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| Project Title | Note on Subacoustech's modelling approach for the underwater piling noise propagation |
| Authors | R Barham, S East |
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## Introduction

Subacoustech Environmental has undertaken predictive subsea noise modelling using Subacoustech's INSPIRE underwater noise propagation model.

In December 2013, the National Physical Laboratory (NPL) issued a draft "Good Practice Guide for Underwater Noise Measurement" document (National Physical Laboratory, 2013)[1]. This note summarises how the approach used by Subacoustech's INSPIRE model falls within the guidance proposed by NPL's Good Practice Guide.

### Criteria in choosing a model

The guidance gives several criteria for choosing a suitable model that is appropriate for the task at hand. Each of the headings below (range dependent bathymetry, frequency dependence for broadband signals, interaction with medium boundaries, benchmarking and agreement with experimental data) are given in the guide as criteria to consider when choosing a model, and have been used here to address the suitability of the use of the INSPIRE model for projects relating to the use of offshore impact piling.

The INSPIRE model is a semi-empirical underwater noise propagation model, based around a combination of numerical modelling and actual measured data. It is designed to calculate the propagation of noise in shallow, mixed coastal water, and primarily from piling in the coastal conditions around the UK.

The guidance outlines the different choices available for underwater noise propagation models and gives several factors that affect sound propagation in water. Of these, INSPIRE takes into account; the geometrical spreading of sound from the source, the absorption of the sound by the sea-water and sea-bed and the bathymetry between the source and receiver positions. The source and receiver depth used in INSPIRE is determined by the measurements used in developing the model, this is generally at mid-water depth.

## Range dependent bathymetry

The guidance sets out different types of models. INSPIRE is based around "N log R" calculations with extra terms added to account for various environmental factors including bathymetry. This means it can calculate the changes in noise propagation due to variation in water depth. This approach is one of those outlined in the guidance as being a reasonable approximation, particularly in the far-field. The values used for N along with the other terms are based on 50 sets of sound propagation transect data sampled by Subacoustech at various locations in UK waters.

[1] National Physical Laboratory (2013) *Good Practice Guide for Underwater Noise Measurement - Final Draft*. Report (Final Draft) for National Measurement System of the Department for Business Innovation and Skills, the Scottish Government and The Crown Estate. Crown Copyright 2013.

## Frequency dependence for broadband signals

INSPIRE is a broadband model that estimates the propagation loss of the source level over distance. As such the model is less susceptible to the spatial variations that need to be taken into account with models based on single frequencies, such as for sonar.

## Interaction with medium boundaries

It is recommended that the interaction with the sea-surface and propagation through the sea-bed are taken into account, as well as the refraction of sound due to the sound speed gradient. The INSPIRE calculations include additional parameters that take sea bed transmission, absorption and surface reflections into account, and the values of these terms are obtained from the measured data used in the model.

## Benchmarking and agreement with experimental data

With regards to accuracy, the guidance states that extra confidence will be provided if the model predictions can be compared with experimental data to obtain good agreement. The INSPIRE model is based on 50 sets of transect data from real world measurements obtained from a wide range of piling events and this is built into the model. It has also been blind tested against data from piling undertaken at the Beatrice Demonstrator, and a peer-reviewed paper presenting these results, authored by the Sea Mammal Research Unit (University of St. Andrews, Scotland[2]) has been published, which states that INSPIRE "gives a relatively good fit of the measured data".

Internal benchmarking undertaken by Subacoustech showed that any error between modelled and measured data is normally less than 5 dB and differences of just 1-2 dB are common between predicted and measured data.

As a further check, INSPIRE is also routinely compared with other purely theoretical models, in particular RAMSGeo (a widely used parabolic equation (PE) model). A comparison of propagation loss with range between the RAMSGeo and INSPIRE shows a good agreement within their known limitations and provides further confidence in the validity of INSPIRE.

## Conclusions

The INSPIRE modelling approach, used for the assessment of sound propagation caused by offshore impact piling, meets the requirements set out by the guidance for good practice in underwater sound modelling (National Physical Laboratory, 2013). It takes into account various factors that affect noise propagation stated by the guidance and compares favourably with measured data and other established modelling approaches.

[2] Thompson *et al*, 2013. *Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population.* Environmental Impact Assessment Review 43 (2013) pp 73-85.