

Using An Instrumented Mine To Validate Models Predicting Mine Burial

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LONG-TERM GOALS

Our long term goal is the validation of an integrated mine burial model.

OBJECTIVES

This project intends to test the instrumented mine's ability to measure rates and percent burial. Furthermore, the project will test predictions of mine burial models, especially the vortex lattice scour model of Inman and Jenkins and the surface-gravity-wave-induced momentary and cyclic liquefaction models.

APPROACH

In FY98 we designed and constructed a mine analogue instrumented with sensors for detecting motion, orientation, burial and scour. Burial models will be improved by, first, investigating mine burial as a continuing process of interacting mine burial mechanisms (impact/scour/liquefaction/sand ridge migration). Hydrodynamic conditions are monitored at the deployment sites, with data collected on wave statistics and sediment size. Furthermore, conclusions drawn from this research will prove the mine analogue value for its future training applications/operations and fleet exercises. Such predictions would allow calculation of probabilities of discrimination of targets from baseline seafloor reverberation based on degree of burial.

The instrumented mine is identical to Mine Type A used in the mine burial models. The instrument is 47 cm in diameter, 150 cm in length and weighs 619 kg in air; 354 kg in water. Sensors inside the instrument measure orientation with a compass (the body is constructed of aluminum) and attitude with three independent accelerometers. Sensors arrayed outside the instrument to detect burial consist of LEDs and photo-detectors arranged in three bands of 24 pairs, one band around either end of the instrument and one around the center.

WORK COMPLETED

An initial deployment of the instrumented mine was made in June 1999 to test the water-tight integrity and operation of the instruments inside the container. In August-September 1999 the instrumented

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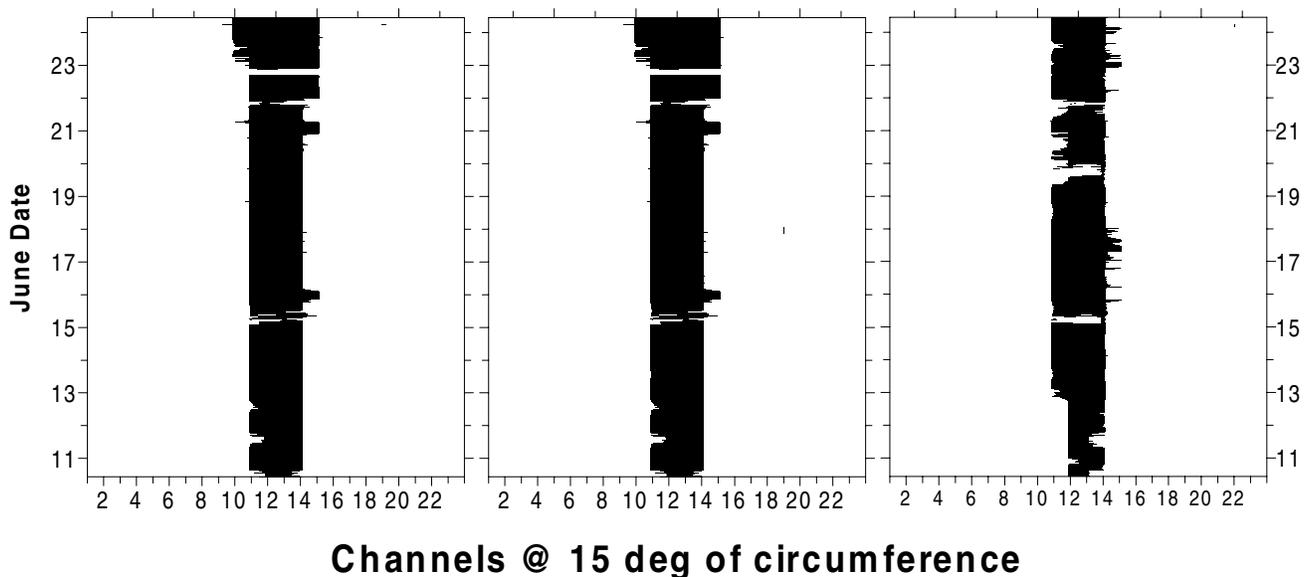
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mine was deployed off Scripps Pier for 60 days. Wave statistics were compiled with the aid of the Center for Coastal Studies at Scripps Institution of Oceanography. In each deployment an optical stake, developed by NRL, was deployed in the same location to monitor sand wave migration (Lott and Bradley, *in review*). Preliminary results have been compiled for the two deployments, with a full reporting expected to be completed in early FY00. We have many digital photographs of the buried mine, as well as wave statistics during the mine burial for the Scripps pier deployment. Predictions from WISSP, SPMBP and vortex lattice scour models will be made using these data.

RESULTS

The 14-day operational test was conducted in 8 m water depth during rather quiescent weather conditions off Panama City Beach, Florida. Because conditions were not conducive to scour (wave height 0.9-1.2 m; wave period 4-5 s), the only scour detected was biogenic (Fig. 1).

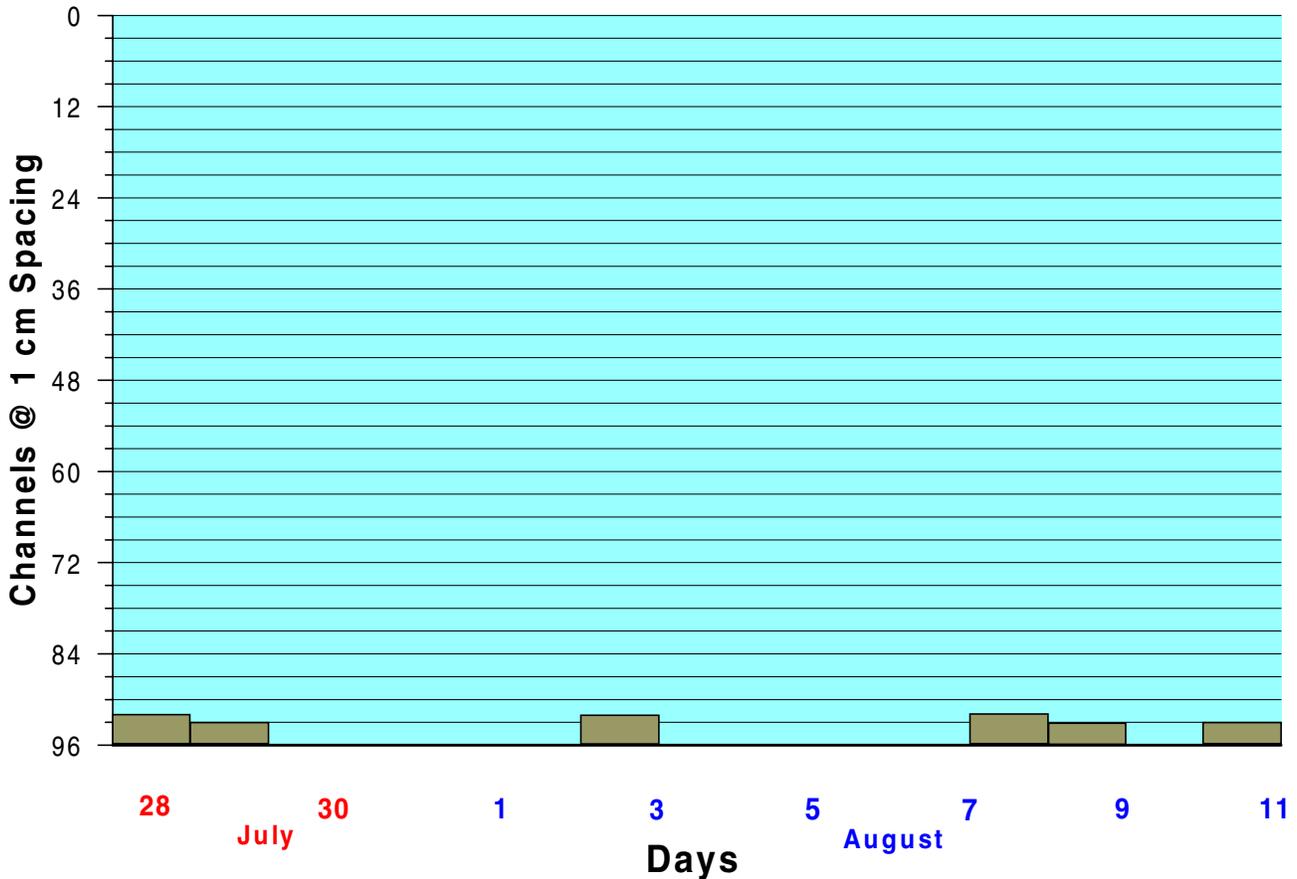


1. Biogenic scour from 14-day operational test of mine analogue off Panama City Beach.

The above figure represents the three bands of 24 light-emitting diodes (LEDs) around the circumference of the mine. Blacked out regions indicate light paths blocked by sediment. Several crabs and some small fish were noted colonizing the mine as habitat. Sand was excavated from around the number 11 through 15 light sensors arranged at 15 degree intervals around the mine, resulting in an unimpeded path between emitter and receiver. No real burial was detected, but the action of the colonizing fauna had the potential to promote scour provided the hydrodynamic conditions were adequate. The optical stake data collected over the same period indicated that no bedform migration occurred during the deployment (Lott and Bradley, *in review*)

During the 60-day deployment off the Scripps pier, diver observations indicated scour down to a coarse, pebbly-to-cobbly lag, evident on the flat end of the mine (the end not “chamfered”). Sediment covered nearly 50% of the mine for much of the deployment. Movement of the nearshore bar (Inman et al., 1993) alternately buried and exposed many of the 24 LEDs on the mine once in the last 30-60 days of deployment. There was only one re-orientation of the mine and this occurred at the beginning of the deployment when the mine oriented itself from the initial emplacement in accordance with the local

slope produced by piling scour to a position conforming to orthogonal to the wave/swell direction. No axial rotation of the mine occurred. Optical stake data, restricted to the first 14 days of deployment, indicated no initial net sand ridge (bar) movement (Fig. 2). Figure 2 below displays the covering of receiver diodes number 93-96, which reflects the depth to which the instrument was initially buried.



2. Optical stake data for 14 days of the Scripps Pier deployment.

IMPACT/APPLICATION

The trial deployment of the mine analogue indicates that the instrument performs as designed, retains its integrity, and collects complete orientation and degree of burial information for its entire programmed period (in this case, 60 days). Processes as incidental as biogenic scour and as large in scale as burial and exposure by bar migration are equally documented with the instrument. Use of the mine analogue together with environmental groundtruth data (such as wave statistics and current velocity) will be an effective method to validate mine burial models.

TRANSITIONS

The instrumented mine analogue will be used by the NRL 6.2 Mine Burial Processes project in FY00 (Mike Richardson) in experiments at Destin (East Pass), FL and Duck, NC.

RELATED PROJECTS

1 – The 1999 NRL 6.1 High-Frequency Acoustics Spatial Variability field experiment off Panama City Beach, FL included the first field test deployment of the mine analogue and optical stake.

2 – Results from modeling the mine burial constitute a valuable database for the NRL 6.2 Mine Burial Processes project (Mike Richardson, principal investigator).

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