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I: Overview and Welcome

Greetings from Peninsula College

Luke Robins, President, Peninsula College, Port Angeles, WA

I am pleased to welcome you to Peninsula College for the 9^{th} annual Elwha Nearshore Consortium. Students choose Peninsula College because they know they can get an excellent education at a fraction of the cost they would pay at other colleges and universities. They also know our location offers unparalleled opportunities to participate in studies and research projects that take them outside the classroom and into a unique natural environment that includes a World Heritage National Park, snowcapped mountains, rainforests, ocean beaches and old-growth forests.

Students are also drawn by our growing international program, which provides opportunities to study in other countries and to get to know international students in and outside the classroom. Additionally, they can study right here on campus with scholars from other countries, and are able to meet and take courses with visiting Fulbright Scholars.

Leadership opportunities also abound. Many students quickly become involved with the Associated Student Council and various clubs, and can even choose to become Student Ambassadors.

Bruce Hattendorf, Dean of Instruction, Peninsula College, Port Angeles, WA

It is a pleasure to have this ongoing partnership with the Elwha Nearshore Consortium. As a college, we are committed to involving students in undergraduate research, and the experiences offered to our students through the consortium and this meeting are great opportunities. Peninsula College is committed to finding ways to use our local setting as a natural laboratory, and we encourage partnerships with groups like the Consortium, the National Park, and other community organizations. In addition, the college prides itself on being a place where scholarship can be shared and we are interested in hosting more workshops in the future that are a good fit with the college priorities. For all these reasons, we are very happy to have you here today and we appreciated your scholarly work. Finally, we have a peer-reviewed journal that encourages submissions of original research and scholarship intended for scholarly and professional communities and the broader public, and we encourage all to consider submitting work to it in the future. (http://www.pencol.edu/aboutpc/pc-press).

Remarks from the Superintendent of Olympic National Park

Presented by Sarah Creachbaum, Superintendent of Olympic National Park

I want the audience to recognize and thank all those who have worked tirelessly behind the scenes and received minimal recognition for their immense contributions to this project. These people include Brian Winter and his team of contract administrators in Colorado, a team of solicitors from the Department of the Interior, engineers, Barnyard Construction, folks at Veolia Water North America, and at least 45 other people within the National Parks Service. All of these contributors, many who do not get the chance to see the results of their work, poured their heart and soul into this project over the past several years, and it would not have been possible without their efforts. We want to THANK THEM! I'm looking forward to today and its proceedings.

Background and Introduction from the Coastal Watershed Institute

Anne Shaffer, Elwha Nearshore Consortium (ENC) coordinator, Coastal Watershed Institute (CWI)

Welcome to the ninth annual Elwha nearshore consortium. After over 20 years of planning, we are so very fortunate that the removal of the Elwha dams is complete. This is a once-in-a-lifetime, career-spanning event. With the advent of the dam removal, we have about 20 million cubic meters of material being liberated into the river, about half of which is expected to come to the nearshore (Figure 1). The nearshore of the Elwha is large—approximately twelve miles long—and it has a number of important landforms and features. It is home for a number of the iconic species that are at the center of the Elwha River restoration project. The Elwha nearshore is also the migratory corridor that links the coastal and inland waters of the Salish Sea. It is significantly disrupted ecologically (Shaffer et al., 2008).

As Brian Winter, Olympic National Park, stated repeatedly over the last twenty years:

The fundamental basis for the Elwha dam removal project is ***restoration****, not research.*

The ENC goal: 'To understand and promote the nearshore restoration associated with the Elwha dam removals'.

The ENC is a mixture of scientists, managers, and the community. Our first goal was to get a focus on the nearshore. Over the last decade we have made great strides in conceptualizing the Elwha nearshore (Figure 2) and understanding the Elwha nearshore basic physical and ecological processes. Many of today's talks will provide important updates to these monitoring efforts. But it has been a constant, challenge to keep the collective focus on nearshore restoration instead of basic monitoring. As a result, nearshore restoration and adaptive management have not been addressed as intended in our original model (Figure 3). Dam removal sediment delivery is a unique, but finite, opportunity, and the clock is now ticking to ramp up where we need to go in the nearshore, not just for monitoring, but for restoration.

One of the products of our many years of being together, is a proceedings of the workshop. This year's student editors are Dottie (Dorothy) Metcalf-Lindenburger, from the University of Washington, who is coordinating and editing the physical processes presentations, and Nathan Moore, from Western Washington University, who is compiling the ecological processes presentations. These students are sponsored by our local chapter of Surfrider and the University of Washington. Be sure and say THANK YOU to them.

Today's meeting is an update on our science of the physical processes in the Elwha nearshore, and how it is evolving. We'll talk about the updated results of the monitoring of the ecological responses to dam removal in the nearshore. And we will talk about the continued management issues, and our need is to address them relative to dam removals. Also, we want to address priority next steps for research, management, and most importantly, restoration. Our continued contributors, collaborators, and funders include: Patagonia, Surfrider Foundation, Rose Foundation, Puget Sound Keepers Alliance, Peninsula College Foundation, state agencies including WDFW and DNR, and our community partners.

As we go forward we have a philosophy of sincere gratitude to the Olympic National Park and the Lower Elwha Klallam Tribe; without these two entities, this project would not have happened. We also extend a specific word of thanks to Brian Winter, Elwha restoration project manager at Olympic National Park: he is the titan that made this project go.

Figures:

Figure 1: Photos showing the progress of the Elwha dam removal, which began in September of 2011 and ended in the summer of 2014.

Figure 2: Photos showing the evolution of the Elwha Nearshore Consortium since 2004.

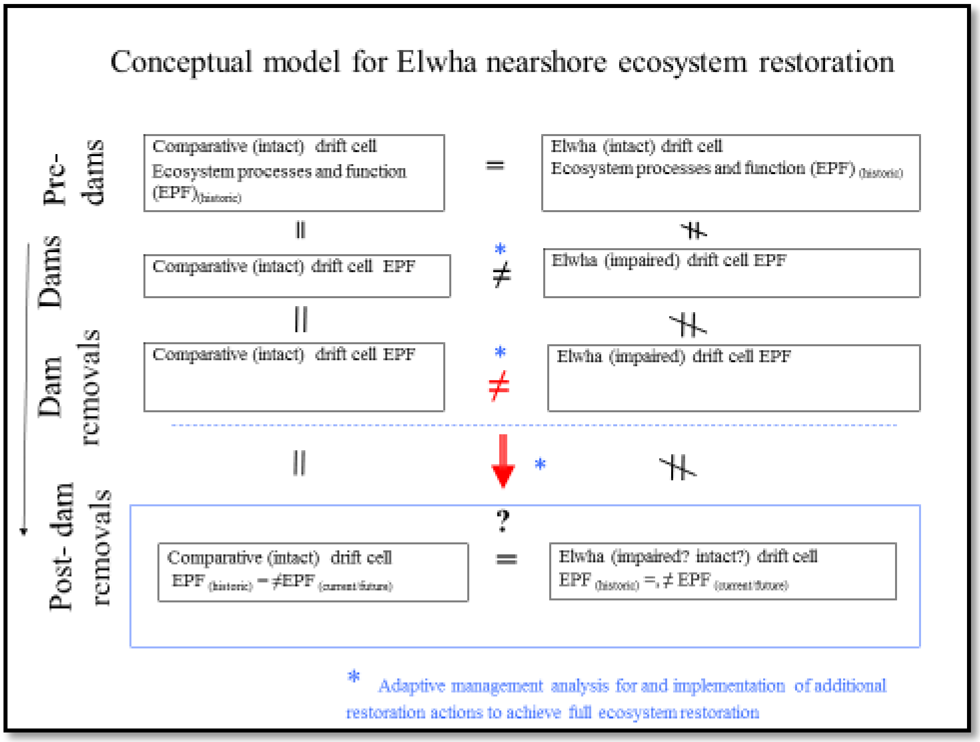

Figure 3: The conceptual model for Elwha nearshore ecosystem restoration.

References:

Shaffer, J.A., Crain, P., Winter, B., McHenry, M.L., Lear, C., and Randle, T.J., 2008, Nearshore restoration of the Elwha River through removal of the Elwha and Glines Canyon dams: an overview: Northwest science, 82 (Special Issue), p. 48-58.

II: ELWHA NEARSHORE PHYSICAL PROCESSES

Sediment monitoring on the Elwha River: River and reservoir response to dam removal through February 2015

As prepared to be presented by Andy Ritchie, Elwha Restoration Project Hydrologist, and geomorphologist for Olympic National Park

Reservoir conditions

Dam removal is complete on both Elwha and Glines Canyon dams, and a revised total sediment volume was published in 2014 based on improved topographic models for both reservoirs that incorporate data collected since dam removal was completed (Randle et al., 2015). Approximately half of the sediment stored behind both reservoirs has eroded through January 2015 (Figure 1), and there is relatively little sediment left in the reservoirs that is accessible to the river during typical flows and 1-2 year storms. The trend has been toward decreasing sediment export from the reservoirs, with it taking bigger storms to erode significant additional volumes of sediment, and this is expected to continue absent any significant change in base level at either dam site.

River response

The primary sediment pulse has passed although sediment and wood flux are still high. The trend is toward decreasing turbidity, and increasing stability. Bed elevation at riffles is similar to pre-dam in most places, with the notable exception of the river mouth, where the channel has lengthened by more than 300 meters (1,000 feet). Many pools remain partially filled relative to pre-dam elevations, and this is expected to persist since finer sediment is now available to fill pools on the falling limb of storms. The river has responded to the increase in sediment load by increasing the active channel width and the amplitude of meanders, and developing a more braided channel (Figure 2). Like in the reservoirs, channel response is stabilizing and we expect channel response to decrease for a given storm event. In other words, additional channel changes will mostly be limited to larger storms than we have seen to date (Figure 3).

Table 1. Sediment volumes in m^3 and yd^3 at start of dam removal and through 16 January 2015.

Sediment Volumes – Cubic Meters x 10^6

	Starting Volumes				Remaining			Pct Remaining		
Period	Aldwell	Mills	Total	Cumulative	Aldwell	Mills	Total	Aldwell	Mills	Total
July 2010	4.88	16.07	20.95	N/A						
	Eroded Volume									
September 2011 to October 2012	0.93	0.17	1.10	1.10	3.95	15.90	19.85	81%	99%	95%
October 2012 to September 2013	0.19	5.78	5.97	7.07	3.76	10.12	13.88	77%	63%	66%
September 2013 to September 2014	0.04	2.04	2.08	9.15	3.72	8.08	11.80	76%	50%	56%
September 2014 to Jan 16 2015	0.42	1.20	1.62	10.77	3.29	6.89	10.18	68%	43%	49%

Sediment Volumes - Cubic Yards x 10^6

	Starting Volumes				Remaining			Pct Remaining		
Period	Aldwell	Mills	Total	Cumulative	Aldwell	Mills	Total	Aldwell	Mills	Total
July 2010	6.38	21.02	27.40	N/A						
	Eroded Volume									
September 2011 to October 2012	1.22	0.22	1.44	1.44	5.17	20.80	25.96	81%	99%	95%
October 2012 to September 2013	0.25	7.56	7.81	9.25	4.92	13.24	18.16	77%	63%	66%
September 2013 to September 2014	0.06	2.66	2.72	11.97	4.86	10.57	15.43	76%	50%	56%
September 2014 to Jan 16 2015	0.55	1.57	2.12	14.09	4.31	9.01	13.32	68%	43%	49%

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Randle, T.R., Bountry, J.A., Ritchie, A., Wille, K., 2015, Large-scale dam removal on the Elwha River, Washington, USA: Erosion of reservoir sediment, Geomorphology, Available online 26 January 2015, ISSN 0169-555X, http://dx.doi.org/10.1016/j.geomorph.2014.12.045.

Figures

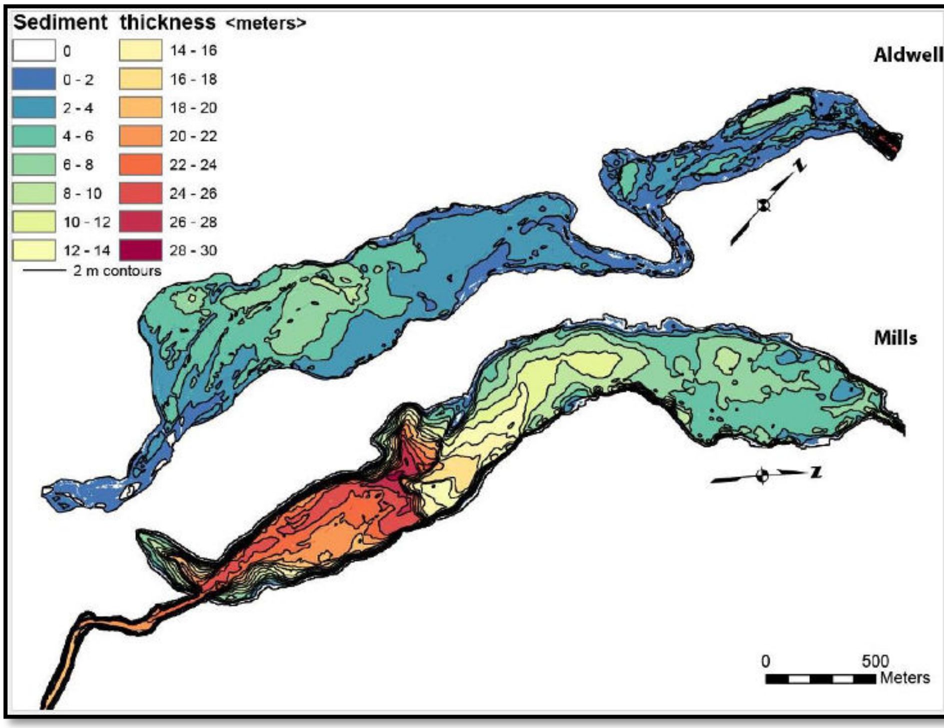

Figure 1: Reservoir sediment thickness (m) and 2-m contour lines of Lake Aldwell and Lake Mills in 2010, prior to the start of dam removal on the Elwha River, Washington (Randle et al., in press).

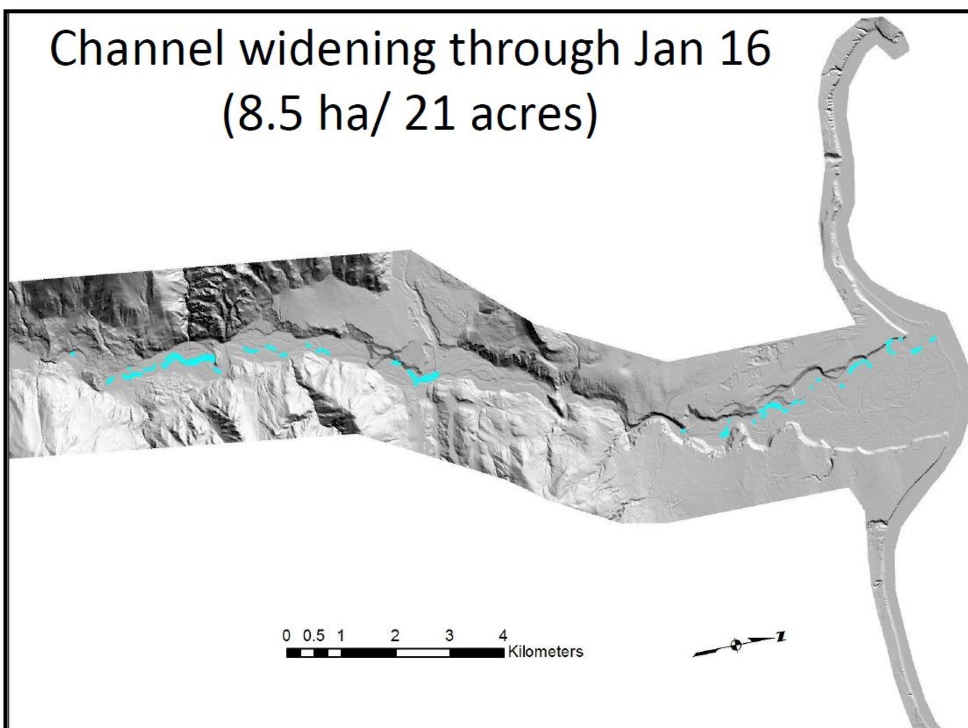

Figure 2: The cyan highlights show the active channel changes through January 16, 2015.

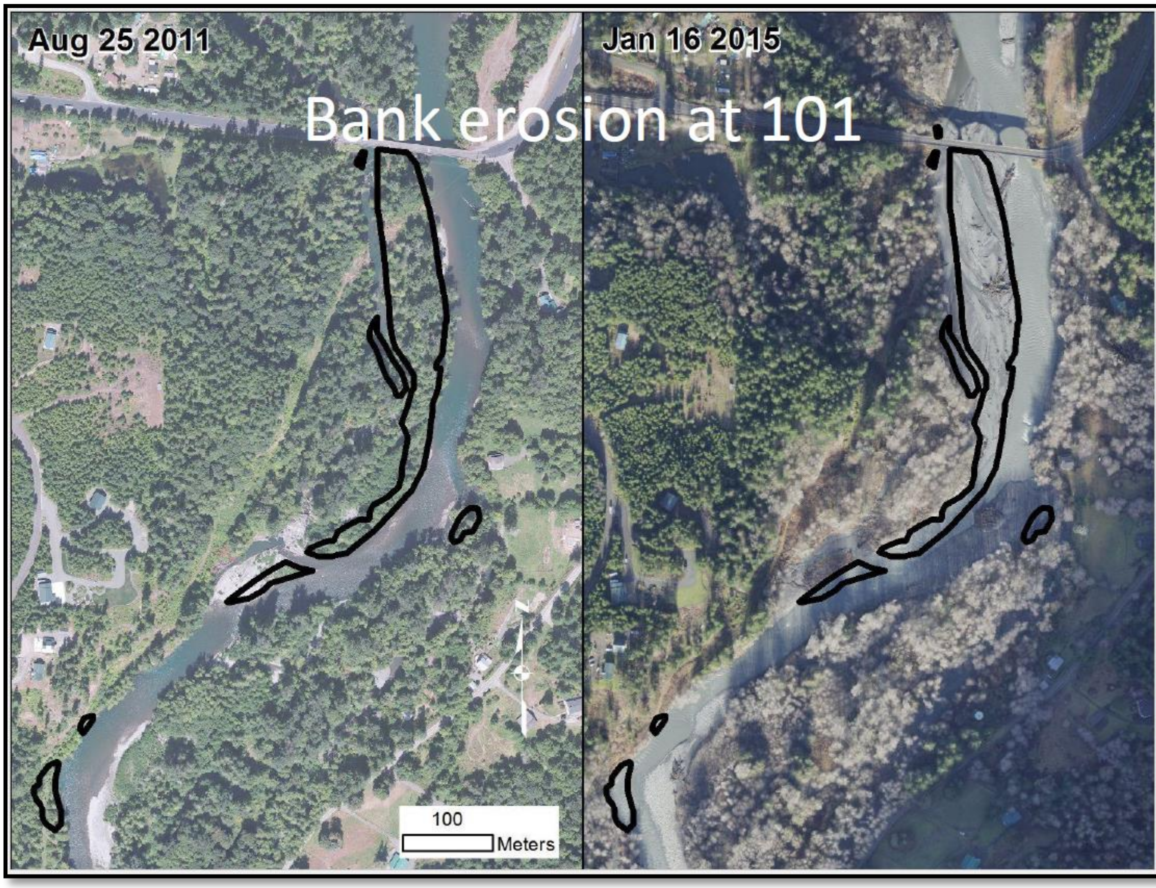

Figure 3: A comparison of the active channel's banks near the Highway 101 Bridge across the Elwha River. The left photo was taken August 25, 2011, and the right photo was taken on January 16, 2015.

Elwha River delta morphology: An update

Presented by Ian Miller, PhD, Washington Sea Grant
Co-authors: Andrew Stevens, Guy Gelfenbaum, Jon Warrick, and Heather Weiner

Introduction
The focus of this work is on the morphology of the Elwha River delta and its changes over time. The following questions motivated the research:

- What are the processes and pathways for dam removal sediment in the coastal environment?
- What are the ecological consequences?
- How can what is learned be applied to coastal management elsewhere?

This is a groundbreaking dam removal. The transport and distribution of sediment to the coastal zone has implications for a variety of coastal problems around the country and the world. Therefore, the implications of this study are much wider than just informing future dam removals.

The guide for this study is the conceptual model published before the dams' removal. This model suggested that fine sediment would move offshore because it remained suspended, while coarser sediment would move along the shore due to the longshore, littoral transport system.

Methods
In order to measure the topography, which is defined as the form and shape of the beach, researchers collected information by walking with Real Time Kinematic (RTK)-Global Positioning Systems (GPS) mounted on their backs. Extending similar data collection into the shallow, sub-tidal zone, they mounted the same system on a jet ski, and occasionally they used it on a kayak to gather information within the Elwha River.

For characterizing grain size, they used two different methods. The first method involves physically dropping a grab to the bottom and grabbing samples. The second method utilizes digital photography and computer processing to determine grain size (Figure 1).

Findings
This presentation picks up from the end of a series of papers published recently in Geomorphology and brings in the latest data from January 2015 (Figure 2). It shows the deposition in the Elwha and nearshore, which includes the inter-tidal, backshore, and sub-tidal zones. The data ranges from prior to dam removal to the present—January 2015. The delta received $3.5x10^6$ m^3 of sediment, mostly sands and gravels but with some mud. Mud is also found in localized areas within the inter-tidal zones. The trend from year two to year three was slow deposition, only about $4x10^5$ m^3 (Figure 3). In 2014, the fall floods brought $5x10^5$ m^3.

The sediment budget, as provided by Andrew Ritchie of the Olympic National Park Service on 18 February 2015, is:

- ~$21x10^6$ m^3 total sediment accumulated behind the dams and measured in the reservoirs
- ~11 $x10^6$ m^3 eroded from reservoirs so far
- ~3.5 $x10^6$ m^3 deposited at the Elwha River delta
- ~6.5 $x10^6$ m^3 lost beyond the study area. This is likely mostly fine sediment that remains in suspension in the coastal environment.

The Five Stories of Sediment
These stories are about the results of deposition and erosion trends around the Elwha River delta.

1. The formation of three deposition centers with unique characteristics:
    a. Mouth of the river has massive deposition
    b. An area to the west of the river mouth characterized primarily by mud deposition
    c. Secondary sand deposit ~700 m east of the delta.

2. Longshore inter-tidal transport of sand from the river mouth to the west. This deposit thins westward and the beach has grown an average of 4.6 m/yr seaward since dam removal started.

3. Continued sub-tidal deposition and transport between -1 m and -3 m in depth, east of the delta. This deposit (the secondary sand deposit referred to above) appears to be growing eastward and offshore. The deposition is mostly in the sub-tidal, and it is comprised of mostly sand.

4. Continued high rates of erosion on the beach on the east side of the delta. Sand is slowly creeping along the sub-tidal zone, but the eastern beach has eroded, on average -5.4 m/yr since dam removal. The sand from the river mouth made a continuous deposit along the entire inter-tidal beach and lasted for a month or so, but then it got stripped away.

This leads to a working hypothesis that sand may be incompetent on the beach and grain size partitioning is taking place. Eventually, the gravel fraction may be transported east and perhaps accreted in the future along the eastern beach.

5. Based on comparing recent survey data, there is little indication that dam removal sediment is adding significant volume to beaches east of Creek.

The delta's morphology continues to evolve, and this is shown by the floods of fall 2014.

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Randle, T. J., Bountry, J. A., Ritchie, A. C., and Wille, K. (2015). Large-scale dam removal on the Elwha River, Washington, USA: erosion of reservoir sediment, *Geomorphology*, http://dx.doi.org/10.1016/j.geomorph.2014.12.045

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Figures

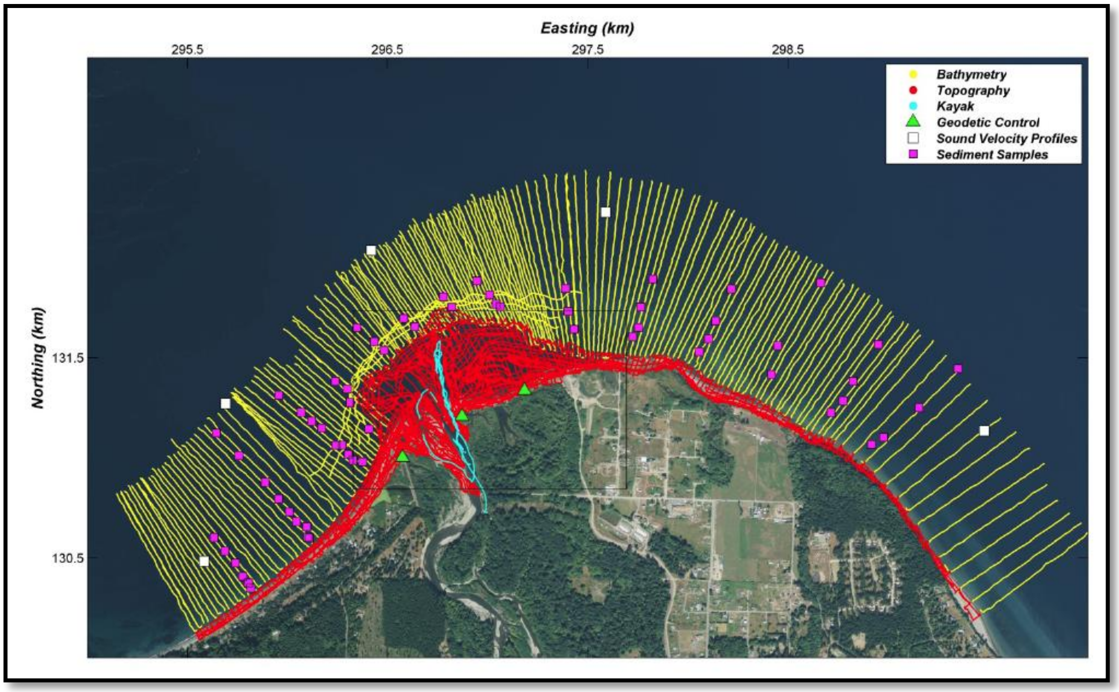

Figure 1: A map of the topography and bathymetry sampling for the January 2015 survey of the Elwha River delta. Also included are the locations of geodetic control monuments, sound velocity profiles to correct the sonar soundings, and seafloor sediment samples for grain-size analyses.

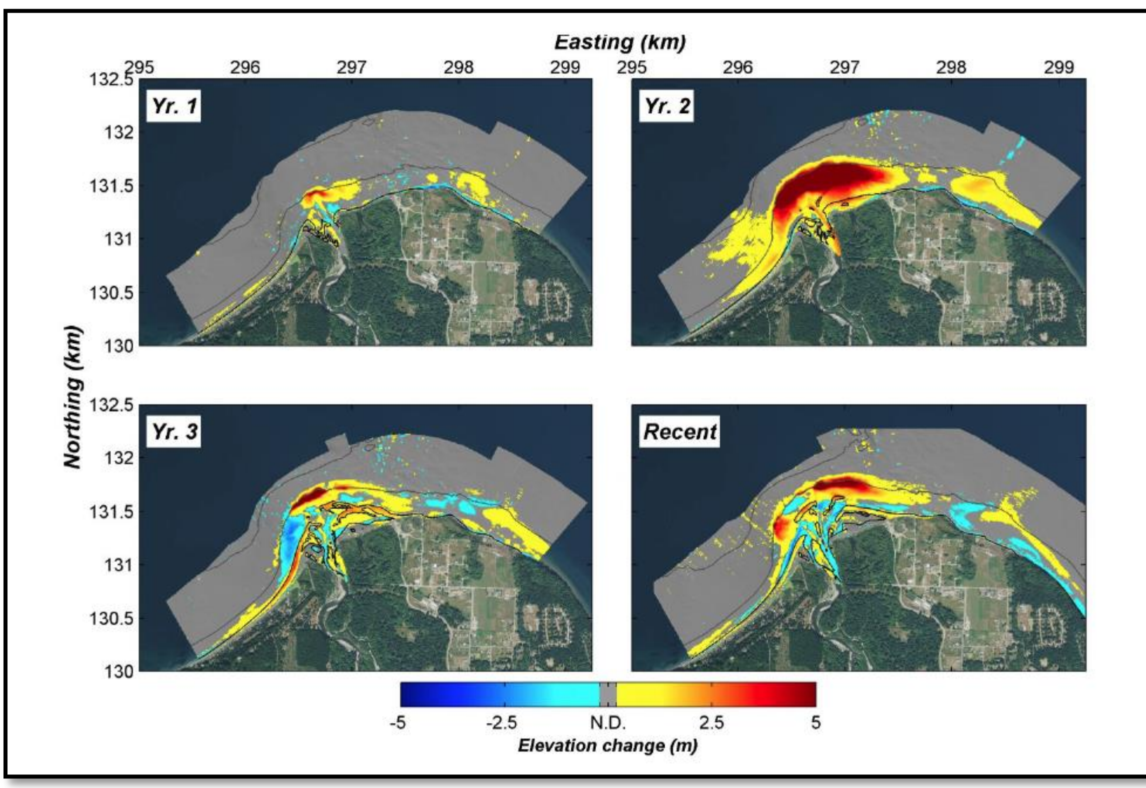

Figure 2: Maps of elevation change in the Elwha River mouth morphology since the start of dam removal. Changes below the detection limit are shown in gray color and denoted "N.D.". Survey dates used in these maps include Sept. 2011, Sept. 2012, Sept. 2013, Sept. 2014, and Jan. 2015.

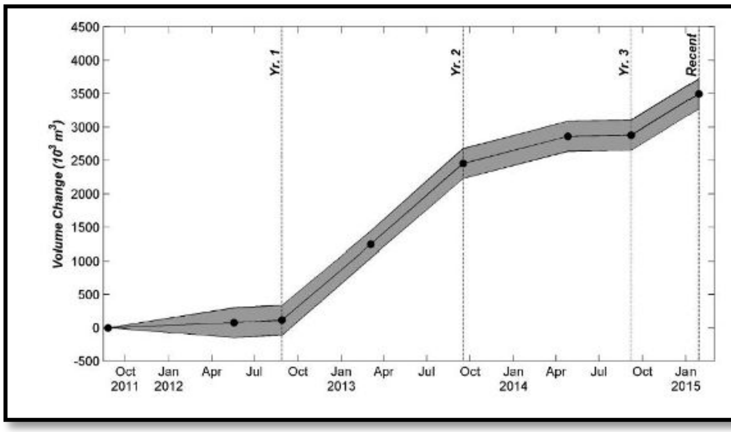

Figure 3: Time-dependent changes in the sediment volume within and offshore of the Elwha River mouth. Survey dates are shown with dots, and uncertainty in the volume calculations are shown with shading.

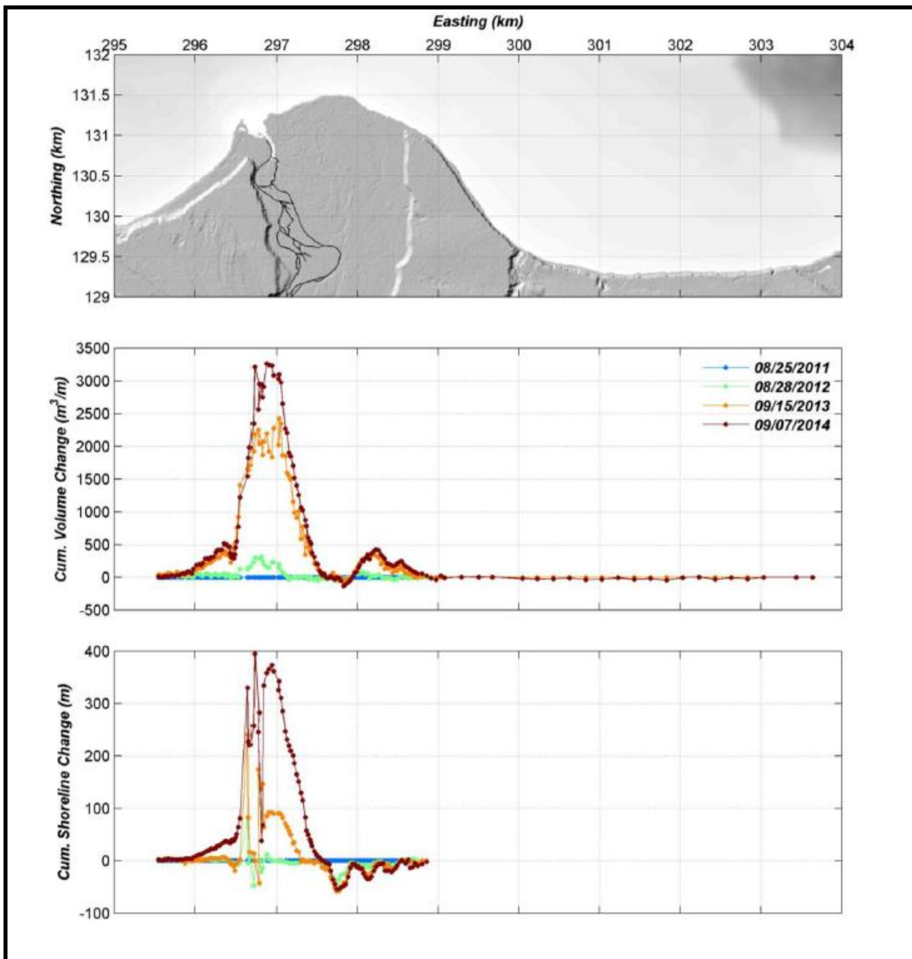

Figure 4: Plots showing cumulative volume change (middle) and cumulative shoreline change (bottom) for combined beach and nearshore profiles collected between August 2011 and September 2014. Shoreline change data east of the delta are limited by a lack of topographic data (bathymetry data do not capture the position of the MHW shoreline).

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

Presented by Dave Parks, Washington Department of Natural Resources

This presentation focuses on two projects:

1. Bluff erosion rates
2. Sediment characterization and beach topography away from the Elwha River delta before, during, and after dam removal.

Both of these studies are in the context of the Elwha drift cell being the treatment area after dam removal and the Dungeness drift cell as the comparative area. The objectives of these studies are to measure accurate rates of bluff retreat for both of these locations, and to improve estimates of sediment volumes contributed from bluffs to the inter-tidal zone.

Fundamental Questions Addressed:

1. How fast are the bluffs eroding? This is especially important to landowners along the bluffs.
2. How much sediment volume do the bluffs contribute to the nearshore? This is important as scientists try to understand and assess if the restoration effort within the Elwha drift cell is viable and if the sediment contribution from the Elwha River will accumulate on intertidal beaches or deposit in deeper water offshore.
3. What are the effects of shoreline armoring on bluff recession? The Elwha drift cell has 68% of its length armored along its coastline, while the Dungeness has less than 1%.

Methods for Bluff Erosion:

This study followed the standard U.S. Geological Survey (USGS) protocols for determining bluff erosion rates (Hapke, 2004). It involved digitizing aerial photos from 1939 to 2001 and conducting surface differencing between the 2001 and 2012 LiDAR Digital Elevation Models (DEMs). The sampling scheme was a series of transects spaced 30m apart along the entire shoreline length of the Elwha and Dungeness drift cells.

Results for Bluff Erosion:

The rates of bluff recession for the Elwha drift cell are lower than the rates for the Dungeness drift cell (Figures 1, 2, and 3). The range of retreat is from 0 m to 1.8 m/yr, with mean values of 0.26 +/- 0.23 m/yr (N=152) in Elwha and 0.36+/- 0.24 m/yr (N=433) in Dungeness. The armored bluffs retreat at a slower rate than the unarmored coastline (Figure 3). The highest retreat rates are observed near the Port Angeles landfill in the Elwha and near residential development in the Dungeness.

The volume of sediment contributed to the drift cells shows a similar trend as the rate data (Figure 4). Unarmored bluffs provide larger volumes of sediment than armored bluffs, so the Dungeness bluffs contribute more sediment than the Elwha bluffs due to substantially less armoring in the Dungeness. On an annual basis, the Dungeness drift cell produces, 1-2 $x10^5$ m^3/yr, which is five times the amount of sediment volume that the Elwha produces, only 2-5 $x10^4$ m^3/yr.

Conclusions for Bluff Erosion:

Overall bluff erosion rates are about 0.5 m/yr, which is similar to earlier findings. The Dungeness bluffs produce five times more sediment volume than the Elwha bluffs, and shoreline armoring reduces the rate of erosion by about 50%. Therefore, the Elwha drift zone has lower erosion rates than the Dungeness.

Methods for Beach Monitoring and Sediment Characterization:

This portion of the study observes the beach topographic profile and sediment texture. Over 27 surveys were completed between July 2010 and January 2015 at nine sites in the Elwha drift cell and eight sites in the Dungeness (Figure 5).

In order to record the topography of the beach, an RTK-GPS is used to relocate sites along the beach for precise measurements. Along these profiles, a digital photograph is taken of the surface of the beach at 1-meter intervals, and the grain size-autocorrelation method from digital photos is applied (Buscombe et al., 2011).

Results from transect Elwha Bluff (EB)-1:
EB-1 is an example of how the beach profile and texture changes and evolves after the dam removal. EB-1 is located to the east of the delta. Figure 6 shows that the beach profile built outward. It used to have a gradual slope, then it steepened right after the dam removal, and it is trending towards a gradual slope again. In addition to these changes in morphology, the sediment texture of this area shows that the grain size is fining with time (Figure 7).

In the larger scope, EB-1 is just one of seventeen transects. The trend for all of the Elwha transects is that they are becoming less steep, the foreshore is lengthening, and the grain-size is fining. In the Dungeness, slopes are steepening and the foreshore is shortening.

Next steps:
Future work includes continued monitoring for another five years and repeating the data processing for grain sizes. Additionally, a repeat of an in-depth topography survey done in 2011 needs to be conducted. The Department of Ecology ran boat-based LiDAR of the bluffs, and this data needs processing. Finally, a focused look at oceanographic conditions that drive beach morphology and bluff retreat would inform how wave energy along this coastline influences bluff erosion rates.

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Figures:

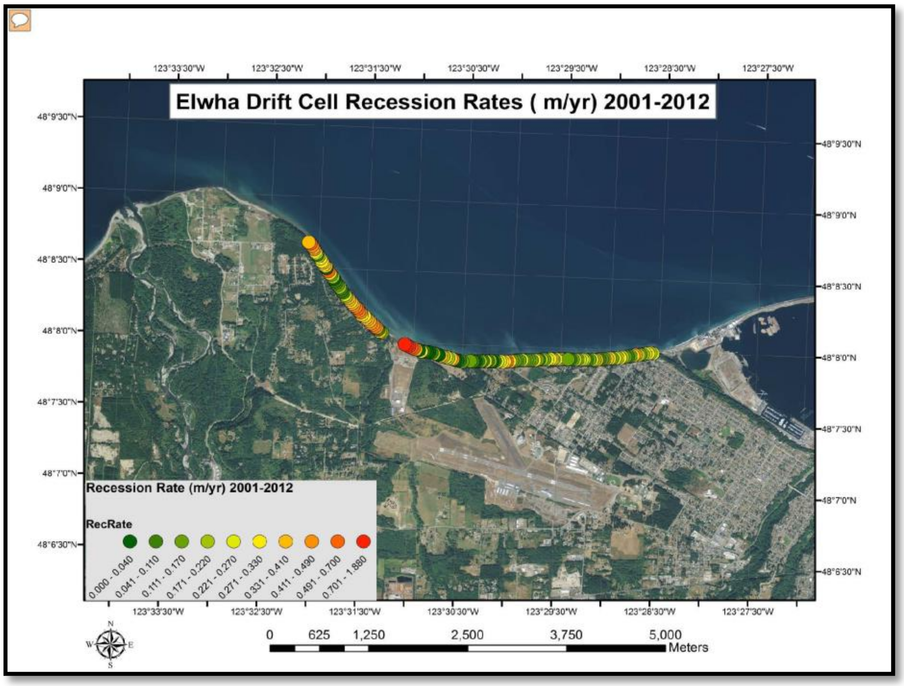

Figure 1: Map of Elwha drift cell recession rates (m/yr) from 2001-2012.

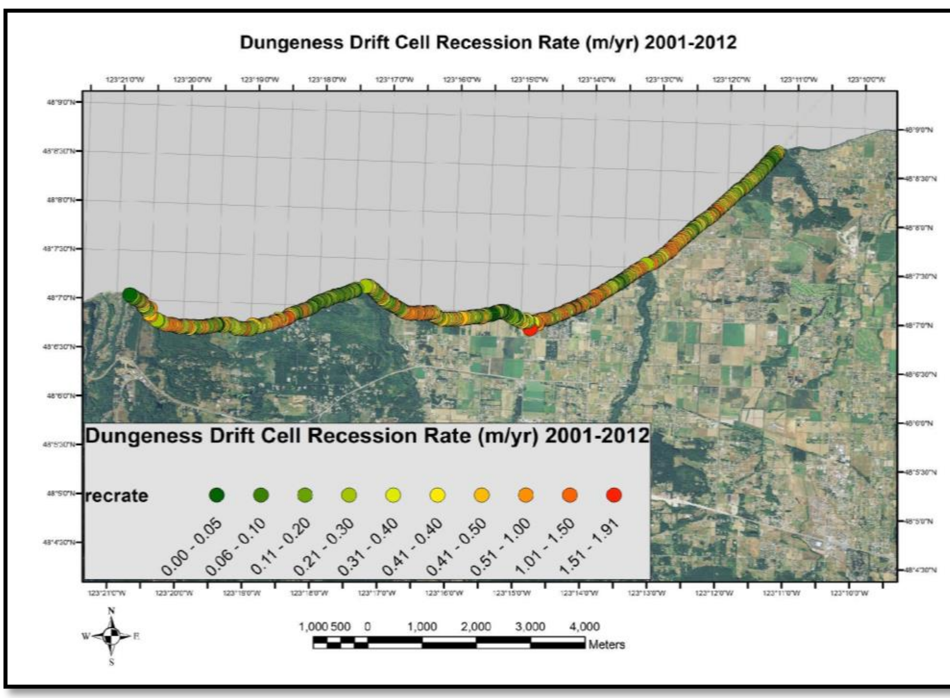

Figure 2: Map of Dungeness drift cell recession rates (m/yr) from 2001-2012.

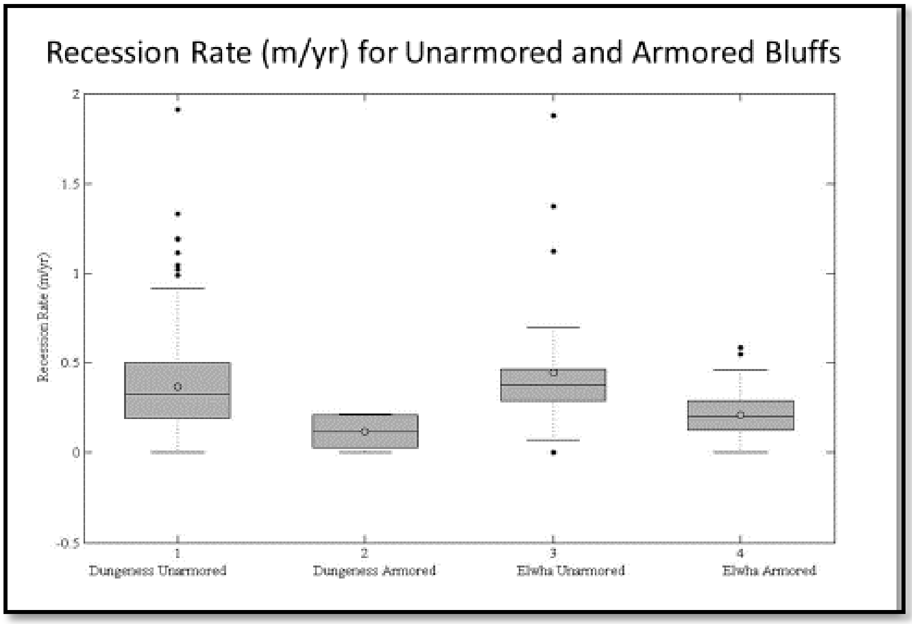

Figure 3: Box plot of recession rates (m/yr) by drift cell and shoreline type (created in *ABOXPLOT*; Bikfalvi, 2012). The central line within the box represents the sample median, while the circle represents the sample mean. The upper and lower limits of the box represent the 50th percentile of the population, and the whiskers represent the 75th percentile. Dots beyond the upper and lower whiskers represent outliers of the population. (Figure from Parks, 2015).

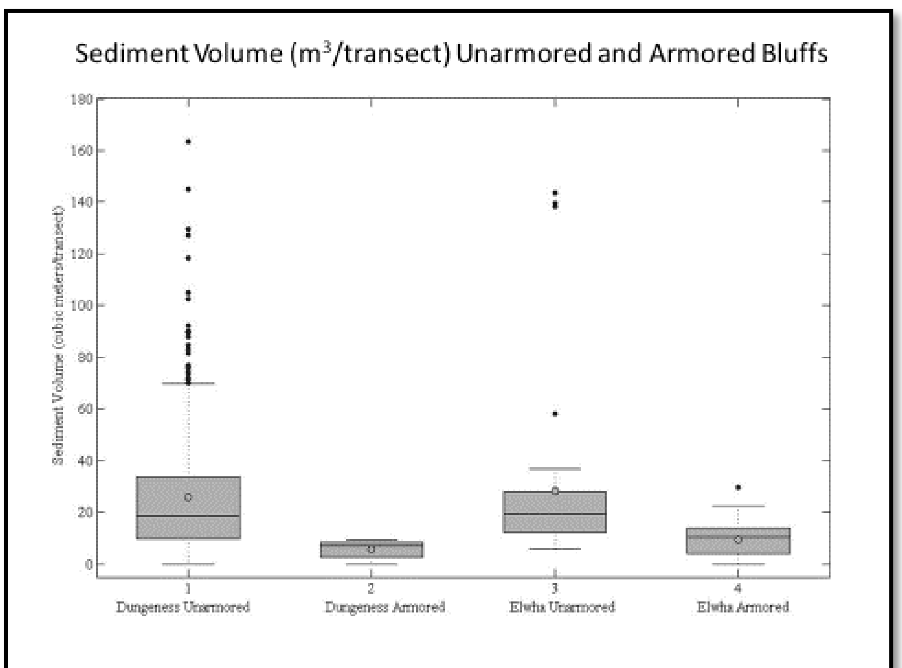

Figure 4: Box plot of sediment volume (m^3/transect) by drift cell and shoreline type (created in ABOXPLOT; Bikfalvi, 2012). (Figure from Parks, 2015).

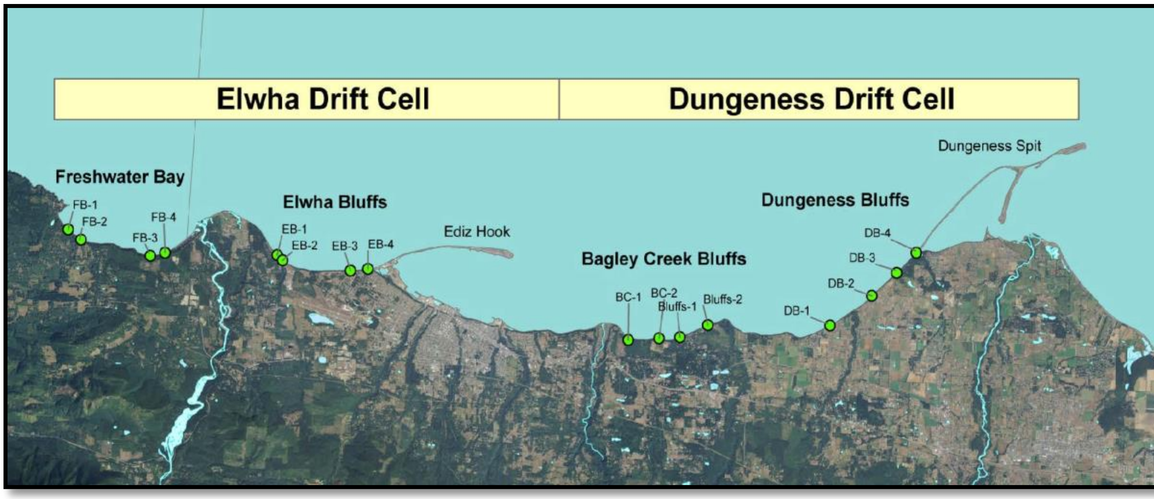

Figure 5: Map showing beach monitoring sites in Elwha and Dungeness drift cells.

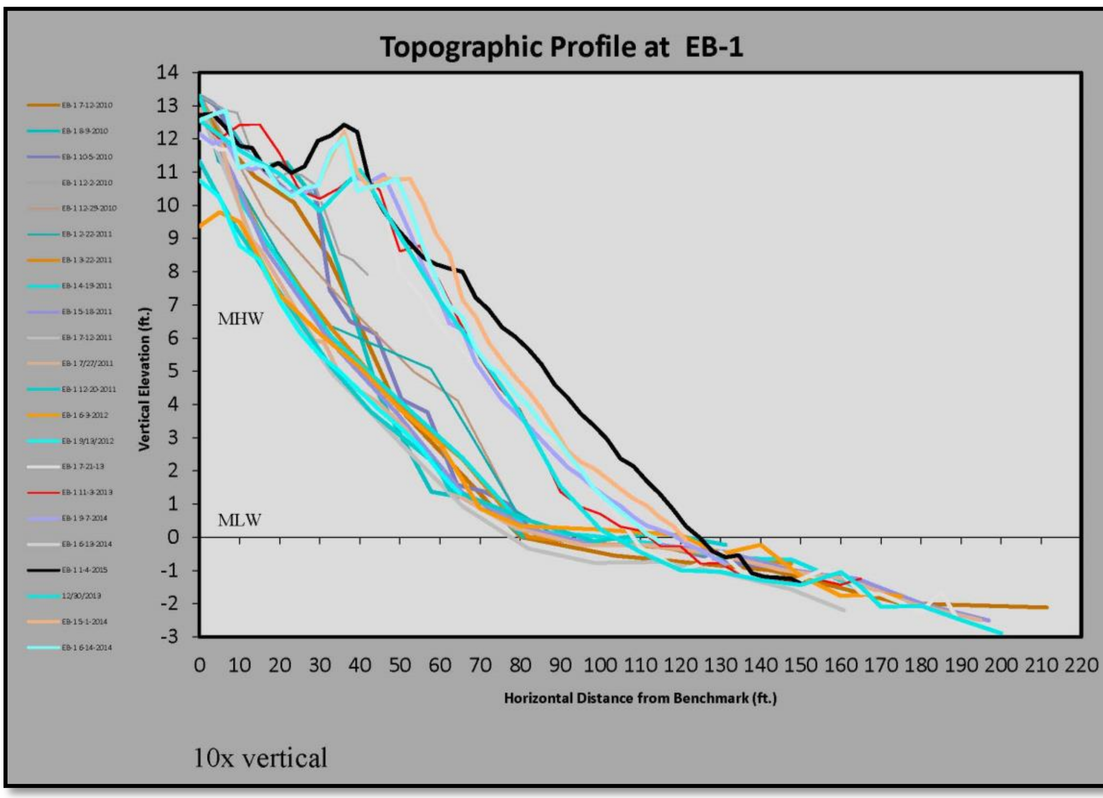

Figure 6: Topographic profiles at EB-1 showing the evolution of the beach topography from July of 2010 to January 2015.

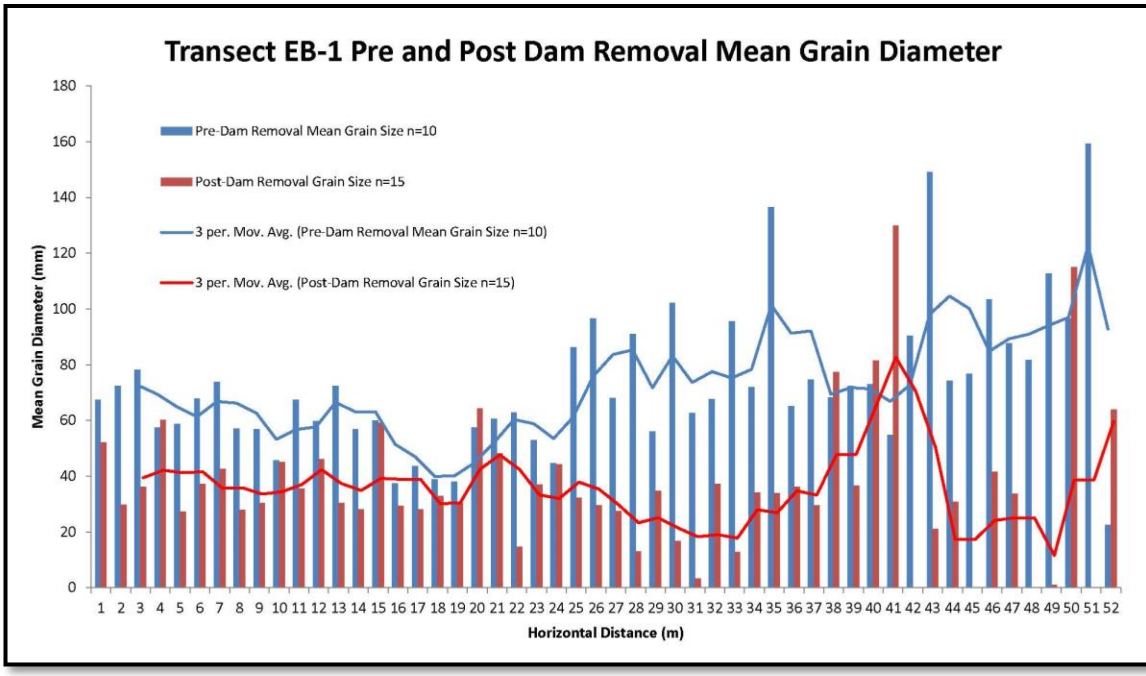

Figure 7: A graph showing distribution of average grain diameter at transect EB-1 before (blue) and after dam removal (red). Note: Transect begins at the upper bluff beach margin and extends down the beach with distance towards low water.

Wave energy and sediment movement in Freshwater Bay, Washington

Presented by Niall Twomey, MESSAGe student from the University of Washington

Introduction

This study focuses on sediment movement within Freshwater Bay from 2010 through 2014.

The data used for the study comes from the National Oceanic and Atmospheric Administration's (NOAA) Neah Bay and Dungeness buoys. Additionally, Dave Parks, from Washington's DNR, provided his sediment data, and Jon Warrick, from the USGS provided tripod data that were utilized for this project. Figure 1 shows the location of four transects along Freshwater Bay where Dave Parks collected his sediment data.

This study focuses on several transects near the boat ramp and Coville Creek. The shore-normal log located near transect 2 shows that sediment builds up on the westward side, and the sediments range in size from sand to cobbles (Figure 2). At the boat ramp, which is at the far western end of Freshwater Bay, sand and gravel are transported eastward. On the west side of the boat ramp, the beach sediment is mixed sand and fine gravel. As you head eastward, toward Coville Creek, the beach gets coarser in the upper foreshore, but remains finer towards the slope break.

Possible source for sand

If sediment is moving eastward, the source for sediment is to the west. However, to the west there are six kilometers of rocky shore, and it is unlikely that sediment is transported from Agate Beach eastward to Freshwater Bay. All along the shoreline of Freshwater Bay, the bluff is sliding, but it is not apparent that recent slides are large enough to supply the necessary sediment for Freshwater Bay littoral transport.

Additionally, mass wasting is less frequent at the western end of Freshwater Bay, which removes it as a possible source for sand.

Wave Energy Environment
The waves at Neah Bay Buoy are from the west. The dominant wave is the wave with the greatest energy recorded during the twenty-minute sampling period. From May through September, wave energy is lower than the rest of the year. The assumption that profile stability or aggradation coincides with these low-energy summer conditions was not supported by the data.

Primary wave approach at the New Dungeness buoy is just south of west, with a secondary peak from the southeast in the direction of Admiralty Inlet. Similar to Neah Bay, the New Dungeness Buoy experiences lower energy from May through September.

The Olympic Peninsula shields Freshwater Bay from wind in both southern quadrants. For an eight-month deployment, the USGS tripod recorded 85% of wave energy from the northwest (Strait of Juan de Fuca) and 10% from the northeast (presumably katabatic winds from the Fraser River Valley).

Sediment movement along the transects
The sediment data provided by Dave Parks at Mean High Water (MHW), Mean Sea Level (MSL), Mean Low Water (MLW), and Slope break, showed different depositional and transport events at each transect.

Transect 1, in the far western Freshwater Bay, shows MLW generally at the slope break position (Figure 3). There are two events where the location of MLW moves 20 m seaward, only to regress to near the slope break by the following profile date. This is indicative of short-term, temporary deposition on the low-tide terrace.

There is an opposite sense at Transect 2, where MLW is generally 20 m seaward of the slope break. There are three events where MLW regresses to the position of the slope break, but then returns seaward by the time of the next profile date. Transect 2 shows evidence of long-term storage on the low-tide terrace, with occasional scour events that reduce the elevation of the low-tide terrace. The beach profile is re-built by the time the next profile is measured.

Transects 3 and 4 show an apparent long-term increase in sediment deposition which is roughly commensurate with dam removal. Transect 3 shows an increase in sediment deposition on the low-tide terrace, indicated by the seaward movement of MLW from ~28 m cross-shore to ~38m cross-shore. Transect 3 shows an increase in sediment deposition on the upper beach face as well, but shows more variation, including regression that is not mirrored by the position of MLW.

Transect 4 is most exposed to the incident waves and, as a result, the slope break is farther seaward and not exposed at low tide. This means that relatively little data exists for the slope break and no information about sediment on the low-tide terrace. This is the only transect where MLW occurs on the upper beach face with MHW and MSL.

Transect 4 mirrors the sediment deposition on the upper intertidal of Transect 3 between July 2011 and May 2013. Transect 3 and Transect 4 both show a marked beach face regression event between May-July 2013, followed by relative stability in Transect 3 and a return to a prograding beach face in Transect 4.

Grain size analysis
In order to better represent the image as a whole rather than as a mean grain-size distribution, I used a digital photo method that differs from previous presenters. This method classifies the sediment as: (4) cobbles, (3) gravel, (2) sand (coarser), (1) sand with fines (or sand with bed forms and ripples). Figure 4 shows that, at the Slope Break, cobble can be transported as part of a sediment deposition event.

Loss of sediment can happen on shorter time scales. Figure 5 shows a reduction in profile at the Slope Break by approximately 0.5 m within a four-month period. It is unknown if the full four months were required to effect the change.

Conclusion

Ten percent of the time the wind comes from the northeast and the waves associated with this local wind are possibly transporting sand from the Elwha delta to the western portion of Freshwater Bay. Predominant littoral transport would then continue to move this sediment eastward.

The beach morphology of Freshwater Bay can vary on a scale of weeks as shown by the changes along the transects within just seventeen days. Large-grain sediments are moving at the slope break, and sediment is highly mobile.

Figures:

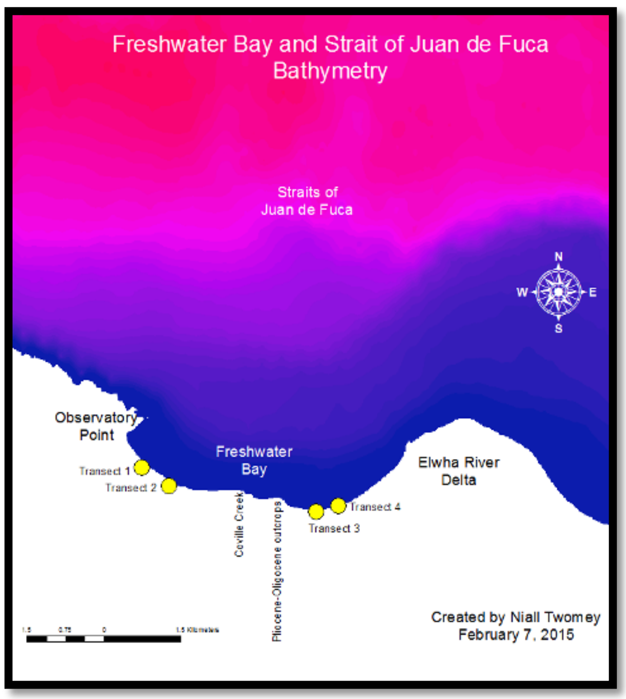

Figure 1: Map showing the four transects along Freshwater Bay, where Dave Parks (DNR) collected the sediment data used for this study.

Figure 2: Photo of shore-normal log east of Transect 2. Note the increased sediment depth on the westward (right) side of image.

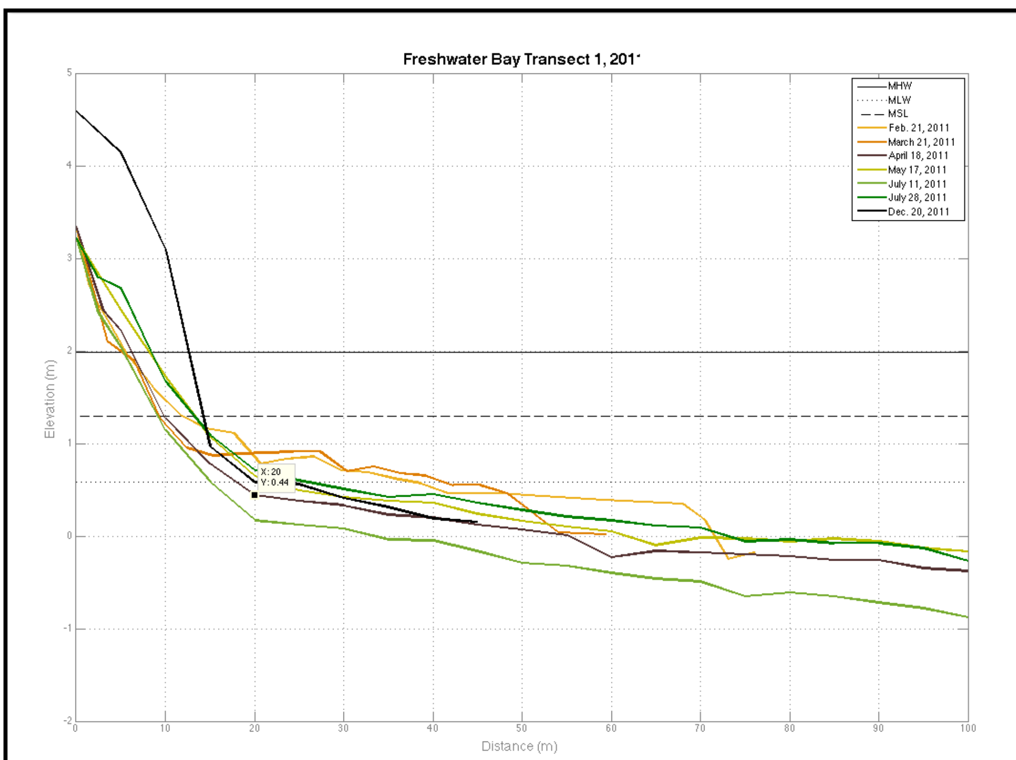

Figure 3: Freshwater Bay Transect 1 for 2011, showing Mean High Water, Mean Low Water, and Mean Sea Level.

Figure 4: Digital images showing surface sediment expression related to Fig. 10. Image on left is categorized as sand with fines (1) and image on right is cobbles (4), 2.5 years later and 0.5 m higher in elevation.

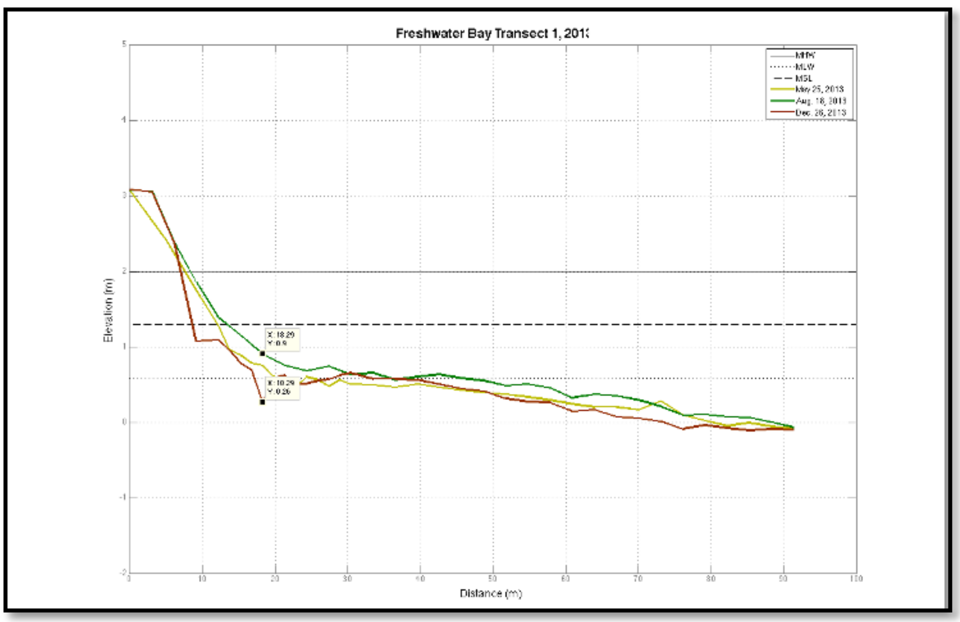

Figure 5: Transect 1 showing loss of 0.5 meter elevation at the Slope Break over a four-month time period.

Sediment changes to marine habitats

Presented by Emily Eidam, PhD student at the University of Washington's School of Oceanography

Introduction
This study investigates and records the movement of sediment offshore of the Elwha River delta. The setting for this study is a large, relict, submarine delta that extends 2-5 km offshore to depths of about 60 m. It is an artifact of the glacial history of this area. Prior to dam removal, the sediments comprising this delta

were coarse sands and gravels. In 2011, this study began in order to understand where sediment from the dam removal went, how it moved to different locations, and how it impacted habitats.

Methods
Every three to four months, a group of researchers conducts surveys from a vessel provided by the University of Washington. In part because of the size of the vessel, the study focuses primarily on the deeper portion of this system (i.e., >10 m). The researchers collect water samples from the surface to determine the amount of suspended sediment in the surface plume.

Additionally, they measure salinity, temperature, and depth (CTD) profiles. They also use grab samples to investigate how sediment sizes are changing every three to four months.

Also they deploy large, seabed instrument systems. These have been out since November 2011, and are showing some wear. These instruments have optical and acoustic sensors that allow them to measure current speed and direction, wave heights, water pressure, salinity, temperature, and sediment concentration.

Observations and Results
Operating since November of 2011, these instruments provide a significant record of what is occurring offshore.

Seabed
From the grab samples, the grain sizes on the relict delta are very coarse—cobble size. The delta was well armored with crusting barnacles. Early after the start of dam removal, researchers saw some medium to coarse grain sizes in Freshwater Bay. In October of 2012, a new, finer-grained deposit began forming in Freshwater Bay. By 2013, the deposit thickened, and started to fine with the presence of silt. Finally, by 2014, the deposit grew enough that they were able to core the deposits. The maximum thickness they found is about 30 cm, and the deposit is broad, extending to 35 m water depth. This material remains localized to Freshwater Bay.

While Freshwater Bay has a new, finer-grained deposit, the relict delta is still coarse. These coarse sediments dominate the seabed due to the strong tidal currents in this area, which keep the finer sediments in suspension and prevent deposition.

Freshwater Bay Box Cores
The team used a box-corer, a 15x40 cm device (Figure 1). The cores show the coarser sediment at the base and then finer sediment at the top, which is about 50% sand and 50% mud. The maximum thickness is 30 cm.

From these cores, they make thin slices and x-ray the samples (Figure 2). In the x-ray images, the coarser sediment appears white, while the finer sediment is dark. Based on rainfall, river discharge events, tidal currents, and waves, the sediment package has a complex structure of grain sizes. Between April and December of 2014 they have noticed that the deposit has stopped growing exponentially, and it maintains a thickness of 30 cm.

Within this 30 cm deposit, they are starting to see bioturbation (Figure 3). This is from a sample near the western side of the delta. They find burrows and colonies in the sands and muds.

Offshore Instrument
At this site, the seabed is still gravel. After the 2014 March storm, a new, 30-cm thick deposit developed (seen in acoustic backscatter data), but within weeks tidal currents eroded it. For organisms, these rapid changes may impact habitats. However, habitat change observed over the time scale of the entire study has largely been localized to Freshwater Bay. Overall, for the relict delta, 50-70% of the area does not have long-term sediment accretion.

Surface Plume
Prior to dam removal, the surface plume was 1-3 m thick. This trend has persisted since dam removal, and the plume remains 1-3 m thick. The plume is more concentrated during significant river discharge events, and has reached concentrations of grams/ liter. This plume affects light availability in the water, but it efficiently disperses sediment into the system. Some mud missing from the Elwha sediment budget may be advected off the delta by tidal currents as it settles from the surface plume.

Future work
The team is helping to constrain how much sediment is entering this portion of the system. The long-term seabed instrumentation is ending in April of 2015. Additionally, the major surveys are ending in April, but they are hoping to do small-scale surveys if additional funding is available. Also they are trying to answer some geologic questions that arose with the March 2014 event, which may have generated a gravity flow. Such events are unusual and so they want to analyze its cause and effects.

Figures

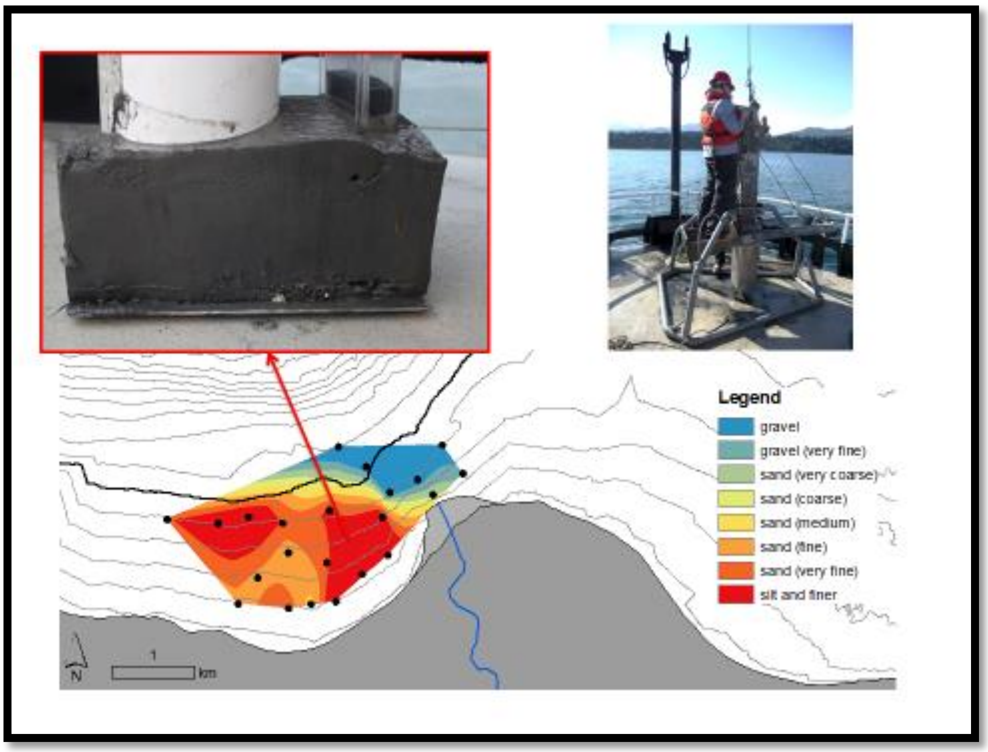

Figure 1: The box-corer used to sample sediment offshore of the Elwha River Delta.

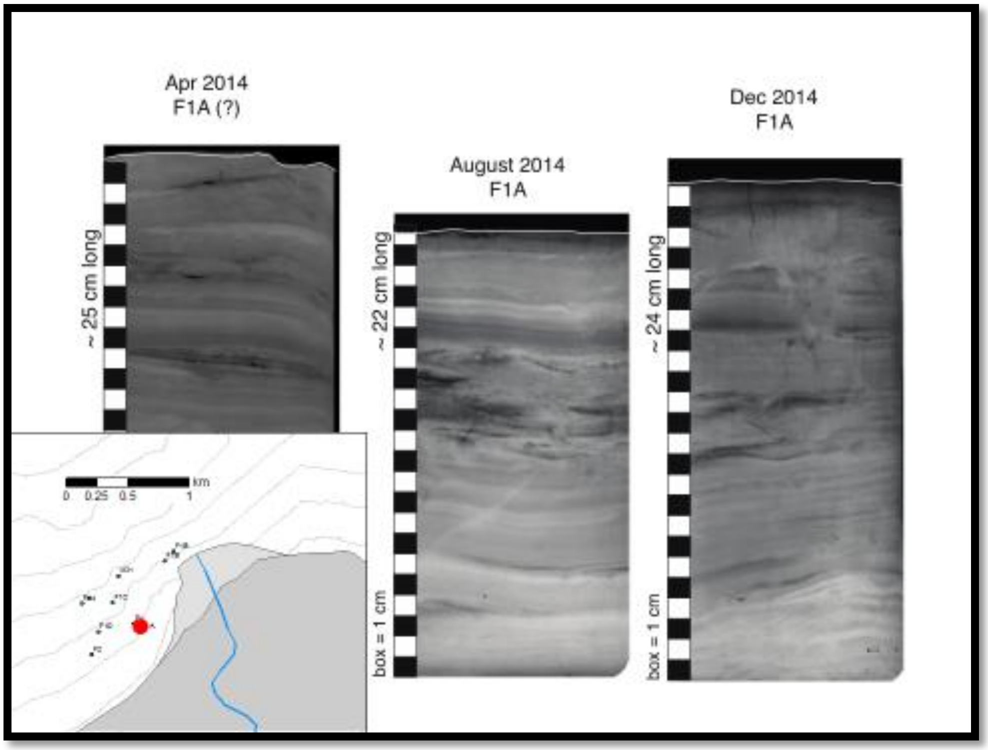

Figure 2: X-ray images from the sediment samples taken offshore of the Elwha River Delta. The coarse sediment is white, while the finer sediment is dark.

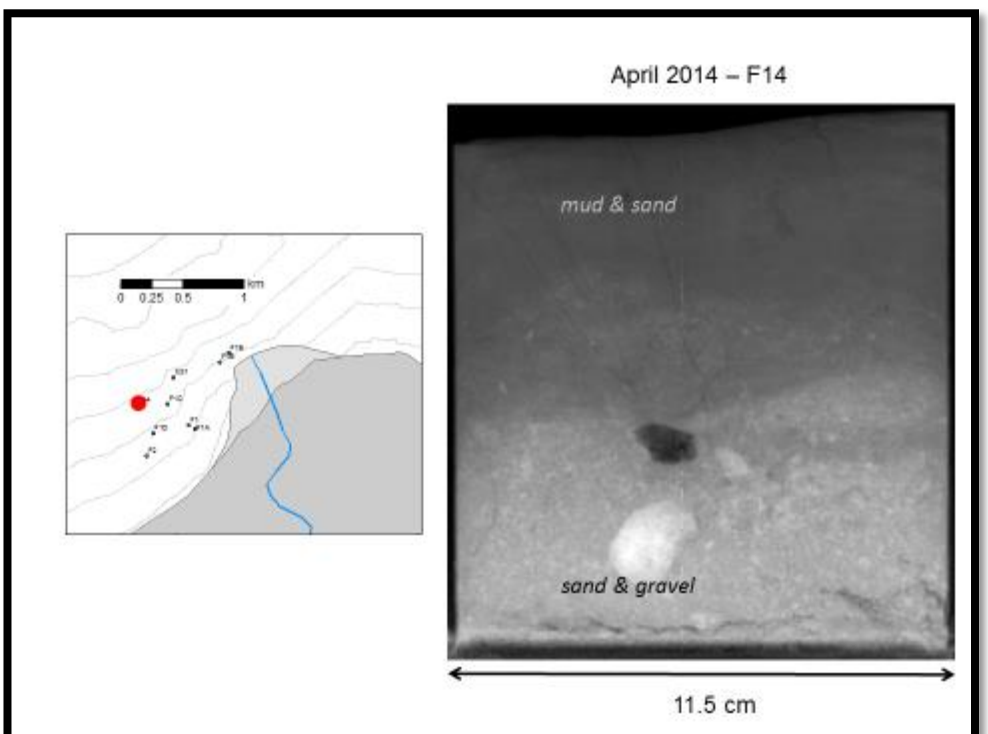

Figure 3: This x-ray image shows evidence of bioturbation within the sediments deposited offshore of the Elwha River Delta.

III: ELWHA NEARSHORE MANAGEMENT

Port Angeles landfill update

Presented by Kathryn Neal, P.E., Engineering Manager, City of Port Angeles

Background
The city of Port Angeles is in the middle of a significant project, where they are relocating the East 304 Cell of the landfill away from the bluff. This is necessary to protect the Strait of Juan de Fuca from the threat of solid waste contaminating the beach and water. Project construction began in July 2014, and workers removed about 200,000 cubic yards of municipal solid waste before closing the site for the winter. Construction is scheduled to begin again in May 2015. The design process began in 2011 when it became clear that only a narrow ten to thirty-foot wide pinnacle of native earth separated the bluff face from a pit of garbage 60-80 feet deep.

History
In order to understand the source of the problem, it is necessary to describe the landfill site and review the history of the landfill. The landfill site is a 70-acre, multi-purpose industrial site located along the shoreline of the Strait of Juan de Fuca on the west edge of Port Angeles, immediately to the east of the mouth of Dry Creek, and about 2.6 miles east of the Elwha River delta (Figure 1).

The property was purchased by the City in 1947 and has served as the solid waste disposal site since then for most of Clallam County, including the cities of Port Angeles and Sequim. The total length of the landfill site along the shoreline is 1370 feet, and the bluffs are about 135 feet high. This length is divided in half into the East 304 Cell and West 304 Cell. The areas closest to the bluff are the oldest parts of the landfill.

Initial practices began at what is now the West 304 Cell, where users drove in their trash and let it spill over the bluff, or burned it onsite, or piled it into various pits. Therefore, the West 304 Cell is a mixture of unregulated garbage. Clallam County adopted the first Comprehensive Solid Waste Management in 1971, and at that time the City ended burning, removed car bodies from the site, and improved other practices. Then the City began filling the Valley Cell, which started as a ravine in about the middle of the site. It was filled in compacted lifts, with daily soil cover. In the early 1980s, when the Valley Cell reached capacity, the East 304 Cell was created. The City dug out a pit about 60 feet deep and 50 feet from the edge of the bluff at that time. The garbage was compacted in lifts, and piled up in the center, to a maximum depth of 80 feet. Unlike the mixture of garbage in the West Cell, the East Cell is a solid block of garbage. In 1991, the East 304 Cell closed, and a geomembrane cover was placed over all three cells of the 304 landfill, in compliance with WAC 173-304.

In 1991, the city developed a set of three lined cells on the south side of the landfill site in compliance with WAC173-351 (the 351 Landfill). The 351 landfill closed in 2007, and a transfer station for municipal solid waste was built on the site (Figure 2). Other municipal facilities on the site include a recycling facility, a moderate-risk solid-waste facility, a composting facility, and a water treatment plant.

At the same time that the 351 landfill was closed in 2007, the City constructed a 454-foot long revetment wall at the toe of the West 304 Cell. The purpose of the 2006/2007 Seawall project was to eliminate the erosion of waste onto the beach from the West 304 Cell. The project also included removing garbage from the beach and re-grading the bluff slope to a less-steep, 1.25:1 slope. The project was successful in that it eliminated any occurrence of garbage eroding onto the beach. However, it requires beach nourishment and maintenance of the wall, especially of the transitional, rock endwalls at each end of the seawall. The total cost of the project was $4.4 million for design and construction.

In June 2011, a routine site inspection revealed a small amount of garbage exposed on the face of the bluff at the East 304 Cell. The city retained Herrera Environmental Consulting to design a solution to the immediate damage, and to develop alternatives for a design to resolve the underlying issue. In 2012, the City and Herrera designed and constructed a project to pull garbage from this section of the bluff and to fix drainage issues. During site investigations it became clear that in some places only eleven feet of native bluff held back the garbage from failing into the ocean. An array of conceptual alternatives were considered, ranging from armoring the entire shoreline to removing all the waste in the 304 Cell. The goal was to balance minimizing environmental impacts, providing a long-lasting reliable solution, and keeping costs within the City's financial capacity.

Evolution of the current project:
In 2013, the City committed to relocating the waste from the 304 Cell to the 351 landfill. The base design involved removing 247,000 cubic yards of waste in order to provide at least 25 years of protection. The conservative estimate of retreat rate of the bluffs is about 5 ft/yr. The City cannot predict with certainty how the retreat rate would change with climate change, sea level rise, and possible sediment contribution from the Elwha dam removal. The base design took these factors into account as much as possible, but it was clear that it would be ideal to remove all of the garbage from the 304 Cell and eliminate the risk of future erosion. Herrera prepared an alternate design bid that involved removing all of the waste, 400,000 cubic yards, within the East Cell. This was the preferred alternative, and the City would award this alternative if the bid prices were favorable.

Both alternatives involve excavating half of the 135-foot bluff, depositing the trash in the 351 Cell, and grading the remaining slope (Figure 3). The rest of the project includes reinforcing the end of the wall so that the wave action does not undermine the Valley Cell. It also involves constructing a mechanically reinforced earth wall (MRE) at the face of the Valley Cell above the seawall, installing native plants, and making habitat improvements in Dry Creek, by removing rip-rap from the stream bank and adding in-stream large woody debris.

Bids opened on April 30, and there were five bidders. Magnus Pacific was the contractor with the lowest bid. The cost of the Bid Alternate was only $1,713,345 more than the base bid, and was awarded by City Council on May 6, 2014. The total allowed for construction is approximately $15M. Other project costs include design, site investigations, 2012 bluff repairs and drainage repairs, financing costs, and construction management for a total estimated project cost of $21.3 million. Note that this is a completely different approach than the 2005 design for the revetment wall. Part of the reason is the very different ways that waste was placed in the two cells, part is consideration of environmental impacts and permitting constraints, and part is consideration of the longevity or durability of the solution. The cost is considerably more. The City received financial assistance from the Department of Ecology in the amount of almost $4 million, and is seeking additional financial assistance and low interest loans. The City borrowed money (issued bonds) to cover the remaining costs. The project represents a significant financial challenge to residents of Clallam County, and provides significant environmental benefit.

The Past Year at the Landfill

Presented by Jeremy Pozernick, Public Works Inspector and Field Engineer

Magnus Pacific is the contractor, and they brought in equipment to start removing the garbage in June 2014. Their trucks are capable of removing 30 cubic yards at a time. Within the first month, they removed the cover system from the East 304 Cell. The haul routes are about 1500 feet in length, and it takes about 10 minutes to complete the haul from the 304 to the 351 Cell. When the garbage is deposited in the 351 Cell, it is compacted. They also established plastic sheeting to temporarily cover the exposed garbage and reduce odor and protect stormwater runoff. The progress started off very strong (Figures 4 and 5).

Then they ran into asbestos containing material, so this stopped work temporarily. Due to the early dumping practices at the landfill, the history and location of hazardous garbage was unknown. Based on initial borings, the engineer's estimate was that 15 cubic yards of asbestos were buried in the 304 Cell. The team worked with Labor and Industries to come up with a safe new approach to remove the scattered asbestos they found. This new plan involved using the large haul trucks to move the asbestos material in a large mass. Because asbestos is most dangerous when it becomes airborne, they sprayed the area with water and the workers wore the appropriate personal protective equipment (PPE). The trucks and the loads were misted with water, and the asbestos waste was covered with non-hazardous waste, so that the trucks could safely haul the material from the 304 Cell to the 351 Cell (Figure 6). The total amount of contaminated material relocated in 2014 was 7,283 cubic yards, over 450 times the amount initially estimated within the East 304 Cell.

The asbestos effort caused a set back in the timeline for the overall work at the landfill. Today's standards for depositing asbestos require that it is contained and its location is documented. Therefore, the contractor created a special berm in the 351 Cell for the asbestos.

After the asbestos removal, the contractor dug into the bluff material and left the area in a stable configuration to make it through the winter season (Figure 7). All total, during the 2014 season, the contractor removed 192,851 cubic yards of municipal solid waste, 12,465 cubic yards of clean bluff material, and 7,283 cubic yards of asbestos containing material.

Construction will start again in May 2015. The remaining tasks for 2015 are:

- Complete the relocation of the entire 400,000 cubic yards of waste from the 304 Cell
- Install the final cover system on the 351 landfill
- Modify the access road and seawall ends
- Stabilize the face of the Valley Cell (construct MRE wall)
- Stabilize other slopes and plant native vegetation
- Install wood habitat structures in Dry Creek and remove rock rip-rap.

Figures:

Figure 1: Location of the Port Angeles Landfill site between Port Angeles and the mouth of the Elwha River. Extent of existing shoreline armoring is shown in red.

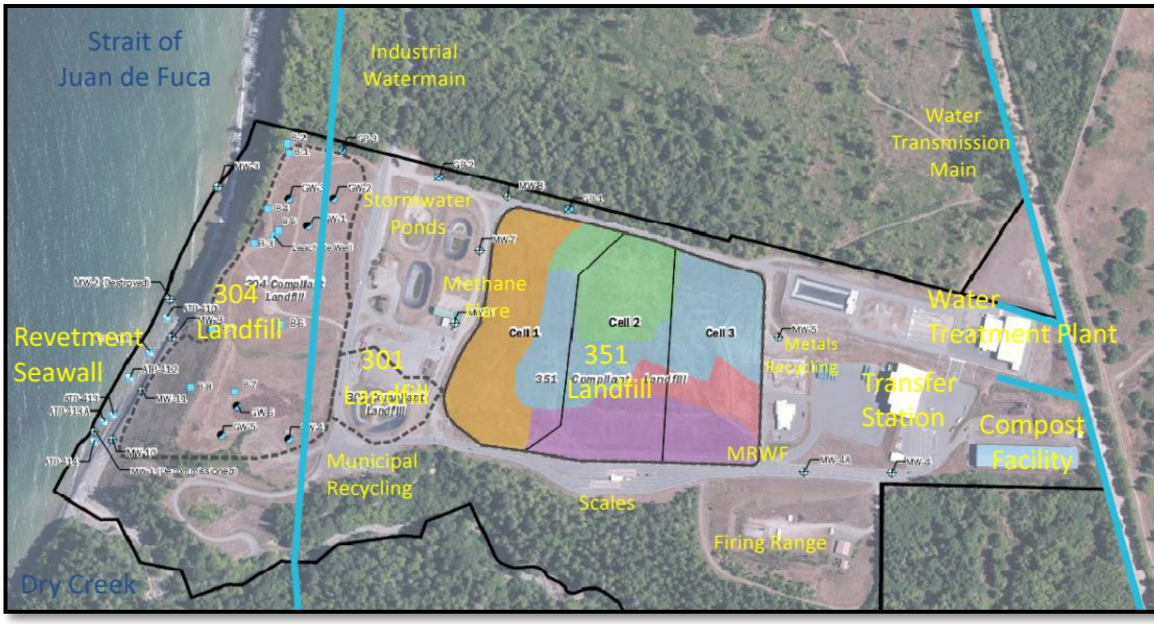

Figure 1: Site map, showing the closed 304- and 351-compliant landfills, and the other facilities on the municipal industrial area site.

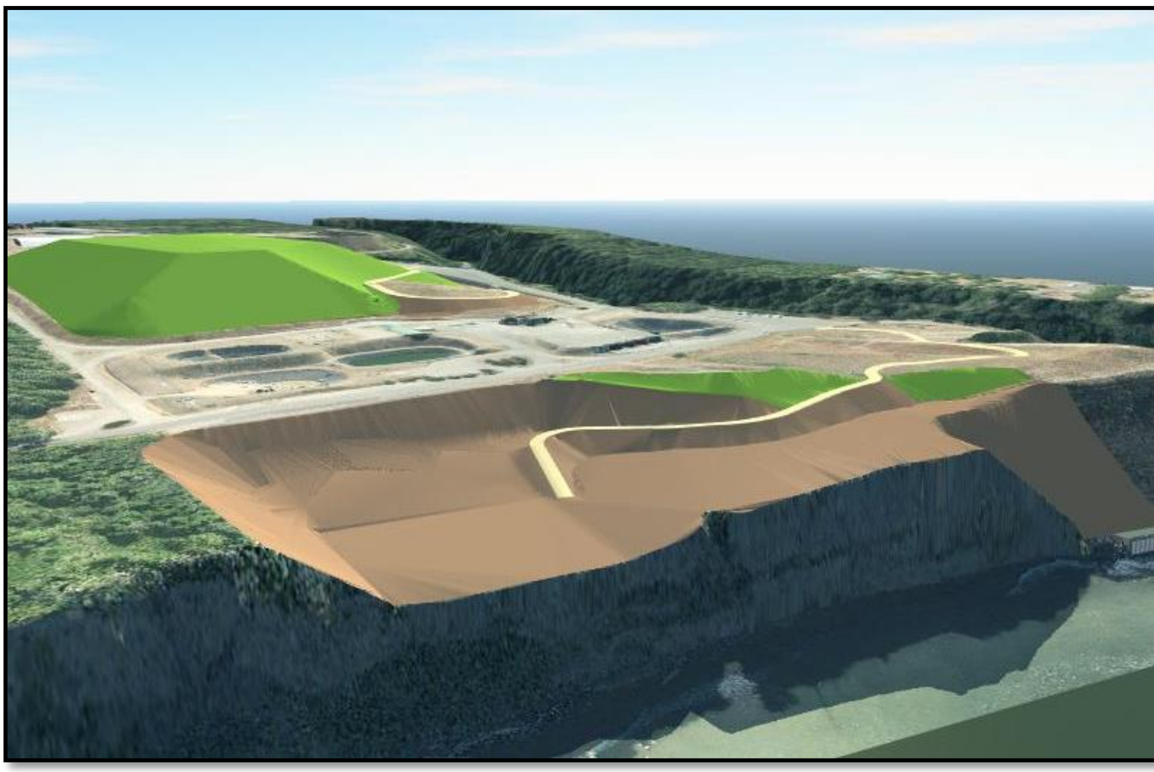

Figure 3: Project visualization from Herrera Environmental showing all waste removed from the 304 landfill and relocated to the 351 landfill.

Figures 4 and 5: Aerial photos showing the Port Angeles Landfill before construction began (June 20, 2014) and after significant progress on the waste relocation (August 21, 2014).

Figure 6: Computer rendition of the extent of the asbestos pockets in the 304 Cells.

Figure 7. Port Angeles Landfill construction site as it appeared in December 2014, stabilized for the winter. View is looking north toward the Strait of Juan de Fuca.

Elwha nearshore restoration status

Presented by Jamie Michel, Coastal Watershed Institute

Background
As the community—management, science, and residents—look at the Elwha River Ecosystem restoration, we must remind ourselves why we removed the dams.

We did this for fish. Ultimately, the dams were barriers to fish passage and habitat. What scientists are seeing with the removal of these dams, is that the river and estuary are beginning to be restored by sediment processes. However, down drift (east of the river) there is heavy impairment to the entirety of the shoreline, and it remains damaged and neglected. If we desire full ecosystem restoration, then we need to consider the condition of the shoreline that supports early saltwater salmonid life stages.

The focus of the nearshore restoration opportunity and need is the 7-mile, eastern stretch of shoreline east of the river mouth where sediments flow from the mouth of the river toward Ediz Hook (Figure 1). When the dams interrupted sediment delivery to the nearshore, the lack of sediment and woody debris caused the Elwha shoreline to transition from a beautiful, natural beach that was littered with wood and offered great fish habitat, to a modified, heavily-armored, over-steepened shoreline which offers very little in the way of habitat for forage fish and migrating fish. It also became fairly unfriendly for human beings.

But now we have an opportunity to link the Elwha River restoration with the restoration of the nearshore. Dam removal sediments present the best opportunity to utilize the low-cost, natural delivery of sediments to restore beaches severely degraded by sediment starvation associated with the former dams.

Questions and Goals for Restoration
With this unique opportunity, the new questions are:

1. When, where, and how will beaches re-establish along seven miles of shoreline as a result of this sediment pulse?
2. How will existing armor affect sediment deposition?
3. How long will beach material remain in the drift cell?
4. Are current river and bluff sediment supplies sufficient to maintain beaches in the drift cell after the dam removal sediment pulse?
5. What can be done to enable the shoreline to more effectively receive newly available sediments?
6. Can we re-establish self-sustaining beaches throughout the drift cell?

These questions are specifically targeting the stretch from the eastern side of the Elwha River delta to Ediz Hook because the change in substrate of Freshwater Bay has been remarkable and offers tremendous habitat. Therefore, conservation is the focus of Freshwater Bay, while restoration is the focus to the Elwha nearshore. Protection in Freshwater Bay should conserve unimpeded beach processes, including unaltered beach faces and encompassing riparian zones of the dune and log line. Backshore wetlands and the LWD that protects these processes should also be conserved to maximize ecosystem benefit (Shaffer et al., 2012; Rich et al., 2013).

Current status of the Elwha nearshore

This status goes from west to east along the shoreline (Figure 2). Starting at Place Road, the west levee alters sediment movement westward. Additionally, a new setback levee built on the east side of the river constrains water flow and sediment movement to protect floodplain residents and infrastructure. Approximately 100 acres of new estuary habitat has formed at the river mouth.

Moving toward the east of the river mouth, the armored shoreline is not gaining sediment, and, unfortunately in January, a section was re-armored. This addition was conducted without permits. Given the data that armored beaches do not accrete sediment, this begs the question: was this the best management practice for this shoreline, or rather, should shorelines be managed to encourage sediment deposition?

Further east, stretches of un-armored feeder bluffs exist, where Dave Parks (DNR) saw some minor material deposition that was transported away, shortly thereafter. At the landfill, the 454-foot-long seawall with its failing endpoints has the highest rates of erosion observed in the drift cell. However, this erosion rate is unnatural and attributable to the seawall. Next is the industrial waterline, which comes out, and results in two miles of beach armor that run towards Ediz hook. In 1929, this waterline was built at the base of the bluff and buried at 8-foot depth. The pipe has been exposed and re-armored several times since installation and now, it sits well away from the bluff with portions of pipe again exposed.

Beyond the landfill along Ediz Hook, the United States Army Corps of Engineers (USACE) added 3.5 miles of armoring to attempt to protect industry, a road, and the landing strip for the U.S. Coast Guard which are located on Ediz Hook. USACE continues to augment this beach with cobble to mitigate high rates of erosion due to lack of sediment supply associated with the former dams and armored feeder bluffs updrift.

The nearshore in the future

The Elwha River provides natural material to the nearshore, but where will it end up? Currently, 3.5 million m^3 of sediment have been delivered to the nearshore. This is out of the projected 8 million m^3 of sediment that is of the appropriate size (sand, gravel, and cobble) made available by dam removal to form natural beaches along the drift cell. We do not know when, where, and how sediment will get to the area of concern or if it will stay. CWI is working with the scientists and mangers including the City of Port Angeles, DNR, and the USACE to try to answer these questions.

It is important to point out, that in other parts of the world, countries dedicate significant resources to do the same thing that is happening here for free. For instance, in Holland, 20 million m^3 of sand were added to the shoreline to establish a broader, low profile beach that attenuates erosion (Stive et al., 2013).

However, with 5.5 miles of armor, will our sediment be capable of re-establishing beaches of historic profile and substrate? In the summer of 2014, some sediment settled in the area, but it did not settle in the areas of armored beach and what deposited was quickly moved away. With the exceptional data on sediment budgets to the delta and the erosional rate calculations provided by the DNR and Department of Ecology, we know what the river and bluff contributions of sediment are to the drift cell. Now it is important to assess what the wind and waves will do with the sediment as it interacts with the impaired shoreline.

Coastal Watershed Institute priorities and restoration recommendations

While trying to answer the questions above, CWI restoration recommendations are:

- stop further harm to the Elwha nearshore due to increased shoreline alteration and armoring
- add LWD to help restore natural beaches in the Elwha drift cell.
- Protect LWD and intact shoreline beaches (Rich et al 2014; Wefferling 2014 and these proceedngs)

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Figures

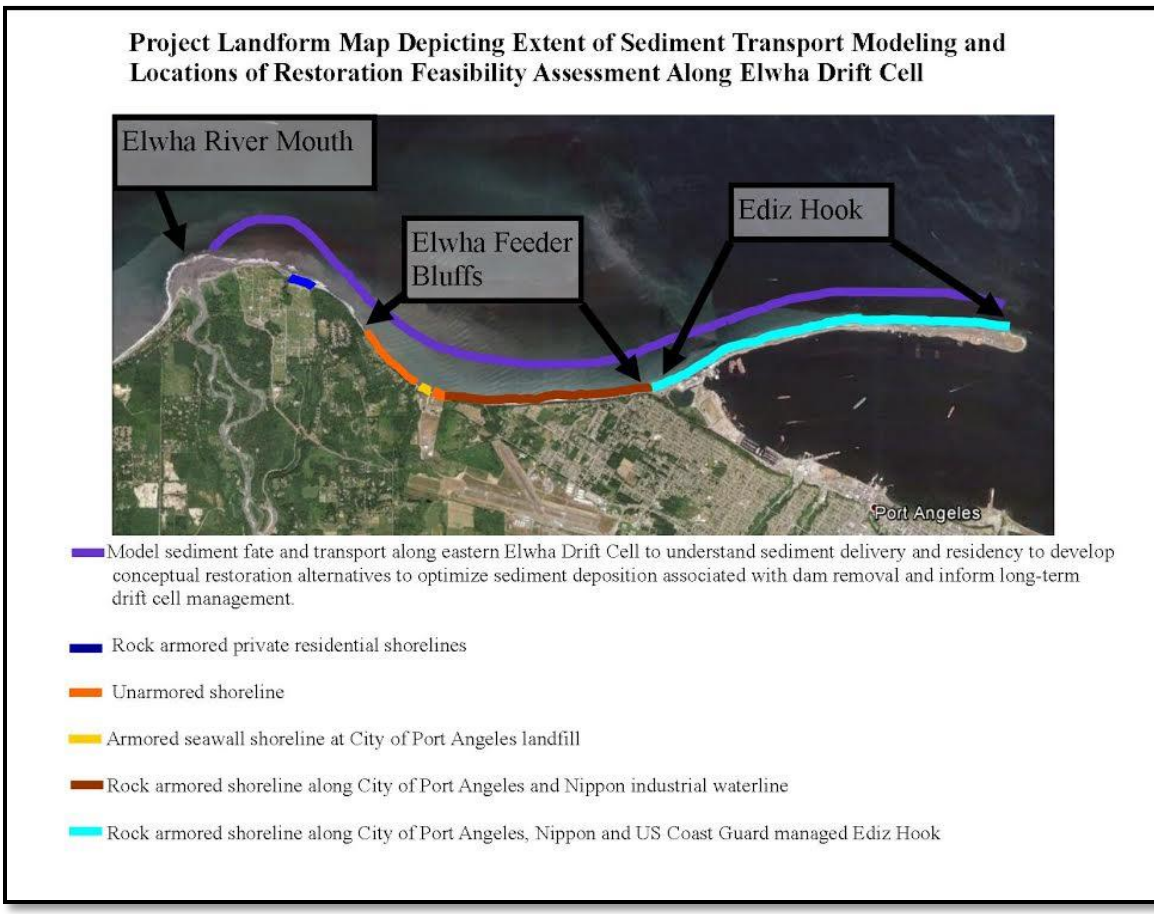

Figure 1: A map of the 7-mile, eastern stretch between the Elwha River and Ediz Hook. This length is the focus of the nearshore restoration effort.

Figure 2: A map identifying the areas of interest for the current status of the Elwha nearshore.

Shoreline change

Presented by David R. Michalsen, P.E., U.S. Army Corps of Engineers, Seattle District

Recent funding

The money to move forward on modeling the Elwha Drift cell comes from the regional sediment management program, which is a program funded through the USACE headquarters. With the sediment coming from the Elwha, the USACE has a responsibility and desire to understand how the sediment interacts with this stretch of shoreline.

Scope of Work

The plan is to take bi-annual surveys on the bluffs and Ediz Hook, and to also complete beach profile surveys along with the USGS (Figure 1). Then the USACE will use a shoreline change model called GenCade. This model combines the GENESIS (Hanson and Kraus, 1989) and Cascade (Kraus, 2002) models. The Cascade model looks at regional sediment budget constraints. These will then be inputs into the Genesis model, which simulates shoreline changes over time, based on wave climate and tidal regime. This information allows the USACE to analyze a typical fifty-year lifecycle and determine where the best opportunities exist for costal or ecosystem restoration. Also, it allows the USACE to manage the re-nourishment of Ediz Hook.

Right now the USACE surveys at Ediz Hook occur once a year, but the additional funding expands the work to two surveys per year. This work is in cooperation with George Kaminsky of the Department of Ecology. He already uses a suite of tools, and the Corps will compare its data with his work.

The USACE will also couple the GENCADE modeling with a spectral wave model developed for the coastal waves through the Strait of Juan de Fuca. This provides localized data on the characteristics of the shoreline. The existing surveys will help to calibrate and validate the long shore transport coefficients needed for the model.

Project goals

The USACE wants to quantify long-shore rates using the shoreline change model. This will allow the USACE to identify segments within the littoral cell which are accretionary or erosive. This further allows the USACE to prioritize beach restoration efforts, identify areas that need attention due to increased erosion, and watch storm erosion. This all ties back to Ediz Hook and how to nourish that section within the scope of the whole system.

Figure

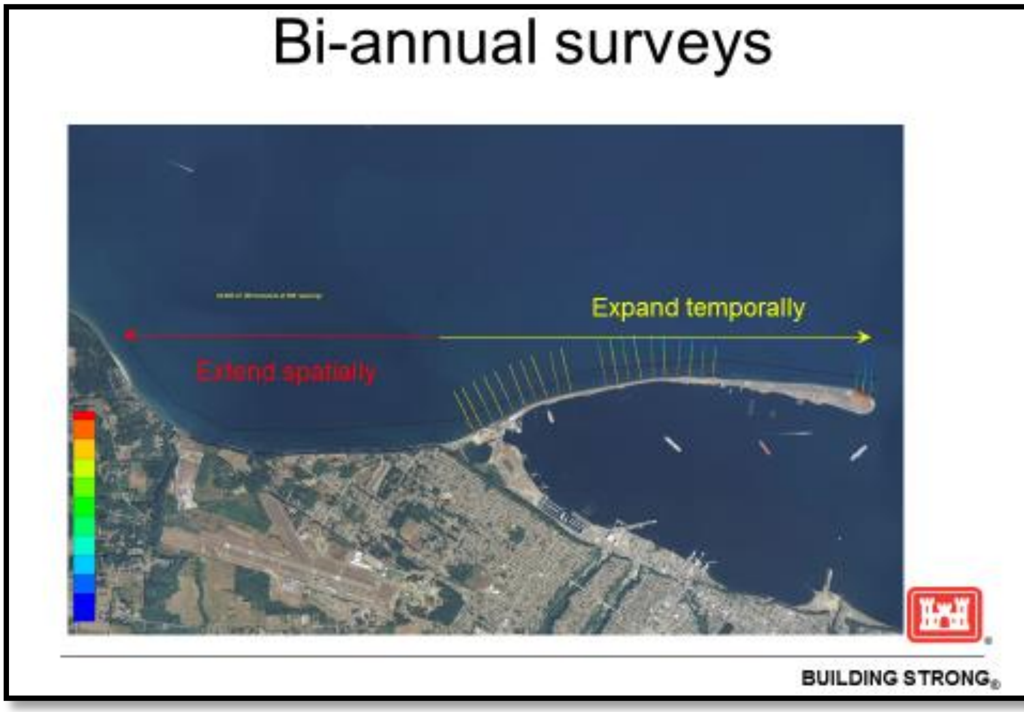

Figure 1: This map shows Ediz Hook and the areas the USACE will make additional surveys for increasing the accuracy of their models.

IV: NEARSHORE BIOLOGICAL PROCESSES

Nearshore Vegetation Responses to Dam Removal in the Elwha Drift Cell – Preliminary Findings

Presented by: Steve Rubin, USGS
Written by: Helen Berry, Washington State Department of Natural Resources, Olympia, WA.

DNR's Nearshore Habitat Program monitors vegetation and other indicators of nearshore habitat health. Nearshore vegetation in the Salish Sea is diverse and ecologically important; 23 species of kelp, 5 native seagrasses and hundreds of red and brown algae species provide an important source of primary production and create three dimensional habitat for a wide range of species.

This study explores changes in nearshore vegetation abundance and distribution following initiation of the Elwha River Restoration Project. Anticipated short-term physical impacts to vegetation due to dam removal include increased turbidity, scour, and burial (sediment deposition). In the longer term, a shift from hard sediment species to soft sediment species was predicted in the Environmental Impact Statement.

Two methods were used to monitor different constituents of the nearshore vegetation community. Floating kelp canopies were surveyed annually with aerial photography as part of DNR's long term floating kelp canopy monitoring program (https://fortress.wa.gov/dnr/adminsa/DataWeb/dmmatrix.html). Submerged vegetation was surveyed along transects using towed underwater videography at 6 sites (Figure 1). Underwater videography was classified to identify presence and density of a series of vegetation types that can be differentiated remotely (Figure 2). The imagery was subsampled and one video frame was classified every 5 seconds.

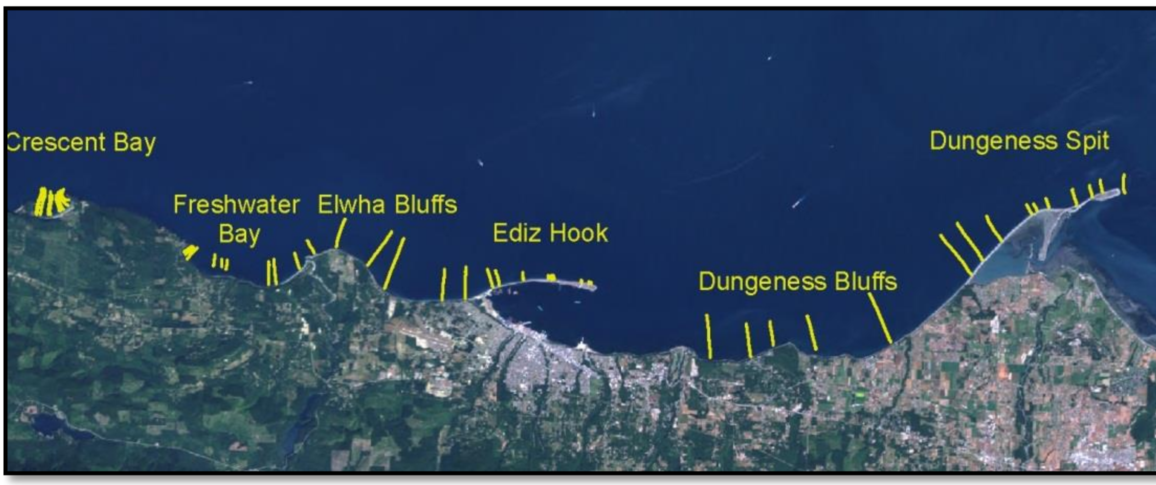

Figure 1. Underwater videography transects surveyed at 6 sites.

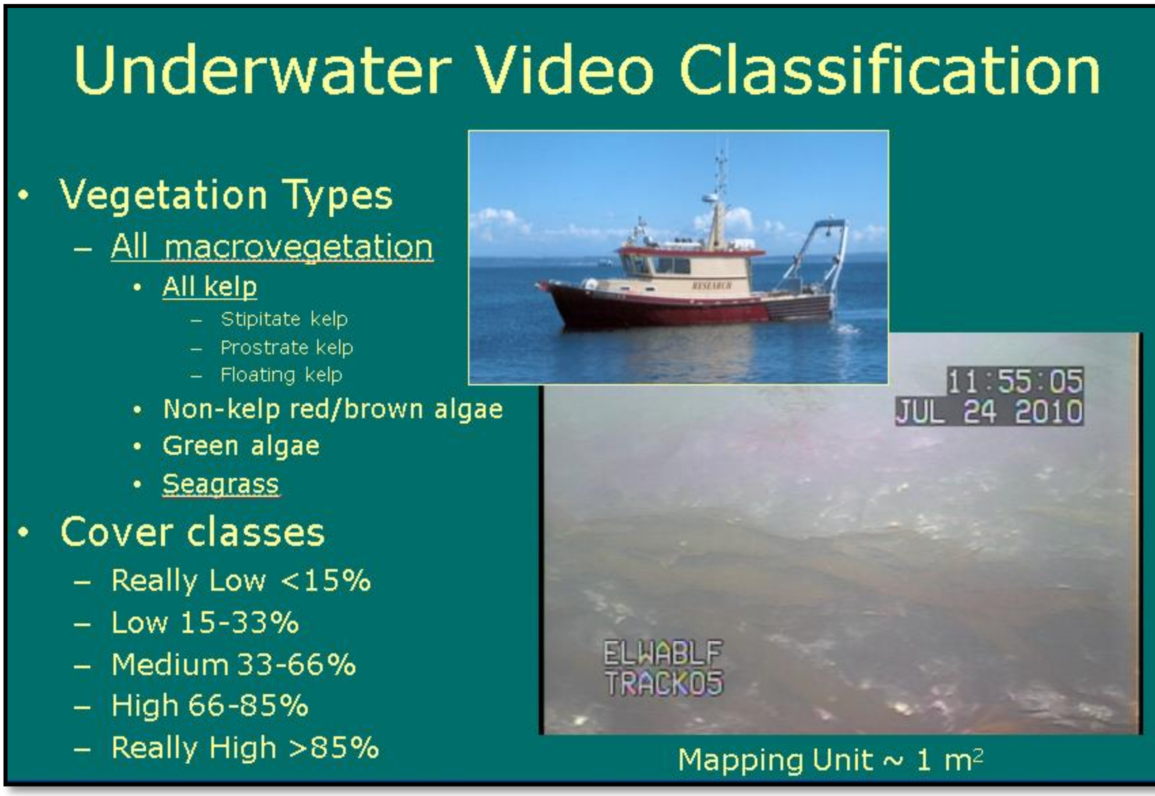

Figure 2. Underwater videography classification method summary.

Findings: These preliminary findings are presented for collaboration with other researchers and interested parties, they are subject to change.

In the years following dam removal initiation, profound changes have been observed in both floating kelp and understory algae, with a gradient of greatest change near the river mouth.

Floating kelp canopy area in the Elwha Drift Cell decreased approximately 30% per year, for a total decrease of 68% between 2011 and 2014 (Figure 3a). The greatest decreases were measured near the delta, however, substantial losses also occurred at more distant sites (Figure 3b). In 2014, sub-surface juveniles were observed on the underwater imagery, which suggests that floating kelp sporophyte growth may had been delayed seasonally (discussed below). The observed decline since 2011 continues a gradual decrease observed in the area since 2007 which is unrelated to dam removal (https://fortress.wa.gov/dnr/adminsa/DataWeb/dmmatrix.html).

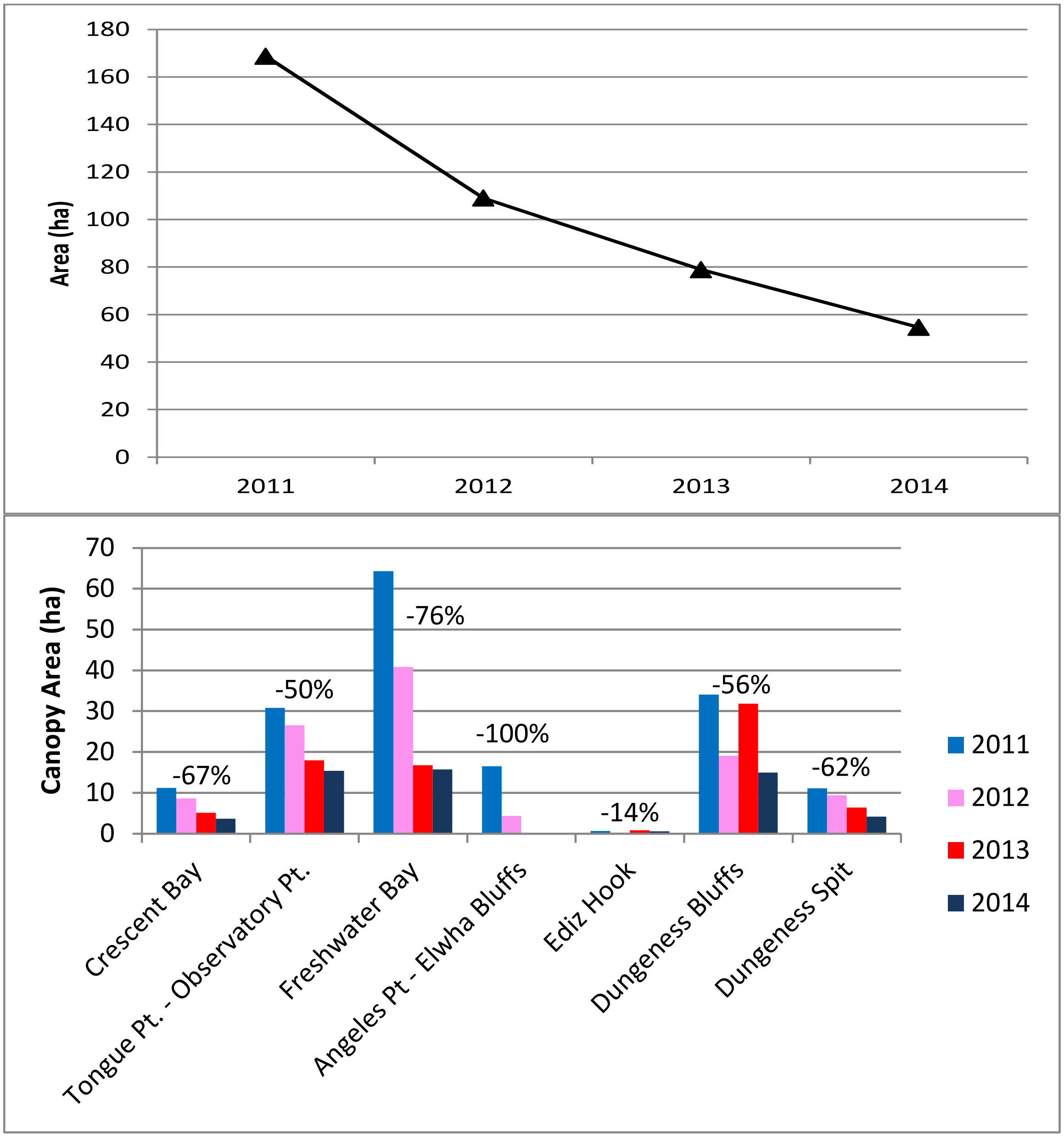

Figure 3. Total floating kelp canopy area in the vicinity of the Elwha River mouth (Top) and sub-divided into sub-regions from west to east (Bottom).

Understory vegetation in the vicinity of the Elwha Drift Cell decreased in 2012 and in 2013, relative to the 2010 baseline (Figure 4). Understory vegetation then increased in 2014 relative to 2013. The 2014 observed increase may be due in part to sampling later in the season (September rather than July). Sampling was delayed because high turbidity associated with the plume during summer months precluded effective sampling. Dive survey data from USGS (Rubin & Elder) suggests macrovegetation growth may be seasonally delayed. The abundance of the ephemeral species *Desmarestia spp.* and *Laminaria ephemera* appeared to be higher in September 2014. No changes were observed in seagrass abundance overall. However, there is high uncertainty in seagrass results because its restricted distribution led to relatively few samples.

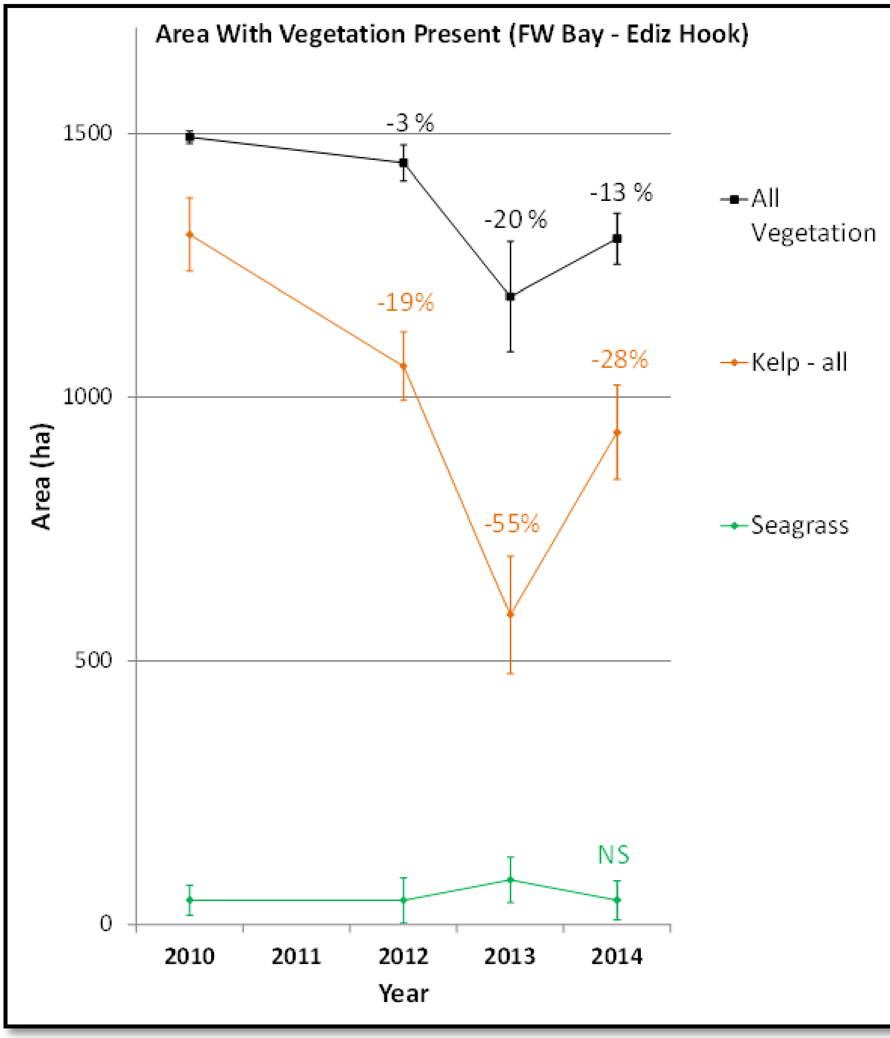

Figure 4. Areal extent of all vegetation, kelp and seagrass in the vicinity of the Elwha River delta (Freshwater Bay to Ediz Hook).

In addition to estimating changes in aerial extent, we estimated changes in median cover classification of vegetation types. Changes in median cover were most distinct near the mouth (Figure 5), and the magnitude of change decreased with distance from the mouth. Median kelp cover decreased in 2012 relative to 2010, and then decreased further in 2013. In 2014, changes varied spatially: median cover continued to decrease in Freshwater Bay and at the base of Ediz Hook, while it increased along the eastern portion of Angeles Point.

Burial is likely to be a primary driver of change in the river mouth and areas of sediment deposition, while scour and turbidity are likely to be important in other areas.

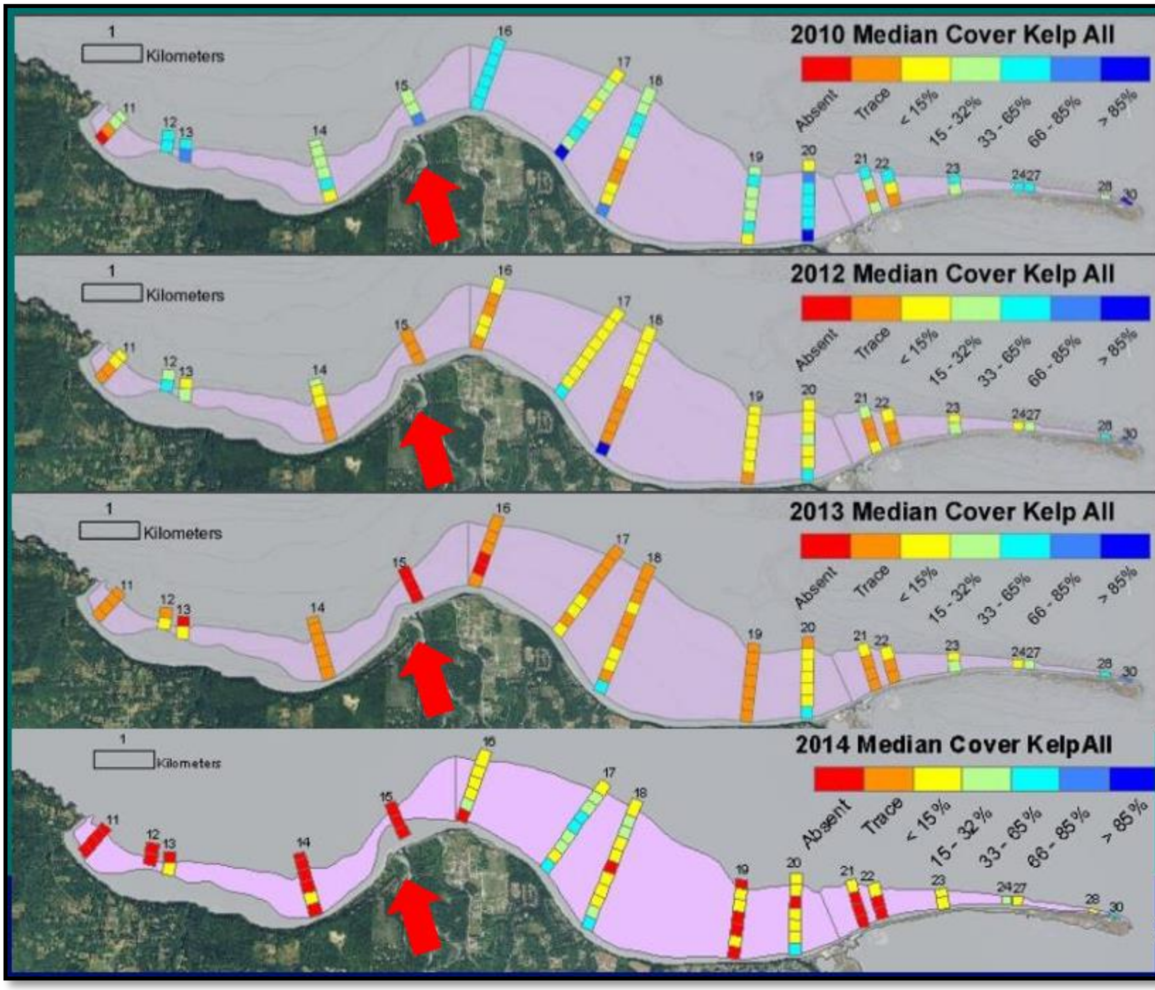

Figure 5. Median cover of kelp over time in the vicinity of the river mouth (2010-2014). The location of Elwha River mouth is identified by a large red arrow.

Editor's note: See also Norris et al. 2007, 2009, and 2011 sponsored by Clallam County MRC.

Norris, J, Ward, I., Shaffer, A., and Lear, C., 2007, Eelgrass mapping of the Elwha Nearshore.: In Proceedings of the 2007 Georgia Basin/Puget Sound Research Conference, Olympia, Washington.

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Changes to Shallow Subtidal Benthic Communities During Elwha dam Removal

Presented and written by: Steve Rubin, USGS
Authors: Steve Rubin, Nancy Elder, Ian Miller, Jeff Duda, Melissa Foley, Matt Beirne, Mike McHenry, Rob Pedersen, Marshal Hoy

Abstract: Deconstruction of two dams on the Elwha River began in September 2011, resulting in large inputs of sediment previously entrained in reservoirs to the Strait of Juan de Fuca. We have conducted annual dive surveys since 2008 to assess the response of the marine benthic community (seaweeds, invertebrates, and fish) to these changes in sediment input. During 2009-2011 we established permanently marked sites, allowing resurveys of the same transects, along 10 km of shoreline bracketing the river mouth (12 treatment sites) and 20 km to the east near Green Point (2 reference sites). In 2008 and 2009 we conducted more spatially extensive surveys at treatment sites spread between west Freshwater Bay and the base of Ediz Hook and reference sites near Low Point (to the west) and Green Point, and some of these sites were resurveyed from GPS coordinates (no permanent markers) during dam removal. Mean density of large brown algae (kelp and *Desmarestia*) and percent coverage of brown and red algae decreased substantially near the river mouth in the first year following project initiation (year 1), decreased further in year 2, and remained at low levels in year 3. While all 10 kelp species declined, annuals were more impacted than perennials. In contrast to the general decline, juveniles of several brown and red algae species appeared in late August of years 2 and 3, a substantial delay compared to typical spring timing of juvenile growth. Invertebrate and fish taxa dependent on vegetation also declined; for example, sessile jellyfish (*Haliclystus*) which attach to vegetation, and graceful kelp crab and kelp greenling which associate with it all decreased in abundance after the start of dam removal. However, many invertebrate and fish species did not decline to the same extent as seaweeds.

Large Scale Dam Removal and Ecological Changes Unfolding in the Elwha River Estuary: Fish Use

Presented by: Anne Shaffer[1, 2], Coastal Watershed Institute/University of Victoria
Co-authors: Cayla Nauman[1,2], Jamie Michel[1], Tara McBride[1,3] , Dave Parks[4], Beth Connelly[1,3], Jenna Moore[1,5], Chris Byrnes[6]Francis Juanes[2], Thomas P. Quinn[7], and Andie Ritchie[8]

[1]Coastal Watershed Institute, Port Angeles WA., [2]University of Victoria, Victoria, British Columbia, Canada; [3]Western Washington University Huxley College of the Environment on the Peninsulas/Peninsula College, Port Angeles WA;. [4]Washington Department of Natural Resources; [5]Central Washington University; [6]Washington Department of Fish and Wildlife , Port Angeles WA [7]University of Washington, Seattle WA; [8] Olympic National Park, Port Angeles, WA.

Summarized by Nathan Moore, Western Washington University

Introduction: Located on the north Olympic Peninsula, the Elwha River nearshore is a critical component of the Salish Sea. It is depended on by no fewer than six state and federally listed species, including five species of salmon and numerous forage fish including eulachon, surf smelt, and sand lance. The Elwha nearshore is impaired ecologically due to extensive shoreline armoring, in-river channelization, and dams. The Elwha nearshore is undergoing an unprecedented restoration event with the removal of two large in-river dams, which began in September 2011 and completed in August 2014. As of September 2014 approximately 2.3 million cubic meters of sediment had been delivered to the sediment starved Elwha delta. This has resulted in striking changes in the Elwha nearshore, including Freshwater Bay, the lower Elwha, and its delta. As a result, approximately 85 acres of new estuary habitat has formed.

This presentation provided highlights of an ongoing, long-term nearshore study that is working to understand nearshore ecological response to dam removal. Fish presence over time is used as a metric of ecological change. The study also highlights the changing function of the lower Elwha River and its estuary. Data are sectioned into three sets corresponding to three phases of dam removal (prior to, during, and after dam removal) and used to address the following questions.

- What is the change in aerial extent of ecological habitat in the Elwha nearshore, delta, estuary, and lower river?
- Do metrics of fish abundance, size, composition, and species richness and diversity in the Elwha estuary change during dam removal?
- Are these metrics in the newly formed estuary different than the original estuary and comparative areas?
- What additional steps are needed to restore the Elwha nearshore ecosystem?

Methods: Habitat change: Orthorectified aerial photographs of the river delta were used to map changes in the Elwha estuary and intertidal beaches immediately east and west of the river mouth. Polygons were delineated for estuary and shoreline photos taken from 1939-2014. Photos were binned into three categories: at dam installation (DI) (1939 war photo), dammed (D) (1939-2011), and dam removal (DR) (2011-2014). Areas of shoreline, estuary (west, east, and total), and river channel (length and area) were mapped and averaged within the three photo categories in order to assess the change in area. Results are represented as absolute values and percent changes in table X. Acreages were then analyzed for diversity, and abundance of fish across the Elwha delta through the three phases of dam removal.

Fish use: Monthly seines are taken before dam removal (2007-2011), during dam removal (2012-2014), and after dam removal (2015-present). Abundance, timing, and size of fish, by species including surf smelt, sand lance, and eulachon are used as a metric to define ecosystem function for the nearshore habitats of the lower Elwha River and estuary.

Sampling sites: Sample sites are located on the West side of Elwha River delta (Figure 1).

Two new sample sites were added in 2013 due to new habitat development.

Salt Creek provided a reference site eight miles to the west.

Figure 1. Sample sites of monthly beach seines

Analysis: We conduct series of Mixed Effect Logistic and Generalized Logistic Models, using the LaPlace approximation and a Poisson distribution. The best-fit model is defined using R by model dredging and averaging of top models with AIC scores that had differences of less than four (Bolker et al. 2009; Gardner et al. 2012, R core team 2013). Significant relationships between species richness, chum abundance, and chum size relative to predictive variables of month, year, site, and dam removal phase were defined through this analysis.

Data analysis is currently underway. Here are highlights of results from habitat mapping through May of 2014, and beach seining through March 2014. Note that juvenile fish outmigration occurs through September, so fish use data for 2014 are incomplete.

Results: Habitat mapping: The Elwha estuary and delta changed dramatically, with upward of 80 acres of new habitat created since dam removal. Most of this change occurred in the second year of dam removal (Table 1).

Table 1. Example of change in areal extent of habitats of the Elwha estuary and lower river due to dam removal sediment delivery 2011-2014. Numbers are generated by mapping of ortho-rectified aerial photographs using ArcGIS

Nearshore Region on Elwha lower river and delta	Lost Area (ha)	Gained Area (ha)	Net Change Area (ha)	Cumulative Area (ha) Post 2011
2011-2013				
West Shore	0.38	0.69	0.31	0.00
East Shore	0.05	3.16	3.11	0.00
River mouth	0.00	0.72	0.72	0.00
Total Area	0.43	4.56	4.13	4.13
2013-2014				
West Shore	0.24	6.98	6.74	0.00
East Shore	0.27	23.35	23.08	0.00
River mouth	0.00	1.36	1.36	0.00
Total Area	0.51	31.68	31.18	35.31

Fish species richness was highly variable by month, and not significantly different between the Elwha and comparative site for either pre-dam removal or dam removal phases (Figures 2 and 3).

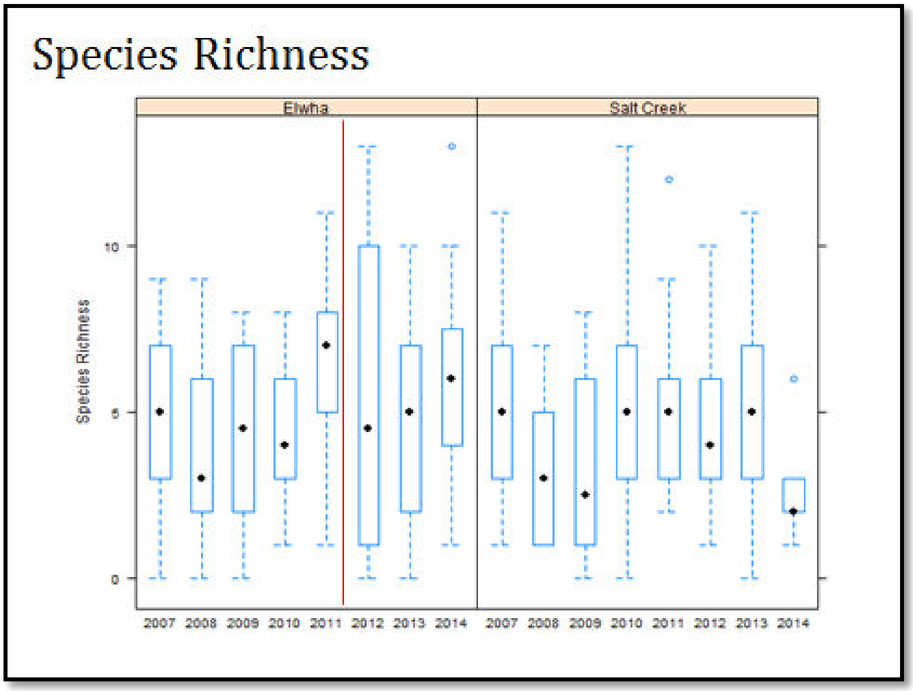

Figure 2. Species Richness of Elwha and comparative site through May 2014. Red line indicates dam removal.

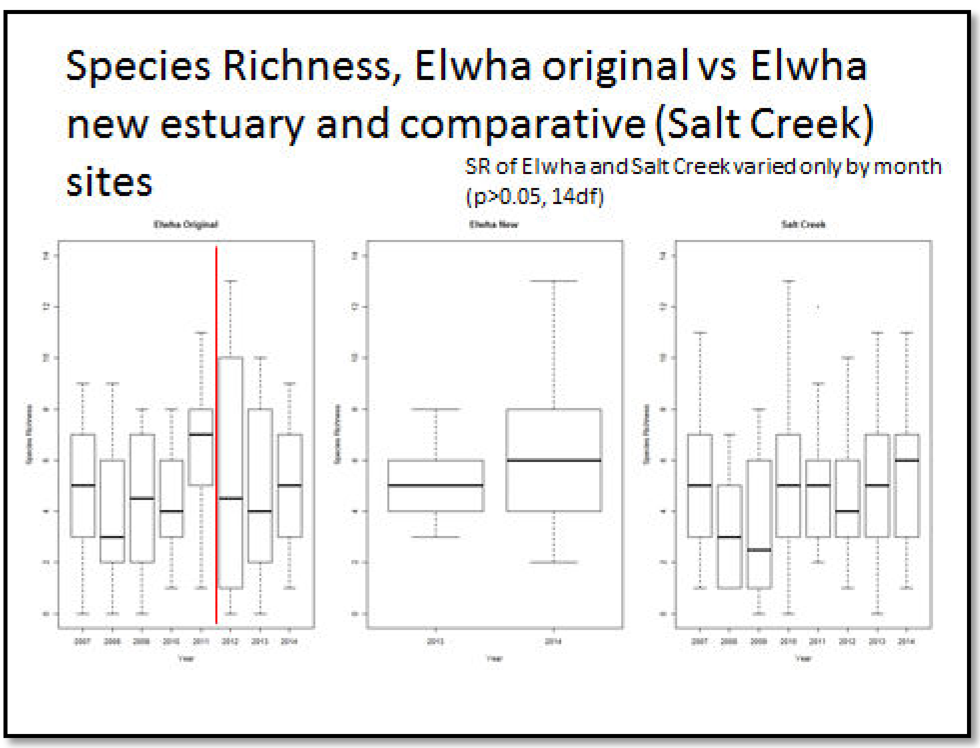

Figure 3. Species Richness of the original and new Elwha estuaries, and comparative site through May 2014. Red line indicates dam removal.

In a nutshell, the Elwha nearshore function varies dramatically by season, as well documented by Shaffer et al. (2012), and species composition in the estuary as of March 2014 does not appear to be changing dramatically due to dam removals (Table 2). We are seeing changes in some of the fish species use (data not provided as they are being analyzed. Contact Shaffer for details).

Table 2. Percent species composition of Elwha west estuary. Red line indicates dam removal. 2008-2014.

Elwha west estuary — **Percent species composition**

Red line indicates dam removal

	Original estuary							New estuary	
	Pre-dam Removal				Dam Removal		Post dam removal	Dam Removal	Post dam removal
Species	2008	2009	2010	2011	2012	2013	2014	2013	2014
Chinook *O. tshawytscha*	36%	31%	66%	15%	8%	3%	2%	10%	26%
Coho *O. kisutch*	6%	15%	13%	19%	22%	6%	2%	4%	6%
Chum *O. keta*	2%	7%	1%	1%	5%	1%	1%	3%	2%
Cutthroat *O. clarki*	1%	0%	0%	0%	1%	0%	0%	0%	0%
Steelhead *O. mykiss*	0%	0%	0%	1%	1%	1%	0%	0%	0%
Unided juvenile trout	0%	0%	0%	0%	0%	0%	0%	0%	0%
Surf Smelt *Hypomesus pretiosus pretiosus*	1%	0%	0%	0%	2%	0%	0%	0	3%
3-Spine stickleback *Gasterosteus aculeatus*	39%	42%	9%	44%	29%	74%	91%	4%	8%
Starry Flounder *Platichthys stellatus*	3%	1%	0%	1%	1%	1%	0%	10%	0%
Prickly Sculpin *Cottus asper Richardson*	1%	0%	1%	6%	15%	9%	1%	36%	3%
Staghorn sculpin *Leptocottus armatus*	9%	8%	3%	8%	8%	2%	0%	33%	13%
Redsided Shiner *Richardsonius balteaus*	0%	0%	0%	0%	4%	2%	2%	1%	0%

Also of note, in 2015 there was a dramatic increase in the number of eulachon, *Thalicthys pacificus*, observed in the Elwha estuary (Figure 4). Eulachon are federally listed and culturally and economically important. In 2014, a total of eight eulachon were collected. In 2015, 150 eulachon were collected. While observed in the lower river in the past (Shaffer et al. 2012), this was the first time these fish have been intercepted in the estuary. This increase in eulachon presence may be a result of a change in sediment grain size needed for eulachon spawning. This is supported by the finding of gravid eulachon primarily in the newly established habitat, and spent eulachon in the older, no longer tidally influenced, original sites. Evidence for increased numbers of eulachon is also resulting in the recent feeding frenzies of birds throughout the Elwha estuary and lower river.

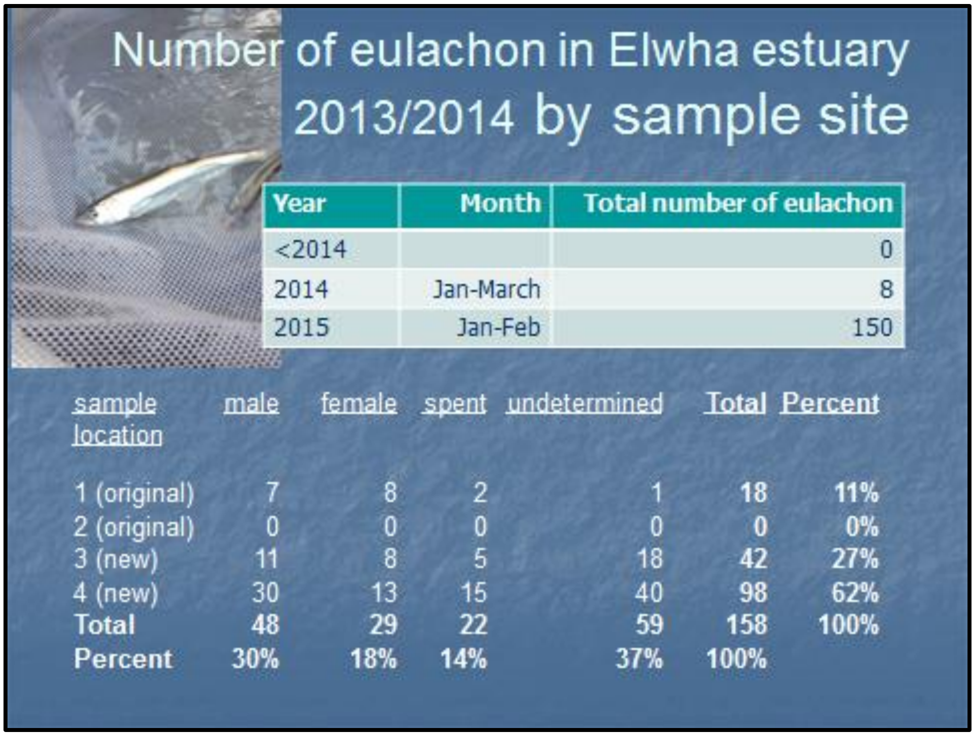

Figure 4. Eulachon observed in monthly beach seine hauls at Elwha nearshore. These fish were not observed at the comparative site.

Estuary Restoration Priorities: The western 1/3 of the Elwha estuary continues to be disconnected from the river and the rest of the west estuary. The west levee's disruption of Elwha hydrodynamics may also cause a reduction of useable estuary area by baring fish from approximately 1/3 of the otherwise highly functioning estuary. Based on visual observation it appears the west levee is likely causing some of the highest functioning area of the Elwha nearshore to fill in. If this happens there will be a decrease in restored habitat in the Elwha nearshore. This dike was identified decades ago as a concern and continues to be a top priority for restoration.

Summary (to date):

- Nearshore use is highly variable both seasonally and annually;
- Seasonal variation in fish use of nearshore is significant element of ecosystem function
- The Elwha estuary and lower river habitat is changing rapidly; both estuary and lower river habitat are expanding, and fish use reflects these changes.
- We are early in the Elwha nearshore restoration process; only approximately 1/3 of sediment has been delivered to the nearshore, and shoreline processes are just beginning. The physical and ecological transformation will continue for years to come.
- Overall, ecological function of the Elwha estuary is functioning at pre-dam removal level through the dam removal phase. New estuary sites are functioning at the same ecological level for fish as original Elwha sites
- The west levee is a growing concern, blocking access to high quality habitat when it is sorely needed, and may be disrupting sediment dynamics resulting in an important portion of the river to fill in. This is a high priority for restoration.

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Evaluating Changes in Nearshore Fish Communities Following Removal of the Elwha River Dams

Presented and written by: Kurt L. Fresh, NOAA
Co-Authors: Anna Kagley, Larry Ward, Doug Morrill, Kinsey Frick, Todd Sandell, Nikki Sather, and Josh Chamberlin

Introduction: Since 2006, we have collected biological data on intertidal/sub-tidal (defined as the nearshore) fish communities at sites near the mouth of the Elwha River and at more distant reference sites in the central and eastern Strait of Juan de Fuca to assess if nearshore fish were responding to sediment changes resulting from removal of the dams. Such responses are of particular interest because sediment changes resulting from dam removal will likely be significant in these nearshore habitats. Ecologically important forage fish spawn and rear in nearshore areas and juvenile salmon from federally protected populations migrate to ocean rearing areas through nearshore areas.

There are a number of potential changes possible due to dam removal, including changes in abundance of individual species or species groups, changes in fish size, and changes in fish community composition. Responses of nearshore fish can occur during two general time periods. One period is immediately following dam removal when much of the accumulated sediment from the last 100 years is discharged; as this will not happen immediately, most predictions have suggested this process should occur over 3 to 5 years. The second period will begin after accumulated sediment has moved out and more natural sediment processes are restored to the river and nearshore region. Here, we briefly describe some of the results of our work conducted to date.

Methods: Our basic study design was a modified BACI (Before, After, Control, Impact) approach. Because there is not a true control for the impact area, we instead used reference areas that were similar in terms of wind and wave exposure, vegetation, and so on but located distant enough that there would be no impact to habitat resulting from dam removal. Reference areas are useful in this type of change analysis to distinguish natural variability in fish metrics (e.g., abundance) to variability resulting from dam removal. We had two reference areas (Figure 1). One (Area 4) was near Green Point, several miles to the east of Port Angeles and the second (Area 8) was the north end of Miller Peninsula, between Sequim and Dungeness Bays. The impact area (Area 2) included the shoreline immediately west of the mouth of the river (Freshwater Bay) and the east side of Angeles Pt. (east of the river mouth) (Figure 1). Within each area, multiple sites were sampled.

Field Methods. Samples were collected monthly from April to September (weather and tides permitting) using a 37m Puget Sound beach seine. We made all collections during a flooding tide. The net was set about 33m from and parallel to shore and then hauled in. The catch was typically processed in its entirety by identifying all fish to species and then measuring the length of up to 25 individuals of each species and life stage. On occasion, when catches were large, the catch is volumetrically sub-sampled and the sub-sample processed. Salinity and temperature at a depth of 1 meter were measured at each site. Sampling occurred in 2006-2008, 2010-2012, and 2014 in the three geographic regions.

Data Analysis. All data were QA/QC'ed and entered into an Access Data Base. All catch data were standardized to catch per haul with a haul representing an area of about $1000m^2$. For surf smelt, sand lance, and Pacific Herring, individuals were also placed into different life history classes: adults, juveniles, and post-larvae. Catch data were analyzed for the most abundant individual species (e.g., juvenile Chinook salmon, surf smelt) as well as for the major fish species groups. Species groups that we considered included forage fish, salmonids, gadids (cod family), perches, greenlings, sculpins/flatfish, and other.

We computed several species diversity indices, including total number of species, Shannon Wiener Diversity, and Simpson Evenness Index. We used Multivariate Analysis using the Primer-e V.6 software package (Clarke and Gorley, 2001) to test hypotheses about changes in species composition. In particular, we used MDS analysis (Multi-Dimensional Scaling) and similarity/dissimilarity analysis to determine if there were changes in fish community composition as a function of year, area, and season. We eliminated all species where only one individual was caught and sites where the catch was zero. Data were square root transformed and Bray-Curtis similarity coefficients computed.

Results and Discussion: To date (at the end of 2014), we have obtained 5 years of data prior to dam removal (which began in fall 2011) and two years of data post-dam removal. During this period, we recorded 76 species of nearshore fish that included transient (e.g., salmon), resident (flatfish), benthic, mid-water, and pelagic species (Table 1). Most individuals were juvenile life stages. Some of the species caught were federally protected under the Endangered Species Act.

The numerically most abundant species group was forage fish which accounted for 71% of the catch in all years combined and was represented by nine species (Table 1). Surf smelt was the most consistently caught forage fish while several species such as sardine and anchovy were absent in most years but were present in only several of the years we sampled. The two species categories sculpin/flatfish and "other" represented 48 species but only accounted for 5% of the catch (Table 1).

The MDS analysis revealed that there were strong annual differences in species composition, with most years being quite distinct from each other. This was driven in part by the fact that the dominant species groups and species within a group varied considerably between years. For example, the composition of forage fish varied from a high of 89% in one year and to a low of only 10% in another (Table 2). Anchovy were absent in two of the years, rare in three, and abundant in two. Salmonids accounted for 73% of the catch in one year and a low of 6% in another year (Table 1).

Surprisingly, the multivariate analysis suggested that the species assemblages were dissimilar in spring (April-June) vs. summer (July-September). In fact the spring and summer assemblages were more similar to each other in the Area 8 reference than they were to similar seasons in other areas. Salmonids and forage fish were the dominate fish in the spring and flatfish, sculpins, and perch were the primary species in occurring in summer.

We also found that there was some separation in community structure between areas. In particular, area 8 was most dissimilar to area 2 and area 4. Differences between regions were primarily a result of differences in abundance of several forage fish species (notably Pacific sand lance, and surf smelt).

Overall and to date, we can find little in the way of changes in abundance of individual species or species groups; species diversity; or community composition that might be due to effects of dam removal. Trends in species richness and abundance were consistent prior to and following dam removal with reference areas generally possessing more species and overall abundance of fish than the sites closest to the mouth of the river. There was one species, night smelt, which exhibited a significant change in abundance in area 2 following dam removal (abundance increased). However, further study is needed to determine if this might be a response to dam removal.

We specifically looked at the fish community changes in area 2 (the Impact area) before and after dam removal. We predicted that there might be a change in community structure following dam removal which would show as a difference with the other years. This however did not occur (Figure 2). We also hypothesized that flatfish and sculpins would be sensitive to the habitat changes in the Elwha nearshore but detected no significant change in abundance before and after dam removal.

Future Goals: Our plan is to continue our fish monitoring for the foreseeable future. We will also evaluate sediment and vegetation at our impact and reference areas as the system continues to evolve. Our ability to detect responses of fish communities to sediment changes will ultimately depend on both biotic factors, such as species and life stages being considered, and a variety of abiotic factors, such as when sediment reaches the coastal environment, how long it takes material to distribute from the river's mouth, and where it goes.

Table 1. Percentage of the overall annual catch comprised of each species group, all areas combined in the Central Strait of Juan de Fuca.

Group	# Species	2006	2007	2008	2010	2011	2012	2014	0verall
% Forage Fish	9	60	89	73	10	66	45	81	71
% Cod Family	3	0	0	15	1	1	17	2	5
% Greenlings	4	17	1	1	1	1	2	0	3
% Perches	5	7	2	1	6	5	10	2	4
% Salmonids	7	7	6	7	73	11	14	13	12
% Sculpins & Flatfish	23	8	1	2	2	13	2	1	3
% Other	25	1	1	1	7	2	10	1	2

Table 2. Catch per haul of forage fish species by year for all areas combined in the Central Strait of Juan de Fuca.

	2006	**2007**	**2008**	**2010**	**2011**	**2012**	**2014**
Northern Anchovy	0.00	67.6	0.01	4.19	1.34	0.01	1.02
Pacific Herring	110.55	91.46	20.37	1.30	20.30	6.93	201.13
Longfin smelt	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Night smelt	0.00	4.24	1.40	0.00	23.58	5.90	113.44
Pacific Sardine	0.00	0.00	0.00	0.00	0.00	0.00	69.85
Sand lance	27.83	11.94	14.80	3.32	33.02	60.22	192.33
Shad	0.00	0.06	0.08	0.20	1.60	0.00	0.00

Surf smelt	142.40	241.37	277.03	0.67	85.90	68.51	303.26
Whitebait Smelt	0.00	0.00	0.00	0.00	0.00	0.04	0.00

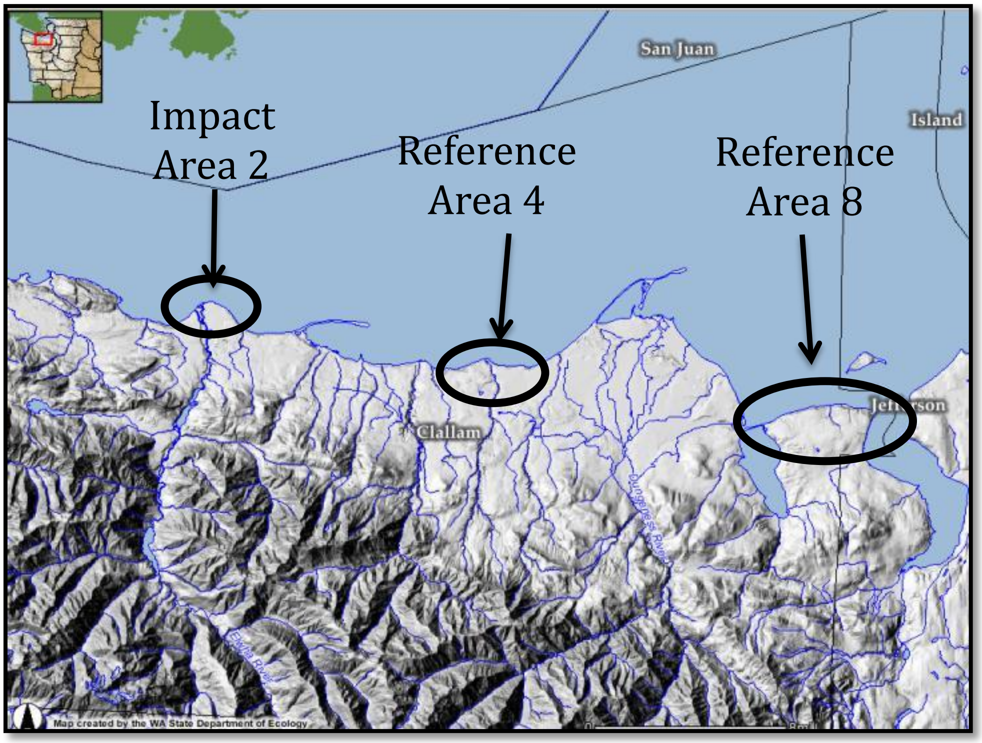

Figure 1. Map of Central Strait of Juan de Fuca study are showing location of impact and reference areas.

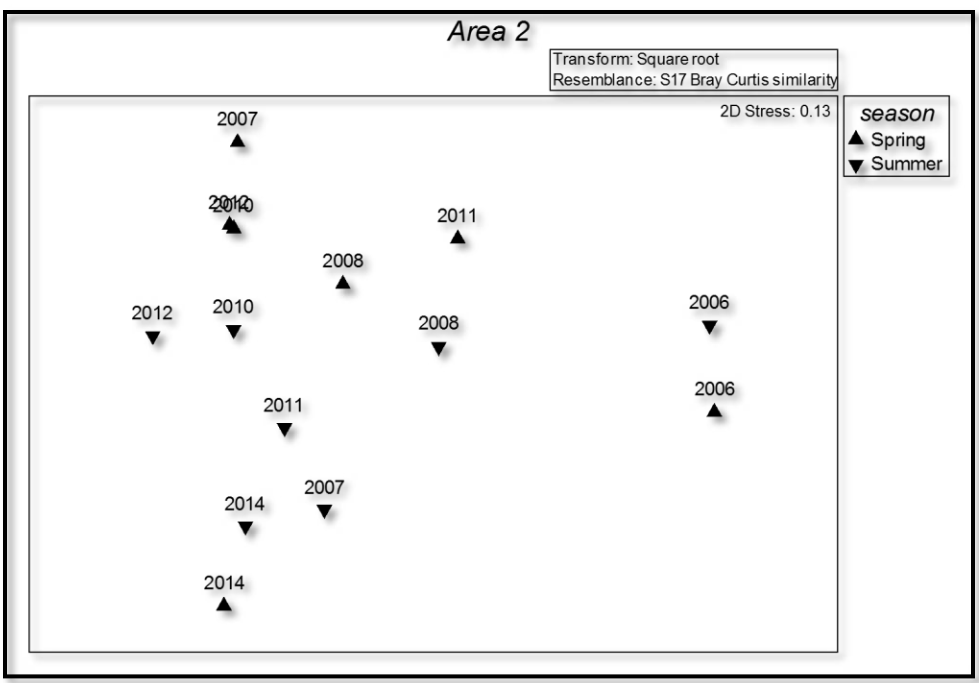

Figure 2. MDS (Multi-Dimensional Scaling) plot of Area 2 (impact area) by year and season within a year. All values were square root transformed and the Bray Curtis similarity.

Nearshore Function for Forage Fish: Defining, Protecting, and Restoring the Critical Ecosystem of the Elwha Nearshore and Salish Sea

Presented by: Leif Wefferling, The Evergreen State College
Co-authors: Anne Shaffer, Nicole Harris, Carol Holman, Dan Penttila, Tara McBride, Carri LeRoy

Summarized by: Nathan Moore, Western Washington University

Introduction: Intertidal beaches within the Elwha nearshore are documented habitat for forage fish migration and spawning. Sediment processes of the Elwha drift cell, critical for forage fish spawning habitat, were historically altered by armoring of the shoreline, lower river alterations, and the in-river Elwha and Glines Canyon dams. However, the recent removal of these dams and the consequent release and transport of upwards of 2.5 x 10^6 m^3 of fluvial sediment to the Elwha nearshore has begun a partial restoration of sediment processes within the drift cell. This will potentially restore nearshore function for forage fish spawning. Forage fish come in on the high tide and spawn in the upper intertidal zone. Sand lance do so in summer to early fall while surf smelt spawn in winter. They both require a loose mixture of sand and gravel (1-7 mm), although sand lance can spawn in finer-grained substrate. Eggs find protection by mixing into the substrate.

This study sought to answer the question of how forage fish spawning activity in the nearshore environment is changing in response to the Elwha dam removal project.

In order to answer the research question, spawning activity of sand lance and surf smelt was compared across impaired/intact drift cells, geomorphic habitat types (GMHTs), and before/during dam removal time periods. Both these species depend on nearshore for migration, feeding, and spawning and both are eaten by salmon, birds, and marine mammals.

Methods: In collaboration with the Coastal Watershed Institute (CWI), egg surveys for two species of forage fish, surf smelt (*Hypomesus pretiosus*) and sand lance (*Ammodytes hexapterus*) were conducted over a four year span, including two years before dam removal (2007-08) and two years during the dam removal process (2012-13). Samples were collected from GMHTs (embayment, bluffs, and spit) within the impaired Elwha drift cell and from the comparative, intact Dungeness and Crescent Bay drift cells. See Parks et al. 2012.

Moulten and Penttila's (2001) method was modified and used for data collection. Samples of beach substrate were collected and sieved through a series of screens to isolate the light fraction.

Findings: No sand lance eggs were found during the course of this study, so analysis was conducted on surf smelt data (Figure 1).

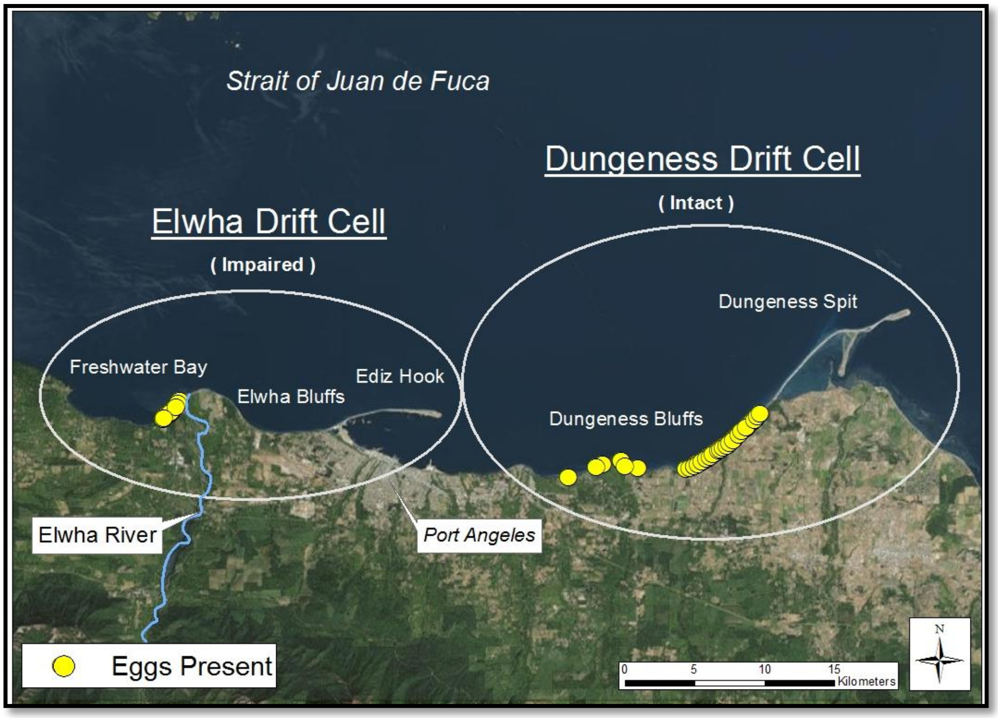

Figure 1. All surf smelt samples containing eggs.

Results show that the intact Dungeness drift cell supports more robust surf smelt spawning activity than the impaired Elwha drift cell (Figure 2). Egg productivity did not differ significantly between the two time periods. We also conclude that egg abundance is highly variable across GMHTs, with the greatest abundance in the intact bluffs site (Dungeness Bluffs) followed by the impaired embayment (Freshwater Bay) where spawning habitat expanded during the dam removal period. Outer spit sites did not support any spawning activity.

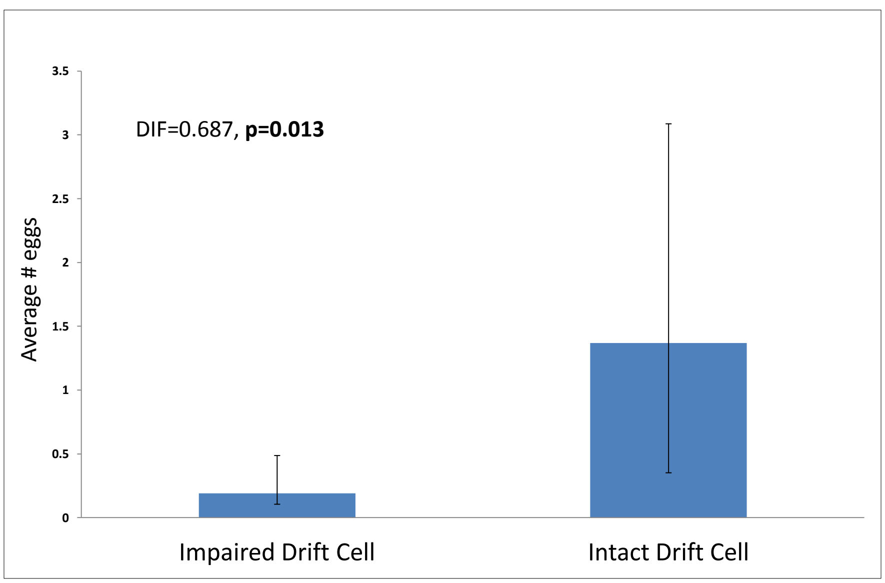

Figure 2. The intact drift cell supports a significantly greater abundance of surf smelt eggs than the impaired drift cell.

Last July, eggs were found on Freshwater Bay beaches where there was no suitable habitat prior to dam removal. Also in July, the first longfin smelt was found in the Elwha drift cell.

Restoration recommendations

- The remaining areas of intact coastline, including Freshwater Bay, should be preserved because of their role in forage fish spawning.
- Measures should be taken to protect and restore forage fish spawning grounds throughout the drift cell, including Freshwater Bay, Elwha lower river, and Elwha bluffs.
- Sediment delivery should be restored along the Elwha bluffs and spit if possible to best serve forage fish spawning and the general public.

Summary

- The intact drift cell supports a significantly greater abundance of surf smelt eggs than the impaired drift cell.
- Elwha bluffs site needs more time to receive restoration sediment. Fluvial sediment from the former reservoirs could continue to wash down the Elwha River for another seven to ten years.
- The bulkheads at Elwha bluffs represent a long-term restoration issue.

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V: Elwha Nearshore Consortium Priorities and Recommendations

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

In general, the Elwha nearshore is experiencing extensive biological and physical changes. These changes have the potential to greatly benefit the environment and its inhabitants – people, fish, and algae all alike. And so we must take what we have learned and apply it to our future actions.

Physical Processes Recommendations and Priorities

- Wave buoys along the Elwha nearshore for long term wave climate modeling.
- The USACE wants to quantify long-shore rates using the shoreline change model. This will allow the USACE to identify segments within the littoral cell that are accretionary or erosive. This further allows the USACE to prioritize beach restoration efforts, identify areas that need attention due to increased erosion, and watch storm erosion. This all ties back to Ediz Hook and how to nourish that section within the scope of the whole system.
- A repeat of an in-depth topography survey done in 2011 needs to be conducted. The Department of Ecology ran boat-based LiDAR of the bluffs, and this data needs processing. Finally, a focused look at oceanographic conditions that drive beach morphology and bluff retreat would inform how wave energy along this coastline influences bluff erosion rates.

- CWI is investigating the removal of beach armor and the addition of LWD to help restore natural beaches in the Elwha drift cell. A project along the coast of Oregon used beach nourishment and LWD placement to manage erosion on high-energy shorelines. Similar efforts along the Elwha drift cell may be necessary pre-restoration actions to enable the currently over-steepened beaches to dissipate wave energy and allow for sediment deposition and the establishment of low profile beaches.

Ecological Restoration Recommendations

- Stop further harm to the Elwha nearshore due to increased shoreline alteration and armoring. Protect intact nearshore/shorelines along lower river and Elwha shoreline including Freshwater Bay (FWB), and unarmored Elwha bluffs for protection of nearshore processes including salmon and forage fish migration and forage fish spawning
- Protect Large Woody Debris (LWD) along the Elwha FWB shoreline.
- Work collaboratively to investigate the removal of beach armor and the addition of LWD to help restore natural beaches in the Elwha drift cell including Elwha lower river, delta, and armored bluffs and spit.
- Measures should be taken to protect and restore forage fish spawning grounds throughout the drift cell, including Freshwater Bay, Elwha lower river, and Elwha bluffs.
- Sediment delivery should be restored along the Elwha bluffs and spit if possible to best serve salmon and forage fish migration, forage fish spawning and the general public.
- The western 1/3 of the Elwha estuary should be connected to the rest of the estuary via shortening or adding tide gates to the west levee. The west levee's disruption of Elwha hydrodynamics may cause a reduction of useable estuary area by baring fish from approximately 1/3 of the otherwise highly functioning estuary. If the situation is not remedied soon, the area could fill in, removing the possibility of returning the area to a highly functioning ecosystem.

Landfill Priorities

Plans for the landfill strive to protect people and the environment by relocating and stabilizing certain parts of the landfill: the compromised waste cell will be moved to a safe location where it won't wash into the strait; exposed waste will be covered up; the access road, sea wall, and other components of the physical landscape will be modified so as to slow erosion.

ENC Workgroup Directory

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VI: Saturday's Workshop

Birds of the Elwha Nearshore

Barbara Blackie, Peninsula College and Huxley on the Peninsulas/Western Washington University

This presentation prepared the audience for the afternoon excursion to the Elwha River delta. Barbara introduced us to several bird populations that we may see along the Elwha, and she left us thinking about several questions that cannot be readily answered, but are worth answering with future investigations.

John Muir quote:

"When we try to pick out anything by itself we find that it is ***bound fast by a thousand invisible cords that cannot be broken****, to everything in the universe."*

With the removal of the Elwha dams, there is interest in the return of fish populations, but fish are not the only animals that will respond to the dam removal. There may be repercussions up the food chain as well, and some bird species will be winners and others losers. In either case, it will be interesting to see which birds will use the nearshore and the upper river. She provided the example that, in mid-February a variety of species of gulls came to the nearshore, just as a number of eulachon were in the river mouth. Here is a great connection between the fish and the birds.
Other birds that may increase along the Elwha are the Glaucous-winged x Western Gull hybrids (locally and unofficially referred to as "Olympic gulls") and Mew Gulls. A local breeding population that needs large trees for cavity nesting and fish to eat, are the Common Mergansers. Several cormorant species (Double-crested, Brandt's and Pelagic cormorants) are nearshore foragers. Like their pelican relatives, they need fish, too. As the fish return, these populations may increase.

Harlequin ducks are benthic foragers; they eat invertebrates off of rocks. The influx of sediment to the mouth of the Elwha after dam removal may be making this area less attractive for harlequins than it had been in the past. Barbara did her master's thesis on these birds before the dams were removed, and she is mentoring students to do research at the same areas so they can draw a comparison between the pre- and post- dam removals.

Other birds that may benefit from the increased sediment are the shorebirds. These birds need sandy estuaries where they can probe for food. Spotted Sandpipers and Black Oystercatchers are shorebirds that breed in our area but many other shorebird species could use the estuary during migration. Finally, the Bald Eagles should also benefit from the returning fish, and, as they are predators and scavengers, they will also benefit from the increase in birds.

Barbara left us with the reminder that fish are nutrient conveyor belts; they bring elements from the ocean that are returned upstream as the salmon spawn and die. The effects of added nutrients to the system may have ecological effects. Additionally, she encouraged us to become active in two citizen groups that help scientists and birds: the Coastal Observation and Seabird Survey Team (COASST) or the Puget Sound Seabird Survey (PSSS).

Barbara Blackie presenting at the February 21, 2015 Public Workshop on the Elwha nearshore birds.

Elwha Delta and Nearshore Bird Talk and Walk

Bob Boekelheide, former director of the Dungeness Audubon Center in Sequim

It was chilly and clear at the Elwha Delta. Bob gave the crowd a Gull 101 course. He pointed out that gulls are able to drink salt water, but they also like freshwater for drinking and bathing, so river mouths are superb locations to see them. Here we can see gulls from all over North America. The Mew Gulls nest in Alaska and western Canada, then spend the winter along the West Coast. California Gulls nest in the interior of western North America as far east as Manitoba, then cross the Rockies and Cascades after nesting and reach salt water at the Salish Sea. Thayer's Gulls winter along the West Coast, but breed in the Canadian Arctic. And the Olympics have their own hybrid bird—the Olympic Gull — a cross between Western Gull and Glaucous-winged Gull. After describing these birds, Bob turned the crowd over to a series of spotting scopes, and we enjoyed seeing the effects of a river in recovery.


21.02.2015 13:46


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