Modelling the impact of sea-level rise and intensified storminess on Roberts Bank

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Reducing Canada's vulnerability to climate change

Introduction

Intertidal flats represent important sediment sinks within the coastal environment. An understanding of the processes governing deposition and erosion in these environments is important to describing their evolution. The cross-shore profile of intertidal flats is primarily controlled by tidal range, wave climate, sediment composition and supply. Progradation requires that sedimentation exceed erosion; even ***small*** waves can resuspend significant quantities of sediment, which may then be transported by tidal currents from the source area. In this respect, the mechanisms by which tidal flat surfaces transform wave energy and the efficiency with which they do so remains a central

Feedback Mechanisms

Wave attenuation is a reflection of ***self-organizing processes*** in which sediment transport and changes to the profile in response to changes in water levels and waves are directed (to greater or lesser degrees) by the pre-existing morphology. This ***morphological feedback*** occurs from the scale of the entire tidal flat to smaller scale bedforms (Figure 1). Variations in the morphology are not predictable from the characteristics of the incident wave field alone. Rather a detailed understanding of how the waves are modified by the pre-existing morphology is required. In order to predict the response of Roberts Bank to accelerated sea level rise and intensified storminess (Figure 2), a wave/current model is being developed to predict sediment resuspension and changes in bed elevation.

Figure 1. Bedforms that affect the attenuation of waves across the tidal flat at a range of spatial and temporal scales.

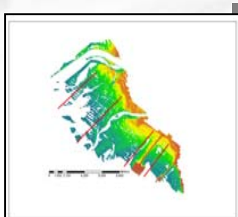


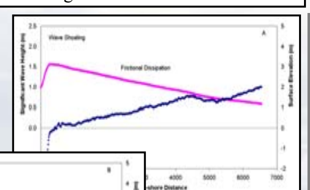
Figure 2. Satellite photo of Fraser River Delta and surface elevation map of Roberts Bank. Wave and tidal current monitoring and modeling will be completed along the four transects marked in red.

Lagrangian Wave Model

Wave attenuation results from a complex balance of processes typically dominated by shoaling, frictional dissipation and breaking. To quantify the combined effects of shoaling and friction on the wave energy dissipation across the tidal flat a Lagrangian model was developed. The equation for wave height attenuation (from an initial height, H_o) along a wave ray can be expressed as:

$$\frac{H}{H_o} = K_s K_f K_r$$

where K_s is the shoaling coefficient (wave growth), K_f is the friction coefficient (wave decay) and K_r is the refraction coefficient (wave turning). Sample model results are presented in Figure 3.



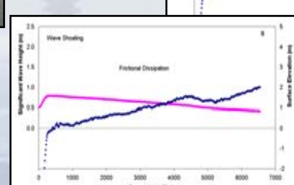


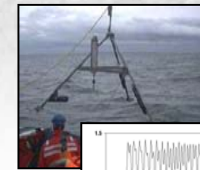
Figure 3. Representative plots of the cross-shore profile in the Northern part of Roberts Bank and the predicted variation in wave height for offshore waveheights (H_o) of 0.5 m and 1.0 m at high tide.

Spring 2003

A total of 760 hours of combined wave, current and concentration measurements were collected over 31 days under a wide range of offshore wave conditions and tidal elevations (Figure 4). Four storm events (with H_o>0.5 m) were observed over the study period with peak wind speeds of ~12 m s-1 from the NW on April 22, 2003.

Preliminary Results

Comparison with the Lagrangian wave model reveals a dependency of wave attenuation on the relative depth (h L^{-1}) over a broad sandy shoal seaward of the instrument station. While the ability of the model to predict wave heights improves when the relative depth over the shoal is between 0.05 and 0.1 the wave change in wave period due to a *blue-shifting* of the spectra is not predicted. The spectral transformation is associated with the release of secondary (harmonic) waves as the incident waves *deshoal* landward of the sandy shoal. The generation of harmonic waves results in a decrease in the significant wave period and a reduction in wave heights, which may promote deposition and the local expansion of the tidal flat seaward.



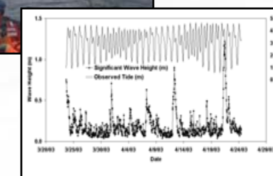


Figure 4. Instrument array deployed in spring 2003 and plot of offshore wave heights and tidal elevations observed during the deployment.

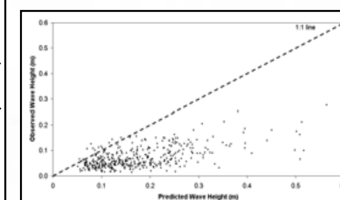


Figure 5. Comparison of model predicted wave heights and observed wave heights at a station on the tidal flat.

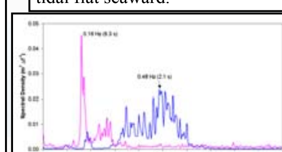


Figure 5. Comparison of spectral density plots for waves offshore and on the tidal flat. Note the dominance of higher frequency waves on the tidal flat indicating a shift towards short period waves. This process is called *blue-shifting*. It is typically not considered in tidal flat environments.

Blue-shifting

Commonly observed on beaches (Houser and Greenwood, 2004), this process develops as a wave shoals it becomes asymmetric in form (steep face and long sloping back). If this wave moves into deeper water (behind a bar or sandy shoal) it starts to ***deshoal***. The asymmetric wave form is no longer stable and the

Winter 2004

A total of 1320 hours of combined wave, current and concentration measurements were collected between December 24, 2003 and February 16, 2004 under a wide range of offshore wave conditions and tidal elevations. These measurements are being completed in conjunction with morphological mapping an bed erodibility measurements. Results from this experiment will be available in ~1 year.

References: Houser, C., and Greenwood, B., 2004. Hydrodynamics and sediment transport within the inner surf zone of a lacustrine multiple barred nearshore, Submitted to *Marine Geology*. Luternauer, J.L., Mosher, D.C., Clague, J.J., and Atkins, R.J., 1998. Sedimentary environments of the Fraser delta. In *Geology and Natural Hazards of the Fraser River Delta, British Columbia*. Cague, J.J., Luternauer, J.L., and Mosher, D.C., Geological Survey of Canada Bulletin, 525: 27-39.