Oregon State University
College of Earth, Ocean, and Atmospheric Sciences

Sea Grant Oregon

Laboratory Activity:
Identifying Tsunami Sand in Salt Marsh Stratigraphy

Developed: 2019
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Levels: middle school, high school, early college
Time: 30 - 60 min
Classroom setting: laboratory
Style: demonstration or small group activity

Table of Contents:

Online Resources:
Sediment coring video:
https://www.youtube.com/watch?v=mXHhzlfCKEQ&t=2s

Materials:
These items will be described in more detail in the activity setup description.
- ❑ Sediment core
- ❑ Timeline for sediment core
- ❑ Hydrogen peroxide (250 mL; 30%)
- ❑ Eye dropper
- ❑ Nitrile gloves (for anyone handling hydrogen peroxide)
- ❑ Safety glasses (for everyone)
- ❑ Metal spatula or steel scoop
- ❑ 3 small beakers
- ❑ Hot plate
- ❑ Water in squirt bottle

Optional Materials:
- ❑ Map of sediment core location
- ❑ Basic stereoscope/microscope
- ❑ Watch glasses or microscope slides (~3)

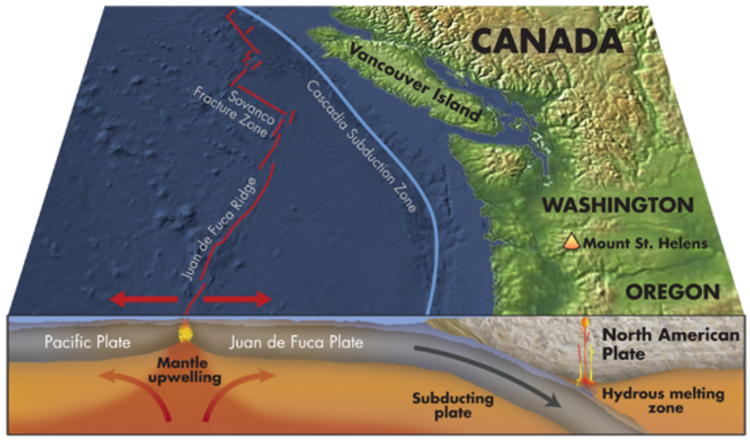
Vocabulary:
Estuary - where a river meets the ocean
Salt marsh - located within estuaries, these vegetated habitats are regularly flooded by tides
Sediment - in salt marshes, sediment is wet and composed of fine-grained sand, silt, and clay combined with organic material
Sediment core - tube of layers of sediment collected by inserting a tube into the ground and extracting the material, usually material is youngest at the surface and oldest at the base
Stratigraphy - layers of sediment (or rock) that accumulate over geologic time and that record Earth's climatic and tectonic history
Organic matter - fraction of sediment composed of material created by organisms

Overview

Through a hands-on activity using salt marsh sediment cores from Pacific Northwest estuaries, students will learn how these environments record the history of earthquakes and tsunami. Students will analyze the stratigraphy through visualization, touch, and experimentation.

Background

Cascadia Earthquakes



Kathleen Cantner, American Geosciences Institute

The U.S. Pacific Northwest coast is a tectonically-active subduction zone called the Cascadia Subduction Zone, where the ocean crust (Juan de Fuca Plate) is colliding with and submerging under the continental crust (North American Plate). This collision produces strain that builds up and is released approximately every 530 years, causing very large earthquakes (magnitude 9). In addition to shaking the land, these earthquakes also cause the ground at the coast to drop up to 10 ft and multiple, large tsunami that flood coastal areas. The last Cascadia Subduction Zone earthquake was in 1700.


Greg Harlin

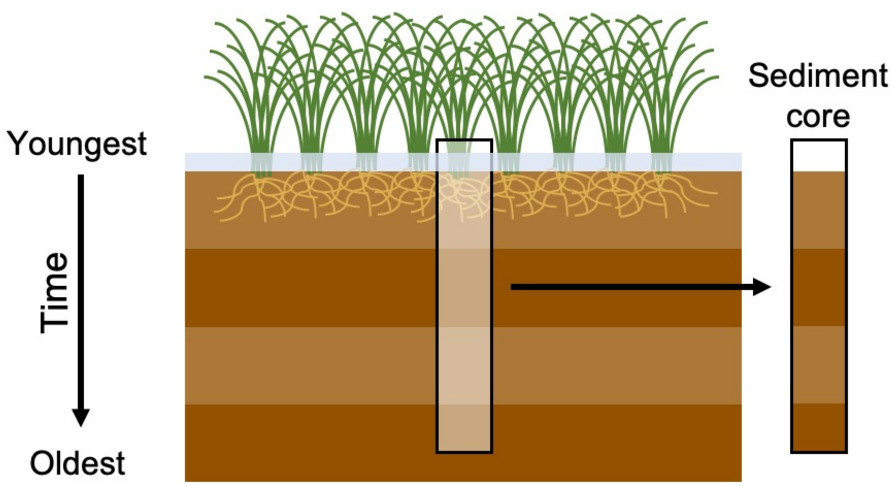
Pacific Northwest Salt Marshes

Salt marshes are vegetated habitats that are located within estuaries and are regularly flooded by tides. In the U.S. Pacific Northwest, salt marshes provide a number of important ecosystem services. For instance, Pacific Northwest salt marshes filter out pollutants, protect coastal communities from flooding during storms, provide habitat for many organisms including fish and migratory birds, serve as areas of recreation and hunting, and regulate climate through carbon burial. However, salt marshes are under threat from climate change and human alteration to the landscape. Threats to Pacific Northwest salt marshes include drowning caused by sea level rise, pollution from upstream urban areas, land reclamation for agriculture, and the spread of invasive species.

Background (Continued)

Studying the Past Through Sediment Cores

In lakes, coastal areas, and the deep sea, sediment accumulates through time. The type of sediment, its chemistry, and preserved biology changes with shifts in climate change, tectonic events, landscape evolution, and biological influence. Scientists can collect samples called sediment cores to study these past changes by age dating and analyzing the stratigraphy.



Because the 1700 earthquake was not recorded in written in Euro-American history, scientists did not realize that the U.S. Pacific Northwest experiences large-magnitude earthquakes until the late 1980s. One of the first indications of these tectonic events came from analysis of coastal sediments.

Within salt marsh sediments we see stratigraphy that is indicative of the 1700 earthquake. Starting at about 2 to 3 ft within the sediment there is usually a thick layer of dark brown, organic-matter-rich mud with vegetation or plant matter present. This is ancient, buried salt marsh. Moving up to the surface, or forward in time, there is often an abrupt transition to sandy sediment that often has very little plant matter. This is the tsunami deposit. Above this, there is often a gradual transition back to organic-matter-rich mud with a lot of plant matter. The surface, or present day, has a lot of organic-matter-rich mud that is characteristic of vegetated salt marshes. We can distinguish earthquake/tsunami deposits from other types of sandy deposits (tsunami caused by other events or large storms) because there is evidence that the land dropped in the fact that the sediment abruptly transitions from salt marsh mud to a sandy environment (tsunami and open water) and then gradually grows back to salt marsh mud. If the stratigraphy was salt marsh mud, sandy deposit, then immediately salt marsh mud, we would conclude that the deposit was caused by something else, such as a large storm.

Learning Outcomes

Students will be able to…

1. Describe how sediment cores are collected in estuaries and how these samples record the history of landscape change
2. Identify ecosystem services provided by estuaries and the threats these ecosystems face
3. Discuss the unique features of estuaries located in tectonic environments, such as those found on the U.S. Pacific Northwest coast
4. Visually analyze and compare salt marsh stratigraphy
5. Identify tsunami sand layers and place them within the context of Pacific

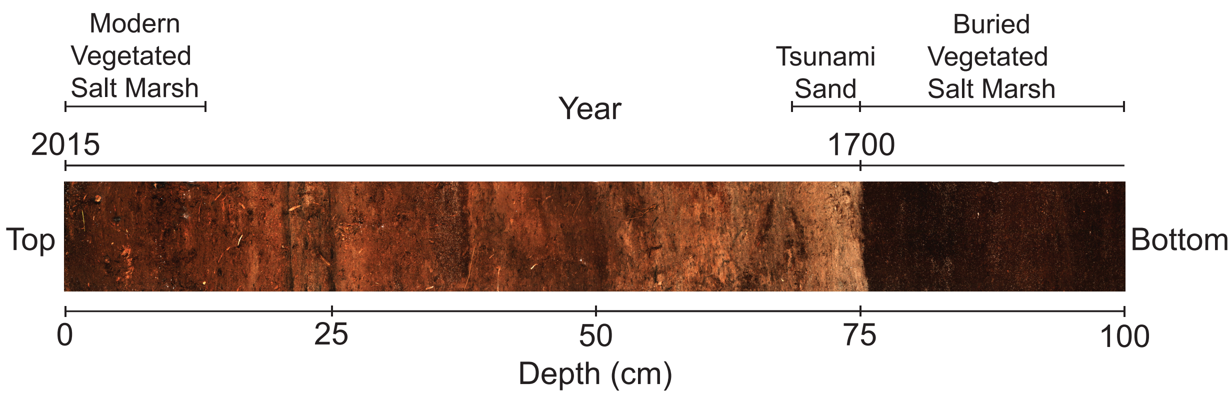
Sediment Core Preparation

Though sediment cores for this activity would ideally be collected directly from a Pacific Northwest salt marsh, field collection may be impractical for most. Instead, teachers can create their own sediment cores to replicate real ones. If the time required for replicating a core is prohibitive, teachers could alternatively print out the sediment core image and provide sand and mud samples for touch in beakers.

Materials:

- ☐ Something to replicate a sediment core barrel such as PVC tube cut in half lengthwise, clear plastic pipe, or even a cardboard paper-towel role cut in half and waterproofed with duct tape
- ☐ Organic rich mud collected from a local marshy area or backyard ideal with plant fragments
- ☐ Sand
- ☐ Water
- ☐ Spatula or credit card for smoothing the sediment surface

To create a replicate core, simply fill the "core barrel" with wet mud and sand to replicate the stratigraphy of a real salt marsh sediment core, such as the one shown below. Use a spatula or the edge of a credit card to smooth the surface of the core.



Activity Setup

1. Prior to the activity, be sure to review all included document as well as the presentation and YouTube video provided

2. Open the presentation and YouTube video on the presentation screen

3. If you are using the handout with questions for students, print a copy for each student

4. Set sediment cores out on lab tables/ benches

5. Either tape timeline to sediment core or place it next to the core. Make certain that the youngest date is at the top of the core

Safety

- Before working in a laboratory with chemicals, always be familiar with your institutions environmental health and safety protocols
- Read the Material Safety Data Sheet (MSDS) for 30% hydrogen peroxide before use
- Those handling hydrogen peroxide must wear gloves, eye protection, and appropriate protective clothing
- Students should also wear eye protection and protective clothing if participating in the demonstration or observing the experiment up close
- Only plug the hotplate in when in use, do not leave the hotplate on when unattended, do not touch the hotplate

6. If you are providing a map of core locations, place it on the table

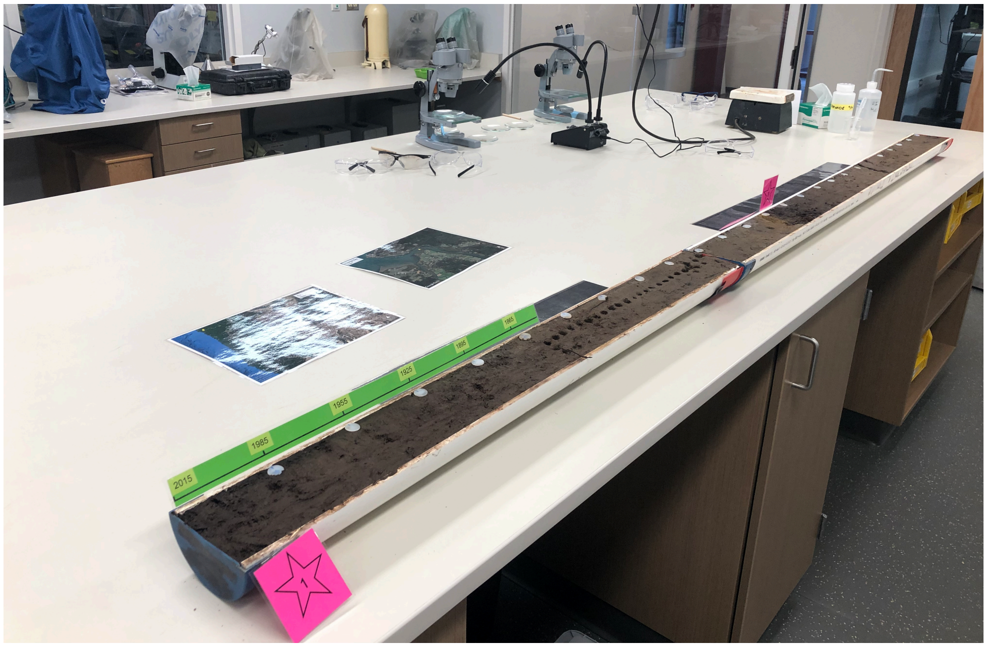
7. If you are using a microscope, setup microscope on the table, making sure there is a light source if none is attached to the microscope

8. If you are using a microscope, take 3 samples from the sediment core - 1 from the surface, 1 from within the tsunami deposit, and 1 from below the tsunami deposit - and place them on individually-labeled watch glasses. You may either label the depth or number the samples. If you label the samples (e.g., 1, 2, 3), you could either add tags with corresponding labels to the core or have students try to determine where the samples came from within the core. Place 3 labeled watch glasses near the microscope

9. Place hotplate on table or in fume hood, making certain there is an electric outlet available. Do not turn the hotplate on until you are ready for the demonstration

10. Place at least 3 pre-labeled beakers (e.g., Sample 1, Sample 2, Sample 3), a metal spatula/scoop, and a squirt bottle filled with tap water on the table

11. Make certain the hydrogen peroxide is available for the demonstration but place it out of the way of children’s hands. When not in use, store it in a fume hood



Activity Timeline

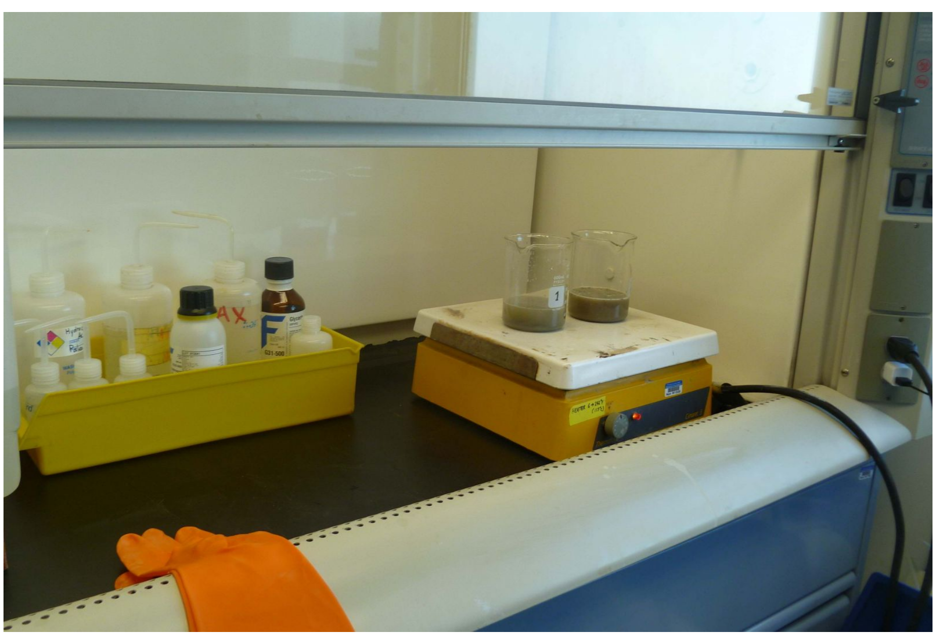
1. Presentation
    1. Engage students during the presentation by asking guiding questions
2. Video on how sediment cores are collected in salt marshes
3. Explain sediment core display
    1. Either explain that the core is a replica or show where the sediment core was collected on the map if you provide it
    2. Explain the timeline on the sediment core
    3. Explain that students may touch the sediment in the core or the samples provided
    4. Explain how the microscope works and where each watch glass sample was taken from within the core
4. Sediment core description
    1. Either guide students through the questions or provide students with a worksheet to answer the questions in small groups
    2. Once the students have worked through the sediment core description, call students back together, this would be a good time to discuss what they have discovered so far.
5. Experiment
    1. Either guide students through the questions or if students are advanced enough to work through the experiment in small groups, add these guiding questions to their worksheet
6. Recap, lingering questions, final thoughts

Experiment Explanation

This experiment is to test the organic matter content of sediment samples collected from within the sediment core. Organic matter is made up of plants and other things that were once living but have now decomposed to form carbon-rich mud. Hydrogen peroxide is a type of bleach often used in household products; however, 30% hydrogen peroxide is stronger than most of these products and when it comes in contact with organic matter, it slowly devolves it, creating bubbles. The more organic-matter-rich the sediment, the greater the number of bubbles.

To compare the organic matter contents in different samples in the core, ask students to scoop small (nickel size) sediment samples from the surface of the core and place them individually into labeled beakers. At this point everyone should be wearing goggles and the person handling the hydrogen peroxide should be wearing gloves. The teacher should handle the hydrogen peroxide unless students are advanced and have been trained to use chemicals properly. Using the eye dropper, drip enough hydrogen peroxide into each beaker to cover the sediment. Use the water in the squirt bottle to carefully squirt down any sediment stuck to the edges of the beakers. Since heat speeds up the reaction, you will place the beakers on the hotplate. Make sure the hotplate is turned onto a medium heat and do not let the beakers go dry while sitting on the hotplate (if necessary, add water). Watch the beakers - the ones that bubble most are rich in organic matter, those that do not bubble as much are poor in organic matter.

To clean up, rinse beakers and contents down the drain with ample water.



Guiding Questions & General Answers

Presentation

1. Could someone describe what a salt marsh is?
   vegetated habitats are regularly flooded by tides
2. Salt marshes are located on the coast, but can anyone name the location where you would find salt marshes?
   estuaries or bays
3. Can someone describe what an estuary is?
   where the river meets the sea
4. Call out some reasons why salt marshes are important to humans.
   filter pollutants, storm and flood protection, habitat for animals including fish and shell fish, areas for recreation and hunting, navigation, carbon burial, etc.
5. What are some ways salt marshes are threatened?
   invasive species, sea level rise, pollution, urbanization, etc.

Sediment core description

1. What stands out to you in the sediment core?
   open-ended but students may notice tsunami, encourage students to describe other features
2. If we know that the last Cascadia Subduction Zone earthquake happened about 300 years ago in 1700, where in the sediment core do you think you see an earthquake and tsunami deposit? Why?
   theoretically - since the earthquake happened 300 years ago, we would not expect to see it at the very surface, but further down in the sediment core
   visually - earthquake/tsunami deposits should display as a change in sediment type: buried, organic-matter-rich (dark brown) salt marsh sediment below a sandy deposit with a sharp transition then a gradual transition back to salt marsh sediment
   texturally - the mud feels smooth/slimy and sand feels gritty when rubbed between fingers
   microscope slides - the sediment below the sand deposit and at the surface look similar under the microscope indicating a similar habitat, the sand looks different
3. What other evidence would allow us to tell that the sand layer is maybe evidence of an earthquake/tsunami?
   Open-ended but students might say that they would expect to see other buried objects (broken trees, shells, other organisms) from the destruction caused by the earthquake and tsunami, they could do other scientific analyses (try to determine the date of the sand, see if the chemistry of the sand tells you about where the sand originated), compare the sediment core to others in the same area or along the whole coast (you would expect to see the sand at the same depth in all cores), compare to the records, art, and oral stories from the Native people living in the area 300 years ago

Guiding Questions & General Answers (continued)

Experiment

1. Where do you hypothesize that the highest organic matter content is in the sediment core? Where do you hypothesize that the lowest organic matter content is in the sediment core?
    highest organic matter content should be at the surface or possibly beneath the earthquake/tsunami deposit, lowest organic matter content should be in the earthquake/tsunami deposit
2. Where should we select samples from within the sediment core for the experiment?
    allow students to choose; however, you may guide them to pick more samples to include the buried marsh, the earthquake/tsunami deposit, and the surface
3. What happened? Were your hypotheses correct?
    Open-ended but have students assess whether they were correct or not

Middle school students part of Oregon State University's SMILE (Science & Math Investigative Learning Experiences) program examining an earthquake/tsunami deposit in a salt marsh core collected in an Oregon estuary.

Middle school SMILE students comparing sediment taken from different depths in the core under microscopes.