Deepwater Archaeology of the Black Sea

Karadeniz'de Sualtı Arkeolojisi

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Türkiye'nin kuzey kıyıları boyunca, Karadeniz'de Boğaz'ın doğusundan Sinop limanına kadar olan bölgede büyük bir araştırma yürütülmüştür. Bu araştırmanın üç ana amacı vardır: ilk olarak Karadeniz'in sularla dolmasından önce, yani 7 500 yıl önce, araştırmacılarca yörede varolduğu öngörülen yerleşme yerlerine ait verilerin araştırılması; ikinci olarak açık deniz gemi rota yollarının saptanması ve üçüncü olarak da Karadeniz'in oksijensiz dip sularında eski ahşap gemi kalıntılarını bulmaktır. Bu araştırmada kullanılan aygıtlar kademe dizinli yan taramalı sonar, yedek kızak ve uzaktan kumandalı küçük dalma aracıdır (ROV). Karadeniz'de, öngörülen su taşkınından önceye ait olasılıklı bir yerleşme yeri ve üç adet gemi batığı 100 m derinlikte saptanmıştır. Bir diğer batık 324 m derinlikte oksijensiz seviyede bulunmuştur. Bu oksijensiz tabakadaki batık tüm halde son derecede iyi korunmuş halde ve M.S. 450 yılına yani Bizans Devrine aittir.

1. Introduction

A joint program of land-based research through the University of Pennsylvania's Black Sea Trade Project and underwater research through the Institute for Exploration has been investigating ancient seafaring and settlement along the Black Sea coast at Sinop since 1996. The Black Sea has unique potential for archaeological and oceanographic research due to the highly preserving environment of its non-oxygenated (anoxic) waters below 200m. While most of the southern Black Sea coast is rugged and inaccessible, Sinop has a natural harbor and its fertile and gentle

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coastal plain with evidence of occupation from Paleolithic through modern times (Hiebert 2001). Sinop has been at the crossroads of maritime trade routes (north-south and east-west) for millennia. We have used this ideal location to extend the scope of archaeological survey from land survey of the hinterland behind the port of Sinop, to shallow water survey and explorations in waters deeper than 200 m. We report here the results of the 2000 underwater season and new results of chemical and botanical analyses of samples. These findings demonstrate that deeply submerged archaeological remains can be surveyed and sampled in a fashion comparable to survey on land and in shallow water.

2. Background

In 1976, Willard Bascom (1976) published a book entitled "Deep Water Ancient Ships". In that book, Bascom predicted that the unique anoxic bottom water conditions of the Black Sea should result in the preservation of ancient wooden ships.

In support of Bascom's prediction, researchers working in the oxygenated waters of the open oceans at that time (Turner, 1975), had clearly documented that wooden objects falling to the bottom of the deep sea were quickly found and consumed by wood-boring organisms.

The vulnerability of wooden ships to the attack of wood-boring organisms in the deep sea was most recently documented in the 1990's by a series of expeditions conducted by the Institute for Exploration (Ballard et al., 1999 and Ballard et al., 2002). In the first case (Ballard et al, 1999), five shipwrecks of the Roman period were located in approximately 1000 meters of water along the deep water trade route connecting ancient Carthage with the Roman seaport of Ostia. In all five cases, the exposed wooden portions of these ships had been removed by the activity of wood-borers, although highly preserved wooden timbers of the ship were found a short distance beneath the surface of the bottom sediments.

In the second case (Ballard et al., 2002), two Phoenician ships were located in 400 meters along the deep-water trade route connecting the ancient seaport of Ashkelon to the Egyptian Nile. Unlike the Roman ships, which were largely buried in the deep sea mud, the two ships off Ashkelon had been scoured by bottom currents to a depth of two meters exposing a larger percentage of the ships' hulls. Once again, wood-boring mollusks had removed all of the exposed wood from those two ships.

Given these results, an expedition was organized in 2000 to search for ancient shipwrecks in the anoxic bottom waters of the Black Sea to determine if their state of preservation was different from ships found in oxygenated waters as Bascom had suggested.

As the 2000 expedition was being organized, however, a book was published about the Black Sea by William Ryan and Walter Pitman entitled "Noah's Flood" (1998). In that book, the authors challenged the conventional sequence of events leading to the conversion of the Black Sea in the Holocene from a lacustrine environment prior to post-glacial melting to its present marine conditions. Earlier authors (Ross et al., 1970; Degens and Ross, 1972; Deuser, 1972; Ross and Degens, 1974) had argued that this conversion was a gradual event beginning around 9000 BP while Ryan et al. (1997) argued it was sudden and took place later, around 7150 BP.

Ryan et al. (1997) based their findings upon a survey conducted in 1993 during which a high frequency sub-bottom profiling system was used to survey two areas on the Black Sea's northern continental shelf, to the east and west of the Crimea peninsula. These surveys were then followed by a systematic coring effort along the profile lines.

Their seismic survey revealed an erosional angular unconformity throughout the survey areas everywhere above the present 150-meter contour of the Sea's shelf. Draping the erosional surface is a thin uniform layer of sediments that lack any internal structure or evidence of transgressive features that might be associated with a slow rise in sea level.

Cores taken during the survey penetrated the uniform layer as well as the underlying erosional surface. The upper draping layer proved to be sapropel mud, further suggesting a sudden transition from a well-oxygenated environment to one now lying in a macerating and putrefying anaerobic environment. Mollusks extracted from the cores at the base of the uniform draping layer and resting on the unconformity had identical radiocarbon ages of 7150 +- 100 yr B.P.

Ryan et al. (1997) went on to conclude that the flooding of the Black Sea at 7150 BP was instantaneous, resulting in the submergence of 150,000 km^2 of previously exposed land that now makes up the Black Sea's continental shelf. Finally, they conclude that this sudden flooding "may possibly have accelerated the dispersal of early Neolithic foragers and farmers into the interior of Europe at that time."

In the summer of 1999, the Institute for Exploration carried out a survey of the continental shelf off the north central Turkish seaport of Sinop (figure 1) to determine if such a flood had occurred and at what time (Ballard et al, 2000). Using a side-scan sonar, small remotely operated vehicles, and a series of dredge lowerings, an ancient exposed high energy shoreline at a depth of 155 meters was located, inspected, and sampled. Analysis of mollusks collected from this ancient beach revealed a sudden flooding of the Black Sea in this area around 7500 BP changing it from a lacustrine to marine environment. This ancient relic surface remained in contact with the bottom waters of the Black Sea for a long period of time before being draped by a thin layer of sapropel mud characteristic of today's anaerobic conditions.

Based upon the results of this 1999 study, the operational plans of the 2000 expedition were modified to include an effort to search landward of the 155 meter contour for evidence of human habitation prior to this flooding event.

3. Research Tools

Three major mapping systems were utilized during the 2000 survey. These included the *DSL*-120 side-scan sonar system; the *ARGUS* imaging vehicle; and the *LITTLE HERCULES (LITTLE HERC*, for short) remotely operated vehicle system .

The *DSL-120* is a phased-array 120 kHz side-scan sonar (Figure 2) developed by the Woods Hole Oceanographic Institution and capable of working in over 6000 meters of water (Bowen et al., 1993). Owing to the small targets (i.e. less than 10 meters on a side) that were being sought, the effective total swath wide of the sonar was 600 meters from one side to the other while the sonar was being towed at an average altitude of 40-50 meters. Tuning the sonar to detect these small targets, however, resulted in the inability to measure the phase of the returning signal and therefore the loss of topographic information within the acoustic swath of the returning signal.

The *ARGUS* imaging vehicle, developed by the Institute for Exploration (Figure 3), is towed at the end of 0.68-inch fiber-optic cable (Coleman et al., 2000). It has an operating depth of 3000 meters and carries multiple cameras (a low-light level SIT video camera, a 3-chip color video, two 1-chip color video cameras, and a 35 mm still camera) mounted on a trainable platform. At the back end of the vehicle are three HMI lights (two 400 watt lights and one 1,200 watt light). It also carries a 675 kHz obstacle avoidance sector scanning sonar, an

electronic still camera (ESC), magnetic compass, altimeter, and depth sensor. Thrusters are mounted on either end of the 4-meter long stainless steel frame perpendicular to the long axis of the vehicle capable of spinning the vehicle on its vertical axis while being towed. The *ARGUS* vehicle system can be deployed alone or used in conjunction with the *LITTLE HERC* ROV.

The *LITTLE HERC* remotely operated vehicle (Figure 4) was developed by the Institute for Exploration and also is capable of working to 3000 meters. It has four thrusters, a 330 kHz obstacle avoidance sector scanning sonar, altimeter, magnetic compass, depth sensor, two 400 watt HMI lights, and either can carry a 1-chip color video camera and 35 mm still camera or a 3-chip color video camera. *LITTLE HERC* operates from the end of a 30-meter long neutrally buoyant tether that is connected to the *ARGUS* vehicle (Coleman et al., 2000).

Although the vehicle does not have a manipulator system, it was outfitted at various times on the expedition with a scoop bag or coring device to recover objects and wood samples from the seafloor.

The support ship for the expedition was the British trawler, *NORTHERN HORIZON*, a 75-meter long vessel outfitted with a bow thruster and dynamic positioning system.

4. Survey efforts in 2000

Preliminary Surveys

Survey efforts using all three-vehicle systems in 2000 were carried out in three separate areas (Figure 5). The western most area was selected in hopes of finding evidence of human habitation prior to flooding 7500 years ago as well as for the possibility of finding ancient shipwrecks in oxygenated water. The other two areas were surveyed specifically in hopes of finding ancient shipwrecks lying in anoxic water. For discussion purposes, the results of the 2000 expedition will be divided into those pertaining to human habitation and those dealing with ancient wooden ships.

Evidence of Human Habitation

Figure 6 shows the DSL-120 side-scan sonar track lines in the western search box. The red colored lines represent the 155 and 90 meter contours. This is the region lying between the shoreline of the ancient freshwater lake and the near shore area where archaeologists (Hiebert 2001) predict people would be living prior to the flood proposed by Ryan and Pitman (1998). A steep coastal cliff not conducive to human habitation characterizes approximately 50 percent of this area. The remaining 50 percent is divided into three distinct areas.

The study carried out in 1999 (and mentioned above) was conducted in the eastern region. It was there that the ancient shoreline was located and both fresh and saltwater shells collected dating from 15000 to 2500 BP (Ballard et al., 2000). That survey concentrated on mapping the ancient shoreline at 155 meters, with little work done landward of that shoreline. During the survey, attempts were made to delineate the ancient drainage pattern of this area but due to stream piracy farther inshore in today's Turkish landscape, no major rivers flow into this area and the likelihood of finding sites of pre-flood habitation are greatly reduced.

For these reasons, the 2000 study concentrated on the central area just west of Sinop. It is there that more than 400 square kilometers of underwater terrain lies between the 155 and 90 meter contours. The bathymetry of this area, however, was poorly defined based upon limited bathymetric data. As a result, the *DSL-120* side-scan sonar was used to obtain bathymetric information as well as side-scan sonar data. Although the phased array was not

tuned, it was possible to combine the vehicle's altitude with its depth to determine total depth beneath the tow fish. This data , combined with a series of separate lines using the ship's echo sounder, was used to construct a bathymetric map of the study area (Figure 7).

The bathymetry of the study area is characterized by a series of valleys and ridges cutting across the area. A south-north cross section through the region reveals the nearly flat relief around 100 meters water depth, which then plunges steeply and continuously to deeper water (Figure 8). An ancient stream channel flows into the southwest portion of the study, turns and then heads east across the area before turning to the north as it enters the ancient lake.

More than 200 sonar targets were detected during the survey of this area. Most were obvious rock outcrops as well as possible shipwreck targets that were subsequently inspected visually and will be discussed later. A clearly visible submerged river channel indicated that the bottom surface of the Black Sea in this area had little sedimentation (figure 9). Of the 200 sonar targets, one (target 82) was unique (figure 10).

The micro-bathymetry of Site 82 shows that it was located on a gently sloping bluff overlooking the ancient shoreline (figure 11). The site has raised topographic relief with an array of more than thirty stone blocks located over an area 15 m by 5 m, on a gently sloping, otherwise featureless bottom (figure 12). The irregularly shaped blocks are generally smaller than $1m^2$, approximately 10cm thick, and protrude from the Black Sea floor. The stone appears to be similar to the thinly bedded limestone visible in outcrops both along the coast ridges and underwater in this region (Ketin 1962). The blocks in site 82, in contrast to observed outcrops, do not lay in *in situ* geological context, but lie in diverse orientations from horizontal to protruding at least 45° from the horizontal sediments. These topographic details led us to hypothesize that site 82 might be a submerged structure attributable to humans. Such a structure would necessarily have been built prior to the infilling of the Black Sea, (prior to 7600 years ago) when the location of this site would have been approximately 1 km from the beach line identified in the 1999 survey (Ballard et al. 2000). Similar habitation remains from pre-7600 BP contexts are found along the present coast of the Black Sea (Özdoğan 1997). Such architecture typically has wood or wattle and daub superstructure and occasionally has stone foundations (Özdoğan 1999). In the Sinop region, typical ancient settlements consist of isolated house structures scattered along low bluffs near the sea (Doonan 1998), and pre-7600 BP sites are found on the Sinop peninsula. Ince Burun, located at the northwest corner of the Sinop peninsula, would be a contemporary "upland" site, within 30 km of site 82 (Hiebert, 2001).

Site 82 was mapped using an electronic still camera mounted on *ARGUS*, and visually checked with video from *LITTLE HERC* (figure 13). A scale was placed on site allowing us to create a preliminary grid of $1m^2$ squares for future study. The raised topographic relief and stones follow in generally rectilinear orientation N-NW. The north boundary is marked by stone blocks and pieces of wood, including a 1-meter long log with one end that is cut and one end that is notched (figure 14). Traces of a circular feature 85 cm in diameter are located along the east side. To the southwest, a 2.5 x 2.5 m rectilinear feature with raised outline edges is visible from faint topographic relief.

As on all other targets in this region, driftwood and other debris appear clustered on the surface of the site, where the relief and stone blocks act to collect materials drifting over the bottom of the seabed. This complication of stratigraphy is comparable with archaeological sites on

land. We recovered several clearly worked objects from the surface within the boundaries of site 82. These objects, which initially appeared to be stone, were carved and drilled from oak (*Quercus*) (figure 15). Four worked wooden objects were found in square G4. Three drilled objects, 22 cm in length were found in close proximity to each other in square G4. Fiber remains in one of the drilled holes suggests that they were originally connected together with rope. A further worked but less shaped piece of wood was also recovered from the surface of square G4. A chisel-shaped wooden object, 14 cm long, was recovered from square E10. None of this wood appeared to have been modified by wood-boring mollusks or other marine organisms. A fragment of known modern milled lumber was recovered at the site as a control sample. Radiocarbon analysis of these wooden objects, all with modern dates including the control sample, confirms that these objects were surface materials recently deposited on the site (Ballard, et al. 2001)..

Matrix samples from three locations were fine sieved and examined at the University of Pennsylvania by Dr. Naomi Miller. Control bottom mud samples came from dive 34, 5 km from site 82, and from a 1999 bottom sample, recovered east of Sinop in 140 m depth just above the ancient beach line. These samples contained only shell and marine organism debris. Two samples were taken of the top 5-7 cm of deposit from within site 82, both from square G4 (dive 23 - 3 dl, and dive 29 - 1.5 dl). Both samples contained small fragments of burnt wood (charcoal fragments of oak and conifer) and several seeds, but no ceramics, stone debitage or diagnostic artifacts. One possible bone fragment was also reported. The identification of charcoal, seeds and bone from the matrix of the site is consistent with the hypothesis that the site represents a submerged archaeological site. Such results are typical of upper fill from a terrestrial archaeological site.

Chemical analysis of the mud matrix from the deposit taken from the stone blocks of site 82 was conducted by William Wood of Southern Illinois University. Samples comprised two 32 ml soil plugs from G4, from the upper 5 cm of deposit, and a similar control sample from the Black Sea bottom mud (dive 34). Both wet chemical analyses and near infrared spectroscopy were conducted, providing a preliminary assessment of the site 82 matrix as compared to a typical Black Sea bottom mud away from site 82. Preliminary results from the two site 82 samples indicate elevated phosphorus and magnesium compared to the off-site samples, consistent with the interpretation of site 82 as a potential habitation site. One of the two samples from site 82 (dive 29) had concentrations of zinc and copper, which are typically associated with excrement and urine. Further, in comparison to the control samples, site 82 samples have lower sulfur, sodium, and nitrogen, observations with unclear significance at this time.

Analyses of sediments and chemical compositions from site 82 samples show considerable differences to samples outside of the site. The results are consistent with the hypothesis that this location is a submerged habitation site but do not confirm it. The results of the radiocarbon dating indicate that the wooden artifacts recovered from the surface of the site represent a modern accumulation with no direct association to the site. These analyses, though inconclusive, point to the rich possibility of deep-water archaeological survey using robots and submersibles to investigate landscapes that have been uniquely unseen since the moment that they were flooded. Further sampling of site 82 is clearly necessary to confirm its archaeological nature. Additionally, further collection of baseline data concerning the nature and chemistry of the Black Sea floor is essential in order to clarify the relationship between the submerged former landscape and the marine environment.

Ancient Shipwrecks: Above Anoxic Layer

The discovery of the first ancient shipwreck on the 2000 expedition occurred while searching for evidence of human habitation above the anoxic layer in water depths between 90 and 155 m. During this search, wood material was found to be pervasive throughout the area. Tree fragments from entire trees to stumps, to branches and twigs were seen in large number, particularly wedged beneath rock outcrops along the banks of the now submerged stream system.

Their large-scale occurrence was not expected, since the water in this depth zone is well oxygenated, characterized by schools of pelagic fish. On closer inspection, however, it was apparent that the benthic community was quite limited, characterized by small sponges instead of the rich benthic community typical of shallow depths.

In discussing this issue with local fishermen, they reported (personal communication) that when trawling with nets at this depth, they commonly caught pelagic fish such as bonito. On other occasions, no fish were recovered and their nets had been stained black and smelled of hydrogen sulfide suggesting periodic mixing of the anoxic water below 155 m with oxygenated water above.

Given the layered nature of the Black Sea waters, the occurrence of internal waves is quite possible, which could aid in the vertical mixing. Such a possible mixing mechanism was further supported by the occurrence of extensive areas of sand waves at the anoxic boundary, which was typically found at a depth of 170 m.

The periodic introduction of anoxic water into shallower depths through internal waves or other mixing mechanisms would result in the death of benthic organisms such as wood-boring mollusks. Pelagic fish such as bonito could escape such mixing by moving into shallower oxygenated water. For that reason, wood would have a higher probability of surviving for longer periods of time than previously thought. A wood sample, for example, collected in 1999 (Ballard et al., 2000) at a depth above 170 m having a carbon-14 age of over 3000 years further verifies the notion that wood-boring organisms are absent at these depths.

Archaeological data from land surveys on the Sinop peninsula document maritime trade between the Sinop peninsula and the Bosporus from as early as the Chalcolithic period (4500 BC) and continuing through the Ottoman period (17th c AD). The most intense trade appears to be during the Roman and Byzantine periods (2nd c AD - 7th c AD) (Hiebert 1997). With the understanding that bottom net fishing obliterated the archaeological record to a depth of 85 m off the Turkish coast, we conducted our systematic survey along this trade route, searching between 85 and 150 m, over a 50 km stretch west of Sinop. Three shipwrecks were located with side-scan sonar and verified visually with *LITTLE HERC*. No sampling was conducted on these sites. The shipwrecks were found in approximately 100 m of water, and appear to be undisturbed by any bottom net fishing, trawling scars, or diving activity. All of the shipwrecks appear to have foundered in the open sea and sunk with the cargo in discrete piles. All three appear to date to the late Roman/Byzantine period of vibrant trade between the Sinop peninsula and the west, and all appear to have been carrying amphorae (large transport ceramic vessels) of a distinctive form made only in Sinop.

Shipwreck A consists of two discrete dense clusters of ceramic vessels located on a flat featureless bottom (figure 16). The larger cluster is approximately 23 m in length and 10 m wide, oriented approximately north to south. A second cluster is 4 m by 4 m square. The visible artifacts in

both clusters are distinctive carrot-shaped amphorae (figure 17). Dating to the late Roman period (2-4 c AD) (Kassab-Tezgör 1998), they are known from kiln sites at Sinop from the Demirci valley (Kassab Tezgör 1997). The lack of scouring around the debris indicates that the bottom is firm. The nearly two meter tall site profile suggests that the ship descended right-side up and splayed open upon impact with the bottom, rather than settling into a soft mud bottom. Several large (5-7 m) timbers are aligned along the side of the clusters, and may be planking from the vessel. However, as on site 82, modern seabed debris is concentrated on the topographic anomaly that the site represents. This debris includes small wood branches (20-40 cm) and cultural debris such as a cloth sack visible in the center of the larger cluster.

Shipwreck B is a single cluster of amphorae, also located on a flat featureless bottom. The lack of scouring around the shipwreck suggests that the bottom is firm. Shipwreck B is oriented NNE and is larger than Shipwreck A: 15m wide and at least 25m in length - its total length is unclear based on our initial recording of the site. Carrot shaped amphorae from Sinop are visible covering the entire site representing at least the upper layer of cargo from the ship. One large oval transport vessel suggests that this shipwreck dates later than Shipwreck A - perhaps to the Byzantine period (5th-7th c AD) (Bass 1982). A possible bilge pipe, which may be associated with the vessel, is visible several meters away from the amphorae pile to the south. Scattered among the amphorae are two types of large wooden planks - long planks (5-8m), mostly parallel to the length of the amphorae pile, and shorter planks (1-3m), both parallel to and perpendicular to the amphorae pile. While most of the planks appear to be lying on the surface, several are clearly embedded within the matrix of amphorae , allowing us to suggest that they are hull planks from the ship itself.

Shipwreck C was located on sidescan sonar and checked visually via video by *LITTLE HERC*. The site appears to be similar to Shipwreck A: an amphorae pile approximately 5m across consisting of primarily carrot shaped amphorae. No further investigation was made and no photo mapping was carried out. The importance of Shipwreck C is that it confirms that our protocol of sidescan sonar and target checking with a ROV can efficiently carry out systematic survey in underwater environments where the pattern of shipwrecks has not been disturbed by subsequent human activity. The discovery and identification of Shipwreck C confirms that the technology and methodology utilized here can be used in the development of large-scale systematic survey and site identification. This information is critical to our goal of evaluating the quality and density of archaeological remains along a trade route, and to provide a baseline for underwater archaeological resource management and protection.

Within Anoxic Layer

Separate searches for ancient wooden ships were carried out in the anoxic layer at three separate locations: just seaward of site 82 to a depth of 600 meters, east of Sinop to a depth of 450 meters, and north of Sinop to a depth of 2200 meters.

One of the original objectives of the 2000 study was to determine if an ancient deep-water trade route once existed between Sinop and the Crimea (Hiebert et al., 1997). Unfortunately, that proved difficult. The ocean floor just north of Sinop plunges rapidly from a hundred meters to over 1,000 meters. Based upon the sidescan sonar record and subsequent visual inspection, this region was observed to consist of massive slumps and landslides producing complex bottom morphologies. As a result, searching for ancient shipwrecks within this terrain using both the

acoustic and visual imaging vehicles proved extremely difficult, time consuming, and unproductive.

The focus of the search then shifted to the region east of Sinop. Here there was a broad and somewhat flatter terrain within the anoxic layer. It was also relatively close to shore and along what might have been a coastal trade route connecting Sinop to the regions farther east. Several targets were detected on sonar but no ancient shipwrecks were found in this area and further searching was abandoned.

Near the end of the expedition, a final search effort was conducted north of site 82 between the region of sand waves, which ends at a depth of 200 meters, and the beginning of landslides and slumping at a depth of 600 meters. Within this narrow depth range a few promising targets were detected, one of which we investigated visually with *LITTLE HERC*. That target proved to be a sunken wooden ship.

The shipwreck was located in an area where the seafloor has little topography and lies at a depth of approximately 320 m. The bottom sediments are soft and not compacted in comparison with the bottom near site 82 and Shipwrecks A, B, and C. The wooden structure of the shipwreck appears covered in silt up to its deck, with drifting of sediments across the ship structure, unlike the bottom characteristic of shallower depths where bottom geology and topographic features were visible.

Shipwreck D is comprised of a very well preserved wooden vessel sitting virtually upright in the bottom silts (figures 18, 19). The outline of the hull is defined by 18 frame ends; the mast of the ship rises, at a slight angle, approximately 11 m above the hull. The height of the mast was measured using the altimeter on *LITTLE HERC*. The hull seems to be nearly as long as the mast is tall (11-12 m) and approximately one third as wide (3.5 -4 m). A number of timbers (particularly the bulwark/uppermost planking strakes) are missing or have been displaced. The wood surfaces appear clean cut and even display wood grain. Several wood knots are visible near the top of the mast, however, it was impossible to determine visually whether this was the result of the erosion of the softer wood surrounding, or the natural, unworked state of the timber. A short length of rope coils around the mast near its top. There is no metal visible on the site/vessel.

Many of the eighteen frame ends have a hole through their molded face (wider face). One has what appears to be a wooden cleat remaining in this position. Two frame ends flank the mast and may indicate the main frame. One frame end is situated in association with a beam approximately twice its thickness. Both the end of the beam and the frame end are mortised or notched.

The cant of the mast towards one end suggests the direction of the bow, but it may be that the mast slipped with the impact of the shipwreck. A bracing timber has a stepped cut and wooden treenails through it (figure 20). Two pairs of upright stanchions, located immediately aft of/adjacent to the mast, probably had crosspieces that connected them. There are notches facing inboard (towards each other) on the pair of stanchions closest to the mast and the second pair of stanchions is topped by square tongues, presumably fashioned to fit into mortises on a crosspiece, now missing. This arrangement may have been intended to support yards when lowered or it is possible that it was once lightly roofed as a shelter.

Beyond the stanchions are what seems likely to be a rudder support and the sternpost, which rises up out of the sediment in line with the mast (figure 21). A large spar with a round tenon at one end lies on the

surface nearby. Several spars (long, tapering timbers that were part of the rigging) are visible on the shipwreck. These probably are yards for a sail. If the cant of the mast is not the result of impact, it may indicate that this was a lateen-rigged hull. The mast's height also suggests a lateen hull.

The only visible fastenings are wooden treenails in the bracing timber with stepped cut and treenail ends protruding from the faces of five of the frame ends. There are no other visible fastenings: no mortise-and-tenon joints, no nails, no sewing, no bolts, and no pegs.

An unglazed ceramic jug with a small neck and handle appears *in situ* on the shipwreck near the mast step. The jug is not typologically distinctive, as such pots are found on sites in the Mediterranean and the Black Sea from antiquity through recent times.

A wood sample for radiocarbon dating was collected from the rudder support using a coring device measuring approximately 1.5 centimeters in diameter and 10 centimeters in length. The rudder support was chosen for sampling because it was a large timber with visible exterior surface, ensuring that the sample would date approximately to the felling of the tree. Dr. Naomi Miller from the University of Pennsylvania identified the wood as fir (*abies*); wood traditionally used in boat building in the Black Sea region. A sample submitted to Beta Analytical Lab in Florida for AMS C-14 resulted in a date of 1610 +/- 40 (Beta-147532) calibrated to 410-520 AD. The results of the AMS dating suggest that this vessel was contemporary with the Yassi Ada and Boz Burun shipwrecks located off the Turkish Mediterranean coast (van Doorninck, 1997). Both of these vessels, however, were found in Mediterranean waters and are not nearly as well preserved as this Black Sea vessel. Shipwreck D is unique, not only because of its level of preservation, but because it is the first vessel to be found in the anaerobic waters of the Black Sea. Its presence suggests that many better-preserved vessels await discovery.

5. Conclusions

The Black Sea is a unique body of water that holds much promise for archaeology and anthropology. Just as Willard Bascom predicted in 1976, its anoxic bottom waters create a unique preserving environment coupled with vertical mixing that introduces anoxic water into shallower depths resulting in a further zone of good preservation. This survey identified a zone between 85m and 150m of intact ancient landscape relatively unclouded by sedimentation and undisturbed by fishing or trawling. The identification of site 82, a potential pre-flood coastal habitation site, resulted from our first efforts to survey the submerged landscape along the Black Sea coast. This same zone provided a critical area for the preservation of ancient shipwrecks documenting trade along the coast between the Sinop peninsula and the Bosporus. The identification of three shipwrecks in this initial survey provides a baseline methodology for the systematic survey of a trade route that was in use for thousands of years. Finally, the identification of an intact wooden ship in the deep water of the Black Sea proves that the unique anoxic water is a highly preserving environment for wooden shipwrecks and other normally perishable materials.

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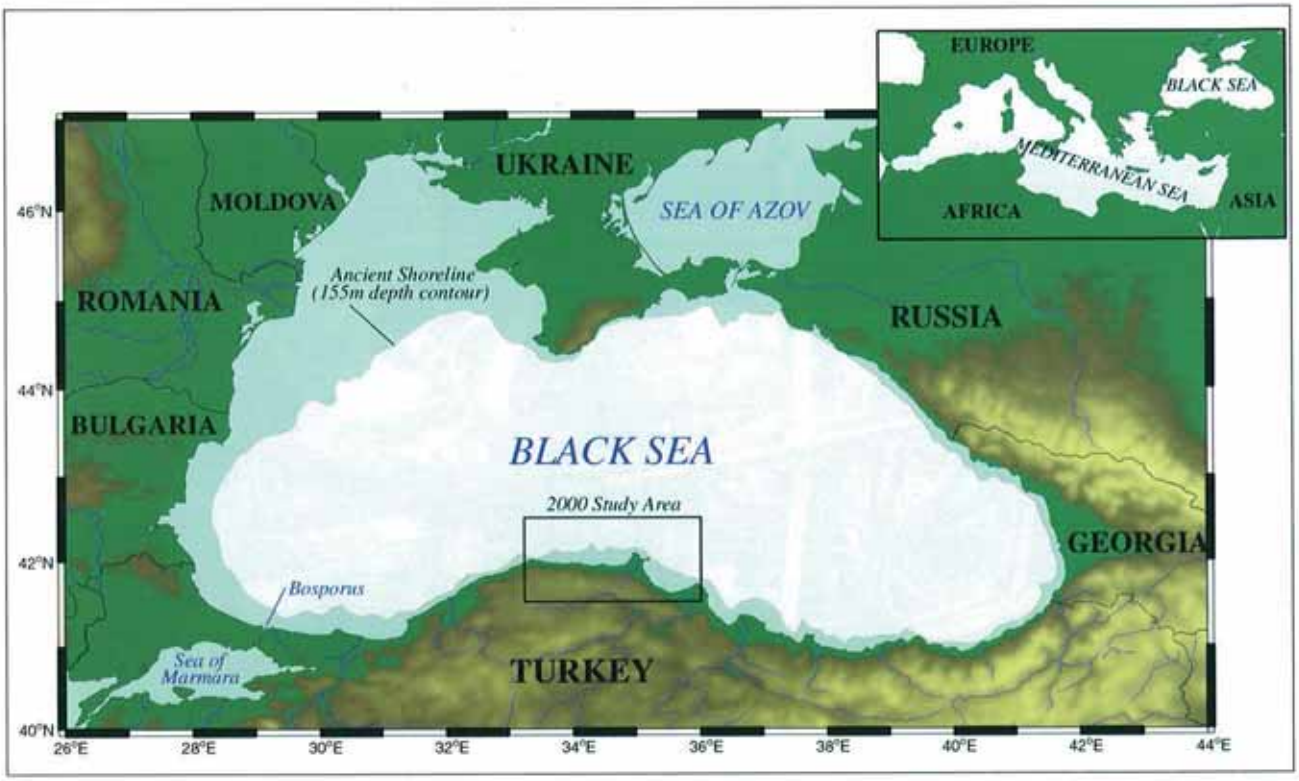

Fig. 1. Index map of the Black Sea showing the ancient shoreline (155 m depth contour) and study area for the 2000 expedition

Fig. 2. *DSL-120* side-scan sonar

Fig. 3. *Agrus* optical sled

Fig. 4. *Little Hercules* remotely operated vehicle

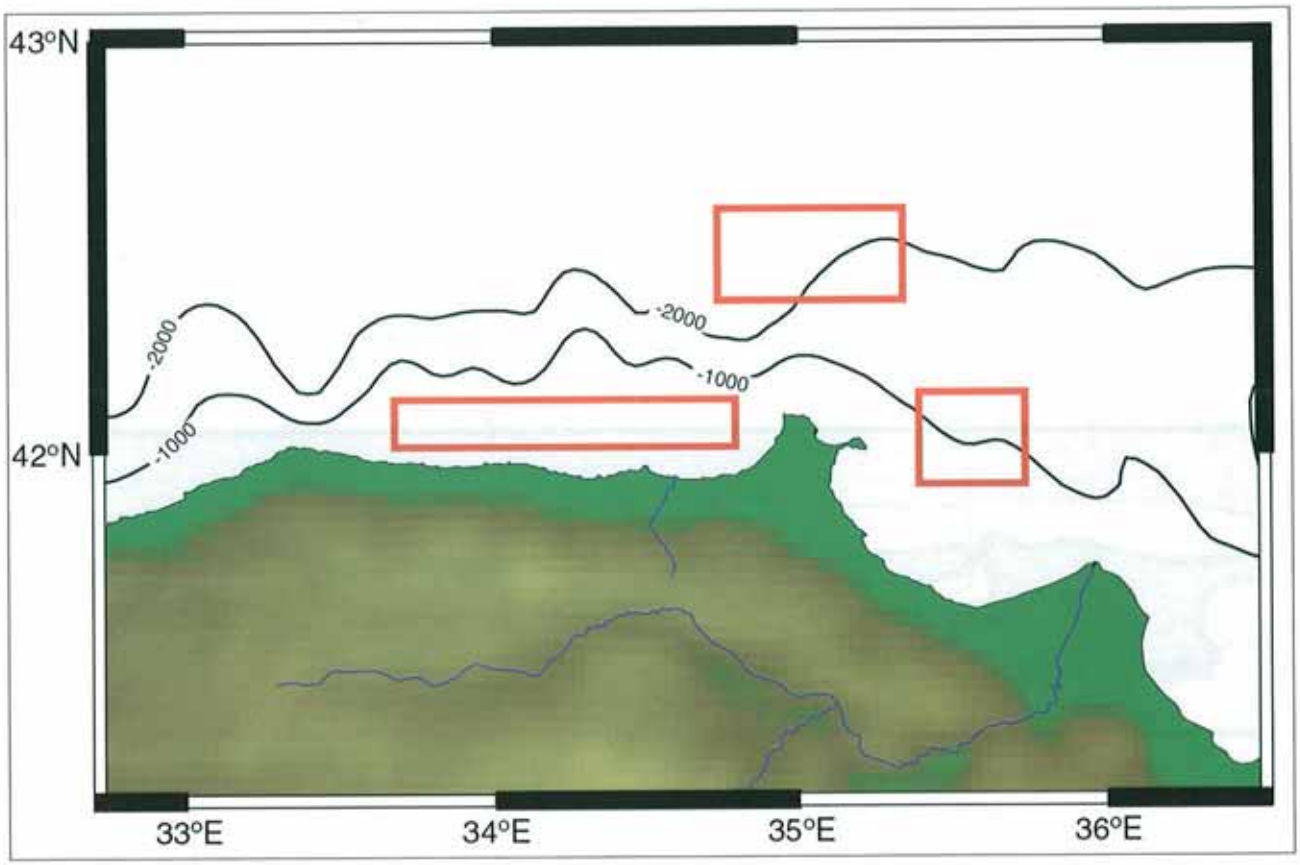

Fig. 5. Locator map for three primary study areas (within red boxes) off of the Turkish coast

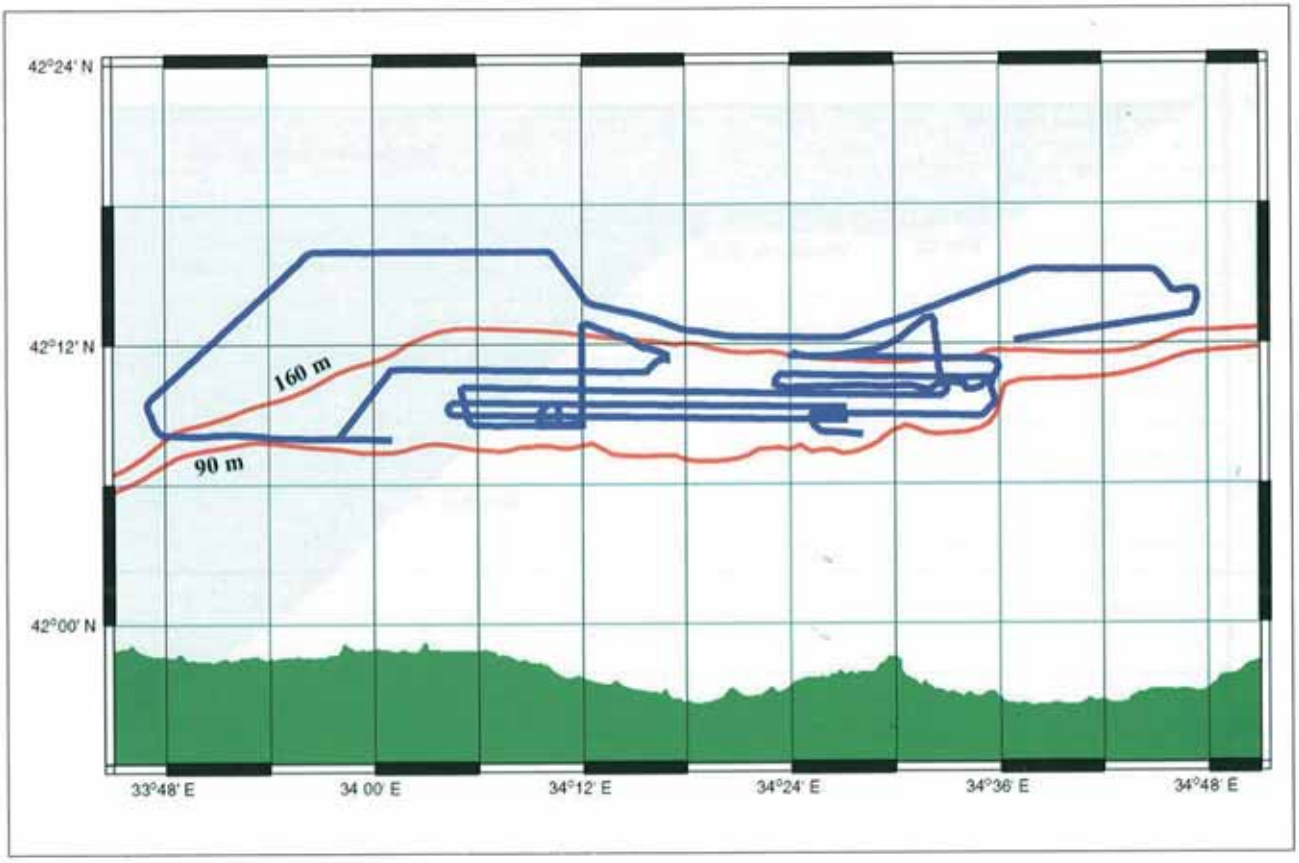

Fig. 6. DSL-120 side-scan sonar track lines in the western search box. The red colored lines represent the 155 and 90 m contours.

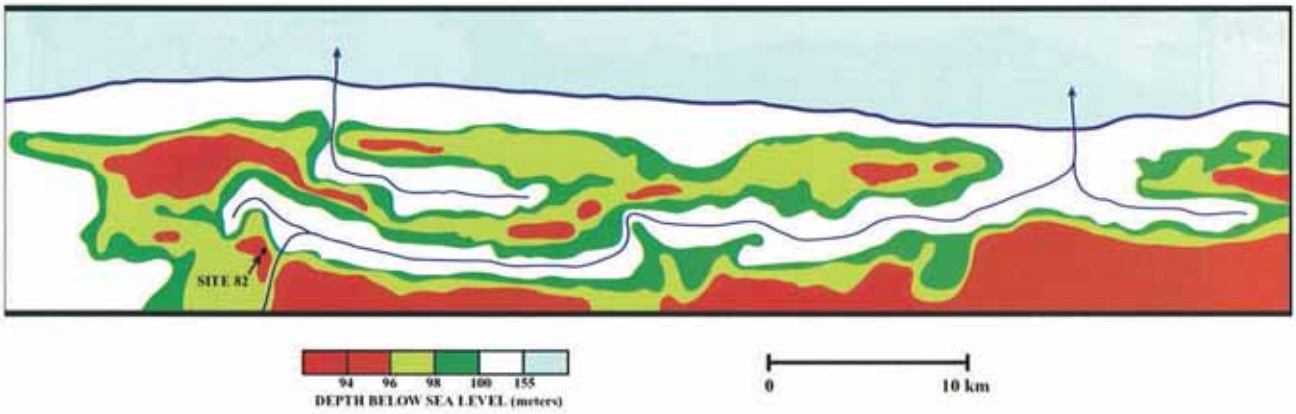

Fig. 7. Bathymetric map of study region west of Sinop

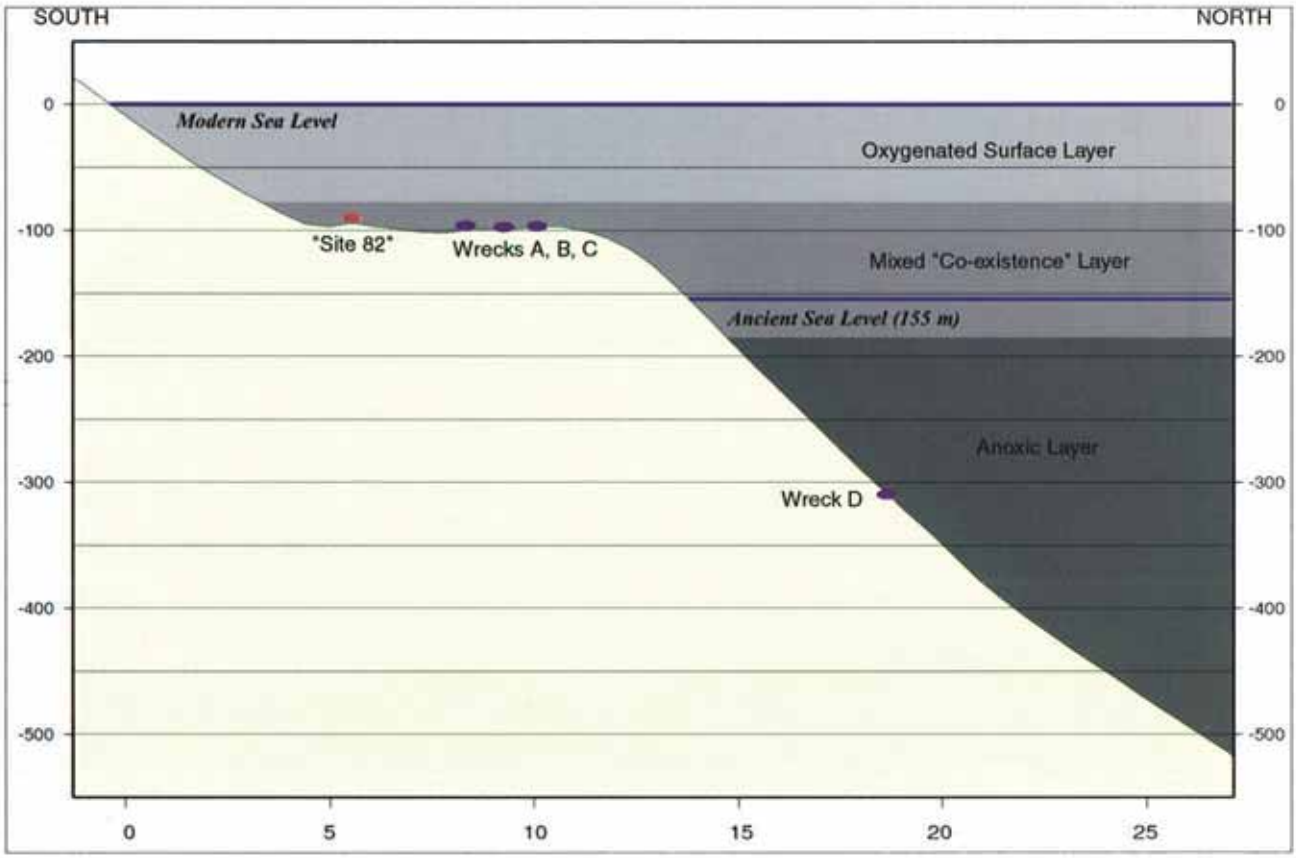

Fig. 8. Cross sectional profile through study area showing anoxic layering and depths of archaeological finds

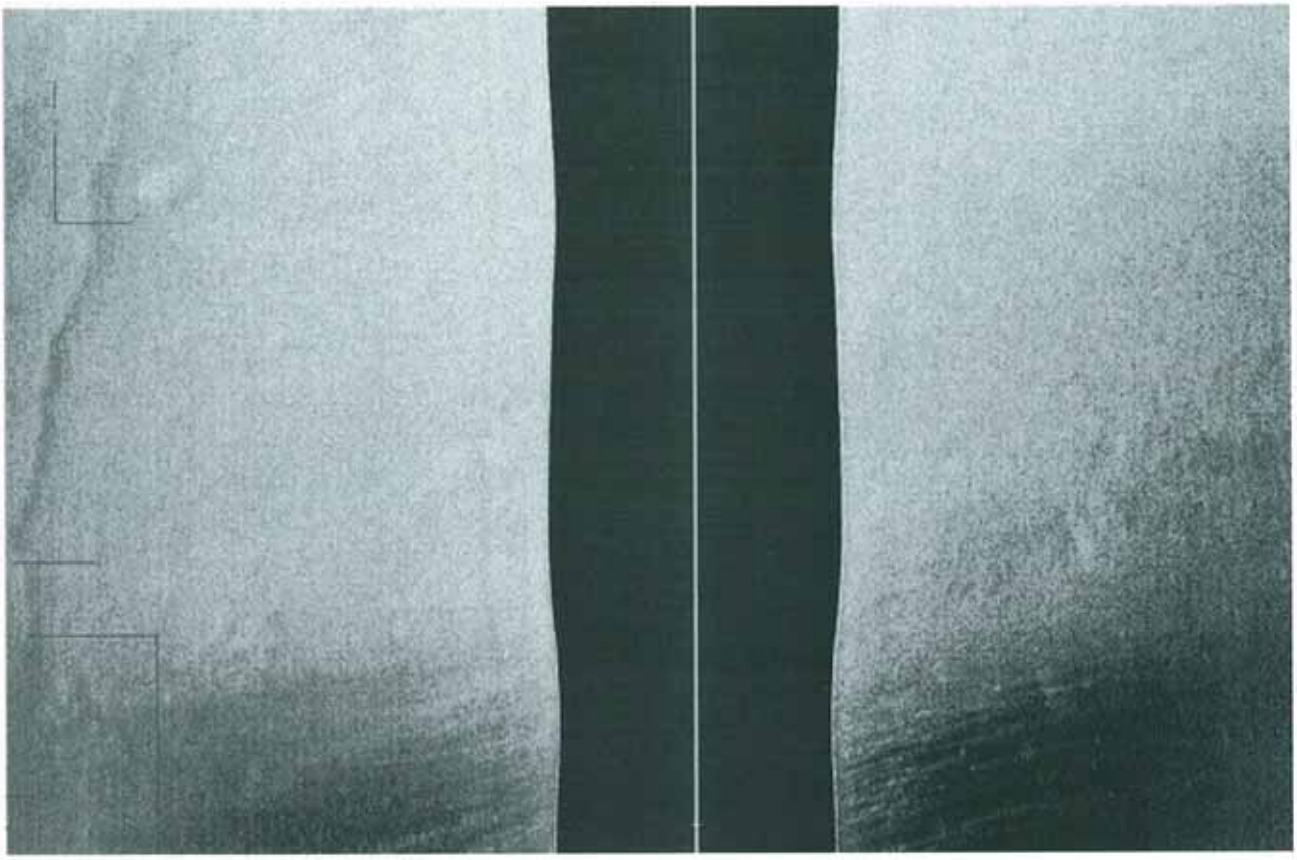

Fig. 9 . Side scan sonar image of river channel (upper left hand corner)

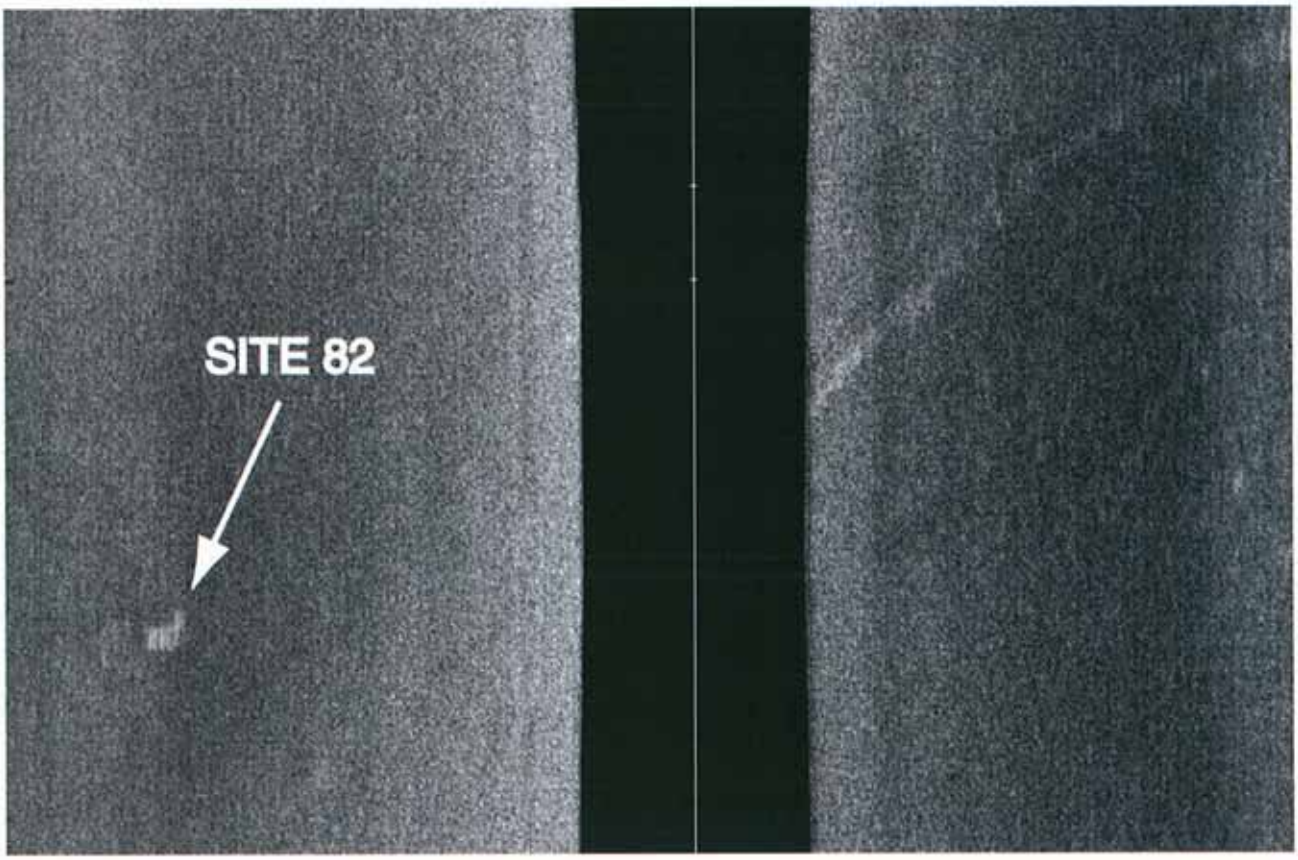

Fig. 10 . Side-scan sonar image of site 82. East is up.

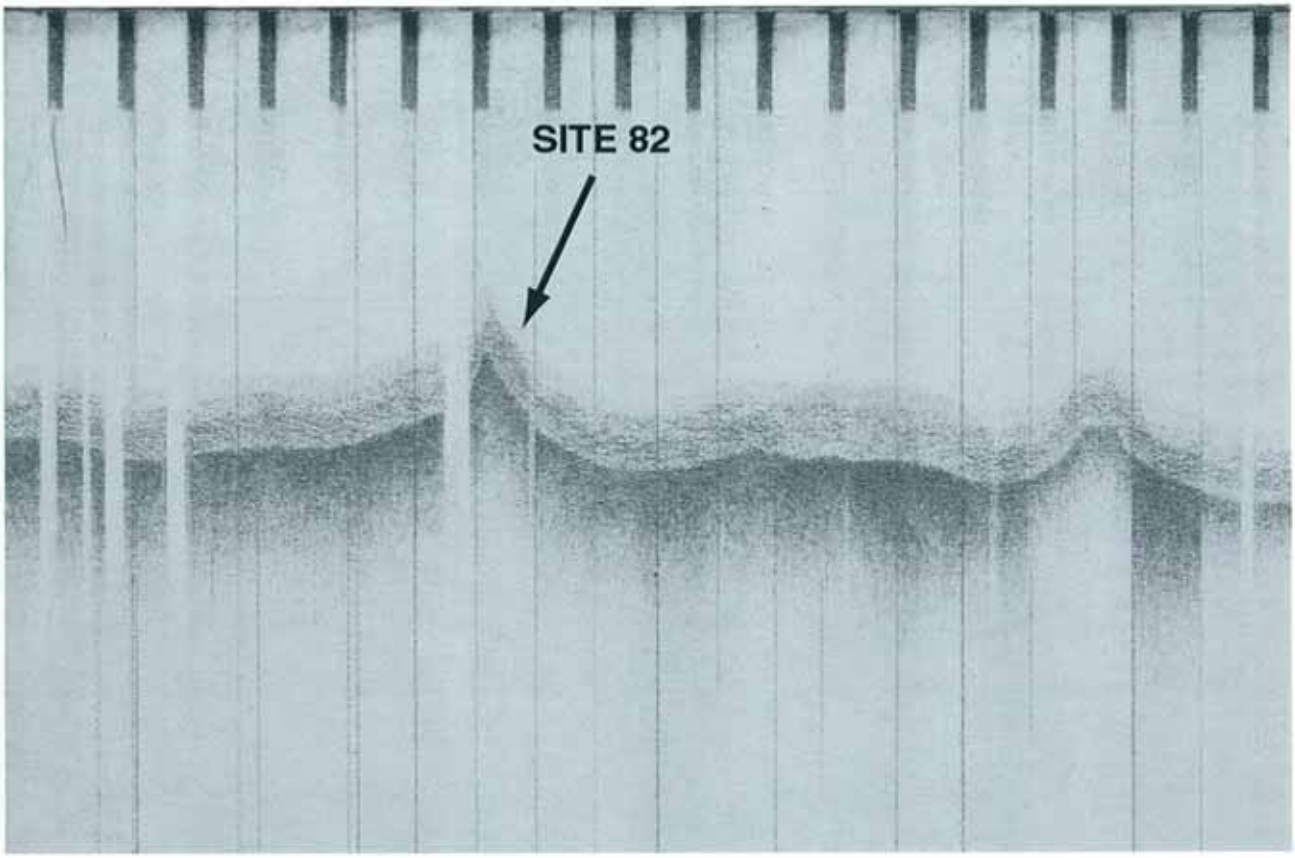

Fig. 11 . Bathymetric profile over site 82

Fig. 12 . Site 82 as viewed from Argus, with *Little Hercules* ROV hovering.

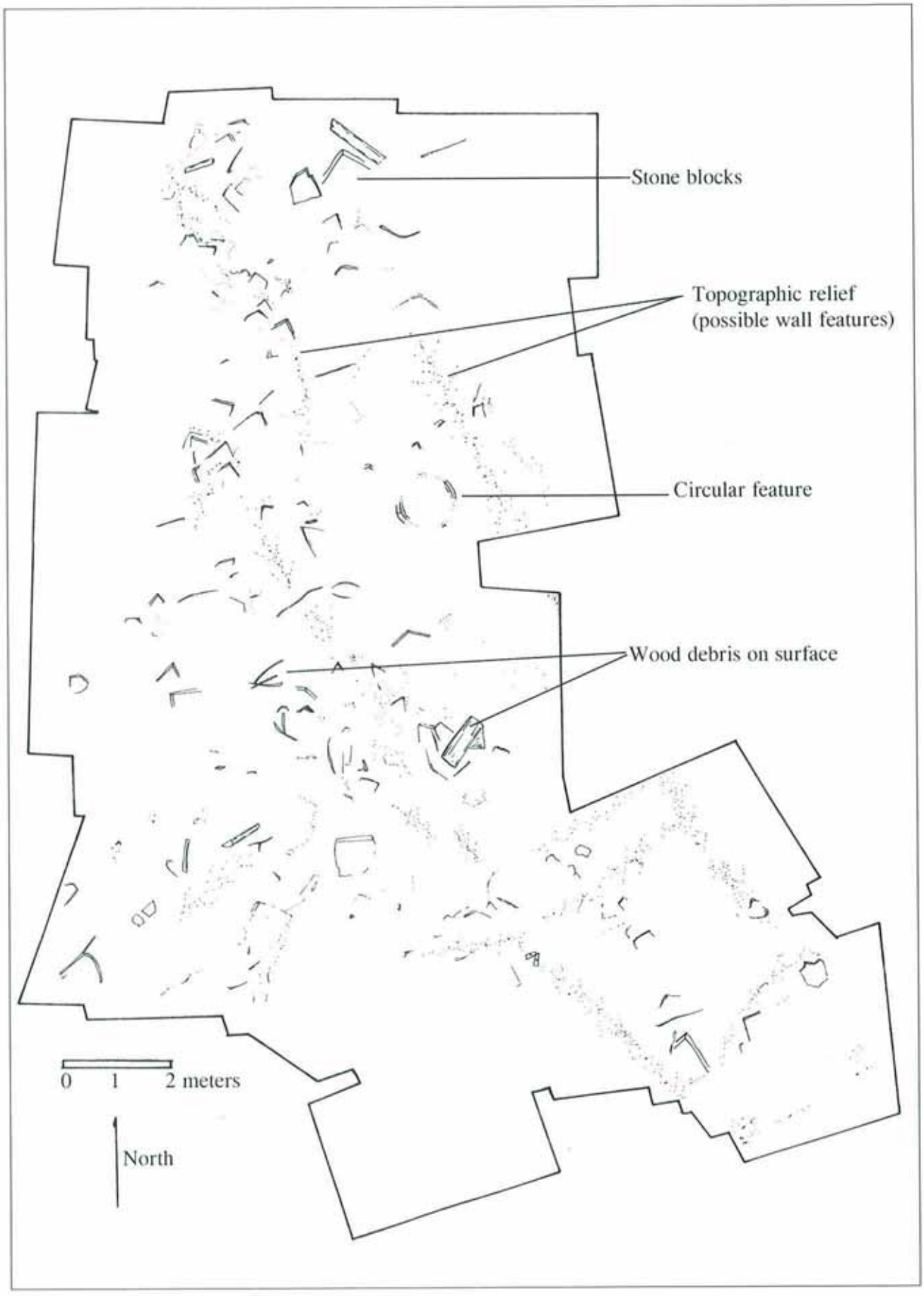

Fig. 13. Plan of site 82

Fig. 14. Image of stone blocks and hand crafted logs

Fig. 15. In situ wooden debris on site 82

Fig. 16. Video camera image of Shipwreck A

Fig. 17. Electronic still camera image of Shipwreck A

Fig. 18. Video still of the top of the mast, of Shipwreck D

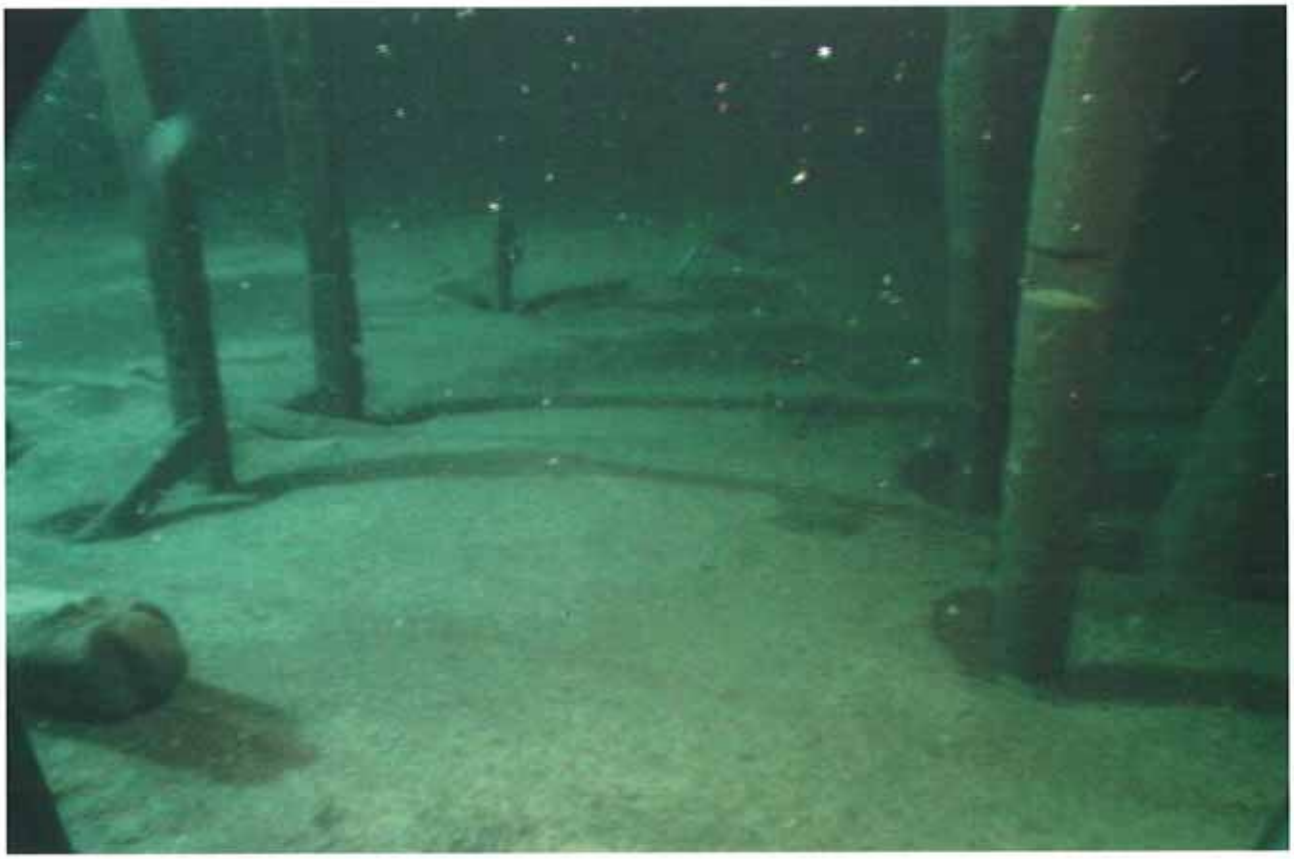

Fig. 19. Video image of stanchions along the deck of Shipwreck D

Fig. 20. Maststep of shipwreck D

Fig. 21. View of the stern deck, shipwreck D