EIMR2014-928

Improved Arrays for Towed Hydrophone Surveys of Small Cetaceans at Offshore Marine Energy Sites

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ABSTRACT
Planned developments of marine renewables in areas which are important habitats for small cetaceans is providing an increased requirement for quantitative surveys in areas which are often physically challenging to work in. Towed passive acoustic surveys can be a cost effective method of providing abundance estimates over extended areas. There are some short comings with existing methods, especially in reliably measuring range from a track line for distance sampling analysis. We built, tested and compared the performance of three different arrays. All provided measures of range to sound sources that would be useful in Distance analysis. A long baseline planar array provided the lowest % error for target motion analysis (11%) and using newly developed code it was possible to calculate "instantaneous" locations for short vocalisation bursts using data from this array. An array with a tetrahedral configuration of hydrophones within an acoustically transparent "torpedo" housing showed promise as it provided unambiguous 3D bearings while being easy to deploy and retrieve at sea. We are encouraged by these early results and suggest some obvious next steps to achieve further improvements.

INTRODUCTION

The sites of many offshore marine renewable developments are the natural habitat of a variety of cetaceans. Environmental impact assessments at these sites usually require surveys to be undertaken. The very factors that make them attractive for energy generation, waves and strong currents, also make them challenging sites in which to conduct surveys. For example the disturbed waters and high sea state severely reduce visual detection efficiency. Towed hydrophone acoustic surveys are increasingly being accepted as a practical way of providing cost-effective density estimates for small cetaceans over extensive areas. Being robust to weather and light conditions acoustic surveys can be particularly helpful at marine renewables sites[1]. Data collection and analysis are now highly automated and hence data collected at different location and times is generally consistent[2]. Further, when collected alongside visual data from mammal or bird observers, it has proven possible to use mark recapture techniques to estimate g(0) for both visual and acoustic detection, allowing absolute abundance to calculated [3]. To provide data that can be analysed using standard Distance based techniques it is essential that the distance from the track line to detections is determined.

Traditionally this is achieved with stereo arrays by using target motion analysis [4]. However, this method has some shortcomings,

- Locations are ambiguous, it is often not clear if they lie to the left or right of the track line.
- Calculated bearings are slant angles rather than horizontal angles
- TMA relies on the assumption that the animals don't move over the several

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minutes or so that it can take to make sufficient detections to localise the animal.

An additional problem in tidal waters is that the hydrophone and the boat towing it will be affected independently by turbulence and tidal eddies and the hydrophone array is unlikely to follow the boat predictably as assumed. Although software and analysis capabilities for PAM have improved enormously over recent years, thanks to cheaper more powerful computing hardware and programs such as PAMGUARD [2] towed hydrophone designs have advanced little if at all.

To address these issues and develop a methodology better suited to surveying in energetic offshore waters we have been exploring improved towed hydrophone equipment and methods, including the use of long baseline arrays that should allow instantaneous accurate localisation of vocalising animals.

METHODOLOGY

Three towed hydrophone arrays were built and tested: a simple stereo array (ST), a long baseline planar array (LBP) and a tetrahedral configuration within an acoustically transparent streamlined "torpedo" (TT). Orientation loggers (OpenTags, Loggerhead Instruments) were fixed to arrays to provide data on hydrophone depths and orientation every 0.01sec. A series of trials simulating towed array survey scenarios were carried out. During these, each array was repeatedly towed past a sound source emitting porpoise-like click trains at a range of closest approach distances from 20 to 300m.

Sequences of bearings calculated from each array were analysed using target motion analysis (TMA) and the differences in ranges between the calculated and actual location of the sound source were compared. In addition, new routines were written within the PAMGUARD software suite to allow the location of the porpoise sound source based on the "instantaneous" (IN) analysis of a half second burst of clicks received at elements in the LBP array.

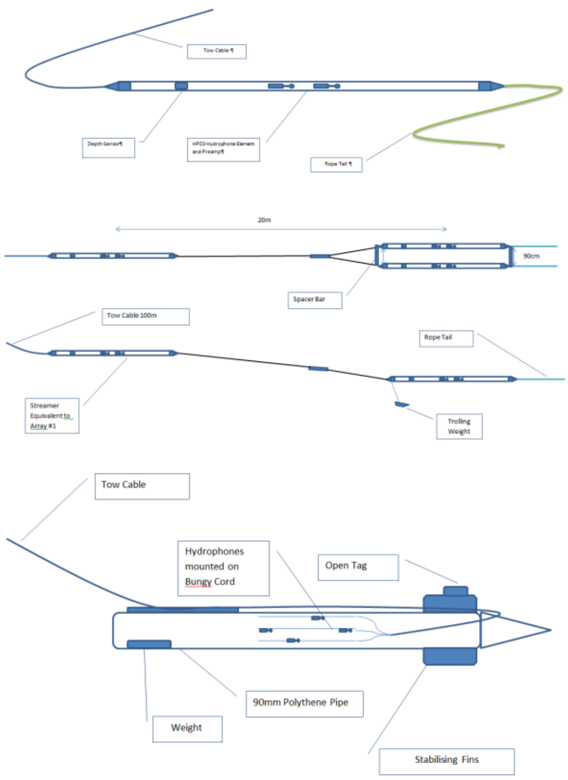

Figure 1 Three hydrophone arrays tested in this trial. a simple stereo array (ST), a long baseline planar (LBP) and a tetrahedral torpedo (TT) array

Real porpoises were also located using all three array types, although, as the actual location of these animals were not known, the trails provided no additional information on locational accuracy.

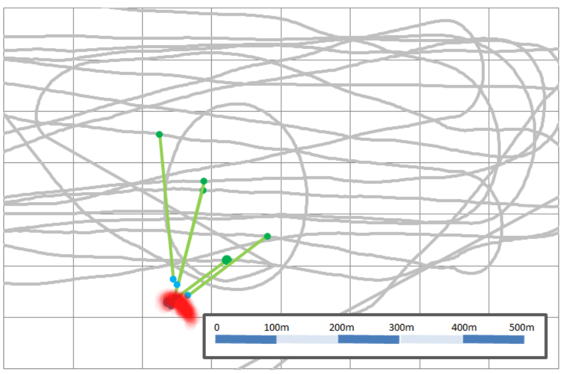

Figure 2. Map showing target motion analysis trial using towed LBP array: red cloud shows the location of the sound source during the trail, grey lines are the ship's tracks, green dots are the location of the hydrophone when the source first detected and blue dots are the calculated source location.

OBSERVATIONS

All four combinations of analysis method and array type provided locations with a level of accuracy that could be used for distance analysis. Mean % errors are shown in Table 1. TMA analysis using the more sophisticated arrays provided the lowest errors. The TT array was easy to deploy, gave unambiguous 3D bearings and provided better TMA accuracy than the ST array. The instantaneous analysis of the LBV array also provided a useful level of accuracy while relying on fewer assumptions. In particular it was not necessary to assume that animals were stationary. In this case we can expect these % errors to be the same as those achievable with real porpoises during surveys.

Table 1. Percent Error in Range for Trials with Different Analysis TM= Target Motion, IN Instantaneous and Array Types ST= Stereo, TT =tetrahedral torpedo, LBV = long baseline volumetric

Method Array	TMA ST	TMA TT	TMA LBP	IN LBP
Mean % Error	17.1	12.6	10.9	24.1

CONCLUSIONS

Target Motion Analysis of data from the more sophisticated arrays provided the most accurate locations but to achieve this in real world surveys animals would have to remain stationary and continue to vocalise throughout encounters. These are unrealistic assumptions. The instantaneous analysis of data from the LBP provided useful accuracy which is a fair indication of what is likely to result during real encounters with small cetaceans. This method should also be more robust to the effects of tidal turbulence. It is likely that the performance of the LBP array could be improved through extending its baseline by increasing the spacing between the forward and rear sub-arrays. The TT array was very easy to deploy and retrieve and provided unambiguous 3D bearings. A promising future development would be to make a long base line array with a forward stereo pair and a rear TT sub-array.

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