Pacific International Engineering PLLC

Point White

Introduction

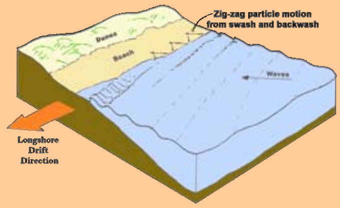
Beaches at Point White, Puget Sound, WA are exposed to the forces of wind waves, tidal currents, and wakewash that move sediment on the intertidal foreshore. The sediment on the foreshore is composed of a pebble and gravel armor overlying a mixture of medium to fine pebble and gravel in a medium sand matrix – a typical composition found in Puget Sound (Finlayson, 2006). Previous studies of sediment transport in Puget Sound have consisted of large scale measurements of sediment accumulation , shoreline change, and spit growth rates acquired from aerial photos (Wallace, 1988). Few studies address the relative importance of mechanism to sediment transport in Puget Sound

Extensive research has been conducted on sediment transport on sand beaches, however, considerably less is focused on gravel beaches. The aim of this research is to better understand the physical processes that control gravel transport at Point White in order to (1) accurately describe the seasonal patterns of transport, (2) determine the dominant forcing mechanisms for transport (3) better predict the implications of changes in wake climate on sediment transport in Rich Passage. The research is a two year study with the first year dedicated to data collection and the second year to data analysis and synthesis.

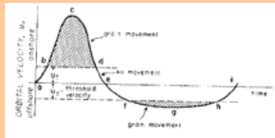
Background

Sediment transport in the coastal nearshore is driven by the physical forces of breaking waves and local currents that move unconsolidated beach sediment. When a critical shear stress along the bed is reached sediment will begin to move. Two modes of transport may occur depending on the grain size and the excess shear above critical: suspended or bedload transport. Bedload transport, in which grains remain close to the bed and move by rolling or saltating, is prevalent for gravel size particles

Alongshore & Cross-shore Transport Mechanisms



Wave induced longshore transport



Wave asymmetry resulting in net onshore transport

Methodology

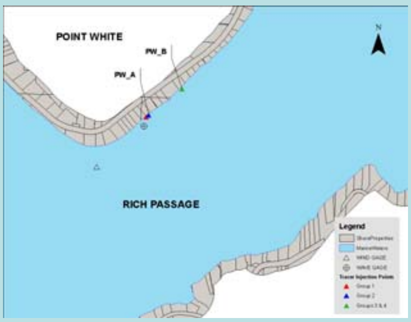
Gravel Tracing System

Direct measurements of pebble, gravel and cobble (gravel) transport were obtained from two sites on Point White through the use of particle tracing. The tracing technique follows Allan et al. (2006) and Nichols (2004). The system uses Radio Frequency Identification (RFID) technology, Passive Integrated Transponder (PIT) tags to track location of sample particles and Real Time Kinematic – Global Positioning System (RTK GPS) surveying to record locations in space and time.

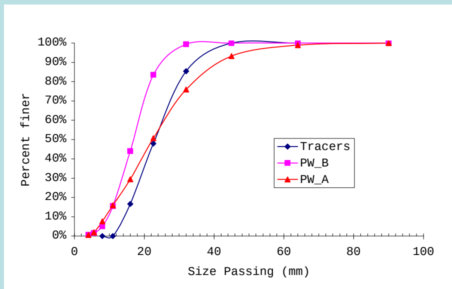
Making The Tracers

Gravel tracers are made from sediment samples obtained from beach armor layer. Each tracer set consists of 48 particles. The particles are classified by four mean size groups: 16 mm, 22.6 mm, 32 mm,and 45 mm. Maximum detection range is 40 cm.

Deployment Locations

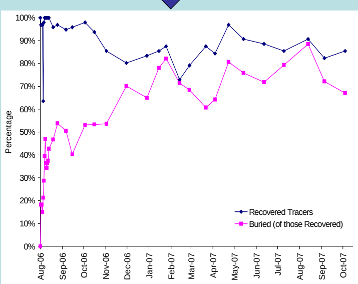


Groups 1 and 4: short term tracers
Groups 2 and 3: long term tracers

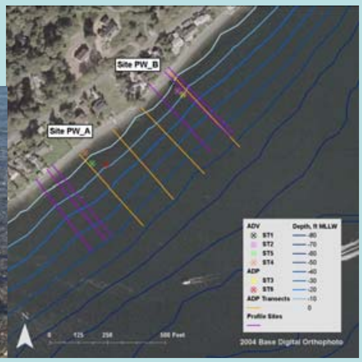


A comparison of the size distribution of the tracers sets and the beach surface particles at both sites. Median (d50) size of the tracers, PW_A, and PW_B are: 23 mm, 22.5 mm and 17 mm respectively.

Tracking technology results in high recovery rates & accurate data



Concurrent Hydrodynamic Measurements



Tracer measurements supported by long term measurements of:

- Wind Speed and Dir
- Waves, wakes & water levels
- Synoptic and point current measurements

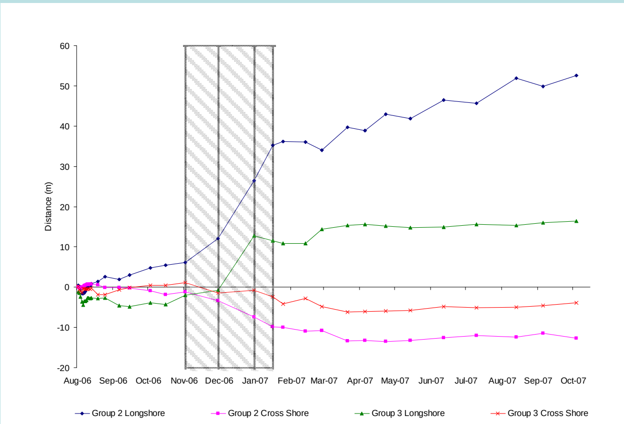
Sediment Transport Research

Results

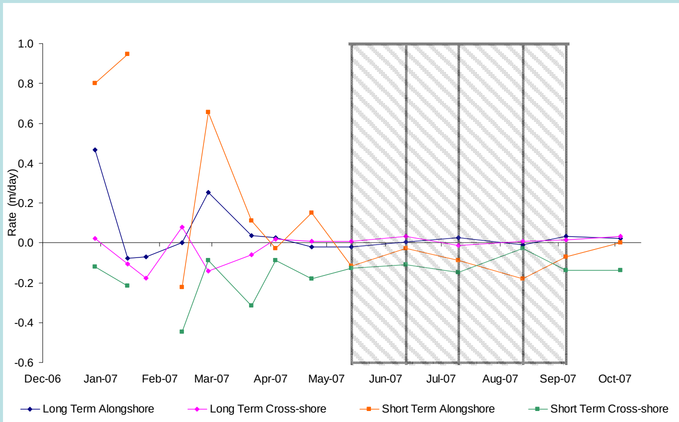
Tracers positions after fourteen months

Centroid positions of tracers through time

High burial rates of long term tracers → Use short term tracers to complement long term tracers



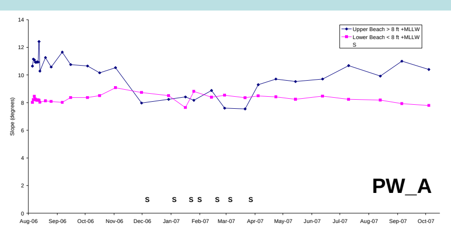
Positive is Onshore and Alongshore NE
Negative is Offshore and Alongshore SW

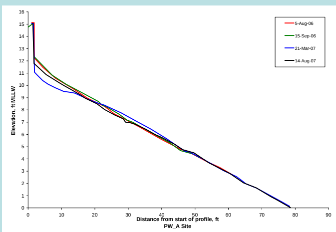


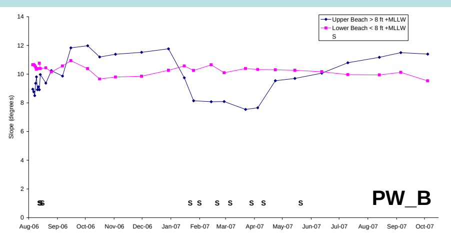
Net alongshore and cross-shore transport for both sites. Increased alongshore transport is seen from November to January (shaded region) due to storm events. Movement of Group 3 then stagnates while Group 2 moves steadily alongshore.

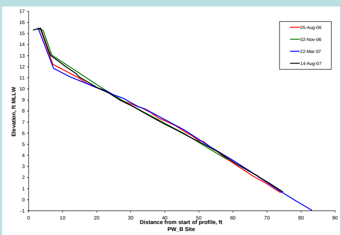
Comparison of short term and long term tracer transport rates. Short term tracers indicate a slight SW alongshore transport between May and September (shaded region) while the long term tracers show little significant movement during this period.

Beach profiles





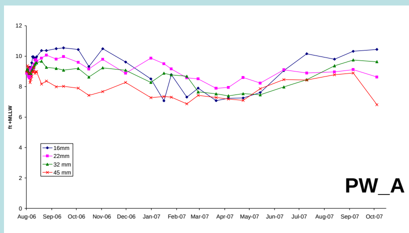


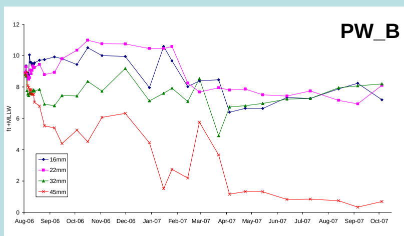


Calculated slope of upper and lower beach S indicates exposure of sand on the profile

Seasonal beach profiles show cross-shore storage of sediment in winter months

Sorting patterns





Tracer particles grouped by size show preferential sorting cross-shore

Project

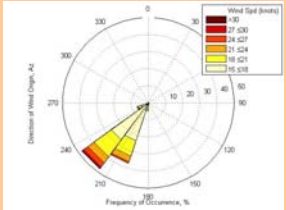
University of Washington

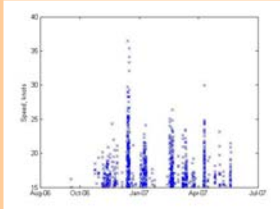
Summary

Forcing Mechanisms

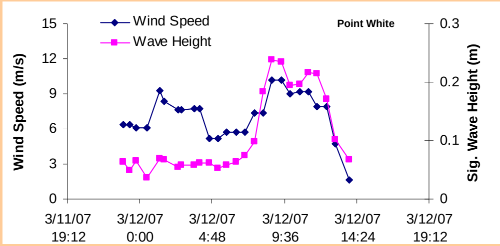
A ferry wake breaking on Point White in April 2007

Wind speeds > 15 knots



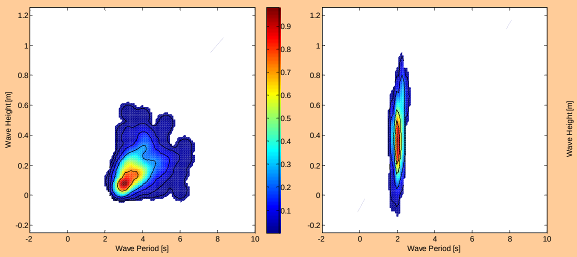


The transport by wind waves is predominately an alongshore uni-directional process that occurs mainly in winter. Winter waves can also be destructive to the upper foreshore berm resulting in exposed sand from the removal of the gravel armor layer



Analysis of storm waves and related winds

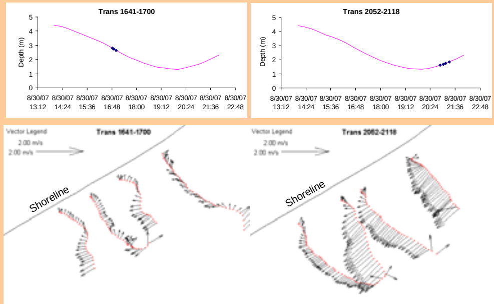
Vessel Wake and Wind Wave Analysis



Joint density plot of measured WSF car ferry wakes (left) and characteristic storm waves (right) at Point White.

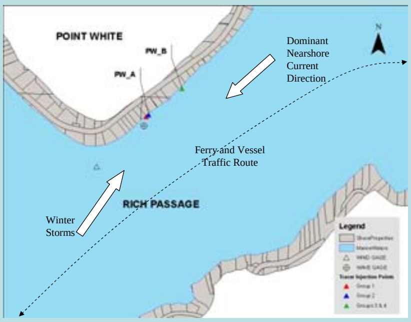
Vessel wakes and nearshore tidal currents drive sediment transport during calm periods. A recirculation eddy in Rich Passage forces the nearshore current SW during most tidal phases

Currents



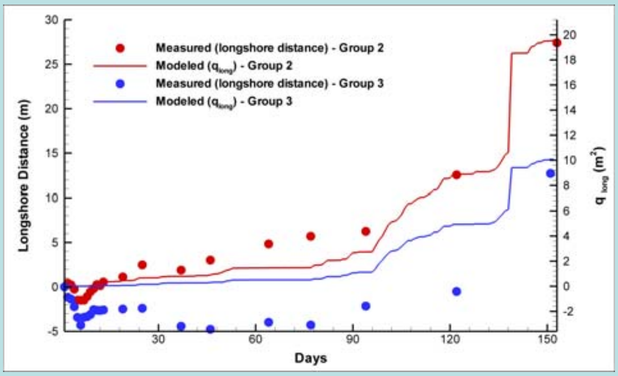
Depth-averaged current vectors from boat-based measurements at flood and ebb tides

Conclusions



Transport is highly seasonal and site specific. A long term background forcing condition of vessel wakes and tidal currents counter balance short term episodic storms. The net loss of sediment is minimal over a year but may be changing over a longer time period

- PW_A is more exposed to wind waves. The result is seen in steady alongshore movement of Group 2 tracers.
- PW_B beach is steeper and experiences more offshore movement of the largest particles



Comparison of tracer transport distances to integrated modeling results

Continuing Work

- Further analysis of wave characteristics to determine how wave steepness and beach slope affect net transport.
- Work is being done on an improved conceptual model to better isolate the physical processes
- Further work is being done to refine the model based on gravel tracer results and enhance predictive capabilities

Sources

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