CENTERS FOR OCEAN SCIENCES EDUCATION EXCELLENCE
BEST OF COSEE HANDS-ON ACTIVITIES

Activity Title: Plankton Feeding

Learning Objectives

This activity provides a hands-on experience with a scale model, a relatively high viscosity (a property of a fluid), the interactions of an organism with its environment, and feeding behaviors.

Ocean Literacy Principles

#5 -- The ocean supports a great diversity of life and ecosystems

d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

#7 -- The Ocean is largely unexplored.

b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Supplies and Materials

- 2 pints of corn syrup (or honey which is more expensive and less transparent)
- 8 oz clear plastic cups
- Popsicle sticks (or forks, spoons and knives. Plastic or metal both work)
- Dry lentils (or beads, or dry peas)

Background

Suspension feeders such as copepods (the most abundant animal on Earth), krill, mollusks, or barnacles are animals that feed on small particles in water. Suspended particles are an abundant food source that is comprised of small phytoplankton, detritus, and bacteria. Suspension feeders are critical components of aquatic food webs converting small food sources into larger organisms. Filter feeders such as clams or oysters can remove millions of particles from the water column and clarify water bodies.

The food particles are small (~1-10 μm), so at these length scales, water seems to be very viscous to the suspension feeder. Successful suspension feeders have evolved specialized strategies or appendages to capture a suspended particle without moving the water so that the particle escapes capture. As an example of the relative viscosities of 3 fluids, try to move a plastic knife (blade perpendicular to the direction of movement) through air, water, and corn syrup. The increasing difficulty of moving the knife is provided by the increasing viscosity of the fluid from air to corn syrup.

By using corn syrup to represent water at low Reynolds Numbers (small length scales and high viscosities), students find that it is very difficult to move their feeding appendages (represented by popsicle sticks) through the fluid, and even more difficult to catch a food particle (represented by the lentil). Even with different shaped feeding appendages (forks, spoons, knives), it is very difficult unless you try to use a very thin appendage (e.g. a pin or the edge of the knife), or move the appendage very fast.

Life at low Reynolds Numbers, or the experience of common suspension feeders trying to catch their dinner, can be modeled at normal spatial scales by using a very viscous fluid. In this activity, suspension feeding is modeled by trying to catch a lentil in corn syrup.

The math behind this phenomenon is as follows. The relative property of the fluid is called its Reynolds Number, R_e, which is defined as:

$$R_e = \frac{\rho L U}{\mu}$$

Re is the Reynolds Number

ρ = the density of the fluid (kg m^{-3})

L = a length scale for the object (m)

U = the velocity of the fluid before it reaches the object (m s^{-1})

μ = the dynamic viscosity of the fluid (kg m^{-1} s^{-1})

As you can see, if the density, velocity and viscosity are similar, a much smaller length scale suggests a very low Reynolds Number. Alternatively, at length scales familiar to us, but with low Reynolds Numbers, viscosity must be high (in the denominator). This means to appropriately model suspension feeders at small length scales, we must use a high viscosity fluid to represent water at length scales of cups and Popsicle sticks.

Duration

30 minutes

Audience

Grades 4-12

Procedure

1. Fill a cup ½ full with corn syrup.
2. Place a few lentils in the syrup. You can also use a variety of dry beans or peas, or beads, but keep the numbers low so you can track a single target lentil.
3. Tell students to imagine that they are trying to capture food particles that are only $1/1000^{th}$ of a millimeter long. Their feeding appendage looks like a Popsicle stick.
4. Challenge the students to capture a lentil with their feeding appendage.
5. Have the students observe their success or failure, observe the movement of the syrup and the lentil, and write down their observations.
6. Discuss how life on a much smaller scale is different. The small particles and relatively high viscosity of water at these scales makes suspension feeding difficult for suspension feeders.
7. Discuss how suspension feeders have evolved elaborate (and sometimes fast) feeding appendages to overcome this property of water at these scales. You might view some of the videos or read the Purcell article below to explore further.

Assessment

Students can be asked to describe other processes that occur on very small scales in water. How does the relatively high viscosity affect these processes?

Students can be asked to design feeding appendages that might work at low Reynolds Numbers. How do these designs compare with those that can be found in the resources below or on the internet? With krill feeding strategies (fast, many thin appendages)?

Additional Resources

The following videos (accessed on December 8, 2011) show filter and/or suspension feeders in action.

- http://www.youtube.com/watch?v=vNqEQjGaDVk
- http://en.wikipedia.org/wiki/Filter_feeder
- http://www.coralscience.org/main/articles/aquaculture-a-husbandry-4/filter-feeders

E.M. Purcell, 1977, "**Life at Low Reynolds Number",** American Journal of Physics, volume 45, pages 3-11: http://jila.colorado.edu/perkinsgroup/Purcell_life_at_low_reynolds_number.pdf

Acknowledgements

This lesson is based on a Lesson: (With) Honey, I shrank the spoon, fork and knife! Developed by Pete Jumars (jumars@maine.edu) with corrections by Mark Patterson (mrp@vims.edu), 18 April, 2008. Adaptations to K-12 by Bob Chen, COSEE OCEAN.

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