

The HMS *Sussex* Shipwreck Project (Site E-82): Preliminary Report

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In December 2005 and January 2006, Odyssey Marine Exploration conducted a comprehensive pre-disturbance survey and limited trial-trench excavation on a shipwreck near the Straits of Gibraltar as part of the HMS *Sussex* Shipwreck Project. The site, designated E-82, lies in international waters in the Mediterranean Sea at a depth of 821m in the Straits of Gibraltar.¹ The research was undertaken within the framework of an agreement between the project sponsor, Odyssey Marine Exploration (OME), and the Her Majesty's Government of the United Kingdom (HMG), which has exercised its sovereign right to claim ownership of the wreck of HMS *Sussex*. This report introduces the technology utilized and the environmental and archaeological results obtained during the first deep-sea shipwreck excavation in the Mediterranean Sea.²

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1. Introduction

An archaeological investigation of site E-82, possibly the wreck of the third-rate 80-gun British warship HMS *Sussex*, lost off Gibraltar during a severe storm on 19 February 1694, commenced in December 2005 after the discovery of the wreck site in 2001 using side-scan sonar (Fig. 1). This followed a decade of documentary research, archaeological survey and site identification, and adhered to an unparalleled, stringent Project Plan submitted to, and accepted by, the *Sussex* Archaeological Executive (SAE), a team of archaeological consultants approved by the Government of the United Kingdom.³ This preliminary report introduces the technology and field methodology developed for the project and presents the primary environmental, biological and archaeological data obtained in order to help clarify how shipwrecks form in deep water, to

assess the level of artefact and structural remains preserved and to determine whether Site E-82 is a valid candidate for HMS *Sussex*.

The archaeological investigation of deep-water shipwreck sites is a relatively new discipline that demands specialized diving equipment and expertise. On site E-82, the main archaeological tool was a 7-ton Remotely-Operated Vehicle nicknamed Zeus, which functioned as the archaeologists' eyes and hands. Zeus was custom-equipped with specialized illumination and recording systems, including high definition, multi-camera stations using still and digital photography, video supported by powerful lighting platforms, and highly sensitive excavation, sifting and artifact recovery tools.

All of the archaeological techniques and recording methods were designed to dovetail with international standards

for archaeological investigation practices currently utilized on land. No best-practice guides have been formulated to date for deep-sea shipwreck survey and excavation, but OME's experienced personnel conducted the world's first deep-sea shipwreck excavation from 1989-1991, scientific-



Fig. 1. Side-scan sonar of shipwreck site E-82.

ly recording and recovering 16,480 artifacts from a Spanish colonial shipwreck wrecked off the Tortugas Islands in 1622. Based in part on this experience, OME self-imposed professional standards recommended for terrestrial field-work on the *Sussex* project, such as those formulated by the UK Institute of Field Archaeologists.

Pursuant to the project plan approved by the SAE (the *Sussex* Archaeological Executive), the investigation of site E-82 was sub-divided into three main phases of activity:

Phase 1, Stage 1A: site survey (non-intrusive).

Phase 1, Stage 1B: site evaluation (including limited trial excavation of a maximum 10% of the wreck site).

Phase 2: intensive excavation of target areas.

This report concentrates on the results of Phase 1, Stages 1A-1B. Phase 2 awaits the resolution of political developments (see Section 10 below). The Phase 1, Stage 1A non-disturbance methodology designed for the investigation of site E-82 demanded an inter-disciplinary approach incorporating the following diverse components:

1. A 1000 x 1000m bathymetric survey centered on the wreck, with line spacing of 20m beyond the confines of the wreck and 10m over it.
2. A 300 x 300m bathymetric survey centered on the wreck, with 2m line spacings.
3. Environmental study of the site and seabed.
4. Marine biological characterization.



Fig. 2. Odyssey's research platform during the *Sussex* shipwreck project, the 76m-long, 1431-ton Odyssey Explorer.

5. Video survey: coverage of the 300 x 300m square area centered on the wreck.

6. Pre-disturbance photomosaic (60 x 30m area).

7. Production of a pre-disturbance master site plan based on the photomosaic.

8. Imposition of an electronic grid over the wreck site for the contextual recording of artifacts, trench locations and modern intrusions (Fig. 13).

9. Measurement of all surface archaeological features. The heavily concreted iron cannon and anchors were surveyed as individual elements. Measurements were taken from the ROV while it maintained a constant altitude over the wreck. Metric data were acquired from target points, such as the cascabel and muzzle ends of cannon. The ROV laser pointer was centered on each target point and a total of 10 fixes in the x and y planes were taken for each one in reference to the site grid. The measured data were then processed and the averages of the 10 values plotted on the site grid.

10. Designation of sterile lanes for ROV movement to ensure non-disturbance of the wreck's integrity.

11. Recording of modern contamination on the wreck site.

12. The removal of 4-10cm of sterile sediment overlying the cultural remains on the site to 'dust off' the surface archaeological features.

13. Production of a second photomosaic and a related master site plan following the exposure described in Item 12.

By agreement with HMG, the Phase 1, Stage 1B trial excavation permitted one 3m-wide evaluation trench to be excavated at the south-western end of the wreck, tentatively interpreted as the stern. Its precise location and dimensions would be determined by the results of Phase 1, Stage 1A, but would be limited to 10% of the total wreck area. Due to the dense nature of concretions on the surface of site E-82, a judgemental methodology was finally adopted, whereby five small trial trenches were opened with the objective of assessing the level of site preservation and determining the ship's orientation on the seabed.

2. Field Methodology

Odyssey's research platform during the *Sussex* shipwreck project was the 76m-long, 1431-gross-ton *Odyssey Explorer* (Fig. 2). This ship is fully-equipped to support deep-sea exploration and is classed to Ice Class 3 for operations in extreme latitudes. It has accommodation for a crew and staff of 41 people and contains deck-mounted deployment capability, umbilical cable and recovery equipment suitable

for the operation of a work-class ROV system. The *Odyssey Explorer* has the ability to work offshore without re-supply for 60 days.

An ROV formerly used in the heavy-duty cable industry for trenching and cable-burying operations was adopted for the project, with the capacity to operate in strong currents with requisite powerful precision-controlled thrusters and state-of-the-art manipulator arms. The ROV system was also required to be well-balanced for operations in proximity to delicate artifacts and shipwreck structure. The ROV used on site E-82 was the Soil Machine Dynamics Ltd. 'Nereus', now renamed Zeus (Fig. 3). At 7.26 tons and measuring 3.7 x 3.1 x 2.38m, Zeus has the capacity to conduct all aspects of seabed survey, excavation and recovery with sustained duration at depths down to 2,500m. Zeus has been rendered safe for use in delicate archaeological environments through buoyancy compensation and a precision control system. When configured for field operations after a series of sea trials, the ROV operates at neutral buoyancy, overcome for descent to the sea floor by using its thrusters in a powered dive.

There are three main electronic navigation aids that work together to enable Odyssey to conduct accurate positioning and measurement: GPS, Ultra Short Baseline (USBL), and Long Base Line (LBL). This hardware works in conjunction with a navigation software program called 'Winfrog'. Integration of these positioning and acoustic systems, along with custom proprietary computer software, enables tracking of the work platform to a position above the site, the ROV to the seabed and then provides for precise measurement across the wreck site.

During sub-sea operations, a transducer/receiver head is mounted on a pole that can be deployed and retracted through the work platform hull. This device triangulates the position of the ROV as it descends toward the seabed, sends acoustic signals back and forth to the ROV and, later on in the process, to sub-sea acoustic beacons secured on the seabed. The Winfrog program then decodes and displays this data, which is also correlated with Odyssey's own proprietary data-logging software. For survey, the ROV is also fitted with a Kongsberg Simrad Mesotech 6000m Digital Sonar.

Zeus is powered by a pair of 75kW electro-hydraulic power packs, combining for a total vehicle power of 150kW from a 50Hz supply. The propulsion system consists of eight reversible hydraulic thrusters: four 43cm-diameter units aligned on the horizontal plane, and four 30cm-diameter units operating on the vertical plane. Each thruster's speed is controlled via electro-hydraulic valves.

For manipulation, Zeus is fitted with two Schilling

The fieldwork staff on site E-82 comprised:

Role	Name	Organization
Company Director	Greg Stemm	OME
Project Manager	Tom Dettweiler	OME
Project Manager	Andrew Craig	OME
Principal Investigator	Anthony Martin	Gifford Ltd
Director of Field Archaeology	Neil Cunningham-Dobson	OME
Director of Field Archaeology	Hawk Tolson	OME
Director of Field Archaeology (Substitute)	Christopher Preece	OME
Geoscientist	Richard Bates	TEAM, Fife *
Marine Biologist	Fernando Tempera	TEAM, Fife *
Historian	Lange Winckler	OME
Consulting Project Conservator	Herb Bump	OME
Conservator	Wyatt Yeager	OME
Data Manager	Gerhard Seiffert	OME
Data Logger	Alexandre Soenen	OME
Data Logger	John Vorus	OME

The project post-excavation specialists comprised:

Role	Name	Organization
Geo-environmental Assessment	Richard Bates	TEAM, Fife *
Petrological Analysis	Peter Kokelaar	Department of Ocean and Earth Sciences, University of Liverpool
Naval Historian	Brian Lavery	Curator Emeritus, National Maritime Museum, Greenwich
Wood Species Analysis	Jill McVee	Histology Unit, University of St. Andrews
Pottery Specialist	Jacqui Pearce	Museum of London Archaeology
Brick Analysis	Terence Paul Smith	Museum of London Archaeology
Marine Biology	Fernando Tempera	TEAM, Fife *
Wood Species Analysis	Alyson Tobin	School of Biology, University of St. Andrews

* Topaz Environmental and Marine Ltd.

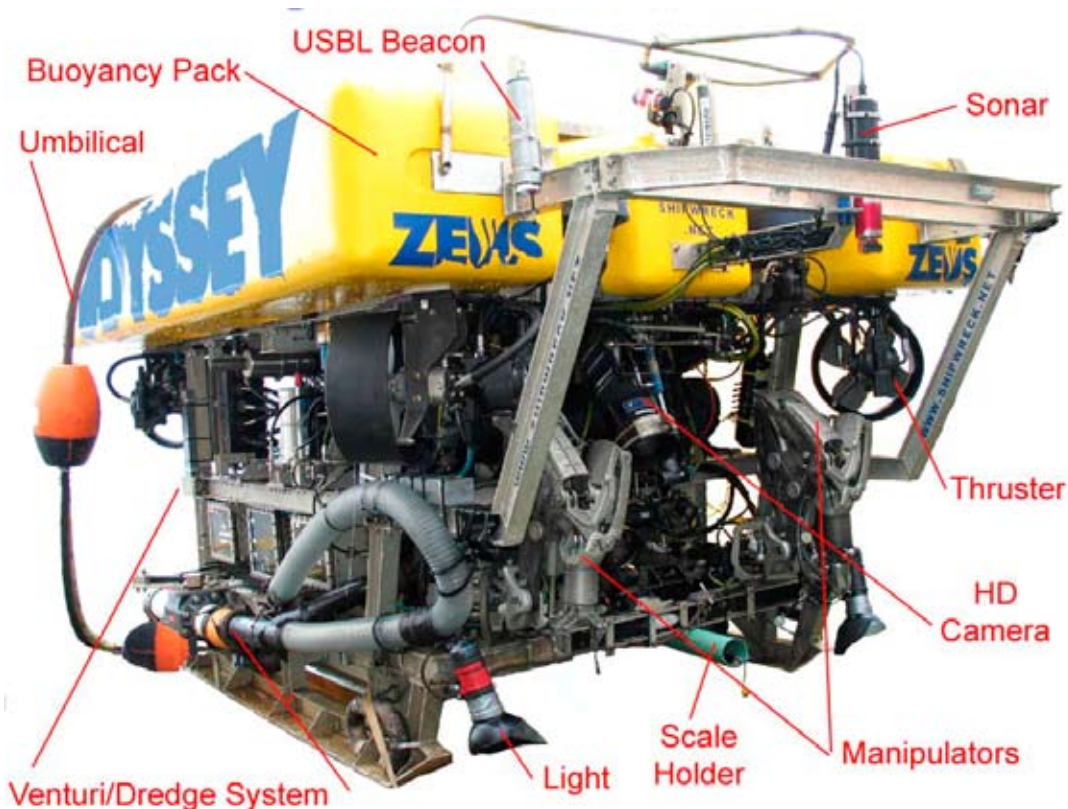


Fig. 3. The anatomy of ROV Zeus.

Conan seven-function 'master/slave' manipulator arms at either side of the front of the vehicle with a reach of 1.79m, a working arc of 120° and a lifting capacity of 170kg at full extension. A master/slave feature causes the manipulator arms to duplicate in seabed operations the movements of the operator on the research ship above. The rest of the ROV system consists of Odyssey's unique, proprietary sediment collection and filtration system (SeRF™), a shipboard deck crane acting as a launch and recovery system, an umbilical winch on the aft deck, a surface control cabin from which the ROV is directed, an acoustic vehicle location and navigation system and an electrical power distribution system.⁴

Conducted at considerable distances from the surface, the collection of sediments or their displacement by dredging presents unusual technical complexities. To meet this challenge, Odyssey has developed techniques and proprietary equipment for controlled excavation and sediment removal. For excavation and artifact recovery, a specialized sediment sifting and collection pump and a limpet suction device are utilized.

From a turbine water pump located at the rear of the ROV, water is drawn in through the intake and diverted through a hose to a venturi fitted on the starboard side of the vehicle. This creates suction without the use of any

moving parts, which can be adjusted for sufficient strength to lift or move large, heavy objects. The flow can also be reversed through a valve to enable the hose to discharge rather than suck, a capability that is sometimes useful for gently dusting overburden during archaeological operations under controlled conditions, as well as for clearing blockages in the hose.

In addition to providing dredging functions for site clearance, the venturi pump is the central component for operating both Odyssey's proprietary Sediment Removal and Filtration System (SeRF™) and the suction limpet. This system meets the challenge of collecting and sifting sediments at great depth. Standard shallow-water marine archaeology practice generally employs large suction dredges to remove sand and sediment, which is sometimes sieved for small finds and ecofacts.

SeRF™ incorporates a dredge head/nozzle with separate collection and filtration elements housed in a box-like structure mounted on the stern of the ROV. When the system is engaged, collected sediments and small finds are channeled into a collection and filtration chamber, instead of being exhausted. This chamber captures very small artifacts, such as buttons or seeds (amongst a far wider variety of assemblage forms), while sediments are discharged through

an opening to the rear of the container. The SeRFTTM unit is also configured to retain the sediments within which smaller artifacts are embedded. The container for excavated spoil contains a wire mesh shelf that can be removed following recovery of the ROV and used to transport collected artifacts and sediment directly to the ship's artifact processing and conservation facility for study and recording.

Delicate artifacts are retrieved from the seabed using a silicone rubber limpet suction device. Known simply as the 'limpet', it consists of a soft bellows-shaped tube with a small suction pad at the distal end. These are available in different sizes, with suction pads ranging from diameters of 2-10cm (Fig. 9).

The limpet assembly is fitted to the port manipulator and powered by the venturi pump. It can be used to pick up delicate items, such as small buttons weighing a few grams or less, or even tiny glass ampoules. When fitted with a large suction pad, the limpet can lift objects comparable to a 60-liter Roman amphora weighing 45kg or more. On previous projects, this device has been used to recover glass inkwells, panes of window glass, thin sheets of slate, ballast stones and coins without any physical or cosmetic damage to the artifacts.

Photography and lighting are a vital component of any ROV archaeological survey or excavation in deep water. Zeus serves as the eyes as well as the hands of the archaeologist, so a complex suite of cameras was added to her on-board equipment. These high-resolution cameras, combined with Halide Mercury Incandescent (HMI) lighting, supply the archaeologist and ROV operator with high-quality images, significantly surpassing the visibility that might be experienced by a diver. The main cameras also have pan and tilt controls.

Large HD Plasma monitors aboard the work platform allow the archaeologist, ROV pilots and project manager to view every aspect of seabed operations, including close-up images of items only a few millimeters in size. In addition, two desktop computer screens set side-by-side display the Winfrog results of navigation/survey activity. Data from the ROV is simultaneously transmitted to three separate on-board work areas: the 'ROV Shack', which houses the ROV pilots; the 'Online Room', which houses the surveyor, navigator, and datalogger; and the 'Offline Room', the work area for the archaeologists, project manager, and specialist observers.

A ship-wide intercom communication system links the archaeologist directly to the ROV pilot, the surveyor/navigator, the data loggers, the officers on watch and the ROV deck crew. During all operations involving excavation, documentation, or any other potential disturbance of the

wreck or its environment, the archaeologist supervises all ROV tasks and is in constant contact with all stations. The Offline Room also contains a high-speed Laser Jet printer, a large format plotter for producing site photomosaics, a dedicated graphics computer, a curator's computer where all the images, logs and other artifact records are stored and a large map table for producing site plans and illustrations.

Deep-water archaeology demands accurate sea bottom survey and navigation capabilities. For these purposes, Odyssey has adapted advanced sub-sea acoustic systems to establish accurate positioning information for the location of the ROV and its manipulator arms or other tools during exploration and excavation activities, with the objective of achieving accurate relative position recording at all times. Detailed positioning information creates an analog to the physical grid and hand-measurement recordings common in shallow-water wreck investigations.

In addition, Odyssey has developed a unique data logging system (compatible with Microsoft 'Access' software) to record all events and activities. Known as DataLog[®], it receives and processes data from the ROV in real time. All activities, artifact manipulations and environmental and archaeological observations are recorded through the selection of choices from drop-down menus and accompanied by a typed comment from the datalogger. The system is manned 24 hours a day when the ROV is in the water and automatically logs all events, including time, date, dive number and X, Y, Z coordinates of any activities.

Every second of every dive is recorded in triplicate on high-capacity digital DVD. Archaeological and other interesting footage for which detailed examination is desirable is also recorded on High Definition tape. Detailed photo and video records are kept by the crew and these logs allow complete reconstructions and analysis of each dive. Data sheets, maps and reports for a variety of individual requests are created from this extensive digital archive.

Artifacts, wreck structure and other objects of interest collected using the limpet and manipulators can be placed in numbered plastic baskets and containers that are set in sterile areas within reach of the ROV. Artifact baskets/containers are placed into a 4-Plex, a large metal basket with 16 divisions for separation of archaeological materials by context. Each division is numbered and every bucket/basket numbered and photographed for recording in DataLogger[®].

3. Site Description

Site E-82 is located to the south-east of Gibraltar at a depth of 821m. The seabed consists of clay and sand formed on the surface of a soft bluish sediment base (Table 1).

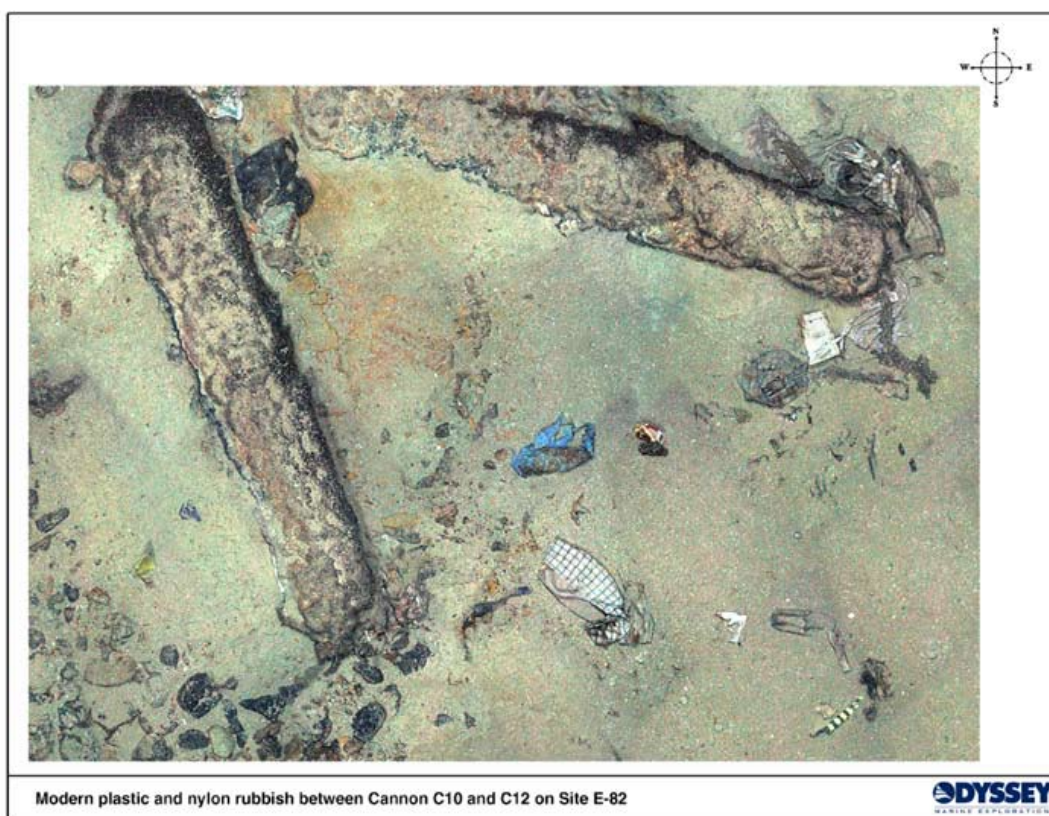


Fig. 4. Modern plastic trapped between cannon C10 and C12.

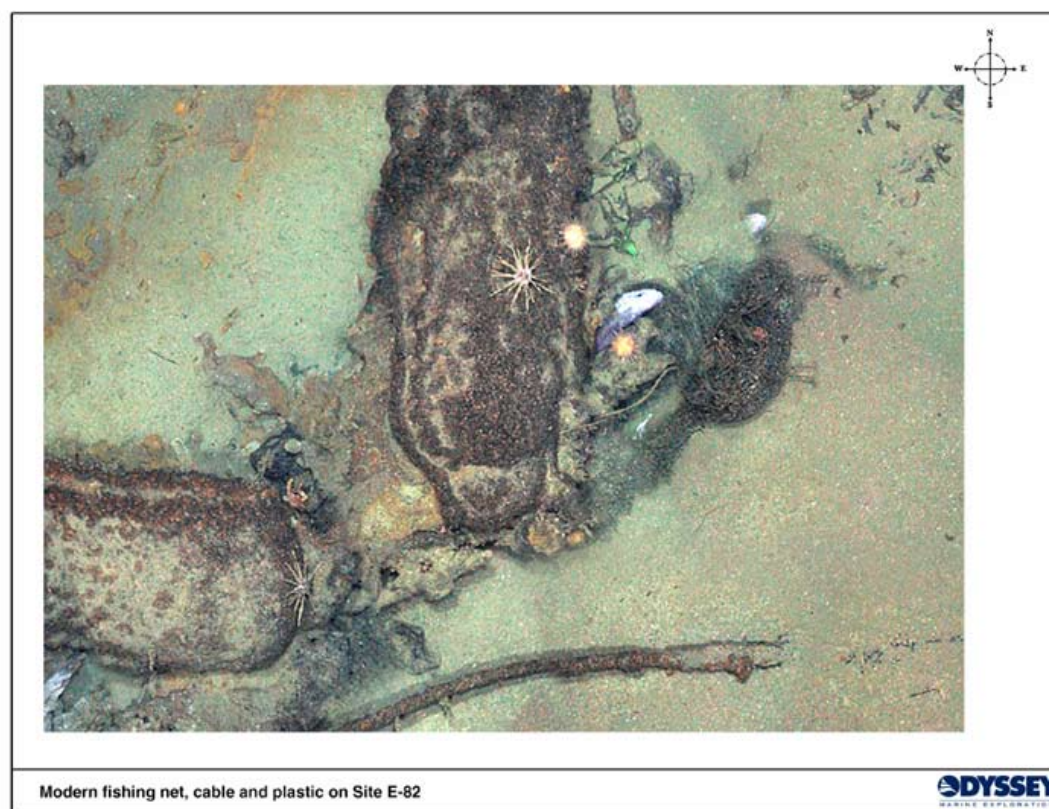


Fig. 5. Modern plastic, fishing net and trawler cable near cannon C5 and C6.

Contrary to prevailing stereotypes of wreck formation, observation of this site, and many other deep-sea sites discovered by Odyssey, indicate that no correlation exists between increased depth and superior site preservation. In fact, site E-82 displays widespread evidence of accretion and scouring caused by the constant movement of sediments and currents across the site. Evidence of modern pollutants is especially extensive (Figs. 4-5). Rather than 'frozen in time' on the seabed, site E-82 lies in a highly dynamic and unstable environment of deterioration and decay.

The prevailing surface currents mostly derive from the north-east. Between the surface and depths of about 300m, rates vary from nearly slack to 5 knots. Beyond this depth, the lower stratum of water is a high-salinity layer, with flow rates varying from near slack to 3 knots at the seabed. The water temperature of approximately 13° centigrade is relatively consistent.

In addition to 92 hours of survey data recorded on high-definition video, a pre-disturbance photomosaic and a second 'post-dusting' photomosaic served as the primary visual tools to characterize site E-82 and select optimum areas for trial trench excavation (Fig. 11). To collect the

primary data for the preparation of each photomosaic, ROV Zeus ran 81 parallel transit lines across an area of 60 x 30m, spaced 80cm apart, at a constant speed of 0.5 knots, creating a stable horizontal altitude platform of 2.5m above the seabed from which to photograph. A 75% overlap of flanking lines was maintained to ensure the highest level of coverage control, and three 1m-long scales were placed on the site to generate information on dimensions. Creation of the pre-disturbance macro-photomosaic required 2,902 individual digital still photographs to be taken and the 'post-dusting' close-up of the wreckage itself was assembled from 642 images.

The surface manifestations of the wreck, lying on a north-east/south-west axis, measure 26.5m long and 6.5m wide maximum. A total of 17 iron cannon, two anchors and large areas of concretions functioning as sealing layers were visible on the site's surface at the time of the survey. Towards the north-western flank is a dense rectangular concentration of stones, interpreted as possible ballast (Fig. 6). Each individual artifact and context was measured *in situ*, photographed, and videoed in Stage 1, Phase 1A (Figs. 7-9).



Fig. 6. Possible ballast stones and planking on the north-western side of the wreck.

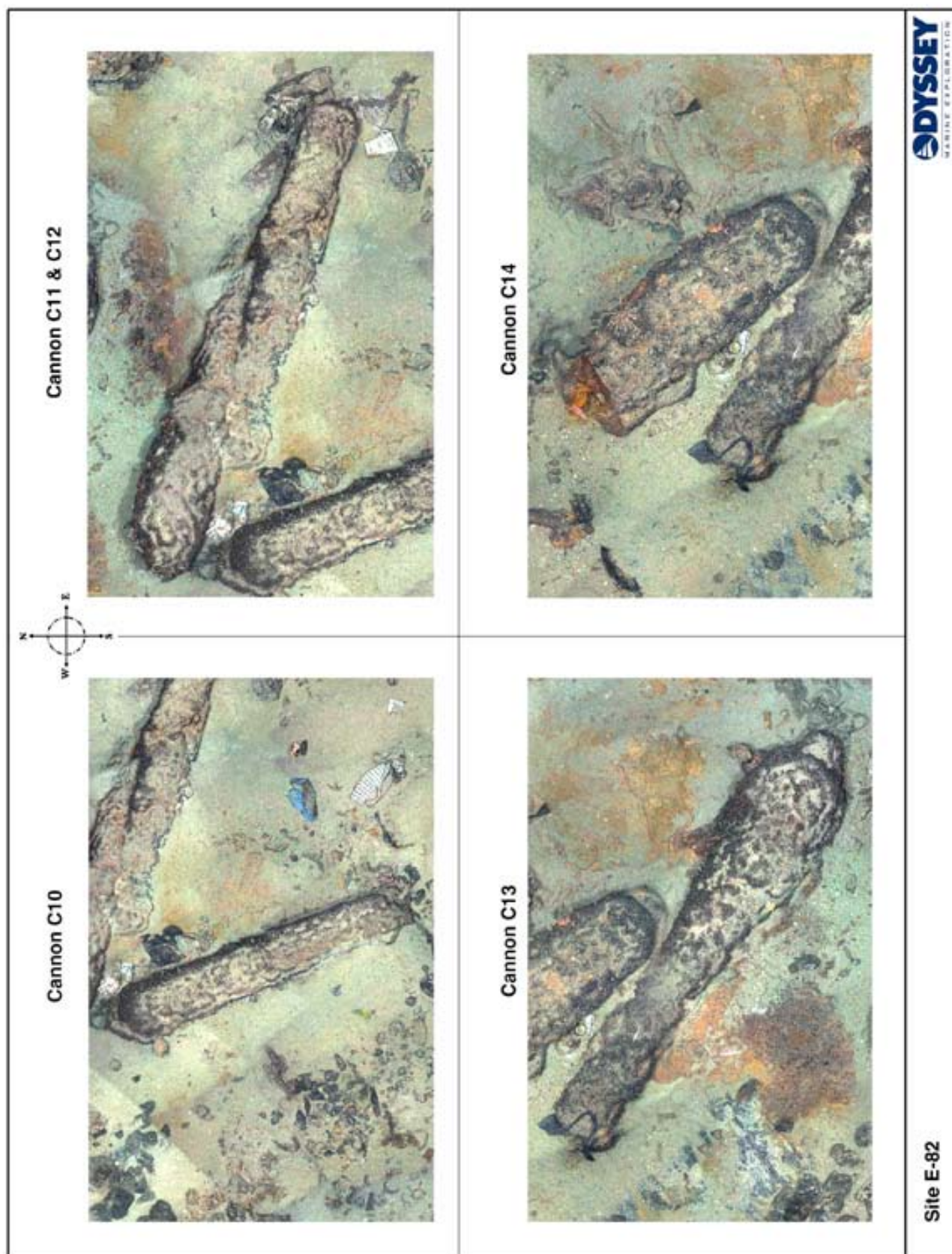


Fig. 7. Heavily concreted iron cannon from the shipwreck. Note the modern plastic pollutants around cannon C10, C11 and C12.



Fig. 8. Encrusted iron anchor A2, with substantial modern pollutants to the east.

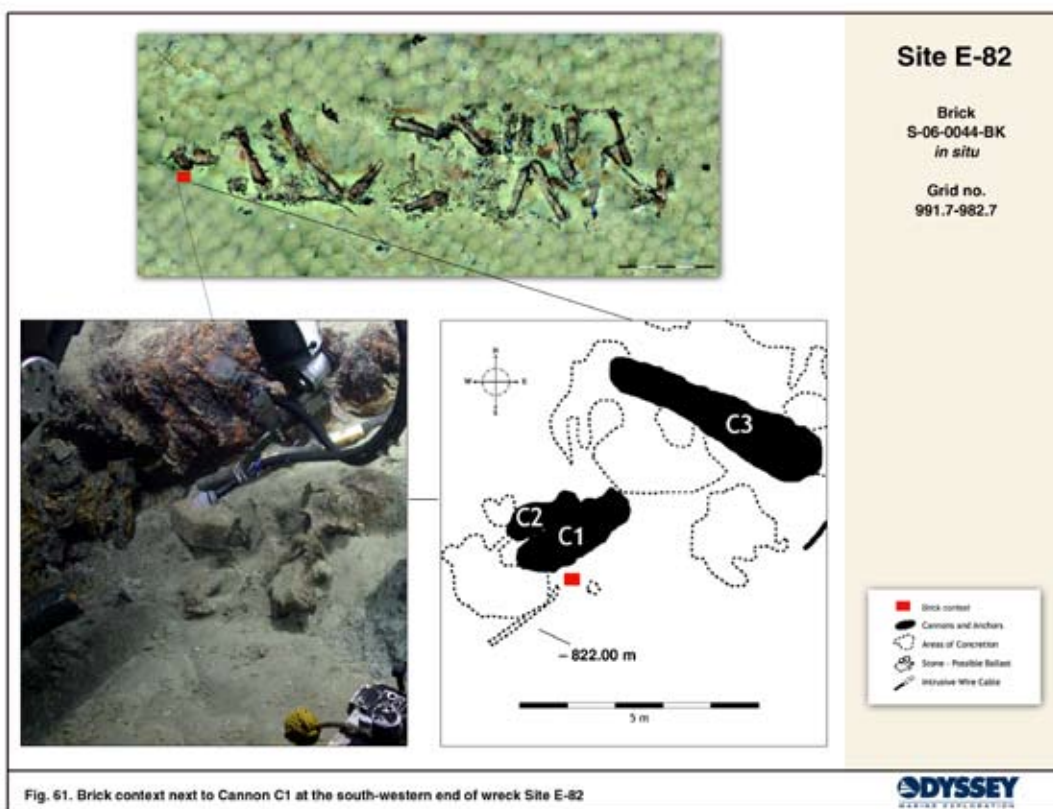


Fig. 9. The context of a brick fragment, probably from the galley, recovered from the south-eastern end of the wreck.

A disturbing volume of modern rubbish has polluted the wreck site and continues to accelerate its degeneration. Visibly snagged beneath cannon and scattered across the site are black plastic bags containing domestic waste, scrap wire, cable, rope and sections of fishing nets (Figs. 4-5). Plastic intrusion is especially notable north of cannon C9. Some of the plastic bags have ripped open, spilling their contents over the archaeological deposits and seabed sediments. Plastic food containers and tin cans penetrate at least 30cm beneath sediments around cannon C14, while a beer can is encrusted onto the surface of cannon C10. More hazardous material includes asbestos waste clearly labeled 'DANGER' (Cunningham Dobson, N., *Cambridge Expedition 2001. An Archaeological Investigation*: figs. 18, 19, 75). This rubbish probably derives from a combination of vessels sailing the busy shipping lanes around the Straits of Gibraltar, as well as washed offshore from land, and has mixed into the site matrix through vigorous current activity. Trapped fishing trawler gear is extensive on the south-western area of the wreck and extends over an area of 5m on a south-west to north-east axis.

To assess the seabed topography, two bathymetric sur-

veys were conducted. A 1000 x 1000m bathymetric survey area centered on the wreck was based on 76 east-west traverses of the ROV, which maintained a minimal line spacing of 20m beyond the confines of the site and a 10m line spacing over the wreck itself. Over 36,375 depth measurements were assessed, corrected for tidal variation, to derive the final bathymetric profile. A more intensive bathymetric survey was conducted over a grid of 300 x 300m, with ROV Zeus operating in auto-depth mode to maintain a constant altitude above the seabed and running 151 east-west traverses at a line spacing of 2m. A total of 22,000 individual acoustic readings were accumulated by the altimeter and processed to develop the bathymetric profile (Fig. 10).

The bathymetric survey exposed a largely flat seabed gently sloping to the north-west by 3°, with a maximum amplitude of some 2.32m across a 60 x 30m core area centered on the wreck. The average depth of the site is -821.7m, with a maximum amplitude of 0.78m across the visible wreck. The shallowest area lies at -821.35m to the north-east in the vicinity of cannon C10. The deepest area of the wreck is located on its western flank at -822.13m (Fig. 12).

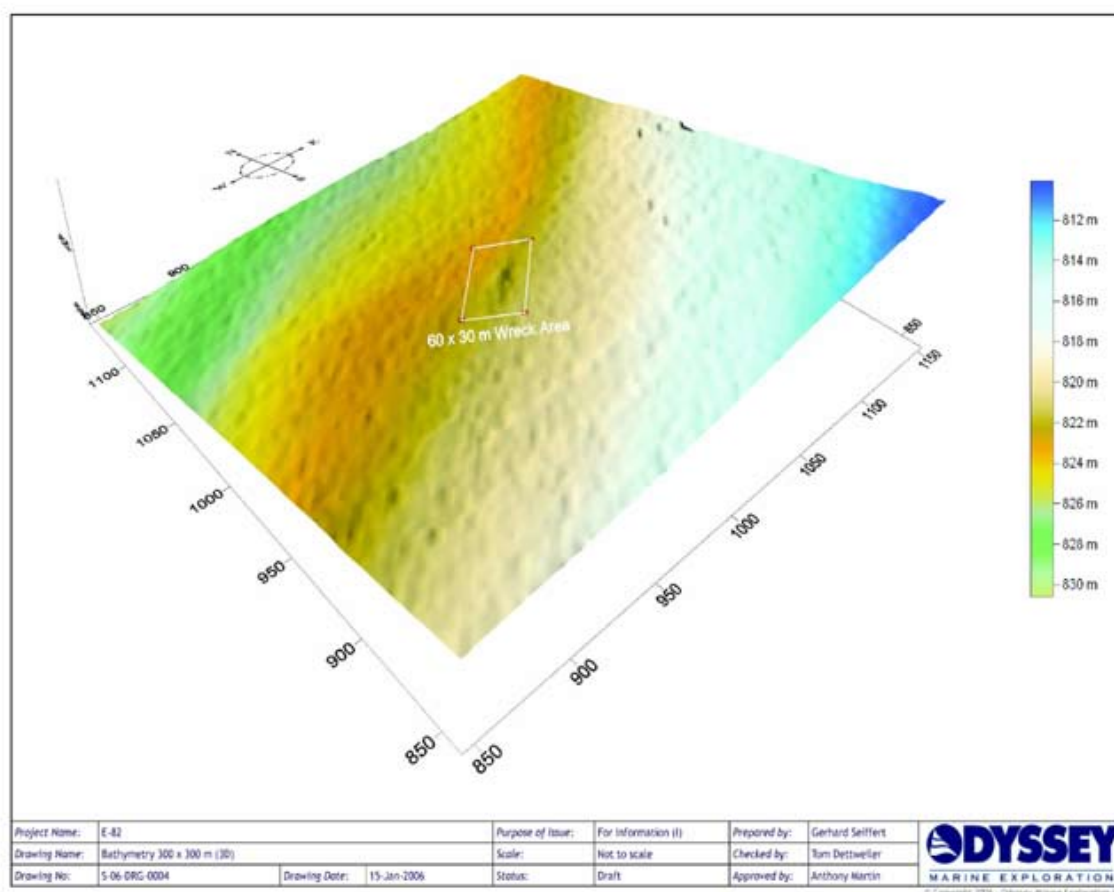


Fig. 10. 3D bathymetric profile (300 x 300m) centered on the wreck site.

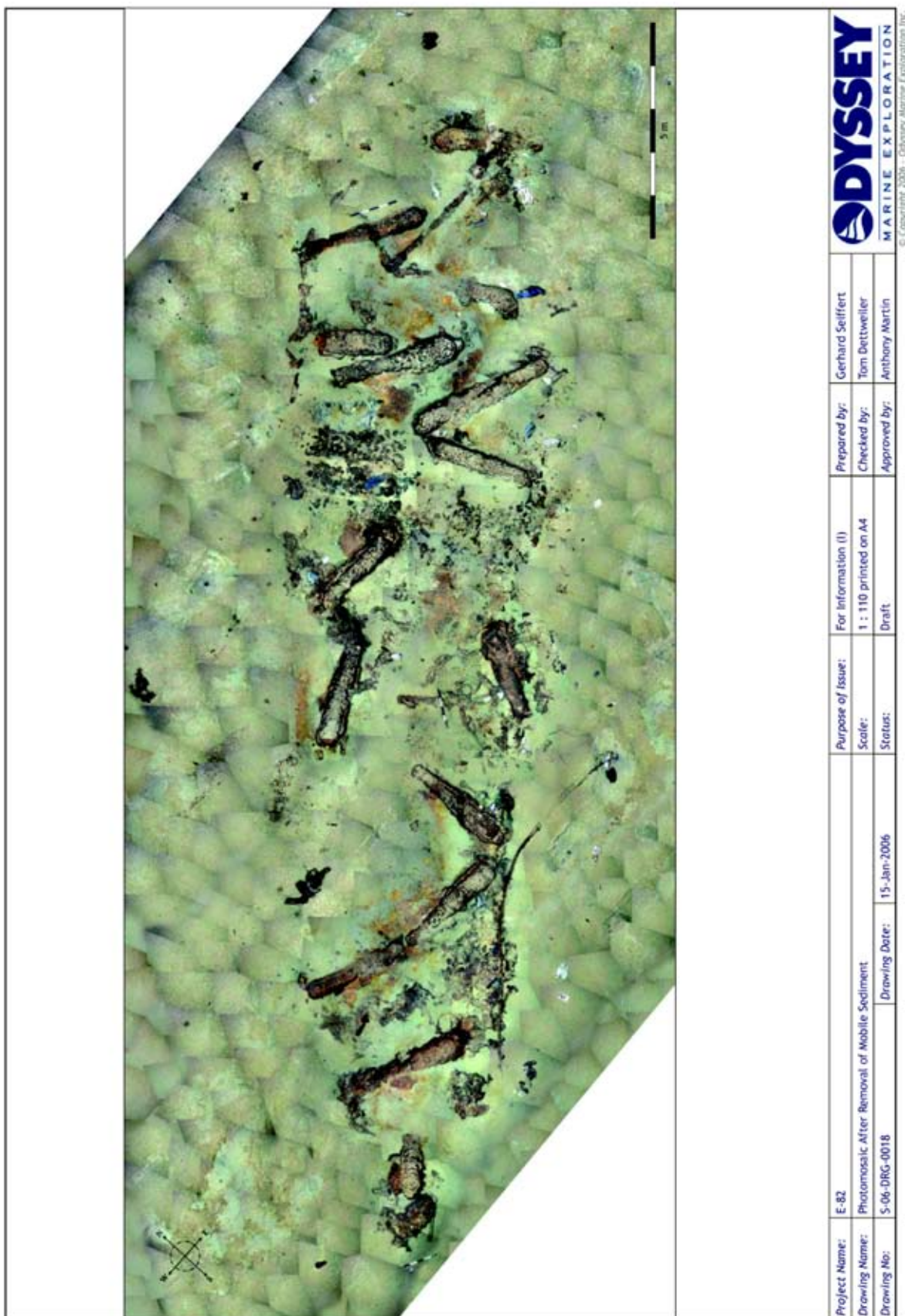


Fig. 11. Photomosaic of the wreck after the removal of mobile sediment.



Fig. 12. Master plan of shipwreck site E-82.

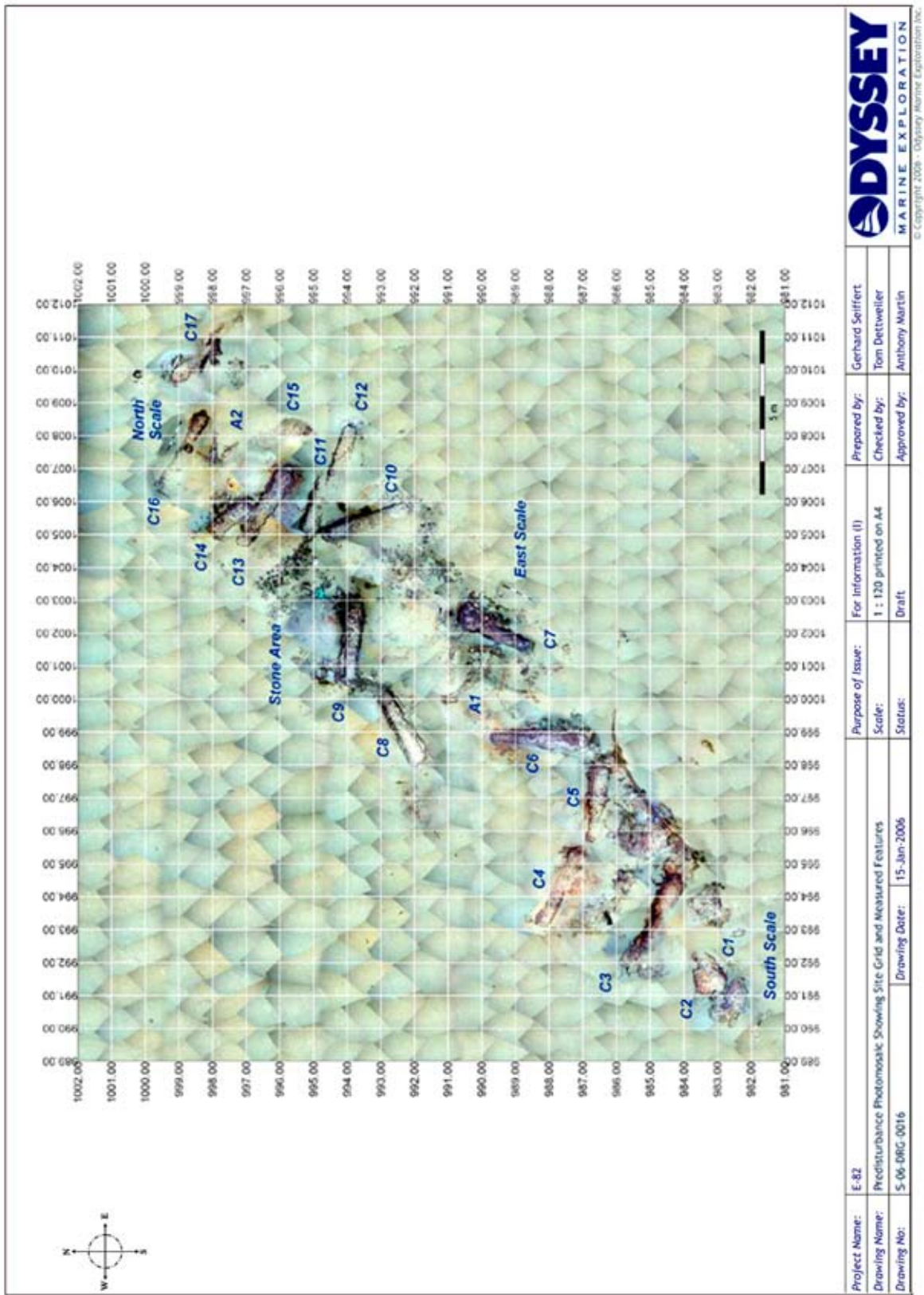


Fig. 13. Photomosaic of the wreck, with the superimposed electronic site grid used for contextual recording.

Layer	Thickness (mm)	Max Depth Below Seabed (mm)	Sedimentological Description	Context Equivalence
Surface	20-100	100	Light brown, soft unconsolidated mud. Occasional coarser material. Occasional fragments of yellow and orange (iron stained) concretions. Occasional to persistent bioturbation 30-150mm long vertical burrows, 2-15mm diameter tubes; burrows sometimes horizontal.	1
	20-40	140	Discrete and diffuse boundary seen to layer below 20mm-40mm thick.	1
Gray Clay	100-300	440	Light gray, soft semi-consolidated mud-clay. Occasional light brown discrete horizons and light gray, silt grain size horizons (5-15mm). Dislocation surfaces, sub-horizontal, 2-20mm wide. Dislocation surfaces often with silt grain size and complete shell (bivalve dominant)/shell fragments. Surfaces cross whole core and partially through core. Occasional organic flakes, typically less than 2mm size.	2
	5-15	455	Usually discrete boundary, occasionally diffuse boundary seen to layer below 5-15mm thick.	2
Organic	20-150	605	Organic layer of mixed wood fragments up to 25mm long. Mixed complete (up to 25mm) shell and broken shell fragments. Red/Yellow concretions (iron) up to 35mm long.	2
	2-20	625	Usually discrete (2-8mm), sometimes diffuse (10-20mm) boundary into stiff clay.	3
Stiff Gray Clay	>50	>675	Stiff gray clay, occasional partings of silt with shells. Uniform color. Uniform remoulded CP values.	3

Table 1. Summary of seabed stratigraphy across site E-82.

4. Environmental Analysis

On the advice of Dr. Richard Bates of Topaz Environmental and Marine (TEAM) of the Department of Geography and Geosciences at the University of St. Andrews, a block area of 300m per side around the site was selected to conduct a mini-core program and shear vane measurements. Coring focused on three lines spaced 150m apart in total, with the centerline passing through the middle of the wreck. Five core samples were taken along each line at intervals of 75m for a total of 15 cores. On the wreck site itself, samples were obtained using the same mini-coring techniques, but on an area measuring 60m long and 30m wide. Five lines of the grid were covered, spaced 6m apart, with core samples taken

every 6m, thus producing 30 samples in total (Fig. 14).

The core tubes consisted of 45cm lengths of clear cylindrical PVC pipes fitted with a core deployment mechanism (Fig. 15-16). This enabled the tubes to be inserted vertically into the seafloor using the manipulator arms of the ROV, simultaneously permitting water to escape out of vents cut into the tubes' upper lengths (Fig. 17). Each tube was chamfered on the base to facilitate cutting into the sediments. Management of the ROV for position on the seafloor was achieved through a local transponder grid, allowing cores to be located with centimetric accuracy.

To characterize the geotechnical properties of the cores, upon recovery full descriptions and visual classifica-

tions were recorded using standard sediment descriptions (grain size, bedding) and color classification with a Munsell Soil Chart. This method also revealed significant structural features, such as delamination surfaces and fractures. Where present, macrofossils were recorded, together with the content of the organic horizons and, in particular, the type and size of organic components.

The results of the core samples taken from Environmental Sampling Area I focused on the visible wreckage and revealed the stratigraphic sequence of the upper levels of seabed to comprise a 2-10cm layer of light brown, unconsolidated mud with persistent bioturbation, succeeding a stiff gray clay with occasional partings of silt and shell (Table 1). The sediment recovered was consistently observed to have a shear vane value too low to register.

The 15 cores in the wider Environmental Sampling Area II produced three distinct core sequences. The first was similar to the sterile cores taken from Environmental Sampling Area I; the second possessed minor organic traces (fragments less than 2mm long); and the third sequence contained major organic traces of wood, fragments of broken shell and corroded iron. Some of the wood fragments were sufficiently well-preserved and of sufficient size to perceive growth rings. The distribution of these cores was plotted onto a site plan. Based on this information, it was decided to locate the remaining 15 cores at points that would refine the distribution and boundaries of the zones of nil organic presence, minor organic presence and major organic presence.

The complete environmental program took 54 cores, an increase of nine above the minimum performance spec-

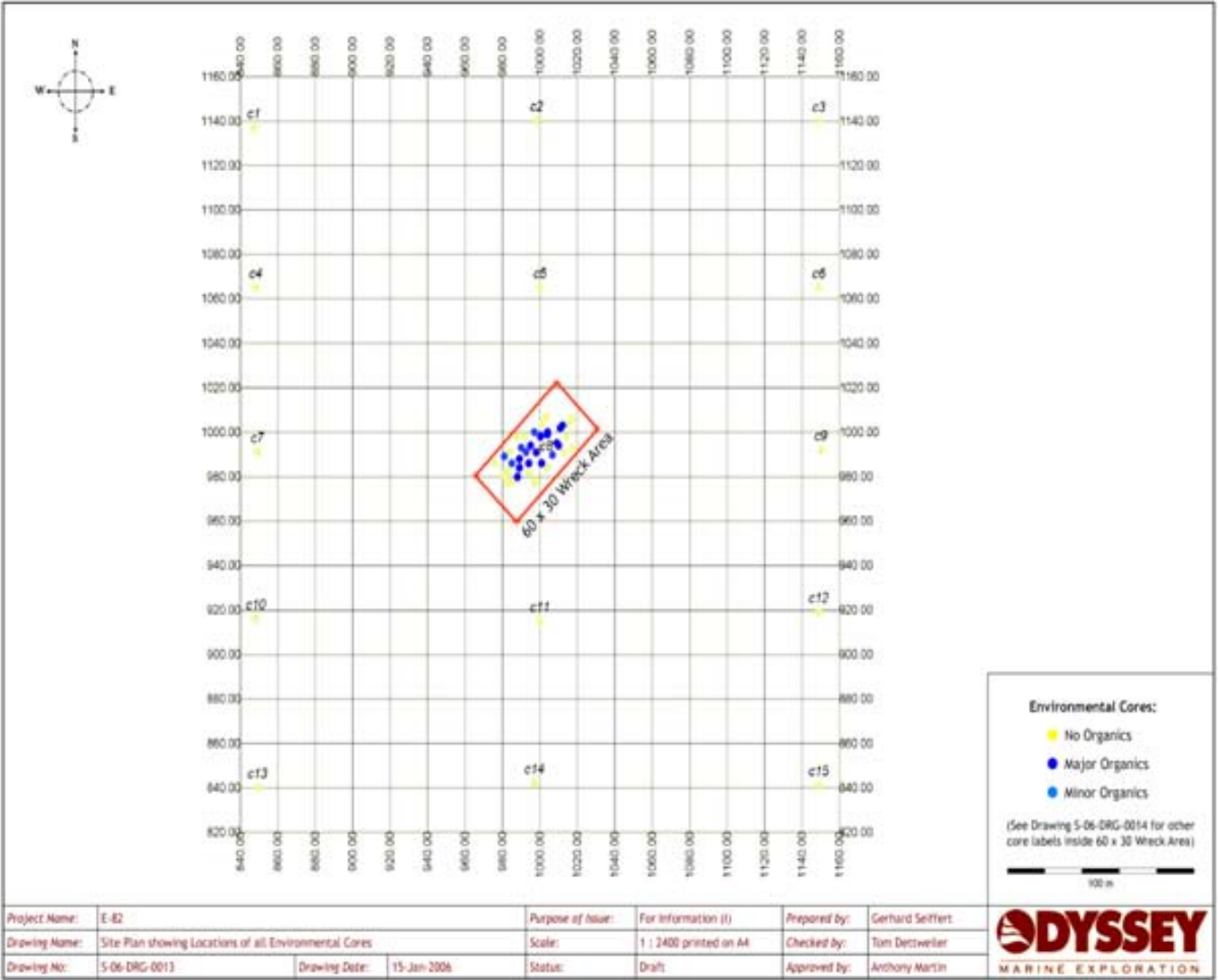


Fig. 14. Schematic site grid showing the locations of environmental cores taken during Phase 1, Stage 1A.



Fig. 15. Preparing environmental core tubes for descent onto the wreck.



Fig. 16. A 2m 'long core' installed on ROV Zeus for descent onto the wreck site.

ification. The sediment recovery within the cores varied from 30% to 100%. The environmental data redefined the boundaries of the wreck site by demonstrating that the zone containing significant major organic material should be taken into consideration. The visible wreck material covers an area of some 164m², while the newly projected wreck site covers 348m² – an increase of 112% (Fig. 18). This dimension assumes that the outermost cores containing wreck material constitute the furthest site boundaries. The wreck area, however, may expand out even further to the cores that did not exhibit wreck material, and it is also possible that wreck material may exist deeper than the cores were able to penetrate.

5. Site Biology

To assess the interactive effects between the wreck site and the marine biology, Fernando Tempera of Topaz Environmental and Marine (TEAM) of the Department of Geography and Geosciences at the University of St. Andrews initiated a suite of non-intrusive analytic measures to characterize the biological oasis effect formed on the shipwreck and on the flora and fauna residing on and around the vessel. The effects of the localized sea life and ecosystem on the

disintegration and decomposition of the shipwreck and its contents were also determined.

Analyses drew on a 993m² geo-referenced image mosaic, which was composed of 55m² hard bottom and 938m² of soft bottom, classed as bathyal hemipelagic fine muds and silts. The site is also characterized by extensive burrowing activity in the form of holes, burrows, mounds and trails, indicative of the presence of endofauna and bioturbation processes.

A total of 40 distinct epibenthic megafaunal life forms belonging to six different phyla were identified (from anemones to shrimp, hermit crabs, diamond back squid, white starfish, electric rays and blackbelly rosefish, amongst others). Of these forms, seven were sessile on the hard bottom artificially provided by the archaeological artifacts. Most extensively, gorgonians of a few tens of centimeters length protrude from the artifacts, but their density is not high. Accounting for 14 of the species, fish represent the highest diversity. A total of 16 species were observed in association with hard bottom, while 24 occur on soft bottoms. Four of these co-existed in both types of seafloor. Seventeen species are of commercial value.

The values of species richness (number of species per area of habitat) illustrate a concentration of conspicuous

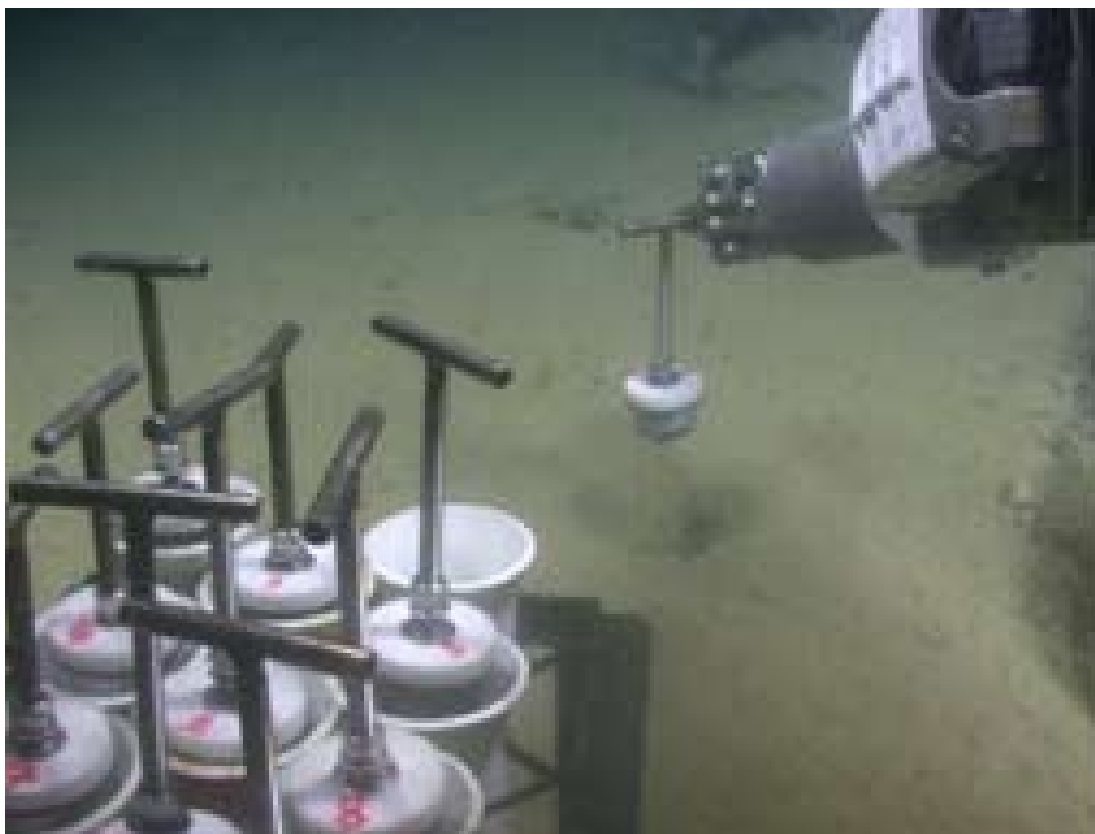


Fig. 17. Environmental data being acquired using a core tube descending into the seabed.

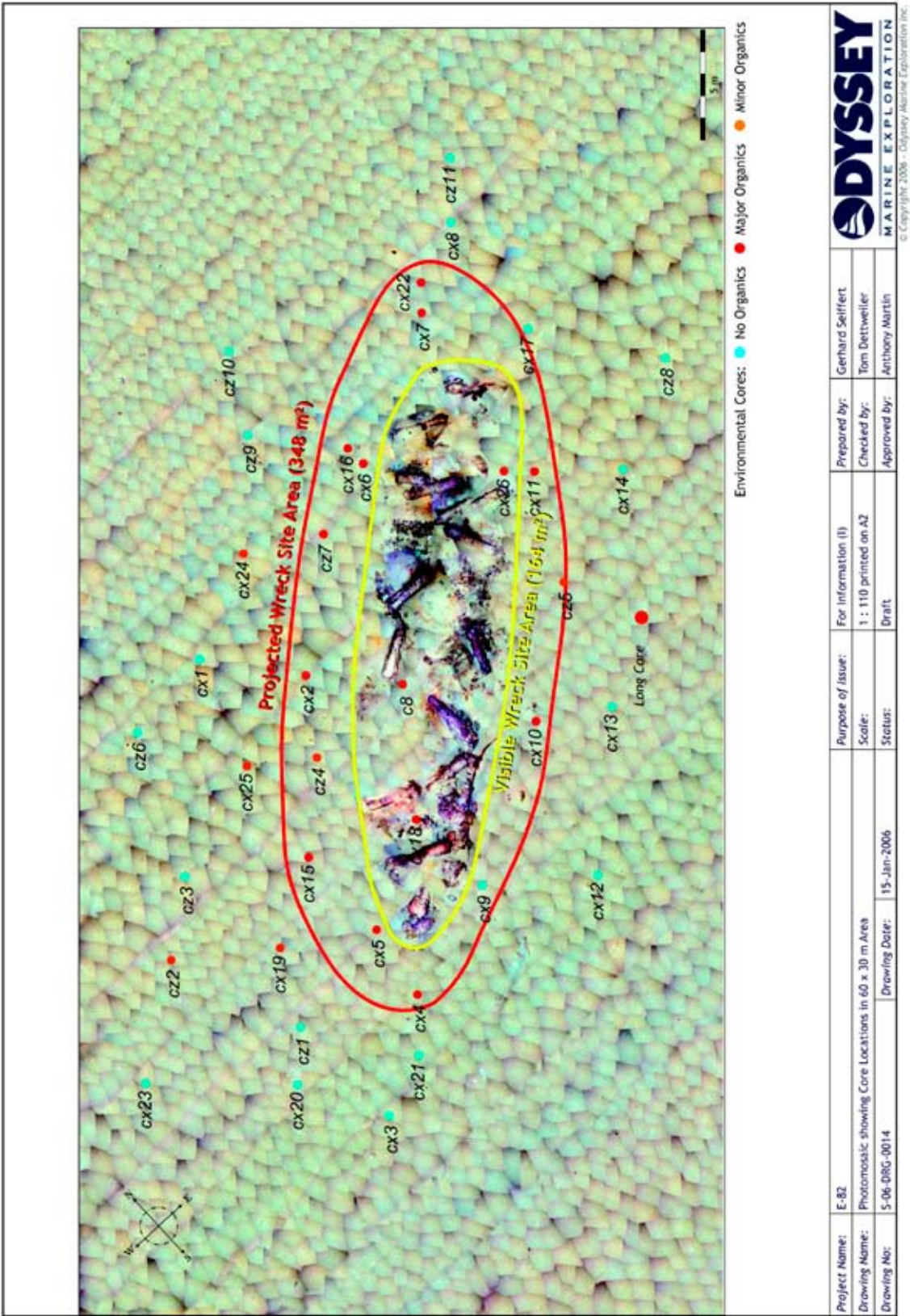


Fig. 18. Photomosaic showing core locations and expanded wreck site area based on coring results. The yellow outline delineates the extent of the visible wreck. The red outline defines the predicted minimum extended wreck site revealed by core testing and analysis, although the wreck area could continue further out to the cores that contained minor organics and beyond to areas whose depth was not penetrated by coring.

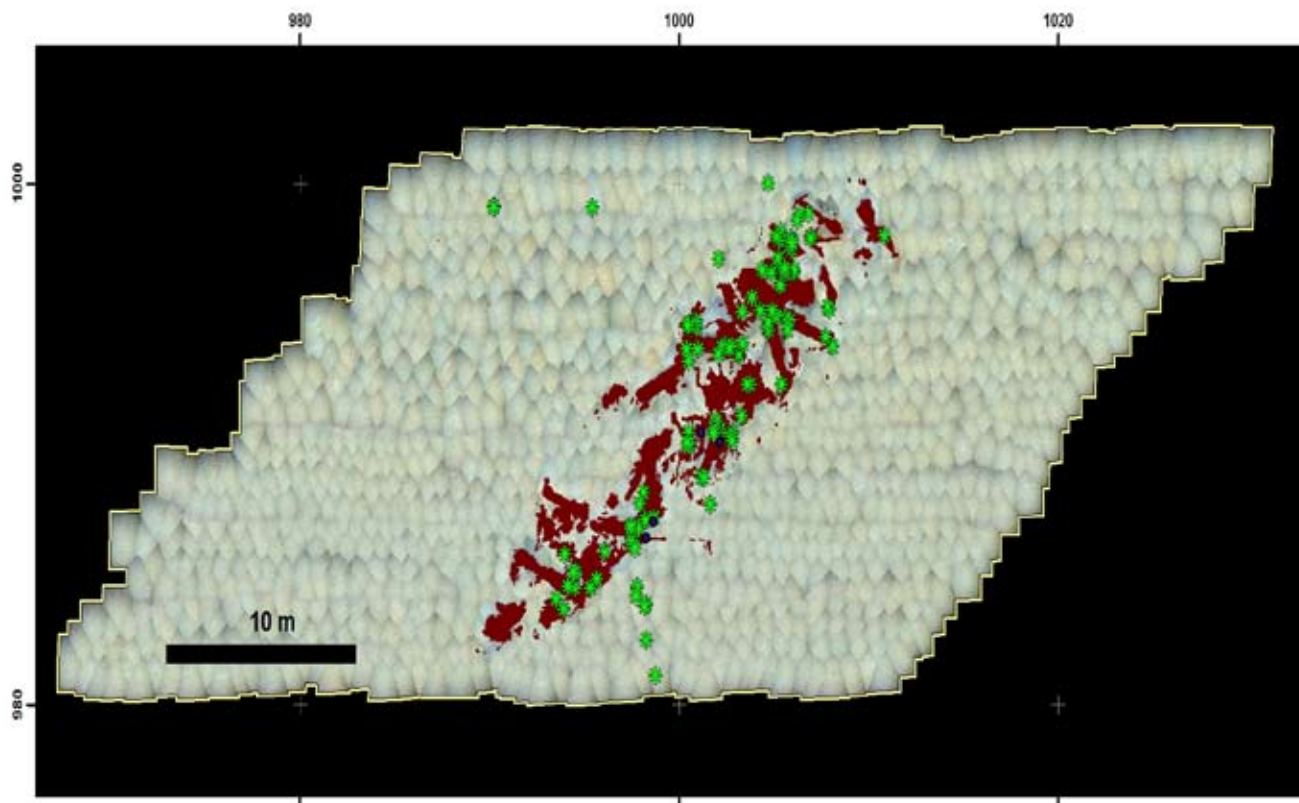


Fig. 19. Distribution of cidarid sea urchins across the wreck site.

megafaunal species on the hard bottom artifacts: 29.1 species/100m² over the artifacts, compared to 2.6 species/100m² on sediments. The difference is even larger if only the sessile epibenthic species are taken into account – 12.7 species/100m² over the wreck, compared to 0.4 species/100m² on sediments.

No flora (macroalgae or seagrasses) was observed because the site is located below the euphotic zone. Neither reefs of cold-water corals, nor massive sponges have been identified. The density of gorgonians was also insufficient to classify the habitat as a coral garden. These facts are significant because the presence of such deep-sea features would have had important implications on the nature conservation valuation of the artifacts.

The epibenthic sea urchin *Cidaridae* sp. was selected to investigate the ecological role of the artifacts as aggregators of marine life creating any oasis effect. This is a slow-moving epibenthic macroinvertebrate for which fully-grown individuals are easily recognizable on the video and stills imagery collected. The species was present both on hard and soft bottoms. Thus, a spatial analysis of the relationship of the individuals with the presence of hard bottom analysis was considered a suitable indicator of the extent to which the artifacts influence the surrounding marine life.

The analysis of the density of cidarid urchins provided values of 2.018 individuals/m² for hard bottoms and 0.013 individuals/m² for soft bottoms, amounting to a 158-fold difference in abundance between the two habitats (Fig. 19). Some 90% of the individuals are found within 15cm of hard structures. Despite the significant number of species attached to the artifacts, the total amount of biofouling can be considered trivial.

6. Pre-disturbance Recording of Surface Features

A. Cannon

Site E-82 contains 17 visible cannon (Figs. 7, 11, 12), while concretions identified 1m west of cannon C8 and between cannon C3 and C4 may represent additional buried guns. Several hard obstructions detected close to the visible wreck mound during the environmental coring program probably represent additional examples. These iron guns can be divided into three categories based on recorded lengths: cannon of less than 2m length, which are either partly buried or fractured; longer than 2m, but less than 2.5m long; in excess of 2.5m long (Table 2).

Cannon No.	Cannon Length (m)	Grid No.
C1	1.51	991.1-992.4/982.8-983.8
C2	1.04	991.0-991.8/983.2-983.7
C3	2.94	991.8-994.7/983.9-985.8
C4	2.68	993.2-995.5/986.8-988.4
C5	2.62	995.7-998.2/986.3-986.9
C6	2.80	998.4-999.2/986.8-989.7
C7	2.48	1001.4-1003.0/988.5-990.7
C8	2.63	997.9-1000.3/991.7-993.1
C9	2.86	1000.3-1002.9/993.5-994.2
C10	2.78	1004.8-1006.0/992.2-994.8
C11	2.70	1004.9-1006.9/994.6-995.3
C12	2.66	1005.8-1008.4/993.8-994.8
C13	2.87	1004.7-1007.1/995.6-997.3
C14	1.60	1004.9-1006.2/996.8-998.2
C15	2.15	1007.6-1008.5/995.2-996.9
C16	2.74	1006.3-1008.8/998.2-999.8
C17	2.22	1009.7-1010.4/998.5-999.2

□ = < 2m incomplete/partly buried

□ = > 2m but < 2.5m

□ = > 2.50

Table 2. Site E-82 cannon measurements and grid contexts.

During the late 17th century, as previously in history and for some decades later, no precise proportional relationship existed between the length of a cannon and the weight of shot fired. The most accurate means of determining the classification of cannon is to determine the diameter of the bore. The bore of broken cannon C14 was positively measured at 8.5cm, which could correspond to a generously bored 3-pound cannon with significant wind-

age. Cannon C3, at 2.94m (9'6") the longest example on site E-82, is a possible 24-pounder. The minimum expected length for a 24-pounder in the second half of the 17th century would be 9'6", corresponding to published surveys of similar guns (Caruana, A., 1994, *The History of English Sea Ordnance 1523-1875, Vol. I*. Rotherfield, 98-122).

Cannon C8 is most likely identifiable as a 6-pounder of the 'new' English design (Cunningham Dobson, N.,

Cambridge Expedition 2001. An Archaeological Investigation, 33) and is tentatively dated to the period of gun founding between approximately 1660 and 1719. Pursuant to a request from the UK Ministry of Defence, the remains of cannon C8 were handed over to the Spanish Institute of Underwater Archaeology in Cartagena, Spain, for conservation. Repeated requests for access to this and other artifacts from site E-82 for study and publication remain unanswered by the Institute.

B. Anchors

Two concreted iron anchors and a possible anchor fluke characterize the surface of site E-82 (Fig. 12). Anchor A1 lies midship on a north-west to south-east axis, with its arms to the east and ring preserved to the west. Its shank is 2.3m-long, the arms 1.4m-wide and the ring's diameter about 40cm. The arms are broadly bowed, with indistinct palms, while the anchor in general, especially the shank, is extremely delaminated and corroded. The seabed around

it is heavily covered with leached iron and encrustation. No stock is visible.

Anchor A2 lies to the north-eastern end of the wreck on an east-west orientation (Fig. 8). Its shank is 3.1m long and arms 1.3m wide. The gently bowed arms face due east and appear to incorporate a reinforced and thickened collar at the throat. As far as can be observed from the anchor's concretion, the southern fluke palm seems to be undeveloped (compared to the classic Admiralty anchor form). The northern fluke is trapped under cannon C16. The circular ring is visible with a hole at its center to the east, engulfed by white plastic bags. A 'knotted' linear concretion stain observable immediately below the ring, extending north-east to south-west, may be a stock.

C. Ballast

A cluster of roughly rounded stones, each measuring approximately 20 x 10cm maximum and extending across an area of about 2.10 x 1.55m, is a distinct feature on the

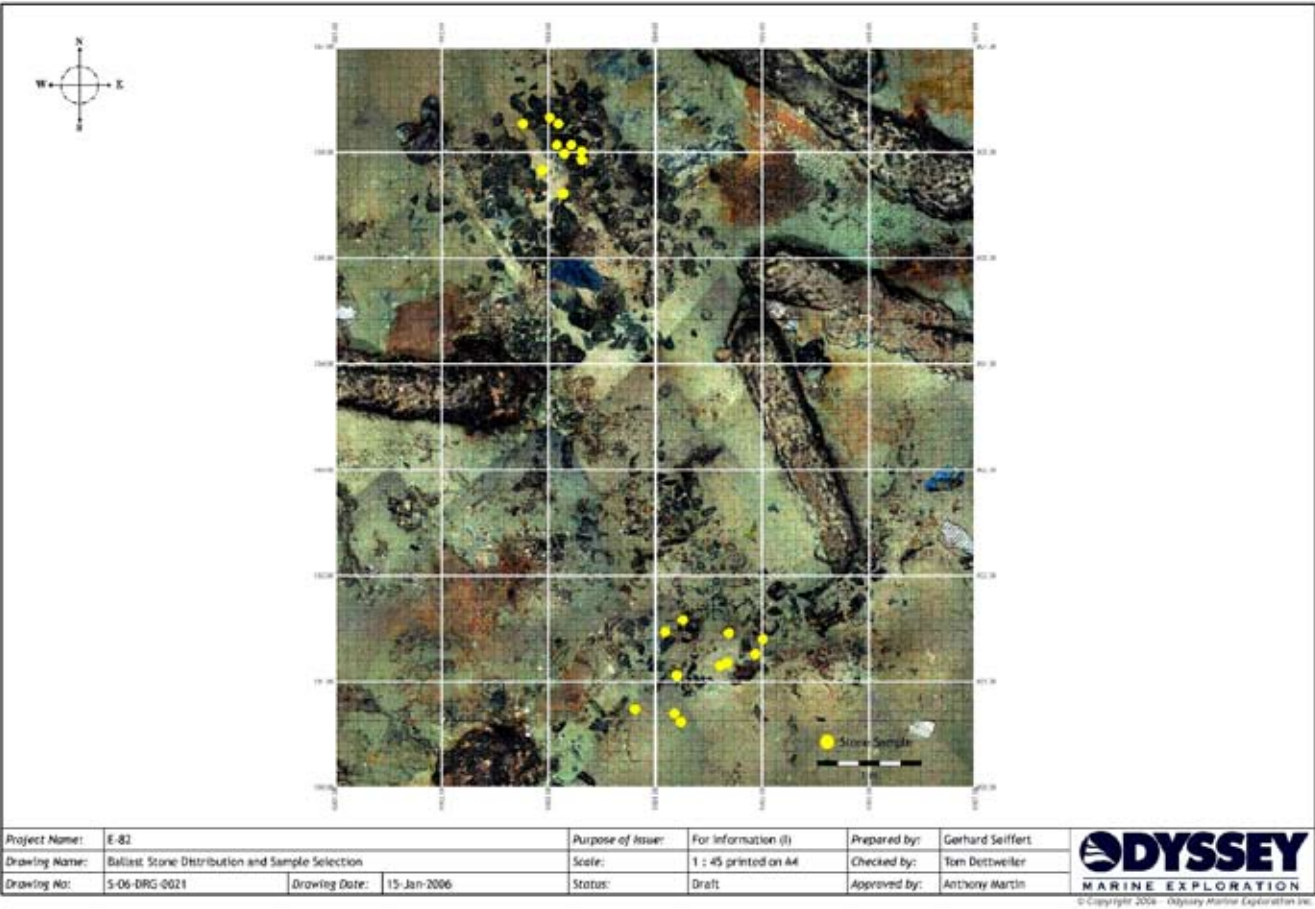


Fig. 20. The locations of possible ballast stones recovered for petrological analysis (labelled in yellow).

north-western flank of the wreck site (Figs. 6, 12). A second scattered cluster of stones extends to the south-east.

The north-western zone consists of three discrete strips of stones, each 2.10m-long and running in a north-west to south-eastern orientation between cannon C9 to the south, C13 to the north and C10 to the east. Both the northern and central strips of stone are devoid of sediment, while the southern cluster is largely concealed. The northern strip is about 88cm-wide and contains some 73 visible stones, while the central one measures about 70cm-wide and consists of some 58 stones. Only about 22 stones are visible amongst the southernmost cluster. Immediately north-east of the northern stone strip seems to be a coherent area of wooden planking (see Section 9 below). While it is tempting to assume that these strips of stone are ballast, the amount visible is clearly insufficient to constitute a classic ballast pile. For the purposes of this report, and pending further investigation, however, it will be assumed that these stones are likely ballast.

A significant archaeological feature between these possible ballast strips, north-east and south-west of the central cluster, are clearly defined linear voids extending parallel to the main ballast orientation (north-west to south-east). In the case of the southern void, sharp edges define its length. These 'ghost' linear recesses may occupy the locations of decomposed wooden frames or riders, which, on the basis of the photomosaic, would have measured approximately 15cm in width (Fig. 6).

Towards the eastern flank of the center of the shipwreck is a second exposed section of possible ballast stones between cannon C7 to the south and C10 to the north. This scattered material is strewn amongst intrusive modern glass bottles across an area of some 2.2 x 1.9m. At least 55 stones define this feature.

A sample of 20 stones was recovered for geochemical and petrological analyses to identify their geological source (Fig. 20). Geochemical analysis was conducted on a sub-sample of ten stones by TEAM and petrological analysis performed on a sub-sample of a further 10 stones by Dr. Peter Kokelaar of the Department of Ocean and Earth Sciences at the University of Liverpool. The assemblage comprises rounded to well-rounded stones with a high density, indicative of deliberate selection to maximize weight displacement in relation to minimal spatial volume. Nine of the ten samples subjected to geochemical analysis derived from an igneous origin with a metamorphic imprint classified as altered ultramafic rocks.

The stone is unusual, but could have originated in a single field location because all the rock types are found in or around ophiolite complexes. The TEAM analysis con-

cluded that the three most likely coastal candidates where ophilites are found in the UK are the Lizard in Cornwall, Unst and Ballenrae in Scotland. Complementary petrological analysis similarly identified possible origins for the stones at coastal ophiolite exposures in the UK, such as the Lizard Ophiolite Complex of Cornwall and the Unst Ophiolite of Shetland. However, the Ballantrae Ophiolite of south-western Scotland has been discounted because its beaches lack this assemblage form. A wider potential for the origin of the stones in the coastal fringe of the Mediterranean was also acknowledged.

Further opinion about the results of the geochemical and petrological analysis was sought from Dr. Alan Bromley of PetroLab, Falmouth, a specialist in the geology of the Lizard peninsula. Bromley's examination concluded that some of the stones contain the relatively rare mineral glaucophane, which excludes the Lizard peninsula as the source of site E-82's possible ballast. However, outcrops exhibiting glaucophane are indigenous to the Shetland Islands and Anglesey. A source in the British Isles is therefore possible. Other European sources for ophiolitic stones include Brittany, the heel of Italy and the Greek shores of the Aegean.

7. Phase 1, Stage 1B

Trial Excavation

Following the dusting of the uppermost layer of 1-4cm of mobile sediment covering the archaeological surface features, a second master photomosaic was produced (Fig. 11) to serve as the primary tool for managing decisions about the positions of trenches during Stage 1, Phase 1B. In turn, this facilitated the production of a master site plan (Fig. 12). Archaeological features and apparent sterile zones on the photomosaic were examined to design a strategy for trench locations, distribution, size and orientation (Fig. 21). Excavation proceeded systematically in six trenches in horizontal stratigraphic units, with the objectives of assessing the wreck's level of preservation and orientation, without disturbing any of the concretions.

A. Trench 1

Trench 1 examined the area between cannon C14 and C16 for the presence or absence of wooden planking to define the form of preserved wooden structure and to assess site stratigraphy and the relationship between the visible wreck site and the visually sterile area beyond the confines of the site to the north-west. The position of Trench 1, which measured 1.0 x 0.6m, was chosen to shed light on the orientation of the wreck and, hence, to provide information

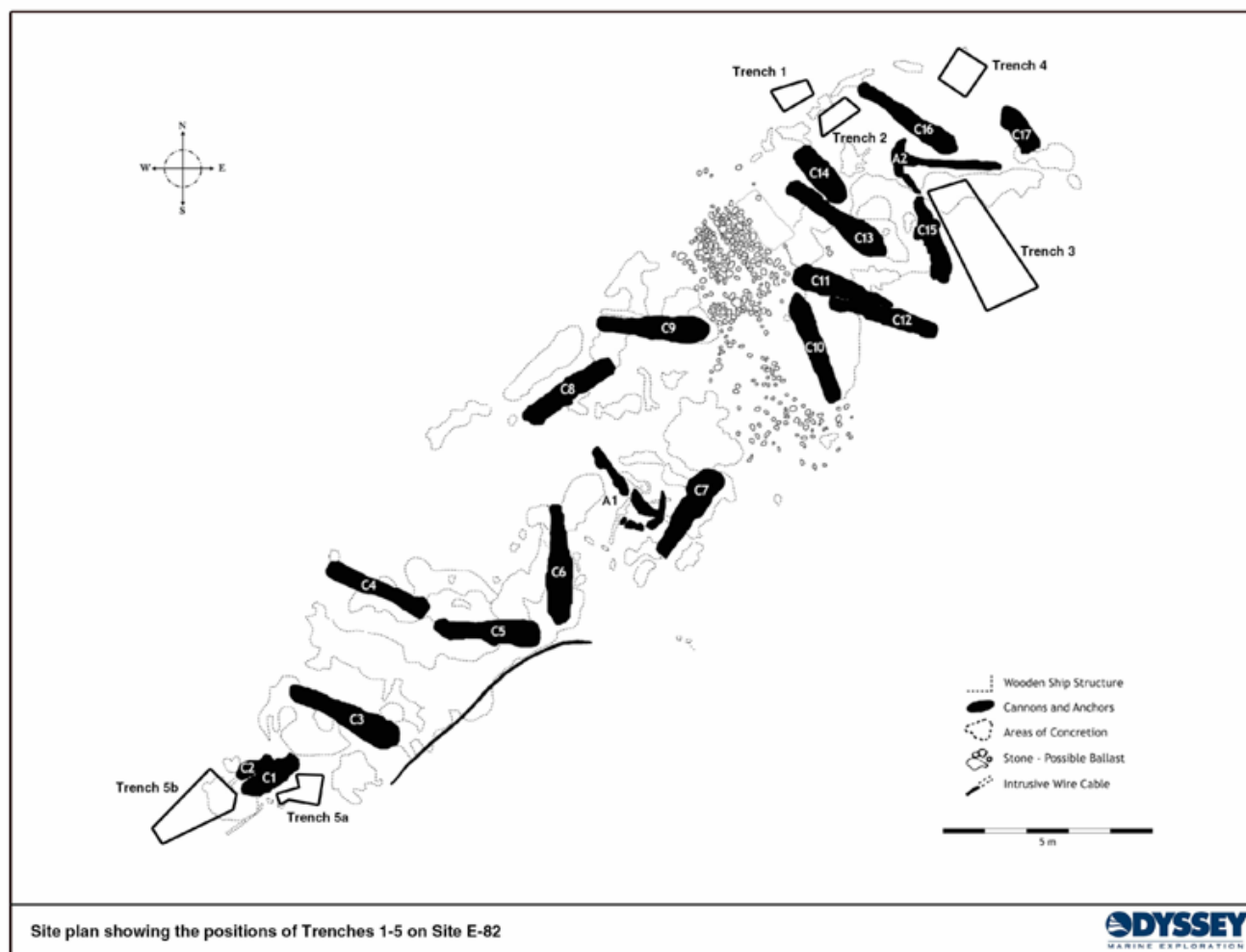


Fig. 21. Plan depicting the locations of trial Trenches 1-5b

about any surviving cargo (Fig. 21).

The excavation of the upper layer of sediment (Context 2) exposed a layer characterized by a common distribution of concreted iron fragments (Context 4), which appeared to overlie what initially resembled wooden planking, but proved to be a concretion crust (Context 5). A deposit of sediment stained with dark patches, presumably from the leaching of organic residues into the clay silt, was observed (Context 6) beneath the concretion crust (Fig. 22; Table 1).

Excavation ceased in Trench 1 following the exposure of Context 6 to leave Context 5 undisturbed. No timber structure was exposed, although of course planking may survive beneath the concretion layer. Instead, the trench was extended to the north-east by strategically 'leap-frogging' over a concreted iron feature lying north-east/south-west at an angle of 90° to the longitudinal axis of Trench 1. (This second sondage to the north-east was designated Trench 2.)

B. Trench 2

The objective of Trench 2, measuring 0.8 x 0.6m, was to investigate the stratigraphic relationship between the wreck site and the visually sterile area to the north-west. The excavation exposed a stratigraphic sequence about 15cm thick in the form of gray clay containing shell and organic smears (Context 2). This overlay more consolidated gray clay, about 54cm thick, with no visible inclusions (Context 3). Trench 2 was excavated to a total depth of 69cm.

This visually sterile area yielded various artifacts from Contexts 1 and 2 in the form of an iron cannon ball, three potsherds, two brick fragments, a copper table/jug leg and fragments of nail concretions and wood, but no evidence of coherent planking. During the exposure of the north-east facing trench section, a wooden plank featuring an iron nail stain was exposed in the section face. Further cleaning revealed what seems to be identifiable hull planking extending south-west to north-east across the face of the trench. The wood is 9cm thick and located at a depth of 15cm

below the seabed. The presence of this timber confirmed that within Context 3 the environmental characteristics of the site have preserved significant sections of hull timber, not just small fragments. A complex stratigraphic relationship seems to exist between the wreck site and the visibly sterile seabed to the north-west of this location, including the presence of sub-surface timbers, whose precise character will only be determined by further exploratory excavation.

C. Trench 3

Trench 3 (Fig. 21), 2.4 x 1.0m and penetrating to a depth of 41cm, yielded evidence of substantial timbers embedded within Context 2. The wood remains are extensively gribbled and in a poor state of preservation, with extremely eroded surfaces inter-cut by worm holes. Fragments of sulphur leaching from iron concretions are visible to the east of the trench, while intrusive modern debris was present to the west.

Trench 3's hull planking is seemingly indicative of

frames and planks preserved in their original configuration. The coherence of the structural remains is less intact in the south-eastern end of test trench: all that could be observed were large lumps of highly decomposed unidentifiable black material (Fig. 23), partly corroded iron apparently obscuring the underlying strakes. What appear to be eroded trunnel ends were observed on the surface of this timber.

Trench 3 seems to contain four frames, each sided 28cm wide, spaced 18cm apart and extending in a north-west to south-east direction out of the northern face of the trench. Three-quarters of the way southwards, the trench is intercut by two extensive longitudinal timbers, most probably identifiable as stringers, over 40cm wide, which are positioned at an angle of about 65 degrees in relation to the frames and extend in a south-west to north-east direction. Artifacts recovered during the excavation of Trench 3 consisted of eight potsherds, six nail concretions, a fragment of rope and fired brick.

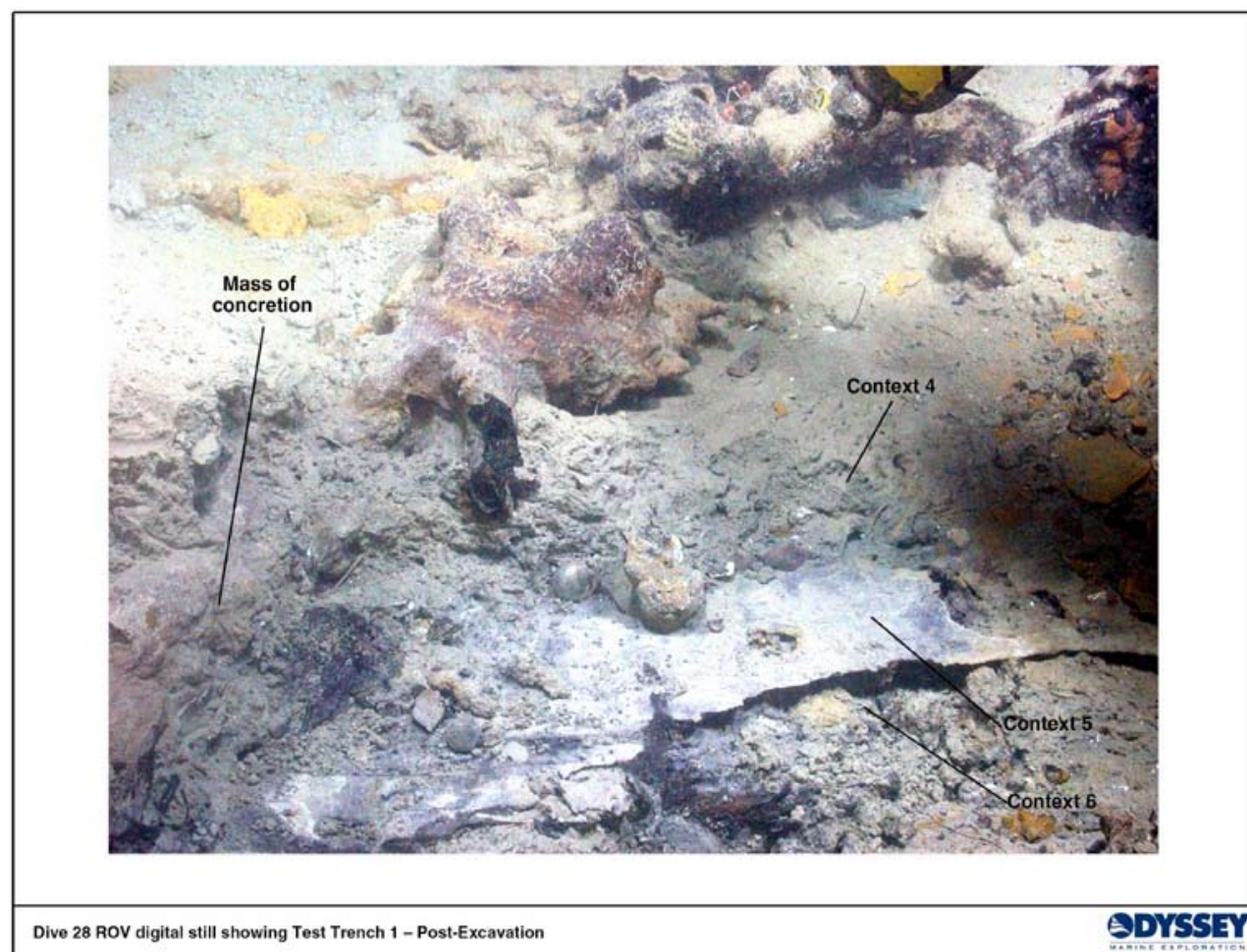


Fig. 22. Features exposed in Trench 1 after excavation.



Fig. 23. Frames and possible stringers (at right in foreground) exposed in Trench 3.

D. Trench 4

Trench 4, measuring 0.8 x 0.8m, was positioned at the north-eastern end of the wreck site, some 1.5m north-east of cannon C16. As soon as the excavation commenced, a compact concreted layer (Context 7) was encountered stratified below a very thin layer of Context 2. As the excavation proceeded cautiously, disarticulated fragments of wood were observed in Context 7. One of these appeared to feature trunnel holes. The concreted mass measures 38 x 22cm.

Excavation and recording of the concreted mass and three sections of straight-sided wood were undertaken. Two of these sections descend at an angle of 100-110 degrees from the top sides of the concretion. The third section runs horizontally beneath, from one side of the trench to the other. This feature, measuring 24 x 13cm and incorporated into the concreted mass, possibly represents the side of a wooden box located at a depth of 47cm below the seabed.

At this stage, the excavation ceased to leave Context 7 undisturbed *in situ* in order to concentrate on the primary objective of the trial excavation phase of Stage 1, Phase 1B: to locate wooden structure and diagnostic material culture without resorting to the removal of concretion layers.

E. Trenches 5a and 5b

To test for the presence of wooden ship structure and attempt to determine the vessel's orientation, Trench 5a, measuring 1.6 x 0.8m, was positioned at the south-western flank of the visible wreck site on the eastern flank of cannon C1 (Fig. 21). Excavation between cannon C1, C2 and C3 revealed an upper layer of semi-consolidated sediment (Context 2). Once removed, an iron concretion was exposed in the north-western corner of the trench. The semi-consolidated sediment superseded a darker gray clay (Context 3). Coherent ship structure extending diagonally across the western side of the trench along a north-east to south-west axis was recorded in Context 3 (Fig. 24).

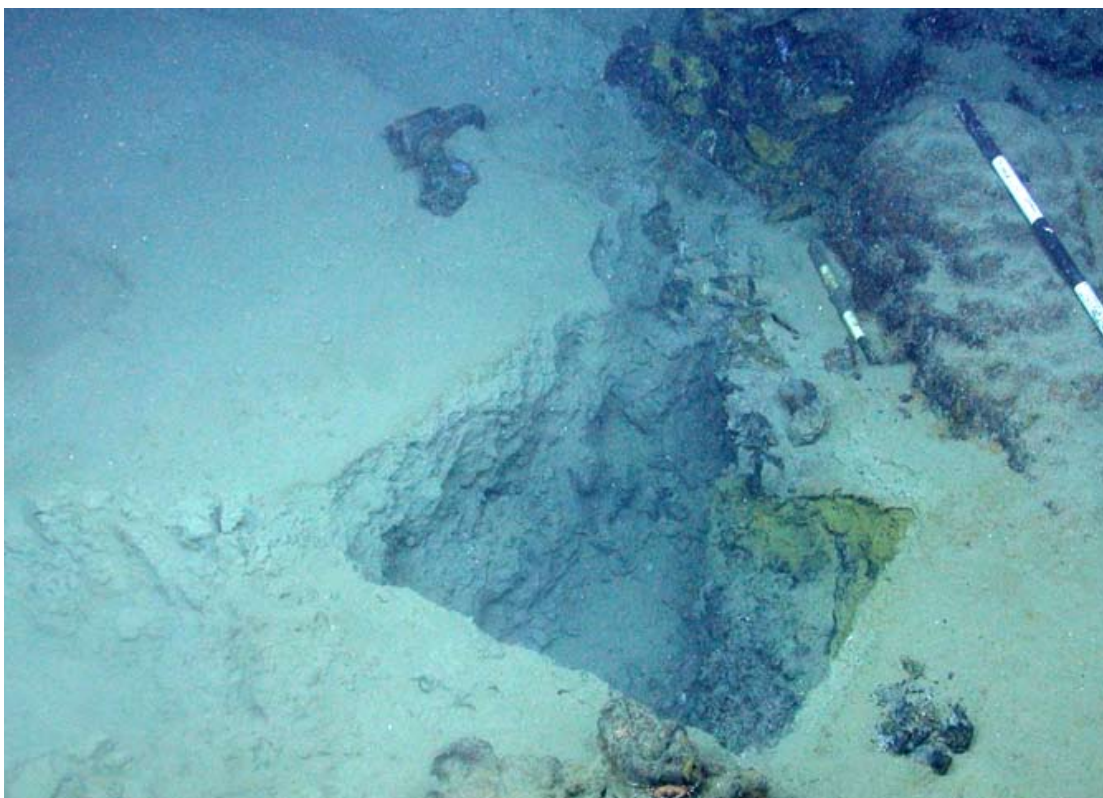


Fig. 24. A substantial timber extending across the western side of Trench 5a, with cannon C1 at right.

To examine its continuation without disturbing cannon C1 and C2, Trench 5b was excavated on the south-west side of cannon C1. What appeared to be heavily encrusted iron cannon balls were identified between the north-western edge of Trench 5a and cannon C1. The stratigraphic succession in Trench 5b, measuring 1.8 x 0.9m, proved identical to Trench 5a, with the same timber element tapering inwards towards the south-west (Fig. 25). To record whether the timber extended any further, excavation was continued in this direction, demonstrating discontinuity. In total, the Trench 5b wood complex measures 1.6m in length and tapers from 60cm-wide to the north-east to 20cm-wide at the south-west. The angled north-east side dovetails precisely with the axis of the timber exposed in Trench 5a and may be considered a 3.2m-long coherent element of the same structural unit.

At this preliminary stage of research, the structural timber in this trench can possibly be identified as located towards the eroded terminal of the ship's hull. The timber features a 90 degree rabbet on both sides. This feature, combined with the tapering of the wood, is not indicative of a keel, and must represent a structural component located at a higher elevation, possibly the keelson. The initial interpretation points towards this feature representing the end of a warship's hull towards the bow, where the lines

of the ship assumed a fluted 'V' shape in plan. If correct, this interpretation would imply that the ship settled on the seabed in an upright formation and that the erosional surface lies on a relatively level plane. These assumptions need to be tested further, and it must be emphasized that this possibility remains tentative at this stage.

8. Pottery Assemblage

Surprisingly, ceramic remains of any form (kitchen, table and luxury wares) proved to be elusive on site E-82. The site formation pattern gives the impression that the ceramic domestic assemblage has been extensively scattered and relocated off-site or remains buried. The likelihood that this fragmentation and disturbance is solely the result of the wreck process is extremely low. The material's absence must be largely explained by post-depositional disturbance by trawler cables shattering ceramic vessels and causing low-density fragments to be washed off site by the prevailing north-eastern currents or to be covered completely by sediment.

The non-disturbance survey of the wreck revealed a total absence of ceramic material, and only 12 sherds were recovered during excavations in Trenches 1, 2 and 3. This material was submitted to Jacqui Pearce of Museum of

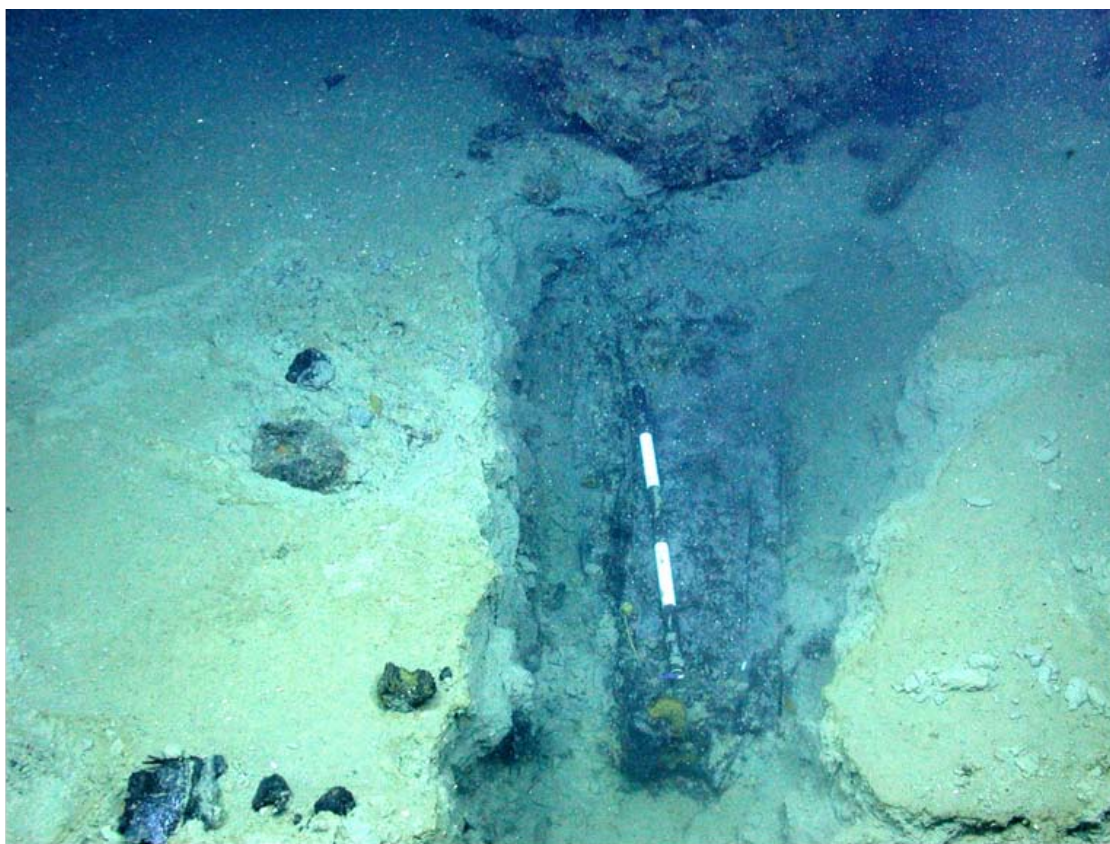


Fig. 25. A substantial timber in Trench 5b, possibly the keelson, tapering inwards towards the south-west.

London Archaeology for identification and assessment. All of the sherds are very small (2.0-5.0cm in length), none weigh more than 13g, and all are highly abraded, consistent with long-term submergence and exposure in a high-energy marine environment. In four instances the sherds are so badly burnt that the original fabric and glaze colors are impossible to recognize with certainty. Two or three sherds may be from a single vessel, but all others derive from different ceramic containers. Positive identification has proven difficult, a consequence of the condition of the pottery's few diagnostic attributes. Initial consultation with a ceramic petrologist was unable to confirm suspected sources.

The pottery does not appear to be cargo, given the evidence for use (sooting), but represents domestic assemblage: part of the everyday shipboard equipment. Two decorated sherds (S-06-0033-CS and S-06-0034-CS) are both probably from ceramic vessels produced in Italy in the 16th or 17th century. Even if the ship wrecked at site E-82 originated in England, this is consistent with the attested presence of imported pottery of this type in London in late 16th- to early 17th-century contexts. Such pottery is generally thought not to have been in circulation beyond the third quarter of the 17th century.

Coarse whiteware sherds with volcanic inclusions may

have an origin in the Iberian peninsula. A fine, green-glazed red earthenware is more difficult to source without further scientific analysis. This fabric, however, is not local to the London area, although one sherd of redware is comparable with pottery produced in the London region during the 17th and 18th centuries.

On the balance of probability, a wreckage date in the 17th century seems most likely for this assemblage. The presence of Italian and Iberian wares does not suggest that the ship is not of English origin, as these wares were widely distributed across Europe. The sherd of possible London-area redware is unlikely to have been present on a ship without an English connection because this ware was not widely traded inter-regionally and certainly was not exported. There is no pottery in the examined sample that was definitely developed after the late 17th century.

9. Vessel Structure

Despite site E-82's overall poor level of preservation, the removal of mobile sediment during cleaning operations and the trial trench excavations identified coherent sections of ship's structure:

1. An area of apparent articulated planking was exposed

during light surface ‘dusting’ between the possible ballast stones and cannon C13 on the north-western side of the wreck (Fig. 6). Extending beneath the stones, this feature may represent either ceiling planking or strakes within the lower hull (see below). Horizontal and parallel plank edges seem to extend in a south-west to north-east direction parallel to the main longitudinal axis of the wreck site. At least 11 possible planks are visible, while an identical surface discolorization south-west of the ballast stones may denote their continuation. An unusual feature observed between these possible ballast strips, to the north-east and south-west of the central cluster, are clearly defined linear voids running parallel to the main orientation. Both of these lines are not covered by stones and, in the case of the southern void, sharp edges define its length. These 15cm-wide ‘ghost’ recesses may occupy the locations of decomposed frame stations or riders.

2. Trench 3: substantial hull planking, poorly preserved, extending down to a depth of 41cm (Fig. 23). Four frames sided 28cm wide, spaced at 18cm intervals, run in a north-west to south-east direction out of the northern face of the trench. Three-quarters of the way southwards, the trench is intercut by two extensive longitudinal timbers – possibly stringers – over 40cm wide, which are positioned at an angle of about 65 degrees in relation to the frames. These latter timbers extend in a south-west to north-east direction.

3. Trench 5a: a coherent timber exposed between cannon C1, C2 and C3 extending diagonally across the western side of the entire 1.6m-long trench along a south-west to north-east axis (Fig. 24). Trench 5b: the continuation of the Trench 5a timber was exposed on the south-west side of cannon C1. In total, this wood complex measures 1.6m in length in Trench 5b and tapers from 60cm-wide at the north-eastern end of the trench to 20cm-wide to the south-west (Fig. 25). A rabbet cut at a 90 degree angle characterizes both sides of the timber. The angled north-eastern structure seems to dovetail precisely with the axis of the timber exposed in 5a and may be considered a coherent element of the same structure.

Several intact nail concretions recovered from site E-82 measure 7.0cm and 8.3cm long. Due to concretion growth, these artifacts are generally amorphous and featureless. Exceptions include S-06-0017-CN, which displays a clear square section profile, and two further nails with circular heads, of which S-06-0030-NA is 6cm-wide.

At this preliminary stage of limited trial excavation, the structural hull timbers offer little more than tentative interpretative possibilities. All wood surfaces are heavily eroded, pitted, warped and covered with worm holes. The

site E-82 timbers unanimously display cracks developed along the natural grain, creating uneven depressed and blistered planes. All of the timbers are charcoal gray in color (almost certainly the result of contact with the soft, semi-consolidated mud-clay in an anaerobic environment). This sedimentological matrix does not seem to favor good preservation, and the water-saturated clays 10-30cm beneath the surface of the seabed seem to have fully decomposed some sections of planking, such as the timbers in the south-eastern end of Trench 3.

At present, the recorded timbers seem to consist of lower sections of the ship’s structure located around the turn-of-the-bilge. The hull displays some continuity and coherence, evident in the approximately 11 possible planks inter-connected between probable ballast stones and cannon C13 on the north-western side of the wreck. These planks underlie the stones and, as far as can be perceived visually on the photomosaic, are concentrated at a level lower than the frame station lines to the south-west. This configuration would suggest that the planks may be strakes and not ceiling planking, which would be expected to cover and conceal the frames. Alternatively, the transversal ‘ghost’ timbers inter-cutting the ballast could be riders, which would identify the underlying longitudinal wood as ceiling planking and not strakes.

The evidence from Trenches 5a and 5b at the south-western extremity of the wreck site may suggest the possibility that one end of the shipwreck has been identified. These trenches contain a single timber extending down the entire length of Trench 5a, which was 1.6m long, and for 1.6m in Trench 5b, providing a total length of 3.2m. It tapers from 60cm-wide at the north-eastern end of Trench 5b to 20cm-wide to the south-west, suggesting the presence of an eroded terminal component of the ship’s hull. The timber features a 90 degree rabbet on both sides. The widening of the wood is not indicative of a keel and is a likely structural component located above this element. The initial interpretation points towards the possibility that this feature represents the terminal at the bow, where the lines of the ship assumed a fluted ‘V’ shape in plan. If correct, this would imply that the ship settled on the seabed in an upright formation and that the erosional surface lies on a relatively level plane. However, these assumptions will need to be tested further, and it must be emphasized that this possibility is just one of several tentative interpretations at this stage.

Eight fragments of wood recovered from Trenches 3 and 5 were submitted to Alyson Tobin and Jill McVee from the School of Biology and Histology Unit at the University of St. Andrews for thin-section preparation, species iden-

tification and possible provenance analysis. Samples from site E-82 were also examined at Kew Gardens. Two fragments were too carbonized for analysis, while the remaining six fragments were positively identified as white oak, pine, laurel and sycamore. Determining a tight geographical provenance for the trees has not been possible.

10. Conclusion

The pre-disturbance survey and trial trench excavation of site E-82 presented a unique opportunity to examine a deep-water shipwreck of probable 17th century date. This collaborative HMG/Odyssey project has contributed extensively to the current largely theoretical and developing paradigm of shipwreck site formation in the abyss. Despite the political complications that disrupted the recording of Phase 1, Stage 1B (see below), significant scientific data has been secured, which addressed the archaeological objectives agreed within the historical agreement devised by Her Majesty's Government and Odyssey Marine Exploration. The HMS *Sussex* Project has proved that both detailed non-disturbance archaeological survey and scientific excavation can be conducted at depths exceeding 800m to a high standard of data procurement.

The formation of site E-82 is intriguing. Contrary to mainstream perceptions of shipwreck preservation improving in relation to depth, articulated within public perception as 'time capsules', a major contribution of the current project has been the presentation of contradictory data. The site has clearly trapped significant quantities of modern rubbish – plastic bags, cartons, tin cans, glass bottles, trawler wire and fishing net, not to mention more hazardous material, such as asbestos. Much of this material is integrated into the matrix of concretions surrounding iron artifacts and has burrowed its way into the wreck, disturbing archaeological contexts.

The presence of these intrusive elements is actually relatively modest compared to many shipwreck sites surveyed by OME in deep water. The impact of modern contamination on the integrity of deep-water site formations must now be taken into consideration alongside the complex interplay of environmental and cultural factors now accepted as moulding wreck formations, from the pre-impact to recoil and post-depositional effects. With such shipwrecks being disturbed in this manner, compounded by destabilization by fishing trawlers and, in some areas, by sand and gravel dredging, the stereotypical ideal of preservation *in situ* is clearly not always workable and is sometimes an inappropriate utopia of maritime cultural heritage management.

In addition to the near-total absence of pottery visible on the site's surface and excavated in the trenches, the erosion of the hull is a second highly conspicuous feature of site E-82's formation. The ship, in fact, compares extremely poorly to the coherence of many hulls surveyed and excavated in shallow, often high-energy environments. The ceaseless strong current of 3-5 knots present beneath 300m of water seems to have been sufficiently powerful during the last three centuries to have eroded the shipwreck down to a flat plane, with archaeological remains sealed in place by overlying cannon, anchors, concretions and probable ballast.

The geographical position of site E-82 is consistent with the reported location of the sinking of the third-rate, 80-gun HMS *Sussex*. The wreck's visible surface features measure 26.5m long and 6.5m wide. When compared with the dimensions the *Sussex* – 47.90m on the gun deck, 40.36m on the keel and a beam of 12.60m – these figures come up short. Nevertheless, given the fact that the upper sediment of the seabed in the wreck environment comprises soft clay, a significant proportion of the vessel may remain buried. The extension of the site beneath the sediments to the north-east remains undetermined. It is potentially revealing that the environmental core analysis located major organic material at distances of up to some 10m beyond the confines of the visible wreck manifestations, which would extend the projected wreck area by 112% (from 164m² to 348m²) or more.⁵

Based on the authoritative British Library Additional Manuscripts 9289, Brian Lavery has demonstrated that the *Sussex's* cannon comprised:

- 24 demi-cannon
- 30 culverins (18-pounders)
- 22 6-pounders
- 4 sakers (5 1/4-pounders)

The exclusively iron cannon form the main feature of the wreck and are consistent with a north European/English ship of the late 17th century, though probably not Mediterranean, because such ships had fewer guns and usually a proportion were cast in brass rather than iron. Research relating to the armament installed on the *Sussex* indicates that the guns were almost certainly all cast of iron. In the late 17th century, and for several decades earlier, the Royal Navy obtained its stocks of guns by commissioning cast ordnance from a few English iron foundries, by purchasing stock from Holland and Scandinavia, and especially by seizing guns from captured ships. The ships of France and Spain were typically armed with bronze guns, mainly as a consequence of long prior experience with their own problems manufacturing suitable iron weapons and largely due

to the nature of ores available and foundry methods.

Guns C15 and C16 are the most easily identifiable and seem to match 6-pounders that could have been fitted on the half deck and coach towards the stern of the *Sussex*. The bore on C14 indicates that it is a 3-pounder, a relatively rare calibre, but recorded to have been on the poop deck of the *Sussex*. Since three guns that appear to be the same size as C14 were found near the north-eastern end of site E-82, this pattern is perhaps an indication that the stern lies in this direction. None of the evidence arising from this examination, or from the analyses of the artifactual and ecofactual data recovered, discounts the site from being the wreck of HMS *Sussex*. Therefore, the working assumption that this site can be considered an ongoing candidate for the *Sussex* remains valid.

The fieldwork designed to identify the wreck at site E-82 remains incomplete. Operations were suspended on 15 January 2006 when the *Odyssey Explorer* returned to port in Gibraltar to re-fuel and change crew. On the afternoon of 17 January, OME departed from Gibraltar to resume operations. In the face of direct hostility from the Spanish Guardia Civil, the ROV was not deployed. Instead, the ship was forced to return to Gibraltar and the project was temporarily suspended.

At the time of departure from site E-82, Odyssey's management had no reason to consider that access would be denied upon return, since the Spanish Government had indicated that Odyssey's operations would not be disturbed, pursuant to the company's invitation for Spanish archaeologists to join the expedition. The deterioration of relations was abrupt and the aggressive nature of the confrontation required immediate action to ensure the health, safety and security of all staff aboard the *Odyssey Explorer*. Given this immediate threat, Odyssey was compelled to take the extreme decision to vacate the shipwreck site.

This protocol, however unsatisfactory, is in line with various advisory guides. The ICOMOS Charter on the Protection and Management of the Underwater Cultural Heritage (1996), Article 11, states that 'The health and safety of the investigating team and third parties is paramount. All persons on the investigating team must work according to a safety policy that satisfies relevant statutory and professional requirements and is set out in the project design.'

Similarly, the Institute of Field Archaeology's *Standard and Guidance for Archaeological Field Evaluation* (2001, 3.3.9), advises that 'Health and Safety regulations and requirements cannot be ignored no matter how imperative the need to record archaeological information; hence Health and Safety will take priority over archaeological matters.' This priority is reiterated and repeated verbatim

in the IFA's *Standard and Guidance for Archaeological Excavation* (2001: 3.3.11) and *Guidance for Nautical Archaeological Recording and Reconstruction* (2007: 5.10).

At present, access to site E-82 remains denied to Odyssey by the Spanish government despite the wreck's location in international waters, as recognized by the UK Government. Consequently, the site cannot be reinstated and all six excavation trenches, in addition to the two reception pits, were left open. Thus, Odyssey was unable to complete the measurement of features exposed in the excavated trenches and to produce the intended photomosaics of each trench, which has complicated the interpretation of the wreck's archaeology.

Concern over the possible vulnerability of these deposits remains acute, but is hopefully alleviated by the constantly moving sediments, which are likely to seal exposed surfaces in a very short period of time. It should also be noted that Odyssey was forced to abandon expensive operational equipment on-site, including six transponders, two datum plates, a mini-plex container and four ranging rods.

Reinstatement of the site, including backfilling of the trenches (and preferably the replacement of the sediment dusted off the visible site), would be desirable to maintain the integrity and stability of the site and its archaeological deposits for the future. However, despite Spanish approval of proposals by Odyssey for these archaeological investigations, the requisite steps necessary to proceed have not been completed by Spanish authorities. Return to the site remains an unresolved intention.

Meanwhile, a final report on site E-82 is under preparation for publication and will include a comprehensive presentation of all archaeological data obtained to date, specialists' reports on the environmental program, marine biology, pottery and brick, geochemical and petrological studies of the ballast, the wood species, and site interpretation.

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Notes

1. The precise co-ordinates of the wreck site are not disclosed in this paper because the shipwreck project remains ongoing and to protect the archaeological integrity of the wreck site from unauthorized interference.
2. The objective of this report is to introduce the primary

archaeological data of site E-82, not to present an historical and archaeological interpretation of the ship's identity or of HMS *Sussex*.

3. The SAE (*Sussex* Archaeological Executive) is a self-regulatory body appointed jointly by HMG and OME, comprising six British and American scholars, to approve archaeological standards employed by Odyssey on-site.

4. The full complexity of the technology on-board the *Odyssey Explorer* (including conservation and archaeological facilities) and custom-designed for ROV Zeus are beyond the limits of this report, and will be presented in the final publication.

5. Two reception pits were cut 10m beyond each end of the visible wreck site in which to deposit temporarily, and in a comparable marine environment, material culture and any timbers not destined for recovery. A discontinuous timber was exposed in the north-eastern pit, indicative of possible archaeological continuation beyond the visible site parameters.