Ocean Energy orjip working to accelerate offshore consenting

Llywodraeth Cymru Welsh Government

# ORJIP Ocean Energy

# Information Note: Underwater Noise

**Report to: Welsh Government**

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aquatera environmental services and products

MarineSpace Making Sense of the Marine Environment™

## Contents

# Information Note: Underwater Noise

## 1 INTRODUCTION

This series of technical, topic specific Information Notes has been co-produced by the Welsh Consenting Strategic Advisory Group's Science and Evidence subgroup (SEAGP) in order to support the consenting of wave and tidal stream energy projects. The Information Notes have been developed to establish the current position of key stakeholders in Wales on the evidence available on interactions of wave and tidal energy technologies with the marine environment. They are designed to set out a starting point for applicants by providing an understanding of where consenting challenges might lie. The aim of the Information Notes is to support marine licence applications that are robust, proportionate, and focused on assessing the key potential significant impacts and possible interactions between marine renewable energy (MRE) devices and the marine environment.

These Information Notes will support careful consideration of how, for a particular development, potential impacts that are considered low risk could be safely retired from further detailed consideration within Environmental Impact Assessments (EIA), where available evidence supports this approach. Ocean Energy Systems-Environmental (OES-Environmental) has set out a general process for risk retirement[1,2] but for developments in Welsh waters, risk retirement should always be discussed between developers and Natural Resources Wales (NRW) at the pre-application stage. In the context of these Information Notes, risk retirement implies that all potential impacts are included for consideration at the project scoping stage, and that following a review of the evidence some impacts may be 'scoped out' of any further detailed assessment to focus EIA on key significant impacts[3]. In all cases, potential impacts should be acknowledged in EIAs, with evidence-based justifications describing why particular impacts could be 'scoped out' of further detailed assessment.

Further information about this series of Information Notes, who these documents are for, how they were produced, and how they should be used can be found in the accompanying document *Information Notes: Background*

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[1] https://tethys.pnnl.gov/events/oes-environmental-webinar-risk-retirement

[2] https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-13-risk-retirement

[3] It should be noted that The Wildlife Trusts expressed concerns about the use of the phrase 'risk retirement' being applied in this context, particularly considering the uncertainties in impact assessment that are likely to arise with increasing scale of MRE developments.

*Information.* The *Information Notes: Background Information* documentation also contains information about the terminology used in this document.

## 1.1 UNDERWATER NOISE – GENERAL

The acoustic environment is an important characteristic of many marine habitats, and sound is used by many animals for communication, navigation, foraging, and reproduction (Tyack and Miller, 2002). The combination of sounds arising from the natural environment, including animal vocalisations, habitat-related sounds, and sounds from the physical environment is known as the acoustic environment, or soundscape.

In this document the term 'sound' refers to the acoustic energy radiated from a vibrating object, with no reference to its function or potential effect. 'Noise', on the other hand is defined as sound that is not a useful signal or cue, i.e., it has no adaptive value or biological meaning for the receiver and may either be neutral or may have adverse effects (Van der Graaf et al., 2012; Southhall, 2018; see also ISO, 2017). The International Standards Organisation (ISO) defines the term 'soundscape' as 'ambient sound in terms of its spatial, temporal, and frequency attributes, and the types of sources contributing to the sound field' (ISO, 2017).

Continuous underwater noise is one of the 11 descriptors of 'Good Environmental Status' (GES) under the UK Marine Strategy. A noise risk assessment may also be a consideration in the marine licensing process, where EIA may be required under the Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended). In addition, in Welsh waters there is a statutory requirement to consider and manage potential impacts on marine biodiversity under the Conservation of Habitats and Species Regulations 2017[4] and the Conservation of Offshore Marine Habitats and Species Regulations 2017[5,6]. Where an appropriate assessment is required to comply with the Conservation of Habitats and Species Regulations 2017 (and the offshore equivalent) underwater noise may be a consideration.

As monitoring underwater noise is frequently included in consent conditions for MRE developments around the world, the International Electrotechnical Commission set out a standard for measuring radiated noise associated with MRE devices in 2019 (International Electrochemical Commission (IEC) 2019). To support delivery of the UK Marine Strategy, a Marine Noise Registry[7] which catalogues human activities that produce loud, impulsive noise (10 Hz – 10 kHz) has been developed as part of the programme of measures to achieve GES.

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[4] https://www.legislation.gov.uk/uksi/2017/1012/contents/made
[5] https://www.legislation.gov.uk/uksi/2017/1013/contents/made
[6] https://www.legislation.gov.uk/anaw/2016/3/contents/enacted
[7] https://mnr.jncc.gov.uk/

To date, establishing a link between operational underwater noise and the behaviour of key receptors (marine mammals, fish and seabirds) has proved challenging, even for industries that are much more established than MRE, such as offshore wind (Bailey et al. 2010; Russell et al. 2016). Measurements of radiated sound from several different types of MRE devices have been made in recent years (see Walsh et al. 2017; Polagye et al. 2017; Schmitt et al. 2018; Risch et al. 2020), although difficulties remain in separating noise associated with MRE devices from ambient noise, and in attributing behavioural changes to device-radiated noise above ambient conditions.

### 1.2 EVIDENCE SOURCES CONSIDERED BY SEAGP

SEAGP members were asked to apply their expertise and were encouraged to read the OES-Environmental Short Science Summary document[8] on underwater noise in advance of providing a response to an Underwater Noise Information Note questionnaire. Respondents were also encouraged to consult the full chapter on underwater noise within the OES-Environmental 2020 State of the Science Report[9]. Additional key references are listed at the end of this document.

## 2 VIEWS OF NATURAL RESOURCES WALES ON UNDERWATER NOISE

The information presented in this section was gathered in consultation with Natural Resources Wales (NRW) specialists including those for fish, marine mammals, ornithology, and benthic receptor groups.

### 2.1 GENERAL PERSPECTIVES ON UNDERWATER NOISE

NRW do not perceive underwater noise to be the issue of greatest environmental concern for any habitats or key receptor groups, although the level of risk associated with underwater noise will increase as the scale of a development increases (Table 1), particularly for large arrays during the construction phase. When a large array is fully operational the risk of noise-related effects on species and habitats from an MRE array is expected to decrease in comparison with the construction and decommissioning phases.

[8] https://tethys.pnnl.gov/summaries/short-science-summary-underwater-noise-2020
[9] https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-4-underwater-noise

**Table 1. NRW perspectives on the general level of environmental risk associated with underwater noise for generic development scenarios.**

| Deployment scale | Very low | Low | Intermediate | High | Very high |
|---|---|---|---|---|---|
| Single device | | | ✓ | | |
| Small array | | | ✓ | | |
| Large array | | | | ✓ | |

**Note that risks are, by their nature very site specific. This table should be treated as a general indication of risk.*

### 2.1.1 Factors influencing effects from underwater noise

The general level of environmental risk that NRW perceive to be associated with underwater noise depends strongly on the receptor group and habitats in question. Additionally, the effects of underwater noise will vary depending on the project phase, with construction noise likely to be a greater concern than operational noise.

### 2.1.2 Status of the evidence base and requirements for data collection

Although sound emission measurements have been made from several MRE devices, these have mainly been recorded at single devices. There is very little information on how soundscapes are affected by increasing MRE array size.

In applications, NRW would generally expect to see underwater noise considered as a potential pathway for effects and 'scoped in' to EIAs. However, it could be ruled out of further assessment and as a significant concern following a review of the evidence or noise propagation modelling.

NRW recommends that applicants use the National Physical Laboratories Good Practice Guide 133 on Underwater Noise Measurement[10] to inform measurement of underwater noise.

### 2.1.3 Mitigation strategies

The Tethys Management Measures tool[11] suggests two useful strategies for management of underwater noise, avoiding or limiting 'noisy works' within close proximity to marine protected areas (MPAs) and measuring the noise generated by devices during operation to better understand the potential effects on sensitive receptor groups. The second of these would be particularly useful in

[10] https://www.npl.co.uk/special-pages/guides/gpg133underwater
[11] https://tethys.pnnl.gov/management-measures

tandem with data uploaded to the Marine Noise Registry, as this would enable decision makers to access the data.

## 2.2 FISH

The main pathways for impact to fish from underwater noise are expected to be through behavioural disturbance caused by construction activities, operational noise, and vessel traffic during construction and routine maintenance. NRW considers the importance of underwater noise to be very low or negligible for fish, provided that piling is not used as a construction method (Table 2).

For most developments, barrier effects, loss of habitat, and collision (tidal stream only) are all likely to be issues of greater concern for fish than low intensity continuous noise, although construction noise will be of greater concern than operational noise.

**Table 2. NRW perspective on the importance of underwater noise as an effect on fish and on the status of the current evidence base**

| Deployment scale | Importance* | Available evidence base** |
|---|---|---|
| Single device | Negligible to very low assuming that piling is not used as a construction method. | Adequate |
| Small array | Negligible to very low assuming that piling is not used as a construction method. | Adequate |
| Large array | Negligible to very low assuming that piling is not used as a construction method. | Poor, depending on location, noise emission and size of array. |

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

### 2.2.1 Factors influencing underwater noise effects on fish

The level of risk associated with underwater noise will depend on the size of the development, the type of turbine or wave energy device deployed, and the level of noise generated during each phase of the project. The level of risk will also depend on the location of the development, for example in relation to fish spawning grounds or migration routes.

Demersal fish may be more sensitive to particle motion during the construction phase, so construction noise may be of greater concern for these species. Continuous operational noise would potentially be a greater concern for diadromous and pelagic fish, or species that are particularly sensitive to sound at the frequencies emitted by the deployed device. Where there are particular

fish species of concern it will be important to consider whether the species in question has a swim bladder, as this will influence their susceptibility to noise impacts.

### 2.2.2 Status of the evidence base and requirements for data collection

Overall, underwater noise is currently a low priority for research and monitoring for fish, as the evidence base is more substantial than for other potential effects from MRE developments. NRW consider that at present there is an adequate evidence base to support a risk-based approach to decision-making around underwater noise impacts on fish for single devices and small arrays, although detailed noise thresholds for impact are not available. The evidence base is not yet sufficient for large arrays and NRW's advice would depend on the location and size of the array and its anticipated noise emissions. At large-array scale there is more uncertainty around the responses of fish to underwater noise emitted from the array.

It is currently expected that applicants would provide evidence related to the devices proposed for deployment in support of their application at all scales. It is recommended that applicants follow the National Physical Laboratories Good Practice Guide 133 on Underwater Noise Measurement[12]. To estimate injury and/or behavioural disturbance to fish from continuous noise the current consensus is to use the interim criteria in Table 7.7 of Popper *et al*. (2014). Hawkins et al. (2020) discusses the gaps in information that must be resolved to establish sound exposure criteria for fishes.

## 2.3 SEABIRDS

Uncertainty remains about the potential impacts of underwater noise on seabirds. NRW suggest that the relative importance of underwater noise is low for single devices in comparison with other potential effects from MRE developments, although scaling up to small arrays could amplify impacts.

[12] https://www.npl.co.uk/special-pages/guides/gpg133underwater

**Table 3. NRW perspective on the importance of collision as an effect on seabirds and on the status of the current evidence base**

| Deployment scale | Importance* | Available evidence base** |
|---|---|---|
| Single device | Low | Poor |
| Small array | Uncertain, although increase in development scale could increase impacts. | Poor |
| Large array | Uncertain, although increase in development scale could increase impacts. | Poor |

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

### 2.3.1 Factors influencing underwater noise effects on seabirds

The importance of underwater noise as an effect on seabirds will be dependent on the type of device, its sound (decibel and/or particle motion) output and the associated impact on seabirds. The proximity of developments to MPAs is an important consideration as this will influence the number of individual birds that may interact with the development. Locations identified as foraging sites for diving bird species may be particularly important.

### 2.3.2 Status of the evidence base and requirements for data collection

The current level of information and research outcomes available to support decision-making on underwater noise for seabirds is not considered to be sufficient, and NRW suggest that the current evidence base at all scales is 'poor' for seabirds.

NRW would expect to see project-specific data or information for this effect in applications for developments at all scales, dependent on the measured sound output and potential impact on diving birds. Best practice associated with specific effects on birds was not identified. General best practice is set out in section 2.1.

## 2.4 MARINE MAMMALS

The relative importance of underwater noise as a potential effect of MRE developments on marine mammals is high for single devices and would become more important for small and large arrays, depending on the type of MRE devices deployed, and methods used to place the devices on the seabed. However, NRW consider that the risk of collision and its associated uncertainty represented a greater concern than underwater noise for marine mammals, particularly in Wales.

For marine mammals, NRW considers that the main routes of impact from underwater noise are expected to be:

- behavioural disturbance caused by construction activities,
- operational noise, and
- vessel traffic during construction and routine maintenance.

**Table 4. NRW perspective on the importance of underwater noise as an effect on marine mammals and on the status of the current evidence base**

| | | Available evidence base** | Available evidence base** |
|---|---|---|---|
| **Deployment scale** | **Importance*** | **Injury thresholds** | **Behavioural disturbance** |
| Single device | High | Good | Adequate |
| Small array | High, but dependent on size of array, type of devices, and construction methods | Good | Adequate |
| Large array | High, but dependent on size of array, type of devices, and construction methods | Poor | Very poor |

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

In Wales, MPAs have been designated for certain marine mammals such as harbour porpoise and bottlenose dolphins. However, marine mammals can be found in all Welsh waters, and most marine mammals are part of populations that occupy large spatial ranges. The potential effects from MRE deployments on marine mammals outside of MPAs may therefore also be a consideration in EIAs to ensure there are no adverse effects on populations or MPAs for marine mammals.

### 2.4.1 Factors influencing underwater noise effects on marine mammals

Although tidal arrays are generally expected to generate low levels of operational noise, the specific level and frequency of sound varies with the type of device deployed, the location, and seabed type of the deployment.

NRW considers that the level of risk associated with underwater noise effects on marine mammals would also depend on the proximity of a development to an MPA, the size of the infrastructure in comparison with the area of the MPA, and the level of noise generated during each phase of the project. During the construction phase impacts will also depend on the method used to fix the

devices to the bottom. Underwater noise is expected to become more important as the size of arrays increases, particularly during the construction phase.

Depending on the specific level and frequency of the sound emitted there is a possibility of hearing injury (temporary or permanent threshold shifts) to marine mammals. Should acoustic mitigation devices such as acoustic deterrent devices be used, there is a further risk of injury or disturbance.

### 2.4.2 Status of the evidence base and requirements for data collection

NRW considers that the level of information currently available about underwater noise may be satisfactory to support applications. The evidence base on underwater noise interactions for marine mammals and single devices and small arrays is adequate for behavioural disturbance effects (given evidence presented in Southall et al. 2021 and Tyack and Thomas 2019) and good for marine mammal injury thresholds. NRW perceive the level of evidence available to support applications for large arrays to be negligible to poor, because of the lack of deployed large arrays and associated noise measurements.

Given the consensus on existing auditory injury thresholds for marine mammals, for large arrays a conservative probability of injury risk could potentially be estimated by scaling up sound modelling. However, less certainty would be associated with behavioural impacts associated with underwater sound emissions from large arrays as there are no agreed behavioural thresholds specifically for MRE devices and as behavioural effects vary between different marine mammal species, individual animals, and across different temporal and spatial scales. These characteristics will be in addition to the type of MRE device, scale of development, length of deployment, and methods used to deploy the devices. NRW suggests that this should remain an area of focus for research.

NRW would expect applicants to include project-specific data and/or information to address underwater noise effects for all scales of development. NRW has identified several ‘best practice’ methods for estimating injury and behavioural disturbance to marine mammals from underwater noise impacts (Table 5).

**Table 5: Best practice guidance identified by NRW for collecting project-specific information on underwater noise associated with MRE deployments.**

| Activity | Suggested best practice guidance |
|---|---|
| Measurement of underwater noise | Use techniques described in the NPL Good Practice Guide 133 – Underwater Noise Measurement |
| Estimation of injury | Use thresholds for injury outlined in Southall et al. 2019 and in NOAA's technical guidance as revised in 2018 (NMFS 2018) |
| Behavioural disturbance* | |

** JNCC has produced guidance[13] for assessing the significance of noise disturbance against conservation objectives of harbour porpoise MPAs (England & Northern Ireland), which includes the use of fixed effective deterrent ranges (EDRs) for different sources of underwater noise. NRW does not sign up to this guidance, as there is considered to be uncertainty in the evidence underpinning the calculation of these disturbance distances. NRW advises that applicants should calculate disturbance distances on a case-by-case basis using the latest published information and modelling procedures rather than the EDRs. NRW is currently in the process of developing its own guidance on noise disturbance.*

### 2.4.3 Mitigation strategies

Appropriate mitigation strategies exist for reducing the risk to marine mammals from underwater noise for tidal stream energy development and many can be found in the Tethys Management Measures Toolbox[14]. These include:

- Avoiding or limiting 'noisy works' within close proximity of MPAs and other areas important for marine mammals and;
- Measuring noise generated by device(s) during operation to better understand the potential effects on sensitive species and to inform future decision making.

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[13] https://hub.jncc.gov.uk/assets/2e60a9a0-4366-4971-9327-2bc409e09784
[14] https://tethys.pnnl.gov/management-measures

NRW considers the second of these to be particularly useful, particularly if noise measurements are uploaded to the Marine Noise Registry[15], allowing decision-makers to access the data.

No standard guidance has been produced to mitigate the effects of underwater noise from MRE devices, although existing guidance and strategies could be modified. JNCC have produced guidelines for minimising the risk of injury to marine mammals from geophysical surveys[16], and a protocol for minimising the risk of injury to marine mammals from piling noise[17].

Some additional useful strategies or management measures for addressing underwater noise include:

- visual, passive acoustic, and video monitoring (limited in waters with poor visibility);
- soft starts and ramping up for any drilling or piling;
- breaks in activity if marine mammals are detected in the vicinity;
- avoiding construction work during periods of high marine mammal activity in the area; and
- reducing vessel speeds.

Many of these are more suitable for larger arrays, given that with single devices or small arrays construction work is likely to take place over a much shorter period and operating noise levels are very likely to be much lower. The potential effects of using acoustic mitigation, such as acoustic deterrent devices to prevent collisions should also be considered.

## 2.5 SESSILE INVERTEBRATES, MOBILE INVERTEBRATES, AND SEABED HABITATS

At present there is very limited evidence on the impacts of underwater noise on benthic habitats. It is not an impact that NRW would expect developers to scope into EIA, therefore the information in this section should be used accordingly.

NRW consider the evidence base associated with underwater noise is very poor for seabed habitats, sessile invertebrates, and mobile invertebrates at all scales. It is therefore difficult for NRW to comment on the potential impacts of underwater noise on benthic receptors for different device types, locations, and development scales.

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[15] https://mnr.jncc.gov.uk/
[16] https://hub.jncc.gov.uk/assets/e2a46de5-43d4-43f0-b296-c62134397ce4
[17] https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf

Relative to other environmental effects on benthic receptor groups associated with MRE developments, NRW would give underwater noise a very low priority for research and monitoring.

**Table 6. NRW perspective on the importance of underwater noise as an effect on seabed habitat and invertebrates and on the status of the current evidence base**

| Deployment scale | Importance* | Available evidence base |
|---|---|---|
| Single device | Negligible | Very poor |
| Small array | Negligible | Very poor |
| Large array | Negligible | Very poor |

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

# 3 PERSPECTIVES FROM ENVIRONMENTAL ORGANISATIONS

Information in this section has mainly been provided by The Wildlife Trust (TWT). However, some brief commentary from the Royal Society for the Protection of Birds (RSPB) is provided at the end of the section.

### 3.1.1 Factors influencing effects from underwater noise

Like NRW, TWT identify the effects of increasing development sizes and their associated cumulative impacts as their greatest concern associated with underwater noise and MRE developments. Equal concern is associated with both construction and operational phases of MRE development, although this concern was associated with perceived uncertainty in the evidence base, particularly when applied to developments in Wales. Effects of underwater noise on marine mammals are particularly important, although larger fish and elasmobranchs may also be important.

### 3.1.2 Status of the evidence base and requirements for data collection

TWT would welcome specific guidance from regulators on the identification and assessment of underwater noise impacts on species other than harbour porpoise (see Table 6). TWT suggest that they would encourage underwater sound modelling related to individual projects to reflect location-specific features such as topography and seabed substrate type. At a larger geographical scale, wider strategic monitoring of underwater noise is also considered to be important, alongside project-specific monitoring. TWT highlight that the data collected through monitoring programmes should be openly available and as transparent as possible, in order to verify the outcomes of noise modelling in project EIA and to enable regulators to report on the efficacy of the current approach to underwater noise management. The Marine Noise Registry is identified as a useful tool for making such data available.

### 3.1.3 Mitigation measures

Key resource areas for MRE development are often co-located with important areas for marine animals, and particularly for cetaceans. With this in mind, TWT propose that it would be helpful for noise mitigation measures to become standard practice for developers as this would provide an element of certainty in project mitigation requirements.

### 3.1.4 Additional perspectives

RSPB highlight that underwater noise would not normally be an effect that they would assess for MRE developments. However, emerging evidence suggests that some seabirds (auks) may react to underwater sound (Hansen et al. 2020), and so this effect could become of more interest in the future.

## 4 PERSPECTIVES FROM INDUSTRY

Industry members suggest that in comparison with other potential effects from MRE developments, underwater noise was generally of very low importance. Like NRW, industry members consider that although greater levels of noise would be associated with increasingly large arrays of devices, the impact would remain mostly very low in comparison with noise emitted by other natural or manmade activities. For example, many areas in Wales are subject to substantial vessel traffic (recreational and other) that contributes to the underwater noise environment in addition to sound associated with environmental factors such as strong currents and turbulence.

At the project level, industry members consider it important to identify whether underwater noise associated with a development is perceptible with respect to baseline ambient noise levels and whether it is ecologically relevant. The relevance of underwater noise from MRE will be associated with the sensitivity of receptors, and how the species or individual animals in question use the development site (e.g. for transiting, foraging, etc.). Industry members also identify that noise emissions could vary depending on the type of device, although it is uncertain how important this variability would be when considering effects on specific receptors. Industry members also consider that the risk profile associated with underwater sound should not be considered to be the same at every development site.

### 4.1.1 Status of the evidence base and requirements for data collection

The overall level of information currently available to support decision-making about underwater noise is perceived by industry members to be adequate for single devices and small arrays, although industry members identify some uncertainty about larger arrays. This potential effect from MRE deployment is associated with a low priority for research and monitoring activities, although it was suggested that in-situ monitoring around operational arrays could help to

verify and validate existing studies and noise propagation models, particularly for small and large arrays. It is suggested that routine measurements of baseline ambient noise and noise associated with MRE developments at many different development sites, and the transfer and application of such information to development sites across Wales, could also serve to ease decision-making.

Industry members expect that underwater noise is somewhat likely to be scoped in to EIAs for single devices, and very likely to be 'scoped in' to EIAs for small and large arrays. Should monitoring of developments provide evidence that risks associated with underwater noise were low across multiple projects, it is suggested that underwater noise could be 'retired' as a risk.

### 4.1.2 Mitigation measures

Of the two management measures identified by the Tethys Management Measures Tool (see 2.1), industry suggest that there may be some challenges in avoiding or limiting noisy works within close proximity to MPAs and other ecologically sensitive sites. Alternative methods that are both quieter and equally robust and/or cost-competitive would be supported, although in order to implement alternative methods or techniques they must also fit with the project's engineering and safety requirements and so may not be appropriate in all circumstances.

# 5 SUMMARY AND RECOMMENDATIONS

Although the evidence base for underwater noise effects is varied across receptor groups, it was perceived to be adequate or good for receptors thought to be at greater risk of impact from noise (fish and marine mammals). Much of the existing evidence base is drawn from other similar marine industries, and there remains some uncertainties about how it can be applied both to MRE developments and to projects in Wales.

At present, some Wales-specific guidance exists around identification and assessment of impacts from underwater noise on specific animal groups, for example, for harbour porpoise. Similar guidance addressing impacts on other species in Welsh waters could be helpful, especially in cases where the level of risk to species and habitats from underwater noise is considered to be different in Wales. This could help to improve the quality of EIAs.

Improving understanding of background ambient noise levels is an important task that will support decision-making around underwater noise associated with MRE developments, particularly as those developments look to scale up to large arrays, which are associated with the greatest level of risk. Large-scale strategic monitoring of ambient underwater sound would help both applicants and decision-makers to determine the relevance of underwater noise from MRE developments in the context of the overall receiving environment.

Strategic monitoring of ambient underwater sound should be combined with site-specific measurements that help developers and decision-makers to understand the individual risk profile of each site. Such monitoring could be incorporated into a wider programme that considers strategic planning requirements and identifies and funds projects to improve the environmental evidence base for MRE.

Collaboration between regulators, industry, researchers, and other agencies will be important to develop solutions that are proportionate, fit-for-purpose, and function well with MRE devices and other monitoring and measurement equipment deployed at a site.

## 5.1 RECOMMENDATIONS

- Underwater noise should be routinely measured at MRE development sites in the early stages of the industry in a standardised way, to provide information and understanding that could be applied to future developments in Wales.
- Strategic monitoring of background ambient noise levels in Welsh waters should be considered, if not already underway, to provide a baseline for EIA and cumulative impact assessment.
- Learning from other marine industries such as offshore wind energy can provide insight into the acute and ongoing effects of underwater noise from MRE devices and developments, and should be applied, where appropriate.
- Where appropriate, development of guidelines for the identification and assessment of underwater noise impacts on species other than harbour porpoise could help to facilitate improved EIAs.
- The above recommendations could be incorporated into a collaborative, strategic environmental programme for MRE development in Wales and across the UK.

## 6 REFERENCES

NOTE THAT ADDITIONAL REFERENCES ARE INCLUDED THAT ARE NOT CITED IN THIS INFORMATION NOTE

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# APPENDIX A ADDRESSING UNDERWATER NOISE IN PREVIOUS MARINE ENERGY PROJECTS: LICENSING DOCUMENTS AND CONSENT CONDITIONS

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| MeyGen | Scotland | Tidal Stream Array | Constructed | Concerns were raised at the lack of biological information to make a wholly accurate assessment of possible noise impacts on migratory salmonids from the proposal, a request for monitoring and mitigation measures to be put in place was made. | S36 Consent condition (Condition 12) | A condition requiring a comprehensive monitoring programme was included within the consent and Marine Scotland Science undertook strategic research on migratory fish as part of the research theme of "Diadromous Fish and Marine Renewable Energy Research". Outputs from this were incorporated, where appropriate, into the monitoring and mitigation work undertaken on this Development. |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| Morlais | Wales | Tidal Stream Demo Zone | Consented | Underwater noise monitoring was undertaken to determine if noise limits from operational turbines are sufficient for marine mammals to detect them, but not high enough to result in any auditory injury or significant long-term disturbance | Environmental Mitigation and Monitoring Plan (EMMP) | |
| Hywind Scotland | Scotland | Floating Offshore Wind | Consented | Noise modelling (conducted in support of EIA: presented in chapter 12 of the ES) concluded that less than one bottlenose dolphin (0.27% of the Moray Firth MMMU) may be disturbed by the noisiest vessel on site (cable lay vessel), and that there was no risk of fatality or injury. | HRA | |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| Hywind Scotland | Scotland | Floating Offshore Wind | Consented | Marine noise study carried out to inform the EIA identified that noise generated by construction vessels will be temporally and spatially restricted, and at worst evoke an avoidance response in hearing 'specialists' such as herring. Operational noise was assessed as negligible in the context of background levels. Atlantic salmon are considered as hearing 'generalists' that are of low vulnerability to increases in underwater noise | HRA | |
| META | Wales | Wave and Tidal Demo Zone | | Underwater noise assessment undertaken that included calculated effects of continuous vessel/installation noise and continuous operational device noise on marine mammal and fish receptors | EIA | |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| Beatrice | Scotland | Offshore Wind | Consented | Approval of a Pilling Strategy through underwater noise monitoring and mitigation for bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring. | S36 Consent condition (Condition 12 & 34) | Consent Conditions 12 and 34 and the Marine Licence (Offshore Transmission Works) Condition 3.2.2.5 |
| Moray Offshore Renewables (Moray West) | Scotland | Offshore Wind | Consented | Piling Strategy set out Development-specific mitigation measures to minimise the risk to marine mammals and fish species from underwater noise impacts through underwater noise modelling. The Piling Strategy was informed by site specific survey environmental and geotechnical survey data. | EIA | |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| EMEC | Scotland | Wave and Tidal Test Sites | Consented | The following are examples of management measures applied during deployments at EMEC; Use of an MMO prior to the commencement of drilling operations and acoustic monitoring of drilling and anchor/mooring installation noise at various distances and frequencies | EIA | |
| EMEC | Scotland | Wave and Tidal Test Sites | Consented | Adherence to the Scottish Marine Wildlife Watching Code (SMWWC) | EIA | |
| EMEC | Scotland | Wave and Tidal Test Sites | Consented | Development of appropriate vessel management to be integrated with SIMOPS. | EIA | |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| West Islay Tidal Energy Park | Scotland | Tidal Stream Array | Consented | The following steps were undertaken and predicted: Measurement of the baseline ambient noise for the site; Predict the noise emissions for the Development (turbines, vessels, drilling etc.) using data from a literature review; Predict the noise signatures for the Development; Undertake predictive modelling for the noise propagation; And evaluate the effects of the additional noise with reference to the baseline measurements. | | The condition required the Company to ensure that the noise emissions of the array are limited so they will not exceed the maximum emissions identified and, if the designated thresholds are exceeded the array should be deactivated until it can resume operations within the designated noise thresholds |
| European Offshore Wind Deployment Centre | Scotland | Offshore Wind | Consented | Underwater noise impact assessment on marine fauna through subsea noise propagation modelling | | |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| Kincardine | Scotland | Floating Offshore Wind | Consented | Noise monitoring was undertaken during the initial year of operation to gather data on the operational noise characteristics of the semi-submersible floating offshore Wind Turbine Generators (WTGs) during a range of sea states and operational modes. | EMP | |
| Moray Offshore Renewables (Moray East) | Scotland | Offshore Wind | Consented | Adhered to Southall et al.'s (2007) exposure criteria for PTS-onset in pinnipeds exposure to different types of noise (single pulsed, multiple pulsed and non-pulsed sounds) and different types of biological impacts (ranging from traumatic injury and death to more subtle behavioural responses). | EIA | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Seagreen | Scotland | Offshore Wind | Consented | Pilling Strategy that presented underwater noise modelling and the resulting predictions of Permanent Threshold Shift (PTS) impact ranges for marine mammals and fish resulting from refinement of the piling parameters | S36 Consent condition (Condition 11) | Provide details of any mitigation and monitoring to be employed during pile-driving (condition 11c of the s36) to demonstrate that the exposure to and/or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring. In addition, due to the requirement for a European Protected Species (EPS) licence, in order to support those applications, this PS has also considered how exposure to underwater noise will be mitigated for harbour porpoise, |

| Project Name | Location | Technology | Consent Status | How Underwater Noise is addressed | EIA / HRA / Other | Condition |
|---|---|---|---|---|---|---|
| | | | | | | white-beaked dolphins and minke whale. |

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