THE BRITISH SUB-AQUA
JUBILEE TRUST

Exploring the Great Fossil Mine of the southern North Sea

Project Report

Rachel Bynoe

Prepared for the BSA Jubilee Trust

March 2019

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Summary

This report discusses the results of two weeks of diving investigations during the summer of 2018 for submerged landscapes offshore Happisburgh, Norfolk, the earliest site of human occupation in Northern Europe.

For over a hundred years the fossilised remains of mammoths, rhinos and other Pleistocene fauna (c.2.6 – 0.01 million years ago) have been found along the coast of Norfolk and dredged from the seabed in the vicinity (Layton 1827; Reid 1890, 1913; Wessex Archaeology 2008; Bynoe et al. 2016). Whilst Victorian collectors amassed substantial assemblages of these remains, they were considered curios, or of palaeontological value at best. The recent discovery of the archaeological site of Happisburgh on the coast of Norfolk, however, dated to just under 1 million years old (Parfitt et al. 2010a; Ashton et al. 2014), has reinvigorated interest in both these remains, the deposits they relate to and the search for associated stone tools. This site is incredibly important for our understanding of human evolution and migration as it is the oldest evidence of occupation north of the Alps and formed at a time when Britain was joined to the continent of Europe by vast lowland landscapes that extended where the southern North Sea exists today. Crucial for this project, however, is the fact that the work at Happisburgh is indicating that the archaeological deposits are not just exposing on the coastline but are also preserved underwater: large collections of stone tools, cut-marked bones and concreted lumps of Pleistocene deposits are washing up on the beaches, demonstrating the existence of a submerged Pleistocene site—or sites—of great antiquity. Recent analysis of these remains conducted by the team leader, in conjunction with geophysical data to identified areas of net sediment loss and erosion, and led to the identification of high potential areas of seabed that were targeted during this project for outcropping deposits and archaeology.

This project used diver ground-truthing to target key areas of seabed immediately offshore Happisburgh, taking a small group of mainly BSAC divers for both archaeological exploration as well as diver training. Over the course of the two weeks, four areas of seabed were identified as being in situ deposits relating to those yielding archaeology onshore. These deposits were explored, surveyed and sampled for palaeoenvironmental information, allowing crucial information about these internationally important deposits to be gleaned and developing our methods for working with deposits of such antiquity underwater; a poorly developed area of archaeological research. Important skills were learnt by all involved, particularly those new to both archaeological and British diving who were able to combine practical diving skills with evening theory lessons.

The British Sub-Aqua Jubilee Trust (BSAJT) generously provided funding that allowed for a significant part of the boat hire for these weeks, meaning that this innovative and exciting fieldwork was able to go ahead. The diving was conducted from the RIB Humber, skippered by Guy Trees of Safety Boats UK. In total, 129 dives were undertaken by 12 divers totalling 4,533 minutes underwater. Divers were from a range of BSAC clubs including Solent Archaeological Divers Sub-Aqua Club (SADSAC), the Nautical Archaeology Sub-Aqua Club (NASAC) and Solent University Sub-Aqua Club (SUCS). These divers combined both professional archaeologists, students of maritime archaeology and keen amateurs. Several of the students had no archaeological experience and a few were brand new to open water diving; this project gave them invaluable experience to expand both their diving and archaeological skills and all divers contributed a huge amount to the success of these two weeks.

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1 Introduction

The outline of a country or landmass, particularly your own, is instantly recognisable: the particular indentations of the shoreline, the unique placement of small islands around the edges, or perhaps the arbitrary political boundaries and the shape they impose. Seemingly immutable, this configuration—the interplay between fluctuating sea levels and the lie of the land—is in fact relatively recent and, for Britain, has been radically different in the not-too-distant past. Known colloquially as the Ice Age, the Pleistocene epoch extends back from approximately 11 thousand years ago (ka) until 2.6 million years (ma) and for its final half a million years was characterised by a series of pronounced glaciations. These glaciations not only caused dramatic drops in sea-level, up to 130m, but significant changes to the form of our landscapes, resulting in swathes of terrestrial land where the sea is today. As the temperatures warmed, these landscapes were then drowned by rising sea-levels, until the next cycle of glaciation began.

This project focuses on the period of time prior to these intense glaciations. At this point, before 0.5ma, Britain was permanently joined to Europe, with large areas of lowland joining us from Holland in the east to the northwest of France, dissected by large, resource-rich rivers. Climate still fluctuated between warm and cold, but Britain remained a peninsula of Europe throughout. It is within this period that the earliest evidence for the occupation of north-western Europe by our early human ancestors is found, at a site called Happisburgh 3 in Norfolk (Parfitt et al. 2010a [Figure 2]). Dated to between 0.8 and 1ma, this site fundamentally altered the debate about the nature and tempo of early human migrations out of Africa, in particular the timing of migrations into northern latitudes; peripheral areas of challenging seasonality and freezing winters. We know that these early humans were here when winter temperatures were below freezing, we know also that they were here in family groups from the preserved footprints that indicate an array of body sizes (Ashton et al. 2014), but the final thing we know is that a large part of their landscape is now lost beneath the North Sea, the evidence for which this project set out to locate.

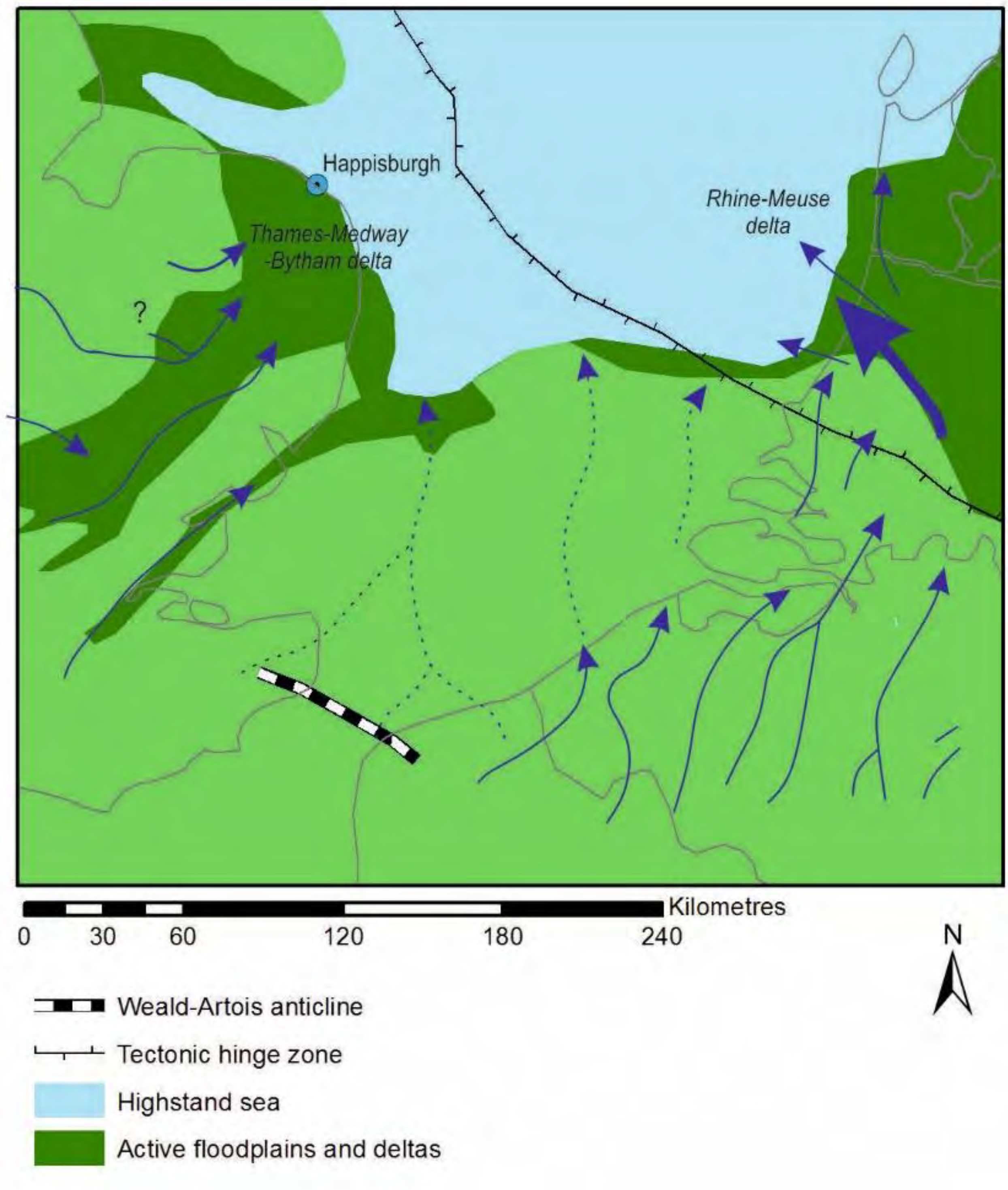

Figure 1 Schematic showing broad location of sea levels during the early Middle Pleistocene in the North Sea, with current outline of UK and Europe shown in grey. (After Hijma et al. 2012)

2 Previous Work

The archaeology at Happisburgh is contained within a group of deposits known as the Cromer Forest-bed Formation (CFbF). These deposits are remarkably rich in organics, with wood regularly emerging with its bark still intact. Pine cones and leaf impressions further attest to the rich array of palaeoenvironmental information that can be found, demonstrating the changes in the Early (2.6 – 0.78ma) – early Middle (0.78 – 0.5ma) Pleistocene environments represented and providing one of the most unique sources of information on this early period in our evolution anywhere in the world. Since the discovery of archaeology within the CFbF in the early 2000s, there has been a renewed interest in the centuries-long practise of collection along this coastline. This has resulted in the recovery of hundreds of bones of long-extinct Pleistocene animals, from mammoths and rhinos to giant deer and bears (Figure 3), some of which show evidence of human butchery. Blocks of concreted CFbF have also been washing up from presumed submerged exposures, some of which contain, or adhere to, faunal material and stone tools (Figures 3 and 4). These have been documented as far back as 1877 by Clement Reid, who took a boat out to grapple for the deposits (Reid 1890), with the area identified as “…a rocky bottom…½ a mile north-northeast of the low lighthouse” (Reid 1890: 173) being the focus of two days diving in 2015 (Ashton et al. 2016). The final dive of this short expedition located outcropping concreted deposits, possibly of the CFbF, and a loose Early Pleistocene rhino radius (lower forelimb) in an area of sea known locally as The Monks (Figures 2 and 5).

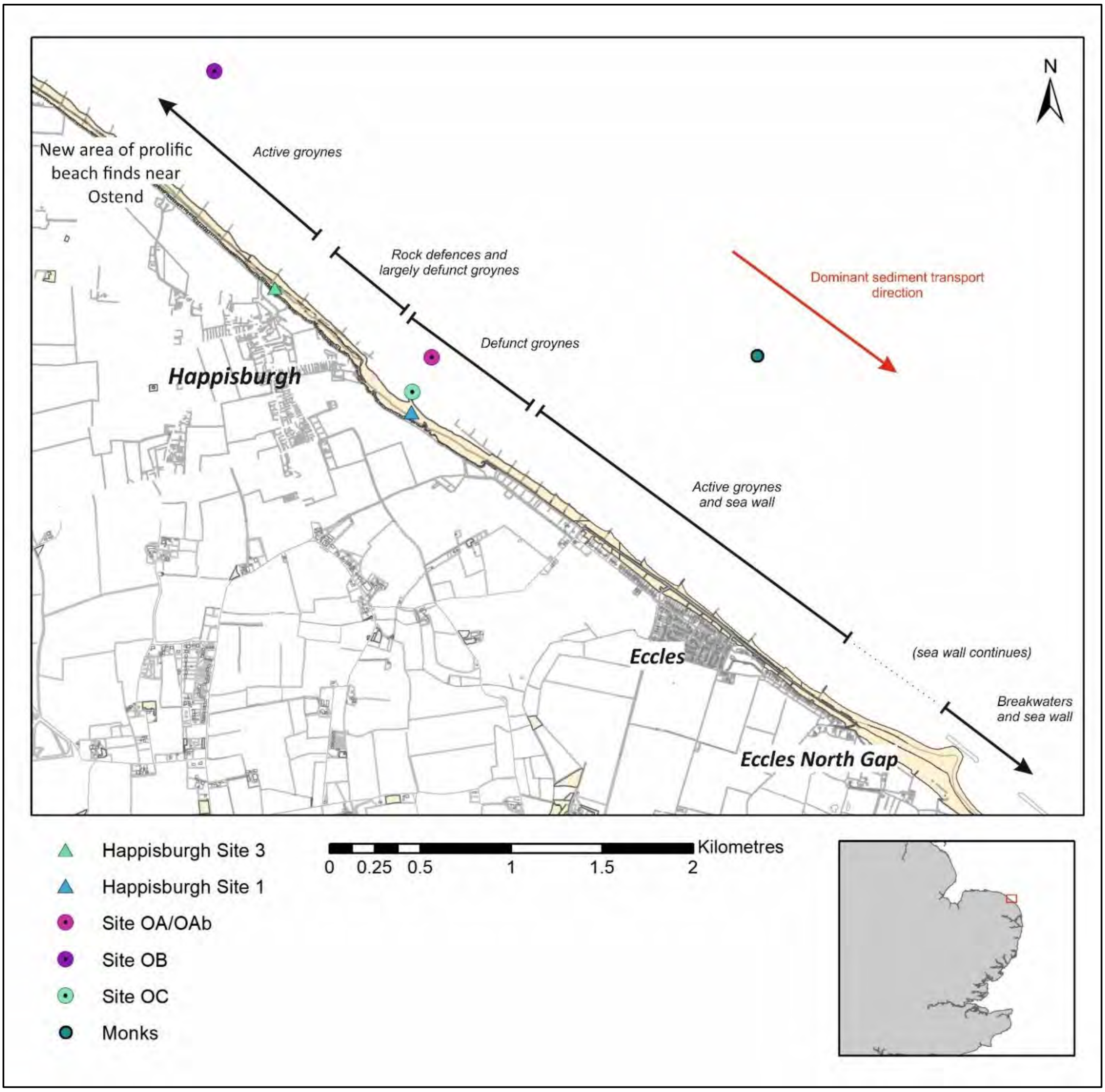

Figure 2 Sites and areas discussed in text, with insert map showing location

More recently, however, large collections of stone tools have also been turning up on the beaches, with more than 800 collected between 2014 and 2016, and these numbers increasing ever since. With exposures of CFbF on the foreshore at Happisburgh there is the possibility that these finds are all simply eroding from these deposits, but analysis of the patterning in their locations (Bynoe et al. forthcoming) indicates it is not this simple: finds are emerging in great densities 3km down-tide of Happisburgh at Eccles North Gap, where there are no known exposures of the CFbF until Happisburgh Site 1, 3km to the northwest. Being separated from Eccles by a stretch of groyne-protected coastline (Figure 2), movement of lithics eroding from Site 1 down to Eccles is therefore unlikely, which is further supported by the relatively fresh appearance of the stone tools. Furthermore, many of the finds show evidence of being in a marine environment: they have barnacles and bryozoa adhering to them. The hypothesis is therefore that there are submerged fragments of CFbF in the nearshore zone that are yielding at least part of this archaeology.

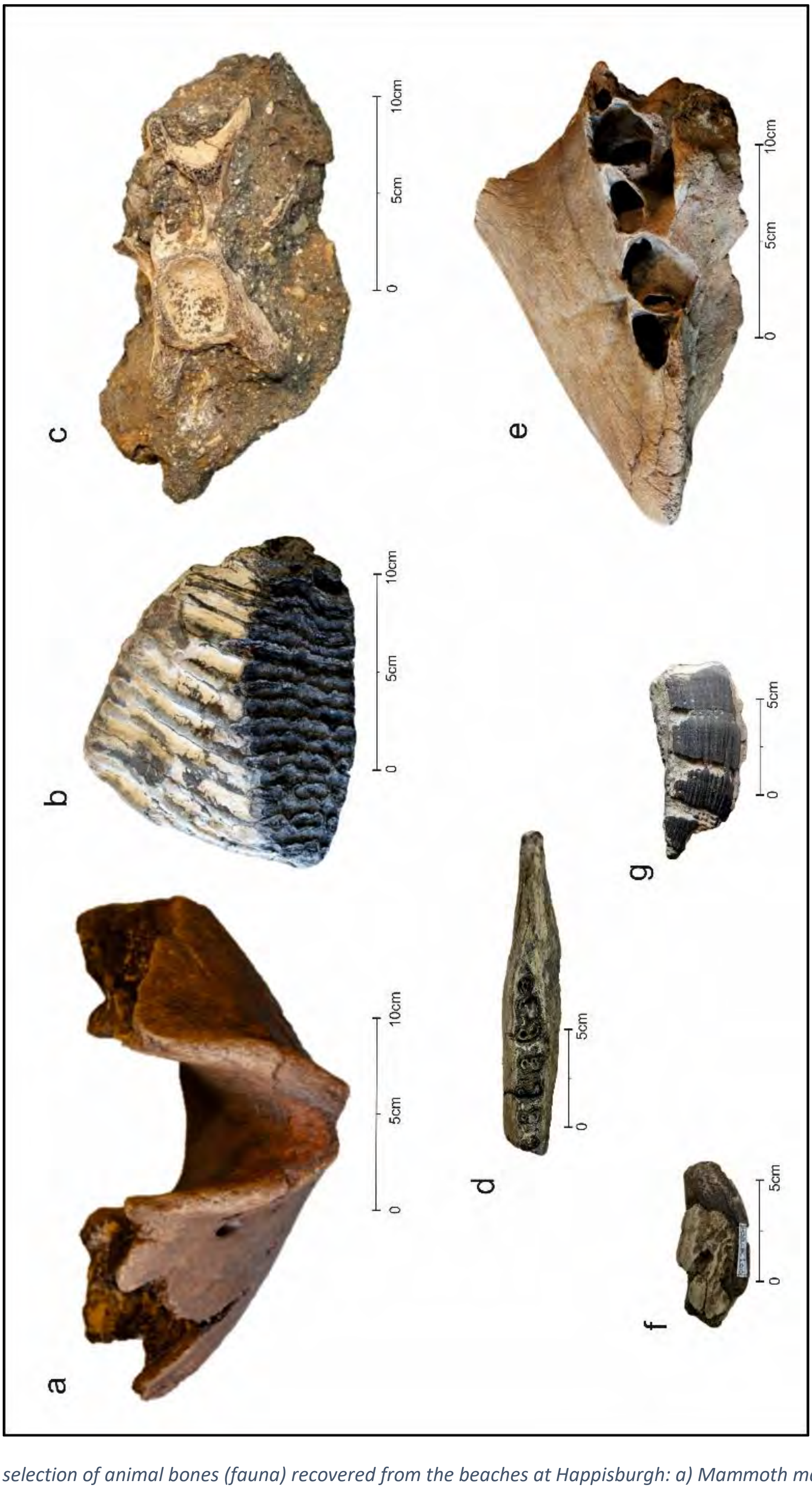

Figure 3 A selection of animal bones (fauna) recovered from the beaches at Happisburgh: a) Mammoth mandible; b) Mammoth molar; c) Rhino pelvis contained in concreted CFbF; d) Giant deer mandible; e) Rhino skull fragment; f) bear canine; g) hippo canine fragment

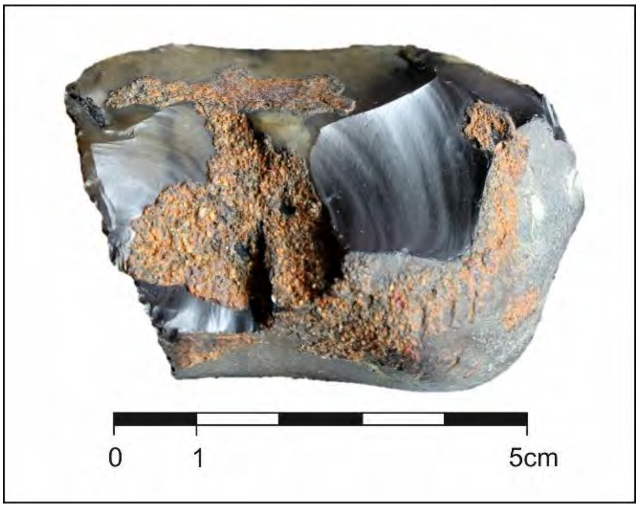

Figure 4 Stone tool (flake) recovered from the beach with concreted CFbF adhering to its surface

The analysis of multibeam bathymetry collected by the Environment Agency in 2011 and 2016 down to the -10m contour, highlighted an area of seabed where there has been net sediment loss just to the northwest of Eccles North Gap (Figure 6). This was calculated by assessing the differences in seabed elevations between the two periods of data collection using ArcGIS 10.6, allowing the identification of areas that had seen erosion vs sedimentation. With the sediment transport in the area moving in a shore-parallel direction to the south-east, this was identified as a key area to target for exposures of archaeologically rich CFbF. Other areas of interest include the formerly identified Monks, as well as areas within 1km offshore of Happisburgh 1, where the spatial analysis and characteristics of the stone tools also indicates that there is the potential for submerged deposits in the nearshore zone.

The identification of submerged archaeological deposits in this area would not only would be the oldest submerged archaeological site in the world but it would significantly develop our methods for both finding and working with sites of such great antiquity underwater.

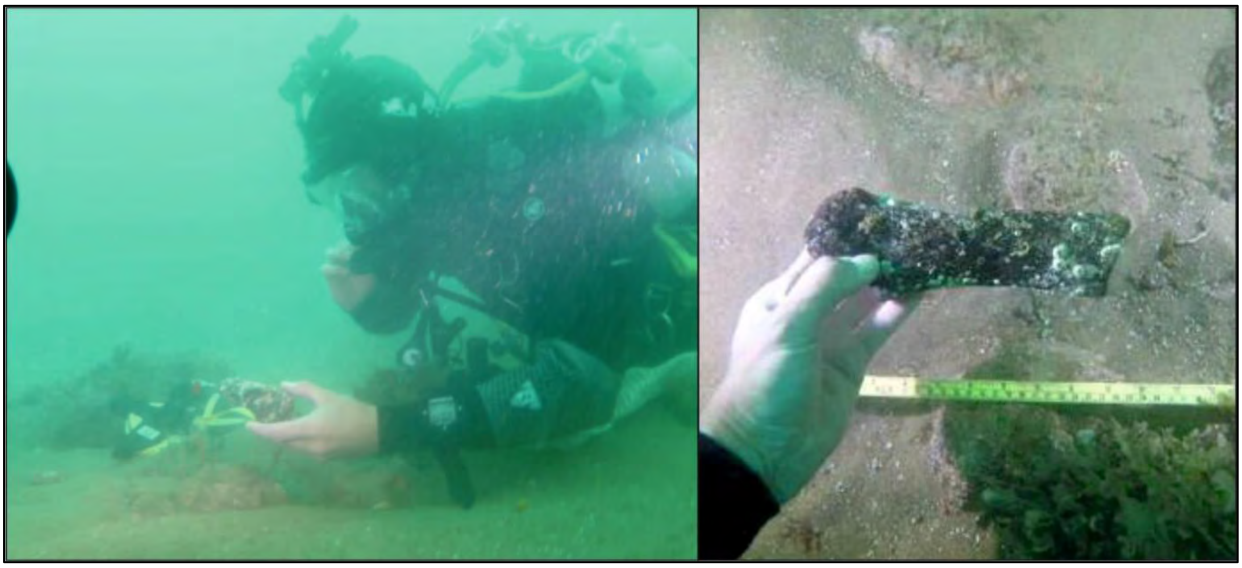

Figure 5 Rhino radius being found underwater on the Monks during the 2015 dives

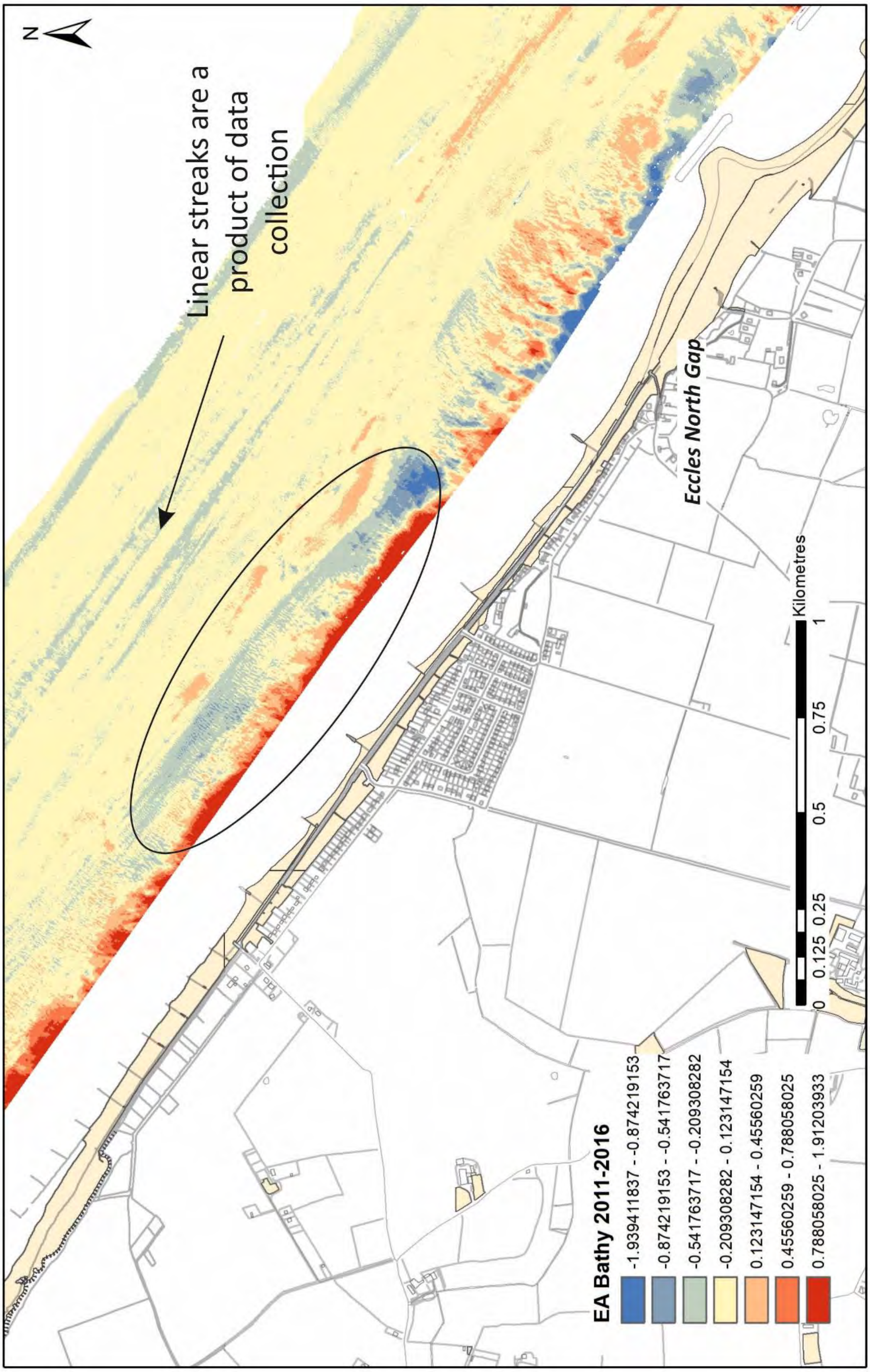

Figure 6 Changes in bathymetry from 2011 – 2016 with main search area circled. Data from data.gov.uk

3 Project Aims and Objectives

The main aim of the project was to target high potential areas of seabed to locate and investigate submerged archaeological deposits.

The objectives were as follows:

1. Through spatial analysis of beach finds, locate areas of exposed Pleistocene deposits in the nearshore zone at Happisburgh for assessment/survey/sampling.
    a. Target areas of the nearshore seabed that have had net sediment loss and fall close enough to shore to feasibly allow the movement of this material onshore. The sediment transport regime is overwhelmingly shore-parallel, meaning that in order to be washing up in these locations their point of origin cannot be very far out to sea.
    b. Employ systematic search methodologies in order to locate exposed and outcropping deposits on the seabed.
2. Determine whether any of these exposures contain archaeology
    a. Once located the deposits will be assessed for archaeological potential. Students will be shown examples of Pleistocene material in advance of this work and this will allow them to refine their search skills underwater, as well as their ability to identify archaeological material.
3. Sample exposed material for comparison with exposures onshore
    a. Sampling of the deposits will allow for further analysis and comparison with modern and historic beach collections. This procedure will train the students in the use of sampling techniques and the use of tools underwater.
4. Collect geophysical data across the surrounding seabed
    a. Crucial for the wider contextualisation of the area the collection of geophysical data will not only provide this wider understanding but will hopefully allow more targeted dives through highlighting areas of exposure.
    b. In addition to helping locate and understand these deposits, this data collection will also provide students with an opportunity to learn about both the collection and processing of geophysical data.
5. Train maritime archaeology students for diving in British conditions.
    a. Students involved will be a group of Maritime Masters students at the University of Southampton and will be made up of new BSAC members (many join the local BSAC club on arrival) as well as more experienced divers. This work is an ideal situation to train them to work in conditions the majority of them are not used to: currents, poor visibility and dry suits, and to encourage new members to join the local BSAC clubs.

4 Methods

This project ran for two separate weeks over the summer of 2018: July 20th – 27th and September 14th to 20th, both periods of neap tides. Both weeks had six days of diving, although those in September were hampered by strong winds and technical problems, which meant a few of these days were only partial. A compressor was generously leant to the project by MSDS Marine, which the team were trained in using and all members participated in during the evenings (Figure 7). The same RIB was used for each of the weeks, hired from Safety Boats UK, with a very competent skipper, Guy Trees. The RIB was launched and recovered on a daily basis at the nearby town of Sea Palling, using a local tractor (Figure 8). Transit to site was then approximately 5 minutes. Although it was initially envisaged that there would be a break for lunch, with divers disembarking, the tides over both weeks turned out to be benign enough to dive through. As such, a series of gentle drifts were used in conjunction with targeted dives.

Figure 7 Diver Crystal El Safadi using the compressor provided by MSDS Marine

4.1 Dive Teams

Week 1:

Diver	Qualification
Rachel Bynoe	BSAC DL
Jane Maddocks	BSAC FC
Dan Pascoe	BSAC DL
Crystal El Safadi	BSAC SD
Kate Recinos	BSAC SD
Ryan Killion	PADI AOW

Table 1 Dive team for week 1. All divers were present for the entire week of fieldwork

Week 2:

Diver	Qualification
Rachel Bynoe	BSAC DL
Jane Maddocks	BSAC FC
Alex Boni-Ball	PADI DM
Aytein Nasr	CMAS 3*
Rebecca Ferreira	BSAC OW
Maddy Fowler	PADI DL
Christin Heamagi	BSAC DL
Fraser Sturt	BSAC AD

Table 2 Dive team for week 2. The final three divers were present at different times, maintaining a six person dive team.

4.2 Diver Safety

Prior to the fieldwork, all divers produced proof of their diving qualifications and medical fitness to dive and were taken for pre-fieldwork diving checks at Andark Lake. Diving operations during the project followed BSAC's code of safe diving as well as the HSE Scientific and Archaeological Approved Code of Practice, with several of the divers (at least four per week) also being HSE SCUBA qualified. Dive Risk Assessments, Daily Risk Assessments, Dive logs and Dive Procedures were produced.

Diving operations were run using a Diving Project Plan, which included the following:

- Diving Risk Assessment
- Dive Plan
- Dive Logs

Figure 8 RIB Humber being launched at Sea Palling

A diver briefing was held at the start of each day's operation to confirm the works for the day followed by a complete check of all equipment to be used. All diving equipment used belongs to the University of Southampton, was in-service and was checked on a daily basis during fieldwork. The operations carried out were subject to risk assessment and all team members involved with the project ensured that all possible safety precautions were taken.

Diving operations were controlled from the dive support vessel, the RIB Humber, skippered by qualified skipper and diver Guy Trees of Safety Boats UK. The international code flag Alpha was displayed during the diving operations.

The method of diving was SCUBA, with two divers working together in the buddy system. All team members utilised an Alternate Air Source (AAS) in the form of a 3 litre pony bottle or similar. This was used as well as an octopus rig allowing an out of gas diver to swim to their buddy and then ascend using the gas in their buddy's main cylinder. A shot line with a marker buoy was deployed at each site before diving commenced to enable divers to access and leave the site safely.

4.2.1 Accident and Emergency

The HSMS outlines procedures for dealing with notifiable injuries, incidents, near misses, and reportable accidents. Contact details were included in every Risk Assessment. Appropriate levels of first aid equipment and trained first aiders were maintained both at the office/home location and in the field, including 0_2 provision for diving operations.

In the event of an emergency the vessel master was ready to radio the Coastguard on VHF channel 16 and explain the situation and ask for helicopter or lifeboat transfer if the patient required medical attention. The closest hyperbaric chamber was:

Great Yarmouth:
James Paget Hospital Hyperbaric Chamber
Lowestoft Road
Gorleston
Great Yarmouth
Norfolk
NR31 6SG
Principal medical director Dr Bothma
Day time phone numbers 01493 414141
Call Out Number 01493 452452
Emergency phone numbers 01493 414164 (North Sea Medical Centre duty doctor)
24 hour cover **Yes**
On site chamber
Time to mobilise chamber: 1 hour
Category of chamber Category **1**

4.2.2 Health and Safety

Responsibility for compliance with the Health and Safety at Work Act (1974) was undertaken by the University of Southampton, given the involvement of their students. The University has a Health and Safety Policy Statement and Management System. The Policy delineates the University's commitment and approach to Health & Safety, the roles and responsibilities of staff and students in relation to Health & Safety, and the organisational arrangements for Health & Safety. The Policy is a legal requirement. The System delineates the requirements of the University for the management of Health and Safety. The University regularly audits its Faculties and Services against the System. The System is derived from the BS OHSAS 18001:2007 standard. This policy governed all non-marine activities and the responsibilities of the sub-contractors working on the project.

All diving work carried out as a part of this project incorporated the advice given in the Scientific and Archaeological Projects Approved Code of Practice (ACoP). However, as new diving equipment, excavation equipment, techniques and procedures are continually being developed, any code of diving practice such as this has to be regularly reviewed and updated with regard to its implementation (the latest Scientific and Archaeological Projects ACoP was published in 2014). Also, the specific conditions or circumstances of a site may require additional safety measures to be adopted. The project leader was therefore prepared to incorporate additional procedures as the need was identified. Advice on both the need for and the nature of such measures can be obtained from the HSE and the UK Scientific Diving Supervisory Committee (SDSC).

Operational responsibilities for health and safety are clearly stated in the University of Southampton HSMS and flow through the University Executive Group and Senior Management to the Project Manager and down to project staff, subcontractors, visitors and members of the public. The Policy statement specifies responsibilities for health and safety for each role/grade of employee. All activities were governed by a health and safety plan and project specific risk assessments.

4.2.3 Diving practice:

Due to the unknown nature of each dive site prior to the commencement of the first week of the project, no fixed schedule of diving was determined until the fieldwork was underway, where it was assessed according to the daily risk assessment. Subsequent to this, the second week of diving allowed for more planning and each day’s diving was discussed with the team in advance. All dives, however, observed the following:

- A marine VHF radio was available on the dive boat enabling communications with the Coastguard and other vessels operating in the vicinity of diving operations. A mobile phone was also available on the dive boat as a secondary communication device;
- All dives were carried out using BSAC 88 tables, with computers also used as depth timers;
- All SCUBA divers were briefed in common hand signals at the start of each diving operation;
- Maximum depth limit was determined by the site but was no more than 15m and was more commonly between 3m and 8m;
- No more than 5 minutes in-water decompression was planned however no decompression time was required at any site. Despite this, all divers observed a 3 minute safety stop at 6m (where the dive had exceeded this depth);
- A shot line was deployed at each working site, allowing the divers direct access to the surface;
- On the seabed, divers deployed a line from the shot to the working area, and thus the surface, at all times, allowing a safe return to the surface to be picked up by the dive vessel;
- SCUBA divers were in visual contact with their buddy at all times underwater or, where necessary, used buddy lines to maintain contact;
- All relevant information on tides and currents were consulted during the planning stages to ensure that diving took place during slack tides. Daily weather reports, as well as on-the-go assessments, were also carried out to make sure that diving only took place when conditions were safe;
- The majority of the diving operations took place within the period around and including slack water. If divers found themselves in an uncomfortable current, however, they were instructed to abort the dive and return safely to the surface using the shot line or their delayed SMB;

- Dives took place from the 21st – 27th July 2018 and the 14th – 21st September 2018 and were carried out from the MCA coded diving support vessel, RIB Humber, licensed to carry six divers plus a skipper. The international code flag ‘ALPHA’ was prominently displayed from the vessel at all times while divers were in the water.

4.3 The Study Area

The area that the project encompasses covers approximately 5km of seabed running parallel with the coastline off Happisburgh, with the main search area within 500m of the shore. Table 3 shows the co-ordinates of this broadly defined area. Associated seabed features on the Monks extend up to 2.5km out to the north-east and the shoreward extent of these—the site of 2015 investigation—was targeted to assess whether these deposits were still exposed and for archaeological potential. This was the deepest of the sites at 12-15m and the furthest out, at 1.3km from the shore (Figure 2).

	Latitude	Longitude
NE	638093	332843
NW	637368	332075
SW	640993	329160
SE	641861	330202

Table 3 OSBG36 co-ordinates for the study area

4.3.1 Diving methods

In order to locate areas of archaeological interest, the following standard dive procedures were undertaken:

- Dive pairs were dropped at locations identified from geophysical survey where they performed circular searches with the aim of locating deposits and archaeology. This was done in accordance with the procedures and guidelines set out in Underwater Archaeology: the NAS Guide to Principles and Practice (Bowen 2008).
- Where possible, particularly in areas of considerable sand coverage, buddy pairs covered larger search areas using drift dives in gentle currents.

Once identified, the deposits were recorded following procedures and guidelines set out in the Institute for Archaeologists *Standards and Guidance for Archaeological Field Evaluation* (CIFA 2014). All recording was based on a unique site identifier, which linked to all archaeological finds, samples and drawings. Initial assessment of identified sites included sketch plans supplemented by digital photographs and video, collected using GoPro HD cameras. The photographs were used to create a photogrammetric survey of the main site (see section 5.2.6.3), with selected areas also recorded using tape-measures for baseline offset measurements. Samples were collected from each identified site using a variety of methods to provide a range of outputs:

- Core samples for stratified collection and analysis of pollen and ostracod data, using 50mm wide tubes for preliminary analysis and 100mm wide tubes for more in-depth work;
    - o The volume collected was well within the limits for not requiring an MMO license and was all recovered to the vessel by hand
- Bulk samples of ~10l to be sieved for microfauna (e.g. water voles, very important for chronological and environmental information)

- Where ex-situ artefacts were encountered, these were recovered to the boat for further analysis and recorded as above.

The spot height of selected features and levels were calculated in metres relative to Chart Datum. Where appropriate due to proximity to the shore, or due to the subject matter (i.e. prehistoric material), levels were converted to metres relative to Ordnance Datum using a UKHO Vertical Offshore Reference Frame (VORF) transformation.

4.3.2 Skills developed

This project hoped to not only search for these elusive and internationally important Pleistocene deposits, but to train new maritime archaeologists in key skills while doing so. Although several of the divers had been part of teams working on wreck sites previously (e.g. BSAJT-funded 'The Invincible Project 2012' and 'Solent Wreck Project 2011 – 2012'), the investigation of submerged landscapes, particularly of those so far removed in time, is something that there are few opportunities for. This therefore provided an opportunity to not just develop diving and archaeological skills but to simultaneously increase awareness of the existence of these types of deposit in the offshore zone.

The team was made up of a variety of divers, from professional archaeologists to archaeology students and keen enthusiasts. These divers also had a range of diving qualifications, from First Class BSAC with HSE SCUBA, BSAC Dive Leaders with HSE Scuba and CMAS divers with Egyptian commercial qualifications to brand-new BSAC Open Water divers. Those with less experience were buddied with more experienced members of the team, promoting safety and a steeper learning curve.

Skills developed or acquired included:

- Entry and exit from a RIB;
- Diving with a pony cylinder;
- Circular searches around a shot;
- Drift dives;
- Use of SMBs and DSMBs;
- Diving in lower visibility conditions and current;
- Traditional survey techniques using baselines and tape-measures;
- Underwater video and photography;
- Sampling;
- Artefact recognition.

Due to the invaluable participation of Jane Maddocks during both weeks of fieldwork, several evenings were spent completing or re-visiting BSAC Sports Diver theory sessions with the newer members of BSAC, a significant contribution to their ongoing progression.

4.3.3 Geophysical data collection methods

During the July week of fieldwork, a side scan sonar StarFish 990F, kindly loaned to the project by Bournemouth University, was used to collect data over the study area. This was set-up on-board the dive support vessel, RIB Humber, and data lines were collected shore-parallel with an aim of 50% overlap to provide for full coverage of the seabed (Figure 9).

Files were collected in .xtf format and were processed using SonarWiz 7.

Figure 9 Divers El Safadi and Kate Recinos preparing to collect Side Scan Sonar data

5 Project Results

5.1 Introduction

Diving was carried-out over two separate weeks of neap tides: July 21st – 27th and September 14th – 21st 2018, with 129 dives by 12 divers totalling 4,533 minutes underwater. The July week was a week of fantastic weather; almost no wind and remarkable visibility even close to shore. As such, no days were lost to weather and the highest number of dives were completed this week (73: 2,372 minutes). The September week was not so lucky, with very strong westerly winds hampering the work. Given the positioning of the sites close to shore, sheltered by the Happisburgh cliffs, diving was still possible although the final day of diving had to be called-off and a few afternoons were blown out. Nevertheless, a total of 57 dives (2,161 minutes) were completed this week.

5.2 July Fieldwork

The initial week of fieldwork was focused on searching the seabed using targets derived from the geophysical datasets and the analysis of beach material. At this stage it was not known whether any areas of exposure or archaeology would be found, so this was planned as an explorative, data-driven week of diving.

The team this week is shown in Table 1, Section 4.1.

Divers El Safadi, Recinos and Killion were all new to UK diving, being unfamiliar with tides, low-visibility and the latter two divers also new to dry suits. As stated above, all divers were familiarised with the kit prior to fieldwork taking place, at Andark Lake, Hampshire. Throughout the week, the less experienced divers were buddied with those having more experience, to ensure safety and the sharing of skills.

Prospection dives and Geophysical data collection

As described in Section 2, pre-existing multibeam bathymetry data was used to highlight areas of seabed that had seen net sediment loss off Eccles North Gap. These formed a significant search area for the initial week, with drift dives and circular searches conducted across the area of interest.

These exploratory dives off Eccles North Gap were begun on day one of the July fieldwork in slack conditions, but only a sandy seabed was encountered. By lunchtime the tides had been predicted to pick-up significantly. However, as is often the case when working in new locations, the predictions were not entirely accurate and the current was still workable. As such, it was decided to head north-west to attempt a south-easterly drift towards the morning's search area, with a drop-in location based on an educated guess of where the extension of onshore archaeological deposits might be, should they be preserved (Figure 10). This, it turned out, was a great choice, as within a few minutes of bottom-time the divers had located our first glimpses of in situ CFbF deposits underwater; an incredibly successful first day of fieldwork! These deposits were raised above the surrounding sands, providing natural sections for investigation, and were very rich in organic remains (Figure 11). Their positioning in-line with the orientation of the archaeologically-rich channel system onshore implies that these deposits may be from an earlier (based on their lower elevation) activation of this channels system. This site was identified as 'Site OA'.

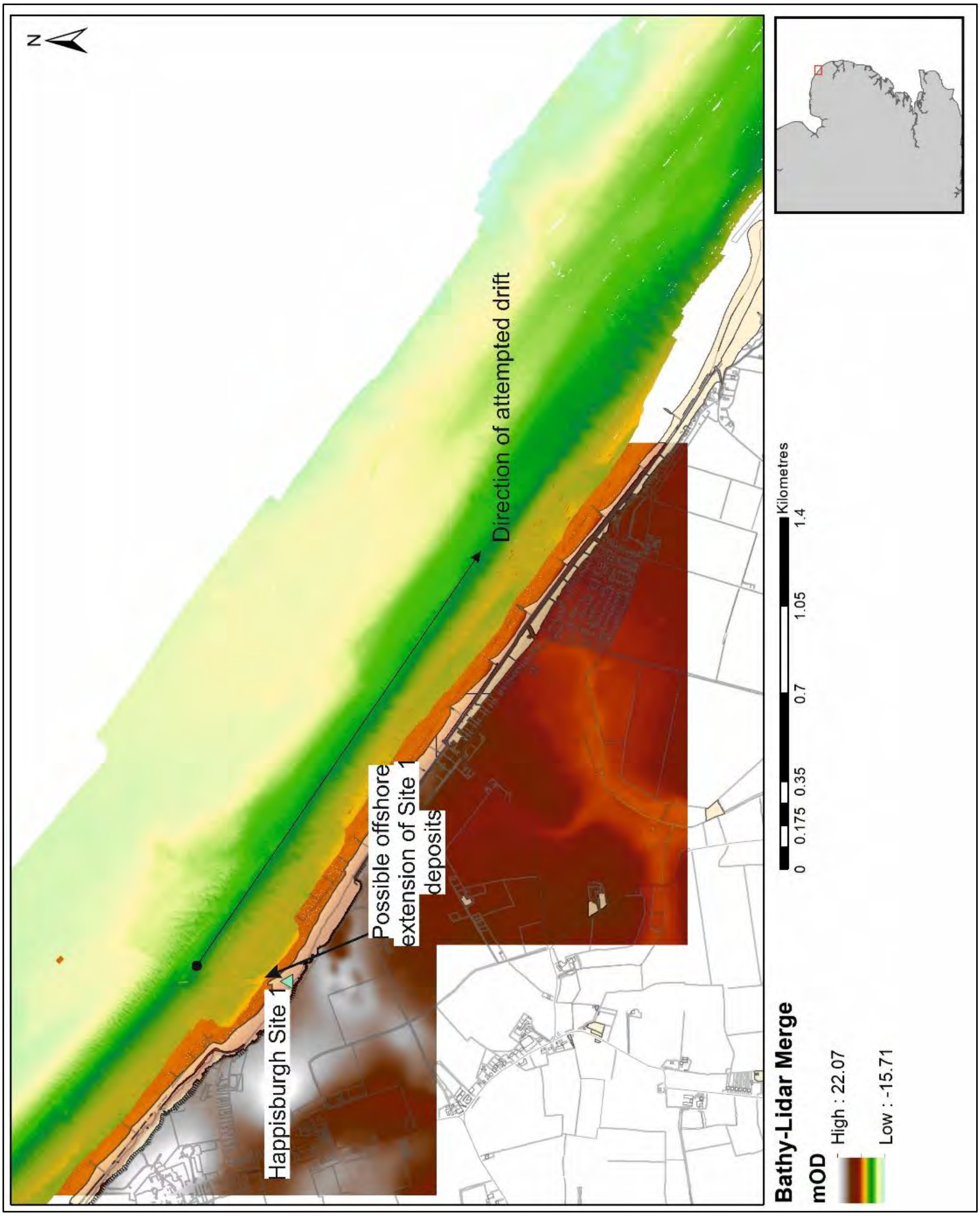

Figure 10 Map showing the locations of onshore deposits and the drop-in point for the drift dive to the south-east

Figure 11 Organic remains in laminated sediments identified at Site OA (Photo: Dan Pascoe)

5.2.1 Data collection

Subsequent to the discovery of Site OA, an afternoon of geophysical data collection was carried-out using the side scan sonar, set-up on our dive support vessel as described in Section 4.3.3, and processed using SonarWiz 7 to produce a GeoTiff of the main area of deposits (Figure 12). This not only allowed us to see areas of possible scour or exposure on the seabed, but, given that we had a known area of outcropping CFbF, site OA, that we could recognise in the sonar imagery, we were then able to calibrate the side scan images that we were seeing, making the likelihood of recognising further outcrops in the data more likely. This provided us with a series of areas to ground-truth (Figure 12), but also further indicated, through on-the-go side scan observations, that the area of our initial search, off Eccles North Gap, was likely to now be covered by sand waves.

Despite the side scan imagery appearing to show no evidence of outcrops near Eccles North Gap, this area was still searched throughout the week. The reasoning being that whilst site OA was extensive and had variations in height making it stand out, other areas may be smaller and less obvious in our collected data. This area was therefore searched through drift dives as well as using circular searches, but only sand waves were found.

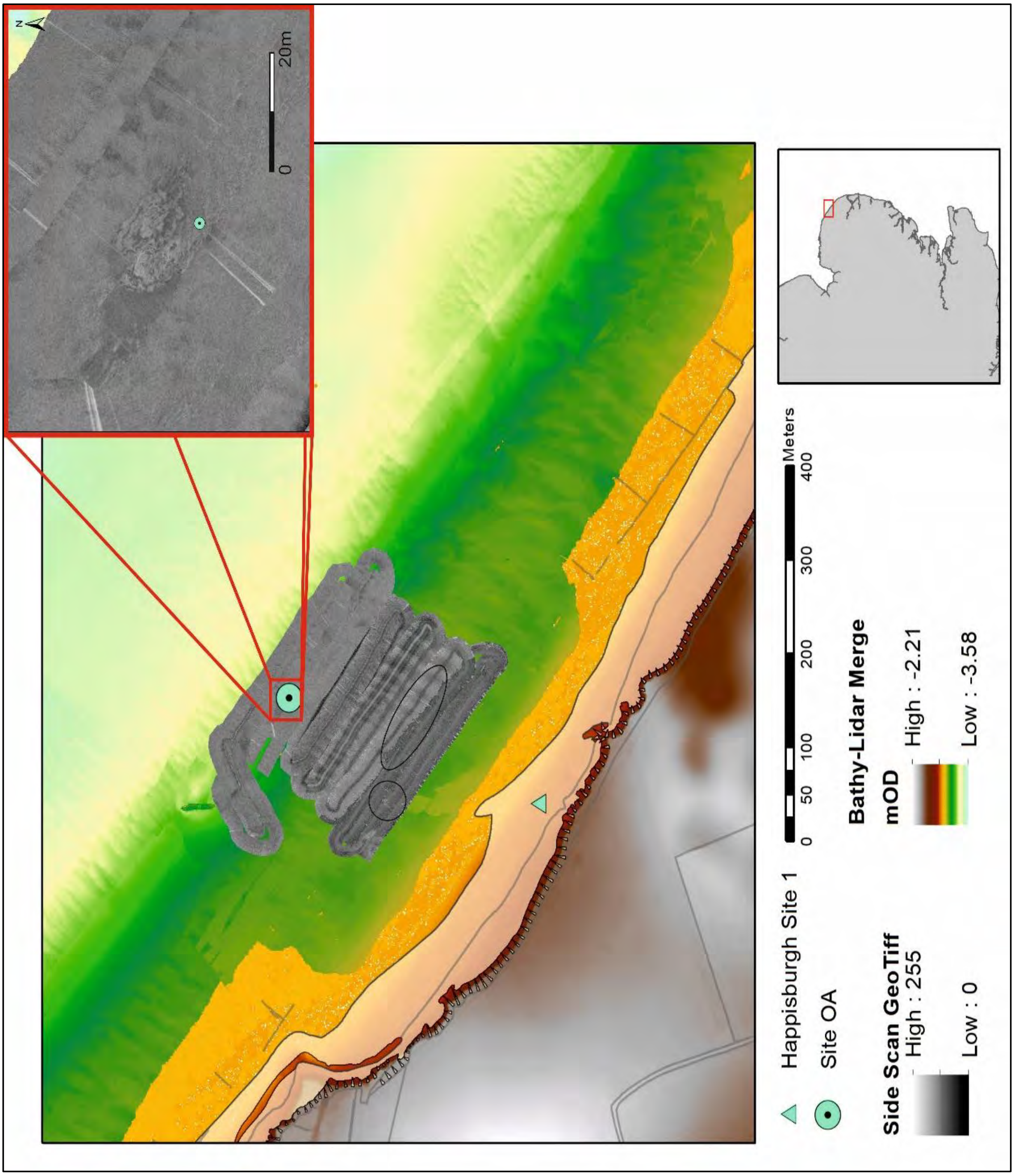

Figure 12 Side Scan Sonar GeoTiff with insert showing close-up of Site OA and circles showing areas of ground-truthing

5.2.2 Sites identified in the Side Scan Sonar data

Given the preservation of the deposits at Site OA in-line with the known channel deposits onshore, it seemed likely that there could be some preservation of related deposits in the intervening zone, and the presence of shore-parallel linear features in the side scan data as well as some possible isolated features, provided good targets to begin ground-truthing (Figure 12). As such, a series of transect dives were conducted, with divers swimming towards the shore on a south-westerly bearing across the linear features and towards the beach.

The linear features turned out to be a change in substrate, moving from sands, which variably covered areas of visible CFbF, to what a appears to be a large area of Sabellaria overlying large rounded cobbles. Sabellaria reefs form on hard substrates, such as cobbles and clays and are common along the North Norfolk coast. Moving across this Sabellaria reef, towards the shore, another area of exposed deposits was located. This area was in far shallower water and has what appears to be upstanding chunks of glacial till appearing, in places, to overlie deposits of the CFbF. This site was termed ‘Site OC’ (Figure 13).

Figure 13 Blocks of upstanding glacial till with large cobbles on the surrounding seabed at the near-shore site of OC.

5.2.3 Sites identified through collectors

In keeping with the nature of the community engagement-led work that has been ongoing at Happisburgh, local beach collectors were visited during the evenings of this project. One such collector, Mr Tim Grimmer, has become integral to the local community of beach walkers for identifying their finds and contacted us regarding a new area of interest that had come up. At his home, he had collated many finds from locals, all of which had been found further north than usual and which contained a surprising number of handaxes and mammoth bones (Figure 14). Collectors had identified a new area of prolific finds between Happisburgh and Ostend, to the north, all of which appeared to be found between the water-line and the wall-like sea defences in this area (Figures 2 and 15); these appear to be washing in from submerged deposits. As the head of the local Lifeboat station, Tim and his colleagues had used their echo sounder to identify a relatively sharp drop in seabed just off this particular find spot and we used their descriptions to target this area for diver ground-truthing.

Figure 14 Tim Grimmer, a local collector, and Nick Ashton, British Museum, with some of the recent finds from north of Happisburgh onshore of Site OB. Mammoth bones can be seen in the foreground, with a selection of handaxes towards the back

Over the course of the next few days the area was drift dived and transects were swam across the drop off. On the fourth dive, another area of laminated sediments from the CFbF were found eroding between the sand waves. This site was identified as ‘Site OB’.

Figure 15 Beach conditions onshore near Site OB showing the sea defences on the left hand side. Photo: Darren Nicholas

5.2.4 Return to the Monks

A final area of interest was the site of previously identified in situ, concreted sediments on what is locally known as The Monks. Dives here in 2015 had identified concreted blocks of what is thought to be the CFbF, possibly related to the blocks of concreted deposits that are found along the coastline that are often found adhering to faunal remains and, occasionally, lithics (Figures 3 and 4). These dives also resulted in the find of a loose rhino radius (Figure 5). This is the furthest area offshore that was investigated being around 1.3km from shore in approximately 15m of water (Figure 2). Being slightly further out, this area is characterised by larger, more mobile sand waves and re-visiting this area showed that these sand waves have now covered-up these areas of concretion. However, within the troughs of these sand waves, a few small finds of very mineralised faunal remains and possible lithics were located (Figure 16), indicating that archaeological deposits do exist somewhere further up-tide of this location. More geophysical work is required to get an idea of the bigger picture of movement and exposure in this area, to make future dives more targeted.

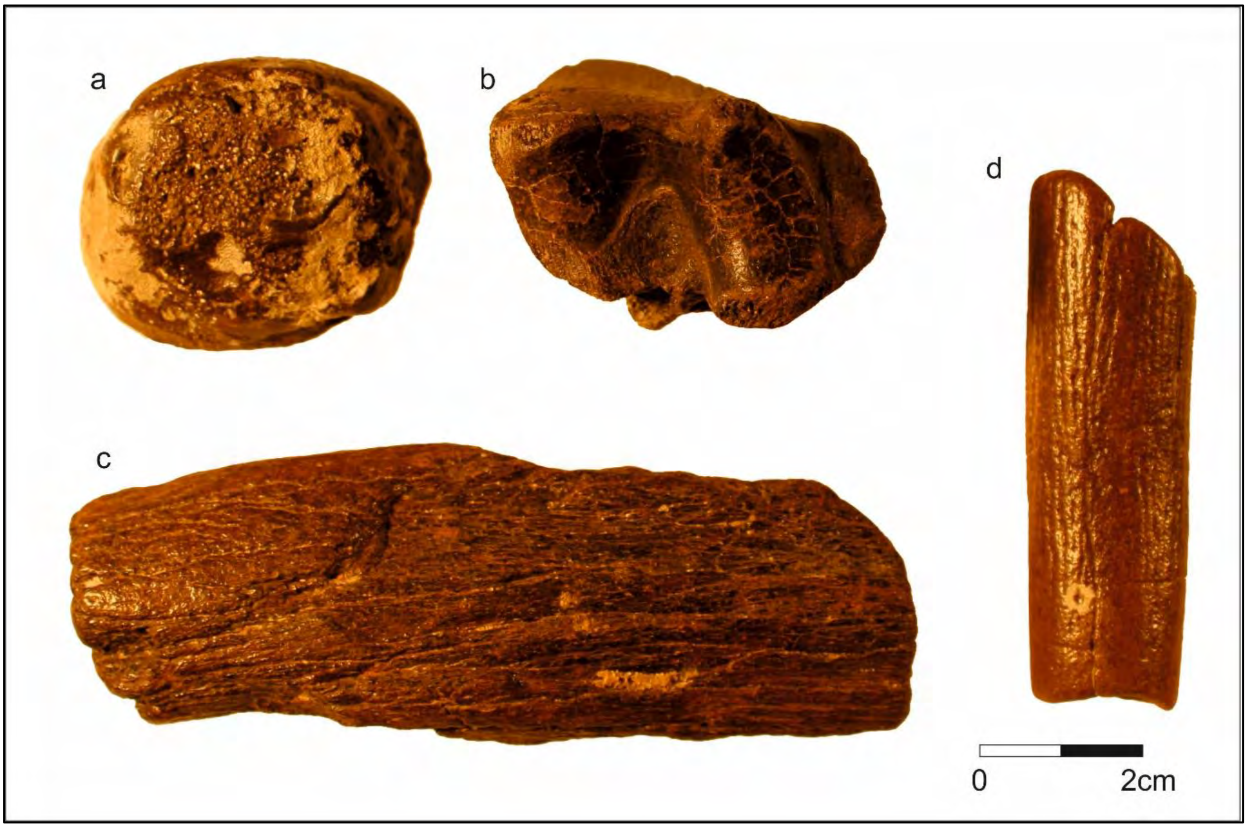

Figure 16 Selection of heavily mineralised faunal remains from the Monks: a) fragment of unidentified epiphysis; b) proximal radius, possible cervid (deer); c) mammoth bone fragment; d) antler fragment

5.2.5 Summary of sites

The first half of the July week was a great success, using targeted information derived from geophysical data and analysis of collected finds to locate three main areas of in situ Pleistocene deposits offshore of Happisburgh: OA, OB and OC (Figure 17):

- Of all the sites, OA was the most exposed and, having clear organic inclusions was considered likely to be the most productive in terms of palaeoenvironmental and, possibly, archaeological finds;
- Site OB was far more sporadically exposed and, whilst in many areas only covered by a thin veneer of sands, appeared to be lacking in organics;
- Site OC was quite extensive but with unclear relationships between the proposed till and any underlying deposits.

To gain more information about these areas, a programme of sampling and searching was thus undertaken.

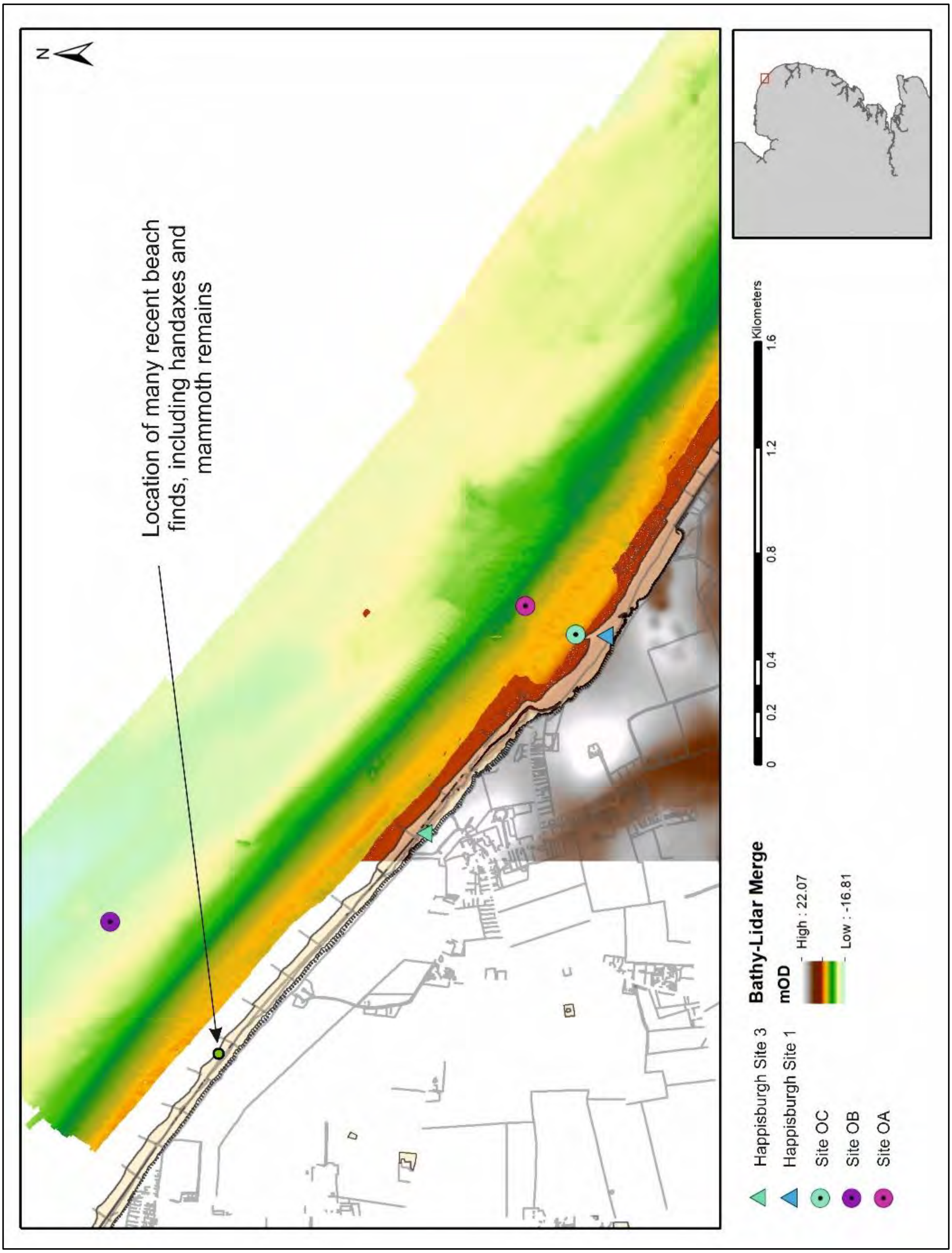

Figure 17 Map showing the locations of the main sites found as well as onshore archaeological sites and area of recent finds shown in figure 14

5.2.6 *Investigation of deposits*

5.2.6.1 *Searching*

Prior to work being undertaken, divers spent several dives exploring the deposits and their surrounds. This was not only important for orientation and attempting to understand the deposits, but in order to assess whether there was any immediately obvious archaeology associated with them.

These sites were searched using systematic circular search methods as well as with divers on SMBs swimming freely.

At site OA, despite being organically rich and on the orientation of the channel deposits of the archaeological site of Happisburgh 1 onshore, no archaeology was visible on the surface. Site OB was similar, but with far less exposure to search. Site OC, being in a more mobile environment subject to the ebb and flow of the tides, as well as having many more nooks and crannies to collect mobile out of context finds, did produce a few small faunal remains as well as one flint flake (Figure 18). This is a complex area and one that will require more in-depth investigation in the coming years.

Figure 18 Flint flake found loose at Site OC, showing dorsal and ventral surfaces

5.2.6.2 *Sampling*

Small tubes of around 400mm in length and 50mm width were used as mini-cores to collect in situ, stratified information on the located deposits at Sites OA, OB and OC (Figure 19).

Figure 19 Diver using mini-cores to collect samples underwater at site OA

Figure 20 BOSCORF Lab at NOCS showing mini-cores being split

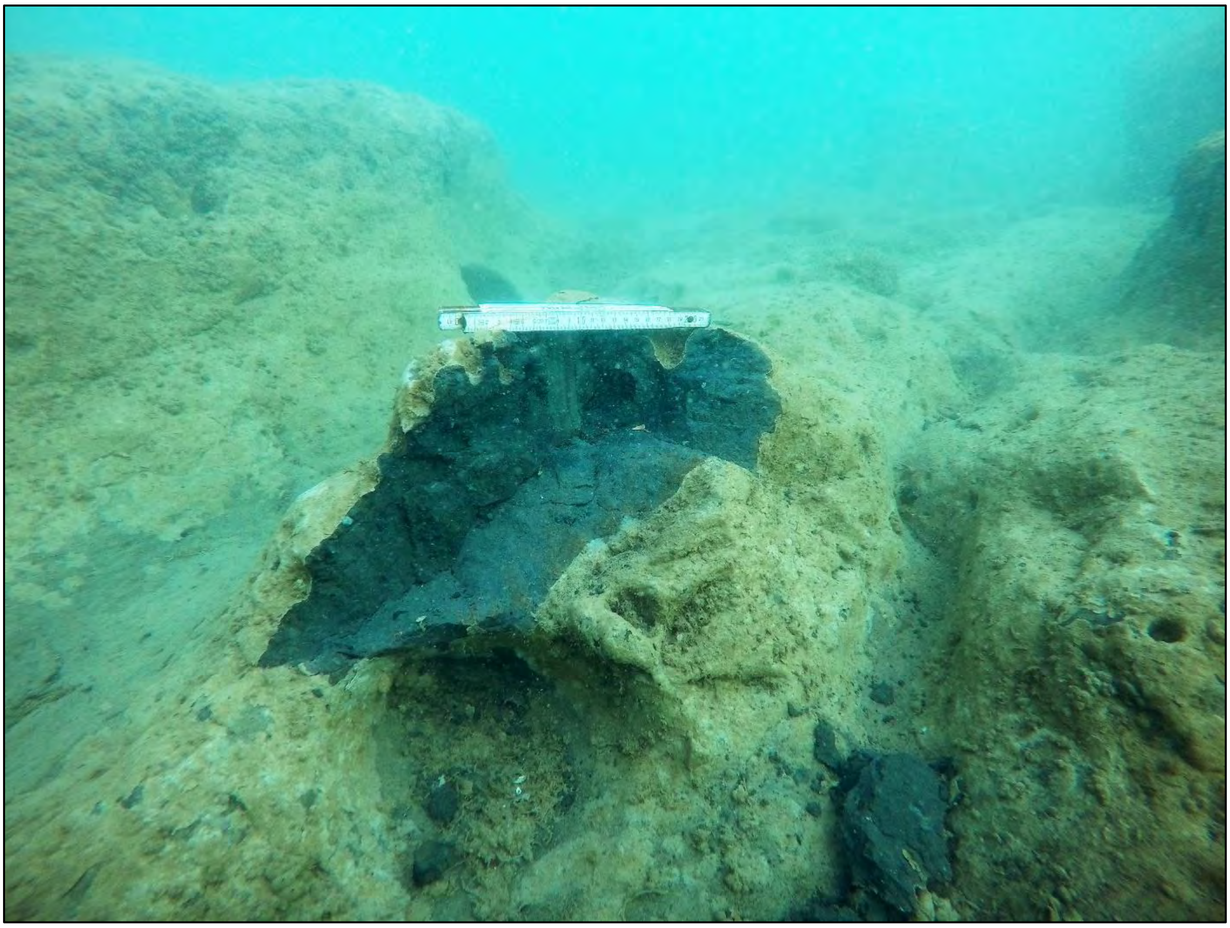

Figure 21 Upstanding glacial till deposits at Site OC showing location of bulk sample

These mini-cores were hammered into the seabed by divers, before being extracted, wrapped in sample bags and recovered to the surface. Each sample tube was carefully labelled with site code, sample number and orientation, so that they could be split open in the lab and analysed for palaeoenvironmental remains (Figure 20).

Bulk samples were taken of the assumed glacial till at Site OC, in addition to a mini-core. These bulk samples were to be used to visually inspect the sediments, before sieving them to assess the remains for comparison with known till deposits (Figure 21).

5.2.6.3 Recording

Film was taken of all of the sites using GoPro HDs, with individual shots also captured. The main site however, Site OA, was selected for further recording during this week. This area was deemed most important due to the extensive nature of the deposits, their organic content and their presumed correlation with the channel deposits identified onshore (Happisburgh Site 1 [Ashton et al. 2008; Lewis et al. submitted]).

This further recording involved divers completing offset measurements from a NW-SE baseline laid along the middle of the clearest area of exposure in order to identify the extent. Subsequently, a photogrammetric survey was completed by Dan Pascoe in order to capture a high level of detail that could be accurately georeferenced and returned to at a later date.

The images captured for this were processed in Agisoft Photoscan and the resulting image is shown in Figure 22.

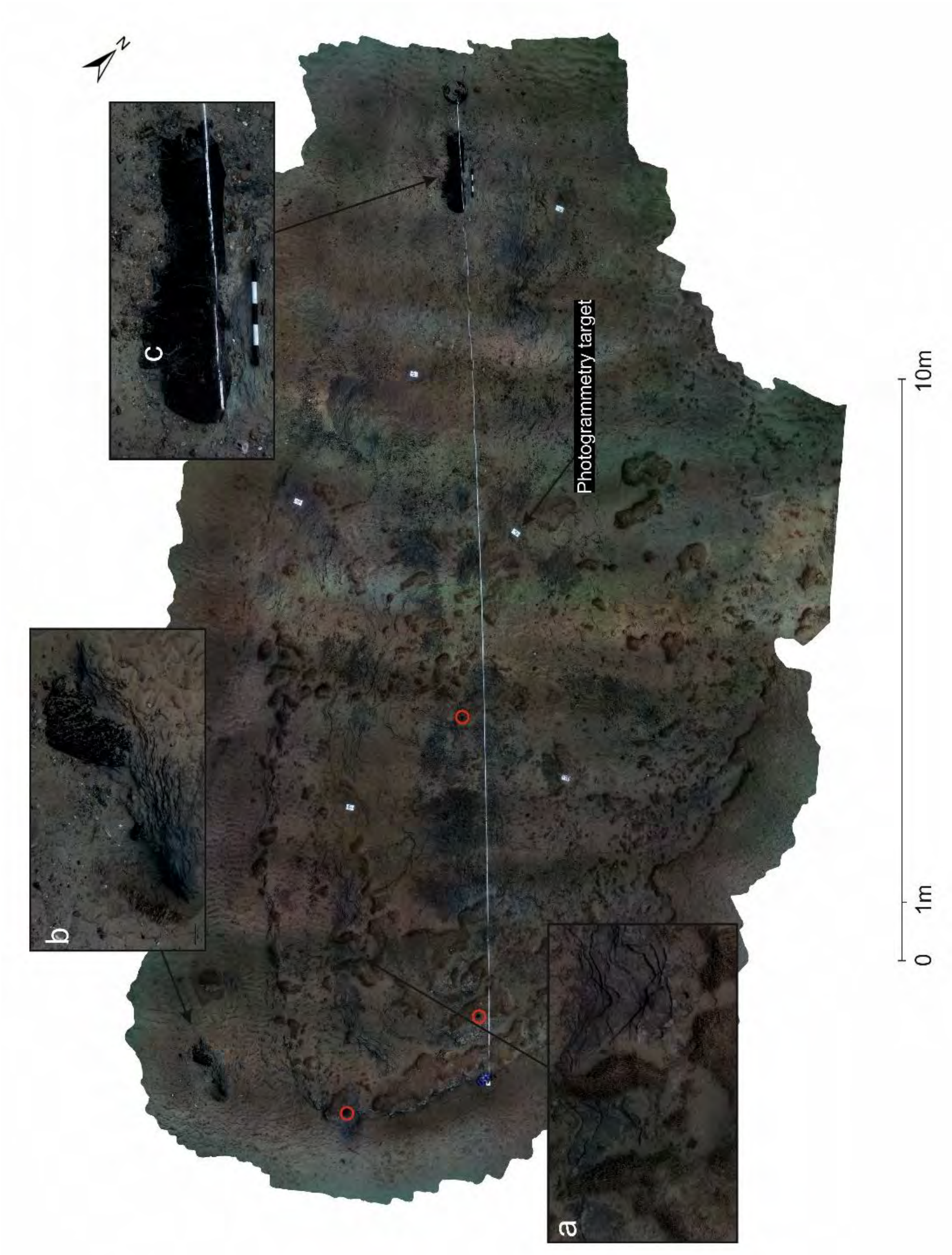

Figure 22 Photogrammetric orthophoto with inserts showing close-ups of a) laminations and Sabellaria; b) and c) organics. Photogrammetry targets are also indicated as well as red circles showing locations of mini-cores taken along and off the baseline. Photogrammetric model produced by Dan Pascoe

Given the sporadic nature of exposures at Site OB, with deposits exposing in small patches among the sand waves, this area was not targeted for a full survey at this stage but can be returned to at a later date. Similarly, the complex nature of the deposits at Site OC meant that more time was needed to properly investigate this site. Film footage, samples and descriptions were therefore collected at this stage.

5.2.7 Summary

Over the course of the July fieldwork week the team were lucky enough to have weather that permitted both a full week of diving as well as geophysical data collection. This was the first time that a considerable period had been available for searching the seabed off Happisburgh and, combined with targets provided by analysis of beach finds, Environment Agency multibeam bathymetry and known locations of outcrops onshore, was able to locate several areas of intact Pleistocene deposits of the CFbF; a significant step forward for research into submerged Pleistocene landscapes. The heights above ODN of these identified deposits will help the task of correlating these offshore deposits in the context of the known deposits onshore (Table 4), with ongoing palaeoenvironmental analysis further facilitating this (see Section 5.4 below).

Site	Easting	Northing	Depth (mODN)
OA	638965	330899	7
OAb	638970	330903	7.5
OB	637772	332477	-13
OC	638856	330711	-2
Monks	640761	330910	-13

Table 4 Heights in ODN of the areas investigated

The location of these areas meant that the second week's fieldwork could be planned in advance. It was decided that, with only one final week left, this should be focused not on searching for more, but on gaining the best understanding we could of these locations in the hope that this would pave the way for even more targeted fieldwork in future.

5.3 September Fieldwork

September's fieldwork included a few of the previous week's divers: the team leader, Rachel Bynoe, and Jane Maddocks. We were also lucky enough to have the same skipper, Guy Trees. The remaining divers were new to the site and of a variety of levels (Table 2). As described above, those of less experience were buddied-up with the more experienced divers for maximum safety and learning of new skills.

This week was more challenging in a number of ways: the winds were very high, blowing gales at times, but for the most part coming from the west, meaning that we were sheltered by the cliffs. Whilst for the most part safely dive-able, however, surface conditions were still challenging and occasionally cut-short our days. In addition, the visibility was reduced relative to the July week, making working conditions more challenging, and the tides were stronger. This presented challenges for working, but particularly for the newer divers. As such, these divers were always within a metre (and certainly sight) of their more experienced buddy. There were also some technical issues with the compressor at the start of the week, which meant that one day of diving was lost. Luckily, however, a local BSAC branch (EAB 11) came to our rescue and filled our tanks, while another group of locals helped us fix the compressor in time for the following day's diving.

The plan for this week was to obtain larger samples and to investigate the relationships at OC more fully. The start of the week was focused on re-finding the main sites. There had been some erosion and burial of the deposits, meaning that aspects of OA were no longer present and some dives were spent reorientating ourselves. Once accomplished, divers set-out with hand-mattocks, trowels and chisels to excavate small test pits across sites OA and OB for investigation of stratigraphy and further sampling.

5.3.1 Site OA

One trench was opened at OA to a depth of c.0.3m. This went down through laminated silty clays which were largely competent meaning that the section edge did not collapse (Figure 23). Six metres from this location a further area was located with a different set of deposits. At this site, the laminated deposits were far thinner, overlying a white, clayey silt containing iron-rich elements and both frequent pebbles and organic remains. This overlay a bed of coarse sands. This area was identified as Site OAb and a smaller trench was opened here (Figure 24).

Both trenches were subject to bulk sampling in sample boxes, which were raised to the boat by hand. OA also had a larger (100mm diameter) core driven through it. Due to the larger size of this core, this was hammered in behind the section edge and dug out, wrapped in sample bags and recovered to the surface by diver to make sure that the sediments were not disturbed. OAb was sampled using one of the smaller cores (50mm diameter) and was also bulk sampled by stratigraphic layer (Figures 24 and 25).

5.3.2 Site OB

Site OB, once located, had a section dug in similar dimensions to that of Site OA (Figure 26). This was also characterised by laminations, although of a more clay-rich deposit that was lighter in colour. Bulk samples were taken and a larger (100mm wide) core was recovered.

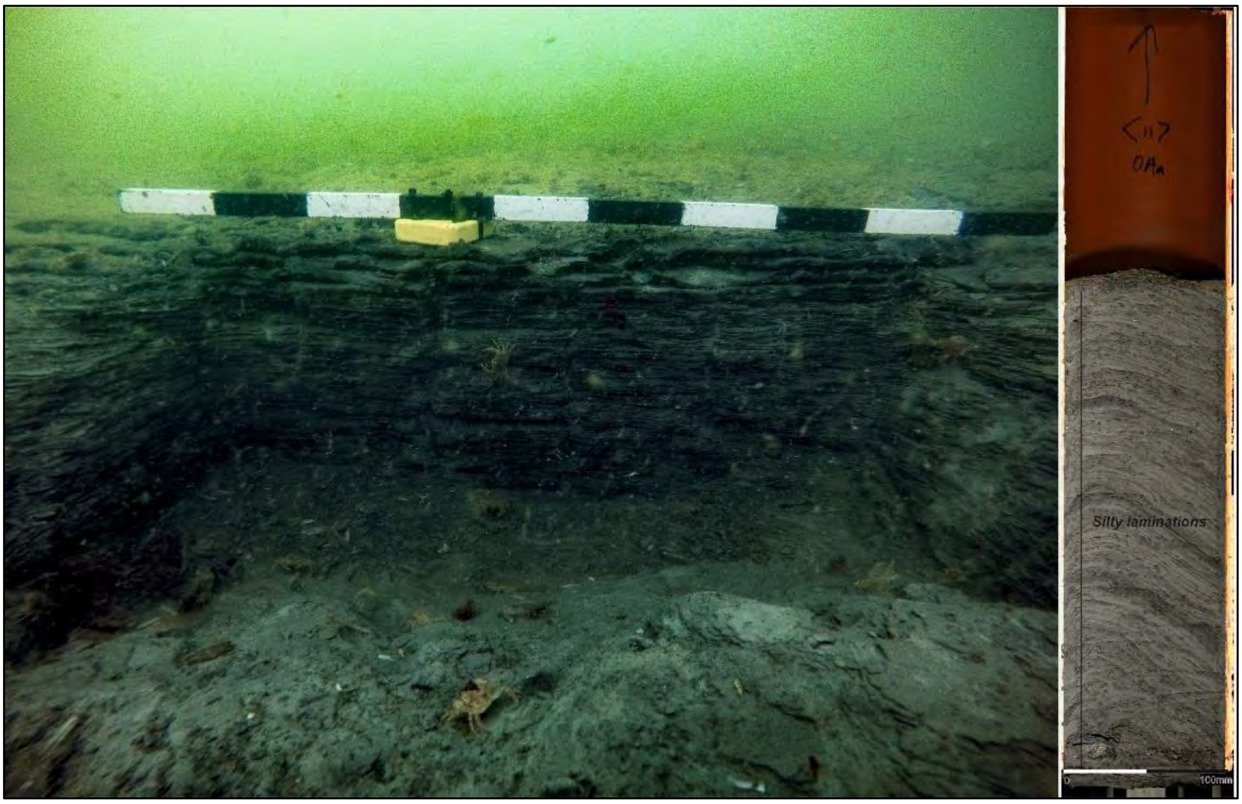

Figure 23 Section dug at site OA with split large core section showing laminations. Scale on split core is 10cm (100mm)

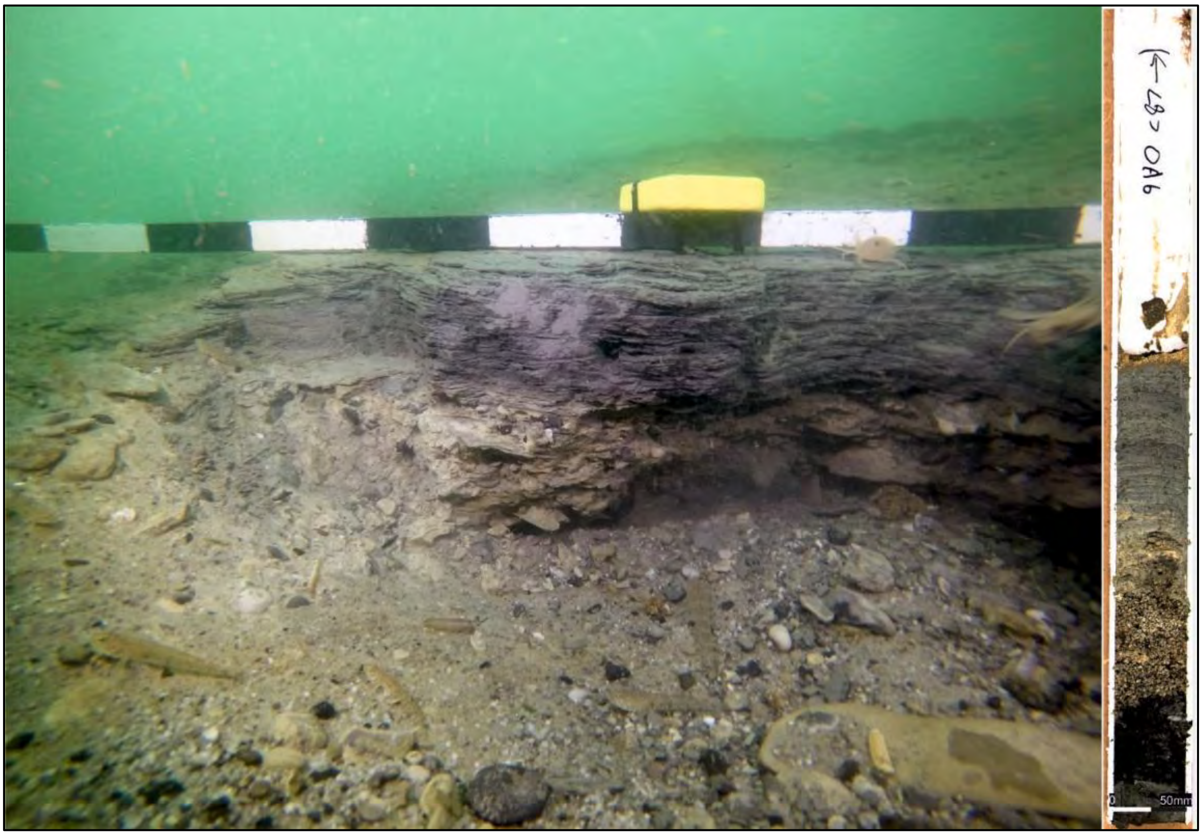

Figure 24 Small section investigated at site OAb, showing the smaller depth of laminated deposits overlying the whiter, clay-rich deposit with sands washing out beneath. Split section through these deposits shows organic material underlying the coarser sands. Scale on split core is 5cm (50mm)

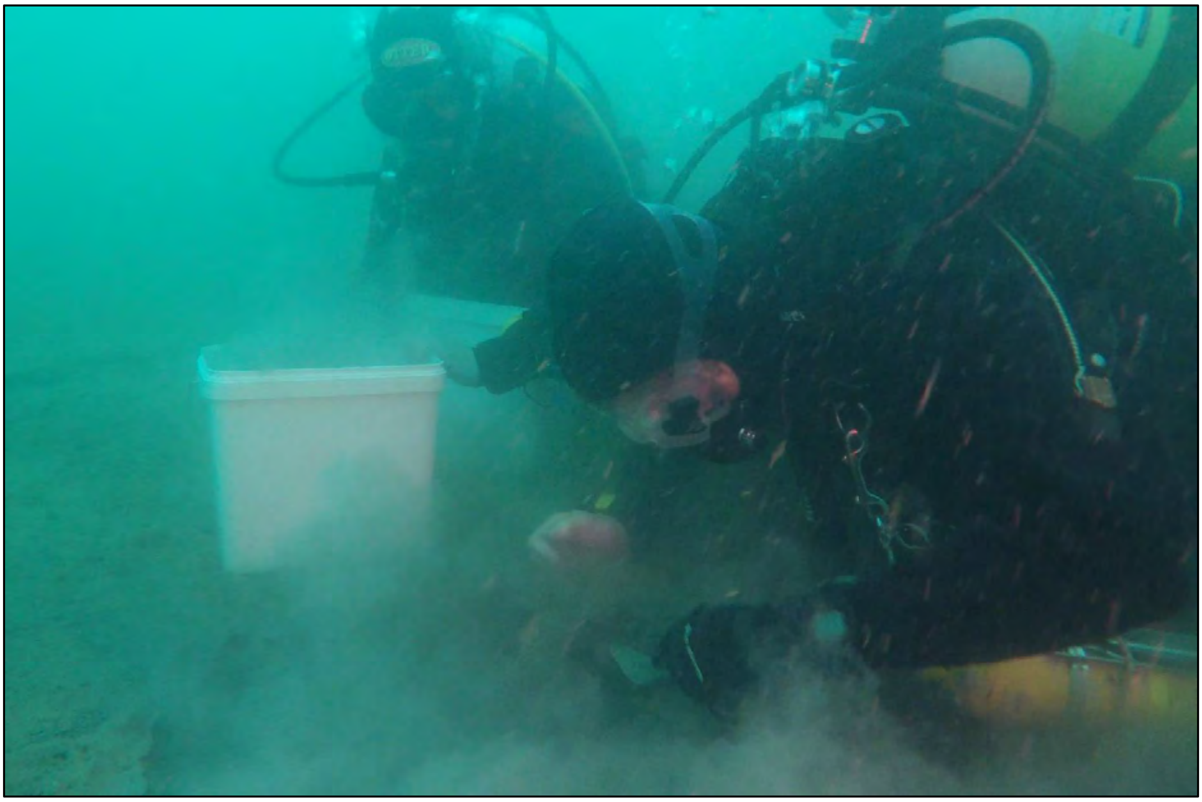

Figure 25 Divers taking bulk samples through deposits at site OAb

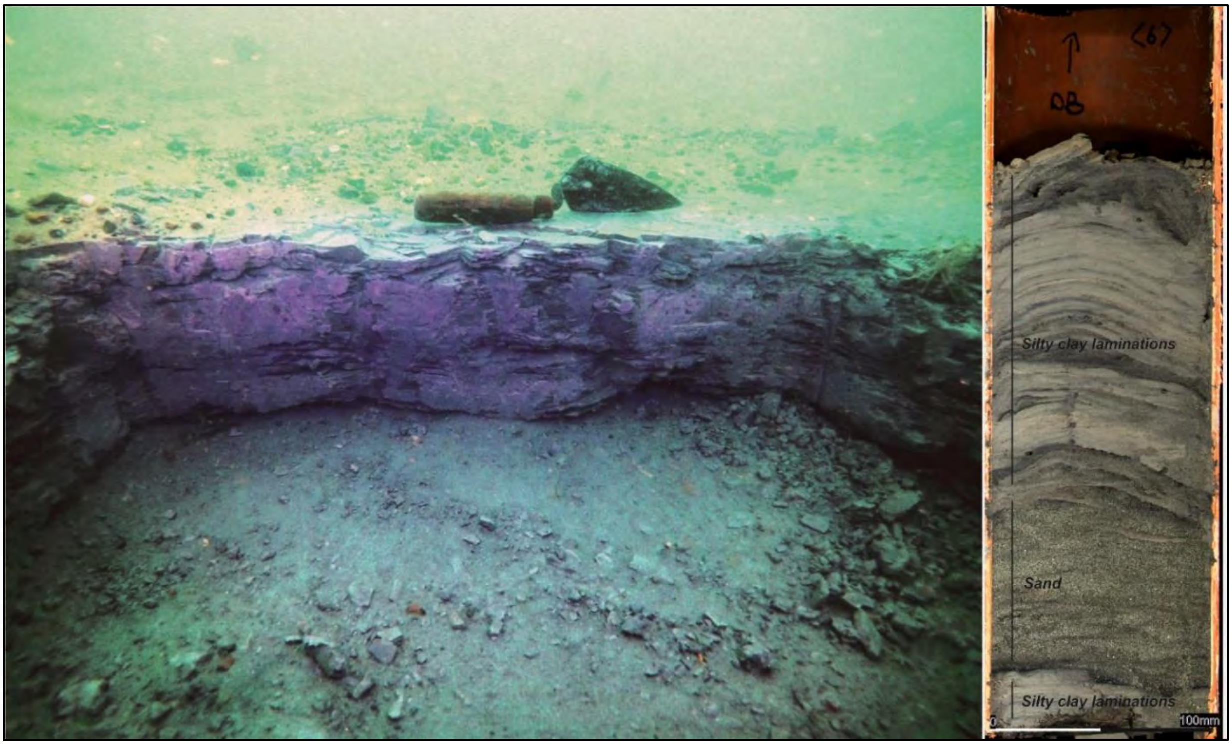

Figure 26 Section dug through more clay-rich laminated sediments at site OB, with split large core shown to the right. Scale on split core is 10cm (100mm)

5.3.3 Site OC

Due to time constraints Site OC was investigated at the end of the week. This investigation was focused on clarifying the relationship of the presumed glacial till with the underlying deposits, with the plan to take a large 100mm core through one of these sections. What was interesting to find, and hampered this plan somewhat, was that underlying the till the deposits had become iron-concreted. Previous investigations on the Monks had identified an area of in situ concretions similar to those found eroded and washed onshore. However, these Monks concretions were of a sand matrix. Those found at site OC are visually far more similar to those found associated with faunal remains onshore, being of a gravelly nature (see Figure 3 for comparison). Whilst this prevented cores being driven through the deposits, blocks of these concretions were able to be retrieved for comparison with those found onshore (Figure 27). One small area was found that was lacking in concretions was able to be sampled using a small, 50mm wide core. This was recovered to the surface for further analysis.

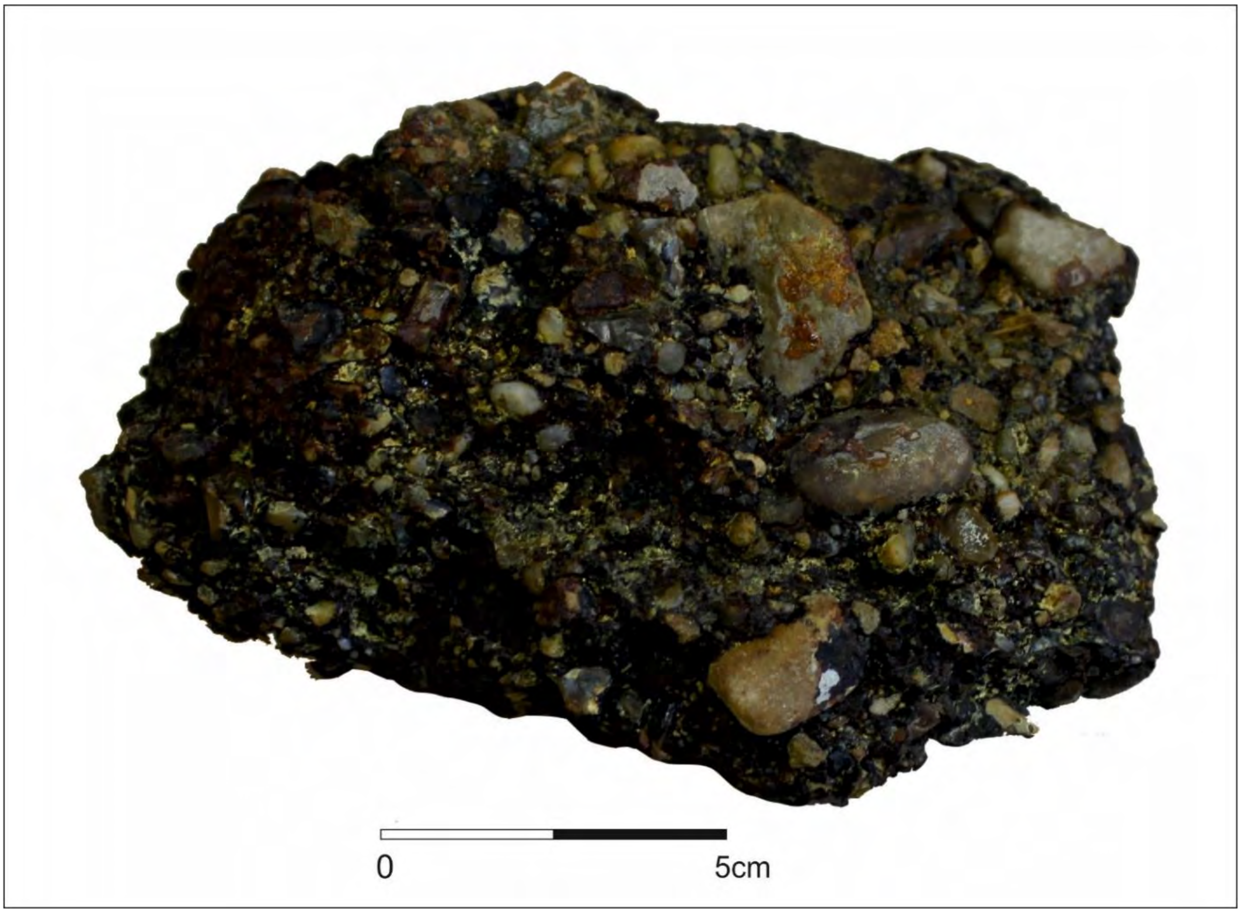

Figure 27 Concreted CFbF block sampled from site OC

5.3.4 Summary

The September week, whilst more challenging and with the weather and technical issues resulting in fewer dives completed, was successful in its aims: larger core samples were retrieved for more in-depth future analysis, bulk samples were recovered and the relationship between the till and underlying deposits at OC are beginning to be clarified.

5.4 Palaeoenvironmental Analysis

The small cores taken during the first week of work have been subjected to some preliminary pollen analysis, kindly provided by Dr Michael Grant, a pollen specialist in Ocean and Earth Science, University of Southampton. The cores were taken to the British Ocean Sediment Core Research Facility (BOSCORF), at the National Oceanography Centre, Southampton, where they were split (Figure 20), photographed (Figure 28) and sampled for pollen (Figure 29).

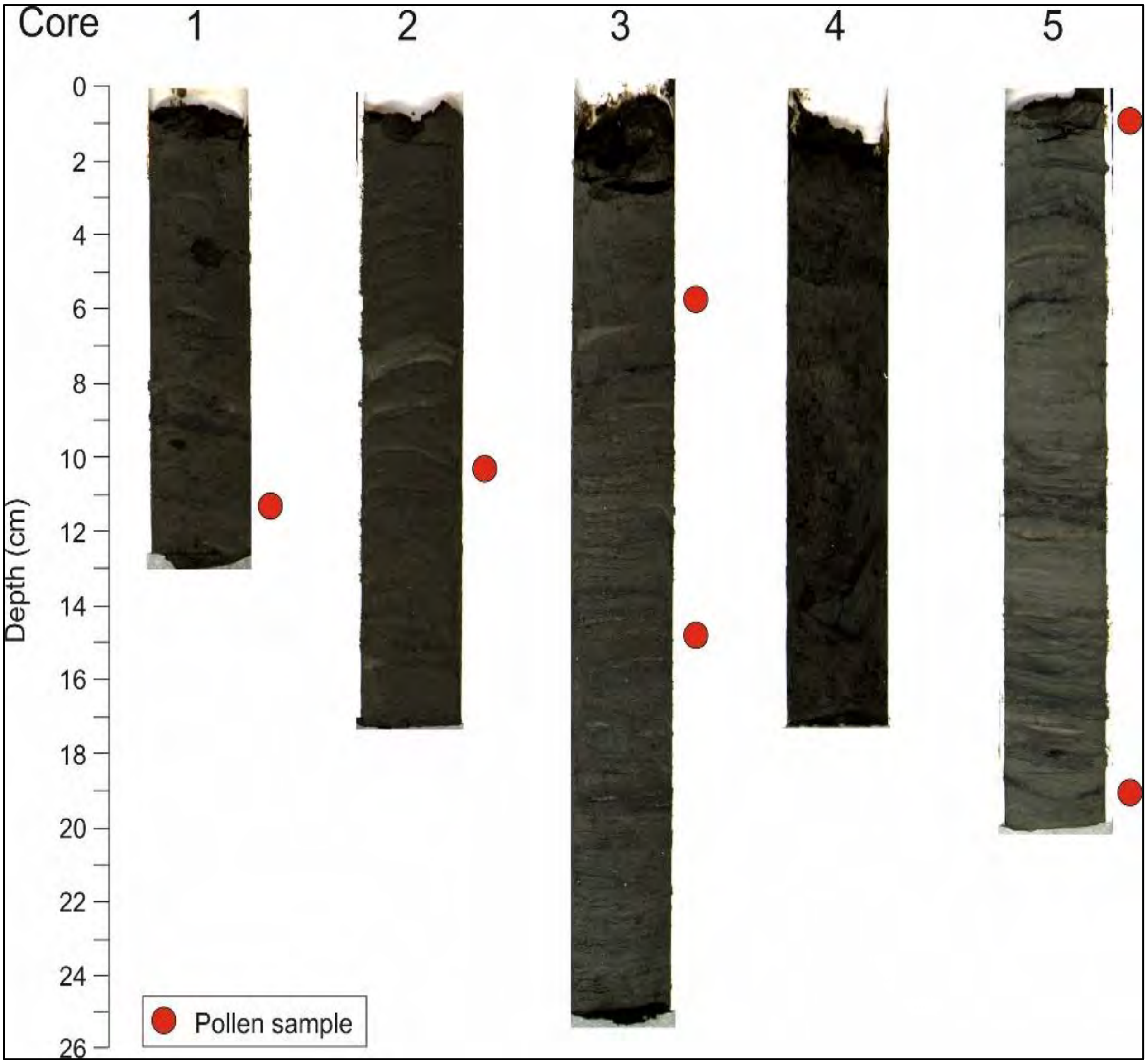

Figure 28 Split mini-cores, with red circles showing the locations of pollen samples

The results of this work have indicated that there are clear differences between site OA and OB, and that the identification of the upstanding deposits in OC are in fact glacial till.

5.4.1 Site OA.

Despite its orientation with the archaeologically-rich deposits of Happisburgh Site 1 onshore, deposits at site OA appear to be from an earlier period. This is unsurprising, given their lower elevation (Table 4), and it is possible that they are channel deposits from an earlier activation of this system.

Pollen indicates that this site formed during an interglacial period that is earlier that Happisburgh Site 1, with high concentrations of *Ostrya* (hop-hornbeam), *Quercus* (oak), *Poaceae* (grasses), *Alnus* (alder) and *Carpinus* (hornbeam), and smaller proportions of *Picea* (spruce), *Pinus sylvestris* (pine), *Ulmus* (elm), *Betula* (birch) and *Fraxinus excelsior* (ash) throughout the sequence. Shrub taxa are also represented by *Salix* (willow) and *Hedera helix* (ivy). This assemblage suggests a mixed deciduous woodland with areas of damp ground characterised by *Alnus* and *Salix.* The proportions of coniferous taxa indicate that this is likely to be a component of the vegetation in the wider area (Grant 2018).

Species found also indicate the presence of slow moving water (e.g *Nymphaea alba* [water lily] and *Lemna* [duckweed]). *Osmunda regalis* (royal fern) was also present, indicating the presence of wet carr woodland.

This pollen assemblage seems, preliminarily, to be similar to that of Bed A of Happisburgh Site 3, correlated with the Early Pleistocene and chronologically more similar to the deposits found associated with the earliest of the onshore sites (Parfitt et al. 2010a). Figure 30 shows a British Museum reconstruction of these environments.

Figure 29 Michael Grant sampling the mini-cores for pollen in the BOSCORF Lab at NOCS

5.4.2 Site OB

Dissimilar to that at site OA, this pollen assemblage is dominated by coniferous taxa such as *Pinus sylvestris* and *Picea*, as well as *Vaccinium*-type (shrubs/heath). The far reduced presence of deciduous taxa perhaps indicates that these deposits formed at the end of an interglacial period, or that these have been reworked from a previous deposit. With aquatic taxa also present, this site is less clear in terms of correlation with known deposits, but appears similar to Bed F of that seen at Happisburgh Site 3 (also Early Pleistocene), as well as younger early Middle Pleistocene deposits encountered north of Happisburgh at Bacton and Ostend (Parfitt et al. 2010b).

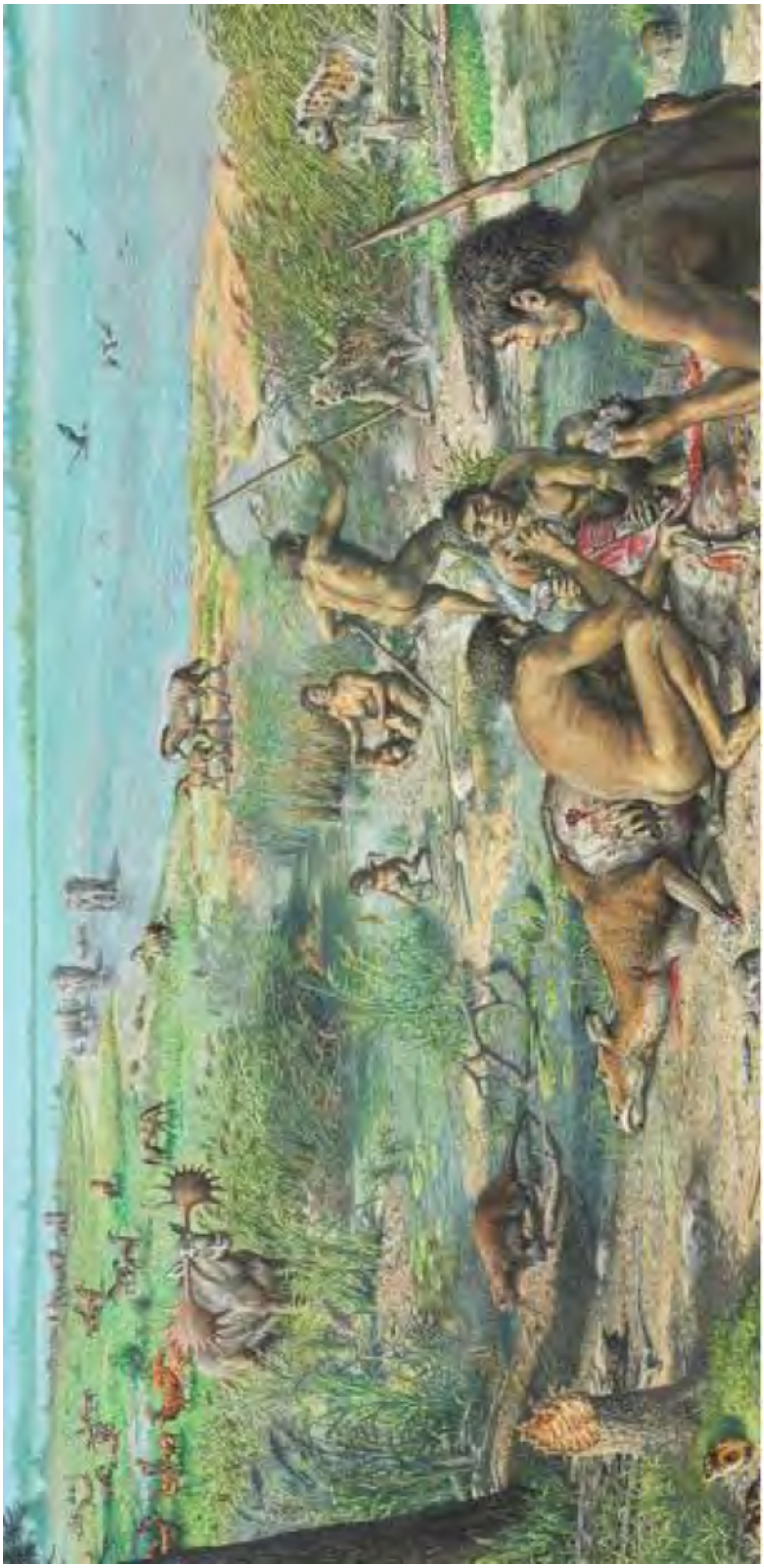

Figure 30 Reconstruction of the environments present at Happisburgh 3, showing the slow-moving river and some of the animal species found. Artwork: John Sibbick for the British Museum

5.4.3 Summary of results

The preliminary pollen analysis gives us an interesting insight into the nature and potential chronology of the deposits encountered. Given their elevations (below 0mOD) it is unsurprising that these generally point to the Early Pleistocene, more in-line with those found associated with the earliest archaeology from the CFbF at Happisburgh 3 (Parfitt et al. 2010a).

As is indicated by the uncertainties, however, pollen analysis on its own cannot provide definitive answers. For this reason, the larger samples obtained during the September fieldwork are currently being subjected to further analysis, including ostracods, particle size analysis and further pollen.

5.5 Overall Discussion of Results and Conclusions

This project set out with the aim to use gathered and analysed beach collections and geophysical data to locate, survey and sample in situ submerged deposits of the CFbF, the formation containing the earliest evidence for human occupation of northern Europe. The ultimate aim is that this will lead to the discovery of archaeological deposits underwater that are yielding the finds washing up on the beaches and, therefore, the oldest submerged archaeological site in the world. This would not only be a significant step forward for our understanding of these significant archaeological deposits, which once formed an important area of terrestrial landscape for some of the earliest humans to live in northwest Europe, their migration patterns and environments of early occupation, but would also develop our methods for finding and working with submerged sites of substantial antiquity.

Given the mobile sand waves in this area, this search is extremely challenging and one that cannot be successful without a substantial amount of time spent underwater. The funding of this project was therefore a huge step forward for this work and the location, investigation and sampling of such an array of deposits over the first summer of fieldwork is considered a great success.

Whilst no archaeological remains were identified in situ, the ongoing palaeoenvironmental analysis is beginning to shed new light on the potential of these deposits, providing further refinement for future fieldwork. We now know that what we are dealing with is likely to be more closely associated with the Early Pleistocene environments similar to those of Happisburgh Site 3, and ongoing analysis will hopefully reveal more information about the specific nature of the submerged deposits. Out of context finds also indicate that there is good potential for finding in situ archaeology associated with fragments of these exposures, making future diving work key to the future of this project.

5.5.1 Skills developed

The skills developed over both weeks were important for all divers involved, as this type of archaeological diving for submerged Pleistocene landscapes is very rarely undertaken. However, those newest to diving experienced the greatest learning curve, learning to work in low-visibility water, currents (both drift-diving and working on-site), circular searching, digging and sampling. Key diving skills were also practised, such as deploying SMBs, RIB diving and the use of lines. Importantly for several of the BSAC members, Jane Maddocks kindly spent several evenings teaching theory lectures for those involved in their Sports Diver qualification (Figure 31). These sessions were also joined by those members who are not BSAC, but who had an interest in learning these skills. Finally, all divers gained experience in the use of GoPro cameras to film and photograph exposures.

Figure 31 Jane Maddocks working through Sports Diver theory lessons with Aytein Nasr and Rebecca Ferreira

6 Future Work and Final Comments

Following on from this project it is clear that there is great potential in continuing to investigate these exposures, and those associated that have yet to be discovered. Far from these Pleistocene deposits being long-eroded by the sea, this project has demonstrated that a significant amount of evidence still exists offshore, supporting the hypothesis that the finds recovered from the shoreline are, at least in part, associated with submerged exposures.

The ongoing palaeoenvironmental analysis will hopefully provide a greater focus for future field seasons, allowing a greater understanding of the deposits being investigated. This will also allow correlation with those studied onshore, with now a far greater possibility for the linking-up of the offshore with the onshore record and a fundamental shift in our understanding of the extent, nature and latent potential of the wider landscape of these early humans.

Recent acquisition of a large body of geophysical data from windfarms operating in this area (specifically Vattenfall working on the Vanguard windfarm) will, through combination with cores taken throughout this project, allow us to start drawing a picture of the greater extent of deposits. Seismic data in particular will allow us to see beneath the sand waves, indicating areas that are close to the surface that could potentially be investigated. This will also allow further understanding of the spread and relationship of the various deposits recognised on and offshore.

Future field seasons will therefore look to address the following:

- Further exploration of the suite of deposits at Site OA and OAb is required to fully understand the extent of these possible channel deposits. These should be tracked shorewards in systematic transects, identifying elevation changes, sediment changes and how these tie-in with those known on the beach.
    - Should the palaeoenvironmental analysis look fruitful, several small test pits will be opened up in key areas of this deposit.
- The area of Site OC requires significant investigation. Knowing that much of the archaeology found on the beach is located just shoreward of these exposures, and that their elevation is more in-line with the archaeological site of Happisburgh 1, this area will be targeted for in-depth investigation. This will include test pitting of key locations and visual inspection of deposits closer to the shore. Specific questions to address include:
    - Are the lithics washing onto the beach deriving from the CFbF underlying the glacial till?
    - Are the concreted deposits consistent across the area, or do they form in only certain locations? If so, what is the cause of this?
    - Do significant areas of Sabellaria growth indicate areas of laminated deposits worthy of further investigation?
- The area onshore of Site OB is continuing to yield large quantities of handaxes, as reported by local collectors. A wider area associated with OB needs to be searched, subsequent to the analysis of the geophysical (particularly seismic) data.
- The Monks, generally characterised by large sand waves, still retains archaeological potential, especially given the finds that have been recovered loose from this area. Assessment of the geophysical data will provide dive locations where there are likely exposures, so that systematic sampling of concreted material can take place for comparison with those both on the beaches and in site OC.
- Finally, the initial search area off Eccles North Gap remains a mystery. The analysis of the seismic data will hopefully allow the tracing of CFbF deposits into this zone, with more multibeam bathymetry being analysed to assess more recent areas of sediment loss to target for dives.

BSAC were the first group to provide funding for this project, which subsequently received additional funding from the Leakey Foundation. This has been vital in the progression of this research, which would not have been able to carried-out otherwise. It is important to note that, whilst academic in its nature, a key part of this work was the training and engagement of new members of BSAC and new divers, many of whom were unfamiliar with British conditions and with archaeological diving in

general. Due to the success of this project and the valuable opportunity it provided for training new divers, the University Of Southampton are currently in the process of setting up their own BSAC training club, with an undergraduate module to encourage students to take up diving and, in the future, set up and run their own diving projects.

7 Acknowledgements

This work was generously funded by the BSAJT in conjunction with the Leakey Foundation, without which none of this research would have been able to progress. Both Mark James of MSDS Marine and Bournemouth University, in particular Dave Parham, kindly leant kit to the project: a compressor and a side scan sonar, respectively, greatly helping the work. Maritime Archaeology Ltd further helped the project by making their SonarWiz software available for a morning to process the side scan sonar data. University of Southampton provided all of the diving equipment and Safety Boats UK were extremely helpful in organising the boat hire and keeping the costs manageable. Guy Trees, our skipper, was also an invaluable team member. Finally, all of the divers who took part in this project were fantastic, giving up time, working hard and being enthusiastic even during strong winds, rain and searching endless sand waves.

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