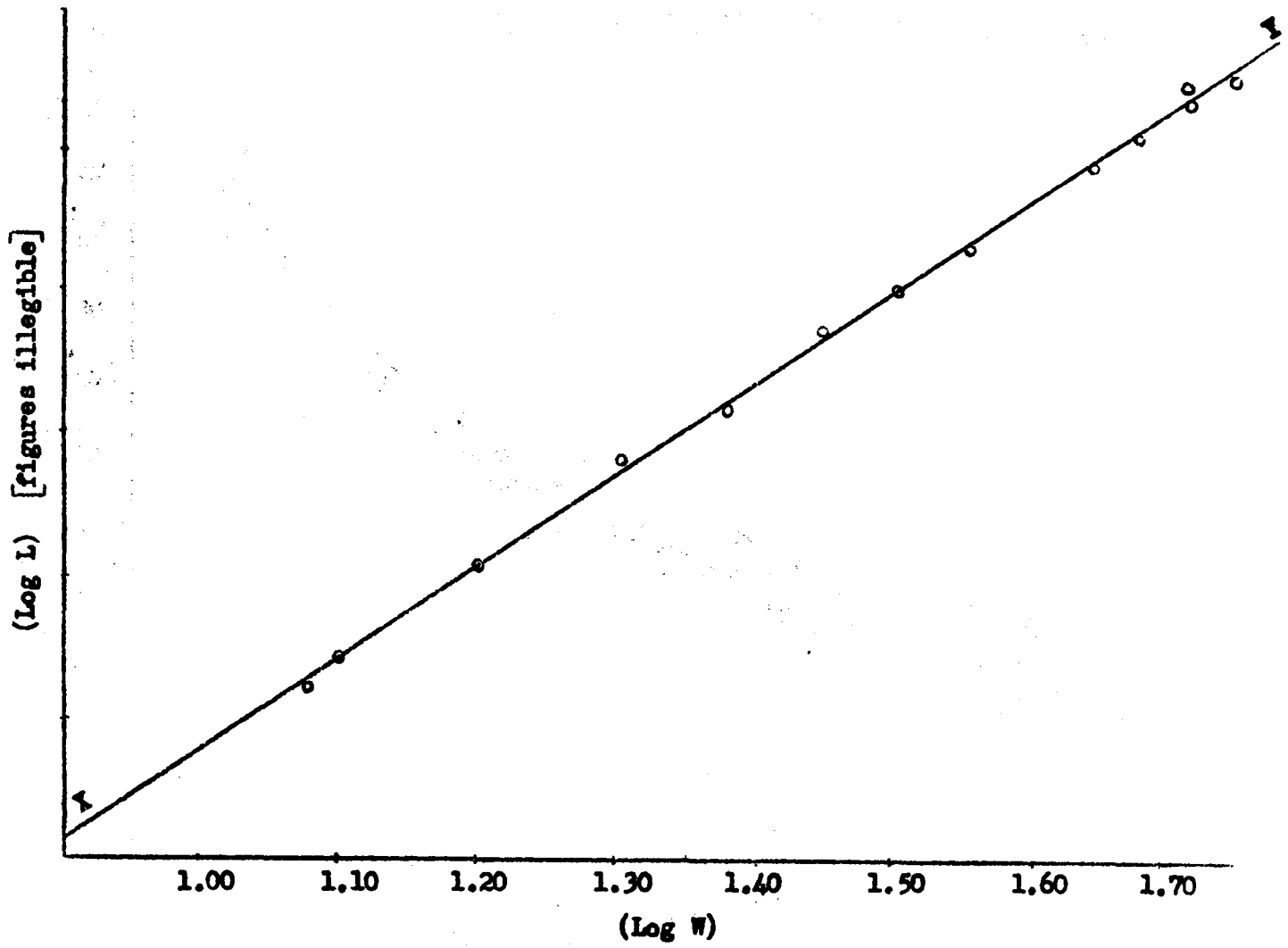

Figure 2

Growth Curves of Blue-Fin Tuna and Yellow-Fin Tuna Based on The Catches

Synopsis [in English]

No investigation has been made on the scale and otolith of the tuna from the Seas of Japan with reference to the growth rate of the fish. In the present paper are given frequency histograms (Figs. 2 and 5) showing body-weight distribution of bluefin tuna (Thunnus orientalis Temminck & Schlegel) and yellowfin tuna (neothunnus macropterus Temminck & Schlegel) from Shigedera fishing ground which is situated at north-eastern corner of the Suruga Bay (Fig. 1). The data were obtained from 1924 to 1931 inclusive, and can be divided into several age-groups as plotted in Figs. 4 and 6, in which solid circle indicates individual fluctuation of the body-weight and encircled dot shows the average body-weight of a large number of specimens which were caught there at the same time and nearly of the same weight. The curves are free-hand smoothing.
[end of English synopsis]

It is difficult to find out the growth of fishes which migrate widely in the oceans, and the study of annuli and otoliths is still not very far advanced. The author has used data on the weights of individual fish from the records of catches of black tuna and yellowfin tuna on the Shigedera fishing grounds in the northeastern corner of Suruga Bay (Fig. 1), and has deduced the growth rates of the fish taken on those grounds on the basis of graphs of the weight distributions.

Young black tuna are first taken in the large set-nets of these fishing grounds around July and August, and thereafter some are taken every day. From the end of the year through the early part of the following year these fish are from 2 to 4 kg in weight; in the peak season of April, May, and July they weight about 5 kg; and in the spring of their third year they attain a weight of about 10 kg. During this period they are called small meji, medium meji, and large meji depending on their weight. In the spring of the third year from about March and April these second-year fish (large meji) disappear completely from the catch, and the only fish taken after this time are either first-year fish or those much larger than the second-year fish. If we except these young fish and separate the large black tuna which are taken by weight groups, we get a graph of weight distribution like that shown in Fig. 2. This graph can be divided according to the differences in the weights of the fish into three groups of small, medium, and large tuna. Although from 1924 to 1928 the average weights of the fish in the small and medium groups tended gradually to increase, it can be seen in Fig. 3, which shows the fishing season for each group, that the season for small and medium fish was coming later each year and it may be thought that the increase in the average weights was related to this lag.

Since it was already possible to ascertain clearly the rate of growth for fish under the second year of age, we were able, by considering the above-mentioned three groups of small, medium, and large fish to be respectively third-, fourth-, and fifth-year fish, to draw a growth curve for the black tuna as shown in Fig. 4. However, the rate of increase in the body weight in the summer season appears to be greater than that shown for the summer season in the corresponding portion of the smoothed growth-rate curve covering a six-year period, and marked differences are noticeable in the case of the fourth- and fifth-year fish. This leads one to believe that there is a marked difference between summer and winter growth. Only one or a few fish of the sixth year and older are taken each year and it is therefore not possible to find their rates of growth.

The catch of yellowfin tuna, both adults and young, on these grounds is a great deal smaller than that of black tuna, and the season is limited to the summer. Excluding the young yellow meji, the weight distribution was sought for yellowfin weighing over 10 kg. The graph of this distribution is shown in Fig.5 where it can be seen that the maximum values for the number of fish of each size in the catch are rather widely separated. If we take these as the average weights for yellowfin of each age in the summer season and plot a growth curve, we get the result shown in Fig.6. In the case of yellowfin over 50 kg in weight the maximum values for the number of fish in the catch are not clear, the number of fish is small, and accordingly their growth rate is unknown.

(at the Fisheries Experiment Station)

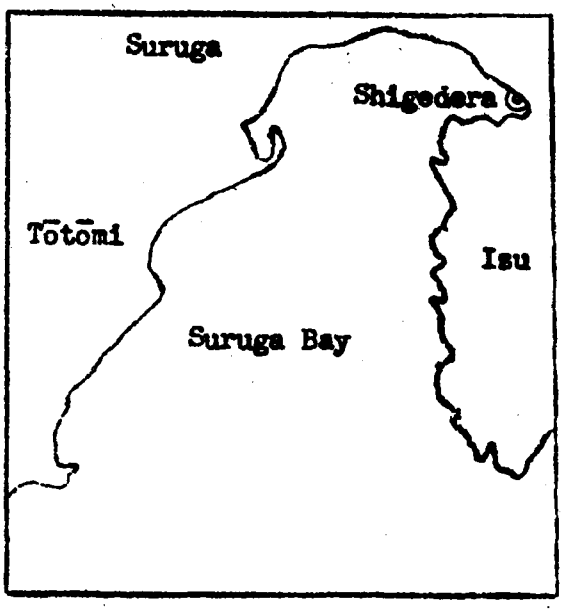

Fig.1 Location of the Shigedera fishing grounds

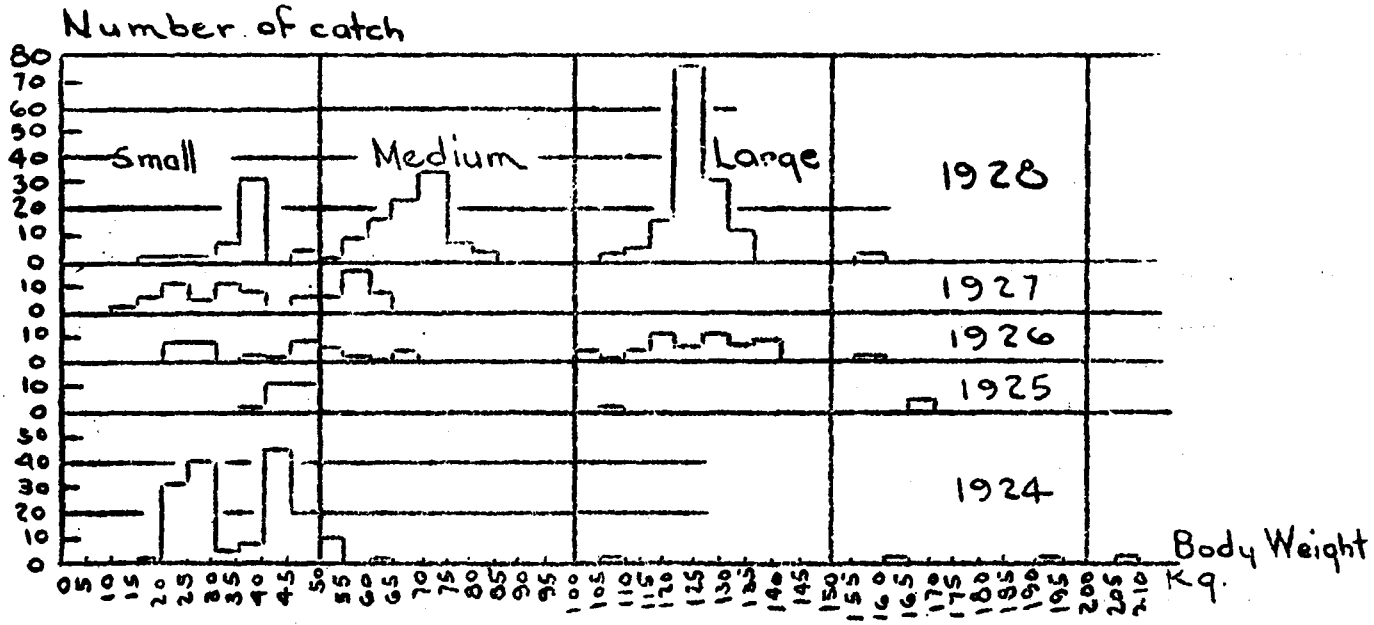

Fig.2 Distribution of weights of black tuna in the catch (young fish omitted)

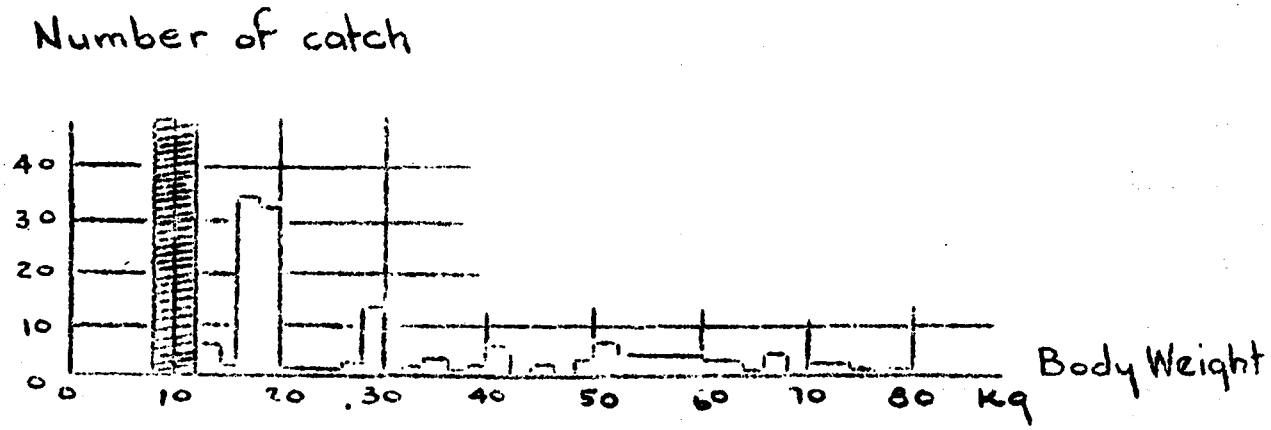

Fig.5 Weight distribution of yellowfin tuna in the catch (young fish omitted)

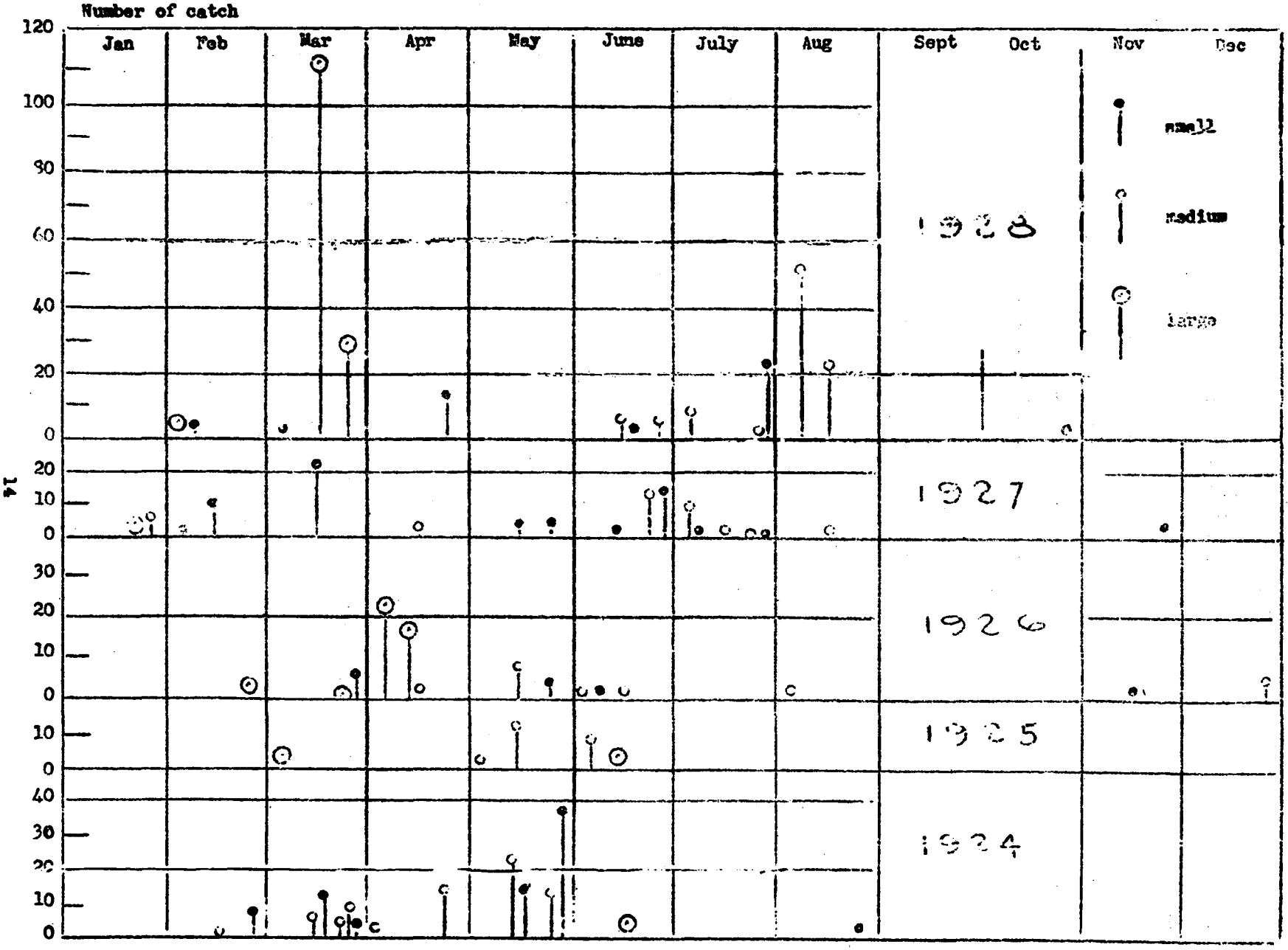

Fig.3 Fishing seasons for small, medium, and large black tuna

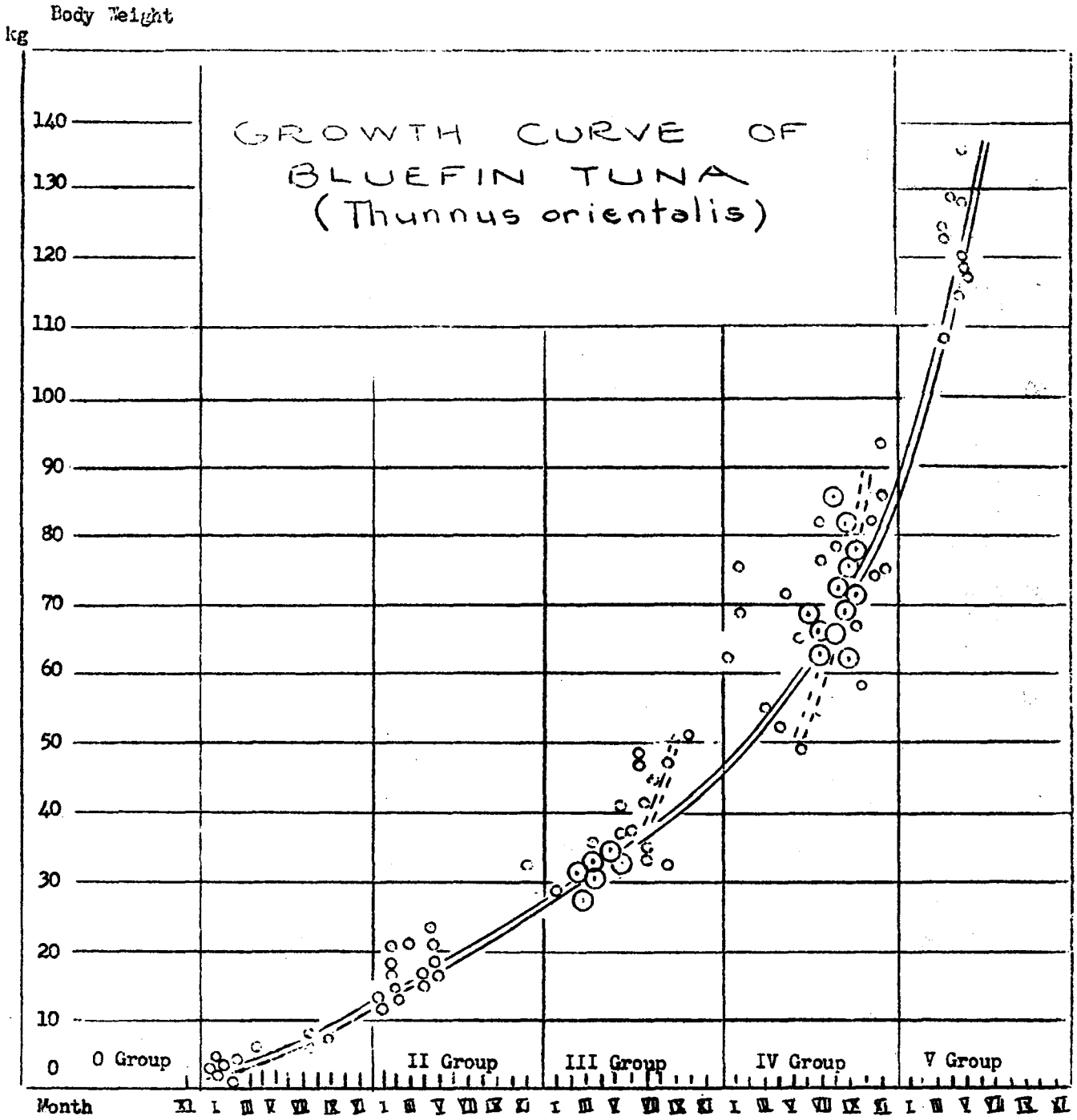

Fig.4 Growth curve for black tuna

———— Fish of the year to fifth-year fish (sixth year after hatching)

– – – – – Summer growth curve

⊙ Average weight of a large number of black tuna of roughly the same size taken at the same time

o Weight of individual fish

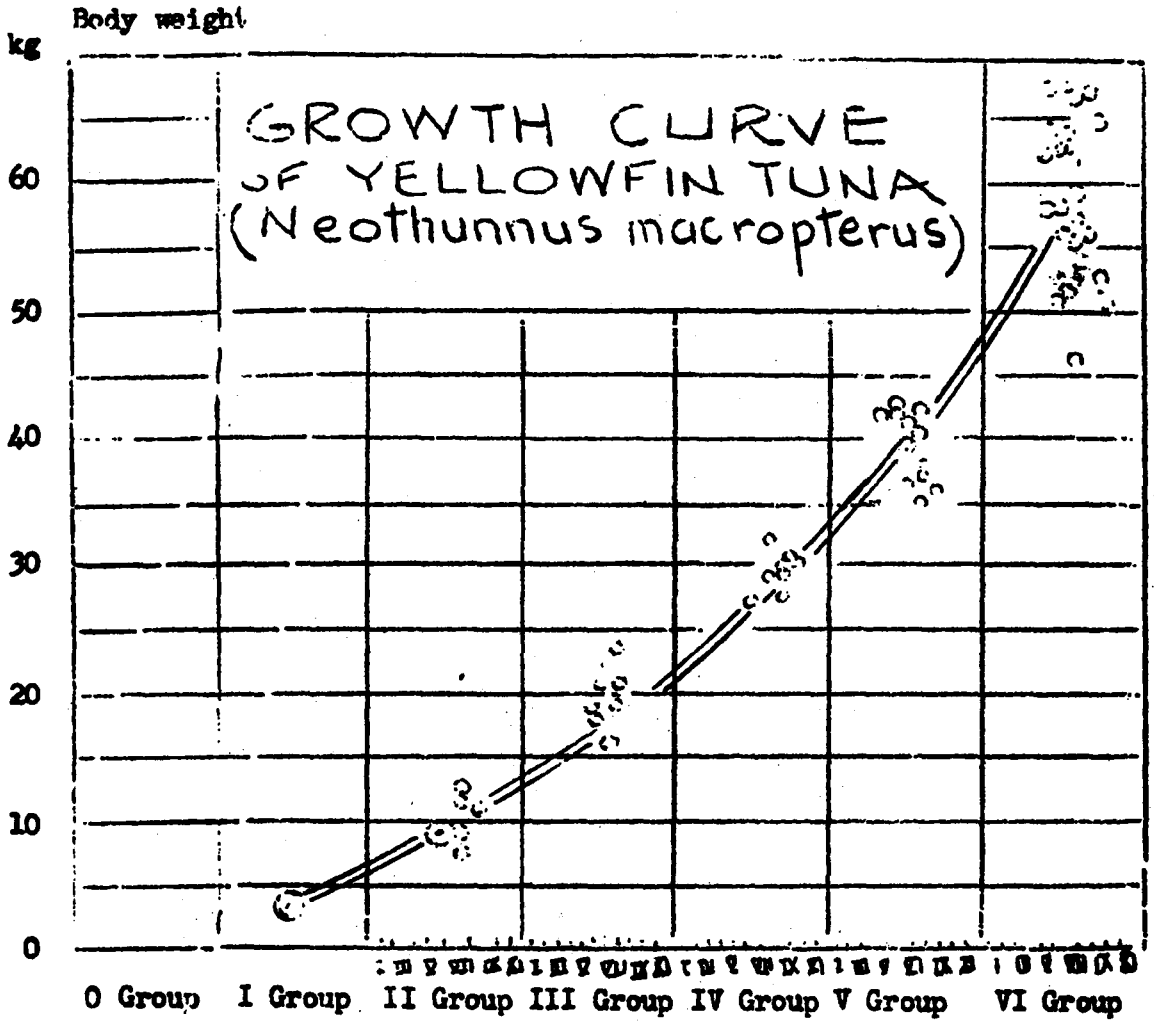

Fig. 6 Growth curve for yellowfin tuna

⊙ average weight of a large number of fish of roughly equal weight taken at one time

o weights of single fish

On the Age of Yellowfin Tuna from Palau Waters

by
Kenzō Ikebe, Technician

[from South Sea Fishery News, Vol.3, No.10. December 15, 1939]

Data on the lengths and weights of fish are of great value as reference materials for the study of the grounds where the fish were taken. For this reason the author took measurements of 11 yellowfin tuna taken on the long lines of the Hakuō Maru November 14 west of Palau (position of fishing grounds, 7° 10' N, 134° 3' E).

The following table shows the results of measurements of the body length, total length, body depth, body width, and weight as well as the condition factor ($\frac{W}{L^3} \times 1{,}000$) calculated according to the method published by Mr. Kinosuke Kimura of the Central Fisheries Experiment Station.

Table 1

No.	Total Length	Body Length	Body Depth	Body Width	Weight	Condition Factor
	cm	cm	cm	cm	kg	
1	158	133	34	27	49.1	20.9
2	138	114	27	23	31.8	21.5
3	141	116	31	25	37.0	23.7
4	141	117	31	26	38.6	24.1
5	149	123	33	25	42.3	22.7
6	141	118	31	23	37.2	22.6
7	133	113	25	22	31.4	21.8
8	145	125	30	23	43.0	22.0
9	152	129	30	25	48.7	22.7
10	142	121	31	25	38.8	21.9
11	135	114	29	24	34.1	23.0

The author then calculated the condition factors for two sets of data which had been collected aboard the Hakuō Maru before he reported for duty at this Station. These data are segregated by sexes and one set was taken from 11 yellowfin caught east of Palau on May 11 of this year (position of fishing ground, 7° 18' N, 134° 42' E) while the other set represents 14 yellowfin taken May 14 at 7° 21' N, 134° 44' E. These data are given in the following tables.

According to a study by Dr. Hiroaki Aikawa entitled "The Age of Fishes and Changes in Their Length and Weight" which was published in Volume 4, Number 11, of Marine Fisheries [Kaiyō Gyogyō], it is possible to find the age of a fish by comparing its weight and length with the figures supplied in a table. (This study originated in the relationship between the length and weight and the vertebral bones of fishes, and was published in Volume 7, Number 2, of the Bulletin of the Japanese Society of Scientific Fisheries.)

The author was greatly impressed and interested when he learned of the existence of such an extremely valuable thing as a ready reference table on the age of fish, and decided to try to compare the results of these three sets of

Table 2

No.	Sex	Total Length	Body Length	Body Depth	Body Width	Weight	C.F.	Gonads
		cm	cm	cm	cm	kg		
1	M	154	128	31	24	39.5	18.8	rather ripe
2	M	140	120	29	23	31.5	18.2	"
3	M	142	123	29	23	34.0	18.3	"
4	F	148	126	30	24	36.5	18.2	"
5	M	148	127	33	25	40.9	20.2	"
6	F	145	123	30	24	34.8	18.7	"
7	M	146	121	31	23	37.0	20.9	"
8	M	163	135	35	26	47.8	19.4	"
9	M	123	104	25	19	19.0	16.9	"
10	M	148	125	32	24	38.0	19.5	"
11	M	145	120	29	24	33.7	19.5	"

Table 3

No.	Sex	Total Length	Body Length	Body Depth	Body Width	Weight	C.F.	Gonads
		cm	cm	cm	cm	kg		
1	F	147	122	28	23	33.5	18.4	rather ripe
2	M	152	129	33	25	42.0	19.6	"
3	M	156	129	32	25	41.0	19.1	"
4	F	145	122	29	22	33.0	18.2	"
5	M	144	122	31	22	34.5	19.0	"
6	M	145	120	30	23	36.0	20.8	"
7	F	135	118	29	22	30.0	18.3	"
8	M	150	125	31	23	39.0	20.0	"
9	M	145	121	31	24	37.0	20.9	"
10	F	143	122	28	23	31.0	17.1	"
11	M	155	127	31	24	42.5	27.5	"
12	F	155	127	31	25	38.0	18.6	"
13	F	102	87	21	16	10.5	15.9	"
14	M	138	118	30	22	32.0	19.5	"

measurements of Palau yellowfin with the table in order to determine the ages of the fish. The following tables show the age related to length and weight.

Species -- yellowfin tuna

Age	Length	Weight
	shaku	kan
First year	under 1.2	under 0.4
Second year	1.2 - 1.8	0.4 - 1.2
Third year	1.8 - 2.3	1.2 - 2.4
Fourth year	2.3 - 2.8	2.4 - 4.1
Fifth year	2.8 - 3.3	4.1 - 6.0
Sixth year	3.3 - 3.8	6.0 - 8.0
Seventh year	3.8 - 4.3	8.0 -12.0
Eighth year	4.3 - 4.8	12.0 -16.0
Ninth year	over 4.8	over 16.0

TN. 1 shaku = .994 foot
1 kan = 8.27 pounds

Converting shaku and kan to centimeters and kilograms,

Species -- yellowfin tuna

Age	Length	Weight
	cm	kg
First year	under 36.4	under 1.5
Second year	36.4 - 54.5	1.5 - 4.5
Third year	54.5 - 69.7	4.5 - 9.0
Fourth year	69.7 - 84.8	9.0 -15.4
Fifth year	84.8 -100.0	15.4 -22.5
Sixth year	100.0 -115.2	22.5 -30.0
Seventh year	115.2 -130.3	30.0 -45.0
Eighth year	130.3 -145.5	45.0 -60.0
Ninth year	over 145.5	over 60.0

Now if we compare the fish listed in Table 1 with these figures, No.1 is in its eighth year, No.2 corresponds to the sixth year in length but to the seventh in weight, No.3 to No. 6 are all in their seventh year, No.7 is in its sixth year by length and in its seventh year by weight, No.8 is a seventh-year fish, No.9 is seventh-year in length and eighth-year in weight, No.10 is a seventh-year fish, and No.11 is within the sixth-year length range and the seventh-year weight range. The following figures show in abbreviated form the age determinations for the fish listed in Tables 1, 2, and 3.

in Table 1	sixth or seventh year.....	3 fish
	seventh year.....	6 fish
	seventh or eighth year.....	1 fish
	eighth year.....	1 fish
	total	11 fish

in Table 2	fifth or sixth year.....	1 fish
	seventh year.....	9 fish
	eighth year.....	1 fish
	total	11 fish
in Table 3	fourth or fifth year.....	1 fish
	seventh year.....	13 fish
	total	14 fish

Combining all of these data we find that of a total of 36 fish

seventh year.....	28 fish
sixth or seventh year.....	3 fish
eighth year.....	2 fish
fourth or fifth year.....	1 fish
fifth or sixth year.....	1 fish
seventh or eighth year.....	1 fish

From a consideration of these data we can conclude that among the yellowfin tuna taken on long lines in Palau waters recently fish in their seventh year predominate with some admixture of both older and younger year classes.

It is the author's intention to obtain as much accurate data as possible hereafter and to use these data to investigate the ages of skipjack and albacore as well as yellowfin tuna not only in Palau waters but everywhere in the archipelago. (December 1)

Measurements and Ages of Tuna from Palau Waters

by

Kenzō Ikebe, Technician

[from South Sea Fishery News [Nanyō Suisan Jōhō], Vol.4, No.1. February 5, 1940]

In the preceding number of this journal the author published a paper on the ages of yellowfin tuna from Palau waters. In presenting a second paper on this subject there is some danger of repetition, but since it is thought that in attempting to determine the age of fish by measuring their length and weight the more data the study is based on the more accurate and reliable will be the results, the author has decided to attempt to write something more on the subject.

Last December on the second cruise of the Nankō Fishing Company's Awa Maru (92 tons, 185 horsepower) after her arrival from Japan she operated on the fishing grounds within a radius of 100 miles to the southeast of Palau. On December 23 a big catch was made at a point 40 miles southeast by south of the Palau lighthouse. Length and weight were determined on 10 spearfish [Makaira mitsukurii], 35 big-eyed tuna [Parathunnus mebachi], and 51 yellowfin tuna [Neothunnus macropterus] from this catch. These data are given below.

These measurements were taken when the catch was being weighed while the fish were being transferred from the Awa Maru to the freighter Ebon Maru. In

order not to interfere with the work it was necessary to do the measuring as rapidly as possible and so only the body lengths and weights were taken, the total length, body depth, and body width being omitted.

Body length was measured from the snout to the caudal peduncle, and the weights were taken after the fish had been completely eviscerated.

Table 1 Makaira mitsukurii

	Body Length	Weight
	shaku	kan
No. 1	5.7	12.8
2	6.1	13.7
3	5.7	13.5
4	6.0	15.9
5	6.5	11.3
6	5.7	12.0
7	5.4	10.5
8	5.6	12.0
9	6.0	13.5
10	5.5	10.8

TN. 1 shaku = .994 foot 1 kan = 8.27 pounds

Table 2 Parathunnus mebachi

	Body Length	Weight		Body Length	Weight
	shaku	kan		shaku	kan
No. 1	4.5	14.5	No. 19	4.0	10.3
2	4.9	18.1	20	4.5	12.7
3	4.4	13.5	21	4.2	12.3
4	5.3	22.5	22	4.1	10.0
5	4.6	17.0	23	4.1	11.5
6	4.9	19.6	24	4.1	12.0
7	4.3	14.5	25	4.8	17.7
8	4.1	10.8	26	4.6	11.3
9	4.4	13.5	27	4.0	10.2
10	4.6	15.8	28	3.8	10.3
11	4.5	16.2	29	4.3	14.3
12	3.8	11.0	30	4.0	10.2
13	4.8	17.7	31	4.0	10.6
14	3.7	8.5	32	4.2	13.0
15	4.1	9.6	33	5.0	20.1
16	4.3	13.5	34	4.3	13.0
17	4.4	13.5	35	4.2	12.1
18	3.7	9.0			

Table 3 Neothunnus macropterus

	Body Length shaku	Weight kan		Body Length shaku	Weight kan
No. 1	4.0	9.5	No. 27	4.0	8.4
2	4.1	9.6	28	4.0	8.8
3	4.5	13.0	29	4.1	10.0
4	4.2	9.5	30	3.9	8.1
5	4.1	10.5	31	3.9	8.5
6	4.2	11.0	32	4.2	11.6
7	4.0	10.5	33	3.8	7.5
8	4.2	10.5	34	4.2	10.6
9	3.7	8.4	35	4.2	10.6
10	4.1	10.7	36	4.0	9.6
11	3.8	9.0	37	4.4	12.5
12	4.2	10.0	38	3.8	8.1
13	4.1	11.0	39	3.7	7.7
14	3.9	8.5	40	4.0	9.3
15	4.0	8.8	41	4.1	9.4
16	4.0	9.5	42	4.1	9.6
17	4.3	11.6	43	3.7	8.0
18	4.3	9.1	44	4.3	11.5
19	4.0	9.2	45	4.5	11.9
20	4.2	11.0	46	3.9	8.5
21	4.2	9.4	47	4.0	10.2
22	4.1	9.3	48	4.1	9.7
23	4.0	8.0	49	4.3	12.1
24	3.7	6.0	50	4.2	11.2
25	3.7	9.0	51	4.2	10.0
26	4.1	10.7			

Unfortunately Tables 1 and 2 can only show the sizes of the fish because no study has been published as yet on a ready reference table of the ages of spearfish and big-eyed tuna. A comparison of the yellowfin tuna data in Table 3 with the age-class table using the same method as reported in the preceding number of this journal gives the following results:

total 51 fish	seventh year.....	41 fish
	eighth year.....	4 fish
	sixth year.....	4 fish
	sixth or seventh year.....	2 fish

It is thought that these figures have further confirmed the fact that the majority of the yellowfin tuna taken on long lines in Palau waters are fish in their seventh year. (Since the table of age-classes was published in the preceding number it has been omitted here.)

Measurements of Yellowfin Tuna from South of the Marshalls

by
Kenzō Ikebe, Technician

[from South Sea Fishery News [Nanyō Suisan Jōhō], Vol.4, No.2.]
March 5, 1940

From March to June of 1939 the South Seas Colonization Company's boat, the Ebon Maru (195 tons, 320 HP), with the Company's Technician Haruo Watanabe and Assistant Technician Seiichi Shimada aboard, carried out experimental tuna long-lining in waters south of the Marshalls. The following is the result of an attempt to determine the ages of the yellowfin tuna reported in the catch data from that cruise.

Table 1

Date -- May 8 Position of fishing ground -- 6° 05'S, 164° 26'E

No.	Body Length	Weight
	meters	kan
1	1.20	9.10
2	1.20	9.10
3	1.20	9.60
4	1.10	9.40
5	1.10	6.60
6	1.40	11.60
7	1.30	10.40
8	1.30	10.20
9	1.20	7.80
10	1.20	8.60
11	1.20	8.60
12	1.15	7.90

TN. 1 kan = 8.27 pounds

Table 2

Date -- May 10 Position of fishing ground -- 9° 00'S, 163° 30'E

No.	Body Length	Weight
	meters	kan
1	1.30	9.60
2	1.30	10.10
3	1.20	8.10
4	1.20	8.10

Table 3

Date -- May 11 Position of fishing ground -- 7° 01'S, 165° 15'E

No.	Body Length meters	Weight kan
1	1.20	8.60
2	1.20	8.10
3	1.20	9.10
4	1.25	9.60
5	1.20	9.10
6	1.20	7.70
7	1.40	12.60
8	1.20	8.30
9	1.30	10.00
10	1.30	11.10
11	1.30	8.60
12	1.30	8.15
13	1.20	6.60

Table 4

Date -- May 11 Position of fishing ground -- 6° 0.5'S, 165° 55'E

No.	Body Length meters	Weight kan
1	1.30	11.40
2	1.20	8.60
3	1.20	8.40
4	1.20	8.70
5	1.20	7.90

Table 5

Date -- May 13 Position -- 3° 48'S, 166° 28'E

No.	Body Length meters	Weight kan
1	1.20	9.00
2	1.20	8.10

Table 6

Date -- May 14 Position -- 1° 03'S, 170° 21'E

No.	Body Length meters	Weight kan	No.	Body Length meters	Weight kan
1	1.20	8.10	16	1.23	9.10
2	1.20	9.10	17	1.23	8.60
3	1.20	7.60	18	1.23	8.70
4	1.20	9.10	19	1.20	9.00
5	1.20	9.80	20	1.20	9.40
6	1.20	8.60	21	1.10	8.80
7	1.20	8.60	22	1.15	8.10
8	1.20	8.10	23	1.30	9.60
9	1.15	6.40	24	1.20	9.30
10	1.20	8.80	25	1.20	8.20
11	1.20	8.90	26	1.20	7.60
12	1.20	8.10	27	1.20	8.30
13	1.20	9.10	28	1.20	9.30
14	1.20	8.60	29	1.25	8.70
15	1.20	8.60			

Table 7

Date -- May 16 Position -- 1° 20'N, 172° 30'E

No.	Body Length meters	Weight kan	No.	Body Length meters	Weight kan
1	1.20	8.60	6	1.30	10.30
2	1.20	9.60	7	1.20	9.10
3	1.20	8.90	8	1.20	9.30
4	1.20	7.60	9	1.30	9.10
5	1.20	8.40	10	1.20	7.60

A comparison of these figures in order beginning with Table 1 with the age-class table used in the preceding number of this journal gives the following results:

in Table 1	sixth year..... 2 fish sixth or seventh year..... 2 fish seventh year..... 7 fish seventh or eighth year..... 1 fish	total 12 fish
in Table 2	seventh year..... 4 fish	total 4 fish
in Table 3	sixth or seventh year..... 2 fish seventh year.....10 fish eighth year..... 1 fish	total 13 fish

in Table 4	sixth or seventh year..... 1 fish seventh year..... 4 fish		total 5 fish
in Table 5	seventh year..... 2 fish		total 2 fish
in Table 6	sixth year..... 1 fish sixth or seventh year..... 4 fish seventh year.....24 fish		total 29 fish
in Table 7	sixth or seventh year..... 2 fish seventh year..... 8 fish		total 10 fish

If the above data are combined we get a total of 75 divided as follows:

sixth year..... 3 fish
sixth or seventh year.....11 fish
seventh year.....59 fish
seventh or eighth year..... 1 fish
eighth year..... 1 fish

According to this the majority of the yellowfin taken on long lines in the waters south of the Marshalls are fish in their seventh year with only a small admixture of fish of older and younger year classes.

A comparison of the yellowfin tuna inhabiting Palau waters and those which occur south of the Marshalls shows that as far as body measurements are concerned they are almost identical, and it is therefore not difficult to deduce that they belong to the same stock of migratory fish. (February 7)

On the Measurements of Albacore and Yellowfin Tuna from Saipan Waters

by

Kenzō Ikebe, Technician

[from South Sea Fishery News [Nanyō Suisan Jōhō], Vol.4, No.5. July 30, 1940]

In May of this year a survey was made aboard the research vessel Zuihō Maru of the albacore fishery around the northern outlying islands of Saipan. The general results of the investigation have been reported elsewhere so I have decided to report in this journal only on those phases having to do with the size and age of albacore and yellowfin tuna, basing my remarks on the data collected during the course of the survey.

This survey was conducted during the period from May 5 to May 28. The area covered was the waters around the outlying islands north of Saipan between 144° 45' and 146° 25' east longitude and 18° 11' and 21° 55' north latitude.

During the course of these investigations a total of 8 albacore and 58 yellowfin were taken (all on long lines). The following table shows the lengths and weights of these fish, the ages deduced from these measurements, and the dates and positions of capture.

It should be noted that the weights are those of eviscerated fish.

Table 1 Albacore [Thunnus germo]

No.	Date	Position	Body Length	Weight	Age
			cm	kan	
1	5-5	18°22'N,145°13'E	102	6.70	9
2	"	" "	102	6.00	8-9
3	"	" "	95	4.80	"
4	5-22	19°50'N,145°02'E	110	7.50	9
5	"	" "	102	5.70	8-9
6	5-27	20°07'N,145°14'E	105	6.70	9
7	5-28	19°04'N,145°48'E	99	4.80	8-9
8	"	" "	102	5.60	8-9

The age determinations in the table are, as in the preceding papers of this series, based on the article by Dr. Aikawa entitled "The Age of Fishes and Changes in Their Length and Weight" (see Marine Fisheries [Kaiyō Gyogyō], Volume 4, Number 11). Of the 8 albacore 3 fall in the ninth-year class and 5 can be considered to be either eighth- or ninth-year fish. In the case of albacore those within the ranges of 4.80 - 6.40 kan in weight and 85 - 94 cm in length are considered to be in their eighth year, and those over 6.40 kan in weight and 94 cm in length are regarded as being in their ninth year. Judging from the fact that the oldest albacore are ninth-year fish, we can see that the albacore which migrate into Saipan waters, although they are very scarce numerically, belong almost entirely to the largest and oldest part of the stock.

Table 2 Yellowfin tuna [Neothunnus macropterus]

No.	Date	Position	Body Length	Weight	Age
			cm	kan	
1	5-21	18°11'N,145°15'E	117	12.00	7-8
2	5-22	19°50'N,145°02'E	112	8.60	6-7
3	5-24	21°55'N,145°01'E	103	10.50	6-7
4	"	" "	125	9.00	7
5	"	" "	122	8.50	7
6	"	" "	125	10.50	7
7	"	" "	117	8.50	7
8	5-25	21°15'N,146°25'E	125	9.10	7
9	"	" "	122	8.90	7
10	"	" "	134	11.50	7-8
11	"	" "	116	8.60	7
12	"	" "	123	8.60	7
13	"	" "	123	8.50	7
14	"	" "	125	9.50	7
15	"	" "	128	10.00	7
16	"	" "	120	8.30	7
17	"	" "	128	9.30	7
18	5-26	20°20'N,146°20'E	125	9.50	7
19	"	" "	128	12.50	7-8
20	"	" "	132	11.50	7-8
21	5-27	20°07'N,145°14'E	129	9.00	7
22	"	" "	114	7.00	6
23	"	" "	130	11.20	7
24	"	" "	115	7.00	6
25	"	" "	115	8.00	6

[Table 2 continued]

No.	Date	Position	Body Length	Weight	Age
			cm	kan	
26	5-27	20°07'N,145°14'E	116	8.00	7
27	"	" "	123	12.50	7-8
28	5-28	19°04'N,145°48'E	55	0.89	2-3
29	"	" "	56	0.95	2-3
30	"	" "	59	1.02	2-3
31	"	" "	51	0.73	2
32	"	" "	105	5.10	5-6
33	"	" "	111	6.00	6
34	"	" "	103	5.00	5-6
35	"	" "	104	6.10	6
36	"	" "	115	6.50	6
37	"	" "	100	4.80	5
38	"	" "	95	3.10	4-5
39	"	" "	80	2.40	4
40	"	" "	90	3.80	5
41	"	" "	95	4.10	5
42	"	" "	105	5.60	5-6
43	"	" "	110	6.20	6
44	"	" "	106	5.70	6
45	"	" "	100	9.30	6-7
46	"	" "	105	5.60	5-6
47	"	" "	100	5.00	5
48	"	" "	104	5.60	5-6
49	"	" "	91	3.90	5
50	"	" "	102	5.50	5-6
51	"	" "	106	6.00	6
52	"	" "	102	6.00	6
53	"	" "	108	5.70	6
54	"	" "	107	5.00	5-6
55	"	" "	123	9.10	7
56	"	" "	97	4.40	5
57	"	" "	98	3.60	4-5
58	"	" "	69	1.70	3

(Note) The four fish from No. 28 to No. 31 were weighed without being gutted because of their small size.

When we examine separately the fish taken from May 21 to May 27 and those taken on May 28, we find that the 27 fish in the former group fall into the following age classes:

seventh or eighth year..... 5 fish
sixth or seventh year..... 2 fish
seventh year.....17 fish
sixth year..... 3 fish

Thus these fish resemble those taken at Palau and south of the Marshalls (described by the author in three previous articles in this journal) in that seventh-year fish are in the majority with an admixture of a few fish from the adjacent older and younger year-classes.

Of the 31 fish in the latter group the number in each age class is as follows:

seventh year	1 fish
sixth or seventh year	1 fish
sixth year	8 fish
fifth or sixth year	6 fish
fifth year	7 fish
fourth or fifth year	2 fish
fourth year	1 fish
second or third year	3 fish
third year	1 fish
second year	1 fish

In this group the seventh-year fish are outnumbered by the sixth-year and fifth-year fish, and there is an admixture of young fish of the fifth, fourth, third, and second year-classes which makes this sample differ greatly in age composition from any yellowfin tuna which I have examined hitherto. Of particular interest is the second-year fish 51 cm in length and 730 momme in weight which was the smallest yellowfin taken in the course of the survey. The presence of such a young fish makes one think that the spawning grounds of the yellowfin tuna cannot be far from this area.

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Dr. Aikawa's table of the age of fishes correlated with length and weight ranges

1. Albacore

Age	Length		Weight	
Fish of the year (0 age group)	27 cm	0.9 shaku	0.49 kg	0.13 kan
Second-year fish (I age group)	27 - 36	0.9 - 1.2	1.13 - 1.39	0.3 - 0.37
Third-year fish (II age group)	36 - 49	1.2 - 1.6	1.39 - 3.19	0.37 -0.85
Fourth-year fish (III age group)	49 - 58	1.6 - 1.9	3.19 - 5.63	0.85 -1.5
Fifth-year fish (IV age group)	58 - 67	1.9 - 2.2	5.63 - 8.62	1.5 -2.3
Sixth-year fish (V age group)	67 - 76	2.2 - 2.5	8.62 -12.38	2.3 -3.3
Seventh-year fish (VI age group)	76 - 85	2.5 - 2.8	12.38 -18.00	3.3 -4.8
Eighth-year fish (VII age group)	85 - 94	2.8 - 3.1	18.00 -24.00	4.8 -6.4
Ninth-year fish (VIII age group)	94	3.1	24.00	6.4

2. Yellowfin Tuna

Age	Length		Weight	
Fish of the year (0 age group)	38 cm	1.25 shaku	1.50 kg	0.40 kan
Second-year fish (I age group)	38- 54	1.25-1.78	1.50- 4.3	0.40- 1.15
Third-year fish (II age group)	54- 70	1.78-2.30	4.3 - 8.6	1.15- 2.30
Fourth-year fish (III age group)	70- 85	2.30-2.80	8.6 -14.0	2.30- 3.70
Fifth-year fish (IV age group)	85-100	2.80-3.30	14.0 -21.4	3.7 - 5.7
Sixth-year fish (V age group)	100-115	3.3 -3.8	21.4 -30.0	5.7 - 8.0
Seventh-year fish (VI age group)	115-130	3.8 -4.3	30.0 -44.0	8.0 -11.7
Eighth-year fish (VII age group)	130-145	4.3 -4.8	44.0 -57.5	11.7 -15.3
Ninth-year fish (VIII age group)	145-160	4.8 -5.3	57.5 -75.0	15.3 -20.

(July 4)