SeaBED AUV Engineering Trials: Puerto Rico Shelf Edge Habitat Characterization

In alphabetical order the team members were -
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One of the basic goals of our research is to examine the role of high resolution imaging underwater with optical and acoustic sensors. As part of the NSF Center for Subsurface Sensing and Imaging Systems Engineering Research Center and with funding from the Office of Naval Research we have developed the 2000m rated SeaBED autonomous underwater vehicle. Last summer we conducted basic engineering trials with this vehicle (see http://www.whoi.edu/DSL/hanu/seabed). As part of our continuing development we ran engineering tests off of the University of Puerto Rico at Mayaguez's Magueyes Island marine science facility. In this document we present a first look at some of the data collected during this expedition.

Our Goals: For these set of engineering trials we had a few basic goals. (i) To complete the integration of our sensors - a pencil beam bathymetric sensor and our high dynamic range CCD camera – in addition to the sidescan sonar that is already integrated onto the vehicle. (ii) To conduct photographic surveys of coral reef habitats and to make photomosaics of these sites so as to characterize coral reef habitat, and to collect a dataset that included in-situ digital images to serve as ground truth for efforts in airborne and satellite based hyperspectral imaging of coral reefs. (iii) To prove that we could conduct our AUV operations cheaply and effectively off of very small platforms

Results: Although this was supposed to be a precursor to the real science cruises in succeeding years we collected a unique publication quality transect of digital still camera imagery and co-registered bathymetry for coral reef habitat characterization. This was accomplished in terrain with slopes in excess of 70 degrees. The vehicle was reliable and the costs of the cruise were a fraction of the total costs of similar operations with other vehicles.

Figure 1. The SeaBED AUV. A hover capable vehicle its suite of sensors include a side-scan sonar, a pencil beam scanning sonar, and a 1280x1024 12 bit CCD camera.

A Transect on the Shelf Edge

In this rather informal report, I have just strung together a series of images and plots that highlight our vehicle capabilities. A formal publication based on an analysis of this imagery and other results associated with these efforts should be forthcoming. The biological science data belongs to Profs Armstrong, Gilbes and Ramirez from the University of Puerto Rico at Mayaguez.

As I stated earlier, our goal for this year was to simply conduct engineering tests of the vehicle and to build photomosaics of coral reefs sites. While conducting these tests Roy Armstrong (a professor at UPRM) came out to watch and then bent our ear about pushing the envelope. One of his interests was in obtaining a transect along the shelf edge from the 20m shelf all the way past 90m (the sealevel 12,000 years ago). So to collect such a dataset we ran a north-south trackline which took us from 20m to 125m of water depth due south of La Parguera. The trackline is shown in Figure 2.

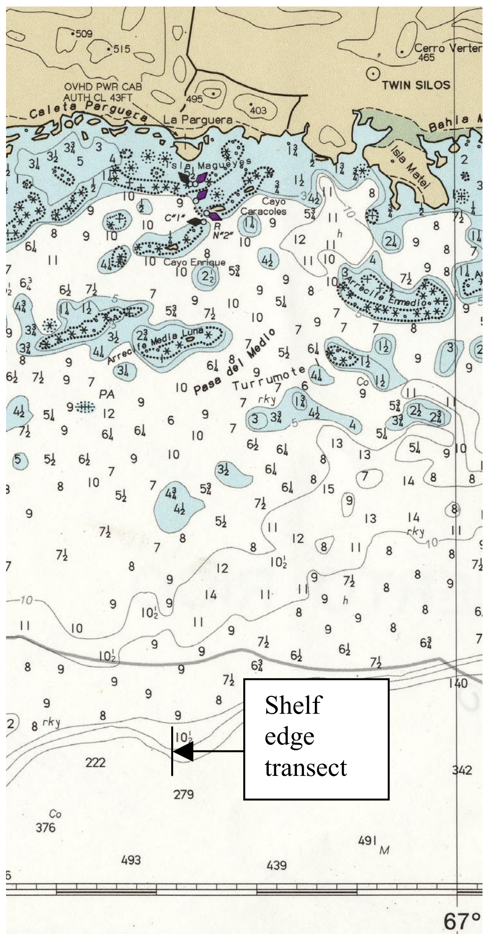

Figure 2. The shelf edge trackline that we ran off of La Parguera (close to the SW corner of Puerto Rico).

While running this trackline we wanted to follow the bottom at an altitude of 3m in order to allow the identification and classification of individual species. What made this task “interesting” was that the terrain had a 75 degree slope to it. At these angles (and these altitudes – the ABE AUV for instance bottom follows at an altitude of 7m) it really makes a difference where your altitude sensor is located and how you define altitude with respect to the whole vehicle as opposed to the sensor itself. The site we chose was where the contours diverged the most but as the depth plot (Figure 3) shows the slope was still quite steep.

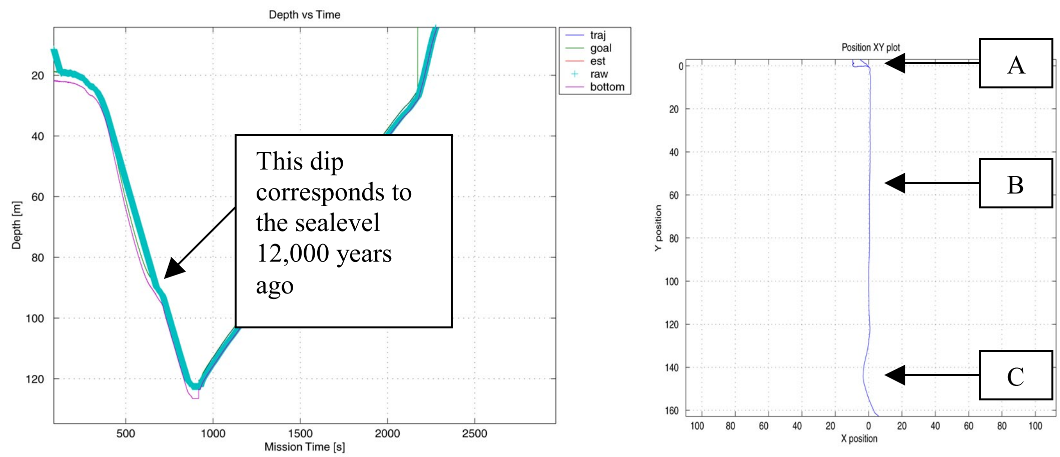

Figure 3. Depth plot for entire transect(left) and xy plot for transect (right). (A) corresponds to the vehicle on the surface before the start of the mission. (B) is the section corresponding to the transect while (C) is the section where we were ascending after completing our transect. We accomplished our goals of running a transect where we went from 20m to well past the ~90m mark corresponding to the sea level 12,000 years ago.

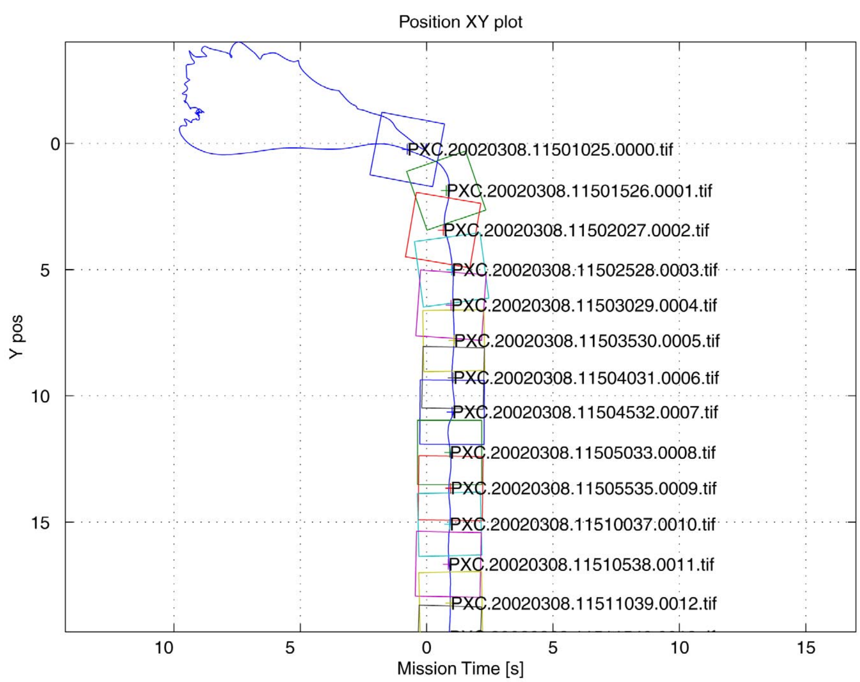

Figure 4. Image footprints for a section of the data. Our basic aim from a mosaicking standpoint was to obtain sufficient overlap to build a mosaic of the data.

If we examine the image footprints for this transect we see that we obtained 30-40% overlap in the imagery. Looking at the images themselves, our new 12 bit camera worked really well. We could take full advantage of its sensitivity to use a low-power strobe adapted to our vehicle.

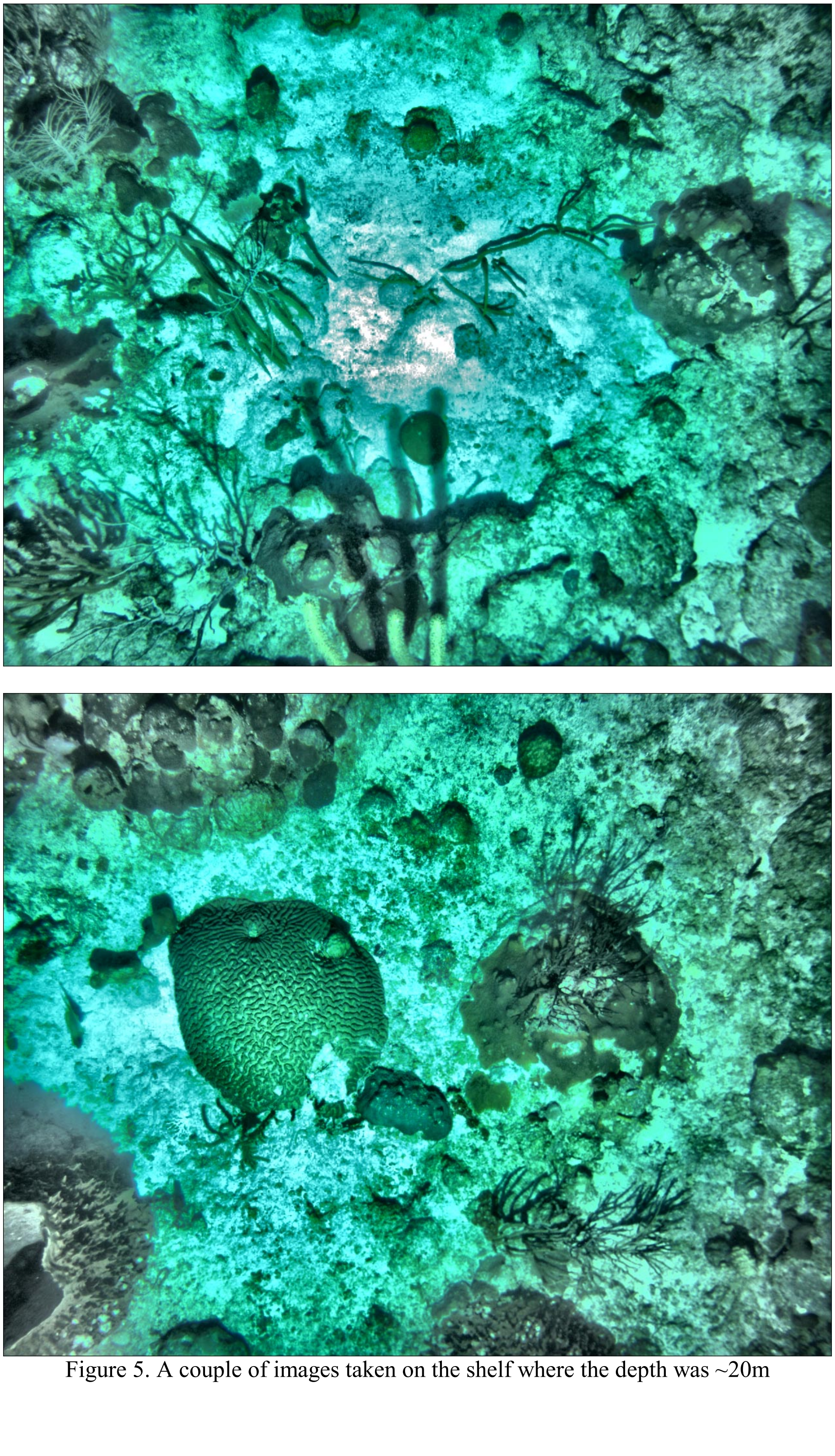

Figure 5. A couple of images taken on the shelf where the depth was ~20m

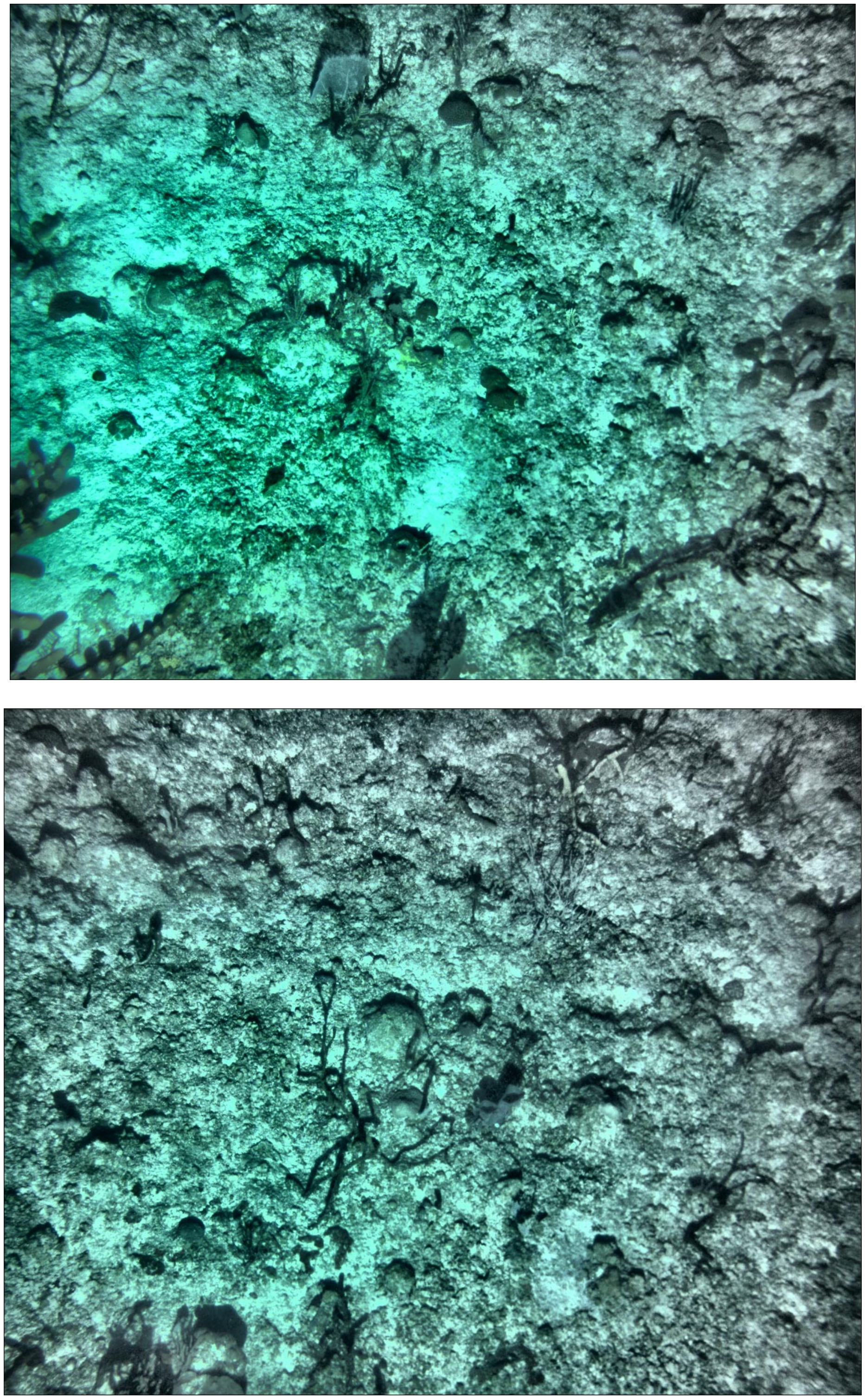

Figure 6. Two images along the slope.

Our Camera: We've packaged a 1280x1024 12bit camera (Pixelfly) from Cooke Corporation into a housing for use on our AUV. We wound up writing our own device driver so that we can grab a 48 bit color image. Its actually 12 bits /channel but padded up to 16 bits. We do all our histogram equalization with the 48 bit image but then rescale to 24 bits which is what most programs and packages can handle. We are in the process of building four of these cameras, one for our vehicle, two for Jason and one for an imaging sled for scallop assessment surveys. It is interesting that our normal mode of developing and testing sensors on tethered vehicles before transitioning them to AUVs has been turned around in this case.

Bathymetry: We have an Imagenex pencil-beam sonar integrated on the vehicle. On this trip we were optimizing all our runs for camera work so we were quite close to the bottom which is not the ideal mode for collecting bathymetry. Figure 7 shows the results of processing the bathymetric profiles with our navigation and attitude for the shelf edge transect.

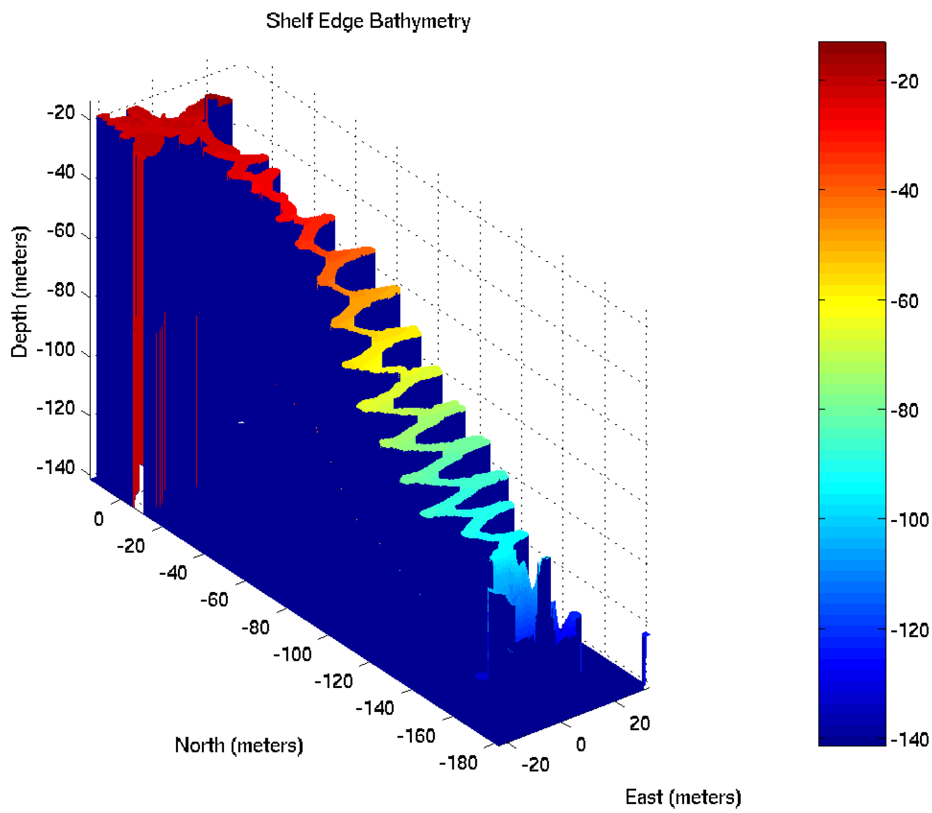

Figure 7. Bathymetric data for the transect collected with a 675kHz Imagenex pencil-beam sonar. Even though the transect altitude was optimized for high resolution imaging with a camera, the bathymetric data we collected was good and will be crucial in allowing us to mosaic the imagery into a linear mosaic.

Logistics: We air-shipped the vehicle (including Lithium Ion batteries) in pieces and drove the boxes down from the airport in a truck. We had the whole vehicle assembled and tested in less than a day of work. Demobilization took part of a morning.

What's next (funded stuff that we will be doing!): We have some MCM work that we are slated to do in the summer. We will be going to Bermuda in late summer in preparation for under-ice operations. Next year we are funded to go back to Puerto Rico.

Figure 8. One last image. We can run SeaBED off of very small platforms. This time we could not even get the vehicle on board but had to instead lash it to the stern of the trusty R/V Sultana. OK, so we proved a point (and next time we will be on a UNOLS class vessel) but the fact remains that all we need to support the vehicle is a power supply, a laptop and a navigation transponder.