# NATURE-BASED COASTAL PROTECTION USING LARGE WOODY DEBRIS

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## INTRODUCTION

Natural accumulations of Large Woody Debris (LWD) are thought to be an important component of a diverse coastal habitat (Rich et al., 2014) and provide shore-stabilization benefits (Heathfield and Walker, 2011; Kennedy and Woods, 2012). Decreasing coverages of natural LWD and increasing demand for ecologically sensitive shoreline protection measures has led to the promotion and usage of LWD as a nature-based coastal protection technique (e.g. Johannessen et al., 2014). In British Columbia (BC), Canada, and Washington State, USA, anchored LWD have been extensively used with the specific aim of reducing erosion and limiting wave run-up (e.g. Figure 1), especially for low and moderate wave conditions. Despite its frequent usage, there is currently limited peer-reviewed literature on the design or efficacy of coastal protection using LWD.

## OBJECTIVES / NOVELTY

**This paper presents the results of the first systematic research project focused on understanding the design and efficacy of anchored LWD in a coastal environment.** Specifically, the project aims to answer the following:

1. Are LWD effective at stabilizing the shoreline under wave action?
2. Are LWD effective at reducing wave run-up?
3. Are LWD durable enough to meet engineering requirements for coastal protection?
4. What are the optimum configurations of LWD coastal protection structures?

A two-pronged approach was taken to answer these questions, which included: (1) extensive field investigations of existing anchored LWD projects, and (2) large-scale experimental wave modeling of simulated LWD on a gravel beach.

## FIELD INVESTIGATIONS

Field investigations were conducted from June to August 2019 at 15 sites with existing LWD installations in British Columbia and Washington State. Measurements of the LWD placement elevation and beach slope were made using an RTK GPS within BC, and a rotary laser level and rod within Washington State where site-access permitted. Surficial sediment sizes were estimated using digital grain size analysis. Additional observations were made on site and LWD design characteristics, including log diameter, log length, installation type, and anchoring technique. Durability indicators were also recorded, including signs of erosion/accretion, wood decay, anchor corrosion/failure, and arson.

Study sites were subject to generally mixed-diurnal tides with tidal ranges from 2.4 to 5.2m. The sites varied from enclosed bays subject to only minor, locally generated waves, to exposed sections of shoreline subject to long fetches and ocean swell. The study sites generally had mixed cobble and gravel upper-intertidal beaches with an average slope of 7.6:1 (H:V), and a relatively flat and broad lower-intertidal sand beach. The average grain size on the upper beach ranged from 18 mm (gravel) to 140 mm (cobble).

Anchored LWD installations were grouped into six distinct installation types: (1) single, (2) multiple, (3) benched, (4) stacked, (5) matrix-style, or (6) groyne-style. Observed anchoring methods generally included cable or chain secured to rock ballast; however ropes, soil-pins, and concrete block ballast were also noted. Durability issues were recorded at all except one site, with most sites having multiple issues. Logs had an average diameter of 0.56 m and an average length of 7.5 m.

Site and design variables that appeared to be correlated to durability were selected for investigation during experimental modeling, including wave characteristics, placement elevation relative to the water level and beach crest, and installation type. Additional variables that were correlated to durability, but not varied in the experimental modeling program due to time constraints, included the upper beach slope.

## EXPERIMENTAL MODELING

Experimental modeling was conducted in a 63m long x 1.22m wide wave flume at the National Research Council's Ocean, Coastal & River Engineering Research Centre (NRC-OCRE) in Ottawa, Canada (Figure 2). The experiments included constructing a sloping gravel beach, installing a range of LWD structures on the beach, and observing hydro-morphological behaviour (Figure 3). The performance of the LWD structures were compared to that of a gravel beach with no structure and one with a seawall. Modeling was conducted at a 5:1 (prototype to model) scale, assuming Froude scaling. Based on the model scale, field investigation findings, and logistical constraints, the model used an initial beach slope of 8:1 (H:V) and a median grain size, $D_{50}$, of approximately 7.9 mm (approximately 40 mm Cobble at full scale). Anchored LWD were modeled using 0.114m diameter cylinders fixed into single, multiple (three), benched, matrix-style, and stacked configurations to mimic the typical installation types observed during field investigations.

A base set of three random wave conditions were tested for each LWD configuration: (1) $H_s$ = 0.10 m, $T_p$ = 1.78 s, (2) $H_s$ = 0.15 m, $T_p$ = 2.17 s, (3) $H_s$ = 0.20 m, $T_p$ = 2.51 s. Tests were also conducted to assess repeatability, sensitivity to test duration, sensitivity to wave height, wave period and water level, influence of regular waves, and influence of log roughness. In total, over 60 experiments were completed. Wave conditions and beach profile evolution (e.g. Figure 4) were measured in all tests. Scouring around the LWD, wave run-up and wave overtopping were also observed and monitored.

## RESULTS/DISCUSSION

The field investigations allowed for characterization of typical site and LWD design characteristics. They also revealed numerous durability issues related to the use of LWD as coastal protection, including wood decay, human interference (e.g. arson), and anchor corrosion/failure. Scouring and/or backshore erosion was observed at most installations.

Typical anchored LWD designs were modeled under wave action as part of an extensive experimental modeling program, in order to assess their efficacy at stabilizing the beach profile and reducing wave run-up. Results for anchored LWD structures were compared against those for a gravel beach with no LWD and for a gravel beach with a typical vertical seawall.

The full paper will present an overview of the study methodology, field investigation and experimental modeling results, and provide initial design guidance for the use of coastal protection using anchored LWD.

## REFERENCES


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Figure 1 – Anchored LWD in Parksville, BC, Canada

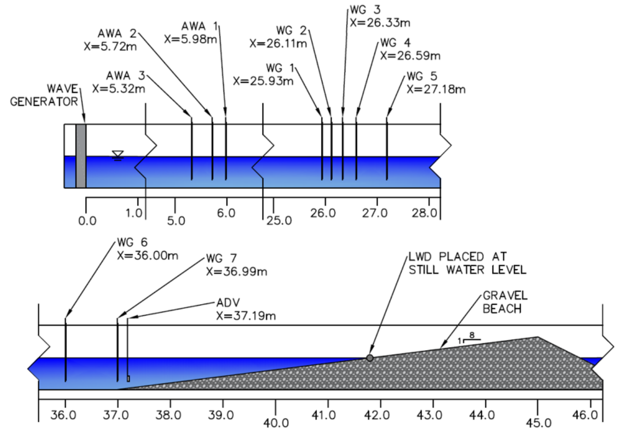


Figure 2 – Sketch of experimental set-up (not to scale).

Figure 3 – Beach profile change after beach equilibrium was met with a single log placed at the still water level. The white line indicates the original 8:1 (H:V) beach profile.

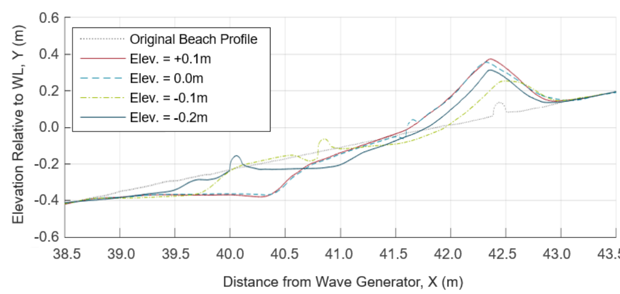


Figure 4 – Comparison of equilibrium beach profile for LWD placement elevations ranging from -0.2 m to +0.1 m for $H_s$ = 0.20 m and $T_p$ = 2.51 s