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High resolution mapping of Puget Sound shorelines

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High-resolution mapping of Puget Sound shorelines using boat-based lidar

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Overview

In an effort to collect high-resolution baseline coastal topographic data of beaches and bluffs around the Strait of Juan de Fuca and Puget Sound, the Washington State Department of Ecology Coastal Monitoring & Analysis Program (CMAP) conducted a series of boat-based lidar surveys in October 2013, May through September 2015, and May 2016 at a total of 16 sites spanning 220 km of shoreline and over two dozen drift cells in 31 days.

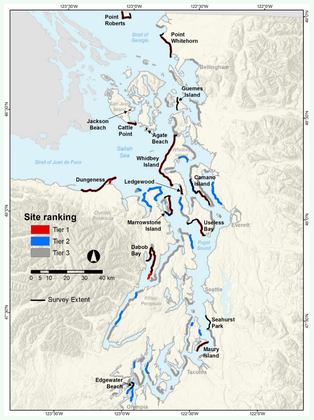
The drift cells were selected based on a rigorous and strategic geospatial analysis of bluff-backed beaches. Boat-based lidar surveys were complemented with ground-based GPS surveys, sediment grain-size photos, and high-resolution photos of the shoreline from the boat to document the landscape at the time of the survey.

Boat-based lidar provides an advantageous point of view of the bluff face, resulting in high-resolution data which is needed to gain insight into bluff erosion mechanisms, barriers to sediment supply, and corresponding sediment transport processes.

Site Selection

Surveyed drift cells were selected based on the following criteria:

- Potential for significant bluff sediment supply to intact shorelines (i.e., contiguous drift cells)
- Relatively high abundance of habitat for forage fish, eelgrass, herring, shellfish, and geoduck
- Previous investments in beach restoration projects
- Potential for future shoreline armoring and habitat loss based on population growth scenarios



All Salish Sea drift cells (> 900) were ranked; the highest ranking drift cells were divided into 3 tiers to prioritize survey efforts.

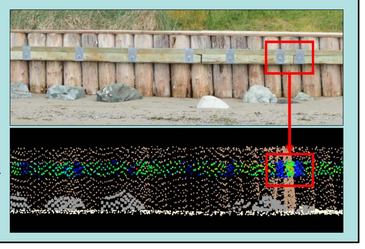
Survey Technology

High-resolution 3D elevation data were collected using boat-based lidar.

The laser scanner is mounted to the cabin top of the vessel next to an inertial measurement unit (IMU) that measures the vessel's motion (roll, pitch, and heave) and two GNSS antennas that provide the vessel's heading and position to map coastal landscape features at sub-decimeter positional accuracy.

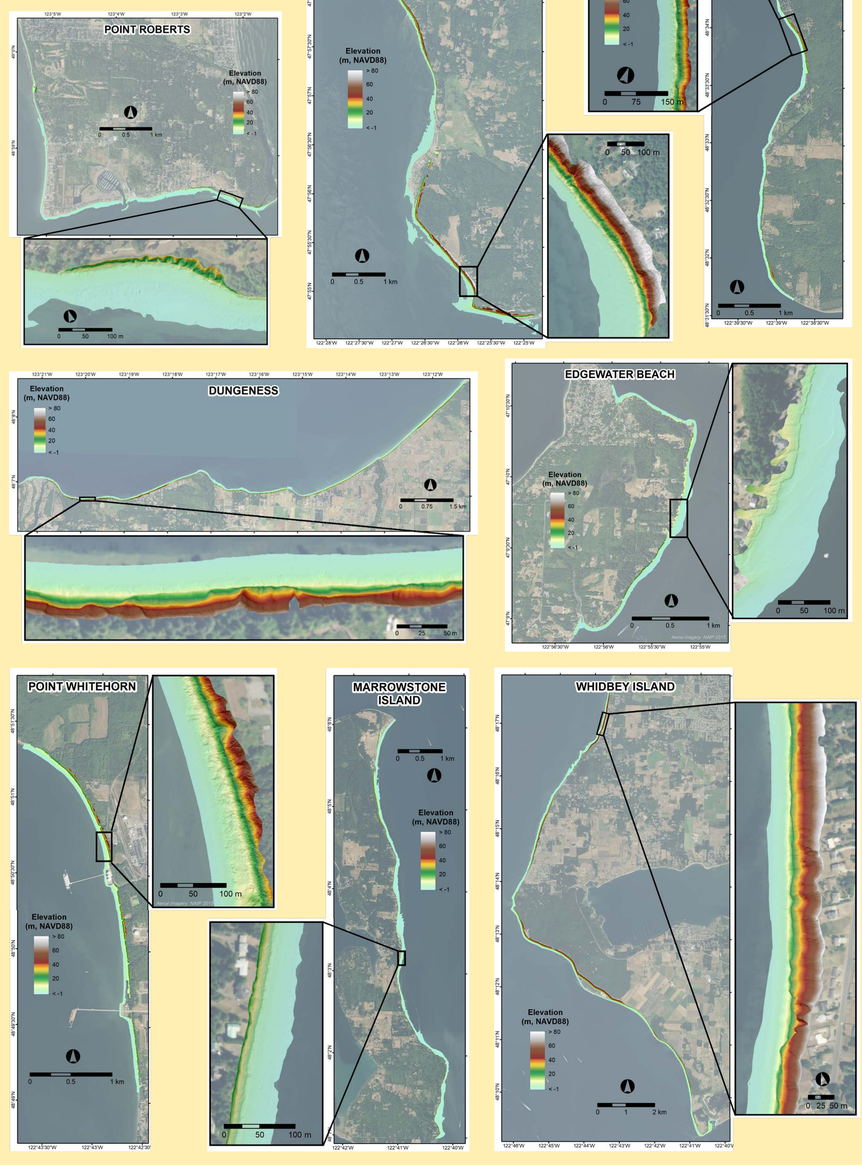
Data density typically ranges between 10-40 points/m^2 for drift cell-scale laser scanning at a distance of about 50-200 m from the shoreline.

The near-horizontal look angle of the laser allows for high coverage and accuracy on vertical features, such as bluffs and shoreline armoring, as well as collecting data under overwater structures and overhanging vegetation.

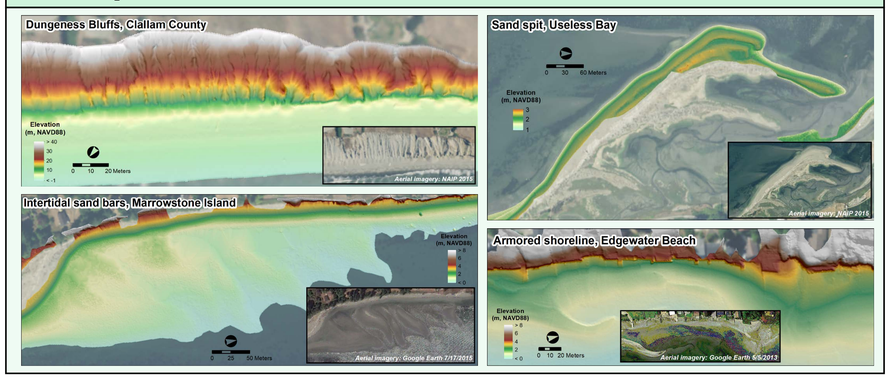


Digital Elevation Models

Boat-based lidar and ground-based GPS data were gridded together and linearly interpolated using a Triangular Irregular Network (TIN) in ArcGIS to produce 0.5-m digital elevation models (DEMs) of the beaches and bluffs for 16 survey sites around the Salish Sea. These DEMs provide an inventory and characterization of nearshore ecosystem services such as feeder bluff activity, beach slope and width, and the position, length, and elevation of shoreline armoring.

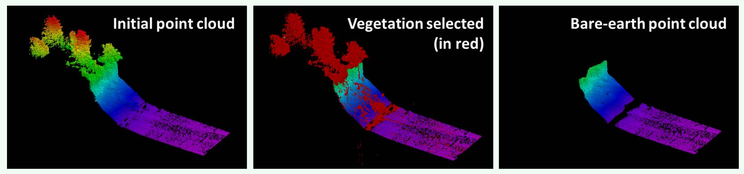


Examples of DEM resolution



Lidar point cloud

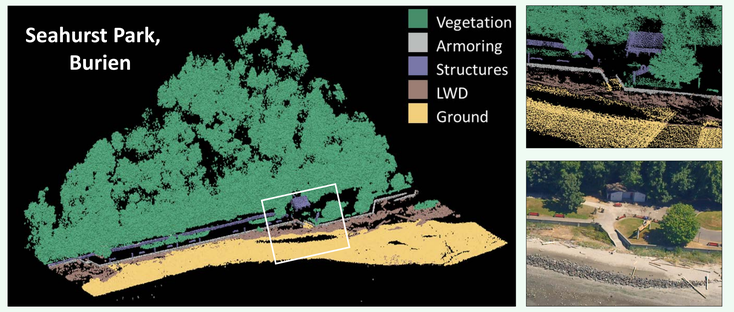
To create the DEMs, vegetation, noise, overwater structures (e.g., docks and piers) and buildings are removed from the lidar point cloud leaving only the ground surface ("bare-earth").



Simultaneously acquired photographs complement laser data for visualization and interpretation during point cloud cleaning.

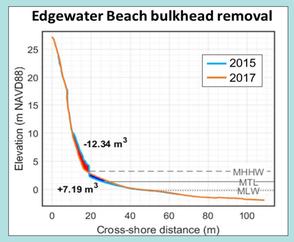
The point cloud can be classified according to different features present, such as vegetation, shoreline armor, man-made structures, large woody debris (LWD), and ground. Classification of the point cloud enables quantitative, geospatially accurate measurements of beach geomorphic and ecological features.

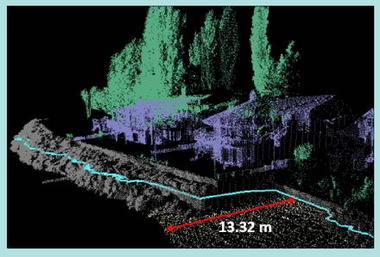
Below: Left—Classified lidar point cloud of Seahurst Park, Burien prior to bulkhead removal and beach restoration.
Right—Close-up view of the point cloud in the white box compared to an oblique shoreline photo from the WA Coastal Atlas (2006).

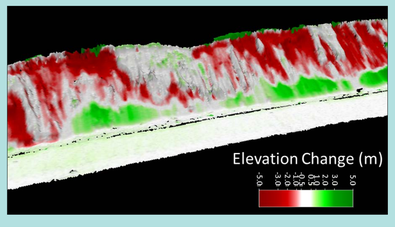


Data Applications

- Ability to extract morphometric parameters for bluffs and beaches (beach slope, beach width, bluff toe elevation, the position, length, and elevation of shoreline armor, etc.)
- Ability to extract metrics for ecological parameters such as beach wrack, large woody debris, and overhanging vegetation
- Accurately locate tidal datums
- Assess shoreline armor encroachment and impacts to beach morphology and ecology
- Document pre- and post-restoration conditions for comparative analysis and assessment







- Ability to extract cross-shore profiles for any shoreline location
- Quantify bluff erosion, sediment supply, beach change, and drift cell sediment budgets through repeat surveys

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