RAPID ARCHAEOLOGICAL SITE SURVEYING AND EVALUATION

Richard Bates, Mark Lawrence, Martin Dean, Phil Robertson (University of St Andrews), Louis Atallah (Imperial College)

EXECUTIVE SUMMARY

The RASSE project was undertaken by the University of St Andrews with partners as part of the three year research project funded by Round 2 of the Marine Aggregates Levy Sustainability Fund (MALSF) administered by English Heritage (EH). The principal aim of the project was to test and develop rapid, quantitative, remote (geophysical) sensing techniques for the enhanced investigation of maritime archaeological sites in sensitive aggregate extraction areas. Furthermore, the project attempted to improve temporal and environmental assessment methods for sites and areas of key archaeological significance. The project addressed issues of direct relevance to the aggregate industry, to archaeological curators, and to academia. The work complemented Round 1 ALSF funded projects administered by EH and Round 2 projects by Wessex Archaeology; and the University of Southampton.

The project involved analysis of historical data sets, and the construction of a test site in Plymouth Sound to enable development of protocols to maximise the potential of geophysical techniques in monitoring marine archaeological sites. Following this background work, methodologies for the enhanced use of multibeam sonar with a spar-buoy, deep-tow arrangement were tested. The resulting increased spatial resolution obtained for data over wreck sites, together with enhanced rendition of the geophysical data, provides both a new level of investigation and also a new forum for visualisation of submerged archaeology. Both of these achievements are of immediate relevance to the offshore aggregate industry and the archaeological community as they will not only allow better site investigation practice together with quantitative site monitoring but they will also allow far wider dissemination of site information to the general public.

BACKGROUND

In recent years, the successful application of investigation technologies currently used in other marine survey industries has aided better understanding of complex environmental parameters that influence submerged cultural material lying on or buried just beneath the seabed surface. Case studies on specific technologies include ultra high resolution, full coverage 3D bathymetry (Dean & Frazer, 2004), single beam acoustic classification using acoustic ground discrimination sonar AGDS (Lawrence and Bates, 2002), classified sidescan seafloor object recognition (Quinn et al, 2005) and acoustic based sediment identification (Bates and Moore, 2002). The distribution of sediment types determined from sidescan sonar images has been recognised as having important archaeological implications (Duck, 1995). The effect on the acoustic response of the seabed (altered backscatter levels) from buried archaeological material has also been recognised (Fish and Carr, 2001). The field of marine acoustics is one of rapidly advancing technology and it was a major goal of the project to take best advantage of this in both the hardware and software developments.

ENHANCED PROCESSING AND IMAGING METHODOLOGIES

Object detection and manual processing in sonar imaging can represent a considerable challenge because sidescan images vary in terms of intensity, scale and rotation, and are generally blurred with noise. Image ‘de-noising’ is therefore necessary to remove the added noise while retaining as much as possible the important image features. Existing datasets from Belfast Lough were initially selected for use in testing advanced algorithms for automated data processing including scale saliency matching and scale-invariant feature transform techniques (Atallah et al., 2005). Seafloor classification methods tested including Questar Tangent, Sideview. The automated routines all proved to have some utility in identifying anomalous areas but each technique still suffered from problems with noise contamination. Further testing on larger data sets is recommended for an evaluation of their full potential.

Through collaboration with Dundee University, new visualisation methods were tested on the data from the Stirling Castle and neighbouring wrecks. The basis of these methods has its roots in digital cinematography and the enhanced visualisations proved extremely beneficial to final data presentation. Furthermore, the output video can be easily viewed through a web-based front and it is therefore anticipated that it will be important in future information dissemination. Visualisations can be down loaded from the project web pages and example screen shots are given in figure 1.

PLYMOUTH TEST SITE
In order to test the limits of different geophysical acoustic survey methods and to provide data for the development of automatic object recognition techniques an artificial test site was constructed in Plymouth outer harbour area in 2005. The site contained objects that can be found on maritime archaeological sites together with other easily identifiable target shapes. Following deployment the site was surveyed with multibeam sonar, sidescan sonar, swath bathymetry and acoustic ground discrimination systems. The results showed not only the potential of the geophysical techniques but also highlighted a number of important procedural lessons for ensuring high quality data of a type that is most useful for archaeological evaluation. Figure 2a and 2b show the multibeam data and sidescan sonar image of the objects on the seafloor.

It was found that the combination of ultra high resolution acoustic data types allows rapid and accurate modelling of exposed archaeological material on the seabed. Important lessons were learned from this investigation, in particular with the advanced use of the Reson 8125 multibeam sonar. With this instrument the advantages of reducing survey height above objects was clearly demonstrated. Following this investigation a series of recommendations were formulated for the use of acoustic techniques in order to obtain the best results

STIRLING CASTLE
Subsequent to the test site programme, the methodologies were deployed on a well known wreck site on the Goodwin Sands – the *Stirling Castle*. The *Stirling Castle*, lost in the Great Gale of 1703, is located on the Goodwin Sands, a series of banks off the East Kent coast that dry at low water and change shape on a periodic basis. Previous acoustic data collected over the site includes sidescan sonar and a high resolution multibeam data set collected in 2002 using a Reson 8125 sonar. Two further data sets were collected over the site in 2005 and two in 2006. Based on a comparison between the data sets it is possible to attribute changes in elevation of the surrounding seabed level to real effects, *i.e*., the movement of sediment surrounding the site. It is also possible to monitor changes (deterioration) within the wreck site resulting from the wreck exposure.

The datasets suggest that between 2002 and 2005 several metres of sediment have accreted in places around the stern and to the north east of the wreck with a loss of sediment to the south (figure 3). This is most likely due to the ongoing collapse of hull structure at the stern port quarter of the wreck presenting less of an obstruction to the dominant north-easterly tidal flow and thereby diminishing scouring at the stern. Between 2005-2006 however relatively little change is apparent at the *Stirling Castle*. Conversely there was significant change at the ‘bowsprit’ wreck site located 700m to the south-west of the *Stirling Castle* during the period 2005-2006. It is clear that in addition to the larger scale changes in sediment regimes on the Goodwins which were responsible for the exposure of the wreck in the first instance, subsequent localised, site specific sediment movements are evident. The data evaluated for the wide area shows spatially different change on the site but the periodicity of change is still unclear. Environmental data for the site suggest the cause of changes over the time periods studied to be due to changes in current, wind and wave action. Despite the extensive use of multibeam on this site, understanding the true timescale of change would involve not only geophysical techniques but also the use of insitu instrumentation on the site for continuous recording of environmental parameters.

In 2006 a new method of multibeam sonar deployment was built that allowed the acoustic head to be lowered closer to the target. The independent sonar head attitude and positioning system

(ISHAP) provided an increase in the fidelity of the data thus giving far higher resolution images (figure 4). From the results of trials of this technique it is proposed that a method of routinely achieving a closer inspection of a survey site in the future would be a major advance for rapid marine archaeological survey and site management. Investigation of such methods including remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) is recommended for the future.

CONCLUSIONS

The RASSE project has demonstrated that acoustic techniques can be used to investigate and monitor marine archaeological sites with the resolution necessary to quantitatively evaluate small changes on a site that ultimately could lead to site deterioration. In the future these techniques should form a routine aspect of wide-area investigation and detailed archaeological site investigation in order that the potential impact of anthropogenic activity such as aggregate extraction and natural cycles of change can be assessed more effectively. Furthermore, advances in acoustic processing techniques demonstrated the potential to provide new insights into the acoustic data that could offer not only enhanced discrimination of archaeological material but also offer significantly increased site investigation efficiency. In the future, these new techniques will provide crucial information for the long-term management of the submerged archaeological resource in UK coastal waters where there is increasing pressure from aggregate extraction as well as other commercial and recreational activities.

REFERENCES

Atallah,L., Shang,C., and Bates, C.R., 2005. Object Detection at different resolution in archaeological sidescan sonar images. Proceedings of Oceans '05 Brest, France

Bates, R., Dean,M., Lawrence, M., Robertson, P., Tempera, F., 2004. Innovative approaches to rapid archaeological site surveying and evaluation Unpublished project design 3837 submitted to English Heritage

Dean, M. & Frazer, J. 2004. The application of high resolution multibeam sonar to the investigation of archaeological sites underwater. The Application of Recent Advances in Underwater Detection and Survey Techniques to Underwater Archaeology. Bodrum

Duck, R.W.,1995. Science and Site: Evaluation and Conservation, edited by J. Beavis and K.Barker(1995). Bournemouth University School of Conservation Sciences, Occasional Paper 1, 109-124

Fish, J. P. and Carr, H. A. 2001. Sound Reflections: Advance Applications of Side Scan Sonar. Lower Cape Publishing, Orleans, MA.

Quinn R., Dean, M., Lawrence, M., Liscoe,S., and Bolan,D., 2005. Backscatter responses and resolution considerations in archaeological side-scan sonar surveys: a control experiment. Journal of Archaeological Science 32 pp. 1252-1264

Title:	MALSF, 3837 MAIN. Innovative approaches to Rapid Archaeological Site Surveying and Evaluation
Contractor:	University of St Andrews
Contact:	Richard Bates. Tel 0334 463997 E-mail: crb@st-and.ac.uk
Full Report Site:	http://www.st-andrews.ac.uk/rasse/

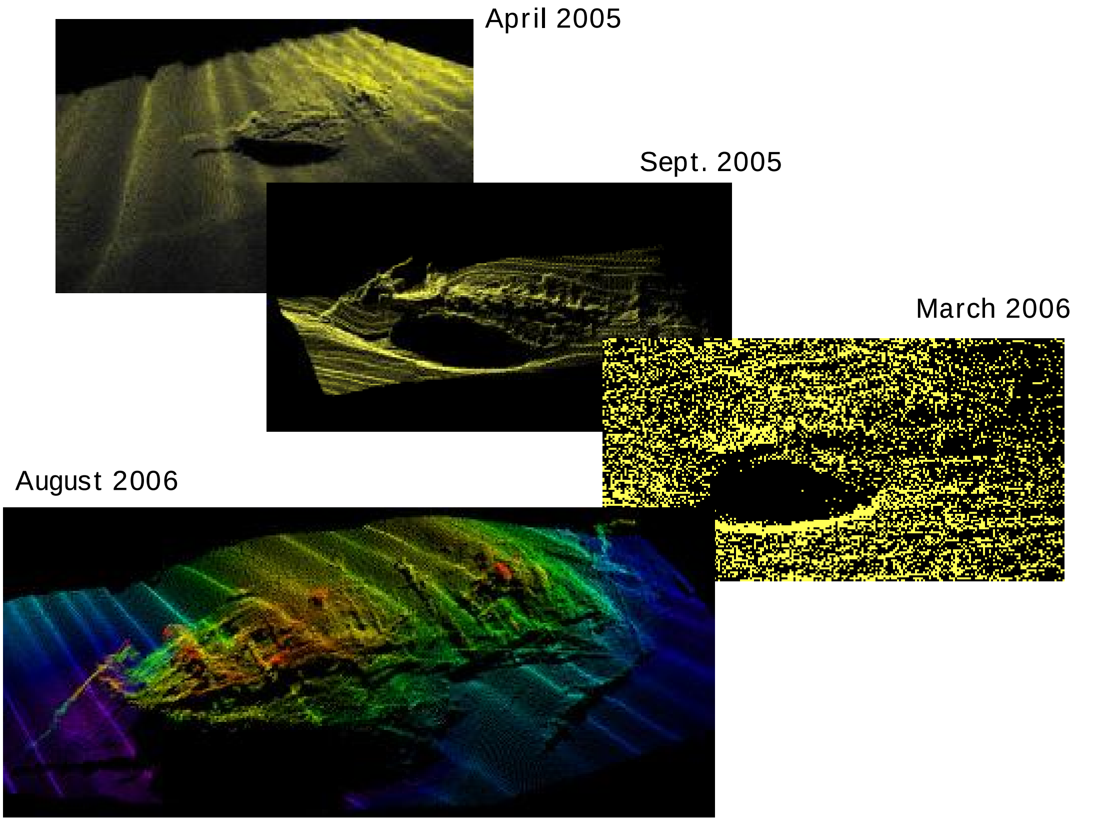

Figure 1 – three point cloud views of the Bow Sprit wreck site taken from the 3D visualisations of the site: note the fallen bow sprit which occurred between April and September 2005

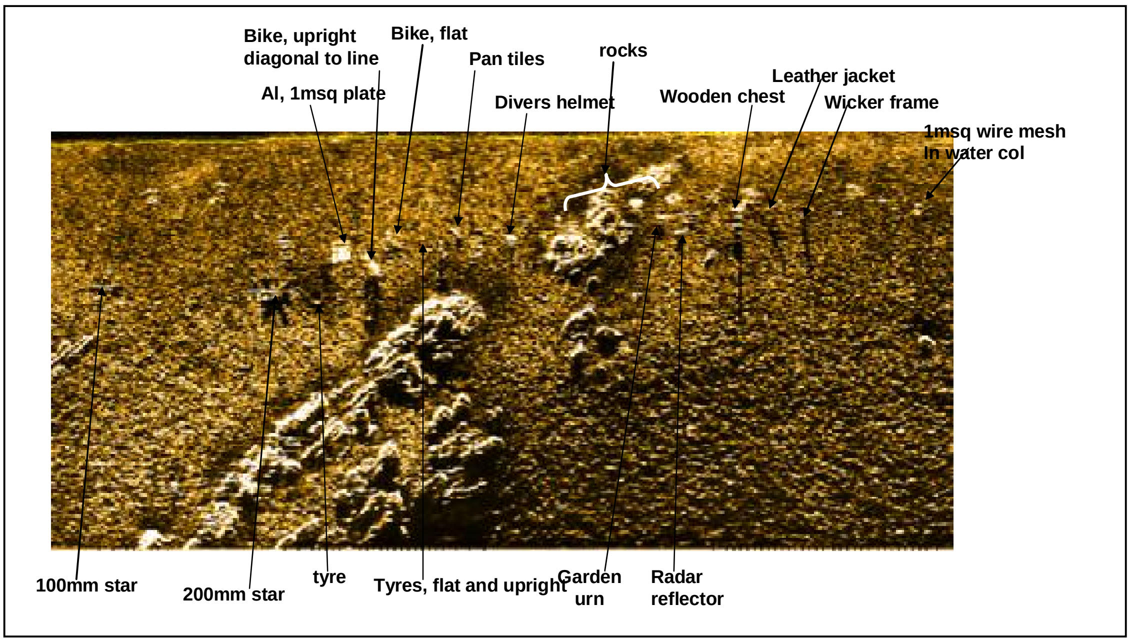

Figure 2a – Klein 3000 sidescan sonar image of the Plymouth test site

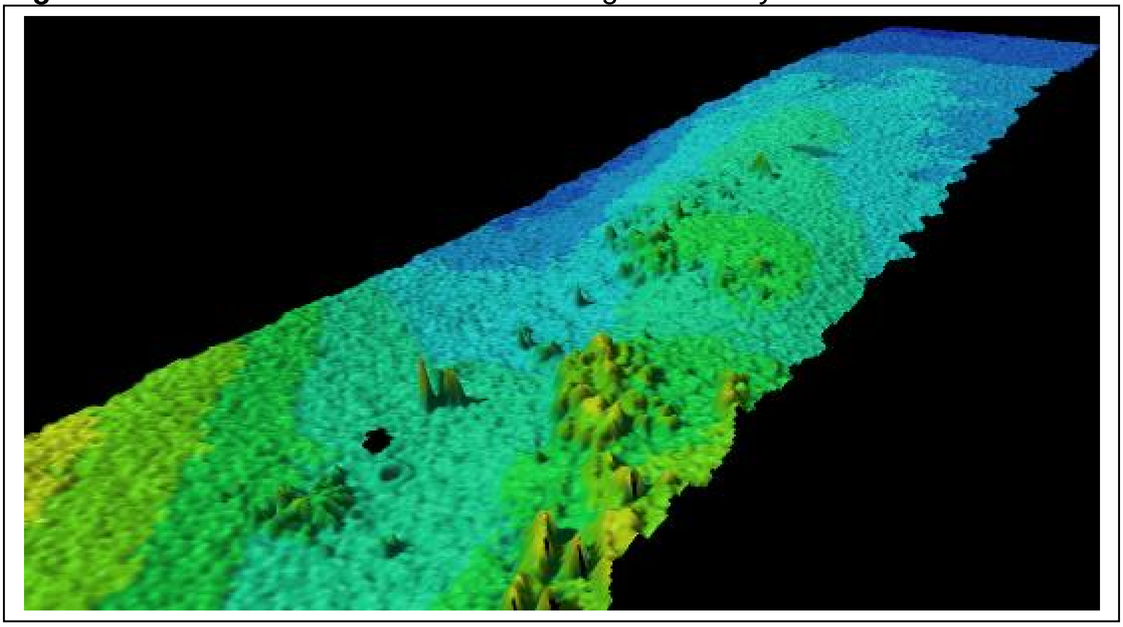

Figure 2b – Reson 8125 image of the Plymouth test site

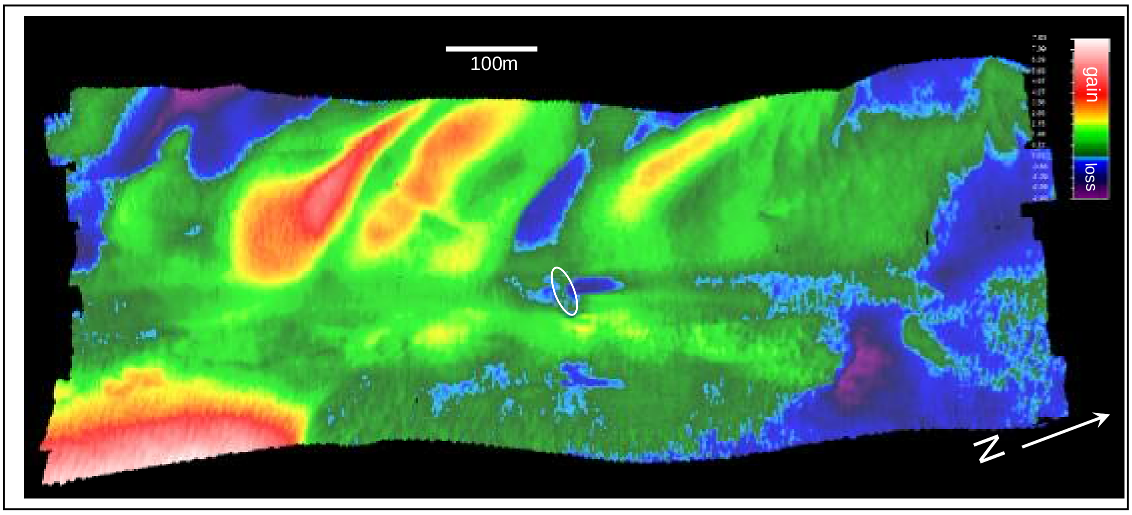

Figure 3 – *Stirling Castle* – Area Difference Map August 2006 Subtract July 2002

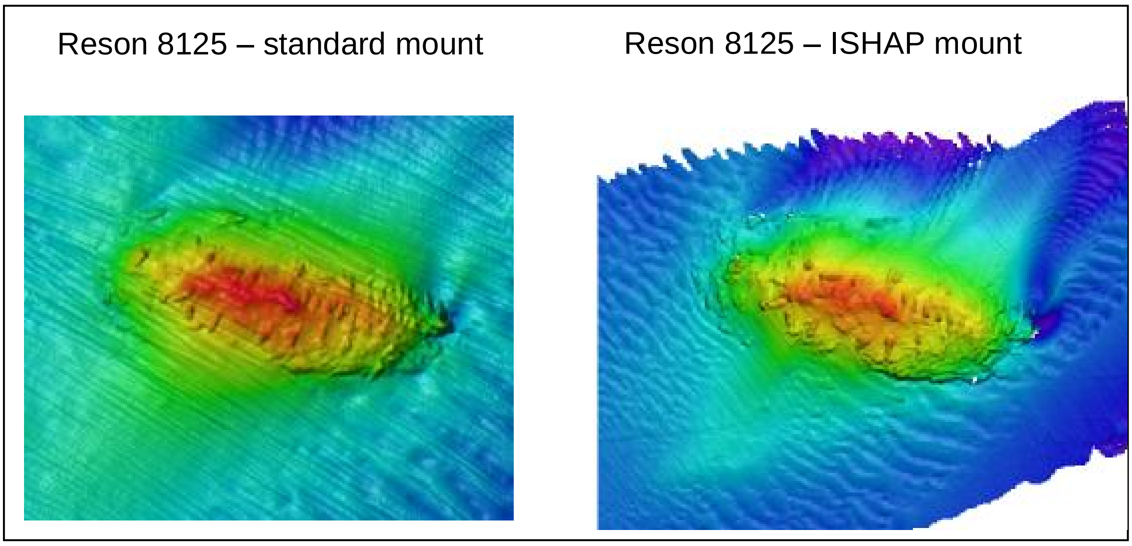

Figure 4 – difference of ISHAP sonar deployment to standard sonar deployment