Rip Currents

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LONG TERM GOAL

To examine the dynamics of rip currents and the factors governing the evolution and magnitude of the cross-shore fluxes of sediment and water associated with rip cell circulation on a medium to high energy beach over a wide range of space and time scales.

OBJECTIVES

Scientific

- To examine the spatial and temporal variability of rip currents using remote video imaging techniques.

- To quantify changes in nearshore circulation and topography in response to varying incident wave conditions at different time scales including;
  - wave groupiness (time scales of 1-10 minutes),
  - tidal modulation (time scales of 12h and 24 h) and
  - wave height fluctuations associated with passing weather systems (time scales of 2-5 days).

- To develop a coupled hydrodynamic and sediment transport model to simulate the coupling between the nearshore circulation forced by the incident wave field, and the nearshore topography.

Technical

- To advance current nearshore video imaging techniques using a high resolution digital camera system.

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APPROACH

A two year time series of video images has been used to build up a statistical description of rip cells on a swell dominated beach. These data provide quantitative information on the formation and evolution of rip cells on a swell dominated beach and are used to test predictions of some existing rip current models. Using the Wright and Short (1984) model all four intermediate beach states can be identified in the video images which can then be used to examine the conditions necessary for transition from one state to another. The video observations of morphological evolution also provide the basis for numerical simulations. A coupled hydrodynamic/sediment transport model is used to simulate the morphological response to prescribed incident wave forcing and the associated rip circulation.

WORK COMPLETED

From two years of video images we have extracted daily time series of mean surf zone width and longshore profiles of intensity averaged across the surf zone. Troughs in the longshore intensity profiles correspond with the locations of the deeper rip channels. Using daily, low tide, time exposure images, a data set of rip locations over the two year study period has been produced. These data were used to examine rip spacing and persistence as a function of deep water incident wave height and direction. Preliminary results are described by Ranasinghe et al (1999). The Palm Beach video images are now available on a new web site at http://www.ge.adfa.edu.au/pb.htm.

A two dimensional, depth integrated numerical model with radiation stress forcing was used to model rip circulation over idealized, barred topography with a rip channel. The model was used to examine how rip strength varied with incident wave height and mean water depth. This model was then coupled with a sediment transport model to simulate the morphological evolution inferred from the video time exposure images. Results are described by Ranasinghe et al (2000).

A new model for rip current generation on a plane beach has been developed which involves an interaction between incident wave groups and an edge wave at the group frequency. The lower group frequency results in a longshore rip spacing which is significantly larger than earlier models based on forcing at incident wave frequencies. The model is described in Symonds and Ranasinghe (2000).

Personnel exchanges for 1999/2000 are listed in table 1.

Table 1. Personnel exchanges 1999/2000

Name	Institution	Position	From	To	Dates
Holman	Oregon State University	Professor	OSU	Palm Beach, Sydney	Oct 19-28, 1999
Symonds	Australian Defence Force Academy	Senior Lecturer	ADFA	OSU	Jan 30-Feb 9, 2000
Alexander	Oregon State University	Student	OSU	ADFA	Jun 15-Jul 21, 2000

RESULTS

Rip spacing and persistence on a swell dominated beach

The analysis of the time series of daily video images showed the probability of rips occurring on Palm Beach was 78% with a mean longshore spacing of 193m and standard deviation of 52m. The observations indicate that rip channels which disappear when storms re-work the nearshore morphology do not re-appear at the same locations in a majority of the cases. In contrast to Short's (1985) findings at Narrabeen Beach, Australia, rip channels do not appear to have preferred locations at Palm Beach. Two examples of video time exposures of Palm Beach are shown in figure 1, the first showing typical, reworked morphology immediately after a storm, the second image showing well defined rip channels. Estimates of rip spacing from early models (eg Bowen, 1969; Dalrymple, 1975; Hino, 1974; Dalrymple and Lazano, 1978; Miller and Barcillon, 1978) compared poorly with the observed rip spacing, even when the analysis was restricted to periods of initial formation of rips, i.e. immediately after storms. The observed rip spacing is consistent with recent results reported by Reniers et al (2000) and Damgaard et al(2000). The results also indicate that rip spacing does not adjust to variations in offshore wave height suggesting that, after the initial formation of the rip channels, rip currents may be topographically controlled by the underlying shoals and channels. The observations also indicate that rip channels migrate alongshore with speeds of 2 – 20 m/day under obliquely incident waves, independent of changes in offshore wave height as suggested by Short (1985).

Figure 1 Time exposure images from the new colour camera installed in January 1998. The left panel shows the Longshore Bar-Trough morphology while the right panel shows Transverse Bar and Rip morphology as defined by Wright and Short (1984).

Modelling

2DH Model

Attempts to estimate rip magnitude from video time stacks was unsuccessful and so a numerical model was used to simulate rip circulation over idealized topography as shown in figure 2. The model was used to examine the variation in rip strength with varying incident wave height and the still water depth over the bar crest. An example of a numerical simulation is shown in figure 2.

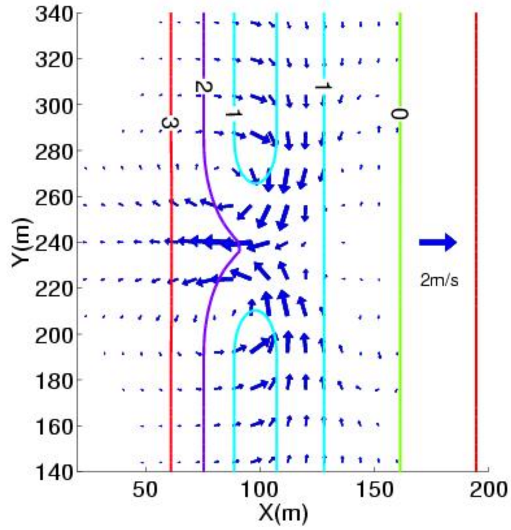

Figure 2 Rip circulation over idealized bathymetry. Incident wave height of 1m and minimum water depth over the bar crest of 0.3m

The effects of varying the incident wave height and water depth are shown in figure 3. Figure 3a shows, for a given wave height, the rip magnitude increases with decreasing water depth, consistent with the observations reported by Brander (1999) who showed rip magnitude was a maximum at low tide. A slightly different picture emerges if we consider the offshore transport (hU), integrated across the rip channel, as shown in figure 3b. In this case, for a given wave height there is a broad maximum in offshore transport at some intermediate depth, below which the transport decreases with decreasing water depth.

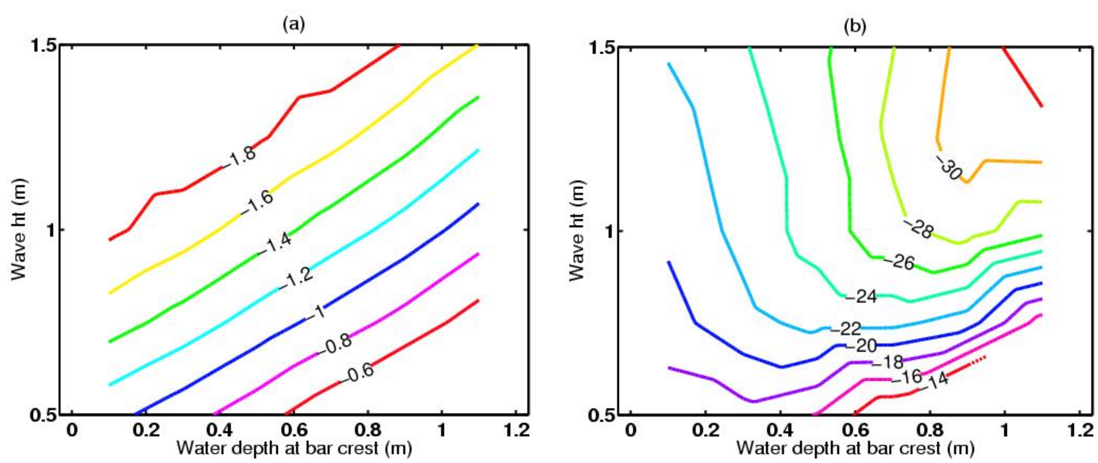

Figure 3 (a) Maximum rip velocity as a function of water depth and wave height, and (b) offshore transport integrated across the rip as a function of depth and wave height.

Morphological modelling

Using the same hydrodynamic model the morphological response was estimated using Bagnold's (1963) energetics approach for sediment transport. At each time step the predicted distribution of waves and currents was used to estimate the sediment transport and associated changes in bed levels.

Results from the coupled hydrodynamic/sediment transport model are shown in figure 4. The top panel shows the model bathymetry and the middle panels show the corresponding distribution of wave breaking as predicted by the model. The observed distribution of wave breaking is shown in the time exposure video images shown in the bottom panels. The predicted and observed breaking patterns are qualitatively similar.

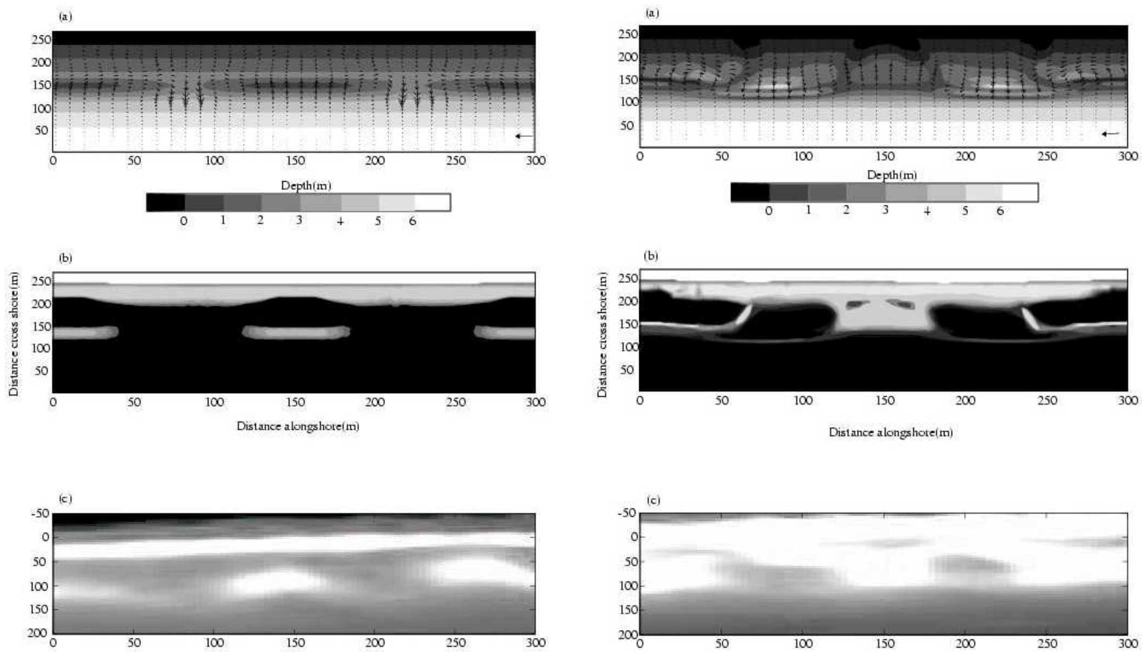

Figure 4 (a) Initial bathymetry (top) and corresponding time exposure images (bottom) from May 15, 1996. (b) Final bathymetry (top) and corresponding time exposure image (bottom) from May 25, 1996. The middle panels show the model predicted wave breaking pattern.

The results shown in figure 4 simulate, according to the Wright and Short (1984) model of beach states, the transition from the Rythmic Bar and Beach to the Transverse Bar and Rip state. In a similar manner we were able to simulate the transition from Transverse Bar and Rip to Low Tide Terrace, though in this case it was necessary to impose obliquely incident waves.

A new model for rip formation on a plane beach

A new model for rip formation on a plane beach has been developed involving the superposition of normally incident wave groups and an edge wave at the same frequency. The model differs from the well known model described by Bowen (1969) in two ways. Firstly, the edge wave slowly modulates the total water depth instead of the incident wave height. Secondly, the lower infragravity frequency results in longshore scales one to two orders of magnitude larger than Bowen's model. An example of a model solution is shown in figure 5. While the model is an idealized, conceptual model, the larger rip spacing is consistent with the mean rip spacing obtained from the analysis of the video images.

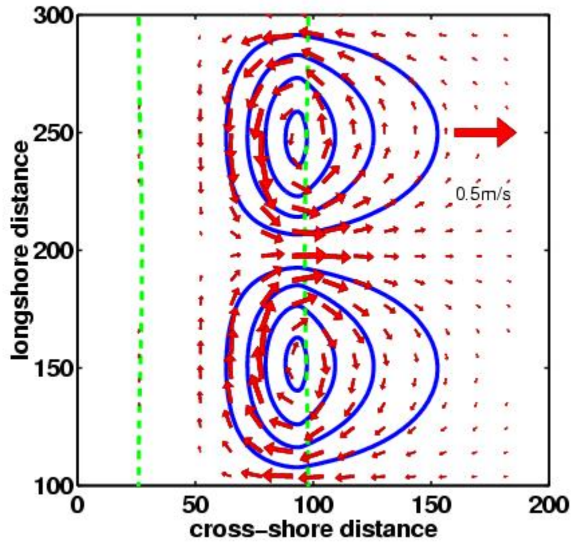

Figure 5 Contours of the stream function, and corresponding velocity vectors, resulting from the superposition of an incident wave group and an edge wave at the same frequency (T=100s). The vector field has been decimated by ten in both the cross-shore and alongshore.

IMPACT/APPLICATIONS

The recent increase in focus on the littoral environment has pointed out weaknesses in our understanding of nearshore dynamics. While our knowledge of nearshore fluid motions on simple topography has become quite good, such simple cases are actually rare. Most often beaches are three-dimensional leading to longshore and cross-shore variations in wave heights and associated mean flows. The development and evolution of such systems has only been poorly sampled. This work takes advantage of a strong combination of low-cost, data-rich sampling of the Argus program, mixed with modelling skills, to help advance understanding of these ubiquitous fluid/sediment interactions. The result of this work will help provide environmental understanding of important mean current and topographic variability that is likely to be encountered on natural beaches. This type of understanding is needed for all amphibious operations in nearshore waters on sandy coasts.

TRANSITIONS

Recent advances in the development of morphodynamic modelling and rip channel formation, for example Reniers et al (2000) and Damgaard et al (2000), emphasise the need for quantitative observations of morphological evolution on natural beaches. Time exposure video images from Palm Beach provide the most comprehensive set of observations of rip channel formation and evolution currently available. These data are being made available to other researchers and further collaborative work with A. Reniers is planned.

This project will significantly expand our scientific knowledge of rip locations, dynamics and impacts, and transfer this information directly to Surf Life Saving Australia (SLSA) for use in training, beach management and education, as well as to state authorities such as the NSW Department of Land and Water Conservation (DLWC) managing rip-generated beach erosion. DLWC is also investigating installation of Argus stations at other coastal sites in NSW.

RELATED PROJECTS

1. Rip current dynamics - social and shoreline implications and management

Chief Investigators: Assoc. Prof. A. D. Short, Dr P. Cowell (University of Sydney)
Dr. G. Symonds (University of New South Wales)

Industry Partners: Surf Life Saving Australia
N.S.W Department of Land and Water Conservation

Funding Agency: Australian Research Council, Strategic Partnerships with Industry - Research and Training

Funding:

1999	$90,256
2000	$60,256
2001	$45,256

2. Gold Coast Video Monitoring

In collaboration with Dr. I. Turner (Water Research Laboratory) and Delft Hydraulics an Argus station has been installed on the Gold Coast, Queensland, to monitor a major beach renourishment and the impact of an artificial reef currently under construction.

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