Tsunami Shake 'n' Quake: Evidence for Past Tsunamis in Oregon

Material adapted from
The Pacific Northwest Seismic Network: The January, 1700 Cascadia Subduction Zone earthquake and tsunami
http://www.ess.washington.edu/SEIS/PNSN/HAZARDS/CASCADIA/cascadia_event.html
Handout excerpts were taken from Cascadia Megathrust Earthquakes in PNW Indian Legend
http://www.ess.washington.edu/SEIS/PNSN/HIST_CAT/STORIES/legend.html

Introduction:

The study of past tsunamis is important in understanding subduction earthquake events and helps develop warning systems to prepare coastal communities for future tsunamis. Scientists believe that on January 26th 1700, a great earthquake shook the Pacific Northwest, originating from the Cascadia Subduction Zone. This quake, with magnitude estimated at 9.0, rocked the region with strong shaking for several long minutes while coastal Washington plummeted as much as 1.5 meters relative to coastal waters. How is it possible to know that a tsunami event occurred over 300 years ago? This class will demonstrate how scientists have used both sediment evidence and Native American legend to determine this past tsunami that may have affected the Pacific Northwest.

Materials:

(Materials in **bold** are provided by SMILE)

Test Tubes
Rubber Stoppers
Orange Sand
Black Sand
Plastic Bowls
Plastic Spoons
Stickers
Markers
Scrap Paper (Optional)

Materials provided are enough to support **5** student teams

Handouts/Overheads:

Sediment Evidence for Tsunamis overhead
Native Americans and Tsunamis handout

Activity

1. Review tsunamis and their potential as a coastal hazard. Describe to the students how scientists have found there may have been a large-scale tsunami that affected the Pacific Northwest in 1700. Evidence has been found through both sediment data and Native American legends.

Ask the students to stand up. Describe how the average earthquake lasts around 30 seconds, depending on your distance from the epicenter. Tell the students to shake their arms and legs around on the spot while you time them for 30 seconds. How do they feel? Tired?! Ask them to imagine what effect that amount of shaking might have on the ground after that period of time.

Rivers carry sediment (soil and other debris) into the ocean, and sediment collects on the continental shelf and continental slope, which slopes into deeper water. More and more material builds up on the continental shelf sea floor until it becomes unstable and slides down the continental slope, much like an avalanche, in what is called a turbidity current. The resulting layer of sediment this current deposits on the sea floor is called a turbidite. A number of events can potentially trigger turbidity currents. These events include tsunamis, storm induced waves, slope failures, and earthquakes. The turbidite record strongly suggests the latter — coastal Washington and Oregon experienced strong coast-wide shaking typical of a large subduction zone earthquake. Core samples were taken to study the layers and tubidites formed on the seabed of the Pacific Northwest to help discover key environmental characteristics about specific years.

2. Divide the class into teams and assign them a letter, A, B, C, etc. Distribute the test tubes, stoppers, orange and black sand (Go Beavers!) and plastic spoons. Inform the students they are to make their own sediment core samples by layering the black and orange sand inside the test tubes, including some that represent a disturbance by a subduction zone earthquake/tsunami that other teams will have to guess at.

3. Students make their core samples by adding small amounts of black and orange sand in layers of various thicknesses with the plastic spoons. Folded scrap paper can also be used to pour the sand inside the test tubes with minimal spillage.

Each layer should represent a time period (e.g. 50 years) and at one or two chosen points in the layering process the students should create a disturbance to that current top most layer. This can be done simply shaking the test tube gently (not too much otherwise all layers are disrupted!) with the rubber stopper in, this will represent the period where a turbidity current occurred and hence create a tubidite.

The students can then finish layering their core sample until the test tube is full (with space left for the stopper). The final layer will represent present day sediments (i.e. all layers below represent years before today). Let students know the thinner the layer, the more difficult it will be for another team to guess which year(s) they chose to create a turbidite.

4. Once two core samples have been made, teams should make sure the rubber stoppers are inserted securely and each of their test tubes are labeled by applying a sticker to the top of the rubber stopper and marking them accordingly, e.g. Team A would mark their first core sample A1 and their second A2.

5. Next all core samples should be switched with another team. The students then have to study the new test tubes carefully to determine where the turbidites (disturbed layers) are in the core and how long ago they occurred. Teams should note their findings and answers should be revealed at the end of the activity. Teams can switch core sample as many times as time allow so everyone has a chance to check out all the different core samples made.

Questions to ask students:

- How difficult was it to find the turbidites? Were some teams' harder than others?
- How accurate was your team in finding the turbidites?
- The core samples made are very small-scale models of core samples taken from the seabed, what problems would arise from studying the real core samples? (Think about the sediment colors you used!)

Evidence from sediments has also come from research into sand deposits found in wetland areas of coastal Oregon and Washington

(where there are usually mud deposits). These sand deposits, or sheets, are layers of ocean sand in between layers of soil and mud. Researchers believe that these sand sheets were created when a series of tsunami waves washed over subsided regions of the coastline and deposited sand, which later became covered over in mud.

6. Now discuss with the students how other evidence has helped scientists hypothesize the Cascadia earthquake and tsunami of 1700, including evidence taken from Native American legends. Many Native American (U.S.) and First Nations (Canada) stories describe earthquake effects: shaking, tsunamis, and subsidence. Native peoples have inhabited the Cascadia coast for thousands of years and witnessed cycle after cycle of great earthquakes. Some stories are myths others are historical

7. Distribute the Native American and Tsunamis student handout. Working with a partner, ask the students to read the accounts and discuss the following questions:

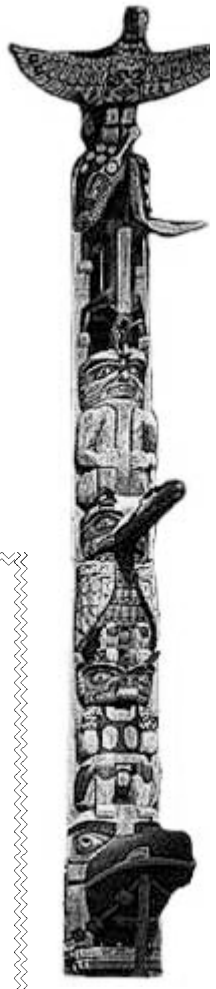
1) Which account do you think is more an eyewitness report and which do you think is a legend?
2) In both accounts, underline the sections you think are referring to the actual action of either an earthquake or a tsunami. Why do you think this?
3) What similarities are there between the accounts? What are the differences?
4) Do you think these legends are usable as evidence? If so, how would you use this information as a scientist to find actual data to support the theory of a 1700 Cascadia event? If not, why?

Questions could also be answered as a whole class discussion.

Class Extensions:

- Using further Native American legends from the Pacific Northwest Seismic Network website, hold a class debate on the students opinions of the appropriateness of using these accounts as evidence in scientific research.

Native Americans & Tsunamis– Student Handout



Scientists have found evidence of a large-scale earthquake and tsunami in the Cascadia Subduction zone not only through sediment data, but also through land level information (levels can drop during a subduction zone earthquake), dendrochronology (tree rings showing impacts against forest areas) and Native American legends.

Native American Legends & Stories

Read the accounts below and discuss the questions proceeding.

Account A

"The only tradition that I have heard respecting any migratory movement among the Makahs, is relative to a deluge or flood which occurred many years ago, but seems to have been local, and to have had no connection with the Noachic deluge which they know nothing about, as a casual visitor might suppose they did, on hearing them relate the story of their flood. This I give as stated to me by an intelligent chief; and the statement was repeated on different occasions by several others, with a slight variation in detail."

"A long time ago," said by informant, "but not at a very remote period, the water of the Pacific flowed through what is now the swamp and prairie between Waatch village and Neeah Bay, making an island of Cape Flattery. The water suddenly receded leaving Neeah Bay perfectly dry. It was four days reaching it lowest ebb, and then rose again without any wave or breakers, till it had submerged the Cape, and in fact the whole country, excepting the tops of the mountains at Clyoquot. The water on its rise became very warm, and as it came up to the houses, those who had canoes put their effects into them, and floated off with the current, which set very strongly to the north. Some drifted one way, some another; and when the waters assumed their accustomed level, a portion of the tribe found themselves beyond Nootka, where their descendants now reside, and are known by the same name as the Makahs in Classett, or Kwenaitchechat. Many canoes came down in trees and were destroyed, and numerous lives were lost. The water was four days regaining its accustomed level."

[From an account by J.G Swan, who studied Native American lore and wrote the article "The Indians of Cape Flattery, at the entrance to the Strait of Fuca, Washington Territory" in 1868]

Account B

"In the beginning Kwattee created the animals of the earth. Then by the union of some of these animals with a star which fell from heaven, came the first human beings. And from these sprang the various races of men. Years came and went and all was good. Then Chief Thunderbird attempted to destroy all the good whales of the ocean. Kwattee then interfered, and a terrible drawn battle was fought between him and Thunderbird. Enraged, that bird caused the waters of the great deep to rise. For four days the sea continued to rise. It rose till it covered the very tops of the mountains. Again Kwattee joined his adversary in battle, and while the conflict was in progress, the waters receded. This engagement, too, was a drawn battle, and following it the waters again rose. The water of the Pacific flowed through what is now the swamp and prairie westward from Neah Bay on the Strait of Juan de Fuca to the Pacific, making an island of Cape Flattery. Again Kwattee and Thunderbird engaged in terrible conflict, and again the waters suddenly receded, leaving Neah Bay, the Strait of Fuca, and Puget Sound perfectly dry. For four days the water ebbed out, and numerous sea monsters and whales were left on dry land. The battle was again indecisive. Then without any waves or breakers the waters again rose till they had submerged the whole country. Then Kwattee killed Chief Thunderbird. The waters were then four days receding. And since then there has been no great floods on the earth. Also each time that the waters rose, the people took to their canoes and floated off as the winds and currents wafted them, as there was neither sun nor land to guide them. Many canoes also came down in trees and were destroyed, and numerous lives were lost. And the survivors were scattered over the whole earth. One segregation of the Quileutes found themselves at Hoh, another at Chemakum (near the present Port Townsend), and a third succeeded in returning to their own home here on the Pacific.

[From "Some Additional Myths of the Hoh and Quileute Indians", Albert B. Reagan, Utah Academy of Sciences, Arts, 1934]

Questions:

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4) Do you think these legends are usable as evidence? If so, how would you use this information as a scientist to find actual data to support the theory of a 1700 Cascadian event? If not, why?