Introductory Guide to Zooplankton Identification

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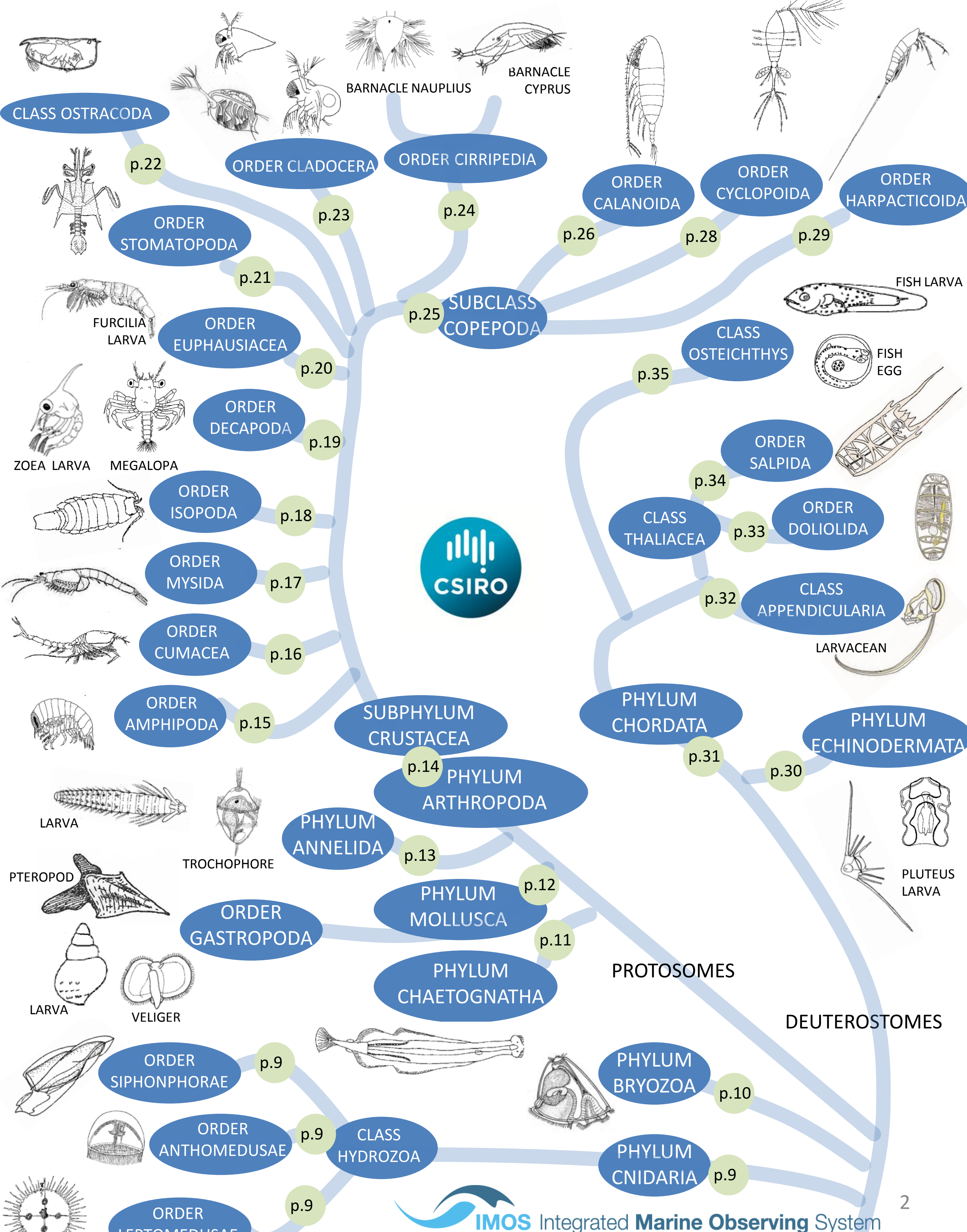
Phylogenetic tree of major zooplankton groups (i.e. those covered here)



Plankton diagrams sourced from: Newell, G.E. and Newell R.C. (1979). Marine Plankton

What are plankton

Zooplankton are a fascinating, diverse and abundant group of animals living in water bodies throughout the world. Most zooplankton are microscopic, but others are the largest creatures on Earth (e.g. some siphonophores can be 10s of metres long). Zooplankton drift with the currents, and although most can swim, they cannot progress against currents. Zooplankton encompass representatives of all major invertebrate phyla, including some that can only be found in the plankton, and includes vertebrate fish eggs and larvae. Zooplankton ultimately support most marine life. They directly support young fish (larvae) and invertebrates (e.g. larvae of squid and lobster), many small planktivorous fish (e.g. sardine and anchovy), and large marine animals (e.g. baleen whales and manta rays). They also indirectly support large ocean predators (e.g. tuna and sharks) that feed upon the small planktivorous fish. Since zooplankton are the major link in the oceans between phytoplankton and fish including commercially important species, their study helps form a more complete understanding of the functioning of marine ecosystems.

Meroplankton and holozooplankton

Zooplankton can be subdivided into *holoplankton*, i.e. permanent members of the plankton that spend their entire lives in the water column, and *meroplankton*, i.e. temporary members. Examples of holoplankton include krill, copepods, larvaceans, some jellyfish (i.e. those without a bottom-dwelling stage) and salps. Many species in the ocean are part of the meroplankton because they have planktonic stages for dispersal, including larval and young stages of animals that will settle out to the bottom or shoreline when they mature (e.g. larvae of crabs, lobster or barnacles), become large enough to swim against currents (e.g. fish eggs larvae and squid), regularly emerge from the seafloor into the water column to feed (e.g. stomatopods, cumaceans) or have alternation of generations (e.g. most jellyfish).

Holoplankton

Meroplankton

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Diversity
In terms of phyla, marine fauna is much more diverse than its terrestrial counterpart, with 80% of all phyla represented in the seas, whereas only 20% of all phyla are represented on land. However, this is reversed when considering the number of described species, with 85% of all species found on land and only 15% in the oceans.

This lack of species-level diversity in the ocean is commonly attributed to the lack of structure in the pelagic and benthic environments compared with terrestrial systems. Not only is the water column much more dynamic than the land, but the primary producers are microscopic in the ocean (the phytoplankton) providing few microhabitats, where the primary producers are macroscopic on land (e.g. trees) and provide many niches for other species.

It is difficult to know how many species can be considered part of the zooplankton. Given that almost all marine species are either holoplanktonic or have eggs or larvae that are meroplanktonic, most marine species are part of the zooplankton at some time in their life. The Table below summarizes the number of marine species that have been described in the phyla covered in this guide (from Bouchet 2006) and give some indication of the rich biodiversity in the zooplankton. These numbers are undoubtedly underestimated because of lack of effort, considering there are 20 times more specialists studying insects alone than all marine invertebrates, and only 13% of taxonomic surveys are marine (Schminke 2007).

Animal phylum	Number of marine species described
Cnidaria	10,000
Ctenophora	166
Mollusca	52,525
Annelida	12,000
Crustacea	44,950
Echinodermata	7,000
Chaetognatha	121
Chordata	21,513
Bryozoa	5,700
TOTAL	153,975

Sampling zooplankton

Zooplankton are normally sampled with a plankton net made from monofilament nylon mesh. Mesh size generally varies from 50-500 µm and the size chosen depends on the purpose and the region of the study; there is no one ideal mesh size. Commonly, a 200 µm mesh or larger is used in temperate and polar regions where generally the zooplankton are larger, but a smaller mesh size of 70-100 µm is used in tropical regions where the zooplankton are smaller. Mesh size is also chosen dependent upon the focus of the study and thus the size of organisms to be retained. For example, studies of the food environment of marine megafauna that target zooplankton such as whale sharks, manta rays and baleen whales usually use a 200 µm or larger mesh, as these animals do not retain the small zooplankton when feeding, whereas studies of zooplankton biodiversity, particularly in tropical areas, use a finer mesh. An additional consideration is that fine mesh nets will clog more quickly with phytoplankton, need to be towed more slowly so they do not burst, and faster moving zooplankton can detect their approach and avoid them. However, coarse mesh nets miss much of the zooplankton present.

Nets can either be towed horizontally from a boat, pulled vertically while a boat is stationary, or towed obliquely through the water column. When the net is hauled to the surface, the plankton accumulates in the codend, a removable container that can be emptied into a screw-topped jar for storage.

Standard plankton net

Deploying a drop net off a boat to sample plankton

Plankton is collected in the cod end

Dissecting microscope and plankton manual ready for the identification of plankton

About this Guide

This is an Introductory Guide targeted at beginners to zooplankton identification: school and university students; those starting post-graduate work; and field workers. This Guide is not intended to be comprehensive, but selective in only including the zooplankton most commonly encountered. When confronted with an unknown zooplankton specimen under the microscope, it is hoped that this Guide will enable someone to identify the specimen to a major group (usually order). Our approach is to describe some basic characteristics of the body form of each group and provide illustrations and images. For interest, we fleetingly mention diversity, distribution and ecology of many of the groups. Once a specimen is identified to a broad taxonomic group, there are more detailed guides available to identify it to species (e.g. see Australian Marine Zooplankton: A Taxonomic Guide and Atlas http://www.imas.utas.edu.au/zooplankton/home). However, note that it is not possible to identify all specimens to species, as in general juveniles and meroplankton do not have diagnostic features. Two techniques are normally used to identify the meroplankton of fish, crustaceans and other marine life: (1) rearing eggs collected in the field, or eggs artificially fertilized in a tank, and following the developmental stages; and (2) following the developmental series of field-collected larvae to juveniles.

Before you start identifying zooplankton

1. *You will need specimens.* Specimens are best observed in a dish with water. Zooplankton are always more beautiful when they are alive and you can observe their swimming behaviour, but preserved specimens are usually easier to see species-level features
2. *You will need a microscope.* For identification to coarse taxonomic level, this can be a fairly cheap dissecting microscope, but species-level identification generally requires more expensive dissecting or a compound microscope
3. You will need a counting tray. A Bogorov tray is usually used (see below)
4. A counting sheet can help (see over)

ZOOPLANKTON COUNT SHEET

Date:		**Sample #:**	
Group:		**Time:**	
Name/s:		**Sample volume:**	
Notes:		**Subsample volume:**	

Broad group	Subgroup	Type	
Crustaceans	Copepods	Calanoids	
		Cyclopoids	
		Harpacticoids	
	Decapods	Larvae	
	Euphausiids	Larvae	
	Amphipods	Adults	
	Cladocerans	Adults	
	Cirrepedes	Larvae	
	Other crustaceans (Mysids, Stomatopods, Isopods, Ostracods)		
Chordates	Fish	Larvae	
	Salps	Adults	
	Doliolids	Adults	
	Larvaceans	Adults	
Chaetognaths		Adults	
Annelids		Adults	
		Larvae	
Molluscs		Adults	
		Larvae	
Echinoderms		Larvae	
Jellyfish		Adults	
Other zooplankton (e.g. Bryozoa)		Larvae	
		Adults	

Zooplankton Identification: Getting Started

This is a general guide only and is not comprehensive and there are exceptions to these general guidelines.

1. *Does it have a hard, jointed exoskeleton?*
    A. It is probably a crustacean (Phylum Arthropoda, p. 14)
        A. Is it shrimp-like and relatively big? (Order Euphausiacea, Decapoda, Mysida, Cumacea, Stomatopoda, Amphipoda, Isopoda)
            A. Does it have big eyes and spines? (Order Decapoda, p. 19)
            B. Does it have big 'arms' (Order Stomatopoda, p. 21)
        B. Is it bullet-shaped and relatively small (Subclass Copepoda, p. 25)
        C. Is it like a water flea with a large eye (Order Cladocera, p. 23)

2. *Does it look long like a worm or tadpole?*
    A. If it has similar segments and bristles then it is probably a worm (Phylum Annelida, p. 13)
    B. If it is not segmented and has large eyes then could be a fish larvae (Phylum Chordata, p. 35)
    C. If it has 'hooks' on its head then it could be an arrow worm (Phylum Chaetognatha, p. 11)
    D. If it has a distinct 'head' and tail then it is usually a larvacean (Class Appendicularia, p. 32)

3. *Is it soft and jelly-like?*
    A. If it is round it is probably a young jellyfish (Phylum Cnidaria, p. 9)
    B. If it is triangular then it could be a siphonophore (Phylum Cnidaria, p. 9)
    C. If it is barrel-like with thin bands then it is a doliolid or salp (Phylum Chordata, p. 33-34)
    D. If it is worm-like and has hooks then it is an arrow worm (Phylum Chaetognatha, p. 11)

4. *Does it look like a shell?*
    A. It is probably a gastropod (Phylum Mollusca, p. 12)

5. *Does it have two shells like a mussel?*
    A. If the shells look rounded then it could be a bivalve (Phylum Mollusca, p. 12)
    B. If the shells have a small point at one end it could be an ostracod (Class Ostracoda, p. 22)
    C. If it has an eyespot and no shell point then might be barnacle cyprid (Class Cirrepedia, p. 24)

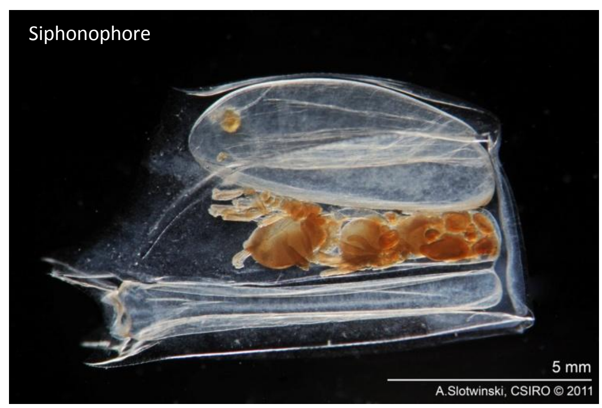
6. *Does it look like a fairly non-descript blob, sometimes with cilia?*
    A. It could be a larval Mollusc, Annelid or Echinoderm (these are difficult)

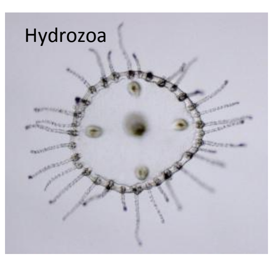
1. *Does it have a triangular shape and cilia?*
    A. It is a cyphonautes larvae (Phylum Bryozoa, p. 10)

Phylum Cnidaria

Hydrozoan cnidarians are often triangular or squarish in shape and sometimes have many tentacles. Many bell-shaped cnidarians are difficult to identify in plankton samples because they are juvenile.

Phylum Cnidaria (formerly Coelenterata) gets its name from the presence of stinging cells called cnidoblasts or nematocysts that all members possess. There are typically two adult forms, the sessile hydroid, which are tubular and usually permanently attached to a substrate, and the mobile medusa, which are usually free-swimming, flattened or bell-shaped. Some cnidarians have only a hydroid stage in their life cycle, others only a medusa stage, and others both. Most alternate between sexual and asexual stages and there are many variations in reproductive strategy. Most jellyfish seen in plankton samples are hydrozoans.



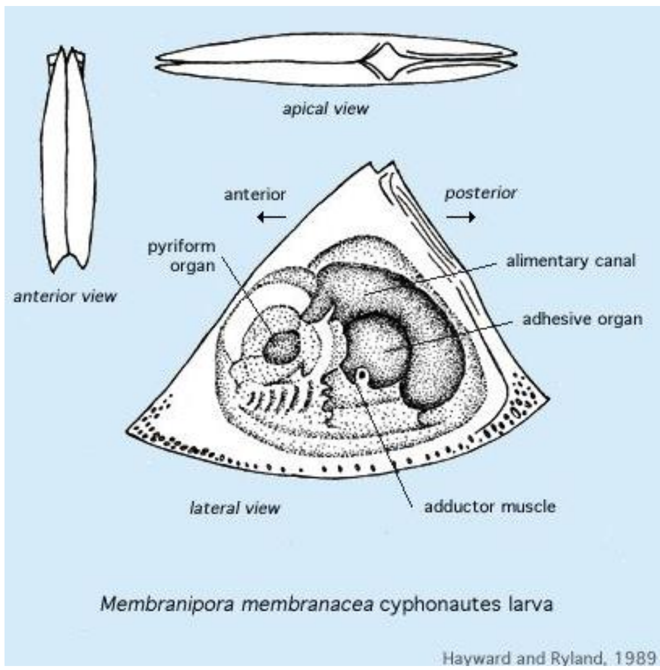


Text source: Conway, D.V.P. (2012) *Marine Zooplankton of southern Britain. Part 1: Radiolaria, Heliozoa, Foraminifera, Ciliophora, Cnidaria, Ctenophora, Platyhelminthes, Nemertea, Rotifera and Mollusca*. A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (25) 138p.

Phylum Bryozoa

Bryozoan larvae are triangular-shaped, with a curve (with cilia) along one edge.

Bryozoan adults are sessile, but their larvae are pelagic and often called cyphonautes larvae. They are triangular in shape and have a characteristic encircling band of ciliated cells, forming the corona. The body shape may be flattened or elongated. Larval sizes range from ~0.2-1.1 mm. Bryozoan species that shed their eggs directly in seawater produce long-lived planktotrophic larvae. These are enclosed by triangular bivalved shells of small size (0.1 mm). Bryozoan larvae are generally found close to the coast.



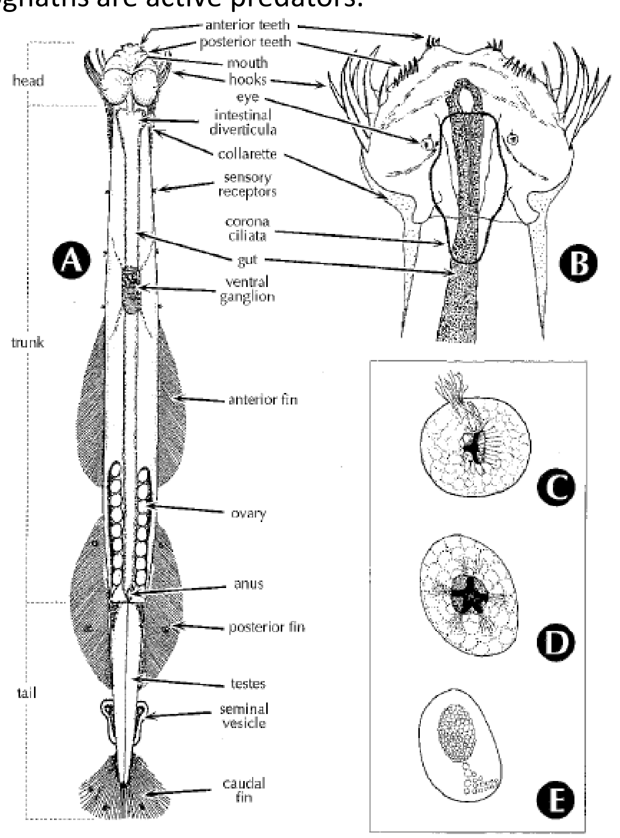
Text and diagram source: *Zooplankton and Micronekton of the North Sea.* Matthijs van Couwelaar
ETI, University of Amsterdam Mauritskade 61 NL-1092 AD Amsterdam ,The Netherlands. Online at http://species-identification.org/.

Phylum Chaetognatha

Chaetognaths are large (>5 mm) unsegmented and have a worm-like appearance and large hooks on the head.

A small group with 70-80 species of exclusively marine, carnivorous, hermaphroditic and holoplanktonic animals, with the exception of one benthic genus. Chaetognaths have an elongated cylindrical body, are bilaterally symmetrical, and are usually transparent or slightly opaque. The body is divided in three parts by internal partitioning: head, trunk and tail. The head is slightly rounded and separated from the trunk by a constricted neck. Each side of the head bears a group of curved grasping hooks and one or two rows of teeth; the hooks and teeth are made of chitin. A pair of pigmented eyespots is present. The trunk bears one or two pairs of lateral fins, usually overlapping the septum between trunk and tail. The fins are thin, transparent and supported by fin rays and often difficult to see in specimens, but their number, shape and position are diagnostic in species identification.

Chaetognatha have a worldwide distribution and a wide depth range; some species perform diurnal vertical migration. Chaetognaths are often abundant in the plankton. Chaetognaths are generally macrozooplankton, varying from 2-120 mm. Fertilised eggs are released in the seawater and develop into a larva, but are rarely seen in the plankton. The life span of chaetognaths may vary from six weeks to two years, depending on the species. Chaetognaths are active predators.



Chaetognath, North Stradbroke Island, QLD

Text source: **Zooplankton and Micronekton of the North Sea** M. van Couwelaar http://species-identification.org/.
Diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Mollusca

Some molluscs look like snails (holoplanktonic and meroplanktonic gastropods), some are top-shaped with ciliary bands, some look like mussels (meroplanktonic bivalve larvae), and still others look like miniature adult cephalopods.

Marine molluscs have unsegmented soft-bodied organisms, partially or wholly covered by a mantle, a sheet of tissue exclusive to this phylum. The body is often divided into a head, with eyes or tentacles, a muscular foot used for locomotion that is modified in some species for swimming, and a visceral mass housing the organs. Most have a protective shell, usually external, excreted by the mantle, but in a few species the shell is internal, reduced or absent.

The most common molluscan groups in the plankton are bivalve (mussel) larvae, gastropods (snails) and cephalopod (squid and octopus) larvae. Molluscs typically develop from eggs that are retained in the mantle cavity and then deposited onto a surface or shed into the water column. In some species a planktonic larval stage called a trochophore (left figure below) emerges from the egg. This is typically small, top-shaped, with a mouth opening just below an equatorial ring of cilia and with an apical tuft of cilia. Beating of the cilia spins them and propels them through the water. The trochophore develops into the veliger stage (right figure below), or veligers are liberated directly. The majority of molluscan larvae caught will be veligers, as trochophores generally only spend a short time in the plankton before developing further. They are generally also small and delicate, so may be destroyed, or not retained, by coarser plankton nets. The veliger characteristically has a shell, the shape depending on the group it belongs to, and a densely ciliated velum composed of a variable number of lobes.

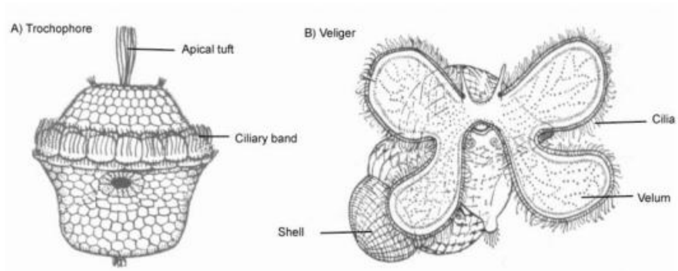


Fig. 1. Typical molluscan larvae. (From Fretter & Graham, 1962).

Adult gastropod, east coast of Tasmania

Adult gastropod, North Stradbroke Island, QLD

Cephalopod paralarvae , east coast of Tasmania

Text source: Conway, D.V.P. (2012) *Marine Zooplankton of southern Britain. Part 1: Radiolaria, Heliozoa, Foraminifera, Ciliophora, Cnidaria, Ctenophora, Platyhelminthes, Nemertea, Rotifera and Mollusca*. A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (25) 138p.

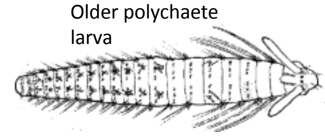
Phylum **Annelida**

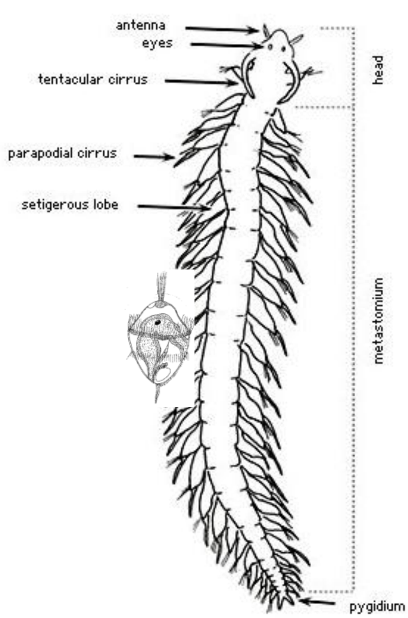
Annelids are typical segmented worms that often have bristles. Larvae when young are top-shaped and have cilia bands (trochophore) and then become more elongate and segmented and as they age.

Most marine annelids are in the Class Polychaeta. They live on or in the sediment, but there are a few holoplanktonic forms. Holoplanktonic polychaetes have developed a number of special adaptations to live in the planktonic environment including small size, long setae, enormous and complex eyes, flattened or gelatinous bodies, a high degree of transparency and sperm storage in females. Pelagic polychaetes are found in the open sea, from surface to abyssal depths, but also near the coast, although these species are more likely to be meroplanktonic. Holoplanktonic species are mainly active predators that attack their prey with the rapidly everted proboscis, but some filter-feed on phytoplankton. As in almost every other pelagic marine phylum of animals, bioluminescence has been observed in pelagic species of the Annelida. The larvae are also common in the plankton, particularly in shallow habitats. They are variable in appearance, but generally have chaeta (spines) or cilia.

Polychaete trochophore larva

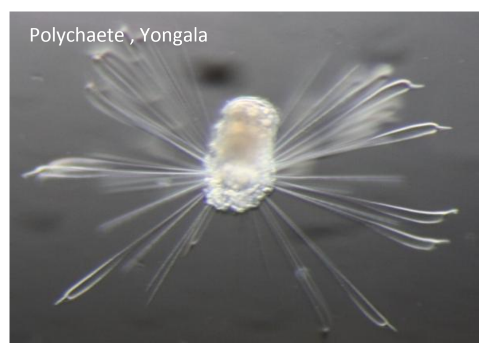
Older polychaete larva



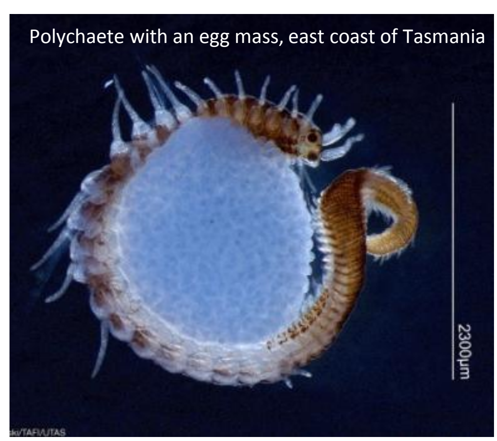


morphologic detail(s) and characters used for the identification of pelagic Polychaeta

basic body plan of a pelagic polychaete (Pelagobia longicirrata)   from Fernandez-Alamo (1983)



Polychaete , Yongala



Polychaete with an egg mass, east coast of Tasmania

Text and diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Arthropoda

Arthropods have an exoskeleton, a segmented body and jointed appendages. Arthropods are extremely diverse and account for about 80% of all described species. They are the dominate multicellular animals on Earth; the insects on land and crustaceans in the sea.

Subphylum Crustacea

Crustacea often contribute >90% of the biomass in zooplankton samples. They include familiar groups such as prawns, crabs, lobsters, krill and barnacles, and also less familiar groups such as copepods, cladocera and amphipods. As in other arthropods, crustaceans moult their exoskeleton to grow. Crustacea are distinguished from other arthropods by two-segmented limbs and naupliar stages before later larval stages.

Summary of Arthropoda covered in this guide:

- **Subphylum Crustacea**
  - **Class Malacostraca**
    - **Superorder Peracarida**
      - **Order Amphipoda**
      - **Order Cumacea**
      - **Order Mysida**
      - **Order Isopoda**
    - **Superorder Eucarida**
      - **Order Decapoda**
      - **Order Euphausiacea**
    - **Superorder Hoplocarida**
      - **Order Stomatopoda**
  - **Class Ostracoda**
  - **Class Branchiopoda**
    - **Infraorder Cladocera**
  - **Class Maxillopoda**
    - **Subclass Copepoda**
      - **Order Calanoida**
      - **Order Cyclopoida**
      - **Order Harpacticoida**
    - **Subclass Thecostraca**
      - **Infraclass Cirripedia**

Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Peracarida – Order Amphipoda

Amphipods are relatively large (> 5 mm) laterally compressed, often with large eyes and sometimes with chelae.

Amphipods have no carapace and generally have laterally compressed bodies. The body is divided into 13 segments, with the head fused to the thorax. Most amphipods are benthic, but the 400 pelagic species inhabit all depths and latitudes of the world ocean. Some have large claws. Hyperiid amphipods have large eyes are all pelagic and half of them are parasites on gelatinous zooplankton. Gammarid amphipods are mostly benthic, with only a few that are pelagic. They are mostly detritivores and scavangers.

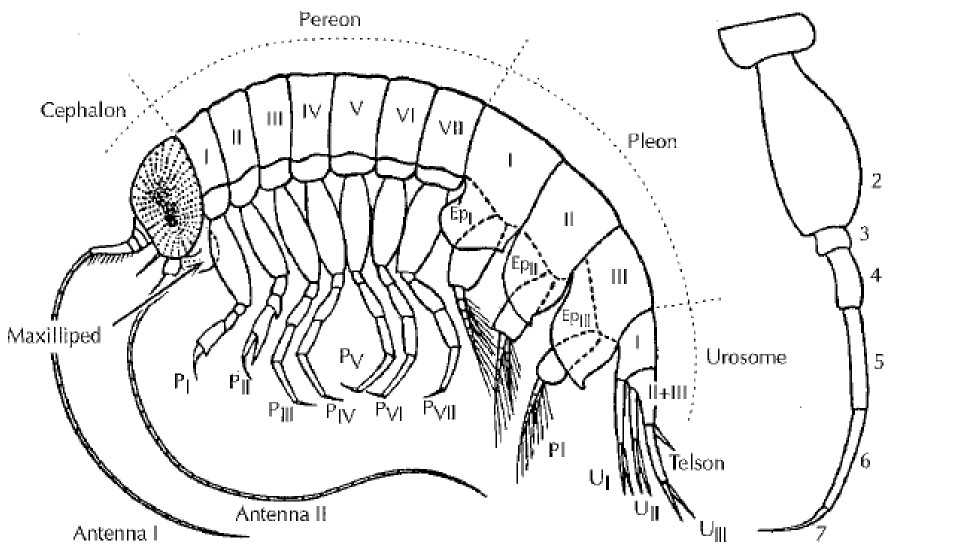


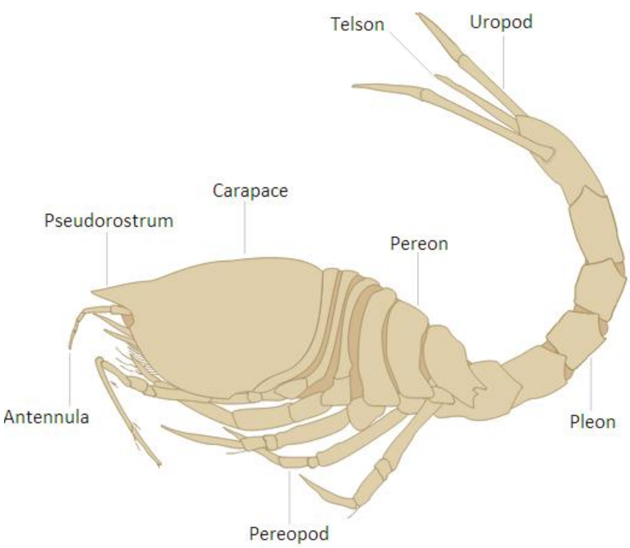
Fig. 1. Diagram of hyperiid amphipod, based on male of *Hyperia* (left; after Vinogradov *et al.*, 1982), and typical pereopod with articles numbered (right).

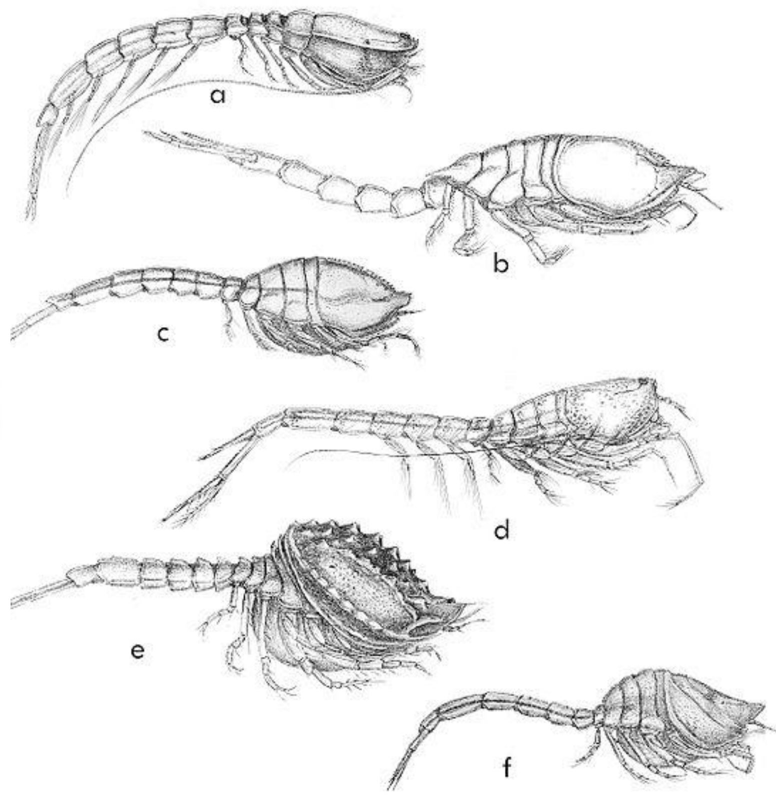
Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Peracarida – Order Cumacea

Cumaceans look like armoured tadpoles, with a an inflated cephalothorax and a slender abdomen with long uropods.

Cumaceans are primarily a marine group, with few brackish and freshwater species. The majority of species are found on soft bottoms, burrowing in the sediment, but they also emerge into the water column at night. Adult males of many coastal species may form pelagic swarms, especially at night, where they are then joined by females for reproduction. After fertilisation, the female keeps the eggs in a brood chamber; hatched larvae are retained there until they develop into a postlarva that resembles the adult.

Below: General body plan of a cumacean





Above: Specimen of six out of the eight extant families of Cumacea. (a) Bodotriidae, (b) Diastylidae, (c) Leuconidae, (d) Lampropidae, (e) Nannastacidae, (f) Pseudocumatidae

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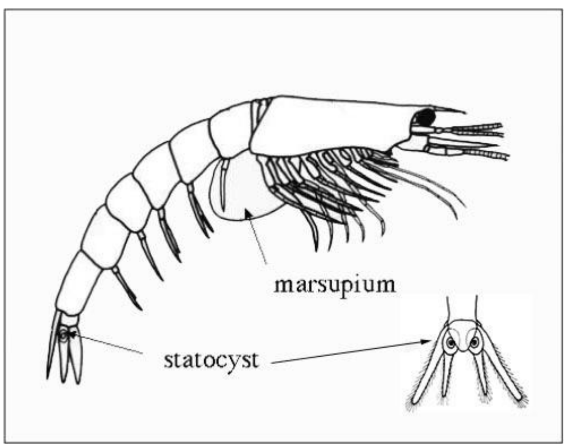
Diagram source (top left): © Hans Hillewaert, online at http://en.wikipedia.org/wiki/File:Cumacea_en.svg.
Diagram source (top right): Sars, G. O., (1900). An account of the Crustacea of Norway: Cumacea, Bergen Museum. http://en.wikipedia.org/wiki/File:Cumacea_(lbl).jpg
Image source (bottom left): Hans Hillewaert http://en.wikipedia.org/wiki/File:Iphinoe_trispinosa.jpg
Image source (bottom right): Hans Hillewaert, http://en.wikipedia.org/wiki/File:Bodotria_scorpioides.jpg

Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Peracarida – Order Mysida

Mysids are relatively large (>5 mm) shrimp-like crustaceans with a pair of statocysts in their uropod (i.e. at the end of their 'tail') used for balance and a relatively 'loose' carapace.

that have a brood pouch in the females. Mysids are characterised by rearing their larvae in this pouch rather than releasing them into the water column as most other crustaceans. Many marine mysids are found in shallow coastal habitats and emerge into the water column at night. Mysids are omnivores that feed on algae, detritus and zooplankton. They are sensitive to water quality and are thus bioindicators.



Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Peracarida – Order Isopoda

Isopods are rare in the plankton and tend to be large (> 5 mm) and dorso-ventrally compressed with unstalked eyes on the carapace.

Isopoda are ubiquitous, being found from the littoral to abyssal depths, in marine to freshwaters, and they are even the only crustaceans that have an entirely terrestrial group. Generally, isopods are benthic or parasitic, with only some occasionally appearing in the plankton, such as juveniles of the Family Gnathiidae that are parasitic on fish, but can be found swimming around in the plankton.

Of all crustaceans, isopods are the most diverse in body form and the body is not always flattened. Isopods can be distinguished from other similar crustaceans because they have only one pair of uropods and lack strong clawed first thoracic legs.

Text source: Zooplankton and Micronekton of the North Sea. Matthijs van Couwelaar
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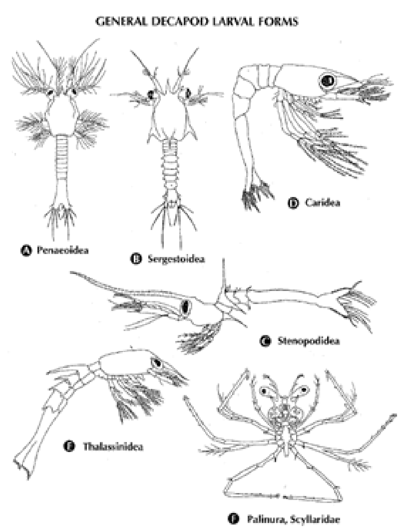
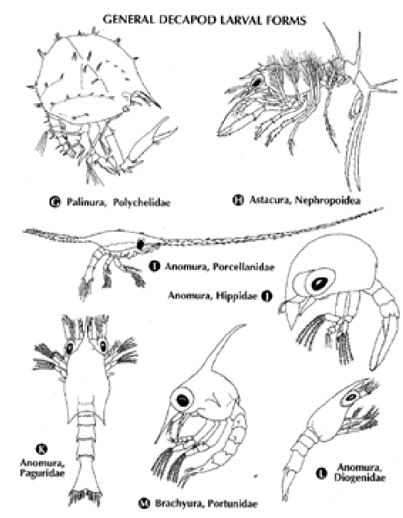
Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Eucarida – Order Decapoda

Decapod larvae are relatively big (> 3 mm), have large eyes, have many segmented appendages, often have spines, and normally have a distinct 'head' and 'tail'.

Decapoda includes the typical larger and well-known crustaceans, many of which live on or close to the sea bottom as juveniles and adults, but spend their larval life as part of the plankton. The largest group of decapods is the Brachyurans, the true crabs, with ~5,000 species worldwide, but most of their larvae remain unknown. Other groups of decapods include the Anomura, the hermit crabs, squat lobsters, porcelain crabs, king crabs and coconut crabs; the Caridea, the true shrimps that swim and brood their eggs; and the penaeid prawns, Sergestids and Lucifer that have large stalked eyes and broadcast spawn.

The different types of decapods have a variety of larval forms including nauplii, zoea, megalopa and mysis, as can be seen below.





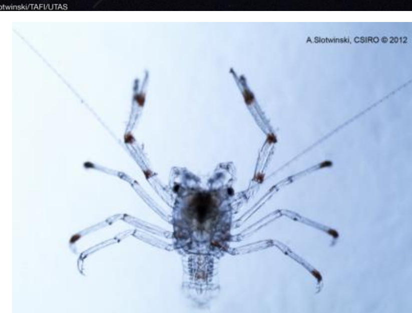


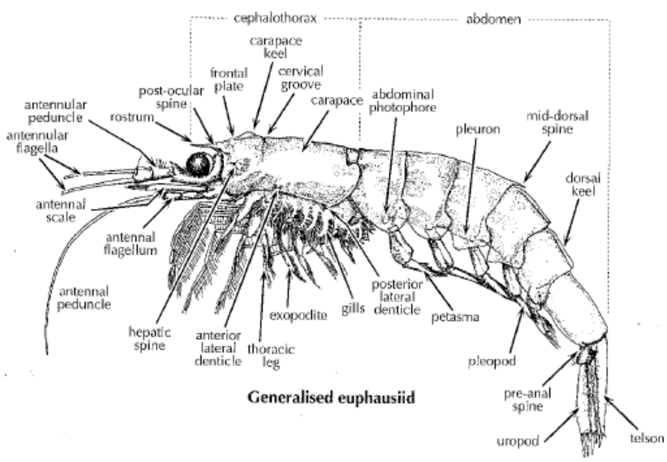
Diagram source: Boltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Eucarida – Order Euphausiacea

Euphausiids are shrimp-like crustaceans that can be distinguished from decapods by their external gills.

Euphausiids are are meroplanktonic (up until ~5 mm), becoming part of the micronekton when larger. This distinction is frequently ignored in analysis of zooplankton net samples, as they often retain substantial numbers of adults if collected at night. The word *Euphausia* derives from Greek *eu* for good or true, and *phausia* for light emitting. Early naturalists were impressed by the brightness of the photophores of these small animals bioluminescence. The term krill has become synonymous with euphausiid and was first used by Norwegian whalers who applied it to the swarming 'little fish' that signaled whale feeding grounds.

Some suggestive features are the eyes tend to be darker with little surrounding whitespace and the telson ('tail') has a middle spine and an odd number of spines, compared with decapods. When visible, photophores of euphausiids are diagnostic.



Larval euphausiid, east coast of Tasmania

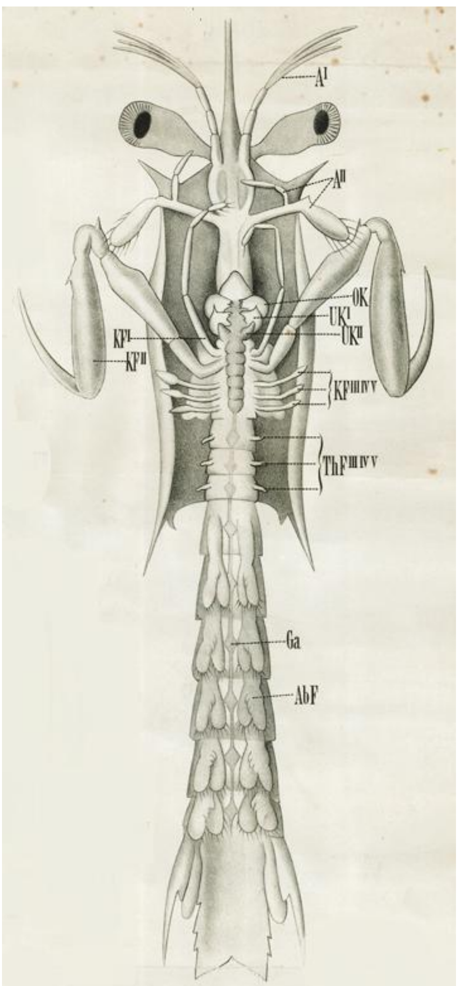
Euphausiid, east coast of Tasmania

Text source: Euphausiids of the World Ocean E. Brinton, M.D. Ohman, A.W. Townsend, M.D. Knight & A.L. Bridgeman http://species-identification.org/
Diagram source: Boltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Arthropoda – Subphylum Crustacea – Class Malacostraca – Superorder Hoplocarida – Order Stomatopoda

Stomatopoda larvae are relatively large (> 5 mm), they have a rectangular carapace, diagnostic large raptorial appendages for feeding and stalked eyes.

Adult stomatopods live on the sea bottom and their larvae are planktonic. Stomatopoda are usually marine and mostly inhabit shallow tropical and subtropical waters, but also temperate seas. They go through several planktonic stages before becoming adult and settling for a benthic life.



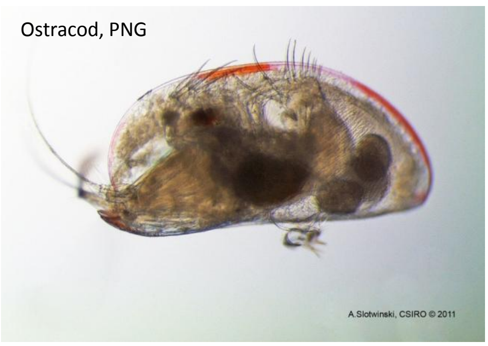
ETI, University of Amsterdam Mauritskade 61 NL-1092 AD Amsterdam ,The Netherlands. Online at http://species-identification.org/.
Diagram source: http://mcgregor.sbs.auckland.ac.nz/files/2011/01/52-Arthropoda-lo-res.jpg
Image source (above right): Peter Parks http://www.imagequestmarine.com/

Phylum Arthropoda – Subphylum Crustacea – Class Ostracoda

Ostracods have a clam-like shell that has a point (or rostrum) at one end of the shells.

The majority of species are benthic, with only a few holoplanktonic. In coastal waters many species are meroplanktonic. Adult sizes of the oceanic planktonic species are in the range of 0.8 to 4 mm. Planktonic ostracods have received scant attention from oceanic ecologists them being more or less ubiquitous at all oceanic depths.

The valve (hard parts) encloses the body with its appendages (soft parts). Planktonic ostracods play an important role in the re-cycling of material within the deep ocean.



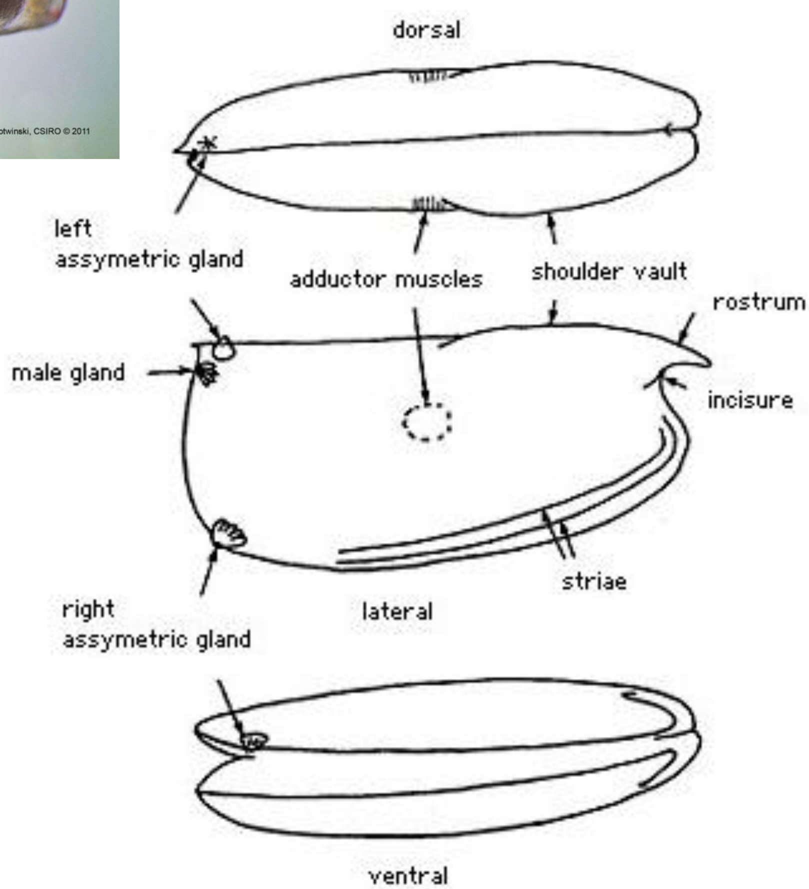


Diagram of a "typical" halocyprid ostracod, showing the main features of the carapace used in identification. from Angel (1999)

Text and diagram source: Boltovskoy, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands. Online edition http://species-identification.org/.

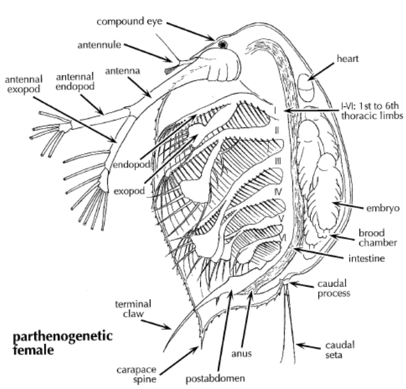
Phylum Arthropoda – Subphylum Crustacea – Class Branchiopoda – Infraorder Cladocera

Cladocera are small (<1.3 mm) crustaceans, most with an anterior, single, large compound eye. The head usually has large, segmented and branched antennae.

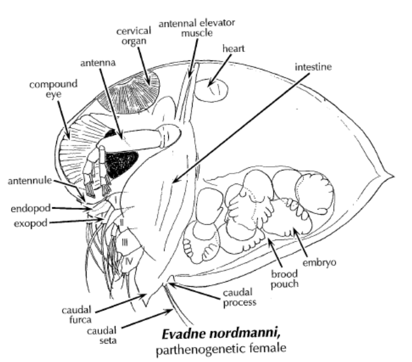
Cladocera are holoplanktonic crustaceans commonly called 'water fleas'. There are only eight true marine species worldwide. Eggs, embryos and young stages are replicas of the adults and are retained in the brood chamber (in their body), so there are no free larval stages. Cladocera are often found floating on the surface of samples, which may be due to trapped air inside the carapace.

Most species are found in fresh or brackish water, near the coast. The life cycle is dominated by parthenogenesis (asexual reproduction), with occasional periods of sexual reproduction. Under favourable conditions, cladocera reproduce through parthenogenesis, producing only female clones, and the populations can increase explosively. These population increases are usually followed by production of males, then sexual reproduction under unfavourable biological, chemical or physical factors, stressing the population. Following copulation, one or two thick-walled, dormant eggs are produced in the brood chambers. These may be released by the females, or reach the bottom when the female dies. They can survive for long periods in the bottom sediments until conditions favour hatching, forming an egg bank for the next year, or later generations.

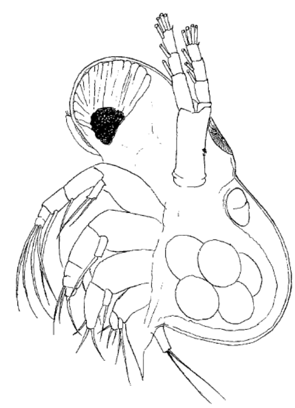
Penilia sp. (with embryos in chamber)



Evadne nordmanni (with embryos in chamber)



Podon intermedius (with embryos in chamber)



Penilia sp., east coast of Tasmania

Evadne sp., east coast of Tasmania

Podon sp., east coast of Tasmania

Text and diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Arthropoda – Subphylum Crustacea – Class Maxillopoda – Subclass Thecostraca – Infraclass Cirripedia

Cirripede nauplii are large compared with copepod nauplii and have two lateral spines; the subsequent cyprid larvae is clam-like, but does not have a rostrum on the shell.

Adult barnacles are obvious members of the intertidal zone attached to rocks and their larvae often dominate inshore plankton during their breeding season. They have two larval stages. The first is a nauplius stage (below left), which is different from all other nauplii of crustaceans in having two lateral spines on its 'head'. They are also usually larger, have a posterior spine, a distinctive eye spot and have lots of setae (i.e. they appear 'hairy'). They have five naupliar stages and then they moult into a cypris larvae (below right). This stage appears similar to an ostracod, but does not have the point (rostrum) on the side of the 'shell' as an ostracod does.

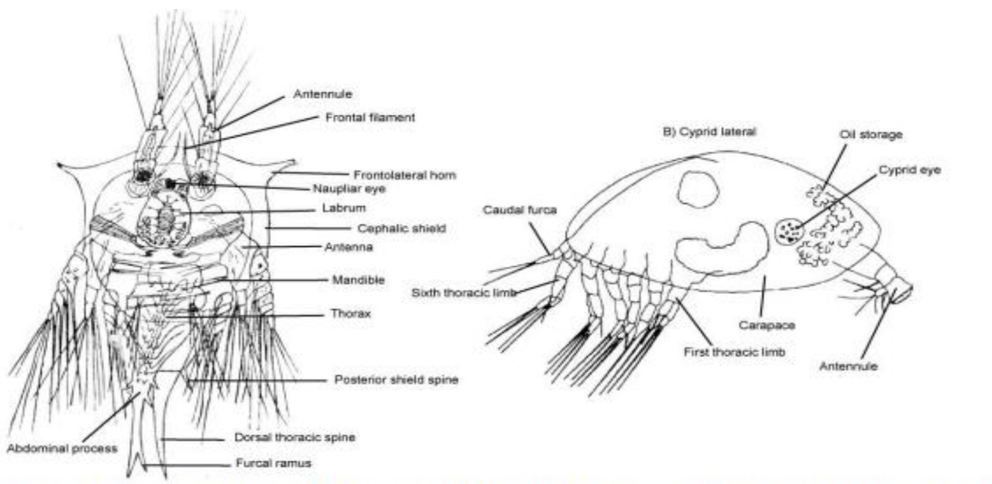
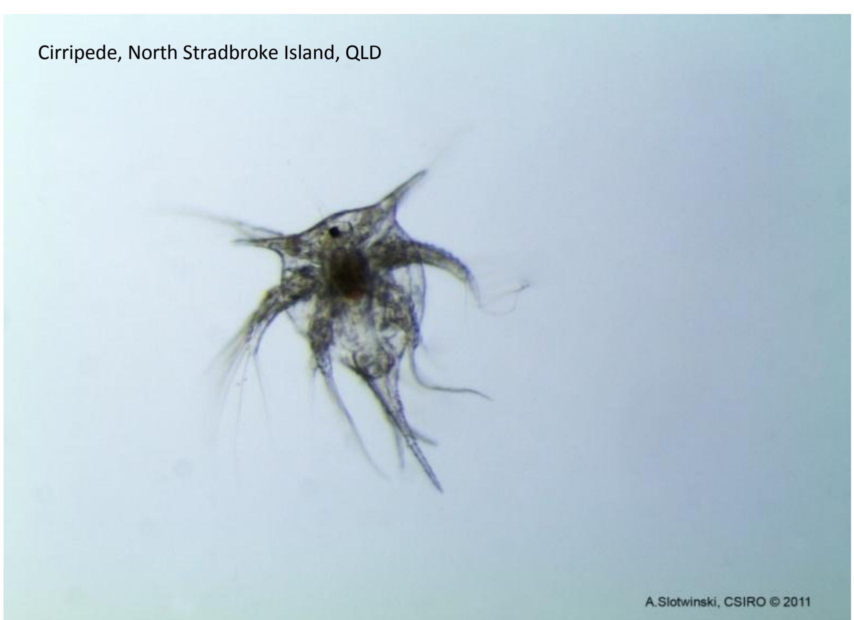


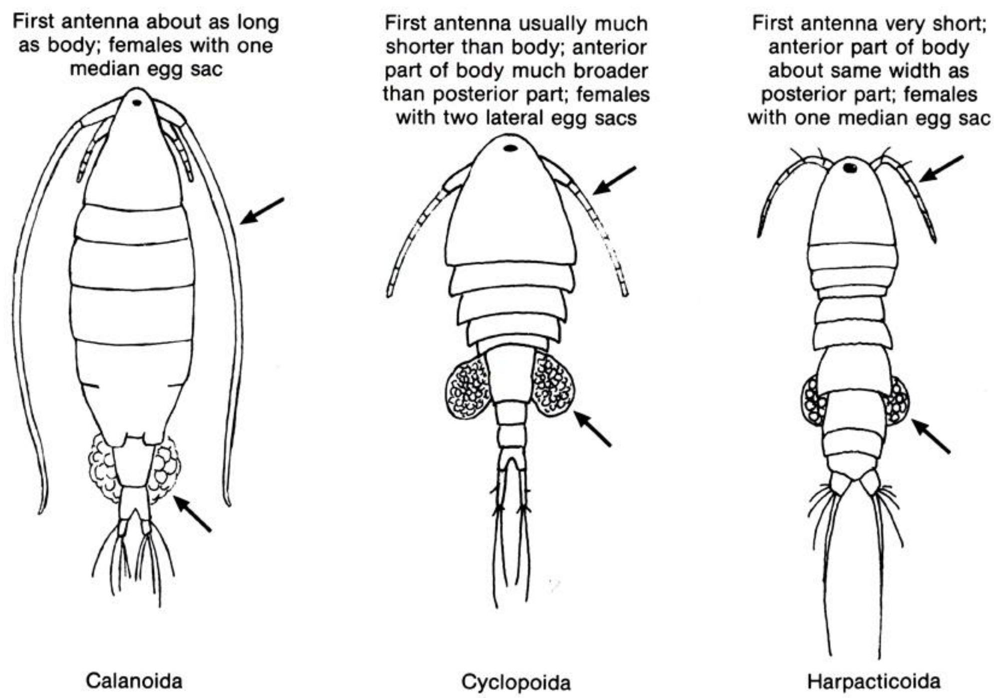
Fig. 1. Typical barnacle larval stages (A from Hoek, 1909; B from Burrows *et al*., 1999).

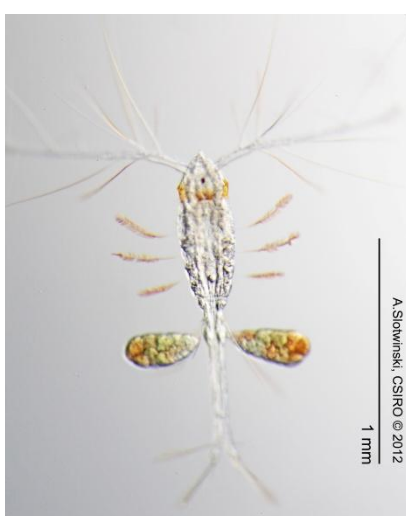


Text and diagram source: Conway, D.V.P. (2012) *Marine Zooplankton of southern Britain. Part 2: Arachnida, Pycnogonida, Cladocera, Facetotecta, Cirripedia and Copepoda*.A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (26) 163p.

Phylum Arthropoda – Subphylum Crustacea – Class Maxillopoda – Subclass Copepoda

Copepods are probably the most abundant multicellular animals on the planet, outnumbering insects by possibly 3 orders of magnitude. Marine copepods are small crustaceans 0.2-10 mm in length. There are >10,000 species of free-living and parasitic copepods. Marine copepods are pelagic, hyperbenthic, benthic or in association with other animals. They are found in all depth and biogeographical zones of the world ocean. Copepods sometimes form up to 90-97% of the biomass of marine zooplankton, therefore copepods are an important link in marine food webs. Calanoida, Cyclopoida and Harpacticoida are the most abundant orders. Copepods typically have a short, cylindrical body, with a rounded or beaked head.





Text source: Boltovskoy, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Arthropoda – Subphylum Crustacea – Class Maxillopoda – Subclass Copepoda – Order Calanoida

Calanoids are typically bullet-shaped, their body (prosome) is much broader and usually longer than the tail (urosome), and antennae about the length of the body.

Calanoida is the most numerous and diverse pelagic copepod order. They are often dominant members of the zooplankton. There are many families and their body shape and fifth legs are often diagnostic (see next page). The main antennae are usually long. Females usually have five pairs of swimming legs, and the fifth swimming leg, when present, are symmetrical, although often much reduced in size and complexity compared to the other legs. Males always have five pairs of legs, with the fifth pair usually modified and asymmetrical for grabbing females during mating. Females either spawn their eggs directly into the sea or they are held on the body.

Calanidae

Calanidae


Temoridae

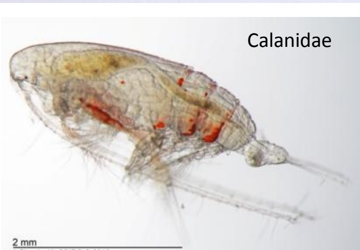

Tortanidae

Euchaetidae


Pontellidae

Mecynoceridae


Pontellidae



Calanidae

Temoridae

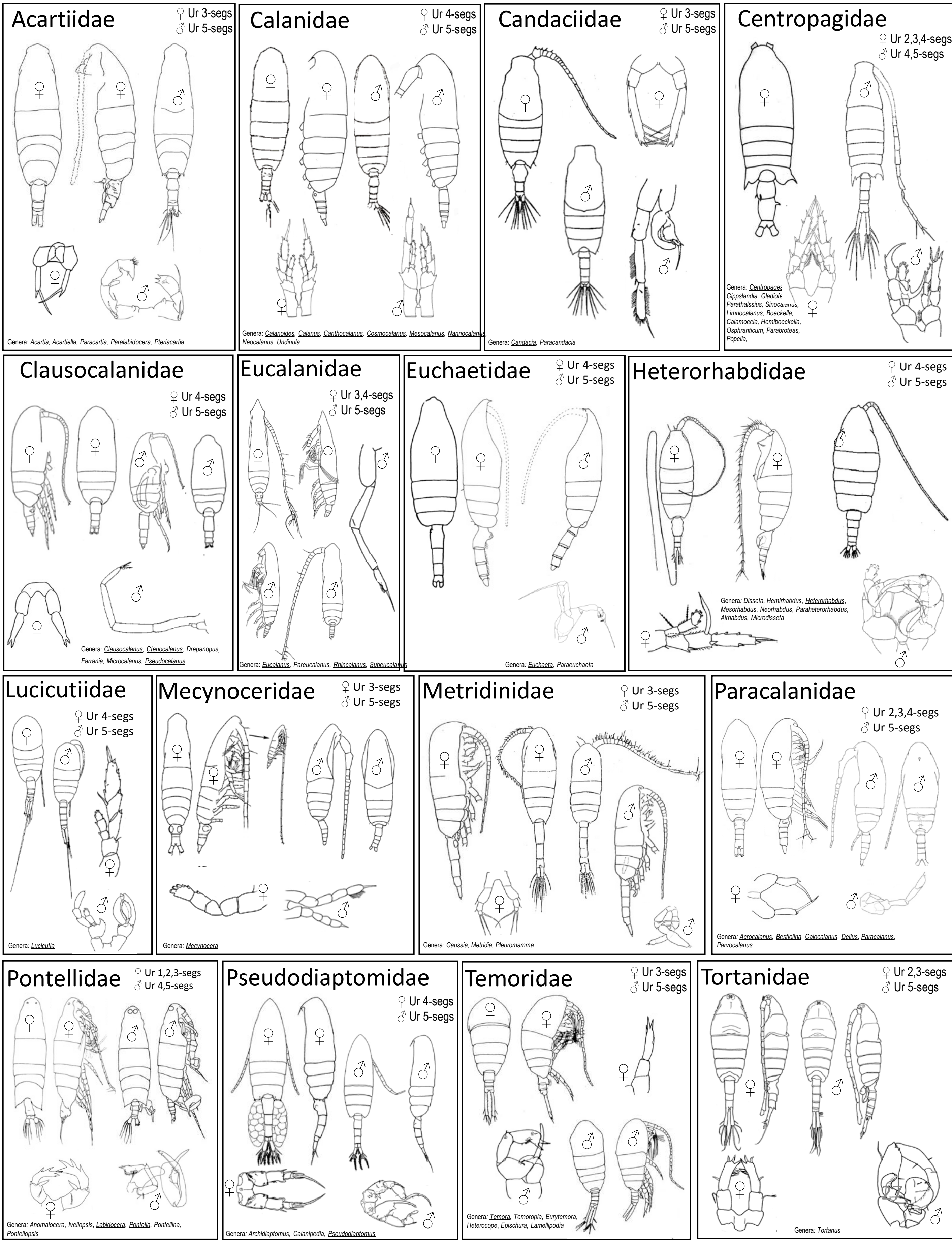
Acartidae

Centropagidae

Text source: Conway, D.V.P. (2012) *Marine Zooplankton of southern Britain. Part 2: Arachnida, Pycnogonida, Cladocera, Facetotecta, Cirripedia and Copepoda*.A.W.G. John (ed.) Occasional Publications. Marine Biological Association of the United Kingdom (26) 163p.

Common Calanoid Families

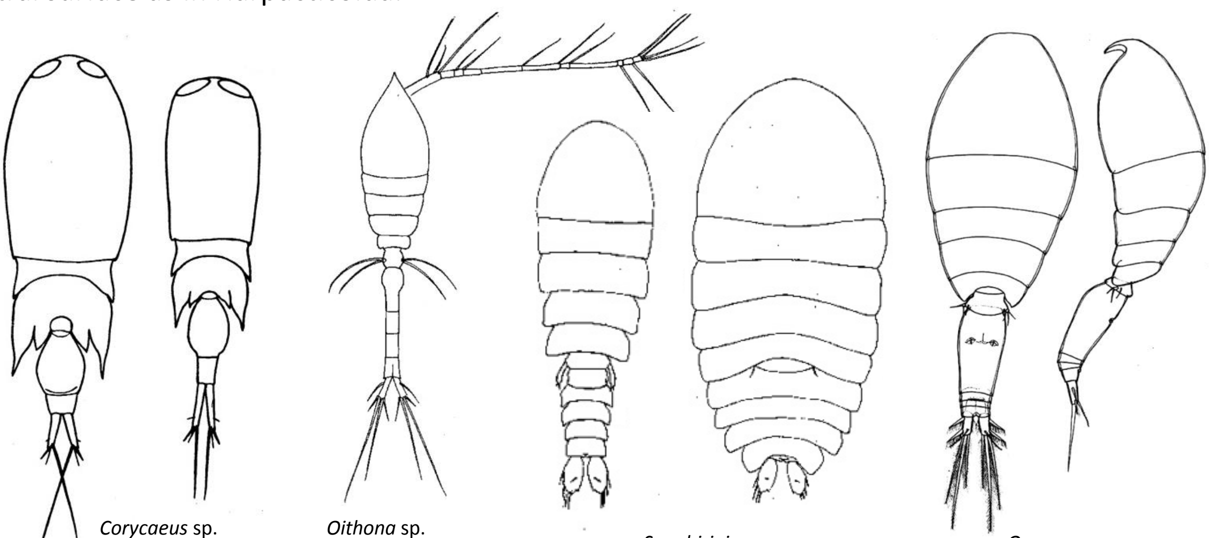
IMOS Integrated Marine Observing System



Phylum Arthropoda – Subphylum Crustacea – Class Maxillopoda – Subclass Copepoda – Order Cyclopoida

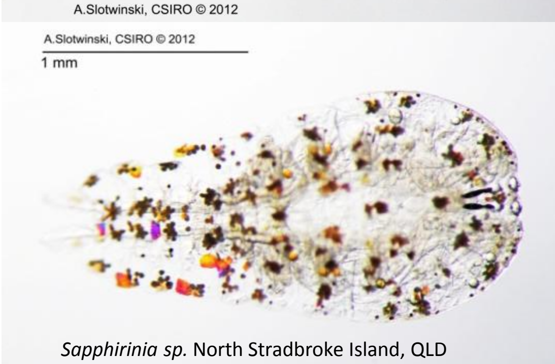
Cyclopoids (<1.3 mm) are typically smaller than calanoids, have a broader body (prosome) than the 'tail' (urosome), have a relatively long urosome (about the same length as the prosome), and antennae shorter than the the body.

Cyclopoid copepods are often more abundant than calanoid copepods. They are underestimated with a 200 µm mesh net. The most common genera are *Oithona*, *Oncaea*, *Coryceous* and *Sappharina*. The species *Oithona similis* could be the most abundant animal on the planet. A few females carry single egg sacs, but most have paired sacs attached laterally or dorsally, never to the ventral surface as in Harpacticoida.



Corycaeus sp. *Oithona* sp. *Sapphirinia* sp. *Oncaea* sp.

Corycaeus sp. North Stradbroke Island, QLD



Sapphirinia sp. North Stradbroke Island, QLD

Oithona sp. North Stradbroke Island, QLD

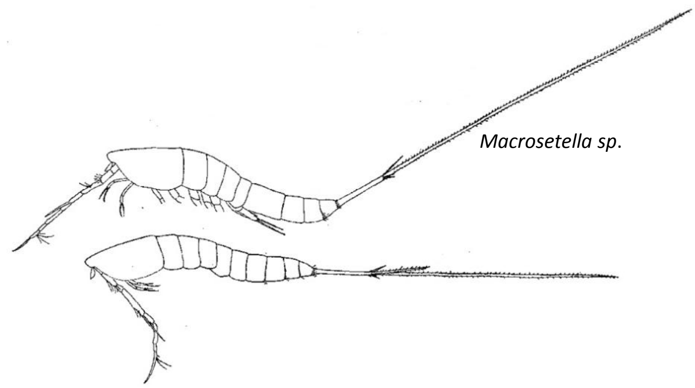
Oncaea sp. North Stradbroke Island, QLD

Diagram source: Corycaeus - O. Tanaka *in* J. Fac. Agricult. Kyushu Univ., 1957, 11 (1). [Pl.3, Figs.7-11]. Oithona - F.C. Ramirez *in* Contr. Inst. Biol. mar., Buenos Aires, 1969, 98. [p.86, Lam. XVII, fig.137]. Sapphirinia - Q.-c Chen & S.-z. Zhang & C.-s. Zhu *in* Studia Marina Sinica, 1974, 9. [Pl.10, Figs.1-5]. Oncaea - J.H. Wi, Y.H. Yoon & H.Y. Soh *in* Ocean Sci. J., 2009, 44 (2). [p.106, Fig.8].

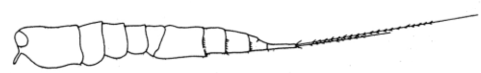
Phylum Arthropoda – Subphylum Crustacea – Class Maxillopoda – Subclass Copepoda – Order Harpacticoida

Harpacticoids (<1 mm) are small copepods, less common than calanoids and cyclopoids, have a body (prosome) that is similar in width to the 'tail' (urosome) resulting in little distinction between the two, and very short antennae.

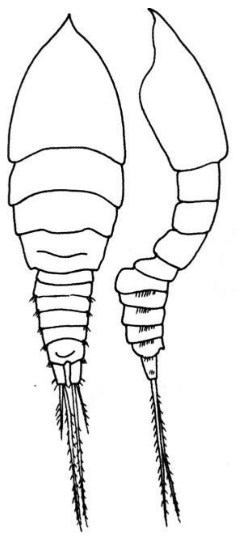
Although a large order with ~3372 species, there are only 17 truly pelagic species, most being either benthic or epibenthic. The large number of non-pelagic species are occasionally taken in samples but require specialist identification.



Macrosetella sp.



Microsetella sp.



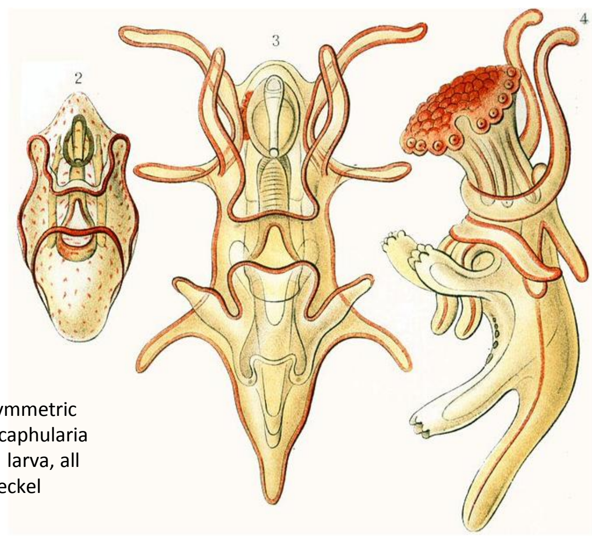
Euterpina sp.

Diagram source: *Euterpina acutifrons* - F.Y. Al-Yamani & I. Prusova *in* Common Copepods Northwestern Arabian Gulf : Identification Guide. Kuwait Institute for Scientific Research, 2003. [p.117, Fig.44]. *Macrosetella gracilis* – Q.-c Chen & S.-z. Zhang & C.-s. Zhu *in* Studia Marina Sinica, 1974, 9. [Pl.24, Figs.3-6]. Oculosetella - H.B. Owre & M. Foyo *in* Fauna Caribaea, 1967, 1 Crustacea, 1: Copepoda. [p.106, Figs.775-779].

Phylum Echinodermata

Some echinoderm larvae are ciliated and tend to look similar to trochophore stages in molluscs and annelids, but others have arms, are bilaterally symmetrical, and are more distinct.

Echinoderms are only found in marine environments. Adults are relatively sedentary on the seafloor (e.g. seastars, sea urchins, sand dollars and sea cucumbers), but their larvae are often common in the plankton. All echinoderms found in the plankton are meroplanktonic. The basic adult pattern is pentamerous (5-pointed) and radially symmetric, but the larvae are bilaterally symmetrical. The fertilised egg of echinoderms develops into a free-swimming larva. The surface of the larva has ciliated locomotory bands and often has arms and is commonly known as a 'pluteus' stage. After spending its time in the plankton, the larva attaches itself to a bottom substrate to prepare for the metamorphosis.



Above: Three kinds of bilaterally symmetric starfish larvae (from left to right) scaphularia larva, bipinnaria larva, brachiolaria larva, all of *Asterias* sp. Painted by Ernst Haeckel

Mature Echinoderm larva, North Stradbroke Island, QLD

Text source: *Zooplankton and Micronekton of the North Sea.* Matthijs van Couwelaar
ETI, University of Amsterdam Mauritskade 61 NL-1092 AD Amsterdam ,The Netherlands. Online at http://species-identification.org/.
Diagram source: Source:http://upload.wikimedia.org/wikipedia/commons/6/61/Haeckel_Asteridea_Larvae.jpg

Phylum Chordata

Chordates are animals that at some stage of their life possess a notochord (a stiff rod of cartillage that develops into the spine in vertebrates), a dorsal nerve tube, pharyngeal slits and endostyle, and a post-anal tail.

There are two main groups of chordates represented in the plankton: the tunicates and the larvae of osteichthyes (bony fish).

The tunicates are a marine group of chordates that includes sea squirts (ascidians) on the seashore. The most common members in the plankton are the thaliaceans (salps and doliolids) and the appendicularians, which are holoplanktonic. Tunicates are filter feeders and have a water-filled sac-like body structure with an inhalent and an exhalent opening that takes in and expels water with food within it. As members of the chordates, tunicates are our closest invertebrate relatives!

The osteichthyes are the bony fish and their eggs and larvae are found in the plankton.

Summary of the common chordates found in the plankton and covered in this guide:

- **Phylum Chordata**
  - **Subphyum Tunicata**
    - **Class Appendicularia**
    - **Class Thaliacea**
      - **Order Salpida**
      - **Order Doliolida**
      - **Order Pyrosomida**
  - **Subphylum Vertebrata**
    - **Superclass Osteichthyes**

Tunicata text source: Macrobenthos of the North Sea - Tunicata M.J. de Kluijver & S.S. Ingalsuo. Online at http://species-identification.org/.
Appendicularia Ttext source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Subphylum Tunicata – Class Appendicularia

Appendicularians are tadpole-like in appearance, with a distinct 'head' and tail.

Appendicularians (also known as larvaceans) are conspicuous and abundant holoplanktonic members of marine zooplankton in near-surface waters. They are found in coastal and oceanic environments, with greatest diversity in tropical regions. There are 70 species of larvaceans described. Appendicularia are the only group of tunicates to retain the chordate characteristics of having a notochord and nerve tube, but lack of a cavity as in the salps and doliolids. The easiest identification characteristic is that they resemble tadpoles. The body is divided into two regions: a trunk ('head' end) and a tail, which is generally several times longer than the trunk and is connected at 90° to the trunk.

Appendicularians feed by means of a complex mucous structure of filters, the 'house', which it secretes and lives inside of. Houses of some species produce bioluminescent flashes. The house allows appendicularians to filter smaller particles (including nanoplankton <2 µm) than other organisms and is replaced every 4 hours. Discarded houses and fecal pellets from appendicularians are a significant contribution to carbon sequestration into deep waters.

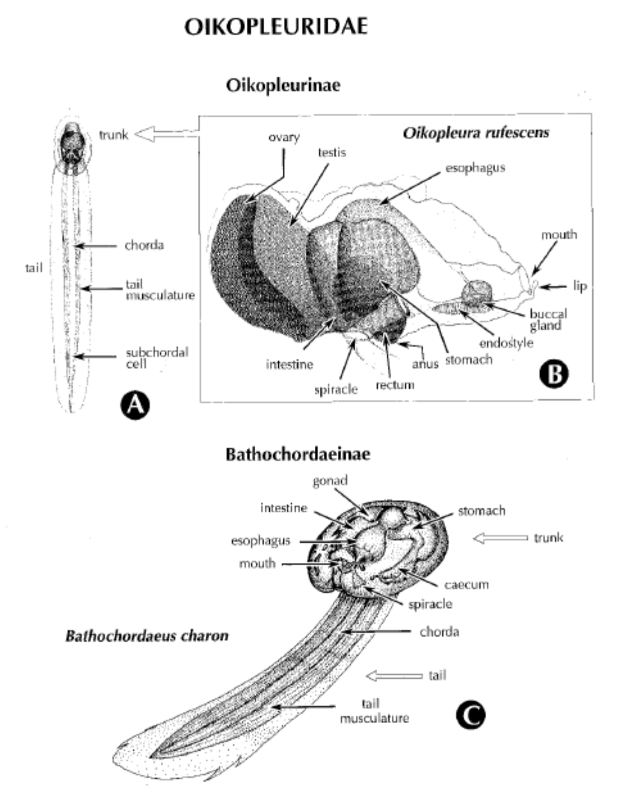


Fig. 1. General morphology of Oikopleuridae. A, C: whole animals, B: detail of the trunk of *Oikopleura rufescens*, right side. A, B: after Lohman (1896); C: after Galt (1979).

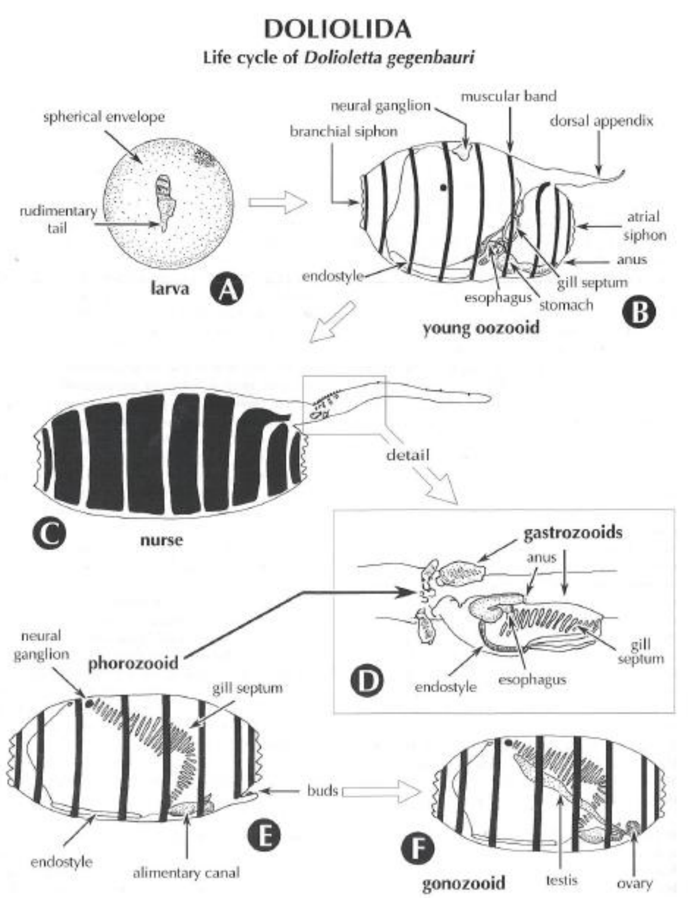
Diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

Phylum Chordata – Subphylum Tunicata – Order Doliolida

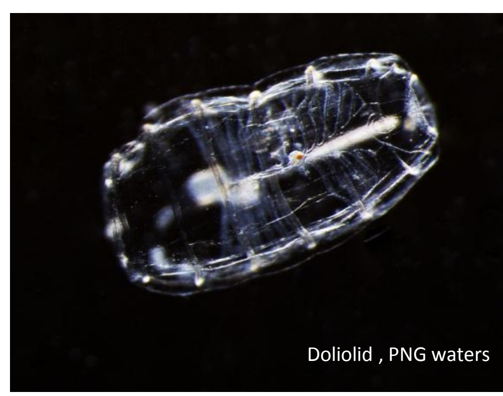
Doliolids are a rounded barrel shape with concentric muscle bands.

They have a inhalent siphon at one end and an exhalent siphon at the other. They can be distinguished from salps by: 1. Having concentric muscle bands that totally encircle the animal; 2. Usually being smaller; and 3. Usually being more barrel-shaped without two ‘horns’.

Doliolids can feed on particles of wide-ranging size, from bacteria to flagellates, diatoms, and other phytoplankton species. They collect food particles by means of a fine mucous filter, secreted by the endostyle. This net with entangled particles is ingested. Water is driven through this filter by ciliary action, instead of the muscular peristalsis used by salps. Most species are found in the tropics.




Doliolid , PNG waters


Doliolid , PNG waters

Text and diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.

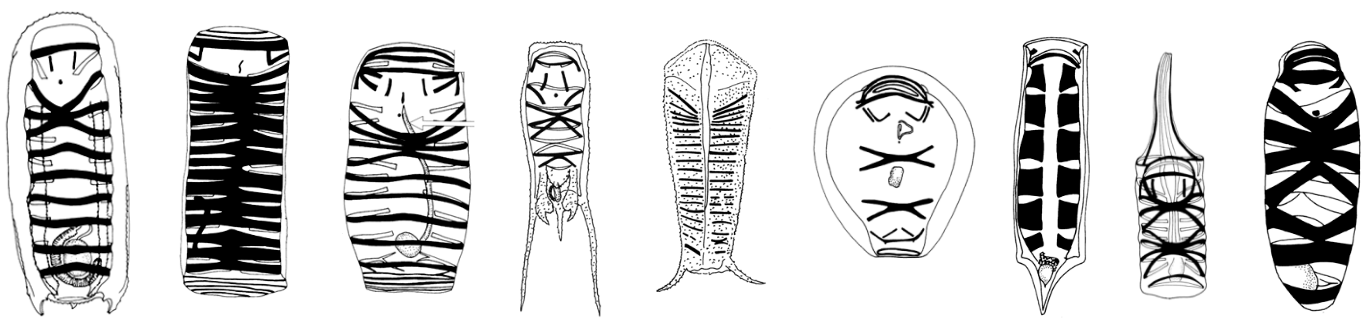
Phylum Chordata – Subphylum Tunicata – Order Salpida

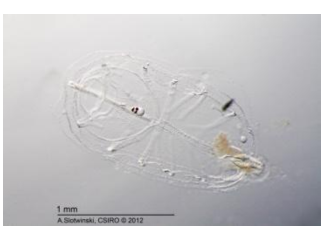
Salps have incomplete muscle bands that often fuse, and tend to be a more a squarish barrel-shape, generally larger than doliolids, and sometimes have two 'horns'.

Salps have two forms: a solitary and an aggregate form. The solitary form reproduces asexually by budding to produce chains of aggregate individuals. These aggregate forms reproduce sexually to produce the solitary forms. Salp populations can grow rapidly under favourable food conditions for several reasons: 1) the asexual production of hundreds of descendants per individual; 2) fast growth rates that are the highest recorded among metazoans; and 3) the short generation times that can vary from 2-14 days.

Salps feed by filtering suspended particles from a stream of water through a continuously renewed mucous net secreted by the endostyle, which is then ingested together with the particles entrapped. Salps normally swim and feed continuously. Salps are food generalists, able to filter a wide particle size-range (from about 1 µm to <1 mm). Most salps are tropical.

Variation in salp morphology





Salp, North Stradbroke Island, Queensland

Salp, North Stradbroke Island, Queensland

Salp, Maria Island, Tasmania

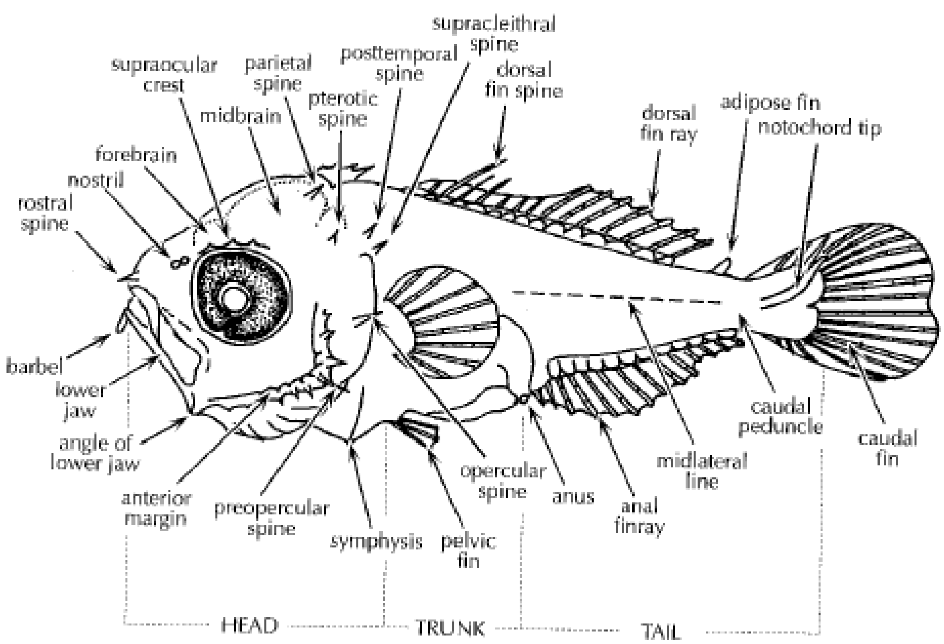
Salp, east coast of Tasmania

Text source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.
Diagram source: Godeaux J (1998) The relationships and systematics of the Thaliacea, with keys for identification. In: The Biology of Pelagic Tunicates, Bone Q (ed). Oxford University Press

Phylum Chordata – Subphylum Vertebrata – Superclass Osteichthyes

Fish eggs are usually spherical and larger (~1 mm) than other planktonic eggs and larvae are elongate with distinctive eyes, jaws and fins.

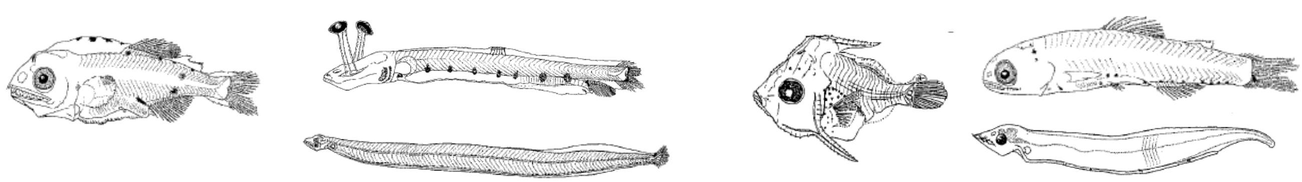
Most marine fish, pelagic and demersal, spawn pelagic eggs and larvae that spend their time in the surface layer. Accurate identification of eggs and larvae is difficult. Identification is based on a variety of morphological characters: shape, number and position of melanophores, meristic characters, relative position of fins, shape and size of fin rays, myomere/vertebra counts, head spination. A recently hatched larva is about 3 mm long, and reaches the metamorphosis stage at about 10-30 mm. During this short larval development period, morphological features change rapidly, making it difficult to construct keys for larval identification. The early life of fish is normally divided into five stages: egg, yolk-sac larva, larva, transformation (or metamorphosis), and juvenile.



Fish egg , east coast of Tasmania

Fish larva, east coast of Tasmania

Above: Schematic description of a fish larva showing anatomical and morphometric features (Leis and Renals 1983). Below: Different shapes of larval fish.



Text and diagram source: *B*oltovskoy:, D. (ed.) (1999). South Atlantic Zooplankton: Backhuys Publishers, Leiden, the Netherlands.