1. INTRODUCTION

This catalogue covers all of the 49 scombrid species presently known, irrespective of their current commercial importance. It is based primarily on information from literature, and this has led inevitably to a certain unbalance in the species accounts. In fact, while there is a wealth of information on the economically important mackerels and tunas, the literature available on the less common species of Spanish mackerels is rather scarce. Sometimes it is difficult to evaluate the reliability of published data, particularly in cases where the identity of the species referred to is doubtful. Moreover, the discovery of new species, the more accurate delimitation of known species, and even the introduction of nomenclatorial changes, have caused confusion and have led to the use of scientific names that are incorrect by modern standards, or apply to more than one species. Although great care was exercised in selecting the published information used in the catalogue, some misjudgements and incorrect interpretations have undoubtedly occurred.

In order to avoid cluttering the text with literature citations, every effort was made to restrict these to papers considered of specific relevance to the species in question. Many others, particularly on systematics, anatomy, distribution and the more general aspects of biology and fisheries, have been included only in the bibliography. Attention is drawn to the existence of rather comprehensive, even if often outdated bibliographies on this group or on parts of it, e.g. Corwin (1930), Shimada (1951), volume 4 of the 'Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species' (Bernabei, ed., 1964), LeGall (1981), and the annotated bibliography on eggs and juveniles by Richards & Klawe (1972). For more detailed information, particularly on tuna and mackerel stocks and their fisheries, the reader is referred to specialized periodical publications, such as the 'Bulletin' and the 'Annual Reports' of the Inter-Ameritan Tropical Tuna Commission (La Jolla), the 'Collective Volume of Scientific Papers' of the International Commission for the Conservation of Atlantic Tunas (Madrid), and the 'Fisheries Newsletters and Reports of the Skipjack Survey and Assessment Programme' of the South Pacific Commission (Noumea). Recent comprehensive papers on certain groups of scombrids include Manooch, Nakamura & Hall (1978) on four Atlantic species of Scomberomorus, Yoshida (1979) on little tunas (Euthynnus), Yoshida (1980) on bonitos (Sarda), Uchida (1981) on frigate tunas (Auxis), and Collette & Russo (ms) on the Spanish mackerels (Scomberomorus). Species synopses are individually quoted in the text where relevant.

Illustrations were adapted and redrawn by Mr Paolo Lastrico, FAO (Rome), from a wide variety of sources, especially primary systematic literature. Most figures of Spanish mackerels were drawn from specimens by Ms Keiko Hiratsuka Moore of the NMFS Systematics Laboratory (Washington, D.C.).

Acknowledgements

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1.1 Plan of the Catalogue

This catalogue is arranged alphabetically by genera and species. Each of the multispecies genera is introduced with general descriptive remarks, illustrations of diagnostic features, highlights on the biology, and relevance to fisheries. The information pertaining to each species is arranged by paragraphs, as follows: (1) scientific name, (2) synonymy, (3) FAO species names, (4) diagnostic features, (5) geographical distribution, (6) habitat and biology, (7) size, (8) interest to fisheries, (9) local species names, (10) literature, and (11) remarks.

(1) **Scientific name** : Reference is given to the original description of each species so no confusion will arise as to precise identification.

(2) **Synonymy** : Synonyms and different name combinations are listed (misidentifications and other nomenclatorial problems are discussed under (11) remarks).

(3) **FAO species names** : English, French and Spanish names for each species, to be used primarily within FAO, were selected on the basis of the following criteria: (i) each name must apply to one species only, in a worldwide context; (ii) the name should not lead to confusion with other groups. Wherever possible, the names selected were based on vernacular names (or parts of names) already in existence within the areas where the species is fished. FAO species names are, of course, not intended to replace local species names, but they are considered necessary to overcome the considerable confusion caused by the use of a single name for many different species, or severa1 names for the same species.

(4) **Diagnostic features** : Distinctive characters of the species are given as an aid for identification, accompanied by pertinent illustrations. Species identifications should be attempted only after consultation of the illustrated key to genera and species. Reference to FAO Species Identification Sheets is given wherever relevant.

(5) **Geographical distribution** : The entire known geographic range of the species, including areas of seasonal occurrence, is given in the text and shown on a small map. In cases where only scattered records of occurrence are available, interrogation marks have been used to indicate areas of suspected distribution.

(6) **Habitat and biology** : The known depth range of the species, and information on salinity and temperature of its habitat are given where known. Information on biological aspects, such as migrations, spawning seasons and areas, food, predators, and longevity is also included.

(7) **Size** : The maximum known, as well as the common fork length and weight (if available) are given. Fork length is measured from the tip of the snout to the tip of the caudal rays in the middle of the fork of the tail. The all-tackle angling record and length at first maturity are given where known.

(8) **Interest to físheries** : This paragraph gives an account of the areas where the species is fished and of the nature of the fishery; its importance is either qualitatively estimated or actual figures of annual landings are provided. Data on utilization (fresh, dried, frozen, canned, etc.) are also given where available. Here too, the quality and quantity of the information available vary considerably with the species.

(9) **Local species names** : These are the names used locally for the various species. The present compilation is necessarily incomplete, since only a fraction of the local names used throughout the world is actually published. In many cases, local names are available only for species supporting documented fisheries. Apart from possible omissions due to limitations of literature available, some of the names included may be somewhat artificial (i.e. through transliteration of indigenous words into English). The local species name is preceeded by the name of the country concerned (in capital letters) and, where necessary, by geographical specifications (in lower case). Whenever possible, the language of the transcribed vernacular name is added in parenthesis. When more than one name is used within a country, the official name, if available, is underlined.

(10) **Literature** : This includes references to the most important publications relevant to the species, the emphasis being on biology and fisheries. Additional references are included in the bibliography. In the case of a few uncommon species, only systematic papers are available.

(11) **Remarks** : Important information concerning the species and not fitting in any of the previous paragraphs is given here. For instance, in some cases the scientific name used in the present catalogue, although nomenclaturally correct, is not the best known. Other nomenclatura1 problems, such as the use of subspecies, are discussed.

1.2 General Remarks on Scombrids

The Scombridae is a family composed of 15 genera and 49 species of mostly epipelagic marine fishes, the mackerels, Spanish mackerels, bonitos, and tunas. Some of their major morphological features have been discussed and illustrated by Collette (1979). The family Scombridae is divisable into two subfamilies: the Gasterochismatinae, which contain only the peculiar Southern Ocean Gasterochisma melampus, and the Scombrinae. On the basis of internal osteological characters, Collette & Chao (1975), and Collette & Russo (1979) have divided the Scombrinae into two groups of tribes (Fig. 1). The more primitive mackerels (Scombrini) and Spanish mackerels (Scomberomorini) are characterized by: (i) a distinct notch in the hypural plate that supports the caudal fin rays, (ii) the absence of a bony support for the median fleshy keel (when present), and (iii) preural vertebrae centra not greatly shortened as compared to the other vertebrae. Grammatorcynus shares the characteristics of the Scomberomorini but has other features indicating that it is more primitive than Scomberomorus and Acanthocybium. The bonitos (tribe Sardini as characterized by Collette & Chao, 1975) are a group of five genera and eight species that are intermediate between the Spanish mackerels (tribe Scomberomorini) and the higher tunas (tribe Thunnini). They lack any trace of a specialized subcutaneous vascular system or dorsally projecting cartilaginous ridges on the tongue, and the bony structure underlying their median fleshy caudal peduncle keel is incompletely developed; they also lack the prominent paired frontoparietal fenestra on the dorsal surface of the skull characteristic of all Thunnini (except Auxis). The four genera of Thunnini are unique among bony fishes in having counter-current heat exchanger systems that allow them to retain metabolic heat so that the fish is warmer than the surrounding water. The three more primitive genera of this tribe (Auxis, Euthynnus and Katsuwonus) and the yellowfin group of Thunnus have central and lateral heat exchangers while the specialized bluefin group of Thunnus have lost the central heat exchanger and evolved very well-developed lateral heat exchangers (Carey et al., 1971; Graham, 1973, 1975). These and other physiological and morphological adaptations are of great interest to physiologists and evolutionary biologists.

The family Scombridae is essentially confined to marine waters. Spanish mackerels (Scomberomorus) enter estuaries to feed and are generally restricted to coastal waters. Most species of Spanish mackerel have fairly restricted ranges, two in the eastern Pacific, four in the western Atlantic, one in the eastern Atlantic, and 11 in parts of the Indo-West Pacific One species (Scomberomorus sinensis) moves long distances in freshwater up the Mekong River into Kampuchea. Bonitos (Sarda) and little tunas (Euthynnus) are also primarily coastal fishes but the distribution of individual species is more widespread, e.g. Sarda sarda and Euthynnus alletteratus throughout the Atlantic Ocean. Tunas generally prefer more oceanic habitats; five of the seven species of Thunnus are found worldwide and are known to migrate extensively.

Scombrids are dioecious (separate sexes) and most display little or no sexual dimorphism in structure or colour pattern. Females of many species attain larger sizes than males. Batch spawning of most species takes place in tropical and subtropical waters, frequently inshore. The eggs are pelagic and hatch into planktonic larvae. Scombrids are active predators.The mackerels (Scomber and Rastrelliger) filter plankton out of the water with their long gillrakers. The Spanish mackerels, bonitos,and tunas feed on larger prey, small fishes, crustaceans, and squids. The main predators of smaller scombrids are other predacious fishes, particularly larger scombrids and billfishes. Being at least tertiary, if not top predators, large tunas (Thunnini) are less numerous and are landed in lesser quantities than the mackerels (Scombrini). The latter accounted for almost two thirds of the world catch of scombrids for many years, even though their share in the catches has recently decreased (about 56% of total scombrid landings in 1981).

Mackerels and tunas support very important commercial and recreational fisheries as well as substantial artisanal fisheries throughout the tropical and temperate waters of the world. World catches oscillated between 5.2 million tons in 1975 and 4.9 million tons in 1981 hitting a maximum of 6.1 million tons in 1978 (FAO, 1983) (Table I). Catches in cold and warm temperate waters predominate over tropical catches, with more than half of the world catch being taken in the northwestern Pacific, the northeastern Atlantic and the southeastern Pacific (Fishing Areas 61, 27 and 87). Many species of tunas and mackerels are the target of long-distance fisheries. The principal fishing methods used for fish schooling near the surface include purse seining, driftnetting, hook and line/bait boat fishing, and trolling; standard and deep longlining are used for (usually bigger) fish occurring at least temporarily in deeper water. Supply of sufficient quantities of suitable baitfish has turned out to be the major bottleneck for the pole and line fishery in recent years. Experimental studies of baitfish culture aimed at overcoming this problem have proved discouraging. Recreational fishing methods involve mostly surface trolling and pole-and-line fishing, while the numerous artisanal fisheries deploy a great variety of gear including bag nets, cast nets, lift nets, gill (drift) nets, beach seines, hook-and-line, handlines, harpoons, specialized traps, and fish corrals.

Virtually all scombrids are highly appreciated fish for their high quality flesh. While mackerels and Spanish mackerels are marketed fresh, frozen, canned, smoked and salted, most of the catch of tunas is canned, though they may also be marketed fresh.

As a result of rocketing fuel prices in the last decade, more sophisticated spotting methods have been introduced in scombrid fisheries for the purpose of reducing expensive search time. Such methods include satellite imagery, airplane spotting and more efficient use of monthly surface temperature charts and other hydrographical information that can now more reliably be applied with our increased understanding of the correlation between environmental parameters and scombrid behaviour.

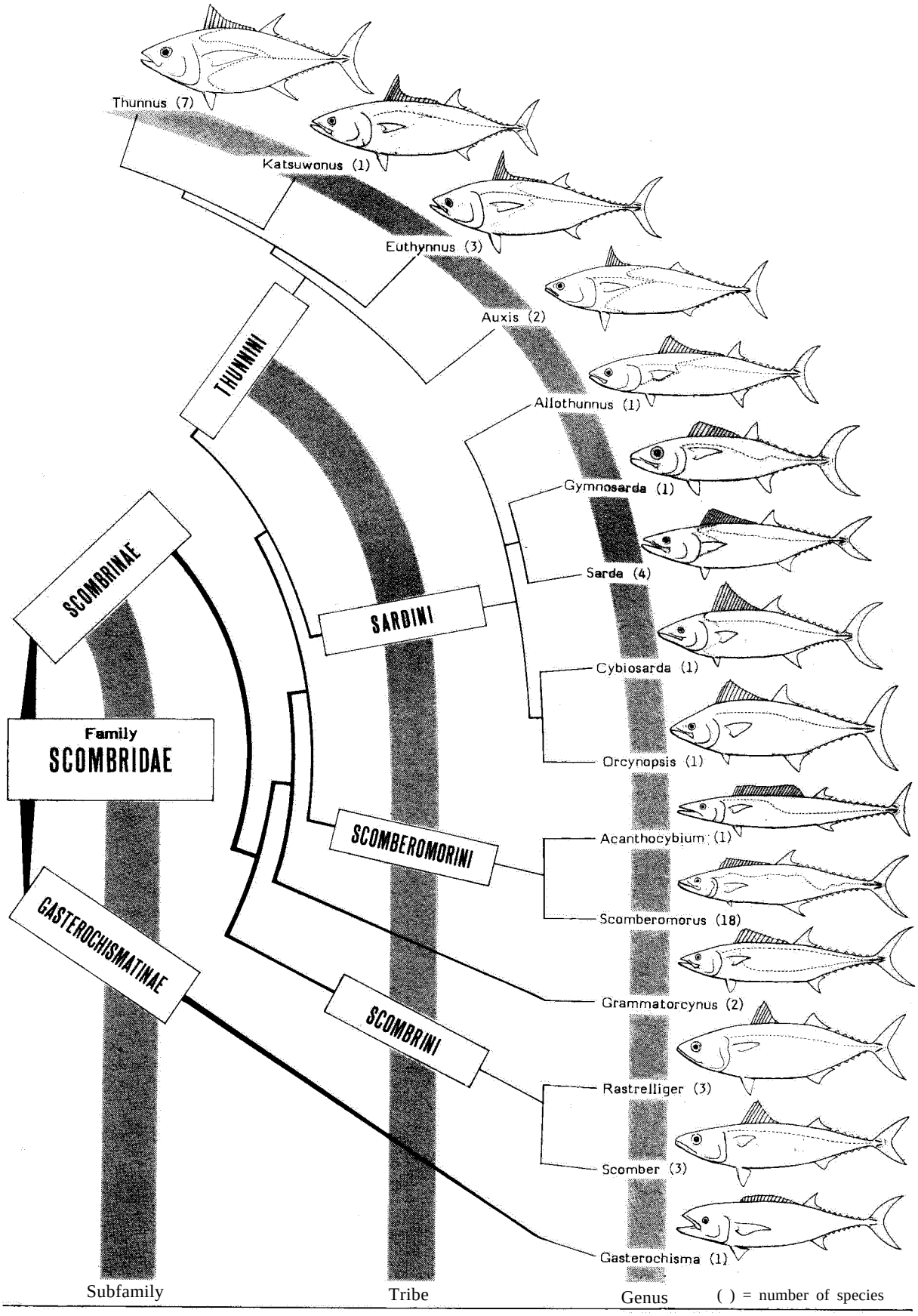


Fig.1 Classification of Scombrids

TABLE I

Estimated world catch of Scombrids in metric tons (source: FAO, 1983)

Systematic Category	1975	1978	1979	1980	1981
Scomber	3 053 427	3 565 530	3 239 211	2 912 052	2 378 518
Rastrelliger	286 292	375 388	355 580	372 663	366 699
Unspecified Scombrini	12 328	26 081	22 404	23 546	23 549
Subtotal Scombrini	3 352 047	3 966 999	3 617 195	2 912 052	2 768 766
Acanthocybium	78	58	59	218	89
Scomberomorus	193 843	192 021	207 873	222 718	252 209
Subtotal Scomberomorini	193 921	192 079	207 942	222 936	252 298
Orcynopsis	104	980	501	696	1 068
Sarda	35 771	28 436	30 717	50 088	57 321
Subtotal Sardini	35 875	29 416	31 218	50 784	58 389
Auxis	58 659	75 760	108 726	137 040	108 689
Euthynnus	65 943	70 754	56 842	53 876	78 196
Katsuwonus	551 277	796 034	705 973	771 286	697 760
Thunnus	949 352	1 033 289	999 993	970 766	955 417
Unspecified Thunnini	1	9	33	675	352
Subtotal Thunnini	1 652 232	1 975 846	1 871 567	1 932 990	1 840 414
GRAND TOTAL	5 207 075	6 164 340	5 727 922	5 118 784	4 919 867

1.3 Illustrated Glossary of Technical Terms and Measurements

Measurements Used

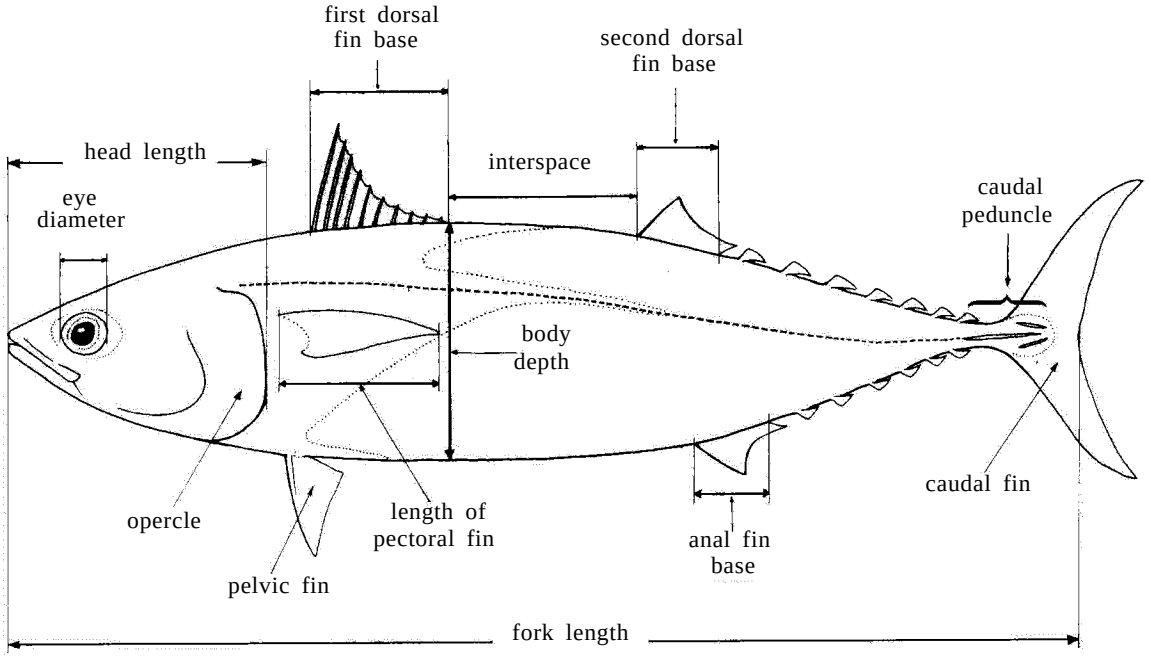


Fig. 2 Schematic illustration of a Scombrid (Auxis thazard)

Glossary of Technical Terms

Adipose eyelid - Translucent fold covering anterior and posterior margins of eye in mackerels (Scomber and Rastrelliger) (Fig. 3).

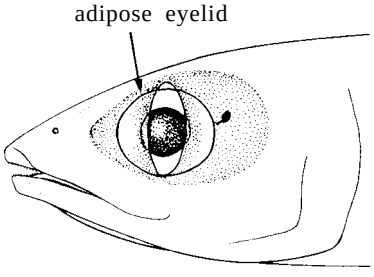
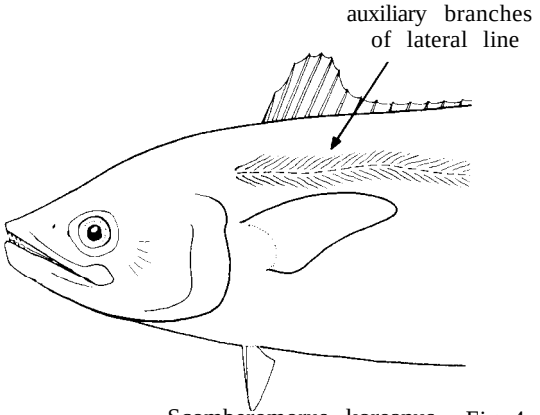


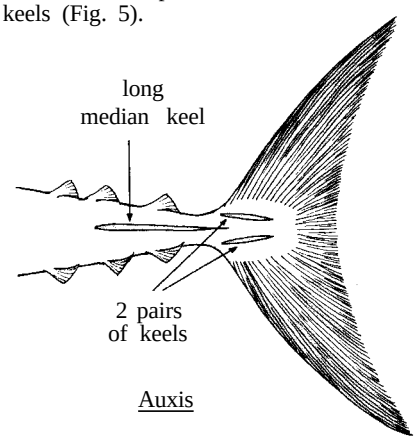
Fig. 3

Auxiliary branches of lateral line - Fine branches that extend dorsally and ventrally from the anterior part of the lateral line in Scomberomorus guttatus and S. koreanus (Fig. 4).



Scomberomorus koreanus Fig. 4

Caudal keel - All members of the Scombridae have a pair of small obliquely oriented keels at the base of the caudal fin. The more advanced members of the family also have a large median keel on the middle of the caudal peduncle, anterior to the pair of small keels (Fig. 5).



Auxis

Fig. 5

Caudal peduncle - The narrow part of the body just anterior to the caudal fin (see illustration of measurements).

Caudal vertebrae - Vertebrae that bear a haemal spine ventral to the vertebral centrum (Fig. 6b). The first caudal vertebra is located near the origin of the anal fin. Caudal vertebrae lack pleural ribs which are characteristic of the precaudal vertebrae.

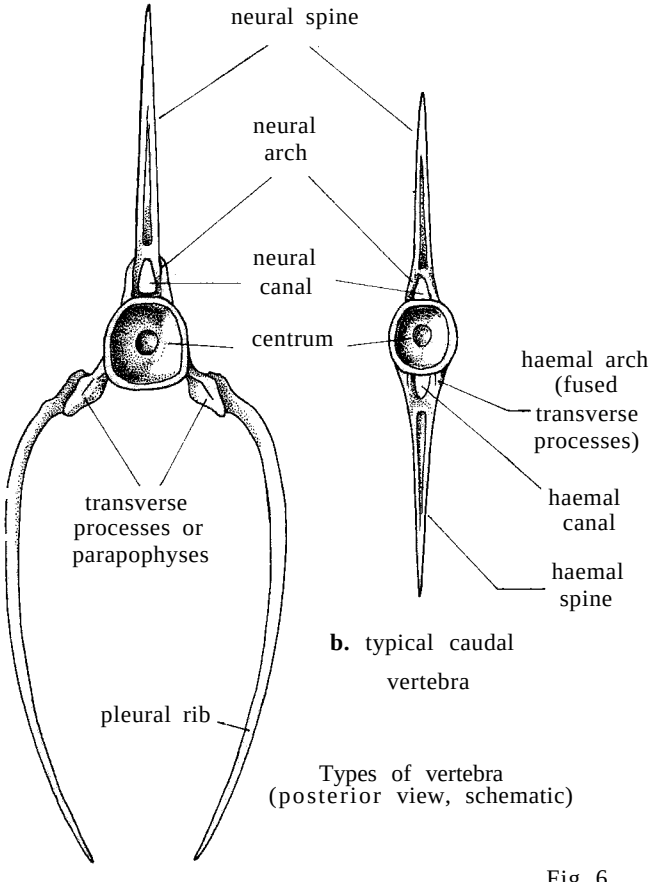


Fig. 6

Corselet - The large thick scales that cover the anterior part of the body in advanced scombrids (Fig. 7).

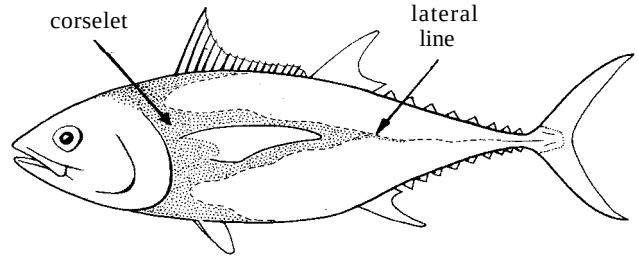


Fig. 7

Cutaneous arteries and veins - Special parts of the circulatory system that lie under the skin and enable tunas to conserve metabolic heat and be warmer than the water in which they live.

Fin groove - The first, or spiny, dorsal fin folds down into a groove on the dorsal surface of the body in all scombrids when they are swimming rapidly.

Fin membrane - The thin membranes between the spines of the first dorsal fin (Fig. 8).

Fin rays - General term for the soft rays and spines that support the fins (Fig. 8).

Fin spines - The sharp, pointed structures that support the first dorsal fin (Fig. 8).

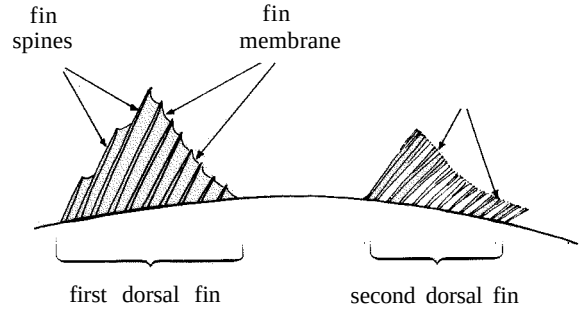
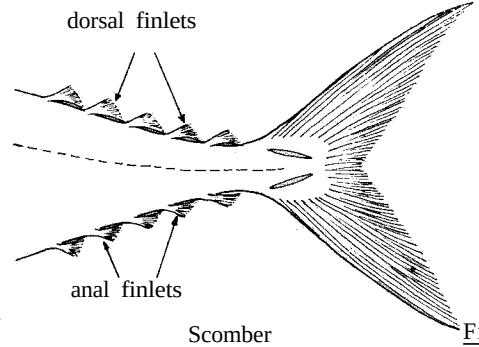


Fig. 8

Finlets - The small individual fins posterior to the second dorsal and anal fins (Fig. 9).



Scomber

Fig. 9

Gill arch - The j-shaped structure under the gill cover that bears the gill filaments. There are 4 gill arches on each side in scombrids (Fig. 10).

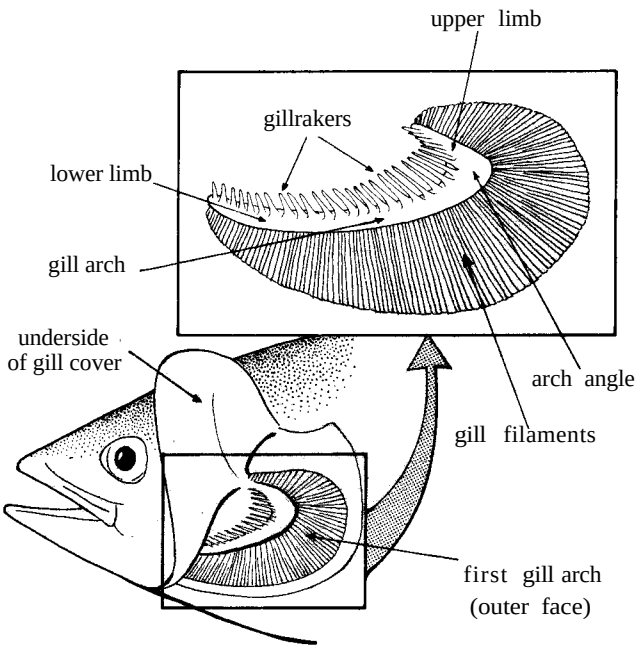
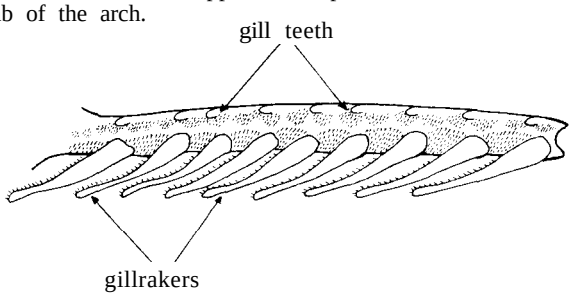


Fig. 10

Gill teeth (or inner gillrakers) - Short, flattened structures on the gill arch located medially from the gillrakers (Fig. 11). Counted like the gillrakers, teeth on upper limb plus those on lower limb of the arch.



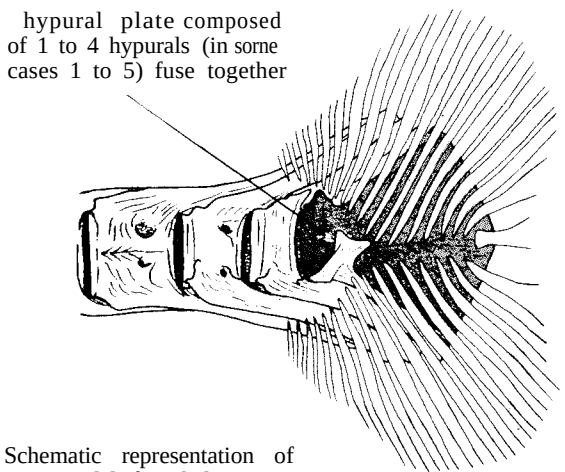
part of lower limb of gill arch seen from above

Fig. 11

Gillrakers - The stiff pointed structures that extend dorsally or anteriorly from the first gill arches towards the mouth. Counts of gillrakers are usually given as the number on the upper limb of the first arch plus the number on the lower limb of the first arch, e.g. 4 + 12 = 16. In scombrids there is usually one at the angle between the upper and lower limbs that is not clearly on either the upper or lower, leading to counts of 4 + 1 + 11 = 16. If not enumerated separately, this gillraker is added to those on the lower arch, 4 + 12 = 16 (Fig. 10).

Haemal spines - The spine that extends ventrally from the centra of the caudal vertebrae (Fig. 6b). The first vertebra with a haemal spine is the first caudal vertebra.

Hypural plate - The expanded ends of the hypural bones form a wide plate onto which the caudal fin rays insert (Fig. 12). Scombrids differ from most other fishes in having the caudal fin rays so deeply divided that they cornpletely cover the hypural plate (Fig. 12).

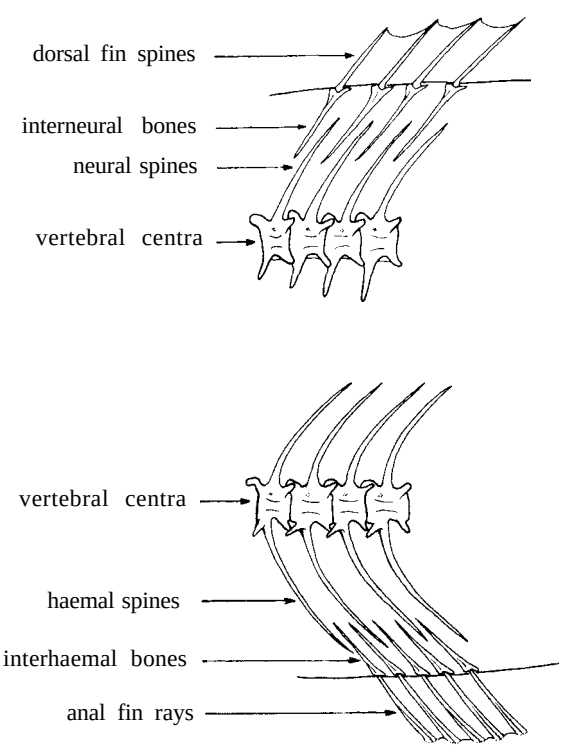


Schematic representation of caudal fin skeleton (Orcynopsis)

Fig. 12

Interhaemal bones - Benes located between the haemal spines of the caudal vertebrae and the rays of the anal fin (Fig. 13)

Interneural bones - Bones located between the neural spines of the vertebrae and the rays of the dorsal fins (Fig. 13).



Position of interneural and interhaemal bones (schematic)

Fig. 13

Interpelvic process - A fleshy process between the inner edges of the pelvic fins. This process may be single (Fig. 14a), or bifid (Fig. 14b), small or large.

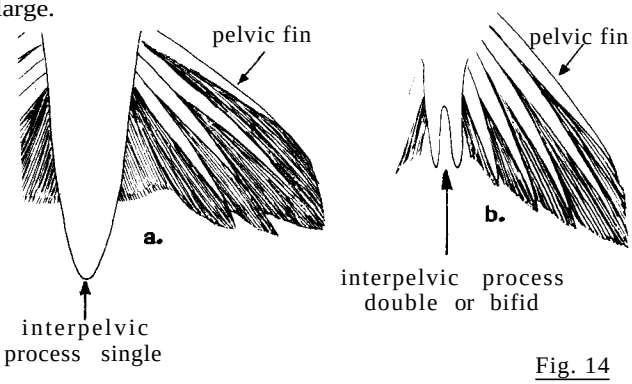
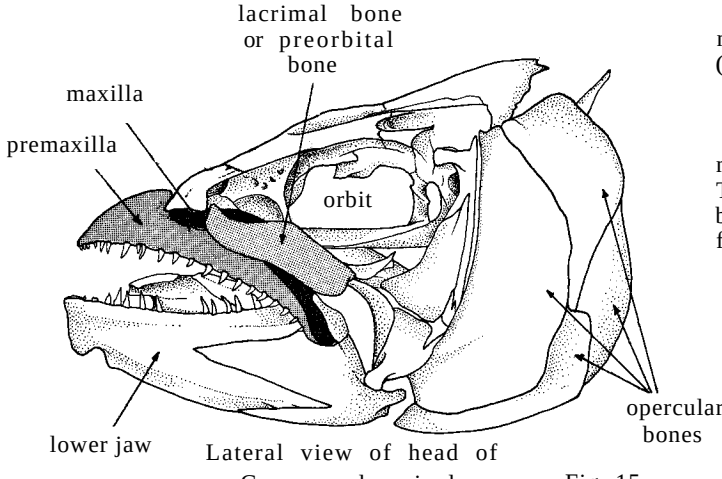


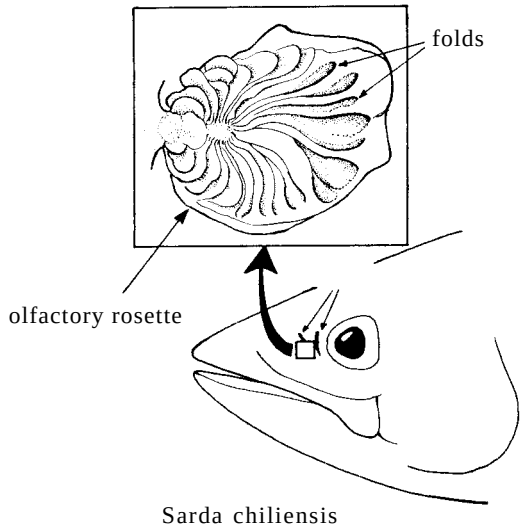
Fig. 14

Lacrimal bone - The largest of the infra-orbital series of bones, located ventral and slightly anterior to the eye. Also known as the preorbital bone (Fig. 15).



Lateral view of head of Gymnosarda unicolor Fig. 15

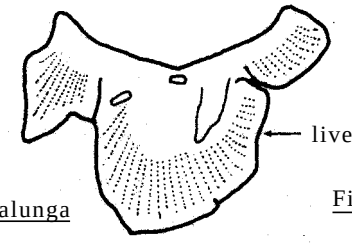
Laminae of the olfactory rosette - Fleshy folds (laminae) containing cells that can detect odours are arranged in a circular pattern (rosette) under the area between the anterior and posterior openings of the nostrils (Fig. 16).



Sarda chiliensis Fig. 16

Lateral line - A series of sense organs enclosed in tubular scales along the side of the body (Figs 4, 7). Most scombrids, like other fishes, have a single lateral line, but Grammatorcynus species have two.

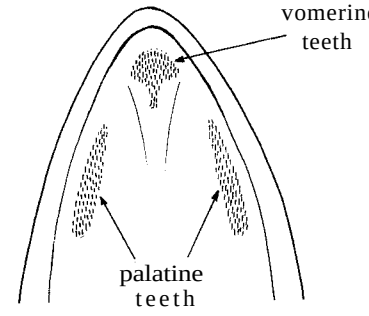
Liver striations - The ventral surface of the liver of 4 species of tunas bears prominent striations. These striations are blood vessels involved in a counter-current heat exchanger system that enables these species to have warm viscera (Fig. 17).



Thunnus alalunga Fig. 17

Maxilla - The supporting bone for the premaxilla, the bone in the upper jaw that bears teeth (Fig. 15).

Palatine - A plow-shaped bone, the ventral margin of which lies in the roof of the mouth. The palatine bone may be toothed (Fig. 18), bearing either a row of conical teeth or a patch of fine villiform teeth.



roof of mouth showing location of dentition (schematic) Fig. 18

Parapophysis - Projection from the vertebral centra (Fig. 6a).

Precaudal vertebrae - The anterior vertebrae which lack a haemal spine. All but the first few bear pleural ribs (Fig. 6a).

Preorbital bone - Another name for lacrimal bone, the largest of the infraorbital series of bones (Fig. 15).

Vertebral protuberances - Rounded bumps on the lateral surface of some of the caudal peduncle vertebrae in several species of Euthynnus.

Vomer - A median skull bone, the ventral surface of which lies in the roof of the mouth. The vomer may bear teeth (Fig. 18).