Science Unit: **Marine Biodiversity: Global Ocean to the Salish Sea**

Lesson 4: **Barnacle Feeding Frenzy**

Summary:	Students observe live barnacles feeding (it's often a wonderful surprise for students to discover that barnacles are living things!) They then conduct an inquiry and collect data to determine if barnacle feeding speed changes in two water temperatures.
Lesson type:	Live animal observations
Grade level:	Presented to grade 3; appropriate for grades K – 12 with age appropriate modifications
Duration of lesson:	75 min
Developed by:	Jonathan Kellogg (Scientist); Andrea Teschner and Gillian Wilson-Haffenden (Teachers)
Developed for:	Lord Kitchener Elementary
School Year:	*2016-2017*
Notes:	Requires live barnacles from a local beach and sea water at two temperatures

Connections to BC Curriculum

Biodiversity in the local environment, Making observations about living things in the local environment, Collect simple data, Identify questions about familiar objects that can be investigated scientifically, Make predictions based on prior knowledge, Knowledge of local First Peoples, Use tables, simple bar graphs, or other formats to represent data and show simple patterns and trends, Compare results with predictions, suggesting possible reasons for findings.

Objectives

a) Observe live barnacles feeding in a cup of seawater and document these observations

b) Predict and determine how barnacle behaviour changes with different seawater temperatures

c) Learn how barnacles use their cirri (feet) to move water over their body when feeding

Materials

- Clear plastic cocktail cups
- Small cooler to hold barnacles
- Two 4L milk jugs
- Small barnacle covered rocks (1 rock per student pair)
- Food colouring
- Drawing or Graphing paper
- Seawater to fill milk jugs. Allow one to warm to room temperature, but keep the other in the refrigerator.

Background Information for the Teacher

Barnacles are extremely common in the rocky intertidal environment of the lower mainland, but are often overlooked since they do not appear to be alive at low tide. This lesson aims to bring live barnacles into the classroom, have the students make observations, then make predictions before changing the temperature of the barnacle environment by changing out the water.

Finally, food colouring is used to illustrate how the barnacles move the water near them while they are feeding. In preparation for the activity, students are reminded that barnacles are members of the phylum Arthropoda and subphylum Crustacea, learn a bit about the barnacle life history, and barnacle anatomy.

Wondering where to get your barnacles? In Vancouver, the beach at David Lam Park has numerous small rocks covered in barnacles. Collect when the tide is below 2.75 m according to False Creek tide predictions.

Vocabulary

- **Plankton** – Generally small and microscopic plants or animals which cannot swim against a current. While most are small, all jellyfish (including the Lions Mane which can reach up to 35+ m) and even the sunfish (1,000+ kg) are considered plankton because they are drifters.
- **Crustacean** – A subphylum of arthropods that are largely aquatic and are characterized by having a nauplius (planktonic) life stage
- **Arthropod** – Invertebrate animal having an exoskeleton, a segmented body, and jointed appendages.
- **Cirri** – Feeding appendages of barnacles. Analogous to legs.
- **Nauplius** – Juvenile life stage of barnacles and other crustaceans
- **Prediction** – An educated guess about the future that may be based on previous experiences
- **Phytoplankton** – Microscopic plants living in seawater that are primary producers.
- **Zooplankton** – Drifting marine animals that cannot swim against currents.
- **Holoplankton** – Zooplankton that spend their whole lives as plankton. May be small like a copepod (~1-3 mm) or as large as an ocean sunfish (3 m).
- **Meroplankton** – Zooplankton that only spend part of their lives as plankton. Examples include, starfish, crab, fish, and of course, barnacles.

Classroom Set-up

Students should make their observations as individuals or in pairs at their desks. Prior to distributing barnacles, students should be warned that they need to keep their hands off the tables until the barnacles open and begin feeding (up to 5 min) since vibrations will scare the animals and opening will take longer.

Lesson Detail

Introduction

1. **Ask students what they know about plankton**.

   If they have not been exposed to plankton before, use pictures and video to enhance your descriptions of both phyto and zooplankton.

   - Plankton comes from the Greek word, planktos, which means 'drifter.' Plankton cannot swim against currents.

   - **Phytoplankton**. As primary producers, phytoplankton are the base of the marine food chain. They use photosynthesis to take the suns energy and convert it into sugars and organic material which can be used by all higher trophic levels in the ocean. Phytoplankton also provide half of all the breathable oxygen on the planet (with land plants providing the other half). Satellite maps of chlorophyll, the green pigment in phytoplankton, show that most phytoplankton grow along coasts, at high latitudes, and near the equator where nutrients are abundant. In the central ocean gyres, plankton growth is often limited due to lack of micronutrients, like iron.

   - **Zooplankton**. Zooplankton are the primary consumers of phytoplankton and are the microscopic animals that eat phytoplankton. There are two main types of zooplankton, holoplankton and meroplankton. Holoplankton are unable to swim against currents for their entire lives. These creatures may be as small as a copepod (~1-3 mm) or krill (~1 cm), or as large as a lions mane jellyfish (40 m) or ocean sunfish (>1000 kg) since these are all unable to swim against the current.

   - **Meroplankton** are plankton for only part of the juvenile phase of their life before growing larger and taking on their adult form. A fun way to engage students in this is to play a game of "Who's your parent?" where students have to match juvenile and adult forms. Animals you may consider for this include: barnacles, crabs, starfish, sea snails, sea urchin, fish, octopus, squid.

2. This discussion can lead to the life history of barnacles:
   - Barnacles are plankton before getting to their adult stage.
   - Barnacles go through multiple naupliar, or juvenile, stages before becoming adults.
   - Adults cement their heads to a hard surface where they will spend the rest of their lives.
   - As adults they have a two component shell, the fixed outer shell and the movable inner plates that protect the barnacle from predators and drying during low tide.

3. Barnacles are examples of **filter feeders** that have adapted to filter phytoplankton out of seawater for their food. Have students pay special attention to the cirri to see the feathered texture of these appendages.

Activity

1. After initial discussion about the life history and anatomy of barnacles, provide students with barnacles in plastic cups and fill the cups with enough of the colder seawater to cover barnacles completely. Have students spend ~5 min observing barnacles, drawing them if desired. Have students choose one barnacle on their rock and count the number of cirri beats for 30 seconds. Have students record how many beats there were.

2. Tell the students that we are going to change the water temperature to some warmer seawater. Have the students make predictions about how the barnacle behaviour will change (more active, less active, same activity) with the different seawater temperature. Record their predictions, either on their own paper or poll the class to see if there is a consensus. Ask students why they have chosen their predictions to check reasoning.

3. Change out the seawater in the cups for the seawater that has been allowed to come to room temperature. When all the water has been changed, and the barnacles are once again active, have students count the number of cirri beats for the same barnacle that they counted for last time. Have them count for another 30 seconds. Have students record their findings and poll students to get a sense of barnacle activity. Barnacles should have gotten more active with the warmer water since they are cold blooded and warmer water holds less oxygen so more water is needed to be exchanged for the same oxygen demand.

4. As a last exercise, put one drop of food colouring into the water and have the students observe the water movement as the dye flows over the barnacle.

Closure Discussion

Examples of questions to help students share their results and observations…

1. Are barnacles alive? Are they animals? How do you know?
2. How did the barnacles respond to the change in temperature? Did it match your prediction?
3. Graph the students results and compare the results as a class. Emphasize why duplications of an experiment are important to the scientific process.
4. Is it okay to have an incorrect prediction in science? Why is it okay?
5. What else did you notice?
6. Do you think being a filter feeder is a good strategy? Why or why not?
7. First Nations on the outer coast of Vancouver Island have recently established a sustainable fishery of gooseneck barnacles. (https://www.youtube.com/watch?v=UcRue9FtgT0)

Extensions of Lesson

1. This activity may be repeated with multiple different temperatures to develop a more robust relationship between barnacles and temperature.
2. Class averaging of the dataset to evaluate if all barnacles increased their rate by the same proportion.
3. Evaluate filter feeding as a survival strategy. Here's a suggested lesson plan: http://www.cosee.net/best_activities/activity/Plankton_Feeding.pdf

References

While originally developed as part of a graduate level course in communicating ocean sciences by Dr. Kellogg, similar versions of this lesson are available online. Another version of this lesson can be found at the FORSEA Institute for Marine Sciences at: http://www.forsea.org/cd9l.html.