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Tidal Energy, Underwater Noise and Marine Mammals

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INTRODUCTION

Obtaining energy from renewable sources is currently a key theme in modern society. Consequently, the pace of development of these emerging technologies is likely to increase in the near future, particularly in marine renewables. However, the environmental and ecological impact of many of these new developments in the marine environment is largely unknown. This PhD project [1] focused on one unknown area of interaction; the potential effect of tidal-stream devices on marine mammals. Two commonly cited concerns with respect to marine renewable devices are collision risk and noise impact [2]. Currently, there is very little information available to quantify collision risk, especially when marine mammal behavioural reactions to anthropogenic stimuli are variable and may depend on context [3].

It is well understood that marine mammals use sound and hearing as their primary sense for communication, foraging, navigation and predator avoidance [4], so it is highly likely that the primary cue for device detection will be acoustic. However, it is not known how operational marine renewable devices might modify the acoustic landscape in these areas, or whether they will be audible to marine mammals in time to alert them to the presence of devices. It has been suggested that the high level of natural and anthropogenic background noise in tidal-stream areas may mask (drown out) the signal of the tidal devices. The acoustic characteristics of underwater noise in shallow coastal waters are also currently not well known.

METHODOLOGY

Underwater background noise levels were measured and mapped for three tidal-stream case study sites, using drifting hydrophone methodology [5] all of which are of interest to tidal-energy developers. These were: 1) the European Marine Energy Centre (EMEC) tidal-stream test facility at the Fall of Warness in Orkney (59^{o} 8’N 02^{o} 49’W), 2) Kyle Rhea (57^{o} 14’N 05^{o} 39’W) a narrow strait between the Isle of Skye and the mainland coast of western Scotland and 3) the Sound of Islay (55^{o} 50’N 06^{o} 06’W), a strait between the islands of Islay and Jura on the west coast of Scotland.

Information detailing the acoustic characteristics of tidal turbines is scarce. So, to consider the acoustic output of tidal devices, data were reviewed from publicly available reports and from commercial data (with developers’ permission). There is a huge diversity in device types [6] and most are at the testing stage with few at full-scale development. The diversity in device types and designs may mean that each device could have a characteristic acoustic output.

A basic geometric spreading transmission loss model was used to compare background noise and potential tidal-stream device output. This enabled estimation of the range that a tidal-stream device may be detectable to the few marine mammals selected as example species. A generic model was run simply to explore the scenario, as there was limited supplementary data available that would be required for inclusion in a more complex model.

OBSERVATIONS

Background noise-maps highlighted spatial heterogeneity in sound levels. Broadband noise levels measured had a mean value of 114 dB re 1 μPa (with a variability of approximately ± 20-30 dB). Frequency spectra from each of the case study locations were generated for frequencies up to 48 kHz from a subsample of the acoustic sound files used to generate the background noise-maps. The comparison of the frequency spectra from all study sites suggests that there is a large within site variability even within the relatively short time frame of the surveys.

Broadband sound pressure levels suggest that these case study tidal stream areas were loud environments when compared to the deep water environment. An increase in noise level was linked to increasing tidal flow; however this increase was minor in comparison to any rise in noise levels due to weather and/or vessel movement.

In addition, the average frequency spectral levels were plotted against the commonly used deep water curves (Wenz curves) [7] and were found to tend towards the upper curve - or higher. Also, frequency spectra all tended towards a flatter profile than the Wenz curves, with higher levels in frequencies above 10 kHz.

Data reviewed suggests that tidal stream device acoustic output includes both a tonal and broadband signal. Estimated source levels from measurements of tidal-stream devices range from 125 to 174 dB re 1 μPa @ 1 m. Based on the data from these

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examples, tidal-stream device acoustic output is dominated by low frequency energy.

This study applied the basic assumption that the signal from the tidal-stream device may be audible where the broadband received level is greater than the broadband background noise levels in the area (signal-to-noise ratio). Using these criteria, the generic model suggested that the range of device audibility varied from inaudible to audible out to a distance of 1.2 km. The signal-to-noise maps presented non-symmetrical acoustic 'zones of influence' due to the 'patchiness' of the background noise levels. These patterns are likely to be further complicated by any directionality of the device sound signatures, and due to any variability in the propagation loss characteristics because of site specific parameters.

CONCLUSIONS

1. Drifting hydrophone methodology is suited to the challenge of tidal-stream locations and enables a greater spatial area to be covered during a survey and is therefore ideal for pre and post deployment surveys and monitoring surveys. This method however only provides snapshot data for the survey, unless repeatedly deployed in one area, which would generate vast quantities of data.

2. The direction of tidal flow (flood or ebb) or tidal cycle (springs or neaps) are not necessarily the parameters of relevance in the measurement of background noise levels in tidal-stream areas. The relevant parameters that have more influence in background noise levels in these areas are the location plus the weather and local anthropogenic activity and then the tidal-flow speed (to a lesser extent).

3. The variability of the acoustic noise-field and the main contributors as detailed in this study, are consistent with existing knowledge, but these data have shown that the spatial background noise-fields in these tidal-stream areas are very patchy, and that the levels measured tended to be higher than the upper Wenz curve.

4. During higher tidal flow-speeds, noise levels in the higher frequencies (1 kHz and above) are elevated, probably due to sediment transport leading to a flatter spectral profile than is observed in the deep water/low tidal-speed Wenz curves.

5. These patterns were consistent across all three areas in the west and north of Scotland and it would be rewarding to look elsewhere to establish how general these findings are.

6. Based on the data presented here, it is unlikely that the operational noise from tidal-stream devices will be a hazardous noise for marine mammals, or that they will present an acoustic barrier, rather that it is conceivable that tidal-devices may not be audible in all circumstances for marine mammals to detect them at distance against the background-noise environment using passive hearing alone.

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