Species Synopsis No. 17
FAO Fisheries Biology Synopsis No. 60 FIb/S60
(Distribution restricted) SAST - Tuna

SYNOPSIS OF BIOLOGICAL DATA ON BLUEFIN TUNA
Thunnus thynnus maccoyii (Castelnau) 1872

Exposé synoptique sur la biologie du thon rouge
Thunnus thynnus maccoyii (Castelnau) 1872

Sinopsis sobre la biología del atún rojo
Thunnus thynnus maccoyii (Castelnau) 1872

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The contents are arranged according to the revised version (Outline, Version No. 2) of the FAO outline for Synopsis of Data on Species and Stocks, where information was available to the Author (See Rosa, H. Jr., 1962). Preparation of synopses on the biology of species of living aquatic organisms. FAO Fish. Biol. Synops., (1):53p.

1 IDENTITY

1.1 Nomenclature

1.11 Valid name

Thunnus thynnus maccoyii (Castelnau) 1872

1.12 Objective Synonymy

Thynnus australis (nomen nudum, pre-occupied) McCoy (1867)
Thunnus maccoyii (Castelnau) 1872
T. phillipsi (Jordan and Evermann) 1926
T. maccoyii (Castelnau), Proc. Zool. Acclim. Soc. Vict., 1:29-248, 1872, Melbourne, Victoria, Australia.

1.2 Taxonomy

1.21 Affinities

- Suprageneric

Phylum Teleostomi
Class Actinopterygii
Order Perciformes
Suborder Scombroidei
Family Thunnidae
Genus Thunnus South (Encycl. Metropolitana V 1845 p. 620)
Species thynnus (L.)
Subspecies maccoyii

- Specific

Status of the species: "Considering all characters it appears that the differences which are perceptible between the various stocks are of an order which distinguishes subspecies or geographical races and are not adequate species differences on modern concepts. The several species and populations already described can be considered as geographically replacing forms of one species, Thunnus thynnus (L.). These could be designated by the currently used trinomial nomenclature as follows:

Thunnus thynnus thynnus (L.), 1758 - European seas
T. thynnus thynnus (C. and V.), 1831 - North America, Atlantic coast
T. thynnus (subspecies) - South Africa
T. thynnus saliens, Jordan and Evermann 1926 - North America, Pacific coast
T. thynnus orientalis (Temminck and Schlegel), 1842 - Asiatic coast of the North Pacific
T. thynnus maccoyii (Castelnau) 1872 - Australia and New Zealand".
(Serventy 1956).

1.24 Standard common names, vernacular names

See Table I.

TABLE I

Standard common names, vernacular names

Country	Standard Common Names	Vernacular Name
Australia	Southern bluefin tuna	Bluefin, tunny
New Zealand	Southern bluefin tuna	
Japan		(a) 1/ Indo maguro (Indian ocean tuna)
		(b) Goshu maguro (Australian tuna = Pacific ocean tuna)

1/ See Abe, T., (1955).

1.3 Morphology

1.31 External morphology

See Section 1.21 - Specific

- Individual variations in the population(s)

Serventy (1956) in a study of morphometrics suggests that around the Australian coast there may be three different populations. This suggestion is based on significant differences found in certain characters between southern and eastern, eastern and western, and western and southern fish. More recent data, on adults, indicates that fish from eastern, southern and western Australia cannot be distinguished morphologically (see also Section 3.52), but different spawning groups occur on either side of the continent. Intermingling occurs between eastern and southern Australian coast juveniles (see Section 3.52). Degree of intermingling not known.

2 DISTRIBUTION

2.1 Total area

- Geographic distribution

As known at present the geographical distribution in south Pacific waters ranges from 28°S to 46°S, between 156°W to the east Australian coast. In the east Indian Ocean (as defined by the International Hydrographic Bureau) the range is from 10°S to 42°S between 100°E and 147°E (Fig. 1). Recent reports (Nankai Regional Fisheries Research Laboratory, Japan) indicate that this species or a variant also occurs in latitude 30°S, longitude 50°E.

In the south Pacific waters the northern boundary of the distribution of this species is marked by the tropical convergence in waters to the north of the North Island of New Zealand; the southern boundary is unknown. In the east Indian Ocean the centre of distribution of southern bluefin off north-west West Australia is associated with a particular water mass (Yamanaka and Anraku 1959), and with major ocean currents (Nakamura et al 1955). This species has been caught in waters with temperatures ranging from 10.9°C to 21°C and chlorinities ranging from 19.30°/oo to 19.77°/oo.

2.2 Differential distribution

2.21 Spawn, larvae and juveniles

- Areas of occurrence and seasonal variations

No data on spawn and larvae. Juvenile stages (30 to 110 cm) are generally found closer to shorelines and swim in shallower layers than adults. Catches of juveniles by longline in oceanic areas form a minor part of the commercial catch in some areas (see Section 2.22), but this small proportion of juveniles in longline catches may be due to selectivity of the fishing gear. Intra- and inter-seasonal variation of age groups within juvenile stage observed (Serventy 1956) in east coast fishery.

2.22 Adults

- Areas of occurrence and seasonal and annual variations

(See Section 2.1). Seasonal variation occurs with population at its northern limit in August then moving south in summer and autumn with a return to lower latitudes in late winter. Annual variations not noted off west coast of Australia (Mimura 1961). In both "old" and "new" fishing grounds all individuals taken by longline are over the length at which sexual maturity is attained (see Mimura 1961). Appears to be clear-cut separation between sexually mature and sexually immature (juvenile) parts of population. Evidence available from the New Zealand area indicates no marked annual variation (Fig. 2).

2.3 Determinants of distribution changes

Effects of ecological determinants such as temperature, currents, etc., on general and differential distribution on different stages of development of individuals of the species: see Sections 3.32, 4.6 and 5.22.

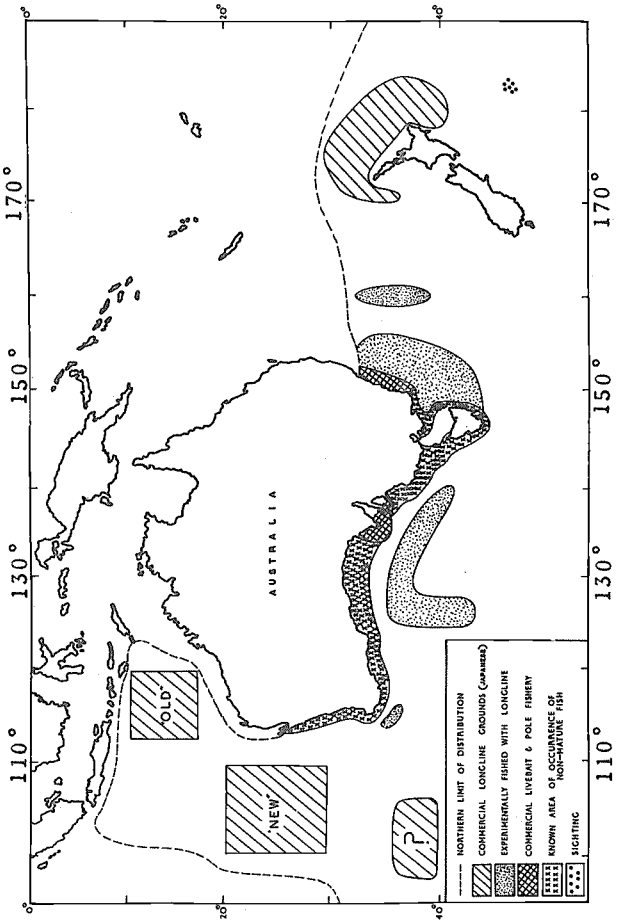

Fig. 1. Distribution of southern bluefin tuna (T. maccoyii), and fishing grounds

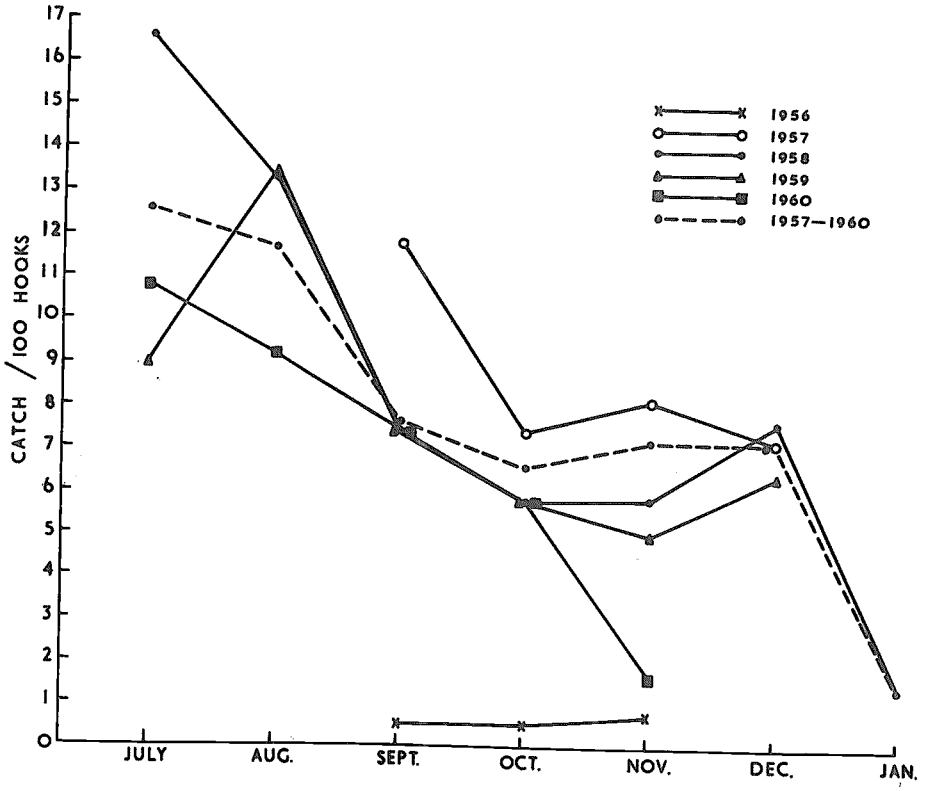

Fig. 2. Monthly average catch rates of "goshu maguro" (T. maccoyii) North Island of New Zealand area (Data from Nankai Regional Fisheries Research Laboratory)

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

Heterosexual. No cases of hermaphroditism or intersexuality observed. Males and females indistinguishable externally.

3.12 Maturity

Analyses of length frequency distributions related to gonad index indicate maturity is attained within the length range 113-128 cm in fifth and sixth (mainly sixth) year of life for both sexes.

3.13 Mating

Polygamous.

3.14 Fertilization

External.

3.15 Gonads

No data on relation of gonad size to egg number, body weight or age. Figure 3 shows relation of gonad weight to body length, with gonads in resting stage, in fish from waters north of New Zealand in September, October. (Data from Nankai Regional Fisheries Research Laboratory). The relation is expressed by the formula:

$$\log y = -11.379 + 6.359 \log x$$

where y = gonad weight (g), x = L.C.F. (cm).

3.16 Spawning

- Number of spawnings per year

(Of one population): Off the west coast of Australia, fish in "old ground" have advanced gonads throughout fishing season (September to March). Fish in "new ground" have advanced gonads in December to February (fishing season October to April).

Although the peaks of the breeding season in each area differ by about one month, it is doubtful whether the individuals which breed in the "old" fishing ground breed again later in the season in the "new" fishing ground, because of the differences which are observed in the size composition of the catches from each area (see Mimura 1961). Large fish with advanced gonads occur in the Albany area (Western Australia) from end October to early March (Serventy 1956). This evidence suggests that the spawning season extends from September to March in east Indian Ocean waters with peaks occurring at different times in each area. Data lacking in eastern Australian area, but see note on length frequency analyses (Sections 3.43 and 3.51).

- Spawning seasons (beginning, peak, end)

"Old" fishing ground (10°S to 17°S, 113°E to 120°E): begins September, peaks in November, ends in March; "new" fishing ground (20°S to 30°S, 100°E to 110°E): begins December, peaks in January, and ends in February (Mimura 1961).

Spawning season unknown in eastern Australian area, but from recent data it may be inferred to be November-February.

- Location and type of spawning ground

"Old" fishing ground 10°S to 17°S, 113°E to 120°E. "New" fishing ground 20°S to 30°S, 100°E to 110°E. For oceanographic characterization see Yamanaka and Anraku (1959).

- Ratio and distribution of sexes on spawning grounds

"Old" fishing ground: observations over nine year period show ratio of 1.2 males : 1 female. "New" fishing ground: observations over three year period show ratio of 1.38 males : 1 female.

3.2 Pre-adult phase

3.23 Adolescent phase

- Differences from adults in diet, feeding methods, etc.

Diet of juveniles predominantly small fish, cephalopods, and other crustacea with few salps.

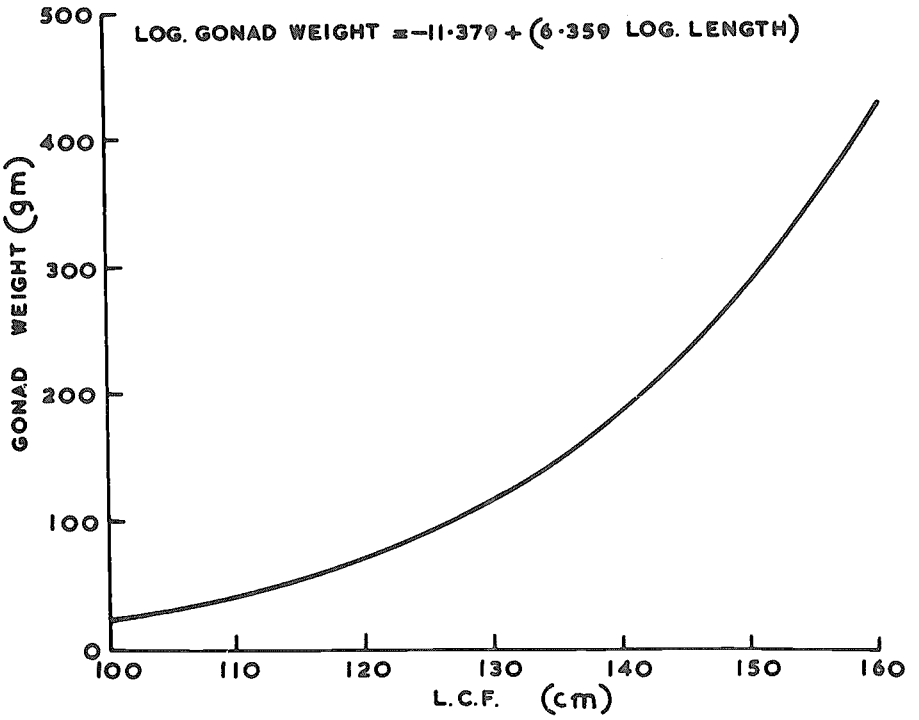

Fig. 3. Gonad weight/length relation (Stage I, mature but resting, + sexually immature females).

3.3 Adult phase (mature fish)

3.32 Hardiness

- Limits of tolerance to changes in or of environment and feeding

In south-west Pacific waters the observed upper limit of chlorinity is 19.77°/oo and of temperature 21°C. No data from southern and western areas. Lower limits not known, but increase in temperature and simultaneous lowering of chlorinity (signifying intrusion of south Equatorial water) excludes.

- Limits of tolerance to handling and life in aquaria or other confined environments

Individuals captured, tagged and liberated after one minute out of water appear to suffer no ill effects, although during this period firm handling, to prevent excessive movement, is required. Free movement on deck is violent, usually resulting in rupture of the gill afferent and efferent systems with subsequent quick death. Fish (59 to 80 cm) captured, tagged, and placed in a livebait tank aboard a vessel and undergoing temperature changes from 15.5°C to 21.1°C to 19.1°C before release, after 80 hours in captivity, survived the period of captivity with no noticeable ill effects.

3.33 Competitors

- Types and abundance of competitors for spawning area, food, shelter, etc.

Feeding area competitors: albacore, yellowfin, bigeye, skipjack mainly in the transitional area where proximity of bluefin and the species mentioned occurs. No quantitative data.

3.34 Predators

- Types of predators

Sharks, dolphins, seals.

- Defence reactions

Rapid sounding, dispersion not noted.

3.35 Parasites, diseases, injuries and abnormalities

- Parasites and diseases

- Types

Internal: gut. Trematoda genus: Hirudinella sp. External: gill, interior of operculum and caudal peduncle region - Copepoda (Harpacticoida).

- Intensity of individual and population infection

Trematode infection light, intensity ranging from 0 to 2/individual.

No quantitative data on copepod parasite.

3.4 Nutrition and growth

3.41 Feeding

- Time of day

Data not analysed.

- Place; general area

Over whole range of distribution.

- Manner; methods of capture, selection

In this species feeding appears to be random on pelagic small fish, squid and crustacea.

One method of capture of food, judged from the manner in which the fish strike trolled lures, is for the fish to make a speedy headling approach to the prey turning slightly on its side as it seizes the prey.

- Abstention from feeding

Supposed to cease feeding just prior to spawning (Serventy 1956).

3.42 Food

- Types eaten and their relative importance in the diet

In juvenile fish in eastern Australian waters the fish have a widely varied diet - fish, cephalopods, crustaceans, salps in order of importance.

Forage fish species are as follows (overall size range from 1 cm to 30 cm, in tuna up to 40 lb in weight) (Serventy 1956).

Scientific name	Common name
Trachurus novaezelandiae	Jack mackerel
Scomber australasicus	mackerel
Sardinops neopilchardus	pilchard
Engraulis australis	anchovy
Trachurus declivis	scad
Emmelichthys nitidus	pearl fish
Nemadactylus sp.	morwong
Thyrsites atun	barracouta
Sphyraena novae-hollandiae	pike
Arripis trutta	salmon
Rexea solandri	King barracouta
Stolephorus robustus	blue sprat, young marine eel
Family Myctophidae	lantern fish
Macroramphosus molleri	bellowsfish
Scombersox forsteri	billfish
Caranx georgianus	trevally
Gonorhynchus greyi	-
Zeus australis	John dory
Gnathagnus innotabilis	star gazer, box fish
Zanclistius elevatus	boar fish
Ruboralga sp.	rock cod
Atherina sp.	hardyhead
Upeneichthys lineatus	-

Cephalopoda
Notodarus gouldi, Enoploteuthis galaxias, Calliteuthis miranda, Argonauta nodosa, Octopus australis

Crustacea
O. Euphausiacea : Nyctiphanes australis
O. Amphipoda : Phrosina semilunata
Brachyschelus crusculum

O. Stomatopoda : Squilla laevis (larvae)

Tunicata
O. Salpida : Oikopleura sp.

Chaetognatha : gen. and sp.
S. Cl. Siphonophorae : Diphyes sp.

The stomachs of a sample of large bluefin tuna caught on longline in the area to the east-northeast of New Zealand contained fish, crustacea and cephalopods. The fish included Alepisaurus sp., Tetragonurus cuvieri, F. Paralepididae, Polyipnus sp., F. Pterotracheidae, Bonteria aesticula, F. Trachipteridae; the crustacea included Amphipoda, Euphausiidae, Penaeidae, and Decapoda; the cephalopoda included both squid and octopus.

From the " old" fishing ground off north Western Australia stomach contents from a sample of a small number of fish showed that crustacea, mainly amphipods were dominant, followed by fish, cephalopods and salps. (Data from Nankai Regional Fisheries Research Laboratory, Japan).

3.43 Growth rate

- Relative and absolute growth patterns and rates

Serventy (1956) from length frequency distributions throughout the year, infers that growth takes place almost entirely in the summer months, between October and May (Fig. 3, data from Tables 2 to 7). From May to October barely any increment in length or weight is gained by the fish. More recent data on length frequencies (Robins 1958) (Fig. 4) shows that growth does not appreciably slow down during these months but does so during months August to November. Recent tag returns (unpublished data) indicate that the growth rate during the winter months is similar to that of the summer months. Tentative analysis indicates that growth is continuous.

Variations in growth rate from year to year are ascribed by Serventy (1956) to " good" and " retarded" growth seasons. Alternatively these variations could be due to the dominance in the fishery of one of the two modal groups which constitute an age class. In the east Indian Ocean off the west coast of Australia there are at least two breeding peaks in the one season (see Section 3.16) thus giving rise to two modal groups within an age class.

A similar situation, as shown by modes in length frequency distributions, exists in the fish occurring in eastern Australian waters. Reduced linear growth rate of successive presumptive age classes in the adult portion of the population makes separation of these presumptive age classes difficult.

Growth increment from the presumptive I+ class to the II+ class, as shown by tag returns,

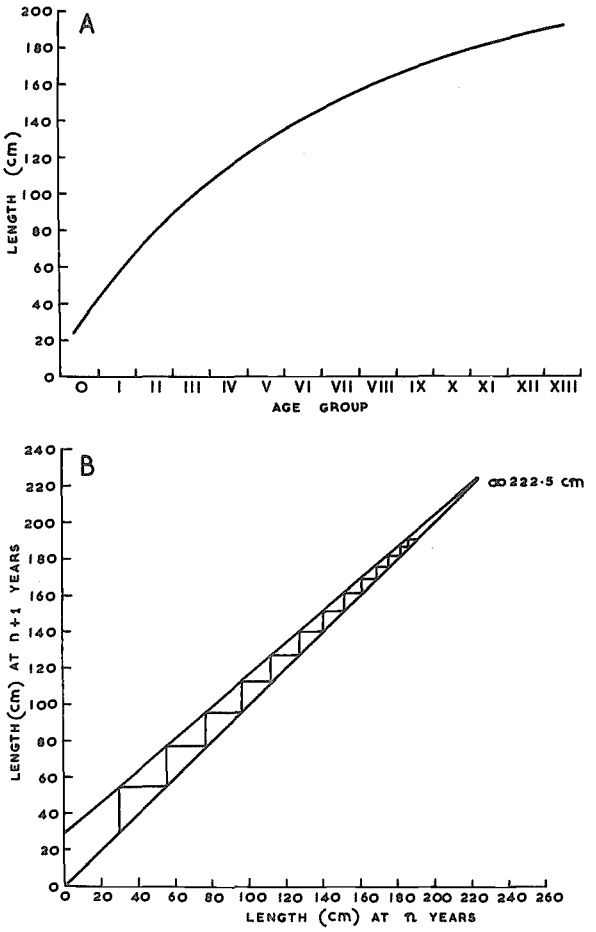

Fig. 4. A. Growth curve (presumptive) of T. maccoyii

B. Walford's growth transformation applied to T. maccoyii (Regression formula $l_{n+1} = 0.8677\ l_n + 29.44$)

is approximately 18.75 cm. This increment agrees fairly closely with the difference shown between the modes of the I+ and II+ classes in the length frequency distributions (i.e. 53 cm to 73 cm). The mode at 83 cm, of fish assumed by Serventy (1956) to be at the end of the fourth growing year, appears to be due to selective sampling of the first spawned group of the two groups which constitute the II+ age group.

Assuming that two modes are found within each age group the dissection of the multimodal length frequency distribution allows a tentative formulation of a growth curve (Fig. 4a), employing the Walford growth transformation technique (Fig. 4b). Comparison with the growth rate of yellowfin tuna (Yabuta and Yukinawa 1959; Moore 1951; Schaefer 1948), indicates that the southern bluefin grows at about half the rate of the yellowfin.

- Condition factors (Ponderal index)

Using $K = \frac{W}{L^3} \times 100$, values of K are found to range from 0.159 to 0.288.

3.5 Behaviour

3.51 Migration and local movements

- Extent of movements or migrations

In eastern Australia juvenile (I+, II+, III+ groups) movements along the south-east coast are to the north in late winter (June, July), and early spring (August) to approximately latitude 34°S; a southerly movement during the late spring and early summer follows. Tag returns (Fig. 5) show (a) that at least part of the juvenile population migrates into south Australian coastal waters by late summer or early autumn and, from other evidence of tagging, a probable return takes place - a minimum distance of 2,000 miles, (b) a part of the population becomes resident in northeast Victorian waters.

From longline catches it can be inferred that there is a parallel movement of the adult population in more oceanic waters of the Tasman Sea, but information is lacking on movement, if any, of the adult stock into oceanic waters south of South Australia.

In South Australian coastal waters the movement into the fishing area commencing in November is from the southeast, with schools becoming most abundant in February and March. Fishermen report (unconfirmed) a secondary small movement from the west into the area in February. In May and June a movement to the southwest is noted.

In Western Australian waters, where the size composition of the juvenile (prematures) catch is made up of very young fish, direction of movement is not clear, but is possibly south along the west coast and east along the south coast in late summer, autumn and early winter, with a return migration in late winter and spring.

Mimura (1961) infers that a southerly migration of the adult population (see Section 2.1 for area) occurs after the end of the fishing season (September to March) i.e. in autumn, and the fishing grounds are reconstituted, commencing in September. Generally described, the movement to the south occurs in autumn and winter and to the north in spring and summer.

- Function of migration

Migration of juveniles appears to be for feeding and in response to environmental change. In Western Australian waters adults migrate to the northern grounds and form breeding groups (Mimura 1961).

Function of migration of adults to the north in eastern area presumed to be one of feeding, but data are insufficient to indicate spawning areas, although specimens of adults with developing gonads are found in November during the relatively slow southern movement off the New South Wales coast.

- Mode of migratory movements

Eastern Australian juveniles in inshore regions on their northward migration are generally dispersed or in loose small schools. On the southerly movement schools can be dispersed or compact. Mode of migratory movement of adults not known.

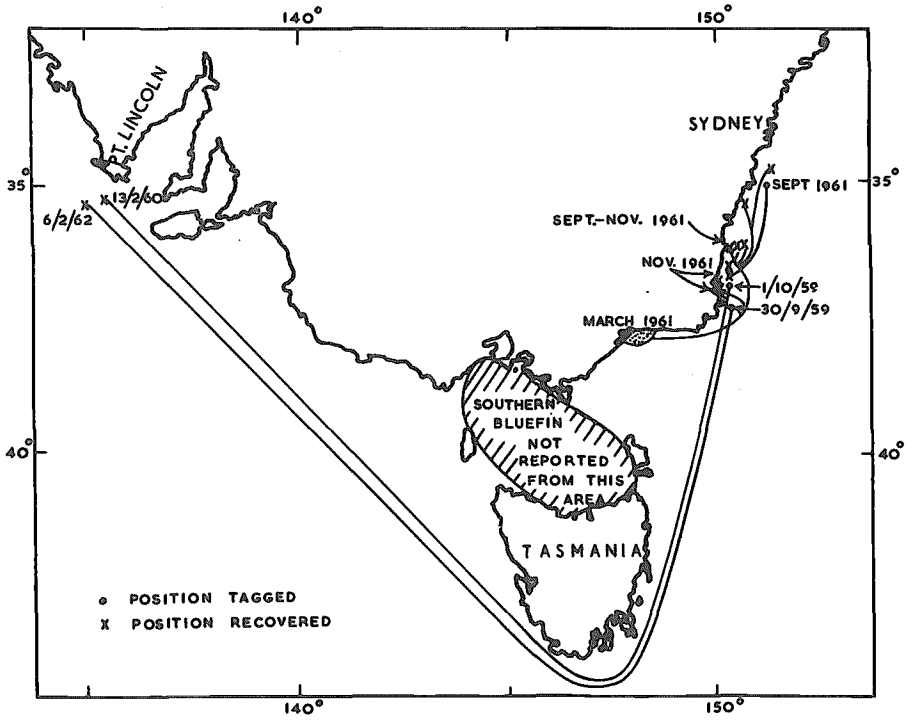

Fig. 5. Presumed movement of some tagged tuna

- Changes in pattern of movements or migrations with age, physiological state, season, temperature and environmental conditions

Juveniles (< 60 lb) occur much more frequently in inshore waters than do adults which swim at deeper levels in more oceanic waters. Adults, caught by experimental longline to depths of 200 m.

In Tasman Sea and north of North Island of New Zealand, northern limit of distribution appears to be controlled (a) by seasonal position of tropical convergence in the area, (b) on the east coast of Australia, northern limit of surface occurring (juveniles) tuna distribution associated with 19° C isotherm.

In Western Australia pattern of migration to the north inferred to be in response to the reproductive cycle.

3.52 Schooling

- Extent of schooling habits

Schools of fish from half-a-ton to 500 tons reported. Catches up to 62 tons made from a single school. Unverifiable reports on file of sightings of much larger schools (Serventy 1956).

- Composition of stocks by size, age and sex

Eastern Australia

(A) New Zealand area (longline caught fish)

(a) Size : range 85-187 cm : dominant group 121-161 cm

(b) Age : range (presumptive) II+ to XII+

(c) Sex : ratio 1.22 male : 1 female

(B) Southwest Tasman Sea area

(i) Longline caught fish

(a) Size : range 83-167 cm : dominant group 130-155 cm

(b) Age : range (presumptive) I+ to IX+

(c) Sex : ratio 1.40 male : 1 female

(ii) Troll and livebait-and-pole caught fish

(a) Size : range 45-163 cm : dominant 80-105 cm

(b) Age (presumptive) I+ to VIII+

(c) Sex : ratio 1 male : 1.22 female

(C) South of South Australia (fish caught on longline, February 1960)

(a) Size : range 86-175 cm: dominant 136-155 cm

(b) Age : range (presumptive) III+ to X+: dominant 6+ and 7+

(D) Western Australia

(i) "Old" fishing ground

(a) Size : range 135-180 cm: dominant 150-160 cm

(b) Age : range (presumptive) V+ to XI+

(c) Sex : ratio 1.2 male : 1 female (nine year period of observation)

(ii) "New" fishing ground

(a) Size : range 137-175 cm: dominant 140-156 cm

(b) Age : range (presumptive) V+ to X+

(c) Sex : ratio 1.38 male : 1 female (three year period).

- Mixing of stocks within species at various stages of the life cycle

Two tags from juvenile fish tagged east of New South Wales were returned from fish caught in South Australian waters (five months, and 28 months later) suggest at least partial mixing between stocks of fish from the east and south coasts of Australia.

- Mixing between species

Mixing at margins of distribution between skipjack tuna (K. pelamis), albacore (T. germo) and yellowfin tuna (N. macropterus) to a very limited extent.

Mixing of schools of two species not noted.

- Patterns of schools

Small schools difficult to " chum" referred to as " wild". Large closely packed schools referred to as " ripplers", and generally easier to " chum".

- Size, density and behaviour of schools in relation to (a) time of day (b) geographic location, (c) season (d) oceanographical factors (e) physiological conditions

(a) No data;

(b) In eastern Australian inshore waters;

(c) Densest and largest schools generally occur in November about latitude 37°S. In south Australian waters, about latitude 35°S, heaviest concentrations occur in February and March. In area to north of North Island of New Zealand July and August are months of greatest concentrations (Fig. 2). In Western Australian area in " old" fishing grounds best concentrations September and October with a secondary concentration during February. In " new" fishing ground concentration occurs during October with a secondary larger concentration during January and February (see Fig. 6).

(d) Schools aggregated at temperature discontinuities and associated with currents.

(e) No data.

- Aggregation (local concentration of several separate schools of some species or various species)

Noted to occur with separate schools of different size, which under certain circumstances conjoin (i. e. during a fishing operation); proximity of schools of different species, e. g. skipjack and yellowfin in same restricted area.

3.53 Responses to stimuli

- Environmental stimuli

- Mechanical (reactions to pressures, currents, sound)

Associated with currents along discontinuities. No data on response to pressures. Except for " rippling" schools, small schools react unfavourably (i. e. school disperses but extent unknown) when subjected to repeated sound frequency of 48 Kc propagated in horizontal direction.

- Artificial stimuli

- Fishing gear components, model gear

Respond at times to livebait which consists mainly of yellowtail (T. novaezelandiae), pilchards (S. neopilchardus) and anchovy (E. australis). Longline bait of favourable size (8-10 in) consists of mullet (Mugil georgii, Lisa argentea, Aldrichetta forsteri) jack mackerel (T. novaezelandiae) and scad (T. declivis). Reasons for non-response unknown.

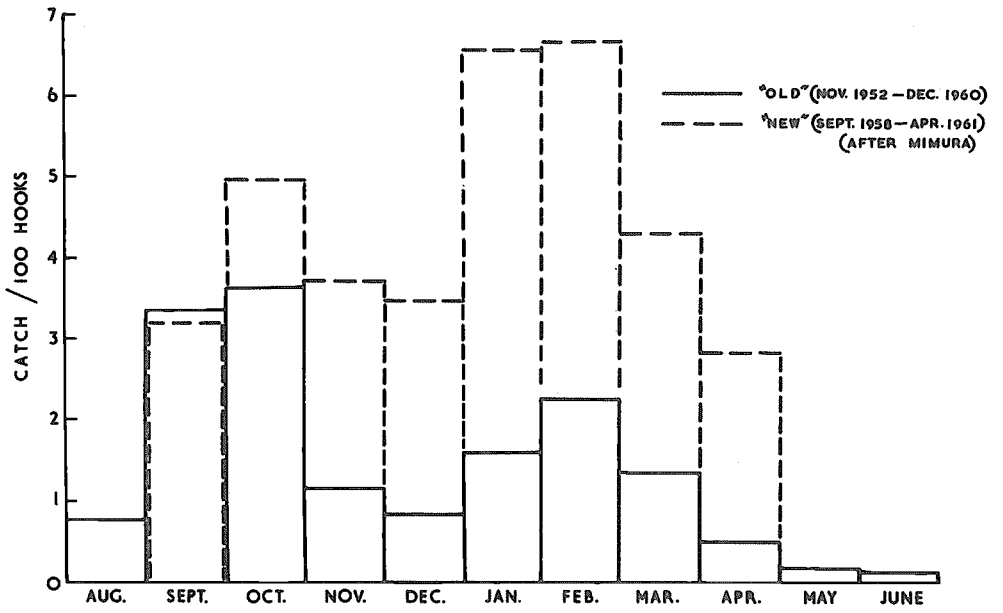

Fig. 6. Monthly average catch rates for Western Australian "old" and "new" grounds.

4 POPULATION

4.1 Structure

4.11 Sex ratio

- Sex ratio of catch

See Section 3.52.

- Variations of ratios with size, age, season

Not determined but livebait and pole-caught juveniles appear to have different sex ratio from longline-caught fish (see Section 3.52).

- Sex ratio on spawning grounds

See Sections 3.16 and 3.52.

4.12 Age composition

- Variations with depth, distance off the coast, density, time of day, season

Juveniles occur more frequently in surface inshore waters. Adults further offshore at deeper levels.

- Age at first capture

0+ group (Serventy 1956), in Western Australian waters. I+ in eastern Australian waters.

- Age at maturity

IV+ to V+ (presumptive).

4.13 Size composition (Fig. 9)

- Size at first capture

32 cm (Serventy 1956).

- Size at maturity

110-128 cm.

- Maximum size

190 cm (commercial catch) – 222.5 cm

- Length and weight relation

See Fig. 7.

Using $\log X = a + b \log Y$, where X = weight (lb), Y = length (cm)

(a) Grouped : a = -4.161, b = 2.9058

(b) males : a = -4.241, b = 2.944

(c) females : a = -4.124, b = 2.886

4.2 Abundance and density (of population)

4.22 Changes in abundance

- Changes caused by hydrographic conditions, food competition, predation, fluctuations and fishing

In eastern Australian coastal fishery, abundance of fish on fishing grounds is variable from season to season. Clear correlation with low plankton values not shown, " but low plankton values, and particularly low euphausean numbers, tend to be associated with or to precede unfavourable features in the tuna". (Serventy 1956). In " good" seasons (i.e. when availability is higher) the penetration of the juvenile schools to the north is greater (Serventy 1956). Seasonal fluctuations in hydrographic conditions suspected to cause fluctuations in accessibility.

4.24 Changes in density

- Seasonal variations in available stock

(a) " Old" fishing ground - two peak seasons (Fig. 6)

(b) " New" fishing ground - two peak seasons (Fig. 6)

(c) North Island of New Zealand - one peak season (Fig. 2)

(d) East coast pole-and-line fishery - one peak season (Fig. 8)

(e) South Australian pole-and-line fishery - one peak season (on available figures) (Fig. 8).

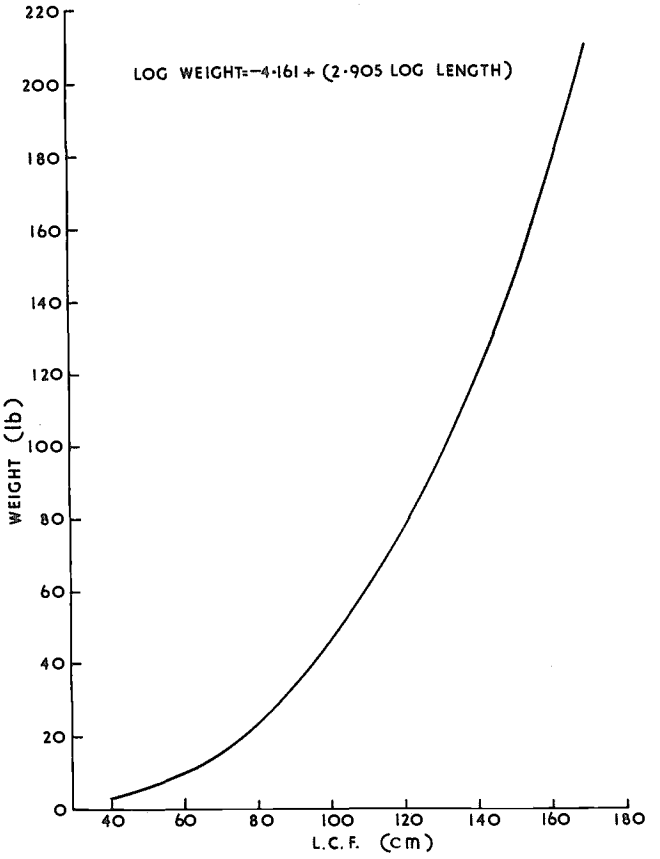

Fig. 7. Length/weight relation (Sexes combined).

4.6 The population in the community and the ecosystem

- Physical features of the biotope of the community

Temperature range 10.5°C to 21°C, convergent systems, divergent systems and associated currents.

- Interrelations of the population of the species in the community and ecosystem; place in the food chain; trophic level, etc.

Climax feeders.

- Changes in environmental factors and their effect on the population

See Section 3.32.

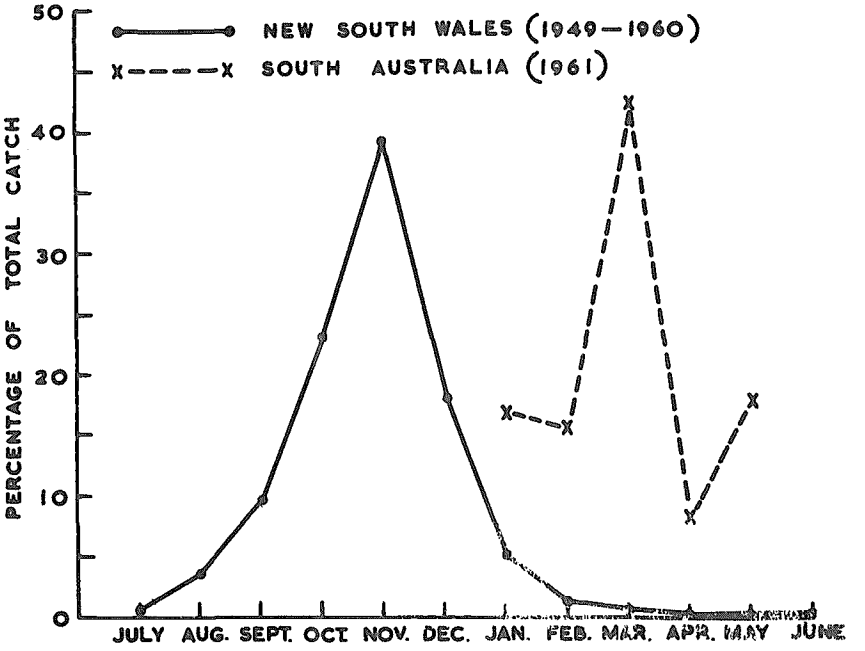

Fig. 8. Seasonal variations in livebait and pole fishery roughly indicative of relative abundance from month to month.

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gear

- Present gear

(a) Pole and line. Conventional pole-and-line as used in American live-bait and pole fishery.

(b) (i) Longline. Conventional Japanese longline as used for capture of other species of tuna, using four but generally five hooks to one unit. Length of one mainline unit is 187.5 m, with branchline 17 m approximately (dropper 9.75 m, sekiyama 4.5 m, trace 2.7 m and hook), float line approximately 18 m, 12 in diameter glass float with net protector, and flag pole approximately 5 m. Up to 400 units comprise one set.

(ii) Experimental longline - using 12 or 6 hooks to one unit (Australia). Mainline of 3/8 in bright galvanised steel wire rope 125 or 62.5 fm in length, with lead ball stops swaged on to mainline at 7 1/2 fm from each end with lead ball stops at 10 fm intervals at intermediate hook positions. Branch lines of 3 fm (2 1/2 fm of dropper 5/8 in H.L. cotton), trace 1/2 fm of 1/4 in bright galvanised steel wire rope and 9/0 hook. Each set of units either 16 (i.e. 125 fm units) or 32 (62 1/2 fm units). Float lines of 10 fm of either 3/4 in H.L. cotton or 1 in dyed sisal. Floats are of various types. Flag pole is 16 ft.

- Changes in types of gear during the development of the fishery

(a) From conventional trolling to conventional live bait and pole fishing;

(b) No change in gear for longlining.

- Use of echosounding or fish detectors

Random use of echosounding for detection.

- Use of light attraction (type of light, power)

Light used only to attract livebait. Variety of lights used - wattage range from 200 to 1000 W. Incandescent white light mainly, with a few mercury vapour lamps.

5.12 Boats

- Type

(a) Longlining. Japanese type longliner.

(b) Pole and line - non standardised, with one exception; vessels range in size from 35 ft to 105 ft. Wheelhouse forward, bait-tanks amidships to abaft amidships, fishing racks on stern and quarters. Larger vessels modified to " clipper type " with freezer capacity. Smaller vessels not refrigerated nor do they carry ice. One American type west coast tuna clipper (105 ft) in fleet.

- Power

Range from 30 H.P. to 600 H.P. main engine.

- Changes in types of boats during the development of the fishery.

With expanding fishery, size composition of fleet is slowly increasing.

5.2 Fishing areas

5.21 General geographic distribution

North Island of New Zealand area (code 631). Southern New South Wales coast and Bass Strait eastern approaches (code 615, 614, 617), South Australia (613), Western Australia (612).

5.22 Geographic ranges

- Distances from coast

(a) North New Zealand area (longlining) from 30 miles to 300 mi offshore

(b) East Australia (pole and line fishing) - from 1/2 mi to 40 mi offshore

(c) South Australia (pole and line fishing) - from 1/2 mi to 50 mi offshore

(d) Western Australia (longlining) - from 120 mi to 700 mi offshore.

- Areas of greatest abundance (political or geographical designations or degrees of latitude and longitude)

(a) North Island of New Zealand area - between latitudes 33° and 38°S, longitudes 170° and 180°E.

(b) Southeast coast of Australia - between latitudes 37°S and 38°S, longitudes 150°E and 151°E.

(c) South Australia - between latitudes 35°S and 36°S, longitudes 135°E and 137°E.

(d) Western Australia -

(i) "Old" fishing ground 10°S to 17°S, 113°E to 120°E;

(ii) "New" fishing ground 20°S to 30°S, 100°E to 110°E.

- Differential abundance associated with hydrographical features

Greatest concentrations near convergencies, temperature discontinuities and along current boundaries.

- Changes in ranges during development of the fishery

(a) North Island of New Zealand area - gradual extension into more southern waters on east coast of New Zealand;

(b) East coast of Australia - slight extension seaward from coast and northward to latitude 34°S from about 37°S.

(c) South Australia - temporarily static;

(d) Western Australia - extension into more southern latitudes.

5.3 Fishing seasons

5.31 General pattern of seasons

- Pattern of season(s) within whole fishing area

In eastern fishing area of the New Zealand region, longline ground in July is situated between latitudes 36°S and 38°S, moves north to latitude 32°S - 33°S by October, and then returns to the south in late November and December. Recent information indicates that fishing occurs in waters off the east New Zealand coast in latitude 40°S during May.

In the southeast Australian region pole fishing usually commences in September, sometimes in August, on lightly schooled fish. As the season progresses, reaching a peak in November, the schools become more dense, and the season usually finishes by the end of December.

In South Australian waters the fish commence moving into the general fishing area from the southeast by November, in a manner similar to that on the east coast in August. The season reaches its peak in February and March and, until recently, was completed in early May. The season may possibly extend into June but adverse weather conditions preclude the possibility of fishing with the present fleet.

In Western Australia (longlining) the season commences on the "old" ground in August peaking in September, October and again in February and carries through until April (at a very low catch rate) after which the fish disappear, even though fishing for other species of tuna continues. On the "new" ground fishing season extends from October to April with catches reaching a peak in October and January-February.

5.32 Dates of beginning, peak and end of seasons

- Approximate dates in various fishing areas

See Section 5.31.

5.33 Variation in date or duration of season

- Variations caused by climate, availability, regulations, economic factors, etc.

Variation in duration of season pole and line

fishing in southeast Australian waters appears to be associated with (a) seasonal variations in the environment, (b) adverse weather conditions. In South Australia adverse weather conditions contribute to variation in duration of season.

5.4 Fishing operations and results

5.41 Effort and intensity

- Type of unit of effort

(a) Longline. Catch/100 hooks.

- Catches per unit of fishing effort

(i) North Island New Zealand area - 8.57/100 hooks (average of four seasons);

(ii) "Old" fishing ground - 1.66/100 hooks (average of nine seasons);

(iii) "New" fishing ground - 4.45/100 hooks (average of three seasons). (Operation number not known).

(b) Pole and line fishery - Not studied.

- Fishing effort per unit area

(a) Longline - Catch/100 hooks/1° square;

(b) Livebait and pole - Not studied.

- Causes of variation in fishing effort and intensity

In longlining economic factors influence fishing intensity; more profitable to fish, seasonally, in waters close to the Japanese markets for other species of tuna.

5.42 Selectivity

See Figures 9a, 9b and 9c.

- Selective properties of gear

Longline selective on the large members of the population. Juvenile fish 25 lb in weight sometimes taken. Selectivity could also be explained on habitat difference between juvenile and adult fish, e.g. spawners and near-spawners taken only on "old" and "new" fishing grounds off Western Australia (Mimura 1961)(Figs. 2 and 3).

Live bait and pole fishing method more selective on juvenile part of the population.

5.43 Catches

- Total annual yields from different fishing grounds

(a) North Island of New Zealand area - unknown.

(b) Southeast Australia

Year	Tons
1949	353
1950	134
1951	27
1952	250
1953	479
1954	667
1955	480
1956	927
1957	851
1958	1691
1959	1526
1960	2015
1961	1550

(c) South Australia

1949-56	-
1957	231
1958	540
1959	687
1960	1371
1961	2200

(d) Western Australian region

Season	Estimated total landings Tons	Remarks
1952-53	680	("Old" and "new"
1953-54	1112	fishing grounds)
1954-55	1259	
1955-56	2248	
1956-57	8046	
1957-58	8728	
1958-59	19257	(Exploitation of "new"
1959-60	42950	ground commenced)
1960-61	41837	

From 1952 to 1956 fishing for bluefin in the "old" fishing ground was of secondary importance to that for yellowfin.

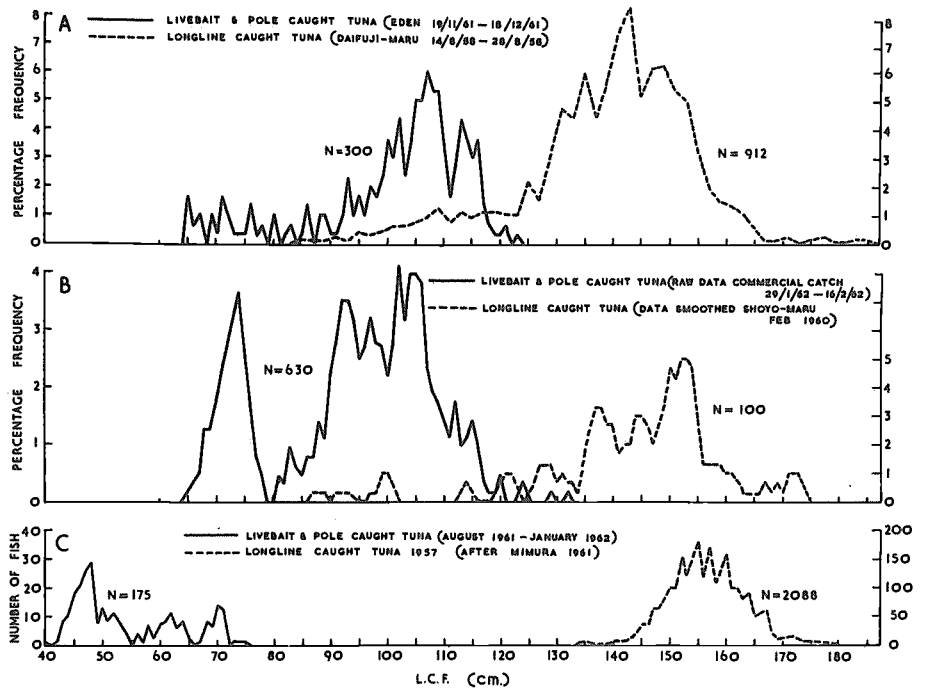

Fig. 9. Length frequency distributions of livebait and pole, and longline caught southern bluefin tuna.

A. in east Australian region.

B. in south Australian region.

C. in western Australian region.

From 1956 to 1958 demand for bluefin increased and the emphasis in fishing changed to bluefin. After 1958 the "new" fishing ground was exploited (these grounds supply bluefin almost exclusively); hence the large increase in total catch figures. (Data from Nankai Regional Fisheries Research Laboratory, Kochi, Japan).

6 PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

Fish weighing less than 10 lb not acceptable to canneries.