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SYNOPSIS OF BIOLOGICAL DATA ON SPECIES OF THE GENUS
Thunnus (Sensu lato) (SOUTH AFRICA)

Exposé synoptique sur la biologie des espèces du genre
Thunnus (Sensu lato) (Afrique du Sud)

Sinopsis sobre la biología de las especies del género
Thunnus (Sensu lato) (Sudáfrica)

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Thunnus alalunga

1 IDENTITY

1.1 Taxonomy1.1.1 Definition^{1/}

A Thunnus with liver densely striated with veins ventrally; cutaneous blood vessels passing through the myotome of the 5th vertebra; with pectoral long, at least reaching beyond the 2nd dorsal; and a total count of 27 to 30 gill-rakers on the first arch.

1.1.2 Description^{2/}

Torpedo-shaped body, less deep and less compressed than most tunas.

Proportions: (expressed as a percentage of fork length). Head, 29 to 30; depth, 25 to 27; eye, 5.3 to 5.7; maxilla, 10 to 12; pectoral length, 40 to 42; first dorsal height, 11 to 12; second dorsal height, 11 to 11.9; anal height, 11 to 12; snout to first dorsal origin, 31 to 34; snout to second dorsal origin, 58 to 60; snout to ventral 33 to 34; snout to anal, 62 to 66; (based on six specimens 741 to 818 mm).

Scaling typical for the genus.

Fin counts: Dorsal XIII-XIV, 20-23 (the last 7 to 8 as separate finlets). Anal, 22 to 23 (the last 7 as separate finlets).

Gill rakers: total, 27 to 30. Upper limb, 7 to 9; lower limb, 19 to 21.

Color: Blue-black above, silver-grey below spinous dorsal hyaline, dusky tipped. Soft dorsal grey with a dusky leading edge and white trailing edge. Dorsal finlets dusky, with white trailing edge. Anal silver-grey with dark leading edge and hyaline trailing edge. Anal finlets hyaline with anterior black patch. Ventral dusky. Differing from other Thunnus

species in having a clear white edge to the caudal.

Liver: Center of the three lobes largest. Densely striated with surface veins ventrally, similar to bluefin tuna.

Swim bladder: Wide, and running nearly the full length of the body cavity, with marked pit anteriorly, not divided into two by a connective tissue wall as found in the bigeye tuna, but may be slightly cleft anteriorly (three specimens dissected).

1.2 Nomenclature

1.2.1 Valid scientific name

Thunnus alalunga (Bonnaterre)

1.2.2 Synonyms^{1/}

Scomber alalunga Bonnaterre, 1788, p.139 (based on Cetti, 1777, p.191, Sardinia).

Thynnus alalunga, Günther, 1860, p.366 (Cape of Good Hope), Gilchrist, 1902, p.128 (Cape of Good Hope). Thompson, 1918, p.108 (Cape of Good Hope).

Germo alalunga, Barnard, 1927, p.799 (South African West Coast).

Germo alalunga, Molteno, 1948, p.29 pl.1, fig.6 (Cape, South West Africa); Smith, 1949, p.299, pl.66 (Cape, Natal).

Thunnus alalunga Talbot, 1962; Talbot & Penrith, 1962, p.558 (Cape).

1.2.3 Standard common names, vernacular names

General: Albacore;

Local: longfin tunny, longfin tuna, langvin tuna.

^{1/} Only synonyms used for material from South Africa are given.

^{2/} Definitions and descriptions are based throughout on South African material.

2 DISTRIBUTION

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

The total area of distribution of the species discussed in this paper is not shown by this survey. Below follows a brief ecological description of the area surveyed^{1/}

Physical Environment: The physical environment of the area surveyed differs markedly between the west and southeast coasts (Figs. 1 and 2). The southeast coast is dominated by the fast-flowing (two to four knots) sub-tropical Agulhas Current, a southerly offshoot of the South Equatorial Current. This runs down the east coast of Africa, and in the area surveyed moves outwards, away from the coast, following approximately the edge of the continental shelf, which broadens towards the southern end of the continent forming the Agulhas Bank. Inside the Agulhas Current lies a belt of cooler water, which may form a slow inshore counter-current. Temperatures in the Agulhas Current east of the Agulhas Bank in the area surveyed range from 20°C (winter) to 25°C (summer). The bulk of the Agulhas Current is thought to move southward until it reaches the west wind drift, then to turn back into the Indian Ocean as the Agulhas Return Current. In summer, under certain conditions, Agulhas Current water is thought to round the Agulhas Bank and enter the Atlantic Ocean, mixing with South Atlantic sub-tropical water outside the cold inshore Benguela Current (Fig. 2). During the summer months surface temperatures of up to 21°C have been recorded right round the Cape (S.A. Division of Fisheries, Annual Report 1958) conditions which would allow even the warmer-water tunas of the area (T. obesus, T. albacares) to move from the Atlantic into the Indian Ocean and vice versa.

In the west coast area, cool water rich in plant nutrients is upwelled and runs northward close inshore as the Benguela Current (approximate surface temperatures: 12 to

16°C). Outside the Benguela Current (restricted as after Hart and Currie, 1960, to the cool upwelled water only) lies warmer, higher salinity water, probably derived from surface South Atlantic water (approximate surface temperatures: summer 20°C, winter 16°C).

The sea areas covered during the survey can therefore roughly be divided into three:-

a) Agulhas Current water. Surface temperatures 20 to 25°C; surface salinities high, above 35.5 pts. per thousand (Clowes 1950; Zoutendyk 1960).

b) Benguela Current water. Surface temperatures 12 to 16°C; surface salinities low, approximately 34.7 to 35.3 pts. per thousand (S.A. Division of Fisheries, Annual Report, 1958, 1960).

c) South Atlantic sub-tropical surface water. Surface temperatures 15.5 to 21°C; surface salinities 35.3 to 35.9 pts. per thousand (Clowes 1950).

No fishing was done in the cooler water inshore of the Agulhas current, as this water lies over the shelf, and the gear design which was used was fished to 80 fathoms on its deeper lines.

In all the three waters fished tunas were found, but the species composition varied markedly between some of them. This will be discussed under 2.2.1 for each species.

Biotic Environment: Few data were recorded on the biotic environment during this survey. The Isaacs-Kidd mid-water trawl did not, as has been found elsewhere, catch the larger and faster-moving forage animals. The Agulhas Current, which carries a low plankton load, was found to be poor in tunas. On the west coast the Benguela Current is extremely rich in plant nutrients, and carries such a heavy plankton flora and fauna that the border between it and the South Atlantic

^{1/} Ecological characterization of this area is dealt with more fully in Species Synopsis No. 18

sub-tropical water is often clearly marked, with the opaque greenish water of the Benguela Current ending abruptly with very clear blue water to the west of it. The Benguela Current water is rich in forage animals of all kinds, larger elements of the plankton, cephalopods and pelagic fishes such as the pilchard (Sardinops ocellata). The South Atlantic sub-tropical water is like the Agulhas Current, a relatively impoverished body of water, and the bulk of the tuna seem to be associated with the upwelled water that forms the Benguela Current, or with its border.

2.2 Differential Distribution

No specimens smaller than 631 mm were caught during the survey, and juvenile stages are not recorded from the area.

T. alalunga was found only in the Atlantic area surveyed, no specimens being taken west of Cape Agulhas on the southeast coast.

A clear differential distribution pattern was shown between mature (over 850 mm) fish and immature fish. In the southern winter (May to September), both were present in the catches (see Fig. 3), but in summer there is an almost complete lack of the adult fishes.

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

The picture given above for adults and juveniles T. alalunga is presumably determined by breeding behavior. As no evidence of breeding has been shown in this area from gonad examination, it is reasonable to assume that the adults are leaving the area in the southern summer to breed in some other area. This is probably in warmer water, and a migration to a more tropical Atlantic area would be in accordance with the findings in the Pacific (Brock and Marr 1960). Long-lining west of Walvis Bay has shown this species to be present there.

The reasons for our not finding this species in the Indian Ocean area of the survey are not easy to understand. The species was caught on the outermost stations west of the Cape Peninsula, in water whose salinity and temperature was very similar to Agulhas Current water. Nor were the two other species associated with it in summer. T. albacares and T. obesus limited only to the Atlantic area in this way. It is possible that this distribution pattern may be connected with the fact that T. alalunga is able to enter the cool upwelled west coast water with its unusually rich feeding. Katuoka (1957) also mentions a dearth of this species in the southwest Indian Ocean.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.2 Maturity: (age and size)

No ripe fish were taken during the course of the survey but all fish over about 850 mm fork length (measured as defined by Marr and Schaefer 1949) had mature gonads. This is in agreement with most recent work: that *T. alalunga* matures at about 850 mm (Bell 1961; Uchida and Otsu 1961; Clemens 1961; Otsu and Hansen 1961; Mimura 1957). This is substantiated by the great seasonal changes in populations of *T. alalunga* off the Cape coast. Smaller fish are present at all times of year but fish of over 900 mm fork length are present only during winter (May to September), suggesting that these larger fish depart to spawn.

Fish of 850 mm are believed to be five years old (Uchida and Otsu, 1961; Aikawa and Kato 1938).

3.1.6 Spawning

If it is assumed that the fish of over 900 mm fork length depart to breed, the spawning season is during the southern summer (October to April). This is in accordance with findings in the Pacific, where albacore are considered to move to tropical and sub-tropical areas to spawn in summer (Brock and Marr 1960). As albacore were never found on the southeast Cape coast it is probable that they move northwards into warmer areas of the Atlantic to spawn.

3.3 Adult history

3.3.3 Competitors

T. alalunga has a very wide range of food, feeding both on macroplankton and larger, deeper living forage organisms. Thus its food requirements compete to some extent with both surface feeding tunas (*T. albacares*) and deeper feeding species (*T. thynnus* and *T. obesus*). More important competitors however are probably *Coryphaena hippurus* (small fish and crustaceans) and *Alepisaurus ferox* (crustacea) which

were found to prey on many of the same species of food organisms.

3.3.4 Predators

Predators of *T. alalunga* are presumably limited to large, fast swimming animals in the area surveyed where the smallest specimens of *T. alalunga* taken were over 600 mm fork length. Possible predators are the marlins (*Makaira* spp.) of which four species are known from this area (Talbot and Penrith 1962); broad bill swordfish (*Xiphias gladius*); and mako sharks (*Isurus glaucus*). Remains of *T. alalunga* have been found in *Isurus glaucus* and black marlin (*Makaira indica*). No remains of *T. alalunga* have been found in any tuna in this area.

3.3.5 Parasites and diseases

Few parasites have been found in *T. alalunga* other than two types of gut parasites, a nemertine and a digenetic trematode. There were in addition occasional external copepod parasites, which will form the basis of further study.

Occasional fish showed a strange condition of the body cavity in which all the organs were contained in a mass of sticky fibrous mesentry.

3.3.6 Greatest size

The largest specimen of *T. alalunga* taken during the survey undertaken by the South African Museum was 1,191 mm fork length.

3.4 Nutrition and growth

3.4.1 Feeding

Time: *T. alalunga*, in common with the other species of tuna off the Cape do not seem to feed at night. Longlines laid at night in areas where large catches were made during the day have caught nothing. In addition, lines laid at dawn catch more than lines laid in the middle of the day, suggesting a major feeding period in the early morning. This is substantiated by the results of sports fishermen

who find a great decline in catches in the late morning. It is probable, however, that a lesser amount of feeding is carried out all the time, increasing towards evening, as fish caught in the late afternoon contain undigested food in the stomach.

This supposition of two main feeding periods is in agreement with the findings of Uda (1940) when working with Katsuwonus pelamis.

Place: Judging by stomach contents, T. alalunga feed at all depths from the surface down to at least 80 fathoms. This is shown by the wide range of food organisms, from macroplankton such as megalopa larva which have only been taken at the surface in Isaac-Kidd trawls, to fish such as Merluccius capensis which seldom reach the surface.

Manner: T. alalunga often feeds on transparent larvae such as those of Jasus lalandii which suggests that at times they may feed by chance rather than sight, for these larvae, if placed in water, are virtually invisible.

3.4.2 Food

Type: As has been stated above, T. alalunga has a wide variety of foods ranging from amphipoda to large fishes and prawns.

Important foods of T. alalunga are:

Fish: Merluccius capensis Castelnau
Lepidopus caudatus (Euphransen)
 Myctophids, and
 many small larval and juvenile fish.

Squid: Loligo reynaudi d'Orb

Abralia gilchristi Robson and
 many other small species as yet unidentified.

Amphipoda: Phrosina semilunata
 Risso

Parapronoë crustulum
 Claus

Platyscellus armata (Claus)

Phronima sedentaria (Forsk.)

Prawns: Funchalia woodwardi Johnson

Crustacean larvae: Megalopa larvae of various types.

Jasus lalandii both phyllosoma and puerulus Stomatopoda.

A further important organism was the "house" of Phronima sedentaria

More occasionally other organisms such as heteropod and pteropod molluscs, anomuran larva, euphausiids and decapod larvae were found.

On a number of occasions bird feathers and ships' galley scraps were also found.

The above results show essential agreement with the findings of Yabuta (1953), although much large food is taken, practically all fish have small crustacea (megalopa and amphipoda, etc.) and often small fish and squid, suggesting a dependence to quite a large extent on macroplankton.

Volume: During the course of the survey 918 stomachs of T. alalunga were kept and examined. Since much of the food still requires detailed identification, only major groupings are used in the present paper.

Of the various methods of evaluating food components and their importance, two are here used, the volumetric method, including the percentage of total food volume, and also the frequency of occurrence expressed as a percentage of the total number of fish examined.

Table I
Importance by volume and percentage occurrence of the major food of
T. alalunga

Food	Volume of food in ccs	Volume of food as percentage of total volume	Percentage occurrence
Fish	11,877.1	40.4	49.5
Squid	11,508.4	39.1	47.8
Amphipoda	2,382.9	8.1	66.7
Prawns	1,425.7	4.8	11.6
Palinuridae	808.8	2.7	32.0
Megalopa	710.9	2.4	37.3
Tunicata ^{1/}	576.5	2.0	29.3
Stomatopoda	124.4	.4	15.6
Other foods	28.5	.1	9.3
	29,443.2		

^{1/} Tunicata includes the transparent "houses" of Phronima

It is clear from the table above that the two major foods of T. alalunga are fish and squids, which were of about equal importance and accounted for nearly 80 percent of the food by volume. Both were found in nearly 50 percent of the fish examined. Unlike the other species of tuna examined, however, T. alalunga had a large number of small food organisms, important by percentage occurrence, but of lesser importance by volume. This includes amphipoda, especially Phrosina semilunata which was important at all times of year, megalopa larvae, also present throughout the year although the species composition varied, and both Phyllosoma and Puerulus larvae of Jasus lalandii, important October to December. Female Jasus lalandii are known to be in berry in this area from May to

August (C. von Bonde 1936).

Only a small number (9.7 percent) of the fish examined were empty, but a large number had only a small amount of food, 50.1 percent having less than 10.0 cc of food in the stomach, 7.5 percent had more than 100.0 cc, while no fish examined had more than 1,000.00 cc of food (Table II).

3.4.3 Relative and absolute growth patterns and rates

Very little is known concerning growth patterns in this area, what is known is dealt with under sections 4.1, 2 and 4.1.3

Table II
Occurrence of different volumes of stomach contents in T. alalunga

Arbitrary Scale of Volumes	Number	Percent	Accumulative Number	Accumulative Percent
Empty	89	9.7	89	9.7
.1 - 1.9	124	13.5	213	23.2
2.0 - 4.9	120	13.1	333	36.3
5.0 - 9.9	127	13.8	460	50.1
10.0 - 24.9	197	21.4	657	71.5
25.0 - 49.9	107	11.7	764	83.2
50.0 - 99.9	85	9.3	849	92.5
100.0 - 199.9	43	4.7	892	97.2
200.0 - 499.9	22	2.4	914	99.6
500.0 - 999.9	4	.4	918	100.0
	918	100.0		

3.5 Behavior

3.5.1 Migration and local movements

(See section 2.1).

No statistical analysis of the catches has so far been attempted, but a study of the log book, kept for recording each hook as it came aboard, suggests that at times T. alalunga were in small compact schools at a single depth, while on

other occasions this distribution was random. The most surprising result was the way fish were very often bunched, several baskets being empty and then one or two baskets would take several fish at all hook depths. The only explanation we can suggest is that a school of fish near the surface took the baits before they had sunk to their fishing depths.

3.5.3 Reproductive habits

Nothing known as fish do not spawn in this area.

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

The sex is known for 857 T. alalunga taken in the course of the survey. Of these fish, 511 (59.7 percent) were males and 346 (40.3 percent) were females. This predominance in numbers of males is probably significant as of all cruises undertaken, only in one was the proportion of females greater than males.

4.1.2 Age composition

4.1.3 Size composition

Thunnus alalunga is interesting because it is the only tuna species found off the Cape at all times of year in large numbers. Although no detailed work on length frequencies has yet been attempted, length frequency plotting suggests the following:

Modal Length	Increase	Probable Age
mm	mm	
650		3
	90	
750		4
	80	
830		5
	70	
900		6
	80	
980		7
	50	
1,030		8

Probable ages are based on the work of Uchida and Otsu (1961), although both faster growth (Clemens 1961) and slower growth rates have been suggested (Aikawa and Kato 1938).

Beyond 1.030 mm fork length there are no definite modes, but fish up to 1,191 mm fork length have been taken.

4.2 Size and density

4.2.1 Average size

4.2.2 Change in size

Because of the great seasonal change in size of the T. alalunga population average size cannot be discussed separately from changes in size (See Fig. 5).

In summer the average size of the fish is about 880 mm fork length, with the majority of fish being this size. In winter the average size is about 1,000 mm, but with the major mode lying between 1025 and 1049 mm, the difference between average size and this mode being due to the fish in the 880 mm mode still being present in quantities equal to those in summer.

4.2.3 Average density

The average density of T. alalunga as shown by catch rates was large. A total of 949 fish were taken on 9,372 hooks set, giving a catch rate of 10.1 percent.

4.2.4 Changes in density

As shown in Table III, T. alalunga was most plentiful in winter when the average size was also greater. While less plentiful it was still present in large numbers in summer.

Table III

Catch rates of T. alalunga at various seasons of the year

Season	No. of Hooks set	No. of fish taken	Hook rate as a percentage
Summer	1230	78	6.5
Autumn	4182	425	10.2
Winter	1608	218	13.6
Spring	2352	228	9.7

Thunnus albacares

1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Liver unstriated, with longer right lobe; marked rod of connective tissue pressing into the swim bladder from the dorsal body wall; soft dorsal and anal fins long, above 17 percent in fish over a meter long.

1.1.2 Description

Body shape similar to Thunnus thynnus, but typically somewhat less deep. Larger fishes have strikingly elongated soft dorsal and anal fins. The pectoral is longer than in T. thynnus, being over 24 percent of fork length and usually reaching at least to the origin of the soft dorsal.

Proportions (expressed as percentages of fork length): Head, 24 (l)^{1/} to 29 (s)^{1/}; depth, 24 to 28; eye, 3.2 (l) to 6.2 (s); maxilla 9.6 to 12; pectoral length, 24 (l) to 29 (s); 1st dorsal height, 11 to 13; 2nd dorsal height, 13 (s) to 34 (l); anal height 11 (s) to 38 (l); snout to 1st dorsal origin, 30 (l) to 32 (s); snout to 2nd dorsal origin 49 (l) to 56 (s); snout to ventral origin, 27 (l) to 33 (s); snout to anal origin, 56 (l) to 62 (s) (based on 11 specimens 592 to 1,661 mm).

Scaling on body: Body fully scaled. Head naked except for the cheek and a band of scales reaching to above the eye. Corselet of larger scales distinct.

Fin counts: Dorsal XIII-XIV, 22 to 23 (8 to 9 posterior rays separated as finlets). Anal 22 (7 to 9 as separate finlets).

Gill rakers: Total 27 to 31 on first arch. Upper limb, 8 to 10, lower limb, 19 to 21.

Color: Body blue-black above to a line from upper corner of opercle, slightly curving down to the caudal keels. In life a golden band below this to upper edge of pectoral, which fades quickly on death. Lower body silver-grey with a pattern of alternating paler bars and rows of spots. Spinous dorsal with yellow or pale

spines and dusky blue membrane. Second dorsal yellow distally. Trailing edge with a fine dark rim. Anal silver-yellow distally and with a fine dark rim. Dorsal and anal finlets bright yellow with narrow black rim (sometimes no black on anal). Some specimens may have white tips to the elongate soft dorsal and anal. Pelvic with yellow or pale rays, membrane dusky blue.

Liver: No peripheral surface striations (occasionally a few striations are present). Right lobe markedly elongate unlike other members of the genus.

Swim bladder: Narrow and elongate, reaching halfway down the body cavity. No clearly defined anterior pits. A dense rod of connective tissue running down the dorsal wall of the body cavity protrudes into the swim bladder, dividing just behind a shallow anterior pit.

1.2 Nomenclature

1.2.1 Valid scientific names

Thunnus albacares (Bonnaterre) 1788.

1.2.2 Synonyms

Scomber albacares Bonnaterre, 1788, p. 140 (Based on Sloan, 1707, Madeira).

Neothunnus itosibi, Smith, 1935, p. 207 (Cape), Molteno, 1948 p. 33, pl. 1, fig. 8 (Cape).

Germo albacora, Molteno 1948, p. 20 pl. 1, fig. 2 (Cape and Natal). Smith, 1949, p. 299, pl. 66 (Cape and Natal).

Germo itosibi, Smith, 1949, p. 299, pl. 65 (Cape).

Thunnus albacares, Talbot, 1962 (Cape); Talbot & Penrith, 1962, p. 558 (Cape).

1.2.3 Standard common names, vernacular names

Yellow tuna, yellowfin tunny.
Local: Yellowfin tunny, yellowfin tuna, geelvin tuna.

^{1/} Note: (l) and (s) means largest and smallest in the proportions

2 DISTRIBUTION

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

World-wide in tropical and sub-tropical waters.

Locally this species occurs in all areas except the cool Benguela Current area.

2.2 Differential distribution

No juvenile stages known. Immature fish as small as 535 mm have been taken.

The seasonal distribution of this species is very similar to that of T. obesus. It is common, and occasionally abundant in summer off the western Cape coast, and disappears entirely from this area in winter. The species differs from T. obesus in often being found in huge surface shoals, mainly in March

in the relatively shallow areas of False Bay and the Agulhas Bank. The deeper-swimming T. obesus was not taken in these areas.

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

Although to prove determinants of distribution is not possible at this stage, rich feeding off the Western Cape coincides with dense concentrations of the species, and relatively poorer feeding in the Agulhas Current with lower concentrations. Lower winter temperatures off the Atlantic coast also coincide with the disappearance of the species. No fish in spawning condition were found, as with all the species here considered, and spawning is probably also a determining factor of the migration in T. albacares. As not even the juveniles remain, temperature is probably a predominating determinant in the Western Cape coast area.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.2 Maturity (age and size)

Practically all the specimens of T. albacares taken during the survey were believed to be mature, except for the very occasional fish in the 550 mm fork length range. Brock and Marr (1960) state that while specimens of T. albacares have been known to be mature at 700 mm, most attain maturity only at about 1,200 mm fork length.

3.1.6 Spawning

Nothing is known concerning spawning in this area except for the fact that no ripe fish have been found. It is thus assumed that the fish spawn while absent from the Cape (May to September). Of interest is the occasional large T. albacares found in the area during the winter months. These fish do not have enlarged or ripening gonads, which suggests that either the fish depart due to some internal stimulus connected with ripening gonads and absent in the fish remaining, or else the gonads ripen due to an external stimulus when the migrating fishes reach the spawning area.

The time when the main bodies of T. albacares are absent (May to September) is interesting as in the northern hemisphere, off Hawaii, they are believed to breed from May to October (Northern summer) (June 1953). In the area of New Caledonia, Legand (1961) found that spawning occurred from October to March (Southern summer).

3.3 Adult history

3.3.3 Competitors

T. albacares have no great competition from other tuna in the area surveyed except for T. alalunga which competes with T. albacares for certain surface macroplankton. Other competitors of T. albacares are the Dolphin (Coryphaena hippurus Linnaeus), Alepisaurus ferox Lowe. When feeding on

schools of small pelagic fishes the tuna must compete with various species of birds, sharks and the sealion (Arctocephalus pusillus) (Schreber).

3.3.4 Predators

T. albacares forms the food of large specimens of black marlin Makaira indica (Cuvier) in this area. Several instances of T. albacares of up to 75 lbs in the gut of this fish have been recorded. (Talbot & Penrith in press). One instance was also noted of T. albacares remains in the stomach of a mako shark (Isurus glaucus).

3.3.5 Parasites and diseases

As in the other tunas, stomach worms and external copepod parasites have been collected, but not yet studied, although Mr. J. Grindley of this institution states that one copepod collected was Penella filosa.

3.3.6 Greatest size

The largest specimen examined from this area was 1,661 mm fork length.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

Time: Thunnus albacares has a major feeding time in the early morning. Feeding slackens in intensity during the day and increases again in the evening. This is shown by surface trolling, in which the fishing falls off rapidly after 11.00 a.m. and only begins again in the evening. Longlining has confirmed this. Catches in descending order are made in (a) early morning set, (b) evening set, (c) midday set. Lines set after sunset and hauled before dawn caught nothing, suggesting that T. albacares does not feed at night. (This is in agreement with Reintjies and King 1953; King and Ikehara 1956; Watanabe 1958).

Place: The large majority of the food

organisms found in T. albacares in this area were macroplanktonic and pelagic in origin, suggesting that T. albacares feeds in the upper layers. This is confirmed by a comparison of different fishing methods used in this area. Normal longline gear, fished between 15 and 80 fathoms takes few T. albacares; a gear with three-fathom buoy lines and one-fathom droppers takes large numbers, while they are the commonest fish taken by surface trolling.

Manner: Surface observations on feeding T. albacares suggest that this species feeds by sight. The cessation of feeding at night also suggests this. A small percentage of apparently transparent foods (stomatopod larvae) are also taken.

3.4.2 Food (type, volume)

The important foods of T. albacares in this area are:

Fish Scomberesox saurus (Walb.)

Sardinops ocellata (Pappé)

Cyclichthys sp.

Scomber japonicus Houttuyn

and many other small surface fishes

Squids Abrolia gilchristi Robson

? Loligo reynaudi d'Orb

Prawns Funchalia woodwardi Johnson

Megalopa larvae (especially in January-March).

It is noticeable that all the fish species commonly taken by T. albacares are surface living forms. The presence of F. woodwardi is rather puzzling but as practically all these prawns were taken at one time of year there may have been some reason for the prawns to rise near the surface in daylight.

The stomachs of 168 T. albacares were examined in the course of the survey and the preliminary results are shown in Table I.

Table I.

Food of T. albacares by volume, percentage by volume and degree of occurrence

Food Group	Volume	Percentage by Volume	Percentage by Occurrence
Fish	16742.6	77.0	72.9
Prawns	2356.6	10.8	12.7
Squid	2214.4	10.2	33.7
Megalopa	272.8	1.2	20.5
Tunicata	121.5	.6	9.6
Amphipoda	27.2	.1	17.5
Other foods	21.8	.1	10.8

As shown in Table II, the main food of T. albacares by volume is fish, comprising 77 percent by volume and occurring in 72.9 percent of the fish. Prawns and squids were of about equal importance (10 percent) but whereas 33.7 percent of the fish contained squids, only 12.7 percent had prawns. Although of minor importance by volume, 20.5 percent of the fish examined contained megalopa larva. T. albacares was the only tuna in which megalopa larva were of greater importance than amphipoda. Isaac-Kidd mid-water trawls made in this area suggest that megalopa larvae are found nearer the surface than amphipoda.

From the following table it can be seen that T. albacares showed far fewer empty fish than in the larger species of tuna. Only 18 fish (10.7 percent) were found empty, but this is still very high in comparison with the central Pacific Ocean where Reintjies and King (1953) found only 1.6 percent of long-line-caught T. albacares empty. The major-

ity of the fish had over 5.0 cc of stomach contents with the majority lying between 10 and 50 cc, but volumes of up to 500 cc were regularly encountered.

3.5 Behavior

3.5.2 Schooling

Longlining gives little information on schooling, but due to the fish often being at the surface, trolling has given much information. T. albacares is usually in compact schools of from ten to several hundred fish. It is possible, but not determinable from our data, that they are occasionally solitary.

Table II

Distribution of volume of stomach contents in T. albacares

Category in cc.	Number	Percentage	Accumulated	
			Number	Percentage
Empty	18	10.7	18	10.7
0.1 to 1.9	8	4.8	26	15.5
2.0 to 4.9	11	6.5	37	22.0
5.0 to 9.9	20	11.9	57	33.9
10.0 to 24.9	24	14.3	81	48.2
25.0 to 49.9	24	14.3	105	62.5
50.0 to 99.9	16	9.5	121	72.0
100.0 to 199.9	20	11.9	141	83.9
200.0 to 499.9	18	10.7	159	94.6
500.0 to 999.9	7	4.2	166	98.8
1,000.0 to 1,999.9	2	1.2	168	100.0

4 POPULATION (STOCK)

It is probable that these modes are of the 2+, 3+, 4+ and 5+ year groups.

4.1 Structure4.2 Size and density

4.1.1 Sex ratio

4.2.1 Average size

The sex is known for 155 fish taken by longline of which 79 (51.0 percent) were males and 76 (49.0 percent) were females - a surprisingly close sex ratio.

The average size of T. albacares is usually, taking fluctuations in years into account, about 1,150 mm fork length ($\pm$ 70 lbs).

4.1.2 Age composition

4.2.2 Changes in size

4.1.3 Size composition

Changes from year to year have been dealt with above.

The size composition of T. albacares differs in this area from year to year, but four modes are usually present, as shown in Table III. (The largest fish are not often encountered in surface trolling from which these figures were obtained.)

4.2.3 Average density

As stated above, longlining during this survey produced rather few T. albacares, but during November to March they are present in

Table III

Size composition

Place	Date	Modes	1	2	3	4
Cape	Nov. 1957		500	900	1,300	
"	March 1958		700	1,050	1,400	
"	March 1960		625	1,150	1,450	1,650

Table IV

Catch rates

Season	Hooks fished		Fish taken	Catch/100 hooks
Summer	1,230		15	1.22
Autumn	4,182		52	1.25
Winter	2,154		8	.37
Spring	1,806		8	.44

enormous numbers off the Cape Peninsula. Sports fishermen alone, fishing mainly on weekends from about 20 boats, take up to 3,000 fish a season, and longlines made up specifically for this species take up to 100 fish a day.

The average catch rate for *T. albacares* off the Cape Peninsula during the survey was found to be only 0.88 fish/100 hooks, for the reasons mentioned above.

4.2.4 Changes in density

Catch rates of *T. albacares* off the Cape Peninsula found during the survey are shown in Table IV.

Results of fishing done to the east of Cape Agulhas, are given in Table V.

The fact that good catches were made on the East Coast just six weeks before the species appeared off the Cape Peninsula points to at least some of the Cape Peninsula populations being derived from the Indian Ocean.

Table V

Results of fishing, east of Cape Agulhas

Season	Hooks fished	Fish taken	Catch/100 hooks
Summer	180	0	0
Autumn	426	13	0.3
Winter	270	0	0
Spring	480	79	1.65

Thunnus obesus

1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

A Thunnus with liver with peripheral blood vessels on the ventral surface (not fully striated and dark) and sub-equal lobes; cutaneous blood vessels passing through the myotome of the 7th vertebra; short-tailed, with the distance from snout to soft dorsal over 50 percent of fork length; over 26 gill rakers on the first arch; no marked rod of connective tissue pressing into the swim bladder dorsally; soft dorsal and anal fins relatively short in adults, less than 17 percent of fork length.

1.1.2 Description

A stout-bodied tuna, with the greatest relative depth of all tunas, and a larger eye.

Proportions (expressed as a percentage of fork length): Head, 24 to 29; depth, 25 to 28; eye, 3.5 to 4.6; maxilla, 10 to 11; pectoral length, 20 (1) to 27 (s); first dorsal height, 11 to 13; second dorsal height, 13 to 16; anal height, 13 to 16; snout to first dorsal origin, 26 (1) to 31 (s); snout to second dorsal, 52 to 54; snout to ventral origin, 29 to 33; snout to anal, 60 to 62; (based on six specimens, 1,280 to 1,885 mm).

Scaling: Typical for the genus.

Fin counts: Dorsal XIII-XIV, 23 (8 to 9 posterior rays as separate finlets). Anal, 22 (8 to 9 posterior rays as separate finlets).

Gill rakers: Total on first arch, 26 to 28. Upper limb, 7 to 9, lower limb, 18 to 20.

Color: Body deep blue above, silver-grey below. The barrier between these two colors

sharply defined in photographs of the living fish with a distinct golden bar at this barrier. After death the transition is not so clearly defined. Spinous dorsal dusky, tinged with yellow distally soft dorsal blue proximally to off-white at its tip and posteriorly yellow with a fine black fringe. Anal silver proximally to yellow distally. Dorsal and anal finlets bright lime yellow with a black rim, broad (broader than in the yellowfin) on the dorsal, and fine on the anal finlets. Ventrals yellow between rays.

Liver: Striated, but striations few in number and peripheral in position. A precise identifying factor from the bluefin tuna.

Swim bladder: Wide, running the full length of the body cavity. Divided anteriorly and entering two pits in the dorsal surface of the body cavity. These pits on a 1,103 mm specimen were 28 mm wide and 30 mm deep. The two horns were sharply separated by a narrow septum. (Two specimens dissected).

1.2 Nomenclature

1.2.1 Valid scientific names

Thunnus obesus (Lowe) 1839.

1.2.2 Synonyms

Thynnus obesus Lowe, 1839, p.78 (Madeira).

Thunnus obesus (Lowe), Talbot & Penrith, 1961, p.240 (Cape); Talbot, 1962; Talbot & Penrith, 1962, p.558 (Cape).

1.2.3 Standard common names, vernacular names

Bigeye tuna. Local: Bigeye tunny, Bigeye tuna, Grootoog tuna.

2 DISTRIBUTION

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

If T. obesus is considered to be conspecific with T. mebachi (Kishinouye) and T. sibi (Temminck & Schlegel), the distribution is probably all tropical and sub-tropical waters.

2.2 Differential distribution

Juvenile stages are not known from the area.

The adults show marked seasonal distribution, being abundant in the southern summer (October to April), but being almost completely absent from the Cape Coast in winter (see Figs. 3 and 4). A few specimens were taken in the winter months, but such fish comprised only 3.3 percent of the total number of fish taken during the survey. The species was found in fair numbers a month earlier (August to September) on the Indian Ocean coast rather than on the Cape west coast.

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

The absence of this typically warm-water species from the cool (16° and lower) waters of the western Cape coast in winter is probably due to temperature preference.

The much higher density of T. obesus off the Atlantic Cape coast as opposed to the low density on the Indian Ocean coast is very likely due to the rich feeding areas of the former. Nevertheless, T. obesus was rarely taken well within the cold Benguela Current, and was more abundant on and outside its westward border.

Movement away from the Cape may also be due to spawning behavior, as no evidence of spawning in the area was indicated from gonad examination.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.2 Maturity (age and size)

All the specimens of *T. obesus* taken in the survey were mature. The sizes of fish taken ranged from 1,116 to 1,885 mm fork length.

3.1.6 Spawning

No ripe fish were found during the survey. Therefore the fish must spawn while absent from this area (May to July).

3.3 Adult history

3.3.3 Competitors

Thunnus obesus in this area has no major competitors, although it may compete with *T. alalunga* for certain foods. It is probable that it will compete with *T. thynnus thynnus*, but due to the small numbers of this species present in the area, it is of academic, rather than practical importance. Much of the food of *T. obesus* is the same as *T. thynnus orientalis*, but due to the main population of the two species being present at different times of year, there is no great competition. The species composition of the food of *T. obesus* differs markedly from that of *T. albacares* in the area surveyed. This agrees with the findings of Watanabe (1958) but differs from those of King and Ikehara (1956).

3.3.4 Predators

Potential predators in this area are probably limited to the mako (*Isurus glaucus*) and the black marlin (*Makaira indica*).

3.3.5 Parasites and diseases

As with the other tunas only intestinal worms and occasional external copepods were found and have not yet been examined.

3.3.6 Greatest size

The largest specimen taken measured 1,885 mm fork length.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

In this area it is believed that *T. obesus* feeds during the day, especially in the morning and evening. Watanabe (1958) believes, however, that *T. obesus* feeds to a large extent at night. As it feeds by sight (see below) it is probable that at least low illumination (sun, moon) is necessary for feeding.

Place. It is widely accepted (Bates 1958; Brock 1949; Murphy & Shomura 1953; Nakamura 1952) that *T. obesus* is a deep swimming tuna. This is born out by the large number of specimens taken off the Cape by longline and the small number (four in the last three years) by surface trolling. It is also correlated with the scarcity of surface-living food organisms in the stomachs examined.

Manner. As the majority of organisms taken by *T. obesus* are large, it is assumed that this tuna feeds by sight.

3.4.2 Food (type, volume)

The important food organisms of *T. obesus* off the Cape are:

Fish *Merluccius capensis* Castelnau

Alepisaurus ferox Lowe

Lepidopus caudatus (Euphrasen)

Squid *Histioteuthis bonelliana* (Fér)

? *Loligo reynaudi* d'Orb

Prawns *Funchalia woodwardi* Johnson

It is clear from Table I that *T. obesus* feeds almost exclusively on fish, squids and prawns, in that order. This agrees with the findings in the Pacific by King & Ikehara (1956) although prawns are of greater importance off the Cape, due probably to the great abundance of prawns (mainly *Funchalia woodwardi*) in this area. In comparison with all other tuna examined,

Table I

Volume, percentage volume and occurrence expressed as a percentage of all fish for the major food groups

Food	Volume	Percentage by Volume	Percentage by Occurrence
Fish	16665.4	50.7	52.0
Squid	12729.5	38.8	52.0
Prawns	3300.4	10.1	32.3
Tunicata	80.8	.2	2.9
Amphipoda	34.3	.1	3.9
Other foods	23.3	.1	5.7

T. obesus was the only species in which the percentage by occurrence of Amphipoda was very low (3.9 percent as opposed to over 15 percent in the other species).

T. obesus, like *T. thynnus orientalis*, showed a large number, (22, 21.6 percent) of empty fish on examination. This is rather surprising as King and Ikehara (1956) in the central Pacific found only a small number (4.8 percent) of long-lined *T. obesus* to be empty.

Of the stomachs containing food, almost all exceeded 10.0 cc by volume (*Funchalia woodwardi* averaged 11 to 13 cc each and many fish

in the category 10 to 24.9 cc contained one or two of these prawns). A greater percentage of *T. obesus* contained over 50.0 cc of food than in the other three species of tuna examined, 47.9 percent of the stomachs having between 50.0 and 5,000.0 cc of food (Table II).

3.5 Behavior

3.5.2 Schooling

No evidence was found to suggest large schools of *T. obesus* in this area, but rather suggested small, rather compact, groups of 10 to 20 individuals. The work of Kataoka (1957) agrees with this.

Table II
Distribution of stomach content volumes for T. obesus

Category in cc.	Number	Percentage	Accumulated	
			Number	Percentage
Empty	22	21.6	22	21.6
0.1 to 1.9	2	2.0	24	23.6
2.0 to 4.9	4	3.9	28	27.5
5.0 to 9.9	2	2.0	30	29.5
10.0 to 24.9	11	10.8	41	40.3
25.0 to 49.9	12	11.8	53	52.1
50.0 to 99.9	9	8.8	62	60.9
100.0 to 199.9	8	7.8	70	68.7
200.0 to 499.9	11	10.8	81	79.5
500.0 to 999.9	10	9.8	91	89.3
1,000.0 to 1,999.9	8	7.8	99	97.1
2,000.0 to 4,999.9	3	2.9	102	100.0

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

The sexes are known for only 99 T. obesus. Of these, 58 (58.6 percent) were males and 41 (41.4 percent) were females, but the number is too small to draw any conclusions.

4.1.2 Age composition

4.1.3 Size composition

Too few T. obesus have been measured to allow anything but very provisional statements. Kataoka (1957) gives histograms of length frequencies for fish taken in the central Indian Ocean, which suggest two modal lengths of 1,250, 1,600, 1,450 and 1,600 mm fork length.

4.2 Size and Density

4.2.1 Average size

The average size of T. obesus in the area surveyed was 1,460 mm fork length.

4.2.2 Changes in size

Nothing known from this area as there are too few fish measured.

4.2.3 Average density

The average density in this area of T. obesus based on longline catches, is very low, being only .96 fish per hundred hooks.

4.2.4 Changes in density

Changes in density by means of longline fishing are shown in Table III.

In addition to these fish taken off the Cape Peninsula a few (14; catch rate 2.9 percent) were taken off Port Elizabeth in August and September, about a month before they reached the waters west of the Peninsula.

Table III
Changes in density

Season	No. of Hooks	No. of Fish	Fish/100 hooks
Spring	2,352	14	.6
Summer	1,230	56	4.6
Autumn	4,182	24	.6
Winter	1,608	4	.2

Thunnus thynnus orientalis

1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Liver striated with veins ventrally; cutaneous blood vessels passing through the myotome of the 5th vertebra, pectoral short, not reaching the origin of the 2nd dorsal fin; first gill arch with a total count of 31 to 36 gill rakers.

1.1.2 Description

Body shape: streamlined, very robust and almost circular in cross section.

Fin and body proportions: (expressed as a percentage of fork length): Head, 29 to 31; depth, 26 to 28; eye, 3.1 (1) - 4.1 (s); maxilla 11 to 13; pectoral length, 20 to 23; 1st dorsal height, 11 to 14; snout to 1st dorsal origin, 30 to 32; snout to 2nd dorsal origin, 54 to 56; snout to ventral origin, 32 to 35; snout to anal origin 59 to 62; based on 13 specimens (970 to 1,695 mm).

Scaling on body: Much of head naked, with large cheek scales. Rest of body fully scaled with fine scales, but with a corselet of larger scales behind the head with indistinct boundaries.

Fin counts: Dorsal XIII to XIV, 23 (7 to 9 posterior rays as free finlets). Anal, 21 to 22 (7 to 8 posterior rays as free finlets).

Gill rakers: 31 to 36 (See Table I)

Color: Back blue-black, lower body silvery-grey, with a faint pattern of paler lines alternating with rows of dots. First dorsal dusky-grey. Second dorsal blue-black with a yellowish tip; anal grey, paling towards the tip, but no distinct white rim. Dorsal finlets bright lemon-yellow with a fine black rim. Pelvics dusky with reddish tinge and no yellow as in the bigeye tuna. Anal finlets pale lemon

yellow with hyaline rim and trailing point. Caudal peduncular keel usually brilliant lemon yellow, but may be translucent and pale, occasionally dark.

Liver: Liver densely striated with blood-vessels, almost black in appearance. Lobes sub-equal.

Swim-bladder: Large and wide, usually extending the full length of the body cavity. No anterior pits.

1.2 Nomenclature

1.2.1 Valid scientific names

Thunnus thynnus orientalis Temminck & Schlegel.

1.2.2 Synonyms

Thynnus orientalis Temminck & Schlegel, 1844, p. 94 (Japan)

Thynnus maccoyii Castelnau, 1872, p. 104 (Australia) Serventy, 1941, p. 27 (Australia).

Thunnus thynnus (Linnaeus) Talbot, 1962; Talbot & Penrith, 1962 p. 558 (Cape).

1.2.3 Standard common names, vernacular names

Southern bluefin tuna, Pacific bluefin tuna, oriental tunny.

Local: Bluefin tunny, bluefin tuna, blouvin tuna.

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

(See under T. thynnus thynnus, Section 1.3.1).

Table I

Total gill raker counts of the first gill arch (right side) of Thunnus thynnus orientalis
and T. thynnus thynnus from South Africa

	31	32	33	34	35	36	37	38	39	40	41	42	43
<u>T. t. orientalis</u> :	1	2	3	5	1	1							
<u>T. t. thynnus</u> :											1		1

2 DISTRIBUTION

2.1 Delimitation of the total area of distribution and ecological characterisation of this area

This species seems to be widespread in the Indo-Pacific area, and the Cape must at present be considered its southwesterly limit (see Fig. 6). With this species it is again very difficult to see what barriers prevent its movement westward, further into the South Atlantic. During the present survey it was found to be abundant west of the Cape Peninsula and as far north as Cape Columbine, the limit of exploration. It therefore enters well into the Atlantic Ocean. The sub-species was not found in the Agulhas Current water of the southeast coast.

2.2 Differential distribution

Juvenile stages are not known from the area.

Adults were present only from May to September, in the southern winter, and were found to be at times in denser concentrations than was found for any other tuna at any time of year. These shoals were present both in the inshore up-welled water of the Benguela Current and further out to sea in the South Atlantic surface water. Catches were greater near the border between these two water masses.

In the warmer period of the year an occasional specimen was taken, but not in January, February or March. The vast bulk of the stocks disappear, however.

This sub-species and *T. alalunga* were the only tunas found in winter. This winter distribution of *T. thynnus orientalis* is in marked contrast with that of *T. thynnus thynnus*, which was present only in mid-summer.

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

The seasonally differential distribution may be related to two factors; (1) rich feeding in the area west of the Cape, and, (2) breeding. Again no ripe or obviously ripening fish were found, and the fishes, most of which are mature (Mimura 1961, found fishes breeding at 1,350 mm), are breeding elsewhere. The avoidance of the warmer Agulhas water of the southeast coast by this species, as was found for *T. alalunga*, is puzzling. If the choices of area were due solely to rich food concentrations, one would expect, as is found for *T. obesus* and *T. albacares*, that there would be dense concentrations on the west coast, and low concentrations on the southeast coast. The complete absence of both *T. thynnus orientalis* and *T. alalunga*, is suggestive of a positive avoidance of the warm Agulhas Current area, possibly due to a demand for cooler conditions in these fishes at this time.

The completely contrasting differential distributions of the two sub-species of *T. thynnus* is surprising, and shows that very marked behavioral differences have developed. Until more is known about the migratory patterns and behavior of these species and their relation to the Cape it is, however, idle to speculate on the possible determinants and their evolution.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.2 Maturity (age and size)

Mimura (1958) states that off the west-east coast of Australia the breeding population is composed of fish from 1,300 mm fork length to 1,800 mm.

3.1.6 Spawning

T. thynnus orientalis has never been found to be ripe in the area surveyed. It is thus clear that the fish move elsewhere to spawn from September to April, but where is not known. The nearest breeding grounds known for T. thynnus orientalis are:

September to March:

10° to 17° S : 113° to 120° E.

October to April:

20° to 30° S : 100° to 110° E.

(Mimura 1958, 1961).

3.3 Adult history

3.3.3 Competitors

The large schools of T. thynnus orientalis that occur off the Cape in the southern winter have no important competitors. The only fish with similar food requirements is T. obesus and this species is not present in the area during the same time of year. For a portion of its food T. thynnus orientalis must compete with T. alalunga, especially for Funchalia woodwardi.

3.3.4 Predators

No definite predators are known for T. thynnus orientalis and large healthy specimens can have few predators. Possible predators are mako sharks (Isurus glaucus), broadbill swordfish (Xiphias gladius) and the blue marlin (Makaira nigricans), all of which are present at the same time as T. thynnus orientalis.

3.3.5 Parasites and diseases

Other than nemertine and digenetic trematode gut parasites, and occasional external copepods, no parasites were found. No examination of the collection of parasites has yet been attempted.

3.3.6 Greatest size

The largest specimen measured was 1,770 mm fork length.

3.4 Nutrition and growth

3.4.1 Feeding

Time: The longlining results suggest that T. thynnus orientalis feed mainly in the early morning, from just after sunrise. Thereafter feeding slackens until evening, when it increases again. It is probable that no feeding is undertaken at night, as lines set after dark and hauled at dawn caught nothing. An interesting, but unexplained, phenomenon is that afternoon fishing, while not yielding as many fish, often produced very large specimens of this species.

Place: From an examination of the stomach contents of 263 specimens of T. thynnus orientalis it is clear that the fish feeds mainly in the deeper layers, feeding as it does to such a large extent on Merluccius capensis and Funchalia woodwardi, both known to be deep living forms (Calman 1925).

Manner: Because such a large proportion of the food of T. thynnus orientalis is composed of large organisms, it is likely that feeding is by sight and pursuit.

3.4.2 Food (type, volume)

The food organisms which were of major importance to T. thynnus orientalis in the area surveyed were:

Fish: Merluccius capensis Castelnau

Lepidopus caudatus (Euphrasen)

Prawns: Funchalia woodwardi Johnson

Often found, but of lesser importance, were:

Fish: Myctophids
 Squids: Various species
 Amphipoda: Phronima sedentaria (Forsk.)
 Tunicata: Pyrosoma sp.
 and the transparent "house" of
Phronima
 (? salp ? Pyrosoma)

In addition, a large variety of different species of small bathypelagic fish were found; most are still unidentified.

As in T. alalunga only major groupings are used in this discussion of the volumetric importance of various foods. This section is based on the examination of 263 specimens (Table II).

Of major importance in Table III, is the large number (62 or 23.6 percent) of empty specimens, as well as large numbers with very little food, in relation to size. (46.7 percent of the fish having less than 10.0 cc of food).

At the other extreme there is a small number (6.9 percent) which contain a large amount of food (over 500.0 cc).

Noteworthy in Table V is the great importance of fish by volume, comprising 64.3 percent of the food. Unlike T. alalunga, however, fish were found in only 28.3 percent of the tunas examined. This is due to the large size of much of the fish preyed upon. Merluccius capensis of up to 7½ lbs were found, as well as very large Lepidopus caudatus. In T. thynnus orientalis squids were of surprisingly minor importance, comprising only 3.7 percent by volume of the food, and being found in 14.4 percent of the fish. This is in marked contrast to all the other species examined. Other food of major importance were prawns (almost exclusively Funchalia woodwardi) accounting for 29.8 percent by volume. Note that large numbers (33.1 percent) of the fish had taken amphipoda, mainly Phronima sedentaria, but due to their small size, and because only a few were found in any one fish, they accounted for only 0.4 percent of the food by volume.

Table II

Food of T. thynnus orientalis by volume and occurrence as a percentage of all fish examined

Food Type	Food Volume	Food as a percentage of Total Volume	Percentage of Occurrence
Fish	26,127.5	64.3	28.3
Prawns	12,115.0	29.8	37.3
Squid	1,496.5	3.7	14.4
Tunicata	632.6	1.6	29.2
Amphipoda	115.4	.4	33.1
Megalopa	48.2	.1	6.5
Other food	48.7	.1	6.1
Palinuridae	13.9	-	2.3

Table III

Percentage of food of all specimens of T. thynnus orientalis examined

Category in cc.	Number	Percentage	Accumulated	
			Number	Percentage
Empty	62	23.6	62	23.6
0.1 to 1.9	18	6.8	80	30.4
2.0 to 4.9	29	11.0	109	41.4
5.0 to 9.9	14	5.3	123	46.7
10.0 to 24.9	29	11.0	152	57.7
25.0 to 49.9	29	11.0	181	68.7
50.0 to 99.9	26	9.9	207	78.6
100.0 to 199.9	21	8.0	228	86.6
200.0 to 499.9	17	6.5	245	93.1
500.0 to 999.9	11	4.2	256	97.3
1,000.0 to 1,999.9	3	1.1	259	98.4
2,000.0 to 4,999.9	2	.8	261	97.2
Over 5,000	2	.8	263	100.0

3.5 Behavior

3.5.1 Migration and local movements

(See section 2.2.1).

3.5.2 Schooling

Although no analysis of catches has yet been attempted, preliminary work suggests a random distribution or small schools randomly distributed, rather than large schools.

4 POPULATION (STOCK)

This means that fish in the area surveyed belong in the five-year class upwards.

4.1 Structure4.2 Size and density

4.1.1 Sex ratio

4.2.1 Average size

The sex is known for 226 specimens of T. thynnus orientalis. Of these fish 141 (62.4 percent) were males and 85 (37.6 percent) were females. This was noticed on all but one cruise on which T. thynnus orientalis were taken.

The average size of T. thynnus orientalis in the area west of the Cape Peninsula was 1,400 mm fork length.

4.1.2 Age composition

4.2.2 Changes in size

4.1.3 Size composition

No changes in size were evident.

Little is known concerning age in this tuna. The size range in the area surveyed was from 930 to 1,770 mm fork length. In length frequency graphs, modes were apparent at 950; 1,100; 1,250 mm fork length but from 1,400 mm modes are very indistinct, although there are suggestions of modes at roughly 1,400, 1,500, 1,600 and 1,700 mm fork length.

4.2.3 Average density

The average density of T. thynnus orientalis as based on longline catches was 3.7 percent of hooks laid.

4.1.4 Changes in density

Serventy (1956) suggested that at an age of 4+ years the fish has a length of 829 mm.

Great changes in density of T. thynnus orientalis at different times of year were found, as shown in Table IV.

Table IV
Changes in density

Season	No. of Hooks	No. of Fish	Fish/100 hooks
Summer	900	3	0.3
Autumn	2,526	8	0.3
Winter	1,608	166	10.3
Spring	2,352	92	3.9

Thunnus thynnus thynnus

1 IDENTIFY

1.1 Taxonomy

1.1.1 Definition

A Thunnus with liver densely striated with veins ventrally; cutaneous blood vessels passing through the myotome of the 5th vertebra; pectoral short, not reaching the origin of the 2nd dorsal fin, and a total count of 41 to 43 gill rakers on the first gill arch.

1.1.2 Description

Body shape: streamlined, very robust and slightly compressed in cross-section. Body proportions and fin lengths: (expressed as a percentage of fork length) Head, 23 to 26; depth 24 to 28; eye, 2.4; maxilla, 10; pectoral length, 16 to 19; 1st dorsal height, 11; 2nd dorsal height, 14 to 17; anal height, 13 to 16; snout to 1st dorsal origin, 27 to 28; snout to 2nd dorsal origin, 50 to 60; snout to ventral origin, 28 to 30; snout to anal origin 52 to 57. (Based on four specimens, 2,151 to 2,503 mm).

Scaling on body: Most of head naked, large cheek scales, rest of body fully covered with fine scales, but with a corselet of large scales behind the head, the corselet having indistinct boundaries.

Gill rakers: 41 to 43 (see Table I).

Color: As T. thynnus orientalis, but caudal keels dark, not hyaline or yellow.

1.2 Nomenclature

1.2.1 Valid scientific name:

Thunnus thynnus thynnus (Linnaeus), 1758.

1.2.2 Synonyms

Scomber thynnus Linnaeus, 1758.

Thunnus thynnus (Linnaeus), Barnard, 1927, p.798 (Cape), Molteno, 1948, p.16, pl.1, fig.1 (Cape); Smith, 1949, p.298, pl.66 (Cape); Talbot, 1962; Talbot & Penrith, 1962 (Cape);

1.2.3 Standard common names, vernacular names

Bluefin tunny, tunny, bluefin tuna, horse mackerel.

Local: Bluefin tunny, bluefin tuna, blouvin tuna.

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

Two races of Thunnus thynnus are present at the Cape, clearly separated by gill raker counts (Table I). They are here dealt with separately. See T. thynnus orientalis.

Table I

Total gill raker counts of the first gill arch (right side) of Thunnus thynnus orientalis and T. thynnus thynnus from South Africa

	31	32	33	34	35	36	37	38	39	40	41	42	43
<u>T. t. orientalis</u> :	1	2	3	5	1	1							
<u>T. t. thynnus</u> :											1	1	

2 DISTRIBUTION

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

If the eastern and western Atlantic blue-fin tuna are considered conspecific, a view that holds some prevalence at present (Pacific Tuna Biological Conference, 1961), the Cape specimens would seem to be at the extreme southeast limit of this sub-species' range, which would include the tropical and sub-tropical areas of the Atlantic Ocean (Fig. 6).

2.2 Differential distribution

No juvenile stages are known from the area.

Large fishes (350 lbs to 800 lbs) have been taken in mid-summer on a number of occasions in the past, usually in shallow water by beach-seining, and also occasionally in trawls. With the advent of longlining it

has been shown to occur in small numbers west of the Cape Peninsula in January to March (mid-summer), in 1961 and 1962. This is in marked contrast with T. thynnus orientalis.

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

It is not easy to see what causes the influx of huge T. thynnus thynnus at the Cape. The area is certainly an extremely rich feeding area. The sub-species seems confined to the warmest period of the year, and coincides with the arrival and duration of stay of Makaira indica, M. audax and M. albida. As the two former are derived from the Indo-Pacific area, and the latter from the Atlantic, (as we assume is T. thynnus thynnus), the influx of warm water to the area seems important, but not its derivation, which is probably Indian Ocean at this time of year.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

Nothing is known concerning this section in the area surveyed except that no specimens examined have been ripe or ripening. Spawning is known to occur in the central Mediterranean from April to July, and in the Caribbean at about the same time, while fish are known from the Cape only in the southern summer (November to March).

3.3 Adult history

3.3.3 Competitors

T. thynnus thynnus in this area has two distinct habitats, the open sea and inshore off sandy beaches. In the open sea T. thynnus thynnus will compete with the other large species of tuna present at this time, T. obesus. In addition there will be some competition with T. alalunga.

In the other habitat, off beaches, no competitors are known.

3.3.4 Predators

A fish growing as large as T. thynnus thynnus can have few predators as a large adult, although a very large specimen seined in shallow water in False Bay, Cape Peninsula, had a large scar on its belly that was assumed to have been caused by a shark. No precise information exists for this area.

3.3.6 Greatest size

The largest specimen recorded from the Cape weighed 800 lbs, but was cut up before it could be measured.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner season)

Nothing is known concerning feeding, except for the habit this fish has of entering shallow, sandy bays, which may be connected with feeding; fish commonly taken in beach seines at the same time are: Trachurus trachurus L; Seriola pappei (Castelnau); Sarda sarda (Bloch); Pomatomus saltator (L) and Liza ramada (Risso).

3.4.2 Food (type, volume)

Nothing is known as the stomach of the only specimen examined was empty. Horne (1959), however, mentions a large specimen taken in shallow water off the Cape Peninsula which disgorged a spotted grunter (Pomadasys operculare (Playfair)), a fish known from shallow water. Biden (1930) records a 542 lb specimen being landed by beach seine and containing seven one-pound Trachurus trachurus in the mouth (taken during the seining).

3.5 Behavior

3.5.1 Migration and local movements

(See section 2.2.1).

3.5.2 Schooling

Most records of T. thynnus thynnus in this area are of only single fish, but quite often they are reported by fishermen (also Biden 1930) in small schools of up to 15 fish. It is usual that with the tackle used to catch them, only one or a few fish are landed. The schools are often sighted swimming close inshore along sandy beaches, sometimes for several days.

4 POPULATION

4.1 Structure

4.1.2 Age composition

4.1.3 Size composition

Only four specimens have been measured
and they were as follows:

<u>Fork length</u>	<u>Weight</u>
2,151 mm	-
2,207	456
2,302	467
2,503	646

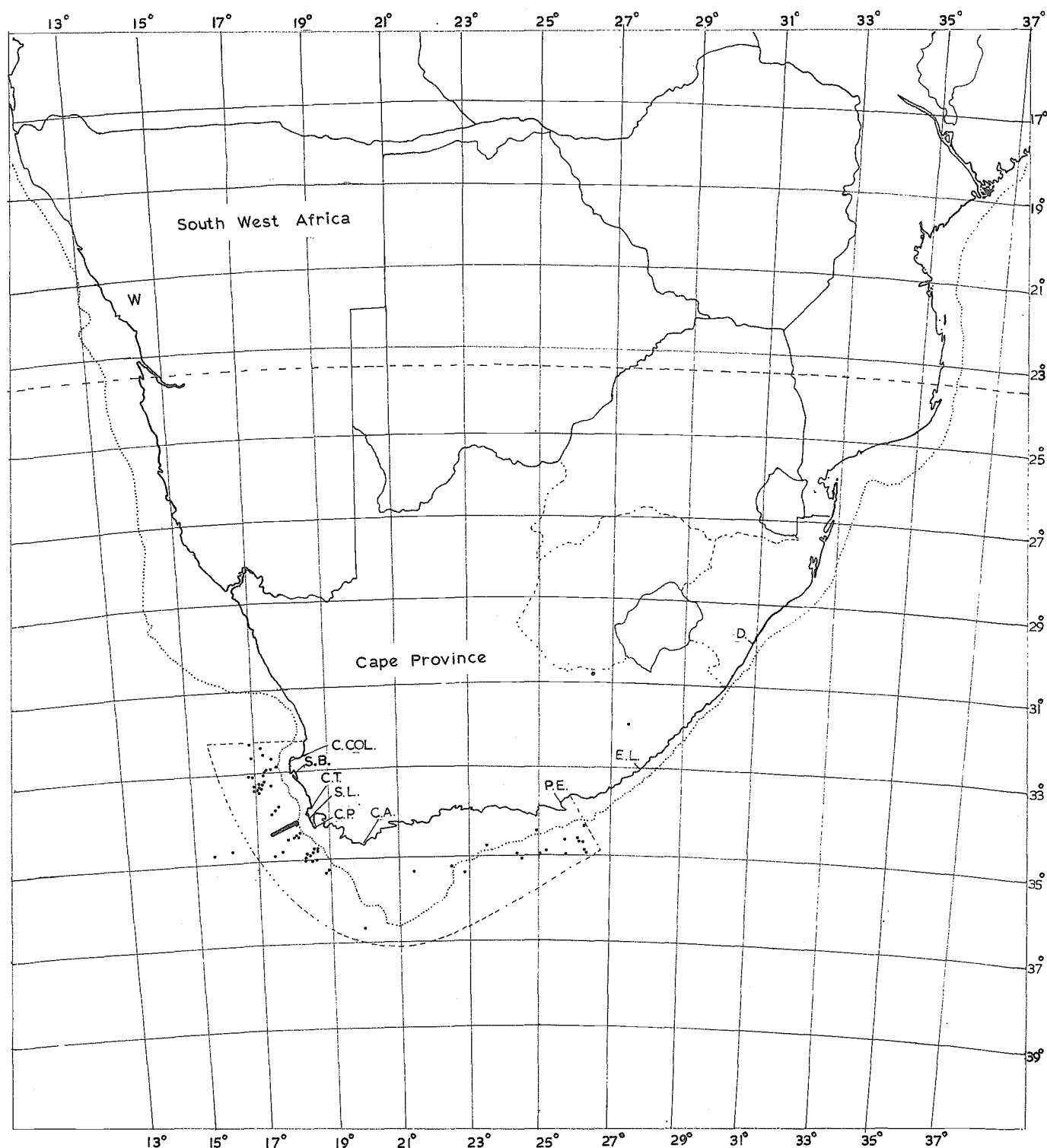


Fig. 1 Map of the South African region. Area surveyed included in a broken line. Each station is marked with a dot except the 60 mile Slangkop line which contains 51 stations.

Abbreviations: C.A. - Cape Agulhas; C.Col. - Cape Columbine;
 C.P. - Cape Point; C.T. - Cape Town; D. - Durban;
 E.L. - East London; P.E. - Port Elizabeth; S.B. - Saldanha Bay;
 S.L. - Slangkop Lighthouse; W. - Walvis Bay.

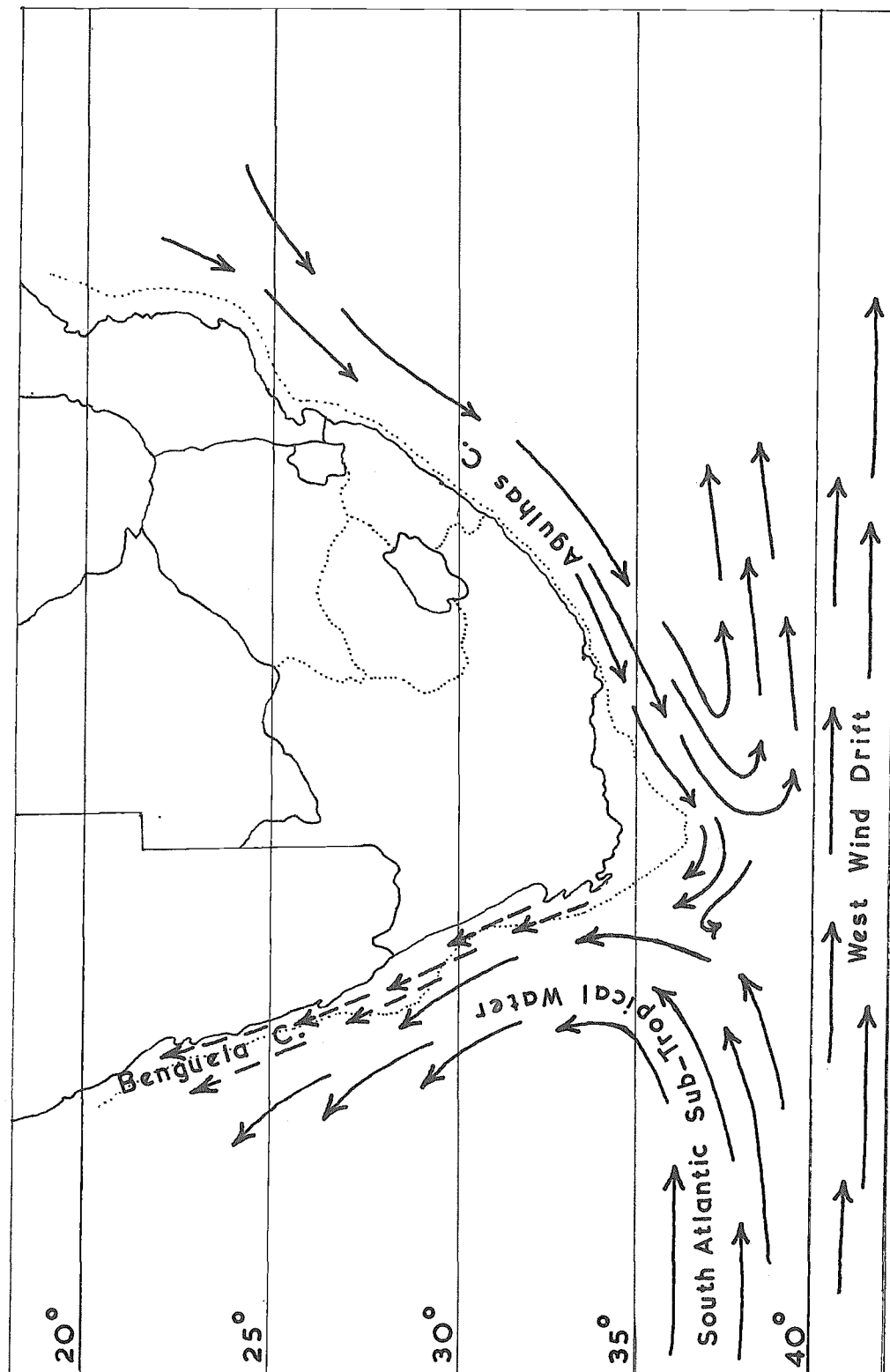


Fig. 2 Current systems around South Africa under some summer conditions.
Broken arrows indicate upwelled water.

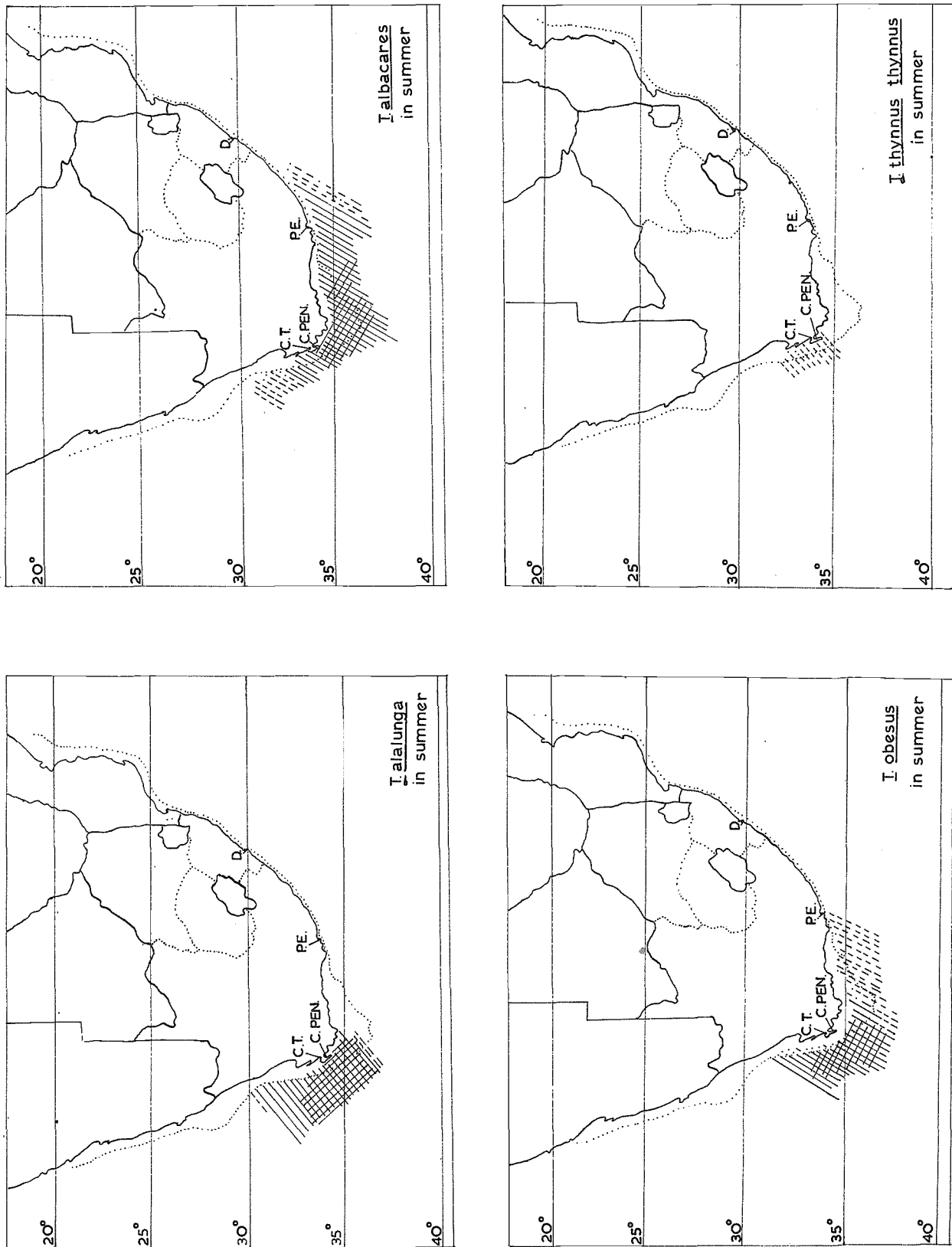


Fig. 3 Distribution of the fishes of the genus *Thunnus* off the South African coast in summer.

Cross-hatching = abundant; oblique solid lines = common; oblique broken lines = present but not common.

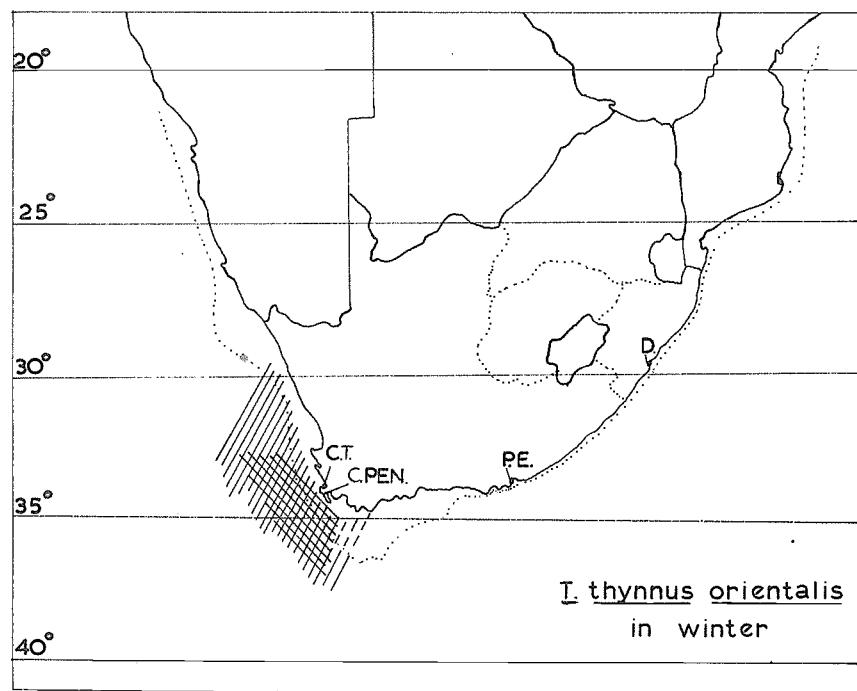
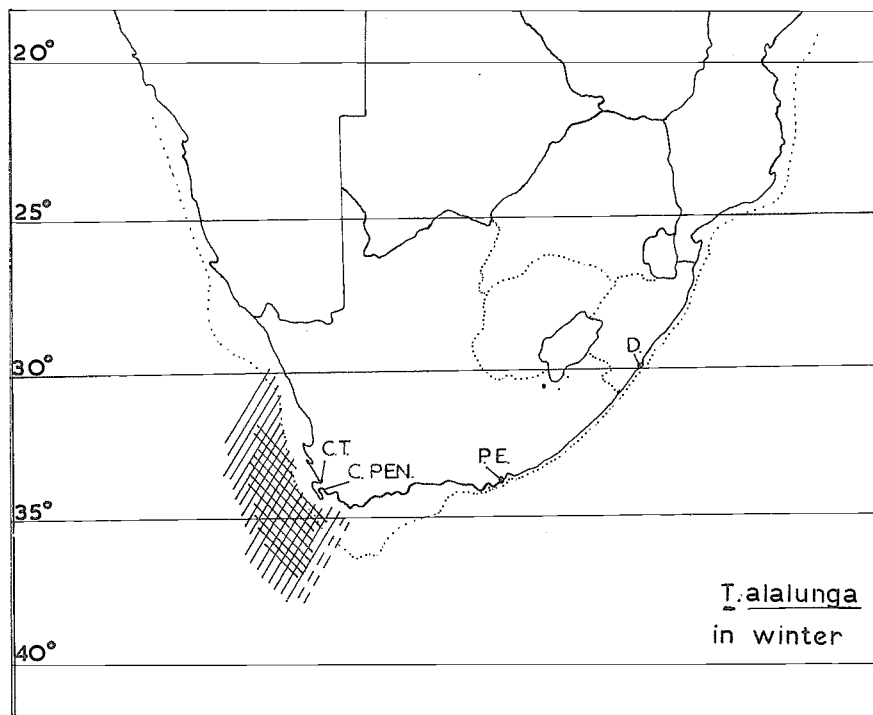


Fig. 4 Distribution of the fishes of the genus Thunnus off the South African coast in winter.

Cross-hatching = abundant; oblique solid lines = common;
oblique broken lines = present but not common.

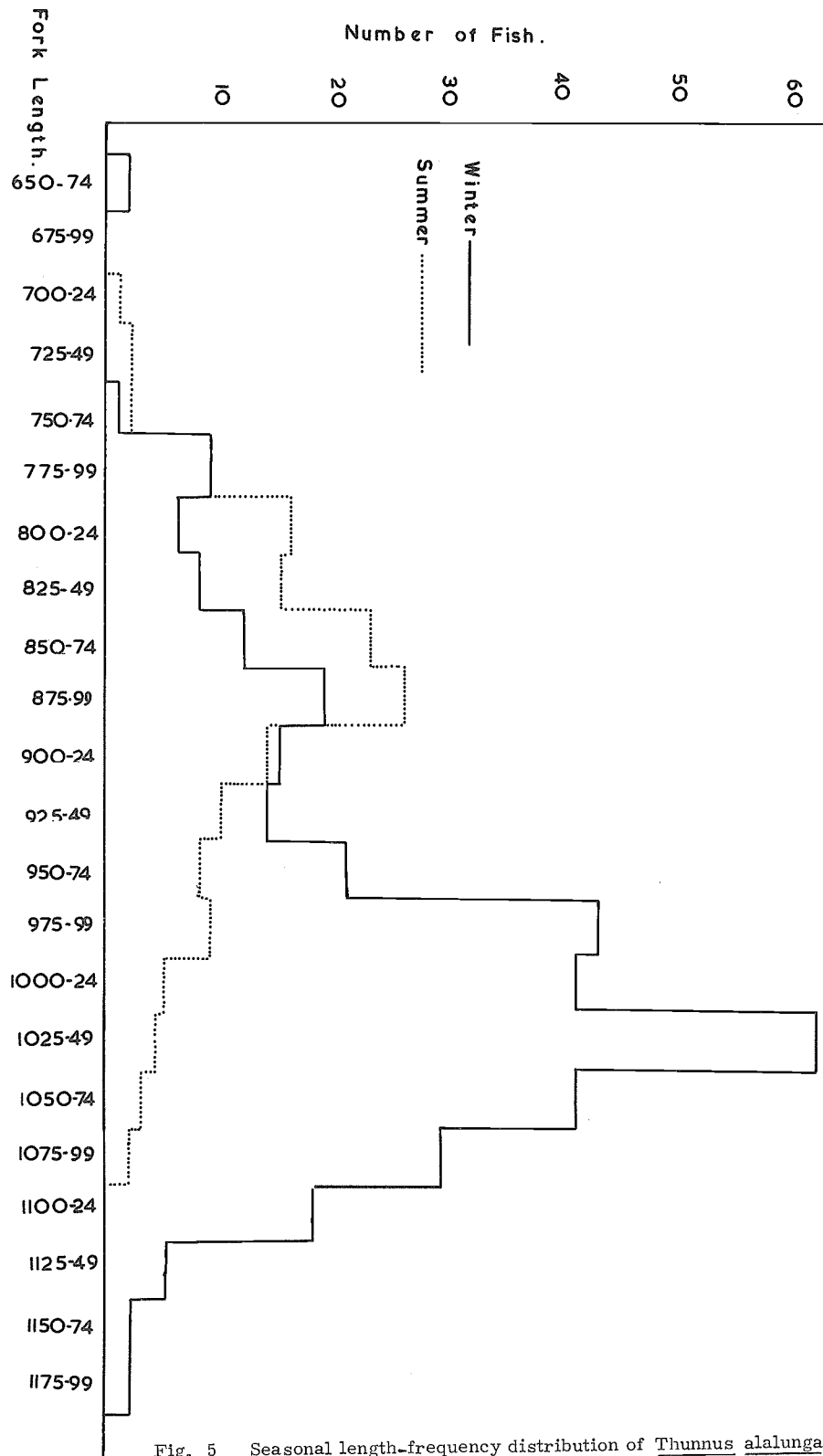


Fig. 5 Seasonal length-frequency distribution of Thunnus alalunga off the southwest Cape coast.

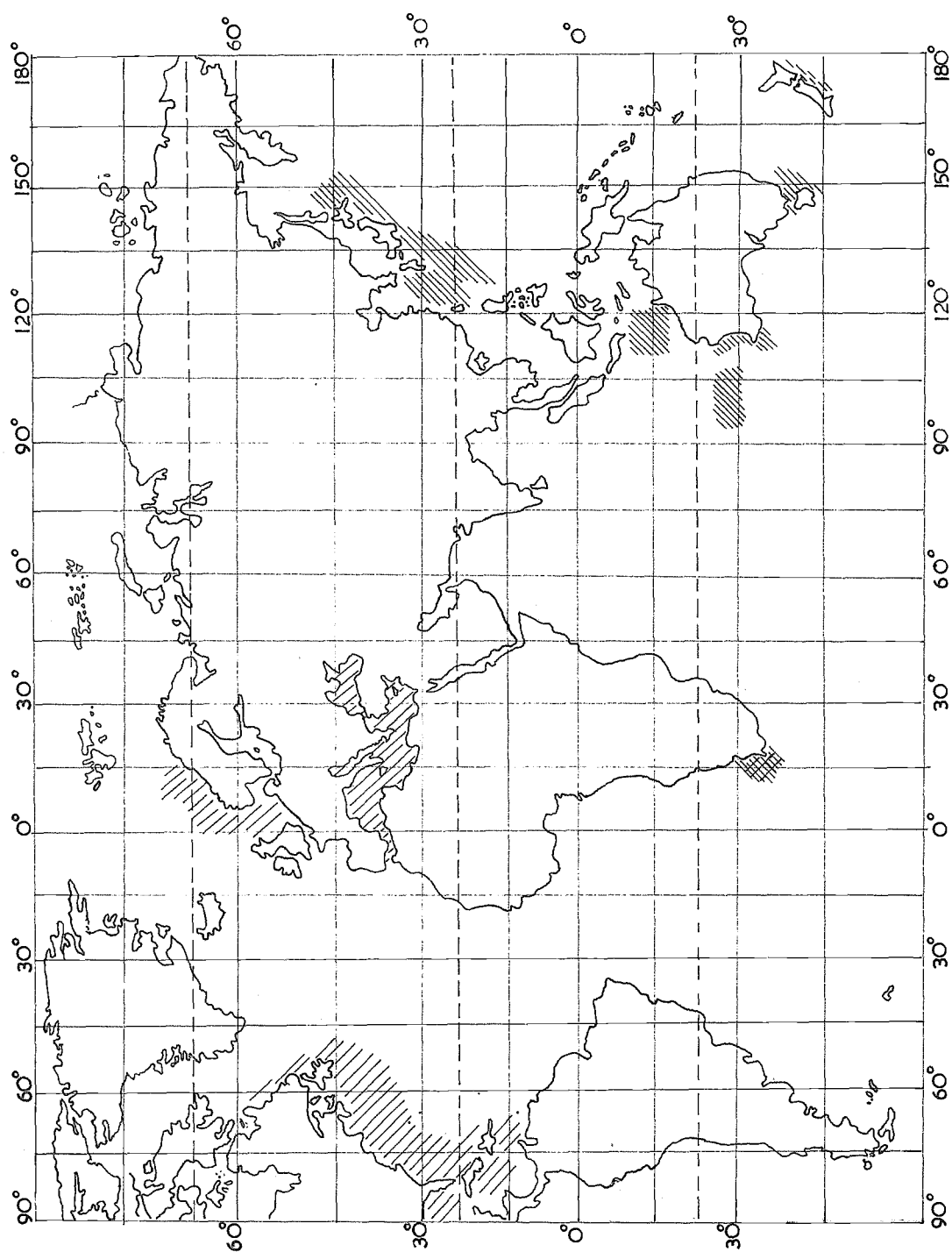


Fig. 6 Distribution of *Thunnus thynnus* (Atlantic to Cape) and *Thunnus thynnus orientalis* (Indo-Pacific to Cape).

