

Regulatory Workshop on Underwater Acoustics: Final Report to NERC

February 2014



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Revision History

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1 Introduction

A key uncertainty associated with the marine renewable energy industry is the potential for negative effects of underwater noise due to installation activities and operation of marine energy converter systems (MECS) on sensitive marine species. Of particular concern is the potential for negative effect or impact on species such as marine mammals and fish that utilise underwater sound as part of their survival strategy. Techniques and equipment are being developed for the measurement of underwater noise in the harsh marine conditions typically found at marine energy sites in order to provide a detailed assessment of the acoustic environment to inform this uncertainty. However, there are currently no standard methods for measuring and reporting underwater noise, resulting in various and inconsistent methods being used, some of which are not informative to any useful extent.

The problem caused by this inconsistency and lack of robustness has been recognised by the acoustics and wider communities and there are various work-streams in progress to address this. This problem was also raised at the EMEC Monitoring Advisory Group (MAG) during the group's routine review of the adequacy of a range of underwater acoustic monitoring studies that had been performed at the EMEC test sites. The group observed that there was a wide range of reporting approaches and assumptions, with a variety of parameters reported, and that each study was found to be lacking in some respect. This highlighted the need for consistency to be introduced during the initial discussion sessions between project developers and regulators, at which recommendations can be made by the Regulator. It was clear that there was a need for a 'guide' aimed at regulators, to enable them to make the appropriate level of detailed recommendation to project developers when discussing the scope of underwater acoustic monitoring to be undertaken.

Having identified this need, EMEC was able to gain funding from the Natural Environment Research Council (NERC) and in April 2013 facilitated an underwater acoustic workshop for marine renewables regulators and their advisors, with input from acoustics experts commissioned to deliver the training. The driver for the workshop was the recognition of the need for a greater appreciation amongst regulators of the key aspects of underwater acoustic data gathering. Specifically: what needs to be measured; how measurement should be undertaken; common pitfalls to avoid; and what to look for in an adequate data gathering and analysis report.

The workshop provided an introduction to the basics of underwater acoustics, a review of underwater acoustic measuring systems and deployment methods, and an overview of propagation modelling techniques. The workshop was attended by representatives from regulators throughout the UK and their statutory environmental advisors.

This document provides a final report on the progress and outcomes of the project to the funder.

2 Scope of the Project

The aim of this project was to deliver a workshop which would inform regulators and their key advisors on the issues associated with the use of passive underwater acoustics in wave and tidal developers' Project Environmental Monitoring Plans (PEMPs). To achieve this, the project would deliver a high-level workshop to address the issues that are important to consider, and the information that can usefully be gleaned from such acoustic monitoring studies.

The workshop was facilitated by EMEC and utilised expertise from NERC scientists and selected external organisations. An additional output from the project was the production of a short guide on underwater acoustic measurement in wave and tidal energy environments, which can be used by case workers in the different UK regulatory organisations.

Full details of the aims and objectives of the project are provided as ANNEX 1: Project Aims and Objectives.

3 Workshop Organisation

3.1 Workshop Location

The workshop was held at the COSLA conference centre in Edinburgh. This venue was chosen for its central location for delegates travelling from throughout the UK with good public transport links to airport/train stations, and excellent meeting facilities.

3.2 Speakers

The three speakers were selected from the key underwater acoustic researchers currently active in the marine renewable energy field.

Dr Paul Lepper, Loughborough University

Paul is the Senior Research Fellow in the School of Electronics, Electrical & Systems Engineering at Loughborough University. He specialises in underwater acoustics, bioacoustics and underwater technologies. These include acoustic and optical underwater systems, sound field measurement, modelling and simulation. He is also working on marine species' hearing as well as the acoustic impact of noise on marine fauna. Paul's research topics include measurement and characterization of underwater noise sources and the assessment of noise impact on marine fauna. This has included work to assess the construction noise from several offshore wind farm developments, investigation of various petroleum platforms, and projects looking at noise from small leisure craft. Source characterization, sound field modelling and modelling marine species exposure are also areas of interest to Paul.

Prof Victor Humphrey, University of Southampton

Victor is a Professor of Acoustics in the Institute of Sound and Vibration Research at the University of Southampton. He has over thirty years of research experience in both underwater acoustics and medical ultrasound. His interests include numerical modelling of transducers and fields; parametric arrays and their applications in the laboratory and at sea; techniques for measuring the acoustic properties of materials; acoustic scattering from structures; and nonlinear propagation in tissues and its use to improve imaging in medical

ultrasonics. Victor has a keen interest in applied acoustics and the potential for cross fertilisation of ideas between different fields of acoustics. He has extensive experience of conveying acoustic concepts to students from a wide range of backgrounds.

Stephen Robinson, National Physical Laboratory

With over 27 years' experience in underwater acoustic metrology as an acoustical physicist, Stephen leads the technical work in underwater acoustics metrology at NPL. His current research interests include: characterisation of underwater noise sources; in situ measurement of ocean noise; hydrophone and sonar calibration techniques (including at simulated ocean conditions); characterisation of the acoustic properties of materials; underwater acoustic propagation and modelling. Stephen is a Member of the Institute of Acoustics and the Institute of Physics. He serves on numerous Standards committees for ISO, IEC and BSI as well as steering committees for Defra and the UK Marine Science Coordination Committee (Underwater Sound Forum). Stephen represents the UK on the EC Marine Strategy Framework Directive (MSFD) Technical Sub-Group on underwater noise.

3.3 Workshop Programme

The workshop consisted of four sessions covering the basics of: underwater acoustics; underwater acoustic measurement technologies; propagation modelling techniques; and underwater acoustic measurement methodologies. The programme allowed time for interactive discussion involving delegates and speakers between each session, and the workshop ended with a group discussion focused on regulatory requirements for acoustic monitoring to be undertaken by developers, together with criteria for acceptance of reports on underwater acoustic monitoring submitted to the Regulator by developers. The full programme is detailed as ANNEX 2: Workshop Programme.

3.4 Attendees

The workshop was well received, with representatives of regulatory bodies from Scotland, England, Wales, and Northern Ireland attending. ANNEX 3: List of Workshop Attendees provides full details of all attendees.

3.5 Delegate Feedback

A feedback questionnaire (see ANNEX 4: Workshop Feedback Form) was circulated to all attendees after the workshop. Unfortunately, only 6 forms were completed and returned (out of a possible 19) although one delegate did submit an eMail to say how useful and informative the workshop was for them and their colleagues. Verbal feedback from delegates both during and after the workshop confirmed that all aspects of the workshop were a success (venue, choice of speakers, content, and materials) and that they would be keen to see repeat workshops available to their colleagues.

Of the delegates who did respond to the formal feedback questionnaire, 67% replied that the workshop met their expectations, while 33% replied that it exceeded their expectations. All respondents agreed that further training for regulators/advisors would be beneficial, while 50% thought that a follow-on event covering similar materials but aimed at project developers would be beneficial. 50% agreed that a similar workshop to include regulators/advisors and project developers would be worthwhile. All respondents agreed that the choice of venue was ideal and the location convenient.

The workshop speakers were rated as follows:

	1	2	3	4	5	Ave.
Subject knowledge	0	0	0	0	6	5
Ability to explain concepts clearly	0	0	1	3	2	4.17
Audience engagement	0	0	1	3	2	4.17
Presentation materials	0	0	1	3	2	4.17

Natural Resources Wales' Marine Spatial Planning, Energy and Infrastructure Team provided comments and extensive feedback on what might be useful to consider in taking the work initiated by the workshop forward in the form of a short paper (see ANNEX 5: Natural Resources Wales Feedback) and this has been taken into consideration in compiling the 'Guidance for Regulators' document.

4 Guidance Notes for Regulators

In addition to providing input to the workshop, the three speakers authored a short document intended to be used as interim 'guidance notes' for regulators and their advisors. This document will be sent to all workshop delegates, and will as a minimum be made available on the EMEC website and published on the NERC Knowledge Exchange portal. Further dissemination will be undertaken in line with the funder's wishes.

5 Summary

The incentive and need for the workshop was enthusiastically endorsed by all organisations contacted, and the workshop itself was considered of great value and benefit by all attendees. It was clear that there are definite knowledge gaps amongst regulatory organisations, varying according to individual staff members' backgrounds. Feedback from delegates, both on the day and post-workshop, suggests a strong desire for further similar workshops for colleagues within the same organisations, and an event aimed at project developers, or perhaps involving regulators and project developers jointly.

Regulatory Workshop on Underwater Acoustics

ANNEX 1: Project Aims and Objectives

Project title: Regulatory Workshop on Underwater Acoustics

Aims and objectives:

The aim of this project is to deliver a workshop which will inform regulators and their key advisors on the issues associated with the use of passive underwater acoustics in wave and tidal developers' Environmental Monitoring and Mitigation Plans (EMMPs). Concerns are still generally being expressed by regulators and their environmental advisors about the (as yet unknown) potential for either harm or displacement to be caused to marine species by any acoustic output to the water column during device installation, operation and decommissioning. Such concerns tend to result in licence conditions requiring developers to undertake acoustic monitoring during relevant phases of their projects.

As many demonstration and commercial projects are beginning to enter the licensing phase, underwater acoustic monitoring during all phases is likely to take place, with scheduled plans being discussed in detail between developers and regulators, and reports on activities being submitted to regulators by developers as these activities are undertaken. This places a responsibility on regulators (and their advisors) to assess the scope of all such planned works, and to assess the adequacy of the output reports as they are submitted.

A full understanding of the issues associated with underwater acoustic monitoring requires a highly specialist technical expertise, which is normally not found within regulators' or environmental advisors' skill sets. This project will deliver a high-level workshop to address the kinds of issues that are important to consider, and the kinds of information that can usefully be gleaned from such monitoring studies.

The workshop will be facilitated by EMEC and utilise expertise from NERC scientists and selected external organisations. The event will be followed up with the production of a short guide which can be used by case workers in the different UK regulatory organisations.

Brief description of workshop activity:

The workshop will be split into two sessions. The morning session will involve talks on passive acoustics from invited experts. The precise scope is still to be confirmed, but will utilise experts who have experience related to wave and tidal devices, and would cover the following three themes:

1. Overview of measurement techniques, technology, and equipment, including what to look for in a report, and parameters that should be reported on;
2. Overview of analytical methods and the manner in which potentially harmful elements should be considered and identified;
3. Overview of modelling techniques, with emphasis on techniques aimed at answering regulatory questions, both for single devices and multiple devices at different sites.

In the afternoon session EMEC will facilitate an information sharing exercise to look at developing some appropriate techniques that could be used by regulators in assessing (i) the scope of acoustic monitoring proposals and (ii) the quality of outputs from underwater acoustic monitoring which developers commit to undertaking within their EMMPs.

Proposed attendees:

Regulators / Government	SNCB's	Others
MS-LOT	SNH	Selected experts e.g. NPL, Qinetiq
MSS	JNCC	Workshop funder (NERC)
MMO	CCW	
DEFRA	Natural England	
CEFAS	NIEA	

EMEC will be match funding their elements internally and the invitees will be expected to attend the workshop at their own cost.

Potential beneficiaries:

The outputs from this group will positively influence the following:

- 1. Regulators & Key Advisors.** The workshop will provide regulators from around the UK with the opportunity to discuss a common issue in an open forum and make collective use of the expertise which exists in the UK. The provision of a short acoustic guidance note for case workers will also be of direct benefit in the day to day activities of these organisations.
- 2. Majority of UK wave and tidal developers.** The provision of consistent, accurate and informed feedback from Regulators into the design, implementation and reporting of underwater acoustics monitoring in developers EMMPs will provide developers with a much clearer pathway through the Environmental Impact Assessment process.
- 3. Researchers.** The event will make use of some of the key underwater acoustic researchers who are active in the wave and tidal field. This will provide them with the opportunity to disseminate the latest findings from their work, but also gain input on what the regulatory community requires from this field.
- 4. Wider Industry.** Whilst the outputs from this exercise are primarily aimed at the groups above, EMEC will also facilitate dissemination of the findings to a wide range of interested stakeholders. This will make use of EMEC's unique position, having close links with a range of different developers, academic institutions, regulatory bodies and government, whilst remaining independent.

Deliverables:

1. Workshop event, to be hosted in Edinburgh
2. Short "Regulators' guide" to passive underwater acoustic monitoring of wave and tidal energy devices

Regulatory Workshop on Underwater Acoustics

ANNEX 2: Workshop Programme

Underwater Acoustic Workshop for Marine Renewables Regulators and Advisors

23rd April 2013, 10:00 – 16:00
 (COSLA Conference Centre, Edinburgh)

Event Programme

09:30	Welcome - Tea/Coffee	
10:00	Background to the Workshop	(Jennifer Norris, EMEC)
10:15	Basics of Underwater Acoustics	(Prof. Victor Humphrey, University of Southampton)
10:50	Interactive Feedback Session 1	(All)
11:00	Underwater Acoustic Measurement: Hydrophones and Acquisition Systems	(Stephen Robinson, National Physical Laboratory)
11:25	Underwater Acoustic Measurement: Deployment Techniques	(Dr Paul Lepper, University of Loughborough)
11:50	Interactive Feedback Session 2	(All)
12:05	Overview of Propagation Modelling Techniques	(Prof. Victor Humphrey, University of Southampton)
12:30	Interactive Feedback Session 3	(All)
12:45	Lunch	
13:30	Underwater Acoustic Measurement Methodology: Radiated Noise	(Dr Paul Lepper, University of Loughborough)
14:05	Underwater Acoustic Measurement Methodology: Ambient Noise	(Stephen Robinson, National Physical Laboratory)
14:40	Interactive Feedback Session 4	(All)
15:00	Tea/Coffee	
15:15	Group Discussion	

Workshop Deliverable – “Regulators’ Guide to Underwater Acoustic Monitoring of
 Wave & Tidal Energy Converter Devices” to include:

- (i) requirements for acoustic monitoring by developers
- (ii) criteria for acceptance of reports on underwater acoustic monitoring submitted
 by developers

15:50	Follow-up event(s), eg	(Jennifer Norris, EMEC)
	- more detail for regulators/advisors? - follow-on event aimed at developers? - joint workshop with regulators/advisors and developers?	

16:00 Close

workshop funded by



Regulatory Workshop on Underwater Acoustics

ANNEX 3: List of Workshop Attendees

Name	Organisation	Position
Adam Cooper	NRW*	Marine Licensing Officer
Caroline Carter	SNH*	Policy and Advice Officer
Craig Loughlin	MMO*	Marine Case Officer
Daniel Wood	CEFAS*	Marine Management Scientist
David Cowan	EMEC*	Research & Consents Manager
Fiona Manson	SNH	Marine Adviser, Coastal & Marine Ecosystems Unit
Giles Alcock	Natural England	Lead Advisor - Marine
Ian Davies	Marine Scotland	Marine Renewable Energy Programme Manager
Jamie McPherson	Natural England	Marine Adviser
Jennifer Norris	EMEC	Research Director
Joanne Hanna	DoE Northern Ireland	Marine Adviser
Karema Warr	CEFAS	Senior Marine Adviser
Karen Hall	SNH	Policy and Advice Officer, Marine Ecology
Kate Smith	NRW	Marine Renewable Energy Advisor
Lily Pauls	NRW	Marine Renewable Energy Advisor
Lisa Hopkinson	NRW	Marine Licensing Officer
Paul Lepper	University of Loughborough	Senior Research Fellow in the School of Electronic, Electrical & Systems Engineering (Speaker)
Richard Green	MMO	Marine Case Officer
Rob Main	Marine Scotland	Marine Casework Issues Manager
Stephen Robinson	NPL*	Principal Scientist (Speaker)
Stephen Simpson	NERC	NERC KE Fellow
Tom Stringell	NRW	Senior Marine Mammal Ecologist
Victor Humphrey	University of Southampton	Professor of Acoustics, Institute of Sound and Vibration Research (Speaker)
William Harris	Marine Scotland	Orkney & Pentland Firth Renewables Co-ordinator

***Organisation Acronyms:**

CEFAS – Centre for Environment, Fisheries and Aquaculture Science

EMEC – European Marine Energy Centre Ltd

MMO – Marine Management Organisation

NRW – Natural Resources Wales

NPL – National Physical Laboratory

SNH – Scottish Natural Heritage

Regulatory Workshop on Underwater Acoustics

ANNEX 4: Workshop Feedback Form

Underwater Acoustics Workshop – Delegate Feedback Form

1. Workshop Content

(a) What did you expect to get out of the workshop?

(b) Did the workshop meet your expectations?

Yes, better than expected

Yes, as expected

No

If no, please state what you think could have been done differently to make it better:

(c) Is there anything that you would have liked to see included that was not covered (if yes, please detail below)?

Yes No

2. Level of Understanding

What is your physics background?

No prior knowledge of physics

Studied physics at GCSE/Standard grade

Studied physics at A-level/Higher grade

Studied physics as part of a university/college non-physics degree course

University/college degree in physics

Other (please detail below)

What is your mathematics background?

Studied maths at GCSE/Standard grade

Studied maths at A-level/Higher grade

Studied maths as part of a university/college non-mathematics degree course

University/college degree in maths

Other (please detail below)

3. Do you think that further training in this area would be beneficial, eg:

Further training with more detail for Regulators/Advisors
(please specify what training – eg broader coverage of the subject, review of topics covered, same detail for wider audience/other colleagues).

Follow-on event covering similar material for developers

Joint workshop with Regulators/Advisors and developers

Other (please detail below)

4. On a scale of 1-5 (with 1 = poor and 5 = Excellent) please rate the speakers in terms of:

Subject Knowledge 1 2 3 4 5

Ability to explain concepts clearly 1 2 3 4 5

Audience Engagement 1 2 3 4 5

Presentation Materials 1 2 3 4 5

Please add any other comments below:

5. We believe that the choice of venue was ideal, but if you would like to make any comments regarding the venue (location, facilities, catering, etc) please detail below:

6. Please include any other feedback below:

Regulatory Workshop on Underwater Acoustics

ANNEX 5: Natural Resources Wales Feedback

**NRW suggestions for the development of guidance
to assist advisors in the provision of advice on underwater noise**

This paper has been written following a workshop on 23 April 2013 in Edinburgh on 'Underwater Acoustics for Marine Renewable Regulators and Advisors' organised by the European Marine Energy Centre Ltd and funded by the Natural Environment Research Council. It provides some initial views from the advisory side of Natural Resources Wales (NRW) on key areas where we consider that guidance or further work would help us in the delivery of our advice to marine renewable energy regulators and developers on matters relating to underwater noise and acoustics. It is acknowledged that various areas of work relating to underwater noise are currently underway around the UK, some of which may wholly or partially address issues raised in this paper. However, it is unclear to what extent these projects and initiatives will cover the requirements detailed below and so all have been included, to provide a comprehensive view.

Please note that this paper is written from the perspective of the advisory side of NRW rather than the regulatory functions side carried out by the Marine Licensing Team in NRW. To discuss any aspect of the requirements listed in this paper, please contact Dr Kate Smith in NRW's Marine Spatial Planning, Energy and Infrastructure Team. Contact details area provided at the end of the paper.

The paper is divided into the following sections:

1. Advice at project design stage and general noise considerations for project scoping.
2. Ambient noise and baseline surveys involving acoustic techniques.
3. Approach to assessing noise impacts in Environmental Statements - acoustics metrics.
4. Approach to assessing noise impacts in Environmental Statements - propagation modelling.
5. Approach to assessing noise impacts in Environmental Statements – noise exposure thresholds.
6. Measurement of noise during device installation and operation.
7. Guidance on interpretation and evaluation of acoustic monitoring data.
8. Suggestions for additional future work relating to underwater acoustics and noise impacts.

In each section, suggestions are made where guidance, additional work or other measures would be beneficial.

Key points and suggestions are highlighted.

1. Advice at project design stage and general noise considerations for project scoping

Discussions at the early project scoping stage are usually fairly general, since the developer will not have finalised the project details. For example they may not have established how many turbines the project will consist of, or what type, what type of foundations and installation methods will be used, the deployment area, etc. The UK

Statutory Nature Conservation Advisors (SNCA) encourage developers to talk to us as early as possible, to avoid issues and problems at later stages and to encourage the development of the 'right projects in the right places' from an environmental perspective.

A checklist of noise related issues to consider at this early stage of projects would help us to formulate and standardise and our advice to the developer, to help them to refine the project design and scoping stage. Such a checklist would help ensure that developers are fully aware of all environmental issues relating to noise that they will need to consider in their Environmental Statements. In addition, encouraging at least a preliminary consideration of all possible noise related issues at this early stage should encourage the development of a final project design, or range of designs or options, which are the least impacting from an acoustic perspective. Things for the checklist to cover might include:

- What acoustic considerations or issues should be considered at this early project scoping stage - the need to fully consider all possible sources of noise from the project (e.g. piling, drilling, increased vessel traffic, any key decommissioning issues)?
- Is there a reliable, good source of guidance to help developers consider options for project design and installation methods, etc, which we can suggest they use as a resource to help in their project planning and scoping? For example advice has been requested in the past on views regarding piling into rocky substrate. Is there a resource for information or list of key scientific literature on the generic noise levels created by different types of marine engineering activities, that we can provide to developers to encourage best practice and the best use of the available evidence base?

2. Ambient noise and baseline surveys involving acoustic techniques

Developers often plan and commence baseline monitoring and survey work well in advance of submitting their applications or preparing their Environmental Statements. For many environmental receptors or parameters, the SNCAs request two years baseline information and data, in order to characterise seasonal and annual variation. Advice on ambient noise or other acoustic surveys (e.g. for receptors such as cetaceans) would be more formally required when the developer requests an opinion from the Regulator on the scope of the project's Environmental Impact Assessment.

A checklist of prompts and questions relating to surveys of ambient noise and baseline or site characterisation surveys utilising acoustic techniques would help SNCAs provide advice to Regulators and developers, to ensure that approaches will be fit for purpose.

It would be useful if this checklist could help us provide advice on issues such as:

- Agreed definition of what we mean by ambient noise in the context of baseline surveys (i.e. excluding or including background noise from anthropogenic sources?).
- Does the developer need to establish a rough idea of bathymetry and seabed (sediment type etc) *before* they can plan their baseline acoustic measurements, or can surveys be designed prior to detailed knowledge about these parameters?
- What is the recommended spatial and temporal extent of baseline ambient acoustic surveys? For example:
 - What time period should each survey event cover?

- What frequency of survey events is appropriate – every fortnight / month or should the survey design incorporate other factors (such as meteorological conditions, tidal conditions diurnal and tidal cycles), so that the sampling programme is designed and structured to incorporate all these possible sources of variation?
- What overall time period should baseline acoustic surveys cover – a year / two years? For many natural heritage receptors the SNCAs ask for two years minimum, so that seasonal and annual variation issues are addressed – is this excessive for noise measurements? We need to be able to relate the ambient noise measurements back to the likely consequences of any additional noise caused by the development on sensitive marine wildlife, such as mammals, fish etc. The ambient noise measurements need to cover the ‘worst case scenario’, while developers also usually like to include the ‘most likely scenario’ for installation or operational parameters, so it might be appropriate here too, expressed as some kind of mean measurement (see also Section 3 on acoustic metrics)? From the SNCAs perspective, defining the worst case scenario is important, as it would be when the difference between operational noise from devices and ambient noise is expected to be greatest, so in theory when behavioural and auditory effects are likely to be greatest. We need to be sure that the ‘quietest’ times of the year are covered by the ambient noise measurements such that we can see if these coincide with particularly sensitive times, such as breeding seasons. It would also be useful to have an idea of the variation in ambient noise throughout the year so we have an idea of how often the increase in noise levels caused by activities related to device installation or operation might be significant (see metrics below).
- Spatial coverage of baseline surveys? How far from the development area should ambient noise surveys extend?
- What questions should we be asking about the acoustic monitoring equipment used to measure ambient noise, to reassure ourselves that they are fit for purpose and that we can have confidence in the results? For example, how can we be confident that hydrophones or other acoustic equipment are of sufficient quality and capable of detecting the full range of frequencies we are concerned about, etc? What about equipment self-noise?
- If passive acoustic techniques (e.g. hydrophones) are also to be used to gather information on the presence and activity of cetaceans in the development area, can the same equipment be used for these types of surveys as for ambient measuring ambient noise or should these surveys be undertaken by separate equipment? In either case, would it be prudent or practical to request that surveys are undertaken concurrently, so that analyses can be undertaken to correlate cetacean activity with ambient noise levels?
- What other parameters should be collected alongside acoustic data during surveys in order that analyses can be undertaken to correlate ambient noise levels with other parameters (e.g. meteorological conditions, tidal state, neaps / springs, water temperature profile, etc? A standard list of key parameters would be useful.
- TPODs and CPODs in areas of high tidal energy. Experience has suggested that static PODs don’t work well in these areas, given the high levels of background noise. A checklist of issues to consider, specific to high energy environments would be useful, as techniques traditionally employed by offshore wind farm developers may not be appropriate for wave and tidal energy sites.

- Should the developer be considering the likely acoustic impacts of the project etc when planning what equipment to use for the ambient noise measurements? – i.e. should the same equipment be used for comparisons to be made between ‘before impact’ (i.e. baseline) and ‘during impact’ monitoring?
- What are the environmental constraints for acoustic surveys, i.e. in what sea state, meteorological conditions (heavy rain?), etc, should acoustic surveys not be undertaken?

3. Approach to assessing noise impacts in Environmental Statements - acoustics metrics

A standard checklist of metrics that should be used and presented in Environmental Statements or post-consent noise monitoring reports would help advisors in the provision of their advice on the adequacy of Statements and in interpreting monitoring data. A checklist would also help drive consistency between projects across the whole sector.

It would be useful if this checklist could consider the following issues:

- What standard list of metrics should be presented in Environmental Statements or noise monitoring reports?
- Are there alternative ways of expressing underwater noise other than in [dB re 1 μ Pa re 1m]? If so, how would values expressed using alternative metrics compare to [dB re 1 μ Pa re 1m]? Could standard comparison tables be produced comparing values expressed in one metric against another, or is the relationship not that straightforward?
- How should these metrics be presented in Environmental Statements and noise monitoring reports, for example are there any standard graphs and figures which should be included?
- Environmental Statements needs to relate the ambient noise measurements to the likely consequences of any additional noise caused by developments on sensitive marine wildlife such as mammals, fish, etc.
- The metrics used to express ambient noise measurements need to cover the ‘worst case scenario’, while developers also usually like to include the ‘most likely scenario’ for installation or operational parameters.
- From the SNCAs perspective, the worst case scenario would be when the difference between operational noise from devices and ambient noise is greatest, so when behavioural and auditory effects might be expected to be greatest. We need to be confident that the metrics presented in Environmental Statements clearly identify this scenario, or scenarios. We also need to have an understanding for the spread or variation in ambient noise and sound propagation throughout the year so that the significance of any noise resulting from the development can be properly assessed.
- Developers need to provide information on the in-combination and cumulative acoustic impacts of their projects other ‘noisy’ activities and projects, in their Environmental Statements. Use of a standard series of metrics would help them with this aspect of Environmental Impact and Habitats Regulations Assessments, since standardisation across the sector would assist any comparison of effects.
- A reference table of noise metrics for commonly measured ‘noisy’ activities in the marine environment would be very useful, so that predicted noise levels from marine renewable energy developments can be placed in context. This might include, but not be limited to, side-scan sonar, multibeam, distant ship noise,

drilling, piling, seismic survey, etc. It would also be useful if this comparison table could provide metrics on 'natural' sources of noise and ambient noise measurements.

- Some Environmental Statements use the dBht metric to measure the behavioural and auditory effects of underwater noise on marine mammals. Some advice on how to interpret this metric in relation to standard notation would be useful and how it compares to Southall's thresholds (see also Section 5 on noise exposure thresholds).

4. Approach to assessing noise impacts in Environmental Statements - propagation modelling

A checklist of prompts and questions to help the SNCAs provide advice on the propagation model to be used or developed for marine renewable energy projects would help to provide reassurance that models will be fit for purpose and would also help drive consistency between projects across the whole sector.

It would be useful if this checklist could help us provide advice on issues such as:

- Is the propagation model suitable for application to the development area? E.g. is it a shallow or deep water propagation model etc?
- What data does the developer need to collect to input into the propagation model?
- What parameters should the sounds propagation model include (e.g. water depth, temperature profile, etc)?
- We need to be sure that the noise propagation modelling covers the worst case scenario (e.g. in winter when the water temperature is lowest and so noise is likely to travel furthest).
- What are the commonly used propagation models (if there are any?) and what are their advantages and disadvantages – when is it appropriate, or not, to use them?

5. Approach to assessing noise impacts in Environmental Statements – noise exposure thresholds

There are a number of areas related to noise exposure thresholds and criteria for marine wildlife where additional work or the production of guidance or training would help the SNCAs to provide advice to regulators, including:

a. Guidance on the application of noise exposure thresholds and criteria

Various thresholds and criteria exist, for example, Southall's thresholds and Nedwell's Subacoustech dBht metric. It would be useful to have a step-by-step interpretation, or 'dummies' guide to applying these thresholds and criteria to EIA processes. Ideally this would also make reference to other existing guidelines, for example on metrics, so that the user knows how to evaluate the outputs from acoustic propagation models against Southall and Nedwell's thresholds, or other criteria and areas where developers may need to make their own assumptions or interpretation, etc. See also comments under Section 3 on 'acoustic metrics', but simple explanations of what is meant by metrics such as 'dBht' would also be useful.

b. Refinement of noise exposure thresholds and criteria for marine mammals

Refinement of existing criteria and thresholds, to develop a more evidence based and robust approach to defining thresholds for behavioural and auditory effects for the key marine mammal species in UK waters is required, since current approaches are based on limited data and understanding.

c. Development of noise exposure thresholds and criteria for non-marine mammal receptors

Thresholds for behavioural, auditory and injury effects are also needed for other species (e.g. sensitive or important fish species, etc), although it's acknowledged that we currently probably don't have the evidence required to set exposure thresholds.

d. Standard metrics used in noise exposure thresholds and criteria

A standard checklist of metrics that should be used and presented in Environmental Statements for noise exposure thresholds, or for predicting the likely consequences of noise generated by renewable energy projects for marine wildlife would help advisors in the provision of their advice on the adequacy of Statements and would help drive consistency between projects across the whole sector. See also comments under Section 3 on 'acoustic metrics'.

6. Measurement of noise during device installation and operation

SNCAs often request post-consent monitoring of device operational noise, or of noise generated during installation activities, in order to validate models and predictions made in Environmental Statements to assist with future consenting, and to inform mitigation and adaptive management programmes for the project.

A checklist of prompts and questions to help SNCAs provide standard advice on the surveys required to measure the noise resulting from the project would help to ensure that they will be fit for purpose and would help drive consistency between projects across the sector.

It would be useful if this checklist could help us provide advice on issues such as:

- Frequency and duration of sampling?
- How large an area should surveys cover (presumably largely governed by the predictions of the sound propagation model, but should areas beyond the predicted area of concern be included, if validation of propagation models is a requirement)?
- Key points to consider to provide confidence that what is being measured is what we want and not some other near or distant source of noise?
- Other issues, as described above for ambient noise (see section 3), to ensure equipment is fit for purpose.

7. Guidance on interpretation and evaluation of acoustic monitoring data

Expertise in underwater acoustics within the SNCAs is limited, with most marine advisors having a biological, rather than a physical background. Many of the metrics and principles underwater acoustics introduce are new to staff dealing with marine renewable energy projects. Interpreting the data and information presented to us in Environmental Statements and noise monitoring reports can be very challenging. Often we don't have

the expertise to question or interrogate the conclusions of Environmental Statements and noise monitoring reports, and so potentially significant impacts might be overlooked. Similarly, our lack of expertise and confidence in evaluating and interpreting acoustics data may lead to the provision of advice which is overly cautious. We need to be able to have confidence that data presented to us in Environmental Statements and monitoring reports allows us to undertake our own evaluation of the significance of impacts without ambiguity.

Guidance for advisors on how to interpret acoustic monitoring data and information presented in Environmental Statements and noise monitoring reports, including the metrics used and graphs and figures would help us to have confidence in providing advice and comments.

Such guidance might include:

- Interpretation of commonly used and standard noise metrics.
- Interpretation of commonly used graphs and figures in Environmental Statements and noise monitoring reports.
- Key things to look for in Environmental Statements and noise monitoring reports and what should trigger 'alarm bells'?
- See also comments under section 5. on noise exposure thresholds.

8. Suggestions for additional future work relating to underwater acoustics and noise impacts

There are a number of other pieces of work which would help advisors in the delivery of advice in relation to the measurement of underwater noise or the assessment of its impacts on marine wildlife for marine renewable energy projects, including those detailed below.

a. A review of mitigation options for reducing acoustic impacts

Including:

- Use of ADDs to avoid PTS and hearing injury.
- Use of MMOs to avoid PTS and hearing injury. The effectiveness of bubble curtains during piling or other noisy activities.
- A review of 'pingers' currently available and their advantages and disadvantages.
- A review of real time detection systems currently available and their advantages and disadvantages.

b. A glossary of terms for underwater acoustics

It would be good if the glossary could cover terminology from basic to quite advance, including all the terms we will need to be familiar with to provide sensible advice, as well as being able to understand Environmental Statements including the technical appendices on underwater acoustics.

c. A reference list for key publications on underwater noise measurement and impacts

Including:

- Scientific literature
- Grey literature
- Key websites

- Relevant guidance
- Other sources

d. A review or summary of progress on the above issues and areas of work

It is acknowledged that progress is being made in many of the areas detailed in this paper, but dissemination of this progress is limited. In addition, the lack of expertise within the SNCAs hampers the ability of staff to maintain a current knowledge of the issues. A review or summary of work and progress to date on the issues detailed in this paper, or a central coordination of information dissemination, such as through a web based portal, would help to ensure that our advice is based on as comprehensive an evidence base as possible.

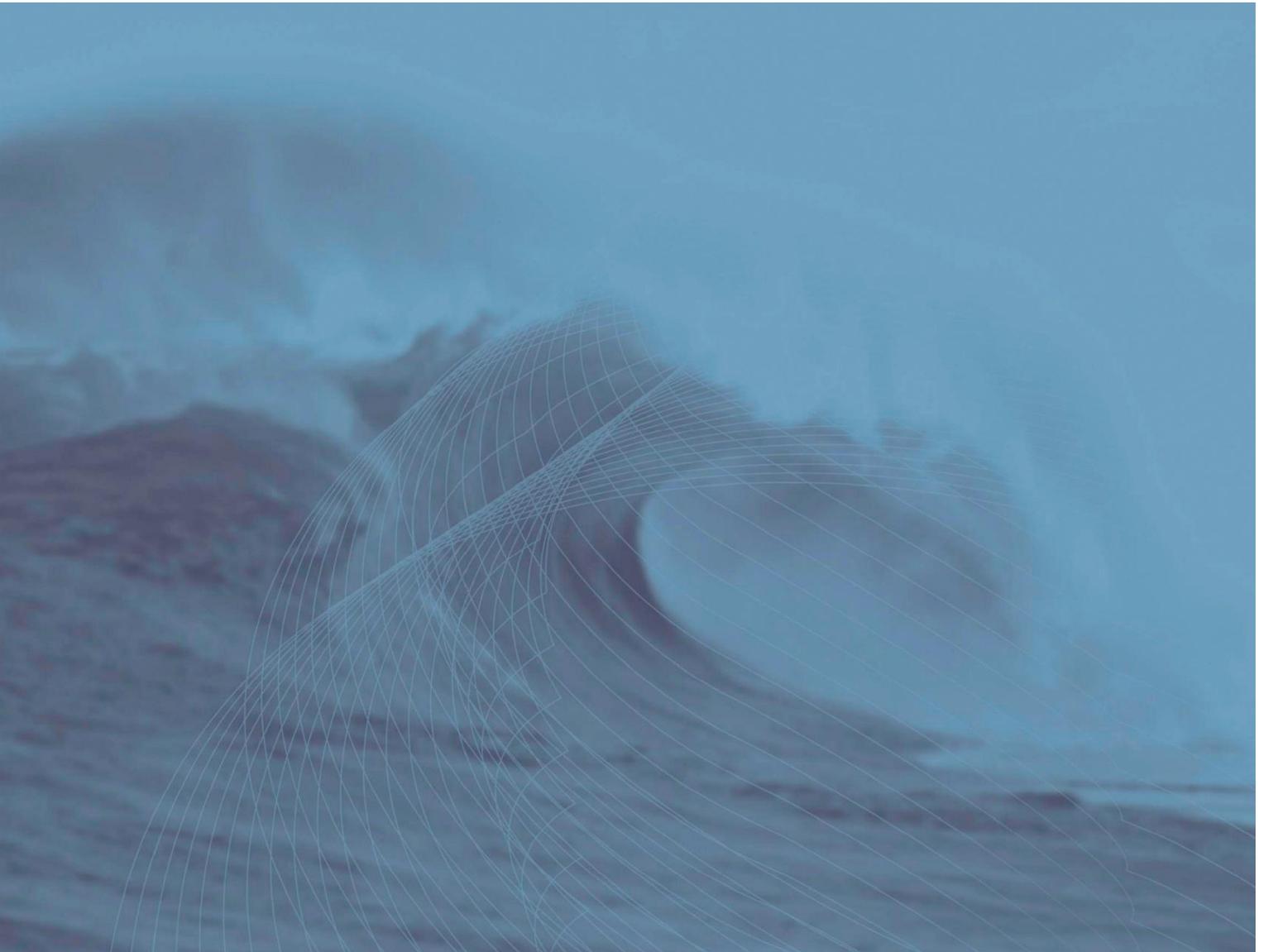
e. Further training for SNCAs in underwater acoustics

Additional training on the issues detailed above would be extremely useful for the SNCAs, as expertise in underwater acoustics is currently limited. Most marine advisors in the SNCAs have a biological rather than a physical background and so many of the metrics and principles of underwater acoustics are new to staff dealing with marine renewable energy projects and Environmental Impact Assessment processes. The training could usefully include the following:

- Basic introduction to underwater acoustics (covering only the essential concepts)
- Acoustic metrics
- Ambient noise Measuring underwater noise (including techniques and equipment)
- Basic introduction to propagation models
- Responses of underwater wildlife to noise
- Exposure thresholds for marine wildlife
- Essentials of noise for Environmental Impact Assessment

For all of the above, the challenge is to balance providing sufficient information with the need for it to be presented to an audience with a predominantly biological, rather than physical, background.

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