The Use of GIS in Maritime Archaeology - the Cattewater Wreck Case Study

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Part of the planning for geophysical survey work on the Cattewater wreck in 2006 included a reassessment of the documentary archive for the site. The many reports about the work on site provided a rich source of information and it was decided to collate what was known in digital form using the computer program Site Recorder 4. A result of the reprocessing work was to make this dataset more widely available in a digital form, at the conclusion of this phase of the work the entire current dataset has been made available on CD and by download from the Web.

Keywords: Geographic Information System, Site Recorder, Cattewater, Reprocessing, Digital Data

Introduction

The Cattewater wreck was a site at the forefront of maritime archaeology in the U.K. in the early years, found in 1973 by accident it was partially excavated culminating in a detailed report published in 1984 (Redknap). In 2006 the opportunity arose to be able to complete some geophysics work on site with the assistance of the University of Plymouth and this was the spur needed to re-visit the site and its documentary archive.

Planning for the geophysical survey required a re-assessment of what was known about the site, its extents and any likely targets to be found. The many reports about the work on site provided a rich source of information and it was decided to collate what was known in digital form using the computer program Site Recorder 4 from 3H Consulting Ltd (Holt 2007). Reprocessing the disparate paper documentary archive produced an integrated digital archive containing much, if not all, that was known about the site itself as well as providing the foundation on which to base the geophysical survey work.

A second aim of the reprocessing work was to make this valuable dataset more widely available in a digital form, as the site report monograph was out of print and a digital publication could provide much more information than a paper publication. At the conclusion of this phase of the work the entire current dataset has been made available on CD and by download from the Web.

The Cattewater

The Cattewater is the name given to the lower reaches of the River Plym, the river associated with the City of Plymouth in South West England (*Fig 1*). The Plym starts on the high ground of Dartmoor and drains into the waters of Plymouth Sound at its north-east corner through a drowned river valley or ria. In times of a much lower sea-level, the deep-cut limestone gorge at the mouth of the River Plym met with the deep-cut limestone gorge at the mouth of the River Tamar to the West, before the confluence then flowed south towards the Eddystone Reef now 17 miles offshore. To the North of the Cattewater is the much-quarried limestone hill of Cattedown and to the south lie the quarries of Turnchapel and the promontory of Mount Batten, a mass of Devonian limestone joined to the land by a narrow strip of land.

There is a large potential for discovering cultural material in the sediments at the bottom of the Cattewater. The story of man’s involvement with the River Plym is long; it is known that the land around the Cattewater has been occupied since the Palaeolithic. In caverns in the limestone quarry just up the river in Oreston were found human bones in association with those of woolly rhinoceros, mammoth, cave lion and cave bear (Langdon 1995 p9). As transport overland would have always been difficult through the hilly terrain of South Devon and Cornwall, it can be assumed that the waters around Plymouth have been used as a harbour for transport and trade from the time when people first occupied the area. Cunliffe (1988 p1) describes the Cattewater as ‘one of the most important prehistoric ports-of-trade in Southern Britain and maintained its significance well into the Roman period’.

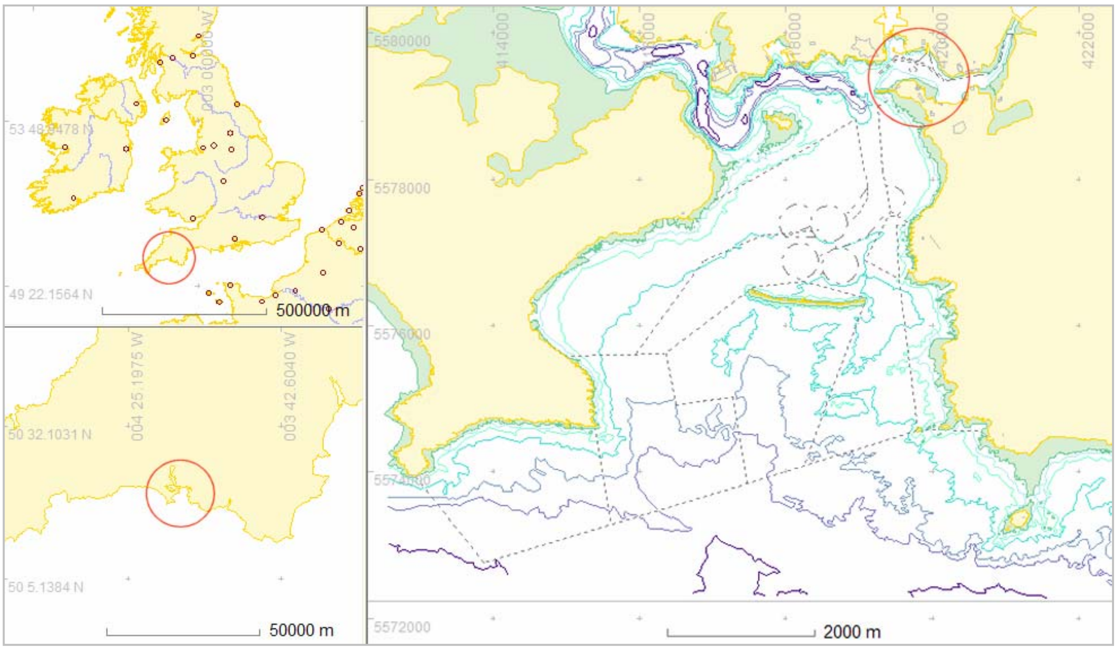

Figure 1: Location of the Cattewater Wreck (Peter Holt)

Metal ores were first exploited in Britain in the second millennium BC (Gerrard, 2000 p15) and it would have been clear at the time that Devon and Cornwall were rich in tin because of the alluvial deposits visible in the riverbeds. Recovery of the tin started with the easily accessible alluvial deposits by streaming and many streamworks exist on Dartmoor at the head of the rivers Plym and Meavy. Tin ingots found off the mouth of the River Erme (SWAG 1993) a few miles to the East of Plymouth hint that tin trading would have occurred at similar locations such as the Cattewater; the heads of the rivers Plym and Erme on Dartmoor are less than 2km apart. As Mount Batten lies near a safe and convenient harbour down river from the Dartmoor tin works it suggests that it too would have been used for this purpose, in fact Mount Batten has a good claim to be the fabled site of *Ictis* mentioned by Diodorus Siculus (90-21BC) (Hawkins, 1811; Green, 1906)

The first recorded trade was in tin and slates exported from Plympton Earle which lies up the river Plym, at the time its furthest navigable extent. By 1328 AD, tin streaming had deposited so much silt in Dartmoor's rivers that the upper reaches of the Plym gradually became too shallow to allow access to the harbour (Worth, 1873). By that time ships had already started to use Sutton Pool at the entrance to the Cattewater to unload their cargoes, in 1300 AD the town of Sutton was already a thriving community (Ray, 1995 p61); Sutton Pool also had the advantage of allowing relatively large ships right up to the centre of the town.

In the Middle Ages, Sutton Pool was the haven for ships but the Cattewater was the roadstead for those ships even though it was somewhat exposed. Then as now the silting up of the river was a perennial problem. In 1531 an act of Parliament was passed to prevent gravel from being washed downriver by tin streaming work on Dartmoor. The earliest chart of the area, dated pre-1549, shows the waters of the Sound as well as fortifications along the Hoe coastline and the Stonehouse peninsula (Stuart, 1991 p77), with two ships shown at anchor in the Cattewater lying close in to Turnchapel in Clovelly Bay. By 1650 the ships had increased in size making access to the safety of the Cattewater and Sutton Pool difficult, so the ships had to remain outside in the Sound. Dredging still allows large vessels access to the Cattewater and Cattedown Wharves are still in active use, but the dredged area is limited leaving much of the seabed untouched. Coupled with the good preservation environment offered by the stiff clay sediments in the river, the Cattewater offers a huge potential for historic discoveries.

The Cattewater Wreck

The site of the Cattewater wreck lies to the south of the main ship channel of the Plym in a shallow area now filled with small boat moorings, the only hint of its existence being a gap in the pattern of mooring buoys and a poorly sited English Heritage sign at Queen Annes Battery. This area of the Cattewater was used as a mooring first for seaplanes and then for fast air-sea rescue craft operating from the RAF station that used to occupy Mount Batten. In 1973, a dredger being used to deepen the moorings brought up timber wreckage and parts of iron guns. An underwater investigation of the site later that year produced a provisional site plan and involved the more controlled recovery of loose wreckage from the seabed. The structure was found to be the lowest section of a hull from one end (bow or stern) to past the midships area where the dredging work had caused extensive damage. Based on the assessments the site was recommended for designation under the new U.K. Protection of Wrecks Act (1973) and the site was designated under order No 1. Further recording and excavation work on the site was carried out between 1974 and 1978 (Bax, 1976; Bax, 1977; Redknap, 1984).

The southern end of the site was the first to be discovered and the deposits in this area were found to be intact above the hull. An area of undisturbed deposits to the north of this area was left undisturbed, and excavation resumed northwards along the western hull edge, until the northern end of the hull structure had been located. Very little of the debris field was examined. In contrast to the southern area, the northern sector had been severely damaged by dredging, and deposits only remained in situ between futtocks. Most of the artefactual evidence came from the southernmost area of the hull, from deposits which were associated with the ship's ballast.

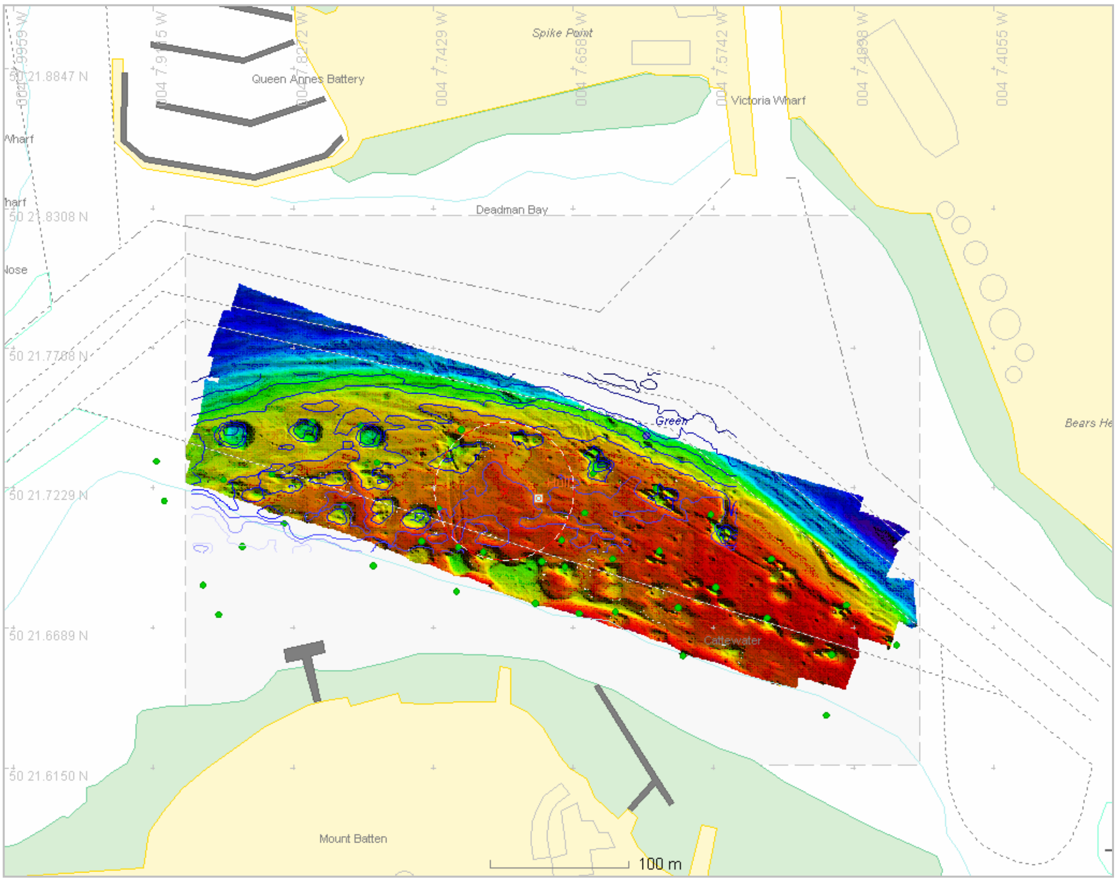

Figure 2: Screenshot from Site Recorder showing colour rendered site bathymetry (Peter Holt)

The name of the vessel remains unknown and the site was not fully understood as very little of the debris field was investigated. The site was visited by the Archaeological Diving Unit (as part of the Contract for Archaeological Services in relation to the Protection of Wrecks Act (1973)) but remained largely forgotten, protected from interference from divers by local lore that said that the site was inaccessible as it was buried by many metres of sediment.

Environment

The drowned river valley of the Cattewater now contains a considerable depth of sediment; coring in the river showed that in places the limestone bedrock was found at a depth of 35m below chart datum (Wessex Archaeology, 1995 p11). During construction of the first Laira Bridge upriver from the site, the underlying rock was found below 20m of granite sand and when the new bridge was built solid rock was found 30m below the river bed (Gill, 1997 p10). Cores taken from the nearby Clovelly Bay before dredging work showed that the upper levels of sediment on the site are very stiff green-grey sandy clay; this is thought to be composed principally of waterborne waste from mining activity on Dartmoor. The lack of visible stratigraphy and relative homogeneity of the clay suggests that the deposit formed rapidly and without interruption (Wessex Archaeology, 1996). The sediment in the area of the Cattewater wreck is formed from the same clays but it is expected to contain rock or shingle ballast dumped overboard from ships and waste from quarry workings on Mount Batten. The nature of siltation and how it has changed over time since tin streaming and china clay extraction stopped is poorly understood. The area of the wreck site itself is now largely undisturbed by regular dredging, unlike the channel to the North which is maintained at a depth of 5m.

Recent Work

The spring of 1993 saw the start of a long-term project, co-ordinated by the author, to collate maritime historical and archaeological information from the area in and around Plymouth Sound, U.K. The Cattewater wreck was included in this study in 2006 when the opportunity to collect on-site geophysical data became available with the help of the University of Plymouth. Work was started to integrate all that was known about the Cattewater wreck within a single digital archive as part of the planning phase of the geophysical survey. The available information was integrated into a digital archive using the Site Recorder 4 (SR4) software from 3H Consulting Ltd., this software can be used as a tool to aid the recording and preservation of cultural heritage sites by collecting together and presenting site information in an integrated and more meaningful way (*Fig 3*). The archive would include mapping, geophysical, archaeological and documentary data from as many sources as could be found. The synthesis of these disparate data sources would produce a single point of reference for the Cattewater wreck that could be widely published at minimal cost.

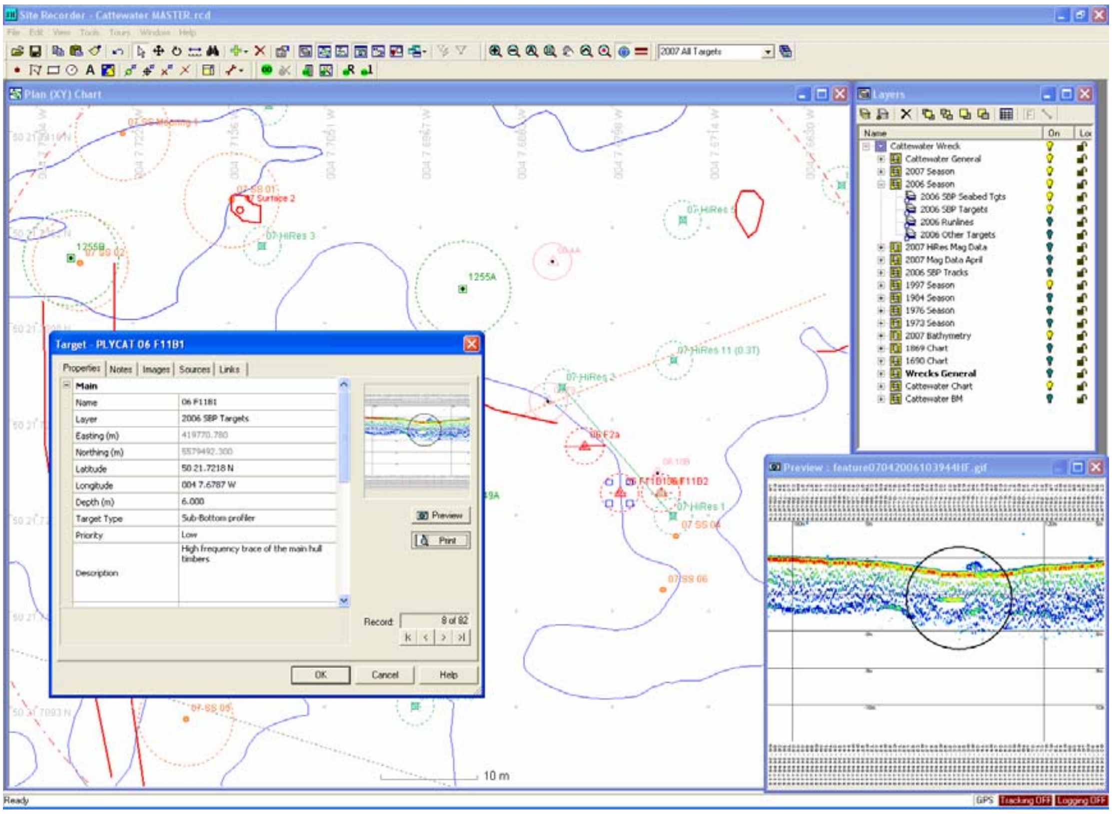

Figure 3: Screenshot of SR4 showing a Target properties page and linked image (Peter Holt)

Site Recorder 4 is similar in principle to a generic Geographic Information System (GIS) program but has the advantage of being tailored for recording maritime sites and landscapes. Information can be shown in list or table form like a database but can also be shown on a chart like a drawing program. Similar data is collected together in layers that can be selectively shown or hidden on the chart allowing a variety of views of the information to be produced. The main advantage to using this system is to be able to combine data from a number of different sources and to extract more information through correlating the results. The program is not limited to recording spatial data but can also record temporal events describing when things happened on or in relation to a site.

The integration work was started by adding modern digital chart of the Cattewater area to place the other spatial information in context. The area of interest was limited to the lower reaches of the River Plym between Fishers Nose to the West and the Laira Bridge to the East. The chart was imported into SR4 as vector (line) information onto a number of separate layers including coastline, depth contours, buildings, buoys and navigation channels. A number of early charts of the river were scanned (Collins, 1693) and included as raster images scaled and positioned relative to the modern chart. These charts showed changes in the coastline as well as providing information about the changes in water depth in the river over the years. Difficulties were experienced in geo-referencing some of the earliest charts as the original mapping was poor however useful details could still be extracted.

Geophysical Surveys

The geophysical survey data was added to this basic framework, this is described in detail in Holt (2008). The site itself is difficult to survey as the area of the wreck is a mooring for small boats so contains floating mooring buoys, underwater chains and ground tackle. Interpretation is complicated as the seabed is littered with debris thrown or lost overboard from vessels on moorings or at anchor and may contain unexploded ordnance in the form of bombs dropped during WWII. Because of this a multi-sensor approach was adopted to see what could be obtained from each instrument, this included sub-bottom profiler, sidescan sonar, multibeam sonar and magnetometer. The excavation report showed that the hull should present a target 11m long by 4m wide and 1m in height lying level within the seabed, the main timbers in the surviving structure being made of oak (Redknap, 1997). The sawn outer planking was fastened using a combination of iron nails and treenails so the iron collectively may present a detectable magnetic target. If one or more swivel guns remain on site they may be detected by a magnetometer as an approximately 200kg mass of iron.

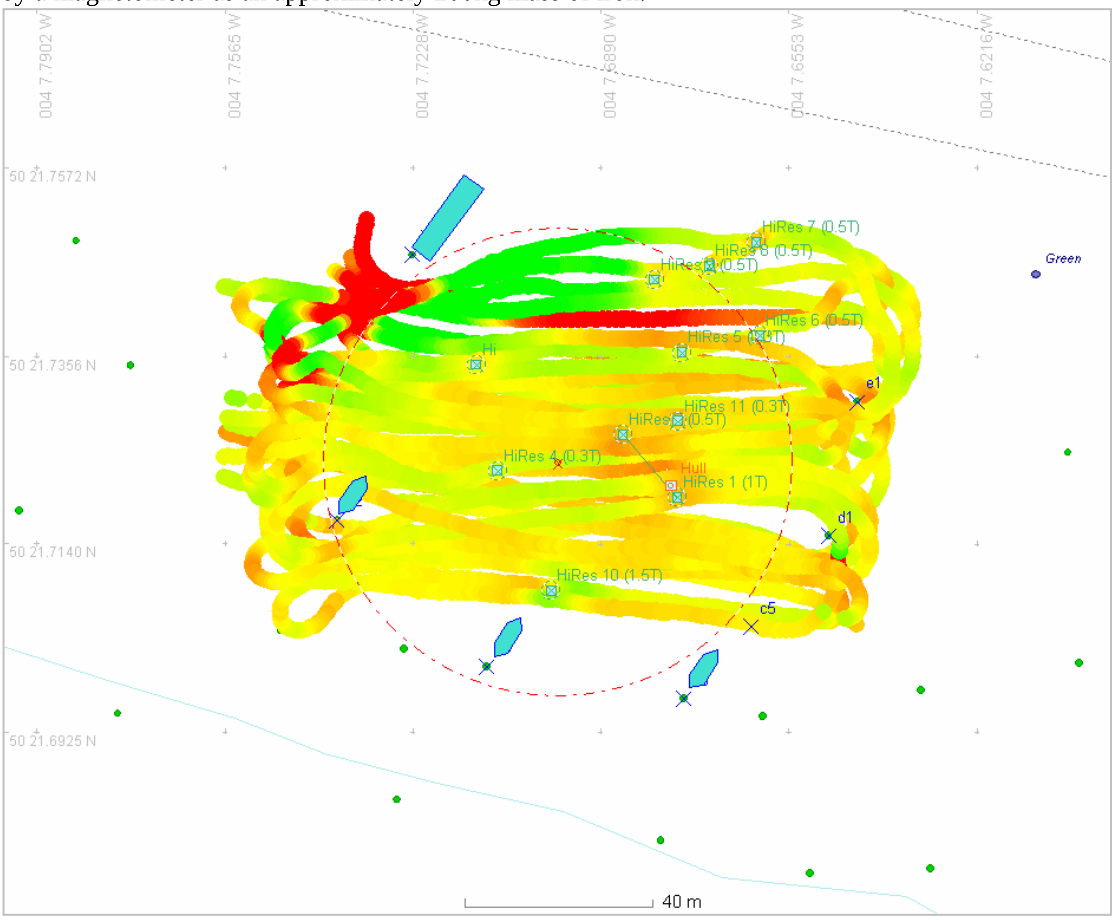

Figure 4: Screenshot from Site Recorder showing magnetometer data (Peter Holt)

Geophysical data had been collected over the site in 1997 (Potten, 1997) but suffered from poor positioning so was of little real value. The opportunity to collect better data came about in September

2006 via project work by Amelie Thebault of the University of Plymouth, submitted in partial fulfilment for an MSc in Hydrography (Thebault 2006). The primary survey work was undertaken in an area to the North of Drake's Island in Plymouth Sound however some data was collected over the Cattewater site.

An Innomar SES-2000 parametric sub-bottom profiler was used for the 2006 survey, this profiler uses the parametric acoustical effect to transmit a low frequency, narrow beam sonar signal into the seabed. The reflected primary signal of 100 kHz is used to determine water depth while the 12 kHz secondary signal is used to penetrate the seafloor. The 3.6 degree beamwidth gives an approximate footprint of 0.5m in the depth of water over the site, vertical resolution is up to 70mm and penetration can be up to 50m depending on the seabed type. East-West lines were run at 20m spacing then many repeated runs were made over the estimated position of the hull timbers. North-South lines were also run but these were 20m to the West of the designated position so were not over the hull remains. The data from this survey was integrated into Site Recorder in a number of ways. The vessel tracks were imported as a series of fix points that would show survey coverage of the site. The sonar records were interpreted by hand to create a list of targets or anomalies that could be imported as a set of Target objects within SR4. As well as recording the position of each anomaly the Target object allows other information to be recorded such as target type, dimensions and a description. Along with each Target we could also link one or more images showing the actual target on the sonar trace, a powerful feature that directly links the interpretation with the original raw data.

In 2007, a two day geophysical survey of the Cattewater Wreck site was completed by Elizabeth Swann from the University of Plymouth as part of an MSc in Hydrography using sidescan sonar and an Overhauser magnetometer (Swann, 2007). The work was done in conjunction with Ashley Gould who was undertaking a Masters in History and Archaeology at the University of Bristol. Survey lines were run over the site using East-West runlines at 5m spacing however this proved difficult as the vessel had to negotiate the mooring buoys that surround the site. The survey produced low quality data so it was decided to re-run the exercise using a different method, the problem of negotiating the mooring buoys whilst towing was overcome by mounting the magnetometer on the bows of a small boat. The GPS antenna was co-located with the magnetometer to minimise position errors and avoid the problems of computing positions from layback. For this task a wooden vessel with a diesel engine was used as the hull would not affect the magnetometer and the diesel engine would affect the magnetometer far less than a petrol engine. The raw magnetometer measurements were a series of magnetic field values at known positions; these were imported into Site Recorder directly as Data Points that could be colour rendered on the chart for interpretation (*Fig 4*). The raw magnetometer measurements were distilled down to a set of Targets, each with an estimate of position and position accuracy along with other descriptive information.

In 2007 the site was surveyed by a team from the Royal Navy Flagship Training at HMS Drake in Plymouth using a Simrad EM3002 multibeam echo sounder (MBES), the resulting image has proved to be the highest quality achieved on this site to date (*Fig 2*). Multibeam bathymetry data was represented in SR4 as a set of isobath contour lines and as a composite image where colour is used to indicate depth. Sidescan sonar mosaics from previous surveys were also added to SR4 as basemap images.

With the many different geophysical datasets incorporated into the archive it was then possible to correlate the targets to see if the targets from one survey corresponded with any others. The geophysical targets are represented in SR4 as a point surrounded by a circular confidence region where the radius of the region is proportional to the position error estimate. The combination of the data sets showed a complex mix of correlations between sets leading to a mix of target groups along with single, uncorrelated or unrepeatable targets. Where target confidence regions overlap or are very close these targets were considered to be detections of the same object on the seabed allowing for position errors. With all of the data available within one archive it was then possible to reprocess datasets to look for smaller targets that may have been missed suggested by targets from other surveys. In this way it was possible to extract the maximum amount of information from the available data and when more data is added the process can be repeated quite easily.

Migrating Legacy Data

Another aspect of the reprocessing work was the recreation of the Cattewater wreck within SR4. As the Cattewater wreck had been partially excavated and fully published there was much information available about the site itself that could be used. The primary source was Redknap (1984) but other sources included earlier site plans and detail that was missing from the 1984 report that could be readily included (Carpenter et al., 1974; Bax 1977, Mortlock& Redknap, 1978). The 1984 site plan was scanned, added to SR4 as a raster image on the chart then digitised using tools within SR4 as a vector drawing, the resulting monochrome drawing was then coloured to aid interpretation separated onto a number of layers to allow different views of the plan to be created (*Fig 5*). The position of the hull was taken from the published position used to define the area of designation and converted from OSGB to WGS84 datum. The initial orientation of the hull was taken from the 1984 site plan. Earlier site plans were similarly scanned, imported, digitised and recoloured. With all of the plans incorporated into the archive we could create a single amalgamated view of all of the plans and hence a more comprehensive plan of the site.

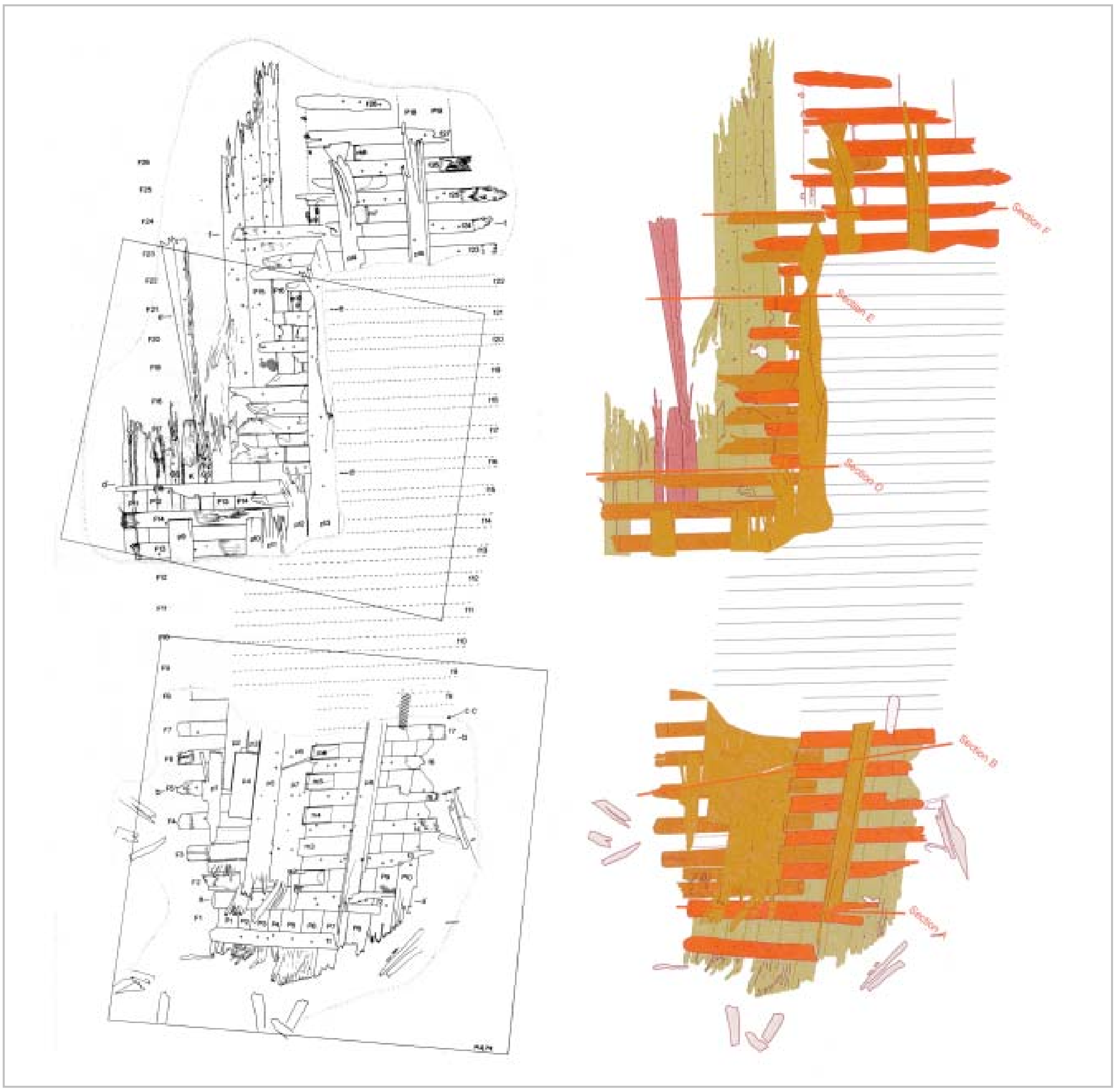

Figure 5: Comparison of hull drawing from 1984 report (left) and digitised version (right) (Peter Holt)

Inspection of the geophysical targets showed a series of sub-bottom and magnetometer targets to the East of the published position of the site, and no targets at that position, so the conclusion was that the original position was in error and the hull lay 20m to the East. The line of targets also suggested that the orientation of the site was incorrect so this was also altered. Significantly, this also realigned the original seabed grid laid down on the site in 1977 (Bax, 1976 p7) back to a North-South alignment, also suggesting that the new alignment of the site was correct (Dean, 2007 pers. comm.).

It was also possible to import information about the finds and samples recovered in 1973 to Site Recorder as Artefact and Sample objects. These objects can be shown either as simple point objects on the site plan or as detailed plan drawings of each artefact in situ. Artefact objects can also be used to record a comprehensive set of information about each find that can be displayed as a simple finds record. Drawings of each find in published reports were scanned then linked to the relevant Artefact object along with any available photographs. Clicking on an Artefact on the chart or in a list brings up the linked photograph in the finds record or in a preview window within the SR4 program; so finds location, plan drawing, records, photographs and publication drawings are all linked together. Finds from later years will also be imported when a reanalysis of the finds has been completed.

There have been many recorded shipwrecks in the Cattewater so the archive also includes records of each as a Wreck object in the GIS with information taken primarily from Larn (1995). Where the position of the wreck is given in the account the wreck can be shown on the chart, this helps build up a picture of the areas of highest potential for finding any remaining cultural material.

The Cattewater site has a long history and has been visited and investigated many times since being found in 1973. Each of the visits has created information of one sort or another so it was useful to record all of these as Events within the digital archive. Data from each of these events has been cross-referenced with the event itself so we can readily identify data sources and see where information is potentially missing. Documents relating to the site have also been added as Source objects and the documents themselves linked in if they are available in electronic form. Still remaining to be added are dive logs and logbooks from the excavation fieldwork.

The migration of the Cattewater wreck archive to digital form has enabled the electronic publication of the entire primary dataset, as originally completed for the *Mary Rose* (1545) site in 2007. The entire archive is available on CD and includes all of the spatial information, full resolution images along with any linked documents. A smaller version with the same data but low resolution images is available for download from the Web from http://www.3hconsulting.com/SitesCattewater.htm.

Conclusions

The process of integration of the diverse data sets from the Cattewater wreck in a single digital archive has been more successful that was originally expected, primarily because of the richness of the original documentary archive. Migrating paper-based archives to digital form for publication gives additional life to what is often seen as the rather ‘dead’ product of previous work, and publication should be the reason for the work in the first place.

Not only has the comparison of datasets extracted more information about the site itself, it has also helped in the understanding of the migration process and what will be required when reprocessing data from other projects in the future. The Site Recorder program was adapted and improved during this project so that it could be used to collate and render the data in a useful way. Much has been learned during this exercise that can be used by other projects, much of which has been embodied within the program itself.

The results from the geophysical survey work undertaken on the site of the Cattewater wreck between 1997 and 2007 form an unusual and perhaps unique body of work. There are few maritime archaeological sites that have been investigated by such a complete range of instruments as magnetometer, sidescan sonar, multibeam echo sounder and sub-bottom profiler while fewer still can claim to have been investigated by these instruments more than once. By collating and integrating the results from the surveys we have a better understanding of the site itself and the seabed in which it lies. Previously undiscovered targets buried within the seabed detected during the survey work may be the remains of similar vessels or parts of this same ship. There is still much to learn so only further investigation will help answer that question.

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