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Morphological Monitoring on the Elwha River delta

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September 2013 Update

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Survey Summary

On September 16-19, 2013 a team of scientists from the USGS Pacific Coastal and Marine Science Center (PCMSC), USGS Eastern Geographic Science Center (EGSC), Washington State Department of Ecology, and Washington Sea Grant participated in a survey (USGS Field Activity W-07-13-PS) to collect nearshore bathymetry, beach topography, and sample surface sediments on the Elwha River delta (Table 1).

Nearshore bathymetry data were collected using two personal watercraft (PWC), both equipped with single-beam echosounders and GPS operating in Real Time Kinematic (RTK) mode. Differential corrections were transmitted to the PWC GPS receivers at 1-Hz from a base station placed on a pre-existing benchmark (Table 2). Depths from the echosounders were computed using the mean sound velocity (1484.96 m/s) measured at six locations throughout the survey area. Topographic data were collected on foot with RTK GPS mounted on backpacks. A total of 130 km of nearshore bathymetric data and 130 km of topographic data were collected during the survey. Environmental conditions were favorable resulting in excellent coverage of the beach and nearshore region (fig. 1). A continuous DEM surface was produced from all available survey data using linear interpolation with a grid-spacing of 5 m (fig.2).

Bed sediment was sampled using a small ponar sampler on March 19, 2013 from the R/V *Frontier* at a total of 62 locations in water depths between -12 and -1 m around the delta (fig. 1). Additional sediment samples were collected by hand during low tide site visits. A handheld GPS was used to determine the locations of sediment samples. The grain-size distributions of suitable samples will be determined in the PCMSC sediment lab.

Change Analysis

Comparison of the provisional data collected during the September, 2013 survey with past surveys conducted prior to the commencement of dam removal (figs. 3-8) shows large changes in the morphology of the river mouth and submarine delta. Sediment accumulation was widespread at elevations between -12 and +2 m, NAVD88. The depositional area adjacent to the river mouth covered approximately 6.27 ha (627,000 m²) with an average thickness of 3.3 m and a maximum of 10 m. Grain-size analysis of sediment samples collected in March, 2013 suggest the surface sediment adjacent to the river mouth is coarse (primarily sand and gravel), while depositional areas to the east are much finer (fig. 7). Between March, 2013 and September, 2013, sediment deposition was observed in subtidal areas to the west of the river mouth. Visual observations during sediment sampling suggest this material to be primarily fine-grained.

Net accumulation within the study area totals roughly 2,500,000 m³ since the removal of the two dams began in 2011 (fig. 8; Table 3). The majority of sediment accumulation (74%) occurred in subtidal areas adjacent to the river mouth. The alongshore extent of net deposition has widened since the beginning of dam removal. Sediment accumulation has been observed 1.2 km and 2 km on the west and east side of the river mouth, respectively (fig. 9). Despite the large net accumulation of sediment in subtidal areas, subaerial beaches east of the river mouth continue to erode (fig. 9).

Tables and Figures

Table 1. List of Survey Personnel

Person	Title	Affiliation
Guy Gelfenbaum	Chief Scientist	USGS PCMSC
Andrew Stevens	Oceanographer	USGS PCMSC
Gerry Hatcher	Ocean Engineer	USGS PCMSC
Cindy Thatcher	Geographer	USGS EGSC
Heather Baron	Coastal Scientist	Wash. State Dept. of Ecology
Diana McCandless	Coastal Scientist	Wash. State Dept. of Ecology
Rebecca Sexton	Field Technician	Wash. State Dept. of Ecology
Ian Miller	Coastal Scientist	Washington Sea Grant

Table 2. Names and locations of the base stations used during the Sept. 2013 survey. Base station positions are provided in Washington State Plane, North, meters.

Dates	Base Station ID	Easting (m)	Northing (m)	Orthometric height (m, NAVD88)
9/16/2013	1 Reset (revised)	296575.122	131001.691	4.220
9/17/2013-9/18/2013	2B (revised)	297049.106	131279.738	3.941

Table 3. Cumulative volume change ($\times 10^3 \text{ m}^3$) measured between September, 2007 and September, 2013. See fig. 8 for the locations of the Beach and Nearshore polygons.

Date	Nearshore West	Nearshore River	Nearshore East	Beach West	Beach River	Beach East	Total
09/07/2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0
08/27/2008	-1.8	8.1	-3.8	3.0	25.5	3.7	34.8
09/17/2009	-1.4	12.2	-10.7	3.4	33.3	8.8	45.6
09/05/2010	15.5	22.6	-10.5	6.9	50.0	5.2	89.7
05/17/2011	18.5	55.4	28.6	6.3	62.7	-2.0	169.4
08/25/2011	17.5	47.6	14.6	5.1	52.2	-13.1	123.8
05/18/2012	16.4	124.3	22.2	12.2	57.9	-35.3	197.7
08/28/2012	25.1	153.3	40.4	13.3	59.7	-39.7	252.1
03/05/2013	48.6	1103.6	149.9	14.3	110.4	-52.4	1374.3
09/16/2013	143.9	1829.6	429.9	15.8	125.6	-54.7	2490.1

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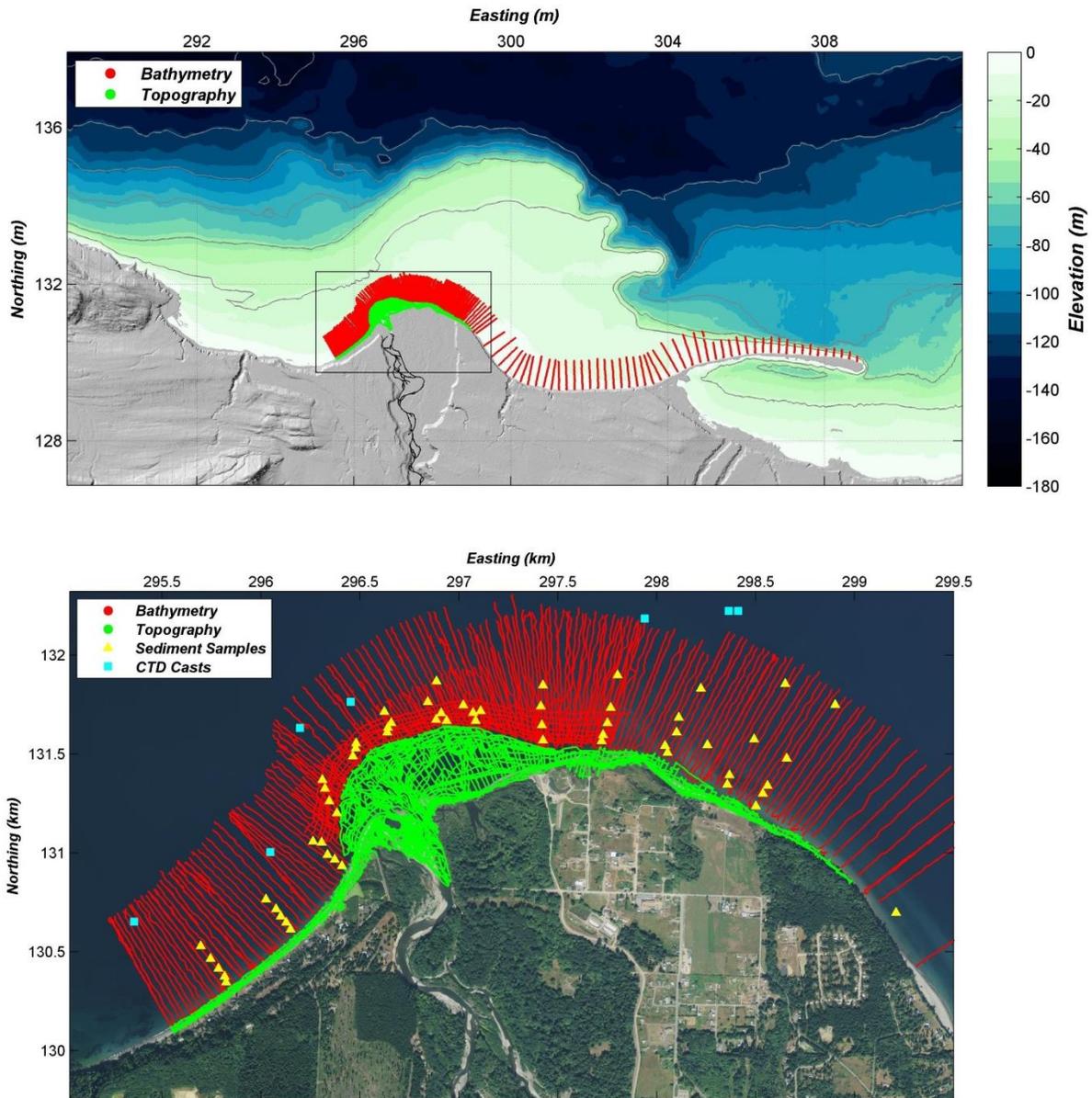


Figure 1. Maps showing survey coverage for nearshore bathymetry (green) and beach topography (red). Yellow triangles show the locations of sediment samples and blue squares denote the locations of CTD casts.

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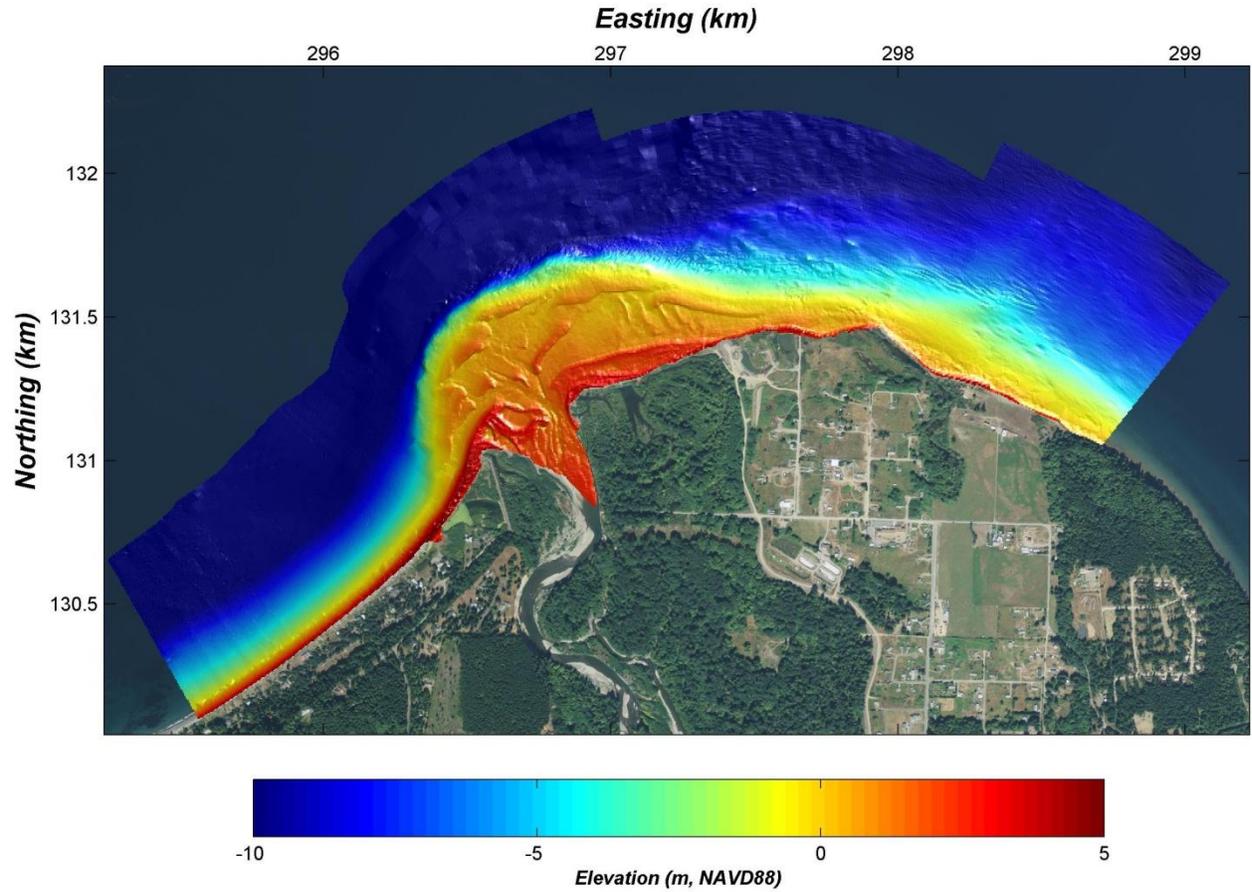


Figure 2. Map of interpolated bathymetry and topography showing the delta morphology during the September, 2013 survey. Grid was produced using linear interpolation with a resolution of 5 m.

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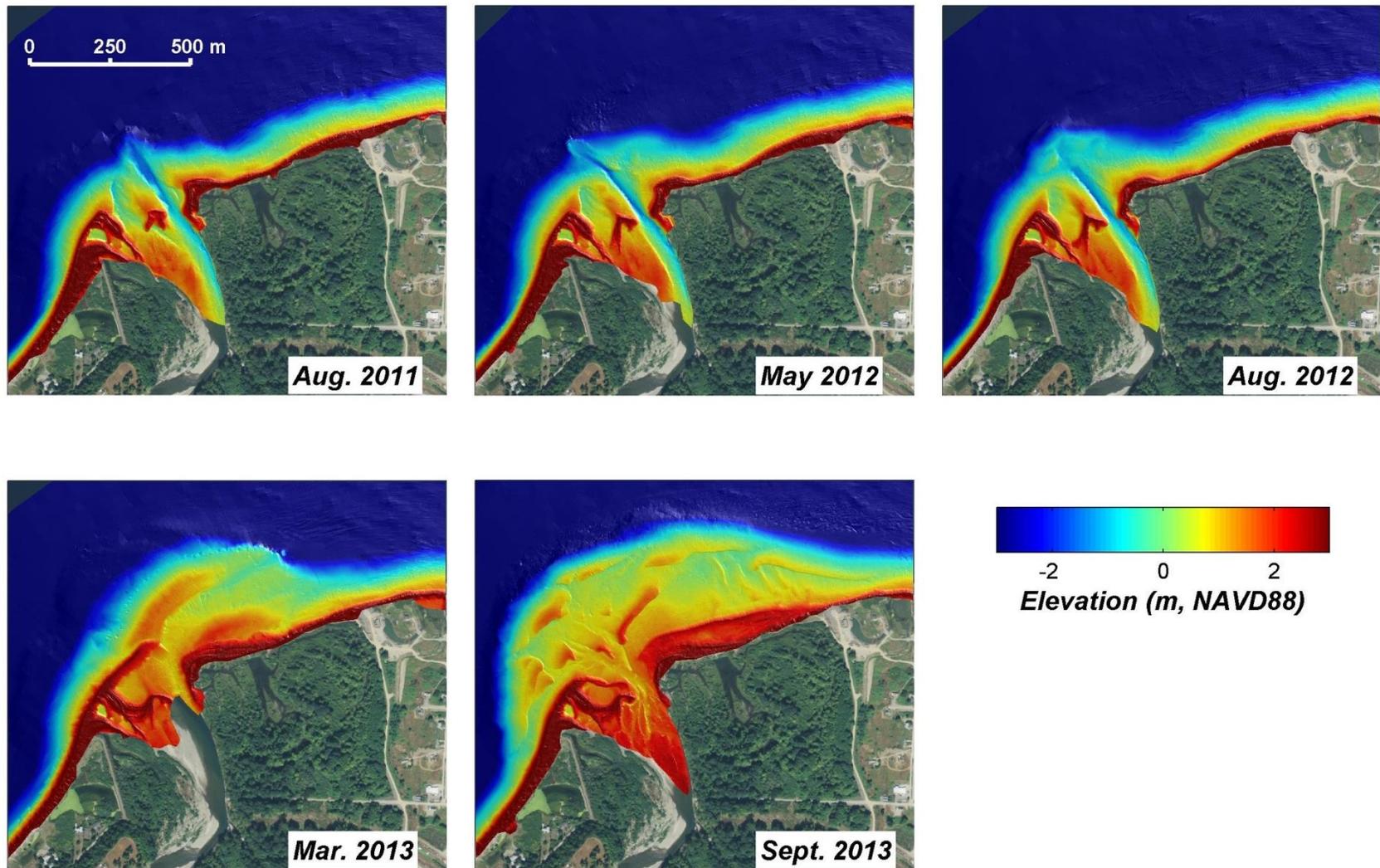


Figure 3. Maps of interpolated bathymetry and topography showing the river mouth morphology between August, 2011 (before dam removal began) and September, 2013. Grids were produced using linear interpolation with a resolution of 1 m.

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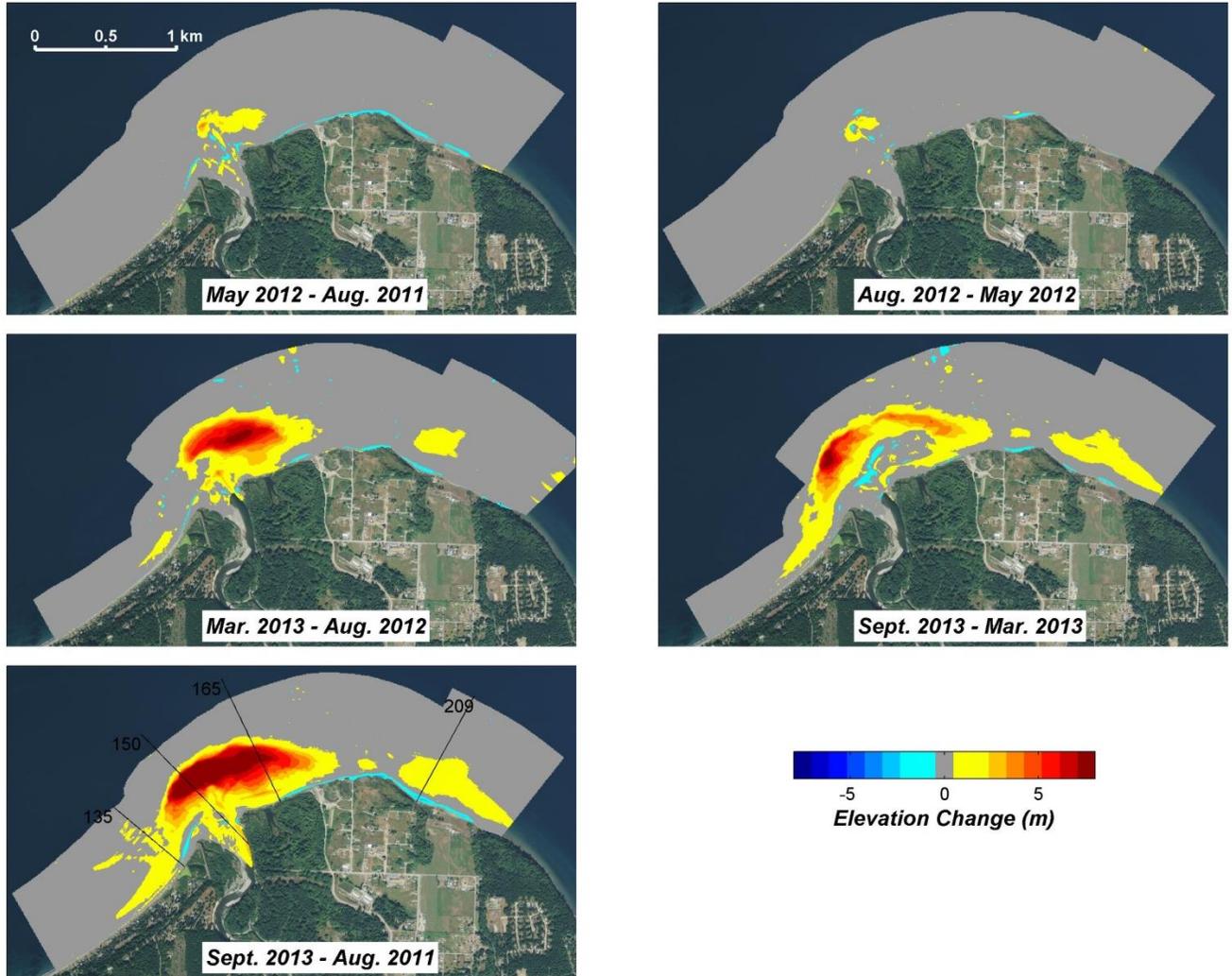


Figure 4. Maps of elevation change measured between Aug. 2011 (prior to commencement of dam removal) and September, 2013. The top 4 panels show instantaneous change between surveys. The bottom panel shows cumulative change between September, 2013 and Aug. 2011.

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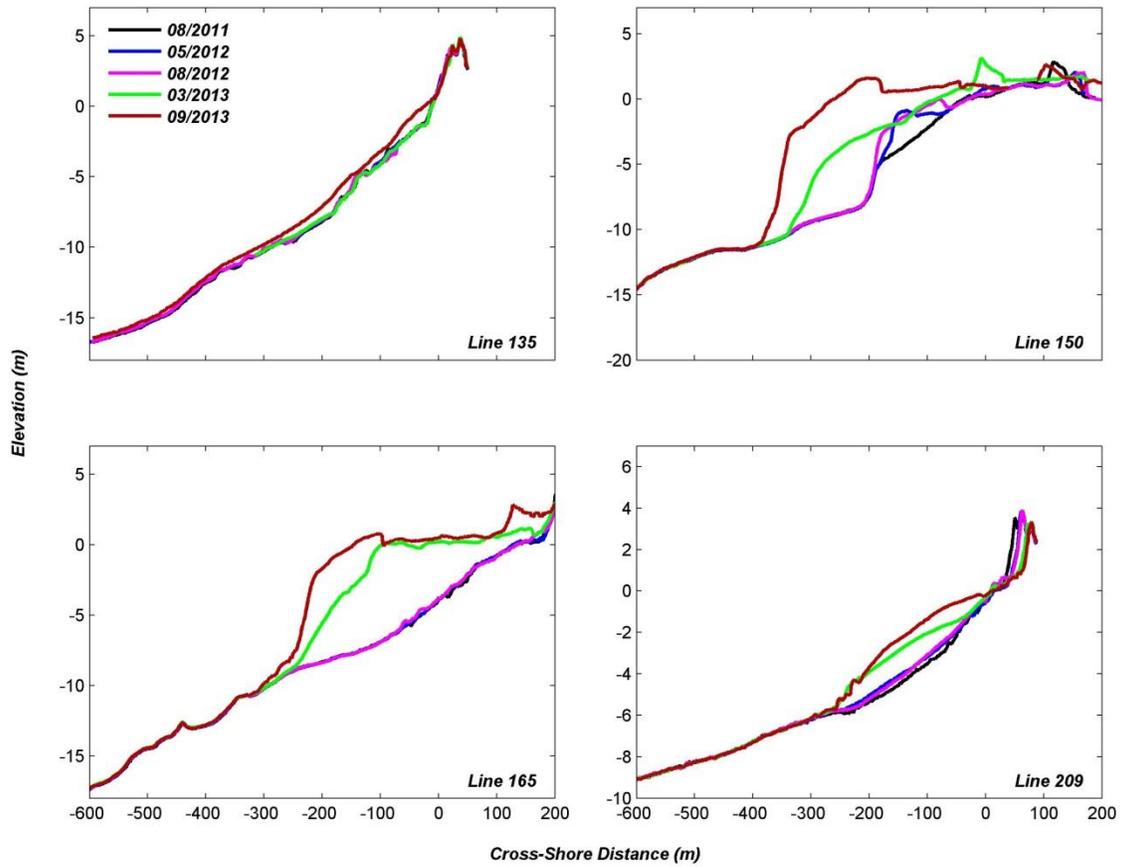


Figure 5. Profiles showing elevation change between Aug. 2011 and September, 2013 at selected locations. The locations of the profiles are shown in Fig.4.

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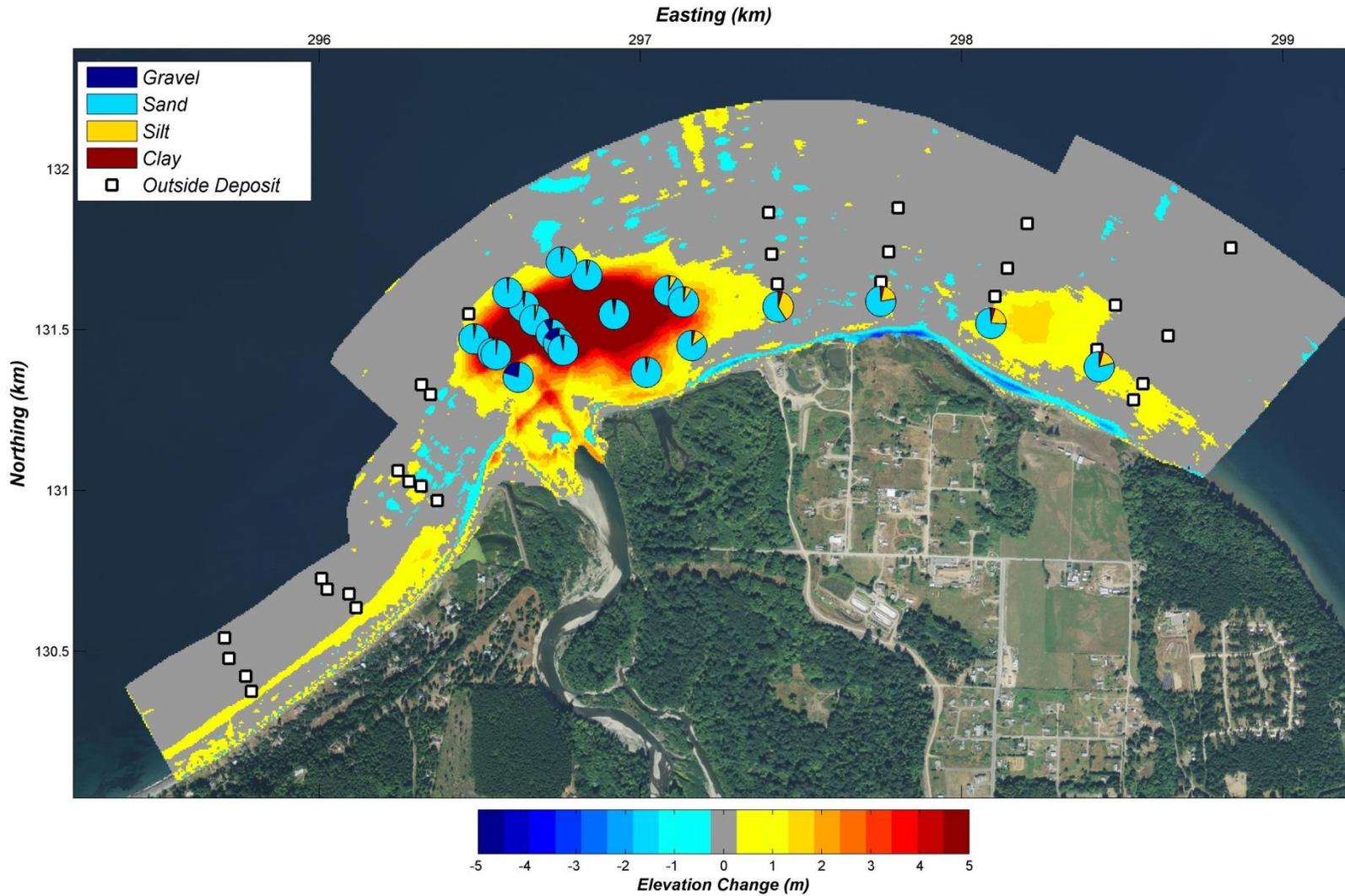


Figure 6. Map showing grain-size distributions of samples collected in March, 2013. A pie graph shows the relative distribution of gravel, sand, silt and clay for each sample that was taken within areas of sediment deposition measured between August, 2011 and March, 2013.

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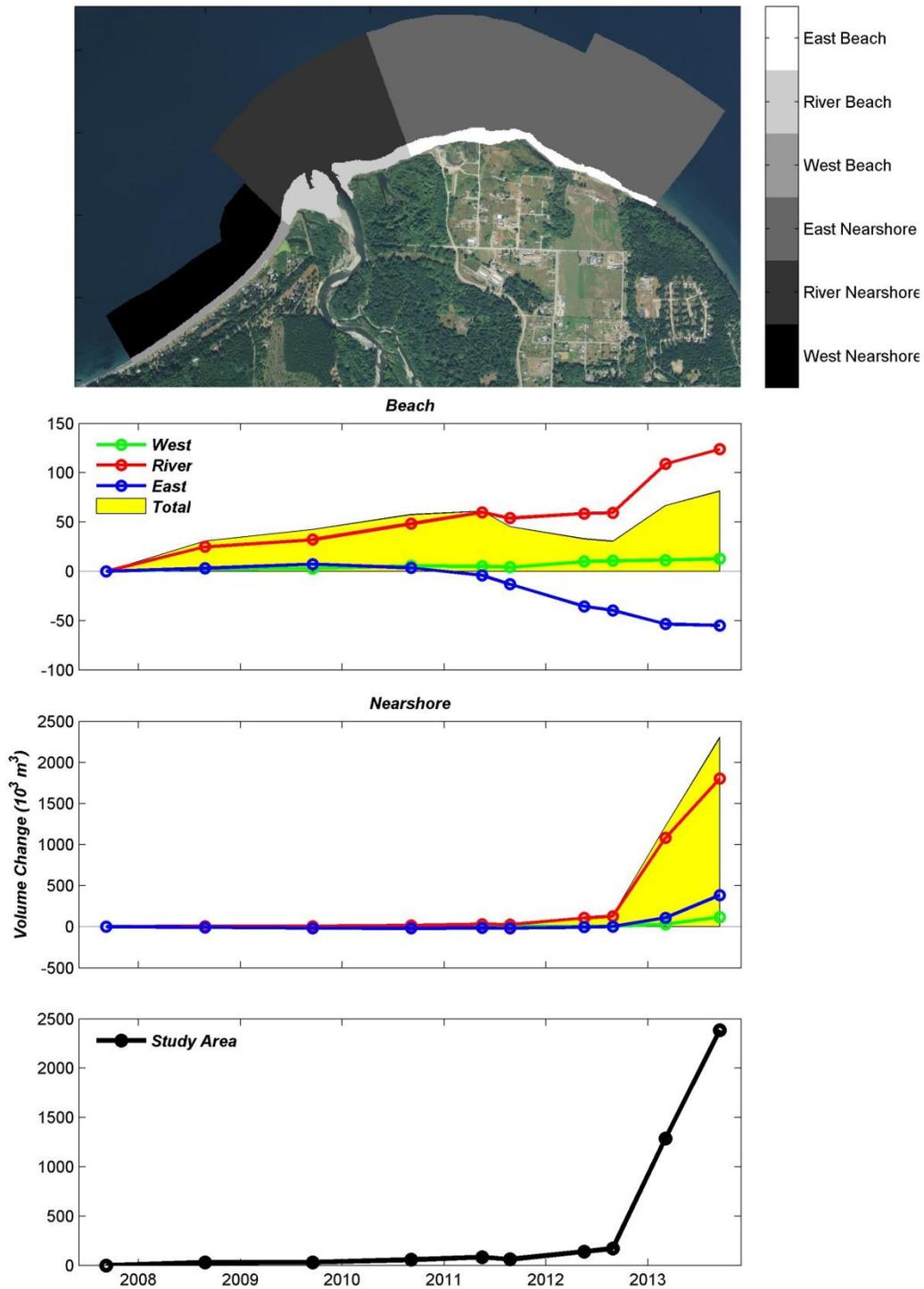


Fig. 7. Cumulative volume change for different regions within the study area. Beach and nearshore areas are separated by the 0 m (NAVD88) contour based on the bathymetry prior to dam removal beginning (Aug., 2011).

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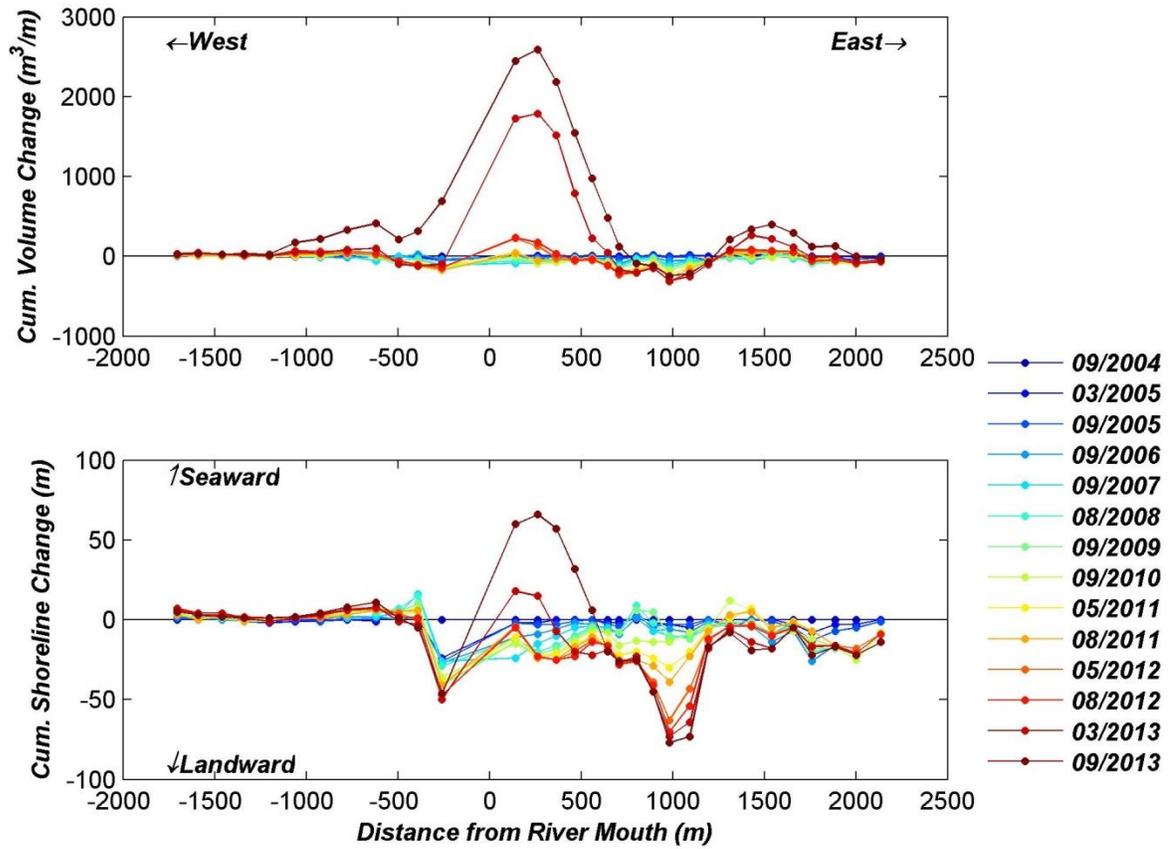


Figure 8. Cumulative volume (top) and shoreline (bottom) change for the subset of profiles collected since 2004. The shoreline here was defined as the position of the +2 m contour.