

BUOYANT DRIFTWOOD DYNAMICS IN THE SURF ZONE

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OBJECTIVES AND NOVELTY

Wood, a naturally-occurring material in many coastal regions, is seeing growing utilization in nature-based shore protection schemes, to capitalize on the ecosystem services it purportedly provides. In contrast, wood and logs are often removed from coastal marshes as part of restoration efforts, particularly where substantial quantities of driftwood are introduced by human activities, such as forestry and construction. Accumulations of driftwood can pose hazards to coastal communities, infrastructure and ecosystems; particularly if mobilized by storms. An improved understanding of driftwood transport and dispersion on open coasts exposed to waves is needed to guide sustainable use and risk management (Murphy *et al.*, 2021). This novel numerical modeling study builds on the results of an experimental program conducted by the authors at the Ocean, Coastal and River Engineering Laboratory of the National Research Council of Canada.

DRIFTWOOD DYNAMICS IN THE SURF ZONE

Numerous dye and drifter (drogue) release experiments have been conducted in field and laboratory settings to evaluate circulation, mass transport and dispersion in nearshore, wave-dominated environments (e.g., Spydell *et al.*, 2007; Pattiaratchi *et al.*, 2009). However, most studies involving drifters have been designed to minimize interactions with breaking wave bores inside the surf zone (e.g., “surfing effects”) (Jones & Pattiaratchi, 2005). Scale physical modelling experiments by Murphy *et al.* (2020) showed a strong tendency for buoyant driftwood to be transported onshore by oblique, breaking waves (Fig. 1). Under such conditions, rough model driftwood was observed to become stranded on beaches, strongly influencing mean transport and dispersion.



Figure 1. Model driftwood being transported onshore by breaking waves in the physical model (Murphy *et al.* 2020).

PREVIOUS NUMERICAL INVESTIGATIONS

The persistent onshore-directed transport observed in the laboratory could not be replicated numerically using a Lagrangian driftwood model (Murphy *et al.*, 2023) relying on depth average hydrodynamic output from a 2-layer non-hydrostatic XBeach model (Roelvink *et al.*, 2009), despite reasonable agreement with observed sea states and mean current speeds at the edge of the surf zone. Wave breaking in the XBeach model was parameterized using a hydrostatic front approximation (de Ridder *et al.*, 2021). Such approaches are known to underestimate horizontal velocities near the wave crest. It is hypothesized that vertical non-uniformity in wave-induced velocities (Putrevu & Svendsen, 1999) and breaking wave bore dynamics play important roles in controlling buoyant driftwood transport, dispersion and interactions with the shore in wave-dominated settings. If so, wave-induced velocities near the surface must be properly resolved by models employed to simulate driftwood fate and transport in exposed coastal settings.

METHODS

Driftwood release experiments described by Murphy *et al.* (2020) were simulated numerically using the Lagrangian driftwood model described by Murphy *et al.* (2023), this time using hydrodynamic output from a multi-layer SWASH model (Zijlema *et al.*, 2011). SWASH permitted greater vertical resolution of horizontal wave-induced velocities and reduced parametrization of depth-induced wave breaking compared to XBeach. Lagrangian driftwood transport simulations were implemented with two different forcings: (i) wave-induced velocities from the surface layer of the SWASH model; and (ii) depth-averaged velocities.

RESULTS AND DISCUSSION

The results of the numerical simulations confirm the strong influence of the vertical non-uniformity in horizontal wave-induced velocity profiles on buoyant driftwood transport within the surf zone. For example, driftwood positions and orientations at time $t = 22 T_p$, where T_p is the peak wave period, are shown in Figs. 2 and 3 for Lagrangian simulations driven by depth-averaged and surface-layer wave-induced velocities from SWASH, respectively. Driftwood in Figs. 2 and 3 is colored by length class (yellow = 3 m, blue = 9 m, and green = 12 m), and is shown colored red when beached and stationary. The results driven by surface-layer velocities show a much greater tendency for driftwood to be transported onshore and become trapped on beaches, more closely mirroring the experimental observations by Murphy *et al.* (2020). Mean driftwood transport velocities and dispersion coefficients are numerically evaluated with and without beaching and washoff algorithms switched on in the Lagrangian model, to quantify the effects of driftwood roughness and beaching on transport and dispersion.

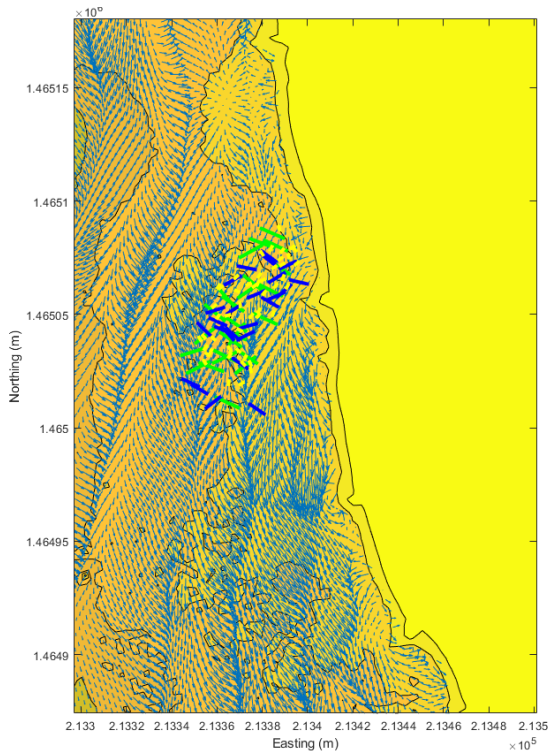


Figure 2. Depth-averaged velocities and simulated driftwood locations at $t = 22 T_p$ following a point release from the north end of the reach. $H_s = 0.65$ m, $T_p = 8$ s.

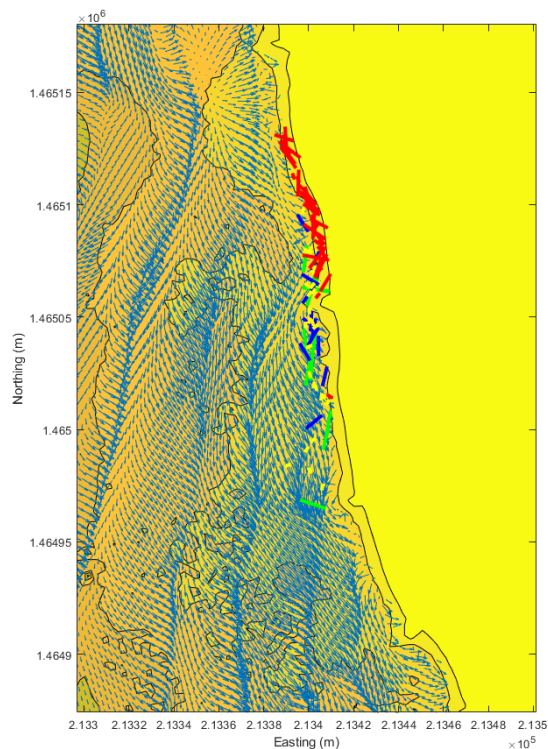


Figure 3. Surface layer velocities and simulated driftwood locations at $t = 22 T_p$ following a point release from the north end of the reach. $H_s = 0.65$ m, $T_p = 8$ s.

CONCLUSION

The onshore-directed mean transport of buoyant driftwood by oblique, breaking waves observed in physical modelling experiments can only be numerically predicted using models that adequately resolve the vertical profile of wave-induced horizontal velocities and bore celerities in the surf zone. Replicating these processes is essential to ensure beaching, a key factor controlling driftwood transport and dispersion, is properly simulated. Given the strong influence of near-surface velocities on buoyant driftwood transport, care is needed when attempting to infer driftwood dispersion coefficients from studies involving drifters designed to resist surfing effects. The findings of this study may be expected to apply to a variety of floating marine debris types (e.g., macro-plastics). However, most numerical models employed to simulate fate and transport of marine debris at oceanic scales do not resolve surf zone processes, owing to the high computational burden. Where floating debris is expected to encounter surf zones, nested or multi-scale simulation techniques should be considered.

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