Elwha River Delta: Geomorphology and Shoreline Change of a Mixed-Sediment Beach

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Presented at:
AGU Fall 2007 Meeting
Poster H41B-0496

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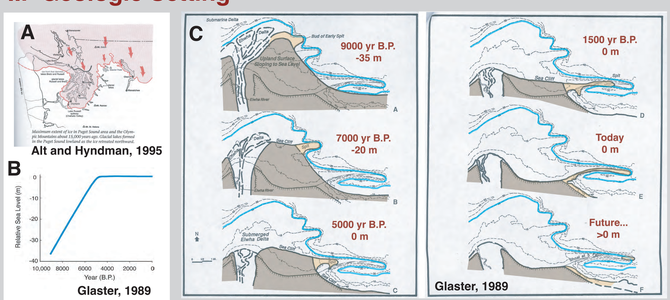
ABSTRACT

The Elwha River drains the Olympic Peninsula of Washington and forms a mixed grain-size delta in the Strait of Juan de Fuca. The Elwha River has been dammed for almost a century, and a pending dam removal project is expected to reconnect upstream sediment sources to the river mouth. Topographic and grain-size mapping of the delta during 1939-2007 is synthesized and the geomorphology and shoreline changes of this system are described. Data sources include historical aerial photographs, airborne LIDAR, semiannual RTK DGPS topographic surveys and grain-size analyses from digital photographs. The delta is divided into three geomorphic regions: west delta, river mouth and east delta. The river mouth is the most complex region due to the river channel movement, side-channels, and bars immediately offshore of the mouth. The east and west delta differ in beach profile and shoreline change rates. The west delta is steep, cuspate and lacks a low-tide terrace. Further, the west delta has exhibited little semi-annual or inter-annual shoreline change. In contrast, the east delta has a steep foreshore, flat low tide terrace that is dominated by cobble, and a consistent trend of erosion during the surveys. These observations can be used to track coastal changes following dam removal on the Elwha River.

I. The Elwha River Delta

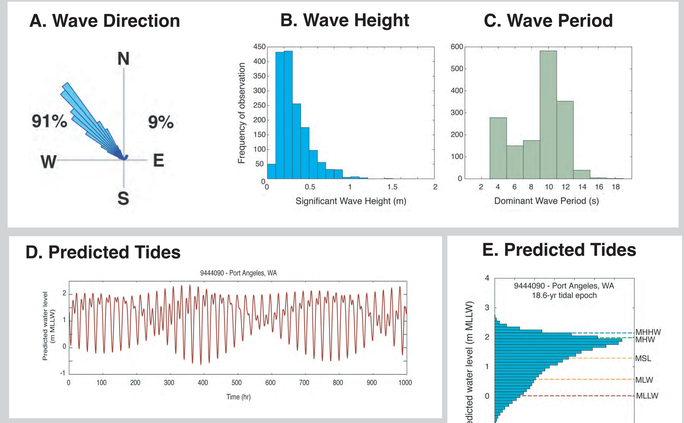
The Elwha River delta protrudes ~1 km into the Straight of Juan de Fuca and consists of a mixed grain size shoreline (photos). Our interests focus on the geomorphology and shoreline change of this delta and the pending dam removal, which will release and restore sediment transport to this coast.

II. Geologic Setting



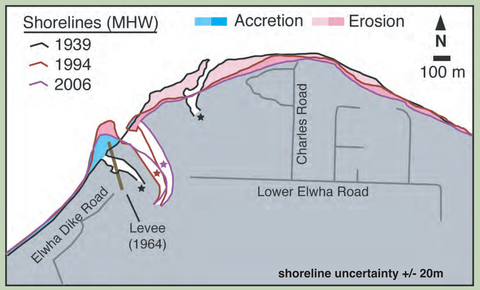
Glacial processes and coastal evolution since the last Ice Age are understood to be key elements to the formation of the Elwha delta. The delta region was clearly covered by the continental ice sheets (A) and experienced ~40m of relative sea level rise during the Holocene (B). The Holocene development of the delta (C) suggests coastal erosion and formation of a series of spits (including Ediz Hook) from littoral transport.

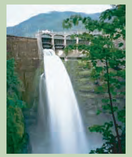
III. Waves and Tides

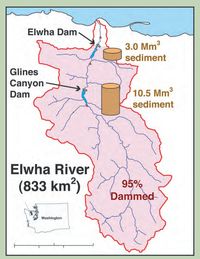


Few wave data exist for the Strait, however two winter/spring deployments of an ADCP show that waves arrive largely from the northwest with significant heights only on the order of 1m. The tides are semi-diurnal and mesotidal, although winter storm surge (not shown) can be up to 0.5 m.

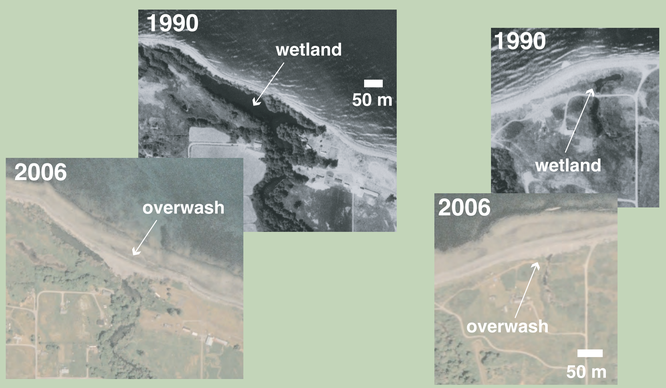
IV. Historical Changes





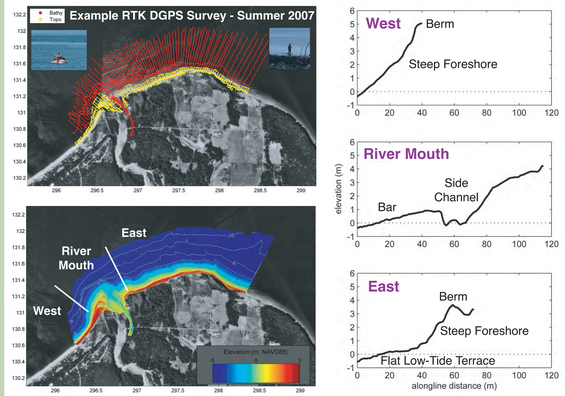


Erosion along the delta has occurred east of the river mouth at rates of 1-3 m/yr, which is likely attributed to 2 dams that trap sediment from 95% of the watershed. Accretion to no change has occurred west of the river mouth, which may be in part to a levee built in 1964 for flood control for homes.

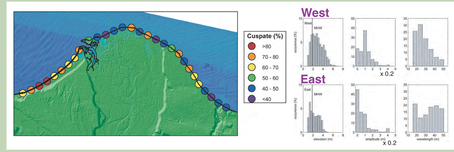


Erosion along the delta is greatest near coastal wetlands, where overwash deposits have resulted in significant wetland loss.

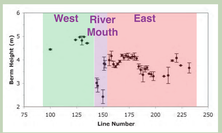
V. Geomorphology



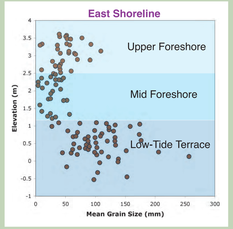
Coastal geomorphology and change are being documented with RTK DGPS topographic and bathymetric suveys, bi-annual since 2004, (example lines and data shown above), historical aerial photographs, and an airborne LIDAR survey from 2000. Preliminary results suggest that there are three distinct sections of shoreline: west of the river mouth, the river mouth, and east of the mouth.



The western shoreline is consistently observed to have beach cusps (see photos). Cusp measurements were obtained from the aerial LIDAR and and local alongshore sine-wave curve fit. Results suggest that cusps are larger (0.4 m relief and 20-30 m wavelength) and more frequently observed on the western shoreline.

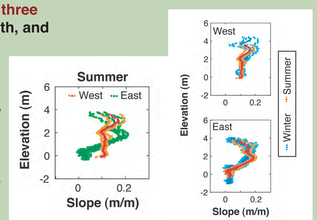


The berm crests west of the river mouth (4.8 ± 0.2 m) are consistently higher than those eastof the river mouth (3.8 ± 0.3 m).

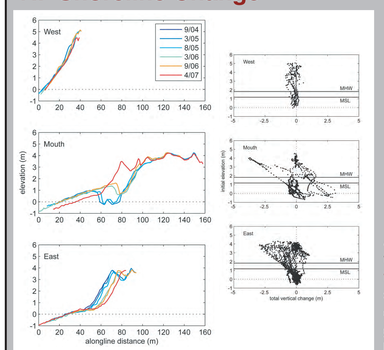


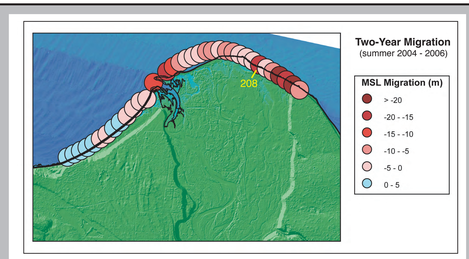
Grain size on the eastern shoreline is related to elevation, and the mean grain size of the low tide terrace (104 ± 44 mm) is coarser the middle (28 ± 15 mm) or upper foreshore (49 ± 22 mm).

The shape of the shoreline profiles is largely a function of location, rather than season. The plots at right show the relation between mean local (5 m) slope and elevation across the profiles of 6 biannual topographic surveys over ~100 surveyed lines, and the 25, 50 and 75 percentiles are plotted. East profiles have a consistent slope break at ~1 m, whereas west profiles are consistently steep at all elevations.

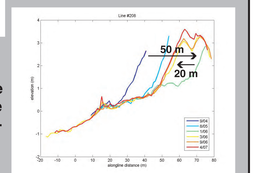


VI. Shoreline Change

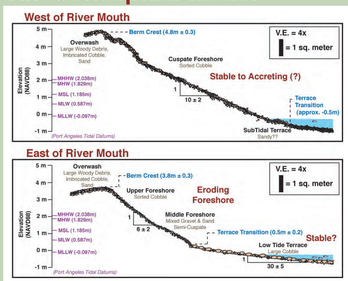




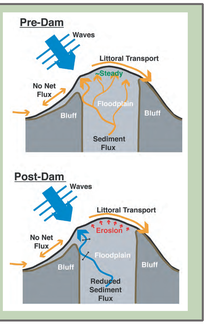
Although topographic profiles do not change shape with time, they do change position. Erosion has been observed only along the foreshore - not along the low tide terrace - and largely for the east shoreline, which is consistent historical patterns. Evidence of erosion abounds on the western delta as shown by the photographs. Erosion is not always systematic, however, as shown by the winter 2005 erosion at line 208 to the right.



VII. Conceptual Model



We propose that the Elwha River delta has differed in both time and space. The present location of the river mouth divides two distinct shoreline sections with respect to morphology and coastal change (left). This is likely due to differing potential for littoral transport around the delta (right), which was likely in near-balance with river sediment supply prior to the dams, but now is in excess of river supply causing erosion of the eastern beach foreshore.



Acknowledgements

We are very grateful for the assistance of the Lower Elwha Klallam Tribe, who owns much of the land of the delta and graciously allows us to survey. Surveys are made possible with a partnership between the USGS and the Washington State Department of Ecology. We would also like to thank Peter Ruggerio, Jodi Eshlemann and Andrew Stevens for assisting with survey operations and data analyses. This work supported by the USGS Coastal Habitats in Puget Sound (CHiPS) project.