

MONITORING NOISE EMISSIONS FROM OCEAN ENERGY DEVICES

E McKeown Biospheric Engineering Ltd., Galway, Ireland

1 INTRODUCTION

Ireland has two ocean energy test sites, one in Galway Bay for quarter scale devices and the Atlantic Marine Energy Test Site (AMETS) off the Mayo coast. Both sites are located on the west coast which has a significant marine mammal population and some internationally important fisheries such as the Corrib and Moy systems.

The effect of anthropogenic noise on marine species is of concern internationally and the increasing focus of environmental impact assessments. In order to address a knowledge gap, the Irish Government is supporting a significant R&D project in which IBM and the Marine Institute are the major partners. The project goal is to develop real time anthropogenic noise monitoring capability for the two ocean energy test sites.

2 OCEAN ENERGY DEVICE NOISE

2.1 Sound Pressure

Underwater noise levels have been monitored since at least the middle of the last century. Data indicates that sound pressure levels have increased significantly since quantitative measurements began. The impact of increased sound pressure levels on marine mammals has also been examined and results have shown both tissue trauma/injury and behavioural impacts. Due to the importance of sound to marine mammal species international legislation requiring monitoring, reporting and control of anthropogenic underwater sound pressure levels is now emerging.

2.2 Particle Velocity

Marine mammal hearing is not dissimilar to human hearing, albeit more highly developed and with a greater frequency range. Research on the hearing capabilities of fish indicates that fish with swim bladders can sense sound pressure changes but many fish are more sensitive to particle velocity changes. The hearing range of fish species is relatively low frequency and particle velocity changes are also a low frequency phenomenon.

The impact of low frequency sound, manifesting as particle velocity, on fish populations is an area of increasing concern. Ocean energy sites are by necessity located in high energy locations, which happen to coincide with strong currents, upwellings and other ocean phenomena associated with food production. With the advent of locating moored marine hydrokinetic devices in such areas the Precautionary Principle requires some research to quantify the potential impact of such plans.

2.3 Background Noise

The standard methodology for environmental impact assessment requires the quantification of the existing background levels of both sound pressure and particle velocity. In Ireland we have decided to measure both sound pressure using hydrophones and particle velocity which, being a vector quantity requires measurement of both the scalar and the direction. Sensors for both sound pressure and particle velocity are now commercially available and the increasing availability of digitisation and communication equipment facilitates the gathering of information on background levels.

In order to cover the 'complete' range of background noise levels it is necessary to determine an appropriate frequency range. Consideration has been given to the vocalisation range of cetaceans found in Irish waters and common anthropogenic noise sources. As in air high frequency sound attenuates rapidly underwater. It has been decided to limit the upper frequency to 150 kHz as this will facilitate the detection of Harbour Porpoise, the smallest and most common marine mammal in Irish waters.

Particle velocity measurement at a high energy site represents a significant challenge due to the very nature of the location. Background particle velocity levels have the potential to saturate sensors located near the surface. With increasing water depth, the background particle velocity level decreases, but obviously the impact from any marine hydrokinetic device is also more difficult to detect. A significant part of the research programme will be to determine the optimum location for the hydrophone and particle velocity sensors.

It is planned to locate a continuous monitoring buoy over 1 km from the test berths to monitor background levels. This location will be used to provide tidal, lunar and seasonal cycle data. The design of this buoy presents some significant engineering challenges, not least the fact that we have recorded a 22m wave passing through the site!

2.4 Device Noise

In addition to background noise in both manifestations it is planned to develop a three dimensional matrix of sensors that will provide the capability to measure the 'sound power' of specific devices. The methodology for this has not yet been developed and there are no standards to comply with. The only (civilian) international standard for underwater vessel noise measurement was published last year. This standard codifies measurement techniques for vessels in deeper (>300m) waters.

Significant work will be required to develop an appropriate methodology for the calculation of sound power from devices. Sufficient resources are being put in place to gather large datasets in real time and process the data as standards emerge. Links with the US Department of Energy have been established and it is planned to cooperate internationally on the development of appropriate standards.

3 PROJECT METHODOLOGY

3.1 Project Plan

The project is a two year programme which starts in September 2011. Equipment procurement is already underway and the project team is in place. Work will begin initially using the Marine Institute SmartBay platform. A dedicated buoy with WiMax communications infrastructure is in place in Galway Harbour, with another on an offshore site at Mace Head. Parallel development of sensors, digitizing and communications equipment is planned while another team works on the design of a new bespoke buoy platform and mooring for the project. Initial testing will be in sheltered waters in Galway Harbour and as the project develops relocate to the wave energy test sites.

3.2 Sensors

Following a public procurement tender process hydrophones and particle velocity sensors will be sourced from Geospectrum, NS, Canada. The sensors are being customised for the project from existing Geospectrum product offerings. The hydrophones will have an operating frequency range of 5 to 150 kHz. Sensor sensitivity is subject to ongoing evaluation and incremental design. Trials are being carried out on both sites using over-the-side and drifting buoy deployments.

3.3 Signal Processing

IBM are leading the project and their research technology known as System S or InfoSphere Streams will provide the processing platform for the project. This technology has the capacity to handle multiple parallel data streams and carry out a wide range of computational tasks in real time. Streams processing language has the ability to seamlessly remove or add processor nodes to or from the cluster dynamically including an ability to continue running correctly by isolating any node failures.

The system has already been applied to analyse acoustic data from Galway Bay including the dynamic filtering and identification of echolocation clicks from Harbour Porpoise.

3.4 Communications

Multi-channel data acquisition of signals at high sampling rates presents a significant challenge in real time communications. Wireless links over water have a definite distance/bandwidth relationship which has to be an integral part of the system design process. Communications links are currently provided through a dedicated WiMax network at the Galway Harbour and the Mace Head sites, with a link at the Galway Bay test site planned for Q4 2011. Ultimately each site will be provided with a fibre-optic cable link (work is at planning stage for both sites).

At present there are no wireless communications links at the Belmullet site. The outer berth is over 10km from shore and 20km from the nearest existing communications mast. The site has a typical wave height of 2 to 3 metres. A dedicated team of communications specialists have been tasked with developing a wireless communications capability for the site.

4 CONCLUSIONS

The potential impact of noise from marine hydrokinetic devices is little understood and requires a significant research effort to provide even basic datasets. This project has the goal of addressing that knowledge gap. The Irish Government has recognised ocean energy as a field in which Ireland has the potential to take an international leading role and is investing significant but constrained funding resources in the area.

The combination of a significant resource, Government funded grid infrastructure and technical support such as real time acoustic data monitoring provides an attractive package for device developers. This project is part of that package and we look forward to collaboration on the development of standards and presenting interesting data at future conferences.

5 REFERENCES

1. ANSI/ASA S12.64-2009/Part 1, "American National Standard, Quantities and Procedures for Description and Measurement of Underwater Sound from Ships- Part 1: General Requirements
2. Kolar, H.R., Sweeney, E., Russell, A.K., McKeown, E., Gaughan, P.J., and McGowan, A.T., "Stream analytical processing of acoustic signals for cetacean studies and environmental monitoring of ocean energy conversion devices," Proceedings of Oceans '11 IEEE Santander, Santander, Spain, June 6-9, 2011 (In Press)
3. Slabbekoorn, H., Bouton, N., van Opzeeland, I., Coers, A., ten Cate, C., Popper, A.N., "A noisy spring: the impact of globally rising underwater sound levels on fish", Trends in ecology and Evolution, **25**, (2010), 419-427.