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Assessing bulkhead removal and shoreline restoration using boat-based lidar

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Assessing bulkhead removal and shoreline restoration using boat-based lidar

Hannah Drummond, Heather M. Weiner, George M. Kaminsky, Diana McCandless, and Amanda Hacking

Washington State Department of Ecology

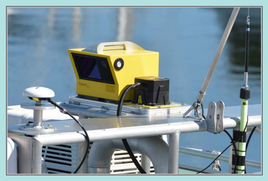
Overview

The Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) performed before and after boat-based lidar surveys of a shoreline restoration project in which **~800 feet of shoreline armor was removed** from the base of a historic feeder bluff at Edgewater Beach in South Puget Sound.

Two bulkhead sections, two rock revetments, a large wood and rock groin, and several large boulders were removed or realigned from the restoration project site in fall 2016.

Boat-based lidar data were collected along the entire drift cell to generate topographic digital elevation models and classified point clouds that are used to quantify the effectiveness of the restoration at the project site and throughout the drift cell.

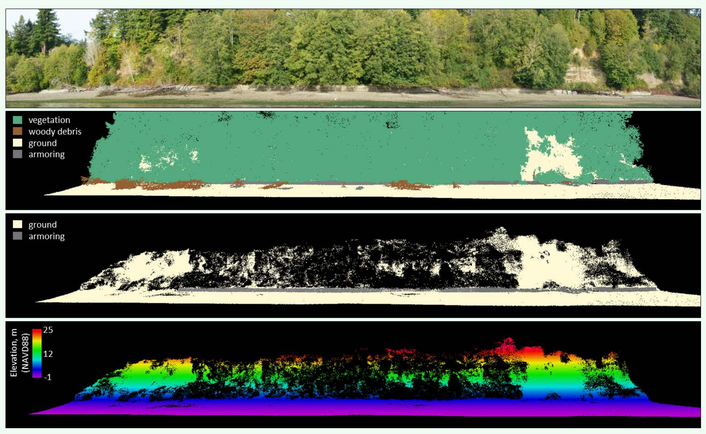
Data Collection



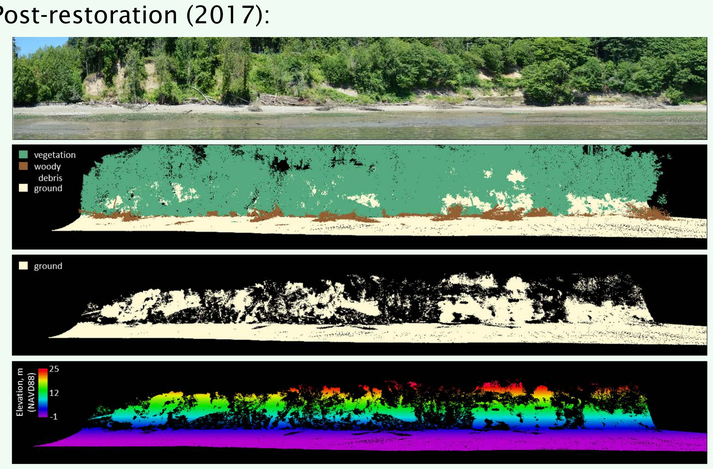
Boat-based topographic lidar surveys were conducted in Sept. 2015, about a year before removal of the shoreline armor, and June 2017, almost eight months following removal. Each survey involved the collection of boat-based lidar along 5 km of shoreline using Real Time Kinematic (RTK) corrections. Surveyors on foot set up lidar targets for ground truthing and collected photos for digital grain-size analysis. High-resolution shoreline photos were also taken during each shoreline scan to aid with point cloud cleaning.

Lidar Point Cloud

Pre-restoration (2015):



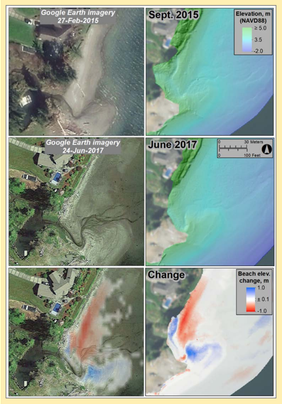
Post-restoration (2017):



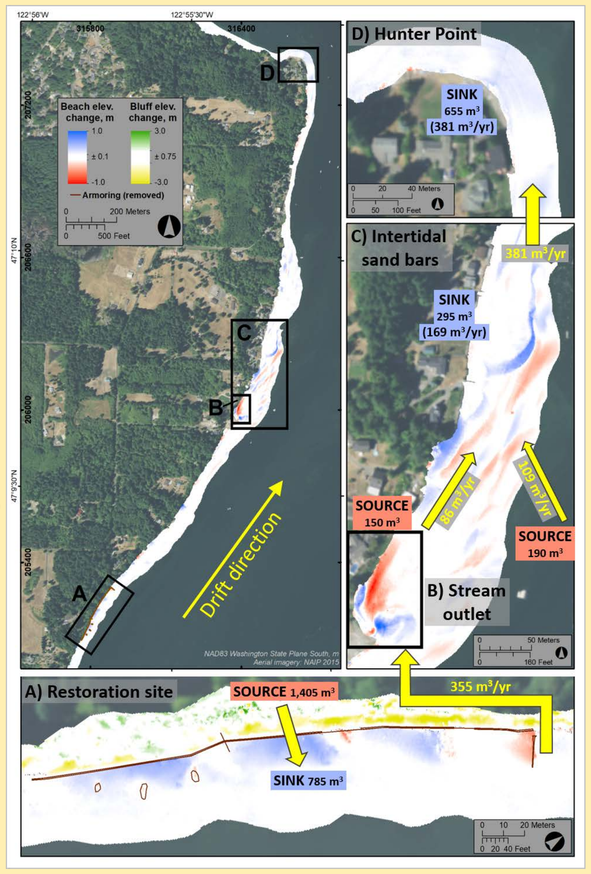
Morphology Change

Difference surface

A difference surface is created by subtracting the digital elevation model (DEM) of the post-restoration survey from the baseline survey DEM, and is used to quantify morphology changes on the beach and bluff.

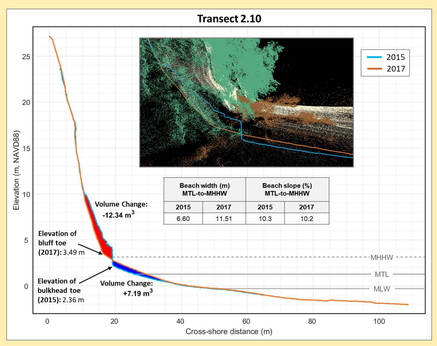


Four sub-regional areas within the drift cell had significant morphology change between the two surveys: the restoration site, a stream outlet (shown above), an accretionary beach with sand wave migration, and Hunter Point. The rest of the drift cell remained relatively unchanged. The figure to the right shows these changes and presents a preliminary sediment budget for the drift cell. The feeder bluff restoration accounts for 65% of the downdrift sediment accumulation, while the stream mouth and nearshore contribute 15% and 20%, respectively.

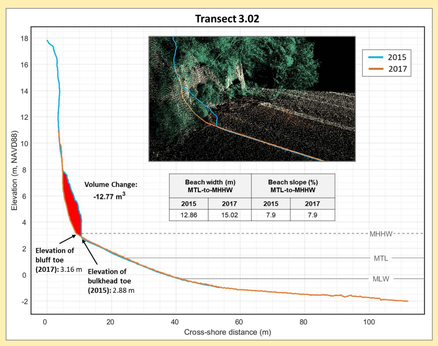


Cross-shore profiles

Profiles were extracted from the pre- and post-survey lidar point clouds and plotted together to show morphology and volume change.

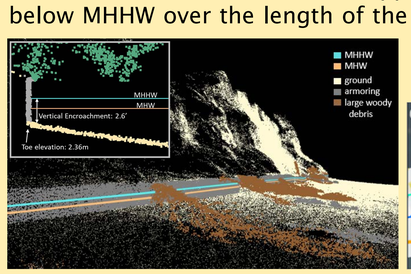


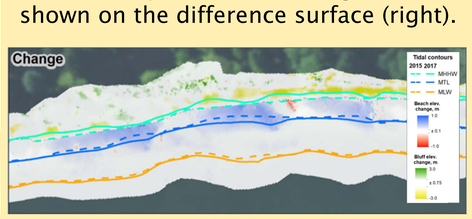
Beach width (m) MTL-to-MHHW		Beach slope (%) MTL-to-MHHW	
2015	2017	2015	2017
6.60	11.51	10.3	10.2



Beach width (m) MTL-to-MHHW		Beach slope (%) MTL-to-MHHW	
2015	2017	2015	2017
12.86	15.02	7.9	7.9

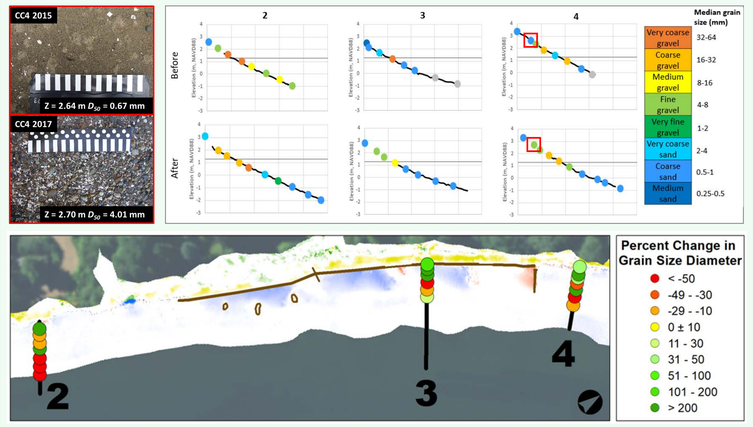
Below, the water levels plotted on the bulkhead face in the point cloud show how it had encroached on the upper beach (bulkhead toe averaged 2.0 ft below MHHW over the length of the armoring) (left). The upper beach width increased by 3.6 m, on average, as shown on the difference surface (right).





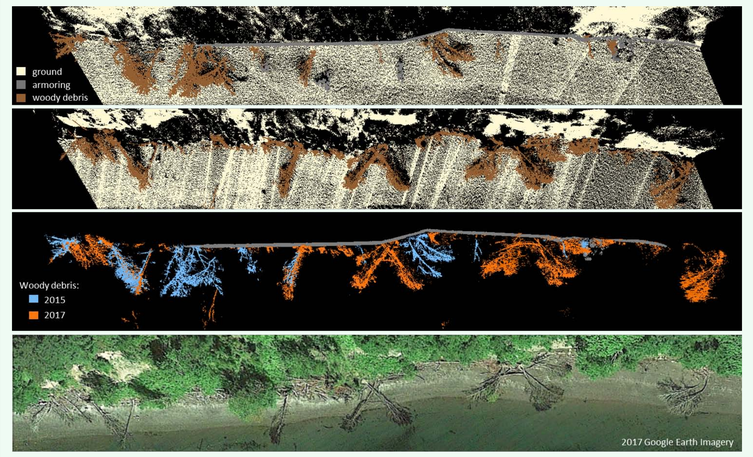
Sediment Grain Size

A digital grain-size analysis tool known as “cobble cam” was used to collect sediment grain-size data at 0.5-m elevation intervals along 5 transects in and adjacent to the restoration site. Cobble cam photos from Transect 4, down drift from the restoration, and changes in grain size for Transects 2-4 are displayed below:



Large Woody Debris

The beach area covered by large woody debris found seaward of the bulkhead at the project site was calculated for each survey, and indicates an 81% increase post-restoration. The classified point cloud and 2D area used for calculations are shown below:



Conclusions

- Beach width between MHHW and MLW increased from the 2015 survey to the 2017 post-restoration survey, with the MHHW line moving landward and MTL and MLW contours moving seaward
- An increase from very coarse sand to fine gravel on the upper beach and a decrease from very coarse gravel to medium gravel around the MTL contour led to an improvement in surf smelt spawning habitat
- The area of large woody debris on the beach increased by 81%, primarily as a direct result of the bulkhead removal process
- Approximately 1,405 m^3 of material eroded at the base of the bluff with about 785 m^3 of accretion on the upper beach at the bulkhead removal site persisting for almost 8 months

Acknowledgements

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