Observations of Megaripples

Steve Elgar and Britt Raubenheimer
Woods Hole Oceanographic Institution
Applied Ocean Physics & Engineering, MS # 11
Woods Hole, MA 02543
phone: (508) 289-3614 fax (508) 457-2194 e-mail: elgar@whoi.edu

Award Number: N00014-00-10811, N00014-01-1-0328
http://science.whoi.edu/PVLAB/index.html

Thrust category: Mine Burial Prediction (Bedforms)

LONG-TERM GOALS

The long-term objective is to develop models that predict the generation, evolution, migration, and destruction of seafloor megaripples (bedforms with lengths of order of 1-2 m and heights of order 10's of cm) given geological (sediment characteristics, underlying geological framework) and hydrodynamical (waves and currents) conditions.

OBJECTIVES

Bedforms (megaripples, bumps, and holes) are believed to form and migrate on seafloors with mobile sediment for a range of wave and current conditions. Strong currents that produce sheet flow can destroy bedforms. The specific objectives here are to observe seafloor bedforms, waves, and near-bottom currents to determine

- wave and current conditions that produce megaripple-sized beforms
- relationships between megaripple size and waves, currents, and bottom stress
- megaripple migration rate as a function of waves, currents, and bottom stress
- conditions that cause megaripple destruction

APPROACH

To obtain field observations of megaripple sizes and migration rates, waves, currents, and near-bottom stress, in Oct 2000 we deployed 2 sonar altimeters, 4 current meters, and a pressure gage in a dense array close to a sandy seafloor in about 4- to 5-m water depth on the southern California coast (Figure 1). The altimeters were mounted on a frame that was rotated after 6 months, allowing continuous monitoring of megaripple heights and migration rates in both the cross- and the alongshelf direction. The altimeter array was collocated with 4 acoustic Doppler current meters to estimate near-bottom stress. By maintaining the instruments from Oct 2000 until Aug 2001 we observed a wide range of waves and currents.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302 Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number

1. REPORT DATE **30 SEP 2001**	2. REPORT TYPE	3. DATES COVERED **00-00-2001 to 00-00-2001**

4. TITLE AND SUBTITLE **Observations of Megaripples**	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) **Steve Elgar and Britt Raubenheimer,,Woods Hole Oceanographic Institution,,Applied Ocean Physics & Engineering, MS # 11,Woods Hole,,MA, 02543**	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

The long-term objective is to develop models that predict the generation, evolution, migration, and destruction of seafloor megaripples (bedforms with lengths of order of 1-2 m and heights of order 10???s of cm) given geological (sediment characteristics, underlying geological framework) and hydrodynamical (waves and currents) conditions.

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)**	**5**	

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

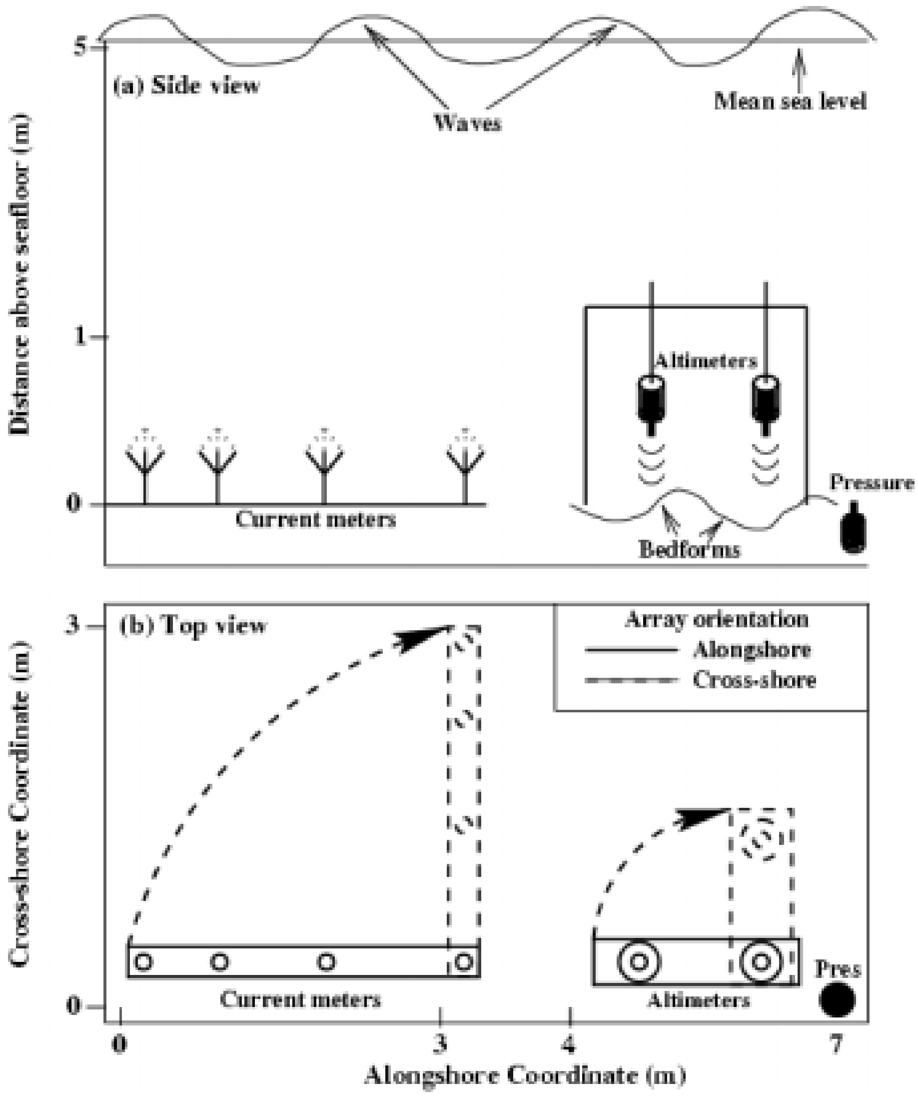

Figure 1. Sketch of megaripple detection instrument array.
The side view in the upper panel (a) shows approximate alongshelf-oriented deployment locations. The top view in the lower panel (b) shows that both the current meter and altimeter arrays can be rotated 90 degrees, allowing cross- and alongshore alignments. [sketch: neighboring near-bottom current meters are separated 0.5, 1.0, and 1.5 m alongshelf. Two altimeters (to measure bedforms and seafloor elevation changes) are deployed about 75 cm above the seafloor 4 m alongshore of the current meters. A pressure gage is deployed next to the altimeters.]

The altimeters provide time series of seafloor location at spatially separated locations, allowing determination of megaripple heights and migration speeds. The pressure gage and the array of current meters provide observations that allow megaripple characteristics to be correlated with waves and near-bottom wave-orbital velocities, mean currents, and stress. By rotating the instrument arrays, megaripple migration can be observed in both the cross- (dominated by wave-orbital velocities) and alongshelf (dominated by mean currents) directions. Hourly time-lapse video images during daylight (R. Holman, Oregon State University) provide information to determine when waves break near the sensor array.

WORK COMPLETED

The instrument arrays were deployed in approximately 4.5 m water depth in Oct 2000, and observations were obtained for 10 months (Figure 2). The current meters were buried by 75 cm of sand in Jan 2001, and became unburied for a few weeks in Apr 2001, and from Jun through Aug 2001. All data have undergone preliminary quality control. Mean (1-hr) cross-shelf, alongshelf, and vertical currents, significant wave height, and power spectra of velocity and sea-surface elevation have been calculated. Cross- and alongshelf bottom stress is being calculated for the entire data set (in collaboration with J. Trowbridge, WHOI).

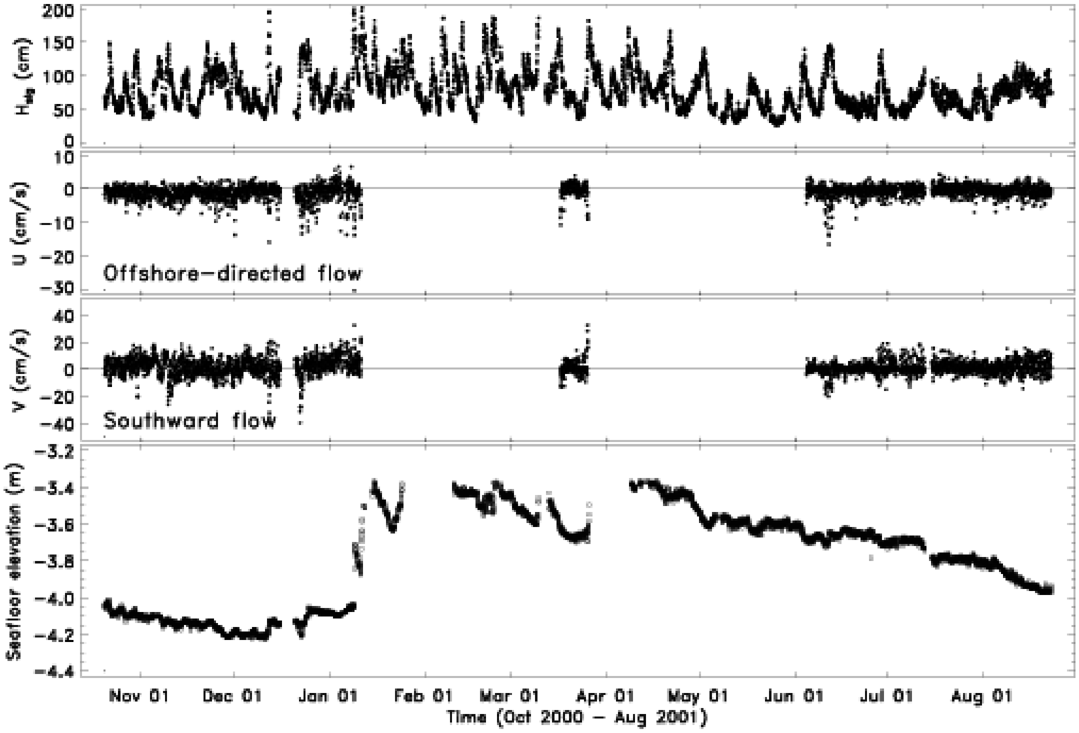

Figure 2. Wave, current, and seafloor observations in shallow water on the southern California coast. From top to bottom: Significant wave height, mean cross-shelf current, mean alongshelf current, and seafloor elevation (relative to mean sea level). All values are 1-hr averages. The mean currents were observed approximately 75 cm above the seafloor. [4 graphs: Each graph is 1-hr mean values versus time from 20 Oct 2000 through 23 Aug 2001. Significant wave height ranges from 25 to 200 cm, with about 20 events with significant height greater than 150 cm. Mean cross-shelf currents range from 5 cm/s onshore to 15 cm/s offshore, with most large values occurring simultaneous with large waves. Mean alongshelf currents range from 40 cm/s toward the south to 30 cm/s toward the north. There are about 10 events with alongshelf currents greater than 20 cm/s. Tidal currents were about 8 cm/s. The seafloor eroded about 20 cm from its initial position of about 4 m below mean sea level between 20 Oct and 10 Dec. Storms with waves above 150 cm resulted in accretion of the seafloor of 10 cm (mid Dec), 75 cm (early Jan), 20 cm (late Jan, after 20 cm erosion in mid-Jan), and 30 cm (early Apr, after slow erosion of 30 cm from mid-Mar to early Apr). There was slow erosion of the seafloor from 3.5 m below sealevel in early Apr to 4.1 m below sealevel in late Aug.]

RESULTS

There were several storms during the 10-month deployment with significant wave heights reaching 200 cm (Figure 2), approximately the maximum possible in the water depth at the sensor array, suggesting the array was located on the seaward edge of the surfzone during the largest waves. There was significant change in seafloor elevation in response to several of the storms, including about 75 cm of accretion over a few days (Jan 7, Figure 2). The accretion was associated with strong offshore-directed mean near-bottom currents (undertow) driven by breaking waves. Cross-shelf bottom stress (not shown) also was strong. Bottom stress is being calculated for all observations to allow comparisons with corresponding changes in seafloor elevation (accretion and erosion). The slow erosion of the seafloor between Apr and Aug 2001 (Figure 2) is hypothesized to be the result of shoreward sediment transport driven by asymmetrical shallow water waves.

IMPACT/APPLICATIONS

One potential impact of this study will be an improvement of Navy operational mine burial prediction models and improvement of sediment transport models. A second impact is improved understanding and ability to model near-bottom stress in flows consisting of waves and currents.

TRANSITIONS

The observations are being used by Dr. J. Trowbridge (WHOI) to determine spatial scales of turbulence in shallow water for a range of wave-orbital and mean current velocities.

RELATED PROJECTS

The near-bottom stress estimates are in collaboration with J. Trowbridge (WHOI).