Improved Towed Hydrophone Arrays

For Small Cetacean Surveys at Marine Energy Conversion Sites

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Introduction:

Towed Hydrophone Surveys (THS) are increasingly being accepted as an efficient and cost effective method for surveying small cetaceans. They can be especially appropriate for offshore marine energy conversion sites where high sea states often seriously degrade sighting conditions.

They Have Some Generic Advantages

They are robust to the effects of weather, sea state and sighing conditions on detection probability
Can continue at night and in fog
Are highly automated

- Allowing use of minimal field teams
- Providing more consistent data
- Localisation and range measurements
- Analysis software is free and continually improving

Can provide a measure of g(0), in conjunction with visual data

- Allowing absolute densities to be calculated

THS can provide absoulute density estimates over broad areas with a design based coverage

But Also Some Shortcomings

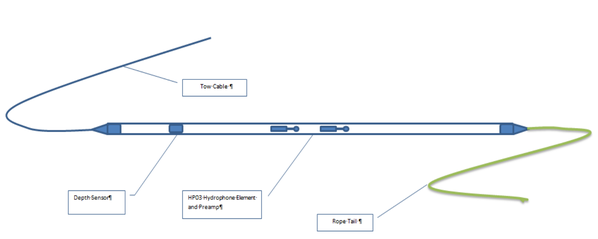
Additional equipment is required.
Noisy vessels compromise performance
Distance from trackline (essential for Distance-based line transect analysis) is usually provided by target motion analysis (TMA) which assumes animals vocalise consistently and remain stationary during encounters
Accuracy of TMA has not been measured

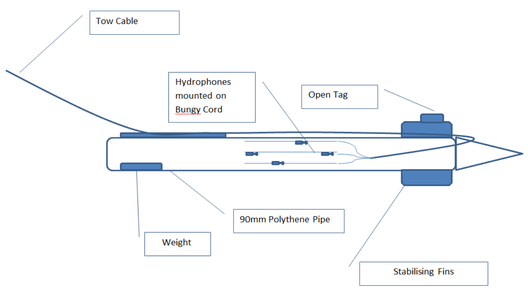
Although acoustic analysis software for cetacean towed hydrophone surveys (e.g. PAMGUARD) has improved significantly over the last decade (thanks largely to support from the oil and renewables industries and Scottish Government) towed hydrophone hardware has hardly developed at all.

Our Aims in this Project Were:

- To measure how accurately a porpoise sound source could be localised using both “traditional” stereo towed hydrophones and two new hydrophone array configurations.
- Develop an “instantaneous” localisation method allowing animals to be localised from short vocalisations detected on a long baseline array

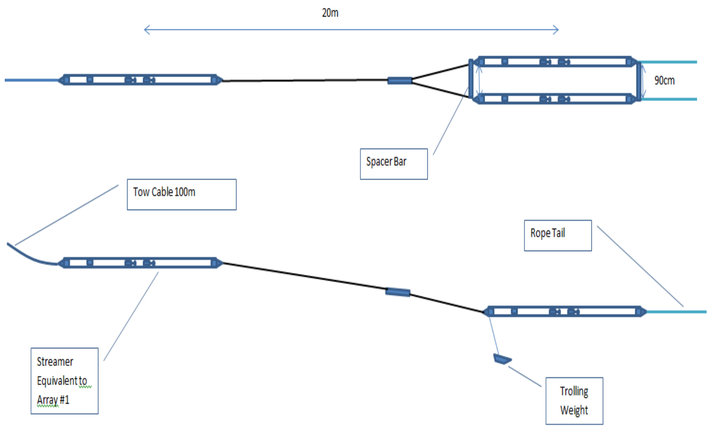
Three Hydrophone Configurations

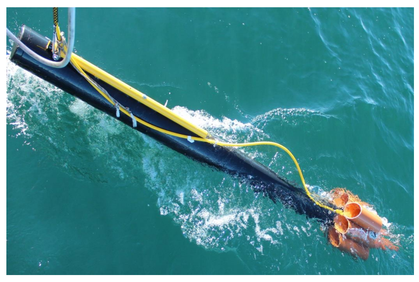




Array #1 A simple stereo array. The current “default” for towed surveys

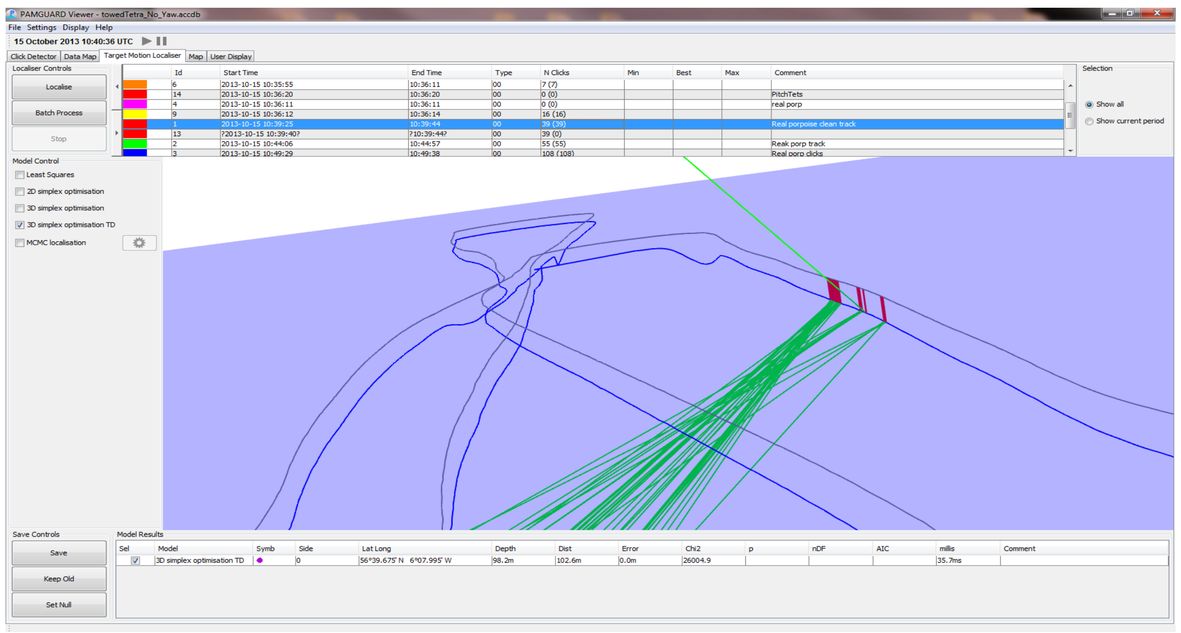
Array #3 “Tetrahedral Torpedo”. A tetrahedral conjuration of hydrophones mounted in a streamlined polythene housing





Array #2 Long Baseline Planar Array : Essentially three simple stereo arrays. Two are mounted parallel to provide a 2D planar sub-array at the rear.

Orientation sensors, OpenTags (Loggerhead Instruments) , were attached to arrays. Tag data, in conjunction with that from the vessel’s GPS, were analysed to allow the location (latitude, longitude, depth), orientation and configuration of hydrophone arrays to be modelled.



PAMGUARD screen shot showing vessel tracks (grey line) hydrophone track (blue line) and bearings to sound source (green lines).

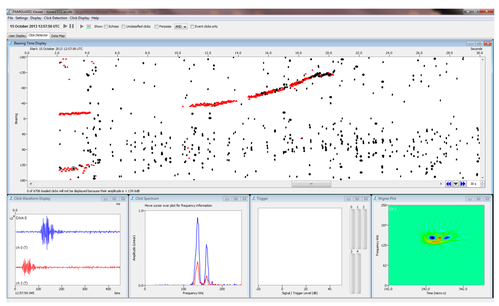
Field Trials:

Field Trials were conducted off the Island of Mull using HWDT’s research vessel *Silurian*.

A sound source transmitting bursts of porpoise-like click trains was established in a moored dinghy.
The main survey vessel then made repeated passes past the sound source (at ranges between 20 and 300m) towing one of the three hydrophone array types.
Multi-channel full bandwidth recordings were made onboard for later analysis ashore.

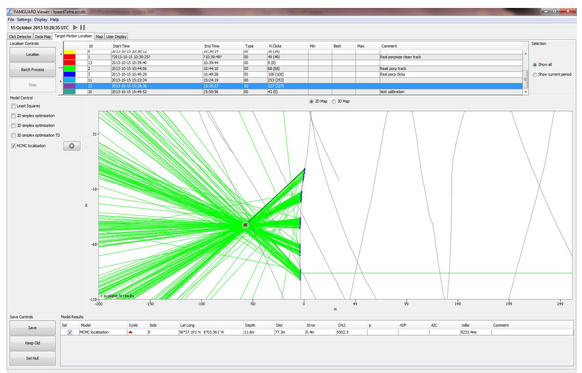
Analysis:

PAMguard was used to detect clicks, calculate time of arrival differences between closely spaced hydrophone pairs and calculate bearings. These were checked and corrected by an operator.

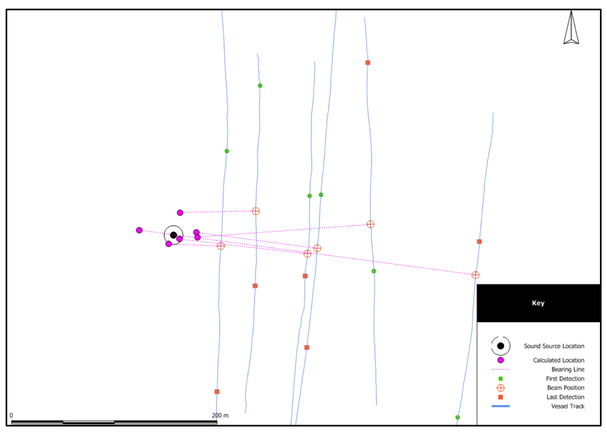


PAMGUARD screen shot showing detection of “porpoise” clicks with consistently changing bearing as hydrophone array is towed past a sound source.

Target Motion analysis routines within PAMGUARD calculated a location for each pass and for each hydrophone type.

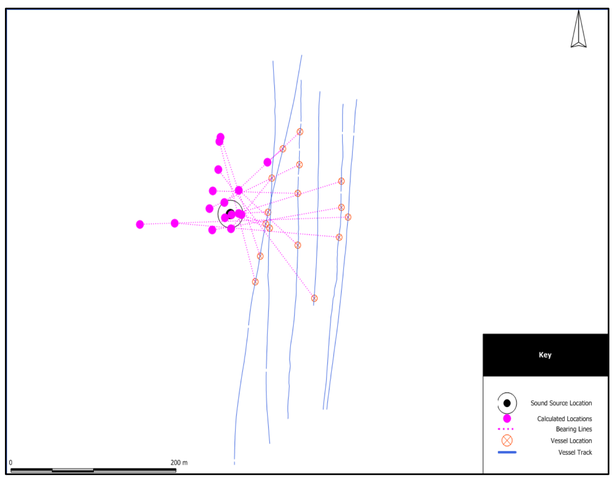


PAMGUARD screen shot showing multiple crossing bearings as tetrahedral torpedo array (#3) is towed past a sound source. Target motion analysis calculates the most likely location for the sound source based on theses patterns of changing bearings. (Faint grey lines show tracks of other passes.)

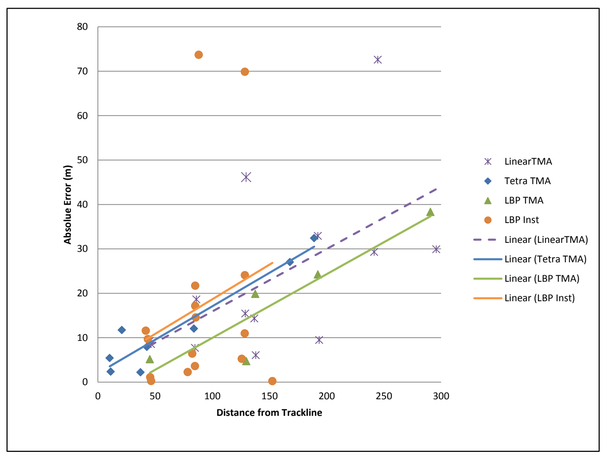


Map showing actual position of the sound source and calculated locations provided by target motion analysis for six passes with Array #2, the Long Baseline Planar Array.

A new “instantaneous” localisation method was developed and programmed into PAMGUARD. This was used to localise brief (<1.5 sec) bursts of clicks recorded with Array #2, the Long Baseline Planar Array.



Map showing actual and calculated locations for sound source determined by “instantaneous” analysis of data from Array #2 the Long Baseline Planar Array.



Absolute error in distance from the trackline plotted against range for target motion analyses for the three hydrophone arrays and instantaneous analysis of data from LBP array.

Conclusions:

All four trials provided distance measurements with an accuracy that would be useful for line transect distance analysis and which is likely somewhat better than that achieved on typical visual surveys.
The “tetrahedral torpedo” was easy to deploy and tow and the hydrophones within it maintained their configuration. It should be a preferred model for a rear section for future long baseline three dimensional arrays
The “instantaneous” method was unreliable at ranges beyond ~7 times the array baseline but within this provided useful range measurements which were not dependent on the assumptions underpinning target motion analysis.
Its likely that much improved “instantaneous” accuracy could be achieved by

- extending the baseline of arrays
- applying kinematic modeling to integrate the multiple locations provided during typical acoustic encounters

Long baseline towed arrays used in conjunction with “instantaneous localisation” promise a substantial methodological advance which should improve the capabilities of towed hydrophone surveys. These preliminary trials are encouraging and highlight several obvious areas for continued development.

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