Morlais Project

Marine Mammals
Monitoring and Mitigation Options

Applicant: Menter Môn Morlais Limited

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1 Monitoring and Mitigation Options for Phased Deployment

This note has been prepared as a starting point for the ongoing development of the Environmental Mitigation and Monitoring Plan (EMMP) so that the proposed approach for the monitoring and mitigation can be agreed with Natural Resources Wales (NRW) prior to consent.

Menter Môn Morlais Limited ('the applicant', hereafter referred to as Menter Môn or the Applicant) is committed to working with NRW and others to develop an EMMP for Morlais. The outline EMMP was provided as a demonstration of this commitment, and to illustrate the form that such an EMMP may take. The evolution from outline to detailed EMMP will require details of technology to be deployed and will necessarily be developed post consent. In the interim, it is planned that the outline EMMP is further developed in advance of consent, to elements that can be anticipated, such as management processes and structures, and a range of potential monitoring methods (with agreed constraints / opportunities for each) can be agreed.

1.1 Environmental Mitigation and Monitoring Plan

A detailed EMMP will be completed post-consent, once the final project design is known, and will be based on the principles provided in the Outline EMMP submitted with the Morlais application. The EMMP will be a working document, updated as the project develops, and will not, therefore, be considered final, but once it is possible to consider technologies planned for deployment, the document will move from an outline to a detailed format. The advantages of completing the detailed EMMP post consent are:

- To ensure that the first phase project design and subsequent deployments can be taken into account, including taking into consideration the devices to be installed (type of device(s), the number to be deployed, and the size of each device). Once this is known, the detailed EMMP can develop a tailored and specific monitoring and mitigation protocol that works best with that device (or combination of devices) – for example, whether is it a seabed, mid-water or surface device.
- To ensure that the latest scientific evidence can be taken into account when assessing the effectiveness of a monitoring or mitigation method.
- To enable use of future monitoring and mitigation technologies and methods that may not be proven or commercially available yet.
- To allow for consultation with NRW once the project design has been finalised, and to enable further discussion on the most effective and proven monitoring and mitigation methods to be used, at the time.

NRW have agreed that detailed design of the monitoring and mitigation within the EMMP is most appropriately done when the technologies for deployment are known. This will necessarily be post-consent. In further developing the outline EMMP pre-consent, it is important that the agreed outline plan remains adaptable to the design of phases of deployment post consent.

Post deployment the EMMP, as a live document, will continue to be regularly updated, in consultation with regulators and stakeholders, through the mechanism of an advisory group for the Project. Updates, changes or revisions will be based upon review and evaluation of the results of monitoring and wider results of scientific and technology advances.

Section 5 of the Outline EMMP provides a schedule for the EMMP tasks and this shows a proposed approach to development of the EMMP post-consent.

Menter Môn is committed to safeguarding the environment through the identification, avoidance and mitigation of potential adverse environmental impacts associated with the construction, operation and decommissioning of the Project.

The EMMP reflects the commitment of the Morlais project to ensure adequate and effective mitigation and monitoring to reduce the potential for collision risk of marine mammals, so there are no adverse effects on marine mammal populations.

1.2 Phased Development

Phase 1 will ensure that the potential collision risk is less than 0.7 bottlenose dolphin as a level of collision risk NRW has suggested below which population level effects may be avoided.
The capacity and number of devices will be determined based on the type of devices to be deployed as the modelling results predict different levels of theoretical impact for different technologies.

The build out to the Project's maximum installed capacity will phased, with the number and scale of each phase of deployment linked to the outcomes of the monitoring and EMMP.

1.3 Monitoring

Outline aims for the marine mammal monitoring are:

- To determine the use of the array area and approaches to the array area by marine mammals.
- Provide information on the behaviour of marine mammals adjacent to operational device(s) in the array, for example:
  - Proximity of approach to device;
  - Passage / non-passage through devices;
  - Evidence of collision; and
  - Avoidance behaviour.
- To determine if mitigation is required.

Information from monitoring and wider knowledge will inform the management and scale of phased deployment of arrays of tidal devices. The monitoring will also allow the identification of any further management or mitigation measures that may need to be included in the EMMP.

Monitoring results will determine the design and implementation of a mitigation plan; and continued monitoring will then assess the effectiveness of that plan.

It is proposed that monitoring of the site will begin prior to development of Phase 1. This will allow data to be collected to further inform the baseline information for the area. This monitoring will be the same approach as used during monitoring of Phase 1 (see Section 1.4 below)).

1.4 Options for Monitoring and Mitigation

As listed in the outline EMMP, monitoring and mitigation requirements for the tidal array are expected to consist of all, or a combination of, the following:

- PAM hydrophones – either seabed mounted, moored or floating arrays of hydrophones / recorders;
- Seal tagging studies;

- Active sonar - seabed mounted, device mounted or moored directional sonar activated by the PAM;
- Acoustic Deterrent Devices (ADDs) - deployment of array around deployed devices and activated by the active sonar;
- Thermal imaging technology – surface mounted;
- Underwater cameras; and
- Device modification or removal.

This note provides additional information on the monitoring and mitigation options and how they could be used during the phased development of the Morlais site. These options will be reviewed, assessed and developed in the EMMP.

1.4.1 Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) could consist of seabed mounted, moored or floating arrays of hydrophones to detect vocalising cetaceans.

Seabed mounted is suitable for long-term baseline monitoring, with devices deployed on the seabed to record data for offline analysis (e.g. data retrieval is required, and monitoring is not 'real-time', but after data collection).

Fixed buoys can be used for both baseline monitoring and mitigation (e.g. moored arrays of hydrophones). PAM transmission systems can be fitted to allow 'real-time' monitoring. Or data can be recorded to be retrieved and analysed at regular intervals. Examples include C-PODs and PAMBuoy.

An array of PAM devices across the area could assess the potential for displacement across and around the site. A static PAM array can provide a long-term continuous time series to assess how animals use the site and monitor for any displacement. Autonomous acoustic monitoring is a cost-effective technique for generating long-term, seasonal information on presence of cetaceans.

However, it should be noted that, PAM depends on species having vocalisations with a useful detection range and that are species-specific. Since pinnipeds do not vocalise underwater in the same way that cetaceans do, PAM is only relevant to cetaceans.

The array of hydrophones would be spaced to ensure sufficient coverage of the area for monitoring. This may be affected by the operating range of equipment in a tidal environment and will vary depending on the exact equipment and method used. Deployment and arrangement of the monitoring and mitigation array will be depended on the type, configuration and spacing of the tidal arrays being monitored.

Depending on the systems in place and the data storage capacity needed, data from hydrophones can be collected during monthly equipment/battery checks and analysed for reporting. It is possible to undertake a real time monitoring equipment but if an extended monitoring period is required this may incur high costs.

The type of PAM, devices and layout will be determined prior to deployment and will be based on the latest information, technology, guidance and consultation. At this stage is it anticipated that monitoring of the site will begin prior to development of Phase 1 will involve an array of seabed mounted and / or fixed buoys suitable for long-term baseline monitoring and cover the area of development. The data will be retrieved and analysed at regular intervals, to provide baseline information. During the development and deployment of Phase 1, the PAM system will continue to use the array of seabed mounted and / or fixed buoys for continuous monitoring, with regular data retrieval and analysis. In addition, the fixed buoys will also be used for 'real-time' monitoring. These 'real-time' monitoring will form the basis of the mitigation and will be used to trigger measures, such as active sonar.

In summary, the PAM data will be used to determine:

- Presence / absence of animals within an array deployment area over time.
- Any change in use of tidal device deployment area pre and post installation.
- Movement of animals through and within an area over time.
- Avoidance behaviour or other interaction.
- Trigger mechanism for mitigation measures, such as active sonar.

PAM has been successfully used at a number of tidal developments, including Strangford Lough and MeyGen (see **Table 1**) and at North Ramsey Sound, Wales. PAM has also been widely used for monitoring and mitigation during seismic surveys and offshore wind farm developments. PAM has been successfully proven to provide long term monitoring, with examples including the Moray Firth, east coast of Scotland (ScotMER) and SEACAMs surveys.

C-PODs (autonomous PAM) have been successfully used to determine the baseline presence of harbour porpoise and the effects of tidal turbine installation and operation on harbour porpoise in the Minas Passage, Bay of Funday in Canada (Tollit *et al*., 2019). The results indicated that harbour porpoise were not excluded by turbine installation and operation over the area. However, when the turbine was operational, there was a significant decrease in porpoise activity with the closest sites (200-230m) to the operating turbine.

1.4.2 Seal Tagging Studies

Other potential monitoring options could include tagging studies of seals, in particular grey seals from the nearest haul-out sites. As PAM does not detect seals underwater, tagging could be used to provide information on how seals use the site, including dive depths, prior to deployment of the tidal devices. Tagging studies could also be conducted during the deployment of Phase 1 to provide information on any changes to seal movements and behaviour before and after deployment, avoidance of the devices, proximity to the devices and transits through the site. Similar studies have been successfully undertaken at SeaGen Strangford Lough and at MeyGen.

1.4.3 Active Sonar

Active sonar may provide a system for detecting and monitoring close range interactions between marine mammals and tidal devices.

Modern sonar systems can acquire detailed images of the underwater environment. Variables such as occurrence, size, class and behaviour of a variety of aquatic species of fish, birds, and mammals that coexist within marine energy sites can be monitored using imaging sonar systems.

The type of active sonar devices, number and locations will be determined prior to deployment and will be based on the latest information, technology, guidance and consultation. At this stage it is anticipated that the active sonar system would be used in conjunction with the PAM system during the deployment of Phase 1. In addition to detecting and monitoring marine mammals in close proximity to the tidal devices, the active sonar will also be used to trigger mitigation measures, such as ADDs. Options will be considered for mounting the active sonar on the tidal devices or on separate structures in close proximity to the tidal devices, this is likely to be dependent on the design of the tidal device and the potential for any interference in the optimal operation of the tidal devices.

There is the potential that signals from sonar systems could be audible to marine mammals and could elicit behavioural reactions. Trials have indicated that marine mammals, e.g. grey seals and harbour porpoise, exhibit different responses to different sonar systems[1]. Therefore, there is the potential for mitigation effects, which will be assessed based on the type of active sonar devices considered for the site.

In summary, active sonar could be used from seabed mounted platforms for:

- Tracking of movement of animals and behaviour in real time, or through review of stored data.
- Tracking of avoidance.
- Detecting marine mammals in close proximity to the tidal devices.
- Trigger mechanism for mitigation measures, such as ADDs.

Active sonar systems have been successfully used at a number of tidal developments, including Strangford Lough and MeyGen (see **Table 1**). Active sonar systems are being further developed to improve detections and classifications.

1.4.4 Acoustic Deterrent Devices

The use of ADDs is the proposed mitigation measure for use within EMMP to mitigate collision risk for marine mammals by deterring mammals from proximity to active tidal devices.

ADDs have been proven to be effective mitigation and are currently used to deter marine mammals during piling at offshore windfarms. **Appendix 1** provides a summary of the effectiveness of ADDs.

Underwater noise modelling is currently being undertaken to determine the potential range of ADDs at the Morlais site, taking into account ambient noise levels. The results and assessment of the underwater noise modelling will be presented when available.

The type of ADDs, number and locations will be determined prior to deployment and will be based on the latest information, technology, guidance and consultation. At this stage it is anticipated that the active sonar system would be used in conjunction with the ADD system during the deployment of Phase 1. The proposed approach for the use of ADDs would be 'detect and deploy', in that the ADDs would only be activated if marine mammals are detected in close proximity to the tidal device and there is the potential for a collision. This would be based on active sonar detecting and identifying marine mammals that could be at risk and automatically setting off the ADDs. This automation to detect and activate is being researched, but initial information indicates it will be possible to be developed to meet the requirements of the site.

Options will be considered for mounting the ADDs on the tidal devices or on separate structures in close proximity to the tidal devices, this is likely to be dependent on the design of the tidal device and the potential for any interference in the optimal operation of the tidal devices.

Prior to deployment a detailed review will be conducted to determine the most suitable and effective ADDs for the Morlais site. This will take into account the hearing range of marine mammal species likely to be present, ambient noise levels at different tidal states, the underwater noise modelling and proven effectiveness of different types of devices and systems. In addition to the ADDs referred to in **Appendix**

[1] Hastie, G.D. (2012). Tracking marine mammals around marine renewable energy devices using active sonar. SMRU Ltd report URN:12D/328 to the Department of Energy and Climate Change. September 2012 (unpublished).

1, the latest technology, devices and systems will also be considered, including, if required, adapting systems such as FaunaGuard, so they are suitable for the intermittent activation as animals approach the tidal devices. There is the potential that more than one type of ADD could be used to ensure adequate mitigation.

1.4.5 Light Mitigation Methods

There is current research underway on the use of LEDs to reduce bycatch of dolphins and porpoises. This will be assessed and reviewed to determine if this could also be a possible mitigation option. Consideration will also be given to any potential ‘visual’ effects or other environmental impacts.

1.4.6 Thermal Imaging Technology

In addition to the use of PAM, the option for using thermal imaging technology is also being considered, which could be used to provide continuous real-time coverage.

It is proposed the system would be surface mounted on environmental monitoring platforms to cover the site. The systems have been used to provide a 24-hour marine mammal monitoring tool to mitigate an exclusion perimeter zone during geophysical exploration surveys.

The system can include a specialised suite of sensors, such as uncooled thermal imager and High Definition (HD) daylight camera. It can be used in conjunction with a range of software to allow automated distance estimation and automated recognition of cetaceans. Thermal imaging has proven capability for consistent detection of marine targets, such as dolphins, at up to 2km distance[2].

Initial discussions have been conducted on the options for using the system at the Morlais site, and if there is the potential to use the automatic detection system to initiate the activation of mitigation devices, such as ADDs, if marine mammals enter a zone in close proximity to the tidal devices where there could be the potential for increased collision risk.

If this is a potential option, is it anticipated that the system would be used in conjunction with the PAM system during the deployment of Phase 1.

1.4.7 Underwater Cameras

The option and benefit of using underwater cameras is also being considered.

Underwater cameras could be mounted on or near devices to provide visual information on the avoidance or collision of marine mammals when they are in close proximity to the tidal devices. However, the limitations with visibility would have to be taken into account. Although there may be benefits for short-term deployments on new types of tidal devices.

1.4.8 Tidal Device Checks and Maintenance

It is anticipated that tidal devices may have sensors to ensure the devices are working optimally, if possible, these sensors will also be used as part of the monitoring to determine if there have been any collisions with devices. In addition, the tidal devices would be regular checked, which could also provide information on any potential collisions.

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[2] For example, https://www.seiche.com/underwater-acoustic-products/specialist-systems/thermal-imaging-hd-camera/

1.4.9 Device Modification or Removal

The final option for mitigation would be the modification or removal of any devices where there was evidence of unacceptable levels of collision risk.

1.4.10 Other Options

We are continuously monitoring and reviewing possible mitigation and monitoring options that could be developed and deployed at the Morlais site, this includes the use of automated underwater vessels for PAM and other sensors.

Developing the EMMP post consent will, as outlined above, ensure that the latest scientific evidence can be taken into account when assessing the effectiveness of a monitoring or mitigation method and enable the use of future monitoring and mitigation technologies and methods that may not be proven or commercially available yet.

1.4.11 Innovative Research and Development

The monitoring and mitigation at the Morlais site offers a unique opportunity for innovative research and development of new techniques and to improve current methods. It is therefore envisioned that the marine mammal monitoring and mitigation will be undertaken with collaboration from universities, research groups or other organisations to ensure effective and adequate measures are put in place.

1.5 Instances of Mitigation Failure

At the stage of finalising this EMMP, in the post-consent phase, once the final design of the monitoring and mitigation is known, consideration will also be made to what may happen in the case that any of the mitigation or monitoring methodologies fail, either through a technical failure or by not deterring marine mammals effectively.

1.6 Examples of Mitigation and Monitoring at Tidal Developments

Mitigation and monitoring that has been undertaken at other tidal developments, including Strangford Lough, MeyGen and EMEC as well as non-UK developments are outlined in **Table 1**.

MeyGen is an example of monitoring and mitigation methods for a phased approach, and provides an example of options that may be available to the Morlais project:

- The MeyGen advisory group recommended a PAM system with four or more hydrophone clusters but with detection capabilities to around 200m to provided significant coverage of the area.
- MeyGen is also using the following (as well as other methods specific to seals):
  - Multibeam sonar – Tritech Gemini; and
  - Video camera mounted on devices.
- Monitoring is being reviewed per Phase:
  - First phase capacity 6MW (86 MW planned); and
  - Construction of Phase 1b consisting of an additional four turbines is currently underway.

Monitoring for the MeyGen tidal array is being reviewed per Phase; Phase 1a consisted of four turbines which were installed in October 2016. The array formally entered the operational phase of 25 years in April 2018. Seal tagging and monitoring of marine mammal in the area has been undertaken since 2015 in the lead up to the construction works and continues throughout the project. The AAM/PAM/video environmental monitoring system was successfully installed on the TSS at Nigg on 3 October 2016 and deployed at the MeyGen site on 24 October 2016. In February 2017, initial commissioning of the monitoring system revealed a communications failure with all of the sensors. The Atlantis turbine was successfully re-deployed on the TSS in mid-October 2017 and a second period of monitoring system commissioning was conducted. Reporting on the monitoring was conducted until February 2018.

At the end of June 2017, the consent for construction of Phase 1b consisting of an additional four turbines was given and construction is currently underway. This decision was made after the reviewed Encounter Rate Model and Collision Risk Model for harbour seals (the main focus of the mitigation) showed no additional predicted impact from the addition turbines, but SNH requested monitoring of animal interactions with tidal turbines. Phase 1c is planned with an additional 49 turbines before the consideration of Phase 2 & 3.

Table 1 Examples of mitigation and monitoring at tidal developments

Project	Background	Mitigation	Monitoring
Sea Gen, Strangford Lough, Northern Ireland	o 1 tidal turbine (now removed) o Total capacity 1.2MW o Within Strangford Lough SAC (harbour seal), objective to maintain 200 individuals within the Lough o Shut down protocol means very little data collected on collision risk o A risk assessment using sonar to monitor harbour seals between 2010 and 2013 suggested keeping the turbine running for a short unmitigated period would not have a detrimental effect on harbour seal population. However technical issues meant the trial did not go ahead (Tethys, 2016). o Sparling *et al.* (2018) o Tagged seals moved more frequently during slack water when current was running o Transits reduced by 20% when turbine was running o Reduced by 57% when running in daylight hours	o MMO present whenever device is operational – has power to shut down device o Daylight operation o Active sonar development – 80m range, remotely monitored in real time o Shutdown for approaches <50m from the device	o Active acoustics that detects marine mammals within 30m of rotors – precautionary shut-down o Carcass surveys and post mortems of all strandings o TPODs used for acoustic monitoring of harbour porpoise activity in the Narrows and Lough o Boat based and shore based observations o Seal telemetry o Annual aerial seal surveys
MeyGen, Pentland Firth, Scotland	o 4 turbines (2.4MW) o Total capacity 6MW (86 MW planned) o During initial PAM surveys acoustic detection rate of harbour porpoise was higher than visual sightings, suggesting visual sightings may not be accurate estimates of population o Encounter model used rather than CRM based on a lack of knowledge on the response of animals to the presence of turbines o Mean density of harbour porpoise 0.105 per km^2 (peak 0.600 per km^2) o Grey seal mean density 0.226 per km^2 (peak 0.555 per km^2) o Noise o Noise levels estimated from 300kW turbine in Bristol Channel – source level of 178dB re µPa o Avoidance thresholds by Nedwell *et al.* (2005) used for constant noise source.	o MMO present whenever device is operational o Shutdown for approaches <50m from the device o License requires minimum 1 MMO to record sightings and action taken to avoid disturbance to marine mammals o Records must be provided every 6 months	o Multibeam sonar – Tritech Gemini tested by Sparling *et al.* (2016) at SeaGen o PAM o Video camera mounted on legs of turbine o Harbour seal telemetry o FLOWBEC platform (Mutibeam sonar, multi-frequency echosounder, fluorometer, acoustic Doppler velocimeter, ADCP) o ADCP mounted on turbine o Video camera mounted on turbine o Blade strain gauge
Derby Tidal Power Project, Australia	o Situated in a tidal creek - works completed at low tide allowing for isolation from marine megafauna. o No change to ambient noise level >200m away from the turbine. o Long term acoustic disturbance “unlikely to be louder than the current acoustic disturbance from fast moving water”	o Sound absorbing materials including fiberglass mat, false ceiling and heavy mass trap doors	o EIA states monitoring will include: “populations and diversity of marine fauna” during baseline, construction and operations (AECOM, 2016)

Project	Background	Mitigation	Monitoring
European Marine Energy Centre Test Site, Orkney	o OpenHydro have been testing Open-Centre Turbine since 2006 o "To date no marine life incidents have been recorded" o 1MW buoyant tidal generator (Alstom's DEEP-Gen IV turbine) installed in January 2013 o ReDAPT project – monitoring the Alstom turbine o "no unwanted interactions and marine mammals avoided the device" (Harrison, 2015)		o Shore based MMO o Strain gauge to detect collisions
TidGenTM, Ocean Renewable Power Company, Maine, USA	o Vertical axis turbine o MMO data suggests not a barrier for marine mammals entering the bay o Hiatus on monitoring since 2015 for 'technical development phase'		o MMOs o 2 acoustic DIDSON sonar cameras before and after the turbine – monitor fish behaviour in 24h in turbid water
Fundy Ocean Research Centre for Energy (FORCE), Bay of Fundy, Canada	o Cape Sharp Tidal Demonstration o Operational Since 2009 o Have been criticised by Fisheries and Oceans Canada for surveys used in EIA. MMOS only monitored out to 300m which was "suboptimal" (Canadian Science Advisory Secretariat, 2016). o Used baleen whale activity at natural gas platform at Sable Offshore Energy Project as an example of conditioning of marine mammals to offshore devices (AECOM, 2009).	In EIA: o "Collection of ambient noise levels in the area of the turbine devices; o Collection of noise data for each of the turbines during regular operation; and o Collection of noise data at a control point established so as to capture cumulative noise emissions from the three devices." Quarterly monitoring reports published Ongoing adaptive management includes: o Examination of hydrophones, cables and connectors o Examination of video camera and associated cables and connectors	o 4 PAM hydrophones (2 consistently working since deployment, 1 intermittent and 1 failed) o 1 AAM located on the turbine – monitors 60m x 104m area facing ebb tide (operating well) o Video camera used to record turbine rotor (not working since deployment) o Turbine operational sound recorded using separate AMAR (autonomous multichannel acoustic recorder) recorded 100m from the turbine for 3 months – results TBC o Control unit 2km from the turbine o C-PODs used to detect harbour porpoise
Delta Stream, Ramsey Sound, Pembrokeshire	o Prototype axial flow turbine o Subject of Malinka et al. (2018) o Has now been removed o "Harbour Porpoise will hear the device from 280m; grey seals will hear the device from 150m. Location is far from main foraging areas and footprint is small, so a minor adverse effect is expected." (Tethys, 2018) o "Noise will provide advance warning to avoid the device. The	o Did not operate shut down when marine mammals were spotted nearby	

Project	Background	Mitigation	Monitoring
	slack tidal phase is when porpoises are most likely to pass by the area, during which time the blade rotating speeds will be slow." (Tethys, 2018).		

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A1 Appendix 1: Effectiveness of ADDs

The principle behind the use of Acoustic Deterrent Devices (ADDs) is that they produce an aversive signal that causes a marine mammal to move away and out of the zone of potential permanent auditory injury (PTS). ADDs have been adopted as a method of deterring them to a 'safe distance' from the impact zone surrounding a piling event (Gordon *et al*., 2007). ADDs have been used at a number of UK offshore windfarm (OWF) sites and a number of European countries stipulate the use of ADDs as a standard mitigation for OWFs.

The Joint Nature Conservation Committee (JNCC) published a guide to selection of ADDs in industry, which described the commercially available ADDs and their applications (McGarry *et al*., 2018). The Offshore Renewables Joint Industry Project (ORJIP) commissioned a review on the effectiveness of ADD for mitigation purposes (Herschel *et al*., 2013; 2014). The review had the purpose of identifying further mitigation measures (on top of the standard MMOs and PAM) to ensure marine mammals are not at risk of injury due to significant noise sources. ORJIP also published a review of the effectiveness of ADDs on minke whale (McGarry *et al*., 2017). The following information is primarily based on the information provided in these reviews and other data sources and publications, where relevant.

A1.1 Effectiveness for marine mammals

The effectiveness of the ADD devices for the marine mammal species that could be present at the Morlais site is summarised below.

A1.1.1 Harbour porpoise

Studies have shown the Lofitech device to be effective for harbour porpoise with an immediate response on activation of the device (Brandt *et al*., 2012, 2013; McGarry *et al*., 2018). In tests of the effectiveness of the Lofitech device on harbour porpoise at a site in the German North Sea, the Lofitech device was active for four continuous hours and a total of ten trials were conducted (Brandt *et al*., 2013). During these trials, a significant decline in harbour porpoise detection was observed even at the furthest CPOD at 7.5km from the source (Brandt *et al*., 2013). Harbour porpoise were not habituated to the device over trials of 4-6 months (Brandt *et al*., 2012).

During construction at Dan Tysk offshore windfarm the Lofitech device was found to deter porpoise between 12km and up to 18km (although not statistically significant for the latter). Reaction to the ADD was equal or greater than that predicted from pile driving (with a bubble curtain; Dahne *et al.,* 2017). There was also no evidence of reduced effectiveness over the construction period (Dähne *et al.,* 2017).

The device noise source levels are below the sound level that could result in PTS onset in harbour porpoise (202 dB re 1µPa SPL_{peak}) and Temporary Threshold Shift (TTS) onset (196 dB re 1µPa SPL_{peak}) based on the NOAA criteria (NMFS, 2018).

During the ORJIP Project 4, Stage 1 of Phase 2 (Sparling *et al*., 2015) the expert panel (including UK Statutory Nature Conservation Bodies (SNCBs)) accepted that there is good evidence of effective deterrence of harbour porpoise for at least one device, which at the time was the Lofitech device.

The Ace Aquatech universal Scrammer has been shown to be effective for harbour porpoise with exclusion zones up to 6km and is suitable for use during offshore windfarm construction (Sparling *et al*., 2015). Noise modelling by Kastelein *et al*. (2015a) indicated a displacement range of between 0.2km and 1.2km. Significant displacement, higher frequency of surfacing, higher swimming speeds and more jumps were recorded as the mean received SPL increased during tests in 2015 (Kastelein *et al*., 2015a).

A1.1.2 Dolphin species

The majority of studies currently published including ADDs and dolphins are centred around the use of ADDs to prevent accidental by-catch by fishing vessels. For example:

- Franse (2005) conducted a literature review on the effectiveness of pingers and found them to be effective in keeping bottlenose dolphins away from fishing nets.
- Leeny *et al*. (2007) used static trials to test continuous and responsive pingers in the Shannon Estuary, Ireland. The presence of continuous pingers led to significantly lower detection rates of bottlenose dolphin vocalisations. Boat based trials in the same study showed both continuous and responsive pingers to cause dolphins to leave the area rapidly.
- Waples *et al*. (2013) tested 83 SaveWave® SealSalmon Saver (High-impact) ADDs on a gillnet fishery in North Carolina, USA and found dolphins to be less likely to interact with nets, however did not affect fish catches.
- STM Products: Dolphin Deterrent Devices (DDD and DiD) have a deterrence range of 1.2 to 3km (Sparling *et al*., 2015).

There is no information available on the effectiveness of the Lofitech device on dolphin species. However, studies on the effectiveness of ADDs in captive dolphins has shown startle responses in bottlenose dolphins at ADD source levels of 135 dB re 1µPa RMS (Janik and Götz, 2015). It could therefore be assumed that the deterrence range of bottlenose dolphins from an ADD emitting a sound source level of 190 dB re 1 µPa with a high frequency could be more than 4km (McGarry *et al*., 2017). However, it should be noted that this is untested.

A1.1.3 Minke whale

The Lofitech device has been proven to affect minke whale behaviour up to 1km from the source (McGarry *et al*., 2017). Within 15 minutes of ADD activation, minke whale were shown to travel to a minimum distance of 1.7km from the ADD location, with a maximum deterrence range of 4.5km detected.

The device noise source levels are below the sound level that could result in PTS onset in minke whale (219 dB re 1µPa SPL_{peak}) and TTS onset (213 dB re 1µPa SPL_{peak}) based on the NMFS criteria (NMFS, 2018).

Mean swim speeds of minke whale away from the active device was found to be 15km/h (± 4.7km/h) (McGarry *et al*., 2017). This would be the equivalent of 4.2m/s.

The Ace Aquatech MMMD has a range of 50-1,000m from source and measured displacement over ranges greater than 1km, and sound detectable at 7km (ABPmer, 2014).

A1.1.4 Grey and harbour seals

A number of different trials have shown that the Lofitech device is effective at deterring harbour and grey seals to a distance of 1km from the device location (Brandt *et al*., 2012; 2013; Harris *et al*., 2014; Gordon *et al*., 2015). There was no habituation of harbour seals in field trials that occurred over several weeks (Gordon *et al*., 2015).

However, some trials have indicated a potential deterrent range of 60m to 473m (Götz and Janik 2010; Gordon *et al*., 2015; McGarry *et al*., 2018).

The noise source level from the Lofitech device (of a maximum 194 dB re 1 µPa) is also lower than the injury thresholds for seals in water, with PTS onset at 218 dB re 1µPa SPL_{peak} and TTS onset at 212 dB re 1µPa SPL_{peak} (NMFS, 2018).

During the ORJIP Project 4, Stage 1 of Phase 2 (Sparling *et al*., 2015) the expert panel (including UK Statutory Nature Conservation Bodies (SNCBs)) accepted that there is good evidence of effective deterrence of harbour seals for at least one device, which at the time was the Lofitech device.

The Ace Aquatech Universal Scrammer (US3) is suitable for use in offshore windfarm construction and has a deterrence distance between 200m and 1.4km based on noise modelling (Kastelein *et al.,* 2010;

Sparling *et al.,* 2015). The PTS threshold for seals would be exceeded at 100m after 3 hours and 350m after 24 hours (Lepper *et al.,* 2014).

The Airmar: dB Plus II has a variable distance of effects which has led to the device being ruled as not suitable for use in offshore windfarms (Sparling *et al.,* 2015).

A1.2 Example of Effective Use of ADDs at Dudgeon Offshore Wind Farm

During piling at Dudgeon Offshore Wind Farm (DOW) ADDs were used to deter marine mammals from an area where they could potentially be exposed to noise levels that could result in PTS (DOWL, 2016). A detailed review and assessment of the effectiveness of ADDs at the DOW site to mitigate the risk of physical or auditory injury to harbour porpoise and harbour seal (the two key species of concern at the DOW site) was conducted (Sparling and Plunkett, 2015). Based on the findings of the Sparling and Plunkett (2015) report, the Lofitech seal scarer ADD was used. This ADD has been shown to have the most consistent effective deterrent ranges for both harbour seal and harbour porpoise in environments similar to the DOW site and has been successfully used for marine mammal mitigation purposes at a number of offshore wind farm construction projects in Europe (Sparling and Plunkett, 2015).

The ADDs were monitored, as part of the underwater noise monitoring at the first three monopiles. The ADDs were detected at 250m, 500m, 750m and 4,000m from the piling locations for all three monopiles. The ADDs had a centralised frequency of 14.5kHz and were detectable above average background noise level (52-55 dB re 1µPa^2.Hz^{-1} at 14-6kHz (DOWL, 2016).

The mean received level of ADDs at 750m from the installation vessel was 99.7, 101.4 and 98.7 dB re 1µPa^2.Hz^{-1} for three monopiles. The estimated source levels, based on back propagation of the received levels, were 196.9, 194.7 and 197.4 dB re 1µPa^2.m^2 (DOWL, 2016).

The noise monitoring of the ADDs supports the ADD mitigation ranges in the Sparling and Plunkett (2015) report. In addition, there were no reports of any marine mammal sightings during the marine mammal observations when the ADDs were activated.

A1.3 Potential Impacts Associated with the use of ADDs

A potential disadvantage of ADDs is that their use involves introducing additional noise into the marine environment. ADDs rely on behavioural disturbance to work. The risk of marine mammals receiving a dose of sound sufficient to cause auditory injury from ADDs is very low. The JNCC guide to selection of ADDs (McGarry *et al*., 2018) modelled the potential for injury from ADDs, assuming a swim speed of 2.5m/s and 30 minutes of ADD activation. The results showed that the NOAA (NMFS, 2018) PTS threshold for all mammals was not exceeded beyond 100m for any of the devices modelled, with the exception of the SaveWave Orcasaver where PTS could potentially occur up to 130m from the device. It was therefore concluded that the risk of injury due to ADD deployment is low for all devices (McGarry *et al*., 2018).

There is a risk that using ADDs may add to the degree of disturbance and displacement from important habitats, however the currently predicted displacement ranges for a number of offshore activities are well beyond the effective ranges of ADD devices. For example, harbour porpoises are suggested to be displaced by at least 20km during pile driving (e.g. Brandt *et al*., 2011, Dähne *et al*., 2013) whereas the reported displacement range for ADDs for harbour porpoises were between 3.5km and 7.5km for the Airmar and Lofitech devices, respectively, although it must be noted that these limits reflect the monitoring range rather than the effect limits.

The potential for impact on marine mammals from ADDs themselves was considered by the Scottish Marine Mammal Research Unit (SMRU). It was concluded that although a disturbing noise source will result in approximately 6% increase in the duration of disturbing sound levels, the benefit of reducing the likelihood of injury was more important (Sparling *et al.,* 2015).

A1.4 Summary and Conclusion

ADDs have been successfully used as mitigation, for example at a number of UK and European offshore windfarm (OWF) sites.

However, it should be noted that this information will be reviewed and updated with the latest information for all suitable devices that are available prior to deployment.

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