Tsunami Hazard Assessment of the Strait of Juan de Fuca

Final Report

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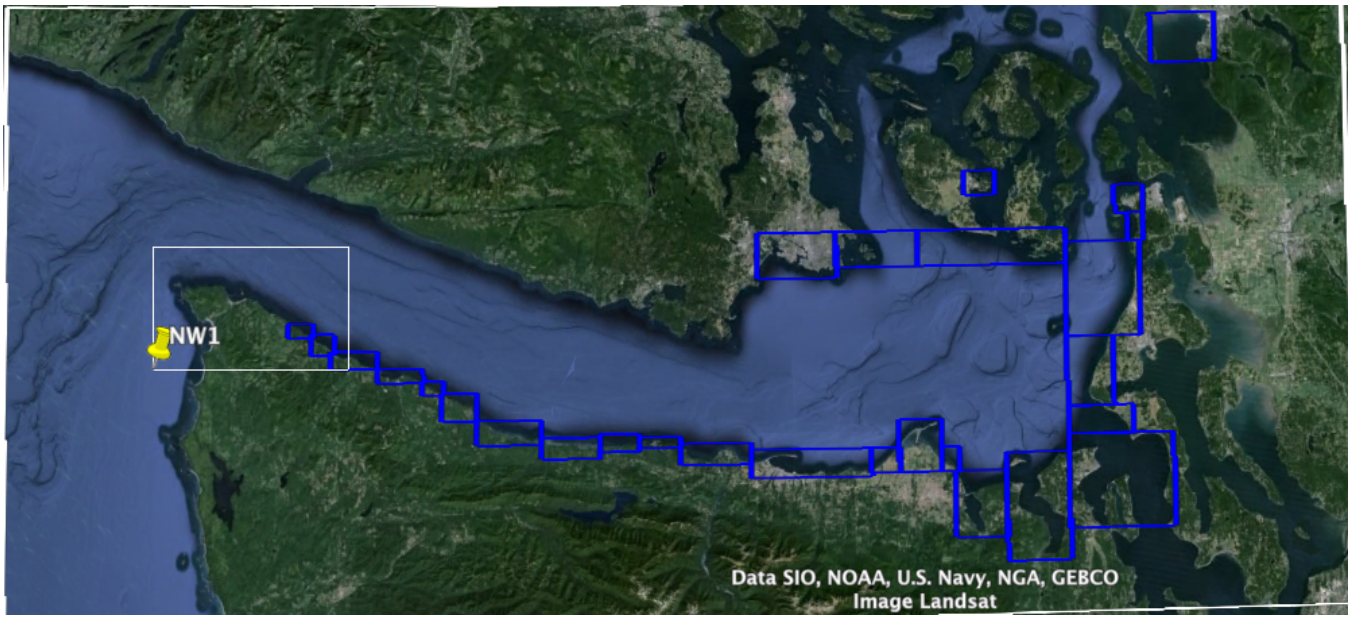

Photo Source: Google Earth

Study funded by Washington State Emergency Management Division

Contents

1 Introduction

This report documents the results of a study supported by the Washington State Emergency Management Division of the tsunami hazard along the Strait of Juan de Fuca. Results include inundation depths and times of arrival that will be useful to communities along the Strait as well as speeds, momentum, momentum flux, and minimum water depths that are useful for harbor masters and the major shipping and ferry industries that operate within the Strait of Juan de Fuca.

The probability that an earthquake of magnitude 8 or greater will occur on the Cascadia Subduction Zone (CSZ) in the next 50 years has been estimated to be 10-14% (Petersen, et. al., 2002 [13]). The last such event occurred in 1700 (Satake, et al., 2003 [14]; Atwater, et al., 2005 [1]) and future events are expected to generate a destructive tsunami that will inundate Washington Pacific coast communities within tens of minutes after the earthquake main shock.

A previous study by Walsh, et al. (2000) [18] documented evidence of two tsunamis that struck the Southwest Washington Coast, generated in 1700 and 1964 by earthquakes on the Cascadia Subduction Zone (CSZ) and Alaska-Aleutian Subduction Zone (AASZ), respectively. Tsunami simulations were conducted for two magnitude 9.1 (M9.1) CSZ earthquake scenarios, one of which included an area of higher uplift offshore of northern Washington and, therefore, a higher initial tsunami wave. These simulations resulted in moderate to high inundation of Washington coastal communities.

In 2003, inundation maps were published for the Quileute tribal area in La Push (Walsh, et al., 2003a [17] on the northern Washington Coast and for Neah Bay (Walsh, et al., 2003b [16]) in the Straits of Juan de Fuca. Based partially on these and other inundation estimates, socioeconomic analyses were conducted of the population within the estimated inundation zones of the Washington Pacific and Straits of Juan de Fuca coast (Wood and Soulard, 2008 [21]). Since then, there have been advances in understanding the potential for great tsunamigenic earthquakes on the Cascadia Subduction Zone, including the development of a new suite of 15 megathrust sources used in a study of Bandon, Oregon (Witter et al., 2013 [19]); this motivated the present effort to update the assessment of tsunami hazards on the Washington coast and the Strait of Jaun de Fuca.

This study presents and discusses the tsunami hazard posed by an updated CSZ earthquake scenerio to the coastal communities of Port Angeles and Port Townsend, based on the results of a high resolution GeoClaw simulation with 2/3 arc second resolution (about 20.56 meters) surrounding these towns. In addition, we will also present the results of a coarse regional simulation of the Strait of Juan de Fuca. This coarse study encompasses 28 regions that span the Strait's coast, including the communities of Anacortes, Bellingham, Friday Harbor, and Victoria, BC in addition to extended areas around Port Angeles and Port Townsend. The finest grid for these 28 regions where we collected results had 2 arc sec resolution (around 62 meters). Finally, we will discuss some inherent uncertainties in the specification of the earthquake scenario, the limitations of the GeoClaw model, and the associated uncertainites in the results.

2 The L1 scenario - A "Worst Considered Case"

The updated local or near-field M9 earthquake on the CSZ used in this study is the L1 scenerio developed by Witter, et al. (2013) [20]; crustal deformation for the region of interest is shown in Figure 1. The L1 source is one of 15 seismic scenarios used in a hazard assessment study of Bandon, OR, based on an analysis of data spanning 10,000 years. This scenario has been adopted by Washington State as the "worst considered case" for many inundation modeling studies and subsequent evacuation map development; it is used because the standard engineering planning horizon is 2500 years and Witter, et al. (2013) [20] estimated that L1 has a mean recurrence period of approximately 3333 years, with the highest probability of occurrence of all events considered with magnitude greater than M9.

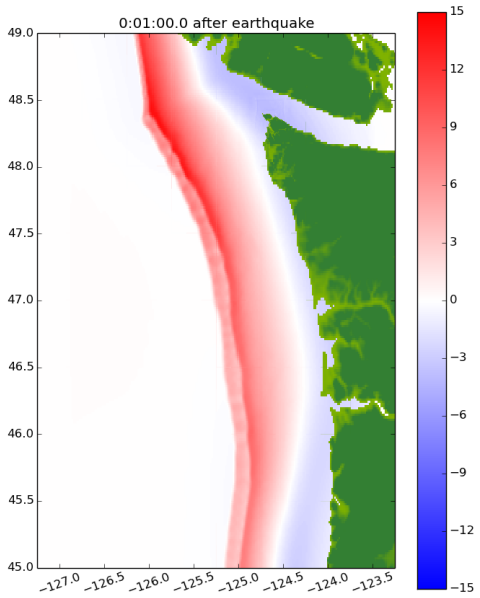

Figure 1: Crustal deformation of the L1 source, in meters

Typically, subduction zone earthquakes are characterized by offshore uplift that generates the crest of an initial tsunami wave, nearshore subsidence that generates an initial tsunami wave trough offshore, and coastal subsidence that increases the depth and inland extent of subsequent flooding on land. The initial wave splits in two; one wave propagates into the open ocean, the other propagates toward a coastal region that has usually subsided and is therefore more susceptible to flooding.

Salient features of the L1 scenario used in this study include a length of 1000 km, a width of approximately 85 km, and a crustal deformation pattern that features a zone of more than 12 m maximum uplift about 75 km offshore of the Washington Coast and coastal subsidence of 2-4 m in the area around Neah Bay (Figure 1). This L1 source causes subsidence of land locations indicated by the pink rectangle in Figure 2. For locations outside this rectangle, no subsidence or uplift occurs. Note that locations further up the Strait, such as Port Angeles and Port Townsend experience no uplift or subsidence. So based on our regional numbering scheme, only Strait-1 to Strait-11 experience subsidence. Port Angeles is in Strait-12 and Port Townsend is in Strait-18. For the Regions reported earlier along the Pacific coast and West of Strait-1, subsidence also occurs.

To judge the uncertainty in subsidence values, we note that uncertainties in the specification of L1 discussed in Section 4.1 result in errors that progagate into subsidence estimates. Although subsidence on

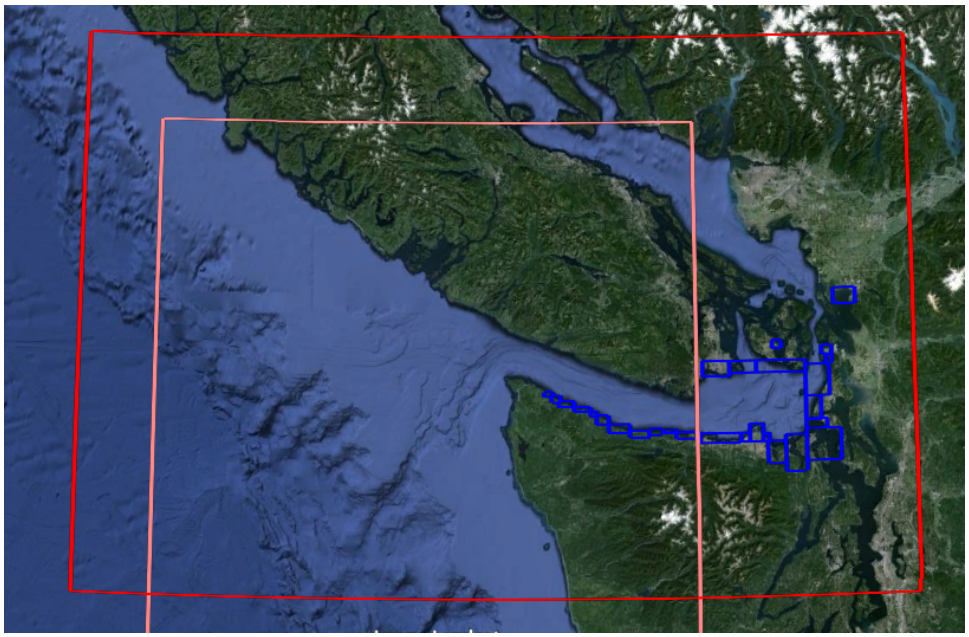

Figure 2: Red: Computational Domain; Blue: Regional Areas; Pink: extent of CSZ-L1

the Pacific Coast is consistent with estimates derived from field data analyzed by Leonard et al. (2004) [8] and Hawkes, et al. (2001) [7] for the 1700 CSZ earthquake, the errors in the field observation databases for these two studies were typically ± 0.5 to ± 0.8 m and ± 0.18 to ± 0.32 meters, respectively. Furthermore, a comparison of field data with a number of elastic location models similar to source L1 of this study was made by Leonard et al. (2004) [8] and the resulting error bars were also on the order of tens of centimeters. Estimates of coastal subsidence presented here must therefore be considered uncertain to at least the same order, i.e. tens of centimeters.

3 The GeoClaw tsunami model

The GeoClaw tsunami model is a branch of the Clawpack open source software package, and is available via the website www.clawpack.org/geoclaw. Clawpack (Conservation Laws Package) was first released by LeVeque in 1994 and the package has been extensively developed and improved over the years. Clawpack is a general package for solving linear and nonlinear hyperbolic systems of partial differential equations, including the important class of nonlinear conservation laws, whose solutions typically contain shock waves and other discontinuities. Robust shock capturing methods are used that are designed to handle strong shock waves. These methods are described in detail in [9].

GeoClaw was originally named TsunamiClaw and originated out of the PhD dissertation of David George [3], completed in 2006. The code has since been further developed for tsunami modeling, and has also been adapted to solve other geophysical flow problems using two-dimensional depth-averaged systems of equations. GeoClaw has undergone extensive verification and validation (LeVeque and George, 2007 [10]; LeVeque, et al., 2011 [11]), and has been accepted as a validated model by the U.S. National Tsunami Hazard Mitigation Program (NTHMP) after completing multiple benchmark tests as part of an NTHMP benchmarking workshop (NTHMP, 2012 [12]).

3.1 Shallow water equations

For tsunami modeling, GeoClaw solves the two-dimensional shallow water equations (also called the St. Venant equations). This system of equations is commonly used for modeling tsunami propagation and inundation, and is also the system of equations solved by other models such as MOST (Method of Splitting Tsunamis) [15].

The shallow water equations (SWE) are a nonlinear depth-averaged system of partial differential equations in which the fluid depth $h(x, y, t)$ and two horizontal depth-averaged velocities $u(x, y, t)$ and $v(x, y, t)$ are introduced. These equations are written in a form that corresponds to conservation of mass and momentum whenever the terms on the right hand side vanish:

$$\begin{aligned} h_t + (hu)_x + (hv)_y &= 0, \\ (hu)_t + \left(hu^2 + \frac{1}{2}gh^2\right)_x + (huv)_y &= -ghB_x - Dhu, \\ (hv)_t + (huv)_x + \left(hv^2 + \frac{1}{2}gh^2\right)_y &= -ghB_y - Dhv. \end{aligned} \tag{1}$$

Subscripts denote partial derivatives. The momentum source terms on the right hand side involve the varying bathymetry $B(x, y, t)$ and a frictional drag term, where $D(h, u, v)$ is a drag coefficient given by

$$D(h, u, v) = n^2 g h^{-4/3} \sqrt{u^2 + v^2}. \tag{2}$$

The parameter n is the *Manning coefficient* and depends on the roughness. For tsunami modeling a constant value of $n = 0.025$ (gravelly earth) is often used and we have adopted that value for much of this work, following standard practice.

Coriolis terms can also be added to the right hand side of equations (1), but these generally have been found to be negligible in tsunami modeling, and we do not include them in this study.

The initial condition is determined by the usual assumption that the sea surface elevation can be taken as a simple replication of the static ocean bottom vertical displacement due to the L1 seismic event discussed above and presented in Figure 1. This is justified on the grounds that the time scale of tsunami generation (minutes) is sufficiently small in comparison to tsunami periods (10s of minutes), so that the seismic event can be considered instantaneous (Hammack, 1972 [6]). All the simulations in our study set the sealevel to that of mean high water (MHW).

The output variables of the shallow water equations can be used to compute derived quantities of interest; current speed, $s = (u^2 + v^2)^{\frac{1}{2}}$; momentum, $hs = h(u^2 + v^2)^{\frac{1}{2}}$; and momentum flux, $hss = h(u^2 + v^2)$. For convenience, the quantity ζ (zeta) is defined in context as either onshore flood depth or the offshore wave amplitude (sometimes called the surface in our plots) referenced to mean high water (MHW).

3.2 Adaptive mesh refinement

The finite volume methods implemented in GeoClaw are based on dividing the computational domain into rectangular grid cells and storing cell averages of mass and momentum in each grid cell. These are updated each time step by a high-resolution Godunov type method [9] that is based on solving Riemann problems at the interfaces between neighboring grid cells and applying nonlinear limiters to avoid nonphysical oscillations. These methods are second order accurate in space and time wherever the solution is smooth, but robustly handle strong shock waves and other discontinuous solutions. This is important when the tsunami reaches shallow water and hydraulic jumps arise from wave breaking.

The methods have been extended to also deal robustly with inundation. Grid cells where the flow depth is zero represent dry land ($h = 0$). Cells can dynamically change between wet and dry each time step. The grid resolution for fine grid runs is taken to be sufficiently fine that the shoreline and edge of the inundated region can be well approximated by the edge of the wet region.

Block structured adaptive mesh refinement (AMR) is used to employ much finer grid resolution in regions of particular interest. Regions of refinement track the tsunami as it propagates across the ocean and then additional levels of refinement are added around the Washington coast and in each area of interest in the Strait of Juan de Fuca. For the fine grid runs around Port Angeles and Port Townsend, we used 5 levels of refinement, going from a coarse grid with 12 minute resolution (22.2 km) to the finest level of 2/3 arc second resolution (20.56 m at 48 degrees latitude) around the towns. Thus the maximum values of flood depth, current speed and other derived quantities were then avaible at this 20.56 meter resolution.

For the coarse regional simulations, we used 4 levels of refinement, again going from a 12 minute resolution to a 2 arc second resolution (61.67 m) around each Strait region of interest. Thus the maximum values of flood depth, current speed and other derived quantities were then avaible at this 61.67 meter resolution.

Time series of the solution parameters and derived quantities were also collected at various GeoClaw computational gauge locations, including ferry locations, light houses, harbors, and community centers.

3.3 Arrival Time Definition

It is important to define what is meant by the arrival time of the tsunami. This is harder than it sounds, and care must be taken in order to report the time the water inundates on land even when the land has subsided from its original topography.

At a location on land, it is desirable to say the tsunami has arrived when the depth of water, h, is larger than some small tolerance, say 1 centimeter. This requires accurate knowledge of the original bathymetry, $B0$, since an original land point can subside and become a water location. Since GeoClaw's bathymetry variable is B, the current bathymetry, not $B0$, this would be hard to implement in the current code.

For locations in the water before the earthquake, the surface $h + B$ is initialized to 0, where h is depth of water above the current bathymetry B and $B = -h$. Since B is measured relative to MHW, $h + B$ is the amount of water above MHW. In previous modeling with GeoClaw, the arrival time of the tsunami was defined to be the time when $h+B$ first rises above the same tolerance, say 1 centimeter. However, with either subsidence (B decreases) or the arrival of the first negative wave (h decreases), the quantity $h+B$ decreases and it could be many minutes later before $h+B$ exceeds the postive tolerance, even though much important fluid dynamics (significant speed and inundation h) due to the tsunami could have already occurred.

In this work a new criterion for flagging arrivals has been used that works in all cases — using the *speed* described above to monitor the arrival times. We will say the tsunami has arrived either on land or in the water (whether subsidence has occurred or not) if the speed of the water is above 1 cm/sec. We tested this choice against using h and $h + B$ as described above. The speed criteria gave the same arrival times for land points that had not subsided, and gave a earlier (and more correct) arrival time for those that had subsided. Likewise, the speed criteria gave earlier arrival times for water points by flagging the first movement of the water due to the tsunami, as would be of interest to mariners.

4 Uncertainties and limitations

Numerical models do not produce perfect simulations of any natural process. Here we discuss uncertainities and limitations most important to this specific study and, where possible, their probable influence on the model output.

4.1 Source specification

This is likely the largest source of uncertainty in the study. Variations in the value of certain earthquake parameters can produce large differences in the subsequent tsunami flooding.

4.2 Earthquake magnitude and recurrence interval

In considering worst considered scenario candidates, an important factor for consideration is that the greater the earthquake magnitude, the larger the initial wave amplitude. (An important exception to this general rule involves details of the slip distribution, discussed below.) But larger CSZ events would be associated with larger recurrence intervals than the estimated 3333 years and would be longer than the standard 2500 year planning horizon, and Witter, et al. (2011) [19] estimate that ...the L1 scenario captures 95 percent of the hazard and more severe events are very unlikely. The L1 scenario thus seems a reasonably conservative choice for a worst considered case on which to base a hazard assessment and related disaster planning and mitigation.

4.3 Earthquake slip distribution

The vertical displacement of the earth's crust presented in Figure 1 is the direct result of a Pacific oceanic tectonic plate slipping (or subducting) beneath the North American continental plate, deforming both plates in the process. But the amount of slip is not distributed evenly on the common contact surface between the two plates, known as the fault plane. There are patches on the fault plane, known as asperities, in which the two plates are more tightly locked by friction or protrusions of one plate into the other. But the relentless movement of the tectonic plates over decades and centuries continues to build up stress until the rock in the asperity region breaks and the plates suddenly slip past one another, initiating an earthquake.

Most earthquake energy is released by the slip in asperities, and the larger the slip, the greater the earthquake energy, and the larger the crustal deformation that moves the overlying water column, generating a tsunami. Details of the slip distribution can thus make a significant difference in the initial amplitude of a tsunami; for example, if the slip is distributed evenly over the entire fault plane, then the initial tsunami amplitude will be about half the amplitude of a tsunami generated by slip distributed evenly over half the fault plane. In particular, high slip values concentrated in an asperity region are associated with large values of vertical displacement of the ocean floor and a higher initial tsunami wave in the region.

As a consequence, the severity of flooding in a community can be highly dependent on the location of a coastal community relative to an asperity and the associated high initial tsunami wave region. When an earthquake is in the far-field, the earthquake resembles a point or line source and the details of the slip distribution are not important. However, details of the near-field slip distribution for the CSZ scenerio L1 can have a significant effect on coastal inundation patterns and the impact of the tsunami on individual communities. For example, about 75 km west of the Northwest WA coast, there is an offshore maxima of 10-12 m in crustal deformation and the initial tsunami waveform (Figure 1); if this maxima were located closer to or farther from the coast, the inundation would likely increase or decrease, respectively. Similarly, if the concentration of slip (and therefore earthquake energy) resulted in a larger or smaller maximum value, then a corresponding increase or descrease in flooding would be expected. In addition to their effect on initial tsunami waveform, these uncertainties in slip distribution result in uncertainties in the amount of coastal subsidence. However, it is not possible to make a reliable prediction of slip distribution at this level of detail, and conducting multiple numerical experiments to test how differing slip patterns affect the

sensitivity and/or the probability of site-specific flooding (e.g., González, et al., 2009 [4], González, et al., 2014 [5]) is beyond the scope of this study.

4.4 Landslide sources

This study did not include modeling of local landslides that are triggered by earthquake shaking. The impact of tsunamis generated by landslides is restricted to the local generation area, so that this is not an important process in the case of a far-field event, but offshore submarine landslides triggered by the near-field CSZ source used in this study could increase the severity of flooding.

4.5 Model physics

Certain values were assumed for important geophysical parameters, and some physical processes were not included in the simulations; their potential effect on the modeling results are discussed below.

4.5.1 Tide stage

The simulations were conducted with the background sea level set to MHW. Larger tide levels do occasionally occur, but the assumption of MHW is standard practice in studies of this type. This value is conservative, in the sense that less severe inundation generally occurs if sea level is set to a lower value.

4.5.2 Friction

The Mannings coefficient of friction was set to n = 0.025, a standard value used in tsunami modeling that corresponds to gravelly earth (V.T. Chow, 1959 [2]). This value of 0.025 is conservative in the sense that the presence of trees and vegetation along the coast might justify the use of a larger value, which would generally reduce flooding. Large spatial variations occur in ground cover (e.g., pavement, gravel, brush, trees, etc.), but the GeoClaw model computations are conducted with a spatially constant value of Manning's coefficient of friction. A more realistic computation would use a spatially variable coefficient of friction, but the development of a grid representing spatially varying values of n is beyond the scope of this study.

4.5.3 Structures

Buildings were not included in the simulations. Local increases in flooding depth and current speed can occur when a tsunami wave encounters a structure, but inland flow is generally impeded and inland penetration of the tsunami is thereby reduced. In general, structures can significantly alter patterns of tsunami flow and flood depth, so that care must be taken in the interpretation of the results.

4.5.4 Debris

Large tsunamis inevitably create fields of debris that act as battering rams, multiplying the destructive impact. This process requires the expenditure of tsunami energy, which would tend to reduce the inland extent of the inundation.

4.5.5 Tsunami modification of bathymetry and topography

Severe scouring and deposition are known to occur during a tsunami, undermining structures and altering the flow and wave height pattern of the tsunami itself. This movement of material requires an expenditure of tsunami energy that tends to reduce the inland extent of inundation.

5 Model results

Detailed results of this study can be found at

http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/index.html

including a movie at 1 minute time frames based on a coarse 10 arc sec simulation of the entire region.

In addition to the simulation movies and time frames, the site above presents maps of maximum values and plots of the time series at the computational gauges that were created from the model output variables and derived quantities. In these maps and plots, time t is referenced to the earthquake main shock at time $t = 0$; the variable B is the current topography, positive for land elevation, negative for water depth; black and gray contours represent the pre-earthquake coastline and the pre-earthquake 20 meter topographic elevation. The parameter ζ (zeta) refers either to offshore wave amplitude that is above MHW or the onshore flooding depth h.

Section 5.1 and Section 5.2 give the fine resolution results (2/3 arc second) for Port Angeles and Port Townsend, respectively. Sections 5.3 to 5.30 give coarse resolution results for the 28 areas along the Strait of Juan de Fuca depicted in the blue boxes of Figure 3.

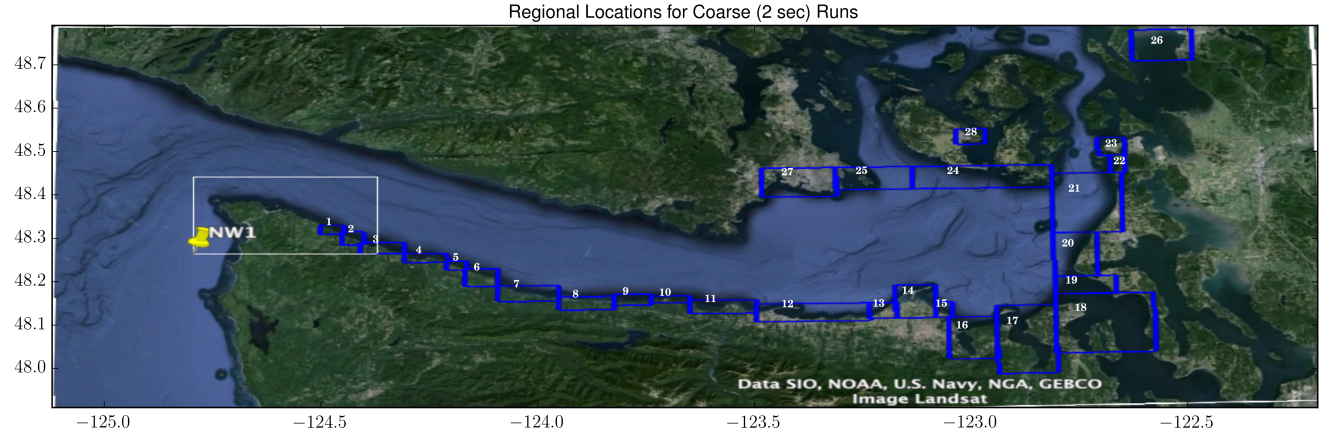

Figure 3: The 28 Regional Areas for the Coarse Study

The results for the area labelled NW 1 in Figure 3 will be discussed separately in another report. The finest resolution for the blue boxed areas was 2 arc second which corresponds to approximately 62 meters. It is our hope that areas flagged in the remainder of this report of special concern be considered by the State for future 2/3 arc second runs to provide more accurate inundation. These coarse results, however, should provide preliminary guidance to the State for which areas do warrant further study.

5.1 Port Angeles - fine resolution results

Figure 4: Port Angeles map with computational gauges

View the results plus a movie of Port Angeles (fine) at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/PortAngeles_fine_5hr/index.html

Interesting Findings:

- Gauge 121, a water location near Ediz Hook at -1.70 meters, had no subsidence or uplift. The largest wave at 75.82 minutes after the earthquake was 5.23 meters above MHW, the initial water surface. The William R. Fairfield International airstrip on the Ediz Hook is inundated with at least 3 meters of water. The tip of the Hook, near the the military installation, receives high speeds, momentum, and momentum flux, which might be important for naval vessels.

- Gauge 122, a water location near the ferry terminal at -10.76 meters, had no subsidence or uplift. The largest wave at 79.62 minutes after the earthquake was 6.31 meters above MHW, the initial water surface.

- Gauge 125, a water location at -11.76 meters, had no subsidence or uplift. The largest wave at 80.41 minutes after the earthquake was 6.17 meters above MHW, the initial water surface.

- Gauge 126, a water location at -13.69 meters, had no subsidence or uplift. The largest wave at 75.09 minutes after the earthquake was 6.21 meters above MHW, the initial water surface. On shore from Gauge 126, the Nippon paper plant near the entrance to Ediz Hook is in the inundation zone, as seen on the Zeta maximum plot.

- Gauge 127, a water location at -25.56 meters, had no subsidence or uplift. The largest wave at 79.74 minutes after the earthquake was 6.00 meters above MHW, the initial water surface.

- Gauge 128, a land point at 70.21 meters, had no subsidence or uplift and remained dry the duration of the tsunami.

- Neither the hospital nor the airport is in the inundation zone. In fact, much of the city is on high ground, but the businesses and houses along W. Front and W. 1st Streets near the water are in the inundation zone. These include Port Angeles Family Medicine and the Port of Angeles Chamber of Commerce. The maximum Zeta plot also shows that Route 117 and South Valley St. inland from the beach receive flooding.
- Gauges 121, 122, 125 were also represented in the Strait 12 coarse grid run around the Port Angeles area. They were not located exactly the same in both the coarse and fine runs as gauges were placed at the center of computational cells. Nevertheless, there is excellent agreement between the coarse and fine results at these gauges.
- A summary for this region is on the next page.

PORT ANGELES, (2/3 arc sec)

Location Box: x1,x2,y1,y2 = (-123.50009259, -123.39990741, 48.11490741, 48.14509259)

Gauges	Longitude	Latitude
121	-1.2340083333e+02	4.8139722222e+01
122	-1.2342972222e+02	4.8122685185e+01
125	-1.2340731482e+02	4.8121018519e+01
126	-1.2348990741e+02	4.8139907407e+01
127	-1.2340990741e+02	4.8129907407e+01
128	-1.2346287037e+02	4.8123055556e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  80.9625083333
minimum of the arrival_time was:  1.6779735
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  81.4079916667
min of tzeta was:  74.3728333333
```

Maximum Zeta Values:

```
max of zeta:  6.58757526
min of zeta:  0.0043004182
```

Maximum Speed Values:

```
max speed = 15.729132
min speed = 0.12698097
```

Maximum Momentum Values:

```
max hs = 480.74252
min hs = 0.00055866703
```

Maximum Momentum Flux Values:

```
max hss = 4264.5427
min hss = 6.876991e-05
```

Minimum Depth Values:

```
max min_depth = 80.92631
min min_depth = -0.0
```

5.2 Port Townsend - fine resolution results

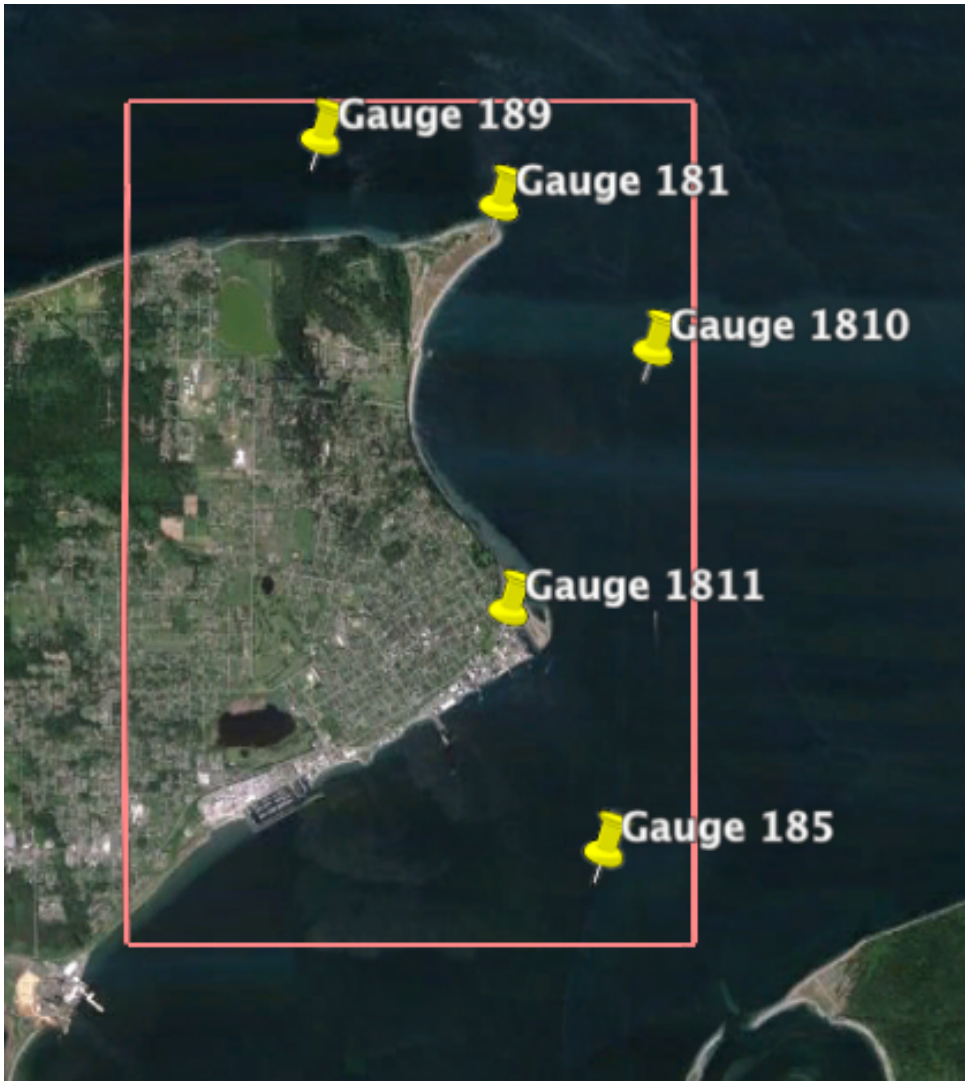

Figure 5: Port Townsend map with computational gauges

View the results plus a movie of Port Townsend (fine) at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/PortTownsend_fine_5hr/index.html

Interesting Findings:

- Gauge 181, a land point near the Point Wilson Lighthouse at 1.15 meters, had no subsidence or uplift. The maximum flow depth arrived at 108.11 minutes after the earthquake and gave 2.03 meters of water above the bathymetry there. This is an active lighthouse as the main shipping route to Seattle must make a right turn around the far side of Maristone Point from this lighthouse on the way to the Port of Seattle. Presently, only a rock barrier separates the lighthouse from the coast.
- Gauge 185, a water location at -21.74 meters offshore from the ferry , had no subsidence or uplift. The

largest wave at 121.70 minutes after the earthquake was 5.53 meters above MHW, the initial water surface.

- Gauge 189, a water location at -11.11 meters , had no subsidence or uplift. The largest wave at 104.96 minutes after the earthquake was 3.82 meters above MHW, the initial water surface. The Port Townsend Wastewater Treatment plant is inland from this gauge and receives around 2 meters of flooding.
- Gauge 1810, a water location at -36.57 meters , had no subsidence or uplift. The largest wave at 111.43 minutes after the earthquake was 3.40 meters above MHW, the initial water surface.
- Gauge 1811, a land point at 1.59 meters in Memorial Athletic field, had no subsidence or uplift. The maximum flow depth arrived at 122.86 minutes after the earthquake and gave 3.49 meters of water above the bathymetry there. This gauge is also close to the Marina and RV Park for which the maximum Zeta map shows heavy flooding.
- The hardest hit area of Port Townsend was the Port on Sims Way. The maximum Zeta plot shows as much as 7 meters of water makes its way inland behind the Port toward 19th Street.
- The hospital is West of the inundation zone on higher ground.
- The speed, momentum, and momentum flux maximum maps show the areas around Point Wilson and the ferry lanes may be of concern.
- Gauges 181 and 185 were also represented in the Strait 18 coarse grid run around the Port Townsend area. They were not located exactly the same in both the coarse and fine runs as gauges were placed at the center of computational cells. Nevertheless, there is excellent agreement between the coarse and fine results at these gauges.
- A summary for this region is on the next page.

PORT TOWNSEND, (2/3 arc sec)

Location Box: x1,x2,y1,y2 = (-122.79009259, -122.73490741, 48.09731481, 48.15212963)

Gauges	Longitude	Latitude
181	-1.2275490741e+02	4.8143240741e+01
185	-1.2274472222e+02	4.8101237040e+01
189	-1.2277231482e+02	4.8147500000e+01
1810	-1.2273990741e+02	4.8133796296e+01
1811	-1.2275398148e+02	4.8116944444e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
The maximum arrival time was:  123.304543333
The minimum arrival time was:  28.3670516667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  238.8112
min of tzeta was:  103.331078333
```

Maximum Zeta Values:

```
max of zeta:  6.80330817
min of zeta:  0.0010218102
```

Maximum Speed Values:

```
max speed = 9.1794621
min speed = 0.023345628
```

Maximum Momentum Values:

```
max hs = 467.0074
min hs = 2.3854801e-05
```

Maximum Momentum Flux Values:

```
max hss = 3667.4444
min hss = 5.569053e-07
```

Minimum Depth Values:

```
max min_depth = 74.521066
min min_depth = -0.0
```

5.3 Strait 1

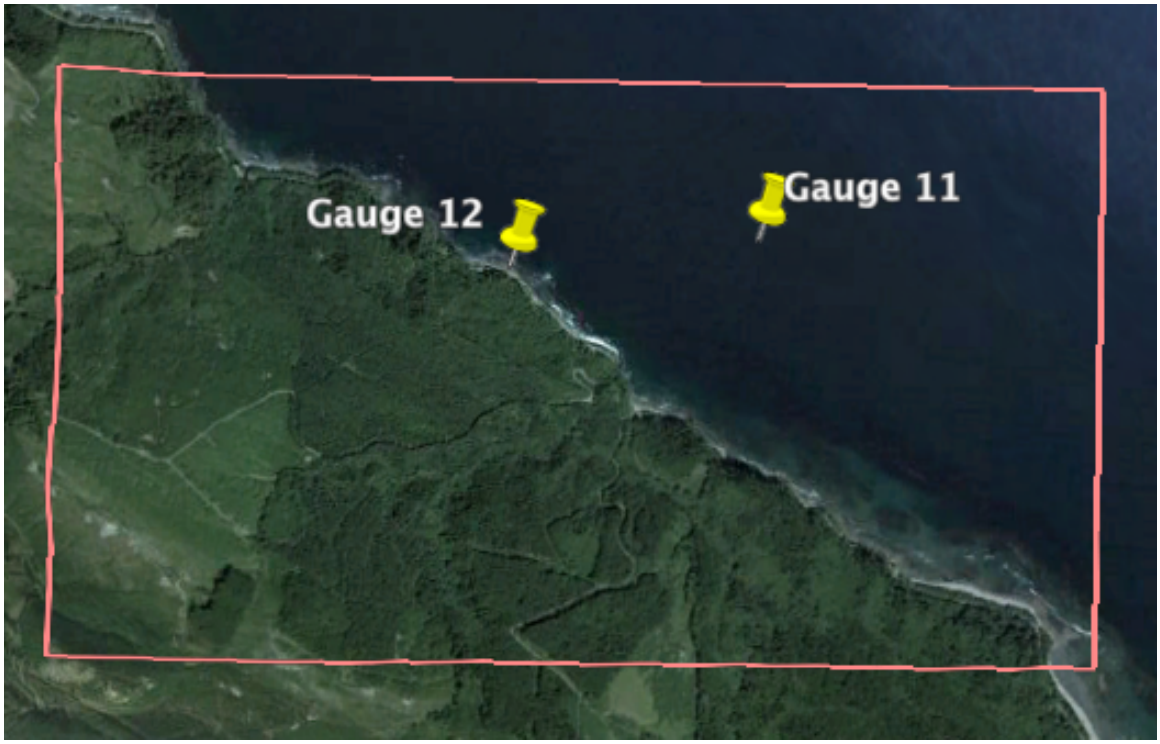

Figure 6: Strait 1 map with computational gauges

View the results plus a movie of Strait 1 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_1/index.html

Interesting Findings:

- Gauge 11, a water location at -21.83 meters, subsided by 3.87 meters. The largest wave at 42.5 minutes after the earthquake was 6.03 meters above MHW which gave 9.90 meters of water above the subsided water surface there.
- Gauge 12, a land point at .27 meters on the beach, also subsided by 3.87 meters. The maximum flow depth arrived at 42.3 minutes after the earthquake and gave 9.6 meters of water above the subsided bathymetry there.
- No houses were observed in the inundation area, but this should be double-checked in case Google Earth is out of date. Route 112 near Gauge 12 appears to be in the inundation zone.
- A summary for this region is on the next page.

STRAIT 1

Location Box: x1,x2,y1,y2 = (-124.500278, -124.444722, 48.314722, 48.335278)

Gauges	Longitude	Latitude
11	-1.2446305560e+02	4.8329722200e+01
12	-1.2447638890e+02	4.8328611100e+01

Average Subsidence or Uplift:

```
Average subsidence/uplift:  -3.85400214479 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  42.056255
minimum of the arrival_time was:  0.0867733433333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  42.8494383333
min of tzeta was:  41.2630833333
```

Maximum Zeta Values:

```
max of zeta:  10.10657
min of zeta:  0.051482243
```

Maximum Speed Values:

```
max speed = 4.8686675
min speed = 0.4680264
```

Maximum Momentum Values:

```
max hs = 127.46053
min hs = 0.023814579
```

Maximum Momentum Flux Values:

```
max hss = 197.25746
min hss = 0.017739367
```

Minimum Depth Values:

```
max min_depth = 73.108436
min min_depth = 0.0008759875
```

5.4 Strait 2

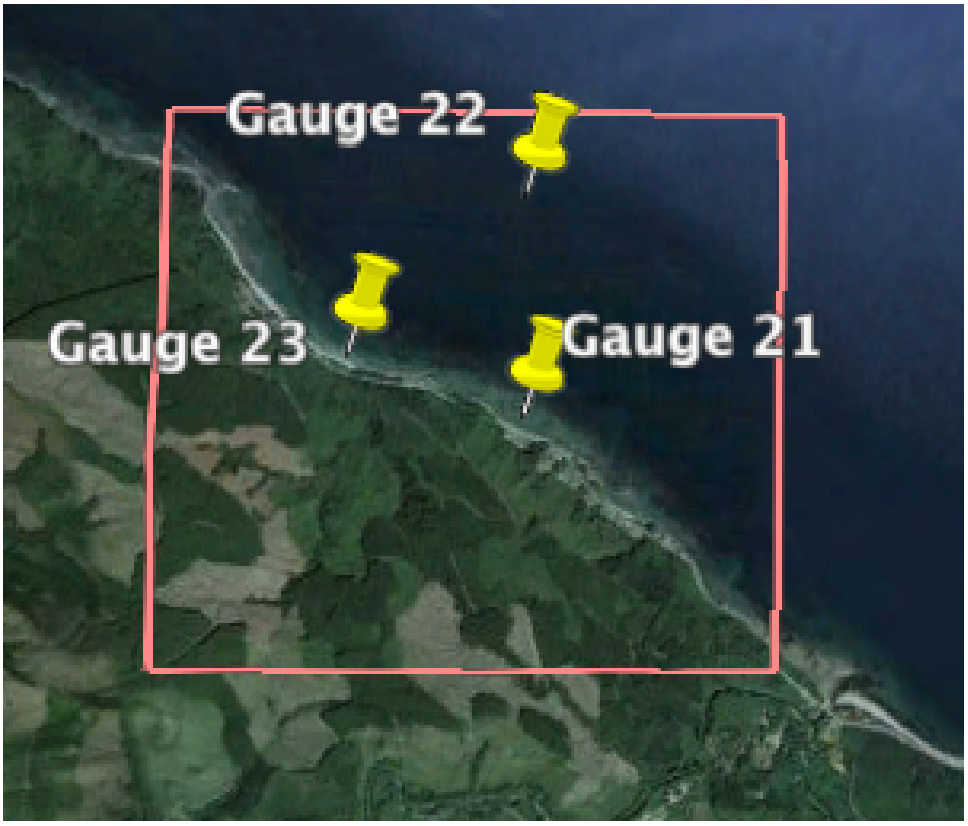

Figure 7: Strait 2 map with computational gauges

View the results plus a movie of Strait 2 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_2/index.html

Interesting Findings:

- Gauge 21, a water location at -2.24 near the beach, subsided by 3.73 meters. The largest wave at 43.54 minutes after the earthquake was 6.43 meters above MHW and gave 10.16 meters of water above the subsided water surface there.
- Gauge 22, a water location at -46.44 meters, subsided by 3.64 meters. The largest wave at 43.29 minutes after the earthquake was 6.22 meters above MHW and gave 9.86 meters of water above the subsided water surface there.
- Gauge 23, a water point at -1.91 meters near the beach, subsided by 3.82 meters. The largest wave at 43.42 minutes after the earthquake was 6.63 meters above MHW and gave 10.44 meters of water above the subsided water surface there.
- The Chito Beach Resort is located between Gauges 21 and 23 and appears in or close to the inundation zone. Other houses are near the inundation zone, as is Hwy 112.
- A summary for this region is on the next page.

STRAIT 2

Location Box: x1,x2,y1,y2 = (-124.450278, -124.399722, 48.289722, 48.320278)

Gauges	Longitude	Latitude
21	-1.2442083330e+02	4.8303611100e+01
22	-1.2442083330e+02	4.8315833300e+01
23	-1.2443527780e+02	4.8306944400e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -3.74722492355 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  44.230185
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  44.40645
min of tzeta was:  41.3512116667
```

Maximum Zeta Values:

```
max of zeta:  10.606882
min of zeta:  0.0068767706
```

Maximum Speed Values:

```
max speed = 5.8681632
min speed = 0.24014301
```

Maximum Momentum Values:

```
max hs = 113.67422
min hs = 0.0016514084
```

Maximum Momentum Flux Values:

```
max hss = 187.03873
min hss = 0.00039657418
```

Minimum Depth Values:

```
max min_depth = 61.96124
min min_depth = 0.00084638744
```

5.5 Strait 3

Figure 8: Strait 3 map with computational gauges

View the results plus a movie of Strait 3 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_3/index.html

Interesting Findings:

- Gauge 31, a land point at 0.71 meters on the beach in front of houses on Vista Drive, subsided by 3.62 meters. The maximum flow depth arrived at 45.35 minutes after the earthquake and gave 9.99 meters of water above the subsided bathymery there.
- Gauge 32, a water location at -12.48 meters, subsided by 3.62 meters. The largest wave at 45.11 minutes after the earthquake was 7.06 meters above MHW and gave 10.68 meters of water above the subsided water surface there.
- Sekiu River Road at Hwy 112 and houses along Sekiu River Road see heavy flooding. Also houses along Cowan Rd E and the beach are in or very close to the inundation zone. A finer grid run would be warranted.
- The zeta maximum plot shows heavy flooding in the river valley from the beach to the South boundary of this region (lat. 48.270). The gray line is the 20 meter bathymetry contour (pre-earthquake).
- A summary for this region is on the next page.

STRAIT 3

Location Box: x1,x2,y1,y2 = (-124.405278, -124.304722, 48.269722, 48.295278)

Gauges	Longitude	Latitude
31	-1.2437305560e+02	4.8284722200e+01
32	-1.2437305560e+02	4.8288055600e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -3.57467139982 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  49.1517616667
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  51.03174
min of tzeta was:  44.4309316667
```

Maximum Zeta Values:

```
max of zeta:  10.951403
min of zeta:  0.016072885
```

Maximum Speed Values:

```
max speed = 7.3212056
min speed = 0.46259458
```

Maximum Momentum Values:

```
max hs = 153.3572
min hs = 0.013882105
```

Maximum Momentum Flux Values:

```
max hss = 231.10898
min hss = 0.010409404
```

Minimum Depth Values:

```
max min_depth = 109.14234
min min_depth = 0.00089644808
```

5.6 Strait 4

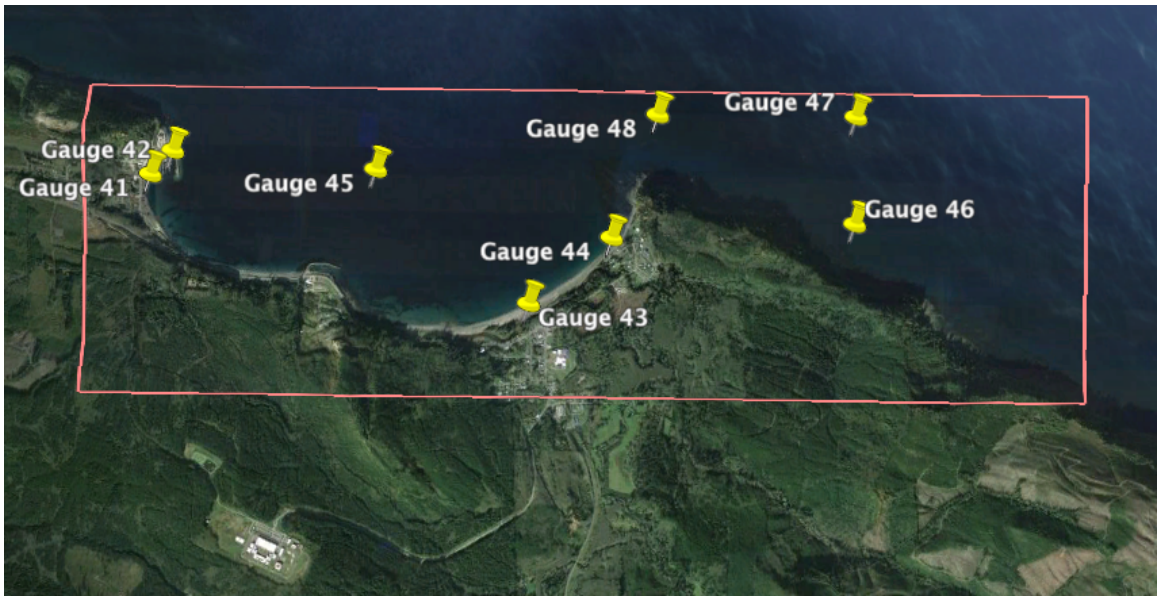

Figure 9: Strait 4 map with computational gauges

View the results plus a movie of Strait 4 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_4/index.html

Interesting Findings:

- Gauge 41, a land point at 0.39 meters near the beach between Rice and Division Streets, subsided by 3.42 meters. The maximum flow depth arrived at 47.89 minutes after the earthquake and gave 9.45 meters of water above the subsided bathymetry there. This gauge is close to beach houses and Van Riper's Resort.
- Gauge 42, a water location at -3.70 meters at the marina in front of Olson's Resort, subsided by 3.36 meters. The largest wave at 47.79 minutes after the earthquake was 6.32 meters above MHW and gave 9.68 meters of water above the subsided water surface there.
- Gauge 43, a water location at -0.58 meters, subsided by 3.23 meters. The largest wave at 49.12 minutes after the earthquake was 6.17 meters above MHW and gave 9.40 meters of water above the subsided water surface there. Gauge 43 is on the beach near Hwy 112 and Bogachiel Streets. The max Zeta map shows flooding in this part of town toward the Callam Bay Medical Center. A finer resolution run may be warranted.
- Gauge 44, a land point at 3.18 meters, subsided by 3.23 meters. The maximum flow depth arrived at 50.08 minutes after the earthquake and gave 6.07 meters of water above the subsided bathymetry there. This gauge is close to Salt Air Street and Fisherman Street in Callam Bay. Nearby residences receive heavy flooding.
- Speeds between 6 and 7 meters/sec are seen at Gauge 44.
- Gauge 45, a water location at -20.68 meters, subsided by 3.23 meters. The largest wave at 47.90 minutes after the earthquake was 6.13 meters above MHW and gave 9.36 meters of water above the subsided water surface there.

- Gauge 46, a water location at -17.38 meters, subsided by 3.01 meters. The largest wave at 48.95 minutes after the earthquake was 5.58 meters above MHW and gave 8.58 meters of water above the subsided water surface there.
- Gauge 47, a water location at -93.15 meters, subsided by 2.82 meters. The largest wave at 48.72 minutes after the earthquake was 5.55 meters above MHW and gave 8.37 meters of water above the subsided water surface there.
- Gauge 48, a water location at -42.56 meters, subsided by 3.23 meters. The largest wave at 48.47 minutes after the earthquake was 5.70 meters above MHW and gave 8.93 meters of water above the subsided water surface there.
- A summary for this region is on the next page.

STRAIT 4

Location Box: x1,x2,y1,y2 = (-124.306389, -124.205833, 48.249722, 48.270278)

Gauges	Longitude	Latitude
41	-1.2430083330e+02	4.8263055600e+01
42	-1.2429861110e+02	4.8264722200e+01
43	-1.2426250000e+02	4.8254722200e+01
44	-1.2425416670e+02	4.8259166700e+01
45	-1.2427805560e+02	4.8263611100e+01
46	-1.2422972220e+02	4.8260277800e+01
47	-1.2422972220e+02	4.8267500000e+01
48	-1.2424972220e+02	4.8267500000e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -3.19709090573 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  50.933825
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  52.911705
min of tzeta was:  46.9975716667
```

Maximum Zeta Values:

```
max of zeta:  9.6750309
min of zeta:  0.023614056
```

Maximum Speed Values:

```
max speed = 7.8528483
min speed = 0.25953007
```

Maximum Momentum Values:

```
max hs = 238.87232
min hs = 0.011868714
```

Maximum Momentum Flux Values:

```
max hss = 339.98281
min hss = 0.006035846
```

Minimum Depth Values:

```
max min_depth = 160.76666
min min_depth = 0.00092420522
```

5.7 Strait 5

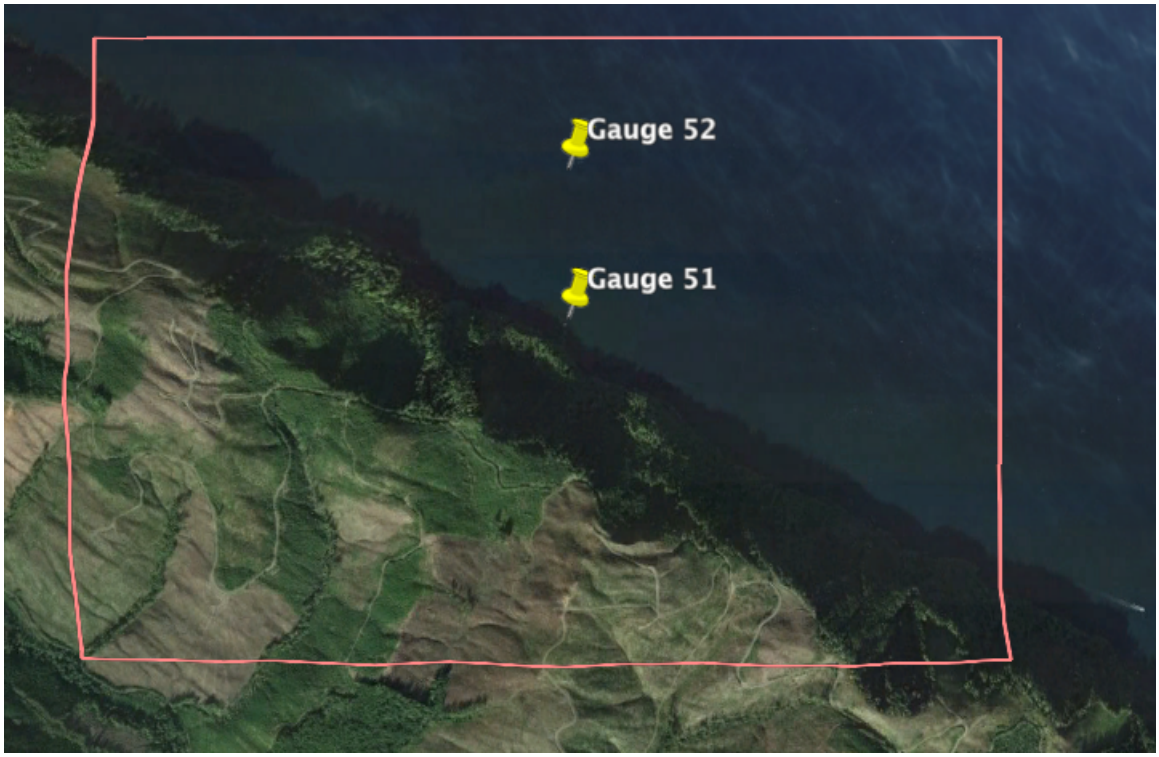

Figure 10: Strait 5 map with computational gauges

View the results plus a movie of Strait 5 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_5/index.html

Interesting Findings:

- Gauge 51, a water location at -11.95 meters, subsided by 2.79 meters. The largest wave at 50.58 minutes after the earthquake was 5.21 meters above MHW and gave 8.00 meters of water above the subsided water surface there.
- Gauge 52, a water location at -85.05 meters, subsided by 2.79 meters. The largest wave at 50.23 minutes after the earthquake was 5.24 meters above MHW and gave 8.03 meters of water above the subsided water surface there.
- There does not appear to be any houses in Strait 5, but that should be checked in case Google Earth is out of date. The Physt River Road also is not along the beach and is out of the inundation area.
- A summary for this region is on the next page.

STRAIT 5

Location Box: x1,x2,y1,y2 = (-124.206389, -124.160833, 48.231944, 48.2525)

Gauges	Longitude	Latitude
51	-1.2418250000e+02	4.8243055600e+01
52	-1.2418250000e+02	4.8248055600e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -2.82081814445 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  49.5825933333
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  51.1884033333
min of tzeta was:  49.592385
```

Maximum Zeta Values:

```
max of zeta:  7.9081617
min of zeta:  0.019155559
```

Maximum Speed Values:

```
max speed = 2.1092264
min speed = 0.11283995
```

Maximum Momentum Values:

```
max hs = 201.91496
min hs = 0.012476439
```

Maximum Momentum Flux Values:

```
max hss = 257.70302
min hss = 0.0098154797
```

Minimum Depth Values:

```
max min_depth = 149.92906
min min_depth = 0.00088244923
```

5.8 Strait 6

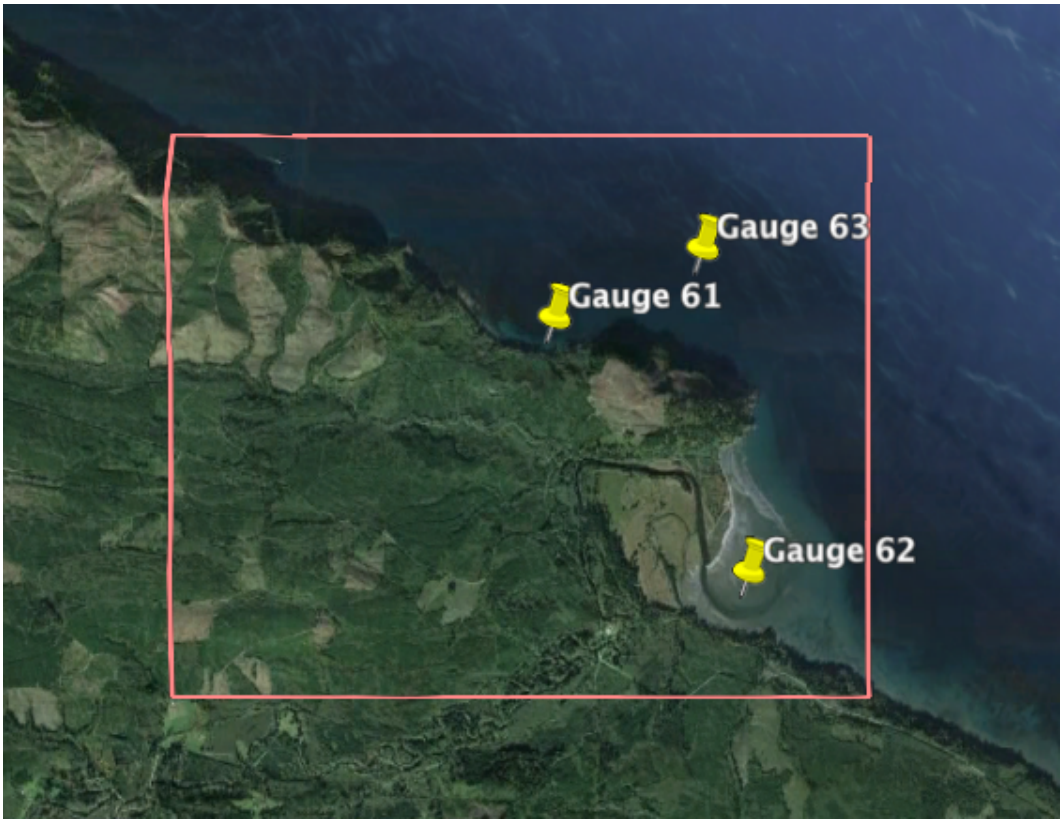

Figure 11: Strait 6 map with computational gauges

View the results plus a movie of Strait 6 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_6/index.html

Interesting Findings:

- Gauge 61, a water location at -3.53 meters, subsided by 2.64 meters. The largest wave at 50.77 minutes after the earthquake was 5.18 meters above MHW and gave 7.82 meters of water above the subsided water surface there.
- Gauge 62, a water location at -2.18 meters, subsided by 2.78 meters. The largest wave at 55.37 minutes after the earthquake was 6.09 meters above MHW and gave 8.87 meters of water above the subsided water surface there. This gauge is close to the Pillar Point Recreation Area, which is accessed by the Pillar Point Road off of Hwy 112. There is a low area inland from Gauge 62 that receives heavy flooding. In particular, at the intersection of the MR Tree Farm Road and the Pysht River Road, residences are heavily flooded. Hwy 112 also crosses this flooded area.
- Gauge 63, a water location at -90.13 meters, subsided by 2.35 meters. The largest wave at 52.14 minutes after the earthquake was 4.97 meters above MHW and gave 7.32 meters of water above the subsided water surface there.
- A summary for this region is on the next page.

STRAIT 6

Location Box: x1,x2,y1,y2 = (-124.165278, -124.089722, 48.194722, 48.235278)

Gauges	Longitude	Latitude
61	-1.2412472220e+02	4.8220277800e+01
62	-1.2410361110e+02	4.8201944400e+01
63	-1.2410861110e+02	4.8225277800e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -2.66963995944 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  60.088115
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  61.3902633333
min of tzeta was:  50.7575783333
```

Maximum Zeta Values:

```
max of zeta:  9.2642093
min of zeta:  0.01346958
```

Maximum Speed Values:

```
max speed = 7.2118177
min speed = 0.15815854
```

Maximum Momentum Values:

```
max hs = 210.2341
min hs = 0.008973516
```

Maximum Momentum Flux Values:

```
max hss = 279.18336
min hss = 0.0059782109
```

Minimum Depth Values:

```
max min_depth = 154.64695
min min_depth = 0.00070607305
```

5.9 Strait 7

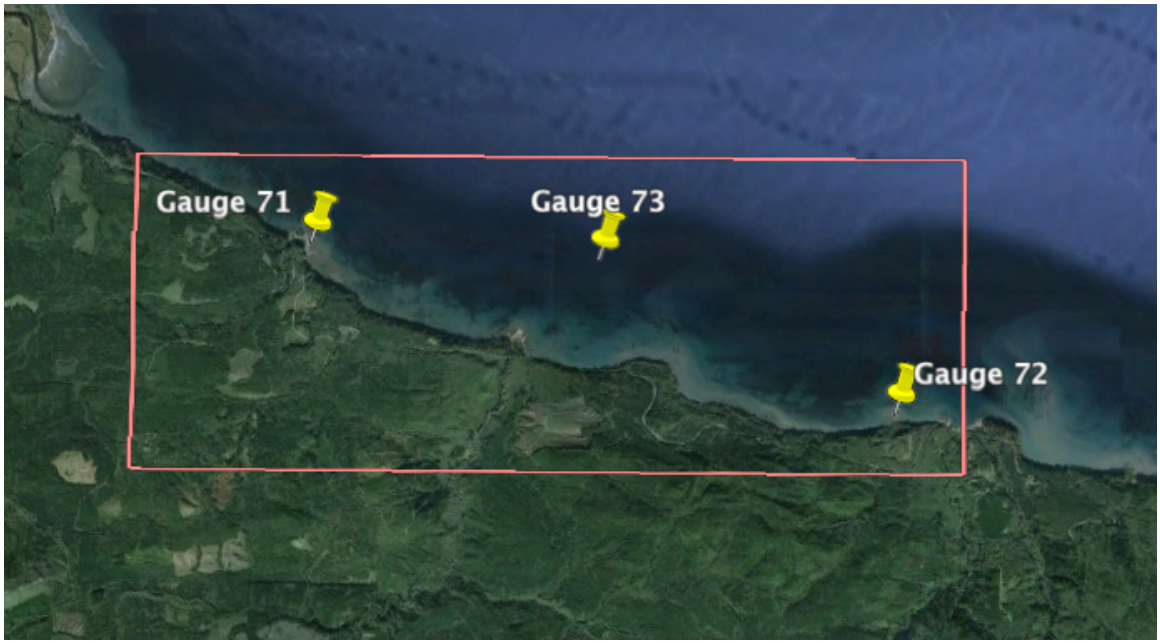

Figure 12: Strait 7 map with computational gauges

View the results plus a movie of Strait 7 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_7/index.html

Interesting Findings:

- Gauge 71, a water location at -0.99 meters, subsided by 2.35 meters. The largest wave at 54.90 minutes after the earthquake was 5.97 meters above MHW and gave 8.32 meters of water above the subsided water surface there. This gauge is located at a recreation area on the beach, and is accessed by the Mr. Jim road from Hwy 112. This area receives heavy flooding.
- Gauge 72, a water location at -1.06 meters, subsided by 1.94 meters. The largest wave at 57.95 minutes after the earthquake was 6.16 meters above MHW and gave 8.10 meters of water above the subsided water surface there. This gauge is near a pier where flooding occurs in a nearby area, possibly crossing Hwy 112.
- Gauge 73, a water location at -15.59 meters, subsided by 2.29 meters. The largest wave at 56.30 minutes after the earthquake was 5.58 meters above MHW and gave 7.87 meters of water above the subsided water surface there.
- A summary for this region is on the next page.

STRAIT 7

Location Box: x1,x2,y1,y2 = (-124.090278, -123.949722, 48.159722, 48.195278)

Gauges	Longitude	Latitude
71	-1.2406083330e+02	4.8185277800e+01
72	-1.2396138890e+02	4.8166388900e+01
73	-1.2401194440e+02	4.8183611100e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -2.21594349802 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  59.5255716667
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  61.0280116667
min of tzeta was:  52.740355
```

Maximum Zeta Values:

```
max of zeta:  8.5867281
min of zeta:  0.065603943
```

Maximum Speed Values:

```
max speed = 4.5700673
min speed = 0.48940976
```

Maximum Momentum Values:

```
max hs = 80.006882
min hs = 0.035492368
```

Maximum Momentum Flux Values:

```
max hss = 100.21714
min hss = 0.023309638
```

Minimum Depth Values:

```
max min_depth = 59.056505
min min_depth = 0.0008163693
```

5.10 Strait 8

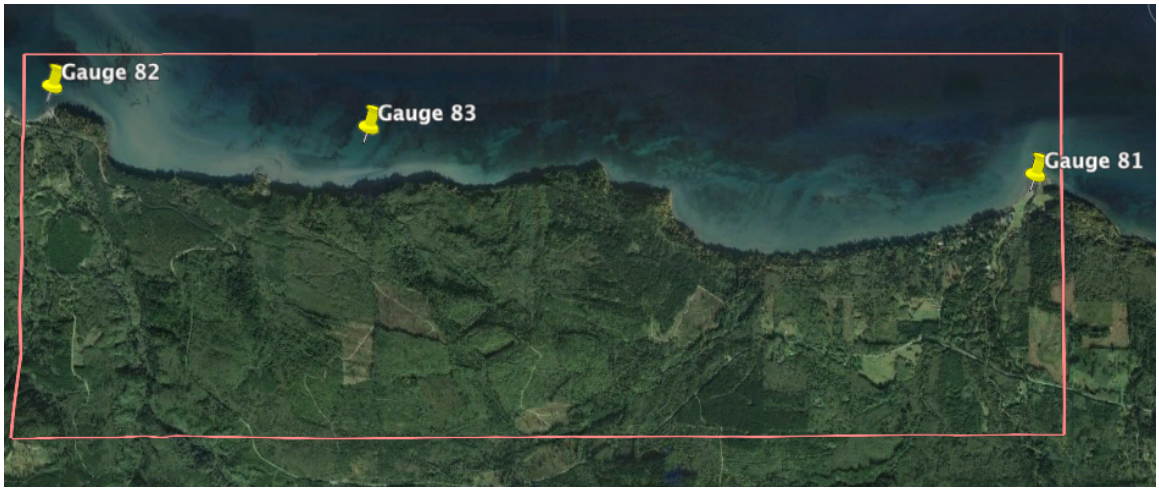

Figure 13: Strait 8 map with computational gauges

View the results plus a movie of Strait 8 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_8/index.html

Interesting Findings:

- Gauge 81, a water location at -0.65 meters, subsided by 1.31 meters. The largest wave at 64.79 minutes after the earthquake was 6.70 meters above MHW and gave 8.00 meters of water above the subsided water surface there. This gauge is at the end of a low valley at the end of W. Lyre River Road. The max Zeta map shows flooding in this valley and some houses are in the inundation zone.
- Gauge 82, a water location at -2.77 meters, subsided by 1.95 meters. The largest wave at 58.09 minutes after the earthquake was 6.05 meters above MHW and gave 8.00 meters of water above the subsided water surface there.
- Gauge 83, a water location at -4.40 meters, subsided by 1.60 meters. The largest wave at 60.46 minutes after the earthquake was 6.36 meters above MHW and gave 7.96 meters of water above the subsided water surface there.
- A summary for this region is on the next page.

STRAIT 8

Location Box: x1,x2,y1,y2 = (-123.950278, -123.824722, 48.139722, 48.170278)

Gauges	Longitude	Latitude
81	-1.2382861110e+02	4.8159166700e+01
82	-1.2394750000e+02	4.8166388900e+01
83	-1.2390916670e+02	4.8163055600e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -1.60901949044 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  66.2561616667
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  270.293766667
min of tzeta was:  57.6898016667
```

Maximum Zeta Values:

```
max of zeta:  8.1650132
min of zeta:  0.0030739333
```

Maximum Speed Values:

```
max speed = 4.6080088
min speed = 0.082034706
```

Maximum Momentum Values:

```
max hs = 35.127899
min hs = 0.00025216921
```

Maximum Momentum Flux Values:

```
max hss = 76.675071
min hss = 2.0686627e-05
```

Minimum Depth Values:

```
max min_depth = 14.575174
min min_depth = 0.0008146945
```

5.11 Strait 9

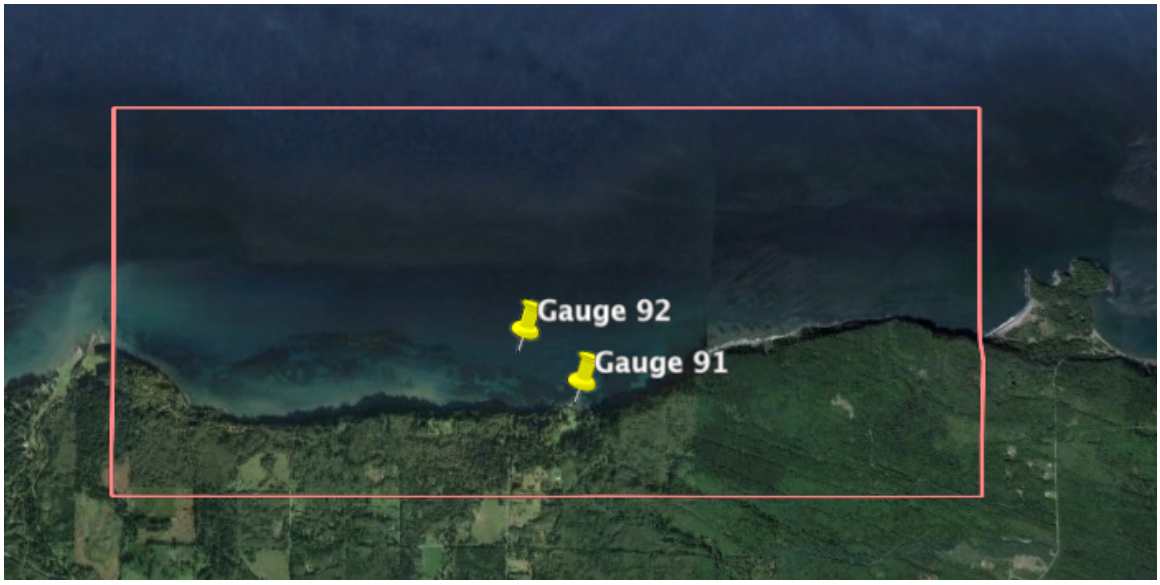

Figure 14: Strait 9 map with computational gauges

View the results plus a movie of Strait 9 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_9/index.html

Interesting Findings:

- Gauge 91, a water location at -1.56 meters, subsided by 1.07 meters. The largest wave at 67.08 minutes after the earthquake was 6.95 meters above MHW and gave 8.02 meters of water above the subsided water surface there. Whiskey Creek Beach is nearby. The recreational area near the beach is in the inundation zone.
- Gauge 92, a water location at -10.38 meters, subsided by 1.12 meters. The largest wave at 66.81 minutes after the earthquake was 6.87 meters above MHW and gave 7.99 meters of water above the subsided water surface there.
- A summary for this region is on the next page.

STRAIT 9

Location Box: x1,x2,y1,y2 = (-123.825278, -123.739722, 48.149722, 48.175278)//

Gauges	Longitude	Latitude
91	-1.2377972220e+02	4.8155833300e+01
92	-1.2378527780e+02	4.8159166700e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -1.16604831739 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  66.637995
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  68.4737583333
min of tzeta was:  62.7462566667
```

Maximum Zeta Values:

```
max of zeta:  8.2380567
min of zeta:  0.035238683
```

Maximum Speed Values:

```
max speed = 3.7478056
min speed = 0.13591103
```

Maximum Momentum Values:

```
max hs = 90.432264
min hs = 0.019533584
```

Maximum Momentum Flux Values:

```
max hss = 119.48311
min hss = 0.011800396
```

Minimum Depth Values:

```
max min_depth = 61.831876
min min_depth = 0.00078037598
```

5.12 Strait 10

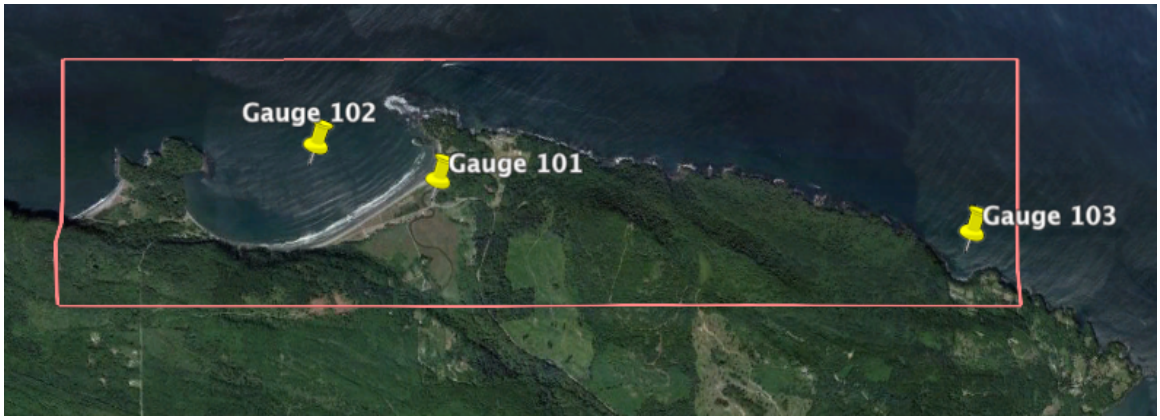

Figure 15: Strait 10 map with computational gauges

View the results plus a movie of Strait 10 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_10/index.html

Interesting Findings:

- Gauge 101, a land point at 1.23 meters, subsided by 0.88 meters. The maximum flow depth arrived at 68.81 minutes after the earthquake gave 6.12 meters of water above the subsided bathymetry there.
- Gauge 102, a water location at -9.37 meters, subsided by 0.89 meters. The largest wave at 67.84 minutes after the earthquake was 6.43 meters above MHW and gave 7.33 meters of water above the subsided water surface there.
- Gauge 103, a water location at -21.58 meters, subsided by 0.78 meters. The largest wave at 69.85 minutes after the earthquake was 6.30 meters above MHW and gave 7.08 meters of water above the subsided water surface there.
- There is flooding very near Crescent Beach Road, and a finer simulation might be necessary to see if it tops the road. The most flooding, however, occurs in the low area around Gauge 101 and inland from Gauge 102 at the Crescent Beach and RV park. Houses along this river valley can receive between 6 and 8 meters of flooding as shown by the max Zeta map.
- A summary for this region is on the next page.

STRAIT 10

Location Box: x1,x2,y1,y2 = (-123.740278, -123.649722, 48.154722, 48.170278)//

Gauges	Longitude	Latitude
101	-1.2370527780e+02	4.8161388900e+01
102	-1.2371694440e+02	4.8163611100e+01
103	-1.2365472220e+02	4.8158055600e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -0.905999450466 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  69.6633583333
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  70.8970383333
min of tzeta was:  66.54988
```

Maximum Zeta Values:

```
max of zeta:  7.2769407
min of zeta:  0.0013488342
```

Maximum Speed Values:

```
max speed = 5.5349032
min speed = 0.027472295
```

Maximum Momentum Values:

```
max hs = 116.37622
min hs = 3.7055571e-05
```

Maximum Momentum Flux Values:

```
max hss = 193.12536
min hss = 1.0180016e-06
```

Minimum Depth Values:

```
max min_depth = 72.810907
min min_depth = 0.00055440906
```

5.13 Strait 11

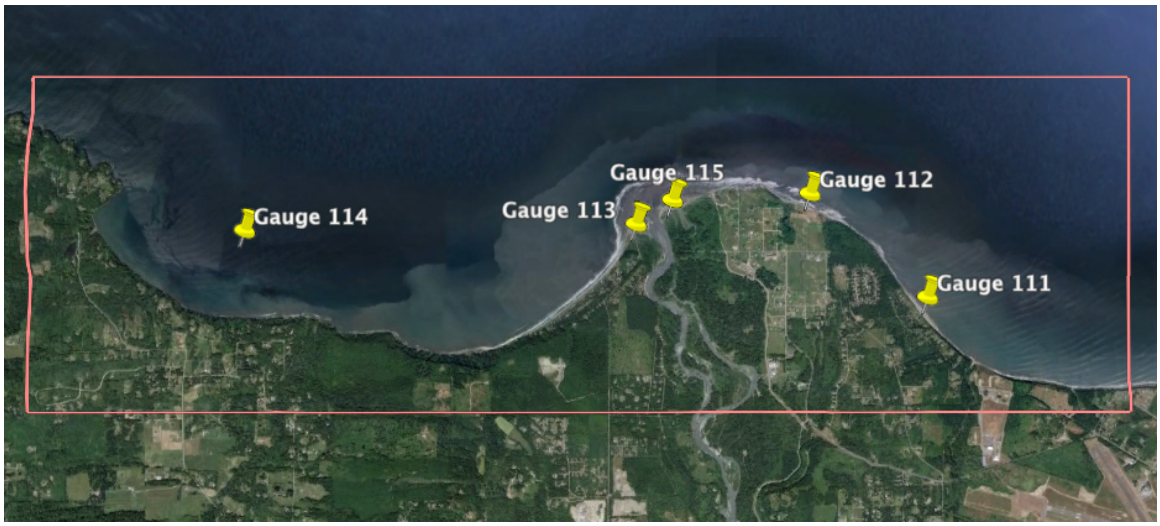

Figure 16: Strait 11 map with computational gauges

View the results plus a movie of Strait 11 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_11/index.html

Interesting Findings:

- Gauge 111, a land point at 3.87 meters, subsided by 0.62 meters. The maximum flood depth arrived at 74.79 minutes after the earthquake and gave 2.73 meters of water above the subsided bathymetry there.
- Gauge 112, a land point at 1.59 meters, subsided by 0.62 meters. The maximum flood depth arrived at 72.31 minutes after the earthquake and gave 4.75 meters of water above the subsided bathymetry there.
- Gauge 113, a land point at 0.77 meters, subsided by 0.62 meters. The maximum flood depth arrived at 72.59 minutes after the earthquake and gave 6.18 meters of water above the subsided bathymetry there.
- Gauge 114, a water location at -16.95 meters, subsided by 0.74 meters. The largest wave at 70.93 minutes after the earthquake was 6.75 meters above MHW and gave 7.49 meters of water above the subsided water surface there.
- Gauge 115, a land point at 0.08 meters, subsided by 0.62 meters. The maximum flood depth arrived at 72.35 minutes after the earthquake and gave 6.81 meters of water above the subsided bathymetry there.
- Gauges 113 and 115 are on opposite sides on a river mouth near the beach. This river valley floods, as does the valley inland from Gauge 112 including the Lower Elwha Tribal Community. The Elwha River Casino appears to be on the border of the inundation zone for this coarse run, so a fine grid simulation is warranted.
- A summary for this region is on the next page.

STRAIT 11

Location Box: x1,x2,y1,y2 = (-123.650278, -123.499722, 48.129722, 48.160278)//

Gauges	Longitude	Latitude
111	-1.2352805560e+02	4.8138611100e+01
112	-1.2354416670e+02	4.8148055600e+01
113	-1.2356805560e+02	4.8145277800e+01
114	-1.2362194440e+02	4.8144722200e+01
115	-1.2356305560e+02	4.8147500000e+01

Average Subsidence or Uplift:

```
Average subsidence or uplift:  -0.646293596429 m
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  79.3029866667
minimum of the arrival_time was:  0.0720853416667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  87.13088
min of tzeta was:  69.8542833333
```

Maximum Zeta Values:

```
max of zeta:  7.5742138
min of zeta:  0.0037389759
```

Maximum Speed Values:

```
max speed = 6.6240923
min speed = 0.055127487
```

Maximum Momentum Values:

```
max hs = 72.188946
min hs = 0.00025869123
```

Maximum Momentum Flux Values:

```
max hss = 221.3082
min hss = 1.7903414e-05
```

Minimum Depth Values:

```
max min_depth = 40.014512
min min_depth = 0.00038726539
```

5.14 Strait 12

Figure 17: Strait 12 map with computational gauges

View the results plus a movie of Strait 12 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_12/index.html

Interesting Findings:

- Gauge 121, a water location at -9.69 near Ediz Hook, had no subsidence or uplift. The largest wave at 79.20 minutes after the earthquake was 5.47 meters above MHW, the initial water surface.
- Gauge 122, a water location at -10.32 near the ferry terminal, had no subsidence or uplift. The largest wave at 78.42 minutes after the earthquake was 6.20 meters above MHW, the initial water surface.
- Gauge 123, a land point at 0.96 meters, had no subsidence or uplift. The maximum flow depth arrived at 81.58 minutes after the earthquake and gave 5.17 meters of water above the bathymetry there. This gauge is close to a housing development on N. Ridge View Drive, and the max Zeta maps show inundation there.
- Gauge 124, a water location at -7.56 meters, had no subsidence or uplift. The largest wave at 81.48 minutes after the earthquake was 5.86 meters above MHW, the initial water surface. This gauge is located in the water in front of houses on Strait View Drive.
- Gauge 125, a water location at -10.86 meters, had no subsidence or uplift. The largest wave at 79.70 minutes after the earthquake was 6.25 meters above MHW, the initial water surface.
- Neither the hospital nor the airport is in the inundation zone.
- Gauges 121, 122, and 125 were also represented on the fine grid simulation of Port Angeles. It is encouraging that the results match very well.
- A summary for this region is on the next page.

STRAIT 12

Location Box: x1,x2,y1,y2 = (-123.500278, -123.239722, 48.109722, 48.150278)//

Gauges	Longitude	Latitude
121	-1.2340083330e+02	4.8139722200e+01
122	-1.2342972220e+02	4.8122500000e+01
123	-1.2335305560e+02	4.8116388900e+01
124	-1.2334750000e+02	4.8120277800e+01
125	-1.2340750000e+02	4.8120833300e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  81.7996266667
minimum of the arrival_time was:  1.17368548333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  85.192265
min of tzeta was:  73.81965
```

Maximum Zeta Values:

```
max of zeta:  6.64715201
min of zeta:  0.0034994927
```

Maximum Speed Values:

```
max speed = 10.84877
min speed = 0.034305084
```

Maximum Momentum Values:

```
max hs = 356.90253
min hs = 0.00010550295
```

Maximum Momentum Flux Values:

```
max hss = 1461.1788
min hss = 3.5359749e-06
```

Minimum Depth Values:

```
max min_depth = 83.425259
min min_depth = -0.0
```

5.15 Strait 13

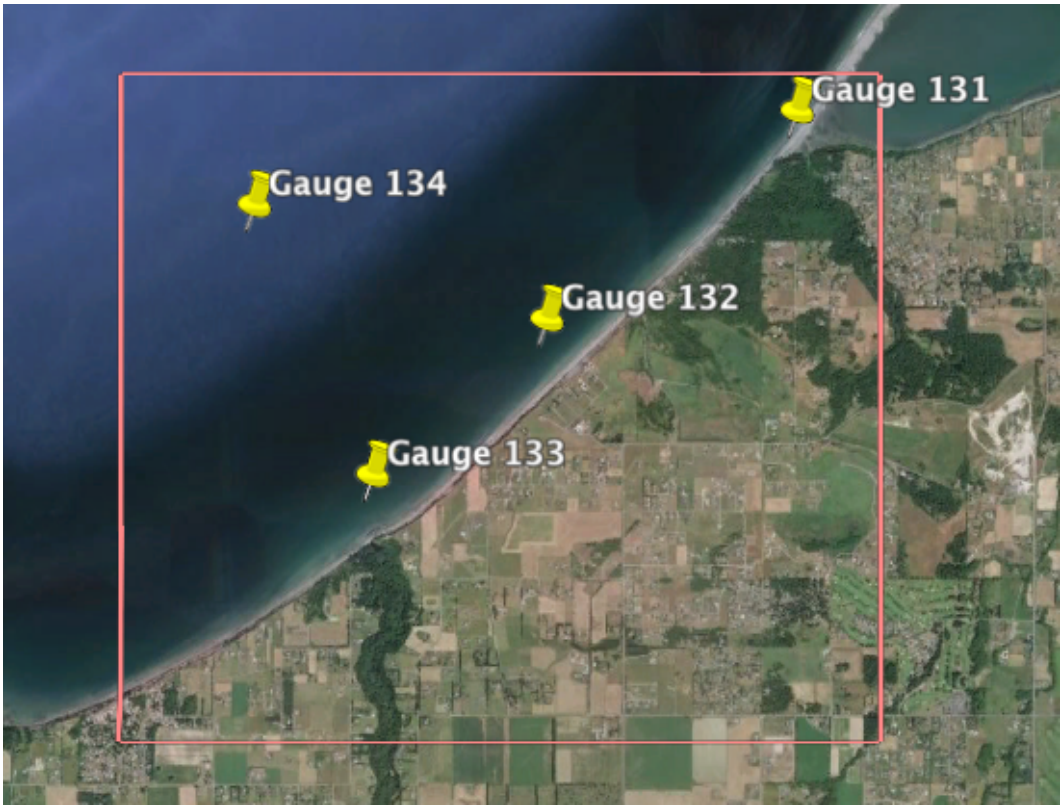

Figure 18: Strait 13 map with computational gauges

View the results plus a movie of Strait 13 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_13/index.html

Interesting Findings:

- Gauge 131, a water location at -0.16 meters, had no subsidence or uplift. The largest wave at 86.35 minutes after the earthquake was 5.06 meters above MHW, the initial water surface.
- Gauge 132, a water location at -8.18 meters, had no subsidence or uplift. The largest wave at 85.96 minutes after the earthquake was 5.68 meters above MHW, the initial water surface.
- Gauge 133, a water location at -5.85 meters, had no subsidence or uplift. The largest wave at 84.91 minutes after the earthquake was 5.88 meters above MHW, the initial water surface.
- Gauge 134, a water location at -15.44 meters, had no subsidence or uplift. The largest wave at 85.09 minutes after the earthquake was 5.46 meters above MHW, the initial water surface.
- The houses in this Strait and the two airports are out of the inundation zone on cliffs. This should be doubled checked in case Google Earth is out of date.
- A summary for this region is on the next page.

STRAIT 13

Location Box: x1,x2,y1,y2 = (-123.240278, -123.179722, 48.114722, 48.150278)//

Gauges	Longitude	Latitude
131	-1.2318694440e+02	4.8146944400e+01
132	-1.2320694440e+02	4.8135833300e+01
133	-1.2322083330e+02	4.8127500000e+01
134	-1.2323027780e+02	4.8141944400e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  84.0613833333
minimum of the arrival_time was:  11.9692545
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  86.866525
min of tzeta was:  83.8263933333
```

Maximum Zeta Values:

```
max of zeta:  5.99220263
min of zeta:  0.33264701
```

Maximum Speed Values:

```
max speed = 6.5725951
min speed = 0.58979069
```

Maximum Momentum Values:

```
max hs = 50.739554
min hs = 0.12309526
```

Maximum Momentum Flux Values:

```
max hss = 101.46455
min hss = 0.057348109
```

Minimum Depth Values:

```
max min_depth = 19.140186
min min_depth = 0.0004376417
```

5.16 Strait 14

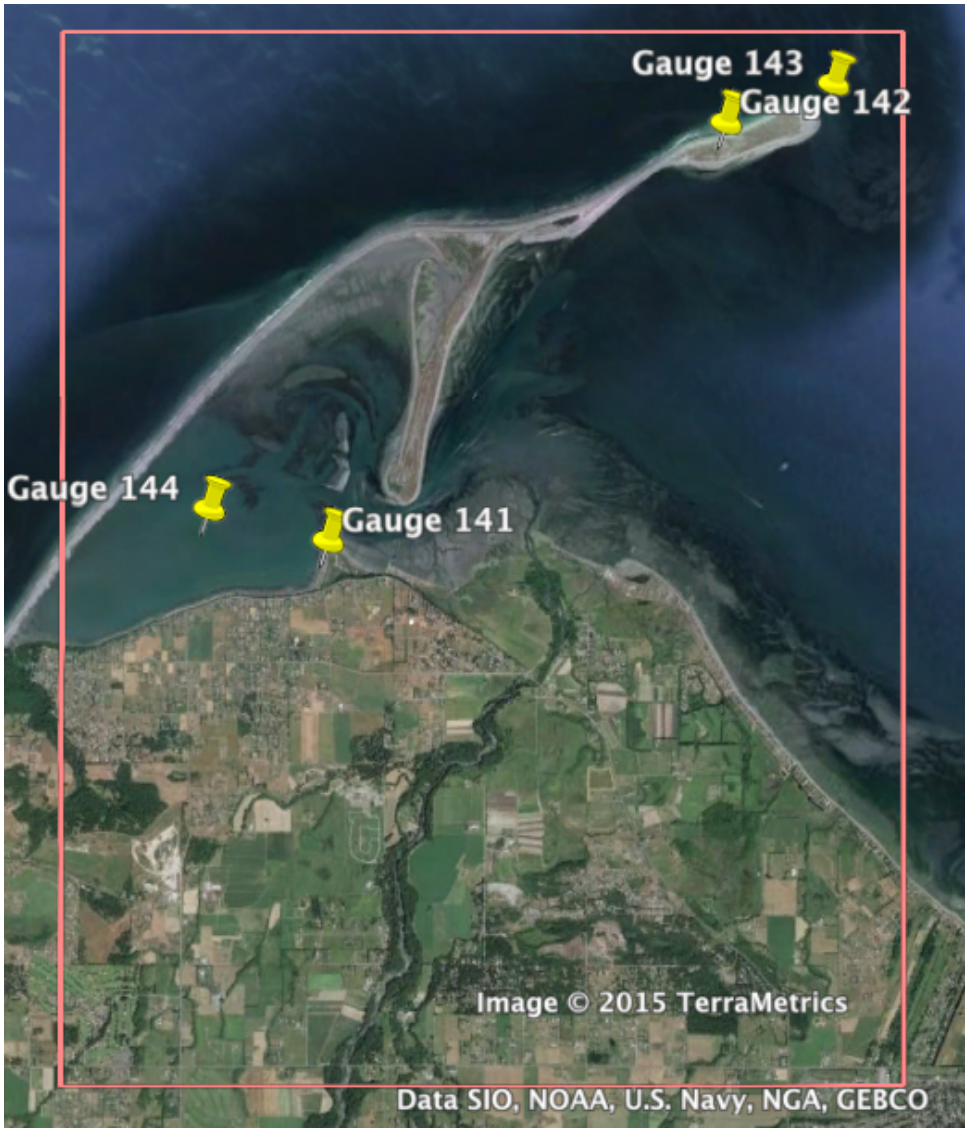

Figure 19: Strait 14 map with computational gauges

View the results plus a movie of Strait 14 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_14/index.html

Interesting Findings:

- Gauge 141, a water location at -0.63 meters, had no subsidence or uplift. The largest wave at 88.47 minutes after the earthquake was 4.78 meters above MHW, the initial water surface. This gauge is on the beach near Cline Spit Road and the boat entry.
- Gauge 142, a land point at 0.48 meters located at the New Dungeness Lighthouse, had no subsidence or uplift. The maximum flow depth arrived at 92.01 minutes after the earthquake and gave 2.47 meters

of water above the bathymetry there.

- Gauge 143, a water location at -8.16 meters at the end of the Spit, had no subsidence or uplift. The largest wave at 92.65 minutes after the earthquake was 2.30 meters above MHW, the initial water surface.
- Gauge 144, a water location at -4.38 meters, had no subsidence or uplift. The largest wave at 88.06 minutes after the earthquake was 4.82 meters above MHW, the initial water surface.
- The maximum inundation occurred from the 3 Crabs Rd along the beach inland toward Sequim-Dungeness Way. The Lucilla's Roost (airport) is in the inundation zone as are residential areas. A fine simulation to tell the extend of the inundation is warranted.
- A summary for this region is on the next page.

STRAIT 14

Location Box: x1,x2,y1,y2 = (-123.180278, -123.089722, 48.114722, 48.190278)//

Gauges	Longitude	Latitude
141	-1.2315250000e+02	4.8151944400e+01
142	-1.2310972220e+02	4.8181944400e+01
143	-1.2309805560e+02	4.8184722200e+01
144	-1.2316527780e+02	4.8154166700e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  98.4501783333
minimum of the arrival_time was:  11.8909201667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  120.646215
min of tzeta was:  85.672025
```

Maximum Zeta Values:

```
max of zeta:  5.02316748
min of zeta:  0.0033889665
```

Maximum Speed Values:

```
max speed = 11.961611
min speed = 0.050751361
```

Maximum Momentum Values:

```
max hs = 472.59624
min hs = 0.00015166539
```

Maximum Momentum Flux Values:

```
max hss = 2650.3193
min hss = 7.5253348e-06
```

Minimum Depth Values:

```
max min_depth = 132.24994
min min_depth = -0.0
```

5.17 Strait 15

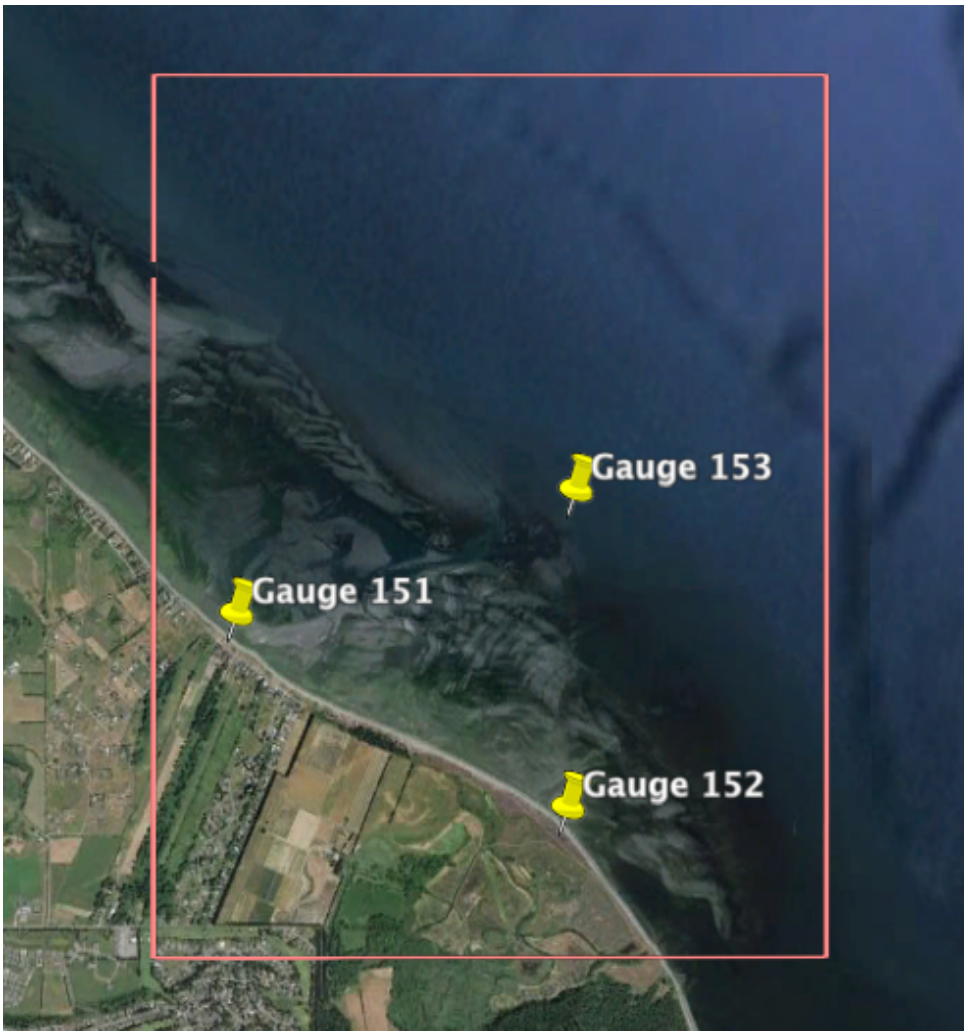

Figure 20: Strait 15 map with computational gauges

View the results plus a movie of Strait 15 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_15/index.html

Interesting Findings:

- Gauge 151, a water location at -0.05 meters on the beach near Jamestown Road, had no subsidence or uplift. The largest wave at 93.82 minutes after the earthquake was 3.71 meters above MHW, the initial water surface. There are houses near this gauge.
- Gauge 152, a land point at 0.24 meters, had no subsidence or uplift. The maximum flow depth arrived at 100.16 minutes after the earthquake and gave 3.76 meters of water above the bathymetry there.
- Gauge 153, a water location at -4.51 meters, had no subsidence or uplift. The largest wave at 97.71 minutes after the earthquake was 3.59 meters above MHW, the initial water surface.

- The Flying S Airfield is in the inundation zone. Harbord Field does not appear in the inundation zone, but much of this Strait sees flooding, and a fine grid simulation would be warranted.
- A summary for this region is on the next page.

STRAIT 15

Location Box: x1,x2,y1,y2 = (-123.090278, -123.049722, 48.114722, 48.150278)//

Gauges	Longitude	Latitude
151	-1.2308583330e+02	4.8127500000e+01
152	-1.2306583330e+02	4.8119722200e+01
153	-1.2306527780e+02	4.8132500000e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  99.1943183333
minimum of the arrival_time was:  18.9022016667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  101.309216667
min of tzeta was:  92.8640566667
```

Maximum Zeta Values:

```
max of zeta:  4.18114
min of zeta:  0.0021353479
```

Maximum Speed Values:

```
max speed = 4.363798
min speed = 0.024791043
```

Maximum Momentum Values:

```
max hs = 60.750809
min hs = 4.7471306e-05
```

Maximum Momentum Flux Values:

```
max hss = 136.72305
min hss = 1.1562449e-06
```

Minimum Depth Values:

```
max min_depth = 22.532992
min min_depth = 0.00080893224
```

5.18 Strait 16

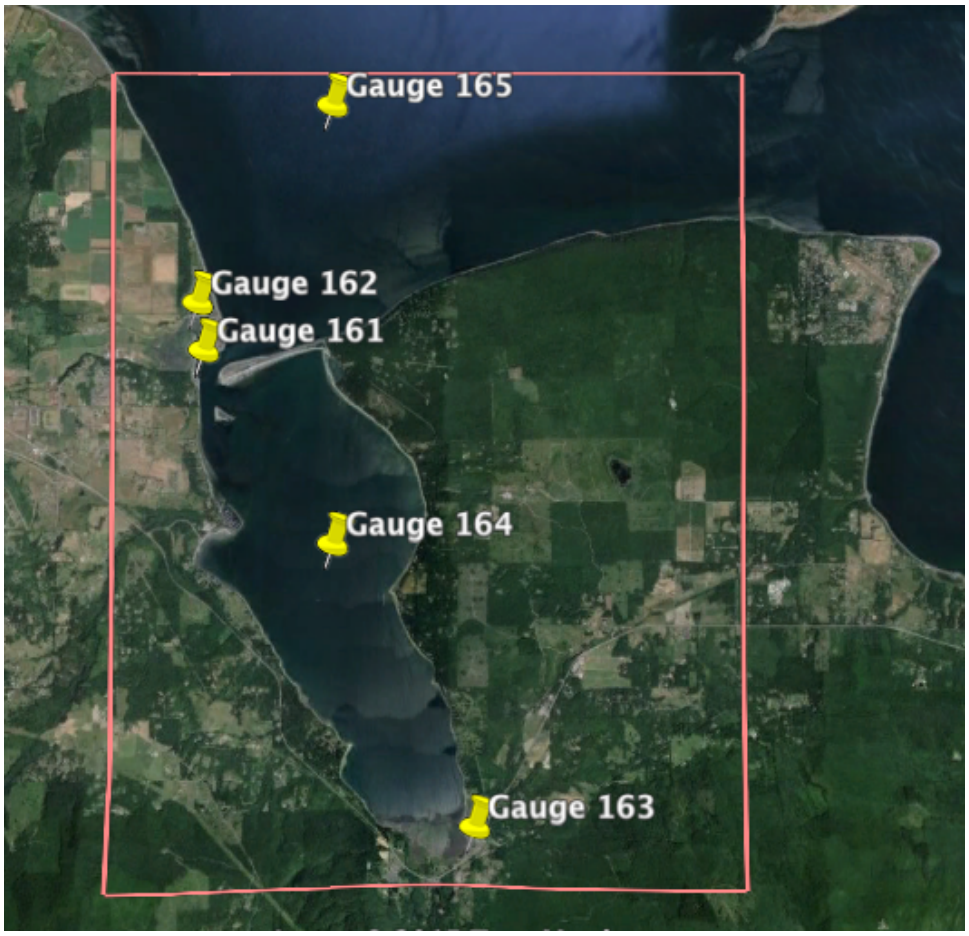

Figure 21: Strait 16 map with computational gauges

View the results plus a movie of Strait 16 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_16/index.html

Interesting Findings:

- Gauge 161, a water location at -0.24 meters, had no subsidence or uplift. The largest wave at 100.09 minutes after the earthquake was 3.67 meters above MHW, the initial water surface. This gauge is at the Batelle Marine Lab on the beach.
- Gauge 162, a water location at -1.66 meters, had no subsidence or uplift. The largest wave at 101.10 minutes after the earthquake was 4.25 meters above MHW, the initial water surface.
- Gauge 163, a land point at 0.80 meters, had no subsidence or uplift. The maximum flow depth arrived at 125.49 minutes after the earthquake and gave 2.18 meters of water above the bathymetry there. This gauge is at the end of Sequim Bay near Old Blyn Hwy close to the Jamestown S'Klallam Tribe.
- Gauge 164, a water location at -26.92 meters in the middle of Sequim Bay, had no subsidence or uplift. The largest wave at 126.33 minutes after the earthquake was 2.69 meters above MHW, the initial water

surface.

- Gauge 165, a water location at -38.31 meters in the Strait of Juan de Fuca near the entrance to Sequim Bay, had no subsidence or uplift. The largest wave at 99.28 minutes after the earthquake was 4.33 meters above MHW, the initial water surface.
- There is some inundation at the end of Sequim Bay as seen in the max Zeta map. This is very close to the Longhouse Market and Deli. The other location of inundation is the river valley between Gauges 161 and 162, which is quite close to the Batelle Marine Lab.
- A summary for this region is on the next page.

STRAIT 16

Location Box: x1,x2,y1,y2 = (-123.060278, -122.949722, 48.019722, 48.115278)//

Gauges	Longitude	Latitude
161	-1.2304583330e+02	4.8079722200e+01
162	-1.2304694440e+02	4.8085277800e+01
163	-1.2299805560e+02	4.8023611100e+01
164	-1.2302305560e+02	4.8056944400e+01
165	-1.2302305560e+02	4.8108611100e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  125.243271667
minimum of the arrival_time was:  22.673195
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  127.54924
min of tzeta was:  98.6362133333
```

Maximum Zeta Values:

```
max of zeta:  4.627209
min of zeta:  0.009531314
```

Maximum Speed Values:

```
max speed = 11.1142
min speed = 0.019641482
```

Maximum Momentum Values:

```
max hs = 229.87536
min hs = 0.00087131041
```

Maximum Momentum Flux Values:

```
max hss = 642.84149
min hss = 8.958238e-05
```

Minimum Depth Values:

```
max min_depth = 91.589655
min min_depth = -0.0
```

5.19 Strait 17

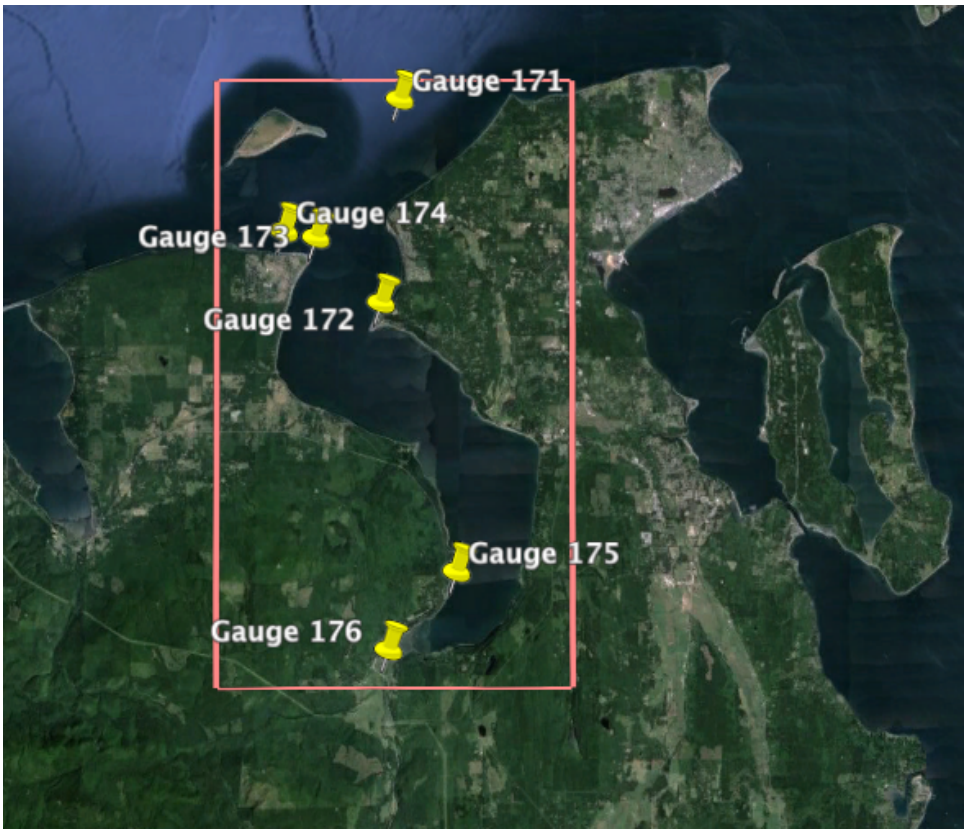

Figure 22: Strait 17 map with computational gauges

View the results plus a movie of Strait 17 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_17/index.html

Interesting Findings:

- Gauge 171, a water location at -83.99 meters, had no subsidence or uplift. The largest wave at 103.29 minutes after the earthquake was 4.77 meters above MHW, the initial water surface.
- Gauge 172, a land point at 0.18 meters, had no subsidence or uplift. The maximum flow depth arrived at 108.50 minutes after the earthquake and gave 5.65 meters of water above the bathymetry there. This gauge is near Beckett Point Road with houses on both sides.
- Gauge 173, a land point at 0.29 meters near Beach Road at the entrance to Discovery Bay, had no subsidence or uplift. The maximum flow depth arrived at 105.36 minutes after the earthquake and gave 4.59 meters of water above the bathymetry there.
- Gauge 174, a land point at 7.81 meters, had no subsidence or uplift. This point remained dry through the duration of the tsunami.
- Gauge 175, a water location at -0.91 meters, had no subsidence or uplift. The largest wave at 112.23 minutes after the earthquake was 9.61 meters above MHW, the initial water surface. This gauge is

located at the end of Holland Drive on the beach in front of the World Mark Discovery Bay houses which are at risk for flooding.

- Gauge 176, a land point at 0.89 meters, had no subsidence or uplift. The maximum flow depth arrived at 116.43 minutes after the earthquake and gave 11.04 meters of water above the bathymetry there.
- The highest inundation, perhaps of all the simulation runs in the Strait, was at the southern end of Discovery Bay near Gauge 176, Hwy 20 and US 101. The Bay becomes very narrow at that location and the max Zeta map shows as much as 11 meters of water inundating land there. This is directly in line for Fat Smitty's and goes to the southern end of the Strait 17 domain. A fine resolution simulation should definitely be done to determine exactly how far the water reaches beyond this boundary of Strait 17.
- The speed, momentum, and momentum flux maps show these quantities to be high at the entrance to Discovery Bay.
- The Diamond Point Airstrip behind Gauges 173 and 174 is out of the inundation zone, and it appears that Olympic Field is also out of the inundation zone.
- A summary for this region is on the next page.

STRAIT 17

Location Box: x1,x2,y1,y2 = (-122.950278, -122.814722, 47.984722, 48.140278)

Gauges	Longitude	Latitude
171	-1.2288305560e+02	4.8129722200e+01
172	-1.2289027780e+02	4.8077500000e+01
173	-1.2291527780e+02	4.8094166700e+01
174	-1.2292750000e+02	4.8095833300e+01
175	-1.2286138890e+02	4.8008611100e+01
176	-1.2288750000e+02	4.7988611100e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  114.781795
minimum of the arrival_time was:  22.991125
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  117.288353333
min of tzeta was:  101.270051667
```

Maximum Zeta Values:

```
max of zeta:  11.88514
min of zeta:  0.0055665584
```

Maximum Speed Values:

```
max speed = 16.49677
min speed = 0.15934743
```

Maximum Momentum Values:

```
max hs = 512.41228
min hs = 0.00087782832
```

Maximum Momentum Flux Values:

```
max hss = 4075.6665
min hss = 0.00013962963
```

Minimum Depth Values:

```
max min_depth = 122.18146
min min_depth = -0.0
```

5.20 Strait 18

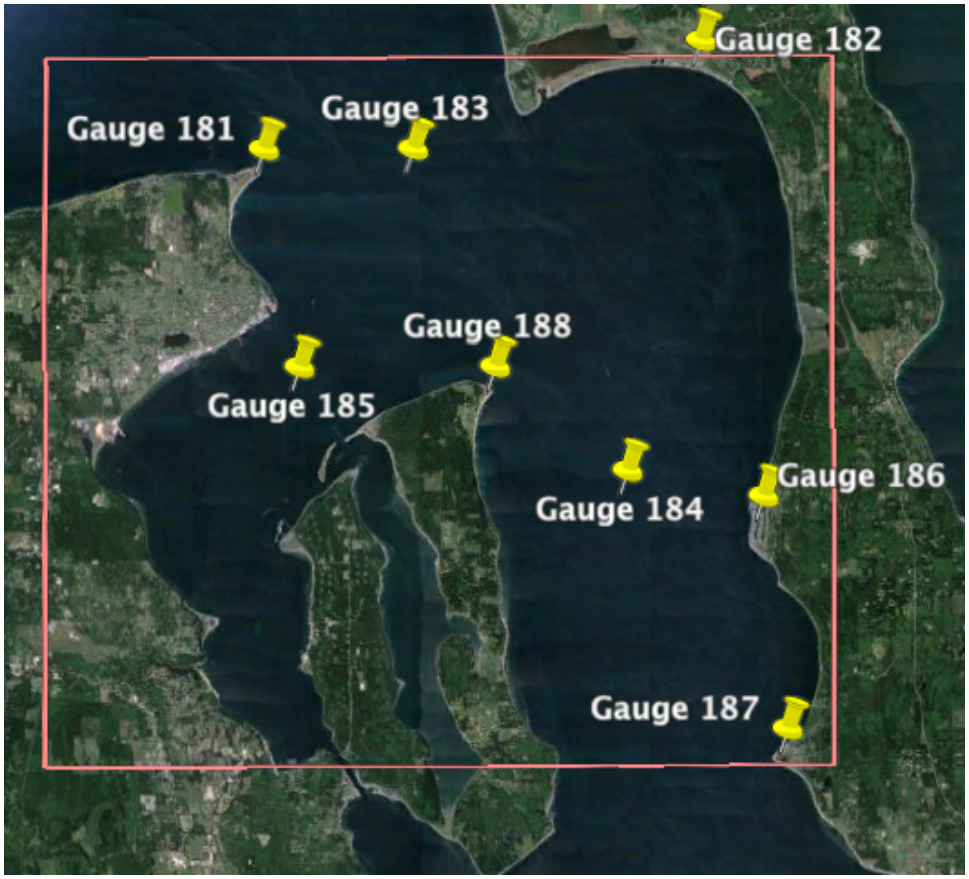

Figure 23: Strait 18 map with computational gauges

View the results plus a movie of Strait 18 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_18/index.html

Interesting Findings:

- Gauge 181, a land point at 0.92 meters at Wilson Point Lighthouse, had no subsidence or uplift. The maximum flow depth arrived at 106.74 minutes after the earthquake and gave 2.21 meters of water above the bathymetry there.
- Gauge 182, a land point at 0.42 meters, had no subsidence or uplift. The maximum flow depth arrived at 113.23 minutes after the earthquake and gave 3.75 meters of water above the bathymetry there. This gauge is located behind houses on Keystone Avenue of Widbey Island. These houses are in the inundation zone. Also, the Ferry harbor at Coupeville on Widbey Island, one terminus of the Port Townsend - Keystone ferry, is not too far from Gauge 182, and receives from 4 to 5 meters of water (above MHW).
- Gauge 183, a water location at -56.28 meters, had no subsidence or uplift. The largest wave at 111.04 minutes after the earthquake was 3.54 meters above MHW, the initial water surface. This gauge is between Wilson Point Lighthouse in Port Townsend and Admiralty Head Lighthouse on Widbey Island near the entrance to the navigational routes around Maristone Island.

- Gauge 184, a water location at -119.51 meters, had no subsidence or uplift. The largest wave at 115.78 minutes after the earthquake was 3.44 meters above MHW, the initial water surface. This gauge is in the middle of the shipping lanes to the Port of Seattle.
- Gauge 185, a water location at -21.71 meters, had no subsidence or uplift. The largest wave at 121.91 minutes after the earthquake was 5.31 meters above MHW, the initial water surface. This gauge is near the Port-Townsend-Keystone Ferry line between Port Townsend and Maristone Island.
- Gauge 186, a land point at 1.10 meters, had no subsidence or uplift. The maximum flow depth arrived at 113.01 minutes after the earthquake and gave 2.50 meters of water above the bathymetry there. This gauge is in a housing development on Oceanside Drive on Widbey Island, so many houses are in the inundation zone here.
- Gauge 187, a land point at 0.67 meters, had no subsidence or uplift. The maximum flow depth arrived at 122.92 minutes after the earthquake and gave 1.98 meters of water above the bathymetry there. This gauge is in a housing development at the end of Lighthouse Way on Widbey Island. Many houses are in the inundation zone here.
- Gauge 188, a land point at 1.02 meters, had no subsidence or uplift. The maximum flow depth arrived at 117.57 minutes after the earthquake and gave 2.27 meters of water above the bathymetry there. This gauge is amongst houses on Maristone Point facing the shipping lanes to the Port of Seattle. These houses are in the inundation zone.
- The Zeta maximum map shows the inundation areas around the Port of Port Townsend, (which is reported in the fine Port Townsend results) and at the Port Townsend Paper Corporation which is near the beach where there is 6 to 7 meters of water above MHW. Kala Point beach is also inundated. The Port Hadlock Marina near the southern border of the Strait 18 region also appears to be in the inundation zone.
- Strait 18 includes waterways and lighthouses that are very important to the shipping and ferry industries. The speed of the water, the momentum, and the momentum flux around Wilson Point, and the Maristone Island would be of interest to mariners.
- Gauges 181 and 185 were represented in the fine resolution study of Port Townsend. It is encouraging that there is very good agreement between results of the fine study and this coarse study at these gauges.
- A summary for this region is on the next page.

STRAIT 18

Location Box: x1,x2,y1,y2 = (-122.815278, -122.589722, 48.029722, 48.165278)

Gauges	Longitude	Latitude
181	-1.2275472222e+02	4.8143055556e+01
182	-1.2262916670e+02	4.8163611100e+01
183	-1.2271194440e+02	4.8143055600e+01
184	-1.2265083330e+02	4.8081388900e+01
185	-1.2274472220e+02	4.8101388900e+01
186	-1.2261194440e+02	4.8076388900e+01
187	-1.2260527780e+02	4.8031944400e+01
188	-1.2268861110e+02	4.8101388900e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  135.225196667
minimum of the arrival_time was:  27.1683633333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  216.501033333
min of tzeta was:  104.148638333
```

Maximum Zeta Values:

```
max of zeta:  7.5838546
min of zeta:  0.0010220877
```

Maximum Speed Values:

```
max speed = 11.092367
min speed = 0.01296324
```

Maximum Momentum Values:

```
max hs = 587.47236
min hs = 1.318699e-05
```

Maximum Momentum Flux Values:

```
max hss = 3348.7135
min hss = 1.7094612e-07
```

Minimum Depth Values:

```
max min_depth = 193.79485
min min_depth = -0.0
```

5.21 Strait 19

Figure 24: Strait 19 map with computational gauges

View the results plus a movie of Strait 19 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_19/index.html

Interesting Findings:

- Gauge 191, a water location at -57.84 meters, had no subsidence or uplift. The largest wave at 105.05 minutes after the earthquake was 4.46 meters above MHW, the initial water surface. This gauge is in the shipping and ferry lanes off the Strait side of Port Townsend.
- Gauge 192, a water location at -64.44 meters, had no subsidence or uplift. The largest wave at 106.55 minutes after the earthquake was 4.17 meters above MHW, the initial water surface. This gauge is close to the shipping and ferry lanes and the coast of Widbey Island.
- Gauge 193, a land location at 38.16 meters near houses off S. Cathedral Place on Widbey Island, stays dry during the tsunami.
- The max Zeta map shows the Fort Casey Inn on Widbey Island is in the inundation zone. Also, some beach areas between the Pacific Northwest Trail and the water receive from 4.0 to 4.5 meters of flooding.
- A summary for this region is on the next page.

STRAIT 19

Location Box: x1,x2,y1,y2 = (-122.815278, -122.67422, 48.164722, 48.205278)

Gauges	Longitude	Latitude
191	-1.2280416667e+02	4.8184722222e+01
192	-1.2274583333e+02	4.8184722222e+01
193	-1.2269861111e+02	4.8184722222e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  112.040098333
minimum of the arrival_time was:  25.901305
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  114.233466667
min of tzeta was:  104.520701667
```

Maximum Zeta Values:

```
max of zeta:  4.89909734
min of zeta:  0.0048546692
```

Maximum Speed Values:

```
max speed = 4.5783828
min speed = 0.1979518
```

Maximum Momentum Values:

```
max hs = 217.72291
min hs = 0.00096099049
```

Maximum Momentum Flux Values:

```
max hss = 452.79963
min hss = 0.00019022979
```

Minimum Depth Values:

```
max min_depth = 116.11947
min min_depth = -0.0
```

5.22 Strait 20

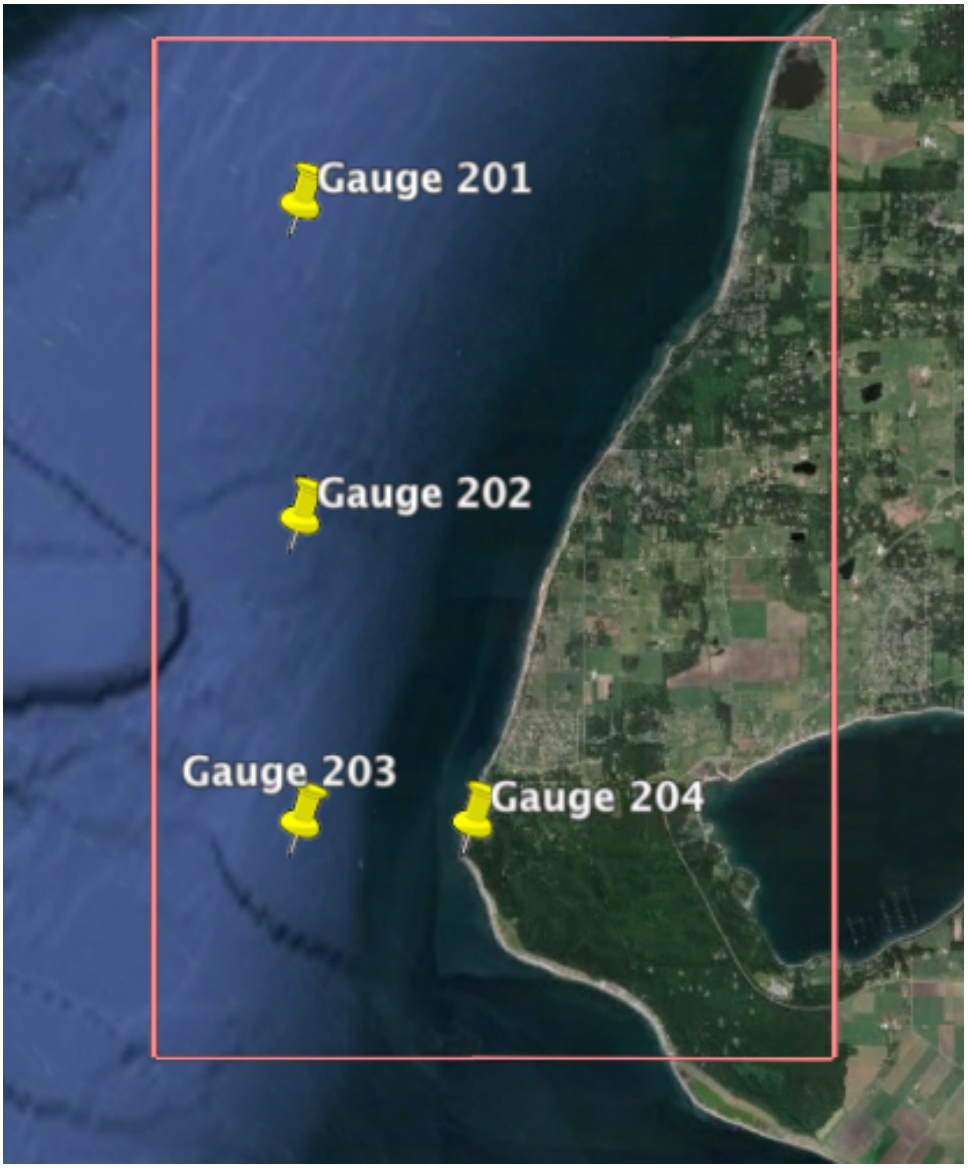

Figure 25: Strait 20 map with computational gauges

View the results plus a movie of Strait 20 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_20/index.html

Interesting Findings:

- Gauge 201, a water location off Widbey Island at -56.33 meters, had no subsidence or uplift. The largest wave at 104.07 minutes after the earthquake was 4.84 meters above MHW, the initial water surface.
- Gauge 202, a water location off Widbey Island at -81.66 meters, had no subsidence or uplift. The

largest wave at 104.78 minutes after the earthquake was 4.83 meters above MHW, the initial water surface.

- Gauge 203, a water location off Widbey Island at -28.91 meters, had no subsidence or uplift. The largest wave at 104.66 minutes after the earthquake was 4.62 meters above MHW, the initial water surface.
- Gauge 204, a land point at 6.19 meters, had no subsidence or uplift and remained dry throughout the tsunami.
- The West Beach Road beach houses on Widbey Island are heavily flooded.
- There is some flooding along Madrona Way near Kennedy Lagoon on Widbey Island.
- A summary for this region is on the next page.

STRAIT 20

Location Box: x1,x2,y1,y2 = (-122.815278, -122.714722, 48.204722, 48.305278)

Gauges	Longitude	Latitude
201	-1.2279527780e+02	4.8285833300e+01
202	-1.2279527780e+02	4.8254722200e+01
203	-1.2279527780e+02	4.8224722200e+01
204	-1.2276972220e+02	4.8224722200e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  203.680183333
minimum of the arrival_time was:  25.6518233333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  211.644833333
min of tzeta was:  103.732515
```

Maximum Zeta Values:

```
max of zeta:  5.91329441
min of zeta:  0.0011417183
```

Maximum Speed Values:

```
max speed = 5.5897183
min speed = 0.018755908
```

Maximum Momentum Values:

```
max hs = 187.88195
min hs = 2.0278888e-05
```

Maximum Momentum Flux Values:

```
max hss = 413.83701
min hss = 3.6555861e-07
```

Minimum Depth Values:

```
max min_depth = 89.249809
min min_depth = 0.00080315913
```

5.23 Strait 21

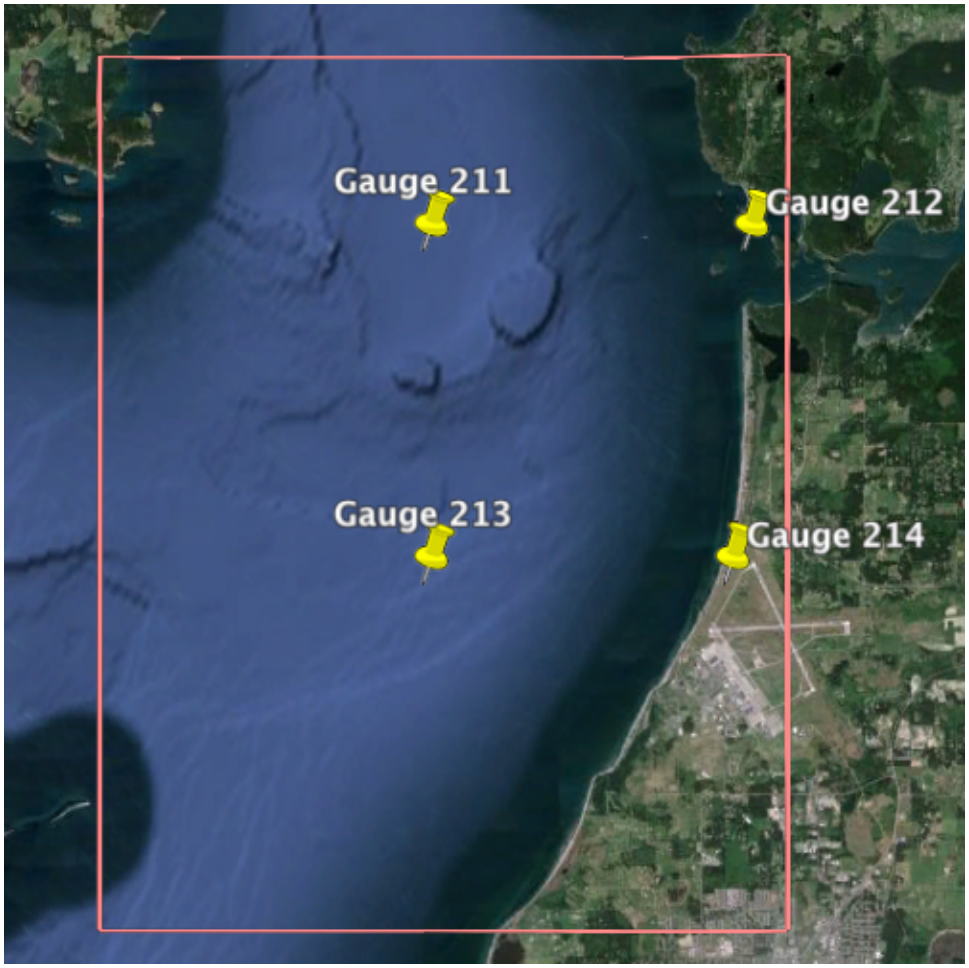

Figure 26: Strait 21 map with computational gauges

View the results plus a movie of Strait 21 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_21/index.html

Interesting Findings:

- Gauge 211, a water location at -81.88 meters, had no subsidence or uplift. The largest wave at 110.04 minutes after the earthquake was 5.15 meters above MHW, the initial water surface.
- Gauge 212, a water location at -23.67 meters, had no subsidence or uplift. The largest wave at 110.33 minutes after the earthquake was 5.37 meters above MHW, the initial water surface. Gauge 212 is off the coast of Widbey Island.
- Gauge 213, a water location at -76.80 meters, had no subsidence or uplift. The largest wave at 107.17 minutes after the earthquake was 5.08 meters above MHW, the initial water surface.
- Gauge 214, a land point at 4.77 meters, had no subsidence or uplift. The maximum flow depth arrived at 107.37 minutes after the earthquake and gave .78 meters of water above the bathymetry there. This

gauge is near N. Saratoga St. near the NAS Widbey Island Airport. The max Zeta map shows flooding at this airport, and at the beach houses north of Gauge 214 all along the coast of Widbey Island toward Deception Pass. Around 5.5 meters of water above MHW is seen in the entrance to Deception Pass.

- The harbor in front of Rosario Beach Marine Laboratory sees between 5.5 and 6.0 meters of water above MHW.
- The beach houses along W. Beach road along the coast see heavy flooding.
- A local increase in speed, momentum, and momentum flux is observed around the southern tip of Lopez Island and at the entrance to Deception Pass.
- A summary for this region is on the next page.

STRAIT 21

Location Box: x1,x2,y1,y2 = (-122.815278, -122.654722, 48.304722, 48.440278)

Gauges	Longitude	Latitude
211	-1.2273972220e+02	4.8410277800e+01
212	-1.2266472220e+02	4.8410277800e+01
213	-1.2273972220e+02	4.8358611100e+01
214	-1.2266916670e+02	4.8358611100e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  291.080583333
minimum of the arrival_time was:  26.7525133333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  299.991766667
min of tzeta was:  103.91365
```

Maximum Zeta Values:

```
max of zeta:  5.65250167
min of zeta:  0.0022908627
```

Maximum Speed Values:

```
max speed = 8.7604922
min speed = 0.020432612
```

Maximum Momentum Values:

```
max hs = 232.78377
min hs = 0.00012679421
```

Maximum Momentum Flux Values:

```
max hss = 841.81697
min hss = 5.3218874e-06
```

Minimum Depth Values:

```
max min_depth = 112.28155
min min_depth = -0.0
```

5.24 Strait 22

Figure 27: Strait 22 map with computational gauges

View the results plus a movie of Strait 22 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_22/index.html

Interesting Findings:

- Gauge 221, a water location at -34.51 meters between Burrows Island and Widbey Island, had no subsidence or uplift. The largest wave at 112.09 minutes after the earthquake was 6.39 meters above MHW, the initial water surface.

- Gauge 222, a land point at 2.82 meters, had no subsidence or uplift. The maximum flow depth arrived at 111.37 minutes after the earthquake and gave 2.64 meters of water above the bathymetry there.

This gauge is near some houses off Bregina Lane that may be in the inundation zone. A fine simulation could help determine the extent of the inundation here.

- Gauge 223, a land point at 2.37 meters, had no subsidence or uplift. The maximum flow depth arrived at 112.12 minutes after the earthquake and gave 4.22 meters of water above the bathymetry there. The most inundation in Strait 22 is along the coast a bit north of this gauge and south of it along N. Del Mar and S. Del Mar drive where there are quite a few beach houses. The max Zeta map shows around 5.5 meters of water at some of these locations.
- A summary for this region is on the next page.

STRAIT 22

Location Box: x1,x2,y1,y2 = (-122.680278, -122.644722, 48.439722, 48.480278)

Gauges	Longitude	Latitude
221	-1.2267527780e+02	4.8478055600e+01
222	-1.2267694440e+02	4.8443611100e+01
223	-1.2266305560e+02	4.8477500000e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  112.945846667
minimum of the arrival_time was:  33.6117683333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  115.663026667
min of tzeta was:  111.080498333
```

Maximum Zeta Values:

```
max of zeta:  6.7070434
min of zeta:  0.0065301611
```

Maximum Speed Values:

```
max speed = 5.0528969
min speed = 0.12810435
```

Maximum Momentum Values:

```
max hs = 95.498337
min hs = 0.0014199279
```

Maximum Momentum Flux Values:

```
max hss = 142.94766
min hss = 0.00030875123
```

Minimum Depth Values:

```
max min_depth = 63.761378
min min_depth = 0.00069075857
```

5.25 Strait 23

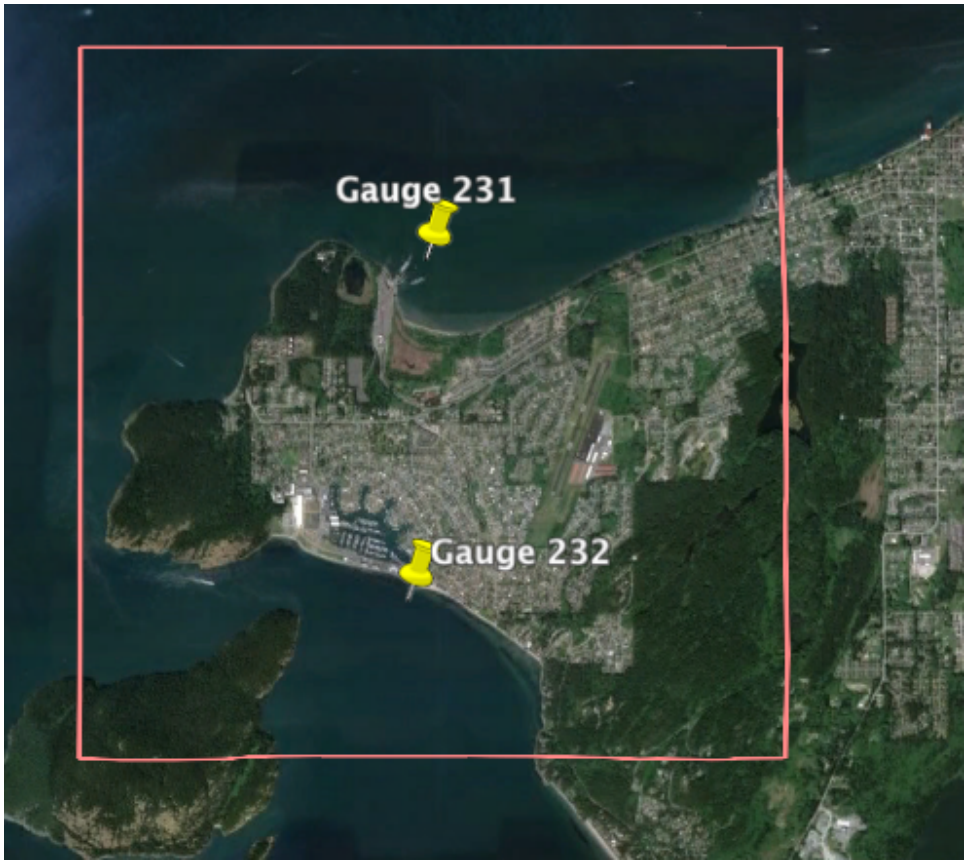

Figure 28: Strait 23 map with computational gauges

View the results plus a movie of Strait 23 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_23/index.html

Interesting Findings:

- Gauge 231, a water location at -14.36 meters at the Anacortes Ferry, had no subsidence or uplift. The largest wave at 118.13 minutes after the earthquake was 4.31 meters above MHW, the initial water surface. The parking lot near the ferry building floods. The housing developments near Channel Marker Ln and Portails Ct, appear to be outside the inundation area of this coarse grid run. A finer resolution would be helpful here.
- Gauge 232, a water location at -13.55 meters, at the entrance to the Skyline Marine Center, had no subsidence or uplift. The largest wave at 111.20 minutes after the earthquake was 5.86 meters above MHW, the initial water surface. There is substantial flooding of the city streets around this Marina as shown in the max Zeta map where the gray line is the 20 meter contour line.
- The Skyline Seaplane Base in the water off the east coast of Burrows Island receives around 5.5 meters of water (above MHW).
- A summary for this region is on the next page.

STRAIT 23

Location Box: x1,x2,y1,y2 = (-122.705278, -122.644722, 48.479722, 48.520278)

Gauges	Longitude	Latitude
231	-1.2267527780e+02	4.8508055600e+01
232	-1.2267694440e+02	4.8488611100e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  116.162383333
minimum of the arrival_time was:  35.5647566667
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  118.86465
min of tzeta was:  107.085545
```

Maximum Zeta Values:

```
max of zeta:  6.11577754
min of zeta:  0.0014692167
```

Maximum Speed Values:

```
max speed = 18.441466
min speed = 0.03069621
```

Maximum Momentum Values:

```
max hs = 239.4902
min hs = 4.5099384e-05
```

Maximum Momentum Flux Values:

```
max hss = 1326.3775
min hss = 1.3843802e-06
```

Minimum Depth Values:

```
max min_depth = 61.034805
min min_depth = -0.0
```

5.26 Strait 24

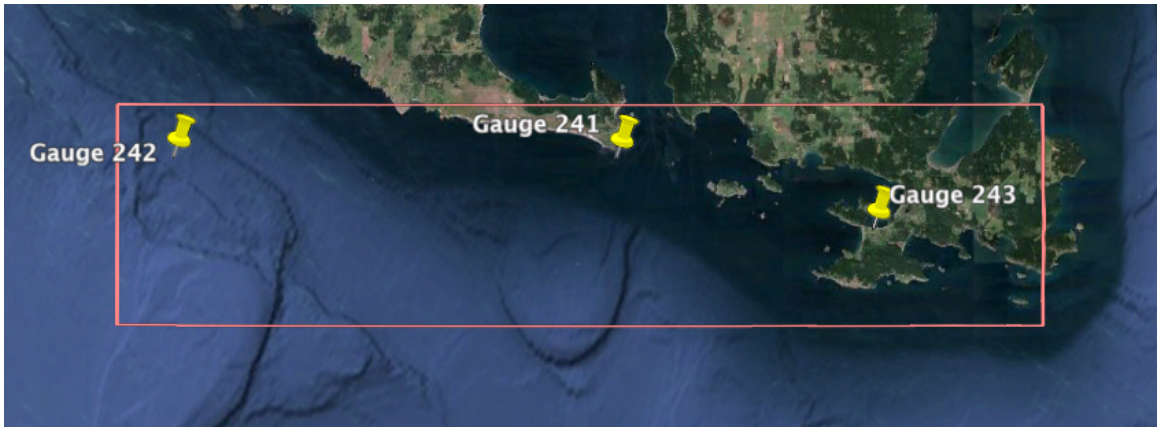

Figure 29: Strait 24 map with computational gauges

View the results plus a movie of Strait 24 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_24/index.html

Interesting Findings:

- Gauge 241, a water location at -10.44 meters off the coast at Cattle Point Lighthouse, had no subsidence or uplift. The largest wave at 117.22 minutes after the earthquake was 2.27 meters above MHW, the initial water surface.
- Gauge 242, a water location at the entrance to Haro Strait at -109.39 meters, had no subsidence or uplift. The largest wave at 94.31 minutes after the earthquake was 3.13 meters above MHW, the initial water surface.
- Gauge 243, a water location at -0.22 meters, had no subsidence or uplift. The largest wave at 100.213 minutes after the earthquake was 4.50 meters above MHW, the initial water surface. This gauge on Lopez Island is near MacKay Harbor Rd and Barlow Bay Rd. The max Zeta map shows there is inundation across this peninsula.
- The max Zeta map show there is inundation at Mud Bay. A finer resolution simulation could determine the extent of this inundation.
- Large speeds, momentum, and momentum flux are recorded between Lopez Island and San Juan Island in the ferry lanes.
- A summary for this region is on the next page.

STRAIT 24

Location Box: x1,x2,y1,y2 = (-123.135278, -122.814722, 48.409722, 48.460278)

Gauges	Longitude	Latitude
241	-1.2296250000e+02	4.8448055600e+01
242	-1.2311583330e+02	4.8448055600e+01
243	-1.2287361110e+02	4.8431944400e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
 maximum of the arrival_time was:  157.040213333
 minimum of the arrival_time was:  17.69917
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  237.934816667
min of tzeta was:  92.4674866667
```

Maximum Zeta Values:

```
max of zeta:  5.3450674
min of zeta:  0.0012177581
```

Maximum Speed Values:

```
max speed = 18.118505
min speed = 0.034335898
```

Maximum Momentum Values:

```
max hs = 1007.4614
min hs = 4.0377982e-05
```

Maximum Momentum Flux Values:

```
max hss = 12055.702
min hss = 1.3864143e-06
```

Minimum Depth Values:

```
max min_depth = 232.89414
min min_depth = -0.0
```

5.27 Strait 25

Figure 30: Strait 25 map with computational gauges

View the results plus a movie of Strait 25 at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_25/index.html

Interesting Findings:

- Gauge 251, a land point at 5.04 meters, had no subsidence or uplift and remained dry through the duration of the tsunami. This gauge is near Somass Drive on Vancouver Island.
- Gauge 252, a land point at 3.12 meters, had no subsidence or uplift and remained dry through the duration of the tsunami. This gauge is near the coast below McAnally Rd.
- Gauge 253, a water location at -125.96 meters in Haro Strait, had no subsidence or uplift. The largest wave at 95.30 minutes after the earthquake was 2.95 meters above MHW, the initial water surface.
- Gauge 254, a water location at -78.57 meters in Haro Strait, had no subsidence or uplift. The largest wave at 94.26 minutes after the earthquake was 2.84 meters above MHW, the initial water surface.
- Large momentum flux, speed, and momentum can be see between Gauge 252 and the Islands off the coast of Vancouver Island (Oak Islands and Discovery Island).
- There appeared to be very little inundation of land in Strait 25.
- A summary for this region is on the next page.

STRAIT 25

Location Box: x1,x2,y1,y2 = (-123.310278, -123.134722, 48.409722, 48.460278)

Gauges	Longitude	Latitude
251	-1.2330694440e+02	4.8429166700e+01
252	-1.2326916670e+02	4.8450833300e+01
253	-1.2316527780e+02	4.8450833300e+01
254	-1.2316527780e+02	4.8416944400e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  97.0989616667
minimum of the arrival_time was:  10.559235
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  225.16645
min of tzeta was:  81.8045216667
```

Maximum Zeta Values:

```
max of zeta:  4.4832351
min of zeta:  0.0054499886
```

Maximum Speed Values:

```
max speed = 8.5279666
min speed = 0.097940455
```

Maximum Momentum Values:

```
max hs = 278.22714
min hs = 0.0011562843
```

Maximum Momentum Flux Values:

```
max hss = 1687.6736
min hss = 0.00019381319
```

Minimum Depth Values:

```
max min_depth = 164.06148
min min_depth = -0.0
```

5.28 Strait Bellingham

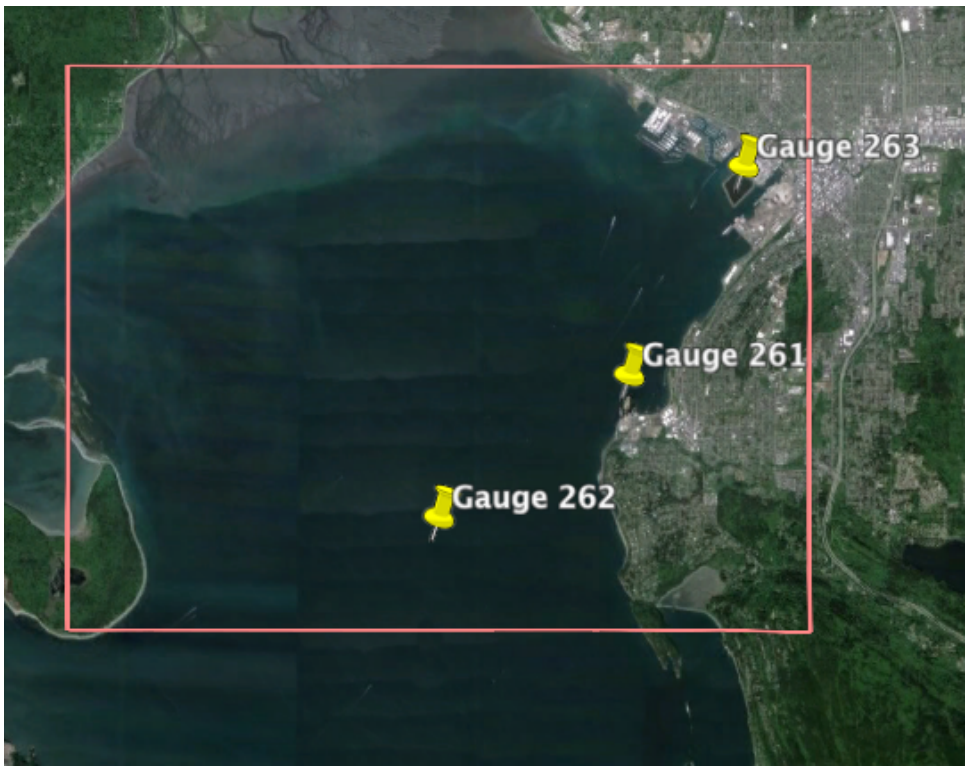

Figure 31: Strait Bellingham map with computational gauges

View the results plus a movie of Strait Bellingham at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_Bellingham/index.html

Interesting Findings:

- Gauge 261, a water location at -15.95 meters at the Bellingham-Ketchikan ferry, had no subsidence or uplift. The 158.48 minutes after the earthquake was 3.94 meters above MHW, the initial water surface. There is flooding inland from this gauge, and the flooding almost reaches the Bellingham Tennis Center, as seen from the max Zeta map.
- Gauge 262, a water location in the entrance to Bellingham Harbor at -31.32 meters, had no subsidence or uplift. the largest wave at 158.68 minutes after the earthquake was 3.46 meters above MHW, the initial water surface. There was increased speed, momentum, and momentum flux near the harbor entrance.
- Gauge 263, a land point at 3.62 meters at Colony Wharf near Bellingham Marina, had no subsidence or uplift. The maximum flow depth arrived at 154.22 minutes after the earthquake and gave 0.64 meters of water above the bathymetry there. There was flooding all along the waterfront inland from Gauge 263 as shown on the max Zeta map. It does not appear that the flooding reaches the Bellingham Health Care facility. A fine resolution simulation is warranted for this area.
- A summary for this region is on the next page.

STRAIT Bellingham

Location Box: x1,x2,y1,y2 = (-122.620278, -122.479722, 48.694722, 48.765278)

Gauges	Longitude	Latitude
261	-1.2251527780e+02	4.8723611100e+01
262	-1.2255138890e+02	4.8705833300e+01
263	-1.2249361110e+02	4.8749722200e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  159.664245
minimum of the arrival_time was:  51.418505
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  161.500013333
min of tzeta was:  149.099286667
```

Maximum Zeta Values:

```
max of zeta:  5.11720111
min of zeta:  0.003824997
```

Maximum Speed Values:

```
max speed = 9.361939
min speed = 0.019583331
```

Maximum Momentum Values:

```
max hs = 81.681646
min hs = 0.00017634597
```

Maximum Momentum Flux Values:

```
max hss = 178.29511
min hss = 8.9991318e-06
```

Minimum Depth Values:

```
max min_depth = 33.689521
min min_depth = -0.0
```

5.29 Strait Victoria

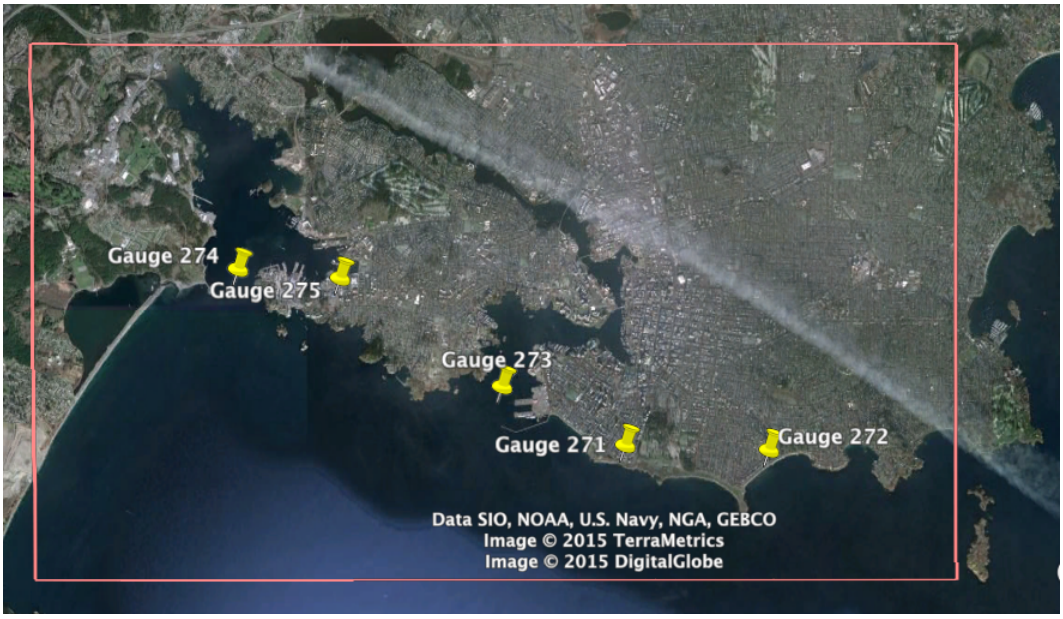

Figure 32: Strait Victoria map with computational gauges

View the results plus a movie of Strait Victoria at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_Victoria/index.html

Interesting Findings:

- Gauge 271, a land point at 13.15 meters, had no subsidence or uplift and remained dry through the duration of the tsunami. This gauge is near the Dallas Rd Waterfront and the Holland Point Shoreline trails. Likewise, Gauge 275, a land point at 15.28 meters, had no subsidence or uplift and remained dry through the duration of the tsunami.
- Gauge 272, a land point at 2.09 meters, had no subsidence or uplift. The maximum flow depth arrived at 80.83 minutes after the earthquake and gave 2.84 meters of water above the bathymetry there. This gauge is located near Dallas Rd., between Eberts St. and Memorial Crescent.
- Gauge 273, a water location at -17.46 meters, had no subsidence or uplift. The largest wave at 81.37 minutes after the earthquake was 5.47 meters above MHW, the initial water surface. This gauge is just past the Breakwater and the Camel Point Heliport at the entrance to Victoria Harbor. This entrance is taken by the Victoria Clipper and the Victoria BC - Port Angeles ferry. The Heliport is inundated with 5.0 to 6.0 meters of water.
- Gauge 274, a water location at -20.60 meters, had no subsidence or uplift. The largest wave at 83.05 minutes after the earthquake was 6.47 meters above MHW, the initial water surface. This gauge is near the Fisgard Lighthouse.
- There is some inundation on land near the coastal areas as shown on the max Zeta map. There were increased speeds, momentum, and momentum flux near the harbor entrances.
- A summary for this region is on the next page.

STRAIT Victoria

Location Box: x1,x2,y1,y2 = (-123.480278, -123.309722, 48.394722, 48.460278)

Gauges	Longitude	Latitude
271	-1.2337194440e+02	4.8409166700e+01
272	-1.2334527780e+02	4.8408611100e+01
273	-1.2339472220e+02	4.8416388900e+01
274	-1.2344361110e+02	4.8430833300e+01
275	-1.2342472220e+02	4.8429722200e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  93.8922
minimum of the arrival_time was:  3.7000095
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  141.888036667
min of tzeta was:  0.0720853416667
```

Maximum Zeta Values:

```
max of zeta:  7.82091227
min of zeta:  0.0
```

Maximum Speed Values:

```
max speed = 11.430717
min speed = 0.0
```

Maximum Momentum Values:

```
max hs = 240.41529
min hs = 0.0
```

Maximum Momentum Flux Values:

```
max hss = 1327.272
min hss = 0.0
```

Minimum Depth Values:

```
max min_depth = 76.157912
min min_depth = -0.0
```

5.30 Strait Friday Harbor

Figure 33: Strait Friday Harbor map with computational gauges

View the results plus a movie of Strait Friday Harbor at 15 minute frames at:
http://depts.washington.edu/ptha/WAcoast/SJdF/Sites/REGIONALS_2sec/Strait_FridayHarbor/index.html

Interesting Findings:

- Gauge 281, a water location at -78.14 meters, had no subsidence or uplift. The largest wave at 113.55 minutes after the earthquake was 2.78 meters above MHW, the initial water surface. This gauge is in the ferry lane to Friday Harbor.
- Gauge 282, a water location at -8.05 meters, had no subsidence or uplift. The largest wave at 114.02 minutes after the earthquake was 2.90 meters above MHW, the initial water surface. This gauge is at the end of the Friday Harbor ferry dock.
- Gauge 283, a water location at -16.72 meters, had no subsidence or uplift. The largest wave at 113.82 minutes after the earthquake was 2.87 meters above MHW, the initial water surface. This gauge is between Brown Island close to the Friday Harbor Seaplane Base.
- Gauge 284, a water location at -18.91 meters, had no subsidence or uplift. The largest wave at 115.02 minutes after the earthquake was 2.92 meters above MHW, the initial water surface. The gauge is at the marina near Albert Jensen and Son's Shipyard.
- Jackson-Beach Road is inundated with 2.5 to 3.0 meters of water.

- The rest of the inundation is very close to the shoreline areas.
- Increased momentum flux, speed, and momentum are observed off the northern end of Turn Island which is close to the ferry lanes.
- A summary for this region is on the next page.

STRAIT Friday Harbor

Location Box: x1,x2,y1,y2 = (-123.030278, -122.964722, 48.509722, 48.545278)

Gauges	Longitude	Latitude
281	-1.2297694440e+02	4.8541388900e+01
282	-1.2301416670e+02	4.8535833300e+01
283	-1.2301194440e+02	4.8539722200e+01
284	-1.2299916670e+02	4.8528611100e+01

Average Subsidence or Uplift:

```
fgmax grid does not overlap dtopo, so no subsidence or uplift
```

Arrival Times of Tsunami:

```
maximum of the arrival_time was:  114.233466667
minimum of the arrival_time was:  26.8552533333
```

Arrival Times of Maximum Zeta:

```
max of tzeta was:  258.074533333
min of tzeta was:  105.675598333
```

Maximum Zeta Values:

```
max of zeta:  3.84381909
min of zeta:  0.022090109
```

Maximum Speed Values:

```
max speed = 12.586695
min speed = 0.033310083
```

Maximum Momentum Values:

```
max hs = 249.78183
min hs = 0.0060830784
```

Maximum Momentum Flux Values:

```
max hss = 1559.4596
min hss = 0.001624337
```

Minimum Depth Values:

```
max min_depth = 129.79617
min min_depth = -0.0
```

6 Recommendations and conclusions

This study consisted of two fine (2/3 arc second - 20.56 meter resolution) simulations, one for Port Angeles and the other for Port Townsend. In addition, we covered the entire Strait of Juan de Fuca with 28 "Strait" areas, and modelled each one with a coarse (2 arc second - 61.67 meter resolution) simulation. These coarse simulations give an appreciation of the extent of inundation, but can not provide answers detailed enough in some instances. Based on the output of this study, we recommend the following Strait areas be considered for fine resolution simulations:

- Strait 3: Sekiu
- Strait 4: Callum Bay
- Strait 10: Crescent Beach
- Strait 11: Lower Elwha Tribal Community
- Strait 14: Dungeness - Sequim
- Strait 15: Near Jamestown
- Strait 17: **Discovery Bay**
- Strait 23: Anacortes
- Strait 26: Bellingham

Discovery Bay had the most land inundation of any of the areas. The extent of this inundation is not known as it exceeded the southern border of the Strait 17 region. A fine grid run is needed where the southern boundary of this region is extended.

Not all the communities in the Strait of Juan de Fuca that could be impacted by the Cascadia L1 earthquake and tsunami were modelled. The San Juan Islands were not modelled in detail. We did not model south of Maristone Island toward and including the Puget Sound and Seattle. Communities East of Straits 18 to 23 were not modelled, for example, Camano Island, Langley on Widbey Island, Oak Harbor and Coupeville. Areas north of Strait 23 up to Bellingham were not modelled. We did, however, model the US coastline of the Strait of Juan de Fuca east to Widbey Island, south to the end of Maristone Island, and north to the southern end of Lopez Island, plus Bellingham and Friday Harbor.

We conclude that the Cascadia L1 earthquake with its subsidence and subsequent tsunami poses a severe hazard to the communities and marine industries in the Strait of Juan de Fuca. These results should aid in the preparation of evacuation maps for the areas at risk.

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