GUIDE TO THE COMMON INSHORE

MARINE PLANKTON

of Southern California - 4th Edition

Late megalopa larva of a crab.

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UCLA OceanGLOBE

Condensed for public educational purposes from the textbook, Ocean Images: the Plankton, available online at www.Blurb.com

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With special thanks to the crew of the R/V Sea World UCLA, 1995-2008.
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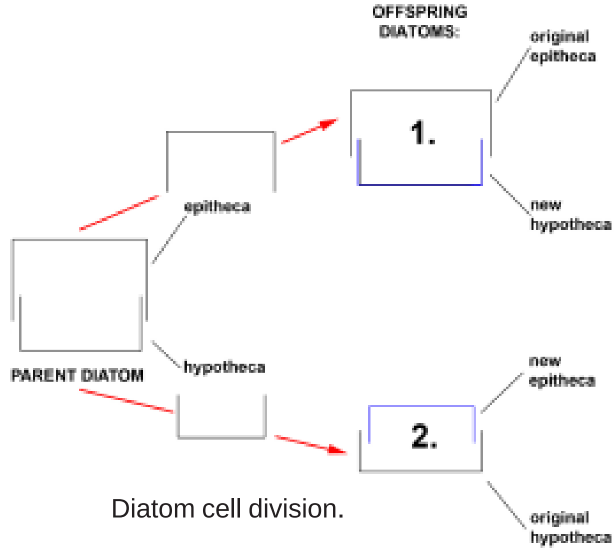
And a special thanks to the students who paddled for plankton at Zuma Beach
as part of their research project at Malibu High School. Go Sharks !

PHYTOPLANKTON
1- Introduction to the Diatoms.

Members of the Division Chrysophyta (or Bacillariophyta) are known as diatoms. The word “Diatom” comes from the Greek ***Dia***, = across, and ***tom***, = to cut. This refers to the fact that diatoms are enclosed within two glass (SiO_2) shells which split across the middle and separate from each other during reproduction. One shell is older (the epitheca) and is slightly larger than the other, younger shell (the hypotheca). The smaller fits inside the larger like a “pill box” or Altoid® mint container. As shown in the diagram to the right, during cell division they split apart to reproduce. Each section grows a new, smaller half that fits inside the original. Thus, half of the new cells are smaller in size than the other half. This means that diatoms of the same species may be quite variable in their size.



Diatom cell division.

Chaetoceros sp. a diatom chain.

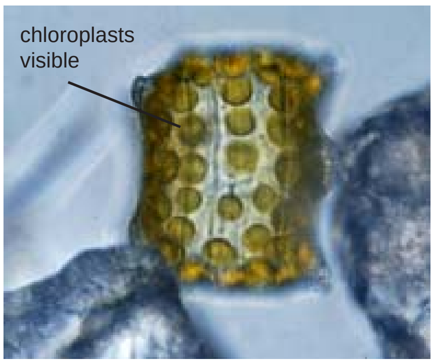
Coscinodiscus sp. a solitary diatom.

Under the microscope most diatoms appear green or golden, and their frustules are as clear as the glass which makes them. In the photos above you can clearly see the chloroplasts inside the cell wall. When diatoms are exceptionally abundant in the surface water, the ocean may appear green. Some species like *Coscinodiscus* (right) are solitary, while others like *Chaetoceros* (left) form long chains.

Diatoms, along with photosynthetic bacteria, are among the most important groups of producer organisms in the marine ecosystem. They inhabit the sun lit upper surface waters of most oceans and help form the base of the food chain using photosynthesis to convert solar energy into chemical bond energy. Many diatoms convert the carbohydrates that are produced during photosynthesis into oils. These oils are less dense than the surrounding seawater and, thus, help buoy the diatoms upward into the illuminated photic zone of the ocean. Some diatom chain-forming species prevent sinking through the growth of spiny extensions (the setae or chaetae). During population explosions or “blooms” of these spiny diatoms they may damage the sensitive gills of fish and other animals.

Pseudo-nitzschia sp. a toxic diatom.

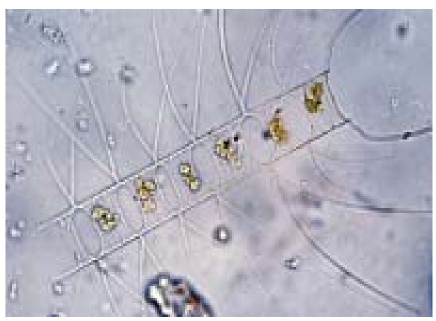
A small handful of diatom species are also toxic to marine animals and humans. For example, *Pseudo- nitzschia* may produce a poisonous chemical known as Domoic Acid (DA) over the outside of its shells. DA is known to cause Amnesic Shellfish Poisoning (ASP), a neurological disorder that affects pelicans, sea lions, and other marine animals including humans. DA builds up inside the tissues of filter-feeding invertebrates such as mussels and clams, which, if eaten during periods of high concentrations of DA, can cause amnesia and even death in humans.



Aulacodiscus kittonii
Found with sand in nano- samples taken from the surf zone.

Ceratulina pelagica

Climacosphenia moniligera



Chaetoceros sp.
Square cells with spines;
Count the number of cells.

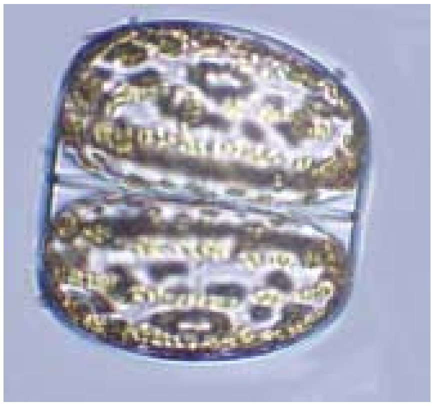
Chaetoceros socialis
Mass of very small square cells with spines.

Corethron hystrix

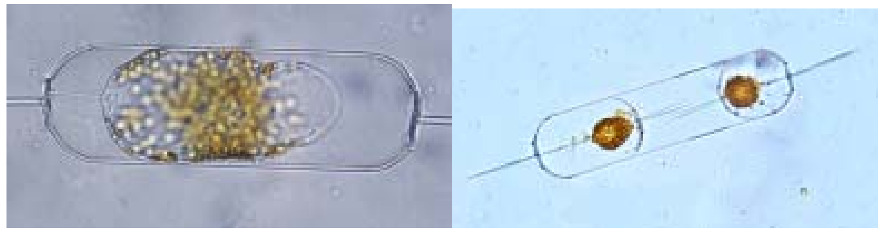
side view

top view

Coscinodiscus sp.



Coscinodiscus granii

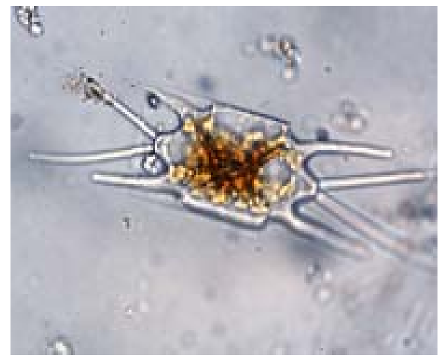


Ditylum brightwellii

top view

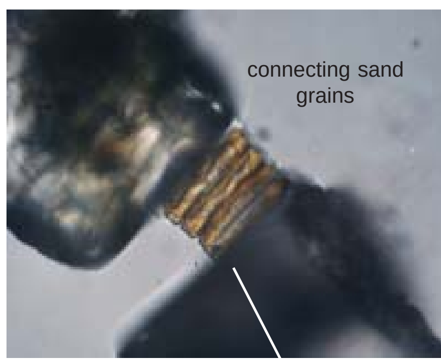
Navicula distans

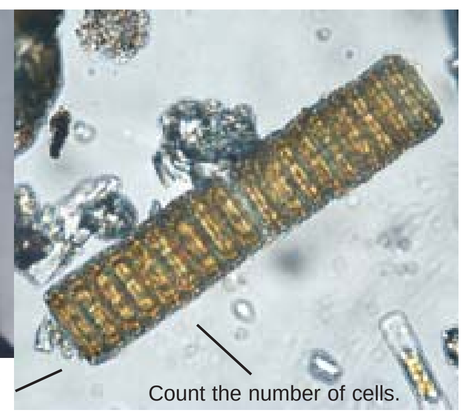
side view



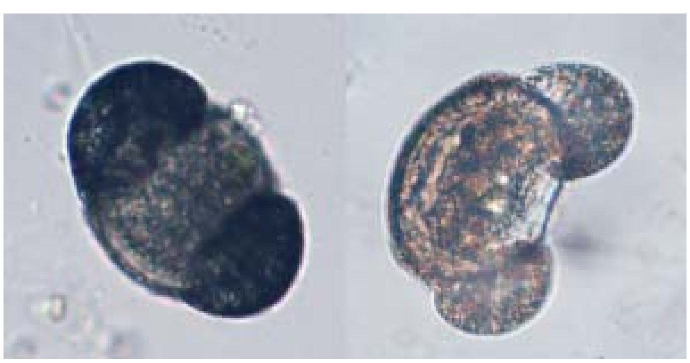
Odontella longicruris

Odontella mobiliensis

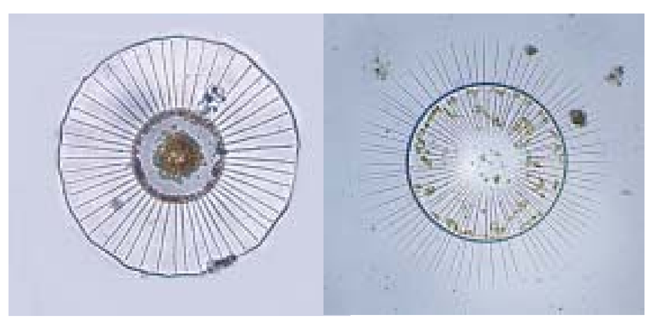




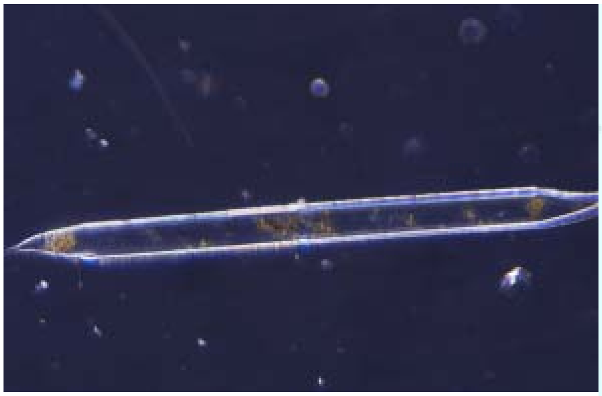
Plagiogrammopsis vanheureckii



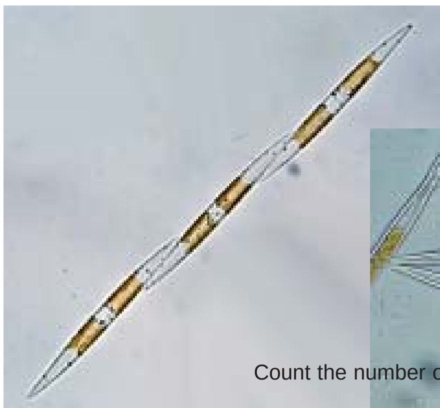
Planktoniella blanda



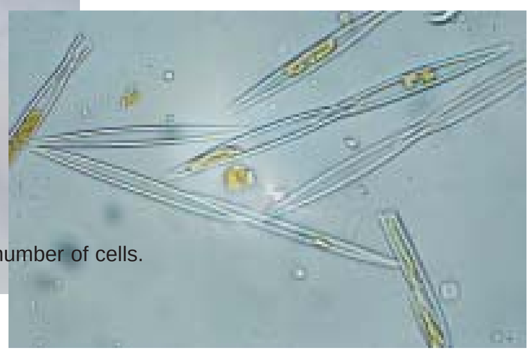
Planktoniella sol



Proboscia alata

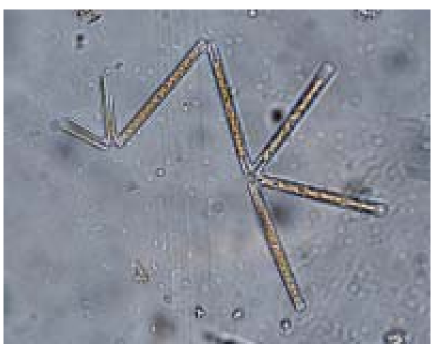


Pseudo-nitzschia australis

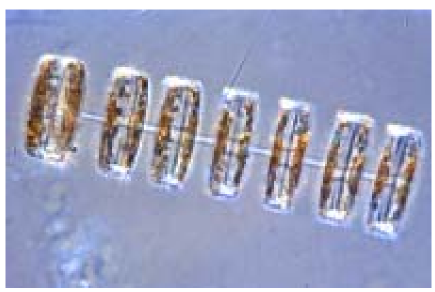


Count the number of cells.

Striatellat unipunctata



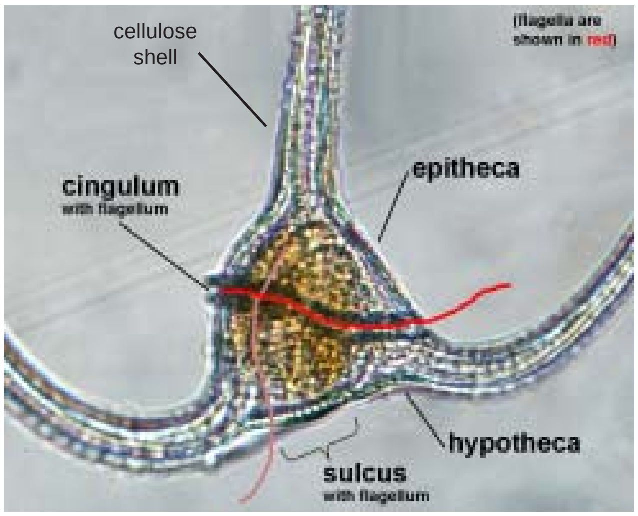
Thalassionema nitzschioides



Thalassiosira rotula

PHYTOPLANKTON
2- Introduction to the Dinoflagellates.

Members of the Division Dinoflagellata (aka Dinophyta or Pyrrophyta) are very common in coastal plankton samples. The name comes from the greek word “***Dinos***” which means “to spin,” and “**flagellate**” which means to have flagella. Flagella are whip-like “tails” that act like propellers and cause these single celled organisms to rotate through the water. When observed immediately after capture, under a microscope, dinoflagellates move in a wonderful spiral pattern. Large species are caught with a 153 µm microplankton net, and smaller species require a 20µm phytoplankton net.

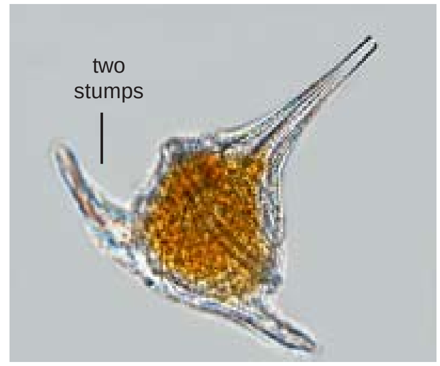


Dinoflagellates appear reddish-brown, or greenish-brown under the microscope. Many dinoflagellates have red or brown accessory pigments along with chlorophyll to carry out photosynthesis. Hence, when very abundant in the water, the phenomenon is called a “red tide.” Red tides are localized patches of discolored water from dinoflagellate population explosions. They can become so abundant that they block out all sunlight except for the upper few centimeters of the ocean surface. Consequently the dinoflagellates in the shade become heterotrophic to survive. As heterotrophs, they may rapidly deplete the oxygen content of the surrounding ocean water causing sessile organisms to die. If the red tide includes very spiny species, they can also clog animals’ gills or cause abrasions in gill tissue that then becomes susceptible to secondary bacterial infection. These factors combine to give red tides, and the dinoflagellates that cause them, a bad reputation for killing fish and other animals in certain places in the world. Dinoflagellates possess external armored plates of cellulose. These cellulose plates protect the tiny single celled organisms from predators. Often these plates are extended to form long, sharp spines that further protect the cells. Another interesting fact is that most members of this group can produce their own biochemical light. Most of the bioluminescence we view from boats or from breaking waves along the shore at night is caused by dinoflagellates.

Dinoflagellates are the second most abundant form of autotrophic life in the marine ecosystem. As such. they are at the base of the food chain and provide food for herbivorous zooplankton and sessile benthic suspension feeders. Many dinoflagellate species are also toxic, and some are poisonous to humans. Although it is unlikely that organisms high up on the food chain like humans swallow enough tiny planktonic dinoflagellates directly to pose a threat, their toxins are “biomagnified” through the food chain. Simply put, this means that it takes approximately 10 pounds of dinoflagellates to make one pound of zooplankton or benthic suspension feeder. Every unit of poison found naturally in a dinoflagellate will magnify ten-fold in the next trophic level, a hundred times in the next level and so forth. Species such as *Alexandrium* and *Gymnodinium* are known to cause PSP (Paralytic Shellfish Poisoning) in humans. PSP results when humans eat shellfish such as mussels, clams or oysters that are suspension feeders who have, in turn, been consuming these dinoflagellates. Symptoms of PSP include nausea, dizziness, a tingling numbness, respiratory failure and even death. It is not wise to consume these shellfish during periods of the year when toxic dinoflagellates are blooming.

Akashiwo sanguinea
formerly known as *Gymnodinium*

Ceratium azoricum

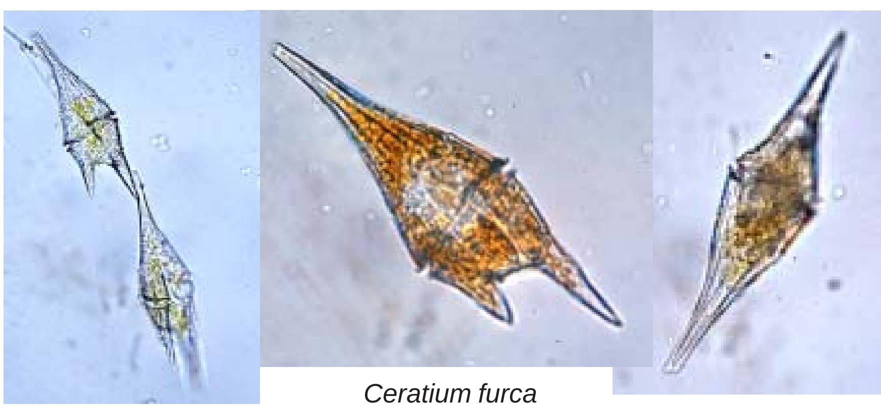


Ceratium balechii

Ceratium carriense

Ceratium divaricatum
previously confused with a gamete of
Ceratium lineatum

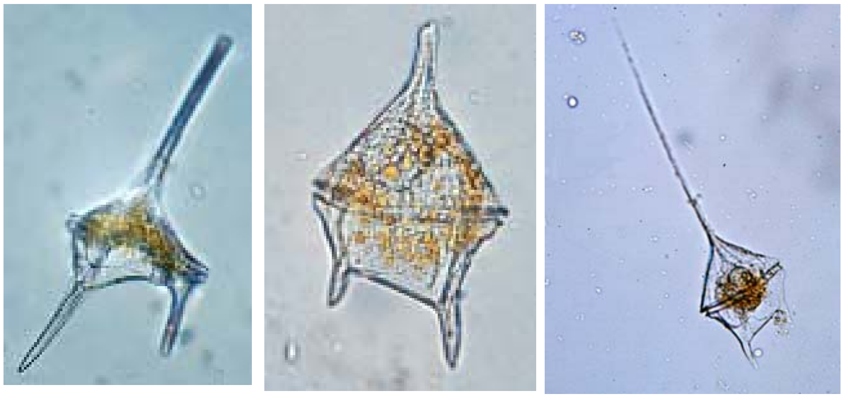
Ceratium extensum



Ceratium furca

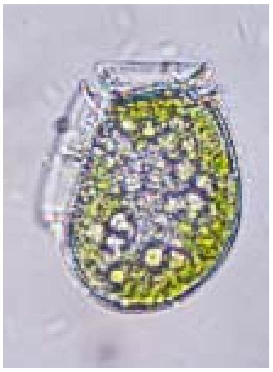
Ceratium fusus

Ceratium gravidum



Ceratium lineatum

Ceratium macroceros



Dinophysis acuminata

Dinophysis tripos

Lingulodinium polyedra
Causes red tide in Southern California

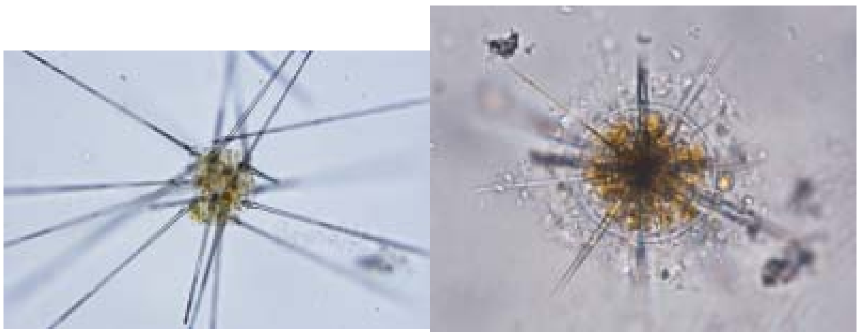
Podolampas palmipes

Prorocentrum micans

Protoperidinium sp.

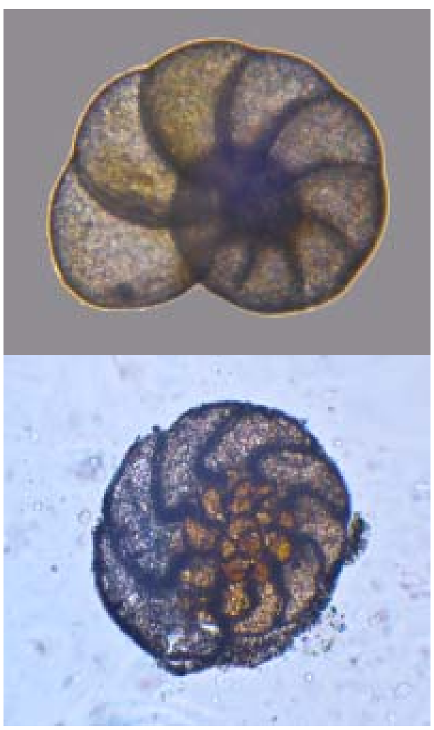
ZOOPLANKTON
Phylum Protozoa

These single celled organisms are different from the other Protists, the Diatoms and Dinoflagellates, because they are heterotrophs and do not contain photosynthetic pigments. Consequently they are mostly without color and appear clear under the microscope. Protozoans occur frequently in our coastal plankton hauls. Two groups of ameboid protozoans, the **Radiolarians**, and the **Foraminiferans**, and one ciliate group, the **Tintinnidae**, are particularly common. Radiolarians feed themselves by sending body extensions called pseudopods out of tiny holes in their shells. When they die, their shells “rain” down and cover vast areas of the seabed many meters thick. Tintinnids use cilia to create feeding currents.

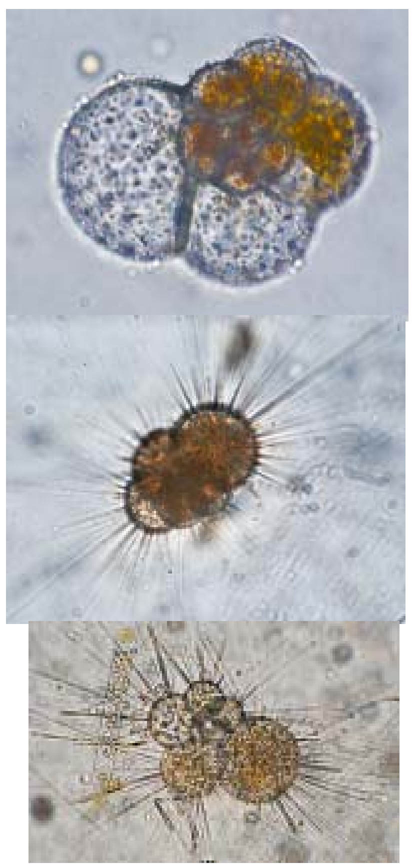


Acanthometron sp. - a Radiolarian

Unidentified Radiolarian



Discorbis sp. - a Foram
(note chambers inside shell)



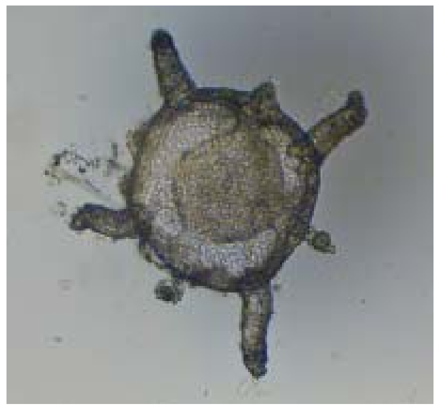
Globigerina bulloides - a Foram

Parafavella sp. - a Tintinnid

Unidentified Tintinnid
(also, a silicoflagellate *Octactis octonaria* appears in the right corner)

ZOOPLANKTON
Phylum Cnidaria

Planktonic Cnidarians (also known as Coelenterates) range in size from large jellyfish such as *Pelagia* sp. (over 2 meters long), to small microscopic **medusa** and **planula larvae** we capture in our microplankton nets. **Medusae** represent one stage in the complex life cycle of a hydroid or jellyfish. All exhibit characteristic radial symmetry, meaning they have a spherical or cylindrical body. They are at the tissue level of organization, not possessing true organs, and have only two kinds of tissues at that. Cnidarians are easy to spot with their ring of stinging tentacles surrounding a central mouth. This stinging capability makes this a group of entirely carnivorous animals, and is the origin of their phylum name, Cnidaria, Greek for “stinging nettle.” Under the microscope, most of the cnidarians we see are colorless.

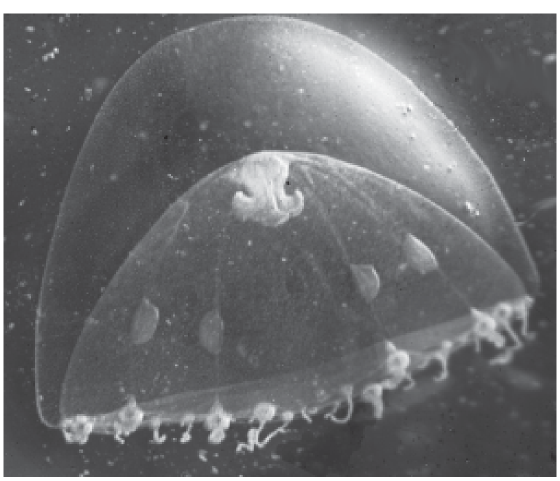


planula larva

Unidentified medusae

stinging
tentacles

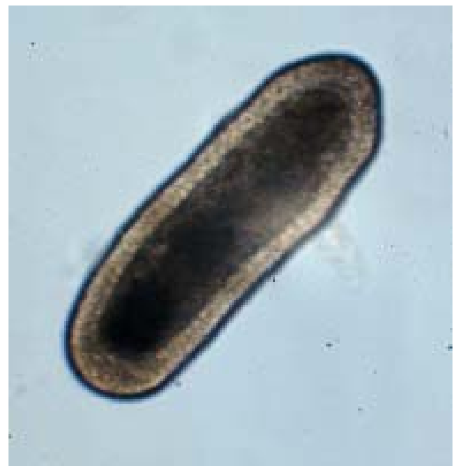
Obelia sp - a hydroid medusa

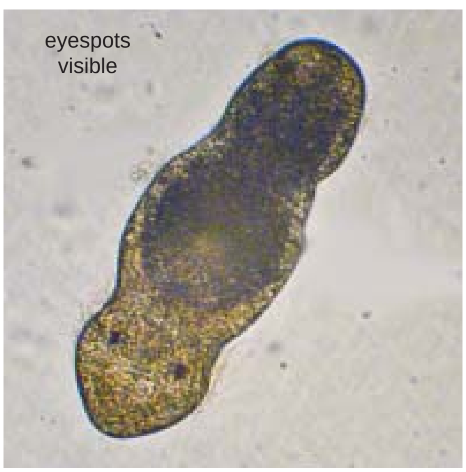


Phyalella a hydroid medusa

ZOOPLANKTON
Phylum Platyhelminthes

Platyhelminthes, or “flatworms,” are compressed dorso-ventrally, like a piece of ribbon. Some people call this “life in 2 Dimensions.” Flatworms are thought to be the first phylum to have evolved a true head on one end of the body, and a tail on the opposite end. The evolution of a head means the flatworms were the first creatures on Earth to move head first through their environment. A head and tail also means that their right and left sides are mirror images, which is to say they were the first organisms on Earth to exhibit **bilateral symmetry**. Flatworms were also the first phylum to have tissues working together as rudimentary organs, but no organ systems exist in this group. Since most of these animals live on the seafloor, it is only occassionally that we capture a flatworm in a plankton net, but it does happen. Even after netting, refrigerating, stirring, and dropping onto a slide, they are often very active under the microscope. Even more rarely we capture their **Muller’s larvae**.





Flatworms

Muller’s larva

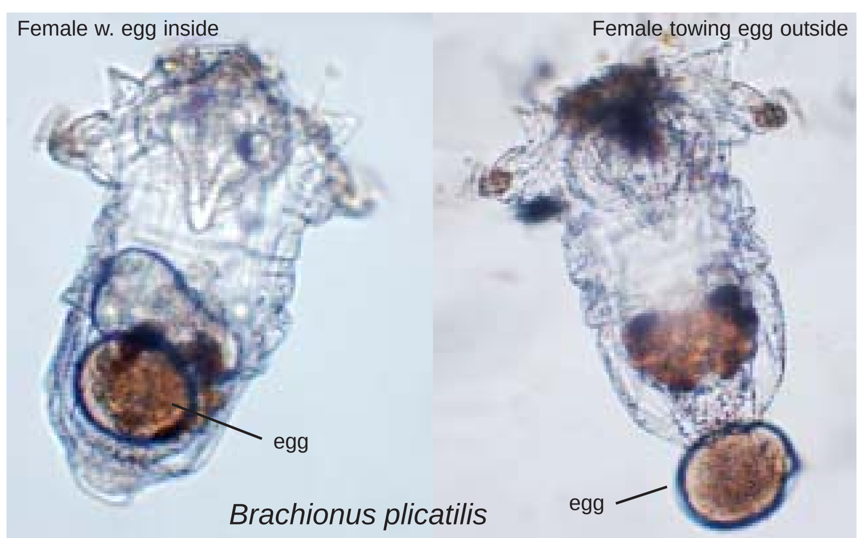
ZOOPLANKTON
Phylum Bryozoa

Bryozoans are ubiquitous benthic colonial animals that attach and spread over rocks, kelp, shells and manmade marine structures. They are tiny wormlike creatures that live inside boxes and are barely visible to the naked eye. Bryozoans reproduce, develop and distribute themselves geographically using a triangular-shaped **cyphonautes larvae**. Cyphonautes shells are transparent, double and the open edge is fringed with active cilia. The internal organs are easy to see inside. Cyphonautes larvae drift in the currents until ready to settle out to the bottom and take up a sessile benthic existance. Once a larva lands it begins to divide asexually and continues to divide until an entire area is covered by identical clones.

Cyphonautes larvae

Phylum Rotifera

Rotifers are small, worm-like animals with ciliary “wheel organs” on their heads that rotate and give the group their name “rotifer.” Rotifers are very small, usually less than 200µm, which, for a complex multicellular animal, brings it to about the size of a typical protozoan. Almost all rotifers are females. Males in some families have never been observed. Females lay fertile eggs without the need of a male or fertilization, using a process known as parthenogenesis. Only one species of planktonic marine rotifer has been recorded along the coastline...they are more abundant in freshwater.



Brachionus plicatilis

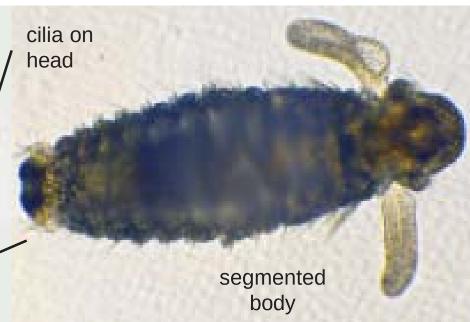
Looking down on head to see ciliary “wheel organs”

ZOOPLANKTON
Phylum Annelida, Class Polychaeta

Segmented worms are members of the phylum Annelida (latin, *annulus*: segment or ring). These "marine worms" or "bristle worms" are the most abundant worms in our local ocean and therefore the most common type of worm we capture in our coastal plankton hauls. The planktonic Annelids are members of the class Polychaeta (*poly* =many; *chaeta* = hairs or bristles) and are relatives of earthworms and leeches. Anatomically they are distinguished from the other kinds of worms by having a body that is divided into segments from head to tail. Each segment has small extensions or "legs" (parapodia) on each side with numerous stiff bristles (chaeta or **setae**). The polychaetes we see in the plankton are the larval stages of benthic species, many of which are sedentary tubedwellers as adults. Very early polychaete **trochophore** larvae are essentially just a swimming "head." As the worm elongates its body and grows, and it adds additional segments behind the head in a posterior direction.

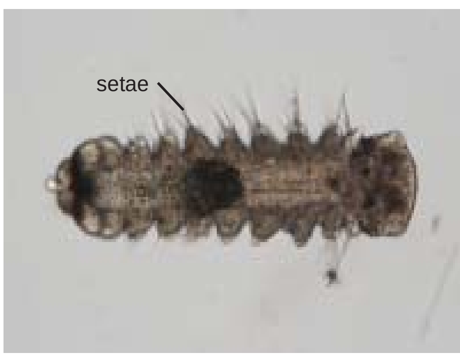
early trochophore

mid trochophore



late trochophore

Family Spionidae



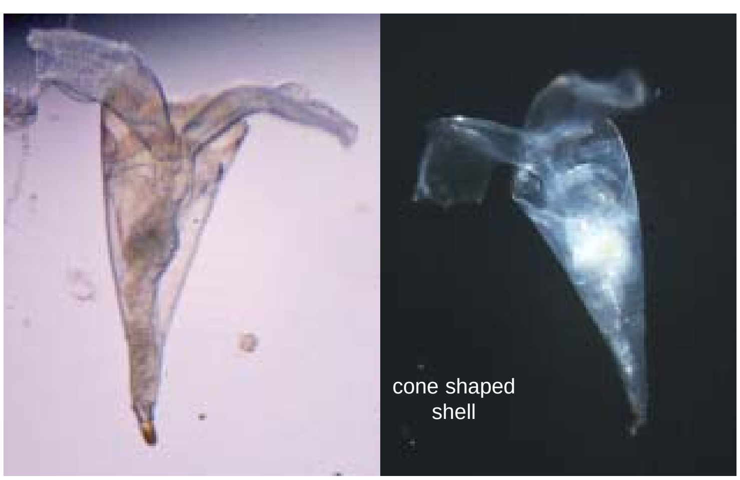
other Polychaete trochophores

ZOOPLANKTON
Phylum Mollusca

Mollusks are a huge phylum in the ocean, with nearly 100,000 different species. The name Mollusca comes from the Greek, *mollis*, which means “soft,” and all members of this phylum have soft, muscular bodies that are usually protected by one or more external calcium shells (in adulthood). There are holoplanktonic mollusks known as **pteropods** and **heteropods**, and all of the bottom-dwelling mollusks have planktonic larval stages known as veligers. Gastropod (snails, slugs) larvae have a single, spiral shell and Bivalve (clams, mussels, oysters) larvae have two “clam shaped” shells. The **veliger larva,** is taken from the latin word *velum*, which means “veil” or “wing.” The velum is a winged structure bordered by actively beating cilia. Veligers live in the plankton and grow until they become too big and heavy to float, when they spend their adulthood living on the seafloor.

Bivalve veliger larvae

Gastropod veliger larvae



Pteropods

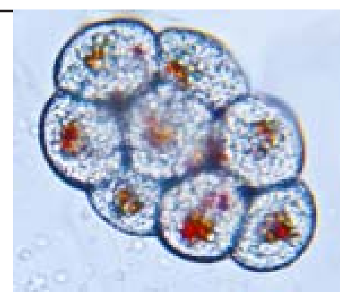
ZOOPLANKTON
Phylum Arthropoda - Class Crustacea

Crustaceans are the most abundant form of animal life in the plankton. There are several important groups that we see frequently, and others that show up only periodically.

Order COPEPODA - the copepods

The most abundant animal plankton in the world belong to the **Order Copepoda** and are known as copepods. You will see these crustaceans in every sample...guaranteed. They are related to lobsters, shrimp and crabs, so they possess an external skeleton or shell which they must shed in order to grow. Thus, we see clear crustacean debris all the time in our samples. Copepods are mostly herbivores that eat diatoms and dinoflagellates, and, in turn are themselves eaten by small bait fish such as anchovies and sardines, as well as larger carnivorous plankton. Since you cannot control whether a copepod will be right-side-up or sideways in your drop of plankton, try to form a 3D image of this animal so you can identify it no matter how it faces.

Calanoid copepods



Copepod eggs

Cyclopoid copepods

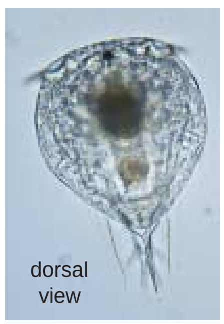
Harpacticoid copepod

Copepod nauplius larvae hatching out of eggs (see crustacean larvae on page 17)

Crustacean larvae

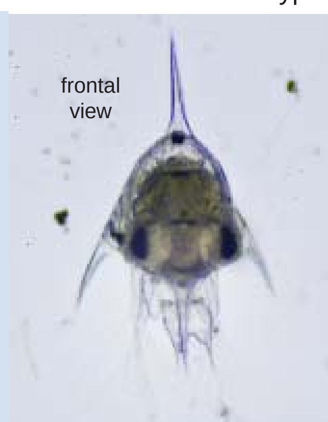
As you can see in the photo on page 16, some crustaceans begin life as a developing embryo inside an egg which is being carried attached to the female along with hundreds or thousands of other eggs. Other crustaceans shed their eggs into the water currents. Many crustaceans show up in our plankton samples in their first stage after hatching from the egg, the **nauplius** stage. There may be several nauplius stages, then a metamorphosis to a second larval stage known as the **cypris** larva. The cypris may develop into a **zoea**, in crabs, for example, or a **phyllosoma**, in the case of the spiny lobster.

Nauplius larvae



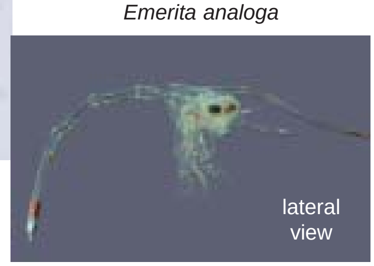
Nauplius larvae

Cypris larvae



Crab zoea larvae

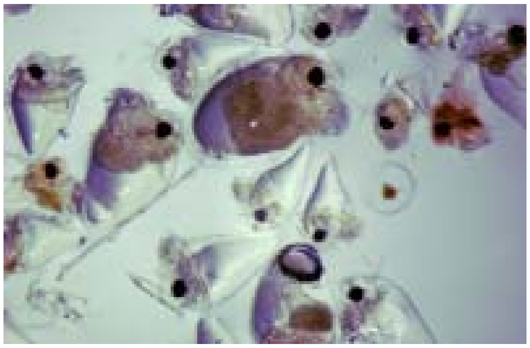
Zoea larvae of
Emerita analoga

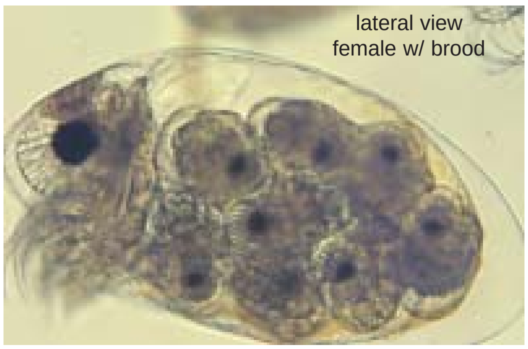


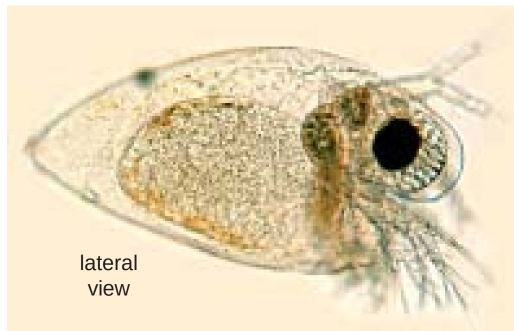
Zoea larvae of
Blepharipoda occidentalis

Phyllosoma larvae of
California Spiny Lobster
Panulirus interruptus

Crustaceans - Cladocerans





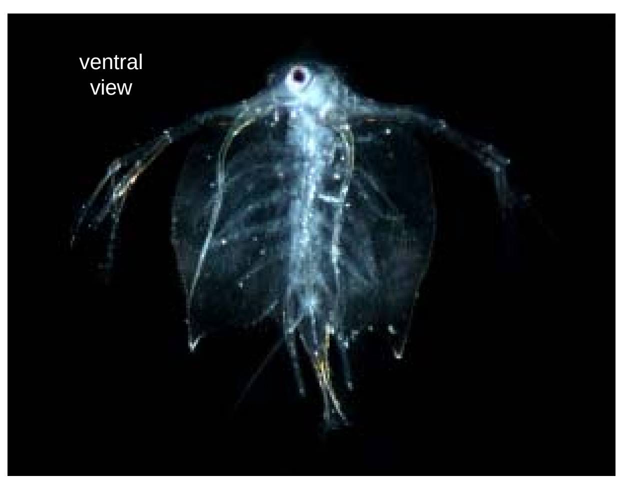


Evadne nordmanni

lateral view
female w/ brood

Podon polyphemoides

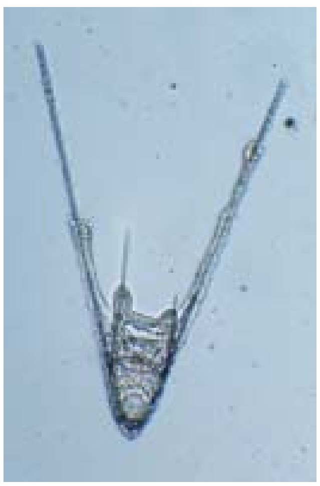
Penilia avirostris



ZOOPLANKTON
Phylum Echinodermata

Echinoderms are entirely benthic animals, and they are among the dominant phyla of the abyssal benthos. These spiny skinned animals are also very abundant on the seafloor in nearshore waters. Such common animals as sea stars, sea urchins, brittle stars and sand dollars belong to this group. In order to reproduce themselves and distribute the species, Echinoderms use planktonic larvae. These larvae are very unique and readily identifyable. Because our samples are taken from Zuma Beach, CA, an exposed sandy beach, we find a lot of sand dollar larvae.

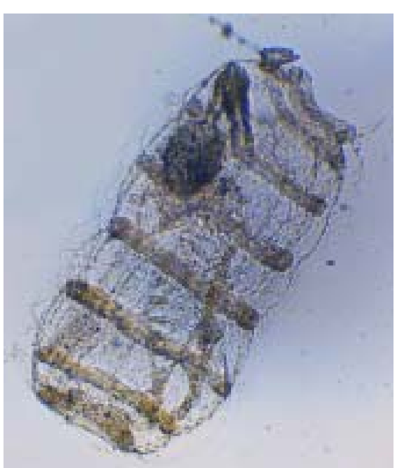
Echinopluteus larvae
probably *Dendraster excentricus*



Echinopluteus larvae

Late echinoid larva
probably *Dendraster excentricus*

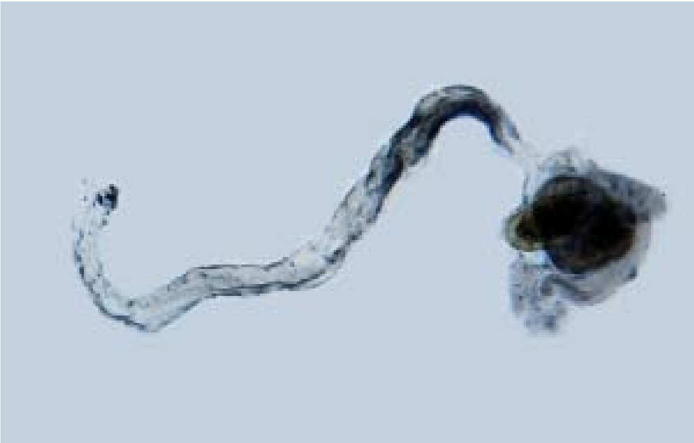
Ophiopluteus larva
of a brittle star



Doliolaria larva
of a sea cucumber

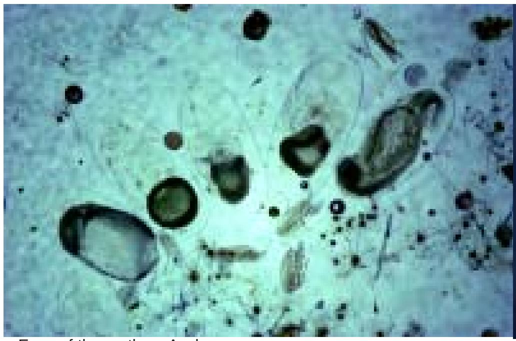
ZOOPLANKTON
Phylum Chordata

The most conspicuous and abundant members of the Phylum Chordata are the modern, boney fishes (subphylum Vertebrata, Class Osteichthyes). Most families of fish cast their eggs into the plankton where they hatch to larvae if they survive. It is common for us to capture fish eggs (technically most are really "embryos" even though they look like eggs from the outside) and fish larvae in our coastal plankton hauls. In addition we find members of the subphylum Urochordata (like *Oikopleura*) which are entirely planktonic and only recently have been appreciated for their enormous role in pelagic ecosystems. These Urochordates, the Larvaceans or "salps," secrete a mucous "house" and live inside where they actively pump water and feed on smaller planktonic life. When disturbed (by our plankton nets, for example) they abandon their mucous home and swim away, leaving their predator with a face full of slime.

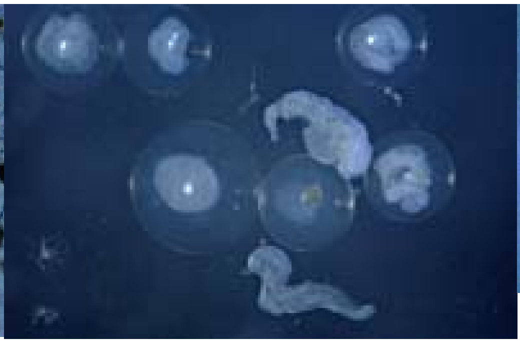


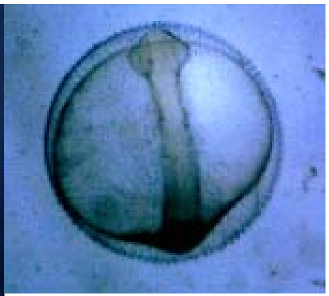
Oikopleura sp.

Tadpole larva of a tunicate



Eggs of the northern Anchovy (*Engraulis mordax*)

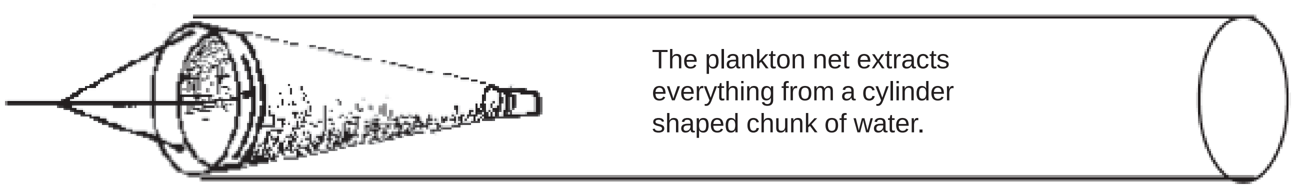




Note developing embryos inside eggs.

Fish eggs

3 Steps to Calculate the Amount of Plankton in a Cubic Meter of the Ocean:



Step One

CALCULATE THE VOLUME OF THE WATER THAT WAS SAMPLED BY THE NET USING THIS FORMULA:

$$\text{Volume} = \pi r^2 L$$

π = 3.14
r = radius of net (in meters) [squared]
L = Length of tow (in meters)

Multiply these numbers together and round-off to 2 decimal places to get the number of cubic meters of seawater the plankton net sampled. Write the answer in the preliminary data at the top of your plankton data sheet where it says "Calculated Net Volume."

You will use the volume in Step Three calculations.

NOTE FOR SAMPLES TAKEN BY BOAT:

When nets are towed behind a vessel, "L" (length of tow in meters) is calculated by knowing the **speed** of the vessel in meters per hour, and the **time** (or duration; the decimal fraction of an hour that the net was fishing). Length is calculated by the formula: **Length of tow = Speed x Time**.

Since most vessels have speed measured in **knots** (nautical miles per hour), you first need to multiply 1,853 meters per nautical mile x Speed in knots to find the speed in meters per hour. If the time (duration) was measured in minutes, you must divide minutes by 60 min/hr to convert the time to hours.

Step Two

CALCULATE THE (AVERAGE) NUMBER OF *EACH SPECIES* PER DROP SAMPLED UNDER YOUR MICROSCOPE:

$$\frac{\textbf{number observed}}{\textbf{number of drops analyzed}}$$

Divide the number of each species you observed by the number of total drops you analyzed in class. This calculation must be repeated for each species of plankton you observed.

Record these calculations (two decimal places) next to each species of phytoplankton and zooplankton you wrote on your data sheet, in the 3rd column.

3 Steps to Calculate the Amount of Plankton in a Cubic Meter of the Ocean (continued):

Step Three (the final step) $\# \, m^{-3}$

CALCULATE THE NUMBER OF PLANKTON PER CUBIC METER OF OCEAN WATER:

$$\# \, m^{-3} = \frac{\text{average number per drop (step 2)} \times \text{total drops in the entire sample}}{\text{volume (step 1)}}$$

This is the final calculation that gets graphed and analyzed. It tells the number of each kind of plankton that was living in a cubic meter chunk of ocean water on Thursday when the net took the sample.

Multiply the number per drop (from step 2) times the total number of drops in the entire sample (provided by instructor), then divide this by the volume you calculated in step 1.

Do this calculation for each species of phytoplankton and zooplankton you recorded, and write the calculation (rounded to 2 decimal places) in the last column on your data sheet. This column has been shaded grey and is marked “graph this column” to help you remember to enter these numbers into your spreadsheet database.