Marine Archaeological Exploration of the Black Sea

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Abstract

Through funding from NOAA's Ocean Exploration Initiative and elsewhere, the Institute for Exploration (IFE) has conducted multiple expeditions to the Black Sea for marine archaeological research. Oceanographically, the Black Sea is a unique body of water, and archaeologically, the region has a rich ancient maritime history. Using a suite of deep sea vehicle systems, including a deep-towed side-scan sonar/subbottom profiler, an optical imaging towsled, and a remotely operated vehicle (ROV), we have discovered, surveyed, imaged and sampled a number of interesting sites. These include a highly-preserved wooden ship that dated to the Byzantine period about 1500 years ago, an amphora-laden trading vessel that dated to the Hellenistic period about 2400 years ago, and a possible site of human habitation along a presently-submerged paleoshoreline that was rapidly inundated more than 7000 years ago, during the Neolithic period. During the summer of 2003, IFE will return to the Black Sea to excavate several of these sites using a new ROV, *Hercules.* This vehicle system is equipped with state-of-the-art imaging equipment, including high-definition video and high-resolution multibeam sonar, precise manipulation and navigation, and an array of other oceanographic sensors and sampling equipment. The entire expedition will be broadcast across Internet 2 using an advanced satellite telecommunication system to deliver scientific and educational content to universities, schools, and other public and private institutions.

INTRODUCTION

The Black Sea region (Fig. 1) has recently been the focus of an intense debate related to the Holocene evolution of the basin and its connectivity to the Mediterranean Sea [1,2]. Despite this debate, it has been well established that the Black Sea was once an inland freshwater lake [3] and existed at some times during the early Holocene at significantly lower elevations, much below present day sea level [4]. Any coastal sites of human occupation that surrounded the ancient lake prior to its refilling were inundated and now exist submerged on the relatively shallow shelf [5]. For this reason, in 2000, the submerged shelf off northern Turkey was surveyed [6] using side-scan sonar and

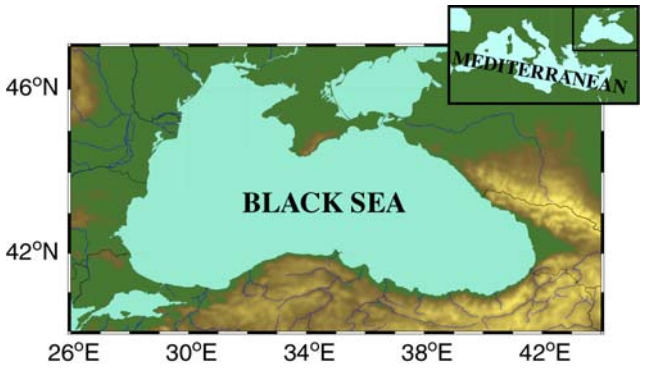

Fig. 1. Map of the Black Sea region. Inset shows the entire Mediterranean and Black Sea regions.

a remotely operated vehicle (ROV) system to explore for potential Neolithic archaeological sites. As a result of this survey, one potential inundated site was discovered [5] (Fig. 2). This site, which currently lies at 95 m depth, consists of a number of "arranged" and "cut" stone blocks together with a number of cut wooden logs. Analysis of sediment samples from the site indicate the possibility (although not definite) that humans once occupied this location [5].

Further exploration during the 2000 survey revealed

Fig. 2. Electronic still camera image of a possible submerged Neolithic archaeological site found off northern Turkey.

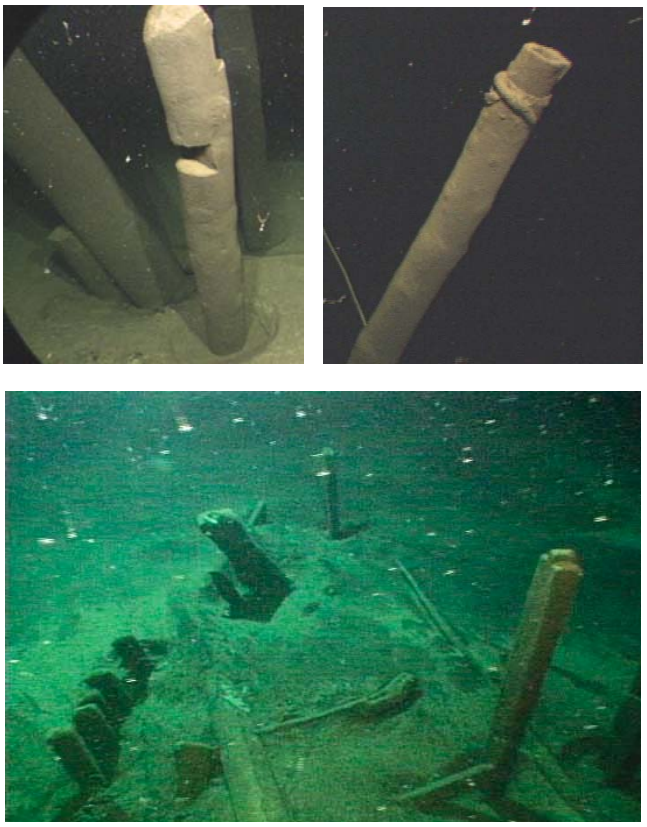

Fig. 3. Video still images of a well-preserved wooden Byzantine period shipwreck found off northern Turkey.

a number of ancient shipwrecks. One shipwreck, found at 324 m depth, was extremely well-preserved (Fig. 3). A small piece of wood collected from this site was radiocarbon dated to the Byzantine period nearly 1500 years ago [5]. Several other shipwrecks from the same time period were discovered, although they were less well-preserved without wooden structural members present. These shipwrecks were trading vessels that carried large quantities of fired clay jars, called amphora (Fig. 4), which held trade commodities such as wine, olive oil, or fish sauce.

The wooden shipwreck (Fig. 3), which was discovered in 324 m water depth, lies within the deep anoxic layer of the Black Sea. Below about 150 m, the bottom waters are devoid of oxygen and thus no life can exist. Wood-boring organisms, such as the toredo worm, which are known to destroy wood in the deep sea, do not exist here and wood is therefore very well-preserved. Above this layer, wood-boring organisms can thrive, and wood on the surface is poorly-preserved. The amphora shipwreck (Fig. 4), which was discovered in 100 m water depth, lies in the oxygenated zone and, therefore, most of the wooden structural members of the vessel, that were once exposed above the seafloor, have been eaten away.

Following upon the success of the 2000 expedition, we expanded our exploration of the Black Sea to the west, off the coasts of Bulgaria and Romania. During

Fig. 4. Video still image of a Byzantine period shipwreck, also found off northern Turkey, but in relatively shallow water compared to the well-preserved wooden shipwreck (Fig. 3).

2001, a side-scan sonar/subbottom profiler survey near the western Black Sea paleoshoreline took place. Hundreds of square miles were surveyed to further explore for inundated sites of human occupation on the shelf. The search areas were expanded to include deep water regions within the anoxic layer where well-preserved shipwrecks could exist.

The most significant sonar targets from the 2001 survey were investigated during an expedition in 2002 using a Bulgarian submersible. In total, nine targets were explored, four of which proved to be shipwrecks. One of the shipwrecks contained a large number of amphorae (Fig. 5). In addition to this discovery, several well-preserved Ottoman period (or later) shipwrecks were found. The shipwreck containing the cargo of amphora was also sampled using the submersible's manipulator and a single amphora was collected (Fig. 6). Analysis of the amphora and its contents revealed it was from the Hellenistic period, and bones from butchered fish that were found inside (Fig. 7) were

Fig. 5. Video still image of a Hellenistic period shipwreck, found off Bulgaria in relatively shallow water.

Fig. 6. The submersible *PC-8B* operated by the Bulgarian Academy of Sciences Institute of Oceanology. The amphora was collected from the Hellenistic period shipwreck (Fig. 5).

Fig. 7. Catfish bones that were found inside the Hellenistic period amphora (Fig. 6). Cut marks on the bones as well as fragile spines that could have only been preserved in the flesh of the fish indicate large chunks of butchered fish (most likely salted) were being transported in these large amphorae.

radiocarbon dated to about 2400 years ago. The primary fish species represented by the bones was identified as a European river catfish. The fish, some of which were more than 1 m in length and weighed more than 10 kg, were common to the Danube region north of Bulgaria in ancient times. Therefore this ship was likely traveling a north-south trade route, sailing south toward the Bosporus Strait and ultimately to Greece.

The style of the amphora is similar to those manufactured in the Sinop region of northern Turkey, which have been found throughout the Crimea region (Ukraine) on the north coast of the Black Sea. In addition, a single olive pit found inside the amphora indicate it may have once carried olive oil, perhaps from the Sinop region, north to the Crimea along a deep-sea trade route. The ship could then have traveled to the Danube region, where it picked up the fish prior to sinking off the Bulgarian coast on its way south. The age of the shipwreck indicates it is the oldest ship ever found in the Black Sea. This discovery is therefore quite significant, as it reveals details of an ancient trade pattern from a period in ancient history that is relatively poorly known.

A major expedition during the summer of 2003, with partial sponsorship by NOAA Ocean Exploration, will return to several of these submerged Black Sea archaeological sites to conduct more detailed mapping and sampling. For this research cruise, a new ROV will be employed and the undersea video footage and scientific data will be transmitted live back to sites in the United States for scientific and educational purposes.

PROPOSED METHODOLOGY

For the 2003 expedition, a newly developed ROV will be used to partially excavate and sample several of the aforementioned archaeological sites. This vehicle system, which is named *Hercules*, was built by Woods Hole Marine Systems (Jim Newman, President) and is specially designed to dig and remove sediment and recover artifacts from ancient shipwrecks in the deep sea (Figs. 8 and 9). It is a neutrally buoyant hydraulic ROV, equipped with a high-definition video camera, an array of lights and piloting cameras, dual manipulators, two scanning sonars, a suite of oceanographic sensors (conductivity/temperature/depth sensor (CTD), acoustic doppler velocimeter (ADV), and dissolved oxygen), a suite of sampling equipment (for collecting sediment, water, biological, and archaeological samples), and a sophisticated excavation "toolkit" used by the

manipulators to perform certain tasks. These tools include pumps and hoses for water jetting and suction, several types of brushes and scrapers, and delicate sampling equipment for handling both large and small artifacts.

The ROV can excavate while anchored securely to a stabilizing platform, which is either a "gantry" – a metal sawhorse-like structure that straddles the excavation site (Fig. 9), or a "pallet" – a smaller platform that will immobilize the vehicle on the bottom adjacent to the excavation site. The gantry will hold the vehicle in place so it can excavate the area immediately below without setting down. Sediment that is removed using suction can be effused several meters down-current (as determined by the ADV). Artifacts that are collected can be stored in baskets, trays, or drawers attached to the ROV, or brought to an elevator system and floated to the surface.

Hercules can be equipped with a range of transponders that operate with different subsea navigation systems, including ultra-short baseline (USBL), long baseline (LBL), and EXACT (a short-range, high precision LBL system). For careful mapping of the archaeological site prior to excavation and sampling, the EXACT system will be deployed to achieve centimeter-scale precision for the location of artifacts prior to their collection. This will provide positioning information for the creation of detailed photomosaics and acoustic maps using both topographical and subbottom imaging techniques.

Fig. 8. Excavation ROV *Hercules*, viewed from the front, being prepared for dock trials in Woods Hole. The high-definition video camera is mounted on a pan-tilt unit in the center. Hydraulic manipulators are on each front side corner and can swing aft and down.

Fig. 9. Artist's sketch of the ROV *Hercules*, coupled to the gantry frame, excavating the sediment within and around an ancient shipwreck.

To help cope with disturbed sediment and the resulting poor visibility during the excavation process, high-resolution acoustic maps of the excavation zone will be generated continuously. This will enable the pilots to monitor progress despite the inability to see. These three-dimensional acoustic maps will permit handling of artifacts in low visibility because each manipulator can be registered within the acoustic space and computer controlled with force-feedback to gauge the pressure with which objects are handled.

EDUCATION AND OUTREACH

The 2003 Black Sea expedition will utilize a state-of-the-art telecommunication system to deliver scientific content from the ship to selected sites in real time using the Internet 2 (Fig. 10). Through a partnership with NOAA, the Immersion Institute at Mystic Aquarium, the University of Rhode Island Graduate School of Oceanography (GSO), and the Jason Foundation for Education (JFE), a portable satellite uplink van was outfitted with sophisticated digitally-encoded video distribution and telecommunication equipment that will enable all data to be IP-encapsulated and distributed in real time via a satellite link to Internet 2. The data includes underwater high-definition video feeds, accompanying telemetry data, oceanographic sensor data, navigational information, and sonar imagery from the remotely operated vehicles and the shipboard control vans. Portable topside video cameras and an

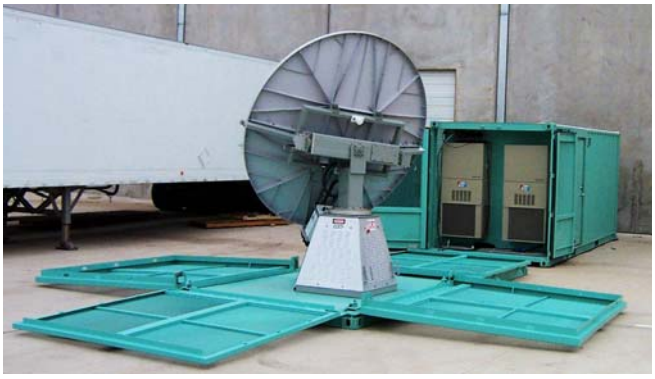

Fig. 10. Satellite communication system being prepared for shipment. The communication van is installed on the ship and the satellite dish is mounted on the roof of the van.

intercom system will also feed into the encoded transmissions for real time communication between the Internet 2 sites and the ship. A prototype system will be installed at the Inner Space Center at GSO to decode and display the incoming data and video feeds. From GSO, the information will be redistributed over Internet 2 to the Immersion Institute and selected JFE downlink sites. Some of the data feeds will be down-converted and made available online using standard internet bandwidths.

The vision for the Inner Space Center at GSO is to create an environment onshore that replicates the control vans onboard the ship. This will facilitate scientists, students, and the general public to participate in oceanographic expeditions in real time from shore. The Inner Space Center will solve many problems related to the difficulties of conducting oceanographic research, including the limited amount of space onboard research vessels, the amount of time and expense it takes to travel to remote sites, and other physical restrictions that may prevent people from participating live. This concept should revolutionize oceanographic science, and this will be put to the test during the Black Sea 2003 expedition.

The Immersion Institute at Mystic Aquarium will produce educational content related to the expedition involving the real-time Internet 2 feeds from the ship. This content will be used onsite in Mystic in its public educational programs, and broadcast to selected JFE downlink sites throughout the United States to provide informal educational content to various boys and girls clubs, summer camps, and student enrichment programs.

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