

CEPHALOPODS

INTRODUCTION AND GENERAL REMARKS

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Living cephalopods include nautilus, bobtail and bottle squids, pygmy cuttlefishes, cuttlefishes, squids, and octopuses. While they may not be as diverse a group as other molluscs or as the bony fishes in terms of number of species (about 600 cephalopod species described worldwide), they are very abundant and some reach large sizes. Hence they are of considerable ecological and commercial fisheries importance globally and in the Western Central Pacific.

REMARKS ON MAJOR GROUPS OF COMMERCIAL IMPORTANCE

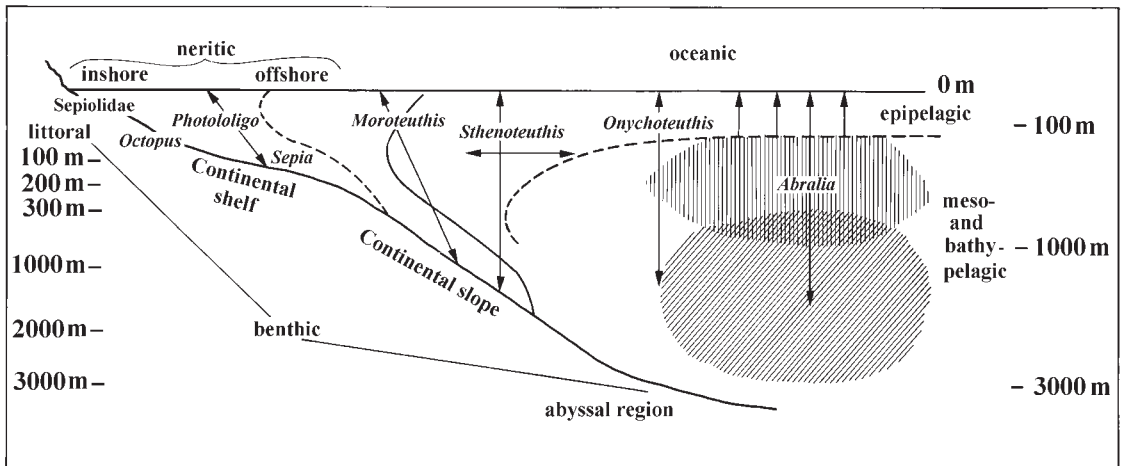
Nautilus (Family Nautilidae)

Nautilus are the only living cephalopods with an external shell throughout their life cycle. This shell is divided into chambers by a large number of septae and provides buoyancy to the animal. The animal is housed in the newest chamber. A muscular hood on the dorsal side helps close the aperture when the animal is withdrawn into the shell. Nautilus have primitive eyes filled with seawater and without lenses. They have arms that are whip-like tentacles arranged in a double crown surrounding the mouth. Although they have no suckers on these arms, mucus associated with them is adherent. Nautilus are restricted to deeper continental shelf and slope waters of the Indo-West Pacific and are caught by artisanal fishers using baited traps set on the bottom. The flesh is used for food and the shell for the souvenir trade. Specimens are also caught for live export for use in home aquaria and for research purposes.

Squids (Order Teuthida)

The 2 suborders, Myopsida, "covered-eyed", nearshore (neritic) squids, and Oegopsida, "open-eyed", oceanic (pelagic) squids, occur in the oceans and seas of the world and the species reaching larger sizes form the basis of major fisheries. Some squids are demersal or epibenthic at some period of their life cycle, but most species are pelagic, living off the bottom in the water column where they are caught using a variety of fishing gear such as trawls, lift nets, and jigs. FAO's Yearbook of Fishery Statistics records about 2 169 000 t of squids taken worldwide in 1995, with around 159 000 t taken from the Western Central Pacific.

The suborder Myopsida is represented in the Western Central Pacific by the very speciose Family Loliginidae which includes 4 genera and is important in many small- and large-scale fisheries. Like all myopsids, the loliginids are demersal, predominantly near-shore or shelf species, frequently feeding near or on the bottom. These squid occur in schools and are often caught in large spawning aggregations. Some species tolerate reduced salinities and more turbid estuarine situations (e.g. *Loliolus* spp.) while others occur in clear waters around coral reefs (e.g. *Sepioteuthis lessoniana*). In some species, the spawning season is extended with peaks in early summer and autumn. Many small- to medium-sized eggs are encapsulated in gelatinous strings attached to shells, corals, and other substrates. Loliginid squids are opportunistic carnivores and grow rapidly. All species so far studied have life spans of less than one year; for the small tropical species, only a few months.



major ocean habitats showing indicative distributions of abundant cephalopods

(after Packard et al., 1972)

Our knowledge of the taxonomy of the Indo-West Pacific loliginids remains poor. This is especially true for members of the genus *Photololigo* which includes the majority of the large commercially important species. The present set of diagnostic morphological characters (fin shape and relative length, sucker dentition, hectocotylus structure) may be highly variable, differ between the sexes, change with growth and do not always ensure a reliable identification of species. In many cases, these characters have been inadequately defined in the type descriptions (many from the mid 1800s), type reference material is poorly preserved and had poor geographic locality information. Several poorly known and new, unnamed species are referred to in the recent literature and “seasonal forms” with different life history characteristics and of questionable taxonomic status and distribution have also been described. This poor state of taxonomic knowledge has been highlighted previously by various researchers but little progress has been made. Current and future fisheries assessments of the loliginid resource and subsequent decisions concerning the management of the stocks are dependent on accurate identification of species. Therefore, there is an urgent need for a substantial cooperative regionwide taxonomic study of the genus *Photololigo* using classical morphology supported by modern techniques including allozyme electrophoresis and DNA analysis.

Oceanic squids of various families of the suborder Oegopsida occur in the tropical Western Central Pacific but do not form a significant component of current reported fisheries catches. However, in some areas, arrow squid of the family Ommastrephidae are taken in localized artisanal fisheries (i.e. *Sthenoteuthis oualantiensis* in Melanesia and the Philippines) and their fisheries resource potential has been considered as large by some authors. In contrast to the loliginids, the taxonomy of this group is relatively well known.

Cuttlefishes (Family Sepiidae)

Cuttlefishes occur on the continental shelf and upper continental slope of tropical and temperate areas in all oceans. All are demersal and are believed to be more active at night. Many of the larger species of cuttlefish are important to fisheries in the Western Central Pacific. Fishing activity ranges from local, or subsistence fisheries to major export industries. Cuttlefish are targeted using a variety of gear including jigs and lures, baited and unbaited traps (sometimes with mangrove branches as attractants to spawning females), and spears. They are also an important component of finfish and prawn trawl bycatch in the area. They are used primarily for human consumption, but also as bait and are marketed fresh, frozen or dried. In 1995, FAO's Yearbook of Fishery Statistics reports 96 198 t of cuttlefish (and bobtail squids) from the Western Central Pacific (about 44% of the total world catch of cuttlefish for that year). This figure comprises 42 700 t caught off Thailand, 37 000 t from Viet Nam and 2 836 t caught in the Philippines. The taxonomy and biology of the cuttlefish in the area is generally poorly known and in need of review. While some, particularly commercial species, can be easily recognized, others which may occur in catches are not well defined by simple external morphological characters.

Octopuses (Order Octopoda)

The order Octopoda contains 2 suborders: the finned “cirrate” octopuses (suborder Cirrata) and the finless familiar “incirrate” octopuses (suborder Incirrata). The “cirrate” octopuses are soft and semigelatinous. All occur in deep water, possess paired fins on the mantle, deep webs, and rows of sensory papillae (“cirri”) adjacent to the suckers. These octopuses are rarely captured and, due to the soft flesh, are of no economic value. The “incirrate” octopuses include the familiar bottom-living octopuses and a range of pelagic species. All lack the fins and sensory cirri of the cirrate octopuses. All incirrate octopuses brood their young, either in lairs, within their webs, within the mantle, or using an egg case (as in the argonauts). Incirrate octopuses are found in all marine waters of the world from intertidal reefs to the deepest ocean trenches.

The benthic octopuses (family Octopodidae) of the continental shelf are the primary targets of commercial fisheries. FAO's Yearbook of Fishery Statistics reports about 247 600 t of octopods taken worldwide in 1995 (about 10% of the total world catch of cephalopods) for which reported catches from the Western Central Pacific accounted for about 8% (24 487 t). The majority are harvested for human consumption as the bycatch of demersal trawl fisheries. They are also caught in artisanal fisheries by trapping, spearing, and using baited hooks or lures with certain species collected primarily as bait for finfish fisheries. They are marketed fresh, frozen, or dried. The taxonomy of this family is very poor. There are a large number of undescribed or poorly-defined species occurring in the Western Central Pacific, a number of which form the basis of local and commercial fisheries. Inappropriate species names are frequently used including many European names, species which only occur in the Atlantic Ocean (e.g. *Octopus macropus*, *O. vulgaris*). Much of this confusion has originated from poorly preserved reference material and use of limited, ill-defined distinguishing characters. Recent research working with live animal attributes and biology has clarified some the taxonomic problems. However, the majority of species in the Western Central Pacific (more than 40 species) still lack formal descriptions or any detailed information on biology, distribution, or importance to fisheries.

PRINCIPAL MEASUREMENTS AND METHODS USEFUL FOR IDENTIFICATION

External characteristics and measurements used

Orientation, arm numbering, and external morphological terms are illustrated in Figure 1. Orientation is relative to the resting animal, the arms and arm/tentacle crown being anterior. The body or mantle is considered posterior. The upper surface of the resting animal is considered dorsal and the underside ventral. Arms are numbered as left or right, commencing from the dorsal arms.

The mantle length is the standard length measurement for all cephalopods (except *Nautilus* where shell diameter is used). In squids and cuttlefishes, the measurement is made along the dorsal surface from the posteriormost point to the anteriormost point of the mantle. In octopuses, mantle length is measured from the midpoint between the eyes to the posterior tip of the mantle along the dorsal surface.

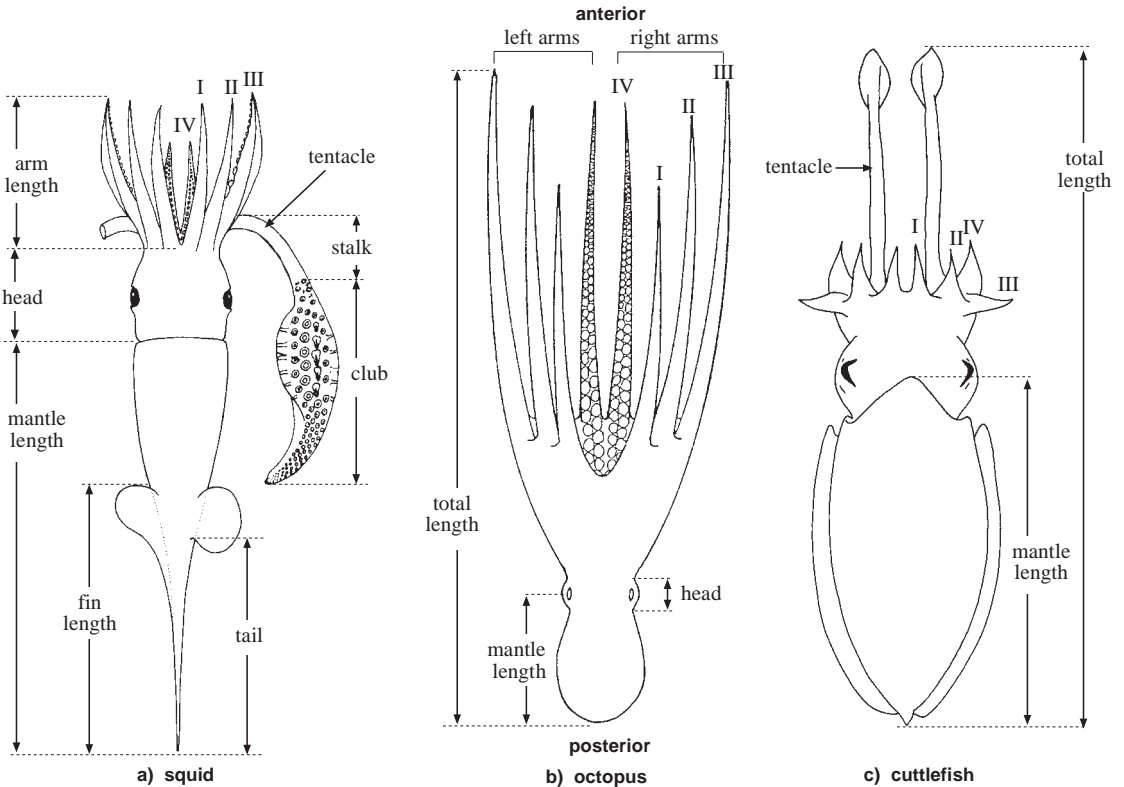


Fig. 1 measurements, arm numbering, and major external features of cephalopods in dorsal view

Determining sex

In most squids and some cuttlefishes, the sex of specimens can be determined externally by examining the arms to find modifications in maturing and mature males (hectocotylyzation). Modifications include change in normal sucker arrangement or loss of suckers, increased sucker size, or thickening or lengthening of sucker stalks, protective membranes, and their supports. For many squids and cuttlefishes, one or both of the ventral arms are modified although in some species, no external modification is apparent. In some groups such as the bobtail squids, these modifications may occur to dorsal rather than (or as well as) ventral arms. The modified arms are used to gather spermatophores from the mantle cavity of the males and transfer them to the mouth region or sometimes in squids, inside the dorsal or ventral mantle of the female.

The sex of benthic octopuses can be determined externally by examining the third arm to find the modified arm developed in maturing and mature males. This is typically the third arm on the right-hand side (left in some genera). It consists of a modified tip with a channel or gutter (the **spermatophore groove**) running along the edge of the arm. In copulation, the spermatophores are shunted along this groove to the modified tip. This tip usually consists of a spoon or club-like structure (**ligula**) and a short tongue-like flap (**calamus**). This tip inserts spermatophores directly into the oviducts of the female octopus.

In poor material, for immature specimens or for species which lack hectocotylyzed arms, dissection of the mantle cavity is necessary to determine sex (see below).

Internal structures in the mantle cavity

In identifying certain species or determining the sex of damaged or immature animals, it is necessary to dissect open the mantle cavity, exposing the funnel-mantle locking apparatus, gills, and reproductive structures.

Figure 2a shows the mantle cavity of typical squids (oegopsids) of both sexes, opened with a mid-ventral longitudinal cut along the length of the mantle. The funnel and mantle elements of the locking apparatus are visible just inside the mantle immediately posterior to the funnel opening itself. Males are recognized by the spermatophoric complex [including Needham's sac (also called the spermatophoric sac) which stores fully formed spermatophores in mature squid and the coiled spermatophoric organ] and penis-like structure on the left side (right in ventral view) of the midline. Females possess paired nidamental glands (white elongate structures) and paired white oviducal glands and oviducts in the anterior part of the mantle. In myopsid squids (such as *Photololigo*), only a single oviducal gland and oviduct is present on the left-hand side of the animal and paired accessory nidamental glands are present anterior to the nidamental glands.

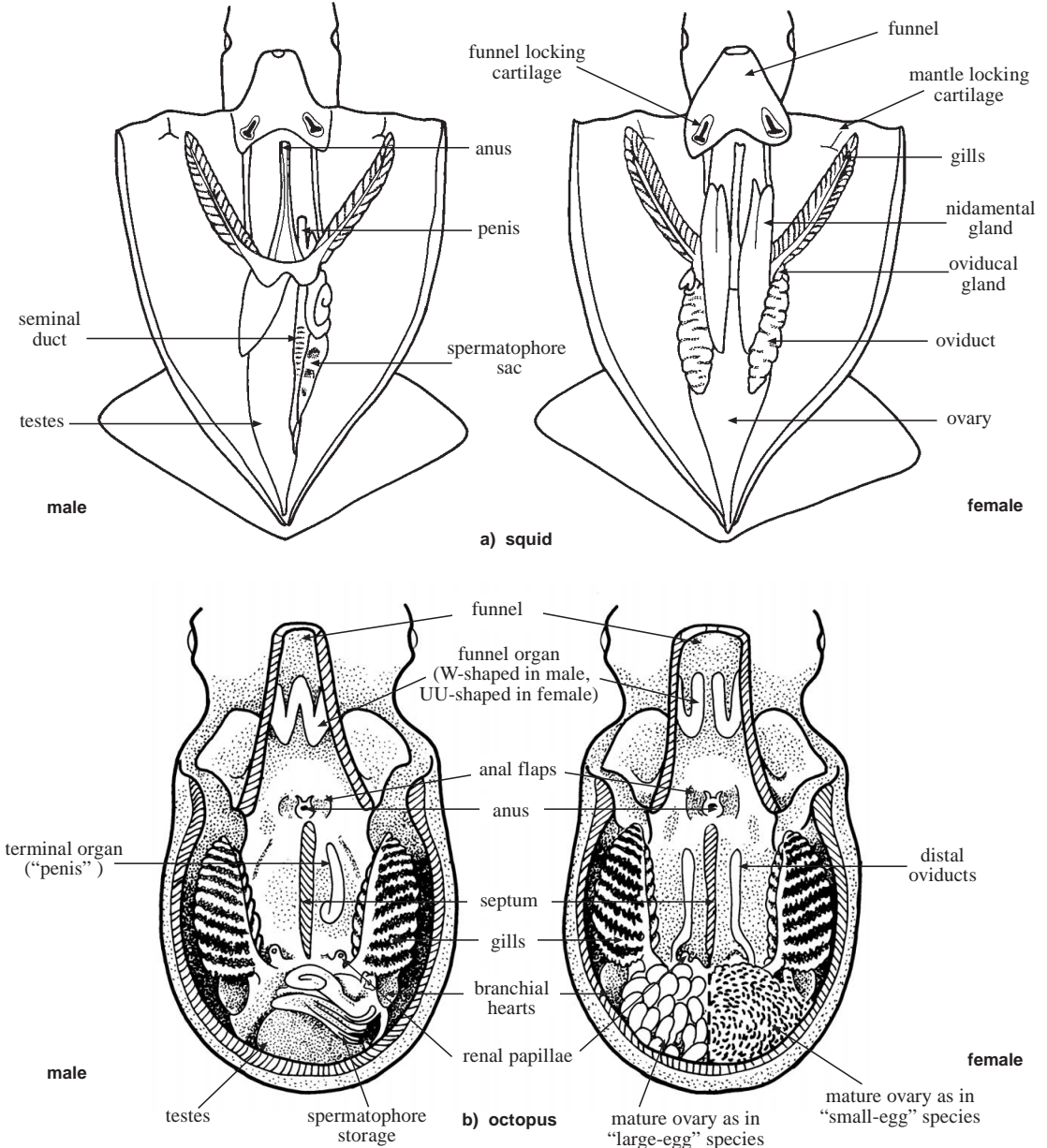


Fig. 2 major features of the mantle cavity of a typical squid and octopus

To examine the contents of the mantle cavity of a cuttlefish, a median longitudinal incision needs to be made through the mantle on the ventral side of the animal. Mature females can readily be distinguished from males by the presence of a pair of leaf-shaped creamy yellow nidamental glands (Fig. 4). Eggs may also be seen in the ovary, below and posterior to the nidamental glands. In immature females, the nidamental glands may be greatly reduced in size or visible only as two short slits. The shape of the male and female genital openings on the left side of the mantle cavity also differs slightly between the sexes.

The open mantle cavity of an octopod is illustrated in Figure 2b for both sexes. There are 2 gills, each consisting of distinct leaves (**lamellae**) in an inner and outer series. Males are recognized by the penis-like structure (**terminal organ**) on the left side (right in ventral view) of the central septum, while females possess paired oviducts on either side of the septum.

Removing internal shells (gladii and cuttlebones)

Squid - In fresh and preserved specimens, the gladius (Fig. 9) may be removed by making a mid longitudinal incision along the length of the dorsal mantle and peeling away the skin laterally. Care must be taken at the posterior end to ensure that all of the skin and muscle tissue is removed from around the cone.

Cuttlefish - The cuttlebone (Fig. 10) can easily be removed from a fresh animal by making a median longitudinal incision along the length of the dorsal mantle, and 2 shorter incisions at the anterior end of the mantle (Fig. 3). The skin can then be peeled open to reveal the cuttlebone.

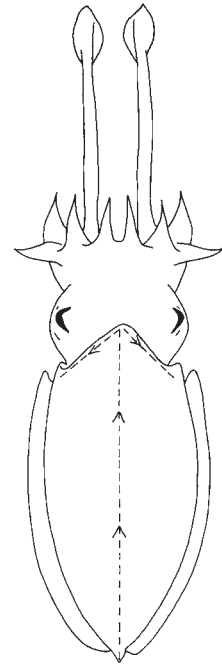


Fig. 3 cuttlefish in dorsal view (broken line indicates suggested incision for dissection)

GLOSSARY OF TECHNICAL TERMS

Accessory nidamental glands - glands of unknown function consisting of tubules containing symbiotic bacteria. Found in cuttlefishes and loliginid squids. Occur in both sexes, anterior to the nidamental glands in females; rudimentary in males (Fig. 4).

Afferent blood vessels - vessels leading towards the gills.

Anal flaps - pair of fleshy papillae that arise on either side of the anus (Fig. 5).

Anal pad - ovoid pads of unknown function, appear glandular, lie either side of the rectum, just behind the anal opening (Fig. 5).

Anterior - toward the head end or toward the arm tips of cephalopods.

Anus - opening of the alimentary canal, or gut, through which undigested remains of food are expelled.

Arm formula - the relative order of arm lengths from longest to shortest, e.g. "I II III IV" is arms decreasing in length from the dorsal pair (arm pair I) to the ventral pair (pair IV), "IV= III=II I" is dorsal pair shorter than all other, equal length, arms (note: arms are numbered in Arabic numerals by some authors, i.e. 2 or II, 3 or III).

Arm - one of the 8 fixed appendages surrounding the mouth of squids, octopuses, and cuttlefishes (see also **tentacles**).

Armature - refers to the presence and arrangement of suckers and/or hooks on the arms and tentacular clubs of cephalopods.

Benthic - bottom dwelling, living on or near the bottom of sea (= demersal).

Branchial - pertaining to the gills.

Branchial canal - canal between afferent and efferent blood vessels.

Buccal membrane - thin web of tissue that encircles the mouth, reinforced by 6 to 8 buccal supports (Fig. 6).

Buccal membrane connectives - muscular bands that connect the supports of the buccal membrane to the bases of the arms (Fig. 6).

Calamus - tongue-like projection at base of ligula on hectocotylized arm of male octopuses (Fig. 7).

Calcareous - chalky, calcified by deposition of calcium salts (calcium carbonate).

Carpus - the proximal zone of (small) suckers (and knobs) on the tentacular club (Fig. 8).

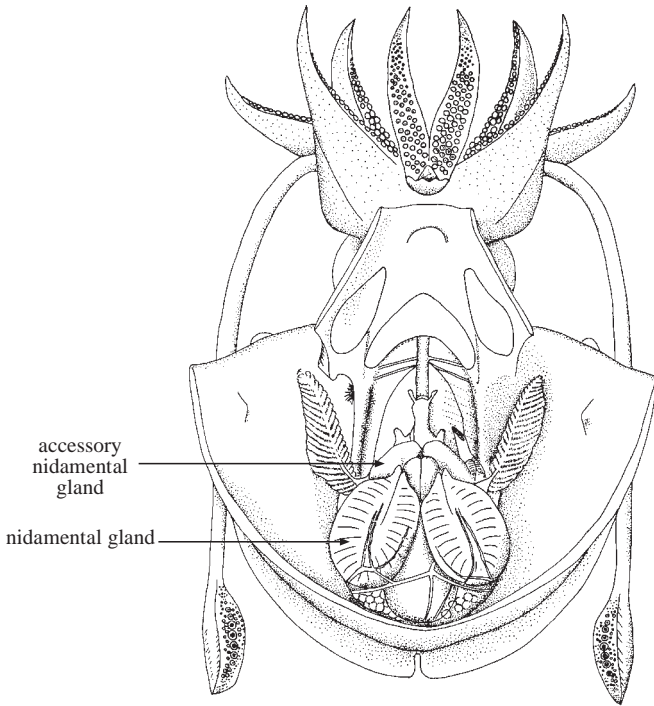


Fig. 4 mantle cavity of female cuttlefish (opened ventrally)

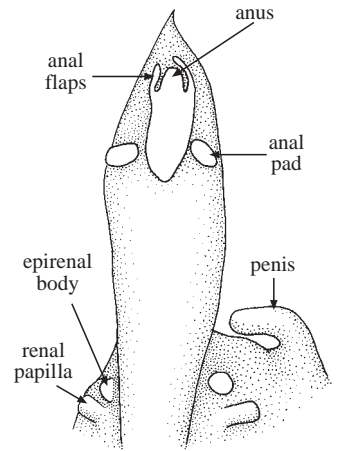


Fig. 5 anterior end of mantle cavity of a sepiolid

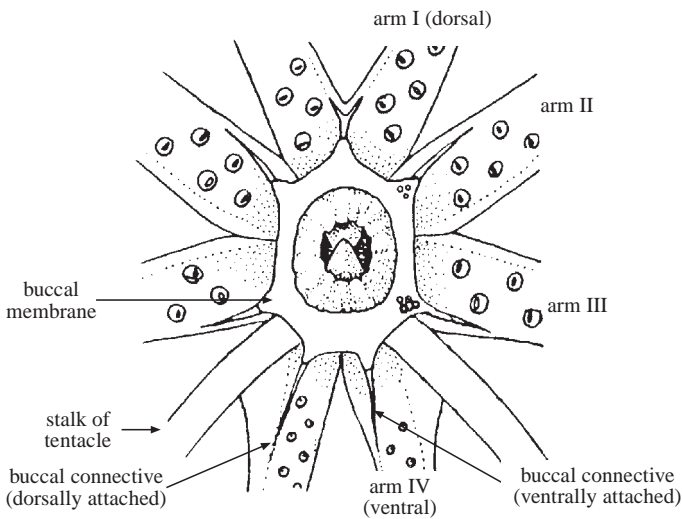


Fig. 6 diagram of oral surface of brachial crown and buccal membrane of a squid

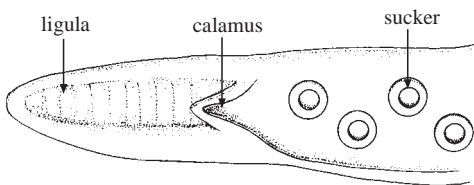


Fig. 7 tip of hectocotylized arm in a male octopus

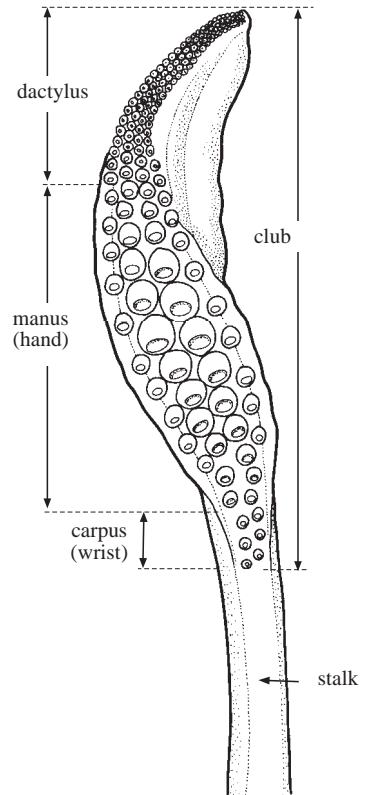


Fig. 8 distal end of tentacle of a squid

Chitin(ous) - a horny polysaccharide substance (fingernail-like) that forms the sucker rings, hooks and beaks of cephalopods.

Chromatophores - pigment-filled, generally flat muscular sacs in the skin under individual nervous control that collectively provide the background colour, colour patterns, and colour play of cephalopods (never ovoid or embedded in muscle tissue as light organs may be).

Club-fixing apparatus - the mechanism of suckers and knobs on the carpal region of the tentacular club that permits the 2 clubs to be locked together during capture of prey (see also **carpus**).

Cone, conus - the spoon-like or cup-like conical posterior terminus of the gladius or cuttlebone (Figs 9 and 10).

Cone flag - lateral extensions of the gladius developed from the cone (Fig. 9).

Corneal membrane - the very thin, transparent skin that covers the eyes of myopsid squids and cuttlefish (Fig. 11b).

Cuttlebone - calcareous supporting plate in the dorsal part of the mantle of cuttlefishes. Organ used to maintain buoyancy. Consists of many thin plates, or **septae**, arranged in a thick bundle. The system of plates is called the **phragmocone** (= sepion). The septae are interconnected by supporting poles and pillars which are visible on the ventral side of the cuttlebone as **striae** (Fig. 10).

Dactylus - the distal, terminal section of the tentacular club in squids and cuttlefishes, often characterized by suckers of reduced size (Fig. 8).

Distal - away from the body or point of origin; toward the peripheral parts (opposite of **proximal**).

Dorsal shield - hard calcareous dorsal surface of the cuttlebone.

Efferent blood vessels - vessels leading away from the gills.

Epipelagic - living in the surface waters of the ocean.

Epirenal bodies - glandular structures of unknown function which lie on either side of the renal papillae (Fig. 5).

Fins - the pair of muscular flaps that arise along the lateral or dorsolateral surface of the mantle of sepioids, teuthoids, and cirrate octopods; used for locomotion, steering and stabilization.

Foveola - transverse membranous fold of skin that forms a pocket in the funnel groove of some oegopsid squids (e.g. some ommastrephids) (Fig. 12).

Funnel - the ventral, subconical tube through which water is expelled from the mantle cavity during locomotion and respiration (Fig. 13) (reproductive and waste products and the ink also pass through the funnel).

Funnel locking apparatus - the combination of the funnel locking cartilage (or component) and the mantle locking cartilage (or component); also called the **funnel-mantle locking apparatus**. It is found laterally at the ventral mantle opening joining the posterior extension of the funnel to the mantle in squids and cuttlefishes (Fig. 13). The cartilages may be very simple in structure such as in loliginid squids or highly complex such as in the ommastrephids (illustrated in Fig. 13). The apparatus may also involve a partial or complete muscular fusion between the funnel and mantle elements such as in the ommastrephid *Sthenoteuthis oualaniensis*, the bobtail squid *Sepiadarium kochii*, and all cranchiid squids.

Funnel locking cartilage - the cartilaginous groove, pit, pocket, or depression on each ventrolateral side of the posterior part of the funnel that joins with the mantle locking cartilage to lock the funnel and mantle together during locomotion, so water is expelled only through the funnel and not around the mantle opening (Figs 13 and 14; see also **mantle locking cartilage**).

Genital opening - exit duct for products formed in the reproductive tract; through which pass eggs and spermatophores.

Gills - paired structures each consisting of many lamellae through which gas exchange occurs. **How to count gill lamellae:** to identify some octopuses, it is necessary to count the number of gill lamellae on each side of each gill (= per **demibranch**, an inner and outer demibranch on each gill). Count per demibranch excludes the central terminal (anterior) lamella, e.g. gill count of 10 refers to 10 lamellae on each side of each gill. The animal illustrated in Fig. 15 has a gill count of 10.

Gladius (pl. = gladii) - the feather or rod-shaped chitinous supporting structure (or shell) in the dorsal midline of squids and sepioids other than cuttlefish (= pen) (Fig. 9).

Hectocotylus - the part of 1 (or more) arm(s) of male cephalopods modified for transferring spermatophores to the female; modifications may involve suckers, sucker stalks, protective membranes, trabeculae in squids and cuttlefishes or a distinct ligula/calamus on tip of the modified arm in octopods.

Hooks - chitinous, claw-like structures derived from the suckers on the arms and/or clubs of some oegopsids (Fig. 16).

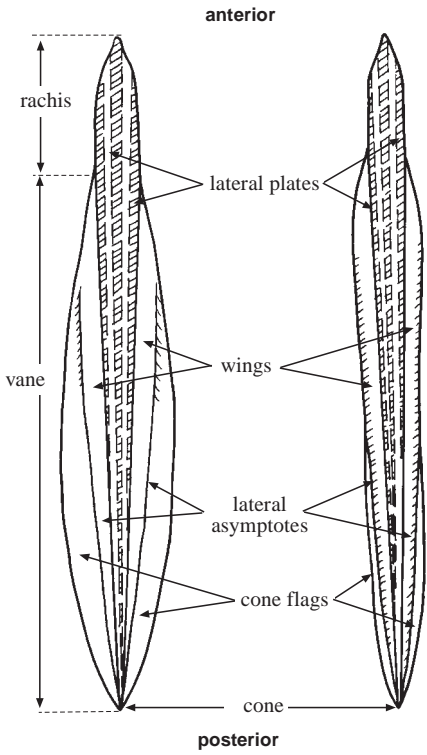


Fig. 9 examples of gladii

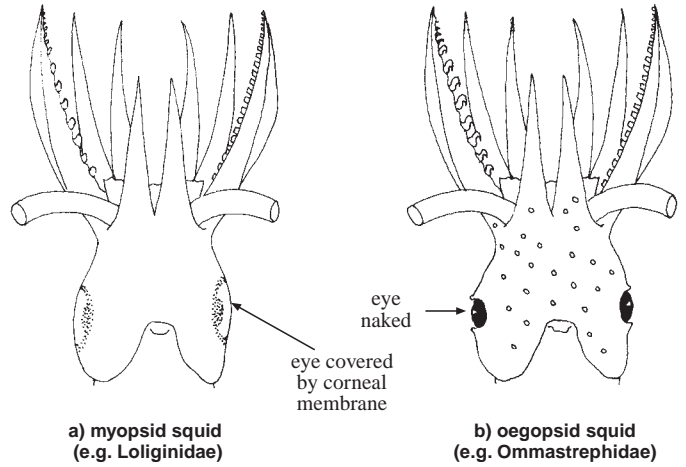


Fig. 11 head, eyes, and arms in ventral view

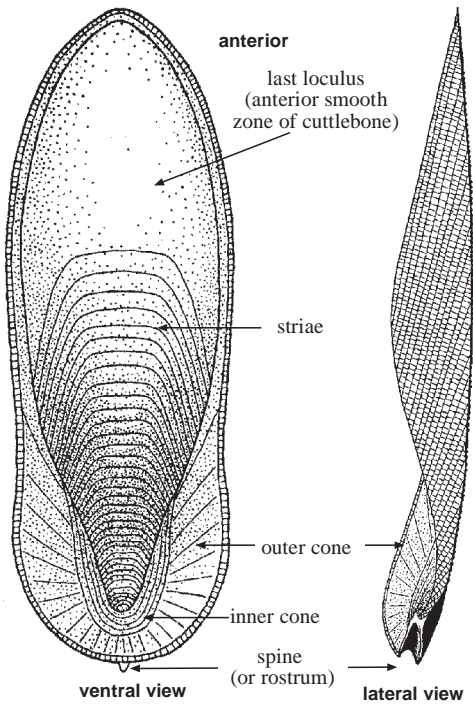


Fig. 10 cuttlebone

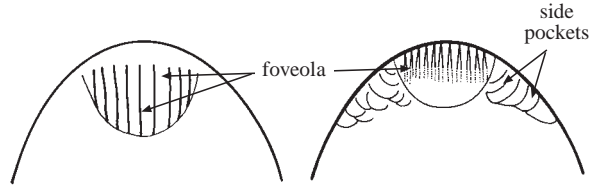
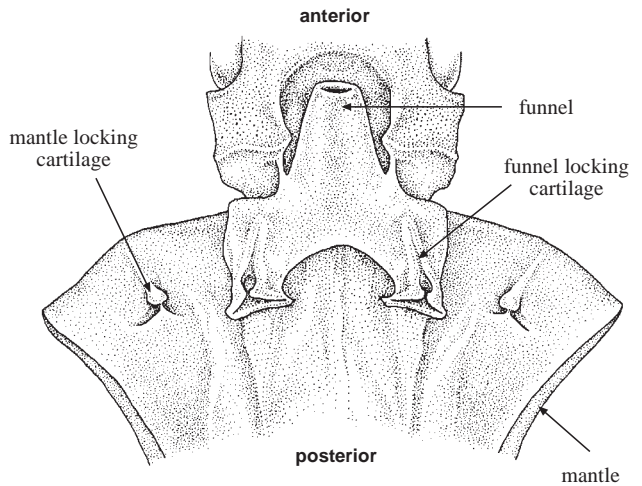


Fig. 12 funnel groove of squids



(illustration: K.Hollis/ABRS)
Fig. 13 internal view of anterior mantle (*Ornithoteuthis*)

Ink sac - the structure that stores the ink of cephalopods; it lies ventrally along the intestine or is embedded in the digestive gland (hepatopancreas) and empties anteriorly via a duct into the rectum.

Inner cone - forked limbs on the ventral side of the cuttlebone, between the inner side of the outer cone and the phragmocone; usually extends to the anterior end of the striated zone (Fig. 10).

Keel - a flattened, muscular extension along the aboral surface of some arms and tentacular clubs to render them more hydrodynamic (= swimming membrane) (Fig. 16); also a narrow longitudinal ridge on the keel of some cuttlebones.

Last loculus - anterior part of the cuttlebone that is smooth, not striated below (Fig. 10).

Lateral ridge - muscular keel along the lateral mantle of some octopuses.

Light organ - a simple or complex structure that produces bioluminescence by intrinsic (self-generated) or extrinsic (bacterial) means. May be present in the skin, on the eyes, embedded in muscle in the mantle, head, arms, tentacles or on the viscera (= photophore) (Fig. 17).

Ligula - spoon- or club-like tip of the modified (hectocotylized) arm of octopuses (Fig. 7).

Mantle - the fleshy (muscular) tubular or sac-like body of cephalopods; provides propulsion through jet-like expulsion of water; contains the viscera.

Mantle locking cartilage - the cartilaginous ridge, knob or swelling on each side of the ventrolateral, internal surface of mantle that locks into the funnel component of the funnel-mantle locking apparatus (Figs 13 and 14, see also **funnel locking cartilage**).

Manus - central or "hand" portion of club between the dactylus distally and the carpus proximally (Fig. 8).

Medial (median) - pertaining to a structure located towards, on, or along the midline.

Mesopelagic - living in the middle layers of the water column in oceanic waters.

Neritic - inhabiting the sea over the continental shelf; arbitrarily taken to be the sea where it is shallower than 200 m.

Nidamental glands - glands inside the mantle of females that secrete a fourth envelope for the eggs. Present in squids (except Enoptoteuthidae), sepiolids, sepiadariids, and cuttlefishes. Glands tongue-like and bifurcated in squids, and oval in cuttlefishes (Fig. 4).

Nuchal cartilages - a pair of cartilaginous structures (a mantle element and a neck element) connecting the mantle to the neck dorsally in many cephalopods.

Ocellus - dark false-eye spot; found in "ocellate" octopuses as a pair of ocelli, one spot below each eye on the lateral arm crown between the bases of arms II and III (as in *Octopus cyanea*).

Olfactory organ - organs of smell; in squids, cuttlefish, and vampyromorphs represented by olfactory papillae, while in octopus there are olfactory pits. Positioned on sides of the head near the neck.

Orbit - cavity, or depression housing the eyeball.

Outer cone - rim surrounding the phragmocone in cuttlebones.

Pedicle - a short, tubular stalk that supports a sucker in sepioids and squids (Fig. 18).

Phragmocone - system of plates comprising the cuttlebone.

Pocket - an open depression in the anteroventral surface of the head between the bases of arms III and IV of cuttlefish into which the tentacles are retracted when not in use.

Posterior - away from the arms and tentacles, towards the tail or rear end of mantle.

Protective membrane - thin web-like integument along the lateral angles of the oral surface of the arms and clubs lateral to the suckers, supported by muscular rods called trabeculae (Fig. 19).

Proximal - toward the body or nearest or next to the point of origin or attachment (opposite of **distal**).

Rachis - the thickened central axis of the gladius that generally extends its entire length. Free rachis is the portion that does not support vanes (Fig. 9; see also **vanes, gladius**).

Renal papilla - kidney opening.

Renal sac - kidney.

Secondary fold - on the eyelid, conspicuous in cuttlefishes.

Secondary sexual character - a characteristic of animals which differs between the 2 sexes, but which is not a primary component of the reproductive system, e.g. enlarges suckers, hectocotylized arms.

Spermatophores - encapsulated packets of sperm. Tubular structures manufactured by male cephalopods capable of holding millions of sperm, being transferred intact by a modified arm of the male and attaching to the female (or being inserted into the oviducts of octopuses) until fertilization occurs.

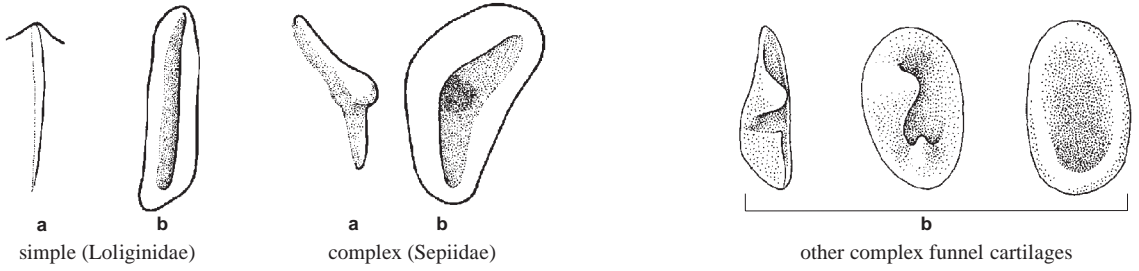


Fig. 14 basic types of mantle locking cartilage (a) and funnel locking cartilage (b)

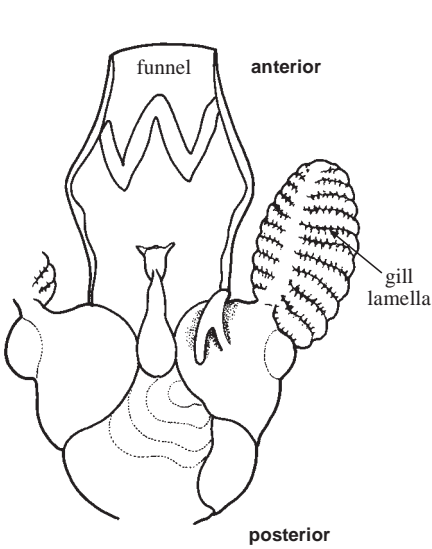


Fig. 15 gills

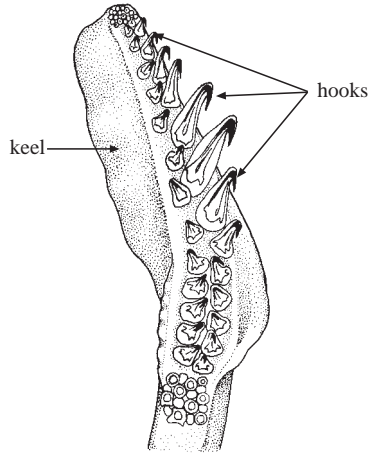


Fig. 16 tentacular club of an onychoteuthid squid

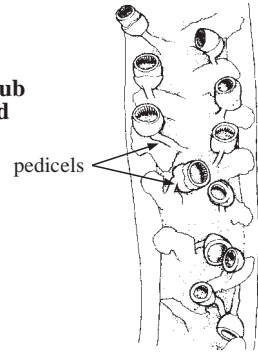


Fig. 18 detail of arm

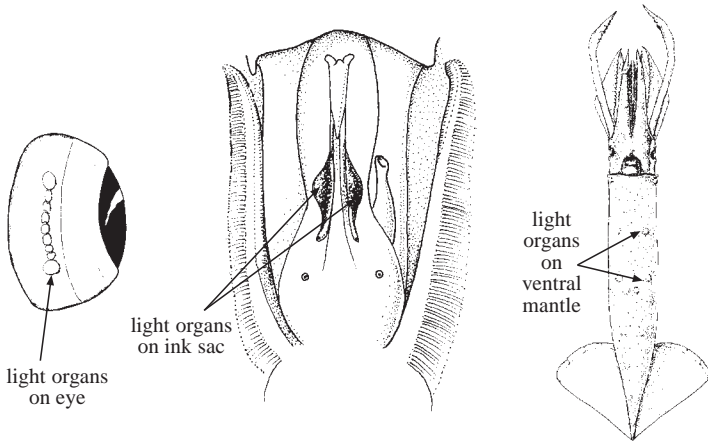


Fig. 17 examples of light organs

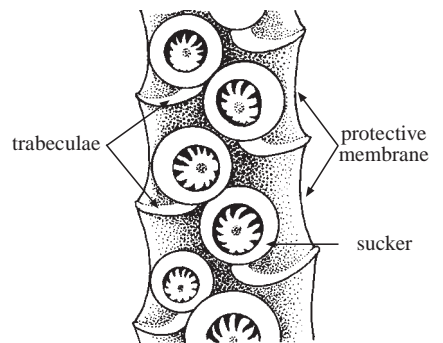


Fig. 19 detail of arm

Spermatophore groove - channel-like groove along the edge of the hectocotylized arm of mature male octopuses along which spermatophores are shunted to the tip for transfer to the female.

Spine - the sharp extension on the posterior tip of the gladius or cuttlebone, dorsal to the outer cone (Fig. 10; also called the rostrum).

Suckers - muscular, suction-cup structures on the arms and tentacles (rarely on the buccal membrane) of cephalopods; stalked and placed on muscular rods that contract (squids and cuttlefishes) (Fig. 20a); sessile and embedded without stalks on the oral surface of the arms of benthic octopuses (Fig. 20b). They are counted in either longitudinal rows (sometimes called "series") or in oblique, transverse rows (Fig. 20c).

Sucker ring - chitinous, often serrated or toothed ring that encircles the opening of suckers of squids and cuttlefishes.

Sulcus - a median longitudinal groove, sometimes flanked by 2 low ridges on the ventral side of the cuttlebone.

Swimming membrane - an elongate, muscular vane along the aboral surface of arms of cephalopods that functions to streamline and support the arms during swimming (= keel).

Tail - the posterior extension of the mantle in some squids, frequently elongate. Fins or tapered terminations of fins may extend posteriorly along the tail.

Tentacles - the 2 elongate, stalked appendages used for prey capture; distal ends contain clubs with suckers (or hooks); stalks usually devoid of suckers. Tentacles in squids can only contract rather than retract into pockets as in cuttlefish.

Tentacular club - terminal portion of a tentacle; armed with suckers (or suckers and/or hooks), used for capturing prey.

Terminal organ - penis-like muscular process of the male reproductive tract in octopuses which passes spermatophores into the base and spermatophore groove of the hectocotylized arm.

Total length - length from posterior tip of mantle to tip of longest arm in octopods or tentacles in squids and cuttlefishes. (Because of the various degrees of contraction of the highly extensible tentacles during capture or fixation/preservation, this is not generally a useful comparative measurement in squids and cuttlefishes).

Trabeculae - muscular rods that support the protective membranes on the arms and clubs of cephalopods; occasionally membranes are reduced and/or trabeculae are elongated, so they extend beyond the edge of the membrane, papilla-like (Fig. 19).

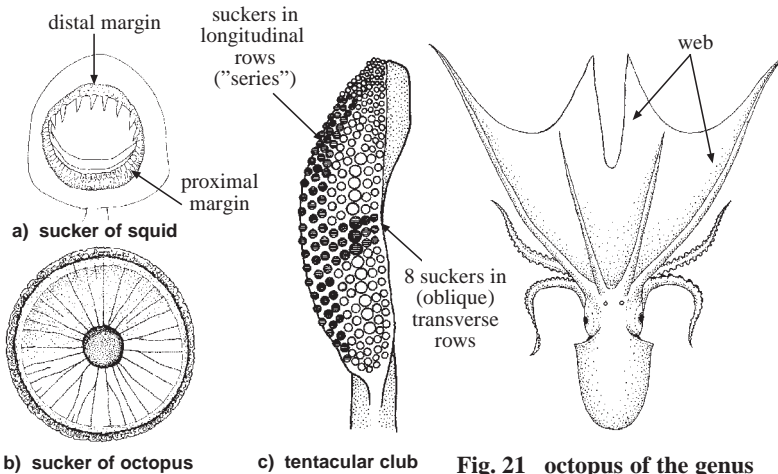
Umbilicus - the central core of the chambered *Nautilus* shell, representing the juvenile shell with its initial coils.

Vane - thin lateral expansion of the gladius that arises from the rachis (Fig. 9; see also **rachis**).

Ventral - the lowermost or belly surface of a cephalopod; the surface on which the funnel is located; opposite the dorsal surface.

Web - a membranous sheet that extends between the arms of many octopuses and some squids and cuttlefish, giving an umbrella-like appearance when the arms are spread out (Fig. 21).

Web depth - distance from mouth to shallowest point of web between adjacent arms in octopods (Fig. 22).



b) sucker of octopus

c) tentacular club

Fig. 20 suckers and how they are counted

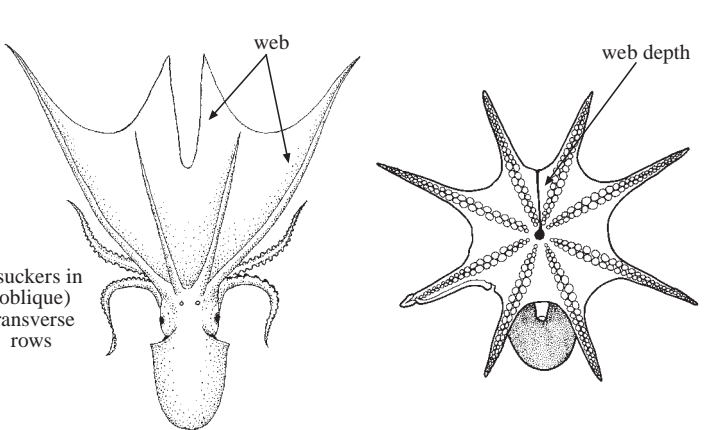


Fig. 21 octopus of the genus *Tremoctopus*, with expanded web

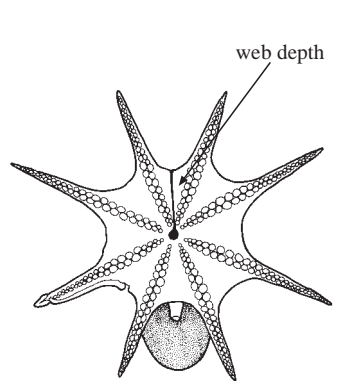


Fig. 22 octopus in oral view

KEY TO FAMILIES OF CEPHALOPODS ENCOUNTERED IN FISHING ACTIVITIES IN THE AREA

(compiled from Nesis, 1987, and Roper et al., 1984)

Note: families and higher taxa which are not treated further in this guide because they are unlikely to be regularly encountered in fishing or research activities are indicated by an asterisk (*). The reader is referred to the general references listed for further information on these groups.

- 1a. Animal with hard, chambered external shell; numerous (more than 50) slender arms without suckers or hooks (Fig. 23) Subclass Nautiloidea: Order Nautilida (monotypic order): Family Nautilidae (p. 709)
1b. Shell absent or internal, external shell only present in female argonauts as thin brittle egg case; 8 arms or 8 arms and 2 tentacles always armed with suckers or hooks Subclass Coleoidea -> 2
2a. Eight arms and 2 tentacles (except in adult Octopoteuthidae which lack tentacles but are otherwise squid-like); suckers with chitinous rings, sometimes modified into hooks; fins always present -> 3
2b. Eight arms only; suckers without chitinous rings or hooks; fins absent or present only as short paddles on the sides of the mantle in certain deep-water gelatinous forms -> 19
3a. Internal shell (if present) either straight and laminate, coiled and chambered, or rudimentary and straight; pockets present which house the tentacles between arms III and IV. (Order Sepiida (= Sepioidea)) -> 4
3b. Internal shell straight, feather- or rod-shaped; no pockets present between arms III and IV (Order Teuthida (= Teuthoidea)) -> 8
4a. Internal shell calcified, as flat laminate cuttlebone or coiled chambered shell -> 5
4b. Internal shell chitinous (thin and transparent) or absent -> 6
5a. Internal shell coiled, chambered, embedded in posterior mantle (Fig. 24). Family Spirulidae (p. 722)
5b. Internal shell a thick, oval to elongate calcareous plate (the cuttlebone) embedded in the dorsal mantle (Fig. 25) Family Sepiidae (p. 723)

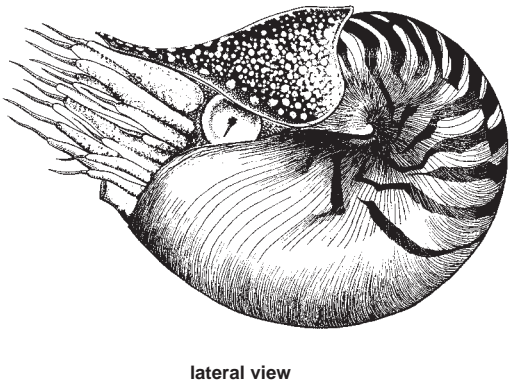


Fig. 23 Nautilidae (Nautilus)

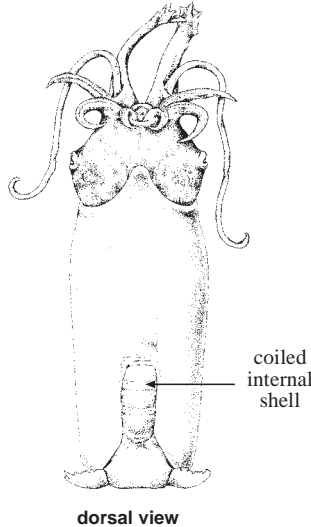


Fig. 24 Spirulidae (Spirula)

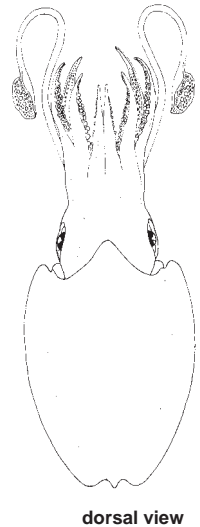


Fig. 25 Sepiidae (Sepia)

(illustration: K.Hollis/ABRS)

- 6a. Fins small and restricted to posterior end of mantle; large adhesive gland on dorsal surface of mantle (Fig. 26). **Family Idiosepiidae** (p. 721)
- 6b. Fins semicircular to kidney-shaped on lateral mantle, never restricted to posterior mantle; adhesive gland absent → 7
- 7a. Shell absent; both or only left ventral arm hectocotylized; dorsal border of mantle always fused to head (Fig. 27) **Family Sepiadariidae** (p. 719)
- 7b. Internal thin chitinous shell (gladius) present (except in *Euprymna*); hectocotylus developed on 1 dorsal arm, both dorsal arms (I) or dorsolateral arm (II); dorsal border of mantle free from, or fused to, head (Fig. 28) **Family Sepiolidae** (p. 712)

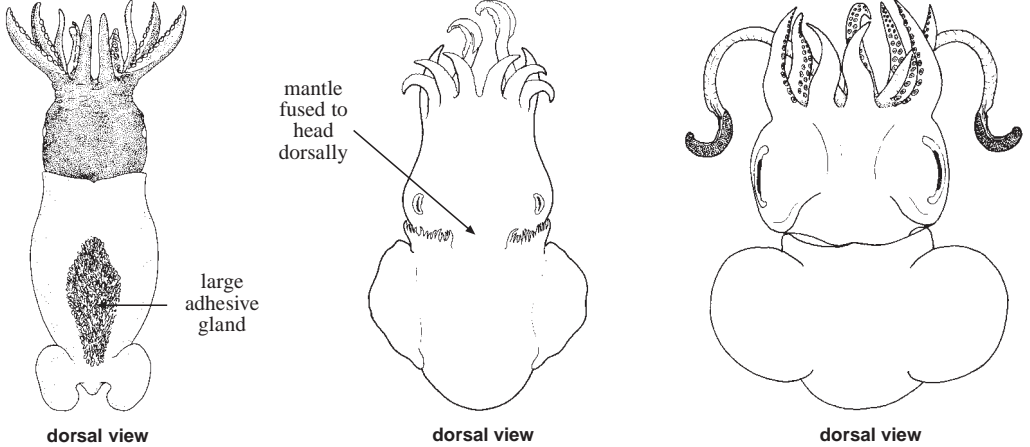


Fig. 26 Idiosepiidae (*Idiosepius*) Fig. 27 Sepiadariidae (*Sepiadarium*) Fig. 28 Sepiolidae (*Rossia*)

- 8a. Eye covered by transparent membrane (cornea); arms with suckers always in 2 rows; hooks absent; left or both ventral arms (IV) hectocotylized; paired light organs either side of the intestine in many species but no external light organs (Fig. 29) (Suborder Myopsida): **Family Loliginidae** (p. 764)

- 8b. Eye without cornea and in open contact with seawater; arm sucker arrangement variable (dependent on family); many species possessing hooks; hectocotylization present or absent; light organs may be present external on the mantle, head, arms and tentacles and ventral surface of the eyes as well as internally (Suborder Oegopsida) → 9

- 9a. Mantle fused to head dorsally and to the funnel; funnel-mantle locking apparatus absent (Fig. 30) **Family Cranchiidae** *

- 9b. Mantle not fused to head dorsally; funnel-mantle locking apparatus present (although funnel and mantle cartilages are fused in some species) → 10

- 10a. Mantle-funnel locking apparatus a simple, straight groove and ridge → 11

- 10b. Mantle-funnel locking apparatus not a simple, straight groove and ridge → 16

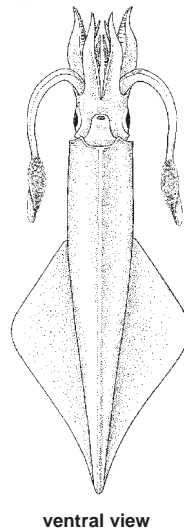


Fig. 29 Loliginidae (*Loligo*)



Fig. 30 Cranchiidae (*Cranchia*)

11a. Arms with hooks rather than suckers in adults; in juveniles where hooks are absent, suckers are in 4 rows → 12

11b. Arms without hooks, suckers in 2 rows → 13

12a. Tentacles with fully developed clubs present; buccal membrane connectives attach to dorsal sides of ventral arms (IV) (Fig. 31)
. **Family Enoploteuthidae** (p.781)

12b. Tentacles and clubs absent in adults although rudimentary clubs present in larvae or occasionally in juveniles; buccal membrane connectives attach to ventral sides of ventral arms (IV) (Fig. 32) . . **Family Octopoteuthidae** *

13a. Buccal membrane connectives attach to ventral sides of ventral arms (IV) → 14

13b. Buccal membrane connectives attach to dorsal sides of ventral arms (IV) → 15

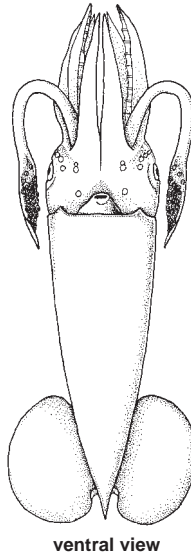


Fig. 31 Enoploteuthidae (*Pterygioteuthis*)

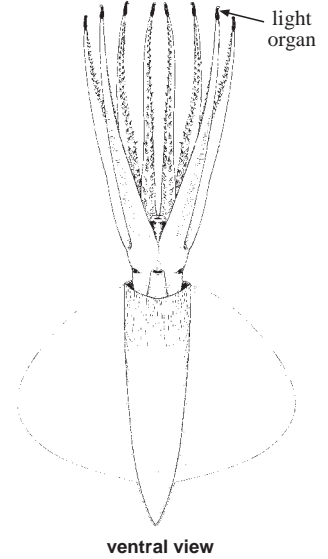


Fig. 32 Octopoteuthidae (*Octopoteuthis*)

14a. Hooks present on tentacular clubs (Fig. 33) **Family Onychoteuthidae** (p.784)

14b. No hooks on tentacular clubs (Fig. 34) **Family Brachioteuthidae** *

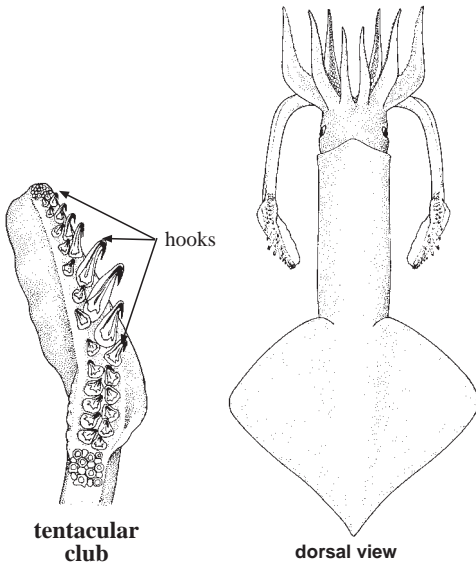


Fig. 33 Onychoteuthidae (*Onychoteuthis*)

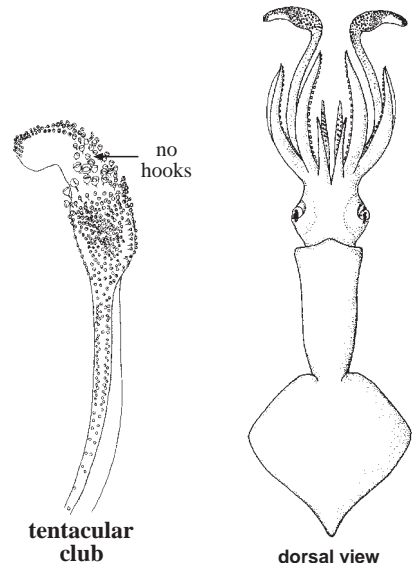


Fig. 34 Brachioteuthidae (*Brachioteuthis*)

15a. Surface of mantle, head and arms covered with many light organs (usually large and distinct); a few small suckers at the proximal end of the manus; left eye considerably larger than right in adults (Fig. 35) **Family Histioteuthidae** (p. 787)

15b. Surface of mantle and head without light organs; many small to minute suckers (or suckers and knobs) at proximal end of manus and along tentacle shaft; eyes equal sized (Fig. 36) **Family Architeuthidae** *

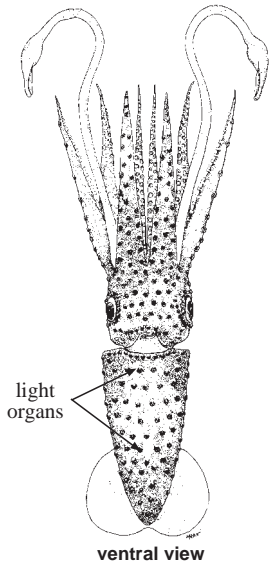


Fig. 35 Histioteuthidae (*Histioteuthis*)

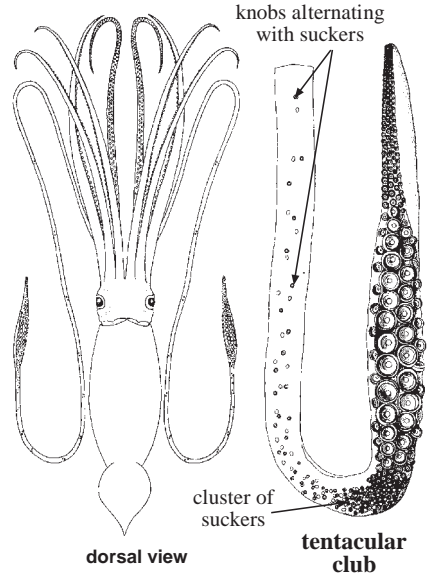


Fig. 36 Architeuthidae (*Architeuthis*)

16a. Funnel locking cartilage with a longitudinal and a transverse groove, ⊥-shaped or T-shaped → **17**

16b. Funnel locking cartilage oval with 1 or 2 knobs directed toward centre of concavity → **18**

17a. Funnel locking cartilage with a longitudinal groove crossed by a transverse groove at its posterior end, ⊥-shaped; fins less than 60% of mantle length (Fig. 37) **Family Ommastrephidae** (p. 788)

17b. Funnel locking cartilage with a longitudinal groove from which a shorter groove branches medially, T-shaped; fin length equal to mantle length (Fig. 38) **Family Thysanoteuthidae** (p. 797)

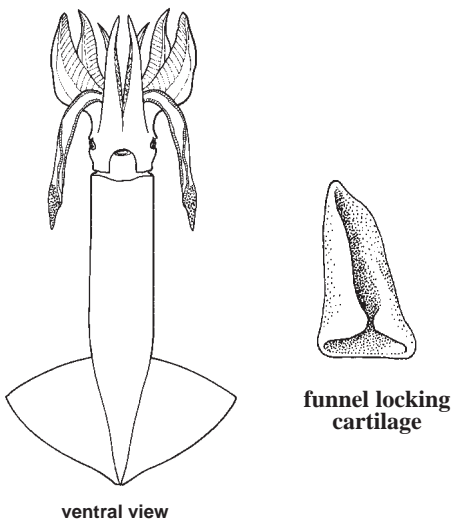


Fig. 37 Ommastrephidae (*Ommastrephes*)

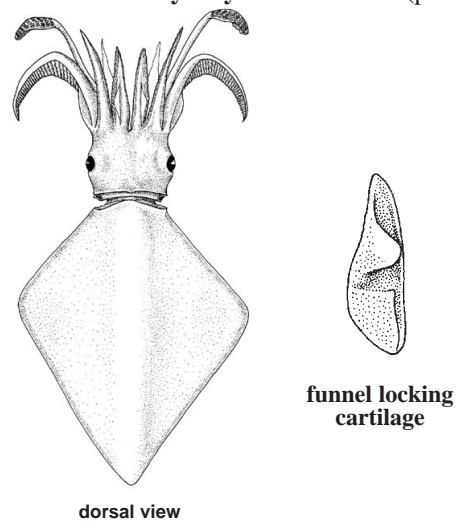


Fig. 38 Thysanoteuthidae (*Thysanoteuthis*)

- 18a. Club with 4 longitudinal rows of suckers (Fig. 39) **Family Chiroteuthidae** (p. 798)
- 18b. Club with more than 15 longitudinal rows of minute suckers (Fig. 40) **Family Mastigoteuthidae** (p. 799)

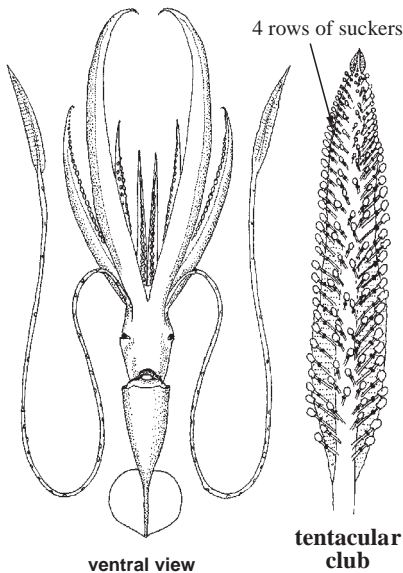


Fig. 39 Chiroteuthidae (*Chiroteuthis*)

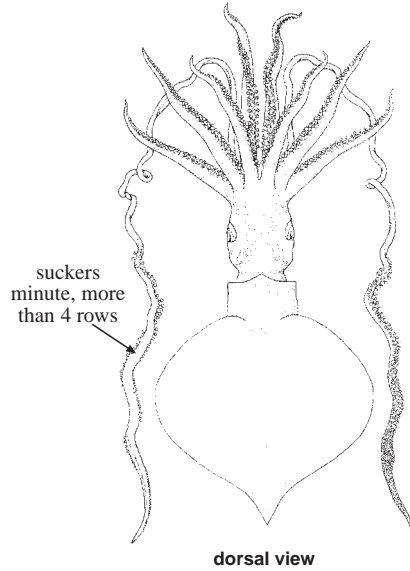


Fig. 40 Mastigoteuthidae (*Mastigoteuthis*)

- 19a. Suckers stalked, with chitinous rings; fins on posterior mantle, 1 pair in adults, 2 pairs in juveniles; internal shell as a thin broad chitinous plate; pair of small filamentous "tentacles" in pouch between bases of arms I and II; whole animal typically black; 2 transverse pairs of light organs present (Fig. 41) **Order Vampyromorpha** (monotypic order): **Family Vampyroteuthidae**
- 19b. Suckers sessile (not stalked), without chitinous rings; fins present or absent; internal shell vestige either a U-shaped fin support, a pair of small rods (stylets), or absent; secondary filamentous "tentacles" absent; light organs absent (except around the mouth in some boliteanids); never completely black **(Order Octopoda) → 20**

- 20a. Fins present; body gelatinous; rows of sensory digits of skin (cirri) adjacent to single row of suckers **(Suborder Cirrata) ***
- 20b. Fins absent; body gelatinous to muscular; sensory cirri absent **(Suborder Incirrata) → 21**
- 21a. Body jelly-like; often semi-transparent **→ 22**
- 21b. Body firm and muscular; opaque **→ 23**

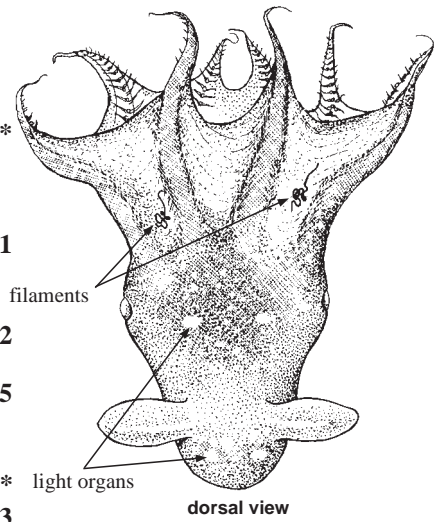


Fig. 41 Vampyroteuthidae (*Vampyroteuthis*)

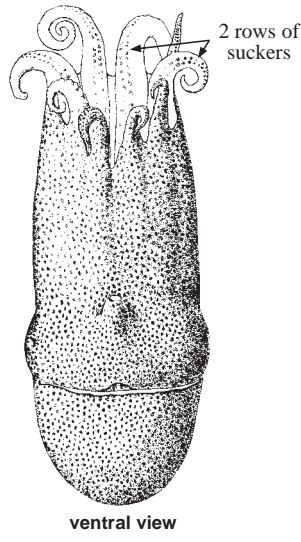


Fig. 42 Alloposidae (*Haliphron*)

- 22a. Suckers on arms in 2 rows (Fig. 42) . . **Family Alloposidae ***
- 22b. Suckers on arms in 1 row . . **→ 23**

- 23a. Arms short, typically less than mantle length; webs shallow (less than 50% arm length); eyes moderate size and not telescopic (Fig. 43) **Family Bolitaenidae ***
- 23b. Arms longer than mantle length; webs deep (more than 50% of arm length); eyes telescopic or small → 24
- 24a. Eyes elongate, tubular; mantle opening reduced to 2 separate small lateral slits; mantle and arm musculature enclosed in gelatinous outer coat (Fig. 44) **Family Amphitretidae ***
- 24b. Eyes small and normal-shaped; single wide mantle opening; body gelatinous; mantle and arm musculature not enclosed in gelatinous outer coat (Fig. 45). . **Family Vitreledonellidae ***

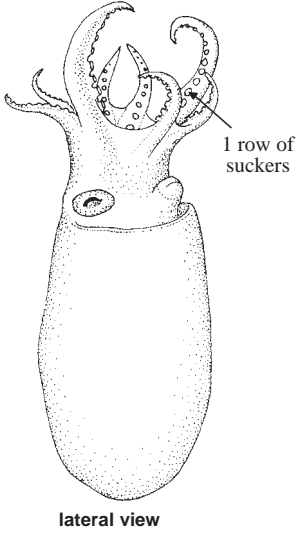


Fig. 43 Bolitaenidae (*Japetella*)

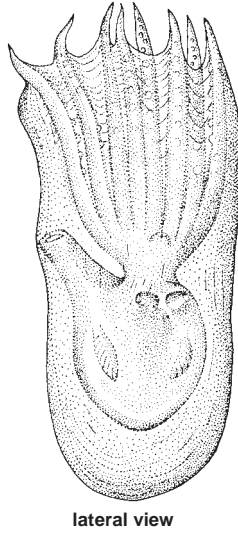


Fig. 44 Amphitretidae (*Amphitretus*)

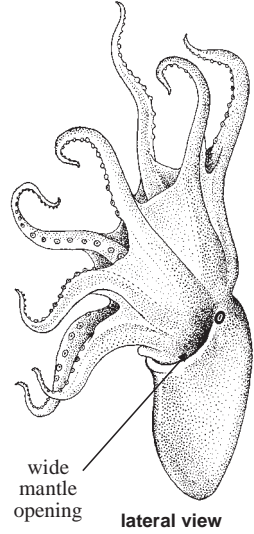


Fig. 45 Vitreledonellidae (*Vitreledonella*)

- 25a. Funnel-mantle locking apparatus absent; suckers in 1 or 2 rows (Fig. 46) **Family Octopodidae (p. 800)**
- 25b. Funnel-mantle locking apparatus present; suckers in 2 rows → 26
- 26a. Female housed in thin calcareous shell ("paper nautilus"); thin flared webs on tips of modified first (dorsal) arms in females (in live animal, webs of each modified dorsal arm can cover each entire face of the shell); third left arm modified in male (Fig. 47) **Family Argonautidae ***
- 26b. Shell absent; web (as in *Argonauta*) on tips of dorsal arm absent in females; third right arm modified in males → 27

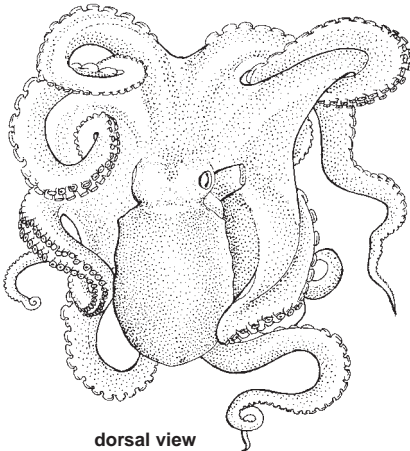


Fig. 46 Octopodidae (*Octopus*)

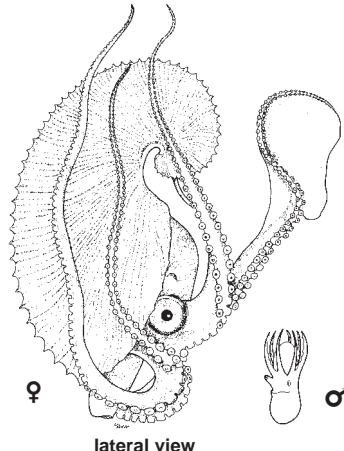


Fig. 47 Argonautidae (*Argonauta*)

- 27a.** Arms I and II of female joined by very deep thin web; arms I and II longer than other arms; ventral mantle smooth; 2 pairs of open holes on head (cephalic water pores), adjacent to bases of arms I and IV (Fig. 48) **Family Tremoctopodidae ***
- 27b.** Web absent; arms I and IV longer than other arms; ventral mantle of female sculptured with keratin-like inclusions in the skin forming a reticulate pattern; 1 pair of cephalic water pores on dorsal surface adjacent to bases of fourth arms (Fig. 49) . . . **Family Ocythoidae ***

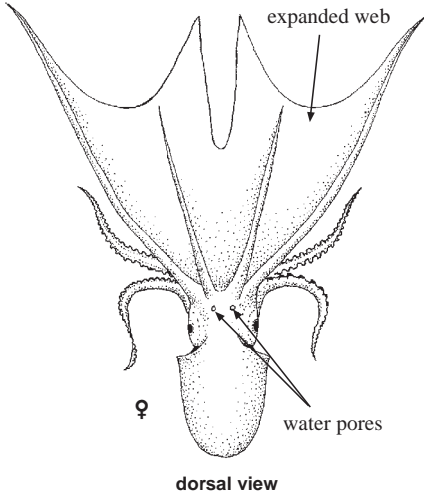


Fig. 48 Tremoctopodidae (*Tremoctopus*)

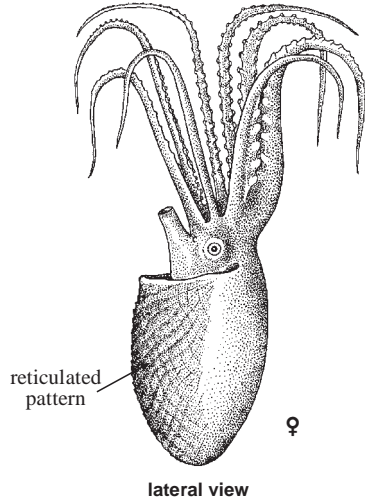


Fig. 49 Ocythoidae (*Ocythoe*)

ANNOTATED LIST OF FAMILIES ENCOUNTERED IN FISHING ACTIVITIES IN THE AREA

Classification modified after Nesis (1987), and Clarke and Trueman (1988). Importance to fisheries listed in increasing order as “non-commercial”, “minor commercial”, “commercial”, or “major commercial”.

Class CEPHALOPODA Cuvier, 1798

Subclass NAUTILOIDEA Agassiz, 1847

Order NAUTILIDA, Monotypic Family Nautilidae Blainville, 1825 (minor commercial) - Chambered nautilus. Characterized by: COILED PEARLY EXTERNAL CHAMBERED SHELL WITH ANIMAL LIVING IN THE OUTERMOST CHAMBER; 2 PAIRS OF GILLS; MORE THAN 50 SMOOTH “ARMS” WITHOUT SUCKERS; EYES SIMPLE WITHOUT LENSES.

Medium-sized cephalopods with shell diameters reaching 250 mm; occur adjacent to coral reefs at the edge of the continental shelf and upper continental slope; 6 species.

Subclass COLEOIDEA Bather, 1888

Order SEPIOLIDA - Dumpling or bobtail squid and pygmy cuttlefishes. Characterized by: FINS ROUNDED AND TYPICALLY WIDE; CHITINOUS GLADIUS RUDIMENTARY (Sepiolidae) OR GLADIUS ABSENT (Idiosepiidae); ONE OR BOTH DORSAL (Sepiolidae) OR BOTH VENTRAL ARMS (Idiosepiidae) HECTOCOTYLIZED IN MALES; LIGHT ORGANS PRESENT ON THE INK SAC IN SOME SPECIES.

Family SEPIOLIDAE Leach, 1817 (minor commercial) - Dumpling or bobtail squid. Small rounded animals up to 80 mm mantle length; associated with sandy or rubbly substrates and seagrass beds in coastal waters and deeper continental shelf to 60 m; 11 species.

Family IDIOSEPIIDAE Appelöf, 1898 (non-commercial) - Pygmy cuttlefishes. Small animals maturing at less than 20 mm mantle length; occur in shallow seagrass and other inshore habitats; 3 species.

Order SEPIIDA - Cuttlefishes. Characterized by: CALCAREOUS SHELL INTERNAL IN THE MANTLE (except Sepiadariidae); TENTACLES RETRACTILE INTO POCKETS; ARM AND TENTACULAR SUCKERS WITH CHITINOUS RINGS; ONE PAIR OF GILLS WITHOUT BRANCHIAL CANAL BETWEEN AFFERENT AND EFFERENT BLOOD VESSELS; LIVER DIVIDED OR BILOBED; POSTERIOR FIN LOBES FREE.

Family SPIRULIDAE Owen, 1836 (minor commercial) - Ram's horn squid. Small (up to 45 mm mantle length); mesopelagic in warm oceanic waters; a single species.

Family SEPIIDAE Keferstein, 1866 (major commercial) - Cuttlefishes. Medium-sized cephalopods to 500 mm mantle length; demersal species of the continental shelf and upper slope; more than 35 species.

Family SEPIADARIIDAE Naef, 1912 (non-commercial) - Bottle squids. Small cephalopods (less than 50 mm mantle length); nektobenthic in coastal waters to depths of 60 m; 2 species.

Order TEUTHIDA - Squids. Characterized by: CHITINOUS GLADIUS INTERNAL IN THE MANTLE, SIMPLE, ROD- OR FEATHER-LIKE; TENTACLES CONTRACTILE BUT NOT RETRACTILE INTO POCKETS; ARM AND TENTACULAR SUCKERS WITH CHITINOUS RINGS AND/OR HOOKS; ONE PAIR OF GILLS WITH BRANCHIAL CANAL BETWEEN AFFERENT AND EFFERENT BLOOD VESSELS; LIVER UNDIVIDED AND SINGLE LOBED; POSTERIOR FIN LOBES MAY BE JOINED.

Suborder MYOPSIDA Orbigny, 1845 - "covered-eyed" squids

Family LOLIGINIDAE Steenstrup, 1861 (major commercial) - Inshore or pencil squids. Medium-sized cephalopods to 500 mm mantle length; nektonic species of the continental shelf; more than 20 nominal species.

Suborder OEGOPSIDA Orbigny, 1845 - "open-eyed" squids

Family ENOPLOTEUTHIDAE Pfeffer, 1900 (minor commercial) (includes M.R. Clarke's families Enoploteuthidae, Ancistrocheirinae and Pyroteuthinae) - Firefly or enope squids. Small to medium squids to 400 mm mantle length; pelagic species of the continental slope and oceanic waters; 17 species.

Family OCTOPOTEUTHIDAE Berry, 1912 (non-commercial) - Octopus squids. Medium to large squids to 1 700 mm mantle length; meso- to bathypelagic and benthic in oceanic waters; at least 4 species.

Family ONYCHOTEUTHIDAE Gray, 1849 (minor commercial?) - Hooked squids. Medium to large squids to 400 mm mantle length; epi- to mesopelagic in oceanic waters and benthic in continental slope waters; at least 4 species.

Family LEPIDOTEUTHIDAE Naef, 1912 (non-commercial) (includes M.R. Clarke's family Pholidoteuthidae) - Scaled squids. Medium to large squids to 970 mm mantle length; nektobenthic in continental slope and oceanic waters; 3 species.

Family ARCHITEUTHIDAE Pfeffer, 1900 (non-commercial) - Giant squids. Reach maturity at large sizes to 2 000 mm mantle length; mesopelagic in oceanic waters; number of species uncertain.

Family HISTIOTEUTHIDAE Verrill, 1881 (non-commercial) - Jewel squids. Small to medium squids to 200 mm mantle length; mesopelagic to nektobenthic in continental slope and oceanic waters; 4 species.

Family CTENOPTERYGIIDAE Grimpe, 1922 (non-commercial) - Ribbed finned squids. Small to medium squids to 90 mm mantle length; meso- to bathypelagic in oceanic waters; 2 species.

Family BRACHIOTEUTHIDAE Pfeffer, 1908 (non-commercial) - Arm squids. Small to medium squids to 90 mm mantle length; meso- to bathypelagic in oceanic waters; 2 species.

Family OMMASTREPHIDAE Steenstrup, 1857 (commercial) - Arrow squids. Medium to large squids to 600 mm mantle length; nektobenthic in deeper continental shelf and slope waters and epi-mesopelagic in oceanic waters; 9 species.

Family THYSANOTEUTHIDAE Keferstein, 1866 (commercial) - Diamond squids. Large-sized squids reaching 1 000 mm mantle length; epi-mesopelagic in warm oceanic waters; a single species.

Family CHIOTEUTHIDAE Gray, 1849 (non-commercial) - Chiroteuthid squids. Medium to large squids to 800 mm mantle length; mesopelagic to nekto-benthic in oceanic and continental slope waters; 2 species.

Family MASTIGOTEUTHIDAE Verrill, 1881 (non-commercial) - Mastigoteuthid squids. Medium to large squids reaching 1000 mm mantle length; mesopelagic to nekto-benthic in oceanic and continental slope waters; several species.

Family CRANCHIDAE Prosch, 1849 (non-commercial) - Cranch squids. Small to large squids to 800 mm mantle length; epi- to bathypelagic in oceanic waters; many species.

Order VAMPYROMORPHA Pickford, 1939, Monotypic Family VAMPYROTEUTHIDAE Thiele, 1915 (non-commercial) - Vampire squids. Characterized by: EIGHT ARMS ONLY, TENTACLES ABSENT; SINGLE ROW OF SUCKERS STALKED WITH CHITINOUS RINGS; DORSAL MANTLE JOINED TO HEAD; PAIRED, ROUNDED FINS PRESENT; INTERNAL SHELL A CHITINOUS THIN BROAD PLATE; A PAIR OF THIN FILAMENTOUS FILAMENTS IN POUCHES BETWEEN ARMS I AND II; LIGHT ORGANS PRESENT IN THE MANTLE AT THE BASE OF EACH FIN AND MEDIAL TO THE EYE DORSALLY; COLOUR BLACK.

Medium-sized octopuses reaching 130 mm mantle length; mesopelagic in slope and deeper waters; a single species.

Order OCTOPODA Leach, 1818 - Octopuses. Characterized by: EIGHT ARMS ONLY, TENTACLES ABSENT; SINGLE OR PAIRED ROWS OF SUCKERS SESSILE WITHOUT SUCKER RINGS OR HOOKS; DORSAL MANTLE JOINED TO HEAD; FINS PRESENT OR ABSENT; CHITINOUS SHELL VESTIGE EITHER SMALL CARTILAGINOUS RODS OR A U-SHAPED SUPPORT; LIGHT ORGANS GENERALLY ABSENT (PRESENT AROUND THE MOUTH IN BOLITAENIDS).

Suborder INCIRRATA Grimpe, 1916

Superfamily BOLITAENOIDEA

Family BOLITAENIDAE Chun, 1911 (non-commercial) - Small to medium-sized octopuses reaching 150 mm mantle length; meso- to bathypelagic (juveniles epipelagic); 2 species.

Family AMPHITRETIDAE Hoyle, 1886 (non-commercial) - Medium-sized octopuses reaching 90 mm mantle length; meso- to bathypelagic (juveniles epipelagic); a single species.

Superfamily OCTOPODOIDEA

Family OCTOPODIDAE Orbigny, 1845 (major commercial) - Benthic octopuses. Small to medium-sized octopuses reaching 200 mm mantle length; demersal species of the continental shelf and upper slope; more than 30 species.

Superfamily ARGONAUTOIDEA

Family TREMOCTOPODIDAE Brock, 1882 (non-commercial) - Banket octopuses. Medium-sized octopuses reaching 200 mm mantle length (females), 15 mm mantle length (males); epi- to mesopelagic in oceanic waters; 2 species.

Family OCYTHOIDAE Gray, 1849 (non-commercial) - Medium-sized octopuses reaching 200 mm mantle length; epi- to mesopelagic in oceanic waters; a single species.

Family ARGONAUTIDAE Naef, 1912 (non-commercial) - Argonauts or paper nautilus. Small to medium-sized octopuses reaching 120 mm mantle length (females), less than 20 mm mantle length (males); epi- to mesopelagic in deeper shelf and oceanic waters although occasionally encountered on the shelf; several species.

Family ALLOPOSIDAE Verrill, 1882 (non-commercial) - Jelly octopuses. Medium-sized octopuses reaching 150 mm mantle length; epi- to mesopelagic oceanic octopods; a single species.

LIST OF FAMILIES TREATED IN THIS CONTRIBUTION

Order NAUTILIDA

NAUTILIDAE - Chambered nautilus

Order SEPIOLIDA

SEPIOLIDAE - Bobtail squids

IDIOSEPIIIDAE - Pygmy cuttlefishes

Order SEPIIDA

SPIRULIDAE - Ram's horn squid

SEPIIDAE - Cuttlefishes

SEPIADARIIDAE - Bottle squids

Order TEUTHIDA

Suborder MYOPSIDA

LOLIGINIDAE - Inshore squids, pencil squids

Suborder OEGOPSIDA

ENOPLOTEUTHIDAE - Firefly or enope squids

ONYCHOTEUTHIDAE - Hooked squids

HISTIOTEUTHIDAE - Jewel squids

OMMASTREPHIDAE - Arrow squids

THYSANOTEUTHIDAE - Diamond squids

CHIROTEUTHIDAE - Chiroteuthid squids

MASTIGOTEUTHIDAE - Mastigoteuthid squids

Order OCTOPODA

OCTOPODIDAE - Benthic octopuses

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