Plymouth Maritime Archaeological Interest Group

Recent Developments in Acoustic Techniques used in Marine Archaeology

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1. Introduction

Underwater acoustic positioning systems have been used for marine archaeological projects in the past with varying degrees of success. Despite this previous work there is still a need for an underwater mapping system which is accurate, efficient yet affordable.

The Plymouth Maritime Archaeological Interest Group (PMARIG) is currently evaluating a number of new underwater acoustic positioning systems. The group is working with Sonardyne Ltd in the UK, using a range of systems suitable for marine archaeology.

PMARIG is a group of amateurs with an interest in marine archaeology in Plymouth. The three main aims of the group are :

1. To train divers using the Nautical Archaeology Society scheme.
2. To locate and survey archaeological remains within Plymouth Sound
3. To assist in the development of tools and technology for marine archaeology.

This paper briefly describes the positioning systems that are currently being evaluated by the PMARIG team.

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2. Positioning Problems

Recording the positions of artefacts and structures is a significant part of any underwater archaeological project. The positioning process involves surveying rather than archaeology but the work tends to be done by archaeologists rather than by surveyors. Any new positioning system must be usable by non-surveyors while still achieving the highest degree of accuracy.

The standard tool for underwater archaeological surveying work is still the cheap and simple tape measure. Underwater survey techniques using tape measures tend to be slow, diver intensive and require well trained divers for the best results. An acoustic system which can be used alongside tape measures must have the advantage of speed and efficiency. One of the aims of a new system would be to minimise the time a diver spends on the seabed.

Accurate tape surveys can only be done successfully in small areas where there is little water movement and some visibility. Acoustic positioning systems should allow a more rapid collection of measurements in deep water, high current or low visibility-conditions over wide areas.

The most obvious drawbacks with acoustic systems are their complexity, cost and availability. Fortunately, these factors are being addressed during the development of new systems.

3. Trials Location

The PMARIG team has access to the Breakwater Fort in Plymouth as a base for trials and training. The Fort is situated to the north of the Breakwater in the middle of Plymouth Sound, Devon, UK. The site provides a sheltered environment with water depths from 10m to 15m over a soft mud or gravel seabed. Underwater visibility varies between 0 and 5m.

The Fort is used by the Fort Bovisand Underwater Centre for commercial diver training so a surface supplied air diving system has been fitted. Dry working areas, classrooms and easy access to the sea all serve to make this site more suitable for underwater survey trials.

The seabed around the Fort contains a wide variety of structures used for diver training. Structures such as the pilot cutter 'Tavy' have been added recently with the aim of creating an artificial but realistic archaeological site. The structures can be mapped many times by many divers without the risk of them being damaged.

4. Acoustic Positioning

There is one underlying principle behind all of the acoustic positioning systems being evaluated by the PMARIG team. They all use pulses of high frequency sound to measure distances between reference beacons on fixed datum points and a unit on a diver or ROV.

The most simple system measures distance and direction to one or more beacons while the most complex system computes the position of the diver in three dimensions.

Like a tape measure, there must be a clear line of sight between a diver held unit and any acoustic beacons being used. Unlike a tape measure, distances of over 500m can be measured with close to the same accuracy as distances under 10m.

Distances are measured by measuring the time taken for a sound pulse to travel from the diver unit, to the beacon and then back again. The time taken is dependent on the speed of sound in water which varies considerably with changes in temperature or salinity, hence all acoustic systems require the speed of sound to be measured.

5. The Homer Locators

One of the first applications of acoustic systems in marine archaeology was the use of the Sonardyne Rangemeter on the Mary Rose project in 1976. The Rangemeter has now evolved into the most simple units that were tested by PMARIG, the Homer locators.

The Homer-Pro is a diver held ‘gun’ which can be used to measure the distance between itself and one of a selection of marker beacons. Unlike the original Rangemeter, the Homer also indicates the direction of the beacon from the diver. The distance and direction information is shown to the diver on a display on the back of the unit.

The Homer Pro was designed to locate acoustic beacons marking objects underwater but can also be used as a distance measuring tool.

Like tape measurements, distance measurements made using the Homer can be fed into an adjustment program such as Web For Windows or Sonardyne’s own TAPS system and be used to position structures and artefacts. The trials of this technique on the Breakwater Fort site have been very successful.

ROV Homer is similar to a Homer Pro except that it can be mounted on an ROV. The distance and direction information is shown to the ROV pilot on a surface display unit. This system will be used by the team to guide ROVs to deep water sites in the main shipping channel within Plymouth Sound. The ROV will be deployed from a vessel moored outside of the shipping channel and flown under the channel to a beacon marking the site. This allows the site to be investigated whilst leaving the shipping channel clear.

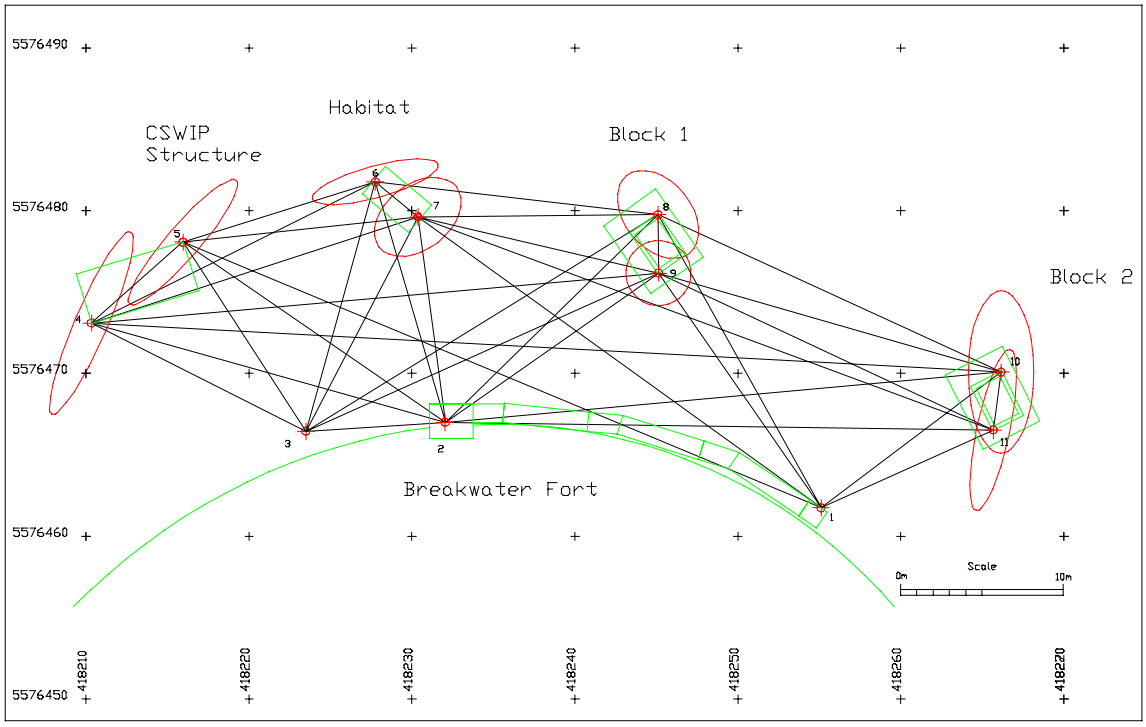

Fig. 1 : Homer Pro Baseline Survey of the Breakwater Fort Structures

6. The DiveTrak System

One off-shoot of the technology developed to track divers on ship inspection tasks has been available for use by the PMARIG team. The DiveTrak mapping system has been evolved from a system supplied to the US Navy and Oceaneering International used for mapping ship's hulls.

The system uses conventional Long BaseLine (LBL) methods to compute the position of a diver or ROV in three dimensions. Instead of measuring to a single beacon, the DiveTrak system measures the distance from a unit on the diver to up to ten beacons simultaneously. The distance measurements are passed up a cable to a PC based processing system on the surface where they are used to compute the position of the diver.
Between four and ten reference beacons are deployed around the survey area. Once in position the relative locations of the reference beacon units are calculated using an automatic calibration routine built into the system software.

If absolute positions are required then the array of beacons can be positioned with the aid of a surface positioning system such as Differential GPS.

The diver wears a small, lightweight unit on his back and a wrist mounted sensor. When underwater, all the diver has to do is to place the acoustic sensor on to the artefact to be located and the surface system then records the position. Positions are computed twice per second in three dimensions using up to twelve measurements each fix. The computed positions and the raw measurements are continuously recorded by the system so that the results can be reprocessed later.

As the diver is connected to the surface with a cable then hard wired communications and a surface supply system can be used.

The prototype DiveTrak system has been used on the Teignmouth wreck site and more recently on the Breakwater Fort site.

7. The ADAN System

The DiveTrak system provides the positions of artefacts quickly and accurately but is limited in some operations by being connected to a surface system. The ADAN system works in the same way as DiveTrak except that it is not connected to the surface by a cable.

ADAN does the same position computation as the DiveTrak surface system but in a self-contained unit mounted on the divers back. A display unit shows position and guidance information to the diver and allows the diver to control the system.

The ADAN prototype has been tested by the PMARIG team within Plymouth Sound but has yet to be used on a working survey.

The ADAN system is of most use when searching an area of seabed. The system can guide the diver to waypoints and steer him along lines between waypoints. With this guidance information the diver can search the seabed efficiently and completely. The track of the diver is recorded by the ADAN system and can be uploaded to a surface computer after the dive.

As the ADAN system is not connected to the surface it is used with SCUBA equipment and through water communications.

8. Conclusions

PMARIG borrows oil and defence industry equipment from a number of companies and uses it for marine archaeological surveys. It is hoped that the opportunity to test and evaluate new systems will encourage greater involvement between companies and other archaeological groups..

Acoustic positioning systems have a reputation amongst marine archaeologists for being expensive, complex and unavailable.
This situation is largely true and will remain that way until technology improves and the requirements of these systems are clearly defined.

It is hoped that the work of the PMARIG team will assist in the development of tools that are suitable for the task, by helping to define the problems and then offering solutions.

The group has done over thirty trials using four different positioning systems and it is hoped that the results of these trials will soon be published. Much has been learned about positioning underwater and acoustic survey techniques and this information will be made available to anyone working on an underwater archaeological site.

The Homer Pro and ROV Homer systems are now in use by a number of companies. This system can be successfully used as an ‘acoustic tape measure’ with minimal training.

The cable connected DiveTrak system is still a surveyors tool as it is not easy to set up. However, once up and running the system is easy to use. A new version running under Microsoft Windows is planned for late 1996, this version will be much easier to set up.

ADAN will also benefit from the new generation of PC applications making it easier to use as well.

9. Acknowledgements

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