6th Grade Estuaries Curriculum

Institute for Applied Ecology

Produced by
the Institute for Applied Ecology
for the
Confederated Tribes of Siletz Indians

Confederated Tribes of Siletz Indians

6th Grade
Estuaries Ecology Curriculum
Curriculum Credits

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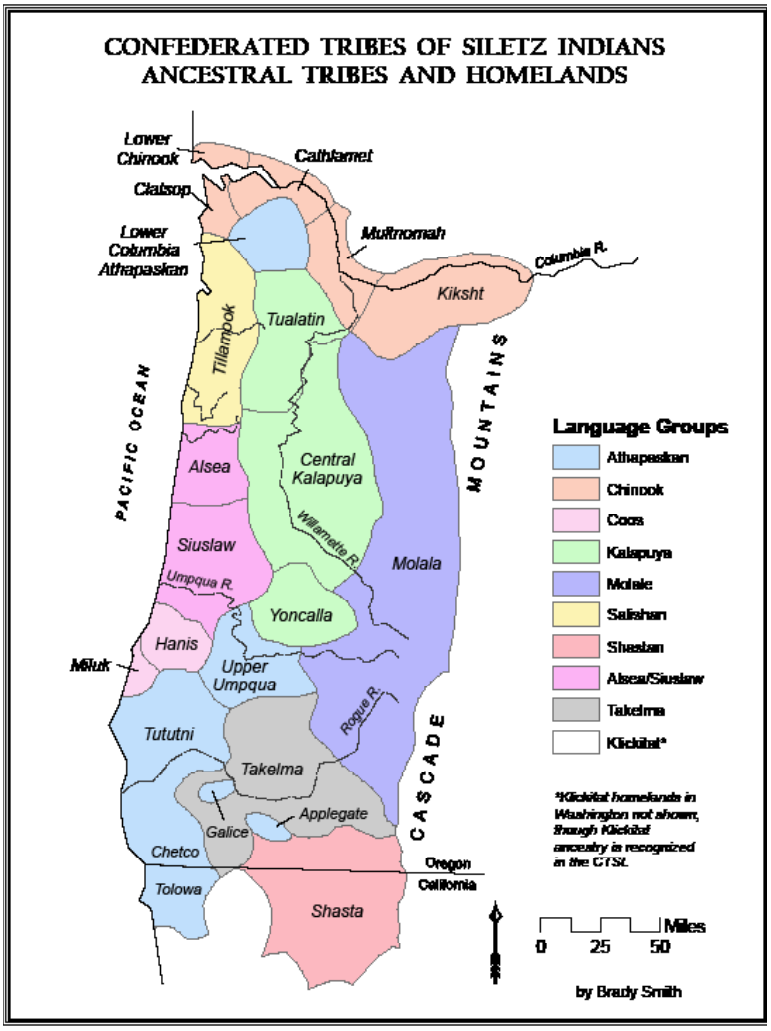
Introduction

The Confederated Tribes of Siletz Indians

The Confederated Tribes of Siletz Indians (CTSI) Is a confederation of many bands and Tribes, each with their own language and customs, whose ancestral homelands include all of Western Oregon from what is now Northern California north to the Columbia River and from the summit of the Cascades to the Pacific.

The 1.1 million-acre Siletz Reservation was set aside by President Pierce on Nov. 9, 1855, to reserve a permanent home for Tribes that had ceded approximately 19 million acres of their lands to the U.S. government under treaty agreements. After the people were relocated to the Siletz Reservation, the seven ratified treaties of the Willamette, Umpqua and Rogue Valley Tribes were ignored. The 1855 Coast Treaty was not ratified, but the Tribes held to its terms without the United States fulfilling its promises.

By 1875, more than 900,000 acres of the Siletz Reservation had been taken and opened to settlement without treaty agreement, recognition of rights or compensation. Starvation, violence, abuse, exposure, depression, epidemics, boarding schools and unscrupulous Indian agents took their toll. The effects of the 1887 Allotment Act continued to reduce the Siletz Tribe's sovereign jurisdiction, lands and resources.



Finally in 1954, Congress passed the Western Oregon Termination Act, severed Tribal relations and took the last scattered parcels from Tribal members. Still, the Siletz people and culture endured.

On Nov. 18, 1977, after years of effort, the Confederated Tribes of Siletz Indians became the second "terminated" Tribe in the nation and the first in Oregon to be "restored" to federally recognized Tribal status by Act of Congress. In 1980, a modest land base consisting primarily of timberlands was re-established by passage of the Siletz Reservation Act. With the Tribe's restoration began decades of growth. The Siletz Tribe now has a strong Tribal government to manage its resources, oversee and implement the many programs and services offered to Tribal members as well as an expanding variety of job opportunities. Committed to serving their people, the ninemember Siletz Tribal Council is the elected governing body of the Siletz Tribe.

Since Restoration, the Tribe has progressed from Bureau of Indian Affairs management to PL 93-638 contracting and finally to status as a self governance Tribe, allowing the Tribe to design and manage its own programs specifically addressing the needs of the Tribal membership. As a result, services to Tribal members are more efficiently managed and new programs have been developed.

The Siletz Tribe's land holdings total more than 15,000 acres, the majority of which lie in Lincoln and Douglas counties, with smaller parcels in Marion, Lane and Multnomah counties. Tribal headquarters and administrative offices are located in Siletz. Satellite offices in Eugene, Salem and Portland provide a variety of services to Siletz Tribal members within an 11-county service area that includes Lincoln, Tillamook, Linn, Benton, Lane, Yamhill, Polk, Marion, Multnomah, Clackamas, and Washington counties in northwestern Oregon.
For more information about CTSI visit www.ctsi.nsn.us and read T*he People are Dancing Again: The History of the Siletz Tribes of Western Oregon* by Charles Wilkinson (2010, University of Washington Press).

Siletz Dee-Ni Language

Each lesson includes Siletz Dee-Ni vocabulary words. Dee-Ni is part of the Athabaskan language group, and is one of many dialects. These dialects vary from region to region and even from village to village. In pre-contact times the area a person hailed from would be recognized by the dialect they spoke in. After being brought to the Siletz Reservation there were five major languages spoken there. The major language stocks were Athabaskan, Hokan, Penutian, Sahaptin, and Salish. Chinook Jargon became the language that different speakers used to communicate with as well as English. With the passage of time each successive generation found itself with an ever smaller pool of speakers. When the Siletz Tribes were Terminated by the Federal Government in the 1950's, the Tribal Government was disbanded and their lands sold, their people were dispersed far and wide. Their languages went unspoken except among Elders. It would take another 20 years and the Restoration of Tribal Status to rekindle any hope of Language Restoration. Following a tribal wide assessment beginning in 1996, it was discovered that they had lost more than 90 percent of the ability to speak the native language Athabaskan. The Tribe has made a concentrated effort to address this loss. In 2003 the Tribe made a commitment to the preservation of traditional arts and language by establishing a permanent position in the Culture Department, Traditional Arts and Language Specialist. Many linguistic archival materials have been used to guide the language teachings at the community language classes, Nuu Wee-ya (Our Words).

The website for the Siletz Tribal Language Project http://www.siletzlanguage.org/ includes many resources for learning Dee-Ni, including a talking dictionary, videos, and language lesson plans for all grade levels.

The Institute for Applied Ecology

Founded in 1999, the Institute for Applied Ecology (IAE) is a non-profit organization established to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems and effective management strategies. IAE offers habitat restoration services complete with habitat management plans, site preparation, maintenance and monitoring. Our Native Seed Network connects buyers and sellers of native seed while our Conservation and Research division conducts native ecosystem research and monitoring and provides surveys for rare plants. The Ecological Education Program provides opportunities for K-12 students, teachers and the adult community in place-based education and service learning projects.

Organization of Curriculum:

The curriculum is designed to be a complete unit of study. We understand that many teachers are unable to commit to the entire unit of study, so lessons can also be used individually. All lessons start with an overview of the lesson, time estimate, teacher preperation tips, learning objectives, materials needed, and the 6th grade Next Generation Science Standards that are met. The vocabulary speech bubble includes English as well as Siletz Dee-Ni words. The "background information" section gives teachers the necessary knowledge to teach the lesson, while the "teacher directions" give step by step instructions for leading each activity. The last page of every lesson includes an "in the field!" section that suggests ways to integrate student studies into field trips or service-learning projects. The "science inquiry" section offers opporunities for further scientific inquiry as homework assignments or extensions of the lessons' activities. The "reflection" bubble offers questions to ask students at the end of each lesson, which can be useful for class discussions or journal writing. The "assessment" circle gives three challenge questions to assess how well the learning objectives were met. Finally the "resources" section lists texts or websites that were either referenced in the lesson, or that are useful for further research into each topic.

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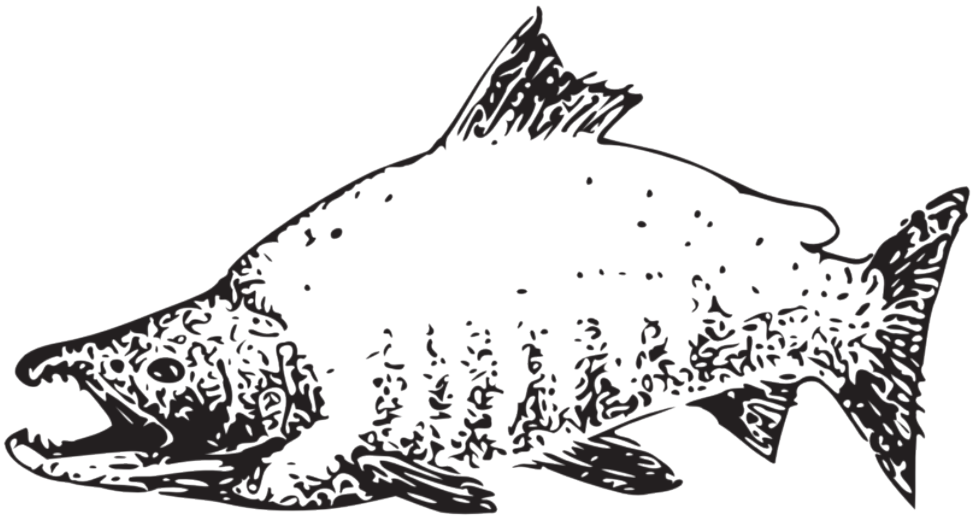
Estuaries Ecology Lessons



Estuaries

Lesson 1

What is an Estuary?

"I'd like to get people to start blessing the water and tell them it's sacred and thank it for what it does for us. ...continue to say a prayer to the Creator to help it with our Earth Mother's blood."

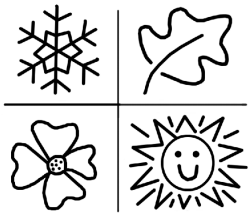
—Agnes Baker Pilgrim, Siletz Tribal Elder

Overview

Students define estuaries and identify their unique characteristics and types. Students learn select Dee-Ni vocabulary that pertains to estuaries.

Time Estimate:

60-90 minutes



Best Season:

Any- Indoor classroom

Preparation

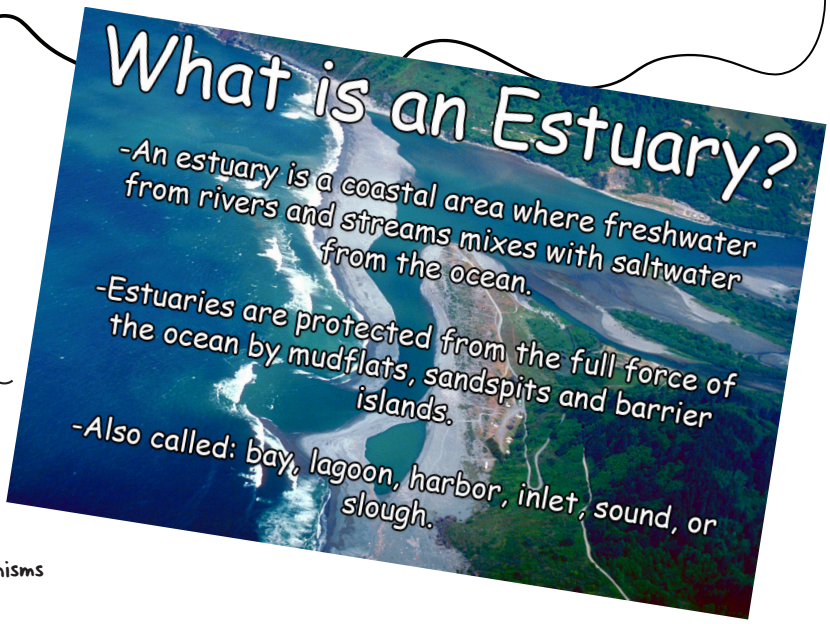
- Make color copies of the provided labeled estuary type photos to pass around or use a document camera to project them.
- Gather all of the Estuary model materials in advance.

Materials

- Whiteboard, flip chart paper or butcher paper and markers.
- Provided labeled wetland photos: Bar-built, Coastal Plain, Tectonic, and Fjord.
- Computer with internet connection and a projector to play the video "What is an Estuary?" https://youtu.be/emVVYG7dSaA
- Estuary model activity materials:
  - 4 medium or large paper or plastic plates
  - Clay- modeling or pottery
  - 1-4 bottles Blue Food Coloring
  - 12 or more Ice Cubes
  - Turkey baster or dropper pipette
  - 3 bottles or cups of water

Learning Objectives

- Describe the four different types of estuaries: Bar-built, Coastal plain, Tectonic, and Fjord.
- Identify where different estuaries are located in Oregon.
- Explain the value and function of estuaries in watersheds and coastal ecosystems.



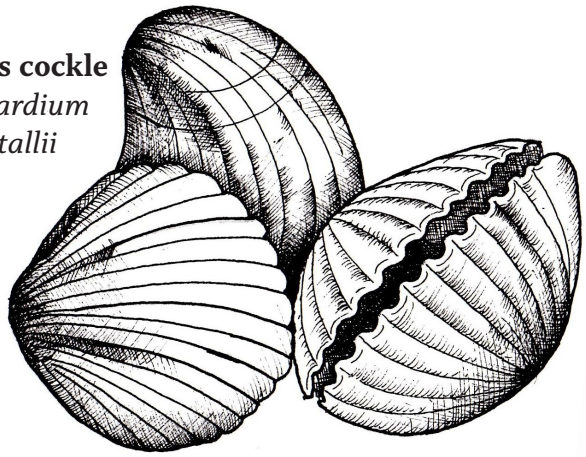
Next Generation Science Standards

This lesson meets the following 6th Grade standards:

MS-ESS2.C The Roles of Water in Earth's Surface Processes
MS-ESS2-6 Develop and use a model to describe phenomena.
MS-ESS2-4 Develop a model to describe unobservable mechanisms

Estuaries
Lesson 1

What is an Estuary?



Nuttall's cockle
Clinocardium nuttallii

Vocabulary

English	Dee-Ni
Estuary	Bay: Tum-sray-me'
Bar-built	Lagoon: Chvslh-mvn
Coastal plain	Salt: Mar'sr-lvsh
Tectonic	River: Nii~-li~'
Fjord	Ocean: Sis-xa
Brackish	Sand: Lhtr'vsh

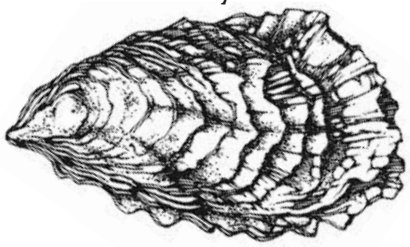
Background Information

Estuaries can be defined as a partially enclosed body of water where salt water from the ocean mixes with fresh water draining from the land, creating"brackish" water. Due to their brackish water, estuaries provide food and habitat for unique plant and animal communities. Salt marshes are one of the habitats located within an estuary. They are ideal places for juvenile fish and shellfish to hide, rest, eat and grow. Many of these animals later provide food for people. This "nursery function" of a salt marsh is critical to our continued supply of fresh seafood to eat. Estuaries are among the most productive ecosystems on the planet. Over 80% of the fish and shellfish we eat spend at least part of their lives in estuaries. Estuaries provide other important ecological functions too, acting as filters for pollution and providing protection from flooding. Estuaries are also of great importance economically, providing us with food, jobs, and recreation.

There are four main types of estuaries, which are differentiated depending on how they formed:

- **Bar-built Estuaries** form when a shallow lagoon or bay is protected from the ocean by a sand bar, sand spit, or barrier island. Examples include Siletz Bay, Coquille River Estuary, and the Salmon River Estuary.
- **Coastal plain Estuaries** are formed by sea level rising and filling an existing river valley. Example: Coos Bay Estuary.
- **Tectonic Estuaries** are caused by the folding or faulting of land surfaces. These estuaries are found along major fault lines, like the San Francisco Bay area in California.
- **Fjords** are U-shaped valleys formed by glacial action. Fjords are found in areas with long histories of glacier activity, like northern Europe, Alaska and Canada.

A fifth estuary type, the delta estuary, is a sub-type of the coastal plain estuary. A delta is modified by the addition of large amounts of sediments deposited at the estuary mouth. Each estuary has its own specific characteristics, but all estuaries play vital roles in the environment and in our lives. Of the 32 largest cities in the world, 22 are located next to estuaries. Not surprisingly, human activities have led to a decline in the health of estuaries, making them one of the most threatened ecosystems on Earth.



Estuaries
Lesson 1

What is an Estuary?

Teacher Directions

1. Get the students to start thinking and talking about estuaries. This will help you assess what they currently know about estuaries, and allow you to focus your teaching on the gaps in their knowledge. Say something to the effect of: "Turn to the person next to you and discuss what an estuary is, and what you know about estuaries. Make a list of what plants and animals might live in an estuary. You have one minute - GO!"
2. Once the minute is up say "Pencils down." Call on groups to share their estuary definitions and plant & animal lists with the class. Make three columns on the white board or flipchart titled "Estuary definition and attributes", "Estuary animals" and "Estuary plants." As the students read off what they listed write those words in the corresponding columns on the board. Compare the words to those listed in the Dee-ni vocabulary and write those next to the corresponding English words. Leave the list up on the board to add the things that they learned about at the end of the lesson.
3. Share the definition of "Estuaries" using the "What is an Estuary?" infographic projected or printed out. Go through the four main types of estuaries by showing the other infographics: **Bar-built, Coastal plain, Tectonic, and Fjord**. Point out to students the example photos, and have them locate them on a U.S. and Oregon map. As a class find other estuaries on a map and guess what type they are. Optionally you can also show the video **"What is an Estuary?"** (2 minutes 50 seconds) https://youtu.be/emVVYG7dSaA
4. Lead a discussion and brainstorm about estuaries. Example questions:

- How does the group list on the board compare with the infographic's estuary definition?
- What are some nearby estuaries? What type of estuary are they? How can you tell?
- Why do estuaries make good habitat for animals, especially fish?
- What animals live in estuaries?
- Have you ever harvested shellfish or gone fishing in an estuary?

5. **Activity: Make an Estuary Model**

a. Divide the class into four groups, and give each group one of the four printed estuary type discriptions. Each group will make a different estuary type using the provided materials.

b. Hand out clay and plates. Have the students use the clay to make a model of their assigned estuary type. This model needs to include connected ocean, estuary, and river sections.

c. This part of the activity teaches about the geologic formation of estuaries. Provide each group with 3 ice cubes and let them place the ice on their clay model. As the ice melts, have the students write down how the water fills in their model. Have each group answer this question: **"Does the way your ice melted and filled in the model correlate with the geologic formation of this particular estuary structure?"** Using a hairdryer or heat lamp can speed up the ice melt. If ice is not available have the students slowly pour water onto their model.

d. The next part of the activity teaches about brackish water. Put several drops of blue food coloring into the ocean portion of the students' models until it is a dark blue. Have the students write down their observations of how the salt (blue) water mixes with and dilutes the fresh (clear) water inside of the estuary. They can pour more fresh water into the estuary to mimic a river. A turkey baster or dropper pipet can be used to suction water out of the ocean portion to mimic the tides.

e. Have a show and tell, where each group shows their model to the rest of the class and uses what they observed and learned to teach the class about the estuary type they built. Allow for questions and answers, as well as a group discussion. How are the estuary types similar or different? Was there a different amount of brackish water in each type?

6. Lesson wrap-up. Review the definition of an estuary, and the different types of estuaries. Look over the list that the class created at the beginning of the lesson, and add anything else that they learned about estuaries.

Estuaries
Lesson 1

What is an Estuary?

IN THE FIELD!

Organize a field trip to a nearby estuary and have the students analyze its' characteristics to determine what type of estuary it is. Tell the students to look for estuary specific plants and animals. Ask them to observe how the plants in the estuary are different from those outside of it, and try to determine where that boundary is. They can document their observations in a drawing, journal entry, or photo journal. Recommend that the students wear rubber boots or other waterproof shoes on the field trip.

SCIENCE INQUIRY

Homework Assignment: Think about an estuary that you have visited in the past. Make a hypothesis of what kind of estuary you think it is and why, write this down. How many acres do you think the estuary covers? Find that estuary on the online Coastal Atlas Estuary Map: http://www.coastalatlas.net/estuarymaps/ Record the data that is listed for that estuary, including the various labels and layers for the map. How does this data differ from the hypothesis that you wrote down? How are the categories for estuary types similar or different from what you learned in the classroom lesson? Research and then make a vocabulary list with definitions for those categories.

Reflection

Think about an estuary that you have visited. How do you know it was an estuary? What type of estuary do you think it was? What are the water sources for the estuary? How did you feel when you were there? Make a drawing of the estuary from your memory, a photo, or by visiting it again. Make a map of the estuary using your memory, a paper map, or an online map.

Assessment

1. Name the factors that define an estuary.
2. List the four types of estuaries.
3. Say or write one estuary specific Dee-ni word.

Resources

- http://www.oregonconservationstrategy.org/oregon-nearshore-strategy/habitats/ons-estuaries/
- https://coast.noaa.gov/estuaries/curriculum
- https://www.coastalatlas.net/estuarymaps/
- *Project WILD Aquatic K-12 Curriculum & Activity Guide*. 2010. Project WILD. Houston, TX.

What is an Estuary?

-An estuary is a coastal area where freshwater from rivers and streams mixes with saltwater from the ocean.

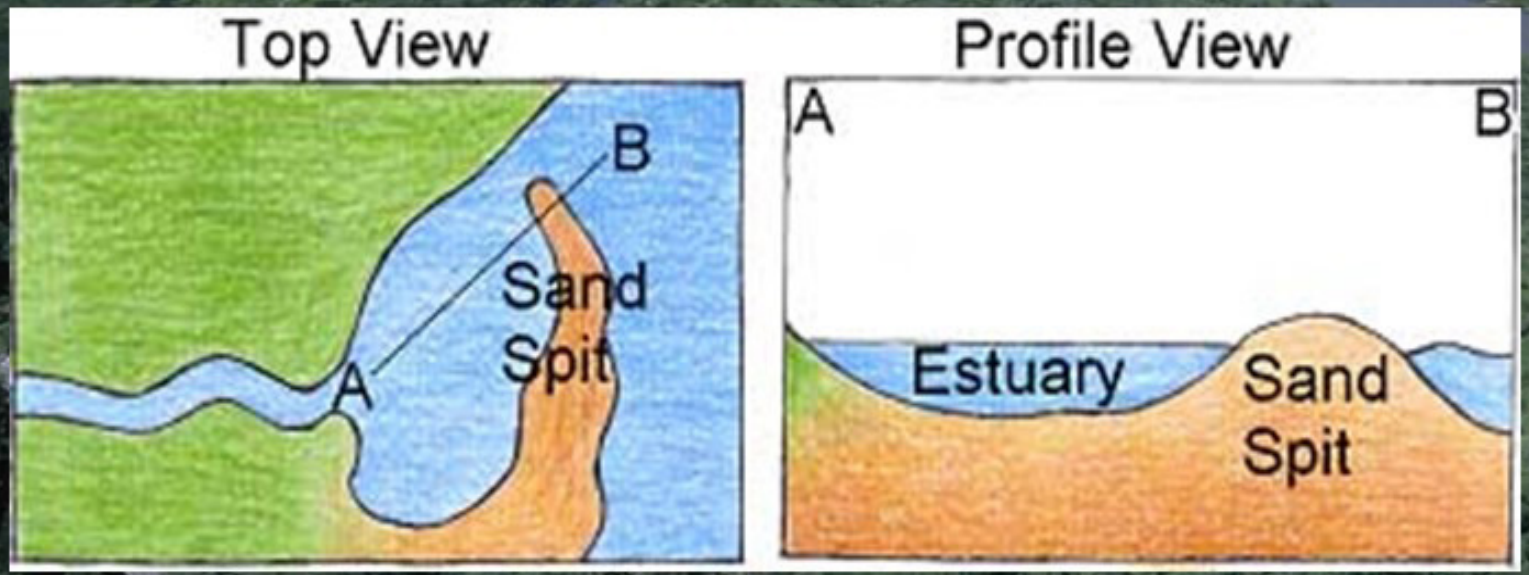
-Estuaries are protected from the full force of the ocean by mudflats, sandspits and barrier islands.

-Also called: bay, lagoon, harbor, inlet, sound, or slough.

Bar-built

- Bar-built Estuaries form when a shallow lagoon or bay is protected from the ocean by a sand bar, sand spit, or barrier island.

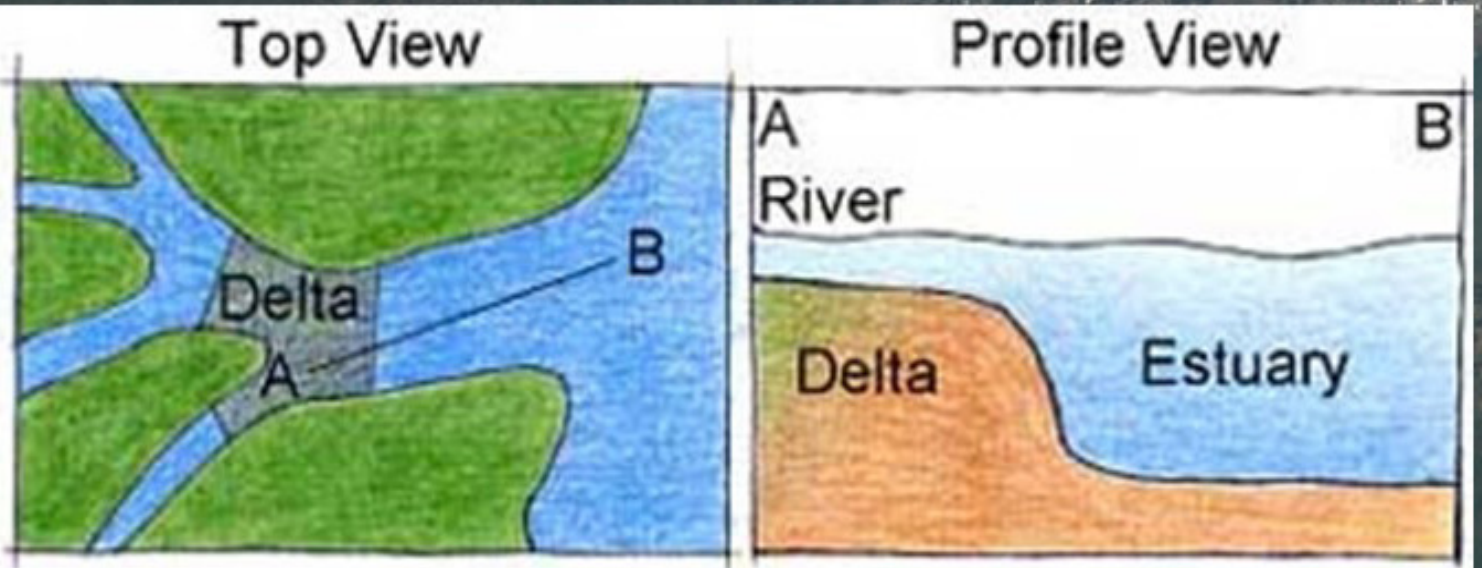
Photo: Siletz Bay & Estuary

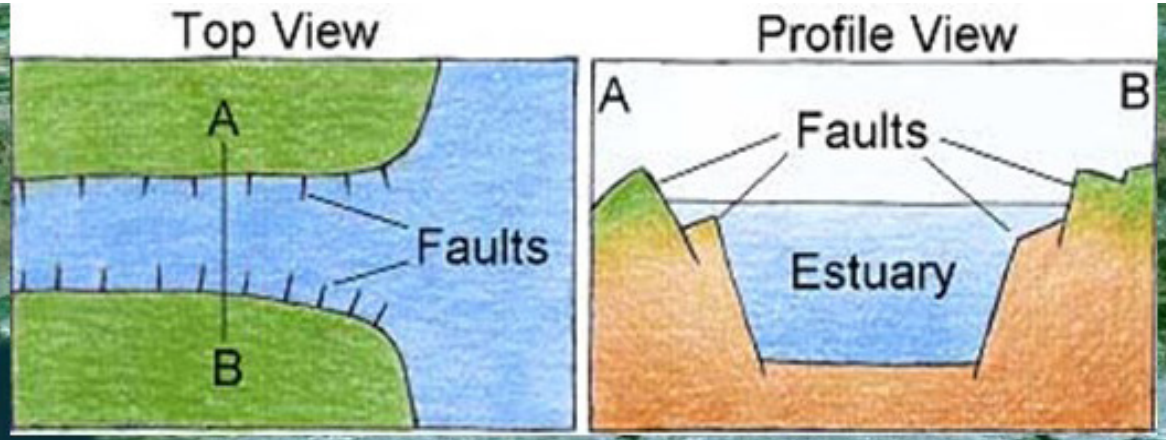


Coastal Plain

- Coastal Plain Estuaries are formed by the sea level rising and filling an existing river valley.

Photo: Coos Bay & Estuary





Tectonic

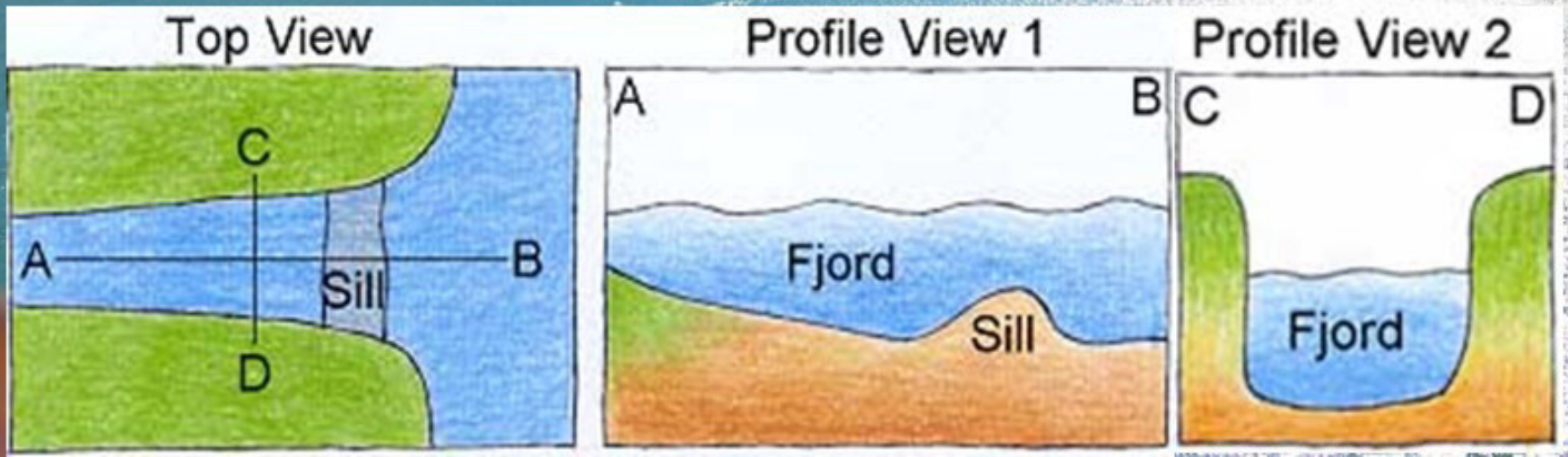
- Tectonic Estuaries are caused by the folding or faulting of land surfaces. These estuaries are found along major fault lines.

Photo: San Francisco Bay & Estuary.

Fjord

- Fjords are U-shaped valleys formed by glacial action. Fjords are found in areas with long histories of glacial activity.

Photo: Tracy Arm Fjord, Alaska



Estuaries
Lesson 2

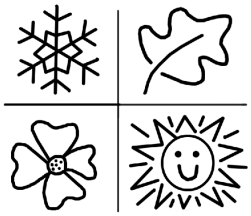
Cultural Uses of Estuaries

"If you are going to go [in nature] and use those resources, you also have the responsibility not to damage them when you're using them and taking them, but actually do some enhancement and try to do some caring for them so that they'll be there the next year and for the next generations."

—Robert Kentta

Time Estimate:

60-90 minutes



Best Season:

Any

Classroom or Outside

Overview

Students will learn about tidal fish weirs (traps) historically used by native people in Oregon's estuaries. Then they will design, build, and test a miniature model fishing weir.

Preparation

Gather the necessary materials for the weir models beforehand from a craft or hardware store. One option for the tray is to purchase a pre-made stream table from an environmental education supply store like this one: https://www.forestry-suppliers.com/product_pages/products.php?mi=89920&itemnum=76579&redir=Y

Materials

* Images of Weirs- printed out or projected
* Items for weir model:
  - craft sticks of various sizes, 12" dowels or toothpicks
  - twine, string, or pipe cleaners
  - paint tray or cement/ grout mixing tub, or stream table
  - Fish Weir Design Worksheets
  - 4" fish shaped rubber fishing lures (e.g., sea shad) with

Learning Objectives

- Define and describe a traditional native fishing weir, including how it is built and used.
- Design and build a miniature model of a fishing weir.
- Evaluate the effectiveness of your weir model and revise the design if necessary.

Vocabulary

English	Dee-Ni
Weir	Weir: Naa-dii~-'an'
Tidal slough	Low tide: Numlh-ts'a
Tidal weir	High tide: Chvtlh-ch'vs
Riverine weir	Fish Bait: Lhuk-svn'
Basket trap	Stick(s): Chvn
	Gill net: Mesh-xa'

Sockeye Salmon
Lhuk
Oncorhynchus nerka

Estuaries
Lesson 2

Cultural Uses of Estuaries

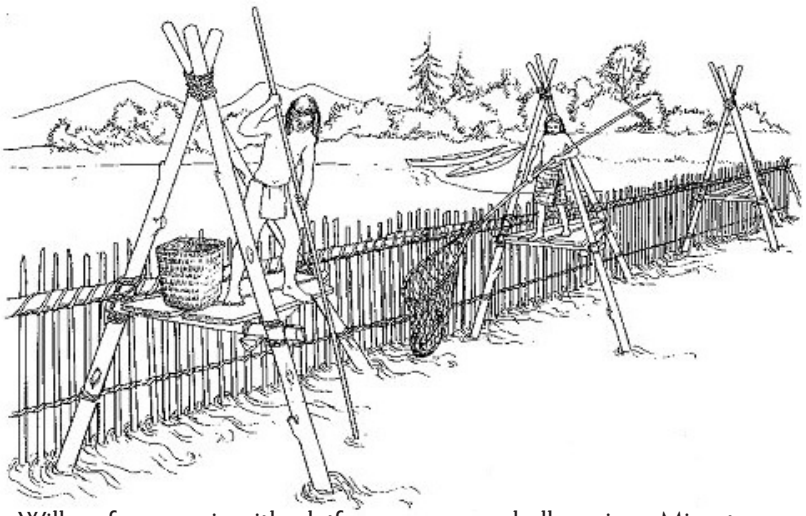
Next Generation Science Standards

This lesson meets the following 6th Grade standards:

MS-LS1-2 Develop and use a model to describe phenomena

MS-ETS1-1 All human activity draws on natural resources.

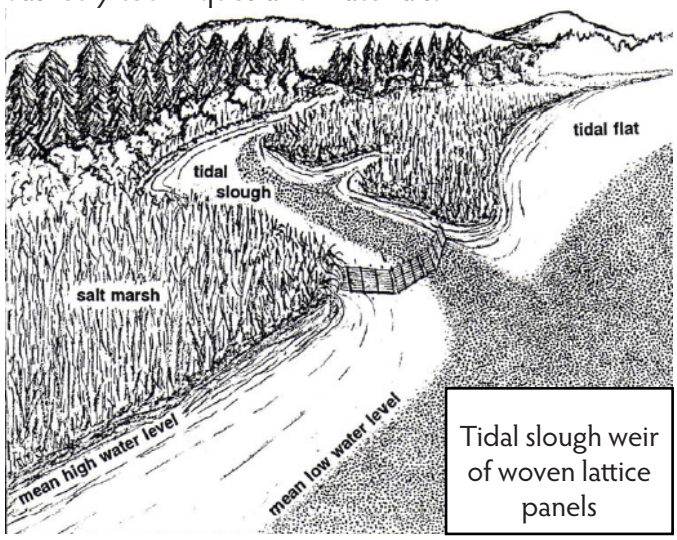
MS-ETS1-1 Define the criteria and constraints of a design problem with which to ensure a successful solution, taking into account scientific principles and potential impacts on people and the natural environment.



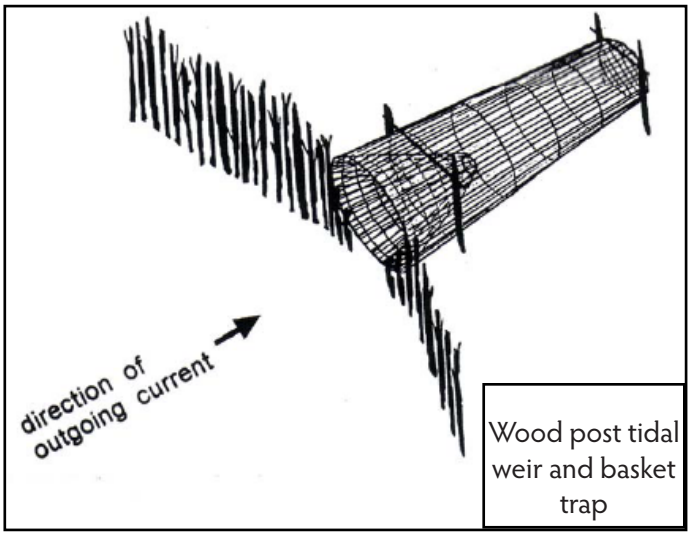
Willow fence weir with platforms across a shallow river. Migrating salmon or lamprey collect at the weir, and unable to proceed upriver they are caught with dip nets. Drawing by Hilary Stewart

Background Information

Estuaries are rich in a diversity and abundance of fish, in addition to other animals. To be closer to this wealth of fishing opportunity there was historically a high concentration of Native villages surrounding estuaries (Byram). Various methods for catching fish were used, but the most popular and successful method was the construction of a type of fish trap called a "**weir**." Fish weirs have been used by varying cultures the world over for millenia using stones, reeds, or sticks placed close together like a fence within a river channel or estuary to capture fish as they swim along with the current (Hirst). **Riverine weirs** are those built in non-tidal rivers and were often large, and only used seasonally to catch large numbers of salmon and lamprey during their runs upstream. However fishing weirs built in estuaries, often referred to as "**tidal weirs**," were smaller, more permanent and used year long to harvest a variety of fish including: herring, , flounder, sardine, smelt, and salmon. Tidal weirs were built in marsh or **tidal slough** channels at the edges of estuaries, and they worked in conjunction with tidal action (incoming and outgoing tides). Some of these included a built in cylindrical **basket trap** which had an opening facing the outgoing current. This allowed for fish to get trapped in the basket as they swam out with the tide (Byram). Other weirs had built in platforms which people could stand on with a dip net and catch the fish that were too big to squeeze through (see illustration above.) Weirs were often built using willow or Western hemlock posts that were partially buried close together into the estuary mud or sand. Cross posts or sticks were tied horizontally to these sunken posts to create what looked like a fence in the water. Oregon tidal weirs were commonly composed of fine woven lattice panels that were made using basketry techniques and materials.



Tidal slough weir of woven lattice panels



Wood post tidal weir and basket trap

Estuaries
Lesson 2

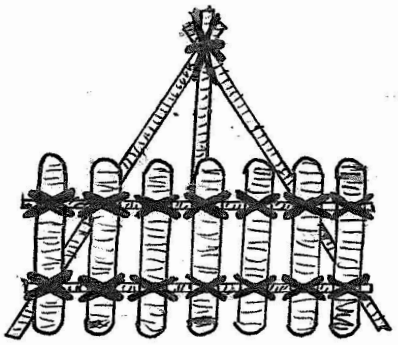
Cultural Uses of Estuaries

Teacher Directions

Lesson adapted from *The Fish Weir: A Culturally Relevant STEM Activity* from NSTA's *Science Scope* Summer 2015 Volume 38 Number 9
http://digital.nsta.org/publication/?i=260740&ver=html5&p=46

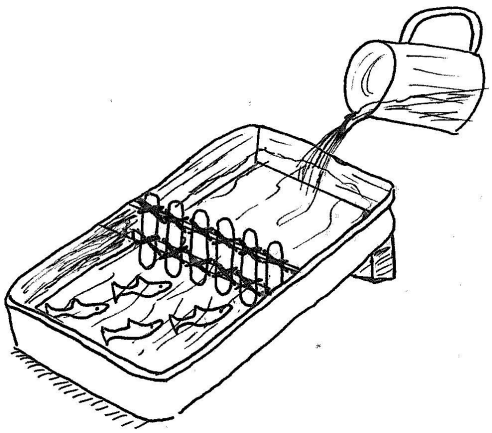
1. Ask students to think about what kinds of foods (especially fish) their ancestors may have eaten from estuaries. Then have them consider what fishing methods would allow for the largest catch in order to feed not just their family, but their whole community. After this discussion present students with photos and information about traditional fishing weirs. Use the "Background Information" section, provided photos and drawings, as well as items from the "Resources" section at the end of this lesson.
2. Tell the students that they are now going to design, build, and test a miniature model of a fishing weir in small groups.

   a. Design: Break them up into groups of four or less, and hand out the "Fish Weir Design Worksheet." Tell the students that they will work together and use the worksheet to draw a diagram of the weir model that they will build. They will need to include specifics including the depth and width of the model estuary, as well as the width of the model fish they aim to capture. Let them know what materials you will be providing. The requirement is that water should be able to flow through the weir, but not allow fish to pass.



   b. Build: Once a group has finished their weir design plan give them the materials for making their model weir. The paint tray or cement/grout mixing tub will represent the estuary or river that they must build the weir in. The craft sticks, dowels or toothpicks will be used as the weir posts, beams, and supports. The twine, string, or pipe cleaners will be used to tie the weir posts together. They can also weave a small basket to include a basket trap in the weir. The weir needs to stand upright on its own.

   c. Test and Evaluate: Next students test how well their model works and see if any changes would improve it. It's recommended to do this activity outside in a grassy area. Give each group a bucket or pitcher of water to pour into their tray. Elevate the tray on one side to make a slope. Have the students slowly pour the water in at the top of the incline so that it flows downhill like a river. Tell the students to tilt the tray slowly back and forth to represent the tides going in and out. Once the water is added students can add the fake fish to see how well the weir traps them. Is the weir effective? If not, what could be changed about it? Does the weir work better with an incoming or outgoing tide? To maintain sustainable fish poplulations some fish should be allowed to pass through the weir. Two possibilities for this would be a larger opening at one end, or a gate that can be opened and closed when people aren't actively fishing. After the students have made their weir successful they can refine their model to make it more sustainable.



   d. Show-and-Tell: Once all of the groups have completed their weirs facilitate a show-and-tell where each group presents their design worksheet, finished weir, and demonstrates its function to the other groups. Lead a class discussion of why and how their weir models work and how they might change their modles to adapt to changes in the environment such as climate change, flooding, drought, or lower fish populations.

   e. Wrap-up: To finish this activity have students draw an "as built" diagram of their final model, labeling features and making a list of materials used. They should use a new blank "Weir Design Worksheet" to draw these final designs. Students can also write a narrative describing the construction, materials, and function of their weir model.

Estuaries
Lesson 2

Cultural Uses of Estuaries

Fish Weir Design Worksheet

Team Member Names:_____
Date:_____
Design Constraints: Width of Estuary_____ Depth of Estuary____ Width of weir:____ Height of weir:____

Width of Fish____ Upright post spacing:____ Scale 1 square = 1 inch

Estuaries
Lesson 2

Cultural Uses of Estuaries

Photos of Pacific Northwest Native American Fish Weirs

Estuaries
Lesson 2

Cultural Uses of Estuaries

IN THE FIELD!

Scout out a nearby estuary or river to find a good spot to build a temporary model weir. Look at tide tables to see where the tide will be during your class visit. Gather sticks beforehand, or have students gather them as part of the activity. Pick up sticks on the ground, or if you have the land owner's permission bring loppers and hand saws to cut branches off of trees. Invite community members to participate. Fish Weirs are not currently legal for catching fish, so you will ned to deconstruct the weir after completion.

SCIENCE INQUIRY

Invite a knowledgeable tribal member to speak to the class about the customs, ceremonies, and practices associated with fish weirs, fishing, including historic and modern management of salmon and lamprey. This could include an Elder who remembers the last active fishing weirs, a tribal fish biologist who manages a modern research weir, or a tribal archeologist who has uncovered remnants of ancient weirs. These talks could also be extended into field trips to visit a hatchery, research weir, or an archeological dig.

Reflection

After making a model of a weir, think about what it would take to build a traditional fish weir today. Where would you build it and why? What natural materials would you use and how much would you need? How many people would you need to help you? What time of year would be best to build and use it? What kind of fish would you try to catch?

Assessment

1. Define "fish weir" and describe how one is used.
2. List two kinds of fish that can be caught using a weir.
3. Name two kinds of fish weirs and explain their differences.

Resources

- Byram, Robert Scott (1998) Fishing Weirs in Oregon Coast Estuaries. In *Hidden Dimensions: The Cultural Significance of Wetland Archaeology*. Edited by Kathryn Bernick; University of British Columbia Press, Vancouver, pp. 199 – 219.
- Stewart, Hilary (1994) *Indian Fishing: Early Methods on the Northwest Coast.* Douglas & McIntyre Ltd. B.C. Canada.
- Hirst ,K. Kris. *Fish Weir: Ancient Fishing Technology.* https://www.thoughtco.com/fish-weir-ancient-fishing-tool-170925

Estuaries
Lesson 3

Estuary Food Webs

'We need to enlighten people and tell the world leaders there has to be a better way. If we allow the animal kingdom to disappear, at the rapid rate it is disappearing, then we are killing ourselves faster than we think."
—Agnes Baker Pilgrim, Siletz Tribal Elder

Overview

Students will build an estuary food web to examine the flow of food energy through the estuary ecosystem through role-playing different organisms.

Time Estimate:
60 minutes

Best Season:
Any- Indoor classroom

Preparation

- Print or write out the note cards with organism names on them ahead of time, and punch two holes in them for yarn to go through.

Materials

* Whiteboard or chalkboard
* Large blank notecards or blank pieces of paper
* Pencils- graphite and colored
* Large ball of Yarn or string

Learning Objectives

- Construct a model of an estuary food web that correctly demonstrates the flow of energy.
- Explain how all living things depend directly or indirectly on green plants for food.
- Describe the three major categories of living organisms in an estuary ecosystem and their roles. (producers, consumers, and decomposers)

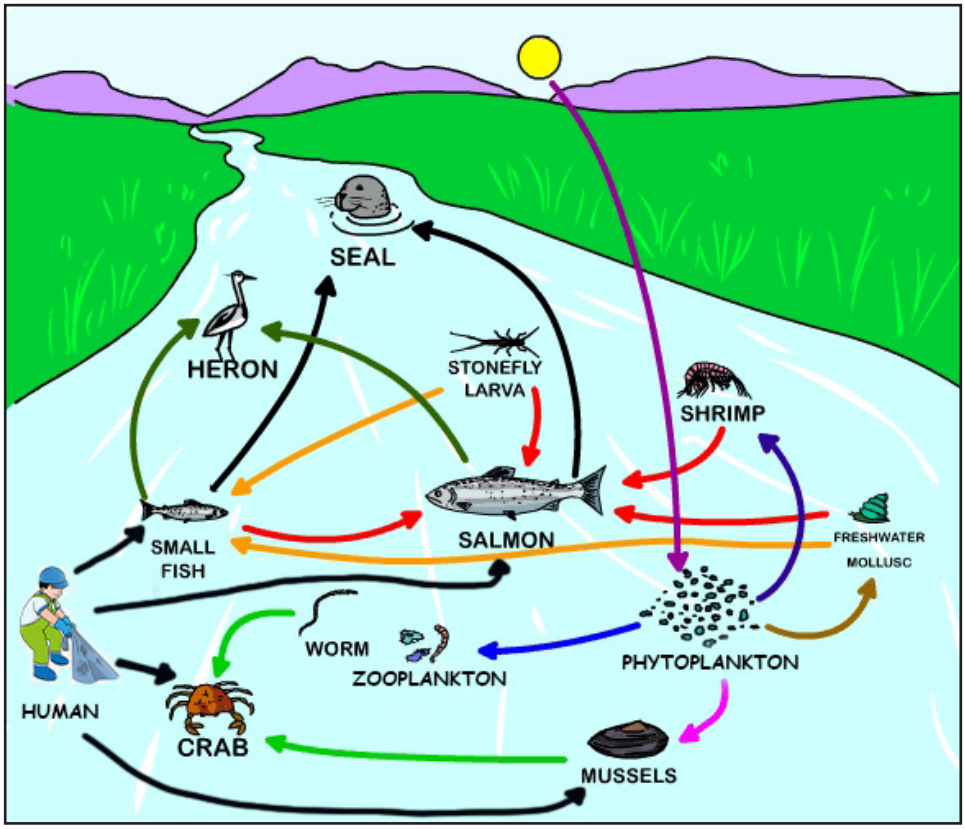
Next Generation Science Standards

This lesson meets the following 6th Grade standards:

MS-LS1-8 Cause and effect relationships may be used to predict phenomena in natural systems.

MS-LS1-2 Complex systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts.

MS-LS1-3 Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.



Estuaries
Lesson 3

Estuary Food Webs

Great Blue Heron
Ch'uu-ket-ni
Ardea herodias

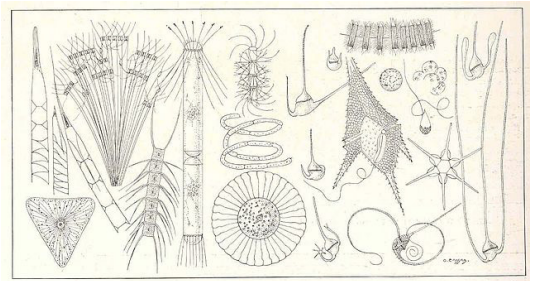
Vocabulary

English	Dee-Ni
Producer	Crab: Ga'-srvsr
Consumer	String: St'vs
Decomposer	Bald Eagle: T'a'-lhki
Food web	Sun: srii-naa ch'aa-ghvtlh-sri~
Phytoplankton	Web: k'wee-dar'sh-mee-ne'

Background Information

When animals eat plants or other animals in order to survive, there is a flow of food energy through the ecosystem. What starts out as energy from the sun is converted into food energy by organisms that use photosynthesis, and is transferred to other organisms as they consume food. There are three major categories of living organisms in an ecosystem and each has a special role. Together, **producers** (plants), **consumers** (animals), and **decomposers** make up the food web. The food energy produced by producers via photosynthesis is cycled through the ecosystem through food chains, which all together make up a **food web**.

In an estuary food web the **producers** are comprised of plants like seaweed, eelgrass, algae and phytoplankton. Phytoplankton, which are microscopic free-floating plants, are one of the most abundant and important producers in an estuary because they are eaten by many small animals like zooplankton, shrimp, molluscs, and shellfish. These animals are all called **primary consumers**. The animals that eat the primary consumers are called the **secondary consumers**, and they consisit of fish, seals, crabs, sea birds, and humans. Many illustrations of food webs don't include humans, but we are animals too and we are consumers of finned fish and shellfish from estuaries. **Decomposers** have the job of 'recycling' dead plants and animals and are made up of bacteria, fungi, some insects, and molluscs like snails.



Phytoplankton
Producers

Clams
Primary Consumers

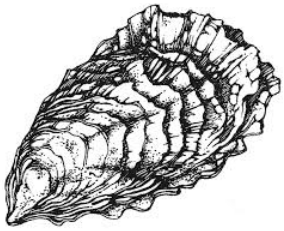
Humans
Secondary Consumers

Estuaries
Lesson 3

Estuary Food Webs

Teacher Directions

Lesson adapted from "Marsh Market" in *WOW! The Wonders of Wetlands.*



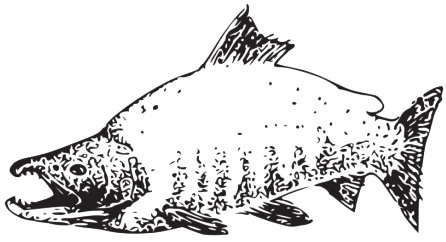
1. Start out the lesson by having students turn to the person next to them and discuss for 30 seconds what they already know about food webs. Then write "food web" in a circle on the board and ask the students what they know about food webs. Use this as a teaching moment and correct any misconceptions the students have. Write the correct things they say around the food web circle. Once everyone has shared add any other information or definitions that you think are necessary. Include in this a discussion about producers, consumers, and decomposers.
2. Hand out the "Estuary Food Web Worksheet" and have the students complete it in pairs, groups or as a class. This worksheet can help further guide discussion and research about producers, consumers, and decomposers.
3. On separate note cards or pieces of paper write the name of each plant and animal listed on the worksheet (including the sun). Tape the cards on the board and have each student select one, or hand them out to the students. If there are more students in your class than organisms listed, feel free to add more or divide up some of the categories like shellfish and sea birds into specific species. Give the students time to add to their cards a drawing of their organism, and the information about it from the worksheet. Punch two holes at the top of each note card to tie a loop of yarn so each student can wear their card around their neck. You will wear the "sun" card.
4. Now you can make an estuary food web. Put the sun card on and have the students put the organism cards on the front of their bodies and get into a circle. Take the ball of yarn or string, wrap the end once around your hand and then pass the ball to a student with the card of an organism that photosynthesizes like a plant or phytoplankton. The student will then wrap the yarn around their hand once and pass the ball to a student with the card of an organism that eats that plant or phytoplankton. Each time the yarn is passed it is connecting the organism that is consumed to the consumer. The sun passes the yarn to a primary consumer, then they pass it to a secondary consumer, who then passes it to a tertiary consumer, and so on. Continue having the students pass the yarn around the circle in this manner until the students can see the visual representation of a food web. Many of the plants and animals should be connected to several others. If a student receives the ball a second time they will need to pass it to a student that they haven't already passed it to. If students are unsure where to pass the yarn they can refer to their cards or worksheets where they listed what their organism eats, and who eats their organism.
5. Once all of the food web is complete and each student is connected to it, have the students slightly move until the web is taut. Ask the students what would happen if one animal or plant disappeared from the estuary.How would this effect the whole food web? Introduce one of these scenarios as an example:

   a. A commercial fishing company their annual catch of salmon in the estuary.

   b. The land at the end of the estuary is converted to intensive farming. There is a big increase in agricultural run-off including fertilizers and pesticedes into the estuary. This increases the risk of phytoplankton blooms.

   c. Due to increased carbon emissions, the ocean is becoming more acidic. Bryozoans and other shelled animals will find it difficult to make shells.

6. With each scenario ask the students which organism would be affected by the change first. Have the student wearing the card for that organism tug on the yarn. Any other student who then feels the resulting tug should raise their free hand, and then tug on the string, and so on as the effect ripples through the food web. Once this has been completed lead a discussion about the food web. Did the absence of some species make a bigger impact than the absence of others? This is a great opportunity to talk about keystone species.



7. Here is an optional second activity you can do with the cards the students made: have the students tape the cards to a white board or a large piece of paper to make their own estuary food web. They can draw arrows showing the connections between different organisms.

Estuary Food Webs

Estuary Food Web Worksheet

Organsim	Producer	Consumer	Decomposer	Eaten by:	Feeds on:
Seals	☐	☐	☐		
Crabs	☐	☐	☐		
Sea birds	☐	☐	☐		
Shellfish (oysters, mussels, cockles, clams)	☐	☐	☐		
Salmon	☐	☐	☐		
Phytoplankton	☐	☐	☐		
Sea Stars	☐	☐	☐		
Seaweed	☐	☐	☐		
Humans	☐	☐	☐		
Zooplankton	☐	☐	☐		
Shrimp	☐	☐	☐		
Small fish	☐	☐	☐		
The Sun					

Estuaries
Lesson 3

Estuary Food Webs

IN THE FIELD!

Go on a field trip to a nearby estuary to observe the living food webs in action. Bring along plant and animal field guides to help you identify the creatures that you see. Make a list of the plants and animals that you see and the things that they eat or what eats them. Take pictures or make drawings of these organisms. When you return to class makean estuary food web as a class using the drawings or photos of the organisms that you encountered.

SCIENCE INQUIRY

Homework Assignment: Do a research project about how humans have adversely affected wetlands and write a paper or make a presenation to the class. Possible research topics include:

- How has pollution, climate change, and over-fishing effected estuarine food webs?
- Research an estuary species that has gone extinct or is endangered. How has the absence or lack of abundance of this species affected the food web?
- Find out information about estuary restoration projects. What were the restoration goals, and what were the results of the project?

Reflection

How have humans use of estuaries in Oregon changed over time? What are some ways that native americans historically used estuaries, and how is that similar or different to modern use? What are some food webs that you are a part of? Make a diagram of the food web that makes up your lunch.

Assessment

1. List the three categories of organisms that make up a food web
2. Diagram an estuarine food web of phytoplankton, clams, and humans.
3. Calculate what species would be effected by the abscence of salmon in the food web.

Resources

- Padilla Bay *The Estuary Guide Level 2* https://fortress.wa.gov/ecy/publications/documents/8958c.pdf
- *WOW! The Wonders of Wetlands.* 2003. Environmental Concern INC, PO Box P, St Michaels, MD 21663. wetland.org
- NOAA *Estuary Food Pyramid* lesson. https://coast.noaa.gov/estuaries/curriculum/estuary-food-pyramid.html

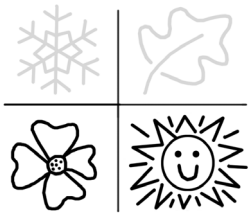
Estuaries
Lesson 4

Salmon Use of Estuaries

"Legend tells us that the salmon were people shaped like us who lived in a beautiful city below the ocean floor. The spirit of the Salmon People chose to come back every spring and fall to feed the two-leggeds of this world."

—Agnes Baker Pilgrim, Siletz Tribal Elder

Time Estimate:
2 class sessions:
1 indoor and 1 outside



Best Season:
Spring & Summer,
indoor & outside

Overview

In this lesson students will learn about the life stages of salmon and their migration from freshwater habitats to saltwater habitats and back. Students will illustrate how salmon regulate the salt concentration in their bodies, and how they use estuaries as important transition zones. Students will also simulate a salmon migration and encounter obstacles and benefits along the way.

Learning Objectives

- Describe the stages of the salmon life cycle
- Discuss the obstacles that salmon face along their migration journeys and the benefits that estuaries and rivers provide for salmon
- Explain how salmon use estuaries to transition from freshwater to saltwater ecosystems

Next Generation Science Standards

This lesson meets the following 6th Grade standards:

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

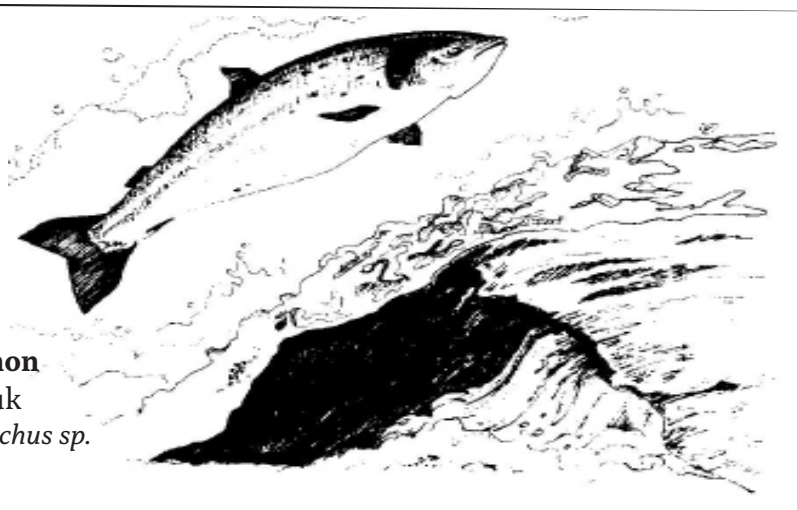
MS-PS3-5 Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.

Preparation

- Make sure that you have access a document reader or computer to show images of the salmon life cycle and access to the internet to show a video to students.
- Gather materials to make a migration obstacle course. Find an area large enough to create an obstacle course that can accommodate your class size and that will give enough room for students to run through the course. The route can be longer or shorter depending on the space available to you. Students can help you set up the route, or you can do this ahead of time to shorten the lesson.

Materials

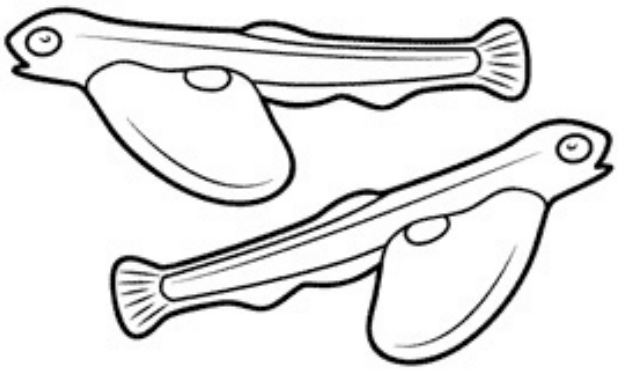
- Internet access for videos
- Document reader or computer to display images
- Ropes, traffic cones, or pin flags
- Hula hoops
- Chairs
- Goldfish snacks, gummy worms, or other small objects to represent "food"
- Construction paper, scissors, string, and hole punch for making costumes and nametags



Salmon
Lhuk
Oncorhynchus sp.

Estuaries
Lesson 4

Salmon Use of Estuaries



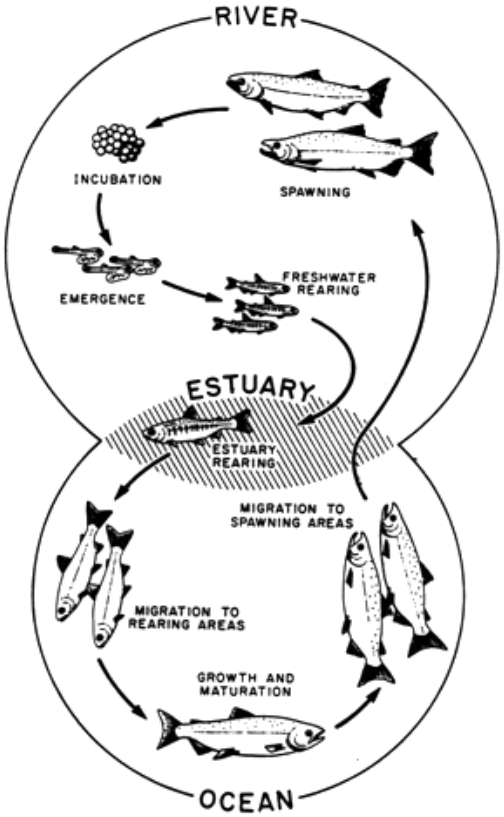
Salmon Alevins
Dan'-dee-ni
Oncorhynchus sp.

Vocabulary

English	Dee-Ni
• Alevins	• Salmon:Dan'-dee-ni
• Fry	• Salmon eggs: Gvmp
• Parr	• Fry: Lhuk mvsh-xee-ye'
• Smoltification	• Salmon Ceremony: Lhuk mii-naa~-li'
• Spawning	• Spring Salmon: Dan'-dee-ni
• Anadramous	• Summer Salmon: Shin-naa-le
• Osmoregulation	

Background Information

The Salmon Life Cycle



1. **Eggs and Alevins**
A female lays a nest of eggs and they are fertilized by a male. The eggs develop during the winter at the bottom of the stream and hatch in the spring. Newly hatched salmon are called alevins. The alevins hatch with a yolk sac attached to them, and they slowly consume the yolk for several months.

2. **Fry**
Once the fish can swim freely they are considered fry. Fry swim to the surface of the water and collect air in a special body organ called a swim bladder, allowing them to hold their position in the water. Fry feed on microscopic plankton.

3. **Parr**
During the fall, fry develop into parr. Parr have stripes and spots for camouflage and they feed on aquatic insects. They spend between a few months to a year in the stream where they were born. They rely on shade from riparian trees to keep the water cool, and they rely on access to shallow waters where they can rest and hide from predators.

4. **Smoltification and estuaries**
Eventually parr begin to migrate downstream towards the ocean. As the parr develop into smolt, their scales become silvery to help them better camouflage in the ocean. Smolts use estuaries to adapt their bodies for life in saltwater and to feed on an abundance of crustaceans and aquatic insects.

Salmon Use of Estuaries

Background Information, continued

5. **Adults**

Salmon may spend anywhere from 1-8 years in the ocean, depending on the species. Some stay in coastal waters while others migrate further away from the coast.

6. **Adult migration**

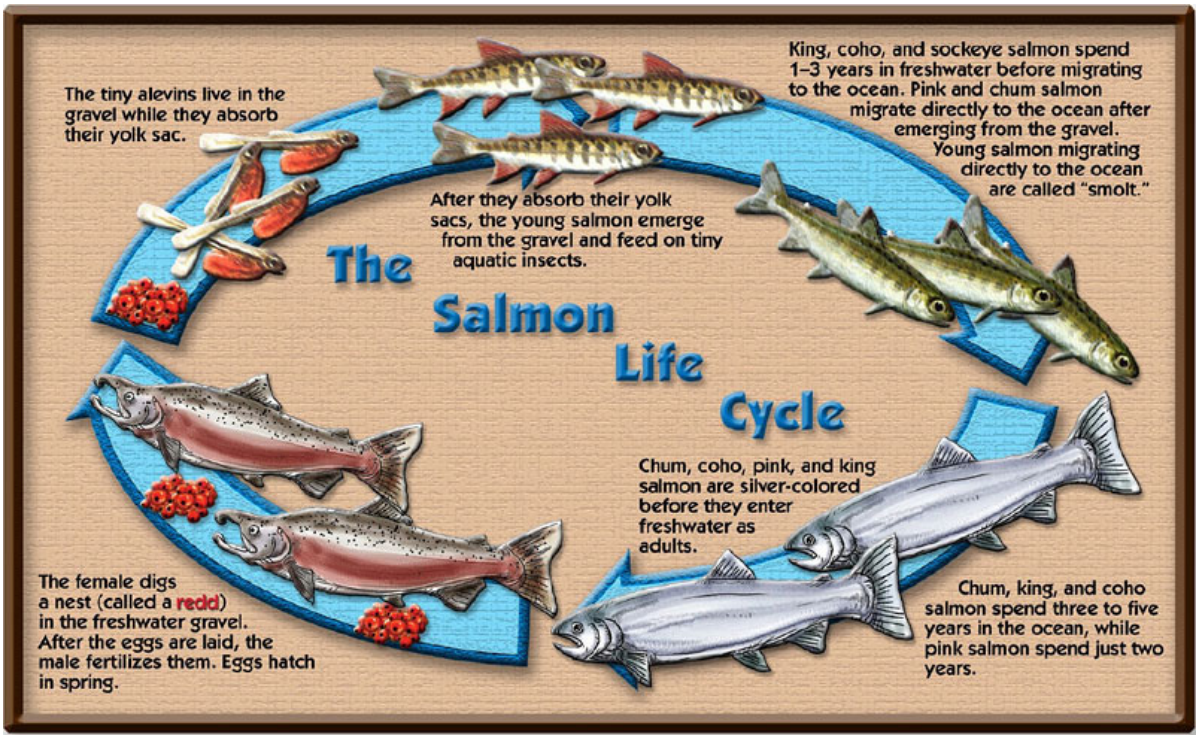
Adult salmon eventually return to their home stream to breed. Scientists believe that salmon use chemical signals, such as smells, and navigate using the sun to find the stream where they were born. Salmon stop feeding once they are in freshwater and males develop humped noses for fighting with other males.

7. **Spawning**

Once they reach the stream where they were born, females build nests in the gravel at the bottom of the stream. Meanwhile, the males fight to determine which males will mate. The victorious male and the female spawn by releasing eggs and sperm at the same time. The female makes many nests and covers them with gravel. The process continues until the adult males and females die.

Osmoregulation

Salmon are **anadromous** fish, meaning that they spend part of their lives living in freshwater and part of their lives living in saltwater. The process by which salmon control the salt and water concentrations in their bodies is called **osmoregulation**. In the ocean, salmon run the risk of having too much salt in their bodies, while in freshwater they may not have enough salt. As salmon smolts begin to migrate towards the ocean, they encounter estuaries. Estuaries are habitats where freshwater and saltwater mix to form brackish water. Smolts must slowly acclimate to the change in salinity in the water, and this may take weeks. In order to live in saltwater, salmon drink the water around them and their kidneys concentrate the salts into urine while their gills use pumps to reverse the flow of NaCl (sodium-chloride) out of their bodies. When adult salmon return to freshwater to spawn after spending years in the ocean, they must readapt their bodies to survive in freshwater. They gradually stop drinking water and stop pumping sodium out of their bodies.



Estuaries
Lesson 4

Salmon Use of Estuaries

Salmon Life Cycle

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

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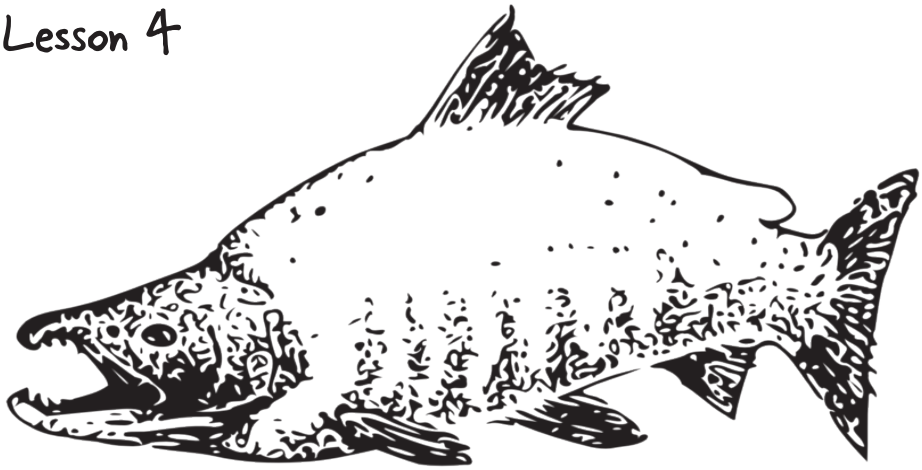
Estuaries
Lesson 4

Salmon Use of Estuaries



Teacher Directions for indoor session

Use a document reader or a computer to show the images of the salmon life cycle to students, and discuss how salmon migrate to and from the ocean during their various life stages. Then, tell the students that you are going to show them a video that discusses how fish can survive in freshwater and saltwater. Tell the students "*Salmon are anadromous fish, meaning that they spend part of their lives living in freshwater and part of their lives living in saltwater. Therefore, they have to change their bodies to adapt to different environments, and estuaries play an important role in this process.*"

Show the video "Do Fish Drink Water?" https://www.youtube.com/watch?v=Pvc4DTwpm_g to the class, and then have students work on student worksheets to label the diagrams of salmon in saltwater and freshwater. Students may work in groups to complete the diagrams.

After the student have labeled the fish, discuss the following questions as a class. The students should be checking their diagrams to make sure that they labeled them correctly, as you are discussing the questions as a class.

1. Which way does water flow across the membrane? Towards the saltier or less salty side? Why?

• *Water flows towards the side with higher salt concentration so that the concentration of salt will be the same on both sides.*

2. When salmon are in freshwater, which will way water flow? Into their gills or out of their gills? Why?

• *Water will flow into their gills because the concentration of salt is higher inside their body than in the water.*

3. When salmon are in saltwater, which way will water flow? Into their gills or out of their gills? Why?

• *Water will flow out of their gills because the concentration of salt is higher outside of their bodies.*

4. When do fish need to drink water? In freshwater or saltwater? Why?

• *In saltwater, because their bodies are constantly losing water so they need to replace it.*

5. If saltwater fish drink saltwater, will that make their bodies even saltier? How do they get rid of salts?

• *Their kidneys can make urine that is very salty to get rid of salts. They also have chloride cells in their gills to push the salt out.*

6. What is the role of estuaries for salmon? What kinds of changes do you think salmon undergo in estuaries? What would happen if salmon had to go directly from freshwater to saltwater or vice-versa?

• *Salmon use estuaries as a transition zone between freshwater and saltwater so that salmon can slowly adapt to change in salinity. Their bodies need to change to push salts in or out or their gills and also to drink water and produce salty or less salty urine. If salmon had to go directly from fresh to saltwater, they might die.*

Another video about salmon migration, return to freshwater (optional)

https://video.nationalgeographic.com/video/news/0000014a-2fd2-de99-abda-3fff7b220000

Salmon Use of Estuaries

Osmoregulation Student Worksheet

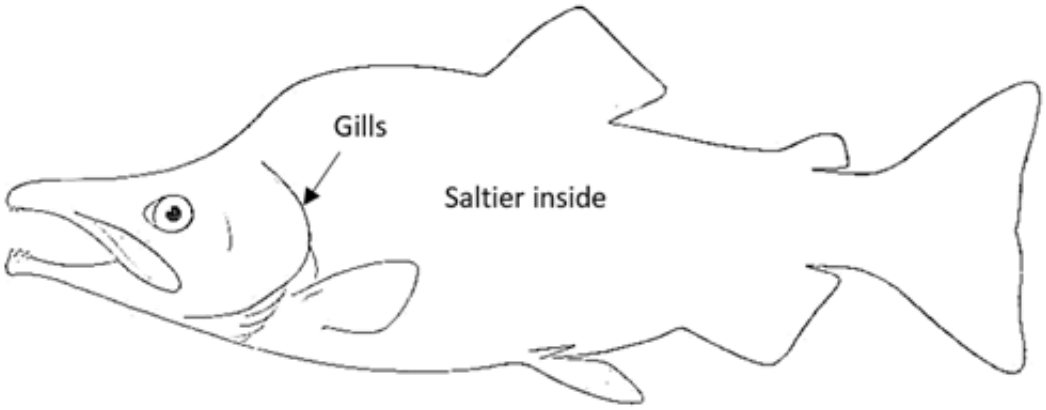
Watch the video "Do Fish Drink Water?" and then complete the following diagrams. You may work in small groups.

1. Draw arrows to show whether water will flow into the gills or out of the gills for fish in freshwater and saltwater. Write "water flows in" or "water flows out."

2. Draw an arrow to indicate if a fish will drink water, or draw an X by its mouth to show that it will not drink water. Write "drinks water" or "does not drink water."

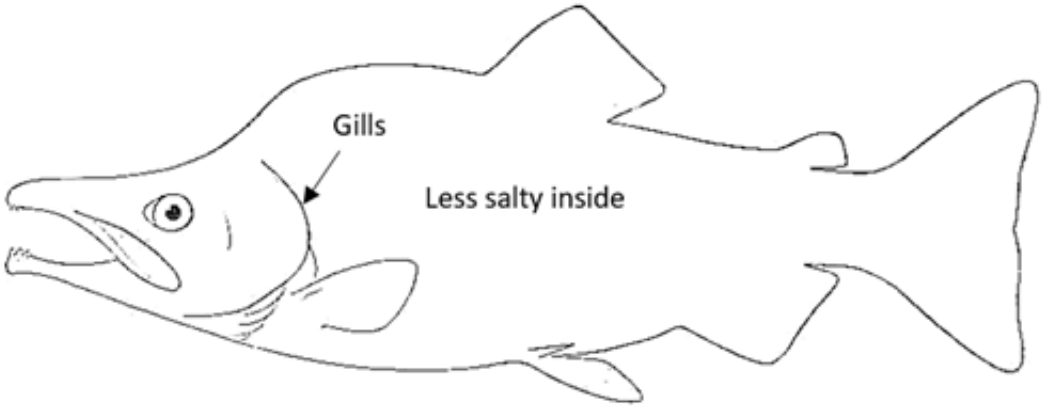
3. Draw an arrow and indicate whether each fish will produce more salty urine or less salty urine. Write "more salty urine" or "less salty urine."

Freshwater



Less salty outside

Saltwater



Saltier outside

Estuaries
Lesson 4

Salmon Use of Estuaries

Teacher Directions for outdoor session: Salmon Migration Game!

1. Ask the students to imagine that they are tiny alevins that just hatched in a stream. They are growing up and will soon be on their way to the ocean. Along the journey, they will face many obstacles, as well as some places where they can rest.
2. Ask the students to name some of the obstacles that the young salmon might face and write these down on the board under "obstacles". Examples might include predators, storms, lack of food, competition for food, fast-flowing water and waterfalls, and adapting to changes in salinity.
3. Now ask the students to name some of the "benefits" that salmon might encounter on their journey. Examples might include an abundance of food, areas to hide from predators, areas to rest where the water is moving slowly, etc.
4. Now, go outside and have students help you set up an obstacle course for the migration from freshwater to saltwater, and then back to freshwater to spawn. The goal of the game is for salmon to survive the migration to the ocean and back.
    a. Use ropes, traffic cones, or pin flags to delineate the path from the stream → river → estuary → ocean. The path should get wider as the body of water gets larger. The path can be windy to represent the natural flow of rivers.
    b. Use hula hoops to indicate areas along the stream and river where the young salmon can rest. These are areas along the banks of the river where the water flows slowly and the salmon can rest.
    c. Place chairs throughout the stream, river, and estuary. These represent rocks and logs where salmon can hide from predators.
    d. Place goldfish snacks, gummy worms, or other small objects along the migration route to represent "food." Each salmon can pick these up as they are swimming and place them in their stomach, represented by a zip lock bag. Make sure to put lots of food in the estuary.
5. Once the game is all set up, assign most of the students to be young salmon.
    a. They must begin their lives hatching in the stream and begin swimming towards the ocean.
    b. Tell the salmon that they must spend some time in the estuary adjusting to the change in salinity in the water and collecting food before they can move to the ocean.
    c. Once most of the salmon have reached the ocean, tell them that it is time to return to their home stream to reproduce. At this point, the salmon stop eating and their only goal is to get back to where they were born.
6. A few students can be freshwater and saltwater predators (e.g. seals, birds, large fish, bears, whales), or they can represent storms and other obstacles. The predators and obstacles have to stay in specific areas and cannot chase the fish throughout the migration course. Each time a predator "catches" a salmon, the salmon dies and has to start over and drop all the food that they picked up. To make the game more exciting, students can make costumes or nametags to indicate which animal or obstacle they are.
7. After playing the game a few times, so that everyone has had a chance to be salmon and an obstacle, ask the students: what was the most challenging obstacle? What were some things that made it easier and safer to migrate? Did most of the salmon live or die?

Estuaries
Lesson 4

Salmon Use of Estuaries

IN THE FIELD!

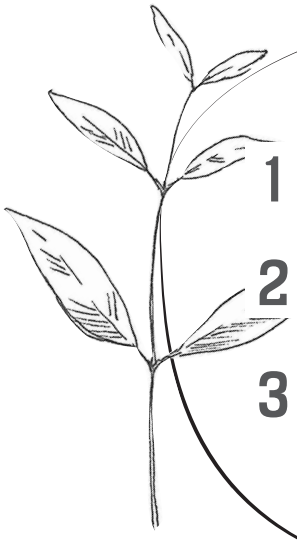
Research places nearby where salmon can be observed migrating. What is the best time of year for seeing the salmon in your area? Plan a trip or a class field trip to see salmon in their natural habitat or visit a hatchery to learn more about salmon. While you are there, take notes about the salmon habitat. Are there places for salmon to hide from predators? Is the water shallow enough in some areas for the salmon to rest? Do you see any aquatic insects or crustaceans for the salmon to eat? Do you see any predators that might eat the salmon?

SCIENCE INQUIRY

Salmon have several mechanisms for ensuring that they keep a balance of sodium inside their bodies, both while living in freshwater and saltwater. For homework, research other animals that practice osmoregulation to regulate water and salts inside their bodies. Pick one animal and describe how this process works, and draw a picture to illustrate the process. Present your findings to the class.

Reflection

Why do you think that salmon spend so much energy migrating to the ocean and migrating back to spawn in the stream where they were born? Why do salmon not stay in freshwater for their entire lives? What might be the advantage of living in the oceans for part of their lives and living in freshwater for part of their lives? Can you think of other animals that make a long migration journey? What are the advantages of migration for these animals?



Assessment

1. During which life stages do salmon live in freshwater, saltwater, and estuaries?
2. How do the bodies of salmon physically change in estuaries?
3. Name some of the obstacles and benefits that salmon may encounter in estuaries.

Resources

- https://www.marine.ie/Home/site-area/areas-activity/fisheries-ecosystems/salmon-life-cycle
- https://www.nps.gov/olym/learn/nature/the-salmon-life-cycle.htm
- Quinn, Thomas P. *The Behavior and Ecology of Pacific Salmon and Trout*, Seattle: University of Washington Press, 2005.
- http://www.unm.edu/~toolson/salmon_osmoregulation.pdf

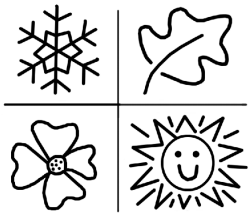
Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration

"... we were taught by our ancestors to conserve these things, that nature provides for us, the sustenance that feeds our bodies..."
—Frank Simmons, Siletz Tribal Elder

Time Estimate:

1 hour



Best Season:
Any- Indoor classroom with a sink

Overview

In activity #1 students learn how native Olympia Oysters filter water through an in-class experiment with live oysters in tanks. In activity #2 Students create an oyster reef restoration design. Instructions for a traditional shell game are also included.

Preparation

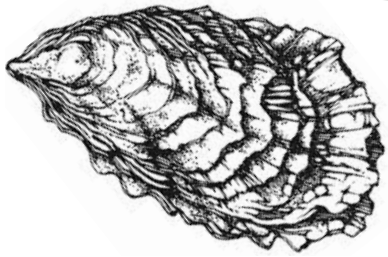
- Gather all of the experiment materials ahead of time. Buy live oysters from a grocery store or fish market. The other materials can be purchased from an aquarium or pet supply store or online.

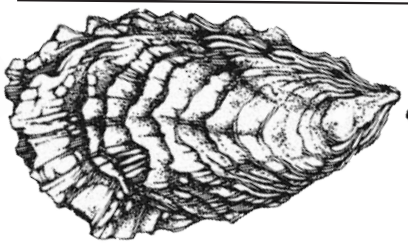
Learning Objectives

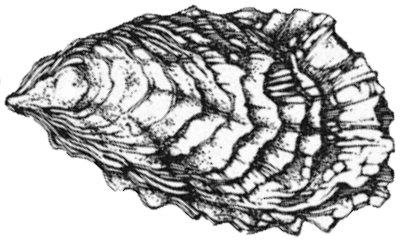
- Explain the three main ecosystem services that oysters provide.
- Describe how the native Olympia oyster almost went extinct.
- Identify one method used in native oyster restoration.

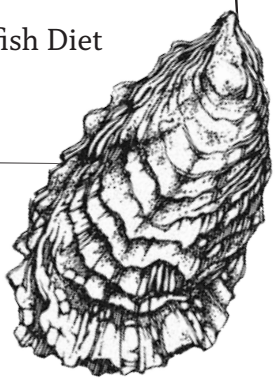
Materials

- Computer with internet connection & video projector
- Two 2.5 gallon (or bigger) fish tanks
- Two tank aerators and accessories
- Seawater (~15ppt) or tap water and Instant Ocean Aquarium Salt + Aquarium Dechlorinator.
- 5-6 live oysters
- Algae (phytoplankton): SD Aquarist algae or Shellfish Diet from Reed Mariculture
- Pipette or eye dropper









Vocabulary

English	Dee-Ni
Filter feeding	Abalone: Lha'-k'wash-ti
Phytoplankton	Mussel: K'wee-san
Bivalve mollusk	Barnacle: K'waa-de
Spat	Clam: Kuu-ni
Carbon sequestration	Digs: Ch'ee-shin'

Next Generation Science Standards

This lesson meets the following 6th Grade standards:

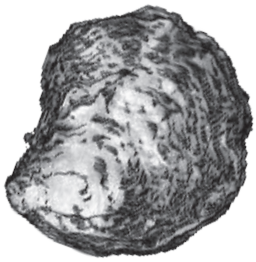
MS-ESS3-3 Changes to Earth's environments can have different impacts (negative and positive) for different living things.

MS-LS1-1 Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration



Olympia Oyster
Ostrea lurida

Background Information

Olympia Oyster Biology

Oysters are **bivalves**, a type of **mollusk** characterized by two opposing shells, or valves. They are related to clams, mussels, and other commonly known and often edible **mollusks**. Many oysters, like other **bivalves**, release sperm and eggs separately in the water, where they meet and fertilize to form embryos outside the body of the mother. But Olympia oysters retain eggs within the mother's shell. They "brood" their embryos for several weeks before releasing the young, now called larvae, into the water column. Native Olympia oysters adhere to rocks, shells, and other hard substrates. Their former species name "*conchaphila*" translates from Latin to "shell loving". This name alludes to the fact that past generations of oysters can provide habitat to future generations, in this way they are excellent reef builders. The Olympia oyster is the only oyster species native to the Pacific Northwest. It is reported to occur from Panama to Sitka, Alaska. Although some populations thrive in pure seawater, this oyster's preferred habitat is usually restricted to bays and estuaries with brackish water. It can be challenging to distinguish native Olympia oysters from non-native Pacific oysters without careful examination. Pacific oysters have thicker shells than Olympia oysters. In addition, the insides of Olympia oyster shells are often pale purple tinged with green, while Pacific oyster shells are light gray or white.

Oyster Ecosystem Services

Oysters provide a number of services to ecosystems. Oysters feed on bacteria and microscopic plants known as **phytoplankton** through a process called **filter-feeding**. Oysters are known for their great capacity to filter food from the water. It has been estimated that an average adult Olympia oyster can filter up to 12 gallons of water a day. The removal of large quantities of plankton from estuary water improves water quality through reducing turbidity and algal blooms while maintaining nutrient balance. The ability to gain their energy needs from phytoplankton makes the oyster a dominant primary consumer in estuarine food webs. Oysters also make an important food for various secondary consumers including fish, crabs, sea stars and sea birds. Young oysters tend to settle near other oysters, forming large beds. These beds help stabilize the muddy bottom of the estuary and improve habitat conditions for eelgrass, an important estuarine plant. The hard, complex surfaces provided by beds of oysters provide a unique habitat in which other estuarine animals can hide, settle, or lay eggs. In this way, a substantial oyster population increases species diversity. Lastly, oysters play an important role in **carbon sequestration** because their shells absorb carbon as they grow.

Annie Ditallo gathering Rock oysters in Newport

Native Olympia Oyster Restoration in Yaquina Bay

Prior to Euro-Americans arrival in the Yaquina Bay area and subsequent over harvesting, Olympia oysters were a major food source of the coastal Tribes. Olympia oysters have been identified by the Confederated Tribes of Siletz Indians as cultural and ecological restoration priorities, recognizing their importance to preserving cultural traditions, restoring traditional food sources, and benefiting community health. The Confederated Tribes of Siletz Indians, The Wetlands Conservancy, and Oregon Oyster Farms have partnered up to restore Olympia oysters at Poole Slough in the Yaquina Bay. By spreading oyster shell along the bottom of the channel, substrate is provided for juvenile native Olympia oysters to settle on, grow, and hopefully reproduce, providing a source population for this significant resource.

Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration

Teacher Directions

Activity #1: Oyster Ecosystem Services

adapted from "*I can See Clearly Now- A Demonstration in Filter-Feeding*" in the Project PORTS Curriculum Guide 3

1. Begin this lesson with a short discussion about how oysters feed and what they eat. Ask the students: What are some of the ecosystem benefits of oysters? How do you think oysters affect water quality?
2. Show the students these YouTube videos to demonstrate how Oysters positively effect water quality: "*Time-lapse: Oysters Filtering Water*" https://youtu.be/VTuBbuUro4g and "*Oyster Filtration*" https://youtu.be/saAy7GfLq4w
3. Explain to the students that they are going to conduct an experiment about oyster water filtration similar to the one in the second time-lapse video. Work together to establish a hypothesis for the experiment. Help them design the experiment, explaining what materials are on hand, and the need for a control and a treatment tank. Develop an experiment observation sheet with the students to monitor the tanks over a week long period.
4. Oyster Water Filtration Experiment Procedures:
    a. Set up two aquarium tanks with aerators in a visible location in the classroom.
    b. Have student volunteers pour approximately 2 gallons of water into each tank. This can be saltwater from the ocean, or you can mix tap water with Instant Ocean Aquarium Salt to 15 ppt and an aquarium dechlorinator. Once the water is ready turn the aerator on in the tanks.
    c. Add approximately 2 mL of phytoplankton(usually in the form of algal paste) to both of the tanks.
    d. Place 5-10 live oysters in one tank and label it "treatment."
    e. Label the tank without oysters "control."
    f. Explain the meaning of the tank labels and have the students hypothesize what the tanks will look like the next morning.
    g. Observe the tanks after 24 hours and document differences in the clarity of the water in each tank.
    h. Have students write up a laboratory report on the experiment.

Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration

Teacher Directions

Activity #2: Design an Oyster Reef

adapted from "*How do you make an oyster reef? Part 1*" in the Billion Oyster Project Curriculum.

1. Begin this lesson with a short discussion about native Olympia oysters and the need for their restoration. Ask the students: Why do you think Olympia oysters almost went extinct? What methods do you think people have used to increase their numbers?
2. Show the students these YouTube videos to help them understand the methods of oyster restoration "*Our Yaquina Bay Oyster Story*" https://youtu.be/_hhPGKYNcts and "*Oyster Reef Restoration: The American Southeast*" https://youtu.be/r5dCMLRH6sw and "*Oyster Restoration*" https://youtu.be/vKrfez3TU6c
3. Use a projector or document camera to show the students the photos of oyster reefs and oyster restoration projects from the next page. Discuss the different methods and materials used in oyster reef restoration. The current restoration process used by the Confederated Tribes of Siletz Indians in Yaquina bay involves spawning adult oysters in a hatchery and letting the babies attach to shells from harvested oysters. Then they hang that shell from docks in the bay for a few months while the babies feed on plankton. Those that survive are then moved to ropes and placed at new sites in the bay where they are monitored for several months.
4. Break the students into small groups of 3-4 and give them the "Oyster Reef Design Worksheet." Each group will need to design an Olympia oyster reef restoration project including deciding on the benthic layer, reef materials, details about the oysters/shells, and what their reef will attach to. Once they have made all of these decisions and filled out the worksheet they will need to sketch a diagram of their proposed reef on the back of the worksheet or on another sheet of paper.
5. Once all of the groups have completed their design have them present it to the rest of the class. Use a document camera to project the oyster reef design sketches. Make time for questions and comments at the end of each presenation.
6. After the presentations have been completed lead a discussion about the differences and similarities between the different designs, and which designs they think will be most effective in meeting the restoration goal. After seeing others' designs would they make any changes to their design?

The native Olympia oyster restoration process used by the Confederated Tribes of Siletz Indians in Yaquina bay involves spawning adult oysters in a hatchery and letting the babies (spat) attach to shells from harvested oysters. Then the shell is hung from docks in the bay for a few months while the babies feed on plankton. Those that survive are then moved to ropes and placed at new sites in the bay.

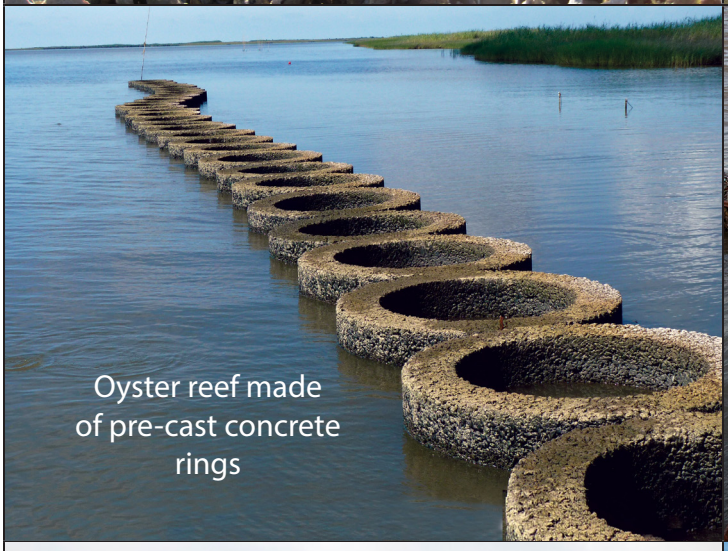
Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration

Examples of Oyster Reef Restoration Materials & Designs


Example of a healthy oyster reef


Reef made of oyster shells in mesh bags


Oyster reef made of pre-cast concrete rings

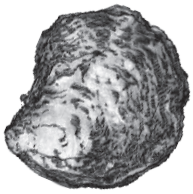

Reef made of rebar and metal fencing filled with oyster shells


"Reef balls" made of pre-cast concrete


Metal oyster cages full of shells donated by restaurants

Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration



Oyster Reef Design Worksheet

Restoration goal: restore native Olympia oysters to be self-sustaining in Oregon estuaries.
A self-sustaining population of oysters is generally found in a large reef, where immature oysters settle on the shells of older oysters, who may be still living or already dead. Use that fact to help you discuss the following issues with your group. Then use the back of this worksheet or another piece of paper to sketch your group's proposed reef design. Be sure to include and label:

The benthic layer (what is sitting on the bottom surface underwater)
Other materials that are part of your reef

These materials include:_____

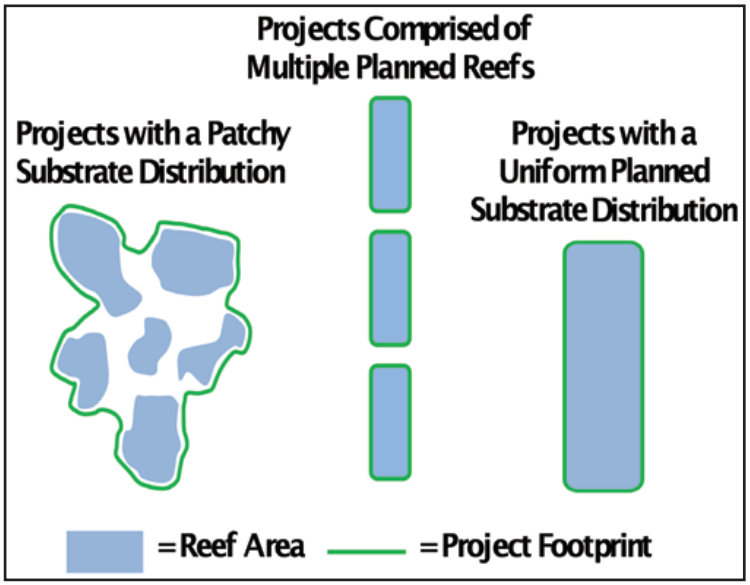
Details about your oysters or oyster shells, such as
Just shells? Spat (baby oysters) on shell? Mature oysters? Some combination?

My oysters will be:_____

How are the oysters or shells held in position (or not), such as attached to each other somehow? In mesh bags? In cages? Embedded in concrete? Tied to ropes? Unattached, sitting in the harbor mud? Attached to a dock or other structure somehow?

My oysters are held together by:_____

My reef is attached to:_____
Other features that have not been mentioned that you think would improve your oyster reef:



Sketch your reef on the other side of this worksheet or on a seperate piece of paper

Examples of project footprints and reef areas in projects with a patchy substrate distribution (left), projects comprised of multiple, distinct planned reefs (middle), and projects with a single uniform substrate distribution (right). The green line denotes the outline of the project footprint while the blue shaded polygons denote the reef area.

Oyster Ecosystem Services & Restoration

The Shell Game

Many tribal customs included games that were played for fun socially or as a competition. To make them more competitive or higher stakes, we gambled using something that was valuable to us. Shells were a resource that was readily available to us and we made tools, money and regalia out of them. We have adapted a traditional game for use in the classroom.

To make your playing deck use:

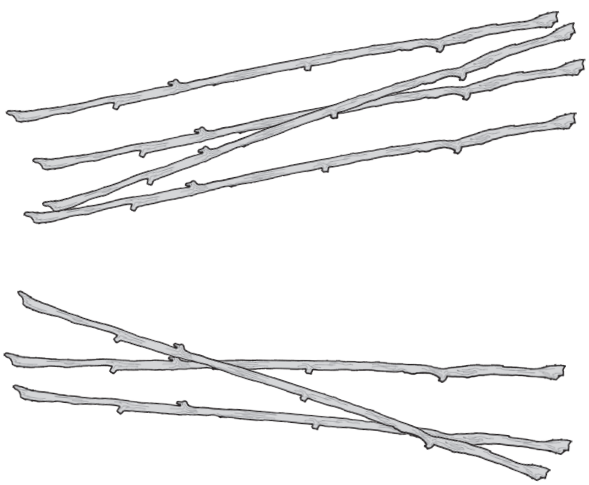
- **10 wooden bamboo skewers with the ends cut flat.**
- **4 small shells that have a flat side. Cowry, oyster, or cockle shells will work well as long as they are small enough that all four can fit your hands like dice.**

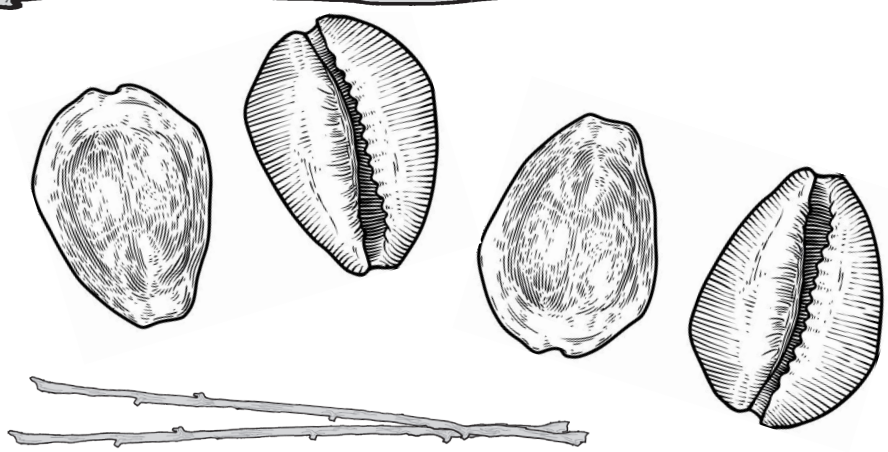
The game begins with all 10 tally sticks in the middle. Players take turns shaking the four shells in their hands and dropping them. Scoring is based on the table below. As players win points, they may take tally sticks from the pile in the middle. When these are gone, players take sticks from their opponents when they win points. The first person to have all the sticks, wins.

2 shells up and 2 shells down -	**3 points**
All shells up -	**1 point**
All shells down -	**1 point**

The winning person would yell: **xaa~-ghii-la! (I won!)**
A team would yell: **xaa-ghit-la! (We won!)**

You can create a fun game with items collected in nature (unique rocks, decorated/marked pieces of wood, smaller shells, etc.)





Estuaries
Lesson 5

Oyster Ecosystem Services & Restoration

IN THE FIELD!

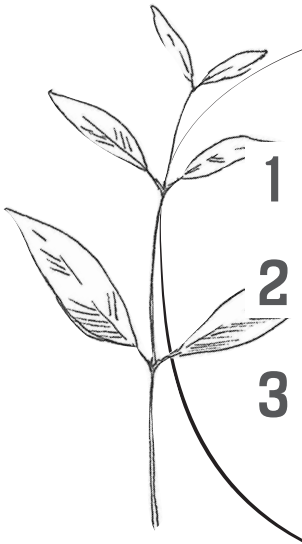
Contact an organization working on oyster restoration in an estuary nearby. Find out if your class can volunteer to participate in an aspect of oyster reef restoration. This might involve filling mesh bags with oyster shells and placing them at low tide, or throwing shells off of a boat. Alternatively go on a field trip to a commercial oyster grower to learn about the process for cultivating oysters.

SCIENCE INQUIRY

Discuss ways that you could measure the effectiveness of your artificial oyster reef designs if they were actually built. How do restoration scientists monitor and assess oyster restoration projects? Use the *Oyster Habitat Restoration Monitoring and Assessment Handbook* to research these methods, or invite a restoration scientist to give a talk to your class.

Reflection

What are some of the nutritional benefits of eating oysters? Does your family or culture have a recipe for oysters? What are ways that native americans harvested oysters traditionally and sustainably?



Assessment

1. Describe three ways that oysters benefit the estuary ecosystem.
2. Name some of the materials used to create artificial oyster reefs.
3. Explain one reason native Olympia oysters almost went extinct.

Resources

- *Reestablishing Olympia Oyster Populations in Puget Sound, Washington*: https://wsg.washington.edu/wordpress/wp-content/uploads/Reestablishing-Olympia-Oyster.pdf
- New York Harbor School. Billion Oyster Project Curriculum: http://100.26.103.210/lessons
- *Oyster Habitat Restoration Monitoring & Assessment Handbook* http://www.oyster-restoration.org/wp-content/uploads/2014/01/Oyster-Habitat-Restoration-Monitoring-and-Assessment-Handbook.pdf
- Rutgers University. Haskin Shellfish Research Laboratory. Project PORTS. Oyster Biology and Ecology Curriculum: https://hsrl.rutgers.edu/PORTS/index.OysterBiologyEcology.Guide.htm