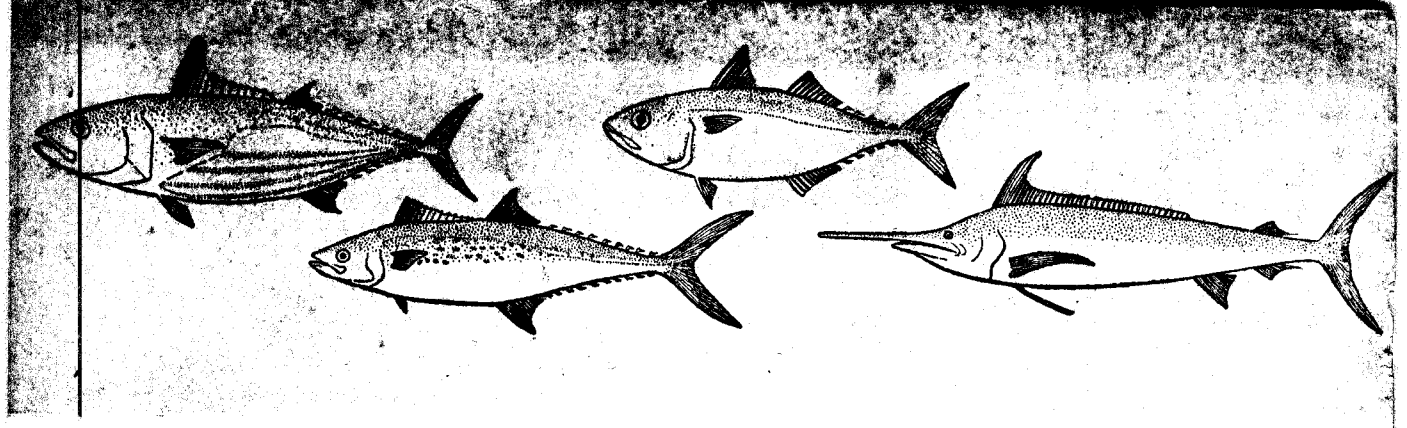
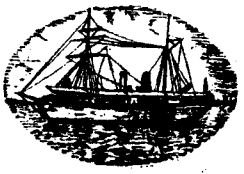


SYMPOSIUM ON

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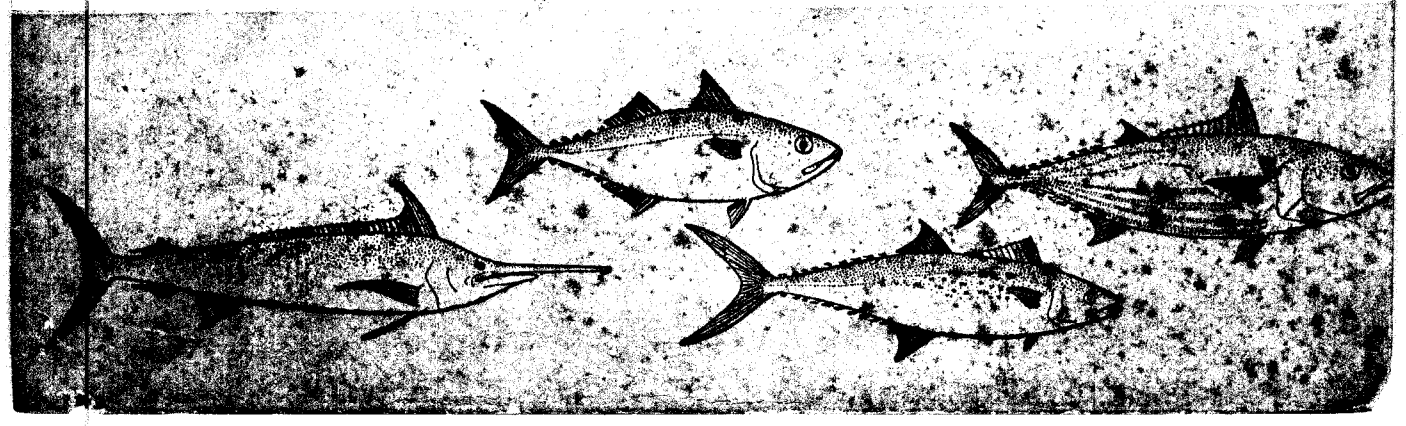
PART III



MARINE BIOLOGICAL ASSOCIATION OF INDIA

MANDAPAM CAMP

S. INDIA

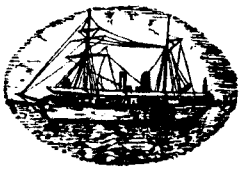


PROCEEDINGS OF THE

SYMPOSIUM
ON
SCOMBROID FISHES

HELD AT MANDAPAM CAMP FROM JAN. 12-15, 1962

PART III



SYMPOSIUM SERIES I

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MANDAPAM CAMP

S. INDIA

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PARASITES OF SCOMBROID FISHES. PART I. MONOGENETIC TREMATODES, DIGENETIC TREMATODES, AND CESTODES*

By E. G. SILAS

Central Marine Fisheries Research Institute, Mandapam Camp

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INTRODUCTION

Recent works on helminth parasites, notably by Southwell (1925, 1930), Dollfus (1912-1949), Price (1936-1943), Manter (1926-1954), Nagaty (1937), Dawes (1941, 1946), Sproston (1946), Wardle and McLeod (1952), Yamaguti (1934, 1955, 1958, 1959), and several others have helped in establishing a sounder classification of helminth parasites, especially those infesting fishes. Detailed observations on the ecology and biology of helminth parasites infesting fishes lag far behind as compared to medical helminth parasitology, as the stage of discovering and describing new species of helminths, the reporting of new host records and distributional records, life history studies, etc., is not over since many groups of fishes still remain uninvestigated for parasites.

The scombroid fishes, which as a whole constitute a very important or in fact the most important single element in the marine fishery resources of the world has received some attention from workers engaged in the study of fish parasites. It may be safely said that in view of the commercial importance of this group of fishes more and more species may be subjected to the scrutiny of those interested in fish parasites. Only within the last decade has our knowledge about the species of scombroid fishes crystallised into some definiteness and this should greatly aid precise host determination.

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There is not a single endemic species of scombroid fish (mackerels, seerfishes or spanish mackerel, tunas and billfishes) in the Indian seas. Several are very widely distributed in the Indo-Pacific (*e.g., Rastrelliger kanagurta, Scomberomorus commerson, Thunnus (N.) a. macropterus*, etc.), while a few evince pantropical distribution (*e.g., Katsuwonus pelamis, Scomber japonicus, Xiphias gladius, Istiophorus gladius*, etc.), and as such it was felt that to serve any useful purpose, this coverage of parasites of scombroid fishes should be on a world-wide basis. The lack of any comprehensive work of this nature on this group of fishes, has made the completion of the present task all the more necessary.

Both structural and physiological adaptations are involved on the part of the parasite species which may occupy diverse situations on or within the body of the host species. The common sites to look for them are the peritoneum, muscles, mesentry, mucous membrane of the branchial cavity or the skin of the head or body, or beneath scales where they may be encysted, or found free in the stomach, pyloric caeca, intestine, anal region, base of branchial arches, mouth, on gill lamellae, inside of operculum, submental groove, etc. In the marine environment, especially amongst cestodes where at least two intermediate hosts are present, only late larval stages infest teleostean fishes, cephalopods, etc. while adults are generally found in elasmobranchs. No doubt this state of affairs has given rise to the chaos in species nomenclature in Cestoda, which thanks to some of the works mentioned earlier has been straightened to a certain extent. In the other groups dealt with also, at the species level the nomenclature is in a nebulous state in many instances, as the criteria for distinguishing the different species are not well defined, and variations seen in the same parasite species from host to host (of closely related host species or 'unrelated' host species), and from different geographical areas have tended to complicate matters. One good instance is that given by Wardle and McLeod (1952) also involving scombroid fishes as host species. They remark that 'There occurs, also, in hosts as far separated taxonomically and geographically as *Tetrapturus albidus, Histiophorus gladius*, and *Tarpon atlanticus* of the north Atlantic, *Histiophorus* sp. of the Indian and Pacific Ocean, a bothriocephalid cestode characterised by a clubshaped holdfast, a broad, frilled body, and a gravid uterus at least one-third of the segment width. At present this form is separated according to host distribution and certain alleged differences into a number of species—*plicatus* Rudolphi, *manubriformis* Linton, *occidentalis* Linton, *laciniatus* Linton, *histiophorus* Shipley, and so forth; but it is not improbable that these, again, are merely forms of the originally described *plicatus*'.

The need for examining good series of specimens before describing new species of helminths is well stressed in the following observation by Hargis (1956) based on his experience of species of the monogenetic trematode genus *Lithiodocotyle*. 'In the early part of the study it was suspected by the writer that several species of *Lithiodocotyle* were represented in the collection because those from *S. maculatus* were smaller than those from *S. cavalla*. However, later studies revealed overlaps in many of the countable and measurable characters and such a similarity of organs that it is impossible to consider either of the populations from these two host species as new.' This finding, no doubt, shows also the close affinities between the two host species belonging to the genus *Scomberomorus*. Another point it stresses is the great need to be cautious and as far as possible refrain from describing new species of helminths of the same genus from one or more than one closely related host species based on single specimens!

Considering the number of species of scombroid fishes left uninvestigated for parasite species, and in the absence of proper distributional data on the known species of parasites, it is rather premature to discuss matters pertaining to host specificity, zoogeography of scombroid fishes and their parasites, and so forth. However, investigations on helminth parasites as a whole indicate that the monogenetic trematodes evince host specificity to the greatest degree, while the cestodes show the least, reflecting on the complicated life cycle of the latter. This general trend is evident in helminth parasites of scombroid fishes also. Meserve (1938) described 22 species of monogenetic trematodes from the Galapagos Islands and vicinity, after examining five hundred fish specimens belonging to at least one hundred species, and all 22 parasite species were from single host species respectively showing the high degree of host specificity. Multiple

infestation is rather less frequent in this group, but is more common among digenetic trematodes and cestodes.

For obtaining a proper perspective of host-parasite relationship, especially of scombroid fishes and their parasites, information about the non-scombroid hosts of the parasite species is also necessary. In all instances this may not be complete, but data of this nature while throwing light on the adaptability of the parasite species to infect successfully different hosts of closely related species or species belonging to widely different families in the same habitat or widely different habitats, will also aid in our understanding of the natural spatial distribution of the parasite species.

The appeal made to parasitologists by Baylis (1926) and several others for the correct use of host names is again repeated. One purpose of this work has been to straighten out the nomenclature of the host species. Often names 'non-existent' are used (e.g. *Cybium lanceolatus* the host of *Pricea multae* Chauhan, 1945), and as the systematics of scombroid fishes in days gone by was not sound, mis-identifications of host species do exist. Careful evaluation based on recent researches on the taxonomy of scombroid fishes, the distributional ranges of the different species, etc., has been made in order to give up-to-date names for host species. When doubt exists as in the case of *Cybium lanceolatus*, which could be meant to 'represent' any one of the three species of *Scomberomorus* from Indian seas, the host is given here as *Scomberomorus* sp., and in the host-parasite list the parasite species name is also given with a query under the names of the three Indian species of *Scomberomorus*. It will be desirable to have it so until fresh collections could be made to determine the host species.

In the absence of any recent monographic work covering all species of scombroid fishes (mackerels, seerfishes or spanish mackerels, tunas, and billfishes), which would have aided in the identification of host species, the next best that could be thought of is to give a list of important references pertaining to the systematics of scombroid fishes published in recent years from various parts of the world. This list is appended at the end after a list of references to scombroid fish parasites. Where it has not been possible to check up original host names of scombroid fishes as given when a parasite was first described, I have used the name as given by Yamaguti (1958 and 1959) for digenetic trematodes and cestodes and also indicated the up-to-date names along side. I shall welcome suggestions and shall be most thankful to readers for drawing my attention to any omissions.

MONOGENETIC TREMATODES

ORDER : MONOGENEA

Suborder : MONOPISTHOCOTYLEA

Superfamily : GYRODACTYLOIDEA

Family : DACTYLOGYRIDAE

Subfamily : DACTYLOGYRINAE

Genus DACTYLOGYRUS Diesing, 1850

Dactylogyrus inversus Goto and Kikuchi, 1917

Scombroid host : *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn]
Locality : Japan.
Non-scombroid host : *Lateolabrax japonicus* [Japan].
Location : Gills.
Reference : Ishii and Sawada (1938).

Superfamily : CAPSALOIDEA

Family : CAPSALIDAE

Subfamily : CAPSALINAE

Genus CAPSALA Bosc, 1811, emend. Price, 1939

(Syn. *Phylline* Oken, 1815 in part; *Tristoma* Cuvier, 1817 in part; *Tricotyle* Guiart, 1938; *Tristomella* Guiart, 1938 ; *Capsala* Guiart, 1938 in part)

Recent reviews on the genus *Capsala* by Price (1938) and Sproston (1946), and later records of new species referrable to this genus indicate that less than thirty valid species are known. Out of these, I have been able to find references to at least eighteen species which occur on scombroid fishes (see also addendum).

Capsala biparasitica (Goto, 1894)

(Syn. *Tristomum biparasiticum* Goto, 1894)

Scombroid host : *Thynnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]
Locality : Misaki, Japan, Pacific.
Non-scombroid hosts : None.
Location : On carapace of copepod *Parapetalus* sp. on gills of tuna.
Remarks : See also Dollfus (1922, p. 292).

Capsala caballerio Winter, 1955

Scombroid host : *Sarda orientalis* (Temminck and Schlegel)
Locality : Pacific coast of Mexico.
Non-scombroid hosts : None.
Location : Gills.

Capsala gouri Chauhan, 1951

Scombroid host : *Thynnus thunnina** [=*Euthynnus affinis affinis* (Cantor)]
[*not *T. thumina* as given in *Zool. Rec.* 1954, p. 91 (1957).]
Locality : Bombay, India (Arabian Sea).
Non-scombroid hosts : None.
Location : Operculum of host.

Capsala katsuwoni (Ishii, 1936), Sproston, 1946
(Syn. *Tristoma katsuwonum* Ishii, 1936)

Scombroid host : *Katsuwonus vagans* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

Capsala laevis (Verrill, 1874), Johnstone, 1929, Price, 1939

(Syn. *Tristoma laeve*, Verrill, 1874 ; *Tristomum histiphori* Bell, 1891 ; *Tristoma laeve* var. *armata* Goto, 1899)

Scombroid hosts : 1. *Histiophorus* (*sic*) *brevirostris* (Day) [=*Makaira indica* (Cuvier)]
2. *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
3. *Tetrapturus lessonae* [=*Tetrapturus belone* Rafinesque]
4. *Tetrapturus albidus*
5. *Xiphias gladius*

Localities : (1) Madras, E. coast of India, Bay of Bengal; (2) South of Martha's Vineyard, N.W. Atlantic ; (3) N.W. France; (4) Block Is.; (5) Atlantic.

Non-scombroid hosts : *Coryphaena hippurus* (from Atlantic).

Remarks : See for discussions on nomenclature, Johnston (1929), Price (1939) and Sproston (1946).

Capsala manteri Price, 1952

Scombroid host : *Euthynnus alletteratus* (Rafinesque)

Locality : Tortugas, Florida, U.S.A. (Atlantic).

Non-scombroid hosts : None.

Location : Gills.

Capsala megacotyle (von Linstow, 1906), Johnston, 1929, emend. Price, 1939

(Syn. *Tristoma megacotyle* von Linstow, 1906 ; *Capsala megacephala* Johnston (*megacephala* for *megacotyle*—an error); *Tristomella megacotyle* Guiart, 1938)

Scombroid host : 'Sword fish, *Histiophorus* sp.' [=? *Istiophorus gladius* (Broussonnet) or *Makaira* sp.]

Locality : Beruwala, W. coast of Ceylon.

Non-scombroid hosts : None.

Location : On surface of body.

Remarks : Accurate host identification is not possible for the following reasons : The popular name 'swordfish' is not used for *Histiophorus* (=*Istiophorus*) which is well known as the 'sailfish'. The swordfish, *Xiphias gladius* is extremely rare in these waters, but on the contrary, species of marlins or spearfishes (*Makaira* and *Tetrapturus*) are not uncommon along the Ceylon coast and in the past have often been mistakenly identified as swordfish. As the host of *C. megacotyle* could thus as well be a marlin, this is indicated. The matter may be settled by making fresh collections.

Capsala nozawae (Goto, 1894)

Syn. *Tristomum nozawae* Goto, 1894 ; ? *Capsala* (*Tristomum*) ? *nozawae*, Baylis, 1939)

Scombroid host : 1. *Thynnus sibi* [=? *Thunnus* (*T.*) *alalunga* (Bonnaterre), or ? *Thunnus* (*Parathunnus*) *obseus mebachi* Kishinouye)]
2. *Thunnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
3. *Katsuwonus vagans* [=*Katsuwonus pelamis*]

Localities : 1. Japan, Pacific ; 2. North Sea ; 3. Japan.

Non-scombroid hosts : None.

Location : On fins.

Remarks : The specific name *sibi* of the host species has been used to denote more than one species of tuna. Boeseman (1947) considered it to be synonymous with *Thunnus alalunga*. However, Rivas (1961) feels that *T. sibi* is a valid species of which *Parathunnus mabachi* Kishinouye is a synonym and *Parathunnus* Kishinouye a subgenus of *Thunnus*. In keeping with Boeseman's findings and a recent review of Indian tunas (Jones and Silas, 1960), two host names are given with query as likely hosts of *C. nozawae* from Japanese waters. Baylis's record as mentioned by him is doubtful.

Capsala ovalis (Goto, 1894), Price, 1938, emend. Sproston, 1946

(Syn. *Tristomum ovale* Goto, 1894 ; *Tristoma ovala* Goto, 1899 ; *Capsala ovale* Price, 1938)

Scombroid hosts : 1. *Histiophorus orientalis* [=*Istiophorus gladius* (Broussonnet)]
2. *Cybium niphonium* [=*Scomberomorus niphonius* (Cuvier and Valenciennes)]
3. *Histiophorus* sp. [=*Istiophorus gladius* (Broussonnet) or ? *Makaira* sp.]

Localities : 1 & 2. Japan, Pacific ; 3. Ceylon.
Non-scombroid hosts : None.
Location : On surface of body.

Remarks : Earlier comments about identity of host species from Ceylon given under *Capsala megacotyle* are also applicable here. For discussion on the nomenclature of the parasite species, reference is invited to Price (1938), Sproston (1946), and Chauhan (1951).

Capsala pelamydis (Taschenberg, 1878)

(Syn. *Tristoma pelamydis* Taschenberg, 1878)

Scombroid host : *Pelamys sarda* [=*Sarda sarda* (Bloch)]
Locality : Naples, Mediterranean.
Non-scombroid hosts : None.
Location : ?

Capsala thynni (Guiart, 1938)

(Syn. *Tricotyla thynni* Guiart, 1938)

Scombroid host : 1. *Thynnus albacora* [=*Thunnus* (*Neothunnus*) *albacares albacares* (Bonnaterre)]
2. *Germo alalunga* [=*Thunnus* (*T.*) *alalunga*]

Locality : 1. Off mouth of River Loire, open Atlantic, off France. 2. Atlantic.
Non-scombroid hosts : None.
Location : Gills.

Remarks : Sproston (1946, p. 525) refers to *Germo alalunga* as the host of *C. thynni*. *Thunnus albacares* is the Atlantic yellowfin, and that from the Indo-Pacific has generally been considered to be distinct and denoted as '*Neothunnus macropterus*'. Provisionally *Neothunnus* is considered subgenerically distinct from *Thunnus* s.str., (Rivas, 1961), and in this work, the Atlantic yellowfin and Indo-Pacific yellowfin tunas will be denoted as *T.* (*N.*) *albacares albacares* and *T.* (*N.*) *albacares macropterus*, respectively.

Capsala poeyi (Vigueras, 1935), Price, 1938

(Syn. *Tristoma poeyi* Vigueras, 1935)

Scombroid host : *Makaira ampla* (Poey) [=*Tetrapturus ampla* Poey]
Locality : Cuba.
Non-scombroid hosts : None.
Location : Gills.

Capsala magronum (Ishii, 1936) emend. Price, 1938

(Syn. *Tristoma magronum*—also *T. magnronum* (misprint) Ishii, 1936)

Scombroid host : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : On body ?

Capsala onchidiocotyle (Setti, 1899)

(Syn. *Tristoma onchidiocotyle* Setti, 1899)

Scombroid host : 1. *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
2. *Parathunnus obesus* [=*Thunnus* (*P.*) *o. obesus*]
Locality : 1. Elba, Portoferraio, Mediterranean. 2. Coast of Angola, Atlantic.
Non-scombroid hosts : None.
Location : ?

Capsala maccallumi Price, 1939

Scombroid host : *Euthynnus alletteratus* (Rafinesque)
Locality : Woods Hole, Massachusetts, U.S.A.
Non-scombroid hosts : None.
Location : Gills.

Capsala interrupta (Monticelli, 1891), Price, 1938

(Syn. *Tristoma interrupta* Monticelli, 1891)

Scombroid hosts : *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Katsuwonus pelamis (Linnaeus)
Locality : Mediterranean.
Non-scombroid hosts : None.
Location : Gills.
Remarks : See Sproston (1946).

Capsala lintoni Price, 1939

(Syn. *Tristoma laeve* Verrill of Linton, 1898. See Price, 1939)

Scombroid host : *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Martha's Vineyard, Mass. U.S.A.
Non-scombroid hosts : None.
Location : Gills.

Genus CAPSALOIDES Price, 1936

[(Syn. *Capsala* Bosc, 1811, in part ; *Tristoma* Cuvier, 1817 in part ; *Calasloides* Price, 1936 (typographical error)]

Capsaloides perugiai (Setti, 1898)

(Syn. *Tristoma perugiai* Setti, 1894)

Scombroid host : *Tetrapterus belone* Rafinesque
Locality : Spezia, Mediterranean.

Capsaloides cornuatus (Verrill, 1875)

(Syn. *Tristoma cornuatum* Verrill, 1875)

Scombroid host : *Tetrapterus albidus* [=*Tetrapturus albidus* Poey)]
Locality : Block Island, N. America (N.W. Atlantic).
Non-scombroid hosts : None.
Location : ? On body.

Capsaloides megaspinosus* Price, 1939

Scombroid host : *Tetrapterus imperator* [=*Tetrapturus belone* Rafinesque)]
Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic).
Non-scombroid hosts : None.
Location : Nares.
Remarks : For long the host *T. imperator* (Bloch and Schneider), had remained a problematic species, the status of which has been well clarified in a recent work by Robins and de Sylva (1960). It is shown that the species has been confused with *T. belone*, but in fact, Schneider's *imperator* was based on a poor drawing of a juvenile specimen of *Xiphias gladius* Linnæus. However, in the present case, there can be no doubt that the host meant could be anything other than *T. belone*.

Capsaloides sinuatus (Goto, 1894) emend. Price, 1938

(Syn. *Tristomum sinuatum* Goto, 1894)

Scombroid host : *Histiophorus* sp. [=*Istiophorus gladius* (Broussonnet)]
Locality : Misaki, Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

* Sproston (1946) emended the spelling of this species as *C. magnaspinosa*.

Genus TRISTOMA Cuvier, 1817

(Syn. *Capsala* Bosc, 1811 in part)

Tristoma integrum Diesing, 1836

(Syn. *Tristoma coccineum* Cuvier, 1817 in part ; *T. cocineum* Cuvier of Taschenberg, 1879 ; *T. rotundum* Goto, 1894)

Scombroid host : *Xiphias gladius* Linnæus

Locality : Genova, Naples, Messina, Venice (Adriatic and Mediterranean) ; U.S. Coast of N.W. Atlantic ; Japan (Pacific).

Non-scombroid hosts : None.

Remarks : See Price (1939) for differences between genotype *T. coccineum* and *T. integrum*; also Dawes (1946).

Tristoma coccineum Cuvier, 1817

[Syn. *Tristomum papillosum* Diesing, 1836 ; *Capsala papillosa* (Diesing) of Nordmann, in Lamark, 1840]

Scombroid host : *Xiphias gladius* Linnæus

Locality : Atlantic.

Non-scombroid host : Hammerhead shark (Woods Hole, Massachusetts, U.S.A.)

Location : Gills in *X. gladius.*

Tristoma levinsenii Monticelli

Scombroid host : *Thynnus* sp. (=*Thunnus* sp.)

Locality : Mediterranean.

Suborder : POLYOPISTHOCOTYLEA

Superfamily : DICLIDOPHORIDEA

FAMILY : MAZOCRAEIDAE

Genus KUHNIA Sproston, 1945

(Syn. *Octostoma* Kuhn, 1829, nec Otto, 1823 ; *Octobothrium* Leucart, 1827 of Leuckart, 1842 in part ; *Octocotyle* Diesing, 1850 in part, nec Goto, 1894 ; *Octoplectanum* Diesing, 1858, in part)

Kuhnia scombri (Kuhn, 1829), Sproston, 1945

[Syn. *Octostoma scombri* Kuhn, 1829 ; *Octobothrium scombri* (Kuhn) of Nordmann, 1832 and other writers ; *Octocotyle scombri* of Dujardin, 1845 ; *O. truncata* Diesing, 1850 ; *Octoplectanum truncatum* of Diesing, 1858 ; *Pleurocotyle scombri* of Taschenberg, 1878 ; *Octocotyle major* Goto, 1894 ; *Octocotyle scombri*, of Nicoll, 1915 ; *Mazocræs* (*Octobothrium*) *scombri* of Baylis, 1939]

Scombroid hosts :
1. *Scomber scombrus* Linnæus
2. *Pneumatophorus colias* [=*Scomber japonicus colias* Gmelin]
3. *Rastrelliger kanagurta* (Cuvier)
4. Mackerel
5. *Scomber japonicus japonicus* Hottuyun

Localities : 1 & 2. North Sea, English Channel, Eastern Atlantic, Mediterranean and Vladivostock ; 3. Macassar, Celebes ; 4. Newport, U.S.A., N.W. Atlantic ; 5. Japanese waters (Misaki, Japan).

Non-scombroid hosts : None.

Location : Gills.

Remarks : For details of variations in this species reference may be made to Sproston (1945), Dawes (1946), and Yamaguti (1953).

Kuhnia minor (Goto, 1894) Sproston, 1945, 1946

(Syn. *Octocotyle minor* Goto, 1894)

Scombroid host : Scomber colias [=*Scomber japonicus japonicus* Hottuyun or ? *Scomber japonicus colias* Gmelin]

Locality : Hagi, and Misaki, Japan.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Although *Scomber colias* is mentioned as the host, in all probability it may be the typical race of *S. japonicus* rather than *S. japonicus colias*, that could be the original host species, as the type locality of the former is Nagasaki, Japan. Kishinouye (1923) remarks that two types of *S. japonicus* occurs in Japanese waters, a deeper bodied form commonly known as ' hirasaba ', and a rounded bodied form known as ' marusaba '. Slight differences in finray counts are said to exist, but it is not known whether these as well as the differences in body form has anything to do with the different size groups of the typical race.

Kuhnia macracanthus (Meserve, 1838)

(Syn. *Mazocræs macracanthus* Meserve, 1938)

Scombroid host : ' An unidentified species of mackerel.'

Locality : Tagus Cove, Albermarle Isl., Galapagos Isles (E. Pacific).

Non-scombroid hosts : None.

Location : Gills.

Remarks : The host identification is incomplete. However, from the pattern of distribution of mackerels, it is likely that the host could be a race of *Scomber japonicus.*

FAMILY : DISCOCOTYLIDÆ

Subfamily : DISCOCOTYLINÆ

Genus GRUBEA Diesing, 1858

(erected for ' *Octobothrium scombri* Nordmann ' of Grube, 1855)

Grubea cochlear Diesing, 1858

(Syn. *Pleurocotyle scombri* of Pratt, 1900)

Scombroid host : Scomber scombrus Linnæus

Locality : Naples, Mediterranean.

Non-scombroid host : Trachurus trachurus (Linnæus) (Mediterranean).

Location : Gills.

FAMILY : GASTROCOTYLIDÆ

I have followed Hargis (1956) in recognising Gastrocotylidæ as a distinct family with the subfamilies Gastrocotylinæ, Vallisiinæ, and Priceinæ.

Subfamily : GASTROCOTYLINÆ

Genus GASTROCOTYLE van Beneden and Hesse, 1863

Gastrocotyle japonica Ishii and Sawada, 1938 emend. Sproston, 1946

Scombroid host : *Scomber japonicus* [=*Scomber japonicus japonicus* Hottuyun]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

Genus PSEUDAXINE Parona and Perugia, 1890

Pseudaxine katsuwonis Ishii, 1936

Scombroid host : *Katsuwonus vagans* [=*Katsuwonus pelamis* (Linnæus)]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

Pseudaxine mexicanus Meserve, 1938

Scombroid host : 1. *Scomberomorus maculatus* (Mitchill)
2. *Scomberomorus cavalla* (Cuvier)
3. *Scomberomorus maculatus* (Mitchill)

Localities : 1. Tangola-Tangola, Mexico (Pacific Coast) ; 2 & 3. Gulf of Mexico.
Non-scombroid hosts : None.
Location : Gills.
Remarks : See Hargis (1956) and also addendum-II.

Pseudaxine texana Koratha, 1955

Scombroid host : *Scomberomorus maculatus* (Mitchill)
Locality : Texas Coast, U.S.A. (Atlantic).
Non-scombroid hosts : None.
Location : Gills.
Remarks : Hargis (1956) opines that *P. texana* could probably be a synonym of *P. mexicanus*, but as the description and figures given by Koratha (1955) are inadequate to settle this question, both are treated as distinct.

Pseudaxine vagans Ishii, 1936

Scombroid host : *Katsuwonus vagans* [=*Katsuwonus pelamis* (Linnæus)]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

Genus LITHIDOCOTYLE Sproston, 1946, emend. Hargis, 1956

Lithidocotyle acanthophallus (MacCallum and MacCallum, 1913), Sproston 1946
(Syn. *Microcotyle acanthophallus* MacCallum and MacCallum, 1913)

Scombroid host : *Scomberomorus cavalla* (Cuvier)
Scomberomorus maculatus (Mitchill)
Localities : Alligator Harbour, Florida, Tampa Bay, Florida, and Grand Isle, Louisiana, U.S.A. (Atlantic).
Non-scombroid hosts : *Roccus saxatilis* (=*R. lineatus*) (New York Aquarium ? or New York fish market ?).
Location : Gills.
Remarks : Refer to rediagnosis of certain characters given by Hargis (1956), who also draws attention to the possibility of *Microcotyle scomberomori* Koratha (1955) being a synonym of this species, but as the original descriptions and figures of *M. scomberomori* are inadequate to settle this question, they are treated at present as distinct.

Lithidocotyle secundus Tripathi, 1954

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]
Locality : Puri, Orissa Coast, India (Bay of Bengal).
Non-scombroid hosts : None.
Location : Gills.

Genus PSEUDOMICROCOTYLE Sanders, 1947

Pseudomicrocotyle elagatis Sanders, 1947

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]
Locality : Madras, India (Bay of Bengal).
Non-scombroid host : *Elagatis bipinnulata* [Australia].
Location : Gills.

Remarks : Sanders (1947) did not assign his genus to any subfamily, but Tripathi (1954) on the basis of its affinities to *Thoracocotyle*, *Pricea*, and *Lithidocotyle* relegated it to the subfamily Gastrocotylinæ. Incidentally, *Pricea* is now placed under a separate subfamily Pricinae.

Ramalingam (1951) mentions *S. g. guttatus* (as *Cybium guttatum*) as a host of *P. elagatis*, but offers no further comments. In view of the fact that monogenetic trematodes are more host specific and are rarely met with in host species of different families, it would have been desirable to know of variations if any in this parasite species from such widely different hosts.

Genus NEOTHORACOCOTYLE Hargis, 1956

Neothoracocotyle acanthocybii (Meserve, 1938)
(Syn. *Gotocotyle acanthocybii* Meserve, 1938)

Scombroid host : *Acanthocybium solandri* (Cuvier and Valenciennes)
Locality : Galapagos Islands (E. Pacific).
Non-scombroid hosts : None.
Location : Gills.
Remarks : See Hargis (1956) for partial rediagnosis of species.

Genus GOTOCOTYLEA Ishii, 1936 emend. Hargis, 1956

Gotocotylea sawara Ishii, 1936

Scombroid host : Sawara, *Cybium niphonium* [=*Scomberomorus niphonius* (Cuvier and Valenciennes)]
Locality : Japan, Pacific.
Non-scombroid hosts : None.
Location : Gills.

Genus SCOMBEROCOTYLE Hargis, 1956

Scomberocotyle scomberomori (Koratha, 1955), Hargis, 1956
(Syn. *Heteraxine scomberomori* Koratha, 1955)

Scombroid host : *Scomberomorus maculatus* (Mitchill)
Locality : Texas Coast, Atlantic.
Non-scombroid host : None.
Location : Gills.
Remarks : See Hargis (1956) for rediagnosis of species as well.

Genus THORACOCOTYLE MacCallum, 1913, emend. Hargis, 1956

Thoracocotyle crocea MacCallum, 1913, Sproston, 1946
(Syn. *Thoracocotyle paradoxica* Meserve, 1938 ; ? *Thoracocotyle paradoxica* Pearse, 1949)

Scombroid hosts : 1. *Scomberomorus maculatus* (Mitchill)
2. ? *Scomberomorus cavalla* (Cuvier)
Localities : 1. New York Aquarium (MacCallum, 1913) ; Tangola-Tangola, Mexico (Meserve, 1938) ; Alligator Harbour, Florida (Hargis, 1956) (Atlantic and Central Eastern Pacific) ; 2. ? Beaufort, North Carolina, U.S.A. (Pearse, 1949) (Atlantic).
Non-scombroid hosts : None.
Location : Gills.
Remarks : Hargis (1956) gives reasons for considering *T. paradoxica* a synonym of *T. crocea*, thereby extending the distribution of the latter species to the Pacific. Pearse's specimens were obtained from *Scomberomorus cavalla*, although erroneously he mentioned that ' It occurred in the same host as Meserve's species' (*S. maculatus*). Hargis (1956) while drawing attention to this discrepancy comments that perhaps Pearse's *T. paradoxica* could be the same as *T. crocea*.

Thoracocotyle ovale Tripathi, 1954

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Puri, Orissa Coast, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Thoracocotyle sp. Ramalingam, 1951

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Name only. See Ramalingam (1951).

Subfamily : PRICINÆ

Genus : PRICEA Chauhan, 1945

Pricea armatum Ramalingam, 1951

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from a single specimen obtained after examining five host specimens (Ramalingam, 1951).

Pricea melane Ramalingam, 1951

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from a single specimen obtained after examining four host specimens (Ramalingam, 1951).

Pricea minimæ Chauhan, 1945

Scombroid host : Thynus pelamys [=? *Katsuwonus pelamis* (Linnæus)]

Locality : Bombay, India (Arabian Sea).

Non-scombroid hosts : None.

Location : Gills.

Remarks : The host record needs confirmation as the Oceanic skipjack *Katsuwonus pelamis* is rarely ever landed at Bombay. On the other hand, *Euthynnus affinis affinis*, and *Kishinœlla tonggol*, the little tunny and the northern bluefin tuna respectively, are usually landed at

Bombay. Hence, in the list on 'hosts and parasites' given at the end of this section, I have placed *P. minimæ* with a query under *K. pelamis*.

Pricea minutum Ramalingam, 1951

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from a single specimen obtained after examining three host specimens (Ramalingam, 1951).

Pricea microcotylæ Chauhan, 1945

Scombroid host : *Scomber microlepidotus* [=*Rastrelliger kanagurta* (Cuvier)]

Locality : Bombay, India (Arabian Sea).

Non-scombroid hosts : None.

Location : Gills.

Pricea multæ Chauhan, 1945

Scombroid host : 1. *Cybium lanceolatus* (=*Scomberomorus* sp.) See remarks.
2. *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Localities : 1. Bombay, India (Arabian Sea) (Chauhan, 1945); 2. Madras, India (Bay of Bengal) (Ramalingam, 1951).

Non-scombroid hosts : None.

Location : Gills.

Remarks : *P. multæ* is the genotype and was described from a single specimen obtained from '*Cybium lanceolatum*'. I am not aware of any species of *Cybium* (=*Scomberomorus*) with this name. Quite likely, Chauhan has erroneously used '*lanceolatus*' for *Scomberomorus lineolatus* (Cuvier and Valenciennes)! Three species of *Scomberomorus*, namely, *S. commerson* (Lacépède), *S. g. guttatus* (Bloch and Schneider), and *S. lineolatus* are at present known to occur along the Indian coast (Jones and Silas, 1961) and Ramalingam (1951) records *P. multæ* (no description) from *S.g.guttatus*. While admitting that the same species could occur on two, or more closely related host species, it is my contention that the 'host type' could be any one of these three and as such until confirmed on further material I have indicated the first mentioned host as corresponding to *Scomberomorus* sp.

Pricea robusta Ramalingam, 1951

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from many specimens obtained from three host specimens (Ramalingam, 1951).

Pricea tetracanthum Ramalingam, 1951

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from a single specimen obtained after examining seven host specimens (Ramalingam, 1951).

Pricea triacanthum Ramalingam, 1951

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Known from a single specimen obtained after examining six host specimens (Ramalingam, 1951).

FAMILY : MICROCOTYLIDÆ

Subfamily : MICROCOTYLINÆ

Genus : MICROCOTYLE Beneden and Hesse, 1863

Microcotyle scomberomori Koratha, 1955

Scombroid host : *Scomberomorus maculatus* (Mitchill)

Locality : Texas Coast, U.S.A.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Hargis (1956) opines that it is very probable that *Microcotyle scomberomori* Koratha, 1955, is a synonym of *Lithidocotyle acanthophallus* (MacCallum and MacCallum).

Microcotyle sp. Ramalingam, 1951

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)].

Locality : Madras, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Name only. See Ramalingam (1951).

FAMILY : HEXOSTOMATIDÆ

Genus : HEXOSTOMA Rafinesque, 1815

nec Hexastoma Rudolphi, 1809 ; *nec Hexastoma* Kuhn, 1828
(Syn. *Hexocotyle* Blainville, 1828)

Hexostoma auxidi Palombi, 1943

Scombroid host : *Auxis thazard* (Lacépède)
Locality : Mediterranean.
Non-scombroid hosts : None.
Location : Gills.

Hexostoma pricei Koratha, 1955

Scombroid host : *Sarda sarda* (Bloch)
Locality : Texas Coast, U.S.A.
Non-scombroid hosts : None.

Hexostoma grossum (Goto, 1894)
(Syn. *Hexocotyle grossa* Goto, 1894)

Scombroid hosts : *Thynnus* sp. [=*Thunnus* sp.]
Parathunnus sibi [=? *Thunnus alalunga* (Bonnaterre) or ? *Thunnus* (*Parathunnus*) *obseus mebachi* (Kishinouye)]
Katsuwonus vagans [=*Katsuwonus pelamis* (Linnæus)]
Thunnus orientalis [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Japan, Pacific.
Non-scombroid host : *Seriola quinqueradiata* [Japan].
Location : Gills.
Remarks : See Ishii and Sawada (1938) ; and Sproston (1946) for discussion on the species.

Hexostoma macracanthum Fujii, 1944

Scombroid host : *Euthynnus alletteratus* (Rafenesque)
Locality : Tortugas, Florida.
Non-scombroid hosts : None.
Location : Gills.
Remarks : This species may prove to be a synonym of *H. euthynni* Meserve (1938).

Hexostoma acutum (Goto, 1894)
(Syn. *Hexocotyle acuta* Goto, 1894)

Scombroid host : *Thynnus sibi* [=? *Thunnus alalunga* (Bonnattere) or ? *Thunnus* (*Parathunnus*) *obseus mebachi* (Kishinouye)] and *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus orientalis*].
Locality : Hagi, Osatsube, Hokkaido, Japan.
Non-scombroid hosts : None.
Location : Gills.

Hexostoma dissimilis (Yamaguti, 1937)

Scombroid host : *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]

Locality : Numadu, Siduoka Prefecture, Japan.

Non-scombroid hosts : None.

Location : Gills.

Hexostoma extensicaudum (Dawes, 1940)

(Syn. *Hexacotyle extensicauda* Dawes, 1940 ; ? *Hexacotyle* ? *acuta* (Goto) of Baylis, 1939)

Scombroid host : *Thunnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* Linnæus)]

Locality : North Sea.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Dawes (1946) comments that the British form listed by Baylis (1939) as *Hexacotyle* ? *acuta* (Goto) is probably *H. extensicaudum.*

Hexostoma euthynni Meserve, 1938

Scombroid host : 1. *Euthynnus alletteratus* (=*Euthynnus affinis yaito* Kishinouye ? or *E. a. lineatus* Kishinouye ?)

2. *Euthynnus lineatus* (=*Euthynnus affinis lineatus* Kishinouye).

Localities : 1. James Island, Galapagos Islands, E. Pacific (Meserve, 1938) ; 2. Baja, California (Millemann, 1956).

Non-scombroid hosts : None.

Location : Gills.

Remarks : The host species, *E. alletteratus* as given by Meserve is incorrect as it is known only from the Atlantic. The Indo-Pacific representatives of *Euthynnus* may be said to fall under three subspecies of *E. affinis*, of which Galapagos Islands is within the distributional range of the two mentioned above. Millemann's collection of this parasite from *E. a. lineatus* would indicate that the host type could also be the same.

Hexostoma thunninæ (Parona and Perugia, 1889)

(Syn. *Octocotyle thunninæ* Parona and Perugia, 1889 ; *Octobothrium thunninæ* (Parona and Perugia) of St. Remy, 1891 ; *Hexocotyle thunninæ* (Parona and Perugia) of Goto, 1899)

Scombroid hosts : *Thunnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnæus)]

Locality : Genova, Italy, Mediterranean.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Palombi (1943) redescribed this species from the same host from the Mediterranean.

Hexostoma thynni (Delaroche, 1811), Rafinesque, 1815

(Syn. *Polystoma thynni* Delaroche, 1811 ; *P. duplicatum* Rudolphi, 1819 ; *Hexacotyle thynni* (Delaroche), Blainville, 1828 ; *Plagiopeltis duplicata* (Rudolphi) Diesing, 1850 ; ? *Hexacotyle thynni* (Delaroche) Linton, 1901 ; Summer *et al.* 1913).

Scombroid host : 1. Tunny, *Thunnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnæus)], and *Sarda sarda* (Bloch)
2. *Sarda sarda* (Bloch)

Localities : 1. Mediterranean ; 2. Atlantic coast of North America.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Palombi (1943) redescribed this species from specimens taken from *Pelamys sarda* (=*Sarda sarda*) from the Mediterranean. The larvæ of *H. thynni* were described recently by Euzet (1956).

HOST-PARASITE LIST No. I

(List of names of scombroid hosts and their monogenetic trematode parasites. Genera are alphabetically arranged. (?) indicates doubtful record of parasite species from host)

HOST	PARASITE
Acanthocybium solandri (Cuvier and Valenciennes)	*Neothorocotyle acanthocybii* (Meserve)
Auxis thazard (Lacépède)	*Hexostoma auxidi* Palombi
Euthynnus affinis affinis (Cantor)	*Capsala gouri* Chauhan ? *Pricea minimæ* Chauhan
Euthynnus affinis lineatus Kishinouye	*Hexostoma euthynni* Meserve
Euthynnus affinis yaito Kishinouye	? *Hexostoma euthynni* Meserve
Euthynnus alletteratus (Rafinesque)	*Capsala maccallumi* Price *Capsala manteri* Price *Hexostoma macracanthum* Fujii
Istiophorus gladius (Broussonnet)	? *Capsala megacotyle* (von Linstow) *Capsala ovalis* (Goto) *Capsaloides sinuatus* (Goto)
Katsuwonus pelamis (Linnæus)	*Capsala interrupta* (Monticelli) *Capsala katsuwoni* Ishii *Capsala lævis* (Verrill) *Capsala lintoni* Price *Capsala nozawæ* (Goto) *Capsala pelamydis* (Taschenberg) *Hexostoma grossum* (Goto) ? *Pricea minimæ* Chauhan *Pseudaxine katsuwoni* Ishii *Pseudaxine vagans* Ishii
'Mackerel'	*Kuhnia scombri* (Kuhn)

'Mackerel—unidentified species of'	*Kuhnia macracanthus* Meserve
Makaira spp.	? *Capsala megacotyle* (von Linstow) ? *Capsala ovalis* (Goto)
Makaira indica (Cuvier)	*Capsala lævis* (Verrill)
Rastrelliger kanagurta (Cuvier)	*Kuhnia scombri* (Kuhn) *Pricea microcotylæ* Chauhan
Sarda orientalis (Temminck and Schlegel)	*Capsala caballerio* Winter
Sarda sarda (Bloch)	*Capsala pelamydis* (Taschenberg) *Hexostoma pricei* Koratha *Hexostoma thynni* (Delaroche)
Scomber japonicus japonicus Hottuyn	*Dactylogyrus inversus* Goto and Kikuchi *Gastrocotyle japonicus* Ishii and Sawada *Kuhnia scombri* (Kuhn) ? *Kuhnia macracanthus* Meserve
Scomber japonicus colias Gmelin	? *Kuhnia macracanthus* Meserve *Kuhnia scombri* (Kuhn)
Scomber scombrus Linnæus	*Khunia minor* (Goto) *Kuhnia scombri* (Kuhn) *Grubea cochlear* Diesing
Scomberomorus cavalla (Cuvier)	*Lithidocotyle acanthophallus* (MacCallum and MacCallum) *Pseudaxine mexicana* Meserve *Thoracocotyle corcea* MacCallum
Scomberomorus commerson (Lacépède)	? *Pricea multæ* Chauhan
Scomberomorus guttatus guttatus (Bloch and Schneider)	*Lithidocotyle secundus* Tripathi *Mictocotyle* sp. Ramalingam *Pricea armatum* Ramalingam *Pricea melane* Ramalingam *Pricea minutum* Ramalingam *Pricea multæ* Chauhan *Pricea robustum* Ramalingam *Pricea tetracanthum* Ramalingam *Pricea triacanthum* Ramalingam *Thoracocotyle ovale* Tripathi *Thoracocotyle* sp. Ramalingam
Scomberomorus lineolatus (Cuvier and Valenciennes)	? *Pricea multæ* Chauhan
Scomberomorus maculatus (Mitchill)	*Lithidocotyle acanthophallus* (MacCallum and MacCallum) *Microcotyle scomberomori* Koratha *Pseudaxine mexicana* Meserve

	Pseudaxine texana Koratha *Scomberocotyle scomberomori* (Koratha) *Thoracocotyle crocea* MacCallum
Scomberomorus niphonius (Cuvier and Valenciennes)	*Capsala ovalis* (Goto) *Gotocotylea sawara* Ishii
Scomberomorus sp. (=*Cybium lanceolatus*)	*Pricea multæ* Chauhan
Tetrapturus amplus (Poey)	*Capsala poeyi* (Vigueras)
Tetrapturus albida (Poey)	*Capsala lævis* (Verrill) *Capsaloides cornuatus* (Verrill)
Tetrapturus belone Rafinesque	*Capsala lævis* (Verrill) *Capsaloides perugini* (Setti)
Thunnus (*Neothunnus*) *albacares albacares* (Bonnaterre)	*Capsala thynni* (Guiart)
Thunnus (*Neothunnus*) *albacares macroptera* (Temminck and Schlegel)	*Capsala biparasitica* (Goto)
Thunnus (*Parathunnus*) *obesus mebachi* (Kishinouye)	? *Capsala nozawæ* (Goto) ? *Hexostoma acutum* (Goto)
Thunnus (*Parathunnus*) *obesus obesus* Lowe	*Capsala onchidiocotyle* (Setti)
Thunnus (*Thunnus*) *alalunga* (Bonnaterre)	? *Capsala nozawæ* (Goto) *Capsala thynni* (Guiart) *Hexostoma acutum* (Goto) *Hexostoma grossum* (Goto)
Thunnus (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)	*Capsala magronum* (Ishii) *Capsala nozawæ* (Goto) *Hexostoma dissimilis* (Yamaguti) *Hexostoma grossum* (Goto)
Thunnus (*Thunnus*) *thynnus thynnus* (Linnæus)	*Capsala interrupta* (Monticelli) ? *Capsala nozawæ* (Goto) *Capsala onchidiocotyle* (Setti) *Hexostoma acuta* (Goto) *Hexostoma extensicaudum* (Dawes) *Hexostoma thunninæ* Parona and Perugia *Hexostoma thynni* (Delaroche)
Thunnus sp.	*Hexostoma grossum* (Goto) *Tristoma levinsenii* Monticelli
Xiphias gladius Linnæus	*Capsala lævis* (Verrill) *Tristomum coccineum* Cuvier *Tristomum integrum* Diesing

DIGENETIC TREMATODES

ORDER DIGENEA

Suborder GASTEROSTOMATA

FAMILY : BUCEPHALIDÆ

Subfamily : BUCEPHALINÆ

Genus BUCEPHALUS Baer, 1826
(Syn. *Gastrostomum* Siebold 1848 ; *Eubucephalus* Diesing 1885)

Bucephalus heterotentaculatus Bravo-Hollis and Sogandares-Bernal, 1956

Scombroid host : *Scomberomorus sierra* Jordan and Starks [=*Scomberomorus maculatus* (Mitchill)]
Locality : Pacific coast of Mexico.
Non-scombroid hosts : None.
Location : Intestine.

Bucephalus jaggannathi Verma 1936

Scombroid host : *Cybium guttatum.* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]
Locality : Bay of Bengal.
Non-scombroid hosts : None.
Location : In intestines of Adults.

Genus RHIPIDOCOTYLE Diesing 1858
(Syn. *Nannoenterum* Ozaki, 1924)

Rhipidocotyle adbaculum Manter, 1940

Scombroid host : *Scomberomorus regalis* [=*Scomberomorus regalis* (Bloch)]
Locality : Florida Coast, U.S.A.
Non-scombroid hosts : None.

Rhipidocotyle angusticollis Chandler, 1941

Scombroid host : *Sarda sarda* [=*Sarda sarda* (Bloch)]
Locality : Texas Coast, U.S.A.
Non-scombroid hosts : None.

Rhipidocotyle baculum (Linton, 1905) Eckmann, 1932

(Syn. *Gasterostomum Baculum* Linton ; *Nannoenterum Baculum* Linton)
Scombroid hosts : *Scomberomorus maculatus* [=*Scomberomorus maculatus* (Mitchill)]
Scomberomorus regalis ? [=*Scomberomorus regalis* (Bloch) ?]
Localities : Beaufort, North Carolina ; Florida, U.S.A.
Non-scombroid hosts : None.

Rhipidocotyle capitatum (Linton, 1940)

Scombroid host : *Auxis rochei* [=*Auxis thazard* (Lacépède)]
Euthynnus alletteratus (Rafinesque)
Locality : Woods Hole, Massachusetts, U.S.A.
Non-scombroid hosts : *Holocentrus ascensionis* [Bahamas, Atlantic] see Sparks (1957)

Rhipidocotyle nagatyi Manter, 1940

Scombroid host : *Euthynnus alletteratus* [=*Euthynnus alletteratus* (Rafinesque)]
Locality : Florida, U.S.A.
Non-scombroid hosts : None.
Remarks : *R. nagatyi* and *R. capitatum* are very closely related and may prove to be conspecific.

Rhipidocotyle pentagonum (Ozaki, 1924)
(Syn. *Nannoenterum pentagonum* Ozaki)

Scombroid hosts : 1. *Scomberomorus nipponicus* [=*Scomberomorus niphonius* (Cuvier & Valenciennes)]
2. *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnæus)].
Localities : 1. Takamatsu, Shikoku Islands, Japan, Pacific Ocean ; 2 Mediterranean.
Non-scombroid hosts : *Caranx* sp., *Caranx compressus* [Red Sea].
Remarks : See also Eckmann (1932) and Nagaty (1937)

Rhipidocotyle septapapillata Krull, 1934

Scombroid host : *Thynnus thynnina* [=*Euthynnus affinis affinis* (Cantor)]
Locality : Red Sea.
Non-scombroid hosts : *Chrysophrys berda* [Bombay, India] ; *Eupomotis gibbosus*, *Fundulus diaphanus* [Virginia, U.S.A.].
Remarks : Also refer Nagaty (1937).

Subfamily : PROSORHYNCHINÆ

Genus BUCEPHALOPSIS Diesing, 1855
(Syn. *Bucephaloides* Hopkins ; *Prosorhynchoides* Dollfus)

Bucephalopsis arcuata (Linton, 1900)
(Syn. *Gasterostomum arcuatum* Linton ; *G. pusillum* Stafford; *Bucephalopsis pusilla* (Stafford)

Scombroid hosts : *Sarda sarda* [=*Sarda sarda* (Bloch)]
Scomberomorus regalis [=*Scomberomorus regalis* (Bloch)]
Localities : Woods Hole ; Beaufort, North Carolina.
Non-Scombroid hosts : *Caranx hippos ; Trichiurus lepturus ; Gadus morrhna*; *Sphyraena barracuda.* [Woods Hole ; Beaufort, N. Carolina ; and Florida, U.S.A.]. *Brevoortia tyrannus*; *Carcharhinus obscurus* [Atlantic coast of Panama ; Bahamas ; Puerto Rico].

Remarks : Also see Sumner *et al.* (1913). *B. arcuata* has been found to occur in the pylorus, stomach, intestine and pyloric caeca of *S. sarda.* For detailed discussion on *B. arcuata* see Sogandares-Bernal and Sogandares (1961) and Ward (1954).

Bucephalopsis cybii Park, 1939

Scombroid host : (1) *Cybium coreanum* [=*Scomberomorus guttatus koreanus* (Kishinouye)]
(2) *Sarda orientalis* (Temminck and Schlegel).
(3) *Scomberomorus* sp.

Locality : 1. Korean waters ; 2. & 3. Pacific coast of Mexico (Bravo-Hollis and Sogandares-Bernal 1956).

Non-scombroid hosts : Acanthogobius hastata (Korean waters).

Remarks : Chauhan (1943) does not refer to this as well as the following species in his 'key' to the species of *Bucephalopsis.*

Bucephalopsis sibi Yamaguti, 1940

Scombroid host : Thynnus thynnus [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck & Schlegel)]

Locality : Hamazima, Japan.

Non-scombroid hosts : None.

Suborder : PROSTOMATA

FAMILY : FELLODISTOMIDAE

Subfamily : TERGESTIINAE

Genus TERGESTIA Stossich, 1899
(Syn. *Cithara* MacCallum ; *Theledera* Linton)

Tergestia laticollis (Rudolphi, 1819) Stossich 1899

Scomber scombrus Linnaeus

Scombroid hosts : Scomber japonicus [=*Scomber japonicus japonicus* Houttuyn]
Auxis thazard [=*Auxis thazard* (Lacépède)], and
Euthynnus alletteratus [=*Euthynnus alletteratus* (Rafinesque)]

Localities : Japan ; Florida, U.S.A.

Non-scombroid hosts : Caranx trachurus [Naples and Arimini] ; *Trachurus trachurus* ; *Apogon lineatus* [Japan].

Location : Intestine.

Remarks : See Dawes (1946) and Baylis (1939).

Tergestia acanthocephala (Stossich, 1887)

Scombroid host : Scomber japonicus [=*Scomber japonicus japonicus* Houttuyn].

Locality : Toyama Bay, Japan.

Non-scombroid hosts : Belone acus [Trieste, Mediterranean] ; *Trachurus trachurus, Apogon lineatus* [Pacific Coast, Japan].

Location : Intestine.

FAMILY : OPISTHORCHIIDAE

Subfamily : APHALLINAE

Genus APHALLUS POCHE, 1826

Aphallus tubaium (Rudolphi, 1819)

Scombroid host : *Scomber japonicus* (=? *Scomber japonicus colias* Gmelin).
Locality : Adriatic, Mediterranean.
Non-scombroid hosts : *Sciaena umbra* [Speiza, Mediterranean : Poche, 1926] ; *Dentex dentex, Morone labrax* [Adriatic, Mediterranean : Janiszewsk, 1953].
Location : Intestine.
Remarks : Dollfus (1951) found the metacercaria of this species encysted in *Gobius* (*Zostericola*) *ophicephalus.* Scombroid host record is by Janiszewska (1953).

FAMILY : ALLOCREADIIDAE

Subfamily : ALLOCREADIINAE

Genus DECEMTESTIS Yamaguti, 1934

Decemtestis biacetabulatus Srivastava, 1936

Scombroid host : *Scomber micropiditorus* [=*Rastrelliger kanagurta* (Cuvier)]. (*microlepidotus* misspelt as *micropeditorus*).
Locality : India.
Non-scombroid hosts : None.

Genus HELICOMETRINA Linton, 1910

Helicometrina orientalis Srivastava, 1936

Scombroid host : *Scomber micropeditorus* [=*Rastrelliger kanagurta* (Cuvier)]. (*microlepidotus* misspelt as *micropeditorus*).
Locality : Bay of Bengal, India.
Non-scombroid hosts : None.

Genus PODOCOTYLE (Dujardin, 1845 : subgeneric name) Odhner, 1905
(Syn. *Sinistroporus* Stafford, 1904 ; *Podocotyloides* Yamaguti, 1934)

Podocotyle simplex (Rudolphi, 1809) Stafford, 1904
(Syn. *Distomum simplex* Rudolphi)

Scombroid host : *Scomber scombrus* [=*Scomber scombrus* Linnaeus].
Locality : Atlantic coast of Canada.
Non-scombroid hosts : *Gadus aeglefinus, Acanthocottus scorpins, Salmo salar, Sebestes marinus, Gastrosteus aculeatus, Phycis chuss, Hemitripterus americanus, Leptocephalus conger, Limanda ferruginea, Microgadus tomcod* [Canada ; Woods Hole, U.S.A.].
Location : Generally intestine and pyloric caeca.

Subfamily : LEPOCREADIINAE

Genus LEPOCREADIUM Stossich, 1904
(Syn. *Lepotrema* Ozaki, 1932)

Lepocreadium retrusum Linton, 1940

Scombroid host : *Pneumatophorus grex* [=*Scomber japonicus japonicus* Houttuyn].
Locality : Woods Hole, Massachusetts, U.S.A.
Non-scombroid hosts : None.

Genus OPECHONA Looss, 1907
(Syn. *Pharyngora* Lebour 1908, *Prodistomum* Linton 1910)

Opechona bacillaris (Molin, 1859) Looss, 1907

(Syn. *Distoma bacillare* Molin, 1859 ; *Distoma* (*Dicrocoelum*) *bacillare* (Molin) Stossich, 1886 ; *Pharyngora bacillaris* Nicoll, 1914)
Scombroid host : *Scomber scombrus* [=*Scomber scombrus* Linnaeus]
Scomber japonicus [=*Scomber j. colias* Gmelin]
Locality : Mediterranean ; Atlantic.
Non-scombroid hosts : *Centrolophus pompilius* [Batavii] ; *Pleurobranchus pileus* [North America] ; *Gadus merlangus, Rhombus laevis, Onas mustela* [Lebour, 1908] ; *Cyclopterus lumpus, Clupea sprattus, C. larengus,* and *Capros aper* [Nicol, 1910]. See also Ward and Fellingham (1934), and Janiszewska (1953).
Location: Intestine and pyloric caeca.
Remarks: See also Dawes (1946).

Opechona olssoni (Yamaguti, 1934)
(Syn. *Pharyngora olssoni* Yamaguti, 1934)

Scombroid host : *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn].
Locality : Pacific coast of Japan and Toyama Bay.
Non-scombroid hosts : None.
Location : Stomach, intestine.

Opechona orientalis (Layman, 1930)
(Syn. *Pharyngora orientalis* Layman, 1930)

Scombroid hosts : 1. *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn].
2. Small mackerel [=*Scomber japonicus japonicus* Houttuyn ?].
3. *Scomber scombrus* Linnaeus.

Localities : 1. Peter the Great Bay, Sea of Japan (original description) ; 2. Galapogos Islands (small mackerel) ; Toyama Bay, Japan ; and Inland Sea of Japan ; 3. Adriatic, Mediterranean (Janiszewska 1953).
Non-scombroid hosts : *Angelichthys* (loc. unknown) ; *Paranthias furcifer* [Mexico] ; *Spheroides rubripes, Engraulis japonicus* [Toyama Bay, Japan] ; and *Girella nigricans* [California coast, U.S.A.].
Location : Stomach, intestine and pyloric caeca.
Remarks : See for more details Ward and Fellingham (1934).

Opechona scombri Yamaguti, 1938

Scombroid hosts : *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn]

Scomber kanagunta [=*Rastrelliger kanagarta* (Cuvier)]. (*kanagurta* misspelt as *kanagunta*).

Localities : Inland Sea of Japan ; Macassar, Indonesia.

Non-scombroid hosts : None.

Location : Pyloric caeca, Intestine.

Subfamily : OPECOELINAE

Genus OPECOELIDES Odhner, 1928

Opecoelides vitellosus (Linton, 1900)

(Syn. *Distomum vitellosus* Linton, 1900)

Scombroid hosts : *Scomber* [=*Scomber scombrus* Linnaeus]

Sarda [=*Sarda sarda* (Bloch)].

Localities : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : Anguilla, Brevoortia tryannus, Clupea harengus, Cynoscion regalis, Decapterus macarellus, Leptocephalus conger, Limanda ferruginea, Lophopsetta maculata, Menticirrhus saxatilis, Merluccius bilinearis, Microgadus tomcod, Morone americana, Paralichthys dentatus, Paralichthys oblongus, Pomatomus saltatrix, Pomolobus pseudoharengus, Prionotus carolinus, Pseudopleuronectes americanus, Spheroides maculatus, Stenotomus chrysops, Tautoga onitis, Tautogolabrus adspersus, and species of *Alosa, Ammodytes, Lagodon, Leiostonmus, Mullus, Urophysics, Syrictes, Trachinotus,* and *Trachuropus* [Woods Hole, Massachusetts, U.S.A.].

Location : Generally intestine, pyloric caeca.

FAMILY : ACANTHOCOLPIDAE

Subfamily : ACANTHOCOLPINAE

Genus TORMOPSOLUS Poche, 1926

Tormopsolus orientalis Yamaguti, 1934

Yamaguti (1934) described this species from the small intestine of *Seriola quinqueradiata,* and *S. aureovittata* from the Inland Sea and Mutu Bay, Japan ; and Pacific coast of Wakayama Prefecture and Toyama Bay, Japan, respectively. Later (1958) he referred to *Zonichthys fasciatus* from Bermuda, Atlantic as an additional host. However, Hanson (1950) lists the ' Bonito ' and possibly *Zonichthys fasciatus* as hosts of *T. orientalis* from Bermuda. I am unable to find any other reference to the bonito [in Atlantic, *Sarda sarda* (Bloch)] listed as a host of *T. orientalis,* and feel that this may be a doubtful host record.

FAMILY : HIRUDINELLIDAE

Genus HIRUDINELLA Garsin, 1730

Hirudinella marina (Garsin, 1730)

Scombroid host : *Scomber pelamys* [=*Katsuwonus pelamis* (Linnaeus)]

Locality : Not known.

Non-scombroid hosts : None.

Location : Stomach.

Remarks : Reference is invited to Nigrelli and Stunkard (1947), who on the basis of a thorough study of the genus *Hirudinella*, recognise only two species, *H. marina* and *H. ventricosa* (Pallas), the latter found only in the wahoo, *Acanthocybium solandri*, and also covers other species of *Hirudinella* hitherto reported from that fish. Yamaguti (1958) has listed six species of *Hirudinella*, some of which as pointed out by Nigrelli and Stunkard (1947) may be synonyms of *H. marina* or *H. ventricosa*. However, as Ward (1954) mentions, the difficulties of species discrimination in this genus is considerable which may be 'explained partly by the fact that never more than a few individuals are found in a single host, and also by the fact that the worms are so large and muscular that the arrangement of the internal organs is easily distorted.' The following list of species of *Hirudinella* as given by Yamaguti (1958) should be appraised in the light of the points raised above.

Hirudinella beebei Chandler, 1937

Scombroid host : *Acanthocybium petus* [=*Acanthocybium solandri* (Cuvier and Valenciennes)].

Acanthocybium solandri [=*Acanthocybium solandri* (Cuvier and Valenciennes)].

Localities : Bermuda ; Galapogos Islands and Panama Bay.

Non-scombroid hosts : None.

Location : Stomach.

Hirudinella poirieri (Moniez, 1891) Dollfus, 1935

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)].

Locality : Atlantic.

Non-scombroid hosts : None.

Location : Stomach.

Hirudinella spinulosa Yamaguti, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)].

Locality : Pacific coast of Japan.

Non-scombroid hosts : None.

Location : Stomach.

Hirudinella ventricosa (Pallas, 1774) Baird, 1853

(Syn. *Fasciola ventricosa* Pallas, 1774 ; *Fasciola fusca* Bosc, 1902 ; *Fasciola coryphaenae hippurus* Tilesius in Litt. Rudolphi 1809)

Scombroid hosts : *Xiphias gladius* [=*Xiphias gladius* Linnaeus].

Locality : Atlantic.

Non-scombroid host : *Coryphaena hippurus* [Amboyna; Europe; Florida]. See also Linton (1940) for hosts of *F. fusca* Bosc. Nigrelli (1938) reported this species from *X. gladius.*

Hirudinella clavata (Menzies, 1791) Blainville, 1928

(Syn. *Fasciola clavata* Menzies, 1791 ; *Distoma clavatum* Rudolphi)

Scombroid hosts : *Gymnosarda alletterata* [=*Euthynnus affinis yaito* Kishinouye].
Pelamys sarda [=*Sarda sarda* (Bloch)] ;
Thynnus thynnus [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)] ;
Thynnus vulgaris [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)] ;
Xiphias gladius [=*Xiphias gladius* Linnaeus)].

Localities : Pacific Ocean ; Atlantic Ocean.

Location : Stomach.

Remarks : See for host species Manter (1940), and for a discussion on the parasite species Nigrelli (1938).

FAMILY : BATHYCOTYLIDAE

Genus BATHYCOTYLE Adolf Darr, 1902

Bathycotyle branchialis Adolf Darr, 1902

Scombroid host : ? Mackerel [=*Scomber* sp.]

Locality : German East Africa (Pemba).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Host identification is incomplete. See Dollfus (1932) for a detailed account on *B. branchialis.*

FAMILY : HEMIURIDAE

Subfamily : HEMIURINAE

Genus HEMIURUS Rudolphi, 1809

(Syn. *Parahemiurus* Vaz and Pereira, 1930)

Yamaguti (1958) recognises the genus *Parahemiurus* Vaz and Pereira, 1930, but Dawes (1946) has pointed out that the main distinguishing feature between *Hemiurus*, and *Parahaemiurus*, namely the bipartite nature of the seminal vesicle in the former and its undivided state in the latter are not sound characters for generic distinction, for ' In *Hemiurus levinseni*, the seminal vesicle has a non-muscular wall, and no doubt under certain conditions of extension or contraction of the body it may assume a variety of shapes, including that attributed to ' *Parahemiurus* '.

' As such " All species of Vaz & Pereira's ' genus ' are under suspicion of being species of *Hemiurus*, and many of them will prove to be known species insufficiently described ' (Dawes 1946). On these grounds, until a thorough study could clarify the matter, *Parahemiurus* is treated here as a synonym of *Hemiurus*.

Hemiurus appendiculatus (Rudolphi, 1802) Looss, 1899
(Syn. *Apolema appendiculatum* Rudolphi, 1802 Blanchard, 1847)

Scombroid host : *Scomber scombrus* [=*Scomber scombrus* Linnaeus].

Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : *Clupea alosa* [Europe] ; *Salmo salar, Osmerus mordax, Clupea harengus, Gadus collarius, Pollachius virens, Amodytes tobianus, Anguilla anguilla, Acanthocottus scorpins, Hippoglossus hippoglossus, Platystomatichthys hippoglossoides* [Canada], *Achirus fasciatus, Anchovia brownii, Brevoortia tyrannus, Clupanodon pseudohispanicus, Clupea harengus, Cynoscion regalis, Decapterus macrellus, Microgadus tomcod, Myxocephalus aeneus, Paralichthys dentatus, Pomolobus mediocris, P. pseudoharengus, Prionotus carolinus, Pseudopleuronectes americanus, Stenotomus chrysops, Trachurops crumenophthalmus, Urophycis chuss* [Woods Hole], *Gadus merlangus* [Australia] ; *Alosa finta* [Egypt-Mediterranean] ; *Caspialosa* spp. [Black Sea]. For additonal hosts see Nicoll (1907), Mola (1928), Zschokke (1933).

Location : Stomach, intestine and oesophagus.

Hemiurus sardiniae (Yamaguti, 1934)
(Syn. *Parahemiurus sardiniae* Yamaguti, 1934)

Scombroid hosts : *Istiophorus orientalis* [=*Istiophorus gladius* (Broussonnet)]

Locality : Toyama Bay, Japan.

Non-scombroid hosts : *Sardinia melanosticta, Engraulis japonicus* [Toyama Bay, Japan].

Location : Stomach.

Remarks : See Manter (1940) wherein *Parahemiurus sardiniae* Yamaguti, is considered a probable synonym of *P. merus* (Linton).

Subfamily : DINURINAE

Genus DINURUS Looss 1907

Dinurus barbatus (Cohn, 1902) Looss, 1907

Scombroid host : *Pelamys sarda* [=*Sarda sarda* (Bloch)]

Locality : Atlantic.

Non-scombroid hosts : *Coryphaena equisitis, C. hippurus* [Atlantic] ; *C.hippurus* [Secas Island, Panama].

Remarks : See Dawes (1946). It is likely that *Dinurus barbatus* along with *D. breviductus* Looss, 1907, and *D. longisinus* Looss, 1907 may be synonyms of *Distoma tornatum* Rudolphi, 1819 [=*Dinurus tornatum* (Rudolphi)]. Of these, *D. breviductus* was also described from *Pelamys sarda* (=*Sarda sarda*) and also from *Coryphaena hippurus* from the Atlantic (latter from Beaufort, N. Carolina, U.S.A.), and Yamaguti (1958) recognises this as a distinct species, a course which was also taken earlier by Manter (1947). Following Dawes (*op. cit.*), Ward (1954) recognises *Dinurus tornatus* (Rudolphi).

Dinurus euthynni Yamaguti, 1934

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific coast, Japan.
Non-scombroid hosts : None.
Location : Stomach.

Dinurus scombri Yamaguti, 1934

Scombroid hosts : *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn]
Euthynnus alletteratus [=*Euthynnus alletteratus* (Rafinesque)]
Localities : Toyama Bay, Japan ; Florida, U.S.A.
Non-scombroid hosts : None.
Location : Stomach.

Genus ECTENURUS Looss, 1907
(Syn. *Erilepturus* Woolcock, 1905)

Ectenurus lepidus Looss, 1907

Scombroid host : *Scomber colias* [=*Scomber japonicus colias* Gmelin].
Locality : Mediterranean.
Non-scombroid hosts : *Lichia amia*, *Atherina hepsetus*, *Caranx trachurus*, *Cepola rubescens*, *Lophius piscatorius*, *Maena vulgaris*, *Samaris alcede*, *Trachypteron taenia*, [Mediterranean] ; *Trachurus trachurus* [Scotland and Black Sea—see Vlasenko, 1931] ; *Helicolenus percoides*, *Trachurus novaezelandiae* [New Zealand—see Manter, 1954].
Location : Stomach.

Genus LECITHOCLADIUM Lühe, 1901

Lecithocladium excisum (Rudolphi, 1819) Lühe, 1901

(Syn. *Distoma excisum* Rudolphi, 1819 ; *Distoma cristatum* Rudolphi, 1819 ; ? *Distomum crenatum* Molin, 1859)
Scombroid hosts : *Scomber scombrus* [=*Scomber scombrus* Linnaeus]
Spanish mackerel (see Dawes, 1946) [=*Scomber japonicus colias* Gmelin]
Localities : Mediterranean, Atlantic, Baltic, Pacific, Sea of Japan, and New Zealand.
Non-scombroid hosts : Immature flukes in *Trachurus trachurus*, *Box boops*, *Lophius piscatorius*, *Cepola rubescens*, etc.
Remarks : Dawes (1946) mentions *Lecithocladium excisiforme* Cohen (1903) as a synonym of *L. excisum* following Looss (1907). *Distomum crenatum* Molin (1859) is considered a doubtful synonym, and so also *Distomum gulosum* Linton (1901). The last said is a relatively larger form than *L. excisum* (6-8 mm. versus 10 mm. extended). I have followed Yamaguti (1958) in treating *L. excisiforme*, and *L. gulosum* (Linton) as separate species.
Location : Stomach.

Lecithocladium excisiforme Cohn, 1903

Scombroid host : *Scomber scomber* [=*Scomber scombrus* Linnaeus]
Locality : Mediterranean.
Non-scombroid hosts : *Stromateoides argenteus* [Inland Sea of Japan]
Location : Stomach.

Lecithocladium gulosum (Linton, 1901)

Scombroid host : *Pneumatophorus grex* [=*Scomber japonicus japonicus* Houttuyn]
Scomber scombrus [*Scomber scomberus* Linnaeus].
Locality : Woods Hole, Massachusetts, U.S.A.
Non-scombroid hosts : *Poronotus triacanthus* [Woods Hole, Massachusetts, U.S.A.].
Location : Stomach.
Remarks: See Linton (1940) ; Dawes (1946).

Lecithocladium angustiovum Yamaguti, 1953

Scombroid host : *Scomber kanagurta* [=*Rastrelliger kanagurta* (Cuvier)]
Locality : Celebes (Macassar).
Non-scombroid hosts : None.
Location : Stomach.

Lecithocladium parviovum Yamaguti, 1953

Scombroid host : *Scomber kanagurta* [=*Rastrelliger kanagurta* (Cuvier)]
Localities : Celebes (Macassar).
Non-scombroid hosts : None.
Location : Stomach.

Lecithocladium scombri Yamaguti, 1953

Scombroid hosts : *Scomber kanagurta* [=*Rastrelliger kanagurta* (Cuvier)]
Scomber microlepidotus [=*Rastrelliger kanagurta* (Cuvier)]
Locality : Celebes (Macassar).
Non-scombroid hosts : None.
Location : Stomach.

Subfamily : HYSTEROLECITHINAE

Genus APONURUS Looss, 1907

Aponurus tschugunowi Issaitsch, 1928
(Syn. *A. tschugunovi* Vlasenko, 1931)

Scombroid host : *Sarda sarda* [=*Sarda sarda* (Bloch)]
Locality : Black sea ?
Non-scombroid hosts : Several species (see Yamaguti, 1958).

Subfamily : STERRHURINAE

Genus STERRHURUS Looss, 1907

(Syn. *Separogermiductus* Skrjalin and Guschanskaja, 1955 ; *Lecithochirium* Lühe, 1901, in part).

Sterrhurus imocavus Looss, 1907

Scombroid host : *Thynnus* sp. [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus) ?]
Locality : Alexandria, Mediterranean.
Non-scombroid hosts : None.

Sterrhurus monticelli (Linton, 1898) Linton, 1910
(Syn. *Distomum monticelli* Linton, 1898)

Scombroid host : *Gymnosarda alleterata* [=*Euthynnus alletteratus* (Rafinesque)]
Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : *Cynoscion regalis, Paralichthys dentatus, Pomatomus saltatrix, Remora remora* Woods Hole ; For additional hosts from Bermuda ; Beaufort, North Carolina, and Tortugas, reference is invited to Linton (1940), Manter (1931, '34), and Pearse (1949).
Location : Intestine.

Genus LECITHOCHIRIUM Lühe, 1901
(Syn. *Synaptobothrium* Linstow, 1904 ; *Plerurus* Looss, 1907)

Sprehn (1933) regards *Synaptobothrium* Linstow to be a synonym of *Lecithochirium* Lühe, which course is also followed by Yamaguti (1958). However, Dawes (1946) considers the two as generically distinct.

Lecithochirium caudiporum (Rudolphi, 1819)

(Syn. *Distoma caudiporum* Rudolphi, 1819 ; *Synaptobothrium caudiporum* (Rudolphi) of Linstow 1904 and Dawes, 1946)
Scombroid host : *Sarda sarda* [=*Sarda sarda* (Bloch)]
Scomber scombrus Linnaeus
Locality : Black Sea.
Non-scombroid hosts : *Zeus faber, Pleuronectes platessa, Lophius piscatorius, Trigla lucerna, Gadus callarias, G. luscus, Scophthalmus rhombus, Conger conger* [Atlantic (Europe), Mediterranean.] Larvae in *Blennius pholis, Labrus bergylta, Crenilabrus melops* (See Dawes, 1946).
Location : Adults in stomach ; larvae encysted in viscera.
Remarks : See also Butzkaya (1952).

Lecithochirium magnaporum Manter, 1940

Scombroid host : *Euthynnus alletteratus* [=*Euthynnus affinis yaito* Kishinouye ? or *E. a. lineatus* Kishinouye ?]
Locality : Galapogos Islands (E. Pacific).
Non-scombroid hosts : *Paralabrax humeralis, Seriola dorsalis* [Galapogos Islands, E. Pacific],

Lecithochirium microstomum Chandler, 1935

Scombroid host : *Euthynnus alletteratus* [=*Euthynnus affinis yaito* Kishinouye ? or *E.a. lineatus* Kishinouye ?]

Locality : Galapogos Islands, E. Pacific.

Non-scombroid hosts : *Trichiurus lepturus* [Galveston Bay, Louisiana], *Galeichthys milberti* [Beaufort, North Carolina] ; *Ancylopsetta dilecta, Promicrops itaiara, Tarpon atlanticus* [Florida] ; *Calamus brachysomus, Caulolatilus* sp., *Paralabrax humeralis, Paranthias furcifer* [Galapogos Islands, E. Pacific].

Lecithochirium texanum (Chandler, 1941) Manter, 1947

Scombroid hosts : *Sarda sarda* [*Sarda sarda* (Bloch)]
Euthynnus alletteratus [=*Euthynnus alletteratus* (Rafinesque)]

Localities : Texas coast ; and Florida, U.S.A.

Non-scombroid hosts : None.

FAMILY : SYNCOELIIDAE

Subfamily : SYNCOELIINAE

Genus SYNCOELIUM Looss, 1899
(Syn. *Capiatestes* Crowcroft, 1948)

Syncoelium Katuwo Yamaguti, 1938

Scombroid host : *Euthynnus pelamis* [=*Katsuwonus pelamis* (Linnaeus)]

Locality : Pacific coast of Japan.

Non-scombroid hosts : None.

Location : Gills and Pharynx.

FAMILY : DIDYMOZOIDAE

Subfamily : DIDYMOZOINAE

Genus DIDYMOZOON Taschenberg, 1878, emend. Odhner, 1907

Didymozoon auxis Taschenberg, 1879
(Syn. *Didymozoum auxis* Taschenberg of Ishii, 1935)

Scombroid host : *Auxis rochei* [=*Auxis thazard* (Lacépède)]
Auxis thazard [=*Auxis thazard* (Lacépède)]

Localities : Naples, Mediterranean ; Taizi, Japan.

Non-scombroid hosts : None.

Location : Gills and outer side of gill lamellae.

Didymozoon filicolle Ishii, 1935

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific coast of Japan.
Non-scombroid hosts : *Seriola quinqueradiata* [Pacific coast of Japan]
Location : Gills.

Didymozoon longicolle Ishii, 1935

Scombroid hosts : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Thynnus orientalis [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Scomber japonicus [=*Scomber japonicus japonicus* Houttuyn]
Locality : Pacific coast of Japan.
Non-scombroid hosts : None.
Location : Gills.

Didymozoon minor Yamaguti, 1934

Scombroid host : *Euthynnus pelamis* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific coast of Japan.
Non-scombroid hosts : None.
Location : Cysts in pairs on gills.
Remarks : Species name spelt as *D. minus* Yamaguti, 1958.

Didymozoon pretiosum Ariola, 1902

Scombroid host : *Thynnus vulgaris* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Locality : Naples, Mediterranean.
Non-scombroid hosts : None.
Location : Gills.

Genus DIDYMOCYLINDRUS Ishii, 1935

Didymocylindrus filiformis Ishii, 1935

Scombroid hosts : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Thynnus orientalis [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Japan, Pacific Ocean.
Non-scombroid hosts : None.
Location : Encysted on gills.

Genus DIDYMOCYSTIS Ariola, 1902

Didymocystis abdominalis Yamaguti, 1938

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific coast of Japan.
Non-scombroid host : None.
Location : Body cavity.

Didymocystis acanthocybii Yamaguti, 1938

Scombroid host : *Acanthocybium sara* [=*Acanthocybium solandri* (Cuvier and Valenciennes)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Base of gill arch.

Didymocystis alalongae Yamaguti, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Occurs in pairs in rounded somewhat flattened cysts about 15 mm. in diameter along gill arch.

Didymocystis bilobata Ishii, 1935

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Gills.

Didymocystis coatesi Nigrelli, 1939

Scombroid host : *Acanthocybium solandri* [=*Acanthocybium solandri* (Cuvier and Valenciennes)]
Locality : Florida.
Non-scombroid hosts : None.
Remarks : It is quite likely that this species may turn out to be a synonym of *D. acanthocybii* Yamaguti, (1938).

Didymocystis crassa Ishii, 1935

Scombroid host : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Pacific Ocean, Japans
Non-scombroid hosts : None.

Didymocystis dissimilis Yamaguti, 1938

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Oesophagus, stomach.
Remarks : Yamaguti (1934) reported this as *D. reniformis* Ariola, 1902, but in 1938, with more material described this as a new species, distinguishing it from *D. reniformis* in the unequal sizes of two individuals enclosed in a cyst.

Didymocystis lanceolata Guiart, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Atlantic.
Non-scombroid hosts : None.

Didymocystis macrorchis Guiart, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Atlantic.
Non-scombroid hosts : None.

Didymocystis miliaris Yamaguti, 1938

Scombroid host : *Acanthocybium sara* [=*Acanthocybium solandri* (Cuvier and Valenciennes)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Base of gill arch.

Didymocystis opercularis Yamaguti, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Encysted in pairs on fleshy lobe of inner surface of operculum.

Didymocystis ovata Ishii, 1935

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Mouth cavity.

Didymocystis scomberomori (G. A., and W. G. MacCallum, 1916)
(Syn. *Koellikeria scomberomori* G. A., and W. G. MacCallum, 1916)

Scombroid host : *Scomberomorus maculatus* [=*Scomberomorus maculatus* (Mitchell)]
Locality : Atlantic.
Non-scombroid hosts : None.
Location : On gill lamellae.

Didymocystis semiglobularis Ishii, 1935

Scombroid host : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Pacific, Japan.
Non-scombroid hosts : None.
Location : On gills.

Didymocystis simplex Ishii, 1935

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : On gills.

Didymocystis soleiformis Ishii, 1935

Scombroid hosts : *Euthynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : *Seriola quinqueradiata* [Pacific Ocean, Japan]
Location : On gills.

Didymocystis submentalis Yamaguti, 1938

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Submental groove.

Didymocystis thynni (Taschenberg, 1879)

(Syn. *Didymozoon thynni* Taschenberg, 1879 ; *Didymocystis reniformis* Ariola, 1902)
Scombroid host : *Thynnus vulgaris* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Locality : Naples, Trieste, Genova, Nice—Mediterranean.
Non-scombroid hosts : None.
Location : Encysted on gills and inside of operculum.

Didymocystis wedli Ariola, 1902

(Syn. *Wedlia katsuwonicola* Okada, 1926 ; *Didymozoon* sp. Kobayashi, 1921 ; *Didymocystis kobayashii* Dollfus, 1926)

Scombroid hosts : *Thynnus vulgaris* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]

Locatities : France, Italy, near Algiers (Mediterranean) ; Pacific Ocean and Toyama Bay, Japan.

Non-scombroid hosts : None.

Location : Gills and gill lamellae.

Didymocystis xiphiados (G. A. and W. G. MacCallum, 1916)
(Syn. *Koellikeria xiphiados* G. A., and W. G. MacCallum, 1916)

Scombroid host : *Xiphias gladius* [=*Xiphias gladius* (Linnaeus)]

Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : None.

Location : Gill cavity and muscles.

Remarks : See Linton (1940).

Genus DIDYMOPROBLEMA Ishii, 1935

Didymoproblema fusiforme Ishii, 1935

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]

Locality : Pacific Ocean, Japan.

Non-scombroid hosts : None.

Genus LOBATOZOUM Ishii, 1935

Lobatozoum multisacculatum Ishii, 1935

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]

Locality : Pacific Ocean, Japan.

Non-scombroid hosts : None.

Location : Gills.

Genus PLATOCYSTIS Yamaguti, 1938

Platocystis alalongae Yamaguti, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]

Locality : Pacific Ocean, Japan.

Non-scombroid hosts : None.

Location : Encysted in pairs in skin.

Subfamily : ATALOSTROPHIINAE

Genus ATALOSTROPHION G. A. MacCallum, 1915

Atalostrophion sardae MacCallum, 1915

Scombroid host : *Sarda sarda* [=*Sarda sarda* (Bloch)]

Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : None.

Location : Under mucous membrane of branchial cavity.

Remarks : Yamaguti (1958) has given reasons for considering *Atalosparganum* Ishii (1935) originally proposed as the type subgenus of *Atalostrophion* to be a synonym of the latter. Ishii described *Atalostrophium* (*Atalosparganum*) sp., from the branchial cavity of *Katsuwonus vagans* [=*Katsuwonus pelamis* (Linnaeus)], but on account of certain discrepancies in the original description, Yamaguti (1958) provisionally refers this form to the genus *Metanematobothrium* Yamaguti, 1938 (Subfamily Nematobothriinae).

Subfamily : COLOCYNTOTREMATINAE

Genus COLOCYNTOTREMA Yamaguti, 1951

Colocyntotrema auxis Yamaguti, 1951

Scombroid host : *Auxis thazard* [=*Auxis thazard* (Lacépède)]

Locality : Taizi, Wakayama Prefecture, Japan.

Non-scombroid hosts : None.

Location : Pyloric caeca.

Genus PHACELOTREMA Yamaguti, 1951

Phacelotrema claviforme Yamaguti, 1951

Scombroid host : *Auxis thazard* [=*Auxis thazard* (Lacépède)]

Locality : Taizi, Wakayama Prefecture, Japan.

Non-scombroid hosts : None.

Location : Pyloric caeca.

Subfamily : GLOMERITREMATINAE

Genus GLOMERITREMA Yamaguti, 1942

Glomeritrema subcuticola Yamaguti, 1942

Scombroid host : *Tetrapturus mitsukutii* [= *Tetrapturus audax* (Phillipi)]

Locality : Naha, Okinawa, Pacific.

Non-scombroid host : None.

Location : Subcutaneous tissue.

Subfamily : KOELLIKERNAE

Genus KOELLIKERIA Cobbold, 1860
(Syn. *Wedlia* Cobbold, 1860 ; *Didymostoma* Ariola, 1902)

Koellikeria bipartita (Wedl, 1855)
Syn. *Didymostoma bipartium* (Wedl, 1855; Ariola, 1902)

Scombroid hosts : *Thynnus vulgaris* [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Thynnys secundo-dorsalis [=*Thunnus* (*T.*) *thynnus thynnus* (Linnaeus)]
Localities : Trieste, Nice, Naples [Mediterranean] ; Atlantic coast, U.S.A.
Non-scombroid hosts : None.
Location : Gills, gill arches, skin of head.

Koellikeria globosa Ishii

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Tokyo, Japan.
Non-scombroid host : *Seriola quinqueradiata* [Tokyo, Japan].

Koellikeria orientalis (Yamaguti, 1934)
(Syn. *Wedlia orientalis* Yamaguti, 1934)

Scombroid hosts : *Germo macropterus* [=*T.*(*N.*)*albacares macropterus* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]
Thynnus thynnus [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Localities : Kuki, Japan ; Kuki and Inland Sea, Japan ; Toyama Bay, Japan.
Non-scombroid host : None.
Location : Small and large intestine, anus, oesophagus, stomach, gills.

Koellikeria reniformis Ishii, 1935

Scombroid hosts : *Thynnus orientalis* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Euthynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)].
Locality : Tokyo, Japan.
Non-scombroid hosts : *Seriola quinqueradiata* (Tokyo, Japan).
Location : Gills.

Genus COELIOTREMA Yamaguti, 1938

Coeliotrema thynni Yamaguti, 1938

Scombroid host : *Thynnus thynnus* [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]
Locality : Suruga Bay, Japan.
Non-scombroid hosts : None.
Location : Mesentery.

Subfamily : NEMATOBOTHRIINAE

Genus NEMATOBOTHRIUM van Beneden, 1858

Nematobothrium faciale (Baylis, 1938)
(Syn. *Didymozoon faciale*, Baylis, 1938)

Scombroid host : *Scomber scombrus* [=*Scomber scombrus* (Linnaeus)]
Locality : English Channel.
Non-scombroid hosts : None.
Location : Cysts beneath outer skin of head, behind eye.

Nematobothrium filiforme Yamaguti, 1934
(Syn. *Nematobothrium sabae* Ishii, 1935)

Scombroid host: *Scomber japonicus* [=*Scomber japonicus japonicus* Houttuyn]
Locality : Toyama Bay, and Pacific, Japan.
Non-scombroid hosts : None.
Location : Encysted in pairs on gills.

Nematobothrium latum Guiart, 1938

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Atlantic.
Non-scombroid hosts : None.
Location : Encysted on stomachal peritoneum.

Nematobothrium pelamydis (Taschenberg, 1879)
(Syn. *Didymozoon pelamydis* Taschenberg, 1879)

Scombroid host : *Pelamys sarda* [=*Sarda sarda* (Bloch)]
Locality : Naples, Genova, Portoferrajo [Mediterranean].
Non-scombroid hosts : None.
Location : Between gill lamellae.

Nematobothrium scombri (Taschenberg, 1879)
(Syn. *Didymozoon scombri* Taschenberg, (1879)

Scombroid hosts : *Scomber colias* [=*Scomber japonicus colias* Gmelin] ;
Scomber scomber [=*Scomber scombrus* Linnaeus] ;
Scomber japonicus [=*Scomber japonicus japonicus* Houttuyn].
Localities : Naples, Genova ; Venice, Trieste, Krestenberg, Ireland, Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Cysts on roof of buccal cavity between pharyngo-branchial elements ; external surface of basibranchials ; parts of gill arch and inner surface of operculum.

Genus METANEMATOBOTHRIUM Yamaguti, 1938

Metanematobothrium guernei (Moniez, 1891)

(Syn. *Nematobothrium* (*Benedenozoum*) *guernei* Moniez of Ishii, 1935)
Scombroid host : *Thynnus alalonga* [=*Thunnus* (*T.*) *alalunga* (Bonnaterre)]
Locality : Atlantic coast of France; Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Gills, submaxillary muscles, intestine.

Genus UNITUBULOTESTES Yamaguti, 1952

Unitubulotestes sardae (G.A., and W. G. MacCallum, 1916)
(Syn. *Nematobothrium sardae* G.A., and W. G. MacCallum, 1916)

Scombroid host : *Sarda sarda* [=*Sarda sarda* (Bloch)]
Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic); Black Sea.
Non-scombroid hosts : None.
Location : Pharyngo-branchial region or gills.
Remarks : See Grabda and Siwak-Grabda (1948) for redescription of species from same host from Black Sea.

Subfamily : NEODIPLOTREMATINAE

Genus NEODIPLOTREMA Yamaguti, 1938
(Syn. *Diplotrema* Yamaguti, 1938 *nec* Spencer, 1900)

Neodiplotrema pelamydes (Yamaguti, 1938)
(Syn. *Diplotrema pelamydes* Yamaguti, 1938)

Scombroid host : *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Locality : Pacific Ocean, Japan.
Non-scombroid hosts : None.
Location : Fifth gill arch.

Subfamily : OPEPHEROTREMATINAE

Genus OPEPHEROTREMA Yamaguti, 1951

Opepherotrema planum Yamaguti, 1951

Scombroid host : *Auxis thazard* [=*Auxis thazard* (Lacépède)]
Locality : Taizi, Wakayama Prefecture, Japan.
Non-scombroid hosts : None.
Location : Pyloric caeca.

HOST-PARASITE LIST NO. II

(List of names of scombroid hosts and their trematode parasites. Genera are alphabetically arranged. (?) indicates doubtful record of parasite species from host.)

HOST	PARASITE
Acanthocybium solandri (Cuvier and Valenciennes)	*Didymocystis acanthocybii* Yamaguti *Didymocystis coatesi* Nigrelli *Didymocystis miliaris* Yamaguti *Hirudinella beebei* Chandler ? *Hirudinella ventricosa* (Pallas)
Auxis thazard (Lacépède)	*Colocyntotrema auxis* Yamaguti *Didymozoon auxis* Taschenberg *Opepherotrema planum* Yamaguti *Phacelotrema claviforme* Yamaguti *Rhipidocotyle capitata* (Linton) *Tergestia laticollis* (Rudolphi)
Euthynnus alletteratus (Rafinesque)	*Dinurus scombri* Yamaguti *Lecithochirium texanum* (Chandler) *Rhipidocotyle capitatum* (Linton) *Rhipidocotyle nagatyi* Manter *Sterrhurus monticelli* (Linton) *Tergestia laticollis* (Rudolphi)
Euthynnus affinis affinis (Cantor)	*Rhipidocotyle septapapillata* Krull
Euthynnus affinis lineatus Kishinouye	? *Lecithochirum magnaporum* Manter ? *Lecithochirum microstomum* Chandler
Euthynnus affinis yaito Kishinouye	? *Lecithochirum magnaporum* Manter ? *Lecithochirum microstomum* Chandler
Istiophorus gladius (Broussonnet)	*Hemiurus sardiniae* (Yamaguti)
Katsuwonus pelamis (Linnaeus)	*Atalostrophion sardae* MacCallum *Atalostrophium* (*Atalospar garum*) sp. Ishii (1935) *Didymocylindrus filiformis* Ishii *Didymocystis abdominalis* Yamaguti *Didymocystis bilobata* Ishii *Didymocystis dissimilis* Yamaguti *Didymocystis ovata* Ishii *Didymocystis simplex* Ishii *Didymocystis soleiformis* Ishii *Didymocystis submentalis* Yamaguti *Didymocystis wedli* Ariola *Didymoproblema fusiformes* Ishii *Didymozoon filicolle* Ishii *Didymozoon longicolle* Ishii *Didymozoon minor* Yamaguti *Dinurus euthynni* Yamaguti *Hirudinella marina* (Garsin) *Koellikeria globosa* Ishii *Koellikeria orientalis* (Yamaguti) *Koellikeria reniformis* Ishii *Lobatozoum multisacculatum* Ishii *Neodiplotrema pelamydes* (Yamaguti) *Syncoelium katuwo* Yamaguti

Rastrelliger kanagurta (Cuvier).....	*Decemtestis biacetabulatus* Srivastava *Helicometrina orientalis* Srivastava *Lecithocladium angustiovum* Yamaguti *Lecithocladium parviovum* Yamaguti *Lecithocladium scombri* Yamaguti *Opechona scombri* Yamaguti
Sarda orientalis (Temminck and Schlegel)..	*Bucephalopsis cybii* Park
Sarda sarda (Bloch).....	*Aponurus tschugunowi* Issaitsch *Atalostrophion sardae* MacCallum *Bucephalopsis arcuata* (Linton) *Dinurus barbatus* (Cohn) *Hirudinella clavata* (Menzies) *Lecithochirum caudiporum* (Rudolphi) *Lecithochirum texanum* (Chandler) *Nematobothrium pelamydis* (Taschenberg) *Opecoelides vitellosus* (Linton) *Rhipidocotyle angusticollis* Chandler ? *Tormopsolus orientalis* Yamaguti *Unitubulotestes sardae* (MacCallum and MacCallum)
Scomber japonicus japonicus Houttuyn.....	*Didymozoon longicolle* Ishii *Dinurus scombri* Yamaguti *Lecithocladium gulosum* (Linton) *Lepocreadium retrusum* Linton *Nematobothrium filiforme* Yamaguti *Nematobothrium scombri* (Taschenberg) *Opechona olssoni* (Yamaguti) *Opechona orientalis* (Layman) *Opechona scombri* Yamaguti *Tergestia acanthocephala* (Stossich) *Tergestia laticollis* (Rudolphi)
Scomber japonicus colias Gmelin	? *Aphallus tubarium* (Rudolphi, 1819) *Ectenurus lepidus* Looss *Lecithocladium excisium* (Rudolphi) *Nematobothrium scombri* (Taschenberg) *Opechona bacillaris* (Molin)
Scomber scombrus Linnaeus.....	*Hemiurus appendiculatus* (Rudolphi) *Lecithochirum caudiporum* (Rudolphi) *Lecithocladium excisum* (Rudolphi) *Lecithocladium excisiforme* Cohn *Lecithocladium gulosum* (Linton) *Opechona bacillaris* (Molin) *Opechona orientalis* (Layman) *Opecoelides vitellosus* (Linton) *Nematobothrium faciale* (Baylis) *Nematobothrium scombri* (Taschenberg) *Podocotyle simplex* (Rudolphi) *Tergestia acanthocephala* (Stossich) *Tergestia laticollis* (Rudolphi)
Scomber sp.....	*Bathycotyle branchialis* Darr

Scomberomorus guttatus guttatus (Bloch and Schneider).....	*Bucephalus jaggannathi* Verma
Scomberomorus guttatus koreanus (Kishinouye)	*Bucephalopsis cybii* Park
Scomberomorus maculatus (Mitchill).....	*Bucephalus heterotentaculatus* Bravo-Hollis & Sogandares-Bernal *Didymocystis scomberomori* (MacCallum and MacCallum) *Rhipidocotyle baculum* (Linton)
Scomberomorus niphonius (Cuvier and Valenciennes)	*Rhipidocotyle pentagonum* (Ozaki)
Scomberomorus regalis (Bloch).....	*Bucephalopsis arcuata* (Linton) *Rhipidocotyle adbaculum* Manter *Rhipidocotyle baculum* (Linton)
Scomberomorus sp.....	*Bucephalopsis cybii* Park
Tetrapturs audax Philippsi.....	*Glomeritema subcuticola* Yamaguti
Thunnus (*Thunnus*) *alalunga* (Bonnaterre)..	*Didymocystis alalongae* Yamaguti *Didymocystis lanceolata* Guiart *Didymocystis macrorchis* Guiart *Didymocystis opercularis* Yamaguti *Hirudinella spinulosa* Yamaguti *Hirudinella poirieri* (Moniez) *Metanematobothrium guernei* (Moniez) *Nematobothrium latum* Guiart *Platocystis alalongae* Yamaguti
Thunnus (*Neothunnus*) *albacares macropterus* (Tem. & Sch.)	*Koellikeria orientalis* (Yamaguti)
Thunnus (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)	*Bucephalopsis sibi* Yamaguti *Coeliotrema thynni* Yamaguti *Didymocylindrus filiformis* Ishii *Didymocystis crassa* Ishii *Didymocystis ovata* Ishii *Didymocystis semiglobularis* Ishii *Didymocystis soleiformis* Ishii *Didymoproblema fisiformis* Ishii *Didymozoon filicolle* Ishii *Didymozoon longicolle* Ishii *Koellikeria globosa* Ishii *Koellikeria orientalis* (Yamaguti) *Koellikeria reniformis* Ishii
Thunnus (*Thunnus*) *thynnus thynnus* (Linnaeus).....	*Didymocystis thynni* (Taschenberg) *Didymocystis wedli* Ariola *Didymozoon pretiosum* Ariola *Hirudinella clavata* (Menzies) *Koellikeria bipartita* (Wedl) *Sterrhurus imocavus* Looss
Xiphias gladius Linnaeus.....	*Didymocystis xiphoides* (MacCallum and MacCallum) *Hirudinella clavata* (Menzies) *Hirudinella ventricosa* (Pallas)

CLASS : CESTODA

Subclass : EUCESTODA

Order : PSEUDOPHYLLIDAE

Genus BOTHRIOCEPHALUS Rudolphi, 1808
(Syn. *Dibothrium* Diesing, 1850)

Bothriocephalus manubriformis (Linton, 1889)

[Syn. *Dibothrium manubriformis* Linton, 1889 ; *Acanthobothrium laciniatum* Linton, 1898 ; *Bothriocephalus histiophorus* Shipley 1909 ; *B. plicatum* (Rudolphi) Shipley 1900]

Scombroid hosts : 1. *Istiophorus nigricans* [=*Istiophorus gladius* (Broussonnet)]
2. *Tetrapterus imperator* [=*Tetrapturus albidus* Poey]
3. *Tetrapturus albidus* [= -do-]
4. *Histiophorus gladius* [=*Istiophorus gladius* (Broussonnet)]
5. *Histiophorus* sp. [= -do-]
6. *Histiophorus grayei* [= -do-]

Localities : 1-4 from Woods Hole, New England Coast, N.W. Atlantic ; 5 from Indian and Pacific Oceans ; and 6 from Pacific coast of Mexico.

Non-scombroid hosts : Tarpon atlanticus, Prionace glauca, Carcharhinus milberti, Carcharhinus obscurus, Isurus dekay, Raja eglanteria, Sphyrna zygaena [Woods Hole, New England Coast, N.W. Atlantic].

Location : Spiral valve in elasmobranchs ; intestine in teleosts.

Bothriocephalus scorpii (Mueller, 1776)

[Syn. *Taenia scorpii* Mueller, 1776 ; *Vermis multiembris rhombi* Leeuwenhoek 1722 ; *Bothriocephalus punctatus* Rudolphi 1810 ; *Dibothrium punctatus* Diesing, 1850 ; and *Bothriocephalus bipunctatus* (Zeder, 1800) Lühe, 1899]

Scombroid host : Scomber scombrus Linnaeus

Locality : Woods Hole, New England Coast, N.W. Atlantic.

Non-scombroid hosts : Decapterus punctatus, Hemitripterus americanus, Hippoglossus hippoglossus, Limanda ferruginea, Lophopsetta maculata, Myxocephalus aeneus, M. octodecimspinosus, Palinurichthys perciformis, Paralichthys dentatus, P. oblongus, Pseudopleuronectes americanus, Trachurops crumenophthalmus, Urophycis chuss, Arnoglossus laterna, A. pegosa, Bothus podas, Hippoglossus platessoides, Lepidorhombus boscii [same as *Pleuronectes boscius* from which Rudolphi (1819) described *B. punctatus*] *Monochirus hispidus, Phrynorhombus norvegicus, Platichthys flesus, Pleuronectes platessa, Pleuronectes* sp., *Scophthalmus aquosus, S. maximus, S. maeoticus, S. rhombus, Cottus scorpei,* and in species of the following genera : *Anguilla, Clupea, Dactylopterus, Enophrys, Eurytemora, Gadus, Gobius, Hexagrammos, Labrus, Lateolabrax, Leptocottus, Lophius, Menticirrus, Merluccius, Mullus, Nerophis, Oligoplites, Pollachius, Pomolobus, Poronotus, Raja, Rhamdia, Scorpaena, Seriola* and in *Syphonostoma typhle* [Atlantic, Mediterranean, Pacific, N. Siberia, White Sea, and Black Sea].

Location : Pleurocerca in stomach and intestine of teleostean hosts.

Remarks : See also Sumner *et al.* (1913).

FAMILY : TRIAENOPHORIDAE

Genus FISTULICOLA Lühe, 1899

Fistulicola plicatus (Rudolphi, 1819), Luhe, 1899

[Syn. ? *Echinorhynchus xiphiae* Gmelin, 1790 ; *Bothriocephalus plicatus* Rudolphi, 1819 ; *Bothriocephalus xiphiae* (Gmelin) Goode, 1883]

Scombroid host : *Xiphias gladius* Linnaeus

Locality : Woods Hole, New England Coast, N.W. Atlantic, European.

Non-scombroid hosts : None.

Location : Walls of intestine and rectum.

Remarks : Refer also Linton (1901), and Cooper (1918). Dollfus (1935) regarded this species and *Bothriocephalus truncatus* Leuckart, 1819, as conspecific with *F. xiphiae* (Gmelin, 1790).

Order : TETRAPHYLLIDEA

Genus SCOLEX Rudolphi, 1919

Scolex pleuronectis Mueller, 1788

(Syn. *Scolex polymorphus* Rudolphi, 1819 ; *Scolex delphinus* Stossich, 1898)

Scombroid hosts : *Sarda sarda* (Bloch)
Scomber scombrus Linnaeus
Xiphias gladius Linnaeus

Localities : Woods Hole, Massachusetts, N.W. Atlantic.

Non-scombroid hosts : Anchovia argyrophanus, A. brownii, Anguilla sp., *Brevoortia tyrannus, Centropristis striatus, Clupea harengus, Cynoscion regalis, Decapterus macarellus, D. punctatus, Etrumeus teres, Fundulus heteroclitus, Hippoglossus hippoglossus, Lagocephalus laevigatus, Leptocephalus conger, Limanda ferruginea, Lophius piscatorius, Lopholatilus chamoeleonichthys, Melanogrammus aeglefinus, Menticirrhus saxatilis, Merluccius bilinearis, Microgadus tomcod, Opsanus tau, Palinurichthys perciformis, Paralichthys dentatus, P. oblongus, Pomatomus saltatrix, Pomolobus mediocris, P.pseudoharengus, Poronotus triacanthus, Raja laevis, Spheroides maculatus, Stenotomus chrysops, Tautoga onitis, Trichiurus lepturus, Tylosurus marinus, Urophycis chuss* [Woods Hole, New England Coast, N.W. Atlantic] ; *Sardinella longiceps* [Indian Ocean and tidal rivers of India] ; *Arnoglossus grohmanni, A. laterna, Arnoglossus* sp., *Bothus podas, Eucitharus linguatula, Hippoglossoides platessoides, Limanda limanda, Pleuronectes platessa, Pseudopleuronectes americanus, P. herzensteini, Scophthalmus maeoticus, S. maximus, S. rhombus and Solea solea* [Atlantic and Mediterranean].

Location : Larvae free in intestine.

Remarks : See also Sumner *et al.* (1913), Southwell (1925, 1930), Ronald (1959) and Wardle and McLeod (1952).

FAMILY : PHYLLOBOTHRIIDAE

Genus PELICHNIBOTHRIUM Monticelli, 1889

Pelichnibothrium speciosum Monticelli, 1889

[Syn. *P. caudatum* (Zschokke and Heitz, 1914) ; *Phyllobothrium salmonis* Fujita, 1922]

Scombroid host : Thynnus thynnus [=*Thunnus* (*T.*) *thynnus orientalis* (Temminck and Schlegel)]

Locality : Pacific coast of Japan.

Non-scombroid hosts : Aspidosaurus ferox [Madeira, E. Atlantic] ; *Prionace glauca, Lampris regia* [Pacific coast of Japan].

Location : Adults in elasmobranchs, tailed larvae in teleosts.

Remarks : Also refer Southwell (1925), and Wardle and McLeod (1952).

Genus PHYLLOBOTHRIUM Beneden, 1849

[Syn. *Crossobothrium* Linton, 1889 ; *Anthocephalum* Linton, 1890 ; *Calyptobothrium* Monticelli 1893 ; *Bilocularia* Obersteiner, 1914]

Phyllobothrium loliginis (Leidy, 1887) Linton, 1897

Scombroid host : Xiphias gladius Linnaeus

Locality : Woods Hole, New England Coast, N.W. Atlantic.

Non-scombroid hosts : Hemitripterus americanus, Mustelus canis, Paralichthys dentatus, P. oblongus, Raja laevis, R. ocellata, Spheroides maculatus, Squalus acanthias, Urophycis chuss, U. tenuis [Woods Hole, Massachusetts, New England Coast, N.W. Atlantic].

Location : Adults in the stomach of squids *Ommastrephes illecebrosus* [Massachusetts coast, U.S.A.], and *O. sagittatus* [Mediterranean]. Immature specimens in stomachs of fish hosts.

Remarks : See also Sumner *et al.* (1913).

Order : TRYPANORHYNCHA

FAMILY : TENTACULARIIDAE

Genus TENTACULARIA Bosc, 1797

Tentacularia coryphaena Bosc, 1797

[Syn. *Stenobothrium macrobothrium* [Rudolphi, 1810) Diesing ; *Tentacularia boscii* Siebold, 1850]

Scombroid hosts : Larvae in
Xiphias gladius Linnaeus ;
Pelamys [=*Sarda sarda* (Bloch)] ;
Thynnus [=*Thunnus* sp.] ;
Scomber [=*Scomber* sp.]

Locality : Atlantic.

Non-scombroid hosts : Coryphaena hippurus ; *Lophius* sp. ; *Pleuronectes* sp., *Hippoglossus hippoglossus, Hippoglossus* sp., *Paralichthys dentatus* [Atlantic] ; Adults in *Prionace glauca, Scoliodon walbeehmi* [Pacific coast of Japan].

Remarks : See Winninger (1929, '30) for list of a variety of hosts for *Stenobothrium macrobothrium* Diesing ; Wardle and McLeod (1952) for discussion.

Tentacularia bicolor (Bartels, in Nordmann, 1832)

Scombroid hosts : 1. *Scomber pelamys* [=? *Katsuwonus pelamis* (Linnaeus)]
2. *Sarda sarda* [=*Sarda sarda* (Bloch)]
3. *Xiphias gladius* Linnaeus

Localities : 1. Unknown, probably Atlantic ! ; 2. and 3. Woods Hole, New England Coast, N.W. Atlantic.

Non-scombroid hosts : Galeocerdo tigrinus, Carcharhinus obscurus, Coryphaena hippurus Paralichthys dentatus [Woods Hole, New England coast, N.W. Atlantic] ; *Coryphaena hippurus, C. equistis,* and *Halichelys atra* [localities unknown].

Location : Cysts and scolices found in all above mentioned hosts in peritoneum, mesentery, stomach and alimentary canal. In scombroids in peritoneum and mesentery. Adult taken in *Carcharhinus obscurus.*

Genus NYBELINIA Poche, 1926

(Syn. *Acoleorhynchus* Poche, 1926 ; *Aspidorhynchus* Molin, 1858-preoccupied ; *Congeria* Guiart, 1935 ; *Rufferia* Guiart, 1927 ; *Stenobothrium* Diesing of Pintner, 1913)

Yamaguti (1959) subdivides the genus into two subgenera, *Nybelinia* s.str., and *Syngenes,* and we are concerned here with species referrable to the former.

Nybelinia (Nybelinia) lingualis (Cuvier, 1817)

Scombroid hosts : Xiphias gladius Linnaeus

Locality : Atlantic.

Non-scombroid hosts : Solea vulgaris, Pleuronectes platessa, Pleuronectes gen?, and *sp*?, *Scophthalmus maximus, S. rhombus, Solea solea, Lophius piscatorius, Trigla gurnardus, Oxyrhina spallanzanii, Galeus canis, Raja* sp., *Acanthias vulgaris, Squatina angelus, Scyllium stellare* [Atlantic]. For additional hosts see Joyeux and Bear (1936).

Nybelinia (Nybelinia) bisulcata (Linton, 1889)

(Syn. *Rhynchobothrium bisulcatus* Linton, 1889)

Scombroid hosts : Xiphias gladius Linnaeus

Scomber scomber [=*Scomber scombrus* Linnaeus]

Localities : Woods Hole, North West Atlantic.

Non-scombroid hosts : Carcharhinus obscurus, C. milberti, Galeocerdo articus, Aqualus acanthias, Cestracion zygaena, Paralichthys albigutta, P. dentatus, P. oblongus, Pseudopleuronectes americanus, Scophthalmus aquosus, Symphurus, plagusia, Cynoscion regalis, Decapterus macarellus, Lophius piscatorius, Lopholatilus chamoeleonticeps, Pomatomus saltatrix, Poronotus triacanthus, Prionotus carolinus, P. strigatus, Seriola zonata, Spheroides maculatus, Stenostomus chrysops, Tetronarce occidentalis, Urophycis chuss [North West Atlantic].

Location : Cysts and scolices in viscera of hosts mentioned above ; adults abundant in pyloris and intestine of *Carcharhinus obscurus.*

Remarks : See Sumner *et al.* (1913), and Ronald (1959) for host records. Refer also Dollfus (1942) for detailed studies on species of the genus *Nybelinia.* Yamaguti (1959) mentions that the species has also been noted to occur in the Cephalopod *Sepiella maindorini* in Japanese waters.

Nybelinia (Nybelinia) lamontae Nigrelli, 1938

Scombroid host : Xiphias gladius Linnaeus

Locality : Nova Scotia, N.W. Atlantic.

Non-scombroid hosts : None.

FAMILY : DASYRHYNCHIDAE

Genus CALLITETRARHYNCHUS Pintner, 1931

(Syn. *Acanthocephalus* Rudolphi, 1819, in part ; *Lintoniella* Yamaguti *nec* Woodland, 1927)

Callitetrarhynchus gracilis (Rudolphi, 1819)

(Syn. *Anthocephalus gracile* Rudolphi, 1819 ; *Rhynchobothrium speciosum* Linton, 1897 ; *Lintoniella speciosa* Yamaguti, 1934 ; *Tentacularia lepida* Chandler, 1935 ; *Callitetrarhynchus gracillimum* Pintner, 1931, and *Tentacularia pseudodera* Shuler, 1938)

Scombroid hosts : *Scomber rocheus* [=*Auxis thazard* (Lacépède)]
Scomber scombrus Linnaeus
Scomberomorus maculatus [=*Scomberomorus maculatus* (Mitchill)]
Thynnus sp. [=*Thunnus* sp.]

Localities : Mediterranean, Atlantic.

Non-scombroid hosts : Carcharhinus obscurus, Dasyatis centrura, Hypoprion brevirostris, Alutera schoepfi, Paralichthys dentatus, P. olivaceus, Galeichthys felis, Chaetodipterus faber, Cynoscion regalis, Lophius piscatorius, Pomatomus saltatrix, Remora remora, Roccus lineatus, Stenotomus chrysops, Trichiurus lepturus, Tylosurus acus, Brama sp., *Sparus* sp., *Muraenesox* sp., *Scomberoides* sp., *Seriola* sp., *Caranx* sp., *Ceratacanthus* sp. [North Atlantic, Mediterranean and Pacific].

Location : In scombroids and other teleosts larvae encysted in viscera. Adults in elasmobranchs (e.g. *Carcharhinus obscurus*).

Remarks : Shuler (1938) records adults of this species as *Tentacularia pseudodera* from *Hypoprion brevirostris*. For host records see Chandler (1935).

FAMILY : GYMNORHYNCHIDAE

Genus GYMNORHYNCHUS Rudolphi, 1819

Two subgenera, *Gymnorhynchus* s.str., and *Molicola* Dollfus, are recognised by Dollfus (1935).

Gymnorhynchus (Gymnorhynchus) gigas Cuvier, 1817

(Syn. *Gymnorhynchus gigas* Southwell, 1930 in part)

Scombroid host : *Xiphias gladius* Linnaeus

Locality : North East Atlantic and Mediterranean.

Non-scombroid hosts : Brama rayi ; Paralichthys dentatus (see Wardle and McLeod, 1952 ; Ronald, 1959).

Location : Pleurocercus in muscles.

Remarks : According to Wardle and McLeod (1952) this species is rarely found in the swordfish *Xiphias gladius*, but not from American waters.

Gymnorhynchus (Molicola) uncinatus (Linton, 1924)

[Syn. *Rhynchobothrium uncinatus* Linton, 1924 ; *Floriceps uncinatus* (Linton) Yamaguti, 1952 ; *Molicola uncinatus* (Linton) Yamaguti, 1959 ; ? *Molicola horridius* (Goodsir, 1841), Dollfus, 1935)]

Scombroid host : *Xiphias gladius* Linnaeus

Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : Mola mola [Atlantic] ; *Vulpecula marina* [North Western Atlantic and Pacific] ; ? *Monochirus hispidus.*

Location : Pleurocercus in muscles of teleosts ; adult in *V. marina.*

Remarks : Wardle and McLeod (1952) comment that *Molicola horridius* may turn out to be the earlier stages of Linton's *R. uncinatus.* However, until we know more about the life-history of the latter species, it will be desirable to follow the present course, but if proven to be the same, then the specific name *M. horridius* should have priority.

FAMILY : LACISTORHYNCHIDAE

Created by Guiart in 1927, the family definition was emended by Dollfus in 1935, and more recently by Yamaguti (1959) to include *Eulacistorhynchus* Subhapradha, 1957.

Genus GRILLOTIA Guiart, 1927

(Syn. *Heterotetrarhynchus* Pintner, 1929 ; *Pintneriella* Yamaguti, 1934)

Grillotia erinaceus (van Beneden, 1858)

(Syn. *Rhynchobothrium imparispine* Linton, 1890- *Tetrarhynchys erinaceus* van Beneden, 1858)

Scombroid hosts : *Scomber scombrus* Linnaeus
Sarda sarda (Bloch)
Xiphias gladius Linnaeus

Localities : Woods Hole, New England coast, N.W. Atlantic.

Non-scombroid hosts : Dasyatis centrura, Mylobatis freminville, Raja eglanteria, Raja erinacea, R. laevis, R. ocellata, Squalus acanthias, Ammodytes americanus, Anguilla chrysypa, Centropristis striatus, Clupea harengus, Cynoscion regalis, Gadus callarias, Hemitripterus americanus-Leptocephalus conger, Limanda ferruginea, Lophius piscatorius, Lophopsetta maculata, Melanogrammus aeglefinus, Menidia menidia notata, Merluccius bilinearis, Microgadus tomcod, Myoxocephalus aeneus, M. octodecimspinosus, Osmerus mordax, Paralichthys dentatus, Pollachius virens, Pomatomus saltatrix, Pomolobus pseudoharengus, Poronotus triacanthus, P. strigatus, Pseudopleuronectes americanus, Stenotomus chrysops, Tautogolabrus adspersus, Tetronarce occidentalis, Urophycis chuss, U. tenuis, Arnoglossus laterna, Glyptocephalus cynglossus, Hippoglossus hippoglossus, Limanda limanda, Microstomus kitt, Paralichthys oblongus, Pleuronectes platessa, Scophthalmus aquosus, S. maximus, S. rhombus, Hexanchus sp., *Theragra* sp., *Dasycottus* sp., *Lotella* sp., *Lota* sp., *Trigla* sp., *Conger* sp., *Glyptocephalus* sp., and *Centrophorus* sp. [Atlantic or Pacific].

Location : Adults in spiral valve of elasmobranchs. Cysts and larvae in viscera, stomach wall, peritoneum, serous coat of intestine, and intestinal wall of teleosts. Both adults and larvae are recorded from *Raja erinacea.*

Remarks : For detailed work on the genus as well as this species reference is invited to Johnstone (1912). Ruskowski (1932) has studied the life cycle of this species, and considers that as in *Diphyllobothriidae, G. erinaceus* has two intermediate hosts, the first a copepod either *Acartia longicornis, Pseudocalanus elongatus, Paracalanus parvus,* or *Temora longicornis. Anguilla vulgaris,* and the salmon are recorded as freshwater hosts of this otherwise marine species. For host records see Sumner *et al.* (1913), Ronald (1959), and for general discussions and identification of related species, Dollfus (1942) and Wardle and McLeod (1952).

Genus LACISTORHYNCHUS Pintner, 1913

Lacistorhynchus tenus (van Beneden, 1858)

(Syn. *L. planiceps* (Leuckart, 1819) ; *Rhynchobothrium gracile* Diesing, 1863 ; *Rhynchobothrium bulbifer* Linton, 1889 ; *Rhynchobothrium benedeni* (Crety, 1890)

Scombroid hosts : *Gymnosarda alleterata* [=*Euthynnus alleteratus* (Rafinesque)]
Sarda sarda (Bloch)
Scomber scombrus Linnaeus
Scomberomorus maculatus (Mitchill)

Locality : Woods Hole, Massachusetts, New England Coast, N.W. Atlantic.

Non-scombroid hosts : Mustelus canis, Alutera schoepfii, Ammodytes americanus, Anguilla sp., *Cynoscion regalis, Elops saurus, Gadus callarias, Menidia menidia notata, Menticirrhus saxatilis, Merluccius bilinearis, Microgadus tomcod, Myoxocephalus aeneus, Paralichthys dentatus, Pomatomus saltatrix, Poronotus triacanthus, Raja erinacea, Spheroides maculatus, Squalus acanthias, Tetronarce occidentalis, Urophycis chuss, Hippoglossus hippoglossus, Monochirus hispidus, Platichthys dentatus, Pleuronectes platessa, Pseudopleuronectes americanus, Scophthalmus aquosus, S. maximus, Solea lascaris, Vulpecula marina,* and *Trlakas semifasciatus* [Atlantic, Mediterranean and Pacific].

Location : Adults common in spiral valve of elasmobranchs (e.g. *Mustelus canis*) ; Cysts in stomach and muscles of back (e.g. *Scomber scombrus*).

Remarks : For details of life cycle of this species see Young (1954).

FAMILY : OTOBOTHRIIDAE

Genus OTOBOTHRIUM Linton, 1890

Two subgenera, *Otobothrium* s.str., and *Pseudotobothrium* Dollfus, 1942, Yamaguti, 1959 are recognised.

Otobothrium (Otobothrium) crenacolle Linton, 1890

Scombroid hosts : Pelamys [=*Sarda sarda* (Bloch)]
Xiphias gladius Linnaeus
Scomberomorus regalis (Bloch)

Locality : Woods Hole, Massachusetts, U.S.A.

Non-scombroid hosts : Sphyrna zygaena, Alutera schoepfii, Carcharhinus obscurus, Cynoscion regalis, Fundulus heteroclitus, Mustelus canis, Paralichthys dentatus, P. albigutta, Poronotus triacanthus, Trichiurus lepturus, [Woods Hole and N.W. Atlantic].

Location : Adults in spiral valves of elasmobranchs (e.g., *Sphyrna zygaena*). Cysts in flesh and viscera of teleosts.

Otobothrium (Otobothrium) balli Southwell, 1929

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Pearl Banks off Ceylon, Gulf of Mannar.

Non-scombroid hosts : Lethrinus ornatus and *Balistes stellatus* [Pearl Banks off Ceylon, Gulf of Mannar] ; *Aprion pristipoma* [Nagapatnam, Tanjore Dt., India, Bay of Bengal].

Location : Larvae in teleosts.

Otobothrium (Pseudotobothrium) dipsacum Linton, 1897
(Syn. *Otobothrium insigne* Linton, 1905 ; *Otobothrium insigne* Southwell, 1912)

Scombroid hosts : Xiphias gladius Linnaeus

Locality : Atlantic.

Non-scombroid hosts : Carcharhinus obscurus, Pomatomus saltatrix, Centropristis striatus, Chelidontichthys kumu [Atlantic and Pacific] ; *Serranus undulosus, Diagramma crassispinum, Balistes mitis, Lutjanus dodecacanthus,* and *Lethrinus ornatus* [Pearl Banks off Ceylon, Gulf of Mannar].

Location : Adult in elasmobranchs (e.g., *C. obscurus*) ; Larvae in teleosts.

FAMILY : PTEROBOTHRIIDAE

Genus PTEROBOTHRIUM Diesing, 1850
(Syn. *Synbothrium* Diesing, 1850 ; *Syndesmobothrium* Diesing, 1854)

Pterobothrium filicolle (Linton, 1889)
(Syn. *Syndesmobothrium filicolle* Linton ; *Synbothrium filicolle* Linton ; *Gymnorhynchus gigas* Southwell, 1930 in part)

Scombroid hosts : 1. *Scomberomorus maculatus* (Mitchill)
2. *Scomberomorus regalis* (Bloch)
3. *Scomberomorus cavella* (Cuvier)
4. *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : 1-3. North Western Atlantic ; 4. Pearl Banks, Gulf of Mannar, India.

Non-scombroid hosts : Trygon centura, Cynoscion regalis, Galeocerdo articus, G. tigrinus, Lobotes surinamensis, Mustelus canis, Paralichthys dentatus, P. albiguttus, Pomatomus saltatrix, Pomolobus mediocris, Brevoortia tyrannus, Mustelus laevis, Carcharhinus milberti, C. obscurus, Lophopsetta maculata, Micropogon undulatus, Pteroplatea micrura, Scoliodon terrae-novae, Dasyatis say, Seriola dumerili [Woods Hole, New England Coast ; Beaufort, North Carolina coast, N.W. Atlantic].

Location : Scolex in spiral valve of elasmobranchs (e.g., *Dasyatis centrura*). Larvae in teleosts

Remarks : Southwell (1930) relegated *Pterobothrium filicolle* (Linton) to the synonymy of *Gymnorhynchus gigas* (Cuvier) along with several other species, giving the following fish hosts : *Dasybatus walga* (adult) ; Larvae from *Cybium guttatum, Chorinemus toloo, C. lysan, Chirocentrus dorab, Serranus* sp., *Balistes* sp., *Lutjanus* sp., *Pristis cuspidatus, Arius gagora, Harpodon nehereus, Hemigaleus balfouri, Trichiurus savala,* and *Clupea ilisha,* all from Indian waters. Of these, Yamaguti (1959) only mentions *C. lysan, C. ilisha, C. guttatum,* and *H. nehereus* as hosts for *P. filicolle.* The following three species of *Pterobothrium* are also treated by Southwell (1930) as synonyms of *Gymnorhynchus gigas,* but I have followed Yamaguti (1959) in considering them as distinct.

Pterobothrium heteracanthus Diesing, 1850

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Pearl Banks off Ceylon, Gulf of Mannar.

Non-scombroid hosts : Micropogon lineatus [Brazil] ; *Pristipoma coro, Drepane punctata* [Indian seas].

Pterobothrium platycephalum (Shipley and Hornell, 1906)
[Syn. *Tetrarhynchus platycephalus* Shipley and Hornell, 1906 ; *T. rubromaculatus* Diesing, 1863 ; *Tentacularia rubromaculata* (Diesing, 1863) Southwell, 1930]

Scombroid hosts : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Pearl Banks off Ceylon, Gulf of Mannar.

Non-scombroid hosts : Chorinemus toloo, Chirocentrus dorab, Serranus sp., *Lutjanus* sp., *Pristis cuspidatus, Trachinotus botla* [Gulf of Mannar, off Ceylon Pearl Banks] ; *Arius gagora*

(Delta of Ganges, Bengal, India) ; *Hemigaleus balfouri, Trichiurus savala* [East Coast of India] ; *Dasybatus wagla* [Gulf of Mannar, off Pearl Banks of Ceylon].

Location : Adults in elasmobranchs (e.g. *D. wagla*) ; Larvae in teleosts.

Pterobothrium tangoli (MacCallum, 1921)
(Syn. *Rhynchobothrium tangoli* MacCallum, 1921)

Scombroid host : ' Scomberiform fish ' (The specific name in vernacular is applied for the little tunny *Euthynnus affinis affinis*, or to the northern bluefin tuna *T. (Kishinoella) tonggol* in Indonesia. The host could be any one of these or some other species of tuna).

Locality : Borneo.

Non-scombroid hosts : None.

Location : Encysted in peritoneum.

SPECIES INCERTE SEDIS

According to Yamaguti (1959), the following are the species whose generic assignment is obviously incorrect or doubtful or those which were referred to heterogenous genera that have no right of standing in modern taxonomy. Of the several listed by him, the following given in their original combination have also scombroid fishes as hosts. Species are given in alphabetical order.

Rhynchobothrium ambiguum Diesing, 1863

Scombroid host : Xiphias gladius Linnaeus

Non-scombroid hosts : Heptanchus sp., *Pristiurus* sp., *Raja* sp.

Tetrarhynchus attenuatus Rudolphi, 1819

Scombroid host : Xiphias gladius Linnaeus

Non-scombroid hosts : Carcharhinus sp., *Vulpicula* sp., *Squalus fernandinus, Thrysites atun, Merluccius capensis.*

Bothriocephalus claviger Leuckart, 1819

Scombroid host : Xiphias gladius Linnaeus

Rhynchobothrium longispine Linton, 1890

Scombroid hosts : Scomber scombrus Linnaeus

Scomberomorus maculatus (Mitchill)

Non-scombroid hosts : Adult in spiral valve of *Trygon centrura* ; Larvae in *Leptocephalus, Menticirrhus saxatilis, Paralichthys dentatus, Poronotus triacanthus, Prionotus strigatus, Stenotomus chrysops, Urophycis chuss.*

Tentacularia macfiei Southwell, 1929

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Non-scombroid hosts : Chorinemus lysan, C. toloo, Lutjanus argentimaculatus, L. gibbus, Serranus undulosus, Balistis mitis, B. stellatus, Balistis sp., *Psettodes erumei, Cossyphus axillaris, Trichiurus savala* [Ceylon Pearl Banks, Gulf of Mannar]

Tetrarhynchus megabothrius Rudolphi, 1819

Scombroid host : Scomber sarda [=*Sarda sarda* (Bloch)]

Tetrarhynchus pearsoni Southwell, 1929

Scombroid host : Cybium guttatum [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)] (Pearl Banks off Ceylon, Gulf of Mannar ; Orissa coast, India).

Tetrabothriorhynchus scombri Diesing, 1854

Scombroid host : Scomber scomber (=*Scomber scombrus* Linnaeus)

? **Tetrarhynchus scomber-gobius** Wagener, 1854

Tetrarhynchus scomber-pelamys Wagener, 1854

Scombroid host : Scomber pelamys [=*Sarda sarda* (Bloch)]

Tetrarhynchus scomber-rochei Wagener, 1854

Scombroid host : Scomber rochei [=? *Auxix thazard* (Lacépède)]

Tetrarhynchus scomber-thynnus Wagener, 1854

Scombroid host : ? *Thunnus thynnus thynnus* (Linnaeus)

Rhynchobothrium spiracornuatus Linton, 1907

Scombroid host : Thynnus sp. (='*Thunnus* sp.') [Gulf of Mannar off Ceylon].

Non-scombroid hosts : Epinephalus maculosus, Paranthias furcifer (N.W. Atlantic) ; *Caranx* sp. [Gulf of Mannar].

Remarks : Thynnus sp. is from the Gulf of Mannar and this could represent any one of the following species which are fairly common in the Pearl Banks off Ceylon and India in the Gulf of Mannar : *Euthynnus affinis affinis* (Cantor), *T. (Kishinoella) tonggol* (Bleeker), and *T. (Neothunnus) albacares macropterus* (Temminck and Schlegel). For the description of larvae infesting *Caranx* sp., and *Thunnus* sp., reference may be made to Southwell (1930).

Tetrarhynchus thynni Wagener, 1854

Scombroid host : Thynnus sp. (=*Thunnus* sp.)

Dibothriorhynchus xiphiae MacCallum, 1921

Scombroid host : *Xiphius gladius* Linnaeus

Remarks : Nigrelli (1938) considers this a synonym of *Dibothriorhynchus attenuatus* (Rudolphi, 1819) (=*Rhynchobothrium attenuatus* Rudolphi, 1819). Wardle and McLeod (1952) consider *Dibothriorhynchus*, a synonym of *Hepatoxylon* Bosc, 1811.

Besides these species listed by Yamaguti (1959) the following should also be mentioned as known from scombroid fishes.

Cestode cysts and larvae from *Scomberomorus regalis* (Bloch). See Linton (1904).

Rhynchobothrium sp. Cysts in viscera of *Scomberomorus maculatus* (Mitchill), and *S. regalis* (Bloch), besides a few other teleosts. See Linton (1904).

Dibothrium sp. Cysts in intestine of *Scomber scombrus* Linnaeus and other teleosts, adults in elasmobranch. See Linton (1901) and Sumner, *et al.* (1913).

Tetrarhynchus sp. (Linton, 1901). Cysts from *Sarda sarda* (Bloch), and *Scomberomorus regalis* (Bloch) in addition to several other teleosts from the Woods Hole area (see Sumner *et al.* 1913).

Tetrarhynchus sp. I. Cysts from *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]. (Gulf of Mannar). See Shipley and Hornell, (1906). Larval form of uncertain generic position (Southwell, 1930).

Tetrarhynchus sp. II. From *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)] (Gulf of Mannar). See Shipley and Hornell, (1906). Larval form of uncertain generic position (Southwell, 1930).

It is likely that helminth literature may contain descriptions of a few more such unidentifiable larval cestodes which are also known from Scombroid fishes.

HOST-PARASITE LIST No. III

[List of names of scombroid hosts and their cestode parasites. Genera are arranged alphabetically. (?) indicates doubtful record of parasite species from host ; (*) species incerte sedis : (**) forms unidentifiable].

Auxis thazard (Lacépède).....	*Callitetrarhynchus gracilis* (Rudolphi) * *Tetrarhynchus scomber-rochei* Wagener
Istiophorus gladius (Broussonnet).....	*Bothriocephalus manubriformis* (Linton)
Katsuwonus pelamis (Linnaeus).....	*Tentacularia bicolor* (Bartels)
Sarda sarda (Bloch).....	*Grillotia erinaceus* (van Beneden) *Lacistorhynchus tenus* (van Beneden) *Scolex peluronectis* Mueller *Tentacularia bicolor* (Bartels) *Tentacularia coryphaena* Bosc * *Tetrarhynchus megabothrium* Rudolphi * ? *Tetrarhynchus scomber-pelamys* Wagener ** *Tetrarhynchus* sp. (Linton, 1901)

Scomber scombrus Linnaeus.....	*Bothriocephalus scorpii* (Mueller) *Callitetrarhynchus gracilis* (Rudolphi) *Grillotia erinaceus* (van Beneden) *Lacistorhynchus tenus* (van Beneden) *Nybelinia* (*Nybelinia*) *bisulcata* (Linton) *Scolex pleuronectis* Mueller * *Rhynchobothrium longispine* Linton * *Tetrarhynchus scombri* Diesing ** *Dibothrium* sp. (Linton, 1901)
Scomber sp.....	*Tentacularia coryphaena* Bosc
Scomberomorus cavalla (Cuvier).....	*Pterobothrium filicolle* (Linton)
Scomberomorus guttatus guttatus (Bloch and Schneider).....	*Otobothrium* (*Otobothrium*) *balli* Southwell *Pterobothrium filicolle* (Linton) *Pterobothrium heteracanthus* Diesing *Pterobothrium platycephalum* (Shipley and Hornell) * *Tentacularia macfiei* Southwell * *Tetrarhynchus pearsoni* Southwell ** *Tetrarhynchus* sp. I. (Shipley and Hornell, 1906) ** *Tetrarhynchus* sp. II. (Shipley and Hornell, 1906)
Scomberomorus maculatus (Mitchill).....	*Callitetrarhynchus gracilis* (Rudolphi) *Lacistorhynchus tenus* (van Beneden) *Pterobothrium filicolle* (Linton) * *Rhynchobothrium longispine* Linton ** *Rhynchobothrium* sp. (Linton, 1904)
Scomberomorus regalis (Bloch).....	*Octobothrium* (*Octobothrium*) *crenacolle* Linton *Pterobothrium filicolle* (Linton) ** *Rhynchobothrium* sp. (Linton, 1904) ** *Tetrarhynchus* sp. (Linton, 1901) ** Cestode cysts (Linton, 1904)
Scombriform fish ' [? *Euthynnus* spp. or *Kishinoella tonggol* ?].....	*Pterobothrium tangoli* (MacCallum)
Tetrapturus albides Poey.....	*Bothriocephalus manubriformis* (Linton)
Thunnus (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel).....	*Pelichnibothrium speciosum* Monticelli
Thunnus (*Thunnus*) *thynnus thynnus* (Linnaeus)	* ? *Tetrarhynchus scomber-thynnus* Wagener
Thunnus sp.....	*Callitetrarhynchus gracilis* (Rudolphi) *Tentacularia coryphaena* Bosc * *Rhynchobothrium spirocornuatus* Linton * *Tetrarhynchus thynni* Wagener

Xiphias gladius Linnaeus.....

Fistulicola plicatus (Rudolphi)
Grillotia erinaceus (van Beneden)
Gymnorhynchus (*Gymnorhynchus*) *gigas* Cuvier
Gymnorhynchus (*Molicola*) *uncinatus* (Linton)
Nybelinia (*Nybelinia*) *bisculcata* (Linton)
Nybelinia (*Nybelinia*) *lamontae* Nigrelli
Nybelinia (*Nybelinia*) *lingualis* (Cuvier)
Otobothrium (*Otobothrium*) *crenacolle* Linton
Otobothrium (*Otobothrium*) *dispactum* Linton
Phyllobothrium loliginis (Leidy) Linton
Scolex pleuronectis Mueller
Tentacularia bicolor (Bartels)
Tentacularia coryphaena Bosc
* *Bothriocephalus claviger* Leuckart
* *Dibothriorhynchus xiphiae* MacCallum
* *Rhynchobothrium ambiguum* Diesing
* *Tetrarhynchus attenuatus* Rudolphi

PRELIMINARY ANALYSIS OF SCOMBROID HOSTS AND THEIR TREMATODE AND CESTODE PARASITES, WITH SPECIAL REFERENCE TO INDIAN SEAS

As already mentioned, it is too early to speculate on the zoogeography of scombroid fishes and their parasites. This paper lists, (excluding the numerous synonymies) 206 species and forms of Monogenea, Digenea, and Cestoda. A preliminary analysis of this data, especially with reference to scombroid fishes from Indian seas, which is no doubt also true of several other geographical areas, shows that :

1. The scombroid parasite data are very incomplete for this area and there is considerable scope for more intensive investigations.
2. Several scombroid species have not been examined for their parasites from this area, while many parasite species have been described from these hosts from extra-Indian waters.

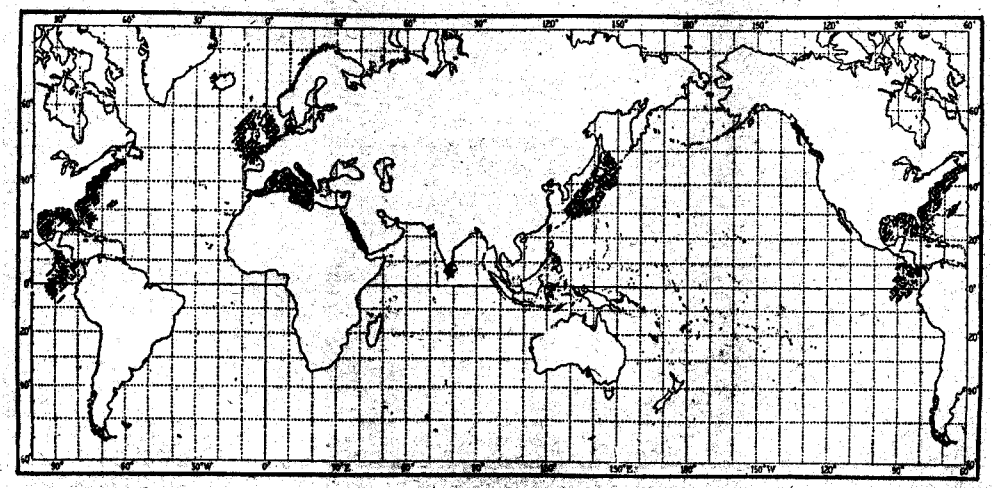


Fig. 1. Map showing areas hatched from where the great majority of trematode and cestode parasites of scombroid fishes have been described.

Tables I and II are given to emphasise the need for more intensive work on Scombroid fishes and their parasites on a world wide basis. At present the areas where a reasonable amount of work has been carried out are (1) the east coast of U.S.A., including the Gulf of Mexico (N.W. Atlantic); (2) British waters, French coast (N.E. Atlantic), and Western Mediterranean; (3) Red Sea; (4) Gulf of Mannar between India and Ceylon (For mostly Cestodes); (5) Japanese Sea; and (6) Galapogos Islands and adjacent Pacific. The intervening areas, from where only stray works are available on scombroid fish parasites, (Fig. 1) will give some idea of the considerable gaps yet to be filled in.

TABLE I

Total number of helminth parasites listed in this work along with the numbers occurring in Indian seas[1]

Parasite group		Total Number	In Indian Seas
Monogenea			
	Species	76	22
	Species unidentifiable	2	2
Digenea			
	Species	100	5
	Species unidentifiable	..	..
Cestoda			
	Species	27	7*
	Species unidentifiable	21+	4
	Total	226	40

[1] Additions given in Addendums I, II and III are also included in Tables I and II.

* Few of the Indian records are from non-scombroid fishes as well.

TABLE II

Species and subspecies of scombroid fishes listed parasite group-wise

Parasite group	Species and subspecies of Scombroid fishes (Host records only)		
	Total No.	Occurring in Indian seas	No. examined for parasites from Indian seas
Monogenea			
A. Valid scombroid sp. & sub. spp. and hosts	32	19*	8*
B. Host identifiable only up to genus..	5	2	2
Digenea			
A.	25	15	4
B.	2	..	..
Cestoda			
A.	13	6	2
B.	3	..	..

**Scomberomorus commerson* (Lacépède), and *S. lineolatus* (Cuvier and Valenciennes), probable hosts of *Pricae multae* Chauhan are also included.

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——— 1959. *Systema Helminthum*, Vol. II. The Cestodes of Vertebrates. 860 pp.

YOUNG, R. T. 1954. A note on the life cycle of *Lacistorhynchus tenuis* (van Beneden) 1858, Cestode of the leopard shark. *Proc. Helminth. Soc. Washington*, 21(2) : 111.

ZEDER, J. G. H. 1800. *Erster Nachtrag zur Natrrgeschichte der eingeweiderwurmer mit Zufassen und Anmerkingen herausgegeben*. Leipzig. 320 pp.

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APPENDIX I

(List of Ichthyological references that may be consulted)

1. BEAUFORT, L. F. de 1951. In Beaufort, L. F. de and Chapman, W. M., *The Fishes of the Indo-Australian Archipelago*. 9.

2. BOESEMAN, M. 1947. Revision of the fishes collected by Burger and von Sibold in Japan. *Zool. Meddel., Leiden*, 28 : 242 pp.

3. FRASER-BRUNNER, A. 1950. The fishes of the family Scombridae. *Ann. Mag. Nat. Hist., Ser.* 12, Vol,3 : 131-163.

4. GODSIL, H. C. 1954. A descriptive study of certain tuna-like fishes. *Calif. Fish amd Game, Fish. Bull.* 97 : 1-187.

5. JONES, S. and E. G. SILAS 1960. Indian Tunas—a preliminary review, with a key for their identification, *Indian J. Fisher.*, 7(2) : 369-393.

6. ————and ———— 1961. On the fishes of the subfamily Scomberomorinae (Family Scombridae) from Indian waters. *Ibid.*, 8(1) : 188-206.

7. ———1962. A systematic review of the scombroid fishes of India. *Symposium on Scombroid Fishes*. Pt. 1:1-105 (1964).

8. KISHINOUYE, K. 1923. Contributions to the comparative study of the so-called scombroid fishes. *J. Coll. Agri. Univ. Tokyo*, 8(3) : 293-475, pls. 13-34, figs. 1-26.

9. LA MONTE, F. R. 1955. A review and revision of the marlins, genus *Makaira*. *Bull. Amer. Mus. Nat. Hist.*, 107(3) : 323-358.

10. MANACOP, P. R. 1956. A preliminary systematic study of the Philippine chub mackerels, Family Scombridae, Genera *Pneumatophorus* and *Rastrelliger*. *Philippine J. Fisher.*, 4(2) : 79-101.

11. MORROW, J. E. 1957. Races of the striped marlin, *Makaira mitsukurii*, in the Indo-Pacific. *Bull. Bingham Oceanogr. Coll.*, 16(2) : 72-87.

12. MORROW, J. E. 1957. Distribution of the blue marlins and black marlins in the Indo-Pacific. *Bull. Mar. Sci. Gulf. Caribbean*, 9(3) : 321-323.

13. MUNRO, I. S. R. 1943. Revision of Australian species of *Scomberomorus*. *Mem. Queensland Mus.*, 12(2) : 65-95, pls. vi-viii, figs. 1-4.

14. ———1955. *The Marine and Freshwater fishes of Ceylon*. Canberra.

15. NAKAMURA, H. 1938. Report on an Investigation of the spearfishes of the Formosan waters. *Reports of the Taiwan Government—General Fishery Experiment Station*. 1937 (10) : 1-34, 15 pls. (English translation : *U.S. Fish and Wildl. Ser. Special Sci. Rept. Fisheries*, 153 : 1-16, 1955).

16. ROBINS, R. C. AND D. P. DE SYLVA 1960. Description and relationship of the longbill spearfish, *Tetrapturus belone*, based on Western North Atlantic specimens. *Bull. Mar. Sci. Gulf. Caribbean*, 10(4) : 383-413.

17. RIVAS, L. R. 1951. A preliminary review of the Western Atlantic fishes of the family Scombroidae. *Bull. Mar. Sci. Gulf. Caribbean* 1(3) : 209-230.

18. ———1961. A review of the tuna fishes of the subgenera *Parathunnus* and *Neothunnus* (Genus *Thunnus*). *Ann. Mus. Civ. Stor. Nat., Genova*, 72 : 126-148.

19. ROSA, H. (JR.) 1950. Scientific and common names applied to tunas, mackerels and spearfishes of the world with notes on their geographic distribution. A Progress Report on the compilation of scientific and common names of important food fishes. *F.A.O. of the United Nations* 1-235, (Washington D.C., U.S.A., December 1950).

20. ROYCE, W. F. 1957. Observations on the spearfishes of the Central Pacific. *U.S. Fish. Wildl. Ser. Fishery Bull.* No. 124, Vol. 57 : 495-554.

21. SERVENTY, D. L. 1941. The Australian Tunas. *Counc. Sci. Industr. Res. Australia, Pamphlet* No. 104, 1-48.

22. SMITH, J. L. B. 1950. *The Sea Fishes of Southern Africa*. 550 pp. Hafner Publ. Co. N.Y.

23. ———1956. Swordfish, marlins and sailfish in South and East Africa. *Ichthyol. Bull.*, No. 2 : 1-34, 2 pls. (Dept. Ichthyology, Rhodes Univ. Grahanstown, South Africa).

24. TORTONESE, E. 1955. Brevi considerazioni sui Pesci mediterranei del sottordine Sgombroidi. *Bull. Inst. Mus. Zool. Univ. Torino*, Vol. 5, No. 3.

For easy reference, these are annotated below, both group-wise as well as region-wise. The numbers refer to those given in the above list.

Group-wise.

General : 1, 2, 3, 7, 8, 14, 19, 22.
Mackerels : 1, 3, 7, 8, 10, 17.
Seerfishes or Spanish mackerels : 1, 3, 4, 6, 7, 8, 13, 17.
Tunas : 1, 3, 4, 5, 7, 8, 17, 18, 21, 24.
Billfishes : 1, 7, 9, 11, 12, 15, 16, 20, 23.

Region-wise.

Indo-Pacific : 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 20, 21, 22, 23.

Atlantic (Including Mediterranean) : 3, 9, 16, 17, 18, 19, 24.

ADDENDUM—I

Since this paper was sent to the press, the following works dealing with trematode parasites, some of which infest scombroid fishes, have come to my notice. In order to make this account up-to-date and useful, these additional references are listed below and the parasites and their hosts are indicated as given in the main paper.

ADDITIONAL REFERENCES

HIDALGO ESCALANTE, E. 1959. Hallazgo de una nueva especie de Capsala, *Capsala pricei* n. sp. (Trematoda, (Monogenea) en un pez Marino del Puerto de Mazatlan, Sinaloa, Mexico. *Anales del Inst. de Biol. Mexico* 29 (1&2) : 209-217.

PRICE, E. W. 1960. The giant marlin *Makaira marlina* Jordan et Evermann, a new host for *Capsala pricei* Hidalgo, 1959, with a review of the sub-family Capsalinae. *Libr. Hom. al Dr. Caballero*, 237-244.

RAMALINGAM, K. 1961a. A redescription of *Lithidocotyle secunda* Tripathi (Monogenea) and its bionomics. *J. Madras Univ.*, B, 31(2) : 143-173.

————. 1961b. On a new species of the genus *Lithidocotyle* (Monogenea : Gastrocotylidae), its juveniles and immature forms from the gills of *Scomberomorus guttatus*. *Ibid.*, B, 31(2) : 175-181.

TRIPATHI, Y. R. 1957. Monogenetic trematodes of fishes from India. *Indian J. Helminthology*, 9(1& 2) : 1-149.

UNNITHAN, R. V. 1957. On the functional morphology of a new fauna of Monogenea on fishes from Trivandrum and environs. Part I. Axinidae Fam. Nov. *Bull. Central Res. Inst. Univ. Kerala*, 5(2) : 27-122.

MONOGENETIC TREMATODES

FAMILY : CAPSALIDAE

Capsala pricei Hidalgo Escalante, 1959

Scombroid host : 1. *Makaira mitzukurii* (Jordan and Snyder) (=*Tetrapturus audax* Philippi)
2. *Makaira marlina* [=*Makaira indica* (Cuvier)].

Locality : 1. Mazatlan, Sinaloa, Pacific coast of Mexico. 2. Panama (Pacific).

Non-scombroid hosts : None.

Location : Ventral side of body.

Remarks : Price (1960) redescribed and figured this species.

FAMILY : MICROCOTYLIDAE

Unnithan (1957) created the family Axinidae and placed it with Microcotylidae and Gastrocotylidae in the superfamily Microcotyloidea. A new genus *Uraxine* was described by him under the family Axinidae. In view of the doubtful validity of some of the higher categories, I have adopted here the emendations of Hargis (1956) placing subfamily Axininae under the family Microcotylidae.

Genus Uraxine Unnithan, 1957

Uraxine chura chura Unnithan, 1957

Scombroid host : *Euthynnus affinis* (Cantor) [=*Euthynnus a. affinis* (Cantor)]

Locality : Trivandrum, S.W. coast of India.

Non-scombroid hosts : None.

Location : Gills.

Uraxine chura macrova Unnithan, 1957

Scombroid host : *Euthynnus affinis* (Cantor) [=*Euthynnus a. affinis* (Cantor)]

Locality : Trivandrum, S.W. coast of India.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Unnithan (1957) described from the same host a second subspecies, *Uraxine chura macrova* and as such the forma typica should have been designated by him as *Uraxine chura chura.* The subspecies *U.c.macrova* is said to differ from the forma typica, *U.c.chura* in being relatively smaller in size, but having larger eggs ; the shape of the body ; the size of the haptorial units in relation to the length of the body ; the anchors of the lappet ; the disposition of the testes in the par ovarian rows and in the shape and extent of the vitelline duct. In spite of these differences Unnithan (1957) opines that '. . . the close similarity of *Uraxine chura macrova* to *Uraxine chura* suggests a more reasonable subspecific rank for *Uraxine chura macrova.*' Ramalingam's recent works (1961a, 1961b) on species of *Lithidocotyle* are very suggestive drawing attention to the extent to which some of the abovementioned characters, such as body shape, number and disposition of haptorial units, etc. could be variable in the same species collected from different parts of the gill arch of a host specimen.

FAMILY : MAZOCRAEIDAE HARMANN, 1782

Genus Kuhnia Sproston

Kuhnia indica Tripathi, 1957 (Pp. 86-89, figs. 41a-d)

Scombroid host : *Cybium guttatum* Bloch and Schneider [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : Puri, Orissa Coast, Bay of Bengal.

Non-scombroid host : None.

Location : ? (Gills and buccal cavity ?).

Genus Indomazocares Tripathi, 1957

Indomazocares jagannath Tripathi, 1957

Scombroid host : *Rastrelliger kanagurta* (Cuvier) [=*Rastrelliger kanagurta* (Cuvier)]

Locality : Puri, Orissa Coast, Bay of Bengal.

Non-scombroid hosts : None.

Location : ? (Gills and buccal cavity ?).

Remarks : This genus is considered a synonym of *Pseudoacanthocotyle* Bychowsky and Nagibina (1954) by Price, 1961 (see reference under Addendum-III).

Genus Lithidocotyle Sproston, 1946. emend. Hargis, 1956

Lithidocotyle secunda Tripathi, 1954

Scombroid host : *Scomberomorus guttatus* [=*Scomberomorus g. guttatus* (Bloch and Schneider)]

Locality : Madras Coast.

Non-scombroid hosts : None.

Location : Gills.

Remarks : The species is redescribed by Ramalingam (1961a).

Lithidocotyle bivaginalis Ramalingam, 1961b

Scombroid host : *Scomberomorus guttatus* [=*Scomberomorus g. guttatus* (Bloch and Schneider)]

Locality : Madras Coast.

Non-scombroid hosts : None.

Location : Gills.

HOST-PARASITE LIST NO. I—(*Contd.*)

SCOMBROID HOST	PARASITE (Monogenea)
Euthynnus affinis affinis (Cantor).....	*Uraxine chura chura* Unnithan *Uraxine chura macrova* Unnithan
Makaira indica (Cuvier).....	*Capsala pricei* Hidalgo Escalante
Rastrelliger kanagurta (Cuvier).....	*Indomazocares jagannath* Tripathi
Scomberomorus guttatus guttatus (Bloch and Schneider)	*Kuhnia indica* Tripathi *Lithidocotyle bivaginalis* Ramalingam *Lithidocotyle secunda* Tripathi. (This species has already been mentioned in the host-parasite list on p. 818)
Tetrapturus audax Philippsi.....	*Capsala pricei* Hidalgo Escalante

REMARKS

Since the above additions refer to monogenetic trematodes, I wish to offer a few comments. As already mentioned, species of this group appear to evince host specificity to a greater degree than digenetic trematodes or cestodes. A glance at the host-parasite list no. 1 would show that up to now the greatest number of species (eleven plus two doubtful = 13) has been reported from the spotted spanish mackerel *Scomberomorus guttatus guttatus* (Bloch and Schneider), from India and the absence of any definite records of monogenetic trematodes from the two other spanish mackerels from this area, namely *S. commerson* (Lacépède) and *S. lineolatus* (Cuvier and Valenciennes) is glaringly conspicuous. Either these species have not been investigated for monogenetic trematode parasites or there is the possibility of faulty host identification. The latter possibility cannot be completely overlooked as it is not uncommon for juveniles and adults of these three species of *Scomberomorus* to be landed with the same gear at the same time, and to the untrained, the identification, especially of the juveniles may be difficult.

ADDENDUM—II

Between 1962 and 1965, a few more papers have appeared wherein references to helminth parasites of scombroid fishes are made. Most of the papers listed below appeared in the Proceedings of the 'World Scientific Meeting on the Biology of Tunas and Related Species' published as FAO Fishery Report No. 6, Volumes 1-3 (1963). The helminth species (Trematodes and Cestodes) mentioned are listed under each reference with additional remarks wherever necessary. A separate 'Host-Parasite' list is not given here as most of the species have already been dealt with in the main part of this paper and there are very few new host records.

BELL, R. R. 1963. Synopsis of biological data on California Bluefin tuna *Thunnus salineus* Jordan and Evermann 1926. FAO Fishery Biology Synopsis No. 55. *FAO Fishery Rept.*, No. 6, 2 : 380-421.

Didymocystis guernei (Several fusiform adults in cysts up to 15 mm long under serosa of the stomach; and reproductive bodies from minute to 4 mm in diameter on the gill filament, arches and rakers); *Hirudinella fusca* (from stomach); and monogenetic trematode *Tricotyla thynni* (from gills).

DEMIR, M. 1963. Synopsis of Biological data on Bonito *Sarda sarda* (Bloch) 1793. *Ibid.*, No. 6, **2** : 101-129.

Trematode *Didymozoon pelamyzis* Taschenberg, and cestode *Callitetrarhynchus gracilie* (Rud.) as parasites of *S. sarda*.

IVERSEN, E. S., and E. E. HOWEN 1958. Some trematodes of fishes from Central Equatorial Pacific. *Pacific Sci.*, **12** (2) : 131-134.

Trematodes *Capsala biparasitica* (Goto) and *Hirudinella marina* Garcin from the yellowfin.

———— and H. O. YOSHIDA 1957. Notes on the biology of wahoo in the Line Islands. *Ibid.*, **11** : 370-379.

Trematode *Hirudinella ventricosa* (Pallas) from stomach of *Acanthocybium solandri*. Also details on rate of infestation.

KING, J. E., and IKEHARA 1956. Comparative study of food of bigeye and yellowfin tuna in the Central Pacific. *Fish. Bull. U. S. Fish Wild. Serv.*, **57** (108) : 61-85.

Trematode *Hirudinella sibi* Garcin, from stomach of *Parathunnus sibi* [=*Thunnus* (*Parathunnus*) *obesus mebachi*) ; also details on rate of infestation.

KISHINOUYE, K. 1923. Contribution to the comparative study of the so-called scombroid fishes. *J. Coll. Agri. Imp. Univ. Tokyo*, **8** (3) : 293-476.

Trematode *Distomum* sp., from *Acanthocybium* solandri ; and cestode *Rhyncobothrium* from *Katsuwonus pelamis*.

MCMAHON, J. W. 1964. Monogenetic trematodes from some Chesapeake Bay fishes. Part II. The superfamily Diclidophoroidea. *Chesapeake Science*, **5** (3) : 124-133.

Records the following four species from the gills of *Scomberomorus maculatus* (Mitchill) : *Scomberocotyle scomberomori* (Koratha, 1955) Hargis 1956 ; *Pseudaxine mexicana* Meserve, 1938 ; *Lithidocotyle acanthophallus* (MacCallum and McCallum, 1913) ; and *Thoracocotyle crocea* MacCallum, 1913.

POSTEL, E. 1963. Expose synoptique sur la biologie du Germon Germo alalunga (Cetti) 1777 (Atlantique Oriental) FAO Fishery Biology Synopsis No. 77. *FAO Fishery Rept.* No. 6, **2** : 931-975.

Lists the undermentioned trematodes and cestodes : Trematoda—*Didymocystis guernei* (from branchiae, muscles and other parts of body) ; *Platocystis alalongae* (from pectoral and posterior dorsal region) ; *Nematobothrium guernei* (from musculature perioesophaginne) ; *Hirudinella fusca*, *H. poirieri*, and *H. ventricosa* (from stomach) ; and the monogenetic trematode *Tricotyle thynni* from the gills. Cestoda—*Heptoxylon trichiuri*=*H. squali* (postlarvae) (from stomach, rectum and liver) ; *Sphyriocephalus tergestinus* (postlarvae) (from pyloric caecae) ; and *Pseudobothrium grimaildi* (from pyloric caecae and duodenum).

PRICE, E. W. 1938. The monogenetic trematodes of Latin America. *Livro Jubilar do Professor Lauro Travassos*, Rio de Janeiro, Brazil, 407-414.

———— 1939. North American Monogenetic Trematodes. III. The family Capsalidae (Capsaloidea). *J. Wash. Acad. Sci.* **29** (2) : 63-92.

RAJU, G. 1963. New records of the giant trematodes of the genus *Hirudinella* Garcin from Indian waters. *J. Mar. biol. Ass. India*, **4** (1 & 2) : 232-234.

Records *Hirudinella marina* Garcin from stomach of *Katsuwonus pelamis* and *Neothunnus macropterus* (=*T.* (*N.*) *albacares macropterus*) (from Minicoy Island, Laccadive Sea) and from *Euthynnus a. affinis* (from Tuticorin, Gulf of Mannar) ; and *Hirudinella ventricosa* Pallas from the stomach of *Acanthocybium solandri* (from Minicoy Island, Laccadive Sea and Tuticorin, Gulf of Mannar). Details of rate of infestation are also given.

ROBINSONS, J. P. 1963. Synopsis of Biological data on bluefin tuna *Thunnus thynnus maccoyi* (Castelanau) 1872. FAO Fishery Biology Synopsis No. 60. *FAO Fishery Rept.* No. 6, **2** : 562-587.

Trematode *Hirudinella* sp. in gut ; infection light, intensity ranging from 0 to 2 per individual.

TIEWS, K. 1963 Synopsis of Biological data on bluefin tuna *Thunnus thynnus* (Linnaeus) 1758 (Atlantic and Mediterranean). FAO Fishery Biology Synopsis No. 56, *ibid.*, No. 6, **2** : 422-482.

Lists the Monogenetic trematodes *Hexacotyle thynni* (Delaroche, 1811) v, Nordmann, 1840 (from gill lamellae of first gill arch) ; and *Tristoma onchidiocotyle* Setti 1899 (from copulae connecting gill arches of both body sides) Digenetic trematodes listed are : *Didymocystis wedli* Ariola, 1902 found encysted in small capsules of each two individuals on gill lamellae ; and *Hirudinella clavata* Menzies, 1791 (from intestine).

UNNITHAN, R. V. 1964. On five new species of Monogenetic trematodes parasitic on the gills of marine fishes from the south west coast of India. *Treubia*, 26 (3) : 159-178.

Describes one new genus and species—*Scomberocola eyela*—from the gills of the Indian mackerel *Rastrelliger kanagurta* (Cuvier).

WALDRON, K.D. 1963. Synopsis of biological data on skipjack *Katsuwonus pelamis* Linnaeus 1758 Pacific Ocean FAO Fishery Biology Synopsis No. 65, *Ibid.*, No. 6, 2 : 695-748.

The detailed list contains the undermentioned species of trematode and cestode parasites not given as infesting this species in ' Host-Parasite Lists ' Nos. 2 and 3 in this paper. Trematodes—*Didymozoon auxis* Taschenberg ; *Tergestia laticollis* ; *Hirudinella clavata* ; *Hirudinella ventricosa* and *Tristomum laeve*. All these have been recorded from other scombroid hosts as will be seen from ' Host-Parasite List No. 2. The cestodes recorded are : *Tentacularia coryphaenae* (Bosc, 1802) ; *Callotetrarhynchus speciosus* (Linton, 1897); *Pelichnibothrium* (larva) (Yamaguti, 1934); and *Rhyncobothrium* (Kishinouye, 1923).

WILLIAMS, F. 1964. The Scombroid Fishes of East Africa. *Symposium on Scombroid Fishes*, Part I : 107-164.

Records : Trematode *Hirudinellia marina* Garcin and cestode *Bothriocephalus manubriformis* (Linton) from the yellowfin ; and *Hirudinella ventricosa* from the stomach of *Acanthocybium solandri*. Details of rates of infestation of *H. ventricosa* are also given.

YOSHIDA, H.O., and OTEU, T. 1963. Synopsis of Biological data on albacore *Thunnus germo* (Lacépède) 1800 (Pacific and Indian Ocean) FAO Fishery Biology Synopsis No. 52. *FAO Fishery Rept.* No. 6, 2 : 274-318.

Lists trematodes *Hirudinella spinulosa* (from stomach) ; *Didymocystis alalongae* from gill arch ; and *Platocystis alalongae* (on skin) ; and the cestode *Metanematobothrium guernei* (in sub-maxillary muscles).

To sum up, the additional helminth parasites with scombroid host records not mentioned earlier in this paper are :

Monogenetic Trematoda :

1. *Scomberocola eyela* from *Rastrelliger kanagurta* from S. W. Coast of India.

Digenetic Trematoda :

1. *Hirudinella sibi* from *Parathunnus sibi* (= *Thunnus* (*Parathunnus*) *obesus mebachi*) from Central Pacific.

Cestoa :

1. *Heptoxylon trichiuri* = *H. squali* (postlarvae) ;
2. *Sphyriocephalus tergestimus* (*postlarvae*) ; and
3. *Pseudobothrium grimaldii* from *Germo alalunga* [= *Thunnus* (*T.*) *alalunga*] from Eastern Atlantic.
4. *Melanematobothrium guernei* from *Thunnus germo* [*Thunnus* (*T.*) *alalunga*] from the Pacific.

ADDENDUM—III

Five recent works pertaining to Monogenea are given here. Of these, Price (1960a) has been already mentioned under Addendum-I. However, the works of Price (1960a, 1960b, 1961) and Yamaguti (1963) contain some emendations in the classification of some of the divisions of Monogenea in addition to descriptions of new taxonomic higher categories. Those concerning species which infest scombroid fishes are briefly dealt with below. Five new species of monogenetic trematodes (three nom. nov., and two new species) are described in these works.

BYCHOWSKY, B. E. and L. F. NAGIBINA 1954. (New monogenetic trematodes from the Pacific Ocean) (In Russian). *Zool. Zhurnal.*, **33** (1) : 30-38.

Describes a new genus and species—*Pseudoacanthocotyle pavlovskyi* from the scombroid host *Scomber canagurta* (=*Rastrelligur kanagurta* (Cuvier)) from Ryukyu Islands, Pacific.

PRICE, E. W. 1960a. The giant marlin, *Makaira marlina* Jordan and Evermann, a new host for *Capsala pricei* Hidalgo, 1959, with a review of the subfamily Capsalinae. *Libr. Hom. al. Dr. Caballero*, pp. 237-244.

Besides the new scombroid host record for *Capsala pricei*, a new genus *Caballerocotyla* with *Capsala biparasitica* (Goto) as genotype is described. Seven other species listed in the present work under the genus *Capsala*, namely *C. caballerio* Winter (1954), *C. gouri* Chauhan (1952), *C. katsuwoni* (Ishii, 1936), *C. magronum* (Ishii, 1936), *C. manteri* Price (1952), *C. megacotyle* (von Listow, 1906), and *C. pelamydis* (Taschenberg, 1878) are relegated to *Caballerocotyla*. At the same time, *C. leavis* (Verril 1874), *C. interrupta* (Monticelli, 1891), *C. lintoni* Price (1939), *C. nozawae* (Gotto, 1894), *C. onchidocotyle* (Setti, 1899), *C. ovalis* (Goto, 1894), *C. poeyi* (Vigueras, 1935) and *C. pricei* Hidalgo Escalante (1959) are included under the genus *Tristomella* Guiart (1938).

PRICE, E. W. 1960b. North American Monogenetic Trematodes. VIII. The Family Hexostomatidae. *Proc. Helm. Soc. Washington*, **28** (1) : 4-9.

Considers *Hexostoma macracanthum* Fujii (1944) a synonym of *Neohexostoma euthynni* (Meserve, 1938). Describes a new genus *Neohexostoma* with *Octocotyle thunninae* Parona and Perugia, 1889 (= *Hexostoma thunninae* as given *vide supra* p. 816) as the genotype. In addition, *Hexostomas extensicaudatum* (Dawes, 1940), and *H. pricei* Koratha (1955) are also placed under this genus. The following are the new species :

(i) *Neohexostoma robustum* Price, 1960 : On *Parathynnus sibi* (= *Thunnus* (*Parathunnus*) *obesus mebachi* (Kishinouye)) from tropical Pacific.

(ii) *Hexostoma lintoni* Price, 1960 : *nom. nov.* for *Hexocotyle thynni* Linton, 1901 (*nec Polystoma thynni* Delaroche) given as a doubtful synonym under *Hexostoma thynni*, *vide supra*, p. 817.

PRICE, E. W. 1961. North American Monogenetic Trematodes. IX. The Families Mazoceracidae and Plectanocotylidae. *Proc. Biol. Soc. Washington*, **74** : 127-156.

Two new names have been proposed as follows :

(i) *Kunhia sprostonae* Price, 1961 : (*nom. nov.*) For *Kunhia minor* Sproston (1946) (*nec.* Goto, 1894) on mackerel found at Plymouth.

(ii) *Grubea pneumatophori* Price, 1961 : (*nom. nov.*) For *Pleurocotyle scombri* Linton, 1940 found on *Pneumatophorus grex* (Mitchell) from Woods Hole, Massachusetts, U.S.A.

YAMAGUTI, S. 1963. Monogenea and Aspidocotylea in *Systema Helminthum*, **4** : vii+699 pp. (with 134 plates).

(i) Regarding *Kunhia thunni* (Ishii and Sawada, 1938) Sproston, 1946, Yamaguti remarks : 'syn. *Dactylocotyle minor* Ishii, 1936, nec *Dactylocotyle minor* (Olsson, 1868) St. Remy, 1898, *Dactylocotyla thunni* Ishii 1936, in Ishii and Sawada, 1938, on *Thunnus orientalis* ; Japan. Price (1943, foot note) stated: "*Dactylocotyla minor* Ishii, 1936, renamed *D. tuunni* Ishii in Ishii and Sawada, 1938, does not belong to the genus *Dactylocotyle* (= *Diclidophora*) but is a species of Mazocreas," but he is now of the opinion (personal communication) that it is a species of *Kunhia*.'

(ii) *Uraxine* Unnithan, 1957 is considered a synonym of *Allopseudaxine* Yamaguti, 1943, the type species being *Pseudaxine katsuwonis* Ishii, 1936. Yamaguti (1963) considers *Uraxine chura* Unnithan (1957) a synonym of this species. *Uraxine chura macrova* Unnithan (1957) is given a specific rank as *Allopseudaxine macrova* (Unnithan).

(iii) *Lithidocotyle* Sproston, 1946 is considered a synonym of *Gotocotyla* Ishii, 1936. Consequently, the two species *L. acanthophallus* (MacCallum and MacCallum, 1913), and *L. secundus* Tripathi, 1954 given on p. 810 in this account are placed under the genus *Gotocotyla*.

(iv) A new genus *Pseudothoracocotyla* is proposed for *Thoracocotyle ovalis* Tripathi, 1956.

In addition to the above five references, I would like to also mention the following reference :

HARGIS, W. J. (Jr.) 1959. Systematic notes on the monogenetic Trematodes. *Proc. Helminth. Soc. Washington*, 26 (1) : 14-31.

As regards the six species of *Pricea* described by Ramalingam (1952) from '*Cybium guttatum*' Hargis opines that 'In all probability he merely described normal infraspecific variability and most of his species are not valid.'

PARASITES OF SCOMBROID FISHES. PART II. PARASITIC COPEPODA*

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INTRODUCTION

The literature on copepod parasites of fishes is profuse and ever increasing, and notable contributions which include parasitic copepods found on scombroid fishes are mainly to be found in the works of Brian (1906, 1935), Heller (1865), Kirtisinghe (1933-), Leigh-Sharpe (1930), Pearse (1951, 1952), Scott and Scott (1913), Shiino (1952-), Steenstrup and Lutken (1861), Wilson (1905-1944), Yamaguti (1936, 1939), and several others. A perusal of the literature shows that hardly a dozen species of copepod parasites have been described as new or recorded as occurring on scombroid fishes (mackerels, seerfishes or spanish mackerel, tunas and billfishes) found in the Indian seas, while at least 58 species appear to have been described or recorded (chiefly from eleven families of Caligoida and Lernaeopodoida) from scombroid fishes from various parts of the world. Our collections from Indian scombroid fishes contain seven species of parasitic copepods, most of which are new distributional records.

Several of the points raised in the introductory part of Part-I of this series (Silas, 1962) are equally applicable in the case of parasitic copepods of scombroid fishes. Some of the parasitic species are known only from single scombroid species while a few are known to be more adaptable and infect fishes which belong to widely different groups, but perhaps occupying a similar habitat. No doubt, it is likely that future investigations may indicate the occurrence of certain parasitic copepods on scombroid fishes, which are at present known only from non-scombroid fishes.

In the absence of any detailed work on copepod parasites of scombroid fishes on a world wide basis, it is hoped that the data presented here will be of help to other workers interested in similar studies. While comments are offered by us for the different species, based on the material examined, as well as an evaluation of the data available in the literature consulted, this does not in any way constitute a critical review of parasitic copepoda of scombroid fishes. This should await more detailed investigations of this problem region-wise, which will eventually augment the list presented here and throw considerable light on the host specificity of these parasites as well as their spatial distributional patterns.

Brief descriptions of each species accompanied by illustrations, and data as to scombroid and non-scombroid host species, localities, locations of infection, etc. are given. A host-parasite list is also presented along with a detailed bibliography on copepod parasites of scombroid fishes. As in Part-I of the series, up-to-date names of scombroid host species are also given. Precise host identification is wanting in many instances, *e.g. Scomber scomber* from Lawson's Bay, Waltair, E. Coast of India (*Scomber scombrus* is known only from the Atlantic); 'swordfish *Xiphias zeugopteri*' (also from the above locality: we are unable to find any reference to this 'species' in ichthyological literature), etc., are mentioned from this area itself, which are incorrect and misleading. Since there is no recent monographic review of all groups of scombroid fishes on a global basis, the list of ichthyological references appended to Part-I of this series may be consulted for host identification.

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* Published with the permission of the Director, Central Marine Fisheries Research Institute, Mandapam Camp.

We will be thankful to readers for drawing our attention to species overlooked by us.

The material we have studied will be deposited in the Research Collection of the Central Marine Fisheries Research Institute, Mandapam Camp.

We are thankful to Prof. P. Kirtisinghe of Ceylon, and Prof. S. M. Shiino of Japan, for helping us with literature.

LIST OF PARASITIC COPEPODS OF SCOMBROID FISHES[1]

SUB-CLASS : *COPEPODA*

ORDER : *CALIGOIDA*

FAMILY : CALIGIDAE

Genus CALIGUS Müller, 1785

Caligus alalonga Kroyer, 1863.
Caligus bonito Wilson, 1905.
Caligus chelifer Wilson, 1905.
Caligus coryphaenae Steenstrup and Lutken, 1861.
(Syn. *Caligus tesserifer* Shiino, 1952.)
Caligus cybii Bassett-Smith, 1898.
Caligus germoi Pearse, 1951.
Caligus infestans Heller, 1865.
Caligus kuroshio Shiino, 1959.
Caligus macarovi Gussev, 1951.
Caligus mutabilis Wilson, 1905.
Caligus pelamydis Kroyer, 1863.
Caligus productus Dana, 1854.
(Syn. *Caligus katuwo* Yamaguti, 1936 ; *C. monacanthi* Kroyer, 1863 ; *C. lobatus* Wilson, 1935.)
Caligus quadratus Shiino, 1954.
Caligus rapax Milne-Edwards, 1840.
Caligus regalis Leigh-Sharpe, 1930.
Caligus thynni Dana, 1852.
Caligus sp.

Genus ANURETES Heller, 1865

Anuretes branchialis Rangnekar, 1953.

Genus LEPEOPHTHEIRUS Nordmann, 1832

Lepeophtheirus dissimulatus Wilson, 1905.
Lepeophtheirus eminens Wilson, 1944.

[1] See 'Addendum' for additional list of species.

Genus PARAPETALUS Steenstrup and Lutken, 1861

? *Parapetalus* sp.

FAMILY : EURYPHORIDAE

Genus ALEBION Kroyer, 1863

Alebion glaber Wilson, 1907.
Alebion gracilis Wilson, 1907.

Genus ELYTROPHORA Gerstaecker, 1853

Elytrophora atlantica Wilson, 1932.
Elytrophora brachyptera Gerstaecker, 1853.
Elytrophora hemiptera Wilson, 1921.
Elytrophora indica Shiino, 1958.

Genus EURYPHORUS Nordmann, 1832 : Milne-Edwards, 1840

Euryphorus nympha Steenstrup and Lutken, 1861.
(Syn. *Euryphorus nordmanni* Kirtisinghe, 1937 ; *Euryphorus coryphaenae* Kroyer, 1863.)

Genus GLOIOPOTES Steenstrup and Lutken, 1861

Gloiopotes ornatus Wilson, 1907.
Gloiopotes costatus Wilson, 1919.
Gloiopotes hygomianus Steenstrup and Lutken, 1861.
Gloiopotes longicaudatus (Marukawa, 1925).
(Syn. *Gloiopotes zeugopteri* Rao, 1951.)
Gloiopotes watsoni Kirtisinghe, 1933.

FAMILY : CECROPIDAE

Genus CECROPS Leach, 1816

Cecrops latreillii Leach, 1816.

FAMILY : ANTHOSOMIDAE

Genus LERNANTHROPUS Blainville, 1822

Lernanthropus hiatus Pearse, 1951.

FAMILY : DICHELESTHIIDAE

Genus HATSCHEKIA Poche, 1902

Hatschekia mulli (van Beneden, 1851).

FAMILY : PSEUDOCYCNIDAE

Genus PSEUDOCYNCUS Heller, 1865

Pseudocycnus appendiculatus Heller, 1865.
(Syn. *Pseudocycnus thynnus* Brandes, 1955).
Pseudocycnus armatus (Bassett-Smith, 1898).
Pseudocycnus buccatus Wilson, 1922.
Pseudocycnus elongatus Pearse, 1951.
Pseudocycnus spinosus Pearse, 1952.

FAMILY : LERNAEIDAE

Genus LERNAEENICUS LeSueur, 1824

Lernaeenicus longiventris Wilson, 1917.
Lernaeenicus seeri Kirtisinghe, 1934.
Lernaeenicus sp. Rao, 1951.

FAMILY : PENNELLIDAE

Genus PENNELLA Oken, 1816

Pennella biloba Kirtisinghe, 1933.
Pennella costai Richiardi, 1880.
Pennella crassicornis Steenstrup and Lutken, 1861.
Pennella filosa (Linnaeus, 1758).
Pennella instructa Wilson, 1917.
Pennella orthagorisci Wright, 1870.

ORDER LERNAEOPODOIDA

FAMILY : CHONDRACANTHIDAE

Genus CHONDRACANTHUS Delaroche, 1811

Chondracanthus lophii Johnston, 1836.
Chondracanthus xiphiae (Guerin) ? Cuvier 1829.

FAMILY : LERNAEPODIDAE

Genus CHAROPINUS Kroyer, 1863

Charopinus quarternius Wilson, 1935.

Genus BRACHIELLA Cuvier, 1817

Brachiella ramosa Richiardi, 1880.
Brachiella thynni Cuvier, 1817.
(Syn. *Thynnicola zeigleri* Miculicich, 1904).

Genus CLAVELLOPSIS Wilson, 1915

Clavellopsis saba Yamaguti, 1939.

Genus CLAVELLISA Wilson 1915

Clavellisa scombri (Kurz, 1877).

FAMILY : ANTHEACHERIDAE

Genus PHILICHTHYS Steenstrup, 1862

Philichthys xiphiae Steenstrup, 1862.

SYSTEMATIC ACCOUNT OF COPEPOD PARASITES OF SCOMBROID FISHES

Order : CALIGOIDA

FAMILY : CALIGIDAE

Genus **Caligus** Müller, 1785

Body distinctly segmented, depressed ; anterior three segments fused with head ; fourth segment narrow, without dorsal plates ; genital segment enlarged, simple, devoid of dorsal plates or processes ; abdomen one- to four-segmented ; frontal plates with lunules ; maxillae simple, spine-like ; furca and maxillary hooks present ; first and fourth legs uniramous, second and third biramous ; basipods of third legs broadly laminate and fused into transverse apron reaching nearly across carapace ; three terminal segments of fourth pair of legs loosely fused and armed with setae or spines which are neither flattened nor winged.

Hosts : Mainly fishes.

Remarks : While several species of *Caligus* have been recorded from Indian seas (Gnanamuthu, 1949, Kirtisinghe (1956), and Rangneker (1956, a, b), apparently no species has been recorded as occurring on scombroid fishes[1]. Our collections indicate the occurrence of two species, *C. bonito* from the oriental bonito *Sarda orientalis*, and the second from the sailfish *Istiophorus gladius*, which it has not been possible to identify beyond the genus, and hence given here as *Caligus* sp.

Caligus alalongae Kroyer, 1863

Scombroid host : *Thynnus alalonga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)].

Locality : Mediterranean and Atlantic ; ? Ceylon (Kirtisinghe, 1937).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Brian (1935) remarks that this species, originally described by Kroyer from males, and later commented on by Carus (1885) and Bassett-Smith (1899) is insufficiently known. Shiino (1959 f) remarks that Kirtisinghe's *alalongae* does not seem conspecific with Kroyer's. see 'Addendum'.

[1] See "Addendum" for several recent records.

Caligus bonito Wilson, 1905

(Figure 1 : 1-10)

Material examined : Numerous specimens, adult females, males, and young stages (mostly chalimus and a few immature adults) were obtained from the buccal cavity (palate), and the gills and inner sides of operculum of the oriental bonito, *Sarda orientalis* (Temminck and Schlegel) taken in shore seines and drift nets off Vizhingam on the south west coast of India during September-October 1960.

Description : Female.—Carapace about one-third total length and slightly longer than wide ; posterior median lobe of carapace broadly rounded and in level with posterior ends of bluntly rounded tips of lateral lobes which are slightly incurved; lunules large, conspicuous, and occupying a greater part of frontal plate ; inter-lunular distance slightly more than lateral dimension of lunule ; fourth segment short, very narrow, and constricted in front ; genital segment elliptical, almost as large as carapace, lateral margins slightly divergent posteriorly ending in bluntly rounded projections ; abdominal segmentation indistinct ; abdomen long, rather spindle-shaped and 3.5 to 4.0 times as long as wide ; a slight constriction towards posterior third of abdomen apparently indicates area of segmentation ; anal laminae normally developed, each carrying five terminal plumose setae ; egg strings elongate, broken and incomplete in all specimens.

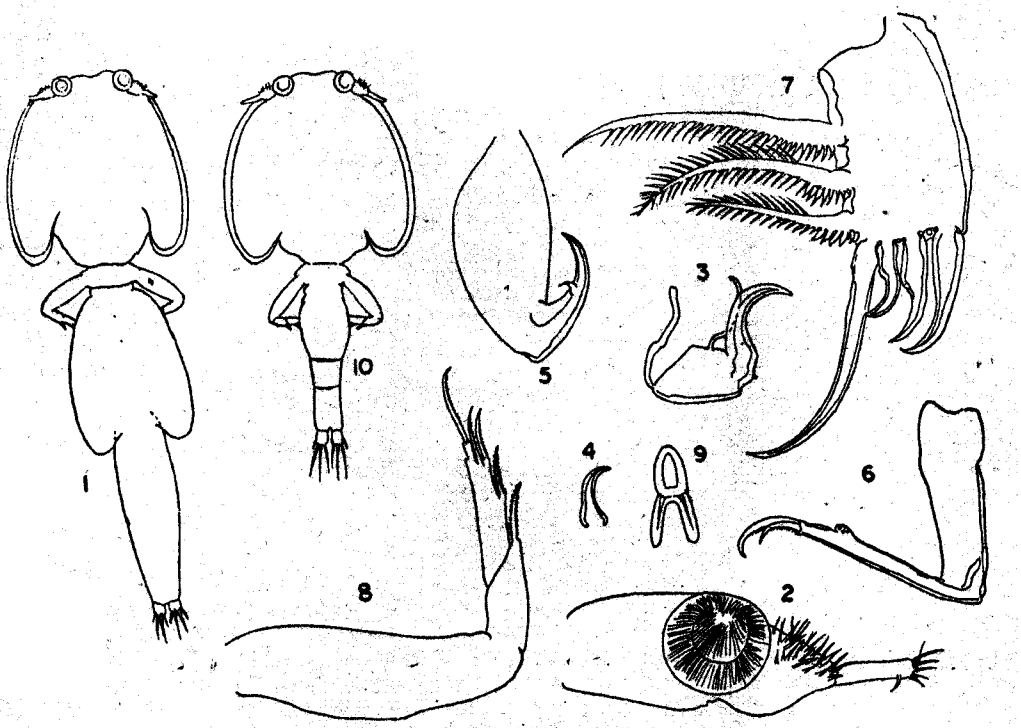


FIG. 1. *Caligus bonito* Wilson. *Female.* (1) dorsal view; (2) part of frontal plate lunule and antennule; (3) antenna ; (4) maxillule; (5) second maxilliped ; (6) first maxilliped ; (7) terminal segment of first leg, enlarged ; (8) fourth leg ; (9) sternal furca. *Male.* (10) dorsal view (based on material collected from *Sarda orientalis* from India).

Male.—Carapace slightly longer than wide ; fourth thoracic segment posteriorly much wider and consequently fourth legs attached to its posterior rather than to its lateral margins ;

genital segment much longer than wide, its length about equal that of abdomen ; abdomen two-jointed, segments of about equal length ; antennules larger and longer than in female, especially basal joints with lunules ; antennae not as stout as in female ; maxillules about thrice as large ; second maxillipeds with basal joint reinforced at distal end by a thick horny plate on its inner side.

Scombroid hosts :
1. *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
2. *Pelamys sarda* [=*Sarda sarda* (Bloch)]
3. *Sarda chilensis* [=*Sarda chilensis chilensis* (Cuvier and Valenciennes)]
4. *Sarda orientalis* (Temminck and Schlegel)
5. *Scomberomorus cavalla* (Cuvier)
6. *Scomberomorus maculatus* (Mitchell)
7. *Cybium* sp. [=*Scomberomorus* sp; ? *S. tritor* (Cuvier and Valenciennes)]
8. *Sarda sarda* (Bloch)
9. *Gymnosarda alleterato* [=*Euthynnus alletteratus* (Rafinesque)]

Localities : 1 and 2. Atlantic and Mediterranean ; 3. Pacific coast of Mexico and Southern California (San Diego) ; 4. South west coast of India (Vizhingam) ; 5 & 6. Atlantic ; 7. Mauritania Coast, W. Africa ; 8. Texas Coast, U.S.A. ; and 9. Grand Isle, Louisiana, U.S.A.

Non-Scombroid hosts : Cratinus agassizii, and *Lutjanus novemfasciatus* from Tangola, Mexico (Wilson, 1905) ; *Lutjanus* sp. from Mazatlan, Sinaloa, Mexico (Causey, 1960 obtained chalimus stages of *C. bonito* from this host) ; and Shiino (1960) gives *Lutianus griens, Mugil cephalus, Oligoplites saurus,* and *Pomatomus saltatrix* as additional non-scombroid hosts.

Locations : Mouth, gills and insides of operculum. Wilson (1905) and Summer *et al.* (1913) remark that as many as 100 specimens of *C. bonito* may be collected from a single individual of *Sarda sarda.* In over 50 specimens of juvenile and adult specimens of *Sarda orientalis* examined by us, all had specimens of *C. bonito,* but not in such profusion. Generally about 2 to 10 specimens were found clinging to the roof of the mouth and bases of branchial arches. Very few were found on the gills and inside of operculum.

References : Wilson (1905); Brian (1924, 1935); Nunes-Ruivo (1956); Shiino (1959, 1960) ; and Causey (1953, 1960).

Remarks : Apparently *C. bonito* is a variable species, for descriptions and figures of the species from various localities indicate slight differences. An extreme case appears to be the material of *Caligus bonito* recorded by Yamaguti (1936) from Japanese waters which Shiino (1959) has redescribed from *Katsuwonus pelamis* (Linnaeus) and *Thynnus thynnus* (Linnaeus) as a new species *Caligus kuroshio,* which shall also be dealt with in this paper. Perhaps inadvertently Shiino (1960) has repeated Yamaguti's reference to *C. bonito* (=*C. kuroshio*) in the list of references under *C. bonito* Wilson.

Brian (1935) has drawn attention to some slight differences between his material from *Pelamys sarda* and that of the typical specimens described by Wilson (1905). In our material a few noticeable differences are seen in the nature and structure of the various appendages from that given by Wilson, and Brian. The shape of the genital segment is in agreement with that figured by Wilson (1905), but differs from the type for the Mediterranean specimens (Brian 1935) where the said segment is more or less of uniform width, while it is distinctly narrower anteriorly in our material. From Wilson's aforesaid description our material differs in the relative length of the terminal seta of the first pair of legs, it being hardly two times the length of the largest terminal spine in our material, while in the American specimens it is distinctly three times longer than the terminal spine. Brian's material agrees with ours in this respect, but shows two distinct constrictions in the abdomen which is not quite evident in our material.

A few salient characters of the species are : the furca with a bluntly conical basal part and moderately divergent branches, the latter not exceeding length of basal part; second maxilliped strongly built, terminal claw half as long as basal segment and with an accessory spine at about mid-length of its inner margin ; denticulated nature of the basal part of lateral setae of first leg ; fourth legs three-jointed, large, long, distal joint bearing three long curved spines at tip and a smaller one upon its posterior margin, and penultimate joint with a single stout spine at distal end of posterior margin (*Female*).

A detailed account of the material including a study of the different chalimus stages will be dealt with elsewhere.

Caligus chelifer Wilson, 1905

(Figure 2 : 10-19)

Description: Female.—Carapace slightly longer than wide ; lunules large, close together ; fourth thoracic segment short, narrow ; genital segment distinctly longer than broad, with anterior margin half as long as posterior ; abdomen two-jointed, narrow, about four times as long

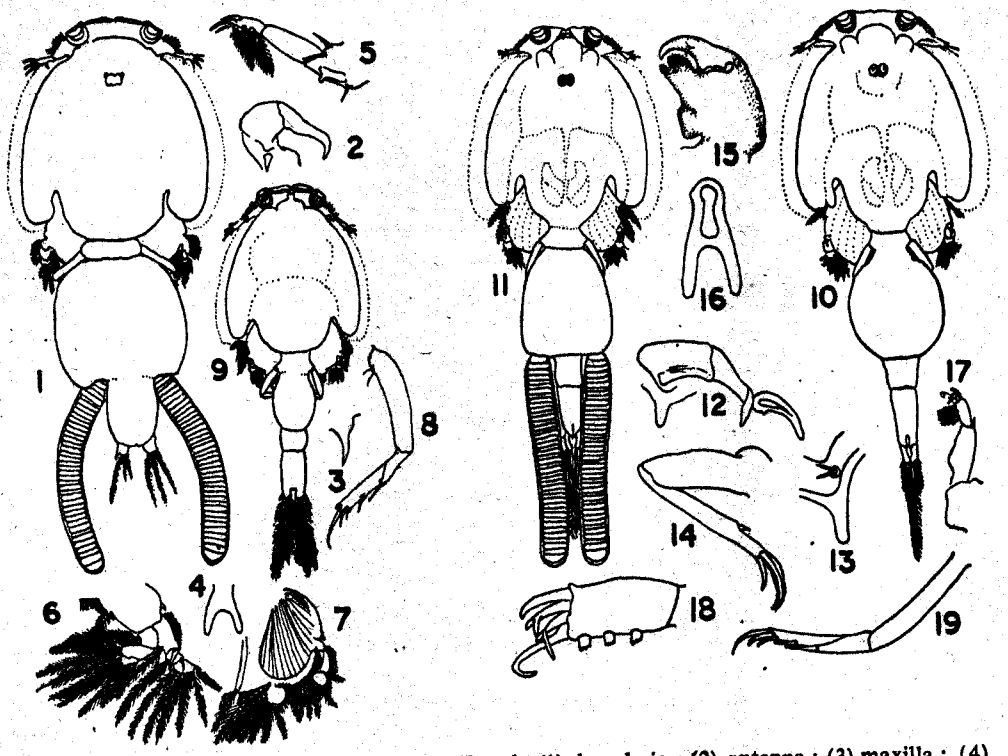


FIG. 2. *Caligus rapax* Milne Edwards. 1-8. *Female.* (1) dorsal view (2) antenna ; (3) maxilla ; (4) furca ; (5), (6), (7), and (8) first, second, third, and fourth walking legs ; *Male.* (9) dorsal view of adult male : *Caligus chelifer* Wilson 10-19. *Female.* (10) dorsal view of young female without eggs ; (11) dorsal view of female with eggs ; (12) antenna and maxillule ; (13) maxilla showing rudimentary endopod ; (14) first maxilliped ; (15) terminal claw or chela of second maxilliped ; (16) furca ; (17) first leg ; (18) terminal joint of same enlarged showing bifid spines, and (19) fourth leg (after Wilson).

as wide and second abdominal segment distinctly longer than first ; anal laminae long, narrow, cylindrical in form and slightly converging at tips ; egg strings broad, width as wide as abdomen

and each with 45 to 50 eggs ; among notable features of appendages, most of which are figured are : antennules small with two joints of same length ; slender antennae with slightly longer terminal claw than basal joint ; base of furca longer than branches, latter U-shaped ; unique prehensile structure of second maxilliped which has large and wide basal joint with two protuberances on its inner margin of which the basal one is large, hemispherical, with flattened tip ; distal, still larger, broad, digitiform, extending towards terminal claw forming an inarticulate half of a large chela (specific name derived from this structure) ; two middle terminal claws of first leg branched ; fourth leg three-segmented, with five spines and no setae.

Male : Unknown.

Scombroid host : *Xiphias gladius* Linnaeus.

Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic).

Non-scombroid hosts : *Brevoortia tyrannus*, and *Trichiurus lepturus* (Woods Hole, Mass., U.S.A.) ; taken free swimming in plankton haul on west coast of Africa (Brian, 1924).

Location : On external surface of body.

References : Wilson (1905, 1932) ; Brian (1924).

Remarks : The branching of the terminal claws of the first legs appears to be variable. According to Wilson (1905) : ' In the alcohol specimen taken from the menhaden, the two posteriors of the three terminal claws are branched, the branches being straight, longer than the tips of the claws and inserted nearly at right angles to the axis of the claw. In the living specimens obtained by the author from the sword-fish the claws are mostly unbranched, but are of the same relative size as in the menhaden specimen.' Wilson has also figured an adult female without egg strings in which the genital segment is almost spherical (Fig. 2 : 10), but with the characteristic features of the second maxilliped present.

Caligus coryphaenae Steenstrup and Lutken, 1861

(Figure 3 : 1-14)

(Syn. *Caligus bengoensis* Scott 1895 ; *C. aliuncus* Wilson, 1905 ; *C. tesserifer* Shiino, 1952 ; ? *C. scutatus* Milne-Edwards, 1840 ; ? *C. elongatus* Heegaard, 1943)

Description : Female.—Carapace longer than broad ; oval lunules at extreme lateral ends ; posterior borders of median lobe of carapace, and slightly incurved tips of lateral lobes reaching to more or less same level ; fourth thoracic segment constricted in front to form a ' neck ' ; segment much broader than long ; genital segment flask-shaped with parallel sides which diverge slightly in posterior half and ends with slightly backwardly projecting triangular lobes on either side ; abdomen two-, three- or four-segmented, narrow and elongate ; egg strings thin and long ; mouth parts and appendages as shown in accompanying figures points of special interest being—distal joint of antennule shorter than basal joint ; branches of furca conical and diverging ; distal joint of first leg with four short terminal spines of which outer three are broad, flattened, with dentate margins, middle two with two short basal spines arising from their bulbous basal halves ; innermost spine, slender and simple, but slightly longer than two median spines ; inner margin of distal segment of first leg with three elongate setae, longest towards base of segment being three times longer than longest terminal spine ; fourth leg distally three-jointed carrying a total complement of five spines, three on terminal joint, one on penultimate joint and one on second joint.

Male.—Carapace longer than wide ; posterior border of median lobe of carapace projecting slightly beyond ends of lateral lobes ; fourth segment narrow considerably broader than

long, being as wide as genital segment; genital segment distinctly wider than long; abdomen relatively broad, more than half width of genital segment, two segmented, basal segment slightly

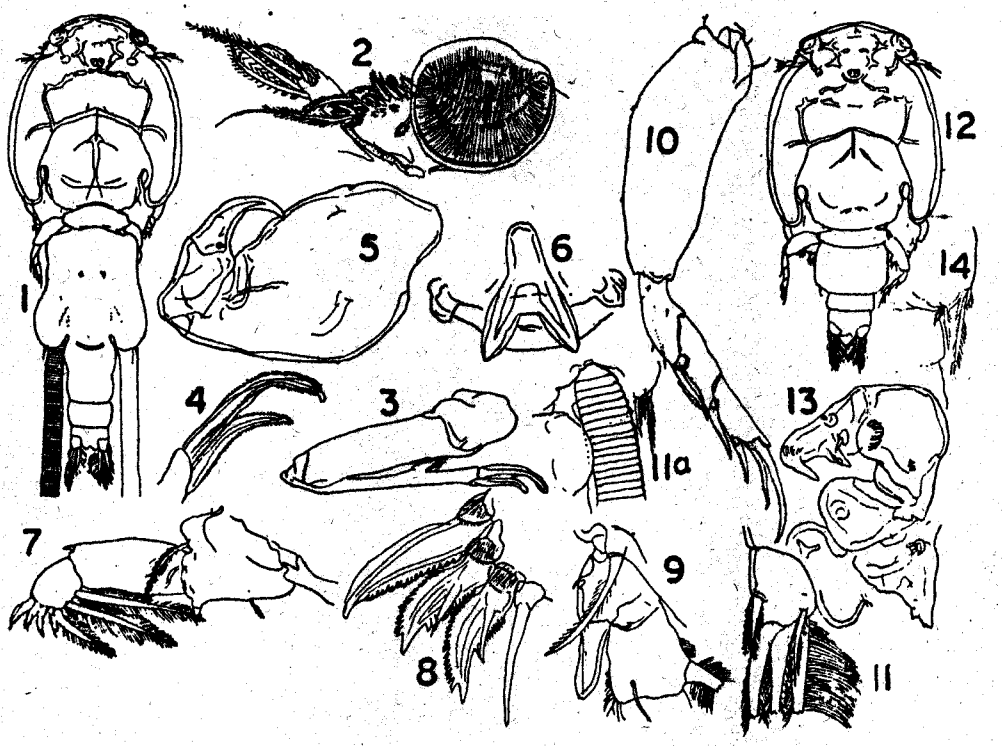


FIG. 3. *Caligus coryphaenae* Steenstrup and Lutken. *Female.* (1) dorsal view; (2) antennule; (3) first maxilliped; (4) same, terminal part; (5) second maxilliped; (6) furca; (7) first leg; (8) same, terminal part; (9) third endopod, posterior view of proximal part; (10) fourth leg; (11) anal lamina; (11a) postero-lateral corner of genital segment. *Male.* (12) dorsal view; (13) antenna and maxilla; (14) postero-lateral part of genital segment showing rudimentary legs (after Shiino).

shorter than distal which is lobed posteriorly; anal laminae as broad as long carrying distally three elongate and three short setae; terminal claw of antenna with a short sharp accessory spine at centre of inner margin and a short broad and blunt process at base; rudiments of fifth legs represented by round lobes tipped by a few setae at either posterior lateral angles of genital segment.

Scombroid hosts:

1. *Katsuwonus vagens* [=*Katsuwonus pelamis* (Linnaeus)]
2. *Thunnus thynnus* [=*Thunnus* (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)]
3. *Euthynnus yaito* [=*Euthynnus affinis yaito* Kishinouye]
4. *Katsuwonus pelamis* (Linnaeus)
5. *Euthynnus lineatus* [=*Euthynnus affinis lineatus* Kishinouye]
6. *Katsuwonus* sp. [=*Katsuwonus pelamis* (Linnaeus)]
7. *Neothunnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]
8. *Sarda* sp.
9. *Euthynnus alletteratus* (Rafinesque)

Localities : 1. Izu Peninsula, Japan ; 2. & 3. Hamajima, Mei Prefecture, Japan ; 4. Hamajima, Japan ; 5. St. Lucas and Guaymas, Pacific ; 6. Magdalena Bay, Gulf of California, Off Mexico ; 7. Indian Ocean (66° 31′ E, 80° 00′ S) ; 8. see Shiino (1959a) ; 9. Dry Tortugas, Atlantic.

Non-scombroid hosts : Coryphaena hippurus (Mediterranean ; Atlantic ; Gulf of California off Mexico ; Hamajima, Japan) ; *Coryphaena pelagica* (Mediterranean) ; *Isurus glaucus* (Owase, Mei Prefecture, Japan) ; ? *Polydactylus opercularis* (21° 26′ N, 106° 06′ W) ; *Squalus acanthias, Rachycentron canadus, Seriola dorsalis*, and *Caranx hippos* (See Shiino, 1959a ; Causey, 1953).

Location : On sides of body of host.

References : Steenstrup and Lutken (1861) ; Scott (1895) ; ? Milne-Edwards (1840) ; Richiardi (1880) ; Valle (1880) ; Carus (1884) ; Bassett-Smith (1899) ; Brian (1906, 1935) ; Wilson (1905, 1923, 1935, 1937, 1950) ; Heegaard (? 1943 ; 1949) ; Pearse (1952) ; Barnard (1955) ; Shiino (1952, 1959 *a, b, c*, and 1960).

Remarks : Shiino's (1959a) discussion on this species is quite comprehensive. He has shown that *Caligus coryphaenae* of Yamaguti (1936) is a synonym of *Caligus quadratus* Shiino (1954), while *C. tesserifer* Shiino (1952) is a synonym of *C. coryphaenae* Steenstrup and Lutken.

Caligus aliuncus was described by Wilson (1905) from a single female obtained free swimming from unkown locality taken during ALBATROSS collections. In 1935, Wilson recorded this species from *Euthynnus alletteratus* from the Dry Tortugas. The salient characters of *C. aliuncus*, namely, the four segments of the abdomen ; the winged margins of claws and spines of the distal segment of the first legs and the fourth legs respectively ; the accessory appendage at the distal end of the basal segment of the fourth leg ; etc. are also present for the earlier described *C. coryphaenae*. We would like to draw attention to certain variations seen in this species as noted from literature. Female specimen figured by Brian (1935 fig. 19, 2) has four abdominal segments, while three are shown by Shiino (1959a), and only two for *C. tesserifer* (Shiino, 1952). In the Japanese specimens the furca is broadly diverging and the fourth legs are distinctly three jointed (Shiino, 1952, 1959a), while in the Mediterranean specimens collected from *Coryphaena hippurus*, the branches of the furca are more or less parallel and slightly converge at tips giving the appearance of a narrow horse-shoe, and the segmentation in the distal half of the fourth legs is indistinct. See also remarks given in "Addendum".

Caligus cybii Bassett-Smith, 1898

Scombroid host : *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]

Locality : India.

Non-scombroid hosts : None.

Caligus germoi Pearse, 1951

(Figure 4)

Description : Female.—Carapace slightly wider than long ; genital segment barrel-shaped, one-fourth wider than long ; caudal laminae slightly broader than long, armed with three long plumose, one short terminal and one lateral plumose setae ; lunules feebly developed ; distal segment of antennule longer than basal, former terminating in six hooks and four setae ; antennae stout with two strong spines near base of hook ; maxillule with a spine on middle of median

margin ; maxillae slender with two curved terminal setae ; maxillipeds with two setae near base of second segment ; terminal claw curved with two stout setae ; furca with divergent branches slightly converging towards tips, basal part as long as branched portion and with a small spine-like protuberance at each angle and a stout conical median anterior spine ; terminal segment of first leg with three spines and six setae ; exopod of second leg with three segments, terminal segment lamellate bearing two spines and five setae ; basal segment of third leg with a strong posterior hook ; a sucker with five stout spines about its margin, a one-segmented setose exopod and a two-segmented endopod present towards median line from hook of basal segment ; segmentation on fourth legs indistinct, with five terminal spines ; fifth legs represented by two short spines at posterior end of genital segment.

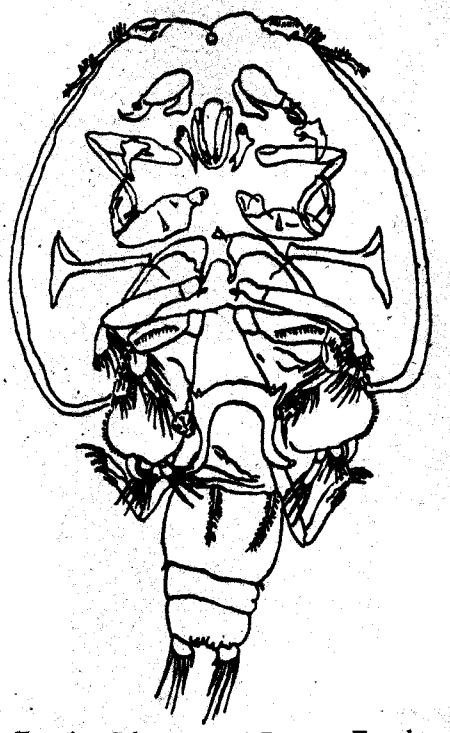


FIG. 4. *Caligus germoi* Pearse. Female, ventral view (after Pearse).

Male.—Unknown.

Scombroid host : *Germo alalunga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)]

Locality : Bimini, Bahamas, Atlantic.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Pearse (1951) mentions his fig. 69d as ' ventral view of male ' of *Caligus germoi*, (Fig. 4 reproduced here) which is an error as the male of this species is unknown. Additional characters noticed from the figure are : abdomen shorter than genital segment ; first abdominal segment shorter than terminal segment ; and width of abdomen almost same as genital segment. Pearse mentions that ' Between the bases of the third leg a furcula-like support bears a large and a small spine at each anterior lateral angle and two posterior arms that curve laterally and have acute tips '. It may be said that on the whole the species is not sufficiently known to institute

comparisons, but the following characters as mentioned by Pearse appear to be of specific importance : feebly developed lunules ; size and distribution of spines on antenna and maxillule ; character of furca ; characteristic furcula-like support between bases of third legs ; and a sucker armed with stout spines on each side of aforesaid structure on base of third leg.

Caligus infestans Heller, 1865

(Figure 5 : 1-6)

Description : Female.—Carapace distinctly longer than broad, being half total length ; median lobe of carapace large, truncate, reaching far backwards of lateral lobes, latter slightly convergent ; fourth thoracic segment small, spindle-shaped ; genital segment large, distinctly longer, lateral margins slightly divergent posteriorly ending in broad lateral lobes, posterior margins of which are in level with hind end of first abdominal segment ; latter shorter than second ; anal laminae short, wider than long, bearing four plumose setae ; appendages as illustrated, noteworthy characters being : nature and disposition of lunule which are wide apart and not projecting ; ornamentation of first and fourth legs ; and shape of furca.

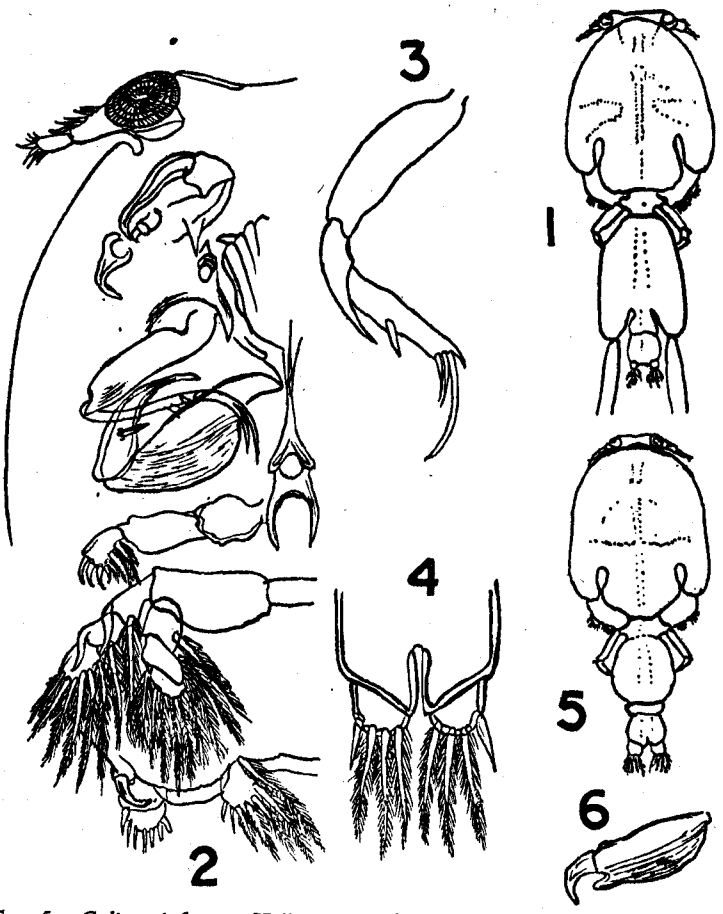


FIG. 5. *Caligus infestans* Heller. *Female.* (1) dorsal view ; (2) ventral view of one half of cephalothorax showing appendages ; (3) fourth leg ; (4) posterior end of body with anal laminae ; *Male.* (5) dorsal view ; (6) antenna (after Heller).

Male.—Carapace distinctly longer than wide and much more than half total length ; posterior extent of median lobe as in female ; genital segment ovate, hardly longer than broad, its length slightly more than length of abdomen and anal laminae ; first abdominal segment hardly one-third length of abdomen ; second segment broader along hind margin ; anal laminae as in female.

Scombroid host : *Scomber* sp. [=*Rastrelliger* sp. ? or ? *Scomber japonicus* sub. spp.]

Locality : Java, Indonesia.

Location : ?

Non-scombroid hosts : None.

Remarks : The host identification is not complete.

Caligus kuroshio Shiino, 1959

(Figure 6 : 1-16)

(Syn. *Caligus bonito* Yamaguti, 1936, *nec* Wilson, 1905)

Description : Female.—Carapace slightly broader than long, length less than half total length ; posterior margin of median lobe in line with tips of lateral lobes ; fourth segment narrow, spindle-shaped ; genital segment longer than broad, posteriorly projecting into lateral lobes ; abdomen much shorter than genital segment being hardly two-thirds its length ; abdominal segmentation indistinct and abdomen narrower posteriorly ; caudal laminae longer than broad bearing six setae ; antennular segments of equal length ; terminal segment of first leg carries lateral setae of moderate length, longest equalling longest terminal spine ; as in *C. bonito*, terminal seta about two times as long as longest terminal spine ; base of lateral setae broad with denticulations along outer margin, rest of setae plumose. The illustrations given by Shiino (1959d) indicate general agreement of females of this species and those of *C. bonito* figured by Wilson (1905) and Brian (1935) for the other characters.

Male.—Carapace as broad as long ; extent of posterior median lobe as in female ; fourth thoracic segment narrow, spindle-shaped and slightly wider than genital segment ; latter anteriorly narrow and ringed, longer than abdomen and laminae ; rudiments of fifth and sixth legs seen ventrally ; basal segment of abdomen shorter than distal ; sexual distinction seen in maxillipeds and antennae.

Scombroid hosts : 1. *Katsuwonus pelamis* (Linnaeus)

2. *Thunnus thynnus* [=*Thunnus* (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)]

Localities : 1 & 2. Hamajima, Mie Prefecture, Japan (West Pacific).

Non-scombroid hosts : None.

Location : Gill cavity.

Remarks : The chief differences between this species and *C. bonito* appear to be in the relative lengths of the carapace, genital segment and abdomen, and the relative lengths of the setae and spines of the terminal segment of the first legs.

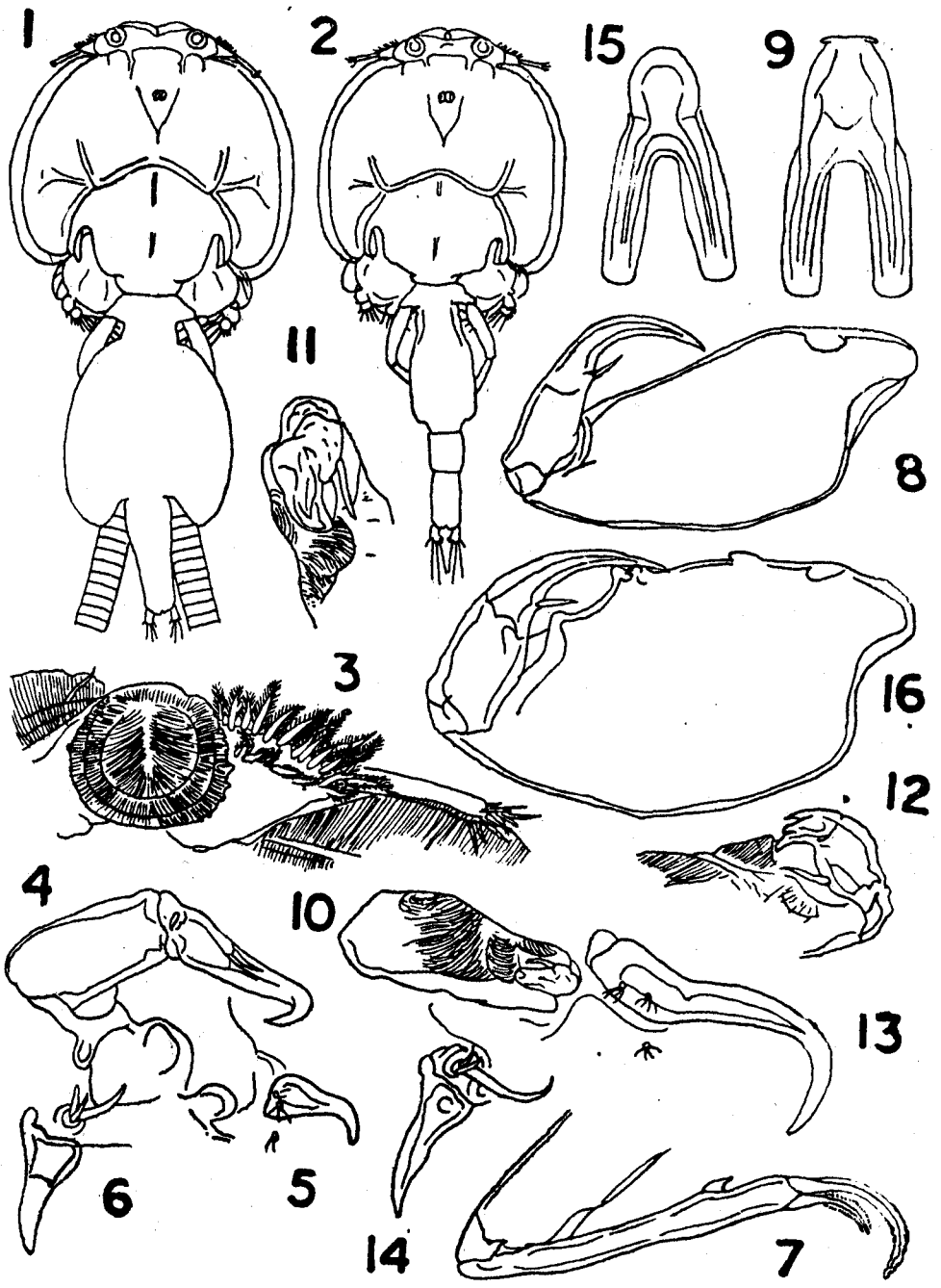


FIG. 6. *Caligus kuroshio* Shiino. (1) Female, dorsal view; (2) male, dorsal view; *Female*. (3) antennule; (4) antenna; (5) maxillule; (6) maxilla; (7) first maxilliped; (8) second maxilliped: (9) sternal furca; *Male*. (10, 11, and 12) different views of antenna; (13) maxillule; (14) maxilla; (15) sternal furca; (16) second maxilliped (after shiino).

Caligus macarovi Gussev, 1951

(Figure 7 : 1-14)

(Syn. *Caligus fulvipurpureus* Shiino, 1954, 1956)

Description : Female.—Carapace longer than wide ; median lobe projecting beyond lateral lobes ; fourth thoracic segment narrow, contracted in front and confluent with genital segment ; latter conspicuously large, rectangular, almost as wide, but shorter than carapace ; abdominal segmentation indistinct ; abdomen about two-thirds as long as genital segment and as wide as fourth thoracic segment or half width of genital segment ; caudal laminae longer than wide ; antennule shorter than interlunular space, segments more or less of equal length ; second maxilliped with a fusiform structure in basal segment to which the terminal claw reaches ; furca with branches more or less parallel ; three lateral setae on terminal segment of each first leg elongate

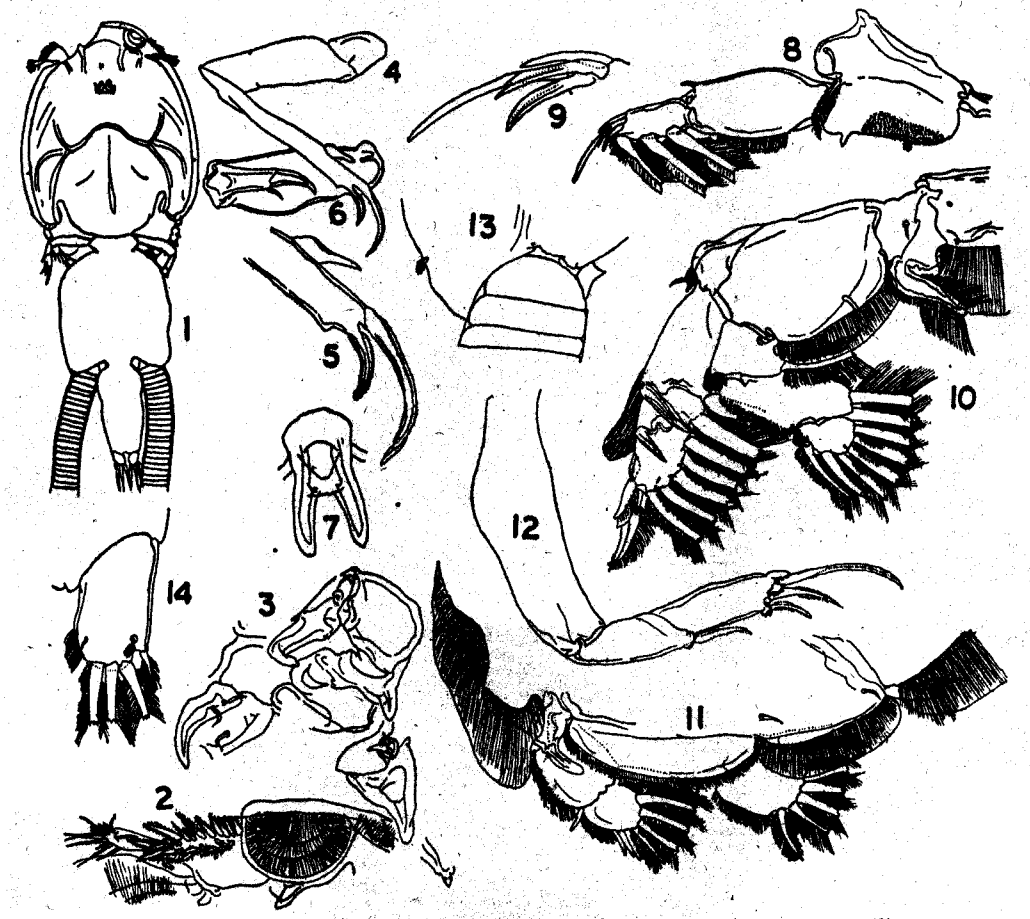


FIG. 7. *Caligus macarovi* Gussev. *Female.* (1) dorsal view ; (2) antennule; (3) antenna, maxillules, and maxilla ; (4) first maxilliped ; (5) end of same; (6) second maxilliped ; (7) sternal furca ; (8) first leg ; (9) tip of same ; (10) second leg ; (11) third leg ; (12) fourth leg ; (13) postero-lateral part of genital segment ; and (14) anal lamina (after Shiino).

while three terminal spines and terminal setae short, latter atleast two times as long as longest terminal spine ; inner two terminal spines bifid ; fourth legs distally two-jointed with three

spines on apical and one on penultimate joints ; each spine associated at base with an oval pectinate lamina ; genital segment with a plumose spine on each posterior lobe on ventral side and a group of two shorter spinules internally which probably represent rudimentary legs ; egg strings about as long as total length.

Male.—Carapace broader anteriorly than in female, but agreeing otherwise with the latter ; fourth thoracic segment distinctly separated from genital segment ; latter one-third as long as carapace, three-fourths as wide as long and equal to length of abdomen ; laterally as well as at posterior angles of genital segment a pair each of rudimentary plumose appendages present, representing rudimentary fifth and sixth legs ; two-segmented abdomen, with basal segment half length of distal, but of equal width ; claw of antenna short, unguiform, penultimate joint elongate and columnar ; maxillule stouter than in female, sharp and falciform ; second maxilliped powerful, base inflated, half as broad as long and on inner margin with an eminent process against which the claw works ; branches of furca with apices more dilated than in female ; terminal spines on anal laminae much longer than in females.

Scombroid hosts : 1. *Euthynnus lineatus* [=*Euthynnus affinis lineatus* Kishinouye]
2. *Auxis maru* [=*Auxis thazard* (Lacépède)]

Locality : 1. Magdalena Bay, Gulf of California, off Mexico ; 2. Japan, Pacific.

Non-Scombroid hosts : *Spheroides rubripes*, *Cololabis saira*, and *Osmerus eperlanus dentex* (Japan and Northern Pacific).

Locations : Outside of operculum and ? between scales.

References : Gussev (1951) ; Markewitsch (1956) ; Shiino (1954, 1956 and 1959).

Remarks : Shiino (1954) has drawn attention to the affinities of his *C. fulvipurpureus* (= *C. macarovi*) to *C. cossackii* Bassett-Smith (1898), *C. rapax* Milne-Edwards (1840), and *C. polycanthi* Gnanamuthu (1949). Attention may be drawn here to the similarities found between this species and *C. chelifer* Wilson (1905), especially in the relatively large size of the genital segment, chelate nature of the maxillipeds, bifid nature of two terminal spines of distal segment of first leg, and in the nature of the anal laminae.

Caligus mutabilis Wilson, 1905

(Figure 8 : 1-13)

Description : Female.—Carapace about as long as wide and about 2.5 in total length ; well defined frontal plates less than half width of carapace ; lunules large ; posterior median lobe of carapace extending slightly beyond level of tips of lateral lobes ; fourth thoracic segment short, narrow, hardly one-fourth width of carapace ; anteriorly slightly constricted, posteriorly truncate ; genital segment distinctly longer than broad, always constricted anteriorly into a short neck wrinkled across appearing as though segmented ; abdomen two-segmented, short, hardly two-thirds length of genital segment and about one-third its width ; basal segment slightly longer than terminal ; egg strings short, about half total length and each with about 50 eggs ; appendages as shown in accompanying figure but points of interest being : furca rounded Y-shaped, base being of same length as branches ; lateral setae of terminal segment of first pair of legs swollen at base and bordered with spine-like projections along outer margin in this area instead of usual plumose hairs ; fourth legs short, weak, three-jointed ; five spines of about same length situated close together along anterior margin.

Male.—Carapace slightly longer than wide and a little more than half total length ; fourth segment much wider than genital segment ; latter narrow, spindle shaped, considerably longer than wide, less than one-fourth width of carapace and as in female, wrinkled anteriorly ; abdomen two-jointed, slightly shorter than genital segment, first segment unlike in female shorter than dis-

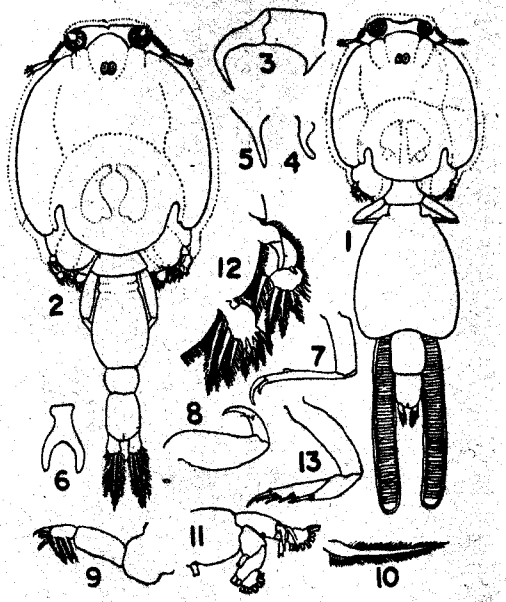


FIG. 8. *Caligus mutabilis* Wilson. (1) Female ; (2) male ; (3) antenna ; (4) maxillule ; (5) maxilla ; (6) furca ; (7) and (8) first and second maxillipeds ; (9) first leg ; (10) plumose seta from posterior border of terminal joint of first leg ; (11), (12) and (13) second, third and fourth swimming legs (appendages from female) (after Wilson).

tal segment ; antennae branched ; maxillule elongated into long slender hook ; maxillae large ; fourth legs relatively large.

Scombroid hosts :
1. *Sarda sarda* (Bloch)
2. *Euthynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
3. *Sarda chilensis* [=*Sarda chilensis chilensis* (Cuvier and Valenciennes)]
4. *Scomberomorus sierra* [=*Scomberomorus maculatus* (Mitchell)]

Localities : 1. Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic) ; 2. Guaymas, Sonora, Mexico ; 3. Acapulco, Mexico (Pacific) ; 4. Cholla Bay, near Puerto Pensaco, Sonora, Mexico ; Guaymas, Mexico ; Mazatlan, Sinaloa, Mexico (Pacific).

Non-scombroid hosts : Centropristis striatus, Pollachius virens (Woods Hole, Massachusetts, U.S.A.) ; *Menticirrhus undualtus* (Ensenada, Mexico) ; *Calamus brachysomus, Paralabrax nebulifer, P. clathratus, P. maculatofasciatus* (Cholla Bay, Sonora, Mexico) ; *Selene oerstedii, Mugil cephalus* (Mazatlan, Sinaloa, Mexico) ; *Centropomus* sp., (San Blas, Nayarit, Mexico) ; *Balistes* sp. (Acapulco, Mexico) ; and *Chaetodipterus zonatus* (Salina Cruz, Oaxaca, Mexico) (Pacific).

Location : Buccal cavity of host.

References : Wilson (1905, 1932) ; Causey (1960).

Remarks : The sketch of the fourth leg of this species given by Wilson (1932, p. 406, fig. 253b) appears to be wrong.

Caligus pelamydis Kroyer, 1863

(Figure 9 : 1-11)

(Syn. *Caligus scomberi* Bassett-Smith, 1896)

Description : Female.—Carapace as long as broad, anteriorly narrower ; about one-third total length ; lunules minute and not projecting ; abdomen two-jointed, longer than fourth and genital segments combined ; basal segment five times as long as terminal ; fourth thoracic segment narrow, spindle-shaped and separated from genital segment ; fourth legs four-segmented with 5 spines and no seta ; furca short with knobular base and broad and widely curving branches ; appendages as shown in figure.

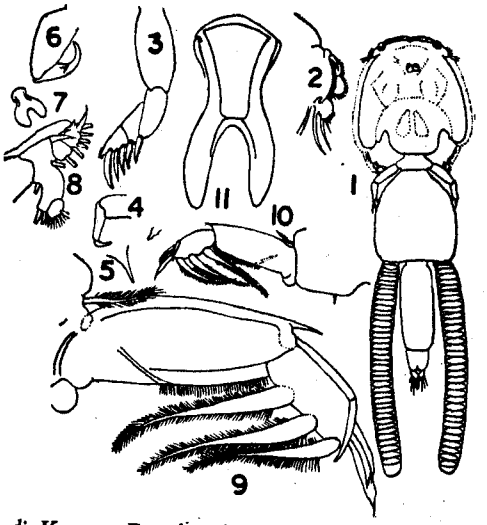


FIG. 9. *Caligus pelamydis* Kroyer. *Female.* (1) dorsal view ; (2) third leg ; (3) fourth leg ; (4) antenna ; (5) maxillule and maxilla ; (6) second maxilliped ; (7) sternal furca ; (8) second leg ; (9) first leg, distal part ; (10) first leg ; (11) sternal furca (figs. 1-8 after Wilson ; 9-11 after Brian).

Male.—Carapace longer than wide, narrower anteriorly ; fourth thoracic segment narrow, spindle-shaped, but broader than genital segment ; latter, slightly longer than broad, but barrel-shaped ; two-segmented abdomen slightly shorter than genital segment ; basal segment shorter than terminal segment ; anal laminae longer than broad and as long as first abdominal segment ; fourth legs four-segmented (including basal segment) as in female.

Scombroid hosts : 1. *Pelamys sarda* [=*Sarda sarda* (Bloch)]
2. *Scomber scombrus* Linnaeus
3. *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
4. *Scomberomorus cavalla* (Cuvier)

Localities : 1 & 2. British waters, Irish Sea (N.E. Atlantic), and Mediterranean ; 3. Woods Hole, Mass. U.S.A., (N.W. Atlantic) ; 4. Veracruz, Mexico (Gulf of Mexico) ; Texas Coast, U.S.A., Grand Isle, Louisiana, U.S.A.

Non-scombroid hosts : Pogonias cromis (Texas Coast, U.S.A.—Causey 1953).

Locations : Inside of operculum, gills and buccal cavity.

References : Kroyer (1863) ; Richiardi (1880) ; Valle (1882) ; Carus (1884) ; Bassett-Smith (1896-99) ; Brian (1899, 1935) ; Scott, T. (1901) ; Scott, A. (1906) ; Wilson (1905, 1932) ; Norman and Scott (1906) ; Stebbing (1910) ; Scott and Scott (1913) ; Brady (1910) ; Barnard (1955) ; and Causey (1953, 1960).

Remarks : Although reported from several localities from the Atlantic, and hitherto mainly from scombroid hosts, the species is relatively rare. Sumner *et al.* (1913) remark that *Caligus pelamydis* is usually found associated with *C. bonito*, a widely distributed species. Wilson (1905) has drawn attention to the discrepancies in Bassett-Smith's descriptions and figures of *C. scomberi* while relegating it to the synonymy of *C. pelamydis*. Wilson (1905, 1932) has shown the fourth thoracic segment to be confluent with the genital segment, while, Scott and Scott (1913) and Brian (1935) indicate these to be distinct. Scott and Scott (1913) draw attention to the rarity of the males of this species while describing it from a single specimen obtained after examining 1500 mackerel (*Scomber scombrus*). The host of this species from South African waters (Simons Bay) from where it was recorded by Brady (1910) and subsequently listed by Barnard (1955) is not known.

Caligus productus Dana, 1852

(Figure 10 : 1-17)

(Syn. *Caligus monacanthi* Kroyer, 1863 ; *C. monacanthi* (female) Wilson, 1937 ; *C. lobatus* Wilson, 1935 ; *C. katuwo* Yamaguti, 1936)

Description : Female.—Length of carapace equalling width ; posterior margin of median lobe in line with posterior tips of lateral lobes ; fourth thoracic segment very short, less than half width of genital segment and distinct from latter ; genital segment longer than broad, with very distinct lateral lobes which reach to posterior margin of first abdominal segment ; abdomen distinctly two-segmented, terminal segment about one-half times longer than basal, latter slightly narrower ; width of abdomen about three and a half times that of genital segment ; anal laminae longer than broad ; egg strings elongate, about three times length of abdomen ; antennules short with large lunules ; mouth parts as shown in figure ; first leg completely devoid of lateral setae on terminal segment, a feature most characteristic of the species and unique in the genus ; fourth leg three-segmented with five spines ; female with three rudimentary setae on ventral side of lateral lobes of genital segment indicating rudimentary appendages.

Male.—Carapace longer than broad, median lobe slightly extending beyond level of lateral lobes ; fourth thoracic segment spindle-shaped, larger than in female ; genital segment barrel-shaped, one half times wider than fourth segment ; abdomen two-segmented, slightly longer than genital segment ; first abdominal segment hardly half length of second ; caudal laminae longer than broad, equalling length of first abdominal segment; sexual distinction noticeable in antennae and second maxillipeds ; clear rudiments of fifth and sixth legs seen on ventro-lateral part of anal segment.

Scombroid hosts :
1. *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
2. *Katsuwonus vagens* [=*Katsuwonus pelamis* (Linnaeus)]
3. *Scomberomorus sierra* [=*Scomberomorus maculatus* (Mitchill)]
4. ' Mackerel ' [=? *Scomber japonicus colias* Gmelin, or *Scomber* sp.]
5. *Katsuwonus pelamis* (Linnaeus)
6. *Thunnus thynnus* [=*Thunnus* (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)]
7. *Neothunnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]

8. *Sarda sarda* (Bloch)
9. *Sarda* sp.
10. *Auxis thazard* (Lacépède)
11. *Scomberomorus cavalla* (Cuvier)

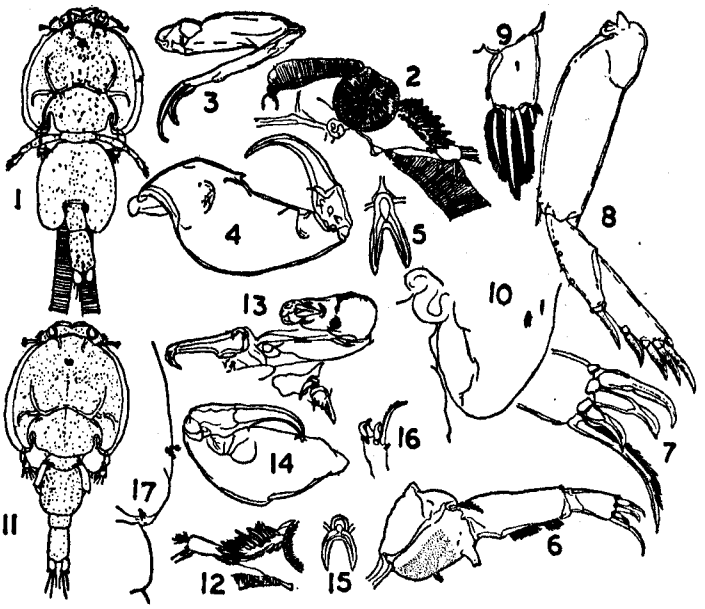


FIG. 10. *Caligus productus* Dana. *Female.* (1) dorsal view; (2) antennule; (3) first maxilliped; (4) second maxilliped; (5) furca; (6) first leg; (7) same terminal part; (8) fourth leg; (9) anal lamina; (10) Hind lobe of genital segment-ventral view; *Male.* (11) dorsal view; (12) antennule; (13) antenna, maxillule and maxilla; (14) second maxilliped; (15) furca; (16) terminal part of first leg; (17) ventral surface of genital segment showing rudimentary leg (after Shiino).

Localities : 1. Atlantic, Mediterranean; 2 & 3. Guaymas, Mexico and Texas Coast; 4. Cholla Bay, Sonora, Mexico; 5. Hamajima, Japan; 6. Same as 5; 7. Owase, Japan; 8 & 9. see Shiino (1959a); 10. 25° 31′ N, 113° 18′ W (Pacific; See Shiino, 1959a); and 11. see Shiino, 1959a and Causey 1953.

Non-scombroid hosts : *Coryphaena hippurus* (West Indies: Dana, 1854); *Balistes* sp., *Sphyraena* sp. (Steenstrup and Lutken, 1861); *Coryphaena* sp. (Kroyer, 1863); *Chrysophrys aurata* (Mediterranean); *Seriola dorsalis, Paralabrax clathratus, P. maculofasciatus, Verrunculus polylepis, Sphyraena argentea, Coryphaena* sp., *Lutjanus* sp., *Calamus brachysomus, Coryphaena hippurus,* and *Centropomus* sp. (Pacific coast of Mexico: Causey, 1960); *Polydactylus* (*Polynemus*) *opercularis* (21° 26′N, 106° 06′ W: Pacific); *Sphyraena barracuda, Pogonias cromis, Monacanthus* sp., and *Naucrates ductor* (See Shiino, 1959a).

Locations : Inner surface of gill covers and outer surface of body of host.

References : Dana (1852, 1854); Kroyer (1863); Steenstrup and Lutken (1861); Brian (1898, 1906, 1935); Bassett-Smith (1899); Wilson (1905, 1913, 1935, 1937); Rathbun (1884); Pearse (1952); Causey (1953a, b, 1955, 1960); Yamaguti (1936); Nunes-Ruivo (1956); and Shiino (1954, 1959a, b, c and 1960).

Remarks : Wilson (1905) has drawn attention to the differences in the descriptions of this species as given by Dana (1854), Steenstrup and Lutken (1861), Kroyer (1863) and as found in material examined by him. On account of the wide variety of host species involved, Causey (1960) remarks that there is little host specificity for *C. productus*, which has also been obtained by him from beach collections.

In view of the variability in this species we have followed Shiino (1959a) in recognising certain synonyms of *C. productus*. Shiino (1959e) has described three chalimus stages of *C. productus* from *Polydactylus* (*Polynemus*) *opercularis*.

Caligus quadratus Shiino, 1954

(Figure 11 : 1-15)

(Syn. *Caligus productus* (female) Wilson, 1905 ; *C. monacanthi* (male) Wilson, 1937 ; *C. coryphaenae* Yamaguti, 1936 *nec* Steenstrup and Lutken, 1861)

Description : Female.—Carapace as long as or slightly longer than wide but distinctly less than half total length ; lunules small, orbicular, hardly projecting ; fourth segment very narrow, spindle-shaped, about one-fourth width of carapace and confluent with genital segment ; latter elliptical, longer than broad, with evenly curved sides and lateral incipient posterior lobes ; abdomen elongate, linear, slightly swollen at centre, segmentation indistinct and longer than genital segment ; egg strings hardly surpass caudal laminae ; each egg string with about 30 eggs ; appendages normal, except basal joint of second maxilliped which is stout and markedly swollen ; terminal claw small and hardly half length of former ; furca slender, knobular, with basal portion equal to length of stumpy divergent branches ; spines on exopod of second leg very long and acuminate ; terminal spines of distal segments of first legs flattened ; fourth leg short, three-jointed, with four or five spines.

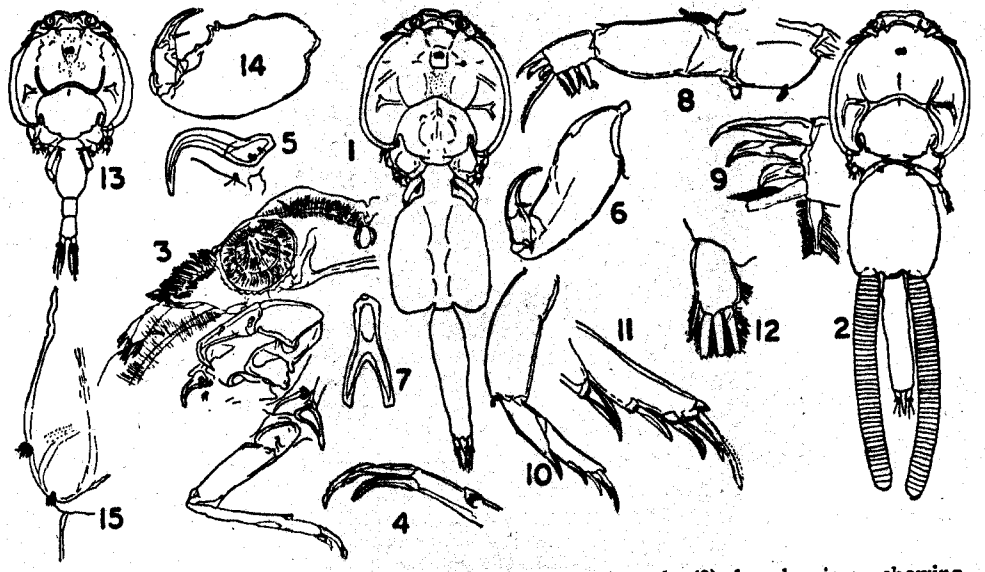


FIG. 11. *Caligus quadratus* Shiino. *Female.* (1) and (2) dorsal view, showing variability ; (3) cephalothoracic appendages, *in situ* ; (4) end of first maxilliped ; (5) maxillule ; (6) second maxilliped ; (7) sternal furca ; (8) first leg ; (9) same, terminal end ; (10) fourth leg ; (11) same, terminal part ; (12) anal lamina ; *Male.* (13) dorsal view ; (14) maxilliped ; (15) part of genital segment showing rudimentary legs (after Shiino).

Male.—Carapace as in female ; fourth thoracic segment relatively shorter and wider ; genital segment ovate, one-third longer than wide, with convex sides ; width much less than width of carapace, length equalling length of abdomen and anal laminae ; abdomen elongate, linear, with two distinct joints, basal segment slightly shorter than terminal ; appendages as in female, except antennae and second maxillipeds which are relatively larger ; rudiments of fifth and sixth pairs of legs present on ventro-lateral sides of genital segment.

Scombroid hosts : 1. *Neothunnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]
2. *Katsuwonus pelamis* (Linnaeus)
3. *Histiophorus orientalis* [=*Istiophorus gladius* (Broussonnet)]

Localities : 1. Shimakatsu, Japan ; 2. Hamajima, Japan, Pacific ; (?) Atlantic ; 3. Hamajima, Japan, Pacific.

Non-scombroid hosts : *Rhinobatus schlegeli* (Hamajima, Japan) ; *Coryphaena hippurus* and *Monacanthus* sp. (Atlantic) ; *Coryphaena hippurus* (Japan, Pacific).

References : Shiino (1954, 1959 a, b, and 1960) ; Wilson (1905, 1937) ; Yamaguti (1936).

Remarks : We are in agreement with Shiino (1959a) in his action of relegating the description and figures of a female ' *Caligus productus* ' given by Wilson (1905) to the synonymy of this species.

Caligus rapax Milne-Edwards, 1840

(Figure 2 : 1-9)

(Syn. *Caligus elongatus* Nordmann, 1832, *et* Milne-Edwards, 1840 ; *Caligus leptochilus* Frey and Leuckart, 1847 ; *C. lumpy* Kroyer, 1863)

Description : Female.—Carapace longer than wide, median lobe projecting beyond level of posterior ends of lateral lobes ; fourth thoracic segment very short, about one-third width of carapace ; genital segment large, quadrangular, with rounded corners, slightly wider than long, about two-third width of carapace ; abdomen unsegmented, varying considerably in length from 0.5 to 0.8 length of genital segment and about half as wide as genital segment ; egg strings hardly longer than half total length ; mouth parts as figured.

Male.—Carapace as broad as long ; fourth thoracic segment considerably longer and narrower than in female ; genital segment pear-shaped, hardly one-third width of carapace and rounded laterally ; abdomen of two joints, same length as genital segment, first abdominal segment one half as long as second segment ; antennae and second maxillipeds stouter than in female and spine on side of latter much larger ; fourth legs with longer terminal joints.

Scombroid hosts : 1. *Xiphias gladius* Linnaeus
2. *Scomber scombrus* Linnaeus
3. *Scomberomorus maculatus* (Mitchell)
4. *Scomberomorus cavalla* (Cuvier)

Localities : 1 & 2. Atlantic, Mediterranean ; 3 & 4. Texas Coast, U.S.A.

Non-scombroid hosts : Mostly gadoids (British waters : Scott and Scott, 1913) ; *Mola mola, Syngnathus phlegon* (Mediterranean : Brian, 1935) ; *Acipencer sturio, Alosa sapidissima, Ammodytes americanus, Carangus crysos, Carcharias littoralis, Cyclopterus lumpus, Dasyatis centrura,*

Gadus callarias, Kyphosus sectatrix, Melanogrammus aeglefinus, Menticirrhus saxtatilis, Monacanthus hispidus, Paralichthys oblongus, Pollachius virens, Pomolobua pseudoharengus, Pseudopleuronectes americanus, Raja erinacea, R. laevis, R. ocellata, Remora remora, Roccus lineatus, Squalus acanthias, Stenotomus chrysops, Trichiurus lepturus, Urophycis chuss, U. tenuis (Woods Hole, Mass. U.S.A.) ; Gulf of Mexico in plankton (Wilson, 1950) ; *Hippoglossus hippoglossus, Limanda limanda, Paralichthys oblongus, Platichthys flesus, Pleuronectes platessa, Pleuronectes* sp., *Pseudopleuronectes americanus,* and *Scophthalmus rhombus* (Ronald, 1959) ; *Gadus morrhua, Trutta trutta* (Pesta, 1934) ; *Caranx hippos,* and *Prionotus* sp. (Causey, 1953).

Location ; External surface of body.

References : Milne-Edwards (1840) ; Frey and Leuckart (1847) ; Baird (1850) ; White (1850) ; Steenstrup and Lutken (1861) ; Kroyer (1863) ; Olsson (1858) ; Macintosh (1874) ; Smith (1874) ; Bassett-Smith (1896, 1899) ; Scott, T. (1900) ; Brian (1908, 1912, 1935) ; Scott and Scott (1913) ; Wilson (1905, 1932, 1950) ; Timm (1894) ; Hofer (1904) ; Neresheimer (1909) ; Hanson (1923) ; Plehn (1924) ; and Pesta (1934).

Remarks : Caligus rapax is known from a variety of hosts and according to Wilson (1932) it is the most common species of the genus which apparently infests any fish host it comes across. Scott and Scott (1913) remark that it is not uncommon in planktonic collections and state that, ' Owing to the wandering habits of this *Caligus* there is scarcely a fish in our seas on which it may not at one time or other be found.' It is surprising that the species has not so far been recorded from the Indo-Pacific. For additional records see ' Addendum '.

C. rapax also evinces considerable variations in size ; proportionate dimensions of various parts and also in colour. The last said is known to differ according to the colour of the host. Wilson (1905) has commented on the range of variations that may be expected in the fourth pair of legs of this species, especially in specimens from the mackerel which appears to show the maximum variations as, ' Sometimes the second of the terminal spines, counting from the proximal end of the terminal joint, is wanting. Again, the ultimate and penultimate joints are relatively shorter and stouter than in the normal specimens ; or the three successive spines on the outer margin may overlap one another ; or the fringed discs at the bases of these spines may be so little developed as to be overlooked.'

Caligus regalis Leigh-Sharpe, 1930

(Figure 12 : 1-11)

Description : Female.—Carapace distinctly longer than broad ; lunules large ; fourth thoracic segment short, wider than long ; genital segment oblong, much longer than wide, posterior lobes sharply arcuate, incurved nearly to touch abdomen ; latter two-segmented, segmentation indistinct ; first segment about thrice longer than second ; anal laminae confluent with distal abdominal segment, broader than long and bearing four plumose setae each ; antennule conspicuously long ; lunules large and lateral diameter contained 1.75 in inter-lunular distance ; antenna two-jointed, basal joint massive, provided with a heart-shaped thickening (chitinous) against which strongly recurved unciform terminal claw bites ; basal segment with a small projection carrying two unequal spines ; other cephalic appendages as figured ; branched portion of furca horseshoe-shaped, slightly longer than basal portion ; basal joint of first pair of legs much enlarged where it joins middle joint, terminal joint provided with three bifid terminal spines and a short terminal seta, and three inner long plumose setae ; fourth pair of legs three segmented (including basal), terminal segment small, ending in a postero-lateral, one small and three large apical setae ; fifth legs vestigeal, represented by a pair of unjointed papillae bearing three setae on postero-ventral process of genital segment ; young females with abdomen distinctly segmented ; egg strings as long as body minus abdomen.

Male.—Differing from female in : shape of genital segment, abdomen, second antennae, fourth legs, presence of sixth pair of legs, and smaller size. Genital segment much wider than long ; abdomen two-segmented, distal segment twice that of basal in size and squarish ; distal joint of antennae bearing a second lateral hook ; furcal branches not converging ; structure of fourth legs (segments of different length, terminal joint slightly longer instead of being shortest as in female) ; and sixth pair of legs which bear two setae.

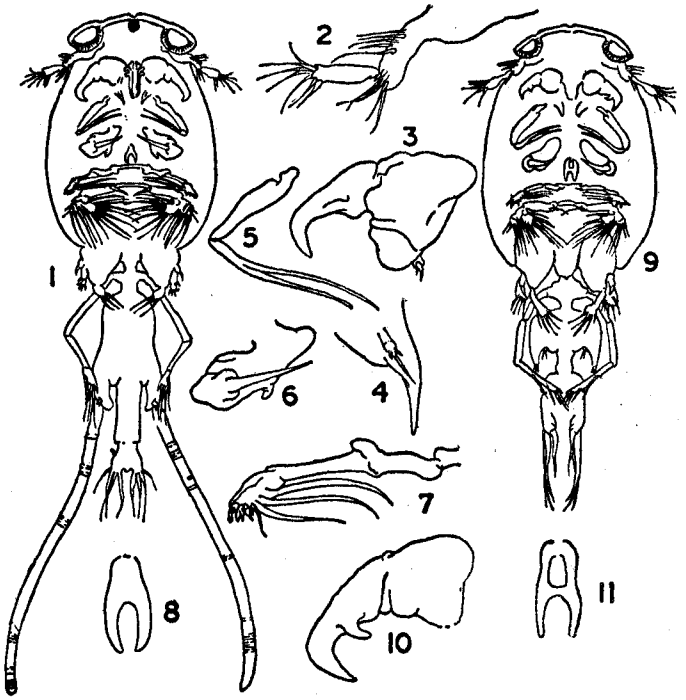


FIG. 12. *Caligus regalis* Leigh-Sharpe. *Female.* (1) ventral view ; (2) antennule ; (3) antenna ; (4) maxillule ; (5) maxilla ; (6) maxilliped ; (7) first walking leg ; (8) furca ; *Male.* (9) ventral view ; (10) antenna, and (11) furca (after Leigh-Sharpe).

Scombroid host : *Euthynnus yaito* =[*Euthynnus affinis yaito* Kishinouye].

Locality : Misool, New Guinea Waters, Pacific.

Non-scombroid hosts : None.

Location : On surface of body.

Remarks : The combination of characters which separates this species is : the relatively long antennule ; carapace which is more than half total length ; the bifid terminal spines of distal segment of first legs ; and the nature of the genital segment and abdomen.

Caligus thynni Dana, 1852

(Figure 13 : 1-5)

Description : Female.—Carapace distinctly longer than wide ; lunules small, not prominent ; fourth thoracic segment short and wide ; genital segment longer than broad, with sides divergent, posteriorly widest ; abdomen two-segmented, about equal to genital segment in length,

but its width less than half that of latter ; first abdominal segment distinctly shorter than second ; egg strings conspicuously narrow, longer than total length, each with about 40 eggs ; maxillule lacking ; other appendages normal except furca and fourth legs ; former with divergent acuminate branches ; fourth leg three-jointed with four simple spines.

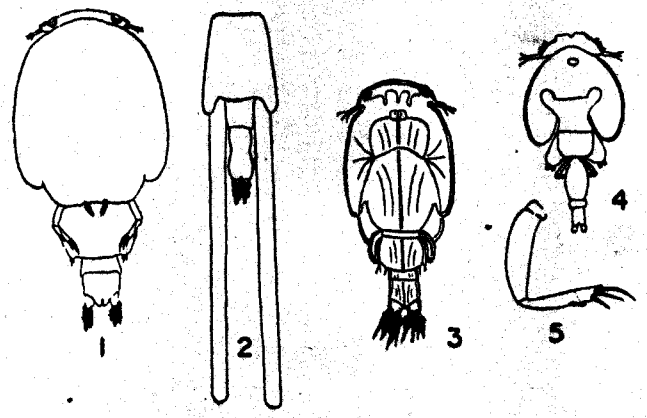


FIG. 13. *Caligus thynni* Dana. *Male.* (1) dorsal view ; *Female.* (2) dorsal view of genital segment and abdomen ; (3) dorsal view of male taken in plankton haul off Philippines ; (4) ? male taken similarly off Falkland Island ; (5) fourth leg of same (after Wilson ; and Scott).

Male.—Carapace longer than broad, width about three-fourths its length ; carapace two-thirds total length ; genital segment about 1.5 times wider than long, with convex lateral margins ; two pairs of rudimentary legs seen dorsally on posterior side of genital segment ; abdomen two-segmented, basal segment about half length of distal ; appendages normal but for larger size of antennae and second maxillipeds ; fourth legs longer and more slender than in female, with larger and weaker spines.

Scombroid hosts : *Gymnosarda pelamys* [=*Katsuwonus pelamis* (Linnaeus)]
Thynnus pelamys [=*Katsuwonus pelamis* (Linnaeus)]

Locality : North Atlantic.

Non-Scombroid hosts : None. However, taken in plankton hauls from Falkland Islands (Scott, 1914) ; and West coast of Mindano, Philippines (Wilson, 1950).

Location : ? Probably buccal cavity and gills.

References : Dana (1852) ; Scott, T. (1894, 1914) ; Bassett-Smith (1899) ; Wilson (1905, 1950).

Remarks : Since the specific name is after the host genus *Thynnus* (Wilson, 1905, p. 604) we have followed the emended spelling for the species as given by Scott, T. (1914), and not *C. thymni* as given by Dana, Wilson, and others.

Caligus sp.

(Figure 14 : 1-9)

Material examined : A single specimen was obtained along with specimens of *Gloioptes* from the sailfish *Istiophorus gladius* (Broussonnet) as external parasite from behind the eye. The specimen shows marked differences from known descriptions of species of *Caligus*, but due to the paucity of material it is merely described and designated here only as *Caligus* sp.

Description : Female.—Carapace broader than long, anteriorly narrower, its length slightly less than half total length ; posterior median lobe of carapace broad and its posterior margin in line with posterior ends of broadly rounded lateral lobes ; frontal plates well developed ; lunules large and projecting ; interlunular space of frontal plates about two times lateral diameter

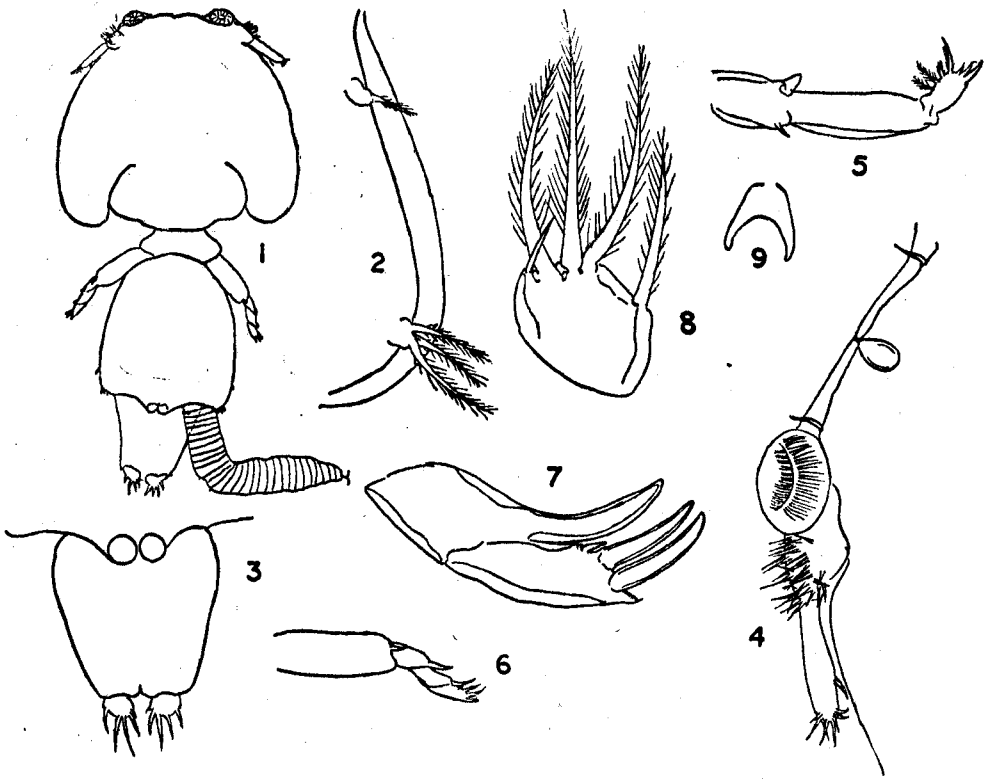


FIG. 14. *Caligus* sp. *Female.* (1) dorsal view ; (2) ventro-lateral margin of genital segment showing rudimentary fifth and sixth legs ; (3) abdomen ; (4) part of frontal plate, lunule and antennule ; (5) first leg ; (6) fourth leg ; (7) same, terminal part enlarged ; (8) anal lamina ; (9) sternal furca.

of lunule ; fourth thoracic segment short and wide, its length three times its width ; genital segment conspicuously large, slightly longer than broad, posterior margin rounded at angles and medially slightly drawn backwards ending in a sulcus ; genital segment narrower anteriorly ; abdomen one segmented, much broader anteriorly, its width (anteriorly) more than half that of genital segment, while its length is hardly half ; anal laminae short and much broader than long ; bearing four plumose setae and a small inner spine each. Salient features of the appendages are as follows : antennule of two segments, terminal segment slender and about twice length of basal segment ; antennae, maxillules, maxillae and maxillipeds normal ; first pair of legs with terminal spines on distal segment in a graded series, there being three, smallest being innermost ; terminal seta hardly longer than longest spine ; fourth leg four-segmented, but showing variations in number and size of proximal spines on terminal segment on either side [on right side spine rudimentary (Fig. 14 : 7), while on left side it is normally developed] ; rudimentary fifth and sixth legs clearly visible from dorsal side of genital segment ; fifth leg represented by single knob bearing a single plumose seta-like appendage ; sixth legs similar, but each knob carrying three seta-like appendages ; egg strings short, broad, length two and a half times that of abdominal length ; each string with about 25 eggs.

Remarks : As mentioned, our single specimen shows variability in the size of the proximal spine of the distal segment of the first legs. A fuller description can be given only when more material becomes available.

TABLE I

Measurements etc. in 17 species of *Caligus* Müller described from or known to occur on scombroid fishes from various parts of the world (Measurements in mm.)

(F=Female; M=Male)

Species		Total length	Carapace L × W	Genital segment L × W	Abdomen L × W	L. of egg string	No. of eggs
C.alalongae	F.	?					
	M.	?					
C. bonito (A) our material	F.	8.1	2.5×2.4	2.1×1.7	1.8×—	..	..
	M.	5.8	2.2×2.3	0.8×0.64	0.9×—	..	..
(B) Wilson's (1905)	F.	8.3	3.0×3.0	3.0×—	2.3×—	8.0	—
	M.	5.5	3.0×2.8	1.0×—	1.2×—	..	..
C. chelifer	F.	6.0-6.5	3.0×2.3	1.6×—	1.45×—	3.2	45 to 50
C.coryphaenae	F.	7.0	3.36×2.78	1.69×1.71	1.57×0.64	..	..
	M.	5.65	3.56×2·93	1.00×1·25	0.71×0.56	..	..
C. cybii	F.	?					
	M.	?					
C.germoi	F.	2.6	1.5×1.7	0.4×0.5	..	..	..
	M.	unknown					
C.infestans	F.	6.0					
	M.	4.0					
C.kuroshio	F.	5.55	2·54×2.45	1·45×1.59	1.14×0.41	..	..
	M.	4.69	2.36×2.09	0.98×0.59	0.91×—	..	..
C.macarovi	F.	4.61	2.28×1·75	1.23×1.23	0.93×0.50	..	..
	M.	?					
C.mutabilis	F.	5.6	2.3×2.2	1.9×—	1.1×—	2.5	..
	M.	3.4	1.85×1.7	0.7×0.43	..	..	..
C.pelamydis	F.	3.3	1.1×1.1	0.9×—	1.2×—	2.0	30
	M.	2.9					
C.productus	F.	6.0	2.1×2.0	1.6×—	2.0×—	2.2	30
	M.	4.5	2.2×2.2	1.1×—	1.1×—	..	..
C.quadratus	F.	5.8	2.04×1.89	1.79×1.71	1.79×0.47	..	..
	M.	3.07	1.71×1.46	0.68×0.43	0.57×—	..	..
C.rapax	F.	5.0-7.0	2.6-3.6× 2.4-3.4	1.5-2.2×—	1.1-1.5×—	2.6-3.0	..
	M.	4.0-5.0	2.35×2.0	0.75×—	1.0×—	..	..
C.regalis	F. & M.	(Not available in original description)					
C.thynni	F.	9.7	4.9×3.4	..	..	..	..
	M.	?					
Caligus sp.	F.	5.0	2.2×2.5	1·5×1.33	0.53×0.60	1.6	25

Genus Anuretes Heller, 1865

Frontal plates well defined; lunules conspicuous by their absence; maxillae small, simple and straight; second maxillipeds large and powerful; rudiments of fifth pair of legs large and prominent; free thoracic segment small, without dorsal plates; genital segment large, well rounded and emarginate posteriorly; abdomen wanting, but anal laminae attached to ventral surface of genital segment; other characters mostly as in *Caligus*.

Remarks : The genus is known from a few species distributed variously in the Indo-Pacific and Atlantic, but only one is hitherto known from a scombroid host, and that from Indian seas.

Anuretes branchialis Rangnekar, 1953

(Figure 15 : 12-22)

Description : Female.—Carapace elliptical, distinctly longer than broad being more than half length of body ; median lobe of carapace projecting backwards completely covering free thoracic segment ; caudal laminae well separated ; maxillae simple ending in a bluntly conical point ; appendages as shown in figure.

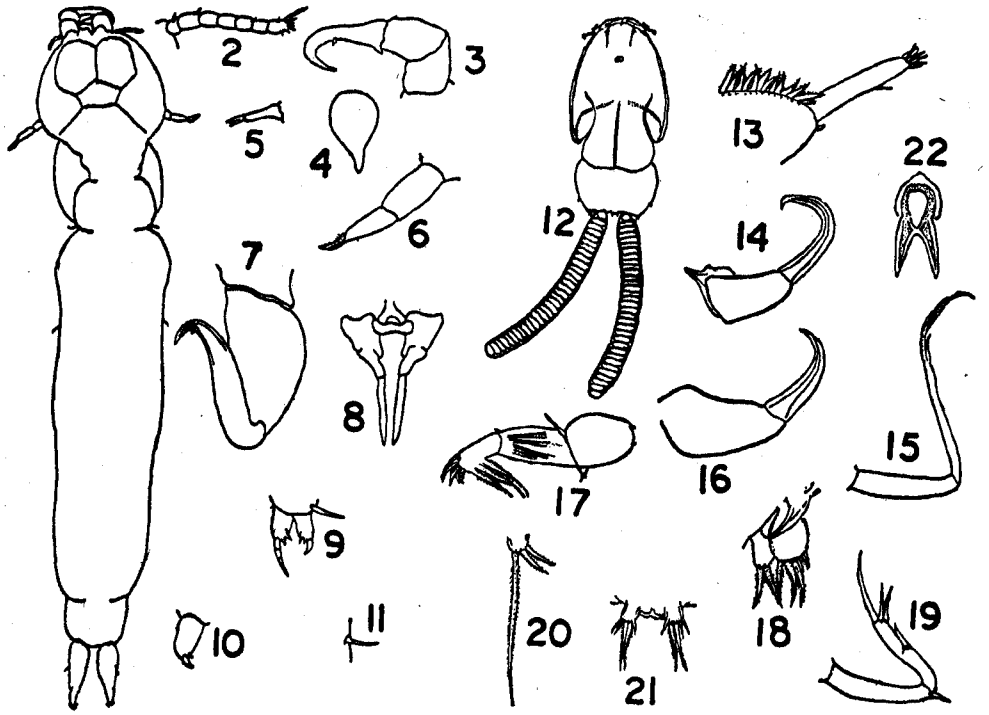


FIG. 15. *Pseudocycnus armatus* Bassett-Smith. 1-11. *Male.* (1) dorsal. view ; (2) antennule; (3) antenna ; (4) mouth tube ; (5) maxillule ; (6) maxilla ; (7) maxilliped ; (8) first leg ; (9) second leg ; (10) third leg, and (11) fourth leg : *Anuretes branchialis* Rangnekar. 12-22. *Female.* (12) dorsal view; (13) antennule ; (14) antenna ; (15) first maxilliped ; (16) second maxilliped ; (17) first leg ; (18) third leg ; (19) fourth leg ; (20) sixth leg ; (21) caudal laminae ; (22) furca ; (after Kirtisinghe ; and Rangnekar).

Measurements (mm.) : Total length excluding egg strings 2.48 ; Carapace length 1.85 ; width 1.20 ; length genital segment 0.85 ; width 1.05 ; length egg strings 2.43-2.45 ; number of eggs, 32 to 35 in each string.

Scombroid host : Thynnus pelamis [=? *Katsuwonus pelamis* (Linnaeus), or ? *Euthynnus affinis affinis* (Cantor)].

Locality : Bombay, India (Arabian Sea).

Non-scombroid host : Platax teira (Bombay, India, Arabian Sea ; Rangnekar, 1955).

Location : From gill filaments.

Remarks : The scombroid host identification needs confirmation as to whether it is the oceanic skipjack *K. pelamis*, or the little tunny *E. a. affinis*, which commonly occurs along the Indian coast and is also landed at Bombay.

In the only other species known from this area, *A. perplexus* Bassett -Smith, 1898 (Trincomalle, Ceylon), the carapace is broader than long, as in *A. brevis* Pearse, 1951 (male) from Bahamas, Atlantic. The last said is suspected to be the male of *A. heckelii* Kroyer (1863) or *A. parvulus* Wilson (1913), both known from the Atlantic. Besides these, the genus is known from two other species described by Shiino (1954) from Japanese waters.

Genus **Lepeophtheirus** Nordmann, 1832

Differs from *Caligus*, but resembles *Anuretes* in the absence of lunules ; but differs from latter in having an abdomen which is one or two segmented, and the maxillae being small and bifurcate.

Lepeophtheirus dissimulatus Wilson, 1905

(Figure 16 : 1-18)

Description : Female.—Carapace orbicular, as wide as long ; frontal plates large, well defined ; median posterior lobe of carapace broad, truncate, half carapace width, projecting slightly backwards beyond tips of lateral lobes ; fourth thoracic segment short, one-third width of genital segment ; latter almost spherical, width more than half that of carapace ; from rounded posterior margin of dorsal surface opposite each egg tube projects a short conical papilla without setae or spines ; ventrally a pair of larger papillae one on each side of abdomen and each carrying three plumose setae, probably representing fifth legs ; abdomen small, less than one-third length of genital segment and attached to ventral surface of latter, and not visible when seen from dorsally ; single abdominal segment three-fifths as wide as long ; anal laminae 0.75 length of abdomen, half as wide as long and bearing four elongate plumose setae longer than abdomen and laminae together ; egg strings short, broad, each carrying 15 to 25 eggs ; terminal segment of antennule longer than basal ; terminal hook of antenna strongly curved ; maxillule and maxilla represented by a pair of strongly curved and a pair of nearly straight spines respectively ; other appendages as figured.

Male.—Carapace as in female ; free thoracic segment larger, as wide as genital segment and half as long ; bases of fourth legs protruding prominently as in female ; genital segment elliptical, about as wide as long ; truncate posteriorly ; fifth legs represented as pair of prominent papillae projecting from postero-lateral margins of genital segment, each papilla carrying three long spines ; abdomen one-segmented, short, wider than long ; plumose setae on anal laminae relatively long ; antennae much longer than in female and branched ' like stag's horn ' ; fourth leg much larger and stouter ; other appendages as in female.

Measurements (*mm.*) : *Female* (*Male*).—Total length 3.5 (2.5) ; length×width of carapace 2.3×2.3 (1.7×1.7) ; length of genital segment 1.0 (0.37) ; length of abdomen (0.2) ; length of egg string 2.0 mm.

Scombroid hosts : *Thynnus pelamys* [=*Katsuwonus pelamis* (Linnaeus)].
' Mackerel ' [=*Scomber japonicus* sub. sp.].

Locality : E. Pacific (See Shiino, 1959e).

Non-Scombroid hosts : *Epinephelus morio* (Bermuda, Atlantic) ; *Paralichthys californicus*, *Hypsopsetta guttulata*, *Sphyraena argentea* (Ensenada, Baja California, Mexico) ; *Paralabrax nebulifer* (Cholla Bay near Puerto Penasco, Sonora) ; ? *Sphaeroides annulatus* (Guaymas, Sonora) ;

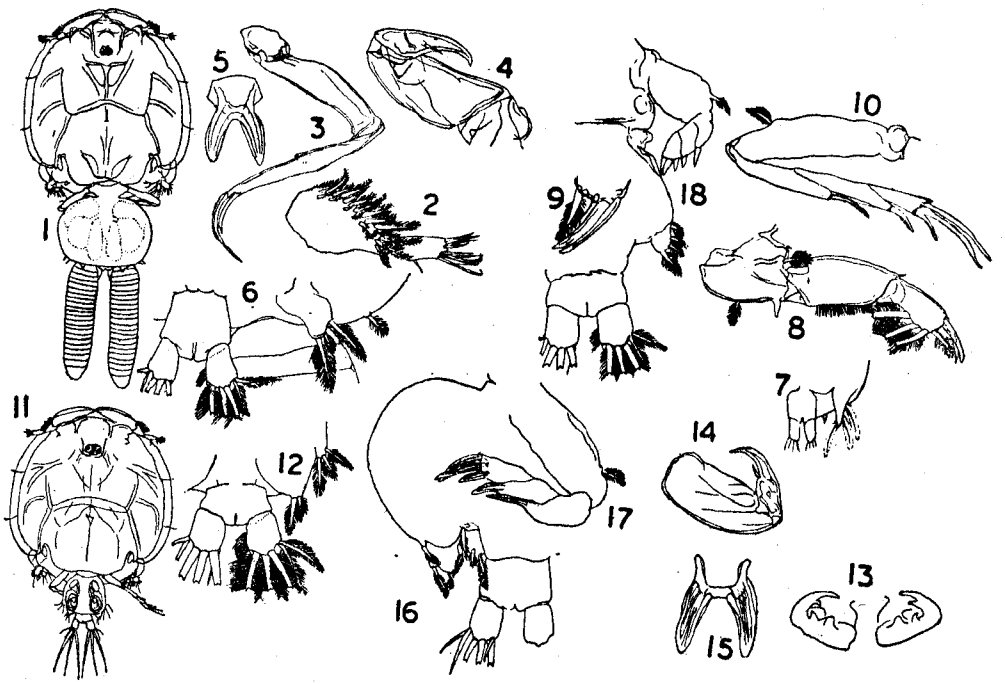


FIG. 16. *Lepeophtheirus dissimulatus* Wilson. *Female.* (1) dorsal view; (2) antennule; (3) first maxilliped ; (4) second maxilliped ; (5) sternal furca ; (6) abdomen and part of genital segment, showing rudimentary fifth leg ; (7) same-Bermuda specimen ; (8) first leg ; (9) same terminal part ; (10) fourth leg ; *Male.* (11) dorsal view ; (12) abdomen and part of genital segment showing rudimentary fifth legs ; (13) antennae ; (14) maxilliped ; (15) sternal furca ; *Young female.* (16) part of genital segment and abdomen ; (17) fourth leg ; (18) fourth segment, and abdomen of young female (7 and 13 after Wilson; others after Shiino).

Galeichthys guatemalensis ? (Mazatlan, Sinaloa, Mexico) ; *Bodianus diplotaenia* (Socorro Island, Revillagigedo Archipelago, Mexico) ; *Epinephelus labriformis* (Charles Island, Galapagos) ; *Epinephelus labrifrons* (Clarion Island, Revillagigedo Archipelago, Mexico) ; *Epinephelus* sp., *Lactophrys triquteter*, *Mycteroperca olfax*, *M. xenarcha*, *Mycteroperca* sp., *Cratinus agassizii*, and *Paralabrax hameralis* (See Shiino, 1959 e).

Location : On outer surface of body.

References : Wilson (1905) ; Shiino (1959 e) ; Causey (1960).

Remarks : The species is most distinct of all members of the genus in the following character : in the extremely small and ' concealed ' abdomen which is ventral to the egg strings. Shiino's figure does not show the ' stag's horn-like ' branching of the antennae of the male noted by Wilson (1905) ; Shiino's specimens appear to have four instead of three marginally arranged plumose setae on the rudimentary fifth legs, the disposition of the setae itself (in females) being characteristic for the species.

Lepeophtheirus eminens Wilson, 1944

(Figure 17 : 1-8)

Description.: Female.—Carapace elliptical, longer than broad, more than half total length ; posterior median lobe extending behind level of tips of lateral lobes ; fourth thoracic segment short, narrower than genital segment, width being hardly one-third carapace width; genital segment broader than long, provided with posterior lateral lobes, one on each side ; abdomen two-segmented, but segmentation indistinct ; length as long as genital segment, width 2.5 times in width of latter; anal laminae fused with abdomen, about as wide as long carrying five setae each, middle one being longest ; appendages normal ; furca more or less H-shaped.

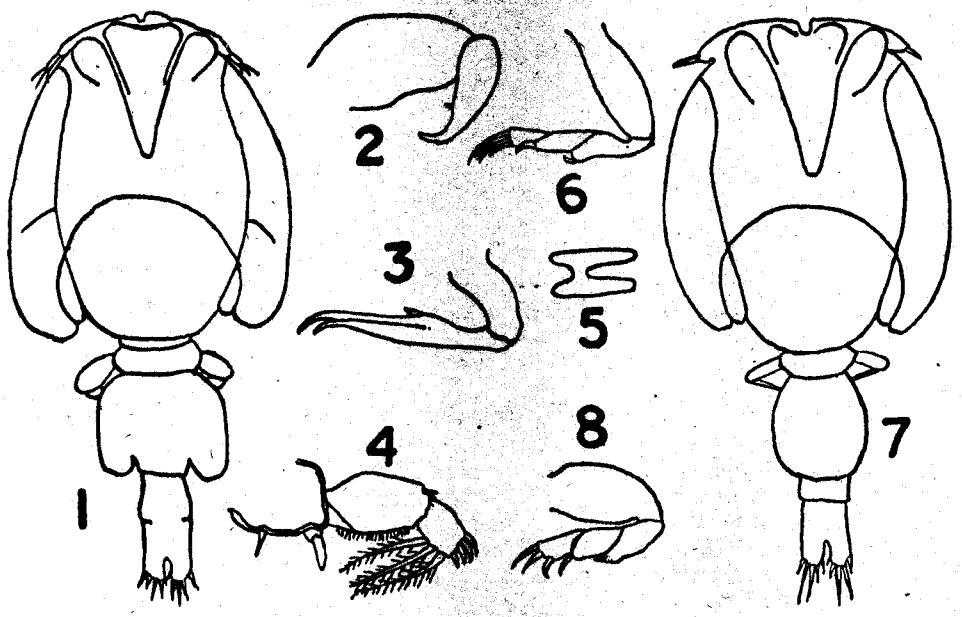


FIG. 17. *Lepeophtheirus eminens* Wilson. *Female.* (1) dorsal view ; (2) maxilliped ; (3) second maxilla ; (4) first leg ; (5) furca ; (6) fourth leg ; *Male.* (7) dorsal view ; (8) fourth leg of male (after Wilson).

Male.—Carapace and fourth thoracic segment as in female, but latter less wider, width being about 3.5 in carapace width ; genital segment elliptical, slightly longer than wide ; length greater than that of abdomen and 3.25 in carapace length ; abdomen two-segmented, half as wide as long, basal segment much shorter than distal ; anal laminae fused with latter and bearing setae ; other appendages as in female except fourth legs which are stout, short, with combined length of three distal segments equalling that of basal segment ; spine at distal corner of second segment short, strongly curved; three terminal spines of unequal lengths.

Measurements (mm.) :. Female (Male).—Total length 6.0 (6.0) ; length of carapace×width 3.95×3.0 (3.66×3.15).

Scombroid host : Makaira ampla marlina ' the black marlin ' [=*Makaira indica* (Cuvier)]

Locality : Ventura, Baja California, Mexico, Pacific.

Non-scombroid hosts : None.

Location : Outside surface of body.

Remarks : In Royce's review of the Pacific spearfishes, the ' black marlin ' is denoted as *Istiompax marlina* (Jordan and Hill) which is a synonym of *I. indicus* (Cuvier).

Characters of specific importance of *L. eminens* are the posteriorly lobed genital segment and fusion of abdominal segments in female and fusion of anal laminae with abdomen in both sexes.

Genus **Alicaligus** Shiino, 1955

Alicaligus tripartitus Shiino, 1955

Scombroid host : Sarda orientalis (Temminck and Schlegel).

Locality : Japan, Pacific.

Non-scombroid hosts : None.

Location : ? Gills.

Remarks : We have not seen the original description of this species as given by Shiino (1955).

Genus **Parapetalus** Steenstrup and Lutken, 1861

? **Parapetalus** sp.

(Figure 18 : 1-8)

A single female specimen was obtained from the buccal cavity of the oriental bonito, *Sarda orientalis* (Temminck and Schlegel) from the south west coast of India (Vizhingam) in September 1960. In several characteristics the specimen differs from *Caligus*, and neither does it belong strictly under *Parapetalus*, but due to the lateral expansions of the genital segment and abdomen, it is provisionally described under the latter genus without species designation. We are unable to comment on *Alicaligus* Shiino as we have not seen the description given by Shiino, but *Alicaligus tripartitus* Shiino, and our ? *Parapetalus* sp. are found on the same host, *Sarda orientalis* (Temminck and Schlegel).

Description : Female.—Carapace slightly longer than broad ; posterior median lobe broadly rounded, posterior margin extending slightly behind level of hind margins of lateral lobes ; frontal plates broad ; lunules conspicuous, lateral dimensions equalling half interlunular distance ; fourth segment short and narrow without dorsal plates ; genital segment conspicuously large, much broader than carapace, but in length slightly less ; posterior margins of genital segment undulating with an incipient broader median lobe ; anteriorly genital segment is constricted where it joins the fourth thoracic segment ; abdomen apparently two-segmented, segmentation indistinct, length two-fifths total length ; first segment more or less spindle-shaped and seven times as long as terminal segment and three times wider ; greatest width of basal segment half width of genital segment ; anal laminae as long as terminal abdominal segment, each bearing four plumose setae and two minute spines ; egg strings broad and long, being equal to combined length of genital and abdominal segments ; each string containing about 50 eggs.

Salient features of appendages are : antennule short, two-segmented, segments of about equal length and together equal lateral dimension of lunule ; antenna, maxillule, maxilla, maxilliped and furca as in *Caligus* ; first pair of legs with terminal segment carrying three long setae laterally and terminally four spines arranged more or less in a row of varying lengths ; basal parts of setae flattened with coarse bristles resembling denticulations along outer margin, inner margin lacking such bristles ; remaining part of setae furnished with fine setules along both margins ;

fourth leg short ; segmentation of terminal part differs being indicated only by irregular constrictions ; five large broadly flattened plumose setae of which four occur along outer lateral margin and one terminally ; at base of each lateral seta a slender spinuous process carrying long fine straight comb-like setules present ; inner base of terminal seta is elevated into a denticulated process.

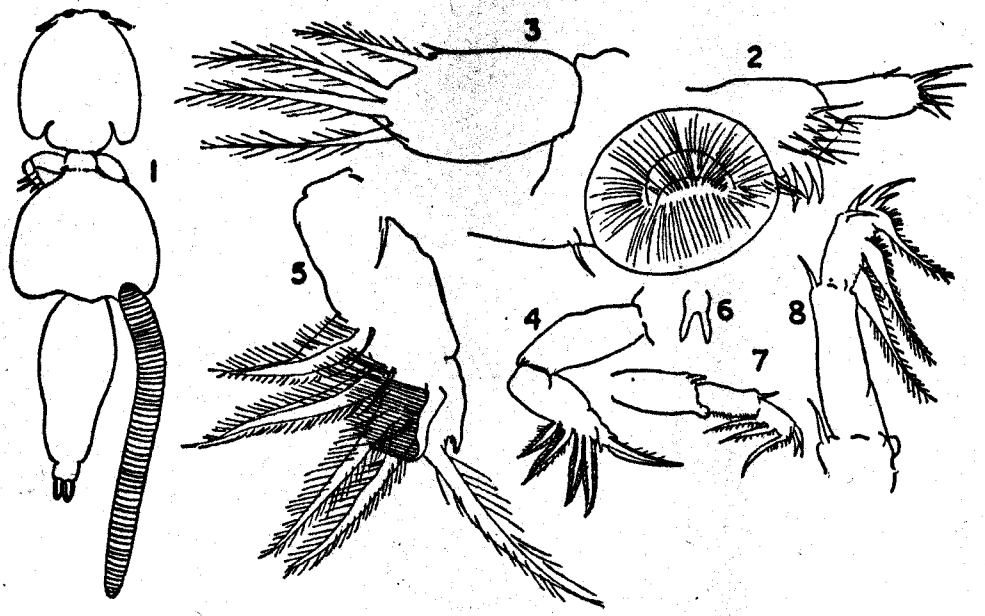


FIG. 18. ? *Parapetalus* sp. *Female.* (1) dorsal view ; (2) antennule and lunule ; (3) anal lamina ; (4) fourth leg ; (5) same, terminal part enlarged ; (6) sternal furca ; (7) first leg ; (8) same, terminal part enlarged.

Remarks : The diffuse segmentation and the non-spinuous appendages carried by the distal half of the fourth legs is another feature which distinguishes the specimen from *Caligus*, besides nature of genital segment and abdomen already mentioned.

FAMILY : EURYPHORIDAE

Genus **Alebion** Kroyer, 1863

Lunules absent ; fourth segment with dorsal plates in female, which are much reduced or lacking in male ; genital segment in female usually produced into long lateral posterior processes, extending backwards beyond tip of abdomen ; males with genital segment smoothly rounded ; abdomen two-segmented in both sexes, basal segment in female with long processes at its posterior corners ; first three pairs of legs biramous, exopod with very large claws ; rami of first pair two-segmented, of second and third pairs three-segmented ; fourth leg rudimentary, consisting of a single segment ; no furca or maxillary hook ; genital segment of male often carrying leg rudiments.

Alebion glaber Wilson, 1907

(Figure 19 : 1-10)

Description : Female.—Carapace orbicular, as long as broad, slightly less than half total length ; fourth segment nearly as wide as genital segment ; dorsal plates small and rounded ;

genital segment squarish, width half that of carapace ; no leg rudiments seen ; basal segment of abdomen bulbous, but equal in length to terminal segment ; fourth leg rudimentary, single-segmented, three times as long as wide and carrying three terminal spines ; egg strings longer than total length.

Male.—Carapace longer than wide, ovate ; fourth thoracic segment long, narrow, slightly more than half width of genital segment, dorsal plates rudimentary ; genital segment barrel-shaped, with posterior corners ending in divergent protuberances ; fifth pair of legs visible at mid-lateral part of genital segment ; basal abdominal joint shorter than terminal.

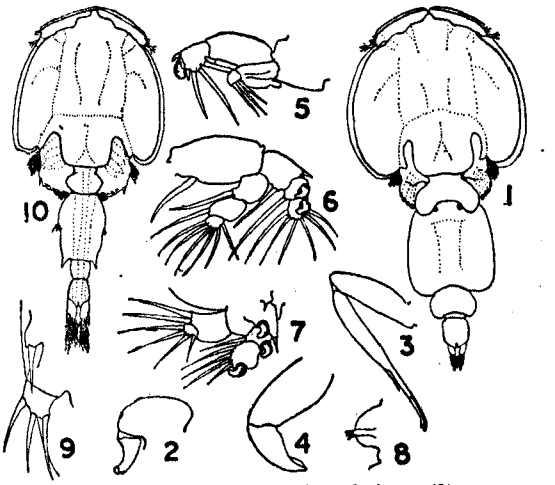


FIG. 19. *Alebion glaber* Wilson. *Female.* (1) dorsal view ; (2) antenna ; (3) first maxilliped ; (4) second maxilliped ; (5-8) first to fourth legs ; (9) rudimentary fifth legs ; *Male.* (10) dorsal view (after Wilson).

Measurements (mm.) : *Female (Male).*—Total length 10-12 (7.0-7.75) ; length of carapace × width 5.9×6.0 (3.5×3.1) ; length×width of genital segment 3.1×3.0 (1.25×1.1) ; length of abdomen 2.5 (1.35) ; length of egg string 15 mm.

Scombroid host : ' Bonito ' [=*Sarda sarda* (Bloch)]

Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic).

Non-scombroid hosts : Mustelus canis, Carcharius littoralis, and *Squalus acanthias* (Woods Hole, Massachusetts, U.S.A.).

Location : External surface of body.

References : Wilson (1907, 1932) ; Sumner *et al.* (1913).

Remarks : The quadrangular shape of the genital segment which is different from other members of the genus helps in easily distinguishing this species.

Alebion gracilis Wilson, 1905

(Figure 20 : 1-13)

(Syn. *Alebion gracile* Wilson, 1905).

Description : Female.—Carapace broadly ovate, longer than wide, fourth thoracic segment slightly less wide than genital segment and half as long ; dorsal plates of fourth segment projecting backwards partly overlapping genital segment ; latter, one-half times broader than

long, with postero-lateral corners produced into greatly elongate conical processes as given for genus ; inner margins of these projections with minute spines ; basal abdominal segment with similar, but lobular lateral projections ; terminal segment squarish and longer than anal laminae ; egg strings slightly shorter than total length.

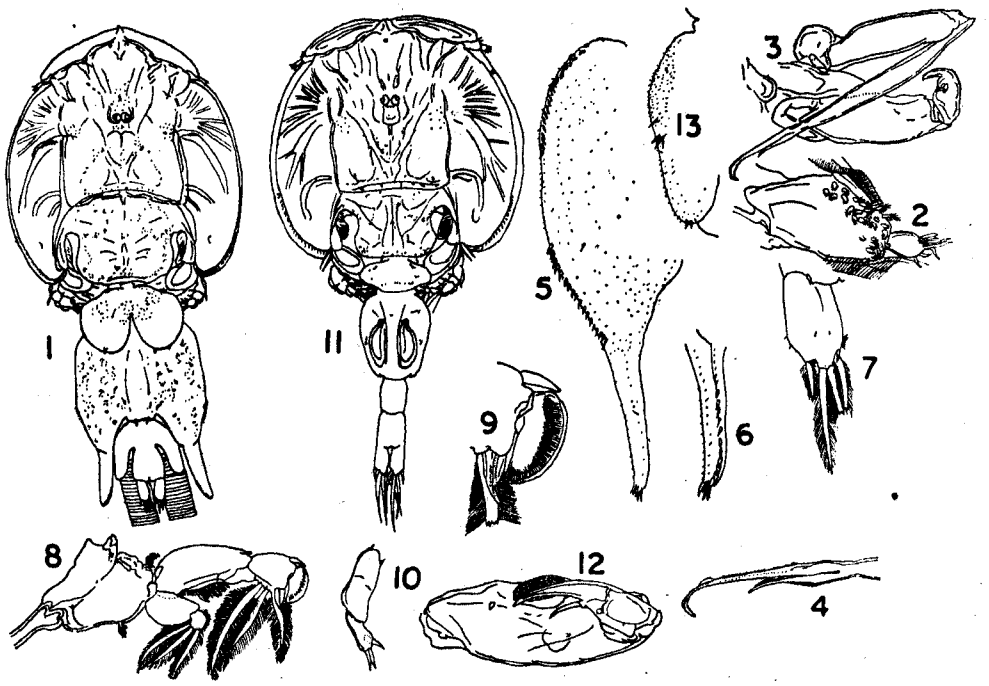


FIG. 20. *Alebion gracilis* Wilson. *Female.* (1) dorsal view; (2) antennule; (3) first and second maxillipeds; (4) tip of first maxilliped; (5) posterior process of genital segment (ventral view); (6) same, dorsal view; (7) anal lamina; (8) first leg; (9) tip of exopod of first leg; (10) fourth leg; *Male.* (11) dorsal view; (12) maxilliped; (13) part of genital segment showing rudimentary legs (after Shiino).

Male.—Carapace slightly broader than long ; fourth thoracic segment as wide as genital segment ; dorsal plates rudimentary ; genital segment slightly longer than broad, widest at centre with convex lateral margins ; a pair of leg rudiments visible ventrally ; abdominal segments of more or less equal dimensions, but without lateral processes as in female.

Measurements (mm.) : *Female (Male).*—Total length 9.0-10.0 (5.0-6.0) ; length of carapace × width 5.35 × 4.9 (3.0 × 3.2) ; length of genital segment × width 3.5 × 2.66 (1.35 × 0.9) ; length of abdomen 1.67 (1.4) ; egg strings 9.0 mm.

Scombroid host : ' Bonito ' [=*Sarda sarda* (Bloch)].

Locality : Massachusetts coast, U.S.A. (N.W. Atlantic).

Non-scombroid hosts : Mustelus canis, Carcharhinus littoralis, Trygon sp. (=? *Dasyatis centrura*), *Pollachius virens* (Woods Hole, Massachusetts, U.S.A., N.W. Atlantic) ; *Carcharinus platyrhynchus* (Clarion Island, Revillagigedo Archipelago, Mexico, E. Pacific) ; *Carcharinus lamiella* (Socorro Island, Revillagigedo Archipelago, Mexico, E. Pacific).

Location : External surface of body.

References : Wilson (1905, 1907, 1932) ; Sumner *et al.* (1913) ; Shiino (1959e).

Remarks : A few minor differences are noticeable between the Atlantic and Eastern Pacific material described by Wilson and Shiino respectively. These are : shape of the dorsal plates of the fourth thoracic segment in the females ; abdominal segmentation distinct in Atlantic specimens ; terminal segment of endopod of first leg with three plumose setae along its inner margin in the Pacific form instead of a single seta found in those from the Atlantic.

Genus **Elytrophora** Gerstaecker, 1853

Differing from *Alebion* chiefly in : 1. first four pairs of legs biramous ; rami of first pair two-segmented, of second and third pairs three-segmented, exopod of fourth pair three-segmented and endopod two-segmented ; 2. fifth leg rudiments present in male ; 3. a furca present ; and 4. no maxillary hook.

Elytrophora atlantica Wilson, 1932

(Figure 21 : 6-15)

Description : Female.—Carapace orbicular, a little wider than long ; fourth thoracic segment forming a short narrow waist anteriorly and provided with elliptical dorsal plates, inclined towards each other and overlapping at their tips ; outer margin of each plate invaginates near its centre ; genital segment barrel-shaped with broad posterior lobes curved inward over basal abdominal segment ; first abdominal segment longer than second, with tiny lobes at its posterior corners ; anal laminae shorter than terminal segment ; egg strings about same as total length ; furca thrice as long as wide, basal half stout with convex sides, branches slender and slightly incurved ; leg rudiments absent in genital segment.

Male.—Carapace as in female ; dorsal plates of fourth thoracic segment with knob-like projections at each anterior corners and no invaginations on outer margins ; genital segment elliptical without posterior lobes, but with leg rudiments on lateral margins just behind mid-length ; abdominal segments of equal dimensions, first segment without posterior lobes ; antennae showing sexual dimorphism.

Measurements (mm.) : Female (Male).—Total length 8.0-9.0 (6.0-6.5) ; width of carapace 4.0-4.5 (2.5-3.0).

Scombroid host : Thunnus thynnus [=*Thunnus* (*Thunnus*) *thynnus thynnus* (Linnaeus)].

Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic).

Non-scombroid hosts : None.

Location : Gills.

Remarks : Wilson (1932) mentions that his material was obtained from the gills of the ' horse mackerel (*Thunnus thynnus*) '. It may be mentioned here that generally the popular name ' horse mackerel ' is applied to the Carangid fish *Trachurus trachurus* (Linnaeus) or some allied carangids.

Elytrophora brachyptera Gerstaecker, 1853

(Figure 21 : 1-5)

(Syn. *Arnaeus thynni* Kroyer, 1863 ; ? *Dinematura thynni* Kollar, 1835).

Description : Female.—Carapace orbicular, hardly half total length ; fourth thoracic segment carrying two small kidney-shaped plates, each in turn lobed ; posterior lobes of each plate slightly overlapping genital segment ; latter distinctly longer than wide, with posterior corners

lobular ; abdomen hardly half length of genital segment ; first abdominal segment with postero-lateral corners slightly projecting backwards ; second segment globular ; anal laminae distinctly longer than wide and slightly expanded distally bearing five apical plumose setae ; appendages as figured.

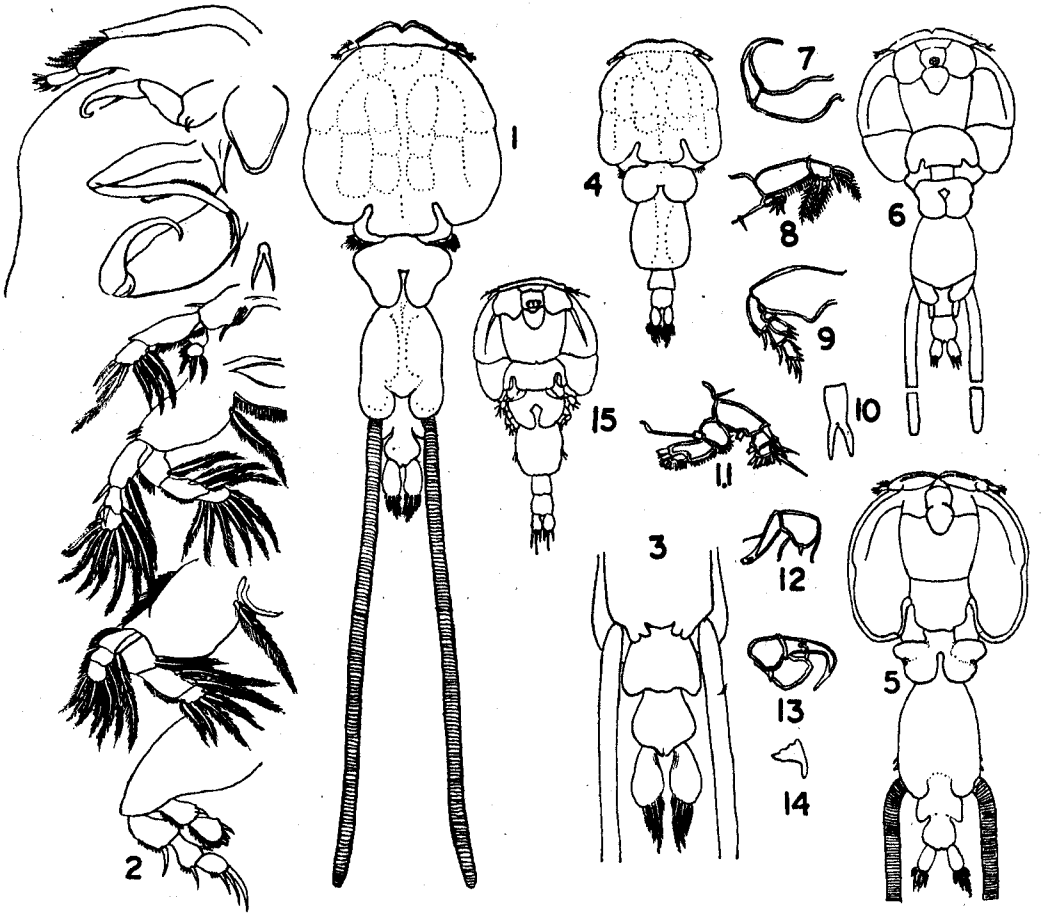


FIG. 21. *Elytrophora brachyptera* Gerstaecker. 1-5. *Female.* (1) dorsal view ; (2) cephalic and thoracic appendages *in situ* ; (3) genital segment and abdomen, ventral view ; *Male.* (4) dorsal view ; *Female.* (5) dorsal view of specimen from British Seas (1-4 after Heller ; 5 after Scott and Scott). *Elytrophora atlantica* Wilson. 6-15. *Female.* (6) dorsal view ; (7) maxilliped ; (8) first leg ; (9) fourth leg ; (10) sternal furca ; (11) second legs ; (12) second antenna ; *Male.* (13) second antenna ; (14) maxilla ; (15) dorsal view of male (after Wilson).

Male.—In general like female, except smaller size ; genital segment rather squarish ; two-segmented abdomen about as long as genital segment ; postero-lateral corners of first abdominal segment angular and produced backwards as in female ; second maxillipeds more powerfully clawed.

Measurements (mm.) : Female (Male).—Total length 10.0-11.5 (9.0).

Scombroid hosts : 1. *Orcynus thynnus* [=*Thunnus (Thunnus) thynnus thynnus* (Linnaeus)]
2. *Thynnus vulgaris* [= -do-]
3. *Thynnus thynnus* [= -do-]

4. *Thynnus orientalis* [=*Thunnus* (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)]
5. *Neothunnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]
6. *Parathunnus obesus* [=*Thunnus* (*Parathunnus*) *obesus mabachi* (Kishinouye) or *T.* (*P.*) *obesus sibi* (Temminck and Schlegel)]
7. *Thynnus alalonga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)]

Localities : 1-3. Mediterranean, Atlantic ; 4-7. Japan, Pacific.

Non-scombroid hosts : None. Heegaard (1955) has reported on six young specimens (size about 6 mm.) taken at surface by ' ATLANTIDE ' off Tropical West Africa (20° 04′ N, 22° 33′ W).

Location : Gills of host species.

References : Gerstaecker (1853) ; ? Kollar (1835) ; Kroyer (1863) ; Heller (1865) ; Bassett-Smith (1896) ; Scott and Scott (1913) ; Heegaard (1955) ; Shiino (1954, 1957).

Remarks : There appears to be slight differences in the figures of the female of *E. brachypters* given by Heller (1865) and Scott and Scott (1913), which can be seen from said figures reproduced here (Figure 21). Shiino (1959b) considers *E. brachyptera* of Yamaguti (1936) from Japan a synonym of Wilson's (1921) *E. hemiptera.*

Elytrophora hemiptera Wilson, 1921

(Syn. *Elytrophora brachyptera* Yamaguti, 1936 *nec* Gerstaecker, 1853).

Scombroid hosts : 1. *Thunnus thynnus* (=*Thynnus orientalis*) [=*Thunnus* (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel)]
2. *Neothunnus albacora* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]

Localities : 1. Owase, Mie Prefecture and Hamajima, Japan, Pacific ; 2. Owase, Mie Prefecture, Japan.

Non-scombroid host : Isurus glaucus (Owase, Mie Prefecture, Japan).

Location : Gill cavity.

References : Wilson (1921) ; Yamaguti (1936) ; Shiino (1958, 1959b).

Elytrophora indica Shiino, 1958

Scombroid host : Makaira mitsukurii [=*Makaira audax* (Philippi)].

Locality : Bay of Bengal (12° 50′ N, 81° 19′ E).

Non-scombroid hosts : None.

Location : Gills.

Genus **Euryphorus** Nordmann, 1832

Wilson (1932) distinguishes *Euryphorus* from *Elytrophora* as follows :

' Abdomen twice as long as genital segment, its basal segment 10 times as long as terminal segment ; genital segment wider than carapace ; gill cavity of fishes ;

(Female only).....*Euryphorus* Milne Edwards '

' Abdomen much shorter than genital segment, its two segments about the same length ; genital segment less than half as wide as carapace ; outside of fishes ;

(male and female).....*Elytrophora* Gerstaecker'

Euryphorus nympha Steenstrup and Lutken, 1861

(Figure 22 : 1-3)

(Syn. *Euryphorus coryphaenae* Kroyer, 1863 ; *Euryphorus nordmanni* Kirtisinghe, 1937 ; For detailed synonymy see Shiino, 1954).

Scombroid host : 1. *Thunnus alalunga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)].

2. *Neothunnus albacora* [=*Thunnus* (*Thunnus*) *albacares macropterus* (Temminck and Schlegel)].

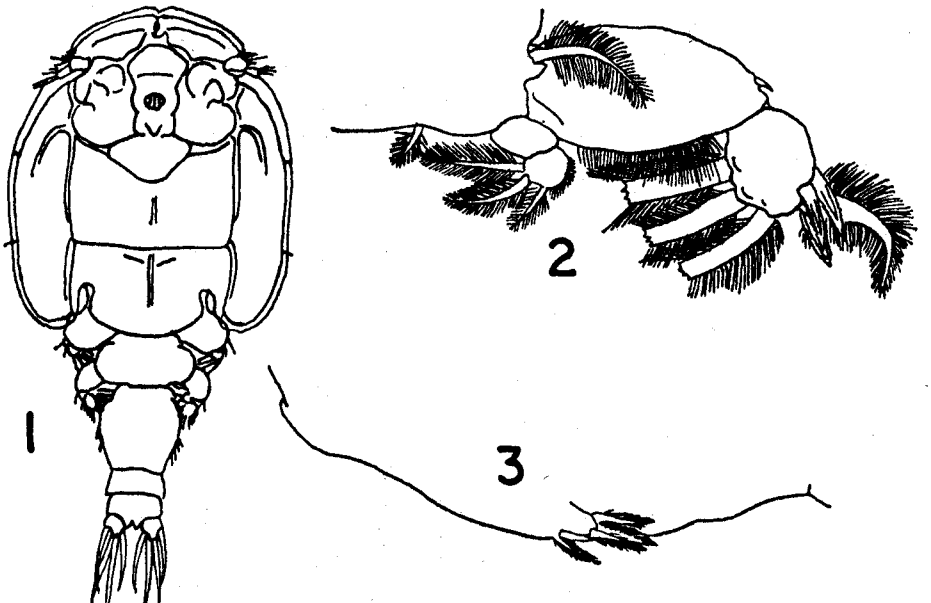


FIG. 22. *Euryphorus nympha* Steenstrup and Lutken. *Young male.* (1) dorsal view ; (2) first leg ; (3) part of genital segment (after Shiino).

Locality : 1. Indian Ocean (6° 52′ S, 74° 49′ E.) ; 2. Pacific.

Non-Scombroid hosts : Coryphaena hippurus (Pacific ; Indian Ocean ; and Atlantic) ; *Lampugus punctatus* (See Shiino, 1959a) ; *Rachycentron canadus* and *Coryphaena hippurus* (Causey, 1953, a, b).

Location : Gill cavity.

References : Steenstrup and Lutken (1861) ; Kirtisinghe (1937) ; Kroyer (1863) ; Shiino (1954, 1958, 1959a, b) ; Causey (1953, a, b).

Remarks : Figure 22 after Shiino (1959a) will give details about the male of *E. nympha.*

For further discussion see ' Addendum '.

Genus **Gloiopotes** Steenstrup and Lutken, 1861

Carapace as in Caligidae ; lunules absent ; a pair of dorsal plates on genital segment which slightly overlap genital segment and basal segments of fourth legs ; genital segment in female produced at each posterior corner into a curved process bearing a serrated styliform appendage on its outer margin ; in males curved posterior process of genital segment absent, but styliform process attached to posterior corners of genital segment ; two-segmented abdomen slender ; caudal laminae filiform ; first and fourth legs uniramous, second and third biramous, rami three-segmented ; terminal claws of first legs tripartite ; furca compound, its branches bifid.

Gloiopotes costatus Wilson, 1919

Scombroid host : 1. ' Swordfish ' [=*Makaira* sp.]
2. *Istiophorus greyi* [=*Istiophorus gladius* (Broussonnet)]
3. *Makaira* sp.

Localities : 1. Catalina Island off California (Pacific) ; 2. Guaymas, Sonora and Mazatlan, Sinaloa. Mexico (Pacific) ; 3. Acapulco, Guerrero, Mexico (Pacific).

Non-scombroid hosts : None.

Location : On outer surface of body.

References : Wilson (1919) ; Causey (1960).

Remarks : As Causey (1960) suggests, Wilson's use of quotation for ' swordfish ' indicates some doubts as to the host. Along the Mexican Pacific coast the species is said to be quite common on marlins and sailfish and the ' blue bodies and red egg strings are quite conspicuous.' Further, Causey found a specimen from the sailfish (at Mazatlan) with a barnacle *Conchoderma* sp. upon it.

Gloiopotes ornatus Wilson

(Figure 23 : 1-6)

Description : Female.—Carapace distinctly longer than wide, half total length ; posterior median lobe broad, very slightly emarginate, carrying ten symmetrically arranged spines on lateral and posterior margins on each side ; fourth segment short, wide, length about 3.5 in width ; latter as broad as genital segment behind and 2/3rd as broad as carapace ; dorsal plates broadly lobular, smooth ; genital segment much broader than long, anteriorly constricted into neck ; styliform appendage from posterior process of genital segment carrying a number of spines along inner margin ; genital segment having on its dorsum and lateral margins several spines more or less symmetrically disposed ; two-segmented abdomen cylindrical, basal segment

squarish, terminal segment longer than broad with slight constriction just behind its mid-length ; both segments with spines along dorsum, in addition terminal segment with spines along lateral margins also ; anal laminae two-thirds second abdominal segment, proximal one-third length much wider than distal two-thirds ; antennule with terminal joint longer than basal ; antenna with broad basal segment and stout terminal claw which carries an accessory spine at its mid-length ; furca as for genus ; first pair of legs with two inner claws on terminal joint being trifurcate ; outermost claw long and pointed ; rami of third pair of legs close together, outer ramus armed with bifurcate claws ; fourth legs large, basal segment stout, broad and exceeding length of three distal segments ; first two distal segments carry one spine, while terminal segment has three ; all three segments carry a fringe of small spines along outer margin ; fifth legs wanting.

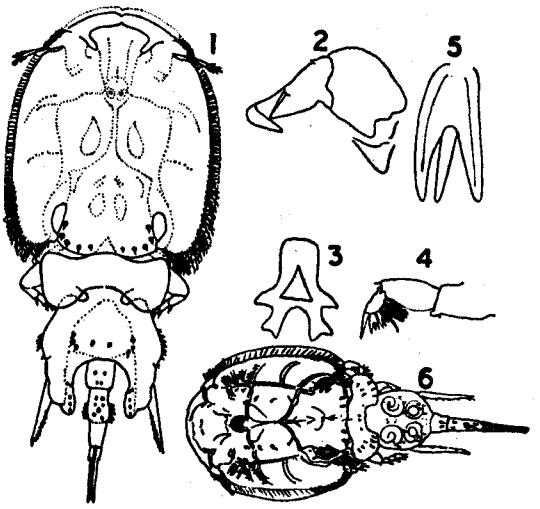


FIG. 23. *Gloiopotes ornatus* Wilson. *Female.* (1) dorsal view ; (2) antenna ; (3) furca ; (4) first leg ; (5) trifurcate spine of terminal segment of first leg. *Male.* (6) dorsal view. (1-5, after Wilson; 6, after Shiino).

Male.—Carapace as in female ; dorsal plates of fourth thoracic segment considerably wider than genital segment ; posterior margin with median sinus, with four spines on either side along posterior border ; genital segment as wide as long with a pair of spines on either side of midline dorsally ; an irregular row of 8 spines along posterior margin along dorsal surface ; each styliform process arising directly from genital segment, reaching level of hind end of second abdominal segment, and tipped with three minute spines ; terminal segment of abdomen twice as long as basal segment ; both segments with parallel lateral sides and few small spines along dorsum ; anal laminae as long as entire abdomen, laterally flattened, closely adpressed, each bearing single seta.

Measurements (mm.) : Female (Male).—Total length 10.0-12.0 (8.0) ; Carapace length × width 5.4×4.6 ; length of genital segment including posterior process 3.4 ; length of abdomen 3.2

Scombroid host : 1. ' Swordfish ' [=*Xiphias gladius* Linnaeus].
2. *Tetrapterus imperator* [=*Tetrapturus belone* Rafinesque : *T. imperator* Schneider is now recognised as a synonym of *Xiphias gladius*, being based on an illustration of a young of the latter species. However, in this case the reference is to *T. belone*]
3. *Makaira mitsukurii* [=*Makaira audax* (Philippi)]

Locality : 1. & 2. Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic) ; 3. Recife, Brazil (Atlantic : See Shiino 1959b).

Non-scombroid hosts : None.

Location : On outer surface of body.

Gloiopotes hygomianus Steenstrup and Lutken, 1861

(Figure 24 : 1-23)

Description : Female.—Carapace longer than broad, narrowing anteriorly, and half total length ; dorsal plates of fourth thoracic segment greatly enlarged, narrowed in its insertion to carapace, plates about half as long as carapace and overlapping half genital segment, both plates separated by deep cleft, but fused on dorsum of fourth segment ; genital segment wider than half width of carapace, little wider than its own length at mid-line, carrying at hind end a pair of elongated processes ; latter extending parallel to but for some distance beyond end of abdomen ; each process bears in front of their blunt end a postero-laterally projecting flattened lobe with pointed apex ; sides of genital segment as well as these postero-lateral lobes bear minute spinules on lateral and posterior margins ; two-segmented abdomen cylindrical, first segment short, half as long as terminal segment, but slightly wider ; both segments provided with minute spinules dorsally. Appendages as shown in figure, notable differences from *G. ornatus* being in the structure of the furca ; external spines on exopod of second leg with narrow rims on two opposite borders, that of first joint associated at its base with a transverse row of short spinules ; in addition, anal laminae about half abdominal length, each bearing three unequal terminal spines, and one solitary spine externally at proximal one-third length ; spinules irregularly present on anal laminae.

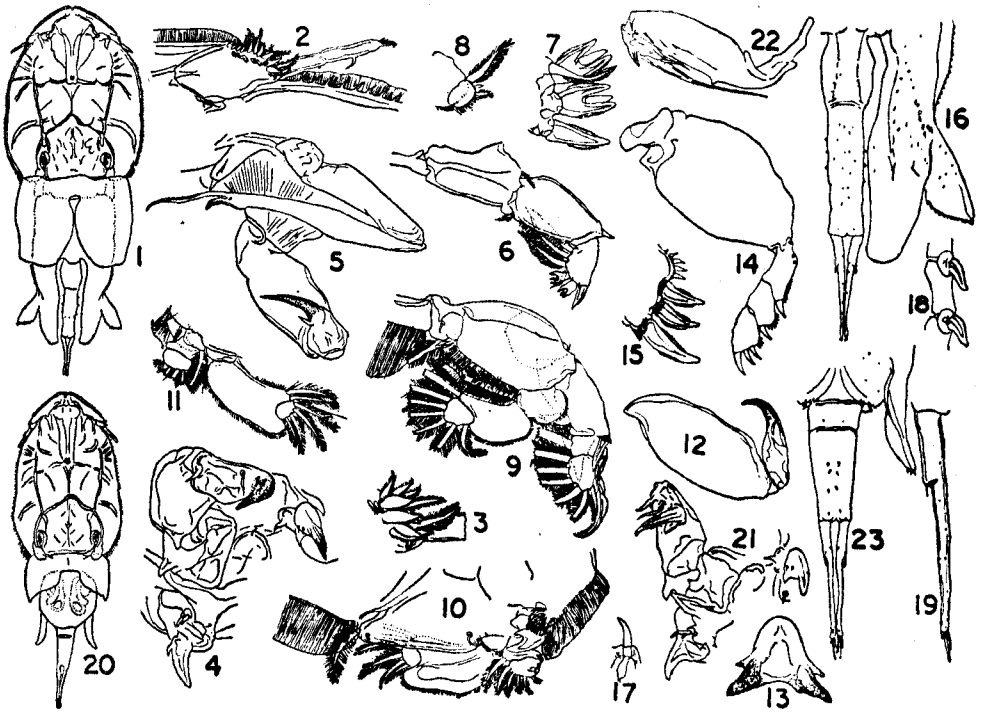


FIG. 24. *Gloiopotes hygomianus* Steenstrup and Lutken. *Female.* (1) dorsal view ; (2) antennule ; (3) same distal part of first joint ; (4) antenna and maxilla ; (5) first and second maxillipeds ; (6) first leg ; (7) apical spines of same ; (8) tip of endopodite of same ; (9) second leg ; (10) third leg ; (11) two rami of same posterior side ; (12) second maxilliped ; (13) sternal fork ; (14) fourth leg ; (15) terminal end of same ; (16) postero-lateral lobe of genital segment and abdomen, ventral view ; (17) spinule on the surface of carapace ; (18) marginal spines of genital segment ; (19) anal lamina ; *Male.* (20) dorsal view; (21) antenna and maxilla ; (22) second maxilliped ; (23) postero-lateral process of genital segment and abdomen (after Shiino).

Male.—Carapace much narrower than in female, two-thirds as wide as long ; dorsal plates of fourth thoracic segment far smaller than and different in shape from that of female ; four-

fifths as wide as carapace in their combined width, foliaceous, and acuminate postero-laterally and overlapping succeeding segment only in antero-lateral angles, and separated from each other by a broad quadrate median sinus ; genital segment about one-third as long as carapace, as long as wide, carrying from postero-lateral angles two styliform processes ; latter extending beyond first abdominal segment, and tipped by three short spinules ; genital segment and its processes without marginal spinules ; basal segment of abdomen one-third as long as second ; anal laminae about equal to length of abdomen ; antennule better developed than in female ; antennae more geniculate ; maxillule bears a short inner spiniform accessory process ; such branching absent in maxilla ; base of second maxilliped slender than in female and armed with short conical processes on inner border ; claw elongate tapering distally to terminate into a thin circular, but well chitinized apex which carries a short conical process on upper surface near base in addition to ordinary accessory spine.

Measurements (mm.) : Female (Male.).—Total length 13.66 (8.27) ; length of carapace × width 6.61×5.45 (4.73×3.20) ; fourth thoracic segment on mid dorsal line 0.98 (0.53) ; same including dorsal plate 3.57×4.55 (1.47×2.46) ; genital segment on mid dorsal line 2.50 ; same including posterior processes 5.89×4.01 (1.77×1.67) ; posterior process 3.39 (1.07) ; abdomen 2.84 (1.20) ; anal lamina 1.60 (1.20).

Scombroid host : Acanthocybium solandri (Cuvier and Valenciennes)

Locality : Cocos Island, E. Pacific.

Non-scombroid hosts : ?

Location : External surface of body.

Remarks : Shiino's (1960) redescription represents the first record of this species from the Pacific. Stebbing (1900) was the first to describe the male of this species (See Wilson, 1905, p. 702).

Gloiopotes longicaudatus (Marukawa, 1925)

(Figures 25 : 1-14, and 26 : 1-2)

(Syn. *Caligus longicaudatus* Marukawa, 1925 ; *Gloiopotes* sp. Yamaguti, 1936 ; *Gloiopotes zeugopteri* Rao, 1951)

Material examined : Several specimens, both males and females collected from the sailfish *Istiophorus gladius* and the blue marlin *Makaira nigricans* at Tuticorin, Gulf of Mannar, during July 1960, and June-October 1961.

Our material agrees with the description of *Gloiopotes zeugopteri* Rao which species has been synonymised with *G. longicaudatus* by Shiino (1954).

Description : Female.—Carapace as long as wide, less than half total length ; shape of carapace more or less circular ; dorsal plates on fourth segment kidney-shaped overlapping genital segment scarcely on anterior part ; genital segment mid-dorsally twice as wide as long, but length with posterior process (excluding lateral process) equals width ; postero-lateral processes of genital segment long, conical, extending to level of hind margin of abdomen ; first abdominal segment about half as long as second ; anal laminae slightly shorter than second abdominal segment ; spinular arrangement on posterior part of body as shown in figure 26 : 1-2. Appendages as shown in figure 25 for *G. zeugopteri*. Egg strings about one-third total length.

Male.—Carapace as in female ; dorsal plates of fourth thoracic segment lobular, hardly overlapping genital segment ; genital segment as in male of *G. ornatus*, but posterior styliform processes reach to level of middle of second abdominal segment ; antennae with an accessory claw on outer margin.

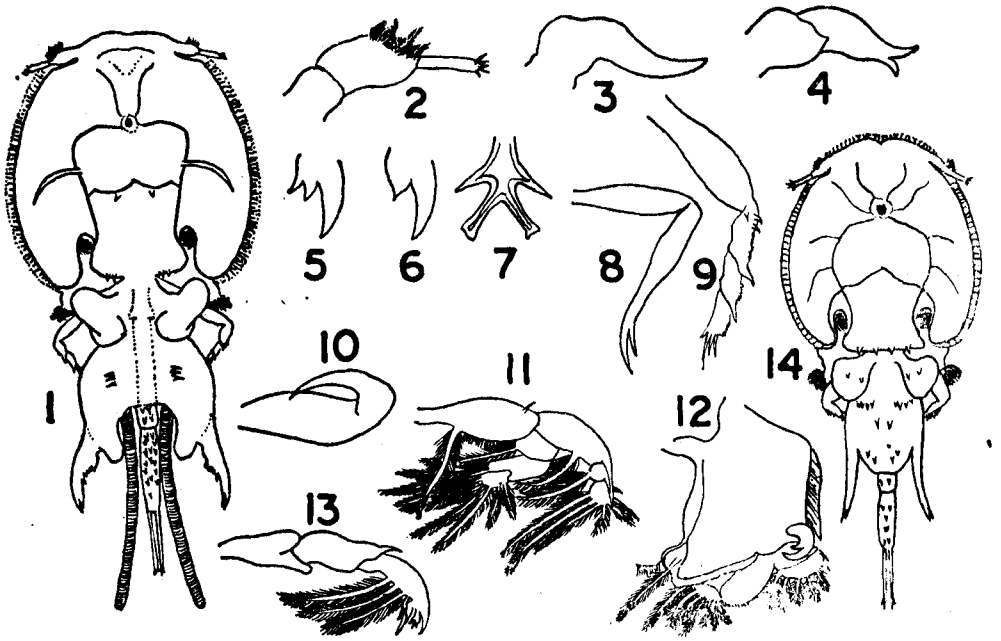


FIG. 25. *Gloiopotes zeugopteri* Rao (= *G. longicaudatus* (Marukawa)). *Female.* (1) dorsal view ; (2) antennule ; (3) antenna ; (4) antenna (*Male*) ; (5) maxillule ; (6) maxilla ; (7) sternal furca ; (8) first maxilliped ; (9) fourth leg ; (10) second maxilliped ; (11) second leg ; (12) third leg ; (13) first leg ; *Male.* (14) dorsal view (after Rao).

Scombroid host : 1. *Makaira mazara* [=*Makaira nigricans* (Lacepede)].
2. *Makaira marlina* [=*Makaira indica* (Cuvier)].
3. *Makaira mitsukurii* [=*Makaira audax* (Philippi)].
4. *Makaira nigricans* (Lacepede).
5. *Istiophorus gladius* (Broussonnet).
6. *Xiphias zeugopteri* [=? *Makaira* sp.].

Localities : 1. Indian Ocean (2°11′ S, 82° 58′ E.) ; 2. Indian Ocean (7° 10′S, 75° 20′ E.) ; 3. Indian Ocean ; 4 and 5. Tuticorin, Gulf of Mannar, India ; 6. Lawson's Bay, Waltair, Andhra Coast, India (Bay of Bengal).

Non-scombroid host : *Galeus glaucus* (Loc. ?)

Locations : On surface of body ; also inside gill cover.

Remarks : As mentioned in the introduction to this paper, the host record for item six in the scombroid host list given above appears to be wrong. We are unable to find any reference to a ' swordfish ' by the name of *Xiphias zeugopteri* in ichthyological literature and feel that Rao could have obtained his material from a species of marlin (*Makaira* sp.)

There appears to be considerable similarities between *G. longicaudatus* as described here and *Gloiopotes watsoni* Kirtisinghe (1933). Rao (1951) separated *G. zeugopteri* (=*G. longicaudatus*) from *G.watsoni*, principally on the following four characters :

1. The shape of the dorsal plates which are longer than broad,
2. the posterior claws of the first legs being trifurcate,
3. the outer ramus of the third leg being armed with bifid claw, and
4. the anal laminae not bearing any plumose setae.

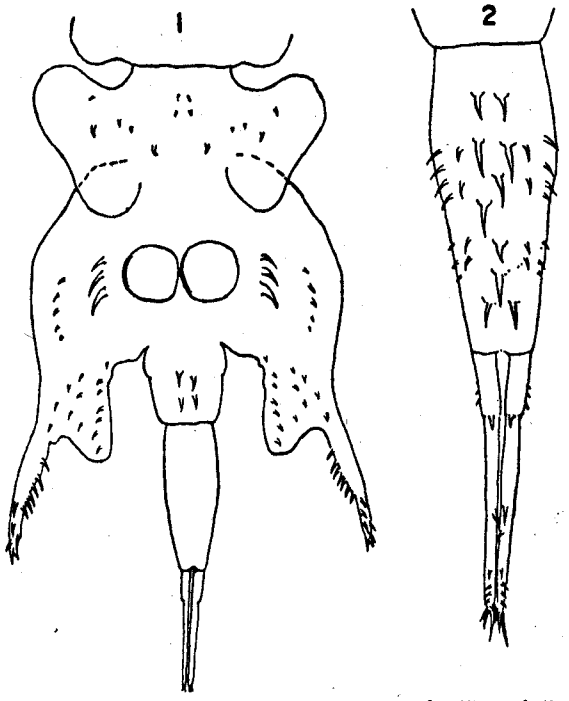


FIG. 26. *Gloiopotes longicaudatus* (Marukawa). *Female*. (1) and (2) fourth thoracic segment, genital segment, abdomen, and anal laminae, showing nature and disposition of spines (material from Gulf of Mannar).

The significance of the first and last characters in specific distinction is dubious. The second and third characters are as for the genus, but *G.watsoni* is said to differ as follows :

Posterior claws of the first legs are bifurcate ; outer ramus of third leg armed with a three-pronged claw.

We have not examined specimens nor the original description of *G. watsoni*. However, an accommodation of a species with the last mentioned two characters will involve a redefinition of the genus.

For further remarks see 'Addendum'.

Gloiopotes watsoni Kirtisinghe, 1933

Scombroid host : 'Sailfish' [=*Istiophorus gladius* (Broussonnet)].

Locality : Off Ceylon.

Non-scombroid hosts : None.

Location : External surface of body.

Remarks : See under *G. longicaudatus* (Marukawa) and also ' Addendum '.

Family : CECROPIDAE

Genus **Cecrops** Leach, 1816

Female.—Carapace oval, robust, distinctly notched in front and deeply excavated posteriorly ; frontal plates fused with carapace ; third thoracic segment with small fused dorsal plates ; fourth thoracic segment with larger fused plates ; genital segment with fused dorsal plates larger than carapace ; abdomen with expanded ventral plates, but small ; caudal laminae short ; abdomen and caudal rami concealed by overlapping plates of genital segment ; antennule small, two jointed ; antenna moderately stout, terminating in a strong hook ; other cephalic appendages as in Caligidae ; all four pairs of thoracic legs biramous ; rami of first three pairs two-jointed and those of fourth pair with a single joint.

Male.—Smaller, similar to female except dorsal plate of genital segment relatively smaller, exposing part of abdomen ; and fourth pair of legs not much enlarged.

Cecrops latreilli Leach, 1816

(Figure 27 : 1-2)

Description : Female.—As given for genus. Ovisacs numerous, irregularly coiled, concealed, eggs uniserially arranged.

Male.—As given for genus. Dorsal plates and margins of carapace smooth as in female.

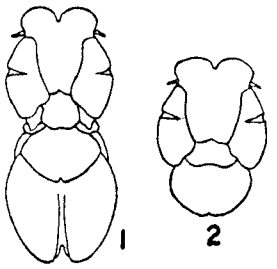


FIG. 27. *Cecrops latreilli* Leach. (1) dorsal view of female; (2) dorsal view of male (after Scott and Scott).

Scombroid host : Thynnus [=*Thunnus* (*Thunnus*) sp.].

Locality : Atlantic.

Non-scombroid hosts : Mola mola (Atlantic, Mediterranean and Pacific) ; *Scophthalmus maximus, S. rhombus* (See Brian, 1912) ; *Diodon, Pleuronectes* (See Barnard 1955).

Location : On surface of body.

References : Leach (1816) ; Baird (1850) ; Hoeven (1857) ; Scott, A. (1892) ; Bassett-Smith (1899) ; Scott, T. (1900) ; Wilson (1907, 1932) ; Elwes (1909) ; Verrill and Smith (1873) ; Rathbun R. (1884) ; Rathbun, M. J. (1905) ; Sumner *et al.* (1913) ; Stebbing (1910) ; Brian (1912) ; Thomp-

son (1899) ; Shishido (1898) ; Yamaguti (1936) ; Scott and Scott (1913) ; Barnard (1955) ; Ronald (1959) ; and Shiino (1959b).

Remarks : This species is fairly large in size, the female attaining about 25 mm. and the male 16 mm., and is reported to breed from May to October. The record from the scombroid host is by Heegaard (1943) who found a specimen on *Thynnus*, but suggests that the said host record may be due to a mistake in labelling or accidental transference from the parasite's normal host.

Family : ANTHOSOMIDAE

Genus **Lernanthropus** Blainville, 1822

Female.—Head and first thoracic segment fused into carapace, with lateral margins curved down ventrally ; second to fourth segments fused, covered by a single dorsal plate, prolonged backwards over genital segment and abdomen ; latter one or two-segmented ; antennule filiform, joints more or less fused ; antenna and maxilliped prehensile, uncinate ; first and second pairs of legs rudimentary, biramous ; rami of third and fourth pairs of legs modified ; each leg of third pair formed of fused inner and outer ramus, folded along middle and fleshy ; rami of fourth legs elongated, extending backwards, fleshy ; ovisacs elongate, filiform, eggs uniseriate.

Male.—Carapace with flat margin ; second to fourth segments fused with genital segment ; no dorsal plates ; abdomen single segmented, visible dorsally ; first, second and third legs as in female ; rami of fourth legs fused, elongate, projecting backwards.

Lernanthropus hiatus Pearse, 1951

(Figure 28 : 1-3)

Description : Female.—Unknown.

Male.—Minute (1.7 mm.) ; cephalothorax half as long as rest of body ; anal laminae not reaching as far back as endopod of fourth leg and armed above with small setae near their bases and tipped with three small setae ; antennule six-segmented ; antenna stout, terminal hook bearing two small spines ; preceding segment with one short spine ; mouth-tube slender, triangular ; maxillule with two stout terminal setae, one of which is three times length of other, maxillule separated from antenna by wide space (0.25 mm.) ; maxilla about two-thirds as long as maxilliped ; hooks of both smooth ; first leg with basipod with several acute spines, one-segmented exopod bearing five terminal spines and endopod bearing long terminal setae ; second leg with endopod terminating in sucker armed with large and small spines ; endopod with one terminal seta ; no segmentation evident in posterior half of body ; third leg with endopod less than one-third length of exopod ; endopod of fourth leg less than half that of exopod.

Scombroid host : Germo alalunga [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)].

Locality : Bimini, Bahamas, Atlantic.

Non-scombroid hosts : None.

Location : Gills.

Remarks : The wide gap between antenna and maxillule, the arrangement of spines of antenna, and the arrangement of setae on anal laminae are said to aid in distinguishing this male from the descriptions of known males of other species of the genus. See also ' Addendum ' for a recent addition to this genus.

Family : DICHELESTHIIDAE

Genus **Hatschekia** Poche, 1902

Female.—Head distinct, first three thoracic segments free or fused with each other ; rest of thorax fused with genital segment into an elongated trunk ; abdomen when present short and

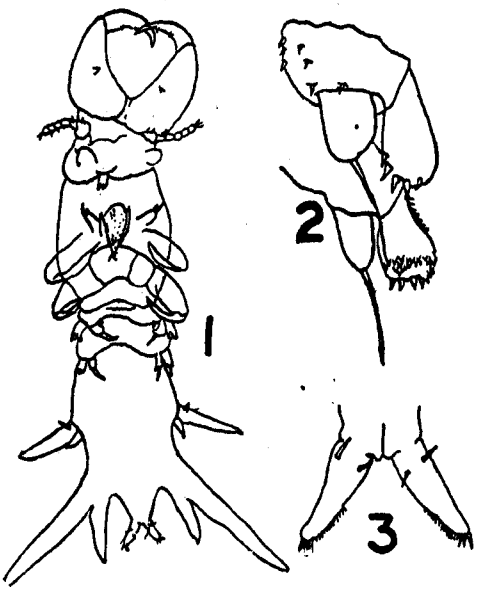


FIG. 28. *Lernanthropus hiatus* Pearse. *Male.*
(1) ventral view; (2) first and second legs; (3) caudal laminae (after Pearse).

one-segmented ; anal laminae minute ; antennule filiform, three to six-segmented ; antennae with stout apical claws ; maxillipeds slender and uncinate ; two pairs of biramous swimming legs and sometimes rudiments of third and even fourth ; fifth legs wanting ; egg strings short ; eggs large.

Male.—Head as in female ; thorax fused with genital segment into spindle-shaped trunk often with indications of segmentation ; more or less distinct, one-segmented abdomen present ; anal laminae large, armed with spines ; other appendages as in female.

Hatschekia mulli (van Beneden, 1851)

(Figure 34 : 1-12)

(Syn. *Clavella mulli* van Beneden, 1851).

Description : Female.—Body elongate, cylindrical, head small, wider than long ; rest of body indistinctly segmented ; a small rounded projection on antero-dorsal aspect of body behind head ; width of body (genital segment) about one-fourth total length ; posterior end of genital segment trilobed, lateral lobes small and distinct ; middle one broad, but not prominent ; antennule short, three-segmented ; third and fourth legs absent ; other appendages as figured.

Male.—Unknown.

Scombroid host : Scomberomorus cavella (Cuvier).

Locality : Grand Isle, Louisiana, U.S.A. (Atlantic).

Non-scombroid host : *Mullus barbatus* (Plymouth, Cornwall—British Seas).

Location : Gills.

References : van Beneden (1851) ; Bassett-Smith (1896) ; Norman and Scott (1906) ; Scott and Scott (1913) ; Causey (1953a).

Remarks : Causey (1953a) recorded this species from the above scombroid host and thus while extending its distribution to the American waters, remarks that 'I feel somewhat uncertain about this determination.'

Family : PSEUDOCYCNIDAE

Genus **Pseudocycnus** Heller, 1865

(Syn. *Cybicola* Bassett-Smith, 1898).

Female.—Head fused with first thoracic segment ; second and third segments free ; fourth and fifth segments fused with genital segment into a cylindrical body several times longer than wide and of uniform diameter throughout its length ; abdomen one-segmented, narrower than genital segment ; caudal laminae of varying length and width ; egg strings filiform, longer than broad, eggs minute ; numerous and strongly flattened ; antennule of several segments, with a tuft of setae at tip ; antenna stout, prehensile, armed with a strong claw, mouth tube short ; maxillae uncinate and setiferous ; maxillipeds large with toothed terminal claw ; first thoracic legs reduced, uniramous, one-segmented, unarmed and may in some cases be absent ; second legs biramous, rami one-segmented and setiferous ; third and fourth legs uniramous with terminal setae ; fifth legs obsolete.

Male.—Head fused with thoracic segment which is narrowed into a short neck connecting second segment ; second thoracic segment free or only partly free ; second, third and fourth segments of about same width ; fifth and genital segment fused forming trunk and of same width as preceding segments ; abdomen one-segmented, abruptly narrowed ; anal laminae foliate, armed with spines ; antennae and mouth parts as in female ; first, third and fourth legs uniramous and one-segmented ; fourth pair cylindrical, extending laterally ; second legs biramous, rami one-segmented.

Remarks : For discussion also refer 'Addendum'.

Pseudocycnus appendiculatus Heller, 1865

(Figure 29 : 1-5)

(Syn. *Pseudocycnus thynnus* Brandes, 1955).

Material examined : Two specimens, females (one damaged) were obtained by us from the gills of the northern bluefin tuna, *Kishinoella tonggol* (Bleeker) caught at Mangalore, on the west coast of India.

Recent records of this species, mainly from scombroid fishes from various parts of the world indicate its very wide distribution in the Indo-Pacific, Atlantic and Mediterranean. The present record would appear to represent the first record of this species from the Indian coast from a new host species.

Description : Female.—Carapace ovate, slightly broader than trunk ; posterior margins prolonged into wide rounded lobes above level of maxillipeds ; first segment seen dorsally as narrow neck between lobes of carapace, less than one-fourth width of latter, and ventrally carrying first legs ; second, third and fourth segments globular, increasing gradually in size, fourth

being slightly the larger ; only slight constrictions between segments ; along antero-dorsal border of each of these three segments, on either side, a latero-dorsal lamina in the form of a thick margin (rudimentary dorsal plates as given by Wilson, 1932) present, the ones on fourth segment digitiform ; fourth and fifth segments fused with genital segment ; abdomen half as wide as trunk, single-segmented carrying anus on dorsal side ; caudal laminae lanceolate, acutely pointed, divergent and about one-third total length ; antennule four-segmented, one spine-like seta on outer terminal end of second segment from base ; terminal segment longer than penultimate and carrying two or three stumpy setae ; antenna of a stout basal segment and a strong terminal claw bearing dentate projections on inner surface ; mandibles styliform apparently toothless ; maxillules filiform, three-segmented, segments bent upon themselves ; terminal segment bifurcate ; maxillae three-segmented ; basal segment enlarged, middle segment slender, with anterior margins crenulate and provided with a row of stout spines ; terminal segment short, curved, claw-like ; maxillipeds stout, powerful, prehensile organ, two-segmented ; terminal segment with undulating margin giving dentate appearance, with a sharp spine on inner margin being capable of flexion against basal joint ; latter with a toothed projection on inner margin at about midlength ; first legs reduced into small flattened plates without setae and situated immediately inside basal joints of maxillipeds ; second and third legs as for genus ; fourth legs minute, four-jointed, each leg projects from lateral margin immediately behind dorsal laminae of fourth segment; egg strings slender, cylindrical and greatly elongate being much longer than total length.

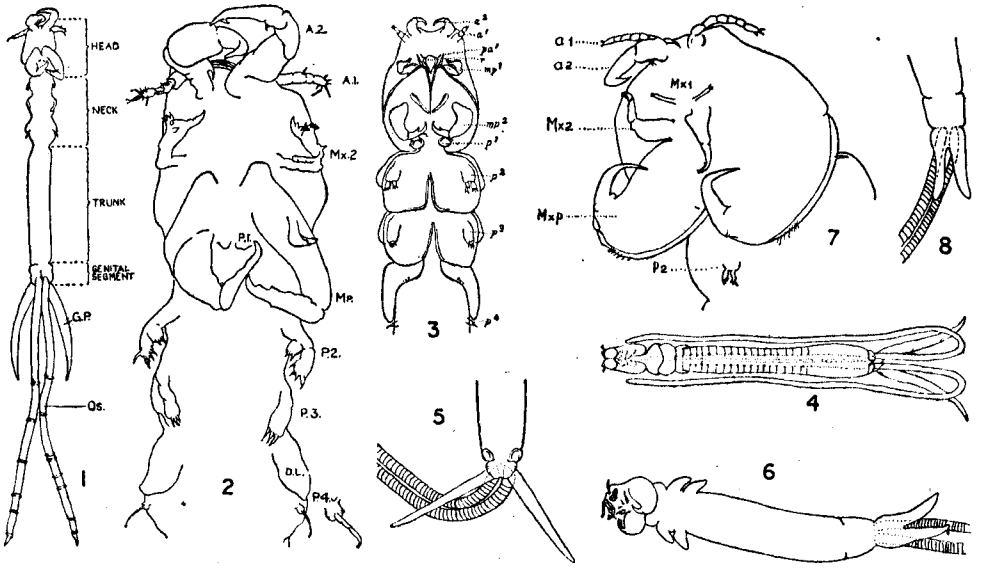


FIG. 29. *Pseudocycnus appendiculatus* Heller. 1-5. *Female.* (1) ventral view; (2) and (3) ventral view of cephalothorax showing appendages; (4) dorsal view; (5) posterior end of body enlarged, showing anal laminae; *Pseudocycnus armatus* Bassett-Smith. 6-8. *Female.* (6) ventral view; (7) ventral view, anterior part of cephalothorax showing appendages (only right antenna shown); (8) posterior end of body showing abdomen and anal laminae (Figures 1-2 after Leigh-Sharpe; figures 3-4 after Heller; figures 5-8 from actual material examined. Figures 5 and 8 are drawn to same scale).

Male.—Carapace ovate, nearly as wide as long, with a small rostrum ; behind head and more or less fused with it the first segment forms a narrow short neck ; second segment wider and at least four times as long as first ; third segment wider than second, but shorter ; fourth segment still wider and longer ; fourth legs extending as cylinders from lateral margin ; fifth and genital segments fused, as wide as fourth segment, with a small spine at centre of each lateral margin ; abdomen one segmented, longer than wide, enlarged posteriorly ; caudal laminae longer than abdomen, divergent, bluntly rounded, each with an apical fringe of minute spines ; appendages similar to those of female. Total length 3.5 mm.

Scombroid hosts : 1. *Orcynus alalonga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterre)]
2. *Sarda chilensis* (Cuvier and Valenciennes)
3. *Euthynnus yaito* [=*Euthynnus affinis yaito* (Kishinouye)]
4. *Neothunnus macropterus* [=*Thunnus* (*Thunnus*) *albacares macropterus* (Temminek and Schlegel)]
5. *Euthynnus alletteratus* (Rafinesque)
6. *Thunnus thynnus* [=*Thunnus* (*Thunnus*) *thynnus thynnus* (Linnaeus)]
7. *Sarda sarda* (Bloch)
8. *Kishinoella tonggol* (Bleeker)

Localities : 1. South of Marthas Vineyard, New England Coast, U.S.A. ; 2. Acapulco, Guerrero, Mexico (Pacific) ; 3. North of Missol, New Guinea (Pacific) ; 4. 18°24′ N., 104°38′ W. ; 5, 6 and 7. See Shiino 1959e ; 8. present record from Mangalore, West Coast of India.

Non-scombroid hosts : *Coryphaena* sp. (Atlantic).

Location : Gills.

References : Heller (1865) ; Bassett-Smith (1898) ; Brian (1902, 1906, 1908, 1912) ; Wilson (1922, 1932) ; Leigh-Sharpe (1930) ; Kirtisinghe, (1935) ; Klinberg (1942) ; Carvalho (1951) ; Brandes (1955) ; Pearse (1956 ?) ; Shiino (1959e) ; Richiardi (1880) ; Carus (1885) ; Stebbing (1900) ; Causey (1960).

Remarks : There appears to be notable differences in the total lengths of mature females described by various authors. Wilson gives 12-16 mm. (total length including caudal laminae) for Atlantic specimens, while Leigh-Sharpe gives 13.2 mm., and Shiino 13.0 to 14.3 mm. The single undamaged specimen in our collection measures only 10.6 mm. It is quite likely, the differences in the length of this parasite species may be due to differences in the lengths of the gill filaments in the different host species, because *P. appendiculatus* is found to lie closely adpressed to the gill filaments. In fact, Leigh-Sharpe (1930) mentions that 'The entire head was buried in a spherical cyst from which it had to be dissected out . . .'

The differences in proportionate measurements for specimens from various localities in the Indo-Pacific may be made out from data given in Table 2.

TABLE 2

Measurements (in mm.) of *Pseudocycnus appendiculatus* Heller from various localities from the Indo-Pacific.

Characters	Shiino, 1959e 6°30′N., 77°53′W.	Shiino, 1959b			Leigh-Sharpe (1930)	Present record from W. Coast, India
		81°00′ E. 11°45′ N.	77°20′E., Spec. No. 1	5°40′S., Spec. No. 2		
Total length (excluding anal laminae)	9.73	8.7	11.6	9.3	10.8	8.0
Carapace length × width	1.10×1.07	1.2×1.2	1.4×1.3	1.2×1.0	1.3×—	—
First thoracic segment : L × W	0.10×0.53	[0.8×1.2	0.6×1.3	0.7×1.6]	[1.7×—	—
Second thoracic segment : L × W	0.73×1.09					0.5×—
Third thoracic segment : L × W	0.60×1.20	0.5×1.2	0.5×1.3	0.4×1.0	—	0.5×—
Rest of body : L × W	7.40×1.33	6.5×1.4	11.1*×1.5	6.5×1.1	..	5.5×1.2
Genital segment	..	..	..	..	0.3	..
Anal lamina	3.73	4.3	5.4	3.3	2.4	2.6
Length of egg string	24.8	..	..	..	6.6	10.5

*Shiino's figure of '11.1' is an error, and should be 9.1 as can be deduced from other measurements given by him for the same specimen.

Pseudocycnus armatus (Bassett-Smith, 1898)

(Figure 29 : 6-8 ; and 15 : 1-11)

(Syn. *Helleria armata* Bassett-Smith, 1898 - genus *Helleria* Bassett-Smith is preoccupied and hence changed to *Cybicola* by Bassett-Smith, 1898).

Material examined : Our collection contains several female specimens obtained from the seerfish, *Scomberomorus commerson* (Lacépède) from the Andaman Sea.

Description : Female.—Head rounded, shallow central sulcus between antennules ; first three thoracic segments fairly distinct, devoid of carapace ; laterally thoracic segments produced into lobes, which in second and third segments are blunt and digitiform, a very conspicuous feature of this species ; fourth, fifth and genital segments fused into trunk ; abdomen short, less than width of trunk and indistinctly separated from latter ; anal laminae foliate, of each side fused in basal one third and confluent with abdomen ; length much greater than width of trunk and about 3.5 in total length ; egg strings greatly elongate, about as long as total length, eggs minute, numerous and greatly flattened ; antennule six jointed ; antenna three jointed, strongly hooked at end ; second maxillipeds very large, basal joint robust ; thoracic appendages as for genus.

Measurements (mm.) : For one egg-bearing female in the collection : Total length excluding anal laminae 6.8 ; length of anal laminae 1.0 ; length of head 1.1 ; second thoracic segment 0.5 ; third thoracic segment 0.32 ; length of egg string 7.0.

Male.—Elongate, head rounded, fused with first thoracic segment to form cephalothorax, latter narrowed posteriorly ; antennule six jointed, directed laterally ; antenna projecting anteriorly ; maxillae visible outside lateral margins of cephalothorax ; maxillipeds as large lateral lobes below posterior region of cephalothorax and second thoracic segment ; latter incompletely fused with first and third segments ; and about two-thirds as wide as head ; third segment fused with fourth and subsequent segments to form elongate cylindrical trunk ; abdomen one segmented, narrower than genital segment ; anal laminae foliate, slightly longer than abdomen ; antennule seven segmented, terminal segment setose ; antenna three segmented forming strong prehensile organ ; terminal claw strongly curved and sharply pointed with a small spine on its inner margin ; mouth tube pear-shaped ; maxillule two segmented ; basal segment long, terminal segment much shorter, bifid at tip ; maxilla two segmented ; basal segment cylindrical, terminal longer and ending in a claw, concavity of which is covered with numerous minute setae ; maxilliped large, two segmented ; second segment ending in a strong curved claw, which carries a minute spine at its inner border ; appendage of first thoracic segment modified to form a pair of elongate styles arising from flattened bases ; second legs biramous, with a basal segment and one segmented rami ; former with a large seta on its outer margin ; rami of about equal size ; endopodite tipped with a long jointed seta and two smaller setae, exopodite with three setae, outermost of which is largest ; third legs uniramous, one segmented, tipped with two or three setae ; fourth legs represented by a seta arising from a short stumpy base on lateral margin of segment.

Measurements (mm.) : Male.—Total length 2.6 ; cephalothorax 0.6 ; thorax and trunk 1.6 ; abdomen and anal laminae 0.4 (after Kirtisinghe).

Scombroid hosts : 1. *Cybium guttatum* [=*Scomberomorus guttatus guttatus* (Bloch and Schneider)]
2. *Cybium commersoni* [=*Scomberomorus commerson* (Lacépède)]
3. *Scomberomorus commerson* (Lacépède)

Localities : 1-3. Bombay coast, India ; Ceylon coast ; Andaman Islands, Andaman Sea (Bay of Bengal) respectively.

Non-scombroid hosts : None.

Location : Gills.

References : Bassett-Smith (1898) ; Kirtisinghe (1935, 1937). For additional recent records reference may be made to the section " Addendum ".

Pseudocycnus buccatus Wilson, 1922

Description : Female.—Carapace ovate, considerably wide anteriorly and narrow posteriorly where it is divided into two lobes by a narrow median sinus ; second segment not as wide as head ; narrowed anteriorly widest across posterior margin ; third segment wider and shorter than second ; subsequent segments fused into trunk which is five times as long as wide ; egg strings relatively broader, being one third as wide as trunk, and as long as it ; abdomen half width of trunk ; one segmented caudal laminae short and conical, each tipped with single seta; antennule indistinctly three segmented ; terminal claw of antenna with an accessory spine on its inner margin near centre ; and maxilliped greatly enlarged, terminal claw long and slender ; first legs mere knobs ; each second leg a bilobed lamina appearing as two rami ; third leg a short and wide lamina ; fourth leg obsolete. Total length 4.0-5.0 mm.

Male.—Unknown.

Scombroid hosts :
1. *Scomberomorus cavalla* (Cuvier)
2. *Scomberomorus maculatus* (Mitchill)
3. *Scomberomorus regalis* (Bloch)
4. *Scomberomorus maculatus* (Mitchill)
5. *Scomberomorus sierra* [=*Scomberomorus maculatus* (Mitchell)]

Localities : 1 & 2. Woods Hole and Marthas Vineyard, U.S.A. (N.W. Atlantic) and Texas Coast, U.S.A. ; 1. also from Veracruz, Gulf of Mexico ; 3 & 4. Veracruz and Anton Lizardo near Veracruz, Gulf of Mexico respectively ; 5. Cholla Bay near Puerto Penasco, Sonora, Mexico.

Non-scombroid hosts : Paralabrax maculatofasciatus (Cholla Bay, near Puerto Penasco, Sonora, Mexico).

Locations : Gills and demibranchs.

References : Wilson (1922, 1932) ; Causey (1960).

Remarks : Wilson (1922) mentioned that in *P. buccatus* the antennule is six segmented, an error subsequently corrected by him in 1932 to read '. . . first antenna indistinctly 3-segmented.' Causey (1960) remarks that the Pacific forms of this species may be slightly smaller than the Gulf of Mexico representatives.

Pseudocycnus elongatus (Pearse, 1951)

(Figure 30 : 1-5)

(Syn. *Cybicola elongata* Pearse, 1951)

Description : Female.—Body elongate, more than 9 times as long as wide ; segmentation indistinct ; head slightly wider than body with a small median sinus in front, rounded behind; head slightly more than 7 times in total length (excluding anal laminae) ; thorax with lateral constrictions that separate first two segments, and swellings that indicate third ; genital segment and abdomen not distinctly demarcated ; caudal laminae shorter than abdomen, tips bearing

one long and two short setae ; antennule seven segmented, a seta on basal segment and at least three on tip ; antenna small, three segmented, terminal hook with a spine on inner margin ; mouth tube slender and conical ; maxillule with a small terminal hook and two strong setae ; maxilla small, slender with curved terminal hook ; maxillipeds enormous, covering most of ventral side of head, with lamellate outer margin on penultimate segment except where terminal hook

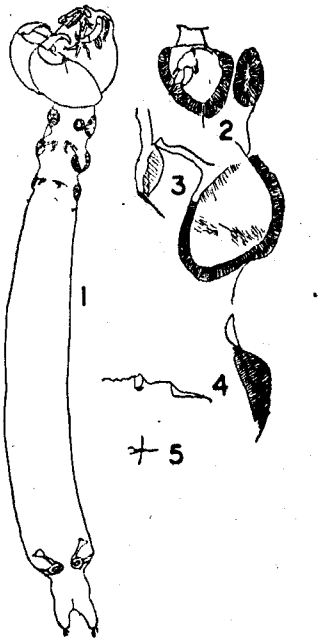


FIG. 30. *Pseudocycnus elongatus* Pearse. *Female.* (1) ventral view ; (2) first legs ; (3) second legs ; (4) third legs ; (5) fourth legs (after Pearse).

meets it where it is smooth, but further proximal it is setose ; a stout short spine at medial base of terminal hook which is sharply curved ; first leg surrounded by, and first three legs associated with, lateral, finely papillose areas ; first leg biramous, with a spine at base and a spine at either side of distal margin of basal segment ; exopod one segmented, with four minute spines at tip ; endopod uniramous with a seta at tip ; papillose area with a seta at posterior margin of disc that surrounds appendage ; another elliptical papillose area on lateral margin near first leg ; second leg uniramous, flat, rounded at tip, with a row of striations on lateral surface ; papillose area lateral to it, oval and larger than that of first leg ; third leg very small, single segment with a small curved terminal hook ; fourth leg represented by a seta that arises from a papilla. Total length 5.3 mm. ; head 0.7 mm.

Male.—Unknown.

Scombroid host : *Scomberomorus maculatus* (Mitchill)

Locality : Bimini, Bahamas, Atlantic.

Non-scombroid hosts : None.

Location : Gills.

Pseudocycnus spinosus Pearse, 1952

Scombroid host : *Scomberomorus* spp.

Locality : Texas Coast, U.S.A. (Atlantic).

Non-scombroid host : *Cynoscyon nebulosus* (Texas Coast, U.S.A., Atlantic).

Location : Gills.

Family : LERNAEIDAE

Genus **Lernaecenicus** LeSueur, 1824

Female.—Head and thorax fused, former furnished with 2 to 10 slender cylindrical horns which are simple or branched ; thorax just behind head enlarged and furnished with four pairs of legs close together ; behind legs thorax filiform and chitinous, twisted, and usually flexed for half length of body or more from whence it enlarges into straight cylindrical trunk eventually narrowing into an abdomen ; caudal laminae minute or lacking ; egg strings filiform and very long ; antennules present ; antennae chelate ; mandibles without teeth ; only one pair of maxilla ; maxillipeds absent ; first two pairs of legs biramous, third and fourth pairs uniramous ; fifth pair wanting.

Lernaecenicus longiventris Wilson, 1917

Description : Female.—Head at right angles to neck, without horns, but with 3 knobs, one posterior and two lateral ; neck much longer than trunk and becoming narrower backwards ; trunk cylindrical, portion representing genital segment one fourth as long as neck, and four times as long as wide ; portion representing abdomen filiform, half as long as neck, about thirty times as long as wide ; legs as for genus, rami two segmented ; and armed with plumose setae. Total length 40-50 mm. ; length of egg strings 10-15 mm.

Scombroid host : *Scomberomorus maculatus* (Mitchill).

Locality : Woods Hole, Massachusetts, U.S.A. (Atlantic).

Non-scombroid hosts : *Palinurichthys perciformis*, *Pomatomus saltatrix*, *Caranx hippos*, *Caranx chrysos* (Woods Hole, Massachusetts, U.S.A. N.W. Atlantic) ; *Coryphaena hippurus* (Atlantic S.E. of Nantucket, U.S.A.) ; *Pogonias chromis* (Norfolk, Virginia, U.S.A.) ; *Mugil cephalus* (Beaufort, North Carolina, U.S.A.) ; *Seriola dorsalis* (Mazatalan, Sinaloa, Gulf of Mexico) ; *Caranx hippos* and *Rachycentron canadus* (Texas Coast, U.S.A.—Causey 1953) ; *Caranx chrysos*, *Coryphaena hippurus* and *Phycis floridanus* (Grand Isle, Louisiana, U.S.A.—Causey, 1953).

Locations : From sides of body of host ; also observed on gills and operculum.

References : Wilson (1917, 1932) ; Causey (1960).

Remarks : Wilson (1932) remarks that the head of this parasite is buried close to the backbone of its host and is surrounded with a fibrous tough membrane. Generally only a single specimen is found on a host individual.

Lernaecenicus seeri Kirtisinghe, 1934

Scombroid host : Seerfish, *Cybium* sp. [=*Scomberomorus* sp.]

Locality : Ceylon coast.

Non-scombroid hosts : None.

Location : Sides of body of host.

Lernaeenicus sp. Rao, 1951

Scombroid host : *Scomber scomber* [=? *Rastralliger kanagurta* (Cuvier)]

Locality : Lawson's Bay, Waltair, Andhra coast, India (Bay of Bengal).

Non-scombroid hosts : None.

Location : On body.

Remarks : Host record is wrong as the true *Scomber scomber* (=*Scomber scombrus*) is thus far known from the Atlantic and Mediterranean. It is quite likely that the specimen was observed on the Indian mackerel *Rastrelliger kanagurta* by Rao (1951). No description of the parasite is given.

Family : PENNELLIDAE

Genus **Pennella** Oken, 1816

(Syn. *Baculus* Lubbock, 1860 ; *Hessella* Brady, 1883—both representing young female).

Female (adult).—Head more or less globular, fused with first segment, with two or three horns or processes for attachment ; anteriorly head truncate, trunk elongate, straight, transversely ridged ; abdomen short, annulated carrying plumose appendages laterally ; a pair of minute caudal laminae carrying long setae ; egg strings filiform, several times length of body ; antennule with few segments ; antenna chelate ; mouth parts obsolete ; first and second pairs of legs biramous, situated close together ; third and fourth pairs uniramous, all rami two jointed, setose.

Copepodid male.—Head fused with first segment ; second third and fourth segments free and diminishing in width ; fifth and genital segments fused ; abdomen one segmented, caudal rami wide, setose ; antennule indistinctly jointed ; antenna two jointed with stout chela ; mandibles, two pairs of maxillae, and a pair of maxillipeds well developed ; legs as in female ; fifth pair absent.

Adult females are parasitic on fishes and marine mammals.

Pennella biloba Kirtisinghe, 1933

(Figure 31 : 6-8)

Description : Female.—Head twice as broad, marked dorsally by two grooves which divide it into a median triangular area and two lateral lobes, base of triangular area merging with neck ; two types of papillae present on heart-shaped ventrally inclined anterior end of head —large irregularly arranged papillae seen along border while smaller papillae present on either side of mouth ; a pair of lateral horns lying at right angles to head ; horns of uniform diameter, bluntly rounded distally ; neck separated from genital segment by slight constriction ; genital segment broader than neck, tapering gently towards its posterior end ; neck and genital segment of same length ; transverse ridges absent on genital segment and abdomen ; appendages ill-developed ; antennule not traceable ; antenna a pair of short three jointed processes on dorsal side of head at apex of triangular area ; legs greatly reduced, retaining only their basal joints ; distance between second and third pairs of legs more than that between first and second or third and fourth pairs. Total length 32 mm. ; head 1.0 ; width of head 2.0 ; length of horn 3.0 ; neck 12.0 ; genital segment 12 ; abdomen 7 ; egg strings 16.

Scombroid host : *Histiophorus brevirostris* Playfair [=*Makaira indica* (Cuvier)].

Locality : South West coast of Ceylon.

Non-scombroid hosts : None.

Location : Found attached close to pelvic fins of host.

Pennella costai Richiardi, 1880

Scombroid host : Xiphias gladius Linnaeus.

Locality : Mediterranean ; probably also N.W. Atlantic (Rathbun, M. J. 1905).

Non-scombroid hosts : None.

Location : Head buried in cyst formed inside internal organs of host (Sumner *et al.* 1913).

Remarks : Heavy infestation of 30 to 40 individuals of this species in one host individual is known, appearing to impair the vitality of the fish. (Sumner *et al*, 1913).

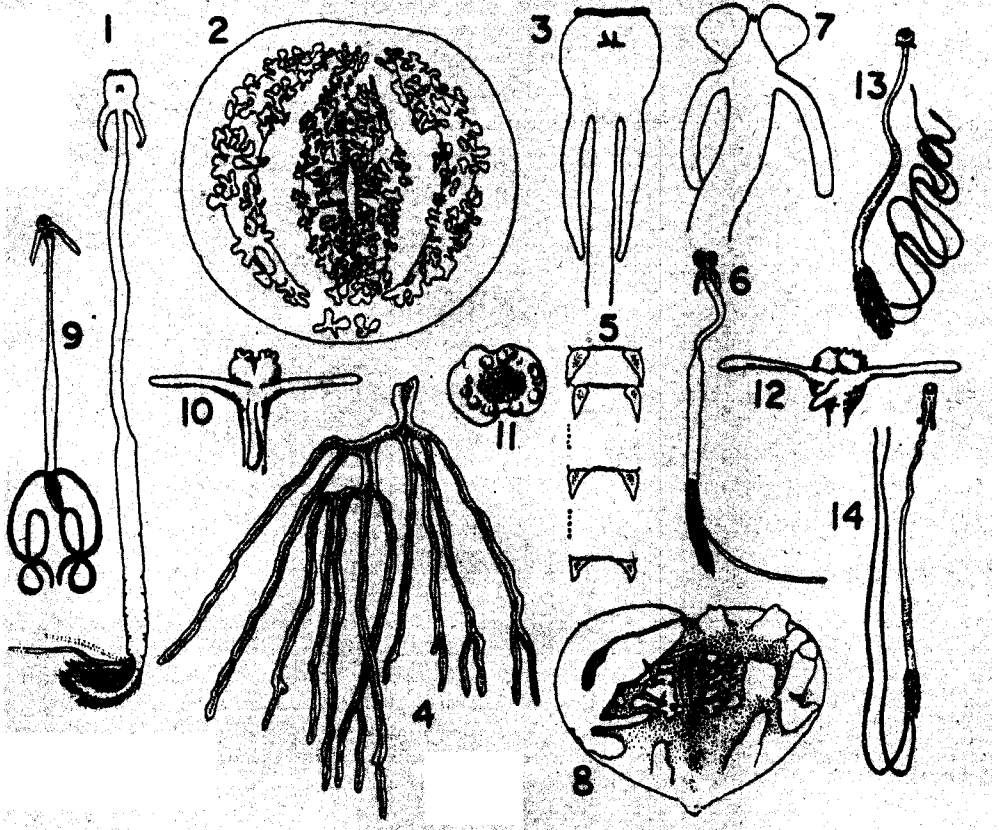


FIG. 31. *Pennella zeylanica* Kirtisinghe. (= *P. instructa*) *Female.* (1) entire specimen ; (2) papillae of head ; (3) head and horns ; (4) abdominal appendages ; (5) thoracic legs : *P. biloba* Kirtisinghe. *Female.* (6) entire animal (7) dorsal view of head and horns ; (8) anterior surface of head showing papillae : *P. orthagoriswi* Wright. *Female.* (9) ventral view of entire animal ; *P. crassicornis* Steenstrup and Lutken. *Female.* (10) and (11) dorsal and slightly oblique views of head ; (12) ventral (buccal) surface of head : *P. filosa* (Linnaeus). *Female* (13) dorsal view of entire animal : *P. instructa* Wilson. *Female.* (14) dorsal view of specimen from Woods Hole area U.S.A. (after Kirtisinghe ; Barnard ; and Wilson).

Pennella filosa (Linnaeus, 1758)

(Figure 31 : 13)

(Syn. *Pennatula filosa* Linnaeus, 1758)

Description : Female.—Head wider than long, papillae uniform in size and distribution, two short stout horns projecting nearly at right angles to head ; often a more or less developed median third horn between bases of aforesaid two ; neck varying in length ; trunk twice as wide as neck and transversely ridged ; abdomen about half length of trunk, plumes profusely branched ; egg strings slender, at least twice length of body.

Scombroid hosts : 1. *Xiphias gladius* Linnaeus.
2. *Istiophorus grayei* [=*Istiophorus gladius* (Broussonnet)]
3. Tunny [=*Thunnus* (*Thunnus*) sp.]

Localities : 1. Marthas Vineyard, U.S.A. (N.W. Atlantic) ; 2. Guaymas, Mazatlan, Acapulco, Mexico (Pacific coast of Mexico—Causey, 1960) ; 3. See Barnard, (1955).

Non-scombroid hosts : *Mola mola* (Atlantic and Mediterranean).

Location : Found partly buried on sides of body of host.

References : Linnaeus (1758) ; Guerin-Meneville (1829-43) ; Steenstrup and Lutken (1861) ; Bassett-Smith (1899) ; Scott, T. (1905) ; Norman and Scott (1906) ; Scott and Scott (1913) ; Sumner *et al.* (1913) ; Stebbing (1905-as *P. orthagorisci*) ; Brian (1908, 1912) ; Quidor (1913) ; Wilson (1917, 1932) ; Leigh-Sharpe (1928) ; Delamare—Deboutteville and Nunes-Ruivo (1954) ; Barnard (1955) ; Causey (1960).

Remarks : Causey (1960) mentions that the species is found often encrusted with the barnacle *Chonchoderma.*

Pennella instructa Wilson, 1917

(Figure 31 : 1-5 and 14)

(Syn. *Pennella zeylanica* Kirtisinghe, 1932)

Description : Female.—Head longer than wide, squarely truncated anteriorly ; short papillae not covering truncated surface, but arranged in pattern ; lateral margins of head concave ; horns long, soft, bluntly pointed, extending backwards parallel to neck and lying close to it ; never more than two horns ; neck two times length and half width of trunk and generally bent and twisted ; trunk transversely ridged ; abdomen half as long as trunk ; plumes about 24 on each side and each dichotomously branched ; antennule four segmented, heavily armed with setae ; antenna two segmented ; distance separating legs are in ratio of 1:5:6. Total length 200-250 mm.

Scombroid hosts : 1. *Xiphias gladius* Linnaeus.
2. *Histiophorus gladius* Day [=*Istiophorus gladius* (Broussonnet)]

Localities : 1. Marthas Vineyard and Nantucket, U.S.A., N.W. Atlantic ; 2. South coast of Ceylon, Indian Ocean.

Non-scombroid hosts : None.

Locations : In a personal communication Dr. Kirtisinghe informs us that his *P. zeylanica* is synonymous with Wilson's *P. instructa*. Kirtisinghe (1932) found at least four specimens of *P. zeylanica* (=*P. instructa*) attached to the sides and belly of the sailfish from Ceylon. Wilson (1932) remarks that in the swordfish *X. gladius* the parasite burrows into the flesh of the host until its head is brought into contact with the fish's dorsal aorta. A tough cyst 50 mm. or more in diameter often forms round the head and neck of the parasite.

Remarks : The disjunct distribution of this species, thus in the North Western Atlantic and in the Indian Ocean near Ceylon is of considerable interest. See also 'Addendum' for recent additional records.

Pennella crassicornis Steenstrup and Lutken, 1861

(Figure 31 : 10-12)

Scombroid host : *Xiphias gladius* Linnaeus.

Locality : Algerian Coast, Mediterranean (Monod, 1938).

Non-scombroid hosts : Fish : *Mola mola* (Mediterranean—Brian, 1912).

Also known from Cetacea, *Balaenoptera acutorostrata*, *Hyperoodon*. (Loc. Table Bay, South Africa and Faroes Islands respectively).

Location : Partly embedded on sides of body of host.

References : Steenstrup and Lutken (1861) ; Brian (1912) ; Monod (1938) ; Delamare—Deboutteville and Nunes-Ruivo (1954) ; and Barnard (1955).

Remarks : Although known from at least two fish hosts and two cetaceans, as Barnard (1955) has drawn attention to, there appear to be variations in this species, at least as could be noted from different descriptions. Present records indicate its occurrence only in the Mediterranean, N.E., and S.E. Atlantic.

Pennella orthagorisci Wright, 1870

(Figure 31 : 9)

Scombroid host : *Germo alalonga* [=*Thunnus* (*Thunnus*) *alalunga* (Bonnaterrae)].

Locality : See Barnard (1955).

Non-scombroid hosts : *Mola mola* (North Atlantic-Europe and N.America) ; Table Bay, South Africa.

Location : Partly embedded in flesh of host.

References : Wright (1870) ; Wilson (1917, 1924, 1932) ; Leigh-Sharpe (1928) ; Stebbing (1905, 1910) ; Giard (1889) ; Scott and Scott (1913-in part) ; Steenstrup and Lutken (1861) ; Brian (1912) ; Barnard (1955).

Remarks : Barnard (1955) doubts whether *P. orthagorisci* could be maintained as distinct from *P. filosa* on Wilson's diagnoses of Wright's species which is characterised as having 2 (or 3) slender horns, longer than head and directed obliquely backwards ; and abdomen one-third to two-fifths length of trunk.

Order : LERNAEOPODOIDA

Family : CHONDRACANTHIDAE

Genus **Chondracanthus** Delaroche, 1811

Female.—Head small, separated from thorax by clearly defined constriction ; first and second segments usually free, narrower than head and posterior body ; remaining segments fused with genital segment into a trunk indistinctly divided near its centre and produced at its posterior corners and ventrally or laterally into paired processes ; abdomen very small, situated between lateral processes; one or two segmented ; caudal laminae absent ; antennule moderately large, fleshy, more or less conspicuous in front and somewhat rudimentary in structure ; antenna very short, armed with strong terminal hooks to form prehensile structure ; mandibles fulciform at proximal end ; but tapering to more or less attenuated distal extremity ; both margins with minute serrations or spines ; maxillule small, provided with a straight terminal spine which is toothed on its outer margin ; two pairs of biramous legs, rami rudimentary.

Male.—Minute, head fused with first segment and considerably dilated than rest of body ; second segment free carrying second pair of legs ; trunk four segmented ; caudal laminae well developed, conical ; two pairs of uniramous one segmented legs, each ramus cylindrical with two apical setae, often laminate with an anterior process.

Chondracanthus xiphiae (Guerin) ? Cuvier, 1829

Scombroid host : *Xiphias gladius* Linnaeus.

Locality : Atlantic ?

Non-scombroid hosts : None.

Location : Gills.

References : See also Milne-Edward (1840) ; Goode (1883).

Remarks : We have not seen a description of this species, except the remarks given by Goode (1883) wherein he merely mentions that ' This species also lives on the gills of the sword-fish.'

Chondracanthus lophii Johnston, 1836

(Figure 32 : 1-7)

(Syn. *Chondracanthus gibbosus* Kroyer, 1837-38).

Description : Female.—Head longer than wide, with lateral projections near hind corner ; thoracic segment indistinctly bisegmented into two lateral processes, hinder one shorter ; genital segment constricted in middle, anterior portion with an obscurely bifid lateral process, posterior portion with two pseudolateral processes ; abdomen small, dorsally concealed by a more or less

elongate process ; mid-dorsally throughout length of thorax and genital segments digitiform processes present ; antennule obscurely jointed, strongly expanded at base ; egg strings long, curved or twisted. Total length 12.0 mm.

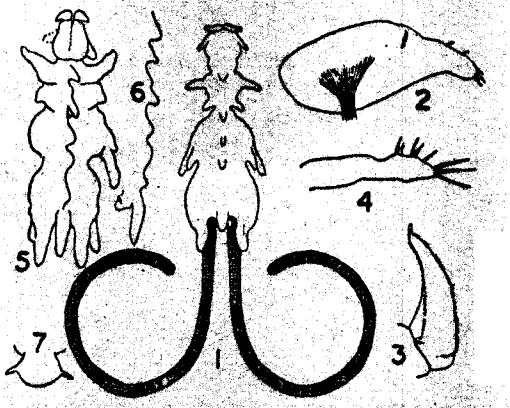


FIG. 32. *Chondracanthus lophii* Johnston. *Female.* (English seas) (1) dorsal view ; (2) antennule ; (3) mandible ; (4) maxilla ; (5) dorsal view of female from Agulhas Bank, S. Africa ; (6) dorsal profile of same ; (7) abdomen of same (Note differences in nature and disposition of lateral process between specimens from English seas and South African coast (after Scott ; and Barnard).

Male.—Minute, pyriform in shape, considerably swollen anteriorly, but tapering posteriorly ; provided with strongly uncinate foot-jaws.

Scombroid host : *Thynnus* sp. [= *Thunnus* sp.]

Locality : Atlantic (see Milne-Edwards, 1840 ; and Pesta 1934).

Non-scombroid host : *Lophius piscatorius* (European waters ; and South Africa).

Location : In *L.piscatorius* found in gill pouch.

References : Johnston (1836) ; Turner and Wilson (1862) ; Bassett-Smith (1899) ; Scott and Scott (1913) ; Goggio (1927) ; Oakley (1930); Sproston (1942) ; Barnard (1948, 1955) ; Pesta (1934) ; Kroyer (1837-38) ; Rathke (1843) ; Thompson (1847) ; Baird (1850) ; van Beneden (1851) ; Vogt (1877) ; Scott, T. (1900) ; Timm (1894) ; Graeffe (1902) ; Brian (1906) ; Hansen (1923) ; Milne-Edwards (1840).

Remarks : Although the species has been very widely known from *L. piscatorius* from the Atlantic and the Mediterranean, the only reference we could find of its occurrence on a scombroid fish is a remark made by Pesta (1934). A definite scombroid host record for *C. lophii* appears to be wanting.

Family : LERNAEOPODIDAE

Genus **Clavellopsis** Wilson, 1915

Female.—Cephalothorax short and thick ; trunk squat, often wider than long, often with posterior processes ; abdomen and anal laminae wanting ; an unpaired genital process present ; antennule four jointed ; antenna biramous, endopod one jointed, exopod two jointed ; maxilla short, broad, fused, with folds of skin or swellings, with apical bulbs.

Male.—Cephalothorax and trunk at right angles, latter strongly arched dorsally, unsegmented, hind end projecting below bases of maxilla ; antennule three jointed ; antenna biramous, each ramus one jointed ; maxillule tripartite.

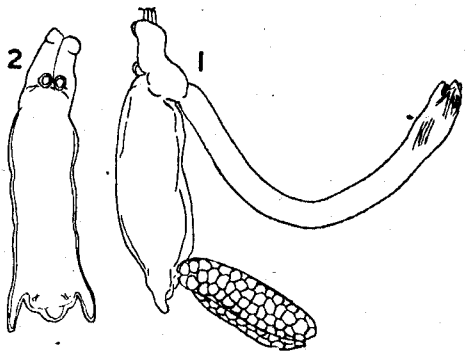


FIG. 33. *Clavellopsis saba* Yamaguti. *Adult Female.* (1) lateral view ; (2) trunk and arm. (after Shiino).

Clavellopsis saba Yamaguti, 1939

(Figure 33 : 1-2)

Scombroid host : *Scomber scomber japonicus* (=*Scomber japonicus japonicus* Houttuyn).

Locality : Tsunodayama, Niigata Prefecture, Japan.

Non-scombroid hosts : None.

Location : Gills.

Reference : Yamaguti (1939) ; Shiino (1959b).

Remarks : See ' Addendum ', for further notes on this and an allied specie.

Genus **Charopinus** Kroyer, 1863

Female.—Head more or less well demarcated from trunk, with or without carapace ; cephalothorax elongate often flexed backwards ; trunk swollen, pear-shaped, flattened dorso-ventrally with a pair of posterior processes dorsal to egg strings ; genital process, abdomen and anal laminae wanting ; egg strings long, cylindrical ; antennules indistinctly four jointed ; antenna biramous ; maxilla elongate, either fused at tips into bulla of varying shape or each one apically enlarged into a chitinous bar or knob.

Male.—Anterior portion of head at right angles to posterior portion of head and thorax ; carapace absent ; thorax segmented ; genital segment enlarged ; abdomen well defined ; segmented and tipped with anal laminae ; antennules two, three or four jointed ; maxillules tripartite palps with two setae each ; maxilla and maxillipede some distance behind other mouth parts, but each, close together and separated by a groove.

The genus is distinguished from *Brachiella* Cuvier by the more elongate maxillae in female, and by the segmentation of body in the male. Generally parasitic in the nasal passages, spiracles and gills of elasmobranchs.

Charopinus quarternius Wilson, 1915

(Figure 34 : 13-20)

Description : Female.—Head with carapace covering entire dorsal surface and part of lateral sides ; neck well defined with indistinct transverse grooves ; two pairs of posterior processes, one median and one lateral, very unequal in length and both pairs ventral to egg strings ; median pair flattened dorso-ventrally and pointed, their bases fused along mid-ventral line and 5/7th as long as trunk ; lateral pairs also flattened ; laminae triangular in shape, one at each posterior corner, one-fourth as long as median pair ; egg strings attached between median and lateral processes and dorsal to both, and equalling total length ; appendages as shown in figure ; however, maxilla removed to some distance behind maxilliped, entirely separate, except a slight adhesion at inner surfaces of two bullas which are in contact and slightly fused ; maxillipeds close behind mouth tube with a long and stout basal segment which is grooved on its inner surface distally for reception of second segment and claw ; second segment less than half length of first, its tip projecting as a rounded process inside base of claw which is short and slender.

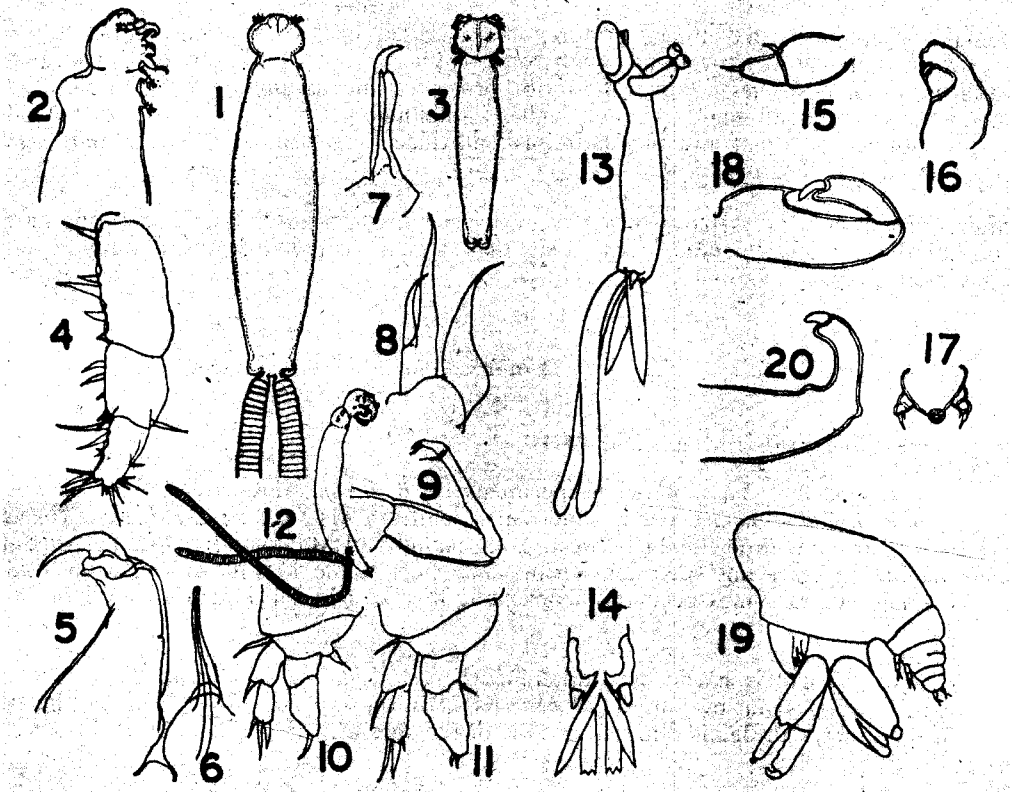


FIG. 34. *Hatschekia mulli* (van Beneden) 1-12. *Female.* (1) dorsal view, adult ; (2) lateral view of head and thorax ; (3) juvenile, dorsal view ; (4) antennule ; (5) antenna ; (6) spiniform process of base of antenna ; (7) mandible ; (8) maxilla ; (9) maxilliped ; (10) and (11) first and second legs ; (12) adult, lateral view with egg strings : *Charopinus quarternius* Wilson. *Female.* (13) adult, lateral view ; (14) ventral view of posterior end of trunk ; (15) antennule ; (16) antenna ; (17) mouth tube and maxillule ; (18) maxilliped ; *Male.* (19) lateral view ; (20) maxilla. (Figures 1-11 after Scott and Scott ; 12 after Causey ; 13-20 after Wilson).

Male.—Dorsal portion of cephalothorax projects far forwards as a large rounded knob, and mouth tube attached to ventral surface at right angles to axis of body ; maxillae in touch

with mouth tube ; first two thoracic segments carry rudimentary legs ; abdomen with slender curved anal laminae ; maxillae and maxillipeds larger than in female to help attachment to female. [Size : female about 5 mm. without processes (from Wilson's figure) ; male 0.35 mm].

Scombroid host : *Scomberomorus cavella* (Cuvier)

Locality : Grand Isle, Louisiana, U.S.A. (Atlantic).

Non-scombroid hosts : *Coryphaena hippurus*, *Peristedion gracilis* (Dry Tortugas, Atlantic).

Location : Gills.

References : Wilson (1935) ; Causey (1953a).

Genus **Brachiella** Cuvier, 1817

Female.—Cephalothorax elongate, more or less flexed backwards ; with dorsal carapace ; trunk swollen, flattened dorso-ventrally with rows of pits, grooves or knobs on dorsal and ventral surfaces in some species ; 2 or 4 posterior processes and an unpaired genital process ; no abdomen or anal laminae ; egg sacs long, slender ; antennule generally three jointed, but may be two or four jointed as well ; antenna biramous ; maxillae long, usually separate and joined at tips by a bulla, but sometimes fused.

Male.—Cephalothorax separated by a constriction from trunk ; latter fusiform, narrower than cephalothorax, unsegmented, with small anal laminae ; antennule three jointed ; antenna biramous, both rami one jointed.

Brachiella thynni Cuvier, 1817

(Figure 35 : 1-17)

(Syn. *Thynnicola ziegleri* Miculicich, 1904).

Material examined : The following specimens of *B. thynni* were collected by us from the Wahoo, *Acanthocybium solandri* (Cuvier and Valenciennes). (1) One female egg-carrying specimen on 10-3-'60 from Wahoo caught between Long Island and Mayabunder, Middle Andamans ; (2) Four female egg-carrying specimens from same host, same locality collected on 12-3-'60 ; (3) Three female egg-carrying specimens from same host caught off Tuticorin, Gulf of Mannar on 23-3-61.

Description : There is hardly any difference between our material and the excellent description of the species given by Shiino (1956). As such, only the salient features of the species are given here, along with detailed measurements of the specimens in the collection in a separate table.

Female.—Body is highly degenerate and consists of two divisions, anterior cylindrical cephalothorax and posterior shield-shaped trunk ; at junction of these two divisions is present a pair of processes (maxillae) which help in attaching to the host ; posterior end of trunk bears two pairs of fleshy prolongations, ventro-caudal and dorso-caudal processes ; trunk divided into a few indistinct segments marked by constrictions ; all appendages, except maxillipeds concentrated in anterior end of cephalothorax.

Shiino (1956) gives 9.30 and 8.58 mm. as the lengths of the ventro-caudal and dorso-caudal processes respectively. Specimens in our collection appear to be smaller in this respect and

also show reverse relations in the relative lengths of these processes, the ventro-caudal processes being longer than the dorso-caudal processes.

The measurements of 6 of the specimens are given in Table 3.

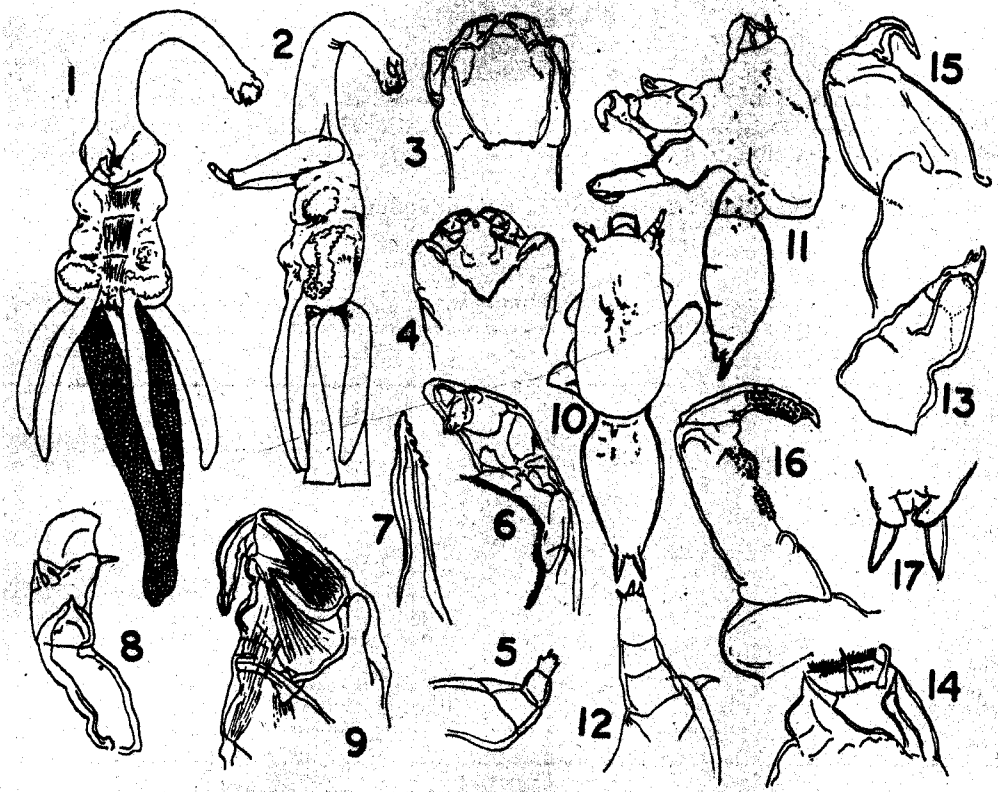


FIG. 35. *Brachiella thynni* Cuvier. *Female.* (1) ventral view; (2) lateral view; (3) carapace, dorsal view; (4) same ventral view; (5) antennule; (6) antenna; (7) mandible; (8) maxilla; (9) maxilliped: *Male.* (10) dorsal view; (11) lateral view; (12) antennule; (13) antenna; (14) proboscis and maxillule; (15) maxilla; (16) maxilliped; (17) caudal laminae (after Shiino).

Males.—All salient characteristics can be made out from Shiino's drawing of the species reproduced here.

Scombroid hosts: 1. *Thynnus thynnus* [=*Thunnus* (*Thunnus*) *thynnus thynnus* (Linnaeus)]
2. *Orcynus thynnus* [= -do-]
3. *Thunnus* (*Germo*) *macropterus* [=*Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel)]
4. *Acanthocybium solandri* (Cuvier and Valenciennes)
5. *Scomberomorus cavalla* (Cuvier)
6. *Acanthocybium solandri* (Cuvier and Valenciennes)

Localities: 1. Adriatic, Mediterranean and British Seas; Atlantic. 2. British Seas; 3. Ceylon; 4. Owase, Mie Prefecture, Japan; and Cocos Island, E. Pacific; 5. Texas Coast, U.S.A., and Gulf of Mexico; 6. Andaman Islands, Bay of Bengal and Tuticorin, Gulf of Mannar, India.

Non-scombroid hosts : *Sciaena aquila* (British Seas) ; *S. umba* (Belgian coast) ; *Pomatomus saltatrix* (Gulf of Mexico).

Locations : Gills and pectoral fins and their axils.

References : Cuvier (1817) ; Guerin-Meneville (1829-'43) ; Nordmann (1832) ; Milne Edwards (1840) ; van Beneden (1851) ; Steenstrup and Lutken (1861) ; Heller (1865) ; Vogt (1877) ; Bassett-Smith (1896, 1899) ; Graeffe (1902) ; Stenta (1904) ; Miculicich (1904, 1905) ; Norman and Scott, T. (1906) ; Brian (1906) ; Scott and Scott (1913) ; Wilson (1915) ; Leigh-Sharpe (1926) ; Kirtisinghe (1935) ; Bere (1936) ; Causey (1953) ; Delamare-Deboutteville and Nunes-Ruivo (1954) ; Shiino (1956, 1960).

Remarks : A recent additional record, see ' Addendum '.

TABLE 3

Body measurements expressed as percentages of total length (excluding processes) in six specimens of *Brachiella thynni* Cuvier collected from *Acanthocybium solandri* (Cuvier and Valenciennes) from Indian seas.

Characters	Specimens *					
	1	2	3	4	5	6
Length, cephalothorax ..	68.04	65.13	64.71	66.92	59.59	68.11
Length, trunk	31.96	34.87	35.29	33.08	40.41	31.89
Width, cephalothorax ..	6.87	6.90	9·40	7.14	9.84	10.27
Width, trunk	19.59	20.31	27.06	20.30	25·39	24.86
Ventro-caudal process ..	54.30	50.57	47.06	56.39	63.73	58.38
Dorso-caudal process ..	33.68	35.25	32.25	34.94	45.60	48.65
Length, maxilliped ..	20.27	21·84	18·82	20.68	20.21	17.84
Right egg string.. ..	63.92	67.05	50.59	broken	80.83	71.89
Left egg string	61.16	65·13	49.41	broken	75.65	67.57

* Host individuals of specimens 1-4 taken at Andamans in March, 1960, and of 5 and 6 at Tuticorin in March 1961.

Brachiella ramosa Richiardi, 1880

Scombroid host : *Xiphias gladius* Linnaeus.

Locality : Woods Hole, Massachusetts, U.S.A. (N.W. Atlantic).

Non-scombroid hosts : ? None.

Location : Gills.

References : Richiardi (1880) ; Goode (1883) ; Rathbun, M. J. (1905) ; Sumner *et al.* (1913).

Genus **Clavellisa** Wilson, 1915

Female.—Cephalothorax much longer than trunk, often wrinkled, attached to centre of dorsal surface of latter ; head separated from neck with carapace ; trunk wider than long, depressed ; genital, posterior processes, abdomen and anal laminae absent ; antennule stout, heavily

armed ; antennae biramous ; maxillule bipartite or tripartite with a palp ; maxillae flat and laminate, fused or separate, apparently attached to anterior end of trunk, some distance in front of base of neck.

Male.—Head folded ventrally into trunk, both completely fused, with no distinction of parts, but with a dorsal carapace ; body ovoid, pointed anteriorly ; antennae, mouth tube and mouth parts on ventral surface ; genital process curved ventrally projecting just behind mouth parts ; antennule three segmented ; antennae biramous ; rami one segmented ; maxillule tripartite with a palp ; maxillae and maxillipeds with strong apical claws.

Clavellisa scombri (Kurz, 1877)

(Syn. *Anchorella scombri* Kurz, 1877)

Scombroid host : 1. *Scomber colias* [=*S.japonicus colias* Gmelin]
2. *Scomber scombrus japonicus* [=*Scomber japonicus japonicus* Houttuyn]

Localities : 1. Portoferraio, Italy, Mediterranean ; 2. Tsunodayama, Niigata Prefecture, Japan.

Non-scombroid hosts : ? None.

Location : Gills.

References : Kurz (1877) ; Brian (1922) ; Yamaguti (1939) ; Shiino (1959b).

Family : ANTHEACHERIDAE

Genus **Philichthys** Steenstrup, 1862

Female.—Head small, rounded, without carapace and separated from first segment ; neck absent ; trunk elongated, narrowing posteriorly and distinctly segmented ; each segment subdivided and all including head furnished with a number of lateral and ventral processes, moderately slender, and more or less curved downwards and inwards upon ventral aspect ; no plates on segments ; anterior thorax swollen and orbicular, posterior part cylindrical and tapering backwards ; abdomen short and segmented ; anal laminae wanting, so also antennae, mouth parts and swimming legs, but a single median eye spot present.

Male.—Much smaller ; body slender, distinctly segmented ; head separated from first segment, without carapace and of same width as first and second segments ; remaining thoracic segments markedly narrower than aforesaid and insensibly passes into abdomen consisting of four segments ; anal laminae long and cylindrical ; antennule six segmented ; antennae two segmented, each provided with 2 hook-like claws ; maxillae stout, armed with strong spines ; maxillipeds feeble.

Philichthys xiphiae Steenstrup, 1862

(Figure 36 : 1-4)

Description : Female.—Mainly as for genus except : anterior portion of cephalothorax consisting of three small segments, first very minute, second moderate with median eye spot dorsally and mouth aperture ventrally ; anteriorly a knob like process on each side of first segment ;

second segment larger with two dorsal processes on each side ; body immediately posterior to front portion of cephalothorax more tumid, and expanding equally on either side to form a nearly circular disc, width of which is more than one-third total length ; each segment with a pair of irregularly branched ventral processes ; fourth, fifth and genital segments of about same width, but much narrower than expanded circular disc anteriorly ; each segment with one or more pairs of lateral processes which surround ovisacs ; abdomen three segmented, median segment only half as wide as other two ; terminal abdominal segment swollen at base with a pair of knobs on dorsal surface and long dactylose posterior processes ; each abdominal segment with a pair of lateral and a pair of ventral processes ; ovisacs fairly elongate, extending forward as well as backward along ventral aspect and enclosed and supported by curved lateral and ventral processes ; egg strings not extending behind posterior end of body. Length from 14.5 to 27.0 mm.

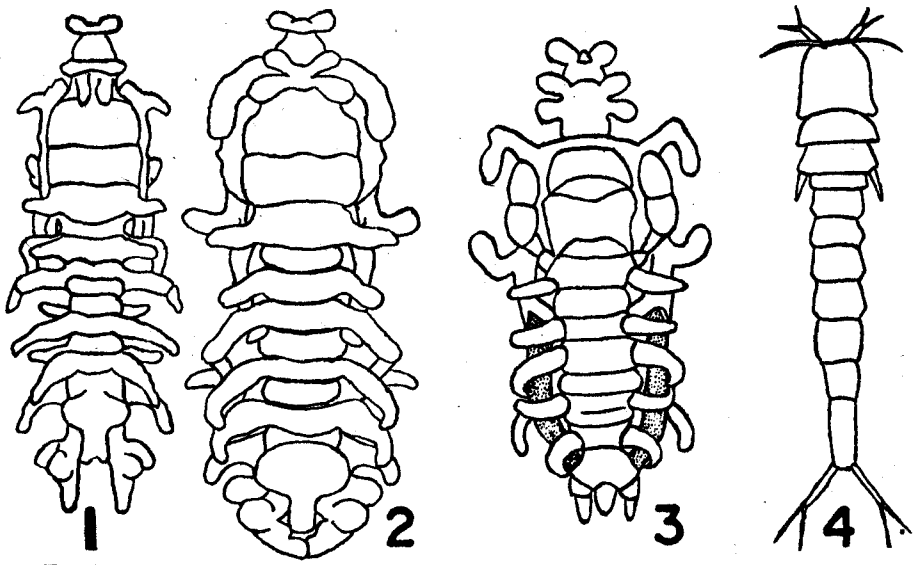


FIG. 36. *Philichthys xiphiae* Steenstrup. *Female.* (1) dorsal view of young specimen ; (2) female, older specimen, both from English seas ; (3) dorsal view of female with eggs ; (4) dorsal view of male, both from N. W. Atlantic : note variation in female (after Scott ; and Wilson).

Male.—As given for genus and : second thoracic segment armed with a stout curved spine at each postero-lateral angle ; genital segment a little longer, but not wider than fifth segment ; anal laminae five times as long as wide, tipped with two setae of equal length ; two pairs of biramous swimming legs, exopod two segmented, endopod one segmented, both rami well armed with spines and setae. Total length 4.0 to 6.0 mm.

Scombroid host : *Xiphias gladius* Linnaeus.

Localities : Kattegat ; Mediterranean ; English seas ; New England Coast of U.S.A. ; New Zealand.

Non-scombroid hosts : None.

Location : Living freely in mucus canal and sinuses of host.

References : Steenstrup (1862) ; Bergose (1864) ; Richiardi (1880) ; Valle (1880) ; Carus (1885) ; Scott and Scott (1913) ; Goode (1883) ; Rathbun M. J. (1905) ; Linton (1901) ; Sumner *et al.* (1913) ; Thompson (1885) ; Wilson (1932) ; Delamare-Deboutteville and Nunes-Ruivo (1952).

HOST—PARASITE LIST

(Generic names of host and parasite species are alphabetically arranged ; a query (?) accompanying the parasite species indicates that the host record is doubtful)

HOST SPECIES	PARASITE SPECIES
Acanthocybium solandri (Cuvier and Valenciennes)	*Brachiella thynni* Cuvier *Gloiopotes hygomianus* Steenstrup and Lutken
Auxis thazard (Lacépède)	*Caligus macarovi* Gussev *Caligus productus* Dana
Euthynnus affinis affinis (Cantor)	? *Anuretes branchialis* Rangnekar
Euthynnus affinis lineatus Kishinouye	*Caligus caryphaenae* Steenstrup and Lutken *Caligus macarovi* Gussev
Euthynnus affinis yaito Kishinouye	*Caligus coryphaenae* Steenstrup and Lutken *Caligus regalis* Leigh-Sharpe *Pseudocycnus appendiculatus* Heller
Euthynnus alletteratus (Rafinesque)	*Caligus bonito* Wilson *Pseudocycnus appendiculatus* Heller *Caligus coryphaenae* Steenstrup and Lutken
Istiophorus gladius (Broussonnet)	*Caligus quadratus* Shiino *Caligus* sp. (Silas and Ummerkutty—in this account) *Gloiopotes costatus* Wilson *Gloiopotes longicaudatus* (Marukawa) *Gloiopotes watsoni* Kirtisinghe *Pennella filosa* (Linnaeus) *Pennella instructa* Wilson
Katsuwonus pelamis (Linnaeus)	? *Anuretes branchialis* Rangnekar *Caligus bonito* Wilson *Caligus coryphaenae* Steenstrup and Lutken *Caligus kurushio* Shiino *Caligus mutabilis* Wilson *Caligus pelamydis* Kroyer *Caligus productus* Dana *Caligus quadratus* Shiino *Caligus thynni* Dana *Lepeophtheirus dissimulatus* Wilson
Kishinoella tonggol (Bleeker)	*Pseudocycnus appendiculatus* Heller
Makaira audax (Philippi)	*Elytrophora indica* Shiino *Gloiopotes longicaudatus* (Marukawa) *Gloiopotes ornatus* Wilson
Makaira indica (Cuvier)	*Gloiopotes longicaudatus* (Marukawa) *Lepeophtheirus eminens* Wilson *Pennella biloba* Kirtisinghe

Makaira nigricans (Lacépède).....	*Gloiopotes longicaudatus* (Marukawa)
Makaira sp.....	*Gloiopotes costatus* Wilson ? *Gloiopotes longicaudatus* (Marukawa) (=*G. zeugopteri* Rao, 1951)
Rastrelliger kanagurta (Cuvier).....	? *Lernaeenicus* sp. (Rao, 1951)
Rastrelliger sp.....	? *Caligus infestans* Heller
Sarda chilensis chilensis (Cuvier and Valenciennes)	*Caligus bonito* Wilson *Caligus mutabilis* Wilson *Pseudocycnus appendiculatus* Heller
Sarda orientalis (Temminck and Schlegel)....	*Alicaligus tripartitus* Shiino *Caligus bonito* Wilson *Parapetalus* sp. (Silas and Ummerkutty—in this paper)
Sarda sarda (Bloch).....	*Alebion glaber* Wilson *Alebion gracilis* Wilson *Caligus bonito* Wilson *Caligus mutabilis* Wilson *Caligus pelamydis* Kroyer *Caligus productus* Dana *Pseudocycnus appendiculatus* Heller
Sarda sp.....	*Caligus coryphaenae* Steenstrup and Lutken *Caligus productus* Dana
Scomber japonicus colias Gmelin.....	*Caligus productus* Dana *Clavellisa scombri* (Kurz) (=*Anchorella scombri* Kurz)
Scomber japonicus japonicus Houttuyn.....	*Clavellisa scombri* (Kurz) *Clavellopsis saba* Yamaguti
Scomber japonicus sub sp.....	*Caligus infestans* Heller *Lepeophtheirus dissimulatus* Wilson
Scomber scombrus Linnaeus.....	*Caligus pelamydis* Kroyer *Caligus rapax* Milne Edwards
Scomber sp.....	*Caligus productus* Dana
Scomberomorus cavalla (Cuvier).....	*Brachiella thynni* Cuvier *Caligus bonito* Wilson *Caligus pelamydis* Kroyer *Caligus productus* Dana *Caligus rapax* Milne Edwards *Charopinus quaternius* Wilson *Hatschekia mulli* van Beneden *Pseudocycnus buccatus* Wilson

Scomberomorus commerson (Lacépède).....	*Pseudocycnus armatus* (Bassett-Smith)
Scomberomorus guttatus guttatus (Bloch and Schneider).....	*Caligus cybii* Bassett-Smith *Pseudocycnus armatus* (Bassett-Smith)
Scomberomorus maculatus (Mitchill).....	*Caligus bonito* Wilson *Caligus mutabilis* Wilson *Caligus productus* Dana *Caligus rapax* Milne Edwards *Lernaeenicus longiventris* Wilson *Pseudocycnus buccatus* Wilson *Pseudocycnus elongatus* (Pearse)
Scomberomorus regalis (Bloch).....	*Pseudocycnus buccatus* Wilson
Scomberomorus sp. (*S. tritor*).....	*Caligus bonito* Wilson
Scomberomorus spp.....	*Pseudocycnus spinosus* Pearse *Lernaeenicus seeri* Kirtisinghe
Tetrapterus belone Rafinesque.....	*Gloiopotes ornatus* Wilson
Thunnus (*Thunnus*) *alalunga* (Bonnaterre)....	*Caligus alalongae* Kroyer *Caligus germoi* Pearse *Elytrophora brachyptera* Gerstaecker *Euryphorus nympha* Steenstrup and Lutken *Lernanthropus hiatus* Pearse *Pennella orthagorisci* Wright *Pseudocycnus appendiculatus* Heller
Thunnus (*Thunnus*) *thynnus orientalis* (Temminck and Schlegel).....	*Caligus coryphaenae* Steenstrup and Lutken *Caligus kuroshio* Shiino *Caligus productus* Dana *Elytrophora brachyptera* Gerstaecker *Elytrophora hemiptera* Wilson
Thunnus (*Thunnus*) *thynnus thynnus* (Linnaeus)	*Brachiella thynni* Cuvier *Elythrophora atlantica* Wilson *Elythrophora brachyptera* Gerstaecker *Pseudocycnus appendiculatus* Heller
Thunnus (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel).....	*Brachiella thynni* Cuvier *Caligus coryphaenae* Steenstrup and Lutken *Caligus productus* Dana *Caligus quadratus* Shiino *Elytrophora brachyptera* Gerstaecker *Elytrophora hemiptera* Wilson *Euryphorus nympha* Steenstrup and Lutken *Pseudocycnus appendiculatus* Heller
Thunnus (*Parathunnus*) *obeseus mebachi* (Kishinouye)*	*Elytrophora brachyptera* Gerstaecker

Thunnus (*Parathunnus*) *obesus sibi* (Temminck and Schlegel)*	*Elytrophora brachyptera* Gerstaecker
Thunnus (*Thunnus*) sp.	*Cerops latrellii* Leach *Pennella filosa* (Linnaeus)
Thunnus sp.	*Chondracanthus lophii* Johnston
Xiphias gladius Linnaeus	*Brachiella ramosa* Richiardi *Brachiella thynni* Cuvier *Caligus chelifer* Wilson *Caligus rapax* Milne Edwards *Chondracanthus xiphiae* (Guerin) ? Cuvier *Gloiopotes ornatus* Wilson *Pennella crassicornis* Steenstrup *Pennella costal* Richiardi *Pennella filosa* (Linnaeus) *Pennella instricta* Wilson *Philichthys xiphiae* Steenstrup

* It is likely that *mebachi* and *sibi* may be identical, and if so, the latter name has priority.

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ADDENDUM

Since the holding of the Symposium in January 1962, several contributions on parasitic copepods of fishes have come out and a few deal with descriptions of new species of copepods parasitic on scombroid fishes. In order to make this work upto date and useful, these additions, along with a few species not referred to in the earlier account and some species on which more information has now become available are included in the following list. As would be seen from the separate ' Host-Parasite list ' given at the end, these additions are recorded from nineteen scombroid host species.

Suborder CYCLOPOIDA

Family : BOMOLOCHIDAE

Genus **Bomolochus** Nordmann, 1832

***Bomolochus aculeatus** Pillai, 1962

Suborder CALIGOIDA

Family : CALIGIDAE

Genus **Caligus** Müller, 1785

**Caligus affinis* Kurian, 1961.
Caligus alalongae Kroyer, 1863.
**Caligus alolaris* Heegaard, 1962.
**Caligus amblygenitalis* Pillai, 1961.
**Caligus auxisi* Pillai, 1962.
**Caligus brevisoris* Shen, 1957.
Caligus coryphaenae Steenstrup and Lutken, 1961.
**Caligus euthynnus* Kurian, 1961.
**Caligus kanagurta* Pillai, 1961.
Caligus kuroshio Shiino, 1959.
**Caligus maculatus* Heegaard, 1962.
**Caligus microdontus* Heegaard, 1964 (Nom. nov. for *C. dentatus* Heegaard, 1962, Preoccupied).
**Caligus obovatus* Heegaard, 1962.
**Caligus proboscidactus* Heegaard, 1962.
**Caligus quinqueabdominalis* Heegaard, 1962.
Caligus rapax Milne-Edwards, 1840.
**Caligus thynni* Pillai, 1962.

Family : EURYPHORIDAE

Genus **Caligulus** Heegaard, 1962

**Caligulus longispinosus* Heegaard, 1962.

An * indicates species not dealt with earlier.

as shown in figure xxxvii ; fifth leg two segmented, first segment short, second with four spines, ventral surface spiny ; sixth leg represented by a bunch of six simple setae ; anal laminae ventrally spiny, with one long and four short setae. Total length 1.3 mm.

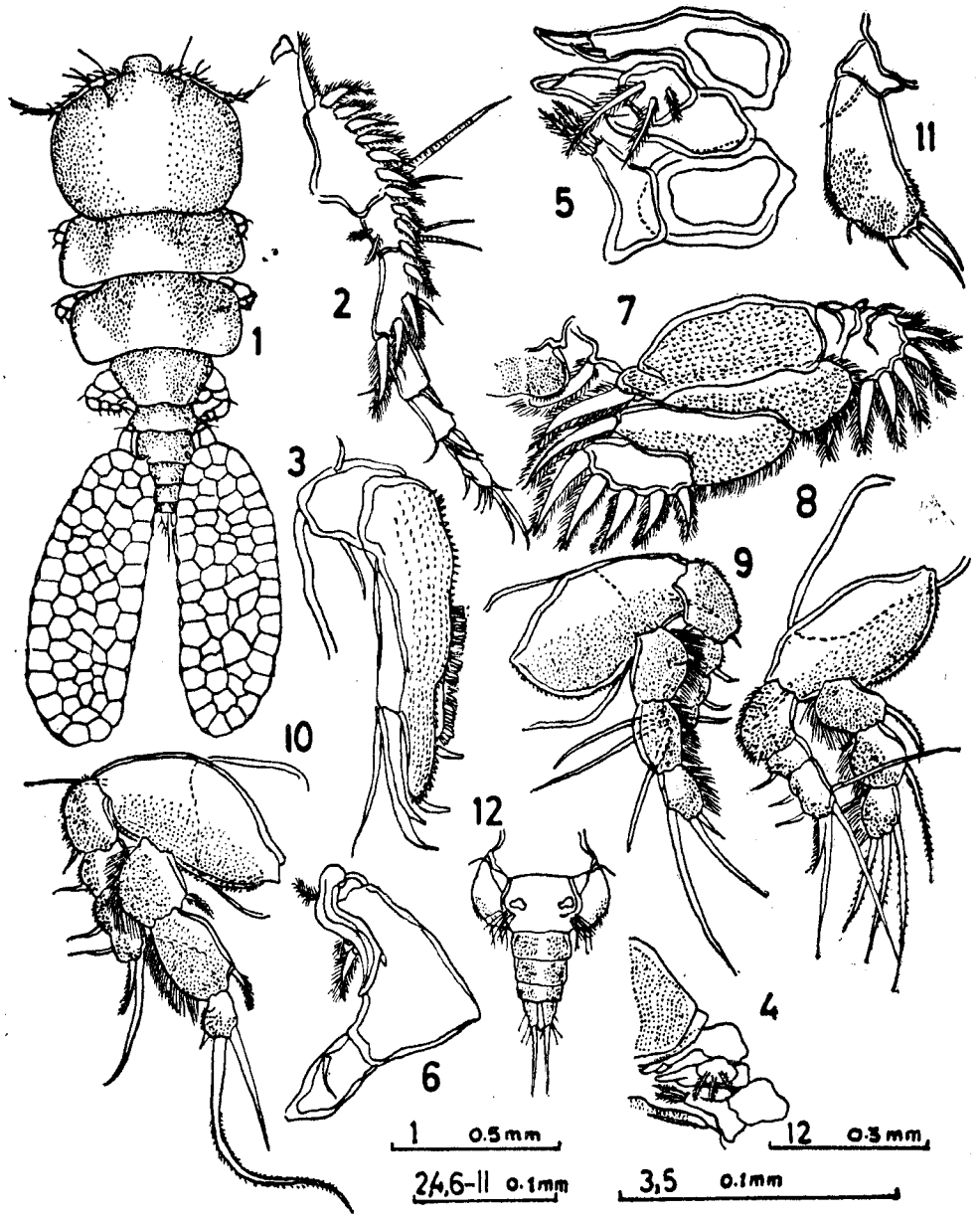


Figure 37. 1-12. *Bomolochus aculeatus* Pillai. Female : 1. Dorsal view ; 2. antennule ; 3. antenna ; 4. mouth parts, ventral view ; 5. mandible, maxilla and first maxilliped ; 6. second maxilliped ; 7. first leg ; 8. second leg ; 9. third leg ; 10. fourth leg ; 11. fifth leg ; 12. genital segment and abdomen, ventral view (After Pillai, 1962).

Male : Unknown.

Scombroid host : Rastrelliger kanagurta (Cuvier).

Locality : Trivandrum, S.W. Coast of India.

Non-scombroid hosts : None.

Location : Inner surface of opercle of host.

Reference : Pillai (1962).

Suborder CALIGOIDA

Family : CALIGIDAE

Genus **Caligus** Müller, 1785

Caligus affinis Kurian, 1961

(Figure 44 : 16-24)

Description : Female.—Carapace ovate, about 1/7th longer than broad ; frontal plate, broad, slightly arched anteriorly ; lunules large and almost circular ; posterior median lobe of carapace surpasses posterior end of lateral lobes slightly and is about 0.5 width of carapace ; fourth thoracic segment wider than long, confluent with genital segment ; latter hexagonal, about as wide as long and slightly more than half length of carapace (distinctly less than half length of carapace in figure) ; abdomen narrow, single jointed, about twice as long as broad (given as about 3 times as long as broad by Kurian, but shown in figure as hardly twice as long as broad) and indistinctly demarcated from genital segment ; anal laminae short, slightly longer than broad, each with five plumose setae. Antennule two segmented, basal segment much broader than terminal, but both of equal length ; antenna with terminal claw long and tip curved at right angles ; maxillule in the form of a long and pointed spine slightly curved inwards ; maxilla reduced to small blunt lobe ; claw of second maxillipede narrow ; sternal furca slender and directed obliquely outwards ; first leg three-jointed with three ciliated spines at free end and three long plumose setae on inner border of third joint ; second and third legs normal [Kurian's text-fig. 42 (p. 76) labelled as ' second peraeopod ' is in fact the third leg]. Fourth leg three-jointed, first joint large, slightly longer than second and third joints combined ; long plumose seta present on distal outer margin of first and second joints ; third joint with four broad or winged spines on outer margin distally ; rudimentary fifth and sixth legs represented by one and two plumose setae respectively. Total length 3.6 mm.

Male.—Unknown.

Scombroid host : Euthynus affinis (Cantor) [=*Euthynnus a. affinis* (Cantor)].

Locality : S. W. Coast of India (Kerala).

Non-scombroid hosts : None.

Location : External surface of body.

Remarks : The species name *Caligus affinis* Kurian, 1961 is preoccupied by *Caligus affinis* Heller (1866. Carcinologische Beitrage zur Fauna des adriatischen Meers. *Verhandl k. k. zool.-botan. Gesellschaft in Wien*, 16 : 723-60) and as such will need a new name. The author's attention is being drawn to this and it is hoped that when a new name is proposed he will also give a redescription of the species if possible, to clarify several of the discrepancies between his description of the species and the drawings.

Caligus alalongae Kroyer

The following information clarifying the status of some of the species mistakenly placed under this species appears pertinent.

We have already drawn attention to Shiino's remarks that Kirthsinghe's (1956 : *Parasitology*, 44 : 14-21) *C. alalongae* does not seem to be conspecific with *C. alalongae* Kroyer (1863). Pillai (1961) has given reasons for considering *C. alalongae* Kirtisinghe (1937) (*nec* Kroyer) and *C. constrictus* Wilson (1937) and Shiino (1959) (*nec* Heller, 1865) as being identical and constituting a distinct species for which he proposed the new name *C. confuses*. Pillai has also drawn attention to the considerable resemblance of *Midias carangis* Ranghekar (1956 : *J. Univ. Bombay*, 24 (n.s.), 5 : 42-65) to *C. constrictus* with the comment that ' *Midias* is an illdefined genus.'

Caligus alveolaris Heegaard, 1962

(Figure 39 : 1-9)

Description : Female.—Carapace quadrangular, longer than wide ; frontal plates wide and not emarginate at centre ; lunules large and slightly project beyond frontal plate ; lateral lobes of carapace narrow, slightly curved inward ; median lobe broad about two-thirds width of carapace and extending to slightly behind level of lateral lobes ; free thoracic segment much broader than long, width about two-thirds that of genital segment ; latter square with two posterior lobes ; two segmented abdomen, about as long as genital segment and with terminal segment hollowed out postero-laterally to accommodate small lateral anal laminae which do not reach beyond the tip of abdomen ; each anal lamina with three plumose setae posteriorly and a short one laterally ; egg strings short, a little longer than abdomen and egg cases about half width of abdomen. Second maxilliped three-jointed with a slender claw with an accessory spine and median side of proximal joint with a short hooked spine ; rudimentary fifth pair of legs seen as knobs at posterior end of genital segment bearing short setae ; other details of mouth parts and appendages as shown in figure. Total length 5.5 mm. ; length of carapace 2.5 mm. ; width 2.0 mm.

Male.—Carapace about same size as in female ; genital segment much smaller and is broader than long ; two-jointed abdomen with proximal joint shorter ; antenna stronger than in female with stronger accessory spine, but distal joints hook-shaped. Maxilla more pointed, second maxilliped stronger and stouter than in female ; vestigal remains of both fifth and sixth legs seen on genital segment ; branches of furca in male more open. Length of genital segment 0.7 mm. ; width 0.9 mm.

Scombroid hosts : Euthynnus alletteratus (=*Euthynnus affinis yaito* Kishinouye).

Locality : Howick Island, North Queensland, Australia.

Non-scombroid hosts : None.

Location : ' from skin ' (External surface of body).

Remarks : Heegaard (1962) remarks that *C. alveolagris* resembles very much the young of *C. coryphaenae* (Heegaard, 1948), but ' is smaller and with accessory spines on the second antenna and second maxilliped. It differs further in the shape of the spines of the first, second and fourth legs.'

Caligus amblygenitalis Pillai, 1961

(Figure 40 : 36-45)

Description : Female.—Carapace oblong, longer than broad, and slightly narrowed towards front ; frontal plates as deep as lunules, latter circular and prominent ; postero-lateral lobes of carapace not extending to level of posterior end of median lobe, latter four times as boad as lateral lobe ; transverse groove on dorsum of carapace situated more or less at its mid length ; short fourth thoracic segment not clearly demarcated from genital segment which is shorter than carapace length, but narrower with nearly parallel sides and with a pair of postero-lateral rounded lobes ;

abdomen single segmented and more or less rectangular ; and laminae longer than broad, being rectangular. Antenna robust with third segment bent at right angles at middle ; maxillule long and blunt with three elongate setae ; maxilla more or less triangular with a narrow apical border and a palp with three short spines. Mouth parts and appendages as shown in figure. Total length 3.2 mm.

Male.—Unknown.

Scombroid host : *Euthynnus affinis* (Cantor) [=*E. a. affinis* (Cantor)].

Locality : Vizhingam, S.W. Coast of India.

Non-scombroid hosts : None.

Location : From outer surface of body.

References : Pillai (1961).

Remarks : The species is described from a single female example. According to Pillai (1961) ' Just behind and slightly internal to the second maxilla there is a pair of short apically rounded chitinous processes resembling the apical part of the maxillae, which may be an abnormality.' In the enlargement of genital segment this species is said to resemble *C. glandifer* Shiino (1954) and *C. klawei* Shiino (1959), but in the shape of the segment and row of teeth on the second claw of the endopod of the second leg it differs from them.

Caligus auxisi Pillai, 1963

(Figure 38 : 1-20)

Description : *Female.*—Carapace orbicular, frontal plates well defined, lunules large; postero-median lobe of carapace broad, about half width of carapace and reaching beyond tip of lateral lobes ; fourth thoracic segment broader than long ; enlarged genital segment broadly triangular with a constricted ' neck ' and broadest posteriorly, but width of segment almost equalling its length ; single segmented abdomen long with parallel sides ; anal laminae longer than broad, each with three long and two short setae ; sternal fork with narrow base and long and stout rami which are apically subtruncate with broad wings ; fourth leg three segmented, basal segment longest ; lower distal border of second segment with small sharp teeth ; claws of distal segment progressively increasing in length to apical claw. Other mouth parts and appendages as shown in figure. Total length 3.8 mm.

Male.—Carapace orbicular, lateral lobes broader and postero-median lobe slightly projecting behind former ; genital segment pyriform ; two segmented abdomen with distal segment longer ; second segment of antenna with a rough raised distal pad, third segment short and claw-like ; base of latter with a stout accessory claw and a spine making it trified ; inner border of second maxilliped raised into four low projections. Total length 2.7 mm.

Scombroid host : *Auxis thazard* (Lacépède).

Locality : Trivandrum, S.W. Coast of India.

Non-scombroid hosts : None.

Location : From inner surface of opercle of host.

Remarks : Description is based on three females and two males. According to Pillai (1963) this species closely resembles *C. bonito* Wilson (1905), *C. kuroshio* Shiino (1959), and *C. indicus* Pillai (1961), especially in the structure of the legs, the maxillule, and the antenna of the female, but the shape of the abdomen and the sternal fork differentiates it from the three species.

Caligus brevisoris Shen, 1957
(Figure 40 : 1-18)

Pillai (1961) records this species from the following scombroid host :

Scombroid host : Indocybium guttatum (Bloch and Schneider) [=*Scomberomorus guttatus gyttatus* (Bloch and Schneider)]

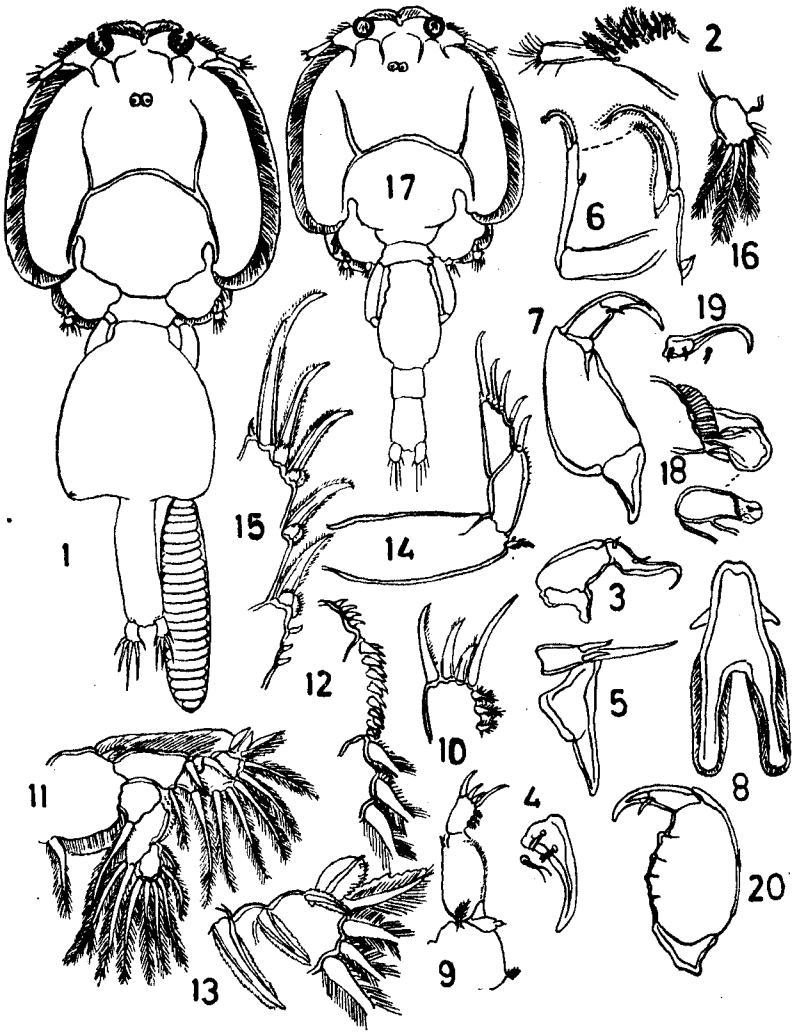


Figure 38. 1-20. *Caligus auxisi* Pillai, 1962c. Female (1-16): 1. dorsal view; 2. antennule; 3. antenna; 4. maxillule; 5. maxilla; 6. first maxilliped; 7. second maxilliped; 8. sternal fork; 9. first leg; 10. same, tip of exopod; 11. second leg; 12. same, endopod; 13. same, exopod; 14. fourth leg; 15. same, tip enlarged; 16. anal lamina. Male (17-20): 17. dorsal view; 18. antenna; 19. maxillule; 20. second maxilliped (After Pillai, 1962c).

Locality : Vizhingam, S.W. Coast of India.

Non-scombroid hosts : ? (Shen's work has not been consulted in original by us).

Location : Inner surface of opercle of host.

Reference : Shen (1957) ; and Pillai (1961).

Remarks : Pillai (1961) has given a redescription of this species based on several specimens (of males and females) with the remarks that his specimens differ slightly from the description of the species given by Shen (1957) ' in the details of the appendages and in the shape of the genital segment.' Unlike Shen's description of the claws arming the fourth leg which are said to be neither pubescent nor possessing a lappet at the base of each, but having only a membraneous border, Pillai's specimens show that all spines are bordered with wings and each spine has a long row of spinules at its base. The spinules are carried on long prolongations at the base of the third and fourth claws.

Total length of female 6.0 mm. ; of male 4.0 mm.

Caligus coryphaenae Steenstrup and Lutken, 1861

This species has already been described and figured (p. xxxxx fig. III : 1-14). It may be mentioned here that Kurian (1961) records this species from two scombroid hosts for the first time from Indian coastal waters.

Scombroid hosts : (1) *Euthynnus affinis* (Cantor) [=*Euthynnus affinis affinis* (Cantor)]
(2) *Katsuwonus pelamis* (Linnaeus).

Locality : 1 & 2 South west coast of India (Kerala).

Non-scombroid hosts : None mentioned by Kurian (1961). But for list see p. 992.

Location : External parasite on body.

Remarks : We would refer to our earlier discussion under *C. coryphaenae* (p. 884) wherein following Shiino (1959a) we have considered *C. tesserifer* Shiino as a synonym of *C. coryphaenae* Steenstrup and Lutken. However, Kurian (1961) recognises *C. tesserifer* as a valid species and mainly distinguishes it from *C. coryphaenae* by its reduced number of abdominal segments (2 *versus* 4 in *C. coryphaenae*). According to him, ' Shiino observes that in alcohol-preserved specimens the segmentation of the abdomen disappears and Heegaard maintains that the number of abdominal segments may increase from three to four even after the female reaches sexual maturity. However, in all the alcohol-preserved specimens I have examined, even though the segmentation is somewhat indistinct, it becomes clear when stained. Contrary to Heegaard's (*op. cit.*—1949. *Vidensk. Medd. fra. Dansk. Maturh. Foren*, 3 : 235-245) observation, it is seen that segmentation is constant in both mature and juvenile specimens.'

Kurian (1961) is also of the opinion that *C. aliuncus* Wilson could be distinct from *C. coryphaenae* ' . . . .especially in view of the fact that the carapace in *C. aliuncus* is less than half the length of the entire animal while in *C. coryphaenae* it is more than half.' However, we find that in his figure of *C. coryphaenae* (Kurian, 1961, fig. 16, p. 68) the carapace is shown as being shorter than half total length !

Kurian (1961) has given a detailed comparison of *C. euthynnus* Kurian, *C. tesserifer* Shiino, and *C. coryphaenae* Steenstrup and Lutken.

Caligus euthynnus Kurian, 1961[1]

(Figure 44 : 1-15)

Description : Female.—Carapace ovate, not half as long as body, but longer than wide ; posterior median lobe broad, more than half diameter of carapace and extending behind lateral lobes and provided with a minute spine at each outer angle ; free thoracic segment twice as wide

[1] Since this species is named after the host genus *Euthynnus*, the specific name *C. euthynnus* Kurian is emended to *C. euthynnus* here.

as long (shown in figure as 2.5 times as wide as long) and one-third width of carapace (shown in figure as still wider) ; genital segment partly demarcated from free thoracic segment by lateral notches ; segment about as long as wide being broader posteriorly ending in two lobular projections ; abdomen two-jointed, about as long as genital segment and indistinctly demarcated from each other and from genital segment ; second abdominal segment about two-thirds as long as first ; egg strings slightly longer than total length which is about 6.2 mm. Antennule two-jointed, basal stout, terminal short and slender, about half as long as basal (shown in figure as being of almost equal length as basal segment) ; maxillule indistinct ; mouth-cone long ; mandible with 12 teeth at curved distal end ; first maxilliped long, two-jointed, basal joint stout and short, distal joint with an acuminate lamina and two curved serrated setae at end ; second maxilliped with basal joint bearing two tubercles, one near its articulation and second near middle of its inner edge, and with a strong terminal claw ; arms of sternal furca parallel, and distal ends rounded ; basal hook of expodite of third leg curved and stout ; fourth leg well developed, four-jointed, first joint thick, slightly longer than rest ; first, second and third joints, each with one spine at distal end ; last joint with three long and one small spine at apex ; fifth and sixth legs rudimentary, but visible dorsally ; anal laminae (from figure) slightly broader than long.

Male.—Carapace shaped as in female, but length more than half total length ; genital segment distinctly broader than long, but narrower than posteromedian lobe of carapace ; exopod of fifth leg in form of tubercular projection with long plumose seta and placed postero-laterally on genital segment ; exopod of sixth leg of similar structure, but smaller ; abdomen two-jointed, as long as genital segment ; first abdominal segment one third (shown in figure as half) as long as second segment ; anal laminae much broader than long (from figure).

Scombroid host : *Euthynnus affinis* (Cantor) [=*Euthynnus a. affinis* (Cantor)]

Locality : S.W. Coast of India (Kerala).

Non-scombroid host : None.

Location : External surface of body.

Caligus kanagurta Pillai, 1961

(Figure 40 : 19-35)

Description : *Female.*—Carapace about as long as wide, being broader posteriorly ; lunules small, frontal plates narrow ; posterolateral lobes short, each one-third as wide as posteriosly rounded median lobe which extends much backwards ; transverse groove on dorsum of carapace falling slightly in posterior half of carapace length ; genital segment large and more or less of same size as carapace, but reniform in shape with posterior ends produced into bluntly rounded lobes ; two segmented abdomen with anterior segment swollen, large and elliptical and second segment short and more or less rectangular ; and laminae longer than broad being oblong.

Distal segment of antennule carrying longer setae ; antenna slender and strongly falcate with two spines ; maxillule with a broad base and a short rounded process ; rami of sternal fork stout and externally winged ; distal exopod segment of first leg with four subsimilar claws and three setae ; first three claws of exopod of second leg simple ; first seta of third segment winged on both sides and second on one side ; mouth parts and other appendages as shown in accompanying figure. Total length 4.2 mm.

Male.—Unknown.

Scombroid host : *Rastrelliger kanagurta* (Cuvier).

Locality : Trivandrum, south west coast of India.

Non-scombroid hosts : None.

Location : From inner side of opercle.

Reference : Pillai (1961).

Remarks : The fourth leg is characteristic for this species and has been described as 'four segmented, first segment as long as the rest of the limb, second and third segments with one each and fourth with three winged prominently pectinate large claws, the spiny lobe at the base of the claws produced into long slanting processes, each carrying a comb of long hairs.' This considerably reduced distal three segments of the fourth leg as a result of which the setae are closely placed and the elongate claws with basal processes is remotely seen in *C. multispinosus* Shen. The reniform shape of the genital segment is also characteristic for *C. kanagurta.*

Caligus kuroshio Shiino, 1959

(Figure 42 : 12-16)

Pillai (1963) records this species from the undermentioned scombroid fish.

Scombroid host : Euthynnus affinis (Cantor) [=*Euthynnus affinis affinis* (Cantor)]

Locality : Trivandrum, S.W. Coast of India.

Non-scombroid hosts : None.

Location : Gill arches.

Remarks : Pillai (1963) has only tentatively identified his material as *C. kuroshio,* as they show the following differences from Shiino's description of the species. The genital segment is broadest posteriorly and not in the middle as in *C. kuroshio.* Secondly, the sternal fork has long apically narrowed slender rami, while in *C. kuroshio* the rami are short, parallel sided and apically subtruncate.

According to Pillai (1963) in the above characters his specimens also differ from *C. bonito* Wilson (1905) and '. . . there is some difficulty in placing the present material under either of the two species (meaning *C. kuroshio* and *C. bonito*). Probably the description of *C. bonito* by Wilson is incomplete. Pending a detailed study of *C. bonito* the present material is identified as *C. kuroshio.*'

Caligus maculatus Heegaard, 1962

(Figure 39 : 10-18)

Description : Female.—Carapace elliptical, slightly longer than broad ; frontal plates distinct with anterior margin emarginate at centre ; lunules large and semicircular ; lateral lobes of carapace narrow and short ; median lobe broad, about two-thirds width of carapace and extending well behind posterior tip of lateral lobes ; large genital segment more or less quadrilateral with rounded margins anteriorly and postero-laterally produced into two quadrangular lobes ; abdomen with two segments of nearly equal size ; (in young female and male, the first abdominal segment is only half length of second segment and towards free thoracic segment genital segment has a short transversely wrinkled neck—fig. XXXIX, 18) ; anal laminae small, each terminated by one short and three long plumose setae ; egg-sacs conspicuously long. Furca open and cut wide beyond centre with branches about twice as long as base ; latter much swollen, with two processes one at each side of peduncle and coalesced with it ; fourth pair of swimming legs three-jointed, basal joint a little longer than combined length of two distal joints ; second joint tipped with a claw, the longest for the leg ; terminal joint tipped with three claws, the distal one being largest while the other two are equal or subequal ; fifth claw placed at lateral margin of terminal joint ; fifth legs wanting in female ; other mouth parts and appendages as in figure. Total length 6.0 mm. ; length of carapace 3.0 mm. ; width 2.25 mm. ; length of genital segment 1.5 mm. ; length of abdomen 1.2 mm.

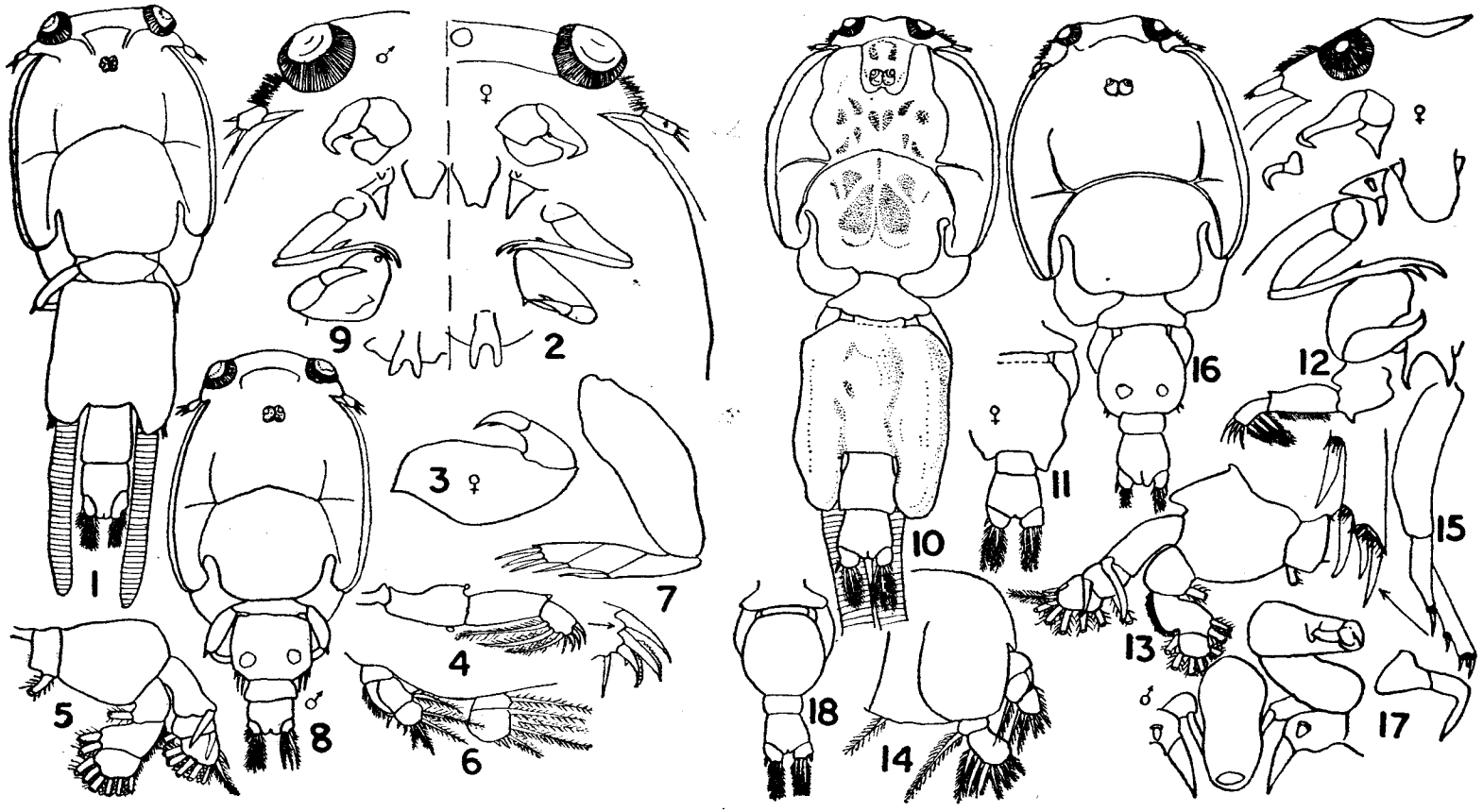


Figure 39. 1-9. *Caligus alveolaris* Heegaard. Female: 1. dorsal view; 2. mouth parts; 3. maxilliped; 4-7. first to fourth legs. Male: 8. dorsal view; 9. mouth parts. 10-18 *Caligus maculatus* Heegaard. Female: 10. dorsal view; 11. posterior region of young; 12. mouth parts; 13-15. second to fourth legs. Male: 16. dorsal view; 17. mouth parts; 18. posterior region of young (1-18 after Heegaard).

Male.—Large, about as long as female ; carapace larger than in female and wider ; genital segment small, acron-shaped with a small neck towards thoracic segment as in female ; rudimentary fifth pair of legs tipped with setae present on genital segment and can also be viewed from dorsal side of segment. Total length 5.0 mm. ; Length of carapace 3.0 mm. ; width 2.5 mm. ; length of genital segment 1.0 mm. ; length of abdomen 0.8 mm.

Scombroid hosts : (1) *Scomberomorus queenslandicus* Munro.
(2) *Scomberomorus commerson* (Lacépède).

Locality : (1 & 2). Cape Bowling Green, Cape Melville, Cape Direction, Princess Charlotte Bay, all in North Queensland ; Stephen Id., Torres Strait.

Non-scombroid hosts : None.

Location : On skin (External surface of body).

Remarks : Heegaard (1962) mentions that this species is more common on *S. commerson.* The fringe of stiff setae at the base of the claws of the fourth legs is said to be of specific importance. The spotted body and large open furca are additional characters of specific importance.

Caligus microdontus Heegaard, 1964

(Figure 41 : 1-6)

(Syn : *Caligus dentatus* Heegaard, 1962. Preoccupied by *C. dentatus* P. Gadd, 1906. *Ark. Zool.*, 3(2) : 1 and hence the above name proposed by Heegaard).

Description : Female.—Carapace orbicular, slightly narrower anteriorly and about as long as broad ; frontal plates well developed ; lunules minute ; lateral lobes of carapace broad and well developed ; median lobe less than half width of carapace and not projecting behind lateral lobes ; free thoracic segment narrow, hardly one-third width of carapace and anteriorly constricted ; genital segment elliptical, about as long as carapace, but only half as wide and postero-laterally produced into blunt conical lobes ; abdomen two segmented, shorter than genital segment ; segments subequal, proximal shorter than distal ; anal laminae longer than broad, each bearing three long and one short terminal setae ; furca represented as delicate long fork with a bulb at base followed by a short delicate peduncle and two long slender branches which are blunt and curved in towards each other ; along anterior margin of all three exopodal joints of second pair of swimming legs a wing is present and the first and second joints of endopods have serrated anterior edges (for which the original name *C.dentatus* was given for the species) ; mouth parts and other appendages as shown in figure. Total length 4.2 mm. ; length of carapace 2.0 mm. ; width 1.7 mm. ; length of genital segment 1.3 mm. ; length of abdomen 0.85 mm. ;

Male.—Unknown.

Scombroid hosts : Scomberomorus niphonius (Cuvier).

Locality : Dalrymple Island, Torres Strait.

Non-scombroid hosts : None.

Location : From external surface of body of host.

Remarks : The species is based on a single female which on account of the absence of egg strings and the two-jointed condition of the terminal claw of the second maxilliped (juvenile character) appears to be an immature female.

References : Heegaard (1962, 1964).

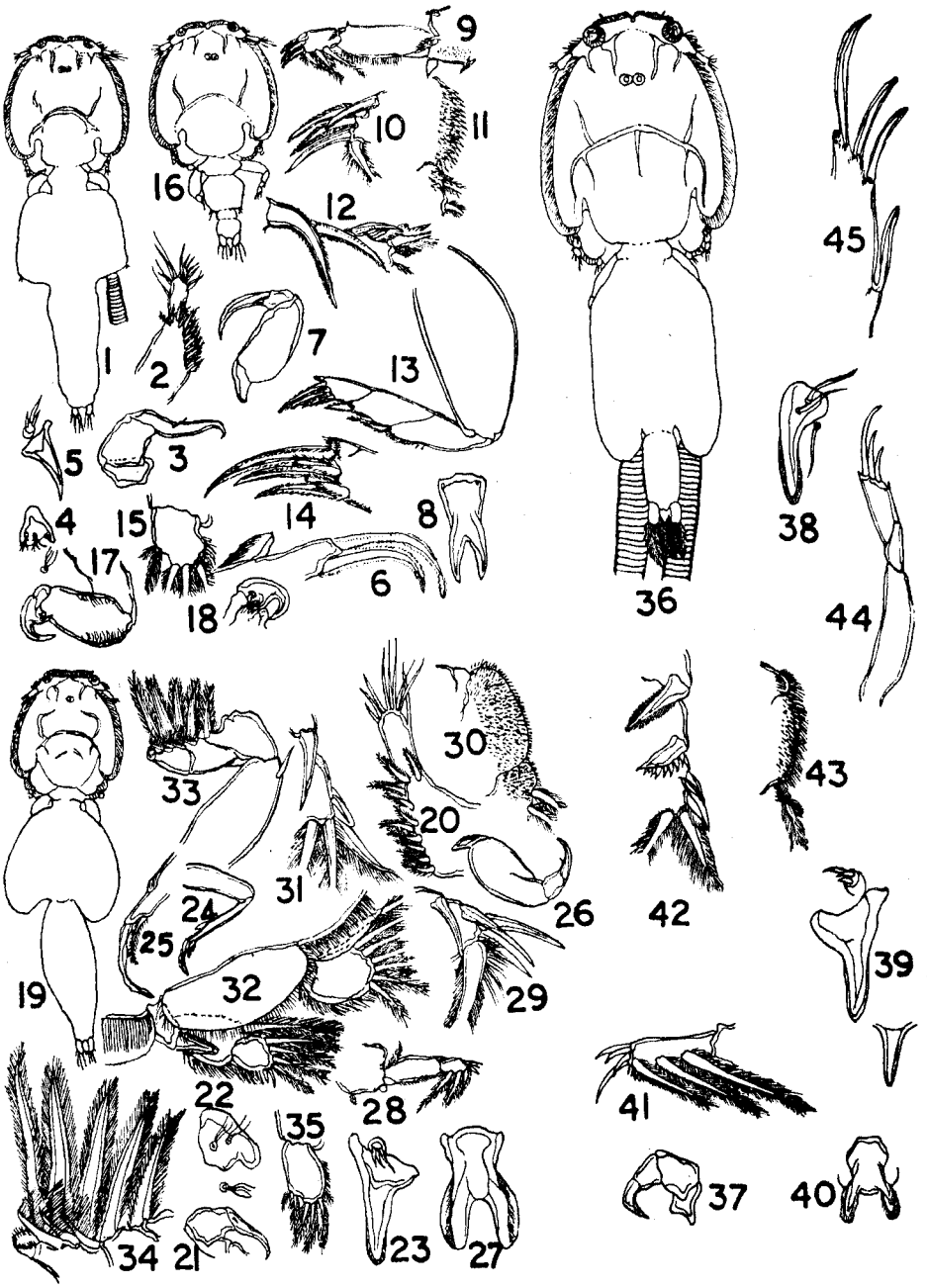


Figure 40. 1-18. *Caligus brevisoris* Shen, 1957. Female: 1. dorsal view; 2. antennule; 3. antenna; 4. maxillule; 5. maxilla; 6. first maxilliped; 7. second maxilliped; 8. sternal furca; 9. first leg; 10. apex of same, enlarged; 11-12. endopod and exopod of second leg; 13-14. fourth leg and its apex enlarged; 15. anal lamina. Male: 16. dorsal view; 17. antenna; 18. apex of same, enlarged. 19-35. *Caligus kanagurta* Pillai, 1961. Female. 19. dorsal view; 20. antennule; 21. antenna; 22. maxillule; 23. maxilla; 24-25. first maxilliped and its apex enlarged; 26. second maxilliped; 27. sternal furca; 28-29. first leg and its apex enlarged; 30-31. endopod and exopod of second leg; 32. third leg; 33-34. fourth leg and its apex enlarged; 35. anal lamina; 36-45. *Caligus amblygenitalis* Pillai, 1961. Female: 36. dorsal view; 37. antennule; 38. maxillule; 39. maxilla; 40. sternal furca; 41. apex of first leg; 42-43. exopod and endopod of second leg; 44-45. fourth leg and its apex enlarged. (After Pillai, 1961).

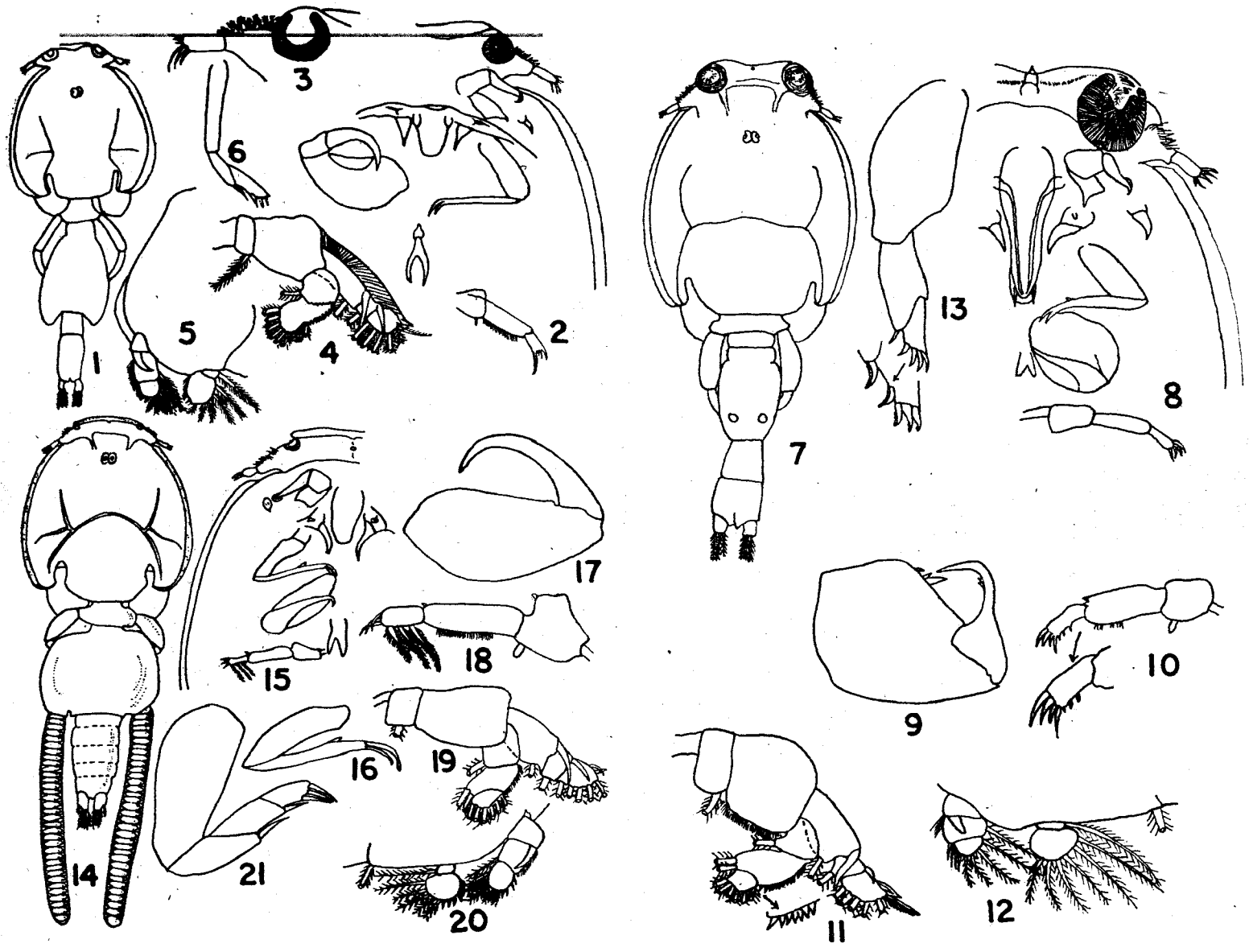


Figure 41. 1-6. *Caligus microdontus* Heegaard. Female: 1. dorsal view; 2. mouth parts; 3. antennule with lunule; 4-6. second to fourth legs; 7-13. *Caligus proboscidatus* Heegaard. Male: 7. dorsal view; 8. mouth parts; 9. maxilliped; 10-13. first to fourth legs. 14-21. *Caligus quinqueabdominalis* Heegaard. Female: 14. Dorsal view; 15. mouth parts,; 16. maxilla; 17. maxilliped; 18-21. first to fourth legs.

Caligus obovatus Heegaard, 1962

(Figure 43 : 1-7)

Description : Female.—Unknown.

Male.—Carapace circular and more than half total length ; frontal plates well formed ; lunules large, circular and project ; lateral lobes of carapace strongly incurved, but short and pointed ; median lobe less than half as wide as carapace, but projects slightly behind level of lateral lobes ; free thoracic segment narrow, about one-fourth width of carapace and anteriorly slightly constricted ; genital segment longer than broad and slightly constricted and wrinkled anteriorly giving false appearance of segmentation ; two segmented abdomen slightly longer than genital segment, segments of about equal size ; anal laminae large, as wide as long and tipped with three strong plumose setae and a small spine on distal corner ; second maxilliped with a stout square basal joint with two knobs where point of distal joint touches proximal one ; distal joint stout, curved and with a small accessory spine ; furca small with divergent branches of about same length as base, and with blunt tips ; second endopodal joint of second walking leg with dentated lamina (as in *C.proboscidatus*) mouth parts and appendages as shown in figure. Total length (average about) 4.0 mm. ; length of carapace 2.0 mm. ; width 2.0 mm. ; length of genital segment 0.7 mm. ; length of abdomen 0.7-0.8 mm. (given erroneously in original description as 70.8 mm.).

Scombroid host : Scomberomorus queenslandicus Munro and *S.commerson* (Lacépède).

Locality : Off Palm Island, Cape Bowling Green, Cape Melville, Cape Direction, Princess Charlotte Bay, and Eden Reef, all from North Queensland, and from Torres Strait.

Non-scombroid hosts : None.

Location : ?

Remarks : Heegaard (1962) remarks that this species is very close to *C.proboscidatus* (also known only from males) found on the same hosts and from the same localities. The wider carapace, remarkably large maxillule, the short mouth cone, and differences in the nature of the second maxillipeds, the furca and in the second and fourth legs differentiate *C.obovatus* from *C.proboscidatus.* (Heegaard, 1962).

Caligus proboscidatus Heegaard, 1962

(Figure 41 : 7-13)

Description : Female.—Unknown.

Male.—Carapace more than half total length ; longer than wide ; frontal plates well developed ; lunules large, projecting a little ; lateral lobes of carapace short and slightly curved inwards ; median lobe about half as broad as carapace and projecting slightly behind lateral lobes ; free thoracic segment narrow, but wider than genital segment ; latter longer than broad, constricted anteriorly and wrinkled giving false appearance of segmentation ; two segmented abdomen about as long as genital segment ; anal laminae short, each bearing three plumose setae ; mouth cone extraordinarily long (as in Pandaridae) ; second maxilliped with an exceptionally stout basal joint and slender strongly curved distal joint which bears two accessory spines ; in place where tip of distal joint touches proximal joint some spiny knobs present ; furca small, Y-shaped and slender ; usual three large plumose setae on posterior margin of terminal joint of first leg wanting ; instead three small spines present ; frontal side of second endopod joint of second leg fringed with a dentated wing or lamina which condition is not met within the other joints of this

appendage ; basal joint of fourth leg large, distal joint shortest ; five curved claws present on distal two joints of which two proximal claws are dentated from base to tip, while the three distal claws are dentated only near the tips on concave side ; fifth legs wanting. Total length 2.5 mm. ; length of carapace 1.35 mm. ; width 1.0 mm. ; length of genital segment 0.6 mm. ; length of abdomen 0.5 mm.

Scombroid hosts : *Scomberomorus commerson* (Lacépède) and *Scomberomorus queenslandicus* Munro.

Locality : Cape Bowling Green, Eden Reef, and Princess Charlotte Bay, all in North Queensland, Australia.

Non-scombroid hosts : None.

Location : From mouth.

Remarks : The species is known from five young males which still retained a little of the frontal filament left from the chalimus stage. The small size, the extremely long mouth cone, the absence of plumose setae on first legs, the serrated edge of the second endopodal joint of the second legs and the dentated claws and the spines of the fourth leg are said to be diagnostic for this species. As regards the absence of plumose setae on the terminal joint of the first leg Heegaard (1962) observes ' This is unusual, although in the present Australian material the same condition is also found in *C.obovatus.* In *C.dentatus* this same posterior margin is even naked.' All these three species are small and delicate.

Caligus quinqueabdominalis Heegaard, 1962

(Figure 41 : 14-21)

Description : *Female.*—Carapace orbicular, narrower anteriorly and slightly longer than wide ; frontal plates broad, lunules minute and placed wide apart ; lateral lobes short, median lobe projects slightly behind posterior end of lateral lobes ; free thoracic segment narrow, about half as wide as genital segment and bearing a narrow neck towards carapace ; genital segment is wider than long, about two-thirds width of carapace and with strongly curved lateral margins ; five segmented abdomen of same length as genital segment ; abdominal segments about equal in size ; anal laminae short bearing small setae ; antennule short, about two-thirds as long as frontal plate and with terminal joint shorter than basal joint ; branches of furca shorter than base ; mouth parts and appendages as shown in figure ; fifth pair of legs wanting. Total length 4.7 mm. ; length of carapace 2.2 mm. ; width 2.0 mm. ; length of genital segment 1.1 mm. ; length of abdomen 1.0 mm. ; length of egg-strings 2.7 mm. (eggs large).

Male.—Unknown.

Scombroid host : *Scomberomorus commerson* (Lacépède).

Locality : Torres Strait.

Non-scombroid hosts : None.

Location : ? (Probably external suface of body of host).

Remarks : The five-segmented abdomen is said to be the most important feature of this species.

Caligus rapax H. Milne-Edwards, 1840

Heegaard (1962) records this species hitherto known only from the Atlantic and the Mediterranean from the Australian waters based on 20 females ' parasitic on a skate (*Raja*) ' from Oyster Bay, Tasmania, in the collection of the Australian Museum (Reg. No. 6792). This is one of the species which is known to occur on a wide variety of fish hosts and

according to, Heegaard (1962) this is on account of both the males and females being more lively than in most species and 'frequently displaying this activity by leaving a host and swimming freely about. This happens more at night than during daytime, as evidenced by several investigators who have recorded the capture of both sexes in two nets, together with non-parasitic copepods.' This extension in the recorded distribution of this species is noteworthy.

Caligus thynni Pillai, 1963

(Figure 42 : 1-11)

Description : Female.—Carapace distinctly longer than broad, anteriorly narrow ; large circular lunules slightly projecting from broad well developed frontal plates ; postero-median lobe broad, projecting well beyond level of lateral lobes ; fourth thoracic segment broader than long ; genital segment triangular, anteriorly narrowed and longer than broad ; one segmented abdomen short and squarish ; short anal laminae sunk in abdomen and not extending beyond posterior end of abdomen ; claws on endopod of second leg large, winged, first twice the size of second, third slender ; first segment of endopod of second leg with four sharp spines, second segment with a row of nine teeth ; fourth leg slender, basal segment as long as rest of limb, but not broader ; claws not elongate, apical claw twice as long as penultimate claw ; Other mouth parts and appendages as shown in figure. Total length 3.5 mm.

Male.—Unknown.

Scombroid host : Euthynnus affinis (Cantor) [=*Euthynnus affinis ffainis* (Cantor)].

Locality : Trivandrum, S.W. Coast of India.

Non-scombroid hosts : None.

Location : Gill arch.

Remarks : The species is described from a single female found along with several specimens of *C.kuroshio* Shiino from the same host. In the shape of the genital segment the species is said to resemble *C.isonyx* Steenstrup and Lutken, and *C.triangularis* Shiino, but the longer abdomen of *C.isonyx* and the shape of the anal laminae and the armature of the endopod of the second leg in *C.triangularis* are said to differentiate the latter two from *C.thynni.* As to the validity of his new species, Pillai (1963) remarks that 'Since I have only a single female, probably slightly abnormal, the identification may be considered provisional.'

The species name *Caligus thynni* Pillai, 1963 is preoccupied by *Caligus thynni* Dana, 1852 emended to *Caligus thynni* by Scott, T. (1914) and as such a new name will have to be proposed for this species as the name *C.thynni* is not available for use. It will be desirable if the author whose attention is being drawn to this could also give a redescription of this species based on more material. Reference may also be made to the information given under the species *Caligus thynni* Dana, on p. in the earlier part of this paper.

Family : EURYPHORIDAE

Genus **Caligulus** Heegaard, 1962

Generic characters as for *Caligus* and in addition the dorsal plate of third thoracic segment entirely covers fourth segment.

Heegaard (1962) places this genus under the family Euryphoridae. Monotypic. Genotype *C.longispinosus* Heegaard.

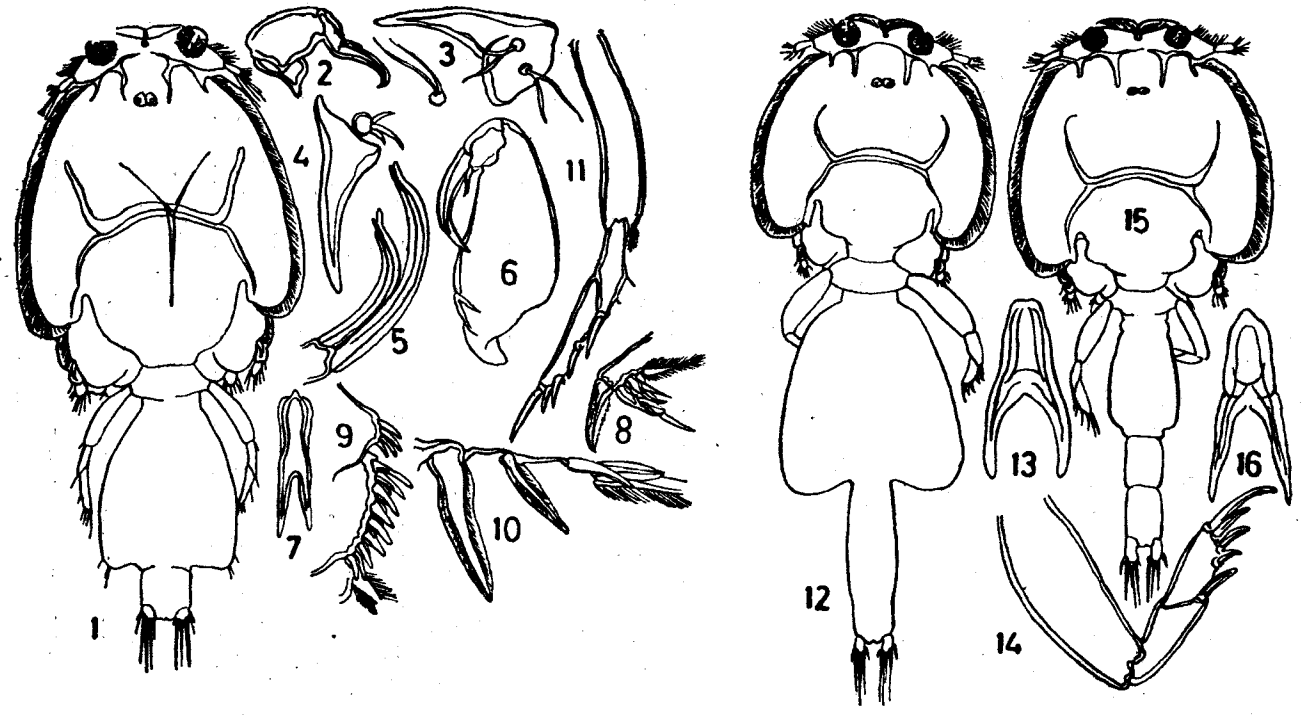


Figure 42. 1-11. *Caligus thynni* Pillai, 1963c. Female: 1. dorsal view; 2. antenna; 3. maxillule; 4. maxilla; 5. first maxilliped; 6. second maxilliped; 7. sternal fork; 8. first leg, tip of exopod; 9. second leg, endopod; 10. same, exopod; 11. fourth leg. 12-16. *Caligus kuroshio* Shiino, 1959. Female (12-14): 12. dorsal view; 13. sternal fork; 14. fourth leg. Male (15-16): 15. dorsal view; 16. sternal fork. (After Pillai, 1963).

Caligulus longispinosus Heegaard, 1962

(Figure 43 : 8-18)

Description : Female.—Carapace markedly elongate, about one-half times greater than width ; lateral margins of carapace nearly parallel ; lunules of moderate size not jutting beyond edge of frontal plates which are wide and separated from carapace by anterior transverse ridge ; lateral lobes of carapace are short ; median lobe large, about two-thirds width of carapace and extending backwards forming dorsal plate entirely covering fourth thoracic segment and even part of genital segment ; genital segment quadrangular with a deep wide incision postero-medially in which one-segmented abdomen with a pair of anal laminae (not one lamina as mentioned by Heegaard, p. 171, 1962) is situated. Mouth parts and appendages as figured (Figure 43). Fifth and sixth pairs of legs wanting in female. Egg strings long, slender, longer than total length. Total length 3.5 mm. ; carapace length 2.5 mm. ; width 1.6 mm. ; length of genital segment 0.9 mm. ; width 1.0 mm.

Male.—About same size as female, but with frontal plates and lunules more prominent ; carapace relatively larger and broader than in female ; genital segment more elliptically rounded than in female ; lateral lobes of genital segment tipped with two short spines representing vestigial fifth pair of legs ; maxilla, and sternal furca are relatively larger than in female. Total length 3.2 mm. ; carapace length 2.7 mm. ; width 1.8 mm. ; length of genital segment 0.6 mm. ; width 0.8 mm.

Scombroid host : Euthynnus alletteratus (=*Euthynnus affinis yaito* Kishinouye).

Locality : Howick Island, North Queensland.

Non-scombroid hosts : None.

Location : On skin (external surface of body of host).

Remarks : Heegaard (1962) mentions that in addition to the large dorsal plates of carapace the species ' can be recognised principally by its swimming legs and the accessory spine on the second antenna.'

Genus **Euryphorus** Nordmann, 1832

Euryphorus nympha Steenstrup and Lutken, 1861

Ho (1963) has given a redescription of this species based on males and females collected from the inner surface of the operculum of the common dolphin *Coryphaena hippurus.* He found that each female carried a male beneath its genital segment and both sexes had their ventral surfaces in contact with each other and had their body axis in the same direction. Remarking on Shiino's (1959) relegation of *Euryphorus nordmanni* Kirtisinghe to the synonym of the above species, Ho draws attention to two differences, namely, the nature of the rudimentary fifth legs and the posterior processes of the genital segment of the female described by Kirtisinghe, from the typical *E.nympha,* and suggests that ' Kirtisinghe's *E.nordmanni* is merely a local variety of *E.nympha.*'

Genus **Gloiopotes** Steenstrup and Lutken, 1861

Gloiopotes longicaudatus (Marakawa), 1925

(Figure 45 : 7-9)

Heegaard (1962) while remarking on the previous records of this species by Marukawa (1925), Yamaguti (1936) and Shiino (1954) from the scombroid fishes *Tetrapturus mitsukurii* Jordan and Snyder, *Parathynnus sibi* (Temminck and Schlegel), *Xiphias gladius* Linnaeus from the Pacific

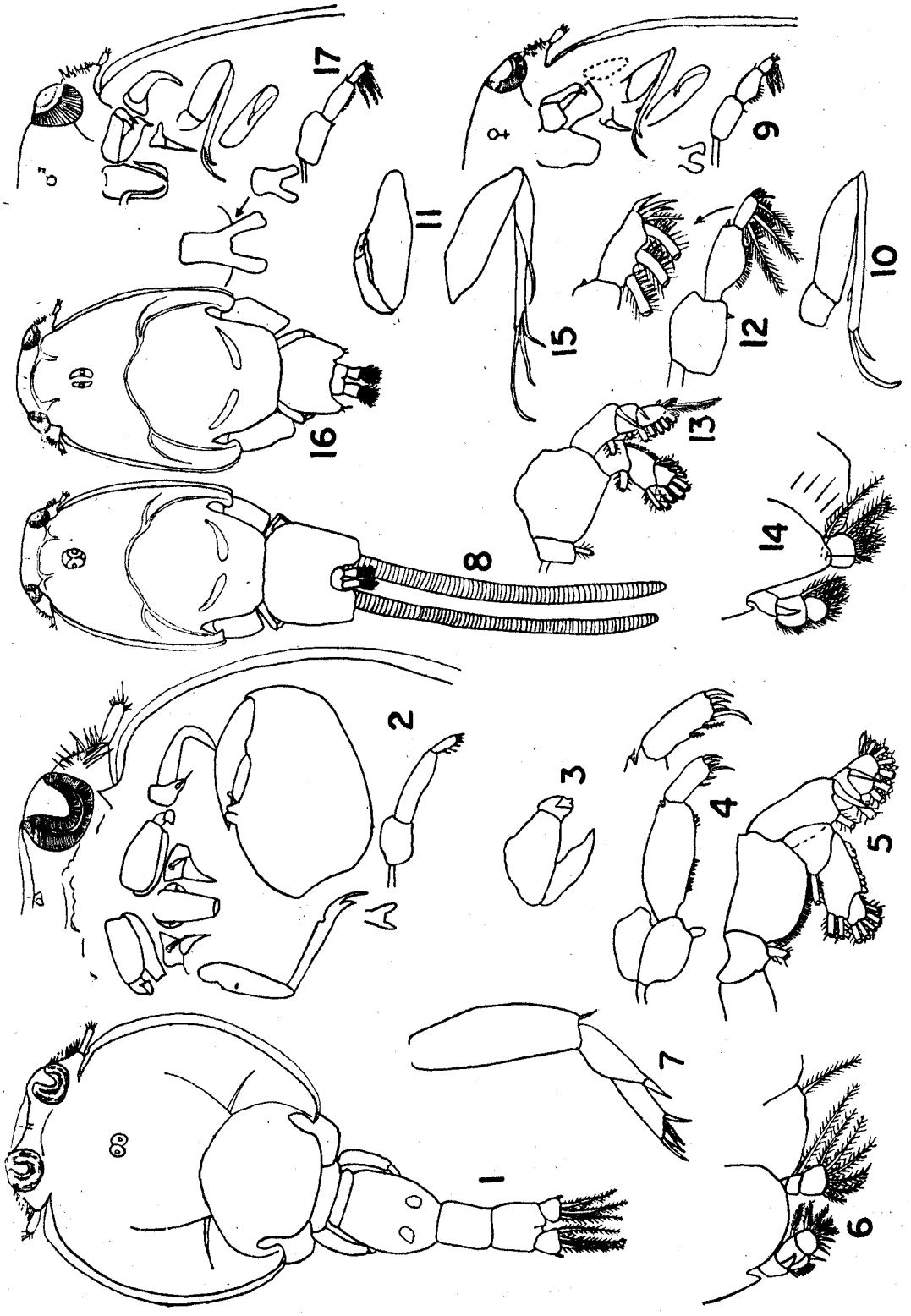


Figure 43. 1-7. *Caligus obovatus* Heegaard. Male: 1. dorsal view; 2. mouth parts; 3. antenna; 4-7. first to fourth legs. 8-18. *Caligulus longispinosus* Heegaard. Female: 8. dorsal view; 9. mouth parts; 10-11. maxilla and maxillipeds; 12-15. first to fourth legs; Male: 16. dorsal view; 17. mouth parts (1-17 after Heegaard).

coast of Japan and the Mariana Islands and from an unknown host collected at the Palao Island, also records this species from the following hosts and localities from Australia :

Scromboid hosts : (1) *Marlina zelandica* (=*Tetrapturus audax* Philippi) ; (2) *Istiompax australis* [=*Makaira indica* (Cuvier)].

Localities : (1) From striped marlin caught at Bateman's Bay, New South Wales, and (2) from the black marlin caught at Port Jackson and off Broughton Island, Port Stephen, New South Wales.

Location : skin near anal fin of striped marlin ; gill opening of black marlin.

Non-scombroid hosts : None.

Remarks : Heegaard (1962) draws attention to slight differences noticeable between his drawings of this species and the descriptions and drawngs of it given by the aforementioned Japanese workers.

Ho (1963) has given descriptions of the males and females of this species based on material collected from the general body surface and the ventral surface of the ' sword ' of *Xiphias gladius* Linnaeus and *Istiophorus orientalis* (Temminck and Schlegel) (=*I. gladius*) caught from the Pacific coast off Suao and in the vicinity of the islets of Keelung. He also remarks on specimens in his collection differing from existing descriptions of the species in (1) the number of setae on the apex of the first antenna ; (2) the disposition of soft hairs and spines on the carapace ; and (3) armature of the terminal segment of the first leg, the fourth leg and the caudal rami.

Gloiopotes watsoni Kirtisinghe, 1933

Kurian (1955) reports both males and females of this species from the scombroid fish *Histiophorus gladius* (Brouss.) (=*Istiophorus gladius* (Broussonet) landed at Vizhingam, S.W. coast of India, in 1952. The specimens are said to resemble the type described by Kirtisinghe (1933) except that the caudal rami are slightly shorter than the second abdominal somite, whereas in the type they are longer than the second abdominal somite.

Measurements : Female (Male) : Total length excluding anal laminae 10.7 (10.0) ; length of carapace 5.3 (4.4) ; and width of carapace 4.5 (3.2) mm.

Genus **Tuxophorus** Wilson, 1908

Diagnosis : Entire body more or less distinctly segmented and depressed ; fourth segment narrowed ; genital segment enlarged, often to the size of the carapace ; three anterior segments fused with the head ; first and fourth legs uniramous ; second and third pairs biramous ; fourth segment separated from fifth with paired dorsal plates, overlapping genital segment in female, but rudimentary in male ; frontal plates with lunules ; claws on first legs simple ; genital segment with lobes and rudimentary legs at its posterior corners. External parasites of fishes.

Tuxophorus cervicornis Heegaard, 1962

(Figure 45 : 1-6)

Description ; Female.—Carapace oval, little longer than wide and length about half of total length ; frontal plates prominent ; lunules small and widely separated ; median posterior lobe of carapace about half as wide as carapace and projects very slightly beyond tip of

lateral lobes which are broad and incurved ; fourth segment free and about two times as wide as long, covered with a pair of lobular wings ; latter extend outwards to a level with the lateral margins of genital segment and far enough backwards to cover its base. In adults with the development of a neck in the fourth segment, the wings get distinctly separated from posterior margin of carapace ; genital segment quadrangular, broader than long ; about two-thirds as wide as carapace ; fifth pair of legs in the form of branched spiny processes at postero-lateral corners of genital segment ; abdomen about as long as genital segment and two segmented, second segment being 1.5 times length of first ; egg strings with about 60-100 eggs each ; antenna three segmented, first joint which is coalesed with carapace possesses a posteriorly directed spine, second and third joints free, last ending in a strong hook ; maxillule and maxilla devoid of palps ; first maxilliped long and slender as in *Caligus*, but differs in being three segmented and having a minute palp at base of third segment ; distal segment ends in a pair of digitiform processes ; second maxilliped also three segmented, the third segment ending in a claw ; sternal furca strongly developed rather simple with a massive base and with dagger-shaped diverging arms ; other appendages as figured.

Male.—Unknown.

Scombroid host : *Scomberomorus commerson* (Lacépède).

Locality : Torres Strait ; and Cape Direction, North Queensland.

Non-scombroid hosts : None.

Location : Mouth and probably also gills.

Tuxophorus cybii Nunes-Ruivo, 1956

We have not been able to see the original description of this species, but from Heeggard (1962, p. 173) note that the furcal structure is not simple as in *T. cervicornis*, but has an extra spine on each branch.

Tuxophorus solandri Kurian, 1962

(Figure 44 : 25-36)

Description : *Female*.—Carapace ovate, rounded in front with a short incision in centre of anterior margin ; frontal plates distinct ; lunules moderate ; median posterior lobe of carapace projecting beyond tip of lateral lobes and about half width of carapace ; lateral lobes broadly rounded and incurved ; free thoracic segment short and with a wing on each side, each wing extending outwards beyond level of median lobe of carapace and overlaps part of genital segment ; wings broadly triangulate ; genital segment broader anteriorly, width of anterior part equalling length of segment ; midventral side with five or six rows of posteriorly directed short curved spines, not hitherto noted for other species of genus ; abdomen shorter than genital segment ; two-jointed and tapering, second segment very small, about three-tenths length of first (in figure shown as about one seventh) ; anal laminae tapering, about half as long as abdomen, with a tooth on outer margin and three short terminal setae ; antennule two-jointed, setose, basal joint stout, about two times as long as distal ; maxillule in form of large plate with a curved terminal spine and a node at outer edge ; arms of furca widely divergent with pointed apices which are short in relation to massive basal part ; outer sides of furca with sharp claws ; first maxilliped long, two-jointed, basal joint stout, terminal claw slender, about 1.5 times length of basal, with two unequal curved distal spines ; second maxilliped with basal joint long and stout and terminal claw long and curved with an accessory spine on its inner side ; fourth leg four-jointed, basal joint much stouter and longer than other three joints combined ; second and third segments each with a terminal spine and fourth with three spines ; fifth leg at postero-lateral corner of genital segment extends backwards and outwards as a strong claw bearing two or three short spines ; sixth legs small, digitiform, with three small setae ; fifth and sixth legs visible dorsally. Total length including laminae 7.9 mm.

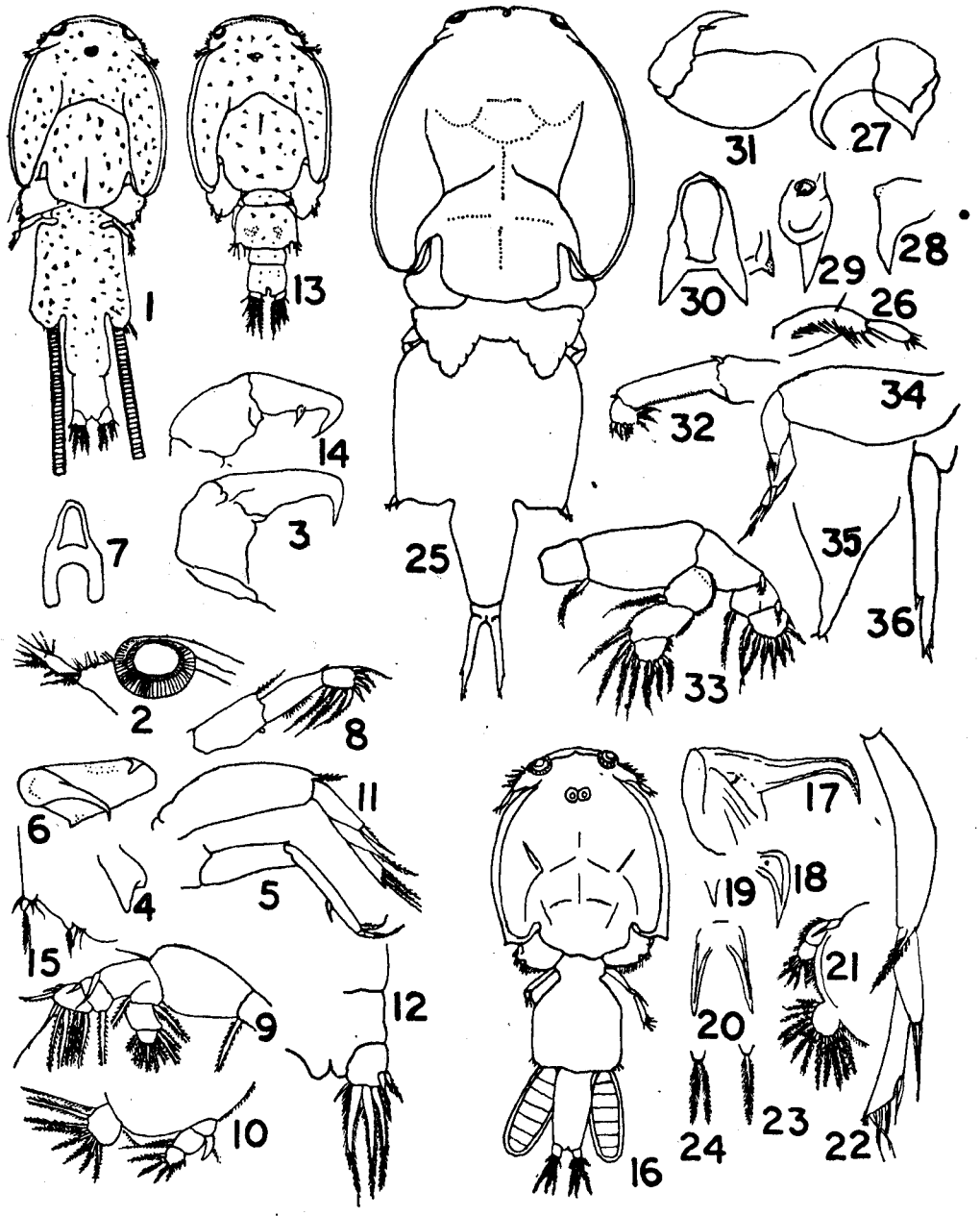


Figure 44. 1-15. *Caligus euthynnus* Kurian. Female: 1. dorsal view; 2. antennule with lunule; 3. antenna; 4. maxilla; 5-6. first and second maxillipeds; 7. sternal furca; 8-11. first to fourth legs; 12. anal lamina; Male: 13. dorsal view; 14. antenna; 15. fifth and sixth legs. 16-24 *Caligus affinis* Kurian. Female: 16. dorsal view; 17. antenna; 18. maxillule; 19. maxilla; 20. sternal furca; 21. third leg; 22-24. fourth to sixth legs. 25-36 *Tuxophorus solandri* Kurian. Female: 25. dorsal view; 26. antennule; 27. antenna; 28. maxillule; 29. maxilla; 30. sternal furca; 31. maxilliped; 32-33. first and second legs; 34-35. fourth and fifth legs; 36. anal lamina. (1-36 after Kurian).

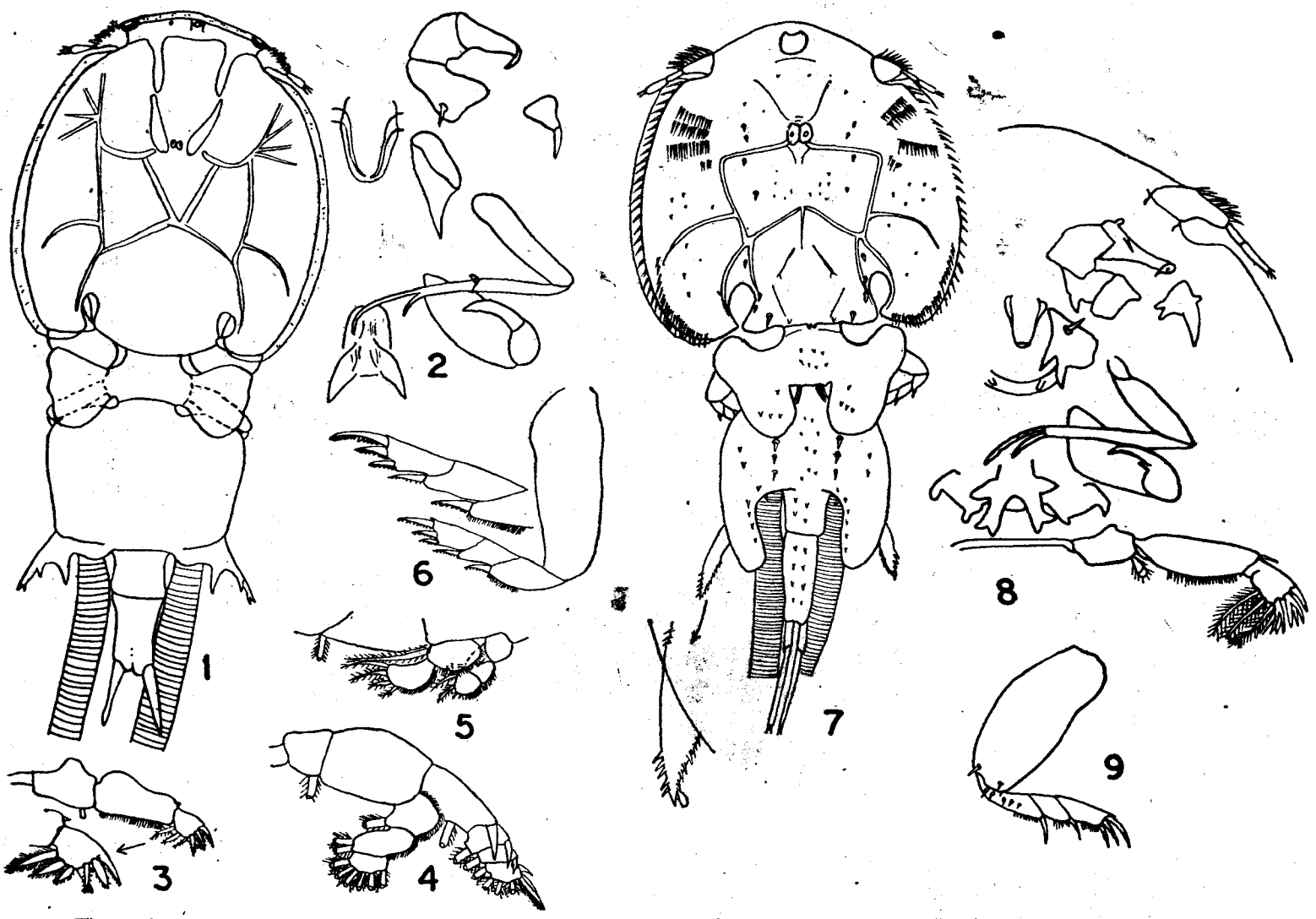


Figure 45. 1-6. *Tuxophorus cervicornis* Heegaard. Female : 1. dorsal view ; 2. mouth parts ; 3-6. first to fourth legs 7-9. *Gloiopotes longicaudatus* (Marukawa). Female : 7. dorsal view ; 8. mouth parts ; 9. fourth leg. (1-9 after Heegaard).

Male.—Unknown.

Scombroid host : *Acanthocybium solandri* (Cuvier).

Locality : Munambom, Kerala, South West coast of India.

Non-scombroid hosts : None.

Location : External parasite.

Remarks : This species is known from an adult female (Holotype) (Kurian, 1961, p. 74) although he has given the description under '*Adult male*'. The figures and descriptions given are convincingly of the female.

The author also gives a key for the identification of the following four species : *T. caligoides* Wilson, *T. wilsoni* Kirtisinghe, *T. tylosuri* Rangnekar, and *T. solandri* Kurian. Of these, *T. tylosuri* is considered by Pillai (1961) as belonging to the genus *Caligus*. Of the above four species only *T. solandri* is known from a scombroid host. Two additional species of *Tuxophorus* from scombroid hosts (recently described) are, *T. cybii* Nunes-Ruivo (1956), and *T. cervicornis* Heegaard (1962).

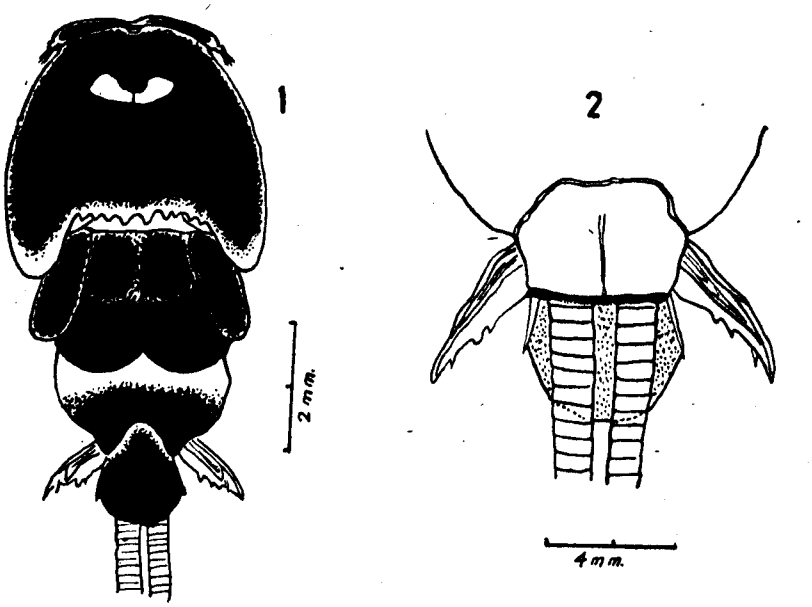


Figure 46. 1-2. *Pandarus satyrus* Dana. Female : 1. dorsal view ; 2. ventral view of posterior part (After Ju-Shey Ho, 1963).

Family : PANDARIDAE

Genus **Pandarus** Leach, 1816

Pandarus satyrus Dana, 1852

(Figure 46 : 1-2)

(Syn : *Pandarus zygaenae* Brasy, 1883).

Scombroid host : *Makaira mitsukurii* (Jordan & Snyder) (=*Tetrapturus audax* Philippi).

Locality : ? Japan.

Non-scombroid hosts : *Zygaena malleus* (Kermadec Island and Cape Verde Islands) ; *Prionace glauca* (Hawaii) ; *Carcharhinus brachyurus* (Gulf of Mexico, and Pacific coast off Suao or in the vicinity of islets of Keelung) ; *Sphyrna zygaena, Isuropsis glauca, Glyphis glaucus* (=*Prionace glauca*), *Alopias pelagicus*, and *Carcharhinus platyrhynchus* (Japan).

Location : Externally on various parts of body.

Remarks : The lone scombroid host for this species otherwise found on sharks is interesting, and raises doubts as to whether there could not have been an accidental transfer of the parasite from shark to marlin on the deck of the fishing vessel !

References : Yamaguti (1936), Ho (1963), Shiino (1954, 1957, 1959).

Family : ANTHOSOMIDAE

Genus **Lernanthropus** Blainville

Lernanthropus kanagurta Tripathi

(Figure 47 : 1-5)

Description : *Female.*—Size small (total length up to 2.3 mm.) ; Cephalothorax quadrangular and narrower than thorax ; lateral sides folded ventrally extend anteriorly like two horns covering first antenna ; neck formed of fusion of first thoracic segment with cephalon ; dorsal plate divided into two almost equal sizes ; genital segment, abdomen and about one fifth of fourth leg covered by posterior dorsal plate ; genital segment round and small ; one segmented abdomen about half as broad as genital segment ; anal laminae about two-thirds as long as abdomen and having small papillae at posterior end ; antennule seven segmented, basal segment longest and distal segment smallest bearing four setae at tip ; antenna two jointed, prehensile with second joint terminating in a strong claw the inner side of which is bullashaped and roughened ; mouth tube as for genus ; maxillule biramous with oval basipodite and one-jointed conical expodite bearing two setae ; endopod smaller with single broad seta ; maxilla two-jointed, inner margin of distal joint with three small spines ; maxillipeds two-jointed, second joint ending in a curved claw ; first leg biramous, rami single jointed ; basipodite with a spined papilla ; exopod with five broad spines, endopod with two short and one long spine ; third leg uniramous, broadly ovate and extends ventro-laterally ; fourth leg biramous and divided up to base, the exopod slightly longer than endopod ; egg sacs long, uniseriate with slightly flattened eggs.

Male.—Body short ; cephalothorax trapezoidal with round corners ; first thoracic segment fused with cephalon ; free part of thorax cylindrical, decreasing in width posteriorly ; genital segment indistinct ; abdomen one-segmented ; anal laminae conical and nearly twice length of abdomen, each with two apical setae and one seta in middle near outer margin ; antennule six-jointed, distal segment smallest bearing three apical setae ; antenna two-jointed, prehensile, second joint clawed ; maxillule and mouth parts as in female ; maxilla two-jointed, second joint clawed and having on its inner side three rows of four spines each ; maxilliped two-jointed, distal joint clawed and inner margin of basal segment with nearly 25 small spines ; first and second legs as in female ; third leg uniramous, long and tubular ; fourth leg biramous, exopod longer than endopod and bifurcated for more than three-fourths its length.

Measurements : *Female.*—Total length 2.175-2.363 ; cephalothorax 0.87-0.89×0.638—0.797 ; thorax 1.42×0.725 ; genital segment 0.145-0.159×0.217 ; abdomen 0.116-0.13×0.116-0.13 ; anal lamina 0.13-0.145 ; fourth leg exopod 1.887×0.159 ; endopod 1.01×0.13 ; egg sacs 2.196-2.329 ; eggs 0.092-0.043×0.188-0.203 ; antennule 0.145; antenna 0.464.

Male.—Total length 0.913 ; cephalothorax 0.435×0.435 ; thorax 0.42×0.39 ; genital segment 0.029×0.101 ; abdomen 0.043×0.058 ; anal lamina 0.087×0.021 ; third leg 0.43×0.072 ; fourth leg exopod 0.362×0.043 ; endopod 0.261×0.029.

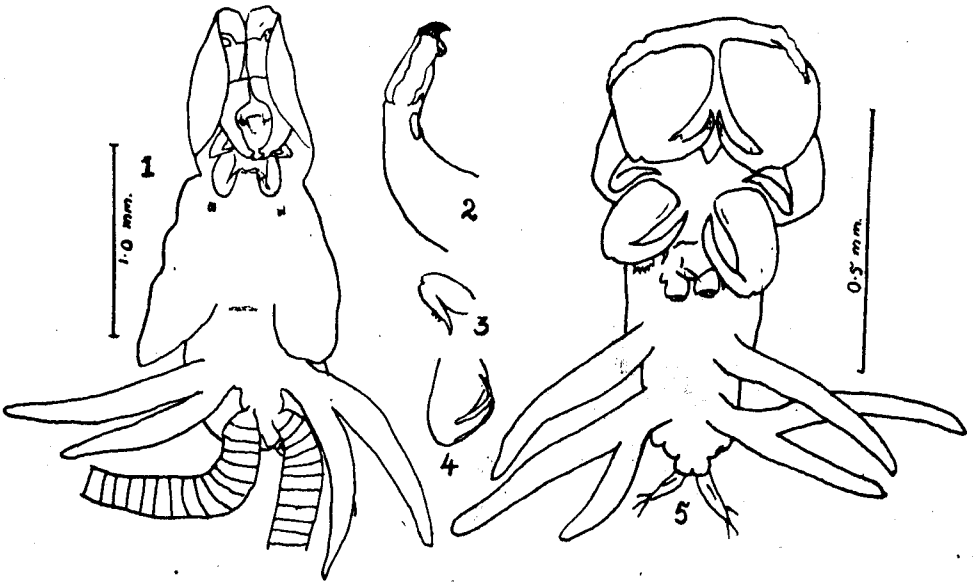


Figure 47. 1-5. *Lernanthropus kanagurta* Tripathi. Female : 1. ventral view ; 2. antenna ; 3. maxilla ; 4. maxilliped ; Male : 5. ventral view (after Tripathi, 1962).

Scombroid host : 1. *Rastrelliger kanagurta* (Cuvier).

Locality : Puri, Orissa Coast, India.

Non-scombroid host : Megalaspis cordyla.

Location : Gills.

Reference : Tripathi (1962).

Family : PSEUDOCYCNIDAE

Tripathi (1962) places the genus *Pseudocycnus* under the family Dichelestidae and subfamily Pseudocycninae. Heegaard (1962) recognises the family Cycnidae Kroyer (1863) in preference to Pseudocycnidae Wilson (1932) and describes a new genus *Paracycnus*, with *P. lobosus* Heegaard as the genotype. However, in this 'Addendum' also we continue the use of the family name Pseudocycnidae.

Heegaard (1962) also recognises four genera under the family Cycnidae (=Pseudocycnidae), namely *Cycnus*, *Paracycnus*, *Helleria*, and *Pseudocycnus* and distinguished them on the basis of the combination of characters shown in the following table :

	Cycnus	*Paracycnus*	*Helleria*	*Pseudocycnus*
1 segment	Fused with head	Fused with head	Not fused with head	Fused with head
Following segments	2, 3 segm. free rest, fused with genital segm.	2 segm. free, rest fused with genital segm.	1, 2, 3 segm. free, rest fused with genital segm.	2, 3 segm. free, rest fused with genital segm.
A_1	Several joints	Several joints	As in *Paracycnus*	Few joints
A_2	Subchela	Subchela	Like *Paracycnus*	Subchela
Mx	Vestigial	Vestigial	3-jointed, small	Vestigial
Mxp-1	Vestigial	3-jointed, small	3-jointed, small	3-jointed, small
Mxp-2	Delicate	Enormously large	Large, like *Paracycnus*, except for basal joint.	Well developed
Pe-1	Bifurcate	Uniramose, 4-jointed	Pe_2 uniramose	Uniramosal, 1 joint
Pe-2-4	Bifurcate, jointed	Bifurcate, unjointed	Pe_3 missing, Pe_4 uniramose	Pe_2 bifurcate, unjointed, Pe_{3-4} uniramose

The answer as to whether these four groups merit generic status or not should await a review of the family and until such time tentative recognition is given to *Paracycnus* Heegaard. As regards this genus, Heegaard (1962) remarks that it '.... is very closely related to *Cycnus* and *Pseudocycnus*' and 'Bassett-Smith's *Helleria* is another genus with some striking resemblances to the new *Paracycnus*.'

We have already mentioned (p. 928) that the generic name *Helleria* Bassett-Smith (1898a) being preoccupied, Bassett-Smith himself (1898b) proposed the name *Cybicola* to replace it with *Helleria armata* Bassett-Smith (=*Cybicola armata* (Bassett-Smith) as the genotype). Kirtisinghe (1937) has given ample reasons for considering *Cybicola* Bassett-Smith a synonym of *Pseudocycnus* Heller with which we agree. Recently, however, Tripathi (1962) has recognised *Cybicola* as a subgenus of *Pseudocycnus* and these nomenclatorial changes will have to be taken into account for evaluating the status of the genera of Pseudocycnidae recognised by Heegaard (1962).

The following combination of characters were used by Tripathi (1962) to group the species of *Pseudocycnus* Heller under two subgenera :

Antennule three- or four-jointed first thoracic segment fused with cephalon ; second and third thoracic segments with no lateral lobes (*Pseudocycnus* s. str.).

Species :

P. (*P.*) *appendiculatus* Heller.
P. (*P.*) *buccatus* Wilson.
P. (*P.*) *spinosus* Pearse.

Antennule seven-jointed ; first thoracic segment not completely fused with cephalon ; second and third thoracic segment with lateral lobes which may or may not be papillose (*Cybicola* Bassett-Smith and not *Cybicola* sub-gen. nov. as given by Tripathi).

Species :

P. (*C.*) *armata* (Bassett-Smith).
P. (*C.*) *elongata* Pearse.
P. (*C.*) *scomberesocis* Yamaguti.

Genus **Paracycnus** Heegaard, 1962

The diagnostic characters of the genus are given in the table on p. 985.

Paracycnus lobosus Heegaard, 1962

(Figure 48 : 1-9)

Description : Female.—Carapace ovate, anteriorly narrow and lateral margins curved into well rounded lobes ; posterior corners of carapace prolonged into well-rounded lobes ; free second segment wider than carapace with free lateral margins drawn out into postero-laterally pointing lobes ; third segment with double lateral lobes, while fourth segment with single lateral lobe as second segment ; the trunk formed also of the fusion of fifth and genital segment long, cylindrical and of uniform width ; one segmented abdomen markedly short, broader than long and carries a pair of long caudal rami broader at their bases and tapering towards their tips. Antennule long, slender, seven-jointed with horn-like seta on second joint ; and common setae on other joints except one, two and four ; antenna three-jointed and prehensile third joint of antenna very movable and can be bent backwards to form a subchela with second joint ; mouth cone short, maxilla rudimentary ; second maxillipeds large and prehensile ; first maxilleped vestigial and present as a small three-jointed organ at inner base of second maxilliped ; first pair of legs uniramous, four-jointed ; second, third and fourth legs with sympodial bulb with two small unjointed lobes representing exopod and endopod, each furnished with a short seta. Head 0.9 mm. ; greatest width 1.1 mm. ; length of free segment 0.5 mm. ; trunk 5. 0 mm. ; and width of trunk a little less than 1.0 mm.

Male.—Unknown.

Scombroid hosts : (1) *Scomberomorus commerson* (Lacépède). (2) *Scomberomorus queenslandicus* Munro.

Localities : (1) Cape Direction, North Queensland ; and Torris Strait. (2) Eden Reef and Princess Charlotte Bay, North Queensland.

Non-scombroid hosts : None.

Location : ? (Most probably gills).

Remarks : There is hardly any need to draw attention to the several similarities of this species to *Pseudocycnus armatus* Bassett-Smith.

Genus **Pseudocycnus** Heller, 1865

Pseudocycnus armatus (Bassett-Smith), 1898

Remarks : Kurian (1961) recorded ovigerous females (total length of one : 5.6 mm. inclusive of anal laminae ; egg case 6.4 mm. long) from the gills of the scombroid fish *Indocybium guttatum* (Bloch and Schneider) [=*Scomberomorus g. guttatus* (Bloch and Schneider)] caught off Alleppey, S.W. Coast of India. The anterior part of the cephalathorax, abdomen and anal laminae and the second maxilliped are figured.

Tripathi (1962) records *Pseudocycnus* (*Cybicola*) *armatus* from the gills of the scombroid fish *Cybium guttatum* (=*Scomberomorus g. guttatus* (Bloch and Schneider) from Puri, Orissa Coast, India. Two females and a male were obtained by him and the following measurements are given by him for a female and a (male).

Total length 4.393 (1.795) ; cephalothorax 0.58×0.58 (p.4×0.4) ; thorax and second segment 0.319×0.58 (thorax, second and third segment in male 0.232×0.232) ; fourth and genital segments

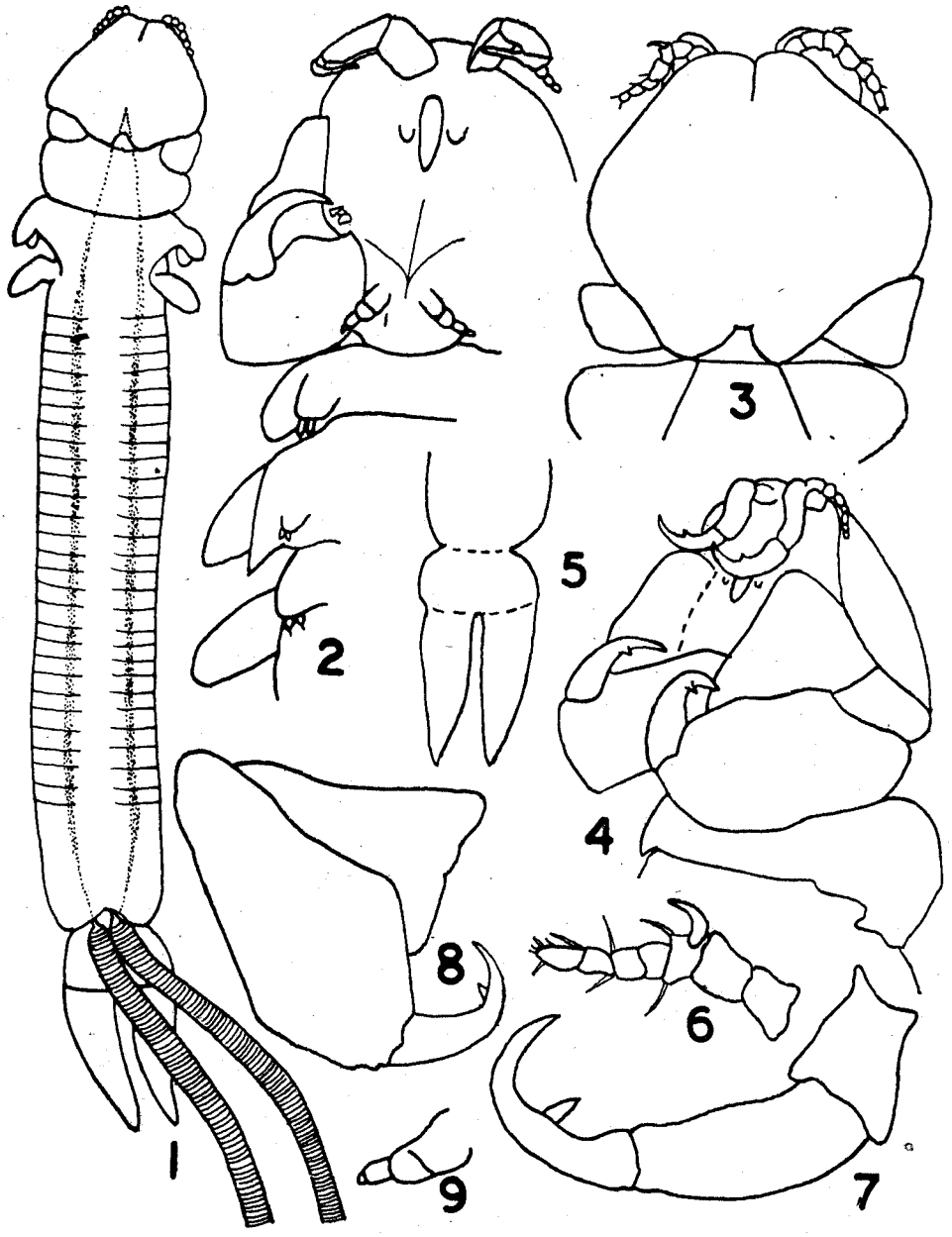


Figure 48. 1-9. *Paracycnus lobosus* Heegaard. Female : 1. dorsal view ; 2-4. ventral, dorsal and lateral views of head ; 5. posterior ventral region ; 6-7. antennule and antenna ; 8. maxilliped ; 9. first leg (1-9 after Heegaard).

2.465×0.58 (1.029×0.348) ; abdomen 0.232×0.507 (0.145×0.174) ; and anal lamina 0.638×0.232 (0.145×0.058 in male).

Pseudocycnus scomberomori Yamaguti, 1939c
(Figure : 49 : 10-18)

Description : Female.—Carapace slightly broader than long, narrowed anteriorly with prominent postero-lateral corners not divided into lobes posteriorly ; first thoracic segment narrower than second ; third and fourth segments with short digitiform processes on either side ; fifth segment indicated by a pair of lateral setae fused with the genital segment ; latter cylindrical, about 3.5 mm. long and 0.55 to 0.65 mm. broad ; abdomen very short, about 0.4 mm. long ; caudal rami

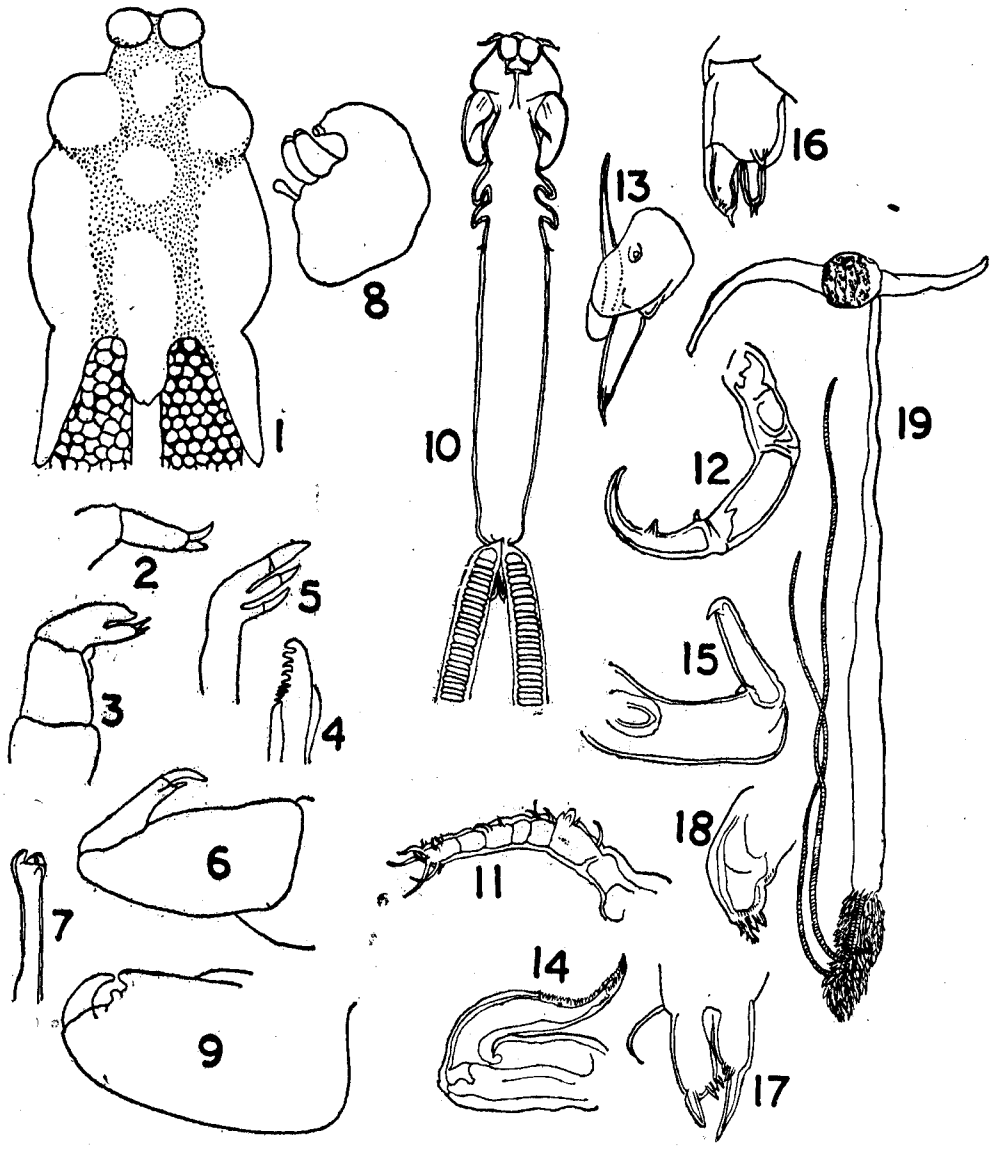


Figure 49. 1-9. *Clavellopsis paradoxa* (van Beneden). Female : 1. dorsal view ; 2. antennule ; 3. antenna ; 4. mandibular apex ; 5. maxillule ; 6. maxilla ; and 7. maxilliped ; Male : 8. lateral view ; 9. maxilla. 10-18. *Pseudocycnus scomberomori* Yamaguti. Female : 10. dorsal view ; 11. antennule ; 12. antenna ; 13. maxillule ; 14. maxilla ; 15. maxilliped ; 16-18. first to third legs. 19. *Pennella instructa* Wilson. (1-9 after Scott & Scott ; 10-19 after Yamaguti).

short, digitiform, about 0.3 mm. long with two setae at about middle of outer margin and a short spine at tip. Egg strings 10.2 to 10.8 mm. long attached to genital segment and dorsal to abdomen. Total length 4.7 to 5.0 mm.

Antennule seven segmented, second segment with a stout blunt spine at distal end of posterior margin ; antenna uncinate, terminal claw with an accessory spine near middle of inner margin and another smaller one at base ; maxillule with two spiniform processes one of which is directed anteriorwards and terminates in two points and the other single and directed inwards ; maxilla with a knob-like protuberance between its base and maxillule ; terminal claw laterally pectinate ; maxilliped when viewed from side consists of stout base with a blunt spine on inner margin and two rami, the inner of which bears two spines and the outer a row of five spines ; second leg biramous, basal segment broad and each ramus tipped with 3 spines ; fourth leg wanting.

Male.—Unknown.

Scombroid host : *Scomberomorus chinensis.*

Locality : Inland Sea, Japan.

Non-scombroid hosts : None.

Location : Gills.

Remarks : Yamaguti (1939c) remarks that the species differs from *P. armatus* (Bassett-Smith) and Kirtisinghe (1935, 1937), primarily in the head being broader than the trunk and the well developed nature of the first leg.

Family : PENNELLIDAE

Genus **Pennella** Oken

Pennella instricta Wilson

(Figure 49 : 19)

Scombroid host: (1) *Istiompax australis* [=*Makaira indica* (Cuvier)]. (2) *Marlina zelandica* (=*Tetrapturus audax* Philippi).

Localities : (1) Broughton Island near Port Stephen, New South Wales, Australia ; (2) Port Jackson, New South Wales, Australia.

Non-scombroid hosts : None.

Location : Heegaard (1962) records seven specimens from the skin of the black marlin and two specimens found embeded in the fin of the striped marlin from Australian waters.

Pennella sp. Ishii, 1916

Ishii (1916) records *Pennella* sp. from the undermentioned scombroid hosts from Japan : (1) *Thunnus orientalis* (Temminck and Schlegel) [=*T. thynnus orientalis* (Temminck and Schlegel)] and *Xiphias gladius* Linnaeus.

Pennella sp. Ho, 1963

Ho (1963) remarks on finding a species of *Pennella* inserted into the bodies of *Xiphias gladius* Linnaeus and *Istiophorus orientalis* (Temminck and Schlegel) (=*I. gladius*) landed at the fishing port of Nanfango in Formosa, but caught off Suao or in the vicinity of the islets of Keelung.

Suborder LERNAEOPODOIDA

Family : LERNAEPODIDAE

Genus **Brachiella** Cuvier, 1817

Brachiella thynni Cuvier, 1817

Scombroid host : *Indocybium lineolatum* (Cuvier) [=*Scomberomorus lineolatus* (Cuvier)].
Locality : Trivandrum, S.W. Coast of India.
Non-scombroid hosts : See p. 940 in main part of paper.
Location : Posterior side of base of pectoral fin.
Remarks : Pillai (1962c) mentions the above additional scombroid host for this species.

Genus **Clavellopsis** Wilson

Clavellopsis paradoxa (van Beneden), 1851
(Figure 49 : 1-9)

(Syn : *Anchorella paradoxa* van Beneden, 1851 ; *Clavella paradoxa* Scott and Scott, 1913).

Description : *Female.*—Cephalathorax fairly elongate, deflected backwards upon genital segment and slightly longer than that ; genital segment subquadriform with posterior corners produced postero-laterally and tapering ; an unpaired knobular process situated dorso-medially between lateral processes of genital segment ; anterior part of genital segment with three shallow knob-like projections ; two similar, but smaller knobular projections on anteriormost part of head ; antennule two-segmented and antenna three-jointed ; distal end of mandible serrated on one side ; maxilla slender with three digitate terminal processes ; first maxilliped two segmented with terminal claws ; second maxilliped short, coalascent and fixed to terminal chitinous plug ; size exclusive of cephalothorax about 4 mm.

Male.—Minute, nearly globular in shape ; second maxilliped relatively stouter than in female with single terminal claw.

Scombroid host : *Scomber scombrus* Linnaeus.
Localities : British and Irish Seas.
Non-scombroid hosts : None.
Location : Gill filaments of host.
References : van Beneden (1851), Bassett-Smith (1896), Scott (1906), Scott and Scott (1913), Wilson (1915), and Yamaguti (1939a).

Remarks : This species does not fully conform to the generic diagnosis given by Wilson (1915, 1932). The presence of the posterior processes of the genital segment distinguishes it from *Clavella* and *Clavellisa.*

Clavellopsis saba Yamaguti, 1939a
(Figure 50 : 1-10)

Description : *Female.*—Trunk elliptical about 2.8 to 3.7 mm. long, 1.0 to 1.8 mm. broad with a pair of conical processes ; median genital process fairly large, rounded, and of same length as lateral processes ; cephalothorax in line with maxillipeds, slender, 4.3 to 5.0 mm. long and 0.34 to 0.6 mm. thick ; head not enlarged, bluntly rounded in front ; antennule three segmented, basal segment with a knobular enlargement on antero-medial side and terminal segment tipped with 4 spines ; antenna biramous, anterior ramus one segmented, bluntly rounded and finely

spined ; posterior ramus two segmented, as long as anterior one, with two short spines and nodule at tip which is spined ; mandible with a row of 10 teeth, distal one rather blunt and proximal pointed ; maxillule terminating in three spiniform processes one of which is small ; proximal segment of maxilla stout with a single median spine on inner side surrounded by spinules ; distal segment with a spine on ventral side denticulated and a terminal claw ; maxilliped fused throughout its length, and abruptly narrows near the tip where it forms a collar-like fold ; a pair of large protuberances present on ventral side of maxillipeds.

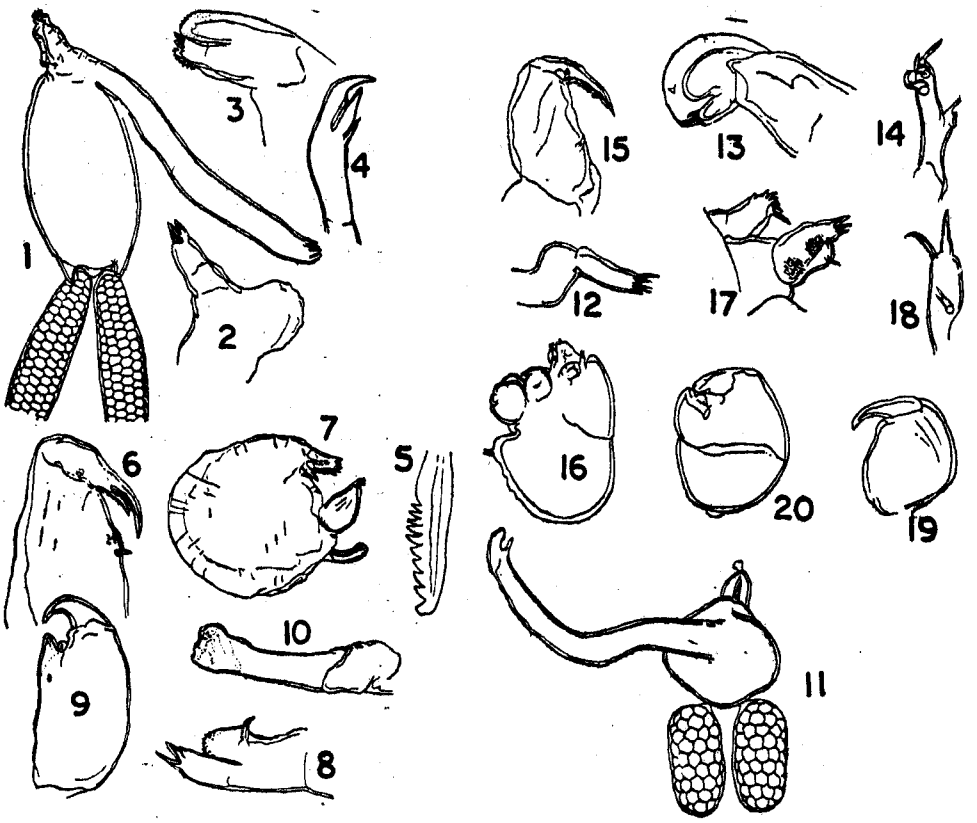


FIG. 50. 1-10. *Clavellopsis saba* Yamaguti. Female : 1. cephalothorax lateral view and trunk ventral view ; 2. antennule ; 3. antenna ; 4. maxillule ; 5. mandible ; 6. maxilla ; Male : 7. lateral view ; 8. antenna ; 9. maxilla ; 10. maxilliped. 11-20. *Clavellisa scombri* (Kurz). Female : 11. adult ; 12. antennule ; 13. antenna ; 14. maxillule ; 15. maxilla ; Male : 16. lateral view ; 17. antennule and antenna ; 18. maxillule ; 19. maxilla ; 20. maxilliped (1-20 after Yamaguti).

Male.—Body 0.56 mm. long ; cephalothorax 0.34 mm. long ; trunk strongly arched dorsally ; antennule similar to female ; anterior ramus of antenna much shorter than posterior one and provided on outer side of its base with a relatively large spine ; maxilla with a stout basal segment and a single terminal claw extending against conical process of basal segment ; basal segment of maxilliped rod-like and attenuated at distal end with a depression covered with minute blunt spines at distal corner against which the small terminal claw shuts down.

Scombroid host : *Scomber japonicus* (=*Scomber j. japonicus* Houttuyn).

Locality : Sizuoka Prefecture, Japan ; Tsunodayama, Niigata Prefecture, Japan.

Non-scombroid hosts : None.

Location : Gills.

Reference : Yamaguti (1939a).

HOST—PARASITE LIST

(The generic names of host and parasite species are alphabetically arranged in the list. As the original description of *Tuxophorus cybii* Nunes-Ruvio (1956) has not been consulted in original, the name of the host species is not available for inclusion in this list).

Host species	Parasite species
Acanthocybium solandri (Cuvier)	*Tuxophorus solandri* Kurian
Auxis thazard (Lacépède)	*Caligus auxisi* Pillai
Euthynnus affinis affinis (Cantor)	*Caligus affinis* Kurian *Caligus amblygenitalis* Pillai *Caligus coryphaenae* Steenstrup and Lutken *Caligus euthynnus* Kurian *Caligus kuroshio* Shiino *Caligus thynni* Pillai
Euthynnus affinis yaito Kishinouye	*Caligulus longispinosus* Heegaard *Caligus alveolaris* Heegaard
Istiophorus gladius (Broussonnet)	*Gloiopotes watsoni* Kirtisinghe *Pennella* sp. Ho, 1963
Katsuwonus pelamis (Linnaeus)	*Caligus coryphaenae* Steenstrup and Lutken
Makaira indica (Cuvier)	*Gloiopotes longicaudatus* (Marukawa) *Pennella instricta* Wilson
Rastrelliger kanagurta (Cuvier)	*Bomolochus aculeatus* Pillai *Caligus kanagurta* Pillai *Lernanthropus kanagurta* Tripathi
Scomber japonicus japonicus Houttuyn	*Clavellopsis saba* Yamaguti
Scomber scombrus Linnaeus	*Clavellopsis paradoxa* (van Beneden)
Scomberomorus chinensis	*Pseudocycnus scomberomori* Yamaguti
Scomberomorus commerson Lacépède	*Caligus obovatus* Heegaard *Caligus maculatus* Heegaard *Caligus proboscidactus* Heegaard *Caligus quinqueabdominalis* Heegaard *Paracycnus lobosus* Heegaard *Tuxophorus cervicornis* Heegaard
Scomberomorus guttatus guttatus (Bloch and Schneider)	*Caligus brevisoris* Shen *Pseudocycnus armatus* (Bassett-Smith)
Scomberomorus niphonius (Cuvier)	*Caligus microdontus* Heegaard
Scomberomorus lineolatus (Cuvier)	*Brachiella thynni* Cuvier

Scomberomorus queenslandicus Munro	*Caligus maculatus* Heegaard *Caligus obovatus* Heegaard *Caligus proboscidatus* Heegaard *Paracycnus lobosus* Heegaard
Tetrapturus audax Philippi	*Gloiopotes longicaudatus* (Marukawa) *Pandarus satyrus* Dana *Pennella instricta* Wilson
Thunnus thynnus orientalis (Temminck and Schlegel)	*Pennella* sp. Ishii, 1916
Xiphias gladius Linnaeus	*Pennella* sp. Ishii, 1916

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THE SCOMBROID FISHERY OF INDIA—PRESENT AND FUTURE

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INTRODUCTION

THE scombroids constitute a significant part of the marine fish landings in India. A number of prime fishes come under this group and the account by Jones and Silas (1962a) may be referred to for information on the different species. Only a very brief review is attempted here with the object of focussing attention on the potentialities for the development of this resource in the seas around India.

The statistics for the last 12 years (1950 to 1961) show that on an average 82,085 tonnes of scombroids are caught every year forming about 12.3 per cent of the total marine fish catches of which the Indian mackerel forms the major part (Figs. 1 and 2). The seerfishes and tunas rank

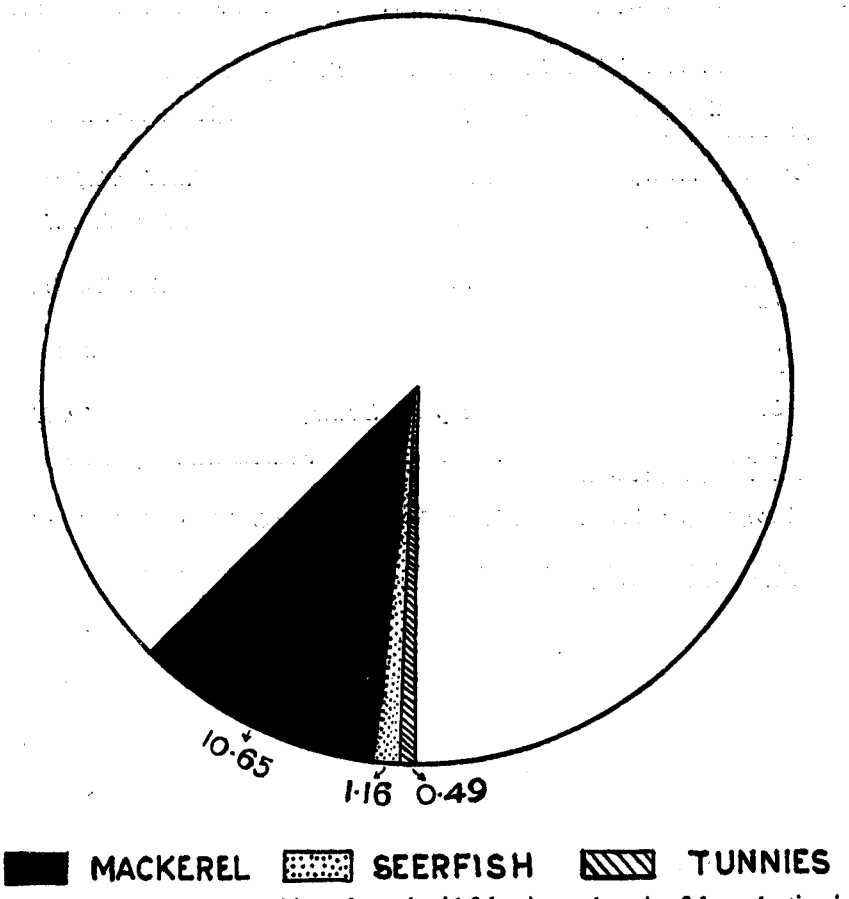


FIG. 1. Percentage composition of scombroid fishes in total marine fish production in India (based on 1950-61 landings).

much less in importance while the billfish catches consist only of stray specimens caught incidentally and as such no statistics are maintained. The catch statistics of mackerel, seerfishes and tunas are given in table I and the scombroid landings in relation to total landings along the West Coast and East Coast are represented in figs. 3 and 4 respectively.

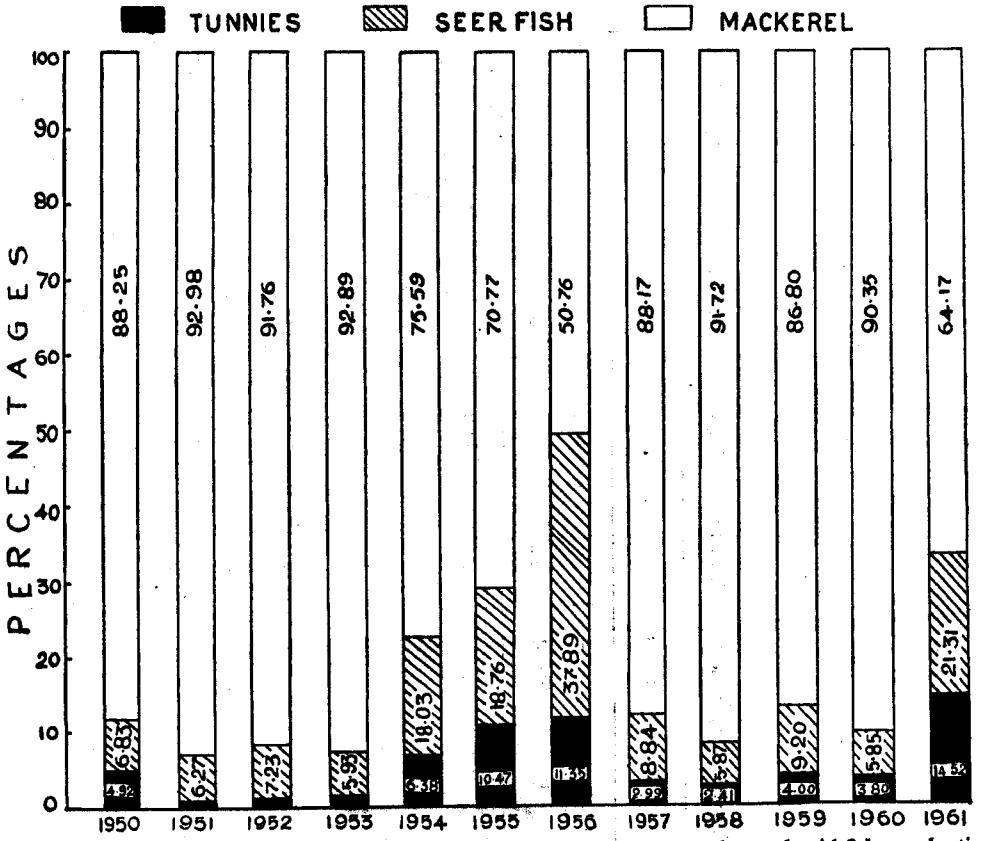


FIG. 2. Percentage composition of mackerel, seerfish and tunnies in total scombroid fish production during the years 1950-61.

MACKEREL FISHERY

The mackerel fishery along the coasts of the mainland of India has been briefly described by Pradhan and Rao (1958) and is constituted by *Rastrelliger kanagurta* while in the Andaman Sea *R. brachysoma* also is found to occur along with the former (Jones and Silas 1962b). The fishery is concentrated along the southern section of the West Coast of India from Quilon—Alleppey to Goa—Ratnagiri where it forms a pelagic fishery of considerable magnitude though subjected to wide fluctuations. The catches range from 15,023 to 1,29,573 tonnes on the West Coast as against 367 to 6810 tonnes on the East Coast. On the East Coast there is no fishery as such for mackerel which is caught mixed with other fishes whereas on the West Coast shore seines, boat seines and gill nets are specially operated for this fish. Fishing is carried out only along the coastal waters, after sighting the shoals and generally not beyond the 15 fathom line. For further details reference may be made to the Rastrelliger synopsis given elsewhere (Jones and Rosa 1962).

At present catches are entirely dependent on the shoals that come close to the coast and the possibilities are that an appreciable part of the stock remains unexploited beyond the range of

TABLE I

Coast-wise landings of scombroids for the years 1950 *to* 1961 (*Figures in metric tonnes*)

	LANDINGS OF SCOMBROIDS											
	Mackerel			Seerfish			Tunnies			Total for scombroids		
	East	West	Total	East	West	Total	East	West	Total	East	West	Total
1950	2,426	86,737	89,163	5,991	915	6,906	..	4,693	4,693	8,417	92,345	1,00,762
1951	1,326	1,03,574	1,04,900	5,340	1,751	7,091	200	648	848	6,866	1,05,973	1,12,839
1952	720	77,294	78,014	5,581	731	6,312	68	794	862	6,369	78,819	85,188
1953	1,156	69,592	70,748	4,114	391	4,505	258	641	899	5,528	70,624	76,152
1954	367	27,891	28,258	4,239	2,016	6,255	225	2,096	2,321	4,831	32,003	36,834
1955	947	21,849	22,796	3,594	2,451	6,045	198	3,173	3,371	4,739	27,473	32,212
1956	1,408	15,023	16,431	4,011	8,254	12,265	398	3,272	3,670	5,817	26,549	32,366
1957	2,270	86,740	89,010	3,979	4,642	8,921	99	2,915	3,014	6,348	94,597	1,00,945
1958	708	1,22,574	1,23,282	3,889	4,000	7,889	352	2,887	3,239	4,949	1,29,461	1,34,410
1959	1,487	60,711	62,198	3,062	3,528	6,590	278	2,588	2,866	4,827	66,827	71,654
1960	4,082	1,29,573	1,33,655	3,852	4,798	8,650	293	5,322	5,615	8,227	1,39,693	1,47,920
1961	6,810	27,675	34,485	6,182	5,267	11,449	844	6,961	7,805	13,836	39,930	53,739

the non-mechanised indigenous fishing craft employed at present. Even large catches of mackerel do not usually bring about glut since the demand in fresh or iced condition is high and the fish could be cured with ease in different ways. The cured product stands storage well without much deterioration for an appreciable length of time and has a wide market especially in the interior tracts of the country. Some quantities are exported to Ceylon also. Extension of fishing operations beyond the areas covered at present with the help of mechanised boats and use of purse seine as is done in Malaya (Jones 1962) are likely to prove successful in augmenting the catches. An area the resources of which we have very little information is the Andaman Sea. Judging from its nearness to Malaya and Indonesia where mackerel forms an important fishery it would appear from the information available that there is scope for the development of the fishery there.

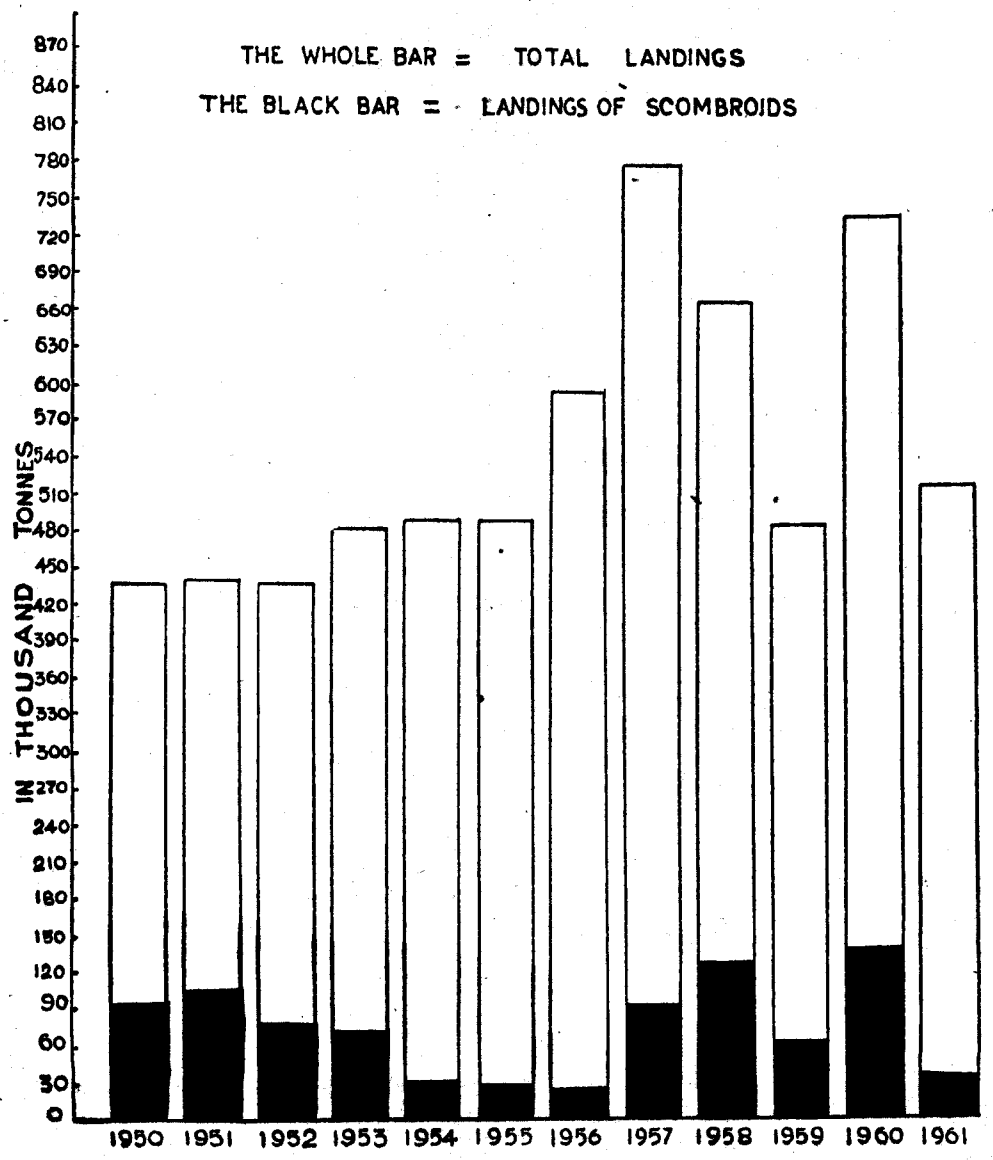


FIG. 3. Scombroid fish landings in relation to total landings in west coast.

SEERFISH FISHERY

This is a coastal fishery of appreciable importance coming next to that of the mackerel among scombroids. Though in quantity it does not come anywhere near the former, the seerfishes constitute a group of prime fishes very much in demand both in fresh and cured condition. The species consist of *Scomberomorus guttatus*, *S. commerson* and *S. lineolatus* of which the first two are more common than the last one. They are generally caught in gill nets, hook and line and troll line though stray numbers occur in shore seines and other types of nets. A considerable quantity of the catch is salt cured either for internal consumption or for export.

In addition to the typical seerfishes mentioned above, there is the wahoo, *Acanthocybium solandri*, a rather rare species generally found near reefs. It is caught in stray numbers in the Gulf of Mannar and the contiguous Cape Region of peninsular India as far as Vizhingam near Trivandrum. It is found in the Andamans and the Laccadives also and does not constitute a fishery of any significance anywhere.

It could be seen from the statistics that during the earlier years more seerfishes were caught in the East Coast than on the West Coast. The situation has changed since 1956 and the catches along both the coasts seem to be more or less the same. An overall increase has been registered since the use of nylon nets and it would appear that there is scope for further increase. More intensive trolling in certain areas might also help to increase the catches.

TUNA FISHERY

The tuna fishery along the mainland of India is constituted by *Euthynnus affinis* which is the commonest species followed by *Kishinoella tonggol*. There is a seasonal fishery in some areas for *Neothunnus macropterus* (Silas 1962). Small numbers of *Auxis* spp. are caught, the more common being *Auxis thazard* though rarely large shoals of *A. thynnoides* have been recorded. *Katsuwonus pelamis* also occurs in stray numbers but it forms a fishery of considerable importance in Minicoy in the Laccadive Archipelago. Among the fishes related to tunas *Gymnosarda* and *Grammatorcynus* occur in the catches in the Andaman area while *Sarda orientalis* occurs in small numbers seasonally in the southern section of West Coast of India. There is practically no information about the larger oceanic species which constitute the bulk of the catches of the Japanese fishing vessels that cover the seas around India.

It may be stated in this connection that there is no fishing specially for tunas in India except in the island of Minicoy where *Katsuwonus pelamis* is caught by pole and line using live bait (Jones 1958, Jones and Kumaran 1959) as in the Pacific. Along the coasts of the mainland of India tunas are caught along with other fishes in hook and line, troll line and gill net and to a lesser extent in shore seine and boat seine.

It is rather disconcerting to see that even though the seas around India are fished for tunas regularly by the Japanese, little attention is paid in this direction by us and it would appear that the very existence of this resource in the offshore waters is not known to many. There is great scope for the development of tuna fishing in the high seas around India and the future of marine fisheries development in this country would depend mainly on the progress made in this direction.

BILLFISH FISHERY

The fishery for billfish along coastal waters is practically negligible. These fishes are generally caught in trolling lines, hook and line and gill nets occasionally along with other fishes. This group is constituted mainly by sailfish and marlins which occur only in stray numbers along the coastal waters (Silas and Rajagopal 1962). Of these the sailfish (*Istiophorus gladius*) is more

common while marlins are only occasionally caught. Records of swordfish (*Xiphias gladius*) are very few and are mainly confined to the Laccadive Sea. The billfishes in general are oceanic fishes and form an untapped resource next to tunas in the seas around India.

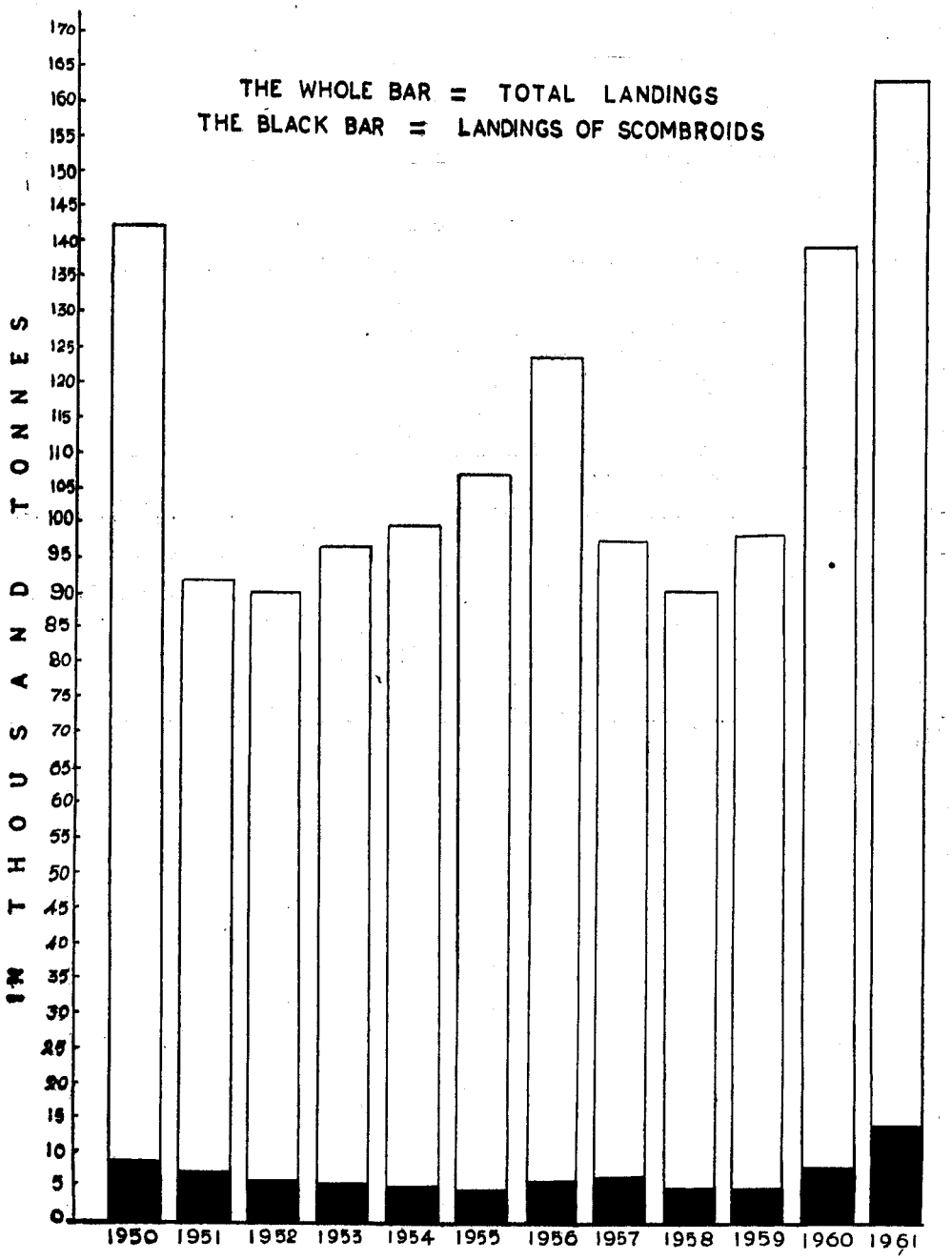


FIG. 4. Scombroid fish landings in relation to total landings in east coast.

General Remarks

The scombroid fishery of India as it is to-day is more or less a static one in view of the fact that the area fished and the fishing methods have also been more or less static. At the present rate of development the future does not seem encouraging. It is obvious that to a very great extent the future depends on the judicious exploitation of our latent oceanic fishery resources, constituted mainly by tunas and billfishes. The initiative is already in the hands of other nations and obviously it is ignorance of the actual situation that is responsible for the present complacency. A proper appraisal of the situation and a dynamic approach to the problem are called for as otherwise we are bound to lose the advantage we have by virtue of our geographical position in the central part of the Indian Ocean.

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NOTE ON THE SCOMBROID FISHERY IN MALAYA

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THE INSHORE SCOMBROID FISHERY

In spite of the uncertainties in the movements of the scombroids, both seasonal and diurnal, which make their fisheries an unpredictable and difficult one the fisheries have progressively developed into the best developed and most productive fisheries in this country. About 20% of the annual catch of fish comprises scombroids which far exceed any other group in yield.

Amongst the scombroids the fisheries for *Rastrelliger* stands high both in the development of the fishery and in the production of fish. Some 75% of the annual scombroid catch comprises *Rastrelliger* and comes from four main centres of fishing, these being Kedah and Pangkor Island on the West Coast of Malaya, Johore and Trengganu on the East Coast. Except in Trengganu, in the other three fishing centres fishing is mainly by purse seines.

Although far less abundant than *Rastrelliger*, about 19% of the annual scombroid catch—Table 1, the *Scomberomorus* spp. are highly esteemed as food and fetch a much higher price in the markets. The catch of 80,860 pikuls during 1960 fetched $10,270,000 as compared to $13,660,000 from 325,378 pikuls of *Rastrelliger*.

The Tunas are unimportant on the West Coast but on the East Coast where there is a good demand for these fish by the local inhabitants, there is scope for further development to improve the fishery for these fish.

TABLE I

Scombroid Catch Statistics

(in pikuls)

	1958	1959	1960
Rastrelliger	247,301	434,284	325,378
Scomberomorus spp.	116,440	76,761	80,868
Tunas	18,963	13,407	28,307

(16.8 pikuls=1 ton)

MAIN SPECIES

The study of the systematics of this group in Malayan waters seems necessary for available works are inadequate, and even recent publications have not, unfortunately, attempted to improve on these older works. The Tunas merit special attention as literature on their systematics and distribution is extremely scanty.

Two species of *Rastrelliger* have been observed although three species are recorded by Fowler for Malayan waters. *Rastrelliger kanagurta* Cuvier, is the commercially important species, and

the second species, identified as *Rastrelliger brachysoma* Bleeker, was observed only on one occasion when three specimens were taken from the catches landed at Pangkor Island.

Scomberomorus commersonii Lacépède, *S. guttatus* Bloch & Schneider, and *S. lineolatus* Cuvier & Valenciennes, are common to both the West and East Coasts, but the last named species appears to be more abundant on the East Coast where it occurs throughout the year.

Although local names are employed to distinguish the various species of tunas yet there appears to be some confusion in the use of these names; the same name has been used to distinguish different species in different localities. Three species are common in Malayan waters and they are *Euthynnus alleteratus affinis* Cantor, *Thunnus sibi* Schlegel, and *Auxis thazard* Lacépède.

Distribution and Seasons of Fishing

Observations of commercial statistics show that the best season for *Rastrelliger* fishing is from April to September, and that *Rastrelliger* appears abundantly particularly off the four main centres mentioned above. Between Kedah and Pangkor Island shoals appear sporadically, and fishing activities of both the Pangkor Island and Kedah based purse seiners are directed to this area especially when catches in their respective grounds are poor. To the south of Pangkor Island there is no fishery for *Rastrelliger*. On the East Coast the two main centres are Johore and Trengganu, one to the south and the other to the north. Between these two centres there is no regular fishery for *Rastrelliger* but occasionally catches are made when shoals appear in these waters.

The distribution of the *Scomberomorus* spp. is widespread in the inshore waters, and seasonal variations in appearance and in numbers are less marked than those displayed by *Rastrelliger*. There are two main seasons of fishing in the West Coast. Towards the north it is from November to February, and towards the south it is from March to July. On the East Coast there are two main fishing seasons towards the south. These are from February to March and August to November. Towards the north the season is more extensive, it being from October to March.

On the East Coast where the tunas constitute an important fishery the main seasons of fishing vary from north to south along this coast. Towards the north the seasons are from June to July, and from October to November, while in the south they are from March to May, and from July to October.

In general, during the North East Monsoon, from November to March, when stormy conditions prevail fishing activities are curtailed and often come to a halt on the East Coast. The establishment of halting bungalows on the islands within the inshore waters has in the past year enabled fishermen to continue fishing during this period and to take shelter on the islands during storms.

Fishing Gears

The variety of gears employed for the scombroids is few but other gears also take them occasionally in varying quantities (Table II). The main gear for *Rastrelliger* is the purse seine. On the East Coast *Rastrelliger* is also taken by gill-nets, lift-nets, and other seines of smaller size used specially for *Stolephorus* and clupeids in shallower inshore waters. The seaward limit of purse seine operations is about 30 miles where the depth is around 30-35 fathoms.

The *Scomberomorus* spp. are taken on both coasts mainly by gill-nets, which are the most widely used gear in the country. The introduction of outboard and inboard engines has enabled gill-net fishermen to extend operations further seaward than it has hitherto been possible with sailing

or rowing boats. Hand lines and troll lines are also important on the East Coast where these gears are employed mainly for the *Scomberomorus* spp. and Tunas. On the West Coast tunas and other pelagic shoaling fish are taken by purse seines whenever shoals are sighted.

TABLE II

Percentage capture of species by gears

	Purse Seine	Gill-Net	Lines	Stake Traps	Lift-Nets
Rastrelliger	87	7,5	—	1	4
Scomberomorus spp.	1	60	29	9	1
Tunas	17	16.5	65.5	1	1

Only after independence was gained was there any attempt to set up a Research Division in the Fisheries Department. The activities of this Division are now directed towards studies on Cockle culture and *Rastrelliger* fisheries. It is hoped in the years to come to expand the activities of this Division to carry out researches on the scombroids and other important food fishes of our coastal waters. A sound knowledge of these fishes and their fisheries is sadly wanting and has been neglected in the past. Such knowledge is indispensable in planning future development of these fisheries.

OFFSHORE TUNA FISHING

The Malayan Marine Industries is a Malay-Japanese venture established in late 1959 to partake of the rich fishery for tunas in the Indian Ocean which was discovered by the Japanese during their surveys between the years 1930 to 1934, and later exploited, almost exclusively, by them since 1952.

Although Malaya is aware of this rich and valuable fishery and is desirous of establishing fisheries for tunas and other offshore fish to increase the production of fish the barrier to such developments is the lack of trained and experienced fishermen with the know-how of offshore fishing techniques.

At present, the actual fishing operations are carried out by vessels contracted by this venture. The vessels and personnel are Japanese. Initially one vessel of 99.37 gross tons, 55 tons load capacity, and of 250 b.h.p. delivered about 45 tons of fish at the rate of a trip per month. Subsequently the number of vessels were increased to five, the largest of these was of 308.46 gross tons, 180 tons load capacity, and of 650 b.h.p.

In 1960 a total of 20 trips, each of about 4-5 weeks duration, yielded 29,395 pieces weighing 2,081,263 lbs. In 1961, up to September, the yield from 15 trips was 20,728 pieces weighing 1,557,339 lbs. Fishing operations during these trips were carried out in the area delimited by E. 80° to E. 110° and N. 5° to S. 12°. On three occasions during 1960 catches were made near the coast of East Africa. The distribution of tunas in this fishing area with regard to space and time is discussed by Nakamura, *et al.* (1955) and observations on catch by position show that it conforms to the pattern described.

During 1960 about 80-90% of the catch by numbers in all trips comprised the following three species—albacore (*Thunnus alalunga* Bonnaterre), yellowfin (*Thynnus macropterus* Temminck &

Schlegel), and big eye (*Parathunnus obesus* Lowe). Although during 1961 these three species again dominated in the catch their proportions in the catch differed as compared with the previous year. A greater percentage was contributed by the yellowfin, Table III, while the albacore was much reduced in numbers. The black marlin (*Makaira mazara* Jordan & Synder), white marlin (*M. marlina* Jordan & Hill), and striped marlin (*M. mitsukurii* Jordan & Snyder), appeared in the catch of every trip and comprised some 10% of the catch. The others, which included the sword fish (*Xiphias gladius* Linnè), sail fish (*Histiophorus orientalis* Temminck & Schlegel), skipjack (*Katsuwonus pelamis* Linné), spanish mackerel (*Acanthocubium sara* Lay & Bennet), blue fin (*Thunnus thynnus* Linné), and sharks, appeared sporadically in the catches in small numbers.

TABLE III

Composition of Catch

	1960		1961 (to September)	
	Pieces	*Weight in lbs.*	*Pieces*	*Weight in lbs.*
Albacore	8,090	399,511	1,950	96,365
Yellow fin	10,874	758,384	13,400	868,268
Big eye	6,621	562,740	4,400	378,178
Black marlin	865	139,521	542	90,217
White marlin	441	65,305	126	26,887
Striped marlin	471	51,634	338	43,722
Others	3,033	104,168	922	54,702

The shore establishments of this venture comprises cold storage rooms for 200 tons of fish, and a quick freezing room with a capacity of 7 tons per day. Canning and processing are carried out in one of the local canneries where local labour work under the supervision of Japanese technicians. The products turned out are canned tuna, tuna sausage, fish meal and powder. Tuna is canned in Soya bean oil, Cotton seed oil, and Tomato sauce either in solid pieces or in flakes. Table IV shows the production of canned tuna which was exported mainly to Europe. Limited quantities of tuna sausages were produced for local consumption as the shelf-life of the sausage is estimated at only two weeks. Pet food as a by-product was produced mainly for export.

TABLE IV

Canned Tuna and Pet food Exports

(cartons containing 48 cans)

	1960	1961
Yellow fin ..	17,510	24,278
Big eye ..	7,005	18,197
Albacore ..	7,038	6,920
Skipjack ..	..	50
Petfood ..	9,354	3,164

It is hoped that local enterprises and fishermen would be stimulated by the activities of this venture to set up similar ventures of their own. Facilities for training in tuna fishing have been offered by this venture to a limited number of local fishermen, and during the past three years a Japanese expert on Tuna fishing has been actively engaged in training fishermen in the construction and operation of the tuna long-line and other gears. Already, the Government has, as the first step to encourage offshore fishing, planned the construction of a 200 ton vessel to train fishermen in offshore fishing methods, particularly for Tunas in the Indian Ocean.

Summary

The importance of the inshore scombroid fishery, the main species landed, their occurrence and seasonal variation along the coastal waters of Malaya, and the gears employed in the fishery with the percentage capture by each gear, are outlined briefly.

A note on the activities of the joint Malay-Japanese company formed in 1959 to partake in the Indian Ocean tuna fishery is also included.

Acknowledgements

I am grateful to the Malayan Marine Industries Ltd. Penang for the information on its activities, and to the Regional Administrative Officers of the Fisheries Division for their assistance in compiling data on the local scombroid fishery.

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SCOMBROID FISHERIES OF MADRAS STATE, INDIA

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THE Madras State has a coastline of 1000 kilometres. The scombroids contribute to 6-10 per cent of the fish landings along this coast.

Important species : The following species occur in the coastal waters of Madras State.

Family Scombridae. (Mackerels)

1. Indian Mackerel—*Rastrelliger kanagurta* (Cuvier).

Family Thunnidae. (Tunas).

2. Mackerel Tuna—*Euthynnus affinis* (Cantor).
3. Yellowfin Tuna—*Neothunnus macropterus* (Temminck & Schlegel).
4. Bluefin Tuna—*Kishinoella tonggol* (Bleeker).
5. Skipjack—*Katsuwonus pelamis* (Linnaeus).

Family Scomberomoridae. (Seerfishes).

6. Barred Spanish Mackerel—*Cybium commersoni* (Lacepede).
7. Spotted Spanish Mackerel—*Indocybium guttatum* (Bloch & Schneider).
8. Streaked Spanish Mackerel—*Indocybium lineolatum* (Cuvier).

Family Xiphiidae.

9. Broadbill Swordfish—*Xiphias gladius* Linnaeus.

The Mackerel Fishery : Mackerel shoals close to the shore and contributes to valuable fisheries. The average annual catch is about 2800 metric tons.

Along the Kanyakumari district coast, the mackerels are landed in shore-seine nets during August-October. In the southern sector of the Gulf of Mannar, boat-seines (bag-nets) are used during November-January, and occasionally drift nets (75 mm. mesh) are employed. In the northern sector of the Gulf, large quantities of mackerels are landed from October to December in shore-seine nets. Dhanushkodi is the most important mackerel fishing centre. In the Palk Bay, fair quantities of mackerel are landed in drift nets along with other varieties of fishes. Along the Coromandel coast, north of Nagapattinam, mackerel is landed in large numbers from February to May, using drift nets of 50-75 mm. mesh. Near about Cuddalore and Pondicherry mackerels are landed in the edavalai (boat-seine net) during April-May. About 500-600 mackerels are captured in one haul of this net. Along the Chingleput and Madras districts coast mackerels are landed in the Periyavalai (shore seine net) which is the most effective gear along this area. About 5000-6000 mackerels are obtained in a single operation of this net during April-May.

Mackerels 150-260 mm. in size, constitute the commercial catches. Mature and spent fish are frequently noted in the months of August, September and October. Juveniles below 120 mm. are found in the landings from February to April. The stomach-contents of specimens collected

off Ennore, Krusadai and Tuticorin consisted uniformly of diatoms (*Asterionella, Biddulphia, Chaetoceros, Coscinodiscus, Nitzschia, Pleurosigma, Rhizosolenia* and *Thalassiothrix*), peridinians (*Peridinium* and *Ceratium*), copepods, mysids, pteropods (*Creseis acicula* and *Spiratella inflata*), larval bivalves and fish eggs and larvae (of clupeioids and carangoids). *Trichodesmium erythraeum*, foraminiferan shells and sand grains have been met with in the stomach-contents of some of the specimens examined.

Mackerels are consumed both in the fresh and cured condition. Cured fish is preferred in the inland areas particularly by the working classes.

Tuna Fisheries: The Mackerel Tuna is more commonly known to the fishermen of Madras State. Fishes weighing 6 to 16 kilograms are common in the catches.

In the Kanyakumari district coast Mackerel Tuna are obtained in bottom-set nylon nets (150 mm. mesh). On certain occasions during August-September, about 600 kilograms of this tuna are obtained in a single haul. Shore-seine nets are also employed in this area for capturing this tuna. In the southern sector of the Gulf of Mannar the fish is landed in good numbers in the Pachuvalai (drift net) of 130-150 mm. mesh in about 30 metres depth from August to October. In the northern sector, in addition to drift nets, trolling lines are used. These lines are of hard twisted cords 4 mm. in thickness and 55 metres in length, and provided with No. 1 hooks attached by means of silvery or coppery wire snooks of 2 metres length. The hook is usually covered with a tuft of lure fibre, and is baited with small fishes like sardines. Fast sailing boats are used for trolling operations. Shore-seine nets are used along the coral islands off Ramanathapuram coast for obtaining these tunas. Up to 200 numbers of the fish are obtained in a single haul. Along the Coromandel coast, these tunas are landed in trolling lines and long lines by the catamaran fishermen who operate these gear on their return (homeward) journey from their normal fishing grounds. The Madras and Chingleput fishermen operate long lines with 4 and 5 hooks baited with squids, during August-October season. Each line has 400 hooks and they are laid in 25-40 metres deep waters.

The Yellow fin Tuna and Blue fin Tuna are also obtained by the fishermen all along the coast in smaller numbers. These tunas weigh 18 to 45 kilograms individually. Whiffing lines baited with squids and sometimes with Chub Mackerel are largely used for capturing these large tunas. Trolling lines and long lines are also used. The main season for these tunas is August-October. The Blue fin Tuna is sometimes landed in the shore-seine nets operated at Thangapattinam, Thoottur and Enayamputhenthura villages of Kanyakumari district coast.

Tunas do not have much market value in Madras State. They are therefore cured and exported to other countries, particularly Ceylon.

Observations at Tuticorin and Ennore have shown that the food of the Mackerel Tuna consists of smaller fishes like *Dussimieria hasselti, Sardinella albella, S. fimbriata, S. gibbosa, Anchoviella indica* and *Caranx sexfasciatus*. Female specimens with fairly developed gonads have been recorded from April to June. But fully mature specimens have not been noted. The excursion of this fish into the coastal waters is evidently for feeding only.

Seer Fish Fishery: The seer fishes are common in the coastal waters of Madras State and are landed throughout the year. The average annual catch is about 3500 metric tonnes. Drift nets, 35 metres long, 10-12 metres broad and 75-115 mm. in mesh, are commonly used for capturing seer fishes. The average weight of a seer fish ranges from 1 to 4 kilograms. Larger ones upto 22 kilograms in weight are caught in trolling lines. Occasionally seer fishes are obtained in bottom-set gill nets.

The Barred Spanish Mackerel spawn in the coastal waters in the months of May-July. Its eggs and larvae have been collected in the Gulf of Mannar and the Coromandel coast. The food of

this mackerel consists of smaller fishes like *Anchoviella indica* and *Dussumieria hasselti*, prawns (*Penaeus indicus* and *P. dobsoni*) and cuttle fish (*Loligo indica*).

Broadbill Swordfish : Bill fishes do not form a fishery along the coast of Madras State. But few numbers, 1500-2000 mm. in length and 30-40 kilograms in weight, are caught in trolling lines and drift nets from September to November in the Gulf of Mannar off Rameswaram and Kanyakumari. Near Ennore at the northern end of Coromandel coast, three specimens weighing 55, 108 and 150 kilograms and measuring 1500-2000 mm. in length, were landed in June, July and August 1960.

General : The salinity of the water of the scombroid fishing areas generally ranged from 33.4 to 36.12%, with about 70 per cent oxygen-saturation. Silicate and phosphate ranged from 2.5 to 125.9 and 0.0 to 8.0 μ gm/l. A programme for better utilisation of this group of fish is being implemented.

Discussion

Dr. S. Jones expressed the view that there could be a possible confusion in the identity of what had been stated as the Broadbill swordfish to some species of marlin as the former had never been found in the catches, while marlins were frequently caught, in the coastal waters of the Madras State.

Mr. P. I. Chacko replying stated that it was not so the case and that he was certain of the identity of what had been referred to as *Xiphias gladius*.

LA PESCA DE LOS ESCOMBRIDOS EN EL LITORAL MEDITERRANEO ESPAÑOL

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ABSTRACT

The scombroid fishes exploited in the Mediterranean Spanish coast are the mackerel *Scomber scombrus*; bluefin tuna *Thunnus thynnus*; bonito *Pelamys sarda* and the frigate mackerel *Auxis thanzard*. Little quantities of albacore *Germo alalunga* are present sometimes.

The landings are different according to species and years. 3,000 Tm of the mackerel are landed yearly, mainly in the north coast. The mackerel is fished by the ring net and the trawl. The other three species are fished by the very large ring nets, but mainly by special trap-nets named in Spanish "almadrabas," and "almadrabillas" according to size and structure. Very important are the "almadrabas" for landings and economical effort. Bonito is specially fished in the Mediterranean south coast and so also the frigate mackerel. The bluefin tuna, which is of considerable importance is fished all along the coast. The tuna landings are in progressive decrease.

Species	Ring-net Tm.	Trap-net specimens
Mackerel *Scomber scombrus*	3000	—
Bonito *Pelamys sarda*	500	140000-60000
Frigate mackerel *Auxis thazard*	274-2500	500000-2,250000
Bluefin tuna *Thunnus thynnus*	500	12000-2000

The ring nets are very large nets — 700 to 900 m. — with meshes of 10 cm. The trap-nets ("almadrabas" and "almadrabillas"), have different chambers; the last is where the fishes are caught. The special net from the trap to the shore compels to the fishes to come in the trap.

LAS especies que con mayor abundancia se pescan en el litoral mediterráneo español son la caballa *Scomber scombrus*; el atún *Thunnus thynnus*; la melva *Auxis thazard* y el bonito *Pelamys sarda.*

El procedimiento empleado en la pesca de estas especies es de tres tipos o modalidades diferentes: con artes de cerco (Ring-nets) especialmente la caballa y algo también las restantes especies, aunque en estos casos se trata de artes de dimensiones y mallas mucho mayores que las empleadas en la captura de la caballa. Artes de trampa llamados almadrabas, las de gran talla y las mas pequeñas almadrabillas o morunas, con las cuales se pesca especialmente el atún y tambien la bacoreta o melva y el bonito. Finalmente en determinadas localidades y cada vez en menor numero, se emplean artes de deriva (gill-nets) para captura de pequeños escòmbridos especialmente túnidos durante el invierno, cuando las almadrabas están prohibidas por la legislaciòn pesquera de este pais.

Desde el punto de vista de las cantidades capturadas de cada una de estas especies la estadística pesquera distingue lo capturado mediante las almadrabas y los peces capturados mediantes los demás procedimentos de pesca. Los datos medios que se obtienen de las estadísticas de pesca de los diez últimos años arrojan los resultados siguientes:

Caballa *Scomber scombrus:* 3000 Tm anuales destacando por su importancia en la pesca la region NE del litoral mediterráneo español. Se peresenta una clara tenden cia al descenso y en estos ultimos años puede darse por casi totalemnte desaparecida de nuestras aguas. No es

posible atribuir la rápida desaparición de este escómbrido a la sola actuaciòn de la pesca, debiéndose suponer que antes se trata de variaciones en las condiciones de las aguas litorales lo que Fha determinado la brusca despariciòn de este pez.

Bonito *Pelamys sarda :* Especie que se encuentra especialmente en la parte meridional de la Peninsula Iberica, presenta una media anual de 500 Tm en las pescas efectuadas con artes corrientes excluidas las almadrabas.

Atún *Thunnus thynnus :* Los ejemplares de pequeña talla que son los que corrientemente se pescan con artes de pequeño tamaño de cerco e de deriva, se encuentran aunque en poca cantidad en todo el litoral. Al igual que en la especie anterior la cantidad media es de unas 500 Tm anuales.

Melva *Auxis thazard* : Abunda especialmente en la parte sur y sus capturas han aumentado durante los ultimos años pasando de 274 Tm anuales hasta 2500 Tm en el mismo tiempo.

Las pescas efectuadas en las almadrabas ; los datos se dan en número, de unidades capturadas. Los atunes han disminuido desde 12000 ejemplares por año hasta unos 2000 en los últimos años. El bonito se pesca en mayores cantidades pasando de 140,000 a 60,000 indivíduos al año. La melva ha duplicado la cantidad pasando de 225,000 a 500,000 individuos al año. Alge se ha pescado de albacora *Germo alalunga* durante los últimos tiempos.

Todas estas pescas han sido efectuadas por las almadrabas las cuales han tenido en su número una clara tendencia a disminuir ; de 9 a 6 en el litoral mediterráneo. Las almadrabillas o morunas son en gran número en todo el litoral mediterráneo de España especialmente abundantes en las Islas Baleares.

A diferencia de los atunes que se pescan con los artes señalados en las anteriores estadísticas, los que se capturan con las grandes almadrabas son aunes de gran talla llamados atunes genésicos porque o se preparan para la freza o vienen de efectuarla. La mayor parte de las almabrabas y las mas productivas se encuentran en los alrededores del estrecho de Gibraltar y aprovechan para su captura las manadas de atunes que penetran en el Mediterráneo y las que sal de sl.

Los artes de cerco empleados en la catura de los escómbridos son de dos tipos principales. Cuando se trata de capturar la caballa *Scomber scombrus*, se emplean redes de malla tupida de hasta 300 m de largo por unos 40-50 de profundidad. La concentracion de cardumen se efectua en el Mediterráneo a ojeo y entonces la pesca se hace de día. Esta modalidad se da especialmente en la parte meridional; y por medio de potentes focos luminosos situados algo por encima del nivel del agua, los cuales son llevados en una o dos embarcaciones auxiliares. Por medio de la luz se consigue concentrar el pescado alrededor de los focos con lo que la pesca es más cuantiosa. Este tipo de pesca, el más abundantes y fructúfero, se practica de noche.

Cuando se trata de capturar pequeños atunes, bonitos o melvas, con artes de cerco se emplean redes de hilo grueso de malla mucho más grande, unos 10 cm de malla del cuadrado, y de 700 a 1000 m. de longitud. La pesca se hace por ojeo a la vista del cardumen, detectable por movimientos especiales del agua, por la abundancia de animales.

En algunos casos muy esporádicos, se utilizan redes de deriva y enmalle (gill-nets) las cuales se colocan atravesadas en la dirección que se supone a de seguir el cardumen de estos pequeños escómbridos, atunes de pequeña talla, bonitos y melvas, para que 'se enganchen en las mallas. Estas mallas són de 10 cm de lado costado yl as piezas estan fabricadas con hilo de càñamo grueso para resistir la presión de estos peces. La longitud total es de unos 100 m. por unos 6 de ancho con flotadores en la parte superior y plomos en la inferior a fin de que se mantenga vertical cerca de la superficie. El sistema de operar es semejante al que se emplea en todo este tipo de redes.

Las importantes son las redes fijas de trampa llamadas almadrabas. Una de estas grandes piezas, consta de una pieza de mallas amplias que se dispone en dirección perpendicular a la costa para interceptar el paso de los peces. Mediante grandes lastres se mantiene fija al fondo y por medio de los flotadores se sostiene derecha. Una serie de anclas mantienen y aseguran la red en su sitio. En la parte más alejada de esta pieza, llamada *rabera*, se encuentra la almadraba propiemente dicha. La rabera suele tener una longitud de unos 1500 m. Las piezas para la captura constan de varias cámaras confeccionadas con redes gruesas mantenidas mediante flotadores, latres y anclas, de tal forma que los atunes, cuyo paso has sido interceptado por la rabera, se dirigen hacia alta mar siguendo la dirección de la misma, hasta que sin darse cuenta penetran en una de estas cámaras de la cual ya no pueden salir, porque redes especialmente dispuestas impiden el retroceso de los animales. Mediante embarcaciones especiales los atunes prisioneros, son empujados hasta la cámara final que presenta una red en el fondo. Es en esta cámara donde se efectua la pesca. Cuando los atunes están todos concentrados en ella, las embarcaciones se disponen alrededor de la misma y empiezan a levantar la red del fondo con lo que los atunes quedan en un reducido espacio y junto a la superficie. En este momento los hombres de las barcas los van capturando mediante unos hierros especiales llamados bene. Cada una de las embarcaciones y de las piezas de red que intervienen recibe nombre especial, aquí omitido, para no hacer excesivamente prolija la descripción. Las almadrabas pueden ser de ida y de retorno según que estén especialmente dispuestas para la captura de los atunes en uno u otros de los movimientos que experimentan antes o después de la puesta. También pueden ser fijas o de monteleva según que se mantengan durante todo el año montadas o se desmonte cada año. Està solamente permitida la pesca de marzo a noviembre.

BIOLUMINESCENCE AND MACKEREL FISHERY*

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INTRODUCTION

BIOLUMINESCENCE or 'phosphorescence' is primarily associated with the marine environment, and this phenomenon has sporadically appeared in several marine organisms often involving even complex light organs and glandular structures as seen in certain species of euphausiids, copepods, ostracods, etc. Quite often spectacular luminescence on the surface of the sea is noticed and this may be caused by a profusion of dinoflagellates such as *Noctiluca*, *Gonyaulax*, and *Peridinium*. For a fuller discussion on the subject of bioluminescence reference is invited to Harvey (1940, 1952).

While all the practical applications to which this phenomenon of bioluminescence in the sea can be made use of to serve man are not yet fully apparent, at least from the fisheries point of view one useful purpose it serves is to aid in scouting movements of surface shoals of fish. Technological progress in the form of sonar devices and other fish finders which aid in scouting for shoaling fish both during daytime as well as at night have not altogether replaced visual scouting of fish such as sardines and mackerel at night. On the Pacific coast of North America, the dinoflagellate *Gonyaulax* which is both photosynthetic and luminescent is known when present to help by their luminescence, purse seine fishermen locate sardine shoals (Scofield, 1926 ; Fry, 1930 ; and Linder, 1930). Sweeny and Hastings (1957) have estimated the duration of the light flash given out by *Gonyaulax* upon stimulation to be 0.1 sec. When large numbers of these are stimulated in the ocean by the passage of a shoal of fish or by wave action, the disturbed water glows as a result of the flashing of myriads of these animals. To use fishermen's parlance—'the water fires' !

Bioluminescence has played and still plays no mean part in aiding purse seine fishery for mackerel along certain parts of the North Atlantic coast of North America. Sette (1950) speaking of the North Atlantic mackerel *Scomber scombrus* remarks that luminescent patches caused by moving schools, especially on moonless nights should be visible from some distance, and this should be so even when they are flashing at depths down to 10 fathoms on such nights. He cites one instance of exceptional clarity when a school was judged to be 'firing' at a depth of 25 fathoms as it was missed by a purse seine 22 fathoms deep.

Writing on Malayan purse seine fishery, Gopinath (1950) comments that the purse seine fishing operations for mackerel off the island of Pangkor on the Malayan Coast are conducted only on dark nights to enable the fishermen to detect the shoals at a distance, as a result of the luminescence thrown up by their movement. At Pangkor a fishing season is of 19 to 20 days duration each month as it starts about six days after the full moon and extends to about 10 or 11 days after the new moon. 'During the waning phase the fishing is done in the dark period preceding moonrise, and in the waxing phase in the hours following the setting of the moon. In the early part of the season, therefore, the fishermen start from their base at about 5 p.m. and return by about 1 a.m The starting time is gradually delayed as the season advances, and by the day of the new moon the men are fishing all through the night. Towards the close of the season they start at 11 p.m.

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or midnight, when the moon is well down in the sky, and fish until the morning, getting back to their base at 7 a.m. or even later. Slack tide is considered to be the best time for the operation of the net, since there is then no chance of it being carried away by strong currents.' Obviously luminescent planktonic organisms occur in the Malayan waters in some profusion all through the year as the data given by Gopinath on the landings of mackerel for all the months of the year by purse seine gear would indirectly indicate. Unfortunately, a qualitative and quantitative assessment of the plankton of those waters is not available to give us an idea of the various species responsible for this phenomenon of bioluminescence and their precentage composition and fluctuations from season to season. Kow's (1950) data on the plankton of the adjacent waters off the Singapore Straits, nor the results of his examination of the stomach contents of a few mackerel from that area throw no light on the organisms responsible for this phenomenon. Of the 12 specimens of *Rastrelliger kanagurta* examined, Kow found the stomachs of 10 to be packed with green digested material in which remains of *Coscinodiscus* and crustaceans including copepods, *Squilla* larvae and brachyuran zoea could be recognised. Of these food items, *Coscinodiscus* is a most conspicuous feature of the phytoplankton of the Singapore Straits for all the months of the year, while copepods and brachyuran larvae similarly occur in the zooplankton. *Squilla* larvae are very rare and are present in the months of March-April and December. Obviously none of these items of zooplankton may be responsible for the production of bioluminescence on such a large scale as mentioned above.

Besides Pangkor, purse seine fishing for mackerel is carried on, on a much smaller scale on other parts of the Malayan coast, namely, on the Mersing coast; Kedah; and off Singapore (Gopinath, 1950; Burdon, 1954).

Bioluminescence and Sighting of Mackerel Shoals off the Ratnagiri Coast (India)

On the night of 17 November 1960, through the courtesy of the Department of Fisheries, Bombay State, I was able to go out for drift net fishing on one of their mechanised fishing vessels, *SURUMAI*, to the 16 fathom line about 16 km. (10 miles) off Ratnagiri on the west coast. We left Mirya Bay, Ratnagiri at 17.30 hours, and being one day prior to new moon, it was sufficiently dark by the time we reached the fishing grounds at 18.45 hours to make out the abundance of luminescent planktonic organisms at the surface, made evident by the disturbance caused by the vessel. This profusion of planktonic life was more conspicuous later in the night when within 30 minutes of hanging a gas-light about half a metre above water on the starboard side of the vessel, a thick scum of luminescent zooplanktonic organisms, predominantly ostracods, amphipods, and coelenterates (siphonophores) started continuously gathering at the surface and gradually drifting in a broad brown band. Hauls with a suspended one metre plankton net were made every 15 or 20 minutes from 19.30 hours to about 02.00 hours on the 18th. An analysis of the plankton collected (graphically shown in text-figure 1) indicate percentage-wise: Ostracods (*Pyrocypris* sp.) 38%, amphipods (*Hyperia* spp.) 31.5%, siphonophores 8%, copepods (*Acrocalanus longicornis*, *Oncaea cleui*, *Corycaeus* (*Corycella*) *gibbula*, *Acartia erythraea*, *Eucalanus* sp.-copepodi tes; *Temora turbinata*) 20%, and other crustacea (e.g. *Lucifer*, Megalopa of crab, etc.) 2.5%. The light as well as the accumulation of the planktonic matter beneath it attracted several smaller fish.

At 20.30 hours a large mackerel shoal was sighted about one mile to the south of *SURUMAI* by the luminescent patch at the surface and with the help of field glasses it was possible to keep track of the shoal for about 7 minutes while it was moving in a slightly north-easterly direction. This was a ' silent shoal ' as the fish were moving just below the surface, and the luminescent patch which had the appearance of a broad crescentic band had one of the arms longer, the distance between the ends of the two arms being about two hundred metres or slightly less. At 21.15 hours a second shoal was sighted about one mile to the south of *SURUMAI* and in about five minutes it approached to within about 400 metres of the vessel, but kept on moving in a northerly direction. Unlike the first shoal, this shoal could be ' heard ' from the time it was sighted by the considerable surface agitation caused by the fish, making the crescentic luminescent patch very

conspicuous and appear to bubble. At 22.00 hours, a third 'silent shoal' was sighted south of the vessel, but heading towards it, which it reached in about four minutes, passing under it at a depth of about a fathom. The luminescence thrown up by the movement of the shoal which had an anteriorly dented crescent shaped pattern was such that when it passed under the vessel individual fishes could be seen very clearly and even the markings on their body were easily discernible. As far as could be seen there was no evidence of any predatory fish or any other species mixing or remaining with this shoal, which was smaller than the first two, being hardly a hundred metres wide.

The patterns of the shoals and the direction of movements which may be of interest is shown in text-figure 2. The sighting of the three shoals first spotted 6 to 8 miles off the coast in the earlier part of the night and the general direction of movements northwards are points worth noting. Mr. A. V. Shivde, Gear Technician, Bombay State Fisheries, who on board the *SURUMAI* was conducting the drift net operations informed me that he had witnessed similar movements of mackerel shoals on previous occassions earlier in November while conducting drift net or gill net fishing operations in the 10 to 25 fathom lines off Ratnagiri. The present state of our knowledge does not permit us to even speculate as to whether these represent movements of shoals from the deeper waters towards inshore waters ; a general northward movement of the whole fishing population or stock ; or localised movements within a particular area.

Possibilities of Purse Seine Fishing for Mackerel at Night in Indian Waters

One of our principal aims is discovering possibilities of establishing suitable offshore fishery for pelagic fishes such as mackerel, the fishery of which, perforce is at present restricted to inshore waters not exceeding two to three kilometres from the shore and dependent primarily on beach seines operated mostly during day time. Considering the likelihood that most of the mackerel shoals may be moving outside these limits, apparently only a fraction of this potential wealth is being tapped at present. The luminescence thrown up by the mackerel shoals at night which probably would be more conspicuous 6 to 7 days prior to and 10 to 12 days after the new moon on the dark nights or dark phases of the nights when they could be sighted at a distance should undoubtedly aid in purse seine fishing for mackerel at night from mechanised boats in Indian waters as successfully carried out off the west coast of Malaya and Singapore (Gopinath, 1950 ; Burdon, 1954) and the same may also apply for sardines. On the south west coast of India off Mangalore and Calicut fishermen use a type of trawl net known locally as *Aila kolli vala* at night for the capture of mackerel shoals. The net is operated from two boats at depths generally less than 10 fathoms and usually within 10 kilometres from the coast. There is antipathy towards the use of this net locally on account of its operation relatively close to the shore and the consequent feeling that this depletes the legitimate catches of shore seiners. However, the picture could be different if such fishing could be carried out from mechanised craft which may enable such fishing to be carried out farther away from the coast.

It may not be proper while drawing attention to the desirability of exploring possibilities of purse seine fishing for these fishes at night, not to indicate some attendant problems. Some of these are :

1. It remains to be seen whether the observations recorded here for the Ratnagiri coast is an unusual event and that the profusion of planktonic organisms, mainly ostracods and amphipods represent local swarming of these organisms probably governed by the phase of the moon or vertical movements to the surface from the bottom layers attracted by the suspended light. However, the sighting of the mackerel shoals by the luminescence thrown up by their movements, is of interest. On 20th November night while travelling by ferry steamer from Ratnagiri to Malwan accompanied by Mr. K. Narasimham, Fishery Survey Assistant of this Institute, the luminescence caused by the slightest agitation of the water was found to be much greater, but unfortunately a sample of the plankton could not be collected. From these and Mr. Shivde's remarks of

sighting mackerel shoals by their luminescence already mentioned it would appear that this phenomenon of bioluminescence which could assist in scouting mackerel shoals is not unusual

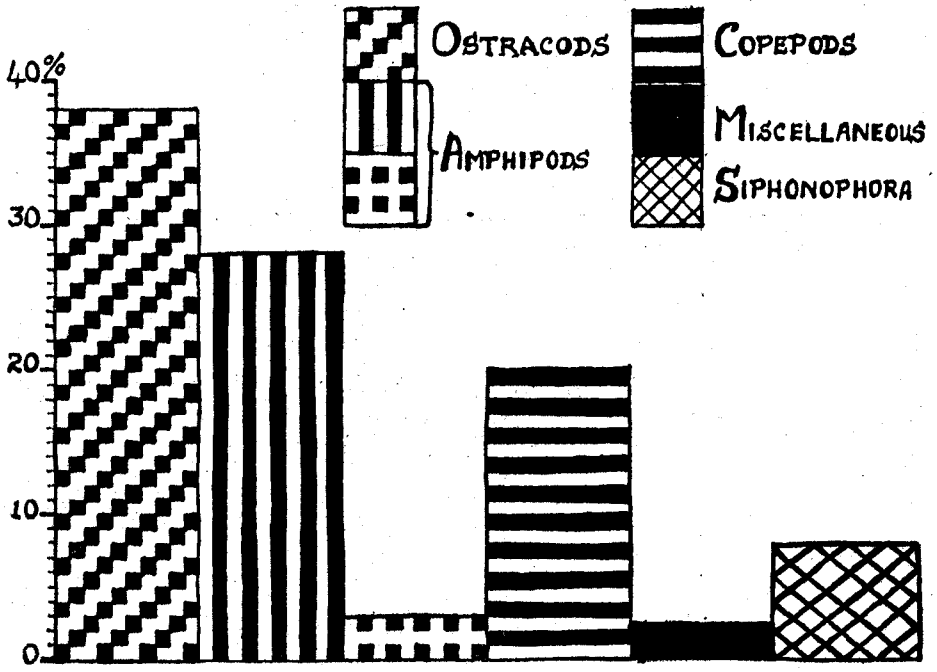


FIG. 1. Percentage composition of zooplankton collected 16 Km. off Ratnagiri on 17-11-1960 night.

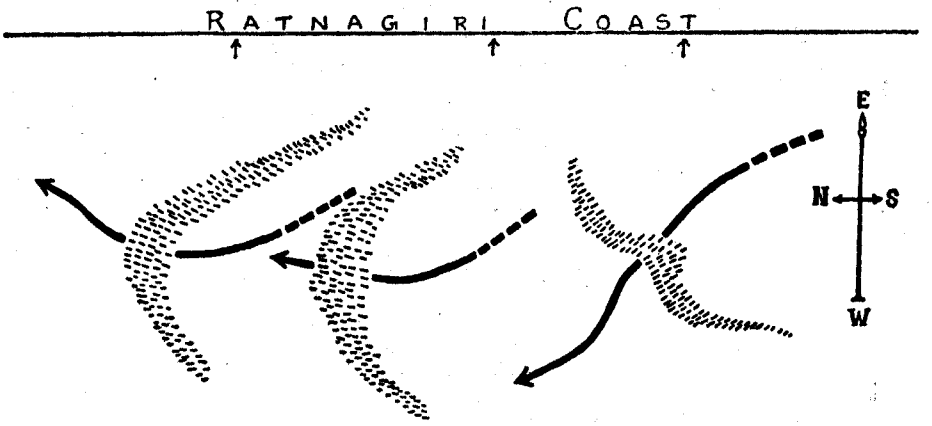


FIG. 2. Showing the pattern and direction of movement of the mackerel shoals sighted off Ratnagiri on the night of 17 November 1960. Shoal numbers 1, 2, and 3 are from left to right respectively.

along the Ratnagiri coast. Quite likely the components in the zooplankton may differ, from time to time, but luminescent organisms may be present in some profusion over an extended period.

2. This could be investigated by work carried out on more fundamental lines, the data of which could indirectly assist mackerel and sardine purse seiners in night fishing. I have in mind

the measurement of the intensity of luminescent flashing in the surface waters using a portable bathyphotometer and also correlating the data with actual analysis of plankton hauls from the area. Some information on measurement of surface luminescence and luminescence at depths in the sea and the methodology used in carrying out such work could be had from the works of Clark and Wertheius (1956), Boden and Kampa (1957), Clark and Hubbard (1959), and Clark and Breslau (1959, 1960). Such study could be carried out in different locations after preliminary scouting to see areas where regularly mackerel shoals could be spotted at night, the depth of water in which the shoals occur to enable use of purse seine gear etc. Comparative measurements of surface luminescence may help in eventually defining areas where such fishing could be carried out both for mackerel and sardines.

3. It will indeed be hasty to find an answer to the last said by an assessment of the previous studies on the food of the Indian mackerel, for as Bhimachar and George (1952) have shown, *R. kanagurta* may be selective in its food habits. They found that in spite of the common occurrence of forms such as *Sagitta*, stomatopoda, spionid larva, hydromedusae, ctenophores, and *Noctiluca* these items were rarely recorded from the stomach of the fish off Calicut on the west coast.

4. Bioluminescence also plays a role in the shoaling behaviour of mackerel and other pelagic fishes. That visual perception is the principal factor underlying the shoaling habit of fishes was postulated by Parr (1927) as a result of his studies of the habits of the scombroid *Pneumatophorus grex*. Elaborating on this theory Sette (1950) remarks that '. . . . if the aggregations into schools depend on vision, it would take place during the daytime and schools should be broken down during every sufficiently dark night. If this is true, the nightly reshuffling of individuals should tend to keep the population homogenously mixed. At certain seasons, however, the breakdown of schools does not take place at night, for purse seiners locate and catch schooled mackerel at night both in spring time and in autumn. At these seasons the schools are located by luminescence associated with them. This occurrence of schools at night need not be contrary to Parr's theory, for obviously the luminescence may be as effective as day light in permitting the visual perception necessary.' Other aspects of mackerel behaviour, such as, whether schools would tend to be 'wild' and scatter to reform into smaller schools when approached by a mechanised boat; the sizes of shoals; direction of movements; difference in size composition within the school; swimming speed, etc., could be studied by observations on mackerel schools at night aided by bioluminescence and from purse seine catches made at night under such circumstances.

5. The average yearly mackerel landings along the Indian coast for the years 1950 to 1959 has been estimated to be about 68,4791 metric tonnes, in other words 10% to 15% of the total yearly fish landings along our coast. That there is scope for improving the position by the introduction of gear such as purse seines cannot be denied. When this is done, it is likely that better fishing could result by using purse seines for mackerel and even sardines at night when scouting for shoals would be easier as successfully carried out from mechanised boats in other parts of the world.

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THE MACKEREL FISHERY OF PANGKOR, MALAYA

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THE present paper is written mainly based on the material collected and observations made during my deputation to Malaya in September 1956 to attend the Rastrelliger Sub-Committee Meeting of the Indo-Pacific Fisheries Council. I am deeply obliged to the Directorate of Fisheries, Malaya for all the arrangements made and facilities given to visit Pangkor and see the mackerel fishery there. My thanks are due to Mr. Soon Ming Kong, the present Director of Fisheries, Malaya for kindly furnishing me with particulars regarding the present condition of the mackerel fishery at Pangkor and for the photographs showing the various aspects of the fishing industry there given in this article. I am grateful to Mr. Lim Eng Chuan, Inspector of Fisheries, Lumut, who accompanied my colleague Mr. S. K. Banerji and myself to Pangkor and rendered very valuable assistance in the collection of information incorporated in this article.

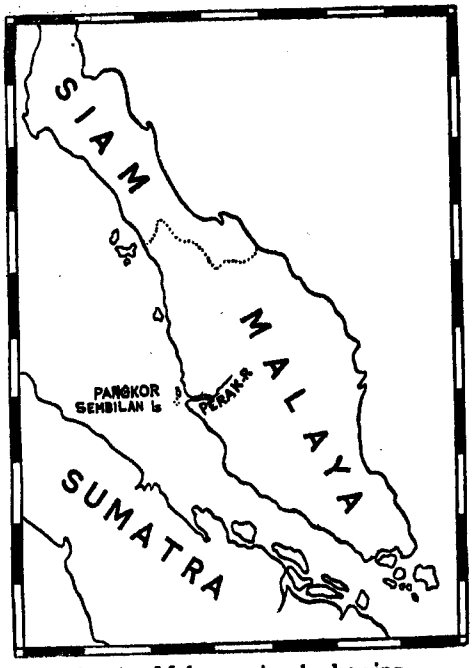


FIG. 1. Malay peninsula showing Pangkor and Sembilan Islands.

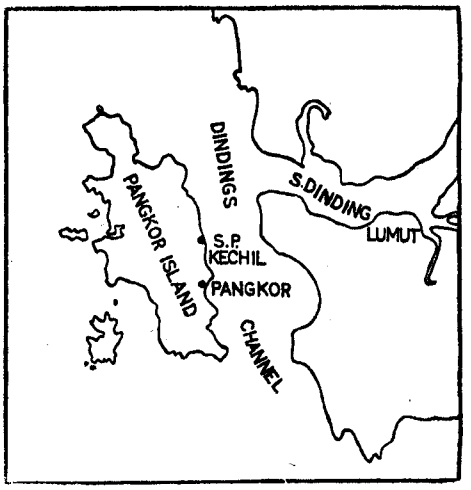


FIG. 2. Pangkor Island.

Pangkor is an island in the State of Perak, Malaya about 85 miles due south of Penang by sea and 3 miles from the mainland (Figs. 1 & 2), having an area of about 30 sq. miles and a population of about 10,000 who are mostly Chinese. The economy of the island is mainly dependent on fishing. Though a few rubber plantations exist their importance is negligible. The island has telephone connection with the mainland and has electric supply also. All communications are through the town of Lumut in the mainland about 5.5 sea miles from Pangkor at the mouth of the Dingings River from where it is about 130 miles by road to Penang. Lumut is connected with the important towns of Ipoh, Taiping, Telok Anson etc., by a good road system. There

are two fishing centres in the Island, Pangkor and Shungai Penang Kechil, about 3 miles apart, of which the former is the larger one.†

The history of the mackerel fishery in Pangkor is hardly three decades old. Till the early part of this century the place was practically unknown from the fisheries point of view and the island was used mostly as a quiet picnic resort and excursion ground by planters and other opulent public from the mainland. Fishing as an industry was non-existent though Malayan fishermen from the hamlets along the coast were engaged in small scale fishing in the inshore waters for their local needs. About 35 years ago some fishermen from the west coast of Thailand came down to fish and located the existence of a potentially rich fishing ground in the neighbourhood of Pangkor. The energetic Chinese seeing the prospects of good fishing took up the cue and gradually built up an industry now estimated to be worth about 10 million Straits Dollars. Mackerel was first caught in appreciable quantities in 1928 when there were about 10 country crafts operating. Mechanisation began in 1935 when a Chinese by name Neeh Eng Hwa built the first motor fishing vessel. The fishing industry received a serious set back during the second world war but came round quickly with the exit of the Japanese. In 1956 there were 52 vessels all owned by Chinese, employing a crew of 1213 fishermen (1148 Chinese and 65 Malays). The strength in 1960 was 55 vessels and 1470 fishermen exclusive of shore labour. Normally 44 boats fish regularly. Though there is in the island a small colony of a little over 100 Indian fishermen hailing from the Districts of South Arcot, Tanjore and Ramnad in Madras State, they are all engaged in operating shore seines known in Malay as *Puket tarek*.

The Pangkor Mackerel : The mackerel at Pangkor is the same as the Indian species viz., *Rastrelliger kanagurta*. Locally they are called Kembong or **Ikan Kembong*. Some people call the large sized ones Mambong or *Ikan Mambong* and their occurrence is only seasonal and they are said to come comparatively nearer to the coast, than the smaller ones. The broader species of mackerel viz., *R. brachysoma* is reported to occur there in stray numbers but were not available during the time of my visit. *R. kanagurta* of two size groups viz., 186 mm. to 193 mm. (total length) and 226 mm. to 235 mm. (total length) were present in the catches.

Shore establishments : Each boat owner or *Towkay* as he is called has a permanent shore establishment from where the landing platform or *Pelantah* extends in the form of a pier about 75 to 100 feet long. It is built on stout wooden piles driven into the bed of the sea and paved with split stem of the Malayan palm. A series of long poles are fixed on the *Pelantah* in the form of scaffolding to dry the nets (Plate II, Fig. 1) and the whole structure gives a weird appearance from a distance. The shore buildings are spacious and are electrified with accommodation for office, living quarters for the fishermen crew and space for handling fish. There is a community kitchen and a common dining table with a radio in the background which gives out almost continuously broadcasts in Chinese. Most of the establishments make their own ice and all have freezing chambers, store rooms and curing and packing sections. All the offices in the shore establishments have telephone connections.

Craft and gear : The boat used (Plate 1, Fig. 1) is plank built and power driven with about 50 to 90 B.H.P. engines with holds in front to store ice and fish and with bunk spaces for the crew in the aft behind the pilot's cabin and immediately above the engine room. It is generally owned by a single person known as *Towkay* who may have more than one vessel at a time. There are no radio-telephone communications with the shore base and no echo sounding or depth recording equipments. There are no winch arrangements and all hauling is done manually. Belief in the supernatural still holds sway and each boat has at the prow a piece of red cloth and some leaves called *Tonkong* to propitiate the Lord of the Sea.

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† Another important mackerel fishing centre in Malaya is Kula Kedah to the north of Penang which I could not visit for want of time.

* *Ikan* means fish in Malaya and this term precedes the names of all fishes.



PLATE I. 1. A purse seine boat anchored close to a landing Platform at Pangkor. The scaffoldings in the background are for drying nets (By courtesy of the Director of Fisheries, Malaya).

2. A morning scene near the shore base showing the removal of the mackerel catches from the boats to the shore buildings in the background (By the courtesy of the Director of Fisheries, Malaya).

Each boat is on an average about 18 m. long and about 4.2 m. broad with a draft of about 1.5 m. and is locally called *Kembong choon* in Chinese and Motor *Pukat jerut* or *Kapal pukat jerut* in Malay. It carries in front immediately above the holds two large boats or *Sampans* locally known as *Jalor* with the net stacked inside and a small dinghy known as *Thing kier* in Chinese (*Jalor* in Malay) behind. The latter is used by the master fisherman for scouting purposes after reaching the fishing grounds. The *Sampan* averages about 8.5 m. in length with 2 m. beam and .75 m. draught and the dinghy about 5.4 m. with 1.2 m. beam and 0.5 m. draught.

The net* used is the round haul net of the purse seine type known locally as *Pukat jerut* varying from 150 fathoms to 220 fathoms in length and 20 to 40 fathoms in depth made of cotton twine. It is made of yarn, 3×4 ply of 20 counts 13 mm. mesh. In many cases the owner of the net is not the *Towkay* (who owns the boat) in which case the former is known as the *Laupan.*

In addition to the engine driver and helmsman who do not take part in the fishing operations each boat has 18 to 25 fishermen crew. The above includes one master fisherman or *Langkong* and two assistants known as *wooi boey* in Chinese.

Fishing operations : Unlike along the west coast of India mackerel seldom come close to the coast and fishing is always carried out only during night time. The vessels go out in the sea between 5 p.m. and 6.30 p.m. to the fishing grounds which may be 10 to 25 miles away from Pangkor and generally fish in depths varying from 20 to 30 fathoms. The main fishing ground extends from about 10 miles north of Pangkor to about 20 miles to the south beyond the Sembilan group of islands, where it is about 50 fathoms deep as a broad belt about 15 miles wide lying on the western side of the island and more or less parallel to the coast. Fishing is done only during dark nights as the shoals are located by the luminescence caused by the movement of the fish. Usually there is no mackerel fishing five days before and five days after the full moon. All operations cease when there is either sun light or moon light.

As soon as the *Langkong* or master fisherman who stations himself on the look out platform half way up the centre mast discovers the presence of mackerel by the characteristic luminescence, the vessel is stopped and he proceeds in the dinghy to study the shoal. In the meanwhile all lights are switched off and the engine is cut out to minimise disturbance to the shoals. If he feels that the net could be cast he signals back to the vessel for the two *sampans* which slip into the water and encircle the shoal as directed by the master fisherman. When the encircling is complete the two boats come very close together and start the hauling of the net. In the meanwhile the ground rope is pursed bringing together all the fish in the bag that is formed at the centre. By this time the motor vessel comes along side the boats and all the catch is transferred into the hold along with crushed ice. It makes 1 to 1½ hours to complete one haul depending on the size of the shoal encircled. Generally 3 hauls are made and for any haul over and above this the fishermen are entitled to extra wages. On occasions when a vessel is overloaded and is not in a position to take into the hold all the catch, a red flag or light is displayed from a long hook shaped structure called *Singki* at the top of the central mast. At the sight of this signal other vessels close in and take in the catches paying the first vessel a royalty in proportion to the quantity taken in by them.

The vessels generally return early if the moon rises early and late if there is darkness till daybreak. The fish taken out of the hold are unloaded (Plate 1, Fig. 2) at the pier or *pelantah* owned by the respective boat owners. From here they are removed in cane baskets to the packing and curing shed on trolleys pushed by the shore labour engaged for the purpose.

Disposal of catches : The catches are disposed in three ways viz. (1) fresh, packed in crushed ice ; (2) brine boiled frozen fish ; (3) salt cured dry fish. Generally 2/3 of the catch is marketed as iced or brine boiled frozen fish and 1/3 is used for curing.

*For details of the purse seines used in Malaya the account by K. Gopinath in the *Journal of the Malayan Branch of the Asiatic Society*, 1950, **23**(3) : 75-96, may be referred to.

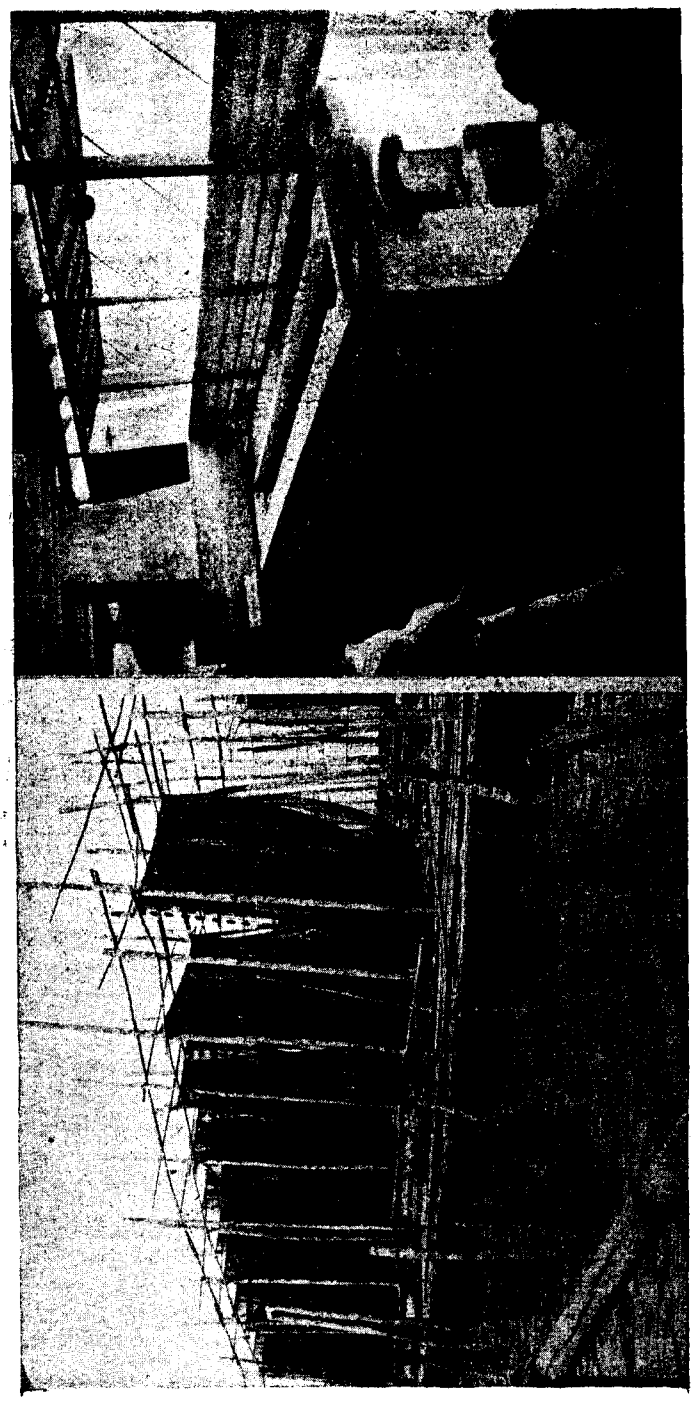


PLATE II. 1. Drying the purse seine nets. (By courtesy of Mr. R. C. Cole through the Director of Fisheries, Malaya).
2. A view of the *Sek hoo chow* or cooling vat used for the preparation of brine boiled mackerel (By courtesy of the Director of Fisheries, Malaya).

(1) *Iced mackerel :* Known locally as *Si'ng kembong hoo,* it is packed in wooden boxes with crushed ice and sent in carrier boats to Lumut and from there transported in lorries to the various markets.

(2) *Brine boiled mackerel :* This is locally known as *Sek kembong hoo.* The fish are washed in salt water and then arranged inside open split bamboo baskets (46 cm. in diameter and 15 cm. high) known as *Kembong kheng* and over this a small quantity of crushed salt is sprinkled. The work is generally done by women. The baskets of fish are put in a row in a long galvanised iron vat known as *Sek hoo chow* in Chinese about 6½ m. long and 58.5 cm. wide in which salt water is kept boiling (Plate II, Fig. 2). The main boiling pan in which the fish baskets are kept first has a diameter of 79 cm. Split bamboo covers are placed over the baskets and are pressed down with hoops to prevent the fish from floating away. The basket kept in the main boiling pan is gradually pushed towards the channel of the pan to give room to those that follow. Over a dozen baskets could be kept in a row at a time and it takes about 15 minutes time for one basket to reach the extreme end of the vat when it is taken out and chilled to be sent as such in carrier boats to Lumut and from there in lorries to the consuming centres. Each basket would hold about 2 piculs of fish which is said to remain in good condition for about 3 days.

(3) *Salted mackerel :* The salt cured mackerel is known as *Kiam kembong hoo.* Curing is done only during the time of heavy catches and those that remain at the bottom of the hold are used for the purpose. The fish are washed and gutted by Chinese women workers who are paid at the rate of $ 1.50 per picul.* The gutted fish are then washed in salt water or brine solution and then arranged in bamboo baskets in which they are kept for some time to allow the excess water to drain off. The fish are then mixed with salt in the proportions of 2 parts of salt to 5 parts of fish by weight and are put inside large wooden tubs known as *Thung* or concrete vats. Stone weights are kept on the fish which absorb the salt and give out water. They are kept in the above condition upto about 2 weeks depending on the local catch trends and general market demand. The salted fish are taken out, washed in sea water and dried in the sun for 2 to 3 days in the landing platform or *pelantah.* When dry they are packed in wooden boxes of 2 picul or 4 picul capacity lined with paper and despatched to the marketing centres.

Distribution of Iced, Boiled and Cured mackerel is given below. Distances shown are from Lumut on the mainland opposite Pangkor.

Name of Place	*Distance*	*Iced*	*Boiled*	*Cured*
South				
Singapore	449 mls.	Yes	Yes	Yes
Johore Bharu	431 ,,	,,	,,	No
Batu Pahat	352 ,,	,,	,,	,,
Muar	321	,,	,,	,,
Malacca	294 ,,	,,	,,	Yes
Seremban	242 ,,	,,	,,	No
Kuantan	368 ,,	,,	,,	,,
Kuala Lumpur	200 ,,	,,	,,	,,
Telok Anson	115	,,	,,	,,
Ipoh	65 ,,	,,	,,	,,
North				
Kuala Kangsar	58 ,,	Yes	Yes	No
Taiping	64 ,,	,,	,,	,,
Bukit Mertajam	98 ,,	,,	,,	,,
Penang	121 ,,	,,	,,	Yes
Sungei Patani	140 ,,	,,	,,	No
Alor Star	177 ,,	,,	,,	,,

* Malayan weights : 100 katties=1 Picul ; 16.0 piculs=1 Ton.

Landings of Mackerel in piculs

	1955	1960	1961*
January	1,600	7,291	8,887
February	6,083	5,613	303
March	4,533	22,145	1,126
April	12,800	28,558	7,795
May	26,538	53,630	4,738
June	29,490	29,536	26,275
July	22,017	20,221	15,809
August	14,900	18,621	8,534
September	20,900	12,649	3,074
October	8,031	10,318	10,618
November	14,940	5,337	1,3927
December	9,615	8,038	13,639
	171,447	221,957	120,725
In tons (approx.)..	10,205	13,212	7,186

* 1961 has been comparatively a year of poor fishing for mackerel.

System of wages : The *Towkay* who owns the fishing establishment has the right to receive the catches at an agreed fixed rate of $ 9.11½ per picul. The total amount derived at the above rate is divided into 135 parts and is shared as follows :

Laupan (Net owner)	30	shares
Langkong (Master fisherman)	5	,,
Fishermen crew	100	,,
	135	shares

In addition to the above the *Towkay* gives free to each fisherman the following every month:

1. 6 piculs of free rice
2. 10 katties of cooking oil
3. Fire wood.

They are also provided with free lodging and normal medical aid. The average monthly income of an ordinary fisherman was about S.$100.00 in 1956. The *Towkay* meets all the fuel expenditure and maintenance charges of the boat and pays the wages of the engine driver and the helmsman. The selling price of mackerel varies from S.$ 25 to S.$60 per picul according to the availability of fish locally and any profit made after meeting all the expenditure towards the wages of the crew, share price to the fishermen and *Laupan* and maintenance of the vessel and shore establishments goes to the *Towkay.*

General remarks : The mackerel fishing industry in Malaya is in a comparatively more prosperous condition than in India evidently due to better economic condition of the consuming public. The standard of living of the fishermen is also high.

In India fishing for mackerel is done along the Malabar Coast (N. Kerala), taking advantage of the luminescence caused during night time, with the help of a kind of boat seine, known locally as *Ayila kolli vala* (*Ayila*=mackerel, *kolli*=killing, *vala*=net) on account of its efficiency. It is operated from two boats in the form of a subsurface trawl both during night-time and daytime. The possibility of fishing for mackerel from mechanised boats with purse seines by locating the shoals during night by the characteristic luminescence could be explored. This would help to extend fishing operations to comparatively more distant fishing grounds than at present. Popularisation of brine boiled chilled mackerel in this country with suitable transport arrangements to facilitate quick distribution should help to make available the fish to the consuming public in distant places in a comparatively wholesome condition.

DISTRIBUTION PATTERN OF FISH IN RELATION TO FISHING METHOD, WITH SPECIAL REFERENCE TO THAT OF TUNA ALONG LONGLINE

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IT is one of the most interesting problems of basic importance why a particular species of fish is traditionally caught only by certain methods. It is, of course, natural to consider that the traditional methods are the integrated results of the knowledge on the habits of fish and the economics of fishing. The most probable key factors of the former are the distribution pattern of fish, its density, its swimming layer, its swimming speed, its position in the food-pyramid, its size, and sometimes the distribution pattern and density of its prey and predators, etc. The key factors of the latter group which govern the availability and the price structure in the market are the cost of catching the fish, the size of the fishery the demand and the habits of the consumer due to religious and traditional reasons.

At the outset, a short discussion of this problem is attempted. For this purpose the following fishing methods are included in the discussion: Seine (including some methods thought to be derived from the seine as a result of some improvements such as the set-net and dip-net), drift-net, handline or pole angling, long-line, trolling and harpooning. The groups of fishes discussed here are those which are of high economic importance viz., anchovy, sardine, flying fish, jack mackerel, mackerel, yellowtail, salmons, skipjack, tuna and marlins.

DESIRABLE CONDITIONS OF CATCHING THE FISH BY EACH METHOD

It is very easily suspected that (1) the abundant fish concentrated in a narrow space (Pattern I) is the most desirable pattern for getting a good catch most easily and economically; (2) next desirable pattern for getting a good catch is the abundant fish scattered in a little wide space (Pattern II), (3) the third one is thought to be not abundant fish in narrow space (Pattern III), although such a pattern can only be the subject of the cheap method in the cost and (4) the most undesirable pattern is not abundant fish scattered in rather wide space (Pattern IV). But, more than how much fish can we regard abundant — in individuals or in weight? And, by what criteria can we distinguish wide from narrow? It seems to be very natural to occur such questions in our mind and it is very important to give their answers. It seems, however, to be very difficult to tell or to set some criteria to them in absolute scale, but the criteria or scales in consideration seem usually to depend on the economic value of the subject fish under study.

When the fish are distributed in Pattern I, they are usually caught by seine; when in Pattern II, they are economically attacked also by seine combining with some auxiliary devices of concentrating them or other methods capable of covering widely (usually long) such as the drift-net and longline; when in Pattern III, the hand-line or pole angling is thought to be one of the most common methods of catching them with economic success; while when in Pattern IV, we may be unable to catch them with economic success by any other method than the widely covering one with very low cost such as trolling or harpooning. But, is the fishing method solely dependent on the type of the distribution pattern? It is very natural to consider that a certain fishing method is economically effective only under some favourable conditions and the distribution pattern is, of course, not the sole one but is nothing other than one of such factors with decisive effect. Therefore, before proceeding with the discussion further, let us devote some space to the discussion on the desirable conditions of each fishing method.

Seine : The presence of the fish in the enclosed space by the net more than made up for all the cost of the operation may be the indispensable condition. But the girth of the space capable of being covered cannot exceed the length of the net ; it is, therefore, the abundant fish concentrated the more densely is the more desirable (Pattern I). And at the same time, the depth capable of being dipped up also cannot exceed the height of the net, which directly means that the fish swimming in the thinner layer is the more desirable. But the seine is usually constructed to keep its buoy-line at the interface between air and water ; accordingly, the fish swimming in the shallower layer with the thinner height is the more desirable. One of the typical examples fulfilling these conditions is the anchovy (sometimes including the sardine and the juvenile individuals of the jack mackerel) hauled up by the twin seiners in the daytime. But when one or both of the above-mentioned conditions are not fulfilled, some auxiliary devices are employed together with the seine for the purpose of putting the fish into the desirable conditions, because the seine is the method capable of catching abundant fish more easily and more economically. The lamp and the bait-casting are the most common devices of concentrating easily and economically the scattered individuals. Therefore, strong phototaxis or active predating on the fish-meat is thought to be the essential condition of the fish being concentrated effectively by these auxiliary devices. It is very natural that the lamp has no effect in the daytime and the bait-casting is not applicable to the fish of the low position in the food-pyramid such as herbivora and plankton-feeders. Here, we should pay attention to the facts that the lamp is cheaper than the bait-casting in the cost, that the fish of the low position in the food-pyramid is usually cheaper than those of the higher position in the market price and to the fact that the fish of low position is usually photo-positive and the most of fish at high position are photo-negative. The lamp is, thus, effectively and economically applied to concentrating the scattered individuals of rather low position in the food-pyramid and the bait-casting is do so to those of rather high position in it. There is, therefore, no auxiliary device applicable to concentrating the scattered individuals of the anchovy and the sardine in the daytime ; accordingly, we cannot catch them economically in the daytime and are obliged to attack them only at night combining the seine together with the lamp. One of the typical examples successfully applying to the lamp for this purpose is a type of the dip-net, so-called *Bouke-ami* in Japanese, aiming the saury which shows extraordinarily strong phototaxis. Another fish well known to show very strong phototaxis is the flying fish in the warm water, which is thought to be the fish corresponding to the saury in the cold waters. But its peculiar and strong ability of escaping through air prevents us from catching it by the seine against the fact that it is very easy to concentrate the scattered individuals because of their strong phototaxis. These are the examples of adopting the lamp to concentrate the scattered fish directly through its phototaxis. Meanwhile, tremendous amount of the scad, the jack mackerel and the mackerel are also caught by the seine by the aid of the lamp. But, there are some differences in the effect of the lamp on the fish in these cases from that of the former ; i.e., in these cases, when the prey does not assemble abundantly under the lamp, it is very hard to allure the fish into very surface layer or hard to concentrate them into extremely high density but they are apt to run away easily even by a slight disturbance ; and in such cases, bait is cast under the lamp, which brought us some satisfactory results. It is very hard to find the example concentrating the fish simply by the bait-casting for the purpose of putting the scattered fish into the desirable conditions of seining ; but the bait-casting employed by the hand-line angling for some reef inhabitants is thought to be the example concentrating the scattered fish solely through it, although this is not for the seining.

The above-mentioned examples are all those of rather coastal fish. And the construction of the seine itself, that of the seiners and the setting and hauling works on her are thought to fit for rather coastal waters ; yet, the seine is not the method of catching the coastal fish only ; and we sometimes employ this method for catching even some pelagic fish when the above-mentioned desirable conditions are fulfilled. For example, the salmons are caught by this method along the Alaskan and Canadian coast, where they are concentrated into extremely high density near the estuary amidst the anadromous migration for spawning, although it is very hard to catch them by any of the method similar to the seine at off-shore where they are scattered into very low density. Another example of the pelagic fish caught by this method is the tuna and the skipjack ; namely, in our country, the tuna and the skipjack are caught by a type of huge purse seine, what-we-call

the American seiners, off Sanriku districts (the Pacific coast of the northern part of the Honshu), with some economic success. But those caught by this method are rather young stage ; and its fishing-ground is restricted to some on-shore waters with special oceanographical conditions usually near some convergence lines, where they are concentrated into extremely high density.

Drift-net : It is most desirable for us to catch the fish by the seine. But we are sometimes obliged to catch them by the drift-net or any other method than the seine, in such a case that it is very hard or expensive to put the scattered fish into Pattern I or that the standing crop of the fish is too low to make up enough for the cost of catching them by the seine or otherwise that we want to catch the fish with small foundation than that of the seine. The mother-ship-type salmon-fishery in the northwest Pacific Ocean is one of the typical examples employing the drift-net because of the difficulty or high expenses of making the scattered fish into Pattern I ; the flying fish drift-net and the half-beak (*Hemirhamphus* being scientific name or *Sayori* in Japanese) net are the examples employing this method because of low standing crop being afraid to be unable to make up for the cost of any other method than this, although to employ this method to the former fish is thought to be partly due to the special ability of escaping through air ; and the drift-net is employed by the fishermen along the coast of some districts of Japan for the purpose of catching such large fish as the tuna or the yellowtail, which is thought to be the example employing this method because of expecting to catch such large fish of high economic value by small foundation, although these are now in failing state. The fully grown up stage (or *Ohba stage* in Japanese) of the sardine is also caught by this method in the southern half of the Japan Sea coast of our country due to the difficulty in concentrating its scattered individuals and also due to poorness of the foundation owned by the coastal fishermen.

This method is well thought to be of most suitable for successfully attacking the fish distributed in Pattern II. But the layer capable of catching the fish is usually only as thick as the height of the net, which is not so high and is restricted to within few meters. Therefore, this method is effective when the thickness of the swimming layer of the fish is limited ; for example, the fishing-ground of the salmons is the south of the Aleutian Islands where it is 3-5 thousand meters deep, but we can catch them successfully even by the net of only few meters high because their swimming layer is limited ; and also because the flying fish are swimming in very surface layer, they are caught by the net of only few meters high.

Besides the distribution pattern, this method basically differs from the seine in the desirable condition of the swimming activity of the fish. That is to say, when we wish to catch the fish by the drift-net, the fish have to frequently meet across the net, which directly means that it is desirable for the fish to swim somewhat actively otherwise it is very hard to expect a good catch. But, too active swimming, which induces too large momentum of the fish as a natural consequence, brings us rather harmful results, because we are obliged to employ considerably strong nets to catch them and this raises the cost of constructing the net. Contrary to this, when we do so by the seine, the fish swimming less actively is the more desirable because the setting speed of the seine is not so high.

Another difference in the desirable conditions of the fish of basic importance is the variability in the body size ; i.e., we can successfully catch by this method the fish whose body girth is neither too small nor too large, which means that the school consisted of the individuals of the more homogeneous size is the more desirable, against the fact that the seine can catch the fish rather regardless of their size, which means that the homogeneity in the size of the fish is out of the limitations.

Hand-line or pole angling :—Applying to this method, the longline and the trolling, there arises another restriction of the habits of the object fish ; i.e., for other methods, whether or not the fish take the food actively and whether or not it is easy for the fish to find out abundantly their food anywhere are rather unessential factors (or secondary factors), but the active feeding of the object fish is the indispensable condition of getting a good catch by these methods. Therefore, we

cannot catch the herbivora and the plankton-feeders which usually feed on such food as those being found out easily and abundantly anywhere or feed on those hardly applicable as the bait chiefly because of its small size. Consequently, the object fish are, usually, restricted to only those whose food-habit is not lower than the fry-feeder or the benthos-eater in the food-pyramid.

But here, two examples of very peculiar exceptions of the limitation of the food-habit will be shown, although they are realized only in somewhat different condition from the ordinary one : These are the cheat-angling (or *Damashi-zuri* in Japanese) of the jack mackerel and the angling by the vacant hooks (or *Kara-biki* in Japanese) of the sardine and the jack mackerel ; i.e., the jack mackerel is the plankton-feeder but sometimes eats macroplankton, therefore, they are attacked, in some parts of our country, by the hooks with small schizopod-like mimetic prey ; on the other hand, when the sardine and the jack mackerel are concentrated into extremely high density and swimming around the lamp as if being possessed of it, they are hooked by a tuft of the hooks without any prey. In the former method, we can, thus, overcome the difficulty in hooking the prey which is only as large as small schizopod ; and in the latter one, we can catch the fish free from its food-habit even from the feeding activity.

The object fish are, as a consequence of high position in the food-pyramid, usually larger than the others in size and at the same time they are higher in the market price in our country. And this method is well thought to be the cheapest method of catching the fish in the cost than any other method. We can, therefore, easily make up for the cost even if we cannot catch the fish abundantly. But this method can cover only far narrower space than any other method. Because of these reasons mentioned above, when the fish is distributed in Pattern III, this is thought to be the most suitable method of attacking them with the highest possibility of economic success. But it is very natural that we expect to get better catch from Pattern I than from Pattern III, although it is very hard to expect from this method to get the catch as good as that from the seine when the fish is distributed in Pattern I. For the purpose of making the scattered individuals (Pattern IV) possible to be the object of the hand-line angling by concentrating them into Pattern III, some auxiliary devices are employed. The bait-casting employed in the yellowtail angling around the reef (what-we-call domesticate angling or *Kaitsuke* in Japanese) will be represented as an example, although this is thought to be very peculiar in respect of its time scale ; namely, it requires considerably long time to concentrate the fish into available density in contrast to the fact that it requires rather short time to do so in the case of other method. Besides the schooling yellowtail, we already knew the presence of some individuals scattering into very low density, but we have no method capable of concentrating them into available density within a short time, and we are obliged to put the bait around the reef day by day during long period, then this prevents the scattered individuals passing the reef and makes them stay long around it, and as a consequence this brings about concentration of fish. And at last when they assemble into available density, we catch them effectively by the hand-line.

Active feeding is, of course, one of the indispensable conditions of getting the good catch, but the swimming speed is not so important a condition, but if insisted, the fish have to swim about for feeding, although too quick swimming brings us rather harmful results. Meanwhile, this method is effective regardless of the depth levels of the habitats ; but if insisted, the fish swimming in the shallower layer is the more desirable. For alluring the fish into shallower layer in company with the purpose of activating the feeding and of concentrating the fish, some auxiliary devices are employed in some of the professional fisheries. And as the examples, I will employ squid angling under the lamp, the skipjack angling, and the method of what-we-call *Saba-hane-zuri*, which is a special angling for mackerel, because most of these fish landed in our country are brought by these methods, although these are rather exceptions of the angling in the large foundation of necessity and large scale. We can angle up the mackerel assembling under the lamp even from deeper layer, but the bait is applied when they are swimming at deep layer, for the purpose of not only activating the feeding of the fish but also alluring the fish into shallower layer. This makes it, at the same time, possible to save the time required for angling up each individual and also to save the bait-loss preventing the bait cast from scattering into too wide space and into too low density

to lose its effect. On the other hand, some other devices are employed for the purpose of preventing the fish from quick passing. The lamp in the squid angling is one of the examples being employed for this purpose in company with the purpose of concentrating the squids, of alluring them into shallow layer and of activating their feeding. The bait-casting and shower in the skipjack angling are the other examples of the devices being employed for the same purpose, although there is no need, in this case, to concentrate the fish because they are swimming in the surface layer forming compact schools.

Longline : The hand-line angling can cover only very narrow space ; accordingly, the good catch is expected only when we fortunately come across or successfully find out the patch of fish ; and whether or not we can get a good catch depends strongly on how well we can find the school. Therefore, it is, of course, very natural that the fishermen pay their considerable effort to school-finding. On the other hand, when the fish are scattered into low density, good catch is hardly expected. But, for the purpose of getting a good catch from the scattered individuals, there may be two ways, by each of which, at the same time, it is more or less possible for us to overcome the difficulty in school finding ; one is to concentrate the scattered individuals into available density; and the other is to catch the fish still in scattered state. Some examples of the former were already, represented. The longline is one of the examples of the latter and is thought to be the consequence of the effort of making the gear into possible to cover considerably long range, in an attempt to filling up the most fatal demerit of the angling—narrowness of the space capable of covering. Therefore, the desirable conditions of this method resemble very closely those of the angling except that of the distribution pattern ; and also this method requires the similar conditions to those of the drift-net except that of the feeding activity. Accordingly, when the fish with good appetite are distributed in Pattern II, the highest possibility of getting the economic success is expected of this method ; but when the fish not willing to take the prey are in Pattern II, the drift-net is thought to have the highest possibility of getting the economic success. The drift-net and the longline are, thus, thought to be the method suitable for attacking the fish in Pattern II. But the longline cannot catch the fish more than the number of the hooks which is limited ; because of this reason, when the fish are a little dense, better catch is expected of the drift-net than of the longline ; yet, the longline needs far less foundations than the drift-net. Therefore, when the fish are scattered into very low density, the longline is more suitable than the drift-net.

In the northern half of the Japan Sea coast of our country, relatively large individuals of the mackerel are caught by the longline. In this case, the fish are scattered into low density and the low water-temperature makes it very hard to concentrate them by lamp, yet they take actively the prey, moreover they are fatty which means that they are rather high in market price, in contrast with the fact that we can catch the fish by this method with very low cost. These are the reasons why this fishery exists with economic success. The example of catching the scattered individuals of the yellowtail concentrating with the bait was already represented. But this is rather peculiar. We frequently catch the scattered individuals of the yellowtail still in scattered state adopting the longline or trolling, because of the same reasons mentioned in the mackerel longline and in the domesticate angling of this fish.

Tuna longline, which is the subject of this article, is the longline of the largest scale and is one of the most leading fishery in Japan and most of the tuna are caught by this method ; but I do not wish to describe here its details, but the readers may be aware of the fact that it is very probable that the tuna are guessed to be distributed in Pattern II in the ocean and it is reasonable to catch them by this method.

Trolling : This is the method of catching the fish in Pattern IV even in Pattern II still in scattered state with economic success. And because of very low cost and very small foundation of necessity and also its ability of covering very wide space, the economic success is expected even to the fish scattered in extremely low density, if only they are swimming in very surface layer and taking the prey very actively. But we cannot catch very large individuals by this method, because such fish shows very large momentum which makes it impossible to endure the fish against

breaking of the hooked part around the mouth and as a consequence hooked fish frequently drops off the hook.

In our country, the scattered individuals of large fish of high economic value such as the dolphin fish, the yellowtail, the skipjack and the tuna are caught by this method.

Harpooning : In our country, many reef inhabitants are caught by this method. But here, let us put them aside the consideration, and give some considerations to the harpooning of the pelagic fish. This method is free from the feeding activity of the fish and only the large fish can be the object of this method. This method needs very small foundation and is of very low cost, in contrast with the fact that the fish such as those capable of being the objects of this method are very large in size, which means that they are very high in the market price. The economic success is, therefore, expected even if only a few individuals are caught. This method is, thus, thought to be suitable for catching the scattered individuals of large fish swimming in very surface layer in low density. The marlins swimming along the coast under strong influence of the Kuroshio Current may be the sole example of this method.

THE HABITS OF FISH IN RELATION TO THE FISHING-METHOD

The desirable conditions of several fishing-methods of importance are discussed in the above comparing with each other. Now let us compare the habits of fish in relation to the fishing-methods with each other.

Anchovy : This is the smallest surface swimmer among all the object fish of the common fishery and measures 9-13 cm. in body length. We should attack their huge schools or catch them concentrating abundantly, because this is the cheapest fish of all the fish caught abundantly. We can rather frequently observe its dense schools not only in the daytime but also at night. The remarkable variability in the catch by the seiners supports the formation of small but dense schools. Its food, phyto-and zoo-plankton, are thought to be rather dense in its habitats ; accordingly, dense schooling does not cause any obstacle to get the foods. Moreover, this fish is thought to be attacked by almost every pelagic fish of medium-and large-size ; accordingly, the dense schooling may be more profitable to survive well against severe attack by its predators. And because they are forming dense school even in the daytime, they can be the object of the daytime seiners ; but, because this fish show strong phototaxis, it is more effective to catch them by the seine at night concentrating them by the lamp. These are the reasons why this fish are caught chiefly by the night-seiners and partly by the daytime ones, although the latter method was prevalent till about twenty years ago but at present this is inclined to change into the former method in most of the districts where there is no legal limitation for using the lamp by the night-seiners. But some attention should be paid to the following facts : few individuals of this fish are occasionally found in the catch by the mackerel seines at off-shore or by the method of aiming the benthonic fish such as Danish trawlers or the trawlers and also we knew some examples of the benthonic fish feeding large individuals of this fish. These are thought to suggest the presence of large individuals scattering in low density and swimming rather deep layer or off-shore, although there is no possibility of the large individuals of this fish being the object of any of the fishery.

Sardine : This fish is a little larger than the anchovy in size and measures 10-25 cm. in body length ; this is thought to be able to swim a little more quickly than the anchovy and can swim ca. 3.3 miles a day (this means neither the maximum speed nor actually swimming one, but indicates the average of daily pass estimated from its migration, therefore, I am afraid it is not suitable to show such a value for the material of the discussion treated here). This fish is also a plankton-feeder, but the proportion of the zooplankton to total plankton taken by this fish is larger than that of the anchovy ; meanwhile, it is evident that the zooplankton is distributed considerably dense in the coastal waters ; on the other hand, increase in size induces to lessen the risk of being attacked by any other fish. This fish occupies the important part of the catch by the seiners,

although the scale of the gears for this fish is somewhat larger than that for the anchovy ; this fact and the remarkably severe deviation in the catch suggest the formation of a little large and dense schools. Far better catch is brought by the night-seiners with the lamp than by the daytime ones, because increase in the size makes the fish swimming in more scattered state. Those caught by the seiners are chiefly the individuals of rather small or medium size (: what-we-call *Koba* and *Chuba* stage) ; meanwhile, when they grew into large : (what-we-call *Ohba* stage), the fall in the water-temperature makes the fish very hard to assemble around the lamp, which makes it very hard to catch them by the seiners. In addition to the difficulty of concentrating them by lamp, we cannot catch them by the angling because they are still plankton-feeders. But we have a method of catching these large and fatty individuals of the sardine with economic success, because they are a little higher in the market price——this is the sardine drift-net, the details of which were already presented in the description of the drift-net.

Flying fish : Despite the fact that it is very easy to concentrate the scattered individuals, we cannot catch them by the seiners chiefly because of their peculiar ability of escaping through air and partly of the small standing crop. But we can catch them by the drift-net with economic success, because they swim actively scattering in very surface layer without any possibility of showing large momentum.

Jack mackerel : This fish is one of the most common on-shore fish swimming in surface layer and situated at a little higher trophic level than the sardine and the anchovy. It is necessary to concentrate them by lamp or rarely by bait before hauling up by the seine, against the fact that the gears for this fish are far larger than those for the anchovy and the sardine. And the catch deviates severely haul by haul, day by day or seiner by seiner ; these facts seem to suggest the formation of large but somewhat dispersed schools. But the scarcity of the fish attacking them does not cause any obstacle to form dispersed schools. Despite the fact that this is very cheap in the market price, considerable amount of this fish are caught by the seine occupying the most important part of its catch. But when they grow larger, they swim more quickly and are distributed less densely but have a little higher market price. And it becomes very hard to catch them by the daytime seiners, but it is possible for us to catch considerable amount of them by the seiners or the anglers by the aid of the lamp. The medium-sized individuals of the jack mackerel are the fish of the lowest position in the food-pyramid being caught abundantly by the angling and the longline all over Japan, although we know such an exceptional method as the flying fish longline which is not prevalent and is restricted to only limited districts. And when we wish to concentrate the anchovy and the sardine, we adopt the lamp only ; and we have no method of catching the concentrated ones other than by the seine or the dip-net. But when we wish to do so the fish not lower than this in the food-pyramid, the bait is employed, in company with the lamp, and, at present, as much fish as those caught by the seiners are brought by the method, what-we-call *Saba Hane-zuri* in Japanese, which is a method very similar to the skipjack angling except the fact that the former needs the lamp to concentrate the fish and operating at night in contrast with the fact that the latter needs not to concentrate the fish and operating only in the daytime. These differences in the fishing-method of catching the medium-sized individuals of the jack mackerel and the mackerel from those of catching the small individuals of the jack mackerel, the sardine and the anchovy are thought to be chiefly due to the difference in their food habits as well as the size which induces to rise in the market price ; and also the more dispersed structure of their schools may more or less contribute to cause the difference in the fishing-method.

Mackerel : The desirable conditions and some other characteristics of the method and habits of the fish are very similar to those of the jack mackerel and they are already described in the former section ; but the mackerel is distributed in more scattered state than the jack mackerel and the weight of the angling and the longline to this fish becomes heavier than that to the jack mackerel. And till several years ago the purse seine was the most prevalent method of catching this fish ; but at present, the fish not less than those caught by the seiners are brought by the method, what-we-call *Saba Hane-zuri* in Japanese. Besides the schooling individuals, there

are some scattered individuals at the deeper layer in the coastal waters. But, it is very hard or expensive to concentrate them in contrast with the fact that they are fatty in such a season, which means that they are high in the market price. Therefore, in our country, especially at the northern half of the Japan Sea coast, the coastal fishermen catch them still in the scattered state with economic success by such gears of low cost as the drift-net and the longline. And also, like the jack mackerel, few far larger individuals than those caught by the drift-net and the longline are caught, in some seasons, by almost every haul of the trawlers and the Danish ones operating in the Eastern Sea and the Yellow Sea, although they are not abundant; this suggests the presence of some large individuals scattering near the bottom of the off-shore waters (of the continental shelf), but we have no method chiefly aiming to catch them with economic success.

Yellowtail: This is one of the on-shore fish swimming in surface layer, but is far larger than the above-mentioned species, and attains about 80 cm. in body length; and this can swim far rapidly than the others, and its swimming ability is estimated to be 10 to 50 miles a day. This fish occasionally visits the waters very close to the coast; and most of the catch of this fish are brought by the set-net showing severe deviation in the daily catch, from which may be evident the formation of huge schools. But, as suggested from its large size and rapid swimming, we know the presence of many other scattered individuals. And the coastal fishermen catch some of them still in the scattered state by such gears of low cost as chiefly the longline and rarely the drift-net, because this is considerably high in the market price which means that we can easily make up for the cost even if we cannot catch many individuals. And some other scattered individuals are caught by the method what-we-call the domesticate angling with the aid of a peculiar method of concentrating the fish, the details of which were already represented. On the other hand, the other scattered individuals of good appetite swimming in the surface layer are caught by the trolling with economic success, because of its high market price and the low cost of the method.

Salmons: They are the typical surface-swimmers living in the subpolar off-shore waters. They are a little smaller than the yellowtail and measure 40-60 cm. in body length; consequently, they are a little inferior to the yellowtail in the swimming ability and are estimated to swim 7-30 miles a day. It is a well known fact that, in summer season, they approach the coast forming large and compact schools amidst the anadromous migration for spawning. Extremely dense prey and considerable dishomogeneity in the environmental conditions in the coastal waters and some special habits of fish during spawning season may strongly contribute to form compact schools; meanwhile, the weak appetite during this season does not cause any obstacle to form dense schools. Therefore, they are successfully caught by large seiners and by the set-nets in the on-shore waters. The good but severely deviating catch by these gears also suggest their huge schooling. In the off-shore, however, the environmental conditions are thought to be far homogeneous than those of the on-shore and each of their prey—large-sized zooplankton, small squids and some fish fry—is thought neither to form clear patches nor to be distributed densely. And the animals attacking them in the off-shore are thought to be far less dense than in the on-shore. Thus, in the off-shore, dense schooling does not bring the fish any benefit but causes many obstacles, and they are thought to be scattering. Meanwhile, it is very hard to concentrate the scattered individuals into desirable density within a short time. Therefore, in the off-shore, we cannot catch them effectively by the seiners; and rough sea also prevents us from employing the seiners for catching the salmons scattering in the off-shore; and they are caught by drift-net and longline. And the rationality in employing these methods is supported by the symptoms suggesting the scattering structures obtained as the results of the analyses on the distribution pattern of captured individuals along the gears and the variability in the catch by these methods.

Skipjack: This fish feeds chiefly on zooplankton and partly on small fish and squids. And it is evident that this fish forms considerably large and compact schools not only in the on-shore but also even in the off-shore; therefore, it is very reasonable that its schools in the on-shore are caught by huge seiners but those in the off-shore are by the special angling boats of exceptionally large size. But those caught by these methods are the migrating schools chiefly consisting of

individuals not older than five years. Moreover, their rich fishing-grounds are found only near the polar front or any other convergence line where the environmental conditions may be considerably dishomogeneous and the distribution of prey is rather dense and considerably dishomogeneous. Meanwhile, like other fish mentioned already, there are many symptoms suggesting the presence of the grown-up individuals scattering in the off-shore of the low latitudinal waters. The environmental conditions of these waters are thought to be, roughly speaking, more homogeneous than those of the youngs' habits, moreover, the prey, chiefly macroplankton and small fish are distributed far less densely. These fish are hardly thought to be frequently attacked by any other animal. Therefore, the scattered structure is thought to be more profitable to survive well, and not so many obstacles are supposed to be induced by scattered structure. But its extremely low density, difficulty in concentrating them into desirable density and extremely distant habitats from the coast prevent us from exercising any professional method of catching them with economic success, although they are expected to be considerably high in the market price. And they are left from the object of any of the fishing-methods, although we frequently find them among the auxiliary catch by the tuna longline; but those scattering in surface layer of the on-shore waters are occasionally caught by trolling.

Marlins: The marlins are the largest surface swimmers in the low-latitudinal off-shore waters. They feed voraciously chiefly on the fish rather regardless of their size although they may be unable to eat very small fish. But the standing crop of their prey in the off-shore is thought to be very low against the fact that such large fish as the marlins is thought to require considerable amount of food to survive. We observe the killer whale attacking the marlin, but it is very hard to consider that such predators are dense in the off-shore and that they frequently meet across the marlins; consequently, the marlins are thought to have less risk of being attacked by any other animals in the sea. These facts in company with their remarkably strong ability to swim induce the fish to need wide space for living. Meanwhile, the theory of pyramid of numbers suggests that marlins are at very low density. Therefore, the marlins are well thought to be extremely scattering in the off-shore. On the other hand, in our country, the fish of the higher position in the pyramid of numbers is appreciated to be the daintier, and is the higher in the market price; in addition to this, the marlins are very large in body size. Summarizing these facts, I find that it is, of course, very reasonable to catch the large and precious fish distributed in very low density such as marlins by harpooning.

THE TUNA LONGLINE

From the above-mentioned facts, the presence of huge but rather compact schools of the young individuals of tuna in the on-shore is very easily suspected. And this fact is also supported by the good but severely deviating catch of bigeye tuna, yellowfin tuna, bluefin tuna and albacore by the huge seiners, what-we-call the American Seiners, off Sanriku districts of our country and that of albacore by pole-angling boat in the same waters. But the fish caught by these methods are rather at young stage; and the rich fishing-grounds are rather restricted to the waters such as those along the coast, near the convergence lines or around the reef or the islands, where the environmental conditions are dishomogeneous and the prey is concentrated. Meanwhile, the presence of some grown-up individuals scattering around the reefs or the islands or along the coast is also very naturally suspected; and our coastal fishermen professionally catch them by trolling with economic success. But at present, the most of tuna landed in our country are brought by huge longliners from off-shore of the low-latitudinal waters. Therefore, let us give some considerations to the habits of tuna and the environmental conditions of its fishing-grounds.

It is a very well-known fact that the organic productivity is very low in the low-latitudinal waters; moreover, that of the off-shore is far lower than that of the on-shore. Therefore, it is very natural way of fish to adapt to survive in such waters of low productivity as the low-latitudinal off-shore waters that tuna feed on the prey rather regardless of the size and they can eat macroplankton, fish, squids and any other animals; even though, it is very hard to think that tuna are not short of food.

Moreover, rather high temperature accelerates the digestion of the cold-blood animals such as the tuna and this makes the tuna always hungry. On the other hand, it is also very well-known fact that their prey are distributed most densely at subsurface layer. The tuna caught by the long-line are very large in body size and measure 100-150 cm. in body length ; this large size and the spindle shape in the body form suggest that they can swim very rapidly; and at the same time, they are obliged to do so for finding out the prey enough to survive.

All these facts summarized, it is very reasonable to consider that the grown-up individuals of the tuna in the low-latitudinal off-shore waters swim about actively at subsurface layer scattering into very low density even in the rich fishing-ground, where they are distributed more densely than any other waters. Therefore, the longline is thought to be the most suitable method for catching them. And also it is very reasonable to make the gears capable of covering the line as long as possible ; but we can dispose of a limited number of the hooks within a working-time in a day, which is usually as much as 1,600 or a little more than this. Therefore, the fishermen incline to use the more main-lines thinning the hooks attached to each main-line (a main-line is called a basket because it is put in basket when it is not in use ; and this is as long as ca. 300 m. and is rather kept in constant length). And as the consequence, the number of hooks in a main-line is changed from 11 to 6 then to 5 ; and at present, the main-line with each four hooks is the most common type.

This recent trend of improvement of gear, can well be admitted reasonable. But, too long main-lines rise the cost for constructing the gear ; moreover, this needs us to haul up the gear in very high speed and at present there arises another new limitation to the total length of a row of main-lines—this is the limit of hauling speed which is governed by the endurable limit of line to tension. Despite this, do you think is it not too large the difference of four hooks from 11 ones? Is there any possibility of over-thinning? Therefore, now, let us give some considerations upon the relation of the distribution pattern of the hooked individuals along long-line to the possibility of over-thinning.

When the hooks are too dense comparing with the distribution of fish or with the influencing range of the hooked individuals, it may be sure that some of the hooks around the occupied ones are of no use ; consequently, it is probable that the occupied hooks apt to be arranged at somewhat regular interval and the occupied rate may be very low, i.e., the occupied hooks are observable self-spacingly. Meanwhile, if dense and wide schools may visit the line, it is highly probable that the occupied hooks may be observed self-spacingly, but, here, the occupied rate may be high. And when we frequently observe such a pattern as this, it may well be thought that the thinning of the hooks may cause rather harmful result than benefit. On the other hand, when hooks are not too dense comparing with the distribution pattern of fish or the influencing range of the hooked individuals, the hooks may be occupied contagiously or randomly.

Accordingly, when the hooks are occupied self-spacingly and the occupied rate is low, it is thought to be better to thin out the hooks ; but when they are occupied also self-spacingly but occupied rate is high, it is suggested the high possibility of over-thinning or this suggests the possibility of employing the drift-net ; meanwhile, the contagiousness or randomness of the occupied hooks is thought to suggest neither over-thinning nor under-thinning.

Therefore, in order to judge whether or not the density of the hooks in the present gears is adequate, we should examine the distribution pattern of the occupied hooks along the line. For this purpose, I intended first to construct the series of the equations representing the theoretical values of the random distribution along a line fulfilling some peculiar conditions specific to the longline and then to discuss the tendency of the distribution pattern of the occupied hooks paying attention to the bias of the corresponding observed values from the computed ones.

1. *Spacing method*

Each set of gears consists of ca. 380 main-lines connected in a series and suspended in the water by buoy-lines of 20 m. long each attached at every joint. Each main-line is 300 m. long and

provided with four branch-lines of 25 m. long set at regular intervals and each ending in a single hook. The interval between each pair of hook on the same basket is 60 m., while the interval between the distal hook of a certain basket and the adjoining one of the consecutive basket is twice as long as this. As each main-line of respective unit of gears forms catenarian, the average buoy-interval is shorter than the length of the main-line in the actual operation and thus the hooks cannot be suspended at the same level, but their situations are separated into two levels. And the depth level of the adjoining hooks to the buoy-lines is measured by chemical tube to be about 100 m. deep while that of the rest of them is to be about 150 m. deep. The gears are set from one end and it takes about four hours to empty all the baskets. The setting always begins at midnight, the boat is let drift for about three hours near the final end of the whole gear and then the hauling of gears begins with the final end of the whole gear. This time, it takes about twelve hours or longer than this to haul up the whole gear. Thus, the soaking of the whole gear lasts generally for three hours from 3 a.m. to 6 a.m.

If most individuals are caught during the period when all units of gears are soaked, then the catch rate of all hooks at the same depth level must be the same throughout, while if a considerable number of individuals are caught during the course of setting or hauling, then the occupied rates have to increase from one end to the other. Even in the latter case, if the population keeps the gradient of the density opposite to the direction of increase of soaking time, the apparent distribution will take the form like that found in the former case. Actually, however, in so many examples, nearly all examples when emphasized, the occupied rate of the hooks increases with the soaking time. For such examples, the influence of the gradient of the occupied rate should be taken into consideration during the construction of the equation, otherwise the results of further analyses will be much more contagious than the actual. Besides the above-mentioned facts, it is a well-known fact that the situations of the hooks are differentiated into two levels and the occupied rate of the hooks differs at different depth levels, being higher at deeper level. When the occupied rates of the hooks at the different depth levels are not the same, the hooks showing higher occupied rate appear at regular intervals, consequently this might mislead to suppose the existence of schools arranged at the intervals as long as a basket. And the similar error to this might also be caused by the presence of the buoy-line where no individual can be hooked. These effects also should be taken into consideration.

Therefore, at first, let us set the following as the basic assumption: if the soaking time and the depth levels of the hooks are the same, the occupied rate of all the hooks are the same and whether respective hooks occupied or not are independent of one another. Then, let us set N_1 and N_2 individuals are scattered, showing a simple gradient, along shallower and deeper hooks in a row of gears constituted of m consecutive baskets of equal length attached to four hooks a basket, and k is representd as $a(4+1)+R$, when it is separated into the part divisible by the length of a basket and the remainder. Furthermore, the occupied rates of a shallower and a deeper hook in the ith basket are set to be represented respectively $(P_1+i\triangle P_1)$ and $(P_2+i\triangle P_2)$ for the purpose of expressing the simple gradient of the occupied rates. Then, we can estimate the number of the individual-pairs of k hook-intervals wide when all the individuals are hooked independently of one another from the following equations :

at $R=0$

$$X_{(k)} = \sum_{i=1}^{m-a}(P_1 + i\triangle P_1)(P_1 + \overline{i+a}\,\triangle P_1) + \sum_{i=1}^{m-a}(P_2 + i\triangle P_2)(P_2 + \overline{i+a}\,\triangle P_2)$$

$$= 2\left[P_1^2(m-a)\left\{1+(m+1)\,\delta_1 + (m-a+1)(2m+a+1)\frac{\delta_1^2}{6}\right\}\right.$$

$$\left. + P_2^2(m-a)\left\{1+(m+1)\,\delta_2 + (m-a+1)(2m+a+1)\frac{\delta_2^2}{6}\right\}\right]$$

at R=1

$$X_{(k)} = \sum_{i=1}^{m-a}(P_1 + i\Delta P_1)\ (P_2 + \overline{i+a}\,\Delta P_2) + \sum_{i=1}^{m-a}(P_2 + i\Delta P_2)\ (P_2 + \overline{i+a}\,\Delta P_2)$$
$$+ \sum_{i=1}^{m-a}(P_2 + i\Delta P_2)\ (P_1 + \overline{i+a}\,\Delta P_1)$$
$$= P_1 P_2 (m-a)\left[2 + (m+1)(\delta_1 + \delta_2) + (m-a+1)\ (2m+a+1)\frac{\delta_1 \delta_2}{3}\right]$$
$$+ P_2^2 (m-a)\left[1 + (m+1)\,\delta_2 + (m-a+1)\ (2m+a+1)\ \frac{\delta_2^2}{6}\right]$$

at R=2

$$X_{(k)} = \sum_{i=1}^{m-a}(P_1 + i\Delta P_1)(P_2 + \overline{i+a}\,\Delta P_2) + \sum_{i=1}^{m-a}(P_2 + i\Delta P_2)\ (P_1 + \overline{i+a}\,\Delta P_1)$$
$$+ \sum_{i=1}^{m-a-1}(P_1 + i\Delta P_1)\ (P_1 + \overline{i+a+1}\ \Delta P_1)$$
$$= P_1 P_2 (m-a)\left[2 + (m+1)\ (\delta_1 + \delta_2) + (m-a+1)\ (2m+a+1)\frac{\delta_1 \delta_2}{3}\right]$$
$$+ P_1^2 (m-a-1)\left[1 + (m+1)\,\delta_1 + (m-a)\ (2m+a+2)\frac{\delta_1^2}{6}\right]$$

at R=3

$$X_{(k)} = \sum_{i=1}^{m-a}(P_1 + i\Delta P_1)\ (P_1 + \overline{i+a}\,\Delta P_1) + \sum_{i=1}^{m-a-1}(P_2 + i\Delta P_2)\ (P_1 + \overline{i+a+1}\ \Delta P_1)$$
$$+ \sum_{i=1}^{m-a-1}(P_1 + i\Delta P_1)\ (P_2 + \overline{i+a+1}\ \Delta P_2)$$
$$= P_1^2 (m-a)\left[1 + (m+1)\ \delta_1 + (m-a+1)\ (2m+a+1)\frac{\delta_1^2}{6}\right]$$
$$+ P_1 P_2 (m-a-1)\left[2 + (m+1)\ (\delta_1 + \delta_2) + (m-a)\ (2m+a+2)\frac{\delta_1 \delta_2}{3}\right]$$

and at R=4

$$X_{(k)} = \sum_{i=1}^{m-a-1}(P_2 + i\Delta P_2)\ (P_1 + \overline{i+a+1}\ \Delta P_1) + \sum_{i=1}^{m-a-1}(P_2 + i\Delta P_2)$$
$$(P_2 + \overline{i+a+1}\ \Delta P_2)$$
$$+ \sum_{i=1}^{m-a-1}(P_1 + i\Delta P_1)\ (P_2 + \overline{i+a+1}\ \Delta P_2)$$
$$= P_1 P_2 (m-a-1)\left[2 + (m+1)\ (\delta_1 + \delta_2) + (m-a)\ (2m+a+2)\frac{\delta_1 \delta_2}{3}\right]$$
$$+ P_2^2 (m-a-1)\left[1 + (m+1)\ \delta_2 + (m-a)\ (2m+a+2)\frac{\delta_2^2}{6}\right]$$

here $\delta_1 = \dfrac{\Delta P_1}{P_1}$ and $\delta_2 = \dfrac{\Delta P_2}{P_2}$

But, when the occupied rate is too low to get the computed and the observed values large enongh to be free from the influence of accidental error, it is recommended to use the following equations, in which the length divisible by a basket length is employed instead of the hook-interval :

Let us set that the number of individuals caught in the ith section is $(N_0+i\Delta N)$, total number of individuals caught by a row of gears constituted of M consecutive sections is $N=\sum_{i=1}^{M}(N_0+i\Delta N)$, and all individuals are distributed showing simple gradient due to that of the soaking time. Then, we can estimate the number of the individual-pairs of k section-intervals wide when all the individuals are hooked independently of one another from the following equations :

$$X_{(0)} = \frac{N(N-1)}{2}\sum_{i=1}^{M}(P_0 + i\Delta P)^2$$

$$= \frac{MN(N-1)}{2}P_0^2\left[1 + (M+1)\delta + (M+1)(2M+1)\frac{\delta^2}{6}\right]$$

$$X_{(k)} = \frac{N(N-1)}{2} \times 2\sum_{i=1}^{M-k}(P_0 + i\Delta P)(P_0 + i\overline{+k}\Delta P)$$

$$= (M-k)N(N-1)P_0^2\left[1 + (M+1)\delta + (M-k+1)(2M+k+1)\frac{\delta^2}{6}\right]$$

here $\frac{N_0}{N} = P_0$, $\frac{\Delta N}{N} = \Delta P$ and $\frac{\Delta P}{P_0} = \delta$.

2. *Interval analysis*

The spacing method does not touch on the fact whether some of the inserted hooks are occupied or not, and this sometimes makes it into confusion to translate the results of the analyses into the actual pattern, although the same fact has such advantage as being able to give consideration upon the relation extending to a very wide range compared with the unit-length. Accordingly, changing the mind, I have devised out another trial. This method treats of the length of the interval from any hooked-individual to the next one, i.e., whether some of the inserted hooks are occupied or not is taken into consideration.

In order to represent the gradient of the occupied-rate of the hooks at respective depth levels, the occupied-rate of a shallower hook in the ith basket is set to be $(P_1+i\Delta P_1)$ and that of the deeper hook is $(P_2+i\Delta P_2)$ and also set that $q_1=1-P_1$ and $q_2=1-P_2$. Then, the total number of the gears connected into a row is set to be m and the interval k is represented as a $(4+1)+R$. From the following equations, we can compute the expectant number of the two occupied-hooks spaced by k hook-intervals each other and without any occupied inserted-hooks, when all the individuals are hooked independently of one another.

at $R = 0$

$$\psi_{(k)} = \sum_{i=1}^{m-a}\{(P_1 + i\Delta P_1)(P_1 + \overline{i+a}\Delta P_1)(q_1 - i\Delta P_1)(q_2 - i\Delta P_2)^2$$
$$\prod_{b=1}^{a-1}(q_1 - \overline{i+b}\Delta P_1)^2(q_2 - \overline{i+b}\Delta P_2)^2\}$$
$$+ \sum_{i=1}^{m-a}\{(P_2 + i\Delta P_2)(P_2 + \overline{i+a}\Delta P_2)(q_1 - i\Delta P_1)(q_2 - i\Delta P_2)$$
$$(q_1 - \overline{i+a}\Delta P_1)$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a}\{(P_2+i\triangle P_2)\,(P_2+\overline{i+a}\triangle P_2)\,(q_1-i\triangle P_1)\,(q_1-\overline{i+a}\triangle P_1)$$

$$(q_2-\overline{i+a}\triangle P_2)$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a}\{(P_1+i\triangle P_1)\,(P_1+\overline{i+a}\triangle P_1)\,(q_1-\overline{i+a}\triangle P_1)\,(q_2-\overline{i+a}\triangle P_2)^2$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

at $R=1$

$$\psi_{(k)}=\sum_{i=1}^{m-a}\{(P_1+i\triangle P_1)\,(P_2+\overline{i+a}\triangle P_2)\,(q_1-i\triangle P_1)\,(q_2-i\triangle P_2)^2$$

$$(q_1-\overline{i+a}\triangle P_1)$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a}\{(P_2+i\triangle P_2)\,(P_2+\overline{i+a}\triangle P_2)\,(q_1-i\triangle P_1)\,(q_2-i\triangle P_2)$$

$$(q_1-i+a\triangle P_1)\,(q_2-\overline{i+a}\triangle P_2)$$

$$\prod_{b=1}^{a-1}(q_1-i+b\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a}\{(P_2+i\triangle P_2)\,(P_1+i+a\triangle P_1)\,(q_1-i\triangle P_1)\,(q_1-\overline{i+a}\triangle P_1)$$

$$(q_2-\overline{i+a}\triangle P_2)^2$$

$$\prod_{b=1}^{a-1}(q_1-i+b\triangle P_1)^2\,(q_2-i+b\triangle P_2)^2\,\}$$

at $R=2$

$$\psi_{(k)}=\sum_{i=1}^{m-a}\{(P_1+i\triangle P_1)\,(P_2+i+a\triangle P_2)\,(q_1-i\triangle P_1)\,(q_2-i\triangle P_2)^2$$

$$(q_1-\overline{i+a}\triangle P_1)\,(q_2-\overline{i+a}\triangle P_2)$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a}\{(P_2+i\triangle P_2)\,(P_1+\overline{i+a}\triangle P_1)\,(q_1-i\triangle P_1)\,(q_2-i\triangle P_2)$$

$$(q_1-\overline{i+a}\triangle P_1)\,(q_2-\overline{i+a}\triangle P_2)^2$$

$$\prod_{b=1}^{a-1}(q_1-\overline{i+b}\triangle P_1)^2\,(q_2-\overline{i+b}\triangle P_2)^2\,\}$$

$$+\sum_{i=1}^{m-a-1}\{(P_1+i\Delta P_1)(P_1+\overline{i+a+1}\,\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

at $R = 3$

$$\psi_{(k)}=\sum_{i=1}^{m-a}\{(P_1+i\Delta P_1)(P_1+\overline{i+a}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)^2 (q_1-\overline{i+a}\Delta P_1)(q_2-\overline{i+a}\Delta P_2)^2 \prod_{b=1}^{a-1}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

$$+\sum_{i=1}^{m-a-1}\{(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\,\Delta P_1)(q_1-i\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

$$+\sum_{i=1}^{m-a-1}\{(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\,\Delta P_2)(q_1-\overline{i+a+1}\,\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

and at $R = 4$

$$\psi_{(k)}=\sum_{i=1}^{m-a-1}\{(P_2+i\Delta P_2)(P_1+\overline{i+a+1}\Delta P_1)(q_1-i\Delta P_1)(q_2-i\Delta P_2)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

$$+\sum_{i=1}^{m-a-1}\{(P_2+i\Delta P_2)(P_2+\overline{i+a+1}\,\Delta P_2)(q_1-i\Delta P_1)(q_1-\overline{i+a+1}\Delta P_1)\prod_{b=1}^{a}(q_1-\overline{i+b}\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

$$+\sum_{i=1}^{m-a-1}\{(P_1+i\Delta P_1)(P_2+\overline{i+a+1}\,\Delta P_2)(q_1-\overline{i+a+1}\,\Delta P_1)(q_2-\overline{i+a+1}\Delta P_2)\prod_{b=1}^{a}(q_1-i+b\Delta P_1)^2 (q_2-\overline{i+b}\Delta P_2)^2\}$$

3. *Arrangement analysis*

Adding the interval analysis makes the distribution pattern analyzable more easily and clearly overcoming the influence of the fact whether any of the inserted-hook in the interval under consideration is occupied or not ; but we can certify from the results of this analysis only the fact that the intervals covering how long are more frequently observable than expected from the chance distribution. But there remains another factor untouched—this is the manner of the arrangement of the intervals covering respectively. And if we want to find out any clear conclusion of the

distribution pattern, the interval analysis is not sufficient, but the following series of analysis should be added, which is, for convenience' sake, called the arrangement analysis.

For beneficial to the methodological meaning, I wish to define here what-we-call school the individuals forming the short intervals arranged successively, although I treated hitherto it involuntary like this. Accordingly, if the length, k, which is the maximum length capable of being regarded as the short interval, is determined, the number of the intervals each as long as or shorter than k, when all the individuals are distributed by chance, is estimative from the theoretical values in the interval analysis. But it is very naturally able to be expected that there will be some short intervals arranged successively, even if all the individuals are distributed by chance; and the expectant number of the lots constituted of W successive intervals each of which is as long as or shorter than k, when all the individuals are scattered by chance, is computable adopting the method mentioned below.

Let us set that N individuals are hooked by a row. Then, total number of the intervals nipped by the individuals is (N—1); while the number of the intervals as long as or shorter than k hook-intervals is $\sum_{k=1}^{k} \psi(k)$, which is estimative from the equation in the interval analysis. Therefore, the probability of any interval as long as or shorter than k hook-interval is $P_{i(k)}=\frac{\sum_{k=1}^{k}\psi(k)}{N-1}$. And the number of the manner picking up the lot of W successive intervals from (N—1) intervals arranged along a line is $\{(N-1)-(W-1)\}$. Among them, to begin counting W successive intervals from the foremost interval or to end in the hindmost one lack each one of the preceding or succeeding interval, but other W successive intervals of $\{(N-1)-(W-1)-2\}$ manner are nipped by other intervals. Accordingly, the expectant number of occurrence of W successive intervals, each of which is as long as or shorter than k hook-intervals and located between the intervals longer than k hook-interval width, is

$$(N-W-2)\ [P_{i(k)}]^{\overline{W}}[q_{i(k)}]^2 \quad , \text{ here } q_{i(k)}=1-P_{i(k)}$$

while that of the terminal W successive intervals sectioned by longer interval is

$$2[P_{i(k)}]^{\overline{W}}[q_{i(k)}]$$

And the sum is

$$S_{(\overline{W}_k)}=[P_{i(k)}]^{\overline{W}}[q_{i(k)}]\ [(N-\overline{W}-2)q_{i(k)}+2]$$

Then, the number of the schools constituted of (W+1) individuals caused as the results of the schooling tendency is estimated to be as equal as the difference in the observed-value from the corresponding estimated one.

4. *Results of the analysis*

Nineteen examples of bigeye tuna observed off the southwest of the Hawaiian Islands are analyzed and the following results are obtained: (1) the extremely strong contagiousness of the catch between the adjoining hooks is one of the most remarkable characteristics of the distribution pattern of the occupied hooks, (2) concerning the problems whether large schools are observable or not and whether the distribution pattern is contagious or self-spacing, no definite answer is obtained, but, generally speaking, however, the hooks are occupied almost by chance.

The results of the analyses on ten examples of yellowfin tuna observed in the same waters mentioned above and twelve ones in the waters central part of the Indian Ocean are as follows: population usually has the contagious schools of several folds and it is suggested as the structure of the highest order observable within a row that about a half of catch constitutes several schools of from 10 to 30 km. in the projected width along the longline and the average occupied-rate of

the hooks in the part covered by these schools is estimated to be from several tenths to several times higher than that computed throughout a row.

The examples of the albacore were increased up to 41 (observed in the waters near New Caledonia), because the school formation is highly probable in this species as a considerable amount of younger individuals are caught by angling. But the essential pattern does not differ so much from those of the bigeye tuna and the yellowfin tuna, i.e., the grownups are roughly said to be distributed almost by chance. Contrary to the expectations that the school formation is highly probable, about one-third of the examples showed the negligibly weak self-spacing pattern, although about a half of the examples showed the contagious pattern. And it may be regarded as one of the characteristics of the distribution pattern of this species that no clear contagious pattern is observable within a short range in contrast with the cases of the bigeye tuna and the yellowfin tuna.

Therefore, as the general conclusion, I wish to consider that it is very rational to employ the longline to catch the tuna and that the recent trend of improvement of the gears—thinning of the hooks—is very reasonable and there is no possibility of over-thinning even if the difference of four hooks from eleven hooks is very large.

DEVELOPMENT OF THE TUNA FISHERY OF BRAZIL AND PRELIMINARY ANALYSIS OF THE FIRST THREE YEARS' DATA

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INTRODUCTION AND HISTORY OF THE FISHERY

This report refers to the long-line tuna fishery of Brazil for the years 1957-1959, and the observations contained in it must be considered somewhat preliminary. Data collected in these three years were analysed for the following information :

1. Area of capture by statistical rectangles.
2. Development of relative indices of abundance in these areas.
3. Fluctuations of abundance, both annually and by seasons.
4. Indications of movements of the fish (as influenced probably by water temperature) based on fluctuations of abundance.
5. Indications of the results of fishing pressure on the stocks.

Before 1956, the tuna fishery of Brazil did not have a specific character. Although the tunas are abundant in waters off Brazil, they were little known and little studied. Small boats fishing with hook and line captured only small quantities, but large schools often were sighted, particularly in the waters of the northeast, from September to March every year. The small boats, some of them only rafts (' jangadas ') or canoes, are able to fish only very close to the shore.

In 1956, work was started, directed at the possibilities of development of a major tuna fishery. Two studies were made, by Robert E. Lee of the Food and Agriculture Organization of the United Nations (Lee, 1957), and by Hiroshi Nakamura of the Fisheries Laboratory, Koshi, Japan. Nakamura used the Japanese research vessel *Toko Maru*, contracted from Japan by the Brazilian Government, and began his cruises in December 1956. He found tuna very abundant relative to his previous work in the Pacific.

Thanks to these researches, a commercial-scale fishery was begun, initially by a Japanese company based in Recife, State of Pernambuco. Later this fishery was partially taken over by Brazilian interests, and in 1958 another Japanese company began to fish from a base in Santos, State of São Paulo. The Japanese fleet based in Recife was originally four boats, augmented in 1958 by two more in Recife and two in Santos. In 1961, about a dozen vessels are fishing out of Recife and three out of Santos. All of these boats are of the Japanese long-line type.

This report is confined to the first three years of the fishery. During the last two years, 1960-61, there does not appear to have been any radical change in the fleet or the fishery.

For clarity, the only names used in this report are the English common names ; members of the scombrid group are referred to as ' tunas ' and other fish captured by long-line are referred to separately or grouped as ' others '. Following is a list, in approximate order of importance, of the scientific names of these fish, the common names in English, and the names used in Por-

tuguese in the north and in the south of Brazil (but not necessarily in other Portuguese-speaking regions of the world) : (Figs. 4-10)

Scientific name	*English common name*	*Portuguese common names*	
	Scombrid Group		
		North east	*South*
Thunnus albacares Bonaterre	Yellowfin	Yellowfin, Albacora de lage	Albacora de lage
Thunnus alalunga Gmelin	Albacore	Atum, Albacora branca	Albacora branca
Thunnus obesus Lowe	Big-eye	Albacora ôlho grande, Bigeye	Atum cachorra
Thunnus thynnus L.	Bluefin	Albacora azul	Atum legitimo
	Xiphiid and Istiophorid groups		
Xiphias gladius L.	Swordfish	Espadarte	Espadarte maka
Makaira ampla Poey	Blue marlin	Agulhao negro	Espadarte preto
Makaira albida Poey	White marlin	Agulhao de prata	Espadarte meka
Istiophorus americanus Cuvier	Sailfish	Agulhao de vela	Agulhao

In addition to these species, others of lesser commercial importance are captured, including bonitos (Katsuwonidae) and mackerels; these are included in ' others '. Although it is not included in the list, *Thunnus atlanticus* Lesson (Albacora preta), is occasionally captured; it is grouped with ' others '. Please note that the scientific names given above and the grouping is solely for the sake of clarity and convenience; no position is taken on the complex problems of the taxonomy and nomenclature of the tunas and their relatives.

Table I shows the relative importance of each species in the capture for the three years. The production is given in numbers of fish captured in each year plus the totals for the three years. In this table, it may be seen that two species of tuna, Yellowfin and Albacore, contribute more than 75% of the catch while the other dozen or so species contributing make up each only a small part. Yellowfin alone makes up more than 50% of the total capture of all fishes. Considering only the tunas, Yellowfin accounts for about 60%, Albacore about 30%, Big-eye about 6%, and Bluefin about 2%.

The species are not treated separately below because of the preliminary nature of this report. It is believed that a clearer picture can be given in this first analysis by avoiding prolongation and a large number of tables, figures, etc. In future works, the more important species will be dealt with separately.

Origin and Nature of the Data Analyzed

The fishing data used in this report were originally taken by the captain of each vessel during fishing operations. In addition to recording the latitude and longitude, the captains took meteorological and hydrographic data, notably water temperatures. Number of hooks used were also recorded for analysis of units of fishing effort. Copies of the log books were made available to various Brazilian institutions. The number of boats whose data were available for this study was different in different years : 1957, 4 ; 1958, 8 ; 1959, 11.

Although the boats are not exactly comparable in size or fishing power, they all use standard Japanese long-line gear and analysis of the data on a basis of capture per hundred hooks eliminates

discrepancies. The logs show that the time the gear is fished is remarkably constant, about six hours. Hence, the basic units used in the following analysis are two : the *number* of fish captured and the numbers (in hundreds) of hooks used multiplied by the numbers of settings of the fishing gear.

Discussions of the hydrography of the fishing areas are based on Sverdrup, Johnson and Fleming 1942, Fuglister 1957, Emilsson 1959, Metcalf 1960, and Miller 1960, plus unpublished data from the cruises of the *Toko Maru* and the Brazilian Navy's hydrographic vessel *Almirante Saldanha da Gama.*

Analysis of the Data

On the basis of the skippers' log books, monthly tabulations of the catch data and effort were made for each year. The data were divided in statistical rectangles of one degree of longitude by one degree of latitude. Each rectangle is numbered by the longitude on its eastern edge and the latitude on its northern edge when it is south of the Equator, on its southern edge when it is north of the Equator. For example, rectangle 25-01S. is limited by the meridians of 25 and 26 degrees W. and the parallels of 01 and 02 degrees S., and rectangle 25-01N. is limited by the same meridians but by 01 and 02 degrees N. In low latitudes these rectangles are almost exactly 60 by 60 nautical miles, but at the latitude of Santos they are approximately 60 by 55 nautical miles.

Although some longliners can span more than one statistical rectangle with a single setting of their gear, this causes no serious difficulty with this method of analysis. The rectangle to which each set was assigned was the rectangle which included most of the gear. However, in analysis of the data, the rectangles are grouped into three major regions : *north* (of the equator) ; *central,* between the equator and 15°S. ; and *south.* The object of this division is for better understanding of the data ; the divisions are more or less arbitrary.

The capture per rectangle, summed by year and region, is presented in Table II and Figure 1. The relative abundance index (capture per 100 hooks) was obtained by dividing the numbers of fish captured by the numbers of hooks used and multiplying the result by 100, and is also presented in Table II and Figure 2. For Yellowfin, Albacore and Big-eye, the abundance indices were calculated separately and are shown in Table III and Figure 3. In interpretation of Figures 2 and 3, it should be borne in mind that rectangles without symbols indicate areas not fished and not necessarily areas of low abundance.

From Figure 1, it may be seen that the fishery was distributed between 13°N. and 31°S. It has extended to the east as far as 2°E., and to the west as far as 53°W. north of the equator and as far as 48°W. south of the equator. However, the fishery has been concentrated from 15°S. to 12°N. between the meridians of 23°W. and 40°W.

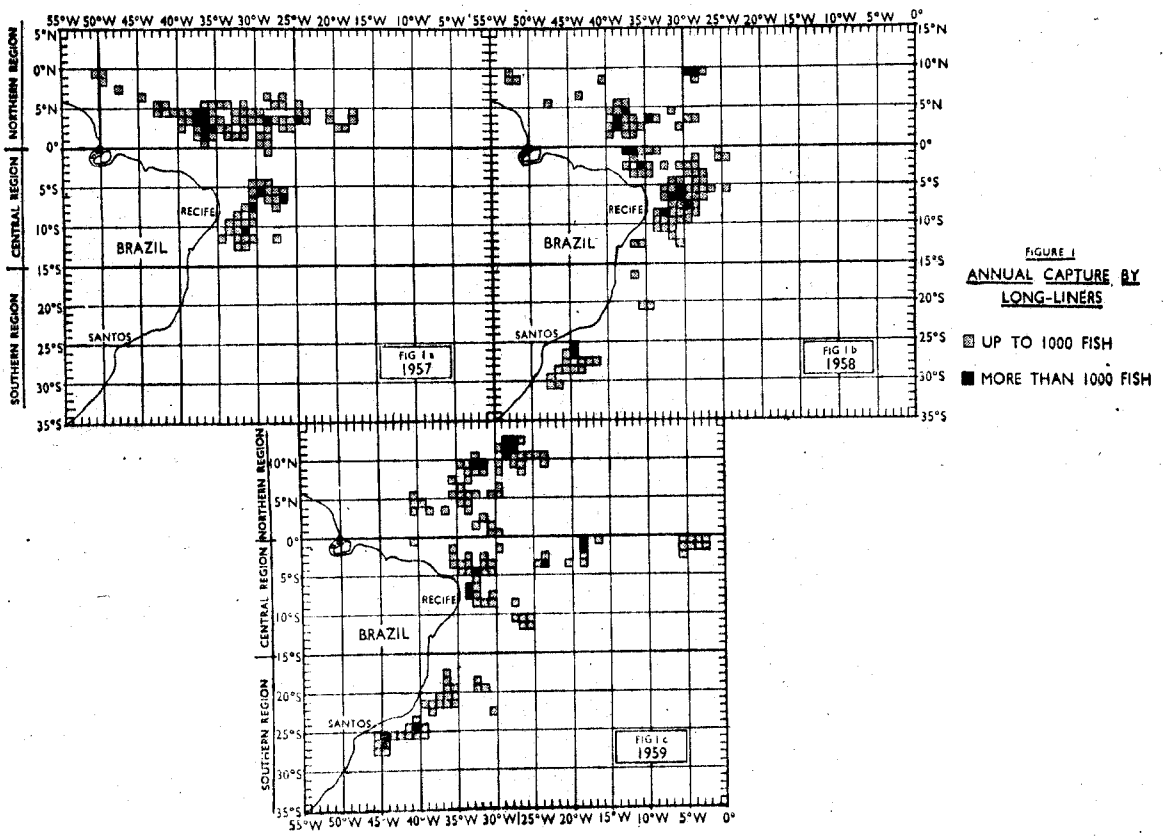
Figure 1a and Table IIA show that in 1957 the fishery was concentrated in the north, where about 70% of the fish were captured. The central region contributed the rest. Note further that the number of rectangles fished was greater in the north, even though the home port was in the central region. Also, the number of rectangles with high production was greater in the north.

In 1958, the fishery was concentrated more in the central region (Figure 1b). The production was higher in this region than in the others, although there was evidence of a small isolated area of high production in the south. Table IIB shows the same data in more detail—the northern region accounted for about 30% of the total, the central for 57%, and the south for 13%.

By 1959 (Table IIC and Figure 1c), the production was about equal in the three regions, each producing 30-35% of the total,

The abundance indices shown in Table II show, however, a different picture:

For 1957, (Table IIA and Figure 2a), the abundance indices are distributed with the most dense region between 3°N. and 5°N., and along the parallel of 6°S. The northern region shows a general index of about 10 and the central about 8.5



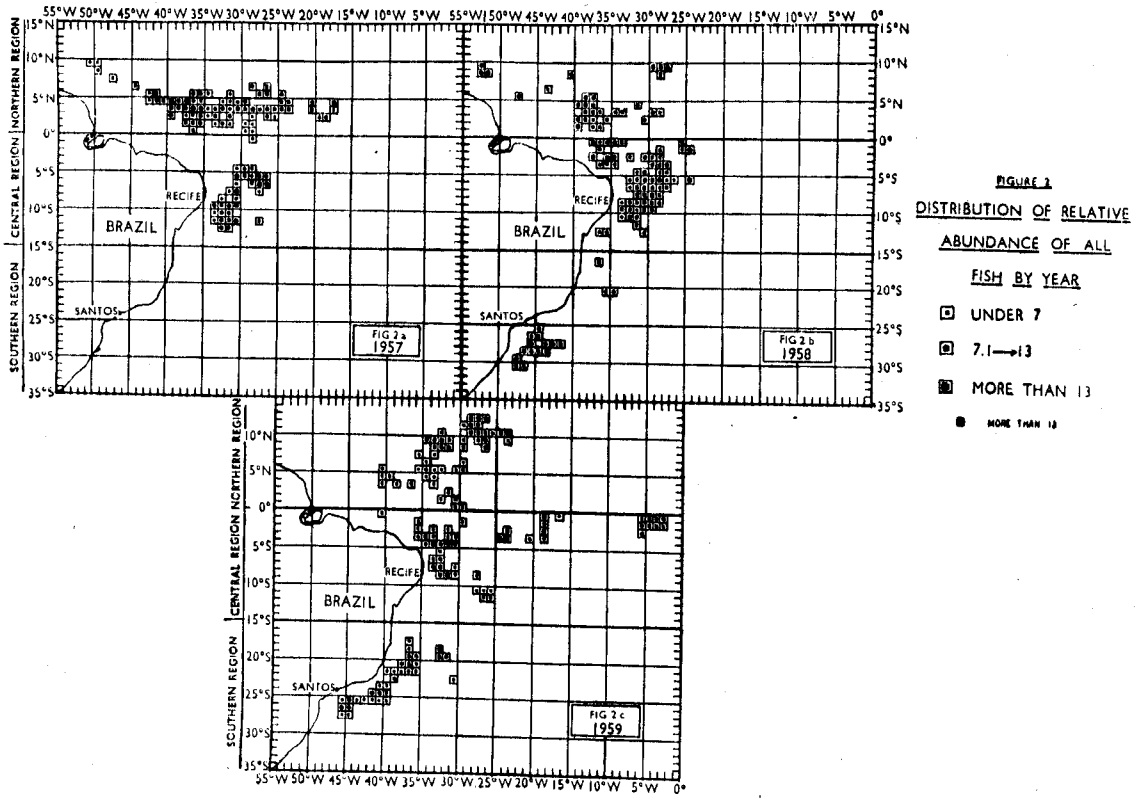
In 1958 (Table IIB and Figure 2b) the central region has the greater number of rectangles with high abundance. In the northern region, although there are concentrations, the fishery was more disperse. In the southern region, fished for the first time, there appears to be a belt of high abundance along the coast at a distance of about 150 miles, between 25°S. and 31°S. All three regions show a value of about 11 fish per hundred hooks, none much superior to another.

In Figure 2c the highest abundance in the northern region centers around 10°N. by 30°W. In the central region there was a band of high abundance just below the Equator extending from Brazil almost to Africa, with the best fishing results obtained in this region. In the southern region there appeared to be three more or less separate regions of high abundance, extending south of Santos. The general abundance indices were about 10 for the north, 11 for the central region, and 9 for the south.

Table III gives the capture per hundred hooks for Yellowfin, Albacore and Big-eye by quarters of the year in statistical rectangles. These species were isolated because of their relative importance to the fishery. It may be seen that for these species during these three years the number captured per hundred hooks varied generally between 1 and 17, with the exception of

six rectangles in which more than 17 per hundred hooks were captured and the occasional one where less than one fish was captured per 100 hooks. The average was 8.3.

In the first quarter of 1957 the highest abundance was found in the central region, although the abundance was higher in the northern region in the second quarter. In the last half of the year, the fishery was localized practically completely between the Equator and 5°N., in the northern region.



In 1958, in the first half of the year the pattern was similar to 1957, although the number of rectangles fished was smaller. In the latter half of the year in the central region there were only three rectangles with yield higher than 13 per 100 hooks ; in the north the centers of abundance seemed much more spread out. It was in this year that the first attempts were made in the southern region, but the abundance figures were low.

In 1959, in the first and second quarters, there was no fishery in the northern region. In the central region the highest abundance was just below the Equator. Abundance was still low in the southern region. Toward the end of the year the fishery was concentrated in the north and towards the end of the year there was a concentration of good fishing in this area.

Considering only the four tuna species, the abundance and effort data for the three years (Table III) are as follows :

Year	*Effort* (100's *of hooks*)	*Abundances*
1957	1704	7.3
1958	3263	8.8
1959	3792	6.5

While this is much too short a series of data on which to base firm conclusions, there does not appear to be a strong relation between effort and abundance, particularly when it is considered that up to 20 per cent variation in tuna abundance figures can be normally expected in the same area from year to year (Nankai Regional Fisheries Laboratory, 1959). Thus, the effects of fishing pressure on the stocks may well be slight, or even negligible.

Consideration of Hydrographic Conditions and Discussion

Thus it may be seen, the distribution of abundance varied widely, changing both in time and in space. One area is different from another, and in the same area there are large differences in different periods of the year. Undoubtedly one of the influences causing these changes is change in the environment. To attempt to analyze this, hydrographic data were analyzed by quarters, roughly corresponding to the seasons of the year. (Of course seasonal changes in the Equatorial region are not so well marked as in higher latitudes.) Looking at these data, the following generalizations may be made :

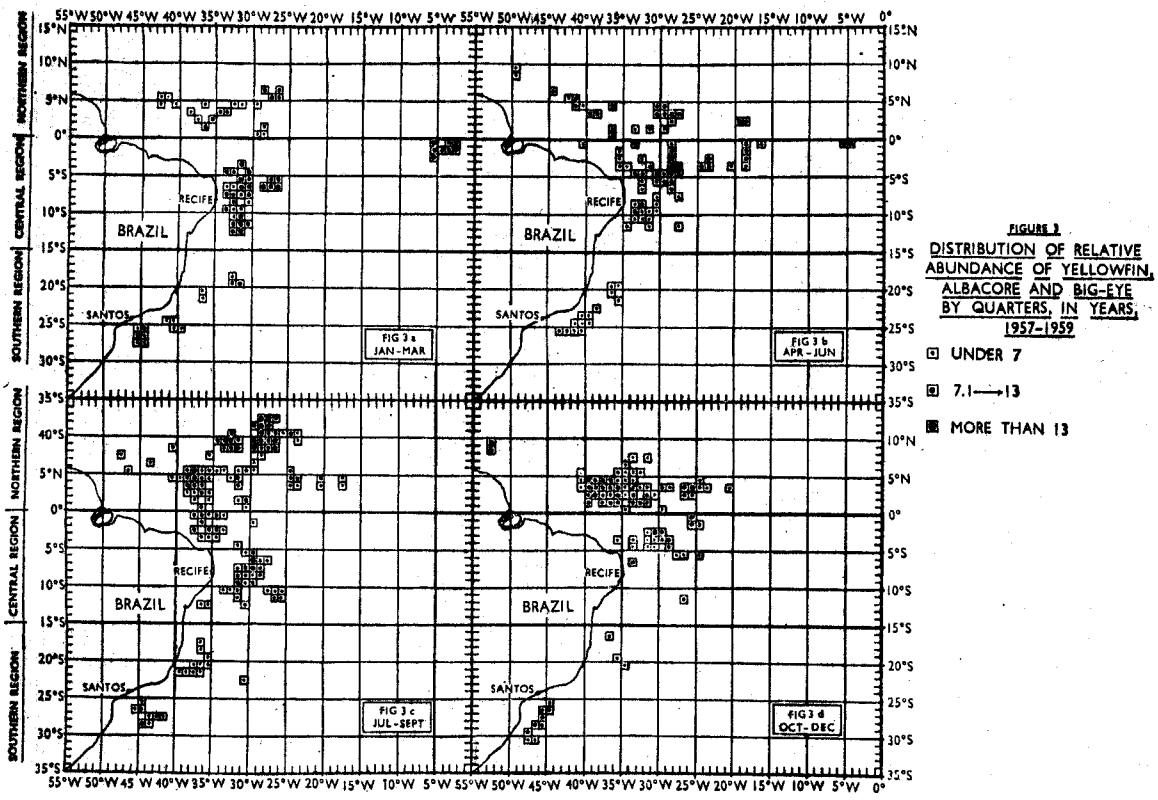


FIGURE 3
DISTRIBUTION OF RELATIVE ABUNDANCE OF YELLOWFIN, ALBACORE AND BIG-EYE BY QUARTERS, IN YEARS, 1957-1959

First quarter—In this period (which corresponds more or less to summer south of the Equator) the principal region of the fisheries was the central, with two concentrations, one near 6°S. and the other just below the Equator. In both of these the surface temperatures taken by fishing boats were 27°-28°C. (Figure 3a). In this region, the temperature never goes below about 25° to a depth of 100 meters (Emilsson 1959), and the hooks of the long-lines are confined to this water, usually fishing between 50 and 80 meters.

At the same time, the temperatures in the northern and southern regions were between 24° and 28°, and the abundance of tunas was medium to low. Research vessel temperatures taken in the same period generally confirm the fishing boat temperatures, but outside of the fishing areas temperatures from 27° to 28° were found in all three regions. It should be noted that these data refer only to certain parts of the regions and that they were collected only in February and March.

Second quarter (Autumn)—Here, as in the first quarter, the highest abundances are found in the central region. Note that they now are concentrated further offshore corresponding, it appears, to a water mass with a temperature of 28°. The abundance in the northern region is seen to increase and the temperature in the fishing areas varies between 27°-28°. In the south, where the temperatures are between 25°-27°, the abundances of tuna are much lower.

Third quarter (Winter)—During this period, the highest indices of abundance are in the northern region, where the temperatures are 27°-28°. In the central region the abundance is lower and the temperatures as low as 26°. In the south, where the temperatures were generally 25°-26°, the abundance is low, but there are on record two exceptional causes of high capture per unit effort when the temperature was only 22°. In these areas at this time, however, Albacore was the predominant species, contrary to the usual pattern.

Fourth quarter (Spring)—The highest abundance of fish is found just north of the Equator (Figure 3d). In retrospect, it now seems that this corresponds to the same concentration which can be seen gradually moving north, probably in response to changing hydrographic conditions in the second and third quarters. Even now, the highest concentrations in the central regions are in its northern part. Where the high abundances of fish are found the temperatures are 27°-28° in the northern region and 26°-27° in the central.

At the present stage of knowledge of the ecology of the tunas as revealed by the Brazilian fishery, a great deal remains to be investigated, particularly as regards the relations between the distribution of the fishes and hydrographic conditions. It is interesting to note, nonetheless, the rather close correspondence between the abundance of the tunas and the current pattern prevailing off Brazil's easternmost bulge, Cape São Roque. At or near this cape, the westerly flowing South Equatorial Current divides, part of it turning south to become the warm Brazil Current and extending in some years at least as far south as the River Plate estuary, and part of it flowing along Brazil's northern coast and eventually into the Caribbean (Sverdrup, Johnson and Fleming 1942, Emilsson 1959). In the years under study, 1957-1959, the fishery took place almost, if not entirely, within this current system, and in 1959 when it was extended eastward the extension was along the path of the South Equatorial Current.

Since the main contributor to the South Equatorial Current is the Benguela Current flowing northerly along the west coast of Africa, and since the tuna fishery along the shores of Angola is dependent on the same species in approximately the same order of importance (Vilela and Monteiro 1959) there is more than a suggestion that the tuna fisheries of western Africa and eastern South America may be prosecuted on the same stocks of fish. Of course, special studies, such as marking experiments, would be required to establish this, but the question is important from the point of view of eventual management of either or both of these fisheries.

CONCLUSIONS

1. In the north and central regions, the best fishing occurs in the third quarter of the year.

2. In the southern region, the best fishing occurs in the first and third quarters.

3. The average abundance for the whole area for the three years was 10 fish per hundred hooks. This is a high value compared to Japanese captures in the Pacific, which run 7-8 fish



FIG. 4. Albacore, *Thunnus alalunga*
Captured in Brazil's coast between latitudes 23° S. and 15° N. Period March-May 1957.
Photo by H. Nakamura

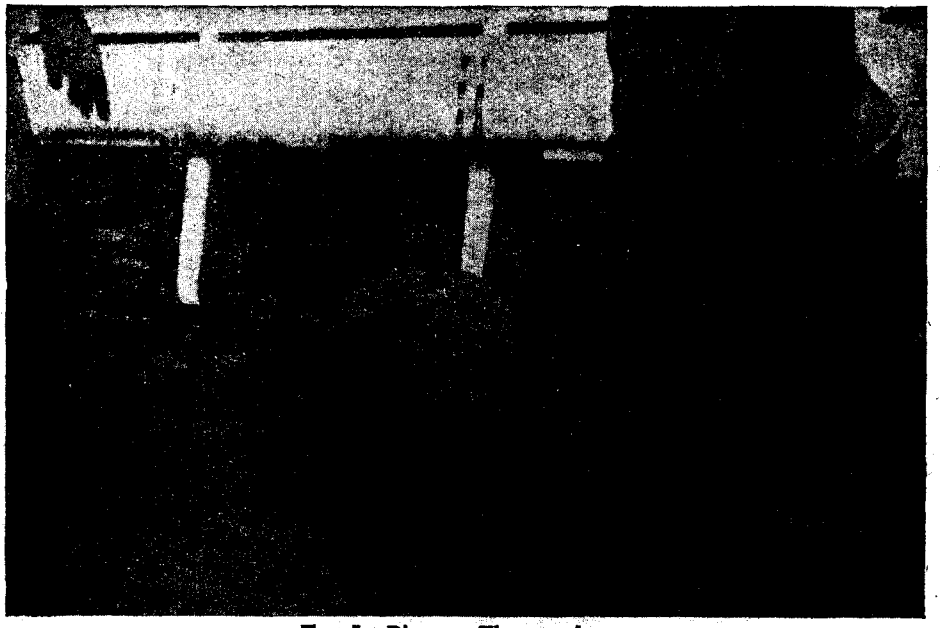


FIG. 5. Big-eye, *Thunnus obesus*
Captured in Brazil's coast between latitudes 23° S. and 15° N. Period March-May 1957.
Photo by H. Nakamura

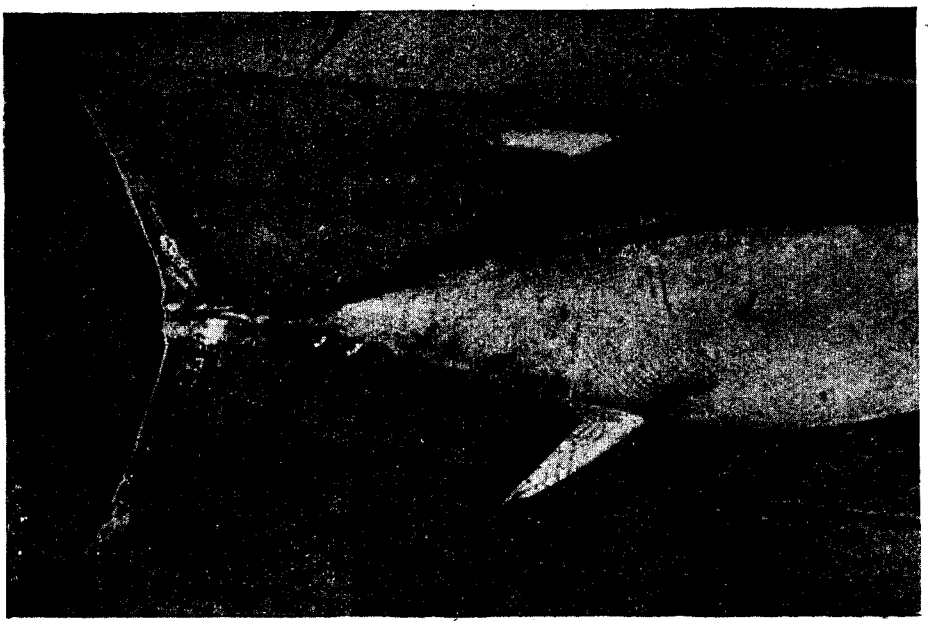


FIG. 6. Albacore, *Thunnus alalunga*
Captured in Brazil's coast between latitudes 23° S. and 15° N. Period March-May 1957.
Photo by H. Nakamura

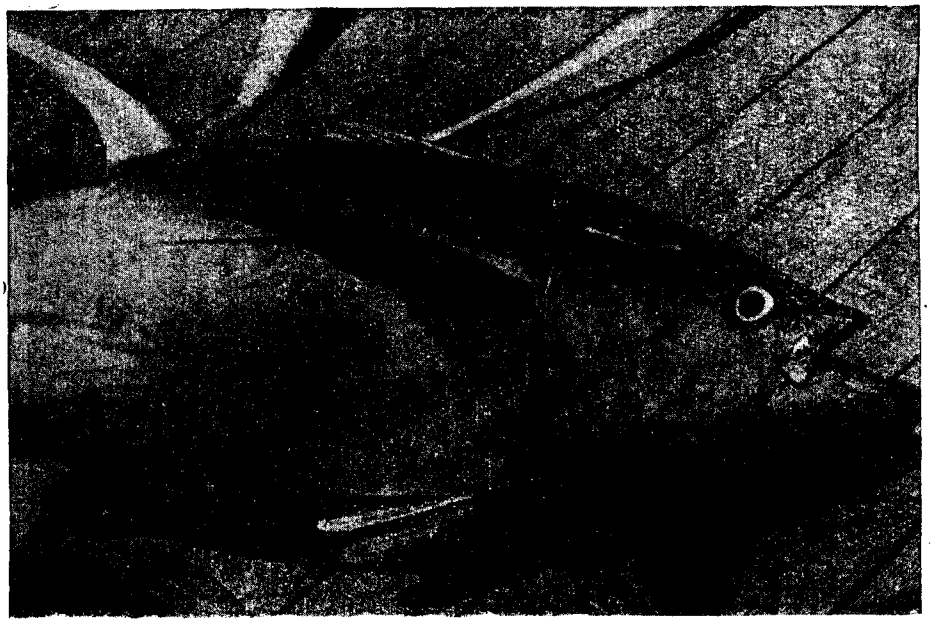


FIG. 7. Yellowfin, *Thunnus albacares*
Captured in Brazil's coast between latitudes 23° S. and 15° N. Period March-May 1957.
Photo by H. Nakamura



FIG. 8. Sailfish, *Istiophorus americanus*
Captured in Brazil's coast between latitudes 23° S. and 15° N.
Period March-May 1957. *Photo by H. Nakamura*



FIG. 9. Big-eye, *Thunnus obesus*
Captured in Brazil's coast between latitudes 23° S. and 15° N.
Period March-May 1957. *Photo by H. Nakamura*

per hundred hooks (Nankai Regional Fisheries Laboratory, 1959 ; *Toko Maru* report, unpub.). Even when all other species are disregarded, the combined catches of Yellowfin, Albacore, Big-eye and Bluefin run over 8 fish per 100 hooks.



FIG. 10. Yellowfin, *Thunnus albacares*
Captured in Brazil's coast between latitudes 23° S. and 15° N.
Period March-May 1957. *Photo by H. Nakamura*

4. For the four tuna species, the abundance and effort data show no clearcut effect of the fishery on the stocks.

5. Generally, the best catches correspond to the highest temperatures in the regions fished.

6. If the high temperature-high abundance relation holds up, there is reason to believe that the high temperatures recorded by research vessels outside the fishing areas, particularly in the first quarter, may be indications of rich unexploited fishing grounds.

7. The fishery is closely related to the current system of the Equatorial Atlantic.

8. Special studies, such as marking, are indicated to determine the relations, if any, of these tuna stocks to those of West Africa.

ACKNOWLEDGEMENTS

Thanks are due to the ' Taiyo ' and ' Inbrape ' fishing companies for making available their records through Dr. A. S. Braga, co-director of the State Research Group, and through Mr. F. R. Lima, fellowship holder of the National Research Council of Brazil.

Mr. J. P. Wise of the Food and Agriculture Organization of the United Nations assisted in the analysis and in the English translation.

RESUMO

O presente relatório tem como finalidade fazer uma apreciação dos primeiros dados coletados na pesca de *long-line* no Atlântico Sul entre as latitudes 15 graus N e 31 graus S, durante os anos de 1957 a 1959.

Neste, a produçao é dada em têrmos de número de peixes capturados em cada área de um grau de lado.

Para cada uma destas áreas foi extraido também um número através da captura por centenas de anzóis empregados. Este número, ou ìndice de densidade relativa, nos serviu para cõmparar áreas entre si e determinar os locais mais densos em cada regiao.

Para as espécies Albacora de lage, Albacora branca e Atúm cachorra (ôlho grande), os dados de densidade sao appreciados por trimestre dē cada ano. Também estao todos englobados em periodos, a fim de se observar a relaçao entre temperatura da água e produti vidade das areas em cada periodo, que deve corresponder a uma esta cao do ano.

Portanto, as comparacoes têm por objetivo indicar em que épo ca do ano, em que locais e a que temperatura correspondem os melho res rendimentos.

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TABLE I

Summary of annual capture of tunas and other species (in numbers) by Brazilian Long-liners, 1957-1959

Year	TUNAS				TOTAL TUNAS	OTHER SPECIES						TOTAL	TOTALS		
	Yellow-fin	Albacore	Big-eye	Bluefin		Blue Marlin	White Marlin	Sword fish	Sailfish	Sharks	Others		No. of fish	No. of hooks	No. per 100 hooks
1957	25,206	15,732	2,134	..	43,072	2,527	133	..	980	..	1,101	4,741	47,813	5173,6	9.2
1958	26,192	14,265	2,846	29	43,332	1,212	740	2,747	618	2,147	1,960	9,424	52,756	4687,7	11.2
1959	31,058	11,960	2,737	224	45,979	1,800	1,418	5,668	493	3,097	1,847	14,323	60,302	6060,7	9.9
TOTAL	82,456	41,957	7,717	253	132,383	5,539	2,291	8,415	2,091	5,244	4,908	28,488	160,871	15922,0	10.1

TABLE II—1957

Capture of fish (in numbers) by statistical rectangles, 1957-1959, number of hooks, capture per 100 hooks

Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks
	NORTHERN REGION		
17-03N	71	15,0	4,7
17-04N	650	48,4	13,4
18-02N	803	78,2	10,3
20-03N	422	53,2	7,9
20-04N	696	58,4	11,9
23-03N	378	51,8	7,3
23-04N	94	10,7	8,8
24-03N	1067	113,8	9,4
24-04N	194	25,0	7,8
24-05N	252	26,2	9,6
25-02N	62	8,8	7,0
25-03N	741	72,4	10,2
26-02N	118	12,9	9,1
26-03N	542	62,4	8,7
26-05N	304	34,6	8,8
26-06N	134	15,6	8,6
27-03N	184	17,2	10,7
27-05N	563	54,8	10,3
28-00N	90	15,3	5,9
28-01N	93	15,3	6,1
28-02N	96	17,2	5,6
28-03N	1372	102,0	13,4
28-06N	179	19,0	9,4
29-00N	49	15,7	3,1
29-01N	104	17,2	6,0
29-03N	209	17,2	12,1
29-04N	234	32,8	7,1
30-03N	180	14,8	12,2
30-04N	84	14,0	6,0
31-01N	397	56,8	7,0
31-03N	194	29,2	6,6
31-04N	128	30,3	4,2
31-05N	54	16,5	3,3
32-01N	229	26,4	8,7
32-03N	321	34,2	9,4
32-04N	205	31,8	6,4
33-01N	162	29,3	5,5
33-02N	98	12,8	7,7
42-04N	93	15,8	5,9
42-05N	483	77,1	6,3
44-06N	68	14,0	4,8
47-07N	51	13,3	3,8
49-08N	101	14,0	7,2
49-09N	92	14,0	6,6
50-09N	132	28,0	4,7
19-02N	860	86,2	10,0
31-02N	646	64,4	10,0
33-03N	107	16,5	6,5
37-01N	261	36,6	7,1
38-04N	134	16,0	8,4
	NORTHERN REGION		
	CENTRAL REGION		
26-05S	702	64,8	10,8
26-06S	1002	71,2	14,1
27-05S	388	32,0	12,1
27-06S	415	25,0	16,6
27-07S	121	17,9	6,8
27-11S	61	16,9	3,6
28-00S	87	20,5	4,2
28-04S	221	26,5	8,3
28-05S	204	39,9	5,1
28-06S	307	32,9	9,3
29-04S	313	46,6	6,7
29-05S	1424	191,7	7,4
30-04S	28	13,4	2,1
30-05S	153	9,8	15,6
30-06S	70	18,0	3,9
30-07S	1428	157,3	9,1
30-08S	859	122,4	7,0
30-09S	157	20,3	7,7
30-11S	673	62,2	10,8
32-12S	166	16,0	10,4
31-07S	228	35,5	6,4
31-09S	462	61,5	7,5
31-10S	1593	174,6	9,1

TABLE II

Capture of fish (in numbers) by statistical rectangles, 1957-1959, number of hooks, capture per 100 hooks.

Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks
34-02N	101	16,0	6,3
34-03N	67	12,8	5,2
34-05N	173	33,0	5,
35-01N	252	32,0	7,9
35-02N	1141	125,2	9,1
35-03N	741	55,2	13,4
35-04N	80	16,0	5,0
35-05N	129	16,5	7,8
36-00N	316	33,0	9,6
36-01N	1858	176,9	10,5
36-02N	1075	130,1	8,3
36-03N	3427	239,4	14,3
36-04N	2425	208,3	11,6
36-05N	345	48,0	7,2
37-02N	434	65,4	6,6
37-03N	1418	130,4	10,9
37-04N	1797	119,2	15,1
38-03N	690	77,6	8,9
39-02N	157	15,2	10,3
39-03N	579	58,3	9,9
39-04N	390	29,6	13,2
40-04N	545	68,3	8,0
41-04N	141	14,4	9,8
41-05N	358	45,7	7,8
31-11S	508	60,0	8,5
31-12S	543	48,0	11,3
32-08S	446	81,0	5,5
32-09S	708	91,5	7,7
32-10S	522	70,8	7,4
32-11S	165	16,0	10,4
33-09S	152	16,0	9,5
33-10S	184	29,0	6,3
34-11S	102	14,5	7,0

RECAPITULATION

Northern :	Number captured	33420
	Hundreds of hooks	3469,7
	No. per 100 hooks	9,6
Central :	Number captured	14393
	Hundreds of hooks	1703,8
	No. per 100 hooks	8,4

TABLE II-B-1958

NORTHERN REGION

28-03N	111	18,0	6,2	28-08S	284	16,0	17,7
28-08N	207	24,7	8,4	29-02S	168	18,0	9,3
34-03N	1116	112,0	9,9	29-03S	319	36,0	8,9
29-03N	492	54,0	9,1	29-05S	125	16,0	7,8
30-02N	112	36,0	3,1	29--06S	511	38,5	13,3
31-04N	113	10,4	10,9	29-07S	1053	79,1	13,3
35-02N	115	16,0	7,2	29-08S	86	48,9	12,0
36-01N	145	16,0	9,1	29-09S	482	38,3	12,6
36-03N	238	31,0	7,7	30-02S	530	36,0	14,7
38-02N	1020	79,0	12,9	30-04S	999	62,4	16,0
38-03N	1254	119,7	10,5	30-05S	5779	419,5	13,8

38-04N	590	74,5	7,9
38-05N	674	49,0	13,7
37-02N	208	32,0	6,5
29-09N	1024	53,5	19,1
27-09N	554	44,6	12,4
28-09N	1602	97,1	16,5
33-03N	274	32,0	8,6
37-01N	74	13,2	5,6
37-03N	160	16,0	10,0
37-04N	1430	96,0	14,9
37-05N	135	7,5	18,0
39-01N	280	16,0	17,5
39-02N	333	32,0	10,4
39-04N	95	13,2	7,2
40-08N	180	16,8	10,7
43-06N	57	8,4	6,8
46-05N	248	24,3	10,2
51-08N	162	8,4	19,3
52-08N	484	31,8	15,2
52-09N	114	7,9	14,4
	CENTRAL REGION		
24-01S	339	33,0	10,3
24-05S	176	16,0	11,0
25-00S	364	34,0	10,7
25-01S	168	17,0	9,9
26-05S	109	17,0	6,4
27-03S	121	13,2	9,2
27-04S	299	26,4	11,3
27-05S	99	17,0	5,8
27-06S	126	11,0	11,4
28-01S	104	13,2	7,9
28-02S	103	13,2	7,8
28-03S	682	67,2	10,1
28-04S	152	17,0	8,9
28-05S	398	39,6	10,0
28-06S	845	75,7	11,2
28-07S	177	16,0	11,1
30-06S	3330	251,9	13,2
30-07S	136	12,5	10,9
30-08S	104	13,0	8,0
30-09S	168	13,1	12,8
30-12S	97	12,6	7,7
31-04S	83	16,0	5,2
31-05S	590	32,0	18,4
31-06S	1631	123,9	13,2
31-07S	227	25,8	8,8
31-08S	140	12,9	10,8
31-09S	91	15,9	5,7
31-10S	245	29,5	8,3
31-11S	112	13,2	8,5
32-02S	73	13,2	5,5
32-05S	91	13,2	6,9
32-06S	83	13,2	6,3
32-08S	1057	113,4	9,3
32-09S	689	92,4	7,4
32-10S	292	39,9	7,3
33-00S	198	26,4	7,5
33-08S	91	13,6	6,7
33-09S	228	26,4	8,6
33-10S	121	26,1	4,6
34-00S	94	10,0	9,4
34-02S	228	25,0	9,1
34-03S	94	25,0	3,8
35-00S	181	25,6	7,1
35-02S	1119	131,0	8,5
35-03S	209	37,5	5,6
35-12S	73	12,5	5,8
36-00S	1426	117,2	12,2
36-01S	167	13,9	12,0
36-03S	52	12,5	4,2
36-12S	67	13,8	4,8
37-00S	2112	178,5	11,8
37-02S	946	69,5	13,6

TABLE II B 1958—(*Contd.*)

Capture of fish (in numbers) by statistical rectangles, 1957-1959, number of hooks, capture per 100 hooks

Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks
	SOUTHERN REGION		
34-20S	175	17,0	10,3
35-20S	165	18,0	9,2
36-16S	152	16,0	9,5
41-27S	52	11,2	4,6
42-27S	261	32,0	8,1
43-27S	274	33,2	8,2
43-28S	63	11,0	5,7
44-25S	2013	121,0	16,6
44-26S	2467	204,2	12,1
44-28S	127	10,2	12,4
45-26S	721	80,0	9,0
45-27S	324	32,8	9,9
45-28S	91	9,6	9,5
46-28S	114	8,6	13,2
46-30S	109	8,6	12,7
47-29S	105	8,6	12,2
47-30S	199	17,2	11,6

RECAPITULATION

NORTHERN REGION	
Number captured	13.601
Hundreds of hooks	1.191,0
No. per 100 hooks	11,4
CENTRAL REGION	
Number captured	31.743
Hundreds of hooks	2.857,3
No. per 100 hooks	11,1
SOUTHERN REGION	
Number captured	7.412
Hundreds of hooks	639,2
No. per 100 hooks	11,6

TABLE II-C-1959

Capture of fish (in numbers) by statistical rectangles, 1957-1959, number of hooks, capture per 100 hooks

Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks	Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks
	NORTHERN REGION				CENTRAL REGION		
23-09N	110	17,0	6,5	02-00S	303	15,2	19,9
23-10N	525	72,0	7,3	02-01S	380	32,0	11,9
24-10N	330	36,0	9,2	03-00S	615	62,4	9,8
25-10N	105	17,0	6,2	03-01S	657	48,0	13,7
26-08N	700	48,8	14,3	04-00S	156	16,0	9,7
26-09N	474	32,4	14,6	04-01S	219	16,0	13,7
26-10N	480	49,0	9,8	05-00S	287	24,0	11,9
26-12N	174	16,0	10,9	05-01S	590	46,0	12,8
27-09N	187	16,0	11,7	05-02S	298	15,2	19,6
27-10N	191	16,0	11,9	16-00S	57	16,0	3,6
27-11N	1143	80,8	14,1	18-00S	1617	115,0	14,1
27-12N	3118	220,6	14,1	18-01S	1194	102,5	11,6
28-10N	1103	80,8	13,6	18-02S	440	33,5	13,1
28-11N	1185	78,8	15,0	18-03S	55	7,8	7,0
28-12N	1376	95,4	14,4	20-03S	90	11,0	8,2
29-00N	35	19,0	1,8	23-02S	955	47,4	20,1
29-05N	130	18,0	7,2	23-03S	2192	130,6	16,8
29-06N	86	18,0	4,8	24-03S	260	15,4	16,9
29-08N	210	18,0	11,7	25-10S	55	10,4	5,3
29-09N	190	18,0	10,5	25-11S	23	9,6	2,4
29-11N	736	68,8	10,7	26-10S	288	48,4	5,9
30-00N	200	36,0	5,5	26-11S	118	18,4	6,4
30-01N	160	18,0	8,9	27-08S	120	17,0	7,0
30-05N	610	72,0	8,5	27-10S	211	29,6	7,1
31-02N	220	56,0	3,9	29-01S	59	10,0	5,9
31-08N	295	18,0	16,4	30-03S	191	38,6	4,9
31-09N	1203	118,0	10.2	30-04S	18	9,6	1,9
32-01N	50	19,0	2,6	30-07S	110	10,8	1,0
32-05N	484	72,0	6,7	30-08S	69	10,0	6,9
32-08N	170	18,0	9,4	31-02S	41	9,6	4,3
32-09N	2091	157,6	3,3	31-03S	375	56,0	6,7
33-03N	70	18,0	3,9	31-04S	90	14,0	6,4
33-04N	80	18,0	4,4	31-08S	629	43,2	14,6
33-05N	80	18,0	4,4	32-04S	1077	84,6	12,7
33-07N	67	18,0	3,7	32-05S	166	24,0	6,9
33-08N	575	54,0	10,6	32-06S	309	41,2	7,5
33-09N	305	36,0	8,5	32-07S	686	57,4	11,9
34-04N	60	18,0	3,3	32-08S	234	31,4	7,4
34-05N	410	54,0	7,6	33-02S	45	10,0	4,5
34-06N	65	18,0	3,6	33-03S	69	10,0	6,9
35-05N	160	36,0	4,4	33-04S	260	26,0	10,0
36-03N	51	18,0	2,3	33-06S	1708	191,0	8,9

TABLE II-C 1959—(*Contd.*)

Capture of fish (in numbers) by statistical rectangles, 1957-1959, number of hooks, capture per 100 hooks

Rectangles	Number captured	Hundreds of hooks	Number per 100 hooks
35-07N	71	15,8	4,5
34-09N	183	15,6	11,7
32-10N	983	85,6	11,5
38-03N	60	16,0	3,7
39-04N	84	16,0	5,2
40-03N	55	18,0	3,0
40-04N	125	36,0	3,5
40-05N	15	18,0	0,8
	SOUTHERN REGION		
30-22S	28	10,5	2,7
31-19S	132	12,0	11,0
32-18S	996	84,0	11,8
32-19S	630	48,0	13,1
35-19S	167	20,0	8,3
35-20S	45	12,2	3,7
35-21S	136	21,2	6,4
36-17S	527	84,2	6,2
36-18S	247	36,6	6,7
36-19S	90	11,0	8,2
36-20S	591	79,4	7,4
36-21S	289	46,3	6,2
37-20S	184	23,4	7,9
37-21S	204	33,3	6,1
38-21S	128	24,0	5,3
38-22S	77	10,2	7,5
39-21S	46	11,0	4,2
39-23S	66	10,2	6,5
39-24S	122	20,0	6,1
39-25S	52	10,2	5,1
40-23S	575	92,3	6,2
40-24S	2355	320,6	7,3
40-25S	265	75,6	3,5
41-24S	649	45,0	14,4
41-25S	56	10,0	5,6
42-25S	65	11,6	5,6
43-25S	49	11,4	4,3
44-25S	8469	723,9	11,7
44-26S	1571	140,6	11,2
44-27S	81	14,9	5,4
45-25S	116	19,2	6,0
45-26S	257	20,8	12,3
45-27S	46	10,2	4,5
33-07S	1549	137,4	11,3
34-03S	164	22,2	7,4
34-04S	118	25,6	4,6
35-01S	59	9,6	6,1
35-02S	43	9,6	4,5
35-03S	131	29,2	4,5
40-00S	41	10,4	3,9

RECAPITULATION

Northern Region :

Number captured	21570
Hundreds of hooks	2148,0
No. per 100 hooks	10,0

Central Region :

Number captured	19421
Hundreds of hooks	1808,8
No. per 100 hooks	10,7

Southern Region :

Number captured	19311
Hundreds of hooks	2103,8
No. per 100 hooks	9,2

TABLE III-A

Relative abundance (as capture per 100 hooks) of Yellowfin Albacore, and Big-eye, by quarters, by statistical rectangles, 1957

North Latitude

Quarters	Rectangles Catch Data	17-03	17-04	18-02	19-02	20-03	20-04	23-03	23-04	24-03	24-04	24-05	25-03	25-02	26-02	26-03	26-05
First	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	293
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	34,6
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8,5
Second	Fishes	..	..	778	835	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	78,2	86,2	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	9,9	9,7	..	..	..	..	..	..	..	..	..	..	..	..
Third	Fishes	51	587	..	..	357	625	239	83	784	99	236	..	..	..	..	..
	Hundreds of hooks	15,0	48,4	..	..	53,2	58,4	38,8	10,7	89,6	13,0	26,2	..	..	..	..	..
	Index of abundance	3,4	12,1	..	..	6,7	10,7	6,1	7,7	8,7	7,6	9,0	..	..	..	..	..
Fourth	Fishes	..	..	..	..	..	..	75	..	176	85	..	61	618	114	488	..
	Hundreds of hooks	..	..	..	..	..	..	13,0	..	24,2	12,0	..	8,8	72,4	12,9	62,4	..
	Index of abundance	..	..	..	..	..	..	5,8	..	7,3	7,1	..	6,9	8,5	8,8	7,8	..
Annual	Number of fish	51	587	778	835	357	625	314	83	960	184	236	61	618	114	488	293
Total Per	Hundreds of hooks	15,0	48,4	78,2	86,2	53,2	58,4	51,8	10,7	113,8	25,0	26,2	8,8	72,4	12,9	62,4	34,6
Rectangle	Average	3,4	12,1	9,9	9,7	6,7	10,7	6,1	7,7	8,4	7,4	9,0	6,9	8,5	8,8	7,8	8,5

TABLE III-A

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by statistical rectangles, 1957—(continued)

North Latitude

26-06	27-03	27-05	28-00	28-01	28-02	28-03	28-06	29-00	29-01	29-03	29-04	30-03	30-04	31-01	31-02	31-03	31-04	31-05	32-01
124	..	529	88	88	..	168	49	..	..	75	..	..	..	..	..	..	68	..	..
15,6	..	54,8	15,3	15,3	..	19,0	15,7	..	..	15,6	..	..	..	..	..	..	13,8	..	..
7,9	..	9,6	5,7	5,7	..	8,8	3,1	..	..	4,8	..	..	..	..	..	..	4,9	..	..
..	170	..	..	..	85	1289	..	..	75	200	144	171	80	105	..	..	..	..	..
..	17,2	..	..	..	17,2	102,0	..	..	17,2	17,2	17,2	14,8	14,0	17,2	..	..	..	..	..
..	9,9	..	..	..	4,9	12,6	..	..	4,4	11,6	8,4	11,5	5,7	6,1	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	24	..	48	52	49	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	13,2	..	13,2	16,5	16,5	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	1,8	..	3,6	3,1	3,0	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	223	531	141	..	..	212
..	..	..	..	..	..	..	..	..	..	..	..	..	..	26,4	64,4	16,0	..	..	26,4
..	..	..	..	..	..	..	..	..	..	..	..	..	..	8,4	8,2	8,8	..	..	8,0
124	170	529	88	88	85	1289	168	49	75	200	219	171	80	352	531	189	120	49	212
15,6	17,2	54,8	15,3	15,3	17,2	102,0	19,0	15,7	17,2	17,2	32,8	14,8	14,0	56,8	64,4	29,2	30,3	16,5	26,4
7,9	9,9	9,6	5,7	5,7	4,9	12,6	8,8	3,1	4,4	11,6	6,7	11,5	5,7	6,2	8,2	6,5	4,0	3,0	8,0

TABLE III-A

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1957—(continued)

North Latitude

32-03	32-04	33-01	33-02	35-05	34-02	34-03	34-05	35-01	35-02	35-03	35-04	35-05	36-00	36-01	36-02	36-03	36-04	36-05	37-01
..	87	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	175	..	..
..	15,3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	43,1	..	..
..	5,7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4,1	..	..
..	..	61	..	..	..	..	..	..	..	..	..	..	102	1014	..	..	432	..	..
..	..	16,5	..	..	..	..	..	..	..	..	..	..	16,5	97,3	..	..	33,2	..	..
..	..	3,7	..	..	..	..	..	..	..	..	..	..	6,2	10,4	..	..	13,0	..	..
..	109		..	95	..	..	151	112	166	..	76	121	211	..	194	1334	1470	295	..
..	16,5	..	..	16,5	..	..	33,0	16,0	32,0	..	16,0	16,5	16,5	..	16,5	116,2	116,0	48,0	..
..	6,6	..	..	5,7	..	..	4,6	7,0	5,2	..	4,7	7,3	12,8	..	11,7	11,5	12,7	6,1	..
201	..	96	96	..	96	66	..	134	927	725	..	..	..	605	752	2009	168	..	193
34,2	..	12,8	12,8	..	16,0	12,8	..	16,0	93,2	55,2	..	..	..	79,6	113,6	123,2	16,0	..	36,6
5,9	..	7,5	7,5	..	6,0	5,1	..	8,4	9,9	13,1	..	..	..	7,6	6,6	16,3	10,5	..	5,3
201	196	157	96	95	96	66	151	246	1093	725	76	121	313	1619	946	3343	2245	295	193
34,2	31,8	29,3	12,8	16,5	16,0	12,8	33,0	32,0	125,2	55,2	16,0	16,5	33,0	176,9	130,1	239,4	208,3	48,0	36,6
5,9	6,2	5,3	7,5	5,7	6,0	5,1	4,6	7,7	8,7	13,1	4,7	7,3	9,5	9,1	7,3	14,0	10,8	6,1	5,3

TABLE III-A

Relative abundance (as capture per 100 hooks) of yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1957—(continued)

North Latitude

37-02	37-03	37-04	38-03	38-04	39-02	39-03	39-04	40-04	41-04	41-05	42-04	42-05	44-06	47-07	49-08	49-09	50-09	Total
..	..	..	23	..	..	..	..	37	..	195	90	378	..	..	..	..	..	2467
..	..	..	14,0	..	..	..	..	14,0	..	31,3	15,8	63,2	..	..	..	..	..	396,4
..	..	..	1,6	..	..	..	..	2,6	..	6,2	5,7	6,0	..	..	..	..	..	6,2
..	..	..	120	..	..	314	..	100	129	142	..	84	59	..	91	87	84	6751
..	..	..	14,4	..	..	43,1	..	14,2	14,4	14,4	..	13,9	14,0	..	14,0	14,0	14,0	732,3
..	..	..	8,3	..	..	7,3	..	7,0	8,9	9,9	..	6,0	4,2	..	6,5	6,2	6,0	9,2
190	371	1619	190	..	..	..	..	361	..	..	..	..	..	46	..	..	39	10384
33,0	34,4	119,2	17,2	..	..	..	..	40,1	..	..	..	..	..	13,3	..	..	14,0	1143,6
5,7	10,8	13,6	11,0	..	..	..	..	9,0	..	..	..	..	..	3,4	..	..	2,8	9,1
173	923	..	236	123	140	199	361	..	..	..	..	..	..	..	..	..	..	10947
32,4	96,0	..	32,0	16,0	15,2	15,2	29,6	..	..	..	..	..	..	..	..	..	..	1197,3
5,3	9,6	..	7,4	7,7	9,2	13,1	12,2	..	..	..	..	..	..	..	..	..	..	9,1
363	1294	1619	569	123	140	513	361	498	129	337	90	462	59	46	91	87	123	30549
65,4	130,4	119,2	77,6	16,0	15,2	58,3	29,6	68,3	14,4	45,7	15,8	77,1	14,0	13,3	14,0	14,0	28,0	3469,6
5,5	9,9	13,6	7,3	7,7	9,2	8,8	12,2	7,3	8,9	7,4	5,7	6,0	4,2	3,4	6,5	6,2	4,4	8,8

TABLE III-A

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1957—(contd.)

South Latitude

Quarters	Rectangles Catch Data	26-05	26-06	27-05	27-06	27-07	27-11	28-00	28-04	28-05	28-06	29-04	29-05	30-04	30-05	30-06	30-07
First	Fishes	668	995	367	412	..	..	..	..	..	216	..	..	..	..	62	1114
	Hundreds of hooks	64,8	71,2	32,0	25,0	..	..	..	..	..	15,0	..	..	..	..	18,0	136,8
	Index of abundance	10,3	14,0	11,5	16,5	..	..	..	..	..	14,4	..	..	..	..	3,4	81,
Second	Fishes	..	..	..	..	109	52	80	208	187	85	303	1357	23	151	..	104
	Hundreds of hooks	..	..	..	..	17,9	16,9	20,5	26,5	39,9	17,9	46,6	191,7	13,4	9,8	..	20,5
	Index of abundance	..	..	..	..	6,1	3,1	3,9	7,8	4,7	4,7	6,5	7,1	1,7	15,4	..	5,1
Third	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..		..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fourth	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annual	Number of fish	668	995	367	412	109	52	80	208	187	301	303	1357	23	151	62	1218
Total Per	Hundreds of hooks	64,8	71,2	32,0	25,0	17,9	16,9	20,5	26,5	39,9	32,9	46,6	191,7	13,4	9,8	18,0	157,3
Rectangle	Average	10,3	14,0	11,5	16,5	6,1	3,1	3,9	7,8	4,7	9,1	6,5	7,1	1,7	15,4	3,4	7,7

TABLE III-A

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1957—(contd.)

South Latitude

30-08	30-09	30-11	31-07	31-09	31-10	31-11	31-12	32-00	32-08	32-09	32-10	32-11	32-12	33-09	33-10	34-11	TOTAL
424	..	520	183	408	228	374	506	..	198	380	119	132	135	129	..	..	7570
61,1	..	62,2	35,5	61,5	20,5	42,5	48,0	..	41,0	57,0	20,5	16,0	16,0	16,0	..	..	860,6
6,9	..	8,4	5,1	6,6	11,1	8,8	10,5	..	4,8	6,7	5,8	8,2	8,4	8,1	..	..	8,8
236	119	..	..	..	968	37	..	..	170	194	310	..	..	..	169	91	4953
61,3	20,3	..	..	..	154,1	17,5	..	..	40,0	34,5	50,3	..	..	..	29,0	14,5	843,1
3,8	5,9	..	..	..	6,3	2,1	..	..	4,2	5,6	6,2	..	..	..	5,8	6,3	5,9
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
660	119	520	183	408	1196	411	506	..	368	574	429	132	135	129	169	91	12523
122,4	20,3	62,2	35,5	61,5	174,6	60,0	48,0	..	81,0	91,5	70,8	16,0	16,0	16,0	29,0	14,5	1703,7
5,4	5,9	8,4	5,1	6,6	6,8	6,8	10,5	..	4,5	6,3	6,0	8,2	8,4	8,1	5,8	6,3	7,3

TABLE III—B

Relative abundance (as capture per 100 hooks), of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles—1958.

North Latitude

Quarters	Rectangles Catch Data	27-09	28-03	28-08	28-09	29-03	29-09	30-02	31-04	33-03	34-03	35-02	36-01	36-03	37-01	37-02	37-03
First	Fishes	..	..	..	..	..	..	..	..	263	1116	115	145	..	..	208	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	32,0	112,0	16,0	16,0	..	..	32,0	..
	Index of abundance	..	..	..	..	..	..	..	..	8,2	9,9	7,2	9,0	..	..	6,5	..
Second	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Third	Fishes	471	..	192	1434	..	943	..	103	..	..	..	..	85	67	..	..
	Hundreds of hooks	44,6	..	24,7	97,1	..	53,5	..	10,4	..	..	..	..	15,0	13,2	..	..
	Index of abundance	10,6	..	7,8	14,8	..	17,6	..	9,9	..	..	..	..	5,7	5,1	..	..
Fourth	Fishes	..	111	..	..	415	..	105	..	..	..	..	..	134	..	..	142
	Hundreds of hooks	..	18,0	..	..	54,0	..	36,0	..	..	..	..	..	16,0	..	..	16,0
	Index of abundance	..	6,2	..	..	7,7	..	2,9	..	..	..	..	..	8,4	..	..	8,9
Annual Total Per Rectangle	Number of fish	471	111	192	1434	415	943	105	103	263	1116	115	145	219	67	208	142
	Hundreds of hooks	44,6	18,0	24,7	97,1	54,0	53,5	36,0	10,4	32,0	112,0	16,0	16,0	31,0	13,2	32,0	16,0
	Average	10,6	6,2	7,8	14,8	7,7	17,6	2,9	9,9	8,2	9,9	7,2	9,0	5,7	5,1	6,5	8,9

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958 (continued)

North Latitude

37-04	37-05	38-02	38-03	38-04	38-05	39-01	39-02	39-04	40-08	43-06	46-05	51-08	52-08	52-09	TOTAL
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
															1847
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	208,0
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8,9
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	126	66	346	542	632	..	..	84	180	57	248	162	124	..	5862
..	7,5	15,0	39,7	74,5	49,0	..	..	13,2	16,8	8,4	24,3	8,4	7,9	..	523,2
..	16,8	4,4	8,7	7,3	12,9	..	..	6,4	10,7	6,7	10,2	19,2	15,7	..	11,2
1220	..	954	759	..	..	250	256	..	..	..	..	..	360	114	4820
96,0	..	64,0	80,0	..	..	16,0	32,0	..	..	..	..	..	23,8	7,9	459,7
12,7	..	14,9	9,5	..	..	15,6	8,0	..	..	..	..	..	15,1	14,4	10,5
1220	126	1020	1105	542	632	250	256	84	180	57	248	162	484	114	12529
96,0	7,5	79,0	119,7	74,5	49,0	16,0	32,0	13,2	16,8	8,4	24,3	8,4	31,8	7,9	1190,9
12,7	16,8	12,9	9,2	7,3	12,9	15,6	8,0	6,4	10,7	6,7	10,2	19,2	15,2	14,4	11,3

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yeilowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958—(Continued)

South Latitude

Quarters	Rectangles Catch Data	24-01	24-03	24-05	25-00	25-01	26-05	27-03	27-04	27-05	27-06	28-01	28-02	28-03	28-04	28-05	28-06
First	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Second	Fishes	..	..	..	..	..	..	117	279	..	..	100	99	130	..	382	733
	Hundreds of hooks	..	..	..	..	..	..	13,2	26,4	..	..	13,2	13,2	13,2	..	39,6	65,2
	Index of abundance	..	..	..	..	..	..	8,9	10,6	..	..	7,6	7,5	9,8	..	9,6	11,2
Third	Fishes	..	..	..	..	..	..	..	..	..	126	..	..	..	..	..	90
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	11,0	..	..	..	..	..	10,5
	Index of abundance	..	..	..	..	..	..	..	..	..	11,4	..	..	..	..	..	8,6
Fourth	Fishes	256	..	138	284	129	94	..	..	82	..	..	..	445	132	..	..
	Hundreds of hooks	33,0	..	16,0	34,0	17,0	17,0	..	..	17,0	..	..	..	54,0	17,0	..	..
	Index of abundance	7,7	..	8,6	8,3	7,6	5,5	..	..	4,8	..	..	..	8,2	7,8	..	..
Annual Total	Number of fish	256	..	138	284	129	94	117	279	82	126	100	99	575	132	382	823
	Hundreds of hooks	33,0	..	16,0	34,0	17,0	17,0	13,2	26,4	17,0	11,0	13,2	13,2	67,2	17,0	39,6	75,7
Per Rectangle	Average	7,7	..	8,6	8,3	7,6	5,5	8,9	10,6	4,8	11,4	7,6	7,5	8,8	7,8	9,6	10,2

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958 (Continued)

South Latitude

28-07	28-08	29-02	29-03	29-05	29-06	29-07	29-08	30-02	30-04	30-05	30-06	30-07	30-08	30-09	30-12	31-04	31-05	31-06	31-07
..	..	..	..	..	..	..	..	..	654	4698	2789	..	..	..	..	..	533	1432	..
..	..	..	..	..	..	..	..	..	49,2	403,5	251,9	..	..	..	..	..	32,0	123,9	..
..	..	..	..	..	..	..	..	..	13,3	11,6	11,1	..	..	..	..	..	16,6	11,5	..
..	..	..	..	..	..	..	..	..	186	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	13,2	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	14,1	..	..	..	..	..	..	..	..	..	..
175	170	..	..	122	504	1046	272	..	..	87	..	117	37	91	48	82	..	..	161
16,0	16,0	..	..	16,0	38,5	79,1	48,9	..	..	16,0	..	12,5	13,0	13,1	12,6	16,0	..	..	25,8
10,9	10,6	..	..	7,6	13,1	13,2	5,5	..	..	5,4	..	9,4	2,8	6,9	3,8	5,1	..	..	6,2
..	..	156	272	..	..	..	..	483	..	..	..	..	..	..	..	..	..	..	..
..	..	18,0	36,0	..	..	..	..	36,0	..	..	..	..	..	..	..	..	..	..	..
..	..	8,7	7,5	..	..	..	..	13,4	..	..	..	..	..	..	..	..	..	..	..
175	170	156	272	122	504	1046	272	483	840	4785	2789	117	37	91	48	82	533	1432	161
16,0	16,0	18,0	36,0	16,0	38,5	79,1	48,9	36,0	62,4	419,5	251,9	12,5	13,0	13,1	12,6	16,0	32,0	123,9	25,8
10,9	10,6	8,7	7,5	7,6	13,1	13,2	5,5	13,4	13,5	11,4	11,1	9,4	2,8	6,9	3,8	5,1	16,6	11,5	6,2

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958—(Continued)

South Latitude

31-08	31-09	31-10	31-11	32-02	32-05	32-06	32-08	32-09	32-10	33-00	33-08	33-09	33-10	34-00	34-02	34-03	34-20	35-00	35-02
..	..	..	..	..	..	..	209	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	31,8	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	6,6	..	..	..	..	..	..	..	..	..	..	..	..
..	74	110	..	69	76	66	714	552	..	99	79	201	39	..	..	..	..	..	..
..	15,9	15,8	..	13,2	13,2	13,2	81,6	92,4	..	13,2	13,6	26,4	13,2	..	..	..	..	..	..
..	4,6	7,6	..	5,2	5,7	5,0	8,7	6,0	..	7,5	5,8	7,6	2,9	..	..	..	..	..	..
99	..	75	67	..	..	..	..	..	177	88	..	..	36	92	185	64	..	173	926
12,9	..	13,7	13,2	..	..	..	..	..	39,9	13,2	..	..	12,9	10,0	25,0	25,0	..	25,6	131,0
7,7	..	5,5	5,1	..	..	..	..	..	4,4	6,7	..	..	2,8	9,2	7,4	2,6	..	6,7	7,1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	98	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17,0	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5,8	..	..
99	74	185	67	69	76	66	923	552	177	187	79	201	75	92	185	64	98	173	926
12,9	15,9	29,5	13,2	13,2	13,2	13,2	113,4	92,4	39,9	26,4	13,6	26,4	26,1	10,0	25,0	25,0	17,0	25,6	131,0
7,7	4,6	6,3	5,1	5,2	5,7	5,0	8,1	6,0	4,4	7,1	5,8	7,6	2,9	9,2	7,4	2,6	5,8	6,7	7,1

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958—(Continued)

South Latitude

35-03	35-12	35-19	35-20	36-00	36-01	36-03	36-12	36-16	37-00	37-02	40-23	40-24	40-25	41-24	41-25	41-27	42-27	43-27	43-28
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..		..	..	..	..	..		..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
183	72	..	..	1248	122	33	43	..	1754	834	..	..	..	..	..	40	186	171	31
37,5	12,5	..	..	117,2	13,9	12,5	13,8	..	178,5	69,5	..	..	..	..	..	11,2	32,0	33,2	11,0
4,9	5,8	..	..	10,6	8,8	2,6	3,1	..	9,8	12,0	..	..	..	..	..	3,6	5,8	5,1	2,8
..	..	85	..	..	..	..	..	113	..	..	..	..	..	..	..	..	..	..	..
..	..	18,0	..	..	..	..	..	16,0	..	..	..	..	..	..	..	..	..	..	..
..	..	4,7	..	..	..	..	..	7,1	..	..	..	..	..	..	..	..	..	..	..
183	72	85	..	1248	122	33	43	113	1754	834	..	..	..	..	..	40	186	171	31
37,5	12,5	18,0	..	117,2	13,9	12,5	13,8	16,0	178,5	69,5	..	..	..	..	..	11,2	32,0	33,2	11,0
4,9	5,8	4,7	..	10,6	8,8	2,6	3,1	7,1	9,8	12,0	..	..	..	..	..	3,6	5,8	5,1	2,8

TABLE III-B

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles, 1958—(Continued)

South Latitude

44-25	44-26	44-28	45-26	45-27	45-28	46-28	46-30	47-29	47-30	29-09	TOTAL
..	..	..	..	..	..	..	..	..	..	..	10315
..	..	..	..	..	..	..	..	..	..	..	892,3
..	..	..	..	..	..	..	..	..	..	..	11,6
..	..	..	..	..	..	..	..	..	..	..	4105
..	..	..	..	..	..	..	..	..	..	..	508,9
..	..	..	..	..	..	..	..	..	..	..	8,0
65	474	74	197	..	..	..	..	..	..	287	10924
12,6	67,0	10,2	34,6	..	..	..	..	..	..	38,3	1372,9
5,1	7,1	7,2	5,7	..	..	..	..	..	..	7,5	7,9
799	989	..	303	209	52	75	48	77	111	..	5430
108,4	137,2	..	45,4	32,8	9,6	8,6	8,6	8,6	17,2	..	735,0
7,4	7,2	..	6,7	6,4	5,4	8,7	5,6	8,9	6,4	..	7,5
864	1463	74	500	209	52	75	48	77	111	287	30774
121,0	204,2	10,2	80,0	32,8	9,6	8,6	8,6	8,6	17,2	38,3	3509,1
7,1	7,2	7,2	6,2	6,4	5,4	8,7	5,6	8,9	6,4	7,5	8,8

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959

North Latitude

Quarters	Rectangles Catch Data	23-09	23-10	24-10	25-10	26-08	26-09	26-10	26-12	27-09	27-10	27-11	27-12	28-03	28-10	28-11	28-12
First	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Second	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Third	Fishes	95	480	324	97	683	466	452	163	178	184	1103	3009	..	1074	1160	1331
	Hundreds of hooks	17,0	72,0	36,0	17,0	48,8	32,4	49,0	16,0	16,0	16,0	80,8	220,6	..	80,8	78,8	95,4
	Index of abundance	5,5	6,6	9,0	5,7	14,0	14,4	9,2	10,2	11,1	11,5	13,6	13,6	..	13,3	14,7	13,9
Fourth	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annual	Number of fish	95	480	324	97	683	466	452	163	178	184	1103	3009	..	1074	1160	1331
Total per	Hundreds of hooks	17,0	72,0	36,0	17,0	48,8	32,4	49,0	16,0	16,0	16,0	80,8	220,6	..	80,8	78,8	95,4
Rectangle	Average	5,5	6,6	9,0	5,7	14,0	14,4	9,2	10,2	11,1	11,5	13,6	13,6	..	13,3	14,7	13,9

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959—*(Contd.)*

North Latitude

29-00	29-03	29-05	29-06	29-08	29-09	29-11	30-00	30-01	30-02	30-05	31-07	31-08	31-09	32-01	32-05	32-08	32-09	32-10	33-03
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	118	73	205	189	732	172	151	..	543	..	288	1140	..	..	162	2039	951	..
..	..	18,0	18,0	18,0	18,0	68,8	36,0	18,0	..	72,0	..	18,0	118,0	..	..	18,0	157,6	85,6	..
..	..	6,5	4,0	11,4	10,5	10,6	,8	8,4	..	7,5	..	16,0	9,7	..	..	9,0	12,9	11,1	..
24	..	..	..	..	..	..	..	..	..	..	140	..	..	44	415	..	..	..	63
19,0	..	..	..	..	..	..	..	..	..	..	56,0	..	..	19,0	72,0	..	..	..	18,0
1,2	..	..	..	..	..	..	..	..	..	..	2,5	..	..	2,3	5,8	..	..	..	3,5
24	..	118	73	205	189	732	172	151	..	543	140	288	1140	44	45	162	2039	951	63
19,0	..	18,0	18,0	18,0	18,0	68,8	36,0	18,0	..	72,0	56,0	18,0	118,0	19,0	72,0	18,0	157,6	85,6	18,0
1,2	..	6,5	4,0	11,4	10,5	10,6	4,8	8,4	..	7,5	2,5	16,0	9,7	2,3	5,8	9,0	12,9	11,1	3,5

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959—(Contd.)

North Latitude

33-04	33-05	33-07	33-08	33-09	34-00	34-05	34-06	34-09	35-05	35-07	36-03	38-03	39-01	39-04	40-03	40-04	40-05	TOTAL
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	518	274	..	..	..	176	..	66	..	..	..	..	..	..	..	18596
..	..	..	54,0	36,0	..	..	..	15,6	..	15,8	..	..	..	..	..	..	..	1662,0
..	..	..	9,6	7,6	..	..	..	11,3	..	4,2	..	..	..	..	..	..	..	11,2
63	64	58	..	..	50	364	60	..	134	..	49	55	..	78	34	98	1	1794
18,0	18,0	18,0	..	..	18,0	54,0	18,0	..	36,0	..	18,0	16,0	..	16,0	18,0	36,0	18,0	486,0
3,5	3,5	3,2	..	..	2,8	6,7	3,3	..	3,7	..	2,7	3,4	..	4,9	1,9	2,7	0,0	3,7
63	64	58	518	274	50	364	60	176	134	66	49	55	..	78	34	98	1	20390
18,0	18,0	18,0	54,0	36,0	18,0	54,0	18,0	15,6	36,0	15,8	18,0	16,0	..	16,0	18,0	36,0	18,0	2148,0
3,5	3,5	3,2	9,6	7,6	2,8	6,7	3,3	11,3	3,7	4,2	2,7	3,4	..	4,	1,9	2,7	0,0	9,5

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye by quarters, by statistical rectangles 1959—*(Contd.)*

South Latitude

Quarters	Rectangles / Catch data	02-00	02-01	03-00	03-01	04-00	04-01	05-00	05-01	05-02	16-00	18-00	18-01	18-02	18-03	20-03	23-02
First	Fishes	273	368	575	626	..	198	137	569	294	..	..	..	..	..	..	..
	Hundreds of hooks	15,2	32,0	62,4	48,0	..	16,0	8,0	46,0	15,2	..	..	..	..	..	..	..
	Index of abundance	18,0	11,5	9,2	13,0	..	12,4	17,1	12,4	19,3	..	..	..	..	..	..	..
Second	Fishes	..	..	..	..	154	..	146	..	..	35	1538	1103	426	48	47	901
	Hundreds of hooks	..	..	..	..	16,0	..	16,0	..	..	16,0	115,0	102,5	33,5	7,8	11,0	47,4
	Index of abundance	..	..	..	..	9,6	..	9,1	..	..	2,2	13,4	10,8	12,7	6,1	4,3	19,0
Third	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fourth	Fishes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Hundreds of hooks	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Index of abundance	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annual Total Per Rectangle	Number of fish	273	368	575	626	154	198	283	569	294	35	1538	1103	426	48	47	901
	Hundreds of hooks	15,2	32,0	62,4	48,0	16,0	16,0	24,0	46,0	15,2	16,0	115,0	102,5	33,5	7,8	11,0	47,0
	Average	18,0	11,5	9,2	13,0	9,6	12,4	11,8	12,4	19,3	2,2	13,4	10,8	12,7	6,1	4,3	19,0

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye by quarters, by statistical rectangles 1959—(Contd.)

South Latitude

23-03	23-09	23-10	24-01	24-03	24-10	25-10	25-11	26-10	26-11	27-00	27-10	27-11	27-12	28-12	29-00	29-01	29-05	29-06	29-08
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2003	..	..	..	245	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
130,6	..	..	..	15,4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15,3	..	..	..	15,9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	45	16	239	96	..	188	..	..	..	..	35	..	..	..
..	..	..	..	..	..	10,4	9,6	48,4	18,4	..	29,6	..	..	..	..	10,0	..	..	..
..	..	..	..	..	..	4,3	1,7	4,9	5,2	..	6,3	..	..	..	..	3,5	..	..	..
..	..	..	..	..	..	..	..	..	86	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	17,0	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	5,0	..	..	..	..	..	..	..	..	..	..
2003	..	..	..	245	..	45	16	239	182	..	188	..	..	..	..	35	..	..	..
130,6	..	..	..	15,4	..	10,4	9,6	48,4	35,4	..	29,6	..	..	..	..	10,0	..	..	..
15,3	..	..	..	15,9	..	4,3	1,7	4,9	5,1	..	6,3	..	..	..	..	3,5	..	..	..

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959—(Contd.)

South Latitude

29-09	30-00	30-01	30-03	30-04	30-05	30-07	30-08	30-22	31-02	31-03	31-04	31-08	31-09	31-19	32-01	32-04	32-05	32-06	32-07
..	..	..	..	..	..	91	521	..	..	..	..	..	..	85	..	160	..	272	606
..	..	..	..	..	..	10,8	43,2	..	..	..	..	..	..	12,0	..	20,0	..	41,2	57,4
..	..	..	..	..	..	8,4	12,1	..	..	..	..	..	..	7,1	..	8,0	..	6,6	10,5
..	..	..	..	..	..	..	..	..	..	145	..	..	..	..	..	630	153	..	..
..	..	..	..	..	..	..	..	..	..	17,6	..	..	..	..	..	64,6	24,0	..	..
..	..	..	..	..	..	..	..	..	..	8,2	..	..	..	..	..	9,7	6,4	..	..
..	..	..	..	..	..	..	26	18	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	10,0	10,5	..	..	..	..	..	..	..		..	..	..
..	..	..	..	..	..	..	2,6	1,7	..	..	..	..	..	..	..	..	..	..	..
..	..	..	167	9	..	..	..	..	38	117	41	..	..	..	..	..	..	..	..
..	..	..	38,6	9,6	..	..	..	..	9,6	38,4	14,0	..	..	..	..	..	..	..	..
..	..	..	4,3	0,9	..	..	..	..	3,9	3,0	2,9	..	..	..	..	..	..	..	..
..	..	..	167	9	..	91	547	18	38	262	41	..	..	85	..	790	153	272	606
..	..	..	38,6	9,6	..	10,8	53,2	10,5	9,6	56,0	14,0	..	..	12,0	..	84,6	24,0	41,2	57,4
..	..	..	4,3	0,9	..	8,4	10,3	10,7	3,9	4,7	2,9	..	..	7,1	..	9,3	6,4	6,6	10,5

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959—(Contd.)

South Latitude

32-08	32-09	32-10	32-18	32-19	33-02	33-03	33-04	33-06	33-07	33-08	33-09	34-03	34-04	34-05	34-06	34-09	35-01	35-02	35-03
174	..	..	554	386	..	..	114	249	1328	..	..	..	..	..	..	..	..	..	..
31,4	..	..	84,0	48,0	..	..	13,0	39,0	137,4	..	..	..	..	..	..	..	..	..	..
5,5	..	..	6,6	8,0	..	..	8,8	6,4	9,7	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	93	..	..	..	..	61	..	..	..	..	51	31	44
..	..	..	..	..	..	..	13,0	..	..	..	..	13,0	..	..	..	..	9,6	9,6	9,6
..	..	..	..	..	..	..	7,1	..	..	..	..	4,7	..	..	..	..	5,3	3,2	4,6
..	..	..	..	..	39	..	..	..	..	..	..	52	..	..	..	..	..	..	..
..	..	..	..	..	10,0	..	..	..	..	..	..	9,2	..	..	..	..	..	..	..
..	..	..	..	..	3,9	..	..	..	..	..	..	5,6	..	..	..	..	..	..	..
..	..	..	..	..	..	46	70	1074	..	..	..	..	..	..	..	..	..	..	54
..	..	..	..	..	..	10,0	25,6	152,0	..	..	..	..	..	..	..	..	..	..	19,6
..	..	..	..	..	..	4,6	2,7	7,1	..	..	..	..	..	..	..	..	..	..	2,7
174	..	..	554	386	39	46	277	1323	1328	..	..	113	..	..	..	..	51	31	98
31,4	..	..	84,0	48,0	10,0	10,0	51,6	191,0	137,4	..	..	22,2	..	..	..	..	9,6	9,6	29,2
5,5	..	..	6,6	8,0	3,9	4,6	5,4	6,9	9,7	..	..	5,1	..	..	..	..	5,3	3,2	3,3

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin. Albacore, and Big-eye, by quarters, by statistical rectangles 1959—(Contd.)

South Latitude

35-07	35-19	35-20	35-21	36-03	36-17	36-18	36-19	36-20	36-21	37-20	37-21	38-03	38-21	38-22	39-23	39-21	39-24	39-25	40-00
..	..	..	..	..	..	..	..	30	72	..	..	..	..	..	..	..	..	22	..
..	..	..	..	..	..	..	..	12,0	12,0	..	..	..	..	..	..	..	..	10,2	
..	..	..	..	..	..	..	..	2,5	6,0	..	..	..	..	..	..	..	..	2,1	..
..	28	..	55	..	..	..	37	20	..	..	..	..	..	37	..	27	70	..	38
..	11,0	..	21,2	..	..	..	11,0	11,0	..	..	..	..	..	10,2	..	10,2	20,0	..	10,4
..	2,5	..	2,6	..	..	..	3,4	1,8	..	..	..	..	..	3,6	..	2,6	3,5	..	3,6
..	30	17	..	..	217	138	..	215	164	121	110	..	39	..	21	..	..	..	..
..	9,0	12,2	..	..	84,2	36,6	..	56,4	34,3	23,4	33,3	..	24,0	..	11,0	..	..	..	..
..	3,3	1,4	..	..	2,6	3,8	..	3,8	4,8	5,1	3,3	..	1,6	..	1,9	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..		..	..	..	..	..	..	..	..	..	..	..	..	..		..	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	58	17	55	..	217	138	37	265	236	121	110	..	39	37	21	27	70	22	38
..	20,0	12,2	21,2	..	84,2	36,6	11,0	79,4	46,3	23,4	33,3	..	24,0	10,2	11,0	10,2	20,0	10,2	10,4
..	2,9	1,4	2,6	..	2,6	3,8	3,4	3,3	5,1	5,1	3,3	..	1,6	3,6	1,9	2,6	3,5	2,1	3,6

TABLE III-C

Relative abundance (as capture per 100 hooks) of Yellowfin, Albacore, and Big-eye, by quarters, by statistical rectangles 1959—(Contd.)

South Latitude

40-03	40-04	40-05	40-23	40-24	40-25	41-24	41-25	42-25	43-25	44-25	44-26	44-27	45-25	45-26	45-27	TOTAL
..	..	..	..	14	32	126	..	..	..	2090	472	43	64	193	15	10753
..	..	..	..	9,0	9,0	24,3	..	..	..	284,0	70,8	14,9	19,2	20,8	10,2	1276,6
..	..	..	..	1,5	3,5	5,2	..	..	..	7,3	6,7	2,9	3,3	9,3	1,5	8,4
..	..	..	213	962	190	33	42	32	24	..	..	..	..	..	..	9662
..	..	..	92,3	311,6	66,6	20,7	10,0	11,6	11,4	..	..	..	..	..	..	1301,4
..	..	..	2,3	3,1	2,8	1,6	4,2	2,7	2,1	..	..	..	..	..	..	7,4
..	..	..	..	..	..	..	..	..	..	..	..	..	..		..	1826
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	490,5
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3,7
..	..	..	..	..	..	..	..	..	..	1212	210	..	..	..	..	3124
..	..	..	..	..	..	..	..	..	..	439,9	69,9	..	..	..	..	844,2
..	..	..	..	..	..	..	..		..	2,7	3,0	..	..	..	..	3,7
..	..	..	213	976	222	159	42	32	24	3302	682	43	64	193	15	25365
..	..	..	92,3	320,6	75,6	45,0	10,0	11,6	11,4	723,9	140,7	14,9	19,2	20,8	10,2	3912,7
..	..	..	2,3	3,0	2,9	3,5	4,2	2,7	2,1	4,6	4,8	2,9	3,3	9,3	1,5	6,5

TUNA FISHERY OF THE TINNEVELLY COAST, GULF OF MANNAR*

E. G. SILAS**

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INTRODUCTION

DURING the last few years, the world-wide demand for fresh sources of protein has increased considerably and this has been a stimulus for the rapid development of the fishery for some of the pelagic fishes in the tropical and subtropical oceans. The scombroid fishes (mackerels, seerfishes, tunas and billfishes) constitute an important element of pelagic fishes, the annual world production of which has more than doubled, from about 0.93 million metric tons in 1948 to about 2.11 million metric tons in 1961. This quantum of increased production has naturally added to the volume of selected, preserved and processed fishery commodities of tunas and related fishes sold in the world markets during the last few years. In figures, from 301,000 metric tons in 1955, it has risen to about 420,000 metric tons (net product weight) in 1961 (FAO, 1960-61). A bulk of the increase in fresh catches as well as in processed goods mentioned above is constituted by tunas, the fishery of which has rapidly expanded during this period, and is being most actively pursued by Japan and the United States. The fact that in the Indian Seas, the tuna resource is a potentially important one is quite evident from the success of the Japanese fishing efforts in this area. However, in spite of the fact that the success of our oceanic fisheries will eventually depend to a great extent on the development of this latent resource, to date, even exploratory fishing has not been attempted by us.

The data on landings, of tuna contained in Fisheries Departmental Reports suffer from the great drawback that species-wise information is almost always wanting. The data given below (Table 1) will give an idea of the total marine fish landings in relation to the three major groups of scombroid fishes (data after FAO, 1960-61).

TABLE 1

Marine fish landings in India (Figures in thousand metric tons)

Year	1955	1956	1957	1958	1959	1960	1961
Total marine fish landings excluding crustaceans and molluscs.	489.1	561.1	738.0	688.2	516.4	807.1	618.7
Indian mackerel ..	22.8	16.4	89.0	123.3	62.2	133.7	34.5
Seerfishes	6.0	12.4	8.9	7.9	6.6	8.6	11.5
Tunas	3.4	3.7	3.0	3.2	2.9	5.6	7.8

In the island of Minicoy in the Laccadive Archipelago there exists a regular pole and line, live-bait fishery for tunas, especially for the skipjack *Katsuwonus pelamis* (Linnaeus), and the yellowfin tuna *Thunnus* (*Neothunnus*) *albacares macropterus* (Temminck and Schlegel) (Ayyengar,

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1922 ; Jones and Kumaran, 1959). During an exceptionally good season, as in 1960-61, about 1200 metric tons of tuna were landed at Minicoy (Thomas, P. T. in litt.). Along the Indian Coast a few species of tunas, such as, the little tunny *Euthynnus affinis affinis* (Cantor), the frigate mackerels *Auxis thazard* (Lacépède) and *A. thynnoides* Bleeker ; the northern bluefin tuna *Thunnus* (*Kishinoella*) *tonggol* (Bleeker) ; and the oriental bonito *Sarda orientalis* (Temminck and Schlegel) occur during certain seasons in the coastal waters. However, up to now there has been no organised fishery for tunas except along the Tinnevelly coast, Gulf of Mannar where for well over fifty years there has been in vogue a regular seasonal fishery for these fishes, mainly using multiple trolling. The present paper is the result of observations conducted on this fishery off Tuticorin from about June 1960 to December 1961. In view of the paucity of information on the biology of these fishes from Indian Seas, the little information given here may be of added interest.

History of Tuna Fishery off the Tinnevelly Coast

As far back as 1915, Sir F. A. Nicholson, then Director of Fisheries of the Government of Madras, while discussing the utility of larger boats for fishing in deeper waters than the catamarans and small canoes in use than, remarked that at Tuticorin the Ceylon boats, usually outriggers and splendid sailers, regularly came over in the cold weather for seer, ' but so far have found no imitators.' The whole picture seems to have changed almost abruptly after 1912, as could be made out from the observations of Hornell (1917). He remarks that ' Until 1912 this fishery was in the hands of the Sinhalese fishermen who came across annually from Ceylon with their outrigger canoes or kūllams, at the beginning of the north east monsoon and who returned home in March. The year named was characterised by an exceptionally severe outbreak of cholera in Tuticorin ; this combined with the restrictive quarantine measures adopted by the Ceylon authorities against passengers coming from Tuticorin had such a deterent effect that no Sinhalese fishermen came that season and, once broken, the custom has not been resumed.'

' As trolling provides the bulk of the fish (seer) most esteemed by Europeans and as the market price in consequence is better than for any other fish, there was distinct inducement for the local fishermen to supply the want caused by the defection of the Sinhalese men. For the first year little progress was made and the catch for the year October 1912 to September 1913 fell by 50 per cent compared with the preceding year's catch (11,835 lbs. as against 24,438 lbs.). But a year's experience revealed to the local men, that, contrary to their own belief, no special virtue in inherent to the Sinhalese outrigger as against their own boats ; the latter sail quite fast enough with a good wind to make trolling for seer a success. The success of the pioneer boats was so obvious that the number engaged in this branch of fishing rapidly increased and if Sinhalese fishermen ever came again to Tuticorin, they will find themselves supplanted and with strong competition to face.'

There is hardly any evidence that Sinhalese fishermen ever came to Tuticorin after 1912 to engage in this fishery. Since 1917, no attempt has been made to review this fishery, the only information being landing figures of ' seerfishes ' and ' tunnys ' (not species-wise) for Tuticorin contained in a few recent annual reports emanating from the Department of Fisheries of the Government of Madras. Suffice it to say, that by trial and error and by experimentation, the fishermen of Tinnevelly Coast (at Tuticorin) have evolved a system of multiple trolling for scombroid fishes, which today they find most suited for conditions obtaining in these waters.

Fishing Grounds

The fishing ground where multiple trolling is carried out is indicated in the accompanying figure (Fig. 1). I have been informed by the older fishermen at Tuticorin that even 15 to 20 years back, multiple trolling for scombroid fishes used to be carried out within sight of land. From the north fish landing centre at Tuticorin, one could see the boats in operation off Hare Island.

The subsequent increase in the number of fishing boats operating from Tuticorin, fishing boats and catamarans from the coastal fishing villages to the south of Tuticorin for regular fishing in the inshore waters, and the consequent numerical increase in the gear, mainly bottomset gill nets

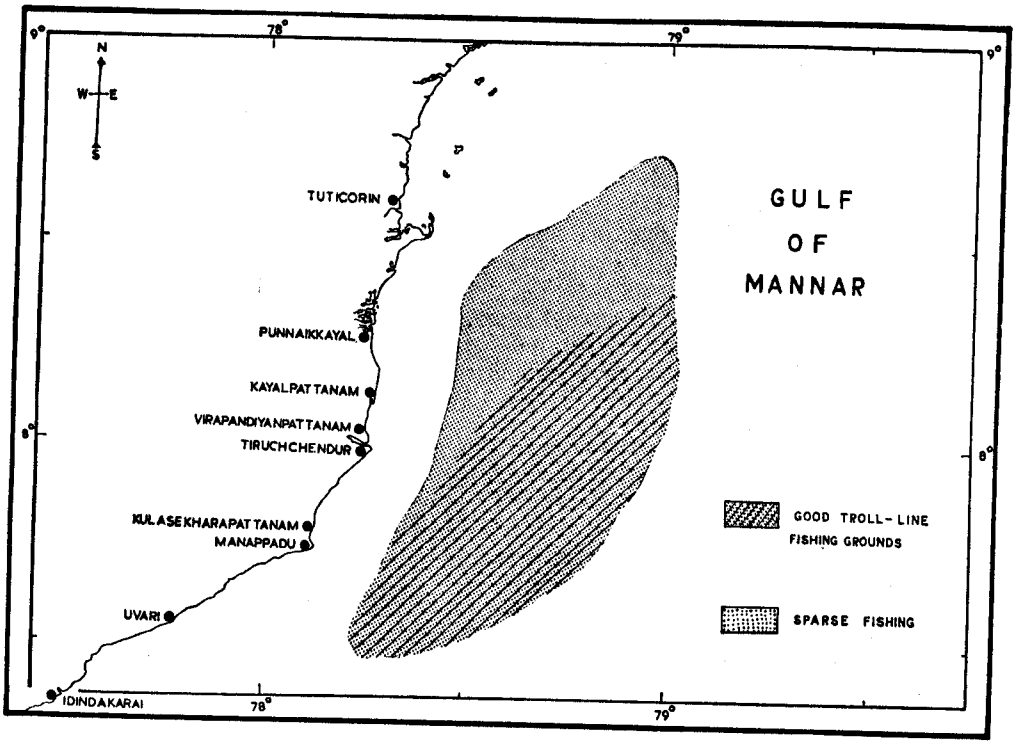


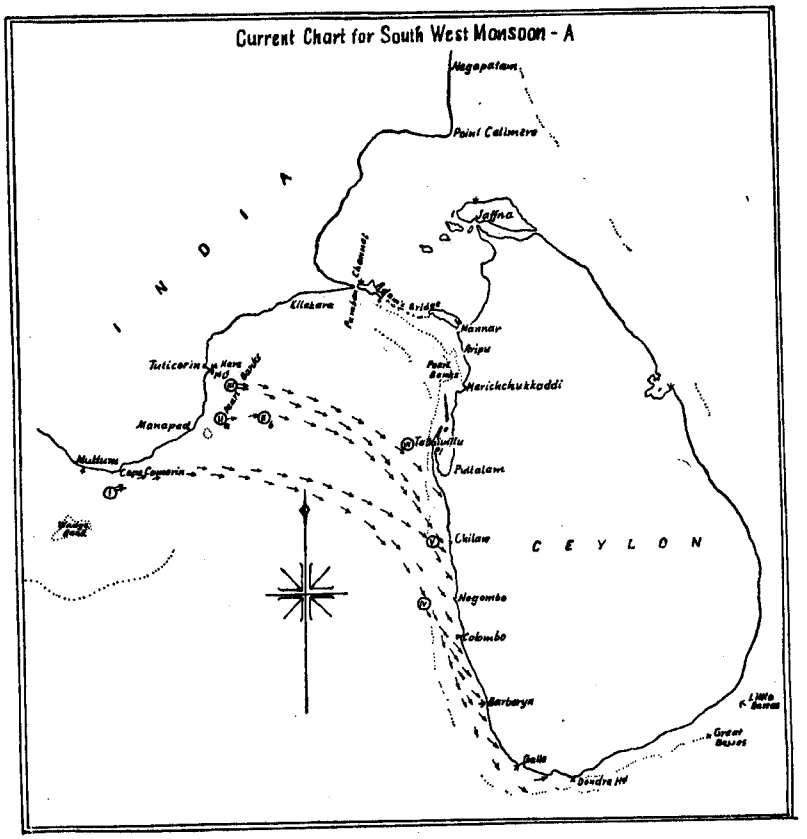
FIG. 1. Map of Tuticorin coast and part of Gulf of Mannar showing the area in which multiple trolling carried out at present.

and boat seines, perforce shifted the trolling grounds further south and offshore. The use of nylon fibre for nets has increased the efficiency of the nets used in the regular fishery in the inshore waters where fishing is carried out throughout the year. This increased activity has no doubt resulted in the more efficient capture of the smaller species, such as *Sardinella* spp., consequent to which larger predatory species, such as the larger seerfishes, and tunas are deflected or kept away from the inshore waters. At present, hardly any trolling is carried out 3 to 4 miles off Tuticorin although boats returning from handline fishing and trolling with one or two lines may take an occasional seer (*Scomberomorus commerson*), sailfish or little tunny.

At the commencement of the fishing season in June, multiple trolling is carried out beyond the 10 fathom line directly off Tuticorin. However, as the season progresses, and if there is evidence of good bite from the fish, the activity is shifted southwards. It is recognised by fishermen using this mode of fishing that the area lying beyond the 10 fathom line off Punnaikkayal and Manapad is good for trolling. This area lies within Long. 78° 15′ to 78° 25′ E. and Lat. 8° 15′ to 8° 40′ N. A part of the Tuticorin Pearl Banks lies within these limits and a few dead or partly alive coral reefs are also present in this area and its vicinity to the south and north. The continental shelf slopes more rapidly beyond the 10 fathom line. There can be hardly any doubt that mechanization of the craft and improvements in the gear would go a long way in extending the trolling grounds to well over 60 miles off this coast. Occasionally during the trolling season, boats which venture 25 miles off Virapandianpattanam and Manapad invariably bring very good catches of tunnies. However, this is a risky operation for the sailboats used, on account of the unpredictable weather . The distance to the fishing grounds from Tuticorin, the wind force and

the direction of wind play an important role in restricting the trolling grounds to its present size. Although the ' Tuticorin-type ' boats are excellent sail boats, the sailing time from Tuticorin to the fishing grounds is very great. Often, 6 to 8 hours are taken to reach the grounds and as usually late in the afternoon the winds are favourable the return journey is done in 3 to 4 hours. This allows for about 4 to 6 hours of fishing time. In order to study the conditions first hand, on 26-8-61 night at 23.00 hours, I left Tuticorin by one of the larger boats ' St. Antho ', with George, an experienced ' chammati ' and a crew of seven inclusive of three boys. On 27th morning we reached the fishing grounds at about 6.30 hours. Sudden change in the weather resulting in strong winds and choppy sea conditions hampered multiple trolling and only one little tunny and one northern bluefin tuna were caught on two of the lines. Deteriorating weather forced all 45 boats which had gone to the grounds that day to return to Tuticorin, some having caught no fish. The return journey hardly took 3 hours, all boats getting back by 11.30 hours. Due to persistent bad weather for several days after this, multiple trolling was discontinued.

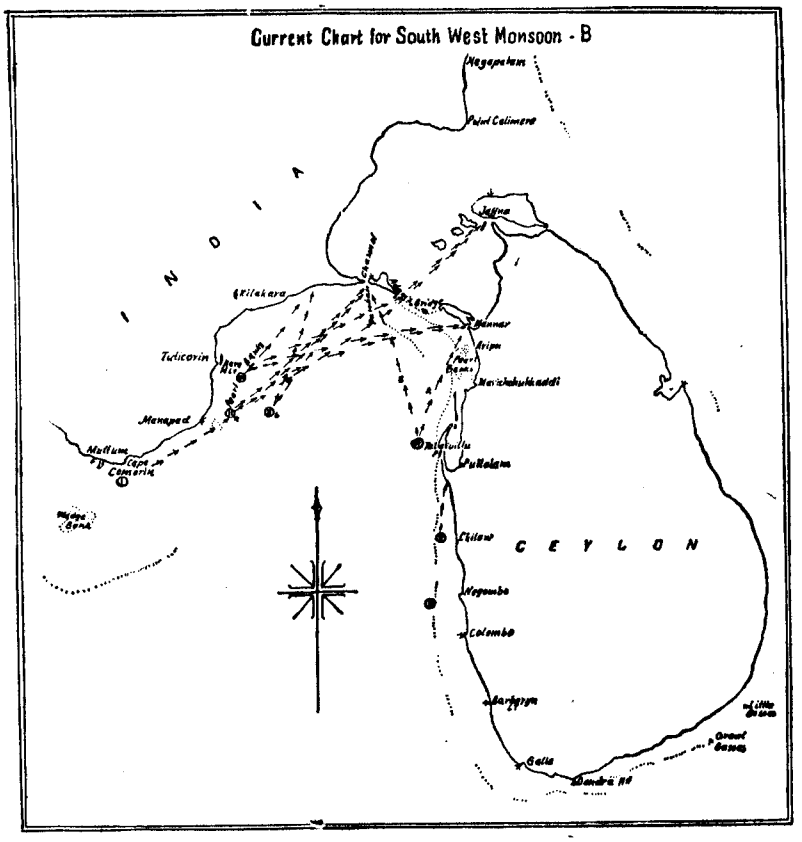
It is mainly on account of the distance from Tuticorin that the base of operation is shifted during any good fishing season to Virapandianpattanam 25 miles to the south. Boats leaving from here around 04.00 hours reach the grounds by 07.00 hours and can fish for about 8 hours before returning to land the catches at Virapandianpattanam.



TEXT FIG. 2. Current chart showing the easterly set when the South West Monsoon was strong from 9 to 25 July and again from 15 to 25 August 1910 (After Southwell and Kerkham, 1912).

HYDROGRAPHY

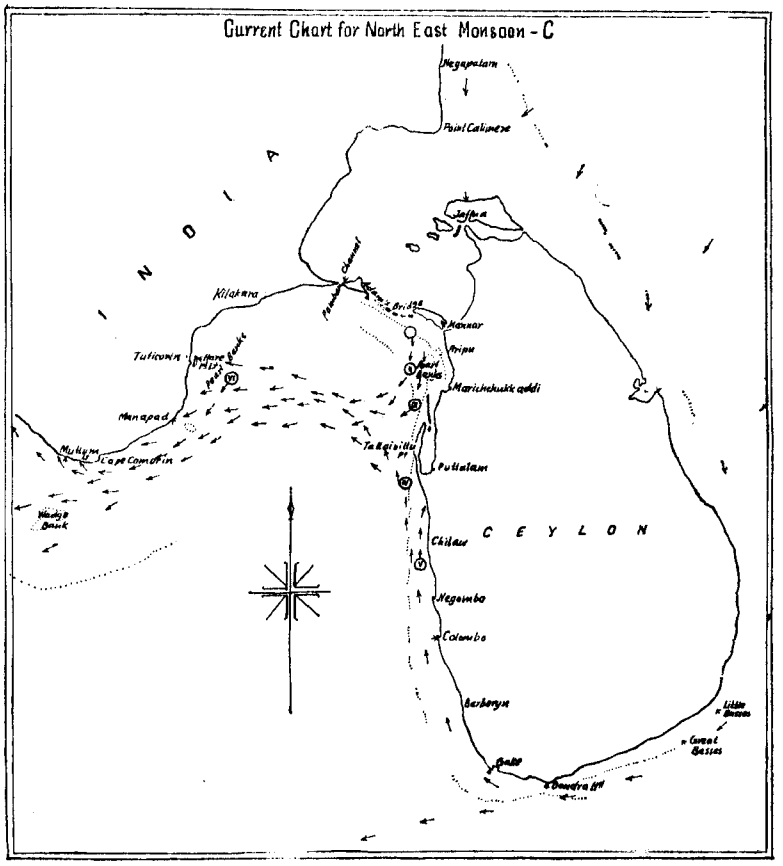
No hydrographic observations are available for the trolling grounds indicated in Fig. 1. The scanty information on the surface currents in the Gulf and the fluctuations in temperature and salinity in the inshore waters off Tuticorin may throw some light on the conditions obtaining in the vicinity.



TEXT FIG. 3. Current chart showing a north westerly current during a lull in the monsoon from 28 July to 5 August and again from when the monsoon commenced to subside from 1 September 1910 after which the current ran steadily to the north during the month (after Southwell and Kerkham, 1912).

Southwell and Kerkham (1912) have given surface current charts for the Gulf of Mannar for the North East and South West Monsoon seasons based on the recovery of drift bottles released at different times at Cape Comorin and off Colombo. The work was undertaken mainly to understand the surface current patterns that may help in the transport and settling of oyster spat in the pearl banks off Ceylon. The three current charts given by them are reproduced here (Figs. 2-4) for reference. They recognise two phases in the surface currents during the south west monsoon. The first, when the currents run northerly towards the Pamban Pass, during which time the monsoon is light or moderate. The second is a phase of strong monsoon, when the oceanic current penetrates the Gulf ' and the water at the head of the Gulf consequently becomes piled up as a cushion. The Oceanic current aided by the westerly wind which prevails over Southern India, takes an easterly course, and eventually reaches the Ceylon coast about Tallaivillu Point. It is here joined by an overflow of water from the head of the gulf and then runs south on to the Ceylon coast ' (Fig. 2). In Fig. 3, a transition between these two phases of the south west monsoon is

shown. During the north east monsoon there is a reversal in the surface drift as shown in Fig. 4. Some of the bottles liberated off Tallaivillu Point on the west coast of Ceylon have been recovered from as far north as Calicut, and one from the Maldive Islands.



TEXT FIG. 4. Current chart showing the westerly set when the North East Monsoon was strong (after Southwell and Kerkham, 1912).

The fishermen at Tuticorin, Virapandianpattanam, and Manapad are also aware of the existence of definite surface drift or current systems, off the Tinnevelly coast in the gulf. The Vāni vadu Nēerottam which commences in the Tamil month of Aāni may extend even up to Thai corresponding to the period June to December. Good fishing is expected in the coastal waters once this Nēerottam is established. Concurrent with this, from ten to fifteen miles off the coast opposite Virapandianpattanam and Manapad, the colour of the water is also said to change from a deep blue to ' murky ' and when such a condition occurs very good fishing by multiple trolling is predicted.

For information on the average monthly surface temperatures of the inshore waters of Tuticorin, reference may be made to Chacko (1956). He has tabulated six years data from 1949 to 1954 inclusive. The Madras Government Department of Fisheries Year Book (1960) contains some information on the average monthly surface and bottom temperature and salinity for the period April 1958 to March 1959 for waters off Tuticorin for depths up to 19 metres.

General Climatological Conditions

Since multiple trolling is carried out from sail boats and upto now no mechanised boats have been used for this purpose, weather conditions play an important role in this fishery. The North East Monsoon from about November to March, and the South West Monsoon more intense from June to September along the east coast of India and the Bay of Bengal are dominant features during which period the direction and strength of winds differ from place to place. Much of the ensuing information of climatological conditions is taken from ' Weather in the Indian Ocean ', Volume 2, part 6A (1940). In the Gulf of Mannar, the North East Monsoon blows until about the end of January and the wind direction is NNE to NE. During the month of April, both land and sea breeze prevail, and from February to May, the sea breezes gradually become of longer duration and increase in force. By the end of April, the winds at night become light and variable and in May the wind begins to blow continuously from SW. The South West Monsoon gains strength from June. In July the weather is cloudy and hazy with generally a fresh breeze. The wind moderates in the northern part in the morning and blows strong again in the afternoon. Fresh South-Westerly to West-South-Westerly winds continue in August and September, but the weather is generally fine ; the afternoon breezes are strengthened and are accompanied by occasional squall or rain. In November, the winds are light and variable between NE. and WNW. and by about the middle of the month the North East Monsoon winds commence blowing.

Throughout the year the visibility is good, except in September when the atmosphere is often hazy. It is estimated that the average difference in temperature between the hottest and coolest months of the shores of the Gulf of Mannar is about 7.5°F. The day to day temperature may vary and may range from as low as 65°F. in the coolest month (January) to about 95°F. in the hottest months (April-May).

As regards sea temperature, the 80°F. line is situated in the extreme north east corner of the Bay of Bengal off Sundarbans in the month of March, but by July, August and September it is in the south-west, off the west coast of Ceylon, and the Gulf of Mannar. The arrival of the South West Monsoon brings about a slight drop in the sea surface temperature and in the Gulf it falls slightly below 80°F.

The humidity is highest in the Gulf of Mannar during December and lowest in June or July.

As regards sea swell, in the Gulf of Mannar a swell from westward occurs during the latter part of April.

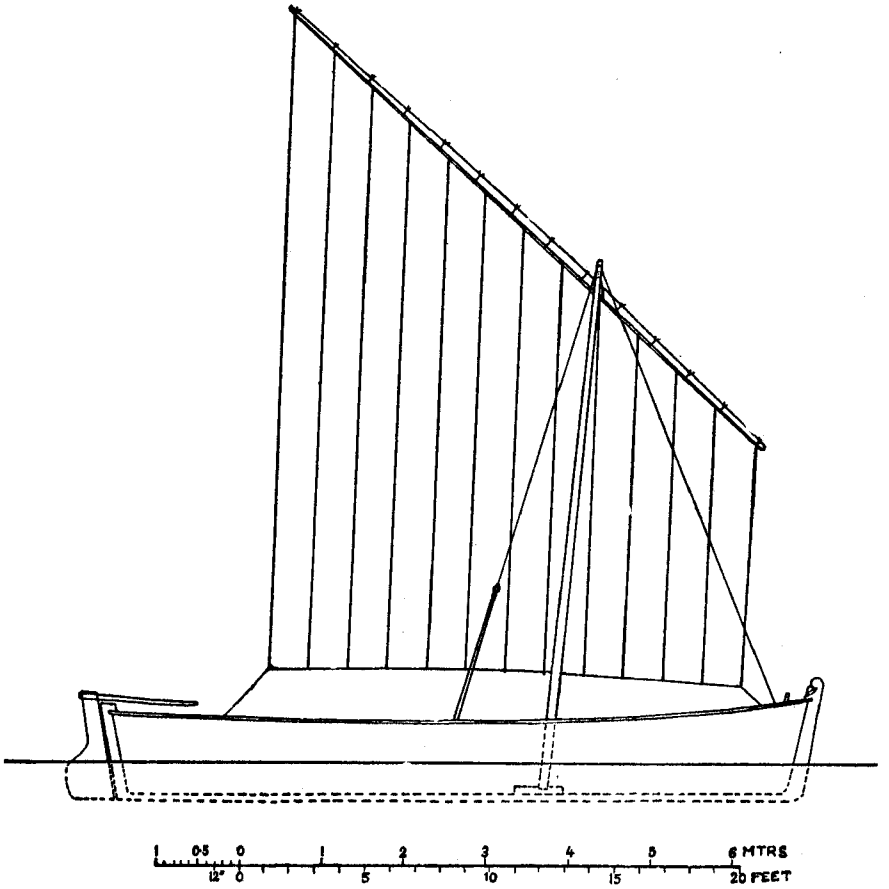
Fishing Craft and Gear used in Multiple Trolling

About 400 to 450 fishing boats commonly known as the ' Tuticorin-type ' boats (Zeiner and Rasmussen, 1958) operate from two fish landing centres at Tuticorin. Of these, generally 150 to 200 boats or even more, depending on the season are engaged in bottomset gillnet, driftnet and boat seine fishing. About 50 to 100 boats are used for handline fishing and invariably the boats while returning troll one or two lines, each about 30 fathoms in length.

If the winds are favourable and trolling is expected to yield good catches, more boats are engaged exclusively in multiple trolling. To suit the convenience of the fishermen who are subsidised with food articles, money, and other sundries by the auctioners, and to take advantage of the shorter distance to the fishing grounds, a great majority of the boats engaged in multiple trolling, often 150 or more, station and operate for the season from Virapandianpattanam. Normally only catamarans are used for regular fishing from this centre.

The boats engaged in multiple trolling may be broadly classed under two categories, namely small boats measuring between 27 and 29 feet in length and larger boats between 30 and 34 feet

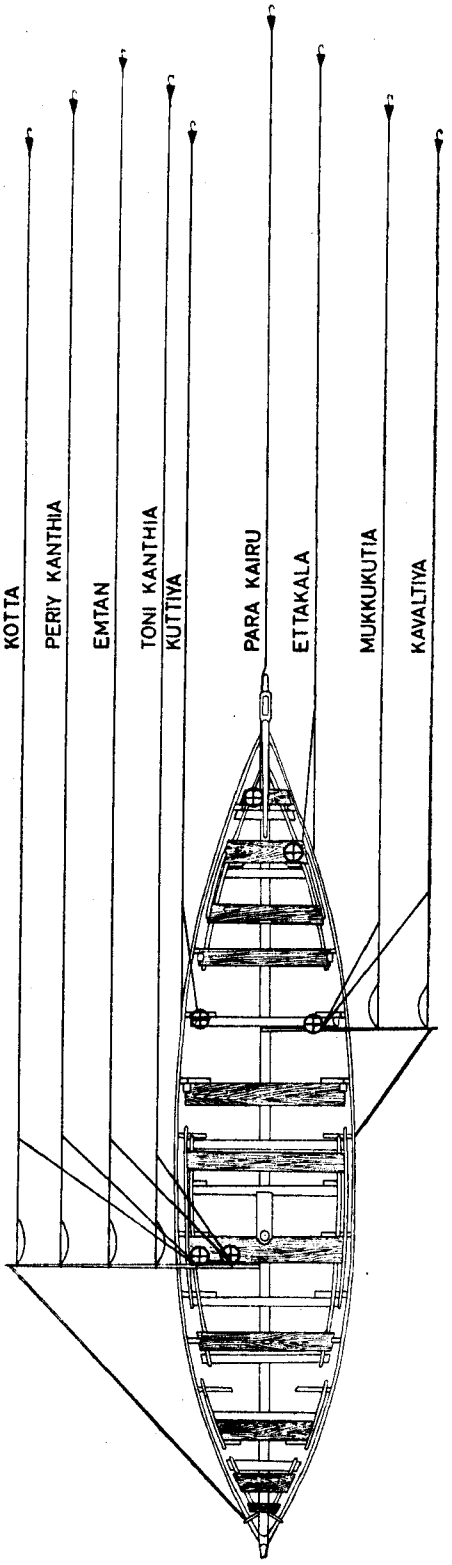
in length. The former generally carry a crew of six or seven persons and generally seven lines are used for multiple trolling. Seven to nine men go out in the larger boats and generally nine lines are used for trolling.



TEXT FIG. 5. Schematic drawing of the typical ' Tuticorin-type ' boat (after Zeiner and Rasmussen, 1958).

But for the difference in size, there is hardly any other difference in the design of these boats which are locally constructed. The timber commonly used in the construction is benteak (*Lagerstroemia lanceolata*) and poovarasu or portia (*Thespesia* sp.). Zeiner and Rasmussen (1958) describe the typical ' Tuticorin-type ' fishing boats as being long and relatively narrow, with vertical stems and sterns. The sheerline is almost straight and both ends of the boat are sharp. The curved wood of portia, locally available at low cost is used for the hull. The frames are cut away at the sheer plank and not carried to the gunwale. The uppermost plank which is very broad is framed with a very short piece not fastened to the main frame, and generally at some distance from it. Only one mast is carried and the sail which is a lugger is peculiar and indigenous. The main dimensions of a typical boat (Fig. 5) are given as : length o.a. 29′ ; breadth 6′ 3″ ; depth 2′ 11″ ; registered tonnage 2.9 and sail area 330 sq. ft. The cost of such a boat in 1958 including rig and sail was estimated to be about Rs. 2,000. In 1961, a boat of these dimensions was estimated to cost around Rs. 3,000.

The arrangement of the trolling lines in a larger boat is shown in Fig. 6. One interesting



TEXT FIG. 6. Schematic drawing showing the arrangement and the vernacular (Tamil) names of troll lines used from the 'Tuticorin-type' fishing boats for multiple trolling. The circle with a + indicate the position taken by fishermen handling the lines.

feature is that each line is denoted by a name starting from the outermost on the starboard side as follows :

1. Kotta
2. Periy Kanthia
3. Emtan
4. Toni Kanthia
5. Kuttiya
6. Para kairu
7. Ettakala
8. Mukkukuntia
9. Kavaltiya

Six of these lines are attached to two booms of varying size. The boom on the starboard side which is longer carries four lines (Nos. 1-4). This boom is about 14 to 16 feet long and about 3.5" in diameter at the tip and 4.5" to 5" at the butt end. The second boom is shorter, 10 to 12 feet long and carries two lines (Nos. 8 and 9). No butt blocks are used and the butt end of the booms rest on the side planks and the basal portions are rigged by ropes to keep them in position, resting also on the gunwale at an angle of about 40° to 45° to the horizontal. Usually, casuarina poles or some other local wood is used as trolling booms.

The length of the lines, vary depending on the location to which it is fixed to the boat, speed of the boat, as well as individual preferences of the fishermen. Those tied to the booms (Nos. 1-4 and 8 and 9) are from 18 to 25 fathoms long, while the other lines (Nos. 5-7) may be 15 to 20 fathoms long. However, I have measured lines of about 50 fathoms length which are coiled and taken, but all this length will not be paid out while trolling. The line used was found to be 3-ply cotton line about 4.2 mm. in diameter. Hooks of two different sizes (between 7 and 8 cm. long) were used with fish bait or with artificial lures. The latter was used only rarely, and made by tying the bleached fibres of *Agave* and pieces of red and white rag-cloth. The fish bait used was almost exclusively *Sardinella* spp. (*S. albela, S. gibbosa, S. sirm*). This was purchased from the previous mornings boat seine and gillnet catches and packed in brine in tin containers and taken along to the fishing grounds. A sum of Rs. 3 to Rs. 6 is spent per boat for the purchase of fish bait which if unexpended is brought back and reauctioned (Plate 3, Fig. A). This would fetch hardly one-fourth its original price and was generally purchased by fisherwomen for local sales.

Natural and other Factors Affecting Multiple Trolling off Tinnevelly Coast

The natural causes mainly responsible for restricting multiple trolling off Tinnevelly coast is inclement weather conditions or lack of proper wind to facilitate operation of the sail boats. The land-to-sea breeze known locally as ' vada kathu ' which blows from the earlier part of the night to the morning hours during the months June to August help in the boats reaching the fishing grounds. The ' sani kathu ' which blows from south to north and from sea towards land from noon or early afternoon to late in the evening aid the speedy return of the boats after fishing. When these favourable winds are not present, multiple trolling is not generally undertaken.

Even during the fishing season, some of the fishermen are attracted to other works which give them a steady remuneration. It is interesting that the passage of time has not brought about any marked change in the nature of the inducements that keep the fishermen away from this mode of fishing during a slack season. A good deal of what Hornell (1917) reported in this connection has remained unchanged. He remarks that the number of fishermen working when the respective fisheries are in vigorous prosecution considerably fluctuates from time to time and some take up alternate employment ' . . . either when the fishery is poor, or the counter attraction is great. For example when the port is busy with exports and imports and the demand for lighterage is great a certain proportion of the fisher class find it more profitable to act as lighter crews.

Or again they may quarry coral on the reefs, or enlist as chank divers. A pearl fishery in Ceylon causes a great exodus of fishermen and lighter men.'

While at present there is no migration of fishermen to Ceylon during the pearl fishery season there, pearl fishery operations from the banks off Tuticorin in recent years have seen considerable reduction in fishing activities including multiple trolling at Tuticorin, as most of the fishermen are expert divers.

Another very important inducement for fishermen who engage in multiple trolling is quarrying coral, which industry has in recent years grown by leaps and bounds in view of the establishment of at least three cement and chemical factories in the Tinnevelly and Ramnad Districts. At the time that these investigations were carried out in 1961, the fishermen were paid a fixed rate per boat load of quarried coral as follows : The larger boats with a complement of 7 to 9 crew (average 8) after a day's quarrying will be able to bring about 2 to 2½ square yards of coral which is stacked 3 feet high and the contractors purchase rate per square yard obtaining in September 1961 was Rs. 12. Most of the fishermen engaged in this work get themselves heavily indebted to the contractors by receiving money in advance. This is additional inducement given by the contractors who eventually pay the fishermen only Rs. 11 per stacked square yard of coral blocks. The larger boats have a capacity for carrying upto 5 square yards of quarried coral. A minimum of Rs. 30 is thus earned per day which means that a man gets an average income of at least Rs. 3.50 per day. This is considerably higher than what they could expect from multiple trolling if the fishery is not exceptionally good.

Added to these, the set back in the dry fish trade with Ceylon of which already mention has been made had forced many fishermen to seek other employment.

Fishing off Virapandianpattanam

During the fishing season which starts from about the middle of June, in addition to the 100 to 150 sail boats of the ' Tuticorin-type ' which congregate at Virapandianpattanam for multiple trolling, the local catamarans numbering about 50 also participate in the fishing. The catamarans fish upto about 10 miles off the coast, while the sail boats fish from even 25 miles off the coast. The catamarans using sail and usually two or three troll lines catch seer, northern bluefin tuna, and the little tunny, while the boats land in addition, yellowfin tuna, bigeye tuna, sailfish, and marlins.

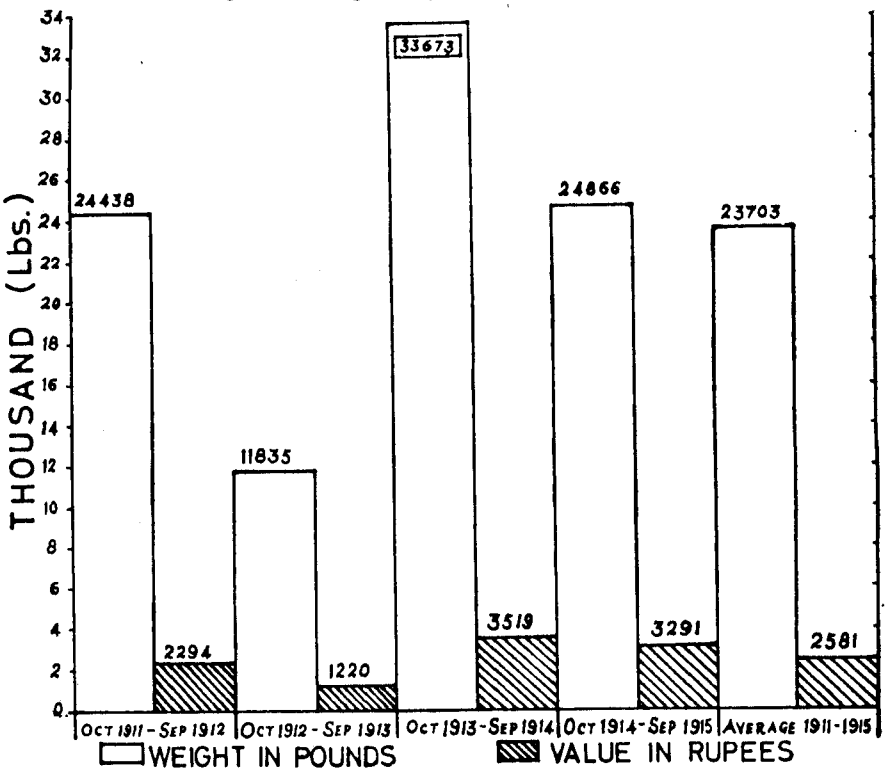
All fish landed by multiple trolling at Virapandianpattanam goes in for salt curing to be eventually exported to Ceylon. The fish when landed is auctioned as at Tuticorin with one difference. The entire catch is handled by only four merchants with mutual understandings to keep out outside competition. The auctioner's share is one anna (= 6 P.) per rupee plus one fish per boat.

During the 1961 season for slightly over a fortnight in July-August about 20 ' Tuticorin-type ' boats were operating from Virapandianpattanam. Fishing was poor and the daily catch instead of being auctioned, was weighed and taken by the merchants at the following rates : *Surai* (little tunny, northern bluefin, and yellowfin) 2½ annas (=15 P.) per lb. ; *Parai, Katta,* etc. (*Caranx* spp., *Chorinemus* spp., etc.) 3½ annas (=22 P.) per lb. ; and *Cheela* (*Scomberonorus commerson*) 5 to 5½ annas (31 to 34 P.) per lb. These prices amount to hardly one-fourth the rates obtaining prior to the curb on the export of dry fish to Ceylon in 1960.

Review of Earlier Work on Fishery for Tunas and Related Scombroids at Tuticorin

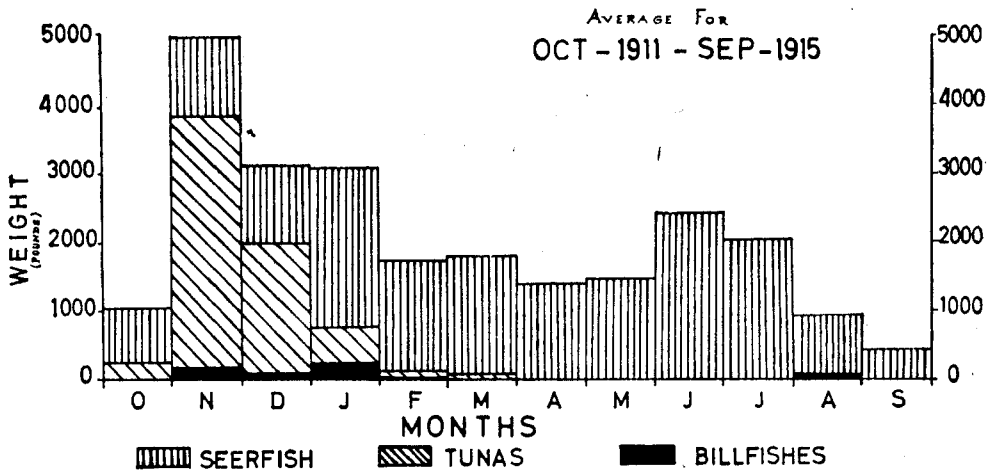
The earliest account is that given by Hornell (1917) wherein he has tabulated the average yearly weight and value of 36 most important species of fish landed at Tuticorin. It is presumed

that ' seerfish ' will include all three species of *Scomberomorus* landed with all gear at Tuticorin ; ' bonito ' more than one species of tuna ; and ' swordfish ' both the sailfish and the marlins. Based on this data, the average annual quantity and value of scombroid fishes landed chiefly by

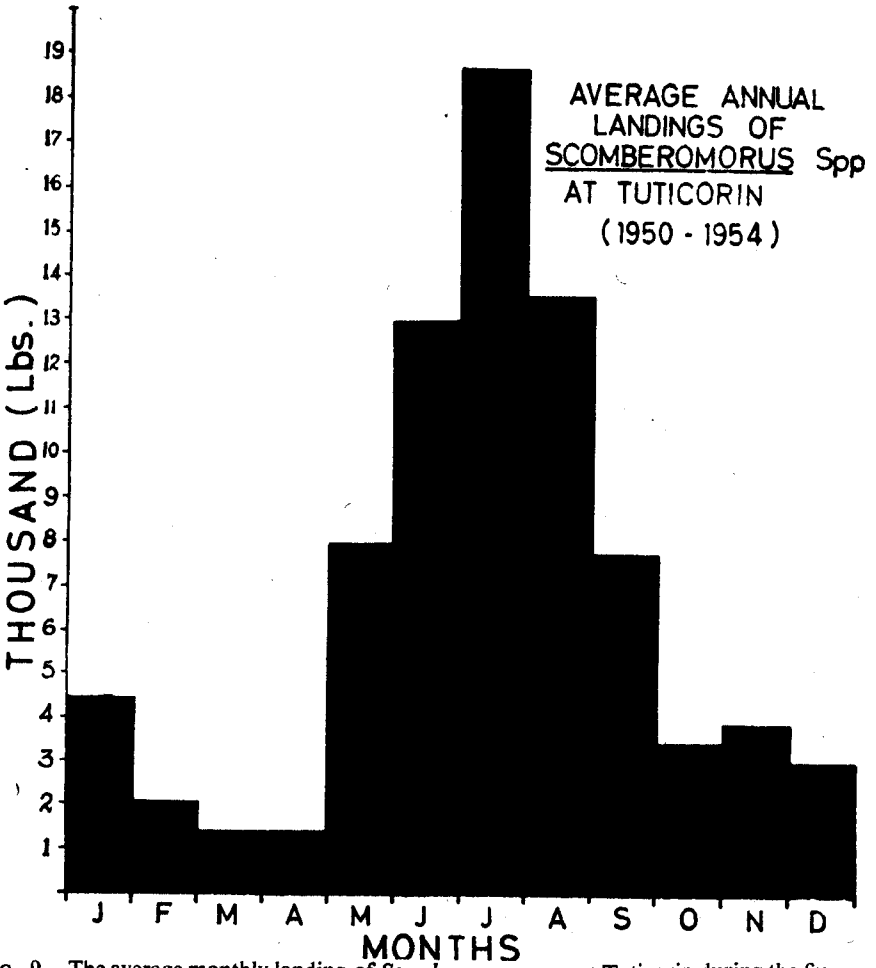


TEXT FIG. 7. The average annual quantity and value of scombroid fishes landed by muliple trolling at Tuticorin during the four year period October 1911 to September 1915.

multiple trolling at Tuticorin is shown in Fig. 7. The weight and value of fish obtained by multiple trolling at Tuticorin for the four year period October 1911 to September 1915, based on Hornell (1917) is given in Fig. 8. This includes the period of take over of this mode of fishing by the Tuticorin fishermen from the Sinhalese migrant fishermen in 1912-1913. From Fig. 8 it will be seen that seerfishes constituted the main catch, and the best landings were during the months November, December and January. Tunas were also caught in the months October, December, and January and in very negligible quantities in February and March. Billfish landings were mainly during November-January and very few were also caught in February and in August. The data relating to the sale of *Scomberomorus* and tunnys caught along the west coast of Ceylon and sold in the various markets of Colombo as given by Pearson (1930) for the years 1928 and 1929 also indicate that the maximum landings of these fishes were during the months November to January coinciding with the North East Monsoon period. As for the waters off Tuticorin, Hornell (1917) adduces the reasons for this seasonal abundance of scombroid fishes coinciding with the period of the North East Monsoon due to the sea being clear '. . . . and the wind just strong enough to give the boats sufficient speed through the water and yet carry full sail. In the south-west monsoon poor fishing results partly from the frequent turbidity of the water and partly (more) from the fact that the wind and sea are then usually too high to permit the local boats to carry full sail. It is at these times that the outrigger canoes of Ceylon and Palk Bay come to the front by reason of their greater power to stand up to heavy weather.' Conditions have greatly changed since then and as shall be discussed presently, the best period for multiple



TEXT FIG. 8. The average monthly catches of tunas, seerfish and billfishes landed by trolling at Tuticorin during the four year period—October 1911 to September 1915, indicating the seasons of good fishing.



TEXT FIG. 9. The average monthly landing of *Scomberomorus* spp. at Tuticorin during the five year period 1950 to 1954, indicating May to September to be the best months of fishing.

trolling is considered to be from June to August or September. Not a single outrigger canoe operates from Tuticorin to influence the change in the main fishing season. On the other hand, the skill of the fisherman has had a lot to do with this. Boats which went out for multiple trolling or handline fishing had a balance board of sufficient length on the weather side to allow for two or three of the crew to stand as counter weight. The fishermen have also become adept at this method of fishing, and more than anything else, venture far off the coast. The average annual landings of *Scomberomorus* and ' tunny ' at Tuticorin in recent years bears this out. The data for 1950 to 1954 (Figs. 9 and 10) shows that more fishing is now carried out during the South West Monsoon period than the North East Monsoon period.

While tunas and related scombroid fishes may be present in the Gulf of Mannar off Tinnevelly coast at all times, from experience, the fishermen feel that during the months June to August there is an influx of these fishes towards coastal waters. Favourable winds for trolling do occur during this season. However, temporary breaks in the fishing operations take place when the weather conditions are really adverse, and this may last for a few days at a time.

Some Observations on the Habits and Behaviour of Scombroid Fishes Caught in Trolling off Tuticorin

During my visits to Tuticorin and other centres along the Tinnevelly coast to conduct the present survey it was possible to obtain some information about the behaviour of some of the species of scombroid fishes usually caught by trolling, from fishermen engaged in this mode of fishing for a long time. Since these may be of some interest, opportunity is taken here to record these.

Adult *S. commerson* do not shoal at the surface as tunas. However, on occasions, especially in the later part of the afternoon and towards dusk this fish is seen to leap out of water. Several may be seen within the range of vision and on such occasions trolling will be very successful. On 19th, 21st and 22nd August 1961 in the trolling grounds off Tuticorin hundreds of *S.commerson* were seen to leap clearly out of the water. Some, close to the boats which were trolling were estimated to have lept about 10 feet clear off the water. The size range of the specimens caught from the same area on 24th and 25th August 1961 was 628 mm. to 1280 mm., weighing from 3.5 to 30.5 pounds. The males had oozing milt and the large females were partly spent. The reason for the fish leaping out of water in such large numbers is not clear.

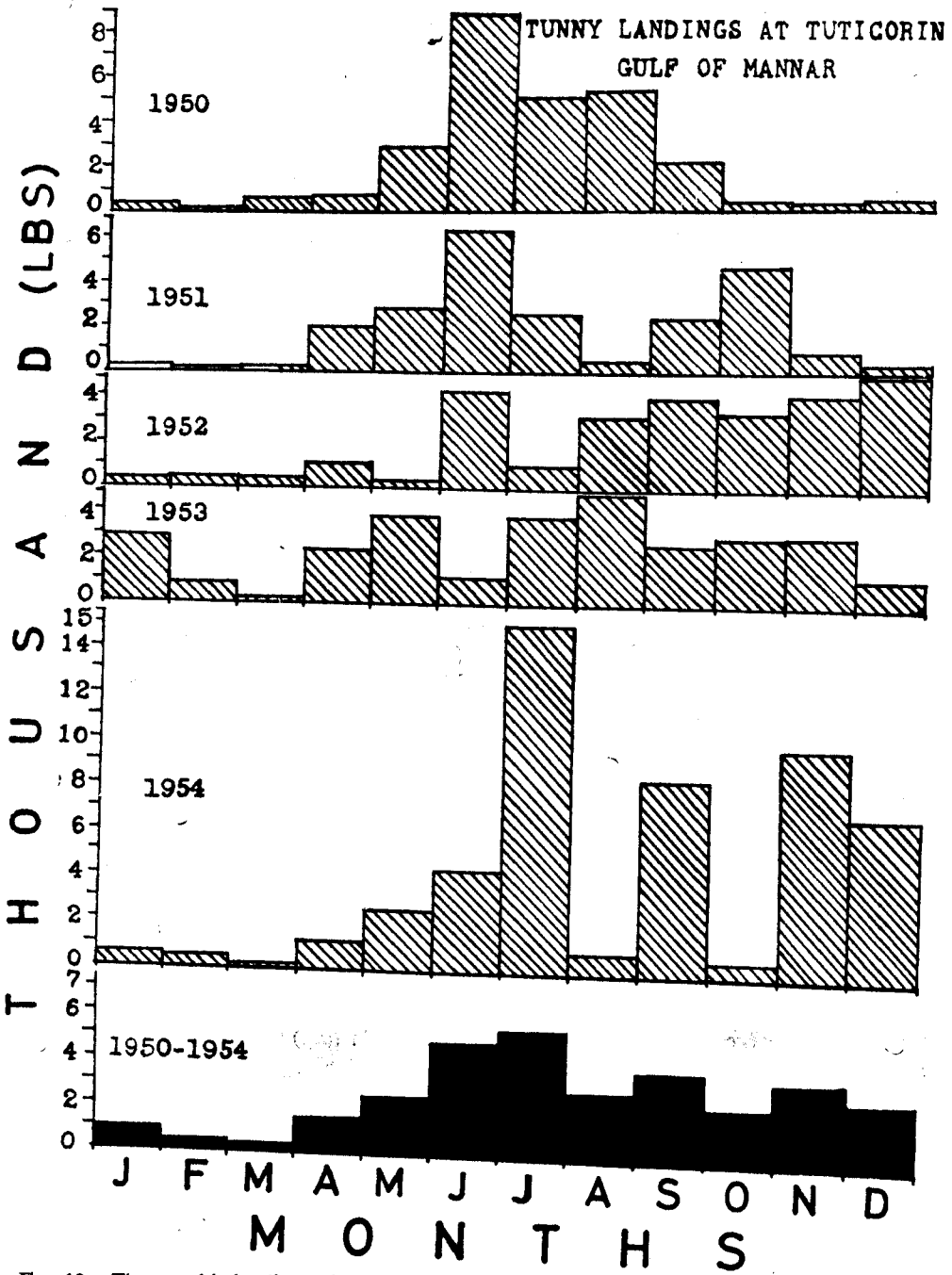
Unlike the little tunny and the northern bluefin tuna, the yellowfin tuna is not sighted by the fishermen as surface schools. Since some of the troll lines are manipulated by hand, the fishermen are adept at distinguishing a yellowfin bite from that of other tunas, as it gives only a small tug on the line and instead of leaping, the fish invariably sounds. The line has to be very slowly hauled in at a steady pace if the fish is to be successfully landed. Even so, when the keel of the boat is within its visual field, the fish again sounds and 15 to 20 fathoms of line is let out and the hauling repeated. The second time the fish is drawn closer to the boat, with a single movement it is gaffed and hauled in. Several yellowfin are lost at this stage by improper gaffing.

On rare occasions, large schools of skipjack (*K.pelamis*) are sighted, and when a school is approached, it usually sounds and only very few fish are caught in troll lines.

Bird flocks are not seen accompanying tuna shoals.

The black marlin and the striped marlin are sometimes sighted at the surface and the fish is also known to leap out of water. When attracted by trolling bait, they usually dash to the bait and the moment the bite is effected, the fish leaps out of water. At this stage, the strain on the line is usually great and often the fish gets away, due to improper hooking, or due to the straight-

ening of the hook or the snapping of the line. When a hooked marlin is drawn alongside the boat, the moment the fish is within reach, the first thing that is done is to tightly grip the bills



TEXT FIG. 10. The monthly landings of tunas at Tuticorin during the five year period—1950 to 1954, and also the average for the five year period. (June-July as the best months of fishing for tunas may be noted).

of the fish, which action I am told immobilises the fish enabling gaffing and hauling in. Strangely enough, no fisherman I had spoken to could ever remember of having seen or heard of damage caused to boats by marlins in the fishing grounds or while the fish is being hauled into the boat.

At Tuticorin it was interesting to find that the liver and stomach of tunas are eaten and these are collected from the place where the fish is filleted for curing. However, the visceral organs of marlins and sailfish are avoided. I was told that in 1959 two families (altogether 11 members) were hospitalised on account of eating the stomach (not gonad) of the black marlin.

Tunas and Related Pelagic Fishes Caught off Tuticorin

Hornell's (1915, 1917) reports indicate that the following scombroid fishes were generally caught at Tuticorin (Table 2).

Table 2

Scientific name (Hornell, 1915)	Vernacular name (Tamil)	Upto date nomenclature
Thynnus thunnia	Suraimin	*Euthynnus affinis affinis* (Cantor)
Cybium commerson	Mavulasi	*Scomberomorus commerson* Lacépède
Cybium interruptum	Vanjaram	*Scomberomorus guttatus guttatus* (Bloch and Schneider)
Cybium guttatum	Velramin	
Cybium guttatus	Mayilmin	*Istiophorus gladius* (Broussonnet)
Histiophorus gladius	Emankōlā	*Makaira indica* (Cuvier)
Histiophorus immaculatus		
Histiophorus brevirostris		

From the above list, only one species of *Scomberomorus*, namely *S.commerson* was taken in multiple trolling during the period of observation. More species of tunas and other pelagic fishes which occurred regularly or sporadically in the multiple troll fishery during 1960-1961 are given in Table 3.

Table 3

Scientific name	Vernacular name (English name)	Remarks
Auxis thazard Lacépède	(short corseletted frigate mackerel)	Rare
Euthynnus affinis affinis (Cantor)	Suraimin (little tunny or mackerel tuna)	Common
Katsuwonus pelamis (Linnaeus)	(skijpack tuna)	Rare
Thunnus (Neothunnus) albacares macropterus (Temminck and Schlegel)	Kelavalai (yellowfin tuna)	Common
T.(Kishinoella) tonggol (Bleeker)	Ettalai (Northern bluefin tuna)	Common
Istiophorus gladius (Broussonnet)	Thalapathu (sailfish)	Common
Makaira indica (Cuvier)	Kopprai Kulla (black marlin)	Rare
Makaira nigricans Lacépède	Kola (blue marlin)	Rare
Tetrapturus audax Philippi	Kola (striped marlin)	Rare
Tetrapturus sp.	Kola	Rare
Scomberomorus commerson (Lacépède)	Chela (Seer)	Common
Scomberomorus lineolatus (Cuvier)	Nonachela (Seer)	Rare
Acanthocybium solandri (Cuvier)	Sawara (Wahoo)	Rare

The oriental bonito *Sarda orientalis* (Temminck and Schlegel) which constitutes a minor fishery in certain parts along the south west coast of India was not encountered off Tuticorin in 1960-1961. During this entire period only one specimen of *Scomberomorus lineolatus* was caught by multiple trolling, while not a single specimen of *S.g.guttatus* was caught by this gear. This is interesting as both these species along with *S.commerson* in the size range 180 to about 700 mm. are caught regularly in bottomset gill nets operated off Tuticorin. *Auxis thynnoides* Bleeker, another species reported from the south west coast of India was not encountered in the catches. One other notable absence in the multiple troll catches off Tuticorin is the bigeye tuna *T(P.) obesus mebachi* Kishinouye, which has a distribution in the tropical waters more or less co-extensive with that of the yellowfin tuna.

In addition to these scombroid fishes, other pelagic fishes such as *Coryphaena hippurus* Linnaeus, *Sphyraena* spp., *Caranx* spp., *Chorinemus* spp., and *Elagatis bipinnulatus* (Quoy and Gaimard) are occasionally taken by trolling.

In a separate contribution presented at this Symposium, Silas and Rajagopalan (1962) have made some observations on billfishes (sailfish and marlins) caught off Tuticorin. For an aid to the identification of tunas and related scombroid fishes caught off Tuticorin, Gulf of Mannar, reference is invited to ' A Systematic review of the scombroid fishes of India ' by Jones and Silas (1962) presented at this Symposium.

Composition of Scombroid Fish in Catch

During 1961 from the time that multiple trolling was commenced in June up to the end of December (total 214 days) day to day observations were carried out at Tuticorin in order to find out the quantity and the species-wise composition of scombroid fishes landed by this gear. It was not possible for me to be in the field on all these days, but I was ably assisted in this by Shri M. S. Rajagopalan. The catch landings showed that on 41 days tunas and other scombroid fishes were caught off Tuticorin using troll lines, but the fishery by multiple trolling was confined to 28 days as follows : 3 in June, 4 in July, 16 in August, and 5 in September. On the other 13 days scombroid fish landings were the result of catches made from boats returning from handline fishing for perches, and using one or two troll lines. In the details of the catch listed date-wise below, it was not possible to estimate the actual number of fish of a particular species on a few days, especially on account of other fishing data which had to be collected. On such occasions, a visual estimate was made of the numbers as follows : 5 or less ; 10 or less meaning 5 to 10 ; 20 or less meaning 10 to 20 ; and ' several ' meaning more than 20 but less than 50. In the following list, the common English names for the species as given by Jones and Silas (1962) is followed, but abbreviated as : FM=short corseletted frigate mackerel ; LT=little tunny ; M=Marlins ; NB=northern bluefin tuna ; SE=seerfish (*S. commerson*) ; SF=sailfish ; WA=wahoo ; and YF=yellowfin tuna.

Month	*Date*	*Species composition*
June	19-6-61	Several SE
	21-6-61	16 NB, 50 LT, 2 YF
	22-6-61	3 FM
July	17-7-61	1 M, 70 NB, 20 LT, 5 FM
	18-7-61	1 SF, 9 NB
	19-7-61	35 NB, 1 YF, 7 LT, 10 SE
	28-7-61	1 SF
	31-7-61	5 or less LT, and NB

Month	*Date*	*Species composition*
August	4-8-61	20 or less LT, and NB, 1 SF
	7-8-61	10 or less LT, and NB
	8-8-61	5 NB, 10 or less LT
	9-8-61	1 NB, 10 or less LT
	10-8-61	5 or less LT
	11-8-61	30 NB, 50 LT, 5 YF
	14-8-61	Several LT, 10 or less NB, 2 YF
	16-8-61	25 LT, 4 NB
	17-8-61	2 NB, 1 SF
	18-8-61	1 M
	19-8-61	Over 300 SF landed after dusk
	21-8-61	Over 200 SF, 10 or less NB, 1 YF
	22-8-61	Several SF, 10 or less NB, 1 YF
	23-8-61	1 WA, 1 M, Several NB
	24-8-61	76 SF, Several YF, 27 NB
	25-8-61	1 SF, 1 M, Several YF, Several NB, 20 or less LT
	30-8-61	1 WA
September	2-9-61	1 SF
	9-9-61	1 SF
	12-9-61	4 NB
	13-9-61	11 NB, 1 YF, 6 LT
	14-9-61	4 NB, 1 YF, 2 LT
	25-9-61	8 LT, 9 NB
	28-9-61	6 NB
	29-9-61	1 NB
	30-9-61	1 LT
October	6-10-61	5 LT
November	14-11-61	1 M
	21-11-61	1 SF
	23-11-61	1 SF
	27-11-61	4 NB
	29-11-61	1 M
December	11-12-61	1 SF

From the above it will be seen that among tunas, the northern bluefin tuna predominated in the catch followed by the little tunny and the yellowfin tuna.

Percentage Composition of Species by Weight in the Catch

It should be mentioned that boats engaged in multiple trolling return at about the same time and the anxiety of the fishermen to have the catch auctioned as early as possible makes it sometimes difficult to weigh and measure all the fish from each boat. At Tuticorin about a dozen auctioners are present at the time when the boats return after fishing, generally between 15.00 and 18.30 hours. The auction is brisk and once the fish is purchased by the retail traders it is difficult to handle the fish for taking data for length, weight, etc. The co-operation of the auctioners was sought and by delaying the auctioning of each lot by a few minutes it was possible to collect a good deal of data. There was no problem when the fish was purchased by merchants for salt curing. It is also customary for fishermen bringing a good catch not to display the entire

TABLE 4

Percentage Composition of Species (Weight)

Name of Species	19-7-61			24-8-61			25-8-61			2-9-61		
	Av. of 5 boats out of 25			Av. of 10 boats out of 35			Av. of 18 boats out of 47			Av. of 2 boats out of 8		
	No. of specimens (Av.)	Actual weight in lbs. (Av.)	% of weight	No. of specimens (Av.)	Actual weight in lbs. (Av.)	% of weight	No. of specimens (Av.)	Actual weight in lbs. (Av.)	% of weight	No. of specimens (Av.)	Actual weight in lbs. (Av.)	% of weight
S. commerson	10 (2)	55 (11)	23.80	13 (1.3)	127 (12.7)	23.3	11	87.25 (4.8)	11.4	1 (0.5)	11.5 (5.7)	46
S.lineolatus	..	..	..	..	..	..	..	10.5 (0.48)	1.4	..	..	..
T.(K.) tonggol	35 (7)	109 (21.8)	47.1	110 (11)	354 (35.4)	64.9	33	126.5 (7.0)	16.6	..	..	..
E.a.affinis	7 (1.4)	24 (4.8)	10.4	19 (1.9)	64 (6.4)	11.74	3	10 (0.5)	1.3	2 (1)	13.5 (6.7	54
T.(N.) albacares macropterus	1 (0.2)	13 (2.6)	5.6	..	..	..	23	377 (20.9)	49.3	..	..	..
A. thazard	1 (0.2)	8 (1.6)	3.5	..	..	..	..	..	..	..	..	..
Elagatis bipinnulatus ..	5 (1)	22 (4.4)	9.5	..	..	..	..	..	..	..	..	..
Sphyraena sp. ..	..	..	..	..	..	..	1	5 (0.27)	0.1	..	..	..
I.gladius	..	..	..	..	..	..	1	36 (2)	4.7	..	..	..
Tetrapturus audax ..	..	..	..	..	..	..	1	112 (6.2)	14.7	..	..	..

catch at one auction, but to do this in lots, and this fact was also taken into account when catch data, auction rates, etc., was studied. In Table 4, the details of the percentage composition of species (weight) and numbers are given for four fishing days for 35 boats sampled at random out of a total of 115 boats. This again would indicate that the northern bluefin tuna was the most common tuna in the catch.

Weight of Fish Caught by Multiple Trolling in Relation to Auction Rates and Earnings of Fishermen

The fish sold at the landing place at Tuticorin to the merchants is not by actual weighing, but by ' eye measure.' Both auctioners as well as wholesale merchants were found to have excellent judgement in estimating weights by ' eye measure ' and this was on several occasions corroborated by actual weighing carried out for the present studies. From Hornell's account (Hornell, 1917) it is seen that this method of appraisement was prevalent even at that time. The prices fluctuated from day to day and this depended not only on the size of the catch, but on the species composition as well. The rates for tunas were the lowest, and during 1961 this was more so on account of the adverse set back in the dry fish trade with Ceylon. The average wholesale price rates per pound avoirdupois reported by Hornell (1917) for these fishes are compared below with the current rates (Table 5). In the same Table, I have also included the rates obtaining during 1959 when the export market for dryfish was very favourable. This information was obtained from the wholesale merchants who purchased the bulk of the catch from multiple trolling for salt curing.

Table 5

Prices per pound avoirdupois of tuna, seerfish, and billfishes at Tuticorin

Name	Rates per pound		
	Hornell (1917)	1959	1961
Seerfish	2½ - 3 annas** (= 15 - 19 P.)	12 - 14 annas** (= 75 - 87 P.)	8 - 10 annas** (= 50 - 62 P.)
Little tunny & Northern bluefin tuna	1½ - 2 annas (= 9 - 12 P.)	8 - 9 annas (= 50 - 56 P.)	4½ - 5 annas (= 28 - 31 P.)
Yellowfin tuna ..	1½ - 2 annas (= 9 - 12 P.)	-Do-	5 - 5½ annas (= 31 - 34 P.)
Marlins and sailfish ..	1 anna (= 6 P.)	-Do-	4½ - 5½ annas (= 28 - 34 P.)

** 16 annas = 100 paise = 1 rupee.

The retail price for fresh seerfish, tunas and marlins at Tuticorin during 1961 was as follows: Seerfish=Rs. 1.25 to 1.50 ; and Tunas, marlins and sailfish from 75 P. to Re. 1 per pound.

In Table 6, information regarding weight of fish caught, actual auction price rates, estimated income per head per fishing trip for multiple trolling, etc. are given. The wide fluctuations in the catch, both species-wise as well as in quantity, and the low income per head for the hours of work are noticeable.

TABLE 6

Details of Weight of Fish landed by Multiple Trolling in relation to auction rates and earnings of Fishermen per head per day' fishing

Details	Dates 19-7-61	24-8-61	25-8-61	2-9-61	Average of 4 days
Actual No. of boats fishing	25	35	47	8	28.72
No. of boats sampled	5	10	18	2	8.72
Actual weight of fish landed in boats sampled (Lbs.)	231	545	764.25	25	391.31
Average weight of fish landed per boat (Lbs.)	46.2	54.0	42.45	12.5	37.78
Estimated total wt. of fish landed by all boats (Lbs.)	1155	1890	2202.2	100	1336.75
Actual price fetched at auction for catch sampled (Rs. P.)	78.00	203.00	213.25	6.00	125.06
Value of fish landed (Average) per boat	15.60	20.30	11.84	3.00	12.68
Estimated total value of fish landed by all boats	488.00	710.50	556.48	24.00	434.49
Average number of men per boat** ..	8	8	8	8	8
No. of hours at sea (Sailing time + actual fishing-approximate)	16	16	16	16	16
Income per head per fishing trip (Rs. P.)..	1.95	2.53	1.48	0.37	1.58

** The smaller boats using 7 troll lines had generally 7 or 8 crew and the larger boats operating 9 troll lines had 8 or 9 crew. Of these, usually 2 or 3 were boys.

OBSERVATIONS ON THE SPECIES OF TUNAS AND RELATED FISHES

1. **Thunnus (Kishinoella) tonggol** Bleeker

(Northern bluefin tuna or the Indian longtailed tunny)

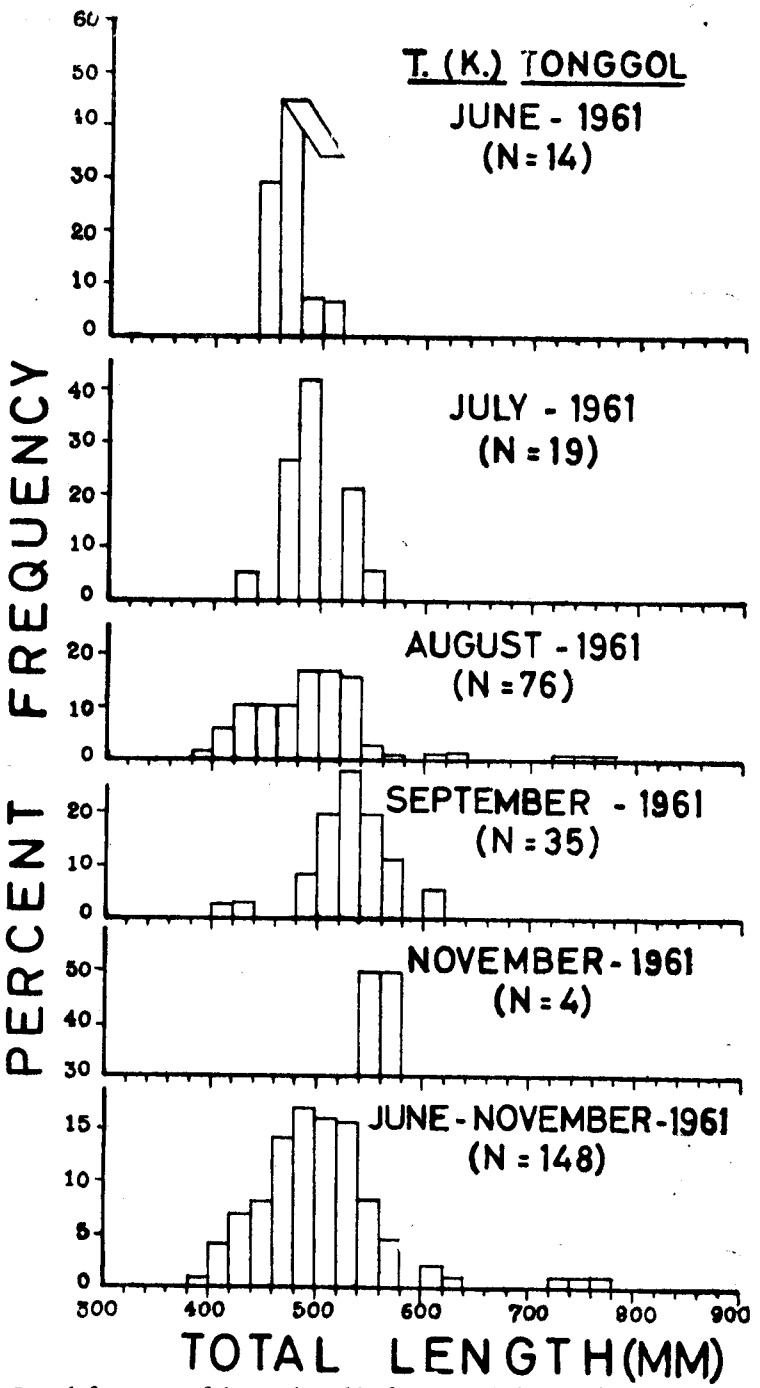
MATERIAL : During the 1960 and 1961 seasons over 250 specimens in the size range 395 to 775 mm. weighing from 2 to 15 pounds were examined. The catch in 1960 was sporadic. The length frequency of 148 specimens in the above size range landed in 1961 (June to November) is shown in Fig. 11. The total length in tunas refer to length from tip of snout to end of hypural.

DESCRIPTION :

Meristic counts :

D1. XII-XIII ; D2+ finlets 14+8-9 ; P1. 31 ; A+finlets 14+8 ; Gill rakers 6-8+16-19.

Published records show hardly any difference in the finray counts for *T.* (*K.*) *tonggol* from various parts of the Indo-Pacific. However, there appears to be regional differences in the modal formulae for the number of gill rakers, and as such this character is dealt with at some length here. The frequency of gill raker counts for the material examined from off Tinnevelly Coast is given in Tables 7 and 8.



TEXT FIG. 11. Length frequency of the northern bluefin tuna *T.(K.) tonggol* (Bleeker) caught by multiple trolling off the Tinnevelly Coast for the months June to November, 1961.

TABLE 7

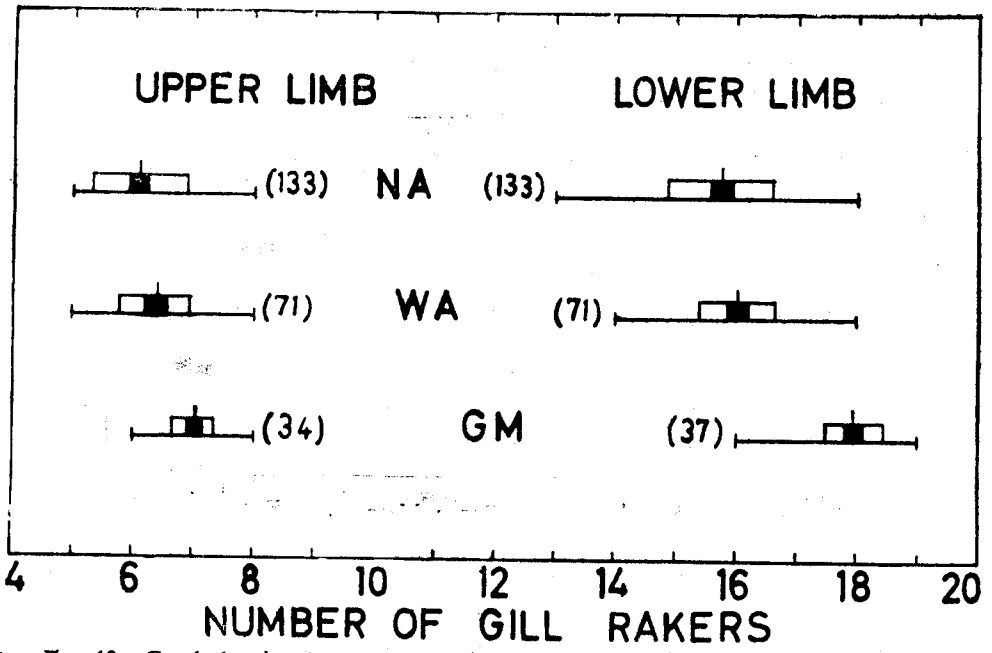
Frequency of gill raker counts

Counts	Upper Limb			No. of specimens	Lower limb				No. of specimens	Combined frequency						No. of specimens
	6	7	8		16	17	18	19		22	23	24	25	26	27	
No. of specimens	5	23	6	34	2	6	21	8	37	1	3	7	16	9	1	37

TABLE 8

Frequency of combination of gill rakers on upper and lower limbs of outer gill arch

Lower limb \ Upper limb	No.	6	7	8
	16	1	1	..
	17	2	5	..
	18	4	12	5
	19	..	6	1



TEXT FIG. 12. Graph showing the variation in the total number of gill rakers on the upper and lower limbs of the outer gill arch of *T.(K.) tonggol* from Northern Australia (NA), Western Australia (WA) ; and the Gulf of Mannar (GM). (The horizontal line represents the total range ; the short vertical line the mean ; the solid rectangle two standard errors on each side of the mean and the hollow rectangle one standard deviation on either side of the mean). The number of specimens are indicated in parenthesis.

The modal formula of 7+18 (=25) differs markedly from that given for a good series of specimens from Western Australia by Serventy (1956). A statistical comparison of the gill raker counts he has given for the northern bluefin from Northern and Western Australia shows no significant difference, but this is not the case when we compare the counts for the Australian specimens with those from the Gulf of Mannar. In table 9, the *t* values were calculated using the formula :

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

where $\bar{x}_1$ and $\bar{x}_2$ are the means, s_1^2 and s_2^2 the standard deviations, and n_1 and n_2 the number of specimens. For the Western Australian and Gulf of Mannar samples the *t* value was calculated to be 10.92 and 3.82 for the gill rakers of the lower and upper limbs respectively, both showing highly significant difference as *P* at 5% level is 1.96. When *t* was calculated for the two samples collected at Western and Northern Australia, it was much lower at the 5% level for the gill rakers of the upper (1.7692) and lower (2.5274) limbs indicating the likelihood of the samples belonging to the same population, though slightly significant difference is noticeable in the number of gill rakers on the lower limb (Table 9). A graphical presentation of the data is given in Fig. 12.

The scope of the present work, besides drawing attention to this significant difference, does not permit further elaboration, especially as there is hardly any data for the intervening area (Indonesian waters). As the species was originally described from the 'Sea of Batavia', data from this area is vital for delimiting the distributional ranges of the subpopulations in this region. Ranade (1961) has detected some difference in the gill raker counts in the specimens of *T. (K.) tonggol* collected off Ratnagiri coast, south of Bombay, but has not presented data to enable detailed comparisons.

28 specimens of *T. (K.) tonggol* collected between 21-6-61 and 14-9-61 were examined for sex and maturity. Of these 14 were females of 430 to 728 mm. in length and 10 males measuring 445 to 743 mm. and 4 sex indeterminable. But for one female 728 mm. (10.5 pounds) and one male 743 mm. (13 lbs.), all specimens were immature, the maturity of gonads corresponding to stages I, II, and III (as defined by Marr and Schaefer, 1948 : *U.S. Fish Wildlife Service Fisher. Bull.*, 47 : 241-44). The large female mentioned above had spent and flacid ovaries weighing 29 gms.

TABLE 9

Comparison of Gill Raker counts between samples of *T.(K.) tonggol* from Gulf of Mannar and Australian Waters[1]

A

Characters	*Northern Australia*					*Western Australia*					Difference between means	t	P
	No.	Range	Mean	σ	σM_1	No.	Range	Mean	σ	σM_2			
Upper limb	133	5-8	6.11	7.6505	0.6634	71	5-8	6.39	5.9161	0.7021	0.28	2.5274	P at 5% level is 1.96
Lower limb	133	13-18	15.74	8.4445	0.7322	71	14-18	16.04	6.2370	0.7402	0.30	1.7692	

B

Characters	*Gulf of Mannar*					*Western Australia*					Difference between means	t	P
	No.	Range	Mean	σ	σ_{M_1}	No.	Range	Mean	σ	σ_{M_2}			
Upper limb	34	6-8	7.03	3.3166	0.5688	71	5-8	6.39	5.916	0.7021	0.64	3.82	P at 5% level is 1.96
Lower limb	37	16-19	17.95	4.6797	0.7693	71	14-18	16.04	6.2370	0.7402	1.94	10.92	

[1] For Australian waters data is based on information given in Serventy (1956).

FOOD OF *T.(K.) tonggol* :

Altogether 40 specimens were examined as under : on 21-6-61 (10) ; 19-7-61 (6) ; 4-8-61 (4) ; 17-8-61 (2) ; 21-8-61 (1) ; 24-8-61 (13) ; 25-8-61 (2) ; and 14-9-61 (2).

The visual grading of the fullness of the stomach for the 40 specimens was as follows :

Grading	*Per cent*
Empty	27.5
Trace	32.5
$\frac{1}{4}$+ or −	37.5
$\frac{1}{2}$+ or −	—
$\frac{3}{4}$+ or −	—
Full (gorged)	2.5

From Table 10, it will be seen that both from the number of occurrences as well as the actual volume, squids constituted the most important item among the food organisms of *T.(K.) tonggol* caught by multiple trolling. Since most of the balistid fish (*Sufflamen capistratus*) were almost fresh in the stomachs, it has been possible to compare the sizes of these fishes in the stomach contents of the northern bluefin and the yellowfin tunas (Fig. 14 and Table 14).

TABLE 10

Food of *Thunnus (Kishinoella) tonggol* Bleeker

Constituents	Occurrence No.	Occurrence %	Actual volume (c.c.)	Actual numbers of food organisms
Crustacea				
Stomatopod larvae	3	7.5	0.1	6
Mysids	2	5.0	Trace	2
Megalopa	4	10.0	5.0	180
Other crustacean remains	3	7.5	0.5	..
Mollusca				
Pteropods (*Clavolina* sp.)	1	2.5	0.3	6
Squids (Ommastrephidae)	11	27.5	187.2	22
Fishes				
Anchoviella spp.	3	7.5	14.5	10
Sardinella spp.	2	5.0	7.0	2
Other clupeoids	5	12.5	10.6	..
Syngnathidae	1	2.5	0.2	1
Cypsilurus sp.	1	2.5	11.0	1
Trichiurus lepturus	1	2.5	15.0	1
Juvenile scombroid fish	1	2.5	Trace	2
Lutjanus sp.	1	2.5	0.5	1
Sufflamen capistratus	8	20.0	48.9	18
Skeletal remains of fish	6	15.0	14.9	..

2. **Thunnus (Neothunnus) albacares macropterus** (Temminck & Schlegel) (Yellowfin tuna)

MATERIAL :

During the 1960 and 1961 seasons this species was caught only during very restricted periods, but mostly with good catches of *T.(K.) tonggol*. The length frequencies of the specimens landed for the months June to September 1961 are shown in fig. 13. The specimens caught measure from 553 to 860 mm. in total length and weigh from 7.5 to 26 pounds.

DESCRIPTION :

Meristic counts :

D1. XIII-XV ; D2+finlets - +8 - 9 ; A+finlets - +8 - 9 ; gill rakers 8 - 10+19 - 22.

For the frequency of gill raker counts (of outer gill arch of right side) see tables 11 and 12.

TABLE 11

Frequency of gill raker counts

Counts	Upper limb			No. of specimens	Lower limb				No. of specimens	Combined frequency				No. of specimens
	8	9	10		19	20	21	22		28	29	30	31	
No. of specimens	9	7	4	20	2	4	10	7	23	2	7	7	4	20
%	45	35	20		8.7	17.4	43.4	30.4		10	35	35	20	

TABLE 12

Frequency of combination of gill rakers on upper and lower limbs of outer gill arch

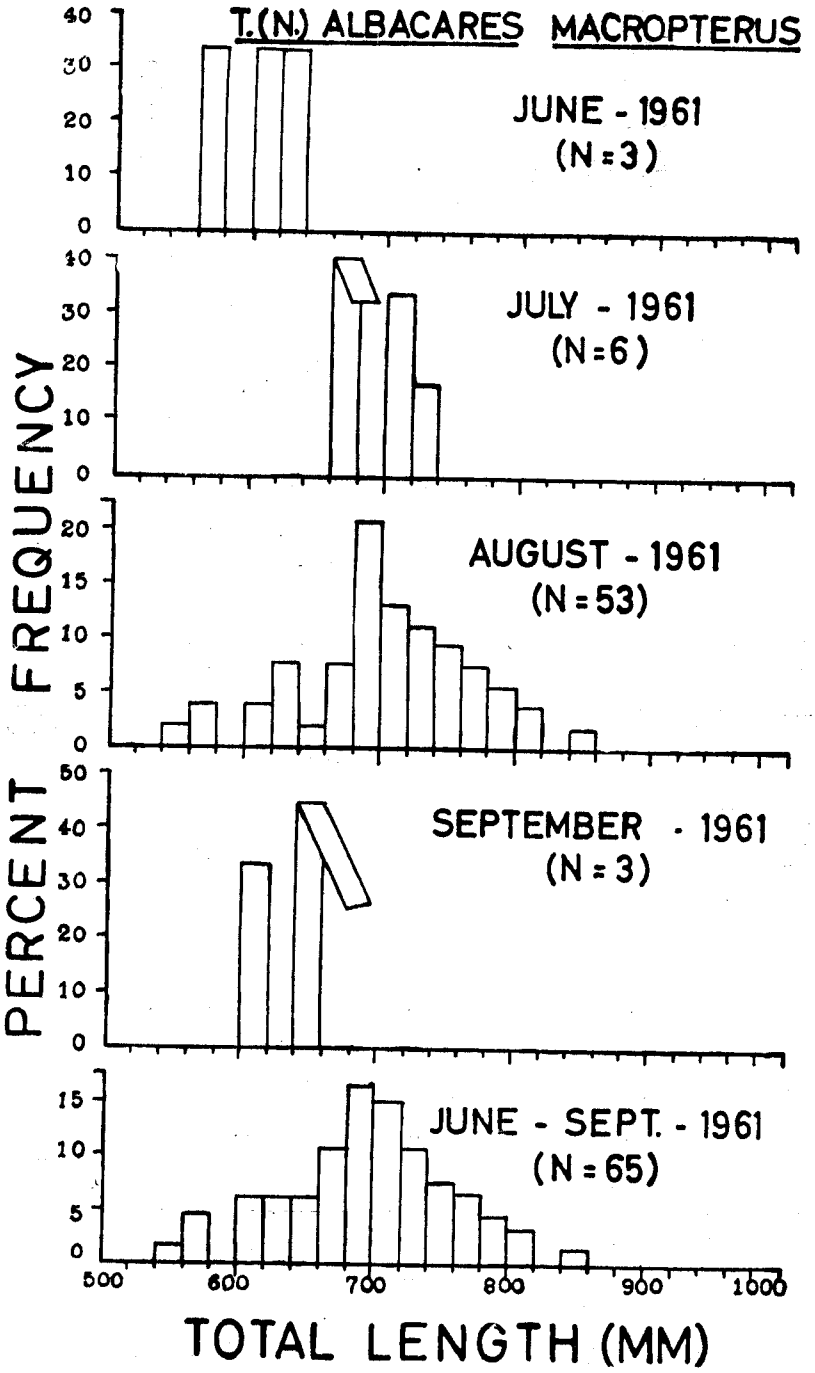
		Upper limb		
	No.	8	9	10
Lower limb	19	..	1	1
	20	1	1	1
	21	4	3	2
	22	4	2	..

The most frequent counts are 8 - 9+21 - 22 (=29 - 30).

Of the 22 specimens sexed, 7 were males and 15 females ; the males measuring from 562 to 744 mm. (mean 644.4 mm.) and the females from 580 to 816 mm. (mean 685.25 mm.). The larger females caught in August 1961 measuring upto 700 mm. were found to be in stages I to III of maturity, the weights of the ovaries varying from 7.5 to 35 gms. Two specimens, 740 and 782 mm. had spent recovering ovaries.

FOOD OF *T.(N.) albacares macropterus* :

Altogether 49 specimens were examined as follows : 27-7-60 (4) ; 20-6-61 (2) ; 10-7-61 (1) ; 19-7-61 (1) ; 11-8-61 (5) ; 23-8-61 (7) ; 24-8-61 (4) ; 25-8-61 (24) ; and 13-9-61 (1).



TEXT FIG. 13. The length frequency of the yellowfin tuna caught by multiple trolling off the Tinnevelly Coast during the Months June to September, 1961.

The visual grading of the fulness of the stomach for the 49 specimens was as follows :

Grading	*Per cent*
Empty	20.4
Trace	18.4
¼ + or −	53.1
½ + or −	4.1
¾ + or −	2.0
Full (gorged)	2.0

From the following Table (Table 13) it will be seen that from the number of occurrences as well as actual volume of the food balistid fishes constituted the most important food item followed by squids. As in the case of the northern bluefin, a great majority of the balistid fishes were undigested indicating that the fish had been feeding just before it was caught. It was interesting to find that the specimens of *Sufflamen capistratus* from the stomach of the yellowfin were relatively larger than those found in the stomachs of the northern bluefin (Fig. 14, and table 14).

TABLE 13

Food of yellowfin tuna

Constituents	Occurrence No.	Occurrence %	Actual vol. (c.c.)	Actual No. of food organisms
Crustacea ..				
Stomatopod larvae	4	8.163	6.00	27
Penaeidae	1	2.040	0.50	1
Mollusca				
Squids (Ommastrephidae)	14	28.571	249.50	24 + 7 pairs of Mandibles (beaks)
Salps	2	4.081	0.40	2
Fishes				
Anchoviella spp.	3	6.122	7.00	4
Sardinella spp.	9	18.367	48.00	10 (not bait)
Caesio sp.	1	2.040	0.50	1
Sufflamen capistratus	24	48.979	362.10	74 of which 41 were fresh
Balistis sp.	1	2.040	10.00	2
Carangids	3	6.122	41.90	3
Fish remains (unidentifiable)	4	8.162	18.20	4

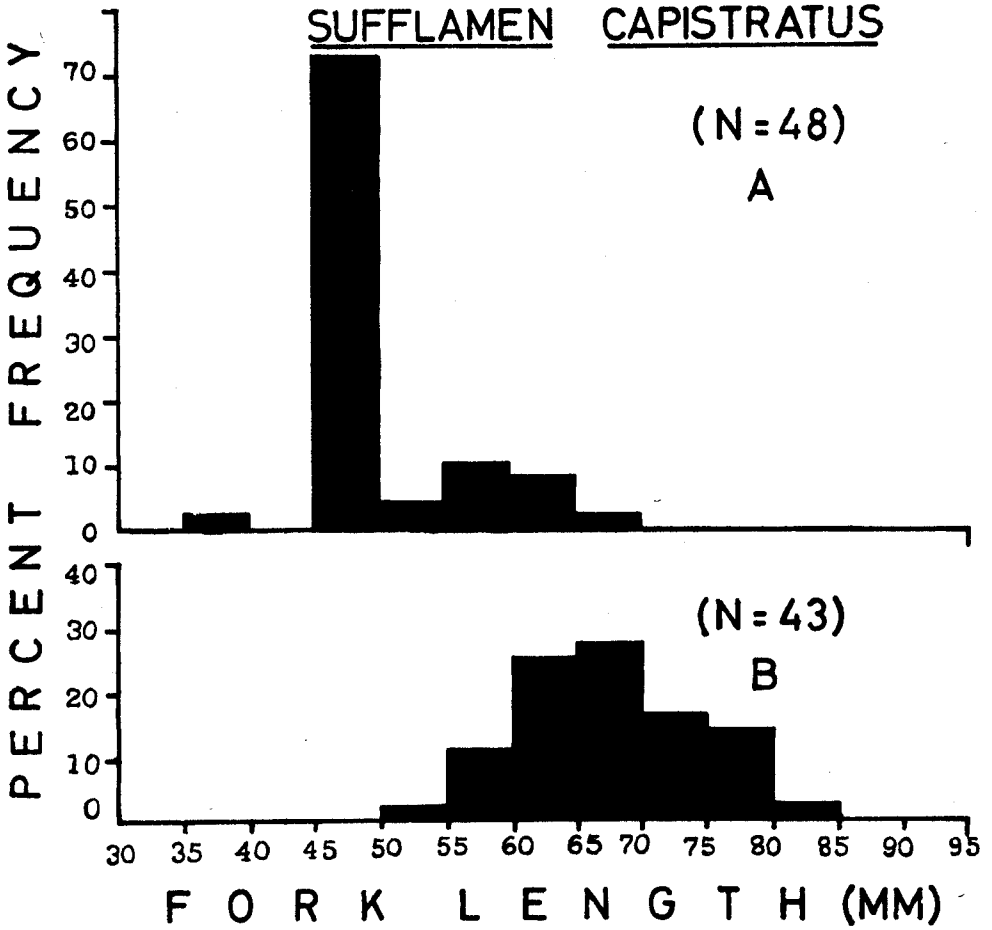
TABLE 14

Size ranges of yellowfin and northern bluefin tuna and the balistid fish *Sufflamen capistratus* found in their stomachs

	Predator-species			Prey-species (*Sufflamen capistratus*)		
Species	No.	Range* (mm.)	Mean (mm.)	No.	Range (mm.)	Mean (mm.)
Northern bluefin tuna	8	460-650	530	18	35-66	56.92
Yellowfin tuna	24	558-816	676	74	54-83	66.16

* The length of tunas refer to only those species in which *S.capistratus* was occurring as a food item in the stomach.

One of the yellowfin caught on 25-8-61, measuring 553 mm. weighed 7 pounds. The fish looked slightly different from several others caught on the same day. When it was filleted for



TEXT FIG. 14. The length frequency and numbers of the balistid fish *Sufflamen capistratus* found in the stomachs of (A) northern bluefin tuna and (B) yellowfin tuna caught by multiple trolling off the Tinnevelly coast.

salt curing, the entire flesh was found to be profusely studded with whitish spore-like rounded bodies. Although the fish was fresh, the flesh was 'jelly-like' and very pale in colour, unlike the usual red. Such infestation was not encountered in other yellowfin or in any of the other tunas landed at Tuticorin during 1960 and 1961.

3. **Euthynnus affinis affinis** (Cantor)

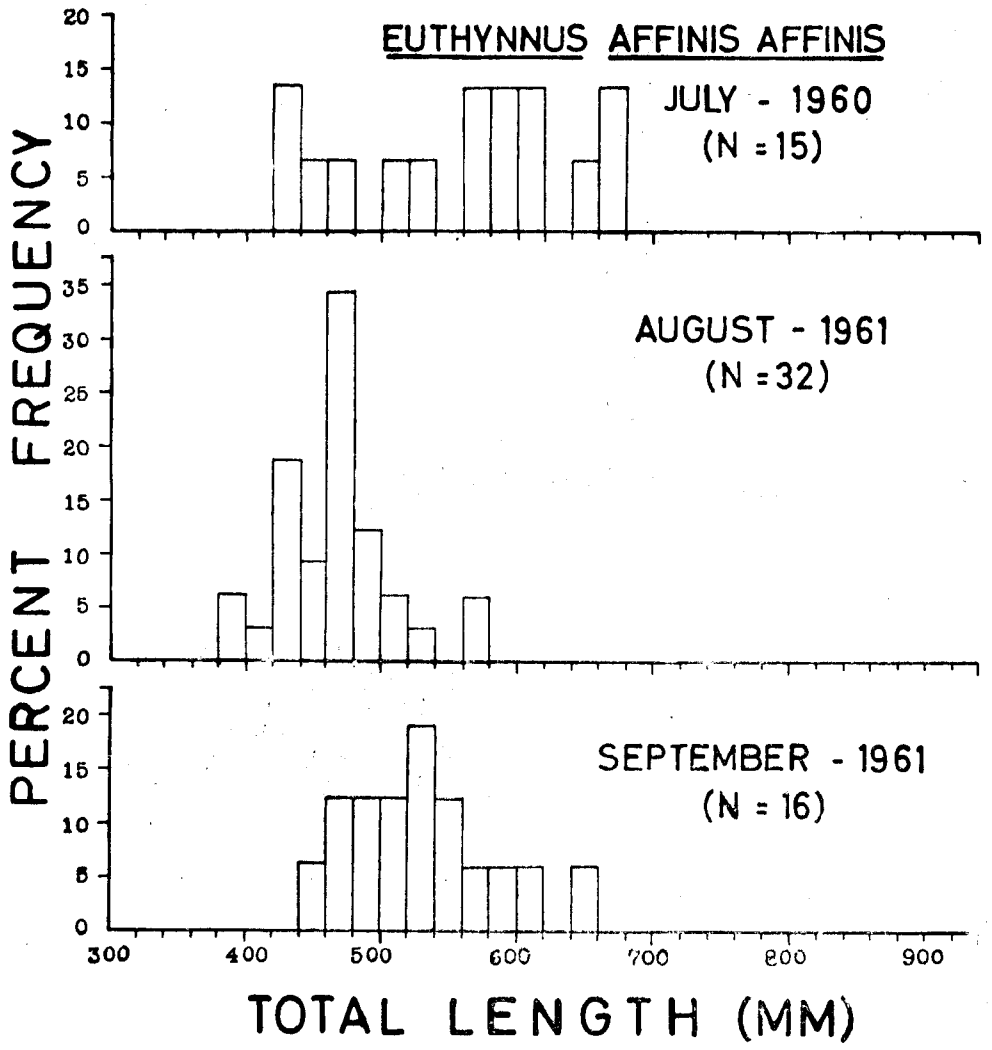
(Little tunny or mackerel tuna)

MATERIAL :

Next to *T.(K.) tonggol*, this was the most common species of tuna landed at Tuticorin by multiple trolling. Detailed data could not be collected for this species, but the length frequency of specimens caught in July 1960 and in August-September 1961 is shown in Fig. 15. The fish caught during the 1961 season were from 396 to 678 mm. in total length, weighing 1.75 to 12 lbs.

DESCRIPTION :

For specimens in the size range 423 to 678 mm., the frequency of gill raker counts are given in tables 15 and 16.



TEXT FIG. 15. The length frequency of the little tunny caught by multiple trolling off the Tinnevelly coast during July 1960 and August-September 1961.

TABLE 15

Gill rakers on outer arch of right side																					
Upper limb				No.	Lower limb						No.	Combined frequency					No.
6	7	8	9		20	21	22	23	24	25		28	29	30	31	32	
1	8	7	3	19	1	1	4	6	5	1	18	1	3	3	7	4	18

TABLE 16

Frequency of combination of gill rakers on upper and lower limbs

Lower limb \ Upper limb	6	7	8	9
20	..	..	1	..
21	..	..	1	..
22	..	1	1	2
23	1	2	2	1
24		3	2	..
25	..	1	..	..

25 specimens examined for sex and maturity in July 1960 showed that 5 were females measuring 534 to 637 mm. (mean 585 mm.) and the rest males measuring 437 to 636 mm. (mean 547 mm). Some of the large males had loose milt, while all females had spent recovering ovaries.

No detailed observations were made of the stomach contents of this species. However, field observations made at the time that the fishes were cut for salt curing showed that roughly 10% of the stomachs were empty. A great majority of those with food were found to be $\frac{1}{2}+$ or $-$, to Full (gorged) with reddish shrimps (euphausiids and penaeids). A few stomachs had remains of squids, cuttlefish and stomatopod larvae. Partly digested fish remains mainly of clupeoids were present in a few stomachs, but unlike the yellowfin and the northern bluefin tunas, no Balistidae were seen in the stomachs examined.

4. **Auxis thazard** (Lacépède)

(Short corseletted frigate mackerel)

On 22-6-61 three specimens measuring 384,395, and 400 mm., weighing 2.25, 2.5, and 2.75 lbs. respectively were caught. The gill raker counts for these specimens are as follows : 10+29 for 2 specimens and 8+29 for one.

On 17-7-61, five specimens of this species were landed, but could not be examined in detail. Daily observations made during the 1960 and 1961 seasons showed that the species was very rare in the multiple troll catches. One reason may be that the size of the hook and lures used in trolling are too large for this species.

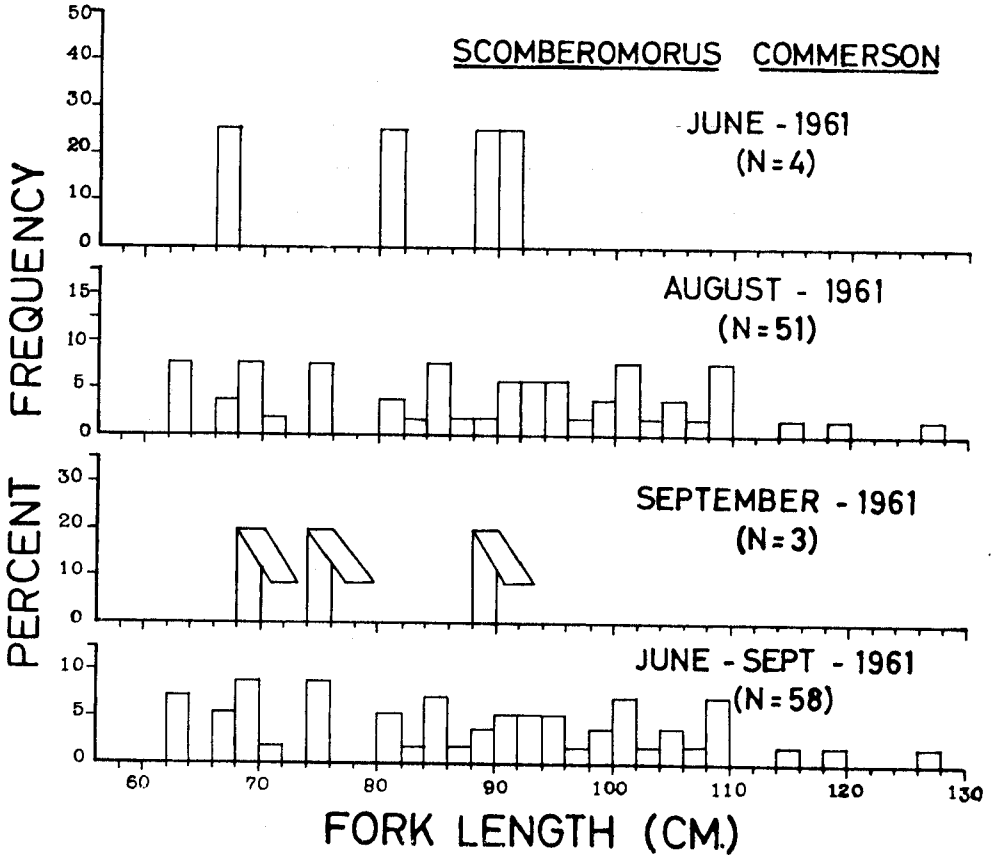
5. **Scomberomorus commerson** (Lacépède)

(Seerfish)

During the 1960 and 1961 multiple troll fishery seasons, there were fairly good landings of seerfish, especially between 19-8-61 and 25-8-61. The length frequency of specimens caught in June, August and September 1961 is given in fig. 16.

6. **Scomberomorus lineolatus** (Cuvier)

Only one specimen (Pl. II fig. C) was caught by multiple trolling on 25-8-61, measuring 845 mm. and weighing 10.5 lbs.



TEXT FIG. 16. The length frequency of 58 specimens of seerfish caught by multiple trolling off the Tinnevelly coast.

Small specimens of this species upto a length of 500 mm. along with similar sized specimens of both *S.commerson* and *S.g.guttatus* are regularly caught during the multiple troll fishery seasons in gill nets operated 5 to 12 miles off Tuticorin in depths upto about 10 fathoms.

7. **Acanthocybium solandri** (Cuvier)

(Wahoo)

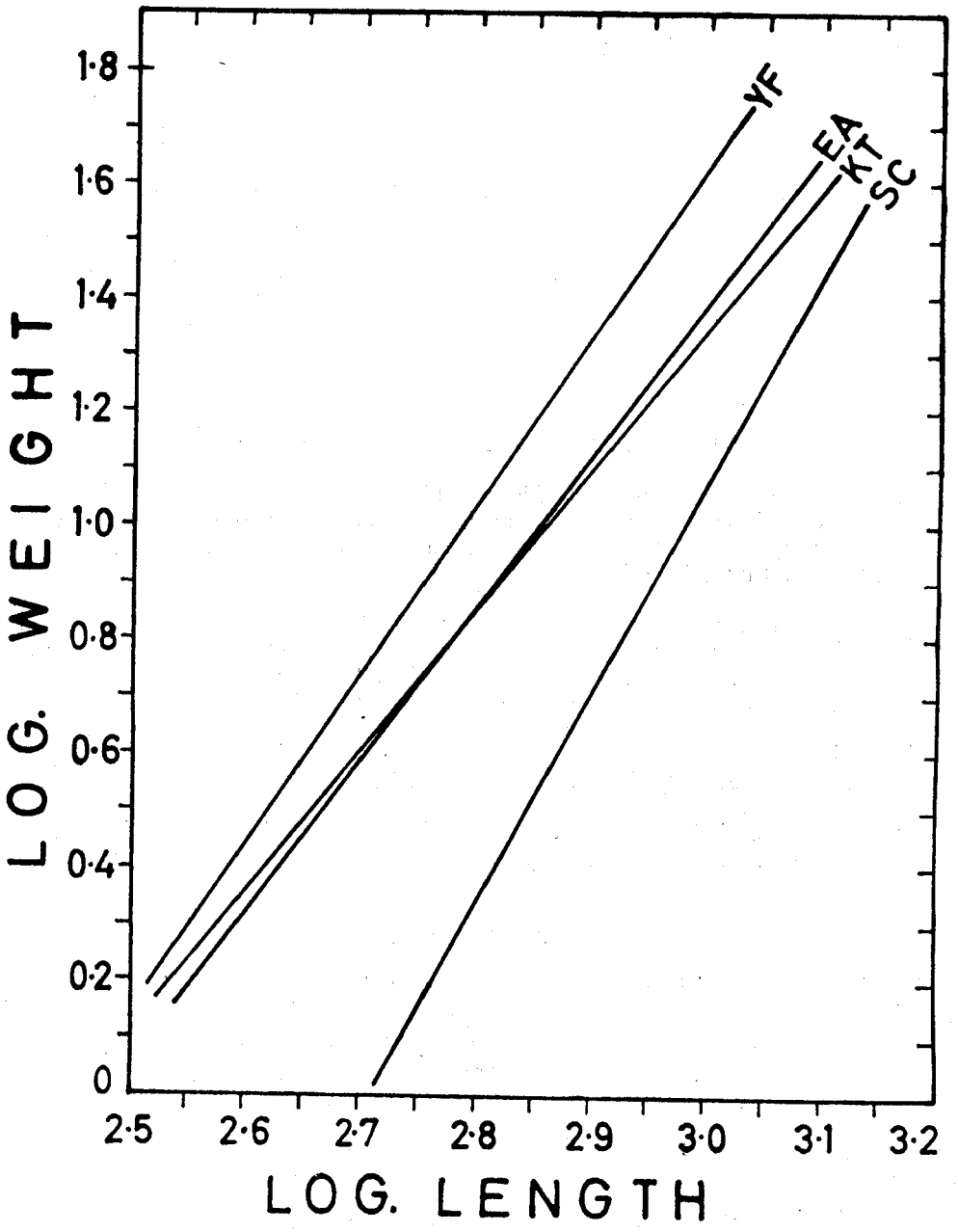
Three specimens were caught during the 1960 and 1961 seasons as follows :

21-7-60 : Length 844 mm. Weight 12.5 lbs.
23-8-61 : Length 1540 mm. Weight 36 lbs. Sex female.
30-8-61 : Length ab. 1600 mm. Weight ab. 38 lbs.

The stomachs of the first two specimens mentioned above contained semidigested remains of fish. The larger of these two fetched Rs. 11.50 at auction. In this specimen, the ovaries were

distended, turgid, with translucent eggs showing through the ovarian wall, but no loose eggs were seen in the lumen of the lobes.

I was told that during certain years a large number of *A.solandri* are caught in multiple trolling off Tuticorin. Even so, when compared to *S.commerson*, the species is rare.



TEXT FIG. 17. The logarithmic relation of length and weight in three species of tunas and the seerfish landed by multiple trolling at Tuticorin. YF=yellowfin tuna, *T. (N.) albacares macropterus*; EA=little tunny, *E. affinis affinis*; KT=Northern bluefin tuna, *T. (K.) tonggol*; and SC=Seerfish, *S. commerson*.

Length-Weight Relationship of Tunas and Seerfish Caught by Multiple Trolling

The weight and length were related by using the equation of the form :

$$\log W = a + b \log L$$

where *a* and *b* are constants. The equation was found to be linear and the regression coefficient was tested for the linearity. The regression equations obtained were as follows :

1. Yellowfin tuna : $\log W = -7.3781 + 3.0056 \log L$
2. Northern bluefin tuna : $\log W = -6.1708 + 2.5128 \log L$
3. Little tunny : $\log W = -7.5442 + 3.0287 \log L$
4. Seerfish : $\log W = -7.0771 + 2.7536 \log L$

The increment in weight per unit length is higher in the yellowfin tuna (YF) than in the little tunny (EA) and the northern bluefin tuna (KT). In the case of the latter, two species, after a length of about 630 mm. (log L=2.8) and weight of 7.25 lbs. (log. W=0.86) (see Fig. 17) the increment in weight per unit length is slightly greater in the little tunny than in the northern bluefin tuna. In the case of the seerfish, the rate of increment in weight per unit length is higher than in the three species of tunas.

Other Fishes Caught by Multiple Trolling

Only two other species, *Coryphaena hippurus* Linnaeus and *Elagatis bipinnulatus* (Quoy and Gaimard) were occasionally caught by multiple trolling during the 1960 and 1961 seasons. Species of *Caranx*, *Sphyraena* and *Chorinemus*, though known to be caught by trolling, were not landed by this gear during this period.

C. hippurus fetches a very low price at auction at Tuticorin. The flesh of the species rapidly deteriorates and is considered inferior for salt curing. Surprisingly, this species was rare in the multiple troll catches, although boats returning from handline fishing frequently caught a few by using one or two troll lines. On 14-9-61, two specimens of *C.hippurus* caught measured 710 and 740 mm. weighing 7.5 and 8 lbs. respectively. The stomach of the smaller specimen contained a partly digested squid, while the larger specimen had semidigested remains of stomatopod larvae, other crustaceans, parts of a squid, and a few pupils of fish eyes.

A few specimens of *E.bipinnulatus* were caught during the 1961 season, and the examination of the stomachs showed the presence of large numbers of the pelagic mollusc *Clavolina* sp.

Concluding Remarks

It should be mentioned here that the collection of data of fish landed by multiple trolling is rather difficult since the fishermen as well as the merchants do not look upon favourably the handling of fish by others. The auction is brisk and the retail merchants purchasing the fish for local markets or to be sent to the interior markets do not generally permit handling of the fish even for taking length and weight data. Hence, most of the data had to be collected at the time the fish were spread out for auctioning through the good will of the auctioneers who delayed the proceedings a few minutes each time, and with the help of the wholesale merchants when they purchased the fish for salt curing.

The considerable fluctuations in this fishery from year to year is not chiefly on account of the non-availability of the fish in the fishing grounds, but due to natural and other causes which play an important part in the actual fishing effort. It is felt that the fishing grounds could be considerably extended to over deeper waters if multiple trolling could be carried out from

mechanised boats or sail boats fitted with suitable motors for plying to and from the fishing grounds. Exploratory longlining for tunas in the area 40 to 80 miles off the Tinnevelly coast (opposite Virapandianpattanam and Manapad) during the fishing season, especially from June to August should give favourable results.

The present investigations show that there has been little change in the fishery from the time it was completely taken over by the Tuticorin fishermen nearly fifty years ago. A shift in the main fishing season from November-January to June-August is seen at present, and this reflects partly on the skill of the fishermen to brave the unpredictable weather in the Gulf during the South West Monsoon. While the quantity of tunas and related fishes landed by multiple trolling at present is not great, it is hoped that this account will help in drawing attention to an area where improvements in the methods of fishing could be effected for the development and utilization of the available resources.

ACKNOWLEDGEMENT

I have great pleasure in thanking Dr. S. Jones, Director, Central Marine Fisheries Research Institute, Mandapam Camp for giving me all facilities for working at the Institute, and for his kind encouragement. In the course of my field investigations, I have been ably assisted by Mr. M. S. Rajagopalan and Mr. S. Mahadevan and other members of the Central Marine Fisheries Research Unit at Tuticorin to whom my thanks are due. I wish to also thank Mr. S. K. Dharmaraja for the help rendered in the statistical calculations.

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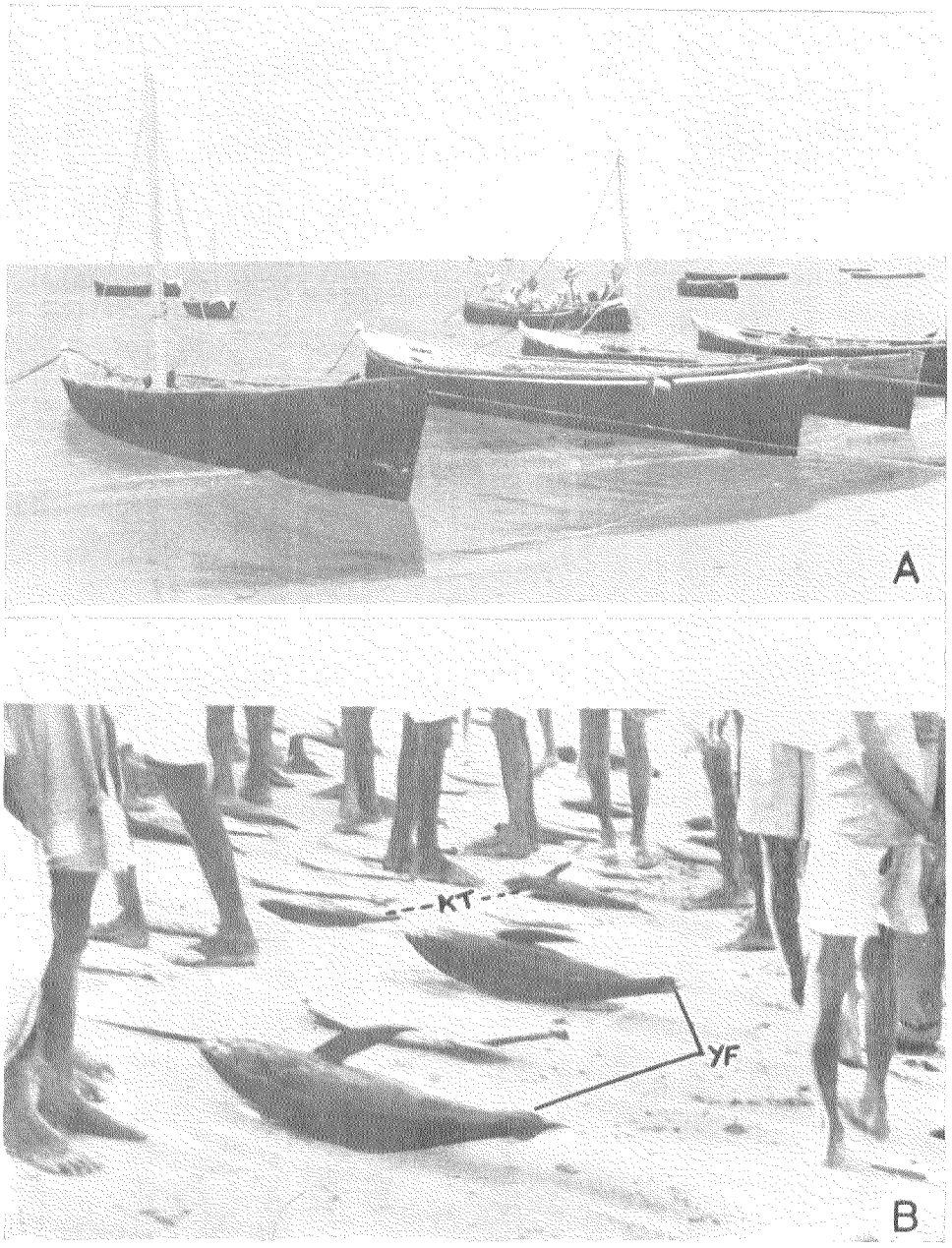


PLATE I. A. 'Tuticorin-type' fishing boats used also for multiple trolling; B. Yellowfin tuna (YF), northern bluefin tuna (KT), and a few carangids spread out on the beach at Tuticorin prior to auctioning. All tunas were caught by multiple trolling, and the carangids by handline fishing (Photos : E. G. Silas).

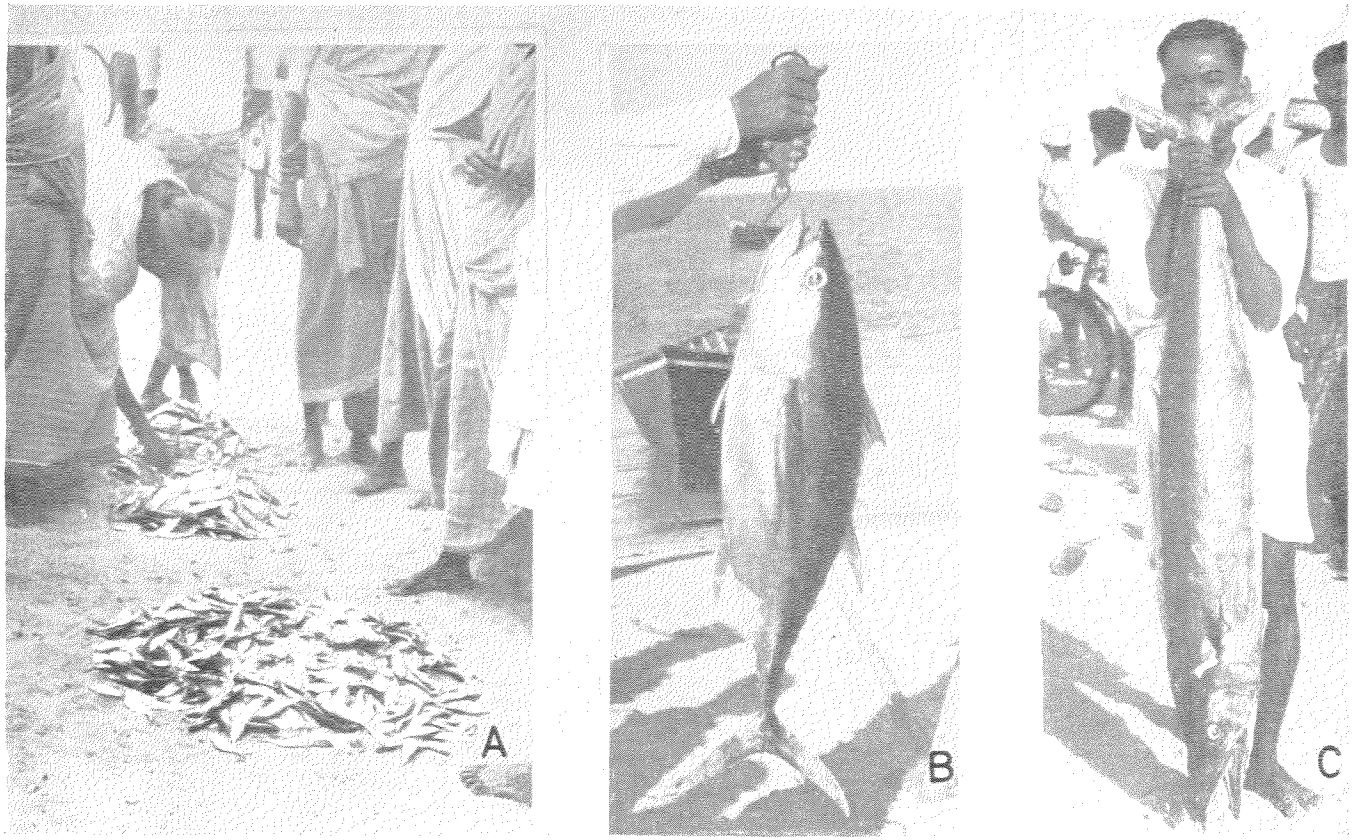


PLATE II. A. Balance of bait (*Sardinella* spp.) being re-auctioned after the day's multiple trolling. The photo shows three such lots from three boats on a bad day's fishing ; B. Yellowfin tuna (640 mm.) ; C. *Acanthocybium solandri* weighing 36 lbs. caught by multiple trolling (Photos : E. G. Silas).

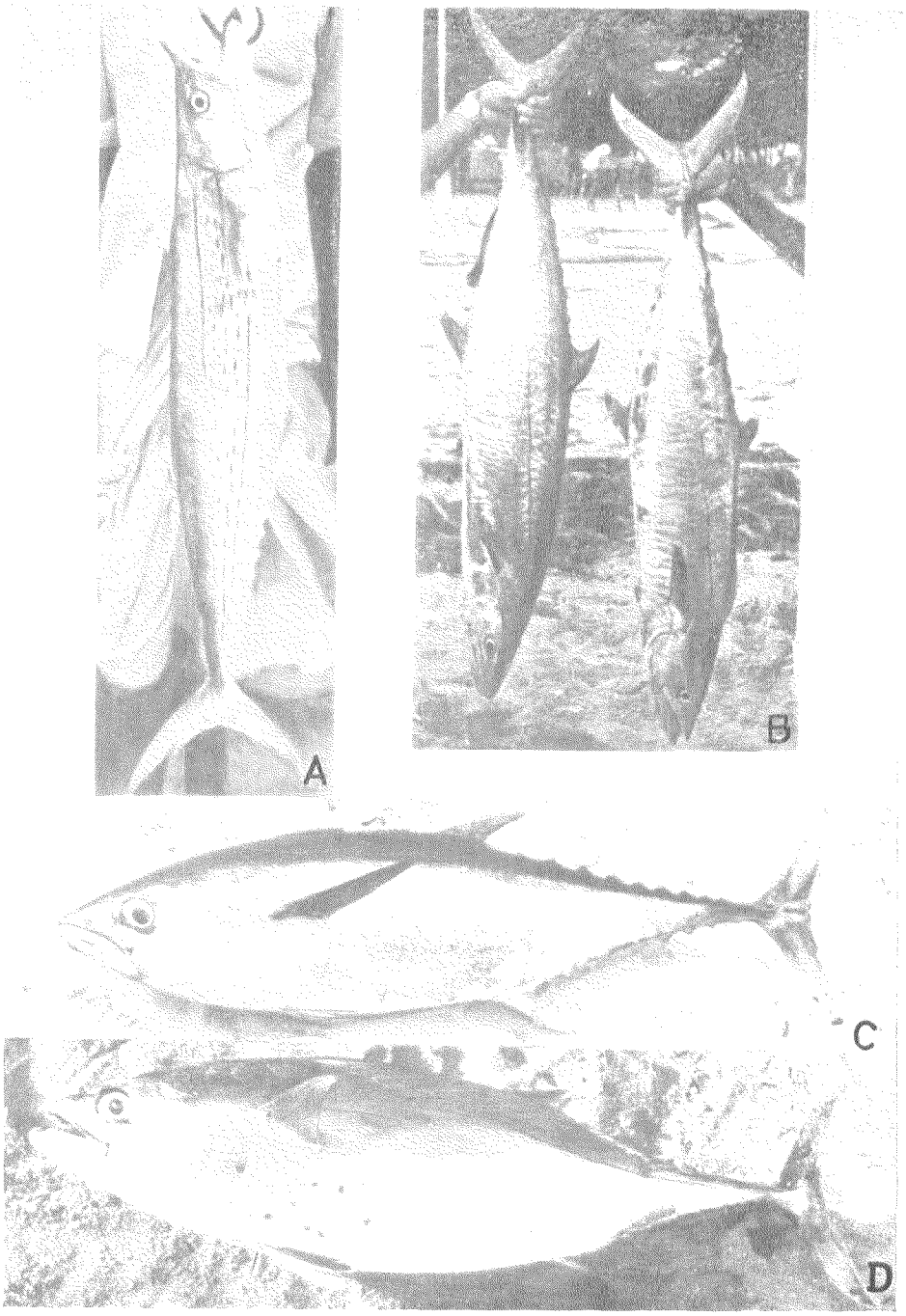


PLATE III. A. *Scomberomorus lineolatus*, 845 mm. in length ; B. Two *S. commerson*, the right—a male (775 mm.) and the left—a female (945 mm.) ; C. *Thunnus* (*Kishinoella*) *tonggol*, 650 mm. ; and D. *Euthynnus a. affinis*, 600 mm. All fish were caught by multiple trolling. (Photos : E. G. Silas).

ON THE SAILFISH AND MARLINS OF THE TUTICORIN COAST*

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INTRODUCTION

Billfishes (Istiophoridae and Xiphiidae) form part of the marine fishery resource commercially exploited by some nations, notably Japan, from parts of the Indo-Pacific. Most of the fishery for billfishes from various parts of the Indian Ocean is carried out by the Japanese and Catch statistics published from Japan (Ann. 1959) indicate the occurrence of rich fishing grounds for billfishes even within a few miles off the Indian coasts during certain seasons. However, little attention has been paid by Indian workers towards the study of the billfishes occurring in the Indian seas, and as such hardly any data is available about their seasonal occurrence, species composition, method of capture etc., along our coast.

Since Day (1878) recorded three species of billfishes, namely, *Histiophorus gladius* (Broussonet), *H. immaculatus* Ruppell, and *Histiophorus brevirostris* Playfair from the Indian coasts the notable contributions on this group have been those by Hornell (1917) who gave some preliminary data on billfish landings at Tuticorin ; and Jones (1959 a, b, 1960) who described larvae and juveniles of billfishes from Indian waters. Deraniyagala (1952) records *Tetrapturus indicus* Cuvier, *Tetrapturus tenuirostratus* Deraniyagala, *Istiophorus gladius* Broussonet, *Makaira indica* Deraniyagala, *M. mitsukurii* (Jordan and Snyder) and *Xiphias gladius* Linnaeus from Ceylon waters while Munro (1955) recognizes only five species, *Histiophorus gladius, Tetrapturus brevirostris* (Playfair), *Makaira mitsukurii* (Jordan and Snyder), *Makaira indica* (Cuvier), and *Xiphias gladius* from Ceylon waters. There is considerable confusion in the nomenclature used to denote the various species of billfishes from different oceans and this is made all the more difficult on account of the pantropical distribution of some of the species ; the marked changes during growth and lack of data of good series of specimens of each species from different areas. Besides, the indiscriminate use of popular names for different species has tended to add to the confusion. Elsewhere (Jones and Silas, 1962) an attempt has been made to straighten out the nomenclature of the species of billfishes occurring in the Indian seas, and based on these findings, the following species were found to occur along the Tuticorin coast, Gulf of Mannar (Plates I and II).

Species Name	*Vernacular name* (Tamil)
1. *Istiophorus gladius* (Broussonet)	Thalapathu
2. *Makaira indica* (Cuvier)	
3. *Makaira nigricans* Lacépéde	Kopparaikulla
4. *Tetrapturus audax* Philippi	
5. *Tetrapturus tenuirostratus* Deraniyagala	

Hornell's aforesaid work (1917) as well as the icthyological literature of Ceylon fishes indicates the occurrence of the broadbill swordfish *Xiphias gladius* Linnaeus in the Gulf of Mannar,

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although we have not come across this species during the course of 18 months (1960-61) of observations of billfish landings at Tuticorin. In view of the paucity of data on billfishes from Indian waters, it is hoped that the observations made herein will be of interest to future workers.

Method of Capture, Season of Occurrence and Size Composition

The occurrence of billfishes along Tuticorin coast coincides with active fishing for other Scombroid fishes from May-June to September (Fig. 1). However, stray catches are made during

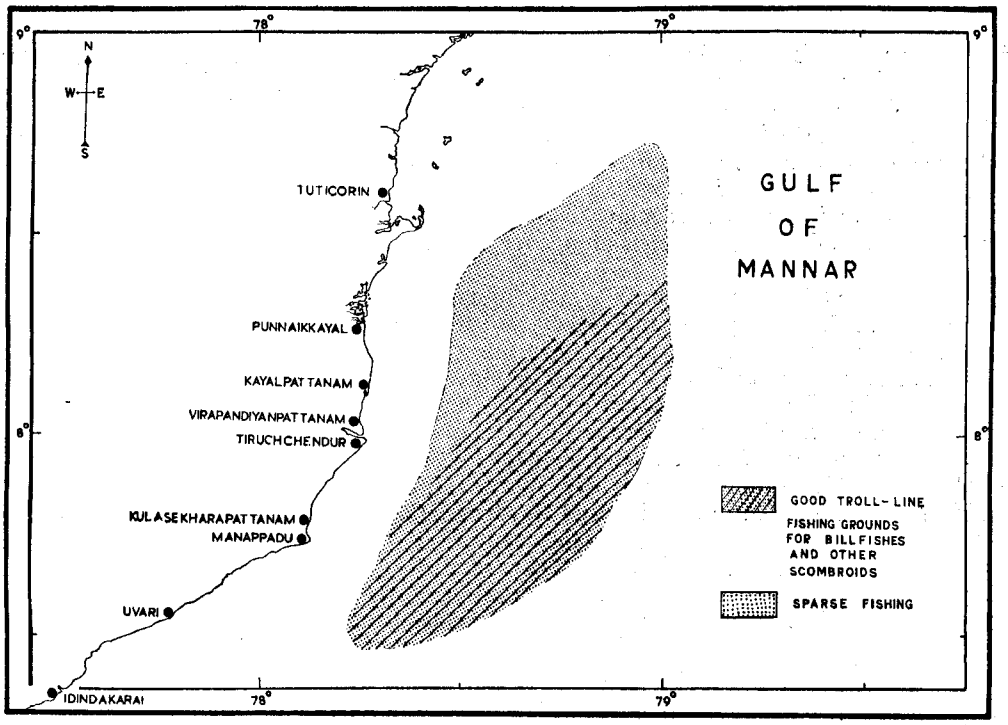
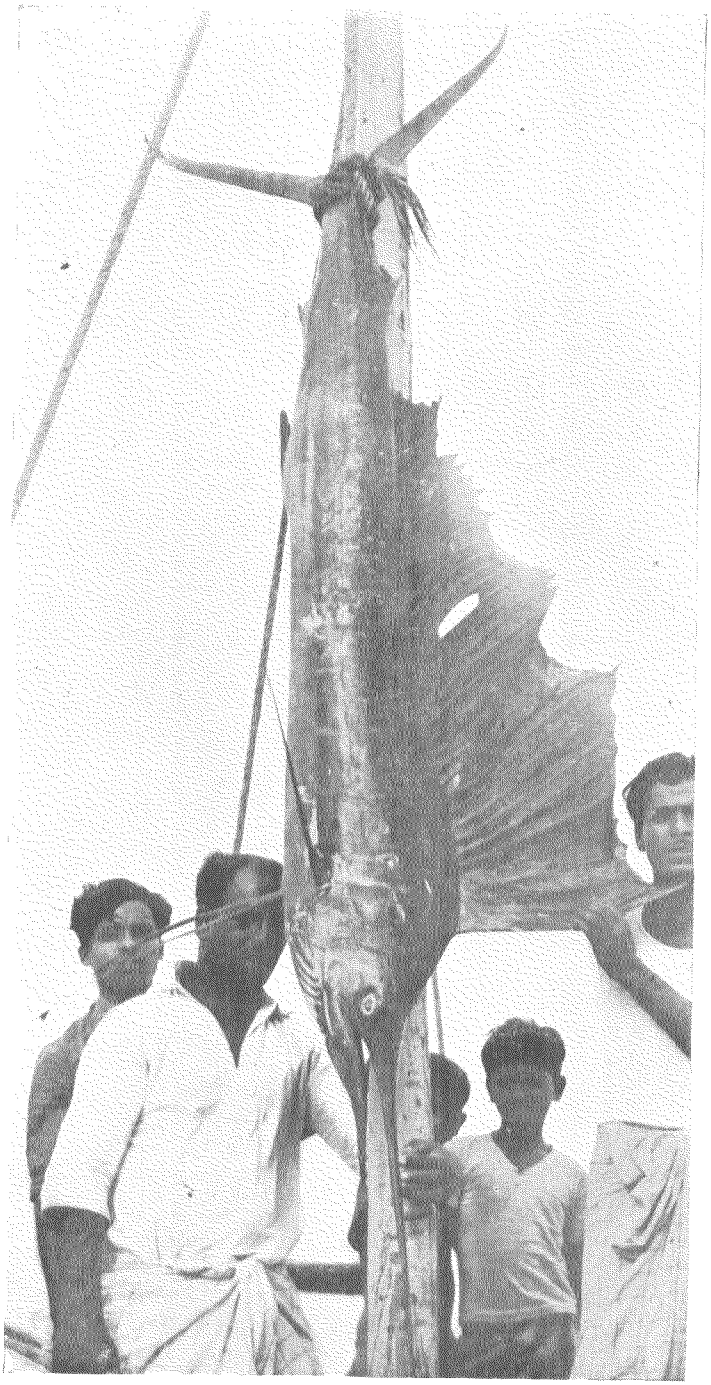


FIG. 1. Map of Tuticorin coast and part of Gulf of Mannar showing the area in which troll line fishing is carried out at present.

off season by returning boats engaged in handline fishing in the vicinity of Thollayiram Paar using one or two troll lines provided the wind conditions are favourable. For a detailed account of trolling in the Tuna fishing grounds of Tuticorin, reference may be made to Silas (1962). But for Hornell's (1917) observations, there is no published data about the seasonal occurrence of billfishes along Tuticorin coast and the data given by him (Fig. 2) when compared with our observations for 1960-61 (Fig. 3) indicates differences in the seasons of occurrences of these fishes. The 1960-61 period shows July-September and November-February to be the fishing seasons for billfishes with a distinct peak for August. Wind conditions may be unfavourable for trolling from late September to the middle of November and a second minor peak in billfish catch is noticed between November and February. The 1913-15 data shows that most of the landings were confined to the latter period, namely, November-February, while in other months the landings were negligible. The causative factors for such changes from time to time may be :

(1) Unpredictable weather conditions.



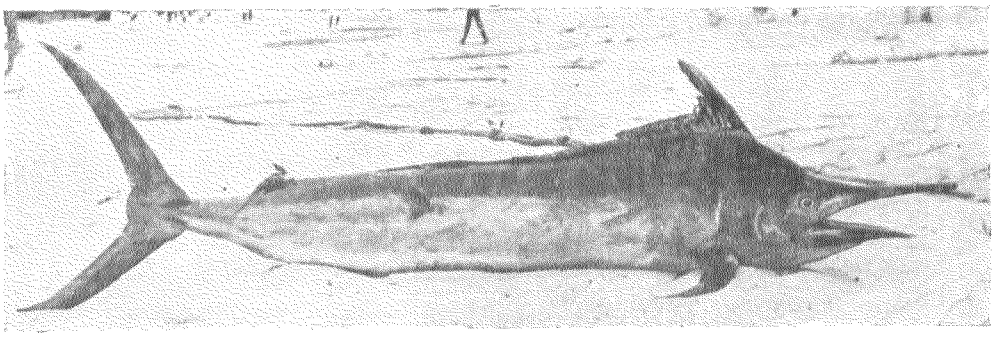
1. Sailfish *Istiophorus gladius* (Broussonet)



2. Black marlin, *Makaira indica* (Cuvier) : side of the body. Note the scalation.



3. *Makaira indica*, lateral view.



4. Blue marlin, *Makaira nigricans* (Lacépède).

(2) More intensive inshore fishing using Gill nets, Drift nets etc., during November-February at present and the likely depletion of prey species or the deflection of shoals of prey species to offshore waters and the consequent shifting of predator species to such areas.

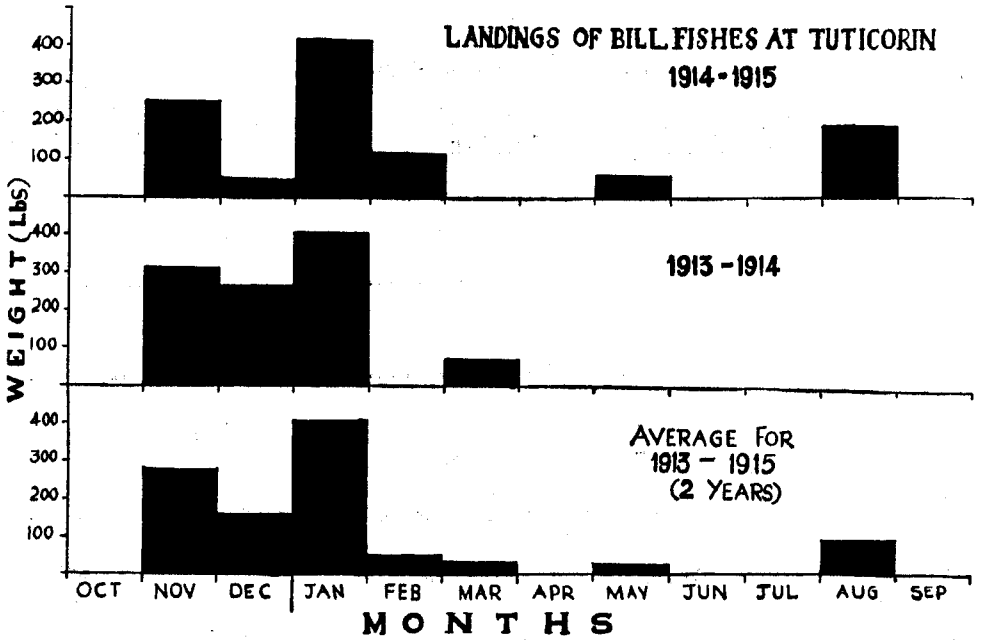


FIG. 2. Landings of billfishes at Tuticorin for the 1913-15 period, based on data given by Hornell (1917). Note that in both years most of the landings were during the November-January months.

(3) In the absence of proper observations on the hydrographical conditions in the trolling ground it may be difficult to point to any ecological factor which influences the season of occurrence of billfishes off Tuticorin coast.

(4) Lack of incentive for troll fishery during certain months when fishermen could have alternate profitable occupations is another very important factor reflecting on the total annual landings. More on this point has been discussed elsewhere (Silas, 1962).

From Fig. 3 it will be seen that three of the five species of billfishes have been caught during both seasons, namely, July-September and November-February. During 1960-61, the black marlin and the blue marlin were not landed during the November-February season, but in view of the availability of the sailfish, striped marlin and short-nosed spearfish during these months, it is likely that the former two could also occur during these months. Of the five species, the sailfish *I. gladius* is the commonest and from observations made by one of us (E.G.S.) as well as talks with colleagues from other Fishery centres along the West coast of India such as, Cape Comorin, Colachel, Vizhingam, Malpe and Ratnagiri, it would appear that wherever billfishes are landed, the sailfish predominates in numbers.

As regards size compositions, very little can be deduced from the meagre data available. However, we find that there is a tendency for a smaller size group of sailfish to occur during the November-February period off Tuticorin (Fig. 4). Weight-wise the black marlin appears to be the largest of these species and those caught off Tuticorin were all over 200 cms. long while the spearfishes were the smallest ranging from 90 to 125 cms. Measurements of sailfish and marlins caught off Tuticorin Coast are presented in Appendix.

DESCRIPTION OF INTERNAL ORGANS

Istiophorus gladius (Broussonet)

Sailfish

Material: 14 specimens ; 4 examined for internal organs.

Description of internal organs from a specimen of length 2030 mm. and weight 35.4 Kg. (78 lbs.) is as follows : The liver is distinctly bilobed and the right lobe is elongate and extends to about

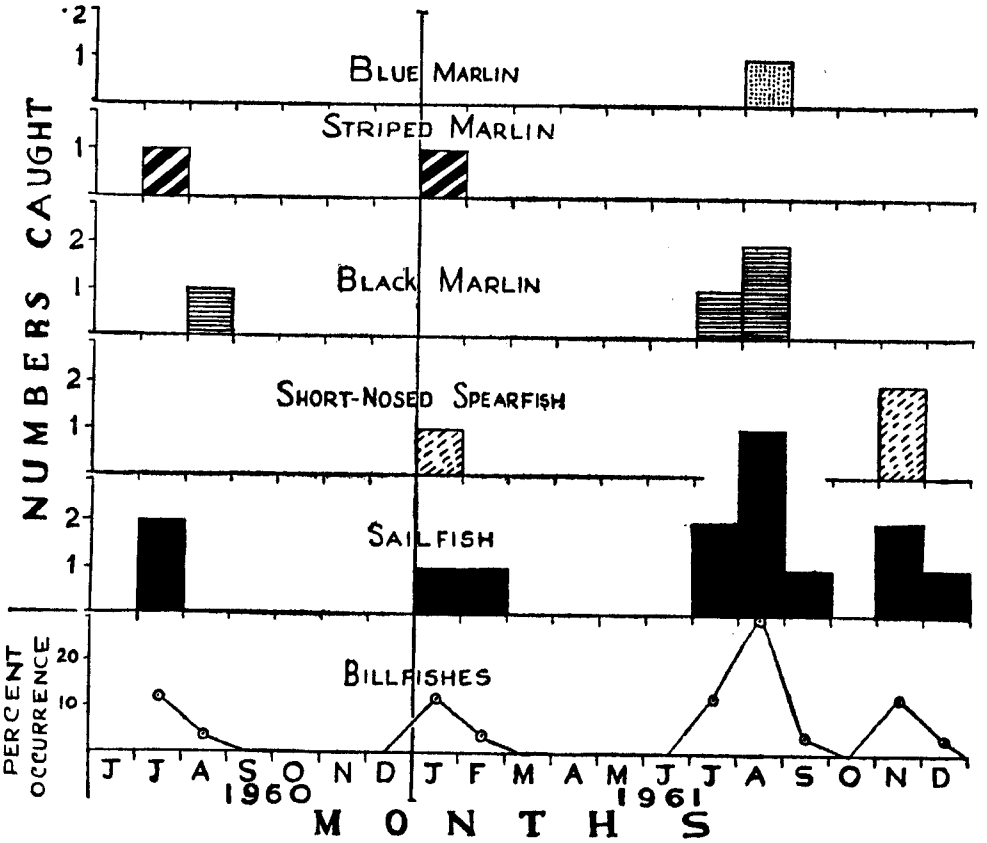


FIG. 3. Number of billfishes (species-wise and total) caught during the period of 18 months from July 1960—December 1961, off Tuticorin.

$\frac{1}{3}$rd the length of the visceral cavity to the point where the loop of the intestine passes along the posterior end of the pyloric caeca. The left lobe is about half the length of the right lobe and the liver on the whole is thinner and pale yellow in colour. The gall bladder is conspicuously long extending posteriorly well beyond the loop of the intestine. The spleen is greatly enlarged and is of about the same length as the caecum when viewed from ventrally. The empty stomach occupies about $\frac{1}{3}$rd the peritoneal cavity and extends posteriorly to the mid-distance between posterior end of spleen and vent. A dissection of the empty stomach shows 16-17 conspicuous mucous folds at its mid-length while these ridges converge to 9-10 at the oesophageal end. It is likely that in the distended condition the stomach may extend still further back. The loop of the intestine is in level with the posterior end of the spleen.

The examination of 4 stomachs showed 3 empty and one in which 2 partly digested clupeid fishes (*Sardinella* sp.) were present.

None of the specimens of sailfish show mature condition of the gonads.

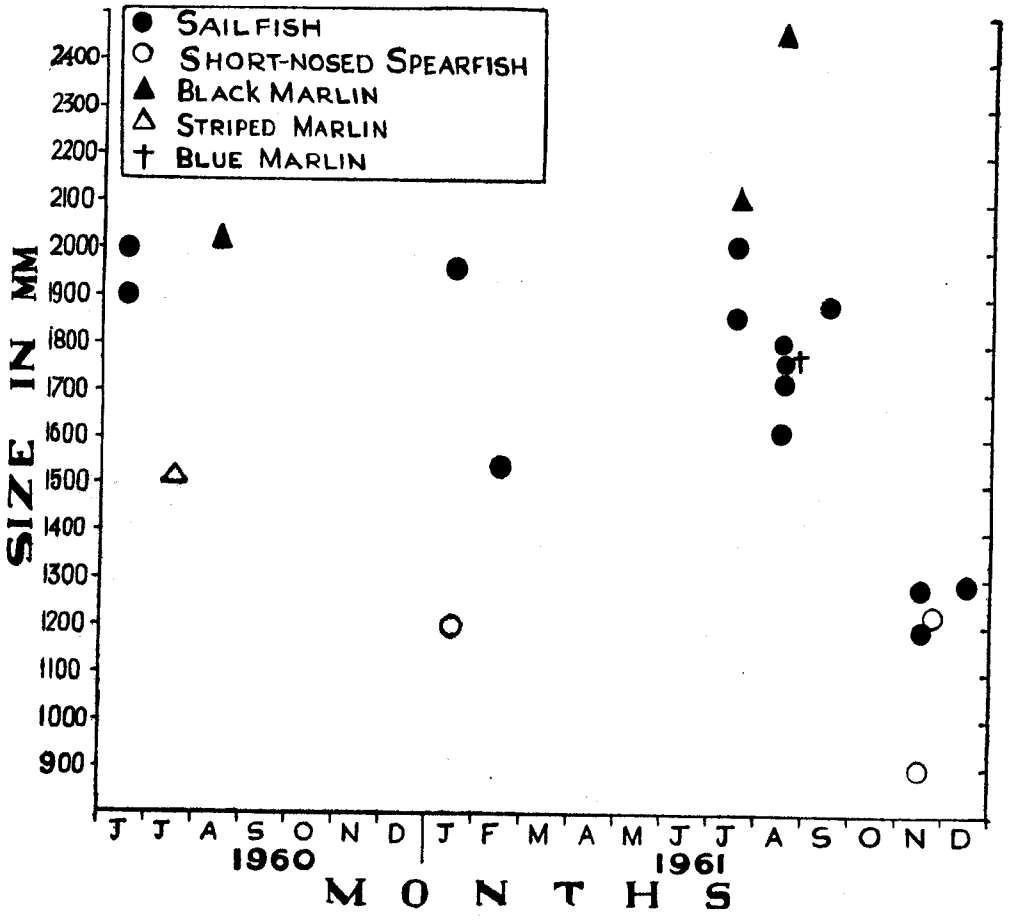


FIG. 4. Total lengths from tip of lower bill to fork of species of billfishes landed at Tuticorin (22 specimens) for the period July 1960—December 1961.

Makaira indica (Cuvier)

Black marlin

Material : 3 specimens ; 2 examined for internal organs.

Description of internal organs from a specimen of length 2445 mm. and weight 79·4 Kg. (175 lbs.) is as follows : Liver is conspicuously large and massive and the right lobe is slightly longer than the left lobe and covers the right side of the caecum almost completely. *Unlike* in *Istiophorus* the gall bladder and spleen are shorter, and the former does not extend to the loop of the intestine. The shape of the spleen is more or less triangular. The stomach is large and when empty occupies more than ⅓rd the peritoneal cavity and extends posteriorly to above the vent. In the distended condition it is likely that the stomach may extend still backwards. Dissection shows 10 thick prominent mucous ridges at the mid-length of the stomach while 9 such

ridges are seen at the oesophageal end. When compared to *I. gladius* the intestine is relatively shorter in this species.

Two of the stomachs examined were empty.

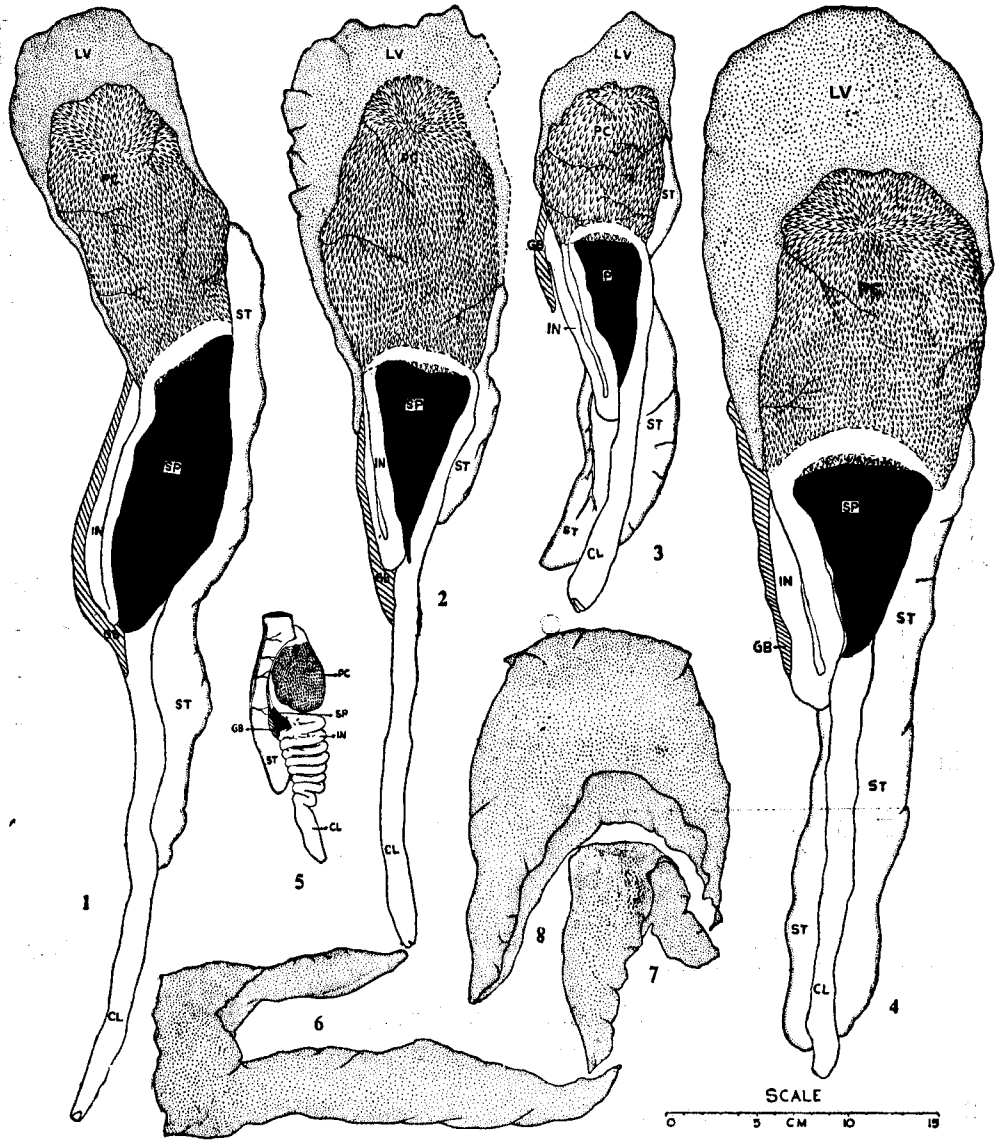


FIG. 5. Visceral organs of: (1) The sailfish *Istiophorus gladius*, 2030 mm. 78 lbs.; (2) the blue marlin *Makaira nigricans* 1785+ mm. 112 lbs.; (3) the short nosed spearfish *Tetrapturus tenuirostratus* 1231 mm. 28 lbs.; (4) the black marlin *Makaira indica*, 2445 mm. 175 lbs.; (5) the broadbill swordfish *Xiphias gladius* (after Suyehiro, 1942); Liver of: (6) *I. gladius*; (7) *Tetrapturus tenuirostratus*; (8) *M. indica*. All taken from material mentioned above. CL = Colon; GB = gall bladder; IN = intestine; LV = liver; PC = pyloric caecae; SP = spleen; ST = stomach)

Makaira nigricans (Lacépéde)

Blue marlin

Material : 1 specimen, also examined for internal organs.

Partial description of a specimen of length 1785 mm. and weight 50.8 Kg. is as follows : Postmortem colour is steel blue in the upper half of the body, greyish laterally becoming lighter on the ventral side and belly whitish. 15-20 pale blue vertical stripes with a posteriorly directed loop along its centre were noticeable when fresh, but faded rapidly. The colour pattern is almost identical to that figured for *M. mazara* by Nakamura (1938). This condition is distinctly different from that seen in the striped marlin where the vertical bands are more distinct and numerous. Another character which aided in the identification of this species is the anterior height of the first dorsal which is hardly $\frac{1}{4}$th the depth of the body ; while in the striped marlin (*Tetrapturus audax*) this may be equal or greater than the height of the body. The specimen has been mounted and displayed in the museum of the Central Marine Fisheries Research Institute.

The examination of the viscera of the specimen shows the liver to be thinner, but the right lobe to be relatively longer extending beyond the caecum. The left lobe was partly damaged but when reconstructed it reaches to $\frac{2}{3}$rd the length of the pyloric caeca on the left side. The gall bladder is long and extends to well beyond the loop of the intestine, but the spleen which is triangular in shape does not surpass this point. One very characteristic feature appears to be the stomach which is short and hardly reaches to opposite the angle of the first loop of the intestine. The short stomach seen in this specimen shows similarity for that described for *Makaira mitsukurii* (the striped marlin) by Suyehiro (1942), but in the latter he mentions the presence of about 15 folds of mucous membrane in the stomach wall. Dissection of the stomach of our specimen showed 12 longitudinal ridges in the mid-portion. While this may be a minor difference, it will be worthwhile if careful observations are made on the disposition of the visceral organs in the blue marlin and striped marlin occurring in Indian seas.

The stomach of the above specimen was found to contain some unidentifiable pulpy matter along with few remains of squids.

Tetrapturus audax (Philippi)

Striped marlin

Material : 2 specimens.

The identity of this species is based on a specimen landed on 26 July 1960 which was measured and photographed. Unfortunately it was not possible to collect the visceral organs for detailed examination, nor obtain similar data for the second specimen.

Tetrapturus tenuirostratus Deraniyagala

Indian long-nosed Spearfish

Material : 3 specimens ; soft parts described from a specimen 1231 mm. weighing 13.72 Kg. (28 lbs.).

The popular name ' Short-nosed spearfish ' applied to *Tetrapturus angustirostris* Tanaka, will not apply to the Indian specimens as these have a longer bill, the distance from its tip to that of the lower jaw being contained about two times in the length of the bill. For a taxonomic discus-

sion of the specimens referred to here as *Tetrapturus tenuirostratus* reference is invited to Jones and Silas (1962).

The liver is relatively smaller and the right lobe which is longer extends to hardly ⅓rd the length of the pyloric caeca. The gall-bladder is relatively shorter extending to hardly half the length to the loop of the intestine. The spleen which is more or less triangular also falls short of the angle of the loop of the intestine. One conspicuous feature is the large stomach which in a partly filled state extends to above the level of the vent. The stomach as a whole appears to be thin walled and dissection shows very weak mucous ridges or folds at the mid-length of the stomach while 9 low ridges are noticed at the oesophageal end.

The stomach contained digested remains of about 10 clupeids.

A specimen, of about same length caught at Vizhingam on 29-11-61 shows similar disposition of the visceral organs, except that the right lobe of the liver is slightly longer.

Relative Weight of Visceral Organs

The weights of the visceral organs in relation to body weight is one aspect of the study of the biology of sailfishes and marlins on which emphasis is laid (La Monte, 1955, Krumholz, 1958). In this preliminary study it was possible to analyse only the data for eight specimens belonging to four species and this is tabulated below.

Table

Percentages of total body weight made up by different organs

	I. gladius			*M. mazara* (1)	*M. indica* (1)	*T. tenuirostratus* (1)
	Max.	*Min.*	*Average* (4)			
Viscera minus air-bladder and kidney	6.09	3.96	5.13	3.83	3.57	4.80
Spleen	0.10	0.23	0.21	0.11	0.09	0.12
Liver	0.83	0.42	0.64	0.33	0.90	0.65
Pyloric caeca and intestine ..	2.3	2.5	2.36	..	0.96	1.6
Stomach (empty)	1.2	1.7	1.46	..	1.07	1.6

* Separate weights for gall-bladder and gonads are not given, but weight of viscera given in column 1 is inclusive of these.

While the data is meagre, there is an indication that weight for weight the liver is relatively heavier in the black marlin *M. indica* while the spleen appears to be so in the case of *I. gladius*.

The nature and disposition of the visceral organs in the five species examined is shown in Fig. 5. In *Xiphias gladius* which has not been examined, the intestine is more or less coiled, zigzaging 7 or 8 times before running straight for a short distance to the vent (Fig. 5) a condition not met with in other billfishes.

General Observations

Billfishes are caught off Tuticorin with the same type of baits (*Sardinella* spp.) or artificial lures as used for other scombroids during the troll fishing season. Experienced fishermen inform us that it is rarely ever that they see the fish at the surface with the dorsal fins showing above water. On rare occasions the fish have been noticed pursuing the moving lure and take it, the first indication of the bite being a small tug on the line and the next moment the fish leaps out of water. On the average during good fishing periods three or four out of five fishes taking the bait are lost on account of the line snapping due to the initial shock ; the hooks straightening ; or the bite being ineffective due to the too fast sailing of the boat. The absence of ' trolling springs ' to act as shock absorbers on the lines is one of the main draw backs ; another being the difficulties in controlling the speed of the boat which often may exceed 12 knots and prove extremely difficult for hauling in lines as well as hazardous for those operating the lines.

Most of the points raised in the case of Tuna Fishery off Tuticorin coast (Silas, 1962) are also applicable to billfish fishery in this area. The distance of the fishing grounds off Tuticorin is such that each day nearly 60% to 70% of the time out is spent in trying to reach the fishing grounds and returning back. Boats operating from Virapandianpattanam 35 km. South of Tuticorin have the advantage of three to four hours less of travel to and fro, but during the period of observation fishing at Virapandianpattanam was at a stand still on account of the slum in the dryfish trade.

Fluctuations in price for billfishes at Tuticorin may be of interest. Hornell (1917) gave the price of billfish (swordfish) per pound as 1 anna (=6 ps). When the dryfish trade with Ceylon was flourishing, in 1960 the auction rate for billfish when landed would go as up high as 50 to 70 ps. per pound while the market rate for the fresh fish was about Rs. 1.25. During the 1961 season, the few billfishes caught fetched very low prices and the auction price at the landing place hardly went up to 25 ps. per pound while the market rate for fresh fish was about 75 ps. In 1960 Rs. 80 was obtained for 1 cwt. of dryfish (rate for billfish), but current rates have dropped to Rs. 35.

As for the habits of the fish one interesting thing was that none of the fishermen could recollect having heard of damage to boats in that area due to ' attacks ' from billfishes. In fact, when a fish is hooked and brought alongside the boat, two simultaneous actions are carried out, the first gaffing and immediately the bill of the fish is held tightly which action, the fishermen say, immobilises the fish. Accidents of wounds caused to fishermen at this stage are extremely rare.

We are informed that in 1959 two families of fisherfolk at Tuticorin were affected (no fatalities) as a result of eating parts of the viscera including the stomach of the black marlin *M. indica*. On account of this event which is still fresh in the minds of many, the visceral organs of billfishes cut on the beach are not taken for cooking, unlike those of the yellowfin, the little tunny, and the northern bluefin tuna.

There is considerable scope for the improvement of the troll-line fishery for billfishes and related fishes off Tuticorin if trolling could be carried out from mechanised fishing boats as well as if slight improvements could be effected to the existing methods used. It is hoped that the billfish fishery of Tuticorin Coast will recover when suitable outlets are found for the disposal of fresh as well as dry fish in the interior markets.

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APPENDIX

MEASUREMENTS (MM.) OF SAILFISH AND MARLINS CAUGHT OFF TUTICORIN

Istiophorus gladius

1. Date	7-7-60	27-7-60	28-1-61	2-2-61	18-7-61	28-7-61
2. Sex	..	..	..	..	..	Male
3. Wt. (lbs)	..	..	..	..	..	75
4. Body Length	2210	2375	1964	1540	1860	2060
5. 1st Pre-dorsal length	(with bill) -400	(with bill) -400	360	..	378	403
6. 2nd ,, ,,	..	..	..	..	1560	1690
7. Pre-pectoral length	..	..	440	..	461	460
8. Pre-pelvic length	..	..	..	..	485	500
9. 1st Pre-anal length	..	..	1215	..	1180	1290
10. 2nd Pre-anal length	..	..	1615	..	1575	1700
11. Or. of D(1) to origin of P.(1)	..	..	..	..	..	230
12. Or. of D(1) to origin of P(2)	..	..	..	..	..	320
13. Or. of D(2) to origin of A(2)	..	..	..	..	..	190
14. Or. of P(2) to Vent	..	..	..	..	..	680
15. Greatest depth of body	..	..	307	222	315	330
16. D. of body at origin D(1)	..	..	..	..	..	300
17. D. of body at origin of A(1)	..	..	..	..	..	251
18. Wdth. of body at origin of P(1)	..	..	..	..	..	110
19. Head length	..	..	..	365	453	460
20. Snout length	..	..	..	..	542	..
21. Bill length	..	..	521	..	..	..
22. Maxillary length	..	..	..	..	..	..
23. Orbit diameter	..	..	48	42	49	50
24. Tip of mandible of tip of bill	..	..	320	260	318	370
25. Ant. ht. of D(1)	..	..	430	336	..	270
26. Length of Middle D.spine	..	..	700	..	..	890
27. Length of P(1)	..	..	442	264	430	450
28. Length of P(2)	..	..	585	462	590	640
29. Caudal Spread	..	..	..	..	..	800
30. Dorsal Spine nos.	..	..	47	47	47	47
31. Interdorsal gap.	..	..		..	38	30

APPENDIX—(*Continued*)

Istiophorus gladius

1.	4-8-61	17-8-61	19-8-61	25-8-61	11-9-61	21-11-61	23-11-61	11-12-61
2.	..	Female	..	Male	..	..	Female	..
3.	..	56	..	36	..	..	78	28
4.	2200 with bill -400	1760	1730	1615	1880	1200	2030	1290
5.		395	400	337	410	..	410	320
6.	..	1500	1440	1400	1525	..	1640	1080
7.	..	425	..	370	415	..	453	290
8.	..	455	..	405	465	..	520	360
9.	..	1100	1200	1007	1120	..	1260	900
10.	..	1480	1440	1337	1515	..	1640	1130
11.	..	210	..	205	..	..	..	..
12.	..	290	..	260	..	..	..	..
13.	..	160	..	145	..	..	..	..
14.	..	550	..	515	..	..	..	..
15.	..	290	..	253	..	..	320	205
16.	..	273	..	250	..	..	..	..
17.	..	210	..	173	..	..	..	..
18.	..	110	..	..	..	..	..	..
19.	..	430	440	348	430	..	450	283
20.	..	..	445	187	..	..	370	..
21.	..	..	..	422	..	..	770	damaged
22.	..	..	..	210	..	..	..	..
23.	..	40	50	40	48	..	50	30
24.	..	280	220	257	..	..	400	..
25.	..	440	380	323	450	..	460	..
26.	..	770	640	630	820	..	700	..
27.	..	390	360	336	390	..	420	210
28.	..	575	480	525	560	..	620	420
29.	..	680	530	575	..	..	800	410
30.	..	47	47	46	46	..	46	46
31.	30	39	20	36	..	..	..	..

APPENDIX—(*Continued*)

	Makaira indica			*Makaira nigricans*			*Tetrapturus audax*	*Tetrapturus tenuirostratus*	
1.	17-7-61	18-8-61	23-8-61	11-8-60	21-1-61	25-8-61	26-7-60	14-11-61	29-11-61
2.	..	..	Female	..	..	Male	..	Male	..
3.	..	..	175	..	..	112	..	28	..
4.	2100	..	2445	2400 -400	1200	1785	1775 -130	1231	900
5.	480	..	510	..	..	405	..	259	
6.	1670	..	1605	..	..	1405	..	963	..
7.	530	..	539	..	..	456	..	304	..
8.	553	..	560	..	..	483	452	334	..
9.	1270	..	1220	..	..	1132	1073	724	..
10.	1680	..	1640	..	..	1438	1420	954	..
11.	..	..	350	..	..	306	..	187	..
12.	..	..	410	..	..	370	..	238	..
13.	..	..	234	..	..	220	..	140	..
14.	..	..	510	..	..	504	..	..	..
15.	462	..	416	..	196	359	329	235	200
16.	..	..	385	..	..	348	..	217	..
17.	..	..	335	..	..	324	..	205	..
18.	..	..	..	..	..	205	..	..	..
19.	512	480	520	..	303	438	..	308	..
20.	570	..	252	..	..	210	288	145	..
21.	..	..	605	..	..	442	..	302	..
22.	..	..	325	..	..	275	..	..	..
23.	60	55	57	..	..	43	54	35	..
24.	310	..	365	..	120	237	..	162	..
25.	280	..	..	..	175	280	348	174	..
26.	..	..	58	..	..	70	..	107	..
27.	445	..	580	..	..	405	338	215	..
28.	250	..	310	..	..	285	268	268	..
29.	..	..	880	..	..	755	..	480	..
30.	..	..	36	..	..	37	..	38	..
31.	..	..	..	..	..	..	..	..	..

SCOMBROID FISHES AND FISHERIES OF THE MALDIVE ISLANDS WITH SPECIAL REFERENCE TO THE TUNA FISHERY

RODNEY JONKLAAS

INTRODUCTION

The writer would like to explain the scope of this paper and the circumstances which permitted him to prepare it for the Symposium. In order to assemble the information herein, the notes and photographs taken on each of four separate expeditions to the Maldive Islands have been compiled in some semblance of order. The first three trips from 1957 till November 1960 were brief ones, and each lasted less than a week in the Maldive Islands. Little opportunity was available to gain any information outside Male', the capital island and Seat of Government.

The last trip which lasted more than 6 weeks was from February 4th till March 27th 1961 and afforded the writer the opportunity of making more sustained and thorough observations in and around Male' and more northerly and westerly atolls. Although this expedition was primarily one for a survey of tropical crayfish for commercial purposes, a fair amount of time was spent observing and photographing several aspects of the fishing industry.

It will be observed that no statistics whatever are published. It is, as a matter of fact, impossible for any statistical data to be obtained in such a vast and relatively undeveloped archipelago of some 2,000 islands, 800 of which are said to be inhabited. The main industry of the Maldives is fishing and not even reasonably accurate statistics of annual catches, exports and similar data can be obtained for lack of communications and systematic recording by trained observers.

The 2,000 odd separate small islands, which grouped in atolls, comprise the Maldives, are situated South-West of the tip of peninsular India and about 400 miles south-west of Colombo, Ceylon. They are, in all probability, a continuation of the Laccadive Islands, a part of India. An almost identical language exists in the two systems and in many ways the economy and racial build-up of these two groups of coral islands are identical.

From the point of view of the fishing industry, about which we are primarily concerned, the most predominant condition that is applicable to the Maldives is oceanic. There is no continental shelf as such; rivers and streams are unknown and lagoons are merely semi-enclosed and relatively wave-free stretches of water where no mud, as such exists. The entire group comprises coral islands of small size, the largest being less than 3 miles long and $\frac{1}{2}$ mile wide. The entire chain is about 700 miles long and stretches from north to south in a series of atolls.

Few countries exist where the conditions are so ideally oceanic and suitable for the tuna fishery.

It is estimated that 90% of the fishes caught and the industry as a whole, is concerned with Scombroid fishes, typified by the Bonito, *Katsuwonus pelamis* (Linnaeus).

Although the so-called lagoons enclosed by chains of islands called atolls harbour a fair proportion of Scombroid fishes, it is outside the atolls, in water several hundred fathoms deep, and for a great part uncharted, that the major portion of the catch is taken. But since, in a great many cases, the inhabited islands lie on the perimeters of atolls, access to deep oceanic water presents no great problems of navigation. Within sight of land, all species of Scombroid fishes

found in these waters are taken in great quantities, and unlike other countries, it is not necessary to traverse great distances of shallow water and continental shelf to get into good oceanic fishing waters.

Notes on Scombroid Fishes

The writer has witnessed capture of and seen alive and dead nearly all specimens of the fishes listed below. Only two species were not actually seen but are included in the list because of reliable identification from photographs of them from Maldivian fishermen. It is possible that more species than those listed are found in these waters.

Thunnidae (Tunas)

Auxis thazard (Lacepede)—a very commonly-caught fish found all over the Maldives and found closer to islands and lagoons, as well as inside them in shallower water than the larger species like the Bonito. This fish is known as ' Ragondi ' by the Maldivians and is caught in good numbers by live-baiting and trolling. The average size seen, measured and weighed by the writer was in the region of 12″ and 3 lb. in weight. It is estimated that this species furnishes about 5% of tuna meat for the well-known ' Maldive Fish ' Industry, which will be dealt with in more detail in another section.

Katsuwonus pelamis (Linnaeus)

The Bonito is by far the commonest of all Scombroids taken in the Maldive Islands and comprises well over 80% of the material for the Maldive Fish Industry. Known as ' Kandu-mas ', this fish is eagerly sought-after by all fishermen and is taken on trolling lines and with poles, using live-bait as ' chum ' to attract the shoals and keep them by the boats. The Bonito is found all over the Maldive Islands but is in its greatest concentrations about 2-5 miles away from the atolls, over very deep oceanic water. The average size and weight of Bonito taken in the Maldive Islands appears to exceed that of those caught off Ceylon ; i.e. at least 40″ long and 9 lb. in weight.

Euthynnus affinis (Cantor)

The Mackerel Tuna, as it is called, is also very common in the Maldives and is found much closer to the islands, often venturing into shallow water in pursuit of bait. Known as ' Latti ', this fish is taken with small lures by trolling and only occasionally on live-bait while pole-fishing. It too, is used for the Maldive Fish Industry. Average size in the Maldives is about 18″ and weight 3 lb.

Neothunnus macropterus (Schlegel)

The Yellowfin Tuna, called ' Kanneli ' by the Maldivians, is a familiar fish and is taken in fair quantity over the deep oceanic water round the atolls. The specimens seen by the writer were all on the small side and were caught on live-bait and trolling lines when fishing for the more numerous Bonito. They were said to be in the company of the Bonito and were only slightly larger than the largest Bonito (about 3 ft.). With the advent of long-lines, more and more larger specimens are taken. According to reliable reports, specimens of over 200 lb. are not uncommon.

Gymnosarda nuda (Gunther)

The Dogtooth Tuna, is a much more-common fish than is popularly supposed. The writer, who spent a great deal of his time underwater observing fishes and other marine life, saw large numbers of this fish including specimens weighing over 100 lb. It is very seldom caught by fishermen and only one specimen was seen in the market at Male'. The Maldivian name is 'Voshimas'. The Dogtooth Tuna seems to be essentially a slow-moving reef-loving species and is most often encountered inside atolls and swimming alongside the coral reefs in fairly deep water (10 to 20 fathoms). It would be well worth investigating the commercial possibilities of fishing for this species as it seems to be more plentiful within the atolls in the South-West Monsoon, at which time fishing outside the atolls is not possible owing to rough seas.

Scomberomoridae

Of the family known as 'Spanish Mackerels', only one species appears to be found in the Maldives. Since the other species are reported to be found in proximity to land-masses in South-East Asia, it is possible that the purely oceanic conditions are not conducive to their being found round the Maldives.

Acanthocybium solandri (Cuvier)

The Wahoo, a well-known oceanic game-fish found in all tropic seas, is the only member of the Seer-fish family observed in the Maldives. It is often caught, mostly on trolling lines with artificial bait and runs up to 75 lb. in weight and a length of over 5 ft. Known as the 'Kurumas' it is, surprisingly, less popular than the Thunnidae, and not used for making Maldive Fish. Its habits seem to be that of pursuit of bait-shoals some distance out at sea off the atolls, but many specimens are taken at the entrances to atolls where strong tidal currents are experienced.

Xiphiidae

The Swordfish [*Xiphias gladius* (Linnaeus)] is said to occur off the Maldives and there is no reason to doubt this, as it has a world-wide distribution in warm oceanic conditions. The Maldivian fishermen readily identified it from drawings and photographs shown to them and called it 'Hibaru', which, however, is the same name given to Marlins. It is taken on long-lines, occasionally while live-baiting and in one area, with harpoons.

Istiophoridae

Istiophorus gladius (Broussonnet)—the Sailfish is very common off the Maldives and is known as 'Fangadu-Hibaru'. Many specimens were seen by the writer and the largest did not exceed 100 lb. in weight. They are taken by trolling, long-lining, live-baiting and also with harpoon. They appear outside the atolls some distance out to sea and there seems to be no marked season for fishing them.

Makaira indica (Cuvier)

The Indian Marlin, also termed 'Hibaru' by the Maldivians, is a fairly well-known fish and is taken in the same way, but not as often, as the sailfish. The writer has seen specimens of well over 300 lb. taken on dead-bait and it is said that the long-lines bring up some weighing well over 600 lb.

The occurrence of *Tetrapturus brevirostris* (Playfair) is still in some doubt although several fishermen claimed to know the fish from photographs shown to them.

Fishing Methods

The Maldivian tuna fishery is by far the greatest economy of the islands and is continually expanding and improving in order to augment the annual output of Maldive Fish for which there is a ready market in Ceylon and South India. New methods have recently been introduced, through FAO assistance to Ceylonese fishermen and Maldivians. At the same time, the old methods which are still effective are in popular use. It is estimated that 95% of the working population of the Maldives is engaged in fishing as a livelihood and the current estimate of the total population is about 85,000. Therefore at least half this (40,000) would have some connection with the Fishing Industry. Perhaps at least 10,000 would be fishermen.

Trolling : Practically every Maldivian fishing craft, big or small, sail or motor-driven, carries one or more trolling lines with artificial lures. The line now used is of nylon monofilament but a few years ago cotton lines treated with bark of the mangrove (*Sonneratia*) were universally used. The lure is, most often, a rude jig made of local chicken-feathers, the colour being immaterial and usually grey or brownish. There is a rude wire trace made from any galvanised wire available, stainless steel wire being rare and expensive. The single hook is from imported stock but occasionally rude locally-forged hooks are used. No trolling leads or swivels are used. The speed depends entirely on that of the craft, which for the most part is wind-driven. The fishes taken by trolling are *Acanthocybium solandri*, *Neothunnus macropterus*, *Euthynnus affinis*, *Katsuwonus pelamis*, *Auxis thazard*, and occasionally the Marlin and Sailfish.

Live-bait pole-fishing : This is the most universally practised form of fishing in the Maldives and it is estimated that 85% of the fishing in the Maldives is by this method. 90% of the annual catch, at least, is taken by pole-fishing methods. Jones and Kumaran (1959), describe this in great detail from the Laccadives (Minicoy Island) and there is scarcely any difference here from methods in vogue in the Maldives. The success of this method is almost wholly dependent on the supply of live-bait, mostly for 'chum' without which the shoals of Bonito cannot be held and fished. The poles used are mostly of strong bamboo, imported from India, the lines, hooks etc., imported or locally-fashioned. The original native lures of bone, mother-of-pearl etc., are seldom seen, being replaced by modern barbless Bonito-hooks or with live-bait. Details of bait storage etc., will be discussed in another chapter. The Bonito and Yellowfin Tuna are the usual fishes caught this way.

Drifting: Drifting with dead or live-bait is often resorted to at times when the lack of wind prevents sailing into distant fishing areas. Drifting with live-bait yields Bonito very occasionally but more often Wahoo, Sailfish, Marlin, and Dogtooth Tuna, also Yellowfin Tuna, along with a great variety of other fishes.

Long-lining : With the advent of motorised craft and long-lining into Ceylon, the Maldivians were not slow to follow suit and now at least 20 such craft operate successfully all over the Maldives with long-lines. The deep long-lines (20 fathoms) are most popular and the fishes taken in this fashion are mostly Yellowfin Tuna, Marlin and Sailfish.

Harpooning : On a few islands, such as Toddu, large fishes are successfully speared from craft after being lured close to them. The method is interesting but not unique. A two-man craft of small size is used, one man at the stern wielding a long fishing-pole at the extremity of which is a stout line and a rude wooden lure carved to resemble a squid. This is moved rapidly to and fro in the water and sooner or later attracts a predatory fish to the vicinity which, when it ventures close enough, is transfixed with a hand-operated harpoon using a rude 'lily' type detachable head and line to the boat from which it is played. The harpoon shaft falls loose and is later recovered. This method sometimes gets Sailfish and Marlin but the commonest catch is, according to the fishermen, the Wahoo.

Fishing-Craft

The Maldivians are considered expert boat-builders and have perfected the art of making very efficient and seaworthy craft of all sizes from local wood and the most primitive of tools. Until about five years ago, all fishing was done from sailing and rowing craft varying in size from 10 feet to 40 feet. The usual wood used is coconut, and the hulls of the craft are beautifully clinker-built from very narrow strips of coconut wood. Cordage is of coir but sails have to be imported.

The smaller craft handled by 2 to 6 men usually operate within the sheltered lagoons and venture outside the atolls only in the calmest weather. The larger craft with up to 20 men, used mainly for Bonito pole-fishing go much farther out to sea.

The usual type of fishing-craft for Bonito follows the same pattern as described by Jones and Kumaran (1959). The techniques is also the same and dependent to a very great extent on the ready supply of live-bait.

In the past five years, small motorised fishing-craft ranging from 25 to 40 ft. and powered by Diesel engines have been imported from Ceylon where they are built to FAO recommended standards. These are, for the most part, engaged in trolling, drifting and long-lining. Netting is said to be in the experimental stage, for capture of large fishes like Yellowfin Tuna.

Photographs of Maldivian craft and boat-building illustrating this, give a good idea of the high standards in vogue.

No figures for the number of sailing-craft engaged in fishing are available. According to reliable reports from suppliers in Ceylon, at least 20 powered craft, which includes two 40-footers, are now used in the Maldives for fishing.

The difficulty of obtaining fuel and suitable repair facilities for motorised craft is considerable and will restrict mechanised fishing for some time to come. Hence the change from sail-driven to motor fishing vessels will be a much slower and gradual process than in Ceylon and India, for instance.

Bait

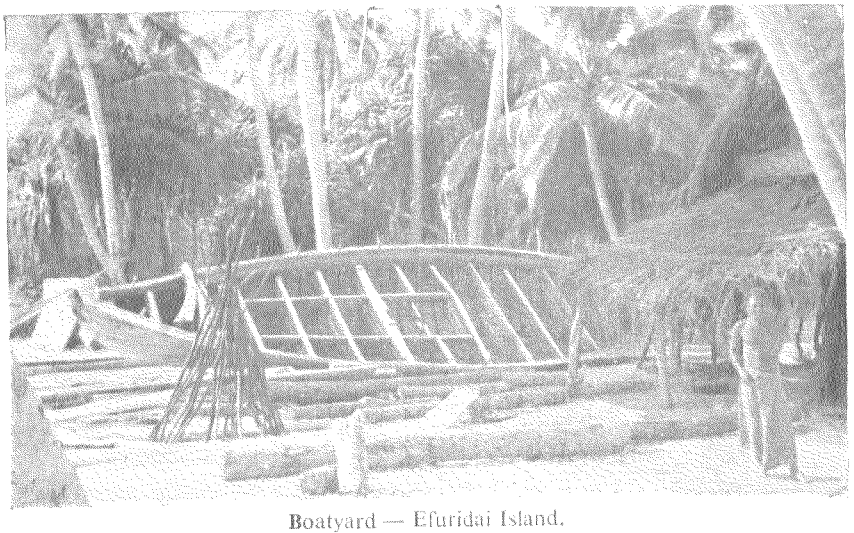
The subject of bait is of extreme importance in the Maldivian Tuna Fishing Industry. Since the bulk of the fishing is in respect of the Bonito, methods of collecting and keeping alive fresh live-bait have been given great consideration by the fishermen and Government alike. It has been reported, that even in the Maldives, where the area for fishing is so immense, a gradual diminution of bait-supply over the past few years has been noticeable, due to over-fishing.

Live-bait: The main species used in many islands for the Bonito Fishing Industry is *Caesio caerulaureus* (Lacépède) and the method of catching this in quantity follows the same pattern as that described by Jones (1958). Several bait-boxes and baskets examined in Male' islands contained nothing but a pure culture of young specimens of this species. It is possible that many other species including representatives from the Apogonidae, Pomacentridae, Labridae, and Anthiidae are taken in the same method but the writer was unable to see any such specimens.

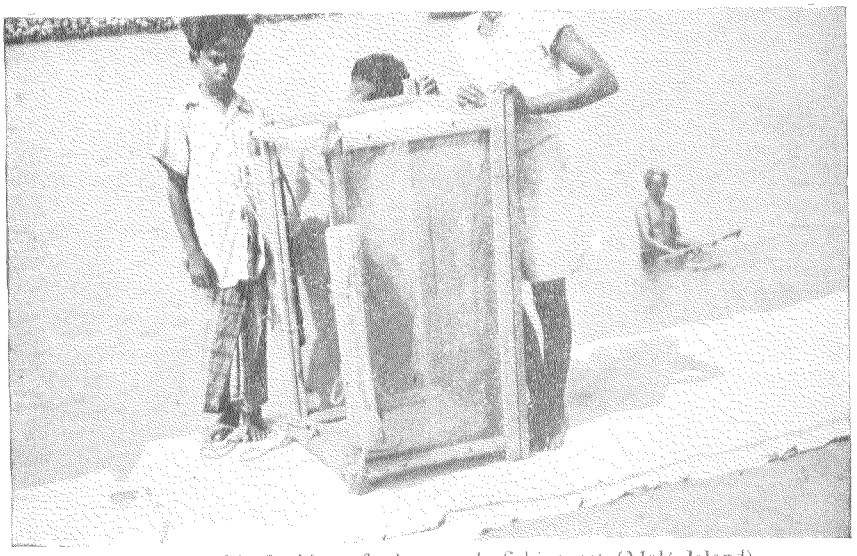
In shallow lagoons overgrown with eel-grass (*Cymodocea* sp.) the bait consist of small Labridae collected by the very simple method of 4 men holding the four corners of a square net and walking with it over the eel-grass beds, laying it on the bottom and raising it when sufficient small Labrids have been chased over the net by assistants.



Gymnosarda nuda. Juveniles of about 2 feet long. Underwater flash photo by Mike Wilson.



Boatyard — Efuridai Island.



Bait Box with 2 sides of close-mesh fishing-net (Malé Island).



All-wood Bait-box — Malé Island.

The same method is in vogue for capture of Atherinids but in this case the fishes are 'chummed' into the area of the net by throwing fragments of fish mashed with sand into the water.

Storage of Bait : Boxes or baskets are used with sufficient perforations to permit a ready flow of water through them, to keep the bait alive. These are kept afloat with logs of light wood and anchored inside sheltered lagoons in shallow water. They are kept covered to prevent the bait from jumping out and predatory birds like Herons from feeding on them.

When the boats set out for fishing, the bait is put into the boat with a small net and kept alive inside the boat by the removal of a plug of wood from the hull. One man is assigned to bail out the water constantly, thereby creating a continuous current of fresh sea-water to keep the bait alive.

Artificial bait: The most popular artificial lure is a bunch of chicken hackle or tail-feathers through which a wire trace with hook is passed. This readily takes Tunas, Bonitos, and Wahoo, in addition to other non-Scombroid forms. Imported lures of better colour and design are now gradually appearing especially in the Male' atoll.

Spoons, artificial squids and sporting lures termed 'plugs' were used by the writer, all with excellent results.

The crude wooden squid used without hooks to attract fishes to the harpoon is not very common and was seen only on one island in the North-West, Toddu.

Disposal of Catch

The bulk of the Tuna catch is made into 'Maldive Fish' a de-hydrated, boiled, and smoked product which has a ready market in Ceylon and South India. Local consumption of this product is mainly in respect of the semi-curved variety which is softer and has the consistency of old, dried roast-beef. All Tunas, including even *Gymnosarda nuda* are used for the production of Maldive Fish. The export item is essentially of Tuna origin but a locally-consumed variety is made with practically any species of fish including Marlin, Sailfish, and Wahoo.

Very seldom do the Maldivians eat fresh fish as we know it. Their basic fish-diet is derived from cured fish and only once did the writer observe some attempt being made to fillet, stuff and fry in an open fire a fresh-caught *Caranx*.

The exportable Maldive Fish is almost a government monopoly and only a Government-controlled trader may export it under strict price-control. The export price per lb. is Rs. 1.75 in Ceylon, often going higher in price. It sells readily in Ceylon for Rs. 4 per lb.

Up till 1947, 90% of the export trade of the Maldive Islands and its national income was derived from the Maldive Fish Industry. Even now the demand far exceeds the supply. Although now the national income is augmented in many other ways, great emphasis is placed on the Tuna Industry. Not only are the waters round the Maldives jealously guarded from inroads by foreign fishing concern (e.g. the Japanese) but even the method of curing Bonito to make Maldive Fish is considered a secret, for fear of competition from other nations.

Conclusions

There is considerable room for improvement and increase of catch in the Maldivian Tuna Fishery. More craft, more personnel and better re-fuelling and repair facilities for motorised craft should bring about a big increase in production.

The bait problem is considerable. From the writer's observations, many species of baits have not yet been exploited. For example, mullets are found in large numbers in the lagoons but are not netted or collected in any effective manner to serve as bait.

More types of artificial bait and the use of multiple trolling lines with outriggers, and the new multiple-lure Lesser Bonito-rig can be introduced with good results.

A good portion of the catch goes to waste. Only the fillets of Bonito, for instance, are used. The heads and offal and bones are thrown into the sea for the sharks whereas they can be utilised for fish-meal and fertiliser.

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PRESENT STATUS OF THE TUNA LONGLINE FISHERY IN THE INDIAN OCEAN (1959)[1]

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THE course of development of the tuna longline fishery in the Indian Ocean, the fishing conditions, and their fluctuations have been reported by Nakamura, Yabuta, and Mimura (1955), Mimura (1957a, 1957b, 1958a, 1958b), and Mimura and Nakamura (1959). All of these reports are based on data for the period up to 1956, but the relationships of fishing grounds and ocean current systems, areal differences and seasonal changes in fishing conditions, et cetera which were discovered then appear at present in about the same way. However, since that time the range of operations has extended to the vicinity of 30°S., greatly enlarging the fishing grounds for albacore and Indian bluefin tuna. Furthermore, the conspicuous annual variations in fishing conditions seen up to 1956 (for yellowfin) became obscure from 1957 on, and the fishery is showing a fairly stabilized condition at about the same level. For these reasons I have decided to write another report on present conditions in the tuna longline fishery, based on 1959 data. The tuna longline fishery operates on spearfishes as well as tunas, but the spearfish catch in the Indian Ocean is small and their importance consequently is low. Therefore in this paper I will take up only the tunas, leaving the spearfishes to be reported on at another time.

The data which I have used were obtained by surveys planned at the Nankai Regional Fishery Research Laboratory and carried out at the Tokyo, Yaizu, and Misaki fish markets.

Monthly Average Catch Rates

Figures 1-4 are plots of the average catch rate for each month and species for areas of 10 degrees of latitude and longitude. The explanation will be set forth on the basis of these figures.

Yellowfin (*Fig.* 1)

This species is taken everywhere within the operating area, but the areas of particularly high catch rates are, as has been pointed out previously (Mimura and Nakamura, 1959), north of 10°S. The catch rates here generally agree with the trends seen up to 1956 (Mimura, 1958b) in that there is a difference between areas, the rates being higher in the west and lower in the east, and a clearcut seasonal change in the more western areas, with high rates in the first half and low rates in the second half of the year.

It has been reported previously how the yellowfin catch rate in the Indian Ocean was generally high at the initiation of operations, showed a decline for 2-3 years, and thereafter showed generally stabilized values. In the western Indian Ocean, which first came under exploitation in 1955, conditions also became more or less stabilized from 1957 on (Mimura, unpublished data), with catch rates of 5-7% in the season of good fishing and 2-4% in the off season. In areas south

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[1] Translated into English from Japanese, by W. G. Van Campen, Director, Scientific Service, Bureau of Commercial Fisheries, Honolulu 12, Hawaii.

of 10°S., on the whole, only catch rates of 1% or lower are found, and areal differences and seasonal changes are obscure.

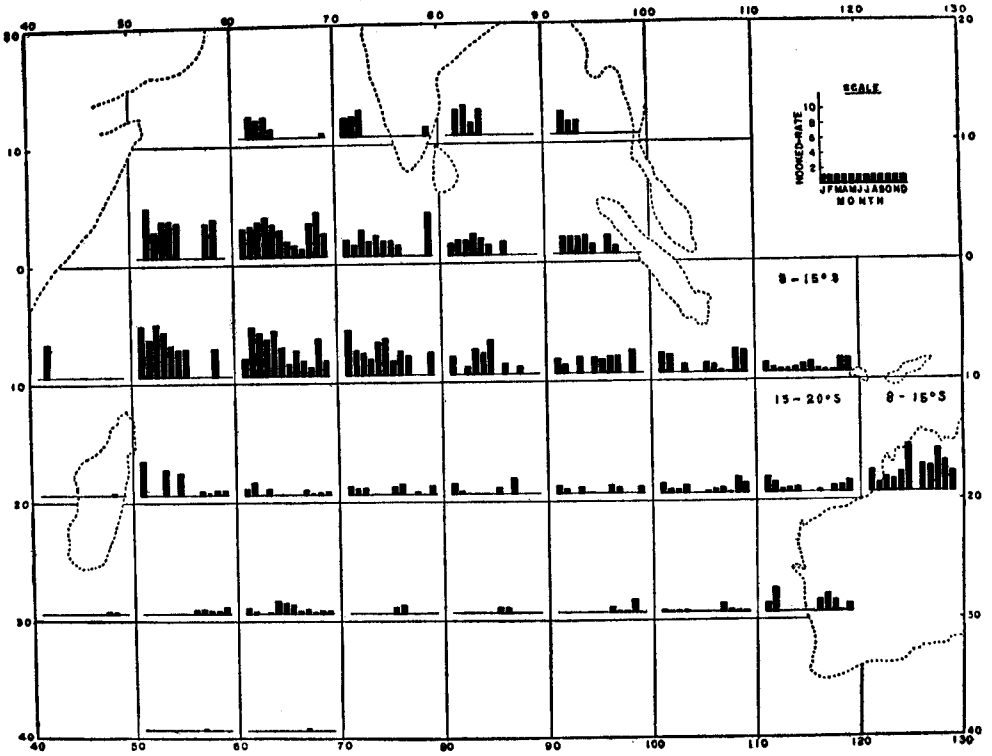


FIG. 1. Monthly hooked rates of yellowfin by area (1959).

Bigeye (*Fig.* 2)

This species resembles the yellowfin in that it is taken over the whole area of operation and shows a boundary at the line of 10°S., with higher catch rates to the north and lower rates to the south, but the catch rates drop again north of 10°N., so that the high values are found between 10°N. and 10°S. Even there the catch rates are in general much lower than those for the yellowfin, being only about 1%.

Differences from east to west show different trends at 0°-10°N. and at 0°-10°S. North of the Equator the catch rates are higher (1-2%) to the west, at 50°-70°E., while between 0° and 10°S. catch rates of 1-2% are found more to the east, at 90°-110°E., and particularly at 100 - 110°E. Seasonal changes are not clear, but at 0°-10°S., 90°-110°E., there is a tendency for catch rates to be higher from September to December. Extremely high values are shown for this area in September, however, they are due to the fact that, as reported by Mimura and Nakamura (1959), from southern Sumatra to the south coast of Java, in waters quite close to the coast, localized dense schools of bigeye tuna frequently appear (July-October). Because data from farther offshore were unavailable for these months, abnormally high average values resulted. South of 10°S. a tendency for catch rates to be lower to westward and higher to the eastward is seen.

Albacore (*Fig.* 3)

As the albacore fishing grounds have been extended remarkably to the southward in recent years, the result has been that past reports are limited to the northern fringes of the present fishing grounds. The catch rates are in contrast with those for yellowfin and bigeye in being high south

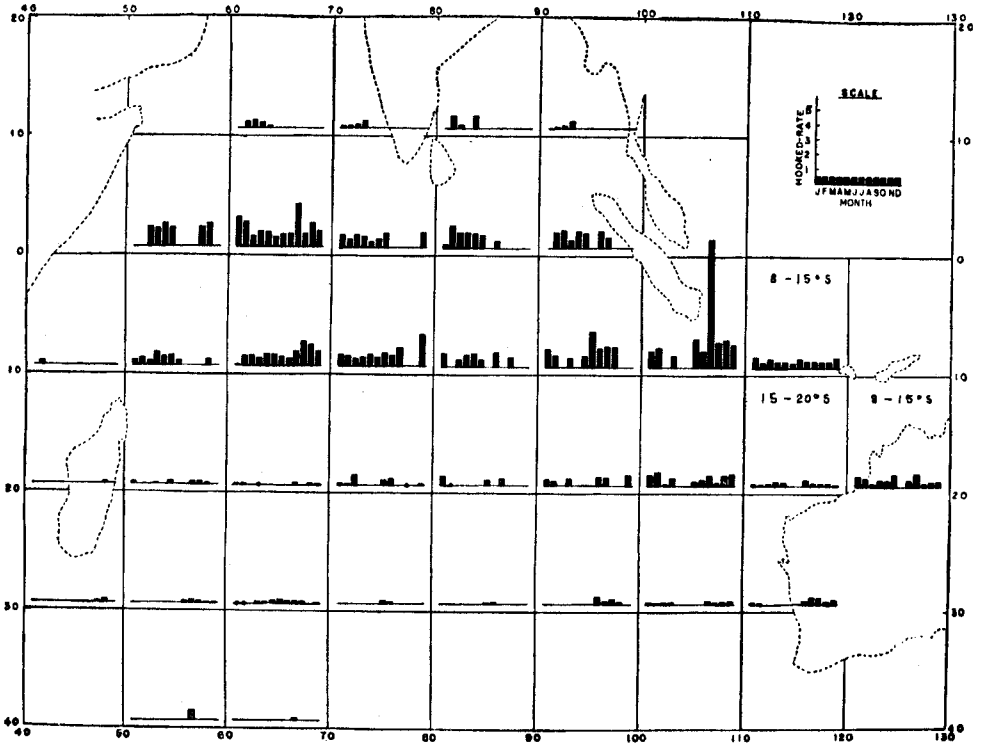


FIG. 2. Monthly hooked rates of bigeye by area (1959). Circles indicate operations with no catch.

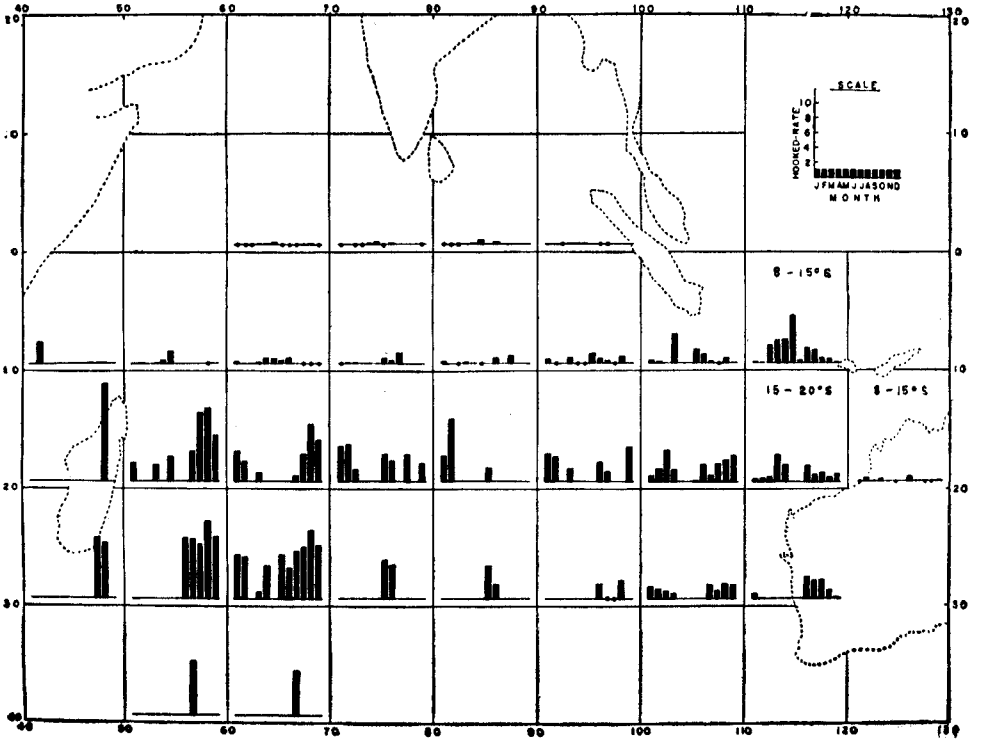


FIG. 3. Monthly hooked rates of albacore by area (1959). Circles indicate operations with no catch.

of and low north of 10°S. The values are particularly low north of the Equator, and north of 10°N. no captures of this species are indicated.

North of 10° [sic] and east of 110°E., in the fringes of the distribution, higher catch rates are indicated for April-September, as has been reported by Mimura (1957a) and by Mimura and Nakamura (1959).

In waters south of 10°S., just as with the yellowfin, there is an extremely clear trend of higher catch rates in the west and lower catch rates in the east. Thus, in October-December the catch rates gradually change from 7-10% in the more western areas to 2-4% in the easterly areas. Seasonally, catch rates are highest around November and lowest around May, the change being especially conspicuous in the western area. At 10°-20°S. and 20°-30°S. some seasonal changes can be seen, and, as is clear between 50°E. and 70°E., the decline in the catch rate in the period centered around May is more conspicuous at 10°-20°S. than at 20°-30°S., and the period of high values, centered in November, is shorter.

Furthermore, in view of the fact that the albacore being taken at present are rather large for the species (Mimura, unpublished data) and the fact that quite a few albacore were taken by the Shoyo Maru Survey (Suda, 1960) below 36°S. south of Australia, the distribution of albacore is presumed to extend to waters south of the present fishing grounds. It is thought that the seasonal changes in catch rates seen at 10°-30°S. may be related to the mechanism of recruitment into the fishing grounds of albacore which are distributed in these more southern areas and to the ecology of these albacore.

Indian Bluefin Tuna (*Fig.* 4)

As can be seen from the figure, this species is taken in a limited area of the southeastern Indian Ocean. Since recent fishing conditions have been reported by Mimura (1961), the details

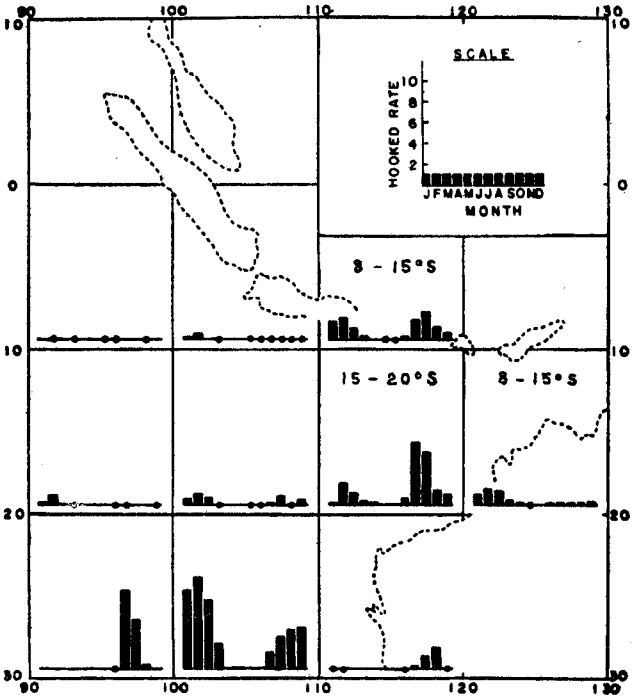


FIG. 4 Monthly hooked rate of Indomaguro (southern bluefin) by area.
Circles indicate operations with no catch.

will not be given here, but north of 20°S. at 110°-120°E. the catch rate is high in September and October ; south of 20°S. in the areas center at 100°-110°E. the catch rate is high in January-March. The former is about 6% and the latter shows values of 6-9%.

As is clear from the foregoing discussions for each species, the tuna longline fishing grounds of the Indian Ocean can be broadly divided into three, differing in the species which is the main object of the fishery : a fishing ground north of 10°S., where the yellowfin is the main object ; a fishing ground south of 10°S., mainly for albacore ; and a fishing ground in the southeastern area, where the Indian bluefin is the principal catch. As bigeye catch rates are low everywhere, no fishing ground primarily for this species is formed, although in some cases it occupies an important position as an incidental catch.

It is already known that this sort of difference in the character of fishing grounds is closely connected with oceanographic conditions. For instance, Nakamura (1954) hypothesized that 'ocean current systems are fishing grounds, each with its own different character.' Mimura and Nakamura (1959) pointed out that the current boundaries of the Indian Ocean fishing grounds coincide with the boundaries which appear on current charts, and Yamanaka and Anraku (1959, 1961), studying the distribution of water masses in the Indian Ocean, have recognized that each of the several fishing grounds develops in a different water mass.

Figure 5 shows the total catch rates for the four species discussed above. Considering it in general, the areas of high catch rates are the southeastern Indian Ocean and the western Indian Ocean, the waters between about 80°E. and 100°E. showing only values that are generally lower than those to the east and west.

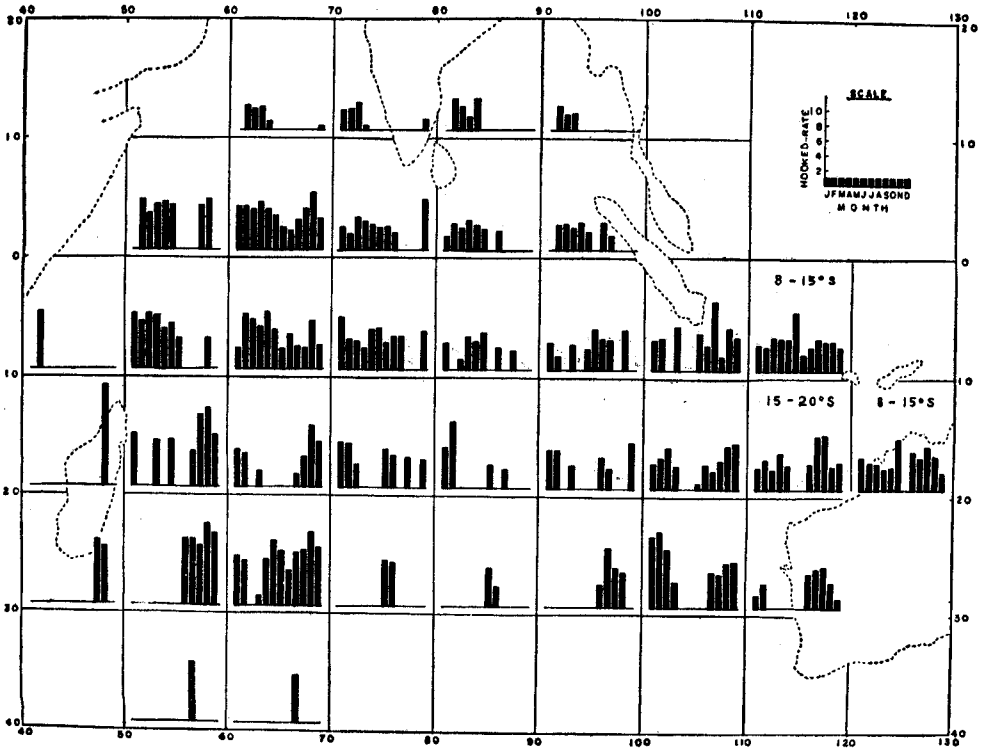


FIG. 5. Monthly hooked rates of tunas by area (1959). (Total of yellowfin, bigeye, albacore and Indomaguro).

The high catch rate in the southeastern Indian Ocean is due to the catch of Indian bluefin there. The fact that in the western Indian Ocean the catch rate is higher than it is to the east results from the fact that on both the yellowfin fishing grounds and the albacore fishing grounds the catch rates of the principal species fished, that is, the yellowfin and the albacore, are higher to the west and lower to the east. This shows that in each fishing ground the fishing conditions for the principal species fished in that ground play a controlling role in the overall fishing conditions there.

If we compare the catch rates of the fishing grounds which have high rates—the Indian bluefin ground and the western Indian Ocean yellowfin and albacore grounds—it can be seen that approximately similar rates are shown for the Indian bluefin ground (February-March) and the albacore ground (October-December), however, the rates for the yellowfin ground (January-June) are somewhat inferior. The catch rate expresses the number of fish taken per 100 hooks, while the weight of catch is expressed by the catch rate X the average weight of the fish. The main weight classes of the catch on the Indian bluefin, yellowfin, and albacore grounds are respectively 55-75 kg., 25-45 gk., and 15-25 kg., so it is estimated that the weight of catch per unit of fishing effort is conspicuously larger on the Indian bluefin ground, followed by the yellowfin and albacore grounds in that order.

Distribution of Fishing Operations

Figure 6 shows by month and area the numbers of operational data used in this report (which is to say, the number of operations covered by the Nankai Regional Fisheries Research Laboratory's market surveys). The number is quite a bit fewer than the actual number of operations (the sampling rate cannot be accurately ascertained but is estimated to be between 50% and 70%), but it is probably adequate for finding out the trends in the distribution of operations.

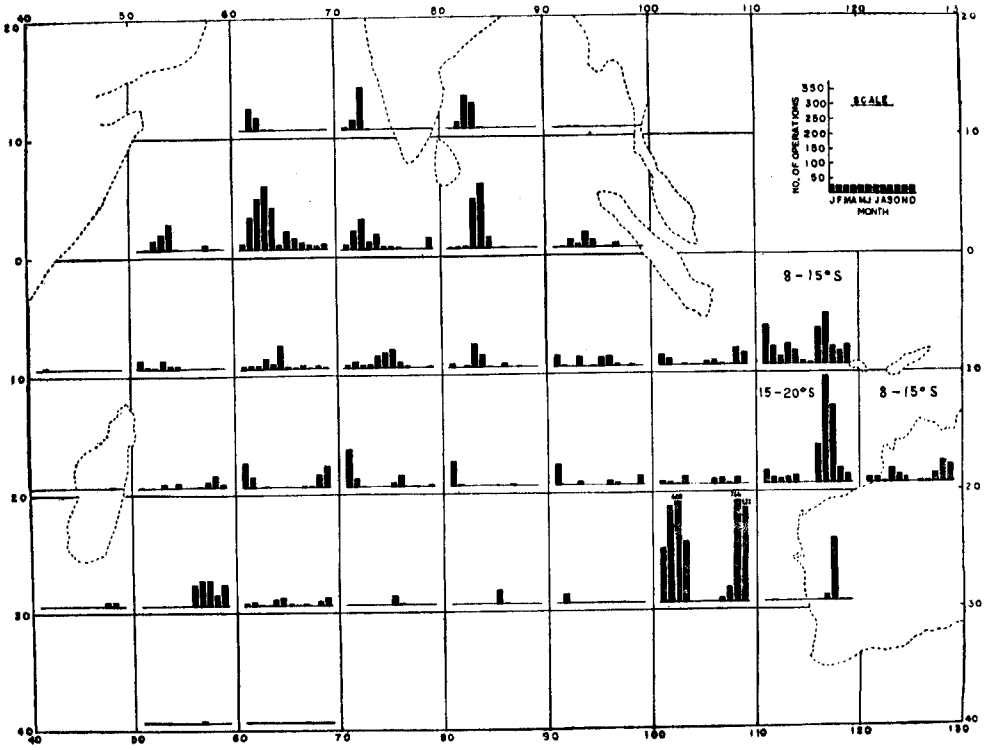


FIG. 6. Number of operations investigated by area (1959).

The number of operations is conspicuously greater in he southeastern Indian Ocean, but this is probably owing to the fact that, as explained above, the productivity of the Indian bluefin ground is high, and this reflects the importance of that fishing ground. In the yellowfin and albacore fishing grounds a tendency can be seen for the number of operations to be greater in the more westerly areas, and this too can be said to be natural, in view of the areal differences in catch rates in the two fishing grounds. However, the fishermen select those fishing grounds which they consider most advantageous, not from catch rates alone, but on the basis of consideration of a combination of such factors as the distance to the ground, weather conditions, fish prices, fishing conditions on other grounds, including those of the Pacific, the incidental catch rate of spearfishes, and so on. Consequently, the pattern of distribution of fishing operations seen Figure 6 shows the result of a complex inter-locking and mutual influencing of these factors. For example in spite of the fact that in the yellowfin fishing ground of the western Indian Ocean similar catch rates are shown for 0°-10°S. and 0°-10°N., there are more fishing operations at 0°-10°N., which is thought to be largely owing to the greater incidental catch of blue marlin and striped marlin there. Again, in the area of 10°N.10°S., 80°-100°E., a comparatively large number of operations is seen in April-June, and this is thought to be due to the fact that at that season, for fishing boats of such size that this area represents their extreme operating radius, no comparably profitable fishing ground is to be found elsewhere.

The total number of operations surveyed in 1959 was 9,758. This figure represents a considerable increase over the 7,962 of 1956, the 6,798 of 1957, and the 7,416 of 1958. (As the Nankai Regional Fisheries Research Laboratory has not changed the scale or the methods of its market survey, the ratio of operations surveyed to the total number of operations should not have changed much from year to year, and the data are probably effective for seeing the relative changes from one year to another).

This increase arises from the fact that the Indian bluefin ground south of 20°S. was first opened up at the end of 1958, and beginning in 1959 there was a rapid increase in operations in this area (Mimura, 1961). Trips to the albacore grounds are also increasing with the expansion of the grounds, so operations on the yellowfin tuna grounds are showing somewhat of a declining trend, despite the increase in the total number of operations.

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* Nankai Regional Fisheries Research Laboratory, Kochi, Japan.

SIZE COMPOSITION OF THE OCEANIC SKIPJACK *KATSUWONUS PELAMIS* (LINNAEUS) AND THE YELLOWFIN TUNA *NEOTHUNNUS MACROPTERUS* (TEMMINCK AND SCHLEGEL) FROM THE LACCADIVE SEA AROUND MINICOY DURING THE SEASON 1960-61*

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THE tuna fishery of Minicoy island depends mainly on the oceanic skipjack *Katsuwonus pelamis* and to a smaller extent on the yellowfin tuna *Neothunnus macropterus*. A comprehensive account of the fishery has been given by Jones and Kumaran (1959). The gear employed is the pole and line, using live-bait fishes. Data on the size composition of tunas are of value in elucidating their population structure and migrations. An intensive study on the fishery of the island was carried out during the tuna fishing season November 1960-April 1961. The results of the investigation are presented in this report. The size composition of the two species for the season has been studied by the examination of samples from the landings in Minicoy. Data on the total catches of each species and the catch-per-man hour-effort are also given.

MATERIAL AND METHODS

Field measurements of the length of *Katsuwonus pelamis* and *Neothunnus macropterus* were taken on all fishing days. The number of fish desired per sample while not precisely determined, was tentatively set at thirty, though it varied from sample to sample, by sudden set-backs in the fishery. The total length of each fish, the distance from the tip of the mouth with the jaws closed to the cartilaginous median part of the caudal fork was recorded in millimeters according to the methods of Marr and Schaefer (1949). The total weight of each fish was taken by means of a spring balance and was recorded in pounds and fractions of a pound. The number of samples examined each month was approximately 20, though during November only two samples were examined, as the observations could be started only by the end of the month.

Twenty-six boats were engaged in tuna fishing in Minicoy during the season. The catches brought in by all the boats on all fishing days were recorded according to the species. As it was not possible to weigh the landings of each boat, the number of fish in each boat was recorded according to the species. The total weight of each species was calculated from this, the average weight of one fish being known from the sample weighed.

In the calculation of man-hour-effort, only the adult men were counted. Almost an equal number of boys of various ages also go in each fishing boat to help in the rowing of the boat and in bailing out the water coming out of the bait wells. As they do not actively participate in fishing, they were left out from the calculation. Time of absence from the landing place has been calculated from observations on the time of departure and arrival. But as the bait fish are collected on the way to the fishing grounds, two hours per boat have been deducted for this. In addition, three hours per boat were also deducted being the average time taken for the journey to the fishing grounds and back.

The frequencies of each length in any one month were combined and converted into percentages of the total for the month. The values are plotted as monthly percentage length frequency distributions. The latter are presented for each species in the accompanying figures.

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Catch Statistics

Table I shows the monthly catches in Minicoy according to the species and also the man-hour-effort for each month. The total catches of all fishes during the season was 1149153.33 Kgs.

Table I

The effort in man-hours and the catch in Minicoy during the season 1960-61

Month	Effort in Man-hours	*Katsuwonus pelamis* Kgs.	*Neothunnus macropterus* Kgs.	Other fishes Kgs.	Total catch Kgs.	Catch-per-man-hour-effort Kgs.
December 1960	6,30,979	3,24,740.85	7,023.33	405.17	3,32,169.35	0.526
January 1961	6,74,417	5,30,295.54	11,951.45	623.00	5,42,869.99	0.805
February 1961	2,17,521	1,26,455.19	4,292.02	660.20	1,31,407.41	0.604
March 1961	1,92,796	73,789.97	604.17	847.20	75,241.34	0.390
April 1961	1,41,296	65,941.48	1,457.69	66.07	67,465.24	0.477
Season	18,57,009	11,21,223.03	25,328.66	2,601.64	11,49,153.33	0.619

This includes *Katsuwonus pelamis*, *Neothunnus macropterus*, *Auxis thazard*, *Euthynnus affinis*, *Acanthocybium solandri*, *Istiophorus gladius*, *Elagatis bipinnulatus*, *Coryphaena hippurus*, *Caranx* sp., *Chorinemus* sp. and sharks. Of this *K. pelamis* formed 11,21,223.03 Kgs. and *N. macropterus* 25,328.66 Kgs. The catch-per-man-hour-effort for the whole season has been calculated to be 0.62 Kgs. (Fig. 1).

The monthly landing of each species are given in Fig. 2. The maximum catch was in January for both the species. December came next followed by February. The lowest catch was recorded in March. There was a revival of the fishery in April.

Length Frequency Distribution of *Katsuwonus pelamis*

The length frequency distribution of the species during the season is given in Fig. 3. 2247 specimens have been examined for the purpose. Only 66 specimens belonging to two samples could be examined during November as the observations were initiated only at the end of the month. Their size ranged from 380 mm. to 545 mm., with the mode at 430 mm. The fishery was comparatively poor during November and the first fortnight of December. During December, 622 specimens belonging to 20 samples were examined. The size composition of the fishes landed during the first fortnight had a marked difference with that of the fishes landed during the second fortnight. Fishes of the size group 340-540 mm. predominated in the catches during the first fortnight, while those landed during he second fortnight belonged to a larger size ranging from 500 mm. to 720 mm. The catches improved by the beginning of the second fortnight of December and

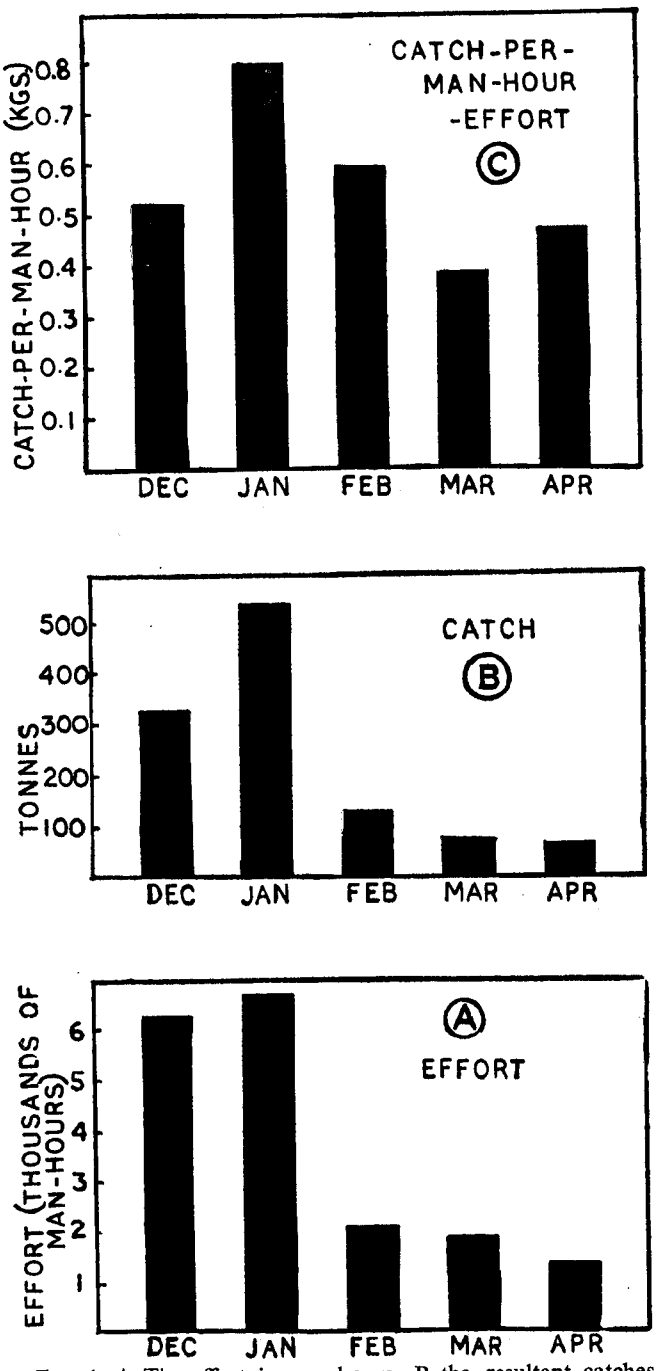


FIG. 1. A The effort in man-hours, B the resultant catches and C the catch-per-man-hour-effort in Minicoy during the season 1960-61.

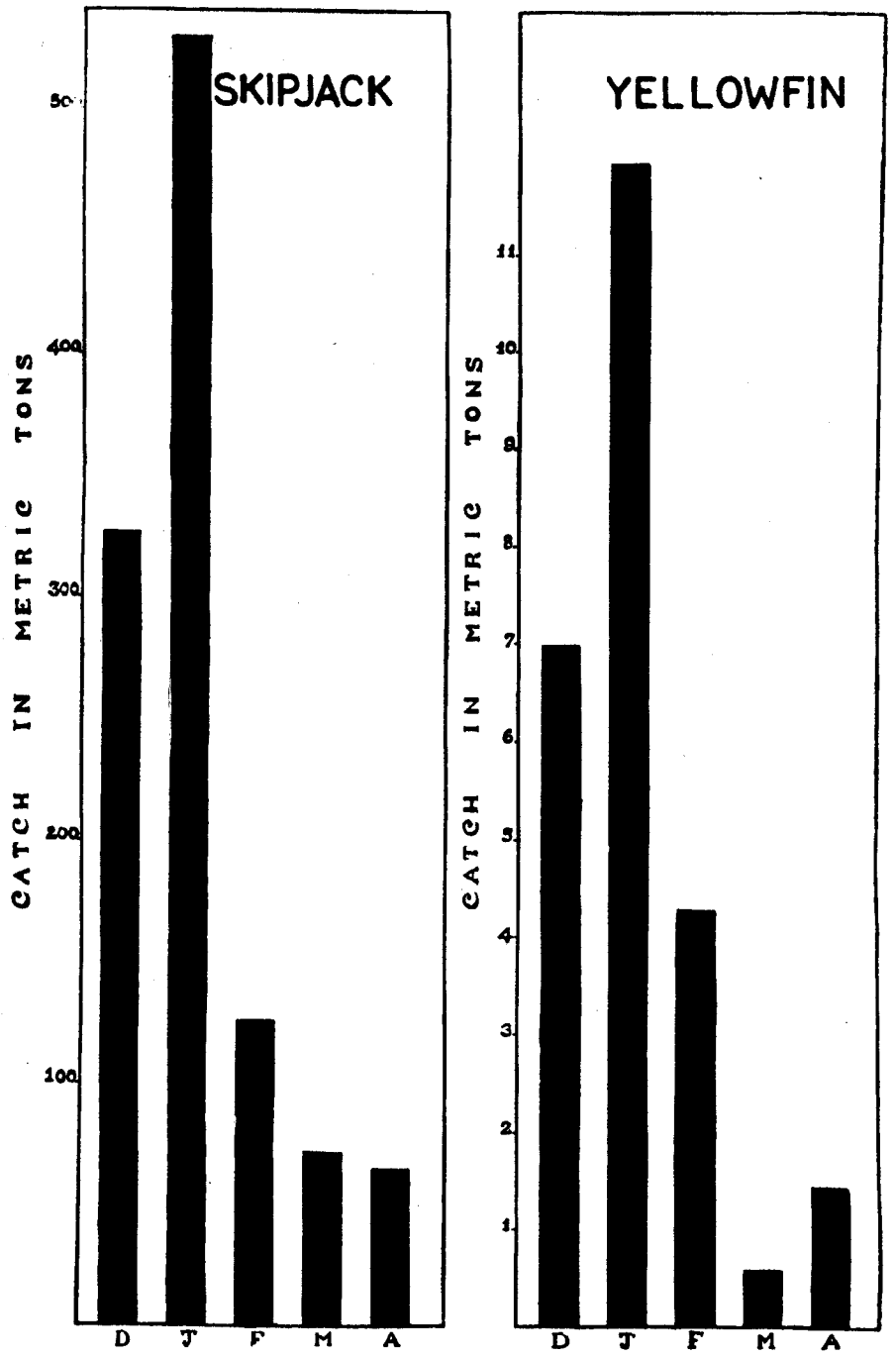


FIG. 2. Catches of *Katsuwonus pelamis* and *Neothunnus macropterus* in Minicoy during the season 1960-61.

during the last week very heavy catches were brought in by all the boats. The fishery continued to be good in January. The total catches in January exceeded those of all the other months. 518 specimens were examined during the month. They belonged to 20 samples. The graph for the month is unimodal, with the size group 560-600 mm. predominating. The mode was at 570 mm. During February, 20 samples comprising 519 specimens were examined. The graph for the month is bimodal, with one mode at 470 mm. and the other at 570 mm. 314 specimens belonging to 14 samples were examined during March. The graph shows two modes, one

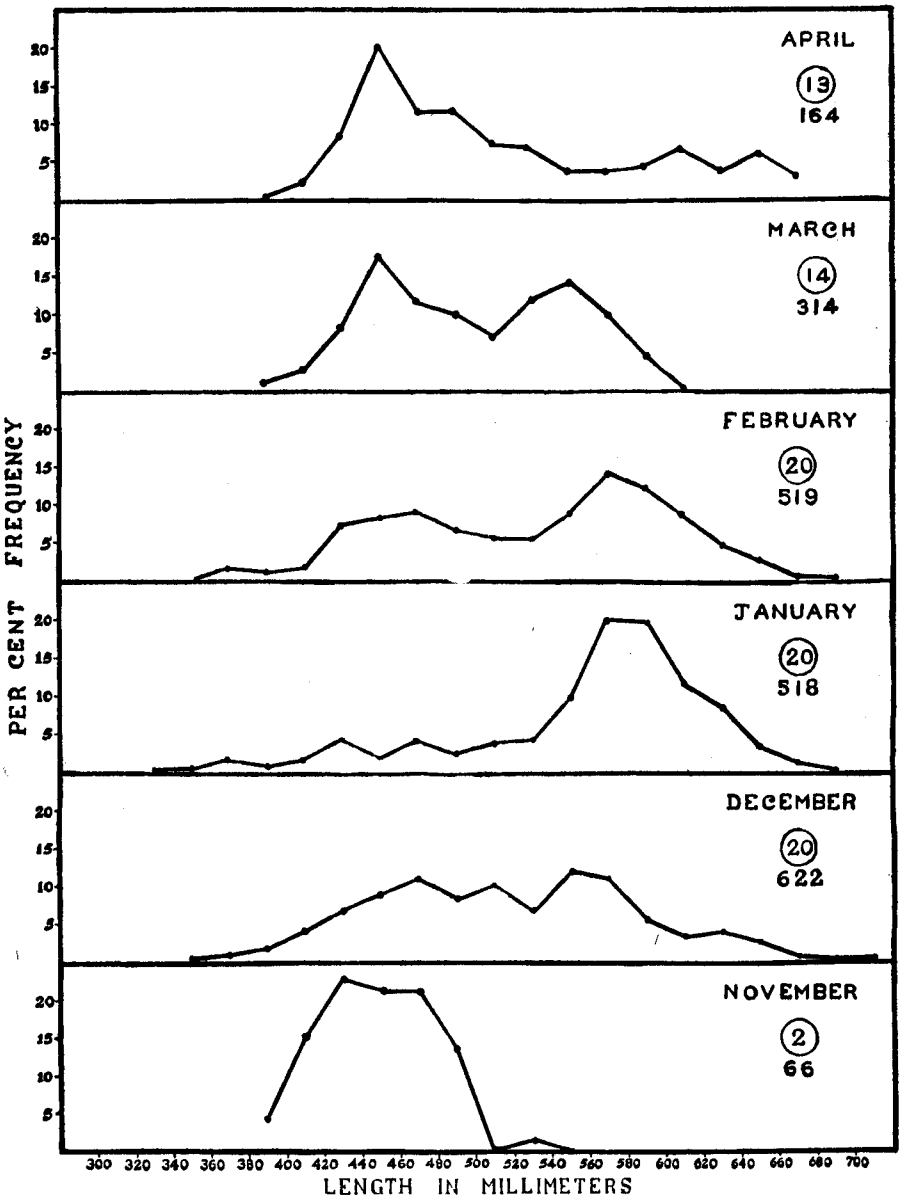


FIG. 3. Length frequency distribution of *Katsuwonus pelamis* in Minicoy during the season 1960-61. The number inside the circle denotes number of samples and that below it is the number of specimens examined during a month.

at 450 mm. and the other at 550 mm. ; the entry of smaller fish into the fishery is indicated. The fishery was comparatively poor during the month. This condition continued during April also. 164 specimens belonging to 13 samples were examined during April. They ranged in size between 380 mm. and 680 mm. with the mode at 450 mm. The number of larger fish dwindled during the month.

Length Frequency Distribution of *Neothunnus macropterus*

The length frequency distribution of the species during the season is given in Fig. 4. 803 specimens were examined during the course of the study. The number of fish in a sample could not be fixed as the specimens became rare occasionally. 269 specimens belonging to 16 samples were examined during December. They ranged in size from 340 mm. to 840 mm. with two modes, one at 450 mm. and the other at 670 mm. During January 17 samples comprising 302 specimens were examined, the majority of them belonging to the size group 470-520 mm. During February, 181 specimens belonging to 15 samples were examined. The smallest fish of the season occurred during the month, the minimum size being 270 mm. The graph for the month shows three peaks, one at 310 mm., another at 410 mm. and the third one at 650 mm. The number of fish available for examination was small during March and April. During March 27 specimens belonging to 11 samples were examined. They ranged in size from 380 mm. to 690 mm. with the mode at 430 mm. 25 specimens belonging to 6 samples were examined during April. They ranged in size from 420 mm. to 670 mm.

Discussion

As the observations are confined to one season only it is not possible to derive the age groups from the data. But a comparison with the observations on the size composition of the two species from the Eastern Tropical Pacific Ocean (Schaefer 1959) shows that the live-bait fishery for the oceanic skipjack and yellowfin tuna in that region also depends more or less on the same size groups. The fishery there operates on one or at the most two age groups of fish in the case of *Katsuwonus pelamis*, which enters the fishery at a size of 45-50 cm. and are probably two years old then. The larger group has a modal size of 60-70 cm. Groups of fish larger than 70 cm. a e almost non-existent in the catches there. The fishery in Minicoy depends probably on three age groups of *Katsuwonus pelamis*. The first group is of the size 280-450 mm. their age being probably above one year. The second group of fish range in size from 450 mm. to 600 mm. and are p. obably above two years old. The larger fish ranging in size from 600 mm. to 730 mm. are probably three years old. Fishes four years old and above that are non-existent in the catches in Minicoy.

Hennemuth (1961) fixes the size of yellowfin tuna one year old as 550 mm. appi oximately. According to him, yellowfin at the age of two years average 850 mm. and at three years 1230 mm. When compared with this it is seen that the entire fishery for yellowfin in Minicoy is suppo ted by fish of less than two years. The majority belong to the O-year group.

Though fish of size less than 280 mm. may occur in the vicinity of the island they do not occur in the catches probably owing to the selectivity of the gear.

Summary

The size composition of *Katsuwonus pelamis* and *Neothunnus macropterus* from the Laccadive sea around Minicoy during the season 1960-61 has been studied. The catch statistics and the catch-per-man-hour-efforts are also given. *K. pelamis* ranges in size from 280 mm. to 720 mm. Fish above 720 mm. do not occur in the fishery there. Yellowfin ranges in size from 270 mm. to 830 mm. Fishes of smaller size groups do not occur in the catches probably owing to the selectivity of the gear though they may occur in the vicinity of the island.

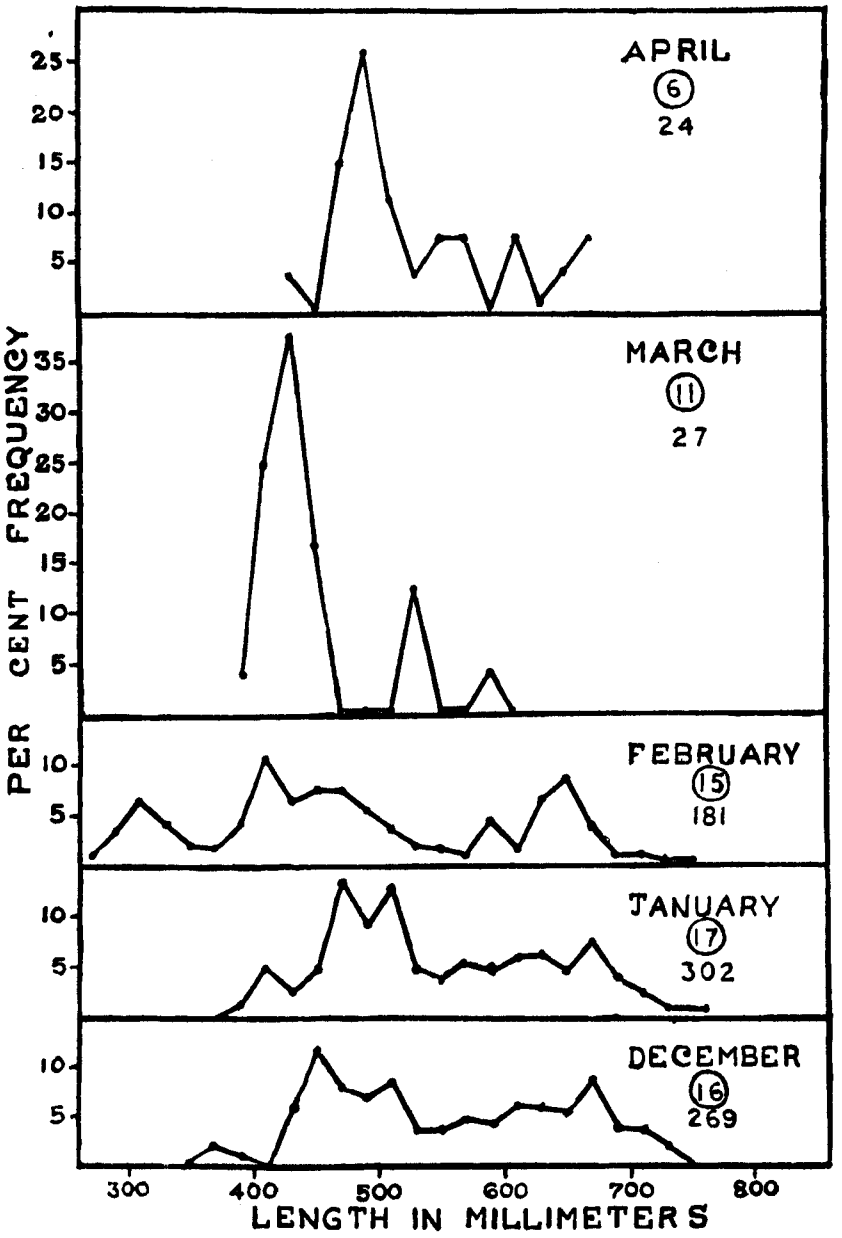


FIG. 4. Length frequency distribution of *Neothunnus macropterus* in Minicoy during the season 1960-61. The number inside the circle denotes the number of samples and that below it is the number of specimens examined during a month.

ACKNOWLEDGEMENT

I am indebted to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for guidance and to the field staff of Minicoy Research Centre for their valuable assistance.

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RESEARCH PROGRAMME OF THE U.S. BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, HONOLULU, HAWAII

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THE research programme of the U.S. Bureau of Commercial Fisheries Biological Laboratory, Honolulu,[2] is designed to further knowledge of the high seas fishery resources, especially the tunas, in the central tropical and subtropical Pacific Ocean, of the ocean in which these fishes live, and, especially, of the interaction between fish and ocean.

Largely as a matter of convenience, the work in progress is grouped in six units ; Oceanography, Fishery Potentials, Skipjack Ecology, Albacore Ecology, Behaviour, and Subpopulations.

Oceanography : All of the oceanographic station data of the Pacific (about 40 per cent of which are now on hand) are being examined to determine (1) average conditions, (2) annual and seasonal variations from the average, and (3) areas in which additional observations are needed. The computing facilities (IBM 650 computer and satellite equipment) of the University of Hawaii are being used in these studies, which would otherwise be prohibitive in terms of man-hour requirements. In addition to their intrinsic interest, the results of these studies are expected to be of value in studies of fish distribution, abundance, spawning areas, subpopulation location, etc.

A recent study of all of the oceanographic data available from a 3 million square mile area around the Hawaiian Islands, plus heat budget considerations, led to the description of the oceanographic climate of the area and the hypothesis that the major observed annual changes are due to advection. A 2-year period of intensive observations in the area is planned in order to test the hypothesis (as well as some of the assumptions in the heat budget calculations) and to measure the rates at which the oceanographic processes occur. The results will also be useful in understanding the seasonal movements of skipjack in the Hawaiian Islands area (see below).

Interesting results were obtained from drift bottle releases in the Hawaiian Islands area during three cruises in 1961. All releases were made under conditions of prevailing Northeast Trade Winds. Recoveries from releases made in the late winter, when the Trade Winds were weak, showed movement from the leeward side of the island chain to the windward side (i.e., movement of the surface waters against the wind), with no recoveries from bottles released to the east and north of the islands. Recoveries from releases in the spring, when the Trade Wind circulation was strong, were similar, with recovery localities extending farther to the northwest. Recoveries from releases in the summer tended to be just the reverse, with recoveries from bottles released to windward, but few from releases to leeward. The possibility of aircraft drops, rather than releases from surface craft, will be investigated, since these will permit more frequent and synoptic coverage of the area at reduced cost.

Temperature and salinity data from monitoring stations have been found to be of increasing value as the length of the time series and the number of stations increase. Land stations now extend from Samoa to Midway and from Wake to the Hawaiian Islands. Data are also obtained from North Pacific Weather Ships.

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[1] Hawaii Area Director, P.O. Box 3830, Honolulu 12, Hawaii, U.S.A.
[2] Formerly known as the Pacific Oceanic Fishery Investigations.

Studies of both invertebrate and vertebrate indicator species over a large area of the Pacific are in progress.

Fishery Potentials : Determination of tuna yield and, especially, estimates of maximum yield may be based on catch data and information on growth, age, and mortality rates. Efforts are being made to compile catch data for those tuna fisheries of the Pacific for which the data are not now readily available.

Accumulation of size data, by sexes, for certain species of tunas has revealed sexual dimorphism in growth. In bigeye tuna, for example, males grow faster than females, so that there is an excess of males at larger sizes. In Hawaii, at least, the sex ratio (in the catch) changes during the course of the year. Differences such as these must be taken into account in maximum yield estimates.

Skipjack Ecology : Owing to the seasonal nature of the occurrence of skipjack, the Hawaiian Islands constitute a natural laboratory for the study of the relationship of skipjack to their environment. Although skipjack occur in the vicinity of Hawaii throughout the year, the larger fish (18-22 lbs.) are most abundant during the summer months, when about 90 per cent of the catch is made. Although tagging experiments have shown that skipjack move freely through the Hawaiian Islands area, their origin is not yet known. It has been observed, however, that their movements are related to oceanographic conditions, with an interesting time lag. In late winter or early spring, the advection of surface water past the island of Oahu changes from a southerly direction to a northerly direction. This change can be simply detected by temperature observations and is signified by the time the surface waters stop cooling and start warming. When this change occurs early in the year, say in early February, the catch of skipjack in the following summer is better than average. When the change occurs in late March, the catch the following summer is less than average.

The nature of this relationship is not yet known. It has obtained over a 10-year period and is used as the basis of predictions to the industry. Predictions not based on understanding may, of course, prove to be disappointing. Major effort on this problem will be devoted to examining all existing data, to see if these suggest a hypothesis which may be tested at sea, and to defining the geographic limits of the subpopulation upon which the Hawaiian fishery is based (see below).

The annual landings of skipjack in the Hawaiian fishery, which is a live-bait fishery, are more frequently limited by live-bait supplies than by the abundance of skipjack. In an effort to alleviate this limitation, experimental fishing trials have been made with monofilament nylon gill nets, using a power block to haul the nets. Although the time available for these trials was inadequate, skipjack can be caught with these nets. At present, it appears that the use of these nets will most likely be complementary to the live-bait fishery, rather than a replacement for it.

Studies of the distribution and abundance of skipjack larvae in Hawaiian waters show a peak of abundance in the summer and a minimum in the winter.

Although the larvae of skipjack and yellowfin have been known for some years, the larvae of other important tuna species have just been identified, including albacore, bigeye, Australian northern bluefin, and Pacific bluefin. It was possible to recognize several kinds of larvae and to assign specific identifications on the basis of the distribution of adults. Owing to differences in the distribution of adults, these identifications appear reasonably firm. Further confirmation will be sought through fertilization attempts at sea.

Albacore Ecology : It has been known for some time, on the basis of tagging experiments that albacore migrate across the North Pacific. The same evidence, however, indicates that this is not a simple, annual trans-Pacific round trip. Consideration of the tagging data and the size distribution of fish in the American coastal fishery (summer), the Japanese west-central longline

fishery (winter), and the Japanese coastal fishery (spring) has led to a migration model consistent with the hypothesis of a single North Pacific albacore subpopulation. Briefly stated, it is : Albacore first enter the fishery, probably at age 2, in the American coastal fishery. Fish from the American coastal fishery migrate westward in the fall. Some return to the American fishery the following summer. Others continue westward through the Japanese longline fishery and enter the Japanese coastal fishery. This pattern tends to be age specific, with more of the younger albacore in the eastern Pacific and more of the older albacore in the western Pacific. The mature albacore move south into the spawning grounds, which probably lie in a broad area to the west of Hawaii.

Additional efforts will be made to define the location of albacore spawning grounds in the North Pacific and also in the South Pacific. No albacore tagged in the North Pacific have been recovered in the South Pacific. There is additional evidence (see below) for regarding the South Pacific albacore as distinct from those of the North Pacific. By analogy with the North Pacific, there may be only a single subpopulation of albacore in the South Pacific.

Behaviour : Observation of tuna at sea, through underwater observation ports, has suggested lines of inquiry hitherto impossible. For example, skipjack exhibit a pattern of vertical bars when feeding, in contrast to their usual pattern of horizontal stripes. This suggests a form of communication ; i.e., the behaviour of other skipjack may be influenced upon observing this barred pattern. Similarly, when making dashes for prey, skipjack erect their dorsal fin, displaying the white anterior edge. This fin is also erected when the fish is turning or decelerating.

Experiments with water sprays and different live-bait species showed that catch rates were higher with the water sprays on than when they were off, regardless of the bait species used. However, the feeding rate of skipjack was higher with the sprays on only when a non-diving bait species was used. When diving bait species were used, water sprays had no effect on feeding rate.

In live-bait fishing it is common, in some area, to encounter what have been considered to be mixed schools of skipjack and yellowfin. Recent observations on a few such encounters revealed that, in reality, these were independent schools of yellowfin and skipjack which momentarily converged on the same prey and then proceeded on their separate ways.

Improvement in handling techniques has made it possible to maintain skipjack in tanks for as long as 5-1/2 months, thus permitting behaviour studies under controlled conditions. Skipjack prove to be easily conditioned to respond to stimuli, and experiments are in progress to determine their visual acuity and colour discrimination. Anatomical studies of sensory systems will be made. The olfactory capsule is presently being examined.

Observations have shown that shrimp exoskeletons began to appear in the faces in as short a period as 1-1/2 hours after skipjack were fed shrimp. It is a common experience of fishermen that they are most likely to catch fish in the early morning or late afternoon. Experiments in which skipjack were fed to satiation at hourly intervals show a peak in feeding rate in early morning and in the afternoon. The morning peak was much greater than the afternoon peak.

Subpopulations : The problem of identifying discrete population units, or subpopulations, has long been recognized as a pressing one in fishery biology. Unfortunately, the techniques available have yielded less than the desired results for most marine fishes. Morphometric and meristic characteristics are frequently modified by environmental conditions. Tagging experiments may be difficult to design so that they will yield the desired information. There is needed a characteristic known to be under genetic control and capable of defining subpopulations. Blood group systems constitute such a characteristic.

Considerable time has been spent in developing reagents capable of recognizing blood group systems in tunas. Most effort has been expended on skipjack and albacore, but the studies are now being expanded to include yellowfin, bigeye, billfishes, and some of the pelagic sharks.

Results thus far show the existence of distinct subpopulations of skipjack in the Hawaiian Islands and in the Marquesas Islands. Similarly, albacore samples from the North Pacific and South Pacific are distinct. As results accumulate, it will be possible to consider the population dynamics of discrete subpopulations, the ecological situations associated with subpopulation divergence, etc.

Studies on the genetics of blood group systems in tilapia are in progress.

In conclusion, I wish to mention the existence of special facilities of the Laboratory, including (1) its location in the Trade Wind zone of the Pacific, (2) the local availability of several species of tunas, (3) underwater observation ports in the research vessel *Charles H. Gilbert*, and (4) extensive collections of zooplankton and bathypelagic fishes. Visiting investigators are welcome.

SUMMARY OF STUDIES ON TUNA RESOURCES CARRIED OUT AT NANKAI FISHERIES RESEARCH LABORATORY, JAPAN

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THIS report is based on the publication 'comprehensive report of studies on tuna resources' issued by the Nankai Regional Fisheries Research Laboratory, Japan in December, 1960. The publication contains the organization of the Laboratory for carrying out studies on tuna resources, the outline of the studies conducted so far and the programme of work for the future. The writer has picked up a part of the results contained in the publication and the same are presented below :

(A) Yellow-fin tuna (' Kiwada ' or ' Kihada ' in Japanese) *Neothunnus macropterus.*

Amongst all tuna species this is distributed in the seas of the lower latitude i.e. yellow-fin tuna live mainly in the tropical seas of Pacific, Indian and Atlantic oceans. Though the fish that live in these three oceans were formerly considered as different species, strong opinion that all the three are the same is gaining ground in recent years. Although the species from the three oceans are the same there seems to be very little interchange of population of the fish of these oceans which affect the stock of the fish in the respective oceans.

The centre of distribution of the fish in Pacific Ocean ranges between 5° N. to 10° S. latitudes. The size composition of this fish differs much from area to area in the Ocean wherefrom the fish is caught. Though the fishing season in Pacific Ocean is almost the year rounds, in the months of March and September of each year there is distinct fluctuation.

About the Indian Ocean species, very little data is available to show its distribution, age or body length composition, fishing season etc. But it is assumed that the yellow-fin tuna in Indian Ocean would also follow the same trend as that of the Pacific Ocean.

The fish spawns throughout the year covering areas dominated by tropical sea currents.

(B) Long-fin tuna (' Bin-naga ' in Japanese) *Germo germo*

This is found in the oceans both of the Northern and Southern Hemispheres and the fish of the two hemispheres are considered to be independent stocks. In the North Pacific Ocean, long-fin tuna is mainly caught while the fish is migrating in searching of food. Spawning area of the fish in the Northern Hemisphere to be the sea of south of the semi-tropical astringency line, particularly in the sea immediately north of the tropical current.

The stock of this fish in the Northern Pacific area is the same and therefore Japan and America appear to be catching the fish of the same stock. The youngest age of the fish caught is 3 to 4 years. There are distinguishable year-wise fluctuations, and the fluctuations are dependent upon the stocks added each year.

In Indian and South Pacific Oceans the fish is mainly caught during the spawning season. Distribution, migration and age composition of the spawning groups of this fish have been studied and published by the Laboratory already.

(C) Big eye (' Mebachi ' in Japanese) *Parathunnus mebachi*

This species is distributed in Indian and Pacific Oceans. Although in Atlantic Ocean also this fish has been recorded, it is considered to be different species from that of the Indian and Pacific Oceans.

The centre of distribution of the fish in Indian Ocean makes a long belt from East to West along the Equator. The fish is mainly caught during its spawning season. The distribution of the fish during the feeding migration is not yet known.

(D) Indian and Australian tunas

' Southern Bluefin ' (*Thunnus maccoyi*) of Australia seems to be the name adopted for Indian and Australian tunas. However, no detailed systematic studies on the species have so far been undertaken.

There are two main fishing grounds for Indian tuna, i.e., 10°-15°S, 110°-120°E. and 20°-30°S., 100-°110 'E. The main fishing season for the former grounds is from September to March and for the latter October to April. The fishing ground of Australian Tuna appears in the area 30°-40°S., 175°E-170°W. during the period from July to December.

As these grounds were explored only very recently few observations are available at present. 10 to 15 tons/day of catch is being procured in these areas when the fishing season is in full swing.

The biological studies on these tunas mentioned above have also been described in the publication and though the studies seem to be interesting and valuable, they are however, omitted in this communication.

SOME NEW TRENDS IN INVESTIGATION OF TUNAS IN THE PACIFIC OCEAN

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INTRODUCTION

THE tunas have been the basis of important fisheries in tropical and sub-tropical seas around the world for a very long time, indeed for centuries in the Mediterranean, and many researchers have investigated various aspects of their biology and life history over the years (see, for example, the bibliographies prepared by Shimada 1951 and Van Campen and Hoven, 1956). Such investigations, however, until about a dozen years ago, were not very comprehensive, being mostly the efforts of individual researchers working with materials that came readily to hand, and utilizing for the most part classical methods which had been applied to other commercial fish species, mostly of high latitudes. This did not provide much in the way of understanding of these large, migratory, high-seas fishes, for several reasons :

(1) The tunas characteristically range over large areas of the sea. Some species, indeed, such as the albacore (*Thunnus germo*) of the North Pacific, have now been shown to range over almost the whole of an ocean. Investigations, to be very meaningful with respect to a population, must be conducted throughout the range of the population.

(2) These species are truly inhabitants of the high seas, spending their whole lives far from land, their distributions and migrations being related primarily to the shifting features of the oceanic environment rather than to the geography of the shore or the sea bottom. Important features of their ecology and life history demand, therefore, expensive and difficult research at sea, and gathering of information not only on the fish themselves, but on their oceanic environment.

(3) For all of the tunas, and especially for the tropical species, some of the classical methods of study of such features as age and growth, population structure, and migrations, which had been largely developed for species of high latitudes, were not quite suitable. Modifications of these techniques, and development of new ones, have been required.

In the United States, very little significant research on the tunas was conducted prior to 1950. Scientists of the California State Fisheries Laboratory had gathered some information on the life history and population structure of albacore, *T. germo*, yellowfin tuna, *Thunnus* (*Neothunnus*) *macropterus*, and skipjack, *Katsuwonus pelamis*, over the years, and had established an excellent system of collection of catch statistics. The Pacific Biological Station of the Fisheries Research Board of Canada had commenced some study of the albacore. John Marr and I, with aid from our associates of the South Pacific Investigations of the U.S. Bureau of Commercial Fisheries, had been able to make preliminary studies of the age, growth, and spawning of yellowfin and skipjack off Central America, and had collected and identified juveniles of these species and also of *Euthynnus lineatus* and *Auxis thazard* from that region, and had conducted a reconnaissance of the Central Pacific, aboard vessels of the Pacific Exploration Company. Marr also conducted limited studies of the distribution and spwaning of tunas near Bikini atoll, in the Marshall Islands, during 1946 and 1947. These researches, together with the investigations which had been carried out by Japanese scientists in the Western Pacific, provided no more than a meagre start toward the understanding of the tuna populations of the Pacific Ocean.

Means for tuna research on an adequate scale commenced to become available with the establishment of the Pacific Oceanic Fishery Investigations of the U.S. Fish and Wildlife Service at Honolulu, Hawaii in 1949. Scientists of that research group have and are conducting comprehensive studies of biology, ecology, and behaviour of the tropical tunas and the albacore, primarily in the Central Pacific, but ranging far from their home base in all directions. In 1951, investigations of the tropical tunas, *T. macropterus* and *K. pelamis*, and of bait species used to capture them, was initiated by the Inter-American Tropical Tuna Commission in the Eastern Pacific, covering the region from California to northern Chile and offshore to about 120° W. longitude. At about the same time, the California State Fisheries Laboratory was able to augment its tuna-research staff. That research group has been engaged in studies of both tropical and temperate-water tunas, including the bluefin, *Thunnus saliens*, but is now concentrating its research on bluefin and albacore. More recently, in 1957, the Tunas Oceanography Research Programme of the Scripps Institution of Oceanography (Blackburn 1960), under contract with the U.S. Bureau of Commercial Fisheries, has undertaken investigations in the Eastern Tropical Pacific of oceanographic and climatic influences on the tunas of this region. Finally, two years ago, a new laboratory of the U.S. Bureau of Commercial Fisheries was established to study the distribution and behaviour of tunas with a view to assisting in devising means of harvesting them more effectively.

These expanded tuna investigations, and the expanded investigations of tunas by other laboratories in Japan, New Caledonia, and elsewhere, have greatly augmented our knowledge of the tunas. In the course of this research there have been developed new techniques, new concepts, and new avenues of investigation. These developments should make possible the more rapid and effective prosecution of research on the presently little-studied tuna populations of the other seas, such as the Indian Ocean.

Population Structure and Migrations

The most widely applied techniques of investigating the population structure of marine fish species are the comparision of morphological characters, from which inferences may be made as to possible existence of sub-populations, and the tagging and subsequent recovery of marked specimens, which can reveal directly the degree of intermixture of fish from different parts of the sea. The latter also, of course, provides information on the migratory behaviour of a population, which may depend on the age and physiological state of the fish as well as on environmental features, such as temperature, food, etc. Both of these mehods have been applied to the Pacific tunas.

Morphometric comparisons

Enumerable meristic characters are widely used for investigation of population structure of marine fishes. Such characters, however, have not proven very useful for the tunas, because the vertebral numbers are usually invariant within a species, and scales are difficult to count, or absent. Gill-raker counts have been of some value for indicating possible independence of populations of yellowfin tuna from different regions of the Pacific (Schaefer, 1952, 1955). Various body dimensions and fin-lengths, in relation to total body length, have been widely employed, most researchers using the standard measurement methods proposed by Marr and Schaefer (1949). In the study of such data, it has been found most useful to employ regression analysis, since, characteristically, the fins and various body parts grow at different relative rates. Schaefer (1952, 1955), employing such techniques, has concluded that there is probably no or little intermixing between yellowfin tuna of three different regions of the Pacific. Royce (1953) comparing regressions of body dimensions of yellowfin from different regions of the Pacific by a ' reduced coefficient of racial likeness ' has similarly shown considerable heterogeneity among yellowfin from different regions. Hennemuth (1959) from analysis of morphometric data of skipjack from near Hawaii, Southeast Polynesia, and the American West Coast has also shown that there is heterogeneity both within and between these regions. On the other hand, Broadhead (1959) was able to demonstrate no differences among samples of yellowfin from various areas off the Americas.

Nakagome (1958) and Kurogane and Hiyama (1958) have also shown that there are quite distinct morphometric differences among yellowfin taken from differnent regions of the Indian Ocean.

The analysis and interpretation of morphometric data is fraught with various statistical and other difficulties, which have been discussed in the papers cited and by Royce (1957). Although this is a useful approach to identification of populations, it is usually, by itself, inadequate, because two populations are clearly shown to be non-mixing only if there is no overlap of the ranges of the dimensions under consideration. If there is some overlap, there may be partial mixing even though the mean values of the dimensions is significantly different between the two populations. Conversely, the lack of demonstrable morphometric difference between two groups of fish does not conclusively show that they are members of a single population. Morphometric studies need, therefore, to be supplemented by other sorts of information.

Tagging

A direct approach to determining the amount of intermixing of fish from different regions is tagging and subsequent recovery of tagged specimens. This, of course, is useful only where there is opportunity for recovery of tags in a fishery in all the regions under consideration.

Early attempts at tuna tagging both in the United States and Japan were not successful ; these have been reviewed by Wilson (1953). The plastic loop tags, and improved tagging techniques, developed since 1952 by scientists of the California State Fisheries Laboratory and of the Inter-American Tropical Tuna Commission (Wilson 1953, Broadhead 1959b, Blunt and Messersmith 1960, Schaefer, Chatwin and Broadhead 1961), and plastic dart tags (Yamashita and Waldron 1958) have had much better success, although, as shown by Schaefer, Chatwin and Broadhead, there is still a very high tagging mortality, at least in tropical waters. Such tags applied to albacore near California have resulted in recoveries in the fishery northwesterly of the Hawaiian Islands and off the coast of Japan (Clemens 1961, McGary, Graham and Otsu 1961). Similarly, albacore tagged near Hawaii have been recovered both off the American and Asian coasts. From this, it appears that this species migrates right across the Pacific Ocean. Since there is no evidence of albacore spawning in the Eastern North Pacific (see below), it was earlier suggested that this might be the case.

Tagging of yellowfin tuna at many localities along the coast of the Americas, from which many hundreds of recoveries have been made (Schaefer, Chatwin and Broadhead 1961, Blunt and Messersmith 1960) has given different results. *All* recoveries have been made within the region of the fishery near the American coast, although there exist Japanese long-line fisheries for this species clear across the Pacific. This lack of recoveries to the westward corresponds to the morphometric evidence of heterogeneity among groups of yellowfin from different regions, referred to above. However, even *within* the Eastern Pacific, the migration patterns of yellowfin tuna revealed by the tag recoveries indicate that it is not inhabited by a single rapidly intermixing population. It appears that there may be at least two sub-populations, with an approximate boundary near 15°N. latitude.

For skipjack, all recoveries from tagging in the Eastern Tropical Pacific have also been made within the areas of the American fishery. However, in this case, this cannot be interpreted as necessarily indicating that the members of the stock along the American coast do not migrate much further westward, because there is no substantial fishery for this species in the Central Pacific to provide opportunities for recapture of tagged skipjack which might migrate there. Indeed, size-composition data and data on skipjack spawning (see below), as well as the nature of the diffusion of tagged fish away from the location of tagging, indicate that members of this species do move well offshore, beyond the present fishing areas, particularly at large sizes. How far off they move, and whether they are coextensive with stocks in the Central Pacific, are yet open questions.

Size-composition analysis

An additional recent technique for investigating population structure and migration is provided by the study of size-frequency data from different areas. The tunas grow sufficiently rapidly that the modes corresponding to different age components are separable in size-frequency samples the time-series progression of the modes indicating the growth of the age classes. By matching the modes in different areas, it is possible to arrive at useful inferences as to migrations, although, of course, such evidence needs to be supplemented by other types of information. This technique has proven useful with respect to the population structure of yellowfin tuna in the Eastern Tropical Pacific, as shown by Hennemuth (1961a). Similar studies are in progress for skipjack in the Eastern Pacific. The largest-scale application of this technique is that of Uchida and Otsu of the Hawaiian Biological Laboratory of the U.S. Bureau of Commercial Fisheries who, in an unpublished manuscript presented at the 1961 Pacific Tuna Biology Conference, have employed the size-composition of albacore catches in various regions of the North Pacific, together with other information, to infer a general model of the trans-Pacific migrations of this species.

Blood typing

Blood group characteristics, revealed by antigen-antibody reactions are under genetic control. Therefore, the frequencies of occurrence of blood-types, which may be studied by agglutination reactions of tuna erythrocytes with suitable reagents, and by other immunochemical techniques, may be used to determine whether there are differences in the genetic composition of groups of tunas (or other fishes) from different areas. Reagents for erythrocyte agglutination reactions may be naturally occurring antibodies in the sera of various animals, or antisera developed by introduction of red blood cells of the tuna into other individuals of the same species or different species. A very convenient group of reagents is the phytohaemagglutinins, extracts of leguminous seeds that contain substances which react like antibodies with the erythrocytes.

Such techniques have recently been employed to study tunas by Suzuki, Shimizu and Morio (1958), Suzuki, Morio and Mimoto (1959), Suzuki (1961), by Lucien Sprague of the Honolulu Biological Laboratory (unpublished M.S. presented at the 1961 Pacific Tuna Biology Conference, and personal communications), and by Witold Klawe and Douglas Vann of the IATTC staff. Marr and Sprague (1961) have provided a most useful discussion of the theory and practices of some of these techniques. The study of blood-group frequencies offers two major advantages over other methods of research into population structure. Since the antigen-antibody reactions are under genetic control, one avoids the environmental phenotypic effects which may confuse conclusions from morphometric studies. Most important, however, is the fact that if one is able successfully to identify a sufficient number of phenotypes in a blood-group system to calculate the allele frequencies, he may then apply the Hardy-Weinberg Law to determine whether the members of a single group of tunas have or have not originated from a single interbreeding unit, or subpopulation. This line of research is, therefore, being actively pursued by the researchers mentioned above, and others.

Sperm morphology

Preliminary investigations by Bernard Fink of the IATTC staff indicate that the morphology of spermatozoa of tunas, as revealed in electron micrographic silhouettes may be a useful character for identifying races of yellowfin, and perhaps other tunas. If so, this will afford yet another approach to the study of population structure.

Spawning Areas and Seasons

Two approaches have been employed to study the occurrence of tuna spawning: gonad examination and collection of larvae and juveniles.

Gonad examination

Occurrence of females with ovaries containing eggs very near to spawning, or recently spent, is evidence of spawning in the near vicinity. More detailed examination of the ovaries may also indicate whether a single fish spawns more than once during a season. June (1953) and Schaefer and Orange (1956), from the occurrence and progression of multiple modes of egg sizes in developing ovaries, and from the occurrence of remnants of mature ova from a previous spawning in ovaries containing maturing eggs, have inferred that yellowfin tuna may spawn more than one batch of eggs per season. Similar inferences have been made by Otsu and Uchida (1959) for albacore and by Yuen (1955) for bigeye tuna (*Parathunnus sibi*).

Studies of the relationship between the size of developing ova and the weight of ovaries relative to body weight (or length) have shown that the latter is a good estimator for the former. Schaefer and Orange (1956) and Orange (1961) have, on this basis, employed a 'gonad index' to indicate stages of ovarian development for studying the temporal and spatial distribution of occurrence of fish in advanced stages of maturity, and hence, by inference, spawning seasons and areas of yellowfin and skipjack. Similar techniques have been employed by Otsu and Uchida (1959), by Yuen (1955), and by Kikawa (1953) studying *Parathunnus*.

In the region of the fishery of the Eastern Tropical Pacific, ovary examinations indicate that yellowfin tuna spawn in various offshore areas between southern Mexico and Ecuador, but that there is little or no spawning off Baja California, and probably none off Peru. At high latitudes, spawning is distinctly seasonal, being confined almost entirely to the spring and summer. At lower latitudes, especially off Central America, spawning extends throughout the year, but with a peak in January-February. Similarly, yellowfin spawning near Hawaii is distinctly seasonal, but is more protracted at lower latitudes in the Central Pacific.

There appears to be very little spawning of skipjack in sea areas adjacent to the coast of the Americas. Very advanced ovaries are encountered only, in some degree, off Central America and near some of the outlying islands. This also corresponds to the occurrences of larvae and juveniles of this species (see below).

Larvae and juveniles

The occurrence of larval tunas in plankton-net hauls, and the occurrence of small juveniles, which may be collected by dip-net under lights at night, or from stomachs of their predators, is another means of determining seasons and areas of spawning, since the tunas hatch in a very short time and the larvae and juveniles grow very rapidly. There is, however, some problem of identification of larvae, especially to distinguish larvae of albacore, bigeye and yellowfin.

The identification and occurrence of larval and juvenile tunas was largely unknown until recent years (Schaefer 1948). Commencing with the work of Schaefer and Marr off Costa Rica in 1947, serious attention began to be directed to these matters in various parts of the Pacific, the work being greatly accelerated by the efforts of the U.S. Fish and Wildlife Service Investigations in the Philippine Islands, the POFI researches in the mid-Pacific, the IATTC studies in the Eastern Pacific, and studies by Jappanese scientists in various Pacific regions. Matsumoto (1958, 1959, and unpublished contribution to the Pacific Tuna Biology Conference in 1961) has reviewed the status of the identification of a number of species.

The identification of larvae and juveniles depends upon building up series of each species, either from the adult stage backward, starting with specimens large enough to recognize from adult characters, or from the egg forward, starting with artificially fertilized eggs from identified adults. The latter technique has not been of much use, so far, because of the infrequency of catches of running-ripe females and because of the difficulty of rearing the larvae. Most of our information on recognizable larval characters comes from the first technique. At the present time, *Katsuwonus*, *Euthynnus*, and *Auxis* larvae and juveniles can be identified with some certainty, although

the species identification within the latter two genera is not yet clear. Separation of larvae of yellowfin, bigeye, and albacore, of the genus *Thunnus, sensu latu*, is most difficult, and uncertain.

Fortunately, in the IATTC region of interest, the Eastern Pacific, there is no albacore spawning, and there is only a single species of *Euthynnus*. While the two species of *Auxis* cannot be separated at very young stages, they are easily distinguishable from other genera. *Katsuwonus* is not difficult to identify except, perhaps, at very small sizes. We have, however, yet no means of separating larval and juvenile yellowfin from bigeye. The latter species is, however, not very abundant in our region.

The occurrences of larvae and juveniles of *Euthynnus*, *Auxis*, *Katsuwonus*, and *Thunnus* (*Neothunnus*) *macropterus* (the latter perhaps including some big-eye) have been charted by Schaefer (1960), and a more extensive analysis of this material is presently in a manuscript being prepared by W. L. Klawe of the IATTC staff. The occurrences of yellowfin and skipjack larvae and juveniles correspond rather well with the spawning areas and seasons inferred from examination of adult ovaries.

It has been suggested that a possible powerful tool for identification of larval tunas may be found in immunochemical methods. It has been indicated by agar-plate diffusion precipitation that there are specific differences in antigens of adult tunas. If these are developed early in the life of the larvae, they might be employed for species identification of larvae. This has not, to my knowledge, yet been much investigated.

Distribution and Abundance, and Effects of the Fisheries on the Stocks

For studying the time and space distributions of the abundance of species of commercial fishes, at catchable sizes, the careful compilation of records of the fishery wih regard to catch-per-unit-of-effort is widely employed, and is especially useful in the tuna fisheries. Since these species typically are distributed over very large sea areas, and there are large seasonal and annual shifts in their distributions due to changing environmental factors, it is most difficult to collect abundance data from research vessels, except at very great expense, although this has been successfully done by POFI (Sette 1955) and by the fisheries research vessels of various Japanese fishery agencies. On the other hand, because the oceanic tuna fisheries are mostly exploited by large vessels, it is relatively easy to obtain excellent catch-per-unit-of-effort data by logbook records of commercial vessels. Scientists of the Nankai Regional Fisheries Research Laboratory (1959), for example, have employed the catch-per-hundred-hooks, per day, recorded by long-line vessels, to study the temporal and spatial distributions of abundance of various tuna species throughout the Pacific and Indian Oceans. In the baitboat and purse-seine fisheries of the Eastern Tropical Pacific, we employ, as a measure of abundance, as observed by the fishermen, the catch-per-day's-fishing (Alverson 1960, Griffiths 1960, Schaefer 1957). This, however, varies with vessel size, the larger vessels being more effective, on the average, under the same conditions than the smaller ones; consequently, it is necessary to correct the crude data to the equivalent catch-per-day of a vessel of standard size. Methods of doing this have been described in detail by Shimada and Schaefer (1956). Data of this sort collected by small areas are of great utility, together with oceanographic data, in elucidating the changes in population distribution related to variable oceanographic factors.

Another important use of catch-per-unit-of-effort data is in studying the effects of the fishery on the tuna populations, and in estimating the average yield which will be produced at various levels on the tuna populations, and in estimating the average yield which will be produced at various levels of fishing effort and the maximum sustainable yield. For these purposes, however, data on catch-per-unit-of-effort alone are inadequate. One needs to study the interrelationships of total effort, total catch, and catch-per-unit-of-effort, over a series of years, encompassing different levels of fishing effort. Given any two of the foregoing three elements, the third may be computed, but

one cannot infer much of use from only one of them. If, for example, the catch-per-unit-of-effort declines over a series of years, even if it is known in a rough way that the effort has been increasing, all one can conclude is that the fishery is having some effect on the stock, but one cannot conclude anything about the sustainable yield, since the catch-per-unit-of-effort will be expected, in any fishery, to decrease as the effort increases, at all levels of fishing effort (Schaefer 1954, 1955).

Fortunately, for the tuna fishery of the Eastern Tropical Pacific we have available, for both yellowfin and skipjack tuna, data on catch-per-unit-of-effort and total catch (enabling the calculation of total effort) for each year since 1934. In the case of the yellowfin tuna, there have been marked changes in catch-per-unit-of-effort related to changes in fishing effort. With the use of a suitable mathematical model (Schaefer 1957) it has been possible to estimate from the data the average relationships among effort, total sustainable catch, and catch-per-unit-of-effort, and to estimate the maximum sustainable yield and the effort corresponding thereto. In the case of skipjack in the Eastern Pacific, there has been no measurable diminution of catch-per-unit-of-effort with increased fishing effort, from which it has been concluded that this species is greatly underfished, that is the fishery has not yet become sufficiently intense measurably to affect the stock (Schaefer 1961).

The urgent requirement for adequate statistics of both catch-per-effort and total catch, by sufficiently small regions so that they may be related to population units, cannot be overemphasized. Without *both* of these kinds of data it is not possible to say much, if anything, about the need for conservation measures. For example, in the Indian Ocean, yellowfin catch-rates of Japanese long-line vessels have fallen over the years in all areas as the fishing effort has, presumably, increased (Mimura 1958, Tsuruta and Tsunoda 1960) and, at the same time, there has been, as shown by these authors, a corresponding decrease in the size of the fish in the catch. From these data it appears probable that the fishery has had a definite effect on the stocks of Indian Ocean yellowfin, but nothing can be said as to where the fishery stands with respect to the maximum average sustainable yield, since data on total catch of yellowfin from these sea areas are not available.

A further use of catch-per-effort statistics is an ancillary evidence as to population structure and migrations. If stocks of fish in different sea areas respond independently to changes in fishing effort, it may reasonably be presumed that they are at least partially independent, that is there is probably at most limited migrations among the areas. This, for example, appears to be the case for the yellowfin tuna in different areas within the Indian Ocean, according to Mimura (1958).

Vital Statistics (Growth, Mortality and Recruitment)

The generalized mathematical models, such as that employed by Schaefer (1957) to investigate the effects of amount of fishing on abundance and yield, based on catch-statistical data alone, involve a number of assumptions which may not, in some circumstances, be quite valid. It is, therefore, also desirable to employ more analytical, ' dynamic pool ' models, involving the vital statistics of the fish population under consideration, that is the rates of growth and natural mortality and, if possible, also the recruitment to the fishable stock, such as those developed by Beverton and Holt (1957).

For the tropical tunas it has not proven practicable to determine the ages of individual fish from scales, or other hard parts, which is the most usual technique applied to fishes of higher latitudes. However, these tropical species grow so rapidly that, over a goodly portion of their rather short life span, it is not difficult to identify modes in size-frequency curves which correspond to age groups. By following the positions of these modes in samples taken at successive time periods (months in the case of the IATTC investigations) it is possible to determine the rate of growth at various relative ages, and, by extrapolation, also to make reasonable estimates of absolute age. This technique has been successfully applied, for example, to the yellowfin tuna of

the Eastern Pacific (Hennemuth 1961a) and to the yellowfin tuna of the Western Pacific by Yabuta and Yukinawa (1957). Hennemuth (1961a) has also shown that the growth of the yellowfin, after an age of about a year and a half at least, is well fitted by the von Bertalanffy growth curve, which is convenient to use in Beverton-Holt dynamic models.

By combining data on catch-per-unit-of-effort and size-frequency samples taken at successive time periods from the same areas, it is also possible to measure the rates of decline of age groups with time, and thus obtain estimates of total mortality rate. Estimates of fishing mortality rate may be obtained by other means, e.g. analysis of catch-effort data (Schaefer 1957), thus providing a basis of estimating the natural mortality rate. Hennemuth (1961b) has applied these techniques to the yellowfin tuna of the Eastern Pacific. It is also possible, in some circumstances, to employ the data of tagging experiments to estimate mortality rates, but this has, so far, proven uncertain with respect to our yellowfin, because of high and variable initial tagging mortality. We hope, however, to develop methods of circumventing these difficulties.

The size-frequency and catch-per-effort data can also be employed to estimate the relative abundance of successive age-classes, and thus gain some insight into variations in recruitment. Hennemuth (1961b) has made such estimates for yellowfin tuna for some recent years. The data are not, of course, yet available for a sufficient period to examine into the relationship between population size and recruitment.

The basic data for these sorts of study consist of large volumes of catch-statistical data and hundreds of thousands of length measurements. We have, therefore, found it convenient to perform the routine repetitive calculations on high-speed digital computers, which have been programmed to make the calculations. Such computers are becoming increasingly important tools of oceanographic and biological research. It is appropriate at this point to express our gratitude to the Western Data Processing Center of the University of California at Los Angeles, and to the Scripps Institution of Oceanography, for the use of their computing facilities for these and other research purposes.

Having obtained estimates of the growth and mortality rates, one is then able to compute yield-per-recruit curves, and yield-per-recruit diagrams taking into account both variations in fishing effort and changes in initial age of exploitation. This we have done for yellowfin tuna (Hennemuth 1961b, Schaefer 1961), employing the 'simple' Beverton-Holt model. Since the estimate of natural mortality rate was uncertain, the calculations have been repeated for a range of values of natural mortality which almost certainly includes the true value. Since these calculations are involved and time-consuming it has, again, proven advantageous to programme a high-speed computer to perform them. Although the programme preparation takes considerable effort and time, there is a very great net saving, since, once the programme is prepared and verified, the machine can run off in a few minutes calculations which would take many man-months using an ordinary desk calculator.

Oceanography and Tuna Ecology

The tunas, being completely pelagic at all stages of their lives, are profoundly influenced by spatial and temporal variations in their oceanic environment. During the past fifteen years or so, there have been initiated several comprehensive programmes of investigation of the relationships between the tuna and their oceanic environment in different parts of the Pacific Ocean, by researchers of a number of nations. Schaefer (1961) has recently summarized some of the more important programmes in the Eastern and Central Pacific. A great deal of research has also been conducted by various laboratories in Japan, which I shall not attempt to summarize here; some of this appears in summary form in the recent publication of the Nankai Regional Fisheries Laboratory (1959).

Research in the Central and Eastern Pacific by scientists of the Pacific Oceanic Fishery Investigations, the Inter-American Tropical Tuna Commission, the Scripps Institution of Oceanography of the University of California, and the Consejo de Investigaciones Hidrobiologicas of Peru, has provided the beginning, at least, of understanding of some of the relationships of the tropical tunas to their environment, although there are many unsolved problems. One important factor is apparently food, since both in the Central and Eastern Pacific, there is a good correspondence between abundance of tunas and the production of organisms lower in the food chain, related to the enrichment of the upper mixed layer by upwelling, mixing, and other processes which bring deeper water into the euphotic zone. At the extremes of the range, both the yellowfin and skipjack tuna are directly affected by water temperatures.

Relations to food supply

The tropical ocean is, in general, a two layer system of persistent stability, the upper layer being separated from the deeper by a strong pycnocline, or thermocline, and it is not annually renewed by overturn and mixing as occurs in high latitudes. Due to falling out of dead organisms and their excreta, the upper layer becomes depleted of nutrients, creating vast deserts. In some places, however, winds and currents cause upward mixing of nutrients into the upper, sunlit zone. Here there is high production of phytoplankton, supporting large crops of zooplankton, forage organisms, and finally large carnivores including tunas.

Such a system has been elegantly documented by Sette (1955), who showed how the wind system causes upwelling along the equator in the Eastern Pacific, bringing to the surface nutrient-rich water which moves westward and northerly, leading to production of organisms which are concentrated near a zone of convergence close to the southern boundary of the Equatorial Countercurrent, causing a zone of rich tuna concentration north of the equator in longitude 150° to 160° W. It has also been shown by POFI scientistis (POFI 1954) that this system is not entirely steady, but that there is variation both within years and between years, causing variations in the abundance of the tunas encountered in the vicinity of Christmas Island.

Relationships among enrichment by physical and chemical oceanographic processes, standing crops of plankton organisms, forage organisms, and tunas have been shown in the Eastern Pacific by Brandhorst (1958), Holmes, Schaefer and Shimada (1957), and Blackburn (1960).

Relations to temperature

As may be seen from Blackburn (1960), and data presented in several of the Annual Reports of the Inter-American Tropical Tuna Commission, the tropical tunas, at the northern and southern extremes of their ranges, respond directly to temperature changes. Off Baja California and California there is adequate tuna forage at all times of the year, yet yellowfin tuna are found in commercial quantities only where the water is about 19°C or warmer, while skipjack occur in somewhat cooler waters, down to 15°C. or 16°C. The seasonal appearance of these species follows the march of the isotherms, and in years when they move extraordinarily far north, the tuna do likewise. This is, it seems, an active migration, since G. Roden of Scripps has shown that the advance and retreat of the isotherms is primarily due to local heating and cooling, not to advection.

Off Peru and Chile there is again a striking relationship between temperature and tuna. In addition to the more or less regular seasonal changes in surface temperature, to which the tuna distributions correspond, there occasionally occur large-scale invasions of warm surface water along the coastal areas normally occupied by the cold, upwelled water of the Peru Current. In such ' El Nino ' periods, the tunas are widely scattered along the coast, and occur also in abundance further south than normal. Bjerknes (1961) has recently developed a theory of how the changes in the meteorological regime cause ' El Nino ', which may eventually lead to a means of forecasting it, and hence the tuna distributions.

Temperature is probably also a significant factor in determining the occurrence of tropical tunas at the warm end of the scale, but the situation is less clear. Yellowfin tuna, in very warm

years such as 1958 and 1959, are much less abundant in the region of maximum temperatures, off Central America, than in cold years, such as 1960 and 1961.

Other phenomena

The tunas undoubtedly respond to oceanographic changes in yet other ways, which are poorly understood. For example, POFI scientists have shown that the year-to-year variations in time of appearance, and in abundance, of skipjack in the Hawaiian Island fishery are related to the changing oceanic environment connected with the seasonal movement of water of the California Current Extension through the region, but just what the fish are responding to is not yet known.

It has also been shown that tropical tunas in the Eastern Pacific tend to be concentrated near seamounts, or ' banks '. Why this is so is not well understood, although in some instances it may be due to their forage being more abundant in such situations, due to various mechanisms.

These, and other, phenomena, require much more study.

Other Lines of Study

The foregoing is a brief discussion of only some of the lines of study currently being pursued by tuna researchers in the Pacific. It is by no means complete.

Additional important avenues of investigation which are, for example, being actively pursued in various laboratories are involved with improving methods of capturing these species through acquiring basic understanding of their behaviour, including the nature of schooling aggregations, responses to food and other stimuli, communication between members of a school, and other things. New tools and techniques are being developed for these studies, including the use of sonar equipment and other types of underwater sound gear, underwater television, and underwater observation chambers built into research ships. It will, I think, not be many years before small mid-water submarines will be available for such research. At Hawaii, scientists have been able also to keep adult tunas in captivity to study their behaviour under laboratory conditions. These, and other, techniques are under such rapid development that a person, such as myself, not currently engaged in this kind of research cannot easily do them justice. I trust that they will be dealt with by other contributors to this symposium.

Summary

A brief history of the research on tunas carried out in the past has been given and lines of study on tunas of the Pacific currently being persued by research workers, discussed. The latter involve techniques widely applied in the investigation of the population structure of tunas, namely, morphometric comparisons, tagging, size-composition analysis, blood typing and sperm morphology. Spawning areas and seasons have been investigated by the collection of larvae and juveniles and by gonad examination. Other aspects covered are, distribution, abundance and the effects of fisheries on the stocks; vital statistics (the rate of growth, natural mortality and recruitment to the fishable stock); and oceanography and tuna ecology. Attention is drawn to the great need of persuing investigations for improving methods of capture of tunas through acquiring basic understanding of their behaviour.

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RECENT TRENDS IN WORLD TUNA PRODUCTION AND SOME PROBLEMS ARISING THEREFROM

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I have been asked to speak on the subject of recent trends in World Tuna production and the biological consequences thereof. This is a subject which would warrant a longer dissertation and more detailed study than I have been able to give to it. Nevertheless statistics are readily available for a good general summary. Perhaps a brief account in these broad lines will be worth the effort and, at the same time, lend the emphasis which may induce someone with more leisure to look into the subject with greater adequacy.

The first year for which I have been able to sort out the species of tuna in the catch separately on a world wide basis on a reasonably satisfactory basis was 1952. In that year my figures show a total production of all tuna by Japanese, Americans, and others in the Eastern Pacific (which was then mainly Peru) of 404,000 short tons (in this paper I have converted every statistic to short tons rounded off to the nearest 1,000 tons despite the fact that all FAO statistics, and recent ones from Japan, are in terms of metric tons). This figure does not include the European or the south-east Asia, or other non-Japanese catch in the western Pacific, Indian and Atlantic Oceans. Perhaps one would be safe in saying that the world catch of tunas in 1952 was not much, if any, in excess of 440,000 short tons.

In contrast the FAO statistics show a world wide catch of 770,000 short tons of tuna in 1960. This was a drop from 813,000 short tons of tuna caught in the world in 1959 (of which more later). Although it is entirely too soon to make more than crude estimates, one could guess that the world catch of tuna in 1961 was in the neighbourhood of 825,000 short tons, or a little better.

These statistics, as here used, consist of the true tunas only (yellowfin, skipjacks, little tunas, bluefin, big-eyed, and albacores ; in the bluefin, presumably, are also the *Thunnus tonggol* of the Indo-Australian habitat, which are normally called northern bluefin in the trade but are in fact a separate species purportedly related to the big-eye).

These statistics are abstracted from the table of ' Tunas, bonitos, mackerels, etc., summary by species and country ' prepared ' by Mr. Gertenbach of FAO in 1961 and not yet, I believe, published. It may be noted that Mr. Gertenbach's tables indicate a 1960 world-wide catch of 2,244,000 short tons of all these sorts of fish, which include the bill-fishes, cutlass fishes, and other related species not mentioned in that title of his table. Out of these 2,244,000 short tons of all these sorts of fishes caught in 1960 in the world there are 158,000 short tons which Mr. Gertenbach could not divide anymore closely than into the category 'various'. Some of these are most certainly tunas, but it may be doubted that any considerable quantity are.

In any event Mr. Gertenbach's judgement as to how to interpret and categorize the fishery statistics he gets in from his hundred-odd member countries is as good as that of anybody else I know of, and certainly better than mine. Accordingly, with these qualifying comments, I am using his numbers, for want of better, upon which to base the discussion.

The first generalized comment that can be based upon these numbers is that the production of tuna on a world wide basis has very nearly doubled in the past ten years.

This broad and rough statement may be juxtaposed against one just as broad and rough about the increase in consumption of tuna in the United States. This market, alone, has doubled on the

average of every ten years for the past forty years. The apparent annual consumption of tuna in the United States, in decade steps, has been approximately as follows :

1910	..	100,000 cases
1920	..	500,000 ,,
1930	..	1,750,000 ,,
1940	..	4,000,000 ,,
1950	..	9,500,000 ,,
1960	..	19,000,000 ,,

This rate of increase in the United States market would work out to about a 6% increase per year, compounded. The rate of increase in the last few years has actually been a little greater than this, at an annual rate of increase between 6% and 7% (occasionally a little higher than 7%).

From this one would hypothesize that the rate of increase in the market currently in progress fits into the general pattern of the past forty years. It is quite difficult to convince oneself that the pattern of tuna consumption in the United States will change considerably in the next decade. But the consequences that would follow from accepting this conclusion are far reaching.

Expressed in very round numbers citizens of the United States are 400,000 short tons out of the total or 770,000 tons of tuna (round weight) produced in the world in 1960. If their consumption does double in the next decade then they will eat very nearly 800,000 tons of tuna (round weight) in 1970. When this is juxtaposed against total world production in 1960 it produces a very sobering reaction.

The United States market for tuna is not the only one in the world which is growing rapidly, or even the one which is growing most rapidly.

Through the courtesy of Mr. S. Di Palma, U.S. Bureau of Commercial Fisheries, I have the calculation that the European market used 47,000 short tons of Japanese tuna in 1960, and that this was about 300 per cent more Japanese tuna than Europe used in 1956.

This is not a correct way to state the situation, however, because this figure is composed of pounds of frozen tuna and pounds of canned tuna. Very roughly speaking it takes about three pounds of round weight tuna to make a pound of canned tuna. Also nearly all of the frozen tuna imported from Japan to Europe in 1960 were headed and gutted, which decreases their weight from the round state by about 12%.

Since the importation of Japanese tuna into Europe amounted to about 37,500 short tons of frozen tuna in 1960 and about 9,500 short tons of canned tuna, one can estimate that, in terms of round weight tuna Europe imported about 67,000 short tons from Japan in 1960. This amounted to about 8½% of world tuna production in 1960.

Next to the United States market, the market for tuna is largest in Japan. The manner in which the statistics for domestic consumption of tuna in Japan are presented by the Japanese Fisheries Agency makes it impractical for me to estimate with any high degree of accuracy anything more than the trends in separate tuna commodities.

For instance the Japanese initiated the making of a quite new product out of tuna (mostly) for the home market in 1954—tuna sausage and ham. The approximate amounts of tuna used in making these products in Japan in succeeding years have been, very roughly, the following :

1954	..	3,000 tons of tuna
1955	..	8,000 ,, ,, ,,
1956	..	15,000 ,, ,, ,,
1957	..	28,000 ,, ,, ,,
1958	..	48,000 ,, ,, ,,
1959	..	63,000 ,, ,, ,,
1960	..	85,000 ,, ,, ,,

It must be emphasized that these are crude estimates, but they are astounding in themselves. So far as can be discerned this new product has not displaced the use of tuna in traditional forms in Japan (canned smoke dried as Katsuobushi, half-dried as Namaribushi, and raw as Sashimi). What statistics are available indicate that each of these uses is also trending upward in Japan and in the case of canned tuna, anyway, at a considerably increasing rate.

It may be noted that there is another trend which may not be reflected at all, or only slightly, in the above statistics. In the last five years, in particular, the Japanese have trended toward the establishment of overseas bases out of which their tuna vessels can operate and tranship their catches to the world market. In some places this has worked as planned. In other places it has not. Japanese tuna vessels have brought in tuna in fair amounts in Venezuela, Brazil, and Argentina and most of it has been eaten by the inhabitants of the port cities where it was landed at prices higher than the world market would pay. Whether all of this is reflected in the above noted statistics is not known to me.

There is nothing in all of this, however, to indicate that the whole world market for tuna is not growing at a rate which will cause it to double in ten years as that of the United States has been doing. Should this be the case, then, it does not take a very smart business man to estimate that the world demand for tuna in 1970 might be in the neighbourhood of 1,500,000 short tons.

It cannot hurt to again emphasize that nearly all of the statistics cited above are to be regarded as estimates and not as refined statistics. Regardless of how crude these estimates may be they give rise to two considerations : (*a*) can the rate of increase in market experienced in recent years (for four decades in the United States) be expected to continue for another ten year period and (*b*) if it does, is there enough tuna in the ocean to supply the demand on a sustainable basis ?

There is a general suspicion in the minds of tuna industry people that the large increase in tuna consumption on a world-wide basis during the past ten years has been primarily due to the fact that continuing gluts and surplus of tuna during the decade of the 1950's kept the price of tuna at the consumer level at a price abnormally below that of animal proteins which are replaceable by it. So far as I know nobody has submitted this thesis to rigorous economic examination, and I for one would like to see this done.

Commonsense says that as the unit price of canned (or other) tuna goes up at a rate greater than that of replacement foods the supply-demand functions will work out and stabilize tuna consumption at a lower per capita consumption level. Experiences from the United States canned tuna market indicate at least in some instances that this is so. The case of these experiences is not conclusive, however, because of the selling devices other than price customarily used in the United States market, the lag in response of level of market to price changes, changing purchaser habits, etc. The matter is very complex and does not seem to be transparently clear even to the top officials of the large tuna companies, who keep it constantly under review.

Even the effect of drastically reduced raw tuna prices cannot be said certainly to result in a decline in primary tuna production. Fishermen are exceedingly ingeneous and appear to have enormous resiliency to economic distress. Perhaps no better example of this could be cited than the history of the San Diego bait boat clipper tuna fishery. From 1954 to 1960 the price picture was almost entirely one of decrease (in the case of yellowfin from $340 per ton in 1954 to $240 in 1960).

Then in 1960 the tuna clipper men took a giant's step ahead and, by converting their vessels to purse seining with nylon webbing and power blocks, they changed their long term loss picture into a sharply profitable one at a price level for tuna under which they could not have continued to operate as bait boats. In the intervening years the total yield from the fleet had showed no sharp and consistent downward trend despite the decrease in numbers and total tonnage capacity of the fleet. When the economic tide turned in 1960 the total yield of the reduced

fleet did show a sharp upward trend which is continuing, augmented by the construction now for the first time in some years of new vessels.

It may be noted that during this decade of the 1950's there were times when the Japanese tuna fleet had severe financial set backs for varying lengths of time, some of which hurt rather badly. Yet the total production of tuna by Japanese vessels has trended steadily upward for twelve years.

On the basis of normal economic reasoning anyone on the outside of the tuna business probably would view the economics of world tuna production somewhat as follows : The great surge of new vessel construction in Japan in the early 1950's (set off at first by construction assistance from the Japanese Government but continued since under its own economic momentum mostly) resulted in a world wide surplus of tuna at then existing prices. The weight of these expanded Japanese catches was sufficient to break the price of tuna in the Japan market first, then in the American market, and then in the European market.

This resulted in succeeding waves of economic disturbance in the tuna market on a world wide basis which resulted in (*a*) a stoppage of new vessel construction for tuna fishing in the United States (the other major producer), (*b*) prevented the full use of the production ability of the American tuna clipper fleet which had been rapidly expanding during the period 1947-1953, (*c*) did not, however, cause any gross decline in total American tuna production because of the excess catching ability of that fleet at then current price levels, (*d*) created disturbances from time to time in the Japanese production, but (*e*) did not prevent the steady and sharp increase in Japanese tuna production on a world wide basis.

In the market place it might be stated that these economic disturbances resulting from the great expansion of Japanese tuna production during the decade of the 1950's, always pressing the raw tuna price down on a world wide basis and finally in every substantial tuna market in the world, had these effects : (*a*) increased the rate of tuna consumption first in Japan, then in the United States, then in Europe, and finally on a world-wide basis, (*b*) created a rather homogeneous world market for tuna in which the raw product slips around rather fluidly in reaction to supply-demand functions, and (*c*) created a world tuna price which responds rather quickly to increased or decreased tuna production anywhere in the world ocean.

Going on from these observations and assumptions the observer might say that sometime in the period 1958-1960, the greater demand for tuna in the world which had been stimulated by this fluid world tuna market and world tuna price (always declining) caught up with the supply which tuna fishermen on a world basis could supply at the new low prices. At any rate the price of raw tuna did stop declining in this period. There is evidence that the average price of yellowfin began to turn upward slightly in Japan in late 1957 and has continued to rise slowly into 1960. Since mid-1960 the price of yellowfin has continued to rise more sharply in Japan, and in 1961 this was accompanied by quite sharp increases in yellowfin in Japan, Europe and the United States, especially in the last half of the year. At the beginning of 1962 the yellowfin tuna price has returned to about where it was at mid-1950, appears to be still on the increase, and the future seems rosy to tuna fishermen everywhere in the world.

The way the price of tuna has been going up on a world-wide basis in the last six months on past history would probably lead this hypothetical outside observer to hypothesize that the demand for tuna would now slack off, and that the demand during the decade of the 1960's would not increase at the rate it did on a world-wide basis in the 1950's, and in the United States market during almost the whole of this century.

As one who has been reasonably close to the heart of these economic turbulences of the tuna industry for the last fourteen years I am inclined to doubt this last conclusion. It may be sound on the basis of classical economic theory, but few people in the tuna industry know much about

classical economic theory. They tend, rather, to produce tuna as much as they can and sell it as fast as they can. In years, or cycles, when profits vanish they tend to use up their accumulated capital and credit as long as they can, and keep on producing and selling as fast as they can until they go broke. In periods when the business is profitable they plow back profits and extended available credit into building new vessels and canneries in order to produce and sell even more rapidly. At some times the whole tuna industry seems more like a religious sect of the world business community and not like a business at all. This does not seem to be much different in Japan than in California, and the European firms now getting into the tuna business do not seem to be much more conservative economically than their more experienced brethren in Japan and the United States.

Some reasons why I expect to see production and demand keep right on expanding during the 1960's include the following :

1. The purse seine revolution in California pumped large shots of new capital into the production of tuna in the Eastern Pacific. This not only revived the construction of vessels but inspired the ingenuity of fishermen and boatowners there to try out other new devices aimed at lowering their cost per ton of production. This giant has been awakened. The profit situation at the vessel level is good.

2. The profit situation at the vessel level in Japan is even better and new construction is still going forward actively. I would estimate that the improvement of methodology in the Japanese tuna fishing industry, designed to lower cost per ton of production, is proceeding even more rapidly and effectively than in the California industry.

3. World-wide research advances in oceanography are going to lead increasingly to lowering the cost per ton of production for all tuna producers in the world by enabling more precise predictions as to where they may go to catch a load of tuna more quickly.

4. American tuna canning companies, in particular, are actively stimulating the development of new native fisheries in the developing countries of the tropics. This is already producing substantial production of tuna in the tropics by non-American and non-Japanese fishermen in Peru, Ecuador, Senegal, Sierra Leone, and the Republic of the Ivory Coast. One can look forward to many other such developments on a world-wide basis in the tropical and subtropical world ocean in the next two or three years.

5. The world tuna price has now become sufficiently high to permit the beginning of substantial native tuna fishing in the southern hemisphere where sophisticated industries in other phases of fisheries production already exist, such as South Africa, Australia and New Zealand.

6. Wide gyrations in tuna prices, gluts, and shortages on a world-wide basis appear to be levelling out, and these have been economically very wasteful in the last ten years. Their gradual elimination will permit the more rapid accumulation of capital in the industry and its more efficient utilization by the industry.

7. There is very good reason for believing that the tuna fishermen will every where always sell their fish, under pressure, at or close to, their actual cost per ton of production.

8. There seems adequate proof that the tuna processing and distributing industry as a whole is so intensively competitive as to press the raw material price toward its actual cost per ton of production and the retail price of the finished product as low as possible in order to continue increasing the volume of sales of the individual components of the industry.

All of this leads me to think that the world price of tuna at the beginning of 1962 is higher than it likely will be a little later, that in itself it contains the force to correct it closer to what

I believe to be reality, and that production and demand will continue to grow right through this decade and into the next. I have not even mentioned such uppushing forces as increased consumer acquaintance, increased consumer purchasing power, increased prices and costs of competitive foods, etc., on a world-wide basis.

It will be apparent to all hands that all, or most, of the above statements are based on experience and feeling (hunch) of an active participant, and would benefit much from critical examination by competent, detached, non-participating economists. Until that is done, or new facts become available, however, my estimate will be that the demand for tuna on a world-wide basis will at least double in 1975 what it was in 1960 by which time the world will be consuming 1,500,000 short tons of tuna per year, or perhaps a little more.

While the economics of tuna production and consumption are unclear, because no competent economists have undertaken rigorous examination of the available facts, the other question—the abundance of tuna in the world ocean is in some places brighter, and in some places worse.

Eleven years of competent research on tuna in the Eastern Pacific by the Inter-American Tropical Tuna Commission has indicated two things with considerable clarity (*a*) the combined yellowfin tuna stocks of the Eastern Pacific will provide about 100,000 tons of tuna per year indefinitely, and (*b*) the stocks of skipjack tuna in the Eastern Pacific are large enough that the support of a considerable fishery by them (reaching an annual level of somewhat more than 80,000 tons per year) has not had a measureable effect upon their abundance.

The scientific data behind these statements is adequate to persuade me of their validity. In one other instance, the albacore fishery of the North Pacific (Japanese and American together) it would appear to me that the biological statistics and knowledge are now sufficient that one could put them into a reasonably accurate picture of the relationship of the fishing pressure to the maximum sustainable level of the albacore fishery of the North Pacific. So far as I know, however, nobody is attempting very hard to do this.

For the rest the picture is almost a complete blank. If there are any biologically useful statistics coming out of the great long-line fishery of Japan for yellowfin, big-eye, bluefin and albacore tuna, especially in the tropics and the southern hemisphere, they are not known to me.

It is quite true that studies have been published in Japan which demonstrate a consistent pattern of decline in catch per unit of effort for yellowfin almost every place that the Japanese have expanded to throughout the Pacific, Indian and Atlantic ocean.

This does not necessarily have any pertinence to the problem of over fishing. The way Japanese tuna statistics are published it is quite impossible to relate these declines in catch per unit of effort to biological productivity in any particular ocean area with much definiteness or to any particular homogeneous stock of yellowfin tuna. So far as I know nobody knows with any satisfactory degree of accuracy what the total long-line catch of yellowfin in the Indian Ocean is, or in the Atlantic Ocean, or in the Pacific Ocean for that matter,—much less in any smaller unit of any of those oceans.

I do not know how one can make any useful estimate of the maximum sustainable yield that a stock of fish is capable of producing without knowing three things : (*a*) the catch per unit of effort of the fishery upon it over a number of years, (*b*) the total yield of the stock for the same years, and (*c*) naturally, the geographical area inhabitated by the stock. None of this work has progressed to a useful level in Japan (or at least not in a published form available to me), and one wonders whether this does not arise more from public policy rather than any other factor.

The Japanese scientists working on such problems say two things, generally : the Japanese fishing companies will not give the Japanese Fishery Agency the information, and that they do

not have the statistical agents to collect the data. Yet everyone acquainted with the long-range Japanese tuna vessels are uniform in their praise of the meticulous and comprehensive logs of vessel activity and catch kept by each vessel. Furthermore, the Japanese Fishery Agency has ten statistical agents for every one that the American Bureau of Commercial Fisheries has. Additionally it is perfectly within the purview of every sovereign government to secure the catch and effort statistics of its citizens wherever they are working in the world.

The Japanese continually attribute this decline in catch per unit of yellowfin fishing to variations in the environment. Nobody seems to note the incongruity of the catch per unit of effort of yellowfin long-lining declining everywhere despite considerable variability both up and down from long term means in all oceanic parameters currently being measured by oceanographers.

Lastly it may be noted that the Japanese Fishery Agency is exceedingly reluctant to provide yellowfin fishing information in the Eastern Pacific to the Inter-American Tropical Tuna Commission, despite continued urging for it to do so from the member countries to the Convention establishing that Commission.

The impression given by all these things is that the Japanese Government simply does not wish to make available to the scientific public, or to other governments, information which would have any chance in the future of indicating that their fishermen are over-fishing any stock of yellowfin tuna in the world, or about to do so in the forseeable future.

Having said all this, there is really no reason that I know of to suspect that the Japanese long-line fishermen are over-fishing any stock of yellowfin in the world, and their catches of bluefin, big-eye, and albacore do not even clearly indicate the steady drop in catch per unit of effort that the yellowfin catches do.

The long-line fishery typically fishes upon larger and older fish that lie just above the thermocline and not at the surface. In the case of yellowfin these are the older fish. Having spent the first two or three years of their life in closely packed schools at the surface, or near it, yellowfin tend to settle out, and spread out, into the deeper water just above the thermocline to spend the remaining years of their life.

Thus these older fish stocks upon which long-liners fish may, in a manner of speaking, be considered to be separate in their biological reactions to the fishery from the surface schools. They have a lower rate of growth than the younger fish of the surface schools, for instance. Also they have already suffered from the heavy mortality that takes place in the surface schools of younger fish and the annual increment in numbers to these sub-surface stocks is thus lower than it is to the surface stocks of young fish. From these reasons alone one would expect the sub-surface stocks of large yellowfin to be more quickly responsive to the fishery than those of the surface schools of younger fish. That is, one would expect the standing crop of large fish in any stock to be fished down quite rapidly, and for the annual increment available for catching to be small (in relation to surface schools of younger fish) so that the catch per unit of effort would fall rather quickly to a level considerably below that at which the fishery started. There it would stabilize.

This has been the consistent pattern in the Japanese long-line fishery for yellowfin on a world-wide basis. So far as I know there is no place where this has happened where the biological knowledge or catch statistics are adequate to indicate, even in broad terms, the relationship of these lower levels of reasonably stable catch per unit of effort (abundance) either (*a*) to the maximum sustainable productivity of these sub-surface large tunas fished by the long-line method or, (*b*) to the total productivity of the biologically homogeneous stock composed of them and the surface schools of younger yellowfin in the same general ocean area.

It may be noted that in most of the world ocean where Japanese fish for yellowfin by long-

line they are the only ones who are fishing substantially for yellowfin at all. The major exception to this is in the Eastern Pacific where there is an intense fishery on surface schools.

In the geographic area where the Japanese and American (in the broader sense) fisheries overlap the Japanese do not catch many yellowfin, but subsist primarily on other fishes such as big-eye and the billfishes which the American's are catching slightly or not at all. Research results from the Inter-American Tropical Tuna Commission leads one to believe that the reason for this is that the total mortality among the surface school yellowfin in this area is such that there are adequate spawners left to support the stock, but insufficient to support a long-line fishery at present price levels.

In the West African, Gulf of Guinea area, the surface school fishery (mostly so far by American, Spanish, French, Portuguese and local fishermen) is still in such an early stage of development that one would doubt that it has been a major effect in the sharp decline of catch per unit of effort experienced in the past two years by the large Japanese long-line fishery which began in the area in 1956. Nevertheless it is noted that no biologically useful statistics on the tuna catches in the Eastern Atlantic are being kept by anyone. Certainly it is prudent that this be begun at once or as soon as possible. The action of CCTA/CSA in recommending the immediate establishment of a West African Tropical Tuna Commission modelled on the lines of the Inter-American Tropical Tuna Commission, is certainly to be commended.

So far as I know, however, there is no place else in the world as yet where the Japanese long-line fishery for yellowfin is competitive with a surface school fishery, except perhaps in their own home waters or immediately adjacent thereto. If they did not fish by this method elsewhere in the Pacific, Indian and Atlantic Oceans these large stocks of valuable food fish would be going to waste, as far as man is concerned, by dying and returning to the web of life in the ocean as nothing more than unneeded fertilizer.

Without the Japanese long-line fishery the production of big-eye, and tonggol tuna on a world basis, and of albacore tuna in the southern hemisphere would scarcely exist at commercial levels. I believe it is safe to say that the Japanese long-line fishery is the only one in the Indian Ocean producing consequential amounts of any kind of tuna for the world market at the present time. And there this fishery does not appear to be competitive in any consequential manner with any surface school fishery for any sort of tuna.

Having looked at these matters one may examine others. No one could reasonably believe from abailable catch statistics that the long-line fishery for big-eye tuna has more than scratched the surface of the stocks of these tuna on a world-wide basis, and this species of tuna does not appear to be available on a steady basis to surface school fishing anywhere in the world.

In the southern hemisphere there is really no fishery for albacore tuna except by Japanese long-liner. In very large sectors of the world ocean the same is true for yellowfin tuna. Every bit of evidence we have leads one to believe that these rapidly growing fishes have their point of maximum sustainable productivity at an age and size at which they are still near the surface and available to a surface fishery by live-bait, purse-seine or other means. It would be felt that the institution of surface school fisheries for these species, even where the Japanese long-line fishery exists on an intensive basis, would considerably increase the production on a sustainable basis from the stocks of those two sorts of tuna in any particular area.

Although bluefin tuna have been studied longer than any of the other kinds of tuna insufficient information is available on population dynamics for any stock of bluefin anywhere in the world to make any useful statement about potential productivity limits from it. Bluefin appear out of the deep and return to it in varying quantities and sizes in different sectors of the world ocean without much apparent relationship to fishing effort.

The big potential producer among the tunas to which we have not referred much yet in this section are the skipjack tuna.

One of these, *Euthynnus*, is not fished to any considerable extent anywhere in the world. Its meat is generally darker and stronger tasting than most markets which now use tuna in consequential volume will readily accept. This is not to say that developing markets in Tropical Africa and south-east Asia which relish strong tastes to accompany the bland carbohydrate component of the traditional diet (rice, manioc, bananas, etc.,) will not change this situation in the relatively near future. It may only be said that both Japanese and American tuna fishermen normally encounter large schools of these *black* skipjack in all three major sectors of the Tropical world ocean and leave them substantially unfished.

The other kind of skipjack, *Katsuwonus*, is, on the other hand, the largest single component of world tuna production already. In 1959 Mr. Gertenbachs statistics show world tuna production by species (in short tons) as follows :

Albacores	..	134,000	short tons
Big-eyed Tunas	..	82,000	,, ,,
Bluefin Tunas	..	95,000	,, ,,
Little Tunas	..	14,000	,, ,,
Skipjacks	..	283,000	,, ,,
Yellowfin Tunas	..	205,000	,, ,,
Total	..	813,000	,, ,,

Thus in 1959 skipjack produced nearly 35% of the tuna produced in the world. Nearly all of this (over 90%) was produced in two areas of the world rather close to land. One hundred and ninety-four thousand tons were produced in the Northwest Pacific near the Japanese home Islands and Okinawa ; 75,000 tons were produced in the eastern Tropical Pacific by Americans and Peruvians as an adjunct to the fishery for yellowfin in the same area.

Several things can be said about this. The fishery in the Japanese area has exceeded 100,000 tons per year in most of the years since the fishery recovered after the war and there is no evidence of over fishing. The American-Peruvian fishery was much depressed from its normal size in 1959 because of market conditions. Much larger catches in that area, carefully examined by the Inter-American Tropical Tuna Commission, had not even produced enough effect on the abundance of the stocks to be detected in the population dynamics studies. Without question the stocks were capable of supporting a much higher level of biological productivity.

Yet despite these catches near shore, *Katsuwonus* perhaps more than any of the other tunas, is typically a fish of the open ocean. They are encountered in considerable schools in the Tropical Pacific 1,000 miles from shore. In the tropical Pacific they are found around every atoll, island and reef. Prior to the war Japan had a fishery for skipjack at Palau, alone, of 15,000 tons per year and that fishery was only getting nicely started when the oncoming Chinese and finally Pacific war, stopped it. At the present time there is no fishery for skipjack in the whole of Oceania except a small one at Hawaii, and subsistence catches elsewhere.

There would appear to be no reason not to think that skipjack are far the most abundant sort of tuna in the Pacific, and that their fishery can and will be increased steadily as time goes on. There is no reason to suspect that they are not also abundant in the Indian and Atlantic Ocean. Certainly they are in the eastern Atlantic where the Portuguese have landed them in Angola in large quantities quite incidentally to other fisheries. Elsewhere nobody has tried seriously to catch them.

Accordingly, in view of these facts, I have no hesitation in saying that the world ocean can

produce, 1,500,000 tons of tuna per year on a sustainable basis. And, as noted above, I believe world demand for tunas will reach that level by 1975, if not sooner.

All of this does not siginify that this rate of expansion of the tuna fisheries in the world will not produce conservation problems of consequential concern during the course of those years. I am certain that it will.

The large yellowfin fishery of the Eastern Tropical Pacific will come under conservation regulation in 1962. I would be surprised if this were not the case with the albacore fishery of the North Pacific, and the yellowfin fishery of the Eastern Tropical Atlantic within this decade.

The world scientific or governmental machinery is not in condition at the present time to cope with this problem. The governmental machinery is in better shape to deal with it than is the scientific machinery.

The ' Convention on Fishing and Conservation of the Living Resources of the High Seas ' adopted at the United Nations Conference on the Law of the Sea in Geneva in 1958, provides a well designed machinery to deal with such problems as well as laying down responsibilities that sovereign nations have in respect of the latter. Article 1, paragraph 2, of that Convention, for instance, reads : ' 2. All States have the duty to adopt, or to co-operate with other States in adopting, such measures for their respective nationals as may be necessary for the conservation of the living resources of the sea.' Article 2 of that Convention reads ' As employed in this convention, the expression ' conservation of the living resources of the high seas ' means the aggregate of the measures rendering possible the optimum sustainable yield from those resources so as to secure a maximum supply of food and other marine products. Conservations programmes should be formulated with a view to securing in the first place a supply of food for human consumption.'

Thus the obligations and objectives of sovereign States in this matter have been spelled out by the community of nations.

The scientific machinery to carry out these laudatory objectives and obligations does not exist. There is no place in the world to my knowledge where there is an adequate scientific staff even looking into the problems of tuna conservation except in the Eastern Tropical Pacific Ocean, where the Inter-American Tropical Tuna Commission works. Elsewhere the void is almost complete.

It would appear to me that these are some of the scientific steps that should be undertaken.

1. In the first place the tuna conservation problem should be viewed as a unit encompassing the whole world ocean, all species of tuna, and all fishermen fishing for them. The creation of a world tuna market and a world tuna price during the past ten years by natural economic forces has rendered any other treatment of the problem out of date.

2. Competent ichthyological systematists should be given the finances and facilities to work out, once and for all, the generic and specific relationships of the tuna's of the world. A most promising start was made on this when, during the course of the Hawaiian Symposium on Pacific Tunas in August, 1961, the Japanese scientists promised to provide the American systematists with specimens from their far flung fisheries around the world.

3. Every method that shows promise for the delimitation of homogeneous tuna stocks should be explored, and work in this field should be pressed forward energetically. Meristic characters and body proportions show merit in some cases and not in others. It was a matter of considerable importance that at the Dakar Symposium on African Tunas in December 1960, the African workers in this field chose to adopt the same methodology as the American workers had developed in order that their data from the Eastern Atlantic and Western Indian Oceans would be comparable. This course is recommended to other workers elsewhere in the world.

The elucidation of racial stocks by blood typing appears likely to provide a most useful new weapon in this attack. It is being actively developed by several workers around the world. At the above cited Hawaiian Symposium on Tunas the principal workers in this field (Japanese, Americans, and Inter-American Tropical Tuna Commission) undertook to study methods of making their results more comparable, and the workers in this field at the Hawaiian Biological Laboratory of the U.S. Bureau of Commercial Fisheries undertook to examine and type any tuna blood samples sent to it in proper condition by any workers in this field in the world. This seems to be a most useful start.

4. A world-wide system of biologically useful tuna catch statistics is the most urgently needed single factor in this whole programme, the easiest to obtain, and the most poorly developed.

What is required is for the workers in this field to get together and lay out a practical numbered grid system covering the whole world ocean where tuna are available commercially and to designate what catch and effort statistics are needed by them from these areas.

It is to be hoped that this will be done during the course of the FAO World Conference on Tunas to be held in La Jolla, California, in July 1962.

Having this system of statistics reporting laid out by the scientists the governments of the world can be pressed to insist upon adequate performance in reporting by their tuna fishermen.

5. In particular areas of the world where the tuna fishery is intense, and engaged in by the nationals of more than one country, those countries should combine as noted in the above quoted ' Convention on Fishing ', into a joint body to deal with tuna conservation problems. This has already been done in the Eastern Tropical Pacific. It is to be hoped that the affected nations will respond similarly to CCTA/CSA's call to do so in the Eastern Tropical Atlantic. I believe that the time is ripe for this same sort of thing to be initiated in the albacore fishery of the whole North Pacific.

6. Every effort should be made to relate the greatly expanded ocean research programme in the world ocean under the Intergovernmental Oceanographic Commission, in the SCOR sponsored Indian Ocean Expedition, the CCTA/CSA—U.S. ' Guinean Year ', the EPOC—IATTA ' Programme of Cooperative Study of the Eastern Tropical Pacific Ocean ' to these problems of tuna production and conservation on a world-wide basis.

It may be hoped that progress along these, and perhaps other lines can be forwarded at the forthcoming FAO World Conference on Tunas to be held next July in La Jolla, California. If so this long series of Tuna Symposia (Dakar, 1960 on African Tuna ; Honolulu, 1961 on Pacific Tuna ; and Mandapam Camp, 1962, on Indian Ocean Tuna) will have served a most useful purpose.

The developing tuna fishery of the world has grown, and will shortly grow, into too large a component of the world protein diet to remain in its formerly neglected stage of scientific inquiry.

CONSERVATION OF THE TUNA AND BILLFISH RESOURCES OF THE INDIAN OCEAN

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FISHING activity in the high seas has now been extended to the Indian Ocean also with the emergence of Japan in the post-war years as a premier fishing nation. With the exception of the intensive fishing carried out for the oceanic skipjack, *Katsuwonus pelamis* in the Maldive Islands and in the Minicoy Island in the Indian Ocean it is doubtful if any organised tuna fishery existed anywhere in this area before the last World War. In the regular commercial fisheries of various countries bordering the Indian Ocean tunas and occasionally billfishes form a part of the catches during certain seasons from the inshore areas. What little fishing is done specially for these fishes is mostly of an exploratory nature.

The object of any fishery management should be the regular maintenance of maximum sustainable catches, minimising, if possible, fluctuations. It could naturally be expected that the success of the Japanese in the Indian Ocean will tend to attract other nations also in the field and

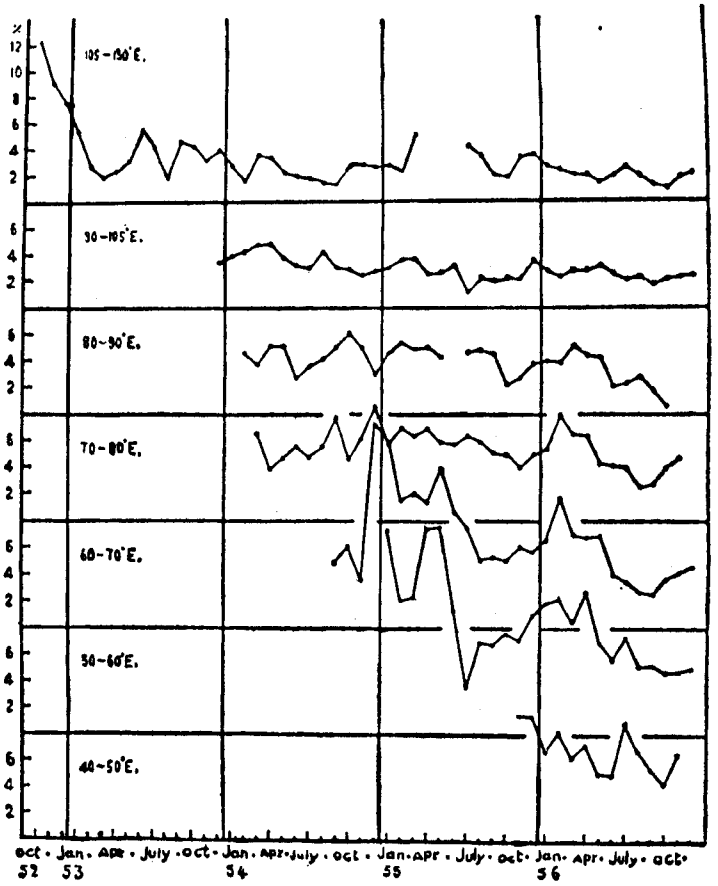


Fig. 1.—Monthly change of the mean hooked-ratio in each sea area (5°-13° S.) (Reproduced from Mimura, 1958).

absence of any concerted action might lead to indiscriminate fishing resulting ultimately in overfishing and depletion. Our marine resources are renewable but could no more be considered as inexhaustible. We harvest from the high seas without sowing and what is called for is judicious management. To carry out this effectively in international waters is no easy matter without the goodwill and co-operation of all concerned. It might be asked whether a situation has arisen to warrant steps towards conservation measures under international auspices. But should we wait till then? Would it not be more rational if the problem could be tackled even before depletion takes place? Investigations could be organised even before exploitation reaches the optimum limits as was done by the Inter-American Tropical Tuna Commission soon after the last war. Initiation of investigations therefore without waiting further would enable determination of the maximum yield and the level of fishing at which the catch curve tends to show a downward trend.

Reverting now to the condition of the tuna fisheries of the Indian Ocean it is evident from the statements of Japanese workers that the warning sign is already up. The yellowfin tuna, *Neothunnus macropterus* which is commercially the most important species in this region has been studied in fair detail by them. It is reported by the Nankai Regional Fisheries Research Laboratory* that in the Indian Ocean '(*a*) The hooked-rate is the highest in the year when the ground was first exploited, and it drops gradually year by year' and '(*b*) the bimodal size of the principal catch becomes smaller year after year.'

The above are indicated in Figures 1 and 2.

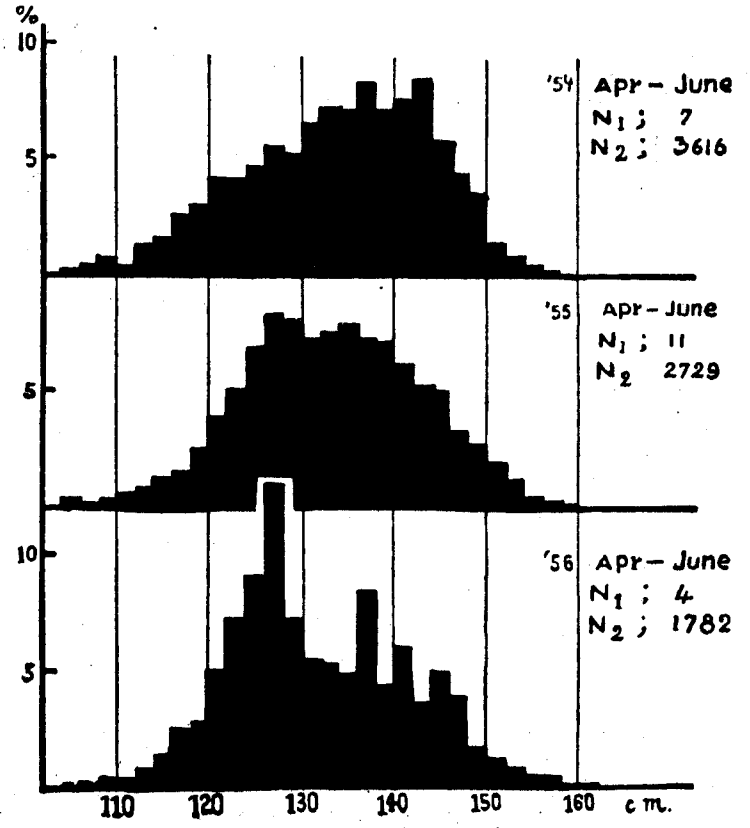


Fig. 2.—Annual length frequency distributions (percentage) of yellowfin tuna, taken in Bengal Bay (north of 0°, 80-100°E.).
N_1 ; Number of ship investigated. N_2 ; Total number of fish measured.
(Reproduced from Mimura, 1958).

* Mimura, Koya 1958. *Report. Nankai Reg. Fish. Res. Lab., No.* 7 : 59-71.

Similarly the work done by the Japanese fisheries training ship *Shuntotsu-Maru** shows that 'in the Indian Ocean the body length of the yellowfin tuna decreased year by year and its range shifted from 130-150 cm. to 110-140 cm. in the years of 1954 to 1959. The fishing conditions also became worse year by year, and except for the Western coast of Sumatra Island, the angling rate showed the reduction above 60%, especially in the western part of the Indian Ocean and in the district adjacent to the Lesser Sunda Island this tendency was remarkable.' It is also stated that the ' stock of yellowfin tuna in the Indian Ocean shows a tendency to decrease from year to year'. The areas referred to are shown in the figure reproduced below (fig. 3).

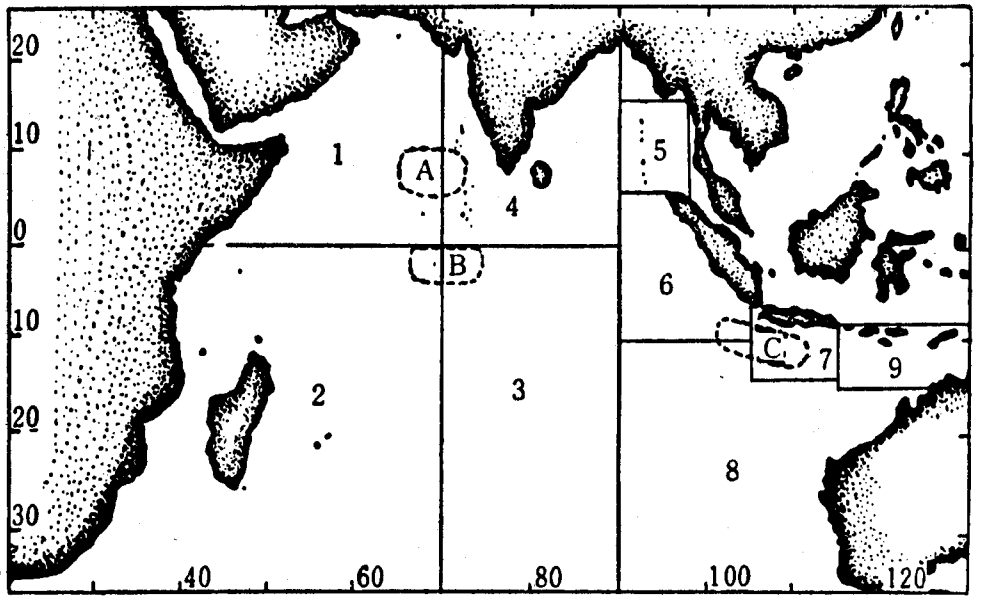


Fig. 3.—Division of fishing area of the Indian Ocean. (Reproduced from Tsuruta and Tsunoda, 1960).
A.....A area. B.....B area. C.....C area.
1. Arabian Sea area, 2. Western part of the Indian Ocean area, 3. Middle part of the Indian Ocean area, 4. Ceylon Island area, 5. Andaman Is. and Nicobar Is. area, 6. Western coast of Sumatra Island area, 7. Southern coast of Java Island area, 8. Western coast of Australia area, 9. Southern coast of Lesser Sunda Is. and Timor Island area.

More or less similar inferences have been drawn as a result of the observations made at the Kanagawa Prefecture Fisheries Experimental Station † on the yellowfin tuna in the Arabian Sea and Bay of Bengal.

Though the above statements relate to the yellowfin tuna, several other species of tunas as well as billfishes are also caught from the high seas and with intensive fishing the fate of their fisheries also will more or less tend to become the same in due course.

In any step taken towards conservation the most essential prerequisite is full data on total catch, catch-per-unit-of-effort and size-composition. Based on these only the behaviour of a fishery could be explained and ways and means could be devised for its regulation. With pelagic fishes like the tunas and marlins, which are very widely distributed and are capable of long range migrations this is a very complex problem, and unless the projection of a complete picture in the

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* Tsuruta, Saburo and Seiichi, Tsunoda, 1960. *J. Shimonoseki Coll. Fish.*, **10** (1) : 5 & 6.
† Nakagome, June 1959. *Japanese Soc. Sci. Fish.*, **25** (3) : 186-188 and *Ibid.*, **25** (6) : 417-420.

pattern of a mosaic could be achieved for the whole region it would be impossible to do anything tangible. What is required is not merely gross statistics but biological statistics with information on the catch-per-unit-of-effort and this calls for in its wake considerable background knowledge based on work of a fundamental nature. Information on the species concerned, their distribution, population relationship, the ecological system in which they exist, etc., is most essential. Several species are involved and each will have its own pattern of distribution and behaviour. Proper catch statistics with the requisite biological data would help to measure the effects of fishing on the abundance and yield of the tuna resources and would provide the scientific basis of maintaining the fishing level at the optimum sustainable yield.

With regard to the species occurring in the Indian Ocean, not only our knowledge about them is meagre but there appears to be certain amount of confusion in the identity of some which grow to a large size. In any attempt at management it is most essential that we should know the ultimate biological entity of the fish we are dealing with. Even in the same species we have to see whether they constitute a natural biological unit or are constituted by different populations or sub-populations. These will have to be studied with the help of comparative morphometric data followed by tagging experiments, blood-typing studies, analysis of the size composition of catches and maturity and spawning studies. The extent to which the different populations and sub-population if any within the same mix, their relative movements with reference to space and time and the factors responsible for the hydrographical containment if any of the populations have to be investigated. Tunas are known to congregate in areas of high organic productivity and react very much to temperature and other environmental conditions. Attention therefore has to be given to the study of the general oceanographical conditions with special reference to currents in relation to the behaviour of the fish. A study of the environment in all its various aspects viz., physical, chemical and biological is very essential. Migration studies would require a common tagging programme and since fishing in the high seas is carried out on an organised scale a fair degree of recovery could be expected. Standardised uniform techniques may have to be adopted for biological investigations. Many of the studies will be essentially of a long range nature.

Since the Pacific and Indian Oceans are contiguous bodies of water and do not have the same degree of isolation that the Atlantic has, a good amount of mixing of stocks might be taking place at least along the region of the Indo-Australian Archipelago. Areas in the immediate south of this in the neighbourhood of Christmas Island, Cocos Keeling etc., are reported to be rich tuna fishing grounds and the effect if any of intensive fishing in south-western part of the Pacific on the tuna stocks in the adjacent areas of the Indian Ocean and *vice versa* require to be studied.

Some of the tunas are caught with bait fishes and as such the degree of success of their fisheries is intimately connected with the proper utilization of the bait fish resources. Though the latter apparently looks like an ancillary problem it is actually an integral one and requires equal attention. Large scale damage to hooked tunas and marlins by sharks is common in some areas and the adverse effect this has on the fishery also requires investigation.

As stated already the existing information on the biology of tunas and related fishes in the Indian Ocean is rather meagre and mostly is of a desultory and preliminary nature. It is obvious that the symposium that is being held now on the biology and fishery of scombroid fishes has helped to bring together all the available information and it is hoped that this would contribute in no small measure to stimulate work on this interesting and important group of fishes. The problem of the conservation of the living resources of the sea has already begun to receive the attention of international bodies and the need for co-ordinated action has been agreed to in principle by all nations. In this connection the organisation of the World Tuna Meeting that is proposed to be conducted this year under the auspices of the FAO is a sign of the special attention that tunas and related fishes have begun to receive on a global basis.

COMMENT OF M. B. SCHAEFER ON PAPER BY S. JONES

As noted by Dr. Jones, and also in my paper for this symposium, publications by various Japanese scientists on the catch-per-unit-of-effort and on size-composition of yellowfin tuna in the Indian Ocean indicate clearly that the fishery for that species has become sufficiently intense to have a marked effect on the population size. A decrease in catch-per-unit-of-effort and in average size of the fish in the catch is, however, the inevitable result of effective exploitation of a fish population. By themselves, such data cannot yield any conclusions as to where the fishery stands in relation to the maximum average sustainable yield. For the latter purpose, there are also required statistics of total catch.

Unfortunately, as far as I have been able to ascertain, there are no data available on total catch of yellowfin tuna from the Indian Ocean, either by geographical subdivisions or the ocean as a whole. It would appear to be highly important that such data be collected for past years from records of companies having operated vessels here, if they exist, and, at least, to ensure that such records are compiled in the future.

This is an outstanding case of need for international co-operation in collection of scientific data to make possible the management of the living resources of the high seas for the benefit of mankind. Paragraph 2 of Article 1 of the Convention on Fishing and Conservation of the Living Resources of the High Seas, adopted by the International Conference on the Law of the Sea in Geneva in 1958 provides : ' All States have the duty to adopt, or to co-operate with other States in adopting, such measures for their respective nationals as may be necessary for the conservation of the living resources of the high seas.' In order to determine when conservation measures are needed, and what type of measures are appropriate, there must be adequate scientific data, including proper information on total catch and catch-per-unit-of-effort. By implication, then, it is the duty of every nation whose nationals engage in fishing on the high seas to collect adequate statistical information for scientific purposes, and to make them generally available for research on the condition of the fish stocks.

ADDENDUM

Since the presentation of the above paper at the Symposium I had the occasion to see the paper (in Russian) entitled " On the productivity and prospects of fishing in waters of the Indian Ocean " by V. G. Bogorov and T. S. Rass (*Oceanology*, 1961, **1** (1) : 107-109) summarising the results of the 31st cruise of the Russian Research Ship *VITIAZ* in the Indian Ocean. Relevant extracts of translation of the above are given below :

" Ichthyological works included observations on tuna and other pelagic fishes (swordfishes, sailfishes), and also simultaneous collection of information concerning the fishing in the Indian Ocean."

* * * *

" According to present literature data, Japanese catches of tuna in the central part of the Indian Ocean are larger than those in all other regions of the World Ocean : on the average 10 tunas 130-140 cm. long, per 100 hooks of a longline."

* * * *

" A great number of findings indicates the existence of far numerous spawning schools of the above stated fishes than those given for the Pacific and the Atlantic Oceans."

* * * *

" There is evidence of significant fishing resources in open parts of the Indian Ocean, first of all in waters of the Arabian Sea. The complex investigations of the Indian Ocean which were started during the 31st cruise of the R/S *VITIAZ* should be continued and developed in future. The route from the Soviet Black Sea ports (Kherson, Odessa, Kerch) to the Arabian Sea is no larger than 4-4.5 thousand miles, and the possibilities of developing our fisheries here are undoubtedly of practical interest."

No comments are made except that the last para offers the most significant reading.

S. JONES.

SYNOPSIS OF BIOLOGICAL DATA ON THE FISHES OF THE GENUS *RASTRELLIGER* JORDAN AND STARKS 1908 WITH AN ANNOTATED BIBLIOGRAPHY

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INTRODUCTION

AN annotated bibliography of *Rastrelliger* was under preparation by one of us (S. Jones) since 1954, more or less in line with the tuna bibliographies published in the Fishery Bulletin Nos. 58 and 111 of the U.S. Fish and Wildlife Service. While this was being got ready for the Symposium on Scombroid Fishes the idea of preparation of a synopsis was suggested by the other author (H. Rosa Jr.) who had already contributed a provisional one for the Indo-Pacific Fisheries Council Rastrelliger Sub-committee Meeting held in Penang in 1956. It was therefore decided to combine the two to come under the present title. The synopsis part has subsequently been taken out and published separately as FAO Fisheries Synopsis No. 29 (1965). Therefore in the proceedings of the symposium only a short version is given omitting the details in Sections 3 and 4. Similarly the figures and photographs are left out to avoid duplication and reference is made at appropriate places to those in the contribution entitled ' Mackerel from the Andaman Sea ' by S. Jones and E. G. Silas published in part I (Pages 255-282) of the proceedings of this symposium. Readers are requested to refer to the above paper for the relevant figures.

The publication of the proceedings has been delayed and in the meanwhile a number of references relating to *Rastrelliger* have appeared and an annotated list of these with a subject index is given as appendix at the end.

Considerable help and assistance have been given by Mr. P. T. Thomas and Dr. P. S. B. R. James in the preparation of the Annotated Bibliography and Synopsis and the authors wish to record their grateful thanks to them for the same. Their thanks are also due to Mr. K. V. Narayana Rao for the preparation of the Addendum and to Mr. M. Kumaran for going through the manuscript critically and checking up the references.

SYNOPSIS OF BIOLOGICAL DATA ON THE SPECIES OF THE GENUS *RASTRELLIGER* JORDAN AND STARKS 1908

1. IDENTITY
   1. 1 *Taxonomy*
      1. 1. 1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Perciformes
Suborder Scombroidei
Superfamily Scombroidae
Family Scombridae

Genus *Rastrelliger* Jordan and Starks 1908

Species *Rastrelliger kanagurta* (Cuvier) 1817

Rastrelliger brachysoma (Bleeker) 1851

Jordan and Hubbs (1925) place the genus *Rastrelliger* under a separate subfamily Rastrelligerinae while they include only *Scomber* and *Pneumatophorus* under the subfamily *Scombrinae.*

1. 1. 2 Description

—Genus *Rastrelliger* Jordan and Starks 1908 *Proc. U.S. Nat. Mus.*, **34** : 607 (Type : *Scomber kanagurta* Cuvier 1817)

The Genus *Rastrelliger* is described by Jones and Silas (1962a) as follows : ' Body compressed from side to side ; body and cheek covered with small scales, eyes with well developed adipose eyelid, mouth large, maxillary reaching nearly vertical below posterior edge of eye ; teeth small, present in jaws ; vomer and palatine edentulous ; gill rakers long, numerous and feather-like and visible when mouth is opened. Spinous first dorsal and soft rayed second dorsal separated by distance equalling length of base of former ; anal devoid of spines ; five or six dorsal and anal finlets ; pectorals short with broad base ; pelvics with spine and 5 rays ; caudal deeply forked '.

Distribution.—Tropical Indian and West Pacific Oceans from the east coast of South Africa to North Australia and as far as Micronesian and Polynesian Islands.

1. 2 *Nomenclature*

1. 2. 1 Valid scientific names

De Beaufort (1951) lists three species of *Rastrelliger* but Jones and Silas (1962a, 1962b) recognise only two species viz., *R. kanagurta* (Cuvier) 1817 and *R. brachysoma* (Bleeker) 1851 whereas the third species viz., *R. neglectus* for reasons stated in Jones and Silas (1962b) is relegated as a synonymn of *R. brachysoma.* They give the following distinguishing characters for the two species (See plate I in Jones and Silas 1962b ; 1964b appendix).

Length of head distinctly greater than depth of body ; latter 23% to 27% in fork length ; snout pointed ; dark stripes or rows of dusky spots along upper half of body ; outer margin of first dorsal dusky.....*Rastrelliger kanagurta* (Cuvier)

Length of head distinctly shorter than depth of body ; latter 28.5% to about 34% in fork length ; snout short and bluntly rounded ; no dark stripes or regular rows of dusky spots along upper half of body ; outer margin of first dorsal black.....*Rastrelliger brachysoma* (Bleeker)

1. 2. 2 Synonyms

Rastrelliger kanagurta (Cuvier) 1817

Scomber kanagurta Cuvier, *Règne Animal.*, II, 1817, p. 313 (footnote)
Scomber canagurta Cuvier, *Règne Animal.*, ed. 2, II, 1829, p. 197 (footnote)
Scomber kanagurta Cuvier and Valenciennes, *Hist. Nat. Poissons*, VIII, 1831 p. 49
Scomber chrysosoma Rüppell, *Neue Wirbelthiere. Fische des Rothen Meeres.* 1835, p. 37
Scomber microlepidotus Rüppell, *Ibid.*, p. 38
Scomber moluccensis Bleeker, *Acta Soc. Indo-Neerl.*, 1, 1856, p. 40
Scomber reani Day, *Proc. Zool. Soc. London*, 1870, p. 690
Scomber lepturus Agassiz, *Pisces Celebes*, 1874, Tab. 2

Rastrelliger brachysomus (nec. Bleeker) Jordan and Dickerson, *Proc. U.S. Nat. Mus.*, XXXIV, 1908, p. 190
Rastrelliger kanagurta Jordan and Starks, *Ann. Carnegie Mus.*, XI, No. 3-4, 1917, p. 440
Rastrelliger chrysozonus Kishinouye, *J. Coll. Agric. Tokyo*, VIII, No. 3, 1923, p. 406
Rastrelliger serventyi Whitley, *Austr. Zool.*, X, 1944, 252-273

Rastrelliger brachysoma (Bleeker) 1851

Scomber brachysoma Bleeker, *Nat. Tijdschr. Ned. Indie*, I, 1851, p. 356
Scomber neglectus Van Kampen, *Bull. Depart. de l'Agric Indes Neerl.*, VIII (Zool. ii), 1907, p. 7
Rastrelliger brachysomus Barnard, *Ann. S. African Mus.*, XXI, Part 2, 1927, p. 796

1. 2. 3 Standard common and vernacular names
R. brachysoma—*India* (Andaman Is.) Chappata Bangadi ' Hindi '.
Indochina (Ca bao ma, Plathu).
Indonesia (Kembung perempuan).
Malaysia (Kembong).
Philippines (Short-bodied mackerel Chub mackerel ; Kabalyas ' Tagalog ' Aguma -a, Kabalyas ' Bikol ', Luman ' Kuyano and Tagbanwa ', Asa-asa ' Pampango ' Aguma-a ' Visayan ' Hasa-hasa ' Visayan Banton ' Hasa-hasa ' Tagalog ' Linachay (immature) Masangi, Tulay).

R. kanagurta—*Burma* (Indian mackerel)
Ceylon (Indian mackerel; Kumbalava, Maha kara bolla ' Sinhalese ' ; Ailai, Karung kuluttan, kumbala ' Tamil ').
India (Indian mackerel; Bangada ' Canarese '; Bangadi ' Hindi ' (Andaman Is.); Kaulagedar ' Marathi '; Ayila, Ayala, ' Malayalam '; Oibiagedor ' Sindhi '; Ayalai, Kumla, Kanangeluthi, ' Tamil '; Kannangadatha, Kanagurta ' Telugu '; Karan-kita ' Oriya ').
Indochina (Ca bac ma, Ca be lau, Trey kamong, Ca nung nuc).
Indonesia (Kembung, Banjar, Kembunglelaki).
Federation of Malaya (Kuala muda, Kedah, Kembong).
Japan (Gurukunmuchji, Naha, Agifurakiya).
Pakistan west (Surmai).
Philippines (Striped mackerel, Chub mackerel ; Alumahan, Lumahan ' Tagalog ' ; Burau ' Bikol ' Salimburaw ' Kuyano and Tagbanwa ' ; Bunatan ' Ilokano ' ; Kabalyas ' Pangasinan ' ; Buyaw ' Visayan-Banton ' ; Mataan ' Iolokano ' ; Hasa-hasa Mataan).
Singapore (Kembong).
Saudi Arabia (Bagha).
Thailand (Pla-long) *Somalia* (Bagha ' Mij ' ; Burei ' Kism ' ; Garmu, Nums ' Baj ').

1. 3 *General variability*
1. 3. 1 Subspecific fragmentation (races, varieties, hybrids) (See Plate II and fig. 3 a & b (page 270) and fig. 4 (page 261) in Jones and Silas 1962b ; 1964b appendix)

Racial studies on *Rastrelliger* have been in progress in the Philippines and India but have not resulted in any tangible conclusions. A critical study of *R. kanagurta* and *R. brachysoma* of Andaman sea by Jones and Silas (1962) presented at this Symposium is perhaps the most significant contribution in this line and might serve as a preliminary lead for the taxonomical studies on this genus.

2 DISTRIBUTION

2. 1 *Delimitation of the total area of distribution and ecological characterization of this area* (Text fig.1)

R. brachysoma—Tropical Indo-Pacific

—Indian Ocean : Rarely found in waters of the Union of South Africa around Durban ; Andaman Is.

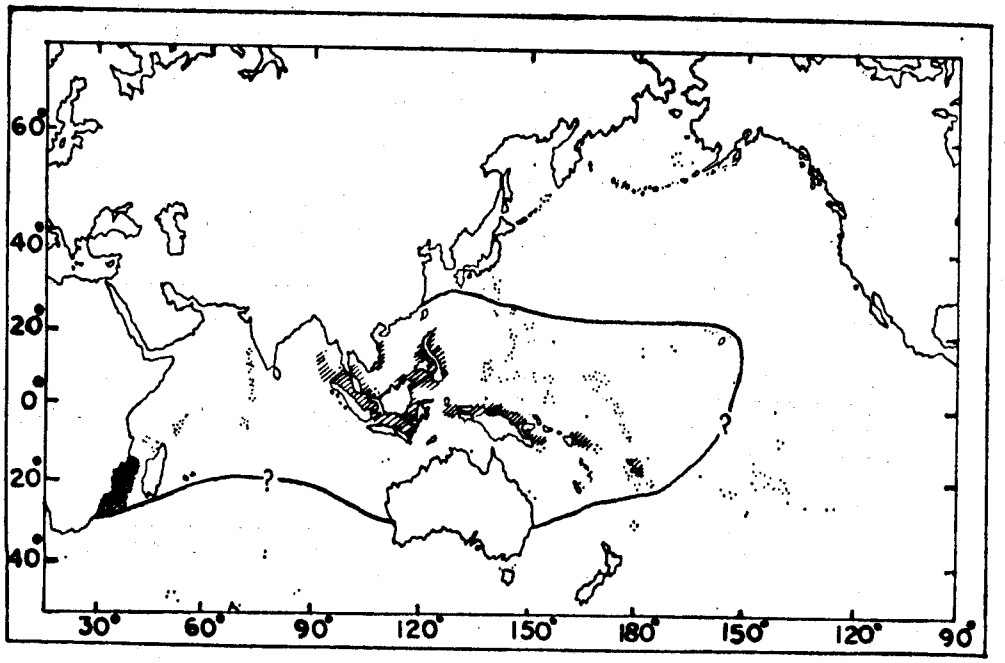


FIG. 1. World distribution of fishes of the genus *Rastrelliger*.

——— Distribution of *Rastrelliger kanagurta*.

Distribution of *Rastrelliger brachysoma*.

Rastrelliger brachysoma, doubtful occurrence.

Central Indo-Pacific

—Malaya, Singapore, Thailand, Philippines, British North Borneo, Indonesia, New Guinea, Fiji and Solomon Is.

R. kanagurta—Tropical Indo-Pacific

—Indian Ocean : Persian Gulf, Trust Territory of Somalia, Seychelles Is., Mozambique in Delagoa bay, Coast of the Union of South Africa around Durban, Pakistan, India, Andaman and Nicobar Is., Ceylon, Burma,

Central Indo-Pacific

—Malay Peninsula, Thailand, Indochina, Philippines, Indonesia, Borneo, Australia along the coast of Queensland, New Guinea, widely distributed in Melanesia Micronesia and Polynesia and reported from the island of Bougainville, Solomon, New Hebrides, Fiji, Samoa and others; Coast of China, Formosa Is., Hong Kong, Ryukyu Is., Hawaiian Is.

2. 2 *Differential distribution*

2. 2. 1 Areas occupied by eggs, larvae and other junior stages: Annual variations in these patterns, and seasonal variation for stages persisting over two or more seasons

—*Eggs :*

Information available on the eggs and their distribution is very fragmentary and hardly confirmatory. They, as in other scombroids, should be pelagic and the species being not oceanic, spawning should be taking place in waters within the continental shelf. The earliest reference to eggs of *Rastrelliger kanagurta* is by Delsman (1926) from the Java Sea, but subsequently he expressed doubts (Delsman 1931) on their identity and suggested that they could belong to *Thunnus thunnina* (=*Euthunnus affinis*).

It has been recorded in the Administrative Report of the Madras Fisheries Department (1937) that eggs suspected to be those of mackerel were obtained from plankton collected off West Hill, Calicut. Devanesan and John (1940) record the collection of 405 eggs in different stages of development on 5th June 1937, 5 miles from the shore off Chaliyam, south of Calicut on the west coast of India.

Balakrishnan (1957) says that 'Hauls made in the 18-25 fathom area off Vizhingam during all the months from March to May showed a few eggs of 0.84-1.009 mm. diameter which are tentatively assigned to mackerel'. No figures or description of eggs are available.

—*Larvae :*

Kuthalingam (1956) refers to the collection of postlarvae measuring 5 mm to 6 mm which 'resembled the juveniles in general form and were collected mainly from the plankton samples brought to the laboratory'. No figures or descriptions are available.

The only reference to the very early larvae of the Indian mackerel is the following statement of their occurrence off Vizhingam on the Kerala coast. 'Plankton hauls made on the 23rd May 1956 on the spot where the fishermen were engaged in fishing showed prolarvae measuring 2.8 mm and 5 mm' (Balakrishnan 1957). However, no figures or descriptions are given. It may be stated here that 5 mm appears to be too large a size to be a prolarva.

—*Juveniles :*

Juveniles have been reported from the west coast of India off the coast of Ratnagiri (George and Annigiri 1960), Karwar (Pradhan 1956), Mangalore (Rao 1962), Calicut (Madras Fisheries Administrative Report for 1940, Bhimachar and George 1952, Quarterly Scientific Reports of the Central Marine Fisheries Research Institute—June-December 1961) Cochin/Ernakulam (Rao 1962) and Vizhingam (Balakrishnan 1957, Jones and Kumaran 1962), from the south coast of Ceylon (de Zylva 1956), from the east coast of India off Madras (Rao and Basheeruddin 1953, Kuthalingam 1956, Basheeruddin and Nayar 1962,)

and Lawson's Bay (Satyanarayana as cited by Rao 1962) Visakhapatnam (Rao and Basheeruddin 1953 and Rao and Rao 1957) and from the Andaman sea near Port Blair (Rao 1962). All the information available hitherto have been compiled and summarised by Rao (1962) and presented at this Symposium. Reference is invited to the above for details.

The records of juveniles hitherto have been from coastal waters caught in shore seines and boat seines along with other fishes. Often commercial catches of mackerel are constituted by juveniles only.

2. 2. 2 Areas occupied by adult stages, seasonal and annual variations of these.

Records so far have been from coastal waters from within the continental shelf. On the west coast of India it is found practically all the year round, the main season being from August to March. Along the coast of Ceylon and on the east coast of India it is caught in stray numbers. Catches are not high in the Andaman Seas but little is known about the fishery resources of this area since there is only very restricted fishing activity there. Both species occur along the Malayan coast and Indonesia but *R. kanagurta* is the dominant one. In the Philippines both the species occur in coastal waters and here also *R. kanagurta* appears to be the dominant species.

2. 3 *Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution*

Hardenberg (1955) states : '*Rastrelliger* species are pelagic fish moving in schools, whose size is determined probably by local conditions in sea. There are at least two species forms or races, one an oceanic form and the other a more neritic one. How far the oceanic form ventures out at sea is not known at present, or at least has not yet been published. So it is not yet certain whether this oceanic form, or species, is found so far away from the nearest coast as for instance the true, Atlantic mackerel. It is still not certain therefore whether they occur in quantities more than 50-60 nautical miles from shore, which is about the limit for practical fisheries in the countries most concerned with *Rastrelliger* fisheries '.

' The neritic form lives in shallow water, often of depth not more than 15 meters, at least according to my own experience. It is probable, however, that depth is not the only determining factor. Hydrological conditions will have something to do about it too. The neritic form seems to prefer a muddy or clayish bottom, but whether this always holds true I cannot say. Clear water of a salinity of more than 32.5‰ seems to be avoided. So are the vicinities of coral reefs. On the other hand a muddy sea is avoided too. The exact degree of silt turbidity avoided is thus far unknown '.

' The oceanic form lives in the clear waters of the open sea with a salinity of 32‰ and more and it seems at least in the Java Sea—that a depth of 20 meters and more is preferred. I have often found a kind of no-man's-land between the two forms. Indonesian fishermen often maintain that the oceanic mackerel prefers a sandy bottom. This is certainly not always true.'

Manacop (1955) states that *R. brachysoma* is evidently a coastal or inshore form feeding mainly on microplankton, and *R. kanagurta* is apparently an open sea form and feeds mainly on macroplankton such as larval shrimps and fishes.

Pradhan (1956) writes that ' Records show that mackerel can withstand the low salinities even down to 2.04‰.'

According to Pradhan and Gangadhar Reddy, (*Indian J. Fish.*, 9(1), 1962 in press) increase in temperature and salinity has been found to affect adversely mackerel catches, whereas

their low values exerted a less pronounced effect. Mackerel appears to be more susceptible to changes in temperature than salinity and the tolerance ranges of these factors seem to depend on the size of the fish. Large fish (19-21 cm.) appear to tolerate increase in temperature and salinity whereas smaller fish usually occur in large numbers during June to September period (at Kozhikode) when low levels of temperature and salinity prevail. One of the criteria for good mackerel season may be the degree of variation of temperature and salinity should be within the tolerance ranges of these two hydrographical factors. High pH may have an added adverse effect on the fishery. Probable effects of wind force and rainfall on the fluctuations in mackerel landings at Kozhikode are also briefly considered.

'Mackerel are known to enter estuarine waters of Kali river and ascend along the tidal current upto a distance of about $1\frac{1}{2}$ miles during April and May when the range of salinity of river water is between 29.73 and 34.6‰.'

Mackerel have also been recorded in Netravati eastuary and Cochin backwaters.

The species of the genus *Rastrelliger* are distributed only in the Tropical Indo-West-Pacific Faunistic Region. It does not go eastward to the East-Pacific Barrier.

The faunistic region is characterized by :

1. The occurrence of reef-building corals.
2. The fish fauna of the shelf of the region is very much richer in species than that of the rest of the main tropical regions.

Oceanographically, the distribution coincides with the Indo-Pacific equatorial current regions. In general, these regions are characterized by

1. High temperature of the surface waters, (the distribution of *Rastrelliger* is inside the area where the temperature at 200 m. depth is 15°C. or where the surface temperature does not fall below 17°C. in any season).
2. Predominant East-Westerly surface currents.
3. Medium basic organic production.
4. Relatively low degree of seasonal variations.

The natural regions where *Rastrelliger* is distributed can be grouped into four and characterized on the basis of similarity. The general characteristics of the groups are the following :

Group I—*Monsoon regions*—

(1.1 Arabian Sea, 1.2 Bay of Bengal, 2.4. South China Sea with Malayan Archipelago).

1. Relatively large continental shelf
2. Monsoon winds
3. Medium to high precipitation and runoff
4. Surface temperatures 20-30°C.
5. Surface currents changing with the change of monsoons
6. Seasonal variations : medium
7. Basic organic production : medium to low
8. Presence of subsurface 0_2 minimum layer

Group II—*Equatorial current regions—N.* and *S.*

(1.3 Indian N.— 4. Pacific N.—1.5. Indian S.—4.9 Pacific S.—Equatorial current regions).

1. Very small continental shelves ; mainly deep oceanic areas
2. Trade winds (except in 1.3 which is influenced by monsoons)
3. Medium precipitation, low runoff
4. Surface temperatures 25-28°C.
5. Easterly surface currents
6. Low degree of seasonal variations
7. Low organic production

BIONOMICS AND LIFE HISTORY

3. 1 *Reproduction*

3. 1. 1 Sexuality (hermaphroditism, heterosexuality, intersexuality).

Heterosexual. Instances of hermaphroditism recorded in Indian mackerel (Prabhu and Antony Raja 1959, Rao, 1962 and Thomas and Raju 1962).

3. 1. 2 Maturity (age and size).

The minimum size at maturity has been found to be 20 cm. by Chidambaram and Venkataraman (1946) and 22.4 cm. by Pradhan (1956). The fish is known to attain a length of 19-21 cm. at the end of second year. It is possible to distinguish sex in fish above 12 cm. total length.

It has been indicated that there is a decrease in the rate of growth after a certain length (standard) has been reached, and it has been suggested that the point of inflexion on the growth curve indicates the length at which full maturity is attained.

Sexual maturity studies indicate that in Manila Bay *Rastrelliger brachysoma* of both sexes mature at a minimum size range of 15.0-16.9 cm. In the range 16.0-16.9 cms. long, all fish examined of both sexes were invariably mature.

The *Rastrelliger kanagurta* from Northern Palawan, on the other hand, matures in the minimum size range of 21.0-21.9 cms. and to a maximum size range of 24.0-24.9 cm. (Philippines Fisheries Handbook, 1952).

3. 1. 3 Mating (monogamous, polygamous, promiscuous)

Polygamous

3. 1. 4 Fertilization (internal, external)

External

3. 1. 5 Fecundity

Relation of gonad size and egg number to body size and to age.

A key has been prepared by Pradhan and Palekar (1956) to help in the interpretation of the maturity stages of the gonads, male and female, of the Indian mackerel. The maturity scales used by the International Council for the Exploration of the Sea for Herring has been adopted up to Stage V inclusive. The Stage VI was divided into Stage VI (a) and VI (b) due to peculiar ripening of ova in batches giving an appearance to the ovary described as ' plum-pudding stage.'

The key is reproduced below excluding the description of the general appearance of the ovaries and testes, and appearance of ova under the microscope.

Key to the stages of sexual maturity of the Indian Mackerel—*Rastrelliger canagurta* (C.) (Female)

Extent of ovary in the body cavity	Range of ova	State of maturity	Maturity stage
Ovaries less than half the length of the body cavity	0.038-0.13 0.14-0.27	Im	I
Ovaries slightly more than half the length of the body cavity	0.28-0.37	m	II
Ovaries extending to about 2/3 the length of the body cavity	0.37-0.46	m	III
Ovaries extending a little over 2/3 the length of the body cavity	0.46-0.56	m	IV
Ovaries extending over the entire length of the body cavity	0.57-0.81	M	V
Do. Do.	Do. Do.	M M	VI(a) VI(b)
Shrunken ovaries about ½ the length of abdominal cavity	..	S	VII

Key to the stages of sexual maturity of the Indian Mackerel—Rastrelliger canagurta (*C.*) (*Male*)

Extent of testes in the body cavity	State of maturity	Maturity stage
Testes less than half the length of the body cavity	Im	I
Testes slightly more than half the length of the body cavity	m	II
Testes extending to about 2/3 the length of the body cavity	m	III
Testes more than 2/3 of the length of the body cavity	m	IV
Testes extending over the entire length of the body cavity	M	V
Do.	M	VI
Testes comparatively much reduced in size	S	VII

Im—Immature ; m—Maturing ; M—Mature ; S—Spent fish.

—Coefficient of fecundity

Devanesan and John (1940) estimate an average of 94,000 eggs in the Indian Mackerel.

3. 1. 6 Spawning

—Spawning seasons (beginning, end, peak)

The spawning season in India appears to be from March to September.

—Number of spawnings per year, frequency

It spawns in succession over a prolonged period and only a small percentage of ova mature each time giving that stage a speckled appearance described as 'plum-pudding' stage. The

number of batches discharged in a spawning season is not known, which makes it difficult to determine the number of eggs spawned during a season.

—Spawning time of day

It is believed that mackerel spawn at night.

3. 1. 7 Spawning grounds

—Coastal (surface, vegetation, shore, shoal, sand, shelter) ; bottom

Spawning grounds appear to be in deeper waters off Vizhingam (see 2. 2).

3. 1. 8 Egg : Structure, size, hatching type, parasites and predators.

Range of ova diameters in mm. : 0.038-0.27 immature ; 0.28-0.56 maturing ; 0.57-0.81 mature. The mature ova is transparent measuring up to 0.88 mm.-0.90 mm. in diameter usually with a large oil globule (Pradhan and Palekar 1956). The oil globule measures 0.23 mm. in diameter. Sometimes 3-4 oil globulets may be present.

3. 2 *Larval history*

3. 2. 1 —Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)

—Feeding

Bhimachar and George (1952) examined the gut content of a large number of young mackerel of sizes from 5.5 to 7.5 cm. and found that their food did not differ radically from that of the adult.

3. 3 *Adult history*

3. 3. 1 Longevity

Probability of a fourth year-class is indicated from length frequency studies, in Indian waters. Larger specimens (25-27 cm. total length) which are caught in small numbers may be attributed to the fourth year-class.

3. 3. 2 Hardiness

(see 2. 3)

3. 3. 3 Competitors

The oil sardine *Sardinella longiceps* on the west coast of India may be considered as competitor for food, as both are plankton feeders grazing on the same patches of plankton in inshore waters. Both are migratory fishes moving in inshore waters in the same season.

3. 3. 4 Predators

Sharks, Seer fish, Ribbon fish, Tunas and Porpoises.

Mackerel shoals when attacked by seer fish scatter and when chased by sharks submerge with the head downwards in a compact mass. On porpoise attack they dive and scatter.

3. 3. 5 —Parasites and diseases

Trematode, cestode and copepod parasites were recorded from Indian mackerel (Srivastava 1936 a & 1936 b ; Chauhan 1945 ; Yamaguti 1953 ; Pillai 1962 ; Rao 1962 ; Silas 1962 b, Silas and Ummerkutty 1962).

3. 3. 6 Greatest size

Largest specimen recorded from Karwar was 307 mm. (January 1955).

3. 4 *Nutrition and growth*

3. 4. 1 Feeding (time, place, manner, season)

Chidambaram and others (1952) studying the intensity of feeding in different size groups of Indian mackerel, found for all size groups two periods of intense feeding ; one in October-December and the other in March-April. The absence of data for various sizes of fish in June, July and August did not allow the authors to draw any conclusion with regard to feeding habits during the spawning season.

The same authors found a distinct correlation between the maturity of the fish and its feeding intensity. From February to the middle of April when the mackerel were maturing, the feeding intensity is high. From the middle of April to June when the fish was advancedly mature, the feeding was low.

3. 4. 2 Food (type, volume)

Mackerel has been found to subsist mainly on phytoplankton and zooplankton, the common items of the food being *Coscinodiscus, Dinophysis, Peridinium, Pleurosigma, Chaetoceros* sp., *Fragilaria oceanica, Thalassiothrix frauenfeldi, Nitzschia seriata, Skeletonema costatum, Thalassionema* among the phytoplankters and tintinnids *Evadne, Penilia, Cypris* larvae, cladocerans, dinoflagellates, copepods like *Oithona* spp., *Acrocalanus* spp., *Temora turbinata, Schmackeria serricaudata, Euterpina acutifrons, Labidocera, Acartia, Eucalanus* and *Squilla* larvae, *Alima*, gastropod larvae, bivalve larvae and fish post-larvae among the zooplankters.

3. 5 *Behaviour*

3. 5. 1 —Migration and local movements

In Karwar, India (Pradhan—1956), with north-easterly winds shoals enter inshore waters.

Shoals usually move along the current of water at high tide. When there is a strong wind in easterly direction mackerel shoals come close to the shore through deeper layers of waters.

It was observed that mackerel shoals move in semicircular or arrow-head formations.

It may be inferred that mackerel shoals move at a speed of about 8 to 10 miles per hour. In Malaya shoals move at 3 knots per hour.

Hardenberg (1955) states that the mackerel tend to follow the highest densities of plankton as has been indicated along the West coast of Borneo and probably along the West coast of Malacca.

Indonesia—Hardenberg gives the following information : ' In the case of the oceanic mackerel one instance of migration is fairly well-known and this is in the Java Sea where the situation is

briefly as follows : ' At the end of the West Monsoon a stock of oceanic *Rastrelliger* is present. At the beginning of the East Monsoon the waters of the Java Sea begin to flow in a westerly direction and the *Rastrelliger* moves off in a westerly direction and disappears. After some weeks a new stock enters the Java Sea through its eastern entrance. At the end of the East Monsoon the reverse happens and two new stocks enter the Java Sea, one from the North West out of the South China Sea and one from the South West out of the Indian Ocean.'

' This study was based on the migration of *Decapterus* but mackerels closely follow the same pattern, generally being one to two weeks behind.'

The possibility of actual spawners moving out of the intensely fished area is indicated by observations at Porto Novo. Appearance of mackerel in inshore waters depends to some extent on the availability of the food elements in the inshore plankton and one of the contributing factors responsible for the failure of the mackerel fishery in the year 1961-1962 at Karwar may be the scarcity of food elements in plankton. During September-January moderate temperature, pH and salinity prevail in the inshore waters (Karwar) during which time mackerel appears in shoals along coast line. A survey of *R. V. Varuna* in the Mangalore-Calicut zone in February 1962 revealed traces of shoals in waters upto 20 metres depth, but beyond this range there were no traces.

During 1961-1962 season occurrence of mackerel was recorded in the trawl catches off Bombay and Saurashtra coasts in November and December.

3. 5. 2 —Schooling

In Karwar, India, (Pradhan 1956) the range size in a single mackerel shoal is very small and the individuals collectively present a striking uniformity of size. This suggests that mackerel of different size groups move in shoals separately and the range of size in the same shoal is not significantly large.

A record catch of 21,00,000 mackerel in one net was noticed on 1-12-1957 at Karwar.

3. 5. 3 Reproductive habits

No segregation of sexes

4. Population (Stock)

4. 1 *Structure*

4. 1. 1 Sex ratio

Generally, males and females were about equal in number in the commercial catches (data from 1955-61 from the west coast of India *Cen. Mar. Fish. Res. Inst., India*).

4. 1. 2 Age composition

Mackerel of the first, second and third year-classes are represented in the commercial catches. Fish of the fourth year-class are rarely represented. Scale studies, at Karwar, have indicated (Seshappa 1958*) the existence of clear rings in the specimens measuring 23 cm and above. These rings are believed to be spawning marks which may prove useful in age studies.

*By mistake it was stated in Jones and Rosa (1965) that "studies at Mandapam (1957-1968) indicated that individuals below 22 cm. showed clear annual rings." It should read : Studies at Karwar (Seshappa 1958) indicated that individulas above 23 cm, showed clear rings in the scales." The error is regretted.

4. 2 *Size and density*

4. 2. 1 Average size

(See 4. 2. 2 below)

4. 2. 2 Changes in size

Karwar (India)—Pradhan (1956).

1948-1949 season—Dominant size-class from December 1949 was 20.5 cm.

1949-1950 ,, —Three dominant classes, 17.5 cm. ; 18.5 cm and 19.5 cm constituted the fishery at various intervals. The 19.5 cm group persisted throughout the season with exception of October and December.

1950-1951 ,, —October 1950 : Dominant size-group, 19.5 cm entered the fishery ; in November, increased to 20.5 cm and disappeared in December. The second group entered the fishery in November 1950 and the dominant size-class was then 17.5 cm, increased to 20.5 cm, in December, 21.5 cm in January 1951 and 22.5 cm in February and March.

1951-1952 ,, —Dominant size-class in October 1951 was 19.5 cm, increased to 20.5 cm in November and persisted throughout the season.

1952-1953 ,, —Dominant size-class in October was 17.5 cm which increased to 19.5 cm. in November and persisted till March 1953. The larger group 22.5 cm which entered the fishery in October increased to 23.5 cm in November and persisted in small number until December.

West coast of India (*Cen. Mar. Fish. Res. Inst., India*, (1953-1962).

1953-1954 season—The 19.5 cm size-class was dominant.

1954-1955 ,, —The total size range was 11.3-23.0 cm.

1955-1956 ,, —Size range was 19.0-25.0 cm.

1956-1957 ,, —Size range was 9.8-26.2 cm the dominant groups being 14-15 cm, 18 cm, 16-19 cm, 19-21 cm and 23 cm, at various places.

1957-1958 ,, —The dominant size groups were 13 cm, 18 cm, 20.5 cm, 21.5 cm and 23 cm in different months at different places. Young mackerel (3-6 cm) were caught.

1958-1959 ,, —The total size range was 4.0-24.5 cm. Prominent size groups were 19.0-20.0 cm and 21.5 cm.

1959-1960 ,, —Size composition varied from 4.5-29.5 cm at different places. Dominant size groups were 18.0 cm 19.0 cm 20 cm 20.0-21.0 cm. Juveniles were recorded (4.5-7.0 cm).

1960-1961 ,, —Total size range was 4.5-28.0 cm. with the 12.0 cm, 13.0 cm, 16.0 cm, 19.0 cm, 20.0 cm and 21.0 cm. groups predominating.

1961-1962 ,, —Size range was 3.5-27.0 cm. The 16.5 cm 18.5 cm and 22.5 cm groups were dominant.

Monacop (1955) states that *R. brachysoma* reaches a maximum length in the Philippines of 22.0 cm and a weight of about 200 grams. The average size commercially taken is about 18.0 cm and the average weight 100 grams. The average size of the commercial catch of *R. kanagurta* is about 25.0 cm and 230 grams with a maximum of about 30.0 cm and 380 grams.

4. 2. 3 Average density

The average density of mackerel at Karwar on annual basis is 57.41 lb. and on monthly basis is 44.33 lbs. per unit effort during the period 1948-58. (Banerji and Chakraborty 1962).

4. 2. 4 Changes in density

The density of the mackerel in the foreshore waters at Karwar varies markedly not only within the season, but also between the seasons, as is evident from the indices of abundance given by Banerji and Chakraborty (1962).

5 EXPLOITATION

5. 1 *Fishing equipment*

5. 1. 1 Fishing gear

Philippines—

Adult chub mackerels (*R. brachysoma* and *R. kanagurta*) are caught mainly by fish corral (Ibaklad') in Malampaya Sound and by purse seines (Italakop') in Manila Bay. The basnig, sapyaw and sinsoro, which capture fish with the aid of light, are also extensively used for catching juvenile and intermediate sizes. Explosives are effectively used in the catching of alumahan *R. kanagurta* on the offshore reefs and shoals by naked divers working from a 'mother' fish-carrier vessel. (Philippines Fisheries Handbook, 1952).

India—

West coast

Fishing area	Type of boat	Type of net	Vernacular name
Konkan area	*Pandi ; Hodi*—both are provided with an out-rigger equipment	Shore Seine	*Rampan* net
		Drift net	*Pettle bale*
		Cast net	Pag
North Canara area	*Pandi ; Doni*—similar to above with out-rigger	Shore Seine	(i) *Rampan net* (ii) *Yendi* or *Payawada*
		Drift net	*Patta bale*
		Cast net	*Pag*
South Canara area	*Pandi* (with out-rigger)	Shore Seine	*Rampan* net
		Drift net	*Pattae balai*
		Cast net	*Deb balai*
Malabar area	Dugout canoes	Seine net	(i) *Odam vala*, also called *Peru vala* and *Paithu vala* (ii) *Aiyla kollivala*
		Gilling net	*Aiyla chala vala*

East coast

Fishing area	Type of boat	Type of net	Vernacular name
Andhra coast	'Masula boat'	Shore seine	*Peddavala*
	Catamaran	Seine net	*Iragavala*
		Gill net	*Oddivala*
Madras coast	'Masula boat'	Shore seine	*Karavalai, Periyavalai*
	Catamaran	Seine net	*Vellavalai Thurivalai*
	Catamaran mostly but occasionally a boat especially in the Gulf of Mannar area	Gill net	'*Valavalai*'

Thailand and Cambodia—

As stated by Durand (1949) large quantities of Indian Mackerel are caught in fixed traps, established on the muddy bottom in depths varying from four to fifteen metres.

The slender variety in Ceylon is known as kumbala and the wider bodied variety as bolla. It has not yet been possible to determine to which of these groups the juvenile forms belong. The juvenile forms often have other local names. The catches of bolla are higher along the south coast. In general, the heaviest landings are made with the beach seine but a great deal of angling with hand lines, bearing from 15 to 25 hooks in a cluster is carried on off the south coast from boats which hover over the shoals of bolla for the purpose. Brightly shining artificial lures, often made of lead, are utilised. They are also taken on rod and line using a little drop-shaped bead of lead with a barb as lure. De Zylva (1956).

5. 1. 2 Fishing boats

India :

See Table under 'Fishing gear.' The Pandi carries only the Rampan net and a crew of 16 to 20 and its size is $45 \times 10 \times 4$ feet. The Doni is a smaller boat used as a scout boat for sighting mackerel shoals or for removing mackerel from an impounded area. Manned by a crew of 6 to 8 and propelled with both oars and sail ; its size is $24 \times 3 \times 2$ feet.

5. 2 *Fishing areas*

5. 2. 1 General geographic distribution

—*Somalia—Rastrelliger kanagurta* is often found in large schools at the surface.

—*India*—West Coast—The most important economic food fish of this coast from Ratnagiri in the north to Quilon in the south.

Pradhan (1951) divides the important mackerel fishing areas on the west coast into four zones according to the different types of boats and nets employed to suit the physical characters of the coast-line. These areas from north to south are :—

(1)Konkan—from Rajeewade in the Ratnagiri District to the mouth of Terkhol creek ; (2) North Canara—from Majali on the southern boundary of Goa to Bhatkal, near the southernmost coastal limit of the Bombay State ; (3) South Canara—from the southern boundary of the Bombay State to the mouth of Baliapatam river near Cannanore and (4) Malabar—from Cannanore in the north to the southern part of Travancore. The chief mackerel fishing centres on the west coast are—Ratnagiri, Malavan, Karwar, Malpe, Tellichery, Calicut, and Cochin.

—India—East Coast—The northern limit of the occurrence of this species is as far as Ganjam. Pradhan (1951) states that ' except for the sporadic occurrence of mackerel, there is no regular fishery of this fish on the East Coast.'

—*Ceylon*—Coastal waters, Gulf of Mannar and trawling grounds.

—*Cambodia*—Neighbourhood of the Bay of Kampong-Som, Cone Island and Kaskapik.

—*Indonesia*—Southern coast of Borneo and Northern coast of Sumatra.

—*Japan*—Neighbourhood of the Ryukyu islands.

—*Philippines*—The principal fishing of the young and adult of *Rastrelliger kanagurta* are : Eastern and north-western Palawan and vicinities ; northeastern Palawan, including Cuyo group ; southern Zamboanga and Sulu Archipelago ; Visayan Sea. Of *Rastrelliger brachysoma* are : Manila Bay, Ragay Gulf South-western Samar, Estancia, Iloilo, Gigantes and Bantayan Is., Northern Negros, Malampaya Sound and vicinity ; Pantao and Malakbala, Albay Province ; Mercedes, Camarines Norte.

5. 2. 3 Depth ranges

Mackerel fishery is usually confined to inshore waters but fish have been recorded in the trawl catches off Bombay and Saurashtra coasts, in November and December during the 1961-62 season. Stray specimens have been caught by trawl over the Wadge Bank (Sivalingam 1955 ; John 1959). A survey of R. V. Varuna in the Mangalore-Calicut zone in February 1962 revealed traces of shoals in waters upto 20 metres depth but beyond this range there were no traces.

Generally, the changes in depth at which mackerel are caught depend on the nature of coastline, the time or season of fishing and the type of net operated. The depth may vary from 2 to 12 fathoms or even more. Mackerel were caught even in deeper waters off Porbandar in trawl operation. Along the Canara and Konkan coast up to Ratnagiri, where the bottom of inshore waters is sandy or muddy, the shore-seine, Rampan net is operated in 2-4 fathoms or within a range of a mile and a half. During the rainy season a smaller shore-seine is operated in 1 or 2 fathoms. The gill nets and the boat-seines, on the Malabar coast in particular are not usually operated so close to the shore or in the shallow waters.

5. 3 *Fishing seasons*

5. 3. 1 General pattern of fishing season

The mackerel season, whether good or poor depends on the density or concentration of mackerel shoals in inshore waters in which they are intercepted and caught. The fishery is thus subject to great fluctuations.

5. 3. 2 Duration of fishing season

Chidambaram and Venkataraman (1946) state that the Indian mackerel fishery on the west coast of India extends from September to April, prior to the outbreak of the south-west monsoon. At Karwar and along the Canara coast as indicated by Pradhan (1956) it is from October to February and may, at times, extend to March. The mackerel shoals subsequently break up, resulting in poor catches in April, and practically disappear from the shores of Karwar during May. In the rainy season, June to end of September, they are occasionally caught in small numbers in inshore waters within a range of about half a mile from the shore. Thus the duration of fishing season may vary from coast to coast. On the Malabar coast, it may be 5-7 months

and on the Canara and Konkan coast up to Ratnagiri, 4-6 months. In general it may be stated that the season starts early on the Malabar coast and closes late in February or March. On the Canara and Konkan coast, it may commence sometime in October and come to an end in February-March.

5. 3. 3 Dates of beginning, peak and end of season

—India

On the Malabar coast, the season begins in August-September, with a peak in November-December and ends in February or March. On the Canara coast, it may begin sometime in October with a peak in November-December closing abruptly in February-March. A secondary peak of a short duration was noted towards the end of the season—February-March on the West coast.

—Cambodia

As indicated by Durand (1949), the mackerel appears on the coast towards the end of October in the neighbourhood of the Bay of Kampong-Som ; a month later near Cone Island and Kaskapik. It remains there until February, a period when the females are ripe and ready to spawn.

—Philippines

The principal fishing areas and seasons of the young and adult ' hasa-hasa ' (*R. brachysoma*)

Fishing Areas	*Fishing Seasons*	
	Young	*Adult*
Manila Bay	Throughout the year	May to December
Ragay Gulf	March to September	December to May
Southwestern Samar	November to January	February to May
Estancia Iloilo	March to June	May to October
Gigantes and Bantayan Is.	March to May	April to October
Northern Negros	May to June	June to August
Malampaya Sound and vicinity	April to May	May to September
Pantao and Malakbala, Albay Province	April	October to May
Mercedes, Camarines Norte		May to September

The principal fishing areas and seasons of the adult ' alamahan ' (*R. kanagurta*)

Fishing areas	*Fishing seasons*
Eastern and northwestern Palawan and vicinities	December to June
Northeastern Palawan, including Cuyo group	April to November
Southern Zamboanga and Sulu Archipelago	December to May
Visayan Sea	April to October

—Ceylon

Large shoals of *R. kanagurta* normally occur on the west coast of Ceylon where they are caught in considerable numbers in the beach seine in the November-February period, and on the east coast almost throughout the year with peaks in September and December-April. Catches of the inshore species are highest on the south coast in the December-February period.

5. 3. 4 Variation in time or duration of fishing season

In some years the season was very short lasting for 3-4 months.

5. 3. 5 Factors affecting fishing season

The monthly total catch of mackerel appears to be more influenced or governed in Karwar (Pradhan 1956), by the dominant size-class or classes, than by the actual number of pieces of Rampan net in operation during the month. In other words, the frequency of appearance of mackerel shoal in inshore waters and probably the size of a shoal itself, appear to be related in some unknown manner to the dominant size-class of the month or season.

The following points are noteworthy with respect to Indian mackerel :

(*a*) High mortality of eggs.

(*b*) Removal of potential spawners and the consequent effect on recruitment.

(*c*) Scarcity of edible forms of planktonic organisms which constitute the major food elements of mackerel.

(*d*) Hydrographical factors like, temperature or sea water, salinity , pH etc.

(*e*) Movement of mackerel of different size groups in inshore waters has been found to be in direct relation to hydrographical factors. Small size groups (12-16 cm) are usually abundant in the period of low salinity and temperature (July-September) whereas larger fish can adopt themselves to higher temperature and salinity.

5. 4 *Fishing operations and results*

5. 4. 1 Effort and intensity

At Karwar the input of effort during the peak season is not commensurate with the abundance of mackerel. Therefore the index of intensity of fishing is not significantly higher than one (Banerji and Chakraborty 1962)

5. 4. 3 Catches

Particulars of total annual yield of mackerel in India during 1950-1961 are given below.

Year	Catch (metric tons)
1950	89,163
1951	104,900
1952	78,014
1953	70,754
1954	28,258
1955	22,795
1956	16,426
1957	89,006
1958	123,282
1959	62,198
1960	133,655
1961	34,485

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