Department for Business, Energy & Industrial Strategy

JNCC

Standardisation of Passive Acoustic Monitoring as mitigation in UK waters: Workshop Report (3–4 March 2021)

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2021

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This resource should be cited as:
Bloor P.D., Canning, S., Abrams, N., Cook, J. and McKay, M. 2021. *Standardisation of Passive Acoustic Monitoring as mitigation in UK waters: Workshop Report (3–4 March 2021)*. Department of Business, Enterprise and Industrial Strategy and JNCC. https://hub.jncc.gov.uk/assets/7090296c-7feb-48eb-824e-8c28176c7da1.

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Executive summary

The Department of Business Energy and Industrial Strategy (BEIS) and the Joint Nature Conservation Committee (JNCC) hosted a workshop on the standardisation of Passive Acoustic Monitoring (PAM) when used as mitigation in UK Waters to engage with other regulators and stakeholders who have experience in using PAM as a tool to mitigate impacts on marine mammals from noise arising from offshore industries.

The goal of this workshop was to inform the development of proposed guidance on the use of PAM as mitigation for noise effects to marine mammals in UK waters, including the development of standardised methods to improve deployment, operation, and reporting.

The workshop was held remotely using Microsoft Teams during the afternoons of 3 and 4 March 2021 and attended by approximately 100 people. It comprised three technical sessions spread out over the two afternoons, plus a final plenary session where key points identified during the previous three sessions were discussed by all attendees.

Key points identified included:

1. Broad agreement that there was a need for guidance and the development of standards on the usage of PAM for mitigation in the UK.
2. Careful and early planning on the use of PAM during any operation is essential.
3. Recognition that the calibration of PAM equipment is important but the challenges of undertaking it should not be underestimated.
4. Training of PAM operators was recognised to be an important component in ensuring that PAM is deployed and operated effectively.
5. Determining the range at which the detected cetacean is from the hydrophones is challenging. Better collaboration between those developing the hardware and those developing the software could help in improving PAM systems, including their ability to determine ranges.
6. Continuously operating PAM over 24 hours would increase the number of overall detections and remove any uncertainty over when PAM should be deployed.
7. PAM operators typically work alone over 12-hour shifts. Continuously working for 12 hours increases the risk of PAM operators missing detections due to fatigue. One potential way to improve the situation would be to have marine mammal observers (MMOs) / PAM operators equally competent in undertaking both roles.
8. It should be recognised by all those involved in the new guidance that transition takes time. There needs to be recognition that implementing any new standards or guidance will not happen overnight and a realistic time should be identified during which any new requirements can become embedded into operating and reporting practices.

Following this workshop, draft guidance will be prepared and made available to workshop attendees for comment. Following consultation, the final guidance document will be prepared and published on the JNCC website alongside the existing mitigation guidelines.

1 Introduction

The Department of Business Energy and Industrial Strategy (BEIS) Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), and the Joint Nature Conservation Committee (JNCC) hosted a workshop on the Standardisation of Passive Acoustic Monitoring in UK Waters as a means of engaging with other regulators and stakeholders who have experience in the use of Passive Acoustic Monitoring (PAM) as a tool to mitigate against the impacts on marine mammals from noise arising from offshore industries.

The goal of this workshop was to inform the development of proposed guidance on the use of PAM as mitigation for noise effects to marine mammals in UK waters, including the development of standardised methods to improve deployment, operation and reporting. OPRED and JNCC wanted to learn from the experience others have in the usage of PAM and the issues surrounding its use that would benefit from standardisation in the form of future guidance.

BEIS is the UK government department responsible for business, industrial strategy, science research and innovation, energy, clean growth and climate change. The Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) is part of BEIS and is responsible for regulating environmental and decommissioning activities for offshore oil and gas operations in the UK. Specific responsibilities include:

- Handling domestic and international policy relating to the environmental regulatory framework for offshore oil and gas (working with other departments, environmental bodies and international organisations).
- Developing, administering, and enforcing the offshore oil and gas environmental regulatory regime (including offshore gas unloading and storage and carbon dioxide storage).
- Implementing the oil and gas decommissioning regime and ensuring that the costs are met by the oil companies and not the taxpayer.
- Managing the department's Strategic Environmental Assessment for Offshore Energy Projects.

JNCC is an executive non-departmental public body, sponsored by the Department for Environment, Food and Rural Affairs (Defra). It is a statutory adviser to the UK government and devolved administrations and provides advice on international nature conservation. The JNCC has responsibility for nature conservation in the offshore marine environment and plays a key role in supporting government and industry to use the offshore environment sustainably, through identifying, monitoring and advising on protected areas; and provide nature conservation advice on the impacts of offshore industries.

1.1 Project Motivation

The use of Passive Acoustic Monitoring (PAM) was first incorporated into JNCC guidelines for minimising risks to marine mammals from geophysical surveys in 2002. While it is acknowledged that current PAM systems have limitations, this technology has been

increasingly used as a mitigation tool for monitoring marine mammals during offshore activities, particularly at night and during periods of poor visibility.

Analysis of oil and gas geological survey mitigation reports (MMO reports) regarding PAM use highlighted concerns around range estimation, deployment, excessive background noise and software issues (Stone 2015). To help address this, JNCC have been working with the Scripps Institute of Oceanography in the USA to contribute to the development of minimum standards for PAM used as mitigation in offshore industries such as oil and gas and renewables. An outline for a proposed American National Standards Institute (ANSI) standard for towed PAM mitigation was drafted in 2015, followed by two US-based workshops (one part sponsored by JNCC) to draw upon the knowledge and experience of UK and US stakeholders, and to outline draft minimum standards. While the ANSI standard (when complete) will be available to be used around the world, it was considered that customised UK guidance, considering UK regulatory processes and setting minimum standards required, would be an achievable first step in the UK. The intention would not be to repeat work already undertaken, rather continue discussions but with specific reference to how it will be applied in UK waters.

1.2 Project Aim

To improve and standardise the deployment, effectiveness and reporting of PAM use as mitigation by offshore industries in UK waters to ensure both the equipment and operation of the equipment is to a standard such that the resulting mitigation is effective.

1.3 Workshop objective

To engage with stakeholders and collate opinion to inform the development of guidance to improve and standardise the deployment and reporting of PAM use in UK waters.

2 Overview of Workshop

The virtual workshop was hosted by OPRED during the afternoons of 3 and 4 March 2021. The workshop was attended by approximately 100 people, with experts invited from the UK and United States who presented on their experiences of PAM and relating guidance.

The workshop started with an introduction during which OPRED and JNCC welcomed the participants and provided an overview of the goals of the workshop. The introduction also included an overview of the UK's regulations with regard to the use of PAM as mitigation by the offshore energy industries.

Following the introduction, the workshop comprised three technical sessions spread out over the two afternoons:

- Session 1: Pre- and post-application reporting (Wednesday 3 March, 12:30 – 14:00).
- Session 2: PAM deployment (Wednesday 3 March, 14:30 – 16:00).
- Session 3: When to use PAM (Thursday 4 March, 12:30 – 14:00).

Each technical session began with presentations introducing the topic and four breakout groups of no more than 25 attendees were formed to discuss the issues arising from the preceding presentations. Each breakout group was facilitated by a workshop organiser. Recordings were made of all sessions solely for the purposes of later reference when preparing the workshop meeting note.

The fourth and final session of the workshop was a plenary session where the key points identified by each of the breakout groups for each of the previous three sessions were presented and discussed by all attendees. The workshop ended with an overview of the next steps presented by the JNCC.

3 Welcome and Opening Remarks

OPRED welcomed attendees and introduced the roles of OPRED and the JNCC and their involvement in the use of PAM. The workshop was motivated following analysis of oil and gas marine mammal observer reports received by the JNCC and BEIS following the use of PAM. This workshop also follows on from a similar workshop held in the USA by the Scripps Institute in March 2016.

Although the workshop was funded by OPRED, the regulator for the oil and gas industry, the scope of the workshop covered all noisy activities regardless of the industry.

3.1 BEIS OPRED

The regulatory framework relevant to oil and gas activities in the UK (The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001) was introduced, which includes regulations requiring written consent from the Secretary of State prior to carrying out a geological survey by physical or chemical means. In addition, the Regulations require the Secretary of State to make an appropriate assessment of the implications of proposed activities on the relevant site prior to granting any consent.

An amendment to the regulations in 2007 (The Offshore Petroleum Activities (Conservation of Habitats) (Amendment) Regulations 2007) extended the requirement for a consent to undertake geological surveys in waters between the low water mark and the seaward boundary of the United Kingdom Continental Shelf (UKCS) (typically 12 nm). Furthermore, the amended regulations introduced the requirement to obtain prior written consent from the Secretary of State for the testing of equipment to be used in geological surveys relating to oil and gas activities.

Oil and gas survey activities requiring consent in the UK include:

- 2D/3D/4D seismic survey
- Ocean bottom seismic survey
- Multiple Component 4C survey (shear wave)
- Sub-bottom profiler survey – pinger, sparker, boomer, Chirp
- Gravity survey
- Magnetic survey

- Vertical seismic profile (VSP).

Following consultation and advice from JNCC, the requirement to use PAM as part of the mitigation may be attached as a condition to the consent.

The number of surveys consented each year between 2014 and 2020 ranged from between 133 and 193, although a large proportion of these only required a notification and no consent was required. Of those that did require consent, the use of PAM was made a condition within the consent for up to 51 surveys per year.

3.2 JNCC

JNCC publishes guidelines detailing marine mammal mitigation required when undertaking geophysical surveys (JNCC 2017), piling activities (JNCC 2010a) and the use of explosives (JNCC 2010b). All these require the use of PAM during periods when visual observations are not practical (e.g. when dark or viability is restricted by bad weather).

The guidelines require PAM to be able to detect the range of frequencies of marine mammal vocalisations expected to be present within the survey area while acknowledging the limits of the method. However, it is recognised that currently there is no requirement to demonstrate the effectiveness of the PAM being used nor to report the conditions when it was deployed.

4 Session 1: Pre- and post-application reporting (Wednesday 3 March 12:30 – 14:00)

Currently, consent applications are not required to contain details of the PAM system that will be deployed during the proposed activity; therefore, a regulator cannot be confident the equipment to be used will be effective for the species of concern (e.g. adequate frequency range sensitivity). The submission of post-activity reports detailing the mitigation undertaken is standard procedure (referred to as the MMO report). However, there is no standard way of demonstrating that the PAM system used was effective.

This session comprised three presentations:

1. American National Standard – Towed array passive acoustic operations for marine mammal applications.
2. Passive Acoustic Monitoring Challenges and Improvements – A Historical Perspective.
3 The PAMGuard Signal Injection and Detection Evaluation (SIDE) Module.

4.1 Aaron Thode (Scripps Institute): American National Standard – Towed array passive acoustic operations for marine mammal applications

What does it mean if PAM does not detect something? PAM surveys may not be able to detect marine mammals due to background noise. A PAM towed behind a relatively noisy

vessel with a short cable will be less able to detect marine mammals compared with a PAM towed along a long cable from a relatively quiet vessel.

The American National Standard Institute designated the Acoustical Society of America to create standards on how PAM should be conducted during mitigation and when reported. Developing a standard has proven challenging and it is currently still at a draft stage. The PAM hardware used is constantly evolving and items that can impact on the effectiveness of PAM may be outwith the control of the PAM operator, meaning that developing standardised methods that can be implemented effectively across all PAM operations is not practical. However, certain activities that are within the control of the PAM operator can be broadly standardised (e.g. the calibration of hydrophones). The US has therefore focussed on the development of standardised reporting and developed detailed reporting requirements both for planning and validation. Tools have also been developed that can demonstrate the effectiveness of the proposed PAM to detect the relevant species. These tools allow the production of noise validation diagrams that clearly identify which species may not be detected by PAM during the proposed activities. They are now being developed into acoustic software which can provide an estimate of the probability of missing a detection by a towed array.

A number of subjects are not covered by the draft standards, and these include operator training and the need for professional certification, setting minimum detection ranges, sound source verification and operational shutdown criteria. This is because there is enough uncertainty over some of the biology and policy that make it inappropriate to try and develop standards on these topics at this stage.

4.2 David Hedgeland (International Association of Oil & Gas Producers (IOGP) Sound and Marine Life): Passive Acoustic Monitoring Challenges and Improvements – A Historical Perspective

Towed PAM was first trialled in the UK in 1998, with further trials in 2002 and 2003. Since then, PAM has been developed into a tool which is used routinely during geophysical surveys (and other noisy activities) as an accepted mitigation tool. However, the reliability and accuracy of PAM is frequently questioned.

The capability of PAM to detect marine mammals is limited by how the system is to be used as these will influence the system design and storage. The species predicted to be present with differing vocalisation characteristics will also influence the PAM system specifications. Ideally a PAM system will be able to detect all species but can be limited to within certain frequency ranges. Practical issues, such as the need for marine mammals to be vocalising in order for them to be detected is recognised to be a limitation when using PAM. Furthermore, operational factors such as the ability to deploy PAM depending on the type of vessel being used and the background sound levels will influence detectability.

The availability of experienced PAM operators that have the broad range of skills required to successfully operate PAM offshore can be limiting. Historically, PAM operators originate

from MMO backgrounds and lack the technical experience in bioacoustics, although this has improved in recent years.

The E&P Sound and Marine Life Joint Industry Programme supports research to help increase understanding of the effect of sound on marine life generated by the oil and gas industry. The programme covers a broad range of topics under five categories, one of which is mitigation and monitoring. The programme supported the development of PAMGuard software and to date there has been more than 143 peer reviewed publications originating from the programme.

4.3 Doug Gillespie (Sea Mammal Research Unit (SMRU)): The PAMGuard Signal Injection and Detection Evaluation (SIDE) Module

Is PAM working? How can we tell the difference between no animals present and the system not working? The PAMGuard SIDE module injects realistic sound into the live data and tests whether it is detected by either the automated detectors or the PAM operators. Equipment can be tested within minutes of the module being switched on, which allows the operator to test that the equipment has been set up appropriately. Alternatively, it can be left to produce random sounds over a period of time in order to test the efficiency of the operator.

Reports from the SIDE module produces results showing the efficiency of single sound detection and the efficiency of sound sequence detection and plots detection probability curves over distance for a range of cetacean groups.

4.4 Breakout Discussion: Session One

Each of the four break-out groups considered the level of information on PAM systems that could be included in applications and ways to standardise post-application reporting in a manner that can be understood by non-technical readers. Groups discussed the points raised during the session with several similar points made across each of the groups as follows:

4.4.1 Calibration of equipment

Each group discussed the importance of ensuring equipment is properly calibrated noting the different configuration requirements of different PAM equipment. It was recognised that there are issues surrounding the calibration of the PAM systems to ensure it able to detect all the frequency ranges for the cetaceans within the area. The whole system should be calibrated but when it is done will vary (i.e. onshore or offshore, and for how long). It was stressed that although the process calibration can vary enormously, calibrating PAM equipment is not straightforward, and undertaking calibration can be very costly and cause significant delays in either getting the equipment onto the vessel or the deployment of it once onboard.

A general view was that clear documentation on how a PAM system is set up, including how it is calibrated, should be part of the permit application.

On a similar point, it was asked whether future guidance should consider making recommendations on the quality of the hydrophones (i.e. should there be guidance on the type of hydrophones that should be used or a minimum specification). However, hydrophone technology is always improving (for example the use of volumetric arrays could help get better localisation) and keeping such guidance up to date would be problematic.

4.4.2 Competency of PAM operators

It was recognised across each of the groups that a good PAM operator should know how to install equipment and be able to determine an optimal set-up. Where two PAM operators are present it may be possible for the more experienced operator to verify and 'sign-off' the PAM set-up and deployment. However, typically there may only be the one PAM operator onboard and they will have sole responsibility of ensuring the equipment is deployed properly, set-up to work efficiently and to ensure that it is working correctly with limited support. When PAM operators are trained it must be more than just the use of the software, a practical component in the training is essential to be able to manage situations that could arise offshore. It is important that all PAM operators are suitably qualified and although there was general support about setting competency standards it was recognised that they are difficult to develop, bearing in mind that experience based solely on years does not necessarily equate into actual technical competency. The US has also considered including PAM training on the use of both the hardware and software as part of their standards and the development of training is being explored by the IMarEST (Institute of Marine Engineering Science and Technology) marine mammal special interest group.

Activities that require the use of PAM also require the use marine mammal observers (MMOs). It was suggested that by training all those involved in the marine mammal mitigation to be competent in both monitoring methods would ensure that there was adequate competency during a survey and the MMOs could provide support to the PAM operator if, or when, needed.

4.4.3 Adequate information in applications

The question was posed as to what information should be presented within applications in order to allow the regulators and Statutory Nature Conservation Bodies (e.g. JNCC) confidence that the deployment and use of PAM will be undertaken in a way that ensures that it is effective mitigation.

The onus is on the applicant to provide enough information to the regulator and the SNCBs on the PAM system proposed to be used, along with the methods of deployment and operation within the application. When preparing an application, it may be difficult to discuss specific PAM systems as the PAM operator may not have been selected by the client at the time the application was submitted. Furthermore, the equipment, vessels and personal may all change in the period between the application being submitted, consent being granted and the start of the activity, with not all requiring a license variation to be submitted and approved. An application could include minimum details that the system would meet, and

these could be included as consent conditions. Alternatively, a condition requiring further information to be provided post-consent could be considered if the required information isn't presented within the application. However, this increases the risk that an already consented activity is later delayed or refused, due to insufficient information or the proposed PAM system and operations being deemed to be inadequate at a late stage.

It was clear during the discussion that the planning of PAM is essential: understanding what species may be present, the appropriate PAM configuration should be clearly identified in all applications and the training and experience of each PAM operators should be presented.

4.4.4 Post-survey reporting

It is important that the post-survey report (the MMO Report) demonstrates that the PAM was used when required and was effective when used.

Post-activity reporting generally focusses on the number of detections but does usually provide some details of the deployment, although this often falls short of saying whether it was effective. One concern raised is that neither companies nor individuals want to highlight to their client there were any issues regarding PAM during their survey that could reflect negatively upon their own competency. Consequently, obtaining unbiased reports of when PAM was not working as effectively as it could or should have been, is challenging.

Concerns were raised over MMO reports being prepared by people who were not present on the activity. Furthermore, the templates that are available for the PAM operators to report what modules they have used are not always completed correctly and sometimes 'cut and pasted' from previous reports. There was a view that all reports should only be completed by those who were present during the activity and that the completion of the reports should be undertaken with greater care. Not all reports confirm whether systems were calibrated, and this should become a requirement.

It is very difficult for a PAM operator to demonstrate that the PAM equipment is working effectively. When PAM is being undertaken at the same time as visual observations are being carried out in suitable conditions it may be possible to compare the results from the two methods, which could help provide confidence that PAM is operating effectively. The recently developed PAMGuard SIDE module may also help verify that both the equipment and operator are working effectively. There were concerns over whether the fake detections produced by PAMGuard SIDE could be identified by the PAM operator as actual marine mammals and cause unnecessary delays in surveys. The use of this module is limited to one type of PAM technology and there are other technologies being used for which the PAMGuard SIDE is not designed for use with. Any future guidance should be written such that it does not inhibit the use of current technologies nor the development of new ones.

5 Session 2: PAM Deployment (Wednesday 3 March 14:30 – 16:00)

Deploying PAM systems can be tricky, especially when undertaken from moving vessels.

The session comprised one presentation, by Stephanie Barnicoat from Seiche (see Section 5.1).

5.1 Stephanie Barnicoat (Seiche): A summary of key PAM deployment issues and challenges

Projects require hydrophones that are sensitive to the vocalisation of all marine mammal species likely to be encountered in that area. The frequency response, sensitivity and the calibration of the whole PAM system is important. Although it is possible to have appropriate hydrophone and pre-amp calibration, this is not straight forward as it requires specialist equipment and calibrated reference transducers.

The Bureau of Ocean Energy Management (BOEM) intend to implement the upcoming Acoustical Society of America (ASA) / American National Standards Institute (ANSI) standard for towed PAM and require that at least one of each type of hydrophone channel in an array is calibrated. This will enable the regulator to assess whether the submitted PAM plan is suitable for use on a particular project and enable an assessment of PAM performance.

PAM operators are key to effective mitigation. They are generally on the vessel for most projects, but they can be on another vessel or operate PAM remotely from onshore. PAM operators require training and experience in collecting of all types of sound from different types of activity in a range of conditions and across different regions. PAM training also requires ensuring that the PAM operator is capable of meeting certain competences, including the ability to configure the PAM system and any associated modules, being able to detect marine mammal vocalisations and the location of the animals detected. Practical experience on the deployment of the cable, installing equipment and real time monitoring is also important. Ideally PAM operators would work in pairs which allows less experienced operators to work alongside and be mentored by an experienced operator. Onshore support is also important.

The deployment of PAM from a position on the vessel that avoids noisy areas is important for PAM to operate effectively. Propeller noise is the dominant source from vessels, accounting for between 80 to 85% of the noise. Many baleen whale vocalisations fall within the noise produced by propellers, making it challenging to detect them using PAM, particularly if using a towed array. Ambient noise from non-biological, biological and anthropogenic sources can also mask vocalisation by marine mammal vocalisation. Consequently, the PAM system must have a good signal to noise ratio, i.e. the ratio of signal amplitude (marine mammal vocalisation) to amplitude of noise. If the ratio is high then this increases the operator's ability to detect the vocalisation, if the ratio is low the ability to detect a vocalisation is reduced. Masking not only affects the ability to detect marine

mammals it also impacts on the automatic detectors and classifiers, which work best on target signals with a high signal to noise ratios.

The deployment of cables away from the stern of the vessel is important in reducing the risk of masking effects. However, on some surveys the PAM operator is not allowed to extend cables beyond 60 m or 90 m behind the stern. Ideally the cable should be extended to 200 m from behind the vessel in order to minimise the risk of masking. This requirement is a condition within some regulations (e.g. the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA)).

Deployment from the stern from seismic surveys is not always possible due to the risk of entanglement with the source umbilicals. To reduce the risk of entanglement, a sliding collar deployment can be used. This offsets the deployment of the cable away from the umbilicals and the propeller wash, thus reducing the risk of the cable becoming entangled. Alternatively, it is possible to deploy the cable with the source array, which significantly reduces the risk of entanglement and also benefits by being further away for the vessel noise and closer to the sound source.

Other ways of deploying PAM are possible for other types of activity, for example, vertical PAM can be undertaken from piling or support vessels where the sound source is stationary. The use of moored devices and unmanned surface vehicle can be run autonomously and may be useful in certain circumstances (e.g. where there are exclusion zones during unexploded ordnance clearance).

Technical issues arising offshore can stop PAM from being undertaken, thus removing it as part of the mitigation. For example, if the cable breaks and there is no back-up onboard, operations would be limited to periods where the visibility was good enough for visual observations only. It is therefore important to ensure that there are always back-ups onboard for all critical equipment.

5.2 Breakout Discussion: Session Two

Groups were asked to consider the questions posed by Stephanie at the end of her presentation. For the most part conversations focussed on having a standardised minimum deployment distance, although other topics were discussed.

5.2.1 For towed arrays, should guidance implement minimum deployment distance?

All four groups tackled this question and it was a key topic of discussion in this breakout session. There was variable support in having guidance that stipulates a minimum distance at which cable should be deployed, typically considered to be 200 m.

Vessel propeller and engine noise and vessel wash can mask detections and could be the most significant issue affecting detection of marine mammals using PAM. In particular, higher frequency detections (e.g. those from harbour porpoise) can be relatively easily masked, which may explain the lower number of detections for this species. To reduce the risk of masking, some countries (e.g. Brazil) require the hydrophone cable to be deployed

out to a minimum of 200 m from the vessel. It was recognised that even in areas where there was no guidance, extending the cable out to 200 m does occur. However, this was not always the case, suggesting that some form of guidance on this topic is required.

Most breakout groups reported instances where PAM operators have met resistance from the vessel operators over deploying cables out to 200 m and therefore had been required to deploy the hydrophone closer to the vessel. The deployment of cables closer to the vessel brings its own problems with noise from ship wash also capable of causing masking out to 500 m.

The main cause of concern over deploying longer cables appears to be in relation to concerns over the risk of entanglement, which can occur, particularly during geophysical survey line turns. Other concerns related to the availability of winches, which may not be present when undertaking PAM operations from smaller vessels. Having winches onboard allow the cable to be moved out of the way, if required, particularly at line turns which reduces the risk of entanglement. Points were also made about the increased distance from the sound source that can occur with increasing length of cable and the reduced potential to detect marine mammals that may be ahead of the vessel. Consequently, it may not always be either practical or necessarily best practice to have cables extending to 200 m behind the vessel.

Although there was general agreement across all groups that future guidance should address the issues surrounding minimum deployment distances, there were differing views as to whether the minimum distance should be specified and become a strict requirement, or a more general requirement based on ensuring optimal deployment as there will be occasions when it is not technically possible or desirable to meet a minimum distance of 200 m. However, it was recognised that finding an alternative safe minimum distance would be challenging. Furthermore, it can be very difficult to specify at the application stage what the optimal deployment position will be. One option proposed was the production of a Hydrophone Deployment Plan that could provide all the necessary information regarding the deployment of the hydrophones including confirming whether a minimum 200 m deployment distance would be achievable.

Can PAM gear be deployed from other vessels if the conditions are suitable? Chase boats may make better vessels for deployment both for technical reasons or as more effective mitigation in that they are usually ahead of survey vessels, and it is the animals that are in front of the vessel that are most important to detect. However, they also have technical issues when being used to deploy PAM and more obvious practical issues such as potentially having to leave the immediate vicinity of the survey when fulfilling their other activities. Although the use of alternative platforms could be considered in the early planning stages of a survey, there was a general view that in nearly all circumstance the deployment of PAM from the source vessel would be the better option, primarily as this will ensure the hydrophones are in close proximity to the sound source at all times and reduces the risk of PAM being operated beyond the range that it would be able to detect marine mammals within the mitigation zone.

5.2.2 Vertical PAM (VPAM)

Vertical PAM (VPAM) can be used during the decommissioning of wellheads, unexploded ordnance (UXO) clearance and pile-driving. Although it may be effective at detecting marine mammals it is not able to localise them. This is estimated based on PAM operator experience and is thought to be precautionary. Should the use of VPAM cause a delay in the start of activities or stop on-going ones there is a risk of any delay based on 'best judgement' being challenged by the client. Experience from those present suggest that this is a very uncommon occurrence but could occur. Consequently, it was suggested that future guidance could look to address how range is best estimated and what should be done in the event of a detection.

6 Session 3: when to use PAM (Thursday 4 March, 12:30 – 14:00)

PAM is typically used during periods of low visibility and at night, however what constitutes low visibility is not defined.

The session comprised one presentation, by Carolyn Barton (see Section 6.1).

6.1 Carolyn Barton: An overview of the existing use and effectiveness of PAM

Preliminary analysis of data presented in MMO reports for geophysical surveys undertaken between 1995 and 2019 in UK waters was presented, from which it is possible to identify when and how PAM has been used. Note, at the time of the workshop, the analysis of the PAM data was still undergoing analysis; consequently, it is possible that some of the initial findings presented at the Workshop may be different in the final report.

Since 1995, when the JNCC guidance on seismic surveys was first introduced, the proportion of seismic surveys using PAM has increased, with 96% of all seismic surveys undertaken in the UK during 2019 now having PAM as part of the mitigation package. Initial usage was predominantly in surveys undertaken in waters to the west and north of Shetland where deeper waters occur and species such as sperm whales are present. Over time, its usage has become more widespread, and PAM is now used throughout UK waters.

Before 2006, seismic airguns were started during the night without the use of PAM. Since then, its usage has increased and since 2017 there have been no occasions reported where airguns were started at night without the use of PAM. In poor day-time conditions (e.g. in sea state 6 or above, or visibility of less than 1,000 m), the use of PAM prior to starting airguns is less frequent, with PAM not being used in over half the occasions when it should have been in 2019. However, on 189 occasions between 2014 and 2019, PAM was the only mitigation used during daytime when conditions were poor (i.e. there was no usage of MMOs during these poor conditions). To some extent this may be due to having a minimal number of MMOs and PAM operators onboard.

Consent conditions may require PAM to be used in good daylight conditions to support the MMO observations, however such consent conditions are not common. Subsequently, there are a large proportion of occasions where PAM is not being used during good conditions and not being used to supplement visual observations. On 97% of such occasions, there has only been one PAM operator onboard and would therefore have required one person to operate PAM for 24 hrs per day if PAM had been operated in good daylight conditions.

JNCC guidelines require that the pre-shooting search is undertaken for at least 30 minutes before the soft-start begins in water depths of less than 200 m, and for 60 minutes in water depths of greater than 200 m. Since 2014, the number of occasions that these minimum durations have been met for PAM deployment at night have been consistently high, with compliance on over 96% occasions. During daylight hours, the conditions were met on less than 60% of occasions.

At dawn and dusk, an adequate pre-shooting search using either PAM or MMOs was carried out on more than 92% of occasions, with PAM more frequently used at dawn compared to dusk.

Comparing the detection rates between visual and acoustic methods shows that when all cetaceans are grouped, and when sperm whale and white-sided dolphin are considered separately, the number of visual observations were significantly higher compared to acoustic detections obtained from PAM. However, for all other cetacean groups/species there were no significant differences in the numbers detected. For detections within 500 m, visual observations are significantly higher for all cetacean groups, but this may be related to the relatively poor ability of PAM to record range. Overall, the number of acoustic detections was 1.14 per 100 hours compared to 3.20 per 100 hours from visual observations. Similarly, within the 500 m mitigation zone, acoustic detections were 0.26 per 100 hours and visual observations were 0.91 per 100 hours.

Data from between 2011 and 2019 show the number of detections by species or species group were far higher by visual observation compared with acoustic detections, with the exception being Delphinid Sp. where the number of sightings between the methods were broadly similar (623 visual sightings compared to 502 acoustic detections). In contrast, harbour porpoise was rarely detected acoustically, with only seven detections made between 2011 and 2019, and no acoustic detections of harbour porpoise made in UK waters since 2014.

The ability to estimate the range of a vocalising cetacean is limited with PAM, and no range was provided for over half the acoustic detections reported. The JNCC geophysical survey guidelines (2017) require a delay in the start of activities should they be within 500 m. It is therefore important to be able to estimate the range at which the cetacean is from the sound source. Of the 152 delays required due to the presence of marine mammals, 29 were caused by acoustic detections only. On another four occasions, acoustic detections were made with no range estimate provided and no delay in the starting of the airguns. When delays were undertaken 89% were implemented correctly.

Reported issues arising from the use of PAM include noise interference, deployment challenges, damage to equipment, entanglement, unable to deploy due to weather and effective coverage of the 500 m mitigation zone.

6.2 Breakout Discussion: Session Three

Groups were asked to consider the issues raised in the presentation. Three themes arose during the discussions: PAM operating conditions, PAM's ability to detect cetaceans and estimate their range, and PAM resources.

6.2.1 PAM operating conditions

It was recognised that clear terminology and definitions were required in any future guidance as to what would be considered to be 'poor' conditions, whether that was in a sea state of 6 or more, within 20 minutes of sunrise or sunset, reduced visibility within the mitigation zone. The guidance should be clear an unambiguous and consent conditions could state the precise conditions that PAM must be used in.

Many of those present at the workshop supported the idea of having PAM operating 24 hours a day, something which is a routine requirement elsewhere. This would increase the probability of detecting cetaceans and therefore strengthen the mitigation and reduce the need to consider whether conditions were poor or not. Furthermore, having simultaneous visual and acoustic detections may help improve or validate PAMs ability to estimate the range at which the cetacean is from the noise source. However, there were concerns over limited space onboard survey vessels for a second PAM operator and therefore it may not always be practical to do so.

6.2.2 Detectability and Localisation

Surprise was expressed at the data showing significant differences in the number of detections compared to observations. This could be due to poor PAM deployment or PAM training. Also, it should be recognised that, for some species, PAM is not as effective at detection as visual observations, in particular minke whale and harbour porpoise. However, other reasons provided as to why these differences in detectability could occur included that it might be expected that cetaceans will predominantly be swimming away from a loud sound source, such as an airgun. In such cases their vocalisation will be away from the hydrophone receivers and the cetacean will less likely be detected; the direction a cetacean swims has less of an effect on whether it is visually observed.

There was a lot of discussion in all four groups about the ability of PAM to estimate the range at which the detected cetacean was from the hydrophones. Range estimations are very difficult, and the estimates should be considered as best estimates. But the estimates can be improved with adequate training and experience.

There appears to be no common method on how detections from PAM are determined to be within the mitigation zone. Some PAM systems have modules to support localisation which may help in determining ranges of detected cetaceans, but they may only be effective on certain species. It was commented that it is important to report on whether the estimated range is based on an operator estimation or from a module calculation. There is potential for technology to improve range measurements but currently there is no significant driver to do so and therefore technical improvements that could improve this situation are not being proactively developed.

There was also a suggestion that a similar review of data from other industries (e.g. pile-driving by offshore wind farms and UXO clearance) would be useful, to see if similar issues were being identified from these other activities. As the noise sources are different from those arising from a seismic survey and the PAM methods used during these other activities may also differ, then it is possible that there will be different detection rates compared to those from seismic surveys.

It was suggested that future guidance should address the question on what should happen if an animal is detected but the range is unknown. When this situation arises should there be a delay in the commencement of activities.

6.2.3 PAM resources

The presentation highlighted the importance of ensuring that there were enough PAM operators onboard to ensure that the usage of PAM met the consent conditions. Where there was only the one PAM operator there was an increased risk that the consent conditions would not be met. Currently, in the UK the consent conditions may stipulate the number of MMOs that are required but this is not usually the case for the number of PAM operators. It is common for PAM operators to be advised that there is limited bunk space on a vessel and room for no more than one operator. If, as the data indicate, JNCC guidance and consent conditions are not being met with the current level of resources, then future guidance could stipulate that there must be dedicated PAM operators for both and day and night operations and these could be enforced through a consent condition. An alternative could be for a PAM operator to work remotely from shore. This reduces the number of PAM operators needed onboard the vessel and is currently being undertaken in the Gulf of Mexico. However, it does require a dedicated and suitable bandwidth for it to work effectively and may require a back-up connection in the event that the connection to the vessel is broken. It will also require the PAM operator onboard to be fully trained in the complete PAM system, in the event that something goes wrong. Future technology using automated detection systems may allow for a reduced presence of PAM onboard and at the same time reduce the potential for operator error to occur.

Concerns were also raised over whether the PAM operators and MMOs onboard the vessel were always provided with the relevant permits and plans within which the relevant conditions were stipulated. Although it is stated in the current geophysical survey guidance (2017) that these should be provided prior to the start of the survey, they were not always available, if at all, until later in the cruise. It was felt important that PAM operators/MMOs should have site of the conditions in order to reduce the risk of non-compliance issues. Future guidance should ensure that clients provided the necessary documents prior to the start of the survey. Updating the MMO data forms could include the question on whether all documentation was supplied within an appropriate timescale.

6.2.4 The need for guidance

Throughout all three sessions and across all four groups there was a general feeling that guidance relating to the use of PAM would be beneficial. PAM is also only one part of an overall monitoring package but is the only system that can detect cetaceans underwater and is of particular importance for the detection of beaked whales and sperm whale.

It was recognised that producing guidance would be challenging but by doing so it would allow a set of standards to be developed that all those undertaking PAM would be required to meet, thus ensuring a consistency across the industry. Guidance would also benefit those operating PAM offshore by specifying the boundaries within which the system must be working, which could also be presented to clients if required. This could be enforced through licence conditions. However, there were concerns raised over any guidance being too prescriptive. Guidance should recognise that systems should be deployed optimally and that no one size fits all; alternative methods of deployment or technologies can be used. The guidance should also be aware of future changes in technology. For example, there will be changes in how seismic surveys will be carried out with the potential increase in the use of e-seismic, which produce different and lower sound levels than traditional air-gun arrays.

Many countries already have guidance on the use of PAM and a review of these could help in formulating the UK guidance. PAM guidance could be made suitable for all industry sectors. Although specific details on PAM usage may differ across industries, there are many activities requiring PAM that all offshore industries undertake and therefore it is important to ensure that the same PAM standards apply to all sectors. When new guidance is developed a transitional period may be required in order to provide a suitable time for it to be fully adopted by the industries.

7 Session 4: Round-up session and next steps (Thursday 4 March 14:15 – 15:45)

A round up of the key points from each discussion topic and an overview of the next steps. This session was an open discussion for all those that attended to raise comments on any of the subjects touched upon during the previous three sessions. The topics discussed in this session are outlined below.

7.1 The need for guidance

There was broad agreement that there was a need for guidance and the development of standards on the usage of PAM in the UK. This workshop was a good initial step in the preparation of guidance and provided an opportunity for those involved in the usage of PAM as a mitigation tool to input their thoughts and ideas on developing standards and any future guidance. Those developing the standards and drafting the guidance should ensure that they are not overly prescriptive, recognising the known limitations of the technology and the challenges faced when deploying and operating PAM systems.

7.2 Early Planning

Careful and early planning on the use of PAM during any survey is essential. Survey companies and other clients should not see it as a last minute ‘bolt-on’ to their other activities, but as an integral part of the survey operations. Greater integration of PAM operators / MMOs into the survey design at an early stage would help facilitate this. Planning should allow the early identification of any issues that might arise over the deployment and use of PAM equipment that could reduce its effectiveness once the survey

has commenced. It will identify the most appropriate PAM system to be used specific to the survey and allow systems to be deployed optimally for each survey. Providing accurate and detailed information within the application, including a hydrophone deployment plan, increases confidence that the PAM will be effective as a mitigation tool. However, at the time an application is submitted details of the PAM system to be used may not be available and this information may need to be supplied at a later date.

7.3 Calibration

The need for calibration of the PAM equipment is recognised to be important but the challenges of undertaking it should not be underestimated.

7.4 Training

The training of PAM operators is recognised to be an important component in ensuring that PAM is deployed and operated effectively. The development of a passport/logbook system that presents the experience of each PAM operator could be useful in ensuring suitably qualified and experienced PAM operators are being used. This has been considered in the USA where the principle of having a passport system is widely supported. However, the differing views amongst the stakeholders on the level of information required to be included within the passport has stalled its development. Similarly, this has also previously been considered for use by MMOs in the UK, where the same issues have arisen. Developing a passport system that meets everyone's expectations on the level of information that should be included has not been achievable so far. There are also practical issues regarding the development, implementation, and maintenance of a passport system.

7.5 Range determination

Determining the range at which the detected cetacean is from the hydrophones is challenging. Improving hydrophone technology or the deployment of more hydrophones could improve the ability to determine ranges but would also increase the risks of entanglement. Better collaboration between those developing the hardware and those developing the software could help in improving PAM systems, including their ability to determine ranges.

7.6 24-hour PAM operations

Continuously operating PAM over 24 hours would increase the number of overall detections and remove any uncertainty over whether conditions were 'poor'. To do this though would require an additional PAM operator located either on the vessel or remotely. If the PAM operator is onboard the vessel this would require additional bunk space, which isn't always available. The JNCC recommendations on the number of PAM operators required are proportionate to the risk arising from each survey and these will vary depending on the geographical location and time of year. Requiring continuous PAM usage may not always be proportionate to the risk and therefore may not always be required. If PAM is not being operated 24-hrs, there needs to be clearer definitions on what would be considered 'poor'

conditions when PAM should be being used. This would help the PAM operator to determine when PAM should be being used.

7.7 Personnel

PAM operators typically work alone over 12-hour shifts, compared to an MMO who may typically work 2–3 hour shifts before having a break. Continuously working for 12 hours increases the risk of PAM operators missing detections due to fatigue. Future recommendations could emphasise that it is only a requirement to monitor for cetaceans for 30–40 minutes prior to the start of the soft-start and for the duration of the soft-start. Therefore, under normal operating conditions, it should be expected that a PAM operator does take suitable breaks to minimise the risk of fatigue. However, there is a balance to be had between taking suitable breaks and the value in obtaining additional data outwith the critical periods and the importance of obtaining data should also be encouraged. One potential way to improve the situation would be to have MMOs / PAM operators equally competent in undertaking both roles. This would allow the MMOs / PAM team onboard to interchange between the roles, allowing greater flexibility in the hours worked, ensuring suitable coverage is available during breaks and potentially improving the overall performance of the monitoring being undertaken.

7.8 New Guidance

It should be recognised by all those involved in the new guidance that transition takes time. There needs to be recognition that implementing any new standards or guidance will not happen overnight and a realistic period of time should be identified during which any new requirements can become embedded into operating and reporting practices.

7.9 Next steps

JNCC summarised the next step. The plan is to produce a summary report of this workshop which will be made available via the JNCC website. Once completed work will start on preparing the draft guidance, which is aimed to be ready for public consultation towards the end of 2021. Following consultation, the final guidance document will be prepared and published on the JNCC website alongside the marine mammal mitigation guidelines.

8 Concluding remarks

The workshop provided an opportunity for OPRED and the JNCC to discuss with interested stakeholders' key issues surrounding the use of PAM as a mitigation tool during offshore activities. Nearly one hundred individuals from at least six countries participated in the workshop. These individuals had a very broad range of experience with people from governments, government agencies, scientists, PAM operators and industry all attending.

The format of the workshop allowed for an interactive opportunity to fully discuss, beyond the initial questions posed, the issues surrounding the usage of PAM and how best to develop suitable standards and guidance. As a result of the workshop, OPRED and JNCC

gained valuable knowledge and improved understanding on the issues regarding PAM and clear ideas on the key subjects that should be considered in any future guidance. It is hoped that all those attending the workshop also gained an improved understanding from the shared knowledge.

OPRED and JNCC would like to thank all the presenters who willingly spent their time sharing their knowledge and all those that participated in the workshop helping to develop future standards and guidance.

Appendix 1: Workshop Agenda

Project background

In the UK there are currently no agreed standards or guidelines for how PAM should be used as part of a mitigation programme, or for reporting its effectiveness. In addition, information on the equipment to be used and its appropriateness is rarely provided in licence applications.

As part of ongoing work to improve and update marine noise mitigation standards in the UK, JNCC contributed to workshops organised by Scripps Institute of Oceanography in the US to contribute to the development of minimum standards for PAM used as mitigation in offshore industries such as oil and gas and renewables. Their aim is to develop an American National Standards Institute (ANSI) standard in collaboration with the Acoustical Society of America. The BEIS/JNCC workshop is to consider aspects of the US work in a UK context, with a view to developing guidance on deployment and reporting for both static and towed PAM systems.

Overall project aim

To improve and standardise the deployment, effectiveness and reporting PAM use as mitigation by offshore industries; to ensure equipment used is appropriate and effective.

Objective of workshop

To collate stakeholder opinion to inform the development of PAM guidance.

Format of the Workshop

The workshop will be held remotely using Microsoft Teams and spread over two days. There will be four session in total, three discussion sessions, each with a presentation to introduce the topic and a final round-up session. Following each presentation, the workshop attendees will be divided into groups and join remote breakout sessions to discuss the topic presented.

Session 1: Pre- and post-application reporting
Wednesday 3 March, 12:30 – 14:10

Currently, licence applications do not contain details of the PAM system that will be deployed during the proposed activity therefore a regulator cannot be confident the equipment to be used will be effective for the species of concern (e.g. adequate frequency range sensitivity). The submission of post-activity reports detailing the mitigation undertaken is standard procedure (referred to as the MMO report) however there is no standard way of demonstrating that the PAM system used was effective.

Presentations:

- Aaron Thode (Scripps): Overview of ASI towed array passive acoustic standard.
- David Hedgeland (BP): Industry perspective and overview of relevant IOGP Sound & Marine Life JIP projects.
- Doug Gillespie (SMRU): Overview of PAMGuard module.

Breakout Discission: Groups to consider/discuss the level of information on PAM systems that could be included in applications and ways to standardise post-application reporting in a manner that can be understood by non-technical readers.

Session 2: PAM deployment
Wednesday 3 March, 14:30 – 16:00

Deploying PAM systems can be tricky, especially when undertaken from moving vessels.

Presentation:

- Stephanie Barnicoat (Seiche): PAM deployment: issues and challenges.

Breakout Discussion: Groups to consider what are the key issues faced when deploying PAM systems and areas where guidance can be developed.

Session 3: When to use PAM
Thursday 4 March, 12:30 – 14:00

PAM is typically used during periods of low visibility and at night, however what constitutes low visibility is not defined.

Presentation:

- Carolyn Barton: An overview of the existing use and effectiveness of PAM

Breakout Discussion: Groups to consider circumstances when it is appropriate to use PAM and what guidance should be produced. Also, to consider potential circumstances or areas where PAM should be used alongside visual observations.

Session 4: Round-up session & next steps
Thursday 4 March, 14:15 – 15:45

A round up of the key points from each discussion topic and an overview of the next steps.

Workshop follow-up

Once complete, a report will be produced detailing the discussions and opinions presented at the workshop. JNCC will use this report to draft guidance which will be offered for public consultation. The draft guidance will then be finalised and sit alongside the existing mitigation guidelines.