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DEEP DIVING, NEW UNDERWATER EQUIPMENT, AND THEIR POTENTIALS FOR THE FUTURE OF ARCHAEOLOGY

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I initially submitted a title and abstract to WAC last June because I heard that the theme for the conference was "archaeology in the 21st century" with particular emphasis on new technology, and I was then working as the Principal Investigator on a deep underwater site off Guam where advanced techniques and equipment were being used. I thought I would have some exciting news about a new wonder machine we were using, but although it did not fully live up to expectations, an honest evaluation of its performance is still useful information to share with the profession, and a discussion of the capabilities, plus the potential of deep diving will point to some new areas that archaeology can explore in the future. I will focus on human beings working at depth and not cover remote operated vehicles (ROVs) or robotics, as was used for instance on the Titanic, because the project did not make any use of the latter. The only remote sensing equipment used on this site has been a magnetometer and side-scan sonar, and both of these items are common in the field.

The project I was working on was the excavation of a Manila galleon, the Nuestra Senora del Pilar de Zaragoza y Santiago, which sank off the southern tip of Guam in 1690. The Pilar Project, begun by a group of private investors in 1991, initially started on a shallow reef in the area believed to be the initial impact zone in about 20

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feet of water, but only a scattering of artifacts was found in this area, and so, in the following years, work has moved to deeper and deeper water in hopes of finding a major portion of ship or cargo. The underwater topography of the site is such that there is a series of wide, flat shelves stepping down from the reef, pierced by underwater gullies which lead to drop-offs to the next lower level. These gullies would have been small rivers at a time when the sea level was lower, and the drop-offs would have been waterfalls. Currents still move objects along these submerged paths, and when the remains of the Pilar were hit by a typhoon, three years after her original grounding, pieces of wreckage were carried into deeper water. At the end of the 1997 excavation season, five long planks of wood, determined to be hull structure, were discovered just at the edge of one underwater drop-off in 160 feet of water. So for the 1998 season, plans were made to investigate the drop-off, referred to as the "chute" on the site map, the bottom of which is at a depth of 205 feet. [SLIDE 1] From the top, the wall slopes down at about a 45(angle, and it was hoped that substantial pieces of wreckage would be found in the semi-compacted rubble.

In order to investigate this area effectively, the divers used and tested a variety of equipment, including one piece which had not been tried before in this type of context. I want to spend most of my time with the evaluation of this piece of equipment, called the TSS 340, but before I turn to it specifically, I will briefly review the entire inventory of equipment and supplies used to excavate at this depth.

First and foremost, in order to maximize bottom time, the divers used Trimix, a combination of nitrogen, oxygen, and helium. (Decreasing the percentage of nitrogen in the breathing mix decreases the amount of time that must be spent decompressing during ascent.) Even with this precaution, the divers could only spend 25 minutes on the bottom at the 200 foot depth. This length of dive required an hour and a half of decompression time.

We also used four rebreathers, tanks designed to remove the carbon dioxide and recirculate the air, rather than regular SCUBA tanks which would not carry enough breathing mix to last the entire dive-plus-decompression time. Not everyone on a dive was on a rebreather though, because a diver can't use a rebreather and communication gear at the same time. Since some communication with the surface was often necessary, one or more divers went down with "doubles" (two regular SCUBA tanks) and the dive was timed to end before their tanks were empty [slide 2].

Besides the breathing mix, tanks, and communication gear, the divers used a scooter which served the double purpose of getting them around the site quickly and clearing out loose sand and debris [slide 3]. For actual excavation, they used a hydraulic eductor [slide 4]. On shallower sites, air pumps or vacuums are used, but getting air down through a hose at that depth is very difficult. The eductor, using a water venturi system to produce suction, deposited the spoil at the edge of the site where it was screened.

The above mentioned supplies and equipment represent accommodation to the extreme depth. They are not new pre se because they have been used for decades in the extreme environments encountered in commercial diving, but they have not been used often on archaeological sites because most of those worked to date have been in much shallower water. It is good for archaeologists and their field assistants to gain experience with deep diving equipment and methods because there are a lot of

potential sites in deep water. I will return to this theme again at the end of my talk, but now let us turn our attention to the TSS 340.

This is a sensing device that was designed to locate metal pipes, such as transoceanic cables, lying on the seabed while being deployed by an ROV cruising many feet above the bottom. It is able to detect all metals, not just ferrous ones, and is in fact so sensitive that it picks up changes in topography which are due to differences in the composition, and therefore the conductivity, of different layers of sediment. The natural conductivity of a site must be read and calibrated before any anomalies within the site can become apparent. The manufacturers claimed that the TSS could sense metal up to 3 meters below the surface, and the project staff hoped that with this sensitivity it would be able to penetrate the deep rubble pile in the "chute." Hand held metal detectors can only penetrate about half a meter. Once deployed and in use however, it appeared that the TSS 340 could only locate anomalies about one meter deep

Since, as mentioned before, it was designed to be operated from an ROV, its size, weight, and unwieldiness was not a problem. Likewise, the fact that its screen remains on the surface vessel is natural for a system designed for remote operation. Both of these characteristics were distinct drawbacks for our situation. Since we were deploying it manually over uneven terrain, its cumbersomeness vastly increased the work effort required at depth. One diver was required to push the specially designed sled the TSS was mounted on [slide 5], and, initially, two more divers assisted [slide 6], one to carry the umbilical cord, and another to communicate with the surface, mark the anomalies, and help in general. After more experience using the equipment, two divers could handle the operation.

The fact that the screen was on the surface vessel also complicated its use. With the TSS, the person monitoring the screen [slide 7] has to communicate to the divers that there has been a reading, and the operator of the sled has to back up and stop, back up and stop, until the surface person communicates that the machine has been correctly repositioned. Then the spot is marked, and the operator can proceed. With a hand held metal detector, the operator wears ear phones that give him or her immediate feedback, and anomalies can be immediately marked.

All this laborious overhead would be well worth the effort, if the TSS did give significantly deeper or more sensitive readings, and it is my opinion that both of those capabilities will be developed in the future, with more field testing and use. The TSS 340 sensing system is based on different principles than hand held metal detectors now in use, and this method of sensing metallic anomalies has much promise for future refinement.

Now before closing, I would like to mention briefly some areas I can see archaeologists in the future making use of deep diving and advanced technological tools. Underwater archaeology began by excavating shipwrecks. This is a very valuable field of investigation, and there are still thousands of wreck sites of significant historical interest, but through a combination of several sources, it has come to my attention that an even greater number of what are essentially "land" sites lie submerged off shore and in relatively shallow seas. The now hypothetical migration routes of early Homo sapiens could be traced across areas that were land bridges before sea levels rose at the end of the last ice age. One such prehistoric site

was discovered in about 20 feet of water off the British Columbian coast in Canada, when a group of archaeologists from the Vancouver Maritime Museum were investigating the area of a shipwreck. Early settlement sites in the Americas will be along rivers and also coastlines which are now submerged. Investigating these sites will shed much light on the very early migration routes as the peoples who settled the Americas moved throughout the land.

Another region that could greatly benefit from investigation of prehistoric campsites is island Southeast Asia. Early *Homo sapiens* and even *Homo erectus* were able to migrate as far as Palawan Island in the Philippines and eastern Indonesia entirely over land bridges now submerged. Much of the area we now call the South China Sea was above water thousands of years ago. There are potentially thousands of sites remaining from these early migrations. If archaeologists studying these and other areas can develop a theory of where to look -- what sort of topography would be a likely spot for a settlement or hunting camp -- and what to anticipate finding - the type of stone tools or other artifacts that could survive, -- the technology is available to conduct such investigations.