RIP CURRENTS

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Award # N00014-97-1-0789

LONG TERM GOAL

To delineate the essential 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

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

q To quantify changes in nearshore circulation and topography in response to varying incident wave conditions at different time scales including;

m wave groupiness (time scales of 1-10 minutes),

m tidal modulation (time scales of 12h and 24 h) and

m wave height fluctuations associated with passing weather systems (times scales of 2-5 days).

q 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

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

APPROACH

Video techniques can be used in three possible ways in our studies;

(i) In principal the video images can be used to build up a statistical description of rip cells including longshore and cross-shore length scales, persistence, surf zone width and some incident wave information (period and direction). It remains to develop an automated approach to obtaining some of these rip cell statistics.

(ii) Fluctuations of the head can be measured through video time stacks and should provide a good proxy for the fluctuating strength of the rip current. Some

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**
4. TITLE AND SUBTITLE **Rip Currents**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon State University,College of Oceanic and Atmospheric Sciences,104 Ocean Admin. Bldg.,Corvallis,OR,97331**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

preliminary results using 15 minute time sequences of shorter time exposures (of order one minute) have shown at least one example in which the entire rip head can be observed to expand offshore

(iii) It may be possible to use the offshore advection of foam (or other visible features) to estimate actual rip current velocities. A similar approach, based on time stacks, for the estimation of longshore current velocities appears quite promising. Testing of this approach would be a research goal of this work.

We also aim to combine the video images with numerical simulations to investigate the spatial and temporal variability of rip current cells in response to changing incident wave conditions and sea level fluctuations. For example, tidal modulation of rip currents has been discussed by Shepard et al (1941), Sonu (1972) and Short and Hogan (1994). Theoretical considerations suggest the magnitude of the onshore flow over the bar due to wave pumping depends on the relative magnitude of the incident wave height and depth over the bar which in turn varies with the tide. We will examine tidal modulation of currents and setup numerically, while variability in rip current intensity may be quantified using the video techniques outlined above.

A preliminary attempt has been made to couple a hydrodynamic model with a sediment transport model such that the mean circulation transports sediment modifying the topography which in turn modifies the wave forced circulation. One of the aims of this project is to refine this model and to attempt to simulate the changes in bathymetry observed in the video images. Offshore directional wave data and local sea level are being routinely collected for the Palm Beach site providing the essential forcing required by the model.

In 1996 G. Symonds received a joint grant with J. Taylor (School of Physics, ADFA) to purchase a high performance digital camera for nearshore applications (Symonds) and atmospheric transmissivity studies (Taylor). The camera purchased was a Photometrics SenSys:1400, high resolution, cooled CCD camera system. The camera features a 1317 x 1035 imaging array with 6.8 x 6.8 m pixels and 12-bit digitisation giving 4096 gray scales. With this higher dynamic range it is anticipated that we will be able to image features not readily seen with the conventional camera system. In particular foam and aerated water carried offshore beyond the surf zone by the rip currents is barely visible with the present camera but provides an important measure of the offshore extent of the rip current cells and should be better resolved with the digital camera. The camera system includes a Pentium 133 computer and a windows based image analysis software package (it remains to be seen to what extent this software can accommodate our needs).

WORK COMPLETED

This project began in June 1997 with a small initial instalment of funds. A postdoctoral position has been advertised in EOS and an appointment is expected to be made before the end of this year. R. Holman will visit ADFA early in 1998 during which time we will upgrade the present Argus station and establish a detailed research plan with the new post-doctoral fellow. The University of New South Wales has approved a six month sabbatical for G. Symonds to visit Oregon State University for the period July to December, 1998.

A portion of the continental shelf off Sydney has been digitised and a wave refraction/diffraction model (Kirby and Dalrymple, 1994) used to predict local wave heights on Palm Beach from deep water observations at a site approximately 20km to the south. This work was done by an honours student and the model will provide basic wave data for our rip current studies.

We have done some preliminary field tests with the digital camera alongside the existing Argus station at Palm Beach. A number of time exposures and longshore and cross-shore time stacks were obtained though low wave conditions at the time meant the wave driven currents were quite weak. The rectification software has been modified to accommodate the larger digital images.

RESULTS

While this project is still in the early stages the following preliminary result demonstrates the potential for estimating longshore flow in rip feeder channels using video imaging. Shown in figure 1 is a time stack from the longshore transect shown on the time exposure image on the right. Intensity has been measured along the linear array of pixels defined by the transect and sampled at 1Hz. The intensity arrays are stacked vertically with time increasing downwards. Foam transported by the longshore flow leaves diagonal streaks in the time stack with the slope being proportional to the velocity (Holman and Frielich, 1995). The transect spans the two feeder channels either side of a rip channel and the time stack indicates flow converging towards the rip channel. The estimated speeds are -0.5 m/s and 0.6 m/s.

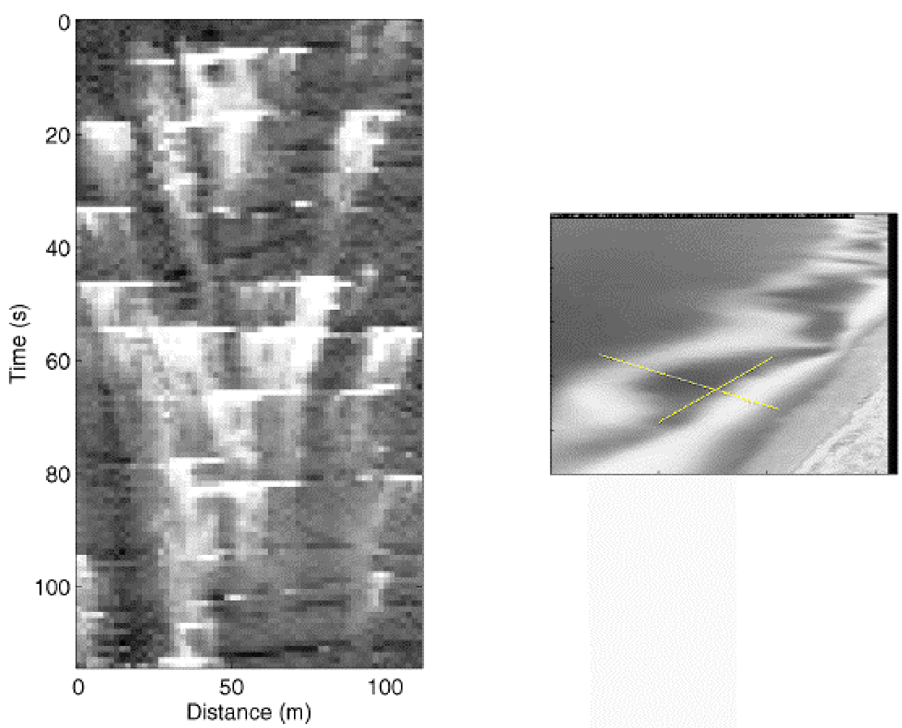

Figure 1 Time stack (left) from the longshore transect shown in the time exposure (right) spanning two feeder channels either side of a rip channel.

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

RELATED PROJECTS

In January 1996 a video imaging station was installed in the Barrenjoey lighthouse overlooking Palm Beach, Sydney, Australia. This project was undertaken in collaboration with Prof. R. Holman, Oregon State University, who provided all of the equipment as part of an ONR supported program to install a number of video imaging stations at selected sites worldwide (known as the **Argus** Program). The equipment includes two video cameras (12mm and 16mm lens), each recording a single time exposure (12 minutes) and instantaneous image hourly.

REFERENCES

Symonds, G., Holman, R.A., and Bruno, B. Rip Currents, Proc. Coastal Dynamics 97, June 23-27, Plymouth, U.K., in press.