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JNCC
Joint Nature Conservation Committee

Survey Report for
Centre for Environment, Fisheries and Aquaculture Science

Project:
CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey

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Marine Mammal Observation and Passive Acoustic Monitoring Report

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29-Oct-2016 to 09-Nov-2016

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EXECUTIVE SUMMARY

- Watches and acoustic monitoring for marine mammals were carried out by a dedicated Marine Mammal Observer (MMO) and Passive Acoustic Monitoring (PAMS) Operator onboard the Research Vessel RV *Cefas Endeavour* during an analogue acoustic survey conducted on the Pisces reef complex cSAC/SCI site in the offshore waters of the Irish Sea from 29-Oct-2016 to 09-Nov-2016.

- Weather conditions recorded during dedicated marine mammal observations were variable. Wind speed varied between Beaufort Force 1 and 6, and from either a northerly or south westerly direction. Sea state was either slight or choppy, with a mostly low swell and good visibility.

- The analogue survey utilised a chirp sub-bottom profiler on four days of the survey to run a total of 107 survey lines.

- There were a total of six soft starts during the survey. All daylight soft starts were covered by full pre-shoot watches. All soft starts conducted during the hours of darkness were covered by full pre-shoot acoustic monitoring.

- The chirp sub-bottom profiler was soft started by gradually increasing the percentage of power from 10% to a full power of 80%. All soft starts were between 20 and 40 minutes in duration.

- There were a total of 101 line turns during the analogue survey where the sub-bottom profilers remained firing. All but one of the line turns were less than 40 minutes in duration.

- Watches for marine animals occurred on four days of the survey and resulted in 11 hours and 8 minutes of observer effort and no marine animal observations.

- Acoustic monitoring for marine mammals occurred on four days of the survey and resulted in 24 hours and 32 minutes of monitoring effort, and three marine mammal acoustic detections.

- During the survey there were two delays where analogue data acquisition was delayed due to the close proximity of cetaceans.

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LOCATION MAP

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF TERMS AND ABBREVIATIONS

CEFAS	Centre for Environment, Fisheries, and Aquaculture Sciences
EPS	European Protected Species
HR	Habitat Regulations
JNCC	Joint Nature and Conservation Committee
MMO	Marine Mammal Observer
OMR	Offshore Marine Regulations
PAM(S)	Passive Acoustic Monitoring (System)
RV	Research Vessel
UTC	Universal Time Coordinate

1 INTRODUCTION

1.1 Marine Acoustic Surveys

Marine surveys utilising analogue equipment are performed to establish and investigate seabed conditions, water depths, oceanographic and environmental conditions. Sub-bottom profiling equipment such as sparkers, pingers and boomers are often used as part of the analogue equipment to characterise the sediments and layers just below the seabed. Such equipment predominantly produces sound between 0.4 and 30kHz, with source levels between 200 and 230dB re 1 μPa^2 m^2 (Richardson *et al*., 2013).

1.2 Marine Mammals and Sound

Sound is conducted through water approximately 4.5 times faster than through air and is the most important sense for many marine organisms. This is especially true for marine mammals which use sound to communicate, navigate, forage and for predator avoidance (Richardson *et al*., 2013). The functional frequency range used by marine mammals varies between 7Hz and 180kHz, with the large baleen whales using the lower frequencies while smaller toothed whales use higher frequencies (Southall *et al*., 2007; See Figure 1.1).

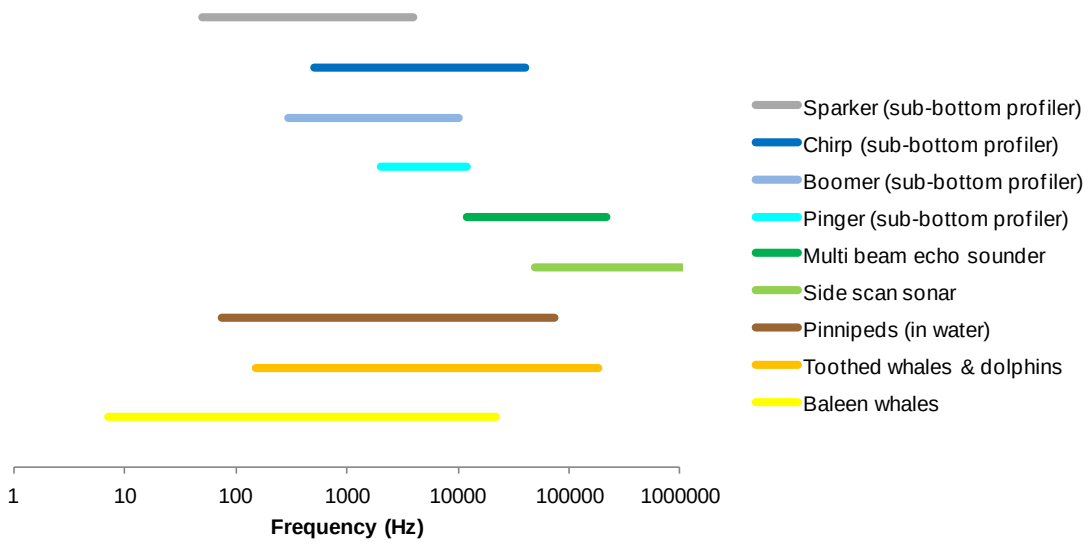

Figure 1.1 Auditory frequencies used by marine mammals and the main frequency range of analogue equipment (based on Gotz *et al.,* 2010 & Southall *et al.,* 2007)

Anthropogenic sound can impact marine mammals in a number of ways from direct injury (physiological and auditory effects) and behavioural responses, to perceptual and indirect effects (Gotz *et al*., 2009; Southall *et al*., 2007). While the operating frequency of analogue equipment is generally above the hearing range of marine mammals their operation can generate sound that falls within the functional hearing range of marine mammals. Therefore such sources may be detectable over distances of several hundred metres, and although below harmful levels could potentially affect the behaviour of marine mammals within close proximity (Deng *et al*., 2014). Recent investigations into a mass stranding of melon-headed whale (*Peponocephala electra*)

indicate the event was primarily triggered by a multi-beam echo sounder system (MBES; Southall *et al*., 2013).
It is clear that behavioural responses to sound are highly variable and context specific, with spatial and temporal relationship, habitat quality, previous experience and similarity to biologically significant sounds, as well as the species, gender, age and behavioural state of the individual influencing the type and severity of the response or even if one is observed at all (Southall *et al*., 2007; Ellison *et al*., 2012).

The ability to perceive biologically important sounds is critical to marine mammals (Richardson *et al*., 2013). Masking by increased sound levels in the natural environment can reduce the range over which signals are perceived and reduced the signal's quality of information, which can have implications for survival, reproduction and foraging (Weilgart, 2007). In many cases changes in vocalisation rates and the frequencies used have been suggested to be compensatory behaviour to elevated background noise levels (Di Iorio & Clark, 2010).

1.2.1 1.2.2 Marine turtles and sharks

There has been little research into the effects of anthropogenic sound on basking sharks (*Cetorhinus maximus*) however their surface feeding has the potential to bring them in close contact with acoustic sources. Avoidance behaviour could lead to changes in migration routes, whilst long term effects of noise disturbance could lead to weight loss and reduced reproductive success (Bloomfield & Solandt, 2007) which in turn could impact population recruitment. Sharks are generally sensitive to frequencies between 40 and 800Hz (Myrberg, 2001) with sensitivity peaking around 20 Hz (Casper & Mann, 2006). The hearing capabilities of basking sharks have not been studied although it seems unlikely that they are well developed due to their planktiverous diet. However a review of the sensory biology of a similar filter feeding species, the whale shark (*Rhinocodon typus*) suggests that this species could be responsive to low frequency sounds (Martin, 2007).

Marine turtles are another group potentially impacted by acoustic activity as their hearing sensitivity falls in the low frequency range (< 1kHz; Bartol *et al*., 1999). McCauley *et al*. (2000) demonstrated avoidance behaviour in two species exposed to a single airgun source. Strong site fidelity to nesting sites, specific feeding grounds and migratory routes (Broderick *et al*., 2007) could mean marine turtles are unable to avoid particular areas and consequently acoustic activity.

1.3 Legislation

The UK Department of the Environment first issued guidelines for minimising acoustic disturbance in February 1995 as part of the government's response to the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS). The guidelines were last revised by the Joint Nature Conservation Committee (JNCC) in August 2010, and aim to reduce the risk of injury and disturbance to marine mammals (Appendix A).

The 2010 version of the JNCC Seismic Guidelines reflects amendments (2007 and 2009 amendments) to the Conservation (Natural Habitats &c.) Regulations 1994 (Habitat Regulations, HR) for England and Wales and the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 (Offshore Marine Regulations, OMR, as amended in 2009 and 2010). Both regulations have revised the definition of deliberate disturbance of European Protected Species (EPS) which now excludes trivial disturbance from the offence. Both regulations now also include the offence of deliberate injury. European Protected Species include cetaceans and turtles.

Seismic surveys have the potential to cause a deliberate injury offence as defined under regulations 41(1) (a) and 39(1) (a) and a deliberate disturbance offence as in 41(1) (b) and 39(1) (b) of the HR and OMR respectively. The JNCC Seismic Guidelines reflect best practice for operators to follow during the planning, operational and reporting stages. It is considered that compliance with the recommendations in these Guidelines will reduce the risk of injury to EPS to negligible levels.

The JNCC recommends that the soft start procedures for marine mammals would also be appropriate for marine turtles and basking sharks. To record procedures and to detect and identify marine animals during the survey, operators are required to employ trained Marine Mammal Observers (MMOs). However due to the incorporation of turtles and basking sharks, all watches carried out were for 'marine animals' and will be referred to as such throughout the report.

In areas considered particularly important for marine mammals the JNCC recommends a Passive Acoustic Monitoring System (PAMS) should be used to supplement visual observations or as the main mitigation tool during periods of darkness or poor visibility.

There is no requirement in the current survey to implement mitigation for the chirp sub-bottom profiler and as such all mitigation measures implemented were voluntary.

1.4 Objective

This report presents the findings of dedicated marine mammal monitoring during an analogue site survey on the Pisces Reef Complex site in the Irish Sea (see Location Map). This survey was conducted for Centre for Environment, Fisheries, and Aquaculture Science (Cefas) on board the Research Vessel (RV) *Cefas Endeavour* from 29-Oct-2016 to 09-Nov-2016.

2 THE MARINE ENVIRONMENT

2.1 Physical and Oceanographic Features

The ocean is a highly heterogeneous environment with large, intermediate and small-scale spatial and temporal patterns in physical, chemical and biological processes (Hunt & Schneider, 1987). Variation in such processes have an effect on primary production and therefore the abundance and distribution of plankton (Mackas *et al*., 1985), which in turn affects marine populations at higher trophic levels (Thompson & Ollason, 2001). Physical processes such as circulatory patterns may also have large-scale implications on the dispersion of marine life. Equally important small-scale features or localised episodes will also have an effect (Hunt & Schneider, 1987). Seasonal fluctuations in temperature, salinity and the formation of fronts will also influence dispersion and primary production (Le Fèvre, 1986; Ellett & Blindheim, 1992).

The distribution of marine animals is primarily related to the movement and abundance of their food source (e.g. Evans, 1990; Macleod *et al*., 2004; Friedlaender *et al*., 2006). Other behavioural, morphological and energetic constraints will also have an influence on the movement and distribution of marine species. For example many species of baleen whale migrate to low latitude breeding grounds during winter (Stern, 2002) while marine turtles migrate between feeding, nesting and developmental areas (Plotkin, 2003; Bolten, 2003). Such seasonal patterns in biology are likely to have evolved to take advantage of oceanographic conditions. As the distribution and abundance of marine animals is influenced by oceanographic characteristics, it is important to describe the marine processes in the survey area.

The study area was situated in the Irish Sea, to the West of the Isle of Man. The Irish Sea is connected to the Atlantic through St. George's Channel in the south and through the North Channel in the north and has a semi-diurnal tide regime, with a fortnight cycle of spring and neap tides. There is a marked bathymetry gradient from deeper waters in the west to shallower waters in the east (Kennington & Rowlands, 2005; Howarth, 2005). In this area, the seabed ranges from coarse gravel to mud, with large areas of gravely sand and muddy sand (Wilding *et al*., 2005). Differences in hydrography, nutrient chemistry and ecology between the western and eastern sides of the Irish Sea are mainly due to the differences in water circulation and depth (Howarth, 2005).

2.2 Marine Communities

There are seven known species of marine mammal to occur regularly in the Irish Sea. The harbour porpoise (*Phocoena phocoena*) is by far the most sighted species of cetacean (DECC, 2005; Evans, 1996). Other species encountered include bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), minke whale (*Balaenoptera acutorostrata)* and Risso's dolphin (*Grampeus griseus*) all of which are most commonly seen during the summer months. Both of the pinniped species, grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*), have known haul out sites in the Irish Sea (Duck, 1996), however the abundance of grey seals is far greater, with harbour seal using this area only sparingly (DECC, 2005).

Basking shark is present in the Irish Sea in the summer, mostly to the west of the Isle of Man (Pawson & Robson, 1996). Leatherback turtle (*Dermochelys coriacea*) is present year round in UK waters, with abundance peaking in between July and September in the Irish Sea (DECC, 2005). Available data for this species suggests some regions of the southern Irish Sea are important feeding areas (DECC, 2005).

3 METHODOLOGY

3.1 Study Area

The CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey was carried out by Cefas. The site was located in the Western Irish Sea (see Location Map). The site is located 45km west of Douglas, Isle of Man. The position of the site can be found in Table 3.1. Water depth in the survey area varied between 67m and 130m.

Table 3.1 Survey location

Site	Latitude	Longitude	Coordinate system
Pisces Reef 1	54°11'13"N	05°10'14"W	WGS84
Pisces Reef 2	54°09'39"N	05°15'20"W	WGS84
Pisces Reef 3	54°05'22"N	05°19'29"W	WGS84

3.2 Survey Vessel

The CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey was carried out onboard the *RV Cefas Endeavour* from 29-Oct-2016 to 09-Nov-2016. The vessel details are as displayed in Table 3.2

Table 3.2 Vessel specifications

Cefas Endeavour	Specifications
Owner	Defra UK
Class	Lloyds +100A1, Ice class 1D
Built	2003
Length Overall	73.9m
Breadth Overall	16.1m
Draught	8.3m
Gross Tonnage	2983T
Speed	11 knots
Main Engine	3 x Wartsila 6L20 1000kW driving single CPP propeller
Thrusters	820kW Schottel pump-jet azimuth bowthruster, 380kW Brunvoll stern tunnel thruster
Accommodation	35

3.3 Survey Parameters

The purpose of the survey was to obtain analogue sub-bottom profiler and multi-beam bathymetry data to contribute to the development of a monitoring time-series for the Pisces Reef Complex cSAC/SCI. The vessel speed was approximately 4-5 knots throughout the survey.

The chirp sub-bottom profiling equipment used to acquire data during the survey was an Edgetech 2000, sweeping between 2 to 12kHz, at 4Hz sample rate. The completed survey line plan is shown in Figure 3.1. The area surveyed was 391km² around the reef complex.

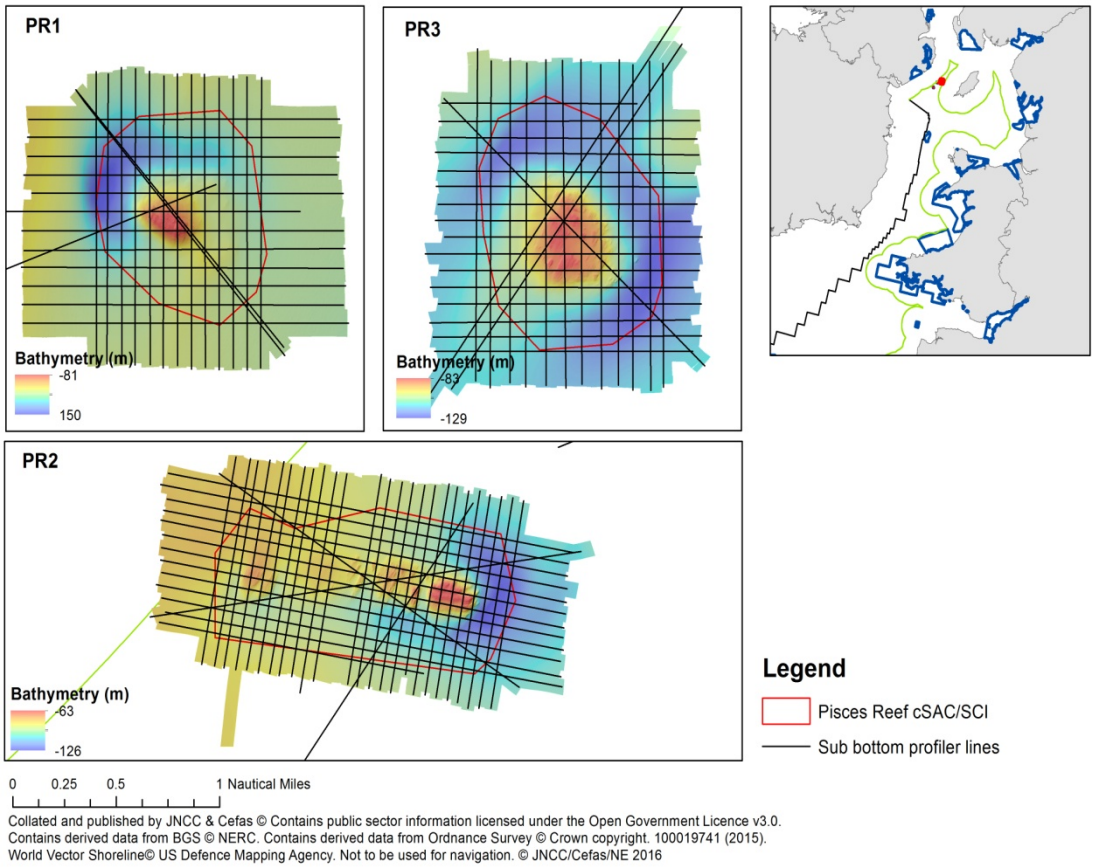

Figure 3.1 Completed line plans for the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey

3.4 Operators Procedures

The survey was voluntarily run in accordance with the JNCC's *'Guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys, August 2010'* at the request of CEFAS, as best practice measures, despite having an exemption from the requirements from the Marine Management Organisation.

The JNCC guidelines required that monitoring for marine animals be performed at least 30 minutes (in water < 200m deep) prior to the use of the acoustic source. Should marine animals be present within 500m of the source during this period, the start was delayed by at least 20 minutes after the last sighting, to allow animals to move out of the vicinity.

The JNCC Guidelines also required that a 'soft start' procedure be operated prior to use of the acoustic source. During this soft start the source volume is built up slowly from a low energy start-up over a period of 20 to 40 minutes before reaching the level required for survey production. It is intended that this slow build up will allow marine animals in the vicinity of the survey vessel to move away from the area of the airguns. The chirp sub-bottom profiler volume could be increased to full operating power of 65% energy, by gradually increasing the power output from 10%.

In line with JNCC guidelines the decision was made prior to mobilisation to conduct mitigation and monitoring for the chirp sub-bottom profiler when possible, without exceeding standard operator working hours.

At the end of each line, if the line turn length was expected to be less than 40 minutes the acoustic source remained firing until the next survey line. Due to operational restraints the firing of the sub-bottom profiler remained at full power during the turn. The line turn was expected to be longer than 40 minutes, firing of the acoustic source was stopped and the next line preceded by a soft start where appropriate.

3.5 Observation Methods

The Marine Mammal Observer (MMO) carried out dedicated watches for marine animals during acoustic survey operations in daylight hours, and completed the relevant recording forms.

Watches were carried out from the bridge and bridge wings. Prior to beginning a watch, the time (UTC) and weather conditions were recorded on the JNCC Location and Effort Form (Appendix B). Weather conditions such as Beaufort wind force, sea state and visibility were noted every hour and whenever a change in conditions occurred. The used definitions of Beaufort wind force and sea state are provided in Appendix C. In addition, the start and end times of marine animal watches and the start and end times of the firing of the acoustic source were recorded each day on the JNCC Record of Operations Form (Appendix B).

The primary observation technique used to spot marine animals was to scan the visible area of sea using the naked eye, and scanning areas of interest with binoculars (magnification x 10; e.g. waves going against the prevailing direction, white water during calm periods, bird activity, bird transiting direction etc.). This technique gave both a wide field of view and the ability to have a sufficient range of 3 - 4km in ideal conditions.

Identifications were based on a combination of the observer's previous experience, aided by the sources listed below:

- Reid, J.B., Evans, P.G.H. & Northridge, S.P. 2003. *Atlas of Cetacean Distribution in north-west European waters.* Joint Nature Conservation Committee, Peterborough.
- Shirihai, H. & Jarrett, B. 2006. *Whales, Dolphins and Seals. A field guide to the marine mammals of the world.* A&C Black Publishers.

The JNCC Marine Mammal Recording Forms were available to record sightings made by the MMO. The information recorded included the date and time, the vessel's position, course, depth and seismic activity. The species, number of animals, behaviour, distance from the vessel and direction of travel were also recorded. Any additional information, such as details on the features used to identify the animals and the reaction of the animals to the acoustic source was also noted.

3.6 Acoustic Monitoring Methods

Passive Acoustic Monitoring (PAM) uses hydrophones (underwater microphones) to detect and monitor the presence of marine mammals through the detection of their vocalisations. Most cetaceans (whales, dolphins and porpoises) vocalise regularly and produce a variety of sounds ranging from low frequency vocalisations of baleen whales (down to about 15Hz) to relatively high frequency echolocation clicks of some toothed whales (up to about 160kHz; Sturtivant *et al*., 1994; Richardson *et al*., 2013; Berchok *et al*., 2006).

During the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey a Passive Acoustic Monitoring System was used to acoustically monitor for marine mammals during acoustic survey

data acquisition during the hours of darkness and the lowlight hours at dawn and dusk, when conditions allowed for the deployment of the hydrophone array. Specific focus was made on acoustically monitoring the pre-shoot period prior to the acoustic source firing. Details of the PAMS used during the survey are provided below.

Prior to commencing monitoring the time (UTC) and weather conditions were recorded on the JNCC Location and Effort Form (Appendix B). Weather conditions including Beaufort wind force, sea state and swell height, were recorded every hour and whenever a change in conditions or source activity occurred. The used definitions of Beaufort wind force and sea state are provided in Appendix C. In addition the start and end times of dedicated pre-shoot monitoring and the start and end times of firing of the acoustic source was recorded on the JNCC Record of Operations Form (Appendix B).

The JNCC Sightings Form (Appendix B) was available to record detections made by the PAMS Operator. The information recorded included the date and time, the vessels position, course, depth and acoustic source activity. Where possible the species, number of animals and an estimation of the range of vocalising mammals from the vessel was recorded.

3.6.1 The PAMS

The PAMS comprised of a towed hydrophone array connected to a data processing system, enabling the acquired sound to be inspected both aurally and visually. The hydrophones are connected to dry-end hardware which digitises the analogue signal allowing it to then be read by the laptop computers. The computers run analysis software which highlights the number of varied clicks and whistles produced by different species of marine mammals.

The system utilised medium frequency and high frequency hydrophones in order to cover the frequency range of vocalising marine mammals. The signal received by the hydrophones is then monitored in real-time by the dedicated software PAMGuard, which through the use of click detectors, whistles and moan detectors, and filters allows the automatic detection of the presence of marine mammal. Detectors and filters can be adjusted manually by the PAMS Operator in order to increase positive detections. The detections identified are then stored in a database (Figure 3.2).

The data processing system comprises the following sub systems:

a) High frequency data acquisition for cetacean clicks up to 180kHz (Max sample rate 350kHz).
b) Medium frequency data acquisition for cetacean click and whistles up to 48kHz (Max sample rate 96kHz).
c) Depth data acquisition.
d) Computer based sound acquisition, display and analysis software.

The directionality and range of the marine mammal is determined by the time difference of the arrival of the acoustic signal (vocalisation) to each hydrophone of the array.

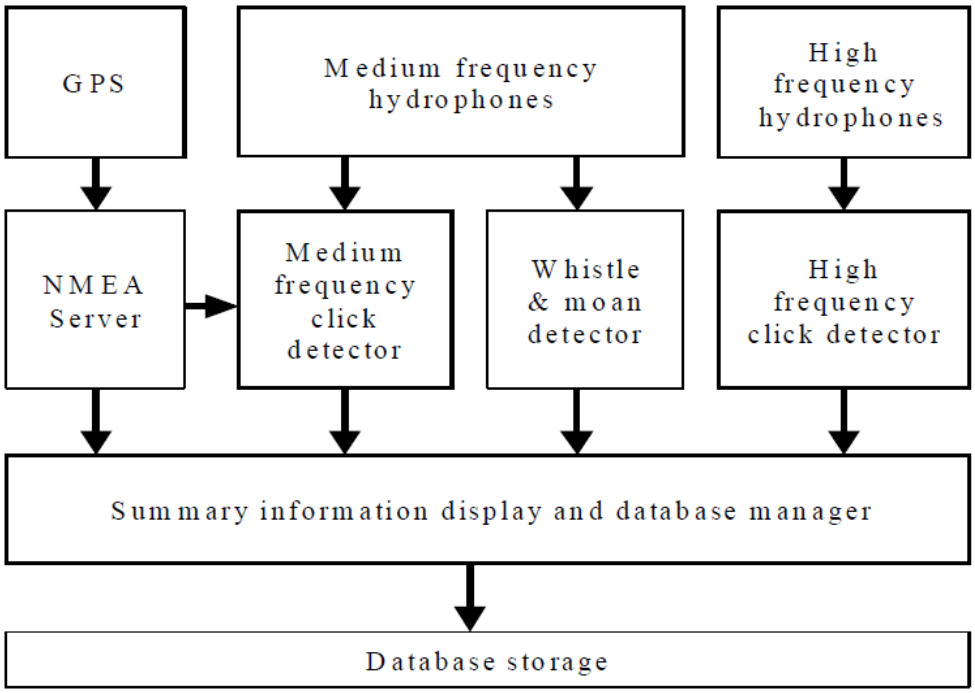

Figure 3.2 Schematic set up of PAMS

3.6.2 The hydrophone array

The PAMS used during the survey was a Gardline Mark III system and consisted of four individual hydrophones; one low frequency and three broadband frequency hydrophones. The manufacturer's specification for the PAMS system can be found in Appendix D. The hydrophone array (3m in length) was integral to the array cable, an electric cable of 250m in length, and towed behind the vessel.

3.6.3 The monitoring system

The latest version of PAMGuard software (Version 1.15.01) was utilised as a graphical display for sound acquisition, visualisation and detection of marine mammal vocalisations. PAMGuard is an open-source software, that is platform-independent (e.g. Windows or Linux), flexible and built in a modular architecture.

For mitigation purposes, during the current survey the PAMS used a specific data model configuration created by Gardline. Using the most appropriate modules and specifications, a Medium Frequency and a High Frequency data module configuration was utilised simultaneously using rack-mounted PC interfaces.

The Medium Frequency configuration is programmed to specifically track and locate clicks, whistles and moans produced by cetaceans in the vicinity of the hydrophones.

The High Frequency configuration is programmed to detect the echolocation clicks of odontocetes such as dolphins and harbour porpoise. Harbour porpoise for example echolocate using high frequency clicks which are undetectable by the human ear so the PAMS relies entirely on automated detection of these clicks.

All of the detection modules were run in real time and monitored by a dedicated PAMS Operator, with audio recordings and screenshots taken for any detection during the survey.

4 RESULTS

4.1 Survey Coverage

The survey mobilised in Liverpool on 29-Oct-2016 and began transit to the Pisces Reef Complex at 22:30h, arriving on location at a swathe bathymetry calibration site at 09:15h on 30-Oct-2016. After calibrations, full survey operations began at 13:40h. Data acquisition temporarily ceased at 16:02h due to darkness and resumed at 19:14h. Operations then continued uninterrupted until 17:50h on 01-Nov-2016, when acquisition was suspended to undertake drop-down camera operations.

On the completion of camera operations, analogue operations resumed 01:50h on 04-Nov-2016. analogue data acquisition was completed at 10:51h the same day. The vessel began transit to its next survey location at 11:15h. Following camera and grab operations at the new survey location, the vessel began transit to Lowestoft for demobilisation arriving at 17:00h.

The CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey took place over seven days including transit to and from site. A total of 107 analogue survey lines were run including one test. These lines were obtained over four days of the survey (Table 4.1).

Table 4.1 Summary of analogue data acquisition for the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey

Data acquisition	CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey
Number of analogue lines	107
Total hours analogue (hrs:mm)	53:34
Total km	391
Number of soft starts	6
Average length of soft start (mins)	23
Average length of line turn (mins)	11

4.2 Marine Mammal Observer Effort

A total of 11 hours and 8 minutes of dedicated marine animal watches were carried out by the MMO and 24 hours and 32 minutes of dedicated marine mammal acoustic monitoring by the PAMS Operator between 30-Oct-2016 and 04-Nov-2016. This includes a total of 5 hours and 5 minutes of dedicated pre-shoot watches and 2 hours and 34 minutes of pre-shoot acoustic monitoring.

4.3 Weather Conditions

Weather conditions recorded during dedicated marine mammal observations were variable. Wind speed varied between Beaufort Force 1 and 6 (Figure 4.1), and came from either a northerly or south westerly direction (Figure 4.2). Sea state was either slight (51% of monitoring time) or choppy (49% of monitoring time), with mostly a low swell (< 2m; 88% of monitoring time) although this was occasionally medium (2 - 4m; 12% or monitoring time). Visibility was predominantly good (94% of monitoring) with short periods of moderate visibility (6% of monitoring time).

It should be noted that weather observations were only made during dedicated marine fauna watches and hence may not fully reflect weather throughout the survey.

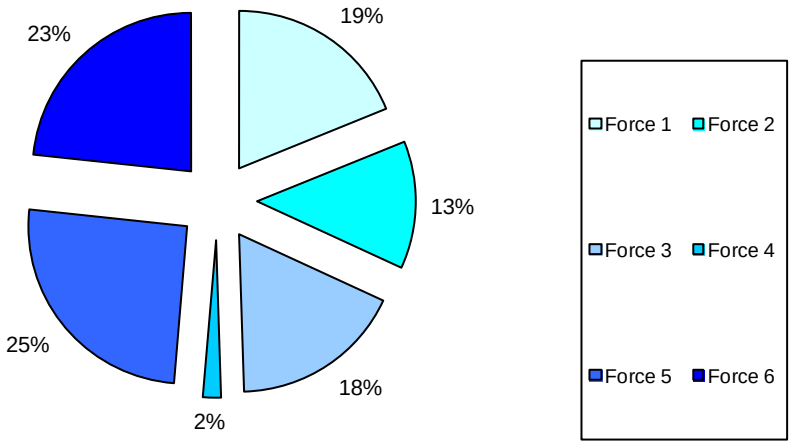

Figure 4.1 Beaufort wind force recorded during dedicated marine mammal watches during the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey

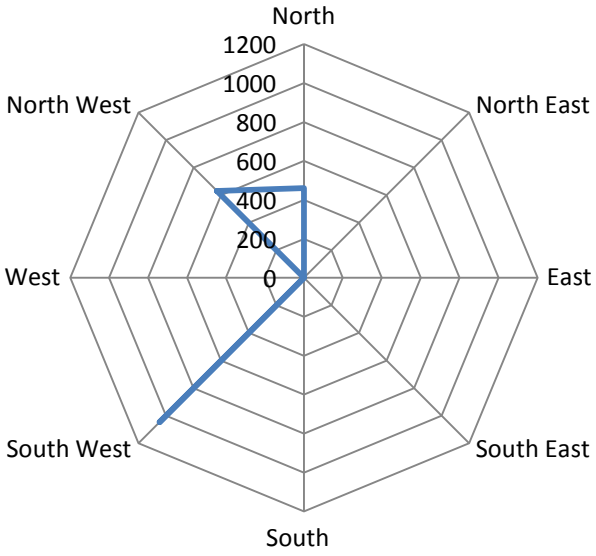

Figure 4.2 Wind direction recorded during dedicated marine mammal watches during the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring Survey

4.4 Compliance with JNCC guidelines

Requirements for MMOs and PAMS are varied according to the energy source volume, energy source pressure level, sound frequency and survey location. The Irish Sea is considered by the JNCC to be a highly variable area in relation to marine animals. CEFAS voluntarily adopted the guidelines as best practice and requested the MMO and PAMS operator to carry out dedicated monitoring throughout acoustic data acquisition.

There were a total of six soft starts during the survey. Full pre-shoot watches were conducted prior to all daylight soft starts. Full pre-shoot acoustic monitoring was conducted prior to all soft starts conducted during the hours of darkness. All soft starts that occurred were between 20 and 40 minutes in duration.

There were a total of 101 line turns during the survey where the acoustic sources remained firing at full power. All but one of the line turns were 40 minutes or less in duration. There was one exception of a 42 minute line turn on 31-Oct-2016 at 01:53h, when the line exceeded the expected time. The remaining line turns were expected to take longer than 40 minutes therefore the acoustic sources were stopped and a full soft start was carried out prior to the next line where appropriate.

There were two delays to analogue data acquisition on 31st Oct-2016 due to marine mammal acoustic detections. The first delay occurred at 19:05h (UTC) due to an acoustic detection of unidentified dolphins, the distance or bearing of the animals could not be determined using PAMS however the PAMS Operator deemed the animals to be inside the mitigation zone. Operations were delayed until no further detections were made for 29 minutes, and operations subsequently began at 19:43h.

The second delay occurred when dolphins were acoustically detected when the sub-bottom profiler was turned off for a long line change at 23:51h on the same day. The operator was not able to get an exact bearing and distance to the animals with the PAMS however the PAMS Operator used their experience and deemed the animals to be outside the mitigation zone before 23:06h. The soft start commenced at 00:31h on 01-Nov-2016.

4.5 Marine Animal Sightings and Detections

During the CEND2316x Pisces Reef Complex cSAC/SCI Monitoring survey between 29-Oct-2016 to 09-Nov-2016, there were three acoustic detections of unidentified dolphins. There were no visual sightings of marine animals.

4.5.1 Unidentified dolphins

The first detection occurred at 19:05h on the 31st Oct-2016, when the PAMS operator heard and saw some faint whistle down sweeps on PAMS from around 12kHz to 8kHz, see Figure 4.3. Distance and bearing information could not be obtained, and the number of animals could not be determined, other than there was at least one individual. The animals were last detected at 19:20h. A delay to the start of operations was implemented for this detection.

The second detection occurred between 19:49h and 19:50h on the 31-Oct-2016, when a few more whistles were heard during the sub-bottom profiler soft start. These 10kHz to 8kHz whistles which swept down and up were short lived. Distance and bearing information could again not be obtained.

The final dolphin acoustic detection occurred on the same day at 23:51h immediately after the cessation of the chirp system for a long line change. This time the whistles were faint to begin with before getting stronger for a time, and they increased in complexity and number. This suggests that there was several animals communicating, with up and down sweeps that varied between 8kHz and 20kHz (Figure 4.4). Unfortunately, a decisive bearing and distance to the vocalising animals could not be determined using PAMS but from the operators experience it was estimated that they were between 1000m and 2000m away by 23:06h, which after a short delay meant that the soft start could begin.

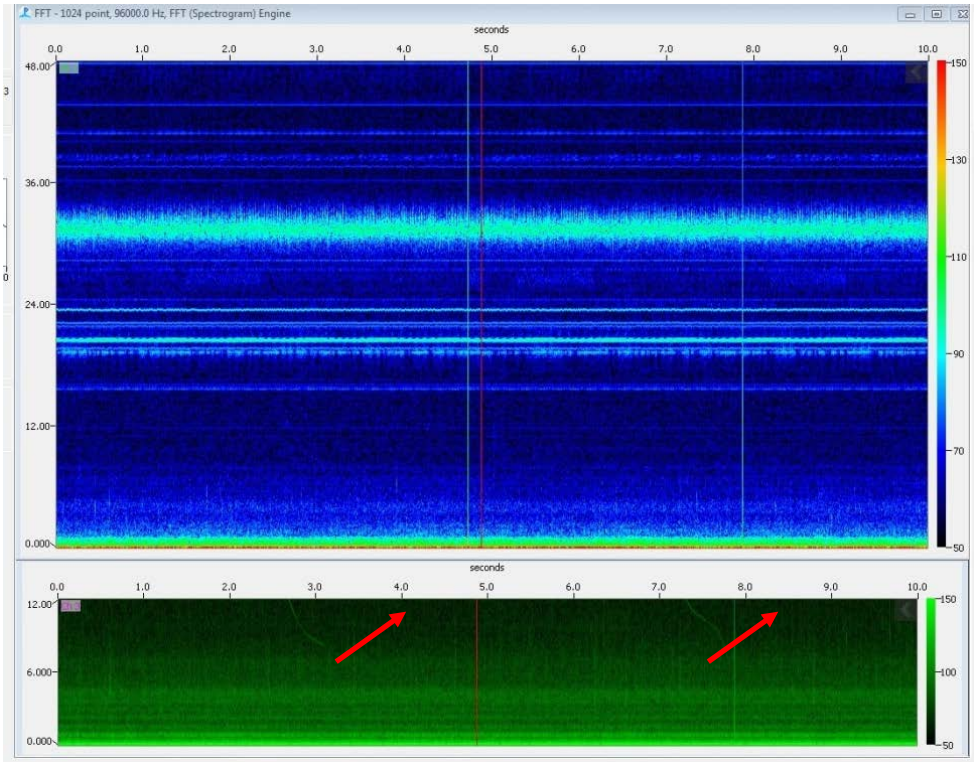

Figure 4.3 Dolphin whistles detected at 19:05h on 31-Oct-2016 on CEND2316x Pisces Reef Complex cSAC/SCI Monitoring survey

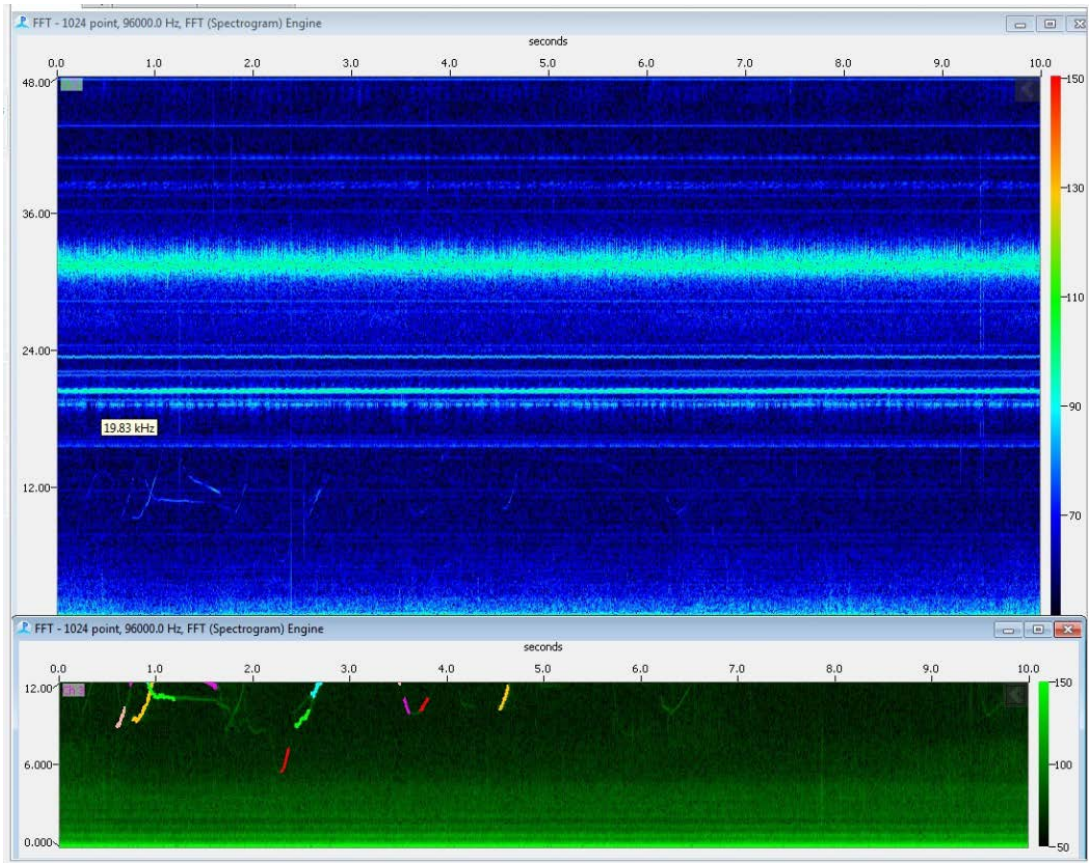

Figure 4.4 Dolphin whistles detected at 23:51h on 31-Oct-2016 on CEND2316x Pisces Reef Complex cSAC/SCI Monitoring survey

5 DISCUSSION

5.1 Marine Mammal Detection

There are a number of factors that may have influenced the detection of marine animals within the survey area.

Weather can affect the ability to detect marine animals in a number of ways, with increasing sea state, wind force and decreasing visibility reducing the detection probability of marine animals (Forney, 2000) particularly those with inconspicuous surfacing behaviour such as the harbour porpoise (Palka, 1996). Weather conditions recorded during dedicated marine mammal observations were variable. Wind speed varied between Beaufort Force 1 and 6, and from either a northerly or south westerly direction. Sea state was either slight or choppy, with a mostly low swell and good visibility. Periods of poor weather encountered may have affected detections. In particular the harbour porpoise, which is one of the most commonly recorded species in the area (Reid *et al*., 2003), and is known for its elusive nature and inconspicuous surfacing behaviour (Shirihai & Jarrett, 2006).

The acoustic detection of marine mammals is generally not as restricted by the weather as visual observations, although the range of hydrophones is occasionally reduced during poor weather conditions due to increased levels of background noise. The main limitation with PAMS is that the animal must be vocalising in order to be detected. For some species, particularly baleen whales, vocal activity may vary with season, location, behaviour and gender (Mellinger *et al*., 2007; Boisseau *et al*., 2008). Some species of cetacean are notoriously difficult to monitor acoustically, for example the beaked whales (Barlow & Gisner, 2006). Despite this many species of cetacean are audible for a greater proportion of time than they are visible at the surface (Gordon *et al*., 2003). In general PAMS has the advantage of being able to detect elusive or small mammals, like the harbour porpoise, that can often be missed by observers during unfavourable weather conditions and the hours of darkness (O'Brien, 2009).

The spatio-temporal distribution and high mobility of marine animals may also have had an effect on detection. Many species of marine animal migrate at certain times of the year, primarily in relation to prey abundance and distribution, breeding opportunities and availability of space (Stern, 2002; Plotkin, 2003). In the survey area the distribution of marine animals is seasonally variable (DECC, 2005). Therefore certain species may not have been present, or present in abundance, in the area during the survey period.

5.2 Marine Mammal Observations

Marine animal research carried out previously within the waters of the Irish Sea have recorded a range of cetacean species and two species of pinniped, occurring throughout the year (Reid *et al*., 2003; DECC, 2005). In addition there are occasional sightings of basking shark and leatherback turtle (Pawson & Robson, 1996; DECC, 2005). While these species occur in spatially distinct areas (Reid *et al*., 2003; DECC, 2005), and not necessarily in the current survey area, it must be remembered that marine animals are highly mobile. It was therefore anticipated that marine animal sightings were possible, and as such MMO duties were carried out during acoustic data acquisition in some daylight hours.

During CEND2316x Pisces Reef Complex cSAC/SCI Monitoring survey between 29-Oct-2016 to 09-Nov-2016, there were no sightings of marine mammals however there were three detections of unidentified dolphins.

5.3 Recommendations

The attenuation of sound, and therefore its potential impact on marine animals is linked to source volume, water depth, seabed properties and sound velocity profile (McCauley *et al*., 2000). In addition it is clear that the responses of marine animals can be highly variable and context specific (Southall *et al*., 2007; Ellison *et al*., 2012). Given this it is recommended that where appropriate dedicated and qualified MMOs and PAMS operators continue to be present onboard vessels conducting analogue surveys.

CEFAS voluntarily adopted the JNCC guidelines as best practice due to the use of a chirp, there was no requirement in the licence issued by the Marine Management Organisation that these guidelines must be followed. However mitigation for the use of this equipment may be considered compulsory for the oil and gas industry in line with the consent issued by the Department of Business, Energy and Industrial Strategy under Regulation 4 of the Petroleum Activities (Conservation of Habitats) Regulations 2001 (and 2007 Amendments). Use of acoustic equipment will have the same effect on marine animals irrespective of their purpose therefore it is recommended that there should not be a divide between adoption of the JNCC Guidelines for industry and for scientific purposes as this promotes best practice.

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APPENDICES

APPENDIX A JNCC GUIDELINES FOR MINIMISING THE RISK OF INJURY AND DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

August 2010

The guidelines have been written for activities on the United Kingdom Continental Shelf and are aimed at minimising the risk of injury and acoustic disturbance from seismic surveys to marine mammals including seals, whales, dolphins and porpoises. Whilst there are no objections to these guidelines being used out-with UK waters JNCC would encourage all operators to determine if any special or local circumstances pertain, as we would not wish these guidelines to be used where a local management tool has already been adopted (for instance in the Gulf of Mexico OCS Region). In this context, JNCC notes that other fauna, for example turtles, occur in waters where these guidelines may be used, and would suggest that, whilst the appropriate mitigation may require further investigation, the soft-start procedures for marine mammals would also be appropriate for marine turtles and basking sharks[i]. The guidelines require the use of trained Marine Mammal Observers (MMOs) whose role is to advise on the use of the guidelines and conduct pre-shooting searches for marine mammals before commencement of any seismic activity. A further duty is to ensure that the JNCC reporting forms are completed for inclusion in the MMO report. In addition to the visual mitigation provided by MMOs, if seismic surveys are planned to start during hours of darkness or low visibility it is considered best practice to deploy Passive Acoustic monitoring (PAM). The 2010 version of the JNCC seismic guidelines reflects amendments (2007 and 2009 amendments) to the Conservation (Natural Habitats &c.) Regulations 1994 (Habitat Regulations, HR) for England and Wales[ii] and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (Offshore Marine Regulations, OMR, as amended in 2009 and 2010). Both regulations have revised the definition of deliberate disturbance of 'European Protected Species' (EPS), which now excludes trivial disturbance from the offence. Both regulations now also include the offence of deliberate injury. European Protected Species include cetaceans and turtles.

It has been recognised that sound generated from seismic sources has the potential to cause injury and possibly also disturbance to marine mammals. Seismic surveys have therefore the potential to cause a deliberate injury offence as defined under regulations 41(1)(a) and 39(1)(a) and a deliberate disturbance offence as in 41(1)(b) and 39(1)(b) of the HR and OMR, respectively. The JNCC seismic guidelines reflect best practice for operators to follow during the planning, operational and reporting stages. It is considered that compliance with the recommendations in these guidelines will reduce the risk of injury to EPS to negligible levels.

Please note that the mitigation measures recommended in the existing guidelines are more relevant to the prevention of injury rather than disturbance as defined in regulations 41(2) and 39(1A), of the HR and OMR, respectively. The onus should be on the entity responsible for the activity to assess whether a disturbance offence is likely to occur. Guidance on how to carry out such risk assessment is provided in the JNCC, NE and CCW document 'The protection of marine European Protected Species from injury and disturbance'.

In relation to oil and gas seismic surveys in the UKCS, it is a requirement of the consent issued under regulation 4 of the Petroleum Activities (Conservation of Habitats) Regulations 2001 (& 2007 Amendments) by the Department for Energy Climate Change (DECC), that the JNCC Seismic Guidelines must be followed, and the elements of the guidelines that are relevant to a particular survey are incorporated into the legally-binding condition of consent. It should be noted that it is the

responsibility of the company issued consent by DECC[iii], referred to in these guidelines as the 'applicant', to ensure that these guidelines are followed, and it is recommended that a copy of the JNCC guidelines are available onboard all vessels undertaking seismic activities in UK waters. Where relevant, when the survey is completed a MMO report must be submitted to the JNCC.

i Basking sharks are protected from intentional capture or disturbance in British waters (up to 12 miles offshore) under a 1998 listing on the Wildlife and Countryside Act (1981), Schedule 5.
ii In 2010 a consolidated version of the regulations came into force: The Conservation of Habitats and Species Regulations 2010.
iii Department of Energy and Climate Change was formerly known as Department for Business and Regulatory Reform (BERR)

Index

Terminology

Marine European Protected Species: These are marine species in Annex IV(a) of the Habitats Directive that occur naturally in the waters of the United Kingdom. These consist of several species of cetaceans (whales, dolphins and porpoises), turtles, and the Atlantic Sturgeon.

Marine Mammal Observer (MMO): Individual responsible for conducting visual watches for marine mammals. For some seismic surveys it may be requested that observers are trained, dedicated and / or experienced. The MMO may also be a PAM operative if trained.

Trained MMO: Has been on a JNCC recognised course

Dedicated MMO: Trained observer whose role on board is to conduct visual watches for marine mammals (although it could double up as a PAM operative)

Experienced MMO: Trained observer with 3 years of field experience observing for marine mammals, and practical experience of implementing the JNCC guidelines

PAM Operative: Person experienced in the use of PAM software and hardware and marine mammal acoustics

Mitigation Zone: The area where a Marine Mammal Observer keeps watch for marine mammals (and delays the start of activity should any marine mammals be detected).

Passive Acoustic Monitoring (PAM): Software system that utilises hydrophones to detect the vocalisations of marine mammals.

Seismic Survey: Any survey that uses airguns, including 2D/3D/4D and OBC (On-Bottom Cabling) surveys and any similar techniques that use airguns. Surveys using multibeam systems and sub-bottom profiling equipment such as boomers, pingers etc are not considered in these guidelines. However, the guidelines can be adapted and applied to the operation of such systems if considered appropriate.

Shot Point Interval (SPI): Interval between firing of the airgun or airguns.

Site Survey: Seismic survey of a limited area proposed for drilling, infrastructure emplacement etc (typically with source size of 180 cubic inches or less).

Soft-Start: Turning on the airguns at low power and gradually and systematically increasing the output until full power is achieved (usually over a period of 20 minutes). The appropriate soft-start method is dependant upon the type of seismic survey and is discussed in section 3.

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: Seismic survey undertaken ‘down hole’ in connection with well operations (typically with a source size of 500 cubic inches).

Section 1 – Assessing and minimising the risk of injury

1.1 The Planning Stage

When a seismic survey is being planned, the applicant should consider the following recommendations and best practice advice:

- Determine what marine mammal species are likely to be present in the survey area and assess if there are any seasonal considerations that need to be taken into account, for example periods of migration, breeding, calving or pupping. For UKCS activities the 'Atlas of cetacean distribution in north-west European waters' (Reid *et al*, 2003) is a useful starting point.
- Consult the latest relevant regulatory guidance notes; in the UK, DECC issues guidance notes for oil and gas seismic activities.
- As part of the environmental impact assessment, assess the likelihood of injuring or disturbing a European Protected Species. In the UK, it will be necessary to assess the likelihood of committing an offence as defined in the HR and in the OMR.
- Consult the JNCC, NE and CCW guidance on 'The protection of marine European Protected Species from injury and disturbance' to assist in the environmental impact assessment. To obtain a copy of the latest draft version of the guidance please contact JNCC.

The operator should whenever possible implement the following best practice measures:

- If marine mammals are likely to be in the area, only commence seismic activities during the hours of daylight when visual mitigation using Marine Mammal Observers (MMOs) is possible.
- Only commence seismic activities during the hours of darkness, or low visibility, or during periods when the sea state is not conducive to visual mitigation, if a Passive Acoustic Monitoring (PAM) system is in use to detect marine mammals likely to be in the area, noting the limitations of available PAM technology (seismic surveys that commence during periods of darkness, or low visibility, or during periods when the observation conditions are not conducive to visual mitigation, could pose a risk of committing an injury offence).
- Plan surveys so that the timing will reduce the likelihood of encounters with marine mammals. For example, this might be an important consideration in certain areas/times, e.g. during seal pupping periods near Special Areas of Conservation for common seals or grey seals.
- Provide trained MMOs to implement the JNCC guidelines.
- Use the lowest practicable power levels to achieve the geophysical objectives of the survey.
- Seek methods to reduce and/or baffle unnecessary high frequency noise produced by the airguns (this would also be relevant for other acoustic energy sources).

Section 2 - Marine Mammal Observers

2.1. Role of an MMO

The primary role of an MMO is to act as an observer for marine mammals and to recommend a delay in the commencement of seismic activity should any marine mammals be detected. In addition, a MMO should be able to advise the crew on the procedures set out in the JNCC guidelines and to provide advice to ensure that the survey programme is undertaken in accordance with the guidelines. Before the survey commences it is important to attend any pre-mobilisation meetings to discuss the working arrangements that will be in place, and to request a copy of the survey consent issued by DECC (if applicable). An MMO may also work closely with Passive Acoustic Monitoring operatives. As the MMO role in relation to the vessel and survey operations is purely advisory, it is important to be aware of the command hierarchy and communication channels that will be in place, and determine who the main MMO / PAM operative contacts should be.

In a typical vessel based seismic survey, the MMO / PAM operative may pass advice to the party chief and client's representative through the navigators or seismic observers, and it is important to establish what the working arrangements are, as this may vary from one survey to the other. The MMOs should consider themselves as part of the crew and respect the chain of command that is in place.

MMOs should make certain that their efforts are concentrated on the pre-shooting search before the soft-start. These guidelines cannot be interpreted to imply that MMOs should keep a watch during all daylight hours, but JNCC would encourage all MMOs to manage their time to ensure that they are available to carry out a watch to the best of their ability during the crucial time - the 30 minutes before commencement of the firing of the seismic source (or 60 minutes if surveying where deep diving marine mammals are likely to be present). Whilst JNCC appreciates the efforts of MMOs to collect data at other times, this should be managed to ensure that those observations are not detrimental to the ability to undertake a watch prior to a soft-start. Where two MMOs are onboard a seismic vessel, JNCC would encourage collaboration to ensure that cetacean monitoring is always undertaken during all daylight hours.

2.2. Training requirements for MMOs

A prerequisite for an MMO to be classified as a 'trained MMO' is that they must have received formal training on a JNCC recognised course. (Further information on MMO course providers is available at: http://www.jncc.gov.uk/page-4703)

2.3. MMO equipment and reporting forms

MMOs should be equipped with binoculars, a copy of the JNCC guidelines and the 'Marine Mammal Recording Form' which is an Excel spreadsheet and has embedded worksheets named: 'Cover Page', 'Operations', 'Effort' and 'Sightings'. A Word document named 'Deckforms' is also available, and MMOs may prefer to use this when observing before transferring the details to the Excel spreadsheets.

The ability to determine range is a key skill for MMOs to have, and a useful tool to perform this function is a range finding stick.

All MMO forms, including a guide to completing the forms, and instructions on how to make and use a range finding stick are available on the JNCC website.

2.4. Reporting requirements – the MMO report

A report, the 'MMO report', should be sent to the JNCC after the survey has been completed. It is the responsibility of the consent holder to ensure that the MMO report is sent to JNCC. Ideally the MMO report should be sent via e-mail to seismic@jncc.gov.uk, or it can be posted to the address on the front page of these guidelines. Reports should include completed JNCC marine mammal recording forms and contain details of the following:

- The seismic survey reference number provided to the applicant by DECC.
- 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), and / or details of any other acoustic energy used.
- Number and types of vessels involved in the survey.
- A record of all occasions when the airguns were used.
- A record of the watches made for marine mammals, including details of any sightings and the seismic activity during the watches.
- Details of any problems encountered during the seismic survey including instances of non-compliance with the JNCC guidelines.

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 DECC. It is therefore essential that MMO reports are completed as soon as possible after the survey has been completed.

Section 3 – Guidance before and during seismic activity

All observations should be undertaken from the source vessel (where the airguns are being deployed from), unless alternative arrangements have been agreed with DECC. The MMO should be positioned on a high platform with a clear unobstructed view of the horizon, and communication channels between the MMO and the crew should be in place before commencement of the pre-shooting search (this may require portable VHF radios). The MMO should be aware of the timings of the proposed operations, so that there is adequate time to conduct the pre-shooting search. Figure 1 illustrates a typical seismic survey with decision making pathways in the event a marine mammal is detected.

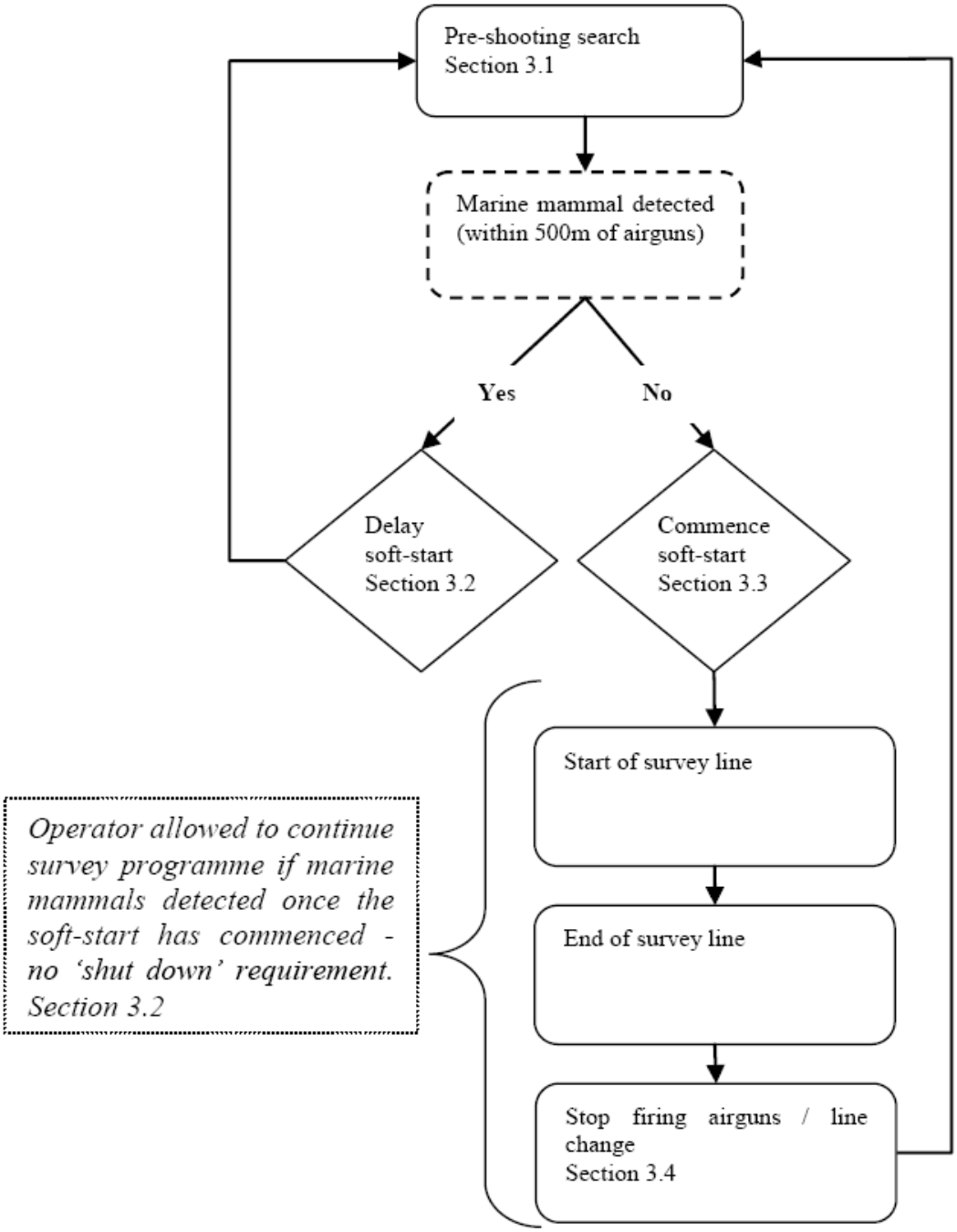

Figure 1. Flowchart illustrating the decision making pathway of a Marine Mammal Observer during a seismic survey.

3.1 Pre-shooting search

The pre-shooting search should normally be conducted over a period of 30 minutes before commencement of any use of the airguns. The MMO should make a visual assessment to determine if any marine mammals are within 500 metres of the centre of the airgun array. In deep waters (>200 m) the pre-shooting search should extend to 60 minutes as deep diving species (e.g. sperm whale and beaked whale) are known to dive for longer than 30 minutes. A longer search time in such areas is likely to lead to a greater detection and tracking of deep diving marine mammals. To facilitate more effective timing of proposed operations when surveying in deeper waters, the searches for marine mammals can commence before the end of the survey line (whilst the airguns are still firing); this condition may be necessary for surveys which have relatively fast line turn times. If any marine mammals are detected whilst the airguns are still firing, then no action

is required other than for the MMO to monitor and track any marine mammals. The commencement of the soft-start for any subsequent survey lines should be delayed for at least 20 minutes if marine mammals are detected when the airguns have ceased firing.

If PAM is used in conjunction with visual monitoring the PAM operatives should ensure the system is deployed and being monitored for vocalisations during each designated pre-shooting period.

3.2 Delay if marine mammals are detected within the mitigation zone (500 metres)

If marine mammals are detected within 500 metres of the centre of the airgun array during the pre-shooting search, the soft-start of the seismic sources should be delayed until their passage, or the transit of the vessel, results in the marine mammals being more than 500 metres away from the source. In both cases, there should be a 20 minute delay from the time of the last sighting within 500 metres of the source to the commencement of the soft-start, in order to determine whether the animals have left the area. If PAM is used it is the responsibility of the PAM operatives to assess any acoustic detections and determine if there are likely to be marine mammals within 500 metres of the source. If the PAM operatives consider marine mammals are present within that range then the start of the operation should be delayed as outlined above.

If marine mammals are detected within 500 metres of the centre of the airgun array whilst the airguns are firing, either during the soft-start procedure or whilst at full power, there is no requirement to stop firing the airguns.

In situations where seal(s) are congregating around a drilling or production platform that is within the survey area, it is recommended that the soft-start should commence at a location at least 500 metres from the platform.

3.3 The soft-start

The soft-start is defined as the time that airguns commence shooting till the time that full operational power is obtained. Power should be built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the area. This build up of power should occur in uniform stages to provide a constant increase in output. There should be a soft-start every time the airguns are used, the only exceptions being for certain types of airgun testing (section 3.3.2), and the use of a ‘mini-airgun’ (single gun volume less than 10 cubic inches), these are used on site-surveys (section 3.3.1). The duration of the pre-shooting search (at least 30 minutes) and the soft-start procedure (at least 20 minutes) should be factored into the survey design.

General advice to follow for soft-starts:

- To minimise additional noise in the marine environment, a soft-start (from commencement of soft-start to commencement of the line) should not be significantly longer than 20 minutes (for example, soft-starts greater than 40 minutes are considered to be excessive, and an explanation should be provided within the MMO report).
- Where possible, soft-starts should be planned so that they commence within daylight hours.
- Once the soft-start has been performed and the airguns are at full power the survey line should start immediately. Operators should avoid unnecessary firing at full power before commencement of the line.

- If, for any reason, firing of the airguns has stopped and not restarted for at least 10 minutes, then a pre-shooting search and 20 minute soft-start should be carried out (the requirement for a pre-shooting search only applies if there was no MMO on duty and observing at this time, and if the break in firing occurred during the hours of daylight). After any unplanned break in firing for less than 10 minutes the MMO should make a visual assessment for marine mammals (not a pre-shooting search) within 500 metres of the centre of the airgun array. If a marine mammal is detected whilst the airguns are not firing the MMO should advise to delay commencement, as per the pre-shooting search, delay and soft start instructions above. If no marine mammals are present then they can advise to commence firing the airguns.
- When time-sharing, where two or more vessels are operating in adjacent areas and take turns to shoot to avoid causing seismic interference with each other, the soft-start and delay procedures for each vessel should be communicated to, and applied on, all the vessels involved in the surveying.

3.3.1 Soft-start requirements for site survey or Vertical Seismic Profiling (VSP)

Surveys should be planned so that, whenever possible, the soft-start procedures for site surveys and Vertical Seismic Profiles (VSP's) commence during daylight hours. Whilst it is appreciated that high resolution site surveys / VSP operations may produce lower acoustic output than 2D or 3D surveys it is still considered desirable to undertake a soft-start to allow for marine mammals to move away from the seismic source.

For ultra high resolution site surveys that only use a 'mini-airgun' (single airgun with a volume of less than 10 cubic inches) there is no requirement to perform a soft-start, however, a pre-shooting search should still be conducted before its use.

For site surveys and VSPs, a number of options are available to effect a soft-start.

- The standard method, where power is built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity.
- As the relationship between acoustic output and pressure of the air contained in the airgun is close to linear and most site surveys / VSP operations use only a small number of airguns and a soft-start can be achieved by slowly increasing the air pressure in 500 psi steps. From our understanding, the minimum air pressure which the airgun array can be set to will vary, as this is dependent on the make and model of the airgun being used. The time from initial airgun start up to full power should be at least 20 minutes.
- Over a minimum time period of 20 minutes the airguns should be fired at an increasing frequency (by decreasing the Shot Point Interval (SPI)) until the desired firing frequency is reached.

3.3.2 Soft-starts and airgun testing

Airgun tests may be required before a survey commences, or to test damaged or misfiring guns following repair, or to trial new arrays. Individual airguns, or the whole 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:

- If the intention is to test all airguns at full power then a 20 minute soft-start is required.
- If the intention is to test a single airgun on low power then a soft-start is not required.

- If the intention is to test a single airgun, or a number of guns on high power, the airgun or airguns should be fired at lower power first, and the power then increased to the level of the required test; this should be carried out over a time period proportional to the number of guns being tested and ideally not exceed 20 minutes in duration.

MMOs should maintain a watch as outlined in the pre-shooting search guidance (section 3.1) before any instances of gun testing.

3.4 Line Change

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 line prior to commencement of the next line. Depending upon the type of seismic survey being undertaken, the time for a line change can vary. Line changes are not necessary for all types of seismic surveys, for example, in certain regional surveys where there is a significant distance between the lines, and for VSP operations.

The guidance relating to line change depends upon the airgun volume.

3.4.1 Seismic surveys with an airgun volume of 500 cubic inches or more

If the line change time is expected to be greater than 20 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. A pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array.

3.4.2 Seismic surveys with an airgun volume of 180 cubic inches or less (site surveys)

If the line change time is expected to be greater than 40 minutes, airgun firing should be terminated at the end of the line and a full 20 minute soft-start undertaken before the next line. The pre-shooting search should also be undertaken during the scheduled line change, and the soft-start delayed if marine mammals are seen within 500 metres of the centre of the airgun array.

If the line change time is expected to be less than 40 minutes, airgun firing can continue during the turn, but the Shot Point Interval (SPI) should be increased (longer duration between shots). Ideally, the SPI should not exceed 5 minutes during the turn.

Depending upon the duration of the line turns and the nature of seismic survey it may be necessary to vary the soft-start procedures. If an applicant determines that an effective line change can not be achieved using the above methods please contact JNCC at the earliest possible opportunity to discuss the proposed alternative, and include the details of the agreed procedure and the consultation with the JNCC in the application for survey consent.

3.5 Undershoot operations

During an undershoot operation, one vessel is employed to tow the seismic source and a second vessel used to tow the hydrophone array, although the main vessel will still tow the hydrophone array. This procedure is used to facilitate shooting under platforms or other obstructions. The MMO may be too far away from the airguns to effectively monitor the mitigation zone, and it is therefore recommended to place the MMO on the source vessel. If this is not possible, for example for logistical reasons, or the health and safety implications of transferring personnel from one vessel to another, the application should explain that the recommended procedure cannot be followed in the

application for the survey consent, or the application for a variation of that consent. Irrespective of the MMO location agreed with DECC, the pre-shooting search and soft-start procedures should still be followed prior to undertaking an undershoot operation.

Section 4 - Acoustic Monitoring

Visual observation is an ineffective mitigation tool during periods of darkness or poor visibility (such as fog), or during periods when the sea state is not conducive to visual mitigation, as it will not be possible to detect marine mammals in the vicinity of airgun sources. Under such conditions, PAM is considered to be the only currently available mitigation technique that can be used to detect marine mammals. Current PAM systems can be particularly helpful in detecting harbour porpoises within the 500 metre mitigation zone, although the systems have their limitations and can only be used to detect vocalising species of marine mammals.

PAM systems consist of hydrophones that are deployed into the water column, and the detected sounds are processed using specialised software. PAM operatives are needed to set up and deploy the equipment and to interpret the detected sounds.

4.1 Use of PAM as a mitigation tool:

PAM can provide a useful supplement to visual observations undertaken by MMOs and JNCC may recommend that it is used as a mitigation tool when commenting on applications for survey consents. However, in many cases it is not as accurate as visual observation for determining range, and this will mean that the mitigation zone will reflect the range accuracy of the system. For example, if the range accuracy of a system is estimated at +/-300 metres, animals detected and calculated to be within 500 metres from the source could, in reality, be 500 + 300 = 800 metres, but their detection would still lead to a delay in the soft-start. Although, at present it is not possible to express the range accuracy of most PAM systems in numerical terms, this example serves to illustrate that it is in the operator's best interests to use the most accurate system available, and for the PAM operative to factor in a realistic estimate of the range accuracy.

Some PAM systems do not have a reliable range determination facility or can only calculate the range for some species. In such cases, the detection of a confirmed cetacean vocalisation should still be used to initiate postponement of the soft-start if the PAM operator is able to make a judgement about the range of the animals from the airgun source, because of their experience gained in differentiating between distant and close vocalisations. In the absence of PAM systems capable of range determination, this expert judgement will constitute the basis for deciding whether an area is free from cetaceans prior to the soft-start.

In all cases where PAM is employed, a brief description of the system and an explanation of how the applicant intends to deploy PAM to greatest effect should be included in the application for survey consent.

In the last few years, software that processes and analyses cetacean sounds has been developed. An example of this is PAMGuard, an open source software that has been developed as part of the International Association of Oil and Gas Producers Joint Industry Project (JIP). JNCC recognises that PAMGuard is currently in a transition period between use as a research tool and widespread adoption as a monitoring technique. Moreover, JNCC recognises the need to balance proactive implementation of PAM with the need to further develop its capability, for example to include species recognition and baleen whale detection, and therefore encourages users of these systems to actively contribute to their development and refinement.

Section 5 – Requirements for MMOs and PAM

Any survey application or consultation received by JNCC will be considered on a case-by-case basis, and the mitigation measures advised to DECC will reflect the particulars of the survey and the importance of the survey area for marine mammals. The following paragraphs are provided as a guide to the advice applicants are likely to receive following submission of an application with JNCC.

For areas that are currently considered particularly important for marine mammals, for example in the UK this includes areas West of Scotland, the Moray Firth and Cardigan Bay, JNCC may recommend that:

- The MMOs should be experienced MMOs, and that PAM should be used.
- The PAM system should be used to supplement visual observations, or as the main mitigation tool if the seismic survey activity commences during periods of darkness or poor visibility, or during periods when the sea state is not conducive to visual mitigation.

JNCC will advise that two marine mammal observers should be used when daylight hours exceed approximately 12 hours per day (between 1st April and 1st October north of 57° latitude), or the survey is in an area considered particularly important for marine mammals.

When a non-dedicated MMO is recommended by JNCC (e.g. for VSPs and certain site-surveys), and the recommendation is incorporated into the conditions of the survey consent, a member of the rig's or vessels crew can perform the duties providing the crew member is a trained MMO.

When a dedicated MMO is recommended and this is a condition of the survey consent, 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 periods of seismic activity.

When two dedicated MMOs are requested and this is a condition of the survey consent, both should be employed solely for the purposes of monitoring the implementation of the guidelines and undertaking visual observations, and the use of a crew member with other responsibilities as the second observer is not considered to be an adequate substitute for a dedicated MMO, or to be in compliance with the conditions of the survey consent.

Section 6 - Background Information

These guidelines were originally prepared by a Working Group convened by the Department of the Environment, and were developed from a draft prepared by the Sea Mammal Research Unit (SMRU). The guidelines have subsequently been reviewed three times by the Joint Nature Conservation Committee, following consultation with interested parties.

6.1. Existing protection to cetaceans

Section 9 of the Wildlife and Countryside Act 1981 (CRoW amended) prohibits the intentional or reckless killing, injuring or disturbance of any cetacean. The UK is also a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and has applied its provisions in all UK waters. Amongst other actions required to conserve and manage populations of small cetaceans, ASCOBANS requires range states to "work towards...the prevention of ...disturbance, especially of an acoustic nature".

Reflecting the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC Habitats and Species Directive (92/43/EEC), the UK has the following legislation in place:

- The Conservation of Habitats and Species Regulations 2010
- The Conservation (Natural Habitats, & co.) Regulations 1995 (Northern Ireland) (and 2009 amendments)
- The Conservation (Natural Habitats, & co.) Amendment (No. 2) Regulations 2008 (Scotland) (and 2009 amendments)
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (and 2007 amendments),
- The Offshore Marine Conservation (Natural Habitats, & co.) Regulations 2007 (and 2009 and 2010 amendments) (beyond 12 nautical miles UKCS)

Section 7 – References and contacts

Further information on DECC's survey consent procedure can be found at: http://www.og.decc.gov.uk/.

A copy of these guidelines, the standard forms (electronic and hard copy) and further background information is available from the above address, or can be found on the JNCC website at: http://www.jncc.gov.uk/page-1534

Reid, J.B., Evans, P.G.H., & Northridge, S.P. 2003. 'Atlas of cetacean distribution in north-west European waters' (Online). http://www.jncc.gov.uk/page-2713

If you have any comments or questions relating to these guidelines, or suggestions on how they may be improved, please email seismic@jncc.gov.uk.

APPENDIX B COMPLETED JNCC RECORDING FORMS

The completed JNCC recording forms can be found in the Excel document entitled 10897_CEFAS_MMOforms.

APPENDIX C BEAUFORT WIND, SEA CONDITIONS AND VISIBILITY

WIND SPEED			
Beaufort Scale	Name	Knots	Metres/second
0	Calm	0 - 1	0 - 0.2
1	Light air	1 - 3	0.3 - 1.5
2	Light breeze	4 - 6	1.6 - 3.3
3	Gentle breeze	7 - 10	3.4 - 5.4
4	Moderate breeze	11 - 16	5.5 - 7.9
5	Fresh breeze	17 - 21	8.0 - 10.7
6	Strong breeze	22 - 27	10.8 - 13.8
7	Near gale	28 - 33	13.9 - 17.1
8	Gale	34 - 40	17.2 - 20.7
9	Strong gale	41 - 47	20.8 - 24.4
10	Storm	48 - 55	24.5 - 28.4
11	Violent storm	56 - 63	28.5 - 32.6
12	Hurricane	64+	32.7+

SEA STATE		
Symbol	Name	Height in metres
0	Calm (glassy)	0
1	Calm (rippled)	0 – 0.10
2	Smooth (wavelets)	0.10 – 0.50
3	Slight	0.50 – 1.25
4	Moderate	1.25 – 2.50
5	Rough	2.50 – 4.00
6	Very rough	4.00 – 6.00
7	High	6.00 – 9.00
8	Very high	9.00 – 14.00
9	Phenomenal	14.00+

VISIBILITY	
Name	Visibility (nautical miles)
Fog or dense snow fall	Less than 0.5
Poor visibility	0.5 – 2.0
Moderate visibility	2.0 – 5.0
Good visibility	5.0 – 25.0
Very good visibility	More than 25.0

APPENDIX D PASSIVE ACOUSTIC MONITORING SYSTEM SPECIFICATIONS

General	
Manufacturer	Gardline
Model	MK3
Towed streamer section	
Length	N/A integrated into tow cable
Section diameter	14/16mm over cable, 24/29mm over mouldings
Number of Hydrophones	4
Hydrophone type	Custom built by Gardline Environmental Limited 1 low frequency, 3 broadband
Receive sensitivity (dB re 1 V/µPa)	-204
Hydrophone separation	Hydrophone 1 and 2 0.25 m Hydrophone 2 and 3 1.2 m Hydrophone 3 and 4 1.2 m
Preamplifiers	4 broadband
Preamplifier type	Sensor Technology SA-02
Depth sensor manufacturer	SensorTechnics
Tow cable	
Length	250 m
Diameter	14 mm
Termination	37 pin CEEP Connectors
Deck cable	
Length	100 m
Diameter	14 mm
Termination	37 pin CEEP Connectors