Seafloor Reconnaissance Surveys and Change Monitoring Using a Small AUV and a Small ROV

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The Role of Bottom Variability in Mine Burial Detection

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LONG-TERM GOALS

Early in 2005 the University of Hawaii purchased a REMUS autonomous underwater vehicle (AUV) and a SeaBotix LBV150S remotely operated vehicle (ROV) with ONR DURIP funding. The instruments are particularly useful for work in coastal waters up to 100m in depth. The AUV provides high-resolution bottom sidescan sonar maps and water column data. The ROV will be used to ground-truth targets picked from backscattered imagery. The littoral environment has become an area of intense interest to naval forces since the end of the Cold War in the early 1990's. Ship To Objective Maneuver and Mine Warfare are two primary applications of data from the near shore. Additionally, the NAVY and DoD in general have been increasingly involved in environmental issues such as reclamation of formerly used defense sites (FUDS) and the spread of water-borne pollution. Homeland security also has a stake in understanding and monitoring coastal shallow waters. Our long term goal is to develop the expertise to easily deploy our assets in the field for economical and rapid data reduction and assessment of areas of interest to the Navy, other governmental agencies, and the research community.

The Mine Burial Prediction (MBP) program was begun in 2000 and culminated in 2006. The primary goal of the program was to develop a stochastic prediction capability that could be transitioned to the NAVY. This objective has been achieved (see Brandt report, this volume).

OBJECTIVES

Objectives during the past year were to (1) edit a special issue of the IEEE Journal of Oceanic Engineering devoted to the MBP program, (2) adapt custom sidescan sonar software used by the Hawaii Mapping Research Group (HMRG) for use with REMUS data, (3) carry on a time series of sidescan surveys off Kakaako (Oahu) around the Kilo Nalu Cabled Reef Observatory, and (4) use our sidescan system and ROV to look for unexploded ordnance in Hawaiian coastal waters.

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APPROACH

Raw data from the sidescan system aboard the REMUS is translated into a standard HMRG format. Data are then processed to form mosaics of bottom sidescan. Both raw and processed data are examined for the location of man-made targets and to characterize sand texture. Targets are then examined using the ROV. Repeat surveys are done on a monthly basis and/or before and after storm events.

WORK COMPLETED

Manuscripts for the IEEE JOE special issue on Mine Burial Prediction were collected during the past Fall and Winter. Reviews were requested and collected as the initial manuscripts arrived. The process has continued into the summer. The MBP special issue will contain 24 peer reviewed contributions from investigators involved in the program. The authorship includes investigators from a wide range of US academic institutions, NRL staff, and NATO colleagues. The issue is planned to be published in January, 2007.

HYDROID supplies software to look at individual REMUS data files that are useful for target identification, but the files are not geographically registered. Algorithms to reformat raw REMUS sidescan data have been written. Batch processing scripts allow rapid initial looks at seafloor mosaics. By adapting HMRG codes, we also have the added benefit of free access to the HMRG programmers and the potential for REMUS-specific processing adaptations in the future. Our code runs on LINUX machines and is available to other ONR-sponsored investigators.

The area around Kilo Nalu was surveyed during REMUS training in March, 2005. A second Kilo Nalu survey was conducted in September, 2005 - meant to be the first of the time series. The REMUS experienced a total systems failure about 45 minutes into the mission. After replacement of the motherboard by HYDROID, a "check-out" small survey was run in November, 2005. REMUS was than taken to Hilo to map an area of reef for a UXO survey. The sidescan system failed before any data were collected. A HYDROID engineer who was already scheduled to come to Pearl Harbor repaired the vehicle in January (dead sidescan board). Another small survey at Kilo Nalu was run. Bad weather and a major sewer spill kept us out of the water in February and the REMUS was sent to HYDROID for a new Seabird CTD in March. What was supposed to be a 2 week turnaround stretched to 6 weeks as a new motherboard eventually had to be mounted in the vehicle. During REMUS's absence we established 4 subsurface buoy positions that will be used for transponder deployment during repeat surveys. After REMUS returned, we ran a full survey of Kilo Nalu. Unfortunately, the pump in the new CTD deflected the compass in the REMUS each time it fired and the sidescan data were useless. HYDROID is now working on a fix.

RESULTS

An example of processing of a single REMUS sidescan file is presented in Figure 1. The original data have had changes in ping-to-ping intensity corrected. The portion of the swath directly below the instrument (nadir) has been removed and the image has been geo-rectified. A composite mosaic of multiple partial surveys of the Kilo Nalu area is presented in Figure 2. Operational difficulties detailed above have prevented a regular series of surveys during the past year. Some of the unusual patterns in the sandy areas of the mosaic are the result of using swaths recorded at different times of the year.

Although REMUS failed in Hilo, we were able to use our LBV 150 ROV to examine the reef where diver reports indicated the presence of UXO. In several hours of observation at 2 sites we were able to identify over 25 individual pieces of unexploded ordnance (Figure 3).

IMPACT/APPLICATIONS

The combined REMUS and LBV 150 system is effective for bottom surveillance. We are now being considered for major funding from the Department of Defense to continue to work on surveys of UXO. The ROV and AUV are also written into several proposals to examine the health of deep water coral communities in the islands.

RELATED PROJECTS

Sand Distribution and Statistical Spatial Characteristics on Pacific Reef Platforms. Charles Fletcher - P.I. We will be using the techniques and software developed in this project to map sand deposits over a wide area of Oahu coastline. www.soest.hawaii.edu/coasts/cgg_main.html

Wave Boundary Layer Processes Over an Irregular Bottom. Geno Pawlak -P.I. The Kilo Nalu observatory is recording environmental data in the area where we will be doing the time series observations, providing us with inputs to models of ripple development as we begin to build a data set. oe.eng.hawaii.edu/~gpawlak/index.html

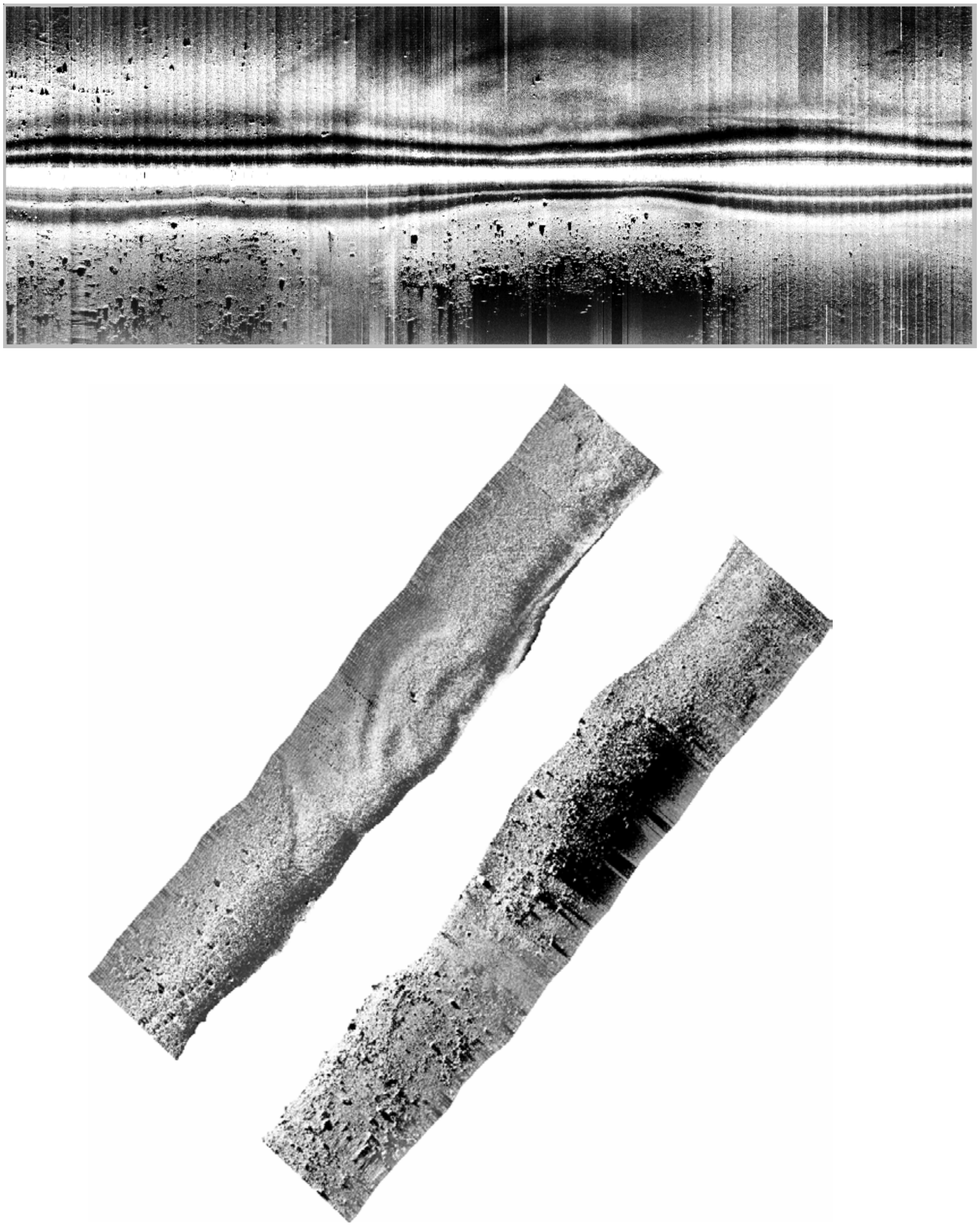


Figure 1. Top - Raw REMUS sidescan file. A strip of backscatter from the seafloor that shows much variation in intensity along track from ping to ping. Bottom - Processed data is geo-referenced and has been corrected for along track intensity variations.

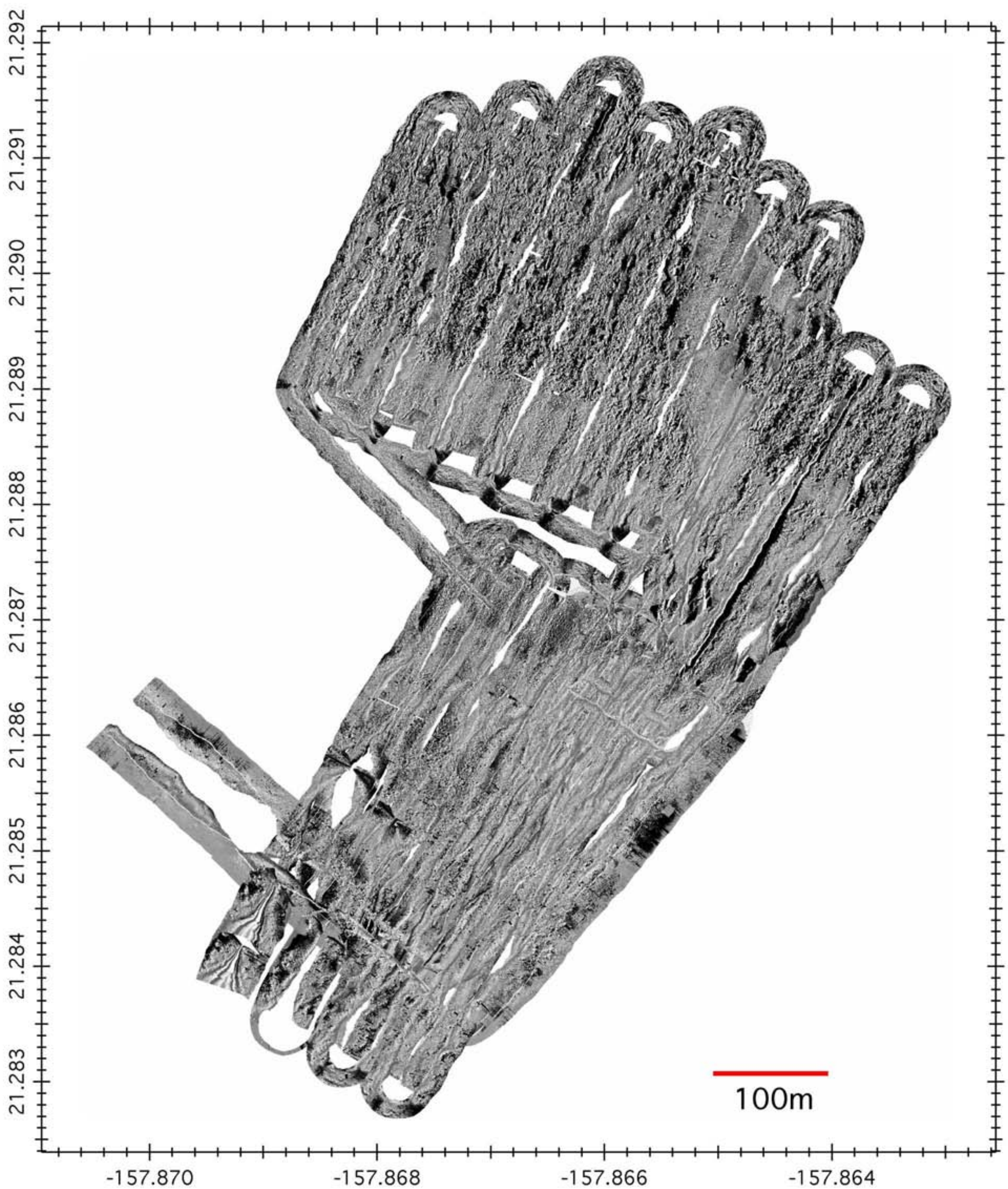
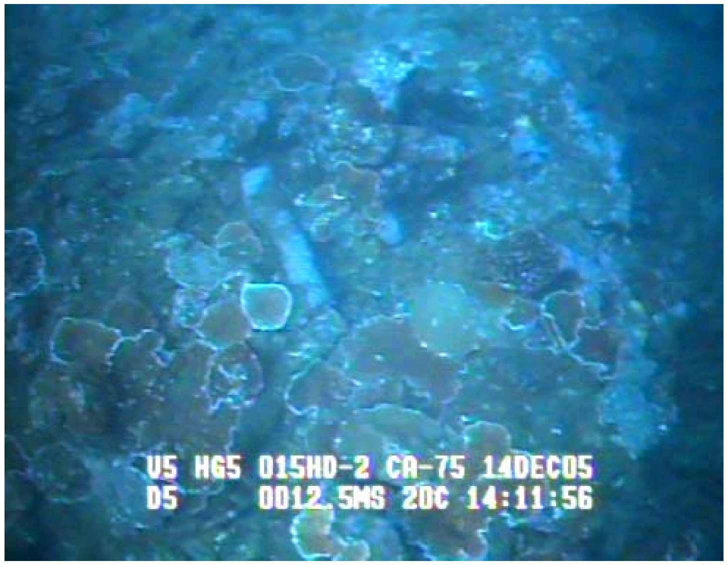


Figure 2. Composite Kilo Nalu backscatter mosaic from multiple partial surveys. There are areas of rougher looking bottom that represent coral reefs. Smoother areas are coral sand. The linear feature, middle right, is a disused sewer outfall.



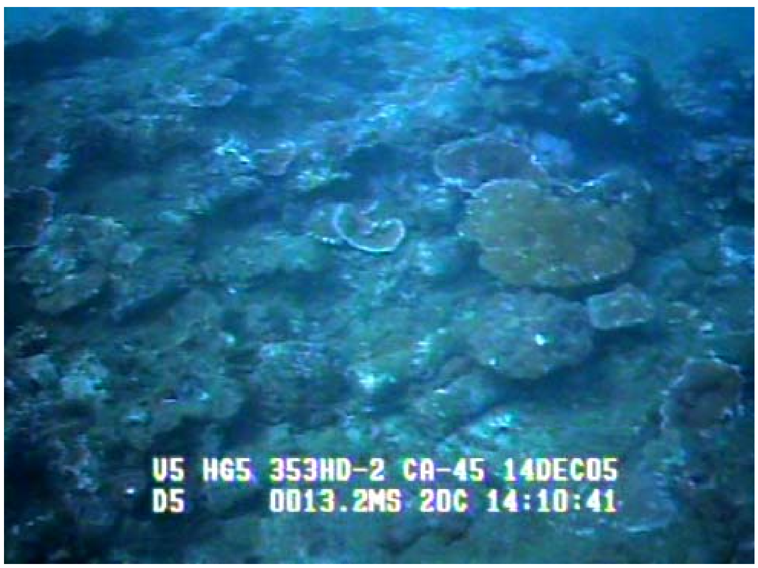


Figure 3. Examples of unexploded artillery shells resting in 13m of water on the reef off Hilo harbor. The projectiles are lying amongst live coral and are partially covered by marine growth.