# Back-beach structures, beach slopes, and sediment grain size around Liberty Bay

Renee Takesue[1] and Vivian Queija[2]

[1] USGS Coastal and Marine Geology, Santa Cruz, CA (rtakesue@usgs.gov); [2] USGS EROS Data Center, Seattle, WA (vqueija@usgs.gov)

## INTRODUCTION

Back-beach structures may alter the characteristics of beaches, particularly if they cut off upland sediment supply to the nearshore or if they cause an increase in wave energy. Beach erosion, sediment coarsening, and downstream beach starvation are the first-order effects of back-beach structures that harden shorelines. Second-order impacts of shoreline armoring are the absence of shade from overhanging back-beach vegetation and changes in benthic infaunal and epifaunal biotic communities.

The shoreline in and around Liberty Bay contains a mix of natural and armored beaches. We measured cross-shore beach elevations and sediment grain size distributions on 20 randomly-selected beaches (Fig. 1) along the shore from Poulsbo to Point Bolin in January and May 2007 to explore whether beach properties were related to back-beach structures.

Washington Department of Fish and Wildlife reports show that some of these beaches are used by forage fish (surf smelt and sand lance) for spawning. Beach characteristics and back-beach structures will be compared to numbers of forage fish eggs on the beach in January (see poster by T. Liedtke et al.).

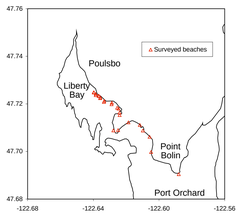



Figure 1. Locations of beaches surveyed in January 2007.

## APPROACH

*Beach elevation*- Beaches were surveyed at extreme low tides < -0.6 m (MLLW) to allow access to the low tide terrace. 19 beaches were surveyed in January and 16 beaches were surveyed in May, but only 15 of these co-occurred. Beach elevations were measured using the Washington State Real-Time GPS Network (RTN), which provided an accuracy of at least 20 cm.

RTN components (Fig. 2):
WA State GPS Network (state-wide permanent, continuously-monitored base stations).
Backpack-mounted dual-frequency receiver (improves accuracy to 6-8 cm).
Cell phone-connected rover unit (real-time corrected GPS data received via wireless Internet).

Figure 2. V. Queija collecting RTN data along a cross-shore transect.

*Grain size*- Surface sediment was collected at 10 evenly-spaced intervals across each beach when the grain size was less than 4 mm. Grains larger than 4 mm were photographed in situ. Sediment was dried overnight at 105 °C to remove water. Grain size distributions were determined at whole-ϕ intervals by dry-sieving.

## RESULTS

The beaches around Liberty Bay fell into three general categories:

A) Wide, low-relief beaches (e.g. Beach 183, Fig. 3) occurred near the mouths of creeks. Beaches were ~100 m wide and had < 2 m elevation change relative to MLLW. Of the 3 beaches that fell into this category, 1 beach was inside LB and 2 were outside the bay. Sediment textures were quite different inside and outside the bay (14% fines inside vs. <1% fines outside).

B) Typical beach characteristics (e.g. Beach 163, Fig. 4). The majority of beaches were 40-50 m wide and had an elevation change about 3-4 m relative to MLLW. The upper beach was composed of barnacle-encrusted cobbles transitioning to muddy sand between below mean sea level. Beach faces had slopes on the order of 1:7.

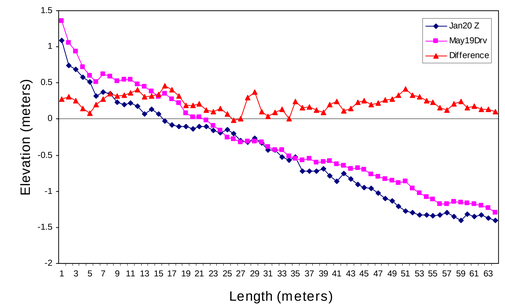
C) Beaches with steep faces (e.g. Beach 268, Fig. 5). A few beaches had extremely steep faces (slopes on the order of 1:4). Beach elevations ranged 5-6 m above MLLW. Of the 3 steep beaches, one had a cement bulkhead on the upper beach, one was backed by a wetland (Beach 268), and one by a low cliff. Sediment grain sizes differed on all beach faces. Average particle diameters ranged from 2 to 5 cm. Steep beaches were located on exposed shorelines.

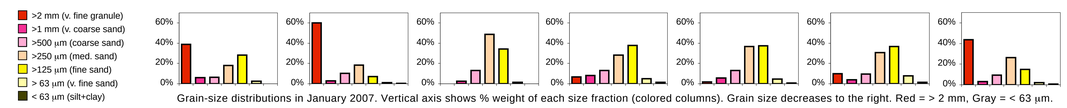
## SIGNIFICANCE

Creeks flowing into the nearshore provided a sediment source to several beaches around LB. Wide, low-relief beaches occurred on deltas or sand spits at the mouths of creeks. Post-depositional processes appeared to be more important in determining sediment texture than proximity to sediment sources, however. Bulkheads and rip-rap on beaches did not impact all beaches in the same way, if at all. For example, several beaches had a sandy berm or terrestrial vegetation in front of back-beach structures. Other bulkheads were intertidal. The fact that the steepest beach-face slopes occurred on natural and bulkheaded beaches suggests that nearshore processes could be as or more important than back-beach structures in determining beach slopes around LB.

**Figure 3. Beach Profile 183**

Beach profiles are roughly 15 meters apart and a length of 146 meters. Each profile length trimmed to roughly equal lengths with outliers (error spikes removed). Bench mark solutions applied.

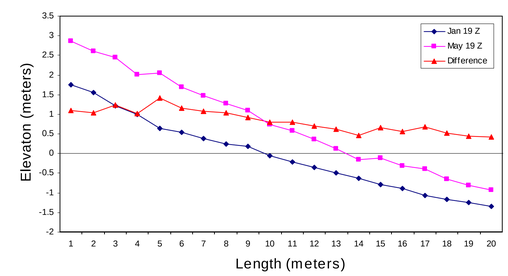


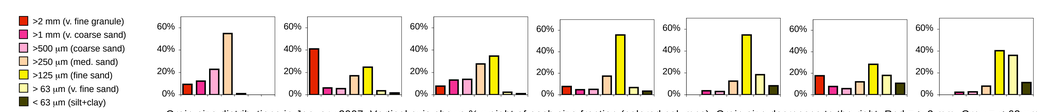




Grain-size distributions in January 2007. Vertical axis shows % weight of each size fraction (colored columns). Grain size decreases to the right. Red = > 2 mm, Gray = < 63 µm.

**Figure 4. Beach Profile 163**

Profiles are 25 meters apart. Each profile length trimmed to roughly equal lengths with survey starting and stopping points excluded. Bench mark solutions applied.

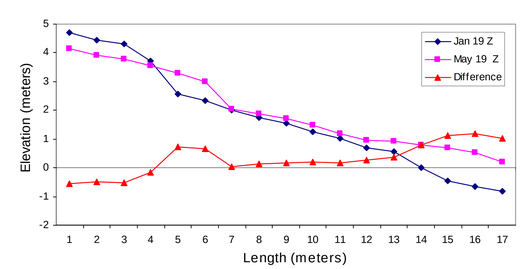


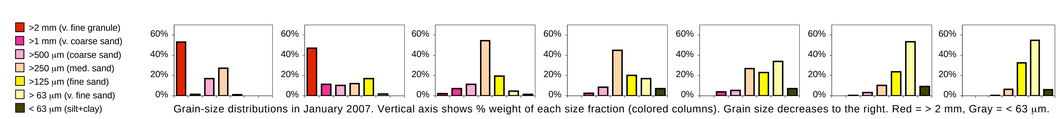




Grain-size distributions in January 2007. Vertical axis shows % weight of each size fraction (colored columns). Grain size decreases to the right. Red = > 2 mm, Gray = < 63 µm.

**Figure 5. Beach Profile 268**

Beach profiles are roughly 11 meters apart and a length of 31 meters. Each profile length trimmed to roughly equal lengths with outliers (error spikes removed). Bench mark solutions applied.




Grain-size distributions in January 2007. Vertical axis shows % weight of each size fraction (colored columns). Grain size decreases to the right. Red = > 2 mm, Gray = < 63 µm.