

Plankton in the Bay

Pre-visit Preparation

Welcome to the University of Maryland Biotechnology Institute's (UMBI) SciTech Education Program. We hope that these materials are useful and will help prepare your students for a unique and exciting "hands-on" lab experience. We encourage you to review these pre-visit materials. The teacher background sheets are designed to increase your depth of understanding of this topic. Students will have a richer experience with us if you go over the pre-visit materials with your class before you visit. For more information regarding SciTech, visit our website: www.umbi.umd.edu~scitech.

Summary of Student Experience

Students will begin with an introduction about spring plankton blooms in Chesapeake Bay and then proceed directly to collecting plankton and measuring water quality at Pier 6 outside the Columbus Center. In the lab, students will use the Olympus America microscope equipment to view the plankton, learn about the different species, and estimate populations in the Baltimore Inner Harbor. The lab will help students understand the dynamics between nutrients, springtime algae blooms, and plankton population growth. Students will explore the environmental factors that favor plankton growth and reproduction in the Bay and learn how their populations are dependent upon key nutrients like nitrogen and phosphorus. Fundamental math applications to estimate plankton populations will help students understand the role of math and sampling in environmental science. In turn, the research conducted at COMB that focuses on the link of zooplankton to cell stress and vectors of human disease will be described and demonstrated.

Tips for a Successful SciTech Experience

The Plankton in the Bay Lab offers some unique opportunities for students and teachers. The Olympus America, Inc., microscope equipment is set up so that you can videotape and photograph your favorite planktonic organisms in the lab while the students are at work. To take advantage of this opportunity, please bring:

- A VHS videotape for recording,
- A roll of 35 mm film, print or slide film, 400 or 800 speed, and
- Some blank computer discs, for digital pictures, Mac or PC format.

Experimental Design Background

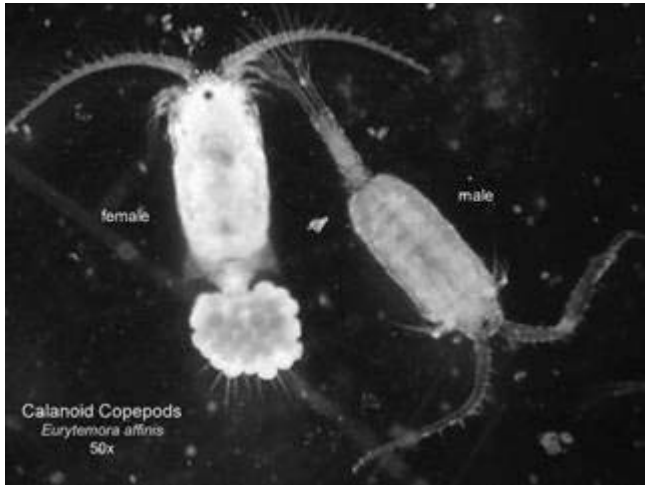
Stating the Question

Every experiment begins with a question that the experiment will be designed to answer. Formulating this question is often the most difficult and most essential part of setting up a research project. Many questions could be investigated during the exploration of plankton. One question could be, "How does temperature affect the number of plankton in Baltimore's Inner Harbor?"

Hypothesis

The clearest way to write a hypothesis is to use "if...then" statements. For example: "If temperatures increase, then the number of plankton will increase." The most common hypothesis is the null hypothesis that simply means that the variable or experimental situation being tested will exhibit no significant difference from the controls. For example, one null hypothesis could state, "There will be no significant effect of temperature on the number of plankton."

Background



Plankton are aquatic organisms that drift with the currents. Plankton in Chesapeake Bay can be divided into 2 groups, phytoplankton and zooplankton. The phytoplankton are "plant-like" drifters that are typically represented by diatoms and other alga. The zooplankton are "animal-like" drifters with well-known members like copepods, larvae, and other small crustaceans.

Each spring, when temperatures warm up and nutrient levels rise from run-off

and increased river flow, phytoplankton take advantage of the conditions and "bloom". High concentrations of phytoplankton in blooms provide a good food source for zooplankton and other consumers. As zooplankton populations increase, blooms diminish and a new growing season begins in Chesapeake Bay.

While spring plankton blooms are natural and essential components of the Chesapeake Bay's ecology, too many blooms are unhealthy for the Bay. An overabundance of blooms can lead to suffocating low-oxygen conditions for fish, changes in the kinds of species that live in the Bay, and even increased diseases in seafood. Plankton blooms are becoming more common and more widespread in the Chesapeake Bay because human populations are increasing and land is changing from forest to other uses.

The information below briefly describes some key points about plankton dynamics in Chesapeake Bay and the role of nitrogen (N) and phosphorus (P).

Phytoplankton Dynamics

The concentration of phytoplankton in Chesapeake Bay peaks each spring in the mid-to lower Bay. This spring bloom constitutes the highest biomass of the year, and it is dominated by diatoms. Diatoms are non-motile algae covered by a silicon shell, and are a nutritious source of particulate organic matter for many animals. As nutrient concentrations and water-flow decrease later in the spring, much of the diatom bloom dies-off, settles to the bottom regions of the Bay, and is broken-down by bacteria. As bacteria metabolize the organic matter, they remove oxygen from the water, resulting in anoxic (no oxygen) conditions in the mainstem of the Bay. The amount of fresh-water flow from the Susquehanna River, the source of > 60% of the fresh water reaching the estuary, has enormous effects on nutrient inputs, phytoplankton growth, and subsequent anoxia.

By late spring, concentrations of chlorophyll generally decline in the lower Bay as nutrient limitation becomes more pervasive and zooplankton populations increase. This is particularly true south of the Rappahannock River mouth where nitrate is depleted. The mid- to upper Bay also shows reduced chlorophyll concentrations, but a switch to a summer flora rapidly ensues and flagellated forms replace the diatoms of spring. Several dinoflagellates reach red tide proportions in late spring and summer. The high densities that are attained in these blooms are extremely patchy and are often more

prevalent on the western side of the mainstem Bay and in the mouths of certain tributaries. By late summer to fall, chlorophyll concentrations drop throughout the Bay, although there is an occasional fall bloom near the time of the fall equinox when wind driven mixing becomes more common and injects nutrients to the surface layer.

*The information on **Phytoplankton Dynamics** was provided by the NOAA/Chesapeake Bay Office.*

Key Nutrients

Nitrogen (N) and phosphorus (P) are two key nutrients required for the growth of plankton in Chesapeake Bay. These nutrients originate from different sources in nature and additional amounts are added to the ecosystem by people's activities.

The nitrogen cycle in an aquatic ecosystem can be complex, but a few basic facts will help your students understand the measurement of nitrate-N that will be used as part of the Plankton in the Bay lab. Figure 1 illustrates the connection of animal (e.g. fish) waste as natural source of nitrate-N in an aquatic ecosystem.

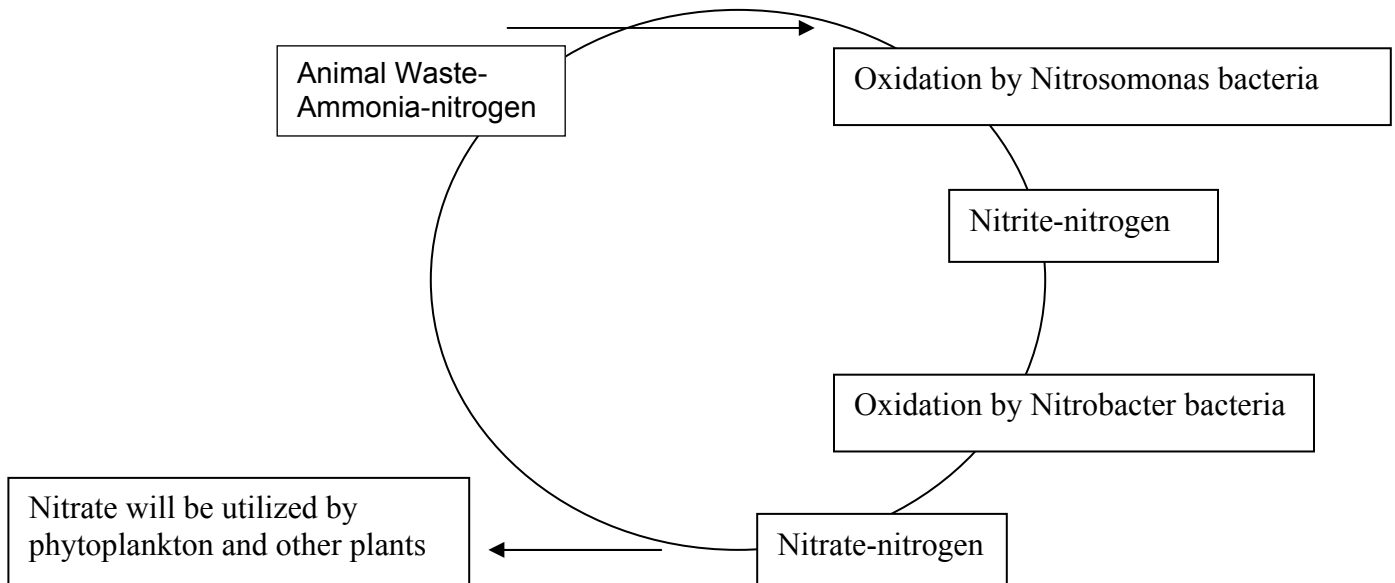


Figure 1. A fundamental part of the nitrogen cycle in an aquatic ecosystem illustrating the forms of nitrogen that originate from animal waste.

Measuring nitrate-N can give us clues to the health of the Chesapeake Bay. Nitrate-N will accumulate in an aquatic ecosystem until it is removed by plants or anaerobically by some bacteria. Nitrate-N is also found in waters due to run-off from fertilizer applied to lawns and agricultural land. High rainfall and subsequent increased run-off during the spring contributes to the "over-fertilization" of the Bay triggering blooms.

Phosphorus naturally occurs in very small amounts in aquatic ecosystems but fluctuations in these small amounts have a big impact on phytoplankton blooms. Natural sources of phosphorus include rocks and minerals that slowly release phosphate-containing compounds into the environment. In many instances these

compounds are bound in fairly insoluble forms and are a limiting factor in the environment.

Inner Harbor Plankton Sampling

In the spring the Baltimore Inner Harbor is full of plankton. At times the plankton are so dense that they give a brown tint to the water and can look like suspended sediment. The most conspicuous zooplankton in Baltimore's Inner Harbor is the same as the type found in many aquatic environments- copepods. There are a few key factors that your students need understood before performing field sampling to collect organisms.

To estimate the population of zooplankton properly it is important to know how much water was sampled and how to properly enumerate the organisms in the sample. The amount of water sampled can be considered equal to the amount of water that passes through the plankton net. Since the opening of the plankton net is circular, the amount of water that passes through the net from a specific depth to the surface would be similar in shape to a cylinder (*Figure 2*).

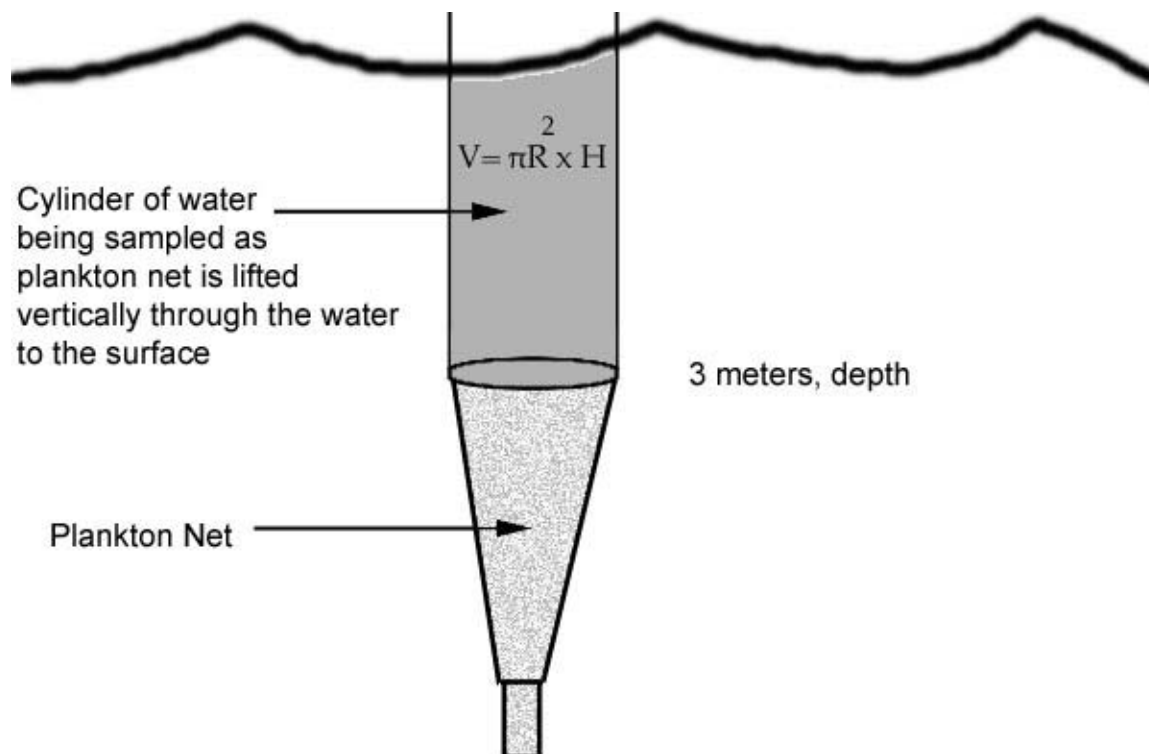


Figure 2. A representation of the volume of water being sampled by a plankton net from a depth of 3 meters.

The formula for the volume of a cylinder is, $V = \pi R^2 \times H$. By applying this formula the amount of water sampled through the plankton net can be calculated.

Once the plankton has been captured in the filter canister at the bottom of the plankton net, small volume (1ml) sub-samples can be placed under the microscope so that each plankton organism can be counted. Finally, the total number of plankton within the sampled water can be calculated by extrapolation. This number can be extrapolated so that the total number of plankton in the Bay can be estimated!

Glossary

anoxia A lack of oxygen in the water column.

bloom A dramatic increase in the population of algae, dinoflagellates, and/or cyanobacteria in an aquatic ecosystem due to high levels of nutrients and optimal conditions of other environmental factors.

diatoms Microscopic algae enclosed in two silicone shells. A major component of spring blooms.

dinoflagellates Microscopic photosynthetic organisms with two flagella that allow them to swim. A major component in summer and fall blooms.

nitrate-N A form of nitrogen that originates from the bacterial decomposition of ammonia waste from animals. It is also the main form of nitrogen in fertilizers.

phytoplankton The base of the food chain in the Bay ecosystem composed of photosynthetic algae, dinoflagellates, and cyanobacteria.

plankton Aquatic organisms that drift with the currents.

red tide Massive blooms of dinoflagellates. The dinoflagellates are in such high concentrations that the water takes on a reddish or brownish color.

run-off Water entering an aquatic ecosystem that has come directly from sewer drains, paved surfaces, lawns, etc., and has bypassed the percolation through soil.

zooplankton Primary consumers in the Bay ecosystem composed mainly of small crustaceans and a variety of larvae including fish.

References

Books

Needham, Paul R. A Guide to the Study of Freshwater Biology. Holden-Day, Inc., Oakland, CA. 1962.

Odum, Eugene P. Basic Ecology. CBS College Publishing, USA. 1983.

Lippson, Alice J. and Robert L. Lippson. Life in the Chesapeake Bay. The John Hopkins University Press, Baltimore, MD. 1984.

Web

Phytoplankton Dynamics, NOAA/Chesapeake Bay Office
(http://noaa.chesapeakebay.net/odas_sas.html#Ref21)

The Plankton Net
<http://www.geocities.com/planktonguy>

Copepod Biology
<http://www.uni-oldenburg.de/zoomorphology/Biology.html>

GLOBEC site on Plankton
<http://octopus.gma.org/onlocation/globecactiv.html>

Maryland State Department of Education Core Learning Goals

The following Core Learning Goals link directly to the COMB SciTech Plankton in the Bay Lab. Take a few moments to review the specific goals, expectations, and indicators below so that you may prepare your students appropriately in conjunction with the pre-visit materials that will be sent when you book your field trip. If you do not have a Core Learning Goals document or CD talk to your department chair, contact your science supervisor, or visit http://www.mdk12.org/mspp/high_school/what_will/index.html.

Core Learning Goal – Science

Goal 1 - Skills and Processes

Expectation 1.2 - The student will pose scientific questions and suggest experimental approaches to provide answers to questions.

Indicator 1.2.1 -

- The student will identify meaningful, answerable scientific questions.

Indicator 1.2.2 -

- The student will pose meaningful, answerable scientific questions.

Indicator 1.2.3 -

- The student will formulate a working hypothesis.

Indicator 1.2.4 -

- The student will test a working hypothesis.

Indicator 1.2.5 -

- The student will select appropriate instruments and materials to conduct and experiment.

Expectation 1.3 - The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.

Indicator 1.3.4 -

- The student will learn the use of new instruments and equipment by following instructions in a manual or from oral direction.

Expectation 1.4 - The student will demonstrate that data analysis is a vital aspect of the processes of scientific inquiry and communication.

Indicator 1.4.9 -

- The student will use analyzed data to confirm, modify, or reject a hypothesis.

Expectation 1.5 - The student will use the appropriate methods for communicating in writing and orally the processes and results of scientific investigation.

Indicator 1.5.1 -

- The student will demonstrate the ability to summarize data (measurements/observations).

Indicator 1.5.2 –

- The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

Expectation 1.7 - The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.

Indicator 1.7.5 -

- The student will investigate career possibilities in the various areas of science.

Goal 3 - Concepts of Biology

Expectation 3.2 - The student will demonstrate an understanding that all organisms are composed of cells which can function independently or as part of multicellular organisms.

Indicator 3.2.2 -

- The student will conclude that cells exist within a narrow range of environmental conditions and changes to that environment, either naturally occurring or induced, may cause changes in the metabolic activity of the cell or organism.

Expectation 3.5 - The student will investigate the interdependence of diverse living organisms and their interactions with the components of the biosphere.

Indicator 3.5.3 -

The student will investigate how natural and man-made changes in environmental conditions will affect individual organisms and the dynamics of populations.