1.3 **Illustrated Glossary of Technical Terms and Measurements**

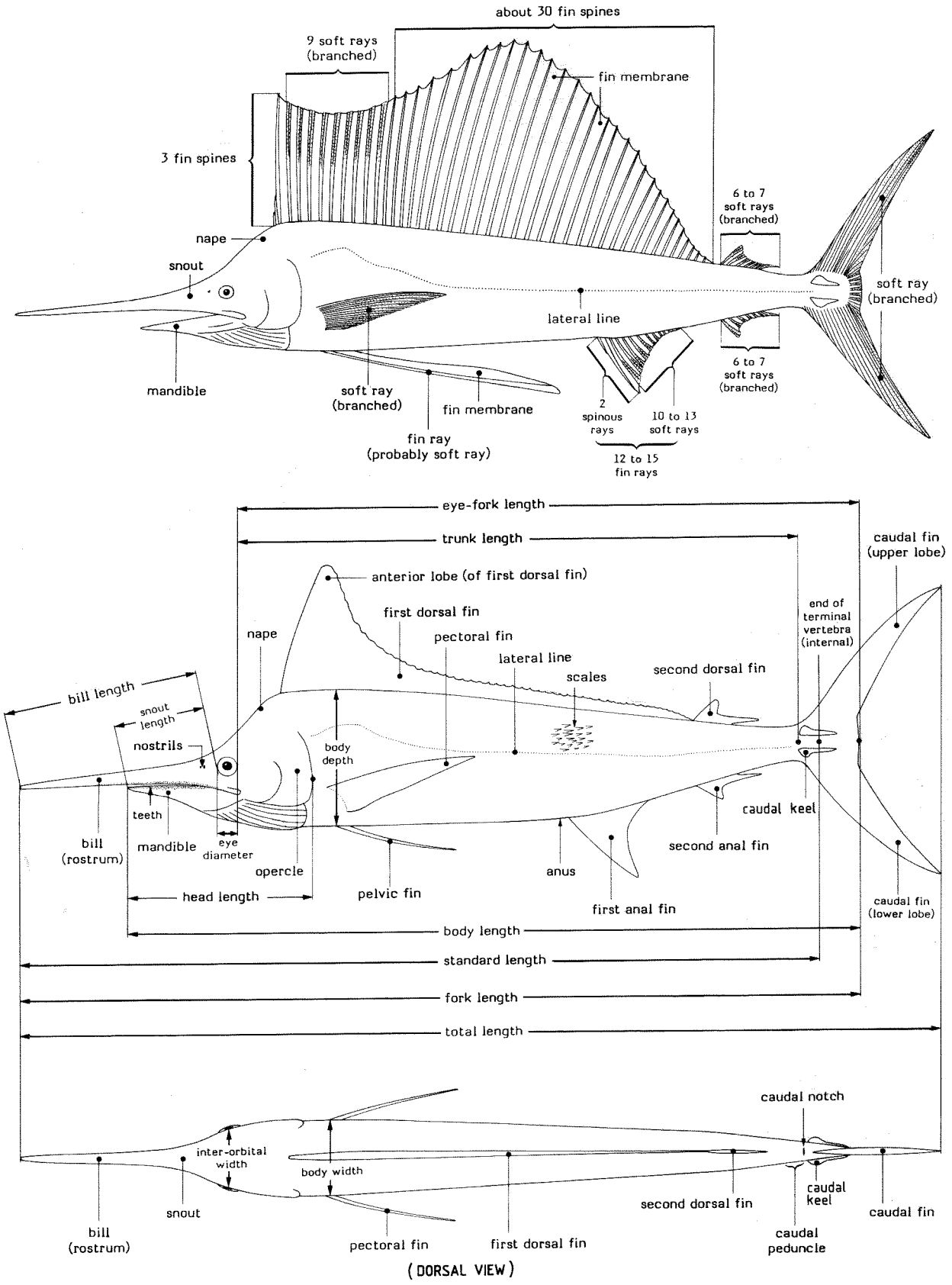
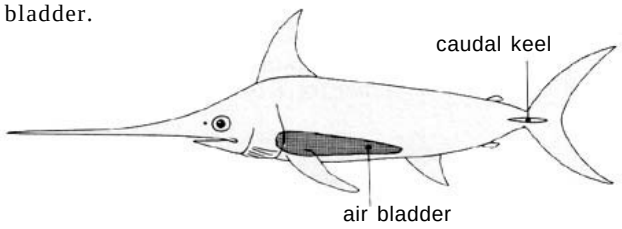
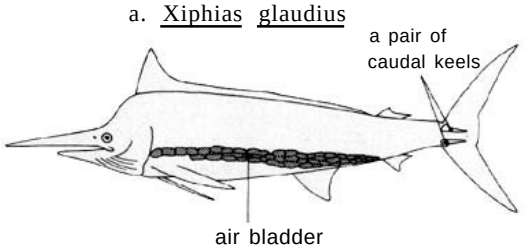


Fig.7 Schematic illustration of Indo-Pacific sailfish, Istiophorus platypterus (above) and a striped marlin, Tetrapturus audax (middle and below)
All measurements are straight line distances. For detail of measurements, see Rives (1956) and Nakamura (1983)

Air-bladder - Membranous sac filled with air or other gases lying in the abdomen just beneath the vertebrae. The swordfish's air-bladder consists of a single chamber (Fig.8a), while that of istiophorids is made up of many bubble-shaped, small chambers (Fig.8b). Also known as gas-bladder or swim-bladder.



a. Xiphias glaudius



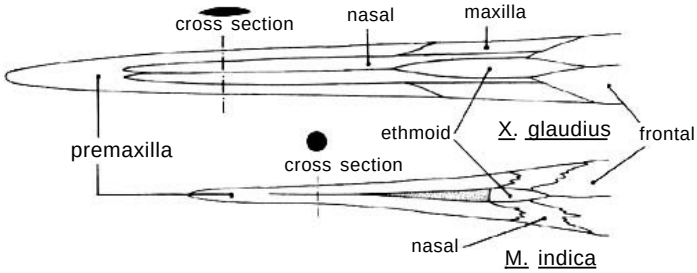
b. Makaira indica

Schematic illustration of air-bladder and caudal keels Fig.8

Anal fin(s) - The fin(s) on the ventral median line of the body behind the anus (Fig.7).

Anus- External opening of the intestine, situated on the ventral midline of the body (Fig.7). The relative position of the anus to the first anal fin is important in istiophorid taxonomy. Also known as vent.

Bill - Long, slender upper jaw. Both jaws are elongate, but the upper is longer than the lower in billfishes. The bill is flat in the swordfish and round in istiophorids (Figs 7,9).



Bill structure in dorsal view (schematic) Fig.9

Bill length - Meausred from the tip of the bill to the anteriormost point on the fleshy margin of the orbit (Fig.7).

Body depth - Greatest depth of body (Fig.7). Body depth at origin of pectoral fins, pelvic fins, and first anal fin is sometimes also used.

Body length - Measured from the tip of the lower jaw (with the jaws closed) to the posterior margin of the middle caudal rays (Fig.7). In other fishes the measurement, "body length" is usually "standard length". In billfish taxonomy, this dimension is used following Rivas (1956).

Body width - Greatest width of body (Fig.7). Body width at origin of pectoral fins, pelvic fins and first anal fin is sometimes also used.

Branchiostegal (rays) - Strut- or ray-like bones attached to the hyoid arch, connected by the branchiostegal membrane (Figs15,16,22).

Branchiostegal membrane - The membrane connecting the branchiostegals and enclosing the gill chamber ventrally (Figs 15,16,22).

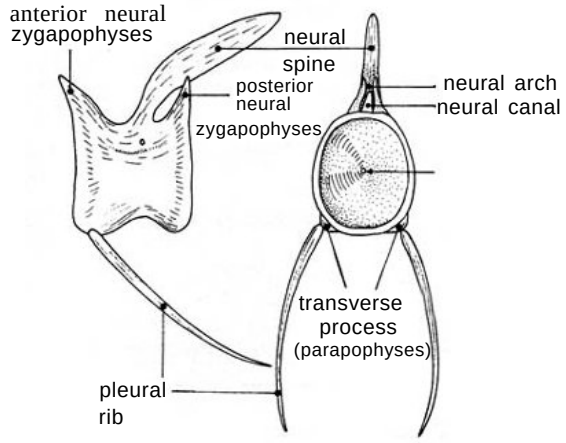
Caudal fin - Median fin situated at the posterior end of the body, consisting of an upper and a lower lobe (Fig.7).

Caudal keel - Xiphiidae have a large median caudal keel (Fig.8a) and Istiophoridae have a pair of caudal keels (Fig.8b) on the middle of the caudal peduncle.

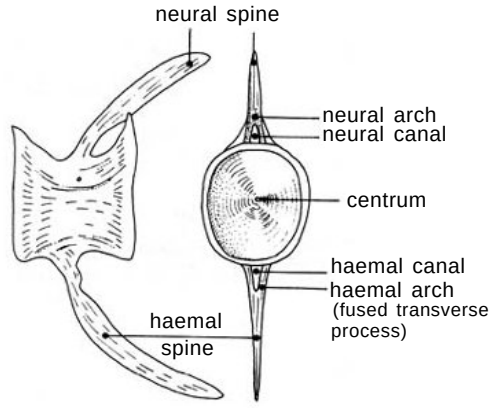
Caudal notch - An elongate, small pit on dorsal and ventral margins of the caudal peduncle (Fig.7). The caudal notch is shallow and small in istiophorids, and deep and rather large in Xiphias.

Caudal peduncle - The narrow part of the body between the posterior ends of the dorsal and anal fins and the base of the caudal fin (Fig.7).

Caudal vertebrae - Vertebrae that bear a haemal spine ventral to the vertebral centrum (Fig.10b). Caudal vertebrae lack pleural ribs. The number of caudal vertebrae is 15 or 16 in Xiphias 12 in Istiophorus and Tetrapturus, and 13 in Makaira.



a. precaudal vertebrae



b. caudal vertebrae

Schematic illustration of vertebrae of Xiphias glaudius

Fig.10

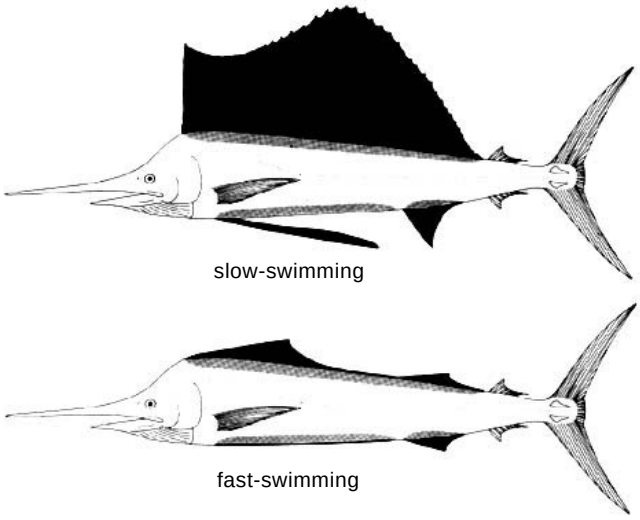
Dorsal fin(s) - Fin(s) on the back of a fish (Fig.7). Billfishes have two dorsal fins.

Ethmoid - Unpaired skull bone on the anterior part of the neurocranium (Fig.9).

Eye diameter - Measured as the greatest distance across the cornea, that is, between the margins of the cartilaginous eyeball (Fig.7).

Eye-fork length - Measured from the posterior edge of the orbit to the posterior margin of the middle caudal rays (Fig.7). This dimension is frequently used by Japanese fishery biologists because it is useful in specimens with bills cut at fish markets or on fishing boats.

Fin grooves - The first dorsal, first anal and pelvic fins fold down into grooves in all istiophorids when they are swimming rapidly (Fig.11). Fin grooves are not developed in Xiphias gladius.



Schematic illustration of fin grooves (shaded areas) in Istiophorus platypterus

Fig.11

Fin membranes - The thin membranes between the rays of the fins (Fig.7).

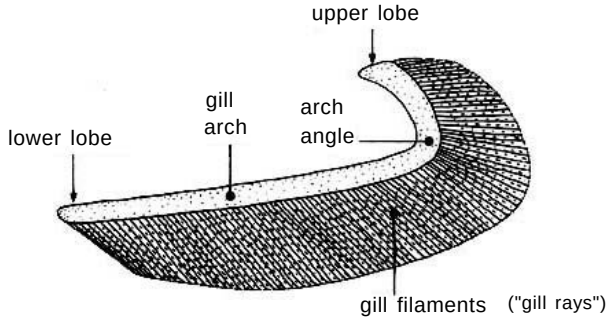
Fin rays - General term for the soft rays and spines (spinous rays) that support the fins (Fig.7). Soft rays are branched, segmented or paired (left and right elements united). Spines are unsegmented fin supports, unbranched, unpaired and usually stiff and sharply pointed.

Fin spines - Sharp, pungent and pointed structures (Fig.7). Usually called merely spines.

Fork length - Measured from the tip of the bill (upper jaw) to the posterior margin of the middle caudal rays (Fig.7). Usually used for scombroid (particularly tunas) studies, because the caudal fork area is very strong, in tunas as well as in billfishes and the snout is not prolonged in tunas.

Frontals - Paired skull bones in middle part of the neurocranium (Figs 9,16).

Gill arch - The J-shaped structure under the gill cover that bears the gill filaments and normally the gillrakers, but the billfishes lack gillrakers (Fig. 12). There are 4 gill arches on each side of billfishes.



first gill arch of Xiphias glaudius (schematic)

Fig.12

Gill filaments - Organ for aquatic respiration. In billfishes the gill filaments are ossified as "gill rays" as in the case of tunas (Fig.12); see also Iwai & Nakamura (1964).

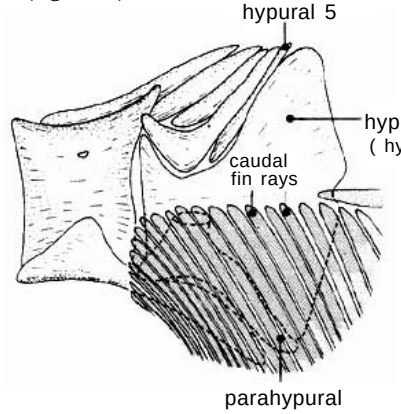
Haemal arch - The arch that is formed above the fused distal ends of the haemal spines of caudal vertebrae (Fig.l0b).

Haemal canal - The canal for the blood vessel, formed by the haemal arch of caudal vertebrae (Fig.l0b).

Haemal spines - The spines that extend ventrally from the centra of a caudal vertebra (Fig.l0b). The first vertebra with a haemal spine is the first caudal vertebra.

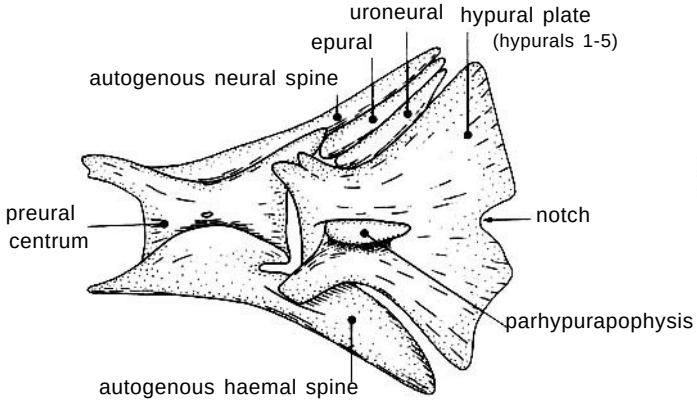
Head length - Measured from the tip of the mandible (lower jaw) to the most distant point on the opercular membrane (Fig.7).

Hypural plate - The expanded ends of the hypural bones form a wide, fan-like plate onto which the caudal fin rays insert distally. Like tunas, billfishes differ from most other fishes in having the caudal fin rays so deeply divided that they completely cover the hypural plate; the hypural plate consists of four hypural bones in Xiphias (Fig.13a) and five in Istiophoridae (fig. 13b).



a. Xiphias gladius

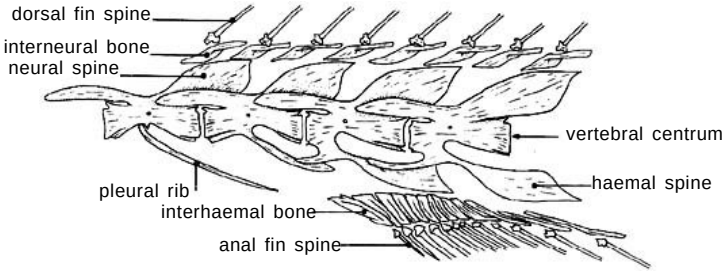
(Caudal fin rays shown only on lower half)



b. Istiophorus platypterus

Schematic drawing of hypural plate Fig.13

Interhaemal bones - The bones situated between the haemal spines of the vertebrae and the spines or rays of the anal fin (Fig.14).

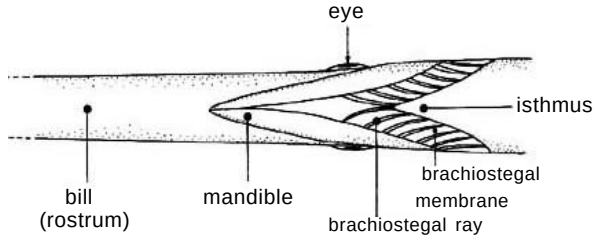


Position of interneural and interhaemal bones in Istiophorus platypterus (schematic) Fig.14

Interneural bones - The bones situated between the neural spines of the vertebrae and the spines or rays of the dorsal fin (Fig.14).

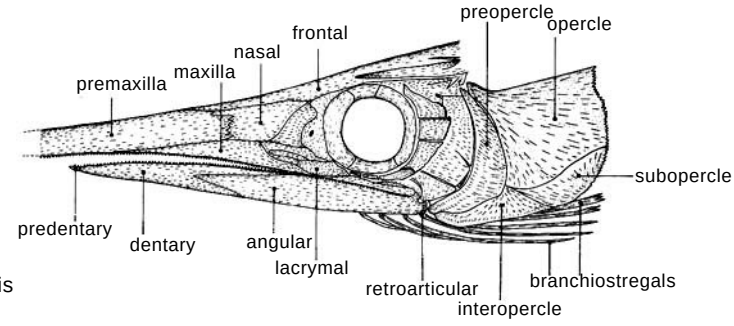
Interorbital width - Measured as the shortest distance between the fleshy margins of the orbits (Fig.7).

Isthmus - Ventral fleshy area on the throat between the gills (Fig.15).



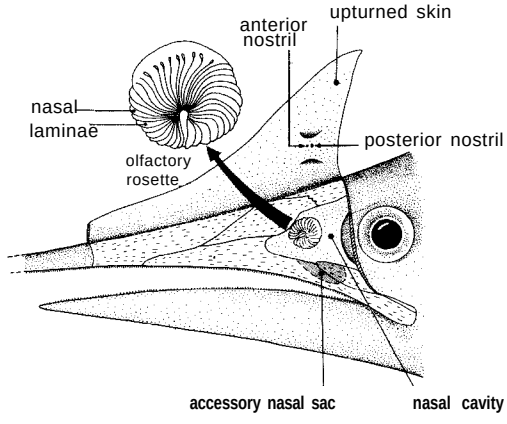
Head of Xiphias gladius in ventral view (schematic) Fig.15

Lacrymal bone - The largest of the infraorbital series of bones, located ventral and slightly anterior to the eye (Fig.16). Also known as preorbital bone or first infraorbital bone.



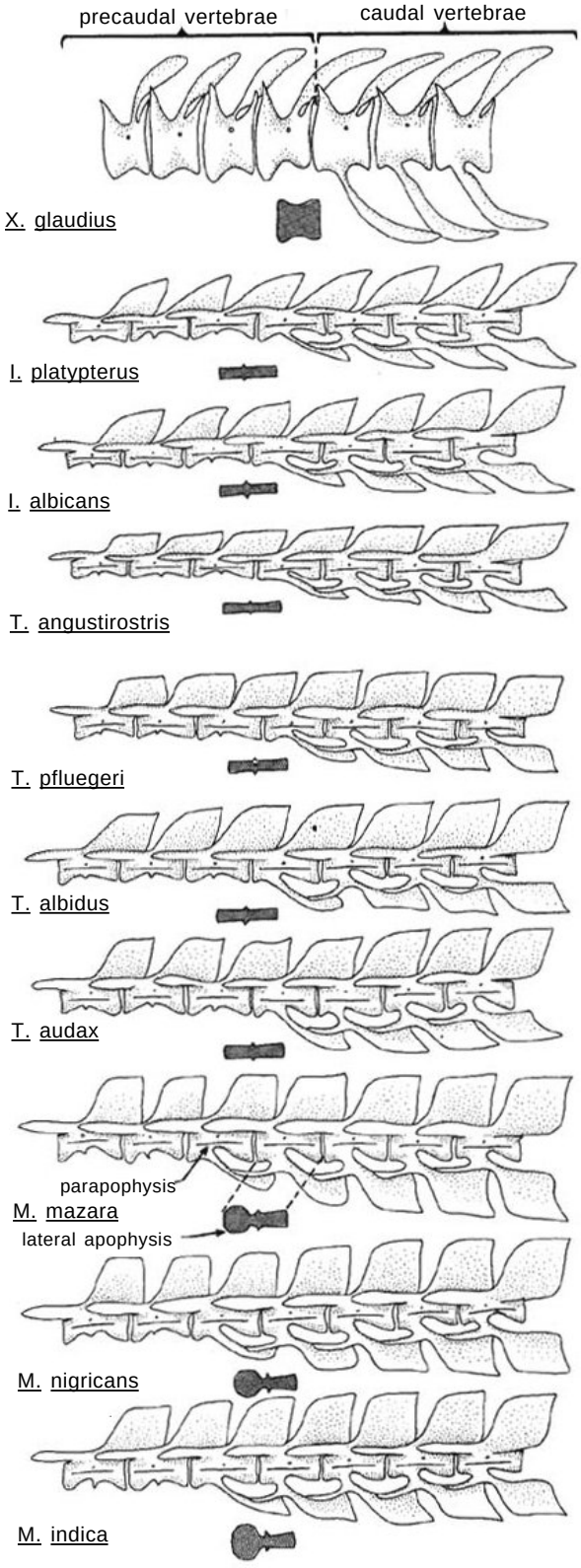
Lateral view of head skeleton of Istiophorus platypterus (Schematic) Fig.16

Laminae of the olfactory rosette - Fleshy folds (nasal laminae) containing cells that can detect odours, arranged in a radiate pattern (rosette) beneath the skin between the anterior and posterior nostril openings (Fig.17).



Nasal cavity of Istiophorus platypterus after dissection (schematic) Fig.17

Lateral apophyses - The flanges that extend laterally from the anterior part of each vertebral centrum (Fig.18). Also known as the transverse flanges.



Lateral apophyses of billfish vertebrae (schematic). White areas: lateral view; black areas: ventral view

Fig.18

Lateral line - A series of sense organs enclosed in tubular scales along the sides of the body (Fig.7). The lateral line is looped in Makaira mazara and reticulate in Makaira nigricans. Other istiophorids have a single lateral line. Xiphias gladius has a single lateral line in immature stages which disappears in the adult.

Mandible - Known as the lower jaw (Figs 7, 15), consisting of predentary (Istiophoridae only), dentary, angular and retroarticular bones (Fig.16).

Maxilla - The supporting bone of the premaxilla which bears teeth in the upper jaw (Figs 9,16). The maxilla itself also bears teeth in istiophorids, unlike most other fishes.

Nape – Dorsum of the neck area immediately posterior to the head (Fig.7).

Nasals - Paired bones in the ethmoid region of the neurocranium (Figs 9,16).

Neural arch - The arch that is formed below the fused basal part of the neural spine of the vertebrae (Fig.10).

Neural canal - The canal for the nerve cord formed by the neural arch (Fig.10).

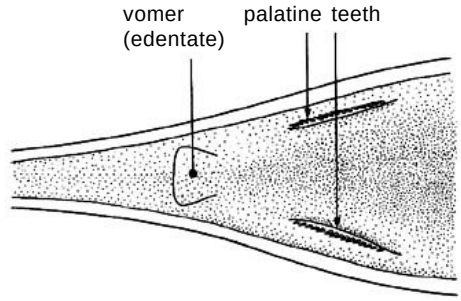
Neural spines - The spines that extend dorsally from the centra of a vertebra (Fig.10).

Nostrils - External openings of the nasal cavity. There are two (anterior and posterior) nostrils in billfishes (Figs 7,17).

Operculum - Gill cover, supported by four bones: opercle, preopercle, interopercle and subopercle (Figs 7,16).

Orbit - The eye socket (Fig.16). The sclera is ossified in billfishes.

Palatine - A pair of plow-shaped bones, the ventral margin of which lies in the roof of the mouth. The palatine bones may be toothed in istiophorids (Fig. 19), but are edentate in Xiphias.



Roof of mouth in Tetratrapturus albidus (schematic)

Fig.19

Parapophyses - (Transverse processes). Projections from the ventral centra of the vertebrae (Fig.10).

Pectoral fins - Lateral paired fins behind the head (Fig.7).

Pelvic fins - Paired fins on the ventral edge of anterior body (Fig.7). Also known as ventral fins.

Precaudal vertebrae - The anterior vertebrae without haemal spines (Figs l0a,18). Also known as abdominal vertebrae. The number of precaudal vertebrae is 10 or 11 in Xiphias, 12 in Istiophorus and Tetrapturus and 11 in Makaira.

Premaxillae - Paired bones of the upper jaw, usually bearing teeth in higher teleosts and associated with the maxillae (Figs 9,16).

Predentary - Unpaired bone anterior to the dentary. Present in Istiophorids (Figs 16,22), but absent in Xiphias.

Rostrum - Projecting snout; or bill (Figs 7,9).

Scales - Thin, flat, bony plates covering the body, usually cycloid or ctenoid. The scales of istiophorids do not fit into these categories, they are elongate and pungent, with sharp posterior points (Fig.7). The arrangement and shape of the scales are useful characters for the identification of billfishes. Xiphias has no scales in the adult stage.

Snout - Forward part of the head, anterior to the eyes and above the mouth (Fig.7).

Snout length - Measured from the tip of the mandibule (lower jaw) to the anteriormost point on the fleshy margin of the orbit (Fig.7) in billfishes.

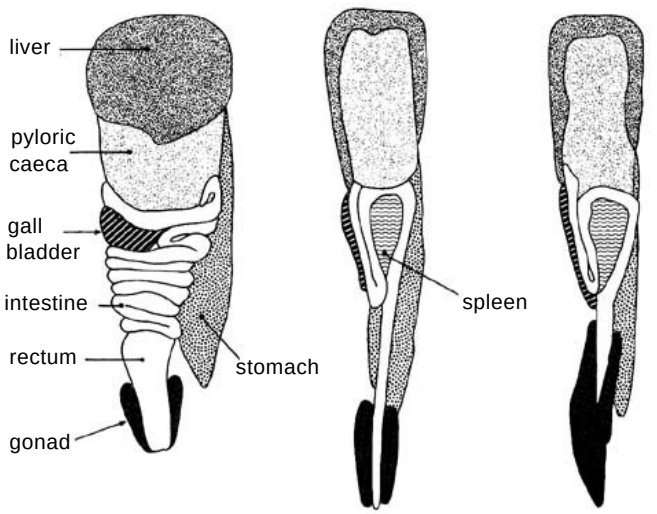
Standard length - In systematic studies, the standard length is the distance from the anteriormost part of the snout to the caudal fin base (theoretically to the end of the terminal vertebra, but this is not practical in general use) (Fig.7). In fishery studies the fork length, e.g., the distance from the anteriormost point of the head to the posterior margin of the middle caudal rays is used.

Total length - Straight-line measurement from the anteriormost to the posteriormost point of the fish (Fig.7).

Trunk length - Measured from the posterior edge of the orbit to the anterior insertion of the caudal keels (Fig.7). Used in sport-fishing.

Vertebra - One of the bony or more or less cartilaginous (in primitive fishes or young fishes) segments composing the spinal column or backbone (Figs 10,18). Number of vertebrae = number of precaudal vertebrae plus number of caudal vertebrae: 26 in Xiphiidae (Xiphias) and 24 in Istiophoridae (Istiophorus, Tetrapturus and Makaira).

Viscera - Internal organs of the body which are well developed in all the species of billfishes (Fig.20). The intestine is coiled, the spleen is not visible in ventral view, and the gonads are symmetrical in Xiphias (Fig.20a). The spleen is visible in ventral view, and the intestine is undulated in Istiophoridae (Fig.20b,c). The gonads are symmetrical in Istiophorus (Fig20b), in Makaira, and apparently in Tetrapturus except T. angustirostris and T. pfluegeri where they are asymmetrical and Y-shaped (Fig.20c) (possibly also in T. belone).



a. Xiphias gladius b. Istiophorus platypterus c. Tetrapturus angustirostris

Viscera of billfishes in ventral view (schematic) Fig.20

Vomer - A median skull bone, the ventral surface of which lies in the roof of the mouth. The vomer is edentate in billfishes (Fig.19), but many other fishes have vomerine teeth.

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