Portable Multi Hydrophone Array for Field and Laboratory Measurements of Odontocete Acoustic Signals

Paul E. Nachtigall
University of Hawaii
2530 Dole Street
Sakamaki D-200
Honolulu, HI 96822
phone: (808) 247-5297 fax: (808) 247-5831 email: nachtiga@hawaii.edu

Award Number: N000141310684
http://www.hawaii.edu/HIMB/

LONG-TERM GOALS

The major goal is to build an array to measure the directionality of whistles and clicks produced by odontocetes. Beam patterns and depth profiles of acoustic signals of several species of odontocetes can be collected and analyzed in order to provide better verification of signals collected via passive acoustic monitoring. Additionally, because the array is versatile and portable, other sound sources can be measured and described in various environments.

OBJECTIVES

This project has several objectives. First, our goal is to build a portable and versatile multi channel array. We have designed a portable 4 to 16 element array that is battery operated and designed to be used both in the field as well as in laboratory settings.

One of the main objectives of this array is to measure the outgoing signals of representative odontocetes so that the identification, direction of travel, depth and location of the animals can be better known to improve passive acoustic monitoring efforts.

Another main objective is to use this array to improve our knowledge of marine mammal acoustic signal parameters in control settings. Measurements both on a small and large scales will be obtained to look at propagation models of acoustic signals.

An additional objective is to use this array to obtain high resolution measurements of anthropegenic sound sources in the field in order to assess propagation models and levels generated by various activities.

APPROACH

We continuously improve the multi channel array. The current iteration is comprised of up to 16 hydrophones with various cable lengths (up to 60m). Because the array has been designed as independent units, the configuration of the array can be modified to accomodate the research questions

of interest, whether it is looking at beam pattern, depth profiles or very finite and detailed measurements close to the sound source.

The analysis programs are also being tested with the current available datasets in order to measure, compare and analyze outgoing clicks and whistles of a bottlenose dolphin and a false killer whale as well as other species such as the Risso's dolphin. We are currently comparing various file types and methods of recording (continuous vs. triggered).

Our analysis is also conducted with current passive acoustic monitoring detectors and classifiers in order to assess if the depth and orientation of the animals can generate missed or inaccurate detection and species identification.

Our work can also provide baseline and empirical data for finite element models looking at sound production in odontocetes.

Finally, the array is currently being tested for field measurements of underwater detonations.

WORK COMPLETED

The array has been tested and all the main components have been assembled. Various amplifiers are still being tested to match the needs of various experimental settings.

Animals have been trained for fixed positioning and click and whistle production.
A 16 element configuration was used to investigate the beam focusing ability of a *Pseudorca crassidens* and this work has resulted in 2 published studies. The same array was used to investigate the echolocation of a *Grampus griseus* and the results are currently in review. Continuous measurements of echolocation and whistles of *Pseudorca crassidens* and *Tursiops truncatus* using 24 elements in vertical and horizontal planes are currently being analyzed using PAM routines. These controlled measurements will be used to evaluate the detection and classification algorithms used for these two species and how they perform across angles from which the signals are received.
A 9 element array was used to collect echolocation signals of *Pseudorca crassidens* detecting longline fishing hooks at various distances.

Preliminary measurements of underwater explosive detonations have also been obtained in the field on the Pu`uloa Underwater Detonation (UNDET) range during Navy training excercises. The sound generated from an explosive charge equivalent to 17 lbs. of TNT was recorded at a range of 1.14 km. Initial analysis shows the magnitude of the sound recorded fits established models for underwater shockwave and acoustic propagation.

RESULTS

Animals are now fully trained for fixed positioning in a hoop. Click and whistle production has been trained on cue. Current array set up is being tested with laboratory animals for calibration and improvements. Results from the preliminary testing with the 24 element array are still be analyzed and the recordings are being processed through PamGuard and ROCCA.

Two studies on the beam focusing abilities of the false killer whale have been published and several studies on the echolocation abilities of a Risso's dolphin are currently being reviewed for publication.

The hook detection study recordings are being analyzed for basic acoustic parameters and will be used to assess signal differences in the horizontal and vertical planes and when the target of intest distance changes.

IMPACT/APPLICATIONS

These measurement will allow direct comparisons between the types of sounds produced, the way that they change as a function of direction and the difference between species. Directionality in both vertical and horizontal planes may also effect automatic detection and classification during passive acoustic monitoring.

Additionally, this array can be used to measure anthropogenic sounds such as underwater detonation in order to better understand how such sound sources propagate in various environments.
Finally, the results obtained with this array can be used to ground proof models of sound propagation based on anatomical measurements.

All the results are expected to be published in peer-reviewed journals and provided to the funding agency as they become available.

RELATED PROJECTS

Preliminary work has been conducted with a different 24 element array in order to obtain horizontal and vertical beam patterns of acoustic signals of a false killer whale and a bottlenose dolphin. The data is currently being analyzed and the different angles and depths are compared for received levels. Additionally, there are further plans to use the array to record more detonation signatures from underwater explosives training on the Pu`uloa UNDET range, and to coorelate those recorded sound levels with behavioral and ecological observations of fish, sea turtle, and coral populations.
Current funding to conduct research in the Philippines investigating the effects of dynamite fishing on odontocete acoustics are being secured and echolocation recordings will be recorded on several species of dolphins that are currently being rehabilitated (including spinner dolphins and stenos).

PUBLICATIONS

Smith, A.B., Kloepper, L. , Yang, W.C., Huang, W.H., Jen, I.F., Nachtigall P.E. Echolocation beam shape of the Risso's dolphin (Grampus griseus) In Review

Kloepper, L. N., Smith, A. B., Nachtigall, P. E., Buck, J. R., Simmons, J. A., & Pacini, A. F. (2014). Cognitive Adaptation of Sonar Gain Control in the Bottlenose Dolphin. PlosONE 9(8): e105938. doi: 10.1371/journal.pone.0105938

Kloepper, L. N., Buck, J. R., Smith, A. B., Supin, A. Y., Gaudette, J. E., & Nachtigall, P. E. (2015). Support for the beam focusing hypothesis in the false killer whale. The Journal of Eexperimental Biology, 218(15), 2455-2462.