NOAA FISHERIES

Oysters in Alaska

Grades 3-5 Lessons on Pacific Oysters (*Magallana gigas*) and Oyster Mariculture in Southeast Alaska

About

The Project

Mariculture (the farming of shellfish and seaweed in the ocean) is a rapidly growing industry in Alaska, with farmed Pacific oysters (*Magallana gigas*) currently significantly contributing to this industry's profit. However, there are no wild oysters in Alaska and the high-latitude estuarine environment of southeast Alaska differs greatly from many other areas in the country where oysters are currently farmed. Therefore, it is important to determine environmental factors that influence oyster health to optimize growing conditions at existing oyster farms and to aid in site selection for future farms as the industry grows. Another challenge associated with farmed oysters is harmful algal blooms (HABs), with paralytic shellfish poisoning (PSP) from *Alexandrium spp.* dinoflagellates being of particular concern for public health in the region. Determining which factors contribute most strongly to the health of farmed oysters, as well as to toxin levels in oyster tissue, is critical in allowing oyster mariculture to expand in a safe and profitable way in southeast Alaska.

To address these questions and challenges, scientists at the National Oceanic and Atmospheric Administration (NOAA) Alaska Fisheries Science Center (AFSC) collaborate with a southeast Alaska oyster farm to monitor environmental conditions, phytoplankton community composition, indicators of oyster health, and PSP toxin levels in oyster tissue and the water column. More information about this project and our findings is available at https://afscmariculture.github.io/oyster_report/.

The Lessons

The following lessons are divided into three modules: Oyster Anatomy, Oysters in the Environment, and Alaska Mariculture. Ocean Literacy Principles (OLP) and Next Generation Science Standards (NGSS) addressed in each module are available at the end of the module. These lessons have been tailored to grades 3-5, but additional grade levels are available.

Who We Are

These lessons were developed by Juliana Cornett, Alaska Sea Grant State Fellow at NOAA AFSC, Dr. Jordan Hollarsmith, Mariculture and Macroalgae Lead Research Biologist at NOAA AFSC, and Stori Oates, Communications and Education Coordinator at NOAA AFSC.

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Module 1: Oyster Anatomy

Summary: Students will learn about the external and internal anatomy of oysters through fill-in-the-blank coloring pages and an oyster dissection.

Objectives:

- Color and label external & internal anatomy coloring pages
- Dissect an oyster
- Participate in discussion of oyster anatomy

Materials Needed:

- Printed external & internal anatomy coloring pages
- Pencils & colored pencils
- Oysters (1 per pair of students)
- Oyster shucking knife
- Paper plates
- Dissection tools
- Dissecting scope/magnifying glass (optional)

Background Information:

Oysters are bivalve mollusks found in coastal waters around the world. Oysters have two, hard external shells made from calcium carbonate to protect their soft bodies inside the shell from predators. Oysters are selective filter feeders that feed on phytoplankton, and they have a digestive system to process these phytoplankton. Oysters also have a small heart and an open circulatory system; however, they lack a central nervous system.

A number of species of oyster are harvested or cultivated for either food or pearls. The Pacific oyster, *Magallana gigas*, is native to the Pacific coast of Asia, but has been introduced to other parts of the world. It is often grown in mariculture settings - including at oyster farms in Alaska!

Pacific oyster, *Magallana gigas*

Key Words:

- Adductor muscle = Muscle tissue that controls the opening and closing of the shells.
- Anus = Opening at the end of the rectum through which waste is eliminated.
- Bill = Larger, curved end of an oyster's shell (opposite the hinge).
- Bivalve = Marine or freshwater mollusk that has two shells.
- Digestive Gland = The gland responsible for the production of digestive enzymes.
- Gills = The gills are the largest organ in the oyster's body, and consists of four folds of tissue. Along with the mantle, it is the chief organ of respiration. They create water currents, collect food particles, and move food particles to the labial palps for further sorting.
- Heart = Organ that lies above the adductor muscle. It is located in a clear sac and looks like a tiny sponge connected to a tube. Oysters have blood but it is not pigmented red like human blood. The heart pumps the blood through the oyster's body. Oysters have an open circulatory system, there are no definite veins and arteries through which the blood can flow; instead, blood drains through open sinuses within the body.
- Hinge = Connection between the two shells/valves of an oyster.
- Intestine = Structure where oysters absorb nutrients from food particles after digestion in the stomach.
- Labial Palps = Lip-like structures which sort particles by both density and size. Direct edible phytoplankton and algae toward the mouth to be ingested and nonedible particles (like sediment) towards the mantle cavity.
- Mantle = Two fleshy folds of tissue that cover the internal organs of the oyster and are always in contact with the shells, but not attached to them. Its principal role is the formation of the shell.
- Mollusk = Animals with soft unsegmented bodies usually enclosed in a calcareous shell
- Mouth = U-shaped slit located between the labial palps that receives food from the palps.
- Oyster = Marine bivalve mollusk.
- Pericardial cavity = Cavity containing the heart.
- Rectum = A tube through which waste is eliminated.
- Shell = External, protective structure of the oyster made from calcium carbonate.
- Shucking = Opening an oyster.
- Stomach = A large sac-like organ that is divided into two chambers used in the digestion and sorting of food particles.
- Tentacles = Small sensory organs attached to the edge of the mantle used for the detection of environmental stimuli.
- Umbo = The pointed and oldest part of the oyster.
- Valves = The two shells of the oyster.

Pre-Activity Questions

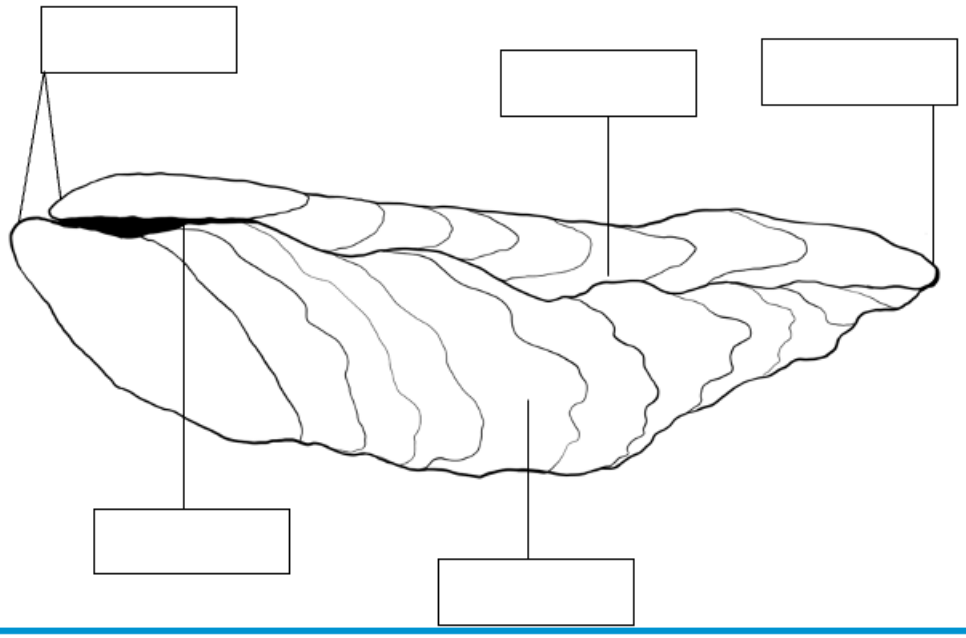
Ask some or all of the following pre-activity questions before beginning the activities, while allowing students to observe an unopened oyster. It may be helpful to write down students' thoughts and answers to return to during the reflection questions.

- What is an oyster?
- What does an oyster look like on the outside?
- What clues does the outside of the oyster give us about the inside?
- What do you think the oyster looks like on the inside?
- What body parts do you think it has inside?
- Which body parts do you think the oyster needs to survive?
- What function does the shell serve?
- How might an oyster be eaten by predators?
- What challenges or barriers must the predator overcome in order to prey on the oyster?
- What part of the oyster will the predator eat? Why?

Coloring Pages

External Anatomy

Name: _____

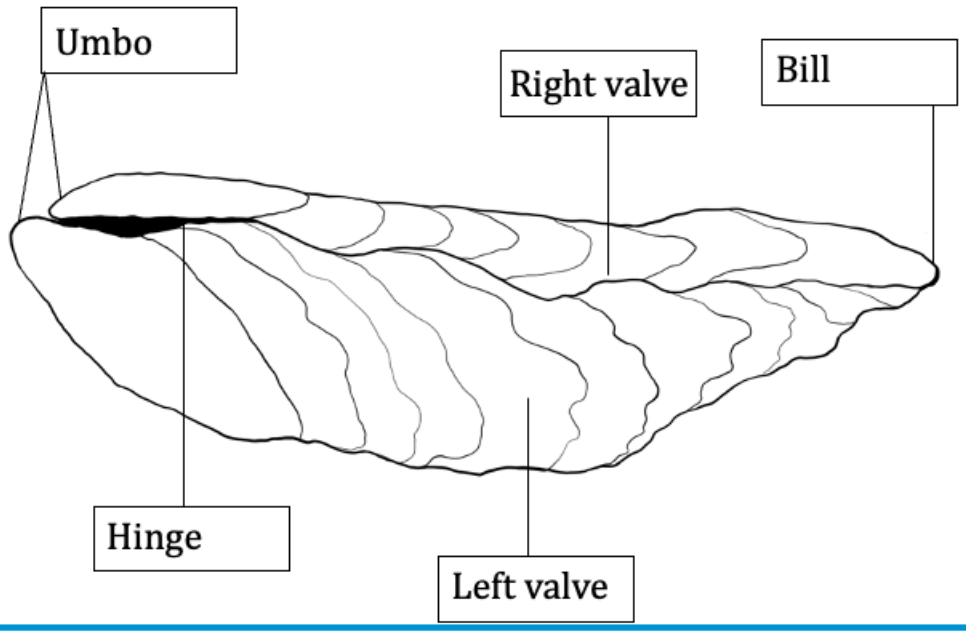


Word Bank:

- ☐ Bill
- ☐ Hinge
- ☐ Left valve
- ☐ Right valve
- ☐ Umbo

External Anatomy: Answer Key

Name: _____



Word Bank:

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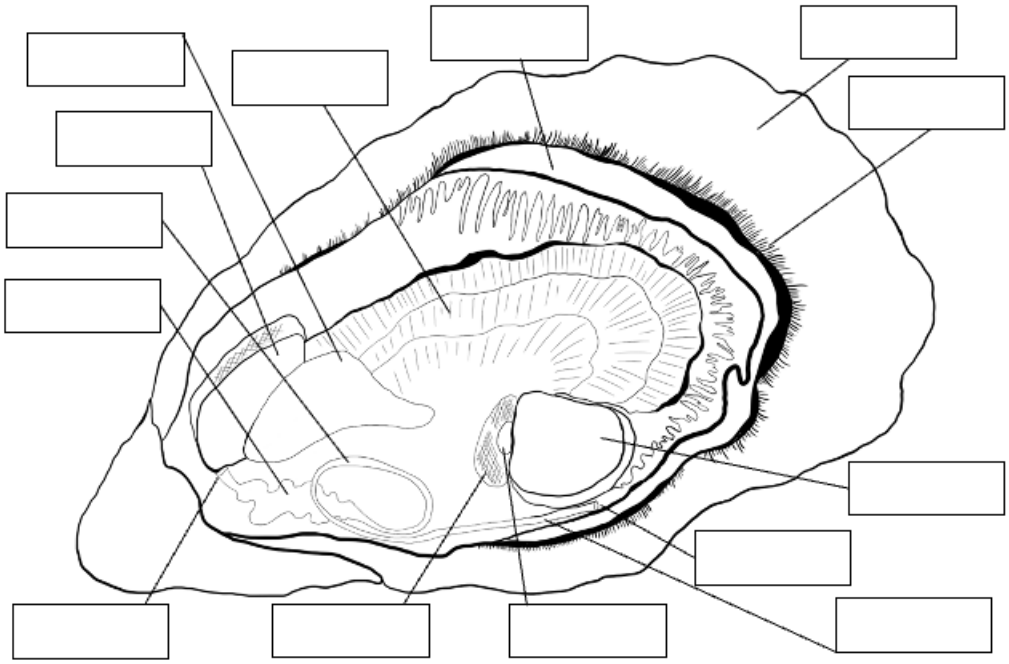
- ☑ Right valve
- ☑ Umbo

Internal Anatomy

Name: _____

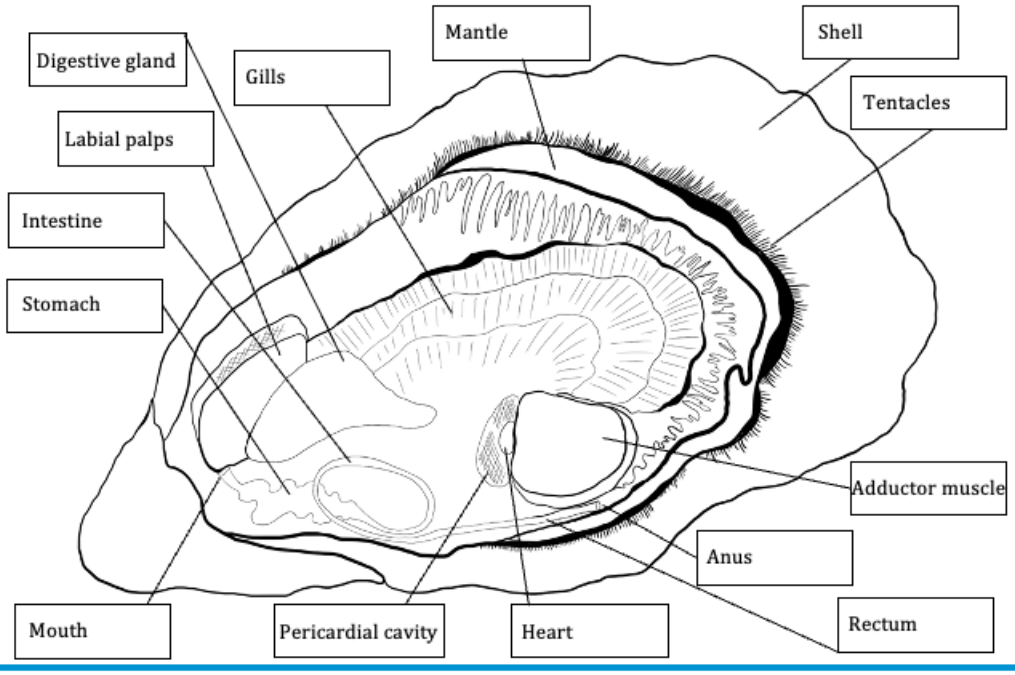


Word Bank:

- ☐ Adductor muscle
- ☐ Anus
- ☐ Digestive gland
- ☐ Gills
- ☐ Heart
- ☐ Intestine
- ☐ Labial palps
- ☐ Mantle
- ☐ Mouth
- ☐ Pericardial cavity
- ☐ Rectum
- ☐ Shell
- ☐ Stomach
- ☐ Tentacles

Internal Anatomy: Answer Key

Name: _____



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- ☑ Rectum
- ☑ Shell
- ☑ Stomach
- ☑ Tentacles

Oyster Dissection

1. Shuck oysters and hand them out to students on a paper plate with dissection tools and a dissecting scope or magnifying glass, if available.

2. Ask students to look for all body parts from the anatomy coloring pages.

3. Encourage students to write down observations and/or make sketches as they dissect the oyster (worksheets available on following pages).

4. Once complete, proceed to the reflection questions.

External Anatomy Worksheet

Name: _____

Draw the outside of the oyster:
What do you notice about the outside of the oyster?

Internal Anatomy Worksheet

Name: _____

Draw the inside of the oyster:
What do you notice about the inside of the oyster?

Reflection Questions

Ask some or all of the following reflection questions after completing the activities. It may be helpful to return to students' thoughts and answers from the pre-activity questions.

- Did the oyster look the way that you expected it to on the inside?
    - Why or why not?

- Do you have any of the same body parts as an oyster?
    - What is similar and what is different?

- What types of animals do you think would be able to eat an oyster?
    - What tools or body parts would those animals need to be able to eat the oyster?

Education Standards

Next Generation Science Standards

- **4-LS1.A.** Plants and animals have both internal and external structures that serve various functions in growth, survival, and reproduction (Disciplinary Core Idea).

Module 2: Oysters in the Environment

Summary: Students will learn about phytoplankton, how oysters feed and interact with their environment, and how oysters compare to some native shellfish in Alaska.

Objectives:

- Learn about some of the different types of phytoplankton (including HAB species)
- Complete filter feeding activity
- Compare and contrast oysters to other shellfish

Materials Needed:

For Filter Feeding Activity

- Clear plastic cups
- Food coloring
- Filtering material (coffee filters/cheesecloth)
- Multiple different types of small objects (pasta, beads, etc…)
- Sticky material (tape/putty)

For Drawing Activity

- Printed phytoplankton drawing worksheet
- Pencils & colored pencils
- Photos of phytoplankton or phytoplankton guides (if available)

Background Information:

Oysters are sessile organisms, meaning that they stay attached in one place (such as a rock on the seafloor), and do not move around their habitat. Since they are unable to move around, they cannot chase after prey. Instead, oysters filter feed - meaning they filter out particles suspended in the water column that drift by them. In particular, the particles they like to eat are phytoplankton, microscopic marine algae that make up the base of the marine food web. However, oysters take up more than just algae when they feed, so they have mechanisms for dealing with things that they don't want to eat.

Key Words:

- Diatom = Phytoplankton with a cell wall made of silica that are either radially symmetrical (centric diatoms) or bilaterally symmetrical (pennate diatoms).
- Dinoflagellate = Phytoplankton with a cell wall made of cellulose that possess flagella and can occur in a variety of shapes.
- Ecosystem Service = A benefit provided by the natural environment or by organisms in the natural environment.
- Filter Feeder = An aquatic organism that feeds by filtering out particles suspended in the water column.
- Harmful Algal Bloom (HAB) = An algal bloom that negatively impacts other organisms, often via the production of harmful toxins.
- Macroalgae = Macroscopic, multicellular, marine algae - also called "seaweed."
- Microalgae = Microscopic, marine algae (may be unicellular or multicellular) - also called "phytoplankton."
- Paralytic Shellfish Poisoning (PSP) = A serious illness caused by consuming shellfish with elevated levels of PSTs.
- Paralytic Shellfish Toxins (PSTs) = Neurotoxins, typically produced by dinoflagellates, that can cause PSP. One of the most common toxins is saxitoxin.
- Phytoplankton = Autotrophic plankton that form the base of the marine food web.
- Pseudofeces = A specialized method of expulsion used by filter-feeding mollusks to get rid of non-food particles.
- Toxin = A naturally occurring organic poison produced by metabolic activities of living cells or organisms.

Pre-Activity Questions

- Have you ever found seaweed at the beach?
    - If so, what did you notice about it?

- Have you ever heard of phytoplankton?
    - If so, what are they?

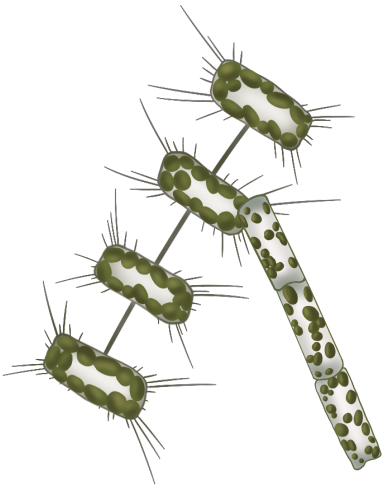
- What do you think oysters eat? How do you think oysters eat?

Phytoplankton & Filter Feeding

Phytoplankton Overview

Algae comes in all sizes, from tiny microalgae (also known as phytoplankton) that can't be seen with the naked eye up to big macroalgae (also known as seaweeds) that can grow over 50 meters long! Seaweeds are multicellular, while phytoplankton may be multicellular or unicellular. Both seaweeds and phytoplankton use nutrients and sunlight to photosynthesize.

Most phytoplankton fall into two main categories: diatoms and dinoflagellates. Diatoms have a cell wall made of silica, and are either radially symmetrical (centric diatoms) or bilaterally symmetrical (pennate diatoms). Dinoflagellates have a cell wall made of cellulose, possess flagella, and can occur in a variety of shapes.



Thalassiosira sp. & Leptocylindrus sp. diatoms

While phytoplankton are extremely important, serving as the base of the marine food web (and producing around half of the world's oxygen!), some species of phytoplankton can be harmful to the animals that eat them and to other animals up the food chain (including humans). When a large number of these harmful species are present in the water, it is known as a Harmful Algal Bloom (HAB). In Alaska, we are mainly focused on three HAB genera: *Pseudo-nitzschia*, *Dinophysis*, and *Alexandrium*. Some species of *Pseudo-nitzschia* produce Domoic Acid (DA), which may lead to Amnesic Shellfish Poisoning (ASP). Some species of *Dinophysis* produce Okadaic Acid (OA), which may lead to Diarrhetic Shellfish Poisoning (DSP). Some species of *Alexandrium* produce saxitoxin and its congeners, which may lead to Paralytic Shellfish Poisoning (PSP). All of these can make marine animals and people very sick, and in some cases, even lead to death. *Alexandrium* species are of greatest concern for public health in the state. As such, all shellfish farmers are required to send their shellfish to the state testing labs to test for PSP toxin levels before they are able to sell their shellfish for people to eat.

Phytoplankton Drawing Activity

After discussing key characteristics of different types of phytoplankton (i.e., diatoms and dinoflagellates), as well as the HAB species of concern in Alaska, students will draw a diatom, a dinoflagellate, and a HAB species in the spaces on the sheet on the following page. Ask students to label their drawings with genus and species (optional) or key characteristics (optional). It helps to have phytoplankton and seaweed photos or guides available to students, if possible (or fresh samples if you are near the ocean!). Some phytoplankton photos are also available at https://afscmariculture.github.io/oyster_report/content/phyto_photos.html.

Name: _____

Draw a diatom:

Draw a dinoflagellate:

Draw a HAB species:

Filter Feeding Activity

1. Mix food coloring and small objects into water in one plastic cup (designate some objects as food or algae that oysters prefer to eat and other objects as non-food and/or algae that oysters prefer **not** to eat)

2. Set filter material in other plastic cup and pour water through

3. Note that the water is less colorful after going through filter (oysters can remove some excess nutrients and other pollutants from water, leading to cleaner water)

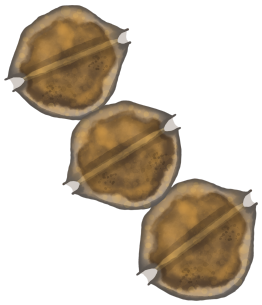
4. Note that all of the objects are stuck in the filter (both the "good" algae and the non-food or "bad" algae)

5. Explain that oysters can preferentially feed to an extent by covering things they don't like in mucus and expelling as "pseudo-feces"

6. Have students use tape or putty to pick up non-food items or "bad" algae out of filter and discard

7. Explain that items remaining in filter are what the oyster will digest

Dealing with Harmful Algal Blooms (HABs)



Alexandrium sp. dinoflagellate

Sometimes oysters end up consuming algae that are bad for them (or bad for other animals or people that then eat the oysters). Out of the Harmful Algal Bloom (HAB) species here in Alaska, we are most concerned about dinoflagellates in the genus *Alexandrium*, which produce saxitoxins that can cause Paralytic Shellfish Poisoning (PSP).

However, the amount of HAB phytoplankton in the water is not necessarily directly related to the amount of toxins in shellfish tissue because oysters and other shellfish have some different ways for dealing with HAB species.

For example, oysters are able to preferentially feed to an extent - by either closing their shells to prevent filter feeding or "spitting out" algae that they don't want to eat as mucus-coated pseudo-feces. Some shellfish are even able to use toxins to their advantage! Butter clams, one of the clam species found in Alaska, are able to sequester saxitoxin from consumed algae in their siphons as a chemical defense against fish that attempt to eat their siphons.

Reflection Questions

Ask some or all of the following discussion questions after completing the activities above.

- What is an ecosystem service?
    - Can you think of any ecosystem services that oysters provide?

- How might oysters impact the water around them? (Can remind students of how the water was clearer after passing through the filter in the filter feeding activity)

- How might oysters impact other organisms around them? (For example, a positive impact could be habitat provisioning - other animals, such as mussels, living on top of oysters. Other oyster species, like the Eastern oyster, also form oyster reefs. A negative impact could be competition for space or food with other species)

- Pacific oysters are not native to Alaska. What are some similarities and differences between Pacific oysters and some of the native shellfish found in Alaska? (Show photos of or shells from native shellfish, if possible, as well as the Alaska Mariculture poster at the beginning of Module 3, which shows a number of native shellfish)

Education Standards

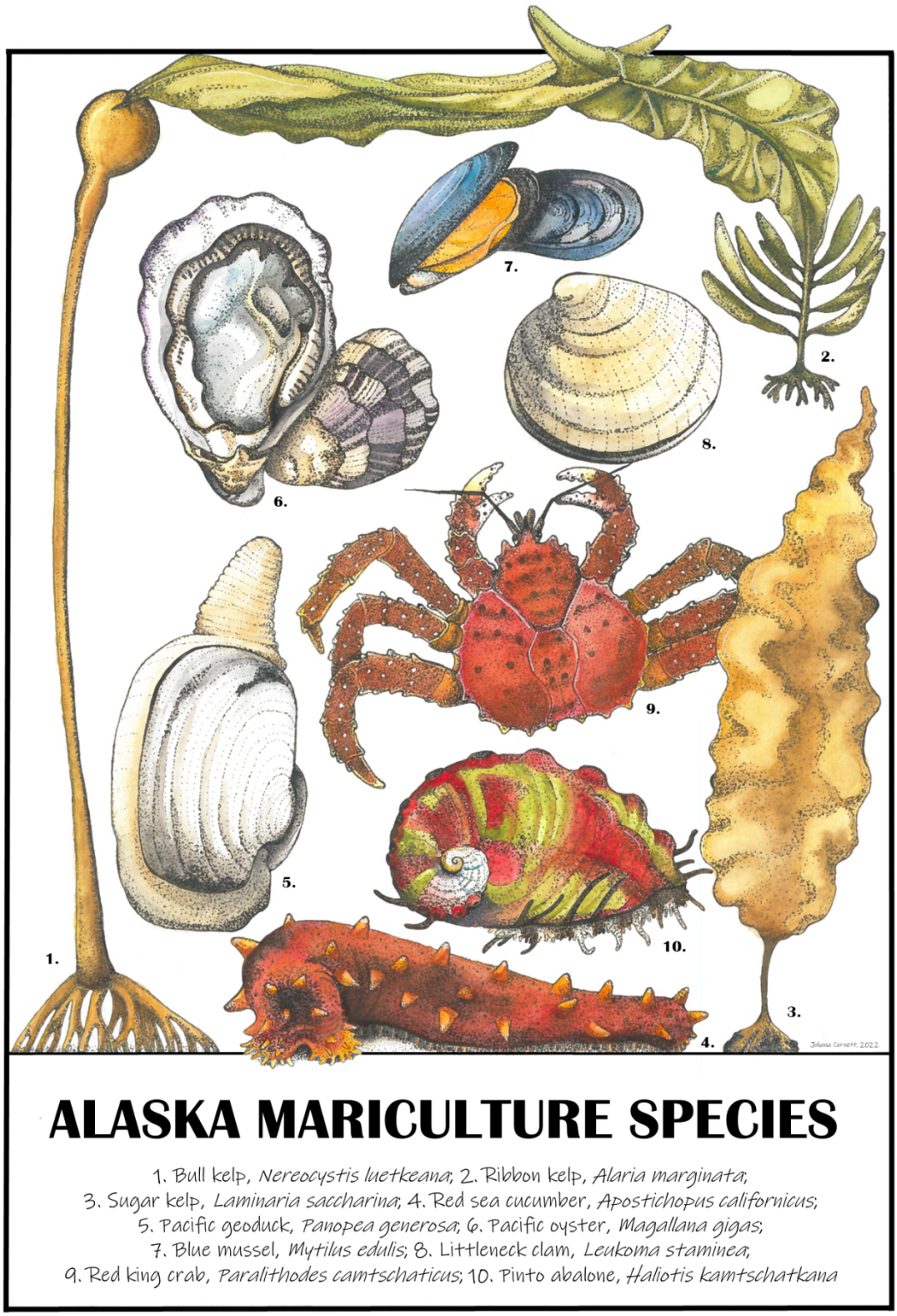
Ocean Literacy Principles

- **Grades 3-5: OLP 5A.2.** Phytoplankton, the base of most ocean food webs, flourish in coastal surface waters where there are plenty of nutrients and sunlight.

Next Generation Science Standards

- **4-ESS2.E.** Living things affect the physical characteristics of their regions (Disciplinary Core Idea).

Module 3: Alaska Mariculture



Summary: Students will learn about oyster farm operations and take a field trip to a local oyster farm.

Objectives:

- Learn about oyster farm operations
- Consider farm site suitability characteristics

Materials Needed:

For Activity

- Beads of three different sizes
- Colander/strainer with large holes/mesh bag with large holes
- Strainer with small holes/coffee filter/mesh bag with small holes
- Paper plates
- Ruler

For Field Trip

- Thermometer
- Refractometer
- Plankton net tow
- Microscope
- Microscope slides and cover slips
- Disposable transfer pipet

Background Information:

Aquaculture is the culturing of aquatic species, while mariculture is the culturing of marine species in particular. In Alaska, mariculture only includes the culturing of seaweed and shellfish, as the culturing of marine finfish is not permitted. However, mariculture does include finfish in some other parts of the country and world. Although some forms of aquaculture and mariculture have been practiced for thousands of years, large-scale commercial mariculture is a fairly new industry - with exciting potential for growth in Alaska!

Key Words:

- Aquaculture = Culturing aquatic species.
- Grow Out Bag = A floating mesh bag, typically clipped to a buoy line, where oysters are placed at low enough densities to grow. Water is able to pass through the mesh so that oysters can feed on plankton.
- Hatchery = A place where the hatching of eggs (such as oyster eggs) is artificially controlled for commercial purposes.
- Larvae = Oysters that have hatched from eggs, but have not yet settled and reached the "spat" life stage.
- Mariculture = Culturing marine species. In Alaska, mariculture only includes the culturing of seaweed and shellfish, as the culturing of marine finfish is not permitted.
- Plankton Net Tow = A net with a very fine mesh, with an attached jar or bottle, used to collect samples of plankton. It is typically attached to a weighted line for towing through the water.
- Refractometer = A tool for measuring salinity by using an index of refraction.
- Salinity = A measurement of the amount of salt dissolved in a body of water.
- Seed = Oyster spat between 3-20 mm
- Spat = Oyster larvae that have settled on a surface.
- Stack = A stack of mesh trays, typically suspended from a dock, where oysters are placed at low enough densities to grow. Water is able to pass through the mesh so that oysters can feed on plankton.
- Tumbling = Mechanically tumbling oysters to improve oyster shape and strengthen their shells.

Pre-Activity Questions

Before beginning the activities, assess what students already know about mariculture in Alaska by asking some or all of the following discussion questions. It may be helpful to write down students' thoughts and answers prior to the activities, and return to them after.

- Have you ever heard of aquaculture or mariculture?
    - If so, what are they?

- Do you know of any mariculture species that are farmed in Alaska?

- Do you like to eat seafood?
    - If so, what types of seafood have you eaten?

- How might mariculture benefit Alaska?

- Do you think there are any negative impacts of mariculture?
    - If so, what are they?

Oyster Mariculture Operations

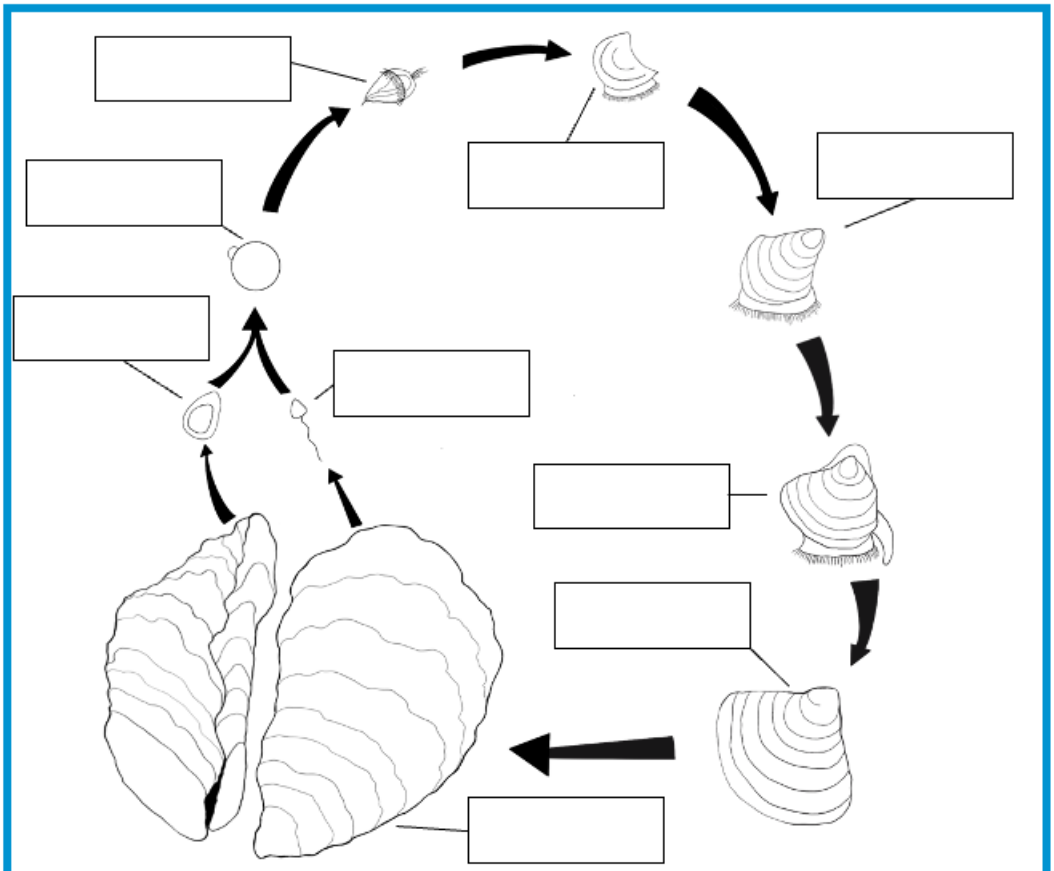
From Hatchery to Farm

Farmed oysters do not naturally reproduce here in Alaska because the water temperature is too cold, and there are no wild oysters in Alaska either. Instead, oyster farmers in Alaska receive their oysters as "seed" (oyster spat that has reached a certain size) from hatcheries, which then grow to mature oysters on the farm.

Have students color in the oyster life cycle coloring page on the following page, and fill in the blanks with the name of each life cycle stage.

Oyster Life Cycle: Coloring Page

Name: _____

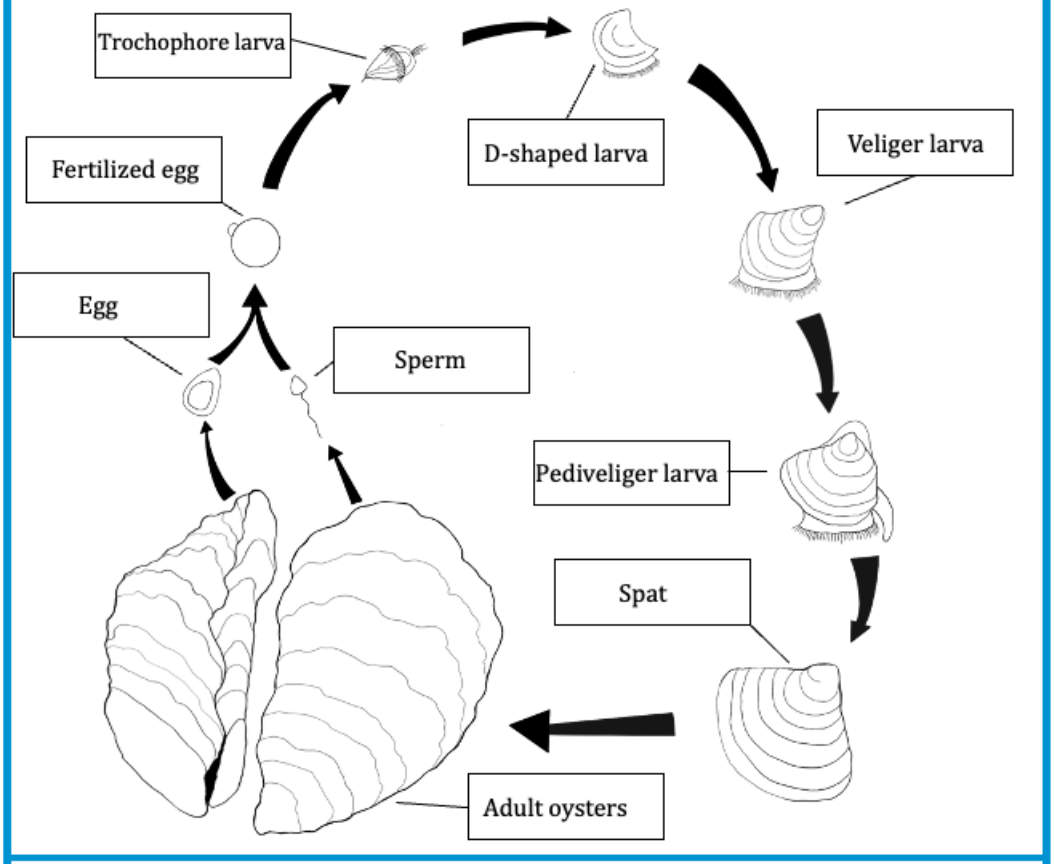


Word Bank:

- ☐ Adult oysters
- ☐ D-shaped larva
- ☐ Egg
- ☐ Fertilized egg
- ☐ Pediveliger larva
- ☐ Spat
- ☐ Sperm
- ☐ Trochophore larva
- ☐ Veliger larva

Oyster Life Cycle: Answer Key

Name: _____



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- ☑ Veliger larva

From Farm to Harvest

1. Mix together beads of all different sizes in a bowl

2. Have students sort out the smallest beads into the container with the smallest mesh (fine mesh bag, coffee filter), and explain that these are the juvenile oysters that still need to grow

3. Medium and large size beads should remain in the bowl. Transfer these medium and large beads to container with larger mesh (strainer/bag with larger mesh)

4. Now, have students "harvest" out of this container

5. Set harvest size as a measurement larger than medium bead and smaller than the large bead

6. Have students measure beads with the ruler and put large beads onto the plate ("harvest") and medium beads back into the container ("grow-out bag")

Site Suitability

Determining where to put oyster farms, as well as other mariculture operations, involves careful consideration to maximize profit for the farm and minimize any negative impacts to the environment, other marine species, or other people who may use the area. This makes it important to determine what characteristics contribute to a good farm site, and to determine how farms may impact the area around them.

Field Trip

For schools local to the Juneau area, students will take a field trip to Bridget Cove, where they are able to observe a commercial oyster farm from shore.

1. Give students time to observe the farm from shore

2. Explain the layout of the farm: space for tumbling and washing oysters and sorting harvest on the dock, stacks of oysters on the far side of the dock, bags clipped to the buoy lines…

3. Allow time for discussion of what the students observe and any questions they may have
4. Now, take a plankton net tow and save the water sample in the bottle attached to the net

5. Using the thermometer and refractometer, measure the air temperature, and water temperature and salinity of the water sample

6. Finally, place a few drops of the water sample on a microscope slide, attach the cover slip, and have students find and observe phytoplankton in the water sample

Reflection Questions

Ask some or all of the following discussion questions after completing the activities above.

- What type of habitat or environmental conditions do you think would make a location a good place to have an oyster farm?

- Do you think the conditions we measured (temperature and salinity) change a lot throughout the year?
    - If so, how do you think this might impact the oysters?

- Do you think the phytoplankton that we observed change a lot throughout the year?
    - If so, how do you think this might impact the oysters?

- Do you think the farm itself and/or the oysters have any impact on the environment around them?
    - If not, why not?
    - If so, in what ways?

Education Standards

Ocean Literacy Principles

- **Grades 3-5: OLP 6A.1.** The ocean is an important source of food for humans.
- **Grades 3-5: OLP 6A.2.** Food from the ocean includes organisms such as fish, crab, and oysters, as well as products that contain organisms, such as algae.

Acknowledgments

Portions of this curriculum were adapted from the NOAA "Oysters in the Chesapeake Bay" curriculum, the Billion Oyster Project "Ecosystem Engineers: How Oysters Help Sustain Our Environment" curriculum, and the Maryland Sea Grant "Eastern Oyster Education" curriculum.