Observations of Megaripples

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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 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 in response to wave- and mean-current-induced bottom stress on seafloors with mobile sediment. Strong currents that produce large bottom stresses result in sheet flow and the subsequent destruction of bedforms. The specific objectives here are to estimate the bed stress induced by wave-orbital velocities and mean flows observed just seaward of the surfzone, and to investigate the corresponding relationships between bottom stress and bedforms.

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 3- to 5-m water depth (depending on tide level) 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 alongshore direction. The altimeter array was colocated 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.

Observations from pairs of current meters allow estimation of the bed stress and the spatial scales of stress-carrying turbulence. The altimeters provide time series of seafloor location at spatially separated locations, allowing determination of megaripple heights and migration speeds. Observations from the pressure gage and the array of current meters allow megaripple characteristics to be correlated with surface 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 alongshore (dominated by mean currents) directions. Hourly time-lapse video images during daylight (R. Holman, Oregon State University) were used to determine when waves broke near the sensor array.

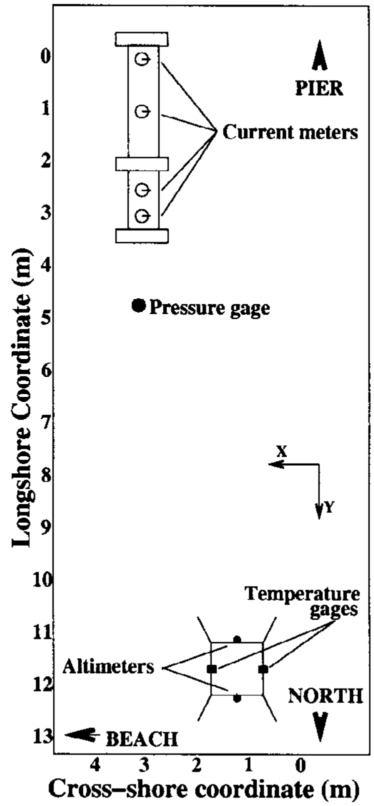

Figure 1. Plan view of bottom-stress and megaripple detection instrument array. The four acoustic Doppler current meters (ADVs) (SonTek "Ocean" probes) were deployed in an alongshore array in approximately 4.5-m water depth, about 60 m north of the Scripps pier, La Jolla, CA. The acoustic altimeters provide estimates of seafloor elevation, and the pressure gage (buried to reduce flow noise) measures bottom pressure, which can be converted to sea-surface elevation using linear wave theory. The temperature measurements were used to estimate the squared buoyancy frequency to determine stratification. [sketch: Neighboring near-bottom current meters are separated 0.5, 1.0, and 1.5 m alongshore. Two altimeters and 2 temperature sensors are deployed about 75 cm above the seafloor 10 m alongshore of the current meters. A pressure gage was deployed between the current meters and the altimeters.]

WORK COMPLETED

The instrument arrays were deployed in approximately 4.5 m water depth in Oct 2000, and observations were obtained for 10 months. 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 quality control. Mean (1-hr) cross-shore, alongshore, and vertical currents, significant wave height, and power spectra of velocity and sea-surface elevation have been calculated. Cross- and alongshore bottom stress have been calculated for the entire data set, and estimates of the length scales of near-bottom stress-carrying turbulence have been made (in collaboration with J. Trowbridge, WHOI).

RESULTS

In shallow water depths on the continental shelf, near-bottom velocity fluctuations with timescales less than 1 hour are caused primarily by a superposition of surface waves and turbulence, complicating the estimation of turbulent length scales that might be important to bedforms. However, by subtracting the time series of near-bottom velocities observed by different current meters from each other, waves can be separated from turbulent motions. A primary result this year has been the determination of the length scales of near-bottom turbulence in shallow water.

The 4-element array of current meters with 6 spatial separations was used to determine the scales of stress-carrying turbulent motions just seaward of the surfzone. During unstably stratified flow conditions, turbulent length scales were approximately 2 m, and during stably stratified conditions the length scales were about 1 m. These results are consistent with Monin-Obukov scaling, and imply turbulence in the shallow coastal ocean, just above the oscillatory bottom boundary layer produced by surface waves, is dynamically similar to turbulence in the atmospheric surface layer.

The array observations also allow estimation of Reynolds stresses, which were consistent with a quadratic drag law, with a drag coefficient of approximately 0.0013, similar to previous results.

IMPACT/APPLICATIONS

One impact of this study is that results from atmospheric turbulence can be used to model turbulence in the shallow coastal ocean.
A second impact is improved understanding and ability to model bedform-inducing 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 and turbulence length scale estimates are in collaboration with J. Trowbridge (WHOI).

PUBLICATIONS

Trowbridge, J. and Steve Elgar, Spatial scales of stress-carrying nearshore turbulence, *J. Physical Oceanography*, **in press**.