Lab 4:
Zooplankton Diversity and Taxonomy

Introduction

Zooplankton are the animal members of the marine planktonic community. They range in size from microscopic protozoans to jellyfish of over 10 m long. Most zooplankton occupy the second or third trophic level of the marine food web. As such, these herbivores and small carnivores play an exceptionally important role in marine food webs. The minute size of phytoplankton dictates that marine grazers are also very small. Therefore, many steps or links in marine food webs are necessary to support large marine carnivores such as fish.

Laboratory studies of zooplankton samples offer an opportunity to study the tremendous diversity found in plankton communities. The present class on zooplankton diversity and taxonomy will consider the metazoan zooplankton only. Protozoan zooplankton, though no less important, require specific and more elaborate study techniques that go beyond the time frame and possibilities of the present course. Among the metazoan zooplankton, two major groups can be distinguished: the **holoplankton**, forms that spend their entire life cycle in the plankton; and the **meroplankton**, forms that spend only part of their life cycle in the plankton, usually larval forms of benthic or nektonic adults. Meroplankton is usually more abundant in coastal areas because of the vicinity of the benthic realm.

Zooplankton is traditionally sampled by plankton nets with a mesh size of 150 µm or larger. These mesh sizes will exclude most of the phytoplankton, which is smaller and slips through the mesh, but can be towed at faster speed to catch mobile animals. Collecting zooplankton by net tows remains somewhat selective, however, as many of the larger, even more mobile forms can escape or avoid the net, and gelatinous forms are often shredded and destroyed by the nets. The technical development in remotely operated submersibles enhanced the possibilities to observe larger and gelatinous zooplankton in-situ and opened the gate to observing their behavior in their natural environment.

Holoplankton

By far the most important metazoan holoplankton in marine systems are the copepods, a group of small crustaceans. They are usually most abundant. Most copepods of epipelagic systems can directly graze on at least the larger phytoplankton (down to a size of approximately 15 µm) but do not exclude similarly sized protozoans from their diet. In this sense, they function primarily as herbivores, although protozoan diet makes them omnivores in a strict sense. In marine systems, copepods replace the water fleas (cladocerans) of freshwater systems in terms of abundance, diversity, and importance. Almost any zooplankton net tow from almost all marine planktonic communities contains numerous copepods. Very often you will also encounter the larval stages of copepods: the nauplii (singular: nauplius), the first larval stage of copepods; and the copepodites, a later larval stage that already resembles the adult copepods (Fig. 1). Copepods usually have 5-6 copepodit stages before their mold to adults. Remember: Although meroplankton is often also termed “larval plankton”, the nauplii and copepodits of copepods do not belong to the meroplankton but to the holoplankton.

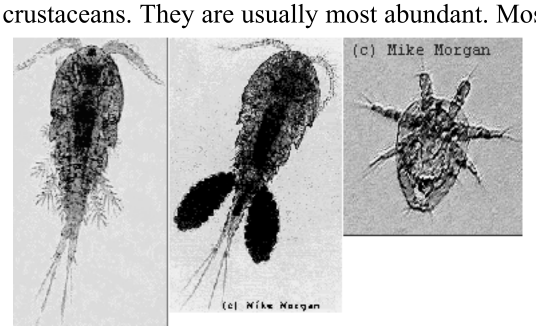

Fig. 1: Copepoda – from left to right: male adult, female adult, nauplius larva. © Mike Morgan

Despite their abundance and diversity in freshwater systems, only seven species of water fleas (cladocerans) occur in marine waters (Fig. 2). One species is restricted to the Baltic Sea, and the other six are most abundant in temperate regions, particularly the North Atlantic Ocean. At times, they can occur in considerable abundance. In subtropical regions such as off Florida, cladocerans do usually not occur in large numbers.

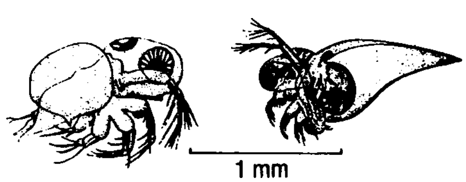

Fig. 2: Marine cladocerans: left Podon sp., right Evadne sp.

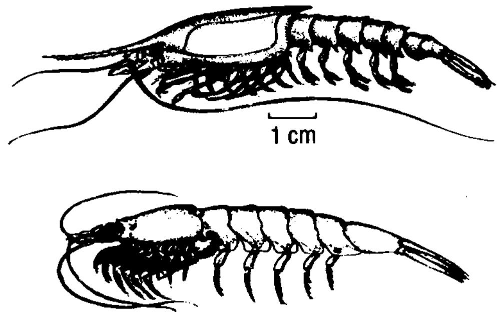

Fig. 3: Mysid (upper) and euphausiid (lower) crustacean zooplankton

Among other crustacean zooplankton, mysids and euphausiids (krill) can be abundant (Fig. 3). They are much larger than the copepods and are an important food source for fish. Krill often assembles in big swarms, and krill swarms can exhibit substantial swimming behavior. Therefore, these crustaceans are in the gray zone between true plankton and nekton.

Jellyfish are another major component of the holoplankton, although they are usually poorly preserved in net tows. Jellyfish exhibit a pronounced seasonality in their occurrence, and depending on the season you might find numerous to no jellyfish in your samples. Whereas jellyfish are single organisms, the siphonophores are colonies of individuals that appear as "jellyfish" on first sight. A common siphonophore in the subtropical ocean (Gulf of Mexico, off the Florida coast) is the Portuguese-Man-of-War (*Physalia physalis*). This species in commonly seen in offshore waters outside the Biscayne Bay, but including them in the plankton tows is carefully avoided. Their long tentacles contain nematocysts with a very potent toxin; skin contact with this species usually requires a physician and cortisol treatment. It should be noted that some of the jellyfish belong actually to the meroplankton because they represent a pelagic life stage of benthic polyps such as sea anemones. These larval jellyfish are usually much smaller than the truly pelagic species. Other gelatinous zooplankton such as salps and appendicularians are more common in open ocean systems.

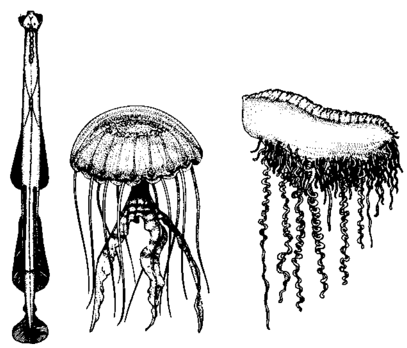

Fig. 4: Zooplankton – left to right: arrow worm (Chaetognatha), jellyfish (Cnidaria), siphonophore (the Portuguese-Man-of-War Physalia physalis) [not same size scale!]

Other holoplanktonic groups you may encounter in your samples are the arrow worms (Chaetognatha; Fig. 4), slim and long raptorial feeders of the plankton, and rotifers, which occur more abundantly in coastal areas and estuaries. Chaetognaths are exclusively marine organisms, whereas rotifers are more abundant and important in lake plankton.

Meroplankton

Some benthic marine invertebrates have no free-swimming larvae, but the majority (70%) releases eggs into the water, which hatch into planktonic larvae. The time these larvae spend in the pelagic realm can vary between few minutes to several months. During this time, the planktonic larvae participate in the food web of the planktonic community, and in some areas and during certain times, planktonic larvae can present a major and important part of planktonic consumers.

During their planktonic stage, the larvae are subjected to a significant loss by predators, and the adult stages have to make up for this loss by usually producing a high number of eggs. Including a planktonic life stage enables these species, though, to spread wider and faster than by benthic stages alone. The high number of benthic species with pelagic larval stages documents how important larval spreading must be in the context of evolution and species selection.

Depending on the time and site of sampling, various invertebrate larvae can be encountered in your samples. Often, these larvae to not resemble their adult stages, and metamorphosis in invertebrate larvae can be quite amazing. Sea urchin and starfish larvae, for example, do not even possess the radial symmetry of their adult stages; the metamorphosis of these pluteus larvae into adult sea urchins or starfish presents one of the most complex cases of metamorphosis, both morphologically as well as anatomically. Fig. 5 depicts a selection of most common invertebrate larvae. Which larvae occur in your samples will depend on the benthic communities near your sample site and the spawning cycles of these species.

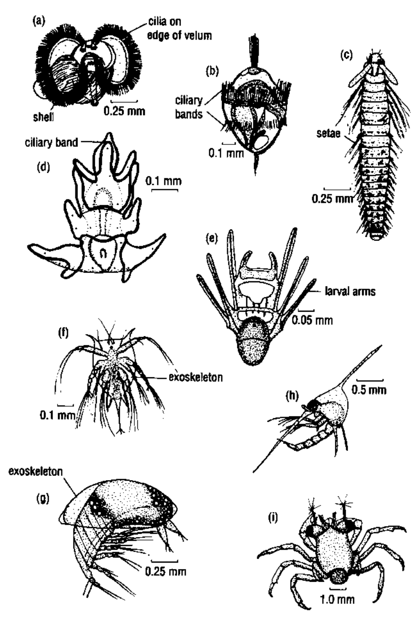

Fig. 5: Common planktonic larvae in the meroplankton. (a) veliger larva of mollusks (snails and shellfish), observe their locomotion and food collection by their ciliated membranes (velum) and the presence of shells; (b) trochophora larva of polychaetes (brittle worms) (c) older larva of polychaetes, segments are added to the tail end of the larva until they reach a length at which they settle to the bottom; (d) bipinnaria larva of starfish; (e) pluteus larva of sea urchins; (f) nauplius larva of barnacles; (g) cypris larva of barnacles, a stage that follows the nauplius stage; (h) zoëa larva of crabs; (i) megalopa larva of crabs, that develop from the zoëa larvae and start to resemble the adult crab.

Lab Work

1. Study of representative specimens of zooplankton groups

Preserved zooplankton net samples will be provided by the instructor for this exercise. The net samples were collected at different stations in Biscayne Bay and offshore by a 154 µm plankton net. Preserved samples are fixed with 1% (final conc.) formaldehyde. Avoid inhaling the formaldehyde (harmful!) and keep sample bottles closed if not in use. You will use the provided plankton samples to study the diversity of zooplankton and to prepare detailed drawings of representatives of the different groups of zooplankton. Details are given below. Include your sheets of drawings in your lab report. Your lab exercise should comprise at least 6 different species. But take the chance to observe many more different species form the samples. You should be able to get out of class and know more than six species of zooplankton. Explore the plankton samples of all stations for this study to find as many different groups and forms of zooplankton as possible.

One zooplankton sample will be tried to be provided alive. Use this sample to study the swimming behavior of different zooplankton forms. Observe the locomotion by antennae in copepods and by cilia in trochophora and veliger larvae.

Try to put effort and patience into your drawings and document as many details as you can observe. Remember that there a good and poor documentations. Take your time to observe structural details, and try to include internal structures (e.g. gut tract). Select your specimen under the dissecting microscope but use the higher magnification of the compound microscope to prepare your drawing. You can observe much more than the rough outer shape of the animals!

Although microphotography has replaced a good deal of hand-drawing these days (particularly since the introduction of digital photography), the old law of microscopy still applies today: You only have really seen what you have drawn! Drawing enhances the quality of your observations and deepens your acquaintance with the specimens. Also remember that this exercise is not a sketch-race; good quality documentations take their time, and fewer good documentations are worth more than a lot of poor sketches.

Start your observation of the plankton samples with the stereo (dissecting) microscope. Take the plankton sample bottle to your desk and use the provided plastic Pasteur pipettes to fill the bottom of a plastic petri dish. Close the plankton sample bottle and return it to the central desk. Place your petri dish under the stereomicroscope and commence your observations. Try to get an overview of what groups of zooplankton occur in your sample.

For a detailed study and preparation of drawings and documentation, use the plastic Pasteur pipette to capture your specimens of interest while observing through the stereomicroscope. You will see the tip of your pipette; once you have focused the microscope on your specimen of interest, use your second hand to hold the other arm, thereby providing stability to your pipetting hand. After you have captured your specimen from the petri dish, place it with a little drop of seawater (not too much) on a microscope slide, cover with a cover slip (never press the cover slip down, it will smash your specimen), place slide on the compound microscope and commence your observation and drawing.

Prepare drawings of the observed specimens on white paper using a soft pencil. Prepare a detailed drawing of one representative, well-preserved specimen. Provide ca. ¼ of a letter sized page for each drawing and try to document as much structure and characteristics as you can observe. Some preparations are better than others; if you feel your slide is of too poor quality for appropriate observations, capture an new specimen from your petri dish. Next to the drawing, include the zooplankton systematic group name (we will not be able to identify the specimens to the genus or species level), and some features that characterize this group and distinguish it form others. Remember that any drawing without correct and detailed annotations is worth nothing. For the larval forms, note which adult animal belongs to your specimen!

For your documentation, we will develop an identification collection on the classroom's blackboard. Whenever you discover a "new" species/group that you are interest in observing and documenting, contact your instructor. We will gather a collection of sketch drawings on the blackboard and assign the appropriate group names; this list will help your colleagues to document their observations. Be aware, though, that these sketch drawings shall not serve as an example or excuse for the quality of your documentations; you should be able to observe and document much more structure than what will be drawn on the blackboard.

2. Semi-quantitative analysis of zooplankton community structure

After having studied your plankton samples, you should be acquainted with the most important groups of zooplankton. Use this knowledge to assess the zooplankton community composition in the net samples of your field station.

Return to the plankton sample of the field station of your group. Use the plastic Pasteur pipette to fill the bottom of a plastic petri dish with sample and study your sample under the stereomicroscope at different magnifications. After you have studied your specimens under the compound microscope in detail, you should be able to recognize the different taxa even under low magnification on the stereomicroscope. Prepare a semi-quantitative list (highly abundant, abundant, occasionally found, rarely found) of the taxa you can differentiate and recognize. Discuss your observations with the members of your research team to come up with a final assessment of which taxa are more or less abundant in your sample.

For the lab report, include the semi-quantitative list of taxa and discuss which taxa were the most abundant in your sample. Which group of zooplankton is the dominant in your sample? Report the most abundant taxa to the classroom blackboard with your station number/location. After all groups have reported their findings to the blackboard, can we see differences in zooplankton community structure among the sampled stations? Discuss these differences in your lab report. Include these results and discussion in the final lab report of the field study [i.e. combine with results and discussion of hydrography (field trip, lab2), nutrient concentrations (lab 3), phytoplankton analyses (lab 5)]. Take the meroplanktonic larvae into account – their occurrence might give you information about the benthic communities at your field station.