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FIb/S61
SAST - Tuna

SYNOPSIS OF BIOLOGICAL DATA ON BLUEFIN TUNA *Thunnus thynnus orientalis* (Temminck and Schlegel) 1842, LONGFIN TUNA *Thunnus alalunga* (Bonnaterre) 1788, YELLOWFIN TUNA *Thunnus albacares* (Bonnaterre) 1788 and BIGEYE TUNA *Thunnus obesus* (Lowe) 1839 (SOUTH AFRICA)

Exposé synoptique sur la biologie du thon rouge *Thunnus thynnus orientalis* (Temminck et Schlegel) 1842, germon *Thunnus alalunga* (Bonnaterre) 1788, thon à nageoires jaunes *Thunnus albacares* (Bonnaterre) 1788 et patudo *Thunnus obesus* (Lowe) 1839 (Afrique du Sud)

Sinopsis sobre la biología del atún rojo *Thunnus thynnus orientalis* (Temminck y Schlegel) 1842, albacora *Thunnus alalunga* (Bonnaterre) 1788, atún de aleta amarilla *Thunnus albacares* (Bonnaterre) 1788 y patudo *Thunnus obesus* (Lowe) 1839 (Sudáfrica)

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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1 IDENTITY [1/]

1.1 Taxonomy

1.1.1 Definition

Phylum CHORDATA
Subphylum Vertebrata
Superclass Gnathostomata
Class Osteichthyes
Subclass Actinopterygii
Superorder Teleostei
Order Perciformes
Suborder Scombroidea
Family Scombridae
Genus *Thunnus*

Spp. *Thunnus thynnus*, *T. alalunga*, *T. albacares*
T. obesus

var. *T. T. orientalis*

1.1.2 Description

See Talbot and Penrith (1963)

1.2 Nomenclature

See Talbot and Penrith (1963)

1/ The data used in compiling this synopsis are based on one year's observations, viz. winter 1960 to autumn 1961; all the findings and conclusions must therefore be regarded as preliminary.

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution, and ecological characterization of this area

The total area in which the four tuna species were recorded by the author's institution is situated between Cape Point in the south and the Orange River in the north, along the western seaboard of South Africa (See Fig. 1).

The ecological characterization of the area (St. Helena Bay - Cape Hangklip) in which the survey was conducted (which is also the main area of fishing activities) is briefly as follows: (See Fig. 2).

(i) Hydrological

The waters of the above-mentioned area consist of the upper part of the Antarctic Intermediate current which has upwelled along the coast to form the Benguela current. Temperatures of this (inshore) water vary from 9° to 13° C and salinities from 34.70 to 35.00°/oo. The influence of solar radiation is, however, responsible for an increase of the temperature range from 9° to 17°C with the same range in salinities. The inorganic phosphate content is of the order of 1 mg atoms/M^3.

(ii) Biological

Phytoplankton is most abundant during spring, summer and early autumn, in which seasons the content of the inorganic phosphate in the surface layer is relatively high compared with that in winter when phytoplankton abundance is at a minimum. During the seasons when phytoplankton is relatively abundant, the surface winds in this area are from a southerly direction with the result that upwelling is increased and heavy, cold, nutrient-rich water is found near the coast. This upwelled water is ideal for the florescence of phytoplanktonic organisms, provided other physical conditions are favorable.

Diatom blooms are maximal in spring, summer and early autumn.

The heaviest blooms of dinoflagellates are recorded during autumn.

Over the period in which the tuna survey was conducted, namely 1960 to 1961, the general trend in the abundance of phytoplankton was similar to the general conditions described above.

Approximately 100 phytoplankton species occur in the area; of these, some occur throughout the year in small numbers, others disappear from the area and reappear later in a sudden bloom. Fourteen species predominate in the area becoming very abundant at times (as much as 14 million cells/litre), and constitute the major portion of the phytoplankton standing crop.

In the colder inshore area (see section 2.3) zooplankton is most abundant during late spring, summer and early autumn; the volumes are relatively low during winter.

The seasonal variation of zooplankton roughly follows that of the phytoplankton, the peaks of the zooplankton production occurring either a few weeks later than the phytoplankton blooms or simultaneously, and usually in an area situated some distance from the dense patches of phytoplankton.

Real "blooms" of zooplankton can occur and are most often found in the zones of mixed water, situated in the vicinity of the areas where upwelled water breaks through to the surface (or to the waters adjacent to the surface). These "blooms" are characterized by enormous quantities of two or three species of Copepoda and sometimes also of Chaetognatha.

A bloom hardly ever contains more than one predominant species at the same place or time. The degree of mixing between upwelled and surface water seems to be a factor on which the abundance of one or another species of copepods depends.

Each of the species which at times occurs in large swarms is preyed upon by pelagic fish.

In the warm Atlantic water (see section 2.3) no large volumes of zooplankton are found, except for swarms of Tunicata. Despite small zooplankton volumes, a much larger variety of species is usually present in this water than is found within the zone of upwelled water.

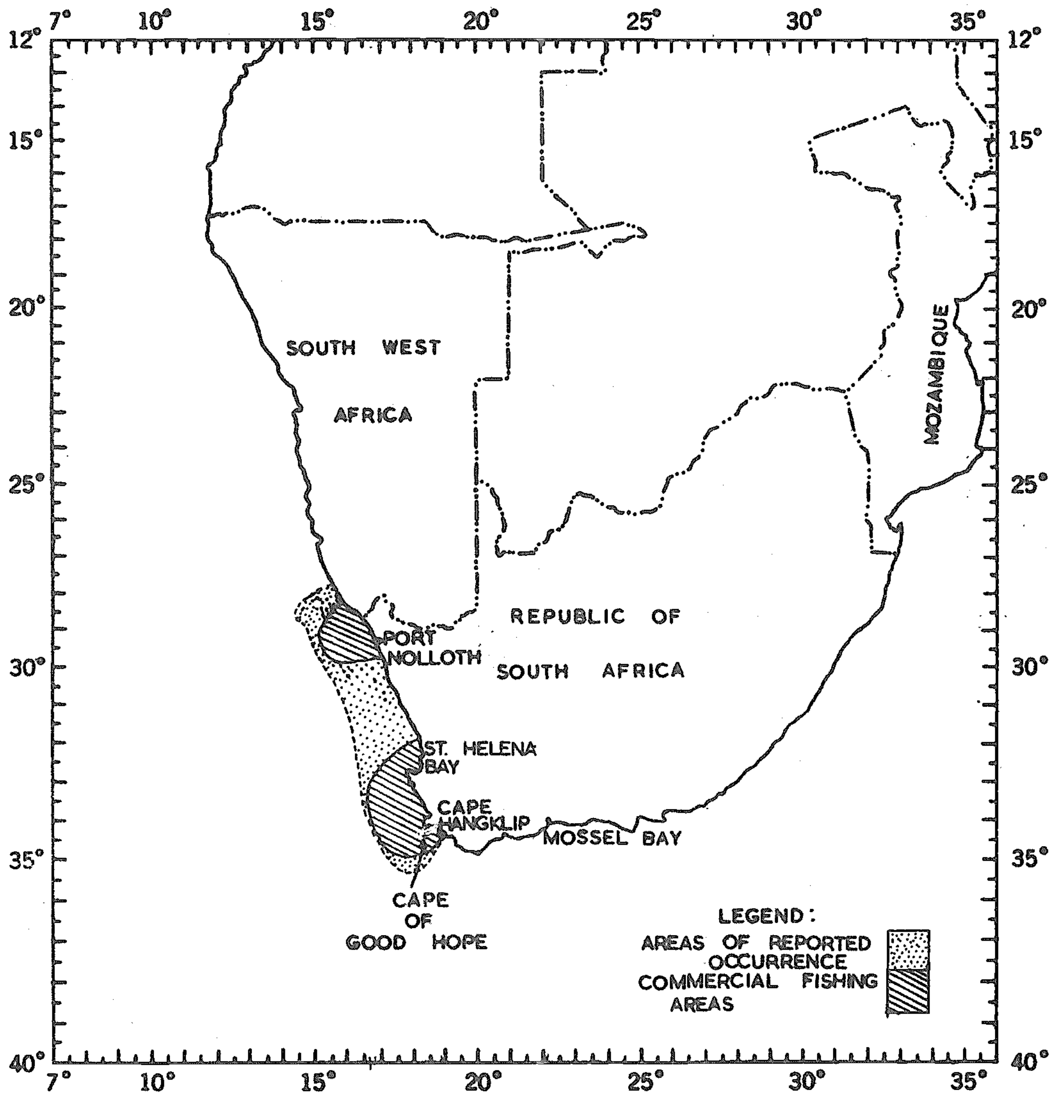

Fig. 1 Areas in which tuna occur

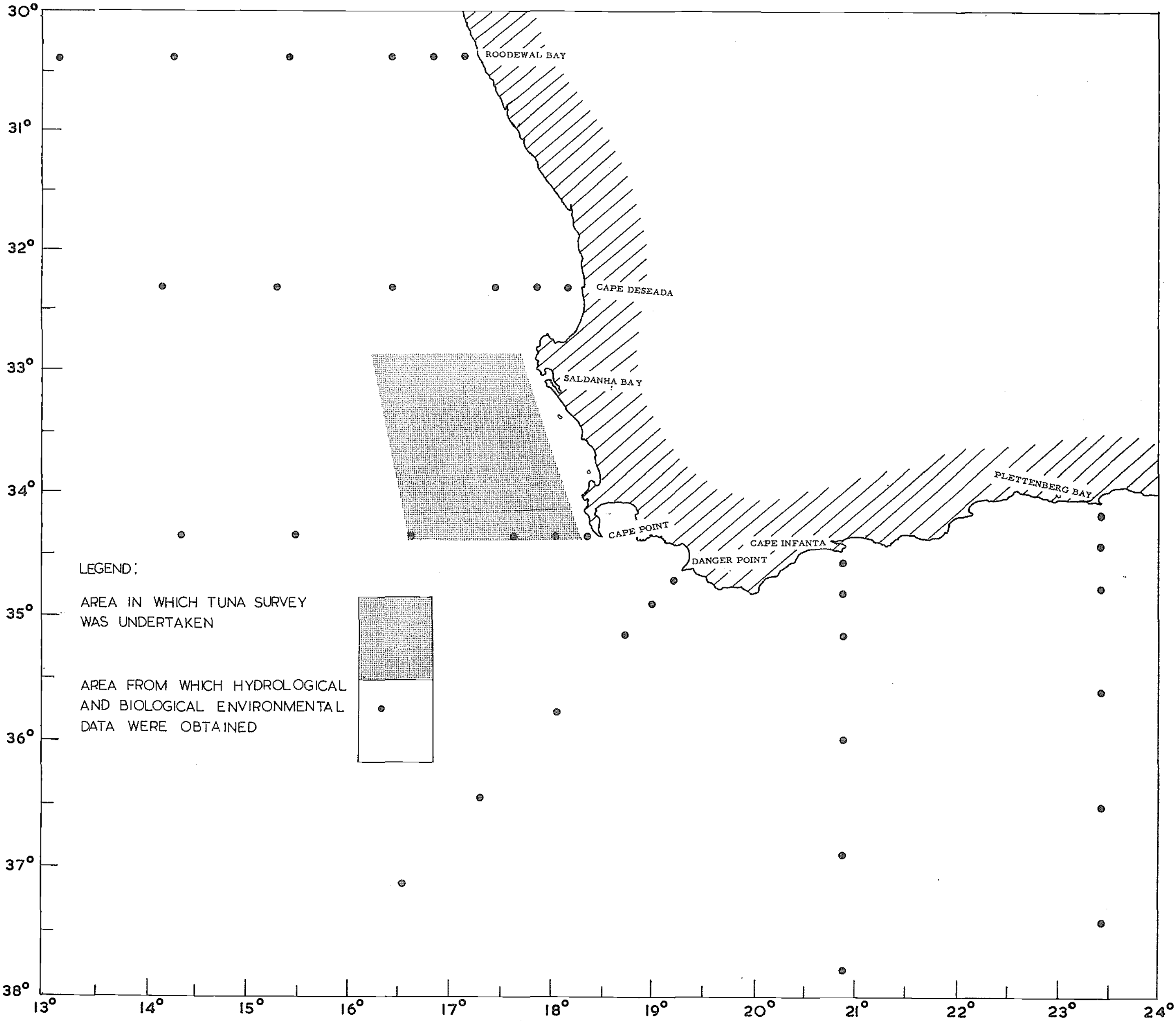

FIG. 2 AREAS OF INVESTIGATION

More than 100 species of Copepoda are known to occur regularly in the warm surface water, whereas only about 24 species are usually found inshore in the 0 to 100 m layer.

No definite seasonal trend in zooplankton volumes has been ascertained in the warm offshore waters; this is due to the irregular occurrence of big swarms of tunicates which obliterate the volume of smaller plankton organisms in the catches.

2.2 Differential distribution

2.2.1 Areas occupied by adult stages; seasonal and annual variations of these

Table I shows the seasonal occurrence of the four species of commercially important tuna. For each species, the catch per season is indicated as a percentage of the annual catch of that species.

From the table it can be seen that bluefin tuna were most abundant during winter, in which season 75.2 percent of the annual catch of that species was taken. This species occurred to a lesser degree during spring (when 21.2 percent of the annual catch was taken) and hardly at all during summer and autumn during which seasons only 1.8 percent of the total annual catch was taken. For the year as a whole, bluefin tuna occurred more frequently than any of the other three species.

Longfin tuna occurred throughout the year but was most abundant in autumn and spring when 43.1 percent and 38.9 percent respectively of the annual catch of that species was taken. During winter and summer smaller numbers of fish were taken and the catches during each of these seasons amounted to 9 percent of the annual total for that species. For the year as a whole this species constituted the second largest group taken.

Yellowfin tuna occurred most frequently during spring and autumn, when 51.2 percent and 41.8 percent respectively of the total annual catch was taken. This species occurred to a lesser extent during summer (when 7.0 percent of the catch was taken), and not at all during winter when no catches were recorded.

Bigeye tuna occurred in relatively larger numbers during spring and winter when 52.3 percent and 25.0 percent respectively of the annual catch was taken, and in relatively fewer numbers during summer and autumn when 18.2 percent and 4.5 percent of the annual catch was taken.

In the above discussion no indication has been given of the fishing effort required to take the number of fish actually caught. It is necessary to qualify the above remarks to allow for the apparent fluctuation in seasonal abundance as a result of fluctuation in fishing effort.

Table I

Seasonal occurrence of commercially important tunas

Season	Bluefin		Longfin		Yellowfin		Bigeye	
	No.	%	No.	%	No.	%	No.	%
Winter	161	75.2	13	9.0	-	-	11	25.0
Spring	45	21.2	56	38.9	22	51.2	23	52.3
Summer	4	1.8	13	9.0	3	7.0	8	18.2
Autumn	4	1.8	62	43.1	18	41.8	2	4.5
Total for year	214	100.0	144	100.0	43	100.0	44	100.0

An analysis of the fishing effort (number of hooks used) indicates that the effort was slightly higher in spring and autumn than in winter and summer, the ratio of effort in the former two seasons to that in the latter two seasons being in the order of 3:2.

Making allowance for this variation in fishing effort does not, however, seem to disturbunduly the pattern of seasonal occurrence obtained.

2.3 Behavioristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

(See Fig. 1.)

General: In the Cape Point region, water of either Indian Ocean or Atlantic Ocean origin is present intermittently. Although the reason for the dominant occurrence of a certain type of water during certain times of the year is not quite clear, it is evident that meteorological conditions are directly concerned.

Thus, it is usually found that during the winter months in the area south of Cape Point, water of Atlantic origin penetrates the area from west to east, resulting in the subsequent deflection of the winter-weakened Agulhas system to the south and east. During spring a reversal of these conditions occurs and it is found that Atlantic water is steadily replaced by Agulhas water. In the regions where the different water masses meet, a varying area of mixing is encountered.

Off the Cape west coast area various stages of mixed water occur, consisting of Atlantic surface water and the upper portion of Antarctic Intermediate water. It is almost certain that during certain seasons a component of Agulhas water is also present in this area.

However, during normal winter conditions the waters are exclusively Atlantic in origin. This is mainly due to the transportation of surface water from the west towards the coast as a result of the prevalence of strong westerly winds. During this season the process of upwelling is temporarily slowed down in this area.

With the advent of spring and the prevalence of strong southerly winds, increased upwelling occurs. These physical conditions create a horizontal temperature transitional area in the proximity of the coast; to the coastal side of this area, cold, heavy and nutrient-rich water is found while on the oceanic side warmer, lighter and relatively nutrient-poor water is present.

It is acknowledged that the boundary zone in which rapid temperature changes occur within a short horizontal distance, is the border of the Benguela current which is generally regarded as a cold current. The area of transition where warm and cold water meet is often characterized by the presence of vast quantities of phyto- and zooplankton (see section 2.1), and large shoals of pelagic fish particularly pilchards (Sardinops ocellata) and maasbanker (Trachurus trachurus).

It would appear that tuna shoals congregate on the oceanic side of the Benguela current along the south west Cape Coast.

The hydrological data collected in the above-mentioned area during the tuna survey (winter 1960 to autumn 1961) (De Jager, Nepgen and Van Wyk 1962), revealed the following trends:

Winter 1960

The horizontal sections of temperature and salinity show little or no upwelling. The "lack" of isotherms is very prominent and the wide spacing of the isotherms is indicative of uniformity. A portion of Agulhas water has been deflected to the south of Mossel Bay but the remainder has moved in a westerly direction and has persisted as a 100 m thick surface layer.

The main feature illustrated by the vertical section is the almost complete absence of upwelling. Upwelling seems to have occurred to a limited degree to levels below 50 m. Above this cold water, the 0 to 50 m layer seems particularly uniform. The striking part of this section is the 100 m thick homogeneous surface layer extending almost the entire width of the section ($T^{o}C = 16^{o}C$; $S^{o}/oo = 35.44$ to $35.48^{o}/oo$). The narrow salinity range indicates the uniform, well-mixed properties of the layer.

It appears that mixed water with a large component of Agulhas water has been pushed against the coast by westerly winds. The Agulhas water also appears to have exerted an effect below 100 m as shown by the presence of warmer water between the two 16° C isotherms on the 100 M T°C chart.

It is interesting to note that bluefin tuna were found in abundance during this season (see section 2.2) when the above-mentioned conditions prevailed in the area surveyed. No yellowfin tuna were recorded during winter and bigeye and longfin were found in small numbers only.

Spring 1960

Appreciable upwelling has taken place to a subsurface level in the inshore region and the appearance is that of a decaying upwelling system. A tongue of Agulhas water extending to the north has apparently isolated a "pool" of cool water possibly of upwelled origin. However a homogeneous 70 to 80 m thick layer lies to the seaward side of the upwelled water having temperatures of 16.8°C to 16.9°C and salinities of 35.51°/oo to 35.54°/oo. Thermoclines are not evident, except in the 50 to 100 m layer at the stations situated closer inshore.

The cool water at low salinity lying offshore has apparently been pushed seawards by intruding water of Agulhas origin.

Bluefin tuna catches were lower this season than during the preceding one (see section 2.2) when little or no upwelling occurred. The catches were made in the 70 to 80 m thick homogeneous layer (16.8°C to 16.9°C) which lay to the seaward side of the upwelled zone. Longfin, yellowfin and bigeye tuna were recorded in appreciable numbers during spring.

Summer 1960 to 1961

Strong upwelling appears near the coast, in conjunction with a marked thermocline close inshore. A much greater horizontal gradient is apparent. Again most of the Agulhas water is deflected southwards of Mossel Bay and only a ± 100 m thick layer penetrates to the southwest of Cape Point; it then moves north to mix with the cool water and its identity is rapidly lost. It can, however, be traced as a maximum temperature layer containing two 21°C isotherms. This water appears as a "pool" on the vertical section offshore, and the "dip" in the isotherms here also points to the intrusion of Agulhas water. The 15°C isotherm here lies at much the same depth as in spring; it appears that only the surface water has changed and warmed. Little vertical stratification is evident.

During this season of marked upwelling bluefin tuna were caught in minimal numbers (see section 2.2) and it appears that this species prefers water where conditions are uniform. Longfin, yellowfin and bigeye tuna were recorded during summer in small numbers only.

Autumn 1961

Agulhas water of relatively very high temperature (24°C) turns back south of Cape Infanta; an upper 100 m layer appears to proceed as far as south of Cape Point. Upwelling is not vigorous but is still present to a considerable degree. The offshore stations are charcterized by a 30 m thick layer increasing to 50 m seawards in the area of mixed water. The thermocline is marked inshore but is less evident offshore.

Bluefin catches were again minimal during this season (see section 2.2) but longfin and yellowfin tuna were recorded in quantity during autumn. Bigeye tuna were caught in minimal quantities only. Surface temperature data taken over the whole year (winter 1960 to autumn 1961) and plotted against the percentage of times the lines were successfully set in water of a specific temperature range, indicate that bluefin tuna were caught between 15° C and 20° C. The catch rates were highest between 16° C and 17° C (See Fig. 3).

Bluefin tuna occurred in abundance off the south west Cape coast in 1960 to 1961 during winter and spring when little or no upwelling was in evidence, and when a homogeneous water layer (100 m thick) was present. Conditions were uniform during these seasons and a horizontal gradient was not evident. Catches were made to the seaward side of upwelled waters, when upwelling took place. Bluefin tuna catches were minimal during summer and autumn when marked upwelling, coupled with large horizontal gradients, took place in the area.

Longfin tuna were recorded within the temperature range 15° C to 23° C; the catch rates were highest between 17° C and 19° C, (See Fig. 4). Longfin occurred in abundance

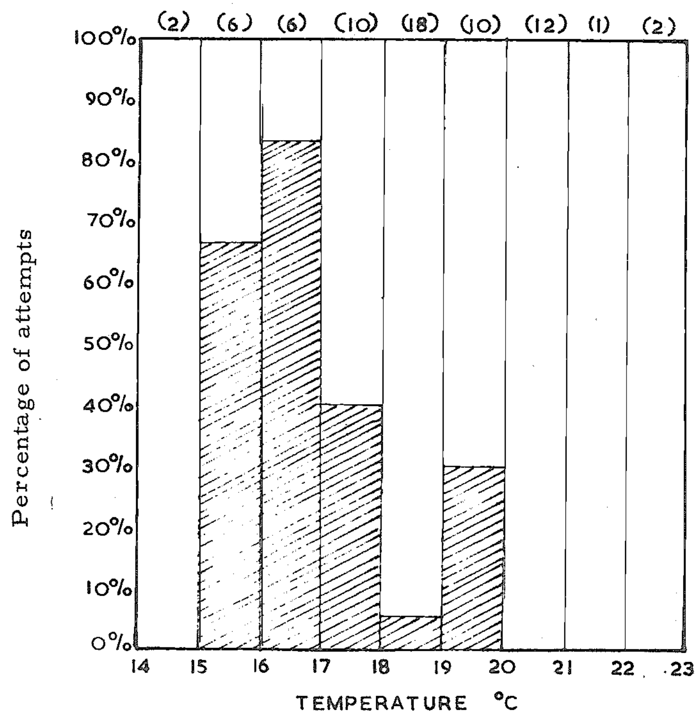

Fig. 3 Bluefin tuna: Percentage of successful attempts at catching tuna for various water temperatures

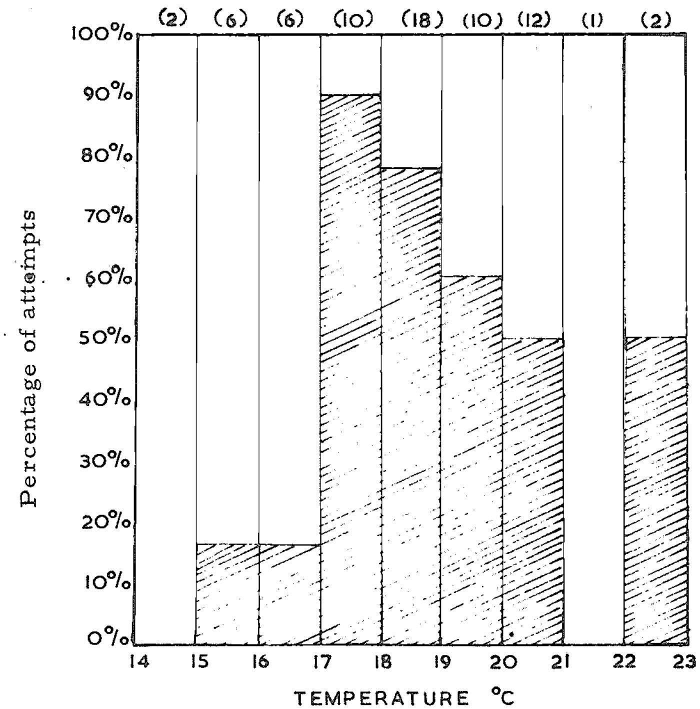

Fig. 4 Longfin tuna: Percentage of successful attempts at catching tuna for various water temperatures

Legend
unsuccessful attempts
successful attempts
( ) number of attempts

during spring (1960) and autumn (1961) (See section 2.2). In spring appreciable upwelling occurred in the inshore region but the longfin catches were made to the seaward side of upwelled waters. During the summer when upwelling was marked, longfin catches were much lower than during spring. In autumn longfin tuna occurred in abundance when upwelling was less vigorous.

Yellowfin tuna were caught within the temperature range of 17°C to 21°C; the catch rates were highest between 20°C and 21° C (see Fig. 5). Although yellowfin occurred in far smaller numbers than longfin, their maximum occurrence was recorded in the same seasons, viz. spring and autumn. During winter yellowfin were not recorded within the surveyed area.

Bigeye tuna were recorded within the temperature range 16° C to 21° C; the highest catches were recorded between 18° C to 19° C (See Fig. 6). This species occurred in relatively large numbers during winter and spring.

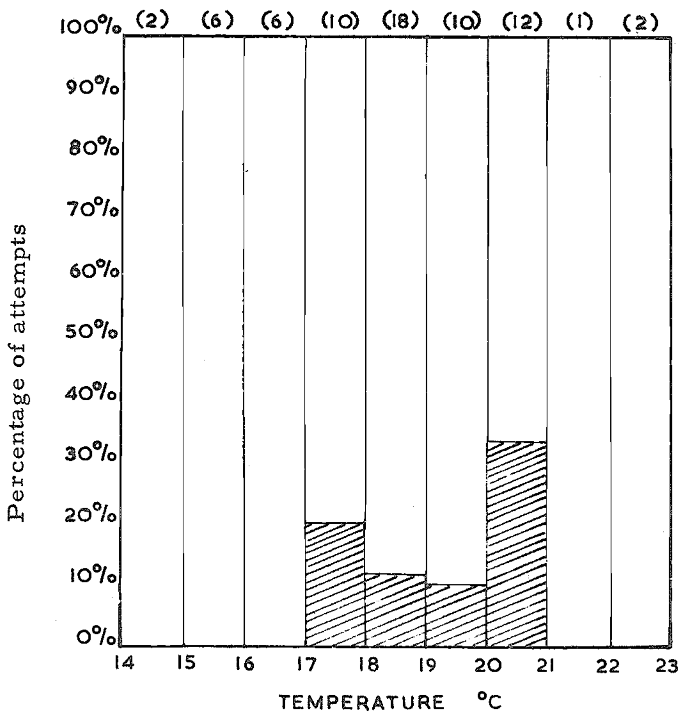

Fig. 5 Yellowfin tuna: Percentage of successful attempts at catching tuna for various water temperatures

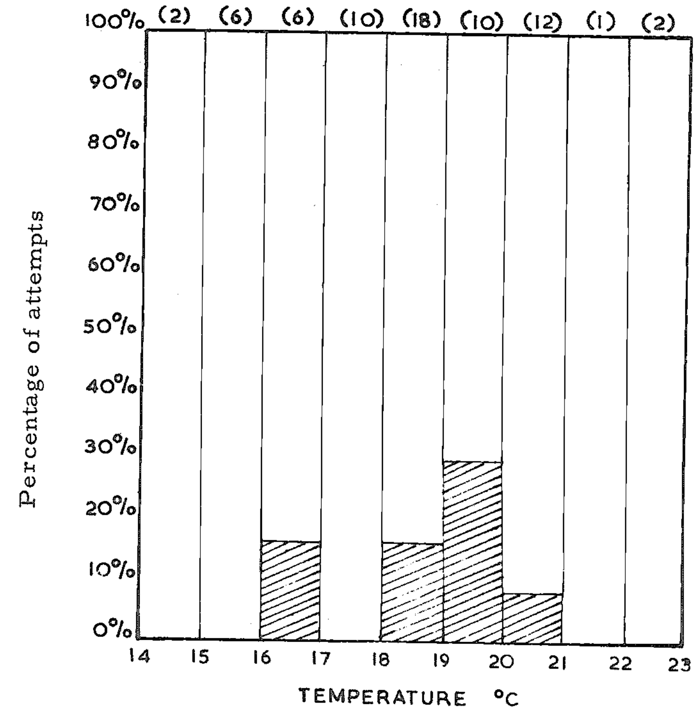

Fig. 6 Bigeye tuna: Percentage of successful attempts at catching tuna for various water temperatures

Legend: unsuccessful attempts; successful attempts

( ) number of attempts

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

All species appear to be heterosexual; no instance of intersexuality was recorded.

3.1.2 Maturity (age and size)

No breeding fish were encountered

3.1.8 Egg: structure, size, hatching type, parasites and predators

Eggs were not present in the plankton catches in the surveyed area.

3.3 Adult history

3.3.1 Longevity

Bluefin tuna; the length range varied between 88 cm to 172 cm for the period winter 1960 to autumn 1961. The corresponding weight range was 35 to 220 lb. According to Sella (1929), age/weight relationship for the Mediterranean bluefin a South African bluefin of 172 cm would be 8 years old if the growth rates of the two species are comparable.

Longfin tuna; the lengths recorded for the period under review were 68 to 118 cm with a corresponding weight range of 15 to 65 lb.

Yellowfin tuna; the length range varied between 82 and 156 cm with a corresponding weight range of 25 to 160 lb. Pacific yellowfin (Migdalski 1958) of 50 lb weight are ± 2.5 years of age; of 100 lb weight they are ± 3.5 years of age; in 6 years the tuna reaches approximately 200 lb. If the growth rates of the South African yellowfin and the Pacific yellowfin were comparable, then our biggest yellowfin will be ± 5 years old.

Bigeye tuna; the length ranged between 104 to 160 cm and the weight range was between 50 and 200 lb.

3.3.2 Hardiness

All four species are robust and firm and are not easily damaged.

3.3.3 Competitors

The following are the possible competitors occurring in association with the four tuna species in the surveyed area:

Blue shark -	Glyphis glaucus
Mako shark -	Isurus glaucus
Brown shark -	Carcharinus obscurus
Thrasher shark	Alopias vulpinus
Moonfish -	Lampris regius
Angelfish -	Brama raii
Frigate mackerel	Auxis thazard
Mackerel -	Scomber japonicus
Lancetfish -	Alepisaurus ferox
Stockfish -	Merluccius capensis
Snoek -	Thyrsites atun
Yellowtail -	Seriola lalandi
Skipjack -	Euthynnus pelamis
Gannet -	Morus capensis
Cormorant -	Phalacrocorax capensis
Cape Penguin	Spheniscus demersus
Wandering Albatross -	Diomedea exulans
Cape Fur Seal	Arctocephalus pusillus
Sperm Whale -	Physeter catodon
Sei whale -	Balaenoptera borealis

3.3.4 Predators

The following species are considered predators of the four tuna species:

Blue shark -	Glyphis glaucus
Mako shark -	Isurus glaucus
Thrasher shark	Alopias vulpinus
Brown shark -	Carcharinus obscurus

3.3.6 Greatest size

Bluefin tuna	172 cm
Longfin tuna	118 cm
Yellowfin tuna	156 cm
Bigeye tuna	160 cm

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

All four species are all selective feeders of a voracious nature.

3.4.2 Food (type, volume)

The food of the tuna may be broadly classified in invertebrates and vertebrates; of these the following were important items in the diet:

Crustaceans:	*Funchalia woodwardii*
	Phronima
	Puerulus stages of *Jasus lalandii*
	Megalopa crab larvae
Cephalopods:	*Cranchia scabra*
	Loligo reynaudii
	Octopoteuthis sicula
	Argo nodosa
Fish:	*Sardinops ocellata*
	Merluccius capensis
	Auxis thazard
	Myctophum humboldti
	Myctophum cocco
	Centropholoides falcatus
	Scomber japonicus
	Oreosoma atlanticum
	Alepisaurus ferox
	Brama raii
	Lepidopus caudatus
	Gempylus serpens

3.5 Behavior

3.5.1 Migration and local movements

(See section 2.2).

3.5.2 Schooling

Longfin and yellowfin tuna were observed in extensive schools at the surface. At no time were bluefin and bigeye observed in surface schools.

Table II

Stomachs analysed

	Bluefin		Longfin		Yellowfin		Bigeye	
	No.	%	No.	%	No.	%	No.	%
Stomachs containing food	50	52.6	54	79.4	22	84.6	10	90.9
Empty stomachs	45	47.4	14	20.6	4	15.4	1	9.1
Total	95	100.0	68	100.0	26	100.0	11	100.0

Table III

Percentage of stomachs in which various food types occur

Type of food	Occurred in percentage of:			
	Bluefin Stomachs	Longfin Stomachs	Yellowfin Stomachs	Bigeye Stomachs
	%	%	%	%
Fish	12	54	65	27
Crustaceans	24	44	23	18
Cephalopods	18	34	19	73
Tunicates	1	4	4	-
Other	-	-	4	-

Table IV

Percentage of weight of various food types found in tuna stomachs

Type of food	Percentage (by weight) of food types in:			
	Bluefin Stomachs	Longfin Stomachs	Yellowfin Stomachs	Bigeye Stomachs
	%	%	%	%
Fish	40	55	85	26
Crustaceans	20	22	4	18
Cephalopods	40	21	7	56
Tunicates	-	2	1	-
Other	-	-	3	-
Total	100	100	100	100

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

The ratios of male to female tuna caught from June 1960 to May 1961 were as follows:

	Males	Females	Ratio males/ females
Thunnus thynnus orientalis	131	81	1.6:1
Thunnus alalunga	96	48	2:1
Thunnus albacares	26	17	1.5:1
Thunnus obesus	22	22	1:1

4.1.2 Age composition

See section 3.3.1.

4.1.3 Size composition

Figs. 7(a) to 10(b) show length frequency distribution, separately for males and females for the four species, caught from June 1960 to May 1961.

Length-weight relationship; the length-weight relationships, expressed in exponential form, are given below for the various species. In each case "W" represents weight in lb, and "L" length in cm.

Thunnus alalunga

$W = 5.088 \times 10^{-5} \times L^{2.98}$ males
$W = 3.094 \times 10^{-5} \times L^{3.09}$ females

Number of fish examined:

males = 96
females = 47

Thunnus thynnus orientalis

$W = 6.394 \times 10^{-5} \times L^{2.92}$ males
$W = 4.831 \times 10^{-5} \times L^{2.98}$ females

Number of fish examined:

males = 131
females = 81

Thunnus albacares

$W = 1.796 \times 10^{-5} \times L^{3.18}$ males [1/]
$W = 8.800 \times 10^{-5} \times L^{2.85}$ females

Number of fish examined:

males = 17
females = 26

Thunnus obesus

$W = 1.8172 \times 10^{-4} \times L^{2.72}$ males
$W = 1.2810 \times 10^{-4} \times L^{2.79}$ females

Number of fish examined:

males = 22
females = 22

4.6 Relation of population to community and ecosystem, biological production, etc.

See sections 2.1, 2.2 and 2.3.

1/ In the case of the male yellowfin only seventeen specimens were examined. Some modification of the length-weight relationship obtained might, therefore, possibly occur if more fish were to be included in the sample.

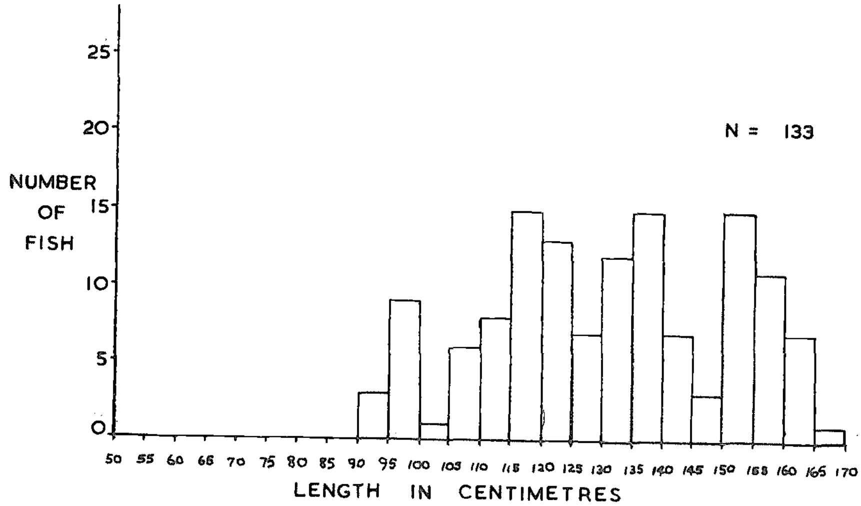

Fig. 7(a) Bluefin tuna males length-frequency distribution

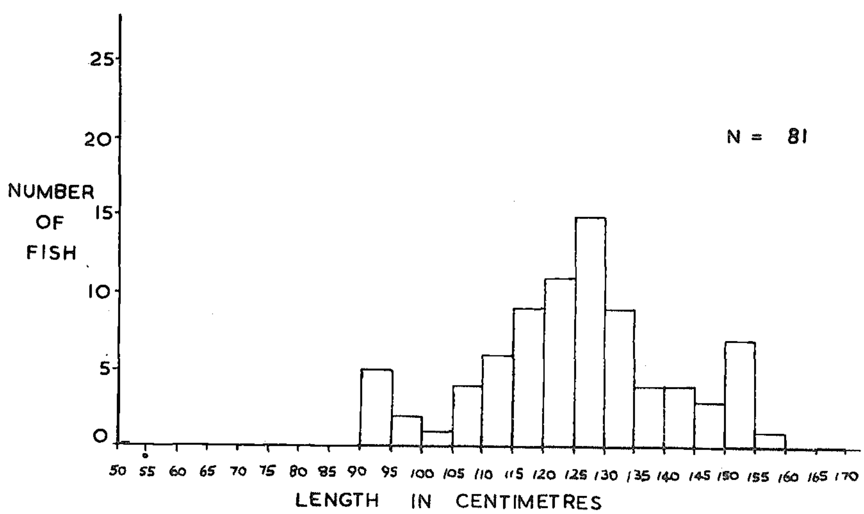

Fig. 7(b) Bluefin tuna females length-frequency distribution

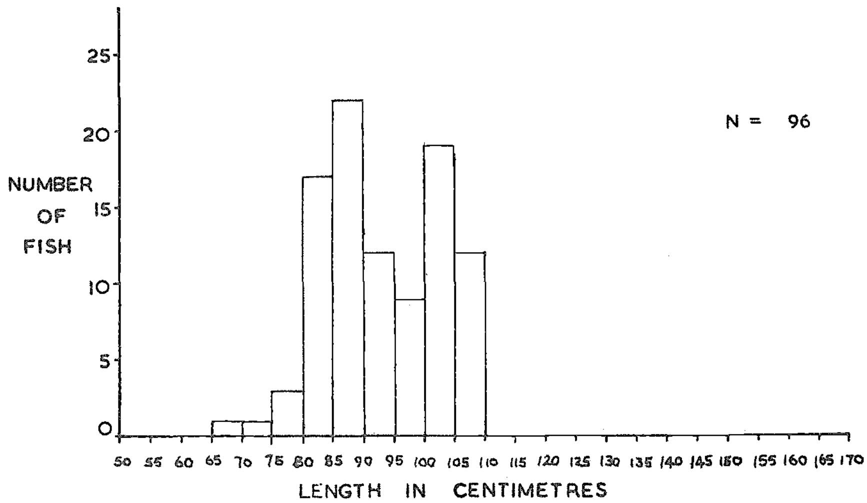

Fig. 8(a) Longfin tuna males length-frequency distribution

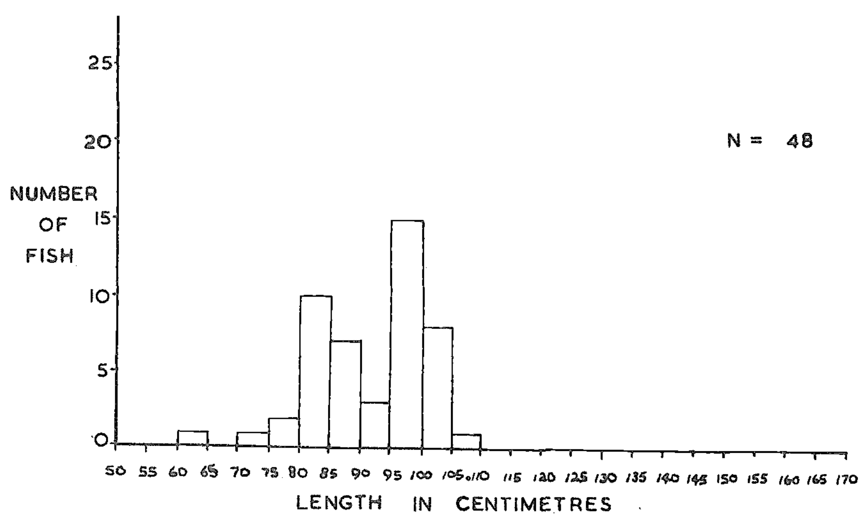

Fig. 8(b) Longfin tuna females length-frequency distribution

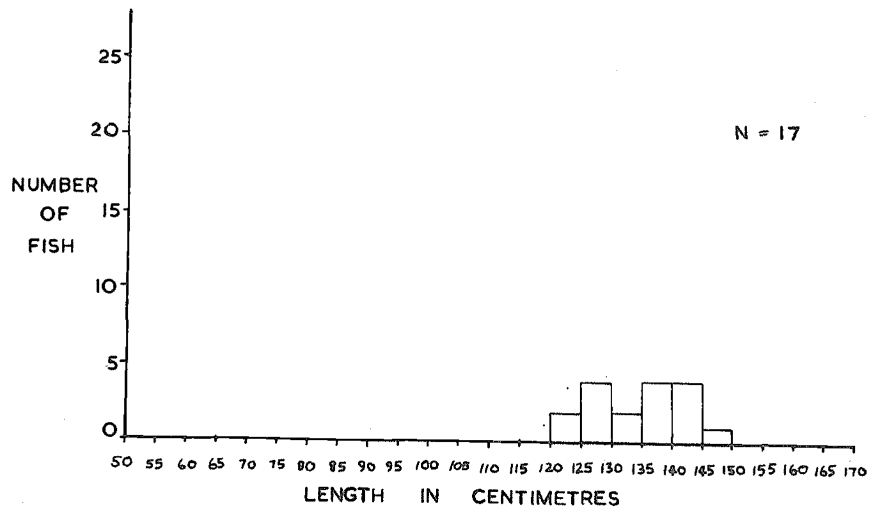

Fig. 9(a) Yellowfin tuna males length-frequency distribution

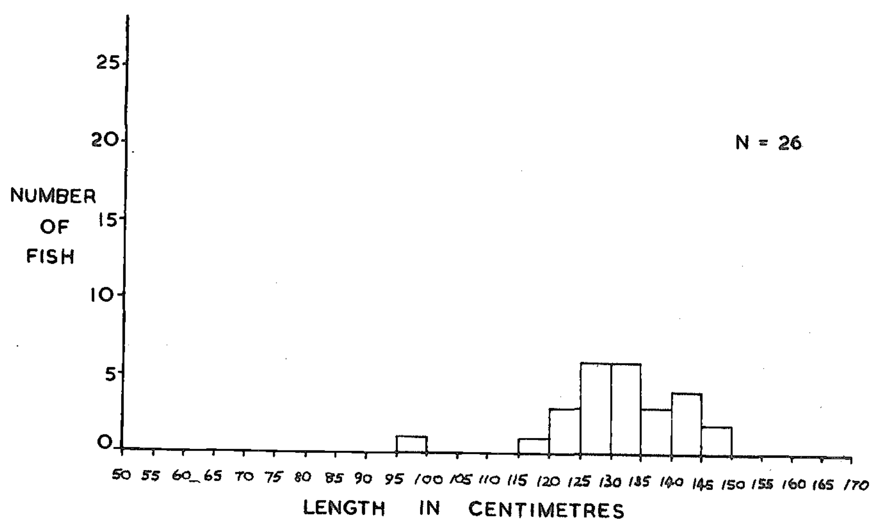

Fig. 9(b) Yellowfin tuna females length-frequency distribution

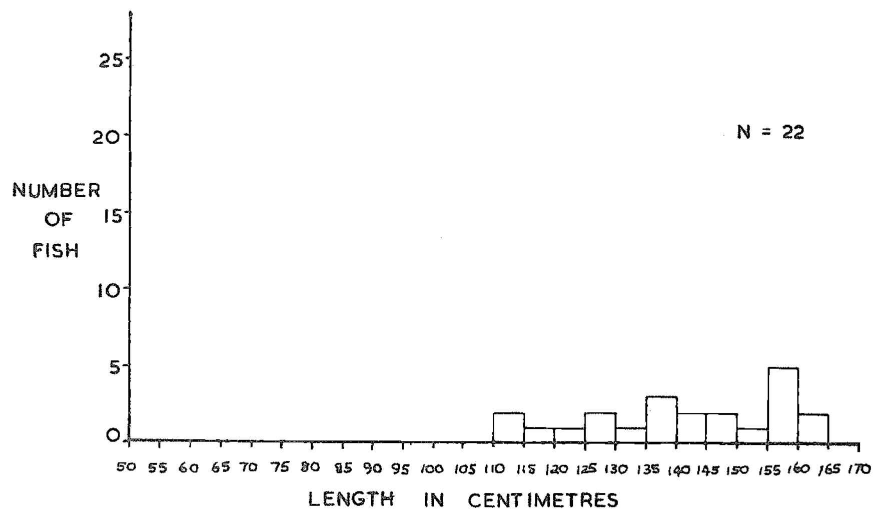

Fig. 10(a) Bigeye tuna males length-frequency distribution

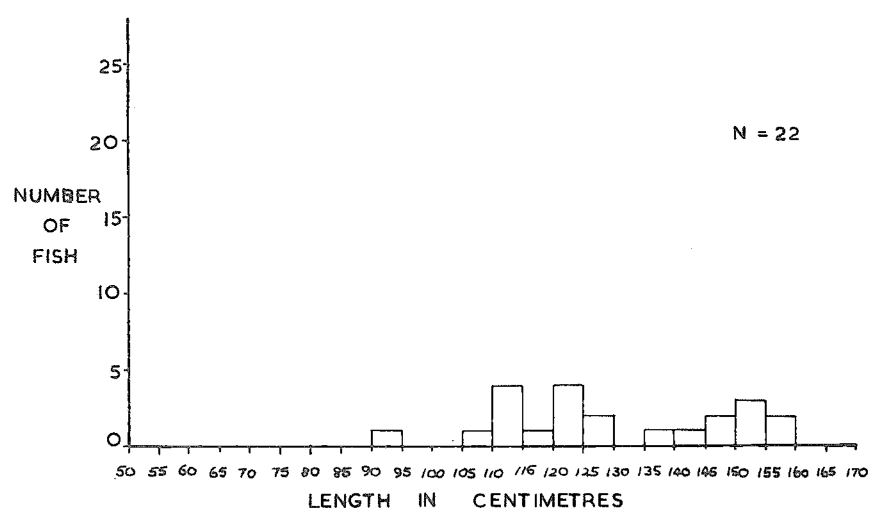

Fig. 10(b) Bigeye tuna females length-frequency distribution

5 EXPLOITATION

As the South African commercial tuna fishery is still in its infancy, very little can be said. Up to the present, tuna have been caught only by long-lining, and the pattern of the fishery with regard to boats, equipment, seasons and areas is not yet clear.