LONG-TERM ACOUSTIC MONITORING

E&P **SOUND
& MARINE LIFE**
PROGRAMME

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LONG-TERM ACOUSTIC MONITORING – TRACKING CHANGES IN MARINE MAMMAL NUMBERS OVER TIME

The JIP has funded independent research into the potential for long-term passive acoustic monitoring (PAM) to be used to track changes in the populations of vocalizing marine mammals in a particular location. Through this and other research efforts:

- All the critical components needed for using passive acoustic monitoring to track changes in animal numbers have been developed and tested.
- Hydrophones arrays can detect a wide range of vocalizing marine mammal species and be linked to automatic systems for identifying species and estimating numbers.
- Research completed in 2017 developed a tool that brought all the elements of a long-term monitoring system together.

Long-term acoustic monitoring

Long-term acoustic monitoring will help the oil and gas industry understand if underwater sound produced by exploration and production related activities such as seismic surveys impacts the behaviour and habits of vocalizing marine mammals. Potentially, 'life of field' monitoring (over years to decades) would enable companies to plan activities and to mitigate, if necessary, potential impacts on animal populations in the area. The hardware needed for long-term passive acoustic monitoring (PAM) of vocalizing marine mammals has developed significantly in recent years and costs have fallen. Significant progress has also been made in developing software capable of detecting, classifying and estimating population densities of different species. Installing systems that integrate these technologies in new or existing production sites is now feasible and field trials are under consideration.

Background

Since 2005, the JIP has funded research related to potential impact on cetaceans, the marine mammal group that includes whales, dolphins and porpoises. Early research efforts focused on potential auditory injury from seismic surveys (where impulsive air gun sound sources are used); the findings were that the potential for injury was limited[1]. In recent years, the focus of investigation has moved to studying the potential impact on cetacean behaviour and population consequences of long-term underwater activities, such as oil and gas production.

The traditional method of monitoring marine animal behaviour relies on visual observations from ships or aircraft. These surveys are labour intensive and expensive and have significant limitations. It is not feasible for human observation to be used for on-going, long-term 'life of field' monitoring of the kind needed to understand impacts on marine mammals around an active production facility.

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Real-time PAM systems comprise towed or static underwater microphones (hydrophones) linked to acoustic processing and recording systems. These offer an alternative method of monitoring vocalizing marine mammals, although trained observers are still needed to verify the data captured. JIP-funded research efforts have focused on developing PAM technologies and other components of automated solutions to address the challenges of long-term acoustic monitoring.

Studies have investigated the suitability of different kinds of hydrophones[2] and how arrays can be designed for identifying different cetacean species. JIP-funded research tested algorithms that can detect cetacean vocalizations, classify by species, and locate individuals in three dimensions (DCL systems)[3]. JIP also funded development of PAMGuard, an open source software package, for use by researchers, regulators and industry, that offers a standardised interface for integrating different hardware and software (vocalisation detectors and classifiers)[4].

Building on these projects, JIP also funded development of a method of estimating cetacean population sizes. The Density Estimation for Cetaceans from Passive Acoustic Fixed Sensors (DECAF) project demonstrated that data recorded by an array of hydrophones dispersed over an area of interest, combined with other information such as call rates derived from tagging studies are needed to identify the number of animals producing the recorded calls[5]. The project used species data and statistical methods to derive estimates of population size from the number of individual animals calling. Following on from this, a 2018 JIP-funded research project used an existing fixed PAM dataset (of eight years duration) to test and compare results of applying different density estimation methods.
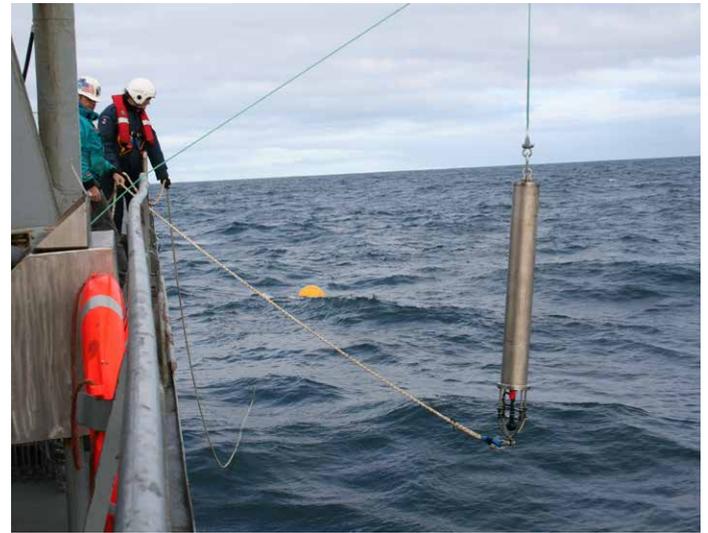
Latest research

JIP-funded research completed in 2017 brought together all the elements of DECAF-based PAM approaches for the first time to develop a simulation tool[6]. The tool enabled researchers to use real acoustic datasets to assess the strengths and weaknesses of different components of a PAM system designed to detect changes in animal population density. Sensitivity analyses identified which elements are the most crucial to a robust population monitoring effort.

The research identified two key hardware dependencies: the need for systems to have range estimation capacity (which increases the probability of accurately detecting individual animals and being able to calculate numbers present); and the *in situ* collection of auxiliary data related to the activity of the species vocalizing.

1   Finneran, J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996-2015. J. Acoust. Soc. Am. 138(3):1702-1726. dx.doi.org/10.1121/1.4927418

2   Norris, T. F., et al. 2010. A Review and Inventory of Fixed Installation Passive Acoustic Monitoring Methods and Technologies. Final report to the International Association of Oil & Gas Producers Joint Industry Programme on E&P Sound and Marine Life'. https://gisserver.intertek.com/JIP/dmsJIP.php

    Moretti, D. et al. 2009. Measuring the Health of the Field: Fixed Passive Acoustic Marine Mammal Monitoring for Estimating Species Abundance and Mitigating the Effect of Operations on the Marine Environment. Final report to the International Association of Oil & Gas Producers Joint Industry Programme on E&P Sound and Marine Life', https://gisserver.intertek.com/JIP/dmsJIP.php

3   Au, W.,Oswald J. 2011. Development of software for real-time acoustic identification of cetacean species, Final report to the International Association of Oil & Gas Producers Joint Industry Programme on E&P Sound and Marine Life', https://gisserver.intertek.com/JIP/dmsJIP.php

    Gillespie, D. White, P. Caillat, M. Gordon, J. 2011, Development and Implementation of Automatic Classification of Odontocetes within PAMGUARD, Final report to the International Association of Oil & Gas Producers Joint Industry Programme on E&P Sound and Marine Life', https://gisserver.intertek.com/JIP/dmsJIP.php

4   Hood, J. 2009. Mitigation & monitoring: Passive Acoustic Monitoring (PAM) software development detection, classification and localisation capabilities, Final report to the International Association of Oil & Gas Producers Joint Industry Programme on E&P Sound and Marine Life', https://gisserver.intertek.com/JIP/dmsJIP.php

5   Thomas, L., Marques, T.A. 2012. Passive Acoustic Monitoring for Estimating Animal Density. Acoustics Today, Volume 8, Issue 3, July 2012. gisserver.intertek.com/JIP/DMS/PRPublications/Cat4/Thomas2012_PAManimaldensity.pdf

    Marques, T.A., et al. 2013. Estimating animal population density using passive acoustics. Biological Reviews. Cambridge Biological Society. Biol. Rev. (2013), 88, pp. 287–309. gisserver.intertek.com/JIP/DMS/PRPublications/Cat4/Marques2013_Passiveacoustics.pdf

6   Booth, C.G. et al. 2017. 'Assessing the Viability of Density Estimation for Cetaceans from Passive Acoustic Fixed Sensors throughout the Life Cycle of an Offshore E&P Field Development'. Report number: SMRUC-OGP-2017-001. gisserver.intertek.com/JIP/DMS/ProjectReports/Cat4/Other/Booth2017_CetaceansandPAM.pdf

The study also highlighted the importance of having accurate data sets for specific species at different times of years and different locations. Estimations of population density rely on (and are sensitive to the accuracy of) 'multipliers' derived from field surveys. The multipliers enable the number of animals present to be calculated from the number of individuals calling – but call rates can vary significantly depending on circumstances. The research emphasised the need for further research into species' vocalisations, requiring significant investment in surveys using acoustic tags or similar technology.

The study also suggested that increased engagement and collaboration are needed within the scientific community between experts in PAM, DCL and density estimation to prevent these fields from developing independently and in parallel – which could hamper the value of such research efforts.

Significance

This latest JIP-funded research represents a significant step forward in making fixed PAM monitoring efforts more focused and cost effective for identifying long-term changes in cetacean populations.

The key hardware and software capabilities required for reliable estimation of cetacean numbers are now better understood. Hydrophones with distance measuring capability are needed for accurate detection – and arrays need to be optimised to monitor specific species or groups of species. Detection algorithms and density estimation methods are improving but rely on developing a better understanding of species behaviour, which is complex and variable.

In its current form, the simulation tool can be used to optimise the design of a monitoring system for a particular location and species or group of species of interest. It can also be used to assess what an existing monitoring system is capable of.

There is good scope for the tool to be developed and become more sophisticated. The use of sensitivity analyses and the simulation framework developed during this research can provide a roadmap for where future research effort needs to go next.

The research team

SMRU Consulting works closely with the Sea Mammal Research Unit (SMRU) and the Centre for Research into Ecological and Environmental Modelling (CREEM) at the University of St. Andrews.

ABOUT THE JIP

One of the most extensive environmental industry research programmes bringing together the world's foremost experts across industry, academia and independent research centres.

This fact sheet has been produced by the IOGP E&P Sound and Marine Life Joint Industry Programme (JIP). The JIP was founded in 2005 and supports research to help increase understanding of the potential effect of sound generated by oil and gas exploration and production activity on marine life.

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