Sediment Migration and the Strait of Juan de Fuca:

Predicting where sand and gravel from the Elwha River will go after dam removal

Abstract

In 2004 the United States Geological Survey initiated a research project in the coastal areas surrounding the mouth of the Elwha River on Washington State's Olympic Peninsula. This project seeks to understand how sediment, carried by the river after the planned removal of two dams, will move and settle in the Strait of Juan de Fuca. The information learned from this study will be crucial in evaluating how dam-removal affects beaches and coastal habitats.

Figure 1: Location of the Elwha River on Washington's Olympic Peninsula.

Introduction

Most rivers, through the process of **erosion**, move **sediment** off the land and deposit it into the marine environment . Once at the coast, this sediment forms features and habitats, including beaches, salt marshes, spits, eel-grass beds, sand flats and dunes. These coastal features are used by humans for business, recreation and food collection, and also as **habitats** by many types of plants, animals, algae and bacteria. Dams, because they impede, or slow, the flow of a river, also act to slow or stop the flow of sediment to the coast. In some instances this can result in the loss of the types of coastal habitats and features described above .

The Elwha River watershed is the largest drainage on the Olympic Peninsula and, because the Olympic Mountains are made up mostly of relatively soft **sedimentary** stone, they erode very easily. In the early 1900's two dams constructed on the Elwha River blocked the free flow of the river. As a result, over the 90+ year history of the two dams almost 18 million cubic yards of sediment has built up in their **reservoirs** (Randle et al., 1996).). This volume of sediment can be visualized by imagining dump trucks, all full of Elwha River sediment, lined up bumber to bumper and stretching three times across the United States! There is a huge amount of sediment in the reservoirs that, if the dams were not in place, could have made it to the coast. It is highly likely that the lack of sediment flow to the coast over the last 90+ years has resulted in erosion of beaches around and near the Elwha River mouth (Casey , 2006).

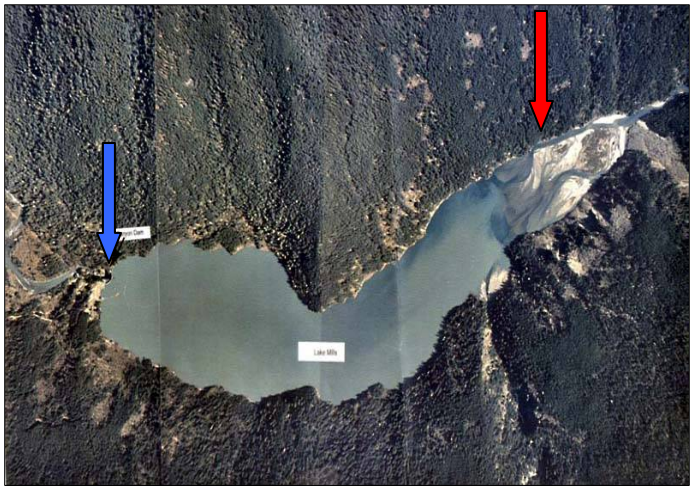

Figure 2: An image shot from an airplane showing the Lake Mills Resevoir. The blue arrow points to the Glines Canyon Dam. The red arrow points to the sediment that, over the past 80 years, has collected in this reservoir.

A major dam-removal project is planned on the Elwha River. When the dams are removed and the river flows freely once again, scientists calculate that up to 7.5 million cubic yards, or 42%, of the sediment stored in the reservoirs will resume its trip down the river and eventually reach the coast (Randle, et al. 1996). It is impossible to know exactly what will happen when this sediment reaches the coastal areas of the Strait of Juan de

Fuca. Will it all move into the deeper waters of the Strait of Juan de Fuca? Will some it of it distribute along beaches and perhaps help to stop or even reverse erosion? Will kelp beds be smothered? Will new eel grass beds be formed? Scientists can use previously acquired knowledge and combine it with careful measurement to try to predict the fate of this sediment.

To accomplish this, Dr. Jon Warrick and a team of researchers from the United States Geological Survey developed a focused research question:

What will happen to the sediment that exits the Elwha River into the Strait of Juan de Fuca after the dams are removed?

They also selected a variety of tools and methods best suited to collecting information that could help them to answer their question.

Figure 3: A researcher maps the bottom of the Strait of Juan de Fuca using a sonar and GPS unit mounted on a jet ski.

Methods

1. **Measure and map the existing coastal area:**

To do this teams of researchers work near the mouth of the Elwha River a few times each year. Using tools like **GPS** units and **sonar** from jet skis and boats, they create maps of the sea-floor and beach. Additionally, they measure and photograph sediment along the beach for later comparison. This information can be compared to data collected later to demonstrate where and how sediment is moving and the beach and sea-floor is changing. All of this allows scientists to better understand how the Elwha system is functioning now (this is known as developing a **baseline**), before the dams are removed.

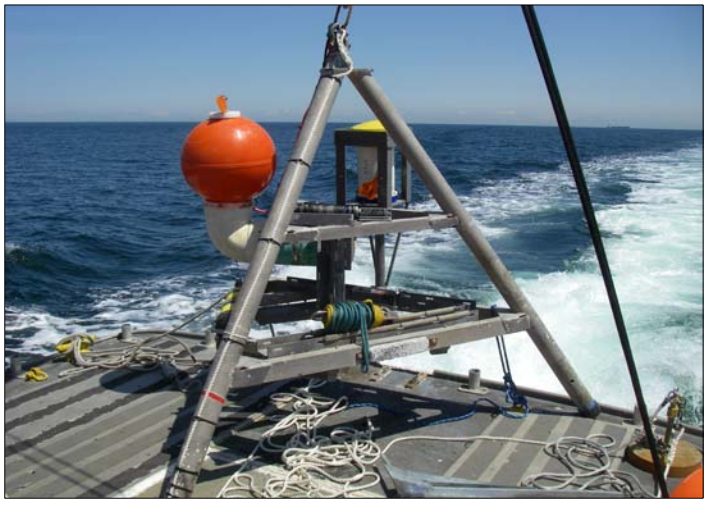

Figure 4: An Acoustic Doppler Current Profiler, shown on the back of a USGS research boat. This device has a long name, but it can be set on the bottom of the ocean and left for a period of time to collect information about currents and waves.

2. **Study wind, waves and currents in the area of the Elwha River mouth:**

To do this USGS scientists use instruments that can be anchored out in the water and left for a period of time to automatically collect information about waves and swell, wind and currents. This information allows scientists to better understand the forces that will move sediment as it comes out of the river.

3. Using the information collected from the methods above, USGS scientists will **build a virtual computerized model of the Elwha coastal system:**

Just like, for example, a model rocket, which can be built and launched to study how rockets fly, the computerized model of the Elwha system is designed to mimic, as closely as possible, conditions in the real world. Scientists can use this model to predict where sediment will distribute in the Strait of Juan de Fuca.

Discussion

This is research in progress. The data collected by this research team has already produced some of the best maps of the sea-floor every seen in this area . These maps allow us to view the sea-floor as if we were standing on a high hill, looking down at the undersea landscape. They also collect data on winds, currents and waves. The next step for this project is the development of the virtual model, which will allow the team to predict an answer to the research question, "What will happen to the sediment that exits the Elwha River into the Strait of Juan de Fuca after the Elwha dams are removed?"

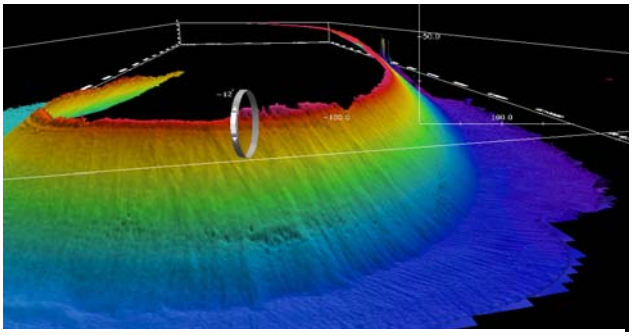

Figure 5: An example a map produced using sonar data. This shows an underwater view of the end of Ediz Hook, Port Angeles Harbor.

References

Randle, T.; Young, C.; Melena, J.; and Ouellette, E. 1996. *Sediment Analysis and Modeling of the River Erosion Alternative.* U.S. Bureau of Reclamation Document ETS-PN-95-9.

Casey, J. 2006. *Storm continues eating away at Angeles Point*. Peninsula Daily News 6 January 2006 edition.

Warrick, J. 2005**.** *Dam Removal on the Elwha River in Washington—Nearshore Impacts of Released Sediment*. Sound Waves, February 2005 edition.

Glossary

Baseline: A measurement, calculation, or location used as a basis for comparison.

Erosion: The gradual wearing away of land surface materials, especially rocks, sediments, and soils, by the action of water, wind, or a glacier. Usually erosion also involves the transport of eroded material from one place to another, as from the upstream portion of a river to the downstream portion.

GPS: **G**lobal **P**ositioning **S**ystem. A system that uses satellites to fix the location of a person or object on the surface of the Earth.

Habitat: The area or natural environment in which an organism or population normally lives

Model: A systematic description of an object or phenomenon that shares important characteristics with the object or phenomenon. Scientific models can be material, visual, mathematical, or computational and are often used in the construction of scientific theories.

Reservoir: A natural or artificial pond or lake, created when dams block or slow the flow of a river or stream, used for the storage of water.

Sediment: Solid fragmented material, such as silt, sand, gravel, chemical precipitates, and fossil fragments, that is transported and deposited by water, ice, or wind or that accumulates through chemical precipitation or secretion by organisms, and that forms layers on the Earth's surface. **Sedimentary** relates to rocks formed when sediment is deposited and becomes tightly compacted .

Sonar: Short for *sound navigation and ranging,* a method of detecting, locating, and determining the speed and location of objects in water through the use of reflected sound waves. A sound signal is produced, and the time it takes for the signal to reach an object and for its echo to return is used to calculate the object's distance.

Researcher Biography

Figure 6: Dr. Jon Warrick on the beach at the mouth of the Elwha River. He is carrying a GPS unit mounted to a backpack.

Dr. Jon Warrick, USGS, Santa Cruz, California

Jon was born and raised in southern California and, from an early age, enjoyed hikes in the mountains and swimming and surfing in the ocean. Although he was always good at math and science, Jon did not know he could study – let alone work in – environmental science until he got to college. Growing up he always thought he would be an airplane pilot or an architect! Once in college Jon learned he could study both the land and the sea, and in doing so help understand the links between the mountains and oceans he enjoyed as a child. Jon has worked on these topics through college, majoring in Soil Science at California Polytechnic State University and in graduate school, earning a Masters in Science from University of Wisconsin and a PhD in Marine Science at the University of California, Santa Barbara. Jon lives in Santa Cruz, California with his wife and two kids, and is now a Research Scientist with the United States Geological Survey.

Curriculum Writer's Biography

Ian Miller shares his enthusiasm for the dynamics and power of the changing coast.

Ian Miller, M.S. Candidate, University of California Santa Cruz

Ian Miller is in his first year of graduate studies at the UC Santa Cruz in California studying beach and coastal sediments and the ways that their movements create habitat for marine organisms. And yes, you guessed it, his study site is the coastal zone in front of the Elwha River mouth. Prior to starting graduate school Ian lived lives as a world traveller, Washington Field Coordinator for the Surfrider Foundation and Education Director at the Olympic Park Institute. In his spare time Ian enjoys immersing himself in cold salt water.

Elwha Research Learning Unit

This research summary is a piece of a larger Elwha Research Learning Unit which has been funded by the Research Learning Network and coordinated by Olympic Park Institute. This is one of seven research summaries which capture the diverse and exciting science which is being done in preparation for the upcoming Elwha River dam removals. All seven summaries are examples of the important work which fits together to help us better understand the Elwha River Ecosystem and neighboring Strait of Juan de Fuca. Three of these research topics have been turned into activities which have been designed for us to practice the scientific process by using real research from this inspiring dam removal effort. For the complete learning unit, go to OlympicParkInstitute.org or ElwhaScienceEd.org.

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