Build Your Own Zooplankton

Grade Level: This specific lesson is geared towards grades 9-12, but it can be modified for older or younger students.

Lesson Summary: Students will use their knowledge of zooplankton types and forms to create a "zooplanktonic" organism that is as close to neutrally buoyant as possible. They will put their creations into a tank of water and see which creature sinks the most slowly. Students will have several opportunities to improve their designs.

Lesson Duration: one 90-minute class period

Learning Objectives:

- Students will understand the relationship between surface area and buoyancy.
- Students will understand why it is beneficial for most zooplankton to be neutrally or slightly negatively buoyant.
- Students will be able to apply their knowledge of surface area and buoyancy to make zooplankton models.
- Students will be able to see the relationship between their zooplankton models and real zooplanktonic organisms.

Content Standards:

- **Ocean Literacy Principles**
  - Essential Principle 5: The ocean supports a great diversity of life and ecosystems.
- **National Science Education Standards**
  - Content Standard (C): Life Science: Characteristics of Organisms
- **California State Science Content Standards**
  - Biology/Life Science 6a: Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.

Cruise Information:

This lesson was created as part of the Cal-Echoes cruise and the Scripps Classroom Connection GK-12 program. The Cal-Echoes cruise was a student led research cruise that collected scientific data from the Santa Barbara Basin during the Fall of 2010. The cruise participants included 25 scientists and 10

educators as well as 23 crew members. The scientific goals of the cruise were to gain a better understanding of the coastal marine ecosystem of the Santa Barbara Basin, attempt to understand the history of the ecosystem in order to better understand why the ocean looks the way that it does today, and to better understand the connections between the ecosystem, its organisms, and the humans who live and use the coast and its resources. The cruise also had a strong educational component, which aimed to bring the experience and the science of the cruise to students and teachers. Additional lesson plans, activities, and videos were created and are available at http://calechoes.wordpress.com/.

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TEACHER Instructions

Background: Zooplankton are defined as animals living in the water column that are unable to swim against currents. They are passive floaters (although many of them can move vertically). They range in size from less than 20 micrometers (e.g. rotifers) to greater than 1 meter (jellyfish). Zooplankton can serve as consumers of phytoplankton (plank-like floating organisms), other zooplankton, larvae from a variety of organisms, and even small fishes. They serve as food for a wide variety of animals, including fish (such as sardines), whales (such as blue whales), and birds (Cassin's Auklet).

Many zooplanktonic organisms feed on phytoplankton, which are located in the upper layers of the ocean. Therefore, it is beneficial for zooplankton to be able stay near the surface where their food source is most likely to be found. This means that zooplankton need to be able to stay near the surface without expending lots of energy. For this reason, many zooplankton are neutrally buoyant or slightly negatively buoyant (so that they can swim above a patch of phytoplankton and sink slowly through it). In many kinds of zooplanktonic organisms, this is done by having a high surface area to volume ratio. Organisms may have spines (like a crab zoea larvae) or antennae (like many copepods) that can be extended (increasing the effective surface area without greatly increasing the volume of the organism). They may also have long, flat body shapes like a chaetognath. So, organisms with a high surface area to volume ratio (but heavy enough to sink below the surface of the water) are going to be closer to neutrally buoyant than those a lower surface area to volume ratio.

Materials:

- Available small materials for making zooplankton models (examples: aluminum foil, sandwich bags, plastic utensils, paper clips, tape, tooth picks, dried beans, rubber bands, corks)
- Worksheets for each group
- 10 gallon aquaria filled to equal heights with water
- Stop watches (1 per group)
- Images of zooplanktonic organisms

Instructional Strategies/5 E model:

Engage: Show students images of zooplanktonic organisms. Have them discuss the identity of any of the organisms that are familiar to them. Have the students discuss what is similar and different about the body shapes of the organisms. Have students answer and discuss the introductory questions.

Explore: Have students break into teams of 3 to 5. Give the teams 3 minutes to create their zooplanktonic organism using the materials provided. At the end of the three minutes, the students should sketch their organism and then bring their organism to the aquaria and place them gently into the water. One team member is in charge of timing how long the zooplanktonic organism is in the water column. Timing should begin when the organism is completely submerged and stop when any part of the organism touches the bottom of the tank. After all of the teams have completed their trials, they should record their data on their worksheets and on the class chart on the main board. This procedure is repeated several times (3 to 5), giving students the opportunity to learn from and improve on their previous designs.

Explain: When all of the trials have been completed, student should answer Follow-Up Questions 1 through 5. In individual groups and as a class, the students should discuss why various organisms were better than others. As a class, the students should come up with a list of characteristics that made organisms successful and a list of characteristics that made organisms unsuccessful. The instructor(s) should help students see the connection between surface area, volume, and buoyancy.

Elaborate: Compare the list of characteristics that students made of the similarities and differences that they noticed in the zooplankton images from the beginning of the lesson to the lists that they made of successful and unsuccessful traits of their models. Hopefully, students will see similarities between the zooplankton characteristics and the successful models. Using this information, the students can answer Follow-Up Questions 6 and 7. Students can discuss how the body shape relates to where you would find zooplankton in the water column and the roles that zooplankton play in ecosystems.

Evaluate: Students draw or design the "perfect" zooplanktonic organism, which can maintain neutral buoyancy. Students should write a paragraph describing why their organism is designed the way that it is and how it would maintain buoyancy.

Answer Key:

Introductory Questions:

1. Why are zooplankton important? *Important part of marine food webs. Important for structuring marine ecosystems.*

2. In general, do you think that planktonic organisms are neutrally buoyant, negatively buoyant, or positively buoyant? Explain your answer. *Plankton are neutrally buoyant so that they stay under water but in the upper layer of the ocean. This allows them to be close to the sun (for phytoplankton) and food (for zooplankton).*

Follow-Up Questions:

5. The surface area to volume ratio is the amount of surface area per unit volume that an object has. For example, a sheet of paper has a high surface area to volume ration and a ball has a low surface area to volume ration Based on your previous answers, explain the relationship between surface area to volume ratio and buoyancy. *Organisms that have a high surface area to volume ratio are more buoyant than animals with a low surface area ratio.*

6. Would you expect that most planktonic organisms have a high surface area to volume ratio or a low surface area to volume ratio? Explain your answer. *Plankton tend to have high surface area to volume ratios because this allows them to be more buoyant. The buoyancy allows them to stay in the upper layers of the ocean without expending lots of energy.*

7. What characteristics help plankton to increase their surface area to volume ratio? *Possible answers include spines, thin bodies, oblong (as opposed to round) body shapes, and outstretched antennae. In general, any thin, spread out aspect of the organism.*

Additional Resources:

- http://www.st.nmfs.noaa.gov/plankton/ Copepod: The Global Plankton Database. Provides background information on zooplankton and databases containing data from a number of time series all over the world.
- http://planktonnet.awi.de/ Collection of zooplankton images.
- http://jellieszone.com/ Jellies Zone. A great source of information and images of gelatinous zooplankton.
- http://www.cmarz.org/ Census of Marine Zooplankton
- http://www.tafi.org.au/zooplankton/ Guide to the Marine Zooplankton of Southeastern Australia. Contains zooplankton image and diagnostic keys.
- http://calechoes.ucsd.edu Cal Echoes Research Cruise
- http://earthref.org/SCC Scripps Classroom Connection GK-12 program with earth, environmental, and marine science lesson plans
- Other versions of this activity:
    - http://www.schoolship.org/schoolship/?id=658
    - http://www.sea.edu/academics/k12.aspx?plan=sinkingraces
    - http://www.schoolship.org/files/inlandseas/659.pdf

STUDENT Instructions

Build Your Own Zooplankton

Names of Group Members:

Activity Driving Question: How do planktonic organisms stay near the surface of the ocean?

Introduction: Working in groups, you are going to create models of zooplankton. Your goal is to make a model organism that will sink as slowly as possible in the aquarium. The team that has the slowest sinking plankton will win the Plankton Race!

Vocabulary

Plankton – drifting organisms; organisms that cannot swim against the current

Phytoplankton – plant-like planktonic organisms

Zooplankton – animal-like planktonic organisms

Buoyancy – the tendency of a body to float when submerged in a fluid

Surface Area – how much exposed area a solid object has

Volume – how much mass a shape contains

Surface Area to Volume Ratio - the amount of surface area per unit volume that an object has

Introductory Questions

1. Why do you think that zooplankton are important?

2. In general, do you think that planktonic organisms are neutrally buoyant, negatively buoyant, or positively buoyant? Explain your answer.

Procedure:

1. Use the materials provided to build a zooplanktonic organism. You have 3 minutes to complete your model.
2. Draw and describe your organism in Question 1 of the Data section of the worksheet.
3. After you have finished your drawing, take your organism to the aquarium. Place your organism GENTLY in the aquarium and hold it just below the surface of the water so that it becomes saturated with water.
4. Using a stop watch, determine how long it takes for your organism to sink. You should start timing as soon as the whole organism is under the water (organisms that float don't count!) and stop timing as soon as the organism touches the bottom of the aquarium.
5. Record the time in the data chart and on the board.
6. Repeat steps 1 through 5 for each trial. Try to use what you learned from watching the behavior of your model and of the models made by other teams to improve your organism in each trial.

Data

Trial Number	Time to Bottom
1	
2	
3	
4	

1. Draw and describe the organism that you will use for trial 1.

2. Draw and describe the organism that you will use for trial 2.

3. Draw and describe the organism that you will use for trial 3.

4. Draw and describe the organism that you will use for trial 4.

Follow-Up Questions

1. Compare and contrast the designs of your best trial organism (slowest time) and your worst trial organism (fastest time).

2. Why do you think that your best organism was the best? Why do you think that your worst organism was the worst?

3. Estimate which of your organisms had the greatest surface area. How do you think that this impacted how well this organism performed in the trials?

4. Estimate which of your organisms had the greatest volume. How do you think that this impacted how well this organism performed in the trials?

5. The surface area to volume ratio is the amount of surface area per unit volume that an object has. For example, a sheet of paper has a high surface area to volume ratio and a ball has a low surface area to volume ratio. Based on your previous answers, explain the relationship between surface area to volume ratio and buoyancy.

6. Would you expect that most planktonic organisms have a high surface area to volume ratio or a low surface area to volume ratio? Explain your answer.

7. What characteristics help plankton to increase their surface area to volume ratio?