Cartographic, Geophysical and Diver Surveys of the Medieval Town Site at Dunwich, Suffolk, England

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This paper presents the results of an integrated historical and geophysical survey of a medieval town lost through cliff recession and coastal inundation. Key objectives included evaluating historic maps in supporting the relocation and identification of major buildings, and applying integrated multibeam, side-scan and sub-bottom profiling to determine the location and extent of archaeological remains. The results demonstrate that cartographic sources from 1587 onwards can be a reliable source of data to guide geophysical survey. Integration of historical mapping with geophysical data enabled identification of the remains of two medieval structures, and the tentative identification of two others.

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describes research on a large medieval port and town site on the east coast of England, where cliff recession and inundation of low-lying land has resulted in the loss of over 90% of the settlement. In the study we integrate historical analysis with the latest marine geophysical survey technology to reconstruct the urban geography and to relocate and identify the remains of some of the larger stone structures within the town.

The site
The former medieval port and town of Dunwich is located in the county of Suffolk, East Anglia (Fig. 1), on the southern margin of the former estuary of the Blyth and Dunwich rivers at British National Grid TM 47678 70558 (52.27731°N, 1.62937°E). The site is located on the western margin of the southern North Sea basin, an area that is currently experiencing slow subsidence as a result of both regional tectonic factors and the collapse of a proglacial forebulge (Shennan, 1989; Lambeck, 1995; Pye and Blott, 2006; Rose, 2008). The solid geology of the Dunwich area consists mainly of Pliocene and Pleistocene age (3.75–1.5 million years old) sediments and weakly-cemented sedimentary rocks, notably the Coralline Crag (Pliocene) and the Red and Norwich Crags (Pleistocene). These latter deposits are mainly shallow marine, coastal, and estuarine in origin (Zalasiewicz et al., 1988; Rose, 2008).

The Westleton Beds are particularly coarse (Rose, 2008: 9) and represent nearshore beach depositional environments. Drift deposits that lie above the Norwich Crag consist mainly of boulder clay and fluvial deposits belonging to the Lowestoft Till Formation, with deposits of Holocene alluvium and peat within the modern valleys. An estuary existed at Dunwich, deriving fluvial drainage from the rivers Blyth and Dunwich catchments. These are now cut off from the sea by a shingle-and-sand barrier system which migrated shoreward and southwards during the Middle Ages to form a spit. The estuary, and former harbour, were formed as a result of early to mid-Holocene flooding of river valleys which were cut to a lower level during glacial low sea-level stands (Pye and Blott, 2009). Since the closure of the southern mouth of the estuary at Dunwich, freshwater marshes and peat deposits have developed. These areas of marsh have been drained and reclaimed. Most recently, rising sea-levels, storms and a decrease in longshore sediment supply have led to increased breaching of the barrier and the deposition of higher-energy sands and shingle over the marshes (Pye and Blott, 2009).

History
The history of Dunwich is relatively well documented (for example Gardner, 1754; Bacon, 1982; Comfort, 1994; Bailey, 2007). The settlement was established as a port due to the presence of a sheltered natural harbour at the mouth of the estuary of the Dunwich and Blyth rivers, with good access to the fishing grounds of the North Sea and later the north Atlantic, and good trade routes with the rest of the country and continental Europe.

The first unequivocal reference to Dunwich is in the Domesday survey of England in 1089 AD. This states that in 1086 the town had one church, but by 1089 there were three. At the time of the Domesday survey Dunwich was the second-largest town in Suffolk, and in terms of population was among the 18 largest towns in England (Darby, 1971: 25). The growth of Dunwich as a leading seaport may be linked to the development
of the marine fishing industry in the North Sea between 950 and 1050 (Barrett et al., 2004). The change to marine fish exploitation (particularly herring) was driven by a series of factors including development of Christian fasting regulations (important post-950), national population growth, increasing urbanism and a declining freshwater fish resource (Barrett et al., 2004). Dunwich, along with other North Sea coastal settlements, was well placed to harvest the near-shore herring shoals.

The town was sufficiently important to have received a Royal Charter granting it borough status in 1199, and the position of mayor was established by charter in 1215 (Comfort, 1994: 3–8). In 1242 Dunwich was the largest port in the county of Suffolk, and at the time of Edward I's assessment of the wealth of towns in England in 1282, Dunwich was ranked 6th in East Anglia (value £66, compared with Ipswich the county town, valued at £100). At its height (c.1250) Dunwich was approximately 1.6 km (1 mile) from north to south, with an area similar to the City of London (Comfort, 1994: 36). The population of Dunwich has been estimated at this time to have been over 5000, with at least 800 taxable houses and an area of c.800 acres (Bailey, 1992: 3; Comfort, 1994: 36).

The economy of the town was focused on the port, with trade in fish, salt, cloth, wool and other agricultural products (Bailey, 1992: 19). Imports were varied and included wine, potash, bowstaffs, pottery and Caen stone for building (Comfort, 1994: 78). Trade links were extensive, mainly with the Low Countries, Germany and France (Bailey, 1992: 20; Comfort, 1994: 77) but extending as far as Spain and Iceland. Coastal trade was also carried out around the east and south coasts of England, with, for example, regular export of agricultural produce to London. Dunwich was also an important shipbuilding centre, often required to send ships to support the king's navy. Royal galleys were built and based at Dunwich up to the 15th century, and merchantmen and fishing barks were built there until the end of the 16th century. Fishing for herring, and later cod, was an important part of the town's economy. Herring fishing was undertaken close inshore from Michaelmas (29 September) until Martinmas (11 November) (Gardner, 1754: 37; Comfort, 1994: 71). The importance of this trade is indicated by the holding of fairs on these dates, and the dedication of two of the town's churches to St Martin and St Michael.

It was revenue from the port which paid the town's rent to the Crown (fee farm) and tithes to the churches. Figure 2 documents the rise and fall of Dunwich as indexed by the total population, the number of ecclesiastical buildings (itself a crude measure of the town's wealth) and the fee farm tax value of the town (Gardner, 1754: 23–5) adjusted to 2008 values (Officer, 2009). Rapid development occurred in the town from 1086 AD, with the Norman occupation enabling free trade with France and continental Europe (Haslam, 1992: 44). In an age when the Church was the only pan-European organisation, creation of an ecclesiastical infrastructure was important for wider economic development (Mann, 1986: 503). The extent of that infrastructure also reflects the capacity of medieval people to invest in religion and the afterlife, both of which were regarded as of paramount importance. Thus in Dunwich, as happened nationwide, church building accelerated rapidly during the 12th and 13th centuries, with the arrival of various religious orders—Greyfriars (Franciscans), Blackfriars (Dominicans) and the Knights Templar—and the building of 15 new ecclesiastical structures. The population grew rapidly over the period 1086–1250, attracted by the opportunities and wealth of the port (Bailey, 1992: 2–3; Comfort, 1994: 36).

Loss of land at Dunwich is recorded as early as the Domesday book, when over half the taxable farmland was lost to the sea between 1066 and 1086 (Gardner, 1754: 6). The storms of 1287–88 resulted in the destruction of c.400–600 houses, particularly in the low-lying portions (Gardner, 1754: 96; Bacon and Bacon, 1979: 19; Bailey, 1991: 196; Bailey, 1992: 2; Comfort, 1994: 132), while in 1328, 375 out of 400 houses were lost from the parishes of St Leonards, St Martins and St Bartholomew (Bailey, 1991: 196; Comfort, 1994: 132). Figure 2 shows a decline in the value of the fee farm rent for the town following the 1328 event. Bailey (1991: 197–8) makes the point that the indirect effects of coastal recession and sedimentation, such as repairs to infrastructure and the cost of rebuilding sea defences, were often as significant as the direct physical damage. Similarly, Galloway and Potts (2007: 372) report that climatic deterioration, particularly the increasing frequency and severity of storms, made it ever more difficult and uneconomic to defend the more vulnerable stretches of the east coast during the period 1250–1450.

The major losses of infrastructure and land at Dunwich between 1275 and 1350 coincided with a period of national economic crisis (Bailey, 2007: 72). Increased costs of harbour maintenance and loss of income due to blockage and diversion of the harbour entrance weakened the town's economy. This is reflected in the collapse in market revenue in Dunwich during this period, and in the repeated pleas to the Crown for easements on the fee-farm rent (Bailey, 1992: 21). An enquiry in 1326 highlighted the abandonment of houses by their owners (and hence a reduction in rental income to the town) due to ‘obstruction and deterioration’ of the port since 1278 (Bailey, 1991: 197). This was made worse by the arrival of the plague in 1340, which reduced the population still further. Economic decline continued into the 15th century. During the first three decades the fishing fleet slumped and income from market stalls fell by 66% (Bailey 1992: 21). In c.1489 the status of royal harbour was transferred to Southwold, 5 km to the north.
The town’s decline was temporarily halted in the late-15th and early-16th century by a resurgence in the fishing industry, notably the long-range Icelandic fleet (Comfort, 1994: 74) which replaced the herring as the mainstay of the town’s fishing economy (Bailey, 1992: 16). In 1533, 22 barks sailed from Dunwich to the Icelandic fishing grounds; but by 1640 this was down to one, and the Icelandic fishing had ended by 1785. Additional physical losses occurred during storms in 1560 and 1570, so that by 1602 the town was reduced to a quarter of its original size (Bacon and Bacon, 1979: 22; Chant, 1986: 18; Comfort, 1994: 141). Further storms in 1740 flattened large areas of what remained, and only All Saints’ church remained open, while surviving ruins included St James’ leper chapel, the Maison Dieu hospital and the Franciscan friary (Gardner, 1754: 95; Bacon and Bacon, 1979: 24; Comfort, 1994: 166). The loss of All Saints’ church occurred during the late-19th and early-20th century, the last part disappearing over the cliff-edge in 1919. Fragments of All Saints’ were still exposed on the lower beach in the early 1970s. By 2007, one whole and one fragmentary tombstone were all that remained of its churchyard, and the south-east corner of Greyfriars perimeter wall had started to collapse down the cliff.

**Archaeological context**

Relative to the prehistoric period (for example Doggerland, Gaffney et al., 2007) and the post-medieval period (for example Port Royal, Hamilton, 1991) there is a lack of information on the archaeological value of medieval sites which have been inundated by the sea around the UK coastline (Fulford et al., 1997). In part this results from the accepted wisdom that any remains would be ‘a strew of materials scattered over the sea bed’ (Fulford et al., 1997: 18) and therefore of relatively limited archaeological value. This is particularly

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**Figure 2.** Rise and decline of Dunwich as indexed by the numbers of religious buildings, total population, and fee farm tax return to the Crown. Estimates of the population vary and hence ranges are given (Bailey, 1992). The growth of Dunwich can be linked to the dramatic growth in marine-fish exploitation that occurred c.1000 (Barrett et al., 2004). Economic collapse is linked to the blockage of the harbour and the general decline in the medieval economy in England in the late-13th and early-14th century. (authors)
the case for structures that have undergone a process of collapse down a cliff, followed by incorporation and transport within the beach and breaker-zone (Allen et al., 1997: 24). These arguments are somewhat circular, since the investigation of such sites is limited, and hence the evidence-base supporting these assumptions is poor. It could be argued that there is important heritage as well as archaeological value to submerged sites where contextual information exists in the form of historical accounts which enable reconstruction of the social, economic and urban geographies. On this basis the Dunwich town site is important as a submerged settlement which spans the medieval period.

This value stems from four main factors. Firstly, an extensive documentary archive survives dating back to the early medieval period, including data on the urban geography, social structures, economy, political structures, trade, and relationships with neighbouring settlements, and including records of erosion and inundation (cf. Bailey, 1991; Bailey, 1992; Chant, 1986; Comfort, 1994). Secondly, the harbour area with its associated sea-defences and port infrastructure are known to have been low-lying and subject to inundation rather than cliff collapse. Repeated reference is made to the uncovering of foundations of former buildings and wharfs (Gardner, 1754), suggesting higher preservation potential in this area of the town. Thirdly, significant medieval and post-medieval structures have survival potential, including nine churches, four chapels, and two friaries. Fourthly, the old courses of the Dunwich and Blythe rivers provide a potentially important sedimentary record of coastal regression, as well as potential for the preservation of early boat remains. Collectively the combination of archived documents, maps and images provides important information on the nature of the town, although the full value of these, before the earliest reliable map (1587), is limited by the absence of a plan. Thus there is historical value in extending our understanding of the urban geography of the town, since this would help with the interpretation of periods of erosion recorded in documents prior to 1587, and aid historians in understanding the recorded disputes between individuals from different parishes, as well as providing geographical context for the declines in economic value reported for each parish over the period 1280–1587.

Prior to the current project, considerable evidence existed which suggested the preservation of larger masonry remains and the potential for higher preservation in lower-lying areas of the former town. Diving surveys (Bacon, 1974; 1982), and the evidence from photographs of the preservation of All Saints’ church despite cliff collapse, provide evidence that large structural remains can be preserved and remain close to the point of entry to the foreshore (Bacon, 1974). For example, survival of the ruins of more massive structures (churches/chapels/wells) is evidenced by the preservation of large sections of All Saints’ and St Peter’s on the sea-floor after 100 and 320 years of submergence respectively (Bacon, 1982). Physically, the highest-energy conditions within the breaker-zone of the beach tend to result in scour around the larger blocks of masonry, resulting in their partial burial. Smaller fragments will be more widely dispersed and incorporated within the beach material following the model of Allen et al. (1997). Off shore, tidal and wave-generated currents have less energy and are therefore less likely to disperse the larger stonework, but instead scour and accretion of sand is known to create periods of exposure and burial at the site (Bacon, 1974). The preservation of subsurface Pleistocene or early Holocene river-channel sediments at the site has been demonstrated by the Institute of Oceanographic Studies (Lees, 1979; Lees, 1983; Gaffney et al., 2007). Knowledge of the position and dimensions of the former Dunwich river would be valuable for reconstructing the location of the harbour area and the northern limits of the town.

Despite the inherent value in undertaking investigations at Dunwich, the site represents a significant challenge to underwater archaeology for three reasons. First, some of the site lies buried beneath mobile sand/silt deposits; secondly, visibility across the site is typically poor to zero; and thirdly, the remains are often in a poor state of preservation after experiencing collapse from cliff retreat. However several factors suggested that a more detailed survey approach to the site was warranted. First, the post-1587 plan of the town is relatively well documented; secondly, extensive sea-floor exploration by divers over the period 1971–1989 has confirmed the preservation of debris from some of the larger buildings in positions similar to those marked on early maps (Bacon, 1974; 1982) and thirdly, technological developments have improved the resolution and positional accuracy of underwater survey including sub-bottom profiling (for example, Plets et al., 2009). Despite over 30 years of very challenging diving on the site (Bacon, 1982), it has proved difficult to map the whole of the site of the town, or accurately to locate and map the ruins discovered on the sea-bed. As a result the archaeological value of the town, despite its shallow depth (<12 m) and proximity to the coast (0–800 m), remained largely unknown.

The aims of the Dunwich 2008 project were to undertake a high-resolution, non-invasive multibeam, side-scan and sub-bottom profiling survey of the former town of Dunwich in order to determine its archaeological potential. This overall aim was broken down into four key objectives. To assess the value of historic mapping in supporting the relocation of major buildings within the former town of Dunwich using remote underwater survey. To evaluate the potential of integrated multibeam, side-scan and sub-bottom profiling for visualizing structures associated with the medieval town. To determine the location and extent of remains which lie exposed or partially buried on the sea-bed. And to document and publish the results of the project for display in the Dunwich Museum, and to
make the data available to the public and other researchers. The project started in December 2007, with survey of the site during May to September 2008. An additional survey of four key areas identified by the 2008 survey was undertaken in June 2009.

**Methods**

The 2008 and 2009 geophysical surveys were integrated in a Geographic Information System (GIS), and included cartographic analysis to create accurate digital maps of the former town with the purpose of guiding and interpreting the geophysical survey. The subsequent geophysical survey combined 3-dimensional multibeam swath bathymetry, 2-dimensional (planimetric) dual-frequency side-scan sonar, and 2-dimensional (vertical) sub-bottom transects.

The approach to cartographic analysis followed standard cartographic procedures (Longley *et al.*, 2001). The maps available for Dunwich were screened to determine those which were of sufficient cartographic accuracy to take forward for georeferencing and those which contained information that could define the survey area, but were known to be speculative. A decision was taken to georeference all the maps for the purpose of constraining the geophysical survey area on the basis that they summarize the available documentary evidence for the extent of the town (Chant, 1986). Although Ordnance Survey maps exist for Dunwich back to 1882, these were not used for guiding the survey since by that time only the position of one of the former churches (All Saints’) was marked (its location was taken from the 1882 OS 1:10560 map). Rather, the maps of the lost town were constructed from the 1826 tithe map and the 1587 Ralph Agas map. In addition, a map of the debris-fields located by Stuart Bacon and associated divers over the period 1970–1989 was made available to the project. These maps were based on compass-bearings and taped offsets measured from known points on the cliff-line (Bacon, 1982). Table 1 lists the maps selected for georeferencing and summarizes their accuracy and use in the geophysical survey.

The absence of any topographic data prior to the Ordnance Survey of 1882 made it impossible to account for terrain effects on position, as would be done with ortho-rectification, so the georeferencing was only able to apply planimetric shifts. In reality, the total topographic variability is less than 20 m across the site, so the positional errors associated with this constraint were assumed to be negligible. All the historical maps were converted into standard WGS-84 projection co-ordinates. Each map was scanned at 600 dpi and the digital raster image was used to identify a range of Ground Control Points (GCPs) which were common to both the historical map and the Ordnance Survey Landline 2000 base-map which was used to derive the accurate co-ordinates for the chosen GCPs. The position accuracy of the Landline map is estimated at 1.1 m (Ordnance Survey, 2005). Georeferencing was performed using a first-order polynomial transformation with RMS-errors ranging from 8.2 to 49.7 m (Table 1). The georeferenced maps were then overlain with the Ordnance Survey Landline 2000 data to check the alignment of features found in both data-sets. If alignment offset was unsatisfactory, georeferencing was repeated with other reference points until alignment errors were as small as possible given the limitations of the mapping (Theiler and Danforth, 1994). All the processing was undertaken within ESRI ARCGIS 9.2 using a minimum of 10 GCPs (Hughes *et al.*, 2006). The difference in location between the GCPs on the transformed layer and base layer is often represented by the total root-mean-square error

<table>
<thead>
<tr>
<th>Map</th>
<th>Basemap</th>
<th>No. GCP/No. Test points</th>
<th>RMS Error +/- (m)</th>
<th>Accuracy +/- (m)</th>
<th>Map use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1826 Tithe Map</td>
<td>OS Landline 2000</td>
<td>23/5</td>
<td>8.203m</td>
<td>10.114</td>
<td>9.698</td>
</tr>
<tr>
<td>1587 Ralph Agas Gardner (1754) (Reconstruction)</td>
<td>OS Landline 2000</td>
<td>10/6</td>
<td>38.357</td>
<td>49.708</td>
<td>Define Survey Area Define Potential Building Location</td>
</tr>
<tr>
<td>1280 Parker (1975) (Reconstruction)</td>
<td>1587 Georeferenced</td>
<td>10/4</td>
<td>28.225</td>
<td>34.304</td>
<td>Define Survey Area Define Potential Building Location</td>
</tr>
<tr>
<td>1300 Watling (1858) (Reconstruction)</td>
<td>1587 Georeferenced</td>
<td>10/4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Summary RMS errors and positional accuracy for different maps georeferenced against the OS 2000 Landline. The resulting maps were used for guiding the geophysical survey.
The geophysical survey was conducted by EMU Ltd using the vessel Emu Surveyor, which was mobilised at Burgh Castle, Great Yarmouth, on 4 June 2008, with survey operations out of Southwold harbour between 5 and 7 June. The survey was designed to collect contemporaneous swath bathymetry and dual-frequency side-scan data from across the whole survey area. In addition, four sub-bottom profiling transects were taken to determine the extent of deposition over the sea-floor during the geophysical survey. The values for mapping accuracy are relevant to subsequent discussions concerning the precise origin of the remains found on the sea-bed during the survey.

The mapped datasets were used to define a search-area for the geophysical survey together with a series of potential targets (ecclesiastical buildings). These were loaded into a GIS on board the Emu Surveyor and used to guide the subsequent side-scan, swath bathymetry and sub-bottom profiling. Positional data was provided by a Hemisphere Crescent DGPS system, which receives corrections from the EGNOS differential network via satellite and Trinity House differential stations. This enables the location of sea-bed information collected on-board sensors to be determined with a high degree of accuracy, typically 2–3 m. At the start of the survey the navigation system was checked against a known reference point. DGPS positions were logged by QINSy software at 1-second intervals for the geophysical and hydrographic survey. Data-quality was continually monitored and the system was set to reject position-solutions which did not meet the accuracy requirements (<3 m RMS). In the event all positional data fell within this limit.

Swath bathymetry was collected using a fully motion-aided Reson Sebat 8101 multibeam echo-sounder, a dual-frequency Klein 3000 side-scan sonar system and an Applied Acoustics 200J Boomer system. Integrated systems such as these are now standard for most underwater archaeology (Quinn et al., 2005). Tidal information was acquired in the form of Post-Processed Kinematics (PPK) recorded using a Leica GX1230 system and post-processed with RINEX data. All data are referenced to the WGS84 datum and the UTM Zone 31 North projection. The vertical reference for the bathymetry data is to Chart Datum at Southwold. All relevant instrument offsets were measured before the survey commenced and entered into the QINSy software. Attitude and motion were measured by the MARHS system giving heave, roll, and pitch data. This information was fed directly into the QINSy system for real-time corrections of the bathymetry. The swath system was calibrated prior to the survey with a standard patch-test operation. This revealed the fixed errors in heading, pitch and roll and also the time-delay in the position data. All this data was applied in the post-processing.

Data was collected across the survey grid along a line-plan designed to give maximum coverage across the site. High tides were used to give data as far inshore as was safely possible. Sound-profiles through the water-column were taken at the start and end of the survey and applied to the data online. Post-processing was performed by Emu Ltd using QINSy v.8.0 software. At this stage all corrections and filters were applied including the patch-test calibration results, removal of outliers with automatic and manual filtering and tides. The cleaned data was then gridded and exported for viewing in ESRI ArcGIS software. Positional accuracy for the swath multibeam was +/– 3 m.

Throughout the side-scan survey the Klein 3000 sonar was operated at 400 kHz with a range set at 75 m. The surface towfish layback was 25 m. The higher-frequency side-scan provides greater resolution of sea-bed features and is therefore the preferred frequency for archaeological surveys (Lafferty et al., 2006). The depths experienced at the Dunwich site are within those identified as optimal by Quinn et al. (2005). The Klein 3000 side-scan is a dual-frequency system with a pixel resolution of 31.2 mm for both high and low frequencies. All layback values and other relevant settings were recorded in the survey logs. The resulting sea-bed features identified in the side-scan sonar data have a horizontal accuracy of approximately +/– 10 m. Inaccuracy is caused by the path of the towfish not being directly behind the tow-point of the vessel, primarily due to tidal currents and differences in cable curvature or tension caused by different boat-speeds and use of the layback method of positioning.

At the beginning of the survey the boomer sub-bottom profiling system was tested to determine optimum project-specific settings. The trigger interval was set at 250 ms with a sweep-length of 50 ms to provide the highest possible resolution of the near-seabed object detection and shallow geology. The boomer catamaran was deployed 20 m astern and layback was subsequently applied to the navigation (GPS) data to provide a boomer XYZ trackplot. All data were logged in the Coda DA2000 system.

Diver ground-truthing surveys were undertaken in order to determine the composition of the features.
identified by the geophysical survey. An underwater video camera with integral lighting system was used to take film and photographic images of the features. Samples of loose stone from two of the church sites were recovered for the identification of provenance and evidence of human origin. Nine individual stones were recovered from positions immediately adjacent to stone structures, four from St Nicholas’ church site and five from St Peter’s church site. These were kept in seawater and examined on shore. Three stones from the St Nicholas site had remains of mortar attached. A small sample of mortar (5 gm) was sent off to Sandberg LLP labs for analysis together with an 8-gm sample of lime mortar recovered from the collapsing south-eastern section of the Greyfriars perimeter wall on the cliff at Dunwich. The samples were prepared and analyzed using a combination of hand and chemical separation techniques and the chemical content and grain-size compared. Eleven dives, totalling 345 minutes, were conducted on 19, 21 and 22 September 2008, over the two main church sites. The position of the centre of each target was occupied using GPS and a shot-line with surface buoy was positioned as close to that point as possible. Divers descended the shot-line to the sea-bed, then carried out a circular offset survey around the shot-line out to a maximum distance of 5 m, while attached to the shot line at all times. Diving was restricted to a 2-hour period of slack water on the turn of the tide. Visibility was <10 cm on all dives.

Results

Cartography

The digital mapping of the Dunwich town site is shown in Fig. 3, where the historically-accurate mapping back to 1587 is overlaid on colour orthorectified aerial photography from 2006 provided by the Environment Agency. The mapping demonstrates the accuracy of the georectification; the current course of the Dunwich river is shown to follow the historical map, only substantially reduced in width. This reflects the reduction in tidal influence and reclamation of the former estuary salt-marshes during the intervening period. The positions of eight ecclesiastical buildings are shown. An assessment of the documentary and map evidence shows that all of these were in a ruinous state prior to their eventual collapse and/or inundation.

Pre-1587, the geography of the town is less certain. Documents report relative positions of some buildings. For example, St John’s church is known to have stood seaward of St Peter’s church on the eastern side of the marketplace (Gardner, 1754: 47; Chant, 1986: 16; Comfort, 1994: 105). St Leonard’s is reported to have been located east of the Dain (the harbour area) and seaward of St John’s (Chant, 1986: 15) giving it a position in the north-east of the town. St Martin’s was located in the east of the town, though its precise position is unknown. The locations of St Michael’s and St Bartholomew’s churches are completely unknown, but their loss prior to 1328 suggests they were further east than the other churches. The association of St Martin (Martinmas) and St Michael (Michaelmas) with the herring-fishing industry might reasonably place them closer to the fishing harbours in the north-east of the town. On the basis of the documentary evidence, the reconstructions generally show a town elongated north-south with a concentration of settlement around the northern harbour and the marketplace. In part this reflects the absence of buildings shown in the southern part of the town in the Agas map of 1587. The conclusion must remain that pre-1587, the geography of medieval Dunwich is largely unknown and at best uncertain. Post-1587, we can be more certain, and, subject to cartographic error, the locations of the buildings shown on the Agas map do reflect an accurate representation of the town at that time. However the distribution of buildings on this map may not reflect the earlier layout, since large open spaces in the south and south-east of the town may be a reflection of the economic decline and outward migration recorded in the period prior to the date of survey (Bailey, 1991: 196; 1992: 3). Table 1 provides the positional accuracy of the map.

Geophysical survey

The spatially-integrated geophysical survey results produced the first detailed bathymetric map of the sea-bed over the Dunwich site. When integrated with the cartographic analysis this provided a method for identification of geophysical targets. The results from the combined multibeam, side-scan and boomer surveys revealed the site of the town to be covered by an inner sandbank with depths of fine sediment up to 3.3 m, sloping down to a platform covered for the most part by sand up to 2.7 m deep. The composition of the sand can be estimated from IOS sediment grab samples (Lees, 1979), diver surveys undertaken by Bacon and others, and the project diver surveys. All report the fine sediments to be composed of brown-coloured fine sands (0.12–0.17 mm, Lees, 1979). To the north and north-east of the town, the bed contains areas of peat and clay overlain by a thin veneer of fine sand. The IOS studies (1975–79) were unable to obtain sediment samples over the site, but report the area of the town as probably being underlain by sticky blue clay (estuarine sediments?) containing organic matter and iron-stained.

The data from this survey appears to show a progression from sandy-gravel mixed beach materials, grading into an inner sand ridge (Fig. 4). Haskoning (2009) identifies this as a swell-induced ridge-and-trough system. This ridge of sand descends onto a hard bed composed of pockets of clay (see IOS report, Lees, 1980), with exposures of intercalated sands and clays typical of the Norwich Crag. The area of exposed bed (no sand cover) has a complex microtopography with linear (north-south) aligned scarps of up to 0.5 m high, and depressions bounded by shallow escarp-
ments. The main exposed archaeological finds lie in this area (Fig. 4). The clay/crag surface has a veneer of fine sands, and patches of gravel that are perhaps associated with the decomposition of the church sites. Seaward of this area, the sea-bed is essentially a flat plain of sand, dipping gently seawards and to the south-east. This then climbs up on to the Dunwich bank, some 2 km offshore.

The boomer data collected for the Dunwich 2008 project produced four transects. These showed a shallow layer of sand and strong sub-surface reflections just below the surface. These are interpreted to represent the fine sand layers lying over more consolidated quaternary deposits, which in this area are comprised of intercalated sand and clay (Lees, 1980). To produce a measure of the fine-sediment depth, the boomer survey transects were sampled every 50 m and the depth from the surface reflection to the lower sub-bottom reflection was obtained. Fine-sediment depths across the site are up to 3.3 m where the inner sandbank covers

Figure 3. Dunwich town digital map. Buildings recorded on Ralph Agas’s map of 1587 are shown in light grey. Buildings on the OS 2000 Landline maps are in white. The course of the present and 1587 Dunwich river is shown in bright white and dark grey respectively. Shrinkage of the river is evident, and demonstrates the reduction in tidal influence over the intervening period. (authors)
the western area of the town, which includes the sites of the Knights Templar Church and St Katherine’s Chapel (post-1600). Thereafter, sediment-depths decrease, reaching a minimum in a narrow zone where the inner sandbank ends. This is the region where the ruins of the church of St Nicholas, St Peter’s and an unidentified ruin are exposed above the sea-bed. The site of Blackfriars lies in an area where fine-sediment depths are between 0.67 and 1.2 m. Seawards (east) of this zone, sediment-accumulation increases, resulting in an average depth of 1.35 m over the pre-1587 area of the town, before increasing to 3 m at 1 km offshore at what might be the start of the Dunwich bank. The site of St John’s church (c.130 m east of St Peter’s) lies under 1.7 m of fine sediment. At the time of survey (June 2008), the earlier (pre-1500) central and northern areas of the town lie under 1.2–1.65 m of fine sediments, with the northern area (former harbour and river) under <0.8 m of fine sediments.

Figure 5 shows the multibeam sonar data over the town together with a transect across the whole site that corresponds to one monitored by the Environment Agency. This shows that the inner sandbank has moved landwards since 2003 with the coastline, and that the depth of the sea-floor (fine-sediment depth) over the town was lower at time of survey compared to 2003. As described above, the majority of the town lies under the inner sandbank or under the fine sediment east of the scoured zone. No topographic features are evident over this area—the site is a featureless plain of fine sand. In the northern area of the town, towards the harbour and Dunwich river, the sea-floor is again partly covered by sediments, but in the area with little sediment accumulation, a series of ridges and scoured basins is apparent, together with some isolated topographic features that might be of archaeological interest. Unfortunately coverage of this important area is poor and/or patchy (Fig. 5 iv).

Identification of archaeological targets
A conceptual model of the most probable structure of the remains of important stone buildings from the town was developed prior to the geophysical survey.
This was based on the evidence already existing from photographs of the ruins of All Saints’ church on the beach (after collapse down the cliff), diver surveys of the All Saints’ and St Peter’s ruins (Bacon and Bacon, 1979; Bacon, 1982) and 18th-century images of an analogous site at the Walton Roman shore fort. This model hypothesized that the ruins would be in the form of an area of rubble blocks standing up to 1 m above the sea-bed, and of the order of between 1 and 4 m in width or length. The ruins were expected to show an accumulation of larger blocks towards the west, associated with the more substantial structure of a western tower, or at the centre where the church had a central tower (St Nicholas’, St John’s, and the Temple church); the positions of the ruins were hypothesized to be offset to the east from their original (mapped) location as a result of their collapse down the cliff; to show a dispersal towards the north-south (drift movement) and east (off-shore movement) during their period within the breaker-zone of the

Figure 5. A 3-D rendering of the Reson 8101 multibeam sonar. The data reveals three main features as you descend from the beach into the sea: i) an inner sandbank separated from the gravel beach by a small gully that parallels the beach; ii) an area where the tide scours the bed of sand and silt to reveal the underlying quaternary sediments and ruins; and (iii) a large plain of fine sands that gently dips away to the south-east. Further east, this rises into the larger Dunwich sandbank. The area to the north of the town was where the old Dunwich River entered the sea, and where the harbour area lay; (iv) we have only partial data coverage in this area. Reconstructed town plan is shown together with ecclesiastical buildings. (authors)
beach; and to be discrete, and not widely dispersed, thus providing a clear area of complex sonar shadows and intense returns, associated with a complex topographic signal from the multibeam.

The multibeam and side-scan sonar surveys over the town revealed four potential targets which contained elements of the conceptual model. Three of the targets (T1, T2 and T4) closely matched the model, of which two (T1 and T2) were close to buildings shown on the digital maps of the town. These two targets were selected for further diver-based ground-truthing.

**Target 1: St Nicholas’ Church**

Figure 6 shows the multibeam swath bathymetry over Targets 1 and 3. Target 1 is close to the assumed position of St Nicholas’ church (Gardner, 1754: 48 records it as lying 20 rods (100 m) SE of Blackfriars). Target 1 lies 124 m SSE of Blackfriars as recorded on the Ralph Agas map, which is close to the value reported by Gardner. The debris-field lies 746 m south of St Peter’s in the scoured area of sea-bed east of the inner sandbank. The ruins appear as scattered blocks of masonry in the multibeam images, lying in an area of the sea-floor which is lower than the surrounding bed. The site lies some 410 m east from the present (2000) cliff-line, at a depth of 8.4 m and covers an area of approximately 630 m². The debris-field is symmetrical with no clear western accumulation of larger blocks. This is in accordance with the description of the church as a cruciform structure with a central tower. St Nicholas’ church collapsed over the cliff some time in the late-15th century (c.1480, Gardner, 1754: 49). This gives an approximate time of submergence under the sea of 529 years. The church was ruined and stripped of the most valuable materials (wood, lead, bells). Thus the remains are those of a ruined structure which collapsed down a cliff (height of cliff unknown, but assumed lower than current cliff height since All Saints’ occupied the highest part of the town).

![Figure 6](image_url)
Diver surveys at this site resulted in the recovery of four stones which were adjacent to larger structural blocks. Three were geologically erratic to the area, being a pink granite, a basalt, and a schist. The other was a large unworked flint. Two of the erratic blocks had traces of what appeared to be a lime mortar adhering to their surface. Blind analysis of a sample of this mortar and a sample of mortar recovered from inside a collapsed section of the southern wall of Greyfriars was undertaken for English Heritage by Sandberg LLP (report 39360/C). This confirmed the sample recovered from the submerged site as feebly-hydraulic lime mortar of identical composition to that of the Greyfriars sample. Hence the structures on the sea-floor are confidently ascribed to human origin and are most likely to be part of St Nicholas’ church. Diver surveys undertaken in poor visibility confirm the presence of relatively-large blocks of flint and rubble scattered over the site, and the possible presence of some worked stone. The divers estimated the block sizes as 1.4 m long and between 0.3 and 0.6 m above the sea-bed. The Klein 3900 side-scan survey (Fig. 6b) gives an average block size of 1.3 × 0.9 m, and the multibeam survey a height above sea-bed of between 0.3 and 0.8 m, similar to those at the St Peter’s and All Saints’ sites.

**Target 2: St Peter’s Church**

Detailed images of Target 2 are shown in Fig. 7. Target 2 lies 48 m east and 20 m north of the centre of the mapped position of St Peter’s church, and 18 m east of the eastern margin of the error-box, and within the error-box to the north. Bacon’s (1974) diver-based survey of St Peter’s ruins from 1973 are shown to be co-located with the digital position for the church on the Agas map of 1587, suggesting either that the ruins revealed in the 2008 survey belong to another structure (St John’s church?) or that the Bacon position is inaccurate. The latter is assumed in this instance. In addition, comparison with his position of All Saints’ church shows a northern offset of similar magnitude. St Peter’s church collapsed down the cliff during storms c.1688–1702, which gives a time of submergence of 307–321 years. Between 1654 and 1690 the church was dismantled much like All Saints’ so what is visible on the
sea-floor is the ruins of ruins. The site lies some 337 m from the present (2000) cliff-line, in line with St James' Street at a depth of 8.2 m, and covers an area of approximately 934 m².

Klein 3000 side-scan data is not clear for this site, despite enhancement, thus making it difficult to interpret the archaeology. More recent side-scan data acquired by Wessex Archaeology in June 2009, using a Klein 3900 towfish, has a much-higher resolution and enables the larger elements of the ruin to be mapped (Fig. 7b). The site is characterised as a series of blocks with concentrations of larger blocks at the western side. The blocks vary in size up to 2.1 m long (based on the Klein 3900 side-scan survey) and stand between 0.2 and 0.8 m proud of the sea-floor (based on swath bathymetry confirmed by diver survey). Average block size is $1.1 \times 0.87$ m, with a tendency to be symmetrical rather than elongated.

Diver surveys confirmed the presence of flint and mortar blocks of similar estimated dimensions to those measured from the side-scan and swath bathymetry. Five sample stones were recovered from this site: all were large flints, and none showed traces of mortar. The sea-floor around the blocks at the St Peter's site is covered in large flints and stones which have fallen out of the walls, presumably as the lime mortar dissolved over time. Recent underwater filming during a rare period of good visibility has revealed evidence of worked stones at the site, and the complete encrustation of the wall and tower fragments with sponges, highlighting the ecological value of the ruins in an otherwise sand-covered sea-floor.

**Target 3: Blackfriars?**

Target 3 (Fig. 8) covers an area of 1643 m², and contains two areas of larger structure, and a field of smaller debris to the east. The site is poorly visualized in the 2008 swath bathymetry and Klein 3000 side-scan sonar survey. However the Wessex Archaeology Klein 3900 side-scan survey reveals more detail. The site differs from all other targets in the absence of large block fields. Instead there are two areas where larger blocks ($4.3 \times 2.9$ m) project 0.4 m above the sea-floor, a more subdued area of sea-floor relief to the east of these blocks (possible burial by fines) and an area of relatively high-intensity sonification return that appears to result from a strew of smaller blocks ($<0.3 \times 0.3$ m). No diver confirmation has been undertaken at
The location of the site immediately north and east of the mapped position of Blackfriars suggests a possible association. The Agas map records Blackfriars as an overgrown ruin similar to that of the current surviving Greyfriars. No tower is shown in the illustration although large masonry structure is present and should have resulted in bocks similar to those found at the other sites. Further investigation is required in order to confirm a human origin to the structures, and to confirm this as the friary.

Target 4: St Katherine’s Chapel?

Target 4 (Fig. 9) covers an area of 183 m², containing a discrete debris-field composed of elongated blocks (up to 3:1 length:width ratio) which average 1.3 × 0.7 m, with a swath bathymetry-derived height of 0.3 to 0.6 m. No diver surveys have been undertaken at this site at the time of writing. The vicinity of the target is associated with a single unidentified building on the 1587 Ralph Agas map. It lies north of the centre of the town, 226 m NNE of the ruins of St Peter’s church, and 600 m south of the harbour. The small area of the debris-field, combined with the relatively discrete and larger blocks, is different from the other sites. It is hypothesized that this results from collapse over a shallower cliff and/or a relatively small structure, perhaps a chapel or large house.

Bacon (1982) reports finding carved imposts and other worked masonry from a site that fits the location of this structure. The recovered materials suggest an ecclesiastical origin, though this remains to be confirmed. Bacon (1982) associates it with the chapel of the Maison Dieu, based on the location recorded in the Hamlet Watling 1858 map. However, this project has cast significant doubt on the validity of this map as a representation of pre-1587 Dunwich. Moreover, the location, relative to the position of the Maison Dieu shown on the Agas map of 1587, strongly suggests that it is not associated with this hospital. At present, therefore, this structure remains unidentified, though it was clearly present as a building in 1587. Its vicinity to St John’s raises the possibility of it being St Katherine’s Chapel. This was lost around the same time as St John’s (c.1550+), and was known to be the wealthiest of Dunwich’s chapels (Gardner, 1754: 53). Further investigation of the site is required in order to confirm its origin and to identify the status of the building.
The Dunwich 2008 project has successfully deployed contemporary geophysical and cartographic analysis to identify positively two of the churches of the former town, and possibly two other structures, one of which is tentatively identified with the Dominican friary. The project has also demonstrated that it is possible to use the 1587 Ralph Agas cartography as a basis for reconstructing the former town, and that it is sufficiently accurate to identify larger buildings. This being said, the positions of the debris-fields associated with the larger buildings are offset from the Agas map by more than the mapping-error estimate. This suggests that the surveyed positions of these buildings were inaccurate, and that some limited post-collapse movement has occurred (<50 m).

Figure 10 shows the locations of major ecclesiastical buildings in Dunwich identified from the Agas map and from the current geophysical survey, with their dates of loss. The location of St Nicholas’ church is the first of the pre-Agas buildings to be confirmed, and suggests that the remains of earlier buildings can be expected to be detectable given the appropriate technology. As a result of the project it is now possible to state with certainty the positions of 12 out of 22 main

Figure 10. Updated map of Dunwich showing the positions of all known structures. These are based on OS Landline 2000 mapping for existing structures, georectified 1587 and 1826 maps, and the geophysical survey of targets 1–4. Dashed circles are sites whose identification or precise position is less certain. (authors)
ecclesiastical buildings (54%). Of these only one pre-dates the Agas map of 1587. The ten buildings lost earlier than 1587 (excepting St Nicholas’) all lie beneath a dynamic and relatively-thin layer of sand (<2 m). The preservation of the church of St Nicholas supports the view that the structural remains of these earlier buildings will be preserved, and are therefore potentially detectable. The main targets, in order of priority based on highest likelihood of detection, are: St John the Baptist (possibly detected in 2008 survey); St Martin’s (lost c.1350); St Leonard’s (lost pre-1350); St Bartholomew’s (lost pre-1350); and St Michael’s (lost pre-1350).

The relocation of St John’s church is a high priority since its position relative to St Peter’s church is known. Identification would enable the location and dimensions of the central marketplace of Dunwich to be determined. This was the commercial centre of the medieval town for which records of market-traders and stall accounts exist (Bailey, 2007). The site currently lies under 1.7 m of fine sands and silt and will require sub-bottom profiling geophysical survey. The four other churches represent the earliest and low-lying part of the town around the area of the main quayside. Detection of these would enable reconstruction of the northern and eastern limits of the town and, given their low-lying position, they may be in a better state of preservation compared to those buildings which have collapsed down a cliff. This hypothesis is supported by the relatively discrete and larger blocks found at the unidentified Target 4 site. These buildings lie under relatively-shallow sediment (0.8–1.5 m) and their detection may be possible using shallow sub-bottom profiling technology coupled to magnetometer survey.

The concentration of erratic lithology derived from boat-ballast associated with stone (church) structures may provide detectable magnetic anomalies. Smaller and earlier buildings are less likely to be detected since the depth of sediment-burial increases eastwards (rising to 3 m), and the structures themselves may be too small to locate using current technology.

The results of the Dunwich 2008 project enable comment to be made on the preservation of ruins of medieval structures in moderate-energy coarse clastic coastal environments. These may be summarized as follows. Substantial structural elements from medieval stone buildings remain in the vicinity of their original location, though with some dispersal due to storm, tide and wave action while in the breaker-zone. The positions are sufficient to enable reconstruction of the relative geography of sites as confirmed by cartographic analysis. Building materials degrade over time, with blocks of flint masonry falling apart as evidenced by the strewn of flints and loose stones with remnant masonry around blocks seen in the side-scan data and reported by divers. Despite this, detectable blocks of flint-and-mortar rubble masonry occur even after c.500 years submergence (for example St Nicholas’ church). Existence of carved masonry fragments—where protected by sediment or of hard stone—show high preservation of detail. Others which have been mobile, or subjected to attrition by sand moving over them, show wear and loss of detail (cf. Dunwich Museum and Suffolk Underwater Studies collections).

Some possible response in the sea-floor to the presence of larger masonry blocks inducing scour around the sites (such as St Nicholas’, Target 4) appears evident. Interactions between the tidal currents (locally attaining 1 m s⁻¹, Lees, 1983: 8) and the larger blocks will induce turbulence and vortex-shedding resulting in the potential to create longitudinal scour. This mechanism results in local lowering of archaeological remains into the sea-floor, which in time could increase the relative depth of deposition. There is limited evidence to support the hypothesis that cliff-collapsed structures present a more dispersed and fragmented assemblage compared with those which have experienced lower or no cliff collapse. The fragmentation of masonry structures into smaller blocks during the collapse process renders them more mobile under storm, wave and tidal action. This may explain the more-widely-dispersed remains of St Peter’s church (this survey) and All Saints’ (Bacon, 1982) compared to the larger blocks and discrete ruins associated with Target 4.

The loss of similar structures over a long period at Dunwich provides an opportunity to explore the effect of different periods of exposure to coastal processes on the preservation of archaeological features in the sea-bed. This is complicated, however, by the different architecture (cruciform/western tower) of these buildings and the mode of entry into the beach/littoral-zone. The dispersed nature of the sites makes interpretation of the buildings difficult. This is particularly the case for smaller worked fragments whose original position within a building is likely to have been changed by the process of collapse and the subsequent mobility under wave and tidal action.

The results from this survey have wider implications for the preservation of maritime heritage dating from the medieval period along the UK coastline. Dunwich is one (albeit the largest) of the coastal settlements known to have been lost to coastal erosion and inundation (Fulford et al., 1997). Other settlements on the south and east coasts contained churches built of stone, and, as the results of this survey demonstrate, their ruins will be extant and close to their original position. Examples where the remains of other church buildings exist include Church Rocks, Shipden-Juxta-Mare (Cromer, Norfolk) located 300 m off shore, and St Helen’s, Old Kilnsea in East Yorkshire. The ruins of the latter are marked on the foreshore in the earliest edition Ordnance Survey maps. In addition to medieval heritage, earlier stone buildings are also documented, including a Saxon church at Selsey, West Sussex, the Roman shore-fort at Walton, and potentially another Roman shore-fort off the coast at Skegness.
Evaluation of the methodology

The survey methodology used in the Dunwich 2008 project has highlighted the limitations of the techniques and methods used as an approach to detailed site investigation. The Reson 8101 MBS and Klein 3000 side-scan sonar were unable to visualize the origin of the structures or to determine the full extent of the site. Inability to identify features out of context has been reported by Quinn et al. (2005). Similarly, the diver surveys were severely limited by the high turbidity at the site. Visibility at the Dunwich site was typically less than 0.1 m and frequently zero, as is normal for most of the year. These conditions effectively limit further mapping and recording of the sites. In turn this prevents any quantitative analysis of the sites in terms of: description of the remains (for example site mapping); the nature of structural preservation; and information on the extent and nature of the dispersal of material by initial collapse and subsequent wave/tidal action. Thus the currently-deployed technology was suitable for a general assessment of the whole site, but was unsuitable, even with diver ground-truthing, at the more local target level.

The use of the higher-frequency, higher-resolution Klein 3900 side-scan sonar, when focused on specific targets, improved the resolution of imaging to the extent that quantitative analysis of the major structural elements of each target was possible where they are exposed above the sea-floor. Despite the improved resolution, it was still not possible to identify individual structural elements within each site. In the future, a higher-resolution geoaoustic technology will be required. Candidate technology includes higher-frequency Edgetech 4200 dual-frequency side-scan sonar, integrated with Reson 7125 high-resolution multibeam swath bathymetry. Each target will be sonified from multiple angles to build up a 3-D DTM over which the higher-frequency side-scan mosaics will be laid. In addition, the use of latest-generation acoustic-imaging systems such as the Soundmetrics Didson system (Belcher et al., 2002) will permit ultra-high-resolution (cm-scale) investigation of the sites. An alternative approach could include the use of environmental sensing to alert local divers to periods of high visibility (Glasgow et al., 2004). Buoy-mounted turbidity-probes coupled to telemetry might usefully be deployed to send mobile-phone alarm-texts to local divers. This has the advantage of maximizing the opportunity to undertake visual identification and mapping of the ruins, but would require rapid mobilization capability.

The Dunwich site bathymetry creates limitations for geophysical survey methodology. Shallow areas, particularly in the vicinity of the inner sandbank, preclude the use of larger boat-mounted equipment. This limits the investigation of the Temple and All Saints’ sites. Shallow-draught boats might be used at high spring tides, or alternatively a diver-towed system (see Plets et al., 2009). Grøn et al. (2007) report application of a Chirp system in 0.5 m depths. However, the application of Chirp sub-bottom profiling at the Dunwich site is limited by the presence of coarser sediments.

The main challenge posed by the site remains the burial of structures under shallow sand-drapes and the inner sandbank. The boomer transects used in this survey were unable to resolve details within the shallow sand-drapes due to the strong return of the underlying bedrock. An alternative technology such as parametric sonar, which returns data on signal-strength and intensity, should be tested over the site in order to determine the most effective frequency to penetrate sand while returning identifiable reflections from buried structures often resting on sea-bed material of similar acoustic signature. Integration of a range of novel geophysical technologies will therefore be necessary to further the archaeological investigations at Dunwich.

Conclusions

The Dunwich 2008 project has achieved the main aim of undertaking a town-scale survey of the site. Integrating geophysical, diver and cartographic methodologies within a GIS has enabled positive identification of two of the lost churches, and identification of two other potential archaeological sites. The survey has also created the first detailed bathymetric survey of the site, enhancing our understanding of its environment.

The archaeological discoveries have confirmed the existence of substantive ruins associated with medieval church structures even after 500 years of submersion. The nature of the sites varies from localized strews of masonry to discrete elements of structure. These suggest different preservation potentials within the littoral zone, which are considered to reflect the mode of entry into the beach environment. Dispersal occurs when structures collapse progressively over larger cliffs. Discrete structural remains occur in the presence of shallow or no cliffs. The preservation potential of earlier stone structures located to the north of the town is therefore considered to be high.

The heritage value of the Dunwich site is significant, representing a mid-to-late medieval port of national and international importance. The ruins on the sea-floor have both worked and carved stone, and contain artefacts which are recoverable. However, the interpretation of the remains is difficult because of the loss of context arising from the collapse and mobilization of the materials. Detailed mapping and careful excavation is required to determine what information can be derived from these types of site in terms of the ability to identify their age, use, architectural design and specific dedication.
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