JNCC guidelines for minimising the risk of injury to marine mammals from geophysical surveys

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Introduction

It is recognised that sound generated from geophysical survey sources has the potential to cause injury (e.g. hearing damage) to marine mammals (cetaceans and seals). Seismic surveys in particular (although not limited to) have the potential to result in a deliberate injury offence as defined under UK regulations[1] to European Protected Species[2] (EPS). "Deliberate" has been interpreted in European Commission guidance as “actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action”[3]. Therefore, anyone carrying out certain activities which they should reasonably have known could cause injury as in the regulations could be committing an offence.

The mitigation measures outlined in these guidelines have been adopted as part of the consenting regime for geophysical activities within the United Kingdom Continental Shelf (UKCS) to reduce the risk of deliberate injury to marine mammals. These guidelines were originally written with the oil and gas industry in mind, however since their conception the use of geophysical technology by other industries in the marine environment has grown. Subsequently, any geophysical survey that has the potential to result in injury to marine mammals should apply the mitigation measures outlined in these guidelines (or an alternative as agreed with the relevant Regulator). Whilst the mitigation measures in these guidelines have some limitations and their effectiveness has not been and may not be able to be fully tested, they are based on reasonably conservative assumptions. It is considered that compliance with these guidelines constitutes best practice and will, in most cases, reduce the risk of deliberate injury to marine mammals to negligible levels.

The focus of these guidelines is marine mammals, however they could be adapted to help reduce the risk of deliberate injury to other marine species if deemed appropriate by the relevant Regulator. For example, other potentially sensitive species include marine turtles, also listed as EPS, and several shark species including basking shark which are UK priority marine species[4].

JNCC has no objections to these guidelines being used in other territories, however we would encourage all operators determine if any special or local circumstances apply, as these guidelines are not intended to be used where local mitigation guidance has been adopted.

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[1] Regulation 41(1a) of the Conservation of Habitats and Species Regulations 2012; Regulation 39(1a) of the Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2012; Regulation 34(1a) of the Conservation (Natural Habitats, &c.) (Amendment) Regulations (Northern Ireland) 2015; Regulation 39(1a) of the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (as amended); Regulation 10(a) of the Offshore Petroleum Activities (Conservation of Habitats) Amendment Regulations 2007.

[2] Species listed on Annex IV of the Habitats Directive2 and in UK waters includes all cetacean species

[3] Section 1.2.1 in The protection of marine EPS from injury and disturbance (JNCC et al., 2010)

[4] http://jncc.defra.gov.uk/page-5167

The following document has been divided into three sections:

- **Section 1**: Background information to assist with survey planning;
- **Section 2**: Mitigation guidelines;
- **Section 3**: Reporting.

Appendix 1 includes a glossary of the terminology used within these guidelines, Appendix 2 provides further details on reporting requirements and Appendix 3 the compliance advice form. In addition, a separate JNCC Guidelines Frequently Asked Questions (FAQ) document is available, which should be read alongside the guidelines[5].

These guidelines were originally prepared by a working group convened by the then Department of the Environment. They have subsequently been reviewed four times by JNCC following consultation with relevant stakeholders. In addition to comments received from stakeholders, the current revision has also considered the 2015 review of marine mammal observer (MMO) data and compliance (Stone, 2015 a and b), new research into potential impacts to marine mammals from anthropogenic noise and new developments in geophysical and monitoring technology.

[5] http://jncc.defra.gov.uk/marine/seismic_survey

Section 1: Planning

The following information is provided to assist personnel involved with geophysical surveys, however should not be seen as definitive advice. When planning a geophysical survey, the applicant should identify and contact the appropriate Regulator and Statutory Nature Conservation Body(s) (SNCB) for specific survey advice as required.

Current UK Regulators, to which these guidelines could be relevant, include the Department for Business, Energy and Industrial Strategy (BEIS)[6], the Marine Management Organisation, Marine Scotland, Natural Resources Wales (NRW), Department of Agriculture, Environment and Rural Affairs (DAERA) and the Planning Inspectorate (PINS). The SNCBs are JNCC (offshore waters), Natural England (English territorial waters), Scottish Natural Heritage (Scottish territorial waters), Natural Resources Wales (Welsh territorial waters) and the Department of Agriculture, Environment and Rural Affairs (Northern Irish territorial waters).

1.1. Consent

It is the responsibility of the organisation planning a geophysical survey (referred to as the applicant) to assess the potential for a deliberate injury and deliberate disturbance[7] offence because of their survey and if the survey will occur within or near any Marine Protected Areas (MPAs), for example SACs. The applicants' assessment will be reviewed by the Regulator and appropriate SNCB(s) on a case by case bases. Further assessment (i.e. Habitats Regulation Assessment) and licensing requirements (i.e. EPS licence) may be deemed necessary by the Regulator.

The SNCBs have provided guidance on '*The Protection of Marine European Protected Species from Injury and Disturbance*' which can assist with applications within English and Welsh territorial waters and the UK offshore marine area. To obtain a copy of the latest version, please contact JNCC. Further EPS guidance for Scottish territorial waters has been produced by Marine Scotland (Marine Scotland, 2014).

The standard radius of the mitigation zone referred to in these guidelines is 500m**.** If during the environmental risk assessments submitted during the application process the potential injury zone is estimated to be different from 500m, the size of the mitigation zone can be adjusted by the Regulator if necessary**.** Alternative mitigation zone sizes can also be proposed by the applicant during the application process, but require a clear rationale, potentially some noise propagation modelling to justify any proposed changes. If mitigation measures discussed within these guidelines are not practical because of changes to mitigation zones, this should also be discussed within the application and alternatives suggested. For advice regarding noise thresholds to be used as part of any assessment, please refer to the EPS guidance and contact the appropriate SNCB(s).

[7] While these guidelines to not deal with disturbance directly, it is considered the mitigation measures contained may assist in reducing potential disturbance.

Typically, any survey consent issued will include a general consent condition that these mitigation guidelines are followed. Furthermore, key elements of the guidelines of particular relevance to the survey in question may also be incorporated as detailed consent conditions by the Regulator. It is the Regulator who ultimately outlines the final consent conditions for an application (taking account of SNCB(s) advice during the consultation), and not the SNCB(s) themselves.

It is the responsibility of the company issued consent (the applicant) to ensure these guidelines are adhered to. Compliance with these guidelines is also usually a condition of any EPS license issued.

Not all geophysical surveys across different industry sectors are subject to a formal consenting process i.e. some surveys require notification (to the Regulator) only. However, the mitigation principles outlined in these guidelines should still be considered and applied where appropriate. The organisation undertaking the survey is still required to determine whether an offence of deliberate injury (and disturbance) may occur because of the survey and apply appropriate mitigation to reduce the risks. Attention should be paid to surveys occurring in MPAs (Section 1.3).

1.2. Survey considerations

The applicant is expected to make every possible effort to design a survey that minimises the sound generated and the likely impacts to marine mammals. Early consultation with the appropriate Regulator and SNCB(s) is encouraged, particularly for situations not specifically covered in these guidelines. Discussions on the use of new seismic techniques or mitigation measures are also welcomed.

When planning a geophysical survey, the following should be considered:

- Use the lowest practicable power levels needed to achieve the survey objectives and seek / consider methods to reduce and or buffer unnecessary high frequency noise produced.
- Airgun firing (including testing) must not occur at any time above the maximum production volumes outlined in the consent conditions.
- Determine what marine mammal species are likely to be present in the survey area and identify if the survey is to occur within or near an area of importance for marine mammals (See Section 1.3). Assess the likelihood of deliberately injuring or disturbing marine mammals and include this assessment as part of the application or notification.
- Assess any seasonal considerations, for example, seal pupping, migration periods and routes and seasonal considerations in MPAs. When possible, plan surveys to avoid areas/ periods of high abundance and key seasons.
- Consider the direction of survey lines and distance to sensitive areas and coastline to reduce any potential for entrapment (i.e. prevent animals being trapped between the vessel and shoreline).

- Ensure sufficient MMO and Passive Acoustic Monitoring (PAM) operatives are employed, considering, for example, the size and location of the survey, the number of line turns and hence soft starts required, daylight hours and requirement for night-time operations. It is the applicant's responsibility (as they hold the consent) to ensure sufficient personnel are provided to prevent observer fatigue and meet Health and Safety requirements. SNCB(s) will recommend a minimum number of personnel, not maximum.
- Reliable lines of communication must be achieved between the MMO/PAM operatives and the crew. Copies of the consent (once available) and any other relevant documentation (electronic or paper) must be provided to the MMO/PAM operatives in sufficient time before any operations begin (Note: this is a condition of consent issued under the Offshore Petroleum Act).
- PAM should be used during periods when visual mitigation is not possible (e.g. darkness, low visibility). Operations should be delayed until conditions improve, unless an alternative method to visual surveys, such as PAM, is available and can be deployed.
- The PAM equipment chosen should be appropriate for the UK marine mammal species most likely to be found within the survey area in question. Options for PAM deployment should also be considered early within the planning stage to ensure it is used effectively (i.e. discuss with equipment supplier/ PAM operative etc.).
- Incorporate pre-shooting surveys and soft-starts into survey design. Where practical, time operations to commence during daylight hours to ensure visual mitigation by MMOs can be undertaken. If this is not achievable, note above points on PAM mitigation measures.
- When vessels are time-sharing, i.e. where two or more vessels are operating in adjacent areas and take turns to shoot to avoid causing seismic interference with each other, the guidelines must be applied on all vessels involved and clear communication channels are required to ensure effective mitigation between vessels.
- If dual source arrays are to be used, particularly if they are to be operated simultaneously rather than in an alternative manner (e.g. flip flop mode), the application should estimate the mitigation zone required to encompass the entire array and from where this distance is to be estimated (i.e. centre point between the two arrays). Any proposed alteration to the standard mitigation zone should be made clear in the in the survey application.
- No equipment testing should be undertaken outside of the consented operational area (or greater working area as defined in some applications).

1.3. Areas of importance

Areas of importance can be defined as discrete areas of important habitat to marine mammal species. These have the potential to be delineated and managed for conservation. Ultimately such areas could be designated as a Marine Protected Area (MPA), which in UK waters include:

- Special Areas of Conservation (SAC), designated under the EC Habitats Directive for habitats and species identified on Annex I and II respectively;
- Marine Conservation Zones (MCZs), created under the Marine and Coastal Access Act (MCAA) 2009 with the aim of protecting nationally important marine wildlife, habitats, geology and geomorphology in English and Welsh territorial and UK offshore waters; and
- Nature Conservation Marine Protected Areas (NC MPAs), created in Scottish seas under the Marine (Scotland) Act 2010 (inshore) and the MCAA (offshore) to conserve some of Scotland's most important marine wildlife, habitats and geodiversity.

With regards to survey applications, all proposed, possible and candidate MPAs are a material consideration within the consenting process.

All MPAs with a marine mammal species as a qualifying feature are considered an area of importance within the context of these guidelines. Consultation with the appropriate Regulator and SNCB(s) at the earliest opportunity is recommended when considering surveys within or near these areas. Additional mitigation requirements for operations in these areas may be required (e.g. combined use of MMO and PAM during daylight hours). Any requirement will consider (as a minimum) the size, duration and timing of the survey and the species most likely to be impacted.

West of Shetland

In addition to MPAs, the deep waters to the west of Shetland are considered an area of importance. Although this area does not currently have legal protection, the area is considered important for a variety of species, including some which do not occur elsewhere in UK waters i.e. deep diving species such as beaked whales and sperm whales. As such, variations to standard mitigation procedures (i.e. 60min pre-shooting searches) are implemented in this area (Section 2.1.2.1.1). Additional requirements such as the use of PAM to maximise detection potential may also be considered i.e. deep diving species are difficult to observe by visual mitigation methods alone.

1.4. Visual and Passive Acoustic Monitoring

The primary aim of these guidelines is to reduce the potential of deliberate injury occurring to marine mammals by monitoring a defined area (mitigation zone) prior to a noise source being switched on and delaying operations should a marine mammal be observed. Monitoring is achieved through a combination of visual and passive acoustic methods. No one method of detecting marine mammals is 100% effective for all species, rather it is considered that these methods seek to complement each other.

Visual monitoring is undertaken by a Marine Mammal Observer (MMO)[8]. It should be undertaken from the source vessel with the MMO located on a suitable platform enabling the best view of the mitigation zone and ahead of the vessel. It is acknowledged that weather conditions influence an observer's ability to visually detect marine mammals (e.g. Hammond

[8] Note the distinction between this mitigation role and that of a marine mammal surveyor (MMS), who undertakes surveys for research or monitoring purposes and may employ different monitoring techniques and survey methods.

et al., 2013; Northridge *et al.,* 1995), as does available daylight. Consequently, visual monitoring should be restricted to periods of good visibility and only be undertaken during daylight hours.

The use of **Passive Acoustic Monitoring** (PAM) was incorporated into the JNCC guidelines as a form of mitigation in 2002 and has been increasingly used as a tool for monitoring marine mammals during night time and poor visibility conditions. Specialist trained PAM operatives are needed to set up and deploy the equipment and to interpret detected sounds. It is acknowledged that current PAM systems are not suitable for detecting seals and some cetaceans (i.e. baleen whales) and has limited range for others (i.e. high frequency cetaceans). However, Stone (2015b) considered it a viable monitoring method during periods when effective visual monitoring is not possible.

Whichever PAM system is used it should be capable as much as possible of the following:

- Detecting the range of frequencies of marine mammal vocalisations expected to be present in the survey area;
- Detecting and identifying vocalising marine mammals and establishing bearing and range in a reasonable period of time;
- Immediately communicate relevant information to the PAM operator (real time) so appropriate and timely mitigation measures can be undertaken (i.e. delay soft start);
- Being repaired on board or replaced in case of breakdown (i.e. appropriate repair tools and backup equipment).

1.4.1. MMO/PAM Operative role during surveys

The role of an MMO/PAM operative is to detect marine mammals as part of the mitigation procedures and to advise a delay in the commencement of activity should any marine mammals be detected within the mitigation zone. This is to reduce the potential for deliberate injury to occur and ensure the survey complies with its consent conditions. Ultimately, however, it is the applicants' responsibility to ensure consent conditions are adhered to, noting the advice provided by the MMO/PAM operative(s).

MMO and PAM operatives should be equipped with an up-to-date copy of the JNCC guidelines and recording forms. The recording form is an Excel spreadsheet with embedded worksheets. Word versions of the spreadsheets named 'Deckforms' are also available which operatives may prefer to use before transferring details to the Excel spreadsheets. All forms, including a guide to completing them, are available on the JNCC website[9].

MMOs should be equipped with binoculars and a tool to estimate distance i.e. range finding stick or binoculars with reticles. The ability to determine range is a key skill for MMOs and a proven tool for distance estimation should be used. For these guidelines, the use of the "most appropriate method" for the survey and observer in question is recommended. Instructions on how to make and use a range finding stick are available on the JNCC website[9].

[9] http://jncc.defra.gov.uk/page-1534

Both the MMO and PAM operative should ensure their efforts are concentrated on the mitigation periods, i.e. the pre-shooting search and soft-start time periods and observing until the survey line has started and data acquisition has begun. The guidelines should not be interpreted to imply that MMO/PAM operatives should continue a visual/ acoustic search during all available hours, unless specified as a survey consent condition. MMO/PAM operatives should manage their time to ensure that they are available to carry out their duties to the best of their ability during the mitigation periods as outlined above. Whilst JNCC appreciates the efforts of MMO/ PAM operatives to record valuable data at other times, this should be managed to ensure those observations are not detrimental to their ability to undertake duties during mitigation periods.

In addition to conducting visual/ acoustic searches, the MMO/PAM operatives will advise the crew on the procedures set out in the JNCC guidelines and provide advice to ensure the survey programme is undertaken in accordance with the guidelines and survey consent conditions. It is essential that MMO/PAM operatives are provided with a copy of the survey consent conditions and any additional information required. In many cases this will be a condition of survey consent (i.e. all consents issued under the Offshore Petroleum Activities (Conservation of Habitats) Regulations). It is also recommended that MMO/PAM operatives attend pre-mobilisation meetings, to discuss working arrangements and their role while on the vessel.

1.4.2. Training

All MMO and PAM operatives are required to be trained.

For a MMO to be classified as trained, the individual must have undertaken formal training on a JNCC recognised course[10] plus have some experience of visually spotting marine mammals[11]. This experience need not be gained while implementing the JNCC guidelines, i.e. can be from other types of at sea survey work. Key to the MMO role is the ability to spot marine mammals within the mitigation zone, however, as mitigation within UK waters is required for all marine mammal species, identification to species level, while preferred, is not essential.

Currently, JNCC do not approve any PAM courses[12], however, a number of training courses are available covering both basic hardware and the use of specialist software. As a minimum a PAM operative should be able to assemble and deploy PAM equipment, configure the software and identify acoustic signals and bearing information.

1.4.3. Experience

An experienced MMO[12] should have a minimum of 20 weeks' experience of implementing JNCC guidelines in UK waters obtained within the previous ten years, preferably within the previous five. Furthermore, they will be experienced at identifying UK marine mammal species (visually and/ or acoustically depending on the role) and be familiar with their behaviour.

[10] Further information on accredited course providers is available at: http://www.jncc.gov.uk/page-4703.
[11] Note: level and form of experience will be considered alongside a general review of training requirements.
[12] Discussions are currently underway to identify minimum standards for the use of PAM as a mitigation tool, including operator training requirements. Further information will be published once available.

We recommend newly qualified MMOs and PAM operatives do not work in isolation for their first few jobs (i.e. are not the sole MMO/ PAM operative on board a vessel). Rather they work alongside experienced personnel who can act as mentors while they gain experience of implementing the guidelines.

The use of experienced MMO and PAM operators is essential in areas of importance for marine mammals.

1.4.4. Recommended requirements for MMOs and PAM operatives

JNCC will recommend to the Regulator a minimum number of MMOs required for each application, and whether PAM should be a requirement rather than recommended together with the recommended minimum number of PAM operatives. This will take into account, as a minimum, the survey location, duration, time of year, maximum airgun volume and species sensitivities.

In addition, MMOs will be referred to (by JNCC) as either:

- **Dedicated:** A trained MMO who is employed for the sole purpose of undertaking visual observations to detect marine mammals and advising on and monitoring the implementation of the guidelines. They are not normally a member of the vessel crew (i.e. are a sub-contracted professional).

  Dedicated MMOs have higher sighting rates than non-dedicated MMOs and supply higher quality data (Stone, 2015b). They also have the advantage of being quickly available outside of the mitigation periods. For example, they can search for marine mammals during operations[13] and advise if any marine mammals are present in the area if operations unexpectedly stop for technical reasons and need to start up promptly after the problem is solved. This can reduce the need for additional pre-shooting searches and soft starts (see below for further details).

- **Non-dedicated**: A trained MMO who may undertake other roles on the vessel when not conducting a mitigation role. This person can be a member of the rig's or vessel's crew providing they do not undertake other roles during mitigation periods.

  These are typically recommended for short surveys using low energy sources e.g. some vertical seismic profiling (VSP), sub-bottom profiling or when using a total airgun volume equal or less than 180 cubic inches.

Given the specialist nature of the PAM operative role, it is expected they will be a sub-contracted professional whose sole role on the vessel is to operate the PAM system i.e. all PAM operatives will be dedicated.

It is the applicants' responsibility knowing the specific requirements and logistics of their survey, to employ sufficient personnel to cover all mitigation periods, thus removing the potential for operative fatigue and meeting health and safety requirements. This is particularly important when working at northern latitudes (i.e. above 57°) during summer months (defined here as between 1st April and 1st October) and when planning 24-hour data acquisition. In this

[13] This should not be done to the detriment of mitigation periods, unless sufficient personnel are employed to allow continual monitoring.

case, the applicant must provide sufficient personnel to allow the work to be carried out in shifts.

PAM must be used if soft starts will occur during hours of darkness and is recommended for use during periods when day-time conditions are not conducive to visual surveys (e.g. fog). If day-time conditions are such that visual observations cannot be undertaken and no other form of monitoring is available, initiation of soft starts and seismic shooting must be delayed until conditions improve.

The use of PAM is particularly important during winter months when hours of darkness are longer. Visual surveys at dusk are not a reliable indicator to inform start-up decisions at night and should not be viewed as an alternative to using PAM. It is not recommended that PAM is used as the sole method of mitigation during periods when visual searches are possible (see Stone, 2015b).

A minimum of one PAM operative is required when PAM equipment is to be deployed with consideration of the survey specifics (including potential use during daylight hours) used to determine the total number. PAM may be required to supplement visual surveys (in addition to use at night and periods of poor visibility) in areas of importance for marine mammals. Under such circumstances, the applicant must ensure sufficient personnel are employed to allow for 24-hour PAM coverage (i.e. minimum of two PAM operatives).

It is not uncommon for individuals to conduct both the MMO and PAM role during the same survey. This is permitted under these guidelines however it is essential such personnel are trained and experienced in both roles.

Regardless of whether the MMO and PAM operatives are conducting sole or dual roles, an applicant not providing sufficient mitigation personnel for their survey is not a valid reason for surveys to be conducted without cover during mitigation periods. Such instances should be recorded as non-compliance and reported to the Regulator and JNCC with further details provided in the MMO report.

Section 2: Mitigation procedures

2.1. Standard Airgun Mitigation Procedures

The following guidelines apply to all geophysical surveys that use airguns.

All survey applications received by JNCC (and other SNCBs) will be considered on a case-by-case basis. All mitigation measures advised to the Regulator will reflect the survey particulars and the importance of the survey area for marine mammals. At all times, the SNCB(s) strive to provide mitigation advice that is proportional to the risk involved.

2.1.1. Pre-shooting search

Clear communication channels between the MMO/PAM operator and relevant crew must be established prior to the commencement of any operations. The MMO/PAM operator must be aware of the timings of the proposed operations. The crew must inform the MMO/PAM operators (or nominated lead) sufficiently in advance of airgun firing so that a full pre-shooting search can be completed prior to the soft start commencing.

Location of MMO/ PAM

All observations (visual and PAM) should be undertaken from the source vessel (where the noise source is deployed from), unless alternative arrangements have been agreed with the Regulator. The MMO should be positioned on a high platform with a clear view of the horizon, mitigation zone and ahead of the vessel.

The PAM operator should be positioned in the most appropriate location to allow them to monitor the PAM equipment for acoustic detections and maintain contact with both the MMO and relevant crew, for both mitigation purposes and ensuring the PAM equipment is deployed correctly.

Mitigation zone

The MMO/PAM operative will monitor the agreed mitigation zone and highlight if any marine mammals are within it. The standard radius of the mitigation zone is **500m** and is estimated from the centre of the airgun array or noise source location (noting comments in Section 1: on dual source arrays)**.** However, if the size of the mitigation zone is adjusted for any reason, this will be stipulated within the survey consent conditions.

Duration of search

The MMO must monitor the mitigation zone for the full duration of the pre-shooting search and soft-start procedure. Whether PAM is being used in conjunction with or in place of visual surveys, acoustic monitoring must also occur for the full duration of the pre-shooting search and soft-start procedure. Once the soft start has ended and data acquisition begins, monitoring can cease.

The duration of the pre-shooting search is determined as follows:

- **Waters less than 200m deep**: 30 minutes prior to the use of any airguns.
- **Waters greater than 200m deep**: 60 minutes prior to the use of any airguns.

This is to allow for deep diving species (e.g. sperm whale and beaked whale) which are known to dive for longer than 30 minutes. PAM may also be required on all pre-shooting searches in deeper waters (i.e. to complement visual surveys) to increase the potential to detect species with long dive times.

Due to the longer pre-shooting search time required in deeper waters, pre-shooting searches can commence before the end of a preceding survey line (whilst the airguns are still firing) **IF** line changes will take less time than the pre-shooting search and soft-start combined (i.e. 80 mins; Section 2.1.4).

2.1.2. If marine mammal detected within mitigation zone

If marine mammals are detected within the mitigation zone during the pre-shooting search (visually or acoustically), the soft-start must be delayed until their passage, or the transit of the vessel, results in them being outside of the mitigation zone. There should be a minimum of a 20-minute delay from the time of the last sighting within the mitigation zone and the commencement of the soft-start, to allow animals unavailable for detection (i.e. not re-surfacing in that time) to have moved outside of the mitigation zone.

A full soft-start must be undertaken after any delay due to the presence of marine mammals.

In situations where seal(s) are congregating around a fixed platform within a survey area, the soft-start should commence at a location at least 500m from the platform.

If marine mammals are detected within the mitigation zone whilst the airguns are firing, either during the soft-start procedure or when at full power, there is no requirement to stop firing.

Figure 1 illustrates a typical seismic survey with decision making pathways in the event a marine mammal is detected.

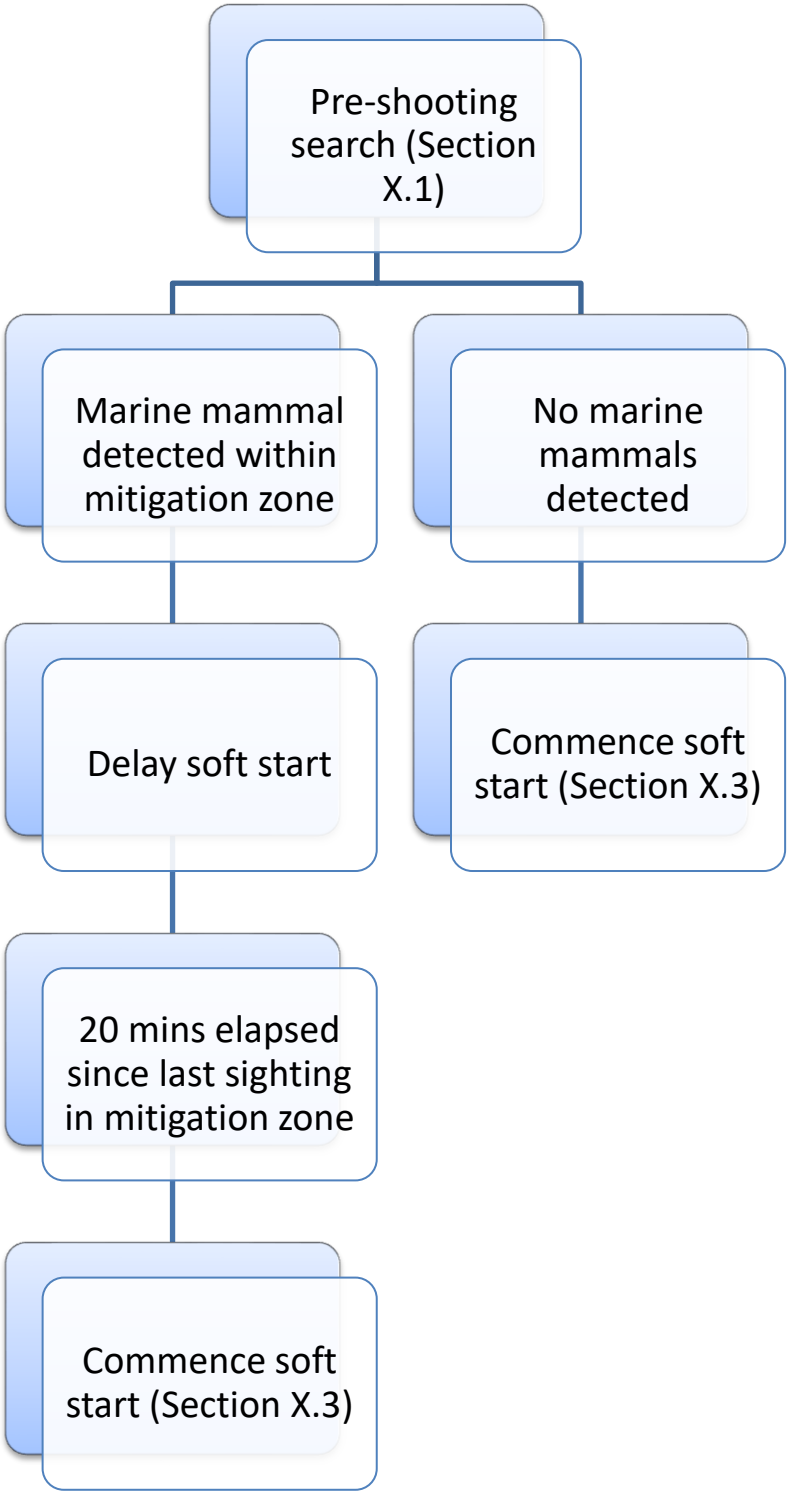

Figure 1. Flowchart illustrating the decision-making pathway of a MMO/ PAM operative during a seismic survey.

2.1.3. Soft-start

The duration of a standard soft start is defined by two criteria:

- From the start of the soft-start until full operational power: minimum of 20 minutes;
- From the start of the soft-start until the start of the survey line: maximum of 40 minutes.

One exception to these criteria is for surveys where the maximum airgun volume is <180 cubic inches:

- From the start of the soft-start until full operational power: minimum of 15 minutes;
- From the start of the soft-start until the start of the survey line: maximum of 25 minutes.

Regardless of duration, power should be built up gradually, in uniform stages from a low energy start-up (i.e. increasing the number of airguns starting with the smallest airgun in the array, or airgun pressure).

There should be a soft-start every time the airguns are used, the only exceptions being for certain types of airgun testing (Section 2.1.5), and the use of a 'mini-airgun' (single gun volume equal to or less than 10 cubic inches).

Surveys should be planned to avoid unnecessary firing at operational power before commencement of a survey line and to time operations to commence data collection as quickly as possible once full operational power is achieved.

2.1.4. Line changes

Seismic data is usually collected along predetermined survey lines. Line change is the term used to describe the activity of turning the vessel at the end of one survey line prior to commencement of the next.

The following procedures depend on the duration of the line change. If an applicant determines that an effective line change cannot be achieved using these procedures, then contact the Regulator and appropriate SNCB(s) at the earliest possible opportunity to discuss a proposed alternative. Details of any agreed alternative procedures should be described during the application process and reiterated, if appropriate, in the survey consent conditions.

One example of airgun use that does not require a line change is **Vertical Seismic Profiling** (VSP), a technique where measurements are made in a vertical wellbore using geophones inside the wellbore and a source at the surface near the well. In this instance, the break required to reposition geophones is to be treated in the same manner as line changes.

If difficulties are encountered when deploying PAM equipment, line changes must be extended to allow the full pre-shooting search to be completed with PAM.

a. If line changes are expected to take longer than 40 minutes:

If line changes (or geophone repositioning) are expected to take longer than 40 minutes, regardless of airgun volume:

- Firing is to be terminated at the end of the survey line (or geophone repositioning);

- A pre-shooting search is to be undertaken during the scheduled line change (or geophone repositioning);
- The soft-start is to be delayed if marine mammals are seen within the mitigation zone during the pre-shooting search (Section 2.1.2); and
- A full 20-minute soft-start is to be undertaken before the start of the next line (Section 2.1.3).

Most seismic surveys with airgun array volumes of 500 cubic inches or more are not able to complete their line changes within 40 minutes (Stone, 2015b) and should therefore follow the procedures outlined above.

b. If line changes are expected to take less than 40 minutes:

If line changes (or geophone repositioning) are expected to be completed within (or equal to) 40 minutes, regardless of airgun volume:

- Airgun firing can continue during the line change **only** if power is reduced to 180 cubic inches (or as close as is practically feasible) at standard pressure. Airgun volumes of less than 180 cubic inches can continue to fire at their operational volume and pressure; **AND**
- The Shot Point Interval (SPI) **is** increased to provide a longer duration between shots, with the SPI not to exceed 5 minutes: **AND**
- The SPI is **decreased** in uniform stages during the **final 10 minutes** of the line change (or geophone repositioning), prior to data collection re-commencing (i.e. mini soft start).

2.1.5. Seismic airgun testing

Airgun tests may be required before a survey commences to trial new arrays or to test damaged or misfiring airguns following repair. Individual airguns or several airguns within the full array may need testing and the airguns may be tested at varying power levels. The following guidance is provided to clarify when a soft-start is required for airgun testing:

- If the intention is to test a single airgun, a soft-start is not required.
- If the intention is to test multiple airguns within an array or the full array, a soft-start is required. This should be carried out over a time period proportional to the number of guns being tested and should not exceed 20 minutes in duration. Airguns should be tested in order of volume, smallest first.

A pre-shooting search (Section 2.1.1) should be undertaken before any instances of airgun testing.

Where feasible, it is recommended that airgun testing be incorporated into the soft start procedure and conducted before the start of a survey line to reduce the total amount of noise being introduced into the marine environment.

2.1.6. Undershoot operations

The MMO/PAM operatives should be placed on the source vessel to ensure they are close enough to the airguns to effectively monitor the mitigation zone. If this is not possible, i.e. for logistical or health and safety reasons, the applicant should explain this during the application

process and suggest alternative mitigation arrangements. Any alternatives would need to be agreed by the Regulator and SNCB(s) and stated in the survey consent conditions.

Irrespective of the location agreed with the Regulator, a pre-shooting search and soft-start procedure must be followed prior to undertaking all undershoot operations.

2.1.7. Unplanned breaks in operations

Unplanned breaks refer to instances where the airguns cease firing **unexpectedly** during data acquisition, i.e. a technical problem or breakdown. It is imperative that MMO/PAM operatives begin to monitor the mitigation zone as quickly as possible after an unplanned break has occurred.

- **Unplanned breaks of less than 10 minutes**: If the airguns can be restarted and data acquisition can resume in less than 10 minutes, there is no requirement for a soft-start and firing can recommence at the required power, **provided no** marine mammal(s) have been detected in the mitigation zone during the breakdown period.

  If a marine mammal is detected during the breakdown period, the MMO/PAM operative will advise to delay recommencement of the airgun firing until their passage, or the transit of the vessel, results in the marine mammals being outside of the mitigation zone. There should be a minimum of a 20-minute delay from the time of the last sighting within the mitigation zone and the commencement of the soft-start, as described in Section 2.1.1.

- **Unplanned breaks of longer than 10 minutes**: If it will take longer than 10 minutes to restart the airguns, a full pre-shooting search (Sections 2.1.1) and soft-start (Section 2.1.3) should be carried out before the survey re-commences. **If** an MMO/ PAM operative has been observing prior the breakdown period, this time can contribute to the pre-shooting search time, however, the full 30 or 60-minute search period is still required.

If the breakdown occurs at night or during daylight conditions not conducive for a visual search, the mitigation zone should be monitored as described above using PAM. If PAM is not available, the survey must be delayed until conditions are suitable for visual observations.

Planned breaks: If breaks in data acquisition other than during a line change are required (i.e. to avoid a structure), these should be considered within the application to allow the Regulator and SNCB to fully understand the survey procedure.

The same procedures as above (for unplanned breaks) can be applied. However, if the planned break will be for less than 10 minutes, the MMO/PAM operatives **must** be ready to begin monitoring 20 minutes prior to the planned break and continue for the duration of the break.

2.2. High Resolution Surveys (HRS)

High resolution data can be achieved either by using small airgun or electromagnetic sources. Sub-bottom profiling (SBP, i.e. pingers, sparkers, boomers and CHIRP systems), side-scan sonars and multibeam echosounders all use electromagnetic sources.

All applications will be considered on a case-by-case basis (by JNCC), with advice provided based on the following:

- **Airguns**: As a precautionary measure, JNCC advise any SBP/ HRS that use airguns require mitigation as described in Section 2.1 above.
- Electromagnetic sources:
    - Pre-shooting monitoring of the mitigation zone and a delay in proceeding if a marine mammal is observed as described in Sections 2.1.2.1.1 and 2.1.2.1.2. Typically, a non-dedicated MMO can be used.
    - Soft start – where practical, ramp up power in a uniform manner. However, it is acknowledged this is not possible for some SBP equipment (i.e. can either be on or off). If such equipment is to be used, highlight this during the application process.
    - Line change – as described in Section 2.1.2.1.4.
- If several pieces of HRS equipment are to be started sequentially or interchanged during the operation, only one pre-shooting search is required prior to the start of acoustic output, **only** if there are **no gaps** in data acquisition of greater than 10 minutes (refer to Section 2.1.2.1.7 for unplanned breaks in operations).

Multi-beam surveys in deep waters

SNCB guidance on the protection of EPS[14] highlights that some multi-beam systems used in deeper waters (> 200m) utilise frequencies (<100Khz) at sound levels that may be of concern to cetacean species, both in relation to deliberate injury and disturbance offences (see Section 3.14, page 43 of the EPS guidance). Therefore, an assessment of the risk to EPS from such surveys should be considered. JNCC (or the appropriate SNCB) will review this information as part of any consultation process and provide advice to the Regulator regarding mitigation requirements on a case by case basis.

Multi-beam surveys in shallower waters (< 200m) are not subject to these requirements as it is thought the higher frequencies typically used fall outside the hearing frequencies of cetaceans and the sounds produced are likely to attenuate more quickly than the lower frequencies used in deeper waters. JNCC do not, therefore, advise mitigation is required for multi-beam surveys in shallow waters.

[14] SNCB Draft Guidance, 2010. To obtain a copy of the latest draft version of the guidance please contact JNCC.

Section 3: Reporting

3.1. MMO report

For all oil and gas geophysical surveys, an MMO report should be sent to JNCC (via e-mail to seismic@jncc.gov.uk) after the survey has been completed. It is the responsibility of the consent holder to ensure that the MMO report is sent in a timely manner. The report should be accompanied by the completed JNCC marine mammal recording forms (i.e. the raw data in the excel spreadsheets) and a copy of the consent conditions. Please include the excel spreadsheets in their original format i.e. do not convert to pdf.

For other industry sectors and respective Regulators, it is suggested that similar procedures regarding MMO reporting could be followed, but this should be agreed with the relevant Regulator and SNCB(s).

Please note that information on marine mammal distribution and general ecology etc. are not required within the MMO report, as such information is provided and reviewed within the survey application prior to consent. The MMO report should provide a brief summary of the specifics of the conducted survey, mitigation watches (visual and acoustic) and required mitigation action as outlined above (see Appendix 2 for further information to be provided within an MMO report).

3.2. Compliance advice form

In addition to observing for marine mammals, the MMO/PAM operatives will advise the crew on the procedures set out in the JNCC guidelines and provide advice to ensure the survey programme is undertaken in accordance with the guidelines and survey consent conditions.

All efforts should be made to resolve any compliance issues during the survey between MMO/PAM operatives and relevant crew personnel. However, occasionally circumstances may arise were an issue cannot be resolved between these parties during the survey.

MMO/PAM operatives and consent holder/operators are encouraged to contact the Regulator/JNCC while still surveying to seek advice/discuss mitigation issues that have arisen to try and resolve these in a timely manner. The purpose of this form is to provide an audit trail of the issue, attempts to solve it and any outstanding matters from the different perspectives. This should help with evaluating compliance with the guidelines as well as in identifying any areas of the guidelines in need of further clarification or development.

When such circumstances arise, the completed form should be emailed to both the Regulator (emt@beis.gov.uk) and JNCC (seismic@jncc.gov.uk) along with a copy of the survey consent conditions. Upon review, it will be determined whether non-compliance will/has occurred and the Regulator will advise any remedial action required.

Details of the issue and how it was eventually resolved should also be included in the MMO report (see Appendix 2

MMO report).

Please note that this process has been written with oil and gas operations and Regulators in mind, but other industry sectors and appropriate Regulators could follow similar procedures. However, this should be agreed with the relevant Regulator and SNCB(s).

New Technologies

Techniques used to collect geophysical data are constantly evolving, for example the acquisition of data using ambient acoustic energy and automated underwater vehicles (AUVs) as a platform for site surveys. JNCC strive to keep up to date with developments and keep their guidelines up to date and relevant to industry practices. We welcome discussions with companies on the emergence of new seismic techniques, the potential for risk to marine species and development of monitoring/ mitigation measures.

References

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Stone, C.J. 2015a. Marine mammal observations during seismic surveys from 1994-2010. JNCC report, No. 463a.

Stone, C.J. 2015b. Implementation of and considerations for revisions to the JNCC guidelines for seismic surveys. JNCC Report No. 463b.

Appendix 1

Glossary

Areas of importance: Discrete areas of important habitat to marine mammal species.

Airgun: Device into which air is pumped into chambers at high pressure and then released through ports to form an oscillating bubble, thereby producing sound waves. Designed to emit a vertical beam of sound towards the seabed, with some unintentional sound radiating out from other angles.

Applicant: the company or organisation applying for (and issued) consent to undertake a geophysical survey

Consent holder: The company or organisation holding consent for a geophysical survey.

Daylight hours: Period between sunrise and sunset when sufficient light is available to effectively conduct visual observations.

Echosounder: Provide a water depth estimate by emitting pulses of sound that reflect from the seabed. The typical frequency range is from 10-200 kHz[15] .

European Protected Species: Species listed in Annex IV(a) of the Habitats Directive that occur naturally in the United Kingdom. In the marine environment, this includes all species of cetaceans (whales, dolphins and porpoises), turtles, and the Atlantic sturgeon.

Full power: Firing the airguns at their full operational level, reached at the end of a soft-start.

Geophysical survey: The systematic collection of geophysical data for spatial studies, using a range of sensing equipment including airguns.

Line turn/ change: The activity of turning the vessel at the end of one survey or production line prior to commencement of the next period of data acquisition.

Marine Mammal Observer (MMO): Individual responsible for conducting visual watches for marine mammals for mitigation purposes and provide advice to enable compliance with the JNCC guidelines. The MMO should be employed solely for the purpose of monitoring the implementation of the guidelines and undertaking visual observations to detect marine mammals during the mitigation periods of seismic activity (e.g. pre- shooting search, soft-start, line turns etc.):

- **Trained MMO**: Individual who has undertaken a JNCC recognised MMO course and has some experience of visually spotting marine mammals.
- **Experienced MMO**: Trained MMO with 20 weeks' field experience of implementing the JNCC guidelines in UK waters obtained within the previous ten years, preferably within the previous five.

Marine Mammal Surveyor: Individual responsible for conducting visual watches for marine mammals for monitoring or research purposes.

Mini-airgun: Airgun of volume less than or equal to 10 cubic inch.

[15] Genesis, 2011

Mitigation zone: The area within which the MMO/PAM operative searches (visually or acoustically) for marine mammals and delays the start of seismic activity should any marine mammals be detected.

Multi-beam echosounder: Similar to echosounder except emits a fan of sound beams. They work in a range of sound frequencies, with higher frequencies used in shallower waters normally outside the hearing range of cetaceans.

Ocean Bottom Seismic: Sound is released from a conventional source vessel and reflections are recorded by sensors placed on the sea floor. Originally introduced to enable surveying in areas of obstructions (i.e. production platforms) or shallow water inaccessible to ships towing seismic streamers. Based on the type of recording sensor used to collect data, these surveys may be referred to as

- **Ocean Bottom Cable (OBC)**: An assembly of vertically oriented geophones and hydrophones connected by cables and deployed on the seafloor to record and relay data to a seismic recording vessel.
- **Ocean Bottom Nodes (OBN)**: Similar to OBC except autonomous recording nodes are placed on the sea floor using ROVs. Nodes may be connected to each other and the recording vessel with cables or have inbuilt recording capabilities.

Passive Acoustic Monitoring (PAM): System that utilises hydrophones and specialist software to detect the vocalisations of marine mammals.

PAM operative: Individual responsible for conducting acoustic searches for marine mammals and experienced in the use of PAM equipment and marine mammal acoustics. The PAM operative should be employed solely for monitoring the implementation of the guidelines and undertaking acoustic observations to detect marine mammals during the mitigation periods of seismic activity (e.g. pre-shooting search, soft-start, line turns etc).

Pre-shooting search: Search for marine mammals (visually and/or acoustically) prior to commencing firing of airguns.

Production line: Survey line during which data is acquired and accepted within specification by the operator. Can also be expressed in terms of the number of shots or lengths (km or miles) of data acquired in a given time.

Marine Protected Area (MPA): A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values[16]. Within the UK, these may be designated under national legislation or international obligations and contribute to a network of MPAs in the north-east Atlantic.

Seismic survey: Any geophysical survey that uses airguns to generate sound which is sent into the seabed and the reflected energy is recorded and processed to produce images of the geological strata below; described as 2D, 3D and 4D and includes any similar techniques that use airguns:

[16] Dudley, N. (Editor) (2008). Guidelines for Applying Protected Area Management Categories. Gland, Switzerland: IUCN. x + 86pp.

- **2D seismic**: Survey vessel with a single towed hydrophone streamer. Reflections from the subsurface strata provide an image in two dimensions (horizontal and vertical).
- **3D seismic**: Uses more than one hydrophone streamers towed by the survey vessel.
- **4D seismic**: 3D seismic surveys repeated over a period of time, for example, to observe reservoir depletion during production and identify areas where there are barriers to flow that may not be easily detectable in conventional seismic.

Shot Point Interval (SPI): Interval between successive shots of the airgun(s), measured in metres along the ground (or sometimes in seconds).

Side-scan sonar: Used in mapping the surface of the seabed. Sound pulses are usually centred at frequencies between 100-500 kHz, the higher frequencies provide a greater resolution but reduce seabed penetration[15].

Site survey: Seismic survey of a limited area proposed for drilling, infrastructure emplacement etc., typically to identify seabed and subsurface hazards such as wrecks and the presence of shallow gas. They use a range of techniques, including multibeam and side scan sonar, sub-bottom profiler, magnetometer and small airguns with shorter hydrophone streamers (with source size of 40-400 cubic inches**Error! Bookmark not defined.**).

Soft-start: Process whereby the power of an airgun array is built up slowly from a low energy start-up, gradually and systematically increasing the output until full power is achieved (usually over a period of 20 minutes).

Source vessel: The vessel from which the seismic source (e.g.airgun(s)) is deployed.

Source: A device that provides energy for acquisition of seismic data, such as an airgun, explosive charge or vibrator.

Sub-bottom profiling (SBP): Systems employed to identify and characterise layers of sediment or rock under the sea floor. Low frequency sound sources (producing lower-frequency pulses) achieve greater penetration though the seafloor, however produce a lower-resolution picture; higher-frequency pulses achieve a higher resolution but do not penetrate as deeply into the sub-bottom strata. In addition to small airguns (typically less than 180 cubic inches), the following systems may be used:

- **Boomer**: Consist of two plates separated by a coil across which a high voltage impulse is created. The induced magnetic field causes one plate to vibrate radiating acoustic energy into the surrounding water. They have a broadband acoustic source ranging between 500 Hz - 5 kHz and are used to map the seabed layers between 30 - 100m depth (Genesis, 2011).
- **Pingers**: Periodically emit a high frequency ‘ping’ and typically operate on a range of single frequencies between 3.5 - 7 kHz (Genesis, 2011) and are used to achieve information from the seabed immediately below the surface layers. They offer a very high resolution but limited penetration dependent upon the seabed sediments, for example, a few tens of metres in mud.

- **Chirp systems**: These were designed to replace pingers and boomers and are now frequently used in oil and gas site surveys in place of the older systems. Chirp systems operate around a central frequency which is swept across a range of frequencies between 3 - 40 kHz (Genesis, 2011).
- **Sparkers**: Use an electrical discharge to generate sound similar to boomers but their use today is infrequent (Genesis, 2011). A high voltage impulse generates a spark across a pair of electrodes forming a gas bubble whose oscillations generate the sound. Sparkers are powerful devices and can be used to penetrate seabed layers up to 1 km.

Time-sharing: When vessels engaged on adjacent surveys take turns to run survey lines to avoid interference from the noise of each other's airguns.

Undershoot: Procedure used to facilitate shooting under platforms or other obstructions. One vessel is used to tow the seismic source and a second to tow the hydrophone array.

United Kingdom waters: Parts of the sea in or adjacent to the United Kingdom from the low water mark up to the limits of the United Kingdom Continental Shelf.

Vertical Seismic Profiling (VSP): Or Borehole Seismic. Measurements made in vertical wellbore using geophones inside the wellbore and a source at the surface near the well. The seismic sources used are generally smaller than for deep geophysical surveys but larger than for site surveys (Genesis, 2011) and can be deployed in several ways:

- **Zero offset:** from the platform;
- **Offset:** source vessel stationed at fixed location some distance from the platform; and
- **Walk away:** source vessel traverses one or more lines away from the platform.

Appendix 2

MMO report

An MMO report must be submitted upon completion of a survey and should include the following information. It should be accompanied by completed JNCC marine mammal recording forms (i.e. the raw data in the excel spreadsheets) and a copy of the consent conditions. Please include the excel spreadsheets in their original format i.e. do not convert to pdf.

Operator details:

Include brief details of the company awarded the consent, contractor details if appropriate and the survey consent reference number issued by the Regulator. Highlight contact details of whoever is responsible for the survey in case JNCC has any follow-up questions.

Survey details:

Provide a summary of the survey including:

- Date and location of survey;
- Total number and volume of the airguns used;
- Nature of airgun array discharge frequency (in Hz), intensity (in dB re. 1µPa or bar metres) and firing interval (seconds);
- Details of any other acoustic energy used (i.e. SBP);
- Details of any airgun testing;
- Average duration of all pre-watch, soft start, line changes and number of occasions were guideline durations were not met (noting the specific times will be detailed in the accompanying MMO excel recording forms);
- Summary of MMO/PAM activities for each period i.e. day/ night (i.e. full excel recording forms of operations and brief written summary)
- Number and types of vessels involved in the survey;

Survey area and greater working area geographical coordinates will have been included in the initial application, however a map illustrating the location of the survey (or the licensing blocks within which it occurred) can be beneficial, as an illustration of completed survey lines.

It should also be highlighted if the survey has occurred within or close to a protected area which includes marine mammals as a feature. Note, general details of likely marine mammal presence in the survey area will have already been included in the application and does not need repeating here.

MMO/PAM effort and detections:

Include details of the number of staff employed, whether dedicated or non-dedicated and their working location on the vessel. Also include details of their experience i.e. level of training, number of previous mitigation jobs or previous experience of observing if new to the role.

Provide details of a lead surveyor who can be contacted if JNCC has any follow up questions.

If PAM has been available on the vessel, include details of the equipment and software used and a summary of how often if was deployed. Also detail any technical issues encountered i.e. equipment failure or deployment issues. Screenshots of spectrograms can be helpful but are not essential.

Details of observer effort should be included in the recording forms, however this information should be summarised within the report. Also, summarise details of any marine mammals encountered, either visually or acoustically. If appropriate, distinguish between those seen inside the mitigation zone and outside.

Application of mitigation procedures

Include details of any survey specific arrangements agreed with the regulator as part of the survey consent conditions prior to the start of the survey i.e. changes to the size of the mitigation zone, location of MMO/PAM operatives etc.

Provide a summary of mitigation procedures applied, including details of soft-starts implemented and whether delays in firing were required. Again, only a summary is required as further details will be provided in the accompanying recording forms.

Compliance issues

Provide details of any compliance issues encountered and how they were resolved. If a compliance advice form was completed during the survey, cross-reference and include details of resultant actions.

If there are instances of non-compliance with the JNCC guidelines that constitute a breach of the survey consent conditions, JNCC will copy the report, and their comments on the potential breach to the Regulator.

Additional information

Additional information, for example, photographs of marine mammals observed, can be included at the end of the report if available.

Appendix 3

Compliance Advice Form			
Date / Time		**Reference**	
Operator		**Survey Location**	
Operator contact name		**Operator contact details (Email/ Phone)**	
Total no. of airguns		**Total volume of airguns (cubic inches)**	
No. of vessels			
No. MMOs		**No. PAM operatives**	
MMO/PAM Name		**Contact details**	
Detail of issue/ non-compliance			
Detail of remedial action attempted			

NOTE:

- The MMO/ PAM operator(s) **must** inform the applicant/ relevant crew personnel and attempt to resolve any compliance issues during the survey and record such actions and their resolution in the standard MMO report, to be submitted once the survey has been completed.
- Only when resolution is not possible during the survey, is this form to be completed and emailed to (the Regulator and JNCC) along with a copy of the survey consent conditions. Upon review, it will be determined whether non-compliance will/ has occurred and the Regulator will advise any remedial action required.