MS20 Laboratory
Marine Plankton

Objectives

- To use a key to identify and recognize the basic characteristics of common inshore marine phytoplankton and zooplankton
- To estimate the relative abundance of plankton in a sample
- To observe the diversity and locomotion of plankton in a living sample
- To observe the effect of light on the movements of living plankton
- To estimate the effect of nutrients and sunlight on the growth rate of phytoplankton

Introduction

Plankton are organisms that live in the pelagic zone and cannot swim freely against a current. They do, however, migrate vertically in the water column on a diurnal cycle. Plankton may be classified in several ways. The most basic classification divides the photosynthetic organisms (phytoplankton) from the heterotrophs (zooplankton). Phytoplankton possess chlorophyll; zooplankton are animals. As seen in Table 1, the phytoplankton are a diverse group. They are represented by members of five different kingdoms. The most common members of the phytoplankton are the diatoms and dinoflagellates.

Table 1. Diversity of the Phytoplankton

Kingdom	Phylum	Common Name
Kingdom Cyanobacteria		blue-green algae
Kingdom Chlorophyta		green algae
Kingdom Rhodophyta		red algae
Kingdom Alveolata	Phylum Dinoflagellata	dinoflagellates
Kingdom Stramenopila	Phylum Phaeophyta	brown algae
	Phylum Chrysophyta	golden algae
	Phylum Bacillariophyta	diatoms

The zooplankton are heterotrophic organisms. Some of these may be simple single-cell protists such as the Phylum Radiolaria and Phylum Foraminifera. However, almost all of the marine animal phyla are also represented the zooplankton. Within the zooplankton, we find the larval stages of many larger, free swimming animals. Thus, we can distinguish between those animals that spend their entire lives as plankton (holoplankton) and those animals that spend only a part of their lives as plankton (meroplankton).

Plankton are collected using a fine mesh net towed through the water. A very typical mesh size is 70 µm. Using this net we will capture any organism larger than 70 µm. Figure 1 shows a typical plankton net.

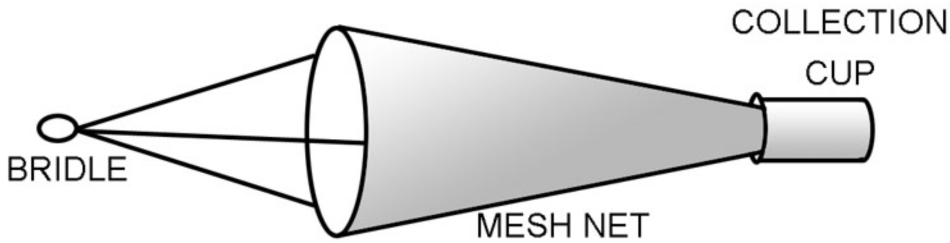


Figure 1. Plankton Net

It is possible to classify plankton based upon size. We use different prefixes to distinguish the sizes pf plankton:

mega plankton	larger than 2mm
macro plankton	0.5 mm to 2 mm
meso plankton	0.2 mm to 0.5 mm
micro plankton	0.06 to 0.2 mm
nano plankton	0.005 to 0.06 mm
ultra plankton	less than 0.005 mm

When observing plankton, we will usually use a microscope. Table Two shows the ranges of size for different types of plankton. It should be clear that a 70 µm net will not trap organisms smaller than 0.070 mm.

Phytoplankton Observation

Observe prepared microscope slides and live samples for phytoplankton. To observe the live sample you must first prepare a “live mount” as follows:

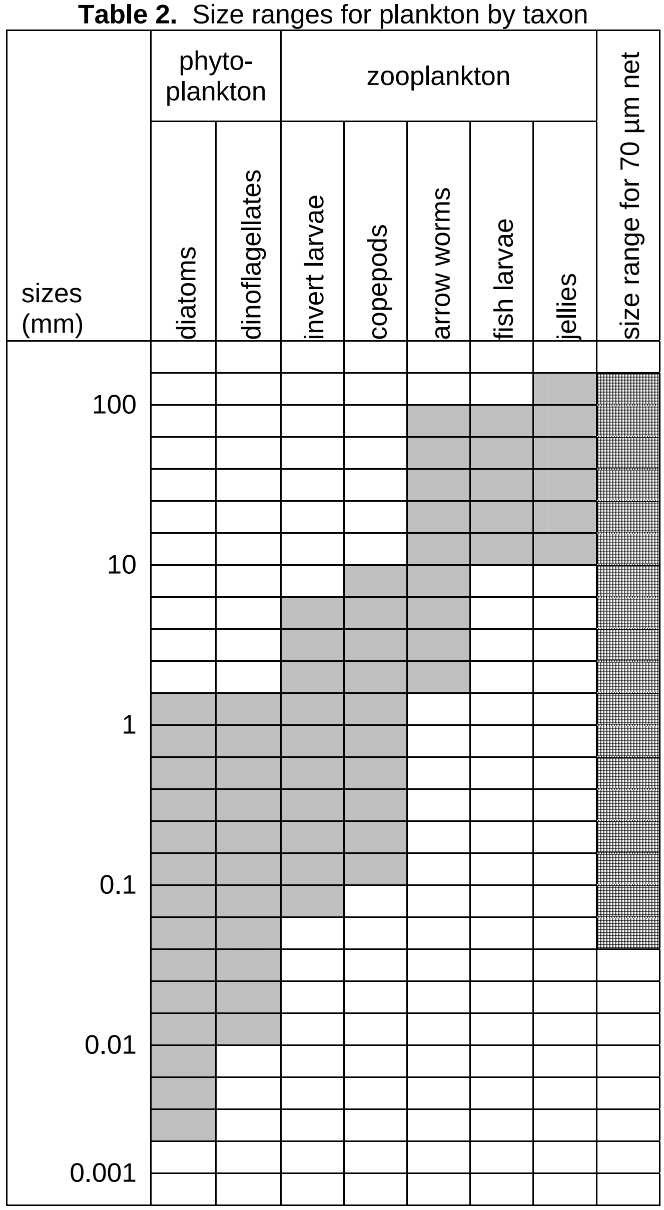
- obtain and clean a depression slide
- obtain a slide cover slip.
- place one to two drops of plankton containing water into the depression
- hold the cover slip over the filled depression
- allow one edge of the slip to touch the slide
- allow the cover slip to drop over the water

Place the slide onto the stage of the microscope and view. You should sketch several of the organisms that you see.

1. Diatoms

Diatoms will occur in two basic types based upon their shape: centric and pennate. Centric diatoms are cylindrical while pennate diatoms are long and tapered, or triangular in shape. Figure 3 shows several of the common types. Using the field guides provided (Smith, D.L and Johnson, K.B., 1996) Try to identify any diatoms you see in the live sample. Diatoms have unique silica skeletons. These skeletal elements and shapes are specific to each species. Diatoms may occur individually or in long connected chains.

Table 2. Size ranges for plankton by taxon



2. Dinoflagellates

Dinoflagellates have two flagella. One flagellum is wrapped around the cell in a groove, called the belt or girdle. The second flagellum is used for locomotion, and thus extends away from the organism. These organisms lack a shell; cellulose plates often form a kind of body armor. Figure 4 shows some of the more common local species.

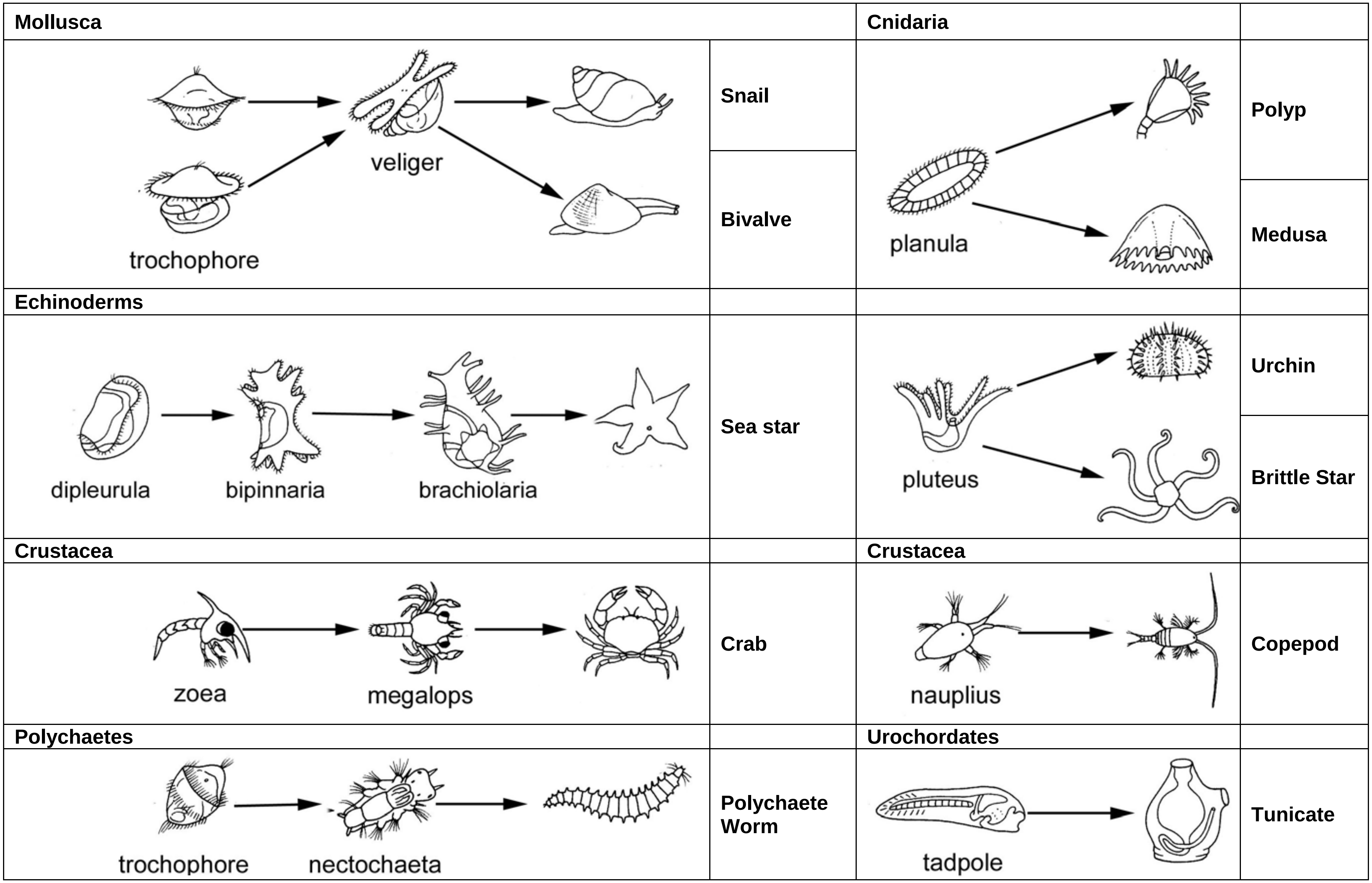


Figure 2. Some planktonic larval stages of selected organisms

Insert Figures 3 and 4 here

Zooplankton Observation

1. Live sample observation
The zooplankton are very diverse. You should observe your live sample for zooplankton. You may want to prepare a sample using methyl cellulose instead of water. This will slow them down (because the methyl cellulose is sticky) and make them easier to see. Again, use the field guide to identify these organisms. Draw several of the animals that you observe. You should see **copepods** in your sample. If you do not, you must look at a prepared slide of these animals.

2. Larval Transformations
Observe the following slides:

- *Asterias* or starfish bipinnaria
- *Asterias* or starfish brachiolaria

These are the larval forms of sea stars. Sketch each of these and sketch and adult sea star. Which of these forms transforms into the adult sea star?

Observe the following slides:

- Crab zoea
- Crab megalops

These are the larval forms of crabs. Sketch each of these and sketch and adult crab. Which of these forms transforms into the adult crab?

Observe the slide of tunicate larvae or tunicate tadpole. This is the larval form of a sea squirt, or tunicate. How does this larval form differ from the adult? How doe it resemble a small fish?

3. Prepared sample observations

Using your microscope, observe and sketch examples of the following:

- Radiolaria (Radiolarian strew) These single-celled animals have skeletal elements made of silica.
- Foraminifera (Foraminifera strew) or *Globigerina* (Globigerina strew) Globigerina is one of the most common “forams.” These animals have shells made from calcium carbonate. Each of the shell segments is connected to the rest of the animal by a foramen (hole).

4. Swimming responses of zooplankton
a. Phototaxis
Many plankton are positively phototaxic (drawn to the light). Fill a cylinder with sea water and then introduce about 25 ml of a well-mixed plankton sample. Place the cylinder into a cardboard box with a flashlight at the top. After 2 minutes open the side panel and observe the position of the plankton. Now, shine the light into the bottom of the cylinder. After two minutes, observe the position of the plankton. How can you explain the results of this experiment?

Now, let's investigate the effect of wavelength on this phototaxis. Using red, green and blue colored plastic, test the phototaxis of your sample. Record your results in Table 3. In this table a positive response (+) means the animals were drawn to the light.

Table 3. Response of zooplankton to light

Color	**response (+ or -)**
White light	
Red	
Green	
Blue	

What conclusions can you draw from the results of this experiment?

b. Swimming speed

Is it possible that these animals could swim enough to account for the vertical migrations seen throughout the day? What is the actual swimming speed of these animals? Using the same cylinder with the light coming from the top and a stop watch, record the swimming speed of ten of the most active animals (most likely animal is copepod). You will need to place a ruler along the cylinder to measure the distance travelled. Compute the average speed. Record the data in Table 4.

Table 4. Swimming speeds of zooplankton

animal #	1	2	3	4	5	6	7	8	9	10	average
speed (cm/s)											

Now, using this speed, compute the maximum distance that could be covered in a 5 hour period (be sure to convert this into meters).

Can we reasonably assume that swimming accounts for diurnal vertical migrations of zooplankton?

Modeling Phytoplankton Growth

The two most important factors affecting the abundance of phytoplankton in marine system is the availability of nutrients and the intensity of sunlight. The most common nutrients, nitrogen and phosphorous, are provided in coastal ecosystems through the process of upwelling. The problem with these nutrients is the variation in their availability.

During an upwelling cycle, and an increase in available nutrients, we can experience a rapid increase in the numbers of phytoplankton (“bloom”). Then, when nutrients are used up and no further upwelling occurs we can experience a rapid die off, or decrease in the abundance of phytoplankton.
Seasonal changes in sunlight intensity and day length also affect phytoplankton abundance. Most of us are familiar with the increase in phytoplankton that follows the increase in day length in spring and early summer along the southern California coast.

How fast do phytoplankton grow? The rate of increase of phytoplankton cells is really relatively easy to understand. One cell divides into two cells and each of those divide into two more. So the population numbers follow a predictable sequence: 1, 2, 4, 8, 16 and so on. This is called geometric growth and the formula to predict the population size at any time is

$$N_t = N_o 2^t$$

where t is the time (in units of the doubling time), N_t is the total population size at time t, and N_o is the starting population size. For example, let’s say we have a beaker with 50 cells per liter. Assume the doubling time is 24 hours, or 1 day. How many cells will be present after 4 days?

$$t = 4$$
$$N_o = 50$$
$$N_t = 50 \times 2^4$$
$$N_t = 50 \times 16 = 800 \text{ cells/L}$$

Assume that you have a starting population of 10 cells and doubling time of 24 hours. Complete the second row (no grazing) of Table 5, using the formula and a calculator to find the population at each of the stated times.

Table 5. Population size of phytoplankton cells at different time with and without grazing

	start	**day 1**	**day 2**	**day 3**	**day 4**	**day 5**	**day 6**	**day 7**	**day 8**
no grazing	50								
with grazing	50								

In the real world, several things could affect the size of a population. For instance, predation by zooplankton would decrease the total population size. The rate of predation is generally a fairly constant number. For instance, it would not be unreasonable for zooplankton to eat 15% of the phytoplankton. This, of course, would reduce the rate of population growth. The formula requires a modification.

$$N_t = N_o 2^{t(1 - \text{grazing rate})}$$

Complete the third row of Table 5 (with grazing) using this new formula and the grazing rate of 15%. This is easily completed using your calculator.

Finally, graph the data for no grazing and grazing in Figure 5.

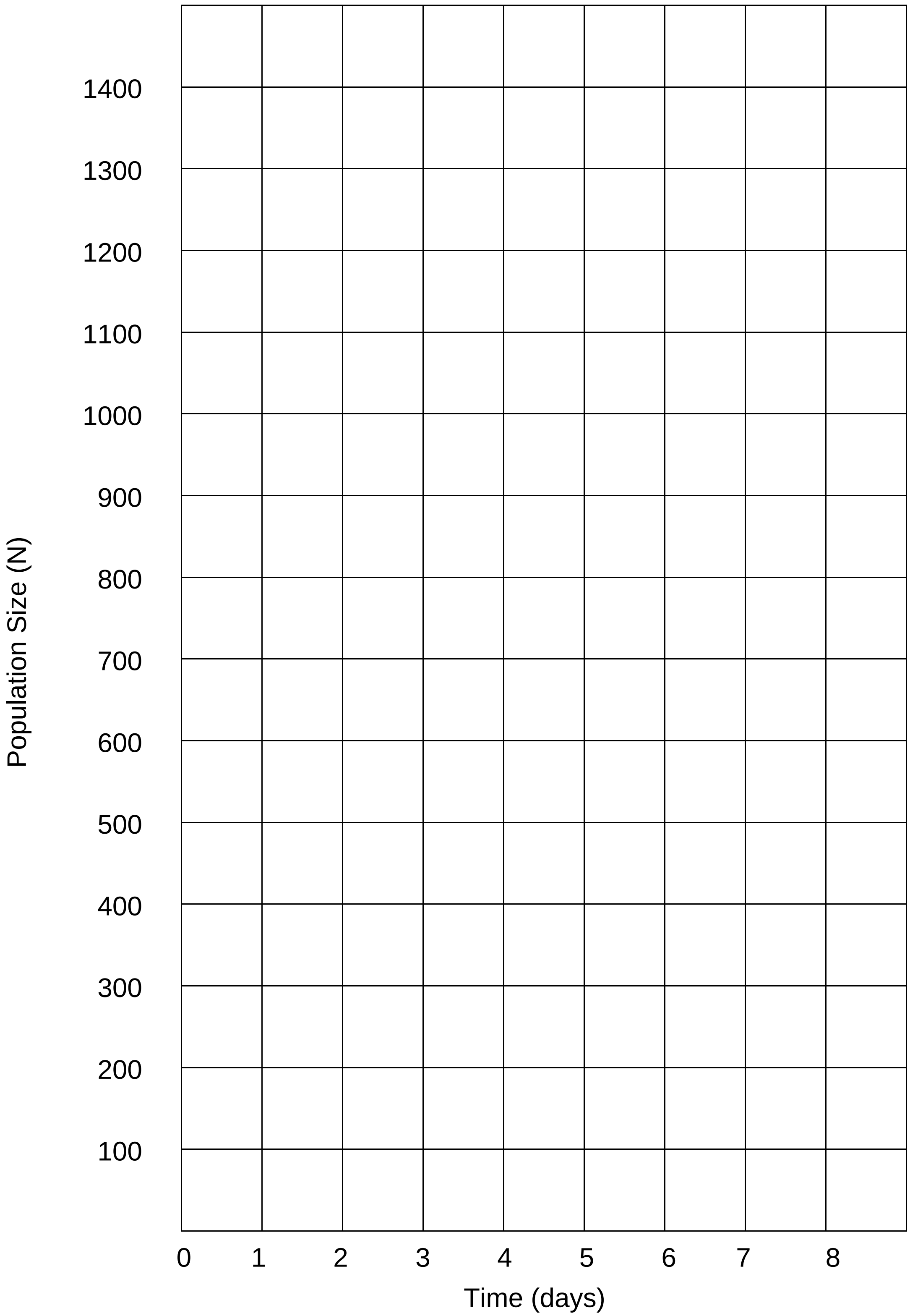


Figure 5. Population size at different times with and without grazing