Beach Morphology and Grain-Size Distributions in the Elwha and Dungeness Drift Cells: Before, During, & After Elwha Dam Removals, 2010-2022.

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Introduction

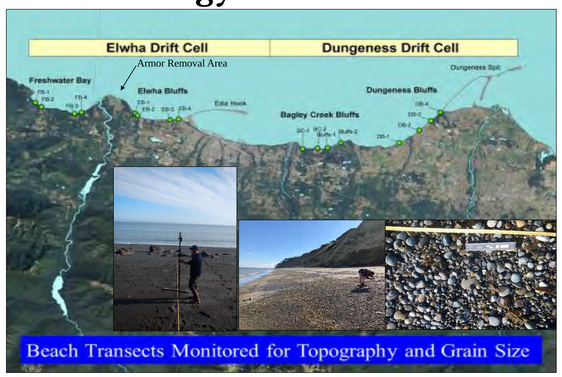
The removal of two hydroelectric dams on the Elwha River in Washington State beginning in 2011 and ending in 2014 released approximately 21-24 million m^3 (30 million tonnes) of reservoir sediments into the fluvial and coastal environments (East et al., 2015, Warrick et al., 2015) These sediments represent approximately 100 years of watershed sediment supply that had been prevented by the two dams from reaching the nearshore marine environment of the Strait of Juan de Fuca resulting in chronic sediment starvation and impairment of ecological habitats for many freshwater and marine species. (Shaffer et al., 2017; Parks, Shaffer and Barry, 2013)

Following dam removal, significant subaerial and subtidal geomorphic change was observed first in the Elwha fluvial system and on the proximal river delta and adjacent nearshore and offshore marine environments with the magnitude of topographic change observed to be a function of distance from the mouth of the river.

In 2016-2017, The Coastal Watershed Institute removed approximately 8,400 m^3 of large riprap (shoreline armor) from over 1200 m of the armored Elwha River east delta, restoring the hydro-dynamics of the eastern delta intertidal beach (Shaffer et al. 2022, In Review).

This research documents a record of topographic and sediment-size changes on inter-tidal beaches away from the Elwha delta before (2010-2011), during (2012-2014) and after (2015 to 2022) dam removal in the Elwha and adjacent Dungeness littoral cells on time-scales intended to document seasonal and inter-annual variability in topography and grain-size distributions during the three phases of dam-removal.

Methodology



Sampling transect sites (Elwha N=9; Dungeness N=8) were selected based on an even spatial distribution within adjacent drift-cells and varied with respect to exposure to wind driven wave and swell from the Pacific Ocean. Nine sites were sampled in the Elwha drift cell and eight within the Dungeness drift cell from 2010-2011 (pre-dam removal), 2012-2014 (during dam removal), and 2015-2022 post dam-removal.

Topographic Change

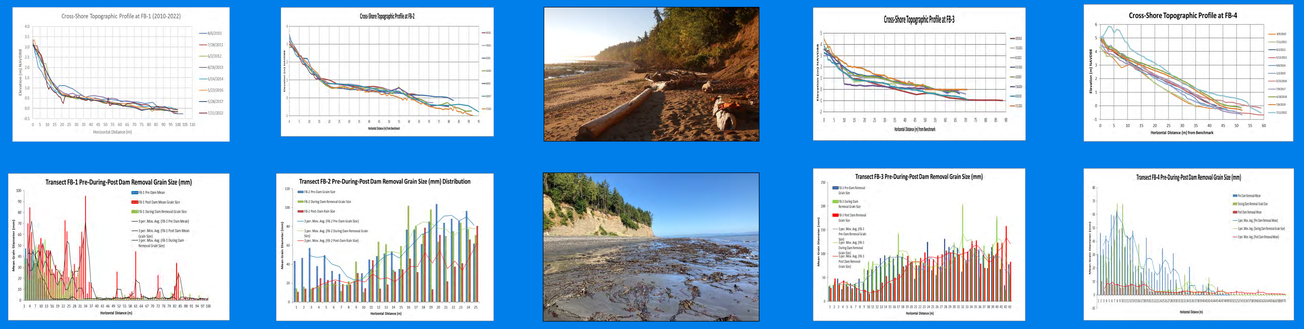
Beach topography was measured along fixed transects oriented normal to the shoreline extending from the base of the coastal bluff down to the lowest extent possible during low tides (-1.0 m NAVD88) using either a geodetic total station or real-time kinematic global positioning system (RTK-GPS) accurate to +/- 10 cm (RMS). The horizontal distance interval was 1.0 meter between measurements. Fixed survey monuments were established in 2010 at the base of coastal bluffs and surveyed using a Trimble GPS system and post-processed to yield vertical and horizontal positions accurate to less than 1 cm. Additional survey monuments in the adjacent area were used as a baseline to assess RTK-GPS survey accuracy throughout the duration of the study.

Grain-Size Distributions

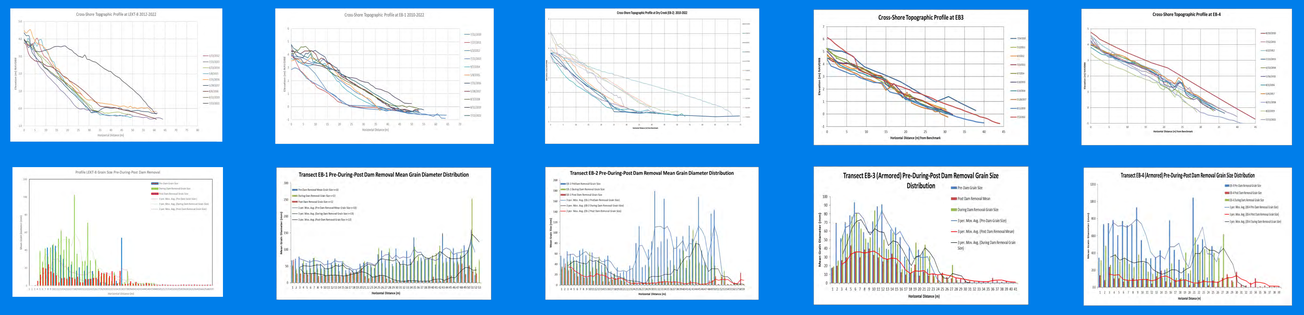
Sub-aerial beach sediment size distributions were measured from digital images of the surface of the beach collected every meter between the upper and lower extents of survey transects collected with a Nikon digital camera and processed in the MATLAB environment using methods (Buscombe et al., 2011) that derive grain size distributions from image pixel-shift values. This method provides an estimate of mean grain-size from fine sand-to-boulder size particles with a lower limit of resolution of approximately 0.05 mm (Buscombe et al., 2010,

Mean-grain size estimates for each position along the fixed transect were then compared between the before, during, and after dam removal periods for the two adjacent drift cells.

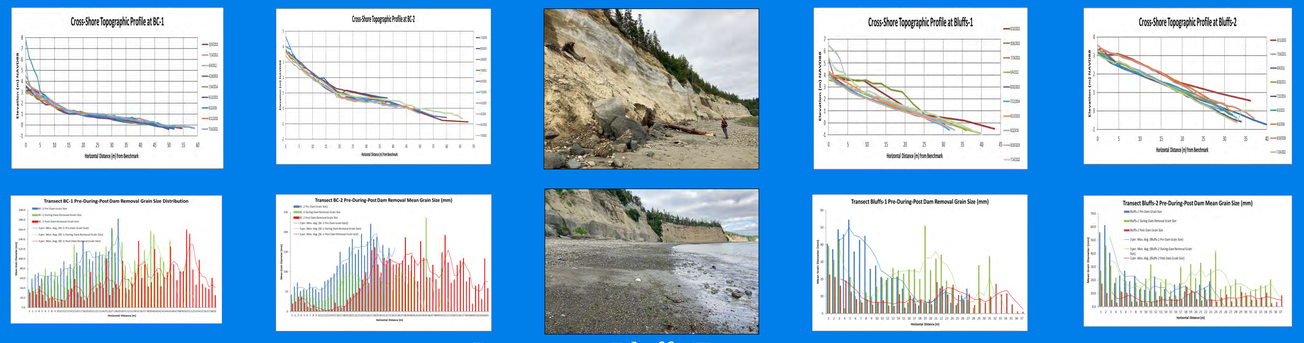
Freshwater Bay Transects



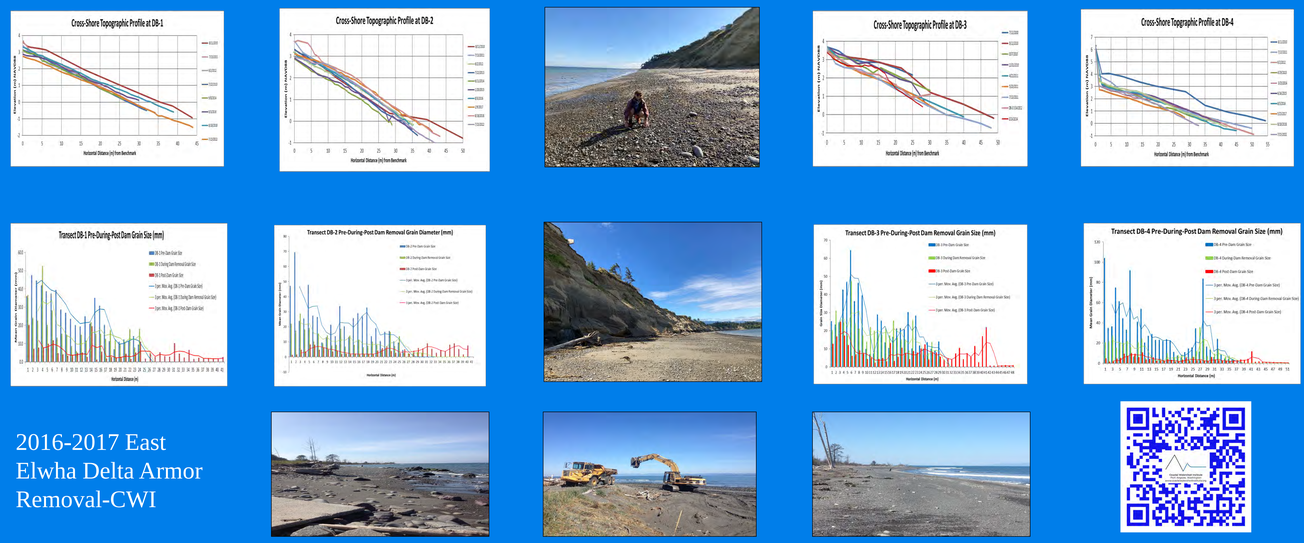
Elwha Bluffs Transects



Bagley Creek Bluffs Transects



Dungeness Bluffs Transects

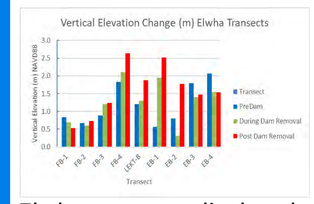


2016-2017 East Elwha Delta Armor Removal-CWI

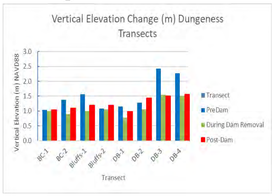
Results

Topographic Change

Elwha



Dungeness



Elwha transects displayed positive elevation change (aggradation) post-dam and post-armor removal compared with Dungeness Transects which displayed erosional trends during and after dam and armor removal.

Grain-Size Change

Both Drift-Cells Displayed a Reduction in Grain-Size Distributions between Pre-Dam and Post-Dam Periods.

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