ADMINISTRATION OF SOUTH WEST AFRICA
MARINE RESEARCH LABORATORY

A Preliminary Investigation of the Tuna Resources off the South West African Coast

BY R. A. VAN DEN BERG AND J. P. MATTHEWS

INVESTIGATIONAL REPORT NO. 15

1969

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CONTENTS

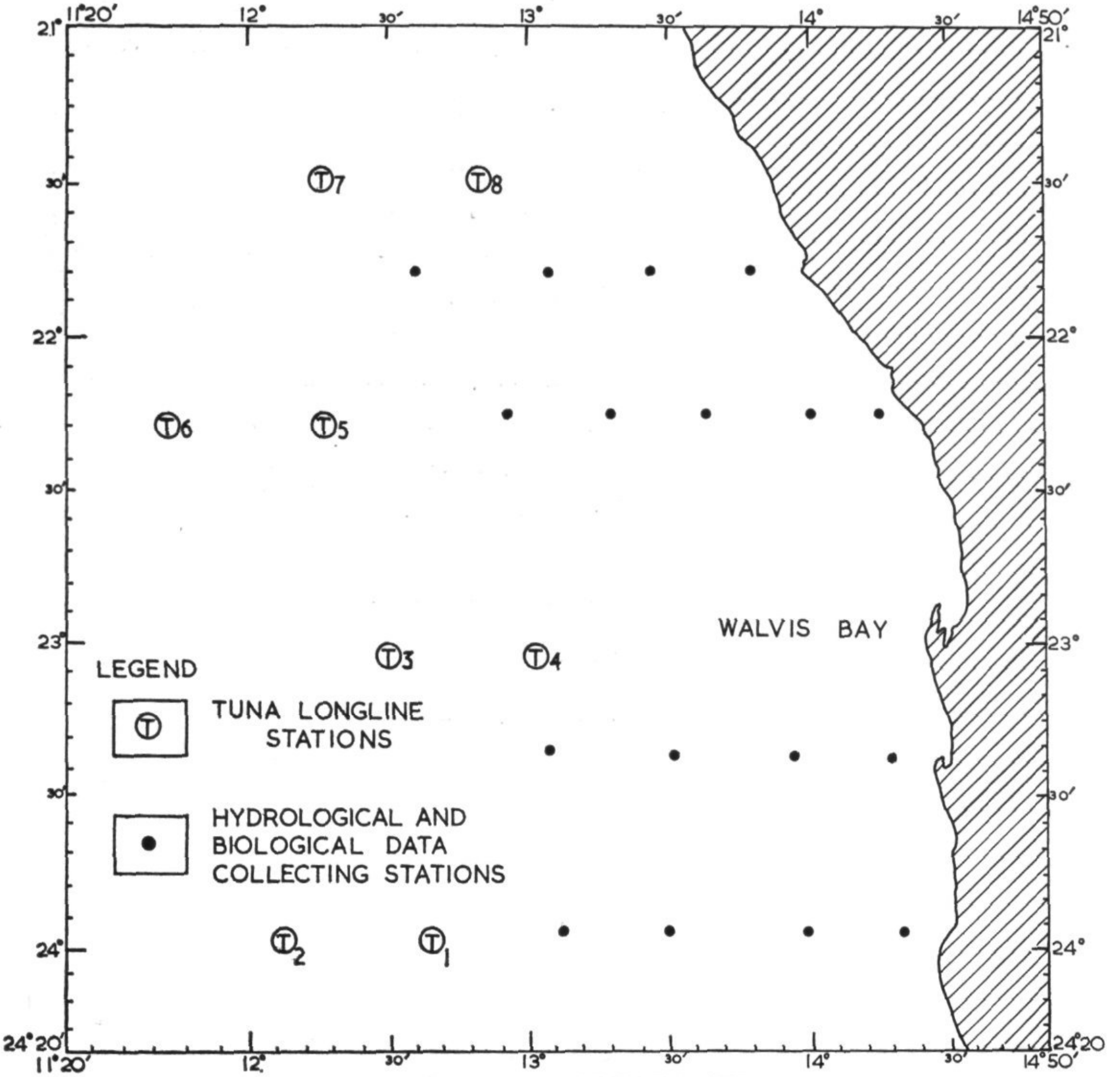

FIG. I. AREAS INVESTIGATED

1. ABSTRACT.

The meristic characteristics, sex ratio, numerical importance and distribution in space and time of **Thunnus alalunga, T. obesus, T. albacares** and **T. thynnus,** occurring off the South West African Coast are discussed. An equation expressing the length — weight relationship of longfin tuna is given. It is found that the four species are susceptible to water temperatures in their distribution and are differentially spread off the coast. The state of development of the gonads suggest that these four species do not spawn in the survey area. Fish and squid are shown to be the most important organisms in the diet of the tuna.

2. INTRODUCTION.

The Division of Sea Fisheries and the South African Museum have carried out exploratory tuna surveys off the CapeWest Coast, but confined their activities mainly to the area between Cape Hangklip and Saldanha Bay. However, from these surveys and from information that became available from tuna longliners that visited the South African and South West African coastal waters, it soon became apparent that tuna must be present in a much bigger area than that which has been surveyed, and possibly in commercial quantities. A survey was therefore also conducted off the South West African Coast by the Marine Research Laboratory of the S. W. African Administration during the period December, 1962 to June, 1964, to obtain information on the possible tuna resources of the area. Because the tuna could be present anywhere along the 700 mile coast of South West Africa, an initial survey was first conducted during the period September, 1961, to August, 1962, in order to delimit a sampling area of practical proportions.

At the moment the rock lobster and pilchard industries are probably working to full capacity so that money, men and materials can be directed into new fields of development in the fishing industries of S. W. Africa. In the near future the development of the trawling fishery will probably absorb all the resources set aside for development but in the distant future, as the demand for protein foods increases, the development of all other available fish resources, including tuna, may become a necessity.

The aim of this report is therefore to make available information on a species which is not yet exploited in South West Africa but which has distinct possibilities for exploitation in the future.

3. AREA INVESTIGATED.

(i) Preliminary survey.

In order to obtain information on the total distribution in space of tuna off the entire S. W. African coast, a preliminary survey was conducted during the period September, 1961 to August, 1962. During this period test fishing was done over the entire area and the data was analysed with the purpose of establishing research stations after the completion of this preliminary survey. This data included yields and environmental conditions thought to be of importance in the distribution of tuna.

It soon became apparent that tuna was not equally distributed throughout the entire area, but that it occurred especially in certain sections which could be identified by temperature characteristics. After statistical analysis of the preliminary results, eight stations were eventually selected for a more systematic and detailed study of the catch rates and other ecological aspects of the tuna occurring in this area. The stations were selected in such a way that the results obtained from them would be indicative of the conditions prevailing in the entire area. The data that were collected are described in section 5 of this report.

The positions of the selected sampling stations were as follows:

T1	24°00'S — 12°40'E,
T2	24°00'S — 12°07'E,
T3	23°00'S — 12°27'E,
T4	23°10'S — 13°00'E,
T5	22°20'S — 12°15'E,
T6	22°20'S — 11°42'E,
T7	21°30'S — 12°15'E,
T8	21°30'S — 12°47'E.

(ii) Hydrological characteristics of Research Area.

Flowing in a northerly direction along the coast of South and South West Africa is the cold, slow moving Benguela Current. The characteristics of the current vary considerably depending mostly on the changes in wind strength and direction. Hart & Currie (1960), consider the current to be identifiable between 15°S and 34°S and within 100 sea miles off the coast line. Stander (1964), found the water movements in the upper layers to be complex; south of 23°S the movement is longshore in a north-north-westerly direction, but further north, the current is deflected in a north-westerly direction and breaks up into smaller sections. The computed surface currents did not exceed ½ knot.

The coastal waters are characterized by upwelling. This phenomenon, which attains maximum intensity during late winter and spring, brings cold, nutrient rich water to the surface. Stander (1964), describes the isotherms generally present in the area; during January the 12°C surface isotherm can generally be found very near the coast and the 19°C isotherm approximately 100 miles off the coast line; in July the 15°C isotherm lies approximately 100 miles off the coast line. Stander found the lowest temperatures and salinities to occur along a stretch of coast line extending from the Orange River northwards as far as 23°S. The highest values were always recorded in the north-west of the area. North of latitude 23°S very sharp increases in salinity with decreasing latitude was often found by Stander.

In contrast to the Benguela Current region, the clear blue oceanic water of the South East Atlantic, further westwards, has much higher temperatures and salinities, but are relatively poor in nutrients. Temperatures of 21°C and salinities of 35.6‰ are not uncommon in the area 200 miles off the coast in January.

The characteristics of the thermoclines occurring off Walvis Bay have been reported on by Du Plessis (1967). He found seasonal thermoclines to be frequently present during the summer months, to be near the surface and to have strong gradients; during the winter months thermoclines, if at all present, were found to be deep and to have weak gradients. Close to stations T1 and T8, Du Plessis found the mean depth of thermoclines at 20 metres in the summer months of the period January, 1959 to November, 1965.

(iii) Biological characteristics of research area.

A phytoplankton population rich in numbers and species is sustained by the nutrient rich waters of the Benguela Current. The animals on top of the food chain supported by this ever available rich phytoplankton crop have become of considerable importance to industry in South West Africa. A very big fish meal and canning industry have developed in Walvis Bay based on the exploitation of pelagic fish such as the pilchard (**Sardinops ocellata**) and anchovy (**Engraulis japonicus**). The snoek (**Thyrsites atun**), which makes a seasonal appearance off the coast, is much sought after as a delicacy. At Luderitz the rock lobster (**Jasus lalandii**) has since the 1920's been one of the main sources of income to the town. The seals which are still abundant on the offshore islands and on the mainland at Cape Cross support a healthy fur-industry and the vast bird population living on the fish shoals, has become of importance as quano producers. The demersal fish resources with stockfish (**Merluccius capensis**) as the numerically most important species have only recently became important and promise rich harvests.

Very little information is available on the prawns, crabs and molluscs of the Benguela Current region. On the other hand, from the works of authors such as Boden (1955), Hart & Currie (1960), and Unterüberbacher (1964) it is clear that the microplankton of the area is rich in numbers and in species.

In contrast to the Benguela Current where some species can be found in vast numbers, the oceanic water to the west of the current is sparsely populated. Unfortunately very little information is available on the ecological features of this area.

The area of contact between the Benguela Current and the westerly oceanic water has temperature and salinity characteristics differing from those of the two main bodies of water. In this area the four species of tuna, to be discussed in section 5, were encountered as well as other fish which may be considered to be competitors of the tuna or predators on the tuna. All the specimens that were found in the stomach contents of the tuna may perhaps also be accepted to frequent the area. In Section 5 a list is given of the tuna competitors and food animals that were encountered. Many of the tuna that were hooked during the survey were damaged by sharks, but whether, under natural conditions, sharks or other big species prey to a noteworthy extent on tuna in the area, is an open question. The plankton volumes given in Table 18 is an indication of the amount of plankton in the area.

The tuna were caught by means of the "Japanese Longline" method. The gear used was essentially the same as that described by De Jager et al (1963), but differs from it in that the total main line length was 625 fathoms, 50 hooks were used and fishing depth was 30-35 fathoms of water.

4. GEAR AND METHODS.

The hooks were baited with frozen pilchard **(Sardinops ocellata).** Setting and hauling the gear took approximately 2½ hours. It was planned to keep every hook of the gear in the water for approximately 2 hours, but due to climatic, technical and other problems, this was not at all times possible and, therefore, to make the catch rates comparative, adjustments for time were made in the actual numbers that were caught.

The body characteristics and dimensions of the tuna were measured in accordance with Marr & Schaefer (1949).

The food preferences of the tuna were studied by examining the stomach contents. The stomachs were ligatured, excised and transported to the laboratory in a ten percent formalin preservative. To facilitate the entry of the formalin into the stomach, a slit was made in the gut wall.

Temperature data and water samples were collected by means of a Nansen Petterson water bottle at 0, 25, 50, 75 and 100 meters.

The plankton samples were collected with N5OV and N7OV nets. The catches were preserved in 10% neutral formalin and the settled volumes were determined on land after a minimum of eight hours settling time.

In this work the months December, January and February are considered to be the summer season; March, April and May the autumn season; June, July and August to be winter; and September, October and November to be spring.

In the script and tables the letter groups LF, BE, YF and BF will be used to denote Longfin-, Bigeye-, Yellowfin-, and Bluefin tuna respectively.

5. DATA AND FINDINGS.

(i) Tuna species caught.

Four tuna species were caught at the sampling stations viz:

- Longfin tuna, **Thunnus alalunga,** (Bonnaterre) 1788,
- Bigeye tuna, **Thunnus obesus,** (Lowe) 1839,
- Yellowfin tuna, **Thunnus albacares,** (Bonnaterre) 1788 and
- Bluefin tuna, **Thunnus thynnus orientalis** (Temminck & Schlegel) 1844.

As Mather (1963), Watson (1963) and Gibbs & Collette (1967) discuss the taxonomic features of the abovenamed species in detail, there is no necessity to discuss them again. Tables 4 to 11 show the meristic characteristics of the tuna species that were collected in this survey. A comparison of the data of these tables with the information summarised by Gibbs & Collette shows that the meristic characteristics of the South-western Atlantic yellowfin and bigeye tuna fall within the normal limits of the various features as it had been measured in other parts of the Atlantic Ocean. The longfin showed a bigger variation than that normally accepted for the species. The free dorsal finlets were found to vary between 7 and 10 while Talbot & Penrith (1963) state the variation to be 7 to 8 for South African longfin tuna. Gibbs & Collette give a variation of 7 to 9. The anal finlets were found to vary between 6 and 9 as against the 7 to 9 generally quoted in the literature. The first dorsal spines were found to vary from 9 to 14 instead of the accepted 12 to 14.

Tiews (1963) mentions the possibility that the South African bluefin tuna may not be **Thunnus thynnus** but another species. He bases his speculation on the fact that Smith, (1949) states that there are between 26 and 31 gill-rakers in South African bluefin tuna whereas various other authors have found more with bluefin. Gibbs & Collette (1967) give the range as being 31 to 43. Unfortunately only counts from 14 fish, which the authors consider to be bluefin tuna, could be obtained but these all showed a much smaller gill-raker count than that which is currently being accepted for the species. The observed variation was between 28 and 39 and it overlaps the range given by Smith and the accepted range given by Gibbs & Collette. Talbot & Penrith (1963), who also did some work on South African tunas, state the range to be between 31 and 36. It looks as if it has become necessary for a fish taxonomist to have a closer look at the identity of the South African bluefin tuna.

(ii) Abundance of different species.

Table 1 shows that longfin tuna was the most abundant species in the longline catches off the South West African coast as 191 longfin tuna were caught against only 56 bigeye, 23 yellowfin and 14 bluefin. This differs from the relative abundance of the four species off the Cape Coast. De Jager, Nepgen & van

Wyk (1963) found bluefin to be the most abundant tuna species off the Cape West Coast in a longline survey which they conducted. Longfin tuna was second in numerical importance while the incidence of the other two species was relatively the same as we have found in this survey. It appears from the work of Postel (1965), that in the longline catches which were made during 1962-1963 off the equatorial West African coast, yellow and skipjack **(Katsuwonus pelamis)** are the numerically important species in these more equatorial latitudes.

(iii) Size composition.

The distribution of the length frequencies of the male and female longfin tuna that were encountered in the catches is shown in Figures 4 and 5 and that of the bigeye tuna in Figures 6 and 7. Too few yellowfin and bluefin tuna were caught to make it worthwhile to show the length distribution frequencies graphically, but tables 8 and 11 give an indication of the size limits of these species as obtained from the catches.

In the distribution of length frequencies of male longfin tuna which occurred off the Cape West Coast during 1960-1961 and which is described by De Jager et al (1963), two numerically important length groups can be discerned i.e. a 85 to 95 cm. length group and a 100 to 105 cm. length group. In the South West African catches the length frequency distribution for male longfin tuna shows a relatively symmetrical curve with the 85 to 90 cm. length group as the numerically most important group, while for females the 80 to 85 cm. length group shows up as being the numerically most important group. In the Cape West Coast this length group is also important but a 95 to 100 cm. group dominates the catch. From the available information it seems therefore as if a larger class of longfin tuna occurred in the Cape West Coast catches which did not appear off the South West African coast in the 1963-1964 survey. It must be remembered, however, that unfortunately the two surveys compared above were not executed at the same time and the class size difference may be merely a chance effect.

Too few bigeye, yellowfin and bluefin tuna were caught during the South West African programme to try and see general tendencies in the length frequency distribution pattern.

The average weights of the tuna that were caught are shown in Table 3. It is interesting to note that, despite the fact that more than three times as many longfin as bigeye tuna were caught, the total weight of longfin that was caught is less than the total weight yielded by the bigeye tuna.

A comparison of the catch-weights of the four tuna species occurring off the South West African coast, with that of the same species occurring off the Cape Coast, as described by De Jager et al (1963), shows that the average weights off the Cape West Coast are higher than the corresponding weights realised off the South West African coast for all tuna except the bluefin species. Once again, this may be due to a chance sampling difference or it may be that there normally occur bigger tuna off the Cape West Coast than off the South West African coast. The average weight of longfin tuna was 29 lb. in the South West African catches but De Jager et al (1963) reported an average weight of 35 lb. for the Cape West Coast catches. The average weight for bigeye was 117 lb. in the South West African catches and 120 lb. off the Cape Coast; for yellowfin the corresponding weights were 81 lb. and 100 lb and for bluefin 197 lb. and 85 lb. Too few bluefin tuna were caught off South West Africa to make the 197 lb. figure reliable.

Curves have been fitted to the data expressing the length-weight relationship of male and of female longfin tuna which occurred in the catches off the South West African coast, using the method of "least squares." Too few bigeye, yellowfin and bluefin were caught to make it worthwhile to process the length-weight data of these species in the same way.

For male longfin tuna the following equation was arrived at:

$$W = (1.236 \times 10^{-4}) \times \text{L}^{2.7767}$$

W = live weight in pounds; L = total length in centimeters. The correlation between log W and log L was found to be 0.6627 and 95 fish were examined.

The corresponding equation for female longfin tuna was found to be:

$$W = (2.592 \times 10^{-3}) \times \text{L}^{2.0988}$$

The correlation between log W and log L is 0.5378 and 83 fish were examined.

De Jager et al (1963) found that the longfin tuna catches off the Cape West Coast gave a length weight relationship of W = 5.088 ×

$10^{-5} \times \lfloor 2.98$ for males, inspecting 96 fish, and $W = 3.094 \times 10^{-5} \times \lfloor 3.09$ for females, examining 48 fish. It must be taken into account, however, that De Jager and his co-workers used the weight of gutted and bled fish.

Nakamura & Uchiyama (1966), using male and female fish, 200 in total, obtained the following length-weight relationship for North Pacific longfin tuna:

$$W = 5.722 \times 10^{-5} \times \lfloor 2.9495$$

From the summary of the length-weight relationship data given by Nakamura & Uchiyama and the abovementioned information it looks as if there is as yet, no acceptable equation describing the length-weight relationship of longfin tuna which is generally applicable to longfin tuna. On the other hand, if the equations in the literature reflect the true length-weight relationships as found at the various centres, it indicates that there are a number of different sub-populations of longfin tuna which differ with reference to the length-weight relationships.

No attempt was made to age the various length groups in this survey or to determine the growth rate. Hamre (1963) gives a general account of the age problem in tuna. Bell, (1963) gives a preliminary age determination for bluefin tuna and Shomura (1966) discusses the age and growth of the Pacific Ocean populations of **T. alalunga, T. albacares, T. obesus** and **Katsuwonus pelamis.**

(iv) Seasonal variation.

From Table 2 and Figure 6 it is evident that there was a considerable variation in the number of tuna that were caught at the sampling stations during the different seasons. To make a comparison of data possible, all the catches are expressed as the number of fish caught by a hundred hooks in two hours time. During the period December to April, 1963, there were very few, May showed a sharp increase in numbers and the peak was reached in June. From July onwards there was a gradual decrease in numbers reaching a minimum in January, 1964. Bluefin, yellowfin and bigeye tuna were only caught in small numbers throughout the collecting period so that it is the longfin catches which give the pronounced seasonal fluctuation in the catch rate.

In the periods December to March of both the sampling years the catches were very low; in the two months May and June of both the sampling years the catches were relatively high. It looks therefore, as if the seasonal phenomenon is not due to a sampling error but that it is a regular variation in the catch rate. Du Plessis (1967) found in a subsequent study on the thermoclines occurring in the area that, during the summer months, the thermoclines are very shallow in the area; three to nine meters deep near the coast and increasing in depth away from the coast (250 miles off the coast the depth varies from 17 to 23 meters). During the winter months Du Plessis found that the seasonal thermoclines mostly disappeared due to wind action and a number of other factors. It is possible therefore, that the hooks were set to deep during the summer months and missed the tuna above the shallow thermoclines. On the other hand it must be taken into account that Du Plessis used a very small temperature gradient in his definition of a thermocline, while it must still be proved on the other hand, that tuna are sensitive to a gradient in the order of 0.1°C per meter.

Off the Cape West Coast, De Jager et al (1963) also found the summer months to constitute a poor tuna fishing season; bluefin was found to be plentiful during the winter months and longfin to be more abundant during autumn and spring. According to Idyll & de Sylva (1963), who are quoting two Japanese authors, Japanese longline catches of longfin in the Brazil Current were also best in winter and poorest in summer during 1958.

(v) Geographical variation.

During the preliminary investigation which took place while this survey was being planned, it became clear that no tuna occurred in the relatively cold water of the Benguela Current itself or in the warm oceanic water with surface temperatures above 22°C. Tuna were only caught in an area lying 60 to 200 miles offshore in the region of stations T1 and T2 and extending further westward to the region of stations T5 and T6 in other words, in the area where the cold Benguela Current water has mixed with the warm Atlantic Ocean water to produce water with a temperature around 17°C to 19°C. The question of temperature preferences will be discussed in a later section.

An inspection of the data in Tables 1, 2 and 12 will show that the catch rate is not the same for the different sampling stations and that there is a tendency for the southern stations, T1 and T2, to show a higher catch rate than the more northern stations such as T7 and T.8. If a null hypothesis is made and the significance of the observed differences is tested with a chi-square test, the chi-square value proves to be significant at the 5 percent significance level, (see table 13). There is, therefore, a significant locality difference for higher or lower catch rates. In this instance the southern stations yielded a much better catch rate than the northern stations.

TABLE 13.

North-South difference in tuna catch rates (all species).

Station	Observed number caught	Postulated number to be caught	
T1 + T2	75	58.25	(Chi-square = 8.426
T3 + T4	61	58.25	and with 3 degrees
T5 + T6	51	58.25	of freedom is signi-
T7 + T8	46	58.25	ficant at the 5 per cent level.)
Total	233	233	

Station TI and T8 lie on the same latitude as also T2 and T7, but they all differ in the distance they lie offshore. This latter fact will influence the temperature characteristics of the area.

Comparing the catch rates of Table 12 with those which were obtained by De Jager et al (1963) off the Cape West Coast, it becomes evident that tuna is more abundant in that area than off the South West African coast and this is especially true for bluefin tuna. Bluefin tuna, which at times are abundant off the Cape West Coast seldom occurred in the survey area off South West Africa and appears to be absent from the Equatorial West African coast. Off the South West African coast, no bluefin tuna were caught at the northern stations in the survey area.

According to Talbot & Penrith (1963), **T. thynnus thynnus** were collected off the Cape coast but De Jager et al (1963) obtained none during their survey. As yet no authenticated specimens have been collected off the South West African coast.

Skipjack **(Katsuwonus pelamis)** which is of commercial importance off the Equatorial West African coast have not been noted off the South West African coast during the survey and is apparently also absent off the Cape West Coast.

Yellowfin tuna which is of little importance off the Cape West Coast and the South West African coast supports a commercial fishery off Point Noire (Postel (1965) and Le Guen, Poinsard & Troadec (1935)). Apparently the yellowfin population is mainly centered off the Equatorial West African coast from where some individuals may move south, west of the cold Benguela Current in the boundary region between the Benguela and the warm oceanic water of the South Atlantic Ocean. They may perhaps move further south to go around the Cape into the warm Agulhus Current of the Western Indian Ocean. Idyll & de Sylva (1963) describe the geographical distribution of yellowfin tuna in the northern Atlantic Ocean.

The distribution of bigeye tuna along the West African coast of the Equator, does not show large variations within the area. Postel, (1965) reports bigeye in limited numbers off Point Noire while this survey showed them to be present off the South West African coast in small numbers. De Jager et al (1963) reported small catches of this species off the Cape West Coast.

Laevastu & Rosa (1963), illustrate a distribution pattern for **T. alalunga** of which the detail for the South West Atlantic agrees very nearly with what is now generally known as being the distribution of the species in the area. The work of Le Guen et al (1965) and Postel (1965) shows that longfin tuna is mainly absent off the Point Noire coast. This survey shows that longfin tuna is fairly abundant off the South West African coast and from the work of De Jager et al (1963) it is apparent that longfin tuna is still present in limited numbers off the Cape West Coast. Laevastu & Rosa's diagram illustrating the distribution must be modified in that longfin tuna are not caught right up to the shore line of South West Africa but only in a boundary region between the Benguela Current and oceanic water of the South Atlantic, at least 60 miles offshore during the summer months and further westward during the winter months.

(vi) Catch rates.

The catch rates of the four tuna species that were encountered in this survey are shown in Table 12. In the interpretation of the catch rate data it must be taken into account that the rates reflect the monthly catches at certain places in the sea which have been selected for a particular longtitude and latitude. They do not reflect the catches which a commercially operating vessel might possibly obtain in the area. A vessel operating commercially, will first of all locate the tuna schools present in the area and will then follow the schools as far as it is practical to do so. In the survey the longline gear was set monthly at the positions corresponding to stations T1 to T8, as mentioned earlier, irrespective of whether there were tuna in the vicinity or not. As a result the observed catch rates will therefore be lower than that which a commercial longliner could have obtained in the area.

The catch rates, which De Jager et al (1963) obtained off the Cape West Coast with comparable methods are much higher than those which were realised off the South West African coast. In the Cape waters the big bluefin tuna constitute the main portion of the catch but in the South West African waters the smaller longfin tuna make up the bulk of the catch. Consequently the weight of tuna yielded off the Cape coast is much higher. Welsh (1968) gives an indication of the size of the commercial catches that have recently been made off the Cape West Coast.

It is also interesting to note that, although 191 longfin were caught against only 56 bigeye tuna, the latter species yielded a higher weight of fish, 6,530 lb. against the 5,616 lb. of the longfin tuna.

The catch rates which have been realised at the southern stations in this survey, the fact that the tuna occur in a welldefined area and also the frequent visits of foreign longliners to the area all suggest that it might be worthwhile for a commercial firm, which has suitable markets, to explore the possibilities of fishing the area commercially.

(vii) Temperature preferences.

In Table 14 the temperature data which have been collected during the survey, are given. In Figures 7 and 8 the variations at stations T1 and T8 have been graphically illustrated for the surface and 50 m. level.

During the initial survey, September, 1961 to August, 1962, it was soon realised that in the sea area between the Orange River and Cunene River, no tuna occurred in the cold Benguela Current or in the very warm oceanic water of the South Atlantic. All the tuna that were hooked, occurred in a mixed boundary layer between the Benguela water and the oceanic water. It was clear that the tuna avoided the 10°C to 14°C temperatures commonly found in the Benguela Current, although the current is characterized by its abundance in pelagic fish and other sea life and could provide the tuna with ample food. Whether the tuna avoided the 22°C and warmer oceanic water because of its lack of food or because the temperature was unacceptable, is not clear.

In Table 14, which shows the seasonal variation in water temperatures and catch rates that were measured during the survey, only the surface and 50 m temperatures are shown. The gear was set to fish at a level of 30 to 35 fathoms (55 m-65 m). It was assumed that the temperatures at this level would be the most suitable for preference studies and these are therefore recorded in the Table. There is mostly a definite relationship between the 50 meter level temperature and the surface temperature and the latter temperature is therefore also shown. It is the temperature which fishermen can most easily measure and which is most widely used by research workers.

In Table 15 an indication is given of the number of times a certain temperature was measured and the number of tuna that were caught. The data from this Table indicate that most longfin and bigeye tuna were caught at a surface temperature range of 16°C to 20°C and 14°C to 18°C at the 50 m level. The contents of Table 15 must be interpreted with caution because, although the number of tuna caught at the low and high temperature ranges are few, these temperatures were also infrequently measured. In compiling the data of Table 16 an attempt was made to avoid the possible effects of seasonal availability and fishing effort on the temperature preference data. Because of the low catch rates of the other species only calculations for longfin are shown. It is evident from Table 16 that the temperature preference range for longfin tuna is 16°C to 19°C at the surface and 14°C to 18°C at the 50 meter level during June. During the survey longfin and bigeye tuna were caught in temperatures ranging from 15°C to 22°C at the surface and from 14°C to 21°C at the 50 meter level.

De Jager et al (1963) found longfin tuna to prefer a surface temperature range of 17°C to 19°C off the Cape West coast and to occur within the range of 15°C to 23°C. For bigeye the corresponding temperatures were found to be 18°C to 19°C and 16°C to 21°C respectively.

Very few yellowfin and bluefin tuna were caught during the survey and it is therefore not desirable to predict temperature preferences for these species on this data. De Jager et al found that bluefin tuna occurred when the temperature of the surface water fell within the range 15°C to 20°C and apparently preferred a temperature range of 16°C to 17°C. For yellowfin the ranges were found to be 17°C to 21°C and 20°C to 21°C respectively.

Taking into consideration the world-wide distribution of tuna species, Laevastu & Rosa (1963), consider longfin tuna to have a temperature distribution range of 14°C to 23°C and what they call a "fishery optimum temperature range" of 17°C to 19°C. The latter temperature is comparable to the 16°C to 19°C preference range indicated by the data of Table 16. Laevastu and Rosa also give similar temperature ranges for the other species of importance in this survey, viz:

	Distribution temperature Range	Fishery Optimum temperature Range
Bluefin	14°C to 21°C	18°C to 20°C
Bigeye	11°C to 28°C	—
Yellowfin	17°C to 31°C	21°C to 24°C
Longfin	14°C to 23°C	17°C to 19°C

The data in Table 15 shows that the temperatures measured during the survey all fall within the distribution temperature ranges of bigeye, longfin and bluefin tuna but, that on numerous occasions the water was too cold to expect yellowfin tuna in it. The high temperatures preferred by yellowfin tuna were infrequently measured in the area. For example, at station T8 the preferred minimum temperature was only measured on two occasions during the whole survey and this is perhaps an important reason why yellowfin was never caught at the station.

It must be taken into consideration that tuna move about in schools and are not evenly distributed throughout the area which they inhabit. If the temperature in a particular area is favourable for the presence of the fish, it does not necessarily mean that the fish must be at that particular place when sampling occurs. In the discussion that follows, temperatures falling in the fishery optimum temperature range of Laevastu and Rosa will be referred to as favourable or preferred temperatures. At station T8 the temperatures were favourable for longfin tuna for 11 months during the survey period but the fish were caught only in four out of the eleven months. At station T1 the temperatures were favourable for longfin tuna for eight months of the survey period but the fish were only caught in six of these months. It was found on the other hand that if the temperature at a particular sampling station was below the minimum of the preference range of a particular tuna species it was unlikely that the fish would be caught. At station T8 the temperatures did not fall in the longfin tuna preference range of 17°C to 19°C for eight months of the survey period (see Figure 7), and in none of these months were any longfin hooked. At station T1 the temperatures were not in the longfin preference range for 10 months of the sampling period. In six of these months no tuna were hooked at all, in three of the months very low catches were made. During August, 1963, a high catch rate for longfin was obtained at station T1, although the surface water temperature was very low. Figures 7 and 8 will show, however, that conditions were abnormal at the station during this month; temperatures were practically homothermal down to the 50 meters level. It would seem advisable therefore, for vessels fishing for tuna in the area, to avoid areas where the temperatures differed markedly from the preference ranges mentioned above, especially as far as low temperatures are concerned.

(viii) Sex ratio and reproduction.

The developmental stage of the gonads were classified according to a maturity scale in which five classifications are recognised, namely: (a) inactive, (b) active, (c) ripe, (d) ripe and running, (e) spent. The terms are selfexplanatory and were used in their normal biological sense.

Of the male longfin tunas examined most showed inactive gonads, very few had gonads indicating any maturing activity at all and none had ripe gonads (see Table 5). A few of the females in the 96 to 100 cm. length group had ripe gonads, but most of the other length groups had inactive gonads. No longfin tuna with ripe and running or spent gonads were caught and it is therefore unlikely that they reproduce in the survey area.

Some of the larger bigeye females had developing gonads, but the majority had inactive gonads. Again this can be interpreted as a sign that the bigeye tuna do not spawn in the survey area.

Very few yellowfin and bluefin tuna were caught and, therefore, no worthwhile deductions can be made about the reproductive cycle of these species in the survey area. The data in Tables 8 to 11 do, however, suggest that they do not reproduce in the survey area.

In Table 1, an indication is given of the numbers of the two sexes of the four species that were caught. The apparent big difference between the number of male and female longfin tuna that were caught, may lead one to suspect that there are normally more males in the natural population than females. With the aid of the chi-square test it can, however, be shown that the difference in observed numbers is probably due to chance. Off the Cape West Coast De Jager et al (1963) caught 96 males against only 48 females in a survey. This is a considerable difference and suggests that there is normally not a 1:1 sex ratio in the population. With more information this question will probably clarify itself.

If an assumption of equal occurrence of the two sexes is made for the other three species that were encountered in this survey, it is highly probable that the observed frequencies fall within the normal variation of an equal occurrence ratio. More information is, however, required to make a reliable estimate of the sex ratio's of the species.

(ix) Food.

In Table 17 data is given on the type and quantity of food organisms that were found in the tuna stomachs. A very wide variety of food organisms was found to be included in the diets of the four species and unusual items such as potatopeels and carrot slices also appeared.

Fish, squids and Decapod Crustacea were found to be the main food items, in order of importance, of longfin tuna. The remains of eight fish species were often found in the stomach contents of longfin tuna viz:

Maasbanker — **Trachurus trachurus;**
Mackerel — **Scomber japonicus;**
Needle fish — Hemirhamphidae spp.;
Flying fish — Exocoetidue spp.;
Latern fish — Myctophidae spp.;
Angel fish — **Brama raii**
Pilchard — **Sardinops ocellata** and
Anchovy — Engraulidae spp.

Talbot and Penrith (1963) also found that the two major foods of **T. alalunga** are fish and squids.

The most important food organism in the diet of bigeye, bluefin and yellowfin tuna in the survey area was clearly fish; various species of squid were second in importance but formed only a small portion of the total weight of food that was eaten.

Sharks are most probably the main competitors for food in the area, especially the blue shark **(Glyphis glaucus)**, of which 78 were caught during the survey. In order of numerical importance the sharks that were caught are the following:

Blue shark — **Glyphis glaucus,**
Mako shark — **Isurus glaucus**
Thresher shark — **Alopuis vulpinus**
Hammer head shark — **Sphyrna zygaena**

The following teleosts were often hooked on the longline gear:

Thyrsites atun,
Brama raii,
Alepisaurus ferox,
Lampris regius and
Mola sp.

A few plankton hauls were made at the survey stations during the months April, May and June, 1964. The results are shown in Table 18. There is a slight tendency for bigger plankton volumes appearing concurrently with bigger catch rates. These few results show that it would be worthwhile investigating the correlation between tuna catch rates and the plankton volumes at the site of fishing.

(x)Morphometric characteristics.

The normal method of identifying a species or of distinguishing subpopulations in fisheries research is by making use of series of meristic counts and morphometric characteristics. In an earlier paragraph mention was made of the difficulties encountered when comparing meristic counts of South West African bluefin tuna with those observed in other parts of the world. Virtually the same applies to the longfin. The result is that we are not only very doubtful about the correct identification of our bluefin, as Tiews (1963) also found in the case of the South African bluefin, but to a certain extent we are also doubtful about the identification of our longfin. Unfortunately, we only obtained 14 bluefin during the period of investigation but we caught an appreciable number of longfin which should have enabled us to correct mistakes which may have occurred, bringing it nearer to the accepted limits. The characteristics for the yellowfin and big-eye, however, fall more or less within the normal limits measured in other parts of the Atlantic.

Normally it should be possible to use the morphometric characteristics not only to identify a species but also to attach it to a subpopulation, should there be more than one in the area of investigation. Many writers use morphometric data in the form of ratios of one dimension to the other but it is doubtful whether this form of presentation is of much value. It is an artificial concept and possibly influenced by the differential growth rate of different parts of the body.

Other writers advocated that the body proportions be expressed as the regression of one dimension on another. However, this is only of value in the specific species if we accept or prove that different parts of the body grow at different rates. Frade has shown this to be the case with **Thunnus thynnus** in the N. E. Atlantic but this could have been a regional occurrence, although Schaefer also proved this to be the same for **Neothunnus macropterus.**

To obviate arguments, we have decided to publish only the original measurements from which readers may then either calculate regressions or ratios. Tables 19-22 illustrate the measurements of all the bluefin and yellowfin caught but, for practical reasons, only some of the measurements of longfin and big-eye are given.

Calculations made here indicate that, when various body proportions are expressed either as regression coefficients or as ratios of one dimension on another, there is very little variation between these expressions in different fish of the same species. In fact, both the ratio and regression coefficient between total length and head length differ very little between the four tuna species investigated. Data received from the Division of Sea Fisheries in the Republic collected during a similar programme covering the four species, also indicated a similarity between individuals of one species and between species in as far as the proportion between total length and head length is concerned. Some of the other proportions (between species) obviously differ appreciably.

We found that it was often exceedingly difficult to use morphometric characteristics when trying to identify smaller specimens. Unfortunately, meristic counts did not assist appreciably and we repeatedly found cases where it was almost impossible to decide between certain species. With larger fish these problems were decreased but it still indicates that morphometric characteristics and meristic counts can only be regarded as limited aids under certain conditions.

6. SUMMARY.

Four tuna species of which longfin is numerically most important, occur off the South West African coast and in numbers which show a marked seasonal fluctuation. All four species have been found in the boundary region between the Benguela Current and the oceanic water of the South East Atlantic Ocean.

In the vicinity of the 22°S latitude catch rates were low but in the region of the 24°S latitude it appears to be high enough to invite commercial exploitation.

Water temperature appears to play a major role in the habitat preferences of the tuna and with due regard to this fact, the yield of tuna in the vicinity of stations T1 and T2 may probably increase considerably and probably to such an extent as to make the exploitation of the resource very profitable.

The meristic characteristics of the bluefin tuna occurring in the area, especially the gill-raker counts, show a variation in range which differ from the range normally accepted by taxonomists.

Off the Cape West Coast investigators found the sex ratio of longfin tuna to be 6 males: 4 females, but the ratio in the S. W. African waters appears to be a 1:1 ratio with the observed differences probably due to chance factors. None of the four species appear to spawn in the surveyed area.

Fish and squids were found to be the main organisms in the diets of the tuna that were caught during the survey and should be used as bait in longlining for the fish.

7. ACKNOWLEDGEMENTS.

The authors wish to say thank you to the officers and crew of the two research vessels

Kuiseb and Namib II who did the fishing part of the work.

To all our colleagues, especially Mr. F. H. Schülein, at the Marine Research Laboratory of the South West African Administration, who helped in one way or another to make this survey and its publication possible, we extend our sincere thanks.

8. REFERENCES CITED.

BELL, R. R. — 1963. Preliminary age determination of bluefin tuna, **Thunnus thynnus.** California Fish and Game **49** (4): 307.

BODEN, B. P. — 1955. Euphausiacea of the Benguela Current Discovery Reports XXVII: 337 — 376.

DE JAGER, B. VAN D., DE V. NEPGEN, C. S. and VAN WYK, R. J. — 1963. A preliminary report on South African West Coast tuna. Investl. Rep. Div. Sea Fish. S. Africa No. 47.

DU PLESSIS, E. — 1967. Seasonal occurrence of thermoclines off Walvis Bay, South West Africa, 1959 — 1965. Administration of South West Africa Marine Research Laboratory, Investigational Report No. 13.

GIBBS, R. H. & COLLETTE, B. B. — 1967. Comparative anatomy and systematics of the tunas, genus **Thunnus** U. S. Fish and Wildlife Service Fishery Bulletin **66** (1): 65 — 130.

HAMRE, J. — 1963. Size and composition of tuna stocks. Proceedings of the World Scientific Meeting on the Biology of Tunas and related species. F.A.O. Fisheries Reports No. 6 Vol. 3: 1023 — 1039.

HART, T. J. & CURRIE, R. I. — 1960. The Benguela Current. Discovery Reports **31:** 123 — 298.

IDYLL, C. P. & DE SYLVA, D. — 1963. Synopsis of biological data on yellowfin tuna **Thunnus albacares** (Bonnaterre) 1788 (Western Atlantic). Proceedings of the World Scientific meeting on the Biology of Tunas and related species. F.A.O. Fisheries Reports No. 6, Vol. 2: 778 — 781.

LAEVASTU, T. & ROSA, H. — 1963. Distribution and relative abundance of tunas in relation to their environment. Proceedings of the World Scientific Meeting on the Biology of Tunas and related species. F.A.O. Fisheries Reports No. 6, Vol. 3: 1835 — 1851.

LE GUEN, J. C., POINSARD, F. & TROADEC, J. P. — 1965. The yellowfin Tuna Fishery in the Eastern Tropical Atlantic Commercial Fisheries Review 27 (8): 7—18.

MARR, J. C. & SCHAEFER, M. B. 1949. Definitions of body dimensions used in describing tunas. U. S. Department of the Interior, Fish and Wildlife Service Fishery Bulletin No. 47.

MATHER, F. J. — 1963. Tunas (Genus **Thunnus**) of the Western North Atlantic. Part 2. Description, Comparison and Identification of species **Thunnus** based on External Characters. Woods Hole Oceanographic Institution Collected Reprints 1964, Part 1, Contribution 1257.

NAKAMURA, E. L. & UCHIYAMA, J. H. — 1966. Length — weight relations of Pacific Tunas. Proceedings of the Governors' Conference on Central Pacific Fishery Resources, State of Hawaii, November, 1966. pp. 197 — 202.

POSTEL, E. — 1965. Les thoniers congélateurs francais dans l'Atlantique Africain. Cahiers O.R.S.T.O.M. Océanographie **3** (2): 19 — 62.

SHOMURA, R. S. — 1966. Age and growth studies of four species of Tunas. Proceedings of the Governor's Conference on Central Pacific Fishery Resources. State of Hawaii, November, 1966. pp. 203 — 220.

SMITH, J. L. B. — 1949. The Sea Fishes of Southern Africa. Central News Agency, Ltd. S. Africa.

STANDER, G. H. — 1964. The Benguela Current off South West Africa. Administration of South West Africa Marine Research Laboratory, Investigational Report No. 12.

TALBOT, F. H. & PENRITH, M. J. — 1963. Synopsis of biological data on bluefin tuna **Thunnus thynnus** (Linnaeus) 1958 (Atlantic and Mediterranean). Proceedings of the World Scientific meeting on the Biology of Tunas and Related Species. F.A.O. Fisheries Reports No. 6, Vol. 2: 422 — 481.

UNTERÜBERBACHER, H. K. — 1964. Zooplankton studies in the waters off Walvis Bay with special reference to the Copepoda. Administration of South West Africa, Marine Research Laboratory Investigational Report No. II

WELSCH, J. G. — 1968. A new approach to research on tuna in South African waters. Fish. Bull. S. Afr. 5: 32 — 34.

Table 1 NUMBER OF TUNA CAUGHT AT THE SAMPLING STATIONS

	LONGFIN			BIGEYE			YELLOWFIN			BLUEFIN			
Station	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Total
T 1	25	11	36	1	7	8	0	3	3	0	1	1	48
T 2	22	13	35	3	4	7	1	0	1	0	1	1	44
T 3	18	16	34	2	0	2	2	3	5	0	2	2	43
T 4	4	6	10	5	5	10	0	0	0	2	3	5	25
T 5	10	9	19	1	1	2	6	2	8	1	2	3	32
T 6	13	16	29	3	1	4	0	0	0	2	0	2	35
T 7	9	11	20	8	5	13	5	1	6	0	0	0	39
T 8	6	2	8	7	3	10	0	0	0	0	0	0	18
Total	107	84	191	30	26	56	14	9	23	5	9	14	284

Table 2 TUNA SPECIES CAUGHT AT THE DIFFERENT STATIONS

Station		T 1				T 2				T 3				T 4			
		Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin
1962	Dec.	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0
1963	Jan.	5	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	Feb.	8	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0
	Mar.	3	0	0	0	2	0	0	0	2	0	0	0	0	0	0	3
	Apr.	6	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0
	May	4	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
	Jun.	1	0	0	0	3	0	0	0	14	0	0	0	7	0	0	0
	Jul.	0	0	0	0	3	0	0	1	2	0	0	0	2	0	0	0
	Aug.	3	1	0	0	1	0	0	0	1	1	0	0	0	4	0	2
	Sept.	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0
	Oct.	2	1	0	0	1	2	0	0	1	0	0	0	0	0	0	0
	Nov.	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1963	Dec.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
1964	Jan.	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0
	Feb.	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0
	Mar.	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0
	Apr.	–	–	–	–	–	–	–	–	0	0	0	0	0	0	0	0
	May.	2	1	0	0	8	0	0	0	3	0	0	0	0	0	0	0
1964	Jun.	0	0	0	0	4	3	0	0	5	1	0	0	1	0	0	0
	Total	36	8	3	1	35	7	1	1	34	2	5	2	10	10	0	5

Station		T 5				T 6				T 7				T 8			
		Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin	Longfin	Bigeye	Yellowfin	Bluefin
1962	Dec.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	Jan.	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	Feb.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mar.	1	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0
	Apr.	0	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0
	May	3	1	7	1	6	0	0	0	0	0	6	0	0	0	0	0
	Jun.	4	0	0	0	2	0	0	0	4	0	0	0	1	0	0	0
	Jul.	0	0	0	1	4	0	0	2	0	0	0	0	2	4	0	0
	Aug.	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	Sept.	2	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0
	Oct.	0	0	0	0	1	1	0	0	0	5	0	0	0	0	0	0
	Nov.	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1963	Dec.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	Jan.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Feb.	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0
	Mar.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	5	0	0	0	2	0	0	0	3	0	0	0	2	0	0	0
	May.	1	0	0	0	2	0	0	0	3	3	0	0	0	2	0	0
1964	Jun.	0	0	0	0	8	3	0	0	3	0	0	0	3	1	0	0
	Total	19	2	8	3	29	4	0	2	20	13	6	0	8	10	0	0

– No information available.

Table 3

AVERAGE WEIGHTS OF TUNA CAUGHT

Date	LONGFIN TUNA Males Number caught	LONGFIN TUNA Males Average weight	LONGFIN TUNA Females Number caught	LONGFIN TUNA Females Average weight	LONGFIN TUNA Total number caught	BIGEYE TUNA Males Number caught	BIGEYE TUNA Males Average weight	BIGEYE TUNA Females Number caught	BIGEYE TUNA Females Average weight	BIGEYE TUNA Total number caught	YELLOWFIN TUNA Males Number caught	YELLOWFIN TUNA Males Average weight	YELLOWFIN TUNA Females Number caught	YELLOWFIN TUNA Females Average weight	YELLOWFIN TUNA Total number caught	BLUEFIN TUNA Males Number caught	BLUEFIN TUNA Males Average weight	BLUEFIN TUNA Females Number caught	BLUEFIN TUNA Females Average weight	BLUEFIN TUNA Total number caught	Total Number all Tuna Species
1962 Dec	0	—	0	—	0	2	130	3	126	5	0	—	0	—	0	0	—	0	—	0	5
1963 Jan.	3	22	4	23	7	1	85	1	84	2	1	42	3	75	4	0	—	0	—	0	13
Feb.	6	31	3	26	9	0	—	1	172	1	0	—	1	100	1	0	—	1	355	1	12
Mar.	5	24	4	25	9	1	98	2	87	3	0	—	0	—	0	1	208	2	104	3	15
Apr.	7	23	4	27	11	1	165	1	120	2	0	—	0	—	0	1	300	0	—	1	14
May	13	26	4	35	17	0	—	2	159	2	11	76	2	76	13	0	—	2	247	2	34
Jun.	18	24	18	26	36	0	—	0	—	0	0	—	0	—	0	0	—	0	—	0	36
Jul.	8	21	5	27	13	3	162	1	188	4	0	—	0	—	0	2	205	2	119	4	21
Aug.	4	36	3	28	7	4	116	2	126	6	0	—	0	—	0	1	188	1	140	2	15
Sep.	7	30	4	31	11	1	68	0	—	1	0	—	0	—	0	0	—	0	—	0	12
Oct.	4	22	1	25	5	6	85	3	91	9	0	—	0	—	0	0	—	0	—	0	14
Nov.	1	28	3	29	4	1	100	0	—	1	0	—	0	—	0	0	—	0	—	0	5
1963 Dec.	0	—	1	30	1	1	138	1	158	2	0	—	0	—	0	0	—	0	—	0	3
1964 Jan.	1	36	1	28	2	0	—	0	—	0	0	—	1	116	1	0	—	0	—	0	3
Feb.	3	27	0	—	3	1	140	2	84	3	0	—	1	138	1	0	—	1	218	1	8
Mar.	1	40	0	—	1	0	—	1	110	1	2	109	1	44	3	0	—	0	—	0	5
* Apr.	6	37	6	38	12	0	—	0	—	0	0	—	0	—	0	0	—	0	—	0	12
May	9	39	10	36	19	4	145	2	140	6	0	—	0	—	0	0	—	0	—	0	25
Jun.	11	37	13	35	24	4	81	4	108	8	0	—	0	—	0	0	—	0	—	0	32
Total	107	—	84	—	191	30	—	26	—	56	14	—	9	—	23	5	—	9	—	14	284

Biggest Longfin	48 lb.	Biggest Bigeye	212 lb.	Biggest Yellowfin	138 lb.	Biggest Bluefin	355 lb.
Smallest Longfin	10 lb.	Smallest Bigeye	28 lb.	Smallest Yellowfin	42 lb.	Smallest Bluefin	78 lb.
Average weight Longfin	29 lb.	Avevare weight Bigeye	117 lb.	Average weight Yellowfin	81 lb.	Average weight Bluefin	197 lb.

Weight caught — Longfin 5,616 lb.
— Bigeye 6,530 lb.
— Yellowfin 1,866 lb.
— Bluefin 2,759 lb.

16,771 lb. for 384 hours fishing time.

* In April, 1964 no sampling could be done at Stations T1 and T2.

Table 4

CHARACTERISTICS LONGFIN — TUNA MALES, 95 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 66 — 70 cm. length group, 3 investigated										
3	7	3	7	3	14	3	28	100	—	—
B. 71 — 75 cm. length group, 6 investigated										
2	7	4	7	2	13	2	27	100	—	—
4	8	2	8	4	14	2	28			
						1	29			
C. 76 — 80 cm. length group, 16 investigated										
3	7	9	7	2	13	1	25	100	—	—
11	8	6	8	14	14	5	27			
2	9	1	9			8	28			
						1	29			
						1	30			
D. 81 — 85 cm. length group, 23 investigated										
6	7	1	6	5	13	2	26	94.4	5.6	—
16	8	11	7	18	14	2	27			
1	9	11	8			8	28			
						6	29			
						2	30			
						3	31			
E. 86 — 90 cm. length group, 33 investigated										
15	7	1	6	7	13	1	26	75	25	—
15	8	19	7	26	14	5	27			
3	9	12	8			10	28			
		1	9			9	29			
						7	30			
						1	31			
F. 91 — 95 cm. length group, 12 investigated										
3	7	1	6	1	13	3	27	90	10	—
8	8	7	7	11	14	3	28			
1	9	3	8			5	29			
		1	9			1	30			
G. 96 — 100 cm. length group, 1 investigated										
1	9	1	9	1	14	1	29	100	—	—
H. 101 — 105 cm. ength group, 1 investigated										
1	9	1	8	1	14	1	28	100	—	—

Table 5

CHARACTERISTICS LONGFIN — TUNA FEMALES, 83 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 71 — 75 cm. length group, 1 investigated										
1	7	1	7	1	9	1	30	100	—	—
B. 76 — 80 cm. length group, 17 investigated										
4	7	9	7	4	13	4	27	100	—	—
10	8	8	8	13	14	5	28			
3	9					5	29			
						3	30			
C. 81 — 85 cm. length group, 24 investigated										
13	7	16	7	1	10	3	26	81.8	18.2	—
10	8	7	8	9	13	2	27			
1	10	1	9	14	14	7	28			
						6	29			
						6	30			
D. 86 — 90 cm. length group, 22 investigated										
12	7	19	7	5	13	1	27	50	50	—
9	8	2	8	17	14	12	28			
1	9	1	9			8	29			
						1	30			
E. 91 — 95 cm. length group, 12 investigated										
4	7	7	7	1	13	5	27	37.5	62.5	—
6	8	3	8	11	14	4	28			
2	9	2	9			2	29			
						1	30			
F. 96 — 100 cm. length group, 7 investigated										
3	7	5	7	3	13	2	27	14.3	42.8	42.8
4	8	2	8	4	14	3	28			
						1	29			
						1	30			

Table 6

CHARACTERISTICS BIGEYE — TUNA MALES, 29 INVESTIGATED

Dorsal Finlets: Number of Tuna	Dorsal Finlets: Number of Finlets	Anal Finlets: Number of Tuna	Anal Finlets: Number of Finlets	First Dorsal Spines: Number of Tuna	First Dorsal Spines: Number of Spines	Gill-rakers: Number of Tuna	Gill-rakers: Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 85 — 90 cm. length group, 1 investigated										
1	9	1	8	1	14	1	26	100	—	—
B. 101 — 105 cm. length group, 3 investigated										
3	9	1	8	1	13	2	28	100	—	—
		2	9	2	14	1	29			
C. 106 — 110 cm. length group, 1 investigated										
1	9	1	9	1	13	1	27	100	—	—
D. 111 — 115 cm. length group, 1 investigated										
1	9	1	9	1	14	1	23	100	—	—
E. 116 — 120 cm. length group, 2 investigated										
2	9	1	8	1	13	2	27	100	—	—
		1	9	1	14					
F. 121 — 125 cm. length group, 2 investigated										
2	8	2	8	1	13	1	27	100	—	—
				1	14	1	28			
G. 126 — 130 cm. length group, 2 investigated										
2	8	1	7	2	14	1	26	100	—	—
		1	8			1	28			
H. 131 — 135 cm. length group, 1 investigated										
1	9	1	8	1	14	1	28	100	—	—
I. 136 — 140 cm. length group, 1 investigated										
1	8	3	8	3	13	1	27	50	50	—
4	9	2	9	3	14	2	28			
1	10	1	10			3	29			
J. 141 — 145 cm. length group, 1 investigated										
1	8	1	7	1	14	1	27	100	—	—
K. 151 — 155 cm. length group, 3 investigated										
3	8	1	7	3	14	2	27			
	1	8				1	28	66	33	—
	1	9								
L. 156 — 160 cm. length group, 4 investigated										
1	8	1	7	1	13	4	28	50	50	—
3	9	1	8	3	14					
		2	9							
M. 161 — 165 cm. length group, 1 investigated										
1	8	1	8	1	14	1	28	100	—	—
N. 181 — 185 cm. length group, 1 investigated										
1	8	1	8	1	14	1	26	100	—	—

Table 7

CHARACTERISTICS BIGEYE — TUNA FEMALES, 25 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 81 — 85 cm. length group, 1 investigated										
1	9	1	9	1	14	1	29	100	—	—
B. 91 — 95 cm. length group, 1 investigated										
1	8	1	8	1	13	1	29	100	—	—
C. 106 — 110 cm. length group, 1 investigated										
1	8	1	8	1	14	1	27	100	—	—
D. 116 — 120 cm. length group, 1 investigated										
1	8	1	7	1	14	1	27	100	—	—
E. 121 — 125 cm. length group, 2 investigated										
1	9	2	9	2	14	1	29	50	50	—
1	10					1	30			
F. 126 — 130 cm. length group, 4 investigated										
1	7	3	8	4	14	1	25	50	50	—
1	8	1	9			1	26			
2	9					1	27			
						1	28			
G. 131 — 135 cm. length group, 2 investigated										
1	9	1	9	1	13	2	29	50	50	—
1	10	1	10	1	14					
H. 136 — 140 cm. length group, 4 investigated										
1	7	1	8	2	13	2	26	75	25	—
3	9	3	9	2	14	1	27			
						1	28			
I. 141 — 145 cm. length group, 1 investigated										
1	9	1	8	1	14	1	28	100	—	—
J. 146 — 150 cm. length group, 1 investigated										
1	8	1	8	1	14	1	27	—	100	—
K. 151 — 155 cm. length group, 4 investigated										
2	8	1	7			1	26	50	50	—
2	9	2	8	2	13	1	27			
		1	9	2	14	1	28			
						1	31			
L. 156 — 160 cm. length group, 2 investigated										
1	8	1	8	1	13	1	26	—	100	—
1	9	1	9	1	14	1	29			
M. 161 — 165 cm. length group, 1 investigated										
1	9	1	8	1	14	1	30	—	100	—

Table 8

CHARACTERISTICS YELLOWFIN — TUNA MALES, 12 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 106 — 110 cm. length group, 1 investigated										
1	9	1	9	1	13	1	30	100	—	—
B. 121 — 125 cm. length group, 3 investigated										
3	8	2	8	3	14	1	30	100	—	—
	1	9				1	31			
						1	32			
C. 126 — 130 cm. length group, 5 investigated										
5	8	2	8	1	13	1	28	100	—	—
		3	9	4	14	1	30			
						2	31			
						1	32			
D. 131 — 135 cm. length group, 3 investigated										
2	8	1	8	1	13	1	28	100	—	—
1	9	2	9	2	14	1	29			
						1	30			

Table 9

CHARACTERISTICS YELLOWFIN — TUNA FEMALES, 9 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
A. 95 — 100 cm. length group, 1 investigated										
1	7	1	7	1	13	1	29	100	—	—
B. 106 — 110 cm. length group, 1 investigated										
1	10	1	10	1	14	1	30	100	—	—
C. 111 — 115 cm. length group, 1 investigated										
1	11	1	10	1	12	1	32	100	—	—
D. 126 — 130 cm. length group, 2 investigated										
2	8	1	8	1	13	1	30	50	50	—
		1	9	1	14	1	32			
E. 131 — 135 cm. length group, 1 investigated										
1	9	1	9	1	14	1	32	—	100	—
F. 136 — 140 cm. length group, 2 investigated										
2	9	1	8	1	13	1	31	50	50	—
		1	10	1	14	1	32			
G. 141 — 145 cm. length group, 1 investigated										
1	9	1	8	1	14	1	30	—	100	—

Table 10

CHARACTERISTICS BLUEFIN — TUNA MALES, 5 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
			A. 151 — 155 cm. length group, 1 investigated							
1	9	1	9	1	13	1	33	—	—	100
			B. 161 — 165 cm. length group, 2 investigated							
2	9	1	8	1	13	1	34	—	100	—
		1	9	1	14	1	35			
			C. 166 — 170 cm. length group, 1 investigated							
1	9	1	8	1	13	1	28	—	100	—
			D. 221 — 225 cm. length group, 1 investigated							
1	10	1	9	1	14	1	38	—	100	—

Table 11

CHARACTERISTICS BLUEFIN — TUNA FEMALES, 9 INVESTIGATED

Dorsal Finlets		Anal Finlets		First Dorsal Spines		Gill-rakers				
Number of Tuna	Number of Finlets	Number of Tuna	Number of Finlets	Number of Tuna	Number of Spines	Number of Tuna	Number of G. Rakers	% Inactive Gonads	% Active Gonads	% Ripe Gonads
			A. 116 — 120 cm. length group, 1 investigated							
1	8	1	8	1	14	1	28	100	—	—
			B. 126 — 130 cm. length group, 1 investigated							
1	9	1	8	1	14	1	28	—	100	—
			C. 131 — 135 cm. length group, 1 investigated							
1	9	1	8	1	14	1	29	—	100	—
			D. 146 — 150 cm. length group, 1 investigated							
1	9	1	9	1	14	1	34	—	100	—
			E. 151 — 155 cm. length group, 1 investigated							
1	9	1	9	1	14	1	34	—	100	—
			F. 156 — 160 cm. length group, 1 investigated							
1	9	1	8	1	13	1	34	—	100	—
			G. 161 — 165 cm. length group, 1 investigated							
1	8	1	8	1	13	1	37	—	100	—
			H. 206 — 210 cm. length group, 1 investigated							
1	10	1	8	1	13	1	38	—	100	—
			I. 216 — 220 cm. length group, 1 investigated							
1	9	1	8	1	13	1	39	—	100	—

Table 12

TUNA CATCH RATES

STATION	T 1			T 2			T 3			T 4			T 5			T 6			T 7			T 8				
DATE	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	Sampling Time — Minutes	Num. Fish caught with 50 hooks	Num. Fish caught with 50 hooks — 2 hours	ALL STATION TOTAL	Num. Fish caught with 100 hooks per 2 hours
1962 DEC.	195	2	1.23	195	0	0	180	0	0	180	3	2.00	180	0	0	180	0	0	180	0	0	180	0	0	5	0.81
JAN.	165	5	3.24	170	0	0	200	4	2.40	190	0	0	150	0	0	180	2	1.33	180	2	1.33	180	0	0	13	2.08
FEB.	180	10	6.67	255	0	0	195	2	1.23	210	0	0	200	4	0	190	0	0	180	0	0	180	0	0	12	1.98
MAR.	195	3	1.85	180	2	1.33	180	2	1.33	180	3	2.00	180	1	0.67	180	0	0	180	3	2.00	165	1	0.73	15	2.48
APR.	160	6	4.50	170	1	0.71	180	3	2.00	85	0	0	180	2	1.33	155	0	0	150	2	1.60	180	0	0	14	2.54
MAY	180	5	3.33	180	4	2.67	165	1	0.73	210	0	0	180	12	8.00	180	6	4.00	200	6	3.60	180	0	0	34	5.58
JUN.	120	1	1.00	120	3	3.00	120	14	14.00	120	7	7.00	120	4	4.00	120	2	2.00	120	4	4.00	120	1	1.00	36	9.00
JUL.	120	0	0	120	4	4.00	120	2	2.00	120	2	2.00	120	1	1.00	120	6	6.00	120	0	0	120	6	6.00	21	5.25
AUG.	120	4	4.00	120	1	1.00	120	2	2.00	120	6	6.00	120	0	0	120	0	0	120	2	2.00	120	0	0	15	3.75
SEPT.	120	0	0	120	7	7.00	120	0	0	120	0	0	120	2	2.00	120	2	2.00	120	1	1.00	120	0	0	12	3.00
OCT.	205	3	1.76	200	3	1.80	120	1	1.00	160	0	0	190	0	0	195	2	1.23	180	5	3.33	120	0		14	2.28
NOV.	120	1	1.00	120	0	0	120	1	1.00	120	0	0	120	0	2.00	120	0	0	120	0	0	120	1	1.00	5	1.25
DEC.	120	0	0	120	0	0	120	0	0	120	2	2.00	120	1	1.00	120	0	0	120	0	0	120	0	0	3	0.75
1964 JAN.	170	1	0.71	150	1	0.80	150	1	0.80	160	0	0	190	0	0	150	0	0	60	0	0	100	0	0	3	0.58
FEB.	135	3	2.67	180	2	1.33	120	0	0	120	0	0	150	0	0	160	0	0	120	2	2.00	120	1	1.00	8	1.75
MAR.	135	1	0.89	240	1	0.50	160	1	0.75	120	1	1.00	180	1	0.67	120	0	0	120	0	0	120	0	0	5	0.95
APR.	—	—	—	—	—	—	120	0	0	120	0	0	120	5	5.00	120	2	2.00	120	3	3.00	120	2	2.00	12	4.00
MAY	120	3	3.00	120	8	8.00	120	3	3.00	120	0	0	120	1	1.00	120	2	2.00	120	6	6.00	120	2	2.00	25	6.25
JUN.	120	0	0	120	7	7.00	120	6	6.00	120	1	1.00	120	0	0	120	11	11.00	120	3	3.00	120	4	4.00	32	8.00

— NO INFORMATION AVAILABLE

Table 14 SEASONAL VARIATION IN WATER TEMPERATURE AND CATCH RATES

	TEMPERATURE °C.																		
	T 1		T 2		T 3		T 4		T 5		T 6		T 7		T 8		All Station Average	All Station Average	Catch rate for 100 HK per 2 hours
DATE	O M	50 M	O M	50 M	O M	50 M	O M	50 M	O M	50 M	O M	50 M	O M	50 M	O M	50 M	O M	50 M	hours
1962 Dec.	16.61	15.4	18.30	17.27	16.62	14.80	16.39	14.44	17.10	14.80	16.99	15.90	17.20	15.48	17.40	15.28	17.10	15.42	0.81
1963 Jan.	19.24	15.71	21.43	15.22	19.95	15.64	19.39	14.38	21.78	16.10	20.72	15.82	21.72	15.32	21.23	15.94	20.68	15.51	2.08
Feb.	19.95	17.10	20.55	18.62	18.42	14.69	17.43	13.90	19.30	14.94	20.48	16.76	19.37	14.42	19.15	15.52	19.20	15.74	1.98
Mar.	17.98	14.46	19.05	16.02	19.37	14.32	18.80	14.85	19.58	15.43	20.50	17.63	20.60	16.83	19.45	15.33	19.41	15.61	2.48
Apr.	17.40	15.63	20.05	17.38	19.11	14.98	17.97	14.52	20.72	16.87	20 82	17.56	20.55	15.18	21.12	16.46	17.74	16.07	2.54
May	17.14	15.50	18.50	17.20	19.38	18.79	17.80	14.56	20.32	16.08	18.88	16.98	19.70	18.65	20.00	18.00	18.96	18.91	5.58
Jun.	16.15	14.70	17.97	17.80	18.80	16.40	17.13	16.40	18.30	16.13	18.19	16.13	18.80	16.15	18.03	15.54	17.92	16.15	9.00
Jul.	16.85	16.85	17.23	17.15	16.90	16.38	16.00	15.85	17.30	17.12	17.17	17.08	16.80	16.70	16.93	16.04	16.89	16.64	5.25
Aug.	15.30	15.25	16.70	16.59	16.60	15.49	15.63	14.98	16.90	16.55	17.12	17.10	16.90	16.85	16.60	15.40	16.44	16.02	3.75
Sep.	16.43	16.12	17.02	16.41	17.50	16.88	15.35	14.64	17.43	17.10	17.18	16.75	17.10	16.80	17.00	16.20	16.87	16.36	3.00
Oct.	15.92	15.44	17.87	16.79	17.00	16.67	15.87	15.18	18.10	15.38	17.58	17.22	16.80	15.02	17.32	15.40	17.05	15.88	2.28
Nov.	18.37	15.85	18.82	15.41	18.56	16.32	17.95	16.90	19.62	17.73	19.80	17.45	19.03	16.42	19.00	15.25	18.89	16.41	1.25
Dec.	19.30	14.92	20.40	14.40	21.80	16.18	19.50	15.21	21.90	16.13	20.05	15.80	20.60	15.63	20.11	15.85	20.45	15.51	0.75
1964 Jan.	19.05	15.44	19.45	15.91	18.90	15.17	17.43	14.81	19.32	15.20	20.11	17.42	19.80	16.65	18.57	15.83	19.08	15.80	9.58
Feb.	17.80	15.22	18.78	15.85	18.62	15.10	18.17	14.03	18.70	14.39	19.27	15.70	19.42	15.03	19.90	14.20	18.83	14.94	1.75
Mar.	20.56	18.23	20.29	17.95	19.57	15.55	16.88	14.93	20.03	14.92	21.00	21.00	19.58	17.63	18.30	14.30	19.52	16.81	0.95
Apr.	—	—	—	—	17.68	15.36	16.70	15.85	19.25	15.27	19.60	19.55	18.13	16.17	17.10	15.35	18.07	16.26	4.00
May	18.05	15.00	19.08	17.90	17.00	15.18	16.50	14.48	17.88	16.40	18.20	16.70	18.22	16.40	18.80	15.60	17.96	15.96	6.25
Jun.	15.80	14.35	16.60	15.20	16.72	15.20	16,28	14.80	17.42	15.70	17.30	16.45	17.45	16.55	18.10	16.65	16.96	15.61	8.00

Table 15

TEMPERATURE RANGES OBSERVED AT ALL STATIONS AND NUMBER OF TUNA CAUGHT AT 30—35 FATHOMS

TEMP. RANGE °C	0 METERS				25 METERS				50 METERS				100 METERS			
	% of Total Readings	Number of Longfin	Number of Bigeye	Number of Yellow and Blue Fin	% of Total Readings	Number of Longfin	Number of Bigeye	Number of Yellow and Blue Fin	% of Total Readings	Number of Longfin	Number of Bigeye	Number of Yellow and Blue Fin	% of Total Readings	Number of Longfin	Number of Bigeye	Number of Yellow and Blue Fin
12.0 — 12.9	0	0	0	0	0	0	0	0	0	0	0	0	8.0	7	6	0
13.0 — 13.9	0	0	0	0	0	0	0	0	0	0	0	0	52.0	70	31	18
14.0 — 14.9	0	0	0	0	0.7	0	1	0	19.3	11	9	7	32.6	91	14	16
15.0 — 15.9	3.3	5	6	2	10.0	11	13	3	36.0	54	24	12	6.7	23	5	3
16.0 — 16.9	17.3	21	20	0	23.3	39	16	7	27.3	87	18	8	0.7	0	0	0
17.0 — 17.9	21.3	62	9	5	27.3	64	16	5	13.3	35	4	5	0	0	0	0
18.0 — 18.9	19.3	62	8	5	20.7	69	3	14	2.7	2	1	5	0	0	0	0
19.0 — 19.9	20.7	31	7	13	10.7	5	3	7	0.7	2	0	0	0	0	0	0
20.0 — 20.9	13.3	9	6	10	7.3	3	4	1	0.7	0	0	0	0	0	0	0
21.0 — 21.9	4.7	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Totals	—	191	56	37	—	191	56	37	—	191	56	37	—	191	56	37

1 Meter = 3.26 ft. = 0.54 fathoms.

	O METERS	25 METERS	50 METERS	100 METERS
Observed Minimum Temperature	15.30°C	14.95°C	14.20°C	12.50°C
Observed Maximum Temperature	21.90°C	20.85°C	19.55°C	15.26°C

Table 16

LONGFIN TUNA TEMPERATURE PREFERENCE

June 1963 and June 1964

SAMPLING LEVEL	0 METERS			25 METERS			50 METERS		
TEMP. RANGE °C	No. Tuna caught at 30—35 fathoms	Total Sampling time hours	Catch rates No. Tuna/100 hooks/2 hours	No. Tuna caught at 30—35 fathoms	Total Sampling time hours	Catch rates No. Tuna/100 hooks/2 hours	No. Tuna caught at 30—35 fathoms	Total Sampling time hours	Catch rates No. Tuna/100 hooks/2 hours
13.0 — 13.9	0	0	0	0	0	0	0	0	0
14.0 — 14.9	0	0	0	0	0	0	1	2	2.0
15.0 — 15.9	0	0	0	0	0	0	10	10	4.0
16.0 — 16.9	10	10	4.0	19	16	4.7	44	32	5.5
17.0 — 17.9	20	16	5.0	15	16	3.7	3	4	3.0
18.0 — 18.9	28	22	5.1	24	16	6.0	0	0	0
19.0 — 19.9	0	0	0	0	0	0	0	0	0

Table 17

TYPES OF FOOD IN TUNA STOMACHS

(WEIGHT IN GRAMS)

	FISH				MOLLUSCA DECAPODA				OTHER MOLLUSCA				CRUSTACEA DECAPODA				OTHER CRUSTACEA				OTHER MATERIAL				NUMBER INVESTIGATED				NO EMPTY STOMACHS				TOTAL TUNA INVESTI-GATED
	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	LF	BE	YF	BF	
STATION T 1 AND T 2																																	
SUMMER	327	124	825	0	41	573	125	25	0	0	0	0	20	308	0	0	141	0	18	3	0	0	0	0	14	6	3	1	2	0	0	0	24
AUTUMN	366	0	0	0	493	865	0	0	16	0	0	0	96	0	0	0	512	0	150	0	26	0	0	0	29	3	1	0	2	1	0	0	33
WINTER	118	9	0	0	321	453	0	4	0	0	0	0	16	94	0	0	143	1	0	0	28	0	0	0	10	2	0	0	0	0	0	0	12
SPRING	102	366	0	0	21	420	0	0	0	0	0	0	0	10	0	0	173	22	0	0	0	0	0	0	9	4	0	0	0	0	0	0	13
TOTAL	913	499	825	0	876	2314	125	29	16	0	0	0	132	412	0	0	969	23	168	3	54	0	0	0	62	15	4	1	4	1	0	0	82
STATION T 3 AND T 4																																	
SUMMER	100	444	850	752	10	508	12	7	0	0	0	266	0	0	0	0	59	1	0	0	0	0	0	0	2	6	3	1	0	1	0	0	12
AUTUMN	53	35	0	711	33	0	51	7	0	0	0	0	16	0	0	0	175	0	6	0	2	0	0	0	9	1	1	4	3	0	0	1	15
WINTER	462	131	0	950	331	94	0	0	0	0	0	0	4	0	0	0	150	7	0	0	31	0	0	0	24	5	0	2	0	0	0	0	31
SPRING	4	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
TOTAL	619	610	850	2413	379	602	63	14	0	0	0	266	20	0	0	0	456	8	6	0	33	0	0	0	37	12	4	7	3	1	0	1	60
STATION T 5 AND T 6																																	
SUMMER	63	0	0	0	1	0	0	0	0	0	0	0	10	0	0	0	56	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
AUTUMN	405	2755	1505	1055	241	3	0	10	0	0	0	0	0	4	0	0	206	1	0	0	10	0	0	0	14	2	7	2	0	0	0	1	25
WINTER	180	0	0	0	541	0	0	264	0	0	0	0	0	0	0	0	6	1	0	0	4	39	0	0	10	1	0	2	1	0	0	0	13
SPRING	293	0	0	0	83	271	0	0	0	27	0	0	0	35	0	0	65	0	0	0	0	0	0	0	7	1	0	0	1	0	0	0	8
TOTAL	941	2755	1505	1055	866	274	0	274	0	27	0	0	10	39	0	0	333	2	0	0	14	39	0	0	34	4	7	4	2	0	0	1	49
STATION T 7 AND T 8																																	
SUMMER	16	363	0	0	15	473	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	5	0	0	0	0	0	0	6
AUTUMN	142	2866	756	0	199	192	10	0	0	0	0	0	0	0	0	0	88	3	0	0	0	0	0	0	10	8	4	0	0	1	0	0	22
WINTER	151	4540	0	0	109	35	0	0	0	0	0	0	6	0	0	0	129	0	0	0	0	0	0	0	9	4	0	0	0	0	0	0	13
SPRING	0	244	0	0	0	93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	6
TOTAL	809	8013	756	0	323	793	10	0	0	0	0	0	6	0	0	0	217	8	0	0	0	0	0	0	20	23	4	0	0	1	0	0	47
TOTAL WEIGHT OR NUMBER																																	
	2782	11877	3936	3468	2444	3983	198	317	16	27	0	266	148	451	0	0	1975	41	174	3	101	39	0	0	153	54	19	12	9	3	0	2	238
% of TOTAL	37	72	91	86	32	24	4.6	7	0.2	0.1	0	6	2	2.7	0	0	26	0.3	4	0.1	1.3	0.3	0	0	—	—	—	—	6	6	0	16	—

Table 18

PLANKTON VOLUMES AND CATCH RATES

	T1				T2				T3				T4			
	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate
1964 April	+	+	+	+	+	+	+	+	18	25	43	0	3	13	16	0
May	10	25	35	3	12	35	47	8	10	2	12	3	20	28	48	0
June	10	20	30	0	5	15	20	7	7	55	62	6	24	42	66	1

	T5				T6				T7				T8					
	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Plank. Vol. N. 50 V Net	Plank. Vol. N. 70 V Net	N. 50 V & N. 70 V Vol.	Catch Rate	Average Vol. N 50 + N 70 V hauls	Catch Rate Whole Area as No. Fish per 100 hooks/2 hours.
1964 April	8	20	28	5	2	11	13	2	6	18	24	3	8	12	20	2	24	4.0
May	12	35	47	1	14	35	49	2	4	48	52	6	2	30	32	2	40	6.3
June	+	+	+	0	11	34	45	11	4	4	8	3	8	10	20	4	36	8.0

+ No information available.

Plankton volumes are given in cubic centimeters to the nearest whole cc.

Table 19 **BLUEFIN TUNA**

1	2	3	4	5	6	7	8	9	10
165.1	49.5	49.8	45.8	38.0	20.0	22.5	6.0	♂ a	208
221.0	57.0	62.3	58.3	39.7	25.0	31.2	5.0	♂ ia	300
161 9	49.9	50.6	46.7	32.5	16.2	21.4	5.5	♂ r	214
153.0	47.2	50.4	43.0	31.0	18.8	18.5	5.0	♂ r	196
162.5	49.0	50.5	41.8	33.5	17.5	20.7	5.5	♂ a	188
207.4	55.6	57.1	52.0	36.3	25.5	36.1	4.0	♀ r	355
127.6	39.0	38.0	35.6	31.0	16.0	19.8	5.0	♀ a	92
133.6	42.7	39.5	35.8	37.4	15.8	28.7	5.3	♀ a	116
217.0	56.0	61.0	52.0	41.0	22.5	30.5	5.1	♀ r	350
160.8	46.9	47.5	40.4	31.4	17.4	15.6	5.1	♀ a	144
149.1	35.6	40.7	41.0	31.4	16.7	19.1	4.5	♀ a	140
165	46.5	51.2	43.6	25.4	17.5	18.6	5.0	♀ a	218
119.4	36.0	37.9	34.1	34.5	15.9	18.4	5.3	♀ ia	78
151.0	45.5	48.3	41.6	27.5	17.6	16.9	5.0	♀ a	160

NOTE:
1. Total length (in Cms.).
2. Head length (in Cms.).
3. Snout to insertion of 1st Dorsal Spine (in Cms.).
4. Greatest depth (in Cms.).
5. Length of Pectoral (in Cms.).
6. Length of 1st Dorsal Spine.
7. Length of 2nd Dorsal Spine.
8. Diameter of Iris.
9. Sex and maturity.
10. Weight (lbs.).

Table 20 **BIGEYE TUNA**

1	2	3	4	5	6	7	8	9	10
158.2	46.4	47.0	45.8	34.1	17.5	25.0	6.0	♂ a	180
131.5	41.5	42.1	38.6	34.1	17.0	19.3	4.5	♂ ia	98
156.8	49.5	51.3	46.0	37.9	18.0	25.8	6.7	♂ a	200
127.5	39.9	41.5	36.3	34.0	16.6	19.5	5.9	♂ ia	108
154.5	46.0	46.1	43.4	34.6	18.7	23.6	6.6	♂ a	188
106.5	33.0	32.8	27.9	29.6	13.2	14.6	4.7	♂ ia	50
137.4	42.1	42.0	35.6	34.0	17.2	19.6	5.4	♂ ia	120
88.5	26.5	28.0	26.0	27.0	11.0	11.3	4.3	♂ i	22
121.5	38.0	39.0	36.4	32.5	16.6	18.1	5.3	♂ a	100
136.6	43.7	43.2	38.1	35.2	16.2	17.8	6.1	♂ a	138
132.0	38.0	39.0	39.0	32.0	16.0	18.0	5.0	♀ a	84
151.4	46.5	46.8	42.7	34.3	18.3	23.1	5.3	♀ a	172
145.1	44.6	44.9	43.3	37.7	19.5	24.2	4.4	♀ ar	147
139.5	42.5	45.7	41.5	35.5	16.0	20.5	5.4	♀ ia	120
156.0	46.4	47.9	45.0	36.8	20.4	24.9	6.0	♀ a	188
134.4	41.5	40.7	36.5	35.0	17.1	20.0	5.1	♀ ia	120
139.9	42.6	43.4	39.7	35.6	17.9	20.2	3.6	♀ a	132
124.0	35.4	36.0	32.0	32.0	14.5	16.0	4.7	♀ a	86
150.2	43.2	44.5	38.0	34.0	18.0	20.5	5.1	♀ a	125
139.2	43.5	44.0	39.3	36.9	17.0	18.9	6.4	♀ a	158

NOTE:
1. Total length (in Cms.).
2. Head length (in Cms.).
3. Snout to insertion of 1st Dorsal Spine (in Cms.).
4. Greatest depth (in Cms.).
5. Length of Pectoral (in Cms.).
6. Length of 1st Dorsal Spine.
7. Length of 2nd Dorsal Spine.
8. Diameter of Iris.
9. Sex and maturity.
10. Weight (lbs.).

Table 21 LONGFIN TUNA

1	2	3	4	5	6	7	8	9	10
78.0	24.0	27.0	25.0	36.0	9.5	9.0	3.5	♂ ia	20
90.0	25.5	29.0	28.0	36.5	9.5	10.0	4.0	♂ s	24
88.9	27.5	29.0	21.2	39.4	9.9	10.2	4.0	♂ ia	40
79.0	24.8	28.3	20.2	33.8	9.9	9.5	3.8	♂ ia	28
82.0	25.0	28.1	19.7	36.9	9.5	9.0	2.9	♂ i	30
85.7	26.5	28.0	21.4	36.8	9.8	10.2	3.9	♂ ia	30
79.5	25.0	27.4	20.5	36.5	9.4	9.2	3.7	♂ i	26
76.4	23.8	25.5	18.2	34.4	8.6	9.2	3.8	♂ i	22
79.8	24.8	25.8	19.8	34.5	9.4	9.2	4.0	♂ ia	28
77.4	24.0	26.3	18.7	33.1	9.2	8.8	3.7	♀ i	22
79.6	25.0	26.7	19.6	34.2	8.4	8.9	4.0	♀ ia	26
81.7	25.7	27.8	20.0	35.6	9.6	9.3	3.8	♀ ia	24
87.8	27.6	30.0	27.8	41.2	11.2	10.9	4.3	♀ ia	30
75.5	22.8	24.8	19.3	32.4	8.4	8.3	3.9	♀ ia	20
79.5	23.8	26.6	20.7	35.0	10.0	8.8	3.3	♀ i	24
74.9	22.1	24.6	17.8	29.9	7.5	7.5	4.0	♀ ia	14
83.0	24.1	26.8	20.3	40.5	10.0	9.7	3.8	♀ ia	20
91.9	27.3	30.9	22.6	41.5	10.2	10.5	4.0	♀ a	30
88.4	26.1	29.6	23.4	38.7	9.1	9.4	4.2	♀ a	30

NOTE:
1. Total length (in Cms.).
2. Head length (in Cms.).
3. Snout to insertion of 1st Dorsal Spine (in Cms.).
4. Greatest depth (in Cms.).
5. Length of Pectoral (in Cms.).
6. Length of 1st Dorsal Spine.
7. Length of 2nd Dorsal Spine.
8. Diameter of Iris.
9. Sex and maturity.
10. Weight (lbs.).

Table 22 YELLOWFIN TUNA

1	2	3	4	5	6	7	8	9	10
84.0	26.2	29.0	21.0	41.0	9.9	10.0	4.0	♂ i	42
109.0	28.0	30.0	27.0	26.5	13.0	19.0	3.4	♂ ia	62
126.0	30.0	37.0	29.0	27.4	13.1	19.1	3.9	♂ ia	70
123.4	21.3	33.2	30.2	32.8	12.6	21.4	4.0	♂ i	84
128.7	30.6	34.3	30.5	34.6	13.5	21.3	4.2	♂ i	64
125.0	32.7	32.6	28.7	30.3	13.1	19.6	3.6	♂ i	80
130.1	32.2	36.3	30.1	31.4	13.9	20.8	3.8	♂ i	72
123.1	30.4	33.7	30.1	32.1	13.0	23.0	3.7	♂ i	80
127.7	32.2	35.7	31.6	32.2	13.1	22.6	3.7	♂ i	78
127.6	31.4	35.0	29.5	30.1	12.9	20.7	3.3	♂ i	118
131.7	34.0	35.8	33.0	31.5	14.4	26.0	4.6	♀ ia	62
115.5	31.0	35.0	28.5	28.0	15.0	19.0	3.8	♀ ia	62
108.0	29.0	31.0	27.0	27.0	12.0	17.0	3.8	♀ i	42
136.5	35.5	40.4	35.5	32.3	16.0	25.0	4.4	♀ a	120
133.1	36.0	38.8	33.3	37.0	17.4	33.8	3.6	♀ a	100
129.4	32.4	35.8	30.8	34.4	14.1	22.3	3.7	♀ ia	76
127.3	32.1	35.6	30.8	33.1	13.0	21.2	3.2	♀ a	76
143.2	37.0	41.2	34.0	30.2	16.5	33.0	4.2	♀ a	116
138.1	35.8	40.7	36.3	35.5	16.8	32.9	4.1	♀ ia	138
95.4	29.0	31.8	24.6	42.4	12.5	11.1	4.5	♀ i	44

NOTE:
1. Total length (in Cms.).
2. Head length (in Cms.).
3. Snout to insertion of 1st Dorsal Spine (in Cms.).
4. Greatest depth (in Cms.).
5. Length of Pectoral (in Cms.).
6. Length of 1st Dorsal Spine.
7. Length of 2nd Dorsal Spine.
8. Diameter of Iris.
9. Sex and maturity.
10. Weight (lbs.).

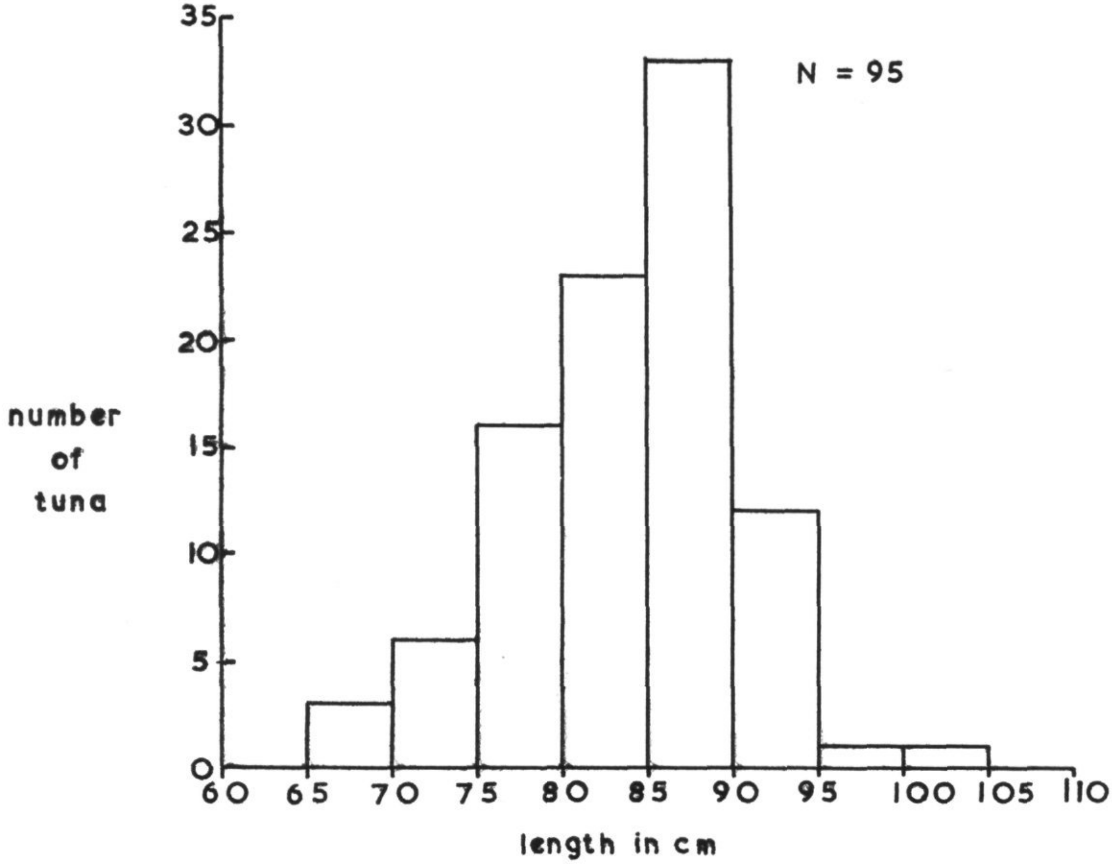

FIG.2

LONGFIN TUNA - MALES - LENGTH FREQUENCY DISTRIBUTION

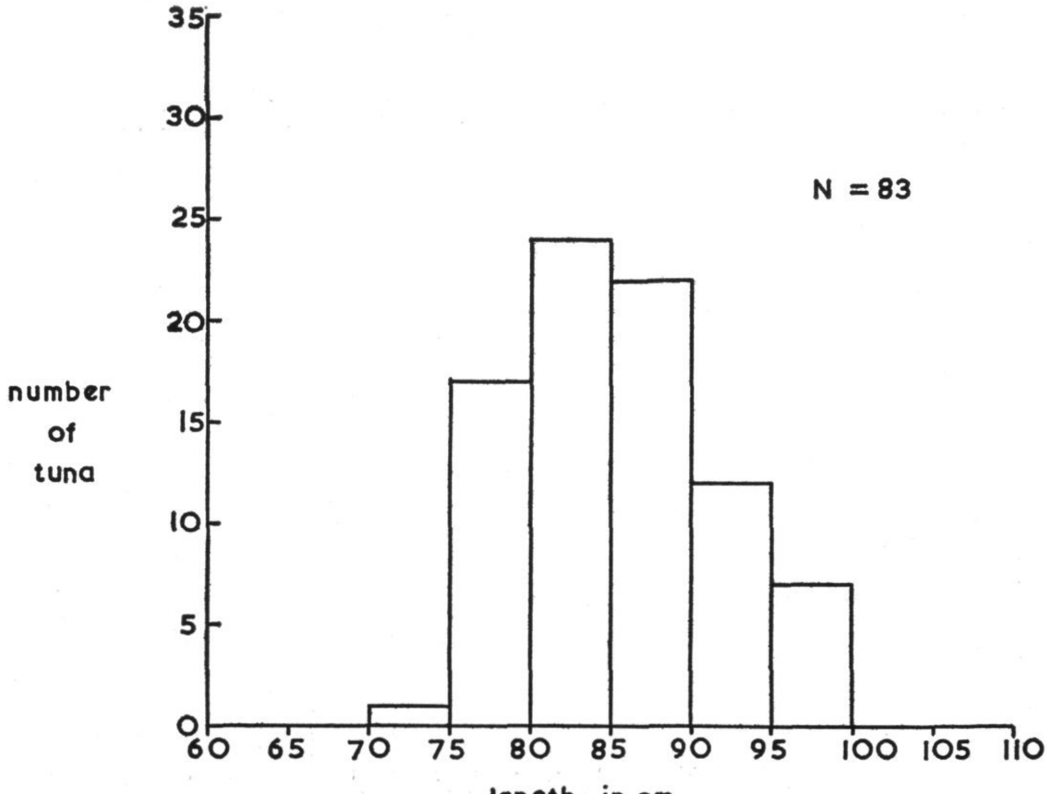

FIG. 3

LONGFIN TUNA – FEMALES – LENGTH FREQUENCY DISTRIBUTION

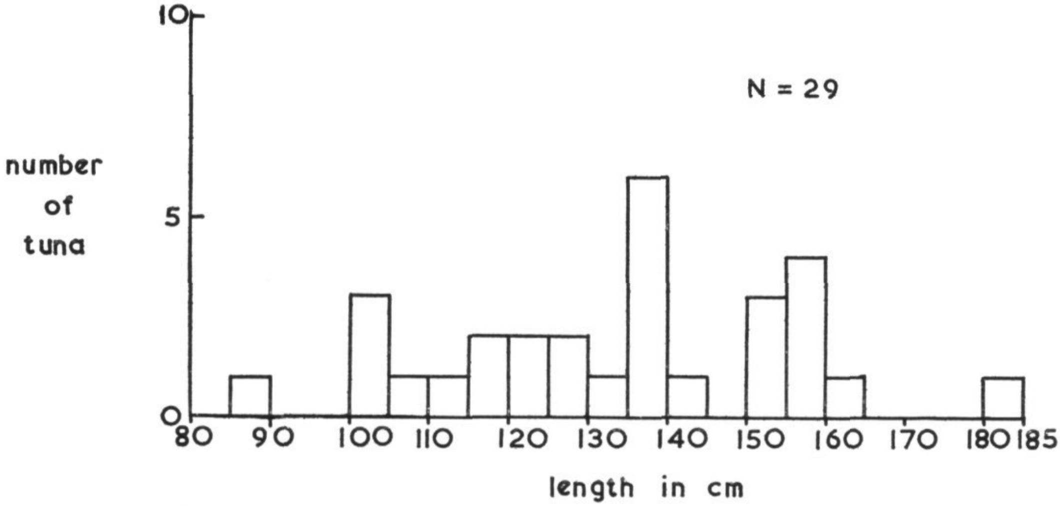

FIG. 4 BIGEYE TUNA – MALES – LENGTH FREQUENCY DISTRIBUTION

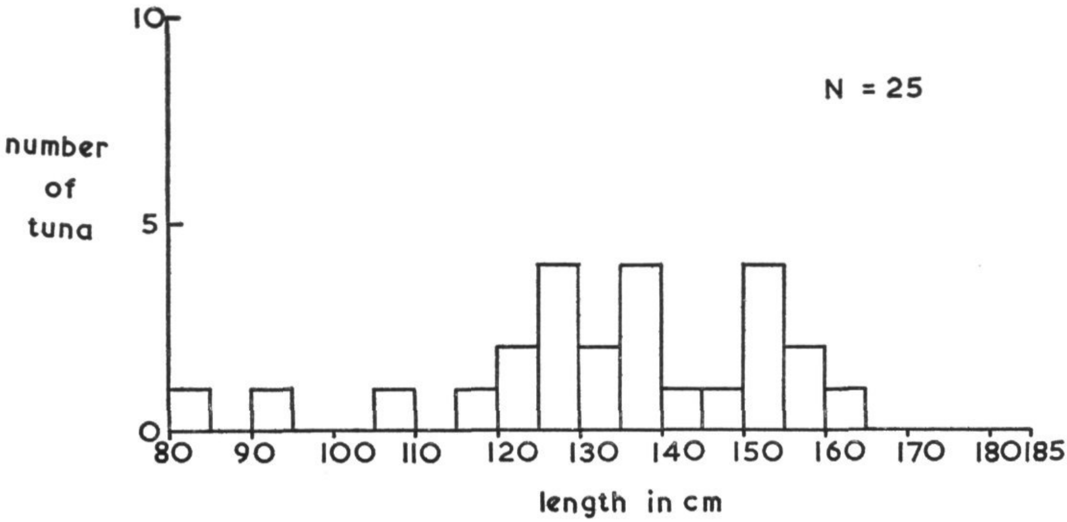

FIG. 5 BIGEYE TUNA – FEMALES – LENGTH FREQUENCY DISTRIBUTION

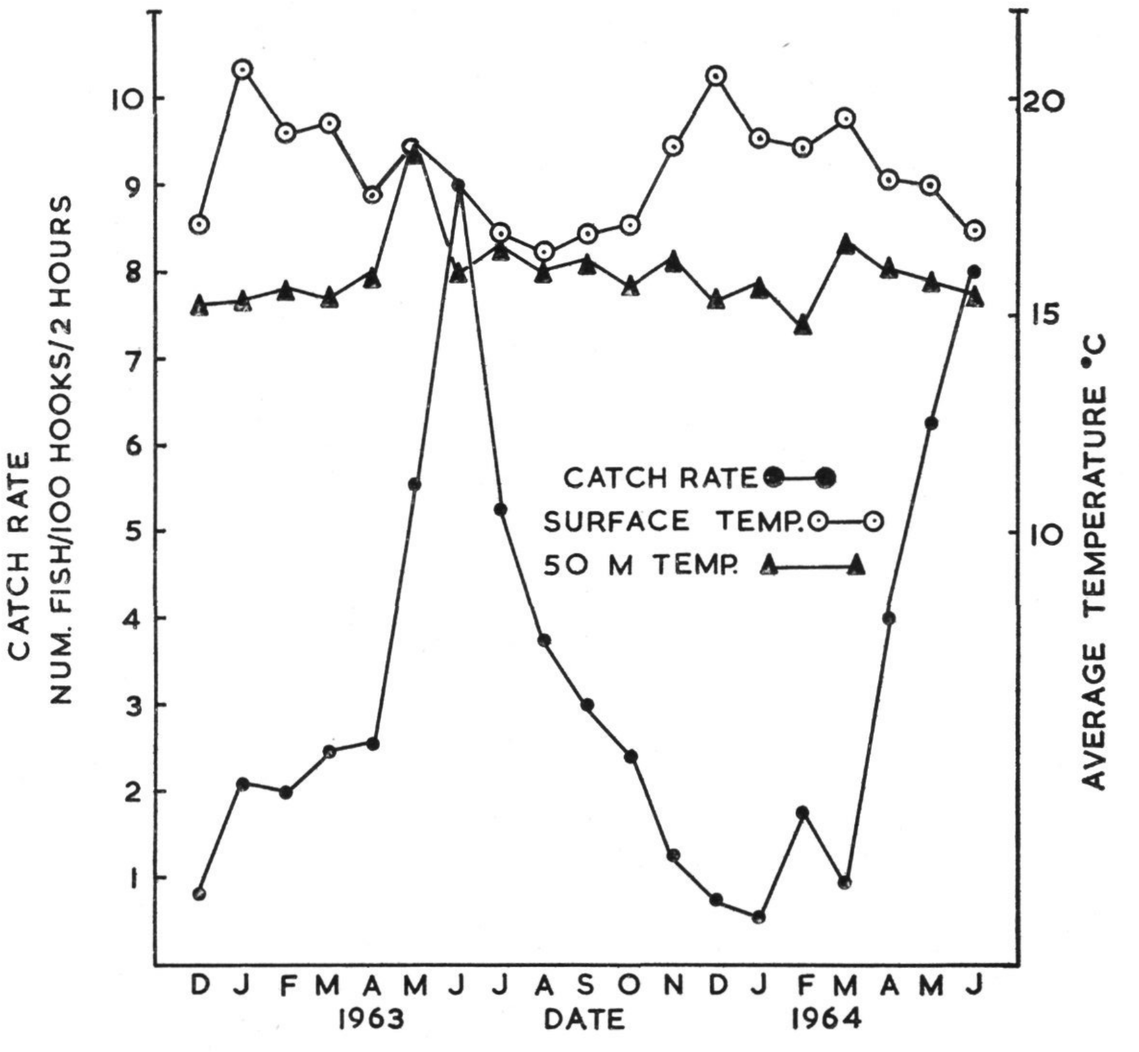

FIG. 6 SEASONAL VARIATION IN CATCH RATE AND AVERAGE SURFACE TEMPERATURE

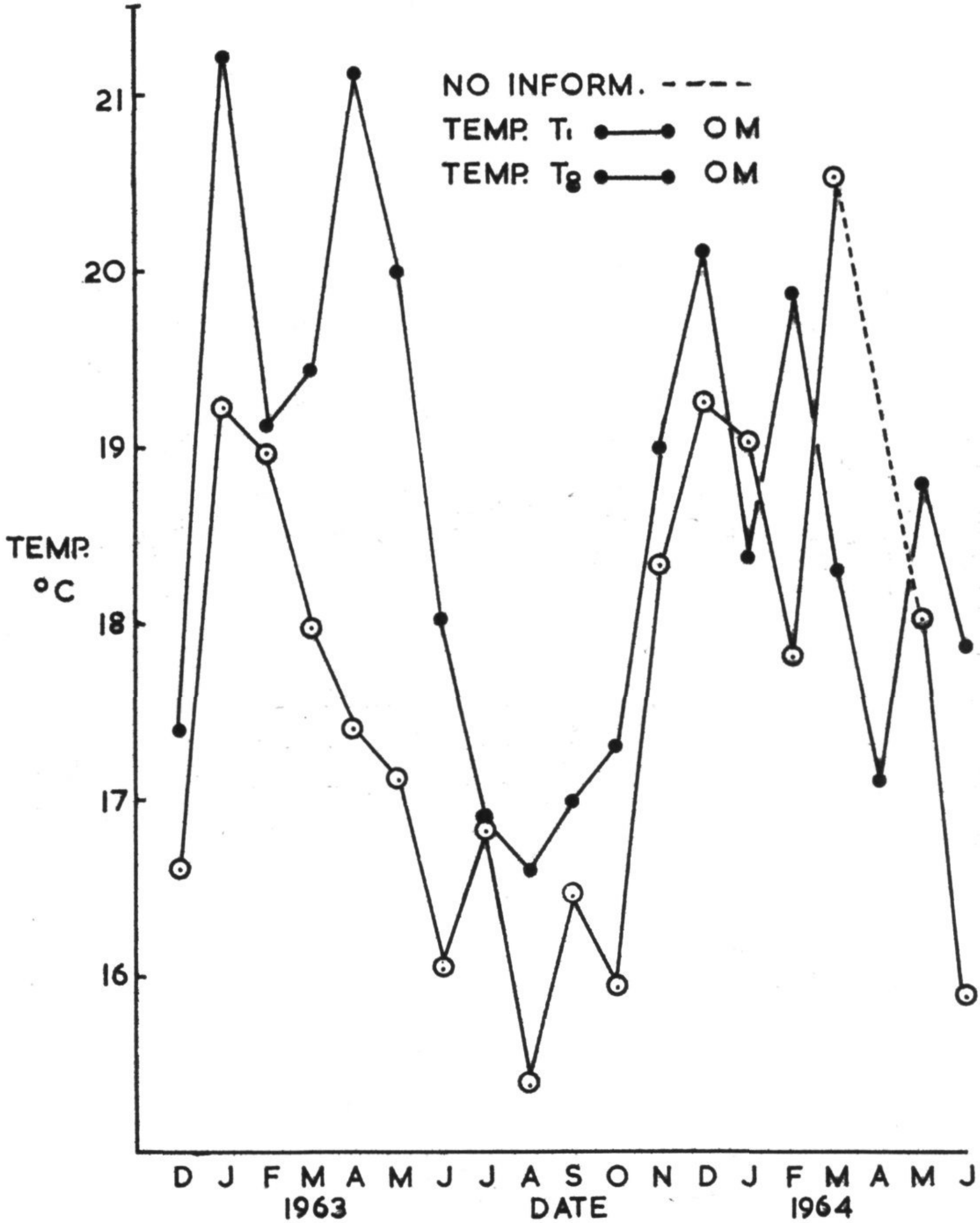

FIG. 7

SURFACE TEMPERATURE VARIATION AT STATIONS T1 AND T8

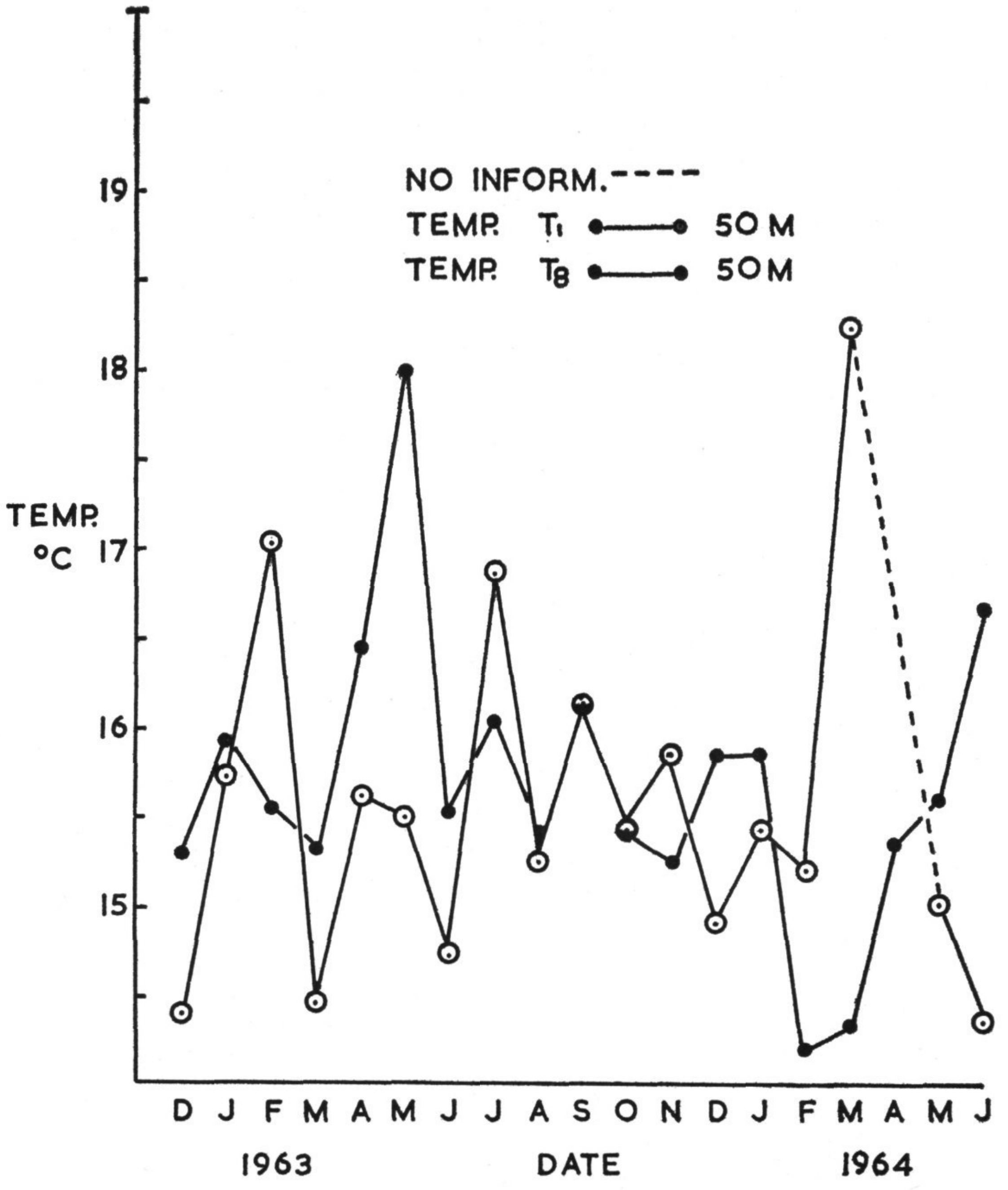

FIG. 8

TEMPERATURE VARIATION AT STATIONS T1 AND T8 AT 50 METER LEVEL

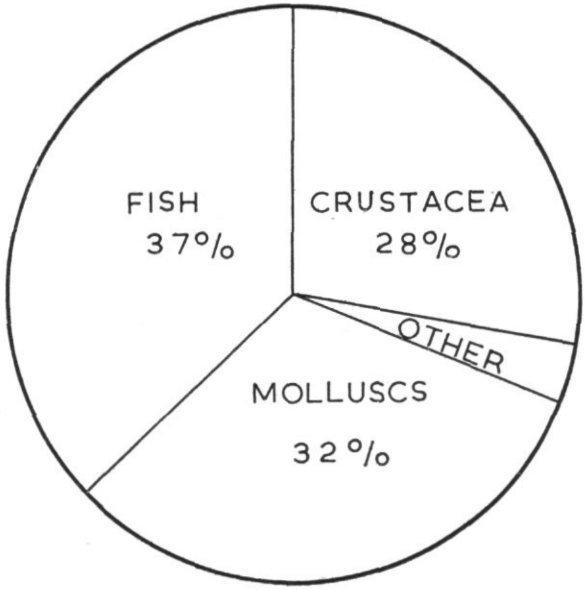

FIG 9 A

FOOD PREFERENCE LONGFIN TUNA

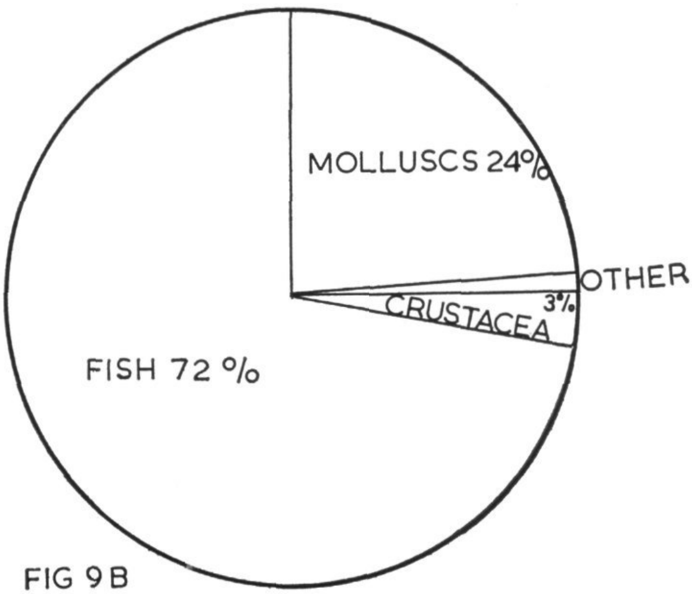

FIG 9 B
FOOD PREFERENCE BIGEYE TUNA

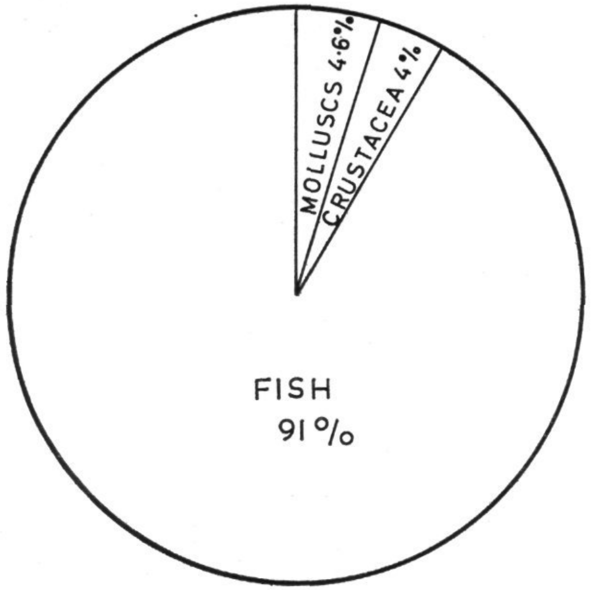

FIG. 10 A
FOOD PREFERENCE YELLOWFIN TUNA

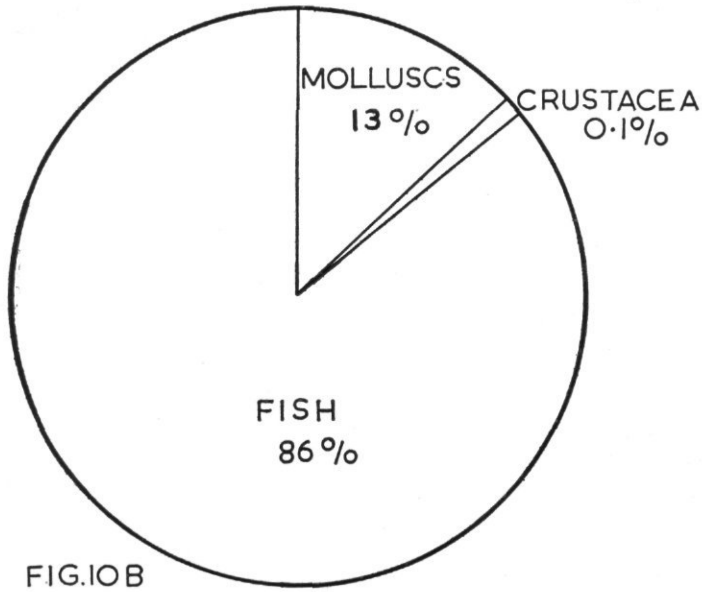

FIG.10 B
FOOD PREFERENCE BLUEFIN TUNA

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