

**G473 Environmental Geology**

**Lab 4 - Assessing Coastal Hazards (Tsunami Run-Up Models)**

### Exercise #3

## Assessing Geologic Hazards Part 1: Tsunamis

### Introduction

Oregon is located in a region of potentially high magnitude earthquakes (M8-9), earthquakes related to fault rupture along the offshore Cascadia subduction zone. Figure 1 describes the plate tectonic setting of this fault system. These earthquakes could potentially deform the seafloor and generate tsunami that would strike the coastline and result in significant flooding of low lying areas, many of which are also the centers of human development. Developing geologic hazard maps that predict potentially high risk areas for such events is the first step in mitigating future damage from tsunami induced coastal flooding. The purpose of this exercise is to familiarize students with the factors involved in determining the potential onshore run-up from tsunami waves, to train students to recognize "at risk areas", and construct hazard maps delineating such areas for the benefit of laypersons.

### Determining Tsunami Wave Run-up

The height to which run-up from a tsunami wave will affect low lying coastal areas depends primarily on the amount of seafloor subsidence that occurs during the earthquake, but may be influenced by local seafloor asperities and by natural and anthropomorphic features of shoreline protection. The amount of seafloor subsidence will determine the total volume of sea surface displacement which ultimately controls the size of the tsunami wave. Seafloor subsidence is related to the length and width of the fault segment which ruptures, in general, the greater the length and width, the larger the subsidence zone and the larger the volume of sea surface displacement.

Two rupture lengths are postulated for the Cascadia subduction zone based on paleoseismic evidence and geophysical data obtained from studies of the fault system. Rupture along the entire length of the fault system from the Nootka fault in the north to the Mendocino fault in the south (Fig. 1), would result in a rupture length of nearly 1000 km. Evidence suggests that the fault system may have ruptured in two segments of nearly equal length several times in the past. The segments are separated at a latitude of about 45° N (Fig. 1), with rupture lengths of about 500 km. Two rupture widths are also postulated for the Cascadia subduction zone, depending on the focal depth and degree of propagation along the fault boundary. Investigation of the Cascadia fault system supports a probable rupture width of about 70 km, although other subduction zones similar to the Cascadia have had measured rupture widths almost twice as wide, or approximately 140 km.

Subduction zone fault boundaries build stress along the fault plane in a heterogeneous manner. Some portions of the fault plane are "rough" and because of a higher degree of friction they are not able to move past each other as readily as other portions. These regions of greater strength are known as asperities, and during a subduction zone earthquake they can produce a concentrated release of accumulated strain, intensified seafloor deformation, and amplified tsunami waves. Combined with long, wide zones of fault rupture, asperities can produce truly large tsunami.

Some shoreline features may protect low lying areas from tsunami wave inundation. Extensive beach berm and sand dune systems can prevent run-up from reaching lowlands and human made jetty systems can deflect wave energy away from the entrance to bays and estuaries. These features reduce the volume of water which can enter low lying coastal areas and reduce wave run-up.

Combining all of the characteristics described above, results in three possible run-up scenarios for the Newport and Lincoln City, OR coastal areas. Assuming that the tsunami wave strikes during mean high tide, run-up heights of 10.7 meters (High), 8.2 meters (Moderately High), and 4.8 meters (Moderately Low) are produced.

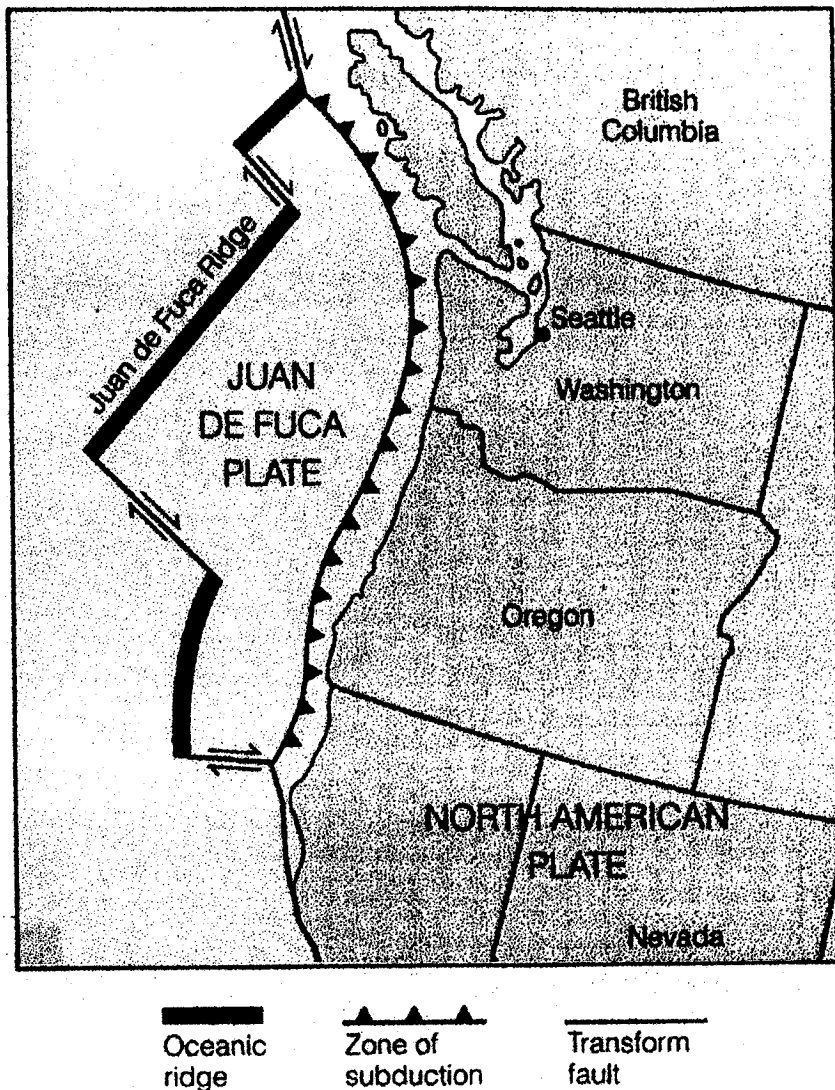


Figure 1. Plate tectonic map of the Cascadia subduction zone fault system indicating the surface trace of the fault at the deformation front relative to the Newport and Lincoln City, OR coastal areas. The subduction zone is bounded by the Nootka and Mendocino transform faults and dips eastward at about 8-12°.

### Assignment

Each student will construct a tsunami run-up hazard map for either Newport or Lincoln City, OR using the topographic base maps provided by the instructor. Based on the information provided above, develop three categories of risk (high, medium, and low) and delineate these areas on the base maps. Use a color code to indicate risk, such as red-high, orange-medium, and yellow-low. Be sure to show this coding system in the form of a legend on the map with a brief explanation of each risk category.

## Lab Exercise 4 Additional Instructions

Step 1 - Arrange Your Tsunami Classification Data Below.

Tsunami Model Run-Up Heights (m)	Tsunami Model Run-Up Heights (ft)	Hazard Classification	Color Code
10.7 m	_____	High	Red
8.2 m	_____	Moderately High	Green
4.8 m	_____	Moderately Low	Blue

Step 2 - Examine the Newport and Lincoln City Map Portions

- Identify contour line elevations and compare to your model run-up heights.
- Using a pencil, delineate the run-up height classification boundaries.
- Color code your classifications for both the Newport and Lincoln City maps.

Step 3 - Answer the Following Questions

A. Fill in the table below

Map Area	Approximate Percentage of City Area Inundated during Tsunami at each Class*		List Examples of Urban Features Inundated at Each Hazard Class**
Lincoln City, OR	High	_____	_____
	Mod. High	_____	_____
	Low	_____	_____
Newport, OR	High	_____	_____
	Mod. High	_____	_____
	Low	_____	_____

\* approximate the percentage of area inundated by comparing hazard class to city limit boundary

\*\* read map and identify significant urban feature located in each hazard class (e.g. schools, churches, etc.)

B. Answer the following questions / perform the following tasks.

- (1) What is the fate of the homes built on Salishan Spit (south of Lincoln City), in the event of a high-hazard tsunami? What about a low-hazard tsunami?
- (2) Which city (Lincoln or Newport) has the greatest percentage of area that will be inundated during a moderate hazard tsunami? A high hazard tsunami?
- (3) Based on the talk by Wang (DOGAMI), comment on the relative earthquake-induced landslide damage potential to highways leading out of Lincoln City and Newport.
- (4) Based on the talk by Darienzo (OR Emergency Management), write a three-paragraph emergency management plan for tsunami events in coastal Oregon. Your discussion should include statements on hazard, risk, emergency preparedness, warning systems, evacuation procedures, and mitigation plans.

NOTE: A significant portion of this lab was conceived and prepared by Dr. Ken Bevis, Adjunct Faculty in Geology at Western Oregon University. Dr. Bevis is acknowledged for his significant efforts in preparing this set of materials.