Coupled sandbar patterns: breaker lines and depth variations

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Introduction

Nearshore sandbars obtain a variety of shapes, ranging from straight ridges to a remarkable alongshore alternation in position and depth (crescentic sandbars). In a double sandbar system, the alongshore spacing of morphological features in the inner sandbar (such as rip channels) may be identical to those in the outer sandbar. Our aim is to characterise the morphodynamics of coupled sandbar morphology.

Figure 1: Location of the study site.

Methodology

We use a 9.3-year data set of hourly time-exposure images from the Gold Coast, Australia (Figure 1). The high-intensity, alongshore continuous bands in these images are the areas of wave breaking, which reflect the bar crest lines. Using a data-assimilation method, called XBeachWizard[1], we estimate the depth variations of the sandbar (Figure 2).

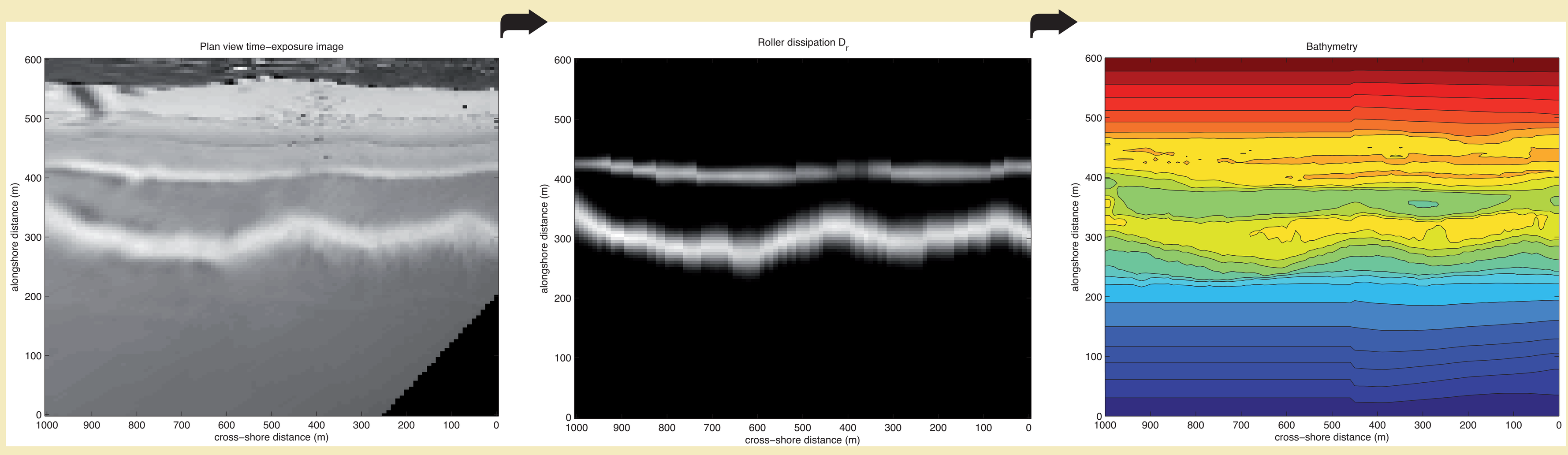

Figure 2: In the plan view time-exposure image (a) the areas of wave breaking provide a measure of roller dissipation (D_r) over the sandbars (b). Assimilation of the observed and modelled D_r (with XBeach) leads to an estimation of the outer bar bathymetry (c).

Results

Shore-normal wave incidence

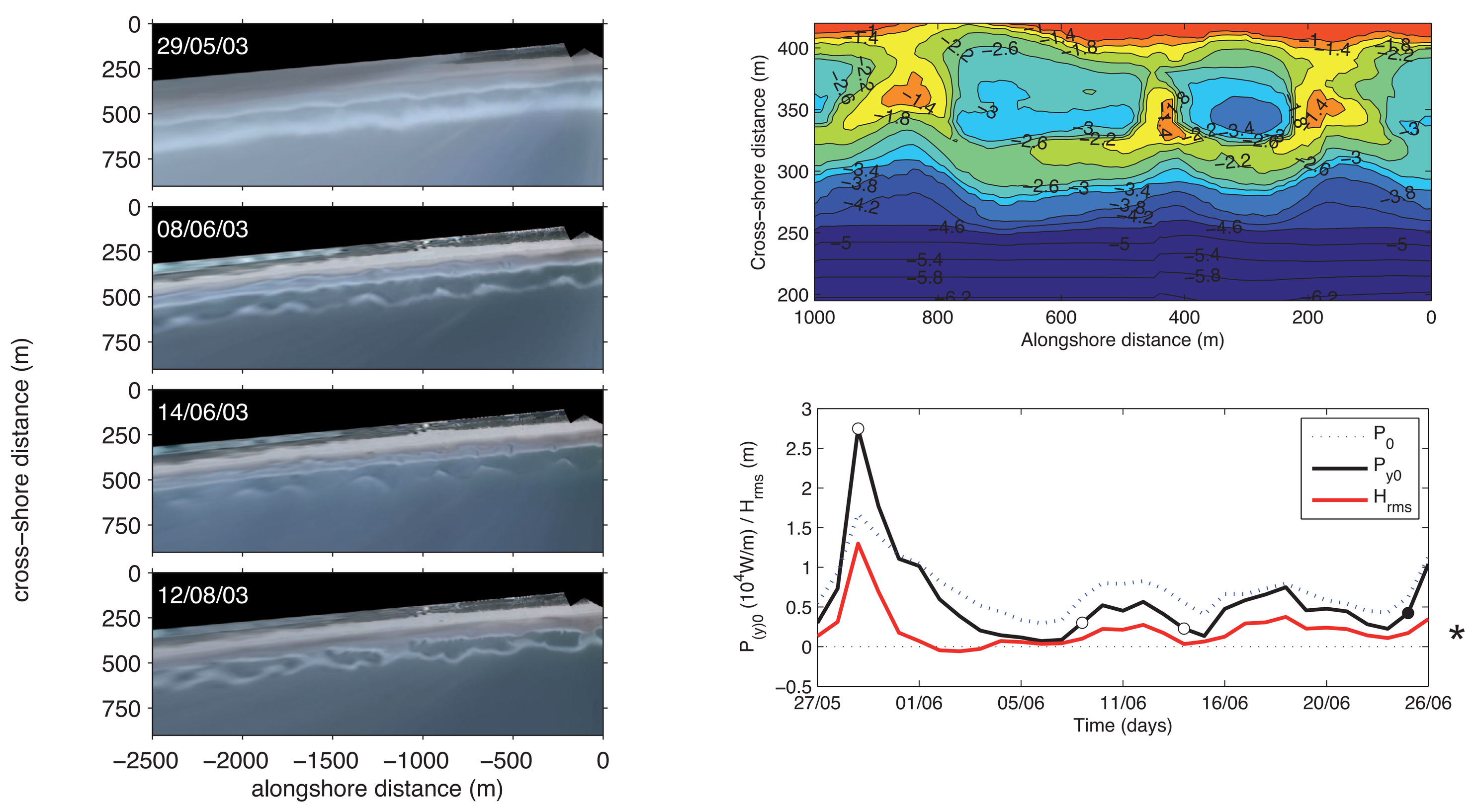

Figure 3: Shore-normal wave incidence leads to a pronounced outer crescentic bar and the development of rip channels in the inner bar at the locations of the outer bar horns. Eventually, the outer bar horns attach to the inner bar. This leads to out-of-phase coupling, where an outer bar horn faces a landward perturbation of the inner barline.

Oblique wave incidence

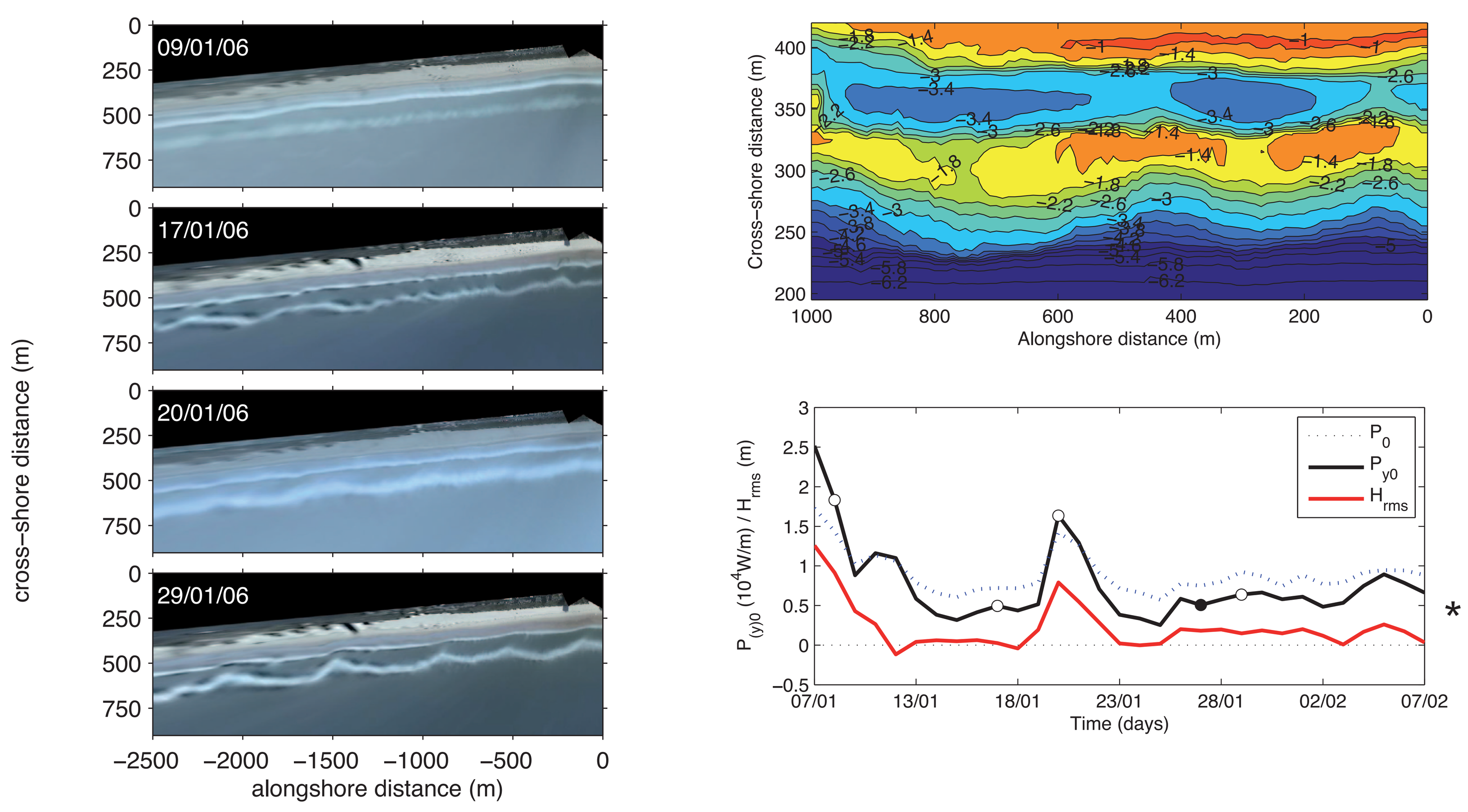

Figure 4: Obliquely incident waves over an existing outer crescentic sandbar deform the existing coupling pattern and result in meandering barlines. This leads to in-phase coupling, where an outer bar horn faces a seaward bulge in the inner barline. Sufficiently energetic waves uncouple the bar system and straighten the barline(s).

*White markers indicate the locations of the planviews in time. The black markers indicate the location of the estimated bathymetry in time.

Hypotheses for coupling

- Shore-normal waves over a crescentic outer bar cause alongshore differences in wave set-up, driving circulation patterns over the inner bar. The amount of wave breaking over the outer bar determines the configuration of rip channels in the inner bar.
- Obliquely incident waves over a crescentic outer bar drive a (meandering) alongshore current, preventing the outer bar horns from welding to the inner bar and counteracting the development of rip channels in the inner bar. Given the predominance of oblique waves at the Gold Coast, in-phase coupling is the dominant coupling type (Figure 5).

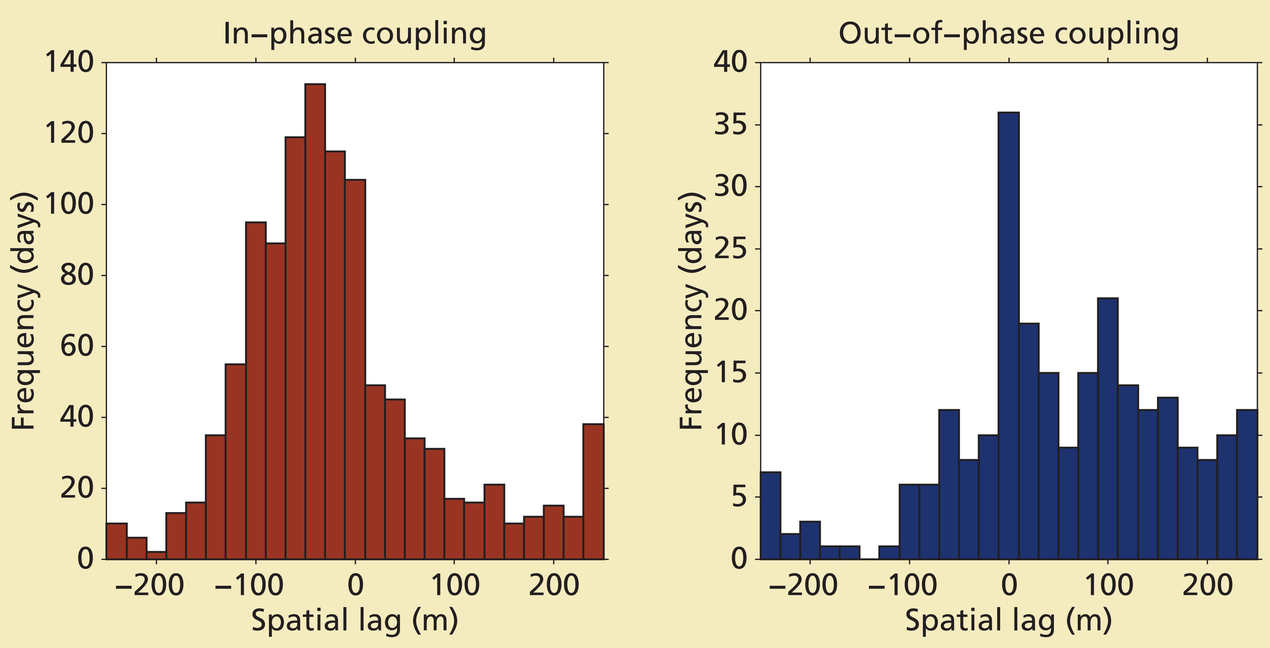

Figure 5: Alongshore offset between the inner and outer barline features for out-of-phase coupling and in-phase coupling, resulting from cross-correlation. The dominant oblique wave incidence (30° shore normal) results in non-zero lags, whereas the mode lag of zero for out-of-phase coupling corresponds to shore-normal wave incidence.

Conclusions

- Shore-normal wave incidence increases the depth variations of the outer bar and permits the development of coupled rip channels in the inner bar.
- Oblique wave incidence leads to a more continuous trough and leads to an in-phase coupled sinuosity of the inner barline.
- Numerical modelling is essential to test our hypotheses on the role of the angle of wave incidence and alongshore currents on coupled sandbar patterns.

Reference

1 van Dongeren, A., Plant, N., Cohen, A., Roelvink, J.A., Haller, M. and Catal-n, P., 2008. Beach Wizard: Nearshore bathymetry estimation through assimilation of model computations and remote observation. Coastal Engineering, 55, 1016 – 1027.

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