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FINAL

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Provisional statement

This summary includes preliminary data presented at the 2013 Elwha Nearshore Consortium Workshop, 27 February 2013, for informational/educational purposes only. Data herein may be subject to further analysis and results may change significantly. These data therefore should not be cited without review and approval by the co-authors. Contact information for presenters is provided above. For more information contact Anne Shaffer, Coastal Watershed Institute, anne.shaffer@coastalwatershedinstitute.org

Chapter 1. Overview and Introduction

Anne Shaffer, ENC coordinator, Coastal Watershed Institute

Welcome to the 8th annual Elwha Nearshore Consortium (ENC) proceedings. The ENC is a work group of scientists, managers, and citizens first formed in 2004 and dedicated to understanding and promoting the nearshore restoration associated with the Elwha dam removals. We are geologists, hydrologists, oceanographers, biologists, anthropologists, economists, engineers, managers, and landowners. Some of us live locally, others in the Puget Sound corridor, others from as far away as California. Our work is founded on collaboration and good will.

This is the first time the ENC has met since dam removal began in September 2011. After almost a decade of talking about what we need to do when dam removals occur, we are now in the midst of dam removal. The changes underway are literally jaw dropping. The scale of this restoration event is surreal. Nobody anticipated the visual impact of a nearshore restoration project of the scale now underway. This is truly a one is a lifetime event- and exhilarating both personally and professionally for each of us to be at this place and time.

The theme of this day long workshop is gratitude. This project would not be occurring if it were not for the tenacity, dedication, and leadership of the staff of Olympic National Park and the federal ecosystem protection and treaty trust responsibilities that are at the core of this project. It also would not be happening without the leadership of the Lower Elwha Klallam Tribe. As you read these proceedings, remember to be thankful for this project, and to these two entities for persevering for over a quarter of a century to make it happen.

The Elwha nearshore, defined as extending from the area of tidal influence to 30 meters MLLW and including the riparian zone, is large (approximately 12 linear miles), complex (including a embayed shoreline, estuary, feeder bluffs, and spit), and severely impaired ecologically primarily due sediment starvation from shoreline alterations and in-river dams. The dams are now coming out-providing us with an opportunity to optimize the delivery of 100 years of sediment to the nearshore (as of January approximately 20% of the total sediment volume of the project was estimated to be mobilized in the river-the fine material has just begun to reach the river mouth). The other nearshore impairments are still in place-and in fact the city is in the process of considering expanding shoreline armoring-making this Elwha nearshore restoration event temporary in some areas of the Elwha nearshore. If we are to understand, promote, and optimize this restoration event we need to start working harder than ever.

This workshop provides updates of work to date on the Elwha nearshore restoration, and the discussion on we can best inform management needs including sediment fate, ecosystem services of historic, current, and future nearshore, and next steps to understand and optimize this event. Information provided in technical presentations is provisional, and the intellectual property of individual authors. Co-authors contact information are listed by topic-please contact them directly with questions and for permission to cite. Cite Proceedings as:

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Chapter 2: Physical Processes

Elwha River sediment status

Ritchie, Andy, Olympic National Park, Port Angeles, WA.

Synthesized by: Joseph M. MacDonald, WWU student editor

In 2010 when an initial assessment of the amount of sediments at both Lake Mills and Aldwell was performed, it was determined that:

- Total sediment load in both reservoirs would be 24 million yd^3 +/- 4 million yd^3.
- Lake Mills has 20 million yd^3, consisting of ½ clay and silt and ½ sand and gravel.
- Lake Aldwell has a 4 million yd^3, consisting of 2/3 clay and silt and 1/3 sand and gravel.

This has proven to be an underestimate. In 2012, a revised sediment load for both reservoirs has been performed and now the numbers are as follows:

- Total sediment load for both reservoirs would be 34 million yd^3 +/- 6 million yd^3.
- Lake Mills has 28 million yd^3, consisting of ½ clay and silt and ½ sand and gravel.
- Lake Aldwell has 6 million yd^3, consisting of 2/3 clay and silt and 1/3 sand and gravel.

The differences between the 2010 and 2012 data are due to a discovery of error at the Lake Mills site and increased accuracy of the upstream delta extent at Lake Aldwell.

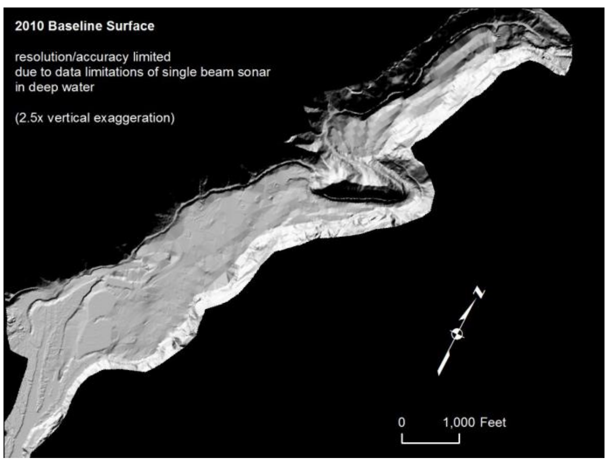
To date, total sediment erosion for both sites is 6 million yd^3, with 4.7 million yd^3 coming from Mills and 1.3 million yd^3 coming from Aldwell. Altogether, this represents about 18% of the total estimated sediment regime. Estimates for total erosion through the end of the project using model outputs are between 13 and 20 million yd^3 (40-60%) of total sediment for both sites.

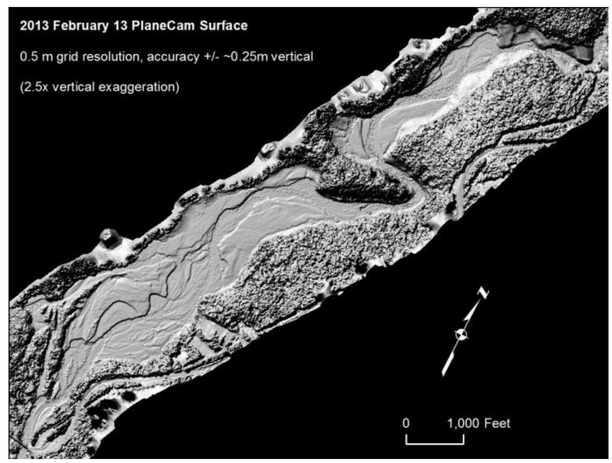
Andy Ritchie showing the PlaneCam mounted to the wing of an aircraft. PlaneCam is one of several methods that Andy has used to monitor sediment loads and movement at both Lake Mills and Aldwell.

Reservoir erosion monitoring required the use of several techniques to get an adequate assessment at both sites, and included the use of PlaneCam Flights, longitudinal profiles, and erosion modeling (Randle

& Bountry). PlaneCam flights used a camera attached to the wing of an airplane that used DSMs for sediment volume and Orthoimages to measure erosion width and active channel locations. Longitudinal profiles provide high accuracy slope measurements that were used for ground-truth of PlaneCam data and used to fill in gaps between flights as needed. Erosion modeling was used to track coarse and fine materials, predict erosion through modeled hydrology, and provide feedback with measured data to refine sediment outputs.

The Elwha dam removal was completed in spring of 2012. Uncertainty in the pre-dam surface limited the precision of the model in determining the sediment load at Lake Aldwell. Using the 2010 "baseline" surface information to calculate erosion sediment volumes, 650,000 yd^3 of sediment have eroded by April 2012, and 1.3 million yd^3 by February 2013.

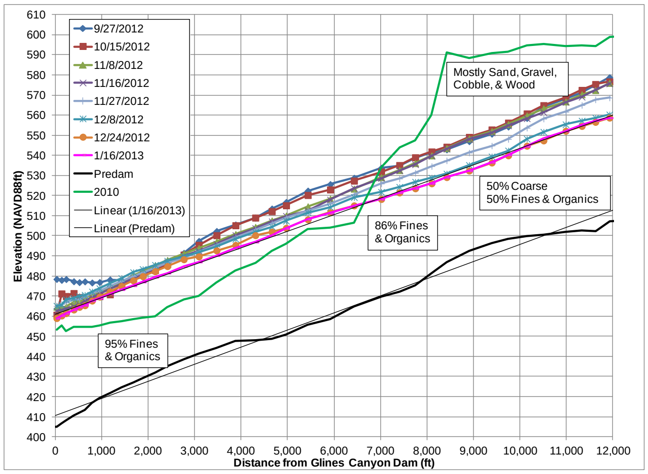




A comparison between 2010 (left) and 2013 (right) images at Lake Aldwell. The 2013 image is more detailed and shows inaccuracies in the 2010 sediment load predictions.

Glines Canyon Dam is now ¾ removed, with Lake Mills completely drained. 17 % of the sediment volume at Lake Mills has left the reservoir, with the remaining sediment having a thickness range of 30-50 feet that will increasingly become silt and clay. As future drawdowns at Glines Canyon Dam occur, this will increasingly expose fractions of fine sediments. To date, about half of the coarse sediment and 15% of the fine sediment has been released.

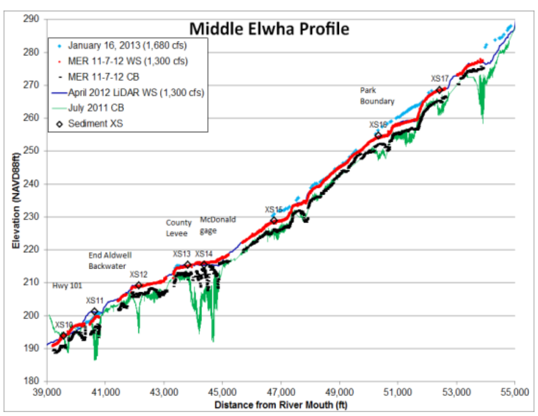
The Elwha's response has been dramatic since the dams' removal. Between March and April 2012, ~0.7 million yd^3 of sediment released from Lake Aldwell have filled in the first few pools and eddies while also depositing organic material at the river's mouth. Between October and February 2012, nearly two decades worth of coarse material and about five years of fine sediment have filled all pools, eddies and most side-channels in five months (~4.7 million yd^3 of material). The river bottom has switched from cobble to a sand and gravel bed with braided reaches. Preliminary estimates have determined that ~0.5 million yd^3 of material are stored in the river and in side-channels.

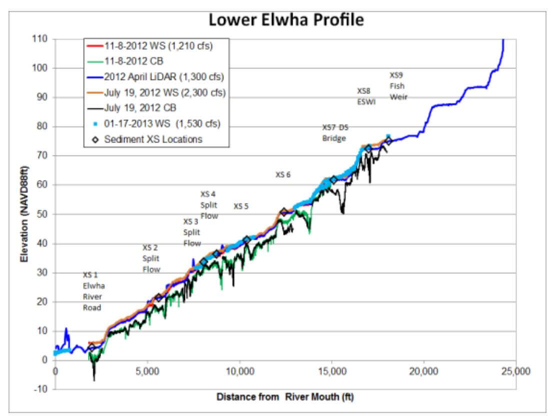


The evolution of the Lake Mills longitudinal profile from pre-dam to 2013 levels.

Middle river responses have been the most dramatic. Currently, all pools have been filled in with sediment, while a coarse sediment wave is propagating slowly downstream. Aggradation of riffle crests are noted as far down as McDonald Gage, while incisions through sediment deposits have started to work their way downstream.

Lower river responses have not been as large as the middle reach. Riffles are still largely exposed with much less evidence of mid-channel bars. Large amounts of sand have made their way to the mouth of the river and are moving into the Elwha drift cell.





Comparison between the Middle and Lower Elwha sediment profiles.

Future drawdowns at Glines Canyon dam will release increasing volumes of fine sediment and smaller volumes of coarse material. The cohesive forces of fine sediment may slow the erosion rates at both sites, especially after the spring melt. The spring melt is expected to move much more sand to the river mouth, and any drawdowns after the spring melt will likely result in the highest turbidity measured in the river to date.

Freshwater Bay and Elwha River mouth sediment and linkages of river and nearshore.

Warrick, Jon[1*] and Guy Gelfenbaum[2]. [1,2]United States Geological Survey, Port Angeles, WA.
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The USGS provides scientific monitoring and assessments of the Elwha River and delta restoration through collaborative, multi-disciplinary investigations of the hydrology, oceanography, sediment transport, geomorphology, and ecology of the Elwha River and its coast. This work is funded by the USGS and an U.S. EPA grant through the Puget Sound Partnership (PSP) and is conducted through collaborative efforts with the Lower Elwha Klallam Tribe, Washington Department of Ecology, University of Washington SeaGrant, University of Washington's School of Oceanography, and the U.S. EPA. Below are brief descriptions of some of the recent work conducted.

River Sediment Discharge and Turbidity. The USGS is monitoring river discharge, turbidity and suspended-sediment concentrations at stations on the Elwha River and has conducted a number of focused surveys and assessments to evaluate site-specific or long-term patterns in Elwha River water and sediment discharge. Three USGS gaging stations are established on the river, and historic and recent data from these stations are available on the USGS National Water Information System (NWIS). A summary of the turbidity and sediment load patterns during the initial part of dam removal were contained in a 2012 article in *Eos*. Real-time data are available from the USGS NWIS website (see: ***www.usgs.gov/elwha***).

River Morphology Surveys. Amy Draut (USGS) leads topographic surveys at numerous river sections, including several across the lower river near the estuary. Surveys conducted in fall 2012 and spring 2013 revealed deposition of sediment that ranged between 10s of centimeters to several meters. While surveying the lower river at the final meander in March 2013, surveyors observed a lack of tidal conditions compared to those observed in the past. This is likely caused by a combination of riverbed aggradation and the new configuration of sediment deposits at the river mouth.

Beach and Nearshore Mapping. Beach topographic, bathymetric and sediment grain-size surveys are conducted twice a year from Freshwater Bay to the eastern most portion of the Elwha delta with collaboration with Washington Department of Ecology, University of Washington SeaGrant, and the Lower Elwha Klallam Tribe. These surveys began in September 2004 and have been used to characterize beach geomorphology and change. Data collected in 2013 revealed that approximately 1.2 million cubic meters of new sediment were deposited near the Elwha River during the 2012-'13 winter. However, the beach east of the river mouth continued to erode at rates of several meters per year.

Benthic Habitat Mapping. Characterization of the nearshore substrate and habitat offshore of the Elwha River mouth during dam removal was conducted in March 2013 using Swath Sonar and underwater video surveys. The 2013 survey replicated similar surveys conducted in 2005 and 2010, which are available in USGS reports (*USGS DS320* and *USGS OFR 2011-1226)*. Preliminary observations from the 2013 surveys suggest that the seafloor around the delta has aggraded with sand, especially in the shallow nearshore (-2 to -8 m water depths).

Coastal Turbidity, Oceanographic Processes, and Nearshore Sedimentation. The release of silt and clay released from dam removal has caused turbidity and nearshore sedimentation. To better understand the nature and dynamics of these sediment plumes, three long-term benthic tripods that measure currents, waves, turbidity, seafloor conditions, and incoming light are deployed offshore of the Elwha River delta, two are placed in 10 m water depth, one at 50 m water depth. Also, a nearshore buoy with CTD salinity and temperature sensor and an OBS turbidity sensor is deployed in Freshwater Bay.

***Scuba Dive Surveys of Nearshore Biological Communities*.** Scuba dive surveys have been conducted since 2008 to evaluate the distribution and variation in nearshore biological communities and how these communities change during dam removal. Scuba surveys are led by Steve Rubin (USGS) and are conducted through collaboration between the USGS, LEKT, WA SeaGrant, and U.S. EPA. Survey techniques are based upon a modification of PISCO methodologies (see www.piscoweb.org for details). During 2008 and 2009, a stratified random approach was used, and results suggested that community structure was partly controlled by substrate type, and four primary habitat types were identified (see: Chapter 6 of *USGS Scientific Investigations Report 2011-5120*). From 2010 to the present, a new scuba survey strategy has been used focusing on repeat annual surveys at fixed stations so that changes in time can be documented. Fixed stations include 12 around the Elwha River delta (at two different depth classes) and 2 control stations away from the river at Green Point. Survey techniques at each site are consistent with the 2008-2009 surveys. Surveys during 2012 revealed that the abundance of kelp was measurably lower at sites near the Elwha River mouth compared to previous years.

***Elwha River Estuary Measurements*.** Monitoring of the Elwha River estuary has occurred with collaboration with the Lower Elwha Klallam Tribe, and includes: CTD instruments in the estuary complex from 2008 to the present to measure water properties, including turbidity; Surface water discharge and sediment concentrations in the eastern estuary; and sedimentation within the estuary from SET stations and topographic surveys. During the summer 2013, the USGS will assist the LEKT in repeating the ecologic surveys of the Elwha River estuary summarized in Chapter 7 of the *USGS Scientific Investigations Report 2011-5120* to identify changes and trends with time.

***Numerical Modeling of the Elwha Nearshore Processes*.** The USGS developed a process-based hydrodynamic and sediment transport model for the Elwha River delta region within the Strait of Juan de Fuca. The model is driven with water levels and waves at the entrance to the Straits. Model calibration and validation are being performed on water levels and tidal currents, and on wave heights, periods, and directions using data collected at two sites off the delta during 2005-2013. Preliminary model results show a complex pattern of strong tidal currents across the delta capable of transporting fine sediment on both flood and ebb tides.

***USGS Mendenhall Postdoc Hired*.** We are pleased to announce that Dr. Melissa Foley has been added to the USGS as a Mendenhall Postdoc. Melissa will be focusing her studies on the implications of the Elwha River dam removals on marine ecosystems, through coordination with project partners at the

USGS, LEKT and UW. Dr. Foley has a Ph.D. in marine ecology from UCSC, and was an early career fellow at Stanford University's Center for Ocean Solutions.

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Beach sediment characterization of, and bluff contribution to, the Elwha and Dungeness drift cells

Parks, David. Washington Department of Natural Resources, Port Angeles, WA.

The objectives of the beach and bluff project in the Elwha and Dungeness Drift Cell are to; 1. Monitor beach topography and sediment texture (grain size) before, during, and after dam removal; 2.Measure historic and recent rates of bluff retreat in the Elwha and Dungeness Drift Cells; 3.Estimate bluff sediment volume contributions (Elwha and Dungeness) to the nearshore using 2001 and 2012 Lidar data; 4. Develop a logistic regression model of bluff erosion to evaluate which environmental factors influence bluff erosion rates.

Our study design follows a BACI Before-After-Control-Impact model where the Elwha drift cell is considered the treatment (impaired) due to dams and shoreline armoring, and the Dungeness is our control.

The Study area encompasses the Elwha drift cell (10 km) and the Dungeness drift cell (13.7 km) in length respectively. We have established 17 Fixed Transects, Elwha (9) and Dungeness (8), where we measure beach topography and grain size and record observations of bluff recession distances and sediment volume contributions over the time period 2001-2012.

Observations

We completed beach topography and grain size baseline surveys (pre-dam removal) of beach topography and grain size distributions so we will be able to detect when changes occur from sediment released from the Elwha reservoirs (2010-2011). These measurements represent a time series of beach profiles before during and after dam removal and document seasonal variability of beach profiles (topography and texture) for volume storage and estimates of cross-shore sediment transport and relate in-fauna communities and forage fish habitat with sediment texture.

The general trend 2010-2012 has been profile lowering 1.5-4.5 feet, especially in the upper-most berm, suggesting continued shoreline erosion in both unarmored and armored cross-sections. Armored beach profiles exhibit vertical change (+/-2 ft.). These armored profiles are super-elevated compared to unarmored profiles. Unarmored beach profiles vary +/- 3 ft. in the upper foreshore area. The low tide terraces display little variation. Beginning in March of 2012 we started to see signs of the arrival of Elwha sediment as far east from the Elwha River as Dry Creek near the Port Angeles landfill.

Sources of bluff recession data include National Geodetic Survey (NGS) survey notes, previous investigations (e.g. USACE, 1971), digitized bluff crest positions from historic aerial photographs, 2001 airborne LiDAR survey data, and 2012 field surveys of bluff geometry with RTK-GPS laser rangefinder and 2012 terrestrial Lidar.

Preliminary bluff recession rates for the period 2001-2012 were for the Dungeness drift cell, maximum observed recession rates of an average of 3.5 ft./yr. In the Elwha drift cell, for armored sections of shoreline the observed maximum average recession rates were 1.0-1.5 ft./yr. while we observed rates of 2.0-3.0 ft./yr. in un-armored sections of shoreline. Recession rates observed east of the City of Port Angeles landfill revetment were 5.0 ft./yr.

Preliminary sediment volume contributions from bluffs for the period 2001-2012 averaged for the Dungeness drift cell were approximately 100 cubic yards/transect and averaged 25 cubic yards/transect for armored portions of Elwha drift cell and averaged 50 cubic yards/transect for unarmored shoreline portions.

Observations of recession rates and sediment volume estimates display strong directional trends from east to west and variogram analysis will be needed to de-trend the data. We believe that this trend is due to the correlation of bluff sediment volumes and bluff height (e.g. taller bluffs produce more sediment volume given the same recession rate as shorter bluffs).

These data are **Preliminary** and will change as we make more measurements in the coming year.

Next Steps:

We will continue monitoring beach topography and grain size-quarterly until Summer of 2014. In the next few months we plan to complete evaluation of Lidar transects and generate summary statistics for recession rates and sediment volume contributions. These data will then be used to populate a logistic regression model of bluff recession and environmental variables (e.g., bluff height, lithology, fetch exposure, wave approach angle, and land-use) that are associated with varying rates of bluff erosion. Finally we will use the boat-based Lidar data collected by George Kaminsky/Heather Baron-(DOE) to refine our near-term bluff erosion estimates.

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Boat based LiDAR mapping of Elwha and Dungeness bluffs

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Synthesized by: Joseph M. MacDonald, WWU student editor

From Dungeness Spit to Freshwater Bay, the Dungeness and Elwha drift cells are of vital importance due to feeder bluffs and their addition of sediments into the marine environment that is used for habitat by a number of species. This all equates out to 47 km of shoreline that are experiencing both high levels of erosion and development. As feeder bluffs erode, homes built along these bluffs threatened. Some homes are now being condemned due their proximity to the bluffs edge and their eventual need to be either moved or torn down due to the instability of the bluff face.

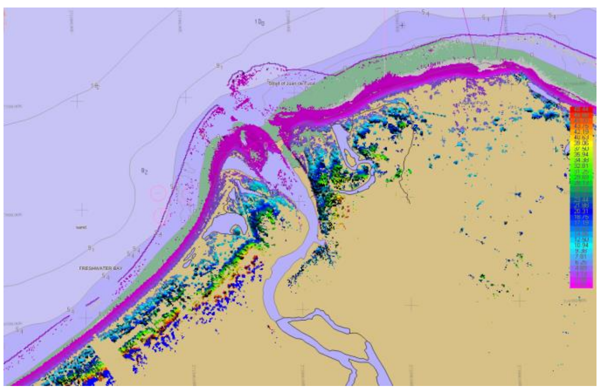
An example of shoreline management and development practices adjacent to feeder bluffs resulting in accelerated bluff erosion. This picture was taken at the Monterra community between MacDonald Creek and Siebert Creek in the Dungeness drift cell.

LiDAR systems used to measure the bluff face has been difficult to ascertain due to the steepness of the bluff face and overhanging vegetation on the edge not allowing for detailed resolution from the air. Instead of using air-based LiDAR measurements, boat-based measurements are used instead at 30-200 m from shore to get more detailed pictures of the bluff face using sideways capture of LiDAR data. While bluff steepness and overhanging vegetation is still a problem with measurements, they are not as difficult to work out.

This study looked to develop a spatial and temporal pattern of bluff erosion in both drift cells while supporting local shoreline management and decision-making policies related to bluff erosion processes in terms of short-term failures and long-term mean erosion rates. This would be done using high-resolution surveys along the Elwha and Dungeness drift cells in order to provide:

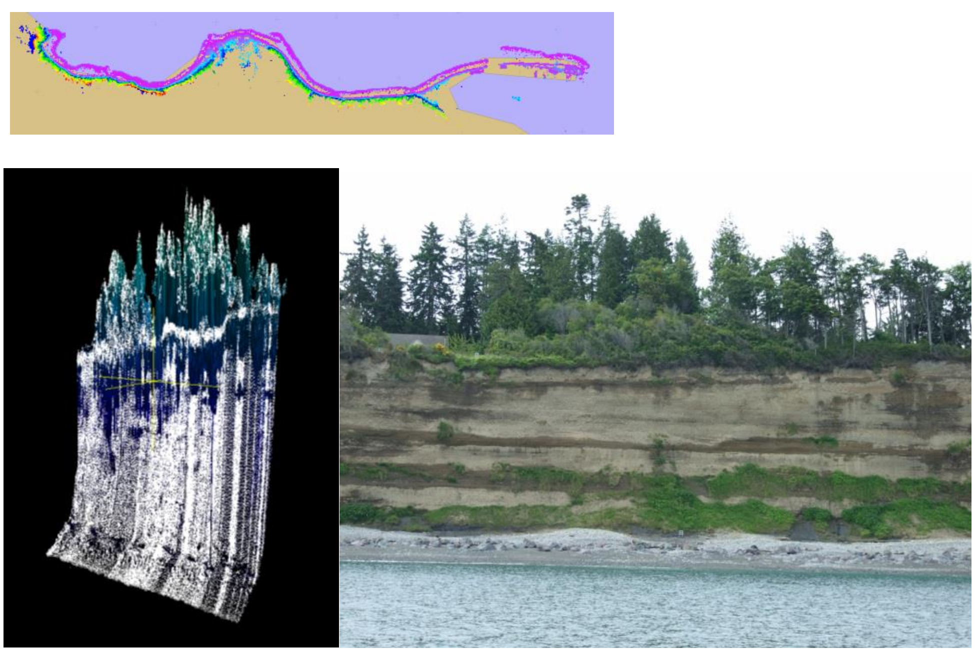
- Essential baseline data on bluff and beach topography.
- Quantitative metrics that document the contemporary state of the bluff and beach, and
- Quantitative short-term change rates and volumes to compare to long-term shoreline change trends.

Three regions are prioritized has areas of concern for bluff development with 42 targets that are surveyed along the shore. Targets are placed at the top and bottom of the bluffs for measurement purposes, and are spaced between the areas of concern to get an accurate picture of the rate of erosion.



Example of raw data being collected by the LiDAR system of the Elwha River mouth.

Photo mosaics captured on the boat can be used in conjunction with the data gathered by LiDAR to determine what is actually the bluff face and what is vegetation in order to get a more accurate portrait of the rate of erosion.



Example of a Laser point cloud (top), LiDAR image (bottom left), and photo mosaic (bottom right) of the same area between Ediz Hook and the Elwha River mouth.

Repeated surveys will be needed to quantify bluff erosion along with data comparisons of material gather by different groups, including Dave Parks, in order to determine the amount of bluff erosion over time. Looking at the data, a determination of which areas of bluff are eroding faster and how is it responding to various pressures such as upland development, precipitation and runoff, or wave undercutting is needed to best determine short- and long-term management. Determining bluff processes with various pressures will allow for better management practices as far as allowable development near bluffs and what to do with areas that are already developed.

Sediment mapping offshore of Elwha

Ogston, Andrea*, Chuck Nittrouer, and Emily Eidam. University of Washington, School of Oceanography. Seattle, WA. *Corresponding author.

Since November 2011, we have been conducting field studies of fine-grained sediment dispersal offshore of the Elwha River mouth under an NSF grant. This work builds on 2008 baseline studies of the same area funded by NSF and Washington Sea Grant. This presentation reviews sampling goals and latest preliminary results.

The study area for this project is the submarine Elwha Delta, a bathymetric high in the Strait of Juan de Fuca which extends roughly 2-5 km north from the Olympic Peninsula shoreline to water depths of roughly 30–60 m. The study area extends into Freshwater Bay to the west, Ediz Hook to the east, and toward the central portion of the Strait (to depths of up to 160 m) to the north. Since November 2011, we have conducted four primary surveys from the R/V Barnes and three secondary surveys from other vessels to collect seabed grab samples, water-column CTD measurements, water samples (mostly from the surface—particularly the surface sediment plume generated by the river), and some videos of the seabed. These cruises have also facilitated the deployment of two instrumented tripods, which collect data from the bottom boundary layer for 2–4 mo. periods. One tripod has collected data nearly continuously since November 2011, and a second tripod has been deployed during periods of elevated river discharge (i.e., spring freshet and fall/winter storms). Tripod instruments include optical and acoustic sensors for measuring water velocity and suspended-sediment concentration, a CTD for measuring water temperature and salinity, sediment tube traps, and video systems.

Sediment from the Elwha River enters the ocean as part of a fresh, buoyant surface plume, but then aggregates and settles to the seafloor where waves and tidal currents resuspend and transport material. Currents across the submarine delta are strong (up to 1 m/s as measured by our instruments) and capable of moving clays, silts, and sands. Baseline studies and grab samples from November 2011 showed that the majority of the submarine delta surface was covered by a coarse lag layer—i.e., a layer of coarse sand, cobbles, and boulders that protect underlying sediment from further erosion. The goal of our study is to characterize the sediment transport mechanics and pathways in this system.

Key results of our work to date include observations of the surface plume, re-suspension near the bed, and seabed grain-size changes. River sediment loads have increased significantly throughout the first 16 months of the deconstruction project, leading to increasing surface plume concentrations. In November 2011, maximum plume concentrations were 0.07 g/L, and in November 2012 (after a rainstorm), we measured sediment concentrations up to 2.1 g/L. Despite increasing concentrations, however, the plume has remained thin (i.e., less than 2 m thick) throughout the project (figures 1 and 2).

After peaks in river sediment discharge, we saw elevated re-suspension signals at the seabed almost immediately. These signals persisted for weeks after the river activity diminished, suggesting that material was cycled through temporary deposition and re-suspension across the delta by tidal currents and waves before ultimately migrating elsewhere. Relative concentrations of sediment moving near the bed in suspension increased from November 2011 to November 2012, suggesting an increase in re-suspendable material on the seabed due to dam deconstruction. Based on water velocity measurements, it appears that the bulk of this material is moving northeastward from the tripod sites. Seabed samples collected in November 2011, April 2012, June 2012, and November 2012 showed persistent sands and gravels beyond ~15 m water depth, while the substrate in shallower water and near the river mouth showed increasing sand and mud fractions in June and November 2012 (see figures 3 and 4). A new sandbar growing at the river mouth will preclude boat-based sampling of some nearshore sites in the future.

Between now and early 2014, we plan to conduct four additional ship-based surveys and accompanying instrument deployments. Further data processing will explore the mechanics of how sediment moves on daily and weekly time scales, and examine sediment fluxes (from the instrument locations)

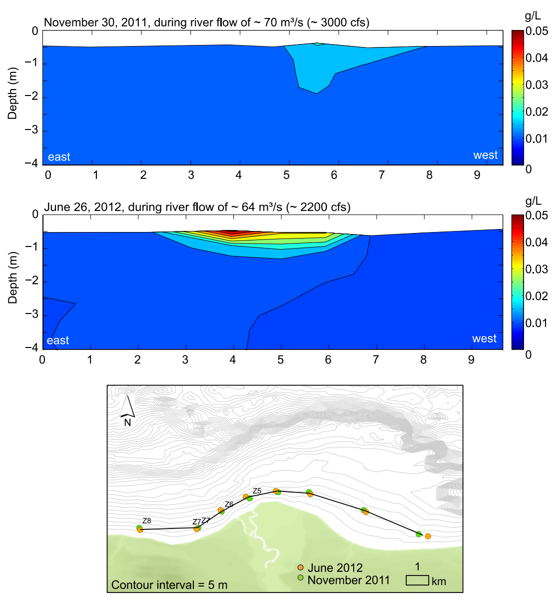


Figure 1. Water-column suspended-sediment profiles from a shore-parallel transect, November 2011 and June 2012. Although sediment concentrations increased, plume thickness did not. Note that the river flow regimes were similar for both measurements.

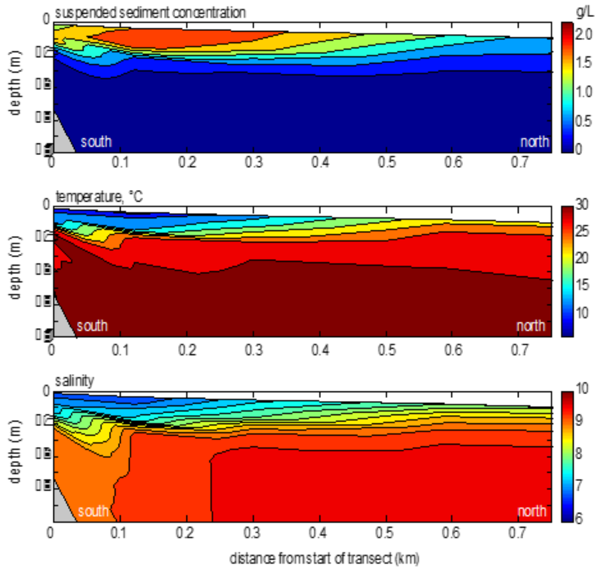


Figure 2. Shore-perpendicular suspended-sediment profile measured one day after a rainstorm in November 2012. Note the thin surface plume.

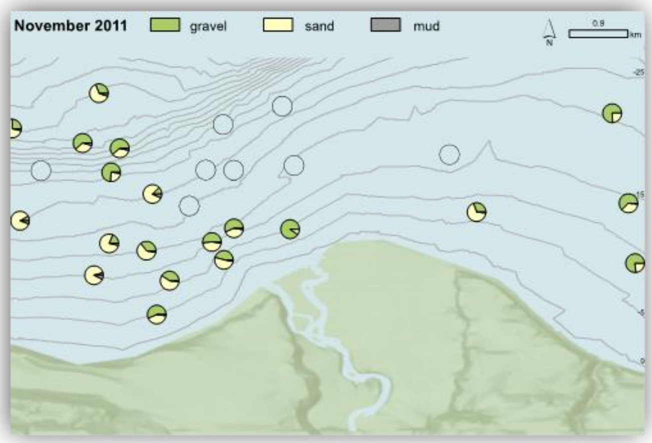


Figure 3. Seabed grain size measured from grab samples collected in November 2011. Note the predominance of gravel and sand. Open circles represent failed samples, suggesting very coarse material on the bed.

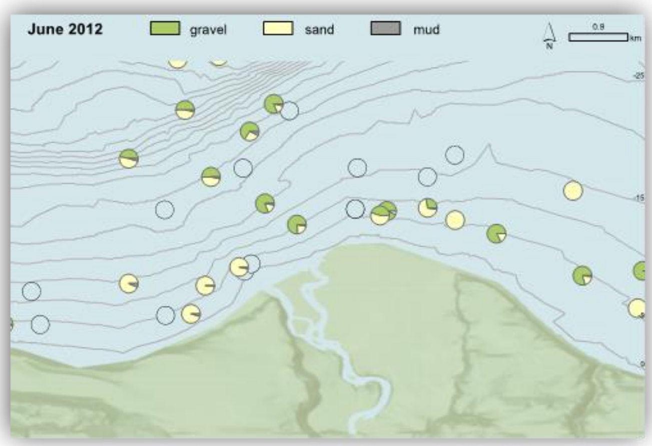


Figure 4. Grain-size measurements from June 2012 grab samples. Note the increasing sand fractions west of the river mouth and persistence of coarse material throughout the rest of the study area.

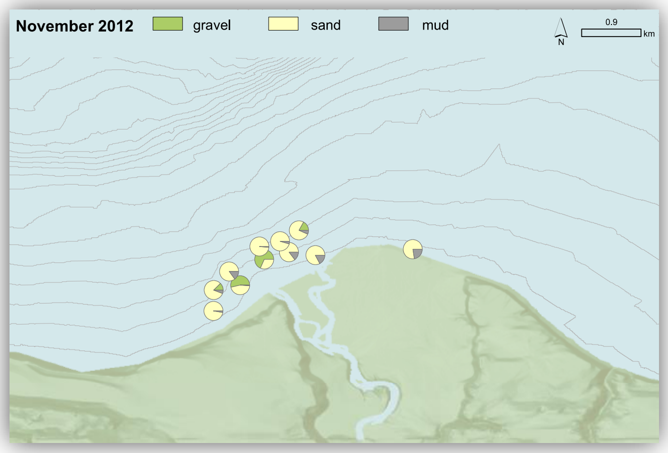


Figure 5. Seabed grain size measurements from grab samples collected in November 2012. Note the increasing sand and mud fractions near the river mouth compared to the November 2011 data. Substrate beyond sample points is presumed to be coarse.

Chapter 3: Biological

Subtidal surveys.

Rubin, Steve* and Nancy Elders. United States Geological Survey, Seattle, WA. *Corresponding author.

Due to the wishes of the authors, this presentation will not be added to this year's proceedings. If you wish to inquire about this study, please contact either Steve Rubin or Nancy Elders. For similar study information, review Jon Warrick's study in Chapter 2.

Long-term juvenile fish use of the Elwha west estuary

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The goals of this study are to determine the long-term juvenile fish use of the central Strait of Juan de Fuca nearshore, including the Elwha nearshore, and to provide pre-dam removal baseline information for Elwha nearshore. The study is based on the Elwha nearshore restoration strategy developed via the Elwha Nearshore Consortium (Shaffer et al 2008). This study began in 2007. Elwha dam removal has been underway since September 2011. We therefore have four years of pre-dam removal, and to date almost two years of post-dam removal data. This paper provides updates to our ongoing monitoring and highlights on our first indications of restoration response in fish use of the Elwha nearshore.

Sampling is conducted monthly in the Elwha west estuary and the comparative site, Salt Creek estuary. Sampling consists of two beach seines at each site. All fish collected are identified to lowest possible taxonomic level and counted. The first twenty of each species are measured to nearest full mm. Salmon are visually assessed for fin clips, hatchery origin fish are externally marked with a clipped adipose fin and all intact adipose fish represent natural origin. All salmon are also scanned for pit tags (collaborative information for Pess et al study).

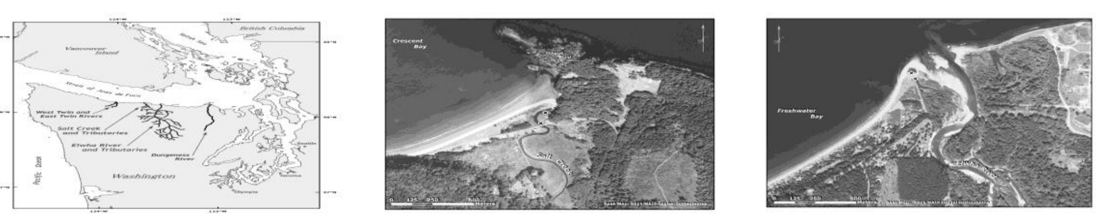

Figure 1. Long term fish use study sites. Figures provided by Terry Johnson, WDFW.

The species richness for both sites show consistent seasonal variation (Figure 2). Total number of fish for both the Elwha west and Salt Creek estuaries also shows high seasonal variation, with 3-spine stickleback (*Gasterosteu aculeatus*) observed as the most abundant fish in Elwha west estuary and shiner perch (*Cymatogaster aggregate*) in Salt Creek (Figure 3)

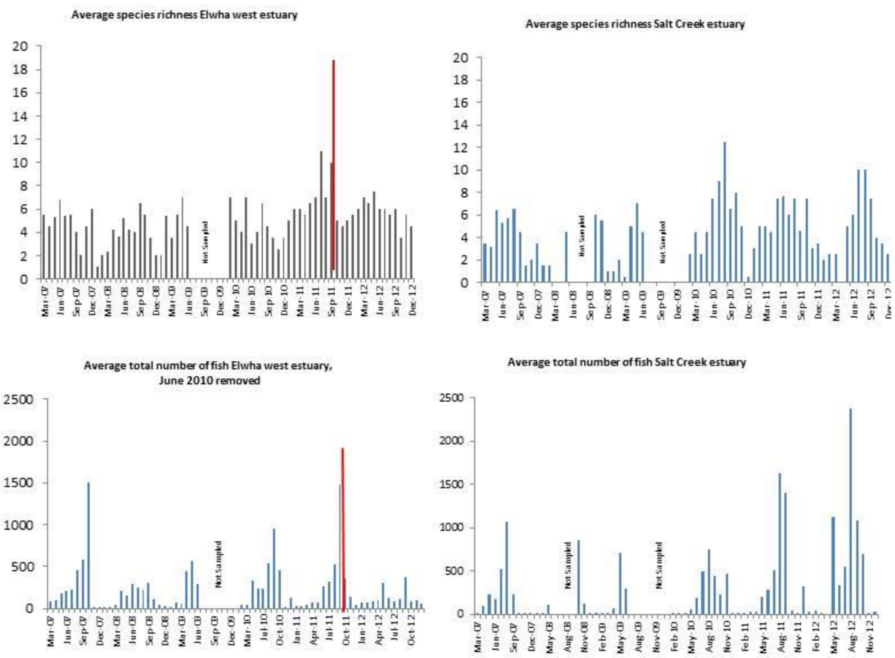

Figure 2. Average species richness and total number of species, Elwha west and Salt Creek estuary 2007-2012. Red line indicates dam removal project

In the Elwha west estuary, the Chinook salmon (*Oncorhynchus tschawytscha)* was the dominant salmon, from 2007-2010 (Figure 3). Since dam removal began in 2011 we have observed lower numbers and percent abundance in juvenile Chinook salmon, and a slight increase in the percent abundance of juvenile coho salmon (*Oncorhynchus kisutch*). Juvenile chum salmon (*Oncorhynchus keta*) appear persistent during pre-dam and post dam removal. Also of interest is the observation of juvenile smelt in the Elwha west estuary during late winter months in 2008 as well as 2012. While the freshwater species redsided shiner (*Richardsonius balteatu*) and prickly sculpin (*Cottus asper*) were not consistent prior to dam removal we have observed a consistent increase in numbers of these fish in the Elwha west estuary since dam removal began in 2011. We are not seeing similar observations in the comparative Salt Creek estuary.

Elwha	2007		2008*		2009*		2010*		2011*		2012	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Total fish	5169		5163		3055		8908		2307		2074	
Chinook	1942	31%	1904	36%	917	31%	5663	66%	361	15%	171	8%
Coho	337	5%	325	6%	439	15%	1493	13%	454	19%	484	22%
Chum	180	3%	103	2%	200	7%	161	1%	31	1%	102	5%
Cutthroat	66	1%	30	1%	6	0%	1	0%	6	0%	11	1%
Steelhead	7	0%	1	0%	2	0%	3	0%	13	1%	29	1%
Smelt (juv = 50-120)	3	0%	38	1%	3	0%	3	0%	3	0%	51	2%
3-Spine stickleback	1334	21%	2079	39%	1210	42%	1094	9%	1073	44%	628	29%
Staghorn sculpin	636	10%	491	9%	236	8%	372	3%	205	8%	166	8%
Prickley Sculpin	166	3%	29	1%	6	0%	93	1%	136	6%	332	15%
Redside Shiner	0	0%	0	0%	0	0%	0	0%	3	0%	83	4%
Starry Flounder	498	8%	163	3%	36	1%	26	0%	22	1%	17	1%

Salt Creek	2007		2009**		2010		2011		2012	
	Total	%	Total	%	Total	%	Total	%	Total	%
Total fish	17748		1964		4376		7288		12029	
Chinook	21	0%	0	0%	0	0%	0	0%	0	0%
Coho	372	2%	713	33%	313	6%	414	5%	2543	20%
Chum	502	3%	31	1%	34	1%	24	0%	126	1%
Cutthroat	92	0%	11	1%	20	0%	19	0%	23	0%
Steelhead	2	0%	1	0%	13	0%	0	0%	0	0%
Smelt (juv = 50-120)	2	0%	0	0%	0	0%	594	8%	3	0%
Starry Flounder	44	0%	13	1%	71	1%	37	0%	35	0%
3-Spine stickleback	982	5%	195	9%	201	4%	35	0%	29	0%
Shiner perch	12780	66%	583	27%	2970	61%	5421	72%	8243	66%
Staghorn sculpin	2943	15%	417	19%	753	16%	733	10%	1017	8%
Prickley Sculpin	8	0%	0	0%	1	0%	11	0%	10	0%
Redside Shiner	0	0%	0	0%	0	0%	0	0%	0	0%

Figure 3. Percent abundance by species in the Elwha west estuary and comparative Salt Creek estuary, the red line indicates dam removal kick off (September 2011).

Since the of dam removals began, bull trout (*Salvelinus confluentus*) observations increased slightly from an average of 1 fish yearly to an average of 2-4 fish yearly to date, and the size distribution indicates smaller fish, averaging   40-50mm. With dam removals we have also observed a decrease in number of cutthroat (*Oncorhynchus clarki*) and an increase in number of steelhead (*Oncorhynchus mykiss*).

Forage fish species surf smelt (*Hypomesus pretiosus*) and sand lance (*Ammodytes hexapterus*) spawn along intertidal coarse sand and fine beaches. The Elwha nearshore supports only a few surf smelt spawn areas and one sand land spawn area, and has been documented to have less suitable habitat than comparative drift cell for forage fish spawning (Parks et al, 2013). With the advent of dam removals, appropriate size material has begun accumulating along Elwha nearshore beaches (details are provided in Parks and Warrick discussions in physical processes section). We are therefore conducting forage fish spawn surveys in the Elwha nearshore. We sample for surf smelt spawn during July-September and sand lance spawn during November – February.

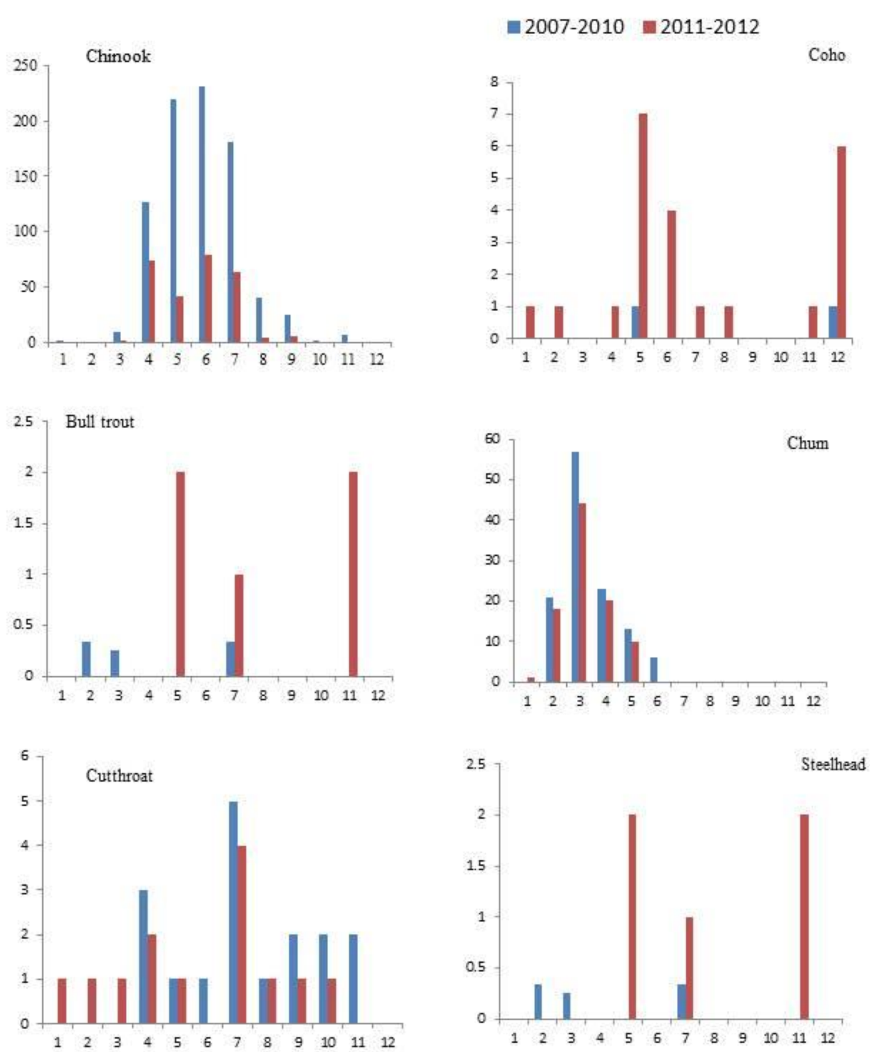

Figure 4. Average monthly abundance of dominant salmon species of Elwha west estuary, 2007-2012. Dam removals began in Sept 2011. Blue is 2007-2010; Red 2011-2012

Date	Site	Species	# of samples	# of eggs
9/2012	Elwha Bluffs	Surf smelt	8	1
12/2012	Elwha bluffs	Pacific sand lance	9	0
12/2012	Freshwater Bay	Pacific sand lance	8	0
1/2013	Elwha bluffs	Pacific sand lance	10	0
1/2013	Freshwater Bay	Pacific sand lance	12	0

Figure 5. Forage fish sampling sites, sampling dates, sample numbers and

In conclusion, our preliminary analysis indicates a restoration response in the juvenile fish use of the Elwha estuary is underway, and to date includes a decrease in the total number of fish, fewer Chinook, higher abundance of coho, steelhead and bull trout, and a change in species percent composition to a lower proportion of Chinook, higher proportion of coho, as well as the addition of new species of prickly sculpin and redsided shiners, which are not estuary species.

Future work. Our long term fish use of the Elwha nearshore will continue. We have added two of the newly formed estuarine features of the Elwha west estuary to our fish use sampling study. We will continue our monthly seining of the Elwha west and comparative estuary, and surf smelt and sand lance spawn surveys of the Elwha and comparative drift cells. Based on nearshore sediment delivery predictions by Bureau of Reclamation and others we anticipate five years of restoration 'response' in fish use of the Elwha nearshore followed by at least five additional years of 'recovery' of fish use of the Elwha estuary. We are building our hypothesis on future juvenile fish use now.

Acknowledgments. Funding for this work is provided by EPA, WDFW, Olympic Peninsula Chapter Surfrider Foundation, Patagonia, and the Clallam Marine Resources Committee.

New estuarine feature in the Elwha west estuary, March 2013.

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Large Woody Debris in Elwha nearshore

Rich, Sam. University of Illinois, Urbana, IL.

Large Woody Debris (LWD) is an important part of the marine ecosystem as it's a base component of physical processes that form critical habitats for numerous fish species such as endangered salmon and their forage fish (smelt and sand lance). The Elwha drift cell has been starved for close to a century as the dams, dikes, and shoreline armoring along it have kept back not only sediment, but also the large wood that would have naturally made its way into the Strait of Juan de Fuca. Little is currently known about LWD in nearshore systems. With removal of the Elwha and Glines Canyon dams, begun in September 2011, there was a need to define baseline parameters of LWD to establish benchmarks and to use in comparison with other drift cells. These will help with predictions of the Elwha's future state as well as inform potential restoration actions in the Elwha nearshore.

This study examines unmodified comparable landforms as well as accessing the historical information available about the Elwha's pre-dam state. Questions addressed:

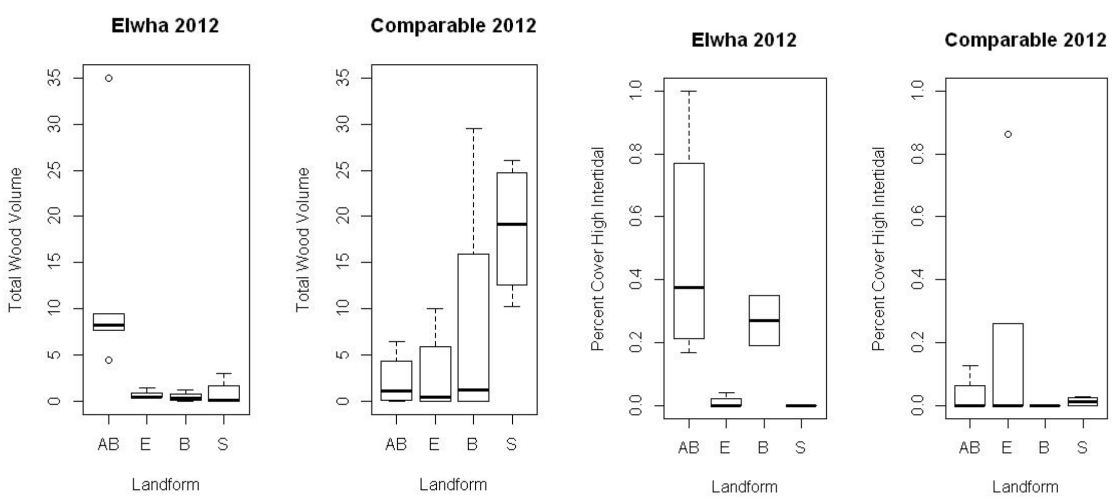
1. What is the current LWD of the Elwha nearshore? and;

2. What are some of the key relationships between nearshore habitat, including beach habitat areal extent and sediment composition, which Large Woody Debris provides?

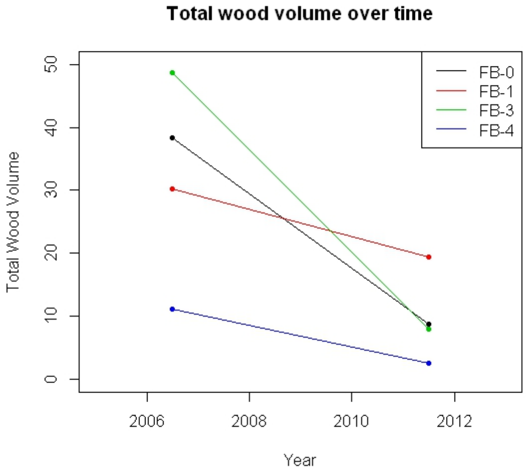
Key sampling parameters include a qualitative description of LWD with an emphasis on location on the beach, general composition, configuration and size. Linkages between LWD's biological functions within the intertidal Elwha nearshore are also illustrated.

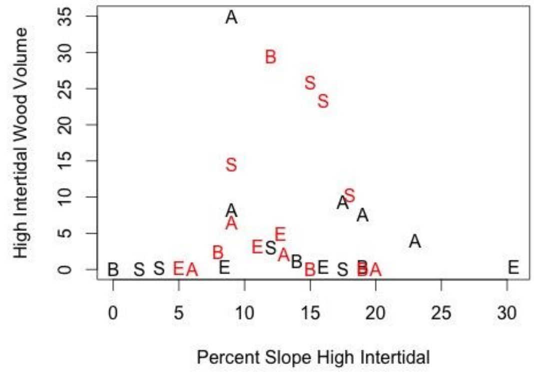
Some Quantitative Findings:

- Wood volume (m^3) between drift cells was significantly different for the spits
- Wood volume on accretion beach in Elwha drift cell has declined over short amount of time
- Riparian vegetation was not related to total wood volume present
- Effect of beach slope was also negligible



A or AB=Accretion Beach, E=Estuary, B=Bluff, S=Spit





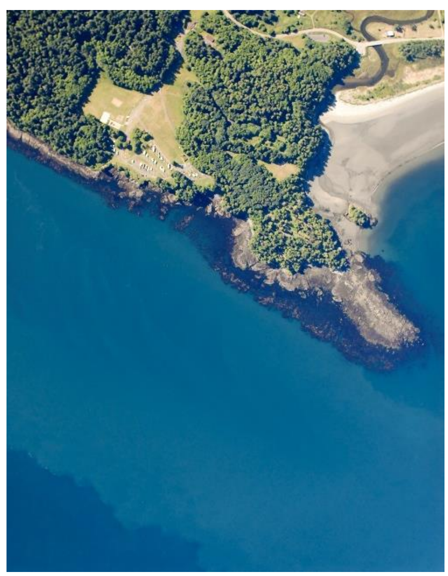
Black letters are in the Elwha Drift cell, while red letters are in the Comparable Drift cell.

Chapter 4: Habitat Mapping

Long-term Kelp Monitoring

Barry, Helen. Washington Department of Natural Resources, Olympia, WA.

Synthesized by: Joseph M. MacDonald, WWU student editor

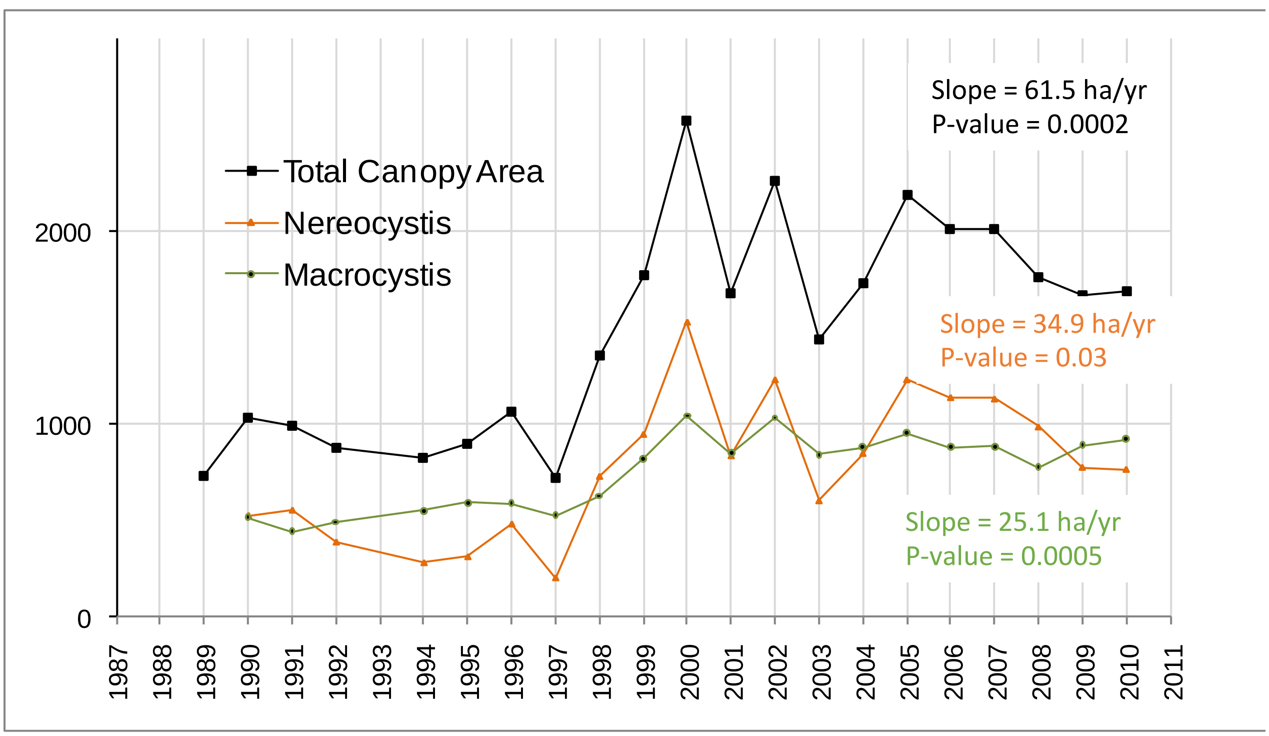


With large increases of sediment from the Elwha River into the emergent marine environment, kelp species are being impacted in a number of ways. Species are experiencing burial/scour which is decreasing available hard substrate on which to anchor themselves, and increased water turbidity lowers available light in the water column for the kelp to use for growth.

Kelp refers to large brown algae (order *Laminariales*), of which 24 species reside in Washington State making it the most diverse kelp community in the world. Floating or canopy-forming kelp are the most recognizable types of kelp within the region, forming dense mats of kelps used for habitat by a large number of species. Stipitate species are another well formed group with a stiff stipitate that adheres to a rocky substrate and has leaves raised into the water column. Prostrate kelps have large fleshy blades that trail their holdfasts attached to the rocky substrate.

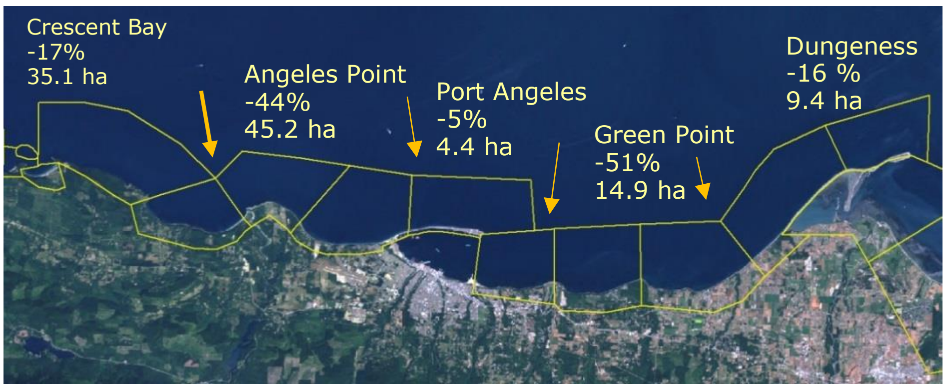
Floating kelp is measured using aerial photography, while prostrate and stipitate kelps are measured with towed, underwater videography. Near-vertical aerial photography collected along coastline areas during early fall (Sept) during clear sky days to limit visibility obstructions. Data has been collected annually since 1989.

Example of near-vertical aerial photography used to map the density of floating kelp densities at the Crescent Bay in Sept, 2012



The data shows that kelp is highly variable annually. One of the possibilities for this large-scale variability is due to temperature variability. The lowest total canopy area is correlated with the warmest El Nino cycle in 1997, while the highest total canopy cover is correlated with a low La Nina event in 2000. Other variables need to be considered and compared with other regions.

Canopy cover measurements were divided into 3 monitoring regions along the Washington State coast; the outer coast, and the western and eastern straits. The outer coast is increasing in many sections, but has an extreme oscillation year-to-year. These increases could be attributed to the return of sea otters to the marine environment. The Eastern Strait has very little kelp, and in areas where it is established, is experiencing little increase. The Eastern Strait includes the Elwha. The Western Strait has the most increased sections with the highest canopy cover overall that is fairly consistent each year.



Changes in floating kelp densities 2011-2012

Looking at data with sharp decreases in separate cells within the Eastern Straits data set, it has yet to be determined whether the decreases were caused by some seasonal variability or whether it is linked with sediment transfer from the Elwha River.

Towed underwater videography uses transects that start near the coast and work out. 6 areas, including Crescent Bay, Freshwater Bay, Elwha Bluffs, Ediz Hook, Dungeness Bluffs, and Dungeness Spit were used for these surveys to determine kelp density. Every fifth frame of video is analyzed to determine the numbers of various types of kelps. This is a rough measure that allows for high samples and large study areas. Vegetation was determined to be alive if it had at least 1 blade.

Video before the dams' removal shows a vibrant kelp community with a rocky substrate has been replaced with a silty substrate and sparse vegetation. Vegetation in the video is classified as present/not present and densities are divided into low (<33%), medium (33-66%), and high (>66%) cover. In all areas around the Elwha River, the measurements have gone from highs to lows in all transects, with medium densities showing near similar distributions in all but 2 transects.

More analysis is required to compare changes in kelp by area and depth ranges along with continued data collection of kelp populations and monitoring of the sediment plume to see how that affects light distribution.

Long-term seagrass mapping

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*Corresponding author.

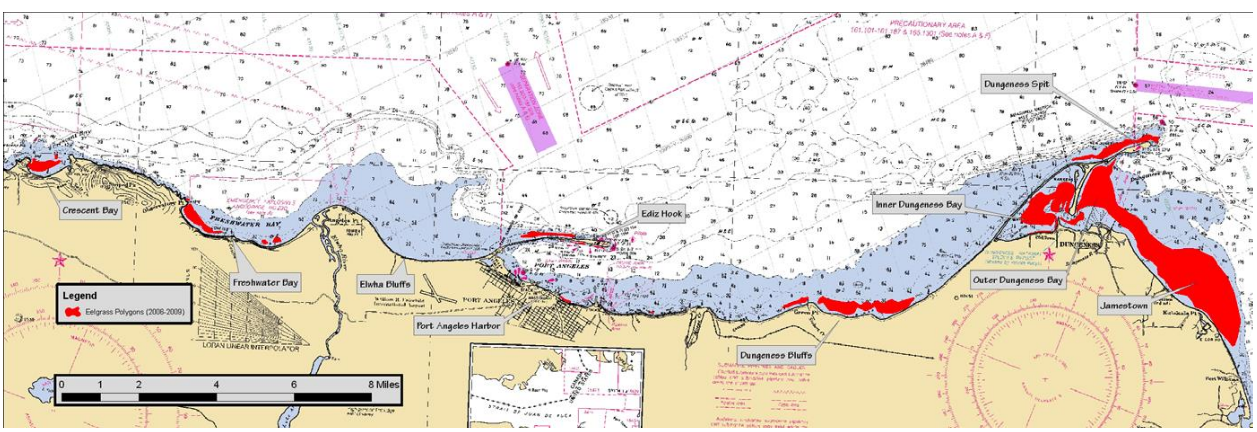
Synthesized by: Joseph M. MacDonald, WWU student editor

Seagrass densities can be affected by the Elwha River due to increased sedimentation causing smothering or increased turbidity reducing light levels in the water column. These affects should only a short term, as long term affects will include the creation of sandy beaches and a change in inter- and subtidal substrates for eelgrass growth.

Eelgrass is a vascular plant that reproduces through flowers and rhizome extensions. The best known seagrass in Washington State is Eelgrass (*Zostera marina L.*), but there are 4 other related species in the state. 3 species of surfgrass is also present in in Washington State, and attach themselves to rocks rather than have roots in sandy substrates, and tend to prefer high energy areas.

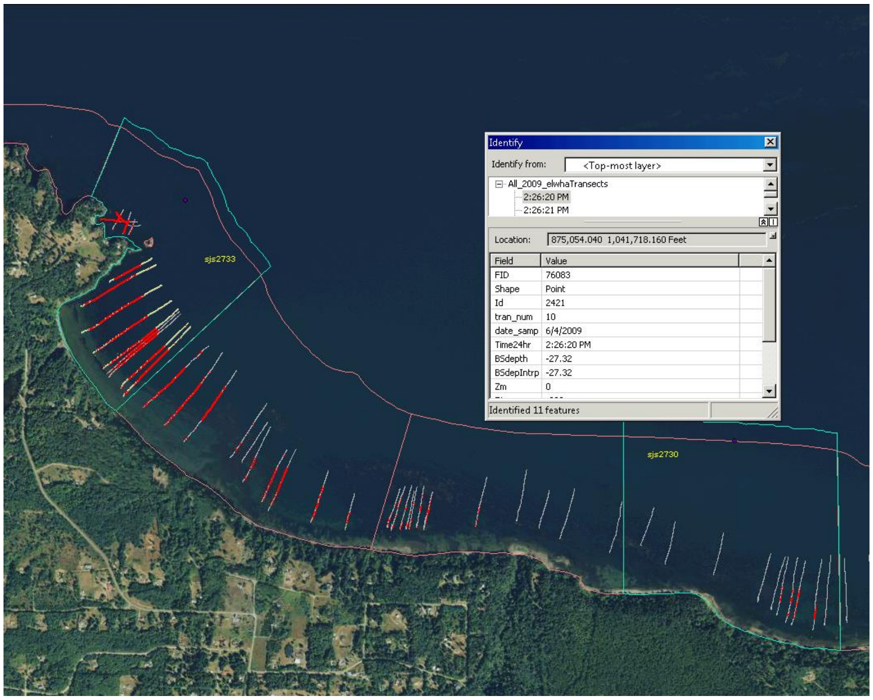
Surfgrass and eelgrasses are important for a number of functions and values that include:

- Primary production
- Nutrient cycling and storage
- Oxygen production
- Physical structure
- Epibenthic and benthic production
- Supports intricate food webs
- Improves water quality
- Stabilizes sediment and reduces shoreline erosion
- Can sequester carbon

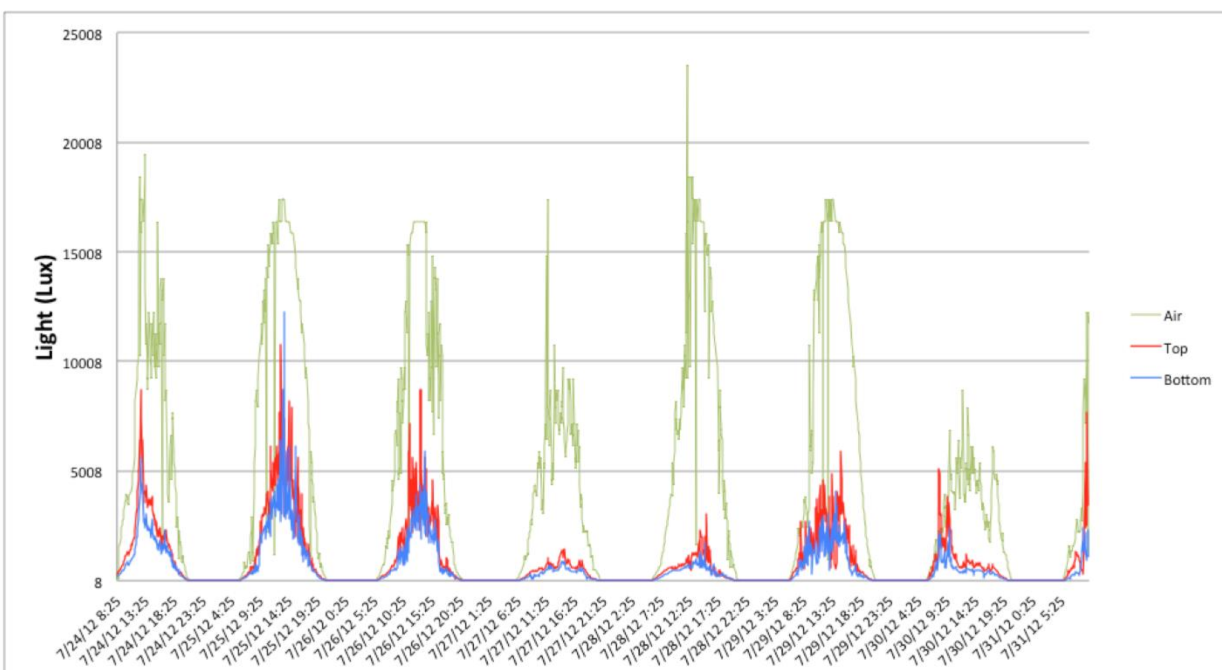


Eelgrass distribution east and west of the Elwha from 2006 to 2009. Eelgrass beds are shown in red.

Eelgrass beds are not in continuous bands, but tend to be in clumped distributions along the coast. These beds are monitored using underwater videography that measures at least 1 rooted shoot in a 1 m^2 area. Monitoring is measured as a present/absent terms along the transect lines.



Example of data collected by underwater videography showing presence (red) or absence (white) along transects in Freshwater Bay in 2009.



Light distribution pattern due to the sediment plume from the Elwha River.

Decreases in light due to the sediment plume from the Elwha can be expected to interfere with surf and eelgrass densities due to light limitations. This sediment plume is far reaching, and has travel as far west as Crescent Bay, though it tends to move towards the east. Of all of the study sites being monitored, only a few sites have shown an increase in seagrass densities while a majority of them continue to remain fairly stable.

Chapter 5: Nearshore Management

Ecosystem Services of the Elwha Nearshore

Flores, Lola* and Jennifer Harrison-Cox. Earth Economics, Tacoma, WA. *Corresponding author.

Synthesized by: Joseph M. MacDonald, WWU student editor

Earth Economics is a non-profit organization that looks to evaluate natural resources with a dollar value to determine their benefits in terms that people can better understand. Using economics and ecology, Earth Economics intents to determine the value of the Nearshore ecosystem. In the current standings, economics tend to dictate how people view the environment. Earth Economics believes that the environment can and should be our focus and the economy will follow.

With built infrastructure no longer being the scarce commodity it once was, natural resources are now scarce and require better management in order to use them effectively. Using four principles; scale, justice, efficiency, and good governance; Earth Economics focuses on four types of capital; built, social, human, and natural. These are gray infrastructure (built) that are used by employees (social and human) to extract resources (natural) for our use.

An example of the importance of natural resource management was the loss of wetlands in Louisiana and the damage caused by Hurricane Katrina in 2005. With the loss of about 1.2 million acres of wetland to agriculture or urbanization, natural buffers were no longer available to help mitigate large volumes of storm water and caused over $200 billion worth of damage in less than 24 hours.

Each ecosystem is unique, and offers its own benefits. In total, 23 ecosystem services have been determined by Earth Economics using four categories;

- Provision Functions: water supply, food, raw materials, genetic resources, medicinal resources, and ornamental resources.
- Habitat Function: habitat and nursery
- Informational Function: aesthetic, recreation, cultural and artistic, spiritual and historic, science and education.
- Regulation Function: climate, gas, disturbance, water regulation, soil retention, soil formation, nutrient regulation, waste treatment, pollination, and biological control.

To apply ecosystem services, we must first identify what services are present in the area and give them a value. Each service is valued in a different way using different methodologies that are unique to that system. Next, maps and models are constructed and later analyzed to determine the scale of the service, and the desired scope. The valuation methods of these analyses include; avoided cost, replacement costs, travel costs, hedonic pricing, market pricing, contingent valuation, and benefit transfer methodologies.

For Clallam County, over 11 land cover types there are 15 ecosystem services present based on GIS information that has been gathered. The more exact the GIS information gathered, the more detailed the list of services and land types will be. A preliminary estimate for natural services provided in Clallam County range from $1 to $12 billion per year. Also, calculating a net present value by using a 3% discount rate over a 100 year period, these services can range from $55 to $300 billion per year. Natural capital, such as forests, tend to increase in value over time given the correct conservation, and with a nominal rate, these services are estimated to be worth anywhere from $170 billion to $1 trillion over the next 100 years. Values for these services vary widely due to the value they are assigned in different areas around the country and over large scales of time when an initial evaluation was done for a comparison.

For the Elwha nearshore, a primary valuation looking at sediment transportation and deposition, invertebrate and forage fish populations, and bluff erosion are being used as a framework to determine a value of this ecosystem's ecological services. A framework of biodiversity, ecosystem functions and services, along with human well-being are also used to determine this value. Data for the primary valuation will occur between November 2012 through March 2013, with the final report finished by May 2013.

PA Land Fill Update and Status

Neal, Kathryn. City of Port Angeles, Port Angeles, WA.

Synthesized by: Joseph M. MacDonald, WWU student editor

The Port Angeles city landfill is a closed system that is located on the west side of the city on a feeder bluff that historically added sediment to be deposited in areas such as Ediz Hook and Hollywood Beach. The northern edge of the landfill where the bluffs are located are divided into three separate areas; an eastern, western, and valley cell unit. The biggest area of concern for the landfill is the eastern cell due to high energy wave action that is eroding the bluff, exposing garbage to fall into the Strait of Juan de Fuca or smolder in the bluff face.

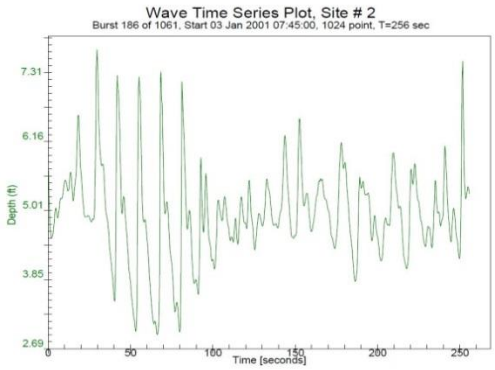
In the past six months, geomorphic and engineering evaluations have been underway to determine the best course of action to help mitigate this potential disaster. Using wave energy monitoring results, feedback from city and public forums, fiscal assistance availability, and adaptive managing approaches, five possible alternatives have been determined:

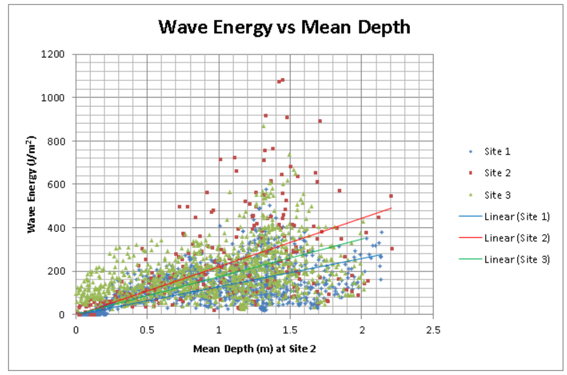
- The seawall will remain
- The seawall will be removed
- Seawall remains with an end wall protection
- Shoreline stabilization of landfill extents
- Complete shoreline stabilization

Garbage spilling out of the East Cell bluff face of the Port Angeles City Landfill.

Photo taken on Oct 29, 2012

Currently on the east end of the bluff were wave action is at its highest, nourishment treatments have been tried in an effort to minimize erosion. These treatments erode within days of their placement. Three wave monitoring stations deployed on December 27, 2012 have measured four foot waves/swash in the intertidal zone. These large waves have an erosion rate of 2 to 6 feet per year on the bluff face. The data collection from the wave monitors focused on high water time periods, and showed high wave energy at all three probe locations with the highest being located on the east end of the seawall. The seawall protects the west and valley cells from further erosion and slope failure, as well as a collection point for leachate from the landfill





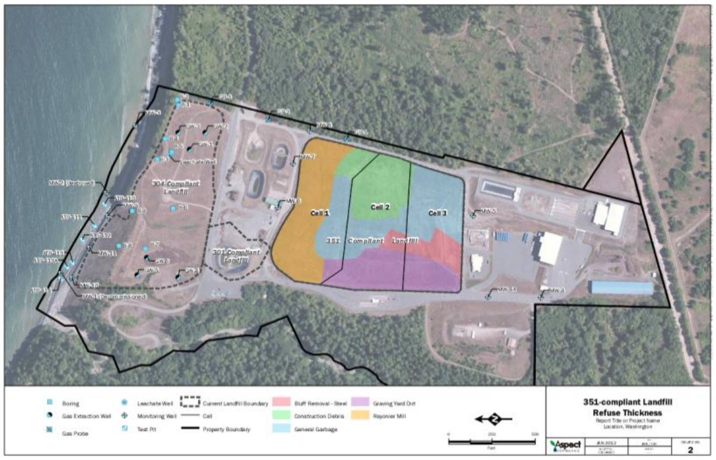
Left: wave energy chart from the Site 2 probe. This probe monitors the valley cell site.

Right: compilation of the wave energy and depth patterns at all three wave sites that monitor below the landfill bluffs.

The current project of managing the landfill is a balancing act of both short and long term priorities and constraints that include environmental concerns, affordability, and solution longevity and risk management. This has required an adaptive management approach that tries to consider a number of uncertain factors such as; sea level rise, high tide trends, and increased wave energy and sediments from the Elwha River. The highest priority of consideration is the removal and relocation of waste from the east cell and the preservation of the seawall's integrity for the near-term. Bluff and shoreline monitoring will continue for an extended period of time to improve decision making while trying to remain flexible to adapt with site management and remain within the City's budget cycle and constraints as well as trying to identify other funding strategies.

The preferred alternative of the city would be a relocation of waste to an on-site repository. Seawall end protection within the existing infrastructure footprint would also be used to protect against west cell erosion and Dry Creek stabilization and habitat enhancement, but allowing for east bluff erosion with monitoring. This would call for 265,000 cubic yards of waste to be relocated to cell 351, allowing cell 304 east to erode naturally onto the shoreline.

Long term management would include monitoring changes in bluff erosion rates and embayment processes over the next 25 to 100 years. Future phases could include additional waste removal from east 304 and west 304, seawall removal, and stabilization along the embayed shoreline with more natural materials if the wave energy and environment permits.



Current overview of the Port Angeles landfill with cell designations.

A proposed near-term project proposal is now in phase 1B that includes the development of cell 351 and a removal design of cell 304, as well as an initial shoreline stabilization permitting process and funding strategy. Phase 1C will begin in 2014 with further development of cell 351 and the beginning of waste removal from cell 304. Phase 2 will occur from 2015 to 2016, and will involve the continued waste removal from cell 304, the potentially commencement of landfilling of new municipal solid waste of cell 351, and begin shoreline stabilization construction below the east 304 cell.

Management discussion Elwha Nearshore Consortium

Synopsis by Anne Shaffer, Coastal Watershed Institute, Port Angeles, WA.

This section of the annual ENC meeting is dedicated to linking the science to management needs of the Elwha nearshore. Goals are to identify top management needs, best available science, data gaps, and collaborative opportunities to address management needs. The Elwha drift cell is a critical migration, rearing, and spawning corridor for a number of iconic species including the federally endangered Puget Sound Chinook and eastern Strait of Juan de Fuca summer chum, as well as forage fish including surf smelt, sand lance, herring, and eulachon. The Elwha nearshore is severely sediment starved, due largely to shoreline armoring of feeder bluffs that once provided 85% of beach forming sediment to the Elwha nearshore (CoE 1971). Sediment starvation from shoreline armoring a significant ecological impediment of the Elwha nearshore (Parks et al, in press, Shaffer et al., 2012. Shaffer et al., 2008.). Approximately sixty two percent of the Elwha feeder bluffs, which extend from the Elwha delta east to the base of Ediz Hook, are armored.

The Elwha river and nearshore are currently undergoing a world scale restoration event that will deliver approximately seven million cubic meters of sediment, including sand and gravel, to the sediment starved shoreline of the Elwha nearshore within the next two to five years. s. Dam removals began in 2011 and sediment is now being delivered to the Elwha nearshore (see Physical Process section for details).The city of Port Angeles shoreline includes a large proportion of the Elwha feeder bluffs, and all of the shoreline of Ediz Hook. The feeder bluffs have been armored thru a series of actions, from the industrial waterline east to the tip of Ediz Hook. In November 2006 the city of Port Angeles installed a 454 ft. seawall without federal permits. This seawall installation has resulted in increased bluff erosion immediately down drift. The city is therefore once again in the process of deciding on actions to take along the landfill shoreline. The nearshore management discussion focused on this portion of the city landfill, and how the Elwha Nearshore Consortium (ENC) can assist the city in making the best ecological and community decisions, including optimizing this world class restoration opportunity.

The delivery of the Elwha sediment to the nearshore is time sensitive, and several short-term actions were discussed. Little is known about the grain size of, and when, where, and for how long sediment will be delivered to the Elwha bluffs and spit beaches. These details are critical to define the best options for the City of Port Angeles. In general there are a few actions that could benefit the city and the shoreline. These include placement of significant amounts of large woody debris and beach nourishment thru placement of cobble sized nourishment projects were discussed as options to capture the Elwha sediment as it reaches the hardened shoreline of the City of Port Angeles. Currently the Army Corps of Engineers has an ongoing maintenance plan for Ediz Hook which entails 50,000 cubic yards of larger cobble placed along the spit every five years. It was asked if the Corps could place this material further updrift, at or east of the city's land fill. The city asked the group if predictions could be made of the Elwha when it comes to various aspects, such as sediment transport, and determining the range of probability in the predictions being presented for consideration. The ENC agreed to try and answer this. The city also asked if the ENC could provide the economic value of the ecosystem services that unarmored shorelines provide to the city. This would help the city evaluate options. The Coastal Watershed Institute, DoE, Clallam County, Earth Economics, and DNR are currently working to define the ecosystem services of the Clallam County nearshore. CWI asked if Earth Economics could provide an ecosystem services for the nearshore of this portion of the Elwha shoreline as a pilot. Ee thought it would be possible, and is now working on the evaluation. Results are due in the next few weeks.

The group discussion came up with several questions for the ENC scientists regarding the Elwha river sediment:

- What proportion, and grain size, of the Elwha sediment is going to be delivered onto the intertidal beaches of Elwha bluffs and Ediz Hook?
- Which beaches will receive the majority of material?
- When is it going to get there (What is the transportation rate)?
- Will it stay on the beaches and for how long?
- If we could get it to stay, would it help with erosional issues?
- What actions can be taken to make it stay?

Answers to these questions could help define specific restoration actions that the city could take over the next two to five years to optimize the dam removal sediment delivery as they manage their city landfill shoreline. The ENC is now working to answer these questions.

The ENC will endeavor to support the city in efforts to restore this landfill shoreline. The ENC physical process scientists will attempt to estimate the composition, volume, trajectory, and timing of sediment delivery to the Elwha nearshore. This will be done with an eye to the ecological habitat function that may be restored as well as the role (if any) this short-term sediment delivery could have in offsetting current erosion, and what actions the city could take to optimize sediment delivery. The ENC agreed to attempt to estimate the ecosystem services provided by this landfill section of shoreline if it was functioning properly. Finally, the CWI will assist the city in pursuing funding for addressing these elements and full ecosystem restoration of the landfill stretch of shoreline.

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Elwha Nearshore Priorities for 2013

Vision statement: To promote full ecosystem restoration of the Elwha nearshore

Category	Activity
Modeling	Model linkages between current habitat extent (for example west estuary extent , use (for example fish abundance) and sediment processes in lower river and shoreline to predict post dam removal sediment fate and anticipated near and long term habitat function response. Develop adaptive management actions to respond to near-term restoration

	process. Prioritize additional nearshore long term restoration actions prior to dam removal. Specifically: 1.Augmenting of Elwha bluffs shoreline to optimize sediment delivery 2. Identify additional restoration actions
Monitoring	Monitoring (lower river, estuary, and shoreline of Elwha and comparative drift cells).
Sediment/Physical processes	1.More detailed and comprehensive sediment mapping and study of lower river and estuary; specifically: Extend current sediment mapping in the lower river north to include river mouth
	2. Definition of relative contribution of bluff erosion to sediment budget of Elwha, Dungeness drift cells. Ground based shoreline LiDAR
	3.Expansion of 2009 Lidar study to include estuary, boat and land based Lidar for bluffs along lower river and shoreline, to and including Dungeness Spit;
	4.Wave buoys (CDIP)
	5.Continue and expand nearshore habitat report and sediment mapping (USGS) update to include: a. Further east and comparative areas; b. Offshore and inshore to include eelgrass area (MLLW-25-30’)
	6. Comprehensive assessment of water quality in impounded, east, and west estuary including turbidity and nutrients (both CTD’s and hand held YSI readings).
	7.Mapping of the historic Elwha nearshore (Brad Collins style study);
	8.Monitor of discharge of river from suspended sediments prior to dam removal

Biological and habitat	1.Continue long term monitoring of fish use of Elwha nearshore by CWI and PC/WWU, NOAA,LEKT, and others, including genetic composition of ESA stocks of salmon and forage fish-at a cross regional scale.
	2.Macroinvertbrate assemblage of Elwha and comparative
	3. Post process eelgrass data for macroalgae and fish presence.
	4.Conduct additional field surveys to define fish composition and extent in and of understory macro algae beds of Elwha and comparative nearshore
	5.LWD, riparian mapping, Elwha and comparative nearshore
	6.Bird surveys of Elwha nearshore for baseline info (both live and stranded birds) and linkages to other monitoring elements
	7.Marine mammal tracking (harbor seals)
Management	
	Develop and implement an Elwha nearshore restoration action plan. Priorities of plan; 1. Preservation of Freshwater Bay and lower river nearshore thru property CE/acquisition; 2. Ecosystem restoration of the Elwha estuary. 3. Restoration of Elwha feeder bluffs and Ediz Hook. Incorporate feed rate into bluff management.
	Analysis of sediment projections to estuary and development of adaptive management actions that might be anticipated;
	Preserve feeder bluffs of Dungeness drift cell, which are comparative sites and of extremely high ecological importance.
	Identify ELJ sites if any in Elwha nearshore
	Cost benefit analysis of changing pipeline alignment so not on beach along feeder bluffs
	Adaptive management priority actions (contingency actions) for sediment processes in river
	Data clearing house for data managers, data integration, shoreline atlas
Education	Continue working with citizens, local colleges and education groups

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