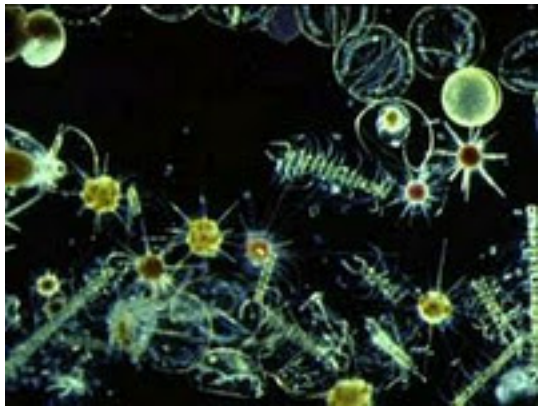
Aquatic Microbes Food Webb

A semi-inquiry-based activity that explores of microscopic life in the aquatic environment



Objective

Students will be able to identify the interactions of the microscopic organisms that make up the aquatic food web.

National Science Education Standards:

K-12 Unifying Concepts and Processes

- Systems, order, and organization

9-12 A. Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

9-12 C. Life Science

- Interdependence or organisms
- The Cell
- The behavior of organisms

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Background

The ocean is home to a wide range of organisms, many which are of great value to people. Fisheries such as tuna and anchovy, support national economies throughout the world. In addition, some marine organisms are vital to traditional cultures, such as whales to the Maori, while others have become icons in pop-culture—think *Shamu*, *Jaws*, or *Nemo*. These familiar ocean critters, however, would not exist without tiny marine organisms that are invisible without magnification. These microscopic organisms not only form the base of the marine food web but they also recycle essential nutrients, such as nitrogen, phosphorous, and carbon.

Microscopic life in the ocean is highly diverse, consisting of the single-celled prokaryotes, (bacteria and archaea), single-celled eukaryotes (like phytoplankton and protists) and multi-celled zooplankton. Each of these groups of organisms plays an essential role in the marine environment. Phytoplankton are primary producers, providing energy for the entire food web. Zooplankton and protists are consumers, and in turn, they serve as food for larger zooplankton or small fish. Bacteria and archaea are decomposers and recyclers, allowing important nutrients contained in waste to be recycled and used again by phytoplankton (known as the "microbial loop"). Plankton and bacteria together create an entirely microscopic food web composed of several trophic levels.

Since students may have difficulty conceptualizing what they cannot see, the following series of activities use an inquiry-based approach to help bring to life this "invisible", yet essential, world of marine organisms to any grade 6-12 classroom.

In this set of Marine Food Web activities, students are given the task of determining which types of microscopic organisms live in a local body of water. They then design tools and techniques to collect data and draw conclusions about the different groups of aquatic microorganisms and how these groups interact.

Part A. Sampling the Aquatic Food Web

Objectives

Students will be able to design and use a tool to collect data. They will gain/improve skills in scientific inquiry and gathering evidence.

Materials

Embroidery hoops
Nylon stockings,
String, scissors, tape, strong rubber bands, key rings,
Small plastic jars with lids and a lip around the edge.

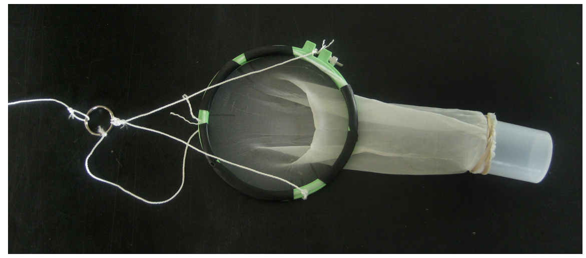
Set-up

1. *Formulating a Question*

Students are shown a water sample from your local beach, bay, or estuary. (These activities could alternatively be done with fresh water from a pond or lake, as the same general principles apply.) They are asked if they can see anything living in the sample and if they think there is anything living in the sample that they cannot see. Students brainstorm how they can figure out whether the sample contains living organisms and how they might determine what these organisms are.

2. *Design a collection device*

Students are given the task of designing a net or another device to collect a concentrated sample of plankton as a first step to answering the guiding questions described above.



Procedure

1. Students work in groups to discuss how to collect a sample containing enough microscopic organisms to examine effectively.
2. Students can use any of the materials supplied to “catch” organisms.
3. Students choose supplies and create their collection device.
   Note: Teachers should resist the urge to give students the “right answer”—the goal is for students to use reasoning to create a tool with a purpose.
4. When everyone has their first “prototype” constructed, students test their devices in a local body of water.
5. Students may make changes and repeat collection until they feel they have attained a satisfactory sample, or as long as time allows.
6. In discussion mode, students compare nets to a real plankton net (photo, or the real thing), and if available, conduct a plankton tow with a real net.
7. Samples fare saved or later analysis.

Part B. Who’s who in the microbial world?

Objectives

Students will use reasoning based on observations to draw conclusions about how organisms in the samples “make their living.” Students will have a basic understanding of “planktonic” organisms, and that form is related to function.

Materials

Plankton samples (from their home-made nets as well as from a fine-mesh plankton net)
Classroom compound and/or dissecting microscopes
Slides, slide covers, pipettes, KimWipes
Sheets of blank paper, colored pencils
Plankton ID guide

Procedure

1. In discussion mode, students determine whether microscopic organisms are present in the samples, and if so what types of organisms the samples contain.

2. Students are supplied with microscopes and proper use and safety procedures are outlined.
3. Students examine samples under microscopes and sketch in color each organism they observe on a different piece of paper, labeling any features that may indicate how the organism moves, size, how it obtains energy. Students observe their own samples first, then examine samples obtained with a real plankton net so that they can observe a greater diversity of organisms.
4. In groups of 2-3, students discuss categories in which the organisms can be grouped, then students group their organism sketches according to these categories. Typically, students will organize according to plant-like organisms, animal-like organisms, and in between or undetermined.
5. Groups share and discuss their findings, including how each category was decided upon and the concepts of producers and consumers.
6. Plankton identification can be made using guides to identify the organisms in their sketches to support or challenge their conclusions.

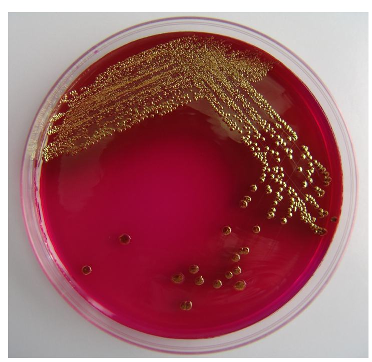
Hint: If you are unable to collect samples, you can use our series of plankton photographs for teachers and students that are posted at http://www.greenteacher.com/contents92.html in the table of contents page for this issue, or photographs of plankton found online at: http://www.teachoceanscience.net/teaching_resources/education_modules/plankton_-_aquatic_drifters/teach/#_Phyto_or_Zoo?

Part C: How do we study the smallest plankton? (Plating)

Introduction
Students brainstorm what they think would be smallest type living organism in their sample. Some guidance may be necessary for them to get the idea that bacteria might be present in their samples. Students brainstorm ways to determine the presence of bacteria in a water sample.

Objective
Students will become familiar with the use plating techniques to determine the number of bacteria in a water sample.

Materials
Petri dishes prepared with agar media
Micropipettes
Sterile spreaders
Parafilm for sealing plates
Water samples
Data sheets



Procedure
1. Discuss the plating technique, explaining that though we can't see single bacteria, we can grow clusters of bacteria, which are visible.
2. Students then count these clusters, or colonies, to determine how many bacteria are in a sample.

3. Proper plating procedure is demonstrated.
4. Students make a few sample plates.
5. Already grown cultures are provided for students to count colonies to determine bacterial abundance.
6. Students record their findings on their data sheets.
7. As a group, bacteria counts are compared among samples. Other ways scientists study bacteria are discussed (e. g. genetic techniques).

How do we study the smallest plankton?

Data Sheet
Counting Bacterial Colonies

Description: To calculate the number of culturable bacteria in a sample, count the number of bacteria colonies that appear on each plate, multiply by the dilution factor (e.g., times 25 for the 1:25 dilution) and divide by 0.1ml (the volume you spread on the plate). You will not be able to count colonies on all the plates, either because there are none or because there are too many. Calculate the mean bacterial abundance for each sample.

Calculations

Dilution	Number of colonies counted	x dilution factor	= # culturable bacteria/ml water (abundance)
1:10A	____________	x 10	= _______________
1:10B	____________	x 10	= _______________
1:10C	____________	x 10	= _______________
1:25 A	____________	x 25	= _______________
1:25 B	____________	x 25	= _______________
1:25 C	____________	x 25	= _______________
1:50 A	____________	x 50	= _______________
1:50 B	____________	x 50	= _______________
1:50 C	____________	x 50	= _______________

1:100 A ____________ x 100 = _______________

1:100 A ____________ x 100 = _______________

1:100 A ____________ x 100 = ______________

1:250 A ____________ x 250 = ______________

1:250 A ____________ x 250 = ______________

1:250 A ____________ x 250 = ______________

Average abundance (for the plates you could count) =_______________

<u>Questions</u>

1. Which plates/dilutions had the most colonies growing on them? Which had the least?

2. Were you able to calculate bacteria abundance for all of the plates? Why or why not?

3. Why do scientists need to prepare different dilutions in order to calculate bacteria abundance?

4. How many different types of bacterial colonies did you see (different colors, shapes, textures, etc)?

5. Describe each kind of colony you see and write down how many of each you can count (use the back of this page or another sheet of paper if you need to).

Description:_________________________ #_______

Description: _________________________ #_______

Description:_________________________ #_______

Description: _________________________ #_______

Description:_________________________ #_______

Description: _________________________ #_______

Part D. The microbial food web

Objective
Students will be able to use logic and reasoning to determine functional relationships of microbial organisms using sketches from Part B above.

Materials
Sketches from Part B, tape, string

Procedure

1. Divide students into groups.
2. Have students organize their sketches from the previous activity based on who they think each organism eats or is eaten by. Then have students tape their sketches onto a wall/board and connect sketches with string based on functional relationships to illustrate the microbial food chain.
3. Have groups present their food chain/web, explaining their design rationale. Discuss concepts of producers, consumers, and interdependence.
4. Ask students what would happen if any organism were removed.
5. Ask students if any organism is missing because they were not able to observe them under the microscope (bacteria, for example). Have students create sketches of bacteria to add to the food web.
6. Discuss the importance of microbes to larger ocean organisms; compare to land food webs.

Hint: Younger students may tend to group organisms by trophic level, connecting each trophic level with one piece of string. More advanced students can be challenged to consider multiple connections between organisms and to create a more complex food web.

Part E. It's all connected
In this game, students play the roles of phytoplankton, copepods, bay anchovies, striped bass, bacteria, and fishermen. Each round of the game simulates different scenarios of organism composition and ratios within an ecosystem to illustrate the concepts of ecological balance and interdependence. The game simulates a food chain through a highly simplified scenario; in the actual environment, many species eat more than one type of food. The food chain in this game can be a strand in a more complex food web. The game works best with 15-30 students.

Objective
Students will be able to make the connection among organisms in the aquatic food web.

Materials
Organism ID Cards (see below), printed out and preferably laminated
50-150 ping-pong or nerf balls
1 gallon plastic bags (one for each student)

Large space, preferably outdoors

Procedure
Introduction to activity
Students are asked:
Where does all their energy comes from? What did they had for dinner last night?
How does the energy in their food link back to energy from the sun (diagram on a dry erase board if available)?

Demonstration
Have 6 volunteers come to the front and give each volunteer a food chain card. Ask the volunteers to line up in the order of a food chain. Review food chain/energy flow through ecosystem concepts: plants (phytoplankton) use light energy to photosynthesize, producing their own "food;" zooplankton, some small fish, and filter feeders eat the phytoplankton to obtain energy (in this case we use copepods); other small fish and filter feeders eat the zooplankton (here bay anchovies); large fish eat the small fish (rockfish), people catch the large fish; bacteria decompose dead things and other organic matter (like waste), recycling nutrients back into the system.

Again students are asked:
Which organisms are primary producers? Which are primary consumers?
What are secondary consumers? What are tertiary consumers/apex predators?

Set-up
1. Print out and laminate the Organism ID cards (available below).
2. Identify boundaries of your ocean ecosystem with cones, about a half basketball court size.
3. Scatter plankton (ping pong/nerf balls) randomly around the playing area, reserving a bunch for use in Round 3.

Rules
1. Everyone has to stay within the boundary.
2. Everyone has to stop "feeding" promptly when instructor indicates.
3. No running: copepods can only hop because this is how copepods move in the water; fish can power walk.

Round 1: Primary consumers (15-30 copepods)
4. Distribute a copepod ID tag to each student.
5. Hand students a stomach (gallon size plastic bag). Students can place ID cards in their plastic bags. Have them start "swimming"/hopping around the ecosystem.
When you say go, students will try to fill their stomachs with as many "phytoplankton" as they can.
6. Start the round, continuing until all phytoplankton are consumed. Give signal to stop feeding. Ask students how many copepods filled their stomach with 6 or more balls? These copepods survived. What happened to all the food?
7. Introduce concept of carrying capacity: that resources in a system can only support certain number of organisms indefinitely. What will happen in the bay now that all the food is gone?

How could we balance the Bay?
8. Have students return plankton to the playing area.

Round 2: Secondary consumers (switch out 4-6 copepods with bay anchovies, depending on class size)
1. Place 2 hula hoops in the ecosystem as hiding places for copepods. Only one person at a time can hide in a hula hoop for only 5 sec at a time, and students must take 5 steps away from the hula hoop before reentering.
2. Add secondary consumers to the ecosystem. Tell students that bay anchovies eat zooplankton, like copepods. The anchovies are now "it" and need to tag copepods.
If a copepod is tagged, he/she is eaten and has to empty the contents of his/her stomach into the anchovy's bag, then sit out on the side. Meanwhile, copepods are still hungry—they still need to eat while trying to avoid the predators.
3. Begin feeding, continuing until most of the plankton have been eaten. How many copepods have plankton in their stomachs? Those copepods survived. How about the anchovies?
4. What would happen to the food if we kept playing? Is there anything missing?
5. Have students return plankton to the playing area.

Round 3: Decomposers (switch out 1-4 copepods with bacteria—there are actually more bacteria than this in the real world, but this number works for the game)
1. Now when copepods are tagged, they hand over half of their "phytoplankton" to the anchovy, then go to the side and pair up with a bacterium to start the decomposition process: bacteria decompose dead things and organic matter (like waste, food particles from sloppy feeding, etc.), releasing nutrients. Since nutrients fuel phytoplankton growth, the pair can throw the copepod's left over ping-pong balls back into the ecosystem. These phytoplankton provide new food for the copepods.
2. Start this round of feeding. If things are going well, you can add some copepods back into the game to illustrate reproduction. Stop until most phytoplankton are consumed or after the ecosystem persists for a few minutes.
3. How many copepods survived? Anchovies? How did the bacteria impact the system?
Is the system balanced? Is anything else missing?
4. Have students return plankton to the ecosystem.

Round 4: Apex predator (switch out 1-3 copepods with rockfish/striped bass)
1. Replace a copepod with a rockfish. You can have some copepods switch out with anchovies/bacteria as well so that everyone gets a chance to be "it."
2. Rockfish eat anchovies. Anchovies still eat copepods, copepods still eat phytoplankton, and bacteria are still decomposers. Again, if a student is tagged, he/she hands over half of his/her phytoplankton to the predator, then sits on the side to share the rest of the phytoplankton with bacteria, throwing the phytoplankton back into the game. Hula hoop rules still apply (one critter at a time, no hovering near the hula hoop). How many of each species survived? Is the ecosystem in balance? If not, how could you adjust the number of each organism to achieve balance?

Round 5: Humans as apex predators (switch out 1-2 copepods with a fisherman/woman)
1. Discuss how people are part of an ecosystem and how they might impact it.
2. Select a copepod to be a fisherman. Fishermen need to first find bait—by tagging and linking

arms with an anchovy—before they can fish. The linked anchovy and fisherman try to catch a rockfish. The fisherman takes any caught rockfish and his/her food to the edge of the lake. At the end of the round, ask what happens to the energy from the rockfish caught by the fisherman.
3. Determine who survived and whether the system is in balance (there should be more copepods than anchovies, more anchovies than rockfish, etc. What would happen if there were too many rockfish? What would happen if fishermen caught too many rockfish?
4. If there's time, try to balance the system by adjusting numbers of each species.

Wrap-up
Review key concepts. What do students think might happen in the bay if rockfish were overfished? Review the concept of interconnectedness. Why are bacteria so important? Discuss the idea of food webs: real ecosystems are complex and are composed of many food chains with multiple pathways to and from each organism.