Utilization of Acoustics for Monitoring Local Sediment Transport Processes

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LONG-TERM GOALS

The goal of the Proudman Oceanographic Laboratory’s, POL, contribution to the Mine
countermeasures Programme, is to apply recent developments in the application of acoustics, to the
high resolution measurement of sediment processes, to advance understanding and modelling of mine
burial processes.

OBJECTIVES

The objectives for POL’s research for 2006 were;

(i) Further analysis of the Laser MSCAT data and the acoustic backscatter, ABS, data collected
    in the Santa Cruz experiment in March 2003.
(ii) Complete papers for the special issue of Journal of Oceanic Engineering
(iii) Complete a paper on reference concentrations from the Santa Cruz experiment carried out in
    March 2003.

APPROACH

To work with co-researchers OMNI technologies and NRL Stennis on the instrumented mine data and
USGS and Sequoia Scientific on the Santa Cruz 2003 data. The work was primarily carried out by
completing papers for the IEEE special issue of Journal of Oceanic Engineering. The instrumented
mine work was carried out with Sean Griffin (OMNI) and Mike Richardson (NRL) and the sediment
processes work with with David Cacchione (USGS) and Yogi Agrawal (SS).

WORK COMPLETED

1. Some further analysis was conducted on the ABS data collected with the Acoustic Instrumented
   Mines deployed as part of the Martha’s Vineyard experiment. This data was used in a paper for the
   IEEE special issue. The paper was accepted.

2. The MSCAT and triple frequency ABS data collected as part of the Santa Cruz process study has
   been further analyzed and a paper completed. This paper was accepted for the IEEE special issue.
3. Progress has been made on a publication of a paper on reference concentrations and should be submitted to a journal this year.

RESULTS

AIM data. The objective of the work was to take recent advances in the application of acoustics to the measurement of fundamental near-bed sediment transport processes and apply the technology to mine burial. The Acoustic Instrumented Mines, AIMs, were developed and constructed as part of the MBP. The AIMs were designed to measure the hydrodynamic processes, sediment movement, and bedforms close to the mine, in addition to the mine behavior of heading, roll, pitch, and percent burial. A total of 4 AIMs were built and have been used in mine burial experiments in the Gulf of Mexico and at the Martha’s Vineyard Coastal Observatory. The AIMs are cylindrical in shape with a diameter of 0.5 m and a length of 2 m and have 112 acoustic transducers mounted on the surface the mines, which operate at 0.5 MHz, 1.5 MHz and 3.0 MHz. A number of the 1.5 MHz and 3.0 MHz transducers were used in a mode for measuring suspended sediment concentration around the mine and this is has been the focus of the present work. Figure 1 shows the concept and the mine.

An illustration of the outcome from this work is shown in figure 2 [1]. A combination of the acoustic and conventional measurements on the AIM’s, with additional data from a sector scanning system monitoring the mines, have been combined to assess the mine burial process. These data sets are being used in the modelling of mine burial.
Santa Cruz. Further comparisons of ABS and MSCAT measurements of suspended sediments from the Santa Cruz pier experiment are presented. The systems used to measure the suspended sediments were a POL ABS, which operated at 0.7 MHz, 2.0 MHz and 4.0 MHz and a Sequoia Scientific Laser MSCAT. Here we illustrate the complementary data sets that can be obtained by combining optical and acoustic systems. Below is an illustration of what can be obtained from the MSCAT. Figure 3 shows the suspended particle size distribution, expressed as volume concentration over time, at one height above the bed. Integration over the particle size distribution provides the total volume concentration. This provides very detailed information of the suspended sediments at the particular height observed. Figure 4 shows the temporal variation in particle size and concentration with height above the bed. It can be clearly seen that some of the periods of increased particle size are associated with substantial suspended sediment events, as one might expect, however, there are one or two events where the correlation is not as clear. The use of the MSCAT to obtain detailed volume concentration size distributions at one height and the ABS to obtain detailed profiles of mean size and concentration, all at high spatial resolution, provides a very powerful combination for sediment process studies. Both are being utilised in a publication on nearbed suspended sediment reference concentrations.
**Figure 3.** MSCAT measurements of particle size at nominally 0.1 m above the bed. The color bar is the suspended volume concentration in millilitres per m$^3$.

**Figure 4.** Measurements of the temporal variations with height above the bed of; a) Particle size with the colour bar scaled in microns and b) logarithmic concentration with the colour bar scaled relative to 1.0 kgm$^{-3}$.

**IMPACT/APPLICATIONS**

The measurements of the hydrodynamics and the suspended sediments at the AIMs has provided data for studying the progression of mine burial and for assessing and developing mine burial models. The data from the physical processes study at Santa Cruz is being used to assess present capability to predict suspended load from a knowledge of the hydrodynamics and the bedforms.
RELATED PROJECTS

POL’s Program 2 Theme 5; ‘Process experiments at small scale in shallow seas’
http://www.pol.ac.uk/home/research/p2t2prcx.html

REFERENCES


PUBLICATIONS


